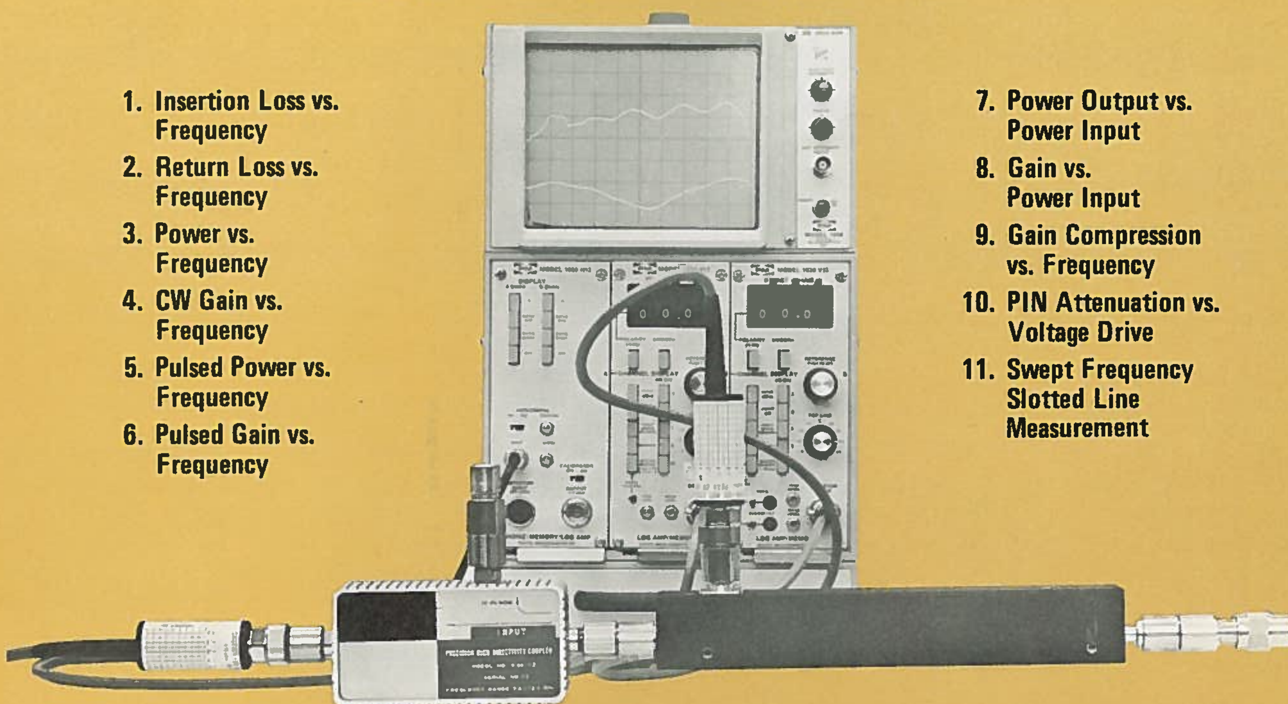
PACIFIC MEASUREMENTS INC.

AMERIKANSKA TELEPRODUKTER AB
TEL. 08-710 06 20

APPLICATION NOTE 18
Eleven Swept Measurements Made Possible by the 1038 Swept Analyzer

SWEEP TESTING SAVES TEST TIME

1. Insertion Loss vs. Frequency
2. Return Loss vs. Frequency
3. Power vs. Frequency
4. CW Gain vs. Frequency
5. Pulsed Power vs. Frequency
6. Pulsed Gain vs. Frequency



7. Power Output vs. Power Input
8. Gain vs. Power Input
9. Gain Compression vs. Frequency
10. PIN Attenuation vs. Voltage Drive
11. Swept Frequency Slotted Line Measurement

PLUG-IN VERSATILITY MEANS VALUE

OVERVIEW

The plug-in design of the Pacific Measurements 1038 Swept Measurement System allows the system to be configured to perform many useful swept microwave measurements. The purpose of this application note is to describe these measurements and to help you select the combination of plug-ins which will meet your needs at minimum cost.

Plug-in versatility enables you to add or change the capabilities of your 1038 system as your measurement needs change. This enhances its value to you and lengthens its useful life.

It is Pacific Measurements' goal to help you make microwave measurements better and faster. Call us or your local PMI representative if we can assist you.

The Importance of AUTOMEMORY® —better than an electric grease pencil.

PMI's unique AUTOMEMORY enables you to automatically remove one of the most awkward errors from swept measurements. The response of the measurement system is a function of frequency. AUTOMEMORY allows this response to be removed from the swept measurement in order to see the correct response of the device tested alone. It also enables you to store *any* response as a 0 dB reference against which future swept measurements may be compared.

