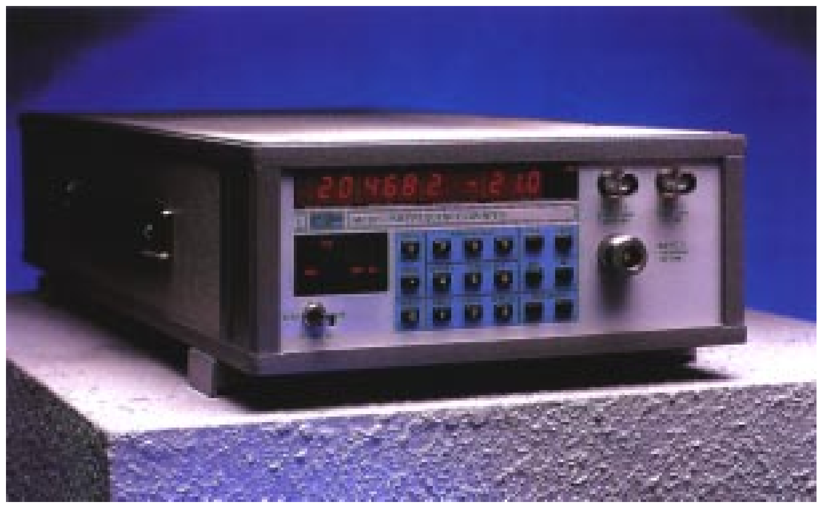
Phase Matrix, Inc.

Instruments You Can Count On

25B
28B

Phase Matrix, Inc.
EIP 25B and 28B
Frequency Counters

High Performance in a Small Package



- Count Carrier and IF Frequencies From 10Hz to 26.5 GHz
- Measure Frequency and Power Level With A Single Connection
- Analyze Individual Signals In A Multi-Channel Spectrum
- 200 Watts Peak Input Protection
- Ideal For Field Maintenance and Bench-Top Applications
- World Wide Proven Reliablity

Phase Matrix has moved. Our new address is:
4600 Patrick Henry Drive
Santa Clara CA 95054
Tel: 408-610-6810

Phase Matrix / EIP 25B and 28B. . . .
High Performance in a Small Package

The Ideal Communications Counters

The 25B and 28B CW frequency counters from Phase Matrix, Inc are the ideal counters for communications applications. These portable, rugged units combine durability and small size with high performance features typically found only in larger, bench-top instruments.

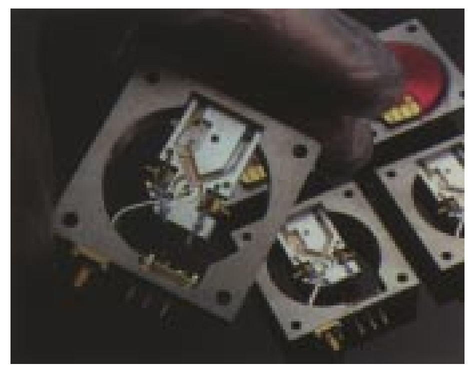
The 25B measures CW, FM and AM frequencies from 10 Hz to 20 GHz, and the 28B extends that range up to 26.5 GHz. With simultaneous power measurement capability, and options for a high stability time base and a protective transit case, these high performance counters are ideally suited for applications in:

- Carrier signal measurement
- Transmitter frequency verification
- Channel specific signal measurements
- Microwave link testing
- Channel monitoring
- ATE

The 25B and 28B are ideal for frequency and power level testing of terrestrial microwave systems.

Unsurpassed Burnout Protection

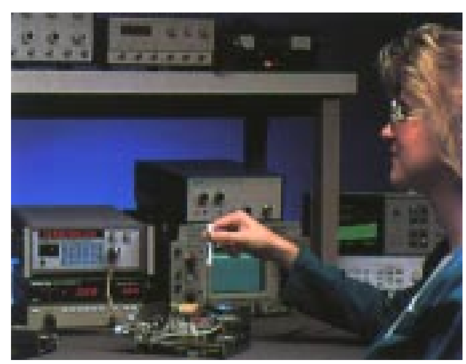
Typically found in high performance spectrum analyzers; only Phase Matrix counters feature a YIG-preselected microwave input, which provides unparralled burnout protection, FM tolerance and frequency selectivity. The YIG preselector works like a tunable bandpass filter, preventing harmonics and other out-of-band spurious signals from interfering with measurement of the desired signal. It also protects the counter from accidental application of high level signals (up to 200 watts peak), reducing downtime and the associated high cost of repairing damaged microwave circuitry.



Only Phase Matrix counters offer the unique YIG-preselected heterodyne technique.

Selective Frequency and Power Measurements

With a single connection, the 25B and 28B can simultaneously measure and display the input signals frequency and power level in the microwave band, eliminating the need for a seperate microwave power meter. Within the 25MHz bandwidth of the YIG-preselector, only the selected signals frequency and power level are measured. Signals to be analyzed are selected by keystroke entry of an individual center frequency, or search a range between a low and high frquency limit. This signal selectivity, combined with 20MHz of FM tolerance at all rates up to 10MHz, allows the 25B and the 28B to make accurate frequency and power level measurements even while the input signal is carrying traffic; there is no need to take the transmitter, or adjacent channels, off the air for routine checks.



These useful counters are as capable on the bench as in the field. Their high performance matches or exceeds the best performance available in larger, bench-top instruments.

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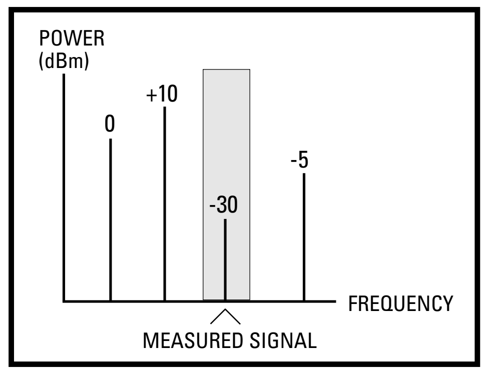
Phase Matrix / EIP 25B and 28B. . . .
Field Proven Reliability

Easy to Read and Operate

Frequency and Power measurements can be made to a resolution of 1Hz and 0.1 dB, respectively. Easy keystroke entry of frequency and power offsets allows system-under-test frequency translation devices and cable losses to be compensated for in the displayed measurement results.



The frequency selective operation of the counters allows measurement of any individual signal's frquency and power in a multi-signal environment.

Portable, Rugged Construction

The small size of the 25B and 28B, along with their convenient carrying handle and protective front cover, makes these units perfect for portable field maintence applications. Their rugged, durable construction will provide years of reliable operation under the roughest conditions. The units even feature an optional fast warm-up ovenized time base (Option 05) that delivers a reference frquency within $5x10^{-9}$ of the final value within 10 minutes of power-up. This ensures the best possible accuracy with minimum warm-up time delay.

Proven Reliability

The design of the 25B and 28B is based on the Phase Matrix / EIP 545B CW microwave frequency counter. This counter has become the standard in reliability, achieving over 26,000 hours (12.5 years) of field-proven MTBF. The high performance, economy and compact configuration of the 25B and 28B make them the ideal choice for your communications applications in the field and on the bench.

The Phase Matrix 25B/28B feature a convenient built-in carrying handle and protective front cover.

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SPECIFICATIONS

MODEL 25B and 28B	BAND 1	BAND 2	BAND 3
Frequency Range	10 Hz-100 MHz	10 MHz-1 GHz	1-20 GHz (25B) 1-26.5 GHz (28B)
Sensitivity	25mV rms	-20dBm	-30 dBm 1-12.4GHz -25 dBm 12.4GHz-20GHz -20 dBm 20GHz-26.5GHz
Impedance	1MΩ/20pF	50 Ohms	50 Ohms
Connector	BNC (female)	BNC (female)	Precision Type N-female (25B) APC 3.5-female (28B)
Input Coupling	DC	AC	AC
Maximum Operating Level	120 V rms*	+10 dBm	+10 dBm
Damage Level	150 V rms*	+27 dBm	+45 dBm (30 watts) continuous +53 dBm (200 watts) peak pulsed (<1uS PW, 0.1% duty)
Acquisition Time			
Standard	N/A	<50mS	<200ms
Center Frequency Mode	N/A	N/A	<20ms
Automatic Amplitude Discrimination	N/A	N/A	10 dB
FM Tolerance	Carrier remains in band	Carrier remains in band	20 MHz P-P up to 10MHz rate
Maximum Tracking Speed	Carrier remains in band	>800MHz/sec typical	>800MHz/sec typical
VSWR	N/A	2.5:1 typical	2.5:1 typical
Center Frequency Mode	N/A	N/A	Keyboard controlled. Unit will measure signal within ± 5 MHz of entered frequency. Signals of equal amplitude must be seperated by 40 MHz
Frequency Limits	N/A	N/A	Keyboard controlled. Unit will measure largest signal within set limits. Signals outside desired range must be seperated by ≥200 MHz (typical) from either limit.

*Above 1KHz, decreases @ 6dB/ octave down to 3.0 V rms

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SPECIFICATIONS

Power Measurement

Frequency Range	1-20 GHz (25B) 1-26.5 GHz (28B)	
Accuracy	±1.2 dB typical (0° to 50°C, input padded by 3 dB) ±0.5 dB typical (25°C, input padded by 3 dB)	
Resolution	Power: ±0.1 dB	
	Frequency:	100 kHz to 1 GHz (selectable) via GPIB 1 Hz to 1 GHz (selectable) via GPIB
Minimum Level	Equal to counter sensitivity	
Display	Simultaneous frequency and power reading	
Offset Range	-99.9 dB to +99.9 dB	
Offset Resolution	0.1 dB	
Offset Input	Keyboard or optional GPIB	
Measurement Time	1 Gate Time + 50ms + Freq Measurement Time	
Measurement Window	25 MHz nominal	

Time Base: Standard TCXO

Crystal Frequency	10 MHz	
Stability	Aging Rate	$<1\text{x}10^{-7}$/month, $<1\text{x}10^{-6}$/year
	Short Term	$<1\text{x}10^{-9}$ rms for one sec. averaging time
	Temperture	$<1\text{x}10^{-6}$, 0° to 50°C
	Line Variation	$<1\text{x}10^{-7}$, ±10% line voltage
Output Frequency	10 MHz square wave, 1V P-P min into 50Ω	
External Time Base	Requires 10 MHz, 1VP-P min into 300Ω	

GPIB (IEEE-488/1978) Programmabilty

GPIB	Functions, special functions and diagnostics are programmable. Address settable from the front panel. Compatible IEEE STD-488. SH1, AH1, T5, L3, SR1, RL1, DC1 and DT1 implimented.

General

Warranty	1 year Standard (Extendable to 3 years)
Frequency Resolution	Selectable 0.1 Hz to 10 MHz in band 1, 1 Hz to 1 GHz in bands 2 and 3.
Display	12-digit LED sectionalized to read GHz, MHz, kHz, Hz or GHz, MHz, kHz, dBm.
Frequency Accuracy	± 1 count ± time base error.
Test	Front panel selected service diagnostics and user information.
Sample Rate	Varies time between measurements, from 0 sec to 10 sec. HOLD freezes display indefinitely.
Reset	Resets display to zero and initiates new acquisition.
Frequency Offset	Displayed frequency is offset by the entered value to 1 Hz resolution.
Frequency Multiply	Displayed frequency is multiplied by an entered integer from 1 to 99 and displayed to 1 kHz resolution. OFFSET is added or subtracted to obtain y = mx ±b result.
Computer Interface	GPIB (IEEE 488/1978)
Certifications	CE Certified for EMI/RFI to EN50011 and EN50082-1 Certified for Safety to IEC 1010-1 (1990)
Operating Temperature	0° to 50°C.
Power	100/120/140/200/220/240/VAC ±10%, 50 to 400 Hz; 60 VA typical.
Net Weight	~ 20 lbs. (9.1 kg).
Shipping Weight	~ 26 lbs. (11.8 kg).
Dimensions	3.5" H x 8.125" W x 18.75" D (89 mm H x 206 mm W x 476 mm D).
Standard Accessories	Power cord, Operating manual, Protective front cover.

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SPECIFICATIONS

OPTION 05	High Stability Ovenized Timebase	
Stability	Aging Rate	<5×10^{-10}/day, (After 24 hour warm up).
	Short Term	<1×10^{-10} rms for one sec. averaging time
	Temperture	<3×10^{-8}, 0° to 50°C
	Line Variation	<2×10^{-10}, ±10% line voltage
	Retrace	<5×10^{-9} of final value 10 minutes after counter is turned on at 25°C

Time base option utilizes a proportional control oven which is energized whenever the line cord is connected to an AC source, and operates even when the unit is switched off.

ORDERING INFORMATION

MODEL 25B	10 Hz - 20 GHz Microwave Frequency Counter	
MODEL 28B	10 Hz - 26.5 GHz Microwave Frequency Counter	
Options	05	High Stability Ovenized Time Base
	14	2 Year Warranty Extension (3 years total)
	15	MIL-STD 45662 (ANSI Z540-1:94)
Accessories	011	Rack Mount Kit without Handles
	016	Chassis Slide Kit for 1 Unit
	018	Front Panel Handle Kit
	021	Suitcase Style Transit Case
	031	Extra Operating Manual (one supplied at no cost)
	032	Maintenance and Service Manual (includes operation information)
	042	Service Kit

For More Information Contact:

Phase Matrix, Inc.
109 Bonaventura Dr.
San Jose, CA. 95134 USA
tel: 408-428-1000
fax: 408-428-1500
toll free: 877-4PhaseM
www.phasematrix.com

Specifications and ordering information subject to change without notice.

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Printed in the USA
Revision 10/99

Datasheet Prepared By:
Sonic Imagery Labs and
PixelJam Productions

Phase Matrix, Inc.

Instruments You Can Count On

545B
548B

Phase Matrix, Inc. EIP 545B and 548B CW Frequency Counters

Full Function CW Microwave Frequency Counters with Selective Power Measurement

- Keyboard controlled frequency limit selection
- Power Measurement to 0.1 dB resolution
- Power Measurement accuracy to ±0.5 dB typical
- -30 dBm sensitivity
- 200 Watt (+53 dBm) peak damage protection
- 10 dB automatic amplitude discrimination
- 200msec acquisition time
- Up to 800 MHz/sec tracking speed
- 20MHz P-P FM tolerance up to a 10 MHz rate

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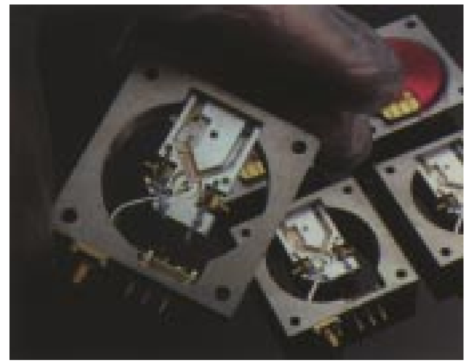
Phase Matrix / EIP 545B and 548B. . . .
Full Function Microwave Frequency Counters

The Ideal Benchtop Counters

The combination of accuracy, simple operation, and the widest range of standard features and options available ina microwave counter makes the 545B/548B family the best choice for your R&D lab or production test bench. Wherever a microwave counter has multiple duties and a variety of applications to meet, only a full function counter with YIG-tuned preselection can provide the capabilities that you need.



Only Phase Matrix counters offer the unique YIG-preselected heterodyne technique.

The 545B measures CW, FM and AM frequencies from 10 Hz to 20 GHz, and the 548B extends that range up to 26.5 GHz. With simultaneous power measurement capability, and options for a high stability time base, these high performance counters are ideally suited for applications in:

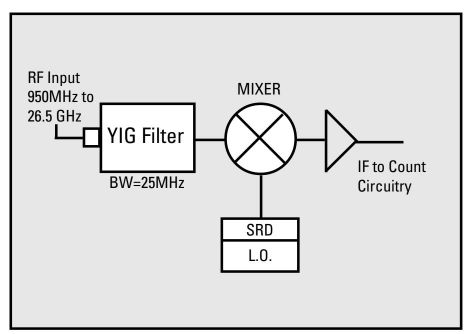
- Carrier signal measurement
- Transmitter frequency verification
- Channel specific signal measurements
- Production Line testing
- R&D Labs
- ATE

Unsurpassed Burnout Protection

Typically found in high performance spectrum analyzers; only Phase Matrix counters feature a YIG-preselected microwave input, which provides unparralled burnout protection, FM tolerance and frequency selectivity. The YIG preselector works like a tunable bandpass filter, preventing harmonics and other out-of-band spurious signals from interfering with measurement of the desired signal. It also protects the counter from accidental application of high level signals (up to 200 watts peak), reducing downtime and the associated high cost of repairing damaged microwave circuitry.

Selective Frequency and Power Measurements

With a single connection, the 545B and 548B can simultaneously measure and display the input signals frequency and power level in the microwave band, eliminating the need for a seperate microwave power meter. Within the 25MHz bandwidth of the YIG-preselector, only the selected signals frequency and power level are measured. Signals to be analyzed are selected by keystroke entry of an individual center frequency, or search a range between a low and high frquency limit. This signal selectivity, combined with 20MHz of FM tolerance at all rates up to 10MHz, allows the 545B and the 548B to make accurate frequency and power level measurements even while the input signal is carrying traffic; there is no need to take the transmitter, or adjacent channels, off the air for routine checks.



All Phase Matrix Counters feature the unique YIG Preselected Heterodyne Down-Convertor.

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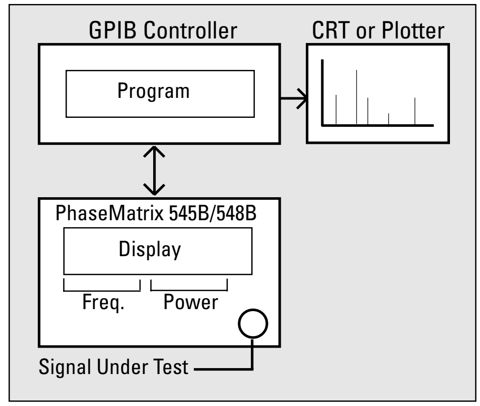
Phase Matrix / EIP 545B and 548B. . . .
The Ultimate Benchtop Instrument

Frequency Extension to 110 GHz

Option 06 provides the ability to extend the frequency range of your 548B, in bands, up to 110 GHz. Remote sensors allow you to reach out to connect to virtually any wave guide system without the complications of the additional plumbing necessary to bring the signal to your counter. A wide selection of sensors provides measurement capability in the wave guide band that you are working in now, and the flexibility to change as your application changes without having to purchase another counter.



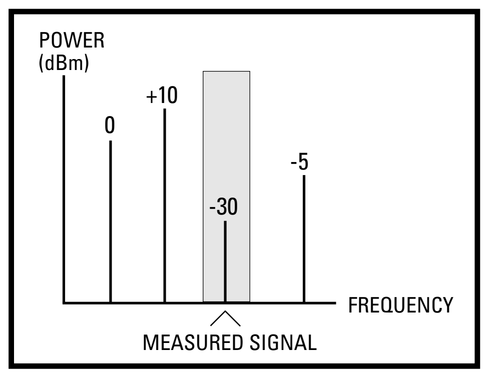
Frequency domain analysis can be accurately and quickly performed by utilizing the counter's selective frequency and selective power measurement capabilities.

