8901B MODULATION ANALYZER

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 2314A.

For additional important information about serial numbers, see INSTRUMENT COVERED BY MANUAL in Section I.

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

Operating Information Supplement Part No. 08901-90081

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HEWLETT PACKARD

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 result in 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 many 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 of 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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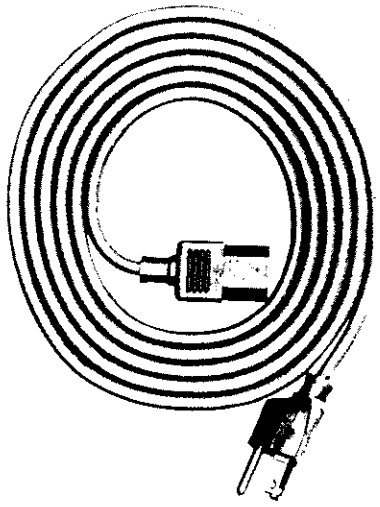
MODEL 8901B



LINE POWER CABLE

Model 08901B Modulation Analyzer and Supplied Accessories

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION

This Operating Information manual and the two Service Information manuals form the Operating and Service Manual which contains information required to install, operate, test, adjust, and service the Hewlett-Packard Model 8901B Modulation Analyzer. The Modulation Analyzer is shown in Figure 1-1 with all supplied accessories. These manuals document Measuring Receivers supplied with Options 001, 002, 003, and 004.

The information contained in the Operating and Service Manual is made available as follows: Sections I through III are contained in this Operating Information manual, Sections IV through VIII are contained in the two Service Information manuals. The three manuals are packaged in a binder as the Operating and Service Manual.

Section I, 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.

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

Section III, Operation: provides information about panel features and includes operating checks, and operating instructions for both local and remote operation.

Section IV, Performance Tests: provides the information required to check performance of the instrument against the critical specifications in Table 1-1.

Section V, Adjustments: provides the information required to properly adjust the instrument.

Section VI, Replaceable Parts: provides ordering information for all replaceable parts and assemblies.

Section VII, Manual Changes: provides manual change information necessary to document all serial prefixes listed on the title page of the second Service Information manual.

Section VIII, Service: provides the information required to repair the instrument.

INTRODUCTION (Cont'd)
Two copies of this Operating Information manual are supplied with the Modulation Analyzer. One copy should stay with the Modulation Analyzer for use by the operator. Additional copies can be ordered separately through your nearest Hewlett-Packard office. The part number is listed on the title page of this manual.

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 in Table 1-2, 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 (i.e., 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 or service) is found throughout these manuals.

1-4. INSTRUMENTS COVERED BY MANUAL

Options. Electrical options 001, 002, 003, and 004, various mechanical options are documented in these manuals. The differences are noted under the appropriate paragraph such as "Options" in Section I, in the Replaceable Parts List, and in 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 these manuals apply directly to instruments having the same serial number prefix(es) as listed under SERIAL NUMBERS on the respective manual title pages.

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

1-5. MANUAL CHANGES SUPPLEMENT

An instrument manufactured after the printing of these manuals may have a serial number prefix that is not listed on the title pages. This unlisted serial number prefix indicates the instrument is different from those described in the manual. The Operating and Service Manual is supplied with a Manual Changes supplement for these newer instruments. The supplement contains change instructions for the manual.

In addition to change information, the supplement can contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. These supplements are identified with the print dates and part numbers that appear on the title page of the Operating and Service Manual. Complimentary copies of these supplements are available from Hewlett-Packard.

1-6. DESCRIPTION

The HP Model 8901B Modulation Analyzer is a complete measurement system for accurately characterizing signals in the 150 kHz to 1300 MHz frequency range. It combines the capabilities of three separate instruments in its ability to measure RF power, carrier frequency, modulation and the characteristics of the demodulated audio signal (as well as those of external audio signals). This flexibility allows you to make those measurements most commonly needed to totally characterize a signal.

The Modulation Analyzer can measure an RF signal's frequency, frequency drift, power level, amplitude modulation (AM), frequency modulation (FM), phase modulation (ϕM), and AM and FM noise components. It recovers the modulating signal and can measure the audio signal's frequency and distortion.

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 via the Hewlett-Packard Interface Bus (HP-IB). (HP-IB is Hewlett-Packard's implementation of IEEE Standard 488 and ANSI Standard MC1.1.)

RF Power delivers the accuracy and resolution of a high-performance power meter. The HP 8901B, with the HP 11722A Sensor Module, measures power from +30 dBm to -20 dBm at frequencies from 150 kHz to 2.6 GHz. (Refer to Table 1-1, Specifications, for specified frequencies limits using other power sensors. The 8901B also accepts all HP 8480 series power sensors for extended measurement capability.)

The Modulation Analyzer is equipped with input power protection to prevent damage from the accidental application of excessive power.

DESCRIPTION (Cont'd)
(This is a common cause of damage in equipment used to measure transmitters.) The Modulation Analyzer is tested for inputs up to 4 watts. Protection is provided by limiting 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.

RF Power Calibration is accomplished with the 50 MHz, 1 mW standard available in every instrument. Also, the front-panel zero function enables you to zero the sensor module without removing it from the source-under-test. After the ZERO key is pressed, the new zero offsets are stored automatically.

RF Power Calibration Factors can be entered from the power sensor into the Modulation Analyzer's non-volatile memory. The instrument automatically compensates for the power sensor's efficiency and mismatch loss at each frequency.

Display Flexibility enables the Modulation Analyzer to offer numerous data-display formats. For example, RF power and tuned RF level can be displayed in watts, dBm, volts, dBv, mv, dBmv, uv, and dBuv. Use the RATIO and LOG/LIN keys to display results in dB or % relative to either a measured value or a value entered from the keyboard. These features eliminate the need for recalculating measurement results.

RF Frequency Measurements. In automatic operation, the Modulation Analyzer has the performance of a high-quality, 150 kHz to 1300 MHz frequency counter. The frequency counter 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.

In automatic operation, the Modulation Analyzer automatically tunes to the largest input signal and measures its frequency.

In manual operation, you can determine the frequency to which the Modulation Analyzer tunes. Entering the approximate frequency on the keyboard causes all but very close interfering signals to be eliminated. This allows the Modulation Analyzer to selectively count signals other than the largest.

A track mode feature enables you to track a signal, as it changes frequency, from either automatic or manual tune operation.

Modulation Measurements. The Modulation Analyzer has extremely low, internal noise. Incidental AM, FM, and ϕM can be measured on a wide range of simple and complex modulated signals. To complement its modulation measurement capability, the HP 8901B characterizes audio signal level, frequency, and distortion.

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

DESCRIPTION (Cont'd)
match those needed for applications such as transmitter or signal generator testing. The >20 kHz filter is a Bessel filter. It minimizes overshoot for squarewave 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 *us*. When selected, the de-emphasis networks always affect the demodulated output. You can select whether the de-emphasis network affects the deviation measured. The ability to select either the actual or "de-emphasized deviation" increases the usefulness of the Modulation Analyzer in many applications.

Modulation Calibrators are included in every Modulation Analyzer. 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 all instruments, a precise AM and FM modulation standard is included.

When the output of the calibrator is connected to the Modulation Analyzer's input, the amount of modulation is measured to create a calibration factor. The calibration factor can be used to automatically compensate all subsequent measurements. The calibration factor is the ratio of the measured modulation to the internally-computed modulation of the calibrator, expressed in %.

Store and Recall functions enable you to store eight, complete instrument settings in non-volatile memory and recall them as needed.

Special Functions. The Modulation Analyzer can do more than is apparent from the front panel. Many functions are accessed using the numeric keys and a Special Function key. The Special Functions provide access to other measurements and functions, manual control of instrument functions, instrument operation verification, and service aids.

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

Operation to 42 GHz is accomplished when an external LO and mixer are included in the measurement path. This system then functions as a single instrument making microwave modulation, frequency, power, and

DESCRIPTION (Cont'd)
level measurements. You control operation from the Modulation Analyzer's front panel. When the external LO frequency must be changed, the Modulation Analyzer requests the external controller to make the change. A separate, non-volatile calibration factor table is available in Frequency Offset mode for your microwave power sensor.

Programmability. The Modulation Analyzer is completely programmable via 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 annunicators make it very easy to determine the state the instrument is in; whether it is in the talk, listen, or service request state.

1-7. OPTIONS

1-8. Electrical Options

Option 001. This option provides rear-panel (instead of front-panel) connections for RF INPUT, SENSOR input, MODULATION OUTPUT/AUDIO INPUT, and AM/FM and RF POWER CALIBRATION OUTPUTs.

Option 002. This option provides a high-stability (1×10^{-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 400 Hz. Operation at frequencies greater than 66 Hz is restricted to $\leq$126.5 Vac line input.

1-9. Mechanical Options

The following kits might have been ordered and received with the Modulation Analyzer. (See Figure 1-2.) 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 5061-0090 for the basic kit and 2190-0048 for lockwashers (8 required).

OPTIONS (Cont'd)
Rack Flange Kit (Option 908). The Modulation Analyzer can be solidly mounted to the instrument rack using the flange kit. Order HP part number 5061-0078.

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 5061-0084 for the basic kit and 2190-0009 for lockwashers (8 required).

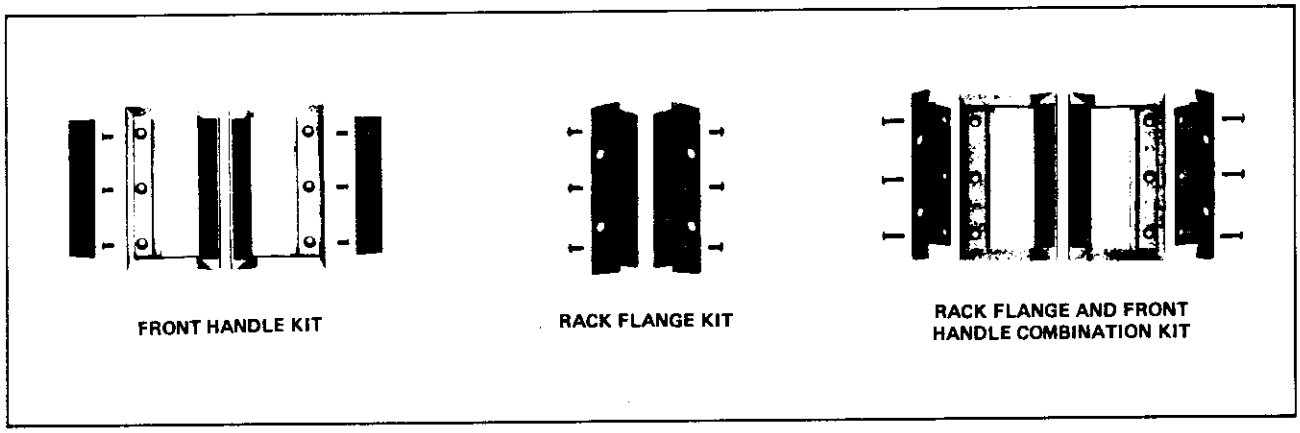


Figure 1-2. Rack-Mounting Options

1-10. 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 via open-collector TTL circuitry. An explanation of the compatibility code may be found in IEEE Standard 488, "IEEE Standard and 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 III of this Operating Information 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 II shows all HP-IB talk and listen addresses. Refer to "HP-IB Address Selection" in Section II of this Operating Information manual.

1-11. 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 II of this Operating Information manual.

b. Fuses with a 2.5A rating for 115 Vac (HP 2110-0083) and a 1.5A rating for 230 Vac (HP 2110-0043) 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 II of this Operating Information manual.

1-12. 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.

Sensor Module. The 11722A Sensor Module enables a single input connector to be used to characterize a signal without switching back and forth between the Modulation Analyzer's SENSOR input and RF INPUT connectors. Special care is taken with each sensor module to minimize input SWR and resulting errors. A low SWR attenuator isolates the power sensor from the source-under-test, reducing mismatch. Microwave hardware and a selected RF input cable further improve SWR and insertion loss.

Test Source. The 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 08901-60089) 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/AUDIO INPUT, and AM/FM and RF POWER CALIBRATION OUTPUT to rear-panel connections. Order HP part number 08902-60026. After installation and calibration, performance will be identical to the HP 8901B Option 001.

ELECTRICAL EQUIPMENT AVAILABLE (Cont'd)

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 RF INPUT, SENSOR input, MODULATION OUTPUT/AUDIO INPUT, and AM/FM and RF POWER CALIBRATION OUTPUTs to front-panel connections. Order HP part number 08902-60027. After installation and calibration, performance will be identical to the standard 8901B.

High Stability Internal Reference Retrofit Kit (HP 08902-60028). 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 8901B Option 003.

Conversion to 400 Hz Line Operation. Measuring Receivers 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 Vac. To convert to 400 Hz operation, order HP part number 08902-60029. After installation, performance will be identical to the 8901B Option 004.

1-13. 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 Slide 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.

1-14. RECOMMENDED TEST EQUIPMENT

Table 1-3 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. Table 1-3 also includes some alternate equipment listings. Table 1-4 lists a number of accessories required in addition to those contained in the Service Accessory Kit, HP 08901-60089.

1-15. PRINCIPLES OF OPERATION FOR SIMPLIFIED BLOCK DIAGRAM

The Modulation Analyzer is a calibrated, superheterodyne receiver, which converts the incoming signal to a fixed, intermediate frequency (IF), which is then demodulated. As in a radio receiver, the Modulation Analyzer contains an RF amplifier, a local oscillator (LO), a mixer, an IF amplifier and bandpass filter, a demodulator (detector or discriminator), and audio filters (tone controls). The Modulation Analyzer, however, contains additional features which make it much more versatile:

- automatic tuning,
- selectable measurement mode: signal frequency, power level, or modulation (AM, FM, or Phase Modulation (ϕM))
- calibrated, wide-band, power level measurements,
- selectable audio detector (peak, average, or rms responding),
- audio counter,
- audio distortion analyzer,
- measurement calibrators (AM, FM, or power level), and
- HP-IB programmability.

The entire operation of the instrument is governed by a microprocessor-based Controller. The Controller sets up the instrument at turn-on, interprets keyboard entries, executes changes in internal hardware, and displays measurement results and error messages. The computing capability of the Controller is also used to simplify circuit operation. For example, it forms the last stage of the Counter, calculates the AM or FM generated by the AM and FM Calibrators, and converts measurement results into ratios (in % or dB). The Controller also contains routines useful for servicing the instrument.

RF. The RF input signal normally enters an external Sensor Module such as an HP 11722A. (See Figure 1-3.) For all measurements except RF Power, the Sensor Module routes the signal to the RF input conector of the Modulation Analyzer. For the RF Power measurement, the input signal passes directly into the Power Sensor, which converts the RF power absorbed by the RF Power Sensor into a low-frequency, chopped, ac voltage whose amplitude is proportional to the average RF power. The Power Meter amplifies the chopped signal and converts it to a dc voltage which is then measured by the voltmeter. (The voltmeter includes the Audio Peak Detector, Audio Average Detector, Voltage-to-Time Converter, and Counter.) The calibration of the Power Meter can be verified by connecting the Sensor Module to the CALIBRATION RF POWER OUTPUT connector on the front panel. (The 50 MHz Power Reference Oscillator is an accurate 1 mW reference.)

PRINCIPLES OF OPERATION FOR SIMPLIFIED BLOCK DIAGRAM (Cont'd)

CAUTION

The Power Sensor is unprotected against and is easily damaged by sudden, large overloads. Refer to Table 1-2 for information on maximum overload levels.

When the RF Peak Detector senses that the input signal level exceeds 1W, it opens the Overpower Relay. This is done without intervention of the Controller. The output from the RF Peak Detector, read by the voltmeter, is used to set the Input Attenuator to optimize the level applied to the Input Mixer.

The Input Mixer converts the input signal to the intermediate frequency (IF). For frequencies greater than 10 MHz, the IF is 1.5 MHz with the Local Oscillator (LO) tuned 1.5 MHz above the input frequency, but an IF of 455 kHz can be manually selected for this frequency range. The 455 kHz IF is selected automatically for input signals between 2.5 MHz and 10 MHz. Below 2.5 MHz, the input passes directly through the Input Mixer without down-conversion.

NOTE

For the input signal to pass through the Input Mixer without down-conversion, the LO must still be present to turn the mixer diodes on. An LO frequency of 101.5 MHz is arbitrarily used. Thus the instrument will respond to input frequencies of 100 or 103 MHz as well as frequencies between 150 kHz and 2.5 MHz.

The instrument can be manually tuned to a desired signal even in the presence of larger signals, although filtering may be necessary since low-frequency signals pass directly into the IF. The RF High-Pass Filter can be inserted (via a Special Function) in the RF path for this purpose.

To measure the input frequency, the Counter measures the frequency of the LO and the frequency of the IF from the output of the IF Amplifier and Filter. The Controller computes and displays the difference between the two frequencies. For input frequencies below 2.5 MHz, only the IF is counted, which equals the input frequency.

LO. The LO drives the high-level port of the Input Mixer and is one of several inputs to the Counter. The LO has four main modes of operation:

- tuning to the frequency required to down-convert a signal whose frequency is entered from the keyboard (manual tune mode),

PRINCIPLES OF OPERATION FOR SIMPLIFIED BLOCK DIAGRAM (Cont'd)

- automatically searching for an input signal, then tuning the LO to the frequency required to down-convert the signal (automatic tune mode),

- automatically searching for an input signal, then configuring the LO in a feedback loop that automatically tracks the signal (automatic tune track mode), and

- tuning to the frequency required to down-convert a signal whose frequency is entered from the keyboard, then configuring the LO in a feedback loop that automatically tracks the input signal (manual tune track mode).

The manual tune track mode is useful when it is desired to follow an unstable signal in the presence of other signals. The non-track modes are used when the LO noise (residual FM) must be minimized.

IF. The gain of the IF Amplifier is fixed. The IF Filters determine the frequency response of the IF. When the 1.5 MHz IF is selected, the IF filter consists of a 150 kHz to 2.5 MHz bandpass filter (with a nominal center frequency of 1.5 MHz). When the 455 kHz IF is selected, the IF filter is the 455 kHz Bandpass Filter (with a bandwidth of 200 kHz).

Audio. The modulation on the IF is demodulated by either the AM or the FM Demodulator. Phase modulation is recovered by integrating the demodulated FM in the Audio Filters and Gain Control circuitry.

The demodulated signal is amplified and filtered in the Audio Filters and Gain Control circuitry. The filters are selected from the front panel, and for FM, the filtering may also include de-emphasis. The processed signal is passed to the front-panel MODULATION OUTPUT/AUDIO INPUT connector and the voltmeter.

The audio signal from the Audio Filters and Gain Control is converted to a dc voltage by the Audio Peak Detector or the Audio Average Detector. The Audio Average Detector is used primarily for measuring noise. The output from the detectors is routed into the Voltage-to-Time Converter.

The Voltage-to-Time Converter within the voltmeter converts the dc input into a time interval. During the interval, the 10 MHz Time Base Reference is counted by the Counter, and the resultant count represents the dc voltage. Other inputs to the voltmeter, which are not shown, include outputs from an audio level detector and the AM calibrator.

The Distortion Analyzer measures the distortion of either the internal demodulated signal or an audio signal applied externally to the MODULATION OUTPUT/AUDIO INPUT connector. The frequency of the input signal must be either 1 kHz or 400 Hz. The distortion on the signal is determined by measuring the amplitude of the signal before and

PRINCIPLES OF OPERATION FOR SIMPLIFIED BLOCK DIAGRAM (Cont'd)

after a notch filter that is set to 1 kHz or 400 Hz. The two ac signals are converted to dc by a the Audio RMS Detector and then measured by the voltmeter. Distortion is computed as the ratio of the voltage out of the notch filter to the voltage into the filter. (The Audio RMS Detector can also be used to measure the demodulated AM, FM, or ϕM internally or the ac level of an external audio signal applied to the MODULATION OUTPUT/AUDIO INPUT connector.)

The frequency of the audio signal at the MODULATION OUTPUT/AUDIO INPUT connector, whether internal or external, is measured by a reciprocal-type Audio Counter. In the Audio Counter, the input signal is used to gate the 10 MHz Time Base Reference into the main Counter. (This gating function is also used by the Voltage-to-Time Converter.) The number of time base pulses received during the count is read by the Controller which computes and displays the signal frequency.

The AM and FM Calibrators provide a nominal 10.1 MHz signal with a precisely known amount of AM or FM. When this signal is applied to the instrument's RF INPUT connector (either directly or via the Sensor Module), the modulation is measured and the calibration factor of the AM or FM Demodulator is computed and displayed. Related front-panel functions are automatically set for proper demodulation of the calibrator signal.

Table 1-1. Specifications (1 of 7)

AMPLITUDE MODULATION

Rates:
20 Hz to 10 kHz, 150 kHz $\leq f_c <$ 10 MHz.
20 Hz to 100 kHz, 10 MHz $\leq f_c \leq$ 1300 MHz.

Depth: to 99%

Accuracy[1,2,3]:

AM Accuracy	Frequency Range	Rates	Depths
±2% of reading ±1 digit	150 kHz-10 MHz	50 Hz-10 kHz	5%-99%
±3% of reading ±1 digit	150 kHz-10 MHz	20 Hz-10 kHz	to 99%
±1% of reading ±1 digit	10 MHz-1300 MHz	50 Hz-50 kHz	5%-99%
±3% of reading ±1 digit	10 MHz-1300 MHz	20 Hz-100 kHz	to 99%

For rms detector add ±3% of reading

Flatness[4,5]:

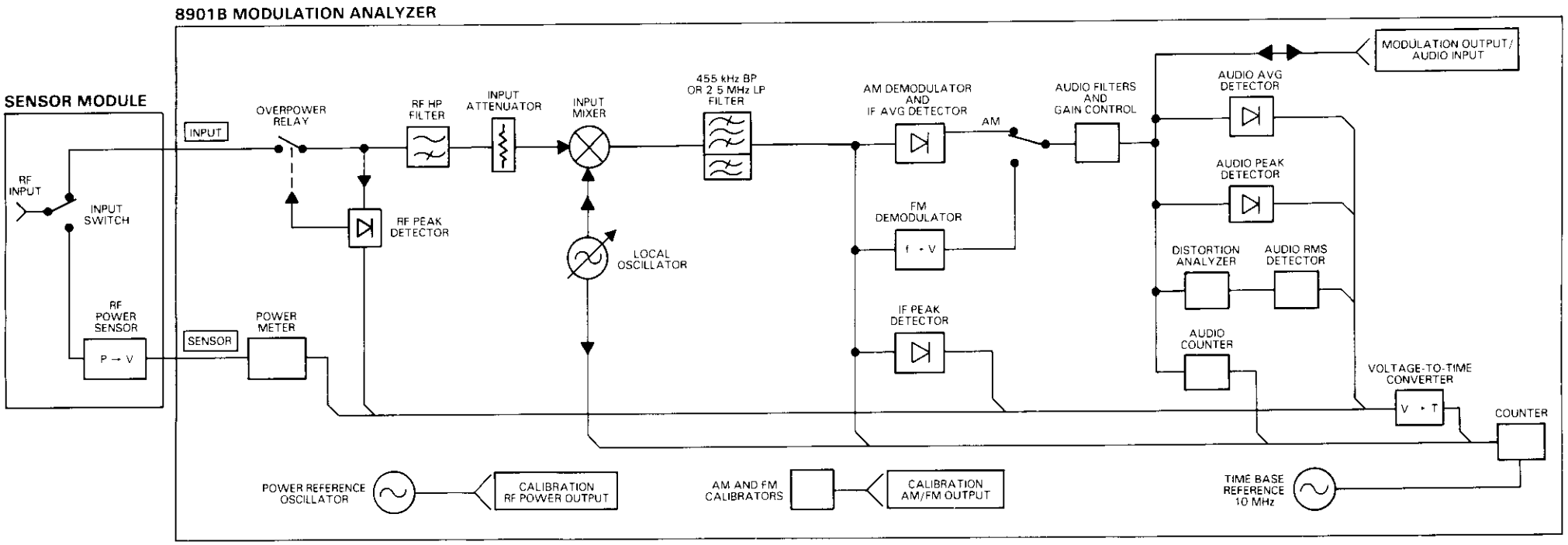
Flatness	Frequency Range	Rates	Depths
±3% of reading ±1 digit	10 MHz-1300 MHz	90 Hz-10 kHz	20%-80%

Demodulated Output Distortion:
<0.3% THD for ≤50% depth.
<0.6% THD for ≤95% depth.