Before AUTOMEMORY it was necessary to plot a wavy grease pencil reference line as a 0 dB reference for swept frequency measurements when high resolution was required. Similarly, wavy calibration lines were plotted (using a precise attenuator as a substitution device). AUTOMEMORY stores the response of the measurements system in a 1024 point digital memory. This response may then be "played back" and subtracted when an unknown device is measured. The displayed response is that of the measured device with the response of the measurement system removed.

The excellent linearity of the 1038 system (0.1 dB per 10 dB over 50 dB of the 60 dB range) eliminates the need for calibration lines—the system is already calibrated.

An important feature of AUTOMEMORY is its automatic scale factor correction. If a reference response is recorded with one sensitivity (say, 0.1 dB per DIV), the comparison measurement may be made on *any* sensitivity. The reference response is automatically scaled to the sensitivity used. One reference response may be used for multiple measurements without re-storing. Usually a single reference response is stored for an entire run of the product tested.

Before AUTOMEMORY, it was often desirable to use a 2 channel ratio system to partially correct system tracking errors. With AUTOMEMORY, a reference channel is seldom needed. AUTOMEMORY corrects for all tracking errors.

The 1038 System as a Power Meter (See Fig. 1)

It may pass unnoticed that the 1038 system is an accurate CW microwave power meter with traceable accuracy. The calibrator in the 1038-H11 or 1038-H13 is a stable 30 MHz source. Its amplitude can be conveniently compared with a primary standard periodically. (Just like the calibrator in any diode or thermocouple power meter.) When the HIGH LEVEL and NOISE LEVEL adjustments have been made (daily) on a 1038-V11 or 1038-V12 vertical amplifier, the display provides specified accuracy as a power meter.

The calibration correction (frequency response) of the detector must also be included. It may be read from the label on the detector.

Precise power measurements are made by selecting the dBm mode on the vertical amplifier and nulling the unknown to the display centerline using the OFFSET thumbwheel switches. Resolution to 0.1 dB per scale division is possible over the entire power range of the instrument (+10 dBm to –50 dBm).

Passive Device Measurements

Probably the most common use of swept measurements is to determine the properties of passive devices. These include cables, waveguide, couplers, rotating joints, etc. Measurements may be made to 18 GHz using PMI detectors, to 110 GHz using external detectors.

Swept Insertion Loss (Figure 2)

The benefits of the 1038's high resolution (0.1 dB per division) memory and display are most pronounced when insertion loss is measured. Fine structure is accurately displayed