Frequency Limits

Automatic amplitude discrimination enables the 545B/548B counters to automatically select and measure the input signal with the highest level, and ignore all other harmonics and other spurious signals that are present. "Frequency Limits" extend this signal selection capability by allowing you to select upper and lower limits, The counter will measure the frequency and power level of only the highest level signal within these limits - even if there are higher level signals present at the counters input. This gives you the ability to measure the frequency and power of a low level signal (such as a harmonic) even when a signal of much higher level (the fundamental) is present.

Power Measurement

The 545B/548B family of microwave counters offers the optional ability to simultaneously measure both the frequency and power level through the same input. This often eliminates the need for a separate microwave power meter. With the 25 MHz bandwidth of the YIG tuned preselector, power measurement is made only of the displayed signal, not of its harmonics or other signals present. Thus you can simultaneously measure and display both frequency and power of individual signals in a multisignal environment. Easy keystroke entry of power offsets can be used to measure power deviation from a reference, or to compensate for losses in external hook-ups such as cable and attenuator losses.



The frequency selective operation of the counters allows measurement of any individual signal's frquency and power in a multi-signal environment.

Proven Reliability

This counter has become the standard in reliability, achieving over 26,000 hours (12.5 years) of field-proven MTBF. The high performance, economy and compact configuration of the 545B and 548B make them the ideal choice for your production and R&D applications on the bench.

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SPECIFICATIONS

MODEL 545B and 548B	BAND 1	BAND 2	BAND 3
Frequency Range	10 Hz-100 MHz	10 MHz-1 GHz	1-20 GHz (545B) 1-26.5 GHz (548B)
Sensitivity	25mV rms	-20dBm	-30 dBm 1-12.4 GHz -25 dBm 12.4 GHz-20 GHz -20 dBm 20 GHz-26.5 GHz
Impedance	1MΩ/20pF	50 Ohms	50 Ohms
Connector	BNC (female)	BNC (female)	Precision Type N-female (545B) APC 3.5-female (548B)
Input Coupling	DC	AC	AC
Maximum Operating Level	120 V rms*	+10 dBm	+10 dBm
Damage Level	150 V rms*	+27 dBm	+45 dBm (30 watts) continuous +53 dBm (200 watts) peak pulsed (<1uS PW, 0.1% duty)
Acquisition Time			
Standard	N/A	<50mS	<200ms
Center Frequency Mode	N/A	N/A	<20ms
Automatic Amplitude Discrimination	N/A	N/A	10 dB
FM Tolerance	Carrier remains in band	Carrier remains in band	20 MHz P-P up to 10MHz rate
Maximum Tracking Speed	Carrier remains in band	>800MHz/sec typical	>800MHz/sec typical
VSWR	N/A	2.5:1 typical	2.5:1 typical
Center Frequency Mode	N/A	N/A	Keyboard controlled. Unit will measure signal within ± 5 MHz of entered frequency. Signals of equal amplitude must be seperated by 40 MHz
Frequency Limits	N/A	N/A	Keyboard controlled. Unit will measure largest signal within set limits. Signals outside desired range must be seperated by ≥200 MHz (typical) from either limit.

*Above 1KHz, decreases @ 6dB/octave down to 3.0 V rms

BAND 4 (option 06, 548B only)

Frequency Range	26.5 GHz - 110 GHz
Sensitivity	-25 dBm typical
Connector	Depends on remote sensor
Maximum Operating Level	+5 dBm
Damage Level	+10 dBm
Acquisition Time	<1 second typical
Amplitude Discrimination	10 dB

SPECIFICATIONS

Power Measurement

Frequency Range	1-20 GHz (545B) 1-26.5 GHz (548B)	
Accuracy	±1.2 dB typical (0° to 50°C, input padded by 3 dB) ±0.5 dB typical (25°C, input padded by 3 dB)	
Resolution	Power: ±0.1 dB	
	Frequency:	100 kHz to 1 GHz (selectable) via GPIB 1 Hz to 1 GHz (selectable) via GPIB
Minimum Level	Equal to counter sensitivity	
Display	Simultaneous frequency and power reading	
Offset Range	-99.9 dB to +99.9 dB	
Offset Resolution	0.1 dB	
Offset Input	Keyboard or optional GPIB	
Measurement Time	1 Gate Time + 50ms + Freq Measurement Time	
Measurement Window	25 MHz nominal	

Time Base: Standard TCXO

Crystal Frequency	10 MHz	
Stability	Aging Rate	$<1x10^{-7}$/month, $<1x10^{-6}$/year
	Short Term	$<1x10^{-9}$ rms for one sec. averaging time
	Temperture	$<1x10^{-6}$, 0° to 50°C
	Line Variation	$<1x10^{-7}$, ±10% line voltage
Output Frequency	10 MHz square wave, 1V P-P min into 50Ω	
External Time Base	Requires 10 MHz, 1VP-P min into 300Ω	

GPIB (IEEE-488/1978) Programmabilty

GPIB	Functions, special functions and diagnostics are programmable. Address settable from the front panel. Compatible IEEE STD-488. SH1, AH1, T5, L3, SR1, RL1, DC1 and DT1 implimented.

General

Warranty	1 year Standard (Extendable to 3 years)
Frequency Resolution	Selectable 0.1 Hz to 10 MHz in band 1, 1 Hz to 1 GHz in bands 2 and 3.
Display	12-digit LED sectionalized to read GHz, MHz, kHz, Hz or GHz, MHz, kHz, dBm.
Frequency Accuracy	± 1 count ± time base error.
Test	Front panel selected service diagnostics and user information.
Sample Rate	Varies time between measurements, from 0 sec to 10 sec. HOLD freezes display indefinitely.
Reset	Resets display to zero and initiates new acquisition.
Frequency Offset	Displayed frequency is offset by the entered value to 1 Hz resolution.
Frequency Multiply	Displayed frequency is multiplied by an entered integer from 1 to 99 and displayed to 1 kHz resolution. OFFSET is added or subtracted to obtain y = mx ±b result.
Computer Interface	GPIB (IEEE 488/1978)
Certifications	CE Certified for EMI/RFI to EN50011 and EN50082-1 Certified for Safety to IEC 1010-1 (1990)
Operating Temperature	0° to 50°C.
Power	100/120/140/200/220/240/VAC ±10%, 50 to 400 Hz, 60 VA typical.
Net Weight	~ 26 lbs. (11.8 kg).
Shipping Weight	~ 32 lbs. (14.5 kg).
Dimensions	3.5" H x 16.75" W x 14.0" D (89 mm H x 425 mm W x 356 mm D).
Standard Accessories	Power cord, Operating manual.

SPECIFICATIONS

OPTION 01	**Digital to Analog Converter**	
	Option 01 will convert any three consecutively displayed digits to an analog voltage output. A display of 000 produces 0 volts output; 999 produces 0.999 volts full scale. Output is updated after every display update.	
OPTION 02	**Power Measurement**	
	Option 02 measures power of signals applied to the Band 3 input. Power and frequency are simultaneously displayed to 0.1 dB and 100kHz resolution, respectively. Option 02 also allows power offsets from -99.99 to +99.99 dB (0.1 dB resolution) to be input from the keyboard or via GPIB.	
OPTION 05	**High Stability Ovenized Timebase**	
Stability	Aging Rate	$<5x10^{-10}$/day, (After 24 hour warm up).
	Short Term	$<1x10^{-10}$ rms for one sec. averaging time
	Temperture	$<3x10^{-8}$, 0° to 50°C
	Line Variation	$<2x10^{-10}$, ±10% line voltage
	Retrace	$<5x10^{-9}$ of final value 10 minutes after counter is turned on at 25°C

Frequency Extention Accessories

590 Frequency extention cable kit
091 26.5-40 GHz remote sensor, waveguide
092 40-60 GHz remote sensor, waveguide
093 60-90 GHz remote sensor, waveguide
094 90-110 GHz remote sensor, waveguide
095 50-75 GHz remote sensor, waveguide
096 33-50 GHz remote sensor, waveguide
097 26.5-50 GHz remote sensor, coax

Note: All remote sensors require cable kit 590 and extended frequency Option 06

ORDERING INFORMATION

MODEL 545B	10 Hz - 20 GHz Microwave Frequency Counter	
MODEL 548B	10 Hz - 26.5 GHz Microwave Frequency Counter	
Options	01	Digital to Analog Converter
	02	Power Measurement
	05	High Stability Ovenized Time Base
	06	Frequency Extension
	09	Rear Panel Signal Input
	10	24" Chasis Slides
	14	2 Year Warranty Extension (3 years total)
	15	MIL-STD 45662 (ANSI Z540-1:94)
Accessories	010	Transit Case
	020	Rack Mount Kit
	031	Extra Operating Manual (one supplied at no cost)
	032	Maintenance and Service Manual (includes operation information)
	040	Service Kit

For More Information Contact:

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109 Bonaventura Dr.
San Jose, CA. 95134 USA
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toll free: 877-4PhaseM
www.phasematrix.com

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Printed in the USA
Revision 10/99

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Datasheet Prepared By:
Sonic Imagery Labs and
PixelJam Productions

Phase Matrix, Inc.

Instruments You Can Count On

575B
578B

Phase Matrix, Inc.
EIP 575B and 578B
CW Frequency Counters

Source Locking CW Microwave Frequency Counters with Selective Power Measurement

- Source Locking
    - Frequency Range of 10 MHz to 20/26.5 GHz (110 GHz optional)
    - Resolution to 10 kHz • 200 msec phase-lock time
- Keyboard controlled frequency limit selection
- Power measurement accuracy to ±0.5dB typical
- -30 dBm sensitivity
- 200 Watt (+53 dBm) peak damage protection
- 200msec acquistion time
- 20 Mhz P-P FM tolerance up to 10 MHz rate

Phase Matrix has moved. Our new address is:
4600 Patrick Henry Drive
Santa Clara CA 95054
Tel: 408-610-6810

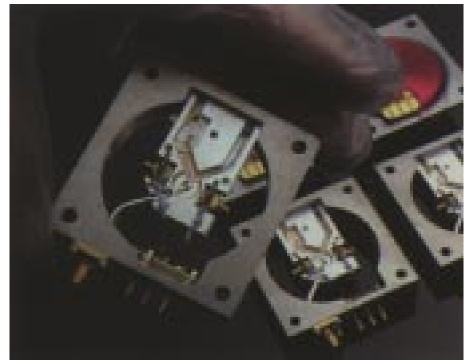
Phase Matrix / EIP 575B and 578B. . . .
Source Locking Microwave Frequency Counters

The Ideal Research Counters

This family of Phase Matrix/EIP microwave frequency counters provides fully automatic source locking of virtually any electronically tunable source to the same accuracy and long term stability as the timebase oscillator in the counter. The ability of the 575B and the 578B to accurately set and stabilize the frequency of a source generator often eliminates the need for an expensive, synthesized signal generator.

The 575B measures CW, FM and AM frequencies from 10 Hz to 20 GHz, and the 578B extends that range up to 26.5 GHz. With simultaneous power measurement capability, and options for a high stability time base, these high performance counters are ideally suited for applications in:

- Production Line testing
- R&D Labs
- ATE



Only Phase Matrix counters offer the unique YIG-preselected heterodyne technique.

Unsurpassed Burnout Protection

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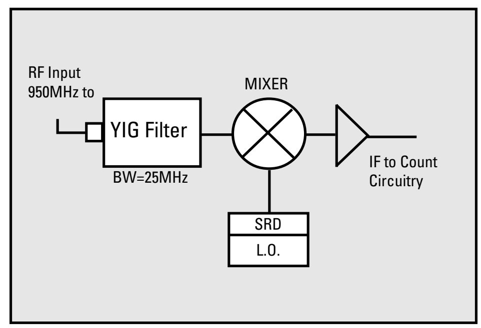
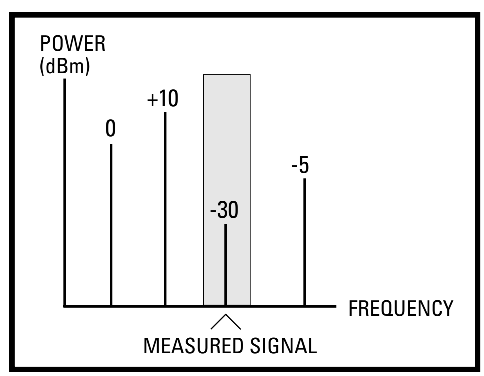


All Phase Matrix Counters feature the unique YIG Preselected Heterodyne Down-Convertor.

Selective Frequency and Power Measurements

With a single connection, the 575B and 578B can simultaneously measure and display the input signals frequency and power level in the microwave band, eliminating the need for a seperate microwave power meter. Within the 25MHz bandwidth of the YIG-preselector, only the selected signals frequency and power level are measured. Signals to be analyzed are selected by keystroke entry of an individual center frequency, or search a range between a low and high frquency limit. This signal selectivity, combined with 20MHz of FM tolerance at all rates up to 10MHz, allows the 575B and the 578B to make accurate frequency and power level measurements even while the input signal is carrying traffic.



The frequency selective operation of the counters allows measurement of any individual signal's frequency and power in a multi-signal environment.

Frequency Extension to 110 GHz

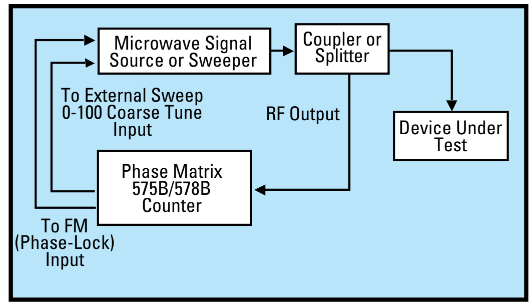
Option 06 provides the ability to extend the frequency range of your 578B, in bands, up to 110 GHz. Remote sensors allow you to reach out to connect to virtually any wave guide system without the complications of the additional plumbing necessary to bring the signal to your counter. A wide selection of sensors provides measurement capability in the wave guide band that you are working in now, and the flexibility to change as your application changes without having to purchase another counter.

Phase Matrix / EIP 575B and 578B. . . .
The Ultimate Reasearch Instrument

New Flexibility For GPIB-based ATE Systems

The Phase Matrix 575B/578B family of counters offers new flexibility and efficiency in controller programming of your source. First, programming steps can be eliminated by letting the counter directly control the sources frequency over its entire frequency range. Second, only a single command string to the counter is needed to set and lock the source. Third, the signal source does not need to have GPIB capability. The counter constantly monitors and corrects the source thereby relieving the controller of the task of checking the frequency and issuing correction commands. The ability to rapidly step and lock the signal source also saves test time as shown by these examples:

Frequency Step	Typical Lock Time
1 MHz	<200 ms
10 MHz	<300 ms
1 GHz	<500 ms



Only three connections are required to coarse tune and then phase-lock an electrically tunable microwave signal source. The ability of the 575B and the 578B to accurately set and stabilize the frequency of a source generator often eliminates the need for an expensive, synthesized signal generator.

Automatic Broad-Band Tuning

Operation of the source and counter combination is straightforward and automatic. Lock frequency is easily entered via the front panel keyboard or via standard GPIB interface. The counter automatically takes it from there, locking the source at the entered frequency.

Frequency Storage and Recall

For repetitive production testing, an operator can store up to nine lock frequencies and rapidly recall them as needed. This also reduces typical lock times for steps over 10 MHz to<300ms.

Frequency Limits

Automatic amplitude discrimination enables the 575B/578B counters to automatically select and measure the input signal with the highest level, and ignore all other harmonics and other spurious signals that are present. "Frequency Limits" extend this signal selection capability by allowing you to select upper and lower limits, The counter will measure the frequency and power level of only the highest level signal within these limits - even if there are higher level signals present at the counters input. This gives you the ability to measure the frequency and power of a low level signal (such as a harmonic) even when a signal of much higher level (the fundamental) is present.

Power Measurement

The 575B/578B family of microwave counters offers the optional ability to simultaneously measure both the frequency and power level through the same input. This often eliminates the need for a separate microwave power meter. With the 25 MHz bandwidth of the YIG tuned preselector, power measurement is made only of the displayed signal, not of its harmonics or other signals present. Thus you can simultaneously measure and display both frequency and power of individual signals in a multisignal environment. Easy keystroke entry of power offsets can be used to measure power deviation from a reference, or to compensate for losses in external hook-ups such as cable and attenuator losses.

SPECIFICATIONS

MODEL 575B and 578B	BAND 1	BAND 2	BAND 3
Frequency Range	10 Hz-100 MHz	10 MHz-1 GHz	1-20 GHz (575B) 1-26.5 GHz (578B)
Sensitivity	25mV rms	-20dBm	-30 dBm 1-12.4 GHz -25 dBm 12.4 GHz-20 GHz -20 dBm 20 GHz-26.5 GHz (578B)
Impedance	1MΩ/20pF	50 Ohms	50 Ohms
Connector	BNC (female)	BNC (female)	Precision Type N-female (575B) APC 3.5-female (578B)
Input Coupling	DC	AC	AC
Maximum Operating Level	120 V rms*	+10 dBm	+10 dBm
Damage Level	150 V rms*	+27 dBm	+45 dBm (30 watts) continuous +53 dBm (200 watts) peak pulsed (<1uS PW, 0.1% duty)
Acquisition Time			
Standard	N/A	<50mS	<200ms
Center Frequency Mode	N/A	N/A	<20ms
Automatic Amplitude Discrimination	N/A	N/A	10 dB
FM Tolerance	Carrier remains in band	Carrier remains in band	20 MHz P-P up to 10MHz rate
Maximum Tracking Speed	Carrier remains in band	>800MHz/sec typical	>800MHz/sec typical
VSWR	N/A	2.5:1 typical	2.5:1 typical
Center Frequency Mode	N/A	N/A	Keyboard controlled. Unit will measure signal within ± 5 MHz of entered frequency. Signals of equal amplitude must be seperated by 40 MHz
Frequency Limits	N/A	N/A	Keyboard controlled. Unit will measure largest signal within set limits. Signals outside desired range must be seperated by ≥200 MHz (typical) from either limit.