FM Rejection (50 Hz to 3 kHz BW)[2]:

FM Rejection	Frequency Range	Rates	FM Deviations
<0.2% AM	250 kHz-10 MHz	400 Hz or 1 kHz	$<5\ kHz_{peak}$
<0.2% AM	10 MHz-1300 MHz	400 Hz or 1 kHz	$<50\ kHz_{peak}$

Residual AM (50 Hz to 3 kHz BW): $<0.01\%_{rms}$



HP 8901B Modulation Analyzer Simplified Block Diagram

Table 1-1. Specifications (2 of 7)

FREQUENCY MODULATION

Rates[6]:
20 Hz to 10 kHz, 150 kHz $\leq f_c <$ 10 MHz.
20 Hz to 200 kHz, 10 MHz $\leq f_c \leq$ 1300 MHz.

Deviations[6]:
40 kHz_{peak} maximum, 150 kHz $\leq f_c <$ 10 MHz.
400 kHz_{peak} maximum, 10 MHz $\leq f_c \leq$ 1300 MHz.

Accuracy[1,2,6]:

FM Accuracy	Frequency Range	Rates	Deviations
±2% of reading ±1 digit	250 kHz-10 MHz	20 Hz-10 kHz	≤40 kHz_{peak}
±1% of reading ±1 digit	10 MHz-1300 MHz	50 Hz-100 kHz	≤400 kHz_{peak}
±5% of reading ±1 digit	10 MHz-1300 MHz	20 Hz-200 kHz	≤400 kHz_{peak}

For rms detector add ±3% of reading.

Demodulated Output Distortion[6,7]:

THD	Frequency Range	Rates	Deviations
<0.1%	400 kHz-10 MHz	20 Hz-10 kHz	<10 kHz
<0.1%	10 MHz-1300 MHz	20 Hz-100 kHz	<100 kHz

AM Rejection (50 Hz to 3 kHz BW)[2]:

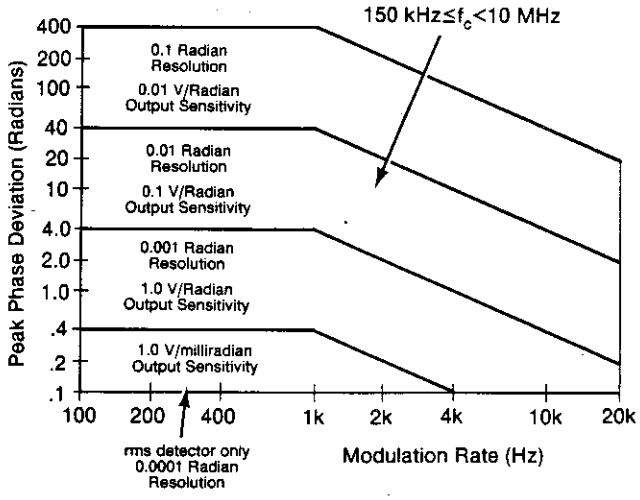
AM Rejection	Frequency Range	Rates	AM Depths
<20 Hz peak deviation	150 kHz-1300 MHz	400 Hz or 1 kHz	≤50%

Residual FM (50 Hz to 3 kHz BW):
<8 Hz_{rms} at 1300 MHz, decreasing linearly with frequency to <1 Hz_{rms} for 100 MHz and below.

Table 1-1. Specifications (3 of 7)

PHASE MODULATION

Rates:
200 Hz to 10 kHz, 150 kHz $\leq f_c <$ 10 MHz.
200 Hz to 20 kHz, 10 MHz $\leq f_c \leq$ 1300 MHz.
Accuracy[2]:
$\pm$4% of reading $\pm$1 digit, 150 kHz $\leq f_c <$ 10 MHz.
$\pm$3% of reading $\pm$1 digit, 10 MHz $\leq f_c \leq$ 1300 MHz.
For rms detector add $\pm$3% of reading.
Demodulated Output Distortion: <0.1% THD.
AM Rejection (for 50% AM at 1 kHz Rates)[2]:
<0.03 radians peak (50 Hz to 3 kHz BW).
Maximum Deviation, Resolution, and Maximum Demodulated Output Sensitivity Across an Open Circuit (600 ohms Output Impedance)[5]:



MODULATION REFERENCE

AM Calibrator Depth and Accuracy:
33.33% depth nominal, internally calibrated to an accuracy of $\pm$0.1%.
FM Calibrator Deviation and Accuracy:
34 kHz$_{peak}$ deviation nominal, internally calibrated to an accuracy of $\pm$0.1%.

Table 1-1. Specifications (4 of 7)

FREQUENCY COUNTER

Range: 150 kHz to 1300 MHz.
Sensitivity:
12 mV_{rms} (-25 dBm), 150 kHz $\leq f_c \leq$ 650 MHz.
22 mV_{rms} (-20 dBm), 650 MHz $< f_c \leq$ 1300 MHz.
Maximum Resolution: 10 Hz
Accuracy: $\pm$3 counts of least-significant digit $\pm$ Reference accuracy.

INTERNAL TIME BASE REFERENCE

Frequency: 10 MHz
Aging Rate:
$<1 \times 10^{-6}$/month
$<1 \times 10^{-9}$/day (Option 002)[8]

RF POWER

The HP 8901B Modulation Analyzer, with HP 11722A Sensor Module, performs RF Power Measurements from -20 dBm (10 uW) to +30 dBm (1W) at frequencies from 100 kHz to 2.6 GHz. The 8901B can be used with any of the HP 8480 series power sensors (8481A/1B/1H/2A/2B/2H/3A/4A/5A) to make power measurements from -70 dBm (10 pW) to +44 dBm (25W) at frequencies from 100 kHz to 26.5 GHz. The 8480 series sensors also work with the HP 435A and HP 436A Power Meters. Unless otherwise specified, the specifications shown below refer to the 8901B only. A detailed explanation of how the uncertainty specifications provided below affect the absolute power measurement accuracy of the 8901B is provided in Application Note 64-1.

RF Power Resolution[9]:
0.1% of full scale in watts or volts mode.
0.01 dB in dBm or $dB_{relative}$ mode.
Linearity (includes sensor non-linearity):
RF range linearity $\pm$ RF range-to-range change error.
RF Range Linearity (using Recorder Output)[10]:
$\pm$0.02 dB, RF Ranges 2-5.
$\pm$0.03 dB, RF Range 1.
Using front-panel display add $\pm$1 count of least-significant digit.
RF Range-to-Range Change Error (using Recorder Output):
$\pm$0.02 dB/RF Range change from reference range. Using front-panel display add $\pm$1 count of least-significant digit.
Input SWR: <1.15, using 11722A Sensor Module.
Zero Set (Digital Settability of Zero):
$\pm$0.07% of full scale on lowest range.
Decrease by a factor of 10 for each higher range.

Table 1-1. Specifications (5 of 7)

POWER REFERENCE

Power Output:
1.00 mW. Factory set to ±0.7%, traceable to the U.S. National Bureau of Standards.
Accuracy: ±1.2% worst case (±0.9% rss) for one year (0°C to 55°C).

AUDIO FREQUENCY COUNTER

Frequency Range: 20 Hz to 250 kHz. (Usable to 600 kHz.)
Maximum External Input Voltage: $3V_{rms}$.

Accuracy (For Demodulated Signals)[11]:

Accuracy	Frequency	Modulation (Peak)
±3 counts of least-significant digit ± Internal Reference Accuracy	>1 kHz	AM ≥10% FM ≥1.0 kHz φM ≥1.5 radians
±0.02 Hz ± Internal Reference Accuracy	≤1 kHz	AM ≥10% FM ≥1.0 kHz φM ≥1.5 radian
±0.2 Hz ± Internal Reference Accuracy (3 kHz low-pass filter inserted)	≤3 kHz	1.5% ≤ AM < 10% 0.15 kHz ≤FM <1.0 kHz 0.15 radian ≤φM < 1.5 radian

Accuracy (For External Signals)[11]:

±3 counts of least-significant digit ± Internal Reference	>1 kHz	≥100 mV_{rms}
±0.02 Hz ± Internal Reference Accuracy	<1 kHz	≥100 mV_{rms}

AUDIO DISTORTION

Fundamental Frequencies: 400 Hz ± 5% and 1 kHz ± 5%
Maximum External Input Voltage: 3V.
Display Range: 0.01% to 100.00% (-80.00 dB to 0.00 dB).
Displayed Resolution: 0.01% or 0.01 dB.
Accuracy: ±1 dB of reading.
Sensitivity:
Modulation:
0.15 kHz peak FM, 1.5% peak AM or 0.6 radian peak φM.
External: 100 mV_{rms}
Residual Noise and Distortion[12]:
0.3% (-50.4 dB), temperature <40°C.

Table 1-1. Specifications (6 of 7)

AUDIO RMS LEVEL

Frequency Range: 50 Hz to 40 kHz.
Voltage Range: 100 mV to 3V.
Accuracy: ±4.0% of reading

AUDIO FILTERS

De-emphasis Filters: 25 *us*, 50 *us*, 75 *us*, and 750 *us*.
De-emphasis filters are single-pole, low-pass filters with 3 dB frequencies of: 6366 Hz for 25 *us*, 3183 Hz for 50 *us*, 2122 Hz for 75 *us*, and 212 Hz for 750 *us*.
50 Hz High-Pass Filter (2 Pole):
Flatness: <1% at rates ≥200 Hz.
300 Hz High-Pass Filter (2 Pole):
Flatness: <1% at rates ≥1 kHz.
3 kHz Low-Pass Filter (5 Pole):
Flatness: <1% at rates ≤1 kHz.
15 kHz Low-Pass Filter (5 Pole):
Flatness: <1% at rates ≤10 kHz.
>20 kHz Low-Pass Filter (9 Pole Bessel)[13]:
Flatness: <1% at rates ≤10 kHz.

RF INPUT

Frequency Range: 150 kHz to 1300 MHz.
Operating Level:

Minimum Operating Level	Maximum Operating Level	Frequency Range
12 mV_{rms} (-25 dBm)	7 V_{rms} ($1W_{peak}$) Source SWR <4	150 kHz-650 MHz
22 mV_{rms} (-20 dBm)	7 V_{rms} ($1W_{peak}$) Source SWR <4	650 MHz-1300 MHz

GENERAL SPECIFICATIONS

Temperature: Operating: 0°C to 55°C.
Storage: -55°C to 75°C.
Remote Operation: HP-IB; all functions except the line switch are remotely controllable.
HP-IB Compatibility: (Defined in IEEE 488-1978) SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.
EMI: Conducted and radiated interference is within the requirements of methods CE03 and RE02 of MIL STD 461A (for inputs <10 mW), VDE 0871 (Level B), and CISPR publication 11.

Table 1-1. Specifications (7 of 7)

GENERAL SPECIFICATIONS (Cont'd)

Conducted and Radiated Susceptibility: Meets the requirements of methods CS01, CS02, and RS03 (1 volt/meter) of MIL STD 461A dated 1968.

Power: 100, 120, 220, or 240V (+5%, -10%); 48-66 Hz; 200 VA maximum.

Weight: Net 23 kg. (52 lb.); Shipping 31.4 kg. (69 lb.).

Dimensions: 190 mm. H x 425 mm. W x 468 mm. D (7.5" x 16.8" x 21.7").

HP System II Module Size: 7 H x 1 MW x 20 D.

FOOTNOTES

1 But not to exceed: 50 Hz to 40 kHz rates with rms detector for stated accuracy.

2 Peak residuals must be accounted for in peak readings.

3 For peak measurements only; AM accuracy may be affected by distortion generated by the Modulation Analyzer. In the worst case this distortion can decrease accuracy by 0.1% of reading for each 0.1% of distortion.

4 Flatness is the variation in indicated AM depth for constant depth on input signal.

5 For optimum flatness, cables should be terminated with their characteristic impedance.

6 But not to exceed: 20 kHz rates and 40 kHz peak deviations with 750 μs de-emphasis filter.

7 With 750 μs de-emphasis and pre-display "off", distortion is not specified for modulation outputs >4V peak. This condition can occur near maximum deviation for a measurement range, at rates <2 kHz.

8 After 30-day warm-up.

9 The 8901B fundamental RF Power measurement units are watts. Further internal processing is done on this number to display all other units.

10 When using 8484A sensor, the noise specification may mask the linearity specification and become the predominant error. When operating on the top RF power range, add the Power Sensor Linearity percentages found in the power sensor specifications.

11 With the low-pass and high-pass audio filters used to stabilize frequency readings.

12 For demodulated signals, the residual noise generated by the 8901B must be accounted for in distortion measurements (that is, residual AM, FM, or ϕM).

13 The >20 kHz low-pass filter is intended for minimum overshoot with squarewave modulation.

Table 1-2. Supplemental Information (1 of 5)

AMPLITUDE MODULATION

Detectors: + peak, - peak, ± peak/2, peak hold, average (rms sinewave calibrated), rms.
Maximum Depth, Resolution, and Maximum Demodulated Output Sensitivity Across an Open Circuit (600 ohms Output Impedance)[1]:

Maximum Resolution	Maximum Demodulated Output Sensitivity	Depths
0.1%	0.01 V/percent	AM_{peak} ≥40.0%
0.01%	0.1 V/percent	AM_{peak} <40.0%
0.001% (rms detector only)	0.1 V/percent	AM_{rms} <3.0%

FREQUENCY MODULATION

Maximum FM Deviation, Resolution, and Maximum Demodulated Output Sensitivity Across an Open Circuit (600 ohms Output Impedance)[1]:

Maximum Resolution	Maximum Demodulated Output Sensitivity	Deviations (Δ F)
100 Hz	0.01 mV/Hz	ΔF_{peak} ≥40 kHz
10 Hz	0.1 mV/Hz	4.0 kHz ≤ ΔF_{peak} < 40 kHz
1 Hz	1.0 mV/Hz	ΔF_{peak} <4 kHz
0.1 Hz (rms detector only)	1.0 mV/Hz	ΔF_{rms} <0.3 kHz

Resolution is increased one digit with 750 μs de-emphasis and pre-display on. The demodulated output signal present at the MODULATION OUTPUT/AUDIO INPUT connector is increased in amplitude by a factor of 10 with 750 μs de-emphasis.

Table 1-2. Supplemental Information (2 of 5)

FREQUENCY MODULATION (Cont'd)

Demodulated Output Distortion:

THD	Frequency Range	Rates	Deviations
<0.3%	150 kHz-400 kHz	20 Hz-10 kHz	<10 kHz

Detectors: +peak, -peak, ±peak/2, peak hold, average (rms sinewave calibrated), rms.
Stereo Separation (50 Hz to 15 kHz): >47 dB.

PHASE MODULATION

Modulation Rates: usable from 20 Hz to 100 kHz with degraded performance.
Detectors: +peak, -peak, ±peak/2, peak hold, average (rms sinewave calibrated), rms.

MODULATION REFERENCE

Carrier Frequency: 10.1 MHz
Modulation Rate: 10 kHz
Output Level: -25 dBm

FREQUENCY COUNTER

Modes: Frequency and Frequency Error (displays the difference between the frequency entered via the keyboard and the actual RF input frequency).
Sensitivity in Manual Tuning Mode: Approximate frequency must be entered from keyboard. 0.22 mV_{rms} (-60 dBm).

Table 1-2. Supplemental Information (3 of 5)

INTERNAL TIME BASE REFERENCE

Internal Reference Accuracy: Overall accuracy is a function of time-base calibration ± aging rate ± temperature effects ± line voltage effects ± short-term stability.

	Standard	Option 002
Aging Rate	$<1 \times 10^{-6}$/mo.	$<1 \times 10^{-9}$/day
Temperature Effects	$<2 \times 10^{-7}$/°C	$<2 \times 10^{-10}$/°C
Line Voltage Effects (+5%, -10% Line Voltage Change)	$<1 \times 10^{-6}$	$<6 \times 10^{-10}$
Short Term Stability	---	$<1 \times 10^{-9}$ for 1s average

RF POWER

Zero Drift of Meter:
±0.03% of full scale/°C on lowest range.
Decrease by a factor of 10 for each higher range.

Noise (at Constant Temperature, Peak Change Over Any One-Minute Interval For the 11722A Sensor Module and 8481A/1B/1H/2A/2B/2H/3A/5A Sensors):
0.4% of full scale on range 1 (lowest range).
0.13% of full scale on range 2.
0.013% of full scale on range 3.
0.0013% of full scale on range 4.
0.00013% of full scale on range 5.
For HP 8484A Sensor multiply noise by five on all ranges.

Zero Drift of Sensors (1 hour, at constant temperature after 24-hour warm-up):
±0.1% of full scale on lowest range for 11722A Sensor Module and 8481A/1B/1H/2A/2B/2H/3A/5A sensors.
±2.0% of full scale on lowest range for 8484A sensor. Decrease by a factor of 10 for each higher range.

RF Power Ranges of 8901B Modulation Analyzer with 11722A Sensor Module:
-20 dBm to -10 dBm (10 uW to 100 uW), Range 1.
-10 dBm to +0 dBm (100 uW to 1 mW), Range 2.
+0 dBm to +10 dBm (1 mW to 10 mW), Range 3.
+10 dBm to +20 dBm (10 mW to 100 mW), Range 4.
+20 dBm to +30 dBm (100 mW to 1W), Range 5.

Table 1-2. Supplemental Information (4 of 5)

RF POWER (Cont'd)
Response Time (0 to 99% of Reading):
<10 seconds, Range 1.
<1 second, Range 2.
<100 milliseconds, Range 3-5.
Displayed Units:
watts, dBm, $dB_{relative}$, $\%_{relative}$, volts, mV, μV, dB V, dB mV, dB μV.
Internal Non-Volatile Cal Factor Tables (User Modifiable using Special Functions):
Maximum number of Cal Factor/Frequency entries:
Table #1 (Primary): 16 pairs plus Reference Cal Factor;
Table #2 (Frequency Offset): 22 pairs plus Reference Cal Factor.
Maximum Allowed Frequency Entry: 42 GHz.
Frequency Entry Resolution: 50 kHz.
Cal Factor Range: 40 to 120%.
Cal Factor Resolution: 0.1%.

POWER REFERENCE

Frequency: 50 MHz nominal.
SWR: 1.05 nominal.
Front-Panel Connector: Type-N female.

AUDIO FREQUENCY COUNTER

Displayed Resolution: 6 digits
Measurement Rate: 2 readings/s.
Counting Technique: Reciprocal with internal 10 MHz time base.
Audio Input Impedance: 100 kohms nominal.

AUDIO DISTORTION

Measurement 3 dB Bandwidth: 20 Hz to 50 kHz.
Detection: True rms.
Measurement Rate: 1 reading/s.
Audio Input Impedance: 100 kohms nominal.

AUDIO RMS LEVEL

Full Range Display: 0.3000V, 4.000V.
AC Converter: True-rms responding for signals with crest factor ≤3.
Measurement Rate: 2 readings/s.
Audio Input Impedance: 100 kohms nominal.

AUDIO FILTERS

De-Emphasis Filter Time Constant Accuracy: ±3%.
High-Pass and Low-Pass Filter 3 dB Frequency Accuracy: ±3%.
>20 kHz Low-Pass Filter: 3 dB Cutoff Frequency: 100 kHz nominal.
Overshoot on Squarewave Modulation[2]: <1%.

Table 1-2. Supplemental Information (5 of 5)

RF INPUT

Tuning:
Normal Mode: Automatic and Manual frequency entry.
Track Mode: Automatic and Manual frequency entry, $f_c \geq 10$ MHz.
Acquisition Time (Automatic Operation): ~1.5s.
Input Impedance: 50 ohms nominal.
Maximum Safe DC Input Level: 5V.

8901B REAR-PANEL INPUTS/OUTPUTS

FM Output: 10 kohm impedance, -9V to 6V into an open circuit: approximately 6V/MHz, dc-coupled, 16 kHz bandwidth (one pole).
AM Output: 10 kohm impedance, -4V to 0V into an open circuit: approximately 8 mV/%, dc coupled, 16 kHz bandwidth (one pole).
Recorder Output: DC voltage proportional to the measured results, 1 kohm impedance, 0V to 4V for each resolution range into an open circuit.
IF Output: 50 ohm impedance, 150 kHz to 2.5 MHz, -27 dBm to -3 dBm.
10 MHz Reference Output: 50 ohm impedance, TTL levels (0V to >2.2V into an open circuit), available only with Option 002, 1 x 10^{-9}/day internal reference, outputs internal reference only.
10 MHz Reference Input:[3] >500 ohm impedance, 0.5 $V_{peak\text{-}to\text{-}peak}$ minimum input level.
LO Input (Option 003): 50 ohm impedance, approximately 1.27 MHz to 1301.5 MHz, 0 dBm.
RF Switch Remote Control Output: Provides output signals necessary to remotely control either an HP 33311B Option 011 or an HP 8761A RF Switch.
Frequency Offset Mode Remote Control Output: TTL high output if in frequency offset mode (Special Function 27.1 or 27.3) with an external LO frequency >0, TTL low output for all other cases.

FOOTNOTES

[1] For optimum flatness, cables should be terminated with their characteristic impedance.

[2] The >20 kHz low-pass filter is intended for minimum overshoot with squarewave modulation.

[3] External reference accuracy affects accuracy of all measurements.

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 Output Level: >-20 dBm FM Deviation: 400 kHz peak maximum FM Distortion: <-72 dB at 12.5 MHz carrier with 12.5 kHz deviation and <10 kHz rate <-72 dB at 400 MHz carrier and 400 kHz deviation at <100 kHz rate FM Flatness: ±0.1% from 20 Hz to 100 kHz rates; ±0.25% to 200 kHz rates CW Residual FM: <3 Hz rms in a 50 Hz to 3 kHz bandwidth at 560 MHz 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 AM Depth: 5% to 99% AM Distortion: <-66 dB at <50% AM at 20 Hz to 100 kHz rates; <-60 dB at <95% AM at 20 Hz to 100 kHz rates AM Flatness: ±0.1% from 50 Hz to 50 kHz; ±0.25% from 20 Hz to 100 kHz 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 Residual AM: <0.01% rms in a 50 Hz to 3 kHz bandwidth AM Linearity: ±0.1% at <95% AM; ±0.2% at <99% AM	HP 11715A	P,A,T
Attenuator 6 dB	Frequency Range: 0.15 to 1300 MHz SWR Maximum: 1.2 Attenuation Accuracy: ±0.4 dB	HP 8491A opt. 006	P
Audio Analyzer	Fundamental Frequency Range: 20 Hz to 100 kHz Distortion Range: -70 dB minimum Distortion Accuracy: ±2 dB Low-Pass Filters: 30 and 80 kHz Oscillator Level: 3V maximum into 600 ohm Oscillator Distortion: <-70 dB Oscillator Frequency Accuracy: ±2%	HP 8903A	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
Audio Synthesizer	Frequency Range: 20 Hz to 400 kHz Output Level: +16 dBm (50 ohms) maximum Frequency Accuracy: ±0.1% Level Flatness: ±0.015 dB from 90 Hz to 10 kHz; ±0.3 dB from 50 Hz to 100 kHz; ±0.07 dB from 20 Hz to 200 kHz Distortion: <-50 dB from 20 Hz to 200 kHz	HP 3325A	P,A,T
Bandpass Filters	Needed if using the HP 8640B Opt. 002 Signal Generator	HP 11697A,C	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 9825A/ 98034A/98213A HP 9835A/ 98034A/98332A	C,P,T
Digital Multimeter	DC Range: 0 to 50V DC Accuracy: ±0.01% at 1V AC Range: 0 to 100V AC Accuracy: ±0.01% at 2V and 2 kHz Ohms Range: 0 to 1 M ohms Ohms Accuracy: ±1%	HP 3455A	A,T
Frequency Standard	Accuracy: ±0.1 ppm recommended	House Standard	A
Oscilloscope	Bandwidth: less than 3 dB down 0 to 100 MHz Sensitivity: 5 mV per division minimum Input Impedance: 10 M ohms and 50 ohms Triggering: External and Internal	HP 1740A	C,A,T
Power Meter/ Power Sensor	Frequency Range: 150 kHz to 1300 MHz Impedance: 50 ohms Instrumentation Accuracy: ±1% SWR: <1.1	HP 435A/8482A or HP 436A/8482A	P

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

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

Instrument Type	Critical Specifications	Suggested Model	*Use
Power Meter or Power Reference	Power Range: 1 mV Frequency Range: 50 MHz SWR: 1.05 Accuracy: ±0.5% (NBS calibrated) Power Output: 1.00 mW. Factory set to ±0.7% (NBS calibrated) Accuracy: ±1.2% worst case (±0.9% rss) for one year (0 degrees C to 50 degrees C)	HP 432A HP 478A opt. H75 HP 435A opt. K05	P,A
Power Splitter	Frequency Range: 150 kHz to 1300 MHz Impedance: 50 ohms SWR: <1.1 Tracking: <0.25 dB	HP 11667A	P,A,T
Power Supply	Output Range: 0 to 25 Vdc	HP 6215A	T
Range Calibrator	Calibration Functions: outputs corresponding to power displays of 10 and 100 uW; 1, 10, and 100 mW. Calibration Uncertainty: ±0.25% in all ranges	HP 11683A	P,A
RF Spectrum Analyzer	Frequency Range: 0 to 2 GHz Input Level: +10 dBm maximum Display Range: 60 dB	HP 8559A/182T	A,T
Sensor Module	Compatible with HP 8901B Input SWR: <1.3, at RF Input, RF Range 1, 2 <1.5, at RF Input, RF Range 3	HP 11722A	P,A,T
Service Accessory Kit	No substitution recommended.	HP 08901-60089	T

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

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

Instrument Type	Critical Specifications	Suggested Model	*Use
Signal Generator	Frequency Range: 0.5 to 1100 MHz Output Level: +19 dBm maximum to 500 MHz; +13 dBm maximum to 1100 MHz Output Level Accuracy: ±1 dB Frequency Accuracy: ±1% Frequency Resolution: 1 kHz Modulation Capability: AM and FM AM Depth: 0 to 95% AM Accuracy: ±10% FM Range: 0 to 400 kHz peak deviation FM Accuracy: ±10%	HP 8640B opt. 001/002	C,P,A T
Signature Analyzer	External Count Range: to 15 MHz Because the signatures documented are unique to a given signature analyzer, no substitution is recommended.	HP 5004A	T
SWR Bridge	Frequency Range: 150 kHz to 1300 MHz Impedance: 50 ohms Directivity: >40 dB Connectors: Type N	Wiltron 60N50	P

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

Table 1-4. Recommended Test Accessories

Accessory Type*	Recommended Part
Adapter (Type N Male to BNC Female connectors)	HP 1250-0067
Capacitor, 620 pF	HP 0160-3536
IC Extender Clip, 16 Pin	HP 1400-0734
Resistor, 909Ω 1% 1/4W	HP 0757-0422
Resistor, 1210Ω 1% 1/4W	HP 0757-0274
Resistor, 2150Ω 1% 1/4W	HP 0698-0084
Resistor, 4640Ω 1% 1/4W	HP 0698-3155
Tee (Coaxial, BNC, one Male and two Female connectors)	HP 1250-0781
50Ω Load (Male, BNC, coaxial)	HP 1250-0207

*Accessories listed in this table are only those not already contained in the Service Accessory Kit, HP 08901-60089.