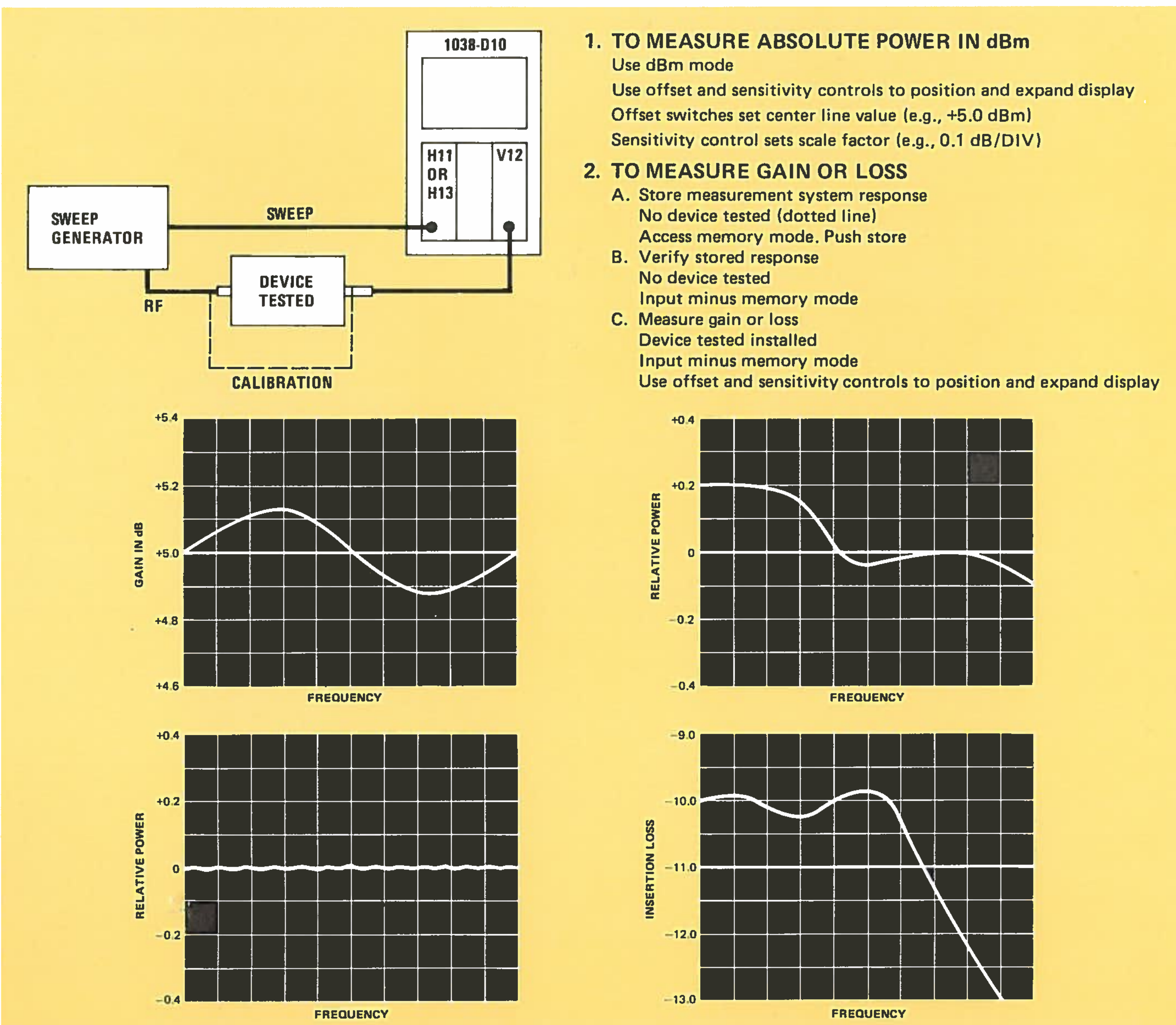


FIGURE 1

1038 AUTOMEMORY System for Swept Frequency Power, Loss or Gain so tight tolerances can be verified with confidence. Please request Application Note 12 for details regarding insertion loss measurements.

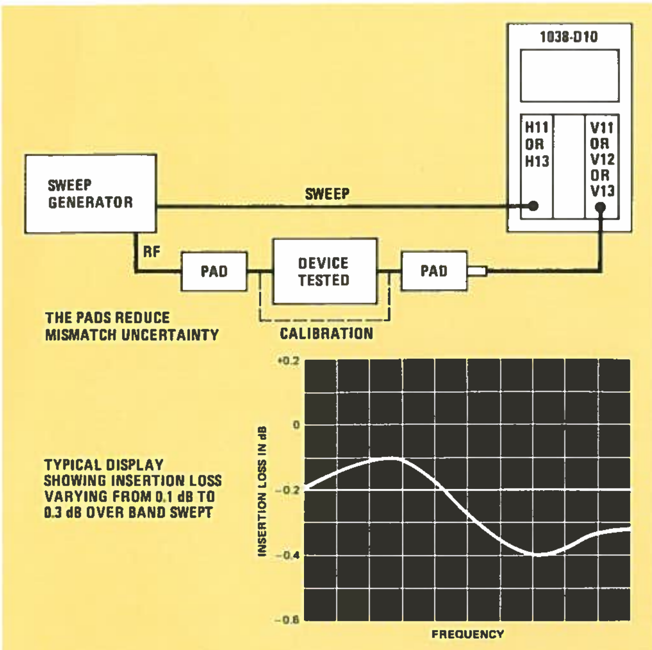


FIGURE 2
Swept Insertion Loss vs. Frequency

Swept Return Loss (Figure 3)
The 1038 may be used for swept return loss in conjunction with a high directivity coupler or bridge. A 0 dB reference is stored in memory using a 100% reflection (short, open, or reversed coupler). The 1038-V13 dual memory amplifier can store short and open reflections and play back the average, further improving accuracy. Please request Application Note 11 and the 1038-V13 data sheet for details regarding swept return loss measurements.

