Models 545B & 548B CW Microwave Frequency Counters

Operation Manual

545B CCN 2220
548B CCN 2320

Manual Assy. Part Number: 5585048-08
Manual Text Part Number: 5580057-07
Printed in USA, October 2008

WARRANTY

Phase Matrix, Inc. warrants this product to be free from defects in material and workmanship for one year from the date of delivery. Damage due to accident, abuse, or improper signal level is not covered by the warranty. Removal, defacement, or alteration of any serial or inspection label, marking, or seal may void the warranty. Phase Matrix, Inc. will repair or replace, at its option, any components of this product which prove to be defective during the warranty period, provided the entire unit is returned COLLECT to Phase Matrix, Inc. or an authorized service facility. Please visit our web site at www.phasematrix.com for up-to-date return information. In-warranty units will be returned freight prepaid; out-of-warranty units will be returned freight COLLECT. No warranty other than the above is expressed or implied.

CERTIFICATION

Phase Matrix, Inc. certifies this instrument to be in conformance with the specifications noted herein at time of shipment from the factory. Phase Matrix, Inc. further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology.

MANUAL CHANGE INFORMATION

As Phase Matrix, Inc. continually improves and updates its products, changes to the material covered by the manual do occur. When a part or assembly in a Phase Matrix, Inc. instrument is changed to the extent that it is no longer interchangeable with the earlier part, the configuration control number (CCN) of the instrument, shown on the title page of the manual, changes, and a new edition of the manual is published.

To maintain the technical accuracy of the manual, it may be necessary to provide new or additional information with the manual. In these cases, the manual is shipped with a Manual Update. Please be sure to incorporate the information as instructed in the Manual Update.

CONTACTING PHASE MATRIX

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SAFETY

The Phase Matrix 545B & 548B are designed and tested according to international safety requirements, but as with all electronic equipment, certain precautions must be observed. This manual contains information, cautions, and warnings that must be followed to prevent the possibility of personal injury and/or damage to the instrument.

SAFETY AND HAZARD SYMBOLS

WARNING

A WARNING denotes a hazard to personnel. It calls attention to a procedure or practice, which, if not correctly performed or adhered to, could result in personal injury.

CAUTION

A CAUTION denotes a hazard to the equipment. It calls attention to an operating procedure or practice, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

This is a general warning that appears whenever care is necessary to prevent damage to the equipment.

Dangerous Voltage

Toxic Substance

Static-Sensitive Component

Fire Hazard

OVERALL SAFETY CONSIDERATIONS

WARNING

Before this instrument is switched on, its protective earth terminals must be connected to the AC power cord's protective conductor. The main plug must only be inserted in a socket/outlet that has a protective earth contact. The protective action must not be negated by using an extension cord (power cable) or adapter that does not have a protective earth (grounding) conductor.

WARNING

Use only fuses of the type specified with the required current and voltage ratings. Never use repaired fuses or short-circuited fuseholders, as doing so causes a shock and/or fire hazard.

WARNING

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

WARNING

All protective earth terminals, extension cords, autotransformers, and other devices connected to this instrument must be connected to a socket/outlet that has a protective earth contact. Any interruption of the protection causes a potential shock hazard that can result in personal injury.

WARNING

The power supply is energized whenever AC power is connected to this instrument. Disconnect the AC power cord before removing the covers to prevent electrical shock. Internal adjustments or servicing that must be done with the AC power cord connected must be performed only by qualified personnel.

WARNING

Since the power supply filter capacitors may remain charged after the AC power cord is disconnected from the equipment, disconnecting the power cord does not ensure that there is no electrical shock hazard.

WARNING

Some of the components used in this instrument contain resins and other chemicals that give off toxic fumes if burned. Be sure to dispose of these items properly.

WARNING

Beryllia (beryllium oxide) is used in the construction of the YTF assembly. This material, if handled incorrectly, can pose a health hazard. NEVER disassemble the microwave converter assembly.

CAUTION

Static sensitive components are used in the YTF assembly. These components can be damaged if handled incorrectly.

CAUTION

Before connecting power to the instrument, ensure that the correct fuse is installed and the voltage-selection switch on the instrument's rear panel is set properly. Refer to Section 2, *INSTALLATION*.

CAUTION

Excessive signal levels can damage this instrument. To prevent damage, do not exceed the specified damage level. Refer to the instrument specifications in Section 1 of this manual.

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1

GENERAL INFORMATION

DESCRIPTION

The Phase Matrix 545B & 548B CW Microwave Frequency Counters are microprocessor-based instruments. These counters perform frequency and (optionally) power measurement. The basic frequency range of the 545B is 10 Hz to 20 GHz, while the 548B extends to 26.5 GHz. When the 548B is equipped with Frequency Extension Capability (Option 06) and used with the Model 590 and a Remote Sensor, the counter is capable of operating up to 110 GHz.

Frequency counting is divided into four bands. Band 1 is a high impedance input (1 M Ω/20 pF) and covers 10 Hz to 100 MHz. Band 2 is a 50 Ω input operating from 10 MHz to 1 GHz. Band 3 is also a 50 Ω input and covers the range of 1 GHz to 20 GHz (575B), or 1 GHz to 26.5 GHz (578B). Band 4 is an optional band that covers 26.5 GHz to 110 GHz and is subdivided into 4 frequency ranges.

Band 4-1: 26.5 GHz – 40 GHz

Band 4-2: 40 GHz – 60 GHz

Band 4-3: 60 GHz – 90 GHz

Band 4-4: 90 GHz – 110 GHz

An optional power-measurement capability (Option 02) is available to supplement Band 3. With this option, the counter can simultaneously display frequency (to 100 kHz resolution) and power (to 0.1 dB resolution) from minimum sensitivity to +10 dBm.

OPERATING CONDITIONS

This instrument is designed to be operated at temperatures from 0° C to 50° C at relative humidity not exceeding 95% (75% for temperatures greater than 25° C and 45% for temperatures greater than 40° C) non-condensing. This instrument performs to specifications at altitudes not exceeding 10,000 ft (3050 m) and tolerates vibration not exceeding 2 g. It is fungus resistant. The chassis is not designed to provide protection from mechanical shock or falling water particles and is intended for normal bench use in an environmentally uncontaminated area.

VENTILATION

Air circulates through the vents in the rear panel of the counter. If these vents are obstructed, the temperature inside the counter may increase enough to reduce stability and shorten component life. Always ensure that the vents in the rear panel are clean and unobstructed.

STORAGE

Store the instrument in an environment that is protected from moisture, dust, and other contaminants. Do not expose the instrument to temperatures below –55° C or above 75° C, or to altitudes above 40,000 ft. (12,000 m).

SPECIFICATIONS

GENERAL

Size	3.5 in H x 16.75 in. W x 14 in. D (8.9 cm H x 42.6 cm W x 35.6 cm D)
Weight	26 lb (11.8 kg) (with no options)
Shipping Weight	32 lb (14.5 kg) (with no options)
Operating Temperature	32° F to 122° F (0° C to 50° C)
Humidity	0% to 95%, non-condensing (75% for > 25° C; 45% for > 40° C)
Power	100/120/220/240 V AC ±10% 50-60 Hz
Display	12-digit LED, sectionalized
Test	Front-panel selected diagnostics
Accuracy	±1 count ± timebase error
Sample Rate	Controls time between measurements; variable from 100 ms (typical) to 10 seconds; switchable Hold postition freezes display indefinitely
Reset	Resets display to zero and initiates new reading
Offsets	Keyboard control of frequency offsets (standard) and power offsets (with power-measurement Option 02); displayed frequency (power) is offset by entering a value to 1 Hz resolution (0.1 dB power)
Resolution	0.1 Hz to 1 GHz (0.1 Hz resolution in Band 1 only; no frequency offset or multiplier in 0.1 Hz resolution)
Gate Time	1 ms for 1 KHz resolution; 1 second for 1 Hz resolution

SPECIFICATIONS (Continued)

BAND 1

Frequency Range	10 Hz to 100 MHz
Sensitivity	25 mV rms
Impedance	1 MΩ/20 pF
Connector	BNC (female)
Maximum Input Level	1 V rms
Damage Level	150 V rms (above 1 kHz, damage level will decrease at 6 dB/octave down to 3.0 V rms)

BAND 2

Frequency Range	10 MHz to 1 GHz
Dynamic Range	30 dB
Sensitivity	–20 dBm
Impedance	50 Ω nominal
Connector	BNC (female)
Max. Input Level	+10 dBm
Damage Level	+27 dBm
Aquisition Time	<50 ms

BAND 3

Frequency Range	1 GHz to 20 GHz (26.5 GHz for Model 548B)
Dynamic Range	40 dB (1 GHz to 12.4 GHz) 35 dB (12.4 GHz to 20 GHz) 30 dB (20 GHz to 26.5 GHz) Model 548B only
Sensitivity	–30 dBm (1 GHz to 12.4 GHz) –25 dBm (12.4 GHz to 20 GHz) –20 dBm (20 GHz to 26.5 GHz) Model 548B only
Impedance	50 Ω nominal
Connector	Model 545B: Precision Type N (female) Model 548B: APC 3.5 (female)

SPECIFICATIONS (Continued)

BAND 3 (Continued)

Max. Input Level	±10 dBm
Damage Level	30 watts (+45 dBm)
Aquisition Time	< 200 ms independent of frequency
Amplitude Discrimination	10 dB (if <10 dB, will count one signal accurately if separated by >200 MHz)
FM Modulation	20 MHz p-p up to 10 MHz rate
VSWR	< 2.5:1 typical
Frequency Limits	Keyboard control of desired limits (standard). The Counter measures the largest signal within the programmed limits. Signals outside the operating band must be separated by at least 100 MHz from either limit. For signals more than 10 dB above the desired signal, the required separation is typically 200 MHz.

TCXO TIMEBASE

Frequency	10 MHz
Aging Rate	$< 1 \times 10^{-7}$/month; $< 1 \times 10^{-6}$/year
Short Term Stability	$< 1 \times 10^{-9}$ rms for one second averaging time
Temperature Stability	$< 1 \times 10^{-6}$ over the range 0° C to 50° C when set at 25° C
Line Variation	$< 1 \times 10^{-7}$ (±10% line voltage change)
Warm-up Time	30 minutes
Output Frequency	10 MHz; square wave; 1 V p-p minimum into 50 Ω
External Timebase Input	Requires 10 MHz at 1 V p-p minimum into 300 Ω
Phase Noise	–95 dBc/Hz at 10 Hz from carrier

DIGITAL-TO-ANALOG CONVERTER (OPTION 01)

Output Voltage	0.000 V to 0.999 V
Accuracy (25 °C)	±0.5% ±1 mV
Temperature Stability (0° C to 50° C)	±0.01%/°C
Resolution	1 mV
Load Impedance	1 KΩ minimum
Connector	BNC female (on rear panel)
Protection	±10 V ac or dc applied to output connector will not cause damage. No damage will occur from any load.

POWER METER (OPTION 02)

Range	Entire operating range of Band 3
Accuracy	±1.2 dB typical at 0° C to 50° C ± 0.5 dB typical at 25° C
Resolution	0.1 dB from sensitivity to –10 dBm 0.2 dBm to maximum input
Power Offset	Math function. Allows the displayed reading to be offset to 0.1 dB resolution. Selectable from the front panel or via GPIB.
Conversion Time	1 gate time + 50 ms

OVENIZED HIGH-STABILITY TIMEBASE (OPTION 05)

Frequency	10 MHz
Aging Rate	$< 5 \times 10^{-10}$/24 hours (after 24-hour warm-up); 1×10^{-7}/year
Short Term Stability (1 sec. avg.)	$< 1 \times 10^{-10}$ rms
Temperature Stability	$< 3 \times 10^{-8}$ over the range of 0° C to 50° C
Line Variation	$< 2 \times 10^{-10}$ (±10% line-voltage change)
Phase Noise	–120 dBc/Hz at 10 Hz from carrier

FREQUENCY EXTENSION (548B ONLY) (OPTION 06)

Frequency	26.5 GHz to 110 GHz
Sensitivity	–25 dBm typical
Dynamic Range	30 dB
Connector	As required by remote sensor
Maximum Input Level	+5 dBm
Damage Level	+ 10 dBm
Amplitude Discrimination	10 dB
Acquisition Time	< 1 second

Remote Sensor	Band	Frequency Range (GHz)	Waveguide Size	Waveguide Flange	Power Range (dBm)	Damage Level (dBm)
91	4-1	26.5 - 40	WR-28	UG-599/U	–20 to +5	+10
92	4-2	40 - 60	WR-19	UG-383/U	–20 to +5	+10
93	4-3	60 - 90	WR-12	UG-387/U	–15 to +5	+10
94	4-4	90 - 110	WR-10	UG-387/U	–15 to +5	+10
95	4-2 or 4-3	50 - 75	WR-15	UG-385/U	–20/–15 to +5	+10
96	4-1 or 4-2	33 - 50	WR-22	UG-383/U	–20 to +5	+10
97	4-1 or 4-2	26.5 - 50	2.92 mm, female, coax (K-Connector®)*	—	–20 to +5	+10

* K-Connector® is a registered trademark of the Wiltron Company.

REAR-PANEL INPUT CONNECTORS (OPTION 09)

Band 1 Connector	BNC (female)
Band 2 Connector	BNC (female)
Band 3 Connector	Model 545B: Precision Type N (female) Model 548B: APC 3.5 (female)

OPTIONS

OPTION	DESCRIPTION
01	Digital-to-Analog Converter
02	Power Meter
05	Ovenized High-Stability Timebase (Aging Rate: 5 x 10^{-10}/day)
06	Band 4 Frequency Extension Module. Available on Model 548B only. Required for frequencies between 26.5 GHz and 110 GHz. Frequency Extension Cable Kit (590) and remote sensor are also required.
09	Rear-Panel Input Connectors
14	Two-Year Warranty Extension (three years total)
15	MIL-STD-45662A (ANSI Z540-1:94) Calibration Compliance

ACCESSORIES

ACCESSORY	DESCRIPTION
010	Carrying Case
031	Operation Manual (one supplied with each instrument)
032	Operation and Service Manual
040	Service Kit
101	Rack-Mount Kit with Chassis Slides and Handles
102	Rack-Mount Kit with Chassis Slides without Handles

The following accesories are for use with Model 548B only and require Option 06:

091	Remote Sensor 26.5 GHz to 40 GHz (WR-28)
092	Remote Sensor 40 to 60 GHz (WR-19)
093	Remote Sensor 60 GHz to 90 GHz (WR-12)
094	Remote Sensor 90 GHz to 110 GHz (WR-10)
095	Remote Sensor 50 GHz to 75 GHz (WR-15)
096	Remote Sensor 33 GHz to 50 GHz (WR-22)
097	Remote Sensor 26.5 GHz to 50 GHz (2.92 mm coax)
590	Frequency Extension Cable kit

DECLARATION OF CONFORMITY

DECLARATION OF CONFORMITY

Application Of Council Directive 89/336/EEC

Standards to which Conformity is Declared:

EMC: EN50011
EN50082-1

Standards to which Compliance is Declared:

Safety: IEC 1010-1 (1990)

Manufacturer's Name:	EIP/Phase Matrix, Inc.
Manufacturer's Address:	109 Bonaventura Dr. San Jose, CA 95134
Type of Equipment:	Frequency Counter
Model Name(s):	545B/548B
Tested By:	Rockford Engineering Services, Inc. 9959 Calaveras Road Sunol, CA 94586 USA
Project Engineer:	Mr. Bruce Gordon and Leo Hernandez
Reviewer:	Mr. Michael Gbadebo, P.E.

I, the undersigned, hereby declare that the equipment specified above conforms to Directives and Standards listed.

For: **Phase Matrix, Inc.**

Name: Mark Espinosa
Title: QA Manager

Signature: Mark Espinosa

Date: 11/01/2004

2

INSTALLATION

UNPACKING

The Phase Matrix 545B and 548B series CW Microwave Frequency Counters arrive ready for operation. Carefully inspect the shipping carton for any sign of damage. If the carton is damaged, immediately notify shipper's agent.

Remove the packing carton and supports, being careful not to mar or damage the instrument. Make a complete visual inspection of the counter, checking for any damage or missing components. Check that all switches and controls operate mechanically. Report any damage to Phase Matrix immediately.

INSTALLATION

There are no special installation instructions for these counters. They are self-contained bench or rack-mount instruments that require only a connection to a standard, single-phase power line for operation.

CAUTION

To prevent damage to the counter, do not connect the power cord to your AC line-voltage source until you have set the counter for the available AC line voltage (see Voltage Selection on page 2-2).

PREPARATION FOR USE

VOLTAGE SELECTION

The voltage-selection switch must be set for the available AC line voltage. Use the following procedure to set the voltage-selection switch:

1. Verify that the power cord is *NOT* connected to a power source.

CAUTION

To prevent damage to the counter, never change the setting of the voltage-selection switch while the power cord is connected to a power source.

2. Insert the tip of a flat-bladed screwdriver into the slotted voltage indicator to the left of the power-cord socket on the counter's rear panel (see Figure 2-1).
3. Turn the voltage indicator so it points to the value of the available AC line voltage.

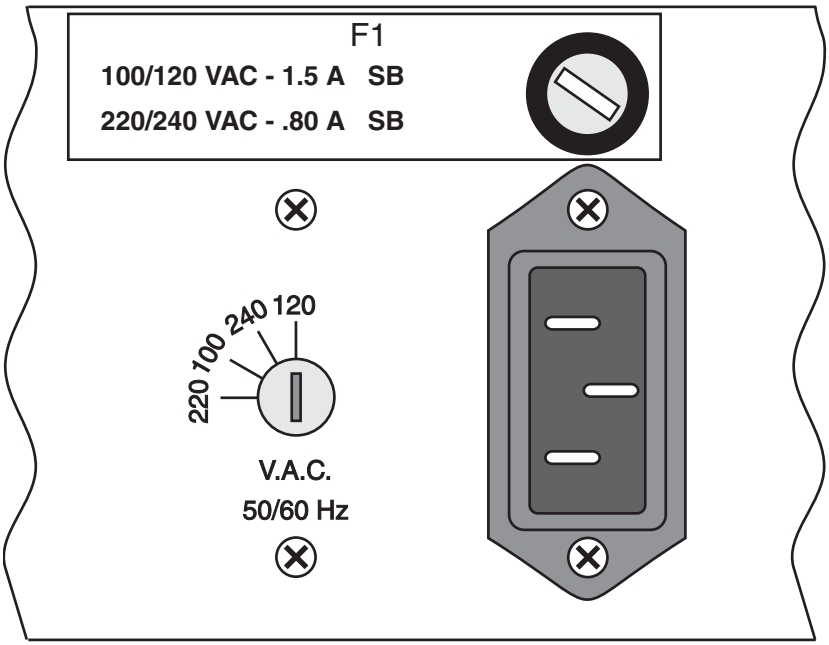

Figure 2-1. Fuse, Voltage-Selection Switch, and Power-Cord Socket

CAUTION

After setting the Voltage Selection switch, verify that the fuse (F1) is of the correct size and type before turning the counter on. If the fuse is not correct, remove it and install the proper fuse (see "Fuse Verification and Replacement" on page 2-3).

FUSE VERIFICATION AND REPLACEMENT

The counter's fuse holder is on the rear panel above the power-cord socket. The line voltage you use to power the counter determines the rating and type of fuse that must be installed in the fuse holder:

- 100/120 VAC: 1.5 A Slow-blow MDL
- 200/220 VAC: 0.80 A Slow-blow FST

Use the following procedure to access the fuse and to determine whether it is the correct fuse for the line voltage you have available:

WARNING

To prevent injury from electrical shock, verify that the power cord is NOT connected to a power source before proceeding.