SECTION II

INSTALLATION

2-1. INTRODUCTION

This section provides the information needed to install the Modulation Analyzer. Included is information pertinent to initial inspection, power requirements, line voltage selection, power cables, interconnection, environment, instrument mounting, storage and shipment. In addition, this section also contains the procedure for setting the internal HP-IB talk and listen address switches.

2-2. INITIAL INSPECTION

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, meters).

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1. Procedures for checking electrical performance are given in Section IV. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance test, notify the nearest Hewlett-Packard office. If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

2-3. PREPARATION FOR USE

2-4. Power Requirements

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 Requirements (Cont'd)
The Modulation Analyzer requires a power source of 100, 120, 220, or 240 Vac, +5% to -10%, 48 to 66 Hz single phase. Option 004 also operates from 48 to 440 Hz single phase (120 Vac, +5% to -10% only). Power consumption is 200 V·A maximum.

WARNING

This is a Safety Class I product (i.e., 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 via an external autotransformer, make sure the autotransformer's common terminal is connected to the earthed pole of the power source.

2-5. 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 cord and the fuse are matched to the power source. Refer to Figure 2-1, Line Voltage and Fuse Selection.

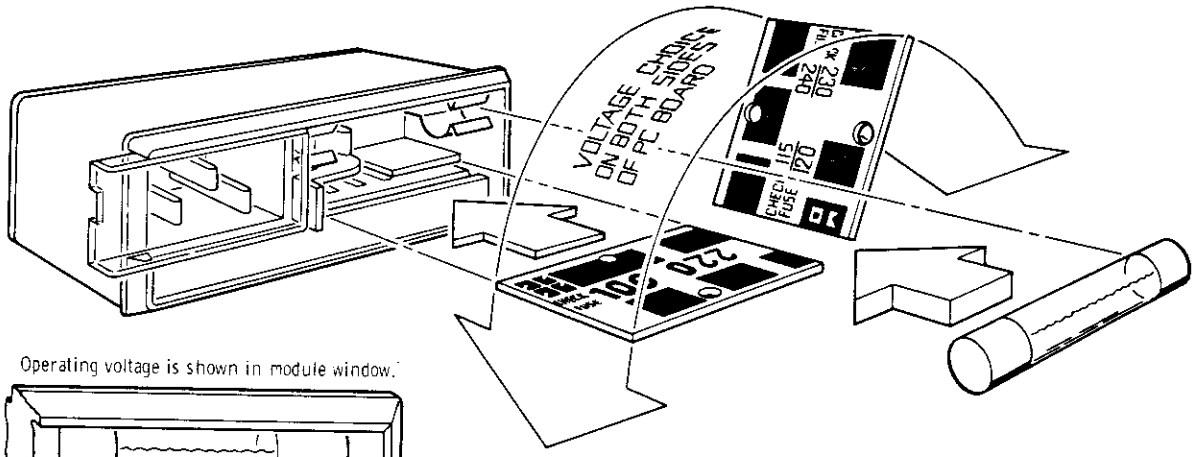
Fuses may be ordered under HP part numbers 2110-0083, 2.5A (250V normal blow) for 115 Vac operation and 2110-0043, 1.5A (250V normal blow) for 230 Vac operation.

2-6. Power Cables

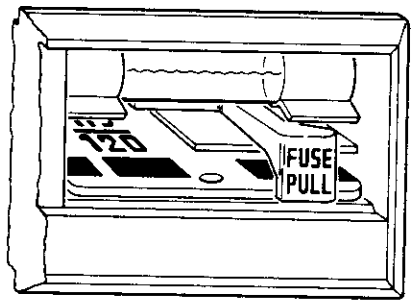
WARNING

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).

Power Cables (Cont'd)
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 Table 2-1 for the part numbers of the power cables available.



Operating voltage is shown in module window.



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).

SELECTION OF OPERATING VOLTAGE

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 firly into the slot.
3. Rotate the Fuse Pull lever to its normal position. Insert a fuse of the correct value in the holder. Cose the cover door.

Figure 2-1. Line Voltage and Fuse Selection

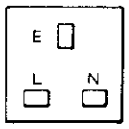
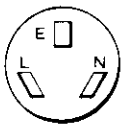
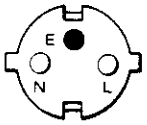
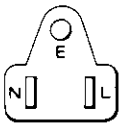
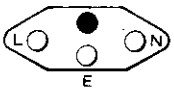
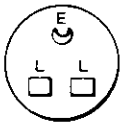
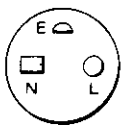
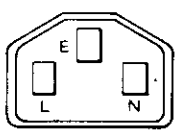
2-7. HP-IB Address Selection HP-IB

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.

Table 2-1. AC Power Cables Available

Plug Type	Cable HP Part Number	CD	Plug Description	Cable Length (inches)	Cable Color	For Use In Country
250V 	8120-1351 8120-1703	0 6	Straight*BS1363A 90°	90 90	Mint Gray Mint Gray	United Kingdom, Cyprus, Nigeria, Rhodesia, Singapore
250V 	8120-1369 8120-0696	0 4	Straight*NZSS198/ASC112 90°	79 87	Gray Gray	Austrailia, New Zealand
250V 	8120-1689 8120-1692	7 2	Straight*CEE7-Y11 90°	79 79	Mint Gray Mint Gray	East and West Europe, Saudi Arabia, Egypt So. Africa, India (unpolarized in many nations)
125V 	8120-1378 8120-1398 8120-1754 8120-1378 8120-1521 8120-1676	5 5 7 1 6 2	Straight*NEMA5-15P 90° Straight*NEMA5-15P Straight*NEMA5-15P 90° Straight*NEMA5-15P	80 80 36 80 80 36	Black Black Black Jade Gray Jade Gray Jade Gray	United States, Canada, Japan (100V or 200V), Mexico, Philippines, Taiwan
250V 	8120-2104	3	Straight*SEV1011 1959-24507 Type 12	79	Gray	Switzerland
250V 	8120-0698	6	Straight*NEMA6-15P			United States, Canada
220V 	8120-1957 8120-2956	2 3	Straight*DHCK 107 90°	79 79	Gray Gray	Denmark
250 V 	8120-1860	6	Straight*CEE22-VI (Systems Cabinet use)			

*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

HP-IB Address Selection (Cont'd)
In the Modulation Analyzer, the HP-IB talk and listen addresses are selectable by an internal switch (Figure 2-2). The following procedure explains setting of the switches. Refer to Table 2-2 for a listing of the talk and listen addresses. The address is 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.

1. Disconnect the line (Mains) power cable.

2. Remove any HP-IB cables or connectors from the HP-IB connector.

3. Remove the Modulation Analyzer's top cover.

   a. Remove the two plastic feet from the rear of the top cover by removing the pan-head Pozidriv screw within each foot.

   b. Unscrew the Pozidriv screw at the center of the rear edge of the top cover. This is a captive screw and will cause the top cover to pull away from the front frame.

   c. Lift off the top cover.

4. Locate the HP-IB address switch on the A14 Remote Interface Assembly near the front right of the instrument. The A14 assembly may be recognized as having one brown and one yellow printed circuit board extractor.

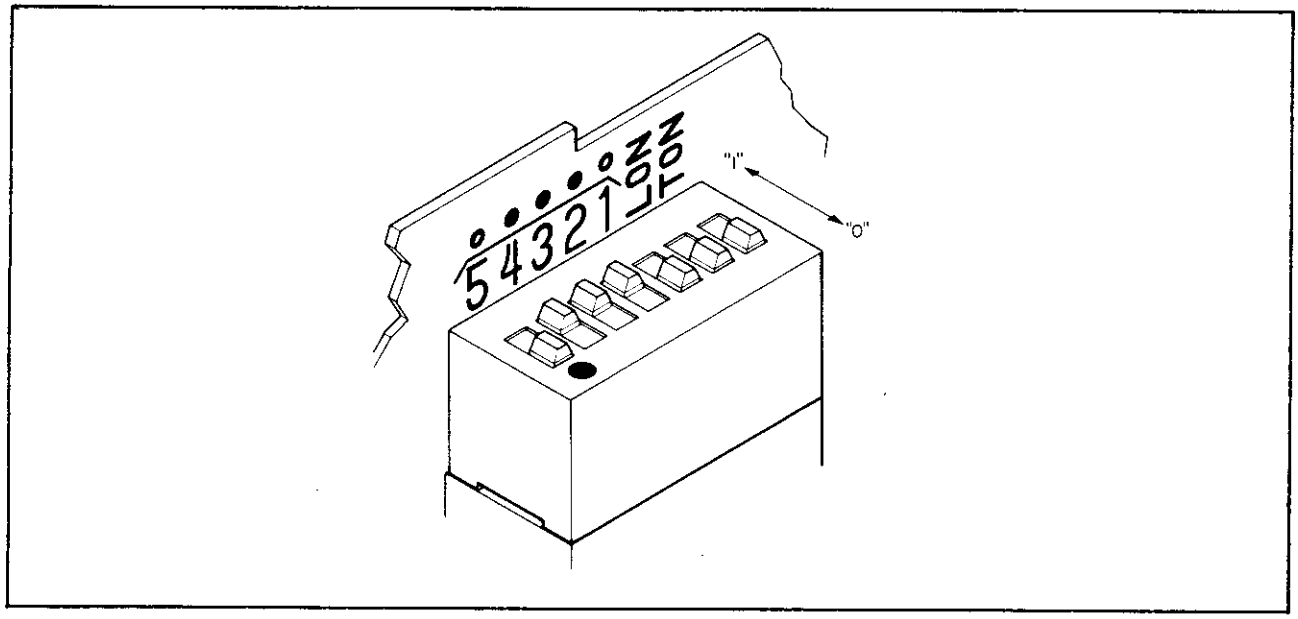
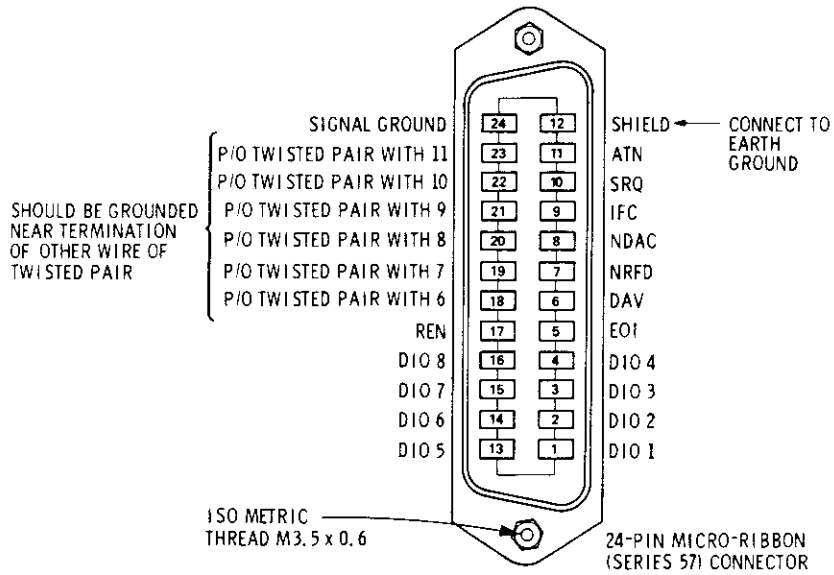


Figure 2-2. The HP-IB Address Switch Shown as Set by the Factory. The Address Shown is 01110 in Binary With Both Talk Only and Listen Only Off

HP-IB



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); HP 10833B, 2 metres (6.6 ft); HP 10833C, 4 metres (13.2 ft); HP 10833D, 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 2-3. Hewlett-Packard Interface Bus Connection

HP-IB Address Selection (Cont'd)

5. Use a pencil to set the switches to the desired HP-IB address and Talk Only (TON) or Listen Only (LON) condition. The switch is illustrated in Figure 2-2. Facing the board, the left hand switch (marked with a "5") is the most significant address bit (A5 in Table 2-2). Setting a switch toward the printed circuit board places it in its "1" position. If the TON and LON switches are both set to "1", the Talk Only setting will override. If the address switches and the TON switch are all set to "1", the Modulation Analyzer will output one byte (the status byte) each measurement cycle. (Setting all switches to "1" defeats HP-IB operation.)

6. Reinstall the top cover by reversing the procedure in previous step 3.

7. Connect the line (Mains) power cable to the Line Power Module and reconnect the HP-IB cable to the HP-IB connector.

8. To confirm the setting, refer to "HP-IB Address" in the Detailed Operating Instructions in Section III of this manual.

Table 2-2. Allowable HP-IB Address Codes

Address Swtiches					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	.	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
1	1	1	1	1	Invalid	Invalid	31

2-8. Interconnections

Interconnection data for the Hewlett-Packard Interface Bus is provided in Figure 2-3.

2-9. Mating Connectors

Interface Connector. The HP-IB mating connector is shown in Figure 2-3. Note that two securing screws are metric.

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

2-10. Operating Environment

The operating environment should be within the following limitations:

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

2-11. Bench Operation

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.

2-12. Rack Mounting

WARNING

The Modulation Analyzer is heavy for its size (23.6 kg, 52 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 paragraph 1-9, "Mechanical Options", in Section I). 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 steps "1" and "2" of the pull-out cards removal procedure that follows.

2-13. Removal and Installation of Operating Information Pull-Out Cards

Steps for Removal. Follow the procedure below to remove the Operating Information pull-out tray and the cards:

1. Remove the two front feet of the instrument.

Removal and Installation of Operating Information Pull-Out Cards (Cont'd)

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 it straight up (away from the tray).

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

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.

2-14. STORAGE AND SHIPMENT

2-15. 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 metres (50 000 feet)

2-16. 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.)

Packaging (Cont'd)

2. Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 psi) test material is adequate.

3. Use enough shock-absorbing material (75 to 100 mm layer; 3 to 4 inches) 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 III

OPERATION

3-1. INTRODUCTION

3-2. 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.

3-3. Operating Characteristics

The major operating characteristics of the Modulation Analyzer are provided in paragraph 1-6 "Description", Table 1-1 "Specifications", and Table 1-2, "Supplemental Information". For information on HP-IB capabilities, refer to paragraphs 3-12 through 3-31.

3-4. 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 250V 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. Refer to paragraph 2-4.

Do not apply greater than 40V (ac + dc) to the RF INPUT connector 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

Turn-On Procedure (Cont'd)
Modulation Analyzer is already plugged in, set the POWER 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.)

2. Check that the fuse rating is appropriate for the line votage used. (See Figure 2-1.) Fuse ratings are provided in the paragraph "Operator's Maintenance" in this section.

3. Plug in the power cable.

4. Set the POWER switch to ON.

NOTE

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

3-5. 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, perform the Operator's Checks. 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.

Panel Features.

Front-panel controls, indicators, and connectors are illustrated and described in Figure 3-1. This figure describes the various functions of the Modulation Analyzer and summarizes briefly how to use them.

Rear-panel features are shown and described in Figure 3-2. The figure provides a quick reference for rear-panel signal levels and frequencies and also includes the impedances at the rear-panel connections.

The information in parenthesis at the end of each feature summary provides the title of the Detailed Operating Instructions relevant to the feature.

Detailed Operating Instructions. The Detailed Operating Instructions provide a 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, RF Frequency, RF Power, Audio Frequency, etc.), but there are also individual discussions of nearly all controls, inputs, and outputs. Also

Local Operation (Cont'd)
included are instructions for using the many User Special Functions. A guide to using the Detailed Operating Instructions is provided ahead of the instructions themselves.

Operating Information Pull-Out Cards. The Operating Information pull-out cards are flexible plastic reference sheets attached to the Modulation Analyzer by a tray located below the front panel. They contain a brief summary of front-panel operation and displays. Also included on the cards is a complete listing of HP-IB codes, data, and error output formats; as well as Error codes, and User Special Functions. The cards show a simplified block diagram for the Modulation Analyzer and provide basic instructions for RF Power operation and AM and FM calibration. The pull-out cards are intended to be a 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. Other information, pertinent to operating the Modulation Analyzer to its fullest capabilities, are contained in Section I. Principles of Operation for a Simplified Block Diagram (in paragraph 1-15) is a fundamental description of what the Modulation Analyzer is and how it works. This information supplements the block diagrams provided on the pull-out card and in the Detailed Operating Instructions. It also provides a basis for applying the Modulation Analyzer to various measurement situations.

3-6. Remote Operation HP-IB

The Modulation Analyzer is capable of remote operation via the Hewlett-Packard Interface Bus (HP-IB). Provided in this section are instructions pertinent to HP-IB operation including 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.

HP-IB information concerning remote information also appears in several other locations. Address setting is discussed in Section II. 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 in the paragraph, "Local Operation" in this section.

3-7. Operator's Checks

Operator's Checks are simple procedures designed to verify the proper operation of the Modulation Analyzer's main functions and to familiarize the first-time operator with basic Modulation Analyzer measurement capabilities. Two procedures are provided:

Basic Functional Checks. This procedure requires only a sensor module, 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.

Operator's Checks (Cont'd)
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).

3-8. Operator's Maintenance

WARNING

For continued protection against fire hazard, replace the line fuse only with a 250V 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 Assembly (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 2110-0083, 2.5A (250V, normal blow) for 100/120 Vac operation or 2110-0043, 1.5A (250V, normal blow) for 220/240 Vac operation.

Front-Panel Features

The following list provides a brief description of each feature. The information in parenthesis at the end of each description provides the title of the Detailed Operating Instructions relevant to the feature.

(1) **MEASUREMENT** keys enable the Modulation Analyzer to make and display the selected measurement. (AM, FM, ϕM, RF Power, RF Input Frequency, Audio Frequency, Audio Distortion and Level, IF Level, Tuned RF Level, RF Frequency Error)

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

(3) **Display Annunciators** indicate the measurement result units. They also indicate that some measurement functions are enabled. All these annunciators are displayed when the Modulation Analyzer is first turned on.

(4) **AUTOMATIC OPERATION** enables the Modulation Analyzer to automatically tune and autorange to make the selected measurement. (Automatic Operation)

(5) **INSTR PRESET** (Blue Key) configures the Modulation Analyzer to its power-up condition. (Instrument Preset)

(6) **TRACK MODE** (Blue Key) and **AUTO TUNING** (Blue Key) select the tuning mode of the Modulation Analyzer. (RF Frequency Tuning)

(7) **STORE** (Blue Key) and **RECALL** (Blue Key) enable the Modulation Analyzer to store and recall up to eight measurement states. (Store/Recall)

(8) **WATTS, uV, mV,** and **VOLTS** keys (all used with the Blue Key) enable selection of different units for level measurements.

(9) **MHz** completes the keyboard entry of frequencies for various functions. (RF Frequency Tuning, Frequency Offset Mode)

(10) **MODULATION OUTPUT/AUDIO INPUT** connector provides either an output for the modulation recovered from the RF INPUT connector, or an input for external audio signals to be processed by the audio circuitry. The MODULATION OUTPUT LEDs indicate the type of recovered modulation available as the output. The AUDIO INPUT key selects whether the internally demodulated signal or an external audio signal is to be processed by the Modulation Analyzer's audio circuitry. (Modulation Output/Audio Input, Audio Frequency, Audio Distortion and Level, SINAD)

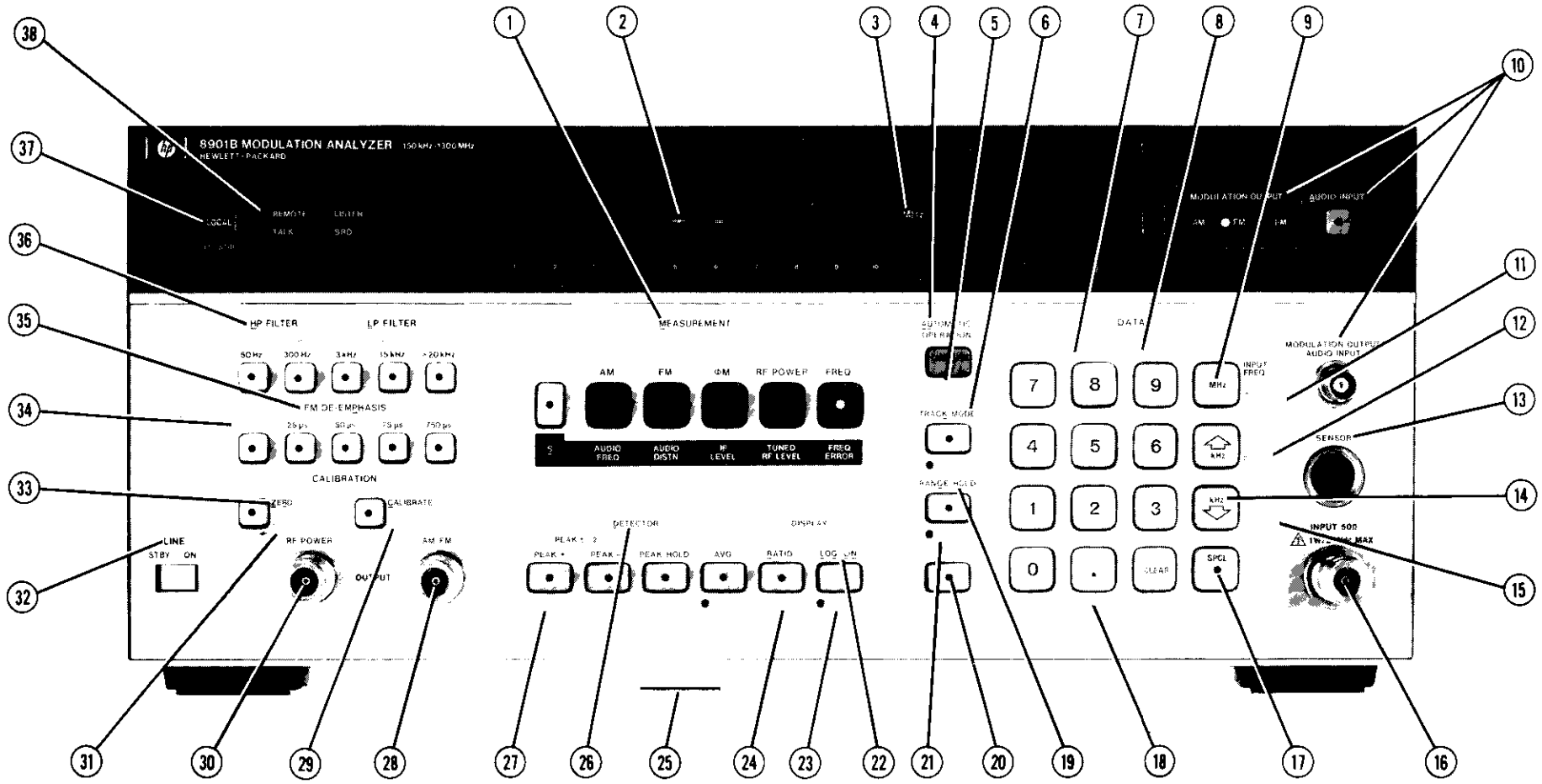


Figure 3-1. Front-Panel Features

⑪ **% CAL FACTOR** (Blue Key) causes the Modulation Analyzer to display the current calibration factor for the selected measurement. This key is also used to complete the entry of calibration factors for various functions. (AM Calibration, FM Calibration, RF Power Calibration Factors)

⑫ **DISPLAY FREQ** (Blue Key) causes the Modulation Analyzer to display the RF frequency that it tuned to last. (Frequency Offset Mode, RF Power Calibration Factors)

⑬ **SENSOR** connector provides the input for the power sensor. (RF Power)

⑭ **kHz** ⇧ (Blue Key) and **kHz** ⇩ (Blue Key) complete keyboard entry of frequency step-size (in kHz) for step tuning, or change the frequency in the increments specified. (RF Frequency Tuning)

⑮ **DISPLAY FREQ INCR** (Blue Key) causes the Modulation Analyzer to display the increment step-size. (RF Frequency Tuning)

⑯ **INPUT** couples the RF input signal into the instrument. (RF Input Frequency)

⑰ **SPCL** completes entry of Special Function codes that access additional instrument operations. Without a preceeding numeric entry, the SPCL key causes a display of the status of Special Functions 1 through 10. (Special Functions)

⑱ **(-)** (Blue Key) enables input data to be entered as a negative value.

