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Innovating the HP Way

June 8, 2000

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Sincerely,

Rebranding Team

HP 8901A
MODULATION ANALYZER

Operation and Calibration Manual

SERIAL NUMBERS

This manual provides complete information for instruments with serial-number **prefixes:**

1836A to **3050A** and **all** ***MAJOR changes*** that apply to your in instrument.

rev. 12MA Y93

For additional important information about serial numbers, **refer** to "INSTRUMENTS COVERED BY THIS MANUAL" in section 1.

Third Edition

EAST 24001 MISSION AVENUE, TAF C-34, SPOKANE, WASHINGTON, U.S.A. 99220

Operation **and Calibration Manual** HP PM **08901-90135**

Other Document8 **Available:**
Service Manual HP **Part** 0690140136
Microfiche Operation **and Calibration Manual** HP Part 06901-90137
Mkrotkhe **Service** Manual HP Put 06901-90136

Printed in U.S.A. : June 1993

HEWLETT PACKARD

Sound Emission

Manufacturer's Declaration

This statement is provided to comply with the requirements of the German Sound DIN 45635 T. 19 (Typprufung).

This product has a sound pressure emission (at the operator position) < 70 dB(A).

- Sound Pressure Lp < 70 dB(A).
- At Operator Position.
- Normal Operation.
- According to IS0 7779 (Type Test).

Herstellerbescheinigung

Diese Information steht im Zusammenhang mit den Anforderungen der schinenlarminformationsverordnung vom 18 Januar 1991.

- Schalldruckpegel Lp < 70dB (A).
- AM Arbeitsplatz.
- Normaler Betrieb.
- Nach DIN 45635 T. 19 (Typprufung).

Printed in FRG March 1991

HEWLETT PACKARD

1 Regulatory Information

(Updated March 1999)

Safety Considerations

GENERAL

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

This product has been designed and tested in accordance with ***IEC Publication 1010,*** "Safety Requirements for Electronic Measuring Apparatus," and has been supplied in a safe condition. This instruction documentation contains information and warnings which must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

SAFETY EARTH GROUND

A uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set.

SAFETY SYMBOLS

⚠ Indicates instrument damage can occur if indicated operating limits are exceeded.

Indicates hazardous voltages.

⏚ Indicates earth (ground) terminal

WARNING **A WARNING note denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.**

CAUTION A CAUTION note denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond an CAUTION note until the indicated conditions are fully understood and met.

Safety Considerations for this Instrument

WARNING **This product is a Safety Class I instrument (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intentional interruption is prohibited.**

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an auto transformer (for voltage reduction), make sure the common terminal is connected to the earth terminal of the power source.

If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.

No operator serviceable parts in this product. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.

Servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.

The opening of covers or removal of parts is likely to expose dangerous voltages. Disconnect the product from all voltage sources while it is being opened.

The power cord is connected to internal capacitors that my remain live for 5 seconds after disconnecting the plug from its power supply.

For Continued protection against fire hazard, replace the line fuse(s) only with 250 V fuse(s) or the same current rating and type (for example, normal blow or time delay). Do not use repaired fuses or short circuited fuseholders.

Always use the three-prong ac power cord supplied with this product. Failure to ensure adequate earth grounding by not using this cord may cause product damage.

This product is designed for use in Installation Category II and Pollution Degree 2 per *IEC 1010* and *IEC* 664 respectively. FOR INDOOR USE ONLY.

This product has autoranging line voltage input, be sure the supply voltage is within the specified range.

To prevent electrical shock, disconnect instrument from mains (line) before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.

Ventilation Requirements: When installing the product in a cabinet, the convection into and out of the product must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the product by 4” C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts, then forced convection must be used.

Product Markings

CE - the CE mark is a registered trademark of the European Community. A CE mark accompanied by a year indicated the year the design was proven.

CSA - the CSA mark is a registered trademark of the Canadian Standards Association.

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of ship ment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to the Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYERS SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

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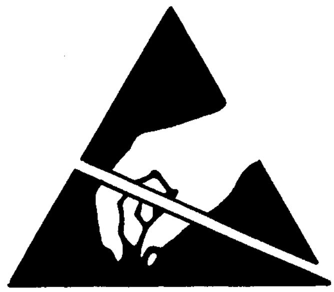
Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office.



ATTENTION
Static Sensitive
Devices

This instrument was constructed in an ESD (electro-static discharge) protected environment. This is because most of the semi-conductor devices used in this instrument are susceptible to damage by static discharge.

Depending on the magnitude of the charge, &vice substrates can be punctured or destroyed by contact or mere proximity of a static charge. The results can cause degradation of device performance, early failure, or immediate destruction.

These charges are generated in numerous ways such as simple contact, separation of materials, and normal motions of persons working with static sensitive &vices.

When handling or servicing equipment containing static sensitive devices, adequate precautions must be taken to prevent device damage or destruction.

Only those who are thoroughly familiar with industry accepted techniques for handling static sensitive devices should attempt to service circuitry with these devices.

In all instances, measures must be taken to prevent static charge build-up on work surfaces and persons handling the devices.

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SAFETY CONSIDERATIONS

GENERAL

This product and related documentation must be reviewed for **familiarization** with safety markings and instructions before operation.

This product is a Safety Class I instrument (provided with a protective earth **terminal).**

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

SAPETY EARTH GROUND

An uninterruptible safety earth ground must be provided from the main power source to the product input wiring **terminals,** power cord, or supplied power cord set.

SAFETY SYMBOLS

A ! Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents.)

Indicates hazardous voltages.

Indicates earth (ground) terminal.

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctlyperformed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION The CAUTION sign denotes a hazard. It calls attention to an **operating** procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

WARNING

***Any interruption** of the **protective (grounding.) conductor (inside or outside the instrument.. or disconnecting the protective earth terminal will cause a potential shock hazard that could resulting personal injury. (Grounding one conductor** of **a two conductor outlet is not sufficient** protection).*

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

***If this instrument is to be energized via an autotransformer** (for voltage **reduction)** make sure the **common** terminal is wnnected to the **earth terminal** of the power source.*

Servicing instructions are** for use by service trained **personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Adjustments described in the ***manual*** are *performed **with power supplied to the instrument while protective covers are removed. Energy a&able at may points may, if contacted, result** in **personal injury.***

Capacitors inside ***the instrument may still be charged even if the instrument has been disconnected from its source*** OS ***supply.***

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s)** of the same current rating and type (for example, normal **blow, time delay, etc.) Do not use repaired fuses or short circuited fuseholders.

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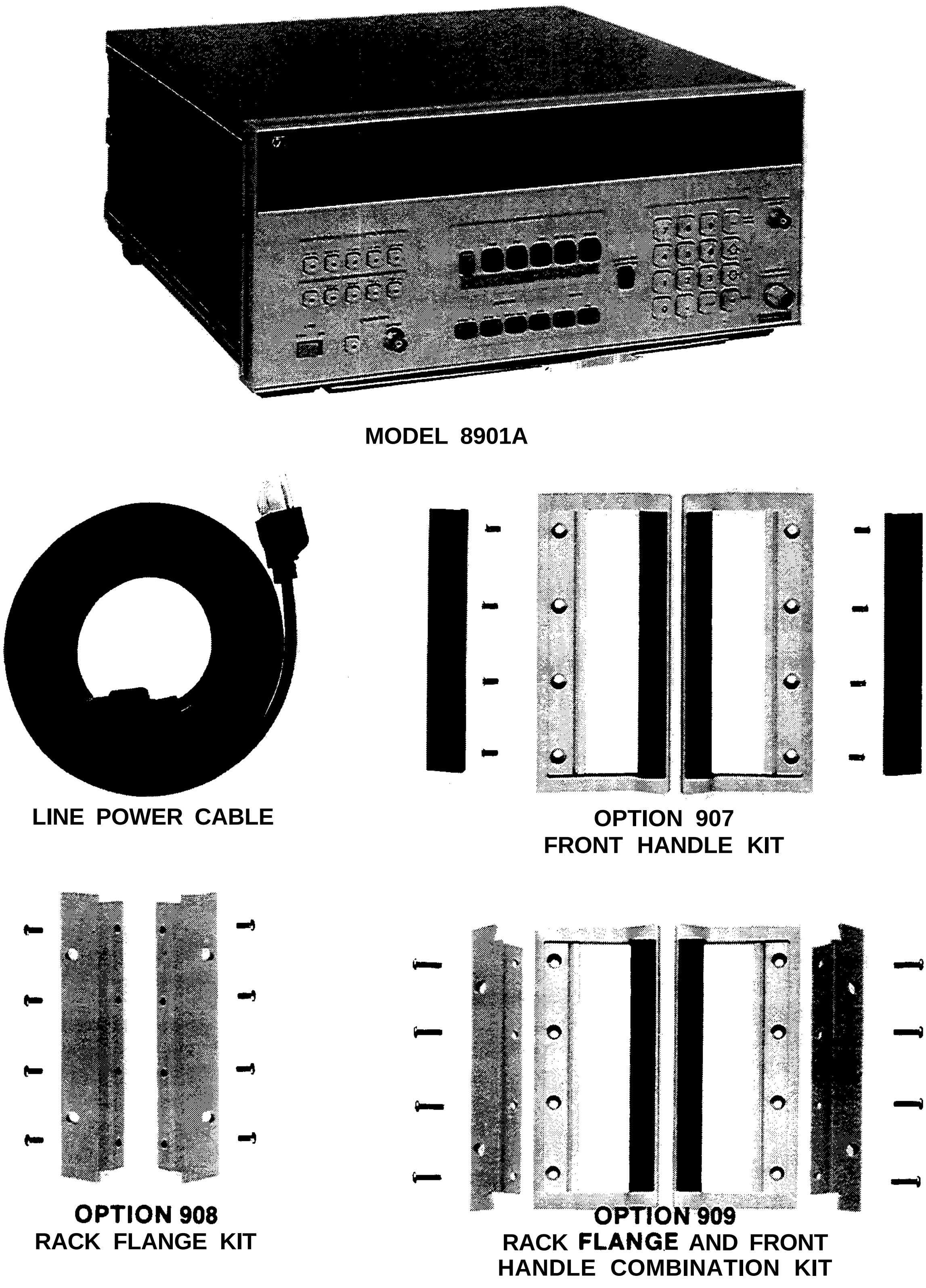


NOTE: Refer to ACCESSORIES SUPPLIEO. page 1-7, for more details.

Figure l-l. HP 8901 A (Option 010) Accessories Supplied, and Options 907, 908, and 909

Section 1
GENERAL INFORMATION

1-1. INTRODUCTION

This Operation and Calibration Manual contains information required to install, operate, test, and adjust the HP 8901A Modulation Analyzer. The Modulation Analyzer (with the AM and FM Calibrators, Option 010) is shown in figure 1-1 with all supplied accessories. This manual documents Modulation Analyzers supplied with Options 001, 002, 003, 004 and 010.

Section 1, General Information describes the instruments documented by this manual and covers instrument description, options, accessories, specifications and other basic information. This section also contains instrument theory of operation on a simplified block diagram level, and a discussion of basic modulation theory.

Section 2, Installation provides information about initial inspection, preparation for use (including address selection for remote operation), and storage and shipment.

Section 3, Operation provides information about panel features and includes operating checks, operating instructions for both local and remote operation, and maintenance information.

Section 4, Performance Tests provides the information required to check performance of the instrument against the critical specifications in table 1-1.

Section 5, Adjustments provides the information required to properly adjust the instrument.

Additional copies of this manual can be ordered separately through your nearest Hewlett-Packard office. The part number is listed on the title page.

Also on the title page of this manual, below the manual part number, is a microfiche part number. This number may be used to order 100 x 150 mm (4 x 6-inch) microfilm transparencies. Each microfiche contains up to 96 photo-duplicates of the manual pages. The microfiche package also includes the latest manual updates.

1-2. SPECIFICATIONS

Instrument specifications are listed in table 1-1. These are the performance standards, or limits, against which the instrument may be tested. Characteristics listed under ***Supplemental Information are*** not warranted specifications but are typical characteristics included as additional information for the user.

1-3. SAFETY CONSIDERATIONS

This product is a Safety Class I instrument (that is, provided with a protective earth terminal). The Modulation Analyzer and all related documentation must be reviewed for familiarization with **safety** markings and instructions before operation. Refer to the ***Safety Considerations*** page found at the beginning of this manual for a summary of the **safety** information.

Safety information pertinent to the task at hand (installation, operation, performance testing, adjustment) is found throughout this manuals.

1-4. INSTRUMENTS COVERED BY THIS MANUAL

Options

Electrical options 001, 002, 003, 004, and 010 and various mechanical options are documented in this manual. The **differences** are noted under the appropriate paragraph such as ***Options*** in section 1, the ***Replaceable Parts List,*** and the schematic diagrams.

Serial Numbers

Attached to the instrument is a serial number plate. The serial number is in the form **1234A00123.** The **first** four digits and the letter are the serial **prefix.** The last five digits form the sequential **suffix** that is unique to each instrument. The contents of this manual applies directly to instruments having the **same serial** number **prefix(es)** as listed under SERIAL NUMBERS on the manual title page.

For information concerning a serial number prefix not listed on the title page or in the Manual Updates Packet, contact your nearest Hewlett-Packard office.

1-5. MANUAL UPDATING

This manual may be revised as needed to make corrections and to document hardware and firmware changes. The lastest revision of the manual can be purchased from the Hewlett-Packard locations shown below:

Inside the U.S.A.

Call ***HP Parts Direct Ordering*** at 800-227-8164. They can also help determine if a new revision is available.

Outside the U.S.A.

Contact the local Hewlett-Packard Sales and Service office for ordering information.

1-6. DESCRIPTION OF THE MODULATION ANALYZER

The HP 8901A Modulation Analyzer is a complete measurement system for accurately characterizing signals in the 150 kHz to 1300 MHz frequency range. It can make more than just one kind of measurement. It combines the capabilities of three separate instruments: it can measure carrier frequency, it can measure RF peak power (often eliminating the need for a separate power meter), and it can accurately measure modulation and recover the modulating signal. This allows you to make those measurements most commonly needed to totally characterize a signal. The Modulation Analyzer can measure a signal's frequency, frequency drift, peak power level, amplitude modulation (AM), frequency modulation (FM), phase modulation (ΦM), and AM and PM noise components. It recovers the modulating signal with very low added distortion and noise for audio analysis.

Besides combining several measurements in one instrument, the Modulation Analyxer makes a second contribution to signal analysis – extremely precise modulation measurements. Its ability to make precise depth and deviation measurements, coupled with its very low internal noise, enables the Modulation Analyxer to characterize very accurate signal sources. Modulation depth or deviation accuracy is generally less than 1% of reading. Residual noise in a 50 Hz to 3 kHz bandwidth is 0.01% for AM and <8 Hz for PM at 1300 MHz carrier frequencies, decreasing to <1 Hz below 100 MHz.

The Modulation Analyzer is fully automatic and all major measurements can be made by pushing a single key. The Modulation Analyzer's large digital display shows measurement results with excellent resolution and is easy to read. All Modulation Analyxer operations can be controlled and all measurement results can be transferred through the Hewlett-Packard Interface Bus (HP-IB). (HP-IB is Hewlett-Packard's implementation of IEEE Standard 488 and ANSI Standard MC1.l.)

Frequency Measurements

In automatic operation, the Modulation Analyzer has the performance of a high-quality, 150 kHz to 1300 MHz frequency counter. Resolution is 10 Hz below 1000 MHz and 100 Hz above 1000 MHz. Sensitivity is -25 dBm (12 mV rms) below 650 MHz and -20 dBm (22 mV rms) above 650 MHz.

Like most frequency counters, the counter in the Modulation Analyzer will measure signals over a wide dynamic range, >50 dB (22 mV rms to 7 mV rms), and is protected from damage for signals up to 35 V rms. However, unlike many frequency counters, it automatically adjusts itself as the input level changes. There is no need to manually set or adjust the input attenuator. Because the Modulation Analyzer is usually used to measure modulated signals, its frequency counter also accurately measures signals with significant levels of AM.

The Modulation Analyzer uses an indirect technique for measuring RF frequencies. The input signal is down-converted to an intermediate frequency (IF') using a mixer and a local oscillator (LO). By counting the frequency of both the IF and LO and calculating their difference, the Modulation Analyzer can determine the frequency of the input signal. In automatic operation, the Modulation Analyzer automatically tunes to the largest input signal and measures its frequency.

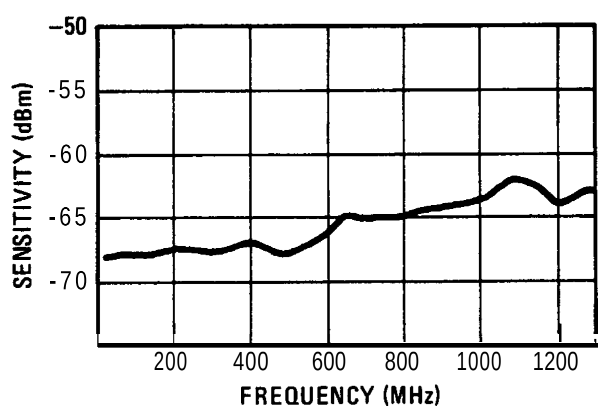


Figure l-2. Typical Sensitivity of Frequency Measurements in Manual Operation

In manual operation, you can determine the frequency to which the Modulation Analyzer tunes. Entering the approximate frequency on the keyboard causes the IF filter to eliminate all but very close interfering signals. This allows the Modulation Analyzer to selectively count signals other than the largest. Also, because of its large IF gain, the Modulation Analyzer can measure very low level signals. In manual operation, the Modulation Analyzer has a typical sensitivity of 0.22 mV rms (–60 dBm), and dynamic range of >90 dB (0.22 mV rms to 7 V rms).

RF Power Measurements

The Modulation Analyzer uses a diode detection circuit to measure RF input power. This technique measures peak voltage and is calibrated from 1 mW to 1 W for sine wave inputs. For amplitude-modulated signals, the Modulation Analyzer measures the peak envelope power. Because a peak detector is used,. distortion of the RF signal can affect accuracy, but for most levels of distortion this error is small.

The Modulation Analyzer is equipped with input power protection to prevent damage from the accidental application of excessive power. (This is a common cause of damage in equipment used to measure transmitters.) The Modulation Analyzer is tested for inputs up to 25 Watts. Protection is provided by limited diodes and an RF relay. When excessive power is applied, the relay opens and protects sensitive components, and the Modulation Analyzer displays an error message. The circuit automatically resets whenever a key is depressed. This technique is superior to fuses which, in many cases, are too slow for adequate protection and require replacement each time an overload occurs.

In addition to normal RF level measurements made directly on the input signal, the Modulation Analyzer can measure the signal level in the constant-gain IF filter passband. This is the TUNED RF LEVEL function. In this mode the Modulation Analyzer accuracy is degraded from normal RF measurements, but relative power measurements at a single frequency can be made with increased resolution. Because the IF filter allows some selectivity, one signal can be measured even when others are present.

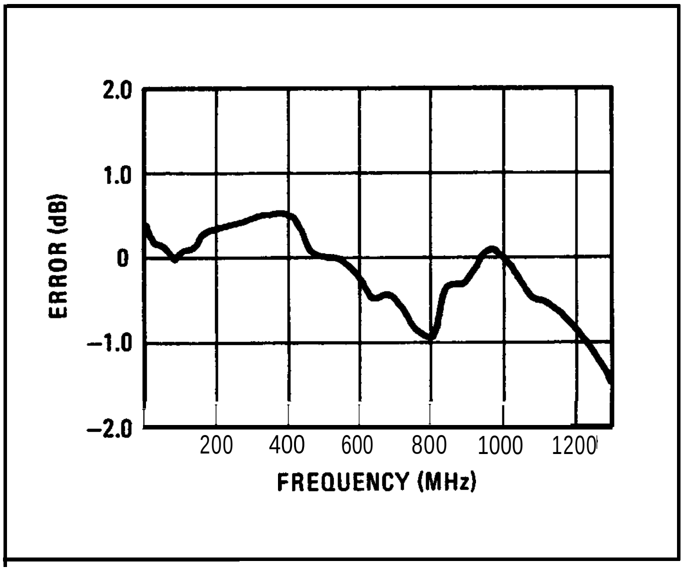


Figure 1-3. Typical Power Measurement Accuracy

Modulation Measurements

In AM, high accuracy and low noise are coupled with resolution of 0.01% below 40% depth and 0.1% resolution to over 100% depth. AM signals at rates up to 100 kHz can be measured and the modulation accurately recovered. AM signals with significant levels of FM can be measured because of excellent FM rejection.

Most AM depth measurements can be made with accuracies better than 1% of reading. This is made possible by very linear amplifiers and detectors. Because these amplifiers and detectors are also low in noise, residual AM in a 50 Hz to 3 kHz bandwidth is <0.01% rms.

FM deviation can be measured with an accuracy of 1% of reading and displayed with resolution ranging from 1 Hz for deviations below 4 kHz to 100 Hz for deviations greater than 40 kHz. Modulation is recovered with less than 0.1% distortion, and most AM is rejected.

The ability to measure low levels of residual FM is one of the key contributions of the Modulation Analyzer. A low-noise local oscillator in combination with a low-noise discriminator allows residual FM measurements of <8 Hz at 1300 MHz and <1 Hz below 100 MHz. This is low enough to allow the direct measurement of residual FM of such low-noise sources as crystal oscillators.

For all AM depth and FM deviation measurements you can select from one of three detectors. Both positive and negative peak (trough for AM) can be measured. The Modulation Analyzer also has an average-responding detector which is rms sine wave calibrated This type of detector is useful for determining the residual noise on a signal where the rms value, not the peak, is generally the desired parameter.

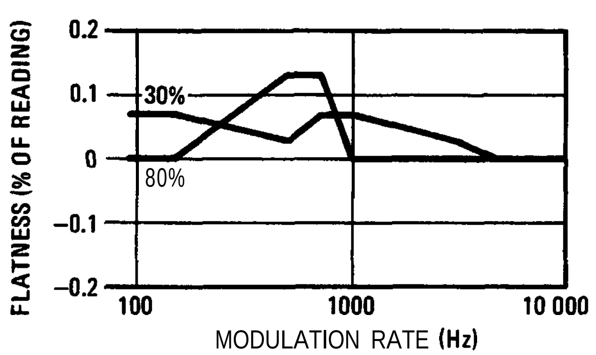


Figure 1-4. Typical AM Flatness

The Modulation Analyzer also has a PEAK HOLD function that is used with either the positive or negative peak detectors. This function captures, holds, and displays the maximum peak modulation of a signal and is ideal for making measurements such as modulation limiting on mobile radios. Measurements can be made for any length of time and either the largest positive or negative peak that occurs will be measured. Pushing the PEAK HOLD key resets the display and initiates a new measurement cycle.

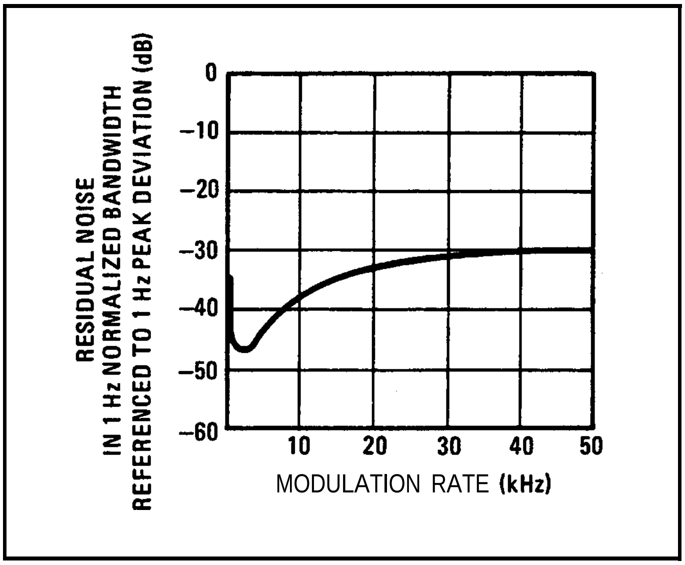


Figure 1-5. Typical Internal Noise Contribution to FM Measurements at 100 MHz Carrier Frequency

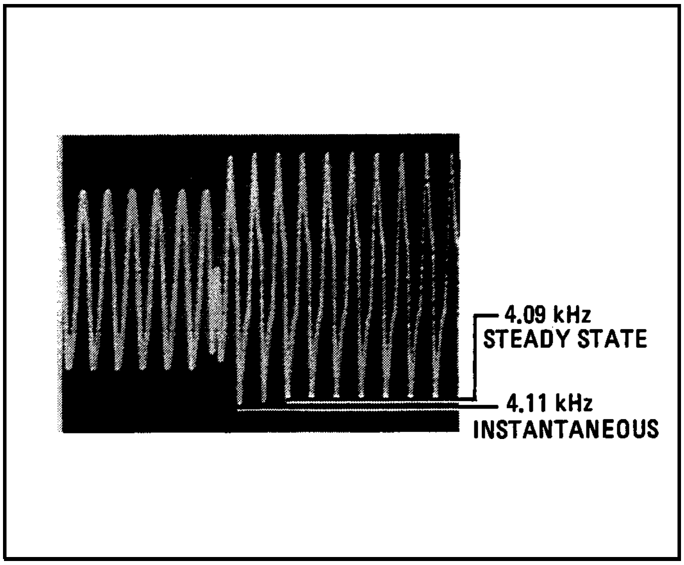


Figure 1-6. FM Mobile Radio Modulation Limiting Measurement Showing Demodulated Waveform and Measured Value of Transient and Steady-State Deviation

Post-Detection Audio Filters

The Modulation Analyzer has two high pass and three low pass post-detection audio filters for filtering the recovered modulation. These filters can be selected individually or in combination. Their cutoff frequencies have been chosen to match those needed for applications such as transmitter or signal generator testing. The >20 kHz filter is a Bessel filter. It minimizes overshoot for square wave modulation so that this type of modulating waveform can also be accurately measured.

The Modulation Analyzer contains four de-emphasis networks that can be used in addition to the audio filters. These are the ones commonly used in FM communications: 2550, 75, and 750 μs. When selected, the de-emphasis networks always affect the demodulated output.

You can select whether or not the de-emphasis network affects the deviation measured and indicated by the display. The ability to select either the actual or "de-emphasized deviation" increases the usefulness of the Modulation Analyzer in many applications.

Modulation Calibrators

One of the most difficult problems involved in making very accurate measurements of AM depth or FM deviation is generating a precisely modulated signal to use as a calibration standard. In instruments with Option 010, a precise AM and FM modulation standard is included.

The AM standard is generated by summing two identical 10 MHz signals. When one of the signals is switched on and off at a 10 kHz rate, the result is 33.33% AM depth. By internally measuring any slight difference in the levels of the 10 MHz signals, the Modulation Analyzer is able to compute internally the actual depth to ±0.1% accuracy. To further improve the modulation envelope, the rise and fall transitions are smoothed to eliminate ringing that might otherwise occur when this signal is measured.

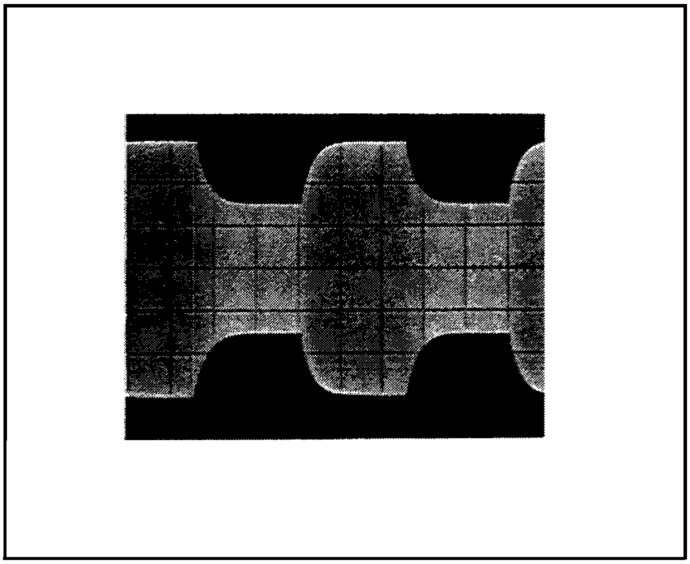


Figure 1-7. AM Calibrator Waveform

The FM standard is generated by square wave modulating a VCO with a nominal 34 kHz peak deviation. By using the internal counter to measure the upper and lower frequency of this signal, the actual peak deviation is computed internally to ±0.1% accuracy. To prevent ringing, the square wave is modified to a round-edge trapezoid.

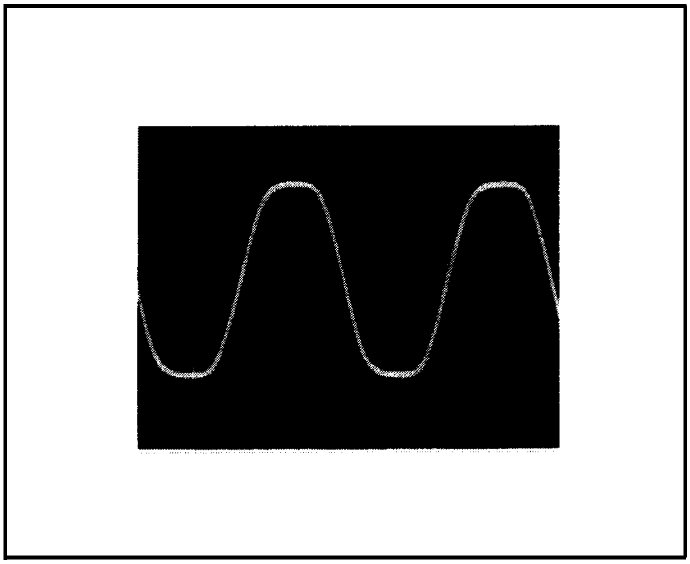


Figure 1-8. FM Calibrator Modulation Waveform

When the output of the calibrator is connected to the Modulation Analyzer's input, the amount of modulation is measured and a calibration factor displayed. The calibration factor is the ratio of the measured modulation to the internally-computed modulation of the calibrator, expressed in %.

Because the modulation standards are internal to the Modulation Analyzer, there is little need for metrology laboratories to purchase separate calibration standards. Also, because of the technique used, it is easy to verify if the calibrators are operating properly.

Operation

Often instruments with state-of-the-art accuracy require highly skilled operators in order to be used. This is not the case with the Modulation Analyzer. It provides excellent accuracy while remaining easy to use. Its front panel is simple, uncluttered, and easy to understand. You need only select the measurement to be made. There is no need to tune, adjust levels, or select the appropriate range; the internal microprocessor does it all and quickly. Because the microprocessor determines the optimum instrument settings for you, most measurements require only a single keystroke.

For those applications requiring tuning to a specific frequency, automatic tuning may be overridden. This feature allows a single signal to be selected in the presence of others but retains the speed and convenience of the other automatic functions.

You can also make measurements relative to either a measured value or one entered from the keyboard by using the ratio keys. Relative measurements can be expressed in either dB or %. This means that when testing FM mobile transmitters, you can enter 3 (kHz), depress the dB key, and make measurements in dB relative to 3 kHz deviation. Similarly, in broadcast FM applications, deviation could be displayed in % relative to 75 kHz deviation where 75 kHz is defined as 100%. You can also enter a measurement limit on the keyboard which will cause the Modulation Analyzer to indicate whenever the measured value exceeds the value entered as a limit.

Special Functions

The Modulation Analyzer can do more than is apparent from the front panel. This capability is accessed by using the numeric keys and a Special Function key. They give access to auxiliary functions, manual control of instrument functions, instrument operation verification, and service aids.

An example of the type of Special Functions found in the category of auxiliary functions is the automatic track-tune mode. This mode is accessed by entering 4.1, then pressing the SPCL key. Once the Modulation Analyzer, has been placed in track mode, it will continuously track the signal as it changes frequency. This eliminates the delays caused by the instrument searching for the signal each time the frequency changes. Using this Special Function, you can continuously monitor modulation accuracy on a signal generator while tuning across the signal generator's frequency band Special Functions can also be used to set any measurement range or instrument function. They can be used to select either of two internal IFs, the one normally used for frequencies above 10 MHz, or a narrow IF where rates and deviations are more restricted but selectivity is increased. All instrument functions not set using these Special Functions remain in the automatic mode. This allows you to select any combination of manual or automatic operations. By depressing the special key alone, the display shows eight digits that indicate which functions are in automatic and the state of those manually set.

There are also numerous Special Functions that can be used in verifying that the instrument and its various sections are operating properly. These, along with service functions make diagnosing and repairing the Modulation Analyzer faster and easier. An additional service aid configures many of the digital circuits for troubleshooting with a signature analyzer. This allows a technician with little knowledge of digital circuits to rapidly troubleshoot a failure in the digital portion of the instrument.

Those Special Functions that are most commonly used in operating the Modulation Analyzer are described on the Operating Information pull-out card under the front panel.

Programmability

The Modulation Analyzer is completely programmable through the Hewlett-Packard Interface Bus (HP-IB). This, coupled with the diversity of measurements the Modulation Analyzer can make, the speed with which these measurements can be made, and the flexibility of the Special Functions, make the instrument ideal for systems applications. In many instances it can reduce the number of instruments in a system, speed measurements, reduce complexity, and improve accuracy.

When the Modulation Analyzer is in remote, the front-panel annunciators make it very easy to determine what state the instrument is in.

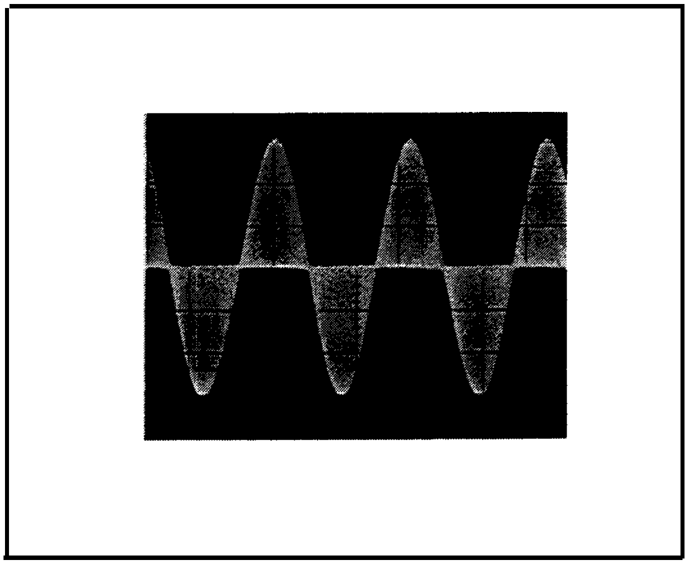


Figure 1-9. Demodulated FM Stereo Test Signal at 15 kHz Rate

1-7. OPTIONS

Electrical Options

Option 001. This option provides rear-panel (instead of front-panel) connections for INPUT, MODULATION OUTPUT, and if present, CALIBRATION OUTPUT.

Option 002. This option provides a high-stability (1 x 10^{-9}/day) internal reference oscillator in place of the standard reference oscillator. In addition, a 10 MHz time base output is provided on the rear panel.

Option 003. This option provides an output for the internal local oscillator signal and an input for external local oscillator signal. Both connections are located on the rear panel and use Type-N connectors.

Option 004. This option allows operation at line frequencies ranging from 48 to 440 Hz. Operation at frequencies greater than 66 Hz is restricted to ≤126.5 V ac line input.

Option 010. This option provides internal AM and FM calibrators. The AM calibrator provides a nominal output of 33.33% AM. The FM calibrator provides a nominal output of 34 kHz peak deviation. Using the calibrators, the Modulation Analyzer computes calibration factors accurate to ±0.1%.

Mechanical Options

The following options may have been ordered and received with the Modulation Analyzer. If they were not ordered with the original shipment and are now desired, they can be ordered from the nearest Hewlett-Packard office using the part number included in each of the following paragraphs.

Front Handle Kit (Option 907). Ease of handling is increased with the front-panel handles. Order HP part number 5061-9690.

Rack Flange Kit (Option 908). The Modulation Analyzer can be solidly mounted to the instrument rack using the flange kit. Order HP part number 5061-9678.

Rack Flange and Front Handle Combination Kit (Option 909). This is not a front handle kit and a rack flange kit packaged together; it is composed of a unique part which combines both functions. Order HP part number 5061-9684.

1-8. HEWLETT-PACKARD. INTERFACE BUS HP-IB

Compatibility

The Modulation Analyzer is compatible with HP-IB to the extent indicated by the following code: SH1, AH1, T5, 'I'EO, L3, LEO, SR1, RL1, PPO, DC1, DT1, CO. The Modulation Analyzer interfaces with the bus through open-collector 'ML circuitry. An explanation of the compatibility code may be found in IEEE Standard 488, ***IEEE Standard Digital Interface for Programmable Instrumentation*** or the identical ANSI Standard MC1.l.

For more detailed information relating to programmable control of the Modulation Analyzer, refer to ***Remote Operation, Hewlett-Packard Interface Bus*** in section 3 of this manual.

Selecting the HP-IB Address

The HP-IB address switches are located within the Modulation Analyzer. The switches represent a five-bit binary number. This number represents the talk and listen address characters which an HP-IB controller is capable of generating. In addition, two more switches allow the Modulation Analyzer to be set to talk only or to listen only. A table in section 2 shows all HP-IB talk and listen addresses. Refer to ***HP-IB Address Selection in*** section 2 of this manual.

1-9. ACCESSORIES SUPPLIED

The accessories supplied with the Modulation Analyzer are shown in figure l-l.

a. The line power cable may be supplied in several plug configurations, depending on the destination of the original shipment. Refer to ***Power Cables*** in section 2 of this manual.

b. Fuses with a 2A rating for 100/120 V ac (HP 2110-0002) and a 1A rating for 220/240 V ac (HP 2110-0001) are supplied. One fuse is factory installed according to the voltage available in the country of original destination. Refer to ***Line Voltage and Fuse Selection*** in section 2 of this manual.

l-10. ELECTRICAL EQUIPMENT AVAILABLE

HP-IB Controllers

The Modulation Analyzer has an HP-IB interface and can be used with any HP-IB compatible computing controller or computer for automatic systems applications.

Test Source

The HP 11715A AM/FM Test Source produces both extremely linear AM and FM at high rates and a low-noise CW signal. This source is required for performance testing and adjusting the Modulation Analyzer; however, it is an excellent stand-alone instrument for generating very low-distortion FM in the broadcast band.

Service Accessory Kit

A Service Accessory Kit (HP 08901-60287) is available which contains many accessories (such as extender boards and cables) useful in servicing the Modulation Analyzer.

Front-to-Rear-Panel Connectors Retrofit Kits

These kits contain all the necessary components and full instructions for converting instruments with front-panel connections for INPUT, MODULATION OUTPUT, and, if installed, CALIBRATION OUTPUT to rear-panel connections. If the instrument to be converted is not equipped with AM and PM calibrators (Option 010), order HP part number 08901-60234. If the instrument has the calibrators, order HP part number 08901-60235. After installation and calibration, performance will be identical to the HP 8901A Option 001.

Rear-to-Front-Panel Connectors Retrofit Kits

These kits contain all the necessary components and full instructions for converting Option 001 instruments with rear-panel connections for INPUT, MODULATION OUTPUT, and, if installed, CALIBRATION OUTPUT to front-panel connections. If the instrument to be converted is not equipped with AM and FM calibrators (Option 010), order HP part number 08901-60100. If the instrument has the calibrators, order HP part number 08901-60105. After installation and calibration, performance will be identical to the standard HP 8901A.

High Stability Internal Reference Retrofit Kit (HP 08901-60102)

This kit contains all the necessary components and full instructions for installation of the high-stability internal reference oscillator. After installation and calibration, performance will be identical to the HP 8901A Option 002.

Rear Panel Local Oscillator Connections Retrofit Kit (HP 08901-60103)

This kit contains all the necessary components and full instructions for installation of rear-panel local oscillator connections. After installation and calibration, performance will be identical to the HP 8901A Option 003.

Conversion to 400 Hz Line Operation

Modulation Analyzers not equipped to operate at line power frequencies greater than 66 Hz may be converted to operate at line frequencies from 48 to 440 Hz. However, operation at line frequencies greater than 66 Hz will be restricted to line voltages less than or equal to 126.5 V ac. To convert to 400 Hz operation, order HP part number 08901-60226. After installation, performance will be identical to the HP 8901A Option 004.

AM and FM Calibrators Retrofit Kits

These kits contain all the necessary components and full instructions for installation of the AM and FM calibrators. If the instrument to be equipped with the calibrators has front-panel connectors, order HP part number 08901-60236. If the instrument has rear-panel connectors (Option 001), order HP part number 08901-60237. After installation and calibration, performance will be identical to the HP 8901A Option 010.

I-11. MECHANICAL EQUIPMENT AVAILABLE

Chassis Slide-Mount Kit

This kit is extremely useful when the Modulation Analyzer is rack mounted. Access to internal circuits and components or the rear panel is possible without removing the instrument from the rack. Order HP part number 1494-0018 for 431.8 mm (17 in.) fixed slides and part number 1490-0023 for the correct adapters for non-HP rack enclosures.

Chassis Tilt Side Mount Kit

This kit is the same as the Chassis Slide Mount Kit above except it also allows the tilting of the instrument up or down 90°. Order HP part number 14940025 for 431.8 mm (17 in.) tilting slides and part number 1490-0023 for the correct adapters for non-HP rack enclosures.

I-12. RECOMMENDED TEST EQUIPMENT

Table l-2 lists the test equipment and accessories recommended for use in testing, adjusting, and servicing the Modulation Analyzer. If any of the recommended equipment is unavailable, instruments with equivalent minimum specifications may be substituted. Note that the Modulation Analyzer listed in table l-2 is required only if the instrument being tested does not already contain the AM and FM Calibrators, Option 010. Table 1-3 lists a number of accessories required in addition to those contained in the Service Accessory Kit, HP 08901-60287.

I-13. PRINCIPLES OF OPERATION FOR SIMPLIFIED BLOCK DIAGRAM

The Modulation Analyzer is most easily visualized as a calibrated, superheterodyne receiver; that is, it is a receiver which converts the incoming signal to a tied intermediate frequency (IF) which is then demodulated. Like a receiver, the Modulation Analyzer contains an RF input, local oscillator (LO), mixer, IF amplifier and filter, demodulator (detector), and audio filters (tone controls). Unlike a receiver, it has no tuned input, RF amplification, or audio power amplifier. Many other features are added to the instrument to make it more versatile. Some of these are automatic tuning, selectable measurement modes (signal frequency, level, or modulation – AM, FM, or ΦM), peak or average responding detectors, AM and FM calibrators (Option 010), and HP-IB programmability.

Referring to figure l-10, the signal at the INPUT is first sensed by an RF Detector. If the signal level exceeds 1W, the Overpower Relay is opened to protect the input circuits. The RF Detector also outputs a voltage proportional to the RF input level which is converted into a front-panel power indication and is used to set the Input Attenuator for an optimum level to the Input Mixer.

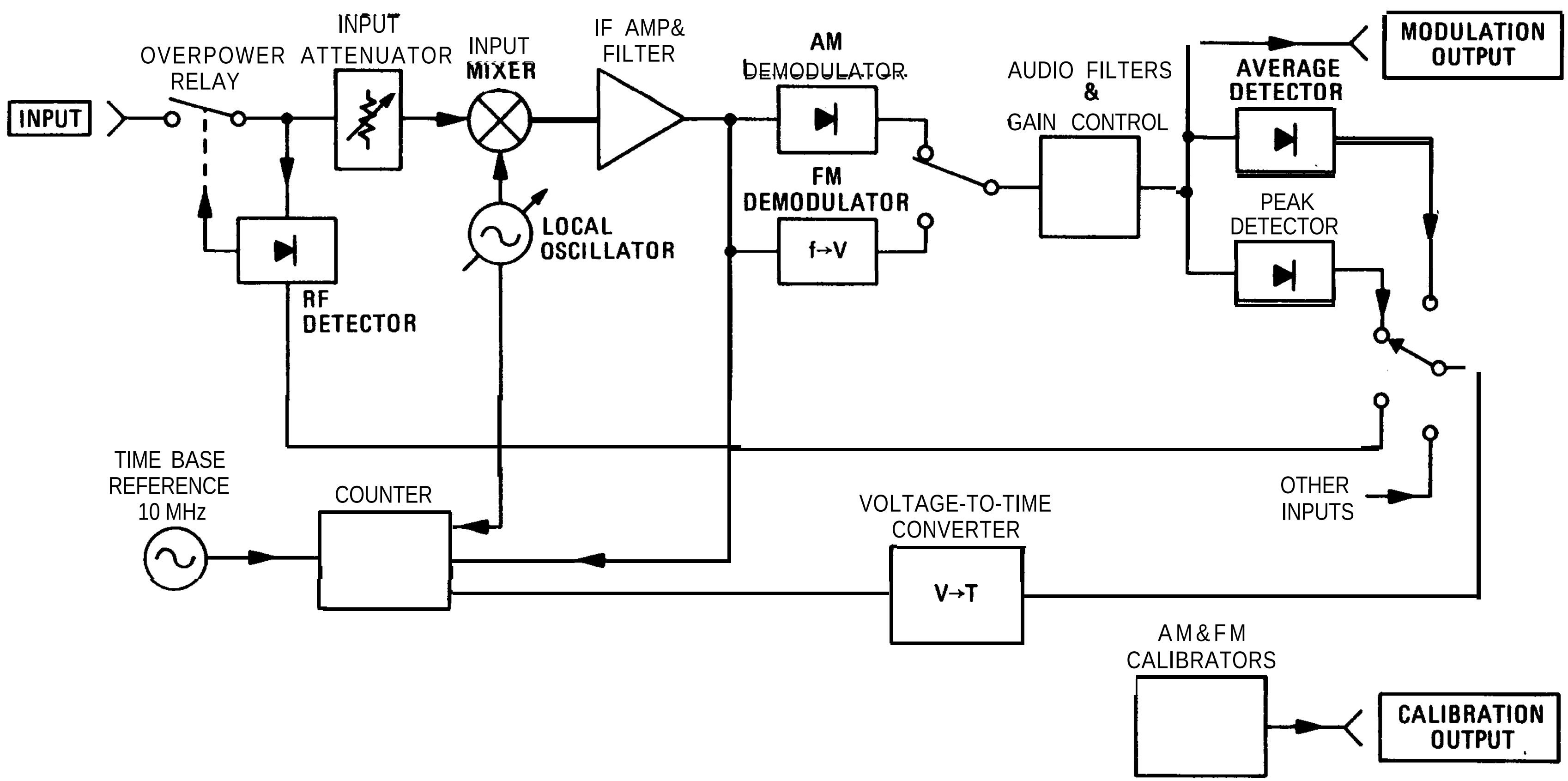


Figure 1-10. HP 8901A Modulation Analyzer Simplified Block Diagram

The Input Mixer converts the input signal to the intermediate frequency. Normally, the IF is 1.5 MHz and the LO is tuned 1.5 MHz above the input frequency. A 455 kHz IF can also be selected (it is selected automatically for input signals between 2.5 and 10 MHz). Below 2.5 MHz, the input passes directly through the Input Mixer without down conversion.

The LO has three main modes of operation:

1. It can automatically tune to the frequency required to down-convert the input to the IF.
2. It can tune to a frequency 1.5 MHz (or 455 kHz) above that entered from the keyboard (the manual tune mode).
3. It can automatically track a slowly moving input signal.

The first two are used where the LO noise must be minimized. The LO is also an input to the Counter.

The IF Amplifier and Filter determine the characteristics of the IF stage. The IF is either a 150 kHz to 2.5 MHz bandpass filter (with a nominal center frequency of 1.5 MHz) or a 455 kHz bandpass (with a bandwidth of 200 kHz). Modulation on the IF is demodulated either by the AM or FM demodulator. Phase modulation is recovered by integrating the demodulated FM in the Audio Filter circuitry. The IF is also an input to the Counter. To measure the input frequency, the Counter measures the frequency of the LO and the IF, and the Controller subtracts the two. (Below 2.5 MHz, the IF is counted directly as the input frequency.)

The demodulated signal is amplified and filtered (which for FM may include de-emphasis) and drives the front-panel MODULATION OUTPUT and the voltmeter circuits. The voltmeter converts the ac input into a dc voltage by means of either a Peak Detector or an Average Detector (used primarily for measuring noise). The Voltage-to-Time Converter converts its dc input into a time interval which is measured by the Counter and displayed. The Voltage-to-Time Converter can also measure the RF Detector output or any one of several other useful voltages such as IF level, AM calibrator level, and service-related voltages.

The AM and FM Calibrators (Option 010) provide a nominal 10.1 MHz signal with a precisely known amount of AM or FM. When the signal is applied to the RF INPUT, the AM or FM calibration factor of the demodulators is displayed. All related front-panel functions are automatically set for proper demodulation of the calibrator's signal.

The entire operation of the instrument is under control of a microprocessor-based Controller (not shown in figure l-10). The Controller sets up the instrument at turn-on, interprets keyboard entries, executes changes in mode of operation, continually monitors instrument operation, and displays measurement results and errors. In addition, its computing capability is used to simplify circuit operation; that is, it forms the last stage of the Counter, calculates the AM or FM generated by the Calibrators, converts measurement results into ratios (in % or dB), compares measurement results to preset limits when requested by the operator. It also contains routines useful for servicing the rest of the instrument as well as itself.

l-14. MODULATION BASICS

The Modulation Analyzer can demodulate and measure three types of modulation: amplitude modulation (AM), frequency modulation (FM), and phase modulation (ΦM). In general, modulation is that characteristic of a signal which conveys the information. A signal without modulation is said to be a continuous-wave **(CW)** signal. CW signals contain two informationcarrying parameters: amplitude and **frequency.** These two parameters, however, are static (time invariant). Consequently, the information conveyed by them is scant, you know only that a signal is present at a certain **frequency.** When one or both of these parameters is altered as a function of time, the signal is said to be modulated.

The RF signal which is modulated is called the carrier. The modulating signal is referred to as the baseband signal and can be of any arbitrary form (for example, voice, tone, noise). Demodulation is the process of recovering the baseband signal **from** the modulated carrier. The Modulation Analyzer can measure the modulation on carriers in the range of 150 **kHz** to 1300 MHz. Measurement accuracy is **specified** for modulation rates generally between 20 Hz and 100 **kHz.** The demodulated signal is present at the MODULATION **OUTPUT** jack.

Amplitude Modulation

As the name implies, a carrier is amplitude modulated when its amplitude is varied as a function of time. Figure l-11 shows a carrier with amplitude modulation and, for reference, also shows the baseband signal. As you can see, the tips of the carrier trace out a waveform that resembles the baseband signal. This trace is called the envelope. The envelope rises to a maximum called the peak and drops to a minimum called the trough.

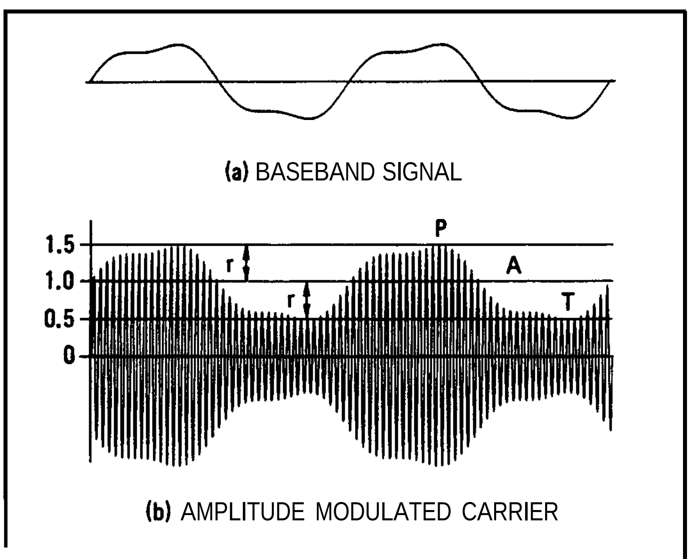


***Figure** l-11. A Baseband Signal and the Corresponding Amplitude Modulated Carrier*

A quantity which describes the amount of AM or the **AM** depth is the modulation index. If the peak amplitude is called P and the trough amplitude is called T, the modulation index m (usually expressed in **%)** is defined as

$$772 = \frac{P - T}{P + T} \times 100\%.$$

In the example of figure l-11, $P = 1.5$ and $T = 0.5$; therefore,

$$m = \frac{1.5 - 0.5}{1.5 + 0.5} \times 100\% = 50\%.$$

Figure 1-12 shows AM signals with modulation indeses varying from 0 to 100%.

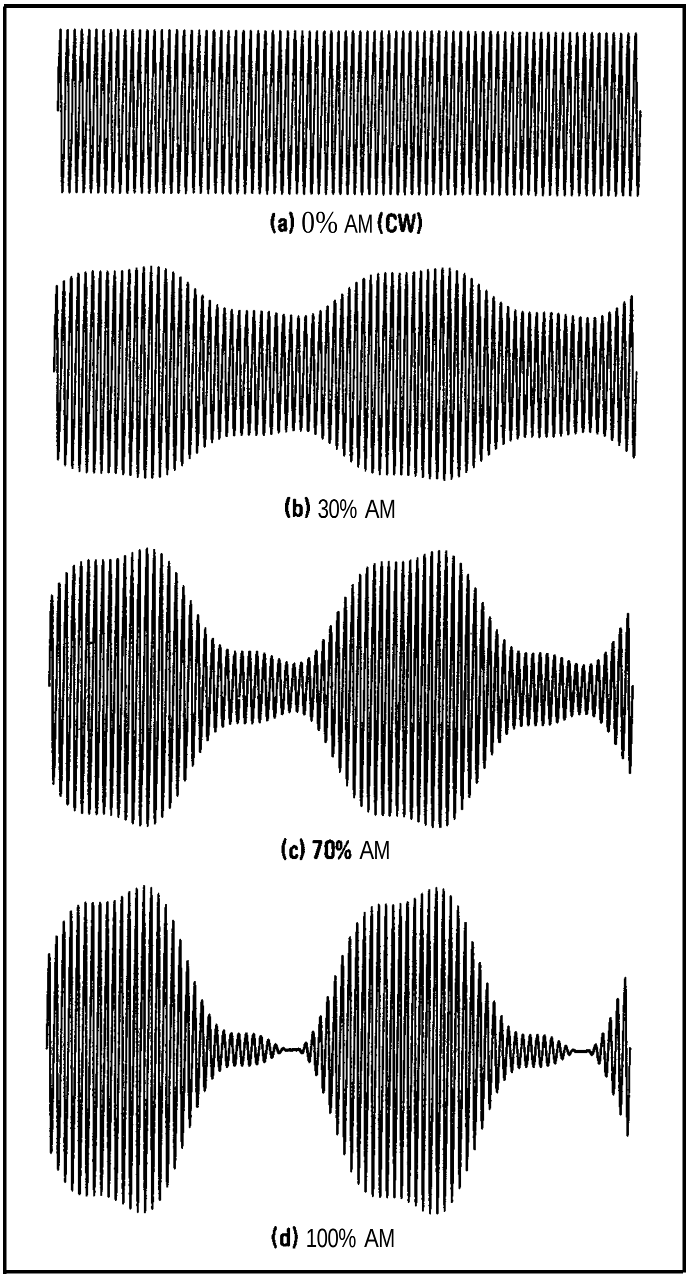


Figure 1-12. AM** for Various **Depths

When the baseband signal is symmetrical, the modulation index can also be expressed in terms of the average carrier level, A, and the envelope peak, r, relative to the carrier. Then $P = A + r$, $T = A - r$, and the expression for modulation index becomes

$$m = \frac{A + r - A + r}{A + r + A - r} \times 100\% = \frac{2r}{2A} \times 100\% = \frac{r}{A} \times 100\%.$$

This is the expression which the Modulation Analyzer evaluates when making an AM measurement. Referring back to figure 1-11, it is apparent that $A = 1$ and $r = 0.5$ so, as before

$$m = \frac{0.5}{1} \times 100\% = 50\%.$$

The Modulation Analyzer makes an AM measurement by forcing the average carrier level, *A*, to a known, fixed level by means of an automatic level control (ALC) circuit. The signal is then demodulated, and the amplitude of the recovered baseband signal is measured with a peak detector. The output of the detector is *r*, which is (in effect) multiplied by the constant 100/*A* and displayed as the % AM.

Figure 1-13 illustrates an AM signal with an asymmetrical baseband source. The first definition of modulation index still applies here. For it, $m = 46\%$. The second definition, however, does not apply since $P - A \neq A - T$. The Modulation Analyzer detects a different value for *r* if the positive peak of the recovered signal is detected than if the negative peak is detected. Thus a different modulation index is measured in PEAK+ than PEAK-.

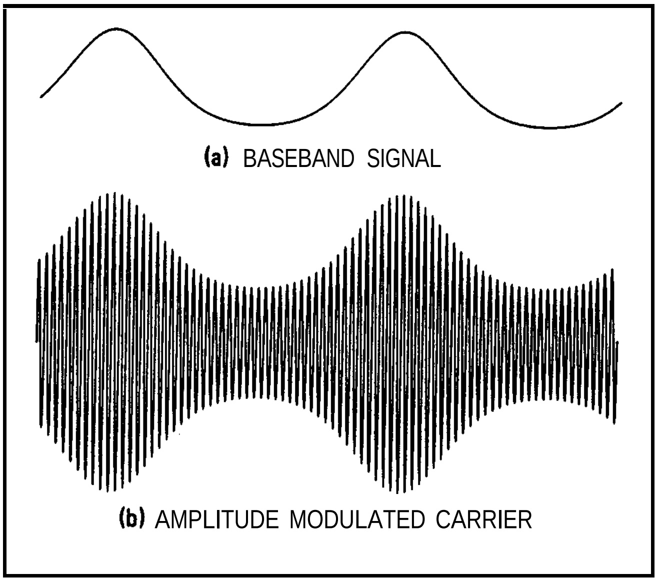


Figure 1-13. AM with an Asymmetrical Baseband Signal

The range of modulation indexes for AM measurements by the Modulation Analyzer is essentially 0 to 100%. There are, however, types of modulation that produce modulation indexes greater than 100%. An example of such is suppressed-carrier AM. The Modulation Analyzer is not intended for measuring such signals. Nevertheless, there are cases, when the Modulation Analyzer will display a modulation index that exceeds 100%. This can occur, for example, on an asymmetrical waveform where a narrow peak is greater than the average carrier level. This is illustrated in figure 1-14.

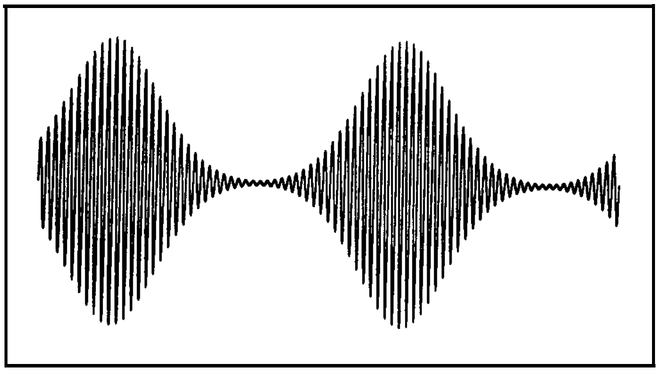


Figure 1-14. AM with Modulation Exceeding 100% as Measured by the PEAK+ Detector

Exponential Modulation

Exponential (or angular) modulation is the generic name given to modulation in which the frequency or phase of the carrier is varied. Frequency and phase modulation are very closely related. In fact, it is impossible to tell whether the signal was produced by a frequency modulator or phase modulator by analyzing the received signal unless specific information about the baseband signal is given.

It is certainly true to say that a signal is frequency modulated when the modulation is generated by a frequency modulator. A varactor diode across the tank circuit of an LC oscillator will produce FM when the varactor bias is varied. It is also true that a signal is phase modulated when the modulation is generated by a phase modulator. A varactor diode across an RF filter will produce ΦM when the varactor bias is varied. (It is assumed that the carrier is on the slope of the filter and that the filter is driven from a well-buffered carrier source. This modulator simultaneously produces AM.)

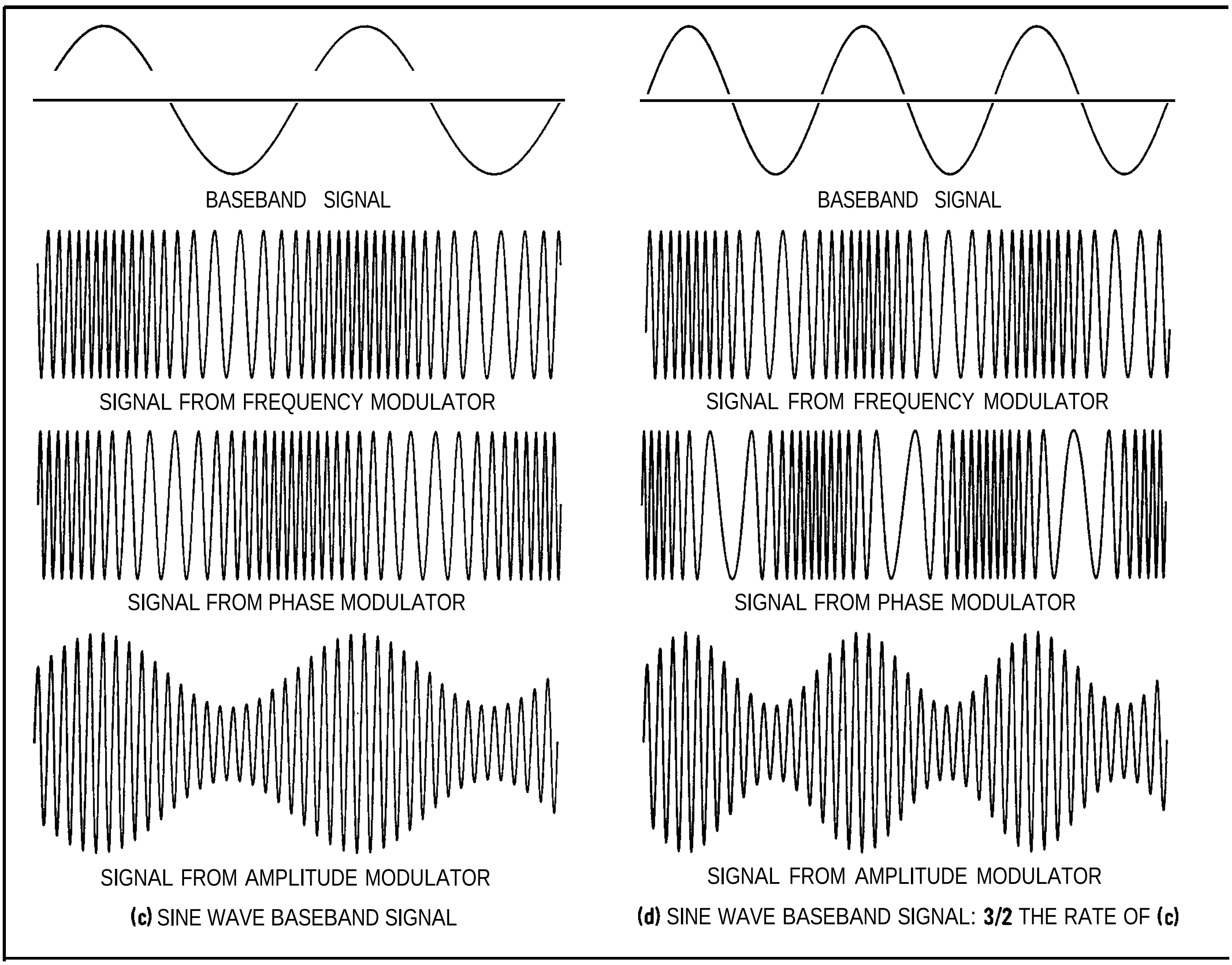
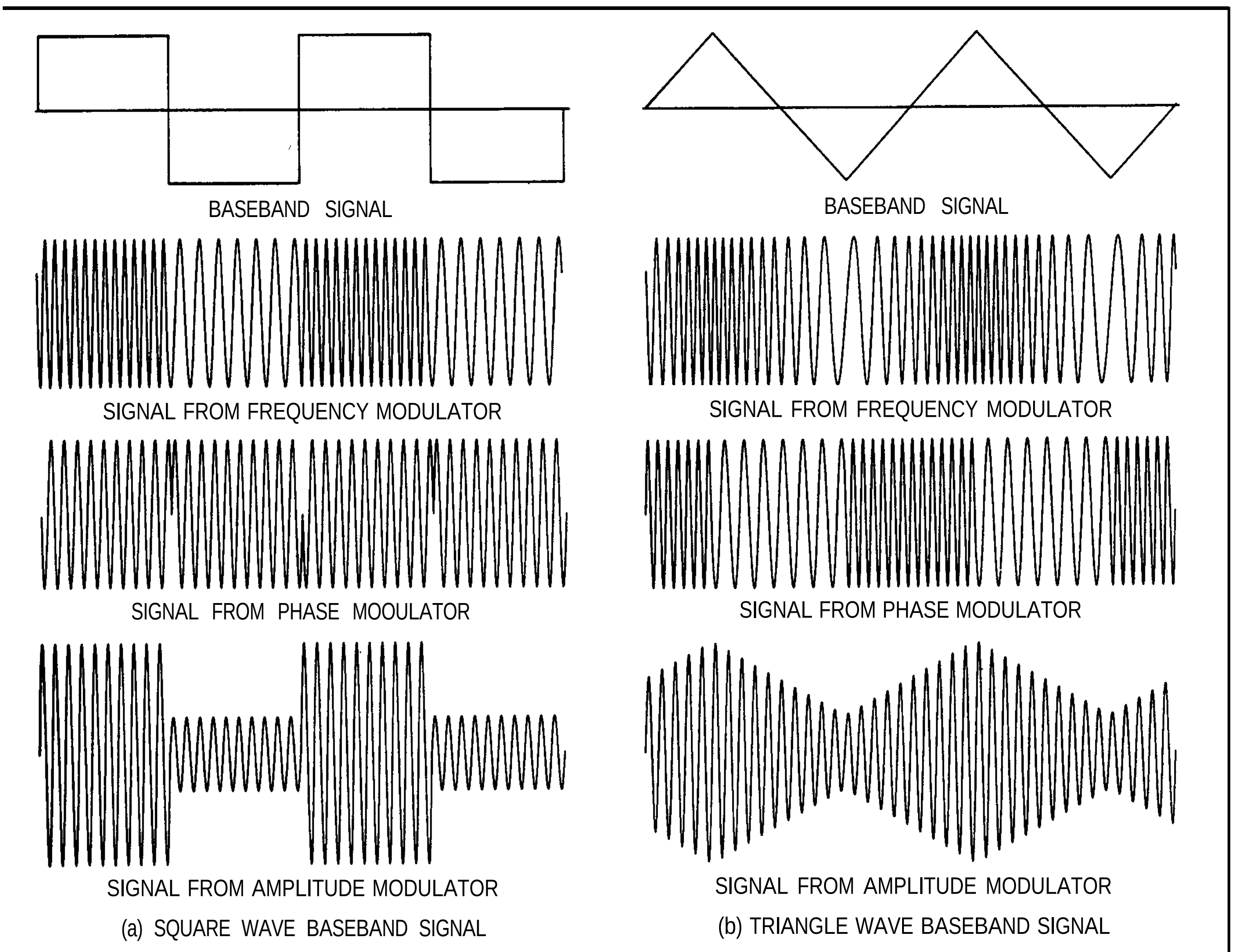


Figure 1-15. Signals from Frequency, Phase, and

The signal **from** both modulators will show readings on the Modulation Analyzer when in both the FM and **ΦM** measurement modes. When in PM, the quantity being measured is the peak **frequency** deviation, which is the maximum **frequency** excursion **from** the average carrier **frequency.** When me**asuring ΦM,** the peak phase deviation is measured, which is the maximum phase excursion **from** the average carrier phase. Phase and frequency have the relationship that phase is the integral of the frequency or frequency is the derivative of the phase. In fact, the Modulation Analyzer demodulates **ΦM** by integrating the demodulated **FM.**

This relationship is most easily visualized by some examples. Look at figure 1-15. The first baseband signal shown is a square wave. The three waveforms under it are the result of applying this signal to an PM, **ΦM,** and AM modulator respectively. (The AM waveform is included only for reference.) It is assumed that the phase modulator doesn't produce AM, **only ΦM.** The **FM waveform is as** expected.. The frequency goes up on the positive peak of the baseband signal and down on the negative peak. The phase modulated signal, however, is peculiar. The **frequency** is generally constant throughout except for a discontinuity where the baseband signal switches amplitude.



Amplitude Modulators for Various Baseband Signals

The waveform of the figure was contrived so that a 180° phase shift occurred exactly at a zero crossing of the carrier. In general, a discontinuity will occur when the baseband signal switches amplitude, but the phase shift is not necessarily 180° and does not need to occur at a zero crossing of the carrier. Mathematically, the derivative of a square wave is the constant zero except for a positive spike (impulse) where the baseband signal switches positive and a negative spike where the square wave switches negative.

Now look at the triangle wave. The frequency modulator produces a continually increasing frequency as the baseband signal slopes upward and a continually decreasing frequency as the signal slopes downward. The phase modulator produces a signal that resembles the signal from the frequency modulator for the square wave baseband signal. This is because the derivative of a constant slope is a constant. When the slope is positive, the phase shift is continually increasing, thus producing a uniform frequency shift upward When the slope is negative, the phase shift is continually decreasing and produces a downward frequency shift. For the triangle wave baseband signal, the shift in frequency when the slope changes is proportional to the change in slope.

Now note the sine wave of figure 1–15(c). The signals from the frequency and phase modulators look the same except for the 90° phase shift between the two. For the frequency modulated signal, the frequency is highest when the baseband signal is most positive and lowest when most negative. For the phase modulated signal, the frequency is highest when the slope of the baseband signal is steepest in a positive direction. This occurs at the positive-going zero crossing. Similarly, the frequency is lowest when the slope is most negative.

If in the last example, the rate, but not the amplitude, of the baseband signal is increased, the highest and lowest frequencies of the signal from the frequency modulator stay the same, they just occur more often. However, for the signal from the phase modulator, not only do the frequency peaks occur more often, but the excursions are large because the slopes of the baseband signal are steeper at the zero crossings. See figure 1–15(d).

The maximum frequency deviation which can be measured is 400 kHz. The maximum phase deviation is 400 radians or 400 kHz divided by the modulation rate, whichever is smaller. As with AM, an asymmetrical baseband waveform will result in different readings in PEAK+ than PEAK-.

Other Considerations

In practice, it is difficult to produce an FM or ΦM signal which does not also have a small amount of AM, called incidental AM or AM-on-FM. Likewise, an AM signal usually contains a small amount of incidental FM and ΦM. In order to accurately measure this incidental modulation, the Modulation Analyzer itself must not contribute to it. This contribution is specified as AM rejection and FM rejection.

A typical CW signal also contains a small amount of residual AM, FM, and ΦM. The residual modulation is generated by such things as line hum, noise, and microphonics. The residual AM and FM specifications quantify the residual modulation internal to the Modulation Analyzer.