1. Insert the tip of a flat-bladed screwdriver into the slotted fuse-holder cap above the power-cord socket on the counter's rear panel (see Figure 2-1 on page 2-2).
2. Carefully turn the screwdriver counterclockwise until the cap pops out of the fuse holder.
3. Remove the fuse-holder cap, and remove the fuse from the cap.
4. Inspect the fuse to determine its rating and type, and compare it to the fuse types listed above.
5. If the fuse is *NOT* the correct type for the available line voltage, obtain the correct fuse and insert it in the fuse-holder cap. If the fuse IS the correct type for the available line voltage, reinsert it in the fuse-holder cap.

CAUTION

To prevent damage to the counter, always ensure that the fuse is of the correct type and rating and that the voltage-selection switch is set to the same value as the available line voltage.

6. Insert the fuse and slotted-cap assembly into the fuse holder, press it in against the spring, and use a flat-tipped screwdriver to rotate the cap clockwise until it locks into place.

INCOMING OPERATIONAL CHECKOUT

The following procedure, which can be performed without special tools or equipment, is designed to check the basic operation of the counter (for more extensive testing, see Section 5, "Operational Verification Tests"):

CAUTION

To prevent damage to the counter, always ensure that the fuse is of the correct type and rating and that the voltage-selection switch is set to the same value as the available line voltage.

1. Connect the power cord to an appropriate single-phase power source. The ground prong on the power cord plug must always be properly grounded.
2. Turn the **POWER** switch on. The display activates (showing dashes) for approximately one second. The counter then displays all zeros, which indicates that the automatic self-test completed successfully.
3. Press: TEST, 0, 1. The display should read 200 000 000 ±1.
4. Press: TEST, 0, 2. The display should read all 8s, and all annunciators should be activated.
5. Press: TEST, 0, 3. Each display segment should activate in sequence.
6. Press: TEST, 0, 4. Each display digit should activate in sequence.
7. Press: CLEAR DISPLAY. This completes the incoming operational checkout procedure.

SERVICE INFORMATION

PERIODIC MAINTENANCE

No periodic maintenance is required. However, to maintain accuracy, Phase Matrix recommends that the counter be recalibrated every 12 months. For further information, refer to Section 6.

CAUTION

Do not attempt to repair or disassemble the microwave converter, millimeter wave converter, or timebase-oscillator assemblies. Such actions void the counter's warranty. Contact Phase Matrix or your sales representative if you think these assemblies require service.

AIR CIRCULATION

Air circulates through the vents in the rear panel of the counter. If these vents become obstructed, the termperature inside the counter may increase enough to reduce stability and shorten component life.

WARNING

To protect your health, do not attempt to disassemble or repair the microwave-converter assembly. This assembly contains beryllia (beryllium oxide), which, if handled improperly, could pose a health hazard.

COUNTER IDENTIFICATION

This counter is identified by three sets of numbers: the model number (545B or 548B), serial number, and a configuration control number (CCN). These numbers are located on a label affixed to the frame at the rear of the counter. The model number, CCN, serial number, and the numbers of any options must be included in any correspondence regarding your counter. A typical serial-number label is shown in Figure 2-2.

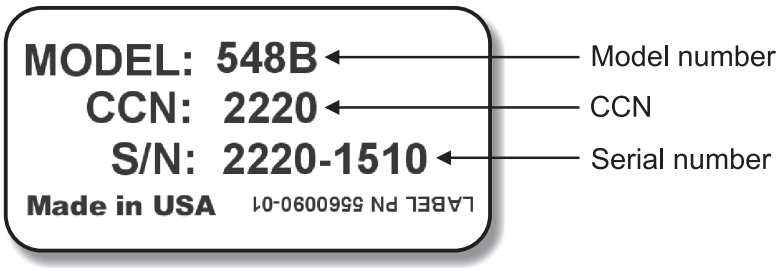

Figure 2-2. Model/Serial Number Label

FACTORY SERVICE

If the counter is being returned to Phase Matrix for service or repair, be sure to include the following information with the shipment:

- Name and address of owner.
- Model, complete serial number, and CCN of the counter.
- A complete description of the problem. (Under what conditions did the problem occur? What was the signal level? What equipment was attached or connected to the counter? Did that equipment experience failure symptoms?)
- Name and telephone number of someone familiar with the problem that may be contacted by Phase Matrix for any further information if necessary.
- Shipping address to which the counter is to be returned. Include any special return-shipping instructions.
- Visit our web site at www.phasematrix.com for additional return information.

SHIPPING INSTRUCTIONS

Wrap the counter in heavy plastic or kraft paper, and repack it in the original container, if available. If the original container cannot be used, use a heavy (275-pound test), double-walled carton with approximately four inches of packing material between all surfaces of the counter and the inner carton. Seal the carton with strong filament tape or strapping. Mark the carton to indicate that it contains a fragile electronic instrument. Clearly mark the carton to indicate that the contents were manufactured in the U.S.A. and that it contains a fragile electronic instrument.

3

OPERATION

INTRODUCTION

This section lists the counter controls, connectors, and indicators, explains how each counter function operates, and provides some general measurement considerations.

FRONT-PANEL CONTROLS, INDICATORS, AND CONNECTORS

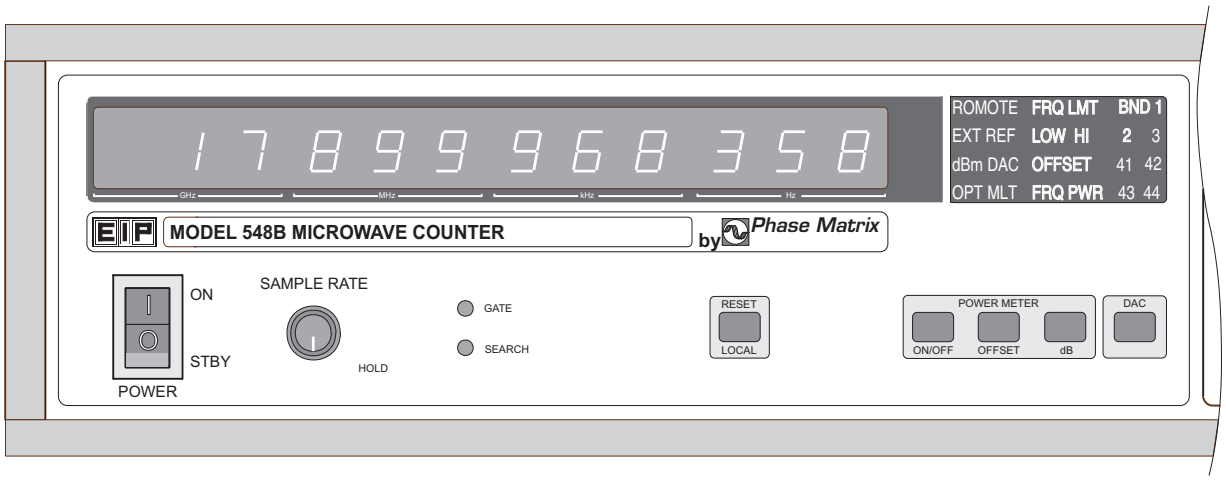

Figure 3-1. Front-Panel Controls and Indicators

- **POWER** switch — selects ON or STBY. In the standby position power is applied to the oven oscillator.
- **SAMPLE RATE/HOLD** control — varies the time between measurements from 0.1 to 10 seconds (nominal). (Gate time is added to sample time, so the minimum reading for 1 Hz resolution is 1.1 seconds.)The last reading is retained indefinitely in HOLD until reset is issued.
- **GATE** indicator — lights when the signal gate is open and a measurement is being made.

- **SEARCH** indicator — lights when the counter is not locked to an input signal.
- Data display — The 12-digit numeric display provides direct read-out of measurement data. Frequency data is displayed in a fixed-position format that is sectionalized in GHz, MHz, kHz and Hz. When the power meter is active (548B only), power readings are displayed in dBm to 0.1 dB resolution on the three right-most digits of the display. When both power and frequency readings are displayed, resolution is limited to 100 kHz.
- Status display — Various annunciators indicate the current operating status of the counter (see Figure 3-2).
- Keyboard — Both data entry and function selection are controlled through the keyboard (see Keyboard Operation on page 3-5).

STATUS DISPLAY

REMOTE	FRQ LMT		BND	1
EXT REF	LOW	HI	2	3
dBm DAC	OFFSET		41	42
OPT MLT	FRQ PWR		43	44

Figure 3-2. Status Display

- **EXT REF** — lights to indicate the counter is set to an external timebase reference.

NOTE

When EXT REF lights, it does **NOT** indicate that the correct signal level has been applied.

- **dBm** — lights to indicate that the Power Meter (Option 02) is active.
- **RMT** — lights to indicate that front panel controls are disabled, and that the counter is being controlled through the GPIB interface.
- **DAC** — lights to indicate that that the Digital-to-Analog Converter (Option 01) is active.
- **OPT** — lights to indicate that a special option is active.
- **MLT** — lights to indicate the multiplier function is active.
- **FRQ LMT LOW** — lights when Band 3 frequency limit low is active.
- **FRQ LMT HI** — lights when Band 3 frequency limit high is active.
- **OFFSET FRQ** — lights when frequency offset is active.
- **OFFSET PWR** — lights when power offset is active.

- **BND 1, 2, 3, 41, 42, 43,** or **44** — lights to indicate which operating range has been selected. When any Band 4 annunciator is lit it indicates that the Extended Frequency Capability (Option 06) has been selected (548B only).

SIGNAL-INPUT CONNECTORS

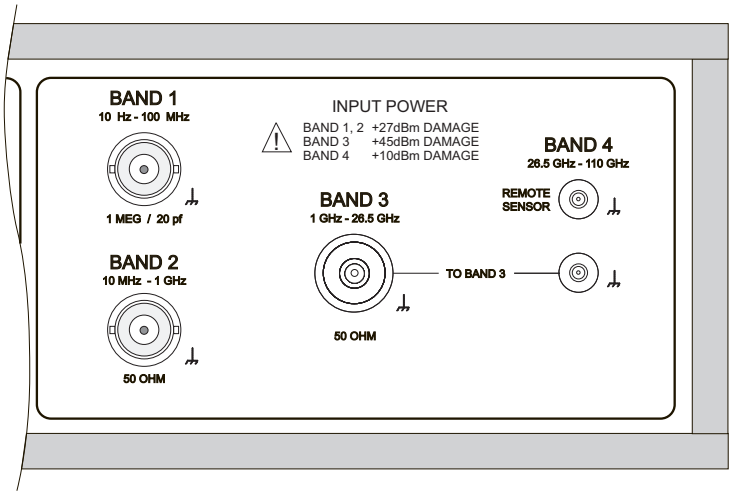

Figure 3-3. Signal Input Connectors (Model 548B Shown)

- **BAND 1** input connector (BNC female) — has a nominal input impedance of 1 MΩ shunted by 20 pF. It is used for measurements in the range of 10 Hz to 100 MHz.
- **BAND 2** input connector (BNC female) — has a nominal input impedance of 50 Ω It is used for measurements in the range of 10 MHz to 1 GHz.
- **BAND 3** input connector (precision type N female for the Model 545B, APC-3.5 female for Model 548B) — has a nominal input impedance of 50 Ω It is used for measurements in the range of 1 GHz to 20 GHz (26.5 GHz for Model 548B).
- **BAND 4** input connector (Bulkhead SMA female) (Option 06, Model 548B only) — has a nominal input impedance of 50 Ω It is used for measurements in the range of 26.5 GHz to 110 GHz. This input is used in conjunction with the Model 590 Frequency Extension Cable Kit and a remote sensor.

REAR-PANEL CONTROLS AND CONNECTORS

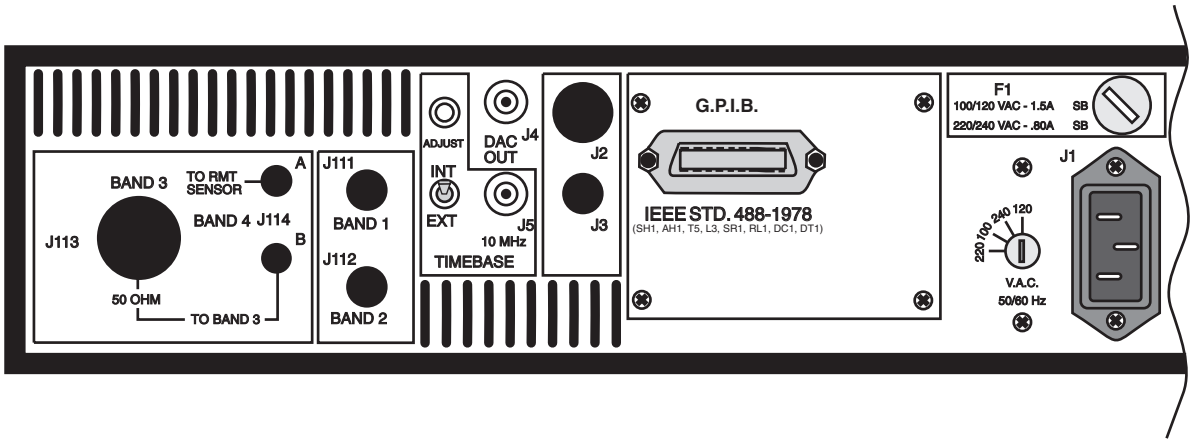

Figure 3-4. Rear-Panel Connectors and Controls

- Items labeled **BAND 1, BAND 2, BAND 3, BAND 4**, and **TO RMT SENSOR** — used only on instruments equipped with Option 09, Rear Panel Input.
- **TIMEBASE INT/EXT** switch — selects either the internal timebase or an external 10 MHz reference signal.
- **TIMEBASE** connector (BNC female) — allows monitoring of internal 10 MHz timebase or input of an external 10 MHz reference signal.
- **DAC OUT** connector (BNC female) — provides an analog voltage proportional to any specified three digits of frequency displayed,(in instruments equipped with Option 01, Digital-to-Analog Converter).
- **G.P.I.B.** connector — is used for remote operation with the IEEE 488-1978 General Purpose Interface Bus.
- **F1** fuse — provides current overload protection.
- **V.A.C.** switch — sets the operating voltage of the counter to match power line voltage.

CAUTION

The V.A.C. switch setting and the fuse rating must match the power-line voltage. Refer to Section 2, "Installation**," for more information.**

- **AC-power** connector — accepts the power cord supplied with the counter.

INSTRUMENT DEFAULT SETTINGS

When the counter is initially turned on, the state of the counter is determined by a set of default values that are stored in memory. The factory-set (default) values for all instrument settings are listed in Table 3-1.

Table 3-1. Instrument Default Settings

Parameter	Default Value
Band	3 (microwave band)
Subband	N/A
Resolution	0 (1 Hz)
Frequency Multiplier	01
Frequency Offset	0 Hz
Frequency Limit Low	950 MHz
Frequency Limit High	20.5 GHz (Model 545B) 26.7 GHz (Model 548B)
Frequency Display	On

KEYBOARD OPERATION

The keyboard consists of 16 push-button keys that control the major functions of the counter (see Figure 3-5).

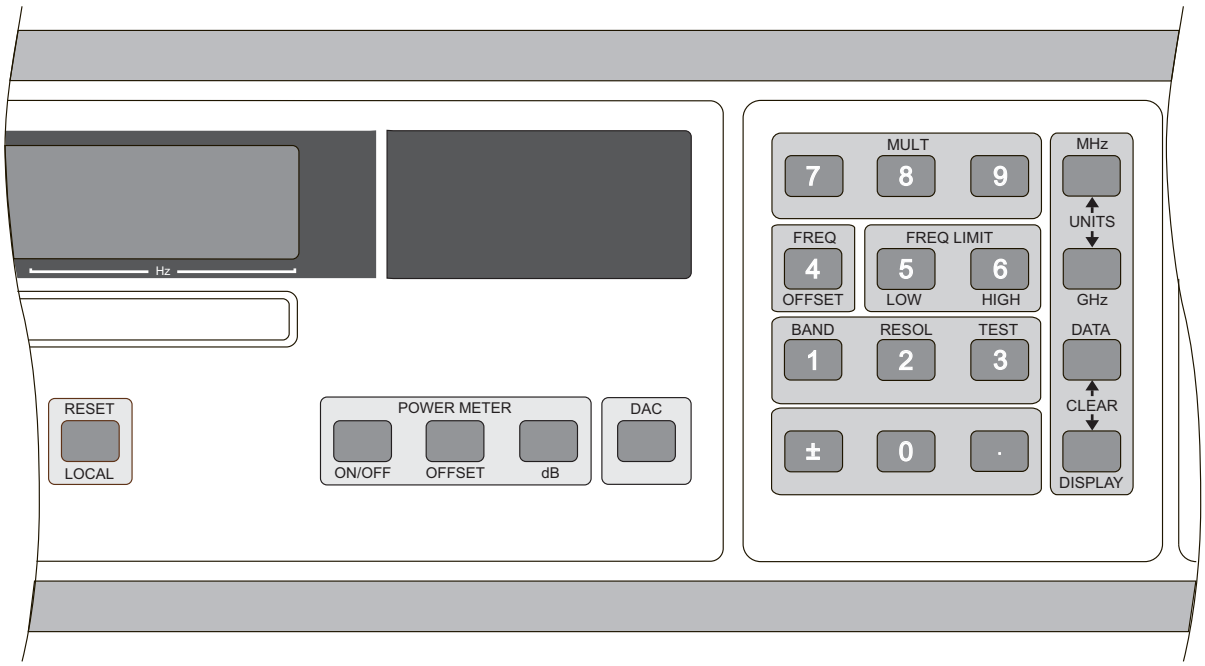

Figure 3-5. Keyboard

NUMERIC ENTRY KEYS

Twelve keys are used for numerical data entry — the digits 0 through 9, the decimal point, and the change sign (±) key.

TERMINATOR KEYS

Two keys (MHz and GHz) act as terminators for the input of frequency offset, frequency limits, and/or phase-lock frequency. The CLEAR DISPLAY and CLEAR DATA keys are also considered terminator keys.

RESET/LOCAL

RESET/LOCAL is a dual-function key. When the counter is in remote mode, pressing the **RESET/LOCAL** key once causes the counter to return to local mode. When the counter is in local mode, pressing the **RESET/LOCAL** key resets the counter and converter and initiates a new measurement.

CLEAR DISPLAY AND CLEAR DATA KEYS

These are also considered terminator keys. At any point during a key sequence, the user has the option either to:

- Press CLEAR DISPLAY to abort the sequence and return to normal operation without changing the value
- Press DATA CLEAR to abort the sequence and assign the default value to the called parameter. This

COUNTER CONTROL FUNCTIONS

BAND SELECTION

The operation of the counter is controlled by the values of the measurement parameters. These parameters can be changed by the user through the keyboard or via GPIB.

BAND

The **BAND** key followed by a numeric key selects the band and thereby controls the frequency measurement range. Select the appropriate band according to Table 3-2 on page -7.

Table 3-2. Band Key

Band	Range
1	10 Hz to 100 MHz
2	10 MHz to 1 GHz
3	1 GHz to 20 GHz (Model 545B) 1 GHz to 26.5 GHz (Model 548B)
4	26.5 to 110 GHz (Optional - Model 548B only)

KEYBOARD EXAMPLES:

Press: BAND [1] to select Band 1.

Press: BAND [2] to select Band 2.

Press: BAND [3] to select Band 3.

GPIB EXAMPLES

Enter: OUTPUT 719;"B1" to select Band 1.

Enter: OUTPUT 719;"B2" to select Band 2.

Enter: OUTPUT 719;"B3" to select Band 3.

On a Model 578B counter equipped with Option 06, four additional frequency bands can be selected (bands 4-1 through 4-4). Select the appropriate band according to Table 3-3.

