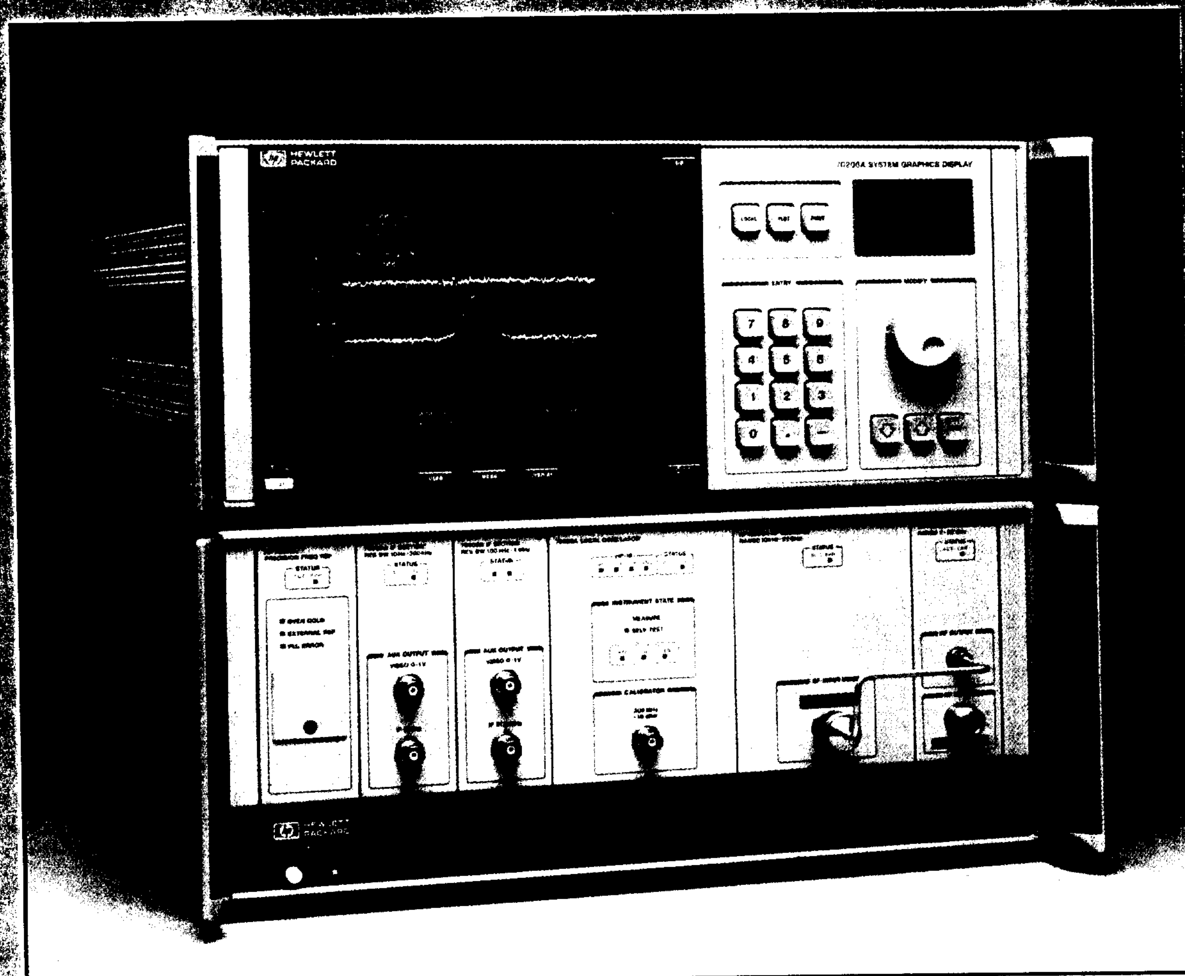
User's Guide

HP 70000 Modular Measurement System

A Self-Paced Tutorial for Front-Panel Operation of the HP 70000 Series Modular Spectrum Analyzers



OVERVIEW

The purpose of this User's Guide is to provide an operator's introduction to the HP 70000 Series Modular Spectrum Analyzers. This document is a subset of the Operation Manual and the Installation and Verification Manual, not a replacement for them. Note further that instruction on the operation of the modular tracking generators, stand-alone Digitizer module, external mixers, or other modular instruments is not covered in this document. It only covers modular spectrum analyzer operation. (Refer to the Operating Manuals of each instrument for their specific operation.)

This document has several uses. First, it can be used as a self-paced tutorial for new operators of the modular spectrum analyzers. We suggest that you have your system turned on and try the key sequences described in the text. Then, to help you see how well you've done, perform the 15 "Review Exercises" located throughout this guide. Solutions to the exercises are included.

This User's Guide can also be used as a quick reference guide for HP 70000 spectrum analyzer use. The function index (on the page following the Table of Contents) is a useful reference for quickly locating the description of any function accessed by the MENU hardkey.

This document also serves as the basis of a classroom training course taught by Hewlett-Packard System Engineers. Classroom courses are an efficient way of training groups of people quickly. Contact your nearest HP Sales Office for more information.

Your system should be ready to operate. (Refer to the "Connections and Configurations" section of this document to confirm proper rear-panel cable connections, including the HP-MSIB cables.) Turn on the power to the mainframe (and to the separate large-screen display if the system includes one). Seven menu keys should appear on the left side of the CRT (**Freq**, **Amptd**, ... **Misc**). However, in some cases the message, "For instrument display press DISPLAY then SELECT INSTR", may appear on the screen. If it does, first press the DISPLAY hardkey, located beneath the CRT, then press the **SELECT INSTR** (Select Instrument) softkey on the right side of the CRT. Now press the MENU hardkey, located beneath the CRT. Seven menu keys should appear (**Freq**, **Amptd**, ... **Misc**).

The functions and menus found in this document are based on the 880901 LO ROM version and the 860625 (6.0) Display ROM version. (880901 and 860625 are firmware date codes in a year-month-day format.) The LO ROM version can be determined by pressing the MENU hardkey, the **Misc** firmkey, the **MORE** softkey, the **service** softkey, and the **ROM VERSION** softkey. The Display ROM version can be determined by pressing the DISPLAY hardkey, the **display tests** softkey, and the **DISPLAY ID** softkey. In terms of the LO ROM version, most of this document will also apply to the previous firmware revision (880314), but there are some minor differences, including the lack of limit lines. Instruments with LO firmware prior to 880314 have a different menu structure (MENU and USER keys) and lack some of the functions found in the latest firmware. Contact your HP Sales Office for information on purchasing the most up-to-date firmware. As new modules and displays are introduced, new firmware features will appear and some rearrangement of the menus may occur. However, the descriptions of the functions given in this document will still apply in most cases. Refer to the Operating Manual Updating Supplements for the latest information.

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MENU Function Index

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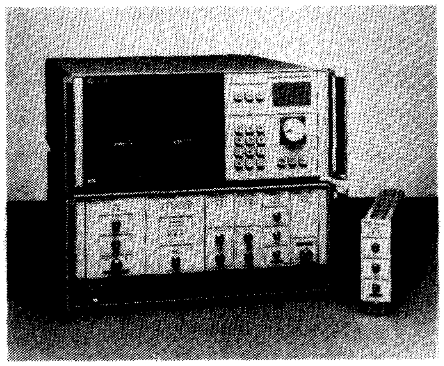
Introduction

THE HP 70000 MODULAR MEASUREMENT SYSTEM



The HP 70000 Modular Measurement System (MMS) presents a new concept in measurement instrumentation, based on a level of modularity never before achieved in commercial measurement instruments. Its powerful system level architecture and protocol enable the system to expand to accommodate virtually any type of instrument. Its central human-machine interface provides the user with system level control and observation never possible before.

The MMS includes many different types of instruments that provide measurement solutions for a variety of application needs. However, the focus of this document is on the manual operation of the HP 71000 family of modular spectrum analyzers.

HP 70000–AN IDEAL SOLUTION FOR AUTOMATIC TEST AND BENCHTOP APPLICATIONS

The modularity and performance of the HP 70000 Modular Measurement Systems make them excellent instruments for both automatic test and benchtop applications. However, before beginning to program the systems, it is necessary to first understand how to operate them manually as is done in most benchtop applications. It is for this reason that this document will be devoted fully to manual operation.

The material in this document will not only include front-panel operation, but it will also include instruction on hardware connections and address configurations. We'll find the complete outline of the contents of this document on the next slide.

The material in this booklet begins with an overview of the 5 factory-configured modular spectrum analyzers and a brief discussion of the benefits of modular systems. The discussion then moves quickly into the theory of how a typical spectrum analyzer works. This will help to compare and contrast how a modular spectrum analyzer works. Then, we'll discuss the function of each module, the block diagram of each module, and how each module fits into the overall system block diagram. Next, an overview of the front-panel user interface (i.e. USER, MENU, and DISPLAY hardkeys) will be given. Many of these front-panel functions are useful in confirming the proper connections and configurations of the modules which is the topic of the next section. Then, an in-depth coverage of the MENU functions will be given. We'll start with those functions found in the top level of the MENU structure since they are most frequently used. Then, the next level of MENU functions found under the "MORE" key will be covered. Creating custom menus using the USER functions will follow. Then, you will be introduced to downloadable programs, which are accessed via the USER keys. The document concludes with a fun and useful exercise of connecting two spectrum analyzer systems to a single display which controls and displays the waveforms from each analyzer system.

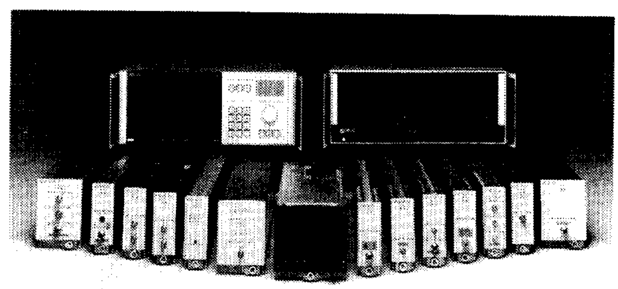
OUTLINE

- MODULAR SYSTEM OVERVIEW
- SPECTRUM ANALYZER THEORY
- MODULE FUNCTIONS AND BLOCK DIAGRAMS
- MENU, USER, & DISPLAY KEY OVERVIEW
- CONNECTIONS AND CONFIGURATIONS
- TOP LEVEL MENU KEY FUNCTIONS
- "MORE" MENU KEY FUNCTIONS
- USER KEY FUNCTIONS
- INTRO TO DLPs
- DISPLAY KEY FUNCTIONS

Modular System Overview

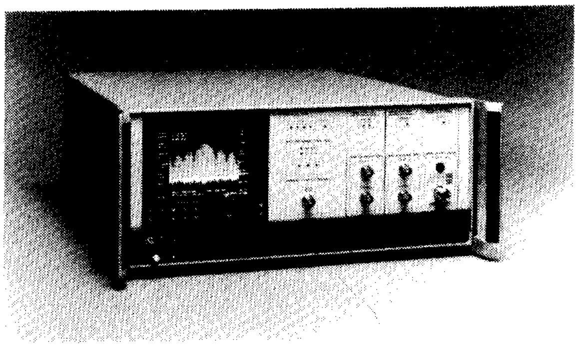
With the aforementioned outline in mind, let's begin with the first section -- Modular System Overview. The HP 70000 family currently consists of a mainframe , two displays, over a dozen modules, and five standard spectrum analyzer systems. We will begin by discussing the systems, then continue with a description of the mainframe, displays, and modules.

THE HP 70000 FAMILY



HP 71100A RF SPECTRUM ANALYZER

(100 Hz – 2.9 GHz)

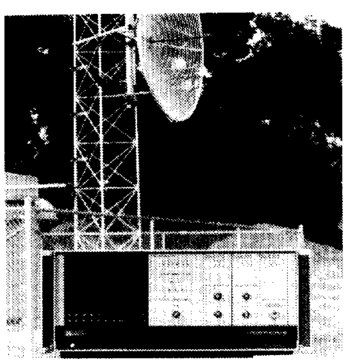


The HP 71100A RF Spectrum Analyzer covers the frequency range of 100 Hz to 2.9 GHz. This system consists of the HP 70001A Mainframe, 70205A Graphics Display, 70900A Local Oscillator, 70902A IF Section and the 70904A RF Section. Options allow selection of the large, stand-alone HP 70206A System Graphics Display and the HP 70903A IF Section.

HP 71200A/201A/210A MICROWAVE SPECTRUM ANALYZERS

(50 kHz – 22/26.5 GHz)

(100Hz – 22 GHz)

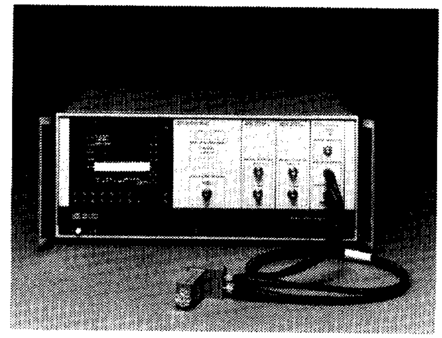


The HP 71200A and 71201A Microwave Spectrum Analyzers provide coverage from 50 kHz to 22 GHz (or with an option to 26.5 GHz). The HP 71201A is preselected (i.e., includes a swept input filter) while the HP 71200A does not include an input preselector. (The preselector eliminates unwanted mixing products which can clutter the display. However, the amplitude accuracy and sensitivity are better for the unpreselected unit.) The HP 71210A includes a built-in preselector and covers the 100 Hz to 22 GHz range. At the time of this printing, it has the best sensitivity available in any preselected spectrum analyzer in the world. Its amplitude accuracy is excellent as well. (In addition to the HP 70001A mainframe, 70205A display, 70900A LO, and 70902A IF, the HP 71200A system contains the HP 70905A RF module; the 71201A system contains the 70905B RF module (instead of the 70905A) and the 70600A Preselector module. The 71210A system contains the 70908A Preselected RF module, 70206A large display, 70900A LO, 70902A and 70903A IF modules, and the 70310A Precision Frequency Reference module.)

The HP 71300A Milllimeter Spectrum Analyzer offers a variety of new millimeter capabilities. Used with the HP 11970 series of mixers from 18 to 110 GHz, it provides excellent sensitivity and amplitude accuracy, and permits measurements to be made quickly through push-button signal identification and elimination of bias adjustments. Used with biased mixers from 2.7 to 325 GHz, it provides programmable biasing functions for full-band, amplitude-corrected sweeps.

HP 71300A MILLIMETER SPECTRUM ANALYZER

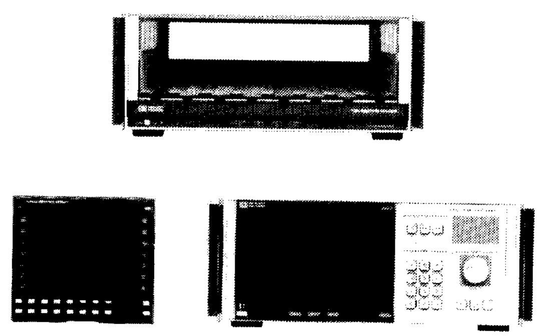
(2.7 GHz – 325 GHz)



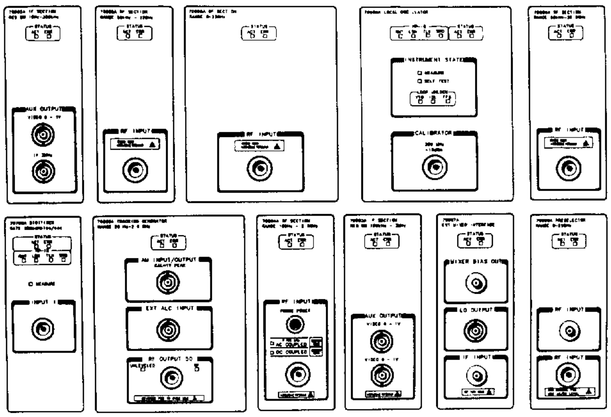
The mainframe and displays form the core of the HP 70000 Measurement System. The HP 70001A Mainframe is a rugged structure into which modules in a variety of widths can be placed. It serves two main functions. In its "life-support" function, it provides power, cooling, and EMC protection for all of its modules. In its "communication" function, it manages all digital communications between modules and between mainframes.

The HP 70205A Graphics Display is a module display that plugs into the mainframe, and the HP 70206A System Graphics Display is a large screen, stand-alone display. Both units serve three main functions. In their "display" function, these raster displays show information (such as traces) from different instruments in the system. They provide far more than the traditional display function because they can display information from several instruments at one time on a single screen, and they update this information in real time. In their "control" function, they control the settings and actions of instruments in the system. They provide more than the traditional control function because they can control any instrument in the system. In their "utility" function, they provide a variety of valuable aids, such as system level error reporting, system level address analysis, and direct printer and plotter outputting.

MAINFRAME AND DISPLAY ELEMENTS



MODULE ELEMENTS



The HP 70000 Measurement System contains over a dozen modules which can be configured in numerous ways for your particular measurement application. Some are 1/8-mainframe width while others occupy 2/8-mainframe slots. Each of these modules will be described in detail shortly.

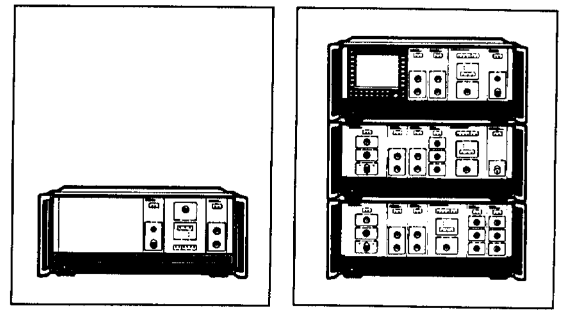
BENEFITS OF MODULARITY

1. EFFICIENT USE OF RACK SPACE
2. FLEXIBILITY
3. EXTENSIBILITY
4. LONGEVITY
5. BREADTH AND DEPTH
6. ON-SITE REPLACEMENT

Most of you have already purchased an HP 70000 Modular Measurement System. Congratulations! You undoubtedly recognized the benefits of modularity when you made your buying decision. These benefits are listed here. Probably the number one benefit is the efficient use of rack space. Now one mainframe with modules can replace several full-rack-width instruments. Flexibility means just the right capability, but not excessive capability. Extensibility is the capacity of a system to be extended beyond its current configuration. New modules extend the product line upward in performance, downward in cost, and into entirely new measurements. Longevity refers to a long product lifetime due to extensibility. Breadth means a broad selection of modules are available. Depth means that there are many modules with a wide selection of features to provide an in-depth capability within each measurement area. Finally, on-site replacement is a natural benefit of a system comprised of modules. If an RF module fails, a production line can be back "on the air" within a few minutes using a spare module, saving a lot of money and maintaining a high level of throughput.

Let's just say a few more words about flexibility since it's an important benefit of modularity. As we said, it means having just the right amount of capability, but not more capability than we really need. This slide shows two modular measurement system configurations. One is the simplest form of a spectrum analyzer system. Note that it contains an RF, LO, and IF module but does not include a display. Why? In many automatic test applications, the computer records all of the trace data and sets all of the controls. Therefore, no display is necessary. In the other configuration shown here, we have two mainframes full of modules and a large display. (Later, we'll have a chance to configure a system similar to this one.) Thus, the system can be big or small, depending on the type of measurement to be made.

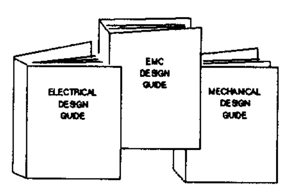
FLEXIBILITY: JUST THE RIGHT AMOUNT OF CAPABILITY



If you have a need for a capability not found in one of the present modules, the module development product family may be the answer. It consists of two sets of design guides and a set of module parts kits. The HP 70595A Design Guides aid in the electrical and mechanical design of a module, including EMC considerations. The HP 70596A Module Communication Design Guides consist of an HP-MSIB interface design guide, a communication protocol design guide, and a display interface design guide. There are four module parts kits to choose from in 1/8 (HP 70591A), 2/8 (HP 70592A), 3/8 (HP 70593A), and 4/8 (HP 70594A) widths. The kits contain front, rear, and base frames; top cover; rear-panel connector; and hardware. Access to HP-IB and HP-MSIB are available at the rear panel. In summary, power, cooling, EMC, communication, display-access, and "real estate" are available for you to design your own module. An example would be an RF switching matrix module.

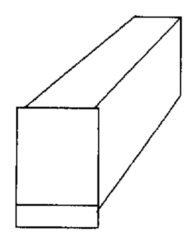
MODULE DEVELOPMENT PRODUCTS FAMILY

- EXTENDS CAPABILITY AND SAVES RACK SPACE
- TOOLS TO ASSIST IN DESIGN AND CONSTRUCTION OF MODULES



- HP-MSIB
- HP-IB

AVAILABLE

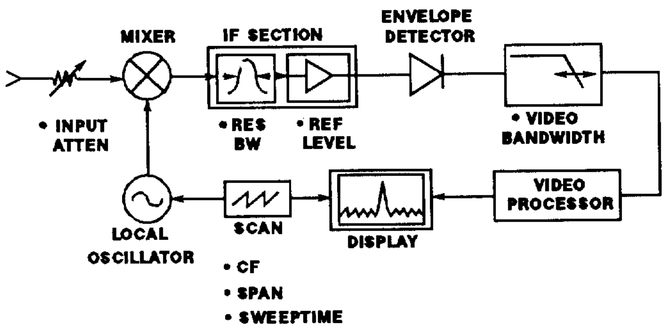


DESIGN GUIDES

PARTS KITS

Spectrum Analyzer Theory

SPECTRUM ANALYZER BLOCK DIAGRAM



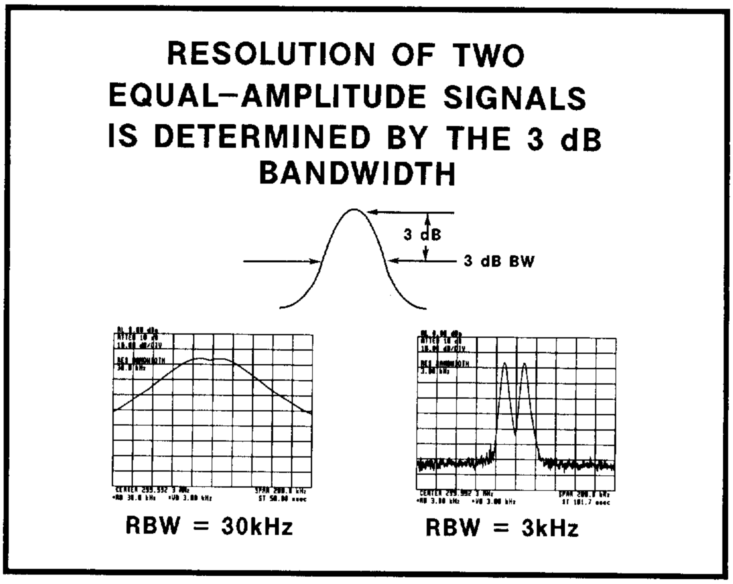
Before we dive into the HP 70000 block diagram (which is unique due to its modularity), let's begin with the block diagram of a simple spectrum analyzer. The superheterodyne approach is used because it provides wide input-frequency coverage while permitting signal processing to be done at the single intermediate frequency (IF). The diagram is greatly simplified, but it gets the point across. An incoming signal mixes with the local oscillator (LO), and when a mixing product equals the IF, this signal passes through to the peak detector. The detector output is amplified to cause a vertical deflection on the CRT display. The synchronism between the horizontal frequency axis of the CRT display and the tuning of the LO is provided by the sweep generator which both drives the horizontal CRT deflection and tunes the LO. The fundamental front-panel control functions such as Center Frequency, Frequency Span, Sweep Time, Resolution Bandwidth, and Reference Level are labeled in the appropriate sections of the block diagram.

THE RESOLUTION BANDWIDTH FILTER DETERMINES:

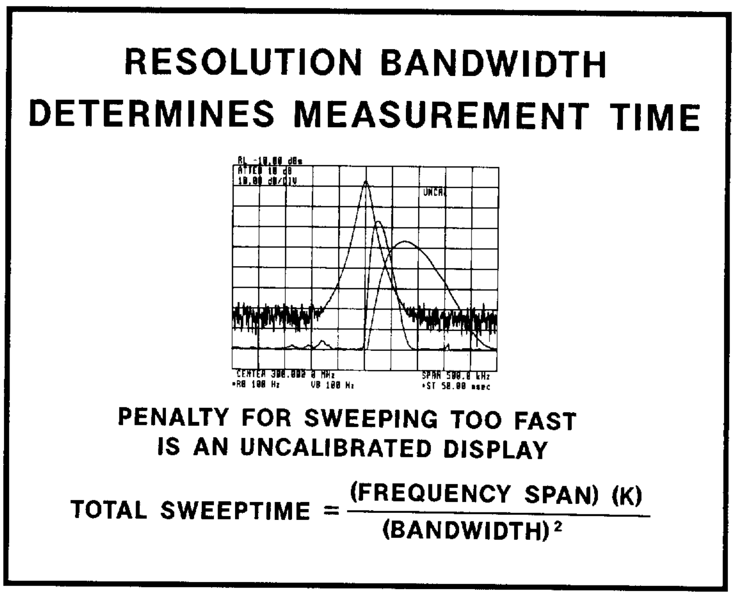
- RESOLUTION OF ADJACENT SIGNALS (SELECTIVITY)
- SPECTRUM ANALYZER SWEEPTIME
- SPECTRUM ANALYZER NOISE LEVEL (SENSITIVITY)

Understanding the effects of changing the resolution bandwidth (RBW) control on the spectrum analyzer is important in determining the selectivity of closely-spaced signals, spectrum analyzer sweeptime, and spectrum analyzer sensitivity. Each of these topics will be described in more detail in the following slides.

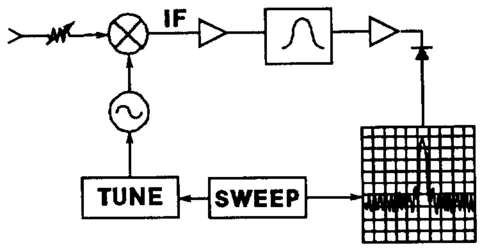
One of the first things to note is that a signal is not displayed as an infinitely narrow line. It has some width associated with it. This shape is the analyzer's tracing of its own IF filter shape as it tunes past a signal. Thus, if we change the filter bandwidth, we change the width of the displayed response. Hewlett-Packard data sheets specify the 3 dB bandwidth. Some other manufacturers specify the 6 dB bandwidth. The 3 dB bandwidth tells us how close together equal-amplitude signals can be and still be distinguishable from one another. In general, two equal-amplitude signals can be resolved if their separation is greater than or equal to the 3 dB bandwidth of the selected filter. In the plot on the left we can barely resolve the two signals with the 30 kHz RBW. We can clearly resolve them using a 3 kHz RBW, as seen in the plot on the right.



When we narrow the resolution bandwidths for better resolution, we must consider the time it takes to sweep through them. Since these filters are bandwidth-limited they require a finite time to respond fully. How much sweep time the filters are given depends upon how far and how fast the analyzer is tuned, i.e., upon the effective sweep rate per unit hertz. When the sweep is too fast, the analyzer cannot fully respond, and the displayed response is too low in amplitude and too high in frequency. For a given frequency span, the sweep time is inversely proportional to the square of the IF bandwidth (or the product of the IF and video bandwidths). The HP 70000 has a warning message to indicate when the sweep rate is too fast. See the "UNCAL" (uncalibrated amplitude) message on the CRT of the accompanying plot. As we will see later, when the HP 70000 sweeptime control is in the **Auto** setting, it is automatically adjusted to sweep slow enough for the bandwidth settings. This results in calibrated amplitude readings.



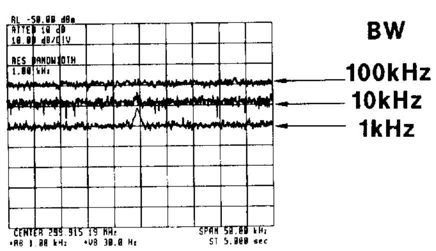
THE ANALYZER GENERATES AND AMPLIFIES NOISE JUST LIKE ANY OTHER ACTIVE CIRCUIT



DISPLAYED NOISE IS ALTERED BY THE IF FILTER

The noise generated within the analyzer itself, together with signal losses in the input attenuator and with mixer conversion, may mask low-level signals. Since our analyzer is absolute-amplitude calibrated, we can relate the displayed noise level to an equivalent level at the input to the analyzer, and thus determine the minimum input signal level that can be ovserved on the CRT display.

DISPLAYED NOISE CHANGES WITH THE IF FILTER BANDWIDTH



DECREASED BW = DECREASED NOISE

The analyzer's noise is thermal in nature; that is, it is random and has no spectral components. Also, the noise level is flat over a frequency range that is wide in comparison to the ranges of the resolution bandwidths. This means that the total noise reaching the detector (and displayed) is related to the RBW selected. Since the noise is random, it is added on a power basis, so the relationship between displayed noise level and RBW is a ten log basis, as shown.

NOISE LEVEL CHANGE (dB) = 10 * log (BW2/BW1)

FOR EXAMPLE:

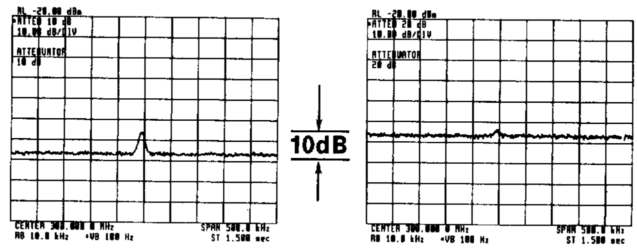
Changing the RBW from 100 kHz (BW1) to 10 kHz (BW2),

Change in Noise = 10 * log (10 kHz/100 kHz)
= -10 dB

Spectrum analyzer noise is specified with respect to a specific bandwidth. The analyzer's lowest noise level is achieved with its narrowest resolution bandwidth.

One aspect of the analyzer's internal noise that is often overlooked is its effective level as a function of the RF attenuator setting. Since the internal noise is generated after the mixer (primarily in the first active IF stage), the RF attenuator has no effect on the actual noise level. However the RF input attenuator does affect the signal level at the input and decreases the signal-to-noise ratio of the analyzer. The best signal-to-noise ratio is with the lowest possible RF input attenuation.

THE EFFECTIVE LEVEL OF DISPLAYED NOISE CHANGES WITH THE RF ATTENUATION



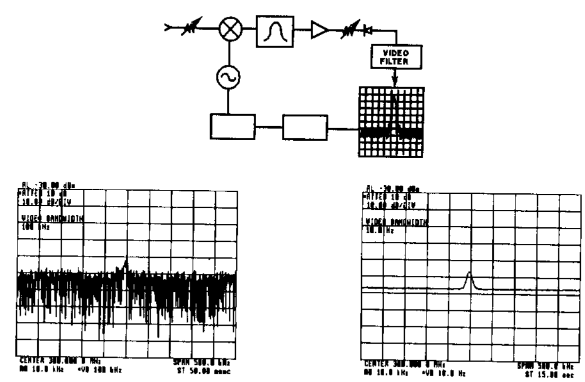
RF ATTENUATION 10 dB

RF ATTENUATION 20 dB

The spectrum analyzer displays signal-plus-noise so that the closer a signal is to the noise level, the more noise is impressed upon the signal trace, making the trace difficult to read. The video filter, a post-detection low-pass filter, smooths the fluctuations of the noise to indicate average noise level. But since the response is still the signal-plus-noise, the closer the signal is to the noise, the greater the error in absolute amplitude measurement.

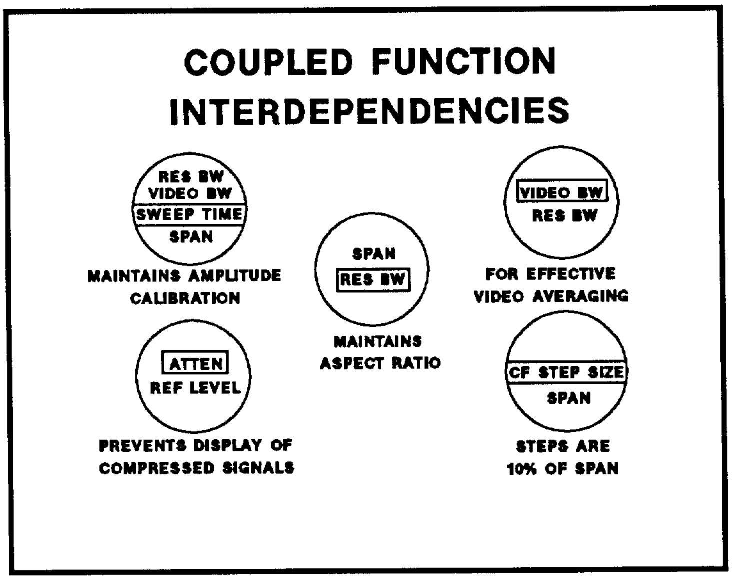
We specify sensitivity for HP spectrum analyzers as the condition at which the signal level equals the displayed average noise level. This is the level where the signal appears to be about 3 dB above the average noise level.

VIDEO FILTER SMOOTHS NOISE



VIDEO FILTER OFF

VIDEO FILTER ON

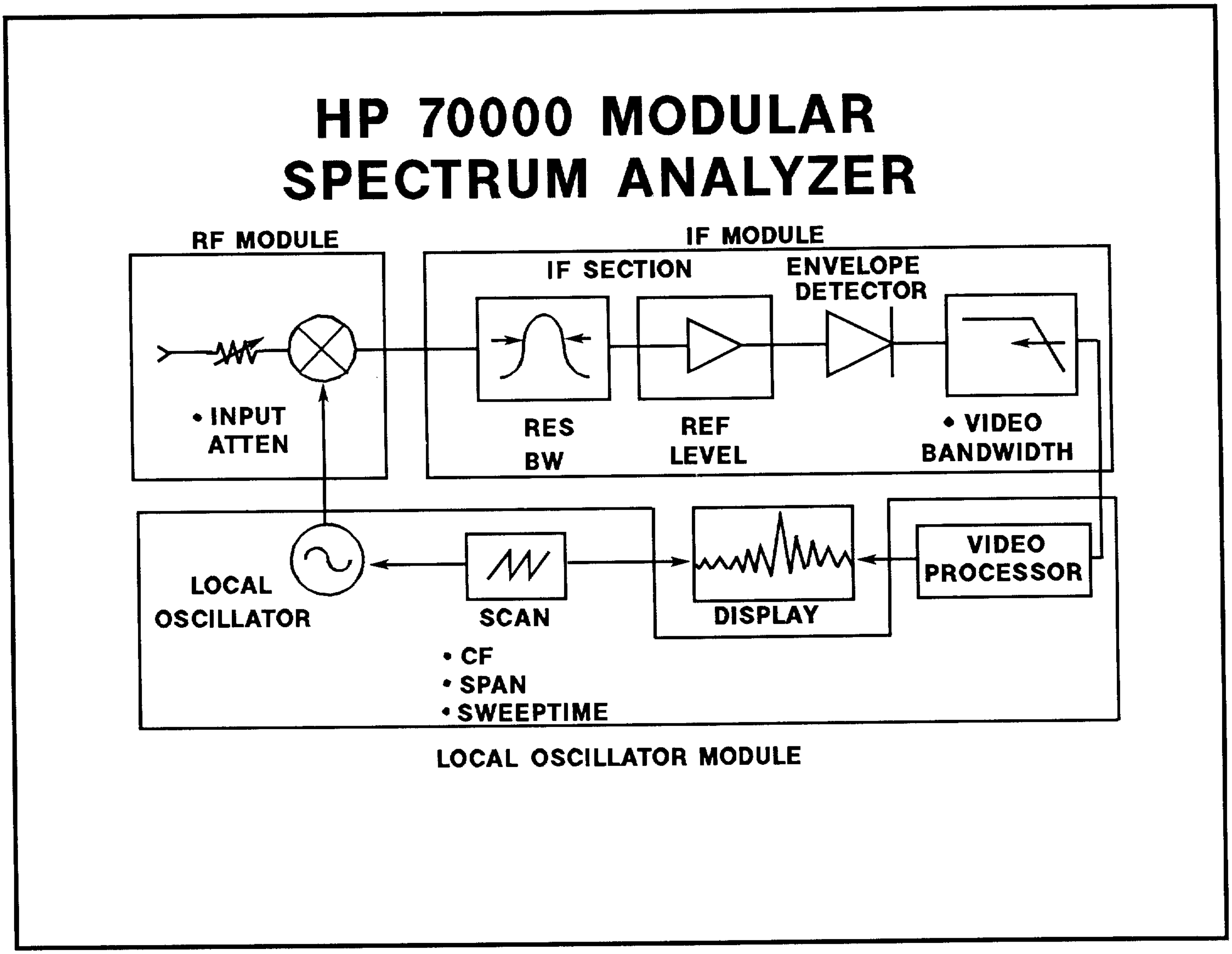


Five groups of interdependent functions exist in the analyzer. Their relationships are governed by a complex set of equations programmed into the analyzer's control memory. The following interdependencies were established to minimize the need for the operator to set all analyzer parameters individually for every measurement. The relationship among these functions in the coupled mode can be represented by the following equations where "f" designates a function:

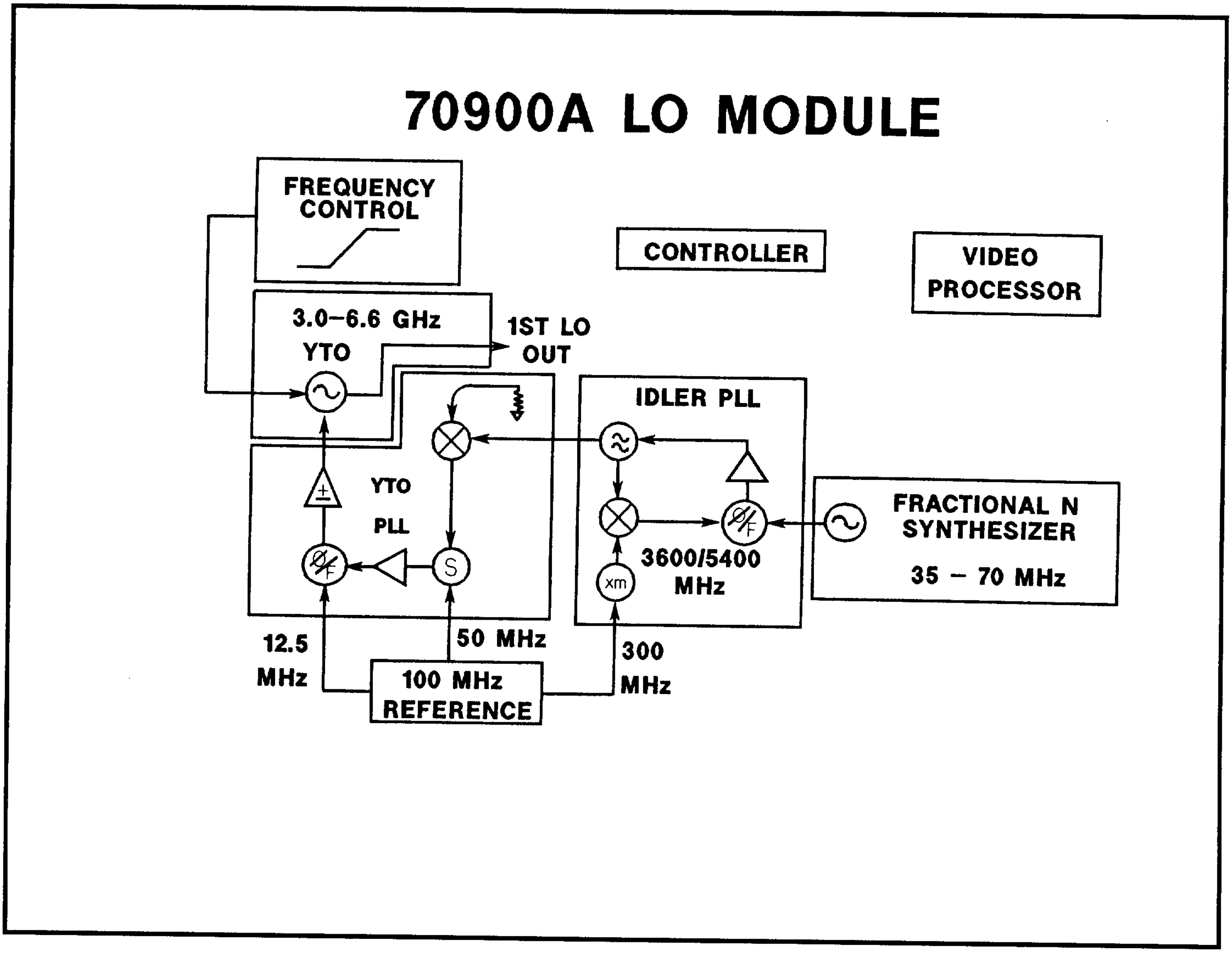
SWEEPTIME = f (RES BW, VIDEO BW, SPAN)
VIDEO BW = f (RES BW)
RES BW = f (SPAN)
CF STEP SIZE = f (SPAN)
ATTEN = f (REF LEVEL)

For example, sweeptime is a function of the resolution bandwidth, video bandwidth, and the frequency span.