*Above 1KHz, decreases @ 6dB/octave down to 3.0 V rms

BAND 4 (option 06, 578B only)

Frequency Range	26.5 GHz - 110 GHz
Sensitivity	-25 dBm typical
Connector	Depends on remote sensor
Maximum Operating Level	+5 dBm
Damage Level	+10 dBm
Acquisition Time	<1 second typical
Amplitude Discrimination	10 dB

SPECIFICATIONS

Power Measurement

Frequency Range	1-20 GHz (575B) 1-26.5 GHz (578B)	
Accuracy	±1.2 dB typical (0° to 50°C, input padded by 3 dB) ±0.5 dB typical (25°C, input padded by 3 dB)	
Resolution	Power: ±0.1 dB	
	Frequency:	100 kHz to 1 GHz (selectable) via GPIB 1 Hz to 1 GHz (selectable) via GPIB
Minimum Level	Equal to counter sensitivity	
Display	Simultaneous frequency and power reading	
Offset Range	-99.9 dB to +99.9 dB	
Offset Resolution	0.1 dB	
Offset Input	Keyboard or optional GPIB	
Measurement Time	1 Gate Time + 50ms + Freq Measurement Time	
Measurement Window	25 MHz nominal	

Time Base: Standard TCXO

Crystal Frequency	10 MHz	
Stability	Aging Rate	$<1\times10^{-7}$/month, $<1\times10^{-6}$/year
	Short Term	$<1\times10^{-9}$ rms for one sec. averaging time
	Temperture	$<1\times10^{-6}$, 0° to 50°C
	Line Variation	$<1\times10^{-7}$, ±10% line voltage
Output Frequency	10 MHz square wave, 1V P-P min into 50Ω	
External Time Base	Requires 10 MHz, 1VP-P min into 300Ω	

GPIB (IEEE-488/1978) Programmabilty

GPIB	Functions, special functions and diagnostics are programmable. Address settable from the front panel. Compatible IEEE STD-488. SH1, AH1, T5, L3, SR1, RL1, DC1 and DT1 implimented.

General

Warranty	1 year Standard (Extendable to 3 years)
Frequency Resolution	Selectable 0.1 Hz to 10 MHz in band 1, 1 Hz to 1 GHz in bands 2 and 3.
Display	12-digit LED sectionalized to read GHz, MHz, kHz, Hz or GHz, MHz, kHz, dBm.
Frequency Accuracy	± 1 count ± time base error.
Test	Front panel selected service diagnostics and user information.
Sample Rate	Varies time between measurements, from 0 sec to 10 sec. HOLD freezes display indefinitely.
Reset	Resets display to zero and initiates new acquisition.
Frequency Offset	Displayed frequency is offset by the entered value to 1 Hz resolution.
Frequency Multiply	Displayed frequency is multiplied by an entered integer from 1 to 99 and displayed to 1 kHz resolution. OFFSET is added or subtracted to obtain y = mx ±b result.
Computer Interface	GPIB (IEEE 488/1978)
Certifications	CE Certified for EMI/RFI to EN50011 and EN50082-1 Certified for Safety to IEC 1010-1 (1990)
Operating Temperature	0° to 50°C.
Power	100/120/140/200/220/240/VAC ±10%, 50 to 400 Hz, 60 VA typical.
Net Weight	~ 26 lbs. (11.8 kg).
Shipping Weight	~ 32 lbs. (14.5 kg).
Dimensions	3.5" H x 16.75" W x 14.0" D (89 mm H x 425 mm W x 356 mm D).
Standard Accessories	Power cord, Operating manual.

Phase Matrix has moved. Our new address is:
4600 Patrick Henry Drive
Santa Clara CA 95054
Tel: 408-610-6810

SPECIFICATIONS

Source Locking Specifications

	Frequency Range	10 MHz-20 GHz (575B), 10 MHz-26.5 GHz (578B)
	Resolution	10 kHz (2.5 kHz <50 MHz)
	Accuracy	Equal to counters timebase
	Long Term Stability	Equal to counters timebase
	Polarity	Automatically selected
	Bandwidth	User selectable, 10 kHz, 2kHz, 500Hz, or counter automatically selects the widest bandwidth capable of locking.
Lock Time (typical)	Coarse Tune	50 msec + 1 counter acquisition time period for source bandwidths greater than 100 Hz; limited by source tuning speed below 100 Hz.
	Phase-Lock	200 ms
	Recall Stored Data	100 ms + 1 counter acquisition period (limited by source tuning speed.)
Output Drive (maximum)	Coarse Tune	0 to +10V into 5K ohms min.
	Phase-Lock	±10V into 5K ohms min. for source gain constant <64 MHz/V. ±75mA into 10K ohms max. for source gain constant <3.2 MHz/mA. ±0.6V into 5K ohms min. for source gain constant >64 MHz/V. ±4.5mA into 10K ohms max. for source gain constant >3.2 MHz/mA.
Capture Range	Coarse Tune	Entire range of selected counter band, limited by the maximum output drive.
	Phase-Lock	Source gain constant multiplied by maximum output drive.
Output Connector		Rear Panel BNC, female Rear Panel BNC, female

Phase Lock Spectrum

Noise Floor vs. Input Frequency
The noise floor extends from the carrier to approximately the loop bandwidth. Beyond this, the noise floor decreases 12 dB/bandwidth octave. The noise floor is the greater of: 1) -70dBc/Hz or 2) (20log F) -65 dBc/Hz where F= Input frequency in GHz.

Required Source Characteristics

External Sweep	Bandwidth	5Hz minimum	
Coarse Tune Input	Tuning Sensitivity	10 MHz/V minimum 10 GHz/V maximum	
FM (Phase-Lock) Input	Bandwidth	2 kHz minimum	
	Tuning Sensitivity:		
	Voltage Driven Input	±2 MHz/V min ±1 GHz/V max	
	Current Driven Input	±0.1 MHz/mA min ±50 MHz/mA max	

Specifications and ordering information subject to change without notice.

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SPECIFICATIONS

OPTION 01	**Digital to Analog Converter**
	Option 01 will convert any three consecutively displayed digits to an analog voltage output. A display of 000 produces 0 volts output; 999 produces 0.999 volts full scale. Output is updated after every display update.
OPTION 02	**Power Measurement**
	Option 02 measures power of signals applied to the Band 3 input. Power and frequency are simultaneously displayed to 0.1 dB and 100kHz resolution, respectively. Option 02 also allows power offsets from -99.99 to +99.99 dB (0.1 dB resolution) to be input from the keyboard or via GPIB.

OPTION 05	**High Stability Ovenized Timebase**	
Stability	Aging Rate	$<5\times10^{-10}$/day, (After 24 hour warm up).
	Short Term	$<1\times10^{-10}$ rms for one sec. averaging time
	Temperture	$<3\times10^{-8}$, 0° to 50°C
	Line Variation	$<2\times10^{-10}$, ±10% line voltage
	Retrace	$<5\times10^{-9}$ of final value 10 minutes after counter is turned on at 25°C

Frequency Extention Accessories

590 Frequency extention cable kit
091 26.5-40 GHz remote sensor, waveguide
092 40-60 GHz remote sensor, waveguide
093 60-90 GHz remote sensor, waveguide
094 90-110 GHz remote sensor, waveguide
095 50-75 GHz remote sensor, waveguide
096 33-50 GHz remote sensor, waveguide
097 26.5-50 GHz remote sensor, coax

Note: All remote sensors require cable kit 590 and extended frequency Option 06

ORDERING INFORMATION

MODEL 575B	10 Hz - 20 GHz Source Locking Microwave Frequency Counter
MODEL 578B	10 Hz - 26.5 GHz Source Locking Microwave Frequency Counter

Options	01	Digital to Analog Converter
	02	Power Measurement
	05	High Stability Ovenized Time Base
	06	Frequency Extension
	09	Rear Panel Signal Input
	10	24” Chasis Slides
	14	2 Year Warranty Extension (3 years total)
	15	MIL-STD 45662 (ANSI Z540-1:94)
Accessories	010	Transit Case
	020	Rack Mount Kit
	031	Extra Operating Manual (one supplied at no cost)
	032	Maintenance and Service Manual (includes operation information)
	040	Service Kit

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4600 Patrick Henry Drive
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Tel: 408-610-6810

Phase Matrix, Inc
575B and 578B

Source Locking CW Microwave Frequency Counters with Selective Power Measurement

For More Information Contact:

Phase Matrix, Inc.
109 Bonaventura Dr.
San Jose, CA. 95134 USA
tel: 408-428-1000
fax: 408-428-1500
toll free: 877-4PhaseM
www.phasematrix.com

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Specifications and ordering information subject to change without notice.

Printed in the USA
Revision 10/99

Datasheet Prepared By:
Sonic Imagery Labs and
PixelJam Productions

Phase Matrix, Inc.

Instruments You Can Count On

585C
588C
595A
598A

Pulse/CW Frequency Counters with Peak Power (595A/598A)

- Pulse and CW Frequency Measurement to 170 GHz
- Peak Power Measurement to 26.5 GHz
- Built-in Pulse Profiling
- 200 Watt (+53 dBm) Burnout Protection

Phase Matrix has moved. Our new address is:

4600 Patrick Henry Drive
Santa Clara CA 95054
Tel: 408-610-6810

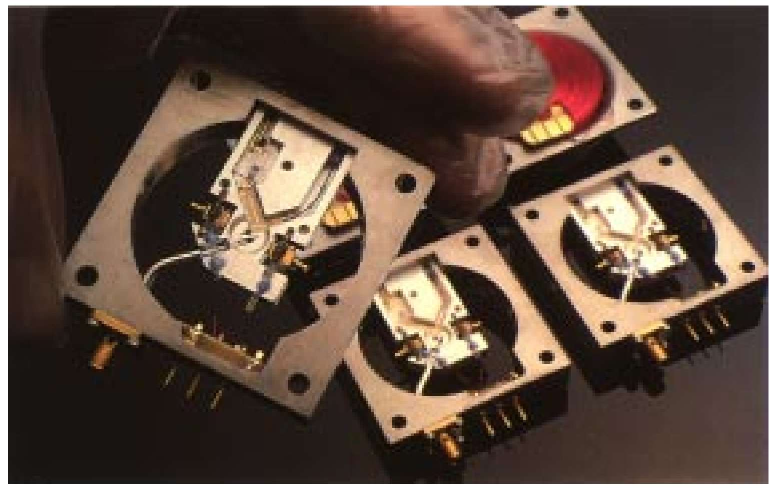
EIP/Phase Matrix Pulse/CW Microwave and Millimeter-Wave Counters

Automatic Acquisition and Profiling (Both Frequency and Power) with the Broadest Frequency Measurement Coverage: 100Hz to 170GHz

585C / 588C full function pulse/CW counters with an optional internal delaying pulse generator for the ultimate in ease-of-use

595A / 598A add practical peak and CW power measurements to the capability of the 585C/588C

Phase Matrix brings to you the broadest spectrum of pulse and CW microwave and millimeter-wave frequency counters available today. These models offer automatic and self contained frequency and power profiling that is ideally suited to such applications as chirped radar analysis, VCO measurement, and frequency agile system analysis over a frequency range up to 170 GHz (depending upon the model selected).



Phase Matrix's frequency selective heterodyne technique with unique YIG filter frontend offers benefits not available in any other counter.

Pulsed or CW Measurements to 170 GHz

The 588C and 598A extended frequency capability enables CW measurements from 100 Hz to 170 GHz, and pulsed measurements from 250 MHz to 170 GHz. Parameters such as frequency, power (595A/598A only), pulse width, pulse period, or PRF can all be measured fully automatically. The 585C/588C and the 595A/598A will detect and measure CW, frequency modulated, amplitude modulated, or pulsed RF signals with pulse widths as narrow as 50nS.

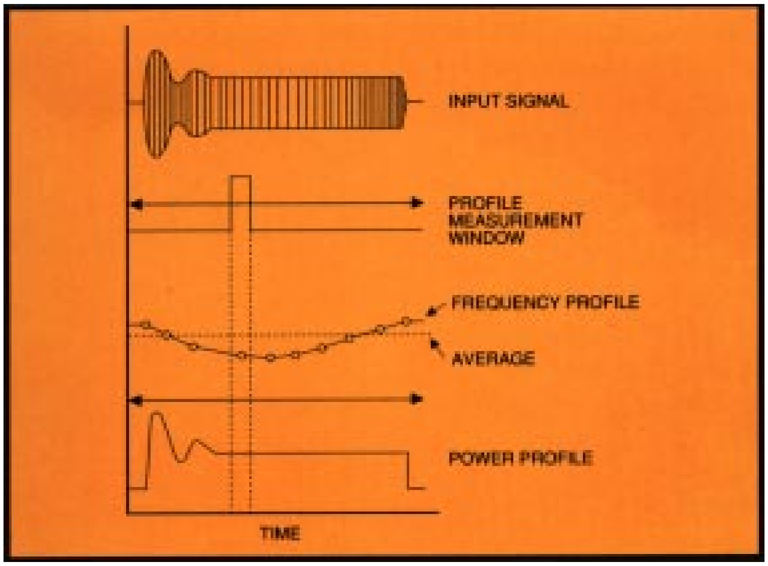
Automatic Peak Power

The 595A/598A greatly simplify the measurement of peak power in your application. By measuring the frequency of the incoming signal, the instrument automatically corrects the power reading for the Calibration Factor of the internal sensor. You no longer have to manually enter the Calibration Factors or the measurement frequency. Careful design and internal calibration tables result in excellent accuracy and repeatability.

Self-Contained Profiling of Frequency and Power

The optional built in delaying pulse generator enables completely self-contained frequency and power profiling measurements. Synchronous outputs on the rear panel show actual measurement window for viewing on an oscilloscope. In addition, automatic measurements of pulse width, pulse period and pulse repetition frequency simplify your measurement task.

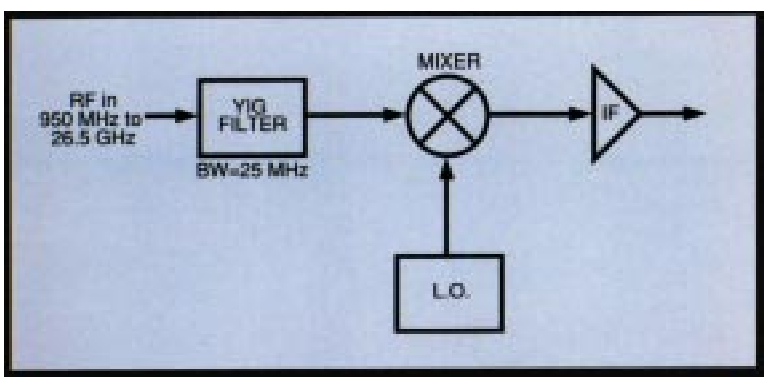
True profiled measurements are possible with a sample window as narrow as 15nS. Careful design consideration was given to accurately and automatically measuring rapidly varying pulse bursts as might be typical in the generation of frequency hopping or wide band chirp signals. The Phase Matrix/EIP Model 595A/598A and 585C/588C actually reacquire the microwave signal for each measurement window, allowing essentially unlimited frequency changes from window to window. Competitive techniques require external gating if the frequency changes more than 10 MHz within the detected burst.



Frequency and power can be automatically profiled with the optional internal delaying pulse generator

Unmatched Frequency Selectivity

Only Phase Matrix/EIP counters utilize the proven YIG Preselected Heterodyne Down Conversion technique. This spectrum analyzer type preselector prevents harmonics and other spurious signals from interfering with the measurement of the desired signal. Additionally, it totally eliminates “kickback” noise. Furthermore, this frequency selectivity allows the user to select any desired signal for measurement of both power and frequency in a multi-signal environment.



All Phase Matrix Counters features the unique YIG Preselected Heterodyne Down-Convertor.

Graceful Overload Protection to 200 Watts

The YIG filter provides effective power limiting to protect against burnout due to accidental application of high-level signals, yet does not reduce sensitivity. This greatly reduces down time, especially in the hands of unskilled operators. At remote sites, this high-level burnout protection often proves invaluable by reducing the need for additional trips if a high power signal is accidentally connected to the counter’s input.

Full Environmental Compliance

The Phase Matrix/EIP 595A/598A and 585C/588C are in full EMI/RFI environmental compliance with MIL-STD-461 and MIL-T-28800, Type III, Class 5. As well as CE certified to EN50011 and EN50082-1.

Full Programmability

These counters have been optimized for integration into ATE systems and have all the systems characteristics you need for your test applications. All front panel controls, data output format and special functions are controllable over GPIB. Also, rear panel inputs simplify the integration of your system.

High Stability Time Bases

Optional ovenized time bases provide higher accuracy and lower cost of ownership. The time base component of error is dramatically reduced with these high-stability time bases. The only periodic maintenance required on the 595A/598A and 585C/588C is time base calibration. With aging rates as low as 2 x 10^{-7}/year, the calibration cycle can be extended to two years while maintaining kHz accuracy on a 20 GHz frequency measurement.

Proven Reliability

The predecessors to the Phase Matrix models 595A/598A and 585C/588C, (EIP 585 and 588, introduced in 1985), have become standards of reliability, achieving a field proven MTBF in excess of 40,000 hours. Phase Matrix is so confident in the quality and reliability of these products that we back them with an optional three year warranty.

Automatic Pulsed/CW Frequency and Power Measurements

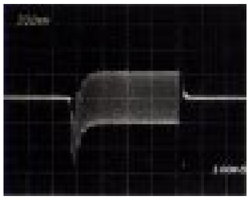


Photo 1

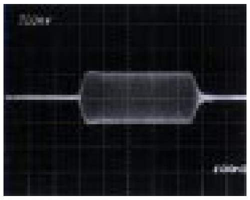


Photo 2

Photo 1 shows extreme video distortion interference on the incoming RF. Photo 2 shows the same RF signal after processing by the Phase Matrix YIG Preselected Heterodyne Down-Convertor input filter, with error causing video component removed.

1. **Automatic Pulsed Millimeter-Wave Counting up to 170 GHz** with the addition of the Model 890 cable kit and one or more harmonic mixers. Large amounts of “chirp”, often encountered in millimeter-wave signals, can be precisely counted using Center Frequency Mode.

2. **Model 595A/598A Power Measurement Capability** operates over the full operating range of the Band 1 and 2 inputs on both CW and pulsed signals.

3. **Phase Matrix’s Unique YIG Preselector** provides an excellent combination of burnout protection, sensitivity, frequency selectivity and video immunity. The inherent frequency selectivity of the YIG filter allows counting the highest amplitude signal even with many other signals present.

4. **Optional Internal Pulse Generator** makes the profiling of frequency and power simple and automatic.

5. **Pulse Width or Pulse Period** can be measured and displayed with a touch of the Pulse Width or Pulse Period key. Pulse repetition frequency can also be easily displayed.

6. **Frequency High/Low Limit** allows the measurement of a lower amplitude signal in the presence of higher amplitude signals.

7. **External Switching Requirements Eliminated** by the use of four independent signal inputs that let the operator apply multiple signals and measure any one by merely switching the band selector from the keyboard or over the IEEE-488 Bus.

8. **Dual Display For Fast, Easy Readout** simultaneously provides <u>two</u> important signal parameters: 1) Frequency to 1 kHz resolution, and either 2) Power to 0.1 dB resolution or 3) Pulse width (or pulse period) to 10 nanosecond resolution. The three-digit (or six digits with special function mode) pulse period/pulse width display utilizes a floating decimal format with annunciators.

9. **Automatic Power-Up Self-Testing and Go-to-Local** allows one key stroke to switch from remote to local, or to fully initialize the system from local. When initialized, the instrument automatically executes power-up self-tests.