Residual modulation affects the modulation readings in a manner which depends on the detector used, the nature of the residuals, and the signal-to-noise ratio. If the residual is predominately noise, when the peak detector is used, the residuals add in a way that is statistically related to the signal-to-noise ratio. This is discussed under ***Residual Noise Effects*** in the ***Detailed Operating Instructions*** in section 3. When the average detector is used, the residuals add approximately in an rms manner, that is, the square root of the sum of the squares of the *noise* and the signal. The effect of this noise becomes insignificant, however, when the signal-to-noise ratio rises above a few dB. Noise can be further reduced by filtering the demodulated signal.

In FM broadcasting and communications, the signal-to-noise ratio is improved by giving the baseband signal a high-frequency boost before applying it to the modulator. This is called pre-emphasis. The boost is a simple 6 dB per octave with the 3 dB corner specified by a time constant; for example, 75 μs (which corresponds to a 3 dB corner of 2.12 kHz) for commercial broadcast FM. If desired, the demodulated FM can be de-emphasized to equalize the signal at the modulation output and at the display.

Table 1-1. Specifications (1 of 4)

All parameters describe performance in automatic operation or with properly set manual controls.

Electrical Characteristic	Performance Limits	Conditions
RF INPUT		
Frequency Range	150 kHz to 1300 MHz	
Operating Level	12 mVrms (-25 dBm) to 7 Vrms (1W peak)	150 kHz to 650 MHz
	22 mVrms (-20 dBm) to 7 Vrms (1W peak)	650 to 1300 MHz
Input Impedance	50Ω nominal	
FREQUENCY MODULATION		
Rates	20 Hz to 10 kHz	150 kHz to 10 MHz carrier
	20 Hz to 200 kHz	10 to 1300 MHz carrier
	20 Hz to 20 kHz	10 to 1300 MHz carrier; 750 μs deemphasia
Deviations	40 kHz peak maximum	150 kHz to 10 MHz carrier
	400 kHz peak maximum	10 to 1300 MHz carrier
	40 kHz peak maximum	10 to 1300 MHz carrier; 750 μs deemphasis
Accuracy[1]	±2% of reading ±1 digit	250 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates
	±1% of reading ±1 digit	10 to 1300 MHz carrier; 50 Hz to 100 kHz rates
	±5% of reading ±1 digit	10 to 1300 MHz carrier; 20 Hz to 200 kHz rates
Demodulated Output Distortion[2]	<0. 1% THD	400 kHz to 10 MHz carrier; deviations <10 kHz
	<0.1% THD	10 to 1300 MHz carrier; rates and deviations <100 kHz
AM Rejection[1]	<20 Hz peak deviation	50% AM at 400 Hz and 1 kHz rates; 50 Hz to 3 kHz BW
Residual FM	<8 Hz rms at 1300 MHz decreasing linearly with frequency to <1 Hz rms for 100 MHz and below	50 Hz to 3 kHz BW
PHASE MODULATION		
Carrier Frequency	10 to 1300 MHz	
Rates	200 Hz to 20 kHz	
Deviation and Maximum Resolution	Refer to Figure 1-16.	
Accuracy[1]	±3% of reading ±1 digit	
Demodulated Output Distortion	>0.1% THD	
AM Rejection[1]	<0.03 radians peak deviation	50% AM at 1 kHz rate, 50 Hz to 3 kHz BW

[1]Peak residuals must be accounted for in peak readings.

[2]With 750 μs de-emphasis and predieplay "off', distortion ie not specified for modulation outputs >4V peak. This can occur near maximum deviation for a measurement range at rates <2 kHz.

Table 1-1. Specifications (2 of 4)

Electrical Characteristic	Performance Limits	Conditions
PHASE MODULATION (cont'd)		

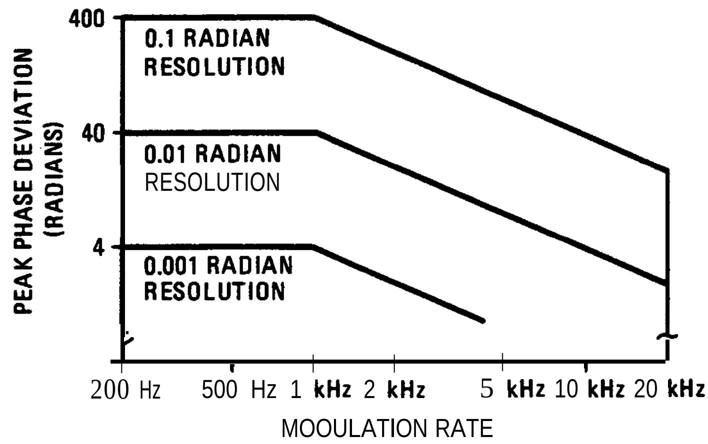


Figure l-1 6. Phase Modulation Deviation and Maximum Resolution

Electrical Characteristic	Performance Limits	Conditions
AMPLITUDE MODULATION		
Rates	20 Hz to 10 kHz	150 kHz to 10 MHz carrier
	20 Hz to 100 kHz	10 to 1300 MHz carrier
Depth	To 99%	
Accuracy[1,2]	±2% of reading ±1 digit	150 kHz to 10 MHz carrier; 50 Hz to 10 kHz rates; >5% depth
	±3% of reading ±1 digit	150 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates
	±1% of reading ±1 digit	10 to 1300 MHz carrier; 50 Hz to 50 kHz rates; >5% depth
	±3% of reading ±1 digit	10 to 1300 MHz carrier; 20 Hz to 100 kHz rates
Flatness (Variation in indicated AM depth for constant depth on input signal)	±0.3% of reading ±1 digit	10 to 1306 MHz carrier; 90 Hz to 10 kHz rates; 20 to 80% depth
Demodulated Output Distortion	<0.3% THD	≤50% depth
	<0.6% THD	≤95% depth
FM Rejection[1]	<0.2% AM	250 kHz to 10 MHz carrier; <5 kHz peak deviation at 400 Hz and 1 kHz rates; 50 Hz to 3 kHz BW
	<0.2% AM	10 to 1300 MHz carrier; <50 kHz peak deviation at 400 Hz and 1 kHz rates; 50 Hz to 3 kHz BW
Residual AM	<0.01% rms	50 Hz to 3 kHz BW

[1] Peak residuals must be accounted for in peak readings.

[2] For peak measurements only, AM accuracy may be affected by distortion generated by the Modulation Analyzer. In the worst case this can decrease accuracy by 0.1% of reading for each 0.1% of distortion.

Table 1-1. Specifications (3 of 4)

Electrical Characteristic	Performance Limits	Conditions
FREQUENCY COUNTER		
Range	150 kHz to 1300 MHz	
Sensitivity	12 mVrms (-25 dBm)	150 kHz to 650 MHz
	22 mVrms (-20 dBm)	650 to 1300 MHz
Accuracy	Reference accuracy ±3 counts of least significant digit	
Internal Reference		
Frequency	10 MHz	
Aging Rate	$<1 \times 10^{-6}$/month	Except Option 002
	$<1 \times 10^{-9}$/day	Option 002 only and after 30 day warm-up
RF LEVEL[1]		Peak voltage responding, rms sine wave calibrated.
Range	1 mW to 1 W	
Serial Prefix 1933A to 2212A:		
Instrumentation Accuracy	±2 dB	150 kHz to 650 MHz
	±3 dB	650 to 1300 MHz
SWR	< 1.5	50Ω system
Serial Prefix 2227A and above:		
Instrumentation Accuracy	±1.5 dB	150 kHz to 1300 MHz
SWR	< 1.3	50Ω system: 150 kHz to 650 MHz
	< 1.5	50Ω system; 650 MHz to 1300 MHz
AUDIO FILTERS		
50 Hz High-Pass G-pole)		
3 dB Cutoff Frequency	50 Hz nominal	
Flatness	<1%	Rates 1200 Hz
300 Hz High-Pass (2-pole)		
3 dB Cutoff Frequency	300 Hz nominal	
Flatness	<1%	Rates ≥1 kHz
3 kHz Low-Pass (5-pole)		
3 dB Cutoff Frequency	3 kHz nominal	
Flatness	<1%	Rates ≤1 kHz
15 kHz Low-Pass (5-pole)		
3 dB Cutoff Frequency	15 kHz nomial	
Flatness	<1%	Rates ≤10 kHz
>20 kHz Low-Pass (9-pole Bessel)		
3 dB Cutoff Frequency	>20 kHz	
Flatness	4 %	Rates ≤10 kHz
Deemphasis Filters (l-pole low-pass) 25 μs, 50 μs, 75 μs, 750 μs nominal		
CALIBRATORS [Option 010)		
AM		
Depth	33.33% nominal	
Calibration Factor		
Accuracy	±0.1%	

[1]The Tuned RF Level function ie not calibrated for absolute power measurements.

Table 1-1. Specifications (4 of 4)

Electrical Characteristic	Performance Limits	Conditions
CALIBRATORS (Option 010) (cont'd)		
FM		
Deviation	34 kHz peak nominal	
Calibration Factor Accuracy	±0.1%	
GENERAL		
Power Requirements		
Line Voltage: 100, 120, 220, or 240 Vac	+5%, -10%	48 to 66 Hz (including Option 004)
100,120 Vac	+5%, -10%	48 to 440 Hz (Option 004 only)
Power Dissipation	200 V•A maximum	
Remote Operation (HP-IB)	IEEE STD 4881978 Compatibility code: SH1, AH1, T5, TEO, L3, LEO, SR1, RL1, PPO, DC1, DT1, CO	The Hewlett-Packard Interface Bus (HP-IB) is Hewlett-Packard Company's implementation of IEEE Std 4881978, "Digital Interface for Programmable Instrumentation". All functions except the line switch are remotely programmable.
Conducted and Radiated Electromagnetic Interference	VDE 0871 (Level B), and CISPR publication 11	Conducted and radiated interference is within the requirements of VDE 0871 (Level B), and CISPR publication 11.
Net Weight	20 kg (44 lb) nominal	
Dimensions:		
Height	190 mm(7.5 in.) nominal	
Width	425 mm (16.8 in.) nominal	
Depth	468 mm (18.4 in.) nominal	
Temperature:		
Operating	0 to 55°C	
Storage	-55 to 75°C	

Table 1-2. Supplemental Information (1 of 2)

All parameters describe performance in automatic operation or with properly set manual controls.

RF INPUT

Tuning:
- Manual Frequency Entry
- Automatic
- Track (frequencies >10 MHz only).

Acquisition Time (Automatic Operation):
- ~1.5 seconds.

Maximum Safe Input Level:
- AC: 35 Vrms (25W for source SWR <4)
- DC: 40V.

FREQUENCY MODULATION

Maximum Deviation Resolution:
- 1 Hz, < 4 kHz deviation
- 10 Hz, 4 to 40 kHz deviation
- 100 Hz, 40 to 400 kHz deviation
- Resolution is increased one digit with 750 μs deemphasis and pre-display "on".

Demodulated Output Distortion:
- 150 to 400 kHz carrier; deviations <10 kHz: <0.3% THD.

Detectors:
- +Peak
- -Peak
- Average (rms sine wave calibrated).

Demodulated Output (600Ω) Across an Open Circuit[1]
- 1 mV/Hz when resolution is 1 Hz
- 0.1 mV/Hz when resolution is 10 Hz
- 0.01 mV/Hz when resolution is 100 Hz.

Stereo Separation (50 Hz to 15 kHz): >47 dB.

PHASE MODULATION

Modulation Rates: Usable from 20 Hz to 100 kHz with degraded performance.

Detectors:
- +Peak
- -Peak
- Average (rms sine wave calibrated).

Demodulated Output (600Ω) Across an Open Circuit[1]
- 1 V/radian when resolution is 0.001 radian
- 0.1 V/radian when resolution is 0.01 radian
- 0.01 V/radian when resolution is 0.1 radian.

AMPLITUDE MODULATION

Maximum Depth Resolution:
- 0.01% for depths <40%
- 0.1% for depths 40 to 100%.

Detectors:
- +Peak (peak)
- -Peak (trough)
- Average (rms sine wave calibrated).

Demodulated Output (600Ω) Across an Open Circuit[1]
- 0.1 V/percent when resolution is 0.01%
- 0.01 V/percent when resolution is 0.1%.

FREQUENCY COUNTER

Modes:
- Frequency
- Frequency Error (displays the difference between the frequency entered via the keyboard and the actual RF input frequency).

Sensitivity in Manual Tuning Mode (Approximate frequency must be entered via the keyboard):
- 0.22 mVrms (-60 dBm).

Maximum Resolution:
- 10 Hz for frequencies <1 GHz
- 100 Hz for frequencies ≥1 GHz.

Internal Reference Accuracy:
- Overall accuracy is a function of time base calibration ± aging rate ± temperature effects ±line voltage effects ± short term stability.

	Standard	Option 002
Aging Rate	$<1 \times 10^{-6}$/mo.	$<1 \times 10^{-9}$/day
Temperature Effects	$<2 \times 10^{-7}$/°C	$<2 \times 10^{-10}$/°C
Line Voltage Effects (+5%, -10% line voltage change)	$<1 \times 10^{-6}$	$<6 \times 10^{-10}$
Short Term Stability	—	$<1 \times 10^{-9}$ for 1s average

RF LEVEL

Resolution:
- 0.1 mW for levels from 0.1 to 1 W
- 0.01 mW for levels from 0.01 to 0.1W
- 0.001 mW for levels <0.01W.

[1]For optimum flatness, cables should be terminated with their characteristic impedance.

Table 1-2. Supplemental Information (2 of 2)

AUDIO FILTERS AND FM DE-EMPHASIS

Overshoot on Square Wave Modulation with **>20 kHz** Low Pass Filter In: 4%.

>20 kHz Low Pass Filter 3 **dB** Frequency: 110 **kHz** typical.

High- and Low-Pass Filter 3 **dB** Frequency Accuracy: **±3%.**

FM De-emphasis Filter 3 **dB** Frequencies:
25 **μs:** 6366 Hz
50 **μs:** 3183 Hz
75 **μs:** 2122 Hz
750 **μs:** 212 Hz.

FM De-emphasis Filter lime Constant Accuracy: **±3%.**

REAR PANEL INPUTS/OUTPUTS

FM **Output:** 10 **kΩ** impedance, -9 to 6V into an open circuit, -6 V/MHz, dc coupled, 16 **kHz band**-width (one pole).

AM **Output:** 10 **kΩ** impedance, -4 to OV into an open circuit, -8 **mV/%,** dc coupled, 16 **kHz** band-width (one pole).

Recorder Output: DC voltage proportional to peak voltage of the MODULATION OUTPUT, 1 **kΩ** impedance, 0 to 4V for each resolution range into an open circuit.

IF Output: 50Ω impedance, 150 **kHz** to 2.5 MHz, -27 to -3 **dBm.**

10 MHz Reference Output: **50Ω** impedance, TTL levels (0 to **>2.2V** into an open circuit); available only with Option **002, 1** x **10^{-9}/day** internal reference, outputs internal reference only.

10 **MHz** Reference Input: **>500Ω** impedance, **0.5V** peak-to-peak minimum input level. (External reference accuracy **affects** accuracy of all measurements.)

LO **Input (Option 003): 50Ω** impedance, -1.27 to 1301.5 MHz, 0 **dBm.**

CALIBRATORS (Option 010)

Carrier Frequency: 10.1 MHz nominal.

Modulation Rate: 10 **kHz** nominal

Output Level: -25 **dBm** nominal.

Table 13. Recommended Test Equipment (1 of 4)

instrument **Type**	Critical Specifications	suggested Model	**Use***
AM/FM Test source	Carrier Frequency: **within** range 10 to 1300 MHz Output Level: > -20 **dBm** FM Deviation: **400 kHz** peak maximum FM Distortion: < -72 **dB** at 12.5 MHz carrier with 12.5 **kHz** deviation and < 10 **kHz** rate < -72 **dB** at 400 MHz carrier and 400 **kHz** deviation at < 100 **kHz** rate FM Flatness: **±0.1%** from 20 Hz to 100 **kHz** rates **±0.25%** to 200 **kHz** rates **CW** Residual FM: < 3 Hz rms in a 50 Hz to 3 **kHz** bandwidth at 560 MHz Incidental AM: < **0.08%** AM at 100 MHz with < 50 **kHz** peak deviatior and 1 **kHz** rate in a 50 Hz to 3 **kHz** bandwidth AM Depth: 5% to 99% AM Distortion: < -66 **dB** at < 50% AM at 20 Hz to 100 **kHz** rates < -60 **dB** at < 95% AM at 20 Hz to 100 **kHz** rates AM Flatness: **±0.1%** from 50 Hz to 50 **kHz** **±0.25%** from 20 Hz to 100 **kHz** Incidental **ΦM:** < 0.008 rad peak at 12.5 MHz with **50%** AM at a 1 **kHz** rate in a 50 Hz to 3 **kHz** bandwidth Residual AM: < 0.01% rms in a 50 Hz to 3 **kHz** bandwidth AM Linearity: **±0.1%** at < 95% AM **±0.2%** at < 99% AM	HP **11715A**	**P,A,T**
Audio Analyzer	Fundamental Frequency Range: 20 Hz to 100 **kHz** Distortion Range: -70 **dB** minimum Distortion Accuracy: **±2 dB** Low-Pass Filters: 30 and 80 **kHz** Oscillator Level: 3V maximum into **600Ω** Oscillator Distortion: < -70 **dB** Oscillator Frequency Accuracy: **±2%**	HP 89038	**P,A,T**
Audio Synthesizer	Frequency Range: 20 Hz to 400 **kHz** Output Level: **+16 dBm (50Ω)** maximum Frequency Accuracy: **±0.1%** Attenuator Accuracy: **±0.1 dB** from 0 to 20 **dB** Level Flatness: f0.015 **dB** from 90 Hz to 10 **kHz** i0.3 **dB** from 50 Hz to 100 **kHz** **±0.07 dB** from 20 Hz to 200 **kHz** Distortion: < -50 **dB** from 20 Hz to 200 **kHz**	HP 3336C Option 005	**P,A,T**

. C = Operator's Checks; P = Performance Tests; A = Adjustments; T = Troubleshooting

Table 13. Rewmmended Test Equipment (2 of 4)

Instrument Type	Critical Specifications	Suggested Model	Use*
Bandpass Filters	Passband Frequency: 512 to 674 MHz Passband SWR: ≤ 1.4 Passband insertion loss: ≤ 0.4 dB Midband insertion loss: ≤ 0.5 dB Stopband Rejection: Below Passband: Frequency: ≤ 337 MHz Attenuation: ≥ 21 dB Above Passband: Frequency:' 768 to 3000 MHz Attenuation: ≥ 21 dB	Telonic TBA 593-218-5FE	P
	Pas&and Frequency: 800 to 1100 MHz Passband SWR: ≤ 1.4 Passband insertion loss: ≤ 0.4 dB Midband insertion loss: ≤ 0.5 dB Stopband Rejection: Below Passband: Frequency: ≤ 550 MHz Attenuation: ≥ 21 dB Above Passband: Frequency: 1333 to 3000 MHz Attenuation: ≥ 21 dB	Telonic TBA 950-375-5FE1	P
Computing Controller	HP-IB compatibility as defined by IEEE Std 488 and the identical ANSI Std MC1 .1: SH1, AH1 , T2, TEO, L2, LEO, SRO, PPO, DCO, DTO, and Cl, 2, 3, 4, 5.	HP 9000 Model 216,226, or 236	C,P,T
Digital Multimeter	DC Range: 0 to 50V DC Accuracy: ±0.01% at 1V AC Range: 0 to 100V AC Accuracy: ±0.01% at 2V and 2 kHz Ohms Range: 0 to 1 MΩ Ohms Accuracy: ±1%	HP 3478A	P,A,T
Divider Probe (2 required)	Divider Ratio: 10:1 Input Impedance: 1 MΩ Input Capacitance: < 10 pF	HP 10040A	A,T
Frequency Standard	Accuracy: ±0.1 ppm recommended	House Standard	A

*C = Operator's Checks; P = Performance Tests; A = Adjustments; T= Troubleshooting

Table 1-3. Rewmmended Test Equipment (3 of 4)

Instrument Type	Critical Specifications	Suggested Model	Use*
Modulation Analyzer	Note: A modulation analyzer is required only for Modulation Analyzers not equipped with Option 010. AM Calibration Factor Accuracy: ±0.1% FM Calibration Factor Accuracy: ±0.1% Compatible with HP 8901A	HP 8901A opt. 010, HP 89018, or HP 8902A	P,A
Oscilloscope	Bandwidth: less than 3 dB down 0 to 100 MHz Sensitivity: 5 mV per division minimum Input Impedance: 10 MΩ and 50Ω 'Triggering: External and Internal	HP 54201A	C,A,T
Power Supply	Output Range: 0 to 25 Vdc	HP 6215A	T
Power Meter/ Power Sensor	Frequency Range: 150 kHz to 1300 MHz Impedance: 50 ohms Instrumentation Accuracy: ±1% SWR: < 1.1	HP 436A/8482A	P
Power Splitter	Frequency Flange: 150 kHz to 1300 MHz Impedance: 50 ohms SWR: < 1.1 Tracking: < 0.25 dB	HP 11667A	P,A,T
RF Spectrum Analyzer	Frequency Range: 0 to 1.5 GHz Input Level: ±10 dBm maximum Display Range: 60 dB	HP 8590A	A,T
Service Accessory Kit	No substitution recommended.	HP 0890160287	T
Signal Generator	Frequency Range: 0.5 to 1100 MHz Output Level: $19 dBm maximum to 500 MHz $13 dBm maximum to 1100 MHz Output Level Accuracy: ±1 dB Frequency Accuracy: ± 1% Frequency Resolution: 1 kHz Modulation Capability: AM and FM AM Depth: 0 to 95% AM Accuracy: ±10% FM Range: 0 to 400 kHz peak deviation FM Accuracy: ±10% Harmonics: < -30 dBc	HP 86408 Options 001 and 002	C,P,A T

. C = Operator's Checks: P = Performance Tests; A = Adjustments; T = Troubleshooting

Table l-3. Recommended Test Equipment (4 of 4)

Instrument **Type**	Critical Specifications	suggested Model	Use*
Signature Analyzer	External Count Range: to 15 MHz Because the signatures documented are unique to a given signature analyzer, no substitution is recommended.	HP **5005A**	**T**
SWR Bridge	Frequency Range: 150 **kHz** to 1300 MHz Impedance: 503 Directivii: **>40 dB** Connectors: Type-N	**Wiltron 60N50**	P

• C = Operator's Checks; P = Performance Tests: A = Adjustments; **T = Troubleshooting**

Tab& l-4. Rewmmended Test Accessories

Accessory Type'	Recommended Part
Adapter (Type N Male to BNC Female connectors)	HP 1250-0067
Capacitor, 620 **pF**	HP 01603536
IC Extender Clip, 16 Pin	HP 1400-0734
Resistor, **909Ω** 1% **1/4W**	HP 0757-0422
Resistor, **1210Ω** 1% **1/4W**	HP **0757-0274**
Resistor, 215052 1% **1/4W**	HP **0698-0084**
Resistor, **4640Ω** 1 **% 1/4W**	HP **0698-3155**
Tee (Coaxial, BNC, one Male-and two Female connectors)	HP **1250-0781**
50Ω Load (Male, BNC, coaxial)	HP 1250-0207

*Accessories listed in this table are only those not already contained in the Service Accessory Kit HP **08901-60287**

Section 2
INSTALLATION

2-l. INTRODUCTION

This section provides the information needed to install the Modulation Analyzer. Included is **information** pertinent to initial inspection, power requirements, line voltage selection, power cables, interconnection, environment, instrument mounting, storage **and** shipment. In addition, this section also contains the procedure for setting the internal HP-IB talk and listen address switches and a procedure for removing the pullout cards.

2-2. INITIAL INSPECTION

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, meters...

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in figure l-l. Procedures for checking electrical performance are given in section 4. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance test, notify the nearest Hewlett-Packard office. If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

2-3. PREPARATION FOR USE

Power Requirements

WARNING

To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 V ac with line frequencies greater than 66 Hz. Leakage currents at these line settings may exceed 3.5 mA.

The Modulation Analyzer requires a power source (+5% to -10%) of 100, 120, 220, or 240 V ac, 48 to 66 Hz single phase. Option 004 also operates from 48 to 440 Hz single phase, 120 V ac, (+5% to -10% only). Power consumption is 200 VA maximum.

WARNING

This is a Safety Class I product (that is, provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or suppliedpower cord set Whenever it is likely that the protection has been impaired, the product must be made inoperative and be secured against any unintended operation

If this instrument is to be energized by an external autotransformer, make sure the autotransformer's wmmon terminal is wnnected to the earthed pole of the power source

Line Voltage and Fuse Selection

CAUTION

BEFORE PLUGGING THIS INSTRUMENT into the Mains (line) voltage, be sure the correct voltage and fuse have been selected

Verify that the line voltage selection card and the fuse are matched to the power source. Refer ***to figure*** 2-1, ***Line Voltage and Fuse Selection.***

Two fuses are supplied with each instrument. One fuse has the proper rating for **110/120 Vac** line operation; the other fuse is rated for **220/240 Vac** operation.

One **fuse** is installed in the instrument at the time of shipment. The rating of the installed fuse is selected according to the line voltage specified by the customer. If the voltage is not **specified,** the rating of the installed fuse will be selected according to the country of destination.

Fuses may be ordered under HP part numbers 2110-0002, 2A (250 V normal blow) for **100/120 Vac** operation and 2110-0001, **1A** (250 V normal blow) for **220/240 Vac** operation.

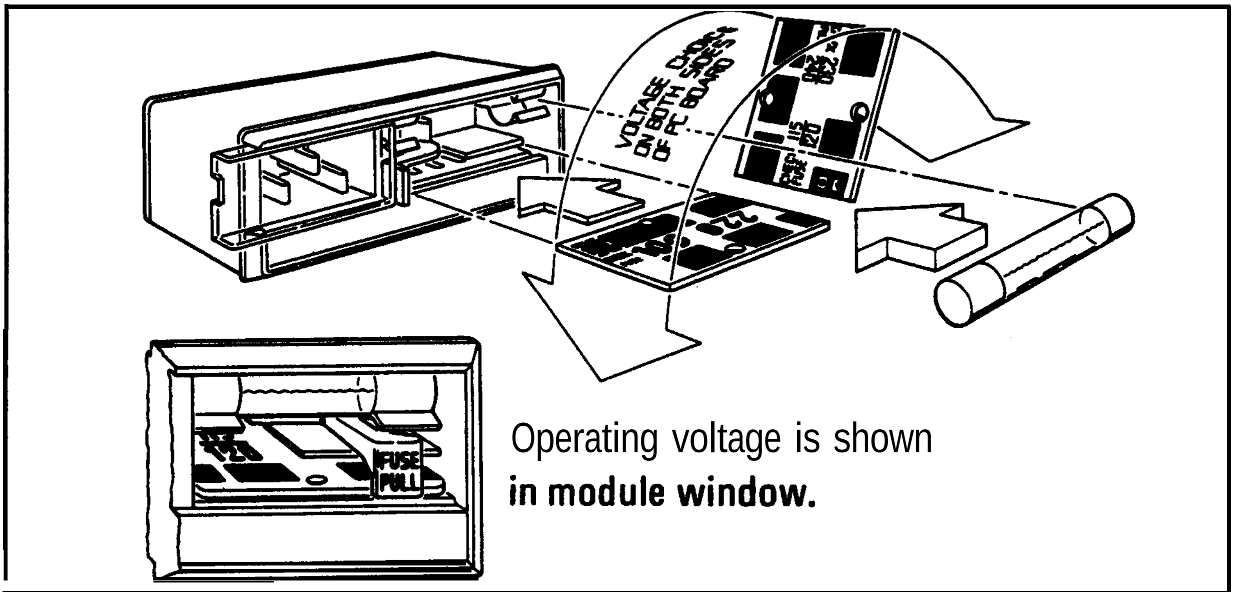


Figure 2-1. Line Voltage and Fuse Selection

1. Open cover door, pull the FUSE PULL lever and rotate to left. Remove the fuse.
2. Remove the Line Voltage Selection Card. Position the card so the line voltage appears at top-left cover. Push the card firmly into the slot.
3. Rotate the Fuse Pull lever to its normal position. Insert a fuse of the correct value in the holder. Close the cover door.

WARNING

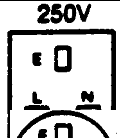
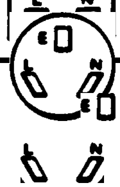
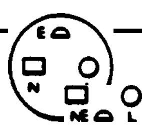
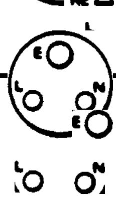
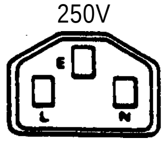
To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz (leakage currents at these line settings may exceed 3.5 mA).

Power Cables

WARNING

BEFORE CONNECTING THIS INSTRUMENT, the protective earth terminals of this instrument must be connected to the protective conductor of the (Mains) power wrd. The Mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding).

This instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument depends on the country of destination. Refer to figure 2-2 for the part numbers of the power cables available.

Plug Type	Cable HP Part Number	C D	Plug Description	Cable Length (inches)	Cable Color	For Use In Country
250V 	8120-1351 8120-1703	0 4	90°/STR BS1363A* 90°/90°	90 90	Mint Gray Mint Gray	United Kingdom, Cyprus, Nigeria, Rhodesia. Singapore
	8120-1369 8120-0696	0 4	STR/STR NZSS198/ASC112 STR/90°	79 80	Gray Gray	Austrailia, New Zealand
250v 	8120-1689 8120-1692	7 2	STR/STR* STR/90°	79 79	Mint Gray Mint Gray	East and West Europe, Saudi Arabia. Egypt, (unpolarized in many nations)
	8120-1378 8120-1751	1 61	STR/STR NEMA5-15P* STR/STR	80 80 90	Jade Gray Jade Jade Gray Gray	United States, Canada, U.S./Canada Mexico, Phillipines. Taiwan
100V (Same plug as above)	8120-4753 8120-4754	2 3	STR/STR STR/90°	90 90	Dark Gray Dark Gray	Japan only Japan only
250V 	8120-2104 81202296 8120-3997	3 4 4	STR/STR SEV1011 1959-24507 Type 12 STR/90° STR/90°	79 79 177	Gray Gray Gray	Switzerland
	8120-0698	6	STR/STR NEMA6-15P	90	Black	United States. Canada
	8120-2956 8120-2957	3 44	90°/STR STR/STR	79	Gray	Denmark
	8120-4211 8120-4600	7 8	STR/STR*IEC83-B1 STR/90°	79 79	Black Gray	South Africa, India
250V 	8120-1860 8120-l 575 8120-2191 8120-4379	6 0 8 8	STR/STR*CEE22-V1 (Systems Cabinet Use) STR/STR STR/90° 90°/90°	59 31 59 80	Jade Gray Jade Gray Jade Gray Jade Gray	

. Part number shown for plug is industry identifier for plug only. Number shown for cable is HP Pan Number for complete cable including plug. E = Earth Ground: L = Line; N = Neutral; STR = Straight

Figure 2-2. Power Cable and Mains Plug Part Numbers

HP-IB Address Selection

WARNING

This task should be performed only by service trained persons who are aware of the potential shock hazard of working on an instrument with protective wvers removed

To avoid hazardous electrical shock, the line (Mains) power cable should be disconnected before attempting to change the HP-IB address

In the Modulation Analyzer, the HP-IB talk and listen addresses are selectable by an internal switch. The following procedure explains how the switches are to be set. Refer to table 2-1 for a listing of the talk and listen addresses. The address in factory set for a Talk address of "N" and a listen address of "." (period). (In binary, this is 01110; in decimal it is 14. To change the HP-IB address, the top cover of the Modulation Analyzer must be removed.

Table 2-l. Allowable HP-IB Address Codes

Address Switches A5	A4	A3	A2	A1	Talk Address Character	Listen Address Character	Decimal Equivalent
0	0	0	0	0	@	SP	0
0	0	0	0	1	A	!	1
0	0	0	1	0	B	"	2
0	0	0	1	1	C	#	3
0	0	1	0	0	D	$	4
0	0	1	0	1	E	%	5
0	0	1	1	0	F	&	6
0	0	1	1	1	G	'	7
0	1	0	0	0	H	(	8
0	1	0	0	1	I	)	9
0	1	0	1	0	J	*	10
0	1	0	1	1	K	+	11
0	1	1	0	0	L	,	12
0	1	1	0	1	M		13
0	1	1	1	0	N		14
0	1	1	1	1	O	/	15
1	0	0	0	0	P	0	16
1	0	0	0	1	Q	1	17
1	0	0	1	0	R	2	18
1	0	0	1	1	S	3	19
1	0	1	0	0	T	4	20
1	0	1	0	1	U	5	21
1	0	1	1	0	V	6	22
1	0	1	1	1	W	7	23
1	1	0	0	0	X	8	24
1	1	0	0	1	Y	9	25
1	1	0	1	0	Z		26
1	1	0	1	1	[	,	27
1	1	1	0	0	\	<	28
1	1	1	0	1	|	=	29
1	1	1	1	0	^	>	30

1. Disconnect the line (Mains) power cable.
2. Remove any HP-IB cables or connectors from the HP-IB connector.
3. Remove the Modulation Analyzer's top cover.
   a. Remove the two plastic feet from the rear of the top cover by removing the pan-head Pozidriv screw within each foot.
   b. Unscrew the Pozidriv screw at the center of the rear edge of the top cover. This is a captive screw and will cause the top cover to pull away from the front frame!
   c. Lift off the top cover.
4. Locate the HP-IB address switch on the Al4 Remote Interface Assembly near the front right of the instrument. The Al4 assembly may be recognized as having one brown and one yellow printed circuit board extractor.

5. Use a pencil to set the switches to the desired HP-IB address and Talk Only (TON) or Listen Only (LON) condition. The switch is illustrated in figure 2-3. Facing the board, the **left** hand switch (marked with a "5") is the most significant address bit (A5 in table 2-l). Setting a switch toward the printed circuit board places it in its "1" position. If the TON and LON switches are both set to "I", the Talk Only setting will override. **If the** address switches and the TON switch are all set to **"1",** the Modulation Analyzer will output one byte (the status **byte)** each measurement cycle. (Setting all switches to "1" defeats HP-IB operation.)

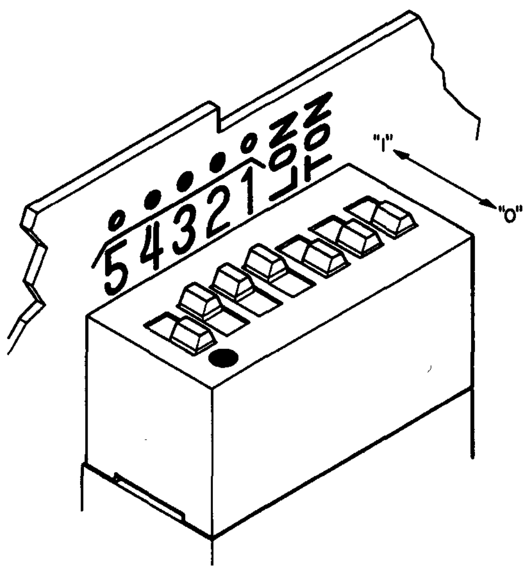


Figure 2-3.* *The HP-IB Address Switch Shown as Set by the Factory.
The Address Shown is 01110 in Binary With Both Talk Only and Listen Only Off.

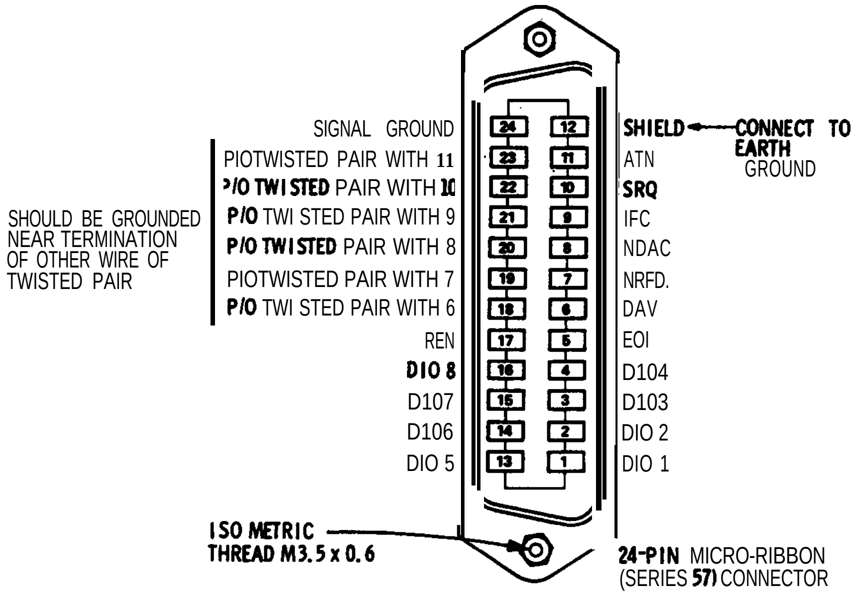
6. Reinstall the top cover by reversing the procedure in step 3.
7. Connect the line (Mains) power cable to the Line Power Module and reconnect the HP-IB cable to the HP-IB connector.
8. To **confirm** the setting, refer to HP-IB Address ***in*** the ***Detailed Operating Instructions*** in section 3 of this manual.

Interconnections

Interconnection data for the Hewlett-Packard Interface Bus is provided in figure 2-4.

Mating Connectors

interface Connector. The HP-IB mating connector is shown in figure 2-4. Note that two securing screws are metric.



Logic Levels

The **Hewlett-Packard** Interface Bus **Logic** Levels are TTL compatible, i.e., the true (1) state is 0.0 Vdc to **+0.4** Vdc and the false (0) state is **+2.5** Vdc to **+5.0** Vdc.

Programming and Output **Data** Format

Refer **to** Section III, Operation.

Mating Connector

HP **1251-0293; Amphenol** 57-30240.

Mating **Cables Available**

HP **10833A,** 1 metre(3.3 **ft), HP10833B,** 2 **metres(6.6 ft)**
HP **10833C, 4** metres(13.2 **ft), HP10833D,** 0.5 **metres(1.6 ft)**

Cabling **Restrictions**

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6 ft) of connecting cable per instrument.

2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20.0 metres (65.6 ft).

Figure 2-4. *Hewlett-Packard Interface Bus Connection*

Coaxial Connectors. Coaxial mating connectors used with the Modulation Analyzer should be the 50Ω BNC male connectors or 50Ω Type-N male connectors that are compatible with those specified in US MIL-C-39012.

Operating Environment

The operating environment should be within the following limitations:

Temperature .... 0°C to +55°C
Humidity .... < 95% relative
Altitude .... < 4570 meters (15 000 feet)

Bench Mounting

The instrument cabinet has plastic feet and fold-away tilt stands for convenience in bench operation. (The plastic feet are shaped to ensure self-aligning of the instruments when stacked.) The tilt stands raise the front of the instrument for easier viewing of the front panel.

Rack Mounting

WARNING

The Modulation Analyzer is heavy for its size (20 kg, 44 lb). Care must be exercised when lifting to avoid personal injury. Use equipment slides when rack mounting.

Rack mounting information is provided with the rack mounting kits. If the kits were not ordered with the instrument as options, they may be ordered through the nearest Hewlett-Packard *office.* (Refer *to Mechanical Options* in section 1. Before rack mounting the Modulation *Analyzer, the Operating Information* pull-out tray (attached to the bottom of the instrument) must first be removed. To remove the pull-out card assembly, refer to the procedure that follows.

Removal and Installation of Operating information Pull-Out Cards

Steps for Removal. Follow the procedure below to remove the *Operating Information* pull-out card assembly:

1. Remove the two front feet of the instrument.
2. Remove the Operating Information tray assembly by sliding the tray toward the rear of the instrument and then down.
3. Remove the information cards by bowing them slightly in the middle and pulling them straight up (away from the tray).

Steps for Installation. Follow *the* procedure below to reinstall the ***Operating Information*** pull-out tray and card:

1. Install the information card by bowing it slightly in the middle and carefully guiding the edges into the plastic guide slots near the front of the tray.
2. Push the information card all the way into the tray.
3. Place the information tray assembly between the rear feet of the instrument and slide it forward until the tabs are locked under the rear feet.
4. Replace the front feet of the instrument.

2-4. STORAGE AND SHIPMENT

Environment

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment:

Temperature .... -55°C to +75°C
Humidity .... <95% relative
Altitude .... < 15 300 meters (50 000 feet)

Packaging

Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number and full serial number. Also mark the container FRAGILE to assure careful handling. In any correspondence refer to the instrument by model number and full serial number.

Other Packaging. The following general instructions should be used for re-packaging with commercially available materials:

1. Wrap the instrument in heavy paper or plastic. (If shipping to a Hewlett-Packard office or service center, attach a tag indicating the service required, return address, model number and full serial number.)
2. Use a strong shipping container. A double-wall carton made of 1.9 MPa (275 psi) test material is adequate.
3. Use enough shock-absorbing material (75 to 100 mm layer; 3 to 4 in.) around all sides of instrument to provide firm cushion and prevent movement in the container. Protect the front panel with cardboard.
4. Seal the shipping container securely.
5. Mark the shipping container FRAGILE to assure careful handling.

Section 3
OPERATION

3-1. INTRODUCTION

General

This section provides complete operating information for the Modulation Analyzer. Included in this section are descriptions of all front and rear-panel controls, connectors, and indicators, remote and local operator's checks, operating instructions, and operator's maintenance. Also included is a basic exercise designed to acquaint the novice operator with the Modulation Analyzers operating characteristics.

Operating Characteristics

Table 3-l briefly summarizes the major operating characteristics of the Modulation Analyzer. The table is not intended to be an in-depth listing of all operations and ranges but gives a rough idea of the instrument's capabilities. For more information on Modulation Analyzer capabilities, refer to section 1 "Description", Specifications, and Supplemental Information. For information on HP-IB capabilities, refer to the summary contained in "Table 3-3. Message Reference Table".

Turn-On Procedure

WARNING

Before the Modulation Analyzer is switched on, all protective earth terminals, extension cords, autotransformers, and devices connected to it should be connected to a protective earth socket. Any interruption of the protective earth grounding will cause a potential shock hazard that wuld result in personal injury.

For wntinued protection against fire hazard, replace the line fuse with a 250 V normal blow fuse of the same rating. Do not use repaired fuses or short-circuited fuseholders.

CAUTION

Before the Modulation Analyzer is switched on, it must be set to the voltage of the power source, or damage to the instrument may result.

Do not apply greater than 40 V (ac + dc) to the INPUT jack or damage to the instrument may result.

The Modulation Analyzer has a standby state and an on state. Whenever the power cable is plugged in, an internal power supply is activated. In instruments supplied with the high-stability reference (Option 002) the supply energizes the internal reference oven. If the

Modulation Analyzer is already plugged in, set the LINE switch to ON. If the power cable is not plugged in, follow these instructions:

1. Check that *the* line voltage setting matches *the power source. (See figure* 2-1, *Line Voltage and Fuse Selection.)*
2. Check that the fuse rating is appropriate for *the line* voltage *used. (See figure* 2-1, *Line Voltage and Fuse Selection.)* Fuse ratings are provided in the paragraph *Operator's Maintenance* in this section.
3. Plug in the power cable.
4. Set the LINE switch to ON.

NOTE

When the LINE switch is set to ON, all front-panel indicators will light for approximately 10 seconds after which the instrument is ready to be operated

Local Operation

Information regarding front-panel operation of the Modulation Analyzer is provided in the sections described in the following paragraphs. To most rapidly learn the basic operation of the instrument, begin with ***Simplified Operation*** and the ***Getting Acquainted exercise.*** Once familiar with the general operation of the instrument, ***use the Detailed Operating Instructions*** for the most in-depth and complete information on operating the Modulation Analyzer.

Simplified Operation. Located in this section, ***Simplified Operation*** provides a quick introduction to front-panel operation of the Modulation Analyzer. It is designed to rapidly orient the novice user with basic operating procedures and, therefore, is not an exhaustive listing of all Modulation Analyzer functions. However, ***an*** index to the ***Detailed Operating Instructions*** appears in table 3-10 to guide the operator to the more complete discussion of the topic of interest.

Getting Acquainted. Located in this section is an informal exercise entitled ***Getting Acquainted.*** This exercise is intended to familiarize the first-time operator with basic Modulation Analyzer operating procedures. It provides a simple walk-through of many Modulation Analyzer functions and discusses a number of the instrument's capabilities. Only a signal generator, oscilloscope, and interconnecting cables and adapters are required.

Panel Features. Front-panel controls, indicators, and connectors are illustrated and described in figures 3-3 to 3-5. These figures describe the functions of the various key groups and summarize briefly how to use them. Rear-panel features are shown in figure 3-6. The figure provides a good quick reference for rear-panel signal levels and frequencies and also includes the impedances at the rear-panel connections.

Detailed Operating Instructions. The ***Detailed Operating Instructions*** provide the complete operating reference for the Modulation Analyzer w. The instructions are organized alphabetically by subject. Not only do the instructions contain information on the various measurements that can be made (listed under titles such as AM, FM, ΦM, Frequency, and Level), but there are also individual discussions of nearly all controls, inputs, and outputs (for example, Filtering, FM De-emphasis, Ratio, IF Output). Also included are instructions for using the many User Special Functions (for example, Attenuation, Input; Modulation Range; Error Disable; Special Functions).

Each section contains a general description which covers signal levels, ranges, measurement limits, and other 'general information. Following the description are related procedures, an operating example, the relevant HP-IB codes, front-panel indications, and, where pertinent, a description of the technique the Modulation Analyzer uses to make the measurement. At the end of each discussion are comments intended to guide the w away from measurement pitfalls and to help him get the most out of the Modulation Analyzer. Also included are references to other sections which contain related information. ***The Detailed Operating*** Instructions are designed so that both casual and sophisticated users can rapidly find at one location all the information needed to apply the instrument to the task at hand.

Operating Information Pull-Out Card. ***The Operating Information*** pull-out card is a flexible plastic reference sheet attached to the Modulation Analyzer by a tray located below the front panel. It contains a brief summary of front-panel operation and displays. Also included on the card is a complete listing of HP-IB codes and data and error output formats, Error codes, and User Special Functions. The card is intended to be reference for the user who already has a basic understanding of front-panel operation; however, sufficient information is included to allow the first-time user to successfully make accurate measurements.

Supplemental Information. In addition to the information described above, several other discussions pertinent to operating the Modulation Analyzer to its fullest capabilities are contained in section 1 of this manual. "Principles of Operation for a Simplified Block Diagram" is a fundamental description of what the Modulation Analyzer is and how it works. This information supplements the block diagrams given *in* the ***Detailed Operating Instructions*** and provides a basis for applying the Modulation Analyzer to various measurement situations. "Modulation Basics" covers the theory behind amplitude, frequency, and phase modulation. It contains numerous illustrations of the various types of modulation the Modulation Analyzer can'measure and is intended to provide an intuitive grasp of carrier modulation rather than an in-depth mathematical analysis.

Remote Operation

The Modulation Analyzer is capable of remote operation through the Hewlett-Packard Interface Bus (HP-IB). Paragragh 3-5, *Remote Operation, Hewlett-Packard Interface Bus* covers all considerations and instructions specific to remote operation including capabilities, addressing, input and output formats, the status byte, and service requests. At the end of the discussion is a complete summary of all codes and formats.

In addition to the section described above, information concerning remote operation appears in several other locations. Address setting is discussed section 2. A summary of HP-IB codes and output formats appears on the ***Operating Information*** pull-out card, and numerous examples of program strings appear throughout the ***Detailed Operating Instructions*** described under ***Local Operation*** above.

Operator's Checks

Operator's Checks are simple procedures designed to verify the proper operation of the Modulation Analyzer's main functions. Two procedures are provided as described below.

Basic Functional Checks. This procedure requires only a signal generator, an oscilloscope, and interconnecting cables and adapters. It assures that most front-panel controlled functions are being properly executed by the Modulation Analyzer.

HP-IB Functional Checks. This series of procedures requires only an HP-IB compatible computing controller and an HP-IB interface and connecting cable. The *HP-IB Functional Checks* assume that front-panel operation has been verified (for example, by performing *the Basic Functional Checks).* The procedures check all of the applicable bus messages summarized in table 3-2.

Operator's Maintenance

WARNING

For continued protection against fire hazard, replace the line fuse only with a 250 V normal blow fuse of the same rating. Do not use repaired fuses or short-circuited fuseholders.

The only maintenance the operator should normally perform is the replacement of the primary power fuse located within the Line Power Module (A30). For instructions on how to change the fuse, refer to figure 2-1, steps 1 and 3.

Fuses can be ordered using HP part number 2110-0002, 2 A (250 V, normal blow) for 100/120 Vac operation or 2110-0001, 1 A (250 V, normal blow) for 220/240 Vac operation.

Table 3-1. Operating Characteristics Summary

Operating Parameter	Capabilities
Input Limits	Frequency: 150 kHz to 1300 MHz. Level: -25 to +30 dBm from 150 kHz to 550 MHz -20 to +30 dBm from 550 to 1300 MHz.
Modulation Measurements	AM: Depths to 99%; rates from 20 Hz to 10 kHz for inputs of 150 kHz to 10 MHz, 20 Hz to 100 kHz for inputs of 10 to 1300 MHz. Ranges: 0 to 40%; 0 to 100%. FM: Deviation fo 40 kHz peak with rates from 20 Hz to 10 kHz for inputs of 150 kHz to 10 MHz; deviation to 100 kHz peak with rates from 20 Hz to 200 kHz for inputs of 10 to 1300 MHz. Flanges: 0 to 4 kHz; 0 to 40 kHz; 0 to 400 kHz. ΦM: Deviations to 400 radians with rates from 200 Hz to 20 kHz for inputs from 10 to 1300 MHz. Ranges: 0 to 4 rad; 0 to 40 rad; 0 to 400 rad nominal.
Level Measurements	RF Level: Peak broadband power at input. Tuned RF Level: Peak envelope power in Modulation Analyzer's tuned bandwidth. IF Level: Percent of optimum (100%) power in Modulation Analyzer's IF amplifier.
Frequency Measurements	Freq: Frequency of input signal from 150 kHz to 1300 MHz Freq Error: Frequency difference between input signal and the Modulation Analyzer's tuning. IF Frequency (Special Function 10): Frequency of signal in IF.
Detectors	Peak: Positiie; Negative (trough for AM): Peak Hold. Average: Calibrated to read rms with a sins wave.
Demodulated Signal Filtering	High-Pass: 50 Hz; 300 Hz. Low-Pass: 3 kHz; 15 kHz; >20 kHz. FM Da-emphasis: 25 μs; 50 μs; 75 μs; 750 μs. De-emphasis can be performed before the displayed measurement is made (Predisplay on) or after (Predispiay off).
Demodulated Signal output	0 to 4 V ac per modulation range. 600Ω output impedance.
Tuning	Automatic, Track, or Manual.
Data Manipulation	Ratio: Data can be displayed as a computed ratio of measurement results to a reference value. Display can be in % or dB. Limit: Data may be entered as upper and lower limits. Limit annunciator lights when limits are exceeded.
Manual Operation	Input attenuation, ranges, tuning, IF frequency, frequency resolution and many other operations may be manually controlled.
Remote Operation	All Modulation Analyzer operations except the line switch may be controlled through the Hewlett-Packard Interface Bus.

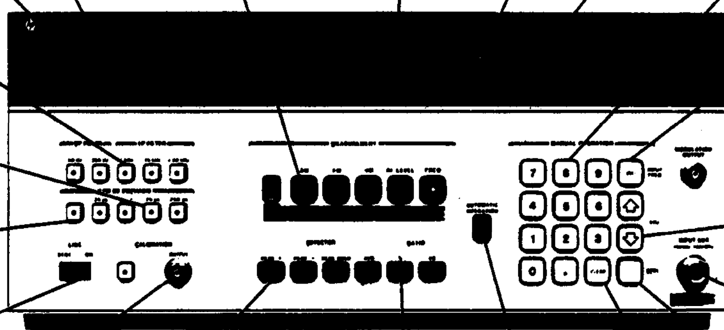


Figure 3-1. Front Panel Features

Simplified Operation

Tuning

Automatic:

Press: AUTOMATIC OPERATION.

Manual:

Input Frequency:

Enter frequency in MHz (using the numeric keys), then press:

MZ MHz INPUT FREQ .

Frequency Step:

Enter step size in **kHz** (using the numeric keys), then press:

kHz ,or 0 kHz

Measurement

Modulation:

Tune, then press: AM, FM, or ΦM; select a DETECTOR;

select the desired HP or LP FILTERS, select the desired FM **DE-**
EMPHASIS (FM only).

Level:

Press: RF LEVEL ; or tune, then press: S IF LEVEL , or S TUNED RF LEVEL .

Frequency:

Tune, then press: FREQ or S FREQ ERROR ; or

enter the reference frequency in MHz (using the numeric keys),

then press: MZ MHz INPUT FREQ S FREQ ERROR

Detector

In general:

Press: AM , FM ,or ΦM , **then** PEAK + , PEAK − , or AVG RMS CAL .

Peak Hold:

Select a peak detector (as shown **above), then press:** PEAK HOLD .

Filters

High-Pass or Low-Pass:
Press one high-pass (HP) and one low-pass (LP) FILTER key to yield the desired demodulated signal bandwidth.

FM De-emphasis (FM only):
To apply de-emphasis after the deviation measurement, press FM, then either 25 µs, 50 µs, 75 µs, or 750 µs.

To apply **de-emphasis** before the deviation measurement, press:
FM PRE-DISPLAY, **then either** 25 µs, 50 µs, 75 µs, or 750 µs.

Ratio

To set the results of the next measurement cycle **to** 100% or 0.00 **dB:**

Press: % for 100% or dB for **0.00 dB**

To set a keyboard-entered value to 100% or 0.00 **dB:**
Enter the value using the numeric keyboard, then press:
% **or** dB

Calibration (Option 010 only)

Connect **a 50Ω** cable from CALIBRATION OUTPUT to INPUT.

AM:
Press: AM CALIBRATION

FM:
Press: FM CALIBRATION

3-2. GETTING ACQUAINTED WITH THE 8901A MODULATION ANALYZER

The HP 8901A Modulation Analyzer was designed to be simple and easy to operate both from the front panel and remotely through HP-IB controllers. We would like to acquaint you with the Modulation Analyzer and its remarkable features in a *way* that is quick and painless.

The Modulation Analyzer makes its measurements automatically, as the discussion that follows will show. Notice, for example, that the front panel has no knobs-only pushbuttons. You simply select the measurement you desire, and the Modulation Analyzer does the work. The measurement is executed and controlled by an internal microprocessor.

You will be measuring and viewing a modulated signal so you will need to gather together an oscilloscope and a signal generator. The signal generator should be capable of putting out a signal in the range of 150 kHz to 1300 MHz at a level between 1 mW and 1 W. It should also have variable rate AM and FM modulation capability.

Now, connect the equipment as shown in Figure 3-2. Follow the steps of the procedure in order (it will only take a few minutes) and avoid the temptation to experiment until you have completed all the steps.

CAUTION

Before the Modulation Analyzer is switched on, it must be set to the voltage of the power source, or damage to the instrument may result.

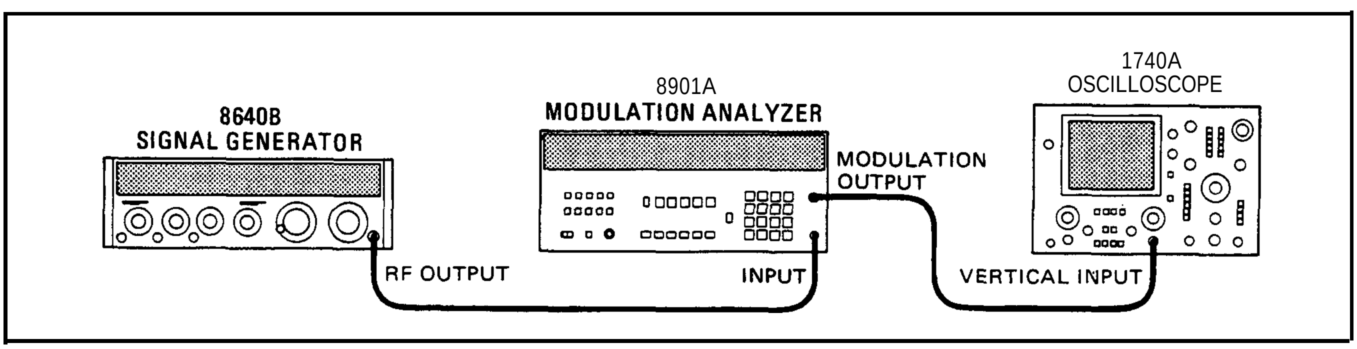
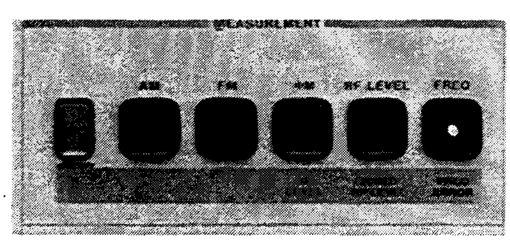


Figure 3-2. Getting Acquainted Setup

Measurements



Turn On and Frequency Measurement. First, let's measure the generator's frequency. Switch the Modulation Analyzer's LINE switch off (STBY) and then back on again. After a power-up period of 10 to 15 seconds, the display should show the generator's frequency in MHz. If an error code appears in the display, consult the ***Operating Information*** pull-out card and take the appropriate action.

At power-up, the Modulation **Analyzer** goes through a series of operational self-checks. One of the checks is to turn on **all front-panel LEDs** for a few **seconds.** After completing the self-checks,"- —" may appear in the display, indicating that the Modulation **Analyzer is searching for a signal; then "— — — —"** will appear, indicating that the signal has been found but measurement **results** are not yet ready.

Of course, you don't have **to** switch the instrument off and back on each time to read **frequency—we** had you do this to reset the instrument to its power-up state. The Modulation Analyzer powers up measuring frequency. Notice that it automatically found the **signal—** you did no tuning or level adjusting.

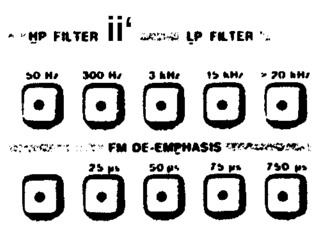
RF Level **Measurement.** Press RF **LEVEL.** The display now shows the generator's output power in **watts** using **scientific** notation: The **"–**03" at the right end of the display is the power-of-ten multiplier, that is, **"milli"** watts.

Now add some AM. Notice that the **RF** level shown on the display goes up. The RF level reading is the peak envelope power and not the average **carrier** power.

AM Measurement. Let's see how much AM is on the signal. Press AM. The AM depth (or modulation index) is displayed in %. Also look at the oscilloscope display. It's showing the demodulated AM. The MODULATION OUTPUT jack allows you to further analyze the demodulated audio signal (that is, you could analyze its distortion or listen to it using a power amplifier and speaker). Both the display and modulation output **are** autoranging.

FM Measurement. Now, turn the AM off and the **FM** on. On the Modulation **Analyzer,** press **FM.** The display now shows the peak **frequency** deviation in **kHz.** The oscilloscope gives you a view of the demodulated signal.

Audio Filters and FM De-emphasis



NOTE

Before continuing, check that the equipment settings match those below.

Signal Generator

Output Level	***1 mW to 1*** W
Frequency	***150 kHz to 1300 MHz***
Modulation	***FM only***

Modulation Analyzer

MEASUREMENT	***FM***
DETECTOR	***PEAK+***
HP & LP FILTERS	***ALL OFF***
FM DE-EMPHASIS	*Off
RATIO	***Off***

If the carrier frequency at INPUT is below 10 MHz, the 15 kHz low-pass filter will remain on

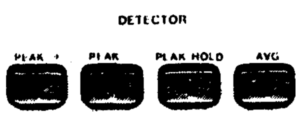
Audio Filters. The power-up mode for the Modulation Analyzer is with all **filters** and **de-**emphasis off unless the carrier **frequency** is less than 10 MHz, in which case the 15 **kHz** low pass filter is in. Adding **filters** limits the bandwidth of the demodulated signal, and hence, may reduce the displayed modulation level. To see this, press 3 **kHz.** Now change the generator's modulation rate above and below 3 **kHz** without changing its deviation. As the rate goes above 3 **kHz,** the displayed FM drops. This is also true of the signal on the oscilloscope.

High and low pass **filters** are used to reduce hum and noise and to simulate the characteristics of a receiver's audio stages. Remove the **filter** by pressing 3 **kHz** again. **(You** could also have selected another low pass filter to remove it.)

FM De-emphasis. De-emphasis is used only with FM. In communications and broadcasting, FM signals are often **pre-emphasized** (given a **high-frequency** boost) to improve the noise performance. De-emphasis compensates (equalizes) the pore-emphasized FM on the received signal. To illustrate this press 75 **μs** and PRE-DISPLAY. Vary the modulation rate below and above 2 **kHz.** The displayed FM deviation should drop about 30% when the rate reaches 2 **kHz.** (The 75 **μs** time constant corresponds to a 3 **dB** frequency of 2.12 **kHz.)**

The display shows the de-emphasized FM deviation. **Press** PRE-DISPLAY again to perform de-emphasis after the deviation is measured. The display now shows the un-de-emphasized FM deviation (which is the actual FM put out by the signal generator). The signal at the MODULATION OUTPUT jack, however, is still de-emphasized. Ress the 75 **μs** key again to turn all the de-emphasis off.

Detectors



Before continuing, check that the equipment settings match those below.

Signal Generator

Output Level	**1 mW to 1 W**
Frequency	150 **kHz** to 1300 MHz
Modulation	FM only

Modulation Analyzer

MEASUREMENT	FM
DETECTOR	PEAR+
HP & LP FILTERS*	**ALL OFF**
FM DE-EMPHASIS	Off
RATIO	Off

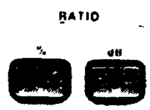
*If the carrier frequency at INPUT is below 10 MHz, the 15 **kHz** low pass **filter** will remain on.

Peak Detectors. The Modulation Analyzer is currently demodulating the positive peak of the FM signal. Now press PEAK-. The negative peak is being displayed. Do you get a different reading? If not, it's because your modulation is symmetrical-it has the same positive and negative frequency excursions. For AM, PEAK+ gives a display of the envelope peak relative to the envelope average and PEAK- the envelope trough relative to the average.

Peak Hold. Does the display vary slightly in its least-sign&ant digit? Press PEAK HOLD. The display shows the peak of the peaks. Try increasing the modulation level, then lowering it. 'The display shows the maximum.

Average (RMS Calibrated). Press PEAK+ or PEAK- to turn PEAK HOLD off. Note the display, then press AVG. The reading should drop by about 30%. You are seeing therms frequency deviation as measured by an average responding detector. This mode is normally reserved for measurement of carrier noise because peak detectors appear to exaggerate noise. Switch the FM off and compare readings of carrier noise in PEAK+ and AVG.

Ratio



Before continuing, check that the equipment settings match those below.

Signal Generator

Output Level .... 1 mW to 1 W
Frequency .... 150 kHz to 1300 MHz
Modulation .... FM only

Modulation Analyzer

MEASUREMENT .... FM
DETECTOR .... PEAK+
HP & LP FILTERS* .... ALL OFF
FM DE-EMPHASIS .... Off
RATIO .... Off

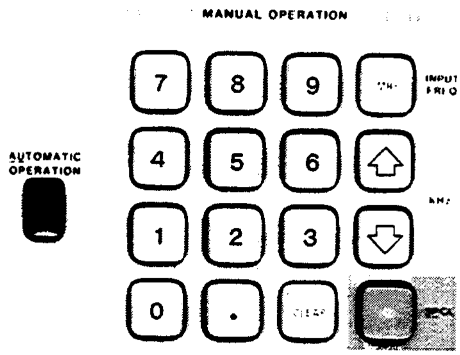
*If the carrier frequency at INPUT is below 10 MHz, the 15 kHz low pass filter will remain on.

The ratio feature will demonstrate the ability of the Modulation Analyzer to make internal computations. Switch the signal generator's FM back on. Turn off any filters (except the 15 kHz low pass filter if the carrier is below 10 MHz) or FM de-emphasis that may be on (simply press the keys that are lighted). Set the detector to PEAK+.

Let's say you want to read modulation relative to the modulation being displayed. Just press %. The display now shows approximately 100%. Decrease the modulation until the display shows 50%. You now have half the modulation you had before. Ress dB. The display is now re-referenced to the current modulation level and shows approximately 0 dB. Now increase the modulation level until the display shows 6 dB. You have doubled the previous modulation level and you are now back to the original level you started with. Check this 3
by pressing dB again.

Let's say you want to set up 20 **kHz** FM. Key in 20 on the keypad. **(If** you mistakenly press a wrong number key, press CLEAR and try again.1 Now press **%.** Adjust the modulation level for **a** display of 100%. You now have the desired modulation. If you don't believe this, **press % again (to turn** it **off)** and note the display.

Tuning



NOTE

Before continuing, check. that the equipment settings match those below.

Signal Generator

Output Level .... 1 mW to 1 W
Frequency .... 150 kHz to 1300 MHz
Modulation.. FM only

Modulation Analyzer

MEASUREMENT.. FM
DETECTOR .... PEAK+
HP & LP FILTERS .... ALL OFF*
FMDEEMPHASIS .... Off
RATIO .... off

**If the carrier frequency at INPUT is below 10 MHz, the 15 kHz low pass filter will remain on.*

Automatic Tuning. You have been in an automatic tuning mode. It's as though AUTOMATIC OPERATION had been pressed. **Press FREQ.** Now tune your signal generator to some other **frequency—do** it slowly and watch the display. The Modulation Analyzer will continue to monitor the **frequency** until the signal drops out of its IF. It then automatically retunes.

Manual Tuning. There is also a manual tuning mode. Round the displayed **frequency** to the nearest MHz. Key in the rounded-off number on the keypad; that is, if the rounded-off frequency is 128 MHz, key in 128. Now press **MHz.**

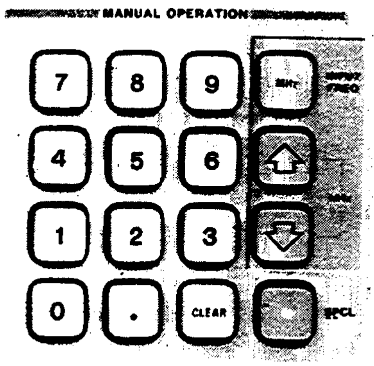
If the display reads **E01,** it is trying to tell you that your signal is not quite centered in the IF. Slowly tune the signal towards the frequency you keyed in until **E01** disappears and the generator's frequency is displayed (Normally, the signal must be within 50 **kHz** of the **frequency** keyed in when above 10 MHz or within 2.5 **kHz** below 10 MHz.)

Notice that the display reads the signal frequency even though the Modulation Analyzer is probably still not tuned exactly to the signal. Now press S (Shift), then F'REQ ERROR. The display shows how far away the signal is from the keyed-in frequency in kHz.

Frequency Stepping. Tune the generator for zero error. Now key in 100 and press ⇑ **kHz.** You have incremented the frequency to which the Modulation Analyzer is tuned by 100 kHz so the error is now – 100 kHz. Tune the generator again for zero error. (In the F'REQ ERROR measurement mode, E01 is disabled.)

The frequency error function is useful for checking the frequency error of a multichannel transmitter. You key in the frequency of the first channel, note the error, key in the channel increment using the ⇑ ⇓ kHz keys and note the error as you increment the Modulation Analyzer and transmitter together.

Other Features



NOTE

Before wntinuing, check that the equipment settings match those below.

Signal Generator

Output Level .... 1 mW to 1 W
Frequency .... 150 kHz to 1300 MHz
Modulation... FM only

Modulation Analyzer

MEASUREMENT... FM
DETECTOR .... PEAK+
HP & LP FILTERS .... ALL OFF*
FMDEEMPHASIS .... Off
RATIO .... Off

**If the carrier frequency at INPUT is below 10 MHz, the 15 kHz low pass filter will remain on*

There are many other features and modes of operation which will not be discussed here. Before leaving this discussion, however, it would be useful to point out the SPCL (Special) key which opens up a large reservoir of other features called Special Functions.

Setting Modulation Range. Press FM. Now key in 2.3 and press SPCL. You have just frozen the FM range to 400 kHz. (The AM range is also fixed to 100%.)

Disabling Errors. Tune the signal slowly until error E01 appears in the display. Now key in 8.1 and press SPCL. E01 will disappear and the AM or FM measurement will be displayed again. Special Function 8.1 disables error message E01. It should be pointed out, however, that error message E01 is one of the error messages used to ensure the integrity of modulation measurements. When this error is disabled, it is assumed that the user understands that measurement may be inaccurate, but that perhaps it is of no consequence in this particular case.

Pressing AUTOMATIC OPERATION will both clear most Special Functions and automatically re-tune the instrument.

Now you are ready to make measurements on your own. Don't be timid. The Modulation Analyzer is designed to prevent you from making invalid measurements, but in the event of a problem, try pressing AUTOMATIC OPERATION or a MEASUREMENT key to get out of trouble.

For More Information

Overall instrument operation is summarized in *Simplified Operation.*

Panel features are described in figures 3–3 to 3–6.

Remote operation is described under *Remote Operation, Hewlett-Packard Interface Bus,* page 3–32.

Your most complete operating reference is the *Detailed Operating Instructions.* They are also indexed in table 3–10, page 3–68 to 3–70.

Special Function and Error codes are also given on the *Operating Information* pull-out card located below the instrument's front panel.

If you wish to know more about how the Modulation Analyzer works, read *Principles of Operation for Simplified Block Diagram* section 1. If you wish to know more about modulation, read *Modulation Basics* also in section 1.

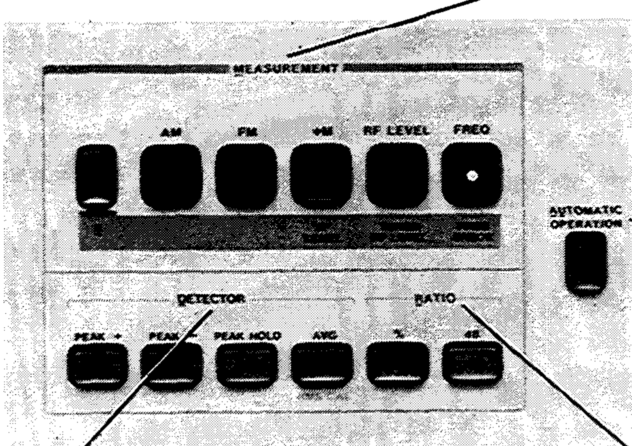
LCL (local) key returns the Modulation Analyzer to local keyboard control from HP-IB (remote) control provided the instrument is not in Local Lockout.

Numeric Display shows measurement results, error codes, instrument or Special Function status, HP-IB address, or service information.

HP-IB Annunciators display remote operation status. The REMOTE annunciator lights when the instrument is in remote mode. The ADDRESSED annunciator lights whenever the instrument is addressed via the HP-IB (regardless of whether or not the instrument is in remote).