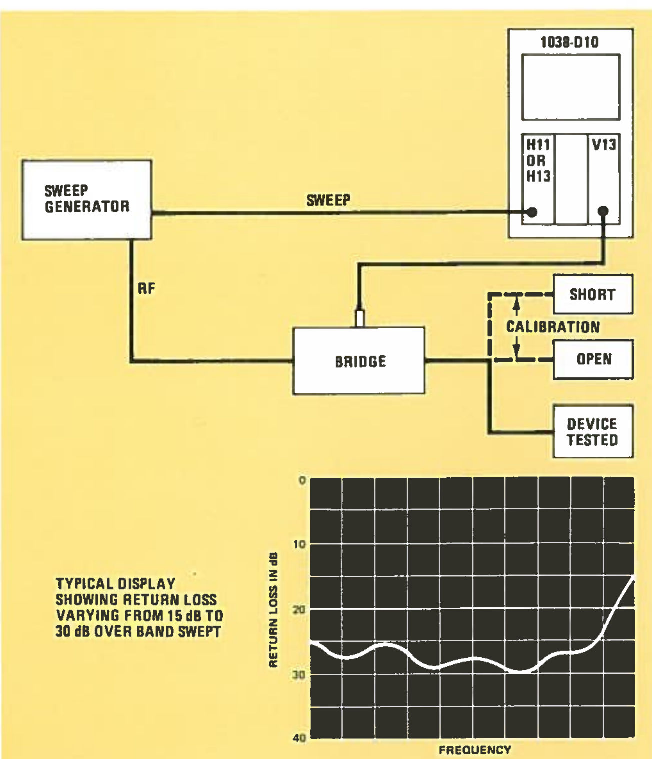


FIGURE 3
Swept Return Loss vs. Frequency

Simultaneous Insertion Loss and Return Loss (Figure 4)
During adjustment or final test, it is often desirable to display both insertion and return loss. This is possible with a 2 channel system. A 0 dB insertion loss reference is stored in the 1038-V12 vertical amplifier memory while a short/open return loss reference is stored in the 1038-V13 memory.

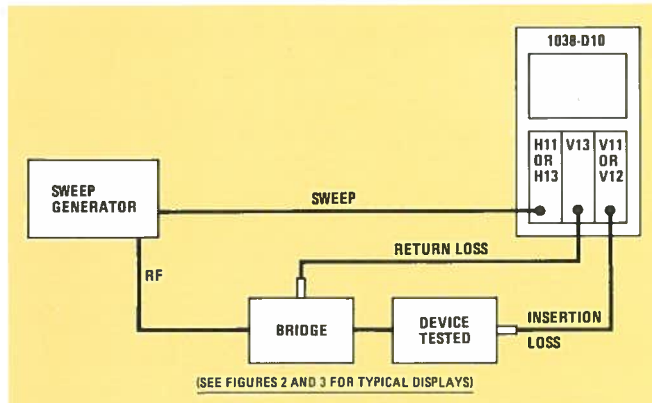


FIGURE 4
Simultaneous Swept Insertion Loss and Return Loss vs. Frequency

Swept Active Device Measurements
Swept measurements of either power or gain may be made using the 1038 system. These measurements are similar to insertion loss measurements, except the memory is not used when absolute power is measured.

It is not so obvious that the 1038 may also be used to measure the power characteristics of active devices such as gain linearity and compression.

Power vs. Frequency (Figure 5)
This measurement does not utilize AUTOMEMORY. The system is operated in the dBm mode. The system acts as a high speed, wide dynamic range (+10 to −50 dBm) power meter. The system does not correct for the tracking error of the power detector. A pad may be required to reduce the device's output to the 1038's measurement range (+10 dBm, maximum).

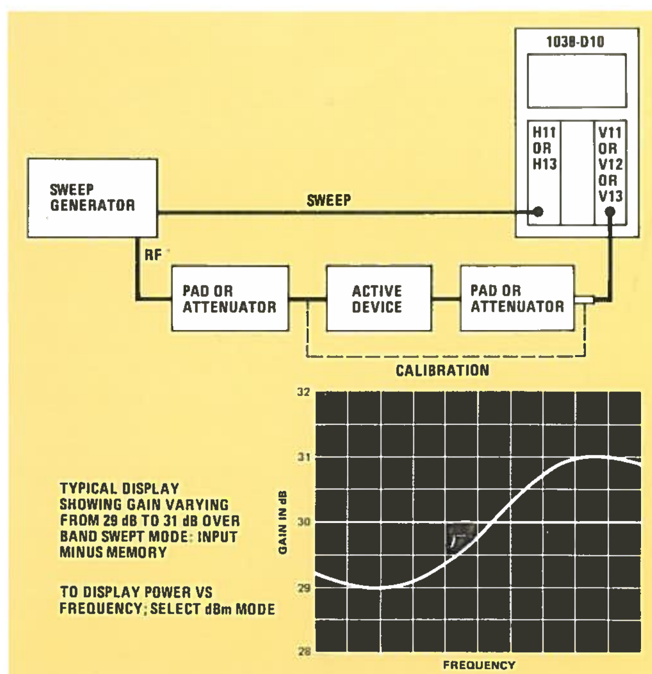


FIGURE 5
Power vs. Frequency or Gain vs. Frequency

Gain vs. Frequency (Figure 5)

The set-up is identical to that for power, except that a 0 dB reference is stored in memory with the device under test removed. Gain is measured in INPUT MINUS MEMORY mode, power is measured in dBm mode. Just push the correct switch to get the desired response. Note that this is the same measurement as for insertion loss, but +dB (gain) is measured rather than –dB (loss).