10. **Precise Pulse Measurements Provided by the IF Threshold and Gate Outputs.** These convenient outputs allow the operator to monitor exactly where within the RF pulse the sample is taken. This feature is especially useful when using external gating for frequency profiling.

11. **All Front Panel Functions and Test Sequences Can Be Placed Under GPIB Control** via the IEEE-488 bus for ATE applications.

12. **Optional Rear Panel Inputs** simplify signal routing in rack-mounted applications.

13. **External Time Base Reference Capability** allows the use of an external 10 MHz reference as a common system time base. Or use the output of the optional ovenized oscillator as the system time base.

	BAND 1	BAND 2	BAND 3 (Option 5804)
Frequency Range	0.25 -1 GHz	595A & 585C: 0.95 - 20 GHz 598A & 588C: 0.95-26.5 GHz	26.5-170 GHz
Sensitivity	-20dBM	0.95 - 2GHz -20 dBm 2 - 12.4 GHz -25 dBm 12.4 - 20 GHz -20 dBm 20 - 26.5 GHz -15 dBm	-20 dBm (26.5 to 60 GHz) -15 dBm (60 to 170 Ghz)
Connector	BNC	595A & 585C: Precision N 598A & 588C: APC 3.5	Depends on remote sensor (See Table)
Impedance	50 Ω nominal	50 Ω nominal	N/A
Maximum Input **Damage Level**	+7 dBm +27 dBm	+7 dBm +45 dBm CW +53 dBm peak pulsed (≤1µS pulse, 0.1% duty cycle)	+ 5 dBm +10 dBm
Amplitude Discrimination	15 dB	15 dB (>50 MHz seperation)	20 dB
Frequency Limits	N/A	Instrument will reject signals >50 MHz outside of Limits Resolution: 10MHz	N/A
Center Frequency	N/A	Instrument will reject signals >50 MHz outside the specified Delta Frequency. Resolution: 10MHz	Instrument assumes any signal present to be in the range ±2 GHz from the specified center frequency.
FM Tolerance **(up to 10 MHz rate)**	Carrier must remain in band	20 MHz P-P	Auto Mode: 20MHz P-P Center Freq: 150 MHz P-P
Acquisition Time* **Pulse**	$AQ = \{\frac{1}{MINPRF}\} + 0.05$	$AQ = 2(FH)\left[(4x10^{-12}) + \frac{(4x10^{-8})}{MINPRF}\right] + \frac{60}{MINPRF} + \frac{(2x10^{-5})(PP)}{GW} + 0.3$	Automatic: $AQ = \frac{70}{MINPRF} + \frac{(6x10^{-3})(PP)}{GW} + 0.2$ Center Frequency: $AQ = \frac{70}{MINPRF} + \frac{(8x10^{-4})(PP)}{GW} + 0.2$
CW	$AQ = \{\frac{1}{MINPRF}\} + 0.05$	$AQ = 2(FH)\left[(4x10^{-12}) + \frac{(4x10^{-8})}{MINPRF}\right] + \frac{60}{MINPRF} + 0.3$	$AQ = \frac{70}{MINPRF} + 0.2$
Measurement Time[2] **Pulse**	$MT = \frac{(4)(PP)}{(GW)(RES)} + 0.05$	$MT = \frac{(PP)}{(GW)(RES)} + 0.05$	$MT = \frac{(4)(PP)}{(GW)(RES)} + 0.05$
CW	$MT = \frac{(4)}{(RES)} + 0.05$	$MT = \frac{1}{(RES)} + 0.05$	$MT = \frac{4}{(RES)} + 0.05$
Gate Error[2]	$GE = \pm\frac{0.07}{GW}$	$GE = \pm\frac{0.01}{GW}$	$GE = \pm\frac{0.03}{GW}$
Distortion Error[2]	$DE = \pm\frac{0.03}{PW - (3x10^{-8})}$	$DE = \pm\frac{0.03}{PW - (3x10^{-8})}$	$DE = \pm\frac{0.02}{PW - (3x10^{-8})}$
Averaging Error[2]	$AE = \pm 2 \times \sqrt{\frac{RES}{(GW)(AVG)}}$	$AE = \sqrt{\frac{RES}{(GW)(AVG)}}$	$AE = \pm 2 \times \sqrt{\frac{RES}{(GW)(AVG)}}$
Total Error[2] **Pulse**	$TE_P = \pm AE \pm GE \pm DE \pm TimeBaseError$	$TE = \pm AE \pm GE \pm DE \pm TimeBaseError$	$TE = \pm AE \pm GE \pm DE \pm TimeBaseError$
CW	$TE_{CW} = TBError \pm 1$ count (Based on 10 averages)	$TE_{CW} = TBError \pm 1$ count (Based on 10 averages)	$TE_{CW} = TBError \pm N$ counts (where $N = \frac{freq}{20GHz}$)

SPECIFICATIONS

BAND 0 (CW only)

Frequency Range	100 Hz - 250 MHz
Sensitivity	-20dBm
Connector	BNC
Input Impedance	50 ohms nominal
Maximum Input	+7 dBm
Damage Level	+27 dBm
FM Tolerance	Carrier must remain in band
Measurement Time	(1/RES) + 50ms
Total Error[2]	TE = Time Base Error± Count

BAND 3

Model 588C/598A Frequency extended, in bands, up to 170GHz. This requires Option 5804, a frequency extension cabling kit (890), and one or more of the following remote sensors:

Remote Sensor	Frequency Range		WaveGuide Size	WaveGuide Flange
091	26.5 - 40	GHz	WR-28	UG-599/U
092	40 - 60	GHz	WR-19	UG-383/U
093	60 -90	GHz	WR-12	UG-387/U
094	90 - 110	GHz	WR-10	UG-387/U
095	50 - 75	GHz	WR-15	UG-385/U
096	33 - 50	GHz	WR-22	UG-383/U
097	26.5 - 50	GHz	K - Conn.*	Coaxial
098	110 - 170	GHz	WR - 6	UG-387/U

STANDARD TIME BASE

Crystal Frequency	10MHz (TXCO)
Stability	
Aging Rate	$<1 \times 10^{-7}$/month
Short Term	$<1 \times 10^{-9}$ RMS, 1s average
Temperature	$<1 \times 10^{-6,}$ 0° to 50°C
Line Variation	$<1 \times 10^{-7}$,± 10% Line voltage change
Warm-Up Time	None required
Output Frequency	10 MHz square wave, 1V p – p minimum into 50 ohms.
External Time Base	Requires 10 MHz square wave, 1V p – p minimum into 300 ohms.

OPTIONAL HIGH-STABILITY OVENIZEDTIME BASE

Option	**5809**
Aging Rate per 24 hrs (after 72 hours warm-up)	$<5 \times 10^{-10}$
Short Term Stability 1s Average (RMS)	$<1 \times 10^{-10}$
Temperature Stability (0° - 50°C)	$<3 \times 10^{-9}$
±10% Line Voltage Change	$<2 \times 10^{-10}$

PULSED MEASUREMENTS

Pulse Width	50 ns - CW
Minimum Profile Sample	15 ns frequency/100 ns power
Pulse Repetition Frequency (PRF)	1 Hz - 4 MHz
Minimum Off Time	200 ns (will count CW)
Minimum On/Off Ratio	15 dB

PULSE PARAMETER MEASUREMENTS

	Pulse Width	**Pulse Period**
Range	50ns - 1 s	250 ns - 1 s
Resolution	10 ns	10 ns
Measurement Points	-6 dB ± 1.5 dB	-6 dB ± 1.5 dB
Accuracy	±30 ns (Timebase Error x PW)	

PULSE GENERATOR SPECIFICATIONS

	Min	**Max**	**Resol.**
Delay	74 ns	800 ms	2 ns
Width	24 ns	800 ms	2 ns
Period	100 ns	800 ms	50ns
Trig In	TTL, 1kΩ input		
Trig Out	TTL, into 50Ω, 50 to 100 ns width		
Pulse Out	TTL, into 50Ω		

POWER MEASUREMENT (595A AND 598A ONLY)

Measured power of signals (pulsed and CW) applied to band 1 and 2 inputs. Power and frequency are simultaneously displayed to 0.1 dB and 100 kHz resolution, respectively. Power off sets from +99.9 dB to -99.9 dB (0.1 dB resolution) can be input from the keyboard for via GPIB.

Frequency Range	250 MHz - 20 GHz (595A) 250 MHz - 26.5 GHz (598A)
Resolution	0.1 dB
Dynamic Range	Same as counter operation range
Measurement Window	25 MHz nominal
Minimum Pulse Width	100 ns (internal or external gating)
Measurement Time	Frequency measurement time plus one gate time plus 150 msec - CW
Accuracy	±0.5 dB CW typical (25°C, input padded by 3 dB) ±1.5 dB CW typical (25°C, input padded by 3 dB, 1µsec measurement window, 10% duty cycle)
Repeatability	±0.3 dB typical CW to 20 GHz ±0.5 dB typical CW to 26.5 GHz ±0.3 dB typical pulse to 20 GHz (1µsec measurement window, 10% duty cycle) ±0.8 dB typical pulse to 26.6 GHz (1µsec measurement window, 10% duty cycle)

Note 2 AE = RMS averaging error (Hz)
AQ = Aquisition time (seconds)
AVG = Number of averages
DE = Distortion error (Hz)
FH = Difference between Frequency Limit High and Low (Hz)
GE = Gate error (Hz)
TE = Total error (Hz)
GW = Logical AND of inhibit input and pulse width -3×10^{-8} (seconds)
MinPRF = Minimum PRF coutner setting (Hz); for MinPRF>1.2 kHz, use MinPRF = 1200
MT = Measurement Time (seconds)
PP = Pulse period (seconds)
PW = Pulse width (seconds)
RES = Counter resolution setting (Hz); for RES>1MHz, use RES = 10%

*K-Connector is a registered trademark of Wiltron Company
Specifications subject to change without notice.

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GENERAL

Dimensions	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	≈ 35 lbs., 15.9 Kg
Shipping Weight	≈ 40 lbs., 18.2 Kg
Operating Temperature	0 to 50°C
Power	100/120/200/240 Vac ± 10% 50 - 400 Hz, 100 VA typical
Resolution	1 Hz to 1 GHz
Gate Time	1 s to 1µs (dependent upon resolution)
Warranty	1 Year Standard (Extendable to 3 years)
Computer Interface	GPIB (IEEE-488/1987)
Certifications	CE Certified for EMC to EN50011 and EN50082-1 CE Certified for Safety to IEC 1010-1 (1990)

ORDERING INFORMATION

Model 585C	Pulse/CW Microwave Frequency Counter, 20 GHz
Model 588C	Pulse/CW Microwave Frequency Counter, 26.5 GHz
Model 595A	Pulse/CW Microwave Frequency Counter, 20 GHz with Peak Power Measurement
Model 598A	Pulse/CW Microwave Frequency Counter, 26.5 GHz with Peak Power Measurement

FREQUENCY EXTENSION ACCESSORIES FOR MODEL 588C/598A

		Waveguide Size	Waveguide Flange
890	Frequency Extension Cable Kit		
091	Remote Sensor 26.5 - 40 GHz	WR-28	UG -599/U
092	Remote Sensor 40 - 60 GHz	WR-19	UG-383/U
093	Remote Sensor 60 - 90 GHz	WR-12	UG-387/U
094	Remote Sensor 90 - 110 GHz	WR-10	UG-387/U
095	Remote Sensor 50 - 75 GHz	WR-15	UG-385/U
096	Remote Sensor 33 - 50 GHz	WR-22	UG-383/U
097	Remote Sensor 26.5 - 50 GHz	K-Conn	Coaxial
098	Remote Sensor 110 - 170 GHz	WR-6	UG-387/U

Note: Remote Sensors require cable kit 890 and extended frequency Option 5804.

OPTIONS

5803	Rear Panel Input Connectors
5804	Band 3 Frequency Extension Module Available on Model 588C/598A only.
5809	Ovenized High Stability Timebase (Aging Rate: $<5 \times 10^{-10}$/day)
5810	Delaying Pulse Generator
14	2 Year Warranty Extension (to 3 years total)
15	MIL-STD 45662A Data and Certification

ACCESSORIES

010	Transit Case
021	Rack Mount Kit with Handles
022	Rack Mount Kit without Handles
031	Extra Operations Manual (one supplied at no cost)
032	Maintenance and Service Manual (includes operations information)
043	Service Kit
050	Sof-Pac Carrying Case
101	Chassis Slide Kit with Handles (includes 021)
102	Chassis Slide without Handles (includes 022)

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Using the EIP 575B/578B Source Locking Counters with the HP 8350A/B and Its Family of Plug-ins

SCOPE: This document describes methods for using the EIP 575B/578B to phase lock the HP8350A and its family of plug-ins.

The HP 8350A with its 83XXX series plug-ins present some new challenges to the user who wants to combine them with our 575B and 578B counters.

The symptoms of the problems are no lock with the CW FILTER on and a very unstable frequency reading when locked with the CW FILTER off. If you were to look at the spectrum of the locked signal, it would have a large amount of residual FM.

These problems are actually caused by two things:

1. HP uses a crossover scheme on their FM input to produce linearity over frequency of modulation. This causes the low frequency modulation to be applied to the main coil while the higher modulation rates are AC coupled to the FM coil in the YIG oscillators.

2. When the large CW FILTER capacitor is removed from the YIG tuning circuit the residual FM on the output signal increases dramatically.

These problems can be overcome through the following procedures:

1. Set the A3S1 position 6 to the "1" state to dc couple the FM input on the HP sweeper plug-in. The A3S1 switch is on the top left hand side of the plug-in. (See operating manual supplied with plug-in.) This setting allows the CW filter to remain on during phase lock, thus producing a cleaner signal. This is all that is required to phase lock with no coarse tune.

2. For coarse tuning, short A8 K1 pins 1,14 to pins 7,8 to keep the CW FILTER on when the sweeper is in an external sweep mode. A8 K1 is the relay that switches the CW FILTER in and out of the circuit. Normally the CW FILTER is disabled in the sweep mode because it slows down the sweep function, but during phase lock it is desirable to have the CW FILTER on to reduce the residual FM in the sweeper.

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SOURCE LOCKING THE HP 8350A WITH THE HP 83592A PLUG-IN

The first set of instructions are for phase lock only, while the second set of instructions are for phase locking with coarse tune.

1. **Phase Lock Only (No Coarse Tune)**

   A. Set A3S1 position 6 to the "1" state (pushed back). This causes the FM input to be directly coupled with a sensitivity of −20 MHz/volt. See page 3-16 of the HP 8350 manual.

   B. Connect a BNC cable from the PHASE LOCK OUT connector on the rear panel of the 575B/578B counter to the FM INPUT on the rear panel of the HP 8350A.

   C. To phase lock the sweeper, the counter needs a sample of the RF signal. Using a coupler or power splitter and a cable, connect a sample of the RF output from the sweeper to the appropriate band on the 575B/578B counter.

   D. Set the switches on the HP 8350A as follows:

1.	FREQUENCY SWEEP MODE	CW
2.	INSTRUMENT STATE	X
3.	FREQUENCY/TIME	X
4.	SWEEP TRIGGER	X
5.	SWEEP	X
6.	SQUARE WAVE MODULATION	OFF
7.	RF	ON
8.	CW FILTER	ON
9.	ALC	X
10.	POWER SWEEP	AS LONG AS POWER MINIMUM IS >SENSITIVITY

   E. Set the frequency output of the sweeper to within 20 MHz of the desired frequency and instruct the counter to phase lock.

   EXAMPLE: To phase lock the sweeper at 10 GHz:

   1. Adjust the sweeper to within 20 MHz of 10 GHz.
   2. Press:

Press:	LOCK FREQ	(Key # 3 on the 575B/578B)
	10	(Frequency)
	GHz	(Frequency terminator)

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2. Coarse Tune and Phase Lock

A. Set A3S1 position 6 to the "1" state (pushed back). This causes the FM input to be directly coupled with a sensitivity of −20 MHz/Volt. See page 3-16 of the HP 8350 manual.

B. Place a shorting clip on A8 K1 pins 1,14 to pins 7,8. (See Note.)

C. Connect a BNC cable from the PHASE LOCK OUT connector on the rear panel of the 575B/578B counter to the FM INPUT on the rear panel of the HP 8350A.

D. Connect a BNC cable from the COARSE TUNE OUT connector on the rear panel of the 575B/578B counter to the SWEEP IN/SWEEP OUT connector on the front or rear panel of the HP 8350A.

E. To phase lock the sweeper, the counter needs a sample of the RF signal. Using a coupler or power splitter and a cable; connect a sample of the RF output from the sweeper to the appropriate band on the 575B/578B counter.

F. Set the switches on the HP 8350A as follows:

1. FREQUENCY SWEEP MODE .... START-STOP, DELTA F
2. INSTRUMENT STATE X
3. FREQUENCY/TIME X
4. SWEEP TRIGGER X
5. SWEEP .... EXTERNAL
6. SQUARE WAVE MODULATION .... OFF
7. RF .... ON
8. CW FILTER X
9. ALC X
10. POWER SWEEP .... AS LONG AS POWER MINIMUM IS >SENSITIVITY

G. Press the LOCK FREQ key on the 575B/578B and enter the desired frequency.

EXAMPLE: To phase lock the sweeper at 10 GHz:

Press:	LOCK FREQ	(Key # 3 on the 575B/578B)
	10	(Frequency)
	GHz	(Frequency terminator)

NOTE:

With A8 K1 shorted out in this fashion, the CW FILTER is effectively ON all the time; therefore, the unit will not be able to be swept rapidly. To use the frequency sweep feature on the HP 8350A, remove the short on A8 K1.

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Rev: 089201

Using the EIP 585B/588B Pulse Counters for Radar Pulse Profiling

SCOPE: This bulletin describes how to use the EIP 585B/588B to profile radar pulse signals

Often it is necessary to know the frequency vs. time characteristic, or frequency profile, of pulsed RF signals. This is especially true when measuring linearity on chirp radar or the stability of klystron radar.

Profiling the frequency across the pulse of a radar or other pulsed signal is a simple task using an EIP 58XB pulse counter and a delaying pulse generator. The inhibit input on the counter allows the counter to measure frequency during a defined window in time. If this window is moved in defined increments, a "profile" of frequency across the pulse can be obtained.

The setup for making the measurement is shown in Figure 1. A sample of the pulsed radar is connected to the input of the counter. A transition corresponding to the beginning of the pulse is connected to the trigger input on the pulse generator. The output of the pulse generator is connected to the INHIBIT input on the counter. The INHIBIT input on the counter appears as 50 ohms to −2 volts and is driven by ECL levels. To drive INHIBIT from a 50 ohm source the source output must be set into a 50 ohm load to 0 volts for the inhibit level and −1 volt for the enable level. When this signal is connected to the counter the voltages become −1 and −2 volts, the proper voltages for driving INHIBIT.

