# HP 8901A
# MODULATION ANALYZER

## Operation and Calibration Manual

### SERIAL NUMBERS

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

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

*rev.12MAY93*

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

Third Edition

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

Operation and Calibration Manual HP Part 08901-90135

Other Documents Available:
Service Manual HP Part 08901-90136
Microfiche Operation and Calibration Manual HP Part 08901-90137
Microfiche Service Manual HP Part 08901-90138

Printed in U.S.A. : June 1993

HEWLETT
PACKARD

# Sound Emission

## Manufacturer's Declaration

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

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

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

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## Herstellerbescheinigung

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

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

HEWLETT
PACKARD

Printed in FRG March 1991

## CERTIFICATION

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

## WARRANTY

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

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

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

## LIMITATION OF WARRANTY

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

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

## EXCLUSIVE REMEDIES

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

## ASSISTANCE

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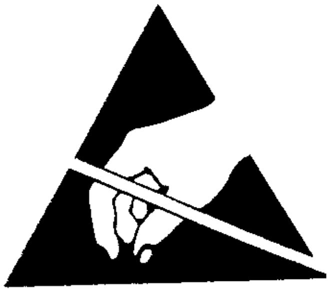

# ATTENTION
## Static Sensitive Devices

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

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

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

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

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

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

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## General Information

## Section 2
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## Section 4
## Performance Tests

# Section 5
# Adjustments

# SAFETY CONSIDERATIONS

### GENERAL

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

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

### BEFORE APPLYING POWER

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

### SAFETY EARTH GROUND

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

### SAFETY SYMBOLS

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

⚡ Indicates hazardous voltages.

⏚ Indicates earth (ground) terminal.

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

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

**WARNING**

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

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

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

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

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

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

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

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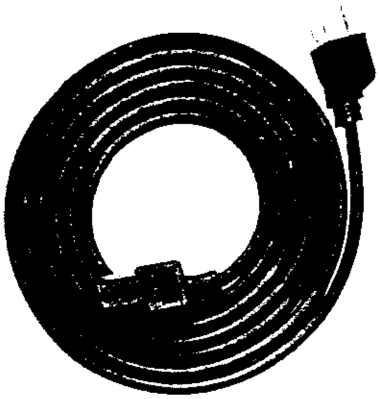
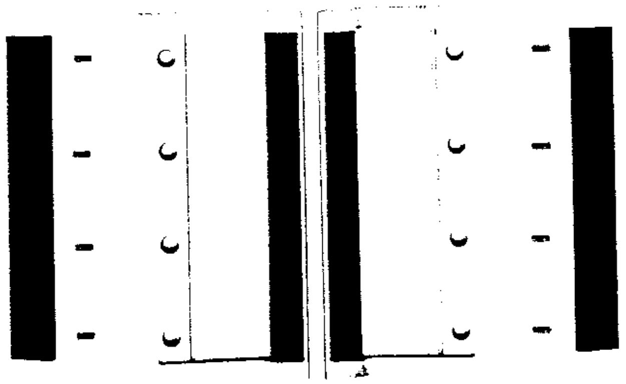
MODEL 8901A

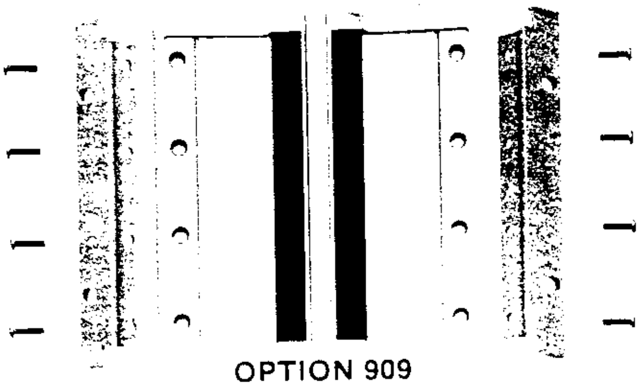


LINE POWER CABLE



OPTION 907
FRONT HANDLE KIT

OPTION 908
RACK FLANGE KIT



OPTION 909
RACK FLANGE AND FRONT
HANDLE COMBINATION KIT

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

*Figure 1-1. HP 8901A (Option 010) Accessories Supplied, and Options 907, 908, and 909*

# Section 1
# GENERAL INFORMATION

## 1-1. INTRODUCTION

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

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

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

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

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

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

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

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

## 1-2. SPECIFICATIONS

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

## 1-3. SAFETY CONSIDERATIONS

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

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

## 1-4. INSTRUMENTS COVERED BY THIS MANUAL

### Options

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

### Serial Numbers

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

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

## 1-5. MANUAL UPDATING

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

### Inside the U.S.A.

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

### Outside the U.S.A.

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

## 1-6. DESCRIPTION OF THE MODULATION ANALYZER

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

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

The Modulation Analyzer is fully automatic and all major measurements can be made by pushing a single key. The Modulation Analyzer's large digital display shows measurement results with excellent resolution and is easy to read. All Modulation Analyzer operations can be controlled and all measurement results can be transferred through the Hewlett-Packard Interface Bus (HP-IB). (HP-IB is Hewlett-Packard's implementation of IEEE Standard 488 and ANSI Standard MC1.1.)

## Frequency Measurements

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

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

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

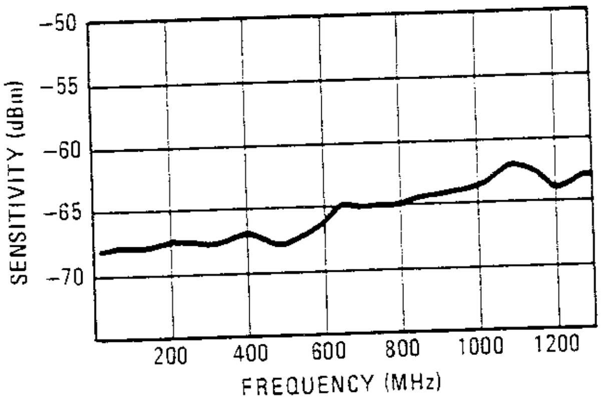


*Figure 1-2. Typical Sensitivity of Frequency Measurements in Manual Operation*

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

## RF Power Measurements

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

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

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

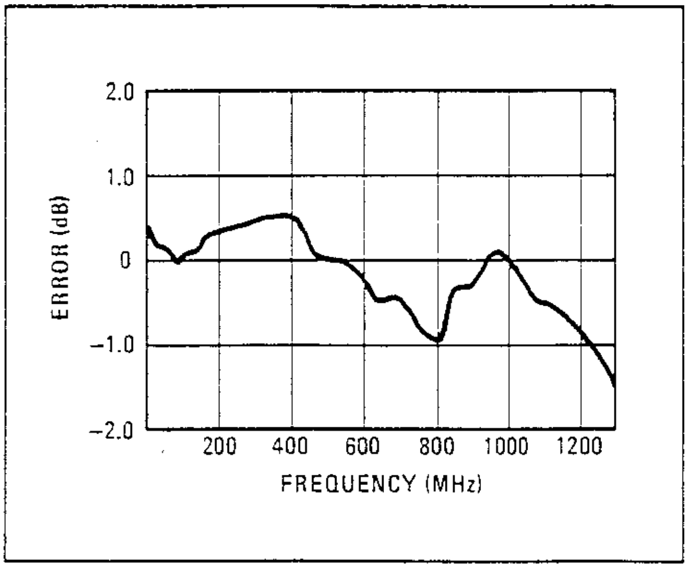


*Figure 1-3. Typical Power Measurement Accuracy*

## Modulation Measurements

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

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

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

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

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

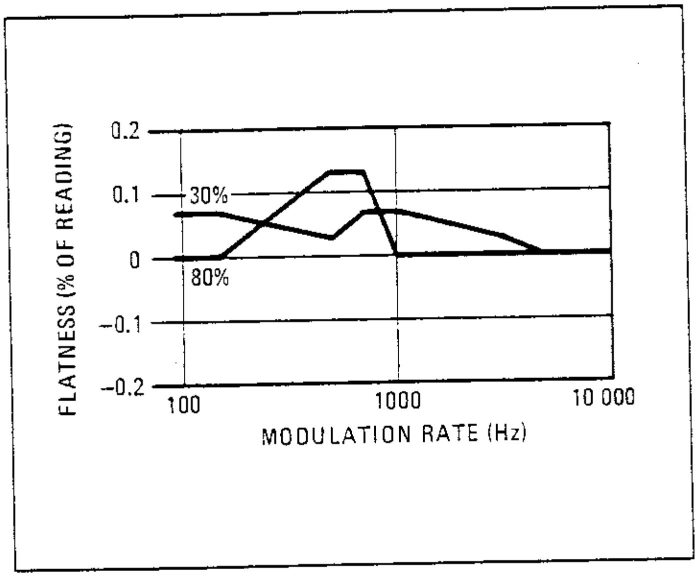


*Figure 1–4. Typical AM Flatness*

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

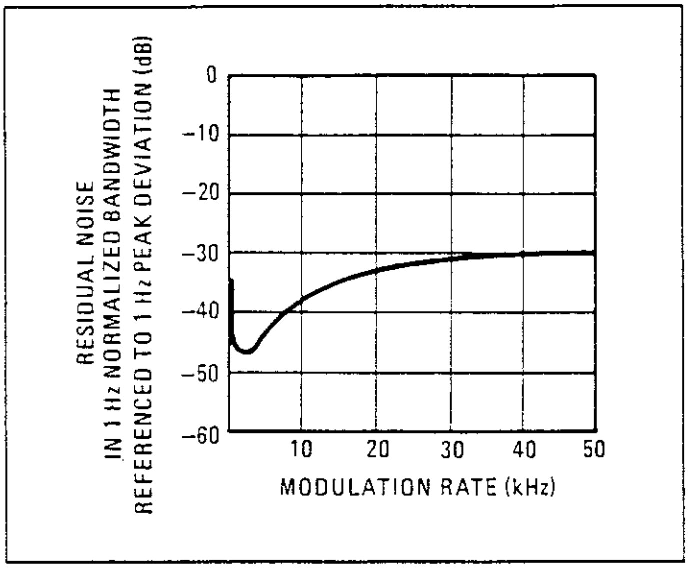


*Figure 1-5. Typical Internal Noise Contribution to FM Measurements at 100 MHz Carrier Frequency*

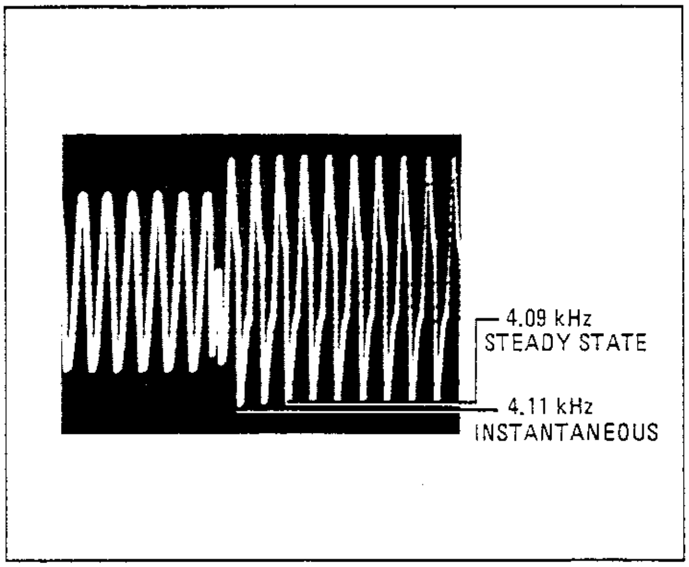


*Figure 1-6. FM Mobile Radio Modulation Limiting Measurement Showing Demodulated Waveform and Measured Value of Transient and Steady-State Deviation*

## Post-Detection Audio Filters

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

The Modulation Analyzer contains four de-emphasis networks that can be used in addition to the audio filters. These are the ones commonly used in FM communications: 25, 50, 75, and 750 μs. When selected, the de-emphasis networks always affect the demodulated output.

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

## Modulation Calibrators

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

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

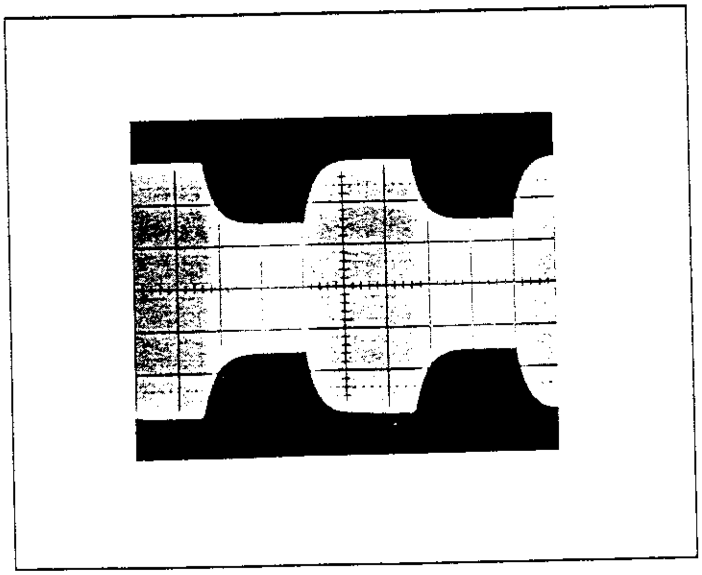


*Figure 1-7. AM Calibrator Waveform*

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

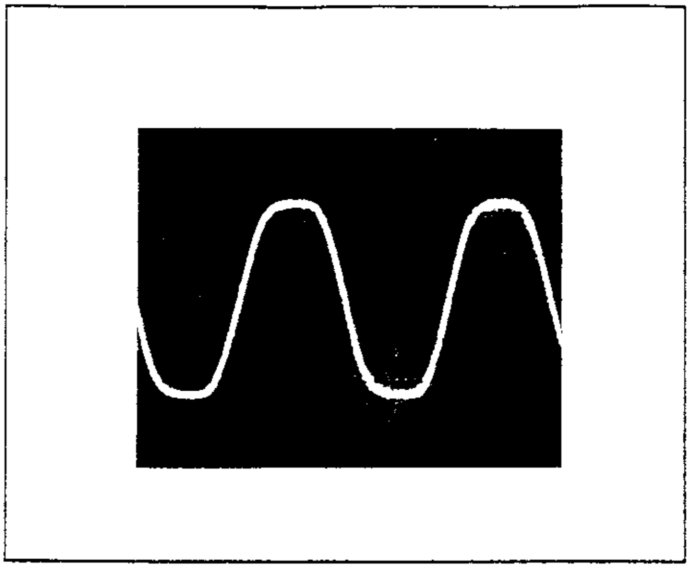


*Figure 1-8. FM Calibrator Modulation Waveform*

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

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

## Operation

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

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

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

## Special Functions

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

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

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

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

## Programmability

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

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

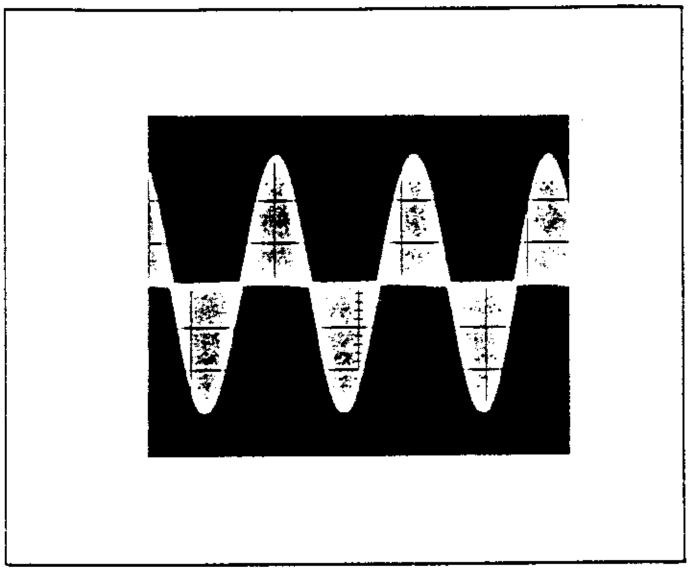


*Figure 1-9. Demodulated FM Stereo Test Signal at 15 kHz Rate*

## 1-7. OPTIONS

### Electrical Options

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

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

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

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

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

### Mechanical Options

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

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

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

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

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

### Compatibility

The Modulation Analyzer is compatible with HP-IB to the extent indicated by the following code: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0. The Modulation Analyzer interfaces with the bus through open-collector TTL circuitry. An explanation of the compatibility code may be found in IEEE Standard 488, *IEEE Standard Digital Interface for Programmable Instrumentation* or the identical ANSI Standard MC1.1.

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

### Selecting the HP-IB Address

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

## 1-9. ACCESSORIES SUPPLIED

The accessories supplied with the Modulation Analyzer are shown in figure 1-1.

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

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

## 1-10. ELECTRICAL EQUIPMENT AVAILABLE

### HP-IB Controllers

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

## Test Source

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

## Service Accessory Kit

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

## Front-to-Rear-Panel Connectors Retrofit Kits

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

## Rear-to-Front-Panel Connectors Retrofit Kits

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

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

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

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

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

## Conversion to 400 Hz Line Operation

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

### AM and FM Calibrators Retrofit Kits

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

## 1-11. MECHANICAL EQUIPMENT AVAILABLE

### Chassis Slide-Mount Kit

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

### Chassis Tilt Side Mount Kit

This kit is the same as the Chassis Slide Mount Kit above except it also allows the tilting of the instrument up or down 90°. Order HP part number 1494-0025 for 431.8 mm (17 in.) tilting slides and part number 1490-0023 for the correct adapters for non-HP rack enclosures.

## 1-12. RECOMMENDED TEST EQUIPMENT

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

## 1-13. PRINCIPLES OF OPERATION FOR SIMPLIFIED BLOCK DIAGRAM

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

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

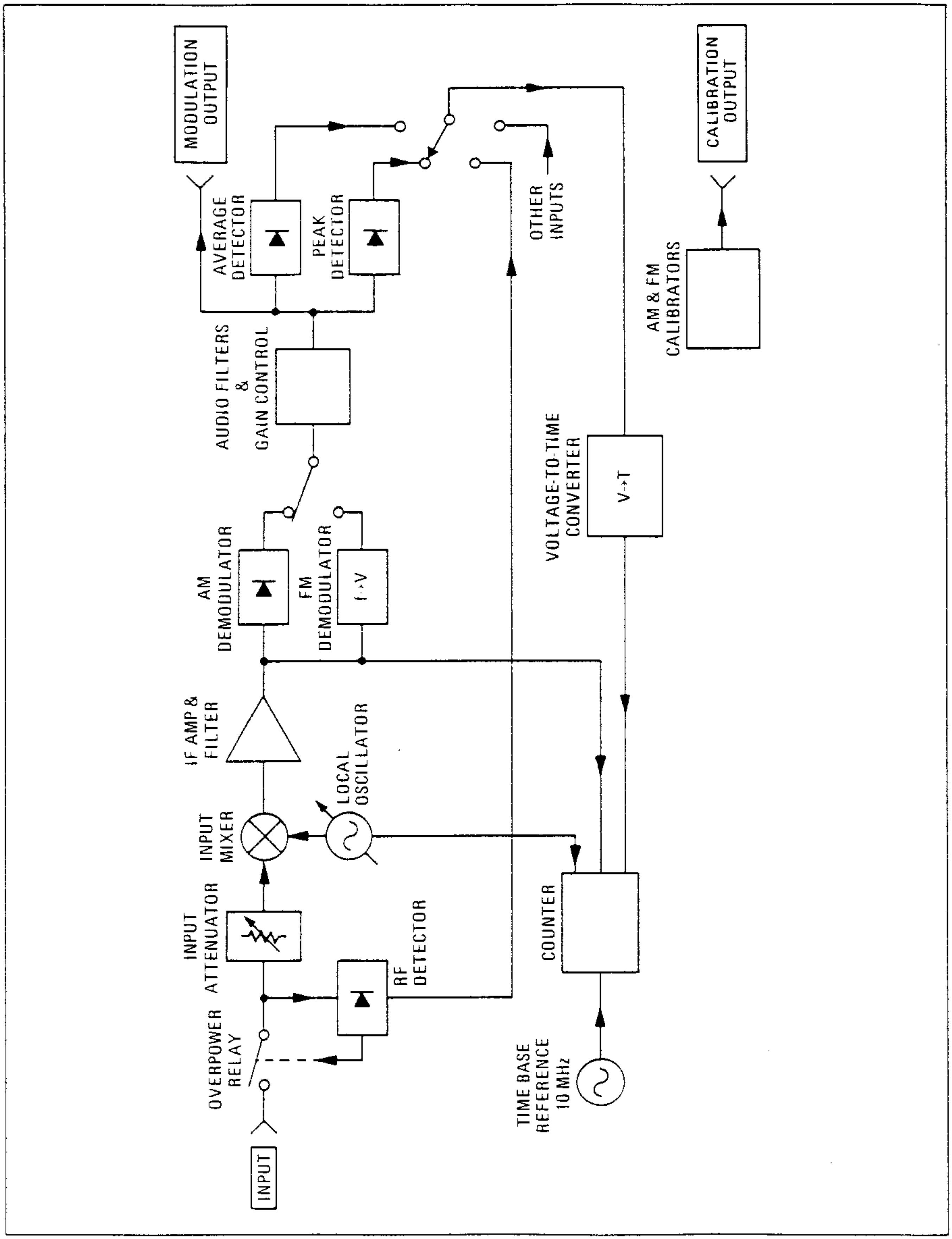


*Figure 1-10. HP 8901A Modulation Analyzer Simplified Block Diagram*

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

The LO has three main modes of operation:

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

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

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

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

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

The entire operation of the instrument is under control of a microprocessor-based Controller (not shown in figure 1-10). The Controller sets up the instrument at turn-on, interprets keyboard entries, executes changes in mode of operation, continually monitors instrument operation, and displays measurement results and errors. In addition, its computing capability is used to simplify circuit operation; that is, it forms the last stage of the Counter, calculates the AM or FM generated by the Calibrators, converts measurement results into ratios (in % or dB), compares measurement results to preset limits when requested by the operator. It also contains routines useful for servicing the rest of the instrument as well as itself.

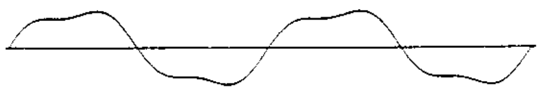
## 1-14. MODULATION BASICS

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

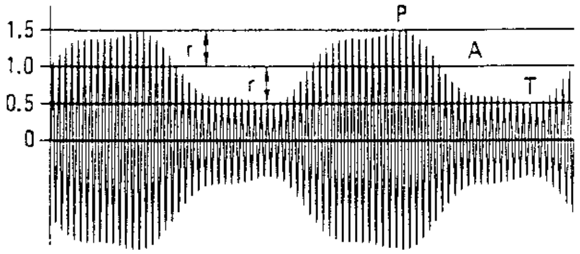
The RF signal which is modulated is called the carrier. The modulating signal is referred to as the baseband signal and can be of any arbitrary form (for example, voice, tone, noise). Demodulation is the process of recovering the baseband signal from the modulated carrier. The Modulation Analyzer can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

## Amplitude Modulation

As the name implies, a carrier is amplitude modulated when its amplitude is varied as a function of time. Figure 1-11 shows a carrier with amplitude modulation and, for reference, also shows the baseband signal. As you can see, the tips of the carrier trace out a waveform that resembles the baseband signal. This trace is called the envelope. The envelope rises to a maximum called the peak and drops to a minimum called the trough.



(a) BASEBAND SIGNAL



(b) AMPLITUDE MODULATED CARRIER

*Figure 1-11. A Baseband Signal and the Corresponding Amplitude Modulated Carrier*

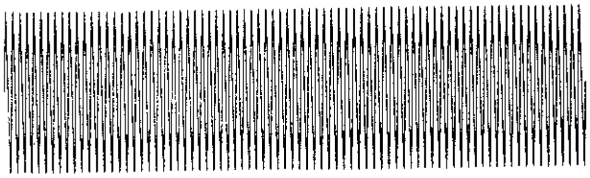
A quantity which describes the amount of AM or the AM depth is the modulation index. If the peak amplitude is called $P$ and the trough amplitude is called $T$, the modulation index $m$ (usually expressed in %) is defined as

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

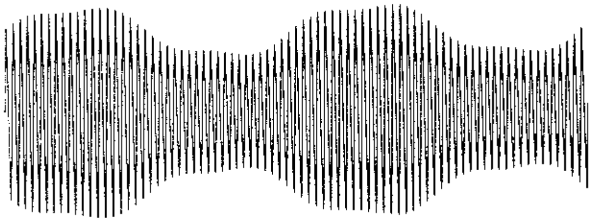
In the example of figure 1-11, $P = 1.5$ and $T = 0.5$; therefore,

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

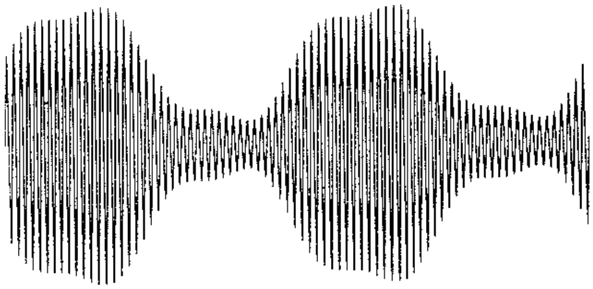
Figure 1-12 shows AM signals with modulation indexes varying from 0 to 100%.