Table 3-3. Band Key (for Bands 4-1 through 4-4)

Band	Range
4-1	26.5 GHz to 40 GHz
4-2	40 GHz to 60 GHz
4-3	60 GHz to 90 GHz
4-4	90 GHz to 110 GHz

KEYBOARD EXAMPLES:

Press: BAND [4] [X] where X is a number between 1 and 4.

Press: BAND [4] [2] to select Band 4-2.

GPIB EXAMPLES:

Enter: OUTPUT 719;"42" to select Band 4-2.

Enter: OUTPUT 719;"44" to select Band 4-4.

RESOLUTION / GATE TIME SELECTION

Pressing the RES key followed by a numeric key between 0 and 9 sets the least significant digit of the display as a power of 10, thereby selecting measurement resolutions from 1 Hz to 1 GHz. Since the gate time is determined by the selected resolution, this key also (indirectly) selects the gate time.

KEYBOARD EXAMPLES:

Press: [RES] [0] to select 1 Hz resolution (1 second gate time).

Press: [RES] [1] to select 10 Hz resolution (.1 second gate time).

Press: [RES] [2] to select 100 Hz resolution (.01 second gate time).

Press: [RES] [3] to select 1 kHz resolution (1 ms gate time).

Press: [RES] [4] to select 10 kHz resolution (1 ms gate time).

Press: [RES] [9] to select 1 GHz resolution (1 ms gate time).

GPIB EXAMPLES:

Enter: OUTPUT 719;"R0" to select 1 Hz resolution.

Enter: OUTPUT 719;"R1" to select 10 Hz resolution.

Enter: OUTPUT 719;"R6" to select 10 MHz resolution.

Enter: OUTPUT 719;"R9" to select 1 GHz resolution.

0.1 Hz Resolution

In Band 1 only, the counter also provides 0.1 Hz resolution. When 0.1 Hz is selected in Band 1, the significance of the digits on the front panel display is shifted left 3 digits. For example, a 9 MHz signal input is displayed as 9 GHz. One digit is displayed to the right of the decimal, and the two right-most digits are blanked out. The display digit to the right of the decimal remains at zero until the measurement is updated at the end of the 10-second gate interval.

KEYBOARD EXAMPLE:

Press: [BAND] [1] to select Band 1.

Press: [RES] [.] [1] to select 0.1 Hz resolution.

GPIB EXAMPLES:

Enter: OUTPUT 719;"B1" to select Band 1.

Enter: OUTPUT 719;"R.1" to select 0.1 Hz resolution.

FREQUENCY LIMITS

The frequency-limit keys enable entry of low and/or high frequency limits to 10 MHz resolution in Band 3. The converter is reset after the entry sequence is complete.

TO INPUT FREQUENCY LIMITS:

KEYBOARD EXAMPLE:

Press: [BAND] [3] to select Band 3.

Press: [FREQ LIMIT low] to display the low-frequency limit last entered. (Notice flashing annunciator.)

Press: [#] (the corresponding number key) to select the desired frequency low limit to 10 MHz resolution.

Press [MHz] or [GHz] to terminate the input sequence. (Notice that the **FRQ LMT LOW** annunciator is solidly lit after the terminator key is released.)

Press: [FREQ LIMIT low] [2] [GHz] to set a low-frequency limit of 2 GHz.

Press: [FREQ LIMIT high] to display the high-frequency limit last entered. (Notice flashing annunciator.)

Press: [#] (the corresponding number key) to select the desired frequency low limit to 10 MHz resolution.

Press [MHz] or [GHz] to terminate the input sequence. (Notice that the **FRQ LMT HI** annunciator is solidly lit after the terminator key is released.)

Press: [FREQ LIMT high] [6] [GHz] to set a low-frequency limit of 6 GHz.

GPIB EXAMPLES:

Enter: OUTPUT 719;"FL2GHZ" to select a low frequency limit of 2 GHz.

Enter: OUTPUT 719;"FH6GHZ" to select a high frequency limit of 6 GHz.

TO DISPLAY STORED LIMITS

KEYBOARD EXAMPLES:

Press [FREQ LIMIT low] or [FREQ LIMIT high] to display the stored low/high-frequency limits.

Press [CLEAR DISPLAY] to return the counter to measurement-display mode.

TO CLEAR FREQUENCY LIMITS

KEYBOARD EXAMPLE:

Press [FREQ LIMIT low] [DATA CLEAR] or [FREQ LIMIT high] [DATA CLEAR] to clear the stored low/high-frequency limits.

> **NOTE**
>
> High and low limits must be separated by at least 100 MHz.

GPIB EXAMPLES:

Enter: OUTPUT 719;"FLP" to reset low frequency limit to factory default.

Enter: OUTPUT 719;"FHP" to reset high frequency limit to factory default.

DATA MANIPULATION FUNCTIONS

FREQUENCY OFFSET

The frequency-offset function enables the entry of a positive or negative frequency offset to 1 Hz resolution. The offset is incorporated into the frequency measurement after the next gate.

TO INPUT FREQUENCY OFFSETS

KEYBOARD EXAMPLE:

Press FREQ OFFSET to display the frequency offset last entered. (Notice flashing annunciator.)

Press: # (the corresponding number key) to select the desired offset frequency to 1 Hz resolution.

Press MHz or GHz to terminate the input sequence. (Notice that the **FRQ OFFSET** annunciator is solidly lit after the terminator key is released.)

Press: FREQ OFFSET 2 GHz to set the frequency offset to 2 GHz.

GPIB EXAMPLES:

Enter: OUTPUT 719;"FO2GHZ" to select a 2 GHz frequency offset.

Enter: OUTPUT 719;"FOP" to clear a frequency offset.

TO DISPLAY A STORED OFFSET

KEYBOARD EXAMPLE:

Press FREQ OFFSET to display the stored frequency offset.

Press CLEAR DISPLAY to return the counter to measurement-display mode.

TO CLEAR FREQUENCY OFFSETS

KEYBOARD EXAMPLE:

Press FREQ OFFSET DATA CLEAR or FREQ OFFSET 0 GHz or FREQ OFFSET GHz .

GPIB EXAMPLE:

Enter: OUTPUT 719;"FOP" to remove all frequency offsets.

MULTIPLY FUNCTION

The multiply function multiplies the measured frequency by a positive integer between 1 and 99. The result is displayed to 1 kHz resolution. The multiplier is incorporated into the frequency measurement after the next gate.

TO ENTER A MULTIPLIER

KEYBOARD EXAMPLES:

Press MULT to display the multiplier last entered. (Notice flashing annunciator.)

Press # # (the corresponding number keys) to select the desired multiplier. (Notice the **MLT** annunciator is solidly lit after you release the second key.)

Press MULT 0 2 to set a frequency multiplier of 2.

GPIB EXAMPLES:

Enter: OUTPUT 719;"ML02" to set a frequency multiplier of 2.

Enter: OUTPUT 719;"ML99" to set a frequency multiplier of 99.

TO DISPLAY THE MULTIPLIER

KEYBOARD EXAMPLES:

Press MULT to display the stored frequency multiplier.

Press CLEAR DISPLAY to return the counter to measurement-display mode.

TO CLEAR A MULTIPLIER

KEYBOARD EXAMPLE:

Press MULT DATA CLEAR or MULT 0 1 .

GPIB EXAMPLE:

Enter: OUTPUT 719;"MLP" to clear the multiplier function.

mX±B

Using the frequency-offset and multiply functions together, the counter can automatically perform mX±B calculations.

The equation for the function performed is:

Displayed Reading = mX±B

where m = multiplier (00 to 99) entered from the keyboard, X = input frequency, and ±B = frequency offset entered from the keyboard.

TO DO AN MX±B CALCULATION FOR M = 2, B = 70 MHZ

KEYBOARD EXAMPLE:

Press [MULT] [0] [2] or [FREQ OFFSET] [7] [0] [MHz].

DAC

DESCRIPTION

The **DAC** key provides control of the optional digital-to-analog converter (Option 01). This key selects three consecutive display digits. The selected digits are converted to an analog voltage between 0 and .999 volts and applied to the rear-panel **DAC OUT** connector. The output voltage corresponds to the value shown on the numeric display, substituting zeros for any non-numeric characters that appear. The output is updated after every display update.

KEYBOARD OPERATION

To enable the DAC, press the **DAC** key followed by two digits (01-12). The number entered selects the most-significant digit.

KEYBOARD EXAMPLES:

Press [DAC] [0] [4] to select the 1 kHz, 100 Hz, and 10 Hz digits.

Press [DAC] [0] [7] to select the 1 MHz, 100 kHz, and 10 kHz digits.

Press [DAC] [0] [0] to turn off the DAC.

GPIB EXAMPLES:

Enter: OUTPUT 719;"DC04" to turn on the DAC and select the 1 kHz, 100 Hz, and 10 Hz digits.

Enter: OUTPUT 719;"DC07" to turn on the DAC and select the 1 MHz, 100 kHz, and 10 kHz digits.

Enter: OUTPUT 719;"DC12" to turn on the DAC and select the 100 GHz, 10 GHz, and 1 GHz digits.

Enter: OUTPUT 719;"DCP" to turn off the DAC.

POWER METER

DESCRIPTION

The **POWER METER** keys provide control of the optional power meter (Option 02). The powermeter option measures the power of signals applied to Band 3. The power measurement is displayed (to 0.1 dB resolution) simultaneously with frequency (to 100 kHz maximum resolution). For AM- and FM-averaging purposes, gate time is controllable in the power-meter mode through the resolution function. Power gate time mirrors frequency gate time. For example, in resolution 0, the frequency gate time is 1 second, and the power gate time is 1 second. In resolution 1, the frequency gate time is 100 ms, and the power gate time is 100 ms. Option 02 allows power offsets from –99.9 dB to 99.9 dB, with a 0.1 dB resolution and does not degrade the basic performance of the counter.

KEYBOARD OPERATION

To turn on the power meter, press the on/off key in the **POWER METER** section of the front panel.

KEYBOARD EXAMPLES:

Press on/off to activate or deactivate the power meter.

Press offset to activate the power-offset function.

Press dB to terminate the power-offset function.

GPIB EXAMPLES:

Enter: OUTPUT 719;"PA" to turn on the power meter.

Enter: OUTPUT 719;"PP" to turn off the power meter.

Enter: OUTPUT 719;"PO10DB" to set a power offset of 10 dB.

Enter: OUTPUT 719;"PO0DB" to clear a power offset.

Enter: OUTPUT 719;"OP" to disable offsets.

Enter: OUTPUT 719;"OA" to enable offsets.

THEORY OF OPERATION

The 545B and 548B counters automatically measure and display the frequency of an input signal within the range of 10 Hz to 20 GHz for the 545B and 10Hz to 26.5 GHz for the 548B. In both models, the frequency is divided into three bands:

BAND 1 operates from 10 Hz to 100 MHz. An impedance converter provides an input of 1 MΩ shunted by 20 pF.

BAND 2 operates from 10 MHz to 1 GHz using a heterodyne downconverter that converts the input signal into an output signal with a range of 10 MHz to 200 MHz.

BAND 3 operates in the microwave range of 1 to 20 GHz (or 26.5 GHz for the 548B) and uses a YIG-tuned heterodyne converter to translate the input frequency downward to an intermediate frequency (IF) of 127 MHz.

BASIC COUNTER

Overall operation is controlled by the Microprocessor Assembly, A105. This assembly contains an eight-bit microprocessor, its control logic, and the system memory. It communicates with all other assemblies in the instrument by means of a triple-bus system: the data, address, and control busses. There is a Peripheral Interface Adaptor (PIA) on each assembly that provides the interface between the bus system and the instrument hardware.

Frequency measurements are performed by comparing an unknown signal to a reference frequency, namely the time base. A 10 MHz crystal oscillator is used as the internal reference and is a part of the Gate Generator Assembly, A107. For increased accuracy and stability, an ovenized oscillator option is available, or the user may select an external10 MHz reference.

A frequency measurement is made by generating a time interval (Gate Time) consisting of a number of cycles of the reference. This Gate Time is then used as an interval during which the input signal is counted by the Count Chain Assembly, A106.

Initially, the microprocessor selects one of several available inputs to the Count Chain Assembly and the appropriate Gate Time based on user-input information: band selection, resolution, etc. The microprocessor then initiates the measurement cycle by resetting the Count Chain to zero and allowing a gate to be generated. During the gate interval, the Count Chain accumulates the number of cycles of the input signal. At the end of the gate time, the microprocessor reads the stored information in the Count Chain and performs any required calculations necessary to convert the measurement into a direct reading of the unknown frequency. The front panel display is then updated with the new measurement results. Figure 3-6 shows a simplified block diagram of the counter.

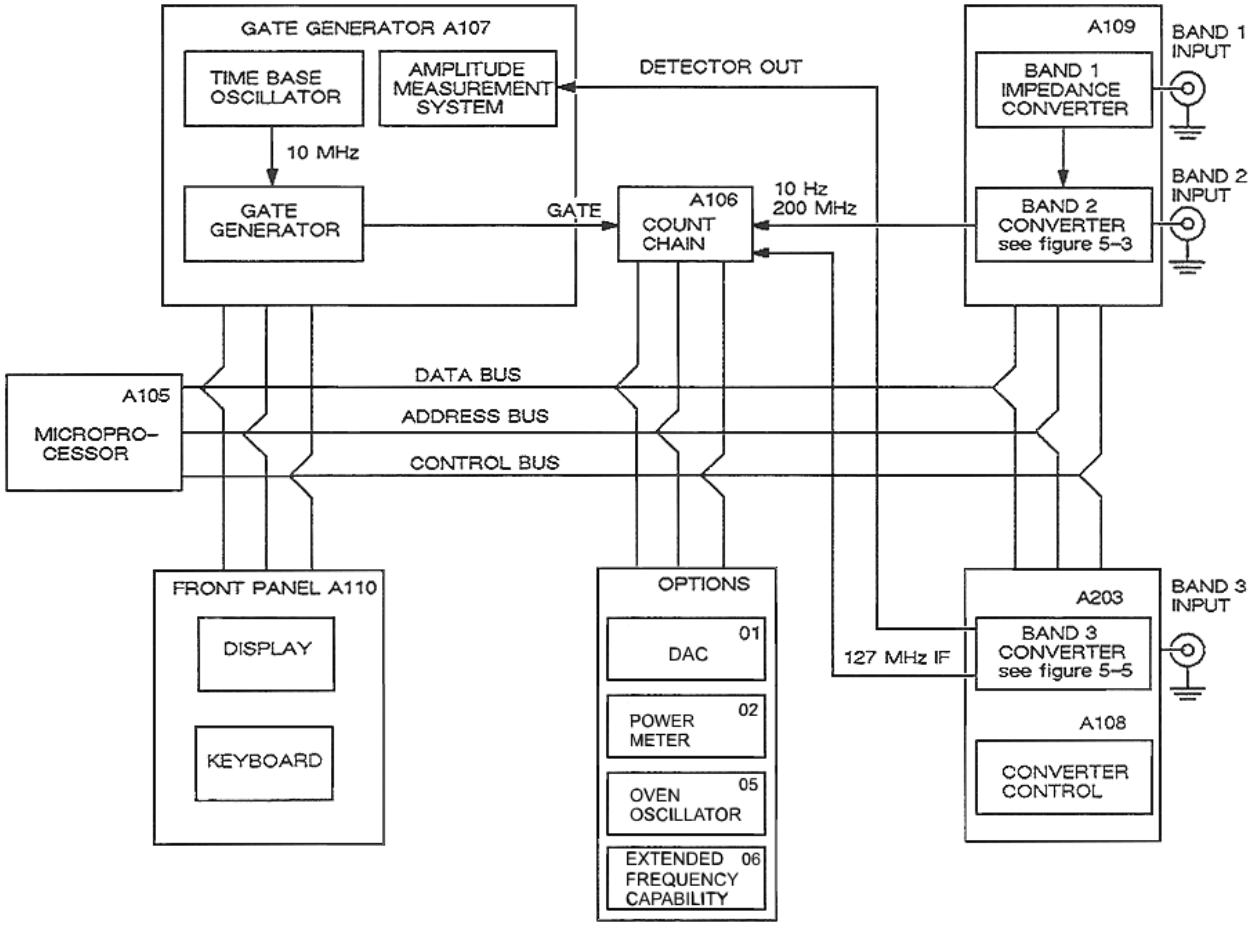

Figure 3-6. 545B/548B Counter Block Diagram (Simplified)

BAND 2 CONVERTER

An input signal is applied to the mixer along with an appropriate local oscillator (L0) to generate an IF frequency in the range of 10 MHz to 190 MHz. This signal is filtered and amplified to a level suitable for direct measurement by the Count Chain.

The LO frequency is generated by the Voltage-Controlled Oscillator (VCO) of the Band 3 Converter. This frequency is phase-locked to the counter's time base and controlled by the microprocessor. A VCO multiplier serves to either pass along the signal directly or double it. It can also turn off the signal and pass only a DC bias to the mixer.

Two detectors provide outputs proportional to the amplitudes of both the applied RF signal and the resulting IF signal. These outputs are compared in the Signal Comparator, which provides a digital output when the IF amplitude exceeds the RF amplitude.

The system's output frequency is the difference between the input signal and the LO applied to the mixer. Since the LO frequency is a harmonic (N) of the VCO frequency, the unknown input

frequency can be expressed as FIN = N Fvco ± FIF. There are three primary functions of the software operating the converter:

- To select the appropriate harmonic number N
- To select an appropriate VCO frequency
- To determine whether the IF frequency is added to or subtracted from the LO frequency.

These functions are accomplished by selecting N and Fvco and looking for an IF signal of the appropriate amplitude and frequency. Overall system gain is such that, whenever the correct LO frequency is applied, the IF power exceeds the RF power. This is the primary information used in determining the correct VCO frequency and harmonic number. Once an IF is obtained. the harmonic number is verified and the ± sign in the equation is determined by shifting the VCO frequency and observing the magnitude and direction of the resulting IF shift. A block diagram of the Band 2 converter is provided in FIGURE, and converter operation is diagrammed in Figure 5-3.