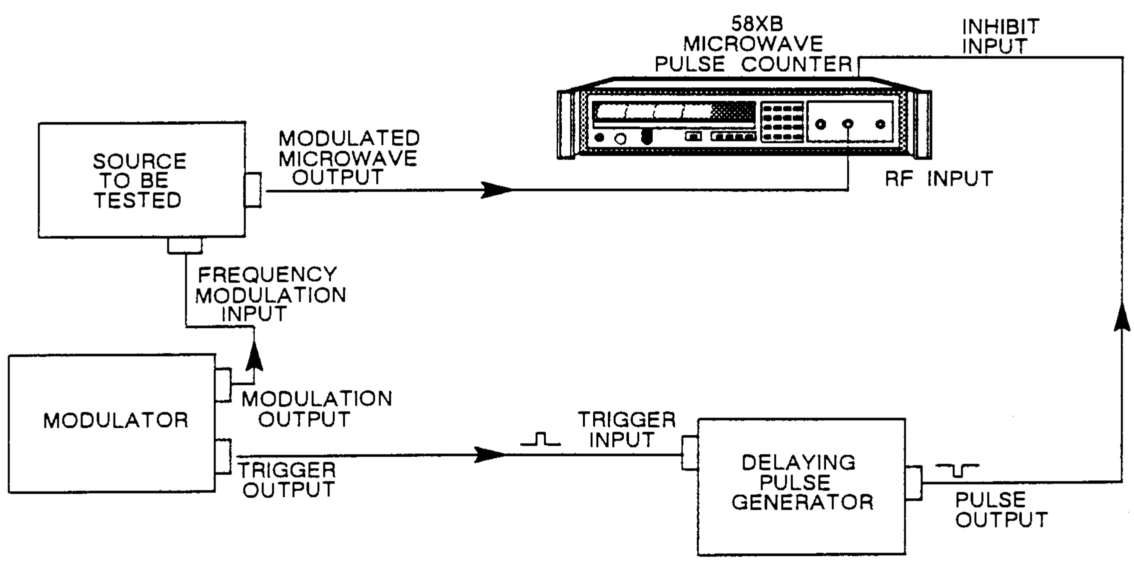

Figure 1. Setup for Using the Inhibit Input

The pulse generator is set to external trigger. The pulse generator width is set to the desired measurement window. The smaller the window, the closer the measurement will be to a point in time, but the measurement will be less accurate. The best window width is the widest one that still gives the desired time resolution. The delay of the pulse generator sets the point in time at which the measurement will be made. The delay of the pulse generator *must* be set so that the enable occurs within the RF pulse and at least 15 ns from the leading or trailing edges of the pulse.

The best method of ascertaining where the counter is measuring is to connect a sample of the envelope of the pulse to channel 1 of an oscilloscope and connect the gate output from the counter to channel 2 of the oscilloscope. For wide pulses the measurement point can be read from the oscilloscope. For precise timing, the delay of the gate signal and the cabling must be considered. The gate signal is delayed from the input by 90 ns. Most solid Teflon or polyethylene cable has a propagation delay of about 1.5 ns/foot. So for a setup such as Figure 2 the timing is: Gate output (as shown on the oscilloscope) – 90 ns – prop delay cable 1 + prop delay cable 2 – prop delay cable 3 = measurement point.

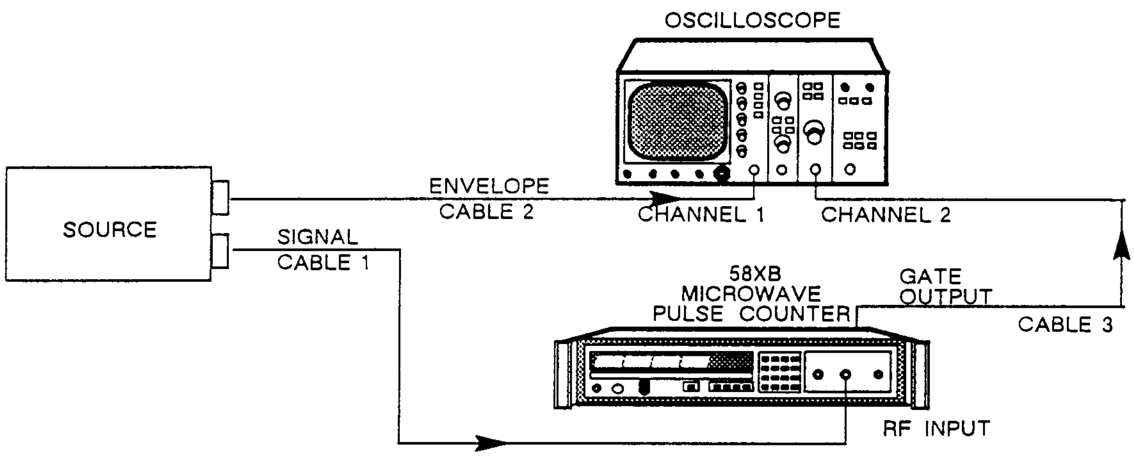

Figure 2. Setup for Determining Measurement Point

Because the INHIBIT input on EIP's 58XB pulse counter allows measurement during a defined window in time, profiling of pulsed signals is possible. Using the technique described above, profiling of pulsed signals, or any time varying signals, can be accomplished simply and easily.

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Using the 585B/588B Pulse Counters for Single Pulse Measurement

The EIP 585B/588B pulse counters are designed to measure the frequency of repetitive pulsed signals, however if you know some information about your frequency, and the pulse is sufficiently wide it is possible to measure a single pulse.

The approximate frequency of the pulse (+/-5 MHz) must be known, and the pulse must be wide enough to include the counter gate time +50 µs. For example, if the resolution is set to 1 MHz in band 2 the gate time is 1 µs and the minimum single pulse width is 1.05 µs.

The general procedure is to prepare the counter ahead of time so it is ready when the pulse arrives. To do this you will need a signal that is within +/-5 MHz of the single pulse. See the equipment setup shown in Figure 1.

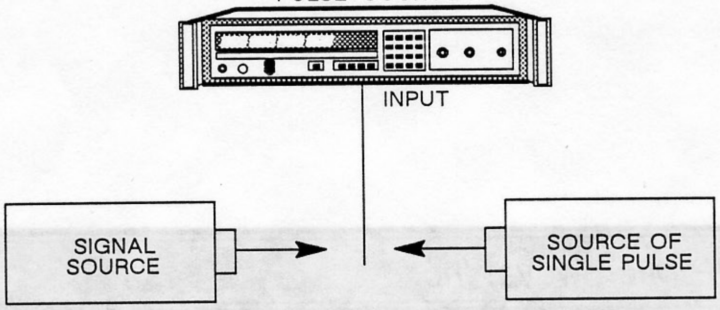

Figure 1. Equipment Setup

The procedure for measuring a single pulse is as follows:

1. Input a signal into the appropriate band of the 585B/588B, within +/-5 MHz of the single pulse frequency.

   The counter should display the frequency.

2. On the 585B/588B select Special Function 61 to disable signal tracking and Special Function 63 to disable sample rate control. To do this, press the SPECIAL FUNC key, key 9 on the keyboard, followed by 61, and then the SPECIAL FUNC key followed by 63.

   The counter should continue displaying the frequency.

3. On the 585B/588B set the MIN PRF (minimum pulse repitition frequency) to 0 HZ. To do this press the MIN PRF key, key 6 on the keyboard, followed by 0 and then the HZ terminator.

The counter should continue displaying the frequency.

4. On the 585B, place the counter in hold using the front panel sample rate control. Turn it fully clockwise, until it clicks into hold.

   The gate light should go out, but the counter should continue displaying its last measurement.

5. At this point, with the signal still applied to the Band 2 Input on the 585B, the counter should flash the gate light every time you press the TRIG key, key 0 on the keyboard.

6. Disconnect the signal from the source and connect the non-recurring pulse into Band 2.

7. Press the TRIG key on the 585B to arm the counter. The gate light should come on, but the counter will not actually be counting. It is simply armed to count.

As soon as the pulse appears the counter will count it, display the results, and the gate light will go out. To arm the counter to make another measurement, press the TRIG key again. Each time you press the TRIG key the gate light should come on. As soon as the counter makes a measurement the gate light should go out.

The above approach describes how the EIP 585B/588B pulse counters, primarily designed for measuring repetitive pulsed signals, can be used for measuring single pulses. Using the above method we have counted single pulses as narrow as 1.03 µs.

For more information about these, or other EIP products, contact your nearest EIP sales representative or contact us at the numbers shown below.

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Rev: 089201

MEASURING THE FREQUENCY ON FREQUENCY AGILE RADAR SYSTEMS

BACKGROUND: Most radar systems transmit repetitive bursts of RF at a single frequency, but some radar systems develop frequency agile signals. The bursts of RF transmitted from these systems vary in frequency from pulse to pulse in a quasi-random fashion.

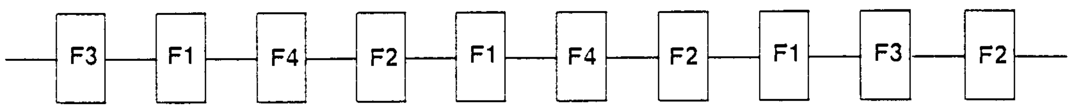

Figure 1. Frequency Agile Radar Signal

PROBLEM: Modern Pulse Microwave Frequency Counters are capable of measuring repetitive bursts of RF at a single frequency. Measuring a radar signal that varies in frequency from one pulse to the next presents unique problems.

SOLUTION: Using the following techniques and the EIP Model 585 or 588 Pulse Microwave Frequency counters, most of the problems in counting frequency agile radar signals can be overcome.

FREQUENCY WINDOWING

The first technique, and the simplest, is to use the frequency windowing feature of the counter. The EIP Models 585/588 are the only microwave pulse counters currently available that offer this capability. They use a narrow bandpass electronically tunable microwave filter (YIG Filter) on the microwave input. In addition to protecting the microwave input from damage at power levels up to 10 watts, the microwave filter also provides the ability to select a minimum and maximum frequency (window) for the counter, eliminating the counting of other frequencies.

To use the frequency windowing technique the following requirements must be met:

1. The minimum frequency separation between signals must be 200 MHz.
2. The maximum time between the leading edges of the RF bursts being measured must be known. The reciprocal of this time must be entered into the counter as the Minimum PRF.
3. The frequency window around the signal to be measured must be set using either the Frequency Limit keys or the Center Frequency key.
4. The pulse width must be 50 nS or greater.

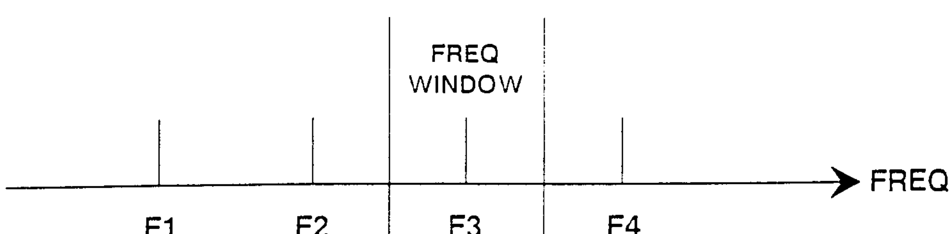

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Figure 2. Frequency Windowing an Agile Radar Signal

Once the requirements are met the counter will automatically search for and measure the frequency of the signal within the frequency window. By moving the frequency window, each different frequency in the agile pattern can be measured.

TIME WINDOWING

The second technique uses a time windowing approach for measuring the frequency of an Agile Radar Signal. Time Windowing uses the measurement inhibit feature of the counter. Measurement inhibit prevents the counter from seeing a signal, unless the measurement enable pulse is active. Unlike Frequency Windowing, Time Windowing inposes no minimum frequency separation between signals. The following method is one technique for using Time Windowing, but any approach that causes the measurement enable pulse to be coincident with the signal to be measured will work.

To use this method, the following conditions must be meet:

1. The radar system must be setup to output its signal in a repetitive pattern (See Figure 3).

2. The maximum time between the leading edges of the bursts of RF at the frequency being measured must be known. The reciprocal of this time must be entered into the counter as the Minimum PRF.

3. A trigger coincident with the start of the repetitive train is required for the Delaying Pulse Generator.

4. The pulse width must be 50 nS or greater.

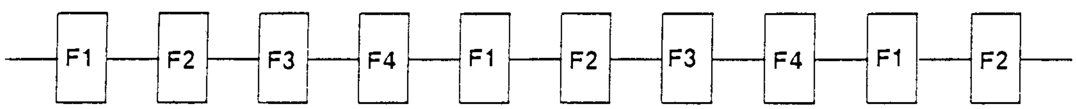

Figure 3. Frequency Agile Radar System Must Be Setup to Output a Repetitive Pattern

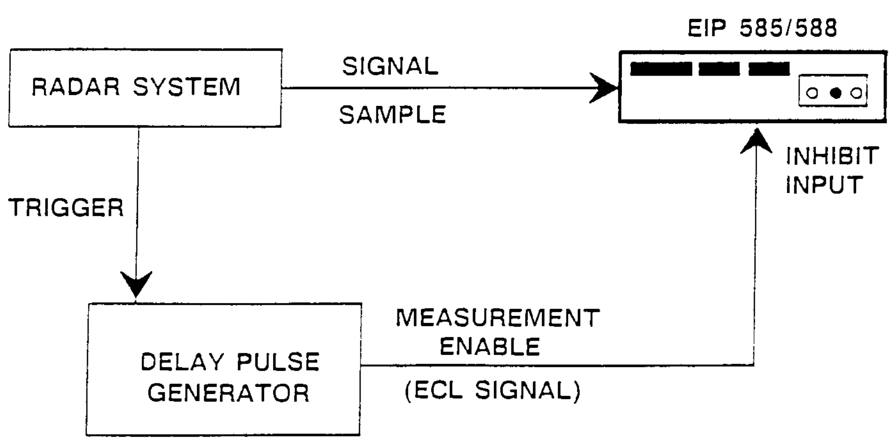

Figure 4. Equipment Setup for Time Windowing Technique

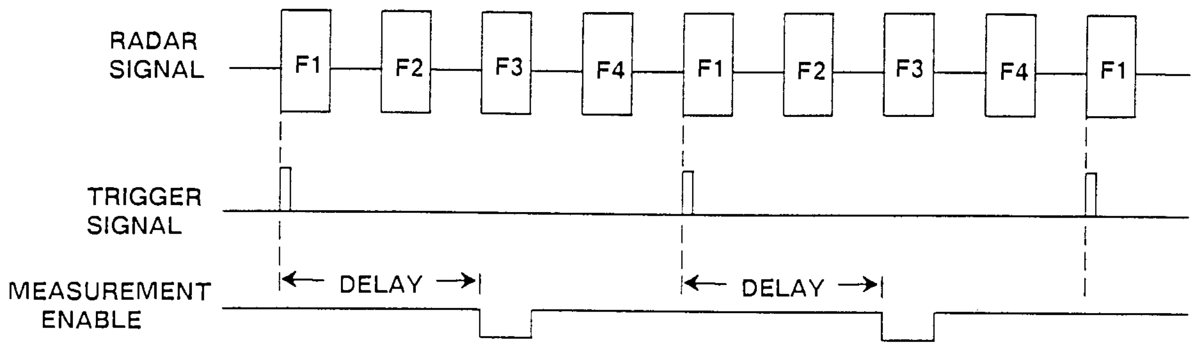

Figure 5. Time Windowing an Agile Radar Signal

Using this technique the counter will automatically measure the frequency of the RF signal coincident with the measurement enable pulse. With the delay set up as shown in Figure 1, the counter will measure the frequency of "F3". By adjusting the measurement enable delay, each signal in the repetitive pattern can be measured.

CONCLUSION: The EIP Model 585/588 Pulse Microwave Frequency Counters offer a superior solution to the problems of measuring Frequency Agile Radar Signals. If you have any questions on this application, suggestions on other unique applications, or other questions on using EIP equipment, please contact your local sales representative or an Applications Engineer at the factory in San Jose, California.

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Rev. 910208

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SOURCE LOCKING FROM 110 GHz TO 170 GHz

A variety of applications, including radio astronomy, plasma physics, and interferometry systems, require stable signals between 110 GHz and 170 GHz. For frequencies up to 110 GHz, the EIP Model 578B Source Locking Microwave Frequency Counter is commonly used for stabilizing electronically tunable millimeter wave signal sources. There are two methods that enable the 578B to stabilize signals above 110 GHz.

One method is to use a tunable source with a fundamental frequency of 1/2 the desired frequency and then double the output to get the final frequency. Using this approach, the 578B could be used for source locking up to 220 GHz, but the source must provide an output at the fundamental frequency. A disadvantage to this method is the conversion loss of the millimeter wave doubler which significantly reduces output power.

Another approach, which is the primary focus of this application bulletin, is to combine the capabilities of the 575B, a 20 GHz version of the 578B, with the 588B, a pulse/CW counter that supports frequency measurement through 170 GHz. In the 575B/588B method, the 588B downconverts the 110 to 170 GHz millimeter wave signal to an IF. The 588B, shown in Figure 1, is modified to provide a prescaled IF output at rear panel. The 575B samples the IF and provides a control voltage to modulate the frequency of the millimeter wave source as required to hold the frequency of the IF constant. By holding the IF constant, the millimeter wave output of the source is stabilized. Figure 1 is a block diagram of the equipment setup required for source locking between 110 GHz and 170 GHz.

Using the setup described in Figure 1, millimeter signals can be stabilized to the accuracy of the 575B time base (typically 1×10^{-7} per month), and can be tuned in steps as small as 40 kHz. Also, the millimeter setup can be automated by putting the counters under GPIB control.

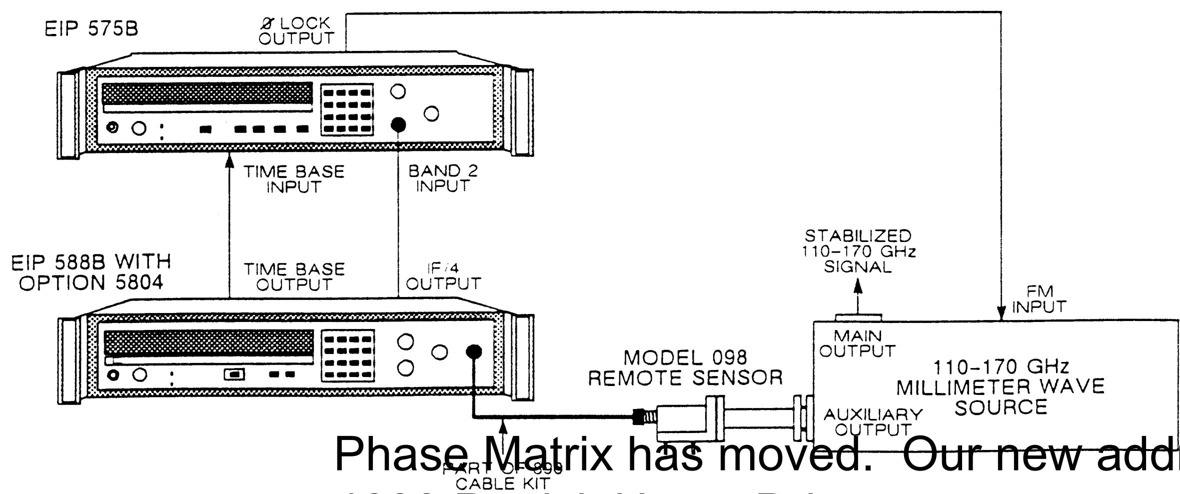

Figure 1. Equipment Setup for Source Locking 110 GHz to 170 GHz.