Module Functions/Block Diagrams



The basic block diagram of the modular system is the same as the simple one we've just examined, except that the elements are divided up into functional groups and packaged into individual modules rather than all residing in one dedicated package like most other analyzers. The RF module contains the front-end elements like the attenuator and mixer. The IF modules contain the resolution and video filters, detector, and IF amplifiers. The LO module contains the local oscillator, sweep circuitry, and video processing elements. Finally, the display contains the CRT and user interface (menu keys, keypad, etc.). We'll look at each of the module block diagrams next.

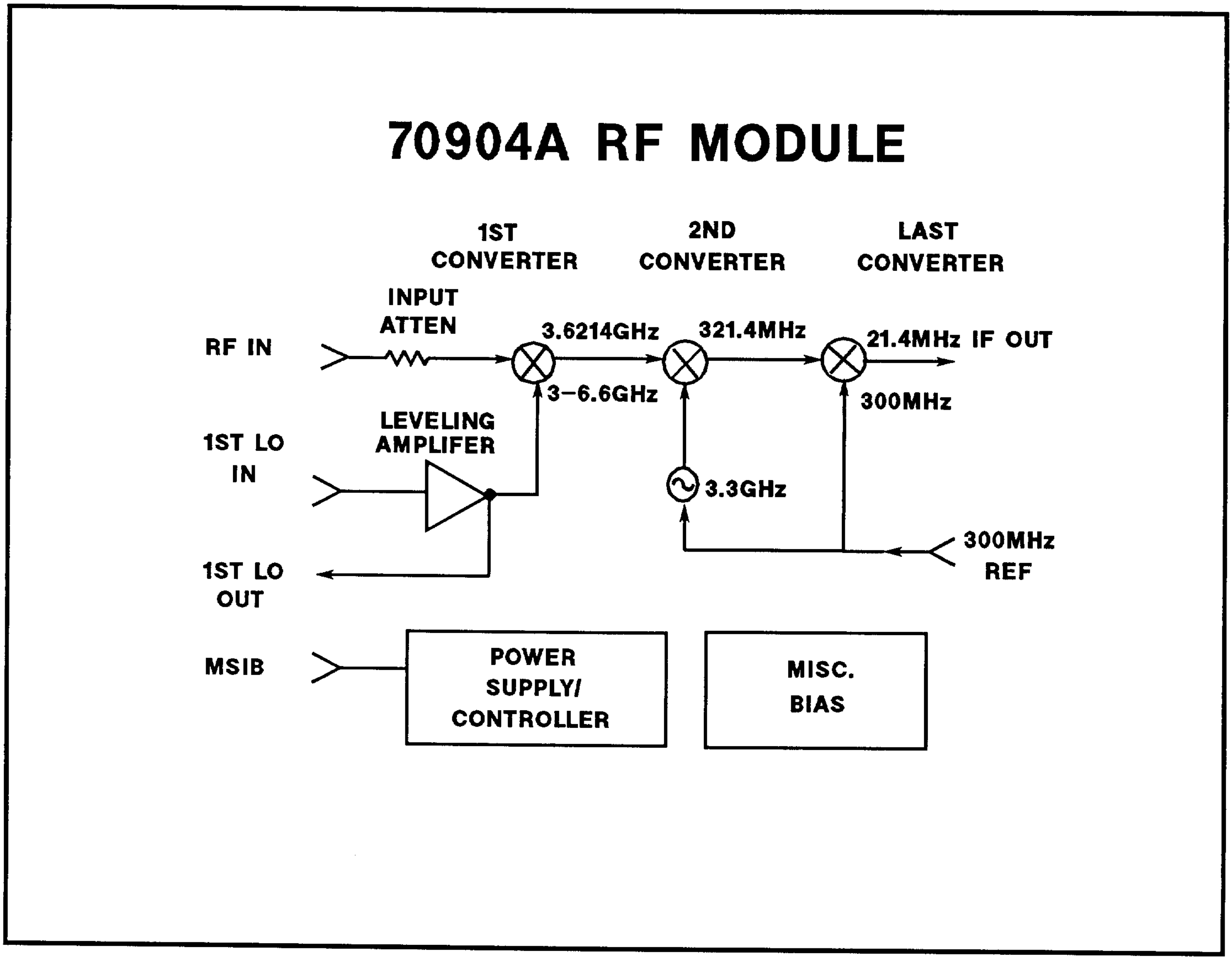


The HP 70900A Local Oscillator module is the "heart" and "brain" of the modular system. In terms of "brains", it contains the main processor and ROM that controls the other modules including the front-panel interface. It also contains the video processor which takes the video (analog) from the IF modules and processes it using positive and negative peak detectors and a 12-bit ADC (Analog-to-Digital Converter). In terms of the "heart" of the system, the LO module contains the hardware that drives the system. The local oscillator is a YTO (YIG-tuned oscillator) which is swept from 3 to 6.6 GHz. The LO module also provides a 300 MHz reference signal to the RF and Tracking Generator modules. It is derived from the 100 MHz reference oscillator shown here. In terms of the LO operation, the Frequency Control section contains a sweep DAC (Digital-to-Analog Converter) which sweeps the YTO in spans > 10 MHz. The Fractional Frequency Synthesizer controls the YTO sweep in spans < = 10 MHz. The YTO and IDLER PLL's are phase locked loops necessary to stabilize and precisely tune the YTO.

RF MODULES

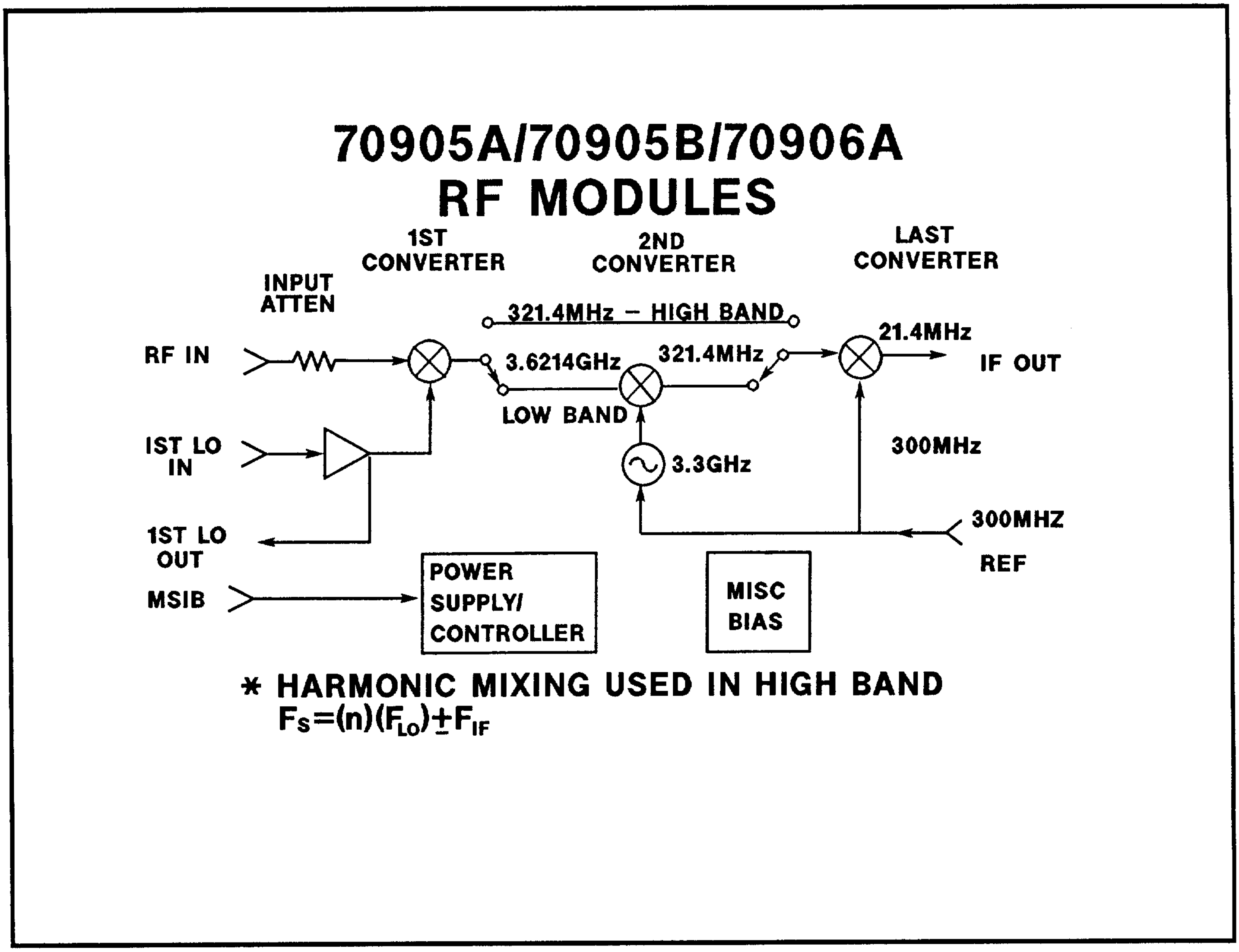
MODEL #	FREQUENCY RANGE
1. 70904A	100Hz – 2.9GHz
2. 70905A/B	50kHz – 22GHz
3. 70906A	50kHz – 26.5GHz
4. 70908A	100Hz – 22GHz

As we saw earlier, an input signal is mixed with a swept LO to produce a swept IF output. We just described the LO, so let's now look at the mixer and other front-end elements which are contained in the RF modules. The RF modules available for the HP 70000 system are listed here. As mentioned earlier, each of these RF modules are contained in a system configuration. For example, the HP 70908A RF module is included in the HP 71210A modular spectrum analyzer system. (The system also includes 2 IF modules, an LO, a display, a precision frequency reference, and a mainframe.) Let's now examine the functions and block diagrams of each of the RF modules.



The HP 70904A RF module converts the RF input signal to an IF of 21.4 MHz. The 21.4 MHz output is then sent to the IF modules. The HP 70904A covers the 100 Hz to 2.9 GHz frequency range. Note that it is a bit more complicated than our previous simple block diagram. It uses 3 conversion stages to mix the input signal down to 21.4 MHz. It uses the 300 MHz reference signal from the LO module to accomplish the final conversion. The power supply section converts the 40 kHz, 24 VAC signal from the mainframe to several different DC voltages (e.g. +/- 12 V, +/- 15 V).

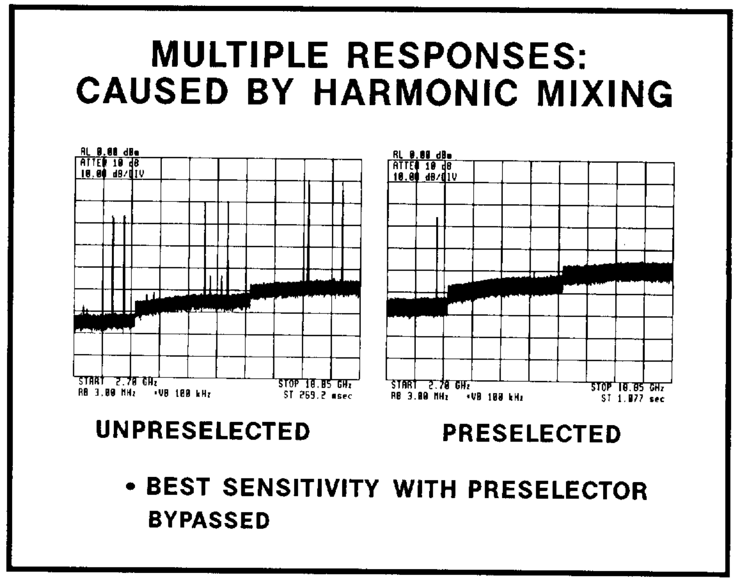
The controller handles module control such as attenuator switching and fault detection, and it handles HP-MSIB interfacing. (This is a modular interface bus which is discussed later.) The miscellaneous bias section provides the attenuator drive circuitry and the leveling amplifier feedback loop. The HP 70904A is the only RF module which has both AC and DC coupling. (The others are only DC coupled.) A DC blocking capacitor is included, but not shown here. Finally, this is the only RF module with a front-panel probe power supply output for use with high impedance active probes.



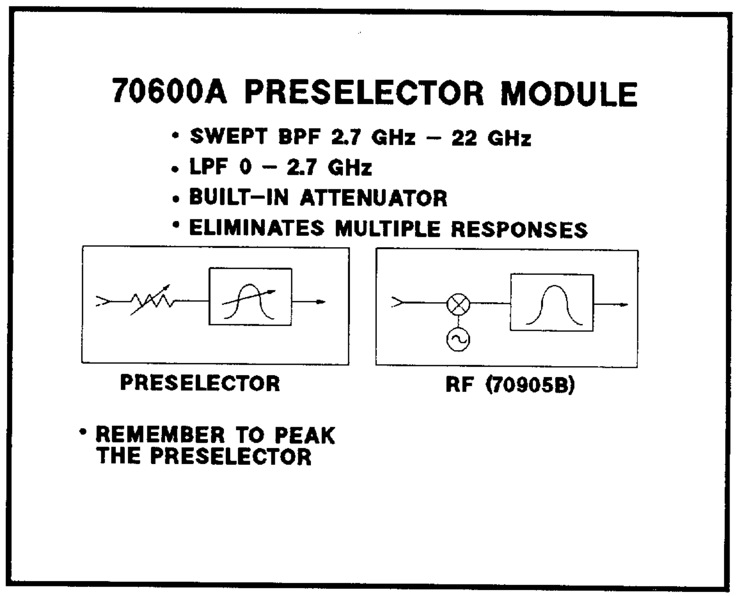
This block diagram is very similar to that of the previous RF module. The major difference is that this block diagram employs a dual IF signal path after the first converter. When a Center Frequency between 50 kHz and 2.9 GHz is selected, the signal is routed to the bottom path (3.6214 GHz IF and one extra conversion stage). When center frequencies between 2.7 GHz and 22 (or 26.5) GHz are selected, the signal is switched to the top path (321.4 MHz IF). In both cases, the result is a signal at 21.4 MHz out of the last conversion stage that then goes to the IF modules. In the high band path, a process called harmonic mixing is employed. Harmonics of the LO are generated in the first mixer to provide high-frequency signals which can mix with the high-frequency incoming signals to produce a sum or difference product at the 321.4 MHz IF. The "n" in the equation given above represents the LO harmonic number, or multiplier.

The HP 70905A and 70905B cover the 50 kHz to 22 GHz range. They are identical with the following exceptions. The "A" has an RF input attenuator; the "B" does not. The "A" has a "type N" RF input connector; the "B" has an sma input connector. The differences relate to their use with the RF Preselector module which will be described in the next slide. The HP 70906A RF module covers the 50 kHz to 26.5 GHz frequency range. It is essentially identical to the HP 70905A/B except that the HP 70906A has an APC 3.5 RF input connector and its attenuator has a better frequency response than the HP 70905A/B.

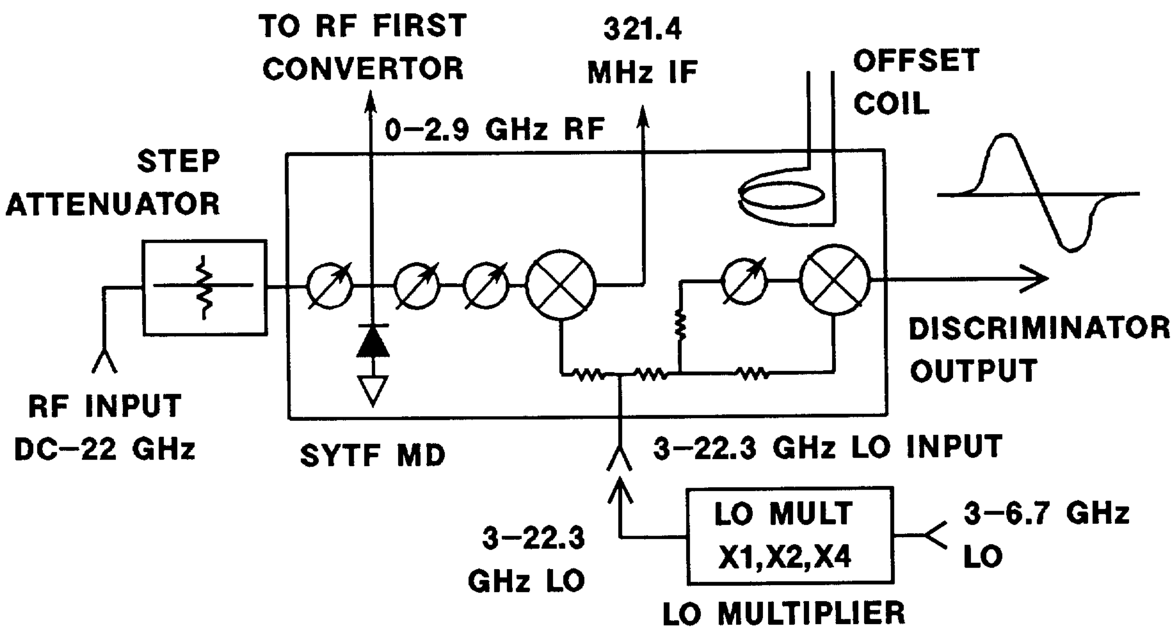
The harmonic mixing process described in the previous slide has the benefit of extending the frequency range of the front-end module, but it also causes unwanted responses on the display. These unwanted signals are called multiple responses. Using a feature called signal identification, we can tell which signal is the correct one, but it's far easier to use a device called a preselector to totally eliminate the multiples altogether. The plots shown here illustrate the benefit of preselected operation. Although the preselector adds insertion loss to the signal level, it can be turned off by using the "Preselector Bypass" feature once you've located the signal of interest using the preselector. Let's now see how a preselector works.



The HP 70600A RF preselector module eliminates multiple responses. It is used with the HP 70905A/B and 70906A RF sections. When the preselector is used with these modules, a signal is first input to the preselector, then out of the preselector, and into the front-end modules. A preselector is a swept bandpass filter which tracks the center frequency tuning of the front-end modules. This preselector sweeps over the 2.7 GHz to 22 GHz range. A 0 to 2.7 GHz low pass filter is switched in for center frequencies below 2.7 GHz. Note that this module has a built-in attenuator. Therefore, the HP 70905B (which has no attenuator) can be used when accompanied by the HP 70600 RF preselector. (In fact, it should not be used without it because of the lack of input protection.) The HP 70905A can be used with or without the preselector, although the "B" offers an advantage of 2 dB better sensitivity. Finally, for best amplitude accuracy, be sure to peak the preselector (found under MENU and **Freq** keys) before taking amplitude readings. Preselector peaking adjusts the tuning of the preselector filter so no signal degradation occurs.



70908A PRESELECTED FRONT–END

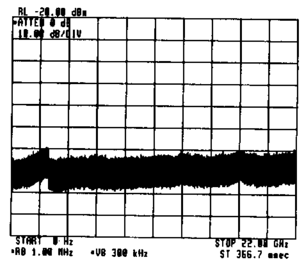


The HP 70908A preselected RF module covers the 100 Hz to 22 GHz frequency range. It includes a YIG tuned preselector, so there is no need for an additional preselector module. Preselector peaking is not required either. The HP 70908A offers outstanding performance with its state-of-the-art design. It contains a three-sphere, YIG tuned preselector in which the input sphere, along with a PIN diode circuit, replaces the slow and mechanical relay switches, that are subject to wear. The third sphere, functions as a balanced, fundamental mixer with low conversion loss and a high third-order intercept. The LO multiplier provides the fundamental, second, or fourth harmonic of the LO as the "fundamental" signal for the mixer. The fourth sphere is tuned to the LO frequency using a small, magnetic offset coil. This sphere acts as a discriminator, generating an error voltage that is fed back to the magnetic tuning circuitry to frequency-lock the preselector. This eliminates swept- amplitude inaccuracies.

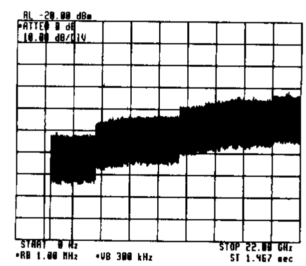
The HP 70908A offers outstanding performance. At 22 GHz its sensitivity is -133 dBm (10 Hz RBW) and its flatness is +/- 2 dB. Dynamic range of 92 dB at 18 GHz is also provided. Faster measurements are also possible since wider RBW's can be used due to the excellent sensitivity. Since preselector peaking is not required, measurement speed is enhanced even further. The biggest advantage of its fundamental mixing design is illustrated in the plots shown here. The flat noise floor out to 22 GHz has never before been achieved. Other analyzers employ harmonic mixing which have a "stair-stepped" noise floor like that shown in the plot on the right. (Since mixer conversion loss is greater at higher frequencies, appropriate internal IF gain must be added to compensate for it, resulting in a higher noise floor.) Even though the input frequency range is divided between two independent IF chains, the HP 70908A allows for continuous sweeps from 100 Hz to 22 GHz. The PIN-diode switch contained in the mixer/preselector assembly makes this possible. This capability is particularly useful in surveillance applications in which the spectrum analyzer's full frequency coverage is desired.

70908A: EXCELLENT SENSITIVITY

- 0 – 22 GHz SWEEPS
- NO PRESELECTOR PEAKING
- FASTER MEASUREMENTS



70908A (71210A SYSTEM)



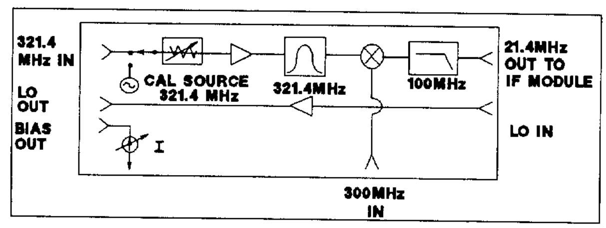
TYPICAL FORERUNNER

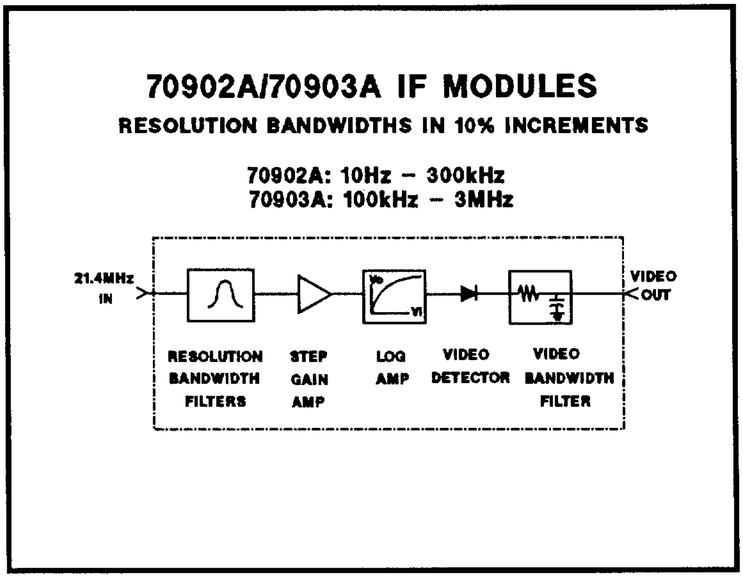
If you need to analyze signals above 26.5 GHz, it is necessary to use external waveguide mixers, since the frequency response of coax degrades at those frequencies. The HP 11970 series of external mixers covers the 18 - 110 GHz frequency range. Mixers from other manufacturers are available up to 325 GHz. Input signals are mixed down to 321.4 MHz by the external mixers, and then input to the External Mixer Interface Module (EMIM). The EMIM downconverts the signal to 21.4 MHz where it is then input to the IF module for further filtering and detection. The EMIM also provides an LO amplifier, which provides a high level LO signal to the external mixer for optimum operation. The EMIM also provides a bias supply for non-HP mixers which require bias current to operate properly. HP mixers are easy to use since they do not require bias. They are also amplitude calibrated.

70907A E.M.I.M.

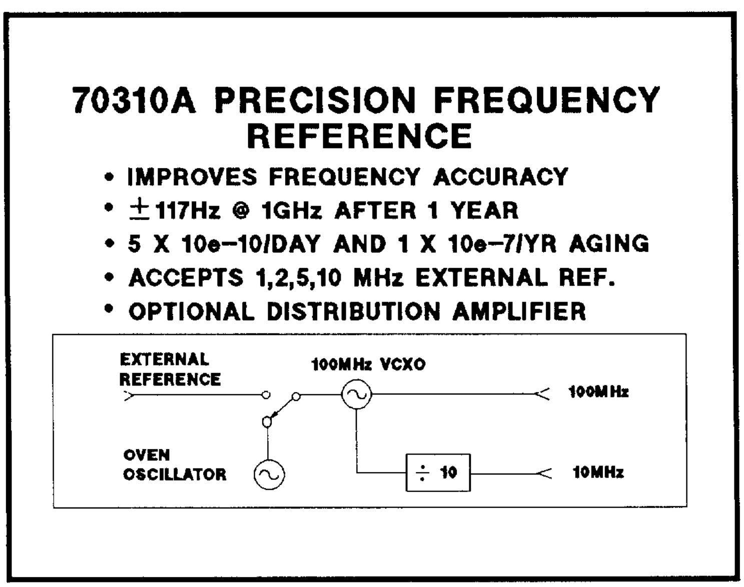
EXTERNAL MIXER INTERFACE MODULE

- HP MIXERS TO 110GHz
- OTHER MIXERS TO 325GHz



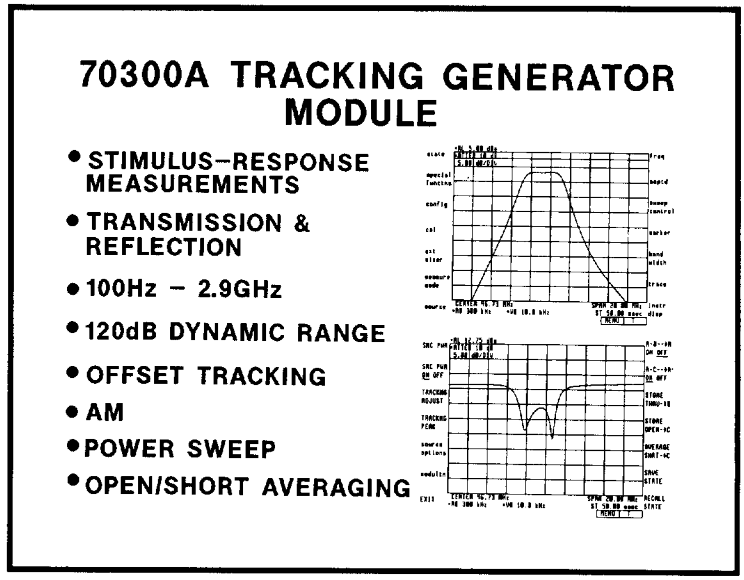


The IF modules convert the 21.4 MHz signal from the RF modules or EMIMs to a band-limited video signal. They also contain resolution bandwidth filters, adjustable in 10% increments (except between 3 kHz and 10 kHz). So, bandwidth choices (using the knob) such as 10 kHz, 11 kHz, 12.1 kHz, and 13.3 kHz are available, allowing generous flexibility in resolution and sweeptime. Most other analyzers have fewer bandwidth choices (e.g. 10 kHz, 100 kHz, 1 MHz choices for some; 10 kHz, 30 kHz, 100 kHz choices for others). The closer the steps are, the more flexibility there is in resolving closely spaced signals and the minimization of sweeptime penalty when reducing the RBW. The HP 70902A IF module contains the high resolution filters: 100 Hz to 300 kHz. The HP 70903A contains the wide band resolution filters: 100 kHz to 3 MHz. IF step gain amplifiers for changing the Reference Level and for insertion loss compensation are also included in the IF modules. In addition, they contain a log amplifier, video envelope detector, and video bandwidth filters (adjustable in a 1-3-10 sequence).

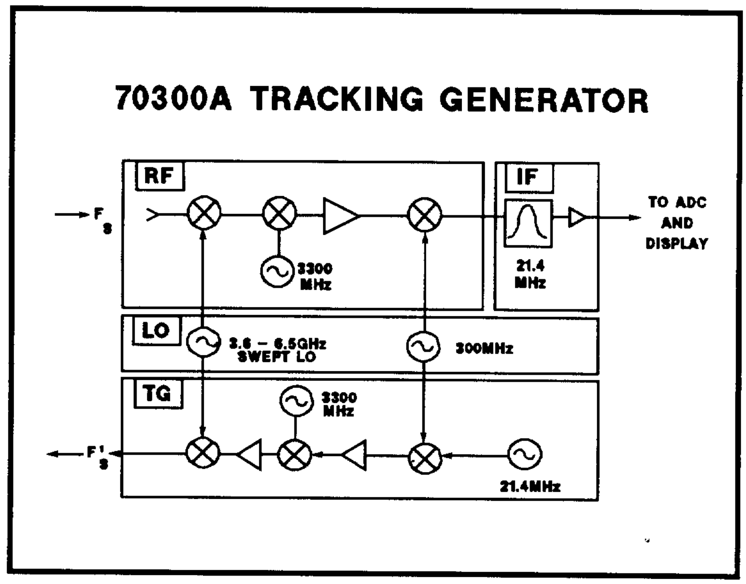


The HP 70310A Precision Frequency Reference module provides a stable ovenized reference oscillator signal to the LO module to improve the frequency accuracy of the spectrum analyzer. The aging rate and an example of the accuracy are given in the illustration. Without this module, the frequency aging would be 3 x 10e-6/year. That translates to +/- 13 kHz frequency accuracy at 1 GHz. Option 002 deletes the ovenized oscillator and accessory power pack. The external reference input capability is retained, allowing external standards at 1, 2, 5, or 10 MHz to be connected to the HP 70310A. In any event, the LO module requires a 100 MHz reference signal from the HP 70310A. Option 001 provides a 2 built-in distribution amplifiers, each with 1 input and 3 outputs, which can be daisy-chained to provide 5 outputs, to distribute the 100 MHz reference signal to multiple LO modules or the 300 MHz reference signal to multiple EMIM modules.

The HP 70300A Tracking Generator module is used for making swept stimulus-response measurements of devices and systems. Examples include transmission and reflection measurements of filters, amplifiers, cables, and antennas. The output precisely tracks the input frequency to which the spectrum analyzer is tuned. In essence, we have a scalar (i.e. no phase information) network analyzer over the 100 Hz to 2.9 GHz range. (This module can also be used as a source (without a spectrum analyzer, but still requiring an LO) from 20 Hz to 2.9 GHz.) As a tracking generator, it offers up to 120 dB of dynamic range for looking at filter skirt rejection, offset frequency tracking capability for mixer testing (2 LO's required), amplitude modulation (400 Hz and 1 kHz modulation frequencies), power sweeps for amplifier gain compression testing, and open-short averaging for the best amplitude accuracy during reflection measurements.



The block diagrams of the tracking generator (T.G.) module, RF module, IF module and LO module are shown here. Note that the LO module supplies the same two signals to both the RF module and the tracking generator module (i.e. the LO and 300 MHz signals). Note further that the block diagram of the T.G. is essentially the reverse of the RF module diagram. The result is that the T.G. output frequency (Fs') is the same frequency to which the spectrum analyzer is tuned (Fs). Therefore, the two sweeps are synchronized, and swept measurements can be made easily.

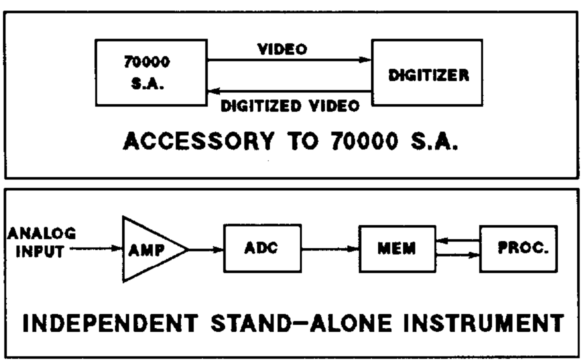


HP 70700A DIGITIZER MODULE: TWO CONFIGURATIONS

1. ACCESSORY FOR 70000 SERIES SPECTRUM ANALYZER
   - FASTER SWEEPS
2. INDEPENDENT STAND–ALONE INSTRUMENT
   - DIGITIZING OSCILLOSCOPE AND WAVEFORM RECORDER FEATURES

The HP 70700A Digitizer module is unique because it can be used in two different configurations. The first use is as an accessory to the HP 70000 spectrum analyzer to provide faster sweeps, since this module has a faster analog-to-digital converter (ADC) than the standard one found in the LO module. A signal is still input to the RF module input as before, but now sweeptimes faster than 50 msec. can be achieved. The second configuration is using the digitizer as a stand-alone instrument (i.e. no RF, IF, or LO modules necessary). Think of it as a single module instrument which has an input and provides waveform recorder and digital oscilloscope features for analyzing all kinds of signals (e.g. video signals).

DIGITIZER CONFIGURATIONS

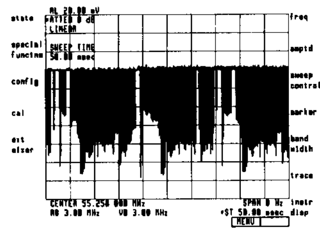


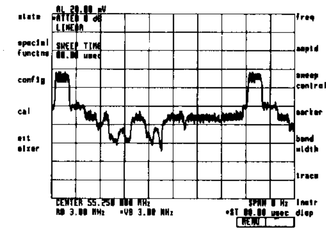
These simple block diagrams should help you to visualize the two different digitizer configurations. As an accessory to the spectrum analyzer, the video out of the spectrum analyzer (specifically the IF module) is fed to the digitizer rear panel input. The digitized video is then sent to the display over the HP-MSIB (Modular System Interface Bus -- explained later.) The result is the capability for faster sweeps. In the stand-alone configuration, an analog signal is input directly to the digitizer where it is first amplified and then digitized at 20 Msamples per second by a 10 bit ADC. The digitizer also has a 256 k-word memory for performing waveform recorder functions.