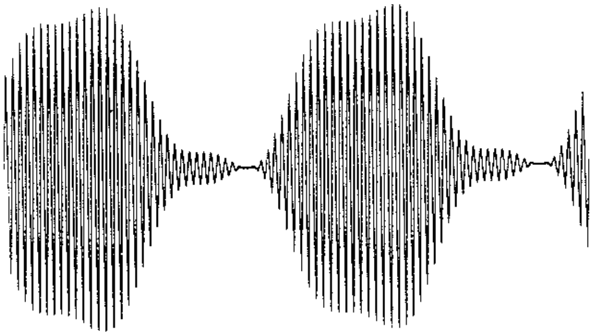
(a) 0% AM (CW)



(b) 30% AM



(c) 70% AM



(d) 100% AM

*Figure 1-12. AM for Various Depths*

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

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

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

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

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

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

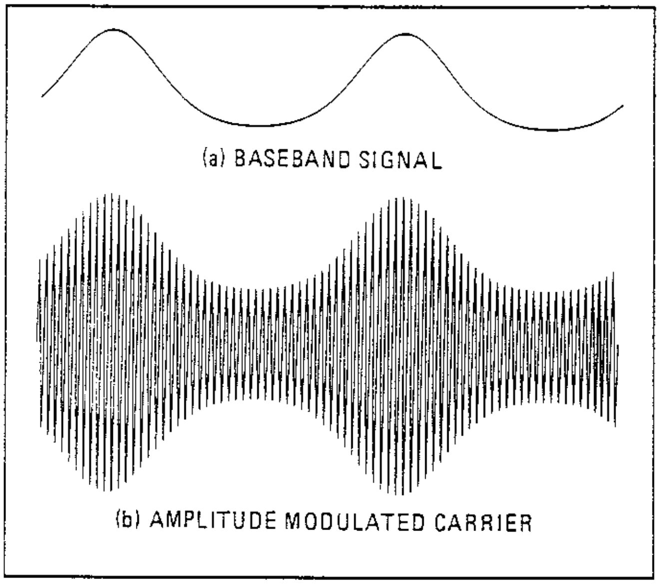


*Figure 1-13. AM with an Asymmetrical Baseband Signal*

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

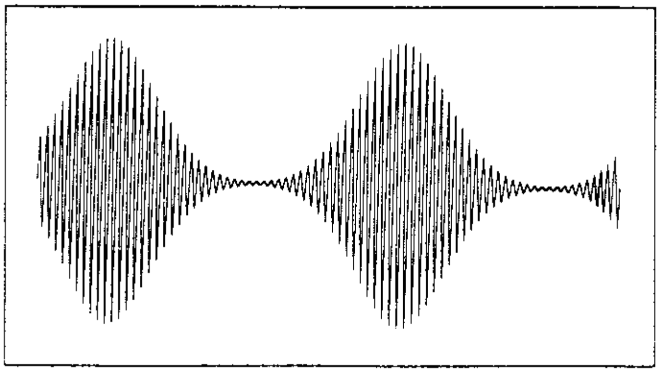
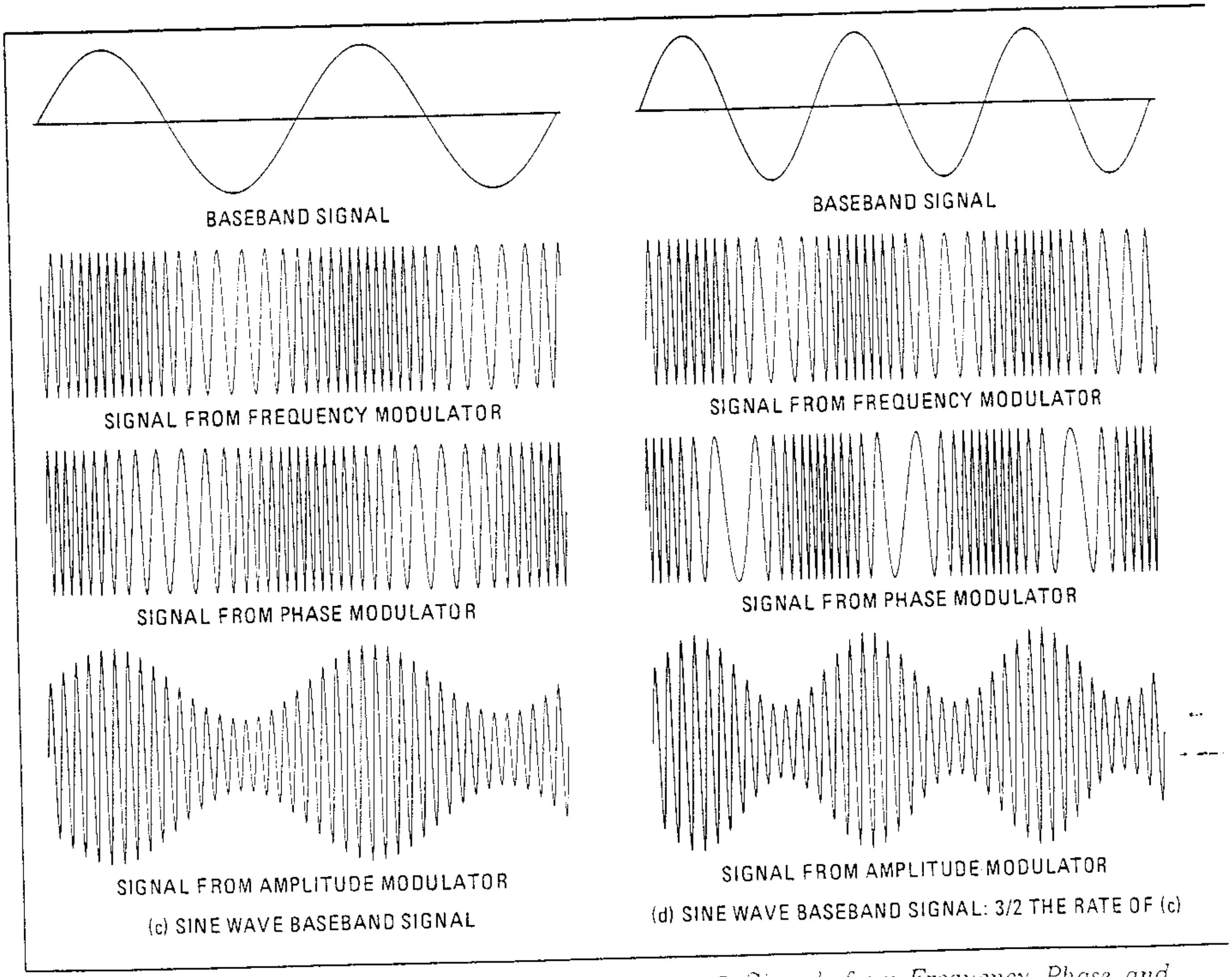


*Figure 1-14. AM with Modulation Exceeding 100% as Measured by the PEAK+ Detector*

## Exponential Modulation

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

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



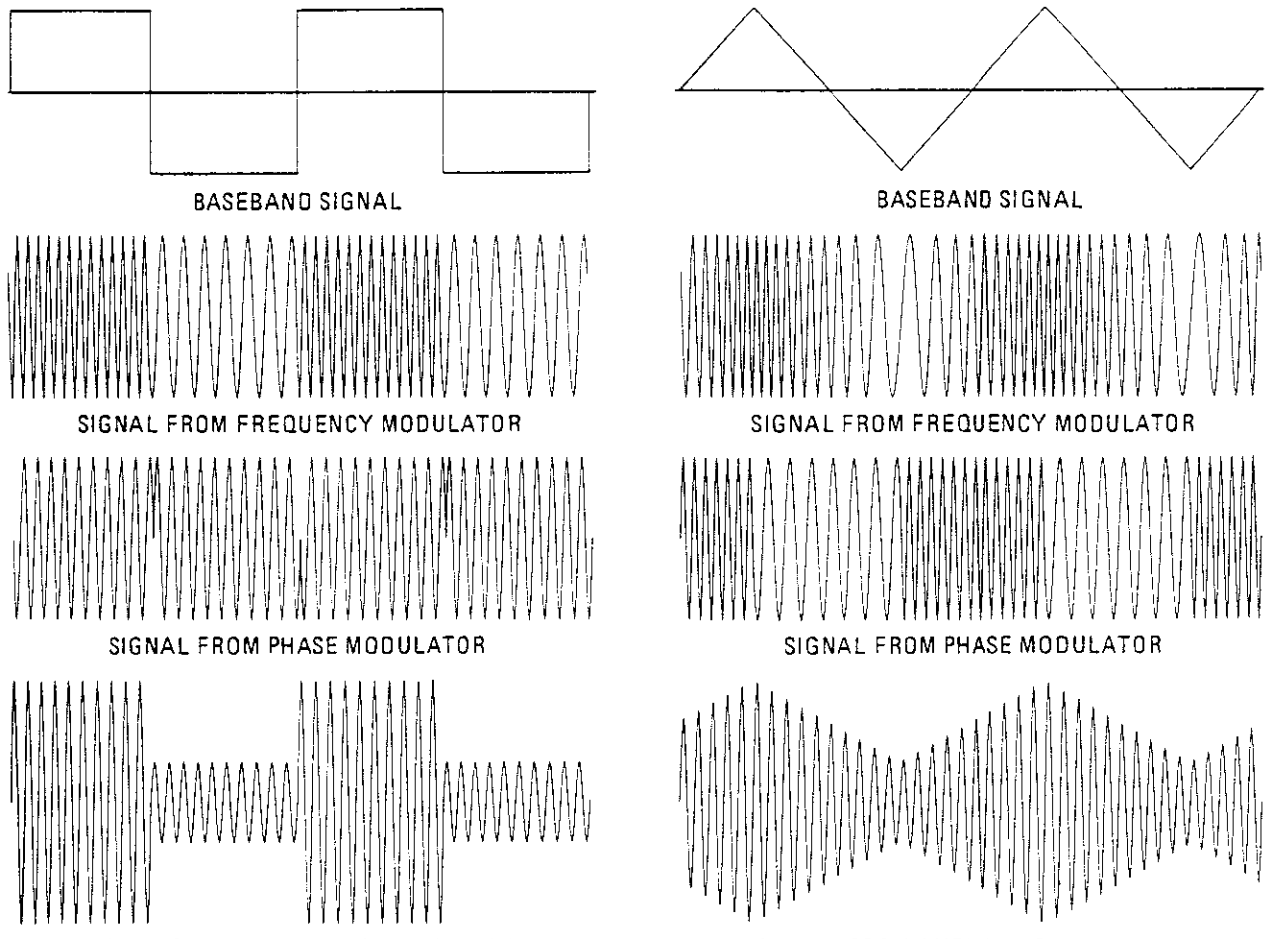
(c) SINE WAVE BASEBAND SIGNAL

(d) SINE WAVE BASEBAND SIGNAL: 3/2 THE RATE OF (c)

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

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

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



(a) SQUARE WAVE BASEBAND SIGNAL

(b) TRIANGLE WAVE BASEBAND SIGNAL

*Amplitude Modulators for Various Baseband Signals*

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

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

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

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

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

## Other Considerations

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

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

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

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

Table 1-1. *Specifications (3 of 4)*

| Electrical Characteristic | Performance Limits | Conditions |
|---|---|---|
| **FREQUENCY COUNTER** | | |
| Range | 150 kHz to 1300 MHz | |
| Sensitivity | 12 mVrms (−25 dBm) | 150 kHz to 650 MHz |
| | 22 mVrms (−20 dBm) | 650 to 1300 MHz |
| Accuracy | Reference accuracy ±3 counts of least significant digit | |
| Internal Reference | | |
| Frequency | 10 MHz | |
| Aging Rate | <1 x $10^{-6}$/month | Except Option 002 |
| | <1 x $10^{-9}$/day | Option 002 only and after 30 day warm-up |
| **RF LEVEL**[1] | | Peak voltage responding, rms sine wave calibrated. |
| Range | 1 mW to 1 W | |
| *Serial Prefix 1933A to 2212A:* | | |
| Instrumentation Accuracy | ±2 dB | 150 kHz to 650 MHz |
| | ±3 dB | 650 to 1300 MHz |
| SWR | < 1.5 | 50Ω system |
| *Serial Prefix 2227A and above:* | | |
| Instrumentation Accuracy | ±1.5 dB | 150 kHz to 1300 MHz |
| SWR | < 1.3 | 50Ω system; 150 kHz to 650 MHz |
| | < 1.5 | 50Ω system; 650 MHz to 1300 MHz |
| **AUDIO FILTERS** | | |
| 50 Hz High-Pass (2-pole) | | |
| 3 dB Cutoff Frequency | 50 Hz nominal | |
| Flatness | <1% | Rates ≥200 Hz |
| 300 Hz High-Pass (2-pole) | | |
| 3 dB Cutoff Frequency | 300 Hz nominal | |
| Flatness | <1% | Rates ≥1 kHz |
| 3 kHz Low-Pass (5-pole) | | |
| 3 dB Cutoff Frequency | 3 kHz nominal | |
| Flatness | <1% | Rates ≤1 kHz |
| 15 kHz Low-Pass (5-pole) | | |
| 3 dB Cutoff Frequency | 15 kHz nomial | |
| Flatness | <1% | Rates ≤10 kHz |
| >20 kHz Low-Pass (9-pole Bessel) | | |
| 3 dB Cutoff Frequency | >20 kHz | |
| Flatness | <1% | Rates ≤10 kHz |
| De-emphasis Filters (1-pole low-pass)<br>25 μs, 50 μs, 75 μs, 750 μs nominal | | |
| **CALIBRATORS (Option 010)** | | |
| AM | | |
| Depth | 33.33% nominal | |
| Calibration Factor Accuracy | ±0.1% | |

---

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

*Table 1-1. Specifications (4 of 4)*

| Electrical Characteristic | Performance Limits | Conditions |
|---|---|---|
| **CALIBRATORS (Option 010) (cont'd)** | | |
| FM | | |
| Deviation | 34 kHz peak nominal | |
| Calibration Factor Accuracy | ±0.1% | |
| **GENERAL** | | |
| Power Requirements | | |
| Line Voltage: | | |
| 100, 120, 220, or 240 Vac | +5%, −10% | 48 to 66 Hz (including Option 004) |
| 100, 120 Vac | +5%, −10% | 48 to 440 Hz (Option 004 only) |
| Power Dissipation | 200 V•A maximum | |
| Remote Operation (HP-IB) | IEEE STD 488-1978 Compatibility code: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0 | The Hewlett-Packard Interface Bus (HP-IB) is Hewlett-Packard Company's implementation of IEEE Std 488-1978, "Digital Interface for Programmable Instrumentation". All functions except the line switch are remotely programmable. |
| Conducted and Radiated Electromagnetic Interference | VDE 0871 (Level B), and CISPR publication 11 | Conducted and radiated interference is within the requirements of VDE 0871 (Level B), and CISPR publication 11. |
| Net Weight | 20 kg (44 lb) nominal | |
| Dimensions: | | |
| Height | 190 mm(7.5 in.) nominal | |
| Width | 425 mm (16.8 in.) nominal | |
| Depth | 468 mm (18.4 in.) nominal | |
| Temperature: | | |
| Operating | 0 to 55°C | |
| Storage | −55 to 75°C | |

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

| Instrument Type | Critical Specifications | Suggested Model | Use* |
|---|---|---|---|
| AM/FM Test Source | Carrier Frequency: within range 10 to 1300 MHz<br>Output Level: > −20 dBm<br>FM Deviation: 400 kHz peak maximum<br>FM Distortion:<br>< −72 dB at 12.5 MHz carrier with 12.5 kHz deviation and < 10 kHz rate<br>< −72 dB at 400 MHz carrier and 400 kHz deviation at < 100 kHz rate<br>FM Flatness:<br>±0.1% from 20 Hz to 100 kHz rates<br>±0.25% to 200 kHz rates<br>CW Residual FM: < 3 Hz rms in a 50 Hz to 3 kHz bandwidth at 560 MHz<br>Incidental AM: < 0.08% AM at 100 MHz with < 50 kHz peak deviation and 1 kHz rate in a 50 Hz to 3 kHz bandwidth<br>AM Depth: 5% to 99%<br>AM Distortion:<br>< −66 dB at < 50% AM at 20 Hz to 100 kHz rates<br>< −60 dB at < 95% AM at 20 Hz to 100 kHz rates<br>AM Flatness:<br>±0.1% from 50 Hz to 50 kHz<br>±0.25% from 20 Hz to 100 kHz<br>Incidental ΦM: < 0.008 rad peak at 12.5 MHz with 50% AM at a 1 kHz rate in a 50 Hz to 3 kHz bandwidth<br>Residual AM: < 0.01% rms in a 50 Hz to 3 kHz bandwidth<br>AM Linearity:<br>±0.1% at < 95% AM<br>±0.2% at < 99% AM | HP 11715A | P,A,T |
| Audio Analyzer | Fundamental Frequency Range: 20 Hz to 100 kHz<br>Distortion Range: −70 dB minimum<br>Distortion Accuracy: ±2 dB<br>Low-Pass Filters: 30 and 80 kHz<br>Oscillator Level: 3V maximum into 600Ω<br>Oscillator Distortion: < −70 dB<br>Oscillator Frequency Accuracy: ±2% | HP 8903B | P,A,T |
| Audio Synthesizer | Frequency Range: 20 Hz to 400 kHz<br>Output Level: +16 dBm (50Ω) maximum<br>Frequency Accuracy: ±0.1%<br>Attenuator Accuracy: ±0.1 dB from 0 to 20 dB<br>Level Flatness:<br>±0.015 dB from 90 Hz to 10 kHz<br>±0.3 dB from 50 Hz to 100 kHz<br>±0.07 dB from 20 Hz to 200 kHz<br>Distortion: < −50 dB from 20 Hz to 200 kHz | HP 3336C Option 005 | P,A,T |

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

*Table 1-3. Recommended Test Equipment (2 of 4)*

| Instrument Type | Critical Specifications | Suggested Model | Use* |
|---|---|---|---|
| Bandpass Filters | Passband Frequency: 512 to 674 MHz<br>Passband SWR: $\leq$ 1.4<br>Passband insertion loss: $\leq$ 0.4 dB<br>Midband insertion loss: $\leq$ 0.5 dB<br>Stopband Rejection:<br>Below Passband:<br>Frequency: $\leq$ 337 MHz<br>Attenuation: $\geq$ 21 dB<br>Above Passband:<br>Frequency: 768 to 3000 MHz<br>Attenuation: $\geq$ 21 dB | Telonic TBA 593-218-5FE | P |
| | Passband Frequency: 800 to 1100 MHz<br>Passband SWR: $\leq$ 1.4<br>Passband insertion loss: $\leq$ 0.4 dB<br>Midband insertion loss: $\leq$ 0.5 dB<br>Stopband Rejection:<br>Below Passband:<br>Frequency: $\leq$ 550 MHz<br>Attenuation: $\geq$ 21 dB<br>Above Passband:<br>Frequency: 1333 to 3000 MHz<br>Attenuation: $\geq$ 21 dB | Telonic TBA 950-375-5FE1 | P |
| Computing Controller | HP-IB compatibility as defined by IEEE Std 488 and the identical ANSI Std MC1.1: SH1, AH1, T2, TE0, L2, LE0, SR0, PP0, DC0, DT0, and C1, 2, 3, 4, 5. | HP 9000 Model 216, 226, or 236 | C,P,T |
| Digital Multimeter | DC Range: 0 to 50V<br>DC Accuracy: ±0.01% at 1V<br>AC Range: 0 to 100V<br>AC Accuracy: ±0.01% at 2V and 2 kHz<br>Ohms Range: 0 to 1 MΩ<br>Ohms Accuracy: ±1% | HP 3478A | P,A,T |
| Divider Probe (2 required) | Divider Ratio: 10:1<br>Input Impedance: 1 MΩ<br>Input Capacitance: < 10 pF | HP 10040A | A,T |
| Frequency Standard | Accuracy: ±0.1 ppm recommended | House Standard | A |

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

**WARNING**

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

*If this instrument is to be energized by an external autotransformer, make sure the autotransformer's common terminal is connected to the earthed pole of the power source.*

## Line Voltage and Fuse Selection

**CAUTION**

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

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

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

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

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

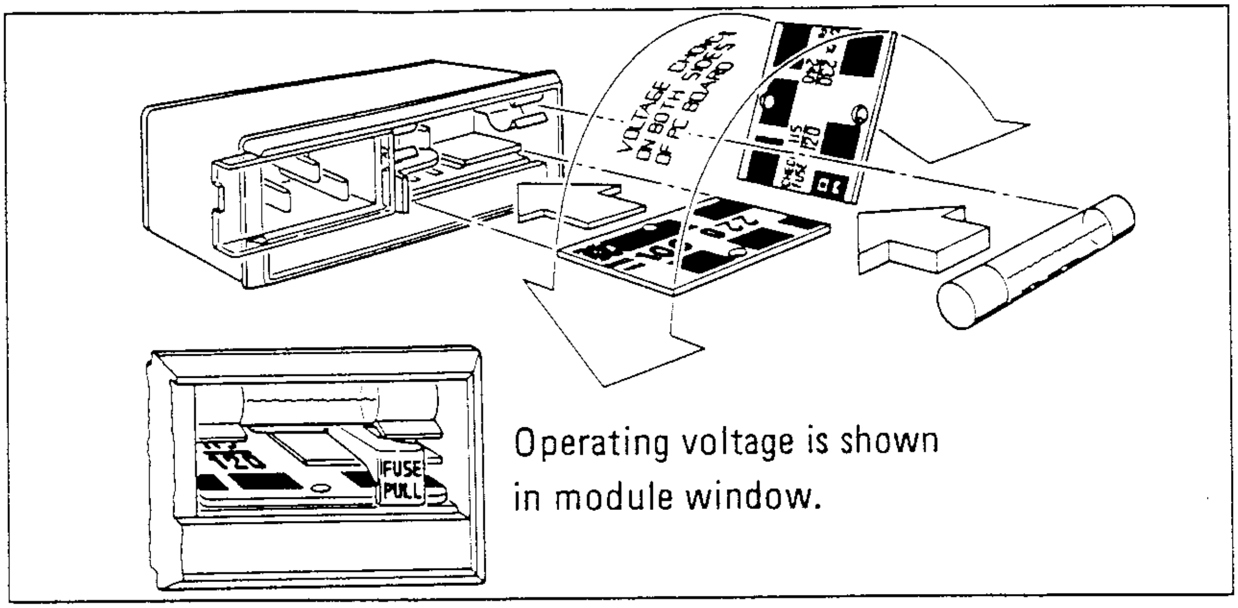


*Figure 2-1. Line Voltage and Fuse Selection*

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

**WARNING**

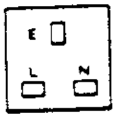
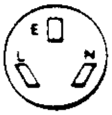
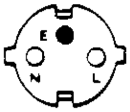
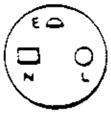
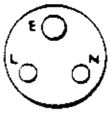
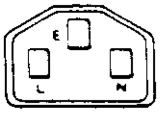
*To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz (leakage currents at these line settings may exceed 3.5 mA).*

## Power Cables

**WARNING**

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

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

| Plug Type | Cable HP Part Number | C D | Plug Description | Cable Length (inches) | Cable Color | For Use In Country |
|---|---|---|---|---|---|---|
| 250V  | 8120-1351 | 0 | 90°/STR BS1363A* | 90 | Mint Gray | United Kingdom, Cyprus, Nigeria, Rhodesia, Singapore |
| | 8120-1703 | 4 | 90°/90° | 90 | Mint Gray | |
| 250V  | 8120-1369 | 0 | STR/STR | 79 | Gray | Austrailia, New Zealand |
| | 8120-0696 | 4 | NZSS198/ASC112*<br>STR/90° | 80 | Gray | |
| 250V  | 8120-1689 | 7 | STR/STR* | 79 | Mint Gray | East and West Europe, Saudi Arabia, Egypt, (unpolarized in many nations) |
| | 8120-1692 | 2 | STR/90° | 79 | Mint Gray | |
| 125V  | 8120-1378 | 1 | STR/STR NEMA5-15P* | 80 | Jade Gray | United States, Canada, Mexico, Phillipines, Taiwan |
| | 8120-1521 | 6 | STR/90° | 80 | Jade Gray | |
| | 8120-1751 | 1 | STR/STR | 90 | Jade Gray | U.S./Canada |
| 100V (Same plug as above) | 8120-4753 | 2 | STR/STR | 90 | Dark Gray | Japan only |
| | 8120-4754 | 3 | STR/90° | 90 | Dark Gray | Japan only |
| 250V  | 8120-2104 | 3 | STR/STR SEV1011<br>1959-24507<br>Type 12 | 79 | Gray | Switzerland |
| | 8120-2296 | 4 | STR/90° | 79 | Gray | |
| | 8120-3997 | 4 | STR/90° | 177 | Gray | |
| 250V  | 8120-0698 | 6 | STR/STR NEMA6-15P | 90 | Black | United States, Canada |
| 250V  | 8120-2956 | 3 | 90°/STR | 79 | Gray | Denmark |
| | 8120-2957 | 4 | 90°/90° | | | |
| | 8120-3997 | 4 | STR/STR | | | |
| 250V  | 8120-4211 | 7 | STR/STR*IEC83-B1 | 79 | Black | South Africa, India |
| | 8120-4600 | 8 | STR/90° | 79 | Gray | |
| 250V  | 8120-1860 | 6 | STR/STR*CEE22-V1<br>(Systems Cabinet Use) | 59 | Jade Gray | |
| | 8120-1575 | 0 | STR/STR | 31 | Jade Gray | |
| | 8120-2191 | 8 | STR/90° | 59 | Jade Gray | |
| | 8120-4379 | 8 | 90°/90° | 80 | Jade Gray | |

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

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

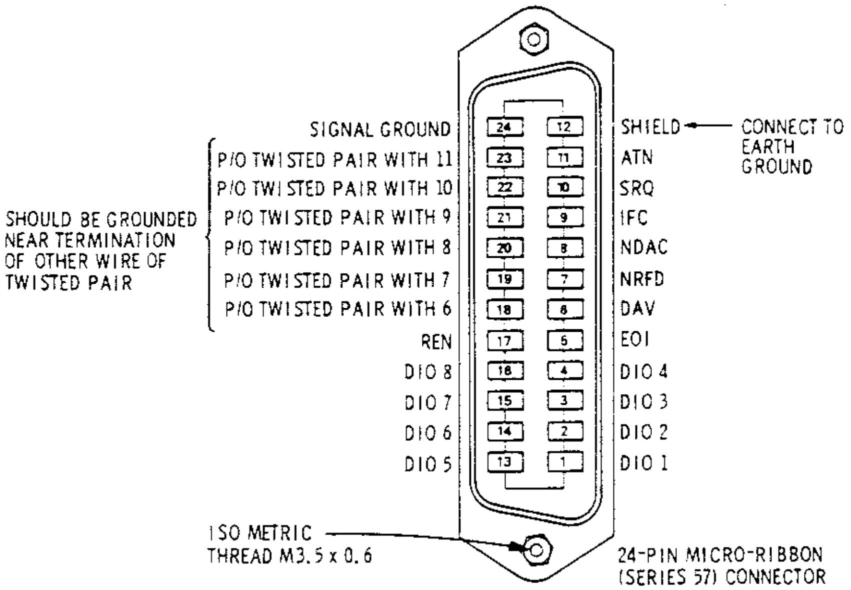
## HP-IB Address Selection

**WARNING**

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

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

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



**Logic Levels**

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

**Programming and Output Data Format**

Refer to Section III, Operation.

**Mating Connector**

HP 1251-0293; Amphenol 57-30240.

**Mating Cables Available**

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

**Cabling Restrictions**

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

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

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

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

## Operating Environment

The operating environment should be within the following limitations:

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

## Bench Mounting

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

## Rack Mounting

**WARNING**

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

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

## Removal and Installation of Operating Information Pull-Out Cards

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

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

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

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

## 2-4. STORAGE AND SHIPMENT

### Environment

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

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

### Packaging

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

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

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

# Section 3
# OPERATION

## 3-1. INTRODUCTION

### General

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

### Operating Characteristics

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

### Turn-On Procedure

**WARNING**

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

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

**CAUTION**

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

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

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

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

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

**NOTE**

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

## Local Operation

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

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

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

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

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

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

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

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

## Remote Operation

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

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

## Operator's Checks

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

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

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

## Operator's Maintenance

**WARNING**

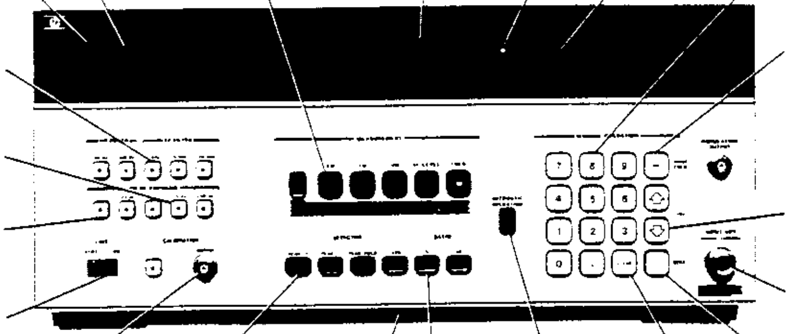
*For continued protection against fire hazard, replace the line fuse only with a 250 V normal blow fuse of the same rating. Do not use repaired fuses or short-circuited fuseholders.*

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

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

*Table 3-1. Operating Characteristics Summary*

| Operating Parameter | Capabilities |
|---|---|
| Input Limits | Frequency: 150 kHz to 1300 MHz.<br>Level: −25 to +30 dBm from 150 kHz to 650 MHz<br>−20 to +30 dBm from 650 to 1300 MHz. |
| Modulation Measurements | AM: Depths to 99%; rates from 20 Hz to 10 kHz for inputs of 150 kHz to 10 MHz, 20 Hz to 100 kHz for inputs of 10 to 1300 MHz.<br>Ranges: 0 to 40%; 0 to 100%.<br>FM: Deviation to 40 kHz peak with rates from 20 Hz to 10 kHz for inputs of 150 kHz to 10 MHz; deviation to 100 kHz peak with rates from 20 Hz to 200 kHz for inputs of 10 to 1300 MHz.<br>Ranges: 0 to 4 kHz; 0 to 40 kHz; 0 to 400 kHz.<br>ΦM: Deviations to 400 radians with rates from 200 Hz to 20 kHz for inputs from 10 to 1300 MHz.<br>Ranges: 0 to 4 rad; 0 to 40 rad; 0 to 400 rad nominal. |
| Level Measurements | RF Level: Peak broadband power at input.<br>Tuned RF Level: Peak envelope power in Modulation Analyzer's tuned bandwidth.<br>IF Level: Percent of optimum (100%) power in Modulation Analyzer's IF amplifier. |
| Frequency Measurements | Freq: Frequency of input signal from 150 kHz to 1300 MHz<br>Freq Error: Frequency difference between input signal and the Modulation Analyzer's tuning.<br>IF Frequency (Special Function 10): Frequency of signal in IF. |
| Detectors | Peak: Positive; Negative (trough for AM); Peak Hold.<br>Average: Calibrated to read rms with a sine wave. |
| Demodulated Signal Filtering | High-Pass: 50 Hz; 300 Hz.<br>Low-Pass: 3 kHz; 15 kHz; >20 kHz.<br>FM De-emphasis: 25 μs; 50 μs; 75 μs; 750 μs. De-emphasis can be performed before the displayed measurement is made (Pre-display on) or after (Pre-display off). |
| Demodulated Signal Output | 0 to 4 V ac per modulation range.<br>600Ω output impedance. |
| Tuning | Automatic, Track, or Manual. |
| Data Manipulation | Ratio: Data can be displayed as a computed ratio of measurement results to a reference value. Display can be in % or dB.<br>Limit: Data may be entered as upper and lower limits. Limit annunciator lights when limits are exceeded. |
| Manual Operation | Input attenuation, ranges, tuning, IF frequency, frequency resolution and many other operations may be manually controlled. |
| Remote Operation | All Modulation Analyzer operations except the line switch may be controlled through the Hewlett-Packard Interface Bus. |



**MEASUREMENT** keys command the Modulation Analyzer to make and display the selected measurement.

**Numeric Display** shows measurement results, error codes, or instrument or Special Function status.

**Display Annunciators** indicate the measurement result units.

**LCL** (Local) key returns the Modulation Analyzer to keyboard control from remote (HP-IB) control.

**Limit** indicator lights when measured value exceeds that entered by the operator.

**HP-IB Annunciators** indicate remote operation status.

**Numeric** keys are used for manual tuning, entry of RATIO references and limit values, and selection of Special Functions.