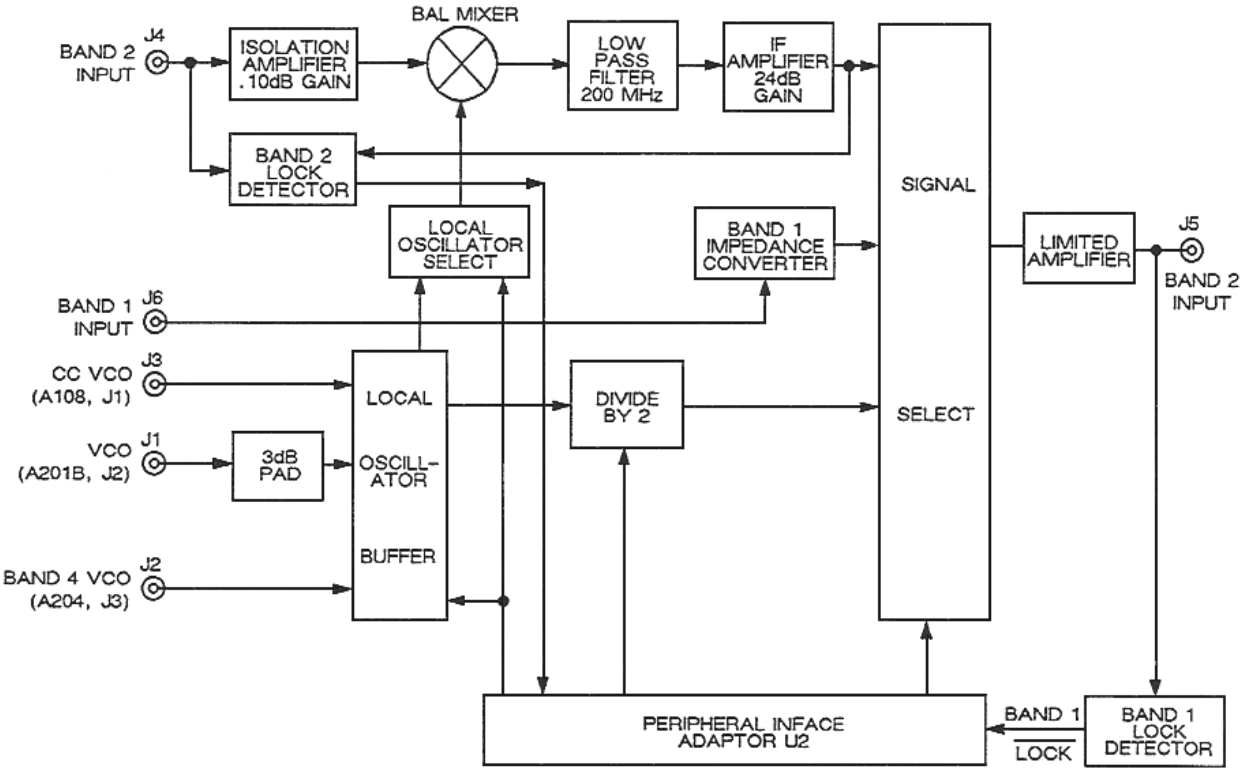

Figure 3-7. Band 2 Converter Block Diagram (Simplified)

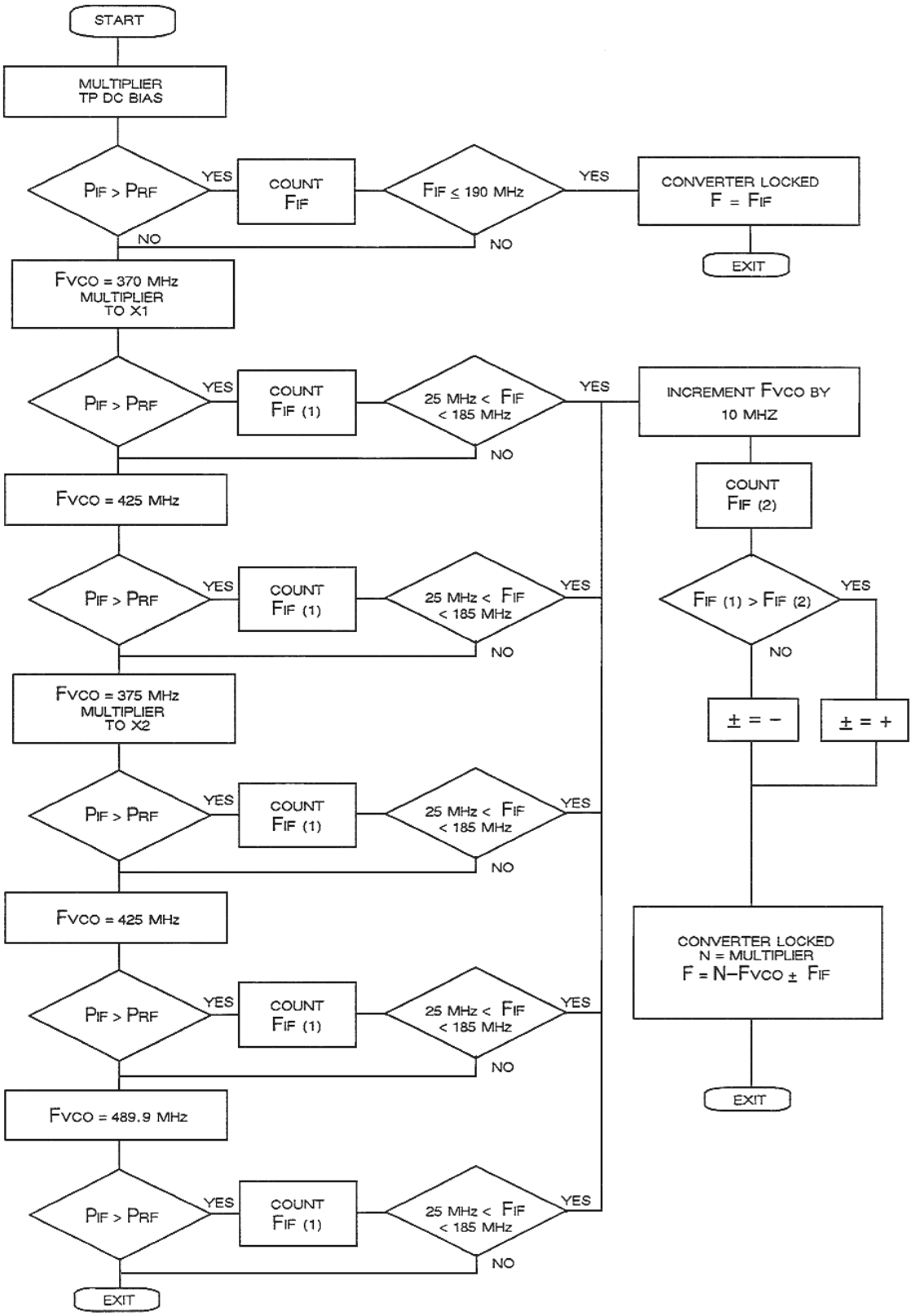

Figure 3-8. Band 2 Converter Operation

The LO frequencies being used, except for the range of direct counting (<190 MHz), have been selected so only IF frequencies from 25 MHz to 185 MHz are required. Since the counter can count signals less than 1 0 MHz, the restricted operating range provides margin for frequency modulation on the input signal and for incrementing the VCO frequency.

Table 3-4 shows the operating ranges for the various harmonics and VCO frequencies used.

Table 3-4. Band 2 Operating Ranges

Input Frequency Range FIN (MHz)	VCO Frequency Fvco (MHz)	Harmonic Number N	IF Frequency Range FIF (MHz)
10 – 190	—	0	10 – 190
185 – 345	370	1	185 – 25
345 – 400	425	1	80 – 25
400 – 560	375	1	25 – 185
560 – 610	425	1	135 – 185
610 – 725	375	2	140 – 25
725 – 825	425	2	125 – 25
825 – 935	375	2	75 – 185
935 – 1035	425	2	85 – 185
1035 – 1164.8	489.9	2	55.2 – 185

BAND 3 CONVERTER

Measurement of a signal in Band 3 is accomplished by downconverting from the microwave range to approximately 127 MHz. This is accomplished by mixing the input signal with a known reference frequency which is a harmonic of the VCO. The VCO frequency (400-500 MHz) can be selected in 50 kHz increments using a microprocessor-controlled phase-lock system while retaining the accuracy and stability of the counter's timebase reference.

A simplified diagram of the Band 3 converter is shown in Figure 5-5. There are two major assemblies: the Converter Control assembly (A108) and the Converter Assembly (A203).

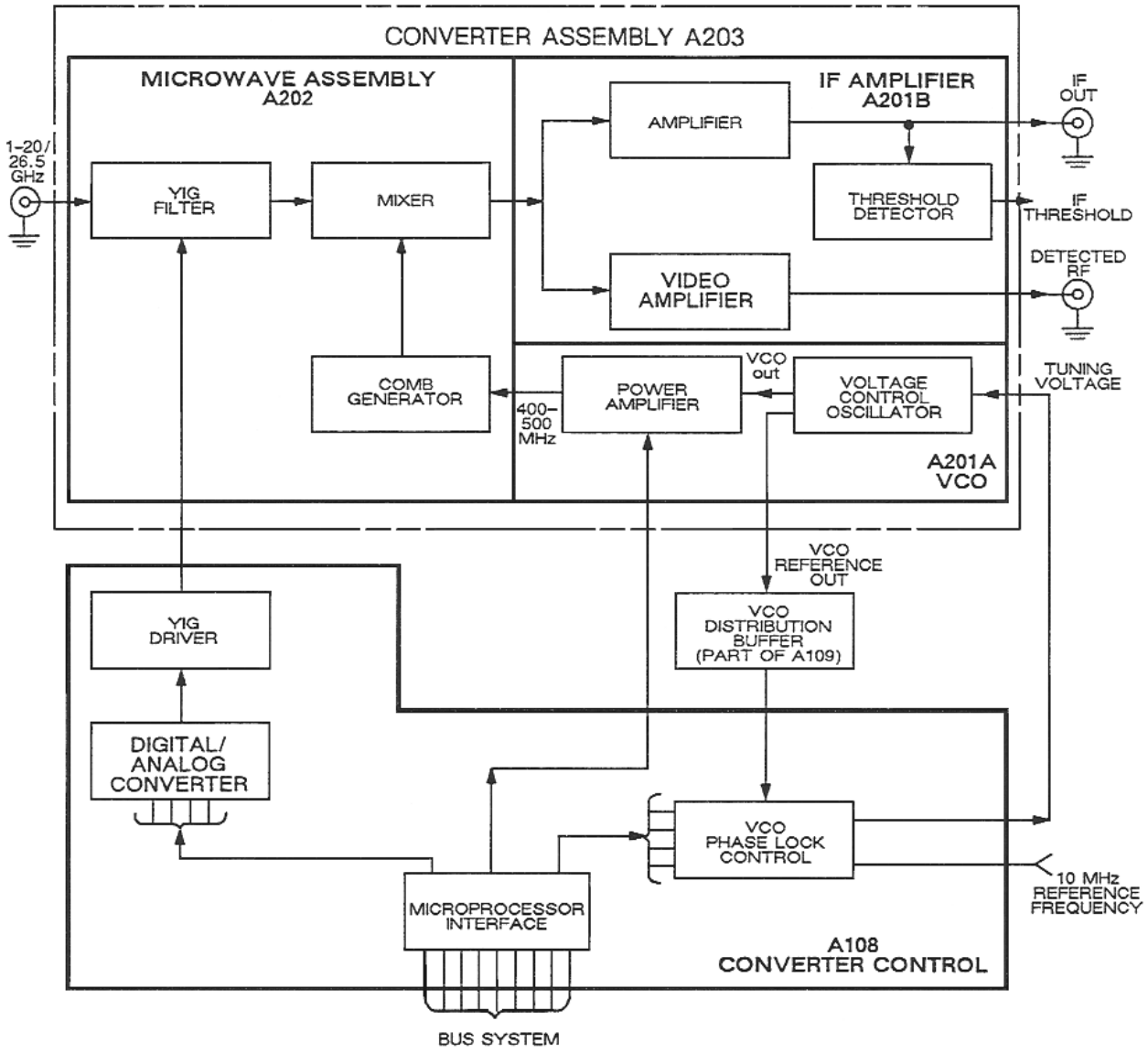

Figure 3-9. Band 3 Converter Block Diagram (Simplified)

CONVERTER CONTROL A108

The Converter Control assembly contains the interface between the microprocessor bus system and the Converter (A203). A digital-to-analog converter and a precision-current driver provide a 2 MHz frequency resolution for setting the YIG filter of A202.

A108 also contains the programmable-VCO phase-lock control system. This system makes it possible for the microprocessor interface to select any VCO frequency between 400 and 500 MHz in increments of 50 kHz.

CONVERTER A203

The Converter assembly consists of three subassemblies:

- A201 A — Voltage Controlled Oscillator (VCO) assembly
- A201 B — IF Amplifier Assembly
- A202 — Microwave Assembly (YIG)

The A202 Microwave Assembly contains the YIG filter, mixer, and comb generator.

The input signal (1 GHz -20 GHz/26.5 GHz) passes through a YIG filter on A202. The filter is an electronically tunable bandpass filter with an operating frequency proportional to its tuning current. This filter determines the approximate frequency of the input signal and filters out any undesired signals, making it possible to count a signal at one frequency even if a larger signal is present at another frequency.

When tuning the YIG filter to the input signal, the mixer is used as an RF detector, and its output is amplified in the video amplifier on the IF assembly.

The output of the Video amplifier is maximum when the YIG filter is tuned to the input signal. In the case of multiple input signals, the video-amplifier output determines which signal is largest.

On units equipped with the Power Measurement Option (02), accurate frequency correction factors are stored in the counter's memory. This allows absolute power calibration of the video-amplifier output.

Once the YIG filter is tuned to the input signal, the appropriate harmonic number (N) and VCO frequency (FVCO) are selected to produce an IF frequency (FIF) at approximately 127 MHz. An approximation of the input signal is found by using this formula:

$$F_{IN} = N\ F_{VCO} \pm F_{IF}$$

The IF frequency produced in the mixer is amplified by the high-gain IF amplifier and sent to the count chain (A106). The IF threshold detector (A201 B) insures sufficient IF amplitude for count accuracy.

OPERATION

First the YlG filter is stepped in 64 MHz steps from its low to high limits. During this search, the RF detected output is fed through a microprocessor-controlled step attenuator to a threshold detector. After each step, the threshold detector is checked. If the threshold detector is triggered, the search mode is halted until the amplitude of the signal is determined. This is done by stepping the filter back and forth through the signal and stepping the attenuator until the signal is attenuated below the threshold. The counter then returns to the search mode to look for any larger signals. After searching the entire frequency range, it returns to the largest signal and begins to center the YIG filter precisely on the input frequency. See Figure 3-10 on page -23 for a simplified diagram of Band 3 operation. For more detailed descriptions of Band 3 operation see Figure 3-11 on page -24 through Figure 3-15 on page -28.

The centering process consists of slowly stepping the YlG filter down in 2 MHz increments until a level of 3 to 6 dB below the peak is reached. This frequency is stored and the process is repeated from the other side by stepping the filter up in 2 MHz steps. The average of the two frequencies obtained is the center of the passband. This is the frequency which is used to determine the Nand Fvco.

After centering, N is determined from $N = \frac{FYIG - 127}{500}$ and then rounded up to the next highest integer. From this, Fvco is calculated using $Fvco = \frac{FYIG - 127}{N}$. Should this yield Fvco < 400 MHz, then Fvco is recalculated using $Fvco = \frac{FYIG - 127}{N}$.

Since FYIG is only approximately equal to FIN, the IF frequency will not be exactly 127 MHz. Therefore, the next step in operation is a VCO frequency adjustment to shift FIF into the middle of the IF passband.

VCO frequency correction is achieved by counting FIF and changing Fvco by $\pm\frac{FIF - 127}{N}$. If the error is large enough to be outside the IF passband (IF threshold is not triggered) then a series of steps (shifting the IF in ± 20 MHz increments) are taken until the signal falls within the passband.

Once the VCO corrections have been made, the converter has acquired the signal and the counter is ready to count and display the input frequency.

After each measurement, the frequency of the IF is examined. If the input frequency has shifted more than 10 MHz, new frequencies for the YIG and VCO are calculated to restore the IF to 127 MHz. This method provides rapid tracking of a signal being tuned.

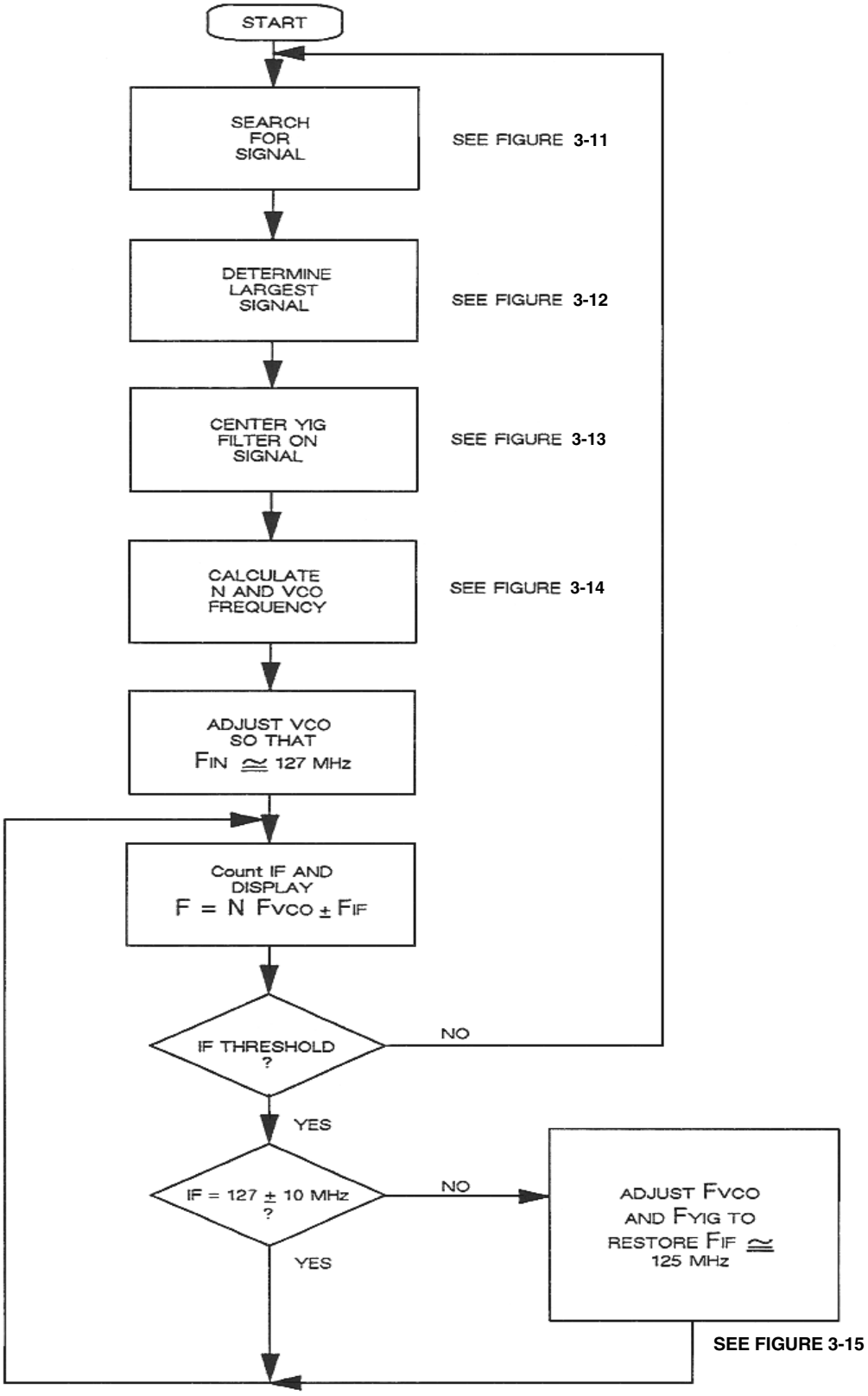

Figure 3-10. Band 3 Operation (Simplified)