Display Annunciators light to indicate the units in which the measurement results are displayed. When results are displayed relative to a RATIO reference, units annunciators do not light, but the REL annunciator lights. The LIMIT annunciator lights when either the upper or lower limit reference is reached.

MEASUREMENT keys automatically configure the Modulation Analyzer to make and display the measurement selected. To select a measurement labeled above a key, press the key. To select a measurement labeled below a key, press the S (Shift) key, then the MEASUREMENT key. MEASUREMENT keys turn off many Special Funcions and always turn off CALIBRATION OUTPUT (Option 010).



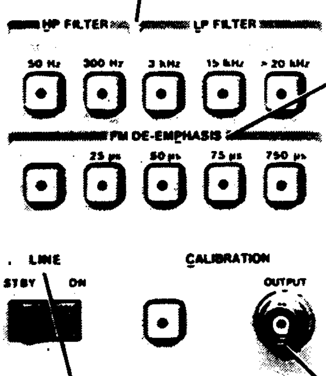
AUTOMATIC OPERATION configures the Modulation Analyzer to automatically tune to the largest detectable input signal and make the measurement selected. This key also sets the Special Functions 1 through 8 to their zero-suffix mode and turns off many other Special Functions.

DETECTOR keys select whether positive peak, negative peak, or average (rms calibrated) value of the modulation is measured. To hold indefinitely the greatest peak reading. select PEAK+ or PEAK-. then press the PEAK HOLD key. Pressing PEAK HOLD again will initiate a new peak hold measurement cycle. To turn off PEAK HOLD, press any DETECTOR key other than PEAK HOLD.

RATIO keys cause measurements to be compared in % or dB to a reference. To enter RATIO, press the % or dB key while the desired reference is displayed. The displayed reference can be either a measurement result or a keyboard entry. To exit RATIO, press the selected RATIO key again or select a new MEASUREMENT key. The RATIO keys are also used to enter upper and lower 'limit values into the instrument.

Figure 3-3. Display, MEASUREMENT, DETECTOR, RATIO, and AUTOMATIC OPERATION Features

HP [High-Pass] and LP (Low-Pass] FILTERS limit the demodulatd signal bandwidth. Press the appropriate key once to insert or change a filter. Press the key again to remove the filter. Only one **high-**pass and one low-pass filter may be active at a time. Filters affect both displayed modulation measurements and the signal at MODULATION OUTPUT but not those at the rear panel AM OUTPUT or FM OUTPUT. Tuning below 10 MHz or using the455 **kHz** IF causes the 15 **kHz** LP FILTER to be inserted. Selecting **ΦM** causes the 50 Hz HP FILTER to be inserted.

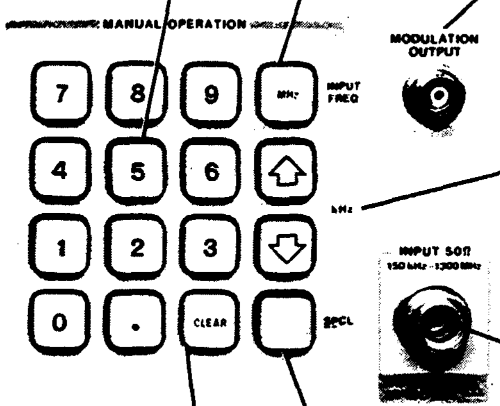


FM DE-EMPHASIS affects FM measurements only. Press the appropriate key to insert or change de-emphasis. Press the key again to remove **de-**emphasis. If the PRE-DISPLAY key is not lighted, the display shows the deviation before **de-**emphasis. If the PRE-DISPLAY key is lighted, **de-**emphasis is performed before the displayed measurement is made. De-emphasis always affects demodulated FM at MODULATION **OUT-**PUT, but never affects the signal at the **rear-**panel FM OUTPUT.

CALIBRATION OUTPUT (Option 010 only) when active, produces a 10 MHz signal with calibrated AM or FM. Connect CALIBRATION OUTPUT to INPUT, select AM or FM, then press the **CALIBRATION** key. The accuracy of the internal **demod-**ulator is normalized to **100%**, displayed, and stored. This Calibration Factor can be enabled to correct measurement results automatically. To turn off CALIBRATION OUTPUT, press the CALIBRATION key or any MEASUREMENT key.

LINE switch applies power to the Modulation Analyzer when set to the ON position. In the STBY (standby) position, power is applied only to the high-stability reference oscillator oven (Option 002 only).

Figure 3-4. *HP and LP FILTERS, FM DE-EMPHASIS, LINE and CALIBRATION OUTPUT Features*



Numeric keys are used to manually tune the Modulation Analyzer, enter RATIO references and limit values, and to select Special Functions. Numeric entries are completed by a RATIO key or the MHZ, **↑ kHz**, **↓ kHz**, or SPCL keys. Numeric entries in progress are cleared by using the CLEAR key.

MHz key completes the keyboard entry of input frequency (in MHz) and tunes the Modulation Analyzer to that frequency. If the instrument is already tuned and no frequency was entered, this key centers the input signal in the IF passband. If the instrument is not already tuned and no frequency entry was made, this key returns the instrument to the last previous tuning. The instrument always enters manual tune mode when MHz is pressed.

MODULATION OUTPUT provides output for demodulated AM, FM, or **ΦM.** If RF LEVEL is selected, this output is turned off. If **FREQ,** IF LEVEL, TUNED RF LEVEL, FREQ ERROR, or IF frequency is selected, the last modulation type previously measured will continue to be output. The output level is from 0 to 4 volts peak into an open circuit for each modulation range **(600Ω** output impedance).

↑ kHz and **↓ kHz** complete the keyboard entry of frequency step size (in **kHz)** and increment **(↑)** or decrement **(↓)** the Modulation Analyzer's tuning by that step size. If no step size entry was made, the tuning will step up or down by the last step size entered. The instrument always enters manual tune mode when a **kHz** key is pressed.

INPUT couples modulated signal (156 **kHz** to **1300** MHz) into the instrument. Specified input levels are -25 to **+30 dBm** from 150 **kHz** to 650 MHz and -20 to **+30 dBm** from 650 to 1300 MHz. The input impedance is **50Ω** nominal.

CAUTION

Do not applygreater than 40V (ac + dc) to the INPUT jack or damage to the instrument may result.

SPCL key completes the keyboard entry of a Special Function code. Special Functions are instrument operations in addition to those accessible from dedicated front-panel keys. If pressed alone once, the SPCL key causes the requested modes of Special Functions 1 through **8** to be displayed. If pressed again while the requested modes are being displayed, the SPCL key causes the resulting instrument settings to be displayed.

CLEAR key removes any keyboard entry in progress. If no entry is in progress, CLEAR turns off many Special Functions with prefixes greater than **8.** In remote hold only (HP-IB code **T1),** the CLEAR key remains active and acts as a manual trigger with settling (HP-IB code T3).

Figure 3-5. MANUAL OPERATION, MODULATION OUTPUT, and INPUT Features

REAR-PANEL FEATURES

MODULATION OUTPUT is a rear-panel output for the demodulated signal. This output is supplied on Option 001 instruments instead of the standard front-panel connection. See MODULATION OUTPUT in Figure 3-l.

IF OUTPUT produces a 150 **kHz** to 2.5 MHz modulated IF signal, The output level ranges from -27 to -3 **dBm (50Ω output impedance).**

LO OUTPUT (Option 003 only) provides an output for the Local Oscillator. Output signal is 1.27 to 1301.5 **MHz** at approximately 0 **dBm (50Ω)** nominal output impedance.

CAUTION

Do not apply reverse power into the LO OUTPUT or damage to the instrument mayresult.

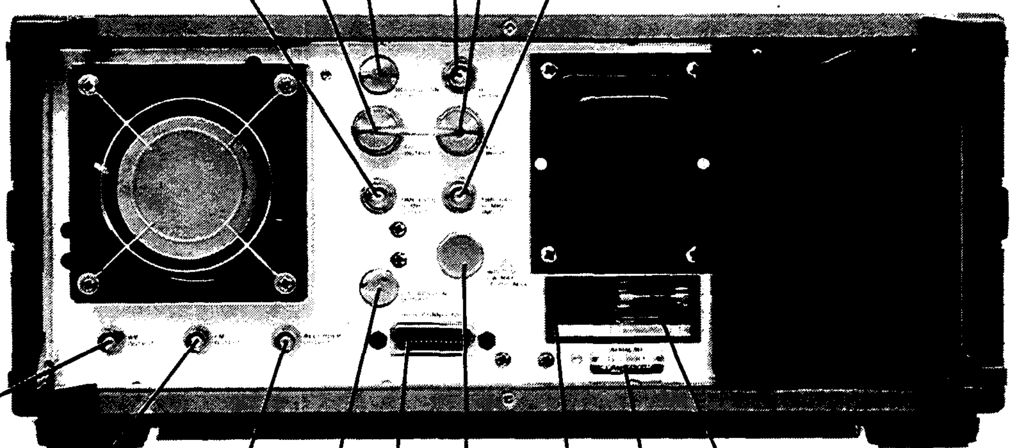
LO INPUT (Option 003 only) provides an input for an external Local Oscillator. External input signal required is 1.27 to 1301.5 MHz at approximately 0 **dBm (50Ω** nominal input impedance).

CAUTION

Do not apply >40 Vdc or +5 dBm of RF power into the LO INPUT or damage to the instrument may result.

TI**ME BASE 10 MHz OUTPUT (Option 003 only) provides** an **output for the internal high-stability 10 MHz reference. Out**put **signal is TTL compatible (50Ω nominal output impedance).**

TIME BASE 10 **MHz** INPUT provides an input for an **external 10 MHz time base reference. External input signal** must be **>0.5V** peak-to-peak (**>500Ω** input impedance).



AM OUTPUT produces an ac signal, whose amplitude is proportional to the AM depth, with a dc component related to the IF level. The output is de coupled with a 16 **kHz** bandwidth and a 10 **kΩ** output impedance.

FM OUTPUT produces an ac signal, whose amplitude is proportional to the FM deviation, with a dc component related to the IF frequency. The output is dc coupled with a 16 **kHz** bandwidth and a 10 **kΩ** output impedance.

RECORDER OUTPUT produces a dc voltage proportional to the peak voltage at MODULATION OUTPUT. The output level is from 0 to 4 Vdc into an open circuit for each display range (1 **kΩ output** impedance).

CALIBRATION OUTPUT is a rear-panel output for AM **and FM** calibrators (Option 010). This output is supplied on Option **001 in**struments instead of the standard front-panel connection. See CALIBRATION OUTPUT in Figure 3-1.

HP-IB CONNECTOR connects the Modulation Analyzer to the Hewlett-Packard Interface Bus for remote operations. When in remote mode, the front-panel REMOTE annunciator lights.

Fuse. 2 Amp **(250** V, Normal Blow) for **100/120 Vac.** 1 Amp **(250V,** Normal Blow) for 2201240 **Vac.**

Serial Number Plate. First four numbers and letter comprise the prefix that denotes the instrument configuration. The last five digits form the suffix that is unique to each instrument.

Line **Power** Module **permits** operation from **100,** 120,220, or 240 **Vac.** The number visible in window indicates nominal line voltage to which instrument must be connected (see Figure 2-1). Center conductor is safety earth ground.

INPUT is a rear-panel input for the modulated signal. This input is supplied on Option 001 instruments instead of the standard front-panel connection. See INPUT in Figure 3-l.

Figure 3-6. Rear-Panel Features

3-3. BASIC FUNCTIONAL CHECKS

Description

Using a signal generator and oscilloscope, the overall operation of the Modulation Analyzer is **verified.**

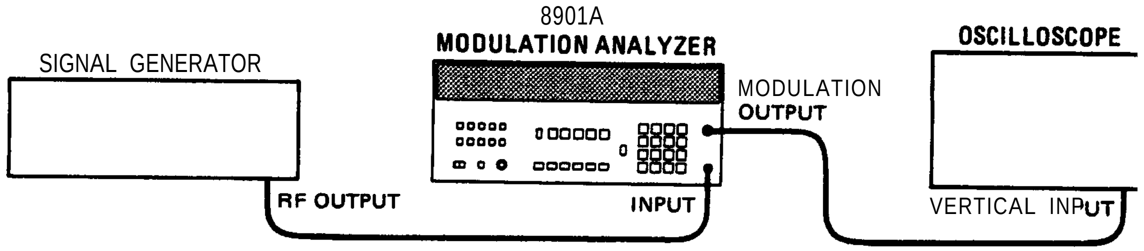


***Figure 3-7.* Basic Functional Checks Setup**

Equipment

oscilloscope .... HP 54201A
Signal Generator .... HP 8640B Options 001 and 002

Procedure

Preliminary Check

1. Remove any cable **from** the Modulation Analyzer's INPUT. Set LINE switch to STBY, then back to ON and note the front-panel LED annunciators, display segments and decimal points, and key lights at turn on. **All LEDs** should light for approximately 10 seconds at turn on and then all should momentarily turn off.
2. After the turn-on sequence, the instrument should show **"— —",** the MHz annunciator should light, and the FREQ key should light.

RF LEVEL Check

3. Press the RF LEVEL key. The display should read between -0.003 and 0.003 **mW.**
4. Set signal generator to 10 MHz CW at **+10 dBm** (as measured on its level meter).
5. Connect the equipment as shown in figure 3-7.
6. The Modulation Analyzer display should read between 6.5 and 16 **mW.**

Frequency Check

7. Press the FREQ key. Set the signal generator's **frequency** as shown in the following table. For each frequency, compare the signal generator's frequency display with the Modulation Analyzer's display. The two displays should agree within the limits indicated.

Signal Generator Frequency (MHz)	Frequency Difference Limits (±Hz)
2	40
4	50
8	70
16	100
25	130
50	230
100	430
200	830
400	1600
800	3200

8. Set the signal generator frequency to 50 MHz. When the Modulation Analyzer has found the signal, press MHz, then S (Shift) FREQ ERROR. The display should read between -2 and 2 kHz.
9. Key in 100 and press the ⇑ kHz key. The display should read between -102 and -98 kHz.

AM Check

10. Press the Modulation Analyzer's MHz key and set the signal generator for 50% AM (as measured on its AM meter) at a 1 kHz rate.
11. Press AM. The display should read between 46 and 54%.
12. Set the signal generator's AM to 25% (as measured on its AM meter). The display should read between 22 and 28% with 0.01% resolution.

FM and Phase Modulation (ΦM) Checks

13. Set the signal generator's AM off and set FM to 50 kHz deviation (as measured on its FM meter) at a 1 kHz rate. Press FM. The display should read between 45 and 55 kHz.
14. Adjust the signal generator's FM deviation for 50 kHz as displayed by the Modulation Analyzer.
15. Press ΦM. The display should read between 45 and 55 radians.

FM De-emphasis Check

16. Press FM. Set RATIO to %. The display should read between 99.8 and 100.2% REL.
17. The oscilloscope should show a sinusoidal waveform with a peak-to-peak amplitude between 0.9 and 1.1 V and a period of 1 ms.
18. Set FM DE-EMPHASIS to PRE-DISPLAY. Set FM DE-EMPHASIS time constant as shown below. The display should read within the limits shown. Also, the oscilloscope waveform should change proportionately to the display. (Allow for a x 10 autorange at the MODULATION OUTPUT when FM DE-EMPHASIS is set to 750 μs.)

FM De-emphasis Time Constant (μs)	Limits (% REL)	
	Minimum	Maximum
25	97.0	98.0
50	94.5	96.2
75	88.8	92.1
750	18.9	23.0

Filter Check

19. Set FM DE-EMPHASIS off. Set FM rate as listed below. For each setting, set **filters** (**HP** or LP FILTER) **to** ALL OFF, and set RATIO off **if it** is on. Then set **RATIO** to **dB** to establish a reference of 0 **dB,** set the appropriate HP or LP FILTER on, and **fine adjust** the FM rate for a reading of -3 **dB** REL. Note the FM rate **(preferrably** as read on the signal generator's count&) which should be within the limits shown.

Approximate FM Rate (Hz)	HP or LP Filter	Frequency Limits (Hz)	
		Minimum	Maximum
50	50 Hz HP	47.5	52.5
300	300 Hz HP	285	315
3000	3 kHz LP	2850	3150
15 000	15 kHz LP	14 250	15 750
90 000	>20 kHz LP	80 000	140000

Detector Check

20. Set RATIO off, set **filters** to ALL OFF. Set the signal generator's FM rate to 1 **kHz.** Set RATIO to % and set DETECTORS to PEAK-. The display should read between 95 and 105% REL depending upon the signal generator's distortion.
21. Set DETECTOR to AVG. The display should read between 69.3 and 72.1% REL.
22. Set DETECTOR to PEAK+, then press PEAK HOLD. Switch the signal generator's FM off. The display should hold the value displayed just prior to pressing PEAK HOLD.

IF and Tuned RF Level Check

23. Press **S(Shift)** IF LEVEL. The display should read between 99.9 and 100.1%.
24. Press AUTOMATIC OPERATION then key in 10.0 and press the SPCL key. The display should read between 1.45 and 1.55 MHz.
25. Key in 3.1 and press the SPCL key. The display should read between 0.4425 and 0.4575 MHz.
26. Tune the signal generator to 5.25 MHz. Press **S(Shift)** TUNED RF LEVEL. The display should read between 6.5 and 16 mW.

27. Set **RATIO** to **dB,** then key in 3.3 and press the SPCL key. The **display** should read between -2 and -8 **dB** REL.

Error Check

28. Tune the signal generator to 50 MHz at 0 **dBm.** On the Modulation Analyzer, press **AUTOMATIC** OPERATION, then FM. Set **DETECTOR** to PEAK+. After the Modulation Analyzer is tuned, key in 9.0 and press the SPCL key. Key in 100, then press ⇑ **kHz.** The display should read **E01.**

29. Press ⇓ **kHz.** Set the generator's FM on and adjust the peak deviation for 6 **kHz** (as read on its FM meter). The Modulation Analyzer's display should read E04.

30. Key in 8.4 and press the SPCL key. The display should read E07.

'31. Set the signal generator's FM off. Set the output level to **+20 dBm.** The Modulation Analyzer's display should read E02.

32. Set the signal generator's output level to -20 **dBm.** The Modulation Analyzer's display should read E03.

Calibrator Check (Option 010 only)

33. Disconnect the signal generator from the Modulation Analyzer's INPUT and connect CALIBRATION OUTPUT to INPUT. Press AM, then CALIBRATION. After about 20 seconds, the AM Calibration Factor will be displayed. The display should read between 99.0 and 101.0%.

34. Press FM, then CALIBRATION. After about 20 seconds, the FM Calibration Factor will be displayed The display should read between 99.0 to 101.0%.

3–4. HP-IB FUNCTIONAL CHECKS

Description

The following ten procedures check the Modulation Analyzer's ability to process or send all of the applicable HP-IB messages. In addition, the Modulation Analyzer's ability to recognize its HP-IB address is checked and all of the bus data, handshake, and control lines except DI08 (the most significant data line which is not used by the Modulation Analyzer) are set to both their true and false states. These procedures do not check whether or not all Modulation Analyzer program codes are being properly interpreted and executed by the instrument; however, if the front panel operation is good, the program codes, in all likelihood, will be correctly implemented.

The validity of these checks is based on the following assumptions:

- The Modulation Analyzer performs properly when operated through the front-panel keys (that is, in local mode). This can be verified with the preceding Basic Functional Checks.
- The bus controller properly executes HP-IB operations.

If the Modulation Analyzer appears to fail any of these HP-IB checks, the validity of the above assumptions should be confirmed before attempting to service the instrument.

The select code of the controller's HP-IB interface is assumed to be 7. The address of the Modulation Analyzer is assumed to be 14 (its address as set at the factory). This select code-address combination (that is, 714) is not necessary for these checks to be valid. However, the program lines presented here would have to be modified for any other combination.

These checks are intended to be as independent of each other as possible. Nevertheless, the first four checks should be performed in order before other checks are selected. Any special initialization or requirements for a check are described at its beginning.

Initial Setup

The test setup is the same for all of the checks. Connect the Modulation Analyzer to the bus controller through the HP-IB interface. Do not connect any equipment to any of the Modulation Analyzer's inputs.

Equipment

HP-IB Controller .... HP 9000 Model 216,226, or 236
Programming Language .... HP BASIC 4.0

Address Recognition Check. This check determines whether or not the Modulation Analyzer recognizes when it is being addressed and when it is not. This check assumes only that the Modulation Analyzer can properly handshake on the bus. Before beginning this check, set the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	BASIC
Set the Remote Enable **(REN)** bus control line false.	LOCAL 7
Send the Modulation Analyzer's listen address.	OUTPUT 714
Check that the Modulation Analyzer's REMOTE annunciator is off and that its ADDRESSED annunciator is on.	
Unaddress the Modulation Analyzer by sending a different address	OUTPUT 715
Check that the Modulation Analyzer's REMOTE and ADDRESSED annunciators are off.	

Remote/Local Messages and the $\boxed{\text{LOCAL}}$ Key Check. This check determines whether the Modulation Analyzer properly switches from local to remote control, **from** remote to local control, and whether the $\boxed{\text{LOCAL}}$ key returns the instrument to local control. This check assumes that the Modulation Analyzer is able to both handshake and recognize its own address. Before beginning this check, set the Modulation Analyzer's LINE switch to **STBY,** then to ON.

Description	BASIC
Send the Remote Message (by setting Remote Enable, REN, true and addressing the Modulation Analyzer to Listen).	REMOTE 714
Check that the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on.	
Send the Local Message to the Modulation Analyzer	LOCAL 714
Check that the Modulation Analyzer's REMOTE annunciator is off but its ADDRESSED annunciator is on.	
Send the REMOTE message to the Modulation Analyzer.	REMOTE 714
Check that the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. Press the LOCAL key on the Modulation Analyzer. Check that the Modulation Analyzer's REMOTE annunciator is now off, but that its ADDRESSED annunciator remains on.	

Sending the Data Message Check (Data Output). This check determines whether or not the Modulation Analyzer properly issues Data messages when addressed to talk. This check assumes that the Modulation Analyzer is able to handshake and recognize its own address. Before beginning this check, set the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	BASIC
Address the **Modulation** Analyzer to talk and store its output data in variable V. (The output is Error 96 since there is no signal at its INPUT.)	ENTER 714;V
Display **the** value of V.	PRINT V
Check that the Modulation Analyzer's REMOTE annunciator is off **but.that** its ADDRESSED annunciator is on. The controller's display should read **9000009600.**	

Receiving the Data Message Check (Data Input). This check determines whether or not the Modulation **Analyzer** properly receives Data messages. The Data messages sent also cause the 7 least-sign&ant HP-IB data lines to be placed in both their true and false states. This check assumes the Modulation Analyzer is able to handshake, recognize its own address, and properly make the remote/local transitions. Before beginning this check, set the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	BASIC
Send the first part of the Remote message (enabling the **Modulation** Analyzer to remote).	REMOTE 7
Address the Modulation Analyzer to **listen** (completing the Remote message), then send a Data message (manually tuning the Modulation Analyzer to 1 MHz).	OUTPUT 7143 MZ
Check that the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. Check also that **its** 15 **kHz** LP FILTER and SPCL key lights are both on.	

Local Lockout and Clear Lockout/Set Local Messages Check. This check determines whether or not the Modulation Analyzer properly receives the Local Lockout message, disabling all front-panel keys. The check also determines whether or not the Clear Lockout/Set Local message is properly received and executed by the Modulation Analyzer. This check assumes that the Modulation Analyzer is able to handshake, recognize its own address, and properly make the remote/local transitions. Before beginning this check, set the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	BASIC
Send the first part of the Remote message (enabling the Modulation Analyzer to remote).	REMOTE 7
Send the Local Lockout message	LOCAL LOCKOUT 7
Address the Modulation Analyzer to listen (completing the Remote message).	OUTPUT 714
Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. Press the Modulation Analyzer's LOCAL key. Both its REMOTE and ADDRESSED annunciators remain on.	
Send the Clear Lockout/Set Local message.	LOCAL 7
Check that the Modulation Analyzer's REMOTE annunciator is off but its ADDRESSED annunciator remains on.	

Clear Message Check. This check determines whether or not the Modulation Analyzer properly responds to the Clear message. This check assumes that the Modulation Analyzer is able to handshake, recognize its own address, make the remote/local changes, and receive Data messages. Before beginning this check, set the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	BASIC
Send the first part of the Remote message (enabling the Modulation Analyzer to remote).	REMOTE 7
Address the Modulation Analyzer to listen (completing the Remote message). Then send a Data message that sets the Modulation Analyzer's tuning to manual (lighting the SPCL light).	OUTPUT 714;"MZ
Check that the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on and that the SPCL key liiht is also on.	
Send the Clear message (setting the Modulation Analyzer's tune mode back to automatic).	RESET 714
Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on and that the SPCL key light is off.	

Abort Message Check. This check determines whether or not the Modulation Analyzer becomes unaddressed when it receives the Abort message. This check assumes that the Modulation Analyzer is able to handshake, recognize its own address, make the remote/local changes, and enter serial-poll mode. Before beginning this check, set the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	BASIC
Send the Remote message to the Modulation Analyzer.	REMOTE 714
Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on.	
Send the Abort message, unaddressing the Modulation Analyzer.	ABORTIO 7
Check that the Modulation Analyzer's ADDRESSED annunciator is off.	
Address the Modulation Analyzer to talk and then store its output data in variable V.	ENTER 714;V
Check that the Modulation Analyzer's REMOTE annunciator is off but that its ADDRESSED annunciator is on.	
Send the Abort message unaddressing the Modulation Analyzer to talk	ABORTIO 7
Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are off.	
Send the serial-poll-enable bus command (SPE) through the interface to place the Modulation Analyzer in serial-poll mode.	SENDBUS 714;1,24
On the Modulation Analyzer, key in 61.3 SPCL. The display should show 1.0. This indicates the Modulation Analyzer is in serial-poll mode (indicated by the "1").	
Send the Abort message, removing the Modulation Analyzer from serial-poll mode.	ABORTIO 7
Check that the Modulation Analyzer's display shows 0.0. This indicates the Modulation Analyzer properly left serial-poll mode upon receiving the Abort message.	

Status Byte Message Check. This check determines whether or not the Modulation Analyzer sends the Status Byte message in both the local and remote modes. This check assumes that the Modulation Analyzer is able to handshake, recognize its own address, and make the remote/local changes. Before beginning this check, set the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	BASIC
Place the Modulation Analyzer in serial-poll mode and address it to talk (causing it to send the Status Byte message).	STATUS 714;V
Display the value of V.	PRINT V
Check that the Modulation Analyzer's REMOTE annunciator is off. The controller's display should read 0.	
Send the Remote message	REMOTE 714
Place the Modulation Analyzer in serial-poll mode and address it to talk (causing it to send the Status Byte message).	STATUS 714;V
Display the value of V.	PRINT V
Check that the Modulation Analyzer's REMOTE annunciator is on. The controller's display should read 0.	

Require Service Message Check. This check determines whether or not the Modulation Analyzer can issue the Require Service message (set the SRQ bus control line true). This check assumes that the Modulation Analyzer is able to handshake, recognize its own address, make the remote/local changes, and receive Data messages. Before beginning this check, set the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	BASIC
Send the first part of the Remote message (enabling the Modulation Analyzer to remote).	REMOTE 7
Address the Modulation Analyzer to listen (completing the Remote message) then send a Data message (enabling a Require Service message to be sent upon Instrument Error).	OUTPUT 714;"22.4SP"
Make the controller watt 2 seconds to allow time for the Modulation Analyzer message. (This step is not necessary if sufficient time is allowed.)	WAIT 2000
Read the binary status of the controller's HP-IB interface and store the data in variable V (in this step, 7 is the interface's select code).	STATUS 7;V
Display the value of the SRQ bit (in this step, 7 is the SRQ bit, numbered from 0).	PRINT "SRQ=";BIT (V,7)
Check that the SRQ value is 1, indicating the Modulation Analyzer issued the Require Service message.	

Trigger Message and Clear Key Triggering Check. This check determines whether or not the Modulation Analyzer responds to the Trigger message and whether the CLEAR key **serves** as a manual trigger in remote. This check assumes that the Modulation Analyzer is able to handshake, **recognize** its own address, make the remote/local changes, and sand and receive Data messages. Before beginning this check, sat the Modulation Analyzer's LINE switch to STBY, then to ON.

Description	**BASIC**
Send the first part of the Remote **message** (enabling the Modulation Analyzer to remote).	REMOTE 7
Address the Modulation Analyzer to listen (completing the Remote message), then send a Data **message** (placing the Modulation **Analyzer** in Hold mode).	OUTPUT **714;"T1"**
Send the Trigger **message.**	TRIGGER 714
Address the Modulation Analyzer to talk and store **the** data in variable V.	ENTER **714;V**
Display the value of V.	PRINT V
Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. The controller's display should read 9900009900.	
Address the Modulation Analyzer to talk and store the data in variabb V.	ENTER 714;V
Check that the controller's 'run" indicator is still on indicating that it has not received data from the Modulation Analyzer. Press the Modulation Analyzer's CLEAR key. The controller's **"run"** indicator **should** turn off.	

3-5. REMOTE OPERATION, HEWLETT-PACKARD INTERFACE BUS HP-IB

The Modulation Analyzer can be operated through the Hewlett-Packard Interface Bus (HP-IB). Bus compatibility, programming, and data formats are described in the following paragraphs.

Except for the LINE switch and the Controller Reset Service Special Function, all Modulation Analyzer operations (including service related functions) are fully programmable through HP-IB.

A quick test of the HP-IB I/O is described under Remote *Operator's Checks. These checks* verify that the Modulation Analyzer can respond to or send each of the applicable bus messages described in table 3-2.

For more information about HP-IB, refer to IEEE Standard 488, *ANSI* Standard MC1.l, the Hewlett-Packard Electronic Systems and Instruments catalog, and the booklet, "Tutorial Description of the Hewlett-Packard Interface Bus" (HP part number 5952-0156).

HP-IB Compatibility

The Modulation Analyzer's complete bus compatibility (as defined by IEEE Standard 488, and the identical ANSI Standard MC1.l) is described at the end of table 8-2. Table 3–2 also summarizes the Modulation Analyzer's HP-IB capabilities in terms of the twelve bus messages in the left-hand column.

Remote Mode

Remote Capability. In remote, most of the Modulation Analyzer's front-panel controls are disabled (exceptions are the LCL and CLEAR keys). However, front-panel displays and the signal at MODULATION OUTPUT remain active and valid. In remote, the Modulation Analyzer may be addressed to talk or listen. When addressed to listen, the Modulation Analyzer will respond to the Data, Trigger, Clear (SDC), and Local messages. When addressed to talk, the Modulation Analyzer can issue the Data and Status Byte messages. Whether addressed or not, the Modulation Analyzer will respond to the Clear (DCL), Local Lockout, Clear Lockout/Set Local, and Abort messages, and in addition, the Modulation Analyzer may issue the Require Service message.

Local-to-Remote Mode Changes. The Modulation Analyzer switches to remote operation upon receipt of the Remote message. The Remote message has two parts. They are:

- Remote enable bus control line (REN) set true.
- Device listen address received once (while REN is true).

When the Modulation Analyzer switches to remote, both the REMOTE and ADDRESSED annunciators on its front panel will turn on.

Table 3-2. Message Reference Table (1 of 2)

HP-IB Message	Applicable	Response	Related Commands and Controls	Interface Functions *
Data	Yes	All Modulation Analyzer operations except the LINE switch are bus-programmable. All measurement results, special displays, and error outputs except the "— — —" display are available to the bus.		AH1 SH1 T5, TE0 L3, LE0
Trigger	Yes	If in remote and addressed to listen, the Modulation Analyzer makes a settled measurement according to previously programmed set-up. It responds equally to bus command GET and program code T3, Trigger with Settling (a Data message).	GET	DT1
Clear	Yes	Sets tune mode to automatic; low-noise LO, MEASUREMENT to FREQ, places demodulated FM at MODULATION OUTPUT, and sets the trigger mode to free run. Resets many additional parameters as shown in table 3-4. Clears Status Byte, RQS bit, Require Service message (if issued), and sets the Service Request Condition to the 22.2 state. Responds equally to Device Clear (DCL) and Selected Device Clear (SDC) bus commands.	DCL SDC	DC1
Remote	Yes	Remote mode is enabled when the REN bus control line is true. However, remote mode is not entered until the first time the Modulation Analyzer is addressed to listen. The front-panel REMOTE annunciator lights when the instrument is actually in the remote mode. When entering remote mode, no instrument settings or functions are changed, but all front-panel keys except LCL and CLEAR are disabled.	REN	RL1
Local	Yes	The Modulation Analyzer returns to local mode (front-panel control). Responds equally to the GTL bus command and the front-panel LCL key. When entering local mode, no instrument settings or functions are changed. In local, triggering is free run only.	GTL	RL1
Local Lockout	Yes	Disables all front-panel keys including LCL and CLEAR. Only the controller can return the Modulation Analyzer to local (front-panel control).	LLO	RL1
Clear Lockout/ Set Local	Yes	The Modulation Analyzer returns to local (front-panel control) and local lockout is cleared when the REN bus control line goes false. When entering local mode, no instrument settings or functions are changed. In local, triggering is free run only.	$\overline{\text{REN}}$	RL1
Pass Control/ Take Control	No	The Modulation Analyzer has no control capability.		C0
Require Service	Yes	The Modulation Analyzer sets the SRQ bus control line true if an invalid program code is received. The following conditions will also set SRQ true when they occur if they are enabled by the operator to do so; Data Ready, Instrument Error, Upper Limit Reached, or Lower Limit Reached.	SRQ	SR1

* Commands, Control Lines, and Interface Functions are defined in IEEE Std 488. Knowledge of these might not be necessary if your controller's manual describes programming in terms of the twelve HP-IB Messages shown in the left column.

Table 3-2. Message Reference Table (2 of 2)

HP-IB Message	Applicable	Response	Related Commands and Controls	Interface Functions *
Status Byte	Yes	The Modulation Analyzer responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when addressed to talk. If the instrument is holding the SRQ control line true (issuing the Require Service message) bit 7 (RQS bit) in the Status Byte and the bit representing the condition causing the Require Service message to be issued will both be true. The bits in the Status Byte are latched but can be cleared by: 1. Removing the causing condition, and 2. reading the Status Byte.	SPE SPD	T5, TE0
Status Bit	No	The Modulation Analyzer does not respond to a parallel poll.		PP0
Abort	Yes	The Modulation Analyzer stops talking and listening.	IFC	T5, TE0 L3, LE0

* Commands, Control Lines, and Interface Functions are defined in IEEE Std 488. Knowledge of these might not be necessary if your controller's manual describes programming in terms of the twelve HP-IB Messages shown in the left column.

Complete **HP-IB** capability as defined in IEEE Std 488 and ANSI Std MC1 **.1** is: **SH1, AH1, T5,** TEO, L3, LEO, **SR1, RL1,** PPO, **DC1, DT1,** CO.

Local Mode

Local Capability. In local, the Modulation Analyzer's front-panel controls are fully operational and the instrument will respond to the Remote message. Whether addressed or not, it will also respond to the Clear, Local Lockout, Clear Lockout/Set Local, and the Abort messages. When addressed to talk, the instrument can issue Data messages and the Status Byte message, and whether addressed or not, it can issue the Require Service message.

Remote-to-Local Mode Changes. The Modulation Analyzer always switches to local from remote whenever it receives the Local message (GTL) or the Clear Lockout/Set Local message. (The Clear Lockout/Set Local Message sets the Remote Enable control line [REN] false.) If it is not in Local Lockout mode, the Modulation Analyzer switches to local from remote whenever its front panel LCL key is pressed.

Addressing

The Modulation Analyzer interprets the byte on the bus' eight data lines as an address or a bus command if the bus is in the command mode, that is, attention control line (ATN) true and interface clear control line (IFC) false. Whenever the Modulation Analyzer is being addressed (whether in local or remote), the ADDRESSED annunciator on the front panel will turn on.

The Modulation analyzer's talk and listen addresses are switch selectable as described in section 2. Refer to table 2–1 for a comprehensive listing of all valid HP-IB address codes. To determine the present address setting, refer to the discussion titled HP-IB Address in the ***Detailed Operating Instructions*** near the end of this section.

Local Lockout. When a data transmission is interrupted, which can happen by returning the Modulation Analyzer to local mode by pressing the LCL key, the data could be lost. This would leave the Modulation Analyzer in an unknown state. To prevent this, a local lockout is recommended. Local lockout disables the LCL key (and the CLEAR key) and allows return-to-local only under program control.

NOTE

Return-to-local can also be accomplished by turning the Modulation Analyzer's LINE switch to STBY, then back to ON. However, this technique has sweml disadvantages.

- *It defeats the purpose and advantages of local lockout (that is, the system controller will lose control of a system element).*
- *There are several HP-IB wnditions that reset to default states at turn-on*

Data Messages

The Modulation Analyzer communicates on the interface bus primarily with data messages. Data messages consist of one or more bytes sent over the bus' 8 data lines, when the bus is in the data mode (attention control line [ATN] false). Unless it is set to Talk Only, the Modulation Analyzer receives data messages when addressed to listen. Unless it is set to Listen Only, the Modulation Analyzer sends data messages or the Status Byte message (ifenabled) when addressed to talk. Virtually all instrument operations available in local mode may be performed in remote mode by data messages. The only exceptions are changing the LINE switch setting and using the Controller Reset Service Special Function. In addition, the Modulation Analyzer may be triggered by data messages to make measurements at a particular time.

Receiving the Data Message

Depending on how the internal address switches are set, the Modulation Analyzer can either talk only, talk status only, listen only, or talk and listen both (normal operation). The instrument responds to Data messages when it is enabled to remote (REN control line true), and it is addressed to listen or set to Listen Only. If not set to Listen Only, the instrument remains addressed to listen until it receives an Abort message or until it's talk address or a universal unlisten command is sent by the controller.

Listen Only. If the internal LON (Listen Only) switch is set to "1", the Modulation Analyzer is placed in the Listen Only mode when the remote enable bus control line (REN) is set true. The instrument then responds to all Data messages, and the Trigger, Clear, and Local Lockout messages. However, it is inhibited from responding to the Local or Abort messages and from responding to a serial poll with the Status Byte message.

Listen Only mode is provided to allow the Modulation Analyzer to accept programming from devices other than controllers (for example, card readers).

Data Input Format. The Data message string, or program string, consists of a series of ASCII codes. Each code is typically equivalent to a front-panel keystroke in local mode. Thus, for a given operation, the program string syntax in remote mode is the same as the keystroke sequence in local mode. Example 1 shows the general case programming order for selecting Modulation Analyzer functions. Specific program order considerations are discussed later in this section. All functions can be programmed together as a continuous string as **typified** in Example 2. The string in Example 2 triggers a settled measurement cycle in which the Modulation Analyzer determines the positive peak de-emphasized (75 **μs) FM** deviation of an input signal at 104.5 MHz

EXAMPLE 1: General Program Syntax and Protocol

Controller Talk
Modulation Analyzer Listen ,

[Automatic Operation] [Tuning] **[Measurement]** [Detector] [Filters] [FM De-emphasis] **[Special** Functions] [Ratio] [Calibration] [Trigger]

EXAMPLE 2: Typical Prqgram String

Controller Talk
Modulation Analyzer **Listen** ,

AU104.5MZM2D1P1P4T3

- AU — Automatic Operation
- 104.5MZ — **Manual Tuning**
- M2 — **FM**
- D1 — Peak + Detector
- P1 — FM De-emphasis Pre-Display
- P4 — **75 μs FM De-emphasis**
- T3 — **Trigger with Settlin**

Program Codes. All of the valid HP-IB codes for controlling Modulation Analyzer functions are summarized in table 3-5. All front-panel keys except the LCL key have corresponding program codes. Some of the tuning functions have additional codes which terminate the numeric data entry in Hz rather than MHz or **kHz** as indicated on the front panel. Where more than one code is given for a function, either code will serve equally. However, the first code given is recommended since its mnemonic more closely represents the function selected, and it will therefore make deciphering program code strings easier. The **first** codes given are the codes used in all programming examples in this manual.

Table S-3 shows the Modulation Analyzer's response to various ASCII characters not used in its code set. The characters in the left-hand column will be ignored unless they appear between two characters of a program code. The characters in the right-hand columns, if received by the Modulation Analyzer, will always cause Error E24 (invalid HP-IB code) and a Require Service message to be generated. As a convenience, all lower case alpha characters are treated as upper case.

Table 3-3. Modulation Analyzer Response to Unused ASCII Codes

Ignored •	Generate Error 24	
!	@	[
"	B	\
"	G	]
#	I	^
%	J	_
&	N	{
(	Q	|
)	V	}
•	W	~
,	Y	DEL
/		

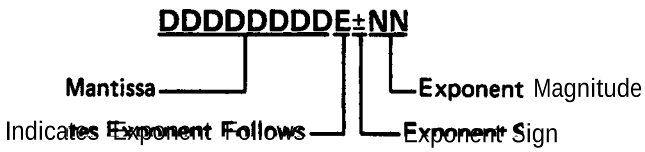
• Except when inserted between two characters of a program code.

Turning Off Functions. When operating in local mode, the High-Pass and Low-Pass Filters, FM De-emphasis, Calibration, and Ratio functions toggle on and off with successive keystrokes. In remote mode, these functions do not toggle on and off. Instead, each of the above groups has a specific code which turns off all the keys in the group. Note that for FM De-emphasis the code that turns off the filters also turns off the PRE-DISPLAY function. Thus, when programming FM de-emphasis, it is advantageous to begin with the PEE-DISPLAY setting, then select the desired de-emphasis. The HP-IB codes for turning off these functions are given in the table below.

Functions	HP-IB Code
HP FILTERS ALL OFF	HO
LP FILTERS ALL OFF	LO
FM DE-EMPHASIS adn PRE-DISPLAY off	PO
RATIO off	RO
CALIBRATION off	co

Programming Numeric Data. When programming input frequency, entering ratio or limit references, or issuing any numeric data (other than specific HP-IB codes) to the Modulation Analyzer, certain precautions should be observed. Numeric data may consist of a mantissa of up to eight digits, one decimal point, and one- or two-digit signed exponent. (The mantissa alone is used when entering ratio or limit references). The decimal point may fall between any two digits of the mantissa but may not appear ahead of the first digit. If it does, a leading zero will be automatically inserted by the Modulation Analyzer. Any digit beyond the eight allowed for the mantissa will be received as zero. The general format for numeric data entry is given below, followed by several examples illustrating various entries and the resulting data as received by the Modulation Analyzer.

General Numeric Data Input Format:



Example: **.12345678E+01** issued
0.1234567E+01 received by Modulation Analyzer

Example: **123456789E+01** issued
123456780E+01 received by Modulation Analyzer

In general, do not issue numeric data with more significant digits than can be displayed on the Modulation Analyzer's eight-digit display.

Triggering Measurements with the Data Message. A feature that is only available through remote programming is the selection of free run, standby, or triggered operation of the Modulation Analyzer. During local operation, the Modulation Analyzer is allowed to free run, outputting data to the display each measurement cycle. In remote, three additional operating modes are allowed: Hold, Trigger Immediate, and Trigger With Settling. In addition, the CLEAR key can act as a manual trigger while the instrument is in remote. The trigger modes and use of the Clear key are described below.

Free Run (T0). This mode is identical to local operation and is the mode of operation in effect when no other trigger mode has been selected The measurement result data available to the bus are constantly being updated as rapidly as the Modulation Analyzer can make measurements. A Device Clear message or entry into remote from local sets the Modulation Analyzer to the Free Run mode.

Hold (T1). This mode is used to set up triggered measurements (initiated by program codes T2 or T3, the Trigger message, or the CLEAR key). In Hold mode, internal settings can be altered by the instrument itself or by the user through the bus. Thus, the signal at MODULATION OUTPUT CAN CHANGE. However, the instrument is inhibited from outputting any data to the front-panel key lights and display or to the HP-IB except as follows. The instrument will issue the Require Service message if a LIMIT is reached (and if enabled to do so) or if an HP-IB code error occurs. The instrument will issue the Status Byte message if serial polled. (A serial poll, however, will trigger a new measurement, update displays and return the instrument to Hold.) If a momentary error condition occurs while the instrument is in Hold, the signal at MODULATION OUTPUT may be temporarily invalid with no indication from the instrument.

Upon leaving Hold, the front-panel indications are updated as the new measurement cycle begins. The Status Byte will be affected (and the Require Service message issued) by the events that occur during the new measurement cycle.

The Modulation Analyzer leaves Hold when:

- it receives either the Free Run, Trigger Immediate, or Trigger With Settling codes,

- when it receives the Trigger Message
- when the CLEAR key is pressed (if not in Local Lockout), or
- when it **returns to local** operation.

Trigger Immediate (T2). When the Modulation Analyzer receives the Trigger Immediate code, it makes one measurement in the shortest possible time. The instrument then waits for the measurement results to be read While waiting, the instrument can process most bus commands without losing the measurment results. However, if the instrument receives GTL (Go To Local), GET (Group Execute Trigger), its listen address, or if it is triggered by the CLEAR key, a new measurement cycle will be executed Once the data (measurement results) are read onto the bus, the Modulation Analyzer reverts to the Hold mode. Measurement results obtained by Trigger Immediate are normally valid only when the instrument is in a steady, settled state.

Trigger With Settling (T3). Trigger With Settling is identical to Trigger Immediate except the Modulation Analyzer inserts a settling-time delay before taking the requested measurement. This settling time is sufficient to produce valid, accurate measurement results. Trigger With Settling is the trigger type executed when a Trigger message is received through the bus.

NOTE

The use of Trigger With Settling does not remove the need to observe the normal warm-up precautions when using either the AM or FM Calibrator. Refer to the procedures under "Calibration, AM," "Calibration, FM" in the Detailed Operating Instructions.

Triggering Measurements With the CLEAR Key. When the Modulation Analyzer is in remote Hold mode and not in Local Lockout, the front-panel CLEAR key may be used to issue a Trigger With Settling instruction. First place the instrument in Hold mode (code T1). Each time the CLEAR key is pressed, the Modulation Analyzer performs one Trigger With Settling measurement cycle, then waits for the data to be read. Once the data is read out to the bus, the instrument returns to Hold mode. If data is not read between trigger cycles, it will be replaced.with data acquired from subsequent measurement cycles.

Special Considerations for Triggered Operation. When in free-run mode, the Modulation Analyzer must pay attention to all universal bus commands, for example, serial poll enable (SPE), or local lockout (LLO). In addition, if it is addressed to listen, it must pay attention to all addressed bus commands, for example, go to local (GTL), or group execute trigger (GET). As a consequence of this, the Modulation Analyzer must interrupt the current measurement cycle to determine whether any action in response to these commands is necessary. Since many elements of the measurement cycle are transitory, the cycle must be reinitiated following each interruption. Thus, if a lot of bus activity occurs while the Modulation Analyzer is trying to take a measurement, a measurement cycle may never be completed.

Trigger Immediate and Trigger With Settling provide a way to avoid this problem. When the Trigger Immediate (T2) and Trigger With Settling (T3) codes are received, the Modulation Analyzer will not allow its measurement cycle to be interrupted. (Indeed, handshake of bus commands is inhibited until the measurement cycle is complete.) Once the cycle is complete, bus commands will be processed, as discussed under Trigger Immediate above, with no loss of data. Thus, in an HP-IB ennvironment where many bus commands are present, Trigger Immediate or Trigger With Settling should be used for failsafe operation.

Program Order Considerations. Although program string syntax is virtually identical to keystroke order, some program order considerations need highlightling.

AUTOMATIC OPERATION (AU). As in local mode, when AUTOMATIC OPERATION is executed in remote, it sets all Special Functions prefixed 1 through 8 to their zero-suffix mode and also affects many other Special Functions. Thus when AUTOMATIC OPERATION is used, it should appear at the beginning of a program string.

FM DE-EMPHASIS PRE-DISPLAY (PO and P1). When pre-display is turned off using PO, all FM de-emphasis is turned off. To avoid mistakes when programming de-emphasis, always arrange the codes in numeric order specifying the PRE-DISPLAY setting (PO or P1) first.

PEAK HOLD (D3). As in local, once PEAK HOLD is specified, any ensuing detector code will turn it off. Thus the peak to be held must be specified before PEAK HOLD is activated A good rule to follow is to specify detectors in numeric order.

Trigger Immediate and Trigger With Settling (T2 and T3). When either of the trigger codes T2 or T3 is received by the Modulation Analyzer, a measurement cycle is immediately initiated Once the measurement cycle is complete, some bus commands can be processed without losing the measurement results. However, any HP-IB program code sent to the Modulation Analyzer before the triggered measurement results have been output will initiate a new measurement cycle. Thus, trigger codes should always appear at the end of a program string, and the triggered measurement results must be read before any additional program codes are sent.

Sending the Data Message

Depending on how the internal address switches are set, the Modulation Analyzer can either talk only, talk status only, listen only, or talk and listen both (normal operation). If set to both talk and listen, the instrument sends Data messages when addressed to talk. The instrument then remains configured to talk until it is unaddressed to talk by the controller. To unaddress the Modulation Analyzer, the controller must send either an Abort message, a new talk address, or a universal untalk command.

Talk Only Mode. If the internal address switches are set to a valid Talk address and the TON (Talk Only) switch is set to "1", the Modulation Analyzer is placed in the Talk Only mode. In this mode the instrument is configured to send Data messages whenever the bus is in the data mode. Each time the measurement is completed, the measurement result will be output to the bus unless the listening device is not ready for data. If the listener is not ready and the Modulation Analyzer is not in a trigger mode, another measurement cycle is executed.

Talk Status Only Mode. If all the internal address switches and the TON (Talk Only) switch are set to "l", but the LON (Listen Only) switch is set to "O", the Modulation Analyzer is placed in the Talk Status Only mode. In this mode the instrument is configured to send a one-byte data message whenever the bus is in the data mode. The byte sent is an exact copy of the Status Byte. Each time this byte is successfully sent on the bus, the internal Status Byte is cleared. The Data Valid (DAV) handshake line is pulsed each time the one-byte Data message is sent.

Data Output Format. As shown below, the output data is always formatted as a real constant: first the sign, then eight digits (leading zeros not suppressed) followed by the letter E and a signed power-of-ten multiplier. The string is terminated by a carriage return (CR) and a line feed (LF), string positions 14 and 15. Data is always output in fundamental units (for example, Hz, watts, radians, dB, %) and the decimal point (not sent) is assumed to be to the right of the eighth digit of the mantissa. Data values never exceed 4 000 000 000.

Data Output Format:

```
±DDDDDDDDE±NNCRLF
Signed Mantissa
Indicates Exponent Follows
Exponent Sign
Line Feed
Carriage Return
Exponent Magnitude
```

When an error is output to the bus, it follows the same fifteen-byte format described above except most of the numeric digits have predetermined values as shown below. Error outputs always exceed 9 000 000 000. The two-digit error code is represented by the last two digits of the eight-digit mantissa. The error code can be derived from the string by subtracting 9 x 10^9, then dividing the results by 100.

Error Output Format:

```
Error Output Format:
+900000DDE+02CRLF
Error Code
Line Feed
Carriage Return
```

Timed Displays in Remote Operation. When operating in local mode, many Modulation Analyzer displays are presented only for a limited time. This allows the instrument to communicate requested information or error messages, then return to displaying the results of the measurement previously selected. In remote, no measurement result, outputs or displays are timed. Error outputs, however, time-out as they do in local operation unless captured during a triggered measurement cycle.

Receiving the Clear Message

The Modulation Analyzer responds to the Clear message by assuming the settings detailed in table 3-4. The Modulation Analyzer responds equally to the Selected Device Clear (SDC) bus command when addressed to listen, and the Device Clear (DCL) bus command whether addressed or not. The Clear message clears any pending Require Service message and resets the Service Request Condition (Special Function 22) such that the Require Service message will be issued on HP-IB code errors only (22.2 SPCL).

Table 3-4. *Response to* a *Clear Message*

Parameter	Setting
High-Pass (HP) Filters	All Off
Low-Pass (LP) Filters	All Off
FM De-emphasis	All Off
Pm-display	off
Calibration	Off
Measurement	Frequency
Detector	off[1]
Ratio	off
Limit	Not Enabled
Lower Limit Reference	150 kHz
Upper Limit Reference	1800 MHz
Limit Measurement Mode	Frequency
Automatic Operation	On
Manual Operation	
MHz Input Frequency	Automatic Tuning[2]
⇑ and ⇓ kHz Step Size	0 kHz
SPCL	Special Functions prefixed 1 through 8 in zero-suffix mode: all others off except Service Request Condition set to 22.2 (HP-IB code error).
Modulation Output	FM (least sensitive range)
Service Request Condition	HP-IB Code Error Only
Status Byte	Cleared
Trigger Mode	Free Run (Code TO)

[1] Detector will be Peak+ if a modulation measurement is selected immediately after the Clear message is received or after power up.
[2] If MHz (code MZ) is selected immediately after the Clear message is received or after power-up, the Modulation Analyzer will tune to 100 MHz.

Receiving the Trigger Message

When in remote and addressed to listen, the Modulation Analyzer responds to a Trigger message by executing one settled-measurment cycle. The Modulation Analyzer responds equally to a Trigger message (the Group Execute Trigger bus command [GET]) and a Data message, program code T3 (Trigger With Settling). Refer to ***Triggering Measurements With the Data Message.***

Receiving the Remote Message

The Remote message has two parts. First, the remote enable bus control line (REN) is held true, then the device listen address is sent by the controller. These two actions combine to place the Modulation Analyzer in remote mode. Thus, the Modulation Analyzer is enabled to go into remote when the controller begins the Remote message, but it does not actually switch to remote until addressed to listen the first time. No instrument settings are changed by the transition from local to remote, but the Trigger mode is set to Free Run (code TO). When actually in remote, the Modulation Analyzer lights its front-panel REMOTE annunciator. When the Modulation Analyzer is being addressed (whether in remote ***or*** local), its front-panel ADDRESSED annunciator turns on.

Receiving the Local Message

The Local message is the means by which the controller sends the Go To Local (GTL) bus command. If addressed to listen, the Modulation Analyzer returns to front-panel control when it receives the Local message. If the instrument was in local lockout when the Local message was received, front-panel control is returned, but lockout is not cleared. Unless it receives the Clear Lockout&t Local message, the Modulation Analyzer will return to local lockout the next time it goes to remote. No instrument settings are changed by the transition from remote to local, but all measurements are made in a free-run mode.

When the Modulation Analyzer goes to local mode, the front-panel REMOTE annunciator turns off. However, when the Modulation Analyzer is being addressed (whether in remote or local), its front-panel ADDRESSED annunciator lights.

If the Modulation Analyzer is not in local lockout mode, pressing the front-panel LCL (local) key might interrupt a Data message being sent to the instrument, leaving the instrument in a state unknown to the controller. This can be prevented by disabling the Modulation Analyzer's front-panel keys entirely using the Local Lockout message.

Receiving the Local Lockout Message

The Local Lockout message is the means by which the controller sends the Local Lockout (LLO) bus command. If in remote, the Modulation Analyzer responds to the Local Lockout' Message by disabling the front-panel LCL (local) and CLEAR keys. (In remote, CLEAR initiates a Trigger With Settling cycle.) The local lockout mode prevents loss of data or system control due to someone accidentally pressing front-panel keys. If, while in local, the Modulation Analyzer is enabled to remote (that is, REN is set true) and it receives the Local Lockout message, it will switch to remote mode with local lockout the first time it is addressed to listen. When in local lockout, the Modulation Analyzer can be returned to local only by the controller (using the Local or Clear Lockout/Set Local messages) or by setting the LINE switch to STBY and back to ON or by removing the bus cable.

Receiving the Clear Lockout/Set Local Message

The Clear Lockout&t Local message is the means by which the controller sets the Remote Enable (REN) bus control line false. The Modulation Analyzer returns to local mode (full front-panel control) when it receives the Clear Lockout/Set Local message. No instrument settings are changed by the transition from remote with local lockout to local. When the Modulation Analyzer goes to local mode, the front-panel REMOTE annunciator turns off.

Receiving the Pass Control Message

The Modulation Analyzer does not respond to the Pass Control message because it cannot act as a controller.

Sending the Require Service Message

The Modulation Analyzer sends the Require Service message by setting the Service Request (SRQ) bus control line true. The instrument can send the Require Service message in either local or remote mode. The Require Service message is cleared when a serial poll is executed by the controller or if a Clear message is received by the Modulation Analyzer. (During serial poll, the Require Service message is cleared immediately before the Modulation Analyzer places the Status Byte message on the bus.) An HP-IB code error will always cause a Require Service message to be issued. In addition, there are four other conditions which can be enabled to cause the Require Service message to be sent when they occur. All five conditions are described below.

- Data Ready: When the Modulation Analyzer is ready to send any information except error codes.
- HP-IB Code Error: When the Modulation Analyzer receives an invalid Data message. (This condition always causes a Require Service message to be sent).
- Instrument Error: When any Error is being displayed by the Modulation Analyzer including HP-IB Code error, E24.
- Upper Limit Reached: When the upper limit reference has been reached or exceeded.
- Lower Limit Reached: When the lower limit reference has been reached or exceeded.

Selecting the Service Request Condition

Use Special Function 22, Service Request Condition, to enable the Modulation Analyzer to issue the Require Service message on any of the conditions above (except HP-IB code errors which always cause the Require Service message to be sent). The Service Request Condition Special Function is entered from either the front panel or through the HP-IB. The conditions enabled by Special Function 22 are always disabled by the Clear message. A description of the Service Request Condition Special Function and the procedure for enabling the various conditions are given under Service Request Condition ***in Detailed Operation Instructions.***

Normally, device subroutines for the Modulation Analyzer can be implemented simply by triggering measurements then reading the output data. In certain applications, the controller must perform other tasks while controlling the Modulation Analyzer. Figure 3-8 illustrates a flow chart for developing device subroutines using the instrument's ability to issue the Require Service message when data is ready. This subroutine structure frees the controller to process other routines until the Modulation Analyzer is ready with data.

Sending the Status Byte Message

The Status Byte message consists of one 8-bit byte in which 5 of the bits are set according to the enabled conditions described above under Sending the Require Service Message.

If one or more of the five conditions described above are both enabled and present, all the bits corresponding to the conditions and also bit 7, the RQS bit, will be set true (and the Require Service message is sent). If one of the above conditions occurs but has not been enabled by Special Function 22, neither the bit corresponding to the condition nor the RQS bit will be set (and the Require Service message will not be sent). The bit pattern of the Status Byte is shown later in this discussion.

Once the Modulation Analyzer receives the serial poll enable bus command (SPE), it is no longer allowed to alter the Status Byte. When addressed to talk (following SPE), the Modulation Analyzer sends the Status Byte message.

NOTE

Since the Modulation Analyzer cannot alter the Status Byte while in serial poll mode, it is not possible to continually request the Status Byte while waiting for a condition to cause a bit to be set.

After the Status Byte message has been sent, it will be cleared if the Serial Poll Disable (SPD) bus command is received, if the Abort message is received, or if the Modulation

Analyzer is unaddressed to talk. Regardless of whether or not the Status Byte message has been sent, the Status Byte and any Require Service message pending will be cleared if a Clear message is received. If the instrument is set to Talk Only, the Status Byte is cleared each time the one-byte Data message is issued to the bus.

Sending the Status Bit Message

The Modulation Analyzer does not respond to a Parallel Poll Enable (PPE) bus command and thus cannot send the Status Bit message.

Receiving the Abort Message

The Abort message is the means by which the controller sets the Interface Clear (IFC) bus control line true. When the Abort message is received, the Modulation Analyzer becomes unaddressed and stops talking or listening.

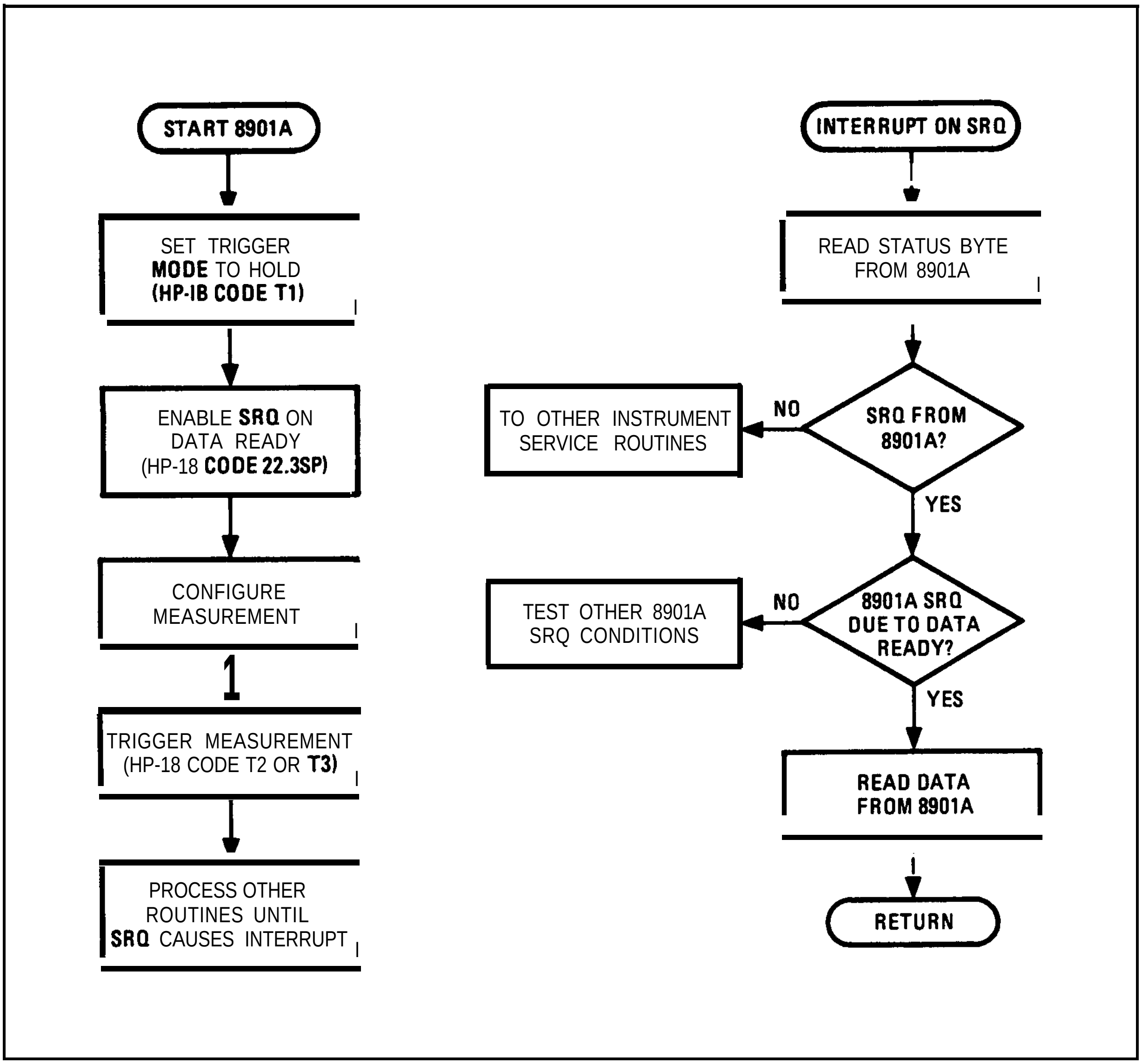


Figure 3-8. Example Flow Chart for Driving the Modulation Analyzer Using the Require Service Message (SRQ)

Table 3-5. Modulation Analyzer Parameter to HP-LB Code Summary

Parameter	Program Code	Parameter	Program Code
HP Filters		Detector	
All Off	H0	Peak+	D1 or U1
50 Hz On	H1	Peak–	D2 or U2
300 Hz On	H2	Peak Hold	D3 or U3
		Average (RMS Calibrated)	D4 or U4
LP Filters			
All Off	L0	Ratio	
3 kHz On	L1	All Off	R0
15 kHz On	L2	%	R1
>20 kHz On	L3	dB	R2
FM De-emphasis		Automatic Operation	AU or A1
FM De-emphasis and			
Predisplay Off	P0	Manual Operation	
Predisplay On	P1	Numerals	0–9
25 μs	P2	Decimal Point	
50 μs	P3	Clear	CL or K1
75 μs	P4	MHz Input Frequency	MZ or F1
750 μs	P5	Hz Input Frequency	HZ or Z1
		⇑ kHz	KU or F2
Calibration		⇑ Hz	HU or Z2
Calibration Off	C0	⇓ kHz	KD or F3
Calibration On	C1	⇓ Hz	HD or Z3
		SPCL	SP or F4 or Z4
Measurement		SPCL SPCL	SS or F5 or Z5
AM	M1		
FM	M2	Trigger	
ΦM	M3	Free Run	T0
RF Level	M4	Hold	T1
Frequency	M5	Trigger Immediate	T2
IF Level	S3	Trigger With Settling	T3
Tuned RF Level	S4		
Frequency Error	S5		

Table 3-6. Modulation Analyzer Special Function to HP-IB Code Summary (1 of 3)

Special Function	Program Code	Special Function	Program Code
Input Attenuation		Modulation Range	
Automatic Selection	1.0SP	Automatic Selection	2.0SP
0 dB	1.1SP		
10 dB	1.2SP	AM (%) / FM* (kHz) / ΦM (rad)	
20 dB	1.3SP		
30 dB	1.4SP		
40 dB	1.5SP	<40 / <4 / <4	2.1SP
50 dB	1.6SP	<100 / <40 / <40	2.2SP
		<100 / <400 / <400	2.3SP
		* 1/10 Range with 750 μs de-emphasis, pre-display	

Table 3-6. Modulation Analyzer Special Function to HP-IB Code Summary (2 of 3)

Special Function	Program Code	Special Function	Program Code
Tune Mode		**FM Calibrator**	
Automatic; Low-noise LO	4.0SP	Display Computed Peak FM Deviation	12.0SP
Automatic; Track	4.1SP	Display Demodulated Peak Residual FM Deviation	12.1SP
Manual	4.2SP	Display Demodulated Peak FM Deviation	12.2SP
Audio Peak Detector Time Constant		**AM Calibrator**	
Fast	5.0SP	Display Computed Peak AM Depth	13.0SP
Slow	5.1SP	Display Demodulated Peak Residual AM Depth	13.1SP
AM ALC Response Time		Display Demodulated Peak AM Depth	13.2SP
Slow	6.0SP	**Set Limit**	
Fast	6.1SP	Clear Limits; Turn Off LIMIT Annunciator	14.0SP
Open ALC	6.2SP	Set Lower Limit to Ratio Reference	14.1SP
Frequency Resolution		Set Upper Limit to Ratio Reference	14.2SP
Automatic Selection	7.0SP	Restore Lower Limit	14.3SP
10 Hz Resolution (f<1 GHz)	7.1SP	Restore Upper Limit	14.4SP
1000 Hz Resolution	7.2SP	Read Lower Limit	14.5SP
Error Disable		Read Upper Limit	14.6SP
Automatic Selection	8.0SP	Read Lower Limit Measurement Code	14.7SP
E01 disabled	8.1SP	Read Upper Limit Measurement Code	14.8SP
E02 & E03 disabled	8.2SP	**Time Base Oven (Opt. 002)**	
E01, E02 & E03 disabled	8.3SP	Display E12 If Oven Cold	15.0SP
E04 disabled	8.4SP	**AM Calibration (Opt. 010)**	
E01 & E04 disabled	8.5SP	Disable AM Calibration Factor	16.0SP
E02, E03 & E04 disabled	8.6SP	Enable AM Calibration Factor	16.1SP
E01 through E04 disabled	8.7SP	Read AM Calibration Factor (0 if disabled)	16.2SP
E01 through E04 All errors enabled	8.8SP		
Hold Settings	9.0SP		
IF Frequency Measurement	10.0SP		
Re-enter Ratio with Previous Reference			
Re-enter % Ratio	11.0SP		
Re-enter dB Ratio	11.1SP		
Read Ratio Reference	11.2SP		
Make Ratio Reference Negative	11.3SP		

Table 3-6. Modulation Analyzer Special Function to HP-LB Code Summary (3 of 3)

Special Function	Program Code	Special Function	Program Code
FM Calibration (Opt. 010)		AAAAA.TLS	
Disable FM Calibration Factor	17.0SP	AAAAA=address;	
Enable FM Calibration Factor	17.1SP	T=1 means talk only;	
Read FM Calibration Factor (0 if disabled)	17.2SP	L=1 means Listen only; S=1 means SRQ.	
Tone Burst Receiver NN is delay in ms from signal detected at INPUT to activation of MODULATION OUTPUT	18.NNSP	Service Request Enables a condition to cause a service request. NN is the sum of any combination of the weighted conditions below: 1. Data Ready 2. HP-IB Error 4. Instrument Error 8. Upper Limit 16. Lower Limit	22.NNSP
HP-IB Address Displays HP-IB Address in binary form:	21.0		

Table 3-7. Modulation Analyzer HP-IB Code to Parameter Summary

Program Code	Parameter	Program Code	Parameter
AU	Automatic Operation	M3	ΦM
A1	Automatic Operation	M4	RF Level
CL	Clear	M5	Frequency
C0	Calibration off	P0	FM De-emphasis & Pre-display off
C1	Calibration on	P1	Pre-display on
D1	Peak+	P2	25 μs
D2	Peak−	P3	50 μs
D3	Peak Hold	P4	75 μs
D4	Average (RMS Calibrated)	P5	750 μs
F1	MHz Input Frequency	R0	Ratio off
F2	⇑ kHz	R1	%
F3	⇓ kHz	R2	dB
F4	SPCL	S3	IF Level
F5	SPCL SPCL	S4	Tuned RF Level
HD	⇓ Hz	S5	Frequency Error
HU	⇑ Hz	T0	Free Run
HZ	Hz Input Frequency	T1	Hold
H0	HP Filters off	T2	Trigger Immediate
H1	50 Hz HP Filter on	T3	Trigger With Settling
H2	300 Hz HP Filter on	U1	Peak+
KD	⇓ kHz	U2	Peak−
KU	⇑ kHz	U3	Peak Hold
K1	Clear	U4	Average (RMS Calibrated)
L0	LP Filters off	Z1	Hz Input Frequency
L1	3 kHz LP Filter on	Z2	⇑ Hz
L2	15 kHz LP Filter on	Z3	⇓ Hz
L3	>20 kHz LP Filter on	Z4	SPCL
MZ	MHz Input Frequency	Z5	SPCL SPCL
M1	AM	0–9	0
M2	FM		

Table 3-3. Modulation Analyzer HP-IB Code to Special Function Summary (1 of 2)

Program Code	Special Function		
	Input Attenuation		
1.0SP	Automatic Selection		
1.1SP	0 dB		
1.2SP	10 dB		
1.3SP	20 dB		
1.4SP	30 dB		
1.5SP	40 dB		
1.6SP	50 dB		
	Modulation Range		
2.0SP	Automatic Selection		
	AM (%)	FM* (kHz)	ΦM (rad)
2.1SP	<40	<4	<4
2.2SP	<100	<40	<40
2.3SP	<100	<400	<400
	* 1/10 Range with 750 μs de-emphasis, pre-display		
	IF Frequency and Input High-Pass Filter		
3.0SP	Automatic IF Selection; Filter Out		
	IF (MHz)	Input HP Filter	
3.1SP	0.455	Out	
3.2SP	1.5	Out	
3.3SP	0.455	In	
3.4SP	1.5	In	
	Tune Mode		
4.0SP	Automatic; Low-noise LO		
4.1SP	Automatic; Track		
4.2SP	Manual		
	Audio Peak Detector Time Constant		
5.0SP	Fast		
5.1SP	Slow		
	AM ALC Response Time		
6.0SP	Slow		
6.1SP	Fast		
6.2SP	Open ALC		
	Frequency Resolution		
7.0SP	Automatic Selection		
7.1SP	10 Hz Resolution (f<1 GHz)		
7.2SP	1000 Hz Resolution		

Program Code	Special Function
	Error Disable
8.0SP	Automatic Selection
8.1SP	E01 disabled
8.2SP	E02 & E03 disabled
8.3SP	E01, E02 & E03 disabled
8.4SP	E04 disabled
8.5SP	E02 & E04 disabled
8.6SP	E02, E03 & E04 disabled
8.7SP	E01 through E04 disabled
8.8SP	E01 through E04 enabled
9.0SP	Hold Settings
10.0SP	IF Frequency Measurement
	Re-enter Ratio With Previous Reference
11.0SP	Re-enter % Ratio
11.1SP	Re-enter dB Ratio
11.2SP	Read Ratio Reference
11.3SP	Make Ratio Reference Negative
	FM Calibrator
12.0SP	Display Computed Peak FM Deviation
12.1SP	Display Demodulated Peak Residual FM Deviation
12.2SP	Display Demodulated Peak FM Deviation
	AM Calibrator
13.0SP	Display Computed Peak AM Depth
13.1SP	Display Demodulated Peak Residual AM Depth
13.2SP	Display Demodulated Peak AM Depth
	Set Limit
14.0SP	Clear Limits; Turn Off LIMIT Annunciator
14.1SP	Set Lower Limit to Ratio Reference
14.2SP	Set Upper Limit to Ratio Reference
14.3SP	Restore Lower Limit
14.4SP	Restore Upper Limit
14.5SP	Read Lower Limit
14.6SP	Read Upper Limit
14.7SP	Read Lower Limit Measurement Code
14.8SP	Read Upper Limit Measurement Code

***Table 3-8.** Modulation Analyzer HP-IB Code to Special Function Summary (2 of 2)*

Program Code	Special Function	Program Code	Special Function
 15.0SP	Time Base Oven (Opt. 002) Display E12 if Oven Cold	21.0SP	HP-IB Address Displays HP-IB Address in binary form: AAAAA.TLS AAAAA = address; T = means talk only; L = means listen only; S = means SRQ.
 16.0SP 16.1SP 16.2SP	AM Calibration (Opt. 010) Disable AM Calibration Factor Enable AM Calibration Factor Read AM Calibration Factor (0 if disabled)		
 17.0SP 17.1SP 17.2SP	FM Calibration (Opt. 010) Disable FM Calibration Factor Enable FM Calibration Factor Read FM Calibration Factor (0 if disabled)	22.NNSP	Service Request Enables a condition to cause a service request. NN is the sum of any combination of the weighted conditions below: 1. Data Ready 2. HP-IB Error 4. Instrument Error 8. Upper Limit 8. Lower Limit
18.NNSP	Tone Burst Receiver NN is delay in ms from signal detected at INPUT and activation of MODULATION OUTPUT.		