⑲ **RANGE HOLD** freezes the current ranges being used by the Modulation Analyzer. (Range Hold)

⑳ **Blue Key** is a shift key that enables some keys to have two different functions. Any function printed in blue can be selected when the key associated with it is pressed after the Blue Key. The Blue Key flashes at the current measurement rate whenever it is pressed.

㉑ **DISABLE ERROR** (Blue Key) disables Error 01 through Error 04. (Disable Error Message Control)

㉒ **LOG/LIN** causes measurements to alternate between logarithmic and linear units. (Ratio and Log/Lin)

㉓ **dB EXT ATTEN** (Blue Key) enables level measurements to be offset with external attenuation or gain. (External Attenuation)

㉔ **RATIO** (Blue Key) and **PREVIOUS RATIO** (Blue Key) cause the current measurement to be compared to a reference. (Ratio and Log/Lin)

(25) **Operating Information** pull-out cards are quick operating references that list Special Function, HP-IB, and Error codes, show a simplified block diagram for the Modulation Analyzer, and provide basic information for RF Power operation and AM and FM calibration.

(26) **DETECTOR** keys select the audio detector used to measure the modulation. Positive peak, negative peak, average (rms calibrated), or true rms (Blue Key) detectors are available. Positive or negative peak values can be captured using the Peak Hold function. (Audio Detectors, Audio Distortion and Level, SINAD)

(27) **1 kHz DISTN** (Blue Key) and **400 Hz DISTN** (Blue Key) enable the Modulation Analyzer to make audio measurements on either 1 kHz or 400 Hz audio signals. (Audio Distortion and Level, SINAD)

(28) **CALIBRATION AM/FM OUTPUT** makes available a precisely modulated signal used to improve the Modulation Analyzer's AM or FM accuracy. (AM Calibration, FM Calibration)

(29) **CALIBRATE** and **SAVE CAL** (Blue Key) enable the Modulation Analyzer to calibrate and save the resultant calibration factor for either RF Power, AM, or FM. (AM Calibration, FM Calibration, RF Power Calibration)

(30) **CALIBRATION RF POWER OUTPUT** makes available a 50 MHz, 1 mW power reference used to precisely determine the sensitivity of the external power sensor. (RF Power Calibration)

(31) **SET REF** (Blue Key) performs the same function as the RATIO key. (Ratio and Log/Lin)

(32) **POWER** switch applies power to the Modulation Analyzer when set to ON. (Instrument Preset)

(33) **ZERO** causes the Modulation Analyzer to cancel any dc offset that may be present in the power sensor. (RF Power Calibration)

(34) **PRE DISPLAY** enables FM deviation to be measured before or after de-emphasis. (FM De-Emphasis)

(35) **FM DE-EMPHASIS** networks equalize pre-emphasized FM. (FM De-Emphasis)

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

(37) **LOCAL** returns the Modulation Analyzer to keyboard control from remote (HP-IB) control.

(38) **HP-IB Annunciators** indicate remote operation status.

Rear-Panel Features

① **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 kohm output impedance. (AM Output)

② **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 kohm output impedance. (FM Output)

③ **RECORDER OUTPUT** allows user-access to all internal measurement voltages. (Recorder Output)

④ **IF OUTPUT** produces a 150 kHz to 2.5 MHz modulated IF signal. The output level ranges from -27 to -3 dBm (50 ohm output impedance). (IF Output)

⑤ **TIME BASE 10 MHz OUTPUT** and **INPUT**. The input connector provides an input for an external 10 MHz time base reference. The external input signal must be greater than 0.5V peak-to-peak (into a 500 ohm input impedance). The output connector provides an output for the internal, high-stability 10 MHz reference. Output signal is TTL compatible (50 ohm nominal output impedance). (Time Base 10 MHz Input and Time Base 10 MHz Output)

⑥ **MODULATION OUTPUT/AUDIO INPUT** is a rear-panel output and input supplied on Option 001 instruments instead of the standard, front-panel connection. Refer to MODULATION OUTPUT/AUDIO INPUT in Figure 3-1.

⑦ **SENSOR** is a rear-panel input for the power sensor supplied on Option 001 instruments instead of the standard, front-panel connection. See SENSOR in Figure 3-1.

⑧ **INPUT** is a rear-panel input for the RF input signal. This input is supplied on Option 001 instruments instead of the standard front-panel connection. See INPUT in Figure 3-1.

⑨ **Fuse**. 2 1/2 Amp (250V, Normal Blow) for 100/120 Vac.
1 1/2 Amp (250V, Normal Blow) for 220/240 Vac.

⑩ **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.

⑪ **Line Power Module** permits operation from 100, 120, 220, or 240 Vac. The number visible in the window indicates the nominal line voltage to which the instrument must be connected. (See Figure 2-1.) The center conductor is safety earth ground.

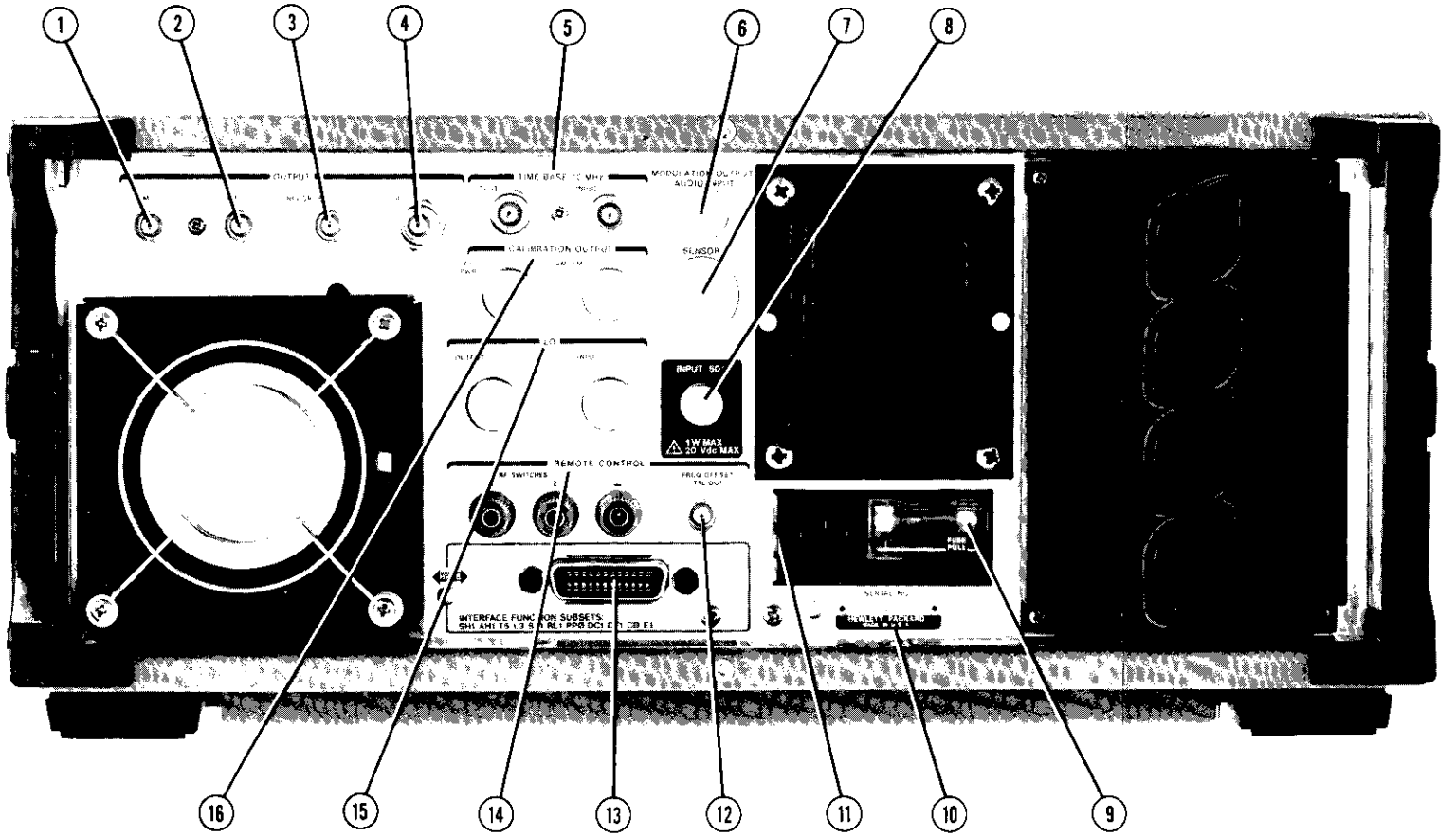


Figure 3-2. Rear-Panel Features

⑫ **FREQ OFFSET TTL OUT** outputs a voltage that can be used to switch an external mixer in and out of the path between a microwave input signal and the Modulation Analyzer when the instrument is in Frequency Offset Mode. The TTL output is always 0V if Frequency Offset Mode is not selected or while Frequency Offset Mode is selected with an entered external LO value of 0 Hz. If the entered external LO frequency of the Modulation Analyzer is less than or equal to 18 GHz, the TTL output is +5V. If the entered external LO frequency is greater than 18 GHz, the TTL output is 3V. (Frequency Offset Control)

⑬ **HP-IB Connector** connects the Modulation Analyzer to the Hewlett-Packard Interface Bus for remote operations. When the HP-IB is being used, the LEDs next to the HP-IB turns on the front-panel light as appropriate (REMOTE, LISTEN, TALK, SRQ).

⑭ **REMOTE CONTROL RF SWITCHES** enable the user to build an enternal sensor module that can switch between the RF INPUT connector and the SENSOR connector. (Remote Control RF Switch)

⑮ **LO OUTPUT and INPUT** (Option 003 only). The LO output connector provides an output for the Local Oscillator. The output signal is 1.27 to 1301.5 MHz at approximately 0 dBm (50 ohm) nominal output impedance. The LO input connector provides an input for an external Local Oscillator. External input signal required is 1.27 to 1301.5 MHz at approximately 0 dBm (50 ohm nominal input impedance). (LO Input and LO Output)

CAUTION

Do not apply reverse power into the LO OUTPUT or damage to the instrument may result. Do not apply greater than 40 Vdc or +5 dBm of RF power into the LO INPUT or damage to the instrument may result.

⑯ **CALIBRATION OUTPUT RF PWR and AM/FM** produces a rear-panel output for RF Power and AM and FM calibrators. This output is supplied on Option 001 instruments instead of the standard front-panel connection. Refer to both CALIBRATION RF POWER OUTPUT and CALIBRATION AM/FM OUTPUT in Figure 3-2.

3-9. OPERATOR'S CHECKS

3-10. Basic Functional Checks

Description

Using a signal generator, an oscilloscope, and a sensor module, the overall operation of the Modulation Analyzer is verified.

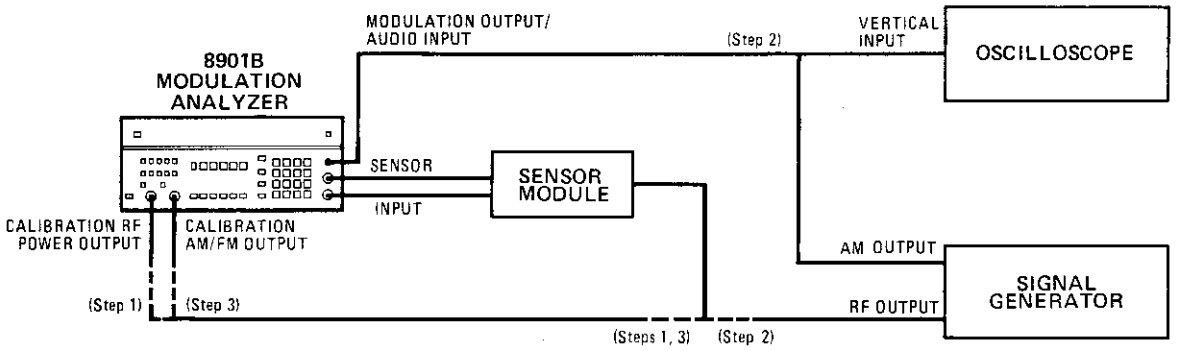


Figure 3-3. Basic Functional Checks Setup

Equipment

Oscilloscope . . . . . HP 1740A
Signal Generator . . . HP 8640B Options 001 and 002
Sensor Module. . . . . HP 11722A

Procedure

Preliminary Check

1. Remove any cables from the Modulation Analyzer's RF INPUT and SENSOR input connectors. Set POWER switch to STBY, then back to ON. Observe the front-panel LED annunciators, display segments and decimal points, and key lights. All LEDs should light for approximately 10 seconds at turn on and then all should momentarily turn off.

2. After the turn-on sequence, the instrument displays "--". The MHz annunciator, the FM annunciator under MODULATION OUTPUT, the AUTO TUNING annunciator (under the TRACK MODE key), and the FREQ key are lighted.

OPERATOR'S CHECKS

3-10. Basic Functional Checks (Cont'd)

RF Power Calibration Check

3. Connect the CALIBRATION RF POWER OUTPUT to the sensor module input. (Step 1 of Figure 3-3.)

4. Press the RF POWER key. The instrument displays Error 15 (unless calibration factors have already been entered).

5. If the instrument displays Error 15, enter the RF Power Calibration Factors that are printed on the bottom cover of the sensor module:

   a. Enter the reference calibration factor by keying in 37.3 and pressing the SPCL key. Then key in the value of the reference calibration factor and press the Blue Key and % CAL FACTOR key (the MHz key).

   b. Enter each frequency/calibration factor pair by first keying in the numeric code 37.3 and pressing the SPCL key. Next, key in the frequency value (in MHz), and press the MHz key. Then, key in the value of the calibration factor, and press the Blue Key and % CAL FACTOR key. Error 15 continues to be displayed until the Modulation Analyzer is able to interpolate a frequency/calibration factor pair from those pairs entered. (For more information, refer to **RF Power Calibration** and **RF Power Calibration Factors** in the Detailed Operating Instructions in this section.)

6. Press the ZERO key. 0.0 is displayed briefly and then a value less than 0.003 mW is displayed.

7. Press the CALIBRATE key. When a value appears in the display, press the Blue Key and SAVE CAL key (the CALIBRATE key). The display shows 1.000 mW. Turn off the calibrator by pressing the CALIBRATE key again.

RF Power Check

8. Set the signal generator to 100 MHz CW at -10 dBm (as measured on its level meter).

9. Connect the RF output of the signal generator to the input of the sensor module, and MODULATION OUTPUT/AUDIO INPUT to the vertical input of the oscilloscope and to the AM output of the signal generator using a BNC tee. (Step 2 of Figure 3-3) (Note: The connection from the MODULATION OUTPUT/AUDIO INPUT to both the oscilloscope and the signal generator could cause a loading problem if the signal generator is not as suggested. Make these connections only when required if this is a problem.)

OPERATOR'S CHECKS

3-10. Basic Functional Checks (Cont'd)

10. Press the LOG/LIN key to display dBm. Read between -11.0 and -9.0 dBm on the display.

RF Peak Level Check

11. Key in the numeric code 35.0 and press the SPCL key. The Modulation Analyzer displays between -16.00 and -6.00 dBm.

Frequency Check

12. Press the FREQ key. Key in 7.1 and press the SPCL key to set the RF Frequency Resolution to 10 Hz. Set the signal generator's frequency as shown in the following table. For each frequency, compare the signal generator's frequency display with the Modulation Analyzer's display. The two displays should agree within the limits indicated.

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

13. Set the signal generator frequency to 50 MHz. When the Modulation Analyzer has tuned to the signal, press MHz, then S (shift) FREQ ERROR. The instrument displays between -2 and 2 kHz.

14. Key in 100, then press ⇧ kHz. The instrument displays between -102 and -98 kHz. Return the RF Frequency Resolution to automatic selection by keying 7.0 and pressing the SPCL key.

Track Mode Tuning Check

15. Press the AUTOMATIC OPERATION key and the FREQ key. Press the TRACK MODE key. Manually sweep the signal generator's frequency to 65 MHz; the Modulation Analyzer's frequency display tracks the frequency as it changes. Press the TRACK MODE key again to turn off the function.

OPERATOR'S CHECKS

3-10. Basic Functional Checks (Cont'd)

AM and FM Calibration Check

16. Connect the CALIBRATION AM/FM OUTPUT to the input of the sensor module. (Step 3 of Figure 3-3.)

17. Press AM, then CALIBRATE. After a few seconds, the AM Calibration Factor is displayed. The displayed value is between 99.0 and 101.0%.

18. Press FM, then CALIBRATE. After a few seconds, the FM Calibration Factor is displayed. The displayed value is between 99.0 and 101.0%. Press the CALIBRATE key again to turn off that function.

AM Check

19. Reconnect the equipment as shown in Step 2 of Figure 3-3.

20. 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.

21. Press AM. The Modulation Analyzer displays between 46 and 54%.

22. Set the signal generator's AM to 25% (as measured on its AM meter). The Modulation Analyzer displays between 22 and 28% with 0.01% resolution.

FM and Phase Modulation (ϕM) Checks

23. Set the signal generator's AM off, and set FM to 50 kHz peak deviation (as measured on its FM meter) at a 1 kHz rate. Press FM. The Modulation Analyzer displays between 45 and 55 kHz.

24. Adjust the signal generator's FM peak deviation for 50 kHz as displayed by the Modulation Analyzer.

25. Press ϕM. The instrument displays between 45 and 55 radians.

FM De-emphasis Check

26. Press FM. Press the RATIO key and set the LOG/LIN key to display %. The instrument displays between 99.8 and 100.2% REL.

27. The oscilloscope shows a sinusoidal waveform with a peak-to-peak amplitude between 0.9 and 1.1V and a period of 1 ms.

OPERATOR'S CHECKS

3-10. Basic Functional Checks (Cont'd)

28. Set FM DE-EMPHASIS to PRE-DISPLAY. Set FM DE-EMPHASIS time constant as listed in the following table. The Modulation Analyzer displays a value within the limits listed. Also, the oscilloscope waveform changes proportionately to the display. (Allow for a x10 autorange at the output of MODULATION OUTPUT/AUDIO INPUT when FM DE-EMPHASIS is set to 750 us.)

FM De-Emphasis Time Constant (us)	Limits (% REL)	
	Minimum	Maximum
25	98.5	99.0
50	94.5	96.2
75	88.8	92.1
750	18.9	23.0

Audio Frequency and Audio Filters Check

29. Set FM DE-EMPHASIS off. Set the FM rate as listed in the following table. For each setting, perform the following steps:

    a. Set filters (HP or LP FILTER) to ALL OFF, and set RATIO off if it is on.

    b. Press S (shift) AUDIO FREQ and set the signal generator's FM rate as listed in the table (as displayed on the Modulation Analyzer).

    c. Press FM and then press the RATIO key. Set LOG/LIN to dB to establish a reference of 0 dB.

    d. Set the HP or LP FILTER as listed in the table, and fine adjust the FM rate for a reading of -3 dB REL.

    e. Press S (shift) AUDIO FREQ and note the FM rate. The Modulation Analyzer displays a rate within the limits listed.

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

OPERATOR'S CHECKS

3-10. Basic Functional Checks (Cont'd)

Audio Distortion and SINAD Check

30. Press the AM key and set filters to ALL OFF. Set the signal generator's FM off, and set the AM depth to 50% (as measured on the Modulation Analyzer's display) at a 1 kHz rate. Press S (shift) and AUDIO DISTN. The displayed distortion is less than 3%.

31. Set the signal generator's AM for a 400 Hz rate. Press the Blue Key and 400 Hz DISTN key (PEAK- key). The displayed distortion is less than 3%.

32. Press the LOG/LIN key to display the distortion in dB. Key in 29.0 and press the SPCL key. The SINAD value is greater than 30 dB.

External Audio RMS Level

33. Press the AUDIO INPUT key. Set the signal generator's audio output level for 3 Vp-p (as read on the oscilloscope). Key in 30.0 and press the SPCL key. Set the LOG/LIN key to display volts. The Modulation Analyzer's displayed level is between 0.95 and 1.17V.

Audio Detector Check

34. Press the FM key. Press the AUDIO INPUT key again to select the FM MODULATION OUTPUT. Set the signal generator's AM off and set the FM rate to 1 kHz. Press the RATIO key and set LOG/LIN to % to establish a reference of 100%. Set DETECTORS to PEAK-. The Modulation Analyzer displays between 95 and 105% REL depending upon the signal generator's FM distortion.

35. Set DETECTOR to AVG. The instrument displays between 69.3 and 72.1% REL. Turn the ratio function off by pressing the RATIO key again.

36. Set DETECTOR to PEAK+ then press PEAK HOLD. Switch the signal generator's FM off. The Modulation Analyzer display retains the largest value obtained after pressing PEAK HOLD. Turn off the peak hold function by pressing the PEAK+ key.

IF Level Check

37. Press S (shift) IF LEVEL and set the LOG/LIN key to display %. The Modulation Analyzer displays between 99.9 and 100.1%.

OPERATOR'S CHECKS

3-10. Basic Functional Checks (Cont'd)

IF Frequency and LO Frequency

38. Set the signal generator to 100 MHz CW at 0 dBm. Press AUTOMATIC OPERATION, then key in 34.0 and press the SPCL key. The frequency displayed is between 1.45 and 1.55 MHz.

39. Key in 33.0 and press the SPCL key. The frequency displayed is between 101.45 and 101.55 MHz.

40. Key in 3.1 and press the SPCL key. The frequency displayed is between 100.4425 and 100.4575 MHz.

Tuned RF Level and RF High-Pass Filter Check

41. Set the signal generator to 5.25 MHz CW at 0 dBm. Key in 36.0 and press the SPCL key and set the LOG/LIN key to display watts. The level displayed is between 0.0 and +6.0 mW.