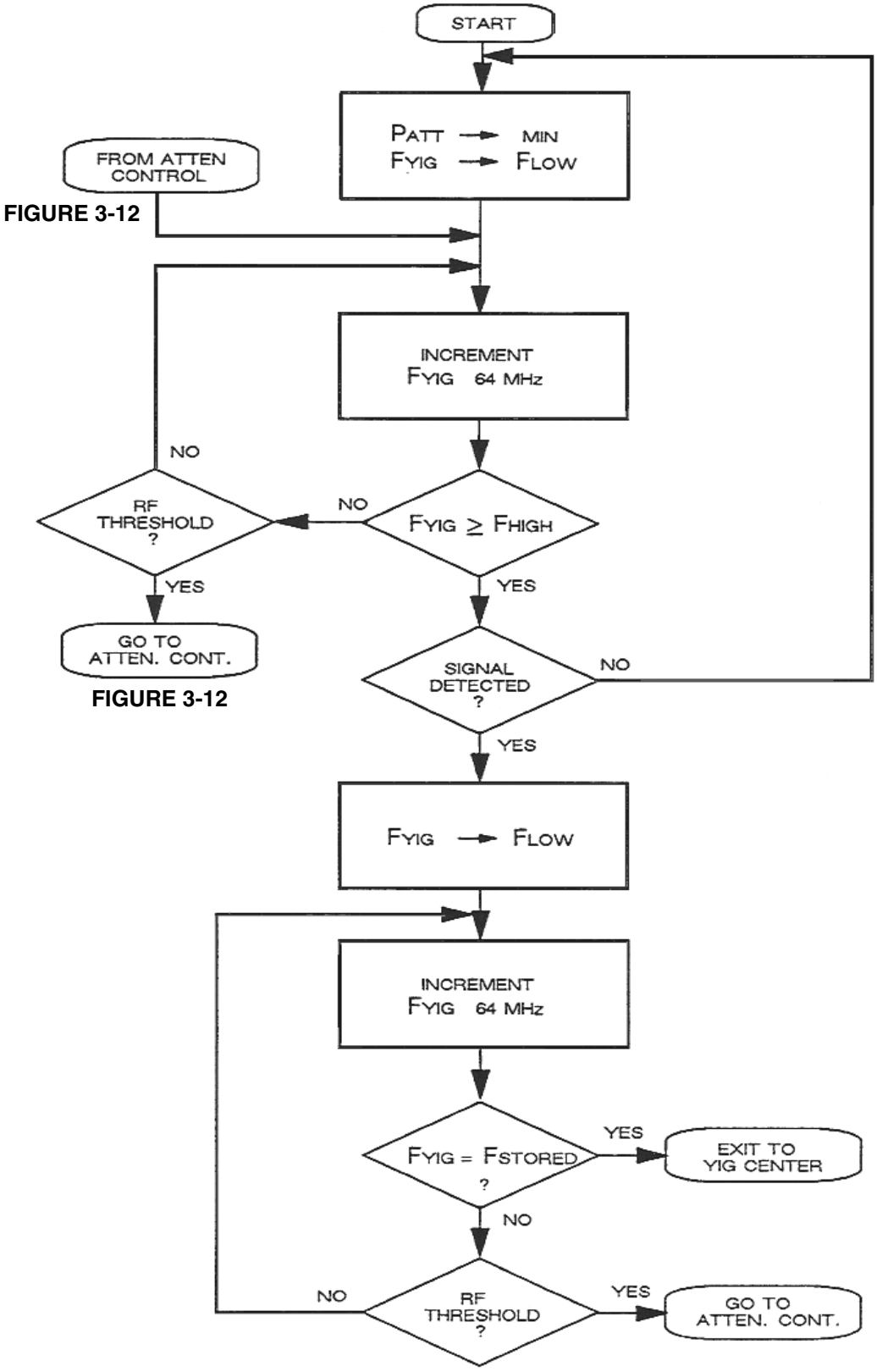

Figure 3-11. Band 3 Search for Signal

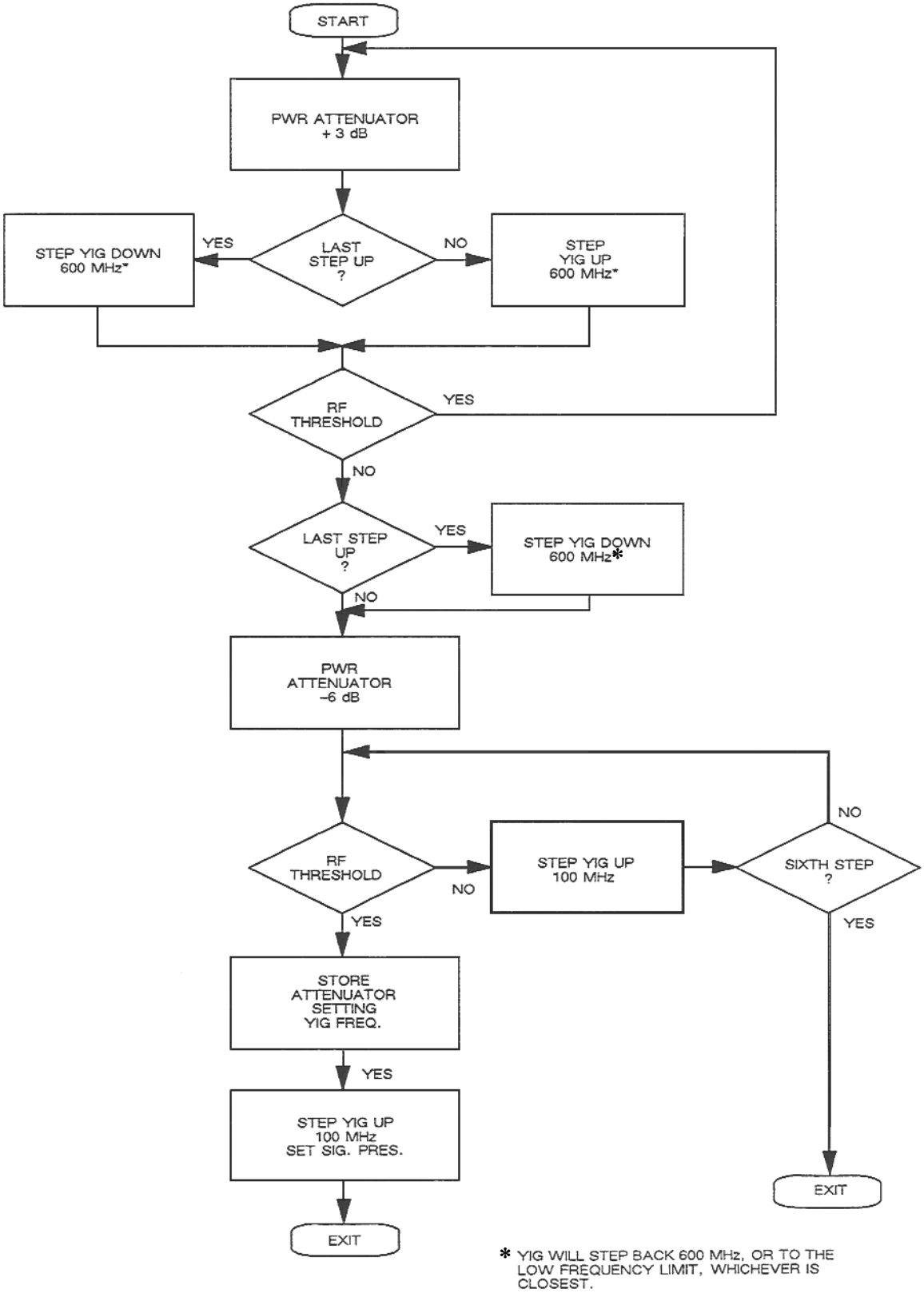

Figure 3-12. Determine Largest Signal

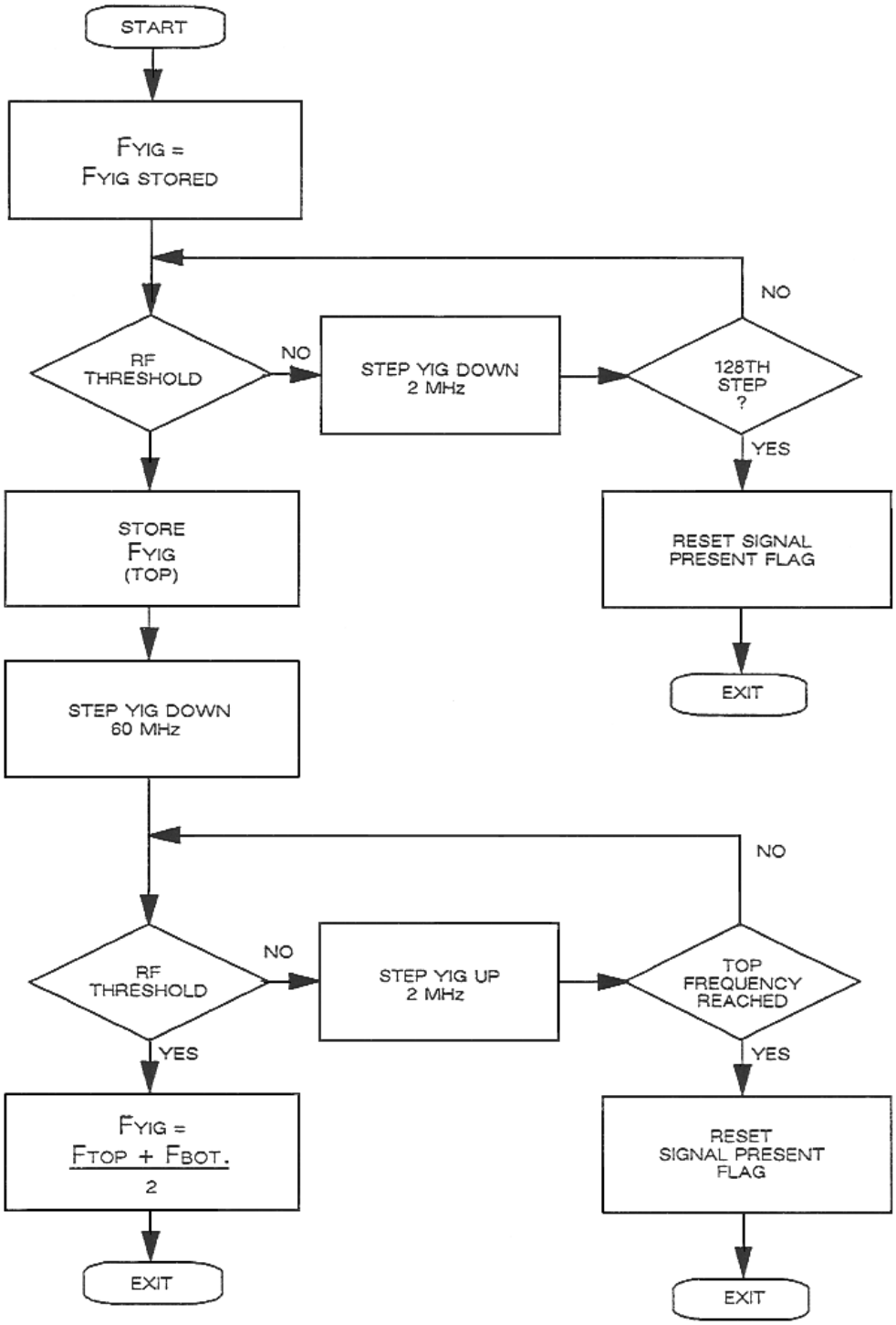

Figure 3-13. YIG Centering

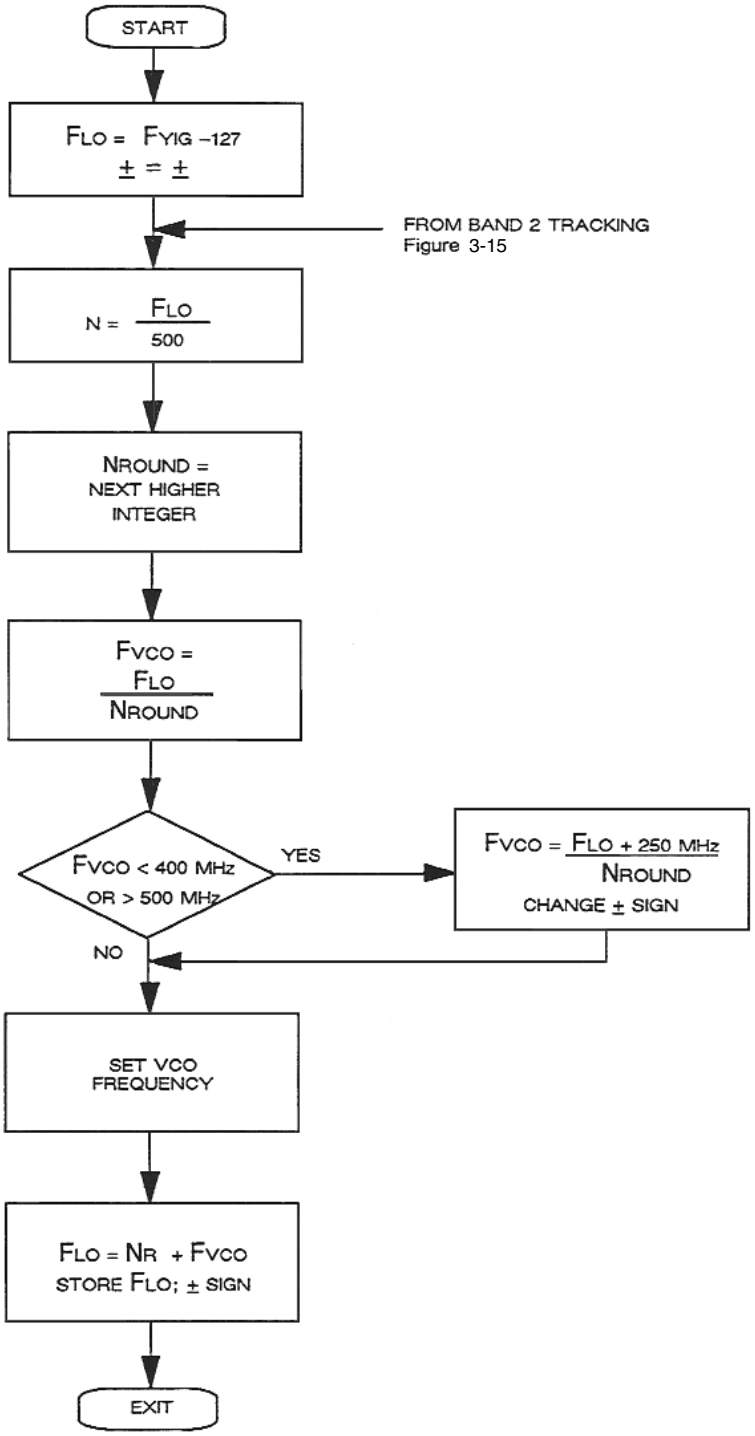

Figure 3-14. Calculate N and VCO Frequency

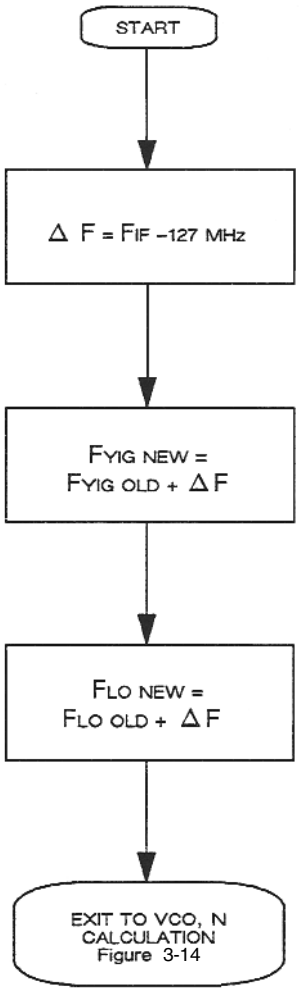

Figure 3-15. Band 3 Signal Tracking

TEST SELECTIONS

This counter incorporates an automatic power-on self-test along with a variety of performance, calibration and troubleshooting tests accessible from the front panel.

POWER-ON TESTS

The power-on tests automatically performed by the counter verify proper operation of most functional areas of the counter. As part of the power-on tests, the counter checks its RAM and PROM memory. During these tests, dashes are displayed on the front panel. If all tests pass, the counter begins normal operation approximately one second after being turned on. If the RAM test fails, all 12 sections of the display read E's to indicate that either the RAM or the RAM-decoding circuit is faulty. If the PROM test fails, the error message displayed indicates that either the PROM or the PROM-decoding circuitry is faulty.

TEST FUNCTIONS

In addition to the power-on tests, the counter features a variety of other performance, calibration, and configuration tests that are accessible via the **TEST** key on the front panel. These tests are listed with brief descriptions on the following pages.

TEST 01 — 200 MHZ SELF-TEST

This test verifies that the Count Chain, Gate Generator, and VCO are operational.

Press TEST 0 1 to activate Test 01.

When this test is activated, the counter does the following:

1. Exits the current band.
2. Sets the hardware to the self-test mode.
3. Sets the VCO to 400 MHz.
4. Sets the counter to take frequency measurements only.
5. Begins frequency measurements.

The display shows the frequency-measurement results. These results are output to the GPIB interface when frequency readings are requested. The measurement result must be 200 MHz ±1 count.

TEST 02 — LIGHT DISPLAY SEGMENTS TEST

This test lights all LEDs, annunciators, and decimal points. It is used to verifiy that all displays light, to check the intensity of the display, and to align the LEDs and annunciators.

Press TEST 0 2 to activate Test 02.

TEST 03 — SCAN DISPLAY SEGMENTS TEST

This test lights each segment of every digit and each annunciator in every bank sequentially. The cycle rate can be adjusted with the sample-rate control. This test is used to verifiy that each segment of the display, each segment driver, and the display multiplexer operate properly and independently.

Press TEST 0 3 to activate Test 03.

TEST 04 — SCAN DISPLAY DIGITS TEST

This test lights all segments of each digit and its decimal point simultaneously. The test cycles through all digits and annunciators. The cycle rate is determined by the sample-rate control. This test checks each digit and digit driver independently, and it verifies operation of the display multiplexer.

Press TEST 0 4 to activate Test 04.

TEST 05 — KEYBOARD TEST

This function is used to verify the operation of the keyboard.

Once this function is activated, the counter stops normal operation. The display shows the key code of the last key pressed. When a new key is pressed, the display is updated to show the code of the new key. When the GPIB controller requests a key code, the counter outputs the code of the last key pressed. (If the controller requests a key code, the counter outputs the code of the last key pressed to the GPIB interface, even if Special Function 05 is not activated.) If the counter is in LOCAL, this function must be terminated by the **CLEAR DISPLAY** key. If it is in remote, this function can be terminated by any device-dependent command.

Press TEST 0 5 to activate Test 05.

TEST 06 — CONVERTER RAMP TEST

This test continuously ramps the Band 3 Converter DAC through its range. It is used to test the YIG DAC, YIG drivers, YIG, and Band 3 RF-level circuits.

Press TEST 0 6 to activate Test 06.

TEST 07 — SWEEP VCO TEST

This test cycles the VCO from 400 to 500 MHz in increments of 50 kHz. The cycle rate can be adjusted using the sample-rate control. It is used to test the VCO and phase-lock circuitry.

Press TEST 0 7 to activate Test 07.

TEST 08 — POWER METER OFFSET TEST

This test sets the power-meter-zero DAC. The setting is entered as a four-digit hexadecimal number.

The first two digits program the coarse-offset DAC, and the last two digits program the fine-offset DAC. Test 08 enables testing of the power-meter-zero DAC and provides a DC-level signal to aid in troubleshooting the power-meter circuitry.

Press TEST 0 8 to activate Test 08.

TEST 09 — POWER METER GAIN TEST

This test sets the power meter sensing circuit to a selected number. The number is entered as a five-digit, hexadecimal number in the following format:

1st digit	A107U10 bits 4-7
2nd digit	A107U10 bits 0-3
3rd digit	A107U12 bits 4-7 (Power-Meter option only)
4th digit	A107U12 bits 0-3 (Power-Meter option only)
5th digit bit 0	Sets Amp marked “15 dB Gain” to high gain.
5th digit bit 1	Sets Amp marked ì30 dB Gainî to high gain.

Digit 5 is a 2-bit number, so any number entered for digit 5 will be justified to a number from 0-3.

Test 09 tests the RF level and power meter circuits.

Press TEST 0 9 to activate Test 09.

TEST 10 — MEMORY READ/ALTER ROUTINE

Test 10 reads the microprocessor address and, if that address is RAM or I/O, it can change its contents. The desired address is entered as a 4-digit hexadecimal number. When the 4th digit is entered, the counter displays the contents of the entered address. The contents can then be changed by entering a two-digit hexadecimal number.