Table 3-9. Commonly Used Code Conversions

ASCII	Binary	Octal	Decimal	Hexa-decimal
NUL	00 000 000	000	0	00
SOH	00 000 001	001	1	01
STX	00 000 010	002	2	02
ETX	00 000 011	003	3	03
EOT	00 000 100	004	4	04
ENQ	00000101	005	5	05
ACK	00000110	006	6	06
BEL	00 000 111	007	7	07
BS	00 001 000	010	8	0a
HT	00 001 001	011	9	09
LF	00 001 010	012	10	0A
VT	00 001011	013	11	0B
FF	00 001 100	014	12	oc
CR	00 001101	015	13	0D
SO	00 001110	016	14	0E
SI	00 001111	017	15	0F
DLE	00010000	020	16	10
DC1	00 010 001	021	17	11
DC2	00010010	022	18	12
DC3	00010011	023	19	13
DC4	00 010 100	024	20	14
NAK	00010101	025	21	15
SYN	00 010 110	026	22	16
ETB	00 010 111	027	23	17
CAN	00 011 000	030	24	18
EM	00 011 001	031	25	19
SUB	00 011010	032	26	1A
ESC	00 011011	033	27	1B
FS	00 011 100	034	28	1C
GS	00 011101	035	29	1D
RS	00011110	036	30	1E
US	00 011111	037	31	1F
SP	00 100 000	040	32	20
!	00 100 001	041	33	21
"	00 100 010	042	34	22
#	00 100 011	043	35	23
$	00 100 100	044	36	24
%	00 100 101	045	37	25
&	00 100 110	046	38	26
'	00 100 111	047	39	27
(	00101000	050	40	28
)	00 101 001	051	41	29
*	00 101010	052	42	2A
+	00101011	053	43	2B
,	00 101 100	054	44	2c
-	00 101101	055	45	2D
.	00101 110	056	46	2E
/	00 101111	057	47	2F
0	00 110 000	060	48	30
1	00 110 001	061	49	31
2	00110010	062	50	32
3	00110011	063	51	33
4	00 110 100	064	52	34
5	00110101	065	53	35
6	00110110	066	54	36
7	00110111	067	55	37
8	00 111 000	070	56	38
9	00 111 001	071	57	39
:	00111010	072	58	3A
;	00 111011	073	59	3B
<	00 111 100	074	60	3c
=	00 111101	075	61	3D
>	00111110	076	62	3E
?	00 111111	077	63	3F

ASCII	Binary	Octal	Decimal	Hexa-decimal
@	01 000 000	100	64	40
A	01000001	101	65	41
B	01 000 010	102	66	42
C	01 000011	103	67	43
D	01 000 100	104	68	44
E	01 000 101	105	69	45
F	01000110	106	70	46
G	01000111	107	71	47
H	01 001 000	110	72	48
I	01 001 001	111	73	49
J	01001010	112	74	4A
K	01001011	113	75	4B
L	01 001 100	114	76	4c
M	01 001 101	115	77	4D
N	01001110	116	78	4E
O	01 001 111	117	79	4F
P	01 010 000	120	80	50
Q	01 010 001	121	81	51
R	01 010010	122	82	52
S	01 010011	123	83	53
T	01 010 100	124	84	54
U	01 010101	125	85	55
V	01010110	126	86	56
W	01010111	127	87	57
X	01 011 000	130	88	58
Y	01 011 001	131	89	59
Z	01 011010	132	90	5A
[	01011011	133	91	5B
\	01 011 100	134	92	5C
]	01 011101	135	93	5D
^	01011 110	136	94	5E
_	01011 111	137	95	5F
`	01 100 000	140	96	60
a	01 100 001	141	97	61
b	01 100 010	142	98	62
c	01 100 011	143	99	63
d	01 100 100	144	100	64
e	01 100 101	145	101	65
f	01100110	146	102	66
g	01100111	147	103	67
h	01 101 000	150	104	68
i	01 101 001	151	105	69
j	01 101 010	152	106	6A
k	01 101 011	153	107	6B
l	01 101 100	154	108	6C
m	01 101 101	155	109	6D
n	01101110	156	110	6E
o	01 101111	157	111	6F
p	01110000	160	112	70
q	01 110001	161	113	71
r	01 110010	162	114	72
s	01 110011	163	115	73
t	01 110 100	164	116	74
u	01110101	165	117	75
v	01 110110	166	118	76
w	01 110111	167	119	77
x	01 111 000	170	120	78
y	01 111001	171	121	79
z	01 111 010	172	122	7A
{	01 111 011	173	123	7B
|	01 111 100	174	124	7C
}	01 111101	175	125	7D
~	01111110	176	126	7E
DEL	01111111	177	127	7F

[1]The ASCII code set is used extensively throughout this manual (for example, in the tables of HP-IB Program Codes).

3-6. INTRODUCTION TO THE DETAILED OPERATING INSTRUCTIONS

The Detailed Operating Instructions provide a complete operating reference for the Modulation Analyzer user. As an operating reference, this section contains all relevant information regarding operating the Modulation Analyzer. (If you intend to operate the Modulation Analyzer remotely, the *Remote Operation., Hewlett-Packard Interface Bus* HP-IB section contains information about how the Modulation Analyzer interacts with a controller.)

This section is intended to be a reference document for users. The Detailed Operating Instructions will enable you to use the full capabilities of the Modulation Analyzer.

How To Find Information About a Specific Measurement

Use table 3-10 to find the Detailed Operating Instruction relevant to the measurement you are trying to make.

In each detailed operating instruction you will find the following:

Functions lists all the Modulation Analyzer functions to be discussed that pertain to the measurement.

Description introduces the measurement and any of the listed Functions.

Procedure provides specific instructions about making the measurement.

HP-IB lists all the Hewlett-Packard Interface Bus (HP-IB) codes relevant to making the measurement in remote operation.

Measurement Technique decribes the basic circuitry used to make the measurement. Sometimes, this information can provide an experienced user with a basis for adapting the Modulation Analyzer to varied measurement situations.

Comments provide miscellaneous information that is not essential to the basic measurement but could be valuable to an experienced user attempting to use the Modulation Analyzer in measurement situations not explicitly described in the "Procedure".

Table 3–10. Detailed Operating Instructions Table of Contents (Functional) (1 of 3)

Table 3-10. Detailed Operating Instructions Table of Contents (Functional) (2 of 3)

***Table 3-10. Detailed Operating Instructions Table** of Contents **(Functional) (3** of 3)*

Calibration

Inputs and Outputs

Miscellaneous

AM

DESCRIPTION

The AM key causes the Modulation Analyzer to measure the amplitude modulation depth of the input signal to which the instrument is tuned. In addition, demodulated AM is present at MODULATION OUTPUT and the rear panel AM OUTPUT. (The demodulated AM is present at AM OUTPUT in all measurement modes except RF level. Refer to ***AM Output.*** AM measurements are specified for rates from 20 Hz to 10 kHz for carriers 10 MHz and below (or whenever the 455 kHz IF is used) and from 20 Hz to 100 kHz for carriers from 10 to 1300 MHz (1.5 MHz IF only). The corresponding 3 dB audio bandwidths are 0.5 Hz to 15 kHz for carriers 10 MHz and below (or with the 455 kHz IF) and 0.5 Hz to 260 kHz for carriers from 10 to 1300 MHz (1.5 MHz IF only). Depths to 99% can be measured.

OUTPUT RANGES

Modulation Range				Display Resolution (%)	MODULATION OUTPUT Sensitivity (Vac/% AM)	RECORDER OUTPUT (Rear Panel) (Vdc/peak% AM)
PEAK ± (%)	AVG[1] (%)	Special Function Code	Program Code HP-IB			
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection		
≤ 40	≤ 28	2.1 SPCL	2.1SP	0.01	0.1	0.1
≤ 100	≤ 70.7	2.2 SPCL or 2.3 SPCL	2.2SP or 2.3SP	0.1	0.01	0.01

[1] Values are for sine wave modulation signal only.

PROCEDURE

To make an AM measurement, first tune the instrument to the input signal (refer to ***Tuning*** or press AUTOMATIC OPERATION). Press the AM key, and select an audio detector: PEAR+, PEAR-, or AVG (refer to ***Detectors).*** To limit the demodulated signal bandwidth, press the appropriate filter keys (refer to Filters). If AM depth is to be displayed relative to a reference, refer to ***Ratio.***

EXAMPLE

To measure the positive peak AM depth of a signal in a 50 Hz to 15 kHz demodulated signal bandwidth:

LOCAL (keystrokes)	Measurement: AM — Detector: PEAK + — Filters: 50 Hz, 15 kHz
HP-IB (program codes)	M1D1H1L2 (Measurement, Detector, Filters)

HP-IB PROGRAM CODE

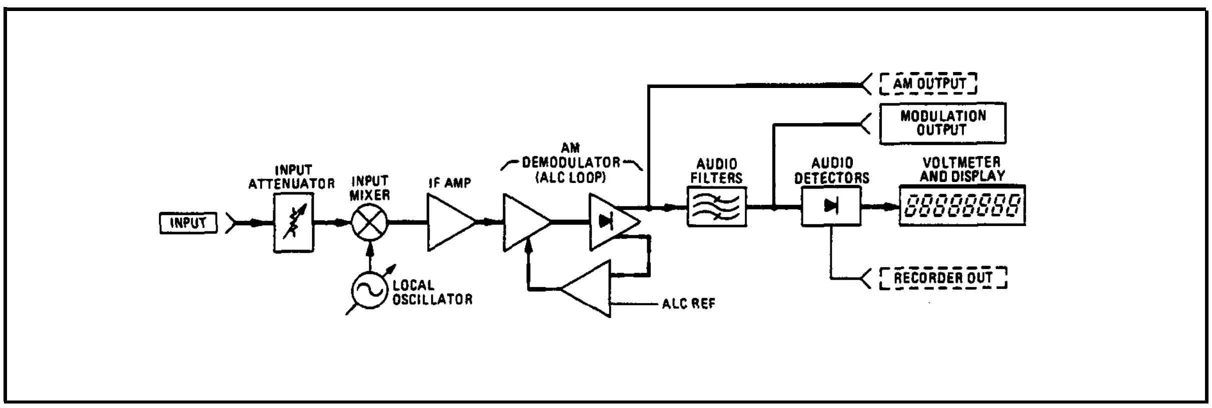
Ml is the HP-IB code for AM.

INDICATIONS

The LEDs within the keys representing the selected functions will light. The % annunciator to the right of the numerical display will light and the display will show the % AM on the carrier.

MEASUREMENT TECHNIQUE

The instrument measures AM as a ratio of the demodulated audio signal level to the average tuned carrier level. An automatic level control (ALC) loop within the demodulator holds the carrier level constant so that the percent AM is proportional to the amplitude of the demodulated audio output. This audio output is then filtered and displayed as % AM.



AM Measurement Block Diagram

COMMENTS

The PEAK+ detector always detects the peak of the carrier envelope while the PEAK− detector always detects the trough.

The routine which automatically selects the modulation range contains a region of overlap between 35 and 40% AM (peak detected). When using the average detector, ranging will occur with lower modulation levels displayed. If the modulation level is reduced from above 40% into this overlap region, only 0.1% resolution may be displayed although 0.01%

resolution is available. To display the increased resolution, press the AM key a second time. To set the instrument to a selected modulation range, refer to ***Modulation Range.***

When operating above 2.5 MHz while using the 455 kHz IF, the modulation bandwidth's upper limit is that of the >20 kHz low-pass filter. Note that the 15 kHz low-pass filter is automatically selected when operating below 10 MHz or whenever the 455 kHz IF is selected. However, this filter may be overridden by selecting the >20 kHz low-pass filter. The modulation bandwidth's lower limit is determined by the ALC response time selected. Refer ***to AM ALC Response Time.***

The signal at AM OUTPUT is inverted for all carrier frequencies.

AM conditions which cause the carrier signal to disappear will cause inaccuracies in measurement of FM, ΦM, or input frequency, or they may cause E05 (FM squelched) to be displayed when these measurements are selected.

RELATED SECTIONS

AM output
AM ALC Response Time
Detectors
Detector, Peak Hold
Filters
Modulation Basics (in section 1)
Modulation Range
Ratio
Residual Noise Effects

AM ALC Response Time

(Special Function 6)

DESCRIPTION

The Modulation Analyzer normally uses a slow-responding AM automatic level control (ALC) circuit, allowing AM rates as low as 20 Hz to pass unaffected by the leveling loop. (Refer *to* the ***AM Measurement Block Diagram)*** in the AM detailed operating instruction. However, a fast ALC response time may be selected to quicken the response to changing carrier levels. Accuracy at AM rates <200 Hz is affected when the faster ALC response is selected. It is possible to disable the ALC entirely.

PROCEDURE

The instrument normally operates with a slow AM ALC response time. To change the response time from slow to fast or vice versa, or to disable the ALC, enter the corresponding Special Function code, then press the SPCL key.

AM ALC	Special Function Code	Program Codes HP-IB
Slow Response	6.0 SPCL	**6.0SP**
Fast Response	6.1 SPCL	**6.1SP**
ALC off	6.2 SPCL	**6.2SP**

EXAMPLE

To enter a fast AM ALC response mode:

LOCAL (keystrokes)	Code: 6 . 1 Function: ● SPCL
HP-IB (program codes)	6.1SP (Code: 6.1, Function: SP)

HP-IB PROGRAM CODE

For HP-IB codes, refer to "PROCEDURE" above.

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Unless Special Function code 6.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

COMMENTS

When the instrument is first turned on or when AUTOMATIC OPERATION is selected, the ALC returns to the slow response mode.

Disabled ALC (Special Function code 6.2) is useful for measuring AM at very low rates using the rear-panel AM OUTPUT. Refer to ***AM Output.***

The display % AM will be incorrect when the ALC is disabled unless the IF level is 100%. Refer to Level, ***IF.***

RELATED SECTIONS

AM
AM Output
Level, IF
Special Functions

AM Output

CAUTION

Do not apply greater than 10 V (pk) (ac+ dc) into the AM OUTPUT jack or damage to the instrument may result.

DESCRIPTION

The rear-panel AM OUTPUT (dc coupled, 10 kΩ output impedance) provides an auxiliary output for the AM demodulated from the signal at INPUT. This output is useful for monitoring AM when displaying FM or ΦM or when the modulation rate is very low. (Use the AM ALC offsetting described under ***AM ALC Response Time.)*** The output signal comprises a dc voltage related to the detected IF level and an ac voltage (bandwidth 16 kHz, one pole) proportional to the AM depth. The dc component contains an offset voltage (V_{off}) which must be subtracted out. The relationship between % AM and the signal levels at AM OUTPUT is:

$$\% AM = \frac{V\,(pk)}{|V\,dc - V_{off}|} \times 100\%$$

where: V (ph) is the peak of the ac component,

$V\,dc$ is the total dc component, and

V_{off} is the dc offset voltage.

When the AM ALC is on, the dc level at AM OUTPUT is held constant, thus,

$$\% AM = K \times v\,(pk),$$

where:

$$K = \frac{100\%}{|V\,dc - V_{off}|}$$

When the AM ALC is turned off, the dc voltage at AM OUTPUT will vary with signal level (although the offset remains constant), and the full formula must be used for each measurement.

PROCEDURE

To measure AM depth with AM OUTPUT, first determine the offset voltage. Press AUTOMATIC OPERATION to clear any Special Functions in effect, then connect a dc voltmeter to the AM OUTPUT jack and remove any signal at INPUT. Press MHz to fix the tuning, and read the offset voltage on the voltmeter. Now disable the AM ALC loop (6.2 SPCL) and apply the carrier to INPUT. Measure the dc and peak ac signals at AM OUTPUT. Use the first equation under "DESCRIPTION" above to compute % AM.

EXAMPLE

To measure AM depth at AM OUTPUT with the AM ALC turned off, measure V_{off} first: Remove any signal at the INPUT and connect a dc voltmeter to AM OUTPUT.

LOCAL (keystrokes)	AUTOMATIC OPERATION MZ MHz INPUT FREQ
HP-IB (program codes)	AUMZ

For this example, assume the voltmeter reads an offset voltage of -0.36 V dc. Connect an AM signal to INPUT and tune the Modulation Analyzer to it. Now disable the AM ALC.

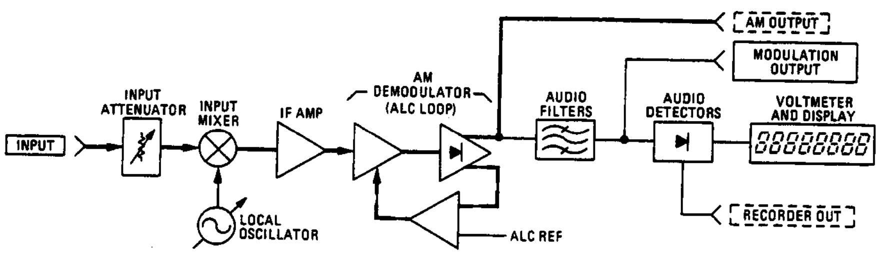
LOCAL (keystrokes)	Code: 6 . 2 Function: • SPCL
HP-IB (program codes)	6.2SP (Code: 6.2; Function: SP)

Measure the dc voltage at AM OUTPUT. (When low AM rates are used, it is easiest to measure the dc voltage at AM OUTPUT before the modulation is applied.) For this example, assume the voltmeter reads -0.46 V dc. Measure the peak ac voltage at AM OUTPUT (for low rates an oscilloscope may be necessary). For this example, assume 0.02 V (pk) was measured on an oscilloscope. The % AM is:

$$\% AM = \frac{V\,(pk) \times 100\%}{|V\,dc - V_{off}|} = \frac{0.02 \times 100\%}{|(-0.46) - (-0.36)|} = 20\%\ AM$$

BLOCK DIAGRAM

A simplified block diagram of the AM demodulation chain illustrating the relationships between AM OUTPUT and various other outputs and circuit blocks is given below.



AM Output Block Diagram

COMMENTS

The AM OUTPUT contains a significant IF component which is greatest when operating at 150 kHz.

When RF LEVEL is selected, 50 dB of input attenuation is inserted. This degrades the accuracy of measurements made on the AM OUTPUT signal.

RELATED SECTIONS

AM
AM ALC Response Time
FM Output

Attenuation, Input

(Special Function 1)

DESCRIPTION

The normally automatically-selected input attenuation can be manually set by keyboard entry using the SPCL key.

PROCEDURE

To set the input attenuation to a selected range, or to re-enter the automatic selection mode, key in the corresponding Special Function code, then press the SPCL key.

Input Attenuation Range	Special Function	Program Code HP-IB
Automatic Selection	1.0 SPCL	1.0SP
0 dB	1.1 SPCL	1.1SP
10 dB	1.2 SPCL	1.2SP
20 dB	1.3 SPCL	1.3SP
30 dB	1.4 SPCL	1.4SP
40 dB	1.5 SPCL	1.5SP
50 dB	1.6 SPCL	1.6SP

EXAMPLE

To set the input attenuation to the 20 dB range:

LOCAL (keystrokes)	Code: 1 . 3 Function: SPCL
HP-IB (program codes)	1.3SP (Code: 1.3, Function: SP)

HP-IB PROGRAM CODE

For HP-IB codes, refer to “PROCEDURE” above.

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Unless Special Function code 1.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

COMMENTS

When the Modulation Analyzer first powered up or when AUTOMATIC OPERATION is selected, the input attenuation is placed in the automatic selection mode.

If the input attenuation is set such that the input signal level causes the input mixer to be overdriven, E02 will be displayed. If the input attenuation is set such that the signal level reaching the circuits is too low for an accurate measurement, E03 will be displayed.

The following table is a guide for manually selecting the appropriate input attenuation for various input signal levels. The values given are approximate only. Typically, conversion loss through the input mixer increases linearly from 150 kHz to 1300 MHz with the higher frequency requiring approximately 5 dB more power for equal performance.

Input attenuation is always 50 dB when RF LEVEL is selected; Special Functions 1.1 to 1.5 are overridden.

Input Signal Level (dBm)		Input Attenuation* (dB)	
150 kHz to 650 MHz	650 to 1300 MHz	FM & ΦM Measurements	Other Measurements
−25 to −16	−20 to −13	0 (1.1 SPCL)	0 (1.1 SPCL)
−16 to −6	−13 to −3	0 (1.1 SPCL)	10 (1.2 SPCL)
−6 to 4	−3 to 7	10 (1.2 SPCL)	20 (1.3 SPCL)
4 to 14	7 to 17	20 (1.3 SPCL)	30 (1.4 SPCL)
14 to 24	17 to 27	30 (1.4 SPCL)	40 (1.5 SPCL)
24 to 30	27 to 30	40 (1.5 SPCL)	50 (1.6 SPCL)

* For measurements other than modulation measurements (except RF LEVEL) use attenuation from either column. RF level overrides manual setting of input attenuation and sets it to 50 dB.

RELATED SECTIONS

Hold Settings
Level, RF
Special Functions

Automatic Operation

DESCRIPTION

The AUTOMATIC OPERATION key configures the Modulation Analyzer to automatically tune to the largest detectable input carrier (refer *to Tuning* for qualifications) and make the measurement selected. MODULATION OUTPUT is blanked while the instrument tunes. AUTOMATIC OPERATION sets Special Functions with prefixes 1 through 8 to their 0-suffix mode, turns off many Special Functions with prefixes greater than 8, and overrides all Service Special Functions (prefixes 0, 40, or greater). AUTOMATIC OPERATION does not affect HP/LP FILTERs, FM DE-EMPHASIS, MEASUREMENT, CALIBRATION DETECTOR, RATIO or Limit settings. The instrument powers up in the Automatic Operation mode.

PROCEDURE

To re-enter the Automatic Operation mode, press the AUTOMATIC OPERATION key. The instrument will immediately re-tune to the input signal and make the measurement selected.

EXAMPLE

To enter automatic operation mode:

LOCAL (keystroke)	AUTOMATIC OPERATION
HP-IB (program codes)	AU

HP-IB PROGRAM CODE

AU is the HP-IB code for AUTOMATIC OPERATION.

INDICATIONS

When AUTOMATIC OPERATION is pressed, the instrument initiates an automatic tuning sequence generally indicated by four dashes on the display. When tuned, the instrument displays the measurement selected and the appropriate key lights will be on. If a MEASUREMENT key light is on, the SPCL key light will be off. If all MEASUREMENT key lights are off, the SPCL key light will be on (the instrument is making a measurement such as IF frequency selected by the SPCL key).

COMMENTS

The AUTOMATIC OPERATION key is the easiest way to make measurements in applications where only a single carrier is present at INPUT. The instrument configures itself to meet the needs of most measurement situations, and all errors preventing inaccurate displays are enabled.

The converse of the Automatic Operation mode is the Hold Settings Special Function (prefixed 9). Refer to ***Hold Settings.***

For maximum sensitivity when making frequency or tuned RF level measurements use manual tuning.

For more information on which Special Functions are turned off by the AUTOMATIC OPERATION key refer to ***Special Functions.***

RELATED SECTIONS

Hold Settings
Special Functions
Tuning

Calibration, AM

(Includes Special Functions 13 and 16)

DESCRIPTION

The internal AM Calibrator (Option 010) provides extremely precise means of determining the instrument's AM measurement accuracy. Taking the measured error into account, AM measurements can be made with an error typically less than 0.5%. The Modulation Analyzer's accuracy is stored in the instrument in the form of a Calibration Factor. If this factor is enabled, the measurement error will automatically be accounted for in the displayed measurement result. The Cal Factor can be enabled or disabled at any time. In addition to self-calibration, instruments with the AM Calibrator may calibrate other HP 8901A Modulation Analyzers not provided with the calibrator option. The procedures for these operations are given below.

PROCEDURES

Self-calibration

To determine the measurement error of the Modulation Analyzer's AM demodulation circuits, first allow at least a half-hour continuous operation before calibration. Connect CALIBRATION OUTPUT to INPUT with a 50Ω cable and select AM. Now press the CALIBRATION key. Pressing the CALIBRATION key automatically configures the tuning, filters, and detectors for the most accurate calibration. After approximately 17 seconds, the AM Calibration factor will be displayed in % and stored. The instrument displays 100.00% if no error is measured. As long as the CALIBRATION key light is on and the cable is connected, calibration continues and the AM Calibration Factor is updated approximately every 17 seconds. To turn off the calibrator, press the CALIBRATION key or any MEASUREMENT key.

NOTE

For optimum accuracy, the instrument should be continuously operating for at least one-half hour before calibration is performed In addition, the first two AM Calibration Factors received after instrument power-up should be discarded even if the instrument is already warm, since the circuits in the audio chain may not be fully charged.

Correcting Measurements with the AM Calibration (Self-calibrated)

Once a Calibration Factor has been determined, the instrument holds that factor internally. This factor may be enabled to automatically correct AM measurements. In addition, it may be disabled or displayed. Select and key in the corresponding Special Function code, then press the SPCL key.

Action	Special Function Code	Program Code HP-IB
Disable AM Calibration Factor	16.0 SPCL	**16.0SP**
Enable AM Calibration Factor	16.1 SPCL	**16.1SP**
Read AM Calibration Factor (Reads 0 if not enabled)	16.2 SPCL	**16.2SP**

Calibrating Another HP 8901A Modulation Analyzer

By duplicating the Modulation Analyzer's internal calibration process step by step with another Modulation Analyzer that does not have an internal calibrator, an AM Calibration Factor can be computed for that instrument. First, connect the CALIBRATION OUTPUT of the instrument with Option 010 (Modulation Analyzer A) to the INPUT of the other instrument (Modulation Analyzer B). Then perform the following:

1. Key 13.0 SPCL into Modulation Analyzer A. Note the reading on the display. This is the computed calibrator peak AM depth excluding noise.
2. Key 13.1 SPCL into both instruments. Note the reading on the display on Modulation Analyzer B. (If display jitter makes readings difficult, key in 5.1 SPCL.) This is the weighted peak residual AM depth of the calibrator's unmodulated output as demodulated by Modulation Analyzer B.
3. Key 13.2 SPCL into both instruments. Note the reading on the display of Modulation Analyzer B. (If display jitter makes readings difficult, key in 5.1 SPCL.) This is the demodulated positive peak AM depth of the calibrator's modulated output.
4. On Modulation Analyzer B, press PEAK-. Note the reading on the display of Modulation Analyzer B. If the difference between the readings of steps 3 and 4 is $\leq$ 3 counts in the least-significant digit, an average between the two need not be computed, use the reading from step 3. If the difference between the two readings is > 3 counts in the least-significant digit, compute the average as follows:

$$(13.2\ reading) = \frac{(\text{reading } of\ step\ 3) + 2\ x\ (\text{rending } of\ step\ 4)}{3}$$

5. Compute the AM Calibration Factor of the Modulation Analyzer B as follows:

$$AM\ Calibration\ Factor = \frac{(13.2\ reading) - (13.1\ reading)}{(13.0\ reading)} \times 100\%$$

6. To use this AM Calibration Factor to correct AM measurements made with the Modulation Analyzer B, enter it as a ratio reference and use % RATIO (refer to Ratio.).

The Special Function codes are summarized in the table below:

Function	Special Function Code	Program Code HP-IB
Display computed peak AM	13.0 SPCL	13.0SP
Display demodulated peak residual AM	13.1 SPCL	13.1SP
Display demodulated peak AM	13.2 SPCL	13.2SP

EXAMPLES

Self-Calibration

To determine the AM Calibration Factor, connect CALIBRATION OUTPUT to INPUT. Determine the AM Calibration Factor:

LOCAL (keystrokes)	Measurement: AM [•] CALIBRATION [•]
HP-IB (program codes)	M1C1 (Measurement1, Calibration)

For example, a display of 100.17% means the Modulation Analyzer is reading 0.17% high. This factor is now stored in the instrument.

Correcting Measurements with the AM Cal Factor (Self-Calibrated)

To enable the AM Calibration Factor to correct AM measurements:

LOCAL (keystrokes)	Code: [1] [6] [.] [1] Function: [•] SPCL
HP-IB (program codes)	16.1SP (Code, Function)

Calibrating Another HP 8901A Modulation Analyzer

One Modulation Analyzer (A) is to be used to determine the AM Calibration Factor of another HP 8901A Modulation Analyzer (B). Connect CALIBRATION OUTPUT of Modulation Analyzer A to INPUT of Modulation Analyzer B. Determine the computed peak AM depth of Modulation Analyzer A's calibrator.

On Modulation Analyzer A:

LOCAL (keystrokes)	Code: 1 3 . 0 Function: • SPCL
HP-IB (program codes)	13.0SP (Code: 13.0, Function: SP)

Read the computed peak AM depth of the calibrator on the display of Modulation Analyzer A, for example, 33.373%. Now, determine the demodulated peak residual AM.

On both Modulation Analyzers:

LOCAL (keystrokes)	Code: 1 3 . 1 Function: • SPCL
HP-IB (program codes)	13.1SP (Code: 13.1, Function: SP)

Read the peak residual AM on Modulation Analyzer B's display, for example, 0.132%. (If display jitter makes readings difficult, key in 5.1 SPCL.) Now determine the demodulated positive peak AM depth of the calibrator.

On both Modulation Analyzers:

LOCAL (keystrokes)	Code: 1 3 . 2 Function: • SPCL
HP-IB (program codes)	13.2SP (Code: 13.2, Function: SP)

Read the demodulated positive peak AM depth of the calibrator on the display of Modulation Analyzer B, for example, 33.544%. Note that the 40% AM range is used but an extra digit of accuracy is given. (If display jitter makes readings difficult, key in 5.1 SPCL.)

Now press PEAR- on Modulation Analyzer B and note the next reading on its display, for example, 33.598%. Since the difference between the readings with PEAR+ and PEAK– detectors is greater than 3 counts, compute the average (13.2 reading) as follows:

$$(13.2\ \textit{reading}) = \frac{(\textit{PEAK} + \textit{reading}) + 2 \times (\textit{PEAK} - \textit{reading})}{3} =$$

$$\frac{(33.544) + 2 \times (33.598)}{3} = 33.580\%.$$

Compute the AM Calibration Factor on Modulation Analyzer B as follows:

$$\frac{(13.2\ \text{reading}) - (13.1\ \textit{reading})}{(13.0\ \textit{reading})} \times 100\% = \frac{33.580 - 0.132}{33.378} \times 100\% = 100.21\%$$

HP-IB PROGRAM CODES

The HP-IB codes for enabling, disabling, or reading the AM Calibration Factor are given above under “PROCEDURES”: Correcting Measurements with the AM Calibration Factor. The HP-IB codes for the AM Calibrator Special Function used to calibrate another instrument are given above under “PROCEDURES”: Calibrating Another HP 8901A Modulation Analyzer. Codes for the CALIBRATION key, the AM key, and the SPCL key are given below.

Key	Program Code HP-IB
CALIBRATION on	C1
CALIBRATION off	C0
AM	M1
SPCL	SP

INDICATIONS

Self-Calibration

During self-calibration, the lights within the AM key and the CALIBRATION key are on. The filter, de-emphasis, ratio and detector keys are all disabled. When the CALIBRATION key is pressed, approximately 17 seconds pass during which the instrument configures itself and tunes to the calibrator’s signal. During this period, four dashes (– – – –) are displayed and the % annunciator lights. Once the AM Calibration Factor has been computed, it is displayed. Subsequent updates occur approximately every 17 seconds.

Correcting Measurements with the AM Calibration Factor (Self-Calibrated)

As the numeric Special Function code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display will return to showing the measurement selected unless the Read AM Calibration Factor function is selected. If this function is selected and the AM Calibration Factor is enabled, the display will show the AM Calibration Factor, and the SPCL key will light. All annunciators and other key lights will turn off. The display will time out in about 2 seconds, returning to the previous display. When reading the AM Calibration Factor (16.2 SPCL), if the factor is not enabled, the display shows a zero. If no calibration has been made since power-up, error E21 (invalid key sequence) will be displayed when Special Function 16 is used.

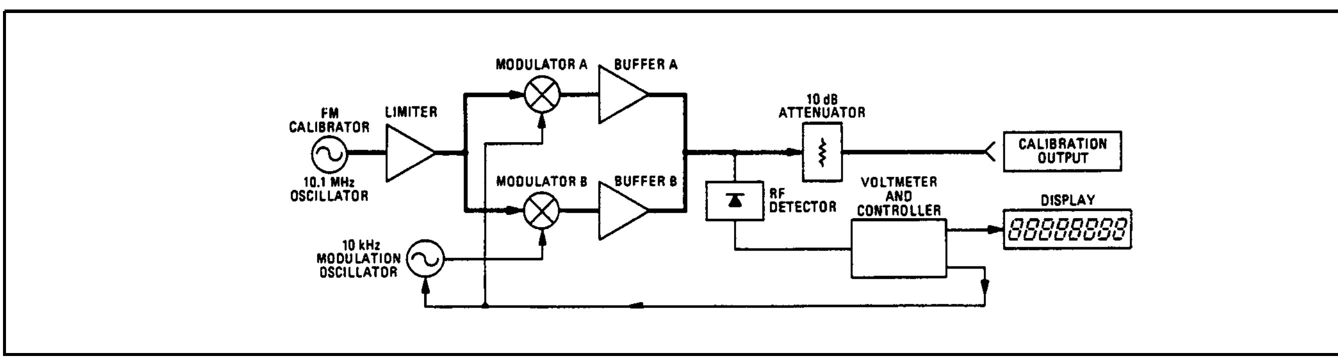
Calibrating Another Modulation Analyzer

As the numeric Special Function codes are entered, they will appear on the front-panel display. The instrument with Option 010 (A) displays the computed AM depth (code 13.0), but shows two dashes (– –) throughout the other measurements. The other instrument (B) displays the demodulated measurements (codes 13.1 and 13.2). During these measurements, no measurement keys will be lighted, but the SPCL and selected DETECTOR keys of both instruments and the CALIBRATION key of the instrument with Option 010 will light.

MEASUREMENT TECHNIQUE

When AM is selected and the CALIBRATION key is pressed, the FM Calibrator sends an unmodulated 10.1 MHz carrier to the AM Calibrator. The AM Calibrator consists of two identical modulators in parallel whose outputs are summed. When the calibration cycle begins, each modulator is turned on individually and the level of its output is measured by an on-board detector to compute AM depth. While one of the modulators is on, the residual AM of the calibrator (very low) and the AM demodulator (more significant) are characterized and weighted (refer to ***Residual*** Noise ***Effects).*** Next, one modulator is left on and the other is toggled on and off at a 10 kHz rate. Since the RF switches between full on and half on, the resultant carrier modulation is very near 33.33%. (The exact depth is derived from the measurements characterizing the individual modulators.) This modulation is then measured by the AM demodulator. (Both peak detectors are used, and the proper average is computed.) The Modulation Analyzer compares the actual AM (static measurements) with the demodulated AM (toggled measurements) and computes its accuracy error as follows:

$$\textit{AM Calibration Factor} = \frac{\textit{Demodulated AM} - \textit{Demodulated Residual AM}}{\textit{Computed AM}} \times 100\%$$



Simplified ***Block*** *Diagram of the* ***AM*** *Calibrator*

COMMENTS

Whenever AM calibration is performed, the AM Calibration Factor stored in the instrument is updated with the new factor.

Pressing the CALIBRATION key cancels all Special Functions.

The modulation waveform of the AM Calibrator is a rounded squarewave. The Modulation Analyzer, which uses it as a calibration standard, must have demodulation and audio-processing circuits which preserve the full fidelity of the waveform.

When Special Functions 13.1 and 13.2 are used to calibrate another HP 8901A Modulation Analyzer, they set the AM modulation range to 0 to 100% (Special Function 2.1). Upon exiting the FM Calibrator Special Function, the modulation ranging is not returned to automatic but remains fixed (thus leaving the SPCL light on).

RELATED FUNCTIONS

AM
Calibration, FM
Ratio
Residual Noise Effects
Special Functions

Calibration, FM

(Special Functions 12 and 17)

DESCRIPTION

The internal FM Calibrator (Option 010) provides an extremely precise means of determining the instrument's FM measurement accuracy. Taking the measured error into account, FM measurements can be made with an error typically less than 0.5%. The Modulation Analyzer's accuracy is stored in the instrument in the form of a Calibration Factor. If this factor is enabled, the measurement error will automatically be accounted for in the displayed measurement result. The Calibration Factor can be enabled or disabled at any time. In addition to self-calibration, instruments with the FM Calibrator, may calibrate other HP 8901A Modulation Analyzers not provided with the calibrator option. The procedures for these operations are given below.

PROCEDURES

Self-Calibration

To determine the measurement error of the Modulation Analyzer's FM demodulation circuits, first allow at least a half-hour continuous operation before calibration. Connect CALIBRATION OUTPUT to INPUT with a 50Ω cable and select FM. Now press the CALIBRATION key. Pressing the CALIBRATION key automatically configures the tuning, filters, and detectors for the most accurate calibration. After approximately 17 seconds, the FM Calibration Factor will be displayed in % and stored. The instrument displays 100.00% if no error is measured. As long as the CALIBRATION key light is on and the cable is connected, calibration continues and the FM Calibration Factor is updated approximately every 17 seconds. To turn off the calibrator, press the CALIBRATION key or any MEASUREMENT key.

NOTE

For optimum accuracy, the instrument should be continuously operating for at least one-half hour before calibration is performed In addition, the first two FM Calibration Factors received after power-up should be discarded even if the instrument is already warm, since the circuits in the audio chain may not be fully charged.

Correcting Measurements with the FM Calibration Factor (Self-calibrated)

Once a calibration factor has been determined, the instrument holds that factor internally. This factor may be enabled to automatically correct FM measurements. In addition, it may be disabled or displayed. Select and key in the corresponding Special Function code, then press the SPCL key.

Action	Special Function Code	Program Code HP-IB
Disable FM Calibration Factor	17.0 SPCL	17.0SP
Enable FM Calibration Factor	17.1 SPCL	17.1SP
Read FM Calibration Factor (Reads 0 if not enabled)	17.2 SPCL	17.2SP

Calibrating Another HP 8901A Modulation Analyzer

By duplicating the Modulation Analyzer's internal calibration process step by step with another Modulation Analyzer that does not have an internal calibrator, an FM Calibration Factor can be computed for that instrument. First, connect the CALIBRATION OUTPUT of the instrument with Option 010 (Modulation Analyzer A) to the INPUT of the other instrument (Modulation Analyzer B). Then perform the following:

1. Key 12.0 SPCL into Modulation Analyzer A. Note the reading on the display. This is the computed calibrator peak FM deviation excluding noise.
2. Key 12.1 SPCL into both instruments. Note the reading on the display on Modulation Analyzer B. (If display jitter makes readings difficult, key in 5.1 SPCL.) This is the weighted peak residual FM deviation of the calibrator's unmodulated output as demodulated by Modulation Analyzer B.
3. Key 12.2 SPCL into both instruments. Note the reading on the display of Modulation Analyzer B. (If display jitter makes readings difficult, key in 5.1 SPCL.) This is the demodulated positive peak FM deviation of the calibrator's modulated output including noise.
4. On Modulation Analyzer B, press PEAK-. Note the reading on the display of Modulation Analyzer B. If the difference between the readings of steps 3 and 4 is ≤ 3 counts in the least-significant digit, an average between the two need not be computed, use the reading from step 3. If the difference between the two readings is >3 counts in the least-significant digit, compute the average as follows:

$$(12.2\ reading) = \frac{(reading\ of\ step\ 3) + (rending\ of\ step\ 4)}{2}$$

5. Compute the FM Calibration Factor of the Modulation Analyzer B as follows:

$$FM\ Calibration\ Factor = \frac{(12.2\ reading) - (12.1\ reading)}{(12.0\ reading)} \times 100\%$$

6. To use this FM Calibration Factor to correct FM measurements made with Modulation Analyzer B, enter it as a ratio reference and use % RATIO (refer to *Ratio.*).

The Special Function codes are summarized in the table below:

Function	Special Function Code	Program Code HP-IB
Display computed peak FM	12.0 SPCL	12.0SP
Display demodulated peak residual FM	12.1 SPCL	12.1SP
Display demodulated peak FM	12.2 SPCL	12.2SP

EXAMPLES

Self-Calibration

To determine the FM Calibration Factor, connect CALIBRATION OUTPUT to INPUT. Determine the FM Calibration Factor:

LOCAL (keystrokes)	Measurement: FM [•] CALIBRATION [E I]
HP-IB (program codes)	M2C1 (Measurement1, Calibration)

For example, a display of 100.17% means the Modulation Analyzer is reading 0.17% high. This factor is now stored in the instrument.

Correcting Measurements with the FM Calibration Factor (Self-Calibrated)

To enable the FM Calibration Factor to correct FM measurements:

LOCAL (keystrokes)	Code: [1] [7] [.] [1] Function: [•] SPCL
HP-IB (program codes)	17.1SP (Code, Function)

Calibrating Another HP 8901 A Modulation Analyzer

One Modulation Analyzer (A) is to be used to determine the FM Calibration Factor of another HP 8901A Modulation Analyzer (B). Connect CALIBRATION OUTPUT of Modulation Analyzer A to INPUT of Modulation Analyzer B. Determine the computed peak FM' deviation of Modulation Analyzer A's calibrator.

On Modulation Analyzer A:

LOCAL (keystrokes)	Code: 1 2 . 0 Function: • SPCL
HP-IB (program codes)	12.0SP (Code: 12.0, Function: SP)

Read the computed peak FM deviation of the calibrator on the display of Modulation Analyzer A, for example, 33.298 kHz. Now, determine the demodulated peak residual FM.

On both Modulation Analyzers:

LOCAL (keystrokes)	Code: 1 2 . 1 Function: • SPCL
HP-IB (program codes)	12.1SP (Code: 12.1, Function: SP)

Read the peak residual FM on Modulation Analyzer B's display, for example, 0.092 kHz. (If display jitter makes readings difficult, key in 5.1 SPCL.) Now determine the demodulated positive peak FM deviation of the calibrator.

On both Modulation Analyzers:

LOCAL (keystrokes)	Code: 1 2 . 2 Function: • SPCL
HP-IB (program codes)	12.2SP (Code: 12.2, Function: SP)

Read the demodulated peak FM deviation of the calibrator on the display of Modulation Analyzer B, for example, 33.453 kHz. (If display jitter makes readings difficult, key in 5.1 SPCL.)

Now press PEAK- on Modulation Analyzer B and note the next reading on its display, for example, 33.459. Since the difference between the readings with PEAK+ and PEAK– readings is greater than 3 counts, compute the average (12.2 reading) as follows:

$$(12.2\ \textit{reading}) = \frac{(\textit{PEAK} + \textit{reading}) + (\textit{PEAK} - \textit{reading})}{2} =$$

$$\frac{(33.453) + (33.459)}{2} = 33\,456$$

Compute the FM Calibration Factor of Modulation Analyzer B as follows:

$$\frac{(12.2\ \text{reading}) - (12.1\ \textit{reading})}{(12.0\ \text{reading})} \times 100\% = \frac{33.456 - 0.092}{33.298} \times 100\% = 100.20\%$$

HP-IB PROGRAM CODES

The HP-IB codes for enabling, disabling, or reading the FM Calibration Factor are given above under "PROCEDURES": Correcting Measurements with the FM Calibration Factor. The HP-IB codes for the FM Calibrator Special Function used to calibrate another instrument are given above under "PROCEDURES": Calibrating Another HP 8901A Modulation Analyzer. Codes for the CALIBRATION key, the FM key, and the SPCL key are given below.

Key	Program Code HP-IB
CALIBRATION on	CI
CALIBRATION off	co
FM	M2
SPCL	SP

INDICATIONS

Self-Calibration

During self-calibration, the lights within the FM key and the CALIBRATION key are all on. The filter, de-emphasis, ratio and detector keys are all disabled. When the CALIBRATION key is pressed, approximately 17 seconds pass during which the instrument configures itself and tunes to the calibrator's signal. During this period, four dashes (– – – –) are displayed and the % annunciator lights. Once the FM Calibration Factor has been computed, it is displayed. Subsequent updates occur approximately every 17 seconds.

Correcting Measurements with the FM Calibration Factor (Self-Calibrated)

As the numeric Special Function code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display will return to showing the measurement selected unless the Read FM Calibration Factor function is selected. If this function is selected and the FM Calibration Factor is enabled, the display will show the FM Calibration Factor, and the SPCL key will light. All annunciators and other key lights will turn off. The display will time-out in about 2 seconds, returning to the previous display. When reading the FM Calibration Factor, if the factor is not enabled, the display shows a zero. If no calibration has been made since power-up, error E21 (invalid key sequence) will be displayed when Special Function 17 is used.

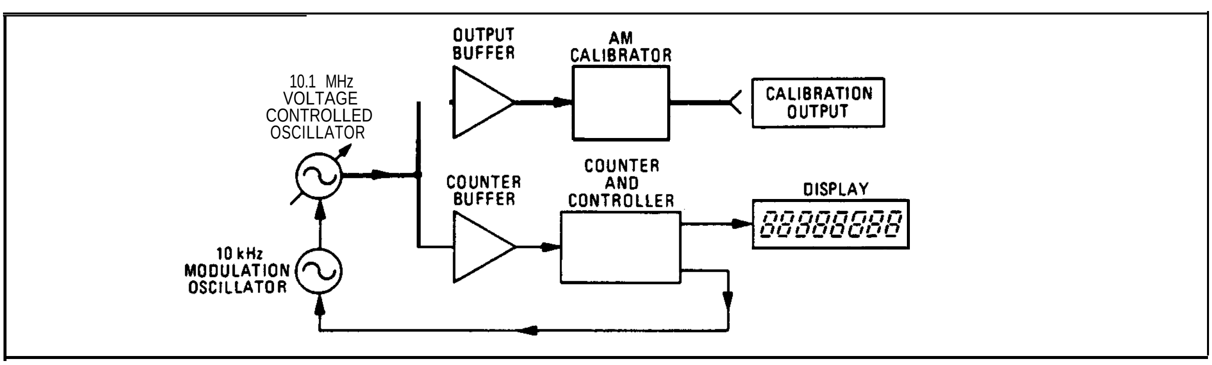
Calibrating Another Modulation Analyzer

As the numeric Special Function codes are entered, they will appear on the front-panel display. The instrument with Option 010 (A) displays the computed FM deviation (code 12.0), but shows two dashes (-- --) throughout the other measurements. The other instrument (B) displays the demodulated measurements (codes 12.1 and 12.2). During these measurements, no measurement keys will be lighted, but the SPCL and selected DETECTOR keys of both instruments and the CALIBRATION key of the instrument with Option 010 will light.

MEASUREMENT TECHNIQUE

When FM is selected and the CALIBRATION key is pressed, a 10.1 MHz voltage controlled oscillator (VCO) within the calibrator is driven to one end of its nominal tuning range. The frequency of the VCO is counted, and then it is driven to the opposite end of its control range. The frequency of the VCO is again counted. From these measurements, the peak FM deviation is computed. While the VCO is at one end of its range, the residual FM of the calibrator (very low) and the FM demodulator (more significant) are characterized and weighted (refer *to Residual Noise Effects).* Next, the VCO is frequency modulated by a 10 kHz modulation oscillator. This modulation is then measured by the FM demodulator. (Both peak detectors are used, and the average is computed.) The Modulation Analyzer compares the deviation computed from the static frequency measurements with the demodulated FM measured when the VCO is modulated and computes the accuracy of its internal FM demodulator as follows:

$$\textit{FM Calibration Factor} = \frac{\textit{Demodulated FM} - \textit{Demodulated Residual FM}}{\textit{Computed FM}} \times 100\%$$



Simplified Block Diagram** of the **FM Calibrator

COMMENTS

Whenever FM calibration is performed, the FM Calibration Factor stored in the instrument is updated with the new factor.

Pressing the CALIBRATION key cancels all Special Functions.

The modulation waveform of the FM Calibrator is a rounded squarewave. The Modulation Analyzer, which uses it as a calibration standard, must have demodulation and audio-processing circuits which preserve the full fidelity of the waveform.

When Special Functions 12.1 and 12.2 are used to calibrate another HP 8901A Modulation Analyzer, they set the FM deviation range to 0 to 40 kHz (Special Function 2.2). Upon exiting the FM Calibrator Special Function, the modulation ranging is not returned to automatic but remains fixed (thus leaving the SPCL light on).

RELATED FUNCTIONS

Calibration, AM
FM
Ratio
Residual Noise Effects
Special Functions

Default Conditions and Power-Up Sequence

DESCRIPTION

When first turned on, the Modulation Analyzer walks through a sequence of internal checks after which the instrument is ready to make measurements. The results of these checks are indicated internally to aid servicing. The power-up sequence is visible to the operator only in that all front-panel indicators are lighted. This allows the operator to determine if any of the LEDs are burned out. After approximately 10 seconds, this sequence is completed. At that time the instrument will be configured as follows:

HP Filter .... All off
LP Filter .... All Off
FM De-emphasis .... Off
Pre-Display .... Off
Calibration (Option 010 only) .... Off
Measurement .... Freq
Detector .... Off[1]
Ratio .... Off
Ratio Reference 0
Limit .... Off
Lower Limit Reference .... 150 kHz
Upper Limit Reference .... 1300 MHz
Limit Measurement Mode .... Frequency
Automatic Operation .... On
Manual Operation .... See below
MHz INPUT FREQ .... Automatic tuning[2]
⇑⇓ kHz (step size) .... 0 kHz
SPCL .... Special Functions[3]
Modulation Output .... FM (Least sensitive range)
Service Request Condition .... HP-IB Error Only (22.2)
Status Byte .... Cleared

[1] Detector will be PEAK+ if a modulation measurement is selected immediately after power-up.

[2] Jf MHz is pressed immediately after power-up, the instrument will tune to 100 MHz.

[3] Special Functions prefixed 1 through 8 in zero-suffix mode; all others off except Service Request Condition.

RELATED SECTIONS

Calibration, AM
Calibration, FM
Tuning

Detectors

DESCRIPTION

The Modulation Analyzer provides two types of audio detectors: peak and average (rms calibrated). (The peak hold function also provided is covered under Detector, Peak *Hold.)* The two peak detector keys select whether the positive peak (PEAK+) or the negative peak (PEAK-) of the demodulated signal is measured. The average detector is calibrated to read rms values with a sine wave input and is suitable for noise and residual measurements. The selected detector at turn on is PEAK+. Once selected, the detector remains unchanged and will be automatically activated each time modulation measurements are made until another detector is selected. The signals at MODULATION OUTPUT or at AM OUTPUT or FM OUTPUT are not affected by the DETECTOR keys.

PROCEDURE

When a modulation measurement is selected, a detector will automatically be activated. To select a different detector, press the appropriate key.

EXAMPLE

To measure negative peak AM modulation:

LOCAL (keystrokes)	Measurement: AM — Detector: PEAK –
HP-IB (program codes)	M1D2 (Measurement2 — Detector)

HP-IB PROGRAM CODES

Key	Program Code HP-IB
PEAK+	D1
PEAK–	D2
AVG (RMS CAL)	D4

INDICATIONS

The LED in the selected DETECTOR key will light.

COMMENTS

The response time of the audio peak detectors can be slowed down; refer to Detector ***(Peak) Time Constant.***

The PEAK+ detector is selected at power-up.

To display measurements made with the AVG (RMS CAL) detector as true average (not rms calibrated), key in 111.07, then press the % RATIO key.

RELATED SECTIONS

Detector, Peak Hold
Detector (Peak) Time Constant
Modulation Output
Ratio
Recorder Output

Detector, Peak Hold

DESCRIPTION

The Modulation Analyzer provides a PEAR HOLD key to be used in conjunction with either of the two audio peak detectors, PEAR+ or PEAK- (refer to ***Detectors.)*** When active, PEAK HOLD causes the Modulation Analyzer to hold and display indefinitely the greatest peak reading (+ or −) made.

PROCEDURE

Peak hold must be used with one of the peak detectors. To initiate peak hold, press the PEAK HOLD key. The instrument will now hold and display the greatest peak reading. To re-initiate a new peak hold cycle, press PEAK HOLD again. The display will now be updated with the new peak. To turn off peak hold, press any DETECTOR key other than the PEAR HOLD key or select a **different MEASUREMENT.**

EXAMPLE

To set up the Modulation Analyzer to measure the modulation transient on the output of a signal generator when the generator's AM switch is turned on:

LOCAL (keystrokes)	Measurement / - - - Detector - AM PEAK+ PEAK HOLD
HP-IB (program codes)	M1D1D3 Measurement2 Detector

HP-IB PROGRAM CODE

D3 is the HP-IB code for PEAK HOLD. (For more HP-IB information on PEAK HOLD, refer to comments below.)

INDICATIONS

When the PEAK HOLD key is pressed, the light within the PEAK HOLD key will turn on. The display will then show the greatest measurement value acquired since the PEAK HOLD key was pressed.

COMMENTS

Since the peak detector circuitry has a limited rise time, narrow one-time peaks may yield PEAK HOLD readings that are slightly low. To prevent errors when measuring narrow peaks, repeat the peak-generating process several times while leaving PEAK HOLD active. This assures the accuracy of the displayed results.

If PEAK HOLD is pressed while the average detector is active, the detector will switch to last peak detector previously selected.

RECORDER OUTPUT is directly linked to the peak detector output and will **also** hold the peak. Its output will deteriorate over a period of time after the signal is removed. The displayed peak, however, is stored in memory and does not deteriorate after the signal is removed.

HP-IB

In remote operation, new peak hold cycles may only be initiated by code D3. Thus, if the instrument is in HP-IB Hold mode (code **T1),** issue code D3 to initiate a peak hold cycle. Although the display cannot be updated when in HP-IB Hold, the peak is captured, stored, and updated Upon leaving HP-IB hold using the triggering codes **(T2** or **T3),** the data output will represent the greatest peak captured since the peak hold cycle was initiated.

RELATED SECTIONS

Detectors
Detector (Peak) Time Constant
Recorder Output

Detector (Peak) Time Constant

(Special Function 5)

DESCRIPTION

The Modulation Analyzer normally makes modulation measurements using a relatively fast-responding audio peak detector. By means of keyboard entry using the SPCL key, the bandwidth of this fast-responding detector's output can be reduced

PROCEDURE

The slow response time (narrower bandwidth setting) is useful in stabilizing peak measurements on unstable or noisy signals or whenever peak-measurement display jitter is considered excessive.

The Modulation Analyzer normally is set for a fast response. To change from fast to slow or slow to fast, enter the corresponding Special Function code, then press the SPCL key.

Peak Detector Time Constant	Special Function Code	Program Codes HP-IB
Fast Response	5.0 SPCL	**5.0SP**
Slow Response	5.1 SPCL	**5.1SP**

EXAMPLE

To enter a slow audio peak-detector response mode:

LOCAL (keystrokes)	Code: 5 . 1 — Function: • SPCL
HP-IB (program codes)	5.1SP (Code: 5.1 — Function: SP)

HP-IB PROGRAM CODES

For HP-IB codes, refer to "PROCEDURE" above.

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Except for Special Function code 5.0, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

COMMENTS

When the instrument is first turned on or when AUTOMATIC OPERATION is selected, the audio peak detector time constant returns to the fast-response mode.

RELATED SECTIONS

Detectors
Detector, Peak Hold
Recorder Output

Error Disable

(Special Function 8)

DESCRIPTION

When the Modulation Analyzer is in AUTOMATIC OPERATION, some measurement safeguards are selectively enabled or disabled in order to allow the broadest range of calibrated measurements to be displayed. Consequently, the quality of the signal at MODULATION OUTPUT is not safeguarded unless the selected modulation type (AM, FM, or ΦM) is being displayed. By entering a Special Function code (8.8), the Modulation Analyzer can be set up as primarily a calibrated receiver. In this mode, all measurement safeguards are always enabled so that not only are displayed results still calibrated but also MODULATION OUTPUT is entirely safeguarded. Thus, if an error message is not displayed, the signal at MODULATION OUTPUT (if present) is calibrated, and measurements (distortion, for example) made on that signal are valid.

The operating modes described above are implemented by disabling or enabling various combinations of the E01 through E04 errors listed below. Most combinations of these errors may be disabled or enabled by the operator allowing the behavior of the instrument to be modified to meet the requirements of the measurement conditions.

Error	Error Message
E01	Signal out of IF range
E02	Input circuits overdriven
E03	Input circuits underdriven
E04	Audio circuits overdriven

Measurement Selected	Errors Disabled When in Automatic Selection Mode (Special Function 8.0)
AM	None
FM	None
ϕM	None
RF LEVEL	E01, E02, E03, E04
FREQ	E02, E03, E04
IF LEVEL	E01, E02, E03, E04
TUNED RF LEVEL	E02, E03, E04
FREQ ERROR	E01, E02, E03, E04
IF FREQUENCY (Special Function 10)	E01, E02, E03. E04

PROCEDURE

To selectively enable or disable the various errors listed under "DESCRIPTION" above, enter the Special Function code corresponding to the condition desired, then press the SPCL key. The codes for the various conditions are listed in the following table:

Error Condition	Special Function Code	Program Code HP-IB
Automatic Selection	8.0 SPCL	**8.0SP**
E01 disabled	8.1 SPCL	**8.1SP**
E02 and E03 disabled	8.2 SPCL	**8.2SP**
E01, E02, and E03 disabled	8.3 SPCL	**8.3SP**
E04 **disabled**	8.4 SPCL	**8.4SP**
E01 and E04 disabled	8.5 SPCL	**8.5SP**
E02, E03, and E04 disabled	8.6 **SPCL**	**8.6SP**
E01, E02, E03, and E04 disabled	8.7 SPCL	**8.7SP**
E01, E02, E03, and **E04** enabled	8.8 SPCL	**8.8SP**

EXAMPLE

To operate the Modulation Analyzer as a calibrated receiver so that the signal at MODULATION OUTPUT is always safeguarded:

LOCAL (keystrokes)	Code: 8 . Function: 8 SPCL
HP-IB (program codes)	8.8SP (Code: 8.8, Function: SP)

HP-IB PROGRAM CODES

For HP-IB codes refer to "PROCEDURE" above.

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display then shows the measurement previously selected (or an error). Unless Special Function code 8.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

COMMENTS

When E04 is disabled, the audio autorange function ranges upward only. Thus, if a transitory peak audio signal is detected, the Modulation Analyzer will increase the audio range to accommodate it but will not down range after it has passed. This prevents audio autoranging from interfering with other measurements such as input frequency.

Errors disabled when in the automatic selection mode may be inadvertantly enabled when a manual mode is selected For example, when measuring frequency (E02 through E04 automatically disabled) if E01 appears, keying in 8.1 SPCL to disable it re-enables E02 through E04. The best selection would really be 8.7 SPCL (E01 through E04 disabled).

Use the Special Display and the Special Special Display (described in ***Special Functions)*** at any time to determine the present mode of the Error Disable Special Function, or the error configuration when the function is in the automatic selection mode.

RELATED SECTIONS

Error Message Summary
Special Functions

Error Message Summary

DESCRIPTION

The instrument generates error messages to indicate operating problems, incorrect keyboard entries, or service-related problems. The error message is generally cleared when the error condition is removed.

Error messages are grouped by error code as follows:

E01 through E19 and E90 through E99

These are Operating Errors which indicate that not all conditions have been met to assure a calibrated measurement. Operating Errors can usually be cleared by a readjustment of front-panel controls (usually, the easiest way is to press AUTOMATIC OPERATION). The Error Disable Special Function (8.N) can be used to selectively disable certain Operating Errors.

E20 through E29

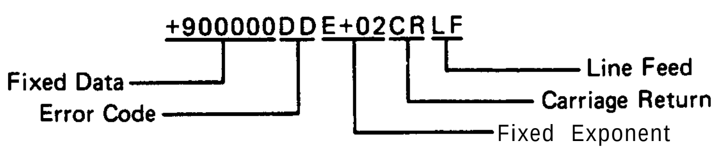
These are Entry Errors which indicate an invalid key sequence or keyboard entry has been made. These errors require that a new keyboard entry or function selection be made.

E30 through E89

These are Service Errors and are generated to give service information or because a service function has been accessed and has generated a message. Service errors do not necessarily represent failures within the instrument and must be enabled to appear. Service Errors are discussed in the Service Manual.

HP-IB OUTPUT FORMAT

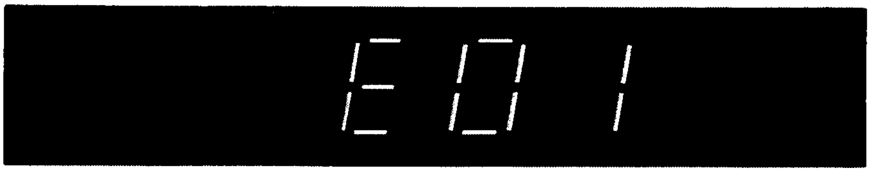
The HP-IB output format for errors is shown below:



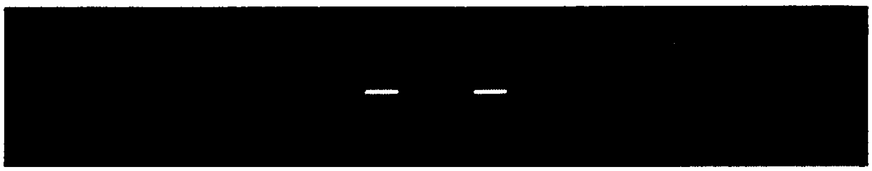
For example, Error E01 is output to the HP-IB as +90000001E+02CRLF. This format differs from normal data outputs since normal data outputs will never exceed 4x 10^9. Once an error has been input to the computing controller, the error code is simply derived by subtracting 9x 10^9 from the input number, then dividing the result by 100.

Error Displays

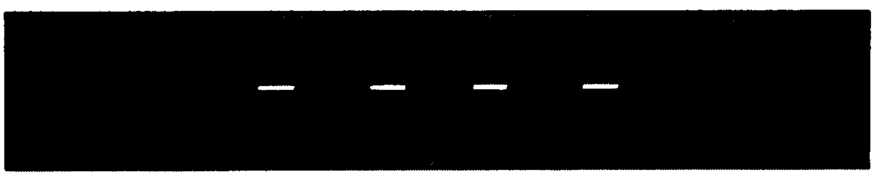
Shown below are three types of error displays. The first is typical of most error displays and is shown as a general case. The second and third have specific meaning and occur often.



The above display exemplifies the general error display format. E means error while the number is the error code. These errors are output to the HP-IB as previously shown under HP-IB Output format.



The display above means that no detectable signal falls within the IF passband. Either no signal is at the input, or the instrument cannot tune to find the applied signal. (For example, it may be manually tuned far enough away from an input signal that no power can be detected in the IF.) This display is output to the HP-IB as E96 using the previously shown HP-IB output format.



This display means that a signal has been detected but for various reasons a measurement result is not yet available. The instrument might be still completing the measurement requested or in some cases, manual settings may prevent a measurement from being completed (for example, frequency measurements made on a low-level input signal with high AM depth, or when the input attenuation is improperly set). This display is never output to the HP-IB, and typically indicates a transitory state in instrument operation.

The following table describes all Operating Errors and Entry errors. The error code, message, and the action typically required to remove the error-causing condition are given. The COMMENTS column that follows provides additional information and references pertaining to particular errors.

Operating Errors			
Error Code	Message	Action Required	Comments
E01	Signal out of IF range.	Retune to signal at input.	1
E02	input circuits overdriven.	Increase input attenuation range or press **AUTOMATIC** OPERATION.	2
E03	Input circuits underdriven.	Decrease input attenuation range or press AUTOMATIC OPERATION.	**3**
E04	Audio **circuits** overdriien.	Increase modulation range or press **AUTOMATIC** OPERATION.	**4**

Comments

1. With 1.5 MHz IF, the IF frequency must be 1.5 MHz **±50 kHz.** With the 455 **kHz** IF, the IF frequency must be 455 MHz **±2.5 kHz.** Refer **to *Tuning.* E01** turns off MODULATION OUTPUT.
2. Refer ***to Attenuation, Input*** for nominal input levels. E02 turns off MODULATION OUTPUT.
3. Refer ***to Attenuation, Input*** for nominal input levels. E03 turns off MODULATION OUTPUT.
4. Attempts to measure modulation levels greater than those specified or improperly set modulation range cause this error. Refer to ***Modulation Range.***

Operating Errors			
Error Code	Message	Action Required	Comments
E05	FM squelched.	Reduce signal level variations (AM) at INPUT.	1
E06	INPUT power protect relay.	Reduce signal level at INPUT; then press any **key.**	2
E07	Display overrange.	Increase range or press AUTOMATIC OPERATION.	3
E08	CALIBRATOR signal not at INPUT (Opt. 010 only).	Connect CALIBRATION OUTPUT to INPUT or turn off Calibrator.	4
E09	Option not installed.	Select another instrument function.	5
E10	Input frequency out of range.	Adjust input frequency to within specified limits.	6
E11	Calculated value out of range.	Enter new RATIO reference.	
E12	Time Base oven cold (Option 002).	For highest accuracy, wait until oven is warm.	8
E96	No input signal sensed by instrument. (HP-IB only).	Increase level of signal at INPUT or decrease input attenuation.	9

Comments

1. E05 often occurs when FM or ΦM measurements are attempted on low-level signals with high AM depth (> 90%). E05 turns off MODULATION OUTPUT.
2. Maximum allowable input level is 7 V rms (1 W peak).
3. If displayed during modulation measurements, increase modulation range. If displayed during level measurements, increase input attenuation.
4. If the connection from CALIBRATION OUTPUT to INPUT is intact, this error may indicate calibrator malfunction.
5. E09 display times out. E09 is not displayed with Special Function 15 and Option 002 not installed. If the option is installed, E09 displayed may reflect option malfunction.
6. E10 turns off MODULATION OUTPUT.
7. In dB RATIO, E11 is displayed when measurement results equal 0. (Log of 0 not allowed.)
8. E12 must be requested by Special Function 15. Refer to ***Special Functions.***
9. E96 corresponds to a display of two dashes (– –). E96 can occur when no signal is applied or when E03 is disabled and the instrument is manually tuned where no signal is found. E96 (– –) turns off MODULATION OUTPUT.

Entry Errors			
Error Code	Message	Action Required	Comments
E20	Entered value out of range.	Reenter new value.	
E21	Invalid key sequence.	Check for compatibility of functions selected.	1
E22	Invalid Special Function prefix.	Check, then reenter correct Special Function code.	2
E23	Invalid Special Function suffix.	Check, then reenter correct Special Function code.	3
E24	Invalid HP-IB code.	Check, then reenter correct HP-IB code.	4
Service Errors			
Error Code	Message	Action Required	Comments
E30 through 89	Service related errors.	Refer to service manual.	5

Comments

1. E21 occurs for example when CALIBRATION is pressed while not in AM or FM. E21 times out.
2. E22 times out. Refer to ***Special Functions.***
3. E23 times out. Refer to ***Special Functions.***
4. This error always causes a Require Service message to be issued on the HP-IB.
5. Service errors are normally disabled.

Filters

DESCRIPTION

The high pass (HP) and low pass (LP) FILTER keys cause the respective filters to be inserted into the path of the demodulated signal ahead of the audio detectors and MODULATION OUTPUT. The high pass and low pass filters, when in use, always affect the signal at MODULATION OUTPUT, but never affect the rear-panel AM or FM OUTPUTs.

PROCEDURE

Select the desired demodulated signal filter by pressing the appropriate keys. Only one high pass and one low pass filter may be in at a time. To turn a filter off, press the key again. To select a different filter, press the key corresponding to the desired filter. HP-IB codes for the various filter keys (shown below) only turn the filters on (defeating others in the group if on). To turn a high pass or low pass filter off using HP-IB, use code HO or LO respectively or select another filter.