42. Press the RATIO key and set the LOG/LIN key to dB, then key in 3.3 (to insert the RF high-pass filter) and press the SPCL key. The Modulation Analyzer displays between -2 and -7 dB REL. Turn off the ratio function by pressing the RATIO key again. Key in 3.0 and press the SPCL key to return the RF high-pass and IF filter selection to automatic.

Error Check

43. Set the signal generator to 200 MHz CW at 0.00 dBm. On the Modulation Analyzer, press AUTOMATIC OPERATION, then FM. Set DETECTOR to PEAK+. After the Modulation Analyzer is tuned, press the RANGE HOLD key. Key in 100 then press ⇧ kHz. The Modulation Analyzer displays Error 01. Press the RANGE HOLD key again to turn off the function.

44. Press ⇩ kHz. Key in 2.1 and press the SPCL key. Set the generator's FM on and adjust the peak deviation for 5 kHz (as read on its FM meter). The Modulation Analyzer displays Error 04.

45. Key in 8.4 and press the SPCL key. The instrument displays Error 07.

OPERATOR'S CHECKS

3-11. 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 described in paragraphs 3-12 through 3-31. 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 operates as expected, 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 via the front-panel keys (that is, in local mode). This can be verified with the preceding Basic Functional Checks in paragraph 3-11.
- The bus controller properly executes HP-IB operations.
- The bus controller's HP-IB interface properly executes the 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 via the HP-IB interface. Do not connect any equipment to any of the Modulation Analyzer's input connectors.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)

EQUIPMENT:

HP-IB Controller....HP 9825A/98213A (General and Extended I/O ROM)
--or-- HP 9835A/98332A (I/O ROM)
--or-- HP 9845A (with HP-IB I/O capability)

HP-IB Interface.....HP 98034A (use "revised" version with 9835A and 9845A)

Address Recognition

NOTE:

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 POWER switch to STBY, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Set the Remote Enable (REN) bus control line false.	lcl 7	LOCAL 7
Send the Modulation Analyzer's listen address.	wrt 714	OUTPUT 714

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's LISTEN annunciator is on.

Unaddress the Modulation Analyzer by sending a different address.	wrt 715	OUTPUT 715

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's LISTEN annunciator is turned off.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)

Remote and Local Messages and the LOCAL Key

NOTE:

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 POWER switch to STBY, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the Remote Message (by setting Remote Enable, REN, true and addressing the Measuring Receiver to listen).	rem 714	REMOTE 714

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE and LISTEN annunciators are on.

Send the Local Message to the Modulation Analyzer.	lcl 714	LOCAL 714

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE annunciator is off but its LISTEN annunciator is on.

Send the Remote message to the Modulation Analyzer.	rem 714	REMOTE 714

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE and LISTEN 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 LISTEN annunciator remains on.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)

Sending the Data Message

NOTE:

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 POWER switch to STBY, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (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.)	red 714,V	ENTER 714;V
Display the value of V.	dsp V	PRINT V

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's TALK annunciator is on. The controller's display should read 90000096000.00 (HP 9825A) or 90000096000 (HP 9835A and 9845A).

Receiving the Data Message

NOTE:

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 POWER switch to STBY, then to ON.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)
Receiving the Data Message (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Modulation Analyzer to remote).	rem 7	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).	wrt 714,"1MZ"	OUTPUT 714,"IMZ"

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE and LISTEN annunciators are on. Check also that its 15 kHz LP FILTER key light is on and the AUTO TUNING light is off.

Local Lockout and Clear Lockout/Set Local Messages

NOTE:

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 POWER switch to STBY, then to ON.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)
Local Lockout and Clear Lockout/Set Local Messages (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Modulation Analyzer to remote).	rem 7	REMOTE 7
Send the Local Lockout message.	llo 7	LOCAL LOCKOUT 7
Address the Modulation Analyzer to listen (completing the Remote message).	wrt 714	OUTPUT 714

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE and LISTEN annunciators are on. Press the Modulation Analyzer's LOCAL key. Both its REMOTE and LISTEN annunciators remain on.

Send the Clear Lockout/Set Local message.	lcl 7	LOCAL 7

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE annunciator is off but its LISTEN annunciator remains on.

Clear Message

NOTE:

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 POWER switch to STBY, then to ON.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)
Clear Message (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Modulation Analyzer to remote).	rem 7	REMOTE 7
Address the Modulation Analyzer to listen (completing the Remote message), then send a Data message that sets the Measuring Receiver's tuning to manual (lighting the SPCL light).	wrt 714,"MZ"	OUTPUT 714;"MZ"

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE and LISTEN annunciators are on and that the AUTO TUNING light is off.

Send the Clear message (setting the Modulation Analyzer's tune mode back to automatic).	clr 714	RESET 714

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE and LISTEN annunciators are on and that the AUTO TUNING light is on.

Abort Message

NOTE:

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 POWER switch to STBY, then to ON.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)
Abort Message (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the Remote message to the Modulation Analyzer.	rem 714	REMOTE 714

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE and LISTEN annunciators are on.

Send the Abort message, unaddressing the Measuring Receiver.	cli 7	ABORTIO 7

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's LISTEN annunciator is off. Note that the HP 9835A and 9845A ABORTIO statement sends both the Abort message and the Local message. Thus, if the HP 9825A is being used, the Modulation Analyzer's REMOTE annunciator should remain on. If the HP 9835A or 9845A is being used, the Modulation Analyzer's REMOTE annunciator should turn off.

Send the Local message (HP 9825A only).	lcl 7	(The local message was already sent with the ABORTIO 7 statement above.)
Address the Modulation Analyzer to talk and store its output data in variable V.	red 714,V	ENTER 714;V

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's LISTEN annunciator is off but that its TALK annunciator is on.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)
Abort Message (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the Abort message, unaddressing the Measuring Receiver to talk.	cli 7	ABORTIO 7

OPERATOR'S RESPONSE:

Check that all the Modulation Analyzer's HP-IB annunciators are off.

Send the serial-poll-enable bus command (SPE) through the interface to place the Measuring Receiver in serial-poll mode.	wti 0,7; wti 6,24	SENDBUS 714; 1,24

OPERATOR'S RESPONSE:

On the Modulation Analyzer, key in 61.3 and then press the SPCL key. 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.	cli 7	ABORTIO 7

OPERATOR'S RESPONSE:

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

NOTE:

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 POWER switch to STBY, then to ON.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)
Status Byte Message (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Place the Modulation Analyzer in serial-poll mode and address it to talk (causing it to send the Status Byte message).	rds(714)⇨V	STATUS 714;V
Display the value of V.	dsp V	PRINT V

OPERATOR'S RESPONSE:

Depending on the vintage of the HP-IB interface (HP 98034A) used, the Modulation Analyzer's TALK annunciator may be either on or off. The controller's display should read 0.00 (HP 9825A) or 0 (HP 9835A and HP 9845A).

Send the Remote message.	rem 714	REMOTE 714
Place the Modulation Analyzer in serial-poll mode and address it to talk (causing it to send the Status Byte message).	rds(714)⇨V	STATUS 714;V
Display the value of V.	dsp V	PRINT V

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE annunciator is on. Depending upon the vintage of the HP-IB interface (HP 98034A) used, the Modulation Analyzer's TALK annunciator may be either on or off. The controller's display should read 0.00 (HP 9852A) or 0 (HP 9835A and HP 9845A).

Require Service Message

NOTE:

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 POWER switch to STBY, then to ON.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)
Require Service Message (Cont'd)

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Modulation Analyzer to remote).	rem 7	REMOTE 7
Address the Modulation Analyzer to listen (completing the Remote message) then send a Data message (enabling a Require Service to be sent upon Instrument Error).	wrt 714, "22.4SP"	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	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).	rds(7)⇨V	STATUS 7;V
Display the value of the SRQ bit (in this step, 7 is the SRQ bit, numbered from 0).	dsp"SRQ=", bit (7,V)	PRINT "SRQ="; BIT (V,7)

OPERATOR'S RESPONSE:

Check that the Modulation Analyzer's REMOTE, LISTEN, and SRQ annunciators are on and that the controller's display reads an SRQ value of 1, indicating the Modulation Analyzer issued the Require Service message.

OPERATOR'S CHECKS

3-11. HP-IB Functional Checks (Cont'd)

Trigger Message and Clear Key Triggering

NOTE:

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 POWER switch to STBY, then to ON.

Description	HP 9825A (HPL)	HP 9835A and 9845A (BASIC)
Send the first part of the Remote message (enabling the Modulation Analyzer to remote).	rem 7	REMOTE 7
Address the Modulation Analyzer to listen (completing the Remote message), then send a Data message (placing the Measuring Receiver in Hold mode).	wrt 714, "T1"	OUTPUT 714;"T1"
Send the Trigger message.	trg 7	TRIGGER 7
Address the Modulation Analyzer to talk and store the data in variable V.	red 714,V	ENTER 714;V
Display the value of V.	dsp V	PRINT V

OPERATOR'S RESPONSE:

Check that both the Modulation Analyzer's REMOTE and TALK annunciators are on. The controller's display should read 90000096000.00 (HP 9825A) or 90000096000 (HP 9835A and HP 9845A).

Address the Modulation Analyzer to talk and store the data in variable V.	red 714,V	ENTER 714;VV

3-11. HP-IB Functional Checks (Cont'd)
Trigger Message and Clear Key Triggering (Cont'd)

OPERATOR'S RESPONSE:

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.

3-12. REMOTE OPERATION HEWLETT-PACKARD INTERFACE BUS

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

A quick test of the HP-IB I/O is described under Remote Operator's Checks (paragraph 3-11). These checks verify that the Modulation Analyzer can respond to or send each of the applicable bus messages described in the following paragraphs.

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, "Improving Measurements in Engineering and Manufacturing" (HP part number 5952-0058).

3-13. HP-IB Compatibility

The Modulation Analyzer's complete bus compatibility as defined in IEEE Standard 488, and the identical ANSI Standard MC1.1 is: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0.

3-14. Remote Mode

Remote Capability. In remote, most of the Modulation Analyzer's front-panel controls are disabled (exceptions are the LOCAL and CLEAR keys). However, front-panel displays and the output signal at MODULATION OUTPUT/AUDIO INPUT remain active and valid. In remote, the Modulation Analyzer can 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 can 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, the REMOTE and either the TALK or LISTEN annunciators on its front panel will turn on.

3-15. 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 LOCAL key is pressed.

3-16. 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: attention control line (ATN) true and interface clear control line (IFC) false. Whenever the Modulation Analyzer is being addressed to listen (whether in local or remote), the LISTEN annunciator on the front panel will turn on. When the Modulation Analyzer is being addressed to talk, the TALK annunciator will turn on.

The Modulation Analyzer's talk and listen addresses are switch selectable as described in paragraph 2-7. Refer to Table 2-2 for a comprehensive listing of all valid HP-IB address codes. To determine the present address setting, refer to the discussion "HP-IB Address" in the Detailed Operating Instructions in this section.

Local Lockout. When a data transmission is interrupted, which can happen by returning the Modulation Analyzer to local mode by pressing the LOCAL 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 LOCAL 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 POWER 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.

3-17. 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 can be performed in remote mode via data messages. The only exceptions are changing the POWER switch setting and using the Controller Reset Service Special Function. In addition, the Modulation Analyzer can be triggered via data messages to make measurements at a particular time.

3-18. 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 its 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 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 us) FM deviation of an input signal at 104.5 MHz.

Receiving the Data Message (Cont'd)

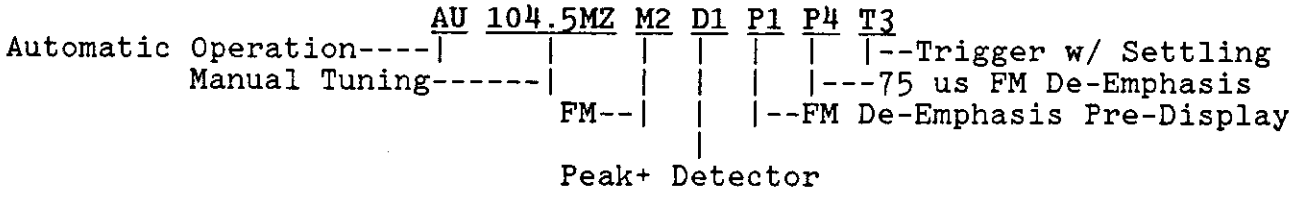
EXAMPLE 1: General Program Syntax and Protocol----------

{Controller Talk}
{Modulation Analyzer Listen},

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

EXAMPLE 2: Typical Program String----------

{Controller Talk}
{Modulation Analyzer Listen},



Program Codes. Table 3-1 lists the Modulation Analyzer's response to various ASCII characters not used in its code set. The characters in the left-hand column are 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 24 (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.

The valid HP-IB codes for controlling Modulation Analyzer functions are summarized in Table 3-2 (and on the Operating Instructions pull-out card). All front-panel keys except the LOCAL 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. The codes provided are the codes used in all programming examples in this manual.

Turning Off Functions. When operating in local mode, many of the functions toggle on and off with successive keystroles. In remote mode, these functions do not toggle on and off. Instead, a specific code turns off the keys. (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.)

Receiving the Data Message (Cont'd)

Table 3-1. 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.

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 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 ten allowed for the mantissa will be received as zero. In general, do not issue numeric data with more significant digits than can be displayed on the Modulation Analyzer's 10-digit display.

Triggering Measurements with the Data Message. A feature that is only available via 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.

Receiving the Data Message (Cont'd)

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 via the bus. Thus, the output signal at MODULATION OUTPUT/AUDIO INPUT 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 output signal at MODULATION OUTPUT/ AUDIO INPUT 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, Trigger With Settling codes, or 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 measurement results. However, if the instrument receives GTL (Go To Local), GET (Group Execute Trigger), or 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 via 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 via 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 RF Power, AM, or FM Calibrator. Refer to the procedures "RF Power Calibration", "AM Calibration", or "FM Calibration" in the Detailed Operating Instructions.

Receiving the Data Message (Cont'd)

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), local lockout (LLO), etc. In addition, if it is addressed to listen, it must pay attention to all addressed bus commands, for example, go to local (GTL), group execute trigger (GET), etc. 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 environment 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 highlighting:

AUTOMATIC OPERATION (AU). As in local mode, when AUTOMATIC OPERATION is executed in remote it sets all Special Functions prefixed 1 through 10 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.

Receiving the Data Message (Cont'd)

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.

3-19. 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.

Sending the Data Message (Cont'd)

Data Output Format. As shown below, the output data is always formatted as a real constant: first the sign, then 10 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, %, etc.), and the decimal point (not sent) is assumed to be to the right of the tenth digit of the mantissa. Data values never exceed 4 000 000 000.

Data Output Format:

```
                  ± DDDDDDDDDD E ± NN CR LF
     Signed Mantissa----|       | | |  |  |------Line Feed
Indicates Exponent Follows---| | |  |---Carriage Return
           Exponent Sign-----| |---Exponent Magnitude
```

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 90 000 000 000. 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 9×10^{10}, then dividing the results by 1000.

Error Output Format:

```
          +900000 DD 00 E+01 CR LF
                  |           |  |----Line Feed
Error Code--------|           |--Carriage Return
```

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.

3-20. Receiving the Clear Message

The Modulation Analyzer responds to the Clear message by assuming the settings listed in the Detailed Operating Instruction, "Instrument Preset". The Modulation Analyzer responds equally to the Selected

Receiving the Clear Message (Cont'd)
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).

3-21. Receiving the Trigger Message

When in remote and addressed to listen, the Modulation Analyzer responds to a Trigger message by executing one settled-measurement 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" that appears earlier in this section.

3-22. 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 LISTEN or TALK annunciator turns on.

3-23. 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 LISTEN or TALK annunciator lights.

Receiving the Local Message (Cont'd)
If the Modulation Analyzer is not in local lockout mode, pressing the front-panel 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.

3-24. 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 LOCAL and CLEAR keys. (In remote, CLEAR initiates a Trigger With Settling cycle.) The local lockout mode prevents loss of data or system control when someone accidentally presses 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 POWER switch to STBY and back to ON or by removing the bus cable.

3-25. 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.

3-26. Receiving the Pass Control Message

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

3-27. 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 six other conditions which can be enabled to cause the Require Service message to be sent when they occur. Refer to "Service Request Condition" in the Detailed Operating Instructions.

3-28. Selecting the Service Request Condition

Use Special Function 22, Service Request Condition, to enable the Modulation Analyzer to issue the Require Service message. HP-IB code errors always cause the Require Service message to be sent. The Service Request Condition Special Function is entered from either the front panel or via 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 provided under "Service Request Condition" in the 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. A device subroutines structure, using the instrument's ability to issue the Require Service message when data is ready, frees the controller to process other routines until the Modulation Analyzer is ready with data.

3-29. Sending the Status Byte Message

The Status Byte message consists of one 8-bit byte in which 7 of the bits are set according to the enabled conditions described in "Sending the Require Service Message" discussed earlier in this section.

If any of the conditions enabled by Special Function 22 are 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 sent). The front-panel SRQ annunciator turns on. If one these 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).

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

Sending the Status Byte Message (Cont'd)
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.

3-30. 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.

3-31. 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.

Table 3-2. Modulation Analyzer to HP-IB Code Summary

MEASUREMENT	CODE
AM	M1
FM	M2
ϕM	M3
RF POWER	M4
FREQ	M5
AUDIO FREQ	S1
AUDIO DISTN	S2
IF LEVEL	S3
TUNED RF LEVEL	S4
FREQ ERROR	S5

DETECTOR	CODE
PEAK+	D1
PEAK−	D2
PEAK HOLD	D3
AVG	D4
1 kHz DISTN	D5
400 Hz DISTN	D6
RMS	D8
PEAK±/2	D9

DISPLAY	CODE
Display LOG Result	LG
Display LIN Result	LN
dB EXT ATTEN Off	N0
dB EXT ATTEN On	N1
RATIO Off	R0
RATIO On	R1
PREVIOUS RATIO	R2

FILTERS	CODE
HP FILTERs Off	H0
50 Hz HIGH-PASS On	H1
300 Hz HIGH-PASS On	H2
LP FILTERs Off	L0
3 kHz LOW-PASS On	L1
15 kHz LOW-PASS On	L2
>20 kHz On	L3

FM DE-EMPHASIS	CODE
FM DE-EMPHASIS Off and PRE-DISPLAY Off	P0
PRE-DISPLAY On	P1
25 μs DE-EMPHASIS	P2
50 μs DE-EMPHASIS	P3
75 μs DE-EMPHASIS	P4
750 μs DE-EMPHASIS	P5

CALIBRATION	CODE
CALIBRATE Off	C0
CALIBRATE On	C1
% CAL FACTOR	CF
SAVE CAL	SC

MANUAL OPERATION	CODE
AUTO TUNING	AT
ENABLE ERRORS	B0
DISABLE ERROR	B1
CLEAR	CL
DISPLAY FREQ	FR
DISPLAY INCREMENT	FN
Step Up (Hz)	HU
Step Down (Hz)	HD
INPUT FREQUENCY(Hz)	HZ
TRACK Mode Off	K0
TRACK Mode On	K1
Step Up (kHz)	KU
Step Down (kHz)	KD
mV Units	MV
MHz (INPUT FREQ)	MZ
RECALL	RC
SPECIAL FUNCTION	SP
SPECIAL, SPECIAL	SS
STORE	TR
μV Units	UV
V Units	VL
W Units	WT

MISCELLANEOUS	CODE
MODULATION OUTPUT	A0
AUDIO INPUT	A1
AUTOMATIC OPERATION	AU
Automatic Ranging	G0
RANGE HOLD	G1
Identify Instrument	ID
INSTR PRESET	IP
Trigger Off	T0
Hold	T1
Trigger Immediate	T2
Trigger with Settling	T3
Hexadecimal A	X0
Hexadecimal B	X1
Hexadecimal C	X2
Hexadecimal D	X3
Hexadecimal E	X4
Hexadecimal F	X5
ZERO	ZR

Table 3-3. Commonly Used Code Conversions

ASCII	Binary	Octal	Decimal	Hexa-decimal
NUL	00 000 000	000	0	00
SOH	00 000 001	001	1	01
STX	00 000 010	002	2	02
ETX	00 000 011	003	3	03
EOT	00 000 100	004	4	04
ENQ	00 000 101	005	5	05
ACK	00 000 110	006	6	06
BEL	00 000 111	007	7	07
BS	00 001 000	010	8	08
HT	00 001 001	011	9	09
LF	00 001 010	012	10	0A
VT	00 001 011	013	11	0B
FF	00 001 100	014	12	0C
CR	00 001 101	015	13	0D
SO	00 001 110	016	14	0E
SI	00 001 111	017	15	0F
DLE	00 010 000	020	16	10
DC1	00 010 001	021	17	11
DC2	00 010 010	022	18	12
DC3	00 010 011	023	19	13
DC4	00 010 100	024	20	14
NAK	00 010 101	025	21	15
SYN	00 010 110	026	22	16
ETB	00 010 111	027	23	17
CAN	00 011 000	030	24	18
EM	00 011 001	031	25	19
SUB	00 011 010	032	26	1A
ESC	00 011 011	033	27	1B
FS	00 011 100	034	28	1C
GS	00 011 101	035	29	1D
RS	00 011 110	036	30	1E
US	00 011 111	037	31	1F
SP	00 100 000	040	32	20
!	00 100 001	041	33	21
"	00 100 010	042	34	22
#	00 100 011	043	35	23
$	00 100 100	044	36	24
%	00 100 101	045	37	25
&	00 100 110	046	38	26
'	00 100 111	047	39	27
(	00 101 000	050	40	28
)	00 101 001	051	41	29
*	00 101 010	052	42	2A
+	00 101 011	053	43	2B
,	00 101 100	054	44	2C
—	00 101 101	055	45	2D
.	00 101 110	056	46	2E
/	00 101 111	057	47	2F
0	00 110 000	060	48	30
1	00 110 001	061	49	31
2	00 110 010	062	50	32
3	00 110 011	063	51	33
4	00 110 100	064	52	34
5	00 110 101	065	53	35
6	00 110 110	066	54	36
7	00 110 111	067	55	37
8	00 111 000	070	56	38
9	00 111 001	071	57	39
:	00 111 010	072	58	3A
;	00 111 011	073	59	3B
<	00 111 100	074	60	3C
=	00 111 101	075	61	3D
>	00 111 110	076	62	3E
?	00 111 111	077	63	3F

ASCII	Binary	Octal	Decimal	Hexa-decimal
@	01 000 000	100	64	40
A	01 000 001	101	65	41
B	01 000 010	102	66	42
C	01 000 011	103	67	43
D	01 000 100	104	68	44
E	01 000 101	105	69	45
F	01 000 110	106	70	46
G	01 000 111	107	71	47
H	01 001 000	110	72	48
I	01 001 001	111	73	49
J	01 001 010	112	74	4A
K	01 001 011	113	75	4B
L	01 001 100	114	76	4C
M	01 001 101	115	77	4D
N	01 001 110	116	78	4E
O	01 001 111	117	79	4F
P	01 010 000	120	80	50
Q	01 010 001	121	81	51
R	01 010 010	122	82	52
S	01 010 011	123	83	53
T	01 010 100	124	84	54
U	01 010 101	125	85	55
V	01 010 110	126	86	56
W	01 010 111	127	87	57
X	01 011 000	130	88	58
Y	01 011 001	131	89	59
Z	01 011 010	132	90	5A
[	01 011 011	133	91	5B
\	01 011 100	134	92	5C
]	01 011 101	135	93	5D
^	01 011 110	136	94	5E
—	01 011 111	137	95	5F
`	01 100 000	140	96	60
a	01 100 001	141	97	61
b	01 100 010	142	98	62
c	01 100 011	143	99	63
d	01 100 100	144	100	64
e	01 100 101	145	101	65
f	01 100 110	146	102	66
g	01 100 111	147	103	67
h	01 101 000	150	104	68
i	01 101 001	151	105	69
j	01 101 010	152	106	6A
k	01 101 011	153	107	6B
l	01 101 100	154	108	6C
m	01 101 101	155	109	6D
n	01 101 110	156	110	6E
o	01 101 111	157	111	6F
p	01 110 000	160	112	70
q	01 110 001	161	113	71
r	01 110 010	162	114	72
s	01 110 011	163	115	73
t	01 110 100	164	116	74
u	01 110 101	165	117	75
v	01 110 110	166	118	76
w	01 110 111	167	119	77
x	01 111 000	170	120	78
y	01 111 001	171	121	79
z	01 111 010	172	122	7A
{	01 111 011	173	123	7B
|	01 111 100	174	124	7C
}	01 111 101	175	125	7D
~	01 111 110	176	126	7E
DEL	01 111 111	177	127	7F

[1]The ASCII code set is used extensively throughout this manual, for example, in the tables of HP-IB Program Codes. The shaded ASCII codes represent HP-IB addresses when the ATN bus line = 1 = Low.