**HP** (High-Pass) and **LP** (Low-Pass) **FILTERS** limit the demodulated signal bandwidth.

**MHz** key completes the keyboard entry of input frequency (in MHz) for manual tuning.

**FM DE-EMPHASIS** networks equalize pre-emphasized FM.

**MODULATION OUTPUT** provides a low-distortion output of the recovered modulation.

**PRE-DISPLAY** key allows FM deviation to be measured before or after de-emphasis.

↑ **kHz** and ↓ **kHz** complete keyboard entry of frequency step size (in kHz) for step tuning.

**INPUT** couples modulated signal into the instrument.

**LINE** switch applies power to the Modulation Analyzer when set to ON.

**SPCL** key completes entry of Special Function codes for accessing instrument operations additional to those having dedicated front-panel keys.

**CALIBRATION OUTPUT** (Option 010 only) produces a precisely modulated signal for determining the Modulation Analyzer's AM or FM accuracy.

**OPERATING INFORMATION** pull-out card is a quick operating reference and lists error and Special Function codes.

**AUTOMATIC OPERATION** causes the Modulation Analyzer to automatically tune and autorange to make the selected measurement.

**CLEAR** key erases keyboard entries in progress. In remote hold, CLEAR initiates a Trigger With Settling measurement cycle.

**DETECTOR** keys select whether positive peak, negative peak, or average (rms calibrated) value of the modulation is measured. Peaks can be captured using PEAK HOLD.

**RATIO** keys cause measurements to be compared in % or dB to a reference.

For more on panel features, see Figures 3-3 through 3-6

Figure 3-1. Front Panel Features

## Simplified Operation

### Tuning

**Automatic:**

Press: AUTOMATIC OPERATION .

**Manual:**

Input Frequency:

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

MZ MHz INPUT FREQ .

Frequency Step:

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

⇧ kHz , or ⇩ kHz

### Measurement

**Modulation:**

Tune, then press: AM [•] , FM [•] , or ΦM [•] ; select a DETECTOR; select the desired HP or LP FILTERS; select the desired FM DE-EMPHASIS (FM only).

**Level:**

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

**Frequency:**

Tune, then press: FREQ [•] or [•] S [•] FREQ ERROR ; or

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

then press: MZ MHz INPUT FREQ [•] S [•] FREQ ERROR

### Detector

In general:

Press: AM [•] , FM [•] , or ΦM [•] , then PEAK + [•] , PEAK − [•] , or AVG [•] RMS CAL .

Peak Hold:

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

## Filters

**High-Pass or Low-Pass:**

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

**FM De-emphasis (FM only):**

To apply de-emphasis after the deviation measurement, press FM, then either 25 µs, 50 µs, 75 µs, or 750 µs

To apply de-emphasis before the deviation measurement, press:

FM PRE-DISPLAY, then either 25 µs, 50 µs, 75 µs, or 750 µs.

## Ratio

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

Press: % for 100% or dB for 0.00 dB

To set a keyboard-entered value to 100% or 0.00 dB:

Enter the value using the numeric keyboard, then press:

% or dB

## Calibration (Option 010 only)

Connect a 50Ω cable from CALIBRATION OUTPUT to INPUT.

**AM:**

Press: AM CALIBRATION

**FM:**

Press: FM CALIBRATION

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

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

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

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

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

**CAUTION**

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

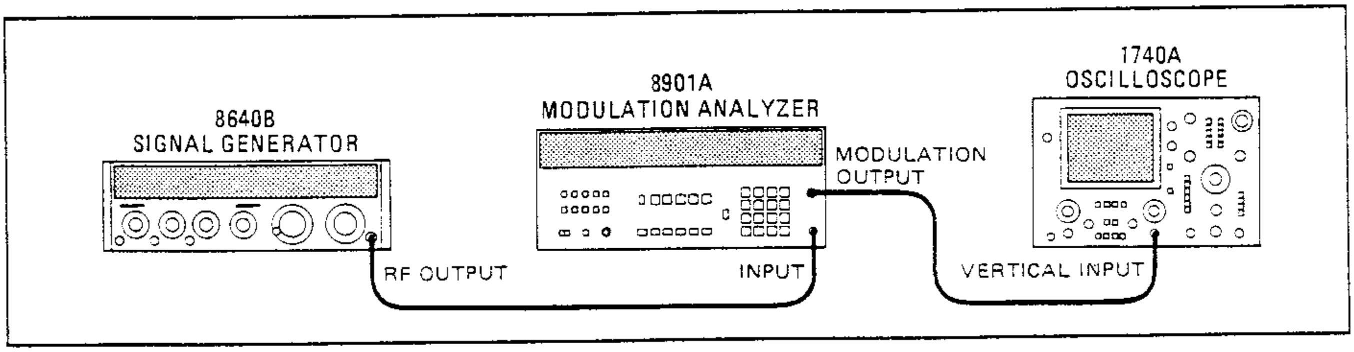
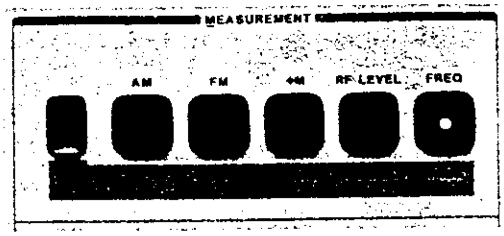


*Figure 3-2. Getting Acquainted Setup*

### Measurements



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

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

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

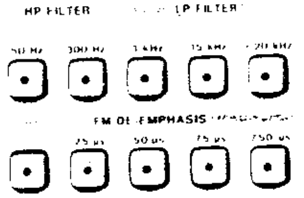
**RF Level Measurement.** Press RF LEVEL. The display now shows the generator's output power in watts using scientific notation. The "–03" at the right end of the display is the power-of-ten multiplier, that is, "milli" watts.

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

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

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

## Audio Filters and FM De-emphasis



NOTE

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

*Signal Generator*

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

*Modulation Analyzer*

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

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

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

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

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

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

## Detectors

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

Signal Generator

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

Modulation Analyzer

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

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

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

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

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

## Ratio

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

Signal Generator

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

Modulation Analyzer

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

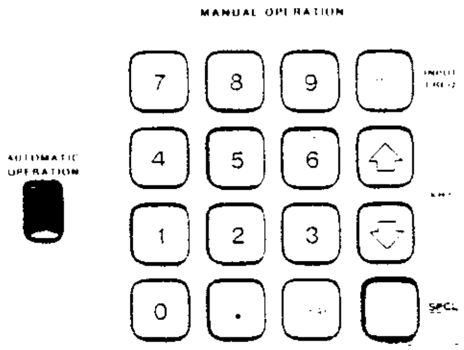
*If the carrier frequency at INPUT is below 10 MHz, the 15 kHz low pass filter will remain on.

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

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

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

## Tuning



### NOTE

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

*Signal Generator*

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

*Modulation Analyzer*

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

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

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

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

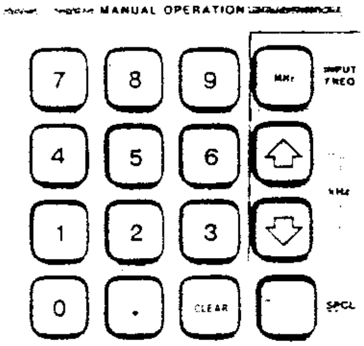
If the display reads E01, it is trying to tell you that your signal is not quite centered in the IF. Slowly tune the signal towards the frequency you keyed in until E01 disappears and the generator's frequency is displayed. (Normally, the signal must be within 50 kHz of the frequency keyed in when above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

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

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

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

## Other Features



NOTE

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

*Signal Generator*

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

*Modulation Analyzer*

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

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

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

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

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

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

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

## For More Information

Overall instrument operation is summarized in *Simplified Operation.*

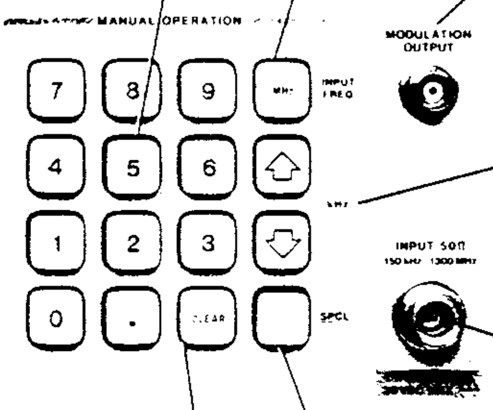
Panel features are described in figures 3–3 to 3–6.

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

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

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

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



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

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

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

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

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

⚠ CAUTION

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

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

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

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

## REAR-PANEL FEATURES

**MODULATION OUTPUT** is a rear-panel output for the demodulated signal. This output is supplied on Option 001 instruments instead of the standard front-panel connection. See MODULATION OUTPUT in Figure 3-1.

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

CAUTION

*Do not apply reverse power into the LO OUTPUT or damage to the instrument may result.*

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

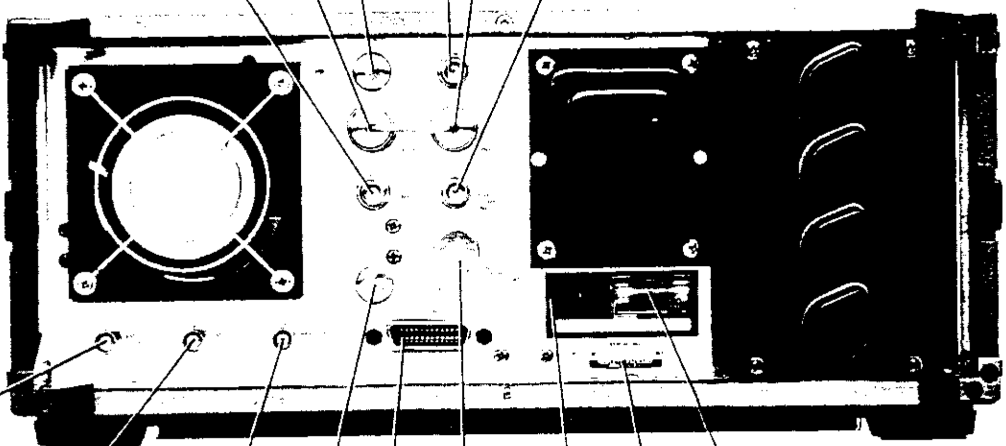
**IF OUTPUT** produces a 150 kHz to 2.5 MHz modulated IF signal. The output level ranges from −27 to −3 dBm (50Ω output impedance).

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

CAUTION

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

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



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

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

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

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

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

**Fuse.** 2 Amp (250 V, Normal Blow) for 100/120 Vac. 1 Amp (250V, Normal Blow) for 220/240 Vac.

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

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

**INPUT** is a rear-panel input for the modulated signal. This input is supplied on Option 001 instruments instead of the standard front-panel connection. See INPUT in Figure 3-1.

*Figure 3-6. Rear-Panel Features*

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

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

### AM Check

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

### FM and Phase Modulation (ΦM) Checks

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

### FM De-emphasis Check

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

| FM De-emphasis Time Constant (μs) | Limits (% REL) | |
|---|---|---|
| | Minimum | Maximum |
| 25 | 97.0 | 99.0 |
| 50 | 94.5 | 96.2 |
| 75 | 88.8 | 92.1 |
| 750 | 18.9 | 23.0 |

### Filter Check

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

| Approximate FM Rate (Hz) | HP or LP Filter | Frequency Limits (Hz) | |
|---|---|---|---|
| | | Minimum | Maximum |
| 50 | 50 Hz HP | 47.5 | 52.5 |
| 300 | 300 Hz HP | 285 | 315 |
| 3 000 | 3 kHz LP | 2 850 | 3 150 |
| 15 000 | 15 kHz LP | 14 250 | 15 750 |
| 90 000 | >20 kHz LP | 80 000 | 140 000 |

### Detector Check

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

### IF and Tuned RF Level Check

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

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

**Error Check**

28. Tune the signal generator to 50 MHz at 0 dBm. On the Modulation Analyzer, press AUTOMATIC OPERATION, then FM. Set DETECTOR to PEAK+. After the Modulation Analyzer is tuned, key in 9.0 and press the SPCL key. Key in 100, then press ⇑ kHz. The display should read E01.
29. Press ⇓ kHz. Set the generator's FM on and adjust the peak deviation for 5 kHz (as read on its FM meter). The Modulation Analyzer's display should read E04.
30. Key in 8.4 and press the SPCL key. The display should read E07.
31. Set the signal generator's FM off. Set the output level to +20 dBm. The Modulation Analyzer's display should read E02.
32. Set the signal generator's output level to −20 dBm. The Modulation Analyzer's display should read E03.

**Calibrator Check (Option 010 only)**

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

## 3-4. HP-IB FUNCTIONAL CHECKS

### Description

The following ten procedures check the Modulation Analyzer's ability to process or send all of the applicable HP-IB messages. In addition, the Modulation Analyzer's ability to recognize its HP-IB address is checked and all of the bus data, handshake, and control lines except DIO8 (the most significant data line which is not used by the Modulation Analyzer) are set to both their true and false states. These procedures do not check whether or not all Modulation Analyzer program codes are being properly interpreted and executed by the instrument; however, if the front panel operation is good, the program codes, in all likelihood, will be correctly implemented.

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

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

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

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

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

### Initial Setup

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

### Equipment

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

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

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

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

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

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

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

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

| Description | BASIC |
|---|---|
| Send the first part of the Remote message (enabling the Modulation Analyzer to remote). | REMOTE 7 |
| Address the Modulation Analyzer to listen (completing the Remote message), then send a Data message (manually tuning the Modulation Analyzer to 1 MHz). | OUTPUT 714;"1MZ" |
| Check that the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. Check also that its 15 kHz LP FILTER and SPCL key lights are both on. | |

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

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

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

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

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

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

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

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

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

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

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

| Description | BASIC |
|---|---|
| Send the first part of the Remote message (enabling the Modulation Analyzer to remote). | REMOTE 7 |
| Address the Modulation Analyzer to listen (completing the Remote message), then send a Data message (placing the Modulation Analyzer in Hold mode). | OUTPUT 714;"T1" |
| Send the Trigger message. | TRIGGER 714 |
| Address the Modulation Analyzer to talk and store the data in variable V. | ENTER 714;V |
| Display the value of V. | PRINT V |
| Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. The controller's display should read 9000009600. | |
| Address the Modulation Analyzer to talk and store the data in variable V. | ENTER 714;V |
| Check that the controller's "run" indicator is still on indicating that it has not received data from the Modulation Analyzer. Press the Modulation Analyzer's CLEAR key. The controller's "run" indicator should turn off. | |

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

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

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

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

For more information about HP-IB, refer to IEEE Standard 488, ANSI Standard MC1.1, the Hewlett-Packard Electronic Systems and Instruments catalog, and the booklet, "Tutorial Description of the Hewlett-Packard Interface Bus" (HP part number 5952-0156).

### HP-IB Compatibility

The Modulation Analyzer's complete bus compatibility (as defined by IEEE Standard 488, and the identical ANSI Standard MC1.1) is described at the end of table 3-2. Table 3-2 also summarizes the Modulation Analyzer's HP-IB capabilities in terms of the twelve bus messages in the left-hand column.

### Remote Mode

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

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

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

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

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

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

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

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

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

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

Complete HP-IB capability as defined in IEEE Std 488 and ANSI Std MC1.1 is: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0.

## Local Mode

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

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

## Addressing

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

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

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

**NOTE**

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

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

## Data Messages

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

## Receiving the Data Message

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

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

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

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

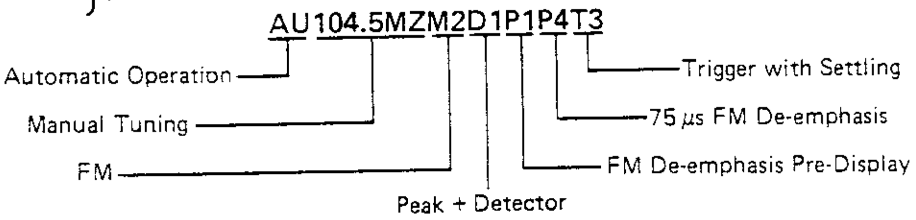
**EXAMPLE 1: General Program Syntax and Protocol**

{Controller Talk
Modulation Analyzer Listen} ,

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

**EXAMPLE 2: Typical Program String**

{Controller Talk
Modulation Analyzer Listen} ,



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

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

*Table 3–3. Modulation Analyzer Response to Unused ASCII Codes*

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

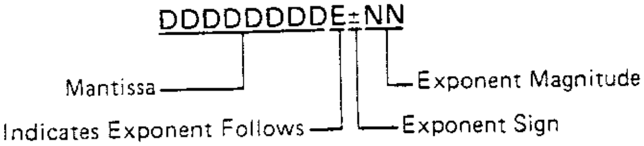
* Except when inserted between two characters of a program code.

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

| Functions | HP-IB Code |
|---|---|
| HP FILTERS ALL OFF | H0 |
| LP FILTERS ALL OFF | L0 |
| FM DE-EMPHASIS adn PRE-DISPLAY off | P0 |
| RATIO off | R0 |
| CALIBRATION off | C0 |

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

**General Numeric Data Input Format:**



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

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

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

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

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

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

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

The Modulation Analyzer leaves Hold when:

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

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

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

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

**NOTE**

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

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

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

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

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

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

**FM DE-EMPHASIS PRE-DISPLAY (P0 and P1).** When pre-display is turned off using P0, all FM de-emphasis is turned off. To avoid mistakes when programming de-emphasis, always arrange the codes in numeric order specifying the PRE-DISPLAY setting (P0 or P1) first.

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

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

## Sending the Data Message

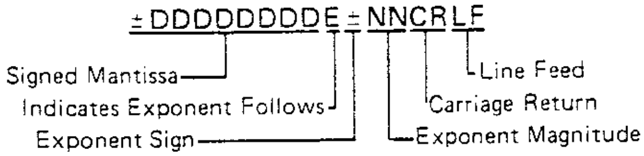
Depending on how the internal address switches are set, the Modulation Analyzer can either talk only, talk status only, listen only, or talk and listen both (normal operation). If set to both talk and listen, the instrument sends Data messages when addressed to talk. The instrument then remains configured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

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

**Talk Status Only Mode.** If all the internal address switches and the TON (Talk Only) switch are set to “1”, but the LON (Listen Only) switch is set to “0”, the Modulation Analyzer is placed in the Talk Status Only mode. In this mode the instrument is configured to send a one-byte data message whenever the bus is in the data mode. The byte sent is an exact copy of the Status Byte. Each time this byte is successfully sent on the bus, the internal Status Byte is cleared. The Data Valid (DAV) handshake line is pulsed each time the one-byte Data message is sent.

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

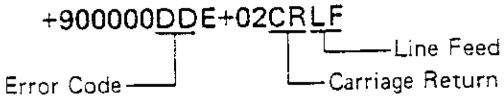
**Data Output Format:**



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

**Error Output Format:**

**Error Output Format:**



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

## Receiving the Clear Message

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

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

| Parameter | Setting |
|---|---|
| High-Pass (HP) Filters | All Off |
| Low-Pass (LP) Filters | All Off |
| FM De-emphasis | All Off |
| Pre-display | Off |
| Calibration | Off |
| Measurement | Frequency |
| Detector | Off[1] |
| Ratio | Off |
| Limit | Not Enabled |
| Lower Limit Reference | 150 kHz |
| Upper Limit Reference | 1300 MHz |
| Limit Measurement Mode | Frequency |
| Automatic Operation | On |
| Manual Operation | |
| MHz Input Frequency | Automatic Tuning[2] |
| ⇑ and ⇓ kHz Step Size | 0 kHz |
| SPCL | Special Functions prefixed 1 through 8 in zero-suffix mode; all others off except Service Request Condition set to 22.2 (HP-IB code error). |
| Modulation Output | FM (least sensitive range) |
| Service Request Condition | HP-IB Code Error Only |
| Status Byte | Cleared |
| Trigger Mode | Free Run (Code T0) |

[1] Detector will be Peak+ if a modulation measurement is selected immediately after the Clear message is received or after power up.

[2] If MHz (code MZ) is selected immediately after the Clear message is received or after power-up, the Modulation Analyzer will tune to 100 MHz.

## Receiving the Trigger Message

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

## Receiving the Remote Message

The Remote message has two parts. First, the remote enable bus control line (REN) is held true, then the device listen address is sent by the controller. These two actions combine to place the Modulation Analyzer in remote mode. Thus, the Modulation Analyzer is enabled to go into remote when the controller begins the Remote message, but it does not actually switch to remote until addressed to listen the first time. No instrument settings are changed by the transition from local to remote, but the Trigger mode is set to Free Run (code T0). When actually in remote, the Modulation Analyzer lights its front-panel REMOTE annunciator. When the Modulation Analyzer is being addressed (whether in remote or local), its front-panel ADDRESSED annunciator turns on.

## Receiving the Local Message

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

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

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

## Receiving the Local Lockout Message

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

## Receiving the Clear Lockout/Set Local Message

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

## Receiving the Pass Control Message

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

## Sending the Require Service Message

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

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

## Selecting the Service Request Condition

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

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

## Sending the Status Byte Message

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

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

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

NOTE

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

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

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

## Sending the Status Bit Message

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

## Receiving the Abort Message

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

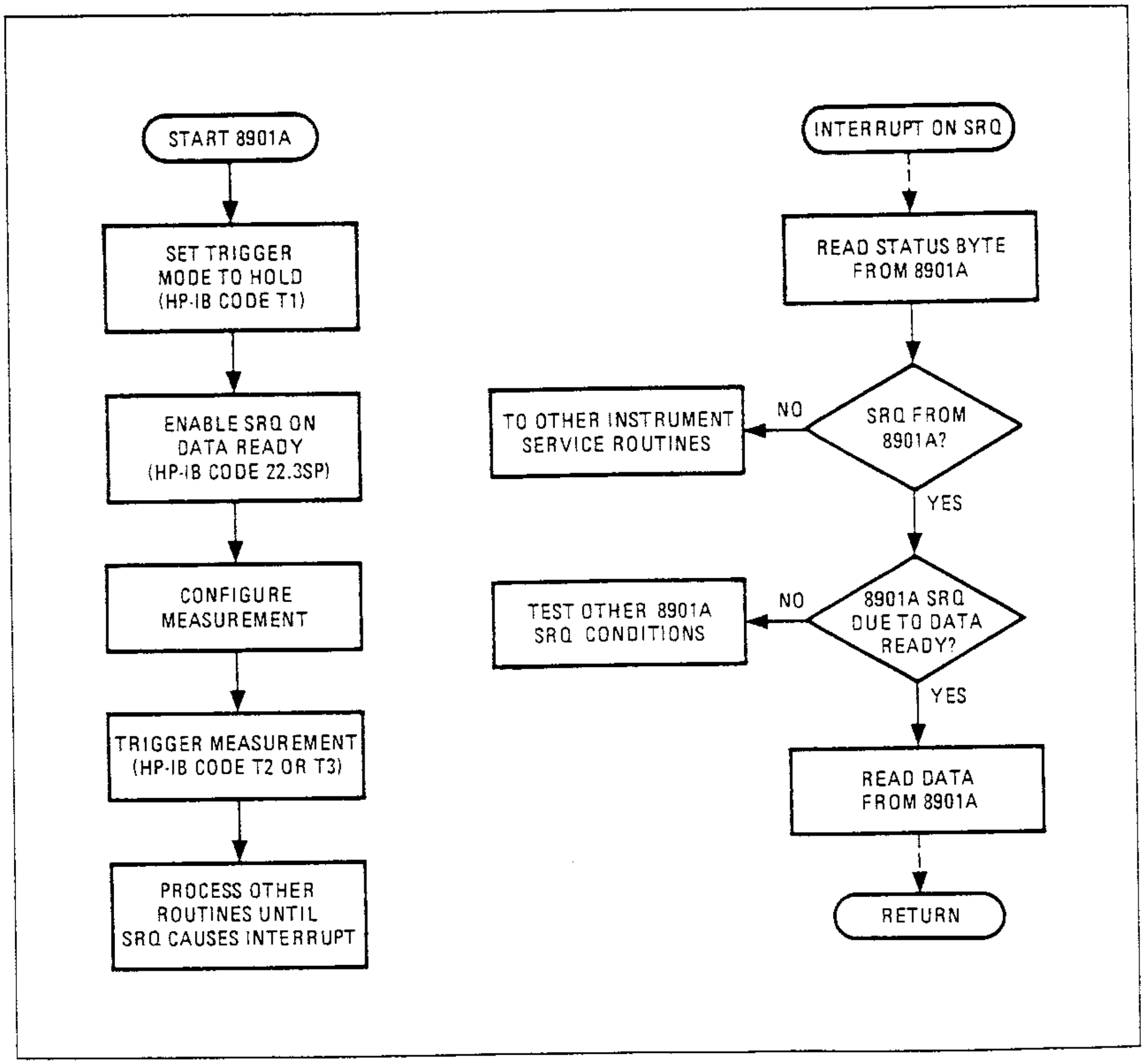


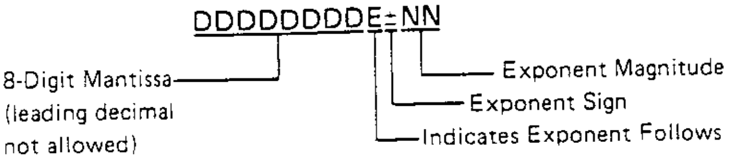
*Figure 3-8. Example Flow Chart for Driving the Modulation Analyzer Using the Require Service Message (SRQ*

## HP-IB SYNTAX AND CHARACTERISTICS SUMMARY

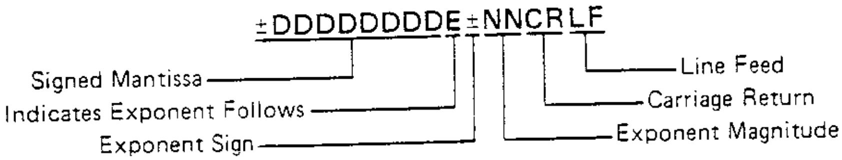
**Address:** Set in binary by internal switches—may be displayed in binary on front panel using Special Function 21, HP-IB Address. Factory set to 14 decimal; 01110 binary.

**General Operating Syntax:** [Automatic Operation] [Tuning] [Measurement] [Detector] [Filter] [FM De-emphasis] [Special Functions] [Ratio] [Calibration] [Trigger]

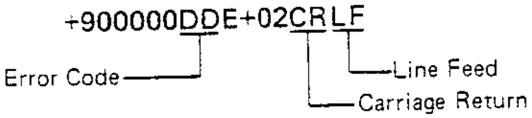
**Numeric Data Input Format:**



**Output Formats:** Data (valid data output value always < 9 × 10$^9$ and in fundamental units):



Errors:



**Return to Local:** Front panel LCL key if not locked out.

**Manual Trigger:** Front panel CLEAR key initiates Trigger With Settling measurement cycle.

**Status Byte:**

| Bit | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|
| Weight | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Service Request Condition | 0 (always) | RQS Bit Require Service | 0 (always) | Lower Limit Reached | Upper Limit Reached | Instrument Error | HP-IB Code Error | Data Ready |

**Notes:**

1. The conditions indicated in bits 1 and 3—5 must be enabled to cause a Service Request by Special Function 22, Service Request Condition.
2. The RQS bit (bit 7) is set true whenever an HP-IB code error occurs or when any of the conditions of bits 1 and 3—5 are enabled and occur.
3. Bits set remain set until the Status Byte is cleared.