EXAMPLE

To select a 50 Hz to 15 kHz demodulated signal bandwidth:

LOCAL (keystrokes)	HP Filter: 50 Hz; LP Filter: 15 kHz
HP-IB (program codes)	H1 L2 (High-Pass Filter H1, Low-Pass Filter L2)

HP-IB PROGRAM CODES

HP FILTER	Program Code HP-IB
ALL OFF	HO
50 Hz	H1
300 Hz	H2

LP FILTER	Program Code HP-IB
ALL OFF	LO
3 kHz	L1
15 kHz	L2
> 20 kHz	L3

INDICATIONS

When a filter is in (by either automatic or manual selection), the LED within that filter's key will light.

COMMENTS

The selected filters are always in the path of the demodulated signal whether or not a modulation measurement has been selected. Thus, unless turned off, the MODULATION OUTPUT is filtered. In addition, the selected filters remain in effect when switching between modulation measurements.

Under certain conditions, filters are inserted automatically. When **ΦM** is selected, the 50 Hz high pass filter is inserted. When the 455 **kHz** IF is used, or when receiving carriers below 2.5 MHz, the 15 **kHz** low pass **filter** is inserted. The 50 Hz high pass filter selected in **ΦM** may be turned off by pressing the key. When automatically inserted, the 15 **kHz** low pass may always be overridden by the 3 **kHz** filter, and **if the** carrier is above 2.5 MHz the 15 **kHz** filter may also be overridden by the > 20 **kHz** filter. When leaving **ΦM,** the 50 Hz high pass filter remains in the signal path until another modulation measurement is selected. The 15 **kHz** low pass selected by operating with 455 **kHz** IF is automatically turned off when the 1.5 MHz IF is used.

With no filters selected, the post-demodulation bandwidth is **<20 Hz** to > 200 **kHz,** however, the IF circuits and demodulators impose more severe bandwidth limits. Refer to ***AM, FM, Frequency, IF, and Input High Pass Filter,*** or ***ΦM*** for bandwidth limitations.

The individual filter characteristics are given below. The 3 **dB** points are typically accurate to **±3%.**

50 Hz High Pass: Two pole Butterworth 1% flat ≥ 200 Hz
300 Hz High Pass: Two pole Butterworth 1% flat ≥ 1 **kHz**
3 **kHz** Low Pass: Five pole Butter-worth 1% flat ≤ 1 **kHz**
15 **kHz** Low Pass: Five pole Chebyshev 1% flat ≤ 10 **kHz**
> 20 **kHz** Low Pass: Nine pole Bessel 1% flat ≤ 10 **kHz** (when used with square wave modulation this filter typically overshoots **<1%).** This **filter's** 3 **dB** point is typically 110 **kHz.**

When the Modulation Analyzer powers up, no filters are inserted.

RELATED SECTIONS

AM
FM
FM De-emphasis
IF Frequency, and Input High Pass Filter Selection
ΦM

FM

DESCRIPTION

The FM key causes the Modulation Analyzer to measure the FM deviation of the input signal to which the instrument is tuned. In addition, demodulated FM is present at MODULATION OUTPUT and the rear panel FM OUTPUT. (The demodulated FM is present at FM OUTPUT in all measurement modes except RF level. Refer to FM *OUTPUT.)* FM Measurements are specified for rates from 20 Hz to 10 kHz for carriers 10 MHz and below (or whenever the 455 kHz IF is used) and 20 Hz to 200 kHz for carriers from 10 to 1300 MHz (1.5 MHz IF only). The corresponding 3 dB audio bandwidths are 0.5 Hz to 15 kHz for carriers 10 MHz and below (or with the 455 kHz IF) and 0.2 Hz to 260 kHz for carriers from 10 to 1300 MHz (1.5 MHz IF only). Peak deviations up to 40 kHz maximum can be measured on carriers below 10 MHz and peak deviations up to 400 kHz maximum can be measured on carriers above 10 MHz.

OUTPUT RANGES

Modulation Range				Display Resolution (Hz)	MODULATION OUTPUT Sensitivity (mV ac/Hz)	RECORDER OUTPUT (Rear Panel) (V dc/kHz peak dev.)
PEAK ± (%) (kHz dev.)	AVG[(1)] (%) (kHz dev.)	Special Function Code	Program Code HP-IB			
Automati Selection		2.0 SPCL	2.0SP	Automatic Selection		
≤0.4[(2)]	≤0.28[(2)]	2.1 SPCL[(2)]	2.1SP	0.1[(2)]	10[(2)]	10[(2)]
≤4	52.8	2.1 SPCL 2.2 SPCL[(2)]	2.1SP 2.2SP[(2)]	1	1	1
≤40	≤28	2.2 SPCL 2.3 SPCL[(2)]	2.2SP 2.3SP[(2)]	10	0.1	0.1
≤400[(3)]	≤280[(3)]	2.3 SPCL[(3)]	2.3SP[(3)]	100[(3)]	0.01[(3)]	0.01[(3)]

(1) Values are for sine wave modulation signal only.
(2) With, 750 microsecond de-emphasis, pre-display only.
(3) Except 750 microsecond de-emphasis, pre-display.

PROCEDURE

To make an FM measurement, first tune the instrument to the input signal (refer to ***Tuning*** or press AUTOMATIC OPERATION). Press the FM key, and select an audio detector: PEAK+, PEAK--, or AVG (refer to Detectors). To limit the demodulated signal bandwidth, press the appropriate filter keys (refer to ***Filters).*** In addition, if de-emphasis filtering is desired, the appropriate time constant and display placement can now be selected (refer to ***FM De-emphasis).*** If FM deviation is to be displayed relative to a reference, refer to ***Ratio.***

EXAMPLE

To measure the positive peak FM deviation in a 50 Hz to 15 kHz demodulation signal bandwidth with a 750 μs de-emphasis time constant placed before the display:

LOCAL (keystrokes)	Measurement: FM · Detector: PEAK + · Filters: 50 Hz, 15 kHz · De-emphasis: PRE-DISPLAY, 750 μs
HP-IB (program codes)	M2D1H1L2P1P5 (Measurement, Detector, Filters, De-emphasis)

HP-IB PROGRAM CODES

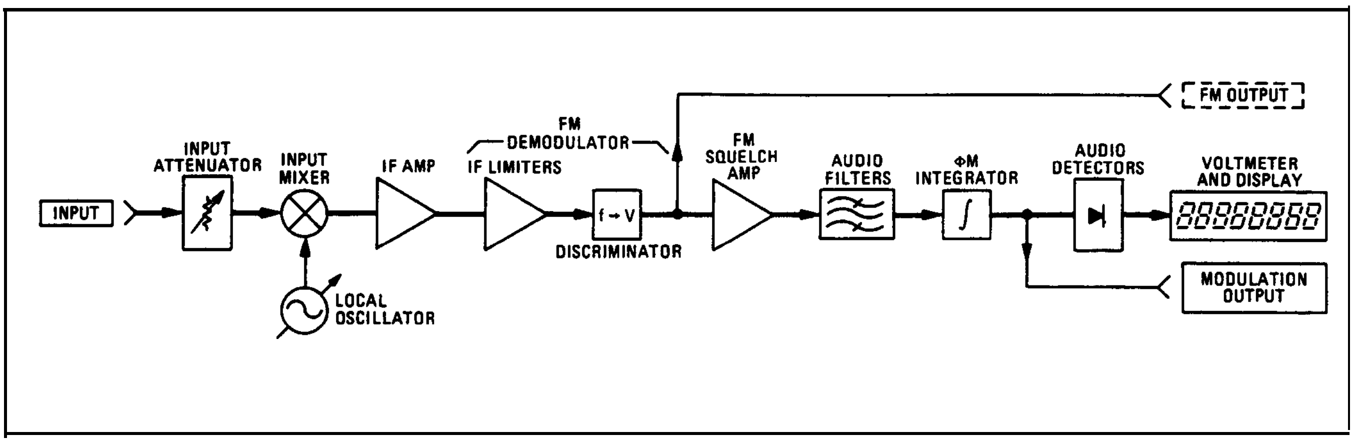
M2 is the HP-IB code for FM.

INDICATIONS

The LEDs within the keys representing the selected functions will light. The kHz annunciator to the right of the numerical display will light and the display will show the kHz deviation on the carrier (or the equivalent de-emphasized deviation).

MEASUREMENT TECHNIQUE

Once the instrument is tuned to the input signal, the FM on the IF is demodulated by a discriminator which produces a signal whose amplitude is proportional to the frequency deviation. The demodulated signal is filtered, detected, and displayed as kHz deviation. The FM de-emphasis filter may be inserted ahead of (PRE-DISPLAY on) or after (PRE-DISPLAY off) the audio detectors (and display).



FM Measurement Block Diagram

COMMENTS

The PEAK+ detector always detects the upward carrier frequency excursion while the PEAK- detector always detects the downward carrier frequency excursion.

When operating with carrier frequencies below 2.5 MHz, the signal at MODULATION OUTPUT is inverted unless the 455 kHz IF is being used. When operating with carrier frequencies above 2.5 MHz or when using the 455 kHz IF, the signal at FM OUTPUT is inverted.

The routine which automatically selects the audio range contains regions of overlap between 0.35 and 0.4 kHz ('750 μs de-emphasis, pre-display only), 3.5 and 4 kHz, and 35 and 40 kHz peak deviation as read on the display. When using the average detector, ranging will occur with lower modulation levels displayed. If the modulation level is reduced from a higher range into an overlap region, the range may not change. To display the increased resolution, press the FM key a second time. To set the instrument to a selected modulation range, refer to ***Modulation Range.***

When the Modulation Analyzer is first powered up, demodulated FM is at MODULATION OUTPUT. The sensitivity is 0.01 V ac/MHz ($\leq$ 400 kHz peak deviation range) and will not autorange to more sensitive ranges. This is because at power-up, FREQ is selected and thus E04 (audio circuits overdriven) is automatically disabled. When E04 is disabled, only autoranging to less sensitive audio ranges is allowed.

AM conditions which cause the carrier signal to disappear will cause inaccuracies in the measurement of FM deviation or they may cause E05 (FM squelched) to be displayed.

RELATED SECTIONS

Detectors
Detector, Peak Hold
Filters
FM De-emphasis
FM Output
Modulation Basics (Section 1-16)
Modulation Range
Ratio
Residual Noise Effects

FM De-emphasis

DESCRIPTION

The de-emphasis filters can be selected to compensate for pre-emphasis on FM signals. Pre-emphasis is a simple 6 dB per octave, high-frequency boost given to the audio signal prior to modulating the carrier. The 3 dB corner frequency, f_o, is commonly expressed as a time constant, τ_o, where $f_o = \frac{1}{(2\pi\tau_o)}$. When selected, the filters are inserted into the audio chain following the modulation filters. They always affect the signal at MODULATION OUTPUT. The audio detector and display may be placed before or after the de-emphasis. De-emphasis has no affect on the rear-panel FM OUTPUT. The 3 dB corners of these filters are typically accurate to ±3% and are given below.

Time Constant (μs)	3dB Frequency (Hz)
25	6366
50	3183
75	2122
750	212.2

PROCEDURE

To de-emphasize the demodulated FM, press the key corresponding to the desired time constant. The deviation will now be measured before de-emphasis is performed. If the deviation measured is to be de-emphasized, press the PRE-DISPLAY key. To change the de-emphasis time constant, press the key corresponding the new time constant desired. In local operation, to turn off one of the de-emphasis functions, press the lighted key a second time. In remote operation, turn filters off by code PO. However, note that code PO also turns off the PRE-DISPLAY-function.

EXAMPLE

To measure the positive peak FM deviation of a carrier with 750 μs de-emphasis inserted before the deviation measurement:

	Measurement	Detector	De-emphasis	
LOCAL (keystrokes)	FM	PEAK +	PRE-DISPLAY	750 μs
HP-IB (program codes)	M2	D1	P1	P5

HP-IB PROGRAM CODES

FM DE-EMPHASIS		
lime Constant (μs)	PRE-DISPLAY on	PRE-DISPLAY off
Filters off	POP1	PO
25	P1P2	POP2
50	P1P3	POP3
75	P1P4	POP4
750	P1P5	POP5

INDICATIONS

When a de-emphasis filter is in and affecting the signal at MODULATION OUTPUT, the LED within that filter's key will light. If de-emphasis affects the displayed measurement, the light within the PRE-DISPLAY key will light.

COMMENTS

Until they are turned off, the de-emphasis filters will always be active whenever demodulated FM is present at MODULATION OUTPUT.

When 750 μs de-emphasis pre-display is selected, the range of deviation measurements is restricted to 40 kHz peak deviation or less after de-emphasis. However, an additional range (0 to 0.4 kHz) is added for greater resolution when measuring very small deviations.

RELATED SECTIONS

FM
Modulation Output
Recorder Output

FM Output

CAUTION

Do not apply greater than 10 V peak (ac + dc. into the FM OUTPUT jack or damage to the instrument may result.

DESCRIPTION

The rear-panel FM OUTPUT (dc-coupled, 10 kΩ output impedance) provides an auxiliary output for the FM demodulated from the signal at the INPUT. This output is useful for monitoring FM while displaying AM or ΦM or when the modulation rate is very low. The output signal comprises a dc voltage related to the detected IF frequency and an ac voltage (bandwidth 16 kHz, one pole) proportional to the FM deviation. With the input signal centered in the IF, the nominal dc offset voltage at FM OUTPUT is approximately 0.8 V dc for the 1.5 MHz IF and -5.6 V dc for the 455 kHz IF. The FM sensitivity is typically 6 V/MHz or 6 mV/kHz. The dc voltage at FM OUTPUT can be calculated as follows:

$$V\ dc = V_{off} - \frac{(K)\ (FREQ\ ERROR)}{1000}$$

where:

$V\ dc$ = the dc voltage at FM OUTPUT in volts,

V_{off} = the dc offset voltage for the IF used in volts,

K = the FM sensitivity in mV/kHz,

and

$FREQ\ ERROR$ = the kHz error displayed when FREQ ERROR is selected.

Measure V_{off} when the frequency error is 0 kHz. The sensitivity can be measured using the following procedure:

PROCEDURE

To characterize the FM sensitivity at the FM OUTPUT, measure the dc voltage at the output with an unmodulated 2 MHz carrier at the INPUT (use the 1.5 MHz IF). Move the carrier to 1 MHz and again note the dc voltage. The sensitivity is:

$$(V\ dc\ @2\ MHz) - (V\ dc\ @1\ MHz) = V/MHz = mV/kHz$$

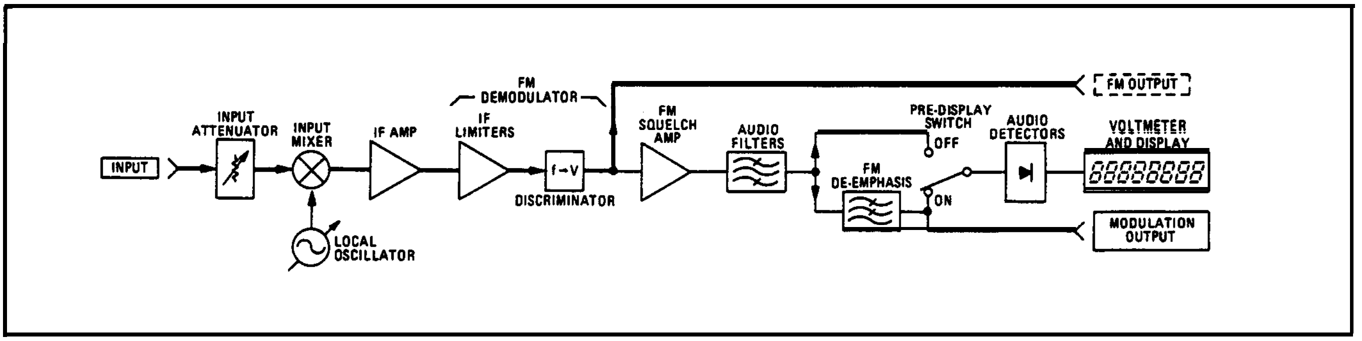
EXAMPLE

A 2 MHz unmodulated signal is applied to the INPUT. A dc voltmeter connected to FM OUTPUT shows +3.89 V dc. When the carrier is set to 1 MHz, -2.272 V dc is read. The FM sensitivity is:

$$(3.890) - (-2.272) = 6.161\ V/MHz = 6.162\ mV/kHz$$

BLOCK DIAGRAM

A simplified block diagram of the FM demodulation chain illustrating the relationships between FM OUTPUT and various other outputs and circuit blocks is given below.



FM Output Block Diagram

COMMENTS

FM OUTPUT is unsquelched and also contains a significant IF component which is greatest when operating at 150 kHz.

Note that the sense of the ac output component (corresponding to the demodulated FM) is inverted for carriers with frequencies above 2.5 MHz.

When RF Level is selected, 50 dB of input attenuation is inserted. This degrades the accuracy of measurements made on the FM OUTPUT signal.

RELATED SECTIONS

AM output
FM
Frequency Error

Frequency Error

DESCRIPTION

The FREQ ERROR key causes the Modulation Analyzer to measure the difference (in kHz) between the input signal frequency and the frequency to which the instrument is tuned This function can be used either to observe frequency drift of input signals or to compare input frequencies against a keyboard-entered reference. The input frequency must fall within the passband of the IF being used. For the 1.5 MHz IF, the passband is approximately 3 MHz wide. For the 455 kHz IF, the passband is approximately 200 kHz wide. When the instrument is measuring frequency error, the signal at MODULATION OUTPUT represents the last modulation measurement made.

PROCEDURE

To make a frequency error measurement, apply the test signal to the Modulation Analyzer's INPUT jack. If a frequency drift measurement is to be made, allow the instrument to automatically tune to the signal, then press MHz to prevent retuning. Now, press the FREQ ERROR key, and the frequency drift will be displayed. If a frequency comparison is to be made, enter the reference frequency (in MHz) on the keyboard, then press the MHz key. The difference frequency will be displayed. The number is negative if the signal frequency is lower than the reference, and positive if the signal frequency is higher than the reference.

EXAMPLE

To measure the error of an oscillator designed to operate at 30 MHz, connect the oscillator's output to the Modulation Analyzer's INPUT jack.

LOCAL (keystrokes)	Measurement: [•] [FREQ ERROR] (S) — Data: [3] [0] — Function: [MHz] (INPUT FREQ) (MZ)
HP-IB (program codes)	S5 30 MZ — Measurement: S5, Data: 30, Function: MZ

HP-IB PROGRAM CODE

S5 is the HP-IB code for FREQ ERROR.

INDICATIONS

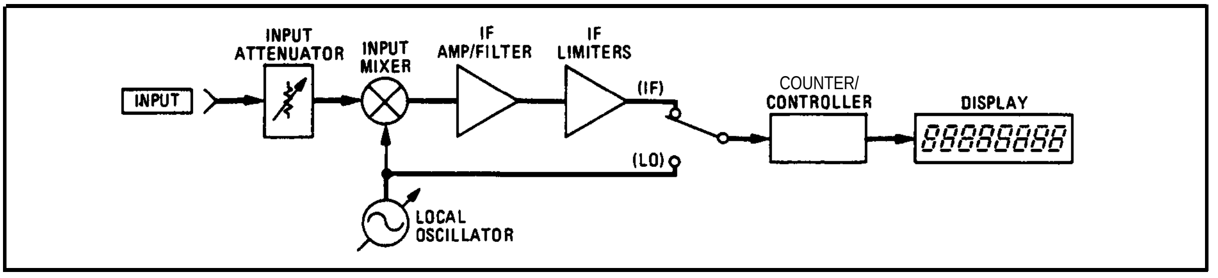
When FREQ ERROR is selected, the LEDs within the S(shift) and FREQ ERROR keys will light, and the kHz annunciator will also light. The display will show the frequency error in kHz.

MEASUREMENT TECHNIQUE

When the Modulation Analyzer is tuned, the IF signal is amplified and limited (> 60 dB of gain). If manually tuned, the input frequency is determined (refer *to Frequency [Input])* and compared to the keyboard-entered frequency or to the frequency the moment MHz was pressed. The difference is displayed as frequency error.

If the instrument is automatically tuned, two methods of determining frequency error are used. Above 2.5 MHz (that is, when down-converting) the frequency of the actual IF signal is subtracted from the selected IF frequency (455 kHz or 1.5 MHz) yielding the frequency error.

Below 2.5 MHz, the input signal is passed directly into the IF without down-conversion. When the signal is first located, the tiequency is counted. When the frequency error is selected, this first-counted frequency becomes the reference. Subsequent frequency counts are subtracted from this reference, and the results are displayed as frequency error.



RF Frequency Error Measurement Block Diagram

COMMENTS

The frequency error function can be used with the automatic tuning low-noise LO tune mode, but it is most valuable when used with manual tuning. It is not recommended that frequency error be used when in automatic tuning track mode since an inherent tuning error exists in this mode.

Frequency Error, in conjunction with the kHz (⇑) and kHz (⇓) keys, is most useful for checking channel accuracy on multichannel transmitters. By setting the step frequency to the channel spacing, the accuracy of evenly spaced channels may be rapidly determined.

When tuning manually, it is possible to adjust the LO so that the input falls in the image passband. This can occur, for example, when the kHz (⇑) or kHz (⇓) keys are used. Frequency error measurements made when this occurs will be inaccurate. Refer to ***Tuning*** for an illustration of the image passbands.

Normally, the counter updates the display five times each second. For selection of other resolutions, refer to ***Frequency Resolution.*** Counter accuracy is the reference accuracy ±3 counts.

When the FREQ ERROR key is pressed, MODULATION OUTPUT continues to produce the last-selected modulation signal, filtered and/or de-emphasized (except PRE-DISPLAY) as previously selected. The calibration of MODULATION OUTPUT depends upon the input signal level and should be assumed only when all errors are enabled (Special Function 8.8).

To display frequency error in parts per million, first display the frequency error, then enter 1/10 the reference frequency (in MHz) as a ratio reference, and press the % RATIO key. The display will now show the frequency error in parts per million.

RELATED SECTIONS

Error Disable
Frequency, IF
Frequency, Input
Frequency Resolution
Tuning

Frequency, IF

(Special Function 10)

DESCRIPTION

Using the numeric keyboard and the SPCL key, the Modulation Analyzer can be set to display the frequency, in MHz, of the signal present in its IF. When the instrument is measuring IF frequency, the signal at MODULATION OUTPUT represents the last modulation measurement made.

PROCEDURE

To measure the IF signal **frequency,** enter the code 10.0 using the numeric keys, then press the SPCL key.

EXAMPLE

To display the frequency of the signal in the IF:

LOCAL (keystrokes)	Code Function 1 0 . 0 • SPCL
HP-IB (program codes)	10.0SP Code Function

HP-IB PROGRAM CODE

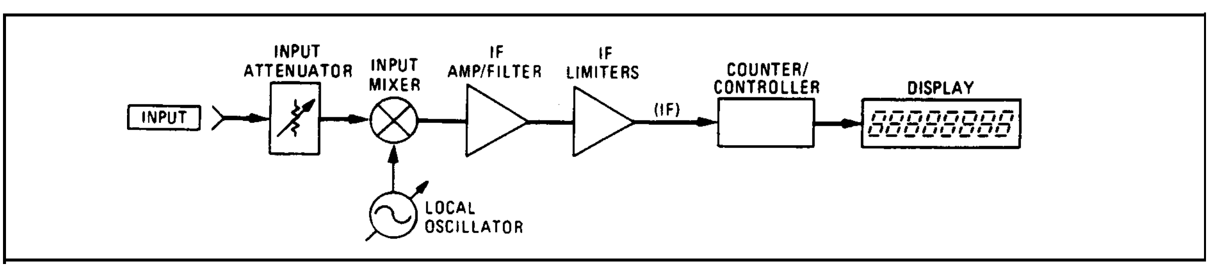
10.0 is the HP-IB code to measure IF frequency.

INDICATIONS

All measurement key lights will turn off, the LED within the SPCL key will light, and the MHz annunciator to the right of the display will turn on. The display will show the IF frequency in MHz.

MEASUREMENT TECHNIQUE

The IF signal, created when the Local Oscillator and the input signal mix, is amplified by the IF Amplifier and FM Limiters. (Below 2.5 MHz no down-conversion is made and the input signal is passed directly into the IF.) The frequency of this IF signal is counted and displayed.



IF Frequency Measurement Block Diagram

COMMENTS

Normally, the counter updates the display five times each second. For selection of other resolutions refer to ***Frequency Resolution.*** Note that counter accuracy is the reference accuracy ±3 counts.

When measuring IF frequency, MODULATION OUTPUT continues to produce the last selected modulation signal, filtered and/or de-emphasized (except PRE-DISPLAY) as previously selected. The calibration of MODULATION OUTPUT depends upon the IF signal level and should be assumed only when all errors are enabled (Special Function 8.8).

RELATED SECTIONS

Error Disable
Frequency (Input)
Frequency Resolution
Special Functions

Frequency (Input)

DESCRIPTION

The frequency of the signal at the input of the Modulation Analyzer can be measured by pressing the FREQ key. The signal frequency must fall between 150 kHz and 1300 MHz and the Modulation Analyzer must be tuned. For input frequencies between 2.5 and 1300 MHz, the instrument is a heterodyne counter; for frequencies from 150 kHz to 2.5 MHz it counts the input directly. If manually tuned to the signal, the instrument can typically count signals with power levels less than -60 dBm. When the instrument is measuring input frequency, the signal at MODULATION OUTPUT represents the last modulation measurement made.

PROCEDURE

To make an input frequency measurement, first tune the instrument to the input signal (refer ***to Tuning*** or press AUTOMATIC OPERATION). Press the FREQ key. Manual tuning will be necessary when measuring low-level signals (inputs < -25 dBm from 150 kHz to *650* MHz or < -20 dBm from 650 to 1300 MHz).

EXAMPLE

To measure the frequency at INPUT:

LOCAL (keystroke)	FREQ
HP-IB (program codes)	M5 Measurement

HP-IB PROGRAM CODE

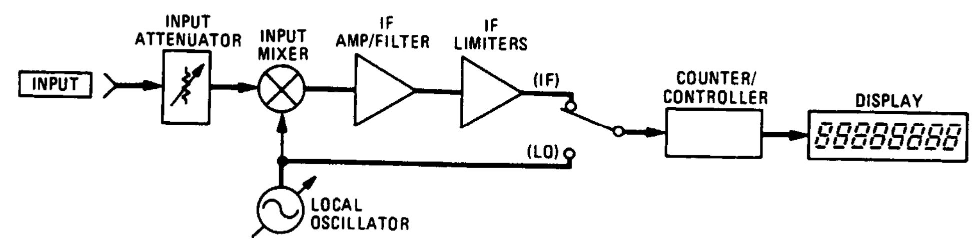
M5 is the HP-IB code for FREQ.

INDICATIONS

The LEDs within the FREQ key and the MHz annunciator to the right of the numeric display will light. The display will show the input frequency in MHz.

MEASUREMENT TECHNIQUE

Once the instrument is tuned, the IF carrier is amplified by the IF Amplifier and Limiters (> 60 dB of gain). (For input frequencies below 2.5 MHz, no down-conversion is made and the input signal acts as the IF. Refer to *Tuning* for an exception.) The frequency of the IF signal is counted. If the input was down-converted, the IF frequency is then subtracted from the local oscillator frequency to derive the frequency at INPUT.



RF Input Frequency Measurement Block Diagram

COMMENTS

The Modulation Analyzer powers up measuring the input frequency.

When the Error Disable Special Function is in the automatic selection mode (code 8.0), very low-level signals can be counted without generating errors (E03 for example).

However, other modes of this Special Function will allow errors to be generated at much higher signal levels. Refer to ***Error Disable.***

It is important to note that when FREQ is selected the IF need not be exactly centered to make valid frequency measurements. A frequency is displayed as long as a signal is present in the IF. Using the ⇑ **kHz** or ⇓ **kHz** functions will not change the displayed input frequency even though tuning has been altered. The FREQ ERROR function will demonstrate the changed tuning. Typically, the instrument must be tuned within 50 kHz of the input frequency or E01 will be displayed. Use Special Function 8.1 to defeat the tuning error (E01) and to increase the usable IF bandwidth.

Whenever signals below 2.5 MHz are tuned to using the 1.5 MHz IF, the LO is placed at 101.5 MHz and the input signal is allowed to pass directly into the 1.5 MHz IF. (The LO serves only to turn the mixer on.) Note, however, that this also creates a passband from 98.5 to 104.5 MHz. If this is a problem, manually tune the LO so the passbands fall in some unoccupied region of the input spectrum. This requires that error E01 must be disabled. Also, as a result, input frequency measurements will be incorrect, but the IF frequency function (Special Function 10) can be used to measure the input frequency instead.

When working with agile frequency sources (such as frequency synthesizers), it is possible for the carrier to hop to a frequency whose spectrum still has sufficient power within the tuned passband of the Modulation Analyzer's input. When this occurs, the Modulation Analyzer may not retune (if in an automatic tune mode) since it appears that the carrier simply dropped in power. If the instrument does not retune, frequency and power measurement results may not be as expected. Use the manual tune mode if possible when working with frequency agile sources.

When tuning manually, it is possible to adjust the LO so that the input signal falls into the image passband. This can occur, for example, when using the ⇑ kHz or ⇓ kHz keys. Frequency measurements made when this occurs will be inaccurate. Refer to *Tuning* for an illustration of the image passbands.

The large gain in the IF Amplifier and Limiters makes frequency measurements on input signal levels less than --60 dBm typical. When automatically tuning, the instrument will always tune to the most powerful signal at the input. However, if the approximate frequency is known, manual tuning will cause more powerful signals to be ignored if they fall outside the bandwidth of the IF amplifier. (Images may also appear within this bandwidth.)

When the FREQ key is pressed, MODULATION OUTPUT continues to produce the last selected modulation signal, filtered, and/or de-emphasized (except PRE-DISPLAY) as previously selected. The calibration of MODULATION OUTPUT depends upon the IF signal level and should be assumed only when all errors are enabled (Special Function 8.0).

RELATED SECTIONS

Error Disable
Frequency Error
Frequency, IF
Frequency Resolution
Ratio

Frequency Resolution

(Special Function 7)

DESCRIPTION

When frequency measurements are made, the Modulation Analyzer normally updates the display five times each second. The resolution is 10 Hz for frequencies below ≈ 18 MHz, 100 Hz from ≈ 19 to ≈ 320 MHz, and 1000 Hz above ≈ 320 MHz. Use the numeric keyboard and the SPCL key to set the frequency resolution to either 10 Hz for frequencies below 1 GHz and 100 Hz for those above 1 GHz or to 1000 Hz for all frequencies. Setting resolution affects input frequency, frequency error, and IF frequency measurements.

PROCEDURE

To set the frequency resolution to a selected range or to re-enter the automatic selection mode, key in the corresponding Special Function code, then press the SPCL key.

Frequency Resolution		Special Function Code	Program Code HP-IB
f < 1 GHz	f ≥ 1 GHz		
Automatic Selection		7.0 SPCL	7.0SP
10 Hz	100 Hz	7.1 SPCL	7.1SP
1000 Hz	1000 Hz	7.2 SPCL	7.2SP

EXAMPLE

To measure frequencies greater than 1 GHz with 100 Hz resolution:

LOCAL (keystrokes)	Code: 7 . 1 Function: • SPCL
HP-IB (program codes)	7.1SP (Code: 7.1, Function: SP)

HP-IB PROGRAM CODES

The HP-IB codes for the various frequency resolution settings are given under "PROCEDURE" above.

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Unless Special Function code 7.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

COMMENTS

The Modulation Analyzer need not be making frequency measurements in order to change resolution modes; however, the resolution mode only affects frequency-related measurements. Counter accuracy is the reference accuracy ±3 counts.

When the Modulation Analyzer is first powered up, or when AUTOMATIC OPERATION is selected, the instrument is placed in the automatic selection mode (code 7.0).

RELATED SECTIONS

Frequency, (Input)
Frequency Error
Frequency, IF
Special Functions

Hold Settings
(Special Function 9)

DESCRIPTION

By keyboard entry using the SPCL key, the Modulation Analyzer ranges can be held. This function is the corollary to the AUTOMATIC OPERATION key and places Special Functions preflxed 1 through 4 and 8 into non-automatic modes. HP and LP FILTERs, FM DE-EMPHASIS, MEASUREMENT, DETECTORS, and RATIO are unaffected. Any of Special Functions prefixed 1 through 8 that are already in manual modes are not affected. The table below summarizes the effect of Hold Settings.

Special Function Prefix	Special Function Description	Effect of Hold Setting Special Function
1	Input Attenuation	Holds Setting
2	Modulation Range	Holds Setting
3	IF Frequency and Input High Pass Filter	Holds Setting
4	Tune Mode	Manual Mode (code 4.2)
5	Audio Peak Detector Time Constant	No Effect
6	AM ALC Response	No Effect
7	Frequency Resolution	No Effect
8	Error Disable	Holds Setting

PROCEDURE

To hold settings, enter the code 9.0 using the numeric keys, then press the SPCL key.

EXAMPLE

To hold settings:

LOCAL (keystrokes)	Code: 9 . 0 Function: • SPCL
HP-IB (program codes);	9.0SP (Code: 9.0, Function: SP)

HP-IB PROGRAM CODE

9.0SP is the HP-IB code for the Hold Settings Special Function.

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. The light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

COMMENTS

Once settings have been held by the Hold Settings Special Function, one or more of them may be returned to their automatic modes by issuing the corresponding Special Function code. As an example, Hold Settings places the instrument in manual tune mode. Use 4.0 SPCL to re-enter automatic tuning.

RELATED SECTIONS

Attenuation, Input
Error Disable
IF Frequency and Input High Pass Filter Selection
Modulation Range
Special Functions
Tuning

HP-IB Address
(Special Function 21)

DESCRIPTION

By keyboard entry using the SPCL key, the Modulation Analyzer's present HP-IB address can be displayed. The display is in binary and also shows whether the instrument is set to talk only or listen only, and whether it is at present issuing a service request. The HP-IB address display will not time out, but it can be cleared by pressing any key except the LCL, **S(Shift),** or number key.

PROCEDURE

To display the HP-IB address, key in the code 21.0 on the numeric keys, then press the SPCL key. To clear the display, press the **CLEAR** key. A list of allowable HP-IB addresses is given below:

Allowable HP-IB Address Codes

Address Switches					Talk Address Character	Listen Address Character	Decimal Equivalent	Address Switches					Talk Address Character	Listen Address Character	Decimal Equivalent
A5	A4	A3	A2	A1				A5	A4	A3	A2	A1			
0	0	0	0	0	@	SP	0	1	0	0	0	0	P	0	16
0	0	0	0	1	A	!	1	1	0	0	0	1	Q	1	17
0	0	0	1	0	B	"	2	1	0	0	1	0	R	2	18
0	0	0	1	1	C	#	3	1	0	0	1	1	S	3	19
0	0	1	0	0	D	$	4	1	0	1	0	0	T	4	20
0	0	1	0	1	E	%	5	1	0	1	0	1	U	5	21
0	0	1	1	0	F	&	6	1	0	1	1	0	V	6	22
0	0	1	1	1	G	'	7	1	0	1	1	1	W	7	23
0	1	0	0	0	H	(	8	1	1	0	0	0	X	8	24
0	1	0	0	1	I	)	9	1	1	0	0	1	Y	9	25
0	1	0	1	0	J	*	10	1	1	0	1	0	Z		26
0	1	0	1	1	K	+	11	1	1	0	1	1	[		27
0	1	1	0	0	L	,	12	1	1	1	0	0	\	<	28
0	1	1	0	1	M	–	13	1	1	1	0	1	]	=	29
0	1	1	1	0	N	.	14	1	1	1	1	0	^	>	30
0	1	1	1	1	O	/	15								

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the light within the key will turn on and all measurement key lights and annunciators will turn off. The display will show a binary number of the form AAAAA. TLS where AAAAA is the HP-IB address in binary and T, L, and S have the meaning indicated in the following table:

	T	L	S
0	NOT TALK ONLY	NOT LISTEN ONLY	NOT REQUESTING SERVICE
1	TALK ONLY	LISTEN ONLY	REQUESTING SERVICE

If T and L are both 1, the instrument is set to talk only (talk overrides listen). If all the A digits are set to 1 and T is 1, the instrument will talk status only (i.e., output the status byte only). (If all digits AAAAA.TL are 1 but S is 0, the HP-IB board is not installed.)

EXAMPLE

Display the HP-IB address:

LOCAL (keystrokes)	- Code - Function 2 1 . 0 • SPCL
HP-IB (program codes)	21.0SP Code Function

If the following was displayed:

then the HP-IB address is 01110 in binary or 14 in decimal. In ASCII, the talk address is N, and the listen address is . (decimal point). The instrument is not set to talk or listen only, but it is issuing a service request (setting the SRQ control line true).

HP-IB PROGRAM CODE

21 .0 SP is the HP-113 code to read HP-IB address.

COMMENTS

The HP-IB address display is continuously updated. This makes setting the address easy since the result of changing a switch setting is immediately visible on the display.

For information on setting the HP-IB address of the Modulation Analyzer, refer to section 2 of this manual.

The factory-set address is as shown in the example, decimal 14.

RELATED SECTIONS

Special Functions
Remote Operation, Hewlett-Packard Interface Bus

IF Frequency, and Input High Pass Filter Selection

(Special Function 3)

DESCRIPTION

The Modulation Analyzer uses one of two IF frequencies. A 1.5 MHz IF is automatically selected for input frequencies below 2.5 MHz or above 10 MHz, while a 455 kHz IF is selected for inputs between 2.5 and 10 MHz. The IF, however, may be manually set to either 455 kHz or 1.5 MHz. In addition, an input high pass filter can be manually inserted to reject low frequencies, if present, when measurements are to be made on higher frequencies (signals greater than 10 MHz). Use the numeric keyboard and the SPCL key to manually select both the IF frequency and the input high pass filter.

The IF 3 dB bandwidth is approximately 3.0 MHz for the 1.5 MHz IF and 200 kHz for the 455 kHz IF. (Refer to the bandwidth diagram *in Tuning.)* Whenever the 455 kHz IF is selected, the Modulation Analyzer automatically inserts the 15 kHz low pass modulation filter. Under these conditions, only the 3 kHz or > 20 kHz low pass filters will override that filter. Whenever the 1.5 MHz IF is used below 2.5 MHz, the 15 kHz low pass is again selected; however, under these conditions only the 3 kHz low pass overrides it. The following procedure selects the IF frequency and input high pass filter combination, however, using the 455 kHz IF below 2.5 MHz requires a special procedure which can be found in the ***Tuning*** section.

PROCEDURE

To manually select the IF frequency and input high pass filter combination, key in the corresponding Special Function code, then press the SPCL key.

IF Frequency (MHz)	Input High-Pass Filter	Special Function Code	Program Code HP-IB
Automatic IF frequency selection	Out	3.0 SPCL	3.0SP
0.455	Out	3.1 SPCL	3.1SP
1.5	Out	3.2 SPCL	3.2SP
0.455	In	3.3 SPCL	3.3SP
1.5	In	3.4 SPCL	3.4SP

EXAMPLE

To use the 455 kHz IF above 10 MHz (input high pass filter in):

LOCAL (keystrokes)	Code: 3 . 3 Function: SPCL
HP-IB (program codes)	3.3SP (Code, Function)

HP-IB PROGRAM CODES

The HP-IB codes for setting various IF frequency and input high pass filter combinations are given under “PROCEDURE” above.

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Unless Special Function code 3.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

COMMENTS

When a new IF frequency is selected, the instrument immediately retunes to accommodate it.

Frequency and tuned RF level measurements may typically be made on very low-level signals (to -60 dBm). Using the narrow bandwidth of the 455 kHz IF for signal frequencies below 2.5 MHz or above 10 MHz increases the sensitivity and selectivity of the Modulation Analyzer in these modes.

When using the 455 kHz IF on input signals with frequencies above 300 MHz, AM due to FM increases substantially.

When first powered up, or when AUTOMATIC OPERATION is selected, the Modulation Analyzer is placed in the automatic selection mode.

RELATED SECTIONS

Frequency, IF
Hold Settings
Level, IF
Special Functions
Tuning

IF Output

CAUTION

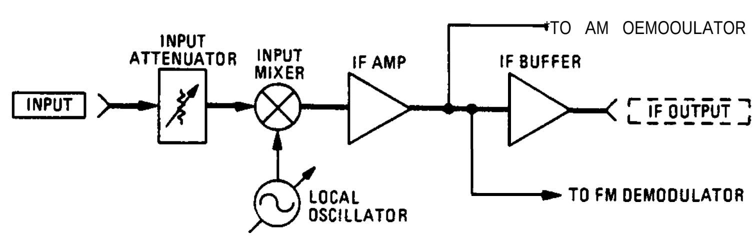
Do not apply greater than 40 V dc or greater than +15 dBm into the rear-panel IF OUTPUT jack

DESCRIPTION

The rear-panel IF OUTPUT provides a buffered IF output useful for monitoring the Modulation Analyzer's intermediate frequency signal. The ac-coupled signal has a range of 150 kHz to 2.5 MHz and normally varies in level from -27 to -3 dBm into 50Ω depending upon the input signal level, input attenuation setting, and the measurement selected. The 3 dB bandwidth of the signal at IF OUTPUT is approximately 3 MHz for the 1.5 MHz IF and approximately 200 kHz for the 455 kHz IF. At any particular input level and front-panel setting, the flatness of the IF OUTPUT with input frequency is typically ±5%. The IF OUTPUT jack is a female BNC connector.

BLOCK DIAGRAM

A simplifled block diagram of the down-conversion circuits that develop the IF OUTPUT signal is shown below.



IF OUTPUT Block Diagram

COMMENTS

The Modulation Analyzer can also be used as a down-converter. Use IF OUTPUT as the down-converter's output.

IF OUTPUT can be used to check for spurious signals in the IF by connecting a spectrum analyzer to the jack.

Loads which may output spurious signals into the IF OUTPUT (such as some counters) may cause spurs in the Modulation Analyzer's IF circuits resulting in inaccurate measurements.

Level, IF

DESCRIPTION

The IF LEVEL key causes the Modulation Analyzer to measure the signal level in its IF and display it as a percent of the optimum level. An IF level display of 100% indicates sufficient signal strength to guarantee accurate AM, FM, and ΦM measurements. When IF LEVEL is selected, MODULATION OUTPUT continues to output the demodulated signal corresponding to the last modulation measurement selected. If, however, the IF level is not 100%, the calibration of the MODULATION OUTPUT signal is not specified.

PROCEDURE

To display the IF level as a percent of optimum, press the S(Shift) key, then the IF LEVEL key. If IF LEVEL is to be displayed relative to some reference level or in dB, refer to *Ratio.*

EXAMPLE

To measure IF Level:

LOCAL (keystrokes)	Measurement S IF LEVEL
HP-IB (program codes)	S3 Measurement

HP-IB PROGRAM CODE

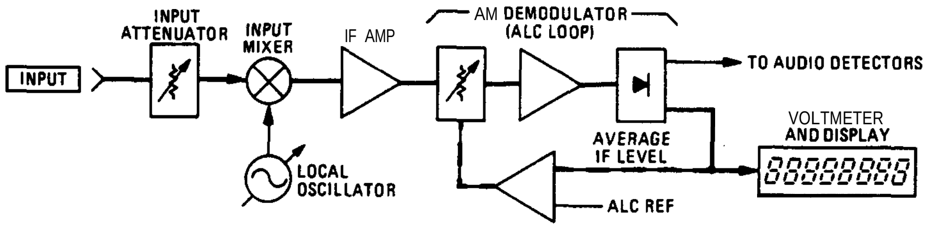
S3 is the HP-IB code for IF LEVEL.

INDICATIONS

When IF LEVEL is selected, the LEDs within the S(Shift) key and the IF LEVEL key will light, the % annunciator will light, and the display will show the percent of optimum IF Level.

MEASUREMENT TECHNIQUE

Once the instrument is tuned, the automatic level control (ALC) loop of the AM Demodulator detects the average IF signal level. This level is then measured and displayed as a percent of the optimum level. If the ALC loop is closed and sufficient signal power is available, the IF level is automatically adjusted to a preset ALC reference level and the display will show 100%. If the ALC loop is open, the input attenuator and the input signal level may need to be adjusted to achieve the 100% level.



IF Level Measurement Block Diagram

COMMENTS

When enabled, E03 (input circuits under-driven) will be generated whenever IF level is less than 100% optimum.

When operating with the AM ALC loop open, the AM displayed represents the demodulated ac riding on the carrier while the IF level displayed represents the average carrier level. The AM % can be computed by the following formula:

$$\frac{\textit{demodulated ac}}{\textit{average carrier level}} \times 100\% = \frac{\textit{AM \% displayed}}{\textit{IF level displayed}} \times 100\%$$

An easy way to make the Modulation Analyzer do the computation for you is to first observe the IF level, then switch to AM and enter the IF level on the numeric keys. Now press the % RATIO key. AM will now be displayed accurately although the IF level was not 100%.

In general, when the AM ALC is off (loop open), use IF levels $\geq$ 100% for FM measurements and $\leq$ 100% for AM measurements.

RELATED SECTIONS

AM ALC Response Time
Level, Tuned RF
Level, RF

Level, RF

DESCRIPTION

The RF LEVEL key causes the Modulation Analyzer to measure the peak broadband RF power at INPUT in watts. In addition, MODULATION OUTPUT is turned off during this measurement; however, AM OUTPUT and FM OUTPUT (rear panel) remain active but uncalibrated. The tuning of the instrument remains unchanged.

MEASUREMENTRANGE

1 mW to 1 W into 50Ω. (0 to +30 dBm or 0.22 V rms to 7 V rms.) 1 μW maximum resolution.

PROCEDURE

To make a broadband RF power measurement, press the RF LEVEL key. (If the RF level is to be displayed relative to some reference level, refer to ***Ratio.)***

EXAMPLE

To measure the peak envelope power of an RF input signal:

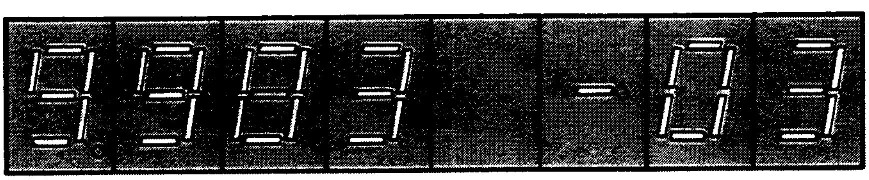
LOCAL (keystroke)	Measurement RF LEVEL
HP-IB (program codes)	M4 Measurement

HP-IB PROGRAM CODE

M4 is the HP-IB code for RF LEVEL.

INDICATIONS

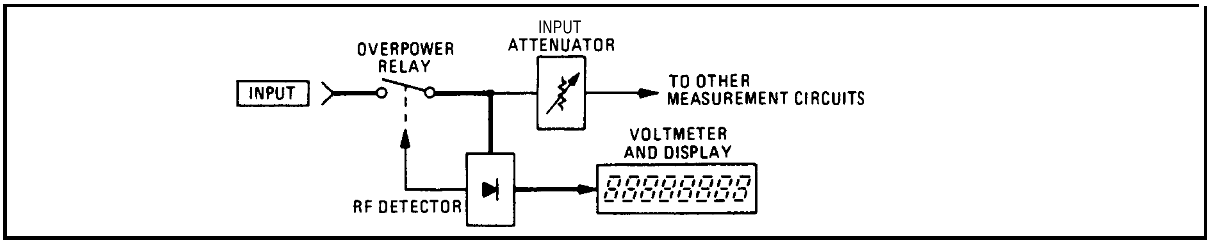
When RF level is selected, the LEDs within the RF LEVEL key and the watts annunciator will light. The display will be in scientific notation form; that is, a 4-digit number followed by a signed power-of- 10 multiplier. For example, if the display shows:



then the power at INPUT is 9.983 × 10^{-3} watts (9.983 mW).

MEASUREMENT TECHNIQUE

The broadband RF power at INPUT is detected by an RF peak detector. The output of the detector is measured and displayed as watts.



RF Level Measurement Block Diagram

COMMENTS

Selection of RF LEVEL causes the Modulation Analyzer to set its input attenuation to 50 dB regardless of any other setting (including Special Function 1). The input high-pass filter (Special Function 3) is also removed if previously inserted.

The maximum allowable input level is 1 W into 50Ω. Input levels greater than 1 W cause the overpower relay to open and the display to show E06. To reset the relay, remove the input signal and press any measurement key.

RELATED SECTIONS

Attenuation, Input
Frequency, IF
Level, IF
Level, Tuned RF
Ratio

Level, Tuned RF

DESCRIPTION

The TUNED RF LEVEL key causes the Modulation Analyzer to measure the peak RF power falling within its tuned IF (refer to the second figure under "MEASUREMENT TECHNIQUE" below). When TUNED RF LEVEL is selected, MODULATION OUTPUT continues to output the demodulated signal corresponding to the last modulation type selected. AM OUTPUT and FM OUTPUT (rear panel) remain active during this measurement.

NOTE

The Tuned RF level function is not calibrated for absolutepower measurements.

MEASUREMENT RANGE

10 nW to 1 W into 50Ω (–50 to +30 dBm or 707 μV to 7.07 V). 1 nW maximum resolution.

PROCEDURE

To make a tuned RF level measurement, first tune the instrument to the input signal (refer to *Tuning* or press AUTOMATIC OPERATION). Manual tuning will be necessary when measuring low-level signals (inputs < -25 dBm from 150 kHz to 650 MHz or < -20 dBm from 650 to 1300 MHz). Press the S(Shift) key, then the TUNED RF LEVEL key. If the tuned RF level is to be displayed relative to a reference, refer to *Ratio.*

EXAMPLE

To measure the tuned RF level of an input signal:

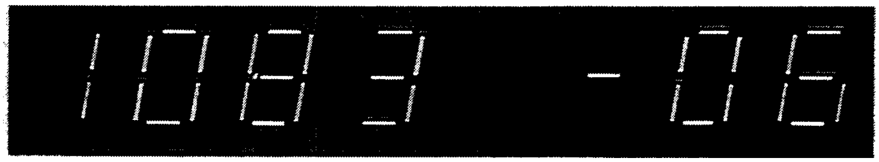
LOCAL (keystrokes)	Measurement: S, TUNED RF LEVEL
HP-IB (program codes)	S4 (Measurement)

HP-IB PROGRAM CODE

S4 is the HP-IB code for TUNED RF LEVEL.

INDICATIONS

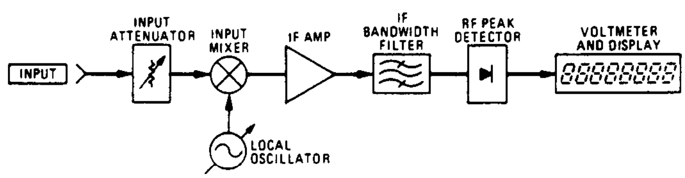
When TUNED RF LEVEL is selected, the LEDs within the S(Shift) key and the TUNED RF LEVEL key will light and the watts annunciator will also light. The display will be in scientific notation form; a 4 or 5 digit number followed by a signed power of 10 multiplier. For example, if the display shows:



then the tuned RF level is 10.83 x 10^{-6} watts (10.83 μW).

MEASUREMENT TECHNIQUE

When the Modulation Analyzer is tuned, all the power falling within the IF is amplified and peak detected. It is then measured by the voltmeter and displayed in watts.



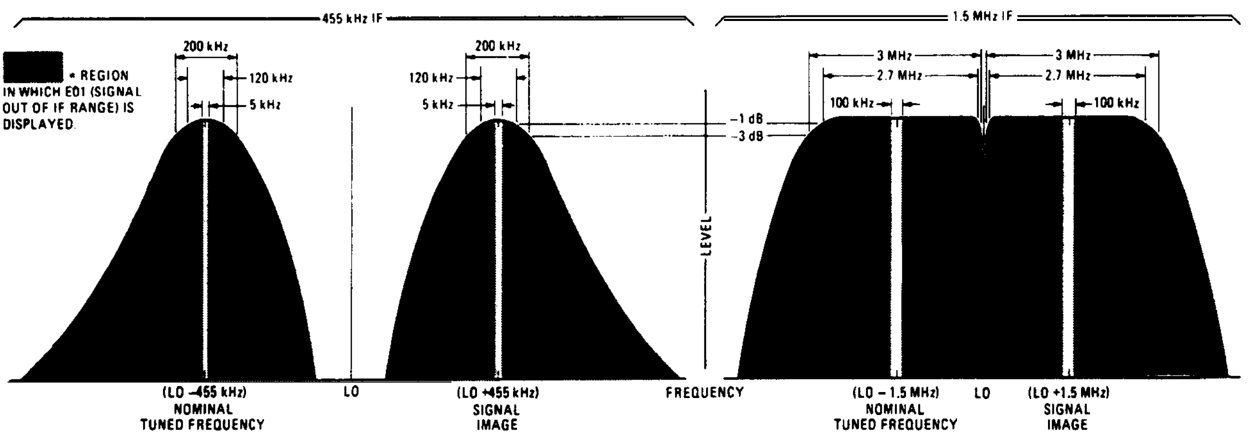
Tuned RF Level Measurement Block Diagram

COMMENTS

The bandwidth of the 455 kHz IF (normally used for input frequencies between 2.5 and 10 MHz) is approximately 200 kHz. The bandwidth of the 1.5 MHz IF (normally used for input frequencies below 2.5 MHz or above 10 MHz) is approximately 3 MHz. However, each nominal IF passband also has an image passband which may contain signals with significant power. The IF and image bandwidths and their relationships to the local oscillator signal (LO) are illustrated for each IF in the spectrum diagram given below.

To display power in dBm, enter the number .001, then press the dB key.

Absolute power measurements are most accurate in RF level; however, power measurements have greater dynamic range in tuned RF level.



Spectrum Diagram of the 455 kHz and 1.5 MHz Tuned Bandwidths

RELATED SECTIONS

Level, IF
Level, RF
Ratio

Limit
(Special Function 14)

DESCRIPTION

Using the numeric keyboard and the SPCL and RATIO keys, upper and lower measurement limits may be entered into the Modulation Analyzer. Subsequent out-of-limit measurements will then cause the LIMIT annunciator to light. If enabled, reaching an upper or lower limit will also cause the Modulation Analyzer to issue an HP-IB service request. (Refer to *Service Request Condition.)* The LIMIT light will turn off after five measurement cycles if further measurements are not out of limits; however, the service request can only be cleared by serial polling or by a Device Clear message. Only one upper and one lower limit can be set at a time and each limit (upper or lower) can only be in effect in one measurement mode. The measurement mode need not be the same for both the upper and lower limits. Both limit references can be displayed, cleared, and restored, and the measurement modes for both limits may be displayed.

PROCEDURES

A limit reference must first be entered as a RATIO reference. To do this, first select the MEASUREMENT in which the limit is to be used, then key in the value of the limit on the numeric keyboard, and press either the % or dB key. (Since the RATIO keys are used here simply to enter the limit into the instrument, it does not matter which key, % or dB, is used.) The entered value is now stored as a RATIO reference. To make this reference negative or to transform it directly into either an upper or lower limit reference, key in the corresponding Special Function code, then press the SPCL key. The Special Function codes most useful when working with the limit functions are listed below:

	Action	Special Function Code	Program Code HP-IB
RATIO	Read RATIO reference	11.2 SPCL	11.2SP
	Make RATIO reference negative	11.3 SPCL	11.3SP
LIMIT	Clear limits: turn off LIMIT annunciator	14.0 SPCL	14.0SP
	Set lower limit to RATIO reference	14.1 SPCL	14.1SP
	Set upper limit to RATIO reference	14.2 SPCL	14.2SP
	Restore lower limit	14.3 SPCL	14.3SP
	Restore upper limit	14.4 SPCL	14.4SP
	Read lower limit	14.5 SPCL	14.5SP
	Read upper limit	14.6 SPCL	14.6SP
	Read lower limit measurement mode	14.7 SPCL	14.7SP
	Read upper limit measurement mode	14.8 SPCL	14.8SP

To determine the measurement in which an upper or lower limit is in effect, key in the corresponding Special Function code, then press the SPCL key. The display shows a code which represents the measurement in which the limit is in effect. These codes are indexed in the following table:

Display	Measurement	Display	Measurement
0.000	AM	0.006	FREQ ERROR
0.001	FM	0.007	Spare
0.002	ϕM	0.008	IF LEVEL
0.003	RF LEVEL	0.009	Spare
0.004	TUNED RF LEVEL	0.010	IF Frequency
0.005	FREQ	0.011	Spare

EXAMPLES

To set an upper limit of 75 kHz FM deviation:

LOCAL (keystrokes)	Measurement · Data · Ratio · Code · Function FM [•] [7] [5] dB [•] [1] [4] [.] [2] [•] SPCL -Enter RATIO reference- Upper limit = RATIO reference-
HP-IB (program codes)	M275R214.2SP Measurement · Data · Ratio · Code · Function

This leaves the Modulation Analyzer in dB RATIO mode. Press the dB key to exit RATIO and to read the FM deviation in kHz with an upper limit set at 75 kHz. Notice that this example could have used the % RATIO key with equal results.

To set a lower FREQ ERROR limit of -660 Hz:

LOCAL (keystrokes)	Measurement · Data · Ratio · Code · Function [•] S [•] FREQ ERROR [.] [6] [6] % [•] [1] [1] [.] [3] [•] SPCL -Enter RATIO reference- Make RATIO reference negative
HP-IB (program codes)	S5.66R111.3SP Measurement · Data · Ratio · Code · Function

LOCAL (keystrokes)	Code · Function [1] [4] [.] [1] [•] SPCL
HP-IB (program codes)	14.1SP Code · Function

This leaves the Modulation Analyzer in % RATIO mode. Press the % key to read the frequency error in kHz with the lower limit set. to -660 Hz.

To determine in which measurement the lower limit is set:

LOCAL (keystrokes)	Code: 1 4 . 7 ; Function: • SPCL
HP-IB (program codes)	14.7SP (Code: 14.7, Function: SP)

If, for example, the display shows 0.006, the lower limit is set for the FREQ ERROR measurement.

HP-IB PROGRAM CODES

The codes for performing the various limit and ratio operations are given above. The codes for the RATIO keys are given below for reference.

Key or Function	Program Code HP-IB
Turn off RATIO	RO
%	R1
dB	R2

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. If limits are being cleared or set, the SPCL key will not turn on if not already on. However, if limits or their measurement modes are being read, the key will turn on if not already on and remain lighted while the limit value or mode is displayed. When operating with limits set, the other key lights and the display behaves as they normally would; however, if a measurement falls out-of-set limits, the LIMIT annunciator lights. The light remains on until five successive measurements are made that fall within the set limits. Thus, the LIMIT light will normally remain on for approximately one second after the last out-of-limit measurement result. If the Modulation Analyzer is set to issue a service request when an out-of-limit measurement occurs, the service request may be cleared by serial polling.

COMMENTS

It does not matter which RATIO key is used to enter the RATIO reference before transforming it into a limit.

The test for out-of-limit results is performed on the actual measurement results, not upon the displayed number. Thus, although the display may show a relative measurement result (that is, using the ratio functions), the limit test is still made upon the result before the ratio is computed. Limits cannot be set in terms of relative measurement results.

RELATED SECTIONS

Service Request Condition
Special Functions
Ratio

LO Input and LO Output

CAUTION

Do not apply greater than 40 V dc or i-5 dBm of RF power into the LO INPUT or damage to the instrument may result. Do not apply dc voltage or RF power into the LO OUTPUT or damage to the instrument may result.

DESCRIPTION

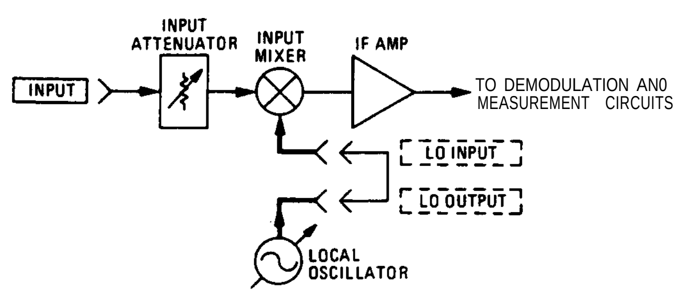
In Modulation Analyzers with Option 003, the internal local oscillator (LO) is brought out of and back into the instrument through the rear-panel LO OUTPUT and LO INPUT jacks. The signal at these jacks ranges from approximately 1.27 to 1301.5 MHz at approximately 0 dBm. Both jacks are 50Ω, ac-coupled, and furnished with female Type-N connectors.

NOTE

For normal Modulation Analyzer operation using the internal local oscillator, the rear-panel LO OUTPUT must be connected to the rear-panel LO INPUT.

BLOCK DIAGRAM

A block diagram illustrating the relationship between the LO INPUT and LO OUTPUT jacks and the Modulation Analyzer's input circuits is given below.



LO INPUT and LO OUTPUT Block Diagram

PROCEDURE

To use LO OUTPUT as a signal source, select an IF frequency (1.5 MHz or 455 kHz) using Special Function 3. The Modulation Analyzer will assume 1.5 MHz IF above 10 MHz (as entered on the keyboard) and 455 kHz IF below 10 MHz if the IF frequency is not specified. Subtract the IF frequency from the frequency desired at LO OUTPUT and enter the result in MHz using the numeric keys; then press MHz.

To tune the LO below 2.96 MHz, use the procedure above, but select the 455 kHz IF (Special Function code 3.1) and disable error E01 (Special Function code 8.1).

To use LO INPUT to apply an external LO, select an IF frequency (1.5 MHz or 455 kHz) using Special Function 3. Press the MHz key to enter manual tune mode (this keeps the internal LO from tuning continuously). Add the IF frequency to the frequency to which the Modulation Analyzer is to be tuned and set the external LO to that frequency. Adjust the external LO to 0 dBm and apply the signal to LO INPUT.

COMMENTS

To tune to inputs below 2.5 MHz with an external LO, select the 1.5 MHz IF, but set the LO to approximately 100 MHz. The LO must be present to bias the Input Mixer on, but down-conversion is not necessary.

When an external LO is used, measurements made using the FREQ or FREQ ERROR keys will not be accurate. To determine input frequency, subtract the IF frequency (Special Function 10) from the LO frequency used.

When using an external LO, rapid changes in LO frequency within the IF passband cause FM transients. Several seconds are then required before accurate measurements will be possible. To avoid the problem, turn off the external LO when switching its frequency.

RELATED SECTIONS

IF Frequency and Input High Pass Filter Selection
Tuning

Modulation Output

CAUTION

Do not apply greater than 10 Vdc or greater than +30 dBm (1 watt) into MODULATION OUTPUT or damage to the instrument may result.

NOTE

For optimum signal flatness, cables attached to MODULATION OUTPUT should be terminated with their characteristic impedance

DESCRIPTION

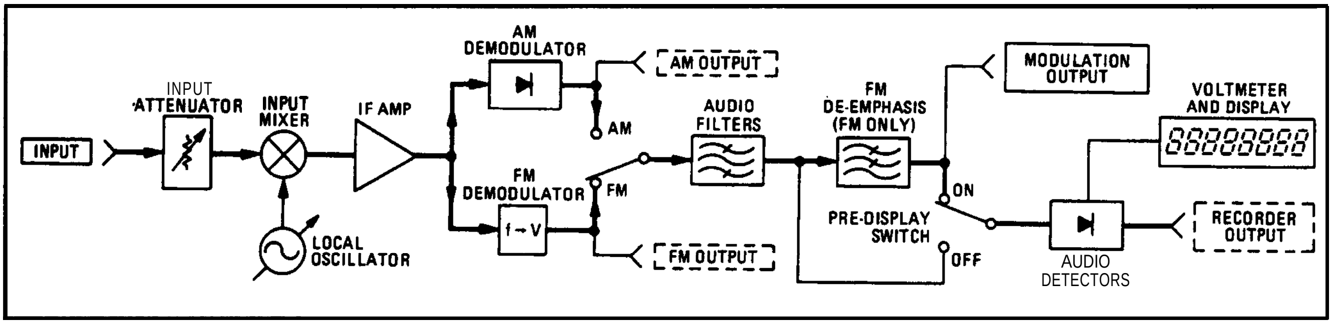
MODULATION OUTPUT provides a calibrated output for signals demodulated by the Modulation Analyzer. The output is dc coupled with a 600Ω output impedance and a BNC female connector. The signal at MODULATION OUTPUT always corresponds to the modulation measurement being made. If FREQ, IF LEVEL, TUNED RF LEVEL, FREQ ERROR or IF frequency is selected, the signal at MODULATION OUTPUT corresponds to the last selected modulation measurement. If RF LEVEL is selected, MODULATION OUTPUT is turned off (that is, set to 0 V). If high-pass or low-pass filters are selected, they always affect the signal at MODULATION OUTPUT. If FM de-emphasis is selected, it always affects demodulated FM at MODULATION OUTPUT, regardless of the PRE-DISPLAY setting. The output level of the signal at MODULATION OUTPUT is autoranging and usually is between 0 and 4 V peak into an open circuit. The output sensitivity (into an open circuit) depends upon both the modulation type and the displayed resolution as given in the table below. (More information on other outputs and the setting of modulation ranges may be found in ***Modulation Range)***

AM		FM		ΦM	
Display Resolution **(%)**	MODULATION OUTPUT Sensitivity **(Vac/%)**	Display Resolution **(Hz)**	MODULATION OUTPUT Sensitivity **(mVac/Hz)**	Display Resolution (radians)	MODULATION OUTPUT Sensitivity **(mVac/radian)**
0.01	0.1	0.1*	10*	0.0001	1
		1	1	0.01	0.1
0.1	0.01	10	0.1	0.1	0.01
		100**	0.01**		

* Available only with 750 microsecond de-emphasis, pre-display.
** Not available with 750 microsecond de-emphasis, pre-display.

BLOCK DIAGRAM

A simplified block diagram of the Modulation Analyzer's measurement circuits illustrating the relationships between MODULATION OUTPUT and the other outputs and circuit blocks is given below.



Modulation Output Block Diagram

COMMENTS

The sense of the demodulated FM and ΦM at MODULATION OUTPUT is inverted for carriers with frequencies below 2.5 MHz.

Errors E01 through E03, E05, E10, and HP-13 error E96 (corresponds to a display of two dashes) turn off the signal at MODULATION OUTPUT.

When the Modulation Analyzer is first powered up, the demodulated signal at MODULATION OUTPUT is FM. The sensitivity is 0.01 mVac/Hz and will not autorange to more sensitive ranges. This is because at power up, FREQ is selected, and thus E04 (audio circuits overdriven) is automatically disabled. When E04 is disabled, only autoranging to less sensitive audio ranges is allowed.

When E01 through E04 are always enabled (8.8 SPCL), the signal at MODULATION OUTPUT is entirely safeguarded. Under this condition an error will be displayed when the signal at MODULATION OUTPUT is uncalibrated. Refer to ***Error Disable.***

RELATED SECTIONS

AM
Error Disable
Filters
FM
Modulation Range
(PM

Modulation Range

(Special Function 2)

DESCRIPTION

When first tuned on, the Modulation Analyzer is set to automatically select the modulation range appropriate for the desired measurement. However, using the numeric keyboard and the SPCL key, the modulation range can be manually set.

PROCEDURE

To set the modulation range to a selected range, or to re-enter the automatic selection mode, key in the corresponding Special Function Code, then press the SPCL key.

AM						
Modulation Range				Display Resolution (%)	MODULATION OUTPUT Sensitivity (Vac/% AM)	RECORDER OUTPUT (Rear Panel) (Vdc/peak% AM)
PEAK ± (%)	AVG[1] (%)	Special Function Code	Program Code HP-IB			
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection		
≤40	≤28	2.1 SPCL	2.1SP	0.01	0.1	0.1
≤100	≤70.7	2.2 SPCL or 2.3 SPCL	2.2SP or 2.3SP	0.1	0.01	0.01

[1] Values are for sine wave modulation signal only.

FM						
Modulation Range				Display Resolution (Hz)	MODULATION OUTPUT Sensitivity (mVac/Hz)	RECORDER OUTPUT (Rear Panel) (Vdc/kHz peak dev.)
PEAK ± (%) (kHz dev.)	AVG[1] (%) (kHz dev.)	Special Function Code	Program Code HP-IB			
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection		
≤0.4[2]	≤0.28[2]	2.1 SPCL[2]	2.1SP	0.12	10[2]	10[2]
14	≤2.8	2.1 SPCL 2.2 SPCL[2]	2.1SP 2.2SP[2]	1	1	1
≤40	≤28	2.2 SPCL 2.3 SPCL[2]	2.2SP 2.3SP[2]	10	0.1	0.1
≤400[3]	≤280[3]	2.3 SPCL[3]	2.3SP[3]	100[3]	0.013	0.01[3]

[1] Values are for sine wave modulation signal only.
[2] With 750 microsecond de-emphasis, pre-display only.
[3] Except 750 microsecond de-emphasis, pm-display.

Phase Modulation (ΦM)						
Modulation Range[1]				Display Resolution radians	MODULATION OUTPUT Sensitivity (mVac/radian)	RECORDER OUTPUT (Rear Panel) (Vdc/rad. peak dev.)
PEAK ± (rad. dev.)	AVG[2] (rad. dev.)	Special Function Code	Program Code HP-IB			
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection		
14	≤2.8	2.1 SPCL	2.1SP	0.001	1	1
≤40	≤28	2.2 SPCL	2.2SP	0.01	0.1	0.1
≤400	≤280	2.3 SPCL	2.3SP	0.1	0.01	0.01

[1] Range limits are nominal. Refer to figure under Phase Modulation for relationship between deviation, rate, and resolution.
[2] Values are for sine wave modulation signal only.

EXAMPLE

To set the modulation range to the ≤40% AM setting (also ≤4 kHz deviation for FM and ≤4 radians deviation for ΦM):

LOCAL **(keystrokes)**	Code: 2 . 1 — Function: • SPCL
HP-IB (program codes)	2.1SP (Code: 2.1 — Function: SP)

BLOCK DIAGRAM

For HP-IB codes, refer to "PROCEDURE" above.

INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to shown the measurement previously selected. Unless Special Function code 2.0 was entered, the light within the SPCL key will turn on, if not already on. If the light is already on, it will remain on.

COMMENTS

When the instrument is first turned on or when AUTOMATIC OPERATION is selected, the modulation range is placed in the automatic selection mode.

If the modulation range selected is too high, no error will be generated, and both MODULATION OUTPUT and RECORDER OUTPUT will track the displayed values. If the modulation range is too low (that is, the audio signal level is too high), error E04 will be generated. The point at which error E04 is generated may not be exactly at the nominal level at which ranges are switched.

When E04 is disabled (Special Function code 8.4), autoranging is to higher modulation ranges only. This feature is used most often when modulation varies widely with time such as off-the-air demodulation of a broadcast signal.

Refer to ***Phase Modulation (ΦM)*** for more information on ΦM modulation ranges.