Introduction to Detailed Operating Instructions

The Detailed Operating Instructions describe most of the functions that can be accessed by the user.

Title: Lists the main function to be discussed as well as any related front-panel keys or special functions that won't be described in any other instructions.

Description: Describes the function.

Procedure: Enables the user to perform the measurement or function that is explained in the "Description". Possible malfunctions and operator errors might be discussed in "Comments".

Example: Describes the necessary steps required to accomplish one of the more complicated functions discussed in the procedure.

Indications: Describes the expected response of the instrument when the procedure is performed; which annunciators will light in the display and which LEDs within the keys will light.

Measurement Technique: Describes the circuit operation that enables the instrument to make the measurement described in "Description".

Comments: Describes any miscellaneous information; any dicrepancies in the instrument's performance during a measurement, or those features that can be used to extend the normal capability of the function.

AM
(Includes Special Function 2)

Description

The AM key enables the Modulation Analyzer to measure the AM depth of the tuned RF input signal. Special Function 2 enables the instrument to set limits on the range of AM depth that can be measured.

The demodulated AM is present at MODULATION OUTPUT/AUDIO INPUT (unless AUDIO INPUT has been selected). The demodulated AM is usually present at the rear-panel AM OUTPUT connector. (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 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). Modulation depths to 99% can be measured.

The demodulated signal's frequency and distortion can also be characterized. (Refer to **Audio Distortion and Level** and **Audio Frequency**.)

Procedure

To make an AM measurement, first tune the instrument to the input signal. (Refer to **RF Frequency Tuning** or press AUTOMATIC OPERATION). Press the AM key.

Select an audio detector: PEAK+, PEAK-, or AVG. (The RMS detector, selected by pressing the Blue Key and the RMS key, is not quite as accurate in measuring AM and is usually only used for audio distortion measurements.)

The following table lists the different measurement range limits that can be selected with Special Function 2:

Modulation Range Peak± (%)	Detector Selected	Special Function Code	Program Code (HP-IB)	Display Resolution (%)	MODULATION OUTPUT Sensitivity (Vac/% AM)
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection	
≤4	RMS	2.4 SPCL	2.4SP	0.001	1
≤40	Pk, Avg	2.4 SPCL	2.4SP	0.01	0.1
≤40	Pk, Avg, RMS	2.1 SPCL	2.1SP	0.01	0.1
≤100	Pk, Avg, RMS	2.2 SPCL or 2.3 SPCL	2.2SP or 2.3SP	0.1	0.01

AM (Cont'd)
(Includes Special Function 2)

Procedure (cont'd)
To filter the demodulated signal, press the appropriate filter keys (refer to **Audio Filters**).

If AM depth is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to **Ratio**.)

Example

To measure the positive peak AM depth of a signal in a 50 Hz to 15 kHz demodulated signal bandwidth:

LOCAL (keystrokes)	
HP-IB (program codes)	

HP-IB Program Codes

All HP-IB codes for changing the limits of the modulation-depth measurements are provided in "Procedures".

AM = M1
SPCL = SP

Indications

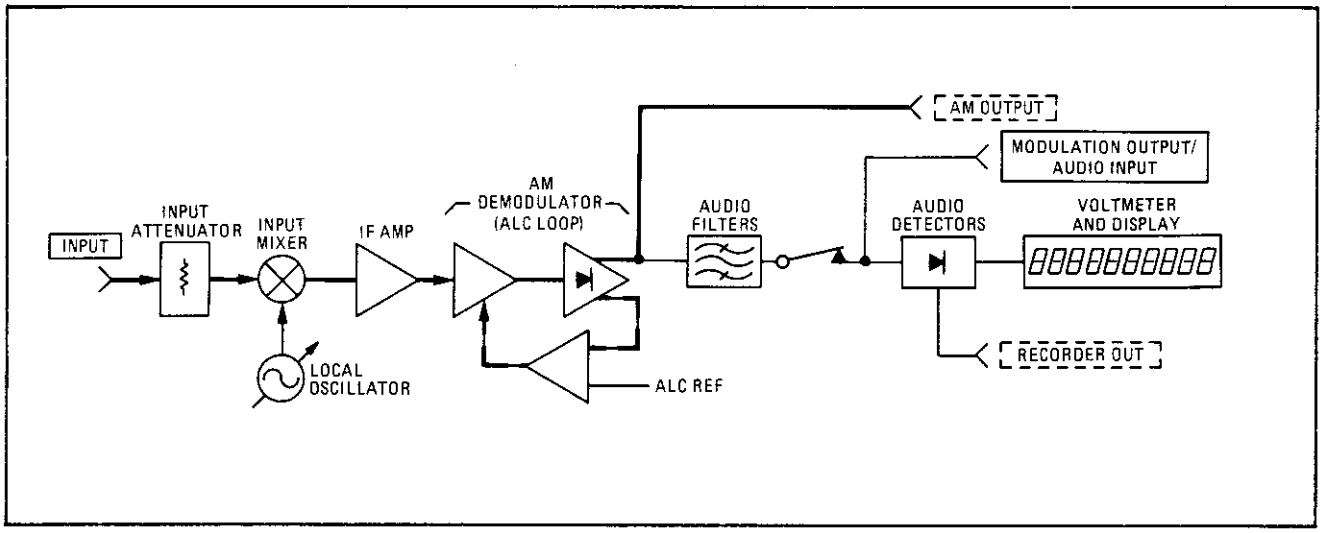
Display: When the AM key is pressed, the measured AM depth is displayed. The % annunciator is also displayed.

Front Panel: The LEDs within the selected functions light.

Measurement Technique

The AM Demodulator measures AM as a ratio of the demodulated audio signal level to the average tuned carrier level. An automatic level control (ALC) loop within the AM Demodulator holds the carrier level constant so that the percent AM is proportional to the peak amplitude of the demodulated audio output. This audio output is then filtered, audio detected, and displayed as % AM. The demodulated AM is available at MODULATION OUTPUT/AUDIO INPUT (unless AUDIO INPUT is selected).

AM (Cont'd)
(Includes Special Function 2)



AM Measurement Block Diagram

Comments

The PEAK+ detector always detects the peak of the carrier envelope while the PEAK- detector always detects the trough. The PEAK ±/2 detector sums the peak and the trough and divides the total by two to provide an average peak value. (This value should not be confused with a detected average value.)

The routine which automatically selects the modulation range contains a region of overlap between 35 and 40% AM (peak detected). When using the average detector, ranging occurs with lower modulation levels displayed. If the modulation level is reduced from above 40% into this overlap region, only 0.1% resolution might be displayed although 0.01% resolution is available. To display the increased resolution, press the AM key a second time. To set the instrument to a selected modulation range, refer to Audio Range.

When operating above 2.5 MHz while using the 455 kHz IF, the upper limit of the modulation rate is that of the >20 kHz LP FILTER. The 15 kHz LP FILTER is automatically selected when operating below 10 MHz or whenever the 455 kHz IF is selected. However, this filter may be overridden by selecting another LP FILTER. The lower limit of the modulation rate is determined by the ALC response time selected. (Refer to AM ALC Response Time.)

The signal at AM OUTPUT is inverted for all carrier frequencies.

AM conditions that cause the carrier signal to disappear (such as 100% AM or pulse modulation) will cause inaccuracies in measurement of FM, ϕM, or input frequency, or they could cause Error 05 (FM squelched) to be displayed when these measurements are selected.

AM (Cont'd)
(Includes Special Function 2)

Related Functions

AM Output
AM ALC Response Time
Audio Detectors
Audio Filters
Audio Range
Ratio
Residual Noise Effects

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 figure in AM, "AM Measurement Block Diagram".)

Select a fast ALC response time to speed up the measurement settling time required for varying carrier levels. (The faster ALC response time affects AM accuracy at rates less than 1 kHz.)

Disable the ALC and use the rear-panel AM OUTPUT to measure very low modulation rates. (Refer to **AM Output**.)

Procedure

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

AM ALC Response	Special Function Code	Program Code HP-IB
Slow ALC (AM rates >20 Hz)	6.0 SPCL	6.0SP
Fast ALC (AM rates >1 kHz	6.1 SPCL	6.1SP
ALC off	6.2 SPCL	6.2SP

HP-IB Program Codes

For HP-IB codes, refer to "Procedure".

Indications

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display returns to the measurement previously selected.

Front panel: The LED within the SPCL key lights (unless 6.0 SPCL is entered).

AM ALC Response Time (Cont'd)
(Special Function 6)

Comments

When the instrument is first turned on, or when AUTOMATIC OPERATION or INSTR PRESET is pressed, the slow ALC response is selected.

The displayed modulation depth is incorrect when the ALC is disabled unless the IF level is 100%. (Refer to IF Level.)

Related Functions

AM
AM Output
IF Level
Special Functions

AM Calibration
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 13 and 16)

Description

The accuracy of the Modulation Analyzer's AM demodulator can be checked with the internal AM calibrator. The calibration process generates a calibration factor that indicates the AM measurement error (within the accuracy limits of the calibrator). The calibration factor can then be enabled to automatically correct the known AM error in subsequent measurements (the SAVE CAL key or Special Function 16). With the calibration factor enabled, AM measurements can be made with an accuracy typically better than 0.5%. The calibration factor can be enabled, disabled, or displayed at any time.

Other instruments in the HP 8901 and 8902 RF signal analyzer family can be calibrated or cross checked with the Modulation Analyzer's AM calibrator using Special Function 13.

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, then perform the following steps:

1. Connect the CALIBRATION AM/FM OUTPUT to the RF INPUT with a 50 ohm cable (or a sensor module with an internal switch such as the HP 11722A), and select AM.

2. Press the CALIBRATE key. After several seconds, the AM calibration factor will be displayed in % and stored.

The instrument displays 100.00% if no error is measured. A display of 100.17% means the Modulation Analyzer is reading 0.17% high. As long as the CALIBRATE 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 CALIBRATE 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 not be used even if the instrument is already warm, since the circuits in the audio chain may not be fully settled.

AM Calibration (Cont'd)
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 13 and 16)

Procedures (cont'd)
Correcting Measurements with the AM Calibration Factor. Once a calibration factor has been determined, the instrument retains that value in its non-volatile memory. (Refer to **Instrument Preset.**) This factor may be enabled to automatically correct AM measurements. The calibration factor can also be disabled or displayed.

Enter the appropriate front-panel key or Special Function code for the desired action described in the following table:

Action: AM Calibration Factor	Measurement Mode	Front-Panel Key or Special Function Code	Program Code HP-IB
Disable	Any	16.0 SPCL	16.0SP
Enable	AM (From CALIBRATE mode)	(Blue Key) SAVE CAL	SC
	Any	16.1 SPCL	16.1SP
Display	AM	(Blue Key) % CAL FACTOR*	CF
	Any	16.2 SPCL	16.2SP

* The % CAL FACTOR key displays the status of the calibration factor: The factor is enabled if the value of the calibration factor is displayed, with 0.01% resolution. The factor is disabled if 100% is displayed. (Note the resolution of 1%. A display of 100.00% would be a true, calibration factor reading.)

Calibrating or Cross Checking Another HP 8901 or 8902 RF Signal Analyzer. To compute an AM calibration factor for another RF signal analyzer that has no internal calibrator, or that has an internal calibrator that is to be cross checked, use the Modulation Analyzer and its calibrator as follows:

1. Connect the Modulation Analyzer's CALIBRATION AM/FM OUTPUT to the RF input of the RF signal analyzer.

2. Key 13.0 SPCL into the Modulation Analyzer. Record the value that appears on the display. This is the computed, calibrated, peak AM depth (excluding noise).

3. Key 13.1 SPCL into both instruments. Record the value that appears on the display of the RF signal analyzer. (If display jitter makes readings difficult, key 5.1 SPCL.) The displayed value is the weighted, peak, residual AM depth of the calibrator's unmodulated output as demodulated by the RF signal analyzer.

AM Calibration (Cont'd)
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 13 and 16)

Procedures (cont'd)

4. Key 13.2 SPCL into both instruments. Record the value that appears on the display on the RF signal analyzer. This value is the demodulated, positive, peak AM depth of the calibrator's modulated output. (If display jitter makes readings difficult, key 5.1 SPCL.)

5. On the RF signal analyzer, press PEAK-. Note the value displayed on the RF signal analyzer. If the difference between the results of steps 4 and 5 is 3 counts or less in the least significant digit, an average between the two need not be computed; use the result from step 4. If the difference between the two results is greater than 3 counts in the least significant digit, compute the average as follows:

$$(13.2\ \text{result}) = \frac{(\text{result of step 4}) + 2(\text{result of step 5})}{3}$$

6. Compute the AM calibration factor of the RF signal analyzer as follows:

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

7. To use this AM calibration factor to correct AM measurements made with the RF signal analyzer, enter the value as a ratio reference and use the Ratio function in the RF signal analyzer.

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	13.2 SP

AM Calibration (Cont'd)
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 13 and 16)

HP-IB Program Codes

HP-IB codes for enabling, disabling, or displaying the internal AM calibration factor are provided in "Procedures". The HP-IB codes for the AM Calibrator Special Function used to calibrate an RF signal analyzer are also provided as part of "Procedures".

AM = M1
CALIBRATE on = C1
CALIBRATE off = C0
SPCL = SP

Indications

Self-calibration.

Display: When the CALIBRATE key is pressed, approximately 17 seconds pass during which the instrument configures itself and tunes to the calibrator's signal. The display indicates four dashes (----) and lights the % annunciator. Once the AM calibration factor has been computed, it is displayed. Subsequent updates occur approximately every 17 seconds.

Front Panel: The LEDs within the AM and CALIBRATE keys light. The LEDs within the FILTERS, FM DE-EMPHASIS, DETECTOR, DISPLAY, Blue Key, DISABLE ERROR, and SPCL keys are all disabled.

Correcting Measurements with the AM Calibration Factor (Self-calibrated).

Display: When the calibration factor is enabled, the AM depth measurement is always a corrected measurement.

If 16.2 SPCL is keyed, the value of the calibration factor is displayed.

If % CAL FACTOR is keyed, and the AM calibration factor is enabled, the value of the % AM calibration factor is displayed. If % CAL FACTOR is keyed, and the AM calibration factor is disabled, 100% is displayed. (Note the resolution of 1%.)

The display times out after a few seconds and returns the previous display.

Front Panel: When the instrument displays a calibration factor, the SPCL key lights and all annunciators and other key lights are turned off.

AM Calibration (Cont'd)
(Includes CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Function 13 and 16)

Indications (cont'd)
Calibrating Another RF Signal Analyzer.
Display: As the numeric Special Function codes are entered, they appear on the front-panel display. The Modulation Analyzer displays the computed AM depth (Special Function 13.0), but shows two dashes (--) throughout the other measurements.

Front Panel: During these measurements, no measurement keys light, but the LEDs within the SPCL key, the selected DETECTOR key, and the CALIBRATE key of the Modulation Analyzer light.

Measurement Technique

When AM is selected and the CALIBRATE key is pressed, the FM Calibrator sends an unmodulated 10.1 MHz carrier to the AM Calibrator.

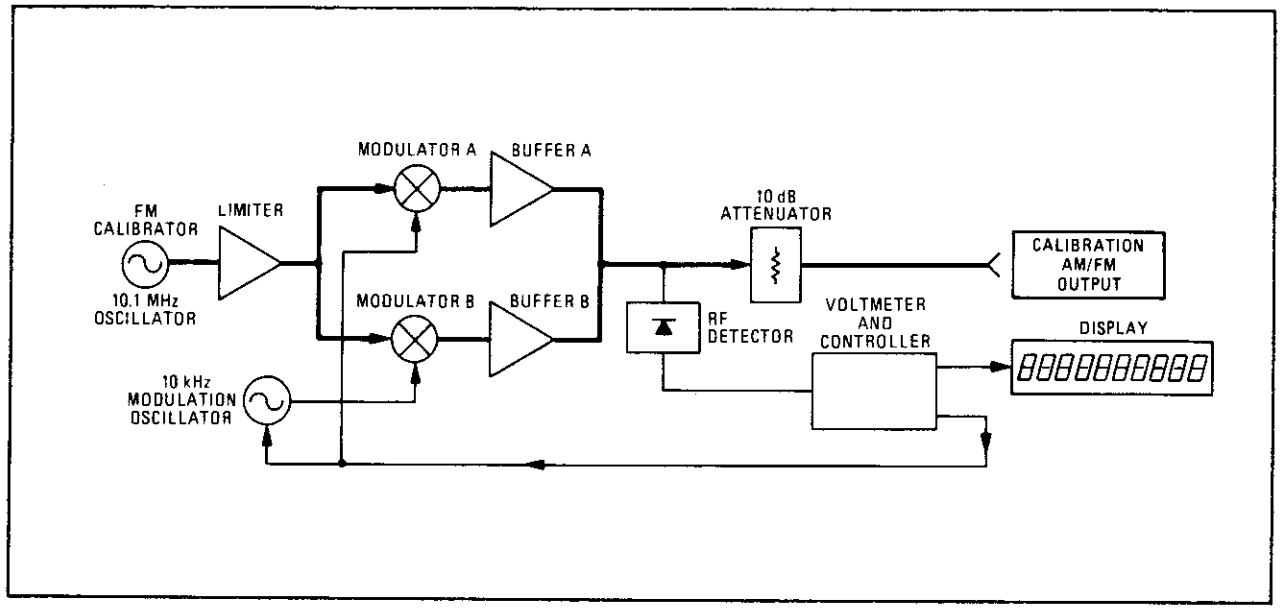
The AM Calibrator contains two identical modulators in parallel (whose outputs are summed). When the calibration operation is initiated, each modulator is turned on and each individual output level is measured via an on-board detector to compute AM depth.

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 signal is switched between full on and half on, the resultant carrier modulation is very near 33.33%. (The exact depth is derived from the measurements that characterize the individual modulators.) This modulation is then measured by the AM demodulator. (Both peak detectors are used, and their 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:

$$\text{AM Cal Factor (\%)} = \frac{\text{Demodulated AM - Demodulated Residual AM}}{\text{Computed AM}} \times 100$$

AM Calibration (Cont'd)
(Includes CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 13 and 16)



Simplified Block Diagram of the AM Calibrator

Comments

If the instrument's non-volatile memory is erased, 100.00% is used as the default calibration factor.

Whenever AM calibration is performed, the instrument updates the stored AM calibration factor.

Pressing the CALIBRATE key cancels all Special Functions.

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

When used to calibrate an RF signal analyzer, Special Function 13.1 and 13.2 set the AM modulation range to that of 0 to 100% (Special Function 2.1). Upon exiting the AM Calibrator Special Function, the audio ranging is not returned to automatic but remains fixed (thus leaving the SPCL light on). Key in 2.0 SPCL to return the audio ranging to automatic.

Related Functions

AM
Ratio
Residual Noise Effects
Special Functions

AM Output

CAUTION

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

Description

The rear-panel AM OUTPUT (dc coupled, 10 kohm output impedance) provides an auxiliary output for the AM demodulated from the signal at the RF INPUT. This output can be used to monitor AM when displaying other measurements. The output can also be used in conjunction with Special Function 6.2 to measure low AM modulation rates. (Refer to **AM ALC Response Time.**)

The output signal comprises a dc voltage related to both the detected IF level and an ac voltage (bandwidth 16 kHz, one pole) that is proportional to the AM depth. The dc component contains an offset voltage (V_{off}) which must be subtracted out. The relationship between % AM and the signal levels at AM OUTPUT is:

$$\% \text{ AM} = \frac{\text{Vpk}}{|\text{Vdc} - V_{off}|} \times 100\%$$

where:
Vpk is the peak of the ac component,
Vdc is the total dc component, and
V_{off} is the dc offset voltage.

When the AM ALC is on, the dc level at AM OUTPUT is held constant, thus,

$$\%\text{AM} = K \times \text{Vpk}, \text{ where } K = \frac{100\%}{|\text{Vdc} - V_{off}|}$$

When the AM ALC is turned off (Special Function 6.2), the dc voltage at AM OUTPUT varies with the signal level (although the offset remains constant), and the full formula must be used for each measurement.

Procedures

To measure AM depth via AM OUTPUT, first determine the offset voltage:

Press AUTOMATIC OPERATION to clear any Special Functions in effect, then connect a dc voltmeter to the AM OUTPUT connector and remove any signal at RF INPUT. Press MHz to fix the tuning, and read the offset voltage on the voltmeter.

AM Output (Cont'd)

Procedures (cont'd)
Disable the AM ALC loop (6.2 SPCL) and apply the carrier to the RF INPUT. Measure the dc and peak ac signals at AM OUTPUT. Use the first equation in "Description" to compute % AM.

Example

To measure AM depth at AM OUTPUT with the AM ALC turned off, measure V_{off} first:

Remove any signal at the RF INPUT and connect a dc voltmeter to AM OUTPUT.

LOCAL (keystrokes)	AUTOMATIC OPERATION; M Z; MHz; INPUT FREQ
HP-IB **(program codes)**	AUMZ

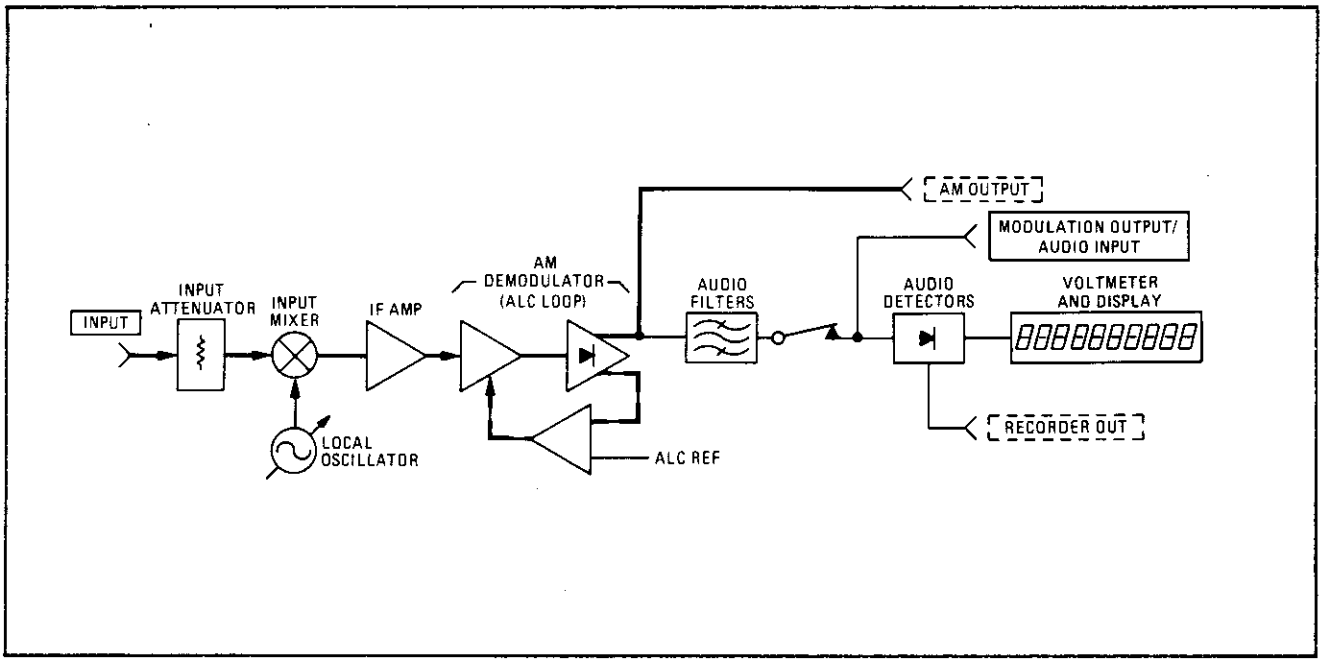
For this example, assume the voltmeter reads an offset voltage of -0.36 Vdc. Connect an AM signal to the RF INPUT and tune the Modulation Analyzer. Disable the AM ALC by keying 6.2 SPCL.