**Complete HP-IB Capability** (as described in IEEE Std 488, and ANSI Std MC1.1): SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0.

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

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

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

<table>
<tr><th>Special Function</th><th>Program Code</th><th colspan="3">Special Function</th><th>Program Code</th></tr>
<tr><td>Input Attenuation</td><td></td><td colspan="3">Modulation Range</td><td></td></tr>
<tr><td>Automatic Selection</td><td>1.0SP</td><td colspan="3">Automatic Selection</td><td>2.0SP</td></tr>
<tr><td>0 dB</td><td>1.1SP</td><td colspan="3"></td><td></td></tr>
<tr><td>10 dB</td><td>1.2SP</td><td>AM (%)</td><td>FM* (kHz)</td><td>ΦM (rad)</td><td></td></tr>
<tr><td>20 dB</td><td>1.3SP</td><td></td><td></td><td></td><td></td></tr>
<tr><td>30 dB</td><td>1.4SP</td><td></td><td></td><td></td><td></td></tr>
<tr><td>40 dB</td><td>1.5SP</td><td><40</td><td><4</td><td><4</td><td>2.1SP</td></tr>
<tr><td>50 dB</td><td>1.6SP</td><td><100</td><td><40</td><td><40</td><td>2.2SP</td></tr>
<tr><td></td><td></td><td><100</td><td><400</td><td><400</td><td>2.3SP</td></tr>
<tr><td></td><td></td><td colspan="3">* 1/10 Range with 750 μs de-emphasis, pre-display</td><td></td></tr>
</table>

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

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

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

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

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

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

*Table 3–8. Modulation Analyzer HP-IB Code to Special Function Summary (1 of 2)*

| Program Code | Special Function | | |
|---|---|---|---|
| | Input Attenuation | | |
| 1.0SP | Automatic Selection | | |
| 1.1SP | 0 dB | | |
| 1.2SP | 10 dB | | |
| 1.3SP | 20 dB | | |
| 1.4SP | 30 dB | | |
| 1.5SP | 40 dB | | |
| 1.6SP | 50 dB | | |
| | Modulation Range | | |
| 2.0SP | Automatic Selection | | |
| | AM (%) | FM* (kHz) | ΦM (rad) |
| 2.1SP | <40 | <4 | <4 |
| 2.2SP | <100 | <40 | <40 |
| 2.3SP | <100 | <400 | <400 |
| | * 1/10 Range with 750 μs de-emphasis, pre-display | | |
| | IF Frequency and Input High-Pass Filter | | |
| 3.0SP | Automatic IF Selection; Filter Out | | |
| | IF (MHz) | Input HP Filter | |
| 3.1SP | 0.455 | Out | |
| 3.2SP | 1.5 | Out | |
| 3.3SP | 0.455 | In | |
| 3.4SP | 1.5 | In | |
| | Tune Mode | | |
| 4.0SP | Automatic; Low-noise LO | | |
| 4.1SP | Automatic; Track | | |
| 4.2SP | Manual | | |
| | Audio Peak Detector Time Constant | | |
| 5.0SP | Fast | | |
| 5.1SP | Slow | | |
| | AM ALC Response Time | | |
| 6.0SP | Slow | | |
| 6.1SP | Fast | | |
| 6.2SP | Open ALC | | |
| | Frequency Resolution | | |
| 7.0SP | Automatic Selection | | |
| 7.1SP | 10 Hz Resolution (f<1 GHz) | | |
| 7.2SP | 1000 Hz Resolution | | |
| | Error Disable | | |
| 8.0SP | Automatic Selection | | |
| 8.1SP | E01 disabled | | |
| 8.2SP | E02 & E03 disabled | | |
| 8.3SP | E01, E02 & E03 disabled | | |
| 8.4SP | E04 disabled | | |
| 8.5SP | E02 & E04 disabled | | |
| 8.6SP | E02, E03 & E04 disabled | | |
| 8.7SP | E01 through E04 disabled | | |
| 8.8SP | E01 through E04 enabled | | |
| 9.0SP | Hold Settings | | |
| 10.0SP | IF Frequency Measurement | | |
| | Re-enter Ratio With Previous Reference | | |
| 11.0SP | Re-enter % Ratio | | |
| 11.1SP | Re-enter dB Ratio | | |
| 11.2SP | Read Ratio Reference | | |
| 11.3SP | Make Ratio Reference Negative | | |
| | FM Calibrator | | |
| 12.0SP | Display Computed Peak FM Deviation | | |
| 12.1SP | Display Demodulated Peak Residual FM Deviation | | |
| 12.2SP | Display Demodulated Peak FM Deviation | | |
| | AM Calibrator | | |
| 13.0SP | Display Computed Peak AM Depth | | |
| 13.1SP | Display Demodulated Peak Residual AM Depth | | |
| 13.2SP | Display Demodulated Peak AM Depth | | |
| | Set Limit | | |
| 14.0SP | Clear Limits; Turn Off LIMIT Annunciator | | |
| 14.1SP | Set Lower Limit to Ratio Reference | | |
| 14.2SP | Set Upper Limit to Ratio Reference | | |
| 14.3SP | Restore Lower Limit | | |
| 14.4SP | Restore Upper Limit | | |
| 14.5SP | Read Lower Limit | | |
| 14.6SP | Read Upper Limit | | |
| 14.7SP | Read Lower Limit Measurement Code | | |
| 14.8SP | Read Upper Limit Measurement Code | | |

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

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

# AM

## DESCRIPTION

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

## OUTPUT RANGES

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

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

## PROCEDURE

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

# AM ALC Response Time

(Special Function 6)

## DESCRIPTION

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

## PROCEDURE

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

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

## EXAMPLE

To enter a fast AM ALC response mode:

| | |
|---|---|
| LOCAL (keystrokes) | Code Function<br>6 . 1 • SPCL |
| HP-IB (program codes) | 6.1SP<br>Code Function |

## HP-IB PROGRAM CODE

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

## INDICATIONS

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

## COMMENTS

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

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

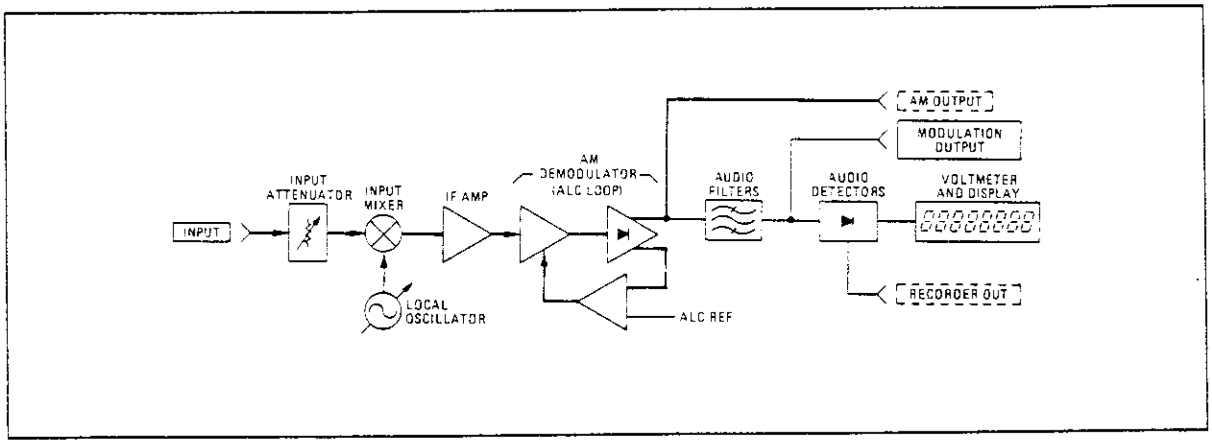
The display % AM will be incorrect when the ALC is disabled unless the IF level is 100%. Refer to *Level, IF*.

## RELATED SECTIONS

AM
AM Output
Level, IF
Special Functions

## BLOCK DIAGRAM

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



*AM Output Block Diagram*

## COMMENTS

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

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

## RELATED SECTIONS

AM
AM ALC Response Time
FM Output

# Attenuation, Input

(Special Function 1)

## DESCRIPTION

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

## PROCEDURE

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

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

## EXAMPLE

To set the input attenuation to the 20 dB range:

| | |
|---|---|
| **LOCAL**<br>(keystrokes) | Code Function<br>1 . 3 • SPCL |
| **HP-IB**<br>(program codes) | 1.3SP<br>Code Function |

## HP-IB PROGRAM CODE

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

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

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

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

## RELATED SECTIONS

Hold Settings
Special Functions
Tuning

# Calibration, AM

(Includes Special Functions 13 and 16)

## DESCRIPTION

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

## PROCEDURES

### Self-calibration

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

NOTE

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

### Correcting Measurements with the AM Calibration (Self-calibrated)

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

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

## Calibrating Another HP 8901A Modulation Analyzer

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

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

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

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

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

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

The Special Function codes are summarized in the table below:

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

## EXAMPLES

### Self-Calibration

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

| | |
|---|---|
| **LOCAL**<br>**(keystrokes)** | Measurement<br>AM • CALIBRATION • |
| **HP-IB**<br>**(program codes)** | M1C1<br>Measurement Calibration |

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

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

To enable the AM Calibration Factor to correct AM measurements:

| | |
|---|---|
| **LOCAL**<br>**(keystrokes)** | Code Function<br>1 6 . 1 • SPCL |
| **HP-IB**<br>**(program codes)** | 16.1SP<br>Code Function |

### Calibrating Another HP 8901A Modulation Analyzer

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

On Modulation Analyzer A:

| | |
|---|---|
| **LOCAL**<br>(keystrokes) | Code — Function<br>1 3 . 0 • SPCL |
| HP-IB<br>(program codes) | 13.0SP<br>Code — Function |

Read the computed peak AM depth of the calibrator on the display of Modulation Analyzer A, for example, 33.378%. Now, determine the demodulated peak residual AM.

On both Modulation Analyzers:

| | |
|---|---|
| **LOCAL**<br>(keystrokes) | Code — Function<br>1 3 . 1 • SPCL |
| HP-IB<br>(program codes) | 13.1SP<br>Code — Function |

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

On both Modulation Analyzers:

| | |
|---|---|
| **LOCAL**<br>(keystrokes) | Code — Function<br>1 3 . 2 • SPCL |
| HP-IB<br>(program codes) | 13.2SP<br>Code — Function |

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

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

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

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

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

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

## HP-IB PROGRAM CODES

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

| Key | Program Code<br>HP-IB |
|---|---|
| CALIBRATION on | C1 |
| CALIBRATION off | C0 |
| AM | M1 |
| SPCL | SP |

## INDICATIONS

### Self-Calibration

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

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

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

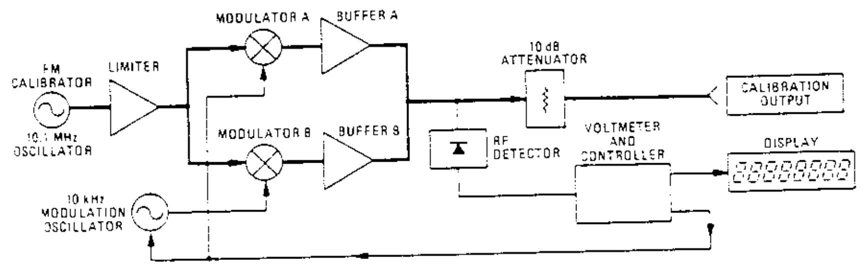
## Calibrating Another Modulation Analyzer

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

## MEASUREMENT TECHNIQUE

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

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



*Simplified Block Diagram of the AM Calibrator*

## COMMENTS

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

Pressing the CALIBRATION key cancels all Special Functions.

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

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

## RELATED FUNCTIONS

AM
Calibration, FM
Ratio
Residual Noise Effects
Special Functions

# Calibration, FM

(Special Functions 12 and 17)

## DESCRIPTION

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

## PROCEDURES

### Self-Calibration

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

NOTE

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

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

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

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

## Calibrating Another HP 8901A Modulation Analyzer

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

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

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

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

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

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

The Special Function codes are summarized in the table below:

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

## EXAMPLES

### Self-Calibration

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

| | |
|---|---|
| **LOCAL** (keystrokes) | Measurement<br>FM •<br>CALIBRATION • |
| **HP-IB** (program codes) | M2C1<br>Measurement: M2<br>Calibration: C1 |

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

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

To enable the FM Calibration Factor to correct FM measurements:

| | |
|---|---|
| **LOCAL** (keystrokes) | Code: 1 7 . 1<br>Function: • SPCL |
| **HP-IB** (program codes) | 17.1SP<br>Code: 17.1<br>Function: SP |

### Calibrating Another HP 8901A Modulation Analyzer

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

On Modulation Analyzer A:

| | |
|---|---|
| **LOCAL** (keystrokes) | Code: 1 2 . 0 Function: • SPCL |
| **HP-IB** (program codes) | 12.0SP<br>Code 12.0 Function SP |

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

On both Modulation Analyzers:

| | |
|---|---|
| **LOCAL** (keystrokes) | Code: 1 2 . 1 Function: • SPCL |
| **HP-IB** (program codes) | 12.1SP<br>Code 12.1 Function SP |

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

On both Modulation Analyzers:

| | |
|---|---|
| **LOCAL** (keystrokes) | Code: 1 2 . 2 Function: • SPCL |
| **HP-IB** (program codes) | 12.2SP<br>Code 12.2 Function SP |

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

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

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

$$\frac{(33.453) + (33.459)}{2} = 33.456$$

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

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

## HP-IB PROGRAM CODES

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

| Key | Program Code HP-IB |
|---|---|
| CALIBRATION on | C1 |
| CALIBRATION off | C0 |
| FM | M2 |
| SPCL | SP |

## INDICATIONS

### Self-Calibration

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

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

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

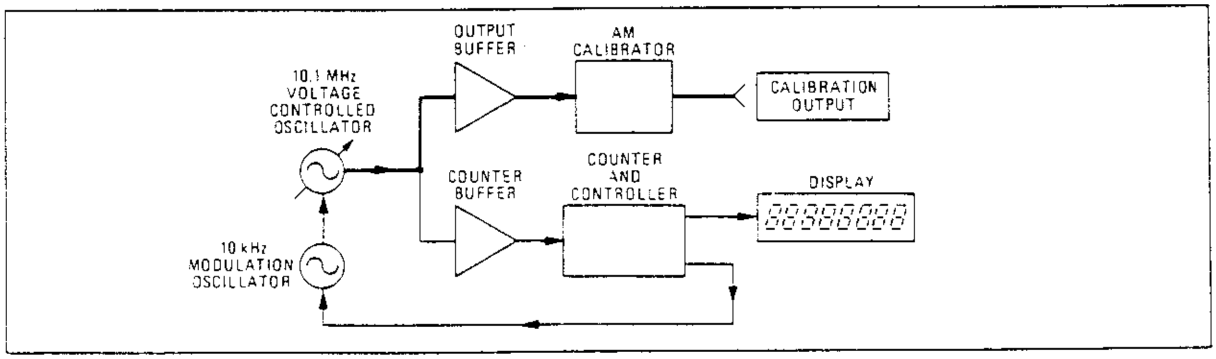
### Calibrating Another Modulation Analyzer

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

## MEASUREMENT TECHNIQUE

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

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



*Simplified Block Diagram of the FM Calibrator*

# Detector (Peak) Time Constant

(Special Function 5)

## DESCRIPTION

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

## PROCEDURE

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

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

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

## EXAMPLE

To enter a slow audio peak-detector response mode:

| | |
|---|---|
| **LOCAL** (keystrokes) | Code Function<br>5 . 1 • SPCL |
| HP-IB (program codes) | 5.1SP<br>Code Function |

## HP-IB PROGRAM CODES

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

## INDICATIONS

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

## COMMENTS

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

## RELATED SECTIONS

Detectors
Detector, Peak Hold
Recorder Output

# Error Disable

(Special Function 8)

## DESCRIPTION

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

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

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

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

## PROCEDURE

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

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

## EXAMPLE

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

| | |
|---|---|
| **LOCAL (keystrokes)** | Code: 8 . 8 Function: • SPCL |
| **HP-IB (program codes)** | 8.8SP<br>Code: 8.8 Function: SP |

## HP-IB PROGRAM CODES

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

## INDICATIONS

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

## COMMENTS

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

Errors disabled when in the automatic selection mode may be inadvertantly enabled when a manual mode is selected. For example, when measuring frequency (E02 through E04 automatically disabled) if E01 appears, keying in 8.1 SPCL to disable it re-enables E02 through E04. The best selection would really be 8.7 SPCL (E01 through E04 disabled).

Use the Special Display and the Special Special Display (described in *Special Functions*) at any time to determine the present mode of the Error Disable Special Function, or the error configuration when the function is in the automatic selection mode.

## RELATED SECTIONS

Error Message Summary
Special Functions

# Error Message Summary

## DESCRIPTION

The instrument generates error messages to indicate operating problems, incorrect keyboard entries, or service-related problems. The error message is generally cleared when the error condition is removed.

Error messages are grouped by error code as follows:

### E01 through E19 and E90 through E99

These are Operating Errors which indicate that not all conditions have been met to assure a calibrated measurement. Operating Errors can usually be cleared by a readjustment of front-panel controls (usually, the easiest way is to press AUTOMATIC OPERATION). The Error Disable Special Function (8.N) can be used to selectively disable certain Operating Errors.

### E20 through E29

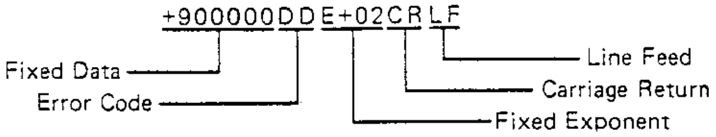
These are Entry Errors which indicate an invalid key sequence or keyboard entry has been made. These errors require that a new keyboard entry or function selection be made.

### E30 through E89

These are Service Errors and are generated to give service information or because a service function has been accessed and has generated a message. Service errors do not necessarily represent failures within the instrument and must be enabled to appear. Service Errors are discussed in the Service Manual.

## HP-IB OUTPUT FORMAT

The HP-IB output format for errors is shown below:



For example, Error E01 is output to the HP-IB as +90000001E+02CRLF. This format differs from normal data outputs since normal data outputs will never exceed $4\times10^9$. Once an error has been input to the computing controller, the error code is simply derived by subtracting $9\times10^9$ from the input number, then dividing the result by 100.

**Operating Errors**

| Error Code | Message | Action Required | Comments |
|---|---|---|---|
| E05 | FM squelched. | Reduce signal level variations (AM) at INPUT. | 1 |
| E06 | INPUT power protect relay. | Reduce signal level at INPUT; then press any key. | 2 |
| E07 | Display overrange. | Increase range or press AUTOMATIC OPERATION. | 3 |
| E08 | CALIBRATOR signal not at INPUT (Opt. 010 only). | Connect CALIBRATION OUTPUT to INPUT or turn off Calibrator. | 4 |
| E09 | Option not installed. | Select another instrument function. | 5 |
| E10 | Input frequency out of range. | Adjust input frequency to within specified limits. | 6 |
| E11 | Calculated value out of range. | Enter new RATIO reference. | |
| E12 | Time Base oven cold (Option 002). | For highest accuracy, wait until oven is warm. | 8 |
| E96 | No input signal sensed by instrument. (HP-IB only). | Increase level of signal at INPUT or decrease input attenuation. | 9 |

## Comments

1. E05 often occurs when FM or ΦM measurements are attempted on low-level signals with high AM depth (> 90%). E05 turns off MODULATION OUTPUT.
2. Maximum allowable input level is 7 V rms (1 W peak).
3. If displayed during modulation measurements, increase modulation range. If displayed during level measurements, increase input attenuation.
4. If the connection from CALIBRATION OUTPUT to INPUT is intact, this error may indicate calibrator malfunction.
5. E09 display times out. E09 is not displayed with Special Function 15 and Option 002 not installed. If the option is installed, E09 displayed may reflect option malfunction.
6. E10 turns off MODULATION OUTPUT.
7. In dB RATIO, E11 is displayed when measurement results equal 0. (Log of 0 not allowed.)
8. E12 must be requested by Special Function 15. Refer to *Special Functions*.
9. E96 corresponds to a display of two dashes (– –). E96 can occur when no signal is applied or when E03 is disabled and the instrument is manually tuned where no signal is found. E96 (– –) turns off MODULATION OUTPUT.

Entry Errors

| Error Code | Message | Action Required | Comments |
|---|---|---|---|
| E20 | Entered value out of range. | Re-enter new value. | - |
| E21 | Invalid key sequence. | Check for compatibility of functions selected. | 1 |
| E22 | Invalid Special Function prefix. | Check, then re-enter correct Special Function code. | 2 |
| E23 | Invalid Special Function suffix. | Check, then re-enter correct Special Function code. | 3 |
| E24 | Invalid HP-IB code. | Check, then re-enter correct HP-IB code. | 4 |

Service Errors

| Error Code | Message | Action Required | Comments |
|---|---|---|---|
| E30 through 89 | Service related errors. | Refer to service manual. | 5 |

## Comments

1. E21 occurs for example when CALIBRATION is pressed while not in AM or FM. E21 times out.
2. E22 times out. Refer to *Special Functions.*
3. E23 times out. Refer to *Special Functions.*
4. This error always causes a Require Service message to be issued on the HP-IB.
5. Service errors are normally disabled.

# Filters

## DESCRIPTION

The high pass (HP) and low pass (LP) FILTER keys cause the respective filters to be inserted into the path of the demodulated signal ahead of the audio detectors and MODULATION OUTPUT. The high pass and low pass filters, when in use, always affect the signal at MODULATION OUTPUT, but never affect the rear-panel AM or FM OUTPUTs.

## PROCEDURE

Select the desired demodulated signal filter by pressing the appropriate keys. Only one high pass and one low pass filter may be in at a time. To turn a filter off, press the key again. To select a different filter, press the key corresponding to the desired filter. HP-IB codes for the various filter keys (shown below) only turn the filters on (defeating others in the group if on). To turn a high pass or low pass filter off using HP-IB, use code H0 or L0 respectively or select another filter.

## EXAMPLE

To select a 50 Hz to 15 kHz demodulated signal bandwidth:

| | |
|---|---|
| **LOCAL** (keystrokes) | HP Filter 50 Hz ⊡ LP Filter 15 kHz ⊡ |
| **HP-IB** (program codes) | H1L2<br>High-Pass Filter Low-Pass Filter |

## HP-IB PROGRAM CODES

| HP FILTER | Program Code HP-IB |
|---|---|
| ALL OFF | H0 |
| 50 Hz | H1 |
| 300 Hz | H2 |
| | |

| LP FILTER | Program Code HP-IB |
|---|---|
| ALL OFF | L0 |
| 3 kHz | L1 |
| 15 kHz | L2 |
| > 20 kHz | L3 |

## INDICATIONS

When a filter is in (by either automatic or manual selection), the LED within that filter's key will light.

## COMMENTS

The selected filters are always in the path of the demodulated signal whether or not a modulation measurement has been selected. Thus, unless turned off, the MODULATION OUTPUT is filtered. In addition, the selected filters remain in effect when switching between modulation measurements.

Under certain conditions, filters are inserted automatically. When ΦM is selected, the 50 Hz high pass filter is inserted. When the 455 kHz IF is used, or when receiving carriers below 2.5 MHz, the 15 kHz low pass filter is inserted. The 50 Hz high pass filter selected in ΦM may be turned off by pressing the key. When automatically inserted, the 15 kHz low pass may always be overridden by the 3 kHz filter, and if the carrier is above 2.5 MHz the 15 kHz filter may also be overridden by the > 20 kHz filter. When leaving ΦM, the 50 Hz high pass filter remains in the signal path until another modulation measurement is selected. The 15 kHz low pass selected by operating with 455 kHz IF is automatically turned off when the 1.5 MHz IF is used.

With no filters selected, the post-demodulation bandwidth is <20 Hz to > 200 kHz, however, the IF circuits and demodulators impose more severe bandwidth limits. Refer to *AM, FM, Frequency, IF, and Input High Pass Filter, or ΦM* for bandwidth limitations.

The individual filter characteristics are given below. The 3 dB points are typically accurate to ±3%.

50 Hz High Pass: Two pole Butterworth 1% flat ≥ 200 Hz
300 Hz High Pass: Two pole Butterworth 1% flat ≥ 1 kHz
3 kHz Low Pass: Five pole Butterworth 1% flat ≤ 1 kHz
15 kHz Low Pass: Five pole Chebyshev 1% flat ≤ 10 kHz
> 20 kHz Low Pass: Nine pole Bessel 1% flat ≤ 10 kHz (when used with square wave modulation this filter typically overshoots <1%). This filter's 3 dB point is typically 110 kHz.

When the Modulation Analyzer powers up, no filters are inserted.

## RELATED SECTIONS

AM
FM
FM De-emphasis
IF Frequency, and Input High Pass Filter Selection
ΦM

# FM

## DESCRIPTION

The FM key causes the Modulation Analyzer to measure the FM deviation of the input signal to which the instrument is tuned. In addition, demodulated FM is present at MODULATION OUTPUT and the rear panel FM OUTPUT. (The demodulated FM is present at FM OUTPUT in all measurement modes except RF level. Refer to *FM OUTPUT.)* FM Measurements are specified for rates from 20 Hz to 10 kHz for carriers 10 MHz and below (or whenever the 455 kHz IF is used) and 20 Hz to 200 kHz for carriers from 10 to 1300 MHz (1.5 MHz IF only). The corresponding 3 dB audio bandwidths are 0.5 Hz to 15 kHz for carriers 10 MHz and below (or with the 455 kHz IF) and 0.2 Hz to 260 kHz for carriers from 10 to 1300 MHz (1.5 MHz IF only). Peak deviations up to 40 kHz maximum can be measured on carriers below 10 MHz and peak deviations up to 400 kHz maximum can be measured on carriers above 10 MHz.

## OUTPUT RANGES

| Modulation Range | | | | Display Resolution (Hz) | MODULATION OUTPUT Sensitivity (mV ac/Hz) | RECORDER OUTPUT (Rear Panel) (V dc/kHz peak dev.) |
|---|---|---|---|---|---|---|
| PEAK ± (%) (kHz dev.) | AVG(1) (%) (kHz dev.) | Special Function Code | Program Code HP-IB | | | |
| Automatic Selection | | 2.0 SPCL | 2.0SP | Automatic Selection | | |
| ≤0.4(2) | ≤0.28(2) | 2.1 SPCL(2) | 2.1SP | 0.1(2) | 10(2) | 10(2) |
| ≤4 | ≤2.8 | 2.1 SPCL<br>2.2 SPCL(2) | 2.1SP<br>2.2SP(2) | 1 | 1 | 1 |
| ≤40 | ≤28 | 2.2 SPCL<br>2.3 SPCL(2) | 2.2SP<br>2.3SP(2) | 10 | 0.1 | 0.1 |
| ≤400(3) | ≤280(3) | 2.3 SPCL(3) | 2.3SP(3) | 100(3) | 0.01(3) | 0.01(3) |

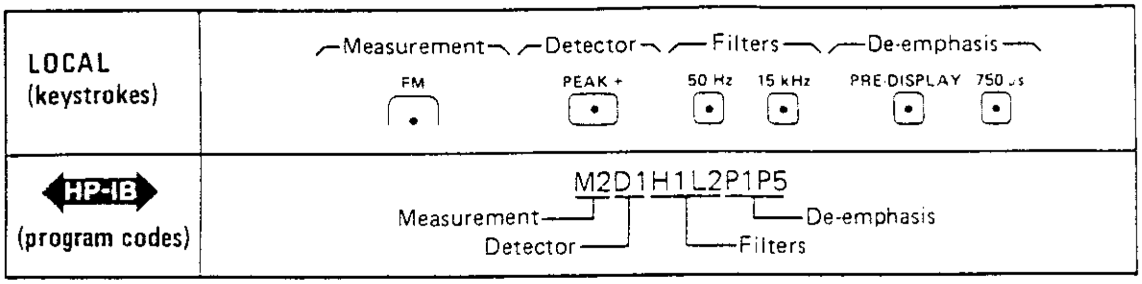
(1) Values are for sine wave modulation signal only.
(2) With 750 microsecond de-emphasis, pre-display only.
(3) Except 750 microsecond de-emphasis, pre-display.