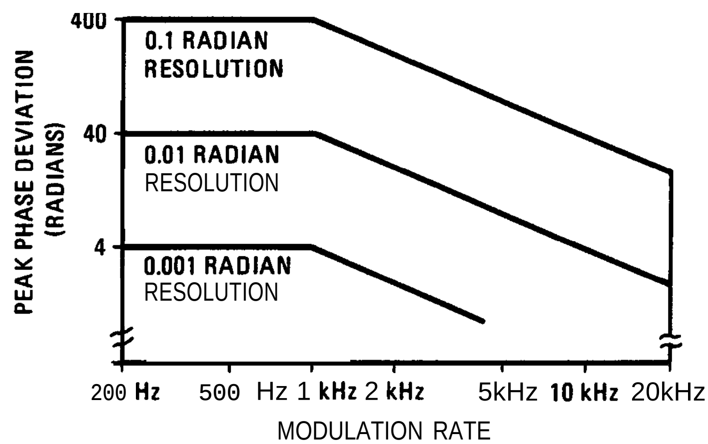
RELATED SECTIONS

Error Disable
Hold Settings
Special Functions

ΦM

DESCRIPTION

The **ΦM** key causes the Modulation Analyzer to measure the phase modulation deviation of the input signal to which the instrument is tuned. In addition, demodulated **ΦM** is present at MODULATION OUTPUT. The **ΦM** measurement is only specified for carriers from 10 to 1300 MHz, however, **ΦM** measurements are allowed on carriers from 150 kHz to 10 MHz. The **ΦM** measurement is only specified for modulation rates from 200 Hz to 20 kHz; however, the low frequency 3 dB limit is typically 7 Hz.



Phase Modulation Peak Phase Deviation and Modulation Rate vs. Display Resolution

Phase Modulation (ΦM)						
Modulation Range[1]				Display Resolution radians	MODULATION OUTPUT Sensitivity (mVac/radian)	RECORDER OUTPUT (Rear Panel) (Vdc/rad. peak dev.)
PEAK ± (rad. dev.)	AVG[2] (rad. dev.)	Special Function Code	Program Code HP-IB			
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection		
≤4	≤2.8	2.1 SPCL	2.1SP	0.001	1	1
≤40	≤28	2.2 SPCL	2.2SP	0.01	0.1	0.1
≤400	≤280	2.3 SPCL	2.3SP	0.1	0.01	0.01

[1] Range limits are nominal. Refer to figure under Phase Modulation for relationship between deviation, rate. and resolution.
[2] Values are for sine wave modulation signal Only.

PROCEDURE

To make a ΦM measurement, **first** tune the instrument to the input signal (refer to ***Tuning*** or press AUTOMATIC OPERATION). Press the **ΦM** key, and select an audio detector: PEAR+, PEAR-, or AVG (refer to Detectors). To limit the demodulation signal measurement bandwidth, press the appropriate **filter** keys (refer to ***Filters).*** When **ΦM** is selected, the 50 Hz high-pass **filter** is automatically inserted which limits the low frequency response. This **filter** may be removed if desired by pressing the 50 Hz key, however, residual **ΦM** will increase and measurement inaccuracies may result. If **ΦM** deviation is to be displayed relative to a reference, refer to Ratio.

EXAMPLE

To measure the positive peak ΦM deviation of a signal in a 50 Hz (filter automatically inserted) to 15 **kHz** demodulated signal bandwidth:

LOCAL (keystrokes)	Measurement Detector-r Filters- ΦM PEAK + 15 kHz
HP-IB (program codes)	M3D1H1L2 Measurement-r Filters Detector

HP-IB PROGRAM CODE

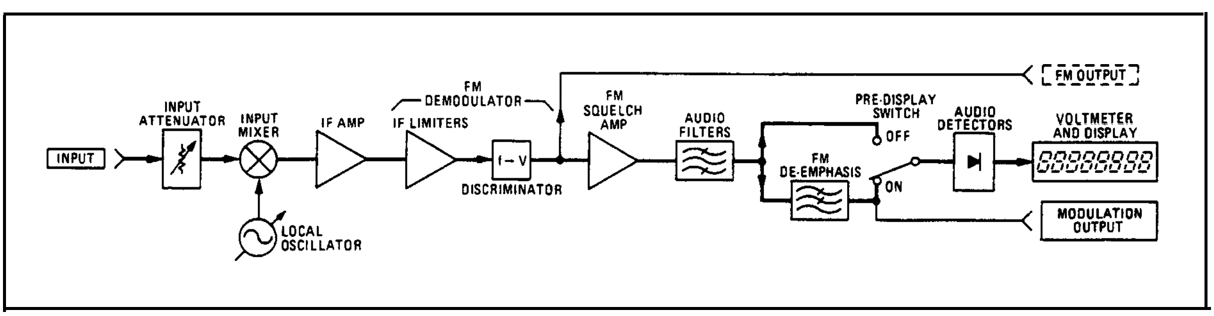
M3 is the HP-IB code for ΦM.

INDICATIONS

The **LEDs** within the keys representing the selected functions will light. The radians annunciator will light and ΦM on the display will show the radian deviation on the carrier.

MEASUREMENT TECHNIQUE

Once the instrument is tuned to the input signal, the ΦM on the IF carrier is demodulated by a discriminator that produces a signal whose amplitude is proportional to the frequency deviation. The demodulated signal is filtered and passed through an integrator. The integrator's output is then detected and displayed as phase deviation in radians.



ΦM Measurement Block Diagram

COMMENTS

The PEAR+ detector always detects the carrier's positive phase deviation while the PEAR- detector always detects its negative phase deviation.

The routine which automatically selects the modulation range contains regions of overlap between 3.5 and 4 radians and between 35 and 40 radians peak deviation as read on the display. When using the average detector ranging will occur with lower modulation levels displayed. If the modulation level is reduced from a higher range into an overlap region, the range may not change. To display the increased resolution, press the **ΦM** key a second time. To set the instrument to a selected modulation range, refer to ***Modulation Range.***

When operating above 2.5 MHz while using the 455 kHz IF, the modulation bandwidth's upper limit is that of the >20 kHz low-pass filter. Note that the 15 kHz low-pass filter is automatically selected when operating below 10 MHz or whenever the 455 kHz IF is selected. However, this filter may be overridden by selecting the >20 kHz low-pass filter.

The 50 Hz high-pass filter, automatically inserted when ΦM is selected, remains on as long as the signal at MODULATION OUTPUT is the demodulated ΦM signal or until the filter is manually turned off.

When operating with carrier frequencies below 2.5 MHz, the signal at MODULATION OUTPUT is inverted unless the 455 kHz IF is being used.

AM conditions which cause the carrier signal to disappear will cause inaccuracies in the measurement of ΦM deviation, or they may cause E05 (FM squelched) to be displayed.

When ΦM is selected, the signal at the rear-panel FM OUTPUT still represents demodulated FM, not ΦM.

To display phase deviation in degrees instead of radians, enter 1.745 as a RATIO reference and select % RATIO (refer to ***Ratio).***

Pulsed phase modulation such as phase shift keying cannot be accurately demodulated or measured by the Modulation Analyzer.

RELATED SECTIONS

Detectors
Filters
Modulation Basics (Section l-16)
Modulation Range
Ratio
Residual Noise Effects

Ratio
(Special Function 11)

DESCRIPTION

The RATIO keys permit any measurement result to be compared in % or dB to a reference value. The reference value may be the result of a previous measurement or a keyboard entry. The RATIO keys can be used with any MEASUREMENT function and with IF Frequency (Special Function 10).

The Modulation Analyzer stores only one RATIO reference at a time. When in RATIO, if a new measurement is selected, RATIO is disabled. This may be inconvenient, especially, when it is necessary to switch between measurements often (for example, to check input frequency while measuring AM). When returning to the previous measurement, it is possible to re-enter RATIO mode with the same factor used before, using Special Function 11.0 or 11.1. Additionally, the RATIO reference may be displayed or made negative (useful for setting frequency error limits), using Special Function 11.2 or 11.3.

PROCEDURES

To use the RATIO keys, set the display to the desired reference value. This can be done by adjusting the signal parameter being measured to a reference setting or by entering the reference on the numeric keys. If % RATIO is desired, press the % key; if dB RATIO is desired, press the dB key. The display will show the measurement result relative to the reference value.

To re-enter RATIO with the previous RATIO reference or to read the reference or make the reference negative, key in the corresponding Special Function code, and press the SPCL key. The Special Function codes are listed below.

RATIO Operation	Special Function Code	Program Code HP-IB
Reenter % RATIO with the previous reference.	11.0 SPCL	11.0SP
Re-enter dB RATIO with the previous reference.	11.1 SPCL	11.1SP
Read RATIO reference.	11.2 SPCL	11.2SP
Make RATIO reference negative.	11.3 SPCL	11.3SP

EXAMPLES

If the display shows 35.35 kHz FM deviation, to enter this value as the RATIO reference for future measurement:

LOCAL (keystroke)	Ratio % [•]	or	Ratio dB [•]
HP-IB (program codes)	R1 Ratio	or	‘t-2 Ratio
Resulting Display	100.0 REL (% key light on)	or	0.00 REL (dB key light on)

If the display shows 35.35 kHz FM deviation, to compare this to an FM deviation of 50 kHz:

LOCAL (keystrokes)	Data Ratio [5] [0] % [•]	or	Data Ratio [5] [0] dB [•]
HP-IB (program codes)	50R1 Data Ratio	or	50R2 Data Ratio
Resulting Display	70.7 REL (% key light on)	or	-3.01 REL (dB key light on)

If after setting up the RATIO reference in the example above, the frequency is checked, RATIO will be disabled. If it is desired to return to FM with the previous (dB) RATIO reference:

LOCAL (keystrokes)	Measurement, , - C o d e - Function FM [•] [1] [1] [.] [1] [•] SPCL
HP-IB (program codes)	M21 1.1SP Measurement Code Function

HP-IB PROGRAM CODES

The HP-IB codes for reentering RATIO or for reading or changing the reference are given above. The HP-IB codes for the RATIO keys are given below:

RATIO Function	Program Code HP-IB
Off	R0
%	R1
dB	R2

INDICATIONS

When the instrument is displaying a RATIO measurement, the REL (relative) annunciator and the appropriate RATIO key both light. Other units annunciators turn off. The displayed value is the measurement result relative to the reference in % or dB.

MEASUREMENT TECHNIQUE

When in RATIO, measurements are made in the same fashion as when not in RATIO; however, before the result is displayed, the internal controller converts it to ratio. The following formulas are used for computing ratio:

$$\left(\frac{M}{R}\right)(100\%) = \textit{\% RATIO for all measurements,}$$

$$(20)\ log\left(\frac{M}{R}\right) = \textit{dB RATIO for all modulation and IF level measurements}$$

$$(10)\ log\left(\frac{M}{R}\right) = \textit{dB RATIO for frequency and level measurements except IF level}$$

where

M = *the current measurement result, and*

R = *the RATIO reference.*

COMMENTS

When using dB RATIO, if a ratio reference is entered or a measurement result occurs that causes the value of M/R (see equation above) to approach 0, E11 will be displayed. This typically occurs when a measurement result goes to 0.

If already in RATIO, pressing the opposing RATIO key causes the Modulation Analyzer to acquire a new reference from the present measurement result. To convert from dB to % (or vice versa) with the same reference, use the re-enter RATIO function (Special Function 11.0 or 11.1).

The RATIO keys are convenient when used to check modulation or RF level flatness across an RF frequency range (use track mode tuning, Special Function 4.1) or across the audio range.

The reference that is stored for ratio measurements may be entered as a limit reference (refer ***to Limit).***

Some useful reference values for making ratio measurements are given below:

To display power in dBm, use 0.001 and dB RATIO.

To display broadcast FM relative to 75 kHz, use '75 and % RATIO.

To display ΦM in degrees, use 1.745 and % RATIO.

To display AM as dB down from the carrier, use 200 and dB RATIO.

To display rms calibrated average as true average, use 111.07 and % RATIO.

To display rms calibrated average as peak, use 70.7 and % RATIO.

RELATED FUNCTIONS

Error Message Summary
Limit
Special Functions
Tuning

Recorder Output

CAUTION

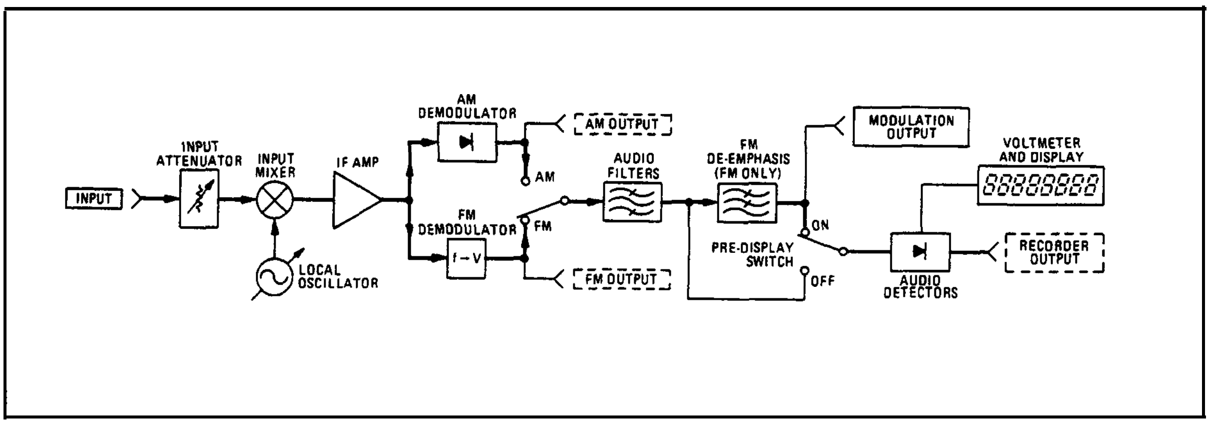
Do not apply greater than 10 Vdc or greater than +30 dBm into RECORDER OUTPUT or damage to the instrument may result.

DESCRIPTION

The rear-panel RECORDER OUTPUT produces a dc voltage equal to the peak level of the signal at MODULATION OUTPUT. The single exception to the above occurs when FM de-emphasis, pre-display "off is selected. In this case, RECORDER OUTPUT produces a dc voltage proportional to the peak FM deviation before de-emphasis, while MODULATION OUTPUT produces de-emphasized FM. RECORDER OUTPUT switches with the signal at MODULATION OUTPUT so that it always corresponds to the modulation measurement being made. If FREQ, FREQ ERROR, TUNED RF LEVEL, or IF frequency (Special Function 10) is selected, the signal at RECORDER OUTPUT is derived from the last selected modulation measurement. If RF LEVEL is selected, RECORDER OUTPUT is turned off (that is, set to 0 Vdc). The dc level at RECORDER OUTPUT ranges from 0 to 4 Vdc into an open circuit for each modulation display range (output impedance is 1 kΩ). For more information on output ranges and setting modulation ranges, refer to ***Modulation Range.***

BLOCK DIAGRAM

A simplified block diagram of the Modulation Analyzer's measurement circuits illustrating the relationships between RECORDER OUTPUT and the other outputs and circuit blocks is given below.



Recorder Output Block Diagram

COMMENTS

The signal at RECORDER OUTPUT represents the last peak detector selected, and it still reflects peak levels when the AVG (RMS CAL) detector is selected.

The dc offset at RECORDER OUTPUT is small (typically 0.001 Vdc).

When PEAR HOLD is selected, RECORDER OUTPUT holds the highest peak, but unlike the display, the voltage level at recorder output represents a stored charge which may discharge over a period of time, if not refreshed by new peaks.

RELATED SECTIONS

Detectors
Detector (Peak) Time Constant
Detector, Peak Hold
FM De-emphasis
Modulation Output

Residual Noise Effects

DESCRIPTION

To make the most accurate peak-modulation measurements, it is necessary to measure and correct the effects of residual noise, that is, noise not on the baseband signal, but modulating the RF carrier. The following procedure describes the measurement technique.

PROCEDURE

The following procedure enables the user to correct for the effects of residual noise on peak-modulation measurements.

NOTE

This procedure applies to sinewave modulation only.

1. Set up and make a normal peak-modulation measurement. The displayed measurement result will include the signal plus its noise, $(S + N)_{pk}$.

2. Key in 9.0 SPCL (Hold Settings) to prevent autoranging. If filtering and/or de-emphasis was used in step 1, make all the following measurements with the same settings.

3. Remove the modulation from the signal and measure the remaining peak-residual noise, N_{pk}, on the carrier.

4. Select AVG. Measure the average residual noise, N_{av}.

5. Compute

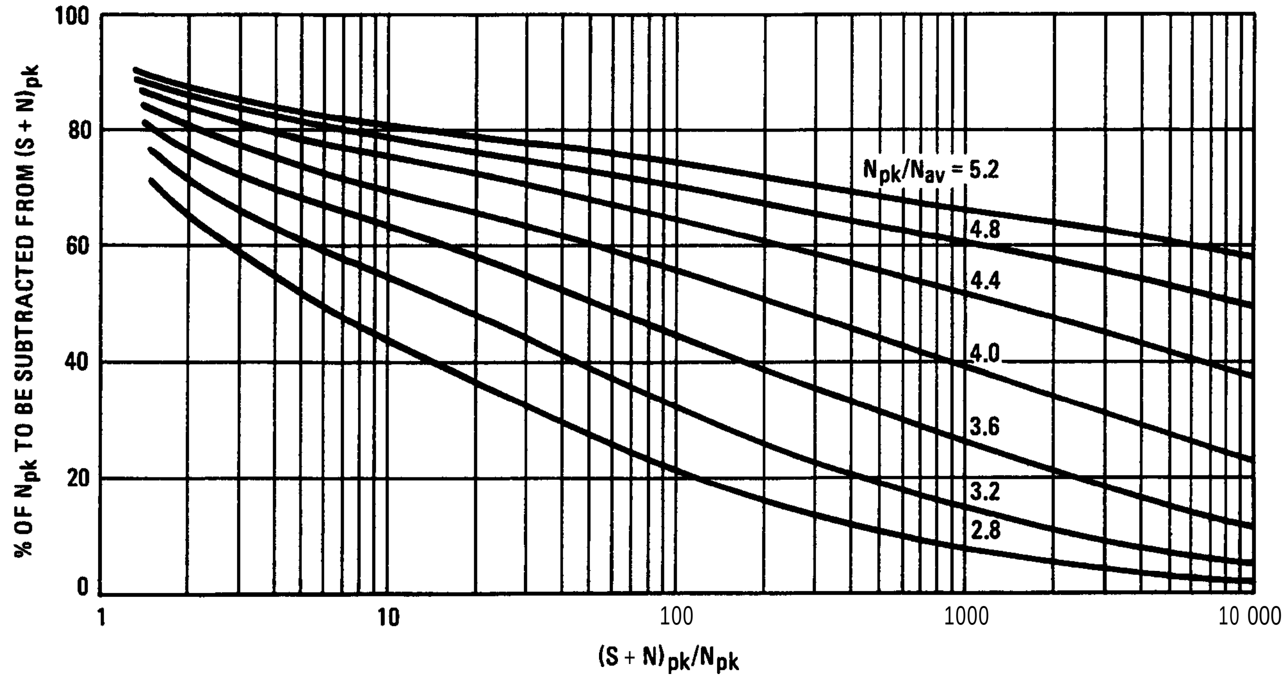
$$\frac{(S+N)_{pk}}{N_{pk}} and \frac{N_{pk}}{N_{av}}$$

6. Use the following nomograph to determine the percent, $N\%$, of the peak-residual noise level, N_{pk}, to be subtracted from the original, peak-signal-plus-noise measurement, $(S + N)_{pk}$.

7. Compute the corrected, peak modulation

$$S_{pk} = (S + N)_{pk} - N_{pk}(N\%)$$

where $N\%$ is expressed as a ratio (rather than in %).



. *Nomograph for Calculating Percentage of N_{pk} to be Subtracted from $(S + N)_{pk}$ to obtain S_{pk} (Sinewave Modulation Only)*

EXAMPLE

An RF signal is applied to the Modulation Analyzer. The modulation rate is 1 kHz and the peak modulation is to be measured in a 15 kHz post-detection bandwidth. To measure the peak AM depth and correct for the effects of residual noise on the modulation:

1. Measure the peak modulation depth, $(S + N)_{pk}$:

LOCAL (keystrokes)	Measurement — Detector — Filter AUTOMATIC OPERATION n · AM · PEAK t · 15 kHz El
HP-IB (program codes)	AUM1D1L2 Measurement · Detector · Filter

For the purposes of subsequent calculations, assume the displayed AM is 30.80%.

2. Disable auto-ranging by using the Hold Settings Special Function:

LOCAL (keystrokes)	Code: 9 . 0 — Function: 0 SPCL
HP-IB (program codes)	9.0 SP (Code 9.0, Function SP)

3. On the RF signal source, switch the AM off. Measure the residual AM, N_{pk}, on the CW signal. For the purposes of subsequent calculations, assume 0.07% is read on the Modulation Analyzer's display.
4. Measure the average residual modulation:

LOCAL (keystrokes)	Detector: AVG (RMS CAL)
HP-IB (program codes)	D4 (Detector)

For the purposes of subsequent calculations, assume the displayed average residual AM is 0.02%.

5. Compute:

$$\frac{N_{pk}}{N_{av}} = \frac{0.07\%}{0.02\%} = 3.5\%$$

6. Compute:

$$\frac{(S+N)_{pk}}{N_{pk}} = \frac{30.80\%}{0.07\%} = 440$$

7. Use the nomograph to find N%. (For the purposes of these calculations, assume N% is 26%.) Compute:

$$S_{pk} = (S+N)_{pk} - (N_{pk})(N\%) = 30.80\% - (0.07\%)(0.26) = 30.78\%$$

NOTE

This correction factor of <0.1% of the peak reading is typical of a modulation measurement of a quality modulation source measured with the 15 kHz low-pass filter.

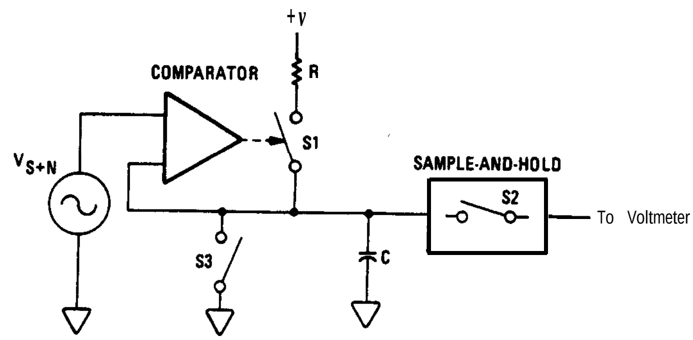
THEORY

Residual noise is the short-term amplitude or phase (and thus frequency) instability inherent in any CW signal source. In a measurement system composed of a signal source and the Modulation Analyzer, residual noise is contributed by both instruments. When modulation is measured with the Modulation Analyzer, both the intended and residual combined are measured. To precisely determine the modulation index due to the baseband signal alone, the effects of residual noise must be factored out of the measurement results.

'Iwo noise components are commonly encountered in modulation measurements: periodic (often line-related) and gaussian (random). Periodic noise and the baseband signal behave identically. The Modulation Analyzer measures the arithmetic sum of the peak or average levels of the two signals (according to the detector selected). To determine the modulation index due to the baseband signal alone, switch the modulation off, measure the peak-residual noise on the same range as before, and subtract the result from the original displayed modulation. The effects of random noise on the measurement system are not as straight forward. True random noise, when viewed in the frequency domain, is a continuous spectrum of frequencies at various amplitudes. The frequency of the noise spectrum is limited only by the bandwidths of the observing and/or generating devices. In the time domain, noise of this kind appears as random amplitude spikes (or fuzz) riding on top of the recovered baseband signal. The amplitude of these spikes is limited by the slow rate of the measuring and/or generating devices. Peak detecting these spikes exaggerates the amount of energy present in the noise spectrum so noise measurements are typically made with average-responding detectors and with limited bandwidths.

The measurement problem arises because modulation index is typically expressed as a peak level. To account for residual noise in these peak measurements, the actual effects of the noise on the Modulation Analyzer's peak detector must be determined.

A simplified diagram of the Modulation Analyzer's peak detector is shown in the following figure. Whenever the signal-plus-noise voltage into the comparator exceeds the voltage stored on the output capacitor, C, the comparator closes switch S1. The capacitor is then charged via the path from +V through resistor R. When the voltage across the capacitor exceeds the voltage of the incoming signal, the comparator opens the switch again. This process continues until the voltage on the capacitor is transferred to the voltmeter through the sample-and-hold switch, S2. C is then discharged by S3. When very narrow noise spikes are imposed on the comparator's input, the charging circuit's RC time constant will not allow the capacitor to fully charge before the noise peak has passed.



Simplified Diagram of the Modulation Analyzer's Peak Detector

When noise alone is imposed on the detector, it is very probable that, as C begins to charge, a noise spike will exceed the voltage across the peak detector capacitor. However, as the voltage across the capacitor more nearly approaches the peak-noise level, this probability decreases. Thus the peak detector, over a significantly long time, can faithfully measure fairly high peak-noise levels.

When noise is riding on a sinewave, only the signal-plus-noise peaks exceeding the sinusoid's peak level can add charge to the peak detector capacitor. Statistically, there is less chance that the composite input signal will exceed the voltage across the capacitor (already charged to the peak of the sinewave) when measuring a sinewave than when measuring only noise. Thus, the contribution of noise on the measured peak-modulation level decreases as the signal-to-noise ratio increases.[1] To simply measure the peak-residual noise present when the modulation is removed and subtract the result directly from the peak reading of the combined input, over-compensates the effects of the noise.

The effects of residual noise on the peak detector depend on the signal-to-noise ratio, the statistics of the noise spikes, and the response time of the specific peak detector. These effects are quantified by taking the ratio of the peak noise reading to the average noise reading. The average noise level is a truer measure of the actual amount of noise energy present, while the peak reading characterizes the peak detector and the statistics of the noise spikes.

[1] Rice, S.O., "Statistical Properties of a Sine Wave Plus Random Noise", Bell System Technical Journal, 27. No.1. (January, 1948). pp. 109-157.

COMMENTS

Noise Must Be Gaussian

The primary restriction placed on this method of accounting for residual noise is that the noise must be gaussian (that is, statistically random). Periodic noise (for example, line-related noise) has repeating peaks and thus does not fall within the statistical model used to derive the nomograph given in the procedure.

A noise-peak-to-noise-average ratio (N_{pk}/N_{av}) greater than 4.4 is a strong indication of a periodic component in the residual noise.

Use Range Hold During Measurement

Both the modulation and the noise measurements used with the nomograph should be made on the same modulation range and with the same peak-detector time-constant. Use the Range Hold key while the instrument is measuring the modulated carrier, then measure the residual noise.

Select the Highest of Successive Readings

When characterizing the effects of residual noise on peak ΦM measurements using the 3 kHz low-pass filter, readings may jump considerably. Use the highest of 10 successive readings for all peak measurements in the computations. (Simply select PEAK HOLD and note the reading after -2 seconds.)

No Residual Noise in Calibration

The residual noise contributions of the AM and FM calibrators and the Modulation Analyzer are accounted for in the calibration procedures. It is not necessary to factor residual noise corrections into the calibration procedures described in this manual. (Refer to AM Calibration and FM Calibration.)

Considerations When Using the RMS Detector

During FM measurements if the RMS detector is selected (Blue Key, AVG), FM de-emphasis pre-display is automatically selected. Pre-display must turn on at this time due to circuit configuration of the Modulation Analyzer. When pre-display is selected this way, it will not turn off automatically when another detector is selected. Turn off pre-display (after selecting another detector) by pressing the PRE DISPLAY key (HP-IB code: PO). Measurements could be affected by this pre-display selection.

Service Request Condition

FUNCTIONS

Special Function 22

DESCRIPTION

The Modulation Analyzer will issue a Require Service message under various circumstances. For exmple, a Require Service message will always be issued if an HP-IB code error occurs. Using the keyboard and the SPCL key, the operator may enable one or more conditions to cause the Require Service message to be issued. Whenever the enabled condition occurs, it sets both the bit corresponding to the condition and bit 7 (RQS bit) in the Status Byte. The bits set in the status byte and the Require Service message are not cleared unless the status byte is read (by serial polling), a Clear message is received and executed by the Modulation Analyzer, or a Controller Clear Service Service Special Function is performed. The enabled Service Request conditions are always disabled again whenever a Clear message is received and executed by the Modulation Anayzer or whenever a Controller Reset or Controller Clear Service Special Function is performed.

PROCEDURE

To enable one or more conditions to cause the Modulation Anayzer to issue a Require Service message, sum the weights of the conditions to be enabled (from the table below). This sum becomes the code suffix of Special Function 22. Enter the Special Function code (perfix, decimal, suffix) using the numeric keyboard. then press the SPCL key. An HP-IB code error (weight = 2) will always cause a Require Service message. This condition cannot be disabled, and if the weight is not summed in, it will be assumed by the instrument.

Condition	Weight
Data ready	1
HP-IB code error	2
Instrument error	4
Upper limit reached	8
Lower limit reached	16

EXAMPLE

To set the Modulation Analyzer to send a Require Service message when an instrument error occurs, or when either an upper or lower limit is reached (or when an HP-IB code error occurs), first compute the Special Function suffix by summing the weights corresponding to those conditions:

$$(2) + 4 + 8 + 16 = 30$$

Enter the code:

LOCAL (keystrokes)	Code: 2 2 . 3 0 — Function: • SPCL
HP-IB (program codes)	22.30SP (Code — Function)

HP-IB PROGRAM CODES

Compute the Special Function code as previously described. SP is the HP-IB code for the SPCL key.

INDICATIONS

As the numeric code is entered, it appears on the front panel display. When the SPCL key is pressed, the display returns to show the measruement previously selected. Special Function 22 has no effect on the SPCL key light. When any enabled condition occurs, both the RQS bit and the bit corresponding to the enabled condition are set in the status byte, and the SQR control line on the HP-IB will set true. The Modulation Analyzer's status byte is shown below for reference.

Bit	Weight	Condition
8*	128	0 (always)
7	64	RQS
6	32	0 (always)
5	16	Lower limit reached
4	8	Upper limit reached
3	4	Instrument error
2	2	HP-IB Code error
1**	1	Data ready

* Most significant bit (MSB)
** Least significant bit (LSB)

COMMENTS

For more information on HP-IB operation, serial polling, and Status Byte message, refer to the discussion REMOTE Operation, Hewlett-Packard Interface Bus, at the beginning of section 3.

The HP-IB Address Special Function provides a convenient means to determine at any time whether a Require Service message is being issued by the Modulation Analyzer.

RELATED SECTIONS

HP-IB Address
Remote Operation, Hewlett-Packard Interface Bus
Limit

Special Functions

FUNCTIONS

All Special Functions prefixed 1 to 39

DESCRIPTION

General Information

Special functions enable extended use of the instrument beyond the control normally available from dedicated front-panel keys. The special functions are best used after a thorough understanding of the instrument is grasped.

Special functions are accessed via keyboard entry of the appropriate numeric code terminated by the SPCL key. (Refer to "Procedures".) The codes comprise a prefix, decimal, and suffix. Special functions are disabled in different ways, depending on the function. Refer to the following comprehensive table for actions which clear or disable any special function. Special functions are grouped by their prefixes into three categories as follows:

Prefix 0

Prefix 0 is the Direct Control Special Function intended for use in servicing the Modulation Analyzer (discussed in detail in Section 8). All instrument error messages and safeguards are inactive. If the Direct Control Special Function is entered inadvertently, press AUTOMATIC OPERATION.

Prefixes 1 to 39

Prefixes 1 to 39 are the User Special Functions that are used during normal instrument operation when a special configuration, a special measurement, or special information is required. All error messages and most safeguards remain in effect unless the operator disables them. These special functions are described in the table in this instruction.

Prefixes 40 to 99

Prefixes 40 to 99 are the Service Special Functions used to assist in troubleshooting an instrument fault (discussed in detail in Section 8). The functions available include special internal measurements, software control, and special service tests and configurations. Most instrument safeguards are relinquished. If a Service Special Function is entered inadvertently, press AUTOMATIC OPERATION. Repair personnel can gain arbitrary control of the instrument as an aid in troubleshooting.

Viewing Special Function States

In addition to completing the entry of special function codes, the SPCL key enables viewing of some special function settings. The operator-requested settings of Special Functions prefixed 1 through 10 can be viewed by pressing the SPCL key once ifollowing no numeric entry). This display is called the Special Display. If some of these Special Functions are in automatic modes (generally the O-suffix setting), the actual instrument settings of these functions can be displayed by pressing the SPCL key a second time while the Special Display is still active. This display is called the Special Special Display. Roth displays can be disabled by pressing any key except the Blue Key, LOCAL, or S (shift) key. (While either display is active, pressing the SPCL key selects the other display.)

A summary of User Special Functions is provided at the end of this instruction. Also included in this instruction are procedures for initiating special functions and for obtaining the Special Display and the Special Special Display.

PROCEDURES

Entering Special Functions

To use a special function, key in the corresponding code, then select SPCL.

Special Display

To display the user-requested modes of special functions prefixed 1 through 10, select SPCL alone one time. The digit position (noted beneath the display) corresponds to the special function prefix, and the number displayed in that position correspond-s to the special function suffix.

Special Special Display

To determine the actual instrument settings corresponding to special functions prefixed 1 through 10, press the SPCL key alone once while the Special Display is active. (If the Special Display is not active, press the SPCL key twice to get this display.) The digit position corresponds to the special function prefix, and the number displayed in that digit corresponds to the special function suffix.

HP-IB PROGRAM CODES

All special function codes are formed by the special function number followed by the code "SP". For example, the code for Special Function 7.3 is "7.3SP".

For special function codes with zero as a suffix, force a single space if the zero is to be ommitted. For example, "10.0SP" could be "10. SP"

EXAMPLES

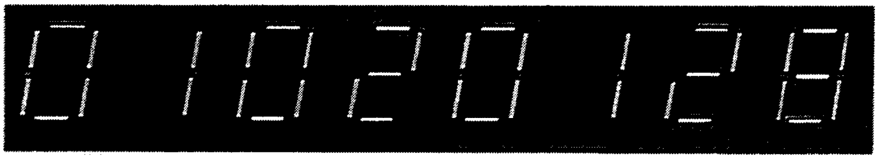
Entering Special Functions

To display the frequency of the signal in the IF (Special Function 10):

LOCAL (keystrokes)	Code: 1 0 . 0 — Function: • SPCL
HP-IB (program codes)	10.0SP (Code: 10.0 — Function: SP)

Viewing the Special Display

When SPCL is pressed alone once, the following display might result:

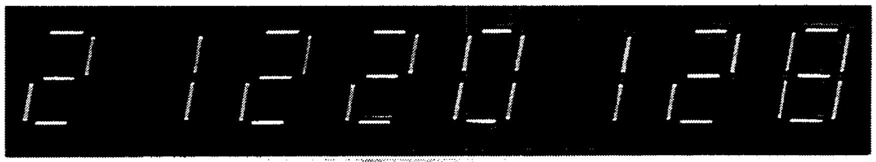


This display is interpreted as follows:

Special Function		User-Requested Setting
Code	Name	
1.0	Input Attenuation	Automatic Selection
2.1	Modulation Range	40% AM; 4 kHz FM; 4 radians ΦM
3.0	IF Frequency and Input High-Pass Filter	Automatic Selection; no Input High-Pass Filter
4.2	Tune Mode	Manual Tuning
5.0	Audio Peak Detector Time Constant	Fast Peak Detector
6.1	AM ALC Response	Fast AM ALC
7.2	Frequency Resolution	1000 Hz Resolution
8.8	Measurement Error Disable	E01 through E04 enabled

Special Special Display

When SPCL is pressed again, the following display might result: (The user-selected Special Functions shown in the previous example are repeated in the Special Special Display. The Special Functions that were left in the automatic selection mode will display the suffix that was automatically selected.)



The display is interpreted as follows:

Special Function		Actual Instrument Setting
Code	Name	
1.2	Input Attenuation	10 **dB** Attenuation
2.1	Modulation Range	**40%** AM; 4 **kHz** FM; 4 radians (PM
3.2	IF Frequency and Input High-Pass Filter	1.5 MHz IF Frequency; no Input High-Pass Filter
4.2	Tune Mode	Manual Tuning
5.0	Audio Peak Detector Time Constant	Fast Peak Detector
6.1	AM ALC Response	Fast AM ALC
7.2	Frequency Resolution	1000 Hz Resolution
3.8	Measurement Error Disable	**E01** through E04 **Enabled**

COMMENTS

Omit Zero Suffixes

If a special function has a suffix of zero, the zero need not be entered. For example, 10.0 SPCL equals 10.SPCL. (However, 22.2 SPCL does not equal 22.20 SPCL nor does 18.1 SPCL equal 18.10 SPCL.) If entering a special function code evokes Error 21 (invalid key sequence), the special function requested has not been executed.

HP-IB

Force a single space in “10. SP” if the zero is to be omitted.

CLEAR Key

If an error is made while keying in the special function code, select CLEAR and re-enter the code.

Special Functions

Special Function Summary (1 of 4)

Special Function Name	Code	Program Code HP-IB	Description	Disabled by: Lights SPCL key	Disabled by: AUTO. OP. key	Disabled by: Any MEAS. key	Disabled by: CLEAR key	Disabled by: All keys*	Display Timed	References and Comments
Input Attenuation	1.0	**1.0SP**	Automatic selection	N		—	—	—	—	Attenuation, Input
	1.1	**1.1SP**	0 **dB** input attenuation	Y	Y	N	N	N	—	
	1.2	**1.2SP**	10 **dB** input attenuation	Y	Y	N	N	N	—	
	1.3	**1.3SP**	20 **dB** input attenuation	Y	Y	N	N	N	—	
	1.4	**1.4SP**	30 **dB** input attenuation	Y	Y	N	N	N	—	
	1.5	**1.5SP**	40 **dB** input attenuation	Y	Y	N	N	N		
	1.6	**1.6SP**	50 **dB** input attenuation	Y	Y	N	N	N	—	
Modulation Range	2.0	**2.0SP**	Automatic selection **AM (%) | FM (kHz) | ΦM (rad)**	N		—	—		—	Modulation Range Modulation Output
	2.1	**2.1SP**	**≤ 40 | ≤ 4 | ≤ 0.4* | ≤ 4**	Y	Y	N	N	N	—	
	2.2	**2.2SP**	**≤100 | ≤ 40 | ≤ 4* | ≤ 40**	Y	Y	N	N	N	—	
	2.3	**2.3SP**	**≤100 | ≤400 | ≤ 40* | ≤400** ***with 750 µs de-emphasis. pre-display**	Y	Y	N	N	N		
IF Frequency and Input High-Pass **Filter**	3.0	**3.0SP**	Automatic IF selection; input high-pass filter out **IF (MHz) | Input High-Pass Filter**	N	—		—	—		Frequency, IF and Input High-Pass **Filter**
	3.1	**3.1SP**	**0.455 | Out**	Y	Y	N	N	N	—	
	3.2	**3.2SP**	**1.5 | Out**	Y	Y	N	N	N		
	3.3	**3.3SP**	**0.455 | In**	Y	Y	N	N	N		
	3.4	**3.4SP**	**1.5 | In**	Y	Y	N	N	N	—	
Tune Mode	4.0	**4.0SP**	Automatic tuning; low noise LO	N	—		—		—	Tuning
	4.1	**4.1SP**	Automatic tuning; track mode	Y	Y	N	N	N		
	4.2	**4.2SP**	Manual tuning via keyboard entry	Y	Y	N	N	N		
Audio Peak Detector Time Constant	5.0	**5.0SP**	Fast peak detector	N	—	—	—			Detector (Peak) Time Constant
	5.1	**5.1SP**	Slow peak detector	Y	Y	N	N	N	—	
AM ALC **Response**	6.0	**6.0SP**	Slow AM ALC response	N	—	—	—		—	AM ALC Response Time
	6.1	**6.1SP**	Fast AM ALC response	Y	Y	N	N	N	—	
	6.2	**6.2SP**	AM ALC off	Y	Y	N	N	N	—	

N = No ; — = Not Applicable : Y = Yes; *Except the LCL. S (Shift). and Numeric Keys

Special Functions

Special Function Summary (2 of 4)

Special Function: Name	Special Function: Code	Program Code HP-IB	Description	Lights SPCL key	Disabled by: AUTO. OP. key	Disabled by: Any MEAS. key	Disabled by: CLEAR key	Disabled by: All keys*	Display Timed	References and Comments
Frequency Resolution	7.0	**7.0SP**	Automatic selection	N		—	—	—	—	Frequency Resolution
	7.1	**7.1SP**	10 Hz resolution (f<1 GHz)	Y	Y	N	**N**	N	—	
	7.2	**7.2SP**	1000 Hz resolution	Y	Y	N	**N**	N	—	
Error Disable	8.0	**8.0SP**	Automatic selection	**N**		—	—			Error Disable; Error Message Summary; Attenuation, Input; Modulation Range; Tuning
	8.1	**8.1SP**	**E01** disabled	**Y**	Y	N	N	N		
	8.2	**8.2SP**	**E02** and E03 disabled	**Y**	Y	N	N	N		
	8.3	**8.3SP**	**E01,** E02, and E03 disabled	**Y**	Y	N	N	N		
	8.4	**8.4SP**	E04 disabled	**Y**	Y	N	N	N		
	8.5	**8.5SP**	**E01** and E04 disabled	**Y**	Y	N	N	N		
	8.6	**8.6SP**	E02, E03, and E04 disabled	**Y**	Y	N	N	N		
	8.7	**8.7SP**	**E01** through E04 disabled	**Y**	Y	N	N	N		
	8.8	**8.8SP**	**E01** through **E04 enabled**	**Y**	Y	N	N	N		
Hold Settings	9.0	**9.0SP**	Holds ranges, tuning, and error modes at present settings; disables automatic functions	Y	Y	N	N	N		Hold Settings
IF Frequency Measurement	10.0	**10.0SP**	Measures IF **signal** frequency	Y	N	Y	N	N	N	Frequency, IF
Reenter RATIO with Previous Reference	11.0	**11.0SP**	Reenter **%** RATIO	N	—	—	—	—		**Ratio**
	11.1	**11.1SP**	**Re-enter dB** RATIO	N		—	—	—		
	11.2	**11.2SP**	Read RATIO reference	Y	Y	Y	Y	Y	Y	
	11.3	**11.3SP**	Make RATIO reference negative	N	—	—	—			
FM Calibrator	12.0	**12.0SP**	Display computed peak FM deviation	Y	**N**	**Y**	**N**	**N**	N	Calibration, FM; NOTE: 12.1 and 12.2 set the Modulation Range to 2.2.
	12.1	**12.1SP**	Display demodulated peak residual FM deviation	Y	**N**	**Y**	**N**	**N**	N	
	12.2	**12.2SP**	Display demodulated peak FM deviation	Y	**N**	**Y**	**N**	**N**	N	
AM Calibrator (Continued on next page)	13.0	**13.0SP**	Display computed peak AM depth	Y	N	Y	N	N	N	Calibration, AM

N = No; — = Not applicable; Y = Yes: *Except the LCL. S (Shift). and Numeric Keys

Special Functions

Special Function Summary (3 of 4)

Special Function Name	Special Function Codt	Program Code HP-IB	Description	Lights SPCL key	Disabled by: AUTO. OP. key	Disabled by: Any MEAS. key	Disabled by: CLEAR key	Disabled by: All keys*	Display Timed	References and Comments
AM Calibrator (Cont'd)	13.1	**13.1SP**	Display demodulated peak residual AM depth	Y	N	Y	N	N	N	NOTE: 13.1 and 13.2 set the Modulation Range to 2.1.
	13.2	**13.2SP**	Display demodulated peak AM depth	Y	N	Y	N	N	N	
Set Limit	14.0	**14.0SP**	**Clear** limits; turn off LIMIT annunciator	N	—	—		—	—	Limit, Ratio
	14.1	**14.1SP**	Set lower limit to RATIO reference	N	N	N	N	N	—	NOTE: 14.5 and 14.6 Special Functions wil display 0 if the limit is not enabled.
	14.2	**14.2SP**	Set-upper limit to RATIO reference	N	N	N	N	N	—	
	14.3	**14.3SP**	Restore lower limit	N	N	N	N	N		
	14.4	**14.4SP**	Restore upper limit	N	N	N	N	N	—	
	14.5	**14.5SP**	Read lower limit	Y	Y	Y	Y	Y	Y	
	14.6	**14.6SP**	Read upper limit	Y	Y	Y	Y	Y	Y	
	14.7	**14.7SP**	Read lower limit measurement code	Y	Y	Y	Y	Y	Y	
	14.8	**14.8SP**	Read upper limit measurement code	Y	Y	Y	Y	Y	Y	
Time Base Oven (Option 002 **only)**	15.0	**15.0SP**	Display E12 if internal reference oven is cold	Y	Y	Y	Y	Y	N	If the oven is warm or if the high stability reference oscillator is not installed; no display change occurs.
AM Calibration (Option 010 **only)**	16.0	**16.0SP**	Disable AM calibration factor	N	—	—		—		Calibration, AM
	16.1	**16.1SP**	Enable AM calibration factor	N	N	N	N	N		
	16.2	**16.2SP**	Read AM calibration factor (0 if not enabled)	Y	Y	Y	Y	Y	Y	
FM Calibration (Option 010 **only)**	17.0	**17.0SP**	Disable FM calibration factor	N	—	—	—	—		Calibration, FM
	17.1	**17.1SP**	Enable FM calibration factor	N	N	N	N	N	—	
	17.2	**17.2SP**	Read FM calibration factor (0 if not enabled)	Y	Y	Y	Y	Y	Y	

N = No; — = Not applicable: Y = Yes: *Except the LCL. S (Shift). and Numeric Keys

Special Functions

Special Function Summary (4 of 4)

Special Function Name	Special Function Code	Program Code HP-IB	Description	Lights SPCL key	Disabled by AUTO. OP. key	Disabled by Any MEAS. key	Disabled by CLEAR key	Disabled by All keys*	Display Timed	References and Comments
Tone Burst Receiver	18.NN	18.NNSP	Configures the Modulation Analyzer as a tone burst receiver where a settling time is inserted between detecting a carrier and turning on MODULATION OUTPUT. NN is that time from 1 through 99 ms. If NN = 0, the delay is 99 ms.	Y	Y	Y	Y	Y	N	Tone Burst Receiver
HP-IB Address	11.0	21.0SP	Displays HP-IB address in form AAAAA.TLS. AAAAA is the binary address. T-l means talk only, L-l means listen only; S=1 means service request issued.	Y	Y	Y	Y	Y	N	HP-IB Address
Service Request	22.NN	22.NNSP	Enables a condition to cause a service request to be issued. NN is the sum of any combination of the weighted conditions below: 1 Data ready 2 HP-IB error 4 Instrument error 8 Upper limit reached 16 Lower limit reached Instrument powers up in the 22.2 state.	N	N	N	N	N	N	Service Request Condition. This function is set to zero suffix by a HP-IB Clear message or by Service Special Functions 40 and 41.

N = No: — = Not Applicable: Y = Yes; *Except the LCL. S (Shift), and Numeric Keys

Time Base 10 MHz Input and Output

GENERAL

CAUTION

Do not apply greater than 20 V (pk) (ac + dc) into the TIME BASE 10 MHz INPUT or damage to the instrument may result.

Do not apply greater than 3 V dc or greater than +20 dBm into the TIME BASE 10 MHz OUTPUT or damage to the instrument may result.

DESCRIPTION

TIME BASE 10 MHz INPUT provides an iinput for an external 10 MHz time base reference. This input is ac coupled and requires an input signal level greater than 0.5 V (p-p). The input impedance is approximately 500Ω. TIME BASE 10 MHz OUTPUT (available only with the high stability reference, Option 002) proviides an output for the internal 10 MHz reference. This is a 50Ω, TTL compatiible output (0 V to > 2.2 V into an open circuit.

COMMENTS

An Option 002 (high stability reference) Modulation Analyzer driven from an external reference will only output the signal form its own internal reference, not the external input signal.

When using an external time base reference, the accuracy of all measurements depends on the accuracy of the external reference.

When an external time base of sufficient amplitude is applied, the Modulation Analyzer time base circuitry automatically switches to the external time base.

If the internal time base fails, an external time base may still be used. Connect the extenal time base to TIME BASE 10 MHz INPUT, the switch the instrument's LINE switch to STBY and back to ON.

To drive several instruments from a singe1 external reference, simply use a BNC tee at the Modulation Analyzer's TIME BASE 10 MHz INPUT.

To determine whether the Modulation Analyzer has actually switched in the externally applied time base, key in 46.9 SPCL. The display should show 1000 000 ±1 if the external time base is in. If the external signal was not switched in, the display will show 0 or 1 only.

Tone-Burst Receiver

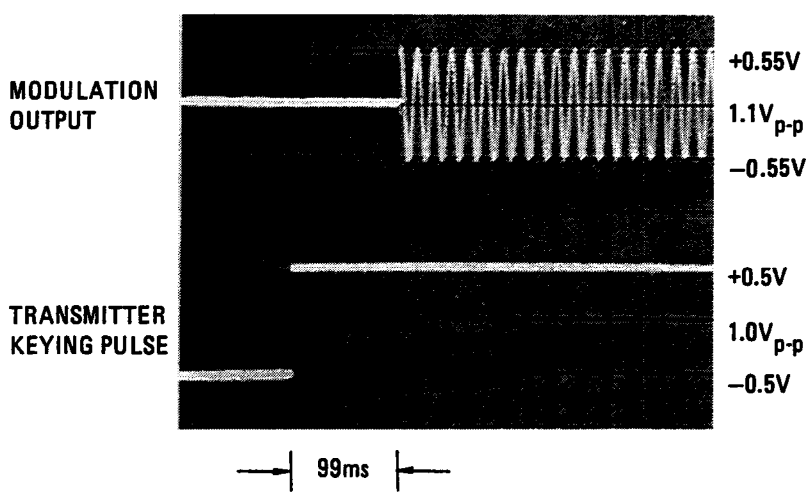
FUNCTIONS

Special Function 18 (Tone-Burst Receiver)

DESCRIPTION

In some FM applications (mobile radio testing, for example), after a transmitter is keyed, it issues squelch tones for a brief interval Often, it is necessary to measure the frequency of the squelch tones. This measurement is made difficult by the noise in the demodulated audio during the short delay between the keying of the transmitter and the appearance of the audio tones.

Special Function 18 enables the Modulation Analyzer to be configured as a tone-burst receiver. This function inserts a user-selectable delay between the instant the instrument senses an RF signal at its INPUT and the time when it turns on the output of MODULATION OUTPUT. When an external counter is connected to this output, the squelch tone will reach the counter only when a valid measurement can be made. The time delay is selectable from 1 through 99 milliseconds. The following photo illustrates a 99 ms delay between transmitter keying (lower trace).



Oscilloscope Photo Depicting a 99 ms Delay Between Transmitter Keying Pulse (Lower Trace) and Activation of MODULATION OUTPUT

PROCEDURE

In order to successfully measure tone bursts:

1. Tune and range the Modulation Analyzer.
2. Select FM.
3. Select an audio detector and if desired, audio filters and FM de-emphasis.
4. Key on the transmitter and allow the Modulation Analyzer to range and tune automatically.
5. Select Hold Settings (9.0 SPCL) to hold all ranges and tuning.
6. Select the time delay to be inserted between the moment the transmitter is keyed and the time MODULATION OUTPUT is to be turned on. This delay becomes the Special Function suffix. (If 18.0 SPCL is selected, the Modulation Analyzer executes a 99 ms delay.)
7. Enter the Special Function code 18.NN (where NN is the selected delay in milliseconds), then select SPCL. (If 18.5 is entered, a 5 ms delay is executed. For a 50 ms delay, enter 18.50.)

The Modulation Analyzer is now set up to receive tone bursts. To exit this mode, select any key except the S (shift), LCL, or numeric keys.

EXAMPLES

A 50 ms delay is inserted by the Modulation Analyzer between the keying of an FM mobile radio transmitter and the measuring of its squelch tone frequency. It is assumed that the Modulation Analyzer is tuned to the transmitter frequency and that the input attenuation, modulation range and tuning are fixed.

LOCAL (keystrokes!	Code: [1] [8] [.] [5] [0] Function: [•] SPCL
HP-IB (program codes)	18.50SP (Code: 18.50, Function: SP)

PROGRAM CODES HP-IB

The Special Function code suffix is derived from the time delay as described previously. The HP-IB code for the SPCL key is SP.

INDICATIONS

As the numeric code is entered, it appears on the front panel display. When the SPCL key is pressed, the display shows two dashes (– –) if no RF is at the INPUT. The display shows 18.NN if RF is present (NN is the delay in milliseconds). All key lights will be turned off (including the FM and DETECTOR) keys) except the filter and de-emphasis keys (if selected) and the SPCL key. Note that if DE-EMPHASIS PRE-DISPLAY is selected, the PRE-DISPLAY key will be turned off since FM is not being displayed.

COMMENTS

Suggested Use of Maximum Delay

When using the Tone Burst Receiver Special Function, use the 99 ms delay for best results. Shorter delays require very careful setup since, with no input, the high-gain IF Amplifier and Limiters "tune" the noise to an average frequency often slightly different than the nominal IF. When RF first enters the instrument, the IF shifts abruptly to the nominal frequency. This shift creates an FM transient which settles out after a short period and thus is not apparent with longer delays. With short delays the transients can be avoided by carefully tuning the instrument so that the IF frequency when the transmitter is on is close to, or equal to the average IF frequency when the transmitter is off.

HP-IB

This function is best used when operating through HP-IB since the external counter connected to the output of MODULATION OUTPUT may need to acquire several sets of data in rapid succession (when counting multiple tones, for example).

Selective Range Holding

Ranges can be held for this function using the individual Special Functions for each parameter instead of using the Hold Settings Special Function (9.0 SPCL).

Default Condition

Special Function code 18.0 provides a 99 ms delay.

Tone Burst Frequency Cannot Be Measured

The audio frequency measurement mode cannot be used to measure the frequency of the tone burst.

ΦM But Not AM

This feature works also with the ΦM measurement mode but not AM.

RELATED SECTIONS

Attenuation, Input
FM
Hold Settings
Modulation Range
Special Functions
Tuning

Tuning

FUNCTIONS

Special Function 4

DESCRIPTION

The Modulation Analyzer is considered tuned to an input signal when the frequency of the Local Oscillator (LO) is adjusted to produce au IF signal that is centered in the IF passbaud. Normally, this occurs when the LO frequency is placed either 1.5 MHz or 455 kHz above the input frequency, depending upon which IF is selected. The only exception to the above is when the 1.5 MHz IF is selected for input frequencies below 2.5 Mhz. Under these conditions, the LO is tuned to 101.5 MHz and the low-frequency input passes directly into the IF.

The Modulation Analyzer employs two techniques to determine what frequency to tune to. In Automatic tuning, the entire input spectrum is searched for the presence of a signal. Once found, the LO is tuned so that the signal is received. In manual tuning, the desired input frequency is entered via the numeric keyboard, and the LO is tuned so that the frequency is received.

The LO can be configured in two ways: a fixed frequency mode that is used for low-noise measurements, and a tracking mode in which the LO follows a moving input signal. The two frequency selection techniques and LO configurations combine to produce three tuning modes: Automatic Tuning — Low Noise LO, Automatic Tuning — Track Mode, and Manual Tuning. Two kinds of manual tuning are allowed: keyboard entry of input frequency and frequency stepping. All of these tuning modes are described in more detail below.

Automatic Tuning — Low-Noise LO

In this mode, if not already tuned, the Modulation Analyzer searches throughout its frequency range for an input signal and tunes to it. To successfully tune to the desired signal, the signal's second and third harmonic levels must be al least 10 dB below the level of the fundamental. All other signals at the input must be at least 30 dB below the level of the desired signal. If two input signal have similar power levels, the higher frequency signal is usually selected. Once tuned, the LO is locked to an internal voltage controlled crystal oscillator for highly stable, low-noise measurements. This tuning is maintained as long as a detectable signal is present. If the input signal disappears (drops below -20 to -25 dBm), the Modulation Analyzer returns to the searching process. This mode of tuning is selected whenever AUTOMATIC OPERATION is pressed, and may be used with either the 1.5 MHz or 455 kHz IF.

Automatic Tuning — Track Mode

In this mode, the instrument searches for the input signal as described above; however, it does not lock to the internal reference oscillator. Instead, the LO is locked to the input signal itself and thus tracks that signal as it moves. This is extremely useful for checking modulation or level as a function of carrier frequency. If the input signal disappears (for example, while switching bands), the Modulation Analyzer will search for, and will re-acquire the input signal. Track mode tuning is not allowed with the lo-rate LFM on the input signal, thus FM measurements should only be made in track mode when modulation rates exceed 1 kHz. Also, track mode tuning is not recommended where optimum noise performance is recommended where optimum noise performance is required.

Manual Tuning by Keyboard Entry

In this mode, the instrument tunes to receive the frequency keyed into it by way of the keyboard regardless of whether a signal is found there or not. Once tuned, it locks to an internal voltage-controlled crystal oscillator for high stability and low noise. Once locked, tuning will not change unless a new frequency is entered. The tuning is stepped up or down using the kHz ⇑ or kHz ⇓ keys, or an automatic tuning mode is selected. The manual tune mode is entered immediately when either the MHz, kHz ⇑, or kHz ⇓ key is pressed or if either the Manual Tuning by Keyboard Entry (4.2 SPCL), or Hold Settings (9.0 SPCL) is selected.

Frequency Stepping

Using the kHz ⇑ and kHz ⇓ keys the tuning of the Modulation Analyzer can be changed by a selectable frequency step. These keys are most often used in conjunction with the frequency error function. The kHz keys may be used regardless of the tune mode the instrument is in, but when pressed, the always set the tune mode to manual. If these keys are pressed while in one of the automatic tuning modes, they will set the tuning to the last successfully tuned frequency plus or minus the frequency step. Once a frequency step is entered on the keyboard (refer to Procedure below), either the kHz ⇑ or kHz ⇓ key pressed alone will change tuning by that step size until a new step frequency is defined. At turn-on, the step size is zero.

PROCEDURE

Tune Mode Selection

To select the automatic tuning — low-noise LO mode, press AUTOMATIC OPERATION or key in 4.0 SPCL. To select automatic tuning — track mode, key in 4.1 SPCL. To select manual tuning by keyboard entry, press either MHz or one of the kHz key (with or without a preceding keyboard entry), key in 4.2 SPCL, or use the Hold Settings Special Function (9.0 SPCL). The special function and HP-IB codes for tune mode selection are summarized in the following table.

Tune Mode	Special Function Code	HP-IB Program Code
Automatic tuning: low-noise lock	4.0 SPCL	4.0SP
Automatic tuning: track mode	4.1 SPCL	4.1SP
Manual tuning by keyboard entry	4.2 SPCL	4.2SP

Manual Tuning by Keyboard Entry

To manually tune to a specific signal frequency, enter the frequency in MHz using the numeric keyboard, then press the MHz key. The MHz key may also be used alone to aid in tuning. If the Modulation analyzer is tuned close but not exactly to the input signal, press the MHz key to center the signal in the IF passband. If in automatic tuning mode, and no signal is present, pressing the MHz key alone tunes the Modulation Analyzer too the last frequency at which a signal was successfully tuned. (If no previous successful tuning has been made, the Modulation Analyzer will tune to 100 MHz.)

When only using the 455 kHz IF, the Modulation Analyzer does not normally tune to input frequencies below 2.5 MHz. If error E01 is disabled, however, the instrument can be manually tuned down to 815 kHz. First select the 455 kHz IF by keying in 3.1 SPCL. Then disable error E01 bye keying in 8.1 SPCL. Now, manually tune by keyboard entry as described above.

Frequency Stepping

To step the tuning of the Modulation Analyzer, enter the desired frequency step size in kHz using the numeric keyboard, then press either kHz ⇑ or kHz ⇓. Once the step size has been set, either kHz key will change the tuning by that step size each time the key is pressed. (At turn-on, the step size is set to 0 kHz.)

Examples

Tune Mode Selection. To enter the automatic tuning — track mode:

LOCAL (keystrokes)	Code: [4] [.] [1] — Function: [•] SPCL
HP-IB (program codes)	4.1SP Code: 4.1 — Function: SP

Manual Tuning by Keyboard Entry. To tune to a 934.5 MHz input signal:

LOCAL (keystrokes)	Code: [9] [3] [4] [.] [5] — Function: MZ [MHz] INPUT FREQ
HP-IB (program codes)	934.5MZ Code: 934.5 — Function: MZ

To tune to a 1 MHz input signal using the 455 kHz IF:

LOCAL (keystrokes)	Code: [3] [.] [1] — Function: [•] SPCL — Code: [8] [.] [1] — Function: [•] SPCL — Data: [1] — Function: MZ [MHz] INPUT FREQ -Select 455 kHz IF -- Disable E0 — Tune to 1 MHz-
- (program codes)	3.1SP8.1SP1MZ Code: 3.1 — Function: SP — Code: 8.1 — Function: SP — Data: 1 — Function: MZ

Frequency Stepping. To set a 10 kHz frequency step and to increase the tuning by that step size:

LOCAL (keystrokes)	Data: 1 0 — Function: [shift] kHz
HP-IB (program codes)	10KU (Data: 10 — Function: KU)

Program Codes

The HP-IB codes for selecting the different tune modes are given under Procedure above. The HP-IB codes for manual tuning are given below. Note that when operating the Modulation Analyzer in remote, the programmer may optionally enter frequencies in fundamental units (Hz).

Key or Function	HP-IB Program Code
MHz (INPUT FREQ)	MZ
Hz (INPUT FREQ)	HZ
kHz ⇑	KU
Hz ⇑	HU
kHz ⇓	KD
Hz ⇓	HD

INDICATIONS

When numeric codes or data are entered using the keyboard, they will appear on the display. When a terminating key is pressed (MHz, kHz, or SPCL), the display returns to show the result of the measurement previously selected. If the automatic tuning — low noise LO mode is selected, the SPCL key will not turn on (unless already on). All other tuning modes will light that key.

COMMENTS

The automatic tuning — low noise LO mode is adequate for most common signal measurements. It should always be used for measuring narrow deviation FM and ΦM, or TUNED RF LEVEL flatness as a function of carrier frequency. Manual tuning mode should be used whenever drops in signal level may occur that may otherwise cause returning (for example AM in excess of 99%). For example, when making TUNED RF LEVEL measurements or when counting frequency, manual tuning allows measurements to be made on very low-level signals.

When manually tuning or frequency stepping, use the FREQ ERROR measurement to determine tuning accuracy.

When the Modulation Analyzer tunes to an input signal greater than 2.5 MHz, its internal local oscillator (LO) is positioned above the nominal tuning by the IF frequency. Since the image passband is not filtered out, image signals pass into the IF amplifier with the same ease as signals in the nominal passband. When signals other than those on which measurements are to be made fall into the image passband, measurement errors may result. One way to solve this problem is to step the tuning down by twice the IF frequency. This causes the desired frequency to pass through the image passband and often places the nominal passband in a portion of the input spectrum where interfering signals do not exist. The spectrum diagram (figure 3–XX) illustrates the relative position of the LO and both the nominal and image passbands for each IF frequency.

Whenever signals below 2.5 MHz are tuned to using the 1.5 MHz IF, the LO is placed at 101.5 MHz and the input signal is allowed to pass directly into the 1.5 MHz IF. (The LO serves only to turn the mixer on.) Note, however, that this also creates a passband from 98.5 to 104.5 MHz. If this is a problem, manually tune the LO so the passbands fall in some unoccupied region of the input spectrum. This requires that error E01 must be disabled. Also, as a result, input frequency measurements will be incorrect, but the IF frequency function (Special Function 10) can be used to measure the input frequency instead.

When making measurements on inputs with frequencies greater than 10 MHz, if signals below, 2.5 MHz are present in the spectrum, they appear directly in the IF. These low-frequency signals can be removed by inserting the input high-pass filter. Refer to *IF Frequency, and Input High Pass Filter Selection.*

When manually tuning, often the exact input frequency is not known. If upon tuning, error E01 (signal out of IF range) is displayed, press the MHz key alone to center the signal in the IF. Also, if searching for a signal using the kHz keys, it is best to search down from above the signal frequency while monitoring IF LEVEL. When the IF level rises significantly , switch to FREQ ERROR and enter the displayed value as a frequency step and complete tuning using the kHz keys.

When the 1.5 MHz IF is used for inputs below 2.5 MHz, FM at MODULATION OUTPUT is inverted.

When working with agile frequency sources (such as frequency synthesizers) it is possible for the carrier to hop to frequency whose spectrum still has sufficient power within the tuned passband of the Modulation Analyzer's input. When this occurs, the Modulation Analyzer may not retune (if in an automatic tune mode) since it appears that the carrier simply dropped in power. If the instrument does not retune, frequency and power measurement results may not be as expected. Use the manual tune mode if possible when working with frequency agile sources.

RELATED SECTIONS

Default Conditions and Power-Up Sequence
Hold Settings
IF Frequency
Special Functions

Section 4
PERFORMANCE TESTS

4-1. INTRODUCTION

The procedures in this section test the instrument's electrical performance using the specifications of table l-l as the performance standards. All tests can be performed without access to the interior of the instrument. A simpler operational test is included in the Basic Functional Checks in section 3.

NOTE

Unless otherwise noted, no warm-up period is required for these tests.

Line voltage must be within +5% and -10% of nominal if the performance tests are to be considered valid.

4-2. EQUIPMENT REQUIRED

Equipment required for the performance tests is listed in table l-3, "Recommended Test Equipment" in section 1. Any equipment that satisfies the critical specifications given in the table may be substituted for the recommended model(s).

4-3. TEST RECORD

Results of the performance tests may be tabulated on the test record at the end of the procedures. The test record lists all of the tested specifications and their acceptable limits. The results, recorded at incoming inspection, can be used for comparison in periodic maintenance and troubleshooting and after repairs or adjustments.

4-4. CALIBRATION CYCLE

This instrument required periodic verification of performance. Depending on the use and environmental conditions, the instrument should be checked using the following performance tests at least once every year.

4-5. ABBREVIATED PERFORMANCE TESTING

No abbreviation of performance testing is recommended.

Performance Test 1

AM TESTS (FOR HP 8901A EQUIPPED WITH OPTION 010)

Specifications

Characteristic	Performance Limits	Conditions
MPLITUDE MODULATION		
ates	20 Hz to 10 kHz 20 Hz to 100 kHz	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier
epth	To 99%	
ccuracy[1,2,]	±2% of reading ±1 digit ±3% of reading ±1 digit ±1% of reading ±1 digit ±3% of reading ±1 digit	150 kHz to 10 MHz carrier; 50 Hz to 10 kHz rates; 5 to 99% depth 150 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates; 5 to 99% depth 10 to 1300 MHz carrier; 50 Hz to 50 kHz rates; 5 to 99% depth 10 to 1300 MHz carrier; 20 Hz to 100 kHz rates; 5 to 99% depth
latness[3,4]	±0.3% of reading ±1 digit	10 to 1300 MHz carrier; 90 Hz to 10 kHz rates; 20 to 80% depth
Demodulated Output Distortion	< 0.3% THD < 0.6% THD	≤ 50% depth ≤ 95% depth
Residual AM[1]	< 0.01% rms	50 Hz to 3 kHz bandwidth
FREOUENCY MODULATION		
M Rejection(')	< 20 Hz peak deviation	50% AM depth: 400 Hz and 1 kHz rates; 50 Hz to 3 kHz bandwidth
PHASE MODULATION		
M Rejection(l)	< 0.03 rad peak deviation	50% AM depth; 1 kHz rate; 50 Hz to 3 kHz bandwidth

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in *Detailed Operating Instructions* in section 3.)

(2) For peak measurements only, AM accuracy may be affected by distortion generated by the Modulation Analyzer. In the worst case, this can decrease accuracy by 0.1% of reading for each 0.1% of distortion.

(3) Flatness is the variation in indiited AM depth for constant depth on input signal.

(4) For optimum flatness, cables should be terminated with their characteristic impedance.

Description

AM accuracy is measured with the internal AM Calibrator (Option **010),** which produces approximately 33% AM at a 10 **kHz** rate. A low-residual AM source is connected to the input and the internal residual AM is measured. A source, which can produce wide-band, linear AM, is modulated at various AM rates and depths to measure distortion, flatness, and incidental FM and **ΦM.** A special AM/FM test source is **required** for these tests to assure that the AM source has adequate bandwidth, low distortion, low residual AM, and low incidental FM and **ΦM.**

NOTE

This procedure is only for Modulation Analyzers equipped with the AM Calibrator (Option 010). For Modulation Analyzers not equipped with Option 010, use Performance Test 1A which uses the AM Calibrator from a second HP 8901A that is equipped with Option 010.

Equipment

AM/FM Test Source .... HP 11715A
Audio Analyzer .... **HP 8903B**
Audio Synthesizer .... HP 3336C (Opt. 005)

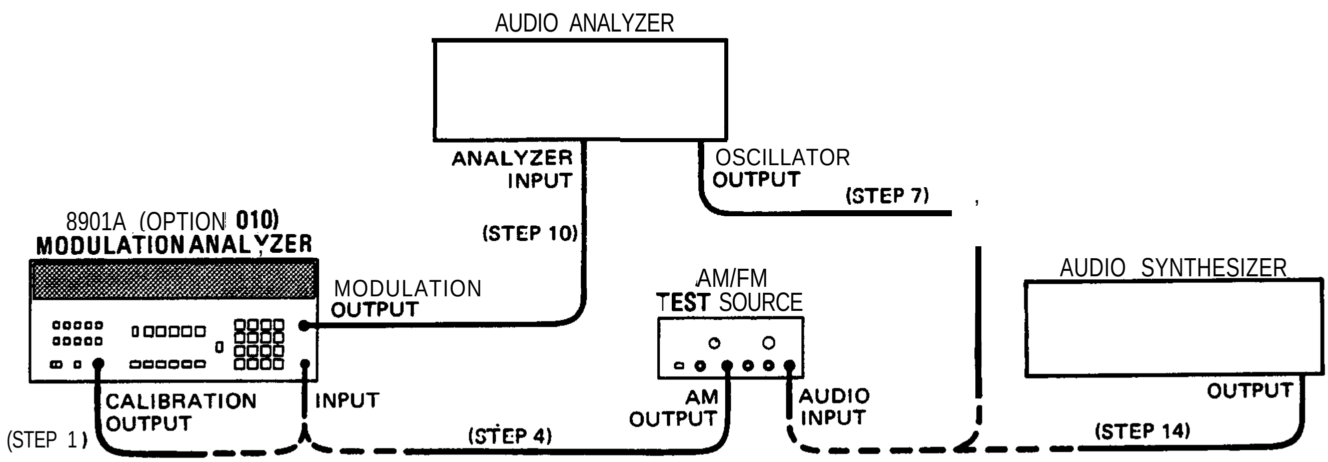


Figure 4-1. AM Performance Test Setup (for HP 8901A Equipped with Option 010)

Procedure

AM Accuracy at 10 kHz Rate

1. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Connect the Modulation Analyzer's CALIBRATION OUTPUT to its INPUT.

NOTE

For greatest accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

2. On the Modulation Analyzer, press AM and then press CALIBRATION. Allow at least two readings (approximately 40 seconds) to pass. The display should read between 99 and 101%.

AM Calibration Factor 40% AM Range: 99 ____________ 101%

3. Key in 2.2 SPCL to set the AM range to 100% AM. Allow at least two readings to pass . The display should read between 99 and 101%. Record this value for future reference.