Let's illustrate some applications of these two different digitizer configurations. Let's start with its use as an accessory. The plot on the right is the result of using the digitizer with the spectrum analyzer system. Note the 80 usec sweeptime and the ability to resolve the waveform in the time domain (i.e. span set to 0 Hz). The same signal was input to a standard HP 70000 system without a digitizer module (plot on the left). Note that 50 msec is the fastest sweeptime, and it is not fast enough to resolve the pulses in the time domain.

DIGITIZER AS AN ACCESSORY

- FASTER SWEEPTIMES
  (ENHANCED ZERO SPAN CAPABILITY)





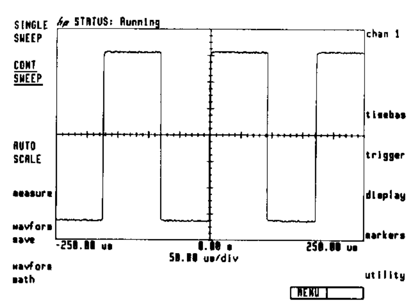
ST = 50mec

ST = 80usec

Now let's illustrate an application of the digitizer in the stand-alone configuration. This means that the signal is input directly to the digitizer, and no spectrum analyzer is present. Here we see a pulse train being displayed in the time domain. Note the new menu keys along side the display. They are similar to those found on some HP waveform recorders (digitizers) and digital oscilloscopes. One of the functions accessed by this menu (under "timebase") is "random event capture" which is used to capture non-repetitive events that have a lot of "dead" time in between. There are other functions which calculate modulation frequency, period, etc. Finally, up to 8 of these digitizers can be placed in a mainframe, each with 256K memory, for multi-channel applications. There are options to support up to 64 digitizers in a single system (8 mainframes), too.

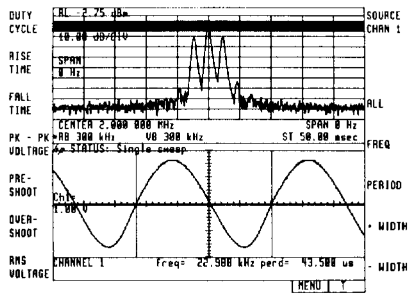
STAND-ALONE DIGITIZER

- DIGITIZING OSCILLOSCOPE AND WAVEFORM RECORDER FEATURES



STAND–ALONE DIGITIZER WITH A SPECTRUM ANALYZER

* OSCILLOSCOPE/WAVEFORM RECORDER FEATURES FOR DEMODULATED WAVEFORMS



Another application of the digitizer is to take the demodulated video output from the spectrum analyzer (in zero span) and input that signal to the stand-alone digitizer. This allows waveform analysis in the time domain taking advantage of the new menu features of the digitizer. As we'll see later, the display of the HP 70000 can be configured to show 1, 2, 3, or 4 simultaneous displays. Here we see 2 display "windows". The top one is a display of the signal input to the spectrum analyzer. The bottom one is a display of the video signal from the IF module that is input to the digitizer. To get the bottom display, the top display must be in zero span and use a wide RBW (i.e. the wide, dark trace at the top). This configuration requires the digitizer to be in Row 0 of the address map.

ADDITIONAL MODULES

- 26.5 GHZ PRESELECTOR
- 18 GHZ TRACKING GENERATOR
- LIGHTWAVE FRONT–END
- 22 GHZ PREAMPLIFIER
- MATE TEST MODULE ADAPTER
- POWER METER
- SOURCES
- OTHERS . . .

We've included the block diagrams of many of the HP 70000 modules in this section of the document. In addition to these modules, new modules are being introduced regularly, which offer you measurement solutions in a wide variety of application areas. This slide lists some of the newer modules available to you. The HP 70601A Preselector covers the 2.7 GHz to 26.5 GHz range. The HP 70301A Tracking Generator module covers the 2.7 GHz to 18 GHz range. The HP 70810A Lightwave module covering the 1200 nm to 1600 nm wavelength range is used with the HP 71210A spectrum analyzer to do baseband analysis on lightwave signals. The HP 70620A preamplifier covers the 2 GHz to 22 GHz range. The HP 70590A-H69 MATE Test Module Adapter allows the HP 70000 to be programmed in CIIL language. Finally, a power meter module, a full rack-width signal source, and many other new modules will be available for the HP 70000 system in the future. Contact your HP Field Engineer for the most up-to-date information.

MENU, USER, & DISPLAY Hardkey Overview

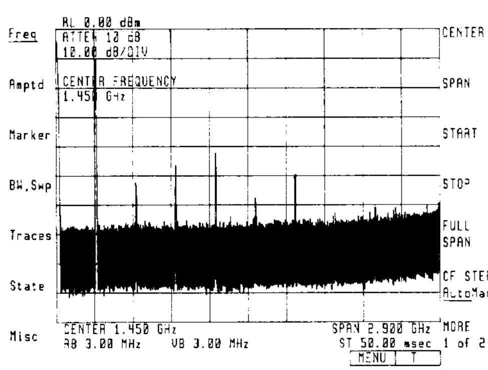
THREE HARDKEYS PROVIDE ACCESS TO MEASUREMENT FUNCTIONS

USER **MENU** **DISPLAY**

The centralized human-machine interface (HP 70205A Graphics Display or HP 70206A System Graphics Display) is designed to provide system level functions and also to provide instrument level functions. As we will see in the next slide, along the left and right hand sides of the display screen are 14 keys. Next to these keys, on the display itself, are 14 labels which change according to the currently accessed menu. These keys are known individually as softkeys and collectively as the keyboard. Above and below the screen display are other familiar keys such as Instrument Preset, Local, numeric keys, backspace, and so forth, and three innovative keys, DISPLAY (DSP), MENU (MNU), and USER (USR). The DISPLAY hardkey accesses system level functions, while the USER and MENU hardkeys access functions of individual instruments such as a complete spectrum analyzer. The user can, through the DISPLAY menu, display the menus of any instrument in the system. This powerful system of softkey control adapts easily to all types of instruments, and makes it easy for a wide variety of measurement instruments to join the HP 70000 family.

MENU HARDKEY

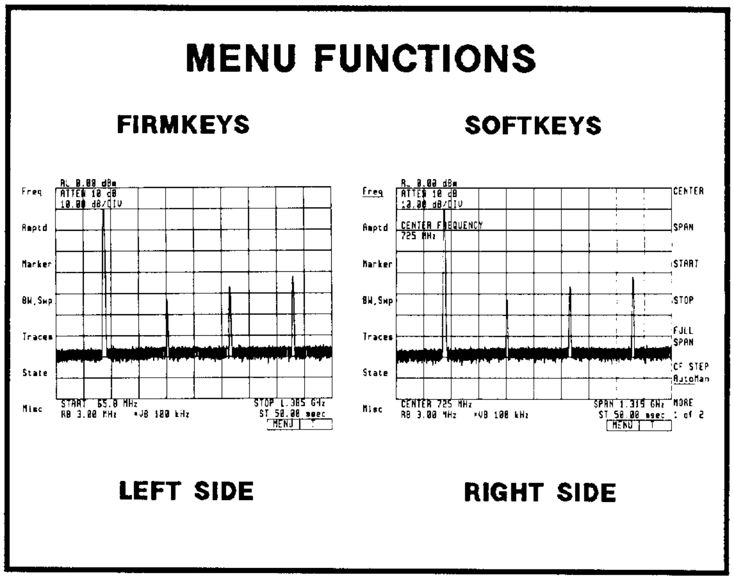
ACCESSES ALL INSTRUMENT FUNCTIONS



SPECTRUM ANALYZER FUNCTIONS SHOWN

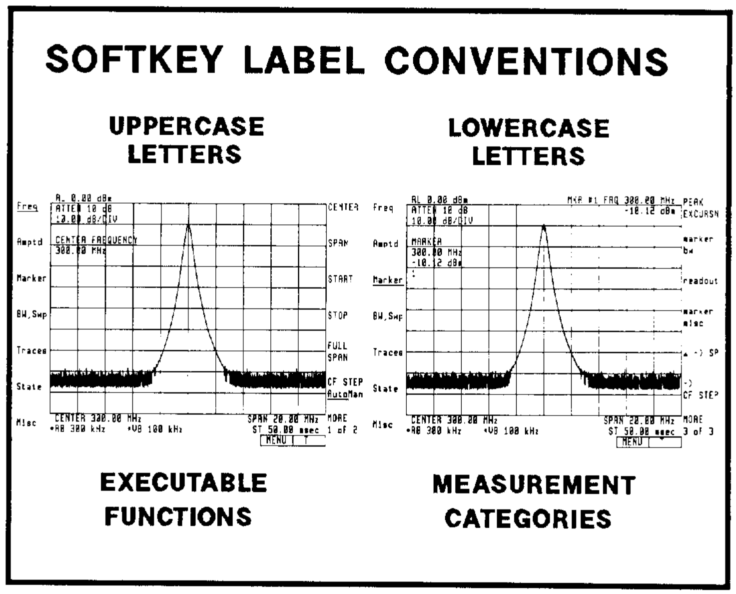
There are over 150 instrument functions available for the modular spectrum analyzer using the MENU hardkey. The exact number depends upon which modules are present. This document will focus on the MENU functions which appear for the HP 70000 modular spectrum analyzers. (A different set of MENU functions would appear if the HP 70700A Digitizer were used in a stand-alone configuration. See the Digitizer operation manual for more information on its operation.)

The MENU functions are grouped into 7 measurement categories (**Freq**, **Amptd**, **Marker**, etc.) called "firmkeys", found on the left-hand side of the display. (See the left plot shown here.) Each firmkey accesses a group of functions called "softkeys", found on the right-hand side of the display. (See the right plot.) Examples of softkeys include the **CENTER**, **SPAN**, **START**, and **STOP** frequency keys. These softkeys are the actual functions that are used to control the spectrum analyzer. Firmkeys are so named because they always remain on screen and do not change or disappear when other keys are pressed. On the other hand, softkey labels do change. For example, a new set of softkeys will replace the present softkeys when a new firmkey is pressed.



The top-level softkeys which appear after pressing a firmkey tend to be those that are used most often. The next level (or levels) of functions are found by pressing the "**MORE**" softkey.

When a firmkey is pressed, a new set of softkeys appears on the right-hand side of the CRT. Since there are only seven softkeys available to access over 150 functions, a simple convention has been set up to find a function as easily as possible. Softkeys with uppercase letters (all caps) are executable functions. That is, they perform a function immediately upon being pressed. **CENTER** frequency, **SPAN**, and **FULL SPAN** are examples of executable functions (shown on left plot). Softkeys with lowercase letters are measurement categories. When pressed, they do not cause a function to be executed. Rather, they call up another set of related softkeys which themselves are generally uppercase executable softkey functions. For example, **marker bw** and **readout** (shown on the right plot) are measurement categories that each access several executable functions. Note that there is a mixture of uppercase and lowercase softkeys shown here. **PEAK EXCURSN** is uppercase, and therefore, is an executable function.



INSTRUMENT PRESET KEY

I – P

QUICKLY RESETS S.A. CONTROL SETTINGS

1. COUPLED CONTROLS RESET
2. RBW & VBW = 3 MHZ
3. REF. LEVEL = 0 dBm
4. ATTEN = 10 dB
5. TRACES RESET
6. MENU KEYS SELECTED
7. MENU SOFTKEYS BLANKED

The **INSTRUMENT PRESET (I-P)** key is the green key located on the front of the display. It is used to quickly reset the control settings of the spectrum analyzer to a known preset state. That includes recoupling the coupled controls (resolution bandwidth, span, video bandwidth, reference level, attenuator, sweeptime, and center frequency step size). In addition, the three digital traces (A,B,C) are reset, the MENU firmkeys are selected, and the softkeys are blanked.

HOLD KEY

HOLD

PRESS ONCE:

- BLANKS ACTIVE FUNCTION AREA ANNOTATION
- TURNS OFF INVERSE VIDEO ON ACTIVE SOFTKEY

PRESS TWICE:

- BLANKS ALL SOFTKEYS

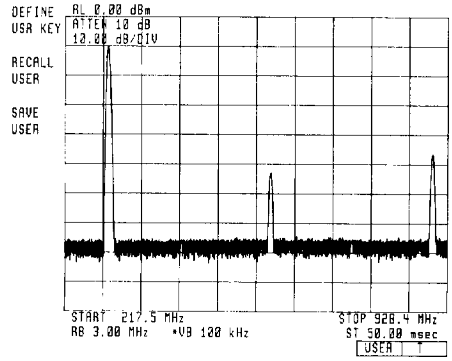
The **HOLD** key is located on the front of the HP 70206A large screen display. It can also be accessed as a softkey by first pressing the **Misc** firmkey. The function of **HOLD** is to deactivate an active function to prevent further control setting changes. For example, if **SPAN** has just been set to 1 MHz, it remains the active function. So, if the knob is turned or the step keys are pressed accidentally, the **SPAN** will change to a new value. **HOLD** also removes the active function annotation from the display, and it turns off the inverse video from an active softkey.

If **HOLD** is pressed twice, the softkeys (on the right-hand side of the display) will be blanked. (**INSTRUMENT PRESET** also blanks the softkeys.)

We've just seen how easy it is to access the more than 150 spectrum analyzer functions using the MENU functions. For simple measurements that require only a few functions, the HP 70000 offers an even easier way of accessing the function than the MENU key. Namely, the USER hardkey allows you to create a custom menu containing only the functions you use for a particular measurement. The **DEFINE USR KEY** function allows you to pick functions found under the MENU hardkey and place them in the USER key area. This will be described later in the "USER KEY FUNCTIONS" section of this document. It is just mentioned here as an overview. In addition, the USER key area is used to access downloadable programs. DLPs are one-button measurement routines capable of performing complex measurement sequences without a controller being present. These will be described in more detail in the "DOWNLOADABLE PROGRAM" section.

USER HARDKEY

CREATE YOUR OWN CUSTOM MENU

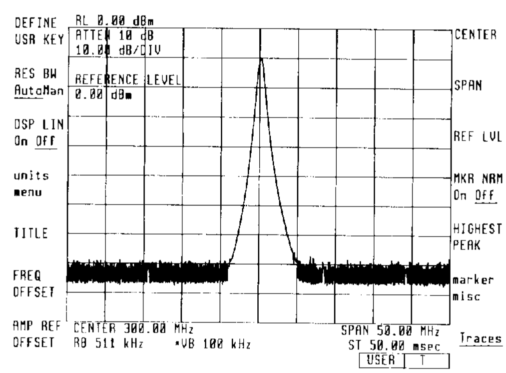


ACCESSES S.A. FUNCTIONS & DOWNLOADABLE PROGRAMS

This plot is an example of a custom USER menu. The functions shown here are just 13 of the more than 150 functions residing under the MENU hardkey. Note that uppercase lettered functions, lowercase keys, and firmkeys can be placed in the USER menu. A much more detailed examination of user-defined keys follows later in this document.

Up to 50 custom USER menus can be saved in non-volatile RAM as long as sufficient memory exists.

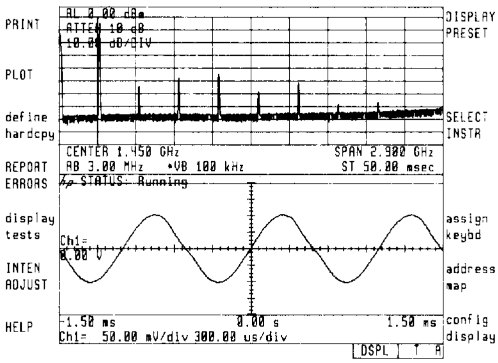
USER KEY EXAMPLE



SAVE UP TO 50 SETS

DISPLAY HARDKEY

ACCESSES SYSTEM-LEVEL FUNCTIONS



CONFIGURATIONS, WINDOWS, & ERROR REPORTING

The DISPLAY hardkey accesses all of the system and display functions on the HP 70000 system, whereas you'll recall that the MENU hardkey accesses spectrum analyzer functions. System functions such as **address map, assign keyboard,** and **SELECT INSTRUMENT** control the addressing, communication, and configuration of the instruments in the system. For example, if several different spectrum analyzers are all connected within a single system, the DISPLAY hardkey would be used to select a particular instrument to change its control settings. We'll see later that DISPLAY functions will be used to display multiple spectrum analyzers or digitizers on a single central Display. The plot shown here previews that capability with its two "windows" on the same screen. The top one is a spectrum analyzer display and the bottom one is a digitizer display. Also, system errors can be reported using one of the DISPLAY functions. The DISPLAY functions will be covered in detail later in this document.

DISPLAY HARDKEY

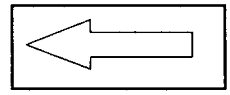
ACCESSES DISPLAY, PRINTING, & PLOTTING FUNCTIONS

- **DISPLAY TESTS**
- **INTENSITY ADJUSTMENT**
- **PRINTER AND PLOTTER DEFINITIONS**

The DISPLAY hardkey not only accesses system level functions like those described in the previous slide, but it also accesses display, printing, and plotting functions. For example, internal display diagnostic tests are used to check the proper operation of the display circuitry. The intensity of the CRT is adjusted by accessing a softkey called **INTEN ADJUST** followed by a number from 1 to 19. The DISPLAY hardkey also provides access to the direct **PRINT** and **PLOT** keys. These keys are also found on the front panel of the HP 70206A display. Printing and plotting over HP-IB are beneficial features of the HP 70000 since a controller is not necessary. Printer and plotter definitions (addresses, plot sizes, etc.) are also performed using DISPLAY functions.

The backspace arrow key is a very useful function. Its most obvious use is that of a backspace key when a mistake is made entering numbers from the keypad (e.g., while entering CENTER freq or SPAN followed by numbers). In the context of its use with the MENU functions, the backspace arrow key is used to return to the next highest level of MENU functions. A very useful function of the arrow key is to move from the USER keys to the last set of MENU keys accessed. This eliminates the need to access the MENU hardkey and each subsequent level of keys to get to the desired function which you last accessed. Finally, to exit **DISPLAY TESTS** (found under the DISPLAY hardkey), it is necessary to press the backspace arrow key.

BACKSPACE ARROW KEY



USES:

1. **BACKSPACE KEY**
2. **RETURN TO NEXT HIGHEST MENU LEVEL**
3. **RETURN FROM USER KEYS TO LAST SET OF MENU KEYS ACCESSED**
4. **EXIT DISPLAY TESTS**

SOLUTION: 1.) Press the MENU hardkey and **Freq** firmkey. **CENTER** frequency is selected. Enter 300 MHz. Press **SPAN** and enter 1 MHz. Press **Amptd** firmkey. **REF LVL** is selected. Enter -10 dBm or use the step keys or knob to bring the signal to the top. 2.) Pressing **HOLD** removes the annotation from the active area and removes the inverse video from the active softkey (**REF LVL**). Pressing **HOLD** twice removes the softkeys. 3.) Press the DISPLAY hardkey and **INTEN ADJUST** softkey. Use the knob, step keys, or keypad to set the intensity to 18 or 19. Press the **display tests** softkey. Step through the tests. The **test pattern** key has 5 tests (1 - 5). Remember that the **backspace arrow key** exits many of the routines.

REVIEW EXERCISE #1

OBJECTIVE:

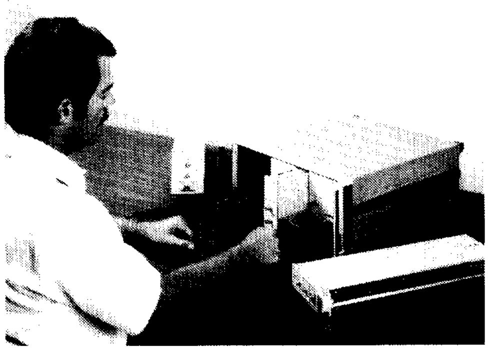
TO OBTAIN AN OVERVIEW OF THE MENU AND DISPLAY HARDKEYS.

TASKS:

1. **USE THE MENU KEYS TO TUNE TO THE 300 MHZ CAL SIGNAL IN A 1 MHZ SPAN, AND MOVE IT TO THE REFERENCE LEVEL**
2. **PRESS THE HOLD KEY TWICE. OBSERVE THE RESULT AFTER EACH KEY PRESS.**
3. **ACCESS THE DISPLAY HARDKEY. OPTIMIZE THE CRT INTENSITY. STEP THROUGH THE DISPLAY TESTS.**

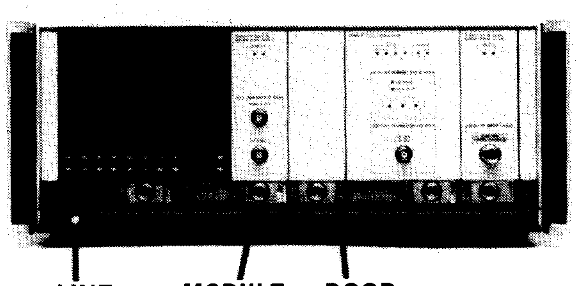
Connections and Configurations

CONNECTIONS AND CONFIGURATIONS



The HP 70000 systems are shipped to you completely set up, including rear panel hardware connections and internal address configurations. You may wish to add different modules in the future (e.g. tracking generator, digitizer, EMIM) or connect additional spectrum analyzers to your existing one and control them from a single display. Or, you may loan a module (e.g. IF) to someone, and when they return it, you'll need to re-install it. This section of the document will give you the necessary information to do these tasks easily.

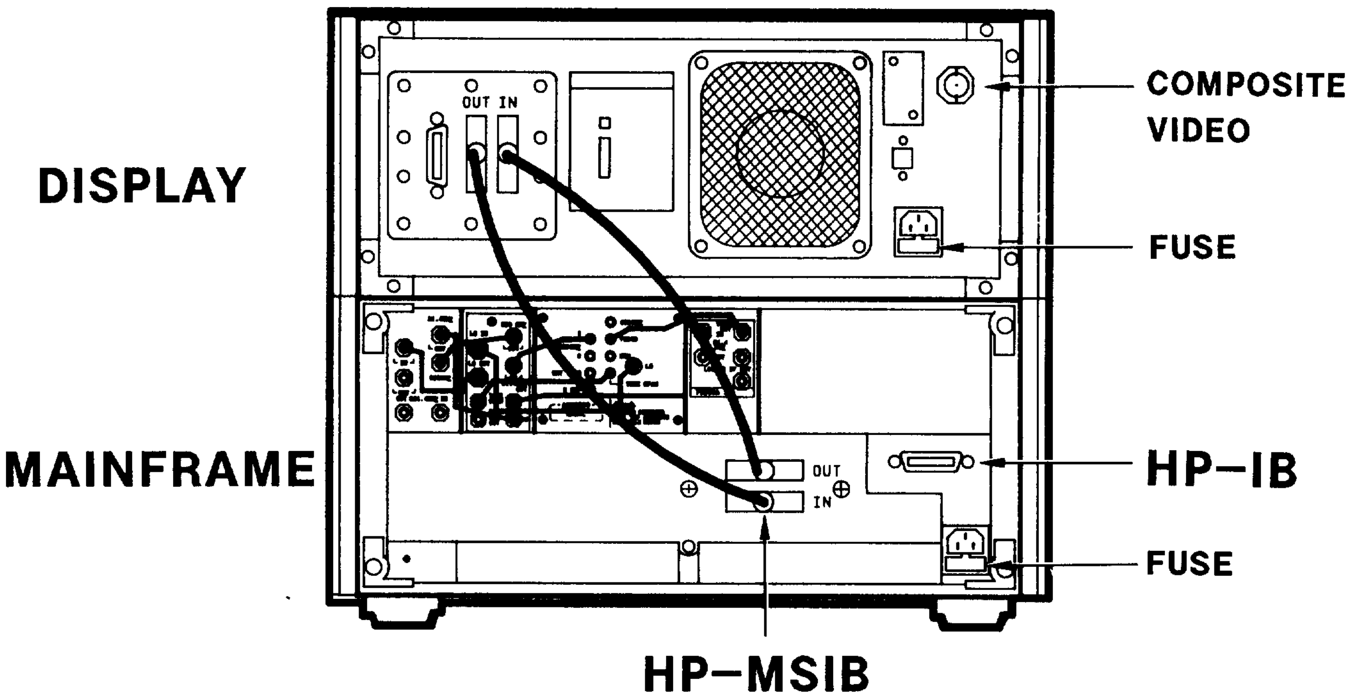
MODULE REMOVAL AND REPLACEMENT



Modules are easy to install and remove. To install a module, simply turn off the power, lower the mainframe front panel and slide the module into place. Then use the 8 mm Hex Ball Driver to tighten the locking nut on the lower front of the module. The module is now connected to power, cooling, HP-IB, and HP-MSIB. However, we're not quite ready to operate the system yet. We need to complete the installation by connecting the appropriate rear panel cabling, configuring the HP-MSIB address switches, and connecting the external HP-MSIB cables to the large-screen display (not necessary if the small, modular display is used) and any other HP 70000 mainframes that may be part of the system (not necessary if you only need one mainframe to contain all of your modules, which is generally the case).

2 REAR PANEL BUSES

(HP–IB/HP–MSIB)



Before describing how to make the rear panel analog connections and how to set the module addresses, let's spend a few minutes describing how to connect external HP-MSIB cables between a mainframe and a large-screen display. HP-MSIB (Hewlett-Packard Modular System Interface Bus) is a new instrument bus concept. Don't confuse it with the HP-IB (IEEE-488) computer bus. Both are shown here on the rear panel of the HP 70000 system. Note how the HP-MSIB cables are connected in a daisy-chain fashion (IN to OUT; OUT to IN). There is also an internal HP-MSIB rear panel bus in each mainframe. The internal HP-MSIB is composed of multiple lines including data lines, a clock line, control lines, and 40 kHz, +24 VAC power supply lines. This internal bus is the means by which the modules communicate with each other.

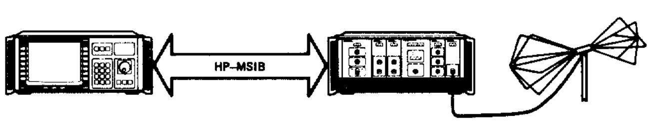
70000 COMMUNICATION BUSES

HP–IB (IEEE–488)	HP–MSIB
• SINGLE CABLE	• DUAL CABLE
• 70000 TO CONTROLLER	• DAISY CHAIN LOOP
• 70000 TO OTHER INSTRUMENTS	• MODULE TO MODULE
• 70000 DISPLAY TO CONTROLLER	• 70000 MAINFRAME TO 70000 MAINFRAME
• 70000 DISPLAY TO CONTROLLING INSTRUMENT	• 70000 MAINFRAME TO 70000 DISPLAY

The main reason for developing the HP-MSIB bus was to allow multiple talkers and listeners at the same time. HP-IB only allows one "conversation" at a time. Further, with HP-MSIB, modules can receive and send messages at the same time, whereas instruments on HP-IB can either talk or listen at any given time, but not both. Other differences between the two buses are shown here. HP-IB requires only a single cable (composed of multiple lines, of course) between 2 instruments whereas HP-MSIB requires two cables (again, multiple lines are contained within each cable) between instruments and connected in a daisy-chain loop. HP-MSIB is built into the HP 70001A mainframe along the bottom of the rear panel, so if an instrument contains only a few modules and a small display (or none at all) all within a single mainframe, no external HP-MSIB cables are required.

OPERATION AT A DISTANCE

HP–MSIB IS THE KEY



- BETTER SENSITIVITY
- IMPROVED ENVIRONMENTAL CONDITIONS
- INCREASED OPERATOR CONVENIENCE
- LENGTHS GREATER THAN 500 METERS

There are many times that you may want the spectrum analyzer in one place and the display (and controls) in another. For example, there may be a long distance between an antenna and a shelter where power (and warmth) are available. Running a long coax cable to the shack can result in a lot of cable loss and therefore a loss of sensitivity. If the spectrum analyzer is located at the antenna, a short coax cable can be used, so there is no loss of sensitivity. Of course, a long HP-MSIB cable is required from the spectrum analyzer mainframe to the display, but since the signals are digital, only measurement speed is slightly degraded. HP-MSIB cable lengths greater than 500 meters are available, but note that two cables, each with lengths of 500 meters would be required in this case to close the daisy-chain loop. In addition, mainframes can be used as repeaters every 500 meters. However, two mainframes would have to be used at each repeater site because of the necessity for daisy-chain connections.

SOLUTION: 1. When the HP-MSIB cables are removed or not securely connected, an I/O light indicator will illuminate on the mainframe or display where the broken connection is present. For example, if you remove the cable as indicated in this lab, the "I/O" light on the Display and the "I/O Check" light on the mainframe will illuminate. 2. Turn back three slides to see the location of the fuses and composite video. A spare fuse is also located in the fuse compartment on both the mainframe and the Display. (Note that the line voltage switch (115/230V) is located on the back of the Display and on the bottom of the mainframe.) The composite video output, when connected to an appropriate video monitor (24 kHz horizontal sweep frequency and 25 MHz bandwidth), can display whatever is shown on the CRT of the Display. The output can also be recorded on a VCR.

REVIEW EXERCISE #2

OBJECTIVE:
TO BECOME FAMILIAR WITH THE HP–MSIB CONNECTIONS AND OVERALL REAR–PANEL LAYOUT.

TASKS:

1. OBSERVE HP–MSIB CABLE CONNECTIONS. WITH THE POWER OFF, DISCONNECT THE HP–MSIB CABLE BETWEEN "OUT" (MAINFRAME) AND "IN" (DISPLAY). TURN POWER ON. OBSERVE INDICATOR LIGHTS. TURN POWER OFF. RECONNECT CABLE. TURN POWER ON. OBSERVE NORMAL OPERATION.
2. FIND LOCATION OF FUSES (DON'T REMOVE) AND COMPOSITE VIDEO OUTPUT.

Now that we've discussed HP-MSIB cabling, let's move on to addressing. In this section, we'll define some new terms that relate to addressing, show how the flow of communication between modules takes place, explain how the **address map** works, and show how to set the address switches properly.

70000 CONFIGURATION
(ADDRESSING)

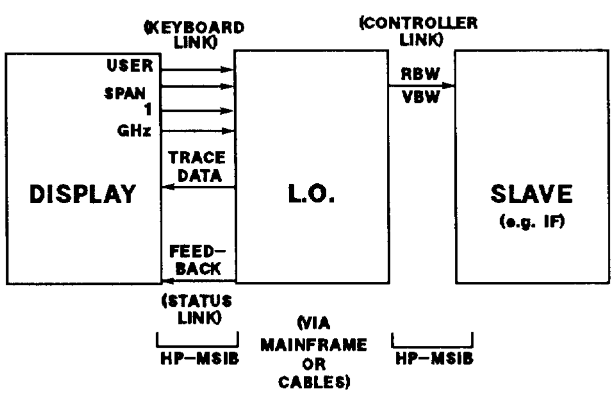
- 70000 SYSTEM TERMINOLOGY
- DATA CONTROL FLOW DIAGRAM
- HP–MSIB ADDRESS MAP
- ADDRESS SWITCH SETTINGS

70000 SYSTEM TERMINOLOGY

ELEMENTS:
- **MASTER (e.g., LO module)**
- **SLAVE (e.g., front end, IF, T.G. modules)**
- **INDEPENDENT ELEMENT (e.g., displays)**

An **element** is any device that communicates over the HP-MSIB (e.g., LO, front-end, and IF modules). In contrast, the HP 70001A Mainframe controls all HP-MSIB communication, but does not communicate over the HP-MSIB and therefore is not an element. A **master** is an element that controls other elements. The HP 70900A LO module is a master. The HP 70700A digitizer module can be a master, but it can only be a master over another digitizer module. A **slave** is an element that is controlled by another element. The IF modules, the front-end modules, the tracking generator module, etc., are slaves of the LO module. An **independent element** is an element that is neither a master nor a slave (e.g., HP 70206A Display).

DATA CONTROL FLOW DIAGRAM



Before we begin our discussion of addressing, let's see how HP-MSIB communication takes place between master and slave elements. This data control flow diagram shows the HP 70900A LO Module (i.e., a master), the HP 70206A Display (i.e., an independent element), and the HP 70902A IF Module (i.e., a slave). Remember that HP-MSIB communication can either take place through the built-in HP-MSIB bus in the mainframe or externally via the HP-MSIB cables (daisy-chain loop). If a SPAN of 1 GHz is entered from the Display keyboard, that communication travels from the Display to the LO Module over the keyboard link (part of HP-MSIB). A new sweep range is computed and the LO sweep is set. If a new RBW is entered or is changed automatically due to coupling to the Span control, the controller link between the LO and IF modules serves as the communication path. Trace data and CRT annotation are updated on the display via the graphics link between the LO and Display.

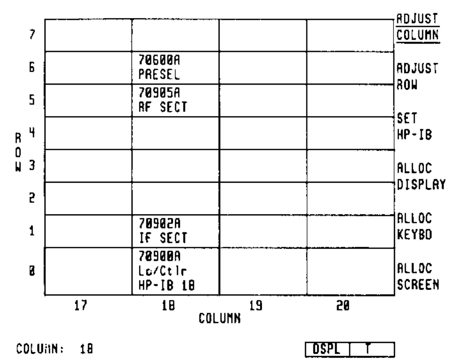
We've just seen the HP-MSIB links where the communication between modules takes place. But with all that traffic on the bus, how do all the commands find their way to the correct modules? The answer is with HP-MSIB addressing. With a modular system, dozens of combinations of module configurations can be chosen, and addressing is one way to keep track of them all. An address map, or matrix, defines the relationship between modules. That is, which module is a master, and which one is a slave? Once determined, a master will communicate with its slaves and no others. Access to HP-IB and error reporting are also based on the address map.

HP–MSIB ADDRESSING

- **DEFINES RELATIONSHIP BETWEEN MODULE ELEMENTS (MASTER, SLAVE, ETC.)**
- **NECESSARY FOR COMMUNICATION BETWEEN A MASTER (e.g. L.O.) AND ITS SLAVE ELEMENTS**

The address map displays the HP-MSIB addresses of all system elements in a row and column format. (The columns also represent default HP-IB addresses). A master may be configured on any row/column address; however, it should be in row 0 for its HP-IB capability to be used. Slave elements are placed on the same column address (or at higher column addresses) and at higher row addresses than their master. The master shown here is the LO Module. The IF, RF, and Preselector modules are the slaves. The empty row addresses between the IF and RF sections have no effect on the addressing. The RF and Preselector modules could have been placed on Row 2 and 3, respectively, and worked just as well.

HP–MSIB ADDRESS MAP

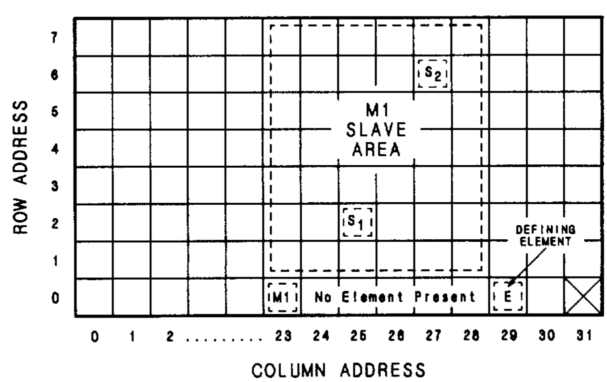


ACCESSING THE ADDRESS MAP

1. PRESS DISPLAY HARDKEY.
2. PRESS address map SOFTKEY.
3. PRESS ADJUST COLUMN SOFTKEY.
4. ROTATE KNOB TO LOCATE DESIRED MODULES.

The **address map** function is found under the DISPLAY hardkey. Since only four columns can be shown at one time, the **ADJUST COLUMN** softkey and knob can be used to scroll over to the column containing the elements. The **ADJUST ROW** softkey can be used to move the cursor (box) to each element. Note the "ACT" (active) light illuminate on each module front panel as the cursor (box) is moved to each of them.

MASTER/SLAVE ADDRESS MATRIX



Masters are located in row 0 because these are the only locations where error reporting and access to HP-IB are allowed. Note the slave area defined by M1 in column 23. It goes all the way to the top row and over to the right to the column where the next defining element (i.e., Display or another master) is located (i.e., column 29 in this example). S1 and S2 are slaves. They can be located anywhere in the slave area. Row 0, column 31 is not a legal address. Finally, in theory, up to 29 spectrum analyzers (each LO in Row 0) and 1 Display (Row 0) could be connected to the same HP-MSIB.

With over a dozen modules available, does it matter how they're arranged in the address map? Yes, the LO requires a very specific order to the placement of the modules in the address map. The order is shown here from lowest row to highest row. The LO should be in Row 0. As we saw earlier, blank address map locations between modules are ignored, but the order given here must be adhered to. Most systems have eight or less modules, so they can all fit in a single column. (If there are more than eight, see the next slide.)

ADDRESSING ORDER REQUIREMENTS

HIGHEST ROW

70300A TRACKING GENERATOR
70310A PRECISION FREQUENCY REFERENCE
70620A PREAMPLIFIER
70600A PRESELECTOR
70904A/5A/5B/6A/8A RF SECTION
70907A EMIM(S)
70903A IF SECTION
70700A DIGITIZER
70902A IF SECTION
70900A LOCAL OSCILLATOR (ROW 0)

When there are more than 7 slaves in a system, a second address map column must be started. The master element searches the address map by beginning at the lowest row address in its own column, then moves up the row addresses to the top of the address map. Then, it moves to the lowest row address in the next highest column, and again moves up the row addresses to the top of the column. Therefore, in this example, the RF module should be placed in Row 1 (or higher) of the next column, followed by the Preselector, etc. This is consistent with the order given in the previous slide.