Swept Power vs. Frequency or Gain vs. Frequency Under Pulsed Conditions (Figure 6)

The 1038 system may be used to measure swept power or swept gain under pulsed conditions by incorporating a 1038-V20 amplifier in the 1038 D-10 mainframe and adding a 1018B Peak Power Meter externally. Dynamic range is +10 dBm to –20 dBm. Request Application Note 14 for details on swept pulsed measurements.

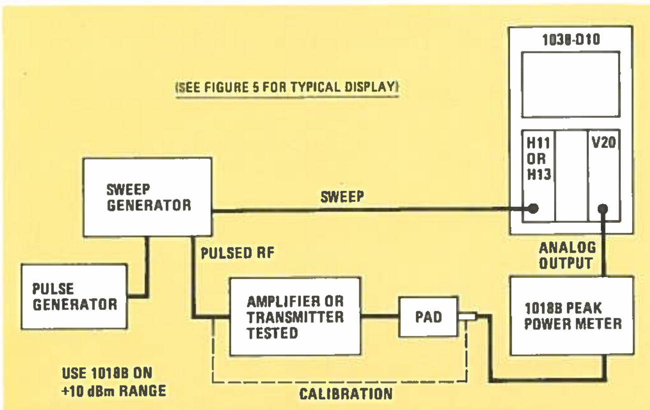


FIGURE 6
Swept Pulsed Power or Gain vs. Frequency

Swept Power Out vs. Power In Measurements (Figure 7)

Often measurements of *power* characteristics of active devices are important, such as gain linearity, 1 dB compression, and limiting. The 1038-K11 Swept Power Plug-In adds the capability to *sweep power* to the device under test. This plug-in also contains all of the capability of the 1038-H11, so swept power or swept frequency measurements are possible. Please request Application Note 16 and the 1038-K11 Data Sheet for information on swept testing of active devices.

Power Out vs. Power In (Figure 7)

This is the normal amplifier power characteristic that is often plotted manually. By sweeping power input over a range as great as 55 dB the 1038 system with 1038-K11 can provide the entire power plot of an amplifier in real time.

Gain vs. Power In (Figure 7)

By storing the power sweep of the K-11 PIN attenuator in memory as a reference and operating in Input minus Memory mode, gain vs. power input of an amplifier may be displayed. The advantage of this display is that sensitivity can be expanded to 0.5 dB/DIV or 0.1 dB/DIV so that the fine structure of gain non-linearity can be seen. When this display is used, it is easy to define the 1 dB compression point within 0.1 dB.