Measure the dc voltage at AM OUTPUT. (When low AM rates are used, it is easiest to measure the dc voltage at AM OUTPUT before the modulation is applied.) For this example, assume the voltmeter reads -0.46 Vdc (=Vdc). Measure the peak ac voltage at AM OUTPUT. (For low rates an oscilloscope may be necessary.) For this example, assume 0.02 Vpk was measured on an oscilloscope. The % AM is:

$$\%\ AM = \frac{Vpk \times 100\%}{|\ Vdc - V_{off}\ |} = \frac{0.02 \times 100\%}{|\ (-0.46)-(-0.36)\ |} = 20\%\ AM$$

AM Output (Cont'd)

Block Diagram



AM Output Block Diagram

Comments

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

The accuracy of measurements made on the AM OUTPUT signal could be degraded during level measurements when the RF peak detector is used (Special Function 35.0).

Related Functions

AM
AM ALC Response Time

Audio Detectors

Description

The Modulation Analyzer provides three types of audio detectors; peak, average (rms calibrated), and true rms. These three detectors yield the following six functions:

- Peak +
- Peak -
- Peak ±/2
- Peak Hold
- Avg (RMS Calibrated)
- RMS

The two peak detector keys, when pressed individually, select whether the positive peak (PEAK+) or the negative peak (PEAK-) of the demodulated signal is measured. When the two peak detector keys are pressed simultaneously, the positive and negative peaks are averaged with the following equation:

$$\text{Peak}_{avg} = \frac{(+\text{Peak}) + (-\text{Peak})}{2}$$

The PEAK HOLD key is used in conjunction with either or both of the two audio peak detectors, PEAK+ or PEAK-. When active, the PEAK HOLD key enables the Modulation Analyzer to hold, and display indefinitely, the greatest peak measurement (+ or -).

The AVG (RMS CAL) key uses an average detector that is calibrated to read rms values of sinewaves. Noise and residual measurements can be measured with this detector.

The RMS key uses a true rms detector to measure audio signals.

The selected detector at turn on is PEAK+.

Once selected, the detector remains unchanged and is automatically activated each time modulation measurements are made until another detector is selected.

The signals at MODULATION OUTPUT/AUDIO INPUT, AM OUTPUT, or FM OUTPUT are not affected by the DETECTOR keys.

Procedures

When a modulation measurement is selected, a detector will automatically be activated.

To select a peak detector function, press the PEAK+ or PEAK- keys individually, or press both keys simultaneously.

Audio Detectors (Cont'd)

Procedures (cont'd)
Peak hold must be used with the peak detectors. To initiate peak hold, press the PEAK HOLD key. To re-initiate a new peak hold cycle, press PEAK HOLD again. The display is now updated with the new peak.

To select the average (rms calibrated) detector, press the AVG key.

To select the true rms detector, press the Blue Key and RMS key.

HP-IB Program Codes

Function	Program Code HP-IB
PEAK+	D1
PEAK–	D2
PEAK HOLD	D3
AVG	D4
RMS	D8
PEAK±/2	D9

Indications

Front Panel: A lighted LED indicates the selected detector.

Comments

Only the rms detector can be selected for most audio measurements.

A slower response time for the audio peak detectors can be used. (Refer to **Audio Detector Response**.)

The PEAK+ detector is selected at power-up.

When the peak hold function is selected, the limited rise time of the peak detector circuitry can cause narrow one-time peaks that could cause slightly low, peak hold measurements. To prevent errors when measuring narrow peaks, repeat the peak-generating process several times while leaving the peak hold function active.

Audio Detectors (Cont'd)

Comments (cont'd)
If the PEAK HOLD key is pressed while the average or true rms detector is active, the detector will switch to the last peak detector previously selected. If the PEAK HOLD key is pressed when the Peak ±/2 function is selected, the key will not light.

HP-IB

In remote operation, new peak hold cycles may only be initiated by code D3. Thus, if the instrument is in HP-IB Hold mode (code T1), issue code D3 to initiate a peak hold cycle. Although the display cannot be updated when in HP-IB Hold, the peak is captured, stored and updated. Upon leaving HP-IB hold via the triggering codes (T2 or T3), the data output will represent the greatest peak captured since the peak hold cycle was initiated.

Related Functions

AM
Audio Detector Response
FM
ϕM
Recorder Output

Audio Detector Response (Special Function 5)

Description

When making modulation measurements, the audio peak detector response (for peak measurements), and the digital averaging response (for rms measurements) is usually fast. A slower response time (narrower bandwidth setting) can be initiated using Special Function 5.

The slow response time (narrower bandwidth setting) helps stabilize measurements on unstable or noisy signals, or whenever measurement display jitter is considered excessive.

Procedure

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

Audio Detector Response	Special Function Code	Program Code HP-IB
Fast	5.0 SPCL	5.0SP
Slow	5.1 SPCL	5.1SP

HP-IB Program Codes

For HP-IB codes, refer to "Procedure".

Indications

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display returns to the measurement previously selected.

Front Panel: The LED within the SPCL key lights (unless 5.0 SPCL is entered).

Comments

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

Related Functions

Audio Detectors
Recorder Output

Audio Distortion and Level (Includes Special Function 30, the 1 kHz DISTN, 400 Hz DISTN, and RMS Keys, and the AUDIO INPUT Key)

Description

The AUDIO DISTN key enables the Modulation Analyzer to make audio distortion measurements. To measure the distortion, the instrument compares the input signal level measured by the true rms detector to the same measurement with the fundamental frequency removed. Distortion can be measured at frequencies of either 1 kHz or 400 Hz using the 1 kHz DISTN or 400 Hz DISTN keys (respectively). Once selected, the 1 kHz or 400 Hz Distortion Measurement mode remains unchanged and is automatically activated each time audio measurements are made until another Distortion Measurement mode is selected.

Special Function 30.0 enables the Modulation Analyzer to measure the true rms level input available at MODULATION OUTPUT/AUDIO INPUT.

The distortion and level of external audio signals can be characterized using the AUDIO INPUT key when the input signal is applied to MODULATION OUTPUT/AUDIO INPUT. When the AUDIO INPUT key is not selected, the Modulation Analyzer can measure the distortion (but not the level) of the audio signal that is demodulated from the signal at the RF INPUT connector.

Procedures

To measure the audio distortion of the audio signal that is demodulated from the signal at the RF INPUT connector, press the S (shift) key and the AUDIO DISTN key. For measurements on signals at the MODULATION OUTPUT/AUDIO INPUT, also press the AUDIO INPUT key. Only the true rms detector can be used; no other detector can be selected.

To change the bandwidth of the internally demodulated audio signal, press the desired filter keys. (Refer to **Audio Filters**.)

If measurements are to be made on a 1 kHz audio signal, press the Blue Key and 1 kHz DISTN (PEAK+) key. If measurements are to be made on a 400 Hz audio signal, press the Blue Key and 400 Hz DISTN (PEAK+) key.

To measure the true rms level of the input signal at MODULATION OUTPUT/AUDIO INPUT, key in 30.0 and press the SPCL key.

If audio distortion or level are to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to **Ratio**.)

Audio Distortion and Level (Cont'd)
(Includes Special Function 30, the 1 kHz DISTN, 400 Hz DISTN, and RMS Keys, and the AUDIO INPUT Key)

HP-IB Program Codes

AUDIO DISTN = S2
AUDIO INPUT = A1
MODULATION OUTPUT = A0
1 kHz DISTN = D5
400 Hz DISTN = D6
LIN results = LN
LOG results = LG
mV units = MV
uV units = UV
VOLTS units = VL
SPCL = SP

Indications

Display: When AUDIO DISTN is selected, the value of audio distortion is displayed in % or dB. The 1 kHz or 400 Hz annunciator is also displayed.

When Special Function 30.0 is selected, the numeric code appears on the display. When the SPCL key is pressed, the measured rms value is displayed, and the selected units annunciator lights. If uV units are selected, the display indicates the measured value in scientific notation; that is, the measured value is followed by a signed, power-of-ten multiplier. The following table shows the annunciator units for linear and logarithmic formats.

Linear Unit	Logarithmic Unit
W	dBm
V	dBV
mV	dB mV
μV	dB μV

Front Panel: When AUDIO DISTN is selected, the LEDs within the S (shift) key and the AUDIO DISTN keys light. The LED next to RMS lights.

When AUDIO INPUT is selected, the LED within the key lights and the LEDs under MODULATION OUTPUT are turned off. If AUDIO INPUT is not selected or is turned off, the appropriate LED lights.

Audio Distortion and Level (Cont'd)
(Includes Special Function 30, the 1 kHz DISTN, 400 Hz DISTN, and RMS Keys, and the AUDIO INPUT Key)

Indications (cont'd)

Front Panel: (cont'd) When Special Function 30.0 is selected, the LEDs within the SPCL and AUDIO INPUT keys light. The LED next to RMS lights.

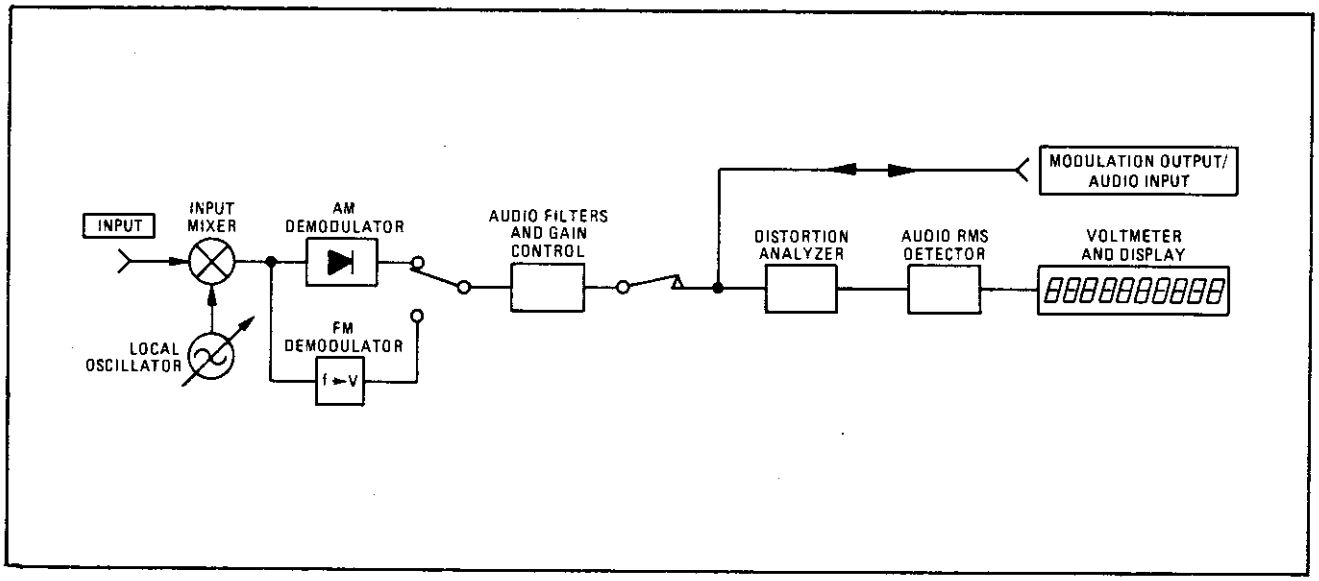
If filters or FM de-emphasis has been selected, these LEDs are turned off.

Measurement Technique

To measure distortion, the broadband audio signal is first measured with the true rms detector; then the audio signal path is switched to go through a notch filter at the distortion frequency (1 kHz or 400 Hz). The notch filter has an approximate 55 dB attenuation at the distortion frequency with a 10% total bandwidth. The two voltages out of the rms detector are measured by the internal voltmeter and the ratio is taken. This ratio is then the distortion of the audio signal.

The direction of the signal at MODULATION OUTPUT/AUDIO INPUT is controlled by the AUDIO INPUT key. The connector has an input impedance of approximately 100 kohms and an output impedance of 600 ohms.

The true rms level (from 0V to 4V) of any audio signal (from 20 Hz to 40 kHz) can be measured using the same rms detector.



Audio Distortion and Level Block Diagram

Audio Distortion and Level (Cont'd)
(Includes Special Function 30, the 1 kHz DISTN, 400 Hz DISTN, and RMS Keys, and the AUDIO INPUT Key)

Comments

At power-up, the instrument defaults to making 1 kHz distortion measurements.

To convert the measured audio level into watts, use the following equation:

20 Log voltage (in volts)

Related Functions

Audio Detectors
Audio Detector Response
Audio Filters
Audio Frequency
SINAD

Audio Frequency
(Includes the AUDIO INPUT key)

Description

The AUDIO FREQ key enables the Modulation Analyzer to count the frequency of either demodulated internal signals or external audio signals.

The AUDIO INPUT key selects measurement of either internal or external signals.

Procedures

To count the frequency of the audio signal that is demodulated from the signal at the RF INPUT connector, press the S (shift) key and the AUDIO FREQ key.

To count the frequency of the signal at the RF INPUT connector, follow the above procedure, and then press the AUDIO INPUT key.

If audio frequency is to be displayed relative to a reference, enter the value as a ratio reference using the Ratio function. (Refer to Ratio.)

HP-IB Program Code

AUDIO FREQ = S1

Indications

Display: When AUDIO FREQ is selected, the frequency is displayed in kHz with a resolution of 0.001 Hz.

Front Panel: When AUDIO FREQ is selected, the LEDs within the S (shift) key and the AUDIO FREQ keys light.

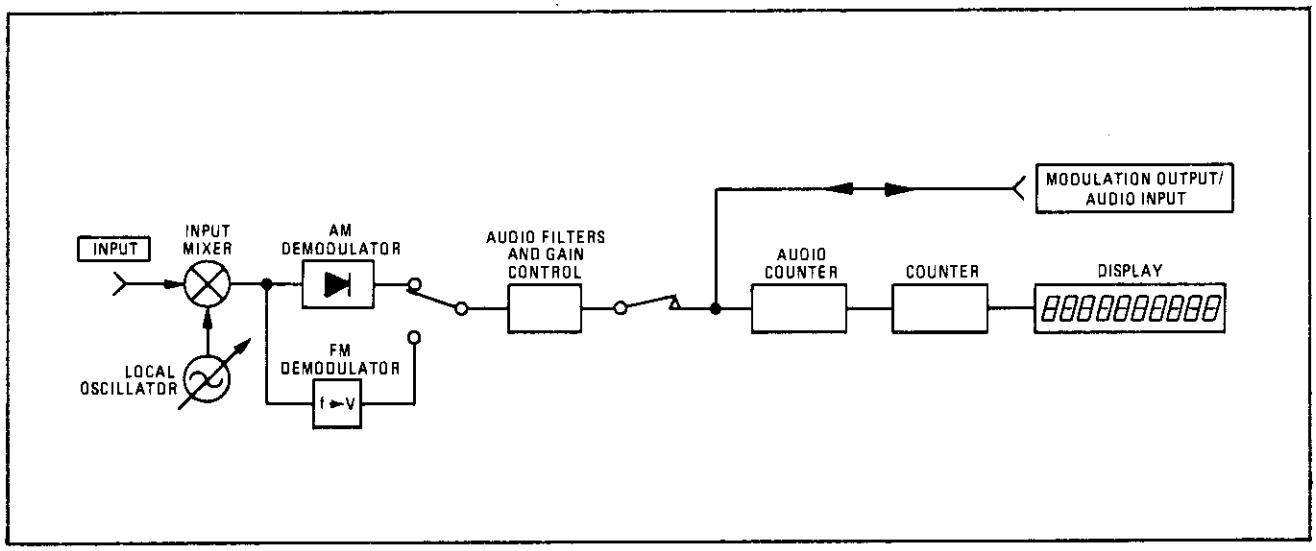
When AUDIO INPUT is selected, the LED within the key lights and the LEDs under MODULATION OUTPUT are turned off.

Measurement Technique

The audio frequency measurement uses a reciprocal counter to count either demodulated internal signals or external audio signals. The Modulation Analyzer gates the 10 MHz time base with the audio signal so the period of the audio signal is equal to the number of time base pulses divided by 10 MHz. The frequency is 1/period. The time base is counted for 100 ms to achieve the resolution of 0.001 Hz.

Audio Frequency (Cont'd)
(Includes the AUDIO INPUT key)

Measurement Technique (cont'd)
The direction of the signal at MODULATION OUTPUT/AUDIO INPUT is controlled by the AUDIO INPUT key. The connector has an input impedance of approximately 100 kohms and an output impedance of 600 ohms.



Audio Frequency Block Diagram

Related Functions

Audio Distortion and Level
SINAD

Audio Range
(Special Function 2)

Description

The Modulation Analyzer is usually set to automatically select the audio range appropriate for the desired measurement. To limit the range of possible measurement, the audio range can be manually set using Special Function 2.

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 Peak± (%)	Detector Selected	Special Function Code	Program Code HP-IB	Display Resolution (%)	MODULATION OUTPUT Sensitivity (Vac/% AM)
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection	
≤4	RMS	2.4 SPCL	2.4SP	0.001	1
≤40	Pk, Avg	2.4 SPCL	2.4SP	0.01	0.1
≤40	Pk, Avg, RMS	2.1 SPCL	2.1SP	0.01	0.1
≤100	Pk, Avg, RMS	2.2 SPCL or 2.3 SPCL	2.2SP or 2.3SP	0.1	0.01

Audio Range (Cont'd)
(Special Function 2)

Procedure (cont'd)

FM

Modulation Range (Peak±kHz dev.)	Detector Selected	Special Function Code	Program Code HP-IB	Display Resolution (Hz)	MODULATION OUTPUT Sensitivity (Vac/% Hz)
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection	
≤0.04	RMS	2.4 SPCL[1]	2.4SP	0.01	100
≤0.4	RMS Pk, Avg Pk, Avg, RMS	2.4 SPCL 2.4 SPCL[1] 2.1 SPCL[1]	2.4SP 2.4SP 2.1SP	0.1	10
≤4	Pk, Avg Pk, Avg, RMS Pk, Avg, RMS	2.4 SPCL 2.1 SPCL 2.2 SPCL[1]	2.4SP 2.1SP 2.2SP	1	1
≤40	Pk, Avg, RMS	2.2 SPCL 2.3 SPCL[1]	2.2SP 2.3SP	10	0.1
≤400	Pk, Avg, RMS	2.3 SPCL	2.3SP	100	0.01

[1] With 750 μs de-emphasis, pre-display only.

φM

Modulation Range (Peak±rad. dev.)	Detector Selected	Special Function Code	Program Code HP-IB	Display Resolution (radians)	MODULATION OUTPUT Sensitivity (mVac/radian)
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection	
≤0.4	RMS	2.4 SPCL	2.4SP	0.0001	10
≤4	Pk, Avg	2.4 SPCL	2.4SP	0.001	1
≤4	Pk, Avg, RMS	2.1 SPCL	2.1SP	0.001	1
≤40	Pk, Avg, RMS	2.2 SPCL	2.2SP	0.01	0.1
≤400	Pk, Avg, RMS	2.3 SPCL	2.3SP	0.1	0.01

Audio Range (Cont'd)
(Special Function 2)

HP-IB Program Codes

For HP-IB codes, refer to "Procedure".

Indications

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display returns to the measurement previously selected.

Front Panel: The LED within the SPCL key lights (unless 2.0 SPCL is entered).

Comments

When the instrument is first powered up or when AUTOMATIC OPERATION or INSTR PRESET is selected, the audio range is placed in the automatic selection mode.

Special Function 2.4 is usually only used in audio distortion measurements. If the true RMS detector is not selected, Special Function 2.4 selects the identical range as that selected with Special Function 2.1.

When the audio range selected is too high (that is, the audio signal level is too low), no error is generated, and the output of MODULATION OUTPUT/AUDIO INPUT tracks the displayed values. When the audio range is too low (that is, the audio signal level is too high), Error 04 is generated. Error 04 might not be generated exactly at the nominal level at which ranges are switched.

When Error 04 is disabled (refer to **Disable Error Message Control**), the Modulation Analyzer automatically ranges to the higher audio ranges. This feature is used most often when modulation varies widely with time (such as off-the-air demodulation of a broadcast signal).

Related Functions

AM
Disable Error Message Control
FM
ϕM
Range Hold
Special Functions

Automatic Operation

Description

The AUTOMATIC OPERATION key configures the Modulation Analyzer to automatically tune to the largest detectable input carrier (refer to **RF Frequency Tuning** for qualifications) and to make the measurement selected.

The AUTOMATIC OPERATION key sets Special Functions with prefixes 1 through 10 to their 0-suffix mode, disables some front-panel keys (TRACK MODE, AUTO TUNING, RANGE HOLD, DISABLE ERROR, and Blue Key), turns off many Special Functions with prefixes greater than 10, and overrides all Service Special Functions (prefixes 0, 40, or greater). The AUTOMATIC OPERATION key does not affect HP/LP FILTERs, FM DE-EMPHASIS, MEASUREMENT, CALIBRATION, SAVE CAL (including all calibration factors), DETECTOR, DISPLAY, RATIO, Limit settings (Special Function 14), or Frequency Offset Control (Special Function 27).

MODULATION OUTPUT/AUDIO INPUT is blanked temporarily during the automatic tuning process that is initiated when the AUTOMATIC OPERATION key is pressed.

Procedure

To re-enter the Automatic Operation mode, press the AUTOMATIC OPERATION key. The instrument will immediately re-tune to the input signal and make the measurement selected.

HP-IB Program Code

AUTOMATIC OPERATION = AU

Indications

Display: Four dashes (----) are displayed while the instrument conducts an automatic-tuning sequence. When tuned, the instrument displays the measurement selected.

If two dashes (--) are displayed, the Modulation Analyzer cannot locate the signal.

Front panel: The LEDs within the selected functions light.

Comments

The instrument powers up in the Automatic Operation mode.

Automatic Operation

Comments (cont'd)

The AUTOMATIC OPERATION key is the easiest way to make measurements in applications where only a single carrier is present at the RF INPUT. The instrument configures itself to meet the needs of most measurement situations, and all errors preventing inaccurate displays are enabled.

The converse of the Automatic Operation mode is the RANGE HOLD key. Refer to RANGE HOLD.

Related Functions

Instrument Preset
Range Hold
RF Frequency Tuning
Special Functions

Disable Error Message Control
(Includes the DISABLE ERROR key and Special Function 8)

Description

When the Modulation Analyzer is in its Automatic Operation mode, some measurement safeguards are selectively enabled or disabled to allow the broadest range of calibrated measurements to be displayed. Errors are displayed when these safeguards must be enabled. The safeguards can be manually disabled or enabled using Special Function 8. The DISABLE ERROR key performs the same function as Special Function 8.7 (Errors 01, 02, 03, 04 disabled).

When any errors are disabled, the quality of the signal at the output of MODULATION OUTPUT/AUDIO INPUT is not safeguarded. When all the errors are enabled, displayed results are calibrated and the output of MODULATION OUTPUT/AUDIO INPUT is entirely safeguarded.

Most combinations of Errors 01 through 04 can be disabled or enabled by the operator to modify the behavior of the instrument to meet the requirements of the measurement conditions. By entering Special Function 8.8 (which enables all errors), the Modulation Analyzer can be set up as primarily a calibrated receiver.

The following table lists the error messages conveyed by Errors 01 through 04:

Error	Error Message
01	Signal out of IF range
02	Input circuits overdriven
03	Input circuits underdriven
04	Audio circuits overdriven

Disable Error Message Control (Cont'd)
(Includes the DISABLE ERROR key and Special Function 8)

Description (cont'd)
The following table lists the errors that are automatically disabled in each Measurement mode:

Measurement Selected	Errors Disabled When in Automatic Selection Mode (Special Function 8.0)
AM	None
FM	None
ϕM	None
RF POWER	01, 04
FREQ	02, 03, 04
AUDIO FREQ	None
AUDIO DISTN	None
IF LEVEL	01, 02, 03, 04
TUNED RF LEVEL	02, 03, 04
FREQ ERROR	01, 02, 03, 04
SINAD (Special Function 29.0)	None
EXT AUDIO RMS LEVEL (Speical Function 30.0)	None
LO FREQUENCY (Special Function 33.0)	01, 02, 03, 04
IF FREQUENCY (Special Funciton 34.0)	01, 02, 03, 04
RF LEVEL (Special Function 35.0)	01, 04

Procedures

To disable Errors 01, 02, 03, and 04, press the Blue Key and DISABLE ERROR (RANGE HOLD) key.