ADDRESS MAP EXAMPLE

(MORE THAN 7 SLAVES)

ROW	17	18	19	20
7				
6		70907A EMIM		
5		70907A EMIM		
4		70907A EMIM	70300A RFTrckG	
3		70903A IF SECT	70310A P.F.A.	
2		70700A DIGITIZER	70600A PRESEL	
1		70902A IF SECT	70905A RF SECT	
0		70900A Lo/Ctlr HP-IB 19		
		COLUMN		

REVIEW EXERCISE #3

OBJECTIVE: TO BECOME FAMILIAR WITH THE ADDRESS MAP

TASKS:

1. **LOCATE ADDRESS MAP.**
2. **VERIFY CORRECT PLACEMENT OF MODULES IN ADDRESS MAP.**
3. **MOVE HIGHLIGHTED BOX IN THE ADDRESS MAP TO EACH ELEMENT AND OBSERVE "ACTIVE" LIGHT ON EACH FRONT PANEL.**

SOLUTION: The address map is located under the DISPLAY hardkey. The LO module should be at Row 0. The IF module should be at a higher row address than the LO module (Row 1 or higher). The RF module should be at a higher row address than the IF module(s) . Access **ADJUST COLUMN** and **ADJUST ROW** (under **address map**) to move the highlighted box to each module in the address map. Watch the "ACT" light illuminate on each module front panel.

ADDRESS SWITCHES DETERMINE LOCATION IN ADDRESS MAP

	ROW	COLUMN
BINARY	010	11000
DECIMAL	2	24

Up to this point we've talked about the correct locations of the modules in the address map. But how did they get there in the first place? The row and column addresses are set by 8-bit switches on each module or display. The switches represent binary numbers which can be converted to decimal numbers. For example, a Row switch setting of binary 010 is the same as a decimal 2. Therefore, a module with this switch setting would be found in Row 2 of the address map. Likewise, a module with an address map column address of 24 would have its binary switches set to 11000.

The address switches for all the modules and the displays are all binary and set in exactly the same way. For your reference, though, we've grouped the modules into three categories because the location of the switches on each one is slightly different, and the area surrounding the switches is also different.

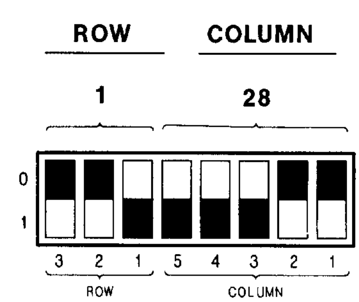
3 SWITCH CONFIGURATIONS

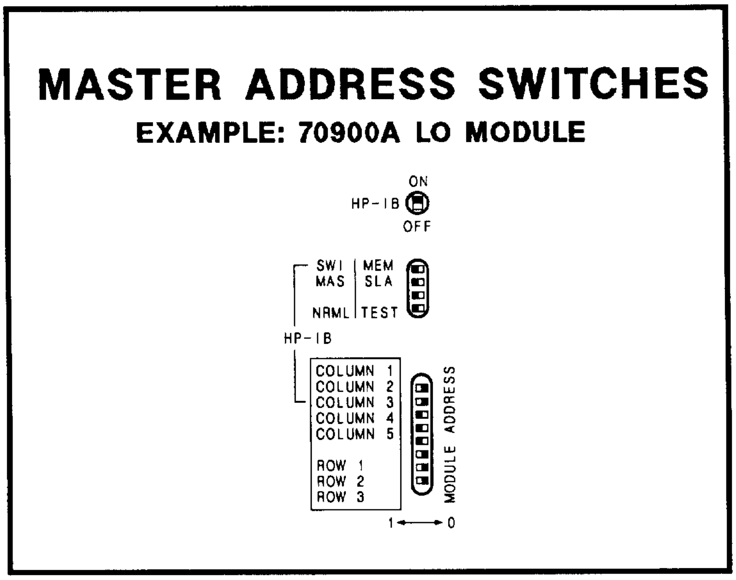
- **SLAVE ADDRESS SWITCHES**
- **MASTER ADDRESS SWITCHES (e.g. LO MODULE)**
- **DISPLAY ADDRESS SWITCHES**

Here's an example of what an address switch looks like on the side panel of an IF module, RF module, Preselector module, and several other slave modules. The three left-most switches determine the row where that module will be placed in the address map. The five right-most switches determine the column address. In each case, the most significant bit is on the left. In this example, the three left-most bits represent a binary 001 which is a decimal 1 -- the row number. The five right-most bits represent a binary 11100 which is a decimal 28 -- the column number.

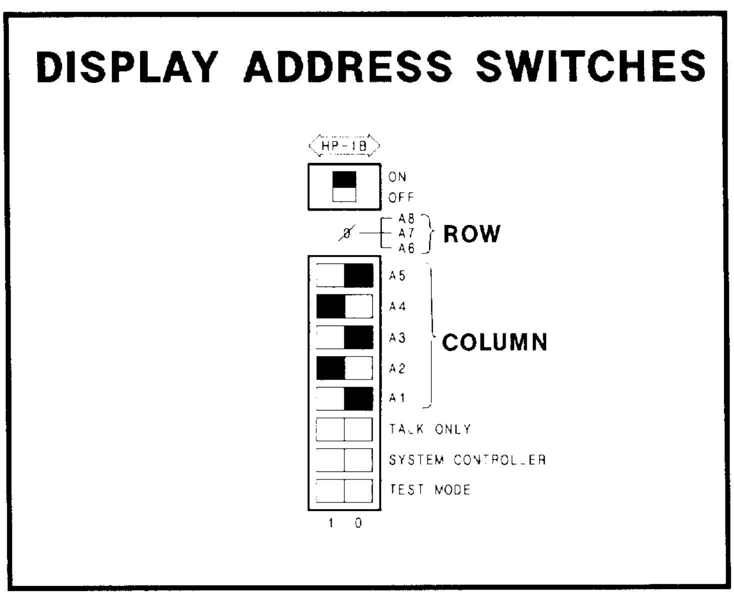
SLAVE ADDRESS SWITCHES

HP–MSIB ADDRESS MAP LOCATION





This is what the address switches on the top of the LO module look like. This illustrates the difference between a master module and a slave module. (However, future master modules will not necessarily look the same. In fact, the Digitizer module can be a master, but it does not have a Master/Slave switch like the LO module, so it must be located in row 0 of the address map.) Note that the address switches are just like those of the slaves. Row 3 and Column 5 switches are the most significant bits as before. There are additional switches such as HP-IB ON/OFF (normally ON; when OFF, the only communication is HP-MSIB), SW1/MEM (normally set to MEM which means the HP-IB address is stored in the LO memory and set from the front-panel; SW1 means the HP-IB is identical to the column switch settings), MAS/SLA (master or slave: normally master), NRML/TEST (normally NRML; TEST used for hard reset and used during production testing).



Finally, here is the switch configuration for the displays for the HP 70000. Note that there are no row switches, since displays are always at row 0. This is set internally. (Note A8, A7, and A6 are all at 0.) As for the column address, the A5 switch is the most significant bit. The column address shown here is 10. Note the other switches such as HP-IB ON/OFF, TALK ONLY (1 is ON and means the display can talk on HP-IB without requiring a reply, since some plotters cannot reply; set to 0 (OFF) normally), SYSTEM CONTROLLER (1 is ON and means the display can function as a system controller on HP-IB; set to 0 (OFF) normally), TEST MODE (1 is ON and means the display goes into a test mode on power-up; set to 0 (OFF) normally).

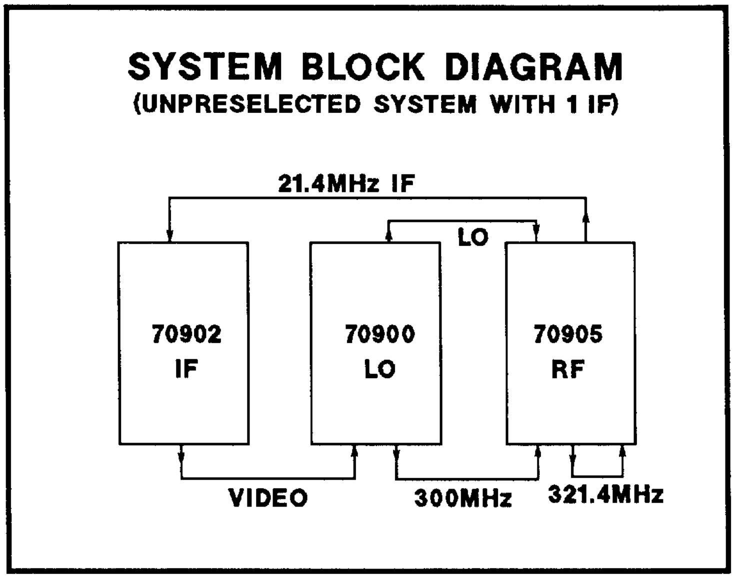
SOLUTION: Here are the correct switch settings: A5 (0), A4 (0), A3 (0), A2 (1), A1 (0).

REVIEW EXERCISE #4

OBJECTIVE: TO BECOME FAMILIAR WITH SETTING HP–MSIB ADDRESS SWITCHES.

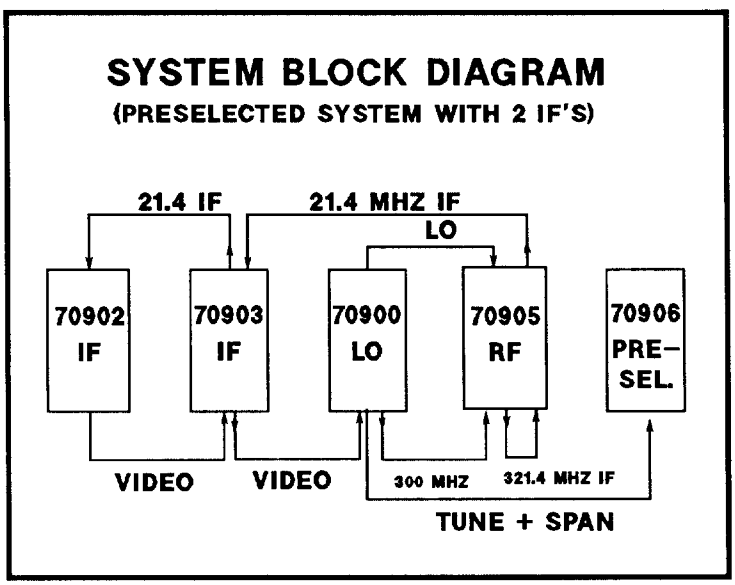
TASKS:

1. **ACCESS THE ADDRESS MAP.**
2. **TURN OFF THE 70000. SET THE HP–MSIB ADDRESS OF THE DISPLAY TO COLUMN 2.**
3. **TURN ON THE 70000. VERIFY THE CHANGE OCCURRED ON THE ADDRESS MAP.**



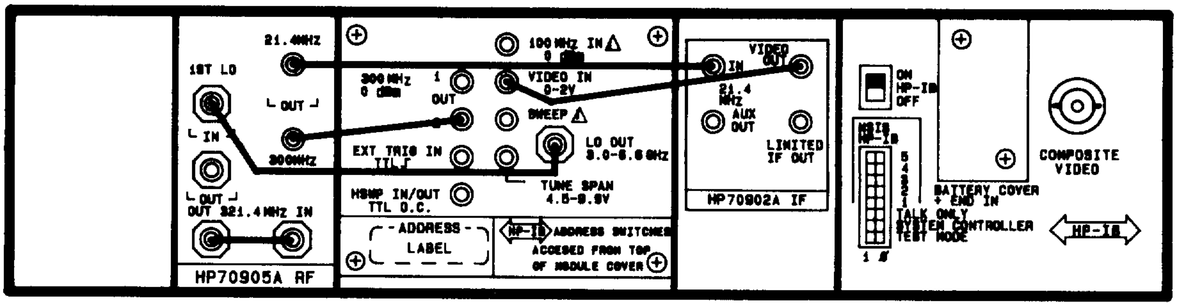
Rear Panel Connections

This is the system block diagram of the HP 71200A Microwave Spectrum Analyzer System. The rear-panel connections are shown here with the arrows indicating "out" and "in". Recall the module block diagrams we described earlier. They will help you to better understand the connections given here. The LO supplies the 3 - 6.6 GHz LO and 300 MHz reference signals to the RF section. The RF section converts the incoming signal to be measured to a 21.4 MHz IF which is transferred to the IF section which in turn produces a detected video output which then goes to the LO module where the signal is digitized. The LO module processes this information and transmits it to the Display over HP-MSIB.



This is the system block diagram for the HP 71201A Microwave System (with an option which adds the HP 70903A IF module). Note the daisy-chaining of the IF and video signals between the IF modules. Make sure the 21.4 MHz IF is input to the HP 70903A first, and then into the HP 70902A. (If this is reversed, there will be a 10 dB loss in signal level due to using the AUX 21.4 MHz output on the HP 70902A.) Note that the Tune + Span connection is the only one required on the rear-panel of the preselector. In terms of the front-panel, remember to connect the rigid coax connector between the Preselector RF output and the RF input on the RF module.

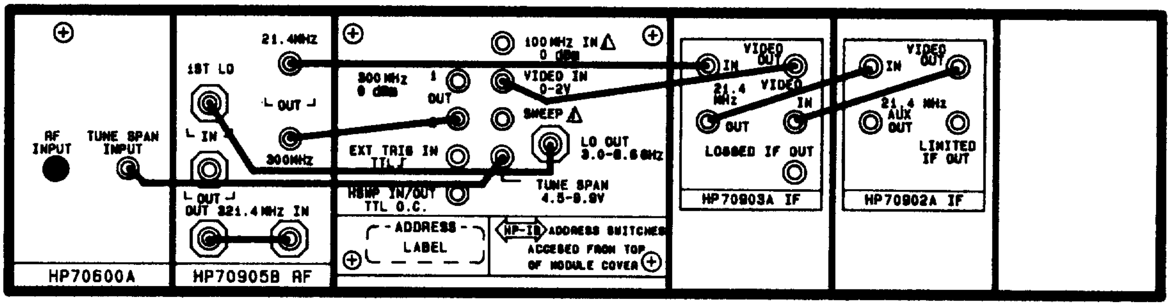
REAR PANEL CONNECTIONS
(UNPRESELECTED SYSTEM WITH 1 IF)



This diagram illustrates the proper rear-panel connections for the unpreselected system given on the previous page. (See the Installation and Verification manuals for a complete set of diagrams.) The HP 70205A modular display is shown here. You have a great deal of flexibility in the actual placement of the modules in the mainframe. You're only limited by the lengths of the rear-panel cables . (Most of the cables are flexible coax, except for the LO connection, which is semi-rigid coax .)

REAR PANEL CONNECTIONS

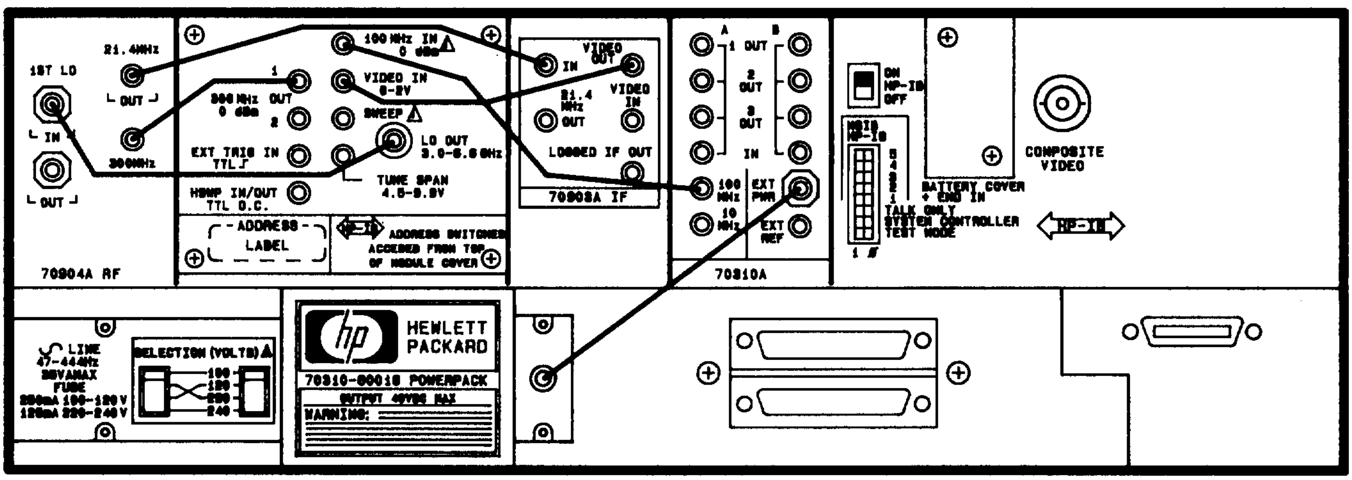
(PRESELECTED SYSTEM WITH 2 IF'S)



Here are the actual rear-panel connections for the preselected system on page 5-13 (HP 71201A with optional wideband IF). If you have the HP 71210A system (which has the HP 70908A preselected front-end module), the connections are nearly identical to those shown here. However, since the preselector is built into the HP 70908A RF module, there is no need for the HP 70600A . Therefore, for the HP 71210A system, the Tune + Span input connection is made on the rear-panel of the HP 70908A module.

REAR PANEL CONNECTIONS

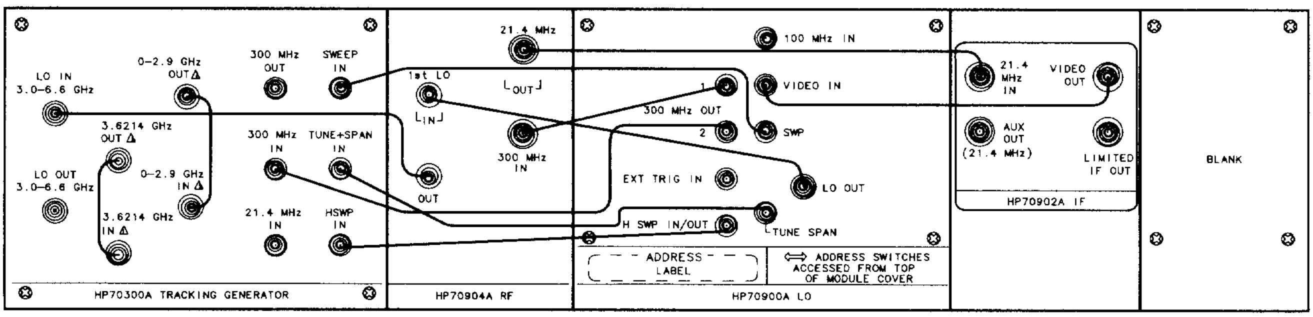
(RF SYSTEM WITH PRECISION FREQUENCY REF.)



Here are the rear-panel connections for an RF spectrum analyzer that includes the HP 70310A Precision Frequency Reference module. Note the 100 MHz reference signal path between the Precision Frequency Reference module and the LO module. Also note the external power from the rear-panel Powerpack to the Precision Frequency Reference module. The Powerpack is not mandatory, but it is recommended to keep the ovenized oscillator warm while the mainframe is turned off. This permits the system to meet its frequency accuracy specifications much more quickly. (The Powerpack has its own power cord.) Finally, note the optional distribution amplifier inputs and outputs for amplifying the 10, 100, or 300 MHz reference signals.

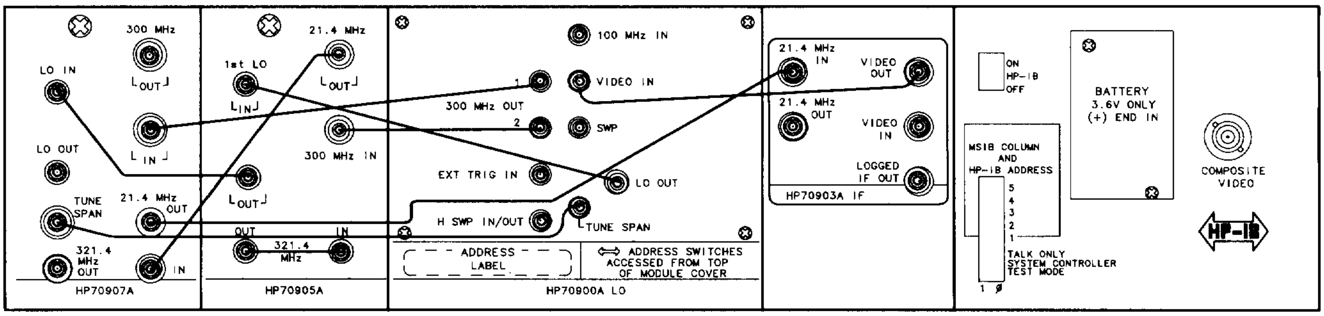
REAR PANEL CONNECTIONS

(TRACKING GENERATOR SYSTEM)



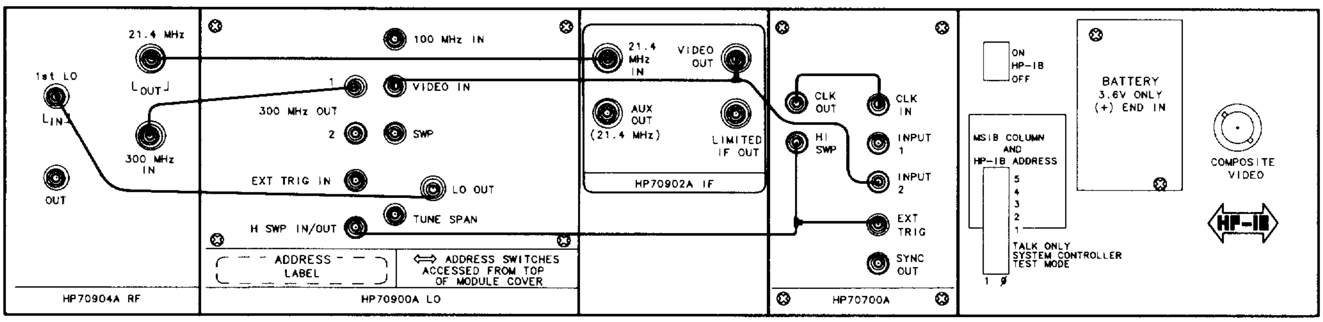
The rear-panel connections for the modular RF spectrum analyzer\tracking generator system are shown here for your reference. The HP 70300A RF tracking generator module is shown.

REAR PANEL CONNECTIONS
(EXTERNAL MIXING SYSTEM)



The rear-panel connections for a spectrum analyzer system comprised of two front-ends is shown here. One front-end is the HP 70907A EMIM (External Mixer Interface Module), and the other is the HP 70905 microwave front-end. The EMIM is used with external mixers (such as the HP 11970 series) to measure millimeter-wave signals. The HP 70905 front-end is used to measure signals up to 22 GHz in coax.

REAR PANEL CONNECTIONS
(SPECTRUM ANALYZER WITH SLAVE DIGITIZER)



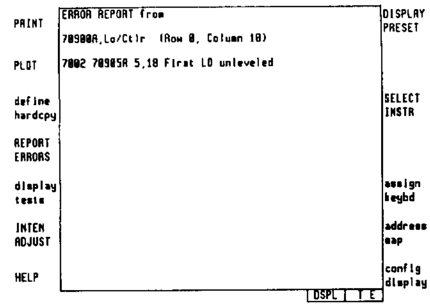
The rear-panel connections for a modular spectrum analyzer and slave digitizer are shown here. The digitizer is the HP 70700A module. In the slave mode, the digitizer is used as the spectrum analyzer's ADC to provide sweeptimes faster than those provided by the analyzer's internal ADC. The digitizer in the slave mode is located between the two IF modules in the address map. (When the digitizer is used in the stand-alone mode, it is located in Row 0 of the address map. For a single-channel stand-alone digitizer, the only rear-panel connection is the CLK IN to the CLK OUT.)

Now that we've set the address switches properly, installed the modules in the mainframe, and connected the rear-panel cables, we can turn on the system and start making measurements. However, if we forgot to connect a cable or set a switch properly, it would be nice to know where the problem exists, and correct it immediately. Using the **REPORT ERRORS** function, this is made possible.

ERROR REPORTING HELPS LOCATE IMPROPER CONNECTIONS

1. PRESS THE DISPLAY HARDKEY

2. PRESS THE REPORT ERRORS SOFTKEY



Now that all of the connections have been made properly, there is just one thing left to do before making the measurement -- calibrate the spectrum analyzer. This can be done easily using the **CAL ALL** function found under the **Amptd** firmkey (under the MENU hardkey). The front-panel 300 MHz calibrator signal is used as the calibration source.

The **CAL ALL** routine generates a set of correction factors that are applied to the amplitude and frequency values of the spectrum analyzer. Until the routine is completed, the "UNCOR" annotation will appear on the CRT (see the accompanying plot). "UNCOR" (short for "UNCORRECTED") lets you know that the system is not presently using the error correction factors. When the routine is finished, the "UNCOR" annotation will disappear, and the correction factors will be applied. "UNCOR" also appears whenever the system configuration changes. For example, if you add another module or remove an existing module, "UNCOR" will appear, which signifies that the system correction factors are no longer valid. Simply run **CAL ALL** again to calibrate the system.

(Another CRT annotation message, "UNCAL" (UNCALIBRATED), often appears during normal operation. It should not be confused with "UNCOR". "UNCAL" means that the analyzer sweep speed is too fast for the resolution bandwidth and video bandwidth settings, resulting in amplitude readings that are uncalibrated.)

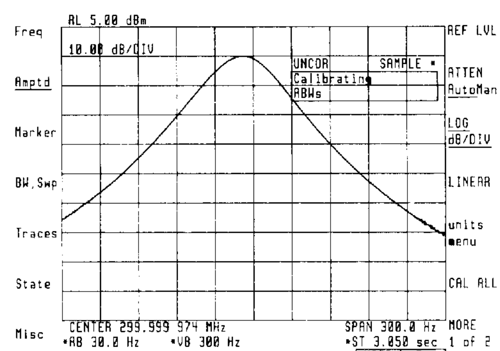
CALIBRATION

1. CONNECT CAL SIGNAL TO RF INPUT.

2. PRESS MENU HARDKEY.

3. PRESS Amptd FIRMKEY.

4. PRESS CAL ALL SOFTKEY.



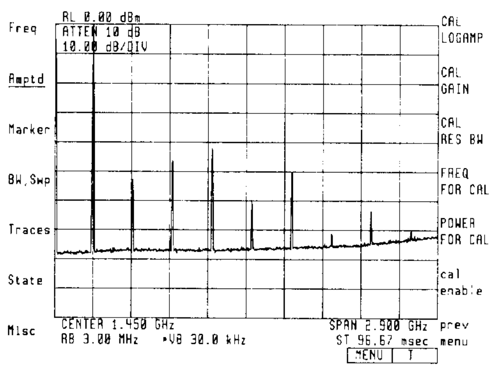
71200A AMPLITUDE ACCURACY

RELATIVE AMPLITUDE	UNCERTAINTY (±dB)
1. LOG FIDELITY	.5
2. IF GAIN CHANGES	.3
3. RBW CHANGES	.1
4. RF ATTENUATOR CHANGES	.2
5. SCALE CHANGES	.03
6. FREQUENCY RESPONSE	2.5
ABSOLUTE AMPLITUDE	
1. CALIBRATOR	.3

After running the calibration routine, the "UNCOR" annotation on the CRT goes away. If new modules are added or if modules are removed, the "UNCOR" indicator will appear again, and calibration is once again necessary. The accuracy after calibration is shown here. Note the excellent log fidelity. Even though the six uncertainty items are listed under "Relative" accuracy, they may also apply to "Absolute" accuracy, depending on how the measurement is made. In addition, many of these factors are eliminated from relative uncertainty if the relative measurement of 2 signals is done without changing RBW, attenuation, scale, etc. Likewise, some factors are eliminated from absolute accuracy if the analyzer is calibrated with the same settings as those used when the signals are measured.

FREQ & POWER FOR CAL

MINIMIZE FREQ RESPONSE ERRORS



1. PRESS THE Amptd FIRMKEY.
2. PRESS THE MORE & cal menu SOFTKEYS.

Frequency response errors within the analyzer can be minimized if the analyzer is calibrated at the frequency at which the measurement will be made. For example, if you're measuring a 10 GHz signal, it is best to calibrate the analyzer at 10 GHz (rather than 300 MHz using the front-panel calibrator signal). Of course, a well-characterized 10 GHz signal must be available. Its amplitude must be accurately measured with a power meter, and its frequency must be accurately known. Given that these conditions are met, the analyzer frequency response errors can be minimized using the **FREQ FOR CAL** and **POWER FOR CAL** functions. When **CAL ALL** is run, the same analyzer calibration routines will be done as before, except that they will be performed using the 10 GHz calibration signal (rather that the 300 MHz calibrator).

Other **cal menu** functions shown here are **CAL LOGAMP**, **CAL GAIN**, and **CAL RES BW**. They are subsets of **CAL ALL** and can be run individually. The **cal enable** softkey accesses keys that allow you to turn the individual calibration correction factors on or off. They should always be kept on, except for service diagnostic purposes (trying to pinpoint a hardware failure). Another function, **CAL SRC INT/EXT**, is normally set to **EXT** for use with the 300 MHz calibrator or other calibrator signal (like the 10 GHz signal mentioned above). It is set to **INT** only when calibrating the HP 70907A EMIM (External Mixer Interface Module).

SOLUTION: 1.) Connect the calibrator signal output (on the LO module) to RF input on the front-end module. 2.) Press the **Amptd** firmkey and the **CAL ALL** softkey. 3.) Press the **Amptd** firmkey, **MORE** softkey, **cal menu** softkey, **cal enable** softkey, and **GAINCAL Off** softkey. The amplitude difference between **On** and **Off** is usually around 1 dB (sometimes a little more, sometimes a little less). The cal factors should always be turned **On** to obtain the best accuracy. They are turned **Off** only when diagnosing hardware failures.

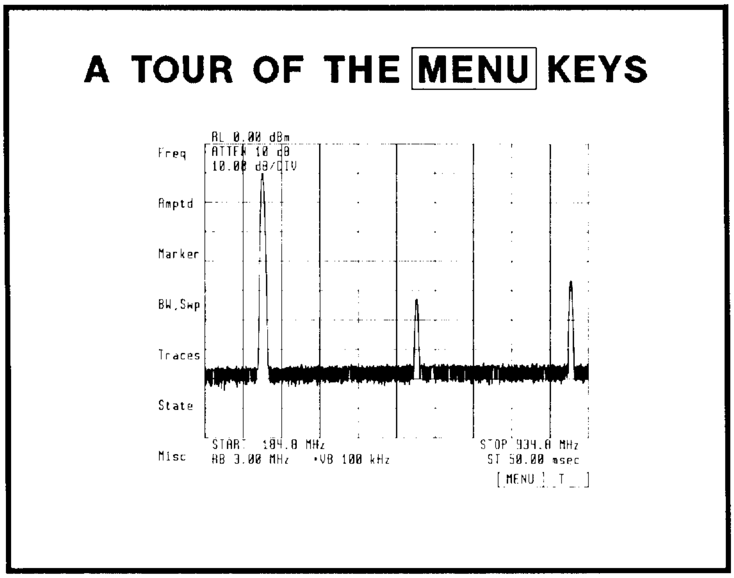
REVIEW EXERCISE #5

OBJECTIVE: TO CALIBRATE THE ANALYZER.

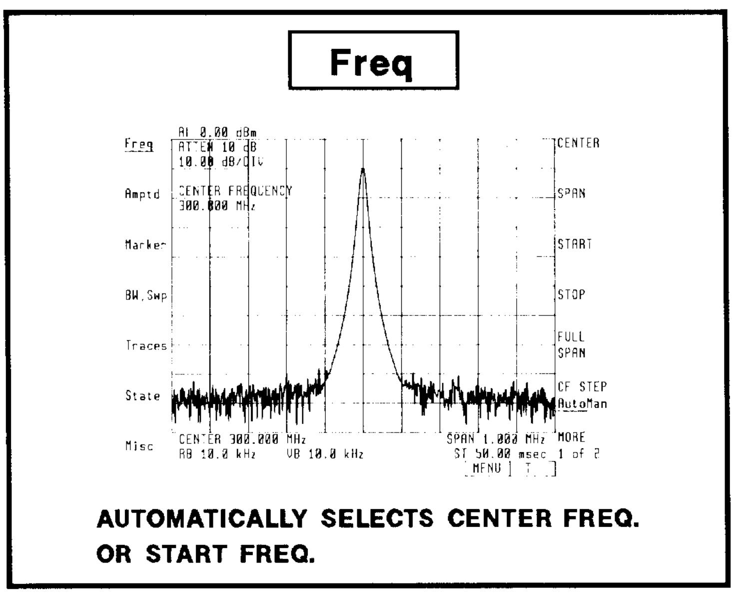
TASKS:

1. **CONNECT CAL SIGNAL TO RF INPUT.**
2. **RUN THE "CAL ALL" ROUTINE.**
3. **TUNE TO CAL SIGNAL.**
   NOTE AMPLITUDE DIFFERENCE
   BETWEEN GAINCAL ON AND OFF.

Top - Level MENU Keys



In an earlier section of this document we overviewed the structure and layout of the MENU hardkey functions. Recall that the seven keys along the left-hand side of the CRT are called firmkeys, and the seven keys along the right-hand side are called softkeys. (The softkeys are blanked in the accompanying plot. This occurs when the instrument is turned on, an **INSTRUMENT PRESET** is performed, or the **HOLD** key is pressed twice.) As each new firmkey is pressed, a new set of softkeys appears along the right-hand side of the CRT. In this section of the document, we'll thoroughly examine the top level softkeys for each of the seven firmkey categories. The top-level functions are typically the ones used most often. We'll start with the **Freq** softkey functions, followed by the **Amptd** softkey functions, and continue down the column of firmkeys until we've examined all of the top-level softkey functions.



The plot shows the softkeys accessed with the **Freq** firmkey. **CENTER** (i.e., CENTER FREQUENCY) and **SPAN** are two of the most frequently used spectrum analyzer functions. Their values can be changed either by entering a number from the numeric keypad, by turning the data entry knob, or by using the step keys (UP and DOWN arrow keys). The **START** and **STOP** (frequency) keys are often used in place of **CENTER** and **SPAN** if the frequency range endpoints are known. Any of the three aforementioned data entry methods can be used to enter values for **START** and **STOP**. When the **Freq** firmkey is pressed, **CENTER** is automatically chosen (and highlighted). However, if **START** was the last function chosen, it will be automatically chosen. (**INSTRUMENT PRESET** resets **CENTER** as the default choice.) **FULL SPAN** sets the start and stop frequencies of the analyzer to its widest range. This range varies depending on the front-end module being used. For example, the HP 71210A FULL SPAN range is 100 Hz to 22 GHz whereas the HP 71100A range is 100 Hz to 2.9 GHz. **FULL SPAN** does not reset the other instrument settings such as resolution bandwidth and attenuation. Recall that **INSTRUMENT PRESET** does change these settings. **CF STEP** sets the center frequency step size for use with the step keys (up/down arrow keys). The **Auto** setting is 10% of the span size.

A unique fast knob mode operation called panning is available on the HP 70000 spectrum analyzers. Panning applies to the following selected controls: **CENTER**, **SPAN**, **START**, and **STOP** frequency. To visualize how panning works, recall what happens on most spectrum analyzers when the sweeptime is extremely long (slow sweeps). When you use the knob to change the center frequency, the analyzer trace does not move to the new location until the current sweep has completed, resulting in a long delay before any feedback is sensed. Panning allows an immediate feedback to occur. For example, now when the knob is used to change center frequency, the current trace information is immediately moved to the new location on the CRT. Then, when the knob is released, the trace is completely updated.

FREQUENCY PANNING

FAST KNOB MODE OPERATION

- **CENTER FREQUENCY**
- **FREQUENCY SPAN**
- **START FREQUENCY**
- **STOP FREQUENCY**

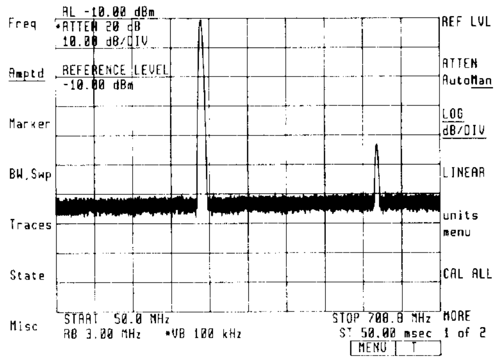
The last function in each column of top-level softkeys is the **MORE** key. It accesses additional softkey functions that are related to its firmkey category. They are very useful and important functions but tend to be used less often than the top-level functions. Therefore, the functions found under the **MORE** key will be covered in a separate section of this document. (See the "MORE" MENU KEY FUNCTIONS" section.)

THE "MORE" SOFTKEY

ACCESSES ADDITIONAL FUNCTIONS

- **NOT COVERED IN THIS SECTION**
- **SEE THE "MORE" MENU KEYS SECTION**

Amptd



AUTOMATICALLY SELECTS REF. LEVEL

The **Amptd** firmkey contains the functions shown here. **REF LVL** refers to the reference level, or top graticule line on the CRT. It is used to accurately measure the amplitude of a signal. The keypad, knob, or step keys can be used to enter a reference level value. When the **Amptd** firmkey is pressed, **REF LVL** is automatically chosen. **LOG dB/DIV** refers to the scale of the vertical log axis. Values ranging from .01 dB/DIV to 20 dB/DIV can be entered. **LINEAR** amplitude display is useful for evaluating demodulated waveforms in zero span. (Zero span is fixed-tuned operation in the time-domain, similar to an oscilloscope. Simply set SPAN to 0 Hz.) For example, a percent AM measurement of a sinusoidal modulating waveform is performed using **LINEAR** mode. **CAL ALL** was described in an earlier section of this document. It is used to calibrate the spectrum analyzer's resolution bandwidths, log amplifiers, gains, etc., to provide the most accurate measurements.