## PROCEDURE

To make an FM measurement, first tune the instrument to the input signal (refer to *Tuning* or press AUTOMATIC OPERATION). Press the FM key, and select an audio detector: PEAK+, PEAK−, or AVG (refer to *Detectors).* To limit the demodulated signal bandwidth, press the appropriate filter keys (refer to *Filters).* In addition, if de-emphasis filtering is desired, the appropriate time constant and display placement can now be selected (refer to *FM De-emphasis).* If FM deviation is to be displayed relative to a reference, refer to *Ratio.*

## EXAMPLE

To measure the positive peak FM deviation in a 50 Hz to 15 kHz demodulation signal bandwidth with a 750 μs de-emphasis time constant placed before the display:



## HP-IB PROGRAM CODES

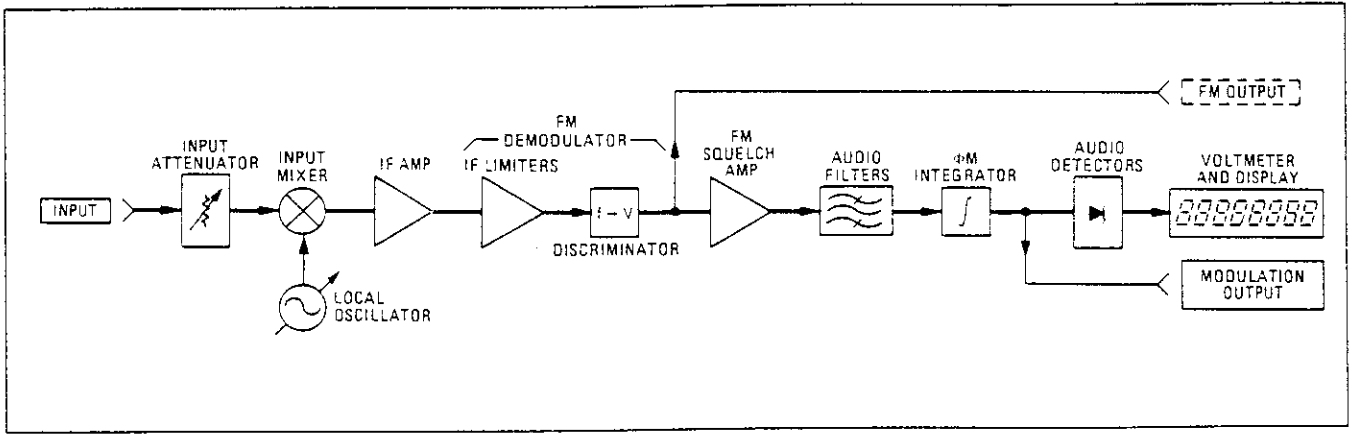
M2 is the HP-IB code for FM.

## INDICATIONS

The LEDs within the keys representing the selected functions will light. The kHz annunciator to the right of the numerical display will light and the display will show the kHz deviation on the carrier (or the equivalent de-emphasized deviation).

## MEASUREMENT TECHNIQUE

Once the instrument is tuned to the input signal, the FM on the IF is demodulated by a discriminator which produces a signal whose amplitude is proportional to the frequency deviation. The demodulated signal is filtered, detected, and displayed as kHz deviation. The FM de-emphasis filter may be inserted ahead of (PRE-DISPLAY on) or after (PRE-DISPLAY off) the audio detectors (and display).



*FM Measurement Block Diagram*

## COMMENTS

The PEAK + detector always detects the upward carrier frequency excursion while the PEAK – detector always detects the downward carrier frequency excursion.

When operating with carrier frequencies below 2.5 MHz, the signal at MODULATION OUTPUT is inverted unless the 455 kHz IF is being used. When operating with carrier frequencies above 2.5 MHz or when using the 455 kHz IF, the signal at FM OUTPUT is inverted.

The routine which automatically selects the audio range contains regions of overlap between 0.35 and 0.4 kHz (750 μs de-emphasis, pre-display only), 3.5 and 4 kHz, and 35 and 40 kHz peak deviation as read on the display. When using the average detector, ranging will occur with lower modulation levels displayed. If the modulation level is reduced from a higher range into an overlap region, the range may not change. To display the increased resolution, press the FM key a second time. To set the instrument to a selected modulation range, refer to *Modulation Range*.

When the Modulation Analyzer is first powered up, demodulated FM is at MODULATION OUTPUT. The sensitivity is 0.01 V ac/MHz (≤ 400 kHz peak deviation range) and will not autorange to more sensitive ranges. This is because at power-up, FREQ is selected and thus E04 (audio circuits overdriven) is automatically disabled. When E04 is disabled, only autoranging to less sensitive audio ranges is allowed.

AM conditions which cause the carrier signal to disappear will cause inaccuracies in the measurement of FM deviation or they may cause E05 (FM squelched) to be displayed.

## RELATED SECTIONS

Detectors
Detector, Peak Hold
Filters
FM De-emphasis
FM Output
Modulation Basics (Section 1–16)
Modulation Range
Ratio
Residual Noise Effects

# FM De-emphasis

## DESCRIPTION

The de-emphasis filters can be selected to compensate for pre-emphasis on FM signals. Pre-emphasis is a simple 6 dB per octave, high-frequency boost given to the audio signal prior to modulating the carrier. The 3 dB corner frequency, $f_o$, is commonly expressed as a time constant, $\tau_o$, where $f_o = \frac{1}{(2\pi\tau_o)}$. When selected, the filters are inserted into the audio chain following the modulation filters. They always affect the signal at MODULATION OUTPUT. The audio detector and display may be placed before or after the de-emphasis. De-emphasis has no affect on the rear-panel FM OUTPUT. The 3 dB corners of these filters are typically accurate to ±3% and are given below.

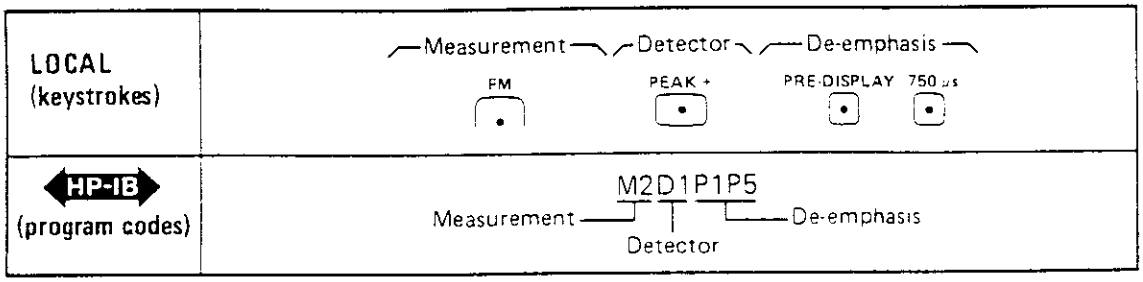
| Time Constant ($\mu$s) | 3 dB Frequency (Hz) |
|---|---|
| 25 | 6366 |
| 50 | 3183 |
| 75 | 2122 |
| 750 | 212.2 |

## PROCEDURE

To de-emphasize the demodulated FM, press the key corresponding to the desired time constant. The deviation will now be measured before de-emphasis is performed. If the deviation measured is to be de-emphasized, press the PRE-DISPLAY key. To change the de-emphasis time constant, press the key corresponding the new time constant desired. In local operation, to turn off one of the de-emphasis functions, press the lighted key a second time. In remote operation, turn filters off by code P0. However, note that code P0 also turns off the PRE-DISPLAY function.

## EXAMPLE

To measure the positive peak FM deviation of a carrier with 750 $\mu$s de-emphasis inserted before the deviation measurement:



## HP-IB PROGRAM CODES

| FM DE-EMPHASIS | | |
|---|---|---|
| Time Constant ($\mu$s) | PRE-DISPLAY on | PRE-DISPLAY off |
| Filters off | P0P1 | P0 |
| 25 | P1P2 | P0P2 |
| 50 | P1P3 | P0P3 |
| 75 | P1P4 | P0P4 |
| 750 | P1P5 | P0P5 |

## INDICATIONS

When a de-emphasis filter is in and affecting the signal at MODULATION OUTPUT, the LED within that filter's key will light. If de-emphasis affects the displayed measurement, the light within the PRE-DISPLAY key will light.

## COMMENTS

Until they are turned off, the de-emphasis filters will always be active whenever demodulated FM is present at MODULATION OUTPUT.

When 750 $\mu$s de-emphasis pre-display is selected, the range of deviation measurements is restricted to 40 kHz peak deviation or less after de-emphasis. However, an additional range (0 to 0.4 kHz) is added for greater resolution when measuring very small deviations.

## RELATED SECTIONS

FM
Modulation Output
Recorder Output

# FM Output

**CAUTION**

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

## DESCRIPTION

The rear-panel FM OUTPUT (dc-coupled, 10 kΩ output impedance) provides an auxiliary output for the FM demodulated from the signal at the INPUT. This output is useful for monitoring FM while displaying AM or ΦM or when the modulation rate is very low. The output signal comprises a dc voltage related to the detected IF frequency and an ac voltage (bandwidth 16 kHz, one pole) proportional to the FM deviation. With the input signal centered in the IF, the nominal dc offset voltage at FM OUTPUT is approximately 0.8 V dc for the 1.5 MHz IF and −5.6 V dc for the 455 kHz IF. The FM sensitivity is typically 6 V/MHz or 6 mV/kHz. The dc voltage at FM OUTPUT can be calculated as follows:

$$V\ dc = V_{off} - \frac{(K)\ (FREQ\ ERROR)}{1000}$$

where:

$V\ dc$ = the dc voltage at FM OUTPUT in volts,

$V_{off}$ = the dc offset voltage for the IF used in volts,

$K$ = the FM sensitivity in mV/kHz,

and

$FREQ\ ERROR$ = the kHz error displayed when FREQ ERROR is selected.

Measure $V_{off}$ when the frequency error is 0 kHz. The sensitivity can be measured using the following procedure:

## PROCEDURE

To characterize the FM sensitivity at the FM OUTPUT, measure the dc voltage at the output with an unmodulated 2 MHz carrier at the INPUT (use the 1.5 MHz IF). Move the carrier to 1 MHz and again note the dc voltage. The sensitivity is:

$$(V\ dc\ @2\ MHz) - (V\ dc\ @1\ MHz) = V/MHz = mV/kHz$$

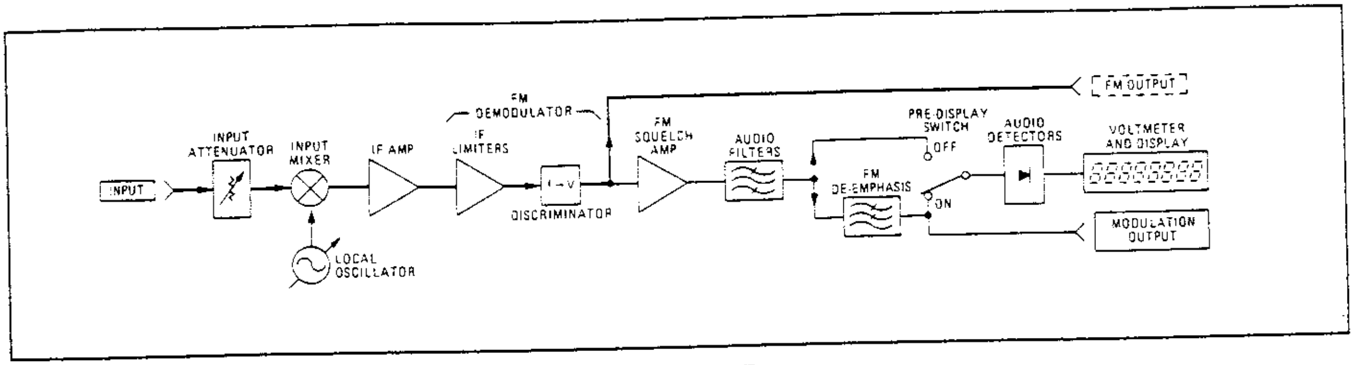
## EXAMPLE

A 2 MHz unmodulated signal is applied to the INPUT. A dc voltmeter connected to FM OUTPUT shows +3.89 V dc. When the carrier is set to 1 MHz, −2.272 V dc is read. The FM sensitivity is:

$$(3.890) - (-2.272) = 6.161\ V/MHz = 6.162\ mV/kHz$$

## BLOCK DIAGRAM

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



*FM Output Block Diagram*

## COMMENTS

FM OUTPUT is unsquelched and also contains a significant IF component which is greatest when operating at 150 kHz.

Note that the sense of the ac output component (corresponding to the demodulated FM) is inverted for carriers with frequencies above 2.5 MHz.

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

## RELATED SECTIONS

AM Output
FM
Frequency Error

# Frequency Error

## DESCRIPTION

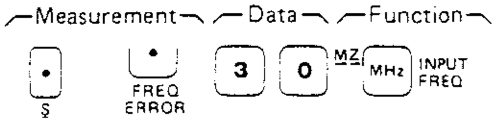
The FREQ ERROR key causes the Modulation Analyzer to measure the difference (in kHz) between the input signal frequency and the frequency to which the instrument is tuned. This function can be used either to observe frequency drift of input signals or to compare input frequencies against a keyboard-entered reference. The input frequency must fall within the passband of the IF being used. For the 1.5 MHz IF, the passband is approximately 3 MHz wide. For the 455 kHz IF, the passband is approximately 200 kHz wide. When the instrument is measuring frequency error, the signal at MODULATION OUTPUT represents the last modulation measurement made.

## PROCEDURE

To make a frequency error measurement, apply the test signal to the Modulation Analyzer's INPUT jack. If a frequency drift measurement is to be made, allow the instrument to automatically tune to the signal, then press MHz to prevent retuning. Now, press the FREQ ERROR key, and the frequency drift will be displayed. If a frequency comparison is to be made, enter the reference frequency (in MHz) on the keyboard, then press the MHz key. The difference frequency will be displayed. The number is negative if the signal frequency is lower than the reference, and positive if the signal frequency is higher than the reference.

## EXAMPLE

To measure the error of an oscillator designed to operate at 30 MHz, connect the oscillator's output to the Modulation Analyzer's INPUT jack.

| | |
|---|---|
| **LOCAL** (keystrokes) |  |
| **HP-IB** (program codes) | S530MZ<br>Measurement — Data — Function |

## HP-IB PROGRAM CODE

S5 is the HP-IB code for FREQ ERROR.

## INDICATIONS

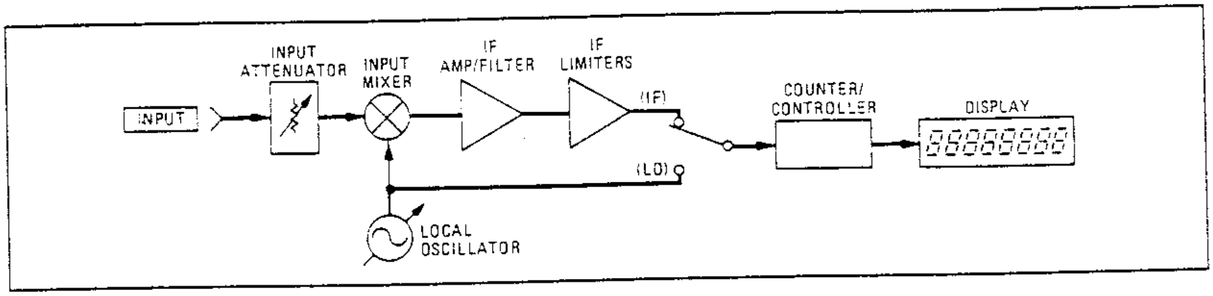
When FREQ ERROR is selected, the LEDs within the S(shift) and FREQ ERROR keys will light, and the kHz annunciator will also light. The display will show the frequency error in kHz.

## MEASUREMENT TECHNIQUE

When the Modulation Analyzer is tuned, the IF signal is amplified and limited (> 60 dB of gain). If manually tuned, the input frequency is determined (refer to *Frequency [Input]*) and compared to the keyboard-entered frequency or to the frequency the moment MHz was pressed. The difference is displayed as frequency error.

If the instrument is automatically tuned, two methods of determining frequency error are used. Above 2.5 MHz (that is, when down-converting) the frequency of the actual IF signal is subtracted from the selected IF frequency (455 kHz or 1.5 MHz) yielding the frequency error.

Below 2.5 MHz, the input signal is passed directly into the IF without down-conversion. When the signal is first located, the frequency is counted. When the frequency error is selected, this first-counted frequency becomes the reference. Subsequent frequency counts are subtracted from this reference, and the results are displayed as frequency error.



*RF Frequency Error Measurement Block Diagram*

## COMMENTS

The frequency error function can be used with the automatic tuning low-noise LO tune mode, but it is most valuable when used with manual tuning. It is not recommended that frequency error be used when in automatic tuning track mode since an inherent tuning error exists in this mode.

Frequency Error, in conjunction with the kHz (⇑) and kHz (⇓) keys, is most useful for checking channel accuracy on multichannel transmitters. By setting the step frequency to the channel spacing, the accuracy of evenly spaced channels may be rapidly determined.

When tuning manually, it is possible to adjust the LO so that the input falls in the image passband. This can occur, for example, when the kHz (⇑) or kHz (⇓) keys are used. Frequency error measurements made when this occurs will be inaccurate. Refer to *Tuning* for an illustration of the image passbands.

Normally, the counter updates the display five times each second. For selection of other resolutions, refer to *Frequency Resolution*. Counter accuracy is the reference accuracy ±3 counts.

When the FREQ ERROR key is pressed, MODULATION OUTPUT continues to produce the last-selected modulation signal, filtered and/or de-emphasized (except PRE-DISPLAY) as previously selected. The calibration of MODULATION OUTPUT depends upon the input signal level and should be assumed only when all errors are enabled (Special Function 8.8).

To display frequency error in parts per million, first display the frequency error, then enter 1/10 the reference frequency (in MHz) as a ratio reference, and press the % RATIO key. The display will now show the frequency error in parts per million.

## RELATED SECTIONS

Error Disable
Frequency, IF
Frequency, Input
Frequency Resolution
Tuning

# Frequency, IF

### (Special Function 10)

## DESCRIPTION

Using the numeric keyboard and the SPCL key, the Modulation Analyzer can be set to display the frequency, in MHz, of the signal present in its IF. When the instrument is measuring IF frequency, the signal at MODULATION OUTPUT represents the last modulation measurement made.

## PROCEDURE

To measure the IF signal frequency, enter the code 10.0 using the numeric keys, then press the SPCL key.

## EXAMPLE

To display the frequency of the signal in the IF:

| | |
|---|---|
| **LOCAL** (keystrokes) | Code: `1` `0` `.` `0` Function: `•` SPCL |
| **HP-IB** (program codes) | 10.0SP<br>Code: 10.0 Function: SP |

## HP-IB PROGRAM CODE

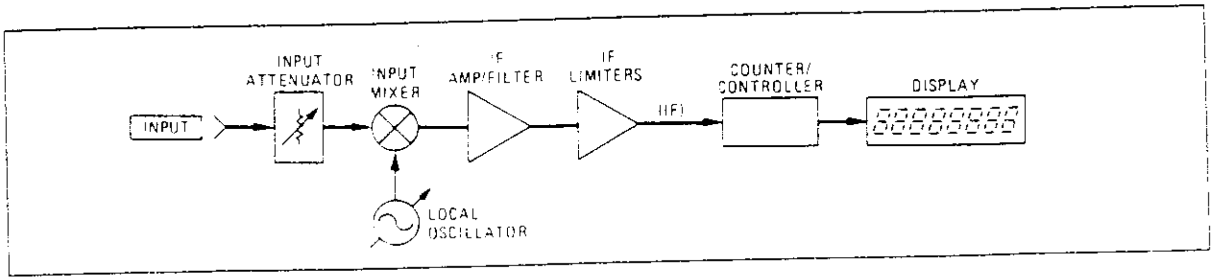
10.0 is the HP-IB code to measure IF frequency.

## INDICATIONS

All measurement key lights will turn off, the LED within the SPCL key will light, and the MHz annunciator to the right of the display will turn on. The display will show the IF frequency in MHz.

## MEASUREMENT TECHNIQUE

The IF signal, created when the Local Oscillator and the input signal mix, is amplified by the IF Amplifier and FM Limiters. (Below 2.5 MHz no down-conversion is made and the input signal is passed directly into the IF.) The frequency of this IF signal is counted and displayed.



*IF Frequency Measurement Block Diagram*

## COMMENTS

Normally, the counter updates the display five times each second. For selection of other resolutions refer to *Frequency Resolution.* Note that counter accuracy is the reference accuracy ±3 counts.

When measuring IF frequency, MODULATION OUTPUT continues to produce the last selected modulation signal, filtered and/or de-emphasized (except PRE-DISPLAY) as previously selected. The calibration of MODULATION OUTPUT depends upon the IF signal level and should be assumed only when all errors are enabled (Special Function 8.8).

## RELATED SECTIONS

Error Disable
Frequency (Input)
Frequency Resolution
Special Functions

# Frequency (Input)

## DESCRIPTION

The frequency of the signal at the input of the Modulation Analyzer can be measured by pressing the FREQ key. The signal frequency must fall between 150 kHz and 1300 MHz and the Modulation Analyzer must be tuned. For input frequencies between 2.5 and 1300 MHz, the instrument is a heterodyne counter; for frequencies from 150 kHz to 2.5 MHz it counts the input directly. If manually tuned to the signal, the instrument can typically count signals with power levels less than −60 dBm. When the instrument is measuring input frequency, the signal at MODULATION OUTPUT represents the last modulation measurement made.

## PROCEDURE

To make an input frequency measurement, first tune the instrument to the input signal (refer to *Tuning* or press AUTOMATIC OPERATION). Press the FREQ key. Manual tuning will be necessary when measuring low-level signals (inputs < −25 dBm from 150 kHz to 650 MHz or < −20 dBm from 650 to 1300 MHz).

## EXAMPLE

To measure the frequency at INPUT:

| | |
|---|---|
| **LOCAL**<br>**(keystroke)** | FREQ |
| **HP-IB**<br>**(program codes)** | M5<br>Measurement |

## HP-IB PROGRAM CODE

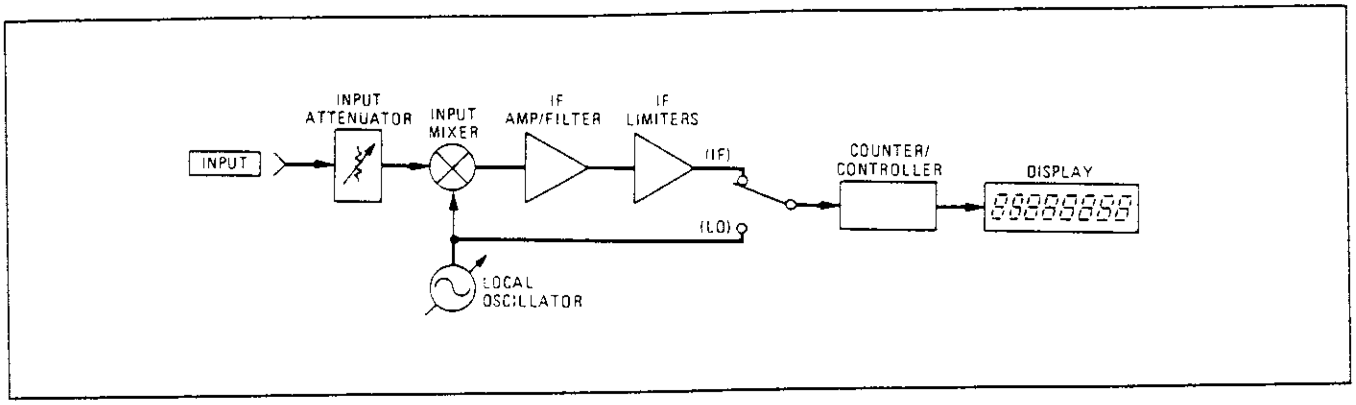
M5 is the HP-IB code for FREQ.

## INDICATIONS

The LEDs within the FREQ key and the MHz annunciator to the right of the numeric display will light. The display will show the input frequency in MHz.

## MEASUREMENT TECHNIQUE

Once the instrument is tuned, the IF carrier is amplified by the IF Amplifier and Limiters (> 60 dB of gain). (For input frequencies below 2.5 MHz, no down-conversion is made and the input signal acts as the IF. Refer to *Tuning* for an exception.) The frequency of the IF signal is counted. If the input was down-converted, the IF frequency is then subtracted from the local oscillator frequency to derive the frequency at INPUT.



*RF Input Frequency Measurement Block Diagram*

## COMMENTS

The Modulation Analyzer powers up measuring the input frequency.

When the Error Disable Special Function is in the automatic selection mode (code 8.0), very low-level signals can be counted without generating errors (E03 for example).

However, other modes of this Special Function will allow errors to be generated at much higher signal levels. Refer to *Error Disable*.

It is important to note that when FREQ is selected the IF need not be exactly centered to make valid frequency measurements. A frequency is displayed as long as a signal is present in the IF. Using the ⇑ kHz or ⇓ kHz functions will not change the displayed input frequency even though tuning has been altered. The FREQ ERROR function will demonstrate the changed tuning. Typically, the instrument must be tuned within 50 kHz of the input frequency or E01 will be displayed. Use Special Function 8.1 to defeat the tuning error (E01) and to increase the usable IF bandwidth.

Whenever signals below 2.5 MHz are tuned to using the 1.5 MHz IF, the LO is placed at 101.5 MHz and the input signal is allowed to pass directly into the 1.5 MHz IF. (The LO serves only to turn the mixer on.) Note, however, that this also creates a passband from 98.5 to 104.5 MHz. If this is a problem, manually tune the LO so the passbands fall in some unoccupied region of the input spectrum. This requires that error E01 must be disabled. Also, as a result, input frequency measurements will be incorrect, but the IF frequency function (Special Function 10) can be used to measure the input frequency instead.

When working with agile frequency sources (such as frequency synthesizers), it is possible for the carrier to hop to a frequency whose spectrum still has sufficient power within the tuned passband of the Modulation Analyzer's input. When this occurs, the Modulation Analyzer may not retune (if in an automatic tune mode) since it appears that the carrier simply dropped in power. If the instrument does not retune, frequency and power measurement results may not be as expected. Use the manual tune mode if possible when working with frequency agile sources.

When tuning manually, it is possible to adjust the LO so that the input signal falls into the image passband. This can occur, for example, when using the ⇑ kHz or ⇓ kHz keys. Frequency measurements made when this occurs will be inaccurate. Refer to *Tuning* for an illustration of the image passbands.

The large gain in the IF Amplifier and Limiters makes frequency measurements on input signal levels less than −60 dBm typical. When automatically tuning, the instrument will always tune to the most powerful signal at the input. However, if the approximate frequency is known, manual tuning will cause more powerful signals to be ignored if they fall outside the bandwidth of the IF amplifier. (Images may also appear within this bandwidth.)

When the FREQ key is pressed, MODULATION OUTPUT continues to produce the last selected modulation signal, filtered, and/or de-emphasized (except PRE-DISPLAY) as previously selected. The calibration of MODULATION OUTPUT depends upon the IF signal level and should be assumed only when all errors are enabled (Special Function 8.0).

## RELATED SECTIONS

Error Disable
Frequency Error
Frequency, IF
Frequency Resolution
Ratio

# Frequency Resolution

(Special Function 7)

## DESCRIPTION

When frequency measurements are made, the Modulation Analyzer normally updates the display five times each second. The resolution is 10 Hz for frequencies below ≈ 18 MHz, 100 Hz from ≈ 19 to ≈ 320 MHz, and 1000 Hz above ≈ 320 MHz. Use the numeric keyboard and the SPCL key to set the frequency resolution to either 10 Hz for frequencies below 1 GHz and 100 Hz for those above 1 GHz or to 1000 Hz for all frequencies. Setting resolution affects input frequency, frequency error, and IF frequency measurements.