GENERAL INFORMATION ON SETUP

The IF output from the millimeter wave converter inside the 588B is approximately 675 MHz. This signal is first buffered and then prescaled by four prior to being routed to the rear panel of the 588B. Therefore, the frequency of the signal applied to the 575B is approximately 168.75 MHz (675 MHz/4).

Most millimeter wave sources have both electrical and mechanical tuning. Coarse frequency adjustment is performed by mechanical tuning. The FM input on the millimeter wave source allows electrical tuning, but only over a very limited frequency range. The phase lock output from the 575B also has a limited tuning range. Therefore, the millimeter wave source needs to be tuned as close as possible (typically within 40 MHz) to the desired phase lock frequency prior to attempting to phase lock.

PHASE LOCK PROCEDURE

1. Connect the equipment as shown in Figure 1.

2. Connect the time base output from the rear panel of the 588B to the time base input on the rear panel of the 575B and switch the INT/EXT time base select switch to EXT (external time base). This references both counters to the same time base.

3. On the 575B, select Band 2 to select the 10 MHz to 1 GHz frequency band.

4. On the 588B, select Band 3-8 to select the 110 GHz to 170 GHz frequency band.

   At this point, the 588B will search for the millimeter wave signal (F_{mm}). Once the signal is found, the 588B will display the millimeter wave frequency and the 575B will display the frequency of the IF prescaled by four (IF/4).

5. Coarse tune the millimeter wave source as close as possible to the desired frequency.

6. On the 588B, press the SPECIAL FUNC key and enter 61. This activates Special Function 61 which disables input signal tracking allowing the Band 3 IF in the 588B to vary over a range of approximately 150 MHz. Normally, the LO in the 588B is adjusted every gate to maintain a constant IF of 675 MHz.

7. On the 588B, press the MIN PRF key and enter 0. This sets the minimum PRF on the 588B to 0 Hz which prevents it from dropping lock if IF threshold is lost.

8. On the 588B, press the SPECIAL FUNC key and enter 75. This special function causes the 588B to display its internal IF by subtracting the LO frequency from the measured frequency. This is accomplished by loading the FREQ OFFSET register with: (-1) * LO frequency. If the displayed frequency is negative, the counter is high side mixing with the input. If it is positive, the counter is low side mixing.

9. On the 588B, press FREQ OFFSET. Disregarding the negative sign, record the LO frequency (F_{LO}) from the 588B display.

   F_{LO} = ______________________

10. On the 588B, press CLEAR DATA to clear the offset frequency. The 588B will again display the frequency of the millimeter wave signal.

11. Calculate the lock frequency (F_{LOCK}) for the 578B.

    $F_{LOCK} = ABS(F_{mm}-F_{LO})/4$

    Example: F_{mm} = 130 GHz (desired mm lock frequency)

    F_{LO} = 129.33 GHz (recorded in step 9)

    F_{LOCK} = ABS (130 GHz-129.33 GHz)/4 = 167.5 MHz

12. On the 575B, press LOCK FREQ and enter the frequency, in MHz, calculated in step 11.

    At this point, the 575B will determine the tuning sensitivity (MHz/V) and tuning polarity of the source by moving the phase lock control voltage while monitoring changes of input frequency. With this information, the 575B adjusts the phase lock circuitry and proceeds to lock the millimeter wave source to the desired frequency.

The following sample program simplifies source locking between 110 and 170 GHz by automatically performing the required calculations. It was written for an HP-85 instrument controller. It could be used as written on a HP85 or modified to run on other controllers or to suit a particular application.

```
10   CLEAR
20   DISP
30   DISP "************************"
40   DISP "   EIP MICROWAVE INC."
50   DISP "  110 GHZ THRU 170 GHZ "
60   DISP " SOURCE LOCKING PROGRAM "
70   DISP
80   ! WRITTEN ON HP-85 INSTRUMENT
90   ! CONTROLLER
100  ! REQUIRED EQUIPMENT
110  ! EIP 575B AND EIP 588B
120  ! DATE: 1 FEBRUARY 1990
130  DISP "  REV DATE: 2/1/1991"
140  DISP "************************"
150  ! INIT VARIABLES
160  ! ***************************
170  F=719 ! 575B GPIB ADDR 19
180  P=718 ! 588B GPIB ADDR 18
190  ! ***************************
200  !INITIALIZE COUNTERS
210  ! ***************************
220  OUTPUT F;"RSB2R0FA"
230  OUTPUT P;"INIT"
240  WAIT 5000 ! WAIT FOR 588B TO INIT
250  OUTPUT P;"BA 3,SUB 8"
260  ! ***************************
270  ! GET DESIRED LOCK FREQ
280  ! ***************************
290  CLEAR
300  DISP
310  DISP "ENTER LOCK FREQUENCY"
320  DISP "IN GHZ BETWEEN 110
330  DISP "GHZ AND 170 GHZ"
340  INPUT L
350  ! RANGE CHECK
360  IF L<110 THEN 370
370  IF L>170 THEN 370
380  GOTO 450 ! NO RANGE ERROR
390  BEEP@BEEP@BEEP ! ERROR BEEP
400  CLEAR ! CLEAR SCREEN
410  DISP "RANGE ERROR"
420  WAIT 1000
430  GOTO 290
440  ! ***************************
450  ! ADJ TO 40 K RESOL
460  ! ***************************
470  L=L * 1000000
480  L1=INT(L/1000) * 1000
490  D1=L-L1
500  D1=INT(D1/40) * 40
510  L=L1+D1 * 1000
520  ! ***************************
530  ! DISPLAY COARSE FREQ ADJ MSG
540  ! ***************************
550  DISP
560  DISP "COARSE TUNE THE SOURCE AS"
570  DISP "CLOSE AS POSSIBLE TO"
580  DISP "THE DESIRED FREQUENCY"
590  DISP
600  DISP "PRESS [CONT] WHEN READY"
610  PAUSE ! WAIT HERE TIL READY
620  ! ***************************
630  ! GET LO FREQUENCY FROM 588B
640  ! ***************************
650  OUTPUT P;"SP 61,MI 0 HZ"
660  WAIT 500 ! WAIT .5 SEC
670  OUTPUT P;"SP 75" ! LOAD LO
680  WAIT 500
690  OUTPUT P;"OUTPUT OFFSET"
700  WAIT 500
710  ENTER P;L3
720  OUTPUT P;"OFFSET 0 HZ"
730  ! CALCULATE ACTUAL LOCK FREQ
740  I=ABS(ABS(L3)-L/4
750  ! ***************************
760  ! LOCK ROUTINE
770  ! ***************************
780  OUTPUT F;"PF",I,"H"
790  S=SPOLL(F)
800  WAIT 100 ! WAIT .1 SEC
810  IF BIT(S,3)<>1 THEN 790
820  ! ***************************
830  ! DISP LOCK INFORMATION
840  ! ***************************
850  CLEAR
860  DISP
870  DISP "**LOCK COMPLETE**"
880  DISP "LOCK FREQ = ";L/1E9);" GHz"
890  DISP "LO FREQ = ";ABS(L3/1E9);" GHz"
900  DISP "IF = ";I/1000000;" MHz"
910  DISP
920  DISP "PROGRAM END"
930  END ! PROGRAM END
940  ! ***************************
```

EIP's Counter Line at a Glance

Model	CW or Pulse	Max. Freq.	Optional Max. Freq.	Damage Level	Microwave Amplitude Discrimination	Freq. Limits	Power Meter Option	Source Locking	VXIbus
625A	CW	20 GHz		200W Peak	X				
628A	CW	26.5 GHz		200W Peak	X				
535B	CW	20 GHz		200W Peak	X				
538B	CW	26.5 GHz	50 GHz	200W Peak	X				
545B	CW	20 GHz		200W Peak	X	X	X		
548B	CW	26.5 GHz	110 GHz	200W Peak	X	X	X		
575B	CW	20 GHz		200W Peak	X	X	X	X	
578B	CW	26.5 GHz	110 GHz	200W Peak	X	X	X	X	
585B	CW & Pulse	20 GHz		200W Peak	X	X			
588B	CW & Pulse	26.5 GHz	170 GHz	200W Peak	X	X			
1230A	CW & Pulse	26.5 GHz	170 GHz	200W Peak	X	X			X
1231A	CW & Pulse	20 GHz		200W Peak	X	X			X

Represented By:

Phase Matrix, Inc.

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Phase Matrix has moved. Our new address is:
4600 Patrick Henry Drive
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ALSO APPLIES TO OUR NEW MODEL 578

APPLICATION NOTE 201

Automated Frequency Measurement of Millimeter Waves

Accurate Measurements to 110 GHz

The trend toward higher microwave frequencies, in both military and civilian applications, has naturally produced a demand for instruments with higher frequency ranges. In general, manufacturers of counters have responded by "stretching" the upper frequency limits of their instruments by one band at a time — say, from 18 to 26.5 GHz.

Now, however, EIP Microwave has introduced a modular, microprocessor-based measuring system that can be equipped for accurate frequency counting in any or all bands. The measurement range is from 10 Hz to 110 GHz — and the accuracy at 110 GHz is the same as it is at the lower frequencies. Moreover, the modular design of the system permits a user to expand the frequency range as required, without buying unnecessary capability. The frequency range can be expanded to the full 110 GHz simply by adding auxiliary modules.

Based on EIP's popular 548A Microwave Counter, the new system uses an automated heterodyne technique to make millimeter-wave frequency measurements in about one second. Not only does the system provide laboratory-quality measurements, but is so easy to operate that it is ideal for use by production personnel with minimal training.

Previous Methods

Since most microwave counters have an upper frequency limit that is typically 18 or 26.5 GHz even when internal heterodyne down-conversion is used, measurements at higher frequencies have often been both laborious and inaccurate. One traditional approach is to use a wavemeter — a tuned cavity which absorbs signal power at its resonant frequency. Of course, as frequencies increase, cavity dimensions become smaller, and mechanical tolerances become more critical. As a result, a wavemeter used to measure frequencies in the 100 GHz range can easily provide a reading that is in error by as much as 100 MHz (0.1 percent). While careful calibration can reduce the error, the wavemeter method lacks the accuracy required in many applications, and can also be quite time-consuming.

Another common technique is to use a transfer oscillator. Here, both a known local oscillator (LO) signal and the unknown signal are fed to a phase detector whose output signal controls the LO frequency, tuning it for a zero-frequency output from the phase detector. At this point, the unknown frequency is equal either to the LO frequency or one of its harmonics. This technique provides better accuracy than the wavemeter, but requires a high level of technical skill. Not only is the test set-up difficult, but the operator must take extreme care to identify which of the local oscillator's harmonics matches the unknown frequency. For example, is it the 15th or the 16th harmonic?

The Heterodyne Technique

Another widely used approach is the heterodyne method (sometimes called "harmonic heterodyne"). In this technique, the unknown frequency is mixed with the harmonic of a known local oscillator signal to produce a signal in a defined intermediate-frequency (IF) range. This IF signal can then be down-converted by the counter for direct measurement.

(Continued on next page)

The theory is relatively simple. In mathematical terms:

$$F_x = \text{harmonic} \times \text{LO freq} \pm \text{IF} \qquad (1)$$

(where F_x is the unknown frequency)

For example, suppose the LO frequency is 6 GHz, the unknown frequency is expected to be in the 100 GHz region, and the IF range is ± 250 MHz centered at 1.1 GHz. (These are typical parameters for an operator doing the job manually with hardware such as that built into a spectrum analyzer.) It will be necessary for the operator to determine:

1. Which harmonic of the LO frequency is producing the IF that is being counted.
2. Whether the IF should be added or subtracted to find the unknown frequency.

The answers to both questions can be found by manually stepping the LO frequency. If a change of 1 MHz in the LO frequency moves the IF by 16 MHz, the desired harmonic is the 16th; if the change is 17 MHz, the harmonic is the 17th, and so on.

Whether one should add or subtract the IF depends upon the way the received IF moves in relation to the change in the LO frequency. Suppose a 1 MHz change in the 6 GHz LO frequency increases the IF by 17 MHz. Obviously, this identifies the harmonic as the 17th (102 GHz), as indicated in Figure 1. Such a change also shows that the unknown frequency is lower than 102 GHz. In other words, the difference between the 17th harmonic and the unknown frequency is the IF. As the LO frequency (and hence its 17th harmonic) increases, and the unknown remains the same, the difference between them increases — thus the IF also increases. This solves the problem of the ± sign in Equation 1 — subtract the IF:

$$F_x = 17 \times 6 \text{ GHz} - 1.1 \text{ GHz}^* \qquad (2)$$

$$F_x = 102 \text{ GHz} - 1.1 \text{ GHz}$$

$$F_x = 100.9 \text{ GHz}$$

(* assuming measured IF = 1.1 GHz)

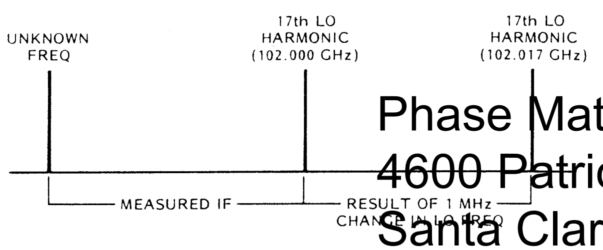

FIGURE 1

Had the IF *decreased* with an increase in the LO frequency, the procedure would have been to *add* the IF, rather than subtract it. Either way, this technique can provide extremely accurate results, depending upon two important factors: The first is the skill of the operator in establishing the proper test setup, in understanding both how to identify the appropriate harmonic, and how to decide whether to add or subtract the IF to find the unknown frequency. The second factor, of course, concerns equipment accuracy. How precisely can the LO frequency be adjusted? A slight error is magnified 17 times when the operative harmonic is the 17th. As for measuring the IF, this is not usually a problem; most microwave counters can down-convert it internally for direct counting.

Of course, the problems with the manual heterodyne technique are similar to those encountered with the other methods mentioned: The process is extremely time-consuming, and requires a highly skilled operator. An engineer in a laboratory can use such methods, but often at the expense of considerable development time. In a production environment, however, such techniques are virtually useless because of the high skill level required.

Automating the Heterodyne Process

Several years ago, the technology of microwave counters reached the practical frequency limit for direct signal inputs. EIP Microwave's Model 548A is typical in that respect. It can accept frequencies up to 26.5 GHz, down-converting them internally for counting and direct digital readout. But, in another respect, the 548A is *not* typical. It was designed "from scratch" as part of a modular system that would be able to handle increasingly higher frequencies as new applications demanded.

For the higher frequencies, the 548A uses essentially the heterodyne process described earlier, except that the internal microprocessor does virtually all the work. It determines which is the appropriate harmonic of the LO; it decides whether to add or subtract the IF (and makes the calculation); and it presents a direct, 12-digit readout of the unknown frequency. Someone with minimal training can get an accurate frequency reading in about one second — compared to perhaps an hour of an engineer's time by the older methods.

The first phase of EIP's frequency extension program permitted the 548A to count frequencies up to 40 GHz. Modules now available cover all bands up to 110 GHz. Moreover, it is not necessary to buy a new instrument to get this expanded frequency capability. Users of existing 548A's may (depending upon the options included in the instrument) either add external waveguide modules in the field or return the instrument to the factory for retrofit of the required internal circuitry.

How It's Done

For measurements in the frequency range of 1 GHz to 26.5 GHz, the Model 548A uses a YIG-tuned heterodyne converter to produce an internal IF of approximately 125 MHz. The IF is then counted directly. For frequencies above 26.5 GHz, an external waveguide mixer provides the first down-conversion step — to about 1 GHz. This signal is then fed to the counter's microwave input, where it undergoes the normal internal down-conversion to the 125 MHz IF of the counter.

As shown in Figure 2, the 548A provides the LO signal to the remote sensor (an external mixer), through a short length of cable. The mixer generates harmonics of the LO frequency and combines them with the unknown frequency to produce the first IF (which is sent to the counter via the same cable). There a diplexer separates the LO and IF signals. Thus, the unknown signal goes only as far as the remote sensor, and the cable carries only signals of relatively low frequency.

The LO signal is produced by a VCO (whose output frequency is referenced to the counter's internal time base) and a multiplier chain. The result is an LO signal of 5.28 to 6.0 GHz which is sent to the remote sensor. The first IF frequency from the sensor is in the range of 1.0 to 1.35 GHz.

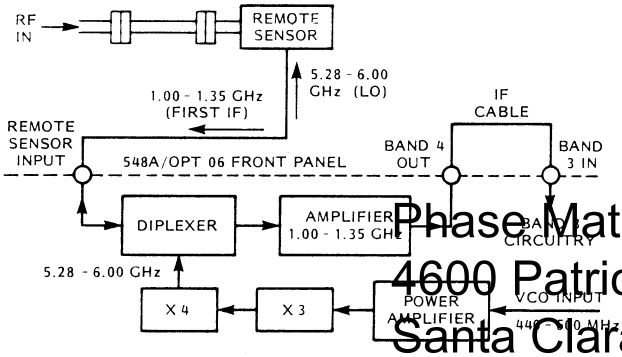

FIGURE 2

In principle, this basic heterodyne process is similar to the manual technique; the difference is that the 548A does it automatically. The microprocessor controls both the front-end YIG filter and the VCO. By varying the LO frequency and the filter frequency, the microprocessor is able to establish:

1. Which harmonic of the LO frequency is producing the IF.
2. Whether that harmonic is above or below the unknown frequency. (This tells the microprocessor whether to add or subtract the IF.)

As a result, the microprocessor is able to compute the approximate RF input frequency. From there, the process is simply a matter of down-converting the first IF so that it can be counted at the internal 125 MHz IF. Of course, the microprocessor also handles the calculations necessary to interpret the counted IF and display the unknown frequency directly. The entire process, shown in the block diagram of Figure 3, takes about one second.

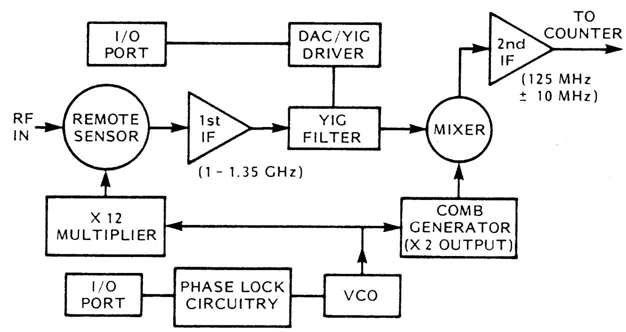

FIGURE 3

Simplicity of Operation

Unlike some microprocessor-controlled instruments, the EIP Model 548A requires no programming ability on the part of the operator. The front panel controls are much like those of any other counter, with front panel connections for four frequency bands:

Band 1: 10 Hz to 100 MHz (1 Meg, 20 pf).
Band 2: 10 MHz to 1 GHz (50 ohms).
Band 3: 1 GHz to 26.5 GHz (50 ohms).
Band 4: Extended Frequency Options (for frequencies above 26.5 GHz).