COUPLED FUNCTIONS

EXAMPLE: RF ATTENUATOR

- **COUPLED TO REFERENCE LEVEL**
- **"AUTO/MAN" TOGGLE**
- **"*" NEXT TO ANNOTATION DENOTES UNCOUPLED (MANUAL) OPERATION**

The **ATTEN** softkey controls the RF attenuator setting of the spectrum analyzer (0 to 70 dB range). The attenuator is necessary to control the level present at the first mixer, since the mixer is vulnerable to burnout, compression, and distortion. The attenuator is coupled to the reference level when the **ATTEN key** is in the **Auto** mode. That is, as the reference level is changed, the attenuator will also change to maintain some specified level at the first mixer. (See the **Amptd MORE** key section for more details.) If the **ATTEN** is in the **Man** mode, it is no longer coupled to the reference level, and an "*" appears next to the ATTEN annotation in the upper left-hand corner of the CRT to remind you of this condition. Pressing the **ATTEN** key toggles the attenuator between **Auto** and **Man**. The other coupled fuctions such as resolution bandwidth, video bandwidth, sweeptime, etc., operate in a similar fashion.

The **units menu** softkey (found under the **Amptd** firmkey) is a measurement category (note the lowercase letters) that accesses another set of softkey labels. The function of **units menu** is to convert the current amplitude units to another set of units. The reference level and markers are affected by this mathematical conversion. For example, if the reference level is set to 0 dBm, pressing **dBuV** automatically calculates the reference level to be 106.99 dBuV. The **A UNITS Auto/Man** softkey stands for "amplitude units - automatic or manual". Whenever you deliberately change from one set of units to another, the **Man** key is underlined. In the **Auto** mode, the analyzer selects the proper units for various control settings. For example, when you change to linear display mode, the units change automatically from dBm to mV. In most other cases, however, dBm is the default mode.

units menu • Amptd

MAKES CONVERSIONS AUTOMATICALLY

- dBm
- VOLTS
- dBmV
- WATTS
- dBuV

AFFECTS REF. LEVEL & MARKERS

SOLUTION: 1.) Press **Freq** firmkey (**CENTER** is chosen.) Use knob to center CAL signal. Press **SPAN**. Use knob to set span to 1 MHz. Recenter signal using **CENTER** and knob. 2.) Enter **CENTER** frequency of 300 MHz. Set **CF STEP** to 300 MHz. Press **CENTER** followed by the UP arrow to see the second harmonic, the UP arrow again for the third harmonic, etc. 3.) Press **Amptd** and enter **ATTEN** 20 dB. Note asterisk in upper left corner next to ATTEN annotation. Press **ATTEN** to recouple the attenuator (AUTO setting).

REVIEW EXERCISE #6

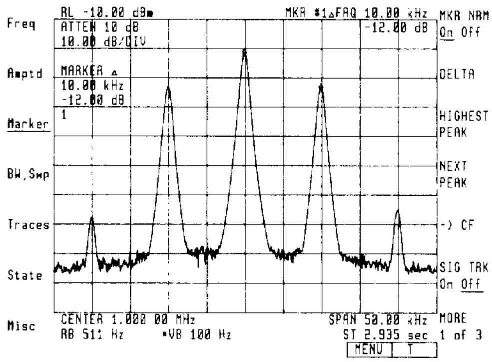
OBJECTIVE:

TO BECOME FAMILIAR WITH THE Freq AND Amptd FUNCTIONS.

TASKS:

1. USE CENTER FREQ AND SPAN PANNING TO TUNE TO THE CAL SIGNAL IN A 1 MHZ SPAN.
2. USE THE CF STEP FUNCTION TO STEP TO EACH OF THE CAL SIGNAL HARMONICS.
3. SET THE RF ATTEN TO 20 dB. NOTE THE "*". THEN, RECOUPLE THE ATTEN.

Marker



AUTOMATICALLY FINDS HIGHEST PEAK

The **Marker** key unveils a treasure of useful marker functions. **MKR NRM** (marker normal) places a marker on the trace point at the center of the display. Then, the knob, step keys, or data entry keys can be used to move the marker to a desired location. Marker **DELTA** is used to measure the relative amplitude and frequency difference between two signals. **HIGHEST PEAK** places a marker on the signal with the largest amplitude being displayed on screen. **NEXT PEAK** places a marker on the next highest signal. Pressing the **Marker** firmkey automatically turns the marker on (**MKR NRM On**) and performs a **HIGHEST PEAK**. (However, if the marker is already turned on, pressing the **Marker** firmkey will not automatically perform a **HIGHEST PEAK.**)

MARKER FUNCTIONS

⟹ CF

- **CENTERS THE SIGNAL IN CURRENT SPAN**

SIG TRK

- **CENTERS THE SIGNAL IN CURRENT SPAN AND NARROWER SPANS**

Two additional functions, **->** **CF** (marker into center frequency) and **SIG TRK** (signal track) are found in the top level of the **Marker** firmkey functions. If a marker is placed on a signal, the **->** **CF** function will move the signal to the center of the CRT in the current span. If the marker is placed on the signal in a wide span, the signal may not remain centered when the span is significantly narrowed, since frequency resolution is worse for wider spans. **SIG TRK** overcomes this objection by automatically retuning the center frequency to keep the signal centered even when the narrowest spans are selected. Therefore, to automatically zoom in on a signal in a narrow span, use **SIG TRK**. (Turn off **SIG TRK** after the routine is finished. Otherwise, any subsequent center frequency changes will be resisted by the **SIG TRK** function.)

SOLUTION: 1.) Press **Freq** firmkey. Set **START** frequency to 250 MHz and **STOP** frequency to 650 MHz. Press **Marker** firmkey (which performs a **HIGHEST PEAK** automatically). Press **DELTA** marker and **NEXT PEAK** to determine the amplitude difference between the 300 MHz signal and the 600 MHz signal. 2.) Turn **MKR NRM Off.** Press **HIGHEST PEAK, SIG TRK On, Freq** firmkey, and **SPAN** 1 MHz.

REVIEW EXERCISE #7

OBJECTIVE:

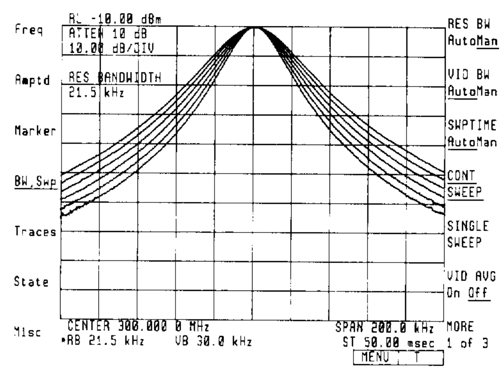
TO BECOME FAMILIAR WITH THE Marker FUNCTIONS.

TASKS:

1. **USE HIGHEST PEAK, NEXT PEAK, & DELTA MARKERS TO MEASURE THE AMPLITUDE DIFFERENCE BETWEEN THE CAL SIGNAL FUND. & 2ND HARMONIC.**
2. **USE SIG TRK TO ZOOM TO CAL SIGNAL IN A 1 MHZ SPAN.**

The **RES BW** control is found under the **BW,Swp** firmkey. **RES BW** is automatically selected when the **BW,Swp** firmkey is pressed. The HP 70000 spectrum analyzers have 3 dB resolution bandwidths adjustable in 10% increments, except between 3 kHz and 10 kHz, which is the crystal/LC crossover range. The plot shows several examples of resolution bandwidths in 10% increments. The resolution bandwidth range is from 10 Hz to 3 MHz if both IF modules are used. The HP 70902A has resolution bandwidths from 10 Hz to 300 kHz, and the HP 70903A has bandwidths from 100 kHz to 3 MHz. When **RES BW** is in **Auto**, it is coupled to the **SPAN**. The default RBW/SPAN ratio is .01. **VID BW** is coupled to **RES BW**. The default VBW/RBW ratio is 1. When **RES BW** or **VID BW** is in **Man** (manual), an asterisk appears next to the CRT annotation.

BW, Swp



- **AUTOMATICALLY SELECTS RES BW**
- **10% RES BW STEPS**

70000 SWEEP TIMES

STANDARD SYSTEM

- 50 msec TO 1000 sec (ANY SPAN)
- 187 usec TO 1000 sec (SMALL SPANS, 3 TRACE POINTS).

WITH DIGITIZER

- 15 msec TO 335 sec (NON-ZERO SPANS)
- 80 usec (ZERO SPAN)
- 300 nsec (ZERO SPAN, 3 TRACE POINTS)

The **BW,Swp** firmkey also accesses the **SWPTIME** (sweeptime) function. The normal range is 50 msec to 1000 sec. As we'll see in the **Traces** key discussion later, if the trace length is shortened to 3 points (instead of 800), the fastest sweeptime becomes 187 usec. (To remain calibrated, this assumes zero span is used.) With the HP 70700A Digitizer module as an accessory to the spectrum analyzer, 15 msec is the minimum sweeptime for swept mode, 80 usec for zero span, and 300 nsec with 3 trace points in zero span. The longest sweeptime becomes 335 sec with the Digitizer. Finally, **CONT SWEEP** allows continuous sweeps, whereas **SINGLE SWEEP** offers single sweep capability.

Remember that the "UNCAL" indicator on the CRT means that the analyzer is being swept too fast for the IF and video filters being used. Any amplitude readings will be uncalibrated. Set **SWPTIME** to **Auto** to regain calibrated measurements. (The "UNCOR" indicator means something entirely different. It means that the calibration routine, **CAL ALL**, has not been run. Once run, the error correction factors will be applied to the amplitude and frequency readings.)

VID AVG

• BW,Swp

VIDEO AVERAGING

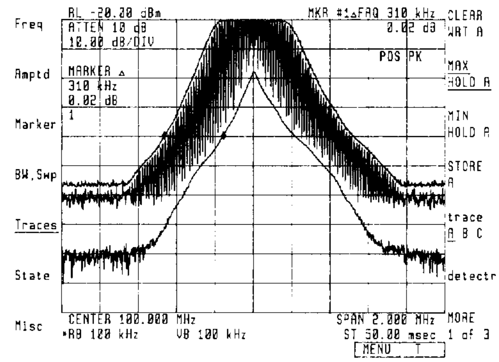
- SWEEP-TO-SWEEP DIGITAL TRACE AVERAGING
- WORKS ONLY FOR TRACE A
- 1 TO 10,000 AVERAGES (DEFAULT IS 100)
- DOES NOT AFFECT SWEEP TIME
- USES SAMPLE DETECTION
- SHOWS POWER DISTRIBUTION

VID AVG performs sweep-to-sweep video averaging on trace data **only** for Trace A. It digitally averages the trace data after each sweep. Unlike analog video filtering (i.e., using the **VID BW** key), digital video averaging does not slow down the sweeptime. **VID AVG** shows the power distribution of modulated signals (e.g., wideband FM). It should not be used for time-varying signals (e.g., drifting signals). **VID AVG** uses sample digital detection, which is described later under the **Traces** firmkey. **VID AVG** often takes about 100 averages to fully smooth out the noise. This often takes as long as video filtering which requires a longer sweeptime, but only 1 sweep is required. Both offer equivalent smoothing, but analog video filtering (**VID BW** key) offers a slight improvement in amplitude accuracy and often improves the probability of intercepting non-CW signals.

Note the **BW,Swp** annotation in the upper right-hand corner of the accompanying slide. It is intended to help you to remember which firmkey must first be pressed to access the **VID AVG** function. The remaining slides in this document use this same convention.

The **Traces** firmkey accesses **trace A,B,C** (trace A, trace B, and trace C). Each trace is an independent digital trace. Each time the **trace A,B,C** softkey is pressed, it "toggles" the **CLEAR WRT**, **MAX HOLD**, **MIN HOLD**, and **STORE** keys between trace **A**, **B**, and **C**. This mimimizes the number of key labels required to perform the same functions on each of the three traces. The plot shown here utilizes all three traces (trace A is the upper one, trace B is the lower one, and trace C is the "noisy" inner one.) It illustrates how FM deviation can be measured on an FM signal using **MAX HOLD A** (captures and holds the maximum peaks of the signal at each trace point), **MIN HOLD B** (captures and holds the minimum peaks of the signal at each trace point), and **CLEAR WRT C** (continually updates the trace with new data). Each trace can be stored independently using the **STORE** function.

Traces



- **3 TRACES (A,B,C)**
- **MAX & MIN HOLD**

Each trace has a default setting of 800 horizontal points. This is the maximum number of points that will fit on the display without overwriting the softkey labels. A length of 1024 can be shown if the display size is set to 1024 (Xmin = 0, Xmax = 1024 (see the Display hardkey section of this document) and the softkey labels are blanked (see the USER hardkey section).

Vertical resolution is approximately .03 dB. However, the displayed marker resolution depends on the log scale chosen (e.g., 10 dB/DIV, 1 dB/DIV, etc.).

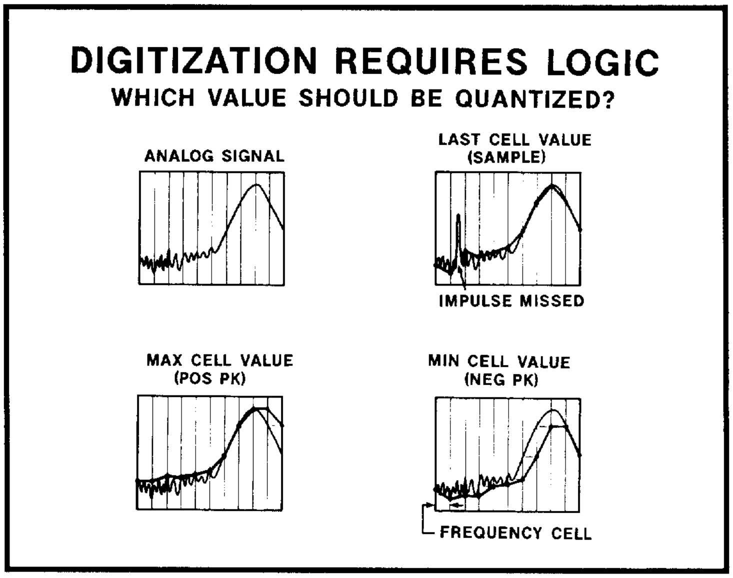
TRACE STRUCTURE

HORIZONTAL

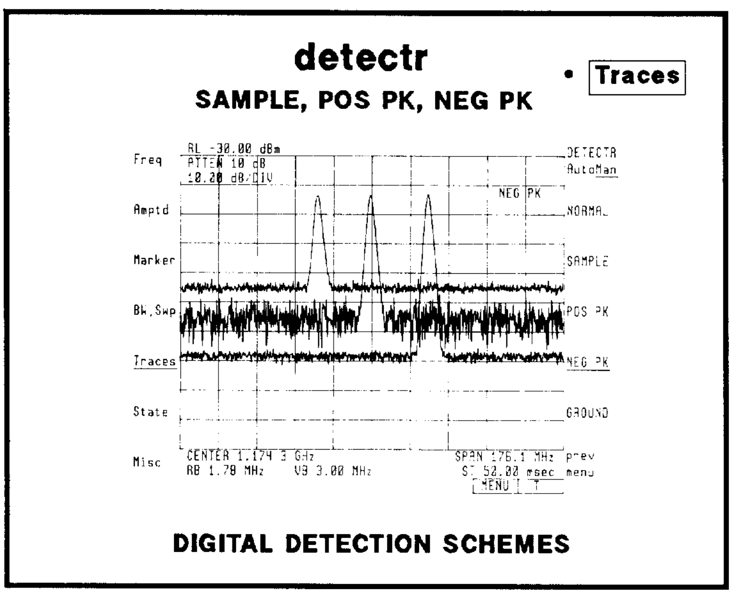
- **TRACE A,B,C EACH CONTAIN 800 TRACE POINTS (DEFAULT)**
- **TRACE LENGTHS FROM 3 TO 1024 ARE POSSIBLE.**
- **THE DISPLAY SHOWS 800 POINTS MAX.**

VERTICAL

- **0.03 dB RESOLUTION**



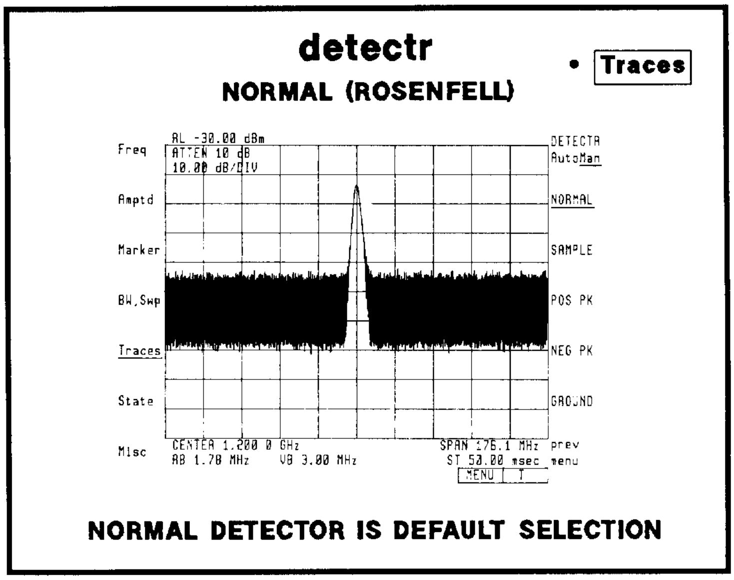
As we examined earlier, the analog detector in the IF module envelope detects IF signals and produces baseband video signals that are digitally processed by the LO module circuitry. Part of this digital circuitry includes four different digital detection schemes that cause the trace information in trace A, B, and C to be displayed in different ways. Normal, sample, positive peak, and negative peak are the four types of digital detection schemes. The proper choice of detection scheme is important to correctly display a signal or noise, as illustrated in the accompanying illustration. The analyzer is faced with the task of finding a single value during each sampling interval (cell) that provides a meaningful indication of the entire signal amplitude history for the cell. In the case where the resolution bandwidth is less than the cell width (top right), a situation that arises when very wide spans are used, the analyzer circuitry must not fail to account for signal responses that lie entirely within a single cell. Sample detection may miss the signal. Positive peak detection would display the signal correctly, but it would not display the noise correctly. Let's now take a closer look at these detection choices.



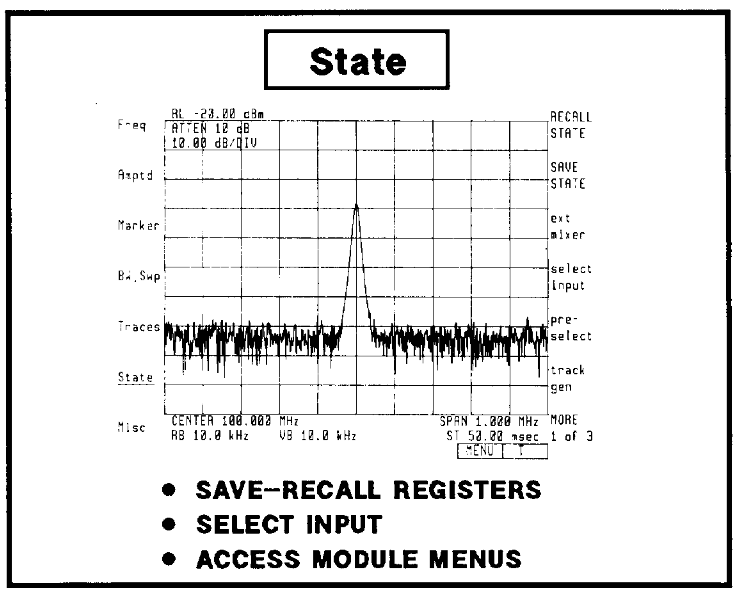
The **detectr** softkey accesses the four digital detection schemes mentioned in the previous slide. (The fifth scheme, **GROUND** detection is only used for service and diagnostic purposes. It connects the detector output to ground.) **POS PK** captures the highest peak in each display cell. (**MAX HOLD** utilizes **POS PK.**) **NEG PK** captures the lowest value in each cell. (**MIN HOLD** utilizes **NEG PK.**) **SAMPLE** displays the instantaneous value detected at the same point in each cell. (**MKNOISE** and **VID AVG** activate **SAMPLE** detection.) An example of each type is shown here. The top trace uses **POS PK**, the middle trace uses **SAMPLE**, and the lower trace uses **NEG PK** detection. (Although it may not be evident from this plot, **NEG PK** detection does not produce better signal-to-noise ratios for signals very close to the noise. The signal and noise are reduced by the same amount.)

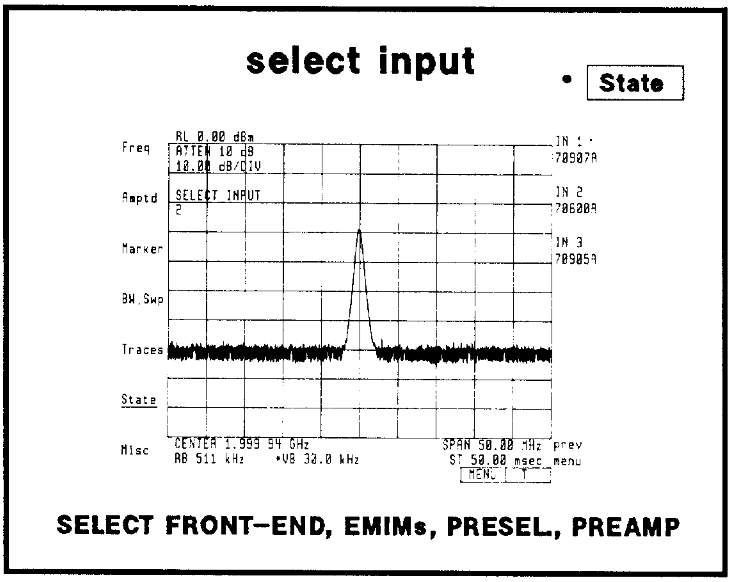
SAMPLE detection works well for analyzing noise, but it can miss narrow impulses. So, how do we get proper readings for both signals and noise using a single detection scheme?

The answer is **NORMAL** detection. It is often called ROSENFELL detection for reasons that we'll explain shortly. It processes the trace data on a horizontal point-by-point basis using positive peak detection in each odd-numbered cell and negative peak detection in each even-numbered cell. This alternating process is used only for detected noise (not for signals) to give it a normal appearance. The term, ROSENFELL, comes from the fact that the detected noise rises and falls (rose and fell) within a trace cell. Since most signals occupy many cells (and therefore do not rise and fall within a cell), the detector circuitry switches exclusively to **POS PK** to correctly reproduce the signal. **NORMAL** detection is shown here using the same signal as that used in the previous slide.

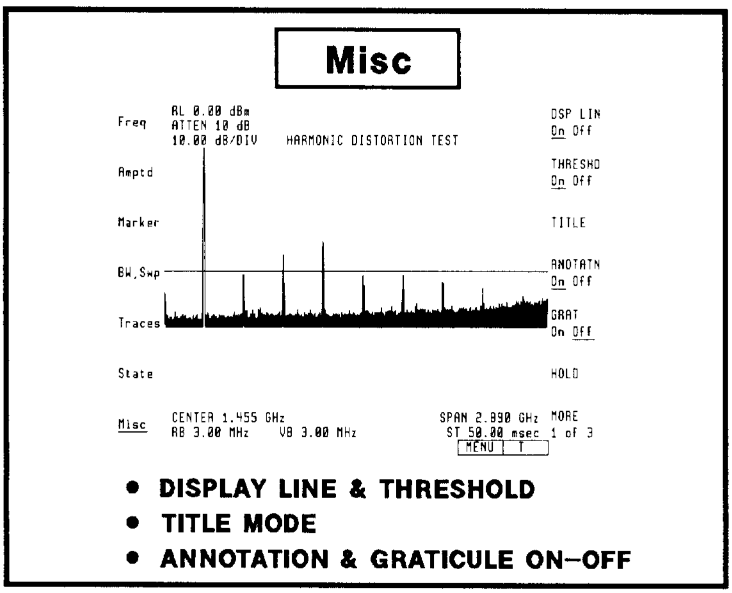


The **State** firmkey accesses the **SAVE STATE** and **RECALL STATE** registers. Depending on the amount of available memory, up to 20 sets of control settings can be saved in the analyzer's non-volatile memory. Even if the power cord is disconnected, the states will be saved. (Another function, **NO. OF STATES**, must be used to allocate memory space. See the "MORE" keys section.) The **ext mixer** softkey accesses additional functions needed to make external waveguide mixer measurements such as conversion loss entry and waveguide band selection. The **preselect** key only appears if the HP 70600A or HP 70601A preselectors are present. It accesses functions such as preselector peaking and preselector bypass (off). The **track gen** key only appears if the HP 70300A or HP 70301A tracking generators are present. They access functions including trace normalization. The **select input** softkey only appears if more than one input is present. It is described in the next slide.





The **select input** softkey allows you to easily select an input. The plot shows an example of the menu that appears after pressing **select input.** In this case, the HP 70907A EMIM (External Mixer Interface Module), the HP 70600A preselector, and the HP 70905A microwave front-end modules are installed and configured in the system. For waveguide signal analysis, simply press **IN 1** (input 1). For preselected operation, select **IN 2.** The full sweep range for this case is 2.7 GHz to 22 GHz. To obtain a 50 kHz to 22 GHz full sweep range and unpreselected operation, select **IN 3.**
If the HP 70620A preamplifier module were installed, it too would appear in this menu as an input choice.



The **Misc** firmkey accesses an assortment of softkey functions. The top-level softkeys are shown here. The **DSP LIN** (display line) function places a horizontal line anywhere on the screen that can be used as a visual pass/fail indicator for a variety of tests. The **THRESHD** (threshold) function acts as a "baseline clipper" to eliminate noise near the bottom of the screen and allow only signals above it to be visible. It is also useful in measurement environments where a "forest" of low-level signals may clutter the display. **THRESHD** eliminates them from the display. The **TITLE** mode is useful for documenting plots. Here we see the title, "HARMONIC DISTORTION TEST". The CRT annotation can be turned off with the **ANNOTATN** function. The graticule can also be turned off (like it is here) using the **GRAT** function. The **HOLD** key was described earlier. It deactivates the active function and turns off the active function annotation.

SOLUTION: 1.) Press **Freq** firmkey (**CENTER** automatically selected). Enter 1.5 GHz. Set **SPAN** to 500 MHz. Press **Misc** firmkey and **TITLE** softkey. Type the title, "TEST #1" using the knob and **SELECT CHAR** softkey for each character. Press **ENTER TITLE** when done. (Use up and down arrow keys as backspace and forward space keys. The **REPLACE** key toggles to **INSERT** and **DELETE** characters.) Press **state** firmkey and **SAVE STATE** softkey followed by "1" and **ENTER**. Press **BW,Swp** firmkey and **VID AVG ON** firmkey followed by "30" and **ENTER**. 2.) Press **IP** and **Freq** firmkey (which selects **CENTER**). Enter 300 MHz. Enter **SPAN** 1 MHz. Press **Traces** and **STORE A**. Then press **trace B** and **CLEAR WRT B**. Press **Freq** (which selects **CENTER**). Enter 900 MHz. Press **STORE B**. 3.) Press **State** and **RECALL STATE 1 (ENTER)**.

REVIEW EXERCISE #8

OBJECTIVE:

TO BECOME FAMILIAR WITH THE BW/Swp, Traces, State, AND MIsc FUNCTIONS.

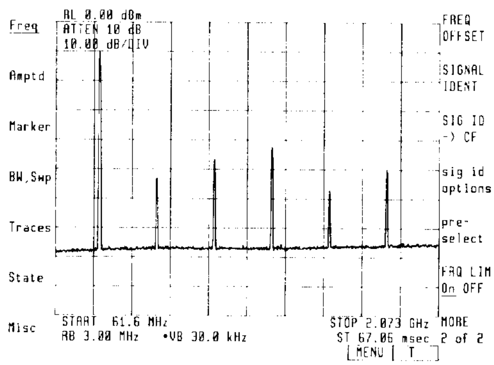
TASKS:

1. **CONNECT CAL SIGNAL. SET CF=1.5 GHZ, SPAN=500 MHZ. CREATE A CRT TITLE. SAVE THESE SETTINGS FOR LATER RECALL. TURN ON VID AVG. SET # AVGS. TO 30.**
2. **PRESS I-P. TUNE TO CAL SIGNAL IN A 1 MHZ SPAN. STORE IT IN TRACE A. TUNE TO 900 MHZ. STORE IT IN TRACE B.**
3. **RECALL THE SETTINGS STORED EARLIER.**

"MORE" MENU Keys

Freq

MORE (2 of 2)



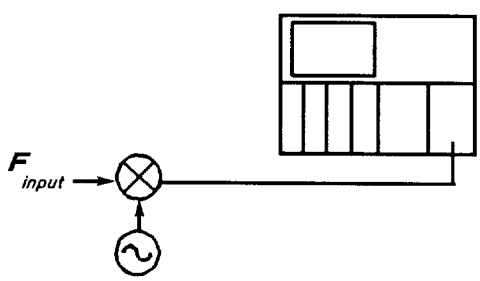
- **SIGNAL IDENTIFICATION USED FOR UNPRESELECTED OPERATION**

In this section of the document we'll examine the spectrum analyzer functions accessed by the **"MORE"** softkeys. The **MORE** softkeys are located at the bottom of each column of softkeys on the right-hand side of the CRT. Since there is only room for 6 top-level softkeys on the right side of the CRT, the seventh key (**MORE**) is used to access the remaining softkeys associated with each firmkey. (Recall that firmkeys are the fixed keys on the left side of the CRT.)

Let's begin with the **MORE** functions found under the **Freq** firmkey. **SIGNAL IDENT** (signal identification) is a function used for unpreselected microwave and millimeter measurements. Extra signals called multiples appear on the CRT during unpreselected operation. (Refer to the description given on page 3-6.) Signal identification is used to correctly determine the amplitude and frequency of "real" signals. **SIG ID -> CF** moves the correctly identified signal to the center of the CRT. The **sig id options** key offers a choice of manual and automatic signal identification modes including the "image" and "shift" methods. (For more information, consult the operating manual.) The **preselect** key is identical to the one found under the **State** firmkey mentioned earlier. It appears only when a preselector module is installed. **FRQ LIM** appears whenever the HP 70908A front-end is installed. When turned **OFF**, it allows sweeps to occur and traces to be viewed up to 26 GHz, but error messages will appear. When turned **ON** (the default setting), traces and sweeps only up to 22 GHz are allowed.

FREQ OFFSET

- **Freq**
- ***MORE 2/2***



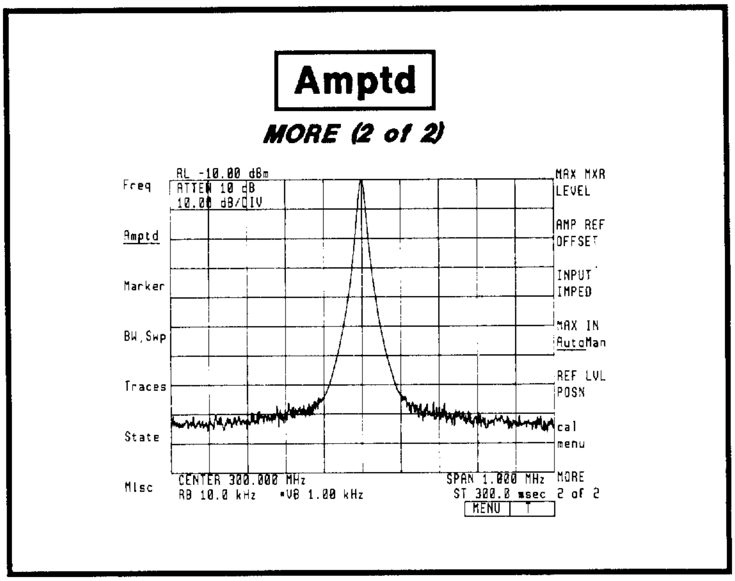
GIVES FREQUENCY READOUT AT INPUT TO MIXER

The **FREQ OFFSET** function is used for testing frequency translation devices such as mixers. Since the mixer input and output frequencies are offset by the external oscillator frequency, the spectrum analyzer measures the output frequency of the mixer rather than its input frequency. **FREQ OFFSET** removes the oscillator offset frequency and allows direct frequency readings at the mixer input. In addition to mixer testing, this function can also be used when a mixer is used to downconvert signals into the frequency range of the spectrum analyzer. (This function is for RF and microwave applications. Because of the firmware of the HP 70000 and the hardware of the HP 70907A EMIM, millimeter measurements using external mixers do not require the use of the **FREQ OFFSET** function. The input frequency is displayed automatically.)

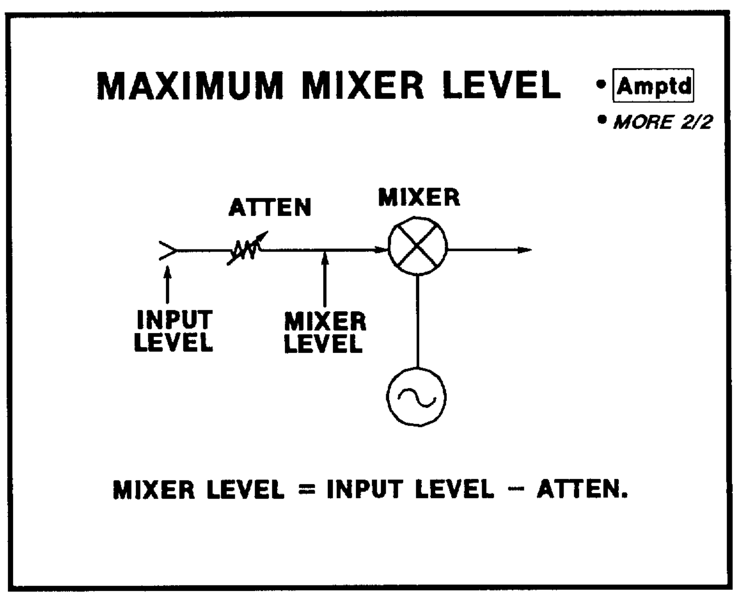
Note the text in the upper right-hand corner of the accompanying illustration. The firmkey and softkey path to access **FREQ OFFSET** is given for your convenience. This convention will be used throughout this section.

The **Amptd MORE** keys are given here. Most of them will be covered in detail in the following slides.

The **cal menu** softkey (category) accesses functions used to calibrate the spectrum analyzer. Most of these functions were covered in the "Connections and Configurations" section of this document. Recall that the **FREQ FOR CAL** and **POWER FOR CAL** functions are useful for calibrating the instrument if signals other than the internal 300 MHz cal signal are used. The flatness errors in microwave measurements can be greatly reduced by using carefully characterized microwave signals as the calibration sources.



To understand the **MAX MXR LEVEL** function, we first need to know that the signal level to the analyzer's first mixer is equal to the signal level at the analyzer's RF input minus the RF attenuator setting. The mixer level affects the amplitude accuracy of the spectrum analyzer. If the level to the mixer is too high, signals may be compressed in amplitude and their levels misrepresented on the display. (See the next slide for more background material.) **MAX MXR LEVEL** is used in conjunction with the **MAX IN** function (described on the next page in more detail) to ensure that gain compression and distortion are avoided by automatically setting the RF attenuator to the proper value, thus making it transparent to the user. **MAX IN** is normally in the **Auto** setting, which means that its value is equal to the top graticule line (reference level) value. Using the relationship, **MAX IN** - attenuation = **MAX MXR LEVEL**, the attenuator setting is automatically set. For example, if the reference level is set to 0 dBm (so **MAX IN** is also 0 dBm), and if **MAX MXR LEVEL** is set to -40 dBm, the attenuator will automatically be set to 40 dB, thus ensuring minimal distortion. Now, if the reference level is set to +20 dBm, the attenuator will automatically be set to 60 dB. The default value (at power-on) for **MAX MXR LEVEL** is -10 dBm, thereby preventing gain compression, at least for the case of CW signals. Impulsive and pulsed RF signals must be treated separately because the displayed power is less than the actual peak power.



AMPLITUDE ACCURACY AFFECTED BY INTERNAL S.A. DISTORTION

GAIN COMPRESSION/DISTORTION

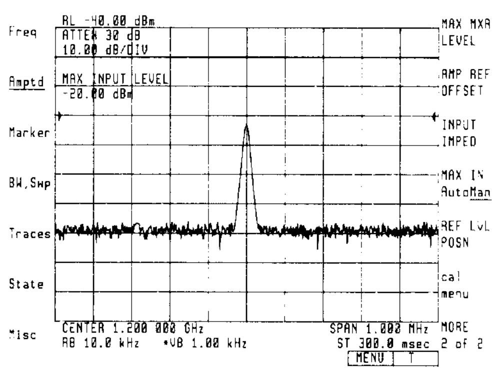
- –10dBm @ MIXER.
- AMPLITUDE COMPRESSED BY .5dB.
- S.A. DISTORTION 40dB BELOW FUNDAMENTAL.

DISTORTION ONLY

- –40dBm @ MIXER.
- S.A. DISTORTION 70dB BELOW FUNDAMENTAL.