## PROCEDURE

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

| Frequency Resolution | | Special Function Code | Program Code HP-IB |
|---|---|---|---|
| f < 1 GHz | f ≥ 1 GHz | | |
| Automatic Selection | | 7.0 SPCL | 7.0SP |
| 10 Hz | 100 Hz | 7.1 SPCL | 7.1SP |
| 1000 Hz | 1000 Hz | 7.2 SPCL | 7.2SP |

## EXAMPLE

To measure frequencies greater than 1 GHz with 100 Hz resolution:

| | |
|---|---|
| **LOCAL** (keystrokes) | Code Function<br>7 . 1 • SPCL |
| **HP-IB** (program codes) | 7.1SP<br>Code Function |

## HP-IB PROGRAM CODES

The HP-IB codes for the various frequency resolution settings are given under "PROCEDURE" above.

## INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Unless Special Function code 7.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

## COMMENTS

The Modulation Analyzer need not be making frequency measurements in order to change resolution modes; however, the resolution mode only affects frequency-related measurements. Counter accuracy is the reference accuracy ±3 counts.

When the Modulation Analyzer is first powered up, or when AUTOMATIC OPERATION is selected, the instrument is placed in the automatic selection mode (code 7.0).

## RELATED SECTIONS

Frequency, (Input)
Frequency Error
Frequency, IF
Special Functions

# Hold Settings

### (Special Function 9)

## DESCRIPTION

By keyboard entry using the SPCL key, the Modulation Analyzer ranges can be held. This function is the corollary to the AUTOMATIC OPERATION key and places Special Functions prefixed 1 through 4 and 8 into non-automatic modes. HP and LP FILTERs, FM DE-EMPHASIS, MEASUREMENT, DETECTORS, and RATIO are unaffected. Any of Special Functions prefixed 1 through 8 that are already in manual modes are not affected. The table below summarizes the effect of Hold Settings.

| Special Function Prefix | Special Function Description | Effect of Hold Setting Special Function |
|---|---|---|
| 1 | Input Attenuation | Holds Setting |
| 2 | Modulation Range | Holds Setting |
| 3 | IF Frequency and Input High Pass Filter | Holds Setting |
| 4 | Tune Mode | Manual Mode (code 4.2) |
| 5 | Audio Peak Detector Time Constant | No Effect |
| 6 | AM ALC Response | No Effect |
| 7 | Frequency Resolution | No Effect |
| 8 | Error Disable | Holds Setting |

## PROCEDURE

To hold settings, enter the code 9.0 using the numeric keys, then press the SPCL key.

## EXAMPLE

To hold settings:

| | |
|---|---|
| LOCAL (keystrokes) | Code Function<br>9 . 0 • SPCL |
| HP-IB (program codes) | 9.0SP<br>Code Function |

## HP-IB PROGRAM CODE

9.0SP is the HP-IB code for the Hold Settings Special Function.

## INDICATIONS

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

## COMMENTS

Once settings have been held by the Hold Settings Special Function, one or more of them may be returned to their automatic modes by issuing the corresponding Special Function code. As an example, Hold Settings places the instrument in manual tune mode. Use 4.0 SPCL to re-enter automatic tuning.

## RELATED SECTIONS

Attenuation, Input
Error Disable
IF Frequency and Input High Pass Filter Selection
Modulation Range
Special Functions
Tuning

# HP-IB Address

(Special Function 21)

## DESCRIPTION

By keyboard entry using the SPCL key, the Modulation Analyzer's present HP-IB address can be displayed. The display is in binary and also shows whether the instrument is set to talk only or listen only, and whether it is at present issuing a service request. The HP-IB address display will not time out, but it can be cleared by pressing any key except the LCL, S(Shift), or number key.

## PROCEDURE

To display the HP-IB address, key in the code 21.0 on the numeric keys, then press the SPCL key. To clear the display, press the CLEAR key. A list of allowable HP-IB addresses is given below:

*Allowable HP-IB Address Codes*

| Address Switches | | | | | Talk Address Character | Listen Address Character | Decimal Equivalent |
|---|---|---|---|---|---|---|---|
| A5 | A4 | A3 | A2 | A1 | | | |
| 0 | 0 | 0 | 0 | 0 | @ | SP | 0 |
| 0 | 0 | 0 | 0 | 1 | A | ! | 1 |
| 0 | 0 | 0 | 1 | 0 | B | " | 2 |
| 0 | 0 | 0 | 1 | 1 | C | # | 3 |
| 0 | 0 | 1 | 0 | 0 | D | $ | 4 |
| 0 | 0 | 1 | 0 | 1 | E | % | 5 |
| 0 | 0 | 1 | 1 | 0 | F | & | 6 |
| 0 | 0 | 1 | 1 | 1 | G | ' | 7 |
| 0 | 1 | 0 | 0 | 0 | H | ( | 8 |
| 0 | 1 | 0 | 0 | 1 | I | ) | 9 |
| 0 | 1 | 0 | 1 | 0 | J | * | 10 |
| 0 | 1 | 0 | 1 | 1 | K | + | 11 |
| 0 | 1 | 1 | 0 | 0 | L | , | 12 |
| 0 | 1 | 1 | 0 | 1 | M | – | 13 |
| 0 | 1 | 1 | 1 | 0 | N | [illegible] | 14 |
| 0 | 1 | 1 | 1 | 1 | O | / | 15 |

| Address Switches | | | | | Talk Address Character | Listen Address Character | Decimal Equivalent |
|---|---|---|---|---|---|---|---|
| A5 | A4 | A3 | A2 | A1 | | | |
| 1 | 0 | 0 | 0 | 0 | P | 0 | 16 |
| 1 | 0 | 0 | 0 | 1 | Q | 1 | 17 |
| 1 | 0 | 0 | 1 | 0 | R | 2 | 18 |
| 1 | 0 | 0 | 1 | 1 | S | 3 | 19 |
| 1 | 0 | 1 | 0 | 0 | T | 4 | 20 |
| 1 | 0 | 1 | 0 | 1 | U | 5 | 21 |
| 1 | 0 | 1 | 1 | 0 | V | 6 | 22 |
| 1 | 0 | 1 | 1 | 1 | W | 7 | 23 |
| 1 | 1 | 0 | 0 | 0 | X | 8 | 24 |
| 1 | 1 | 0 | 0 | 1 | Y | 9 | 25 |
| 1 | 1 | 0 | 1 | 0 | Z | : | 26 |
| 1 | 1 | 0 | 1 | 1 | [ | : | 27 |
| 1 | 1 | 1 | 0 | 0 | \ | < | 28 |
| 1 | 1 | 1 | 0 | 1 | ] | = | 29 |
| 1 | 1 | 1 | 1 | 0 | ⌒ | > | 30 |

## INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the light within the key will turn on and all measurement key lights and annunciators will turn off. The display will show a binary number of the form AAAAA. TLS where AAAAA is the HP-IB address in binary and T, L, and S have the meaning indicated in the following table:

| | T | L | S |
|---|---|---|---|
| 0 | NOT TALK ONLY | NOT LISTEN ONLY | NOT REQUESTING SERVICE |
| 1 | TALK ONLY | LISTEN ONLY | REQUESTING SERVICE |

If T and L are both 1, the instrument is set to talk only (talk overrides listen). If all the A digits are set to 1 and T is 1, the instrument will talk status only (i.e., output the status byte only). (If all digits AAAAA.TL are 1 but S is 0, the HP-IB board is not installed.)

## EXAMPLE

Display the HP-IB address:

| | |
|---|---|
| **LOCAL** (keystrokes) | Code: 2 1 . 0 Function: • SPCL |
| **HP-IB** (program codes) | 21.0SP<br>Code Function |

If the following was displayed:

then the HP-IB address is 01110 in binary or 14 in decimal. In ASCII, the talk address is N, and the listen address is . (decimal point). The instrument is not set to talk or listen only, but it is issuing a service request (setting the SRQ control line true).

## HP-IB PROGRAM CODE

21.0 SP is the HP-IB code to read HP-IB address.

## COMMENTS

The HP-IB address display is continuously updated. This makes setting the address easy since the result of changing a switch setting is immediately visible on the display.

For information on setting the HP-IB address of the Modulation Analyzer, refer to section 2 of this manual.

The factory-set address is as shown in the example, decimal 14.

## RELATED SECTIONS

Special Functions
Remote Operation, Hewlett-Packard Interface Bus

# IF Output

**CAUTION**

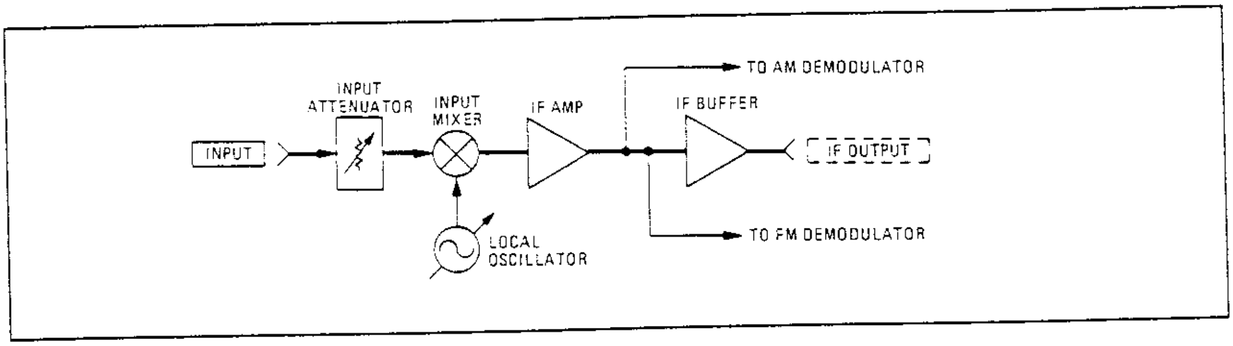
*Do not apply greater than 40 V dc or greater than +15 dBm into the rear-panel IF OUTPUT jack.*

## DESCRIPTION

The rear-panel IF OUTPUT provides a buffered IF output useful for monitoring the Modulation Analyzer's intermediate frequency signal. The ac-coupled signal has a range of 150 kHz to 2.5 MHz and normally varies in level from −27 to −3 dBm into 50Ω depending upon the input signal level, input attenuation setting, and the measurement selected. The 3 dB bandwidth of the signal at IF OUTPUT is approximately 3 MHz for the 1.5 MHz IF and approximately 200 kHz for the 455 kHz IF. At any particular input level and front-panel setting, the flatness of the IF OUTPUT with input frequency is typically ±5%. The IF OUTPUT jack is a female BNC connector.

## BLOCK DIAGRAM

A simplified block diagram of the down-conversion circuits that develop the IF OUTPUT signal is shown below.



*IF OUTPUT Block Diagram*

## COMMENTS

The Modulation Analyzer can also be used as a down-converter. Use IF OUTPUT as the down-converter's output.

IF OUTPUT can be used to check for spurious signals in the IF by connecting a spectrum analyzer to the jack.

Loads which may output spurious signals into the IF OUTPUT (such as some counters) may cause spurs in the Modulation Analyzer's IF circuits resulting in inaccurate measurements.

# Level, IF

## DESCRIPTION

The IF LEVEL key causes the Modulation Analyzer to measure the signal level in its IF and display it as a percent of the optimum level. An IF level display of 100% indicates sufficient signal strength to guarantee accurate AM, FM, and ΦM measurements. When IF LEVEL is selected, MODULATION OUTPUT continues to output the demodulated signal corresponding to the last modulation measurement selected. If, however, the IF level is not 100%, the calibration of the MODULATION OUTPUT signal is not specified.

## PROCEDURE

To display the IF level as a percent of optimum, press the S(Shift) key, then the IF LEVEL key. If IF LEVEL is to be displayed relative to some reference level or in dB, refer to *Ratio*.

## EXAMPLE

To measure IF Level:

| | |
|---|---|
| **LOCAL**<br>**(keystrokes)** | Measurement<br>S IF LEVEL |
| **HP-IB**<br>**(program codes)** | S3<br>Measurement |

## HP-IB PROGRAM CODE

S3 is the HP-IB code for IF LEVEL.

## INDICATIONS

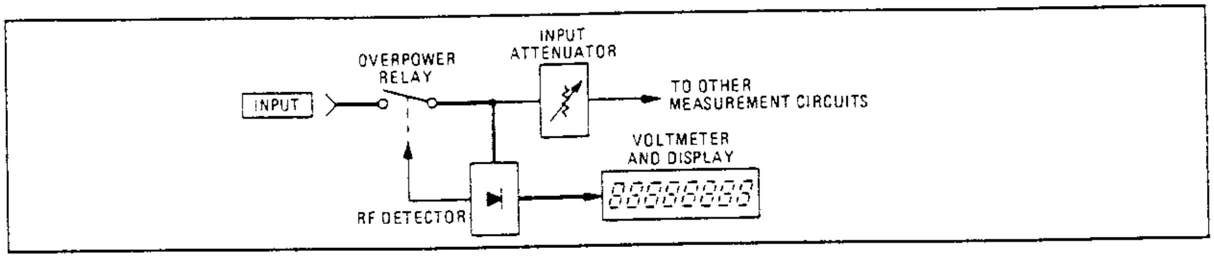
When IF LEVEL is selected, the LEDs within the S(Shift) key and the IF LEVEL key will light, the % annunciator will light, and the display will show the percent of optimum IF Level.

## MEASUREMENT TECHNIQUE

Once the instrument is tuned, the automatic level control (ALC) loop of the AM Demodulator detects the average IF signal level. This level is then measured and displayed as a percent of the optimum level. If the ALC loop is closed and sufficient signal power is available, the IF level is automatically adjusted to a preset ALC reference level and the display will show 100%. If the ALC loop is open, the input attenuator and the input signal level may need to be adjusted to achieve the 100% level.

## MEASUREMENT TECHNIQUE

The broadband RF power at INPUT is detected by an RF peak detector. The output of the detector is measured and displayed as watts.



*RF Level Measurement Block Diagram*

## COMMENTS

Selection of RF LEVEL causes the Modulation Analyzer to set its input attenuation to 50 dB regardless of any other setting (including Special Function 1). The input high-pass filter (Special Function 3) is also removed if previously inserted.

The maximum allowable input level is 1 W into 50Ω. Input levels greater than 1 W cause the overpower relay to open and the display to show E06. To reset the relay, remove the input signal and press any measurement key.

## RELATED SECTIONS

Attenuation, Input
Frequency, IF
Level, IF
Level, Tuned RF
Ratio

# Level, Tuned RF

## DESCRIPTION

The TUNED RF LEVEL key causes the Modulation Analyzer to measure the peak RF power falling within its tuned IF (refer to the second figure under "MEASUREMENT TECHNIQUE" below). When TUNED RF LEVEL is selected, MODULATION OUTPUT continues to output the demodulated signal corresponding to the last modulation type selected. AM OUTPUT and FM OUTPUT (rear panel) remain active during this measurement.

NOTE

*The Tuned RF level function is not calibrated for absolute power measurements.*

## MEASUREMENT RANGE

10 nW to 1 W into 50Ω (−50 to +30 dBm or 707 μV to 7.07 V). 1 nW maximum resolution.

## PROCEDURE

To make a tuned RF level measurement, first tune the instrument to the input signal (refer to *Tuning* or press AUTOMATIC OPERATION). Manual tuning will be necessary when measuring low-level signals (inputs < −25 dBm from 150 kHz to 650 MHz or < −20 dBm from 650 to 1300 MHz). Press the S(Shift) key, then the TUNED RF LEVEL key. If the tuned RF level is to be displayed relative to a reference, refer to *Ratio*.

## EXAMPLE

To measure the tuned RF level of an input signal:

| | |
|---|---|
| **LOCAL**<br>**(keystrokes)** | Measurement<br>S   TUNED RF LEVEL |
| **HP-IB**<br>**(program codes)** | S4<br>Measurement |

## HP-IB PROGRAM CODE

S4 is the HP-IB code for TUNED RF LEVEL.

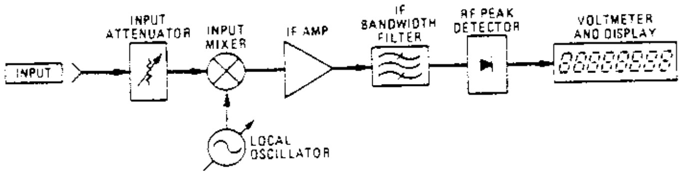
## INDICATIONS

When TUNED RF LEVEL is selected, the LEDs within the S(Shift) key and the TUNED RF LEVEL key will light and the watts annunciator will also light. The display will be in scientific notation form; a 4 or 5 digit number followed by a signed power of 10 multiplier. For example, if the display shows:

then the tuned RF level is 10.83 × $10^{-6}$ watts (10.83 μW).

## MEASUREMENT TECHNIQUE

When the Modulation Analyzer is tuned, all the power falling within the IF is amplified and peak detected. It is then measured by the voltmeter and displayed in watts.



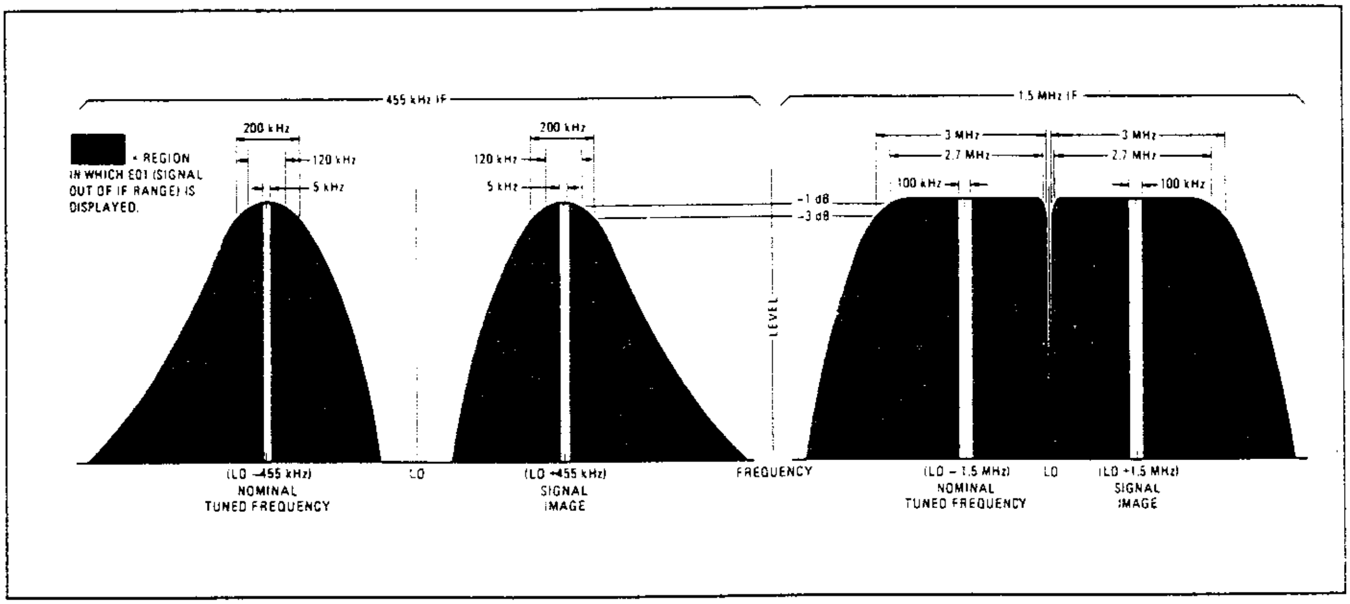
*Tuned RF Level Measurement Block Diagram*

## COMMENTS

The bandwidth of the 455 kHz IF (normally used for input frequencies between 2.5 and 10 MHz) is approximately 200 kHz. The bandwidth of the 1.5 MHz IF (normally used for input frequencies below 2.5 MHz or above 10 MHz) is approximately 3 MHz. However, each nominal IF passband also has an image passband which may contain signals with significant power. The IF and image bandwidths and their relationships to the local oscillator signal (LO) are illustrated for each IF in the spectrum diagram given below.

To display power in dBm, enter the number .001, then press the dB key.

Absolute power measurements are most accurate in RF level; however, power measurements have greater dynamic range in tuned RF level.



*Spectrum Diagram of the 455 kHz and 1.5 MHz Tuned Bandwidths*

## RELATED SECTIONS

Level, IF
Level, RF
Ratio

# Limit

## (Special Function 14)

## DESCRIPTION

Using the numeric keyboard and the SPCL and RATIO keys, upper and lower measurement limits may be entered into the Modulation Analyzer. Subsequent out-of-limit measurements will then cause the LIMIT annunciator to light. If enabled, reaching an upper or lower limit will also cause the Modulation Analyzer to issue an HP-IB service request. (Refer to *Service Request Condition.)* The LIMIT light will turn off after five measurement cycles if further measurements are not out of limits; however, the service request can only be cleared by serial polling or by a Device Clear message. Only one upper and one lower limit can be set at a time and each limit (upper or lower) can only be in effect in one measurement mode. The measurement mode need not be the same for both the upper and lower limits. Both limit references can be displayed, cleared, and restored, and the measurement modes for both limits may be displayed.

## PROCEDURES

A limit reference must first be entered as a RATIO reference. To do this, first select the MEASUREMENT in which the limit is to be used, then key in the value of the limit on the numeric keyboard, and press either the % or dB key. (Since the RATIO keys are used here simply to enter the limit into the instrument, it does not matter which key, % or dB, is used.) The entered value is now stored as a RATIO reference. To make this reference negative or to transform it directly into either an upper or lower limit reference, key in the corresponding Special Function code, then press the SPCL key. The Special Function codes most useful when working with the limit functions are listed below:

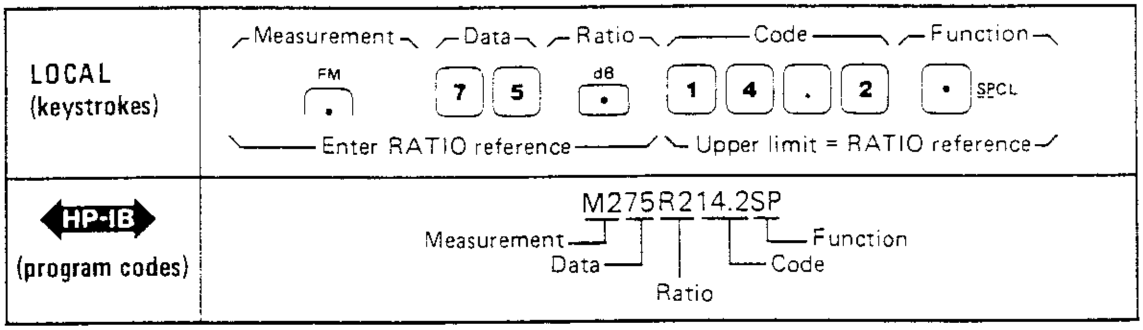
| | Action | Special Function Code | Program Code HP-IB |
|---|---|---|---|
| RATIO | Read RATIO reference | 11.2 SPCL | 11.2SP |
| | Make RATIO reference negative | 11.3 SPCL | 11.3SP |
| LIMIT | Clear limits; turn off LIMIT annunciator | 14.0 SPCL | 14.0SP |
| | Set lower limit to RATIO reference | 14.1 SPCL | 14.1SP |
| | Set upper limit to RATIO reference | 14.2 SPCL | 14.2SP |
| | Restore lower limit | 14.3 SPCL | 14.3SP |
| | Restore upper limit | 14.4 SPCL | 14.4SP |
| | Read lower limit | 14.5 SPCL | 14.5SP |
| | Read upper limit | 14.6 SPCL | 14.6SP |
| | Read lower limit measurement mode | 14.7 SPCL | 14.7SP |
| | Read upper limit measurement mode | 14.8 SPCL | 14.8SP |

To determine the measurement in which an upper or lower limit is in effect, key in the corresponding Special Function code, then press the SPCL key. The display shows a code which represents the measurement in which the limit is in effect. These codes are indexed in the following table:

| Display | Measurement | Display | Measurement |
|---|---|---|---|
| 0.000 | AM | 0.006 | FREQ ERROR |
| 0.001 | FM | 0.007 | Spare |
| 0.002 | φM | 0.008 | IF LEVEL |
| 0.003 | RF LEVEL | 0.009 | Spare |
| 0.004 | TUNED RF LEVEL | 0.010 | IF Frequency |
| 0.005 | FREQ | 0.011 | Spare |

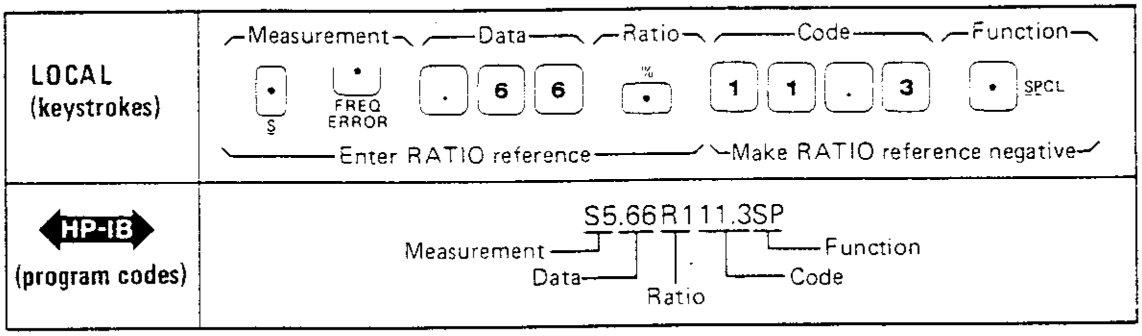
## EXAMPLES

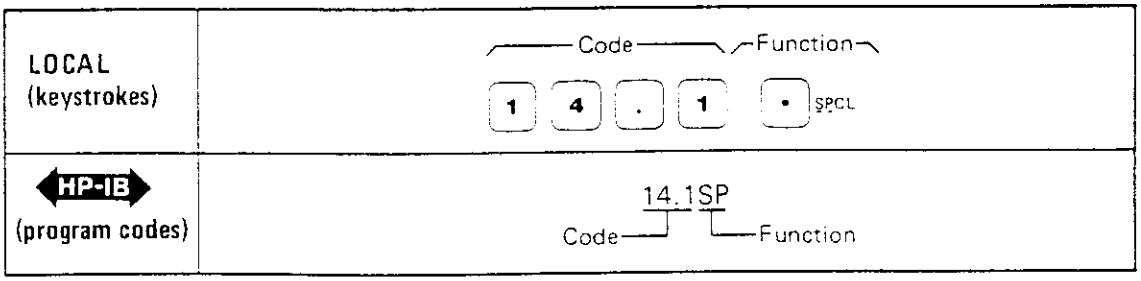
To set an upper limit of 75 kHz FM deviation:



This leaves the Modulation Analyzer in dB RATIO mode. Press the dB key to exit RATIO and to read the FM deviation in kHz with an upper limit set at 75 kHz. Notice that this example could have used the % RATIO key with equal results.

To set a lower FREQ ERROR limit of –660 Hz:





This leaves the Modulation Analyzer in % RATIO mode. Press the % key to read the frequency error in kHz with the lower limit set to –660 Hz.

To determine in which measurement the lower limit is set:

| | |
|---|---|
| **LOCAL**<br>**(keystrokes)** | Code Function<br>1 4 . 7 • SPCL |
| **HP-IB**<br>**(program codes)** | 14.7SP<br>Code Function |

If, for example, the display shows 0.006, the lower limit is set for the FREQ ERROR measurement.

## HP-IB PROGRAM CODES

The codes for performing the various limit and ratio operations are given above. The codes for the RATIO keys are given below for reference.

| Key or Function | Program Code<br>HP-IB |
|---|---|
| Turn off RATIO | R0 |
| % | R1 |
| dB | R2 |

## INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. If limits are being cleared or set, the SPCL key will not turn on if not already on. However, if limits or their measurement modes are being read, the key will turn on if not already on and remain lighted while the limit value or mode is displayed. When operating with limits set, the other key lights and the display behaves as they normally would; however, if a measurement falls out-of-set limits, the LIMIT annunciator lights. The light remains on until five successive measurements are made that fall within the set limits. Thus, the LIMIT light will normally remain on for approximately one second after the last out-of-limit measurement result. If the Modulation Analyzer is set to issue a service request when an out-of-limit measurement occurs, the service request may be cleared by serial polling.

## COMMENTS

It does not matter which RATIO key is used to enter the RATIO reference before transforming it into a limit.

The test for out-of-limit results is performed on the actual measurement results, not upon the displayed number. Thus, although the display may show a relative measurement result (that is, using the ratio functions), the limit test is still made upon the result before the ratio is computed. Limits cannot be set in terms of relative measurement results.