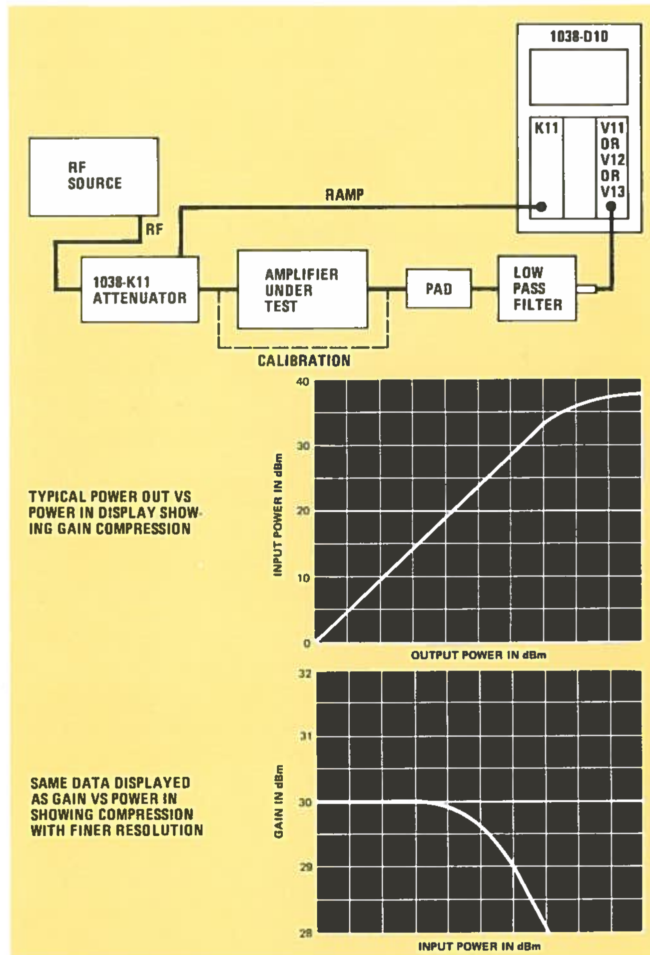
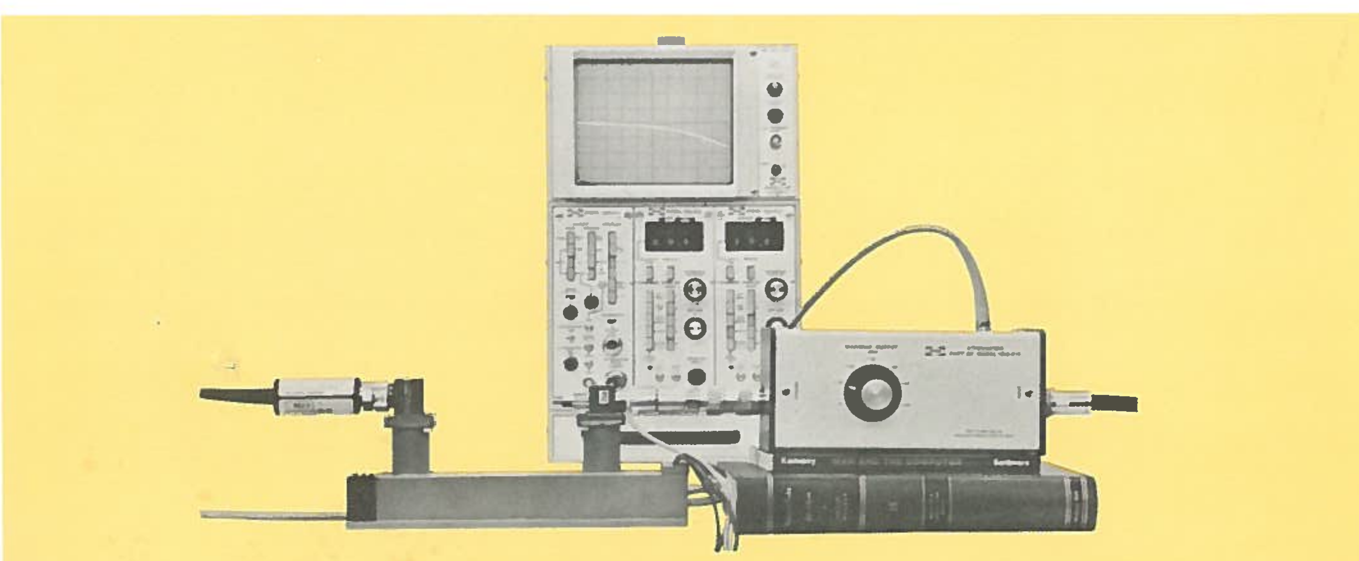


FIGURE 7
Power Out vs. Power In; Gain vs. Power In



Gain Compression vs. Frequency (Figure 8)
It is possible to determine the frequency at which 1 dB gain compression occurs in an amplifier by storing the small signal gain vs. frequency in memory then increasing the drive until input minus memory hits –1 dB.