MAX IN *and* REF LEVEL POSN

- **Amptd**
- *MORE 2/2*

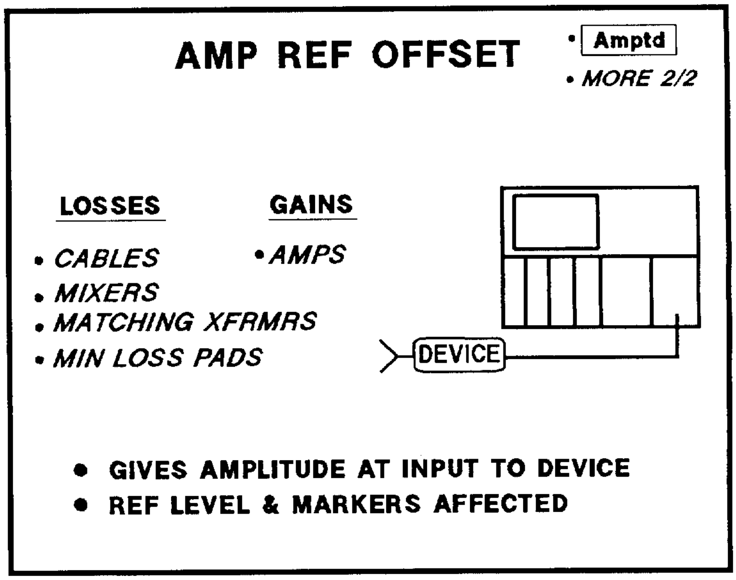


MAINLY FOR TRACKING GENERATOR APPLICATIONS

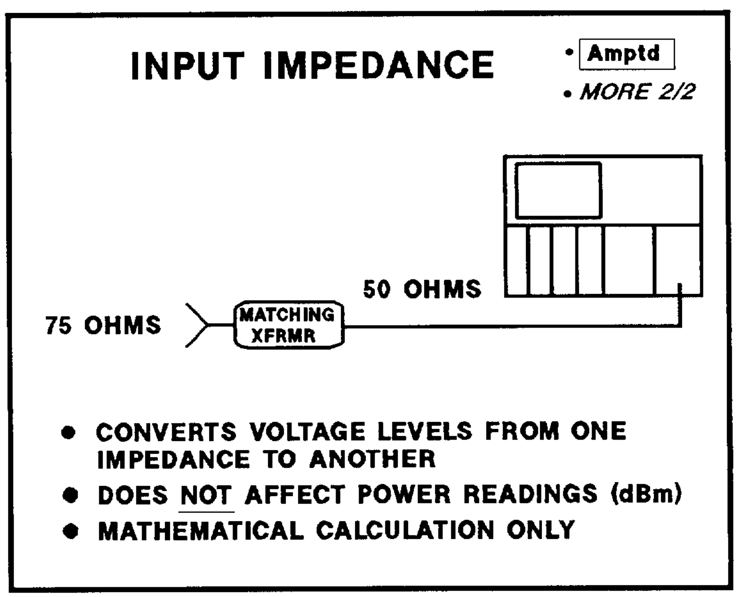
The first mixer in the spectrum analyzer is a non-linear device. Depending on the level input to the mixer, it may either compress the amplitude of the input signal (gain compression) or it may simply create harmonic distortion products in the mixer which are displayed on the CRT. For the HP 70000 spectrum analyers, -10 dBm at the mixer causes the input signal to be displayed .5 dB below its true amplitude (gain compression). With -10 dBm at the mixer, the analyzer's second harmonic distortion is 40 dB below the fundamental. This could easily mask the signals you're trying to measure. A -40 dBm signal at the mixer does not compress the signal appreciably, but the analyzer creates distortion products (mainly second and third harmonics) which are about 70 dB below the level of the input signal. In summary, the lower the input signal to the mixer, the lower the distortion will be. As described on the previous slide, the relationship, **MAX MXR LEVEL = MAX IN -** attenuation, is used to automatically set the attenuator to a value that minimizes compression or distortion in the mixer. As the reference level is adjusted to view signals on the screen, the attenuator also changes by the correct amount to maintain proper levels at the mixer.

MAX IN and **REF LVL POSN** are used mainly for tracking generator applications for testing devices with gain (for example, amplifiers). **MAX IN** refers to the highest anticipated signal level at the RF input to the analyzer (as opposed to the first mixer). When **MAX IN** is in **Auto**, its value is equal to the value of the top graticule line (reference level). It should be left in **Auto** for most applications, since the reference level is generally adjusted to keep signals displayed on-screen. For tracking generator applications where active devices with gain are being tested, either the reference level can be increased or **MAX IN** can be set to remind the user what level can cause the analyzer's mixer to go into gain compression. **MAX IN** is represented by a dashed line on the CRT. (When plotted, the **MAX IN** line is solid, as shown here on the second graticule line from the top. Its level is -20 dBm.) Now, where is the reference level in the accompanying plot? The reference level is normally the top graticule line. However, in this example, it is set to the third graticule from the top using the **REF LVL POSN** softkey. This function is used in applications where the signal level may exceed the reference level (tracking generator applications for devices with gain or those where trace math (A-B) is used). It allows the reference level position to be moved anywhere on screen besides just the top graticule line. Note the arrows on the seventh graticule from the bottom (i.e., the third from the top) denoting a new reference level position. (**REF LVL POSN = 7.**) Therefore, in this example, the third graticule from the top is -40 dBm, and the top graticule is -10 dBm. Note that **REF LVL POSN** only works for log displays. To summarize, for this plot, **MAX IN** is in **Manual**, and set to -20 dBm. **MAX MXR LEVEL** is set to -50 dBm, so the attenuator is automatically set to 30 dB. If **MAX IN** were in **Auto**, it would equal the top graticule value (-10 dBm), not the reference level (-40 dBm).

The **AMP REF OFFSET** key accounts for gains and losses in devices that are connected to the analyzer RF input. It allows the analyzer to read out the correct amplitude level at the input to the device. Positive values of **AMP REF OFFSET** are entered for devices having loss such as cables, mixers, matching transformers, and minimum loss pads. Negative values are entered for devices having gain such as amplifiers. The reference level and marker values are affected by this function.



INPUT IMPED (input impedance) is merely a mathematical calculation that converts voltage levels (Volts, dBmV, dBuV) from one impedance to another. It is adjustable from 1 ohm to 100 Mohms. It does not affect readings calibrated in power (Watts and dBm). To make a proper measurement, a matching transformer or minimum loss pad should be used in addition to using the **INPUT IMPED** function. Doing this will provide proper matching. Any losses can be accounted for using the **AMP REF OFFSET** function.



REVIEW EXERCISE #9

OBJECTIVE:

TO BECOME FAMILIAR WITH THE Freq AND Amptd "MORE" FUNCTIONS.

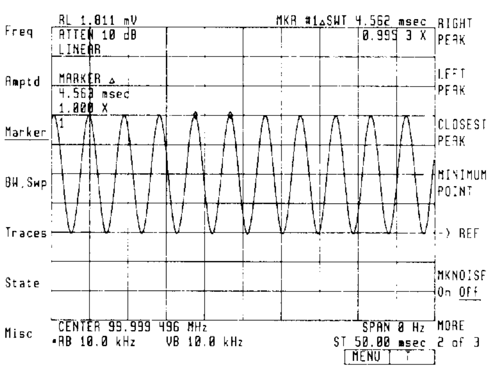
TASKS:

1. TUNE TO CAL SIGNAL IN 1 MHZ SPAN. NOTE THE EFFECT OF SETTING... FREQ OFFSET TO 1 GHZ, AMP REF OFFSET TO 6 dB, amptd units TO dBuV, INPUT IMPED TO 75 OHMS. PRESS I-P WHEN DONE.
2. SET MAX MXR LEVEL TO −40 dBm. NOTE EFFECT ON ATTEN WHEN CHANGING REF LVL

SOLUTION: 1.) Press **Freq** firmkey. Set **CENTER** to 300 MHz. Set **SPAN** to 1 MHz. Press **MORE, FREQ OFFSET**, 1 GHz. Note that the center frequency changes to 1.3 GHz. (Markers are affected, too.) "FOFFSET" annotation appears at bottom of screen. Next, press **Amptd** firmkey, **MORE** key, **AMP REF OFFSET 6 dB**. The reference level changes to 6 dBm. (Markers are affected, too.) "ROFFSET" annotation appears in upper left-hand corner of screen. Next, press **MORE, units menu**, and **dBuV**. The reference level changes to 112.99 dBuV. Press **prev menu, MORE, INPUT IMPED 75 ohms**. The reference level changes to 114.75 dBuV. 2.) Press **Amptd, MORE**, and **MAX MXR LEVEL -40 dBm**. Note that the attenuator changes to 40 dB. As reference level is changed, the attenuator increases or decreases to maintain -40 dBm at the mixer.

Marker

MORE (2 of 3)

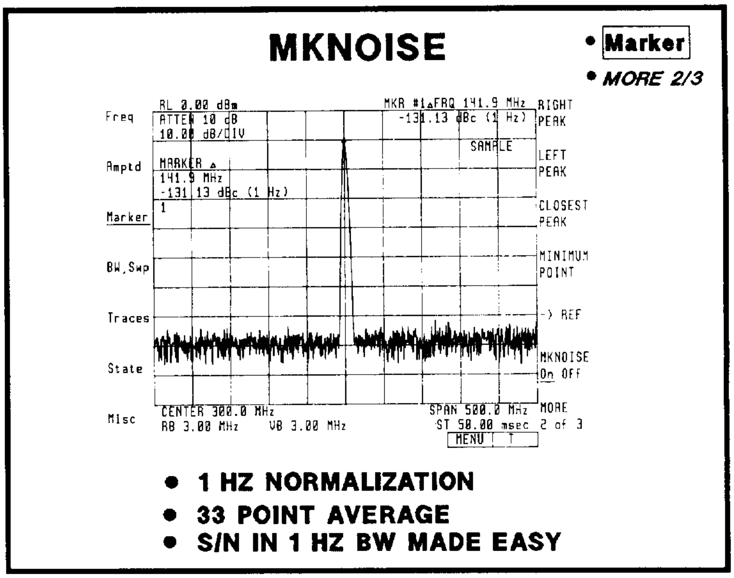


MOD FREQ AND % AM SIMPLIFIED

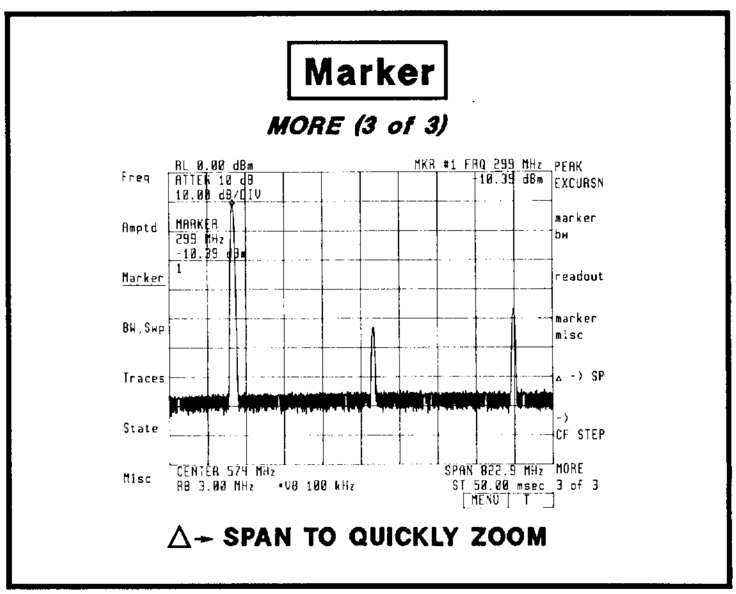
The **Marker MORE** functions shown here each place the active marker on a "peak" as described by their individual function names. A "peak" is defined as trace data which rises and falls by a certain amount (default is 6 dB). **CLOSEST PEAK** will not move the marker if it is already on a peak. It is meant for cases where the marker is on the side of a signal or in the noise. **MINIMUM POINT** and **HIGHEST PEAK** are useful for measuring % AM on a signal demodulated in zero span, as seen here. Zero span means that the span is set to 0 Hz (fixed-tuned operation). Percent modulation = (Emax-Emin)/(Emax+Emin), where the voltage, E, is measured in linear display (not log display). Modulation frequency can also be determined in zero span by measuring the time difference between two successive peaks using **DELTA** marker, and then taking the reciprocal of that measured value.

If a signal has a marker on it, the marker -> **REF** function will move that signal to the reference level.

MKNOISE (marker noise) computes the rms noise level of a displayed noise spectrum, normalized to a 1 Hz noise power bandwidth. Log amp and detector corrections are also applied since noise acts differently than CW signals. **MKNOISE** is especially useful when making signal-to-noise measurements where one marker is placed on the signal and the **DELTA** marker is placed in the noise. (See the accompanying plot.) **MKNOISE** averages the amplitudes of the noise at the marker and 16 points on either side of the marker. **MKNOISE** automatically chooses **SAMPLE** detection.

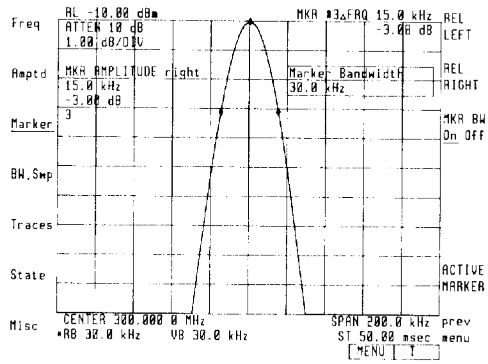


The next level of **Marker** functions is shown here (**MORE 3 of 3**). **PEAK EXCURSN** is used to define the criteria for a "peak". If set too low, noise spikes may be considered to be peaks. If set too high, low-level signals may not be considered to be peaks. The default setting is 6 dB. (The **THRESHD** function can eliminate noise spikes, and it often eliminates the need to use **PEAK EXCURSN**.) Marker **DELTA -> SPAN** eliminates the guesswork that often accompanies setting start and stop frequencies to zoom in on a set of signals. **NORMAL** and **DELTA** markers are first set to define the endpoints. Then when **DELTA -> SPAN** is pressed, the span defined by the markers is automatically displayed. Marker **-> CF STEP** simply eliminates the need to enter the center frequency step size via the front-panel data entry keys. It automatically places the current active marker frequency into **CF STEP SIZE**, which is often used for harmonic distortion measurements.



marker bw

• **Marker**
• *MORE 3/3*

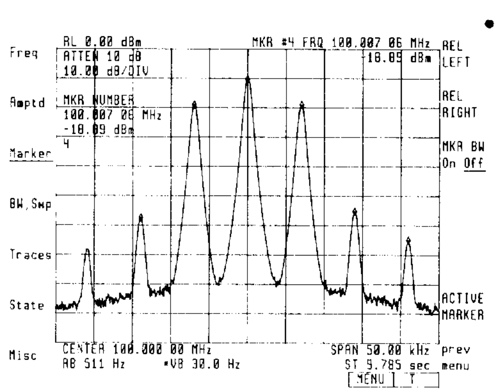


• **FIRST ESTABLISH A REFERENCE MARKER**
• **ENTER dB LEFT/RIGHT AS NEGATIVE #**

The **marker bw** function is especially useful when making swept measurements of filters using the tracking generator module. Enter the **REL LEFT** and **REL RIGHT** values in **negative** dB. For example, to measure the 3 dB BW, enter **-3** dB. When you press **REL LEFT** or **REL RIGHT**, a reference marker will automatically appear at center screen. If your signal is not at center screen, place a reference marker on the signal before pressing **REL LEFT** or **REL RIGHT**. Press **MKR BW On** to display the bandwidth of the signal. (Relative amplitudes can also be entered with the "X" key instead of the "**dB**" key. For example, **REL LEFT** and **REL RIGHT** of **.5X** gives the 3 dB BW in log display.)

ACTIVE MARKER

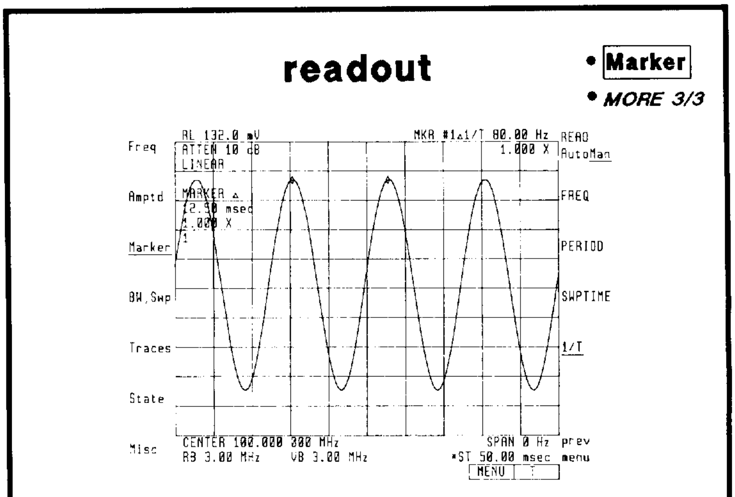
• **Marker**
• *MORE 3/3*
• **marker bw**



UP TO 5 MARKERS PLUS 1 DELTA MARKER

ACTIVE MARKER (found under the **Marker** firmkey, **MORE 3/3** softkey, and **marker bw** softkey) allows you to access up to 5 markers plus 1 **DELTA** marker. Here's the sequence: press **ACTIVE MARKER**, press "1" on the keypad, press **ENTER** (then **MKR NRM On** to move it where you want it). Now for marker #2, press **ACTIVE MARKER**, press "2", **ENTER** (then **MKR NRM On** to move it where you want it). Do the same for markers 3,4, and 5. Then press **DELTA**, and move it to a desired location. Now to quickly check the amplitude and frequency of each marker, simply press **ACTIVE MARKER** followed by the marker number, or use the step keys.

The **readout** key is mainly used when there are two markers present and one of them is a **DELTA** marker. **READ Auto** automatically selects **FREQ** as the default mode for marker separation except when in zero span, where the default is **SWPTIME. PERIOD** is the reciprocal of **FREQ,** and **1/T** is the reciprocal of **SWPTIME.** The **PERIOD** and **1/T** values are displayed in the upper right-hand corner of the display. **FREQ** and **PERIOD** are useful in the frequency domain to determine modulation frequency and period for AM, FM, and pulsed narrowband signals. **SWP TIME** and **1/T** are mainly used in zero span (time domain) to measure modulation frequency and period on demodulated waveforms. An AM modulation envelope is shown here. The difference between successive peaks is 12.5 msec. (**SWPTIME** = 12.5 msec.) Pressing the **1/T** function produces the pulse repetition frequency readout of 80 Hz, shown in the upper right corner of the plot. **SWPTIME** and **1/T** can also be used in non-zero spans for measuring the period (and PRF) of impulsive broadband signals (e.g., radar or EMI).

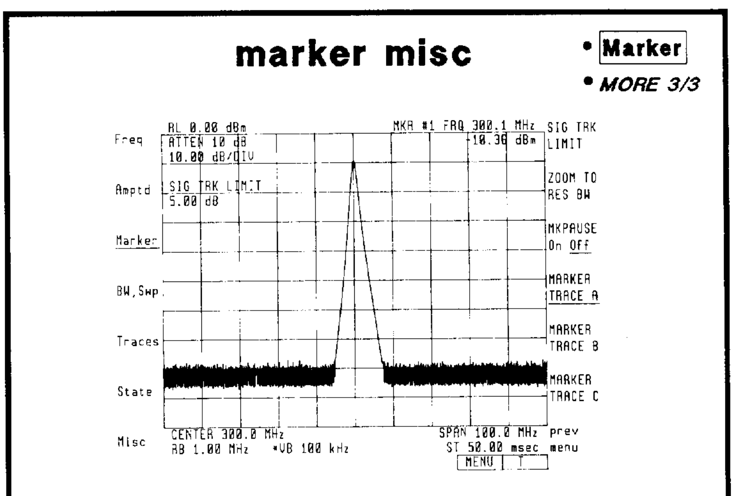


MARKER RECIPROCAL FUNCTIONS

The **marker misc** softkey includes the functions shown here. With the exception of **SIG TRK LIMIT,** these functions will be described in the following slides.

SIG TRK LIMIT is used to set the amplitude limits for which **SIG TRK** will properly operate. Its value must be set high enough to allow for amplitude variations on a modulated signal, yet must be low enough to eliminate other signals (such as sidebands) from interfering with the **SIG TRK** process. The default value for **SIG TRK LIMIT** is 5 dB.

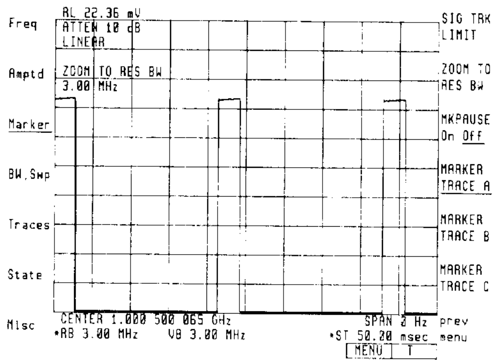
(Recall that **SIG TRK** is an automatic marker zoom function that is used for quickly tuning to a signal in narrow spans.)



SIG TRK LIMIT OFFERS FLEXIBILITY

ZOOM TO RES BW

• Marker
• *MORE 3/3*
• **marker misc**



- **QUICKLY ZOOMS TO ZERO SPAN IN RES BW OF YOUR CHOICE**

ZOOM TO RES BW is used to quickly zoom in on a signal in a specified resolution bandwidth and place the analyzer in zero span. The analyzer sequentially reduces its resolution bandwidth (and frequency span) until it reaches the user-specified value of resolution bandwidth. Then, it immediately sets the span to 0 Hz. Zero span is used to fix-tune the analyzer's local oscillator. If a sufficiently wide resolution bandwidth is selected, zero span can be used to demodulate AM, FM, or pulsed signals. The plot shown here is a demodulated pulsed RF signal in zero span. **ZOOM TO RES BW** was set to 3 MHz (resolution bandwidth), since pulse demodulation requires very wide bandwidths. (Linear display mode was chosen after **ZOOM TO RES BW** was completed.)

When zooming to a signal in zero span, **ZOOM TO RES BW** is much faster than **SIG TRK**. **SIG TRK** is based on the span chosen, whereas **ZOOM TO RES BW** is based on the user-specified resolution bandwidth chosen. **SIG TRK** steps the span down sequentially until it gets to zero span. Since resolution bandwidth is coupled to span, extremely narrow bandwidths are also chosen, resulting in very long sweeptimes. On the other hand, **ZOOM TO RES BW** switches immediately to zero span when the user-specified resolution bandwidth is reached, resulting in faster operation.

MKPAUSE

• Marker
• *MORE 3/3*
• **marker misc**

PAUSES SWEEP AT ACTIVE MARKER

USES:

- **"TUNE AND LISTEN" USING VIDEO OUT AND EXTERNAL SPEAKER**
- **VIEW DEMODULATED WAVEFORM USING VIDEO OUT AND DIGITIZER**

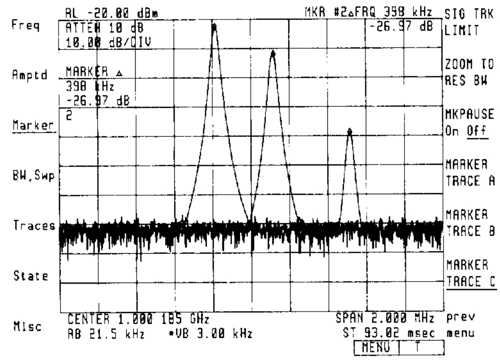
MKPAUSE pauses the sweep at the displayed active marker. It can be used to pause the sweep at a modulated signal for several seconds or longer to allow the analyzer's demodulated video output to be heard on an external speaker. (Additional audio amplification and impedance matching circuitry are also required.) Be sure to use a sufficiently wide resolution bandwidth (for both applications given here). Secondly, when the HP 70700A Digitizer module is used in conjunction with a spectrum analyzer system, the frequency spectrum can be displayed on the spectrum analyzer and the demodulated waveform can be displayed using the digitizer to capture the video output of the analyzer. (See the display hardkey section of this handout to see how to display multiple instrument windows.) **MKPAUSE** has the same effect as going to zero span (for a time length set by the user), but you can still see the frequency domain spectrum. (An smb "tee" is required for both applications.)

(NOTE: Sufficiently wide resolution bandwidths are required for demodulation, so the frequency domain representation may not be optimum for all measurements while in the **MKPAUSE** mode.)

The five markers (accessed by the **ACTIVE MARKER** softkey) can all be placed on either trace A, trace B, or trace C using the **MARKER TRACE A, MARKER TRACE B**, and **MARKER TRACE C** softkeys. Alternatively, the five markers can be distributed among the 3 traces in any combination (e.g. 2 markers on trace A, two on trace B, and 1 marker on trace C). Marker **DELTA** can also be used to measure amplitude and frequency differences between two different traces. This plot shows marker #1 on the trace A signal (far left), marker #2 on the trace B signal (middle), and **DELTA** marker on the trace C signal (right).

MARKER
TRACE A,B,C

- **Marker**
- *MORE 3/3*
- **marker misc**



- **CAN BE USED WITH ACTIVE MARKER AND DELTA MARKER**

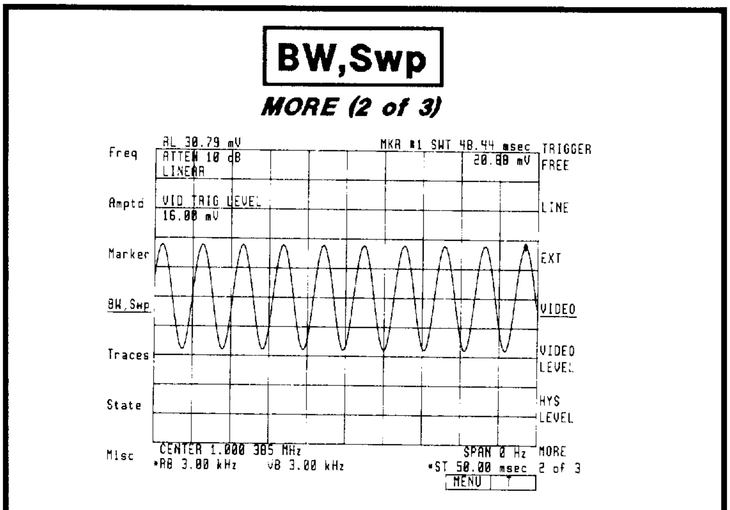
SOLUTION: 1.) Press **Freq** firmkey, **CENTER** 300 MHz, **SPAN** 1 MHz, **Traces** firmkey, **STORE A** softkey, **trace B** softkey, **CLEAR WRT B, Freq, CENTER** 600 MHz, backspace arrow key (< -), **STORE B, Marker** firmkey, **DELTA, MORE 3 of 3, marker misc**, and **MARKER TRACE B** to read out the amplitude difference between the two traces. 2.) Press **I-P** (Instrument Preset), **Freq, CENTER** 300 MHz, **SPAN** 1 MHz, **Marker** firmkey, **MORE 3 of 3, -> CF STEP** softkey, **Marker** firmkey, **DELTA, Freq, CENTER** softkey, and the UP ARROW step key to measure amplitude difference. (Press **Marker** to make the readout appear in the active area on screen.) 3.) Press **I-P, Freq, CENTER** 300 MHz, **SPAN** 1 MHz, **Marker** firmkey, **DELTA** (use knob to move **DELTA** marker into the noise), **MORE 2 of 3**, and **MKNOISE On** to measure signal-to-noise in a 1 Hz noise power bandwidth.

REVIEW EXERCISE #10

OBJECTIVE:
TO BECOME FAMILIAR WITH THE MARKER "MORE" FUNCTIONS.

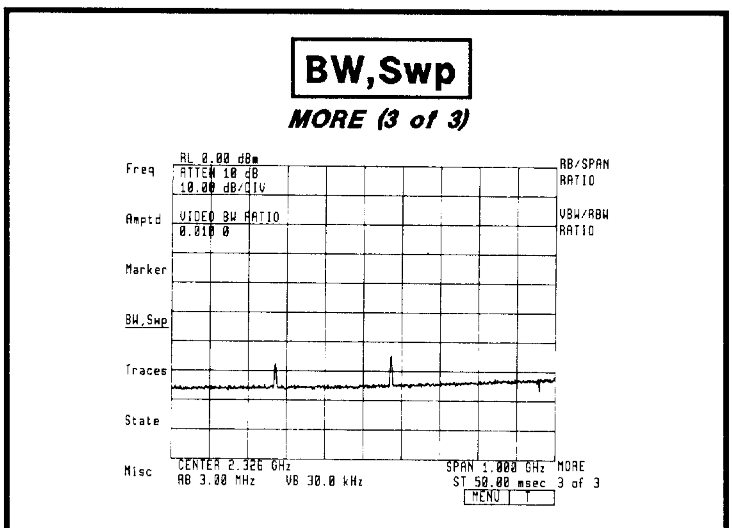
TASKS:

1. **TUNE TO CAL SIGNAL IN 1 MHZ SPAN. VIEW TRACE A. TUNE TO 2nd HARMONIC. VIEW IT IN TRACE B. MEASURE THE AMPLITUDE DIFFERENCE USING MARKERS.**
2. **USE MARKER→CF STEP AND DELTA MRKR TO MEASURE CAL SIGNAL HARMONIC DISTORTION.**
3. **MAKE A S/N MSMT IN A 1 HZ NOISE PWR BW.**



MULTIPLE TRIGGER MODES

There are four trigger modes available on the HP 70000 spectrum analyzers. **TRIGGER FREE** is the default trigger mode, and it allows the next sweep to start as soon as possible after the last sweep. **LINE** trigger allows the next sweep to start if the detected RF envelope voltage rises or falls through the default level. The level can be set using **VIDEO LEVEL. HYS LEVEL** is used to set the hysteresis level in dB. The **LINE** trigger function triggers on the same position of the line voltage. **EXT** trigger allows the next sweep to start when an external voltage level passes through 1.5 volts, becoming positive. The external trigger level must be between 0 volts and +5 volts.



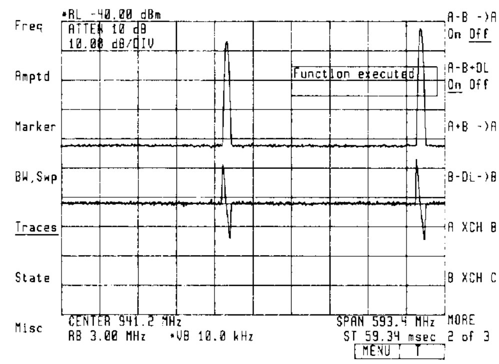
RBW/SPAN & VBW/RBW RATIOS

The **RB/SPAN RATIO** function sets the ratio of resolution bandwidth to frequency span. The default ratio is 0.01. The default ratio guarantees a proper aspect ratio for viewing most signals, but it can be changed for particular uses. **VBW/RBW RATIO** sets the video bandwidth to resolution bandwidth ratio. The default ratio is 1. For noise averaging, a ratio of 0.01 is usually adequate (as shown here). For analysis of broadband signals, such as pulsed RF (radar), a **VBW/RBW** ratio greater than 1 is required. This eliminates the signal degradation that can occur when video bandwidths narrower than the resolution bandwidth are used.

The trace math functions shown here are primarily used for tracking generator applications. However, they can be used for other applications, such as surveillance applications where the number, the amplitude, and the frequency of signals within a frequency band can constantly change. The trace math functions can quickly show when new signals pop up or signal characteristics (such as frequency) change. The plot shown here shows two signals which have drifted in frequency. The original setup requires placing the same signal trace in both Trace A and Trace B. Then, the two traces are subtracted using **A-B->A**. The difference is a straight horizontal line at the Reference Level for the case where no drift occurs. This difference trace can be placed anywhere on screen using the **DISPLAY LINE.** The **A-B+DL** (A minus B plus display line) function then places the difference at the display line, as shown here by the lower trace. When the signal drifts, the difference trace is not a straight horizontal line. Rather, it has "spikes" like those shown in the bottom trace. (NOTE: The value of **A-B->A** is the amplitude difference between Trace A and Trace B in dBm rather than display units. That is, if the Trace A signal is -10 dBm and the Trace B signal is -10 dBm, the difference will appear at 0 dBm.) **A XCH B** (trace A exchanged with trace B) and **B XCH C** (trace B exchanged with trace C) offer a quick way to swap traces.

Traces

MORE (2 of 3)

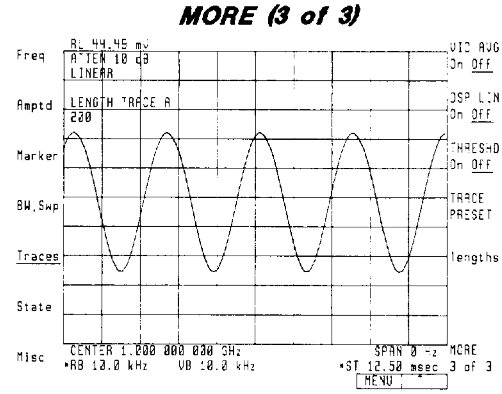


TRACE MATH FUNCTIONS

The trace **LENGTH A**, trace **LENGTH B**, and trace **LENGTH C** functions allow you to set the number of horizontal points comprising each trace. Lengths from 3 to 1024 can be set. The default setting is 800 points. Shortening the trace length has the benefit of allowing faster sweeptimes, since less digital trace memory is required to be updated on each sweep. With 800 trace points, the fastest sweeptime is 50 msec. However, with a trace length of 200 points (as shown here), a 12.5 msec sweeptime is possible in zero span. (Refer to our earlier discussion of sweeptimes in the **BW,Swp** portion of the "Top Level MENU Key" section for more information on the fastest sweeptimes allowed.)

Traces

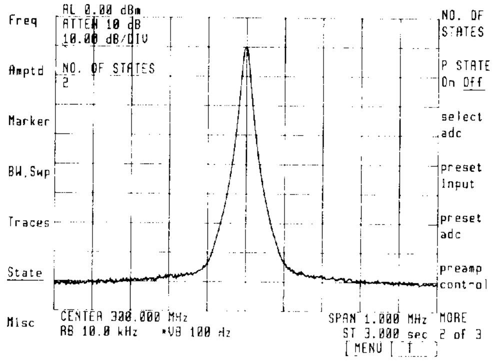
MORE (3 of 3)



- **TRACE LENGTHS ADJUSTABLE**
- **FASTER SWEEPS POSSIBLE**

State

MORE (2 of 3)

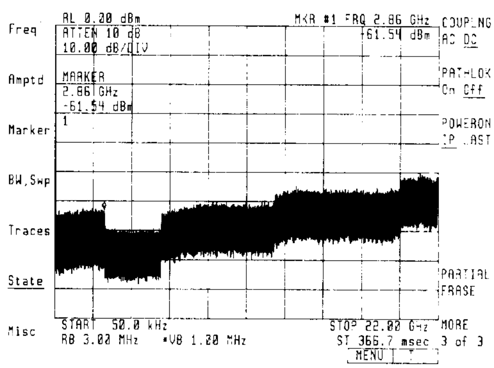


- **SELECT DIGITIZER (ADC)**
- **SELECT PREAMP**

Recall that the **SAVE** function saves up to 20 separate sets of instrument settings in the spectrum analyzer's non-volatile memory. The **NO. OF STATES** function allocates memory for these **SAVE** states. For example, if you need to save 5 sets of analyzer settings, set **NO. OF STATES** to 5. **P STATE** protects the the **SAVE** registers that you've saved. This prevents their accidental erasure. The **select adc** function allows selection of either the internal digitizer (analog-to-digital converter) in the HP 70900A LO module or the faster digitizer in the HP 70700A Digitizer module (allowing faster sweeptimes). The **preset input** function allows a desired input to be selected automatically when **I-P** (Instrument Preset) is selected. (Recall that possible inputs include RF front-end modules, preselector modules, preamplifier module, and external mixer interface modules.) The **preset adc** function allows a desired digitizer (internal adc in HP 70900A or external adc in HP 70700A) to be chosen when **I-P** is pressed. The **preamp control** function is used to turn modular preamps in the system either **On** or **Off**. (**Off** is the bypass mode.)

State

MORE (3 of 3)



- **PATHLOK ALLOWS SELECTED BAND SWEEPS**
- **POWERON LAST SAVES SETUP TIME**

COUPLING AC/DC refers to the input coupling used in the front-end modules. **COUPLING AC** and **COUPLING DC** are both available for the HP 70904A front-end module (100 Hz - 2.9 GHz). Only the **COUPLING DC** function is available on the rest of the front-end modules. (The HP 70904A dc coupled frequency range is specified down to 100 Hz, whereas the ac coupled range is only specified down to 100 kHz due to the input capacitor. The maximum dc voltage allowed for ac coupled operation on the HP 70904A is +/- 25 volts, and 0 volts dc for dc coupled operation on all of the front-end modules.) **PATHLOK On/Off** specifies the signal path through the analyzer such as a particular IF module or specific harmonic mixing frequency band. It can be used to include or bypass the preselector when operating between 2.7 and 2.9 GHz. **POWER ON IP** automatically performs an **INSTRUMENT PRESET** when the analyzer is powered on. **POWER ON LAST** saves the last set of settings that are used before the instrument is turned off. It recalls them when the power is turned back on, saving considerable setup time. **EXT IF On/Off** only appears when the HP 70908A (100 Hz -22 GHz fundamentally mixed front-end module) is present. When **On**, the IF path is switched to the rear-panel 321.4 MHz wide bandwidth output, and the internal IF path is disabled. **PARTIAL ERASE** erases downloadable programs, saved instrument settings, stored limit line data, and saved USER menus from memory (unless they are protected). It does not affect calibration data.