TEST 90 — DISPLAY AND/OR ALTER GPIB ADDRESS

When this function is activated, the counter displays the current address of the GPIB interface. If the address does not need to be changed, the function can then be terminated by pressing the **CLEAR DISPLAY** key.

Once this function is activated, you can change the GPIB address by entering a two-digit number between 01 and 99, inclusive.

Press TEST [9] [0] to activate Test 90.

Press to set the GPIB address to 19.

Press to exit the test.

TEST 91 — YIG DAC AUTOMATIC CALIBRATION

This test function calibrates the Band 3 input filter. Refer to Section 6 for complete information.

NOTE

Access to this test is controlled by an internal memory-protect jumper. Attempting to access this test without installing the memory-protect jumper causes the counter to generate an error message.

TO EXIT TESTS

Press CLEAR / DISPLAY to exit a test and return to normal operation.

MUTUALLY EXCLUSIVE FUNCTIONS

1. When self-test (Test 01) is active, all other counter functions are inactive with the exception of the resolution function. If any key is pushed when the counter is in self-test, the test is exited.
2. The power-meter function is terminated whenever BAND 1, 2, or 4 is selected.

MEASURING SIGNALS WITH THE 545B/548B

AUTOMATIC FREQUENCY MEASUREMENTS

To measure the frequency of a CW signal, apply the signal to the input connector that corresponds to the frequency being measured and select the appropriate band. The counter automatically finds the signal, measures it, and displays the measured frequency.

MULTIPLE-SIGNAL MEASUREMENTS

In actual microwave environments, there are often multiple signals present. In a multi-signal environment, the counter automatically finds and measures the largest signal, as specified by amplitude discrimination.

In Band 3, the counter can also measure signals other than the largest signal present. This is accomplished by setting frequency limits around the desired signal. Figure 3-6 shows an example of the frequency limits feature.

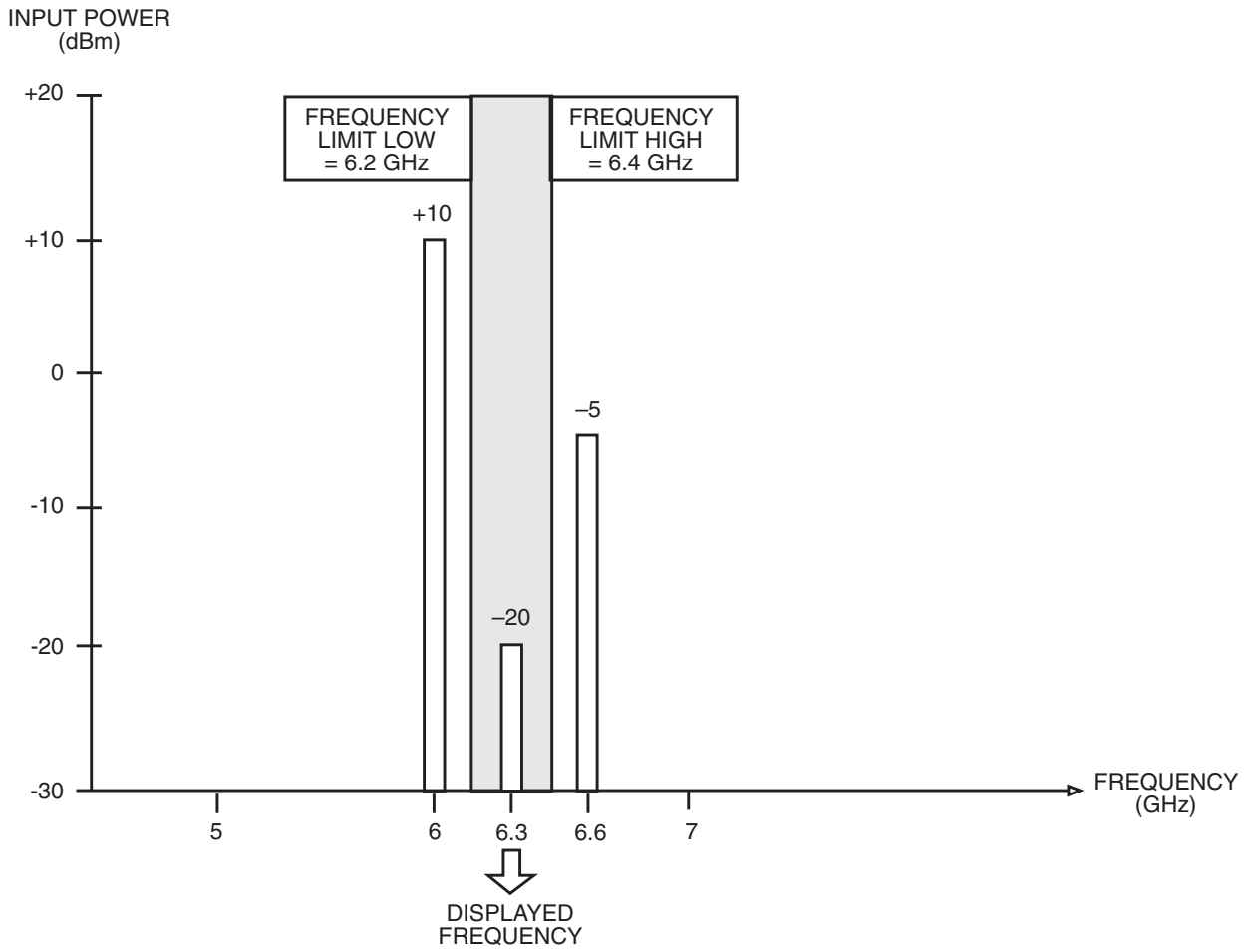

Figure 3-16. Frequency Limits

If the signals shown in Figure 3-6 are applied to Band 3 of the counter, it automatically finds the signal at 6 GHz, since it is the largest signal. To measure the signal at 6.3 GHz, set the low-frequency limit to 6.2 GHz and the high-frequency limit to 6.4 GHz. This prevents the counter from seeing either the signal at 6 GHz or the signal at 6.6 GHz.

OPTIONS

MILLIMETER-WAVE MEASUREMENTS

The 548B counter offers an extended frequency option (Option 06) that allows operation between 26.5 GHz and 110 GHz. This band is designated as Band 4 on the counter and is divided into four sub-bands as shown Table 3-5.

Table 3-5. Band 4 Sub-bands

Band	Frequency Range
41	26.5 - 40 GHz
42	40 - 50 GHz
43	60 - 90 GHz
44	90 - 110 GHz

To perform measurements in this range, the Model 590 Frequency Extension Cable Kit and one or more of the remote sensors are required as shown in Figure 3-8.

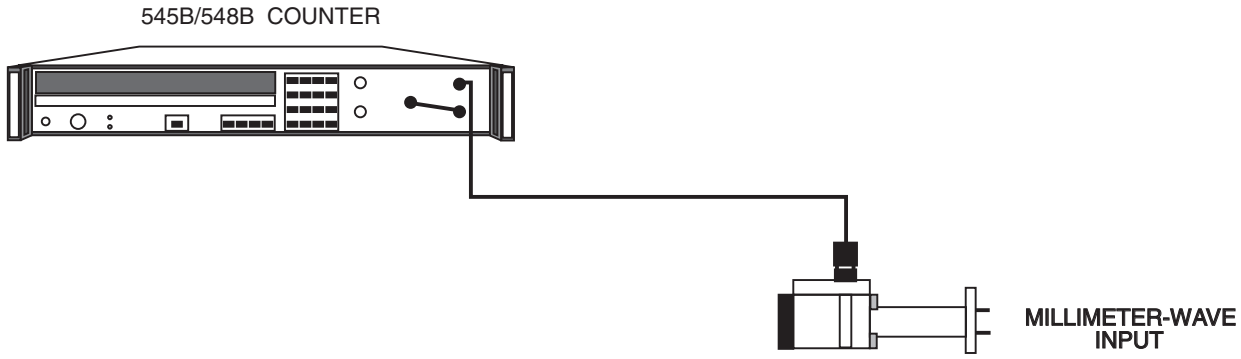

Figure 3-17. Equipment Setup for Band 4 Operation (Option 06)

CAUTION

Before connecting the remote sensor to the frequency source, verify that the power level is within the limits specified for the sensor.

CAUTION

Static discharge or ground loops can damage or destroy the diode in a remote sensor. *ALWAYS* connect the LO cable to the counter first, then touch the shield to the body of the sensor before connecting.

CAUTION

Be sure that the counter and the waveguide port to which the sensor connects have a common ground. If in doubt, connect with a ground strap before connecting the remote sensor.

OPERATION

To operate the counter in one of the Band 4 frequency ranges, connect the short cable (supplied in the Frequency Extension Cable Kit) from the lower Band 4 output jack on the front panel to the Band 3 input. Connect the long cable from the upper Band 4 jack to the remote sensor. Select the desired band. Connect the remote sensor to the frequency source. The counter automatically measures and displays the frequency of the source.

ERROR MESSAGES

When an error occurs, the error number is displayed. The probable cause of each error is listed below.

OPERATOR ERRORS

01 Illegal key sequence

02 A resolution number was not entered

03 A band number was not entered; or the number entered was too large.

04 No power reading in current band

05 Frequency limit high >20.5 GHz, 27 GHz (548B)

06 (Freq Limit Hi) - (Freq Limit Lo) <100 MHz

07 Frequency limit low <.95 GHz (545B/548B)

09 Illegal test mode key sequence

10 Illegal DAC key sequence

11 Illegal multiplier key sequence

12 Service request condition input error (GPIB only)

13 Option not installed

16 Storage register 0 does not exist

17 Illegal bandwidth key sequence

19 Function not allowed in 0.1 resolution

20 Access to this function protected by memory protect switch

40 DAC table error, cannot find YIG frequency

41 Calibration frequency error

42 Signal not found

COUNTER ERRORS

30	EEPROM error	Unable to write to EEPROM
31	Check sum error	Section 1 PROMA105, U14 (2020215-02)
32	Check sum error	Section 2 PROMA105, U13 (2020215-02)
33	Check sum error	Section 3 PROMA105, U17 (2020215-02)
31, 32, or 33	Check sum error	A105, U14 (2020480-01)

4

PROGRAMMING

REMOTE PROGRAMMING

The Phase Matrix 545B and 548B counters' GPIB interface is fully compatible with the IEEE 488-1978 standard. With the GPIB interface, the counter can respond to remote control instructions and can output measurement results via the IEEE 488-1978 Bus interface. At the simplest level, the counter can output data to other devices, such as a printer. In more sophisticated systems, an instrument controller can remotely program the counter, trigger measurements, and read results.

GPIB FUNCTIONS IMPLEMENTED

The GPIB interface function subsets implemented are listed and described in Table 4-1.

Table 4-1. GPIB Interface Function Subsets

Interface Function	Subset	Description
Source Handshake	SH1	Complete capability
Acceptor Handshake	AH1	Complete capability
Talker	T5	Basic talker, serial poll, talk-only mode, unaddress if MLA
Listener	L4	Basic listener, listen-only mode, unaddress if MTA
Service Request	SR1	Complete capability
Remote/local	RL1	Complete capability
Device Clear	DC1	Complete capability
Device Trigger	DT1	Complete capability

REMOTE/LOCAL FUNCTION

When the counter changes from LOCAL to REMOTE or vice-versa, all the stored information is retained. The counter operates in the same state as it was before the change. The only exception occurs when the counter is in the TEST mode, the TEST function is automatically terminated. When the counter is in REMOTE and LOCAL LOCKOUT is not active, the **RESET** key on the front panel acts as the return-to-local key.

DEVICE CLEAR FUNCTION

When the GPIB command DEVICE CLEAR or SELECTED DEVICE CLEAR is received, the counter reverts to its power-on state as listed below:

Display Active
Band 3 Selected
Resolution 0
Offset Active (Offset set to 0)
Power Meter Passive
Frequency Limit High set to default
Frequency Limit Low set to default
Coarse Tune Active
Test Passive (Clear Test Functions)
Exponent Zero (0utput Format)
Service Request Passive

DEVICE TRIGGER FUNCTION

When the GPIB bus command DEVICE TRIGGER is received, the counter initiates a new frequency reading cycle. The converter is not reset. If the counter does not have a converter lock, the DEVICE TRIGGER is not performed until a converter-locked condition exists.

GPIB ADDRESS SELECTION

This counter employs a software-selectable GPIB address, which is stored in non-volatile memory. To verify the GPIB address, select Test 90: the counter displays the current GPIB address. Press the **Clear Display** key to exit Test 90 without changing the GPIB address. (See Table 4-2 on page 4-2 for a list of allowable GPIB addresses.)

To change the GPIB address, select Test 90, and enter the desired GPIB address.

For example, press TEST 9 0 2 0 CLEAR DISPLAY to select GPIB address 20.

Since the GPIB address is stored in non-volatile memory, the counter always defaults to the last GPIB address selected.

The GPIB address selection is also used to put the counter in the Talk Only mode or Listen Only mode. To put the counter in the Talk Only mode, set the address to 32, 33, 34, or 35 (see Table 4-3 on page 4-3).

Table 4-2. Allowable GPIB Addresses

** ADDRESS CHARACTERS		ADDRESS CODES					
Listen	Talk	binary					decimal
		5	4	3	2	1	*
SP	@	0	0	0	0	0	00
!	A	0	0	0	0	1	01
"	B	0	0	0	1	0	02
#	C	0	0	0	1	1	03
$	D	0	0	1	0	0	04
%	E	0	0	1	0	1	05
&	F	0	0	1	1	0	06
'	G	0	0	1	1	1	07
(	H	0	1	0	0	0	08
)	I	0	1	0	0	1	09
*	J	0	1	0	1	0	10
+	K	0	1	0	1	1	11
‘	L	0	1	1	0	0	12
-	M	0	1	1	0	1	13
.	N	0	1	1	1	0	14
/	O	0	1	1	1	1	15
0	P	1	0	0	0	0	16
1	Q	1	0	0	0	1	17
2	R	1	0	0	1	0	18
3	S	1	0	0	1	1	19
4	T	1	0	1	0	0	20
5	U	1	0	1	0	1	21
6	V	1	0	1	1	0	22
7	W	1	0	1	1	1	23
8	X	1	1	0	0	0	24
9	Y	1	1	0	0	1	25
:	Z	1	1	0	1	0	26
;	[	1	1	0	1	1	27
<	/	1	1	1	0	0	28
=	]	1	1	1	0	1	29
>	^	1	1	1	1	0	30

* Decimal Talk/Listen Address is provided as a cross reference for those controllers which use decimal address.

** Address characters in ASCII code.

TALK-ONLY MODES

The TALK ONLY modes enable the counter to output data to other devices on the bus, such as a printer, without the need of an instrument controller. To use the counter in a TALK ONLY mode, enter the GPIB address corresponding to the desired mode of operation.

The counter can be put in four different modes of operation in the TALK ONLY mode. The following is a list of the address settings for entering these modes.

Table 4-3. Address Settings for Entering Talk-Only Modes

Address	Mode of Operation
32	Continuous output determined by the **SAMPLE RATE** control. Exponent in scientific format.
33	Continuous output – fast active. **SAMPLE RATE** control inactive. Exponent in scientific format.
34	Continuous output determined by the **SAMPLE RATE** control. Exponent in zero-output format.
35	Continuous output – fast active. **SAMPLE RATE** control inactive. Exponent in zero-output format.

NOTE

In the Talk Only mode or the Listen Only mode, the address of the counter is always automatically set to decimal 0.

GPIB INSTRUCTION FORMAT

<OP CODE> <NUMBER> < TERMINATOR>

OPERATION CODE or OP CODE can take any of the following formats:

<LETTER> <LETTER> or <LETTER> <DIGIT>

Example: FH (Frequency Limit High) or B3 (Band 3)

The NUMBER portion of the statement can take the form of any of the following:

<SIGN> <DIGIT STRING>

Example: –2457

<SIGN> <DIGIT STRING> . <DIGIT STRING>

Example: –3.483

NOTE

Spaces within the <OP CODE> and <NUMBER> portions of the instructions are always ignored.

The TERMINATOR allows the operator to choose the scale of an input number and to implement special functions.

TERMINATOR = G/M/K/H/D/P/C/L

G, M, K, H, represent GHz, MHz, kHz, and Hz respectively

D = dB, P = clear data, (equivalent to "clear data" key on keyboard)

C = clear display (equivalent to "clear display" key on keyboard)

L = phase lock (equivalent to **Ø LOCK** key on keyboard)

FORMAL DEFINITION OF INSTRUCTIONS

<OP CODE> <NUMBER> <TERMINATOR>

<OP CODE> ::= <LETTER> <LETTER> | <LETTER> <DIGIT>

<NUMBER> ::= <SIGN> <DIGIT STRING> |

<SIGN> <DIGIT STRING> . <DIGIT STRING> |
NULL

<TERMINATOR> ::= G | M | K | H | D | P | C | L | NULL

<SIGN> ::= + | - | NULL

<DIGIT STRING> :: = <DIGIT> <DIGIT> <DIGIT> .....

<LETTER> ::=A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q |R | S | T | U | V | W | X | Y | Z |

<DIGIT> ::= 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0

PROGRAM CODE SET

DISPLAY

DA — Display Active Output Frequency Reading to Front Panel and Bus

DP — Display Passive: Output Frequency Reading to Bus only

DN — Display Normal

BAND

B1 — Band 1: 10 Hz - 100 MHz

B2 — Band 2: 10 MHz - 1 GHz

B3 — Band 3: 1 GHz - 20 GHz (Model 545B / 26.5 GHz for Model 548B)

B4 — Band 4: (Model 548B / Option 06)

RESOLUTION

R.1 — Resolution .1 = 0.1 Hz (Band 1 only)

R0 — Resolution 0 = 1 Hz

R1 — Resolution 1 = 10 Hz

R2 — Resolution 2 = 100 Hz

R3 — Resolution 3 = 1 kHz

R4 — Resolution 4 = 10 kHz

R5 — Resolution 5 = 100 kHz

R6 — Resolution 6 = 1 MHz

R7 — Resolution 7 = 10 MHz

R8 — Resolution 8 = 100 MHz

R9 — Resolution 9 = 1 GHz

MEASUREMENT FUNCTIONS

FA — Fast Active (Ignore sample rate control)

FP — Fast Passive (Terminates FA)

RS — Reset Basic Counter and Converter. Take a new reading after reset.

HA — Hold Active

HP — Hold Passive

DATA MANIPULATION FUNCTIONS

FO — Frequency Offset. Take a new reading after data entry if the counter is not in hold.

PO — Power Offset. Take a new reading after data entry if the counter is not in hold.

OA*— Offset Active:

— Add Frequency Offset to Frequency Reading

— Add Power Offset to Power Reading if Power Meter Function is active

OP — Offset Passive (Terminates OA)

ML — Multiplier. Multiplies frequency readings by an integer number.

* In Start-up condition, although OA is Active, Frequency and Power Offsets are programmed to zero.

POWER METER

PA — Power Meter Option Active. Initiate a new gate.
PP — Power Meter Option Passive (Terminates PA)

FREQUENCY LIMITS

FH — Frequency Limit High. Basic counter and converter to be reset after data entry.
FL — Frequency Limit Low. Basic counter and converter to be reset after data entry.

SELF-TEST FUNCTION

TA — Test Active

TP — Test Passive (clear test function)

DATA FORMAT

EZ — Exponent Zero

ES — Exponent Scientific

DATA OUTPUT

BR — Output both frequency and power readings

FR — Output frequency readings only

PR — Output power readings only

SERVICE REQUEST

SR — Service request enable

DAC OPTION

DC — Select DAC option

DESCRIPTION OF AVAILABLE COMMANDS

DISPLAY

DA — Display Active - Outputs readings to both front panel and GPIB bus.