AM Calibration Factor 100% AM Range: 99 ____________ 101%

Residual AM

4. On the AM/FM test source, set the test mode switch to AM. Connect the test source AM output to the Modulation Analyzer's INPUT. (See figure 4-l. Nothing should be connected to the test source's audio input.)
5. On the Modulation Analyzer, press FREQ and key in 4.1 SPCL to turn on Track Mode. Tune the AM/FM test source's carrier frequency to approximately 12.5 MHz. Key in *4.0* SPCL to turn off Track Mode.
6. On the Modulation Analyzer, press AM. Key in 2.0 SPCL to set the modulation range to automatic. Set the other controls as follows:

   HP Filter .... 50 Hz
   LP Filter *3kHz*
   Detector .... AVG

   The display should show 0.01% or less.

Residual AM: ____________ 0.01%

AM Distortion

7. Set the audio analyzer's source to 20 **kHz.** Connect its output to the audio input of the **AM/FM** test source. (See figure 4-l.)

NOTE

For this test, if the audio analyzer has floating input and output connectors, the low connector should be grounded. Connectiona should be ma& to the high input or high output connector.

8. Set the Modulation Analyzer controls as follows:

HP Filter .... **All Off**
LP Filter .... **All Off**
Detector .... PEAK+

9. Adjust the level of the audio analyzer's source for a Modulation Analyzer display of 50% AM.

10. Connect the audio analyzer's input to the Modulation Analyzer's MODULATION OUTPUT. (See figure 4-l.) Set the audio analyzer to measure the distortion on the 20 **kHz** signal at the MODULATION OUTPUT with 80 **kHz** of low-pass filtering (on the audio analyzer). The distortion should be 0.3% or less (-50.5 **dB** or less).

AM Distortion at 20 **kHz** Rate; 50% **AM:** ________________ *0.3%*

11. Increase the level of the audio analyzer's source until the Modulation Analyzer reads 95% AM. Measure the distortion. The distortion should be 0.6% or less (-44.4 **dB** or less).

AM Distortion at 20 **kHz** Pate; 95% **AM:** ________________ *0.6%*

12. Set the frequency of the audio analyzer's source to 20 Hz. Readjust the level, if necessary, for a Modulation Analyzer display of 95% AM. Measure the distortion. The distortion should be 0.6% or less (-44.4 **dB** or less).

AM Distortion at 20 Hz Pate; 95% AM: ________________ *0.6%*

13. Decrease the level of the audio analyzer's source until the Modulation Analyzer reads 50% AM. Measure the distortion. The distortion should be 0.3% or less (-50.5 **dB** or less).

AM Distortion at 20 Hz Rate; 50% AM: ________________ *0.3%*

AM Flatness

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch it on.

14. Set the audio synthesizer to 1 **kHz** at **+5 dBm.** Connect its output to the audio input of the AM/FM test source. (See figure 4-l.) Fine adjust the audio synthesizer level for a Modulation Analyzer display of 80% AM.

15. On the Modulation Analyzer, press AVG. Set RATIO to %. Set the audio synthesizer frequency as listed in the following table. For each frequency setting, note the Modulation Analyzer's display. The difference in readings between any two frequencies should be less than 0.8% REL.

NOTE

±0.3% of reading is equivalent to a difference of 0.6% between any pair of readings. ±1 digit at a nominal reading of 80.0 is about ±0.1% of the reading in the RATIO mode or ±0.2% for any pair of readings. The total limit is then 0.8%.

Audio Synthesizer Frequency (Hz)	Displayed AM (% REL)
1 000	______
10 000	______
150	______
90	______

AM Flatness (Maximum Difference): ______ 0.8% REL

AM Accuracy

16. On the Modulation Analyzer, press RATIO % to turn it off. Press PEAK+. Key in 5.1 SPCL to set the audio detector time constant to slow.
17. Set the audio synthesizer frequency to 10 kHz. Set its level for a display of 80% AM times the calibration factor of step 3. (For example, if the calibration factor of step 3 is 100.4%, set the level for a display of 86.3% AM.)
18. On the Modulation Analyzer,. key in 80 and press RATIO %. Set the audio synthesizer to the frequencies shown in the following table (without changing the level). For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audi Synthesizer Frequency (Hz)	AM Limits (% REL)		
	Lower	Actual	Upper
50 000	98.9	______	101.1
100 000	96.9	______	103.1
50	98.9	______	101.1
20	96.9	______	103.1

NOTE

±1 digit at a nominal reading of 80.0 is about ±1% of the reading in the RATIO mode.

19. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 kHz. Set the audio synthesizer to the frequencies in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	AM Limits (% REL)		
	Lower	Actual	Upper
20	96.9	________	103.1
50	97.9	________	102.1
10000	97.9	________	102.1

AM Rejection

20. On the Modulation Analyzer, press RATIO to turn it off. Set the HP FILTER to 50 Hz and the LP FILTER to 3 kHz.
21. Set the audio synthesizer frequency to 1 kHz. Set its level for a Modulation Analyzer display of 50% AM.
22. On the Modulation Analyzer, press FM. Momentarily disconnect the audio input to the AM/FM test source and note the residual FM displayed on the Modulation Analyzer.

Residual FM, 455 kHz IF: ________________ Hz

23. Reconnect the audio input of the AM/FM test source. Note the Modulation Analyzer's displayed FM. The displayed FM minus one-half the residual FM noted in step 22 should be 20 Hz peak or less.

AM Rejection (with FM); 455 kHz IF: ________________ 20 Hz

24. On the Modulation Analyzer, key in 3.0 SPCL to set the IF back to 1.5 MHz. Repeat steps 22 and 23.

Residual FM; 1.5 MHz IF: ________________ Hz

AM Rejection (with FM); 1.5 MHz IF: ________________ 20 Hz

25. On the Modulation Analyzer, press ΦM. Momentarily disconnect the audio input to the AM/FM test source and note the residual ΦM displayed on the Modulation Analyzer.

Residual ΦM; 1.5 MHz IF: ________________ rad

26. Reconnect the audio input of the AM/FM test source. Note the Modulation Analyzer's displayed ΦM. The displayed ΦM minus one-half the residual ΦM noted in step 25 should be 0.030 rad peak or less.

AM Rejection (with ΦM); 1.5 MHz IF: ________________ 0.030 rad

Performance Test IA

AM TESTS (USING A SECOND HP 8901A EQUIPPED WITH OPTION 010)

Specifications

Characteristic	Performance Limits	Conditions
AMPLITUDE MODULATION		
Rates	20 Hz to 10 kHz 20 Hz to 100 kHz	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier
Depth	To 99%	
Accuracy[1,2]	±2% of reading ±1 digit ±3% of reading ±1 digit ±1% of reading ±1 digit ±3% of reading ±1 digit	150 kHz to 10 MHz carrier; 50 Hz to 10 kHz rates; 5 to 99% depth 150 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates; 10 to 1300 MHz carrier; 50 Hz to 50 kHz rates; 5 to 99% depth 10 to 1300 MHz carrier; 20 Hz to 100 kHz rates
Flatness[3,4]	±0.3% of reading ±1 digit	10 to 1300 MHz carrier; 90 Hz to 10 kHz rates; 20 to 60% depth
Demodulated Output Distortion	< 0.3% THD ≤ 0.6% THD	≤ 50% depth ≤ 95% depth
Residual AM[1]	< 0.01% rms	50 Hz to 3 kHz bandwidth
FREQUENCY MODULATION		
AM Rejection(')	< 20 Hz peak deviation	50% AM depth; 400 Hz and 1 kHz rates; 50 Hz to 3 kHz bandwidth
PHASE MODULATION		
AM Rejection[1]	< 0.03 rad peak deviation	50% AM depth; 1 kHz rate; 50 Hz to 3 kHz bandwidth

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects in Detailed Operating Instructions* in section 3.)
(2) For peak measurements only, AM accuracy may be affected by distortion generated by ths Modulation Analyzer. In the worst case, this can decrease accuracy by 0.1% of reading for each 0.1% of distortion.
(3) Flatness is the variation in indiited AM depth for constant depth on input signal.
(4) For optimum flatness, cables should be terminated with their characteristic impedance.

Description

AM accuracy is measured with the internal AM Calibrator of a second HP 8901A equipped with Option 010. A low-residual AM source is connected to the input and the internal residual AM is measured. A source, which can produce wide-band, linear AM, is modulated at various AM rates and depths to measure distortion, flatness, and incidental FM and **ΦM.** A special AM/FM test source is required for these tests to assure that the AM source has adequate bandwidth, low distortion, low residual AM, and low incidental FM and **ΦM.**

NOTE

If the Modulation Analyzer under test is equipped with the AM Calibrator (Option 010), perform Performance Test 1, AM Tests (For HP 8901A Equipped with Option 010).

Equipment

Modulation Analyzer with AM Calibrator .... HP 8901A Option 010
AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Audio Synthesizer .... HP 3336C (Opt. 005)

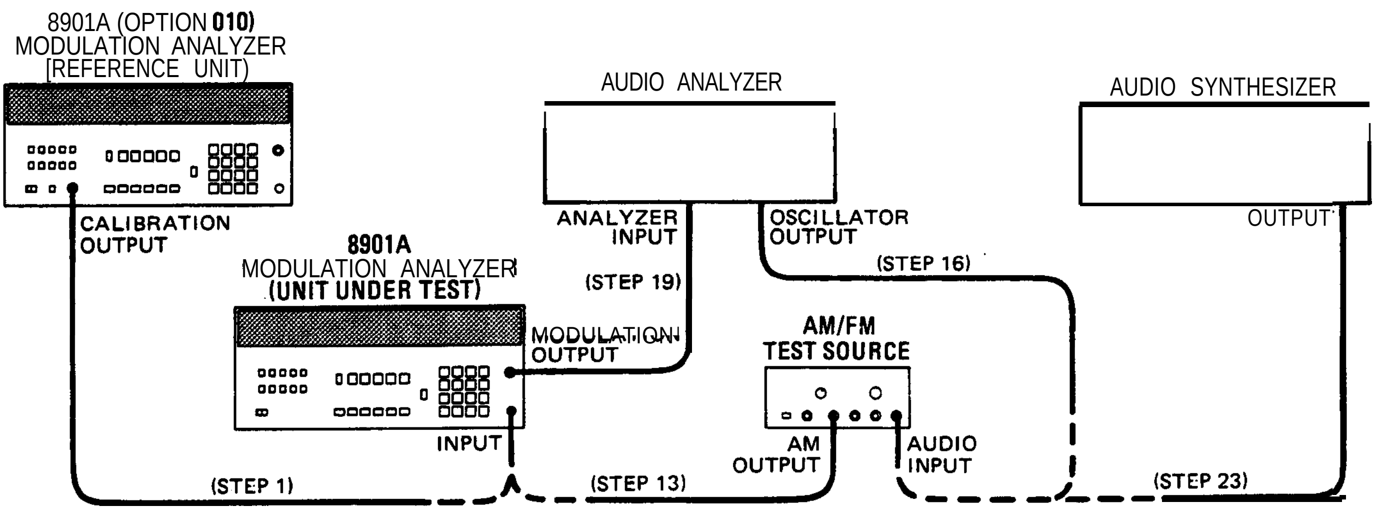


Figure 4-2. AM Performance Test Setup (Using a Second HP 8901A Equipped with Option 010)

Procedure

AM Accuracy at 10 kHz Rate

1. On both the Modulation Analyzers, key in 41.0 SPCL to preset the instruments. Connect the CALIBRATION OUTPUT from the Modulation Analyzer equipped with Option 010 AM calibrator (Reference Unit) to the INPUT of the Modulation Analyzer under test.

NOTE

For greatest accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

2. Key in 13.0 SPCL on the Reference Unit to display the computed peak AM depth and note the reading on its display. The computed AM Depth of the calibrator, excluding noise, is displayed.

Computed Peak AM Depth: __________ %

3. Key in 13.1 SPCL on both Modulation Analyzers to display the demodulated peak residual AM depth. Then, key in 5.1 SPCL on the Modulation Analyzer under test to set the peak detector time constant to slow. Note the reading on the display of the Modulation Analyzer under test. The measured and corrected noise of the AM calibrator in CW is displayed

Weighted Peak Residual AM, 40% Range: ______________ %

4. Add the results of steps 2 and 3 above.

Computed plus Residual AM, 40% **Range:** ______________ %

5. Key in 2.2 SPCL on the Modulation Analyzer under test to set the AM range to 100%. Note the reading its display.

Weighted Peak Residual AM; 100% Range: ______________ %

6. Add the results of steps 2 and 5 above.

Computed plus Residual **AM:** 100% Range: ______________ %

7. Key in 13.2 SPCL on both Modulation Analyzers to display the demodulated peak residual AM depth. Then, key in 5.1 SPCL on the Modulation Analyzer under test. Note the reading on the display of the Modulation Analyzer under test. The AM depth, measured with the PEAK+ detector, is displayed

   Measured Demodulated Positive Peak AM (Including Residual);

40% Range: ______________ %

8. Press PEAK- on the Modulation Analyzer under test. Note the reading on its display.

   Measured Demodulated Negative Peak AM (Including Residual);

40% Range: ______________ %

9. Make the following calculation:

$$\frac{\textit{(reading of step 7)} + 2\textit{(reading of step 8)}}{3}$$

   Measured Demodulated Peak AM (Averaged);

40% **Range:** ______________ %

   This result should equal the result of step 4 **±0.334%** AM.

10. Key in 2.2 SPCL on the Modulation Analyzer under test to set the AM range to 100%. Note the reading on its display.

    Measured Demodulated Negative Peak AM (Including Residual;

100% Range: ______________ %

11. Press PEAK+ on the Modulation **Analyzer** under test. Note the reading on its display Measured Demodulated Negative Peak AM (Including Residual);

40% Range: ________ %

12. Make the **following calculation:**

$$\frac{(\textit{reading of step } 11) + 2(\textit{reading of step } 10)}{3}$$

Measured **Demodulated** Peak AM (Averaged); 100% Range: ________ %

This result should **equal** the result of step 6 **±0.34%** AM.

Residual AM

13. On the AM/FM test source, set the test mode switch to AM. Connect the test source AM output to the INPUT of the Modulation Analyzer under test. (See figure 4-2. Nothing **should** be connected to the test source's audio input.)
14. On the Modulation **Analyzer** under test, key in 41.0 SPCL to **initialize** it. **Tune** the AM/FM test source's carrier frequency to approximately 12.5 MHz.
15. On the Modulation Analyzer under test, press AM. Set the other **controls** as **follows:**

HP **Filter** .... **50 Hz**
LP **Filter** .... **3 kHz**
Detector .... AVG

The display should show 0.01% or less.

Residual **AM:** ________ 0.01%

AM Distortion

16. Set the audio analyzer's source to 20 **kHz.** Connect its output to the audio input of the AM/FM test source (see figure 4-2).
17. Set the Modulation Analyzer controls as follows:

HP Filter .... **All Off**
LP **Filter** .... **All Off**
Detector .... PEAK+

18. Adjust the level of the audio analyzer's source so that the Modulation **Analyzer** under test displays 50% AM.
19. Connect the audio analyzer's input to the MODULATION OUTPUT of the Modulation Analyzer under test. (See figure 4-2.) Set the audio **analyzer** to measure the distortion on the 20 **kHz signal** at the MODULATION OUTPUT with **80 kHz** of low-pass **filtering** (on the audio analyzer). The distortion should be 0.3% or less (-50.5 **dB** or less).

AM Distortion at 20 **kHz** Pate; 50% **AM:** ________ **0.3%**

20. Increase the level of the audio analyzer's source until the Modulation **Analyzer** under test reads 95% AM. Measure the distortion. The distortion should be 0.6% or less (-44.4 **dB** or less).

AM Distortion at 20 **kHz** Rate; 95% **AM:** ________ **0.6%**

21. Set the audio analyzer's source frequency to 20 Hz. Readjust the level, if necessary, for a Modulation Analyzer display of 95% AM. Measure the distortion. The distortion should be 0.6% or less (-44.4 dB or less).

AM Distortion at 20 Hz Rate; 95% **AM:** ________________ *0.6%*

22. Decrease the level of the audio analyzer's source until the Modulation Analyzer reads *50%* AM. Measure the distortion. The distortion should be 0.3% or less (-50.5 **dB** or less).

AM Distortion at 20 Hz Rate; 50% **AM:** ________________ *0.3%*

AM Flatness

NOTE

Flatness of the audio synthesizer is critical for this test. *If the audio synthesizer has leveling capability, switch the leveling on.*

23. Set the audio synthesizer to 1 **kHz** at **+5 dBm.** Connect its output to the audio input of the AM/FM test source. (See figure 4-2.) Fine adjust the audio synthesizer level for a Modulation Analyzer under test display of 80% AM.

24. On the Modulation Analyzer, press AVG. Set RATIO to %. Set the audio synthesizer frequency as listed in the following table. For each frequency setting, note the Modulation Analyzer's display. The **difference** in readings between any two frequencies should be less than 0.8% REL.

NOTE

±0.3% of reading is equivalent to a difference of *0.6%* ***between any pair of readings. ±1 digit at a nominal reading of 80.0 is about ±0.1% of the reading in the RATIO mode or ±0.2% for any pair of readings. The total limit is then 0.8%.***

Audio Synthesizer **Frequency (Hz)**	Displayed AM (% REL)
1 000	________
10 000	________
150	________
90	________

AM Flatness (Maximum Difference): ________________ 0.8% REL

AM Accuracy

25. On the Modulation Analyzer, press RATIO % to turn ratio off. Press **PEAK+.** Key in 5.1 SPCL to set the audio detector time constant to slow.
26. Set the audio synthesizer frequency to 10 **kHz.** Set its level for a Modulation Analyzer under test display of 80% AM times the result of step 10 divided by the result of step 4. (For example if the result of step 10 is 33.40% and the result of step 4 is **33.33%,** set the level for 80% x 33.40 ÷ 33.33 = 80.2%).
27. On the Modulation Analyzer, key in 80 and press RATIO %. Set the audio synthesizer to the frequencies shown in the following table (without changing the level). For each setting, the Modulation Analyzer display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	AM Limits (% REL)		
	Lower	Actual	Upper
50 000	98.9	______	101.1
100 000	96.9	______	103.1
50	98.9	______	101.1
20	96.9	______	103.1

NOTE

±1 digit at a nominal reading of 80.0 is about ±1% of the reading in the RATIO mode.

28. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 **kHz.** Set the audio synthesizer to the frequencies in the following table. For each setting, the Modulation Analyzer display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	AM Limits (% REL)		
	Lower	Actual	Upper
20	95.9	______	103.1
50	97.9	______	102.1
10000	97.9	______	102.1

AM Rejection

29. On the Modulation Analyzer, press RATIO to turn ratio off. Set the HP FILTER to 50 Hz and the LP FILTER to 3 **kHz.**

30. Set the audio synthesizer frequency to 1 **kHz.** Set its level for a Modulation Analyzer display of 50% AM.

31. On the Modulation Analyzer, press FM. Momentarily disconnect the audio input to the AM/FM test source and note the residual FM displayed on the Modulation Analyzer.

Residual FM; 455 **kHz IF:** ________________ Hz

32. Reconnect the audio input of the AM/FM test source. Note the Modulation Analyzer's displayed FM. The displayed FM minus one-half the residual FM noted in step 31 should be 20 Hz peak or less.

AM Rejection (with FM); 455 **kHz IF:** ________________ 20 Hz

33. On the Modulation Analyzer, key in 3.0 SPCL to set the IF back to 1.5 MHz. Repeat steps 31 and 32.

Residual FM; 1.5 MHz **IF:** ________________ Hz

AM Rejection (with FM); 1.5 MHz **IF:** ________________ 20 Hz

34. On the Modulation Analyzer, press **ΦM.** Momentarily disconnect the audio input to the AM/FM test source and note the residual **ΦM** displayed on the Modulation Analyzer.

Residual **ΦM;** 1.5 MHz IF: ________________ radians

35. Reconnect the audio input of the AM/FM test source. Note the **ΦM** displayed on the Modulation Analyzer. The displayed **ΦM** minus one-half the residual **ΦM** noted in step 34 should be 0.030 radians peak or less.

AM Rejection (with **ΦM);** 1.5 MHz **IF:** ________________ 0.030 rad

Performance Test 2

FM TESTS (FOR HP 8901A EQUIPPED WITH OPTION 010)

Specification

Characteristic	Performance Limits	Conditions
FREQUENCY MODULATION		
Rates	20 Hz to 10 kHz 20 Hz to 200 kHz 20 Hz to 20 kHz	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier 10 to 1300 MHz carrier; 750 μs de-emphasis
Deviations	40 kHz peak maximum 400 kHz peak maximum 40 kHz peak maximum	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier 10 to 1300 MHz carrier; 750 μs de-emphasis
Accuracy(1)	±2% of reading ±1 digit ±1% of reading ±1 digit ±5% of reading ±1 digit	250 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates; 10 to 1300 MHz carrier; 50 Hz to 100 kHz rates; 10 to 1300 MHz carrier; 20 Hz to 200 kHz rates;
Demodulated Output Distortion(2)	< 0.1% THD < 0.1% THD	400 kHz to 10 MHz carrier; deviations < 10 kHz 10 to 1300 MHz carrier; rates and deviations < 100 kHz

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects in* section 3.)
(2) With 750 μs de-emphasis and pre-display "off, distortion is not specified for modulation outputs >4 V (pk). This can occur near maximum deviation for a measurement range at rates < 2 kHz.

Characteristic	Performance Limits	Conditions
FREQUENCY MODULATION **(cont'd)**		
Residual FM	< **8** Hz **rms** at 1300 MHz decreasing linearly with frequency to < 1 Hz rrns for 100 MHz and **below**	50 Hz to 3 **kHz** bandwidth
AMPLITUDE MODULATION		
FM **Rejection**[1]	**< 0.2% AM**	**250 kHz** to 10 MHz carrier; < 5 **kHz** peak deviation; 400 and 1 **kHz** rates; **50 Hz** to 3 **kHz** bandwidth
	< 0.2% AM	10 to 1300 MHz carrier; < 50 **kHz** peak deviation; **400** Hz and 1 **kHz** rates; **50** Hz to 3 **kHz** bandwidth
[1] **Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in section 3.)**		

Description

FM is measured with a very low-noise oscillator at the Modulation Analyzer's input. The resulting measured FM is the residual FM of the-Modulation Analyzer's internal local oscillator. FM accuracy is measured with the internal FM Calibrator (Option **010),** which produces approximately 34 **kHz** peak deviation at a 10 **kHz** rate. A source, which can produce wide-band, linear FM, is modulated at various FM rates and deviations to measure distortion, flatness, and incidental AM. A special AM/FM test source is required for these tests to assure that the FM source has adequate bandwidth, low distortion, low residual FM, and low incidental AM.

NOTE

This procedure is only for Modulation Analyzers equipped with the FM Calibrator (Option 010). For Modulation Analyzers not equipped with Option 010, use Performance Test 2A which uses a second HP 8901A that is equipped with Option 010.

Equipment

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP **8903B**
Audio Synthesizer .... HP 3336C (Opt. 005)

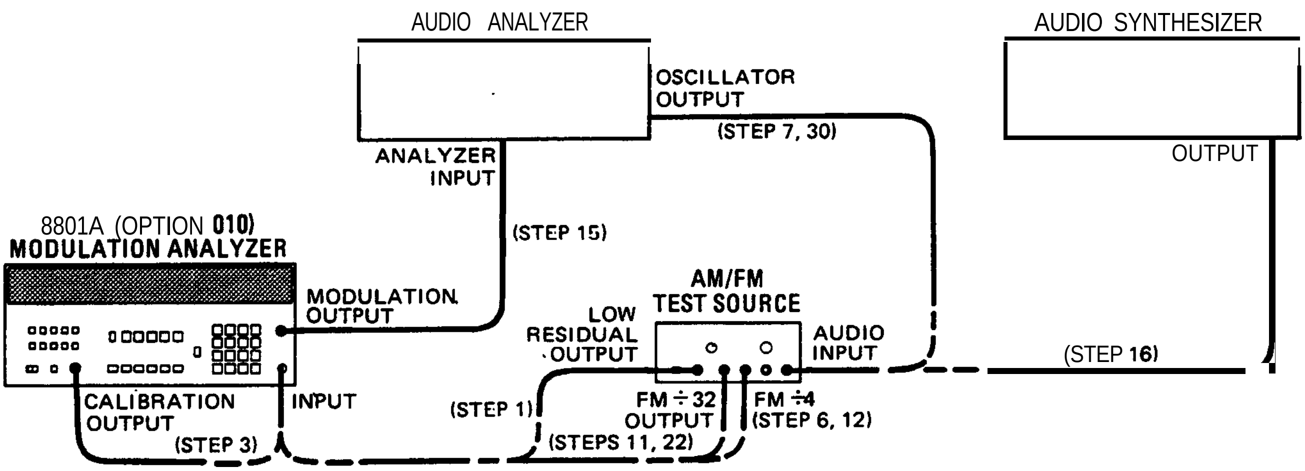


Figure 4-3. FM Performance Test Setup

Procedure

Residual FM

1. On the AM/FM test source, set the test mode to residual FM. Connect its low-residual (560 MHz) output to the Modulation Analyzer's INPUT. (See figure 4-3.)
2. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Set the other controls as follows:

Measurement . . . . FM
HP Filter . . . . 50 Hz
LP Filter 3kHz
Detector . . . . AVG

The display should read 4 Hz or less.

Residual FM at 560 MHz; 50 Hz to 3 kHz bandwidth: ________ 4 Hz

The equation for determining the residual FM limits is:

$$\textit{residual FM in Hz} = 5.83 \times \textit{carrier frequency in GHz} + 0.42 \text{ Hz}$$

For a carrier of 560 MHz, the residual FM limit is 3.7 Hz. Allowing for one digit of uncertainty gives a limit of approximately 4 Hz.

FM Accuracy at 10 kHz Rate

3. Connect the Modulation Analyzer's CALIBRATION OUTPUT to the INPUT. (See figure 4-3.)

NOTE

For greatest accuracy allow the Modulation Analyzer to warm up for at least one-half hour.

4. On the Modulation Analyzer, press CALIBRATION. Allow at least two readings (approximately 40 seconds) to pass . The display should read between 99 and 101%. Record this value for future reference.

   FM Calibration Factor; 40 kHz Modulation Range: 99 ________ 101%

5. On the Modulation Analyzer, key in 2.3 SPCL to set the modulation range to 400 kHz. Allow at least two readings to pass. The display should read between 99 and 101%.

   FM Calibration Factor; 400 kHz Modulation Range: 99 ________ 101%

6. On the AM/FM test source, set the test mode to FM. Connect its FM+4 output to the Modulation Analyzer's INPUT. (See figure 4-3.)
7. Set the audio analyzer's source to 10 kHz at 0.5 V. Connect its output to the audio input of the AM/FM test source. (See figure 4-3.)

NOTE

For this test, if the audio analyzer has floating input and output connectors, the low connect& should be grounded. Connections should be made to the high input or high output connector.

8. On the Modulation Analyzer, key in 4.1 SPCL to turn on Track Mode. Tune the AM/FM test source's carrier frequency to approximately 100 MHz. Key in 4.0 SPCL to turn Track Mode off.
9. On the Modulation Analyzer, press FM. Set LP FILTER to 15 kHz and DETECTOR to AVG. Key in 2.0 SPCL to set the modulation range to automatic.
10. Adjust the level of the audio analyzer's source for a Modulation Analyzer display of 20 kHz average deviation. On the Modulation Analyzer, set RATIO to %.
11. Connect the FM+32 output of the AM/FM test source to the Modulation Analyzer's INPUT without disturbing the AM/FM test source's controls. (See figure 4-3.) Multiply the displayed ratio on the Modulation Analyzer by the calibration factor of step 4. (For example, if the display reads 12.52% REL and the calibration factor of step 4 is 100.4%, the result is 12.52 x 100.4 = 12.57% REL.) The result should be between 12.35 and 12.65% REL.

    FM Accuracy; 4 kHz Modulation Range: 12.35 ________ 12.65% REL

FM Distortion, Accuracy, and Rejection (1.5 MHz IF)

12. Connect the FM+4 output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4-3.)
13. On the Modulation Analyzer, set all LP FILTERs to off, DETECTOR to PEAK+, and RATIO off.
14. Set the frequency of the audio analyzer's source to 100 kHz. Set the level of the audio analyzer for a Modulation Analyzer display of 100 kHz peak deviation.

15. Connect the audio analyzer's input to the Modulation Analyzer's MODULATION OUTPUT. (See figure 4-3.) Set the audio analyzer to measure the distortion on the **100 kHz** signal at the MODULATION OUTPUT (all audio analyzer filters should be off). The distortion should be 0.1% or less (-60 **dB** or less).

FM Distortion at 100 **kHz** Rate, **100 kHz** Peak Deviation: ________________ 0.1%

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch it on.

16. Set the audio synthesizer to 10 **kHz** at **+5 dBm.** Connect its output to the audio input of the AM/FM test source. (See figure 4-3.) Fine adjust the level for a Modulation Analyzer display of **100 kHz** times the calibration factor of step 5. (For ezample, if the calibration factor of step 5 is **100.4%,** set the level for a display of 166.4 **kHz.)**
17. Set the audio synthesizer to the frequencies in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	FM Limits (kHz)		
	Lower	Actual	Upper
100 000	98.9	________	101.1
200 000	94.9	________	105.1
50	98.9	________	101.1
20	94.9	________	105.1

18. On the Modulation Analyzer, set HP FILTER to 50 Hz and LP FILTER to 3 **kHz.**
19. Set the audio synthesizer frequency to 1 **kHz.** Set the level for a Modulation Analyzer display of 50 **kHz** peak deviation.
20. On the Modulation Analyzer, press AM. Momentarily disconnect the audio input to the AM/FM test source and note the residual AM displayed on the Modulation Analyzer.

Residual AM: ________________ %

21. Reconnect the audio input of the AM/FM test source. Note the AM displayed on the Modulation Analyzer. The displayed AM minus one-half the residual AM noted in step 20 should be 0.2% or less.

FM Rejection at 1 **kHz** Rate; **50 kHz** Peak Deviation: ________________ 0.2%

FM Distortion, Accuracy, and Rejection (455 kHz IF)

22. Connect the **FM÷32** output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4-3.)
23. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 **kHz.** Press FM.
24. Set the audio synthesizer level for a Modulation Analyzer display of 5 **kHz** peak deviation.

25. On the Modulation Analyzer, press AM. Momentarily disconnect the audio input to the AM/FM test source and note the residual AM displayed on the Modulation Analyzer.

Residual AM: ________________ %

26. Reconnect the audio input of the AM/FM test source. Note the AM displayed on the Modulation Analyzer. The displayed AM minus one-half the residual AM noted in step 25 should be 0.2% or less.

FM Rejection at 1 **kHz** Rate; 5 **kHz** Peak Deviation: ________________ 0.2%

27. On the Modulation Analyzer, press FM. Set all HP **FILTERs** to off and LP FILTER to **>20 kHz.**

28. Set the audio synthesizer level for a Modulation Analyzer display of **10 kHz** peak deviation times the calibration factor of step 4. (For example, if the calibration factor of step 4 is **100.4%,** set the level for a display of 10.04 **kHz.)**

29. Set the audio synthesizer to the frequencies shown in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer **Frequency (Hz)**	FM Limits **(kHz)**		
	Lower	Actual	**Upper**
10000	9.79	________	10.21
20	9.79	________	10.21

30. Set the audio analyzer's source to 10 **kHz** at 2 V. Connect its output to the audio input of the AM/FM test source. (See figure 4-3.) Fine adjust the oscillator level for a Modulation Analyzer display of 10 **kHz** peak deviation.

31. Set the audio analyzer to measure the distortion on the 10 **kHz** signal at the MODULATION OUTPUT of the' Modulation Analyzer. Set the audio analyzer's **low-**pass filter to 30 **kHz** and the high-pass filter to 400 Hz. The distortion should be less than 0.1% (-60 **dB** or less).

FM Distortion at 10 **kHz** Rate, 10 **kHz** Peak Deviation: ________________ 0.1%

Performance Test 2A

FM TESTS (USING A SECOND HP 8901A EQUIPPED WITH OPTION 010)

Specification

Characteristic	Performance Limits	Conditions
FREQUENCY MODULATION		
Rates	**20 Hz to 10 kHz** 20 Hz to 200 kHz 20 Hz to 20 kHz	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier 10 to 1300 MHz carrier; 750 μs de-emphasis
Deviations	40 kHz peak maximum 400 kHz peak maximum 40 kHz peak maximum	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier 10 to 1300 MHz carrier; 750 μs de-emphasis
Accuracy(1)	±2% of reading ±1 digit ±1% of reading ±1 digit ±5% of reading ±1 digit	250 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates; 10 to 1300 MHz carrier; 50 Hz to 100 kHz rates; 10 to 1300 MHz carrier; 20 Hz to 200 kHz rates;
Demodulated Output Distortion(2)	< 0.1% THD < 0.1% THD	400 kHz to 10 MHz carrier; deviations < 10 kHz 10 to 1300 MHz carrier; rates and deviations < 100 kHz
FREQUENCY MODULATION (cont'd)		
Residual FM	<8 Hz n-ns at 1300 MHz decreasing linearly with frequency to <1 Hz rms for 100 MHz and below	50 Hz to 3 kHz bandwidth
AMPLITUDE MODULATION		
FM Rejection(')	<0.2% AM <0.2% AM	250 kHz to 10 MHz darner; <5 kHz peak deviation; 400 and 1 kHz rates; 50 Hz to 3 kHz bandwidth 10 to 1300 MHz carrier; <50 kHz peak deviation; 400 Hz and 1 kHz rates; 50 Hz to 3 kHz bandwidth

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in section 3.)
(2) With 750 μs de-emphasis and pre-display "off", distortion is not specified for modulation outputs >4 V (pk). This can occur near maximum deviation for a measurement range at rates < 2 kHz.

Description

FM is measured with a very low-noise oscillator at the Modulation Analyzer's input. The resulting measured FM is the residual FM of the Modulation Analyzer's internal local oscillator. FM accuracy is measured using the FM Calibrator from a second HP 8901A equipped with Option 010. A source, which can produce wide-band, linear FM, is modulated at various FM rates and deviations to measure distortion, flatness, and incidental AM. A special AM/FM test source is required for these tests to assure that the FM source has adequate bandwidth, low distortion, low residual FM, and low incidental AM.

NOTE

If the Modulation Analyzer under test is equipped with the FM Calibrator (Option 010), perform Performance Test 2, FM Tests (For HP 8901A Equipped with Option 010).

Equipment

Modulation Analyzer with FM Calibrator .... HP 8901A Option 010
AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Audio Synthesizer .... HP 3336C (Opt. 005)

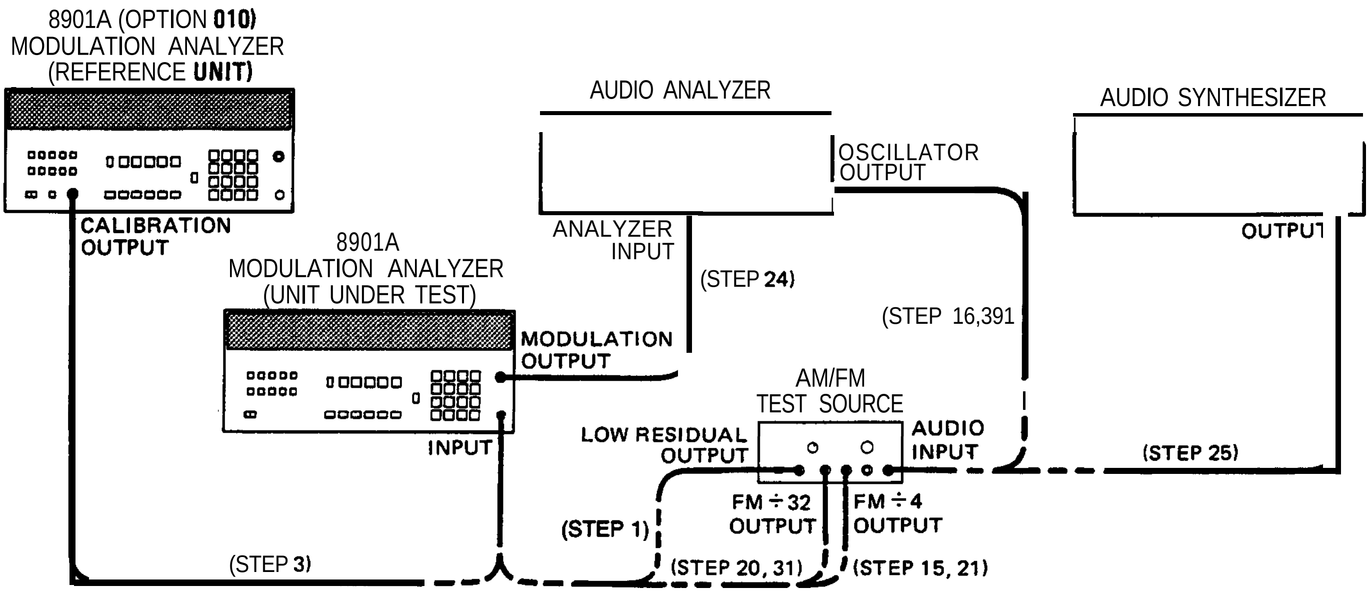


Figure 4-4. FM Performance Test Setup (Using a Second HP 8901A Equipped with Option 010)

Procedure

Residual FM

1. On the AM/FM test source, set the test mode to residual FM. Connect its low-residual (560 MHz) output to the Modulation Analyzer's INPUT. (See figure 4-4.)
2. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Set the other controls as follows:

   Measurement .... FM
   HP Filter .... 50 Hz
   LP Filter .... 3 kHz
   Detector .... AVG

   The display should read 4 Hz or less.

   The equation for determining the residual FM limits is:

   $$\text{residual FM in Hz} = 5.83 \times \text{carrier frequency in GHz} + 0.42\ \text{Hz}$$

   For a carrier of 560 MHz, the residual FM limit is 3.7 Hz. Allowing for one digit of uncertainty gives a limit of approximately 4 Hz.

   Residual FM at 560 MHz; 50 Hz to 3 kHz bandwidth: ________ 4 Hz

FM Accuracy at 10 kHz Rate

3. Connect the CALIBRATION OUTPUT of the HP 8901A with Option 010 (Reference Unit) to the INPUT of the Modulation Analyzer under test. (See figure 4-4.)

   NOTE

   For greatest accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

4. Key in 12.0 SPCL on the Reference Unit to display the computed peak FM deviation and note the reading on its display. The computed FM depth of the calibrator, exluding noise is displayed

   Computed Peak FM: ________ Hz

5. Key in 12.1 SPCL on both Modulation Analyzers to display the demodulated peak residual FM deviation. Then key in 5.1 SPCL on the Modulation Analyzer under test to set the peak detector time constant to slow. Note the reading on the display of the Modulation Analyzer under test. The measured and corrected noise of the FM calibrator in CW is being displayed.

   Weighted Peak Residual FM; 40 kHz Range: ________ Hz

6. Add the results of steps 4 and 5.

   Computed plus Residual FM; 40 kHz Range: ________ Hz

7. On the Modulation Analyzer under test, key in 2.3 SPCL to set the modulation **range** to **400 kHz,** and note the reading on its display.

Weighted Peak Residual FM; 400 **kHz Range:** ________________ Hz

8. Add the results of steps 4 and 7 above.

Computed plus Residual FM; 400 **kHz** Range: ________________ Hz

9. Key in 12.2 SPCL on both Modulation Analyzers to display the demodulated peak FM deviation. Then key in 5.1 SPCL on the Modulation Analyzer under test. Note the reading on the display of the Modulation Analyzer under test. The peak deviation, measured with the PEAK+ detector is being displayed

   Measured Demodulated Positive Peak FM (Including Residual);

   40 **kHz** Range: ________________ **kHz**

10. On the Modulation Analyzer under test, press PEAK-. Note the reading on its display.

    Measured Demodulated Negative Peak FM (Including Residual);

    40 **kHz** Range: ________________ **kHz**

11. Make the following calculation:

$$\frac{\text{(reading of step 9) + (reading of step 10)}}{2}$$

Measured Demodulated Peak FM (Averaged);

40 **kHz Range:** ________________ **kHz**

This result should equal the result of step 6 ~0.334 **kHz.**

12. Key in 2.3 SPCL on the Modulation Analyzer under test. Note the reading on its display.

    Measured Demodulated Negative Peak FM (Including Residual);

    400 **kHz** Range: ________________ **kHz**

13. On the Modulation Analyzer under test, press PEAK+. Note the reading on its display.

    Measured Demodulated Positive Peak FM (Including Residual);

    400 **kHz** Range: ________________ **kHz**

14. Make the following calculation:

$$\frac{\text{(reading of step 12) + (reading of step 13)}}{2}$$

Measured Demodulated Peak FM (Averaged);

400 **kHz** Range: ________________ **kHz**

This result should equal the result of step 8 **±0.34 kHz.**

15. On the AM/FM test source, set the test mode to FM. Connect its FM+4 output to the Modulation Analyzer's INPUT. (See figure 4-4.)
16. Set the audio analyzer's source to 10 **kHz** at 0.5 V. Connect its output to the audio input of the AM/FM test source. (See figure 4-4.)

NOTE

For this test, if the audio analyzer has floating input and output connectors, the low connector should be grounded. Connections should be mud-e to the high input or high output connector.

17. On the Modulation Analyzer under test, key in 41.0 SPCL initialize it. **Tune** the AM/FM test source's carrier frequency to approximately 100 MHz.
18. On the Modulation Analyzer under test, press FM. Set LP FILTER to 15 **kHz** and DETECTOR to AVG.
19. Adjust the level of the audio **analyzer's** source for a display of 20 **kHz** average deviation on the Modulation Analyzer under test. On the Modulation Analyzer under test, set RATIO to %.
20. Connect the **FM÷32** output of the AM/FM test source to the Modulation Analyzer's INPUT without disturbing the AM/FM test source's controls. (See figure 4-4.) Multiply the displayed ratio on the Modulation Analyzer by the result of step 11 divided by the result of step 6. (For example, if the display reads 12.52% REL and the result of step 11 is 33.400 **kHz** and the result of step 6 is 33.333 **kHz,** the desired result is (12.52 x 33.4) ÷ 33.333 = 12.55.) The result should be between 12.35 and 12.65% REL.

FM Accuracy; 4 **kHz** Modulation Range: 12.35 ________________ 12.65% REL

FM Distortion, Accuracy, and Rejection (1.5 MHz IF)

21. Connect the **FM÷4** output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4-4.)
22. On the Modulation Analyzer, set **all** LP FILTERs to off, DETECTOR to PEAR+, and RATIO off.
23. Set the frequency of the audio analyzer's source to 100 **kHz.** Set the level of the oscillator for a Modulation Analyzer display of **100 kHz** peak deviation.
24. Connect the audio **analyzer's** input to the MODULATION OUTPUT of the Modulation Analyzer under test. (See figure 4-4.) Set the audio analyzer to measure the distortion on the **100 kHz signal** at the MODULATION OUTPUT **(all** audio analyzer filters should be off). The distortion should be 0.1% or less (-60 **dB** or less).

FM Distortion at 100 **kHz** Rate; **100 kHz** Peak Deviation: ________________ 0.1%

25. Set the audio synthesizer to 10 kHz at +15 dBm. Connect its output to the audio input of the AM/FM test source. (See figure 4-4.) Fine adjust the level for a Modulation Analyzer display of 100 kHz times the result of step 11 divided by the result of step 6. (For example, if the result of step 11 is 33.400 kHz, and the result of step 6 is 33.333 kHz, set the level for a display of (100 kHz × 33.400) ÷ 33.333 = 100.2 kHz.))

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch it on.

26. Set the audio synthesizer to the frequencies in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the following table.

Audio Synthesizer Frequency (Hz)	FM Limits (kHz)		
	Lower	Actual	Upper
100000	98.9	______	101.1
200000	94.9	______	105.1
50	98.9	______	101.1
20	94.9	______	105.1

27. On the Modulation Analyzer, set HP FILTER to 50 Hz and LP FILTER to 3 kHz.
28. Set the audio synthesizer frequency to 1 kHz. Set the level for a Modulation Analyzer display of 50 kHz peak deviation.
29. On the Modulation Analyzer, press AM. Momentarily disconnect the audio input to the AM/PM test source and note the residual AM displayed on the Modulation Analyzer.

Residual AM: ______________ %

30. Reconnect the audio input of the AM/FM test source. Note the AM displayed on the Modulation Analyzer. The displayed AM minus one-half the residual AM noted in step *20* should be 0.2% or less.

FM Rejection at 1 kHz Rate; 50 kHz Peak Deviation: ______________ *0.2%*

FM Distortion, Accuracy, and Rejection (455 kHz IF)

31. Connect the FM÷32 output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4-4.)
32. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 kHz. Press FM.
33. Set the audio synthesizer level for a Modulation Analyzer display of 5 kHz peak deviation.
34. On the Modulation Analyzer, press AM. Momentarily disconnect the audio input to the AM/FM test source and note the residual AM displayed on the Modulation Analyzer.

Residual AM: ______________ %

35. Reconnect the audio input of the AM/PM test source. Note the AM displayed on the Modulation Analyzer. The displayed AM minus one-half the residual AM noted in step 34 should be 0.2% or less.

FM Rejection at 1 kHz Rate, 5 kHz Peak Deviation: __________ 0.2%

36. On the Modulation Analyzer, press FM. Set all HP FILTERs to Off and LP FILTER to >20 kHz.

37. Set the audio synthesizer frequency to 1 kHz. Set the audio synthesizer level for a Modulation Analyzer display of 0.1 times the display set in step 25. (For example, if the display set in step 25 is 100.2 kHz, set the level for a display of 10.02 kHz.)

38. Set the audio synthesizer to the frequencies shown in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	FM Limits (kHz)		
	Lower	Actual	Upper
10000	9.79	______	10.21
20	9.79	______	10.21

39. Set the audio analyzer's source to 10 kHz at 2 V. Connect its output to the audio input of the AM/FM test source. (See figure 4-4.) Fine adjust the oscillator level for a Modulation Analyzer display of 10 kHz peak deviation.

40. Set the audio analyzer to measure the distortion on the 10 kHz signal at the MODULATION OUTPUT of the Modulation Analyzer. Set the audio analyzer's low pass filter to 30 kHz and the high pass filter to 400 Hz. The distortion should be less than 0.1% or less. (-60 dB or less).

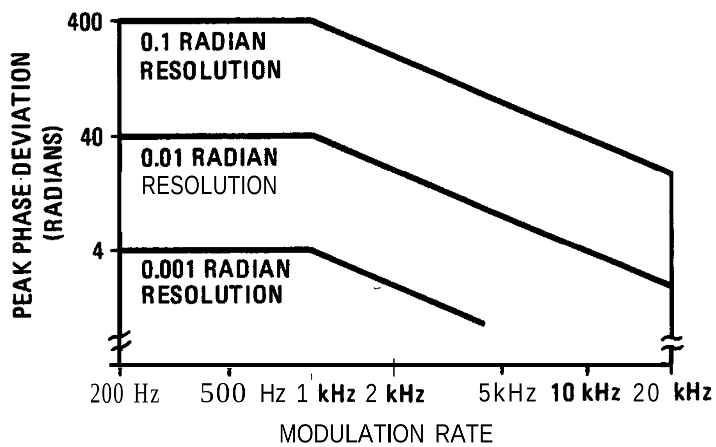
FM Distortion at 10 kHz Rate; 10 kHz Peak Deviation: __________ 0.1%

Performance Test 3

ΦM TESTS

Specification

Characteristic	Performance Limits	Conditions
PHASE MODULATION		
Carrier Frequency	10 to 1300 MHz	
Deviation and Maximum Resolution	Refer to figure below.	
Rates	200 Hz to 20 kHz	
Accuracy[1]	±3% of reading ±1 dgit	
Demodulated output Distortion	<0.1% THD	



Phase Modulation Deviation and Maximum Resolution

[1] Peak residuals must be accounted for in peak readings. (R&r to *Residual Noise Effects in* section 3.)

Description

A signal with a known amount of phase modulation is generated by frequency modulating a carrier at a known peak deviation (as measured by the previously-calibrated Modulation Analyzer) and rate. The relationship between the peak phase deviation and peak frequency deviation is:

$$\text{peak phase deviation} = \frac{\text{peak frequency deviation}}{\text{modulation rate}}.$$

The measured deviation is compared with the calculated deviation for several combinations of FM deviation and rate. The distortion is also measured. A special AM/FM test source is required for these tests to assure that the FM source has adequate bandwidth, low-distortion, and low residual ΦM.

Equipment

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Audio Synthesizer .... HP 3336C

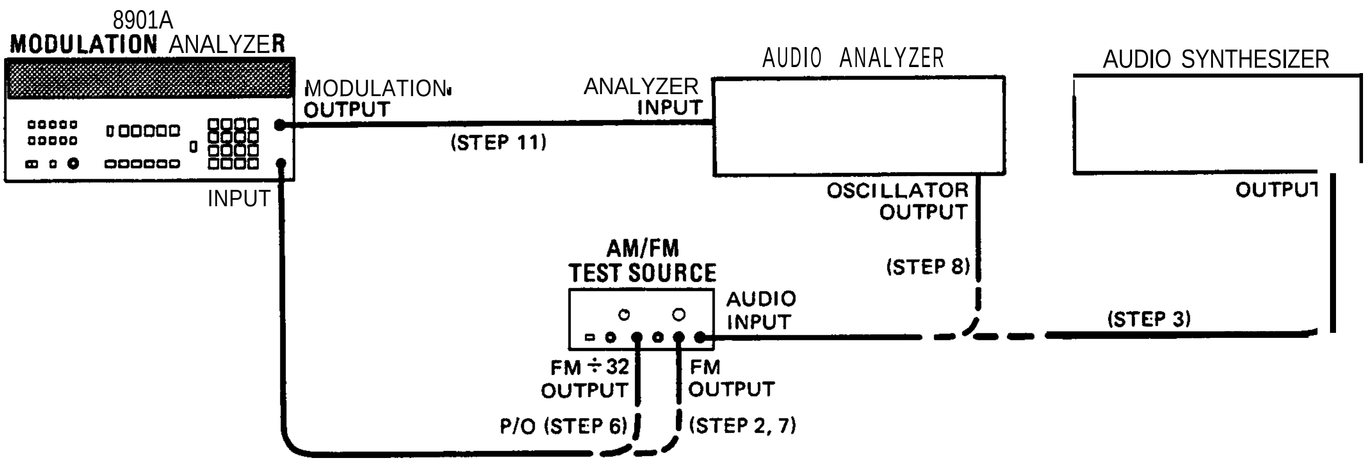


Figure 4-6. ΦM Performance Test Setup

Procedure

ΦM Accuracy

1. Make the tests in *Performance Test 2,* FM Tests.
2. On the AM/FM test source, set the test mode to FM. Connect its FM output to the Modulation Analyzer's INPUT. (See figure 4-5.)
3. Set the audio synthesizer to 200 Hz at -10 dBm. Connect its output to the audio input of the AM/FM test source. (See figure 4-5.)
4. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Press FREQ and then key in 4.1 SPCL to turn on Track Mode. Tune the AM/FM test source's carrier frequency to approximately 400 MHz. Key in 4.0 SPCL to turn off Track Mode.

5. On the Modulation Analyzer, press MHz to center its tuning. Set the other controls as follows:

   Measurement .... FM
   LP Filter .... >20 kHz
   Detector .... AVG

6. Set the audio synthesizer frequency as shown in the following table. Set the Modulation Analyzer high pass filter as shown in the table. Set the audio synthesizer level to give the FM deviation shown in the table (as read on the Modulation Analyzer). After setting each FM deviation, press ΦM. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	High Pass Filter	Average FM Deviation (kHz)	ΦM Limits (rad)		
			Lower	Actual	Upper
200	50	50	242.4	________	257.6
1000	300	250	242.4	________	257.6
20000	300	250	12.1	________	13.0
20000	300	4'	0.193	________	0.207

* Connect the FM÷32 output of the AM/FM test source to the Modulation Analyzer's INPUT to make this measurement. (See figure 4-5.) Press AUTOMATIC OPERATION. then MHz to retune the Measuring Receiver. If the resolution is not 0.001 rad, press ΦM again.

ΦM Distortion

7. Connect the FM output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4-5.) Press AUTOMATIC OPERATION on the Modulation Analyzer.

8. Set the audio analyzer's source to 1 kHz. Connect its output to the audio input of the AM/FM test source. (See figure 4-5.)

NOTE

For this test, if the audio analyzer has floating input and output connectors, the low connector should be grounded. Connections should be made to the high input or high output connector.

9. On the Modulation Analyzer, press ΦM. Set DETECTOR to PEAK+. Set HP FILTER to 300 Hz. Set LP FILTER to 15 kHz.

10. Adjust the audio analyzer's source level to give a display of 400 rad peak deviation.

11. Connect the audio analyzer's input to the Modulation Analyzer's MODULATION OUTPUT. (See figure 4-5.) Set the audio analyzer to measure the distortion on the 1 kHz signal at the MODULATION OUTPUT. Set the high-pass filter on the audio analyzer to 400 Hz. (All audio analyzer filters should be off.) The distortion should be 0.1% (-60 dB or less).

    ΦM Distortion at 1 kHz Rate; 400 rad Peak Deviation;

    1.5 MHz IF: ________________ 0.1%

12. Reduce the level of the audio analyzer's source to give a display of 40 rad peak deviation.
13. On the Modulation Analyzer, key in 3.1 SPCL. The distortion measured on the audio analyzer should be 0.1% or less.

    ΦM Distortion at 1 kHz Rate; 40 rad Peak Deviation;

    455 kHz IF: ________________ 0.1%

Performance Test 4

AUDIO FILTERS TEST

Specification

Characteristic	Performance Limits	Conditions
AUDIO FILTERS		
50 Hz High Pass (2 Pole)		
3 dB Cutoff Frequency	50 Hz nominal	
Flatness	< 1%	> 200 Hz rates
300 Hz High Pass (2 Pole)		
3 dB Cutoff Frequency	300 Hz nominal	
Flatness	< 1%	> 1 kHz rates
3 kHz Low Pass (5 Pole)		
3 dB Cutoff Frequency	3 kHz nominal	
Flatness	< 1%	< 1 kHz rates
15 kHz Low Pass (5 Pole)		
3 dB Cutoff Frequency	15 kHz nominal	
Flatness	< 1%	< 10 kHz rates
>20 kHz Low Pass (9 Pole Bessel)(1)		
3 dB cutoff frequency	> 20 kHz nominal	
Flatness	< 1%	< 10 kHz rates

(1) The > 20 kHz low-pass filter is intended for minimum overshoot squarewave modulation.

Description

A signal is frequency modulated by a source which is known to have FM which is flat with rate. The flatness of the demodulated signal is then measured for various modulation filters.

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch it on.

Equipment

AM/FM Test Source .... HP 11715A
Audio Synthesizer .... HP 3336C (Opt. 005)

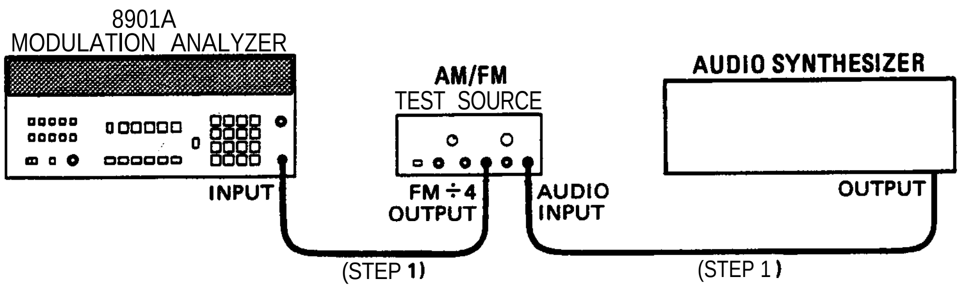


*Figure 4-6. Audio **Filters Performance Test Setup***

Procedure

1. Connect the equipment as shown in figure 4-6.
2. On the AM/FM test source, set the test mode to FM.
3. Set the audio synthesizer to 200 Hz at **+6 dBm.**
4. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Press **FREQ** and then key in 4.1 SPCL to turn on Track Mode. **Tune** the AM/FM test source's carrier frequency to approximately 100 MHz. Key in 4.0 SPCL to turn off **Track** Mode.
5. On the Modulation Analyzer, press MHz to center the instrument's tuning. Set the other controls as follows:

   Measurement .... **FM**
   Detector .... **AVG**

6. Set the audio synthesizer level to give a display of approximately 25 **kHz** average deviation.

7. Set the audio synthesizer frequency to the frequencies shown in the following table. For each setting, set RATIO on the Modulation Analyzer to off, set all HP or LP FILTERs to off, then set RATIO to %, and insert the filter indicated. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	Filter	Ratio Limits (% REL)		
		Lower	Actual	Upper
200	50 Hz HP FILTER	90.99		101.01
2 000	50 Hz HP FILTER	98.99		101.01
1 000	300 Hz HP FILTER	98.99		101.01
10000	300 Hz HP FILTER	98.99		101.01
1000	3 kHz LP FILTER	98.99		101.01
100	3 kHz LP FILTER	98.99		101.01
10000	15 kHz LP FILTER	98.99		101.01
1 000	15 kHz LP FILTER	98.99		101.01
10 000	> 20 kHz LP FILTER	98.99		101.01
1000	> 20 kHz LP FILTER	98.99		101.01

Performance Test 5

RF LEVEL PERFORMANCE TEST

Specifications

Serial Prefix: *1933A to 2212A*

Characteristic	Performance Limits	Conditions
RF LEVEL		Peak voltage responding, rms sine wave calibrated.
Range	**1 mW to 1 W**	
Instrumentation Accuracy	**±2 dB** **±3 dB**	150 kHz to 650 MHz 650 to 1300 MHz
SWR	< 1.5	50Ω *system*

Serial Prefix: *2227A and above*

Characteristic	Performance Limits	Conditions
RF LEVEL		Peak voltage responding, rms sine wave calibrated.
Range	**1 mW to 1 W**	
Instrumentation Accuracy	±1.5 dB	150 kHz to 650 MHz
SWR	< 1.3 < 1.5	50Ω system; 150 kHz to 650 MHz 50Ω system; 650 MHz to 1300 MHz

Description

Power from a signal generator is applied through a power splitter to the Modulation Analyzer's input and a power meter. The power level reading between the power meter and the Modulation Analyzer are compared for various settings of power level and frequency. SWR is measured at several frequencies by driving the input of the Modulation Analyzer through an SWR Bridge. The reflected power is measured by a power meter. A reference point is first made by disconnecting the Modulation Analyzer's input to give an open circuit (high reflection).

NOTE

For the accuracy measurement, the output of the signal generator must be filtered (if its harmonics or spurious signals are less than 30 down from the carrier) to prevent discrepancies between readings of the peak-responding Modulation Analyzer and the average-responding power meter.

Equipment

Bandpass Filter 512 to 674 MHz .... Telonic TBA 593-218-5FE
Bandpass Filter 800 to 1100 MHz .... Telonic TBA 950-375-5FE1
Power Meter and Sensor .... HP 436A/8482A
Power Splitter .... HP 11667A
Signal Generator .... HP 8640B with Option 002
SWR Bridge .... Wiltron 60N50

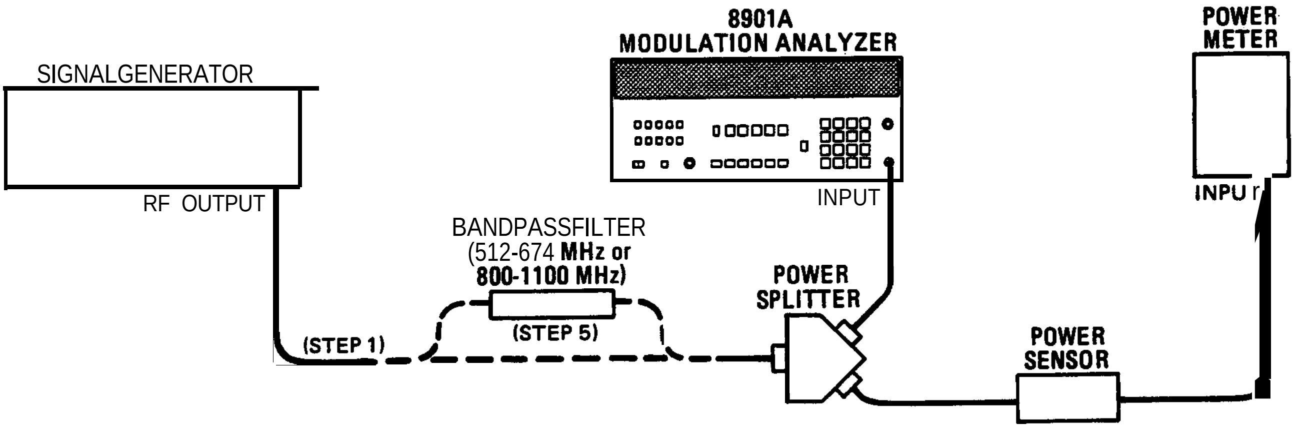


Figure 4-7. RF Level Accuracy Performance Test Setup

Procedure

RF Level Accuracy

1. Calibrate and zero the power meter and sensor.
2. Connect equipment as shown in figure 4-7.
3. Press RF LEVEL.
4. Set the signal generator to 50 MHz CW. Set its level for the power meter readings shown below. For each setting, the Modulation Analyzer's display should read between the limits shown below.

Serial Prefix: 1933A to 2212A

Power Meter Reading (mW)	RF Level Limits (mW)		
	Lower	Actual	Upper
10	6.31		15.8
3	1.89		4.75
1	0.631		1.56

Serial Prefix: 2227A and above

Power Meter Reading (mW)	RF Level Limits (mW)		
	Lower	Actual	Upper
10	7.08	______	14.1
3	2.12	______	4.24
1	0.708	______	1.41

5. Set the frequency of the signal generator to those shown in the table below. For each frequency setting, adjust the power level to give a power meter reading of 3 mW. The Modulation Analyzer should read between the limits shown in the table.

Serial Prefix: 1933A to 2212A

Signal Generator Frequency (MHz)	RF Level Limits (mW)		
	Lower	Actual	Upper
1000'	1.50	______	5.99
650*	1.89	______	4.75
100	1.89	______	4.75
10	1.89	______	4.75
0.5	1.89	______	4.75

* If a signal generator with a doubler is being used, insert the appropriate bandpass filter at the generator's output to suppress harmonic and subharmonic signals.

Serial Prefix: 2227A and above

Signal Generator Frequency (MHz)	RF Level Limits (mW)		
	Lower	Actual	Upper
1000'	2.12	______	4.24
650*	2.12	______	4.24
100	2.12	______	4.24
10	2.12	______	4.24
0.5	2.12	______	4.24

* If a signal generator with a doubler is being used, insert the appropriate bandpass filter at the generator's output to suppress harmonic and subharmonic signals.

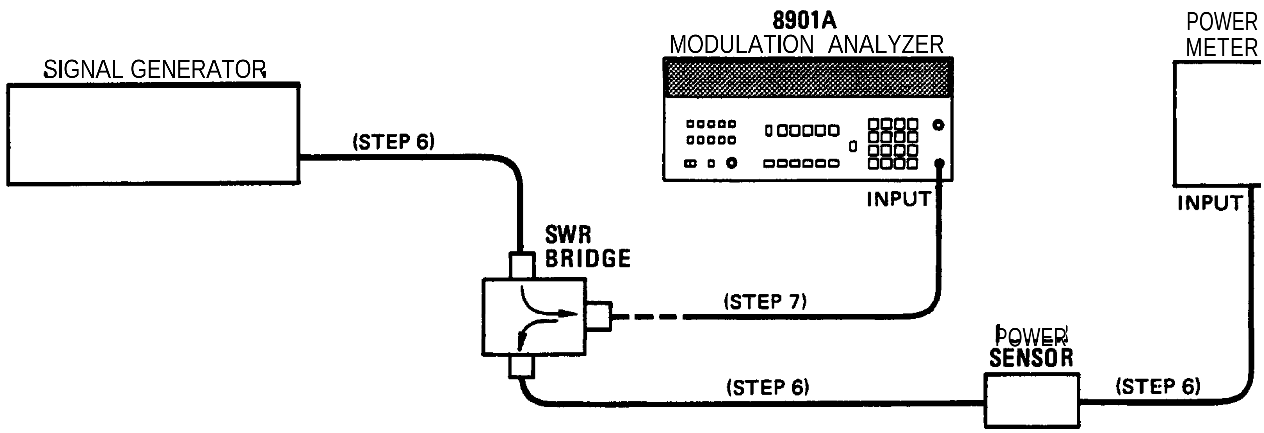


Figure 4-8. SWR Performance Test Setup

SWR Performance

6. Connect the equipment as shown in figure 4-8.
7. Set the signal generator frequency as listed in the following table. For each frequency disconnect the load from the test port of the SWR bridge and adjust the signal generator level for a power meter reading of -5 **dBm.** Then connect the test port of the SWR bridge directly to the Modulation Analyzer's INPUT. The power meter reading should drop by at least 14 **dB.**

Serial Prefix: 1933A to 2212A

Signal Generator Frequency (MHz)	Power Meter Reading (dBm)	
	Actual	Maximum
1000	______	-19
300	______	-19
100	______	-19
30	______	-19
10	______	-19

Serial Prefix: 2227A and above

Signal Generator Frequency (MHz)	Power Meter Reading (dBm)	
	Actual	Maximum
1000	______	-19
650	______	-23
300	______	-23
100	______	-23
30	______	-23
10	______	-23

*Table 4-l. **Performance Test Record (1 of 7)***

Hewlett-Packard Company
Yodel **8901A**
Modulation Analyzer

Tested By ______

Serial Number ______ Date ______

Test No.	Test Description	Results Minimum	Actual	Maximum
1	**AM PERFORMANCE TEST**			
	(Using Optiqn '010)			
	AM Accuracy at 10 **kHz** Rate			
	AM Calibration Factor; 40% AM Range	99%		101%
	AM Calibration Factor; 100% AM Range	99%		101%
	Residual AM			0.01%
	AM Distortion			
	20 **kHz** Rate; 50% AM			0.3%
	20 **kHz** Rate: 95% AM			0.6%
	20 Hz Rate; 95% AM			0.6%
	20 Hz Rate; 50% AM			0.3%
	AM Flatness			
	NOTE *The AM Flatness specification of the Modulation Analyzer is checked by noting the maximum difference between any pair of readings. The difference in readings between any two frequencies should be less than 0.8% REL.*			
	1 000 Hz Rate ______ % REL			
	10 000 Hz Rate ______ % REL			
	150 Hz Rate ______ % REL			
	90 Hz Rate ______ % REL			
	Maximum value ______ % REL			
	Minimum value ______ % REL			
	Difference ______ % REL			0.8% REL
	AM Accuracy			
	IF Frequency / Modulation Rate			
	1.5 MHz 50 000 Hz	98.9% REL		101.1% REL
	100 000 Hz	96.9% REL		103.1% REL
	50 Hz	98.9% REL		101.1% REL
	20 Hz	96.9% REL		103.1% REL
	455 **kHz** 20 Hz	96.9% REL		103.1% REL
	50 Hz	97.9% REL		102.1% REL
	10 000 Hz	97.9% REL		102.1% REL

Table 4-1. Performance Test Record (2 of 7)

Test NO.	Test Description	Results Minimum	Actual	Maximum
1	**AM PERFORMANCE TEST (Using Option 010) [Cont'd]**			
	AM Rejection With Frequency Modulation:			
	455 kHz IF		______	20 Hz
	1.5 MHz IF		______	20 Hz
	With Phase Modulation:			
	1.5 MHz IF		______	0.030 rad
1a	**AM PERFORMANCE TEST (Using Another 8901A With Option 010)**			
	AM Accuracy at 10 kHz Rate			
	NOTE *The AM Accuracy specification of the Modulation Analyzer is checked by comparing the measured values against the computed minimum and maximum results. If the measured values are within the specified tolerance of the computed results, the Modulation Analyzer is within specification.*			
	For 40% AM Modulation Range:			
	Computed result (reading in step 4): ______ %			
	Minimum computed result (reading in step 4 minus 0.334% AM): ______ %			
	Maximum computed result (reading in step 4 plus 0.334% AM): ______ %			
	Measured value (reading in step 9):	______ %	______	______ %
	For 100% AM Modulation Range:			
	Computed result (reading in step 6): ______ %			
	Minimum computed result (reading in step 6 minus 0.34% AM): ______ 0%			
	Maximum computed result (reading in step 6 plus 0.34% AM): ______ %			
	Measured value (reading in step 12):	______ %	______	______ %

Table 4-1. Performance Test Record (3 of 7)

Test No.	Test Description	Results Minimum	Results Actual	Results Maximum
1a	**AM PERFORMANCE TEST (Using Another 8901A with Option 010) (Cont'd)**			
	Residual AM			0.01%
	AM Distortion			
	20 kHz Rate: 50% AM			0.3%
	20 kHz Rate; 95% AM			0.6%
	20 kHz Rate; 95% AM			0.6%
	20 kHz Rate; 50% AM			0.3%
	AM Flatness			
	NOTE *The AM Flatness specification of the Modulation Analyzer is checked by noting the maximum difference between any pair of readings. The difference in readings between any two frequencies should be less than 0.8% REL.*			
	1 000 Hz Rate ______ % REL			
	10 000 Hz Rate ______ % REL			
	150 Hz Rate ______ % REL			
	90 Hz Rate ______ % REL			
	Maximum value ______ % REL			
	Minimum value ______ % REL			
	Difference ______ % REL			0.8% REL
	AM Accuracy			
	IF Frequency — Modulation Rate			
	1.5 MHz — 50 000 Hz	98.9% REL		101.1% REL
	100 000 Hz	96.9% REL		103.1% REL
	50 Hz	98.9% REL		101.1% REL
	20 Hz	96.9% REL		103.1% REL
	455 kHz — 20 Hz	96.9% REL		103.1% REL
	50 Hz	97.9% REL		102.1% REL
	10 000 Hz	97.9% REL		102.1% REL
	AM Rejection			
	With Frequency Modulation:			
	455 kHz IF			20 Hz
	1.5 MHz IF			20 Hz
	With Phase Modulation:			
	1.5 MHz IF			0.030 rad

Table 4-1. Performance Test Record (4 of 7)

Test No.	Test Description	Results Minimum	Results Actual	Results Maximum
2	**FM PERFORMANCE TEST (Using Option 010)**			
	Residual FM			
	550 MHz; 50 Hz to 3 kHz BW			4 Hz
	FM Accuracy at 10 kHz Rate			
	FM Calibration Factor; 40 kHz Modulation Range	99%		101%
	FM Calibration Factor; 400 kHz Modulation Range	99%		101%
	4 kHz Modulation Range	12.35		12.65
	FM Distortion, Accuracy, and Rejection-l.5 MHz IF			
	FM Distortion:			
	100 kHz Rate; 100 kHz FM			0.1%
	FM Accuracy:			
	100 000 Hz Rate	98.9 kHz		101.1 kHz
	200 000 Hz Rate	94.9 kHz		105.1 kHz
	50 Hz Rate	98.9 kHz		101.1 kHz
	20 Hz Rate	94.9 kHz		105.1 kHz
	FM Rejection:			
	1 kHz Rate; 50 kHz FM			0.2%
	FM Distortion, Accuracy, and Rejection-455 kHz IF			
	FM Rejection:			
	1 kHz Rate: 5 kHz FM			0.2%
	FM Accuracy:			
	10 000 Hz Rate	9.79 kHz		10.21 kHz
	20 Hz Rate	9.79 kHz		10.21 kHz
	FM Distortion:			
	10 kHz Rate: 10 kHz FM			0.1%
2a	**FM PERFORMANCE TEST (Using Another 8901A with Option 010)**			
	Resldual FM			4 Hz
	560 MHz/50 Hz to 3 kHz BW			
	FM **Accuracy at 10 kHz Rate**			
	NOTE *The FM Accuracy specification of the Modulation Analyzer is checked by comparing the measured values against the computed minimum and maximum results. If the measured values are within th.e specified tolerance of the computed results, the Modulation Analyzer is within specification.*			

Table 4-l. Performance Test Record (5 of 7)

Test No.	Test Desctiptlon	Results Minimum	Results Actual	Results Maximum
2a	**FM PERFORMANCE TEST (Using Another 8901A with Option 010) [Cont'd]**			
	For 40 **kHz** Modulation Range:			
	Computed result (reading in step 6): ______ **kHz**			
	Minimum computed result (reading in step 6 minus 0.334 **kHz**): ______ **kHz**			
	Maximum computed result (reading in step 6 plus 0.334 **kHz**): ______ **kHz**			
	Measured value (reading in step 11):	______ **kHz**	______	______ **kH**
	For 400 **kHz** Modulation Range:			
	Computed result (reading in step 8): ______ **kHz**			
	Minimum computed result (reading in step 8 minus 0.34 **kHz**): ______ **kHz**			
	Maximum computed result (reading in step 8 plus 0.34 **kHz**): ______ **kHz**			
	Measured value (reading in step 14):	______ **kHz**	______	______ **kH**
	For 4 **kHz** Modulation Range:	12.35	______	12.65
	FM Distortion, Accuracy, and Rejection-l **.5** MHz IF			
	FM Distortion: 100 **kHz** Rate; 100 **kHz** FM		______	0.1%
	FM Accuracy:			
	100 000 Hz Rate	98.9 **kHz**	______	101.1 **kHz**
	200 000 Hz Rate	94.9 **kHz**	______	105.1 **kHz**
	50 Hz Rate	98.9 **kHz**	______	101.1 **kHz**
	20 Hz Rate	94.9 **kHz**	______	105.1 **kHz**
	FM Rejection: 1 **kHz** Rate; 50 **kHz** FM		______	0.2%
	FM Distortion, Accuracy, and Rejection-455 **kHz** IF			
	FM Rejection: 1 **kHz** Rate: 5 **kHz** FM		______	0.2%
	FM Accuracy:			
	10 000 Hz Rate	9.79 **kHz**	______	10.21 **kHz**
	20 Hz Rate	9.79 **kHz**	______	10.21 **kHz**
	FM Distortion: 10 **kHz** Rate: 10 kHz FM		______	0.1%

Table 4-1. Performance *Test Record* ***(6*** *of* ***7)***

Test No.	Test Description		Results		
			Minimum	Actual	Maximum
3	**PHASE MODULATION [ΦM] PERFORMANCE TEST**				
	ΦM Accuracy				
	Modulation Rate (Hz)	Average FM Deviation (kHz)			
	200	50	242.4 rad		257.6 rad
	1 000	250	242.4 rad		257.6 rad
	20 000	250	12.0 rad		13.0 rad
	20 000	4	0.193 rad		0.207 rad
	ΦM Distortion				
	1 kHz Rate; 400 Radians; 1.5 MHz IF				0.1%
	1 kHz Rate: 40 Radians: 455 kHz IF				0.1%
4	**AUDIO FILTERS PERFORMANCE TEST**				
	Modulation Rate Hz	Filter Selected			
	200	50 Hz HP	98.99% REL		101.01% REL
	2 000	50 Hz HP	98.99% REL		101.01% REL
	1 000	300 Hz HP	98.99% REL		101.01% REL
	10 000	300 Hz HP	98.99% REL		101 .Ol% REL
	1 000	3kHzLP	98.99% REL		101.01% REL
	100	3 kHz LP	98.99% REL		101.01% REL
	10 000	15 kHz LP	98.99% REL		101.01% REL
	1 000	15 kHz LP	98.99% REL		101.01% REL
	10 000	>20 kHz LP	98.99% REL		101 .Ol% REL
	1 000	>20 kHz LP	98.99% REL		101.01% REL
5	**RF LEVEL PERFORMANCE TEST** **Serial *Prefix: 1933A* to *2212A***				
	RF Level Accuracy				
	Power Meter Reading				
	10 mW		6.31 mW		15.8 mW
	3mW		1.89 mW		4.75 mW
	1 mW		0.631 mW		1.58 mW
	Frequency				
	1000 MHz		1.50 mW		5.99 mW
	650 MHz		1.89 mW		4.75 mW
	100 MHz		1.89 mW		4.75 mW
	10 MHz		1.89 mW		4.75 mW
	0.5 MHz		1.89 mW		4.75 mW

Table 4-l. Performance Test Record (7 of 7)

Test No.	Test Description	Results Minimum	Results Actual	Results Maximum
5	**RF LEVEL PERFORMANCE TEST [Cont'd]** *Serial Prefix: 1933A to 2212A*			
	SWR			
	Frequency			
	1000 MHz			-19 dBm
	300 MHz			-19 dBm
	100 MHz			-19 dBm
	30 MHz			-19 dBm
	10 MHz			-19 dBm
5	**RF LEVEL PERFORMANCE TEST** Serial Prefix: 2227A and above			
	RF Level Accuracy			
	Power Meter Reading			
	10 mW	7.08 mW		14.1 mW
	3 mW	2.12 mW		4.24 mW
	1 mW	0.708 mW		1.41 mW
	Frequency			
	1000 MHz	2.12 mW		4.24 mW
	650 MHz	2.12 mW		4.24 mW
	100 MHz	2.12 mW		4.24 mW
	10 MHz	2.12 mW		4.24 mW
	0.5 MHz	2.12 mW		4.24 mW
	SWR			
	Frequency			
	1000 MHz			-19 dBm
	650 MHz			-23 dBm
	300 MHz			-23 dBm
	100 MHz			-23 dBm
	30 MHz			-23 dBm
	10 MHz			-23 dBm

Section 5
ADJUSTMENTS

5-1. INTRODUCTION

This section contains adjustments and checks that assure peak performance of the Modulation Analyzer. The instrument should be readjusted after repair or **failure** to pass a performance test. Allow a 30 minute warm-up prior to performing the adjustments. Removing the top cover is the only disassembly required for all adjustments.