SOLUTION: 1.) Press **BW,Swp** firmkey, **MORE** softkey, and **VBW/RBW RATIO** 0.001. Note that the noise is averaged and the sweep slows down. 2.) Press **I-P** (Instrument Preset). Press **Freq** firmkey (which activates **CENTER** frequency), enter 300 MHz, press **SPAN** 1 MHz, press **Misc** firmkey, **DSP LIN On**, enter -40 dBm, press **Traces** firmkey, **trace B** softkey, **CLEAR WRT B**, **MORE**, and **A-B+DL On** to see trace subtraction. (Press **Freq** and rotate knob to simulate drift.) 3.) Press **MORE** key, **lengths**, **LENGTH A**, and enter 200. Note that a 30.5 msec sweeptime is chosen. (50 msec is the fastest sweeptime with the default trace length of 800 points.) 4.) Press **State** firmkey, **SAVE STATE 5** (enter), **MORE**, and **P STATE On**.

REVIEW EXERCISE #11

OBJECTIVE:

TO BECOME FAMILIAR WITH THE BW/SWP, TRACES, & STATE "MORE" FUNCTIONS.

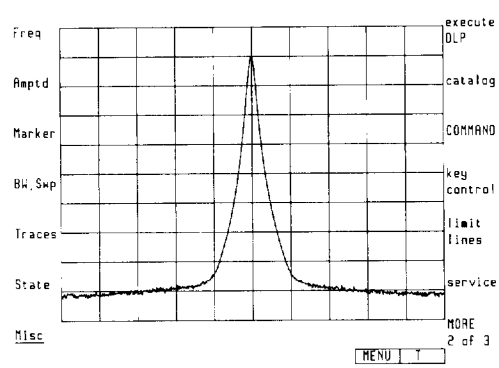
TASKS:

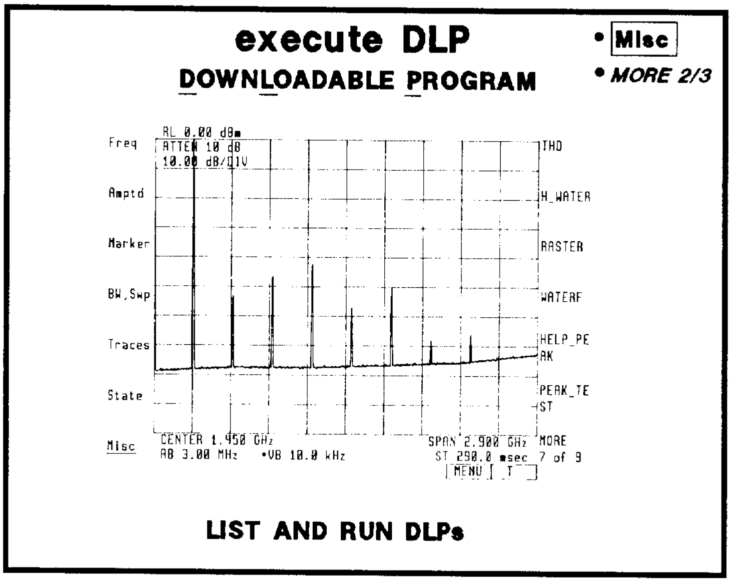
1. SET VBW/RBW RATIO TO 0.001. NOTE THE EFFECT ON THE NOISE & THE SWPTIME.
2. TUNE TO CAL SIGNAL IN A 1 MHZ SPAN. SET DISP LINE TO −40 dBm. CLR WRT TRACE B. PRESS A−B+DL TO SEE TRACE SUBTRACTION.
3. PRESS TRACE PRESET. SET TRACE A LENGTH TO 200. NOTE SWPTIME CHOSEN.
4. SAVE & PROTECT SETTINGS IN REGISTER 5.

The Misc MORE keys will be covered in detail in the following slides.

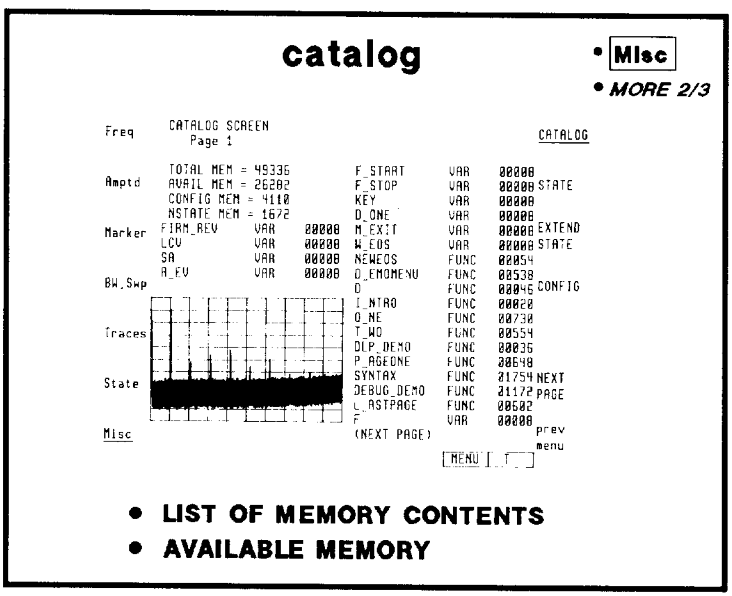
Misc

MORE (2 of 3)



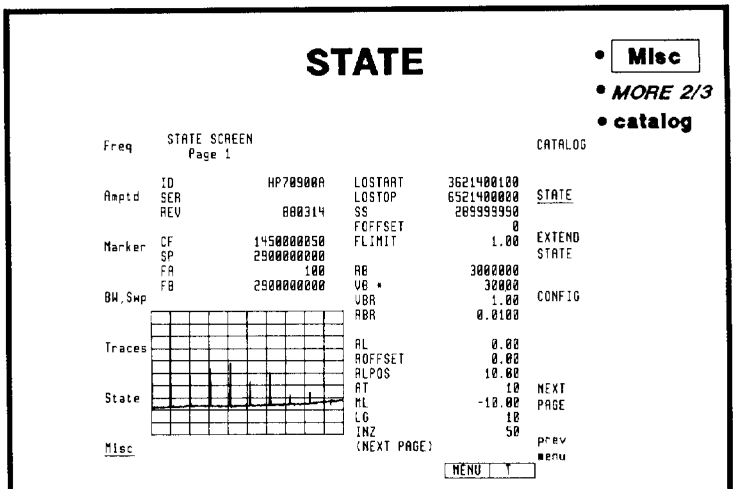


The **execute DLP** softkey accesses automatic measurement routines called downloadable programs, or DLPs. As we'll see in a later section of this document, DLPs are programs downloaded from a computer into the analyzer's non-volatile memory. DLPs are often comprised of many subroutines called FUNCDEFs (function definitions) that are cataloged by the **execute DLP** softkey. This plot shows a partial list of the routines stored in memory. Each of these routines can be run (executed) by pressing the softkey button next to each of them. Generally, however, an entire DLP (comprised of many of these routines) is accessed and run via the USER menu (as described in the DLP section of this document).



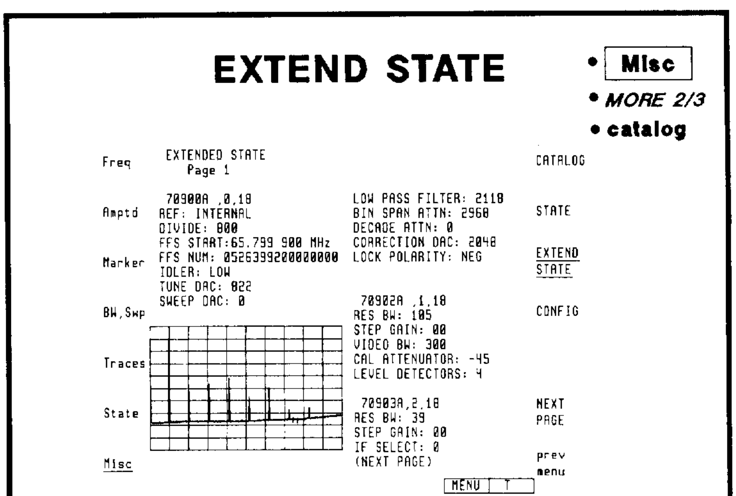
The **catalog** softkey accesses a set of softkeys that will be described here and in the following slides. In each case, the displays provide convenient summaries that can be plotted for convenient record keeping. The first function we'll address is the **CATALOG** softkey. It shows the total amount of accessible memory (RAM located in the LO/Control module), how much of that total memory is still available for use, the amount of memory taken by the modules to configure a system, and the amount of memory that has been allocated for saving instrument states (NSTATE MEM). **CATALOG** also lists what items are stored in memory including DLP function definitions (FUNCDEFs), trace definitions, and variable definitions. In addition, stored USER menus and stored limit lines will be listed using **CATALOG**. The **NEXT PAGE** softkey accesses additional lists of memory contents, if applicable.

STATE is useful for obtaining a summary of the current control settings of the spectrum analyzer. It also includes the firmware revision of the "brains" in the LO module. It maintains the current display trace but at a much reduced size. To get the normal display back, simply press any firmkey.

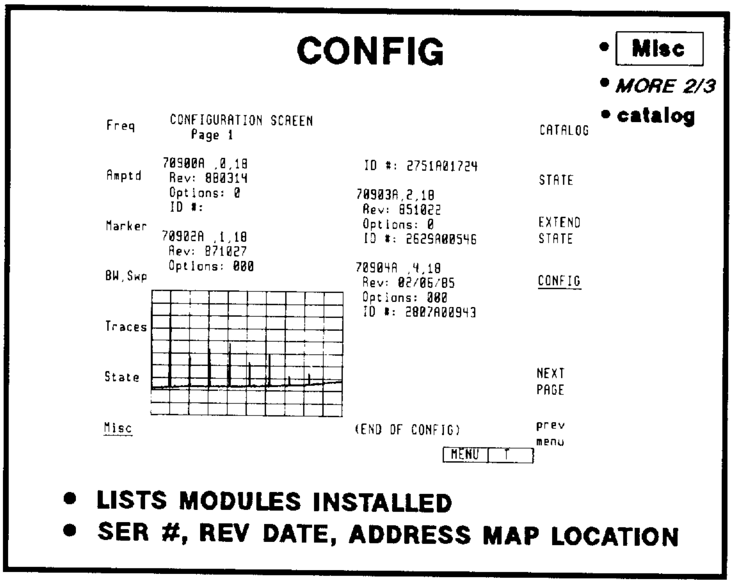


LIST OF CONTROL SETTINGS

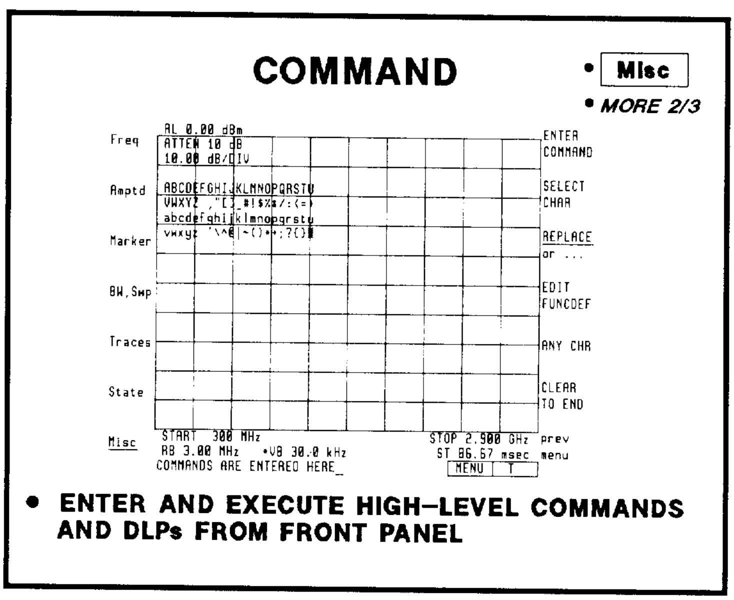
EXTEND STATE provides a module-by-module listing of settings and parameters useful for service diagnostic testing of each module.



SERVICE DIAGNOSTICS



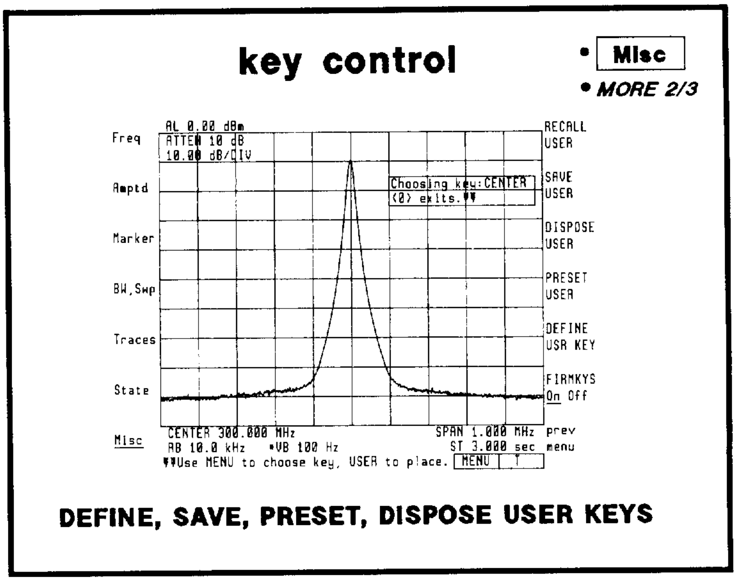
CONFIG provides a listing of module serial numbers, options, firmware revisions, and address map locations.



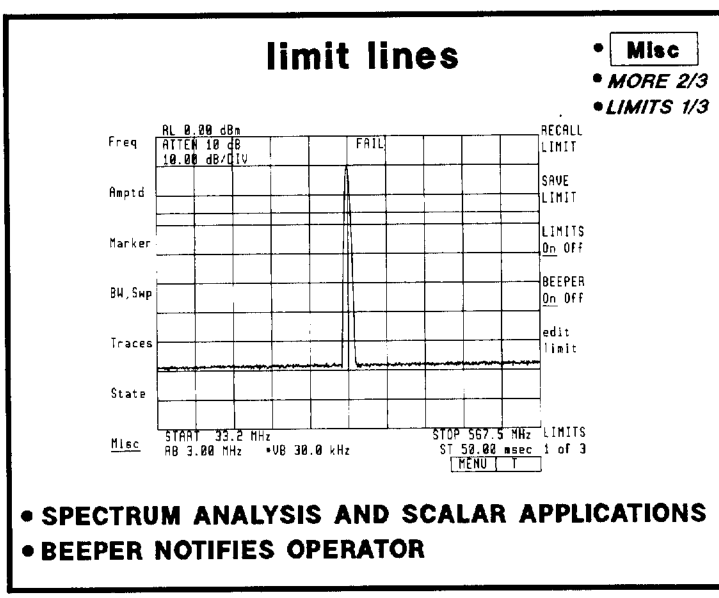
The **COMMAND** softkey enables you to enter and execute high-level commands and downloadable programs via the front panel. The letters, numbers, and characters are selected one-at-a-time with the **SELECT CHAR** softkey and executed with the **ENTER COMMAND** softkey. Normally, the analyzer is programmed from a computer over HP-IB using special commands for each analyzer function. In the absence of a computer, it is possible to execute commands and short DLPs using the **ENTER COMMAND** function. In addition, there are numerous high-level analyzer functions that are not accessible via the standard softkeys. They can only be executed from a controller or entered from the front-panel using **ENTER COMMAND.** Examples include AMPCOR (amplitude correction), FFT (Fast Fourier Transform), and PWRBW (power bandwidth). (Note that additional commands using the correct syntax are required for proper operation of these high-level functions.) The **REPLACE** and **CLEAR TO END** keys are used for editing entries. **EDIT FUNCDEF** calls up a DLP function definition and allows its code to be edited. The function name must first be entered using **ENTER COMMAND.** Then, **EDIT FUNCDEF** is used to retrieve it from memory and display the code comprising it. **ANY CHR** is used to call up additional characters such as Greek symbols. Enter a value from 000 to 255 to select a character.

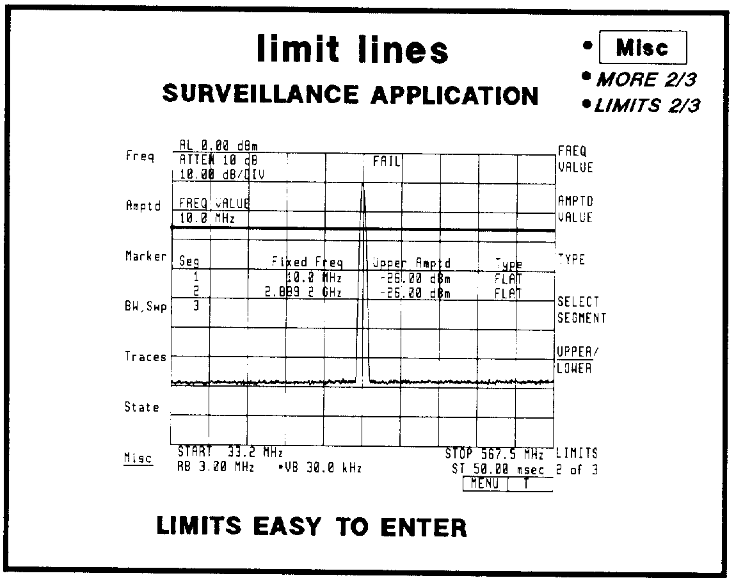
These keys are used to define custom USER menus. **DEFINE USR KEY, RECALL USER,** and **SAVE USER** are also accessed by pressing the USER hardkey on the front-panel. All of these keys relating to the USER hardkey will be described in detail later in this document in the USER KEY section.

FIRMKYS On produces the seven firmkeys found under the MENU hardkey and the three keys found under the USER hardkey. This is the default menu structure that we've been examining throughout this document. **FIRMKYS Off** produces a different menu structure for both the MENU and USER hardkeys. It is the menu structure that was used originally for the modular spectrum analyzers. It features 14 softkeys (lowercase letters) accessed by the MENU hardkey and 14 other softkeys (uppercase letters) accessed by the USER hardkey. (To return from the old keys to the new keys, press **special functns, FIRMKYS On,** and MENU hardkey.) The newer menu scheme was modeled after that used in most of the other newer Hewlett-Packard spectrum analyzers. This provides familiar, friendly front panel operation regardless of which analyzer is used.

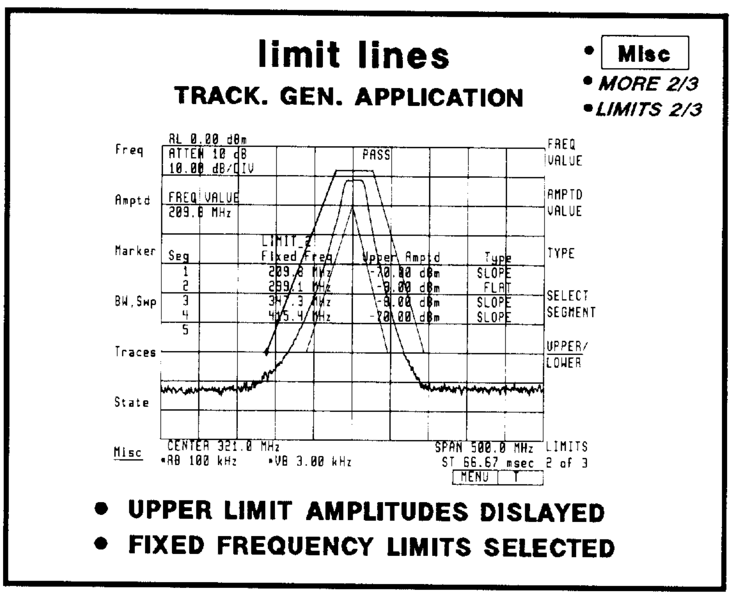


The limit lines firmkey accesses softkeys that are used to enter, save, and recall user-defined limit lines. (**Note**: only firmware dated 880901 or later contains the **limit lines** firmkey and associated softkeys.) Limit lines are useful for both spectrum analysis and scalar (tracking generator) applications. They provide a PASS/FAIL indication on the display, as shown here. In addition, if the **BEEPER** softkey is turned **On**, an audible tone (in the display) lets you know when signals exceed the limits. Here we see the first of three sets of limit line softkeys (**LIMITS 1 of 3**). The limits are turned on or off with the **LIMITS On/Off** softkey. Limits can be saved and recalled using the **SAVE LIMIT** and **RECALL LIMIT** keys followed by a number from the keypad. Even if you forget to save the set of limits you've just entered, the analyzer automatically stores the last set of limits that you've entered. Use the **catalog** softkey (found under the **Misc** firmkey and **MORE** softkey) to obtain a list of the stored limits. (LIMIT_HI and LIMIT_LO are temporary storage registers for the last set of limits entered.) **PARTIAL ERASE** (found under the **State** firmkey and **MORE** softkey) erases stored limits from memory. Finally, as we will see on the next slide, the **enter limit** softkey is used to enter a new set of limits. The **enter limit** softkey label changes to **edit limit** if another set of limits has already been entered. The knob, data entry keys, or step keys can be used to enter limit values. In most cases, you'll probably find the knob to be the most convenient means of entry.



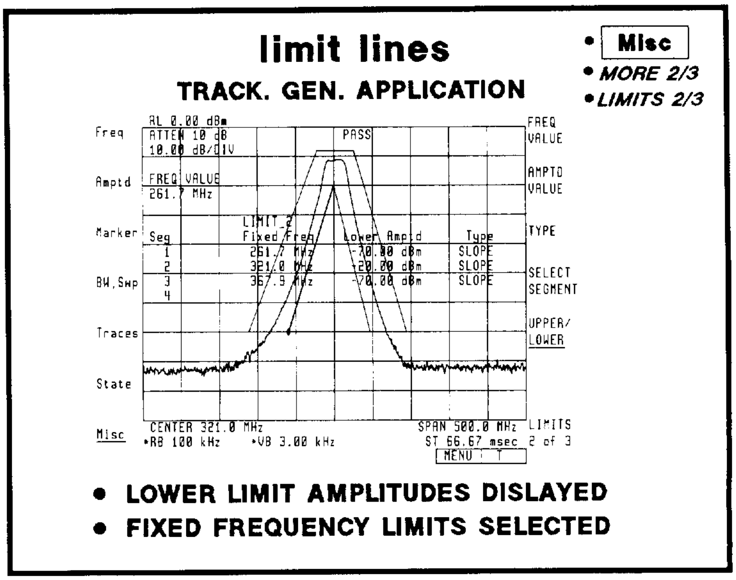


The limit line shown here is used for a surveillance application. When signals appear above the limit line, the beeper will notify the operator, and a "FAIL" indicator will appear on screen. The limit line shown here was generated by completing the accompanying limit line table. Press the **enter limit** softkey to access the limit table. (If the **edit limit** softkey appears instead, access the **LIMITS 3 of 3** softkey, and press the **DELETE ALL** and **CONFIRM DELETE** softkeys. This will clear the entries from the table and toggle the **edit limit** key back to **enter limit.** Now, access the **LIMIT 1 of 3** keys, and press **enter limit.**) Pressing **enter limit** accesses the softkeys and limit table shown here. Frequency, amplitude, and limit type are the three parameters needed to generate a limit line. The frequency and amplitude can be fixed or relative to the absolute value of center frequency and reference level or relative to the position on the display. This example uses limits that are fixed . Amplitude values can be entered for both an upper limit and a lower limit using the **UPPER/LOWER** softkey. This example illustrates only an upper limit. Limits are formed by a series of segments. Segment 1 is the left-most endpoint and is formed by entering a **FREQ VALUE** of 10 MHz, an **AMPTD VALUE** of -26 dBm, and a **TYPE** that is **FLAT.** The **TYPE** refers to how the limit will be drawn from the current segment endpoint to the next segment endpoint. Next, press **SELECT SEGMENT** to move the highlighted box to Segment 2. Press **FREQ VALUE** and enter 2.889 GHz. Press the **SAVE LIMIT** key to save the limit.



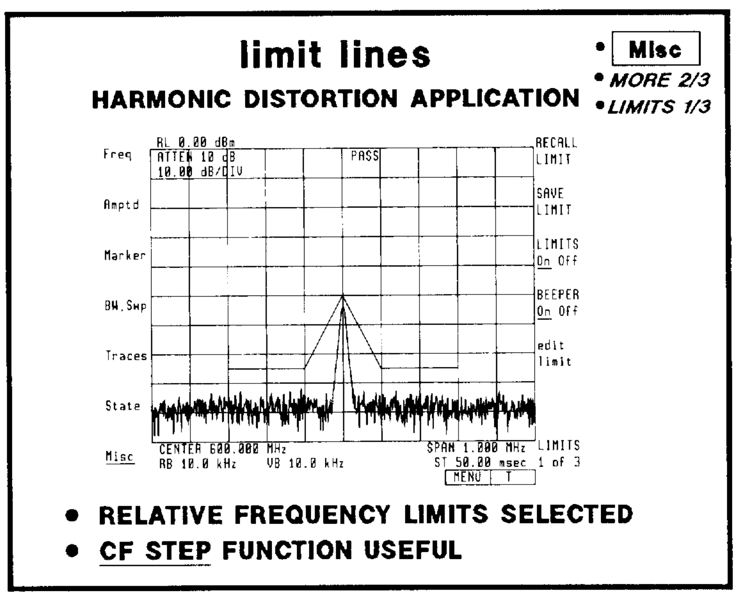
We just examined an application for limit lines using only a spectrum analyzer. Let's now add a tracking generator module to the system to demonstrate how limit lines can be used for making PASS/FAIL scalar stimulus-response measurements. First, set up the tracking generator and set the center frequency and span on the spectrum analyzer. Next, delete the limit line table by pressing **DELETE ALL** and **CONFIRM DELETE** (found under **limit lines** firmkey). Let's first generate the upper limit (which is the default limit) by entering the values shown here. (The lower limits are shown here, too. Their values are shown in the next slide.) Again, the limits are fixed, so as center frequency and reference level are changed, the limits will track accordingly. Now, press **enter limit.** Press **FREQ VALUE,** and use the knob to move the cursor to the desired frequency (209.8 MHz in this example). Press **AMPTD VALUE,** and move the cursor to the desired amplitude (-70 dBm in this case). Press **TYPE,** followed by the **SLOPE** key. (This will result in a limit line segment which slopes from the first segment amplitude point to the second segment amplitude.) Now, press **SELECT SEGMENT.** (This moves the highlighted box to the next segment.) Press **FREQ VALUE,** and move the cursor to the desired frequency (299.1 MHz in this case). Press **AMPTD VALUE,** and use the knob to move the cursor to the desired amplitude (-8 dBm in this case). Press **TYPE** followed by the **FLAT** key. Again, press **SELECT SEGMENT, FREQ VALUE,** and complete the table as shown here. Now, turn the **BEEPER On,** and **SAVE** the limit.

The lower limit values are shown here. Again, the limits are fixed . (As the center frequency and reference level are changed, the limits will move to the new location on the CRT. The limit lines remain faithful to frequency span changes for both fixed and relative modes. Relative limits are described in the next slide.) The limit line values are entered using the procedure just described. First, turn the beeper off. Then, access the lower limit table by pressing the UPPER/LOWER key. (**LOWER** should be underlined, as shown here.) Now, press **FREQ VALUE**, and use the knob to enter the desired frequency (261.7 MHz in this example). Next, press **AMPTD VALUE**, and use the knob or keypad to enter the desired value (-70 dBm in this case). Then, press **TYPE** and press **SLOPE**. Now, press **SELECT SEGMENT**, and complete the table using the same procedure. (Start by pressing the **FREQ VALUE** key, and use the knob to enter the desired frequency.) When finished, save the limits, and turn the beeper on. (The limit shown here was saved in register #2, as indicated by the "LIMIT_2" annotation shown above the "Fixed Freq" values.)



When entering or editing limits, the actual limits and the limit table values are both displayed. To clear the limit table from the CRT, simply press any firmkey on the left-side of the CRT (for example, **Freq**, **Amptd**, **Marker**, **State**, etc.) By pressing the **Limits Off** softkey, the limit lines will be turned off (as long as the limit table values are cleared).

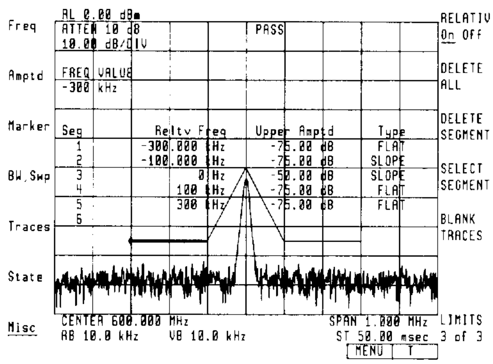
So far we've examined two applications of fixed frequency limit lines. The first was a surveillance application using a spectrum analyzer. The second was a spectrum analyzer/ tracking generator filter measurement. Relative frequency limit lines can also be generated. Since relative limits are relative to the analyzer's center frequency, they remain at the same point on the CRT when center frequency is changed. (Of course, the limit lines will expand or contract with frequency span changes.) Relative limits do not move for reference level changes either. Relative limits are useful when signal masks are required for multiple frequency measurements such as those on TV channels or on oscillator harmonics . The plot shown here illustrates a harmonic distortion measurement using relative frequency limit lines. The second harmonic of the analyzer's 300 MHz calibrator signal is shown here. Furthermore, this limit can be used to test all of the harmonics. First, enter a center frequency step size (**CF STEP** softkey found under **Freq** firmkey) of 300 MHz. Next, press the **CENTER** (center frequency) key, and press the UP ARROW step key on the front-panel of the display to test the third harmonic. Likewise, step to each of the harmonics to see if they pass or fail. (Turn on the beeper.) Let's see how to generate a relative frequency limit such as the one shown here.



limit lines

• **Misc**
• *MORE 2/3*
• *LIMITS 3/3*

HARMONIC DISTORTION APPLICATION



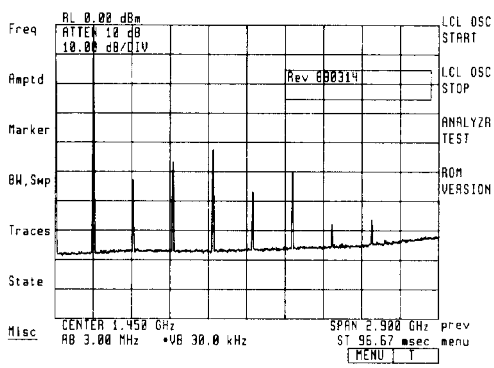
• **UPPER LIMIT AMPLITUDES DISPLAYED**
• **RELATIVE FREQUENCY LIMITS SELECTED**

To generate the limit lines shown here, first clear any limits from the screen by pressing DELETE ALL and CONFIRM DELETE (found in the **LIMITS 3 of 3** key set, shown here). Now, press **enter limit**. Then, press the **RELATIV On** softkey. Access the **UPPER** limit softkey, found under the **LIMITS 2 of 3** key set. (Make sure **UPPER** is underlined.) Now, press the **FREQ VALUE** key and enter -300 kHz (which is 300 kHz to the left of the center of the CRT). Press **AMPTD VALUE** and enter -75 dBm. (-75 **dB** will appear in the limit table). Press **TYPE** followed by **FLAT**. Press **SELECT SEGMENT, FREQ VALUE** -100 kHz, and complete the table as described earlier. Turn on the beeper and save the limit. Then, use **CF STEP, CENTER,** and the UP ARROW to step to each of the harmonics of the calibrator signal.

Segments can be deleted using the **DELETE SEGMENT** key. Successive keypresses of the **SELECT SEGMENT** softkey moves the highlighted box from segment to segment, starting at the top and moving downward. The **BLANK TRACES** key blanks trace A, B, and C while in the **limit lines** menu. This is useful to eliminate clutter on the screen while entering new limits. Pressing the **BLANK TRACES** key again turns the traces back on. (Pressing any firmkey also turns on the traces.)

service

• **Misc**
• *MORE 2/3*



• **QUICK ANALYZER TEST**
• **LO FIRMWARE VERSION**

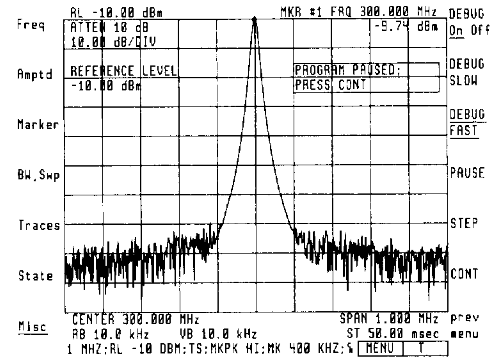
The **service** softkeys are shown here. **LCL OSC START** and **LCL OSC STOP** are used to set the start and stop frequency of the local oscillator. This is useful if the local oscillator output is used as a signal generator. (Proper filtering of harmonics may be necessary.) The **service** key also accesses a service diagnostic test. **ANALYZER TEST** runs the self test routine built into the firmware of the HP 70900A LO module. It runs each module's self test, verifies the ROM and the digital circuitry, and checks for unlocked/unleveled errors. It does not check the RF path. **ROM VERSION** displays the current version of the spectrum analyzer firmware, which is found in the LO/Control module. (The display firmware is found in the display section, and its current version is found using one of the DISPLAY hardkey functions.) The analyzer firmware version (**ROM VERSION**) is given in a year-month-day format. For example, "880314" is the March 14, 1988 firmware revision. **NOTE:** the latest firmware at the time of this printing is the "880901" version. It includes the **limit lines** softkey, found under the **Misc** firmkey. The information given in this document is based on the "880901" version of firmware. If your firmware is "880314", most of the material in this document will apply. (However, the **limit lines** function is not included in the "880314" version.) If your firmware is prior to "880314", the menu structure will be different. If you would like the latest version of firmware, we suggest that you contact your HP Sales Office to order an upgrade kit.

DEBUG On turns on the debug mode. It is useful for debugging programs whether run from an external computer or internally using downloadable programs. The analyzer code appears on the bottom of the screen (see the plot) and scrolls across as it executes. If an error is encountered, the analyzer will stop execution and the bad code will appear near the right end of the code listing. For example, the error in the program shown here is the code "MK 400 KHZ". It should be "MKD 400 KHZ", where MKD is the Marker **DELTA** function. **DEBUG FAST** is the default mode, and is useful when debugging long programs. **DEBUG SLOW** is useful for executing each command slowly to allow errors to be viewed as they occur. The debugging can be paused (**PAUSE**), stepped (**STEP**), and continued (**CONT**). **DEBUG On** has another use. It allows softkeys that are normally blanked (when certain modules are not present) to be viewed.

debug

• **Misc**

• *MORE 3/3*



DEBUG DLPs AND REMOTE PROGRAMS

SOLUTION: 1.) Press **Misc** firmkey, **MORE** key, and **catalog** softkey. Look for "AVAIL MEM". 2.) Press **Misc** firmkey, **MORE** key, **catalog** softkey, and **CONFIG** softkey. Look for ID# (serial number). The serial number is also labelled on the front panel of each module behind the mainframe door mechanism. 3.) Press **Misc** firmkey, **MORE** key, **service** softkey, and **ROM VERSION**. 4.) Press **Misc** firmkey, **MORE** key, **service** softkey, and **ANALYZR TEST** softkey. 5.) Connect cal signal. Press **Freq** and set **CENTER** to 600 MHz. Set **SPAN** to 1 GHz. Press **Misc**, **MORE**, and **limit lines**. Press **enter limit** key. (If **edit limit** key appears instead of **enter limit**, go to **LIMITS 3 of 3**, and press **DELETE ALL** and **CONFIRM DELETE**. Now, go back to **LIMITS 1 of 3** and press **enter limit**.) Make sure that **UPPER** limit is underlined. Enter **FREQ VALUE** 500 MHz, **AMPTD VALUE** -52 dBm, and **TYPE (FLAT)**. Press **SELECT SEGMENT** (moves to Segment 2), and enter **FREQ VALUE** 700 MHz. Turn **BEEPER On**. Press **Freq** firmkey (left side of CRT) and note that the limit table automatically turns off. Set **CF STEP** (center freq. step size) to 300 MHz. Press **CENTER** and press the UP ARROW on the display front-panel. Note that the limit line moves with the 600 MHz signal to the left as CF is changed. Return to **CENTER** freq. of 600 MHz. Now, return to the **limit lines** menu (press BACKSPACE ARROW as a shortcut to get there). Go to **LIMITS 3 of 3** and turn **RELATIV On** (relative limits on). Note that the limit table frequencies change to -100 MHz and 100 MHz and that the amplitudes are in dB rather than dBm. Step the CF to each harmonic again. Note that the limit line does not move from the center of the screen with relative limits turned on. Relative limits are recommended for harmonic tests such as this one.

REVIEW EXERCISE #12

OBJECTIVE:

TO BECOME FAMILIAR WITH THE Misc "MORE" FUNCTIONS.