DP — Display Passive - Outputs readings to GPIB bus only. Decreases the cycle time of the counter.

DN — Display Normal - Resets display only; used for clearing error messages on the display. Cannot be used after verifying preprogrammed data such as Frequency Offsets or Frequency Limits. This OPCODE affects only the display.

BAND

B1 — Selects Band 1.

B2 — Selects Band 2.

B3 — Selects Band 3.

B41 — Selects Band 41. See Option 06.

B42 — Selects Band 42. See Option 06.

B43 — Selects Band 43. See Option 06.

B44 — Selects Band 44. See Option 06.

RESOLUTION

R.1 through R9 — Resolution .1 thru 9 - Picks the front panel resolution from .1 Hz to 1 GHz. Also chooses gate time, which is related to resolution .1 Hz = 10 sec, 1 Hz = 1 sec, 10 Hz = 100 msec, 100 Hz = 10 msec and 1 kHz to 1 GHz = 1 msec.

MEASUREMENT FUNCTIONS

FA — Fast Active - Causes the counter to go into the fast cycle mode of operation. In this mode, the front panel sample rate/hold control is inactive and the fastest sample rate is attained. The counter will not go into the Fast Active mode of operation if Hold Active is enabled.

FP — Fast Passive — Terminates FA.

RS — Reset Basic Counter and Converter — Reacquires input signal and takes a new reading. Has the same function as manual reset button.

HA — Hold Active — The counter stops taking readings and the last frequency and power readings are displayed and held. The counter can be directed to take one reading when it is in this mode by sending Device Trigger or Selected Device Trigger GPIB bus command to the counter. It will also update the reading if the RS mnemonic is received.

HP — Hold Passive — Terminates HA.

DATA-MANIPULATION FUNCTIONS

O — Frequency Offset — Enables entry of frequency offsets. (1 Hz resolution available.) A new gate is initiated after data entry if counter is not in HOLD.

PO — Power Offset (See Option 02).

OA — Offset Active — Add frequency offset to frequency readings. Add power offset to power readings if power-meter function is active.

OP — Offset Passive — Does not add frequency and power offset to readings.

ML — Multiplier — Enables entry of a 2-digit frequency readings multiplier. The multiplier must be an integer between 00 and 99. The results are to 1 kHz resolution. A new reading is initiated after the data entry if the counter is not in HOLD. If the results of the multiplications are larger than or equal to 999.999,999,000 GHz, the counter outputs 999.999,999,000 GHz to the bus if asked to output readings.

Power Meter

PA — Power Active (See Option 02).

PP — Power Passive (See Option 02).

Frequency Limits

FH — Frequency Limit High — Enables entry of frequency limit high (10 MHz resolution available). The basic counter and converter are reset after the data entry.

FL — Frequency Limit Low — Enables entry of frequency limit low (10 MHz resolution available). The basic counter and converter are reset after the data entry.Self-test Functions

TA — Test Active — Enables the counter to perform the selected test function by entering TA followed by two digits. When Test 05, 08, 09, or 10 is active and the counter is being asked to output data, the data that is displayed on the front panel is the data being output. The output data format is:

XXXXXXXXXXXXCRLF

X = alpha-numeric; CR = carriage return; LF = line feed

For detailed descriptions of tests 01 through 09 and test 11, see "Test Functions" on page 3-19.

TP — Test Passive — Terminates test function.

Data Format

EZ — Exponent Zero — output format.

ES — Exponent Scientific — output format.

Data Output

BR — Output both frequency and power readings. (See section on output data format.)

FR — Output frequency readings only. (See section on output data format.)

PR — Output power readings only. (See section on output data format.)

DAC Option

DC — Enables the DAC option. Enter DC followed by two decimal digits which correspond to the location of the most significant digit in the three digits desired. To turn the DAC option off, input DC00 or DCP.

DC00 — turns DAC option off

DC02 — selects 1 Hz digit

through

DC12 — selects 100, 10, and 1 GHz digits.

SERVICE REQUEST

SR — Service Request Enable — Enables the counter to send Service Request to the bus when a certain event has occurred in the counter. To enable the function, input SR followed by two decimal digits. The two digits are the decimal equivalent of the content of the eight bit status register. More than one bit of the status register can be set.

To disable the Service Request function, input SR00

NOTE

Even when the Service-Request function is disabled, the Service-Request status byte is still continuously altered to reflect the internal states of the counter.

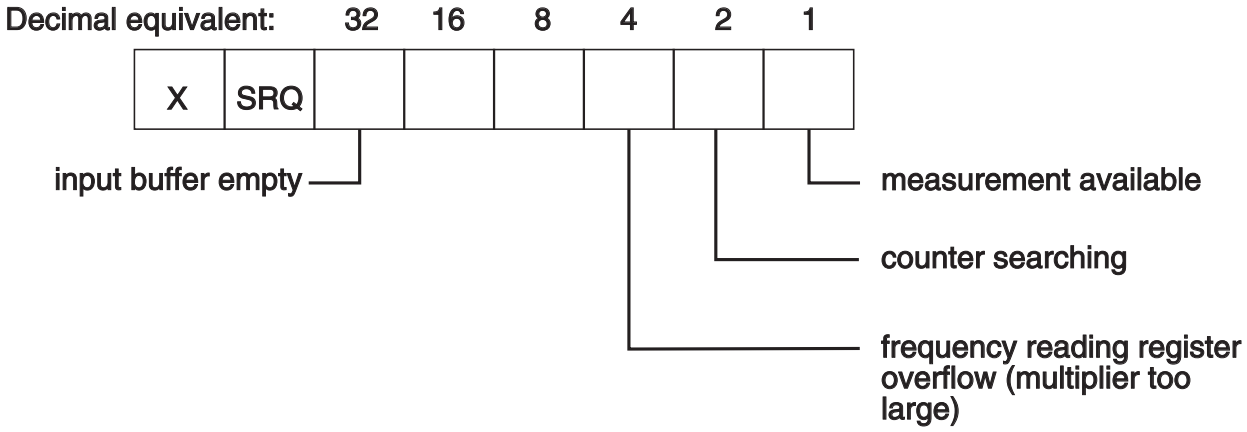

Figure 4-1. SRQ Status Byte

SERVICE-REQUEST MASK

The counter can be instructed to send an interrupt, by setting the SRQ line on the GPIB, when any ORed combination of the bits in the status byte are set. This is done by sending the counter a service-request mask.

For example, to instruct the counter to generate an SRQ on measurement available OR input buffer empty, send the following service-request mask:

OUTPUT 719;"SR33"

This tells the counter to generate an SRQ whenever bit 0 or bit 5 of the status byte are set. Since bit 0 corresponds to measurement-available and bit 5 corresponds to input-buffer-empty, thecounter generates an SRQ whenever either the input buffer is empty or a measurement is available.

The following items must be included in any program using the SRQ feature:

1. Tell the counter when to generate an SRQ. That is, tell the counter which events should generate an SRQ. This is done using the SRQMASK command.
2. Tell the controller to monitor the SRQ line on the GPIB. The SRQ is a maskable interrupt, and the controller needs to know if it should respond to the interrupt.
3. Tell the controller what to do when it receives an SRQ interrupt.
4. Serial Poll the counter after an SRQ is generated to clear the interrupt. When the counter generates an SRQ, it sets bit 6 in the status byte. Serial polling the instrument clears the SRQ bit and allows the instrument to generate a new SRQ on the next occurrence of the conditions specified in the SRQ Mask.
5. It may also be necessary to clear the SRQ register in the controller. Consult your manual on the controller for more information on clearing the SRQ register in the controller.

The following program, written on an HP-9826, demonstrates how to use the SRQ feature to obtain a valid measurement from the counter.

```
10   ASSIGN @COUNTER TO 719     ! Assigns 719 to address variable
                                ! The number 7 is the GPIB interface
                                ! and 19 is the counters GPIB address
20   REMOTE @COUNTER            ! Place counter in Remote
30   OUTPUT @COUNTER; “SR01"    ! Send SRQ mask to counter
40   ENABLE INTR 7;2            ! Enable interrupt in controller
50   ON INTER 7 GOTO FLAG       ! Tell controller how to handle interrupt
60   WAITING:                   ! Label
70   PRINT ”WAITING FOR VALID MEASUREMENT"
80   GOTO WAITING
90   FLAG: PRINT “ * * * * * SRQ RECEIVED * * * * *”
100  ENTER @COUNTER;FREQ        ! Input Frequency from counter
110  PRINT “FREQ = ”;FREQ       ! Print Frequency
120  S2 = SPOLL(@COUNTER)       ! Clear SRQ bit in counter
130  STATUS 7,4;S               ! Clear SRQ bit in controller
140  OUTPUT @COUNTER;"SR00"     ! Turn off SRQ mask in counter
150  OFF INTR 7                 ! Turn off interrupt in controller
160  END                        ! Program end
```

To demonstrate this program, set up the counter with no signal applied and start the program running. The Controller continuously prints out “Waiting for measurement.” Then apply a signal. As soon as the Counter finds the signal and counts it, the controller prints out the frequency of the signal.

DATA-OUTPUT FORMAT

To output measurement results, the 545B/548B transmits the following string of characters:

Position	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Format	
EZ (Exponent Zero)	~~b~~ ± D D D D D D D D D D D D E 0 CR LF
ES (Exponent SCI)*	± D D D D D D D D D D D D D E D CR LF
Power**	~~b b b b b b b b b b~~ ± D D D . D CR LF
Freq. + Power	
FREQ in EZ mode:	~~b~~± D D D D D D D D D D D E 0, ~~b b b b b b b b b b~~ ± D D D . D CR LF
FREQ in ES mode:	± D D D D D D D D D D D D E D, ~~b b b b b b b b b b~~ ± D D D . D CR LF

* In Exponent scientific, one digit represents the position of the decimal point. The exponent digit can be 0, 3, 6, or 9.

** For power data, the output resolution is fixed at 0.1 dB.

When the counter is in Test 05, 08, 09, or 10, the output reflects the data on the display. The format is as follows:

XXXXXXXXXXXXCRLF.
~~b~~ = Blank
D = Digit
X = Alpha-numeric Character
CR = Carriage Return
LF = Line Feed

In the different output modes, counter outputs that can be expected by a listener are listed in Table 4-4.

Table 4-4. Counter Outputs in Various Output and Operating Modes

Output Mode	Counter Operating Mode	Output
BR	PA	FREQ and PWR
	PP	FREQ
	TA01	FREQ
FR	PA	FREQ
	PP	FREQ
	TA01	FREQ
PR	PA	PWR
	PP	-999.9
	TA01	-999.9
BR, FR, or PR	TA05, 08, 09, or 10	Data on front panel display

PROGRAM EXAMPLES

The following measurement conditions are set by addressing the counter to listen and then sending the character string shown in .

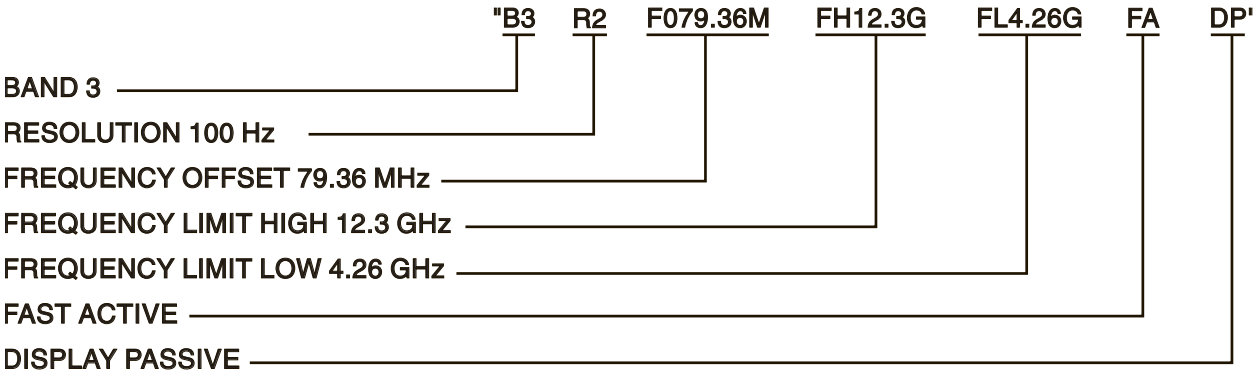

Figure 4-2. Example Character String

READING A MEASUREMENT

To read a measurement from the counter to a controller, the counter must first be addressed to talk and the controller must be addressed to listen. Phase Matrix counters use two different modes. The HOLD ACTIVE or HA mode takes one reading and then waits for a RESET command or a device trigger GPIB Command. In this condition, the counter is sent a RESET or device trigger and (when addressed to talk) a new reading is output to the bus. The counter holds that particular reading on the display until it receives another RESET command or device-trigger command. The second mode is HP, or HOLD PASSIVE. In this mode, data is read out in a normal bus fashion. The display is automatically updated according to the sample rate chosen. In this mode, successive readings can be output without generating a RESET or device-trigger command each time.

INPUT SPEED

It takes a specific amount of time for the counter to process the input data (error checking, formatting, changing the mode of operation, etc.). To prevent the data rate of the bus from slowing down while the counter is processing input data, the data is accepted as soon as it is available on the bus and is temporarily stored in memory. The size of the storage memory is 100 characters.

Users of the GPIB interface need to be aware of the difference between accepting data and complying with it. If the counter is asked to output a reading before it has finished processing the input data, the output will be in error, if the operator makes the assumption that the counter is in the mode that was just programmed. To prevent this, sufficient programmed delays must be provided, or use must be made of the counter's Service Request status byte (see "Service Request" on page 4-10.

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5

OPERATIONAL VERIFICATION TESTS

INTRODUCTION

This section contains test procedures for verifying proper operation of the Phase Matrix 545B and 548B frequency counters. Although these tests are not comprehensive, they do ensure that the instrument is operating properly to a high degree of confidence. The tests can also be useful for incoming inspection and should be performed after any servicing to ensure proper operation of the counter. All tests can be performed without removing the instrument covers. A test report form that can be used to provide a test record is included at the end of this section. If the test application is especially critical in nature, more extensive testing of the counter may be required. See Section 7 for additional information.

Because of the high cost and specialized nature of frequency sources above 40 GHz, testing above this frequency is not covered. Also, for the purpose of operational verification tests, simulated pulsed signals are used in Band 1 and Band 3.

EQUIPMENT REQUIREMENTS

The equipment required for the operational-verification tests of the Phase Matrix 545B and 548B counters is listed in Table 5-1. The critical parameters are the minimum-use specifications required for the performance of the procedures and are included to assist in the selection of alternative equipment. Satisfactory performance of alternative items should be verified prior to use. All applicable equipment must bear evidence of current calibration. For some of the following tests, a Phase Matrix 578B counter is used to source-lock the microwave sweeper, thus providing a stable source for testing. This combination may be replaced by a frequency synthesizer.

Table 5-1. Equipment Requirements

Description	Critical Parameters	Recommended Manufacturer	Model
Synthesized Function Generator	10 Hz to 10 MHz	Wavetek	23
Sweep Generator	10 MHz to 26.5 GHz (40 GHz for Option 06)	Wiltron	6668A
Sweep Generator	3 GHz to 18 GHz	Wiltron	6635A
Source Locking Counter	10 MHz to 26.5 GHz	Phase Matrix	578B
Spectrum Analyzer	3 GHz to 18 GHz	Agilent	8566A
Power Meter	10 MHz to 60 GHz	Agilent	437B
Power Sensor	10 MHz to 18 GHz (.20 to +10 dBm)	Agilent	8481A
Power Sensor	100 MHz to 26.5 GHz (.25 to +20 dBm)	Agilent	8485A
Power Sensor	26.5 GHz to 40 GHz (.25 to +20 dBm)	Agilent	R8486
Oscilloscope	DC to 100 MHz	Tektronix	475
Power Splitter	10 MHz to 26.5 GHz	Agilent	11667B
Directional Coupler	950 MHz to 18 GHz	Narda	4222-16
Directional Coupler	18 GHz to 26.5 GHz	Narda	4017B-10
Remote Sensor	26.5 GHz to 40 GHz	Phase Matrix	091
50 Ω Termination		Pomona	4119-50

SOURCE-LOCKING SETUP

In some of the following tests, a Phase Matrix model 578B counter is used to source-lock the sweep generator to provide a stable frequency source for testing the 545B and 548B counters.

The source-locking setup described on page 5-3 is not limited to locking the Wiltron sweeper. It can also be used to source-lock almost any electronically tunable signal source over a frequency range of 10 MHz to 110 GHz. For more information on source-locking the Wiltron 6600 series of sweep generators, request Application Bulletin 10 from a Phase Matrix sales representative in your area or directly from Phase Matrix.

Regardless of the particular sweeper used, the procedure for source-locking is basically the same. A sample of the output from the sweeper is applied to the appropriate band on the 578B counter. For the setup shown in Figure 5-1, a power splitter provides the sample. The **COARSE TUNE OUT** connector from the 578B counter is connected to the external-sweep input on the sweeper. The **Ø LOCK OUT** connector on the 578B counter is connected to the FM-input on the sweeper. FM modulation is enabled on the sweeper, and the sweeper is set to external-sweep mode.

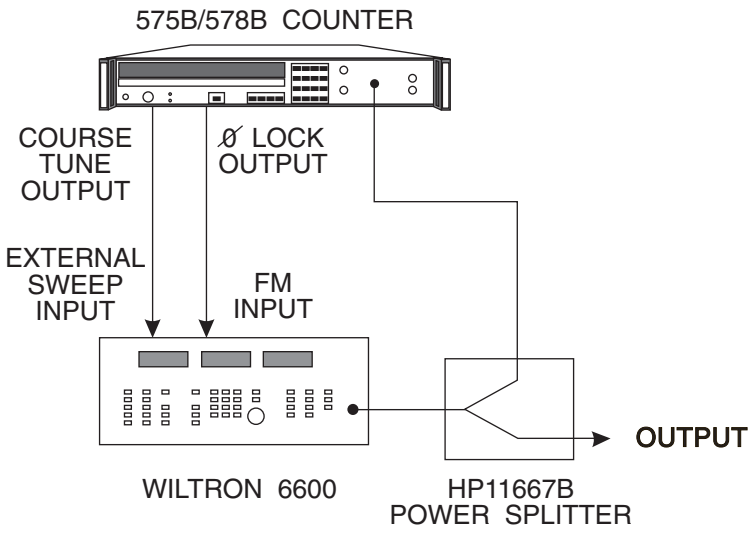

Figure 5-1. Source Locking Setup

With the equipment set up as shown above, source-locking over the entire range of the sweeper can be achieved by entering the desired frequency.

For example, to lock the sweeper at 10 GHz:

Press LOCK FREQ 1 0 GHz .

At this point, the sweeper should be locked to 10 GHz, the **LCK** annunciator on the counter should be lit, and 10 GHz should be the displayed frequency. In the following tests, the output frequency from the sweeper is controlled directly by the 578B counter, while the power is controlled at the sweeper.

OPERATIONAL VERIFICATION TEST PROCEDURES

BAND 1 RANGE AND SENSITIVITY TEST (10 HZ TO 10 MHZ)

DESCRIPTION

This test verifies counter operation from 10 Hz to 10 MHz at 25 mVrms (70.7 mV p-p into 50 Ω). The oscilloscope is used to set signal levels.