## RELATED SECTIONS

Service Request Condition
Special Functions
Ratio

# LO Input and LO Output

**CAUTION**

*Do not apply greater than 40 V dc or +5 dBm of RF power into the LO INPUT or damage to the instrument may result. Do not apply dc voltage or RF power into the LO OUTPUT or damage to the instrument may result.*

## DESCRIPTION

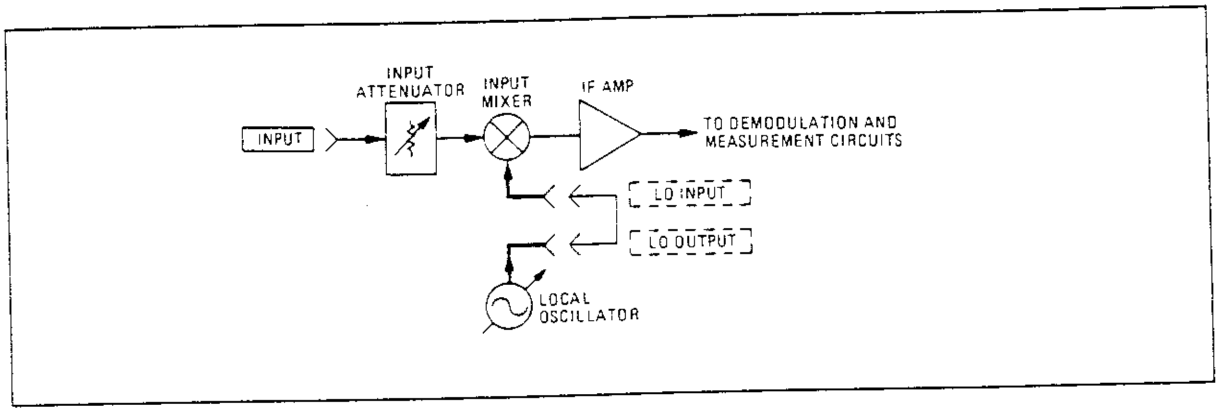
In Modulation Analyzers with Option 003, the internal local oscillator (LO) is brought out of and back into the instrument through the rear-panel LO OUTPUT and LO INPUT jacks. The signal at these jacks ranges from approximately 1.27 to 1301.5 MHz at approximately 0 dBm. Both jacks are 50Ω, ac-coupled, and furnished with female Type-N connectors.

**NOTE**

*For normal Modulation Analyzer operation using the internal local oscillator, the rear-panel LO OUTPUT must be connected to the rear-panel LO INPUT.*

## BLOCK DIAGRAM

A block diagram illustrating the relationship between the LO INPUT and LO OUTPUT jacks and the Modulation Analyzer's input circuits is given below.



*LO INPUT and LO OUTPUT Block Diagram*

## PROCEDURE

To use LO OUTPUT as a signal source, select an IF frequency (1.5 MHz or 455 kHz) using Special Function 3. The Modulation Analyzer will assume 1.5 MHz IF above 10 MHz (as entered on the keyboard) and 455 kHz IF below 10 MHz if the IF frequency is not specified. Subtract the IF frequency from the frequency desired at LO OUTPUT and enter the result in MHz using the numeric keys; then press MHz.

To tune the LO below 2.96 MHz, use the procedure above, but select the 455 kHz IF (Special Function code 3.1) and disable error E01 (Special Function code 8.1).

To use LO INPUT to apply an external LO, select an IF frequency (1.5 MHz or 455 kHz) using Special Function 3. Press the MHz key to enter manual tune mode (this keeps the internal LO from tuning continuously). Add the IF frequency to the frequency to which the Modulation Analyzer is to be tuned and set the external LO to that frequency. Adjust the external LO to 0 dBm and apply the signal to LO INPUT.

## COMMENTS

To tune to inputs below 2.5 MHz with an external LO, select the 1.5 MHz IF, but set the LO to approximately 100 MHz. The LO must be present to bias the Input Mixer on, but down-conversion is not necessary.

When an external LO is used, measurements made using the FREQ or FREQ ERROR keys will not be accurate. To determine input frequency, subtract the IF frequency (Special Function 10) from the LO frequency used.

When using an external LO, rapid changes in LO frequency within the IF passband cause FM transients. Several seconds are then required before accurate measurements will be possible. To avoid the problem, turn off the external LO when switching its frequency.

## RELATED SECTIONS

IF Frequency and Input High Pass Filter Selection
Tuning

# Modulation Output

**CAUTION**

*Do not apply greater than 10 Vdc or greater than +30 dBm (1 watt) into MODULATION OUTPUT or damage to the instrument may result.*

**NOTE**

*For optimum signal flatness, cables attached to MODULATION OUTPUT should be terminated with their characteristic impedance.*

## DESCRIPTION

MODULATION OUTPUT provides a calibrated output for signals demodulated by the Modulation Analyzer. The output is dc coupled with a 600Ω output impedance and a BNC female connector. The signal at MODULATION OUTPUT always corresponds to the modulation measurement being made. If FREQ, IF LEVEL, TUNED RF LEVEL, FREQ ERROR or IF frequency is selected, the signal at MODULATION OUTPUT corresponds to the last selected modulation measurement. If RF LEVEL is selected, MODULATION OUTPUT is turned off (that is, set to 0 V). If high-pass or low-pass filters are selected, they always affect the signal at MODULATION OUTPUT. If FM de-emphasis is selected, it always affects demodulated FM at MODULATION OUTPUT, regardless of the PRE-DISPLAY setting. The output level of the signal at MODULATION OUTPUT is autoranging and usually is between 0 and 4 V peak into an open circuit. The output sensitivity (into an open circuit) depends upon both the modulation type and the displayed resolution as given in the table below. (More information on other outputs and the setting of modulation ranges may be found in *Modulation Range.)*

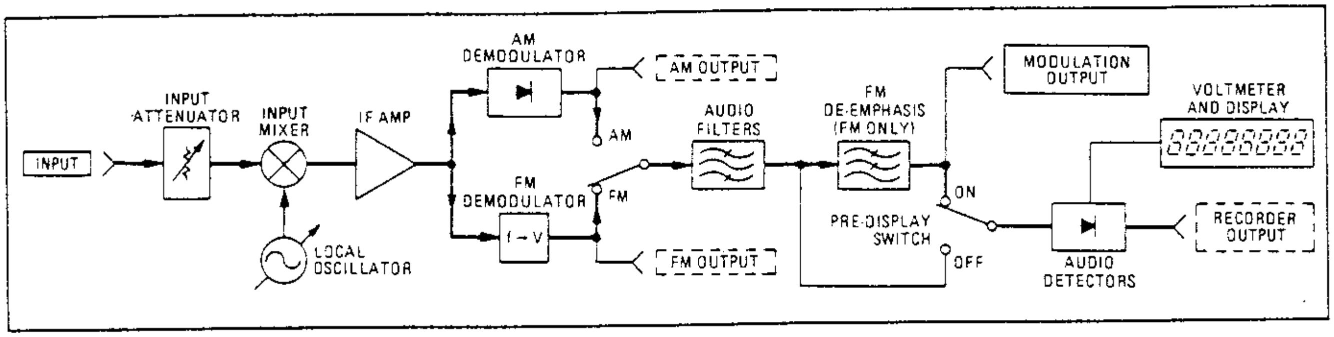
| AM | | FM | | ΦM | |
|---|---|---|---|---|---|
| Display Resolution (%) | MODULATION OUTPUT Sensitivity (Vac/%) | Display Resolution (Hz) | MODULATION OUTPUT Sensitivity (mVac/Hz) | Display Resolution (radians) | MODULATION OUTPUT Sensitivity (mVac/radian) |
| 0.01 | 0.1 | 0.1* | 10* | 0.0001 | 1 |
| | | 1 | 1 | 0.01 | 0.1 |
| 0.1 | 0.01 | 10 | 0.1 | 0.1 | 0.01 |
| | | 100** | 0.01** | | |

* Available only with 750 microsecond de-emphasis, pre-display.

** Not available with 750 microsecond de-emphasis, pre-display

## BLOCK DIAGRAM

A simplified block diagram of the Modulation Analyzer's measurement circuits illustrating the relationships between MODULATION OUTPUT and the other outputs and circuit blocks is given below.



*Modulation Output Block Diagram*

## COMMENTS

The sense of the demodulated FM and ΦM at MODULATION OUTPUT is inverted for carriers with frequencies below 2.5 MHz.

Errors E01 through E03, E05, E10, and HP-IB error E96 (corresponds to a display of two dashes) turn off the signal at MODULATION OUTPUT.

When the Modulation Analyzer is first powered up, the demodulated signal at MODULATION OUTPUT is FM. The sensitivity is 0.01 mVac/Hz and will not autorange to more sensitive ranges. This is because at power up, FREQ is selected, and thus E04 (audio circuits overdriven) is automatically disabled. When E04 is disabled, only autoranging to less sensitive audio ranges is allowed.

When E01 through E04 are always enabled (8.8 SPCL), the signal at MODULATION OUTPUT is entirely safeguarded. Under this condition an error will be displayed when the signal at MODULATION OUTPUT is uncalibrated. Refer to *Error Disable.*

## RELATED SECTIONS

AM
Error Disable
Filters
FM
Modulation Range
ΦM

# Modulation Range

(Special Function 2)

## DESCRIPTION

When first tuned on, the Modulation Analyzer is set to automatically select the modulation range appropriate for the desired measurement. However, using the numeric keyboard and the SPCL key, the modulation range can be manually set.

## PROCEDURE

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

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

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

FM

| Modulation Range | | | | Display Resolution (Hz) | MODULATION OUTPUT Sensitivity (mVac/Hz) | RECORDER OUTPUT (Rear Panel) (Vdc/kHz peak dev.) |
|---|---|---|---|---|---|---|
| PEAK ± (%) (kHz dev.) | AVG[1] (%) (kHz dev.) | Special Function Code | Program Code HP-IB | | | |
| Automatic Selection | | 2.0 SPCL | 2.0SP | Automatic Selection | | |
| ≤0.4[2] | ≤0.28[2] | 2.1 SPCL[2] | 2.1SP | 0.1[2] | 10[2] | 10[2] |
| ≤4 | ≤2.8 | 2.1 SPCL<br>2.2 SPCL[2] | 2.1SP<br>2.2SP[2] | 1 | 1 | 1 |
| ≤40 | ≤28 | 2.2 SPCL<br>2.3 SPCL[2] | 2.2SP<br>2.3SP[2] | 10 | 0.1 | 0.1 |
| ≤400[3] | ≤280[3] | 2.3 SPCL[3] | 2.3SP[3] | 100[3] | 0.01[3] | 0.01[3] |

[1] Values are for sine wave modulation signal only.
[2] With 750 microsecond de-emphasis, pre-display only.
[3] Except 750 microsecond de-emphasis, pre-display.

Phase Modulation (ΦM)

| Modulation Range[1] | | | | Display Resolution radians | MODULATION OUTPUT Sensitivity (mVac/radian) | RECORDER OUTPUT (Rear Panel) (Vdc/rad. peak dev.) |
|---|---|---|---|---|---|---|
| PEAK ± (rad. dev.) | AVG[2] (rad. dev.) | Special Function Code | Program Code HP-IB | | | |
| Automatic Selection | | 2.0 SPCL | 2.0SP | Automatic Selection | | |
| ≤4 | ≤2.8 | 2.1 SPCL | 2.1SP | 0.001 | 1 | 1 |
| ≤40 | ≤28 | 2.2 SPCL | 2.2SP | 0.01 | 0.1 | 0.1 |
| ≤400 | ≤280 | 2.3 SPCL | 2.3SP | 0.1 | 0.01 | 0.01 |

[1] Range limits are nominal. Refer to figure under Phase Modulation for relationship between deviation, rate, and resolution.
[2] Values are for sine wave modulation signal only.

## EXAMPLE

To set the modulation range to the ≤40% AM setting (also ≤4 kHz deviation for FM and ≤4 radians deviation for ΦM):

| | |
|---|---|
| **LOCAL**<br>**(keystrokes)** | Code — Function<br>[2] [.] [1] [•] SPCL |
| **HP-IB**<br>**(program codes)** | 2.1SP<br>Code — Function |

## BLOCK DIAGRAM

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

## INDICATIONS

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to shown the measurement previously selected. Unless Special Function code 2.0 was entered, the light within the SPCL key will turn on, if not already on. If the light is already on, it will remain on.

## COMMENTS

When the instrument is first turned on or when AUTOMATIC OPERATION is selected, the modulation range is placed in the automatic selection mode.

If the modulation range selected is too high, no error will be generated, and both MODULATION OUTPUT and RECORDER OUTPUT will track the displayed values. If the modulation range is too low (that is, the audio signal level is too high), error E04 will be generated. The point at which error E04 is generated may not be exactly at the nominal level at which ranges are switched.

When E04 is disabled (Special Function code 8.4), autoranging is to higher modulation ranges only. This feature is used most often when modulation varies widely with time such as off-the-air demodulation of a broadcast signal.

Refer to *Phase Modulation (ΦM)* for more information on ΦM modulation ranges.

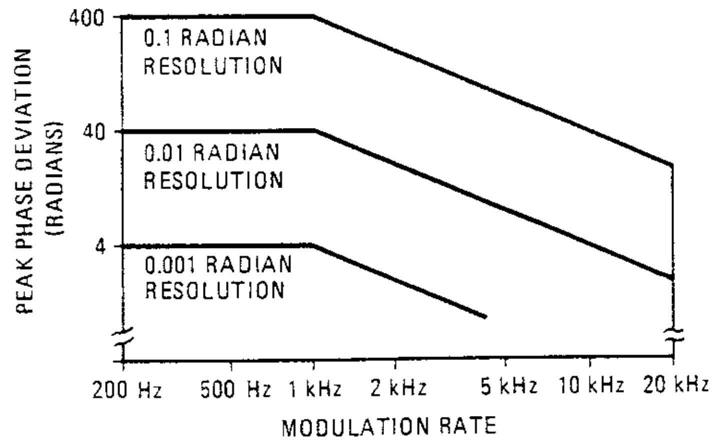
## RELATED SECTIONS

Error Disable
Hold Settings
Special Functions

# ΦM

## DESCRIPTION

The ΦM key causes the Modulation Analyzer to measure the phase modulation deviation of the input signal to which the instrument is tuned. In addition, demodulated ΦM is present at MODULATION OUTPUT. The ΦM measurement is only specified for carriers from 10 to 1300 MHz; however, ΦM measurements are allowed on carriers from 150 kHz to 10 MHz. The ΦM measurement is only specified for modulation rates from 200 Hz to 20 kHz; however, the low frequency 3 dB limit is typically 7 Hz.



*Phase Modulation Peak Phase Deviation and Modulation Rate vs. Display Resolution*

| Phase Modulation (ΦM) | | | | | | |
|---|---|---|---|---|---|---|
| Modulation Range[1] | | | | Display Resolution radians | MODULATION OUTPUT Sensitivity (mVac/radian) | RECORDER OUTPUT (Rear Panel) (Vdc/rad. peak dev.) |
| PEAK ± (rad. dev.) | AVG[2] (rad. dev.) | Special Function Code | Program Code HP-IB | | | |
| Automatic Selection | | 2.0 SPCL | 2.0SP | Automatic Selection | | |
| ≤4 | ≤2.8 | 2.1 SPCL | 2.1SP | 0.001 | 1 | 1 |
| ≤40 | ≤28 | 2.2 SPCL | 2.2SP | 0.01 | 0.1 | 0.1 |
| ≤400 | ≤280 | 2.3 SPCL | 2.3SP | 0.1 | 0.01 | 0.01 |

[1] Range limits are nominal. Refer to figure under Phase Modulation for relationship between deviation, rate, and resolution.
[2] Values are for sine wave modulation signal only.

## HP-IB PROGRAM CODES

The HP-IB codes for re-entering RATIO or for reading or changing the reference are given above. The HP-IB codes for the RATIO keys are given below:

| RATIO Function | Program Code<br>HP-IB |
|---|---|
| off | R0 |
| % | R1 |
| dB | R2 |

## INDICATIONS

When the instrument is displaying a RATIO measurement, the REL (relative) annunciator and the appropriate RATIO key both light. Other units annunciators turn off. The displayed value is the measurement result relative to the reference in % or dB.

## MEASUREMENT TECHNIQUE

When in RATIO, measurements are made in the same fashion as when not in RATIO; however, before the result is displayed, the internal controller converts it to ratio. The following formulas are used for computing ratio:

$$\left(\frac{M}{R}\right)(100\%) = \%\ RATIO\ for\ all\ measurements,$$

$$(20)\ log\ \left(\frac{M}{R}\right) = dB\ RATIO\ for\ all\ modulation\ and\ IF\ level\ measurements$$

$$(10)\ log\ \left(\frac{M}{R}\right) = dB\ RATIO\ for\ frequency\ and\ level\ measurements\ except\ IF\ level$$

where

$M = the\ current\ measurement\ result,\ and$

$R = the\ RATIO\ reference.$

## COMMENTS

When using dB RATIO, if a ratio reference is entered or a measurement result occurs that causes the value of $M/R$ (see equation above) to approach 0, E11 will be displayed. This typically occurs when a measurement result goes to 0.

If already in RATIO, pressing the opposing RATIO key causes the Modulation Analyzer to acquire a new reference from the present measurement result. To convert from dB to % (or vice versa) with the same reference, use the re-enter RATIO function (Special Function 11.0 or 11.1).

The RATIO keys are convenient when used to check modulation or RF level flatness across an RF frequency range (use track mode tuning, Special Function 4.1) or across the audio range.

The reference that is stored for ratio measurements may be entered as a limit reference (refer to *Limit*).

Some useful reference values for making ratio measurements are given below:

To display power in dBm, use 0.001 and dB RATIO.

To display broadcast FM relative to 75 kHz, use 75 and % RATIO.

To display ΦM in degrees, use 1.745 and % RATIO.

To display AM as dB down from the carrier, use 200 and dB RATIO.

To display rms calibrated average as true average, use 111.07 and % RATIO.

To display rms calibrated average as peak, use 70.7 and % RATIO.

## RELATED FUNCTIONS

Error Message Summary
Limit
Special Functions
Tuning

# Residual Noise Effects

## DESCRIPTION

To make the most accurate peak-modulation measurements, it is necessary to measure and correct the effects of residual noise, that is, noise not on the baseband signal, but modulating the RF carrier. The following procedure describes the measurement technique.

## PROCEDURE

The following procedure enables the user to correct for the effects of residual noise on peak-modulation measurements.

**NOTE**

*This procedure applies to sinewave modulation only.*

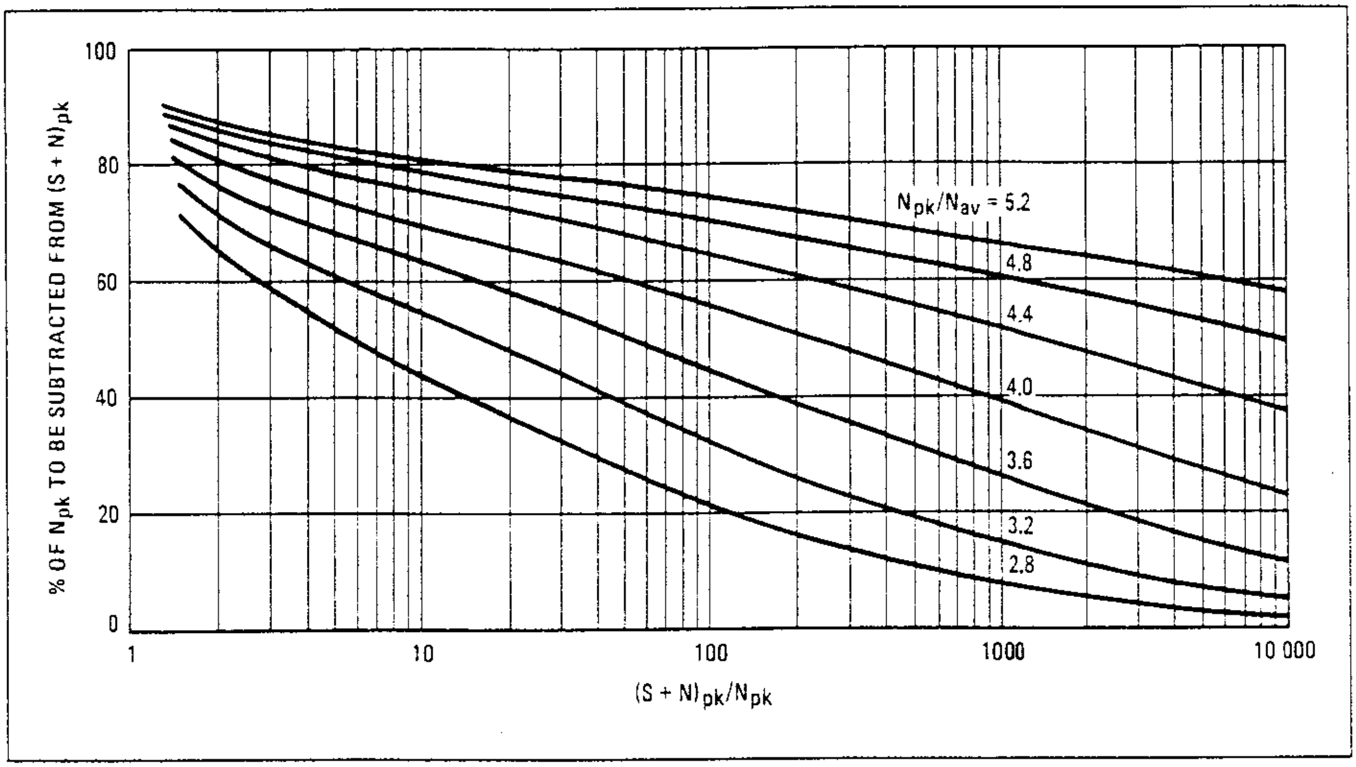
1. Set up and make a normal peak-modulation measurement. The displayed measurement result will include the signal plus its noise, $(S+N)_{pk}$.
2. Key in 9.0 SPCL (Hold Settings) to prevent autoranging. If filtering and/or de-emphasis was used in step 1, make all the following measurements with the same settings.
3. Remove the modulation from the signal and measure the remaining peak-residual noise, $N_{pk}$, on the carrier.
4. Select AVG. Measure the average residual noise, $N_{av}$.
5. Compute

$$\frac{(S+N)_{pk}}{N_{pk}} and \frac{N_{pk}}{N_{av}}$$

6. Use the following nomograph to determine the percent, $N\%$, of the peak-residual noise level, $N_{pk}$, to be subtracted from the original, peak-signal-plus-noise measurement, $(S+N)_{pk}$.
7. Compute the corrected, peak modulation

$$S_{pk} = (S+N)_{pk} - N_{pk}(N\%)$$

where $N\%$ is expressed as a ratio (rather than in %).



*Nomograph for Calculating Percentage of $N_{pk}$ to be Subtracted from $(S + N)_{pk}$ to obtain $S_{pk}$ (Sinewave Modulation Only)*

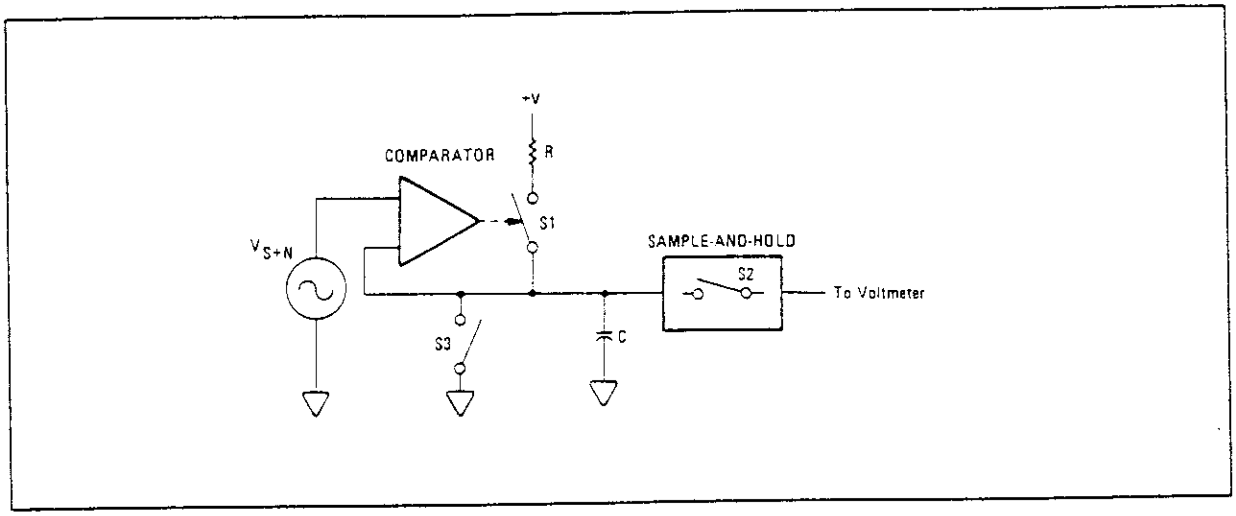
## EXAMPLE

An RF signal is applied to the Modulation Analyzer. The modulation rate is 1 kHz and the peak modulation is to be measured in a 15 kHz post-detection bandwidth. To measure the peak AM depth and correct for the effects of residual noise on the modulation:

1. Measure the peak modulation depth, $(S + N)_{pk}$:

| | | | | |
|---|---|---|---|---|
| | | Measurement | Detector | Filter |
| **LOCAL**<br>**(keystrokes)** | AUTOMATIC OPERATION | AM | PEAK + | 15 kHz |
| **HP-IB**<br>**(program codes)** | AUM1D1L2<br>Measurement: M1<br>Detector: D1<br>Filter: L2 | | | |

For the purposes of subsequent calculations, assume the displayed AM is 30.80%.



*Simplified Diagram of the Modulation Analyzer's Peak Detector*

When noise alone is imposed on the detector, it is very probable that, as C begins to charge, a noise spike will exceed the voltage across the peak detector capacitor. However, as the voltage across the capacitor more nearly approaches the peak-noise level, this probability decreases. Thus the peak detector, over a significantly long time, can faithfully measure fairly high peak-noise levels.

When noise is riding on a sinewave, only the signal-plus-noise peaks exceeding the sinusoid's peak level can add charge to the peak detector capacitor. Statistically, there is less chance that the composite input signal will exceed the voltage across the capacitor (already charged to the peak of the sinewave) when measuring a sinewave than when measuring only noise. Thus, the contribution of noise on the measured peak-modulation level decreases as the signal-to-noise ratio increases.[1] To simply measure the peak-residual noise present when the modulation is removed and subtract the result directly from the peak reading of the combined input, over-compensates the effects of the noise.

The effects of residual noise on the peak detector depend on the signal-to-noise ratio, the statistics of the noise spikes, and the response time of the specific peak detector. These effects are quantified by taking the ratio of the peak noise reading to the average noise reading. The average noise level is a truer measure of the actual amount of noise energy present, while the peak reading characterizes the peak detector and the statistics of the noise spikes.

---

[1] Rice, S.O., "Statistical Properties of a Sine Wave Plus Random Noise", Bell System Technical Journal, 27, No.1, January, 1948), pp. 109-157.

## COMMENTS

### Noise Must Be Gaussian

The primary restriction placed on this method of accounting for residual noise is that the noise must be gaussian (that is, statistically random). Periodic noise (for example, line-related noise) has repeating peaks and thus does not fall within the statistical model used to derive the nomograph given in the procedure.

A noise-peak-to-noise-average ratio ($N_{pk}/N_{av}$) greater than 4.4 is a strong indication of a periodic component in the residual noise.

### Use Range Hold During Measurement

Both the modulation and the noise measurements used with the nomograph should be made on the same modulation range and with the same peak-detector time-constant. Use the Range Hold key while the instrument is measuring the modulated carrier, then measure the residual noise.

### Select the Highest of Successive Readings

When characterizing the effects of residual noise on peak ΦM measurements using the 3 kHz low-pass filter, readings may jump considerably. Use the highest of 10 successive readings for all peak measurements in the computations. (Simply select PEAK HOLD and note the reading after 2 seconds.)

### No Residual Noise in Calibration

The residual noise contributions of the AM and FM calibrators and the Modulation Analyzer are accounted for in the calibration procedures. It is not necessary to factor residual noise corrections into the calibration procedures described in this manual. (Refer to AM Calibration and FM Calibration.)