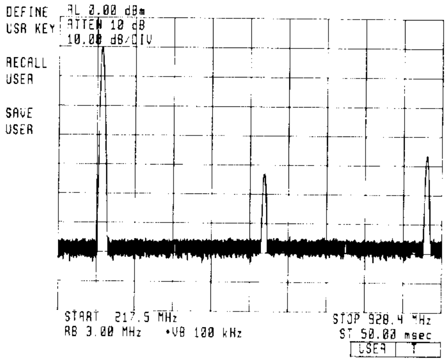
TASKS:

1. **DETERMINE HOW MUCH MEMORY IS AVAILABLE IN THE LO MODULE.**
2. **FIND THE SERIAL NUMBER OF THE HP 70902A IF MODULE.**
3. **DETERMINE THE LO FIRMWARE VERSION.**
4. **RUN THE ANALYZER TEST FUNCTION.**
5. **SET CF TO 600 MHz AND SPAN TO 1 GHz. GENERATE A FLAT −52 DBM LIMIT LINE FROM 500 MHZ TO 700 MHZ (FIXED FREQ). TURN THE BEEPER ON. SET CF STEP TO 300 MHZ. STEP TO EACH HARMONIC. NOTE THAT THAT THE LIMIT LINE MOVES. TURN RELATIV ON. STEP CF AGAIN. OBSERVE EFFECT ON LIMIT LINE OPERATION AND LIMIT TABLE VALUES.**

USER Key Functions

USER HARDKEY

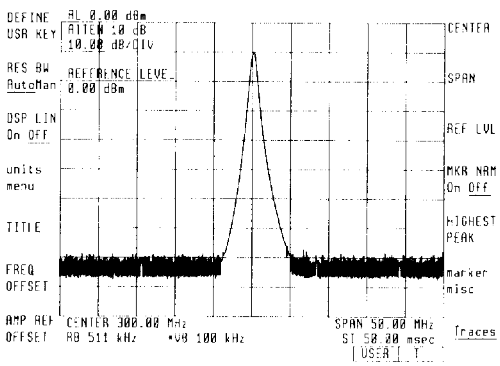
CREATE YOUR OWN CUSTOM MENU



ACCESSES S.A. FUNCTIONS & DOWNLOADABLE PROGRAMS

We've just seen how easy it is to access the more than 150 spectrum analyzer functions using the MENU functions. For simple measurements that require only a few functions, the HP 70000 offers an even easier way of accessing the function than the MENU key. Namely, the USER hardkey allows you to create a custom menu containing only the functions you use for a particular measurement. The **DEFINE USR KEY** function allows you to pick functions found under the MENU hardkey and place them in the USER key area. In addition, the USER key area is used to access downloadable programs. DLPs are one-button measurement routines capable of performing complex measurement sequences without a controller being present. These will be described in more detail in the "DOWNLOADABLE PROGRAM" section.

USER KEY EXAMPLE



SAVE UP TO 50 SETS

This plot is an example of a custom USER menu. The functions shown here are just a few of the more than 150 functions residing under the MENU hardkey. Note that uppercase lettered functions, lowercase keys, and firmkeys can be placed in the USER menu.

Up to 50 custom USER menus can be saved in non-volatile RAM as long as sufficient memory exists.

Let's see how easy it is to create a custom USER menu.

To create a custom USER menu, simply follow the steps given in the accompanying slide. Once you've pressed the **DEFINE USR KEY** function, note the highlighted box in the upper right-hand portion of the CRT. It displays the name of the last function (from the MENU keys) that was pressed. If **DEFINE USR KEY** is pressed after turning on the instrument, the highlighted box displays, "**Placing key: CENTER**", which stands for Center Frequency. If you press the MENU hardkey and select any of the more than 150 functions found there, the highlighted box will "remember" the last key pressed and display it. Once you've found the function (in the MENU keys) that you'd like to place in the USER menu, press the USER hardkey, and place the function in any of the softkey locations. The **DEFINE USR KEY** function is protected to prevent it from being overwritten. If at any time you want to exit the **DEFINE USR KEY** mode, simply press "0" (as indicated by the flashing message, "<0> exits") on the data entry keypad on the display front-panel.

DEFINING USER KEYS

1. PRESS USER HARDKEY.
2. PRESS THE DEFINE USER KEY SOFTKEY.
3. NOTE THE ON–SCREEN INSTRUCTIONS.
4. PRESS THE MENU HARDKEY. SELECT THE DESIRED FUNCTION.
5. PRESS USER HARDKEY.
6. PLACE FUNCTION IN DESIRED LOCATION.

PRESS "0" TO EXIT

To blank a USER key, simply follow the instructions given on the slide. The **DEFINE USR KEY** function cannot be blanked in this manner since it is protected. (To turn off this protected mode, use the "PROTECT ALL,OFF;" spectrum analyzer remote command over HP-IB, or enter this command using the **COMMAND** softkey, which was described earlier in the "MORE" MENU key section under the **Misc** firmkey.)

BLANKING USER KEYS

1. PRESS A BLANK USER KEY.
2. PRESS THE DEFINE USR KEY SOFTKEY.
3. PRESS THE KEY TO BE BLANKED.

PRESETTING USER KEYS

1. PRESS THE MENU HARDKEY.
2. PRESS THE MIsc FIRMKEY.
3. PRESS THE "MORE" SOFTKEY AND THE key control SOFTKEY.
4. PRESS THE PRESET USER SOFTKEY.

To preset the USER keys to their factory-set default labels, follow the steps given on the accompanying slide. The preset keys are **DEFINE USR KEY**, **RECALL USER**, and **SAVE USER**. All of the other keys are blanked.

SAVE & RECALL USER MENUS

SAVE UP TO 50 SETS

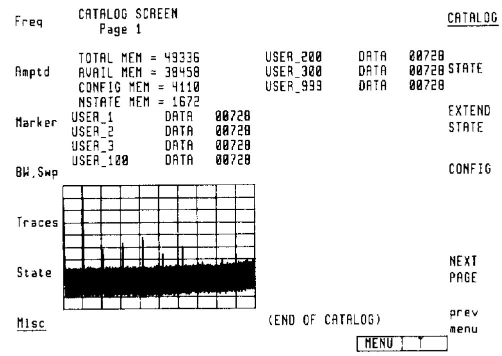
1. PRESS THE USER HARDKEY.
2. PRESS THE SAVE USER (OR RECALL USER) SOFTKEY.
3. ENTER A NUMBER FROM THE KEYPAD. PRESS ENTER SOFTKEY TO TERMINATE ENTRY.

As long as adequate memory exists, up to 50 sets of custom USER key sets can be saved in non-volatile memory. (The number of modules installed, the number of saved control settings, and the volume of DLPs determine how much memory is available.) Follow the instructions on the accompanying slide for saving and recalling USER key sets. Saving multiple USER key sets is valuable when several different people are using the same system. It is easy for each one to recall his or her own customized USER key set.

A listing of the stored USER menus can be accessed by pressing the MENU hardkey, the **Misc** firmkey, the **MORE** softkey, and the **catalog** softkey. A display like that shown in the accompanying plot results.

CATALOG

STORED USER MENUS



1. PRESS THE MENU HARDKEY.
2. PRESS THE Misc FIRMKEY.
3. PRESS THE "MORE" SOFTKEY & catalog SOFTKEY.

If a USER key set has been saved but is no longer needed, it can be disposed (erased) from memory using the procedure given in the accompanying slide. Disposing USER sets from memory provides more available memory for other uses such as DLPs.

DISPOSING STORED USER MENUS

1. PRESS THE MENU HARDKEY.
2. PRESS THE Misc FIRMKEY.
3. PRESS THE "MORE" SOFTKEY AND THE key control SOFTKEY.
4. PRESS THE DISPOSE USER SOFTKEY.
5. ENTER THE NUMBER OF THE USER MENU STORAGE LOCATION.

REVIEW EXERCISE #13

OBJECTIVE:

TO BECOME FAMILIAR WITH THE USER KEY FUNCTIONS.

TASKS:

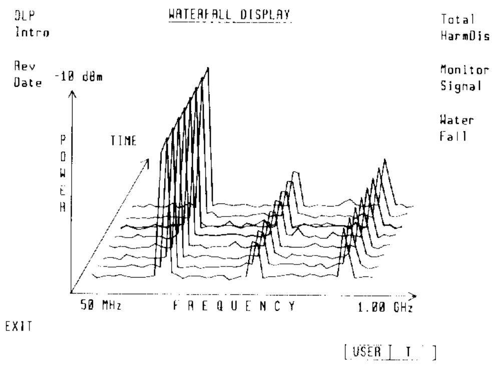
1. CREATE A CUSTOM USER MENU INCLUDING CENTER FREQ, SPAN, REF LVL, AND VID AVG.
2. SAVE IT IN LOCATION #1.
3. BLANK THE VID AVG KEY. SAVE THE NEW USER MENU IN LOCATION 99.
4. USE THE CATALOG FUNCTION TO OBTAIN A LIST OF THE STORED USER MENUS.
5. PRESET THE USER KEYS.

SOLUTION: 1.) Press the USER hardkey and **DEFINE USR KEY** softkey. **CENTER** frequency should appear in the highlighted box on the CRT. (If it does not, press the MENU hardkey, the **Freq** firmkey, and the **CENTER** softkey. Then, press the USER hardkey.) Press the blank upper right-hand softkey. **CENTER** should now appear there. To place **SPAN**, **REF LVL**, and **VID AVG** in the USER key menu, press **DEFINE USR KEY**, MENU hardkey, the appropriate firmkey, and the desired softkey. Then, press the USER hardkey, and place the softkey functions in any blank USER softkey positions. 2.) Press the USER hardkey. Press **SAVE USER 1** and **ENTER**. 3.) Press any blank USER key. Press **DEFINE USR KEY**, press the **VID AVG** USER softkey, and watch it disappear. Press **SAVE USER 99** and **ENTER**. 4.) Press the MENU hardkey, the **Misc** firmkey, the **MORE** key, and the **catalog** softkey to view the saved USER menu listing. 5.) Press the **Misc** firmkey, the **MORE** key, the **key control** softkey, and the **PRESET USER** softkey. Now, press the USER hardkey to verify that the keys were preset.

Introduction To DLPs

DLPs

DOWNLOADABLE PROGRAMS



- **ONE–BUTTON SOLUTIONS**
- **ACCESSED VIA USER KEYS**

As we've seen, the HP 70000 spectrum analyzer is easy to operate using the MENU hardkey with its firmkeys and softkeys. The USER hardkey makes it even easier to use with its ability to create customized menus. Taking it one step further, imagine how easy operation would be if entire measurement sequences could be stored in the analyzer's memory and executed with the push of a single button. The HP 70000 has this one-button solution capability in the form of DLPs (downloadable programs). DLPs are accessed by pressing the USER hardkey. You can name the keys anything you desire, thereby making the USER menu customized to your particular needs. The accompanying plot shows an example of a "waterfall display" DLP that was accessed by the USER softkey called "Water Fall". The DLP shows a power vs. frequency vs. time plot of several signals over a given time span.

DOWNLOADABLE PROGRAMS

1. **ENTER FROM COMPUTER.**
2. **WRITE WITH SA COMMANDS.**
3. **LOAD OVER HP–IB.**
4. **STORE IN SA NON–VOLATILE RAM.**
5. **RUN WITH COMPUTER REMOVED.**

DLPs are developed on a computer, written in spectrum analyzer commands, loaded and stored in the spectrum analyzer's non-volatile RAM, and can be run by simply pressing a single key in the USER key area. Once a DLP is loaded into the analyzer's RAM, the computer can be disconnected from the analyzer, allowing the DLP to run independently. Entire measurement routines can be stored in the analyzer and accessed easily to produce immediate, accurate test results.

The procedure for writing a DLP is quite easy. First, make the measurement manually, and write down each keystroke as you go along (for example, Center Frequency 300 MHz, Span 1 MHz, and Highest Peak). Next, replace each keystroke you've written down with its equivalent spectrum analyzer command, and add delimiters -- "CF 300 MHZ; SP 1 MHZ; TS; MKPK HI;$" (TS stands for take sweep, MKPK HI stands for HIGHEST PEAK marker, and "$" is the delimiter.) Then, define the routine you've just written as a DLP function ("FUNCDEF Z_OOM,$"). This FUNCDEF line should be placed at the top of the program. Both the FUNCDEF statement and the "$" delimiters around the key sequence tell the analyzer that this is a DLP rather than a computer-controlled program. Finally, assign the DLP to a USER key -- "KEYDEF 3, Z_OOM,$ZOOM$;" (Z_OOM is the FUNCDEF name, and ZOOM is the USER key label.) KEYDEF 3 means that the label "ZOOM" will appear on the third softkey from the top on the right side of the CRT in the USER key area. Now whenever you want to execute the DLP, simply press the USER hardkey and then the ZOOM softkey. (Additional code is required to make this DLP run. HP Programming Notes are available to assist you.)

WRITING A DLP

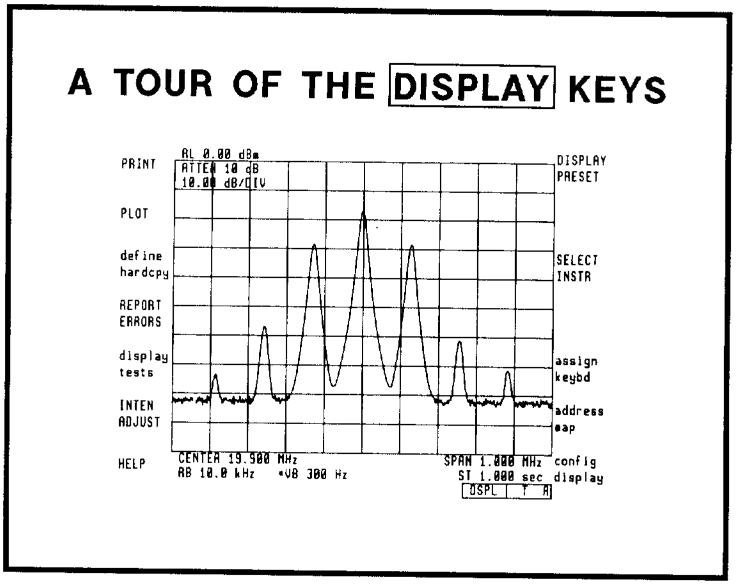
1. RECORD MANUAL KEYSTROKES.
2. REPLACE WITH SA COMMANDS AND DELIMITERS.
3. DEFINE DLP AS A FUNCTION.
4. ASSIGN USER KEY TO EXECUTE DLP.

You've seen how easy it is to write a simple DLP. You can simplify the development of more complex DLPs by using DLP software development tools available from HP. First, internal firmware functions in the HP 70000 include: **DEBUG** mode (which locates program bugs), **REPORT ERRORS** (which reports illegal syntax and commands), **ENTER COMMAND** (which allows short DLP's to be entered without a controller directly from the MMS front panel), and **execute DLP** (which allows you to access any DLP in the HP 70000 memory). HP programming notes tutor you on how to write DLPs. The HP DLP Toolkit contains a floppy disc and documentation to make debugging and program development much easier. Sample DLPs available from your HP Field Engineer demonstrate how to write DLPs and offer functions you can use to simplify your measurement tasks. And, HP System Engineers are available for consultation to either write DLPs for you or help you to write your own. They can also offer training on DLPs.

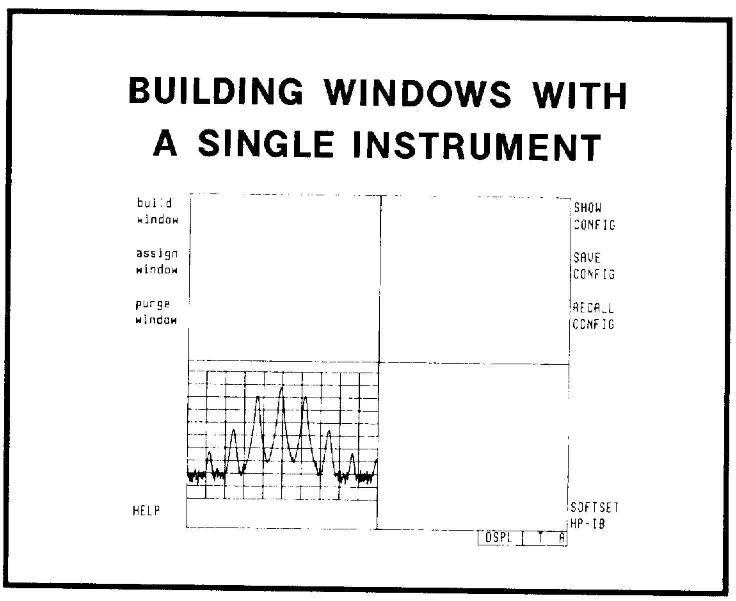
TOOLS FOR DLP DEVELOPMENT

- INTERNAL 70000 FUNCTIONS
- PROGRAMMING NOTES
- DLP TOOLKIT
- DLP CONSULTING
- DLP TRAINING COURSE

Display Functions

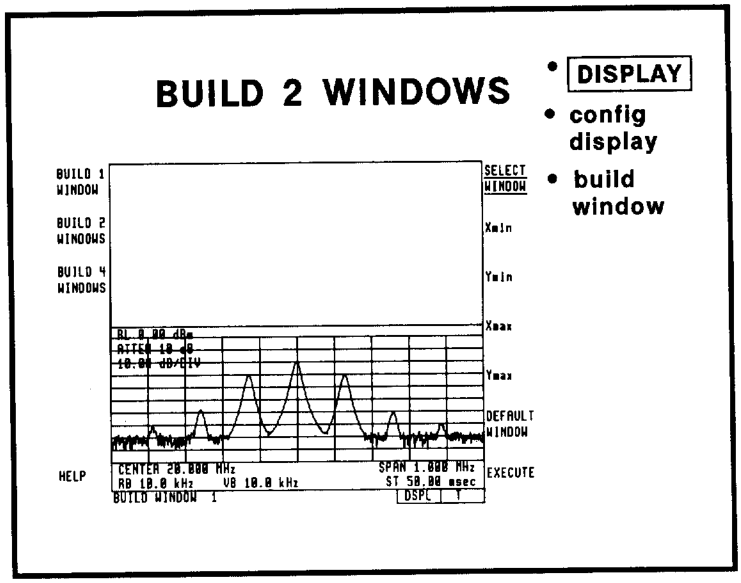


Now we'll see which functions are accessed by the DISPLAY hardkey. We've already used **REPORT ERRORS**, **display tests**, **INTEN ADJUST**, and **address map** earlier in the seminar. Let's now look at some of the others. The **HELP** key provides useful explanations of the functions shown here.

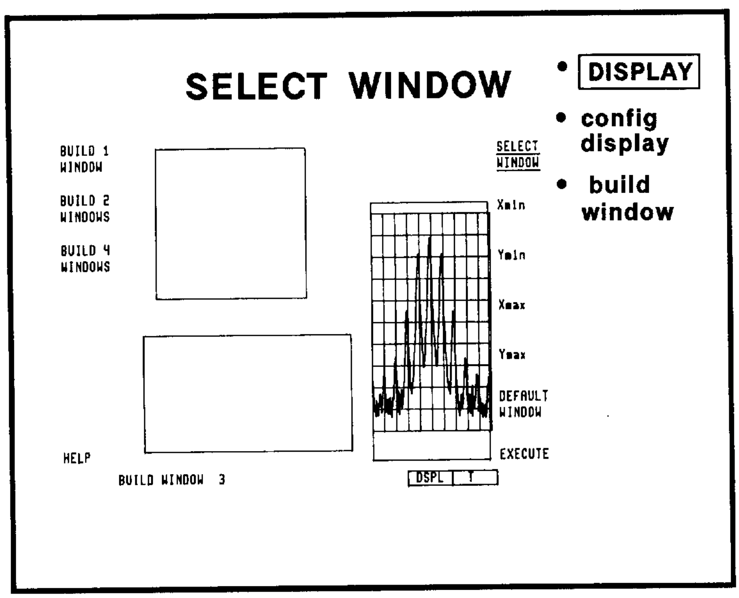


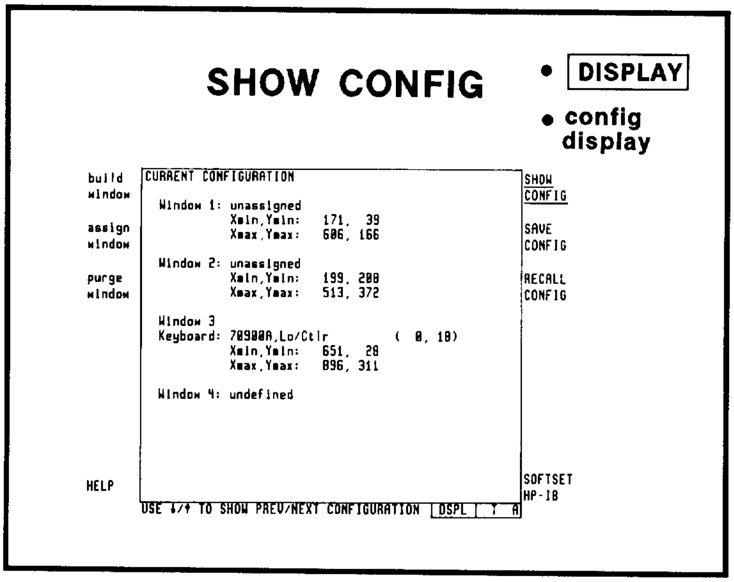
To illustrate the flexible display formatting of the HP 70000 system, we'll begin by making multiple display windows on the single CRT. You can have up to four windows like those shown here to display the traces, annotation, and graticule of four different HP 70000 instruments on a single display. To keep things simple to begin with, we'll build multiple windows but only have one instrument in the system. The **config display** softkey accesses the functions shown here. Next, we'll see how to build multiple windows using the **build window** softkey.

The **build window** softkey accesses the functions shown here. One, two, or four predefined windows can be displayed using these keys. Here's an example of 2 windows created by pressing **BUILD 2 WINDOWS**. The spectrum analyzer trace can be assigned to the upper window, too, as we will see shortly.

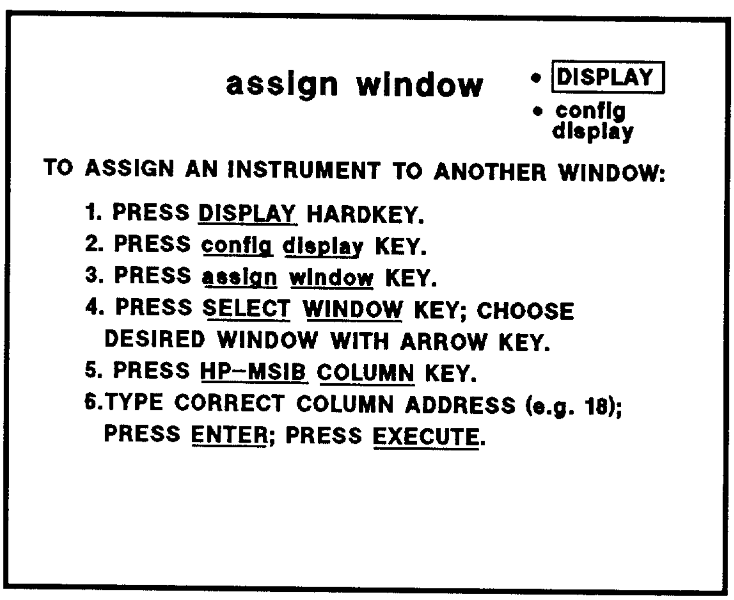


The **build window** softkey also allows you to define your own windows with dimensions defined by the **Xmin, Xmax, Ymin,** and **Ymax** keys. One, two, three, or four windows can be defined. Here we see three windows. **SELECT WINDOW** is used to activate the window that you wish to apply the **Xmin, Ymin, Xmax,** and **Ymax** keys to. **DEFAULT WINDOW** sets the following dimensions: Xmin = 112, Ymin = 16, Xmax = 911, Ymax = 383. **HELP** explains the function of each of the keys shown here.





SHOW CONFIG displays a summary of the current and stored display screen configurations. The example shown here is for the current configuration of the display. It just happens to be the configuration for the three windows from the previous slide. Note that window 4 is undefined. Note further that keyboard control is currently assigned to window 3. (We'll see how to assign it to other windows later.) Four configurations can be saved (with four windows per configuration) using **SAVE CONFIG**. **RECALL CONFIG** recalls the actual windows on the display as they originally appeared when they were stored. **HELP** explains the function of each of the keys shown here.

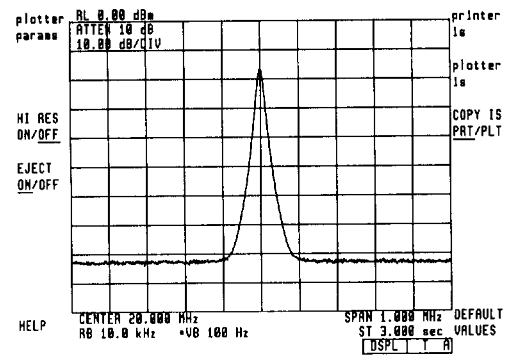


In the example just shown where we had three windows and a single instrument, we can move the active trace to either of the other two windows by following the procedure given here. The **assign window** function is used in the procedure.

PRINT is used to output to a printer. **PLOT** is used to output to a plotter. A hardcopy output may be aborted by pressing any key. The **define hardcopy** function sets the hardcopy output parameters: printer and plotter address, plotter scale points, **KEYCOPY, HI RES**, and **EJECT** options. The **plotter params** function defines the limits used for plotter dumps when the display cannot ask the plotter what limits to use (e.g., for listen only plotters). **KEYCOPY ON** allows the softkey labels, title line, and status box to be printed or plotted. **HI RES ON** sets the printer to high resolution, and all 1024 points are dumped on each line. (OFF sets it to 512 points.) **EJECT ON** sends a page eject at the end of a dump. The **printer is** and **plotter is** functions define the addresses of the printer and plotter. **COPY IS PRT/PLT** determines whether the printer or plotter will be the destination when a **COPY** command is received. See the **HELP** screen to see the printer and plotter **DEFAULT VALUES**.

PRINTING & PLOTTING • DISPLAY

define hardcopy



SOLUTION: 1) Press **config display, build window, BUILD 4 WINDOWS.** 2) Press **assign window**, use the up arrow key to select another window, press **HP-MSIB COLUMN, 18 ENTER, EXECUTE.** (Press **build window**, and **BUILD 4 WINDOWS** to get all 4 windows to appear again.) 3) Select **build window**, use the knob and **Xmin, Xmax, Ymin**, and **Ymax** to make the window as small as possible, and press **EXECUTE.**

REVIEW EXERCISE #14

OBJECTIVE:

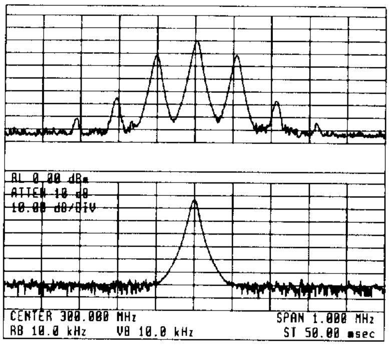
TO BECOME FAMILIAR WITH MANIPULATING WINDOWS.

TASKS:

1. BUILD 4 WINDOWS.
2. MOVE ACTIVE TRACE TO ANY OTHER WINDOW.
3. MAKE THE ACTIVE TRACE POSTAGE–STAMP–SIZE.

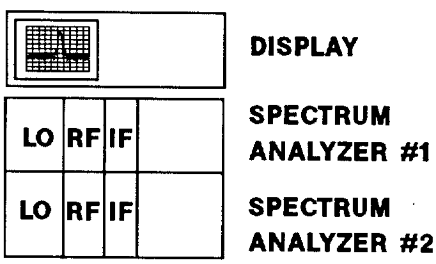
Multiple Instrument Systems

BUILDING WINDOWS WITH MULTIPLE INSTRUMENTS



Now that we're familiar with defining multiple windows for a single instrument (i.e., a single spectrum analyzer comprised of an LO, IF, and RF module), let's define multiple windows for multiple instruments all sharing a common display. Whether you define one, two, or four windows, there are many applications for sharing a single display among several different instruments. For example, in surveillance situations, one analyzer could be set to a wide span to see the "big picture" while the other analyzer is set to a narrow span with the largest signal or a known signal centered in the display. Or, let's say we have one spectrum analyzer and one stand-alone digitizer module each making separate types of measurements. Or, in a satellite up/down link, one analyzer can monitor the up link and the other can monitor the down link, each at a different frequency.

1 WINDOW – 2 INSTRUMENTS



Another example might be for us to check the amplitude levels along a long distribution network with the two analyzers separated by a large distance. The single display can be located at a convenient spot for the operator who can control the two analyzers and monitor the levels. (Long HP-MSIB cables are used.) Each analyzer could have its own window (i.e., **BUILD 2 WINDOWS**) on a common display, but let's start with an example where both analyzers share the same window (i.e., **BUILD 1 WINDOW**) on the same display.

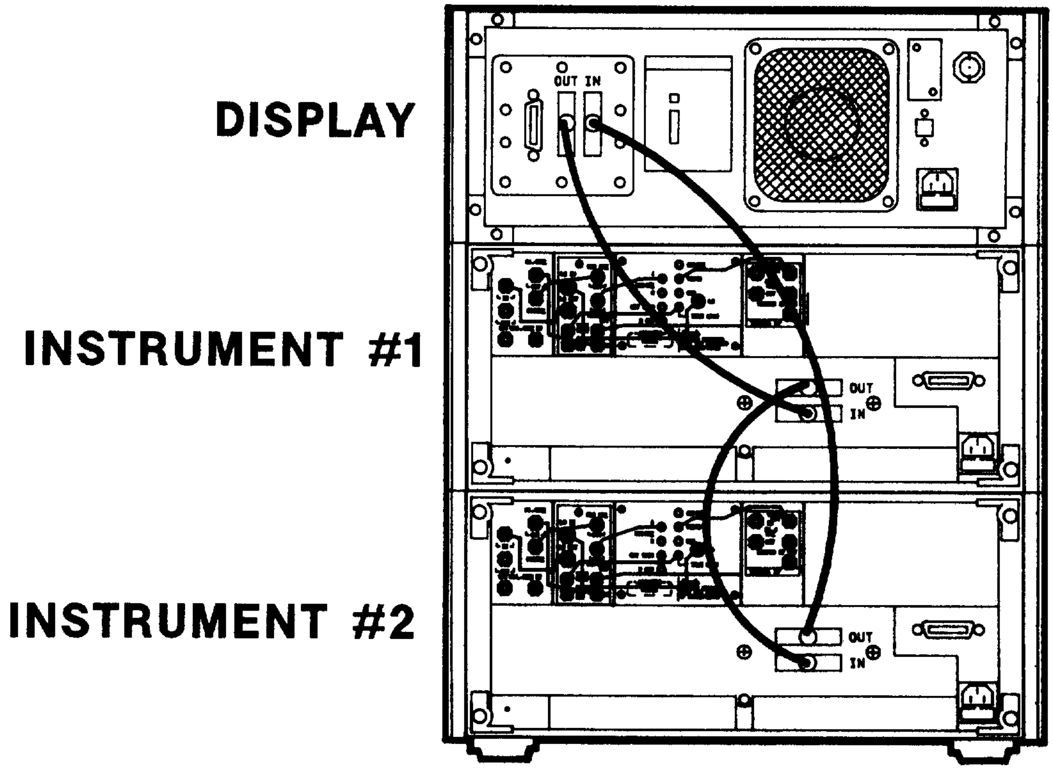
Here is the procedure to use when two instruments (e.g., spectrum analyzers) share a common display. Furthermore, in this case, they share the same window which means that each instrument must be selected alternately, since both cannot be displayed at the same time. Later, we'll build two windows so they both can be simultaneously displayed, but let's work up to that point.

1 WINDOW – 2 INSTRUMENTS

PROCEDURE:

1. **CONNECT HP–MSIB CABLES (SEE NEXT SLIDE).**
2. **SET ADDRESS SWITCHES OF EACH SYSTEM TO DIFFERENT COLUMNS.**
   (VERIFY WITH ADDRESS MAP)
3. **SET CONTROLS ON INSTRUMENT #1.**
4. **PRESS SELECT INSTRUMENT TO DISPLAY INSTRUMENT #2.**
5. **SET CONTROLS ON INSTRUMENT #2.**
6. **PRESS SELECT INSTRUMENT TO DISPLAY INSTRUMENT #1 AGAIN.**

2 INSTRUMENTS – 1 DISPLAY



Here are the rear panel connections when two instrument mainframes and one graphics display comprise a system. Note the daisy-chaining of HP-MSIB cables.

In the procedure just listed for configuring one window for two instruments, the **SELECT INSTRUMENT** function was used. It establishes a link between the display and one instrument at a time. For example, if one analyzer is being displayed on the single window and you instead want to display the other instrument trace on that same window, **SELECT INSTRUMENT** must be used to let the graphics display know which instrument trace to display. **SELECT INSTRUMENT** causes the display to look for the instrument with the next highest address map column address. If none is found higher than the current one, it will start at column zero and work its way up to the current address.

SELECT INSTR • DISPLAY

- ESTABLISHES A LINK BETWEEN THE DISPLAY AND ONE INSTRUMENT.
- NECESSARY FOR DATA DISPLAY AND MANUAL INSTRUMENT CONTROL.
- DISPLAY LOOKS FOR INSTRUMENTS STARTING AT THE LOWEST COLUMN ADDRESS.
- ENTIRE SCREEN AND 14 SOFTKEYS ARE THEN ALLOCATED TO THAT INSTRUMENT.

With the HP-MSIB cables connected properly and the address map configured correctly (i.e., each system at a different column address), we can now observe the procedure for placing two spectrum analyzer displays on the same CRT. The beauty of this configuration is that both analyzers can sweep and their results can be displayed simultaneously.

2 WINDOWS – 2 INSTRUMENTS

PROCEDURE:

1. Press DISPLAY Hardkey.
2. PRESS config display SOFTKEY.
3. PRESS build window SOFTKEY.
4. PRESS BUILD 2 WINDOWS SOFTKEY.
5. PRESS assign window SOFTKEY.
6. (PRESS SELECT WINDOW SOFTKEY).
7. PRESS UP ARROW KEY TO SELECT TOP WINDOW.
8. PRESS HP-MSIB COLUMN SOFTKEY.
9. TYPE COLUMN ADDRESS OF INSTR. #2; ENTER; EXECUTE.
10. PRESS assign keybd KEY,THEN UP ARROW KEY.

assign keybd • DISPLAY

- LINKS THE KEYBOARD WITH AN INSTRUMENT.
- ASSUMES MORE THAN 1 INSTRUMENT SIMULTANEOUSLY WRITING TO DISPLAY.
- ALLOWS CONTROLS OF SELECTED INSTRUMENT TO BE CHANGED.

The **assign keybd** function gives you keyboard control over any instrument currently writing information to a window on the screen. The selected window will be highlighted. Recall that **assign keybd** was used in the procedure just given in the previous slide. Let's take an example. Let's say you want to change the center frequency of the analyzer whose display is in the bottom window, but the keyboard is currently active for the analyzer in the upper window. Simply press **assign keybd** and the down arrow to make the keyboard and softkeys active for the analyzer in the lower window. Then press **CENTER** frequency.

DISPLAY PRESET • DISPLAY

- CLEARS SCREEN
- RESETS DISPLAY TO 1 WINDOW
- ASSIGNS ENTIRE SCREEN TO LAST MODULE TO OWN KEYBOARD
- RESETS HARD COPY PARAMETERS

The **DISPLAY PRESET** key produces one window and assigns it to the last module to own the keyboard. Note that **Instrument Preset** (i.e., green button on the graphics display) does not preset the display since the display is a separate instrument from the spectrum analyzer. So, if you have four windows configured and **IP** is pressed, the four windows will remain, whereas **DISPLAY PRESET** will reset the screen back to one window. It also sets the **define hardcopy** values to the **DEFAULT VALUES.**

REVIEW EXERCISE #15

OBJECTIVE:

CONTROL 2 ANALYZERS FROM A SINGLE DISPLAY.

TASKS:

1. **CONNECT HP–MSIB BUSES BETWEEN 2 MAINFRAMES AND 1 DISPLAY.**
2. **CHANGE COLUMN ADDRESS OF ONE OF THE INSTRUMENTS.**
3. **BUILD 1 WINDOW.**
4. **SET CONTROLS ON S.A. #1 TO DISPLAY 300 MHz CAL SIGNAL IN A 1 MHz SPAN;DISPLAY 600 MHz CAL SIGNAL HARMONIC IN 100 kHz SPAN ON S.A. #2.**

SOLUTION: 1) See rear-panel diagram given several slides back. 2) Remove the LO, IF, and RF modules of one of the instruments, and set their column addresses to a value different than the column address of the other instrument. 3&4) Connect the two cal signals, one to each spectrum analyzer. Follow the "1 WINDOW - 2 INSTRUMENTS" procedure given earlier. 5) Follow the "2 WINDOWS - 2 INSTRUMENTS" procedure given earlier. 6) First build four windows. Then follow the procedure given earlier in the slide entitled "**assign window**" to move analyzer #1 display to one of the unoccupied windows.

REVIEW EXERCISE #15 (CONTINUED)

5. **BUILD 2 WINDOWS. INCREASE RBW ON S.A. #1 TO 30 KHz. INCREASE REF LEVEL ON S.A. #2 BY 10 dB.**
6. **BUILD 4 WINDOWS. MOVE S.A. #1 DISPLAY TO ONE OF THE EMPTY WINDOW LOCATIONS.**

SUMMARY

WE'VE LEARNED:

1. MODULAR SYSTEM BENEFITS
2. BASIC SA THEORY
3. FUNCTION OF EACH MODULE
4. REAR PANEL CONNECTIONS
5. ADDRESS MAP CONFIGURATION AND SWITCH SETTINGS
6. USER, MENU, AND DISPLAY FUNCTIONS
7. DLP FUNDAMENTALS
8. MULTIPLE INSTRUMENT CONTROL AND DISPLAY WINDOWS.

This slide summarizes what we've learned today. You've probably come to realize that the HP 70000 modular measurement system is a very useful tool for making a variety of different measurements. Its features provide measurement solutions for you. The system is extremely flexible because of its modular nature. The USER keys make it easy to use since they can be custom-tailored to meet your needs. With the multiple window capability, the HP 70000 system can provide powerful solutions not available by any other single measurement system.

For more information, call your local HP sales office listed in your telephone directory or an HP regional office listed below for the location of your nearest sales office.

United States:
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Latin America: Latin American Region Headquarters, Monte Pelvoux Nbr. 111, Lomas de Chapultepec, 11000 Mexico, D.F. Mexico

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