Once the remote sensor is coupled to the waveguide carrying the unknown signal, only two cables are required. One connects the

(Continued on next page)

remote sensor to the REMOTE SENSOR input; the other connects the BAND 4 output to the BAND 3 INPUT. Band selection is then simply a matter of pressing the appropriate front panel keys to match the "Select Band" to the remote sensor in use (see Table 1).

In the event that an inexperienced operator should mismatch the select band and the remote sensor (say the operator sets-up Select Band 41 when the 60-90 GHz sensor is installed), the instrument will not be damaged, nor will it provide an erroneous reading — the display will simply indicate all zeros.

The Modular Approach

The key to the 548A's universal appeal is its "from-the-ground-up" design, that not only accommodates direct inputs from 10 Hz to 26.5 GHz, but also accepts the five extended frequency ranges. For extended frequency applications, only two options are required:

1. Option 06 — which is the internal frequency generator that provides the LO signal to the remote sensor. This option can be ordered routinely with a new instrument, or the factory can retrofit it to existing 548A's.
2. The Model 590 Frequency Extension Cable Kit — equipped with at least one of the remote sensors (Options 91-95).

As shown in Figure 4, the Model 590 Kit is packed in a convenient carrying case. It includes the two cables necessary for the test set-up, and can accommodate all five of the

FIGURE 4

remote sensors that are available for extended frequency operation (see Table 1).

This modular approach has an obvious economic advantage in that the user pays only for the capability that is initially required. If in the future it becomes necessary to measure frequencies in certain additional bands, that capability can be added selectively as required — the software is already programmed into the 548A's microprocessor.

For More Information

The best way to fully appreciate the unique capability of the EIP 548A with its extended frequency option, is to see it in operation. For a demonstration, contact your nearest EIP representative, or EIP directly.

OPTIONS	91	92	93	94	95
548A/578 Select Band	41	42	43	44	42, 43
Waveguide Band	KA	U	E	W	V
Range	26.5–40 GHz	40–60 GHz	60–90 GHz	90–110 GHz	50–75 GHz
Sensitivity (typ)	−25 dBm	−25 dBm	−25 dBm	−25 dBm	−25 dBm
Waveguide Size	WR-28	WR-19	WR-12	WR-10	WR-15
Waveguide Flange	UG-599/U	UG-383/U	UG-387/U	UG-387/U	UG-385/U
Max. Input (typ)	+5 dBm	+5 dBm	+5 dBm	+5 dBm	+5 dBm
Damage Level	+10 dBm	+10 dBm	+10 dBm	+10 dBm	+10 dBm

TABLE 1

EIP

Phase Matrix, Inc.
Phase Matrix has moved. Our new address is:
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Tel: 408-610-6810

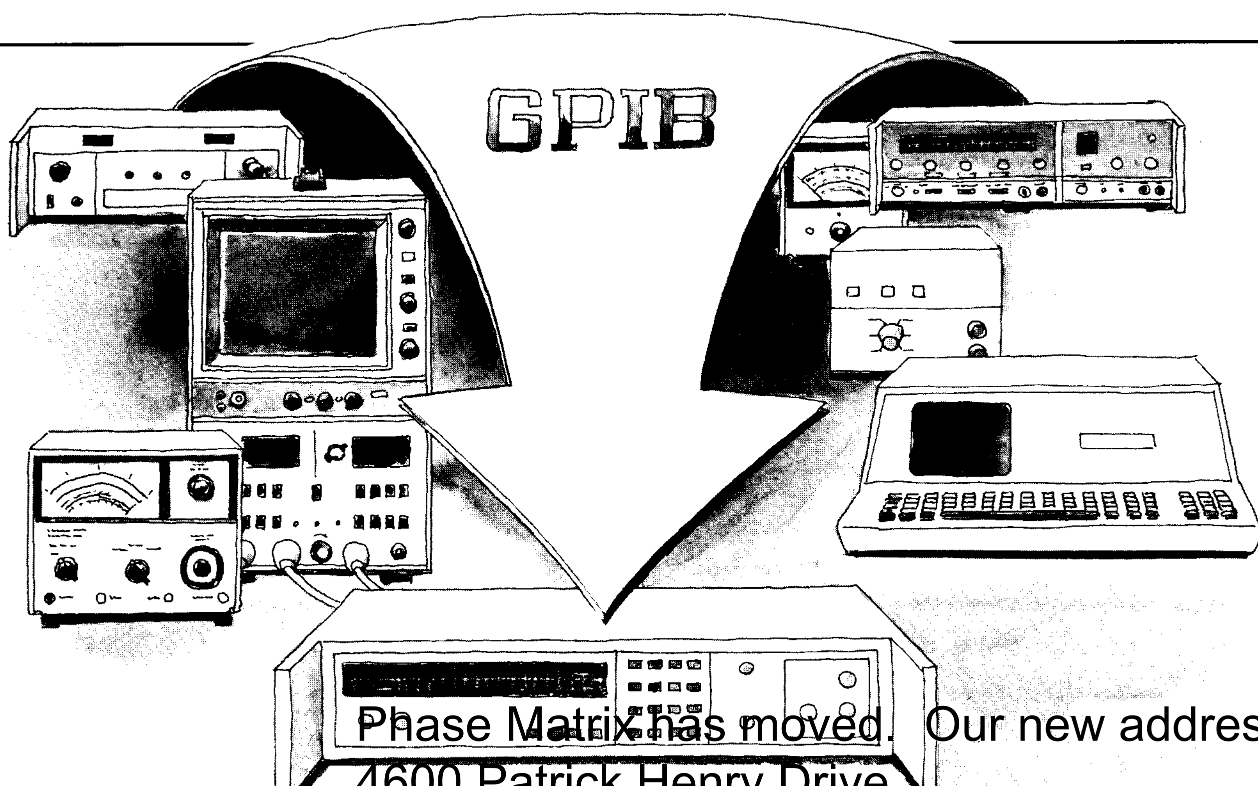
2/84 3M A1817-201

EIP

APPLICATION NOTE #203

GPIB CONTROL OF NON-GPIB SIGNAL SOURCES

Fully automatic test and measurement systems, usually called Automatic Test Equipment (ATE), are becoming increasingly important in improving efficiency. A single controller can supervise the operation of a full complement of instruments which are all connected to a General-Purpose Interface Bus (GPIB). Such a system can make a great many measurements quickly and accurately—without the constant attention of highly skilled and highly paid technical personnel.



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The ATE Designer's Problem

The IEEE standard covering the GPIB was introduced in 1975. Although its value was quickly apparent, it took time for manufacturers to design and build equipment to accommodate GPIB control. The first available equipment, of course, was the simplest to adapt to digital control—such instruments as digital voltmeters and frequency counters. Complex analog devices, such as microwave sweep generators, were among the last to be offered with GPIB control capability.

Such signal sources have always been expensive, and the new GPIB-controlled versions cost even more. Since many companies have large investments in sweepers which cannot be retrofitted for GPIB control, some ATE designers have resorted to "stop-gap" measures to make use of existing equipment.

For example, Figure 1 shows a GPIB-controlled frequency counter combined with a D/A converter to form a frequency-control loop. The software must be set up so the controller can issue instructions, read the result, then repeat the process until the desired frequency is achieved. The arrangement works, but it is quite slow, and it provides limited frequency accuracy. It is used simply because the cost of available alternatives is too high.

Another problem facing the ATE designer who is involved with microwave frequencies is the rapid move to higher frequencies. While 18 GHz was recently considered a high frequency, signals of 100 GHz and above are not uncommon now. Sources operating at these frequencies seldom include GPIB control. Moreover, the solid-state sources that operate in the millimeter-wave region are typically quite unstable. They can vary by tens of megahertz in a few seconds. As a result, this new frequency area, with the limited availability of signal sources, presents a special challenge to the ATE designer.

Cost-Effective Solution

EIP Microwave has developed a simple, easily implemented way to put the frequency of virtually any electrically controllable microwave source under GPIB control. The only additional equipment required is an EIP Model 575 or 578 source-locking frequency counter. (The primary difference between the two models is the frequency range: 10 Hz to 18 GHz for the 575, and 10 Hz to 110 GHz for the 578.) Since the cost of one of these counters is a fraction of what a new sweeper would cost, the savings can be substantial.

As Figure 2 indicates, only three cables between the counter and the signal source are required to permit the counter to exercise full frequency control over the source. One cable provides a sample of the RF output to the counter, while the other two carry the coarse-tune and phase-lock commands to the sweeper. The system controller supervises the counter through its built-in interface.

The only necessary GPIB commands are instructions to the counter. And the only monitoring required of the controller is to check the lock status bit from the counter. The results that can be obtained with existing signal sources are dramatic, in terms of both speed and accuracy.

In contrast, the frequency-loop arrangement of Figure 1 requires the controller to communicate directly with the signal source and the counter.

Flexibility in equipment arrangements is another advantage of using the source-locking counter. Since the only software instructions issued by the controller are those to the counter, signal sources can be easily changed to meet new requirements. A new source can be put into the ATE system simply by connecting the three cables to the counter.

Of course, this interchangeability also offers software standardization among all ATE systems that use source-locking counters. The HP-85 subroutines shown in Figure 3 apply, regardless of the signal source used in a particular system.

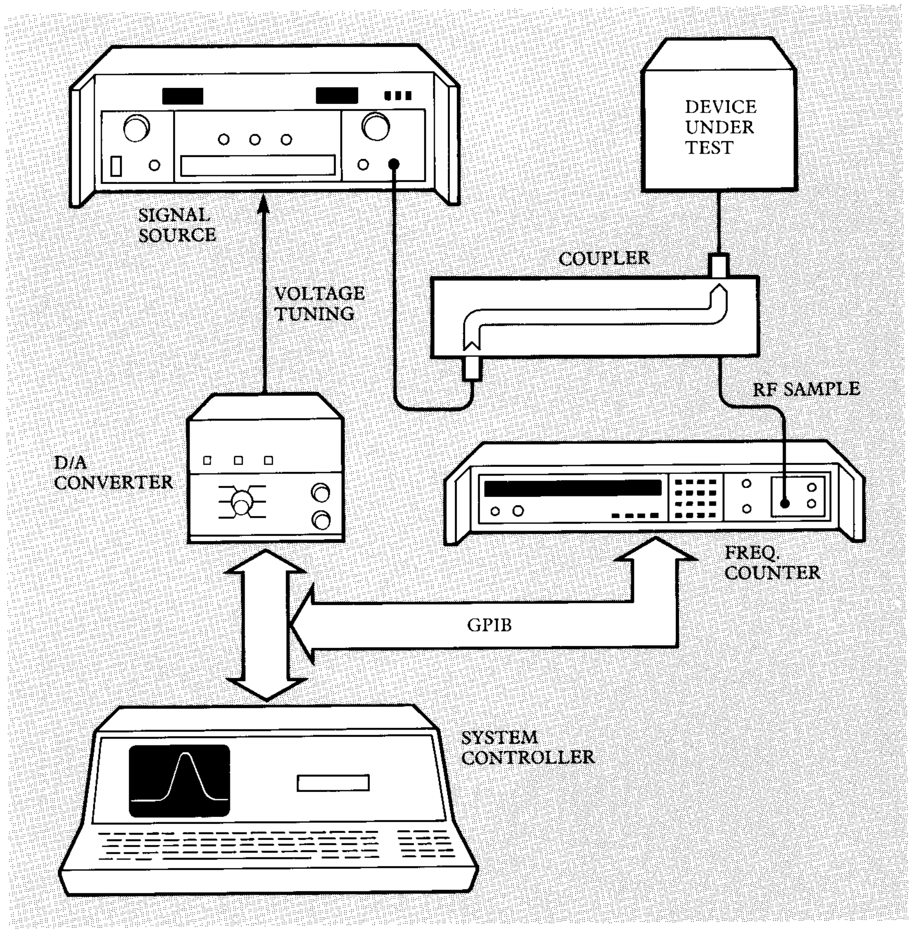


Figure 1. *Software frequency-lock loop suffers from slow operation and limited frequency accuracy.*

Program	Remarks
100 OUPUT 719 ;"PF"&VAL$(F)&"G"	Instruct the counter to Lock
110 WAIT 1000	
120 ENTER 719 ; R	Read the frequency
130 DISP R	
200 END	

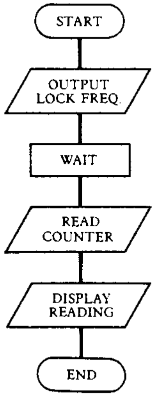


Figure 3a. *Represents the simplest of programs to tell the counter to lock frequency F (Line 100). Wait 1 second (Line 110) and read and display the frequency (Lines 120 and 130).*

Program	Remarks
100 OUTPUT 719;"B3R3PF"&VAL$(P)&"G"	Set counter to Band III on Lock instruction
110 S=SPOLL(719)	Monitor Status byte for Ø Lock indication
120 IF BIT(S,3)=1 THEN 140	
130 GOTO 110	
140 ENTER 719 ; R	
150 DISP R	
200 END	

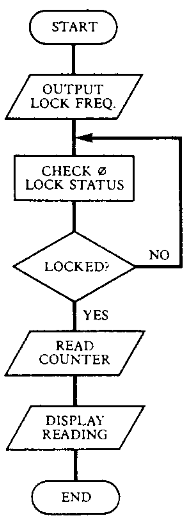


Figure 3b. *Represents a program with minimum time of execution for a lock at a specific frequency F. Note the use of serial Poll to check for Ø Lock (Line 110 and 120).*

Program	Remarks
1060 SET TIMEOUT 7;10000	Breaks Program if handshake fails
1070 ON TIMEOUT 7 GOTO 8000	
1080 OUTPUT 719 ;"SR08B41R3"	Set counter for SRQ on Ø Lock, Band 41, 1KHz Resolution
• • • • • • •	
6825 ON INTR 7 GOTO 9000	Configure IO for Service Request Interrupt
6830 ON TIMER# 1,5000 GOTO 9500	Breaks program if counter fails to Lock
6835 OUTPUT 719 ;"PF"&VAL$(F(S))&"G"	Instruct Counter to Lock
6840 ENABLE INTR 7;8	
6850 WAIT 10 @ GOTO 6850	
• • • • • • •	
8000 OFF TIMEOUT 7	Inhibit Timeout interrupt
8010 PRINT "HP-IB Timeout"	Reset all instruments on the bus
8020 RESET 7	Return to the beginning of the program
8030 GOTO 100	
• • • • • • •	
9000 OFF TIMER# 1	Inhibit Timer #1 interrupt
9005 STATUS 7,1 ; A	Read status bit to clear SRQ
9010 ENTER 719 ; S1	Read count
9020 PRINT S1	Display count
9025 F(S)=F(S+1)	Increment Lock frequency
9030 IF F(S)>=40 THEN 9999	
9035 GOTO 6825	
• • • • • •	
9500 IF N=1 THEN 9990	Limit attempt to Ø Lock to two
9505 N=N+1	
9510 GOTO 6825	
• • • •	
9990 PRINT "NO PHASE LOCK ACHIEV ED AT";F(S);"GHz"	
9995 N=0	
9999 END	

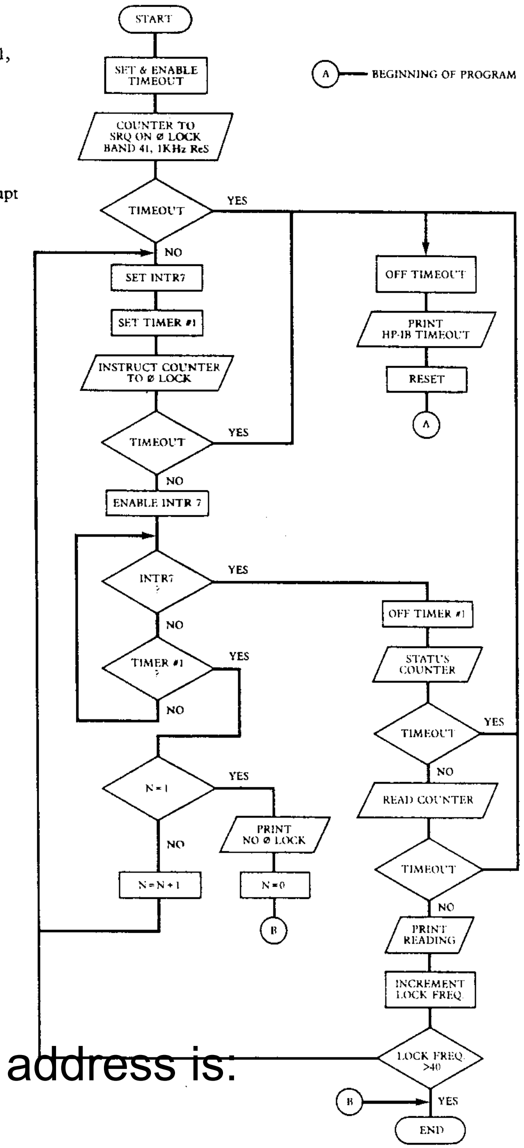


Figure 3c. *Represents a portion of a complete system program with precautions taken to deal with problems in the handshake routine and failure to achieve a Phase Lock. This program also implements the Service Request function to indicate when Phase Lock has been achieved.*

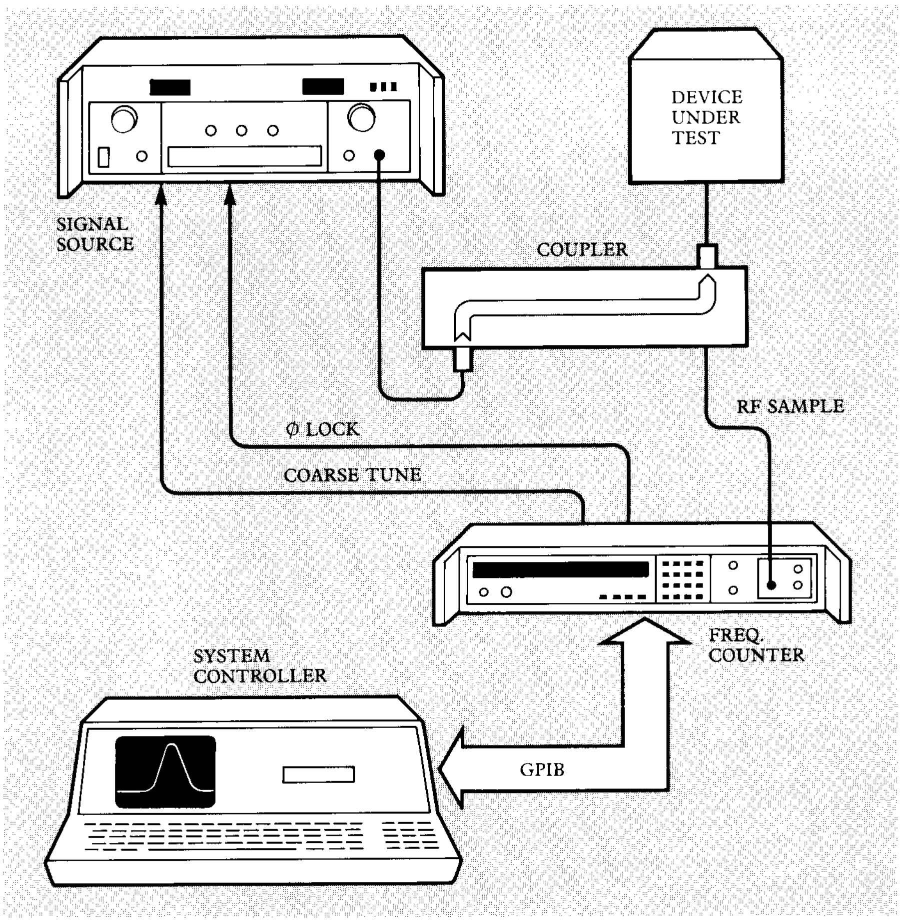


Figure 2. *Source-locking loop uses EIP 575 or 578 counter to provide rapid response and frequency accuracy equivalent to counter's time base.*

Added Value

Source locking is only one function of the 575/578 counters. They not only offer the flexibility of general-purpose counters, but they include other capability (also under GPIB control) that might otherwise require additional instruments:

1. Optional power measurement provides the simultaneous measurement of signal frequency and power.
2. A frequency-limiting feature permits spectral analysis. Both the frequency and power of individual signals can be measured in a multi-signal environment—even when unwanted signals are stronger.