### Considerations When Using the RMS Detector

During FM measurements if the RMS detector is selected (Blue Key, AVG), FM de-emphasis pre-display is automatically selected. Pre-display must turn on at this time due to circuit configuration of the Modulation Analyzer. When pre-display is selected this way, it will not turn off automatically when another detector is selected. Turn off pre-display (after selecting another detector) by pressing the PRE DISPLAY key (HP-IB code: P0). Measurements could be affected by this pre-display selection.

# Special Functions

## FUNCTIONS

All Special Functions prefixed 1 to 39

## DESCRIPTION

### General Information

Special functions enable extended use of the instrument beyond the control normally available from dedicated front-panel keys. The special functions are best used after a thorough understanding of the instrument is grasped.

Special functions are accessed via keyboard entry of the appropriate numeric code terminated by the SPCL key. (Refer to "Procedures".) The codes comprise a prefix, decimal, and suffix. Special functions are disabled in different ways, depending on the function. Refer to the following comprehensive table for actions which clear or disable any special function. Special functions are grouped by their prefixes into three categories as follows:

### Prefix 0

Prefix 0 is the Direct Control Special Function intended for use in servicing the Modulation Analyzer (discussed in detail in Section 8). All instrument error messages and safeguards are inactive. If the Direct Control Special Function is entered inadvertently, press AUTOMATIC OPERATION.

### Prefixes 1 to 39

Prefixes 1 to 39 are the User Special Functions that are used during normal instrument operation when a special configuration, a special measurement, or special information is required. All error messages and most safeguards remain in effect unless the operator disables them. These special functions are described in the table in this instruction.

### Prefixes 40 to 99

Prefixes 40 to 99 are the Service Special Functions used to assist in troubleshooting an instrument fault (discussed in detail in Section 8). The functions available include special internal measurements, software control, and special service tests and configurations. Most instrument safeguards are relinquished. If a Service Special Function is entered inadvertently, press AUTOMATIC OPERATION. Repair personnel can gain arbitrary control of the instrument as an aid in troubleshooting.

### Viewing Special Function States

In addition to completing the entry of special function codes, the SPCL key enables viewing of some special function settings. The operator-requested settings of Special Functions prefixed 1 through 10 can be viewed by pressing the SPCL key once (following no numeric entry). This display is called the Special Display. If some of these Special Functions are in automatic modes (generally the 0-suffix setting), the actual instrument settings of these functions can be displayed by pressing the SPCL key a second time while the Special Display is still active. This display is called the Special Special Display. Both displays can be disabled by pressing any key except the Blue Key, LOCAL, or S (shift) key. (While either display is active, pressing the SPCL key selects the other display.)

A summary of User Special Functions is provided at the end of this instruction. Also included in this instruction are procedures for initiating special functions and for obtaining the Special Display and the Special Special Display.

## PROCEDURES

### Entering Special Functions

To use a special function, key in the corresponding code, then select SPCL.

### Special Display

To display the user-requested modes of special functions prefixed 1 through 10, select SPCL alone one time. The digit position (noted beneath the display) corresponds to the special function prefix, and the number displayed in that position corresponds to the special function suffix.

### Special Special Display

To determine the actual instrument settings corresponding to special functions prefixed 1 through 10, press the SPCL key alone once while the Special Display is active. (If the Special Display is not active, press the SPCL key twice to get this display.) The digit position corresponds to the special function prefix, and the number displayed in that digit corresponds to the special function suffix.

## HP-IB PROGRAM CODES

All special function codes are formed by the special function number followed by the code "SP". For example, the code for Special Function 7.3 is "7.3SP".

For special function codes with zero as a suffix, force a single space if the zero is to be ommitted. For example, "10.0SP" could be "10. SP"

## EXAMPLES

### Entering Special Functions

To display the frequency of the signal in the IF (Special Function 10):

| | |
|---|---|
| LOCAL<br>(keystrokes) | Code Function<br>1 0 . 0 • SPCL |
| HP-IB<br>(program codes) | 10.0SP<br>Code Function |

## Viewing the Special Display

When SPCL is pressed alone once, the following display might result:

This display is interpreted as follows:

| Special Function | | User-Requested Setting |
|---|---|---|
| **Code** | **Name** | |
| 1.0 | Input Attenuation | Automatic Selection |
| 2.1 | Modulation Range | 40% AM; 4 kHz FM; 4 radians ΦM |
| 3.0 | IF Frequency and Input High-Pass Filter | Automatic Selection; no Input High-Pass Filter |
| 4.2 | Tune Mode | Manual Tuning |
| 5.0 | Audio Peak Detector Time Constant | Fast Peak Detector |
| 6.1 | AM ALC Response | Fast AM ALC |
| 7.2 | Frequency Resolution | 1000 Hz Resolution |
| 8.8 | Measurement Error Disable | E01 through E04 enabled |

## Special Special Display

When SPCL is pressed again, the following display might result: (The user-selected Special Functions shown in the previous example are repeated in the Special Special Display. The Special Functions that were left in the automatic selection mode will display the suffix that was automatically selected.)

The display is interpreted as follows:

| Special Function | | Actual Instrument Setting |
|---|---|---|
| Code | Name | |
| 1.2 | Input Attenuation | 10 dB Attenuation |
| 2.1 | Modulation Range | 40% AM; 4 kHz FM; 4 radians ΦM |
| 3.2 | IF Frequency and Input High-Pass Filter | 1.5 MHz IF Frequency; no Input High-Pass Filter |
| 4.2 | Tune Mode | Manual Tuning |
| 5.0 | Audio Peak Detector Time Constant | Fast Peak Detector |
| 6.1 | AM ALC Response | Fast AM ALC |
| 7.2 | Frequency Resolution | 1000 Hz Resolution |
| 8.8 | Measurement Error Disable | E01 through E04 Enabled |

# COMMENTS

## Omit Zero Suffixes

If a special function has a suffix of zero, the zero need not be entered. For example, 10.0 SPCL equals 10.SPCL. (However, 22.2 SPCL does not equal 22.20 SPCL nor does 18.1 SPCL equal 18.10 SPCL.) If entering a special function code evokes Error 21 (invalid key sequence), the special function requested has not been executed.

## HP-IB

Force a single space in "10. SP" if the zero is to be omitted.

## CLEAR Key

If an error is made while keying in the special function code, select CLEAR and re-enter the code.

# Special Functions

## Special Function Summary (1 of 4)

| Special Function | | Program Code | Description | | Disabled by | | | | | References and Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Name | Code | HP-IB | | Lights SPCL key | AUTO. OP. key | Any MEAS. key | CLEAR key | All keys* | Display Timed | |
| Input Attenuation | 1.0 | 1.0SP | Automatic selection | N | — | — | — | — | — | Attenuation, Input |
| | 1.1 | 1.1SP | 0 dB input attenuation | Y | Y | N | N | N | — | |
| | 1.2 | 1.2SP | 10 dB input attenuation | Y | Y | N | N | N | — | |
| | 1.3 | 1.3SP | 20 dB input attenuation | Y | Y | N | N | N | — | |
| | 1.4 | 1.4SP | 30 dB input attenuation | Y | Y | N | N | N | — | |
| | 1.5 | 1.5SP | 40 dB input attenuation | Y | Y | N | N | N | — | |
| | 1.6 | 1.6SP | 50 dB input attenuation | Y | Y | N | N | N | — | |
| Modulation Range | 2.0 | 2.0SP | Automatic selection | N | — | — | — | — | — | Modulation Range<br>Modulation Output |
| | | | AM (%)   FM (kHz)   ΦM (rad) | | | | | | | |
| | 2.1 | 2.1SP | ≤ 40   ≤ 4   ≤ 0.4*   ≤ 4 | Y | Y | N | N | N | — | |
| | 2.2 | 2.2SP | ≤100   ≤ 40   ≤ 4*   ≤ 40 | Y | Y | N | N | N | — | |
| | 2.3 | 2.3SP | ≤100   ≤400   ≤ 40*   ≤400 | Y | Y | N | N | N | — | |
| | | | *with 750 µs de-emphasis, pre-display | | | | | | | |
| IF Frequency and Input High-Pass Filter | 3.0 | 3.0SP | Automatic IF selection; input high-pass filter out | N | — | — | — | — | — | Frequency, IF and Input High-Pass Filter |
| | | | IF (MHz)   Input High-Pass Filter | | | | | | | |
| | 3.1 | 3.1SP | 0.455   Out | Y | Y | N | N | N | — | |
| | 3.2 | 3.2SP | 1.5   Out | Y | Y | N | N | N | — | |
| | 3.3 | 3.3SP | 0.455   In | Y | Y | N | N | N | — | |
| | 3.4 | 3.4SP | 1.5   In | Y | Y | N | N | N | — | |
| Tune Mode | 4.0 | 4.0SP | Automatic tuning; low noise LO | N | — | — | — | — | — | Tuning |
| | 4.1 | 4.1SP | Automatic tuning; track mode | Y | Y | N | N | N | — | |
| | 4.2 | 4.2SP | Manual tuning via keyboard entry | Y | Y | N | N | N | — | |
| Audio Peak Detector Time Constant | 5.0 | 5.0SP | Fast peak detector | N | — | — | — | — | — | Detector (Peak) Time Constant |
| | 5.1 | 5.1SP | Slow peak detector | Y | Y | N | N | N | — | |
| AM ALC Response | 6.0 | 6.0SP | Slow AM ALC response | N | — | — | — | — | — | AM ALC Response Time |
| | 6.1 | 6.1SP | Fast AM ALC response | Y | Y | N | N | N | — | |
| | 6.2 | 6.2SP | AM ALC off | Y | Y | N | N | N | — | |

N = No; — = Not Applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

# Special Functions

## Special Function Summary (2 of 4)

| Special Function | | Program Code | Description | | Disabled by | | | | | References and Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Name | Code | HP-IB | | Lights SPCL key | AUTO. OP. key | Any MEAS. key | CLEAR key | All keys* | Display Timed | |
| Frequency Resolution | 7.0 | 7.0SP | Automatic selection | N | — | — | — | — | — | Frequency Resolution |
| | 7.1 | 7.1SP | 10 Hz resolution (f<1 GHz) | Y | Y | N | N | N | — | |
| | 7.2 | 7.2SP | 1000 Hz resolution | Y | Y | N | N | N | — | |
| Error Disable | 8.0 | 8.0SP | Automatic selection | N | — | — | — | — | — | Error Disable<br>Error Message Summary<br>Attenuation, Input<br>Modulation Range<br>Tuning |
| | 8.1 | 8.1SP | E01 disabled | Y | Y | N | N | N | — | |
| | 8.2 | 8.2SP | E02 and E03 disabled | Y | Y | N | N | N | — | |
| | 8.3 | 8.3SP | E01, E02, and E03 disabled | Y | Y | N | N | N | — | |
| | 8.4 | 8.4SP | E04 disabled | Y | Y | N | N | N | — | |
| | 8.5 | 8.5SP | E01 and E04 disabled | Y | Y | N | N | N | — | |
| | 8.6 | 8.6SP | E02, E03, and E04 disabled | Y | Y | N | N | N | — | |
| | 8.7 | 8.7SP | E01 through E04 disabled | Y | Y | N | N | N | — | |
| | 8.8 | 8.8SP | E01 through E04 enabled | Y | Y | N | N | N | — | |
| Hold Settings | 9.0 | 9.0SP | Holds ranges, tuning, and error modes at present settings; disables automatic functions | Y | Y | N | N | N | — | Hold Settings |
| IF Frequency Measurement | 10.0 | 10.0SP | Measures IF signal frequency | Y | N | Y | N | N | N | Frequency, IF |
| Re-enter RATIO with Previous Reference | 11.0 | 11.0SP | Re-enter % RATIO | N | — | — | — | — | — | Ratio |
| | 11.1 | 11.1SP | Re-enter dB RATIO | N | — | — | — | — | — | |
| | 11.2 | 11.2SP | Read RATIO reference | Y | Y | Y | Y | Y | Y | |
| | 11.3 | 11.3SP | Make RATIO reference negative | N | — | — | — | — | — | |
| FM Calibrator | 12.0 | 12.0SP | Display computed peak FM deviation | Y | N | Y | N | N | N | Calibration, FM<br>NOTE: 12.1 and 12.2 set the Modulation Range to 2.2. |
| | 12.1 | 12.1SP | Display demodulated peak residual FM deviation | Y | N | Y | N | N | N | |
| | 12.2 | 12.2SP | Display demodulated peak FM deviation | Y | N | Y | N | N | N | |
| AM Calibrator | 13.0 | 13.0SP | Display computed peak AM depth | Y | N | Y | N | N | N | Calibration, AM |

(Continued on next page)

N = No; — = Not applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

# Special Functions

## Special Function Summary (3 of 4)

| Special Function | | Program Code | Description | | Disabled by | | | | | References and Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Name | Code | HP-IB | | Lights SPCL key | AUTO. OP. key | Any MEAS. key | CLEAR key | All keys* | Display Timed | |
| AM Calibrator (Cont'd) | 13.1 | 13.1SP | Display demodulated peak residual AM depth | Y | N | Y | N | N | N | NOTE: 13.1 and 13.2 set the Modulation Range to 2.1. |
| | 13.2 | 13.2SP | Display demodulated peak AM depth | Y | N | Y | N | N | N | |
| Set Limit | 14.0 | 14.0SP | Clear limits; turn off LIMIT annunciator | N | — | — | — | — | — | Limit, Ratio<br>NOTE: 14.5 and 14.6 Special Functions will display 0 if the limit is not enabled. |
| | 14.1 | 14.1SP | Set lower limit to RATIO reference | N | N | N | N | N | — | |
| | 14.2 | 14.2SP | Set upper limit to RATIO reference | N | N | N | N | N | — | |
| | 14.3 | 14.3SP | Restore lower limit | N | N | N | N | N | — | |
| | 14.4 | 14.4SP | Restore upper limit | N | N | N | N | N | — | |
| | 14.5 | 14.5SP | Read lower limit | Y | Y | Y | Y | Y | Y | |
| | 14.6 | 14.6SP | Read upper limit | Y | Y | Y | Y | Y | Y | |
| | 14.7 | 14.7SP | Read lower limit measurement code | Y | Y | Y | Y | Y | Y | |
| | 14.8 | 14.8SP | Read upper limit measurement code | Y | Y | Y | Y | Y | Y | |
| Time Base Oven (Option 002 only) | 15.0 | 15.0SP | Display E12 if internal reference oven is cold | Y | Y | Y | Y | Y | N | If the oven is warm or if the high stability reference oscillator is not installed; no display change occurs. |
| AM Calibration (Option 010 only) | 16.0 | 16.0SP | Disable AM calibration factor | N | — | — | — | — | — | Calibration, AM |
| | 16.1 | 16.1SP | Enable AM calibration factor | N | N | N | N | N | — | |
| | 16.2 | 16.2SP | Read AM calibration factor (0 if not enabled) | Y | Y | Y | Y | Y | Y | |
| FM Calibration (Option 010 only) | 17.0 | 17.0SP | Disable FM calibration factor | N | — | — | — | — | — | Calibration, FM |
| | 17.1 | 17.1SP | Enable FM calibration factor | N | N | N | N | N | — | |
| | 17.2 | 17.2SP | Read FM calibration factor (0 if not enabled) | Y | Y | Y | Y | Y | Y | |

N = No; — = Not applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

# Special Functions

### Special Function Summary (4 of 4)

| Special Function | | Program Code | Description | Lights SPCL key | Disabled by | | | | Display Timed | References and Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Name | Code | HP-IB | | | AUTO. OP. key | Any MEAS. key | CLEAR key | All keys* | | |
| Tone Burst Receiver | 18.NN | 18.NNSP | Configures the Modulation Analyzer as a tone burst receiver where a settling time is inserted between detecting a carrier and turning on MODULATION OUTPUT. NN is that time from 1 through 99 ms. If NN = 0, the delay is 99 ms. | Y | Y | Y | Y | Y | N | Tone Burst Receiver |
| HP-IB Address | 21.0 | 21.0SP | Displays HP-IB address in form AAAAA.TLS. AAAAA is the binary address. T=1 means talk only, L=1 means listen only; S=1 means service request issued. | Y | Y | Y | Y | Y | N | HP-IB Address |
| Service Request | 22.NN | 22.NNSP | Enables a condition to cause a service request to be issued. NN is the sum of any combination of the weighted conditions below:<br>1 Data ready<br>2 HP-IB error<br>4 Instrument error<br>8 Upper limit reached<br>16 Lower limit reached<br>Instrument powers up in the 22.2 state. | N | N | N | N | N | N | Service Request Condition. This function is set to zero suffix by a HP-IB Clear message or by Service Special Functions 40 and 41. |

N = No; — = Not Applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

# Time Base 10 MHz Input and Output

## GENERAL

**CAUTION**

*Do not apply greater than 20 V (pk) (ac + dc) into the TIME BASE 10 MHz INPUT or damage to the instrument may result.*

*Do not apply greater than 3 V dc or greater than +20 dBm into the TIME BASE 10 MHz OUTPUT or damage to the instrument may result.*

## DESCRIPTION

TIME BASE 10 MHz INPUT provides an iinput for an external 10 MHz time base reference. This input is ac coupled and requires an input signal level greater than 0.5 V (p-p). The input impedance is approximately 500Ω. TIME BASE 10 MHz OUTPUT (available only with the high stability reference, Option 002) proviides an output for the internal 10 MHz reference. This is a 50Ω, TTL compatiible output (0 V to > 2.2 V into an open circuit.

## COMMENTS

An Option 002 (high stability reference) Modulation Analyzer driven from an external reference will only output the signal form its own internal reference, not the external input signal.

When using an external time base reference, the accuracy of all measurements depends on the accuracy of the external reference.

When an external time base of sufficient amplitude is applied, the Modulation Analyzer time base circuitry automatically switches to the external time base.

If the internal time base fails, an external time base may still be used. Connect the extenal time base to TIME BASE 10 MHz INPUT, the switch the instrument's LINE switch to STBY and back to ON.

To drive several instruments from a singel external reference, simply use a BNC tee at the Modulation Analyzer's TIME BASE 10 MHz INPUT.

To determine whether the Modulation Analyzer has actually switched in the externally applied time base, key in 46.9 SPCL. The display should show 1 000 000 ±1 if the external time base is in. If the external signal was not switched in, the display will show 0 or 1 only.

# Tone-Burst Receiver

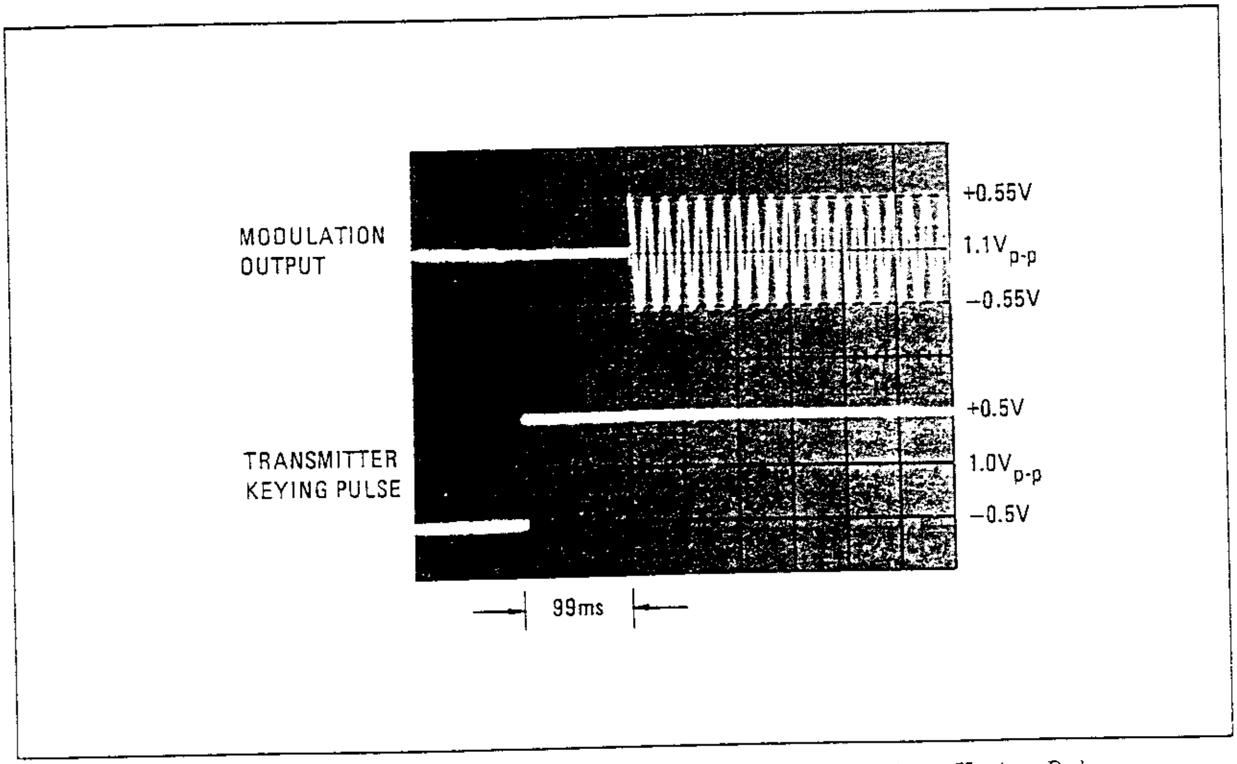
## FUNCTIONS

Special Function 18 (Tone-Burst Receiver)

## DESCRIPTION

In some FM applications (mobile radio testing, for example), after a transmitter is keyed, it issues squelch tones for a brief interval. Often, it is necessary to measure the frequency of the squelch tones. This measurement is made difficult by the noise in the demodulated audio during the short delay between the keying of the transmitter and the appearance of the audio tones.

Special Function 18 enables the Modulation Analyzer to be configured as a tone-burst receiver. This function inserts a user-selectable delay between the instant the instrument senses an RF signal at its INPUT and the time when it turns on the output of MODULATION OUTPUT. When an external counter is connected to this output, the squelch tone will reach the counter only when a valid measurement can be made. The time delay is selectable from 1 through 99 milliseconds. The following photo illustrates a 99 ms delay between transmitter keying (lower trace).



*Oscilloscope Photo Depicting a 99 ms Delay Between Transmitter Keying Pulse (Lower Trace) and Activation of MODULATION OUTPUT*

## PROCEDURE

In order to successfully measure tone bursts:

1. Tune and range the Modulation Analyzer.
2. Select FM.
3. Select an audio detector and if desired, audio filters and FM de-emphasis.
4. Key on the transmitter and allow the Modulation Analyzer to range and tune automatically.
5. Select Hold Settings (9.0 SPCL) to hold all ranges and tuning.
6. Select the time delay to be inserted between the moment the transmitter is keyed and the time MODULATION OUTPUT is to be turned on. This delay becomes the Special Function suffix. (If 18.0 SPCL is selected, the Modulation Analyzer executes a 99 ms delay.)
7. Enter the Special Function code 18.NN (where NN is the selected delay in milliseconds), then select SPCL. (If 18.5 is entered, a 5 ms delay is executed. For a 50 ms delay, enter 18.50.)

The Modulation Analyzer is now set up to receive tone bursts. To exit this mode, select any key except the S (shift), LCL, or numeric keys.

## EXAMPLES

A 50 ms delay is inserted by the Modulation Analyzer between the keying of an FM mobile radio transmitter and the measuring of its squelch tone frequency. It is assumed that the Modulation Analyzer is tuned to the transmitter frequency and that the input attenuation, modulation range and tuning are fixed.

| | |
|---|---|
| **LOCAL**<br>(keystrokes) | Code: 1 8 . 5 0 — Function: • SPCL |
| **HP-IB**<br>(program codes) | 18.50SP<br>Code: 18.50 — Function: SP |

## PROGRAM CODES HP-IB

The Special Function code suffix is derived from the time delay as described previously. The HP-IB code for the SPCL key is SP.

## INDICATIONS

As the numeric code is entered, it appears on the front panel display. When the SPCL key is pressed, the display shows two dashes (– –) if no RF is at the INPUT. The display shows 18.NN if RF is present (NN is the delay in milliseconds). All key lights will be turned off (including the FM and DETECTOR) keys) except the filter and de-emphasis keys (if selected) and the SPCL key. Note that if DE-EMPHASIS PRE-DISPLAY is selected, the PRE-DISPLAY key will be turned off since FM is not being displayed.

## COMMENTS

### Suggested Use of Maximum Delay

When using the Tone Burst Receiver Special Function, use the 99 ms delay for best results. Shorter delays require very careful setup since, with no input, the high-gain IF Amplifier and Limiters "tune" the noise to an average frequency often slightly different than the nominal IF. When RF first enters the instrument, the IF shifts abruptly to the nominal frequency. This shift creates an FM transient which settles out after a short period and thus is not apparent with longer delays. With short delays the transients can be avoided by carefully tuning the instrument so that the IF frequency when the transmitter is on is close to, or equal to the average IF frequency when the transmitter is off.

### HP-IB

This function is best used when operating through HP-IB since the external counter connected to the output of MODULATION OUTPUT may need to acquire several sets of data in rapid succession (when counting multiple tones, for example).

### Selective Range Holding

Ranges can be held for this function using the individual Special Functions for each parameter instead of using the Hold Settings Special Function (9.0 SPCL).

### Default Condition

Special Function code 18.0 provides a 99 ms delay.

### Tone Burst Frequency Cannot Be Measured

The audio frequency measurement mode cannot be used to measure the frequency of the tone burst.

### ΦM But Not AM

This feature works also with the ΦM measurement mode but not AM.

## RELATED SECTIONS

Attenuation, Input
FM
Hold Settings
Modulation Range
Special Functions
Tuning

# Tuning

## FUNCTIONS

Special Function 4

## DESCRIPTION

The Modulation Analyzer is considered tuned to an input signal when the frequency of the Local Oscillator (LO) is adjusted to produce an IF signal that is centered in the IF passband. Normally, this occurs when the LO frequency is placed either 1.5 MHz or 455 kHz above the input frequency, depending upon which IF is selected. The only exception to the above is when the 1.5 MHz IF is selected for input frequencies below 2.5 Mhz. Under these conditions, the LO is tuned to 101.5 MHz and the low-frequency input passes directly into the IF.

The Modulation Analyzer employs two techniques to determine what frequency to tune to. In Automatic tuning, the entire input spectrum is searched for the presence of a signal. Once found, the LO is tuned so that the signal is received. In manual tuning, the desired input frequency is entered via the numeric keyboard, and the LO is tuned so that the frequency is received.

The LO can be configured in two ways: a fixed frequency mode that is used for low-noise measurements, and a tracking mode in which the LO follows a moving input signal. The two frequency selection techniques and LO configurations combine to produce three tuning modes: Automatic Tuning — Low Noise LO, Automatic Tuning — Track Mode, and Manual Tuning. Two kinds of manual tuning are allowed: keyboard entry of input frequency and frequency stepping. All of these tuning modes are described in more detail below.

### Automatic Tuning — Low-Noise LO

In this mode, if not already tuned, the Modulation Analyzer searches throughout its frequency range for an input signal and tunes to it. To successfully tune to the desired signal, the signal's second and third harmonic levels must be al least 10 dB below the level of the fundamental. All other signals at the input must be at least 30 dB below the level of the desired signal. If two input signal have similar power levels, the higher frequency signal is usually selected. Once tuned, the LO is locked to an internal voltage controlled crystal oscillator for highly stable, low-noise measurements. This tuning is maintained as long as a detectable signal is present. If the input signal disappears (drops below −20 to −25 dBm), the Modulation Analyzer returns to the searching process. This mode of tuning is selected whenever AUTOMATIC OPERATION is pressed, and may be used with either the 1.5 MHz or 455 kHz IF.

### Automatic Tuning — Track Mode

In this mode, the instrument searches for the input signal as described above; however, it does not lock to the internal reference oscillator. Instead, the LO is locked to the input signal itself and thus tracks that signal as it moves. This is extremely useful for checking modulation or level as a function of carrier frequency. If the input signal disappears (for example, while switching bands), the Modulation Analyzer will search for, and will re-acquire the input signal. Track mode tuning is not allowed with the lo-rate LFM on the input signal, thus FM measurements should only be made in track mode when modulation rates exceed 1 kHz. Also, track mode tuning is not recommended where optimum noise performance is recommended where optimum noise performance is required.