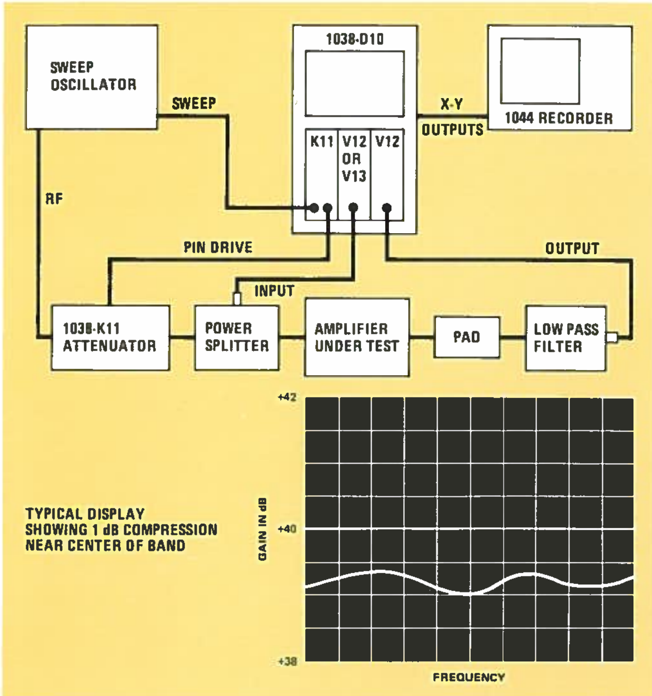
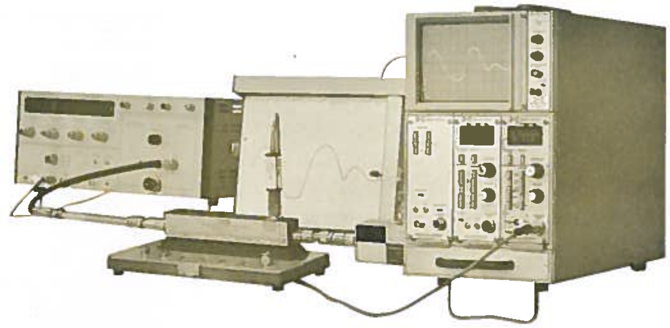


FIGURE 8
Gain Compression vs. Frequency

Swept PIN Attenuation vs. Voltage Drive (Figure 9)
A special horizontal plug-in, 1038-H11 Spec 5116 includes the normal swept frequency capability of the 1038-H11 plus a linear ramp output for driving linearizer/PIN attenuator combinations. This makes possible real-time display of the linearizer characteristic with resolution as fine as .02 dB.



Adjustment of linearizers can be accomplished both quickly and precisely with this set-up. The same system can be used for swept frequency testing without adding a single accessory. Request the 1038-H11 Spec 5116 data sheet for details.

Swept Slotted Line Measurements (Figure 10)
For measurements of large return losses (low VSWR) it may be desirable to make swept slotted line measurements.

The 1038-D11 storage display is recommended so that the entire band of values may be viewed conveniently.

The swept slotted line can provide greater return loss accuracy than a swept reflectometer particularly when broadband measurements are made. The display represents VSWR in dB. If specification limits are converted to VSWR in dB, interpretation of the display is simple. The sensitivity of the probe of the slotted line has an increasing characteristic with frequency. By connecting a low VSWR termination to the slotted line, this sloping characteristic can be stored in memory so that the display is "straightened out" when INPUT MINUS MEMORY is selected.

Then the device under test is connected and the VSWR display is obtained by slowly moving the slotted line probe while frequency is swept. The VSWR (expressed in dB) at a particular frequency is equal to the vertical width of the display at that frequency.