Such capability, combined with a frequency range of up to 110 GHz, offers the ATE designer almost unlimited possibilities.

More Information

EIP Microwave publishes application notes on a variety of subjects involving high-performance counters. And an applications-engineering staff is available to provide advice and answer specific questions. For more information, contact EIP or any EIP representative.

Performance

The accompanying specifications show the basic source-locking performance of the 575 and 578 counters. Most microwave sources (even the older ones) meet the counter's requirements. This provides an opportunity to extend the useful life of equipment that might otherwise be considered obsolete.

Since most microwave sweepers provide poor frequency accuracy, some applications require a very expensive synthesizer. Now the same accuracy can be achieved by *putting* an ordinary sweeper under the control of a source-locking counter. Then the frequency accuracy becomes as good as the counter's time base. With the standard 575/578 time base, this means short-term accuracy of one part in 10^9. The optional oven-controlled time base offers accuracies of up to one part in 10^{11}. While the source-locking arrangement does not transform an ordinary sweeper into a synthesizer, it approximates much of the synthesizer's costly performance.

EIP's 575/578 series counters combine frequency measurement and source locking capability to 110 GHz.

SOURCE LOCKING SPECIFICATIONS

Frequency Range	10 MHz-Max. capability of counter.
Resolution	10 kHz for phase lock freq. ≥ 50 MHz 2.5 kHz for < 50 MHz
Accuracy	Equal to counter's Time Base
Long Term Stability	Equal to counter's Time Base
Minimum Phase Lock Signal Level	Equal to counter sensitivity
Polarity	Automatically selected
Bandwidth	User select, 10 kHz, 2 kHz or 500 Hz, or automatically selects widest bandwidth capable of locking.
LOCK TIME (Typical)	
Coarse Tune	50 m sec + 1 counter aquisition time for source bandwidth greater than 100 Hz; limited by source tuning speed below 100 Hz.
Phase Lock	200 m sec
Recall Stored Data	1 counter aquisition + 100 m sec limited by source tuning speed.
OUTPUT DRIVE (Maximum)	
Coarse Tune Output	+ 10 V into 5 K ohm min.
Phase Lock Output	±10 V into 5 K ohm min for source gain constant <64 MHz/V. ±75 MA into 10 ohm max for source gain constant <3.2 MHz/MA. ±.6 V into 5 K ohm min for source gain constant ≥64 MHz/V. ±4.5 MA into 10 ohm max for source gain constant ≥3.2 MHz/MA.
CAPTURE RANGE	
Coarse Tune	Entire range of selected counter band limited by maximum output drive.
Phase Lock	Source gain constant X maximum output drive.
OUTPUT CONNECTOR	
Coarse Tune	Rear panel BNC, female
Phase Lock	Rear Panel BNC, female

PHASE LOCKED SPECTRUM (See figure below)

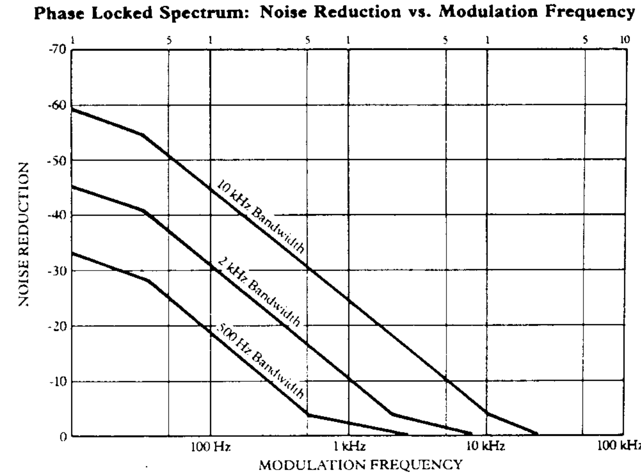
Noise Floor vs Input Frequency:
The noise floor extends from the carrier to approximately the loop bandwidth. Beyond this the noise floor decreases 12 dB/bandwidth octave. The noise floor is the greater of:

1. NOISE FLOOR = .70 dBC/Hz
2. NOISE FLOOR = (20 log F -65) dBC/Hz
   where F = Input frequency in GHz

REQUIRED SOURCE CHARACTERISTICS

External Sweep (Coarse Tune) Input:	
Bandwidth	5 Hz minimum
Tuning Sensitivity	10 MHz/V minimum; 10 GHz /V maximum
FM (Phase Lock) Input:	
Bandwidth	2 kHz minimum
Tuning Sensitivity	
Voltage Driven Input	±2 MHz/V minimum ±1000 MHz/V maximum
Current Driven Input	±0.1 MHz/mA minimum ±50 MHz/mA maximum

Phase Locked Spectrum: Noise Reduction vs. Modulation Frequency



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Complex Modulation with the 1140A Microwave Synthesizer

The 1140A's unique architecture allows "complex modulation" - the ability to upconvert a baseband signal to anywhere in the 1140A's output range. FM "chirps", phase modulated signals, frequency hops, now can be produced as easily at 20 GHz as they can at 500 MHz.

CW Operation

The block diagram below shows the architecture of the output section of the 1140A VXIbus Microwave Synthesizer. The 1140A uses standard microwave synthesizer techniques to produce a stable, spectrally pure signal in the 2 to 20 GHz range with 1 Hz resolution. This signal enters the block diagram at the upper left. To produce a CW output signal, the 1140A mixes this 2 to 20 GHz signal with a 420 MHz or 840 MHz signal from the IF Driver. This produces a signal at the final output frequency. This signal is filtered with a tunable YIG filter with an approximately 50 MHz bandwidth and amplified. To illustrate, suppose a 10 GHz signal is desired from the 1140A. When 10 GHz is programmed over the VXI bus, the 1140A internally sets its fine and coarse loops to generate a 9.160 GHz signal at the LO port of the mixer. This signal is mixed with an 840 MHz signal from the IF Driver to produce the 10 GHz output. The YIG filter is set at 10 GHz to eliminate the other mixer products and a pure 10 GHz signal is sent towards the output.

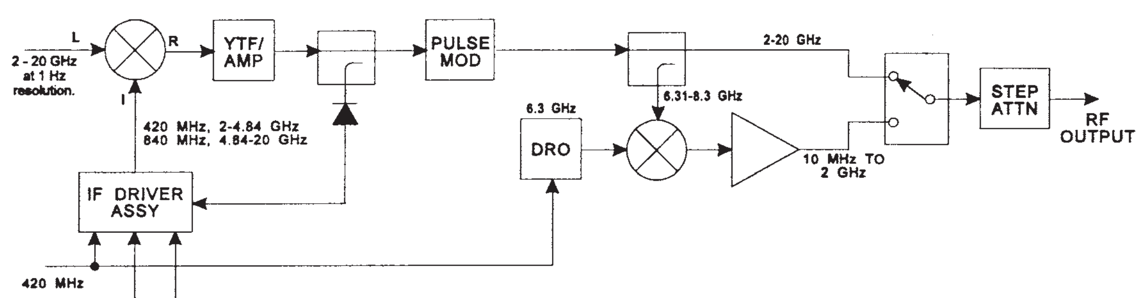
After the YIG filter, the signal is sent through a pulse modulator and step attenuator to generate the final output. Output leveling and AM is done by controlling the amplitude of the IF signal to the mixer, with an external AM input and/or the signal from a diode detector on the output leveling coupler.

To produce a signal below 2 GHz, a signal is coupled off after the pulse modulator and mixed with a fixed 6.3 GHz signal from a dielectric resonant oscillator (DRO). For applications that do not require frequencies in this band, the 1141A is available which is identical except for the absence of the .01 to 2 GHz band.

Complex Modulation

With the above described architecture, it is simple to translate an IF frequency to any microwave output frequency. Instead of providing the fixed 420 MHz/840MHz signal, the IF Driver now passes through a signal from the front panel IF Input. In this way, any modulation present on this signal (within the 50 MHz limit of the YIG filter) is present on the output signal at the desired microwave frequency. Changing the microwave carrier frequency is as easy as programming the 1140A with a new frequency value.

The 1140A can still provide pulse modulation and step attenuation even in the complex modulation mode. In fact, the leveling loop of the 1140A can be used to control the output level of the upconverted signal or, if the level of the IF input is to be maintained, the leveling loop of the 1140A can be turned off.



Block diagram of the 1140A output section. The 2 to 20 GHz signal on the upper left is mixed with the signal from the IF Driver to produce the output frequency. For complex modulation, this IF driver signal uses a front panel input.

EIP Microwave, Inc.

Fast Frequency Switching with the 1140A Microwave Synthesizer

The 1140A offers a number of different modes to accommodate various frequency switching needs. Each mode has different advantages and limitations.

Standard Switching

In normal operation, the 1140A is commanded to change frequencies by writing a VXI message to the instrument. A typical message might be ":FREQ 3.752 GHZ" to switch the unit to 3.752 GHz. There are many factors influencing how fast this message can be transferred to the instrument - the type of VXI interface, speed of the computer, programming language, etc. - but simple measurements indicate that a time of 25 milliseconds is not difficult to achieve. After the instrument receives the command, it must parse it and calculate the loop frequencies necessary to produce it. This is included in the 25 millisecond time. Then the instrument must program these frequencies, unlock the YIG oscillator, move it and the output YIG filter to the new frequency, and acquire lock. This time required for this process is specified at 50 milliseconds, but has been measured to very constantly about 30 to 35 milliseconds. So from initiation of computer command to the frequency settling at the new value the time is about 60 milliseconds. It should be noted that this time is constant regardless of the size of the frequency jump - if this technique of frequency changing is used a 10 kHz step takes as long as a 10 GHz step.

Triggered List Mode

A variation of the above technique that is often useful is what is called the triggered list mode. Here, the frequencies desired are preloaded into the 1140A. The frequencies can then be stepped through by either sending a VXI command, triggering via the VXIbus hardware trigger lines, or in response to an internal delay timer. Up to 201 frequencies can be stored. This mode can overcome the 25 millisecond bus overhead and can also synchronize the frequency switching with an external event via the VXI hardware trigger. However, the 35 milliseconds switching time remains. That is, the new frequency will appear approximately 35 milliseconds after the VXIbus trigger is applied.

Using the IF Input

If faster switching is desired, the 1140A offers a technique where it upconverts an externally applied signal to any frequency within its output range (see the note "Complex Modulation with the 1140A Microwave Synthesizer" for a technical description of how this works). If the fast frequency jump can be generated at a frequency between 300 and 1000 MHz and the bandwidth required (i.e. largest frequency change) is less than 50 MHz, then this technique can offer frequency switching/hopping at microwave frequencies as fast as they can be produced at the IF input. The limitation to this technique is that all the frequencies must fall within 50 MHz and that an external source must produce a baseband signal to be upconverted. For special applications, the 50 MHz bandwidth can be increased over some narrower output ranges - inquire for more information.

Direct Control of the DDS

For very specialized applications, the 1140A offers a mode where the direct synthesizer used in the 1140A internal fine loop can be moved. This provides extremely fast phase coherent switching. However, the bandwidth of this control is only 2 MHz and it is only accessible over the bus, not with the triggered list mode. Therefore the 25 milliseconds VXI overhead is always present, showing up as a delay before the frequency change takes place. When it does take place, it is extremely fast - less than a microsecond.

Summary

The 1140A offers a variety of ways to change the output frequency, each with its advantages and disadvantages. If you have a special application and think we can help, we are always happy to talk to you about our products. Contact at any of the ways listed below.

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Phase Matrix, Inc.

Instruments You Can Count On

Application Note AN303

Phase Matrix, Inc.
Measuring Time Varying Microwave Signals

Using the 1230A/1231A Microwave Counter and the 1911A Delaying Pulse Generator to Measure Time Varying Microwave Signals

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Using the Phase Matrix 1230A/1231A Microwave Frequency Counter and the Phase Matrix 1911A Delaying Pulse Generator to Measure Time Varying Microwave Signals

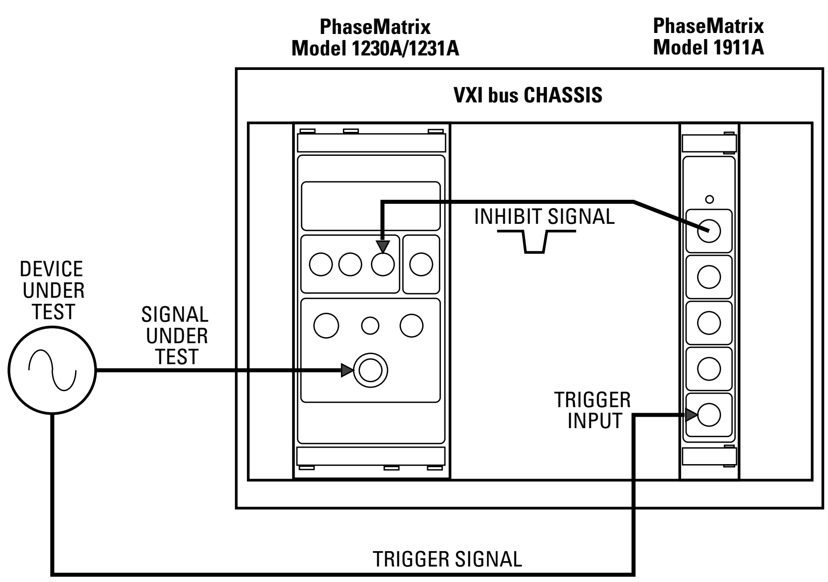
Pulse counters can be used for more than just measuring pulses. By using the Phase Matrix 1911A pulse generator and the 1230A's inhibit input, time varying signals such as agile radars and VCO's can be accurately characterized.

Introduction

The 1230A/1231A VXI Microwave Pulse/CW Counters are flexible, precise measurement tools for characterizing many different types of microwave signals. The inhibit input can be used to define the time interval in which a frequency measurement is to be made. This allows measurement of the frequency verses time characteristics of the repetitive time varying signals such as the output of VCO's, chirped radars or the pulling of microwave signals due to pulse modulation.

Measurement Setup

The setup diagram in figure 1 shows the setup for making the profile measurement. The signal from the device under test is connected to the input of the 1230A/1231A counter. The output of one channel of the 1911A pulse generator is connected to the inhibit input of the 1230A/1231A. A trigger signal from the device under test is used to trigger the 1911A.



This simple setup can fully characterize time varying microwave frequencies quickly and accurately

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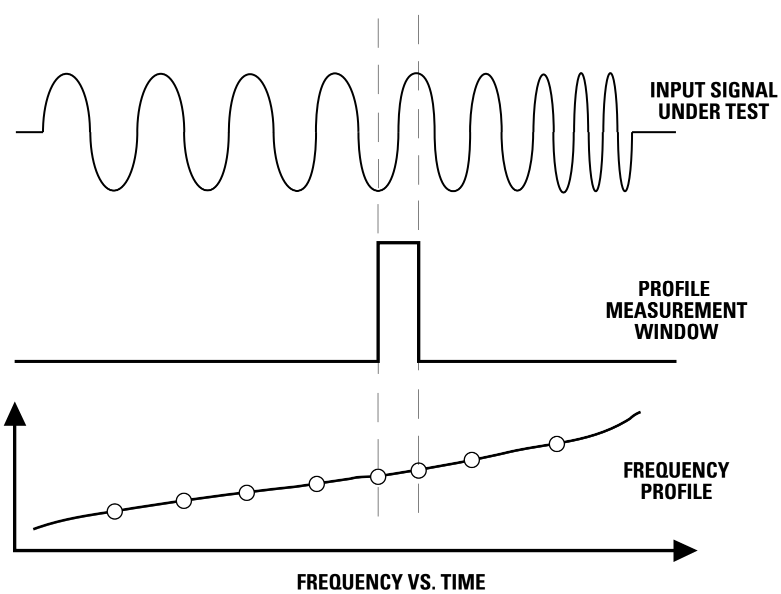
Using the Phase Matrix 1230A/1231A Microwave Frequency Counter and the Phase Matrix 1911A Delaying Pulse Generator to Measure Time Varying Microwave Signals

Measurement Setup (from page 2)

The pulse width if the 1911A can now be set to the desired sample width. For the fastest measurements, as wide as a window should be used that still captures the desired signal detail. The pulse width of the 1911A can be set anywhere from 50 ns to over 800 ms with a 50 ns resolution. The 1911A should be set to trigger externally and the delay set to the minimum value. Since the 1230A/1231A have an internal delay line the trigger produced by the device under test can be coincident with the start of the pulse, I.E. a pre-trigger is not necessary. (When the precise timing information is needed, the threshold and gate outputs from the 1230A/1231A can be used to confirm the exact relationship of the inhibit signal and the microwave signal under test.)

After the measurement at minimum delay is taken, the delay setting of the 1911A is increased (with nanosecond resolution if necessary) to move the window to the next desired position.

The measurement window, generated by the 1911A pulse generator, can be moved through the signal under test to measure frequency verses time.



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Instruments You Can Count On

Application Note AN303

Phase Matrix / EIP 1911A

Four Channel Pulse Generation for VXIbus Systems

Phase Matrix / EIP 1230A/1231A

Pulse / CW Microwave Frequency Counter for VXIbus Systems

ORDERING INFORMATION

MODEL 1911A	VXI 4 Channel Pulse Generator
MODEL 1230A	26.5 GHz VXIbus Pulse/CW Microwave Frequency Counter
MODEL 1231A	20 GHz VXIbus Pulse/CW Microwave Frequency Counter

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