EQUIPMENT

Synthesized function generator (Wavetek 23)
Oscilloscope (Tektronix 475)

TEST SETUP 1

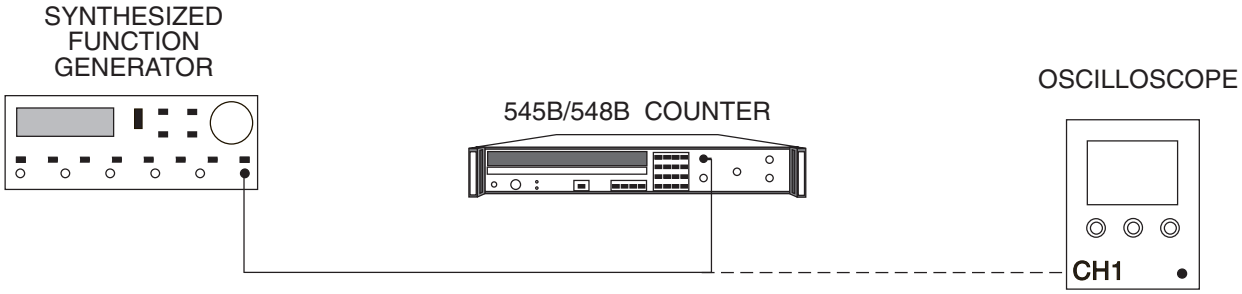

Figure 5-2. Band 1 Range and Sensitivity Test Setup (10 Hz to 10 MHz)

PROCEDURE

1. Connect equipment as shown in Figure 5-2.
2. Set the counter to Band 1 and select resolution 2.
3. Set the output frequency from the synthesizer to 10 Hz.
4. Using the oscilloscope, set the output signal level from the synthesizer to 25 mVrms (70.7 mV p-p into 50 .).
5. Apply the 10 Hz signal to the counter, verify the reading, and record the results.
6. Repeat steps 3, 4, and 5 at 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, and 10 MHz.

BAND 1 RANGE AND SENSITIVITY TEST (20 MHZ TO 100 MHZ)

DESCRIPTION

This test verifies counter operation from 20 MHz to 100 MHz at 25 mVrms (70.7 mV p-p into 50 Ω). The oscilloscope is used to set signal levels.

EQUIPMENT

Sweep generator (Wiltron 6668A)
Source locking counter (Phase Matrix 578B)
Power splitter (Agilent 11667B)
Oscilloscope (Tektronix 475)
50 Ω termination (Pomona 4119-50)

TEST SETUP 2

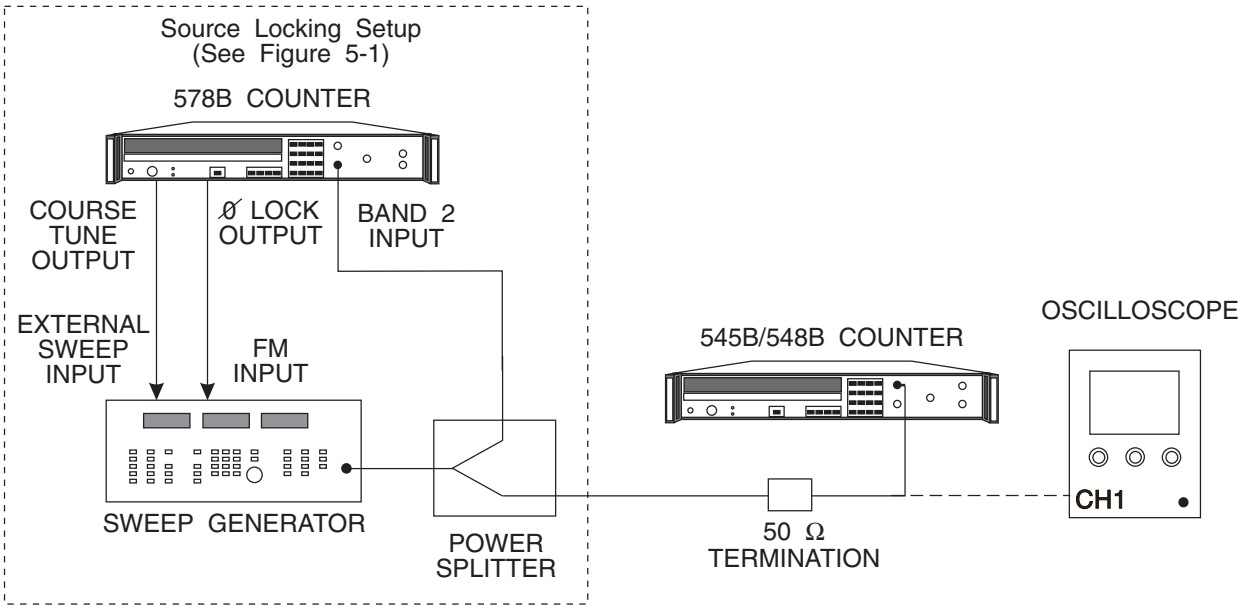

Figure 5-3. Band 1 Range and Sensitivity Test Setup (20 MHz to 100 MHz)

PROCEDURE

1. Connect equipment as shown in Figure 5-3.
2. Set the 545B/548B counter to Band 1 and select resolution 3.
3. Using the 578B counter, source lock the sweeper at 20 MHz.
4. Using the oscilloscope, set the output signal level from the synthesizer to 25 mVrms (70.7 mV p-p into 50 Ω).
5. Apply the 20 MHz signal to the 545B/548B counter, verify the reading, and record the results.
6. Repeat steps 3, 4, and 5 at 50 and 100 MHz.

BAND 2 RANGE AND SENSITIVITY TEST

DESCRIPTION

This test verifies counter operation from 10 MHz to 1 GHz at -15 dBm. The power meter is used to set signal levels.

EQUIPMENT

Sweep generator (Wiltron 6668A)
Source locking counter (Phase Matrix 578B)
Power meter (Agilent 437B)
Power sensor (Agilent 8481A)
Power splitter (Agilent 11667B)

TEST SETUP 3

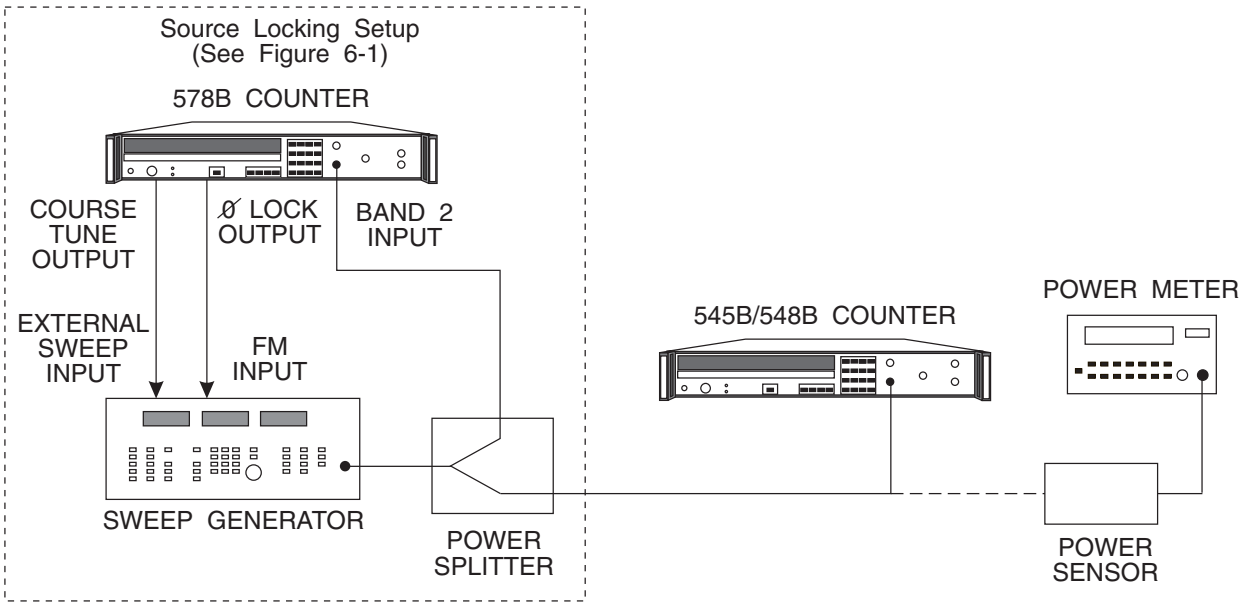

Figure 5-4. Band 2 Range and Sensitivity Test Setup

PROCEDURE

1. Connect equipment as shown in Figure 5-4.
2. Set the 545B/548B counter to Band 2 and select resolution 3.
3. Using the 578B counter, source lock the sweeper at 10 MHz.
4. Using the power meter, set the output-signal level from the sweeper to –20 dBm.
5. Apply the 10 MHz signal to the counter, verify the reading, and record the results.
6. Repeat steps 3, 4, and 5 at 100 MHz, 250 MHz, 300 MHz, 400 MHz, 500 MHz, 600 MHz, 700 MHz, 800 MHz, 900 MHz, and 1 GHz.

BAND 3 RANGE AND SENSITIVITY TEST

DESCRIPTION

This test verifies counter operation from 1 GHz to 20 GHz (26.5 GHz for the 548B counter).

EQUIPMENT

Sweep generator (Wiltron 6668A)
Source locking counter (Phase Matrix 578B)
Power meter (Agilent 437B)
Power sensor (Agilent 8485B)
Power splitter (Agilent 11667B)

TEST SETUP 4

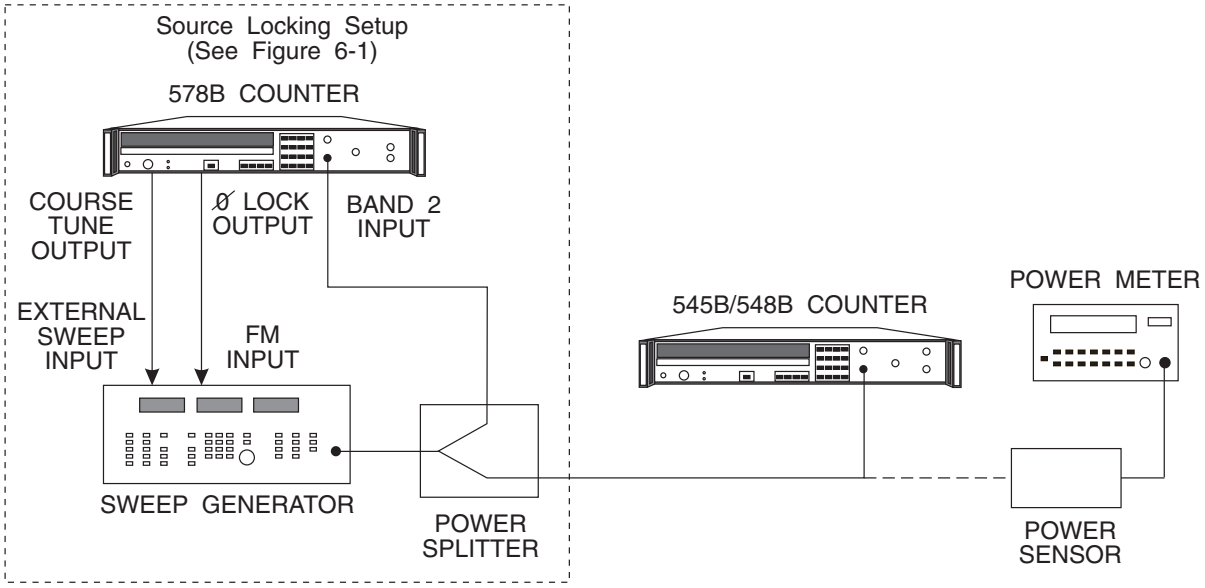

Figure 5-5. Band 3 Range and Sensitivity Test Setup

PROCEDURE

1. Connect equipment as shown in Figure 5-5.
2. Set the counter to Band 3 and select resolution 3.
3. Using the 578B counter, source lock the sweeper at 1 GHz.
4. Using the power meter, set the output signal level from the sweeper to –30 dBm.
5. Apply the 1 GHz signal to the 545B/548B counter, verify proper reading, and record the results.
6. Repeat steps 3, 4, and 5 at 3 GHz, 6 GHz, 10 GHz, and 12.4 GHz. Then, at a signal level of –25 dBm, test at 15 GHz, 18 GHz, and 20 GHz. For Model 548B counters only: at signal level of –20 dBm, test also at 22 GHz, 24 GHz, and 26.5 GHz.

BAND 3 AMPLITUDE DISCRIMINATION TEST

DESCRIPTION

This test verifies that the counter accurately measures the larger of two signals differing in amplitude by 10 dB or more.

EQUIPMENT

Sweep generator (Wiltron 6635A)

Sweep generator (Wiltron 6668A)

Spectrum analyzer (Agilent 8566A)

Power splitter (Agilent 11667B)

TEST SETUP 5

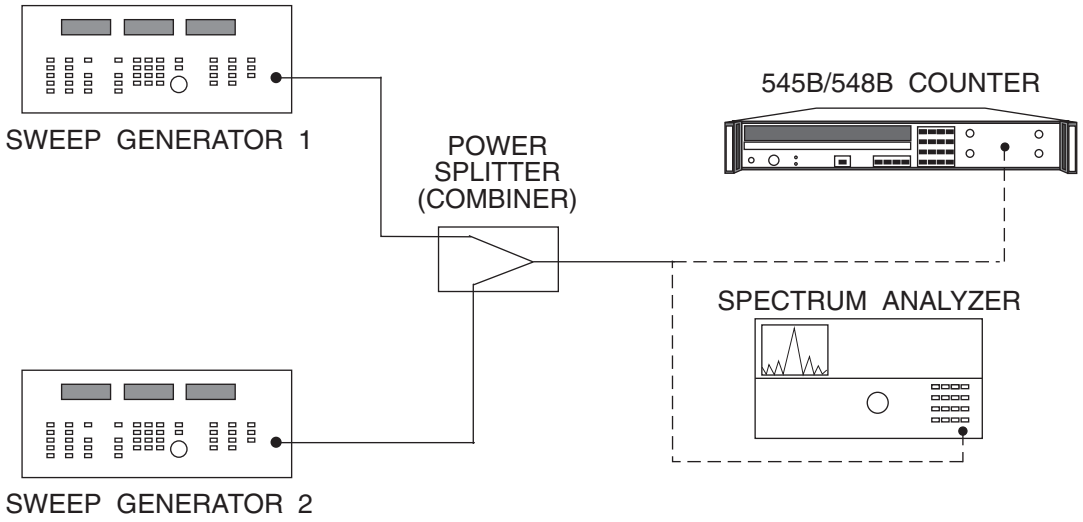

Figure 5-6. Band 3 Amplitude Discrimination Test Setup

PROCEDURE

1. Connect equipment as shown in Figure 5-6.
2. Set signal generator 1 to 3.0 GHz at 0 dBm, and set signal generator 2 to 3.1 GHz at +6 dBm.
3. Using the spectrum analyzer, adjust the generator power levels so that the signal-amplitude difference is 10 dB.
4. Verify that the counter correctly measures the frequency of the higher-power signal source.
5. Repeat steps 2, 3, and 4 at 6 and 6.1 GHz, at 12 and 12.1 GHz, and at 17.9 and 18 GHz.

BAND 4, SUBBAND 1 RANGE AND SENSITIVITY TEST (548B OPTION 06 ONLY)

DESCRIPTION

This test verifies counter operation from 26.5 GHz to 40 GHz at -25 dBm.

EQUIPMENT

Sweep generator (Wiltron 6668A)
Power meter (Agilent 437B)
Power sensor (Agilent R8486A)
Remote sensor (Phase Matrix 091)
Cable kit (Phase Matrix 590)

TEST SETUP 6

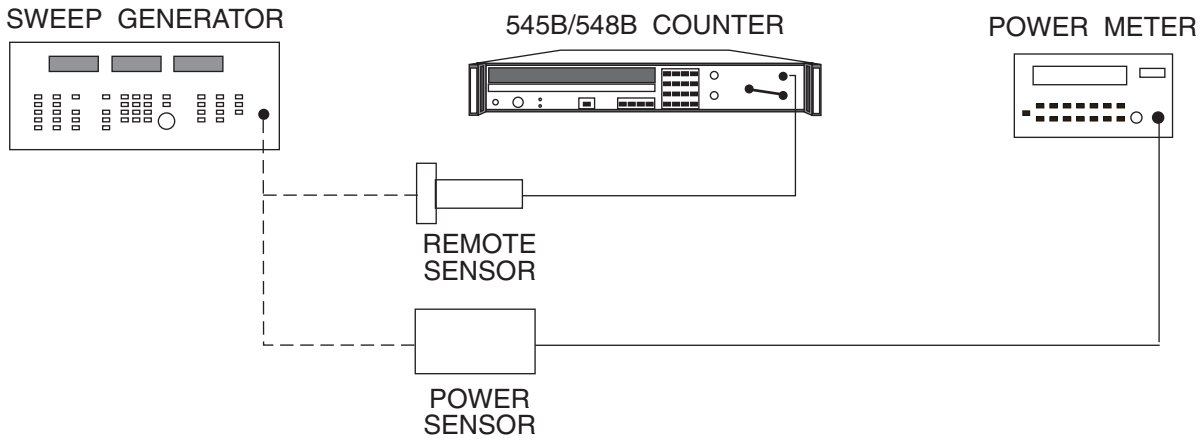

Figure 5-7. Band 4 Range and Sensitivity Test Setup (Model 548B, Option 06)

PROCEDURE

1. Connect equipment as shown in Figure 5-7.
2. Set the counter to Band 4 and select resolution 3.
3. Set the output frequency from the sweeper to 26.5 GHz.
4. Using the power meter, set the output-signal level from the sweeper to –25 dBm.
5. Apply the 26.5 GHz signal to the remote sensor, verify the reading, and record the results.
6. Repeat steps 3, 4, and 5 at 30, 35, and 40 GHz.

OPERATIONAL TEST RECORD

MODEL_____ SERIAL NO._____ DATE_____

TEST		ACTUAL	SPECIFICATIONS
BAND 1 RANGE AND SENSITIVITY TEST			10 Hz TO 100 MHz
INPUT SENSITIVITY	10 Hz		25 mVrms
	100 Hz		
	1 kHz		
	10 kHz		
	100 kHz		
	1 MHz		
	10 MHz		
	20 MHz		
	50 MHz		
	100 MHz		
BAND 2 RANGE AND SENSITIVITY TEST			250 MHz TO 1 GHz
INPUT SENSITIVITY	10 MHz		–20 dBm
	100 MHz		
	250 MHz		
	300 MHz		
	400 MHz		
	500 MHz		
	600 MHz		
	700 MHz		
	800 MHz		
	900 MHz		
	1 GHz		
BAND 3 RANGE AND SENSITIVITY TEST			GHz TO 20 GHz (26.5 GHz)
INPUT SENSITIVITY	1 GHz		–30 dBm
	3 GHz		
	6 GHz		
	10 GHz		
	12.4 GHz		
	15 GHz		–25 dBm
	18 GHz		
	20 GHz		
548B ONLY	22 GHz		–20 dBm
	24 GHz		
	26.5 GHz		

OPERATIONAL TEST RECORD (Continued)

MODEL_____ SERIAL NO._____ DATE_____

TEST		ACTUAL	SPECIFICATIONS
BAND 3 AMPLITUDE DISCRIMINATION TEST			
CONDITIONS: F1>F2 BY 15 dB OR MORE			
	F1	F2	
	3 GHz	3.1 GHz_____	10 dB
	6.1 GHz	6 GHz_____	
	12 GHz	12.1 GHz_____	
	18 GHz	17.9 GHz_____	
BAND 4-1 RANGE AND SENSITIVITY TEST 26.5 GHz TO 40 GHz			
INPUT SENSITIVITY		26.5 GHz_____	–20 dBm (typical)
		30 GHz_____	
		35 GHz_____	
		40 GHz_____	

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