To determine which performance tests and adjustments to perform after a repair, refer **to** paragraph **5-5,** Post-Repair Tests, Adjustments, and Checks.

5-2. SAFETY CONSIDERATIONS

This section contains information, cautions, and warnings which must be followed for your protection and to avoid damage to the equipment.

WARNING

Adjustments &scribed in this section are performed with power supplied to the instrument and with protective covers removed. Maintenance should be performed only by service trained personnel who are aware of the hazard involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

Removal of the Modulation Analyzer's bottom cover is not necessary to perform these adjustments. However, if the bottom cover is removed, hazardous voltage ($\approx$120 V ac) is accessible.

A pin-to-pin voltage difference of 55 V dc may be found on many of the Modulation Analyzer's circuit board connectors. Be careful while working on the circuit boards with power supplied to the instrument.

If a circuit board is placed on an extender board, the possibility of coming in contact with 55 V dc is greatly increased. Be careful while working on the circuit boards with power supplied. Work with one hand. Do not touch the extender board.

5-3. EQUIPMENT REQUIRED

Each adjustment procedure contains a list of required test equipment. The test equipment is **identified** by **callouts** in the test setup diagrams where included

If substitutions must be made for the specified test equipment, refer to table l-3 for the minimum specifications. It is important that the test equipment meet the critical specifications listed in the table if the Modulation Analyzer is **to** meet its performance requirements.

5-4. FACTORY-SELECTED COMPONENTS

Factory-selected components are identified on the schematics and parts list by an asterisk which follows the reference designator. The normal value or range of the components is shown. Table 5-1 lists the reference designator, the criterion used for selecting a particular value, the normal value range, and the service sheet where the component part is shown.

Table 6-1. Factory Selected Components

Reference Designator	service Sheet	Range of Values	Basis of Selection
Serial *Prefixes: 2212A to 2410A (08901-60183)*			
A15R10	*1*	42.212 *68.10*	*Refer to RF Detector Offset Adjustment (Adjustment 3).*
A15R47	*1*	*196Ω 3830*	*Refer to RF Detector Offset Adjustment (Adjustment 3).*
A19C43	11	4.7p to 15p	See LO Doubler Power Output and Balance Adjustment (Adjustment 5).
AI 9R63	11	38.1Ω to 110Ω	See LO Doubler Power Output and Balance Adjustment (Adjustment 5).
AI 9R72, R74	11	619Ω to 1210Ω	See LO Doubler Power Output and Balance Adjustment (Adjustment 5).
A20R1, R2	14	21.5 kΩ to ∞	See Track-Tune Mode Offset Adjustment (Adjustment 19).
A23R55	12	511Ω to 1780R	See Sampler Efficiency and Offset Adjustment (Adjustment 4).
A23C45	12	1.8p to 2.7p	See Sampler Efficiency and Offset Adjustment (Adjustment 4).
A51C20 451 R32	28	9.09 kΩ or 11.0 kΩ	If A51C20 cannot be adjusted for a display within listed limits, then R32 can be selected to shift nominal readings on the display. Increasing R32 one adjustment value will increase the nominal reading by approximately 3%. The only values available are 9.89 k ohms and 11 .O k ohms.
951 R24	28	—	If the FM deviation of the FM Calibrator Option 010 exceeds the peak deviation limits of 30 to 38 kHz, error E08 will be displayed. (If service errors have been enabled by Special Function 43.1, error E74 or E75 will be displayed instead.) To measure the actual peak deviation, connect the CALIBRATION OUTPUT to the INPUT and key in 12.2 SPCL. If the deviation is only slightly out of limits, alter the value of A51 R24. Increasing the value of A51 R24 by 10% will decrease the peak deviation by approximately 2.5 kHz.

5-5. POST-REPAIR TESTS, ADJUSTMENTS, AND CHECKS

Table 5-2 lists the performance tests, adjustments, and checks needed to calibrate or verify calibration of a repaired assembly. The tests, adjustments, and checks are classified by assembly repaired.

The table is also useful as a cross reference between performance tests and assemblies when the failure is a specification that is slightly out of limits.

For all repairs, perform the Basic Functional Checks, the Power Supply Adjustment (but only adjust the +15 V supply if it is out of limits), and the Internal Reference Frequency Adjustment. The Basic Functional Check utilizes automatic tuning and measurement which exercises nearly every circuit in the instrument (except the Remote Interface Assembly).

5-6. RELATED ADJUSTMENTS

The procedures in this section can be done in any order, but it is advisable to check the power supply voltages and time base reference first.

Table 5-2. Post-Repair Tests, Adjustments, and Checks (1 of 3)

Assembly Repaired	Test, Adjustment, or Check	Refer to Page
Al Keyboard and Display	Power-Up Checks Service Special Functions (use 80.0 SPCL, Key Scan, and exercise all keys)	8-17 8-11
A2 Audio Filter	AM Performance Test AM Sensitivity Adjustment 15 kHz and >20 kHz Low-Pass Filter Gain Adjustments	4-2 5-29 5-18
A3 Audio D&emphasis and output	FM Performance Test (FM Distortion 1.5 MHz IF only) ΦM Performance Test Audio Filters Performance Test ΦM Sensitivity Adjustment	4-15, (4-21) 4-28 4-32 5-28
A4 FM Demodulator	FM Performance Test FM Sensitivity Adjustment FM Flatness Adjustment	4-15 5-I 9 5-22
A5 Voltmeter	Voltmeter Off set and Sensitivity Adjustment Service Special Functions (use 49.N and 50.N SPCL, Display Internal Voltages, and check for reasonable readings)	5-14 8-7
A8 AM Demodulator	AM Performance Test FM Distortion and Incidental AM Adjustment (1.5 MHz SF) AM Sensitivity Adjustment ALC Reference Adjustment	4-2 5-24 5-29 5-I 7

Table 6-2. Post-Repair Tests, Adjustments, and Checks (2 of 3)

Assembly Repaired	lest, Adjustment, or Check	Refer to Page
A10 **Power** Supply Regulators	Power Supply Adjustment	**5-6**
All Counter	**Internal** Reference Frequency Adjustment Power-up Checks	5-7 8-17
Al3 **Controller**	**Power-Up** checks	8-17
Al4 Remote Interface	HP-IB **Functional Checks** Power-up checks	3-18 8-17
Al5 RF Input	RF Level **Performance** Test RF Detector Offset Adjustment	4-35 **5-9**
Al7 Input Mixer	FM Distortion and Incidental AM Adjustment (1.5 MHz IF) FM Distortion and Incidental AM Adjustment (455 **kHz** IF)	5-24 5-32
Al 8 IF **Amplifier**	FM Distortion and Incidental AM Adjustment (1.5 MHz IF) FM Distortion **and** Incidental AM Adjustment (455 **kHz** IF)	5-24 5-32
A19 LO Divider	LO Doubler **Balance** Adjustment (only for **Doubler** repairs) Power-up checks	5-12 8-17
A20 LO Control	FM **Performance** Test (Residual FM **only)** Power-Up Checks	4-15, (4-21) 8-17
A21 Low Frequency VCXO Filter	Power-Up Checks	8-17
A22 Low **Frequency** vcxo	FM **Performance** Test (Residual FM **Only)** Power-Up **Checks**	4-15, (4-21) 8-17
A23 **Sampler**	FM **Performance** Test (Residual FM **only)** Sampler Efficiency and Offset Adjustment Power-Up Checks	4-15. (4-21) 5-10 8-17
A24 High Frequency VCO	FM Performance Test (Residual FM **only)** Power-Up Checks	4-15, (4-21) 8-17
A25 Audio Motherboard A28 Power Supply Motherboard A27 Digital Mother Board A28 RF **Mother** Board A29 Series Regulator Heat Sink A30 tine Power Module	Power-Up Checks	a17

Table 6-2. Post-Repair Tests, Adjustments, and Checks (3 of 3)

Assembly Repaired	Test, Adjustment, or Check	Refer to Page
A31 Remote Interface Connector	HP-IB Functional Checks	3–18
A50 AM Calibrator	AM Performance Test (AM Accuracy at 10 kHz only) AM Calibrator Adjustment	4-4 5-28
A51 FM Calibrator	FM Performance Test (FM Accuracy at 10 kHz only) FM Calibrator Adjustment	4-17 5–18

Adjustment 1

POWER SUPPLY ADJUSTMENT

Reference

- **Service Sheets 23 and 24**

Description

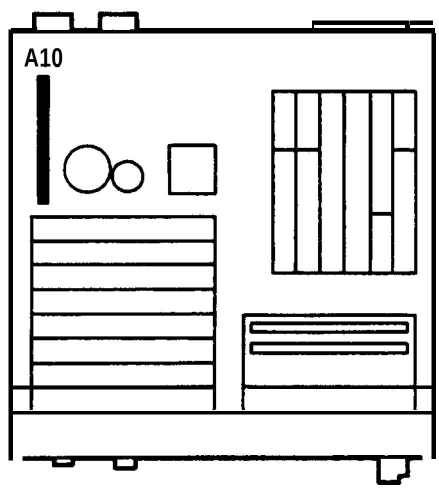
The **+15** V supply is adjusted, and the other supplies, which are dependent upon it, are checked.

Equipment

Digital Multimeter .... HP 3478A

Procedure

1. Set voltmeter to measure **+15** V dc. Connect input to **A10TP3 (+15** V).
2. Adjust **A10R24 (+15** V ADJ) for **+14.9** to **+15.1** V dc at **A10TP3.**
3. Check the other supplies with voltmeter as shown below.



Supply	Test Point	Voltage Limits (V dc)	
		Minimum	Maximum
-15 V	A10TP7	-15.2	-14.8
+5 V	A10TP5	+5.1	+5.3
-5 V	A10TP4	-5.3	-5.1
+40 V	A10TP6	+40.5	+42.5

Adjustment 2

INTERNAL REFERENCE FREQUENCY ADJUSTMENT

Reference

- **Service Sheet 16**

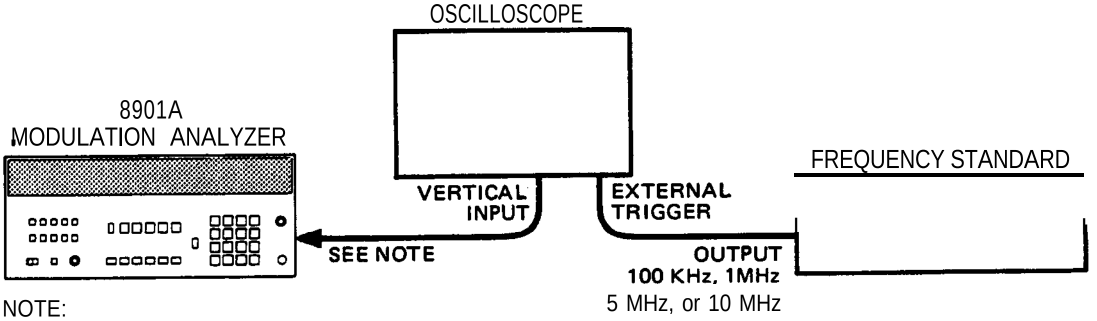
Description

An oscilloscope, triggered by an external reference, is used to monitor the internal reference frequency while it is adjusted.

Equipment

Frequency Standard .... House Standard
Oscilloscope .... HP 54201A

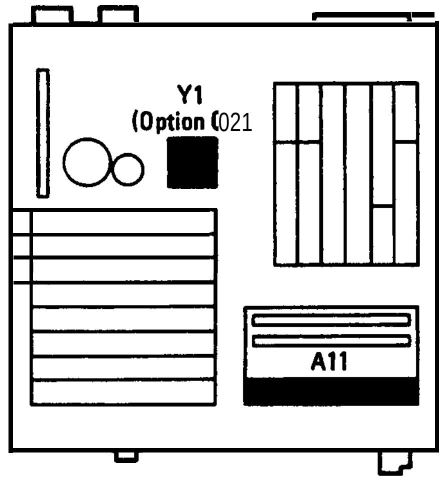
S WR Performance



NOTE:
CONNECT OSCILLOSCOPE VERTICAL INPUT TO AllJ5 (INT 10 MHz OUT) IN THE 8901A OR (OPTION 002 ONLY) 'THE REAR-PANEL TIME BASE 10 MHz OUTPUT.

Figure 6-l. Internal Reference Frequency Adjustment Test Setup

Procedure



1. Allow equipment to warm up for 15 minutes. For Option 002, a warm-up of the Modulation Analyzer of several days with covers on is recommended.
2. Connect equipment as shown in figure 5-l.
3. Set oscilloscope's vertical sensitivity to view the Modulation Analyzer's time base output. Set its horizontal scale for 0.1 μs per division. Set oscilloscope to trigger externally.
4. Adjust AllC14 (10 MHz REF) or, for Option 002, **Y1** (COARSE and FINE) for a stationary waveform. If adjusting AllC14, use a totally non-metallic adjustment tool.

NOTE

Movement of the waveform to the right at a rate of one division per second means that the Modulation Analyzer's time base frequency is low by 0.1 p/m.

If the frequency of the internal reference is quite far off, the oscilloscope display may be difficult to interpret. In that case, connect the frequency standard directly to the Modulation Analyzer's INPUT, press FREQ, and &just the internal reference frequency for a display equal to the standard's frequency. Then begin again at step 2.

Adjustment 3

RF DETECTOR OFFSET ADJUSTMENT

Reference

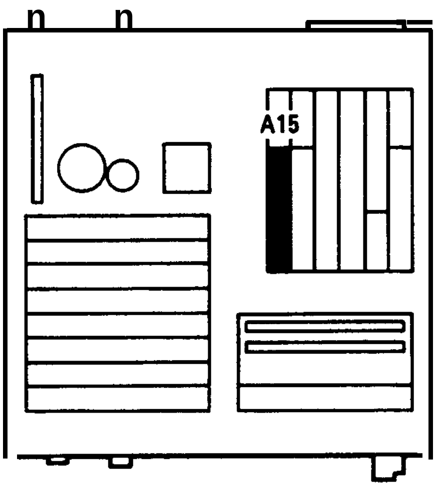
- **Service Sheet 1**

Description

With no RF input, the output from the RF detector is adjusted, for 0 V dc while monitoring it with the **internal** voltmeter.

Procedure

1. Remove any cable from the Modulation Analyzer's INPUT.
2. Press RF LEVEL.
3. Key in 41.0 SPCL to preset the instrument. Then, key in 49.31 SPCL to display the RF level with respect to RF ground. These steps set the input for an RF level measurement and connect the internal voltmeter to the RF detector output.
4. Adjust **A15R42** (DET OFS) for a display between -0.001 and 0.001.



Serial Prefixes: 2212A to 2410A only (08901-60183)

5. ***A15R10 and A15R47 Selection:*** If the instrument slightly exceeds the limits of step 5 of the RF Level Performance Test (Performance Test 5 in section **4),** make an adjustment to the level accuracy versus input frequency by altering the value of **A15R10** and **A15R47.**

   a. If the level accuracy is uniformly high or low, change **A15R47.** Increasing the value of **A15R47** by 10% will lower the indicated level by 0.1 **dB.**

   b. If the level increases or decreases with frequency, change **A15R10.** Increasing the value of **A15R10** by 10% will decrease, by 0.2 **dB,** the indicated level at 1000 MHz relative to the level at low frequencies.

   After altering the resistor values, repeat the test, making additional measurements at frequencies between those indicated in step 5 of the RF Level Performance Test (Performance **Test** 5 in section **4),.** The effects of changing the two resistors are slightly interactive. A large change in one resistor value may require a slight change in the value of the other resistor.

Serial Prefixes: 2421A and above (08901-60256)

5. *AI5 Modification=* If the instrument slightly exceeds the limits of step 5 of the RF Level Performance Test (Performance Test 5 in section **4),** make an adjustment to the level accuracy versus input frequency by one or more of the following methods.

a. If the frequency response rolls off excessively at the higher **frequencies,** try unsoldering the leads of **A15CR1** and raising it slightly.

b. If **A15R10** is 61.59 ohms, replace it with HP Part number **0699-0252, 52.8** ohms.

c. If **A15R10** has been replaced in step b and the frequency response is still not flat, add a nickel disk (HP part number **1600-0265)** to the first 20 **dB** pad.

After altering A15, repeat the the RF Level Performance test, making additional measurements at **frequencies** between those indicated in step 5.

Adjustment 4

SAMPLER EFFICIENCY AND OFFSET ADJUSTMENT

Reference

Service Sheet 18.

Description

Using the track mode special function (4.1 SPCL), the two signals into the sampler are configured so that the low-frequency VCXO is at a set frequency and the high-frequency VCO tracks the RF input signal. The output of the sampler is observed on an oscilloscope. The RF input is tuned to locate a zero-beat frequency at the sampler output then tuned for a 1 MHz beat. The sampler offset and efficiency (or frequency response) are then adjusted so that the dc offset is zero and the amplitude of the 1 MHz waveform is the same for the zero beat.

NOTE

Improper adjustment of efficiency may result in the loop easily breaking or not attaining phase lock.

Equipment

Oscilloscope .... HP 54201A
Signal Source .... HP 8640B

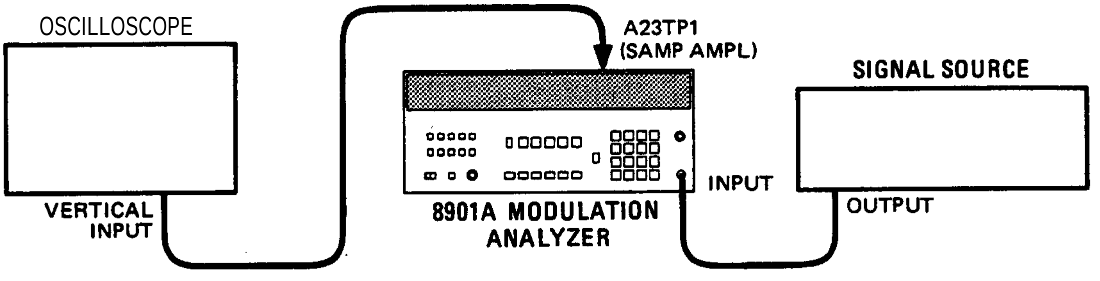
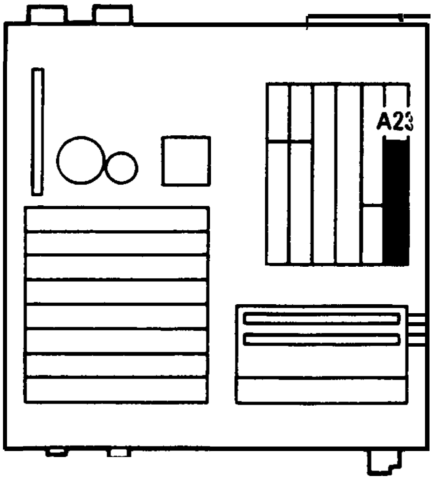


Figure 5-2. Sampler Efficiency and Offset Adjustment Test Setup

Procedure



1. Set the signal source to 18 MHz CW at 0 dBm.
2. Connect the equipment as shown in figure 5-2. (The oscilloscope input should be ac coupled.)
3. Set the oscilloscope's vertical sensitivity to 0.2 V/division and horizontal scale for 10 ,&division.
4. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Key in 4.1 SPCL to set the instrument to TRACK MODE. If the instrument fails to tune to the 18 MHz signal, key in 18 MHz then key in 4.1 SPCL.
5. Fine tune the signal source up slowly until a zero beat signal appears on the oscilloscope. Then increase the signal source frequency for a period of 30 μs. Note the frequency of the signal source. Note the peak-to-peak amplitude on the oscilloscope.

   Signal Source Frequency: ________ MHz

   Waveform Amplitude: ________ mV (p-p)
6. Tune the signal source up by 30.0 kHz. This tunes the high frequency VCO up 32 x 30 kHz $\approx$ 1 MHz since the LO frequency is the HF VCO frequency divided by 32 on this band.
7. Adjust **A23R34** (OFS) such that when the input coupling of the oscilloscope is changed from ac to dc the waveform shifts upward 50 mV. Adjust **A23R34** only when the input coupling is set to dc.
8. Adjust **A23R54 (EFF)** for the same peak-to-peak amplitude on the oscilloscope as noted in step 5. If the adjustment has not enough range:

   a. Set **A23R54** fully ccw and repeat steps 5 to 7.

   b. The signal amplitude should now be less than in step 5. If it is not, replace **A23R55** by higher values of resistance as listed in table 5-2. If this still does not have enough effect, replace **A23C45** with 2.7 pF (HP Part Number 0160-4619).

   c. Adjust **A23R54** for the same amplitude as noted in step 5.
9. Repeat step 7.

Table 5-2. Part Numbers for A23R55

Resistance (ohms)	sistance (ohms)	HP Part Number
511	511	0757-0416
750	750	0757-0420
1000	1000	0757-0280
1210	1210	0757-0274
1470	1470	0757-I 094
1780	1780	0757-0278

Adjustment 5

LO DOUBLER POWER OUTPUT AND BALANCE ADJUSTMENT

Reference

- **Service Sheet 11**

Description

The power output of the LO is monitored with a power meter while the LO is stepped through its doubler band. The bias and coupling components are changed as necessary to obtain the required power output. The output of the LO is then monitored with a spectrum analyzer as the VCO is swept slowly over its doubler band. The doubler balance is adjusted for minimum 1/2 and 3/2 harmonics of the doubled frequency.

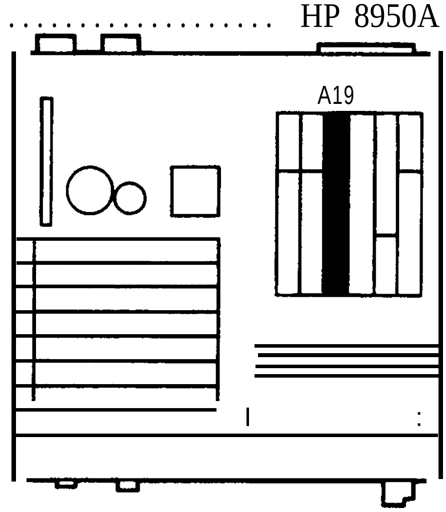
NOTE

Excessive subharmonics may cause the LO to tune to a wrong frequency when automatically tuning.

Equipment

RF Power Meter .... HP 435/8482A
RF Spectrum Analyzer .... HP 8950A

Procedure



1. Connect the power sensor of the power meter directly to A19J3 (LO OUT), or for Option 003, the rear panel LO OUTPUT jack.
2. On the Modulation Analyzer, key in 650 MHz to set the LO to the bottom of its doubler band.
3. Step the LO up in 50,000 kHz increments and record the power obtained at each frequency. The Modulation Analyzer will display error message E20 when the LO reaches the top of its range.
4. The power output of the LO should be between +1.4 dBm and +3.0 dBm at all frequencies prior to the display of error message E20. If the power output is within range, continue with step 6. If the power output is not within range, perform step 5.

   Resistors R63, R72, and R74 and capacitor C43 are changed to obtain the correct power output from the LO. Use the following guidelines when changing these components:

   a. To increase the power throughout the entire doubler band decrease the value of R63.

   b. To eliminate low frequency roll-off, increase the value of C43. Do not use a value for C43 that is larger than necessary or the effectiveness of the high-pass filter is reduced.

Adjustment 6

VOLTMETER OFFSET AND SENSITIVITY ADJUSTMENT

Reference

- **Service Sheets 9 and 10**

Description

First the dc offsets of the peak and average detectors are adjusted The voltmeter sensitivity is then adjusted while comparing the displayed reading to the level read by an external dc voltmeter. The sensitivity of the average detector is adjusted while comparing the average mode to the peak mode when detecting a sinusoidal signal.

Equipment

Audio Analyzer .... HP 8903A
Digital Multimeter .... HP 3478A
Signal Source .... HP 8640B

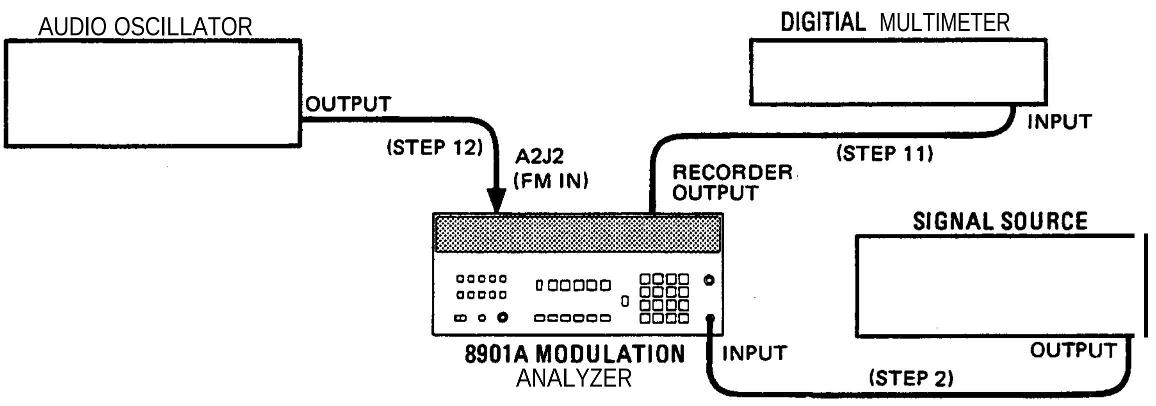
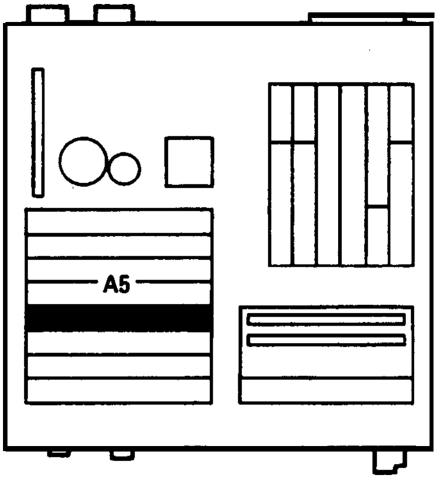


Figure 5-3. Voltmeter Offset and Sensitivity Adjustment Test Setup

Procedure

1. Set signal source to 11 MHz CW at 0 dBm.
2. Connect the signal source output to the Modulation Analyzer's INPUT as shown in figure 5-3.
3. On the Modulation Analyzer, key in 41.0 to initialize it.
4. Set HP FILTER to 300 Hz and LP FILTER to 3 kHz.



5. Key in 2.3 SPCL to set the audio gain to minimum. Nest, key in 0.110 SPCL to set the audio input select and audio overvoltage detector to no input and no reset. Then key in 49. **S(Shift)** 0 SPCL to set the voltmeter to measure and display the peak detector output.
6. Adjust **A5R49** (PK DET OFS) for a display of 0.0003 to 0.0007.
7. Key in 49.9 SPCL. This sets the voltmeter to read the output of the average detector.
8. Set **A5R7 (RECT** OFS) **fully** ccw. This shuts off **A5U2.**
9. Adjust **A5R29** (AVG OFS) for a display of -0.0001 to 0.0001.
10. Set **A5R7** (RECT OFS) **fully** cw then slowly ccw **until** display reads between 0.0004 and 0.0006.
11. Set external voltmeter to read 2.5 V dc. Connect its input to the Modulation Analyzer's rear-panel RECORDER OUTPUT as shown in figure 5-3.
12. Set audio **analyzer's** source for 2 **kHz** at 1 V. Connect its output to **A2J2** (FM IN) of the Modulation Analyzer as shown in figure 5-3.
13. On the Modulation Analyzer, press FM. Set DETECTOR to PEAK+.
14. Adjust level of the audio **analyzer's** source **until** external voltmeter reads between **+1.999** and **+2.001** V dc.
15. Adjust **A5R76** (VM SENS) for a display on the Modulation Analyzer of between 199.9 and 200.1 **kHz,** or if the level has driid slightly, until the four digits of the display agree with the **first** four digits of the voltmeter reading to within **±1** digit.
16. Press AVG.
17. Adjust **A5R35** (AVG SENS) for a display on the Modulation Analyzer of between 141.3 and 141.5 **kHz,** or if the level has drifted slightly, **until** the four digits of the display equals the voltmeter reading times 0.7071 to within **±1** digit.
18. Press PEAK+, Note the display. Press PEAK-. The two readings of the display should agree within **±1** digit.
19. Perform the FM Sensitivity, **ΦM** Sensitivity, and AM Sensitivity Adjustments.

Adjustment 7

15 KHZ AND >20 KHZ LOW-PASS FILTER GAIN ADJUSTMENTS

Reference

- **Service Sheet 7**

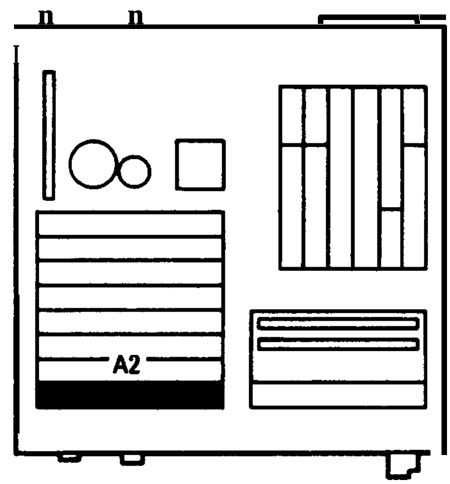
Description

A **signal** generator is amplitude modulated at a 1 **kHz** rate. The **signal** is demodulated by the Modulation Analyzer with no low-pass **filtering.** Using the ratio feature, the demodulated **signal** is referenced to 100%. The low-pass **filtering** is then set to **>20 kHz** and 15 **kHz,** and the **filter** gain for each is adjusted for a reading of 100%.

Equipment

Signal Generator .... HP **8640B**

Procedure



1. Set **signal** generator to 11 MHz at 0 **dBm with** 30% AM at a 1 **kHz** rate. Connect its RF output to the Modulation **Analyzer's** INPUT.
2. On the **Modulation Analyzer,** key in 41.0 SPCL to **initialize** it. Press AM. Set DETECTOR to AVG.
3. Set RATIO to %. The display **should** show between 99.95 and 100.05% REL.
4. Set LP FILTER to **>20 kHz.** Adjust **A2R44 (>20 kHz** LPF GAIN) for a display of 99.95 to 100.05% **REL.**
5. Set LP FILTER to 15 **kHz.** Adjust **A2R40** (15 **kHz** LPF GAIN) for a display of 99.95 to 100.05% REL.

Adjustment 8

ALC REFERENCE ADJUSTMENT

Reference

- **Service** Sheet 3

Description

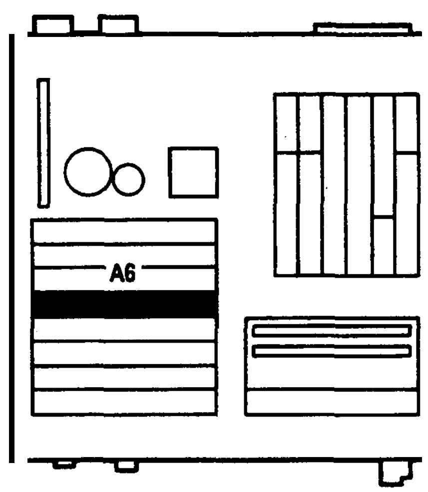
The ALC reference voltage is adjusted **while** monitoring it with the internal voltmeter.

Equipment

Signal Source .... HP **8640B**

Procedure

1. Set **signal** source to 11 MHz CW at 0 **dBm.** Connect its output to the Modulation Analyzer's INPUT.
2. On the Modulation Analyzer, key in 41.0 SPCL and then 49. S(Shift) 1 SPCL to initialize the instrument and connect the **internal** voltmeter to a node which represents the average IF level which the ALC loop forces to **equal** the ALC reference.
3. Adjust **A6R65** (ALC REF) for a display of 2.0970 to 2.1030.
4. If **A51C20** cannot be adjusted for a display within listed **limits,** then **A51R32** can be selected to shift nominal readings on the display. Increasing **A51R32** one adjustment value **will** increase the nominal reading by approximately 3%. The only **values** available are 9.09 k Ω and 11.0 k Ω .



Adjustment 9

FM CALIBRATOR ADJUSTMENT (OPTION 010)

Reference

- **Service Sheet 28**

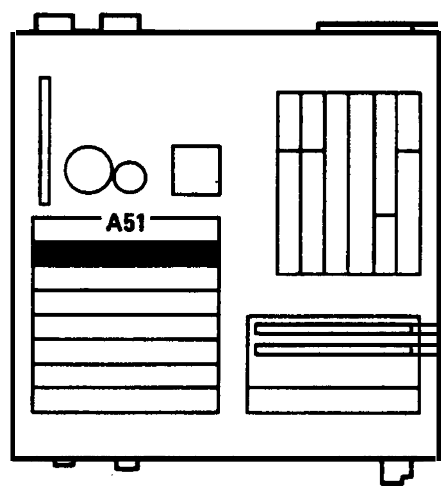
Description

The FM Calibrator is set to CW and its frequency is adjusted while monitoring it with the internal counter. The calibrator is then set to modulate and the symmetry adjusted as the demodulated signal is measured with the PEAK+ and PEAK- detectors.

NOTE

This calibration adjustment is not critical. An erroneous calibration cannot be made because if conditions exist that are out of calibration, the Modulation Analyzer dislays an error message.

Procedure



1. Connect CALIBRATION OUTPUT to INPUT.
2. Key in 12.1 SPCL and 46.3 SPCL. This sets the FM Calibrator to CW and connects the internal counter to measure the calibrator frequency.
3. Using a **non-metallic** tool, adjust **A51C20** (FREQ) for a display of 1009000 to 1011000.
4. Key in 12.2 SPCL then 5.1 SPCL. This sets the instrument to display the demodulated FM from the calibrator and sets the peak detector time constant to slow.
5. Alternately set the DETECTOR to PEAK+ and PEAK- and note the display for each setting. Adjust **A51R12** (TRAPEZOID SYMM) until the readings are the same for both detectors within **±0.010 kHz.**
6. If the FM deviation of the FM Calibrator, Option 010, exceeds the peak deviation limits of 30 to 38 **kHz,** error E08 will be displayed. (If servcie errors have been enabled by Special Function 43.1, error E74 or E75 will be displayed instead) To measure the actual peak deviation, connect the CALIBRATION OUTPUT to the INPUT and key in 12.2 SPCL.

   If the peak deviation is only slightly out of limits, alter the value of **A51R24.** increasing the value of **A51R24** by 10% will decrease the peak deviation by approximately 2.5 **kHz.**

Adjustment 10

FM SENSITIVITY ADJUSTMENT (OPTION 010)

Reference

- **Service Sheet 6**

Description

The FM sensitivity is adjusted for a calibration factor of 100% **while** the Modulation Analyzer measures the output of its FM Calibrator (Option 010).

NOTE

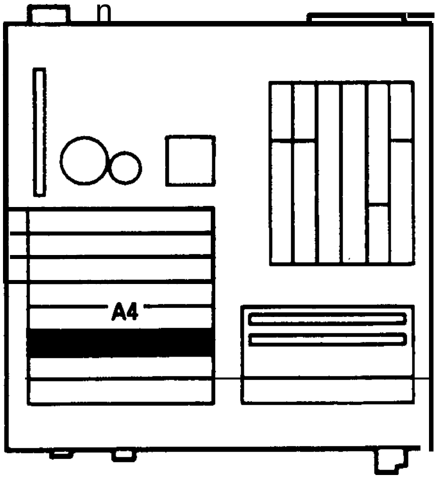
This procedure is only for Modulation Analyzers equipped with the FM Calibrator (Option 010). For Modulation Analyzers not equipped with Option 010, perform the FM Sensitivity Adjustment which uses the FM Calibrator from a second HP 8901A Option 010 (Adjustment 11).

Procedure

NOTE

For best accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

1. Perform the FM Calibrator Adjustment.
2. Connect CALIBRATION OUTPUT to INPUT.
3. Press FM then CALIBRATION. **Allow** at least two readings (approximately 40 seconds) to pass, then adjust **A4R50** (FM SENS) for a display of 99.95 to 100.05%.



Adjustment 11

PM SENSITIVITY ADJUSTMENT (USING ANOTHER 8901A WITH OPTION 010)

Reference

- **Service Sheet 6**

Description

The FM calibrator from a second HP 8901A that is equipped with Option 010 is connected to the Modulation Analyzer's input. The FM is measured and adjusted to **equal** the FM produced by the calibrator.

NOTE

If the Modulution Analyzer is already equipped with the FM Calibrator (Option 010), perform the FM Sensitivity Adjustment (Adjustment 10) instead.

Equipment

Modulation Analyzer with FM Calibrator .... HP 8901A Opt. 010

Procedure

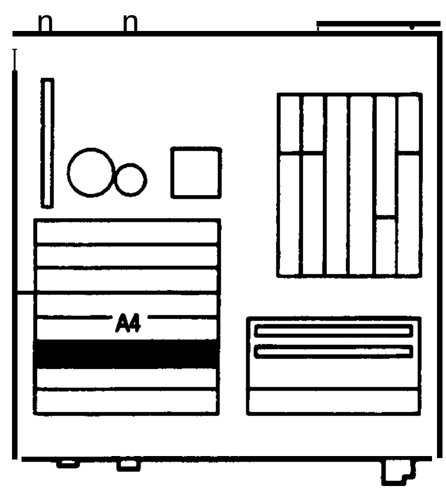
NOTE

For best accuracy, allow both Modulation Analyzers to warm up for at least one-half hour.

1. Connect the CALIBRATION OUTPUT from the Modulation Analyzer equipped with an FM **calibrator** (reference unit) to the INPUT of the **Modulation** Analyzer under test.
2. Key in 12.0 SPCL on the reference unit and note the reading on its display. The computed FM of the calibrator excluding noise is being displayed

   Computed FM: ______ **kHz**
3. Key in 12.1 SPCL on both Modulation Analyzers to display the demodulated peak residual FM deviation. Then, key in 5.1 SPCL on the Modulation Analyzer under test (to set the peak detector time constant to slow). Note the reading on the display of the Modulation Analyzer under test. The measured and corrected noise of the FM calibrator in CW is being displayed.

   Corrected Noise: ______ **kHz**



4. Add the results of steps 2 and 3.

sum: ______ **kHz**

5. Key in 12.2 SPCL on both Modulation Analyzers to display the demodulated peak FM deviation. Then, key in 5.1 SPCL on the Modulation Analyzer under test. Note the display of the Modulation Analyzer under test. The peak deviation, measured with the PEAK+ detector, is being displayed

6. On the Modulation Analyzer under test, adjust **A4R50** (FM SENS) for a display equal to the deviation computed in step 4 within **±0.015 kHz.**

7. Press PEAK- on the Modulation Analyzer under test. If the display does not read within **±0.015 kHz** of the display in step 6, readjust **A4R50** (FM SENS) for a display on the Modulation Analyzer under test of half way between its present display and the result of step 4. Now note the display for both PEAK+ and PEAK-. The FM sensitivity is properly adjusted when

$$\frac{\text{(display for PEAK+)} + \text{(display for PEAK-)}}{2} = \text{result of step 4 within} \pm 0.015\ kHz$$

Adjustment 12

FM FLATNESS ADJUSTMENT

Reference

- **Service Sheet 6**

Description

The AM/FM test source is frequency modulated at a 1 kHz rate with 400 kHz peak deviation. The demodulated FM is used as a reference. The modulation rate is increased to 150 kHz and the FM flatness is adjusted to bring the display back to the reference. The AM/FM test source is required to assure that the FM source has adequate bandwidth.

Equipment

AM/FM Test Source .... HP 11715A
Audio Synthesizer .... HP 3336C Opt. 005

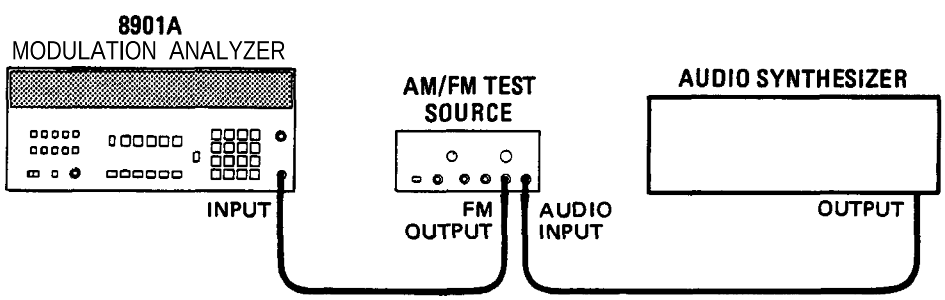
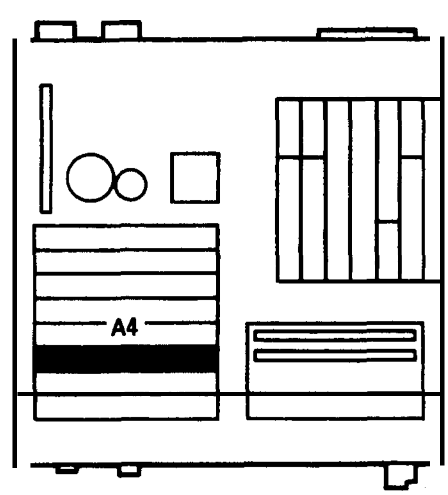


Figure 5-4. FM Flatness Adjustment Test Setup

Procedure



1. Connect equipment as shown in figure 5-4 using a short cable, approximately 0.3 metre (1 foot), to connect the audio synthesizer.
2. With the leveling on, set the audio synthesizer to 1 kHz at +5 dBm. On the AM/FM test source, set the test mode to FM.
3. On the Modulation Analyzer, key in 41.0 SPCL to initialize it.
4. Tune the AM/FM test source's carrier frequency to approximately 400 MHz.

5. Press MHz to center the Modulation Analyzer's tuning. Press FM. Set DETECTOR to AVG. Adjust audio synthesizer level for a display of approximately **280 kHz** average deviation. Set RATIO to %.

6. Set audio synthesizer frequency to 150 **kHz** without changing the level. Adjust **A4R85** (FM FLATNESS) for a reading of 99.9 to 100.1% REL on the Modulation Analyzer.

NOTE

If flatness does not adjust properly, try performing FM Distortion and Incidental AM Adjustments (1.5 MHz IF) (Adjustment 13).

Adjustment 13

FM DISTORTION AND INCIDENTAL AM ADJUSTMENT (1.5 MHZ IF)

Reference

- **Service Sheet 2**

Description

The AM/FM test source is frequency modulated at a 100 **kHz** rate with 400 **kHz** peak deviation. The peak deviation is measured with both the positive and negative peak detectors when the Modulation Analyzer is tuned **first** to the signal and then its image. The IF is then adjusted so that the difference between the detector readings is the same for both signals. This method permits proper adjustment of distortion even in the presence of a small amount of distortion from the FM source. Nest, the (incidental) AM is measured at a 1 **kHz** rate and 50 **kHz** peak deviation and adjusted for a minimum.

Equipment

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B

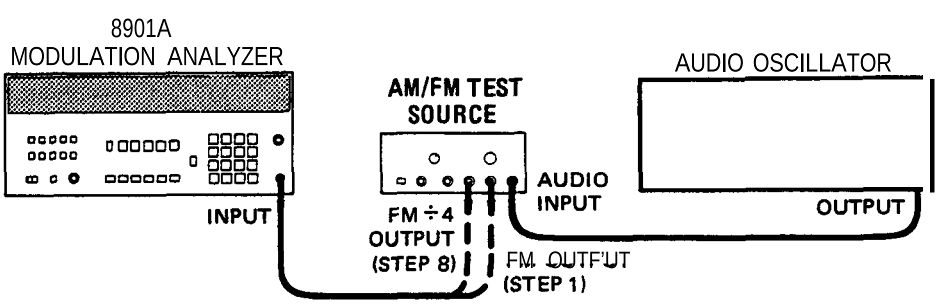
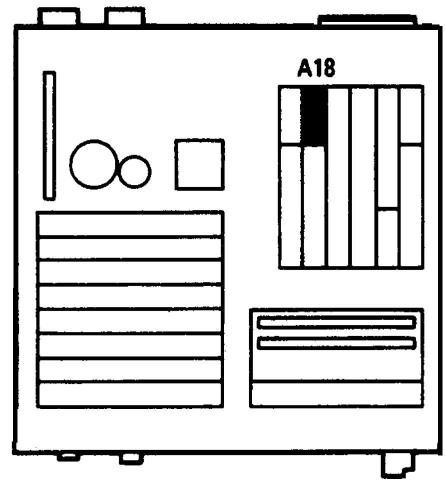


Figure S-6. FM Distortion and Incidental AM Adjustment (1.5 MHz IF) Test Setup

Procedure



1. Connect equipment as shown in figure 5-5.
2. Set the audio analyzer's source to 100 **kHz** at 2 V. On the AM/FM test source, set the test mode to FM.
3. On the Modulation Analyzer, key in 41.0 SPCL to **initialize** it. Set HP FILTER to 50 Hz.
4. **Tune** the AM/FM test source's carrier frequency to approximately **400** MHz.
5. On the Modulation **Analyzer,** press MHz to center tuning. Press FM. Adjust level of the audio analyzer's source for a display on the Modulation Analyzer of **400 kHz** peak deviation.
6. Switch the DETECTOR between PEAK+ and PEAK- and note the difference between the two readings. Adjust **A18R23** (FM DISTN 1.5 MHz IF) for **equal** readings in PEAK+ and PEAK-.
7. Key in **3000 ⇩kHz** to tune the Modulation Analyzer to the **signal** image. Again switch between PEAK+ and PEAK-. The difference between the two readings should be less than 1.6 **kHz.** If it is not, adjust **A18R23** again to diminish the **difference** by one **half.** Now note the reading for PEAK+ **(PK_{+1}**) and PEAK- **(PK_{-1}**). Press ⇑ **kHz.** Note the reading for PEAK+ **(PK_{+2}**) and PEAK- **(PK_{-2}**). The instrument is adjusted properly when:

$$|(PK_{+1} - PK_{-1}) + (PK_{+2} - PK_{-2})| < 1.6\ kHz$$

(Ideally, PK_{+1} should equal **PK_{-2}**, and **PK_{-1}** should **equal PK_{+2}** .)

8. Connect the FM ÷ 4 output of the AM/FM test source to the Modulation Analyzer's INPUT.
9. On the Modulation Analyzer, set LP FILTER to 3 **kHz.** Press AUTOMATIC OPERATION.
10. Set the frequency of the audio analyzer's source to 1 **kHz** and level for 50 **kHz** peak deviation.
11. On the Modulation Analyzer, press AM. Adjust **A18R19** (INC AM 1.5 MHz IF) for a minimum display (but less than 0.2%).

NOTE

The specification for incidental AM requires that 0.5 times the residual AM be subtracted out. The residual AM can be measured by momentarily disconnecting the audio input to the AM/FM test source and noting the displayed AM. Subtracting 0.5 times displayed AM from the AM measured in step 11 gives the actual incidental AM.

Adjustment 14

ΦM SENSITIVITY ADJUSTMENT

Reference

- **Service Sheet 8**

Description

The AM/FM test source is frequency modulated with a sinusoidal **signal** at a 1 **kHz** rate and 100 **kHz** peak deviation. This is equivalent to 100 radians peak phase deviation since

$$\textit{phase deviation} = \frac{\textit{frequency deviation}}{\textit{modulation rate}}$$

The **ΦM** sensitivity is then adjusted for a reading of 100 radians.

Equipment

AM/FM Test Source .... HP 11715A
Audio Synthesizer .... HP 3336C Opt. 005

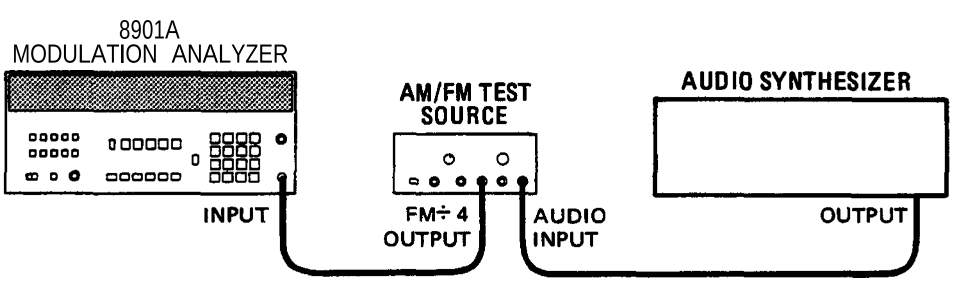
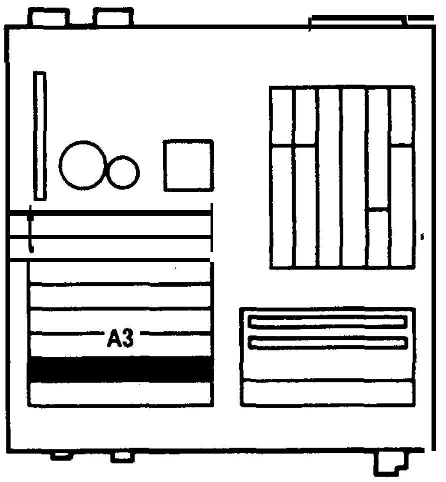


Figure 6-6. ΦM Sensitivity Adjustment Test Setup

Procedure



1. Connect equipment as shown in figure 5-6.
2. Set audio synthesizer **to** 1 **kHz** at **+4 dBm.** On the AM/FM test source, set the test mode to FM.
3. On the Modulation Analyzer, key in 41.0 SPCL **to** initialize it. Set HP FILTER to 300 Hz and LP FILTER to 3 **kHz.**
4. **Tune** the AM/FM test source's carrier frequency to approximately 100 MHz.

5. Press MHz to center the Modulation Analyzer tuning. Press FM. Adjust audio synthesizer level for a display of 100 **kHz** peak deviation.
6. On the Modulation Analyzer, press **ΦM.** Adjust **A3R27 (ΦM** SENS) for a display in radians of the same numerical value as the display in **kHz** of step 5 within **±0.02** radian.

NOTE

If a test oscillator is used in place of the audio synthesizer, the modulation rate must be measured with a counter. The adjustment is then made to give a display equal to the ratio (frequency deviation)/(modulation rate).

Adjustment 15

AM CALIBRATOR ADJUSTMENT (OPTION 010)

Reference

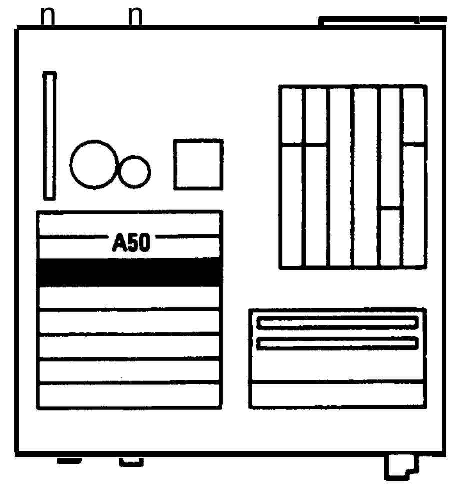
- Service Sheet 29

Description

The Modulation Analyzer is set to read the % AM as computed from internal measurements. The AM depth is adjusted for 33.33%. The AM is then demodulated and the symmetry is adjusted as the signal is measured with the PEAK+ and PEAK- detectors.

NOTE

This calibration adjustment is not critical. An erroneous calibration cannot be made because, if conditions exist that are out of calibration, the Modulation Analyzer displays an error message.



1. Connect CALIBRATION OUTPUT to INPUT.
2. Key in 13.0 SPCL. This sets the instrument to display the AM computed from internal measurements.
3. Adjust **A50R45** ("A" LVL) for a display of 33.330 to 33.336%.
4. Key in 49.5 SPCL. This connects the internal voltmeter to measure the output level from the AM Calibrator. The display should read between 1.8 and 2.2.
5. Key in 13.2 SPCL then 5.1 SPCL. This sets the instrument to display the demodulated AM from the calibrator and sets the peak detector time constant to slow.
6. Alternately set the DETECTOR to PEAK+ and PEAK- and note the display for each setting. Adjust **A50R39** (SYMM) until the readings are the same for both detectors within ~0.015%.

Adjustment 16

AM SENSITIVITY ADJUSTMENT (OPTION 010)

Reference

- **Service Sheet 7**

Description

The AM sensitivity is adjusted for a calibration factor of 100% **while** the Modulation Analyzer measures the output of its AM Calibrator (Option 010).

NOTE

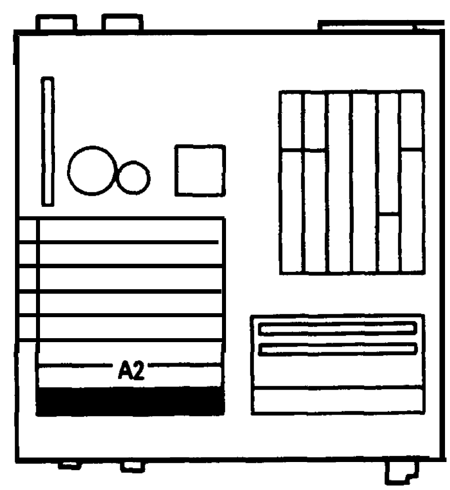
This procedure is only for Modulation Analyzers equipped with the AM Calibrator (Option 010). For Modulation Analyzers not equipped with Option 010, perform the AM Sensitivity Adjustment which uses the AM Calibrator from a second 8901A Option 010 (Adjustment 17).

Procedure

NOTE

For best accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

1. Perform the AM Calibrator Adjustment (Adjustment 15).
2. Connect CALIBRATION OUTPUT to INPUT.
3. Press AM, then CALIBRATION. **Allow** at least two readings to pass (approximately 40 seconds), then adjust **A2R6** (AM SENS) for a display of 99.95 to 100.05%.



Adjustment 17

AM SENSITIVITY ADJUSTMENT (USING ANOTHER 8901A WITH OPTION 010)

Reference

- **Service** Sheet 7

Description

The AM calibrator from a second HP 8901A equipped with Option 010 is connected to the Modulation Analyzer's input. The AM is measured and adjusted to equal the AM produced by the calibrator.

NOTE

If the Modulation Analyzer is already equipped with the AM Calibrator (Option 010), perform the AM Sensitivity Adjustment (Adjustment 16) instead.

Equipment

Modulation Analyzer with AM Calibrator .... HP 8901A Opt. 010

Procedure

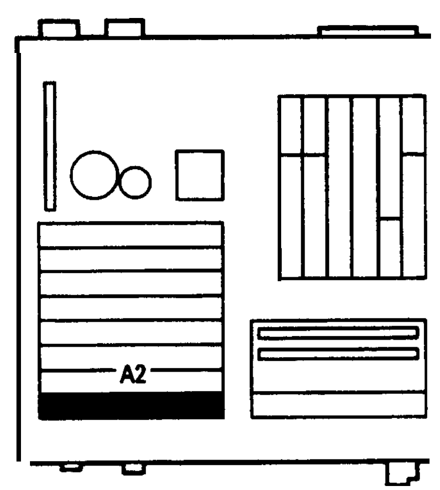
NOTE

For best accuracy allow both Modulation Analyzers to warm up for at least one-half hour.

1. Connect the CALIBRATION OUTPUT from the Modulation Analyzer equipped with an AM **calibrator** (reference unit) to the INPUT of the Modulation Analyzer under test.
2. Key in 13.0 SPCL on the reference unit and note the reading on its display. The computed AM depth of the calibrator excluding noise is being displayed.

   Computed AM: ______ %
3. Key in 13.1 SPCL on both Modulation Analyzers, then key in 5.1 SPCL on the Modulation Analyzer under test (to set the peak detector time constant to slow). Note the reading on the display of the Modulation Analyzer under test. The measured and corrected noise of the AM calibrator in CW is being displayed.

   Corrected Noise: ______ %



4. Add the results of steps 2 and 3.

sum: ______ %

5. Key in 13.2 SPCL on both Modulation Analyzers, then key in 5.1 SPCL on the Modulation Analyzer under test. Note the display of the Modulation Analyzer under test. The AM depth, measured with the PEAK+ detector, is being displayed.
6. Adjust **A2R6** (AM SENS) for a display on the Modulation Analyzer under test equal to the deviation computed in step 4 **within** ~0.015%.
7. Press PEAK- on the Modulation Analyzer under test. If the display does not read within **±0.015%** of the display in step **6,** readjust **A2R6** (AM SENS) for a display on the Modulation Analyzer under test of **1/3** the way between its present display and the result of step 4. Now note the display for both PEAK+ and PEAK-. The AM sensitivity is properly adjusted when

$$\frac{\text{(display for PEAK+)} + 2\text{(display for PEAK-)}}{3} = \text{result of step 4 within} \pm 0.015\%$$

Adjustment 18

FM DISTORTION AND INCIDENTAL AM ADJUSTMENT (455 KHZ IF)

Reference

- **Service Sheets 2 and 3**

Description

The signal generator is set to 2.45 MHz and frequency modulated at a 1 kHz rate with 10 kHz peak deviation. The signal generator is used to reach the 2.45 MHz frequency, The (incidental) AM on the signal is measured and adjusted for a minimum. At 2.45 MHz the signal is not down converted by the Modulation Analyzer but goes directly into the IF. (2.45 MHz is near the top of the IF passband.)

Then the AM/FM test source is frequency modulated at a 10 kHz rate with 10 kHz peak deviation. The demodulated FM is measured with a distortion analyzer and FM distortion is adjusted for a minimum. The (incidental) AM is measured at a 1 kHz rate and 5 kHz deviation and adjusted for a minimum.

Equipemnt

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Signal Generator .... HP 8640B Opt. 001 and 002

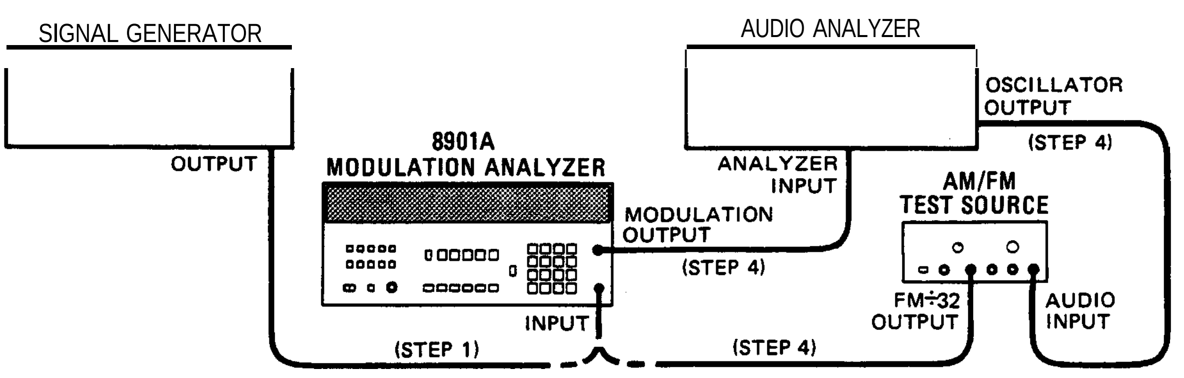
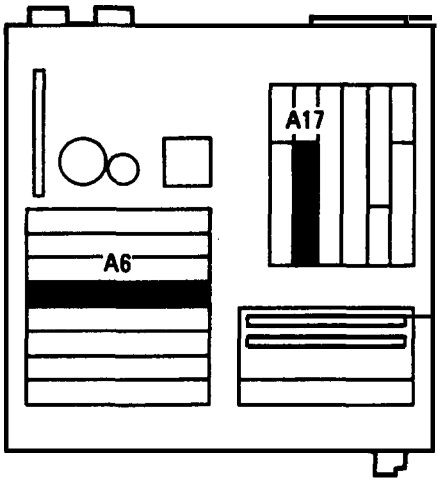


Figure 6-7. FM Distortion and Incidental AM Adjustment (455 kHz IF) Test Setup

Procedure



1. Set the signal generator to 2.45 MHz at 0 dBm with 10 kHz peak FM deviation at a 1 kHz rate. Connect its RF output to the Modulation Analyzer's INPUT as shown in figure 5-7.
2. On the Modulation Analyzer, key in 41.1 SPCL and 10.0 SPCL to initialize the instrument and measure the IF frequency. The IF frequency should be approximately 2.45 MHz. If it reads approximately 0.455 MHz, tune the frequency of the signal generator down slightly until a reading of 2.45 MHz is obtained.
3. Press AM on the Modulation Analyzer. Set HP FILTER to 50 Hz, LP FILTER to 3 kHz, and DETECTOR to AVG. Adjust A6C8 (IF FLATNESS) for a minimum display (but less than 0.2%).
4. Disconnect the signal generator and connect the remaining equipment as shown in figure 5–7.
5. Set audio analyzer's source to 10 kHz at 2 V. On the AM/FM test source, set test mode to FM.
6. On the Modulation Analyzer, press FREQ. Set LP FILTERS to < 20 kHz and DETECTOR to PEAR+.
7. Tune the AM/FM test source's carrier frequency to approximately 12.5 MHz.
8. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 kHz.
9. Press FM. Adjust the level of the audio analyzer's source for a Modulation Analyzer display of 10 kHz peak deviation.
10. Set the audio analyzer to measure the distortion on the 10 kHz signal at the MODULATION OUTPUT with 30 kHz of low-pass filtering on the distortion analyzer.
11. Adjust A17L11 (FM DISTN 455 kHz IF) for minimum distortion but less than 0.1% (less than -60 dB).
12. On the Modulation Analyzer, set LP FILTER to 3 kHz.
13. Set frequency of the audio analyzer's source to 1 kHz and set the level for 5 kHz peak deviation on the Modulation Analyzer.
14. Press AM. Adjust A17L8 (INC AM 455 kHz IF) for a minimum display (but less than 0.2%).

NOTE

The specification for incidental AM requires that 0.5 times the residual AM be subtracted out. The residual AM can be measured by momentarily disconnecting the audio input to the AM/FM test source and noting the displayed AM on the Modulation Analyzer. Subtracting 0.5 times the displayed AM from the AM measured in step 14 gives the actual incidental AM.

15. If a significant adjustment was made in either step 11 or step 14, repeat steps 9 through 14.

Adjustment 19

TRACK-TUNE MODE OFFSET ADJUSTMENT

Reference

- **Service Sheet 14**

Description

The Modulation Analyzer is tuned to a signal and put in the track-tune mode. The frequency error is measured and two resistors selected to bring the frequency error to within ±50 kHz.

Equipment

Signal Source .... HP 8640B or HP 3320B

Procedure

1. Set signal source to 11 MHz CW at 0 dBm. Connect its output to the Modulation Analyzer's INPUT.
2. On the Modulation Analyzer, key in 41.0 SPCL to initialize it. Allow the Modulation Analyzer to tune to the signal, then press S (Shift) FREQ ERROR.
3. Key in 4.1 SPCL to put the Modulation Analyzer in the track-tune mode. If the display does not read between ±50 kHz, replace resistors A20R1 and R2 with resistors of the value shown in table 5-3. (Choose the nearest error frequency.) Table 5-4 lists the HP part number for each resistor.
4. If A20R1 and R2 were replaced, recheck by repeating steps 1 to 3.

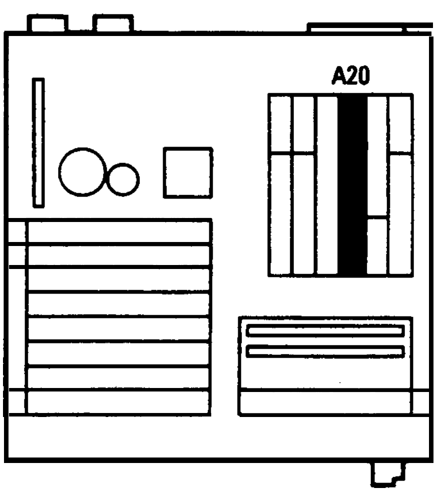


***Table* 6-3. *Frequency Error Resistor Selection* (± 1%, 1/8 W, Metal Film)**

FREQ ERROR (kHz)	A20R1 (kΩ)	A20R2 (kΩ)
183	21.5	omit
166	23.7	omit
124	26.1	147.0
81	31.6	90.9
39	38.3	61.9
0	46.4	46.4
-39	61.9	38.3
-81	90.9	31.6
-124	147.0	26.1

Table* 5–4. *Standard Value Resistors

Resistance (kΩ)	HP Part Number
21.5	0757-0199
23.7	0698-3158
26.1	06983159
31.6	0698-3160
38.3	0698-3161
46.4	0698-3162
61.9	0757-0460
90.9	0757-0464