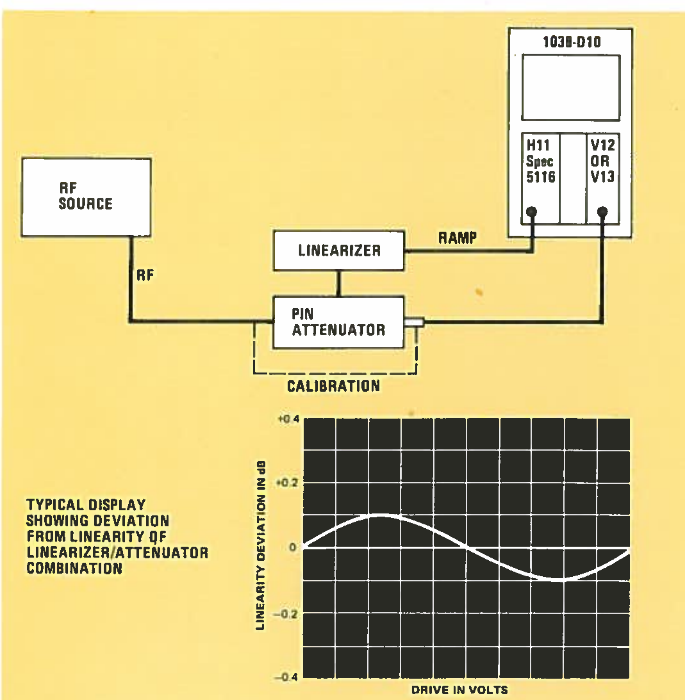


FIGURE 9
Swept Pin Attenuation vs. Voltage Drive

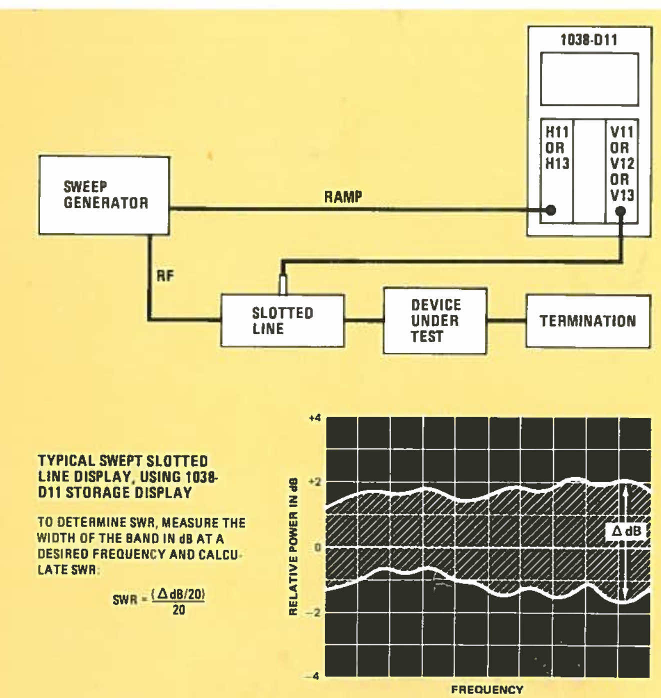


FIGURE 10
Swept Slotted Line

Swept Phase and Amplitude Measurements (Figure 11)
It is possible to use the 1038 AUTOMEMORY system with a network analyzer to display relative phase and relative amplitude. If the network analyzer provides a D.C. output proportional to the measured property, that output can be applied to the input of a 1038-V20 linear amplifier. A reference response can be stored in the amplifier's memory so that the desired relative response is displayed.

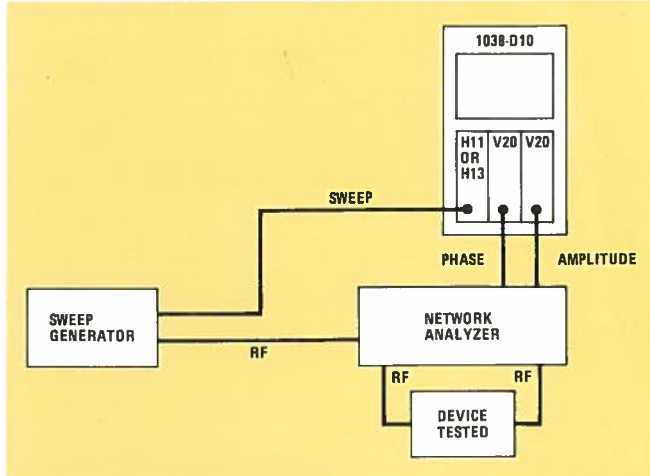


FIGURE 11
Swept Phase and Amplitude vs. Frequency

OTHER P.M.I. PUBLICATIONS

Application Notes

A/N 11	Swept Frequency Return Loss Measurements Using the Model 1038 Measurement System with AUTOMEMORY
A/N 12	Swept Frequency Insertion Loss Measurements Using the Model 1038 Measurement System with AUTOMEMORY
A/N 13	Improve Accuracy in Reflectometer Measurements to 110 GHz with AUTOMEMORY Calibration Correction
A/N 14	Microwave Swept Frequency Gain or Power Testing Under Pulse Modulated Condition, 0.1 to 18 GHz
A/N 15	Digital Measurement of Peak Power 0.1 to 18 GHz with IEEE Bus Option
A/N 16	Swept Frequency and Swept Amplitude Testing of Active Microwave Devices Using the 1038 System with K11 Plug-In
A/N 17	RF Power Ratio Measurements Made Easy

Data Sheets

1038	Swept Frequency Measurement System with AUTOMEMORY
1038-K10/K11	Swept Amplitude Plug-Ins (Amplitude Sweepers for use with Model 1038 Swept Measurement System)
1038-H11	Horizontal Amplifier Plug-In Unit Model
SPEC 5116	
1038-V13	Dual Memory Vertical Amplifier
1038-V20	Linear Amplifier Plug-In
1044	High-Convenience Response Recorder (for use with Model 1038 Swept Measurement System)
1045	Ultra-Fast RF Power Meter
1018B	RF Peak Power Meter
1034A	Portable RF Power Meter

Represented by:

PACIFIC MEASUREMENTS INC.
470 SAN ANTONIO RD., PALO ALTO, CA. 94306
(415) 494-2900 / TWX: (910) 373-1171

Printed in U.S.A.
1038 10/78