To selectively enable or disable combinations of Errors 01 through 04, enter the Special Function code that corresponds to the condition desired, then press the SPCL key. The codes for the various conditions are provided in the following table:

Error Condition	Special Function Code	Program Code HP-IB
Automatic Selection	8.0 SPCL	8.0SP
01 disabled	8.1 SPCL	8.1SP
02 and 03 disabled	8.2 SPCL	8.2SP
01, 02, and 03 disabled	8.3 SPCL	8.3SP
04 disabled	8.4 SPCL	8.4SP
01 and 04 disabled	8.5 SPCL	8.5SP
02, 03, and 04 disabled	8.6 SPCL	8.6SP
01, 02, 03, and 04 disabled	8.7 SPCL	8.7SP
01, 02, 03, and 04 enabled	8.8 SPCL	8.8SP

Disable Error Message Control (Cont'd)
(Includes the DISABLE ERROR key and Special Function 8)

HP-IB Program Codes

The HP-IB program codes for selectively disabling combinations of Errors 01 through 04 are provided in "Procedure".

DISABLE ERROR = B1
Clear DISABLE ERROR function = B0

Indications

Display: When the DISABLE ERROR key is pressed, the display returns to the measurement previously selected.

As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display returns to the measurement previously selected.

Front Panel: When the DISABLE ERROR key is pressed, the LED next to DISABLE ERROR and the LED within the SPCL key lights.

When one of Special Functions 8.1 through 8.8 is pressed, the LED within the SPCL key lights.

Comments

When the instrument is first powered up, or when AUTOMATIC OPERATION or INSTR PRESET is selected, Special Function 8 is placed in the automatic selection mode (8.0 SPCL).

When Error 04 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. Audio autoranging is then prevented 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 (Error 02 through Error 04 automatically disabled). Selecting Special Function 8.1 to override a display of Error 04 would reenable Error 02 through Error 04. (The best selection would really be 8.7 SPCL; Error 01 through Error 04 disabled.)

Use the Special Display and the Special Special Display (described in Special Functions) to identify the current errors that are disabled.

Related Functions

Automatic Operation
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 usually cleared when the error condition is removed.

Four types of error display formats exist in the Modulation Analyzer:

Error __ : The numerical value of the error is displayed.

(--): No detectable signal falls within the IF passband. Either no signal is at the input, or the instrument cannot tune to find the applied signal. (For example, it might be manually tuned far enough away from an input signal that no power is detected in the IF.) This display is output to the HP-IB as Error 96 using the HP-IB output format described in this Detailed Operating Instruction.

(----): A signal has been detected but, for various reasons, a measurement result is not yet available. The instrument might be still completing the measurement requested, or in some cases, unable to complete a measurement because of manual settings of Special Functions. (For example, when frequency measurements are made on a low-level input signal with high AM depth, or when the RF input attenuation is improperly set.) This display is never output to the HP-IB, and typically indicates a transitory state in instrument operation.

Error messages are grouped by error code as follows:

Error 01 through Error 18 and Error 90 through Error 99. These messages are Operating Errors to indicate that some condition has not 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 Disable Error Message Control Special Function (Special Function 8) can be used to selectively disable certain Operating Errors.

Error 20 through Error 29. These messages are Entry Errors which indicate that an invalid key sequence or keyboard entry has been made. These errors require that a new keyboard entry or function selection be made. Some of these error displays time out after a few seconds and then return to the current measurement.

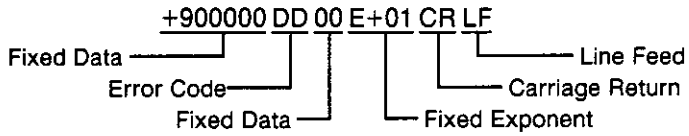
Error 40 through Error 89. These messages are Service Errors and are generated to give service information, or because a service function has been accessed and has generated a message. Service errors do not necessarily represent failures within the instrument and must be enabled to appear. Service Errors are discussed in Section VIII.

Error Message Summary (Cont'd)

HP-IB

HP-IB Output Format

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



For example, Error 02 is output to the HP-IB as +9000000200E+01CRLF. Once an error has been input to the computing controller, the error code is simply derived by subtracting 9×10^{10} from the input number, then dividing the result by 1000.

Error Messages

The following table describes all Operating Errors and includes the error code, message, and the action typically required to remove the error-causing condition. The Comments column that follows provides additional information and references pertaining to particular errors.

Operating Errors		
Error Code	**Message**	**Corrective Action**
01	IF frequency error.	Retune to signal at input.
02	Input level too high.	Increase RF input attenuation and gain.
03	Input Level too low.	Decrease RF input attenuation and gain.
04	Audio circuits overdriven.	Increase audio range.
05	FM squelched.	Reduce signal level variations (AM) at RF INPUT.
06	RF input overload.	Reduce RF signal level at RF INPUT, then press any key.
07	Voltmeter and display overload.	Increase audio range.
08	Calibrator error.	Connect CALIBRATION AM/FM OUTPUT to RF INPUT or turn off calibrator.
09	Option not installed.	Select another instrument function.
10	Input frequency out of range.	Adjust input frequency to within specified limits.
11	Calculated value out of range.	Conversion from % to dB is not possible. Press LOG/LIN for linear display.
12	Time Base oven cold (Option 002).	For highest accuracy, wait until oven is warm. (Refer to Special Function 15.)
13	Power sensor not connected.	Press RF POWER. RF level measurement is initiated if the power sensor is not connected.
14	Power sensor cannot zero.	Assure zero power at SENSOR input.
15	Calibration factor error.	Input calibration factors.
16	Audio circuits underdriven.	Increase external audio input level.
18	RF Power will not calibrate.	Assure 0 dBm at SENSOR input.
96	(HP-IB only) No input signal sensed by instrument.	Increase signal level at RF INPUT or retune

Error Message Summary (Cont'd)

Comments:

Error 01 With the 1.5 MHz IF, the IF frequency must be 1.5 MHz ± 50 kHz.

With the 455 kHz IF, the IF frequency must be 455 kHz ± 2.5 kHz.

Refer to **RF Frequency Tuning**. Error 01 disables MODULATION OUTPUT/AUDIO INPUT.

Error 02 Refer to **RF Input Attenuation** for nominal input levels. Error 02 disables MODULATION OUTPUT/AUDIO INPUT.

Error 03 Refer to **RF Input Attenuation** for nominal input levels. Error 03 disables MODULATION OUTPUT/AUDIO INPUT.

Error 04 Error 04 designates either an improperly set audio range, or an attempt to measure modulation levels greater than those specified. Refer to **Audio Range**.

Error 05 Error 05 often occurs when FM or ϕM measurements are attempted on low-level signals with high AM depth (greater than 90%). Error 05 disables MODULATION OUTPUT/AUDIO INPUT.

Error 06 Maximum allowable input level is 7 Vrms (1W peak).

Error 07 If displayed during modulation measurements, increase audio range. If displayed during level measurements, increase RF input attenuation.

Error 08 If the connection from CALIBRATION AM/FM OUTPUT to RF INPUT is intact, this error may indicate calibrator malfunction.

Error 09 Error 09 display times out. If the option is installed, Error 09 displayed can reflect an option malfunction.

Error 10 Error 10 turns off MODULATION OUTPUT/AUDIO INPUT.

Error 11 In dB RATIO, Error 11 is displayed when measurement results equal 0. (Log of 0 not allowed.)

Error 12 Error 12 must be requested by Special Function 15. (Refer to **Special Functions**.)

Error 13 Error 13 usually only occurs when the power sensor is disconnected during an RF power measurement.

Error 14 Error 14 will not occur when using a sensor module (such as the HP 11722A) or a power sensor with an RF switch controlled by voltages accessed from the rear panel. (Refer to **Remote Control RF Switch**.)

Error Message Summary (Cont'd)

Comments (cont'd)

Error 15 Refer to **RF Power Calibration Factors** for entry and edit information concerning calibration factors.

Error 96 Error 96 corresponds to a display of two dashes (--). Error 96 can occur when no signal is applied or when Error 03 is disabled and the instrument is manually tuned where no signal is found. Error 96 (--) turns off MODULATION OUTPUT/AUDIO INPUT.

Entry Errors		
Error Code	**Message**	**Corrective Action**
20	Entered value out of range.	Re-enter new value.
21	Invalid key sequence.	Check for compatibility of functions selected.
22	Invalid Special Function prefix.	Re-enter correct Special Function Code.
23	Invalid Special Function suffix.	Re-enter correct Special Function Code.
24	Invalid HP-IB code.	Re-enter correct HP-IB code.
26	End of RF Power calibration factor table reached.	Check number of entries.

Comments:

Error 21 Error 21 times out.

Error 22 Error 22 times out. (Refer to **Special Functions**.)

Error 23 Error 23 times out. (Refer to **Special Functions**.)

Error 24 Error 24 always causes the issuance of a Require Service message on the HP-IB.

Service Errors		
Error Code	**Message**	**Corrective Action**
40-89	Service-related errors.	Refer to service section of HP 8901B instrument manual.

Comments:

Errors 40 through 89 Service errors are normally disabled.

External Attenuation
(Includes the dB EXT ATTEN key and Special Function 25)

Description

Level measurements can be offset with external attenuation or gain using the dB EXT ATTEN key.

Special Function 25.2 enables the Modulation Analyzer to display the value of the selected external attenuation.

MODULATION OUTPUT/AUDIO INPUT is blanked during most level measurements.

Procedures

To enter external attenuation:

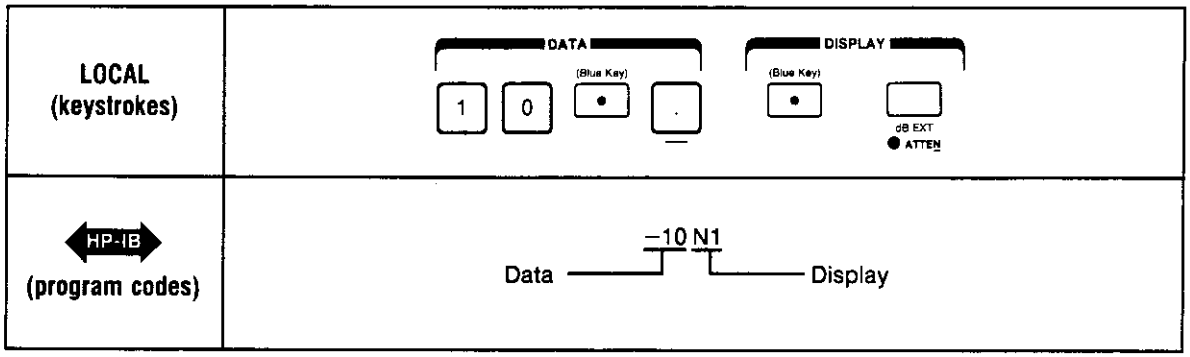
1. Press the keys corresponding to the value of external attenuation or gain.
2. Use a negative sign to enter a gain value by pressing the Blue Key and the (-) key (. key). No sign indication is necessary for entering attenuation.
3. Press the Blue Key and dB EXT ATTEN (LOG/LIN) key.

To display the current offset in dB, key in 25.2 SPCL.

To exit external attenuation, press the Blue Key and dB EXT ATTEN key again. To re-enter external attenuation, press the Blue Key and dB EXT ATTEN key again.

Example

To enter external gain of 10 dB as an offset to subsequent power measurements:



External Attenuation (Cont'd)
(Includes the dB EXT ATTEN key and Special Function 25)

HP-IB Program Codes

dB EXT ATTEN off = N0
dB EXT ATTEN on = N1
SPCL = SP

Indications

Display: When the dB EXT ATTEN key is pressed, the Modulation Analyzer displays subsequent level measurements using the entered offset.

When Special Function 25.2 is entered, the current value of entered external attenuation is displayed with the dB annunciator. The display is timed out.

Front Panel: The dB EXT ATTEN annunciator lights when pressed. Special Function 25.2 causes the LED within the SPCL key to light and then time out.

Comments

If another Measurement mode is selected, and then a level Measurement mode is re-entered, the instrument automatically re-enters the external attenuation mode with the previous offset value to offset subsequent measurements.

Related Functions

Ratio
RF Level
RF Power
Tuned RF Level

Filters, Audio

Description

High-pass and low-pass filters can be inserted into the path of the demodulated signal through the use of the HP and LP FILTER keys.

Procedures

Insert the desired demodulated signal filter by pressing the appropriate keys.

- Only one high-pass and one low-pass filter can be inserted at once.
- To remove a filter, 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 (listed in the following table) only insert the filters. To remove a high-pass or low-pass filter via HP-IB, use code H0 or L0 (respectively), or select another filter.

HP-IB Program Codes

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

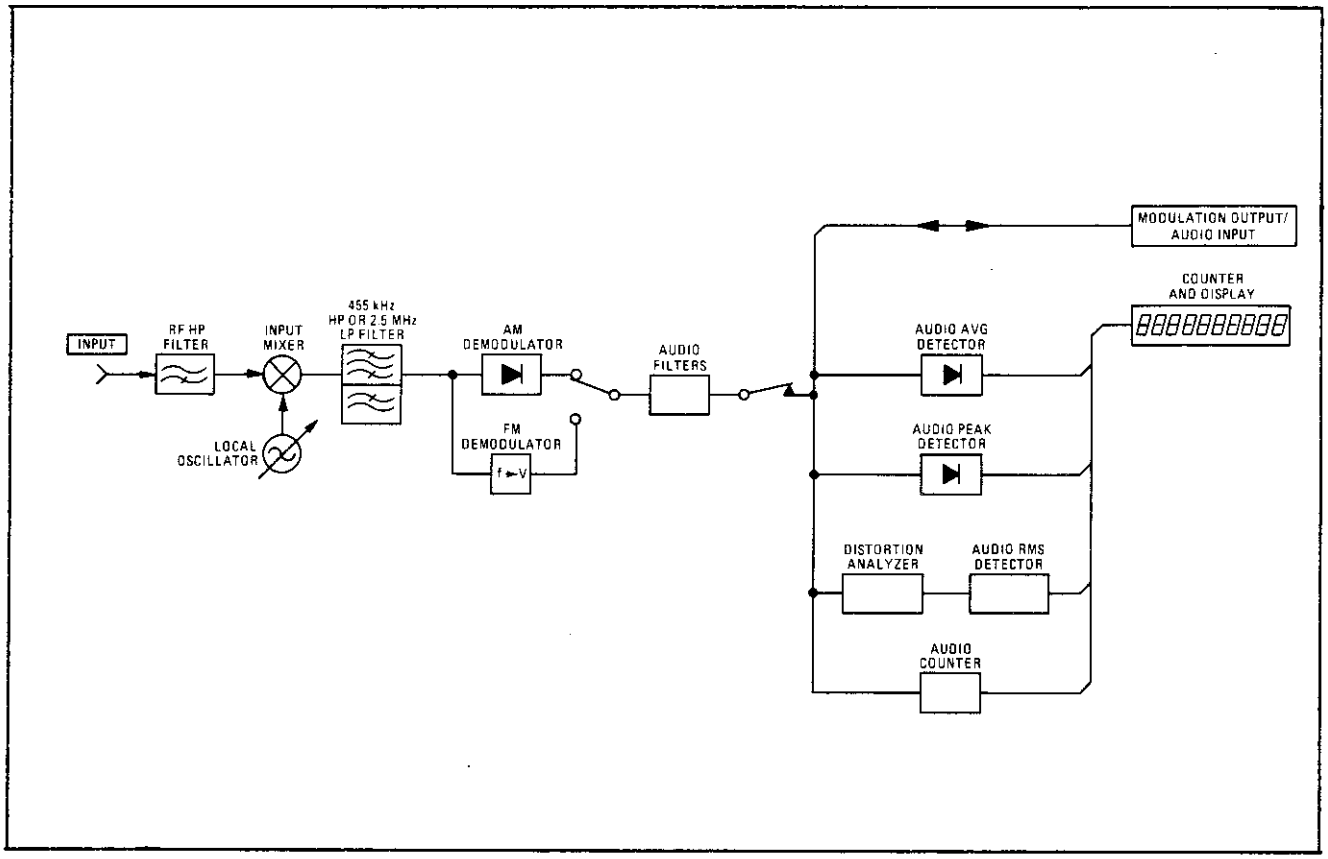
LP FILTER	Program Code HP-IB
ALL OFF	L0
3 kHz	L1
15 kHz	L2
>20 kHz	L3

Indications

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

Filters, Audio (Cont'd)

Block Diagram



Audio Filters Block Diagram

Comments

The selected filters are always in the path of the demodulated signal independent of the selection of a modulation measurement. Thus, unless turned off, the output of MODULATION OUTPUT/AUDIO INPUT is filtered. In addition, the selected filters remain in effect when switching between modulation measurements.

Under certain conditions, filters are inserted automatically. When the 455 kHz IF is used, or when the RF input is less than 2.5 MHz, the 15 kHz low-pass filter is inserted (unless another low-pass filter has been selected). The 15 kHz low-pass filter selected when operating with the 455 kHz IF is automatically turned off when the 1.5 MHz IF is selected.

With no filters selected, the post-demodulation bandwidth is from 20 Hz to greater than 200 kHz, however, the IF circuits and demodulators impose more severe bandwidth limits. Refer to each specific measurement in these Detailed Operating Instructions for bandwidth limitations.

Filters, Audio (Cont'd)

Comments (cont'd)
The individual filter characteristics are given below. The 3 dB points are typically accurate to ±3%.

High-Pass Filters:

50 Hz High Pass: Two pole Butterworth 1% flat ≥200 Hz
300 Hz High Pass: Two pole Butterworth 1% flat ≥1 kHz

Low-Pass Filters:

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 squarewave modulation, this filter typically overshoots <1%. This filter's 3 dB point is typically 110 kHz.

Related Functions

AM
Filters, RF and IF
FM
FM De-emphasis
IF Frequency

Filters, RF and IF (Special Function 3)

Description

To eliminate unwanted low-frequency signals in the RF signal path, an RF filter can be inserted. The 5.25 MHz High-Pass Filter is manually selectable with Special Function 3. Since the IF generally responds to signals less than 2.5 MHz, the filter eliminates any low frequencies that might be present on the input. (For input signals of 150 kHz to 10 MHz, the filter should be switched out.)

The Input Mixer down-converts the RF input to the IF. The IF is usually centered at 1.5 MHz for input signals 10 to 1300 MHz. (An IF of 455 kHz can be manually selected.) For signals between 2.5 MHz and 10 MHz, the IF is 455 kHz. Below 2.5 MHz, the signal is passed directly into the IF without down-conversion (unless the 455 kHz IF has been manually selected). IF filters determine the frequency response of each IF.

When the 1.5 MHz IF is selected, the IF frequency response is determined by the 2.5 MHz Low-Pass (LP) Filter. When the 455 kHz IF is selected, the 455 kHz Bandpass (BP) Filter determines the IF frequency response. Various combinations of these filters can be manually inserted using Special Function 3.

Procedure

To select a desired combination of RF and IF filters, or to re-enter the automatic selection mode, key in the corresponding Special Function code, then press the SPCL key:

Special Function Code	Program Code (HP-IB)	IF Frequency	IF Filter	RF High-Pass Filter (5.25 MHz)
3.0 SPCL	3.0SP	Automatic Selection		OUT
3.1 SPCL	3.1SP	455 kHz	200 kHz BW	OUT
3.2 SPCL	3.2SP	1.5 MHz	2.5 MHz Low-Pass	OUT
3.3 SPCL	3.3SP	455 kHz	200 kHz BW	IN
3.4 SPCL	3.4SP	1.5 MHz	2.5 MHz Low-Pass	IN
3.6 SPCL	3.6SP	455 kHz	2.5 MHz Low-Pass	OUT
3.8 SPCL	3.8SP	455 kHz	2.5 MHz Low-Pass	IN

HP-IB Program Codes

The HP-IB codes for selecting various combinations of RF and IF filters are provided in "Procedure".

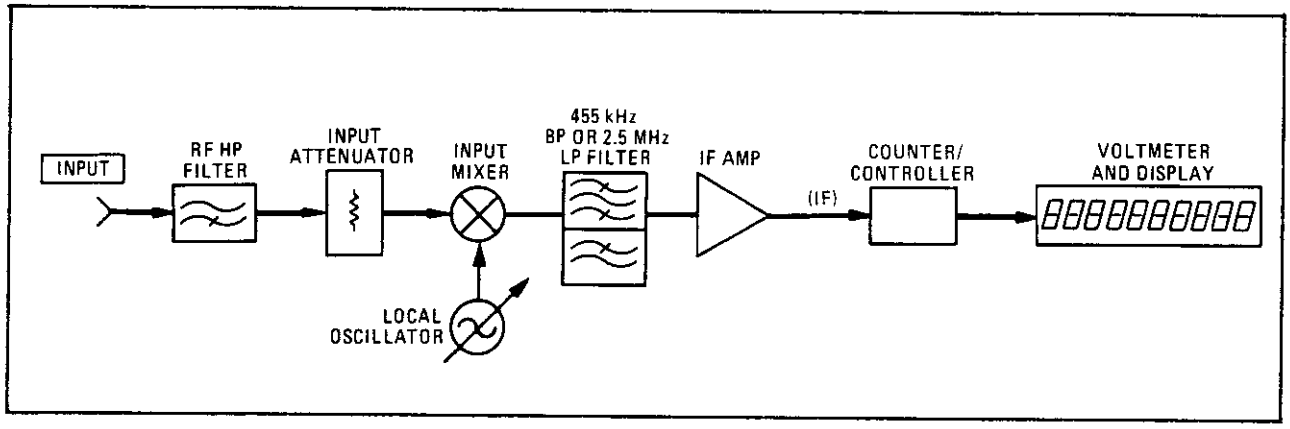
Filters, RF and IF (Cont'd)
(Special Function 3)

Indications

Display: As the numeric code is entered, it appears on the front-panel display. When the SPCL key is pressed, the display returns to the measurement previously selected.

Front Panel: Unless Special Function 3.0 is entered, the light within the SPCL key lights.

Block Diagram



Block Diagram of RF and IF Filters

Comments

When the instrument is first powered up or when AUTOMATIC OPERATION or INSTR PRESET is selected, RF and IF Filters are placed in the automatic selection mode.

When a new IF frequency is selected, the instrument immediately retunes.

Manual insertion of RF input attenuation increases the sensitivity and selectivity of the Measuring Receiver. (Refer to **RF Input Attenuation**.)

Related Functions

IF Frequency
IF Level
Range Hold
RF Frequency Tuning
Special Functions

FM
(Includes Special Function 2)

Description

The FM key enables the Modulation Analyzer to measure the FM deviation of the tuned input signal. Special Function 2 enables the instrument to set limits on the range of FM deviation that can be measured.

The demodulated FM is present at MODULATION OUTPUT/AUDIO INPUT (unless AUDIO INPUT has been selected). The demodulated FM is usually present at the rear-panel FM OUTPUT connector. (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 from 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.

The demodulated signal's frequency and distortion can also be characterized. (Refer to **Audio Distortion and Level** and to **Audio Frequency**.)

Procedures

To make an FM measurement, first tune the instrument to the input signal. (Refer to **RF Frequency Tuning** or press AUTOMATIC OPERATION.) Press the FM key.

Select an audio detector: PEAK+, PEAK-, or AVG. The RMS detector, selected by pressing the Blue Key and the RMS key, is not quite as accurate in measuring FM and is usually only used for audio distortion measurements. (Refer to **Audio Distortion and Level** and to **Audio Detectors**.)

FM (Cont'd)
(Includes Special Function 2)

Procedures (cont'd)
The following table lists the different measurement range limits that can be selected with Special Function 2:

Modulation Range (Peak±kHz dev.)	Detector Selected	Special Function Code	Program Code HP-IB	Display Resolution (Hz)	MODULATION OUTPUT Sensitivity (Vac/% Hz)
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection	
≤0.04	RMS	2.4 SPCL[1]	2.4SP	0.01	100
≤0.4	RMS Pk, Avg Pk, Avg, RMS	2.4 SPCL 2.4 SPCL[1] 2.1 SPCL[1]	2.4SP 2.4SP 2.1SP	0.1	10
≤4	Pk, Avg Pk, Avg, RMS Pk, Avg, RMS	2.4 SPCL 2.1 SPCL 2.2 SPCL[1]	2.4SP 2.1SP 2.2SP	1	1
≤40	Pk, Avg, RMS	2.2 SPCL 2.3 SPCL[1]	2.2SP 2.3SP	10	0.1
≤400	Pk, Avg, RMS	2.3 SPCL	2.3SP	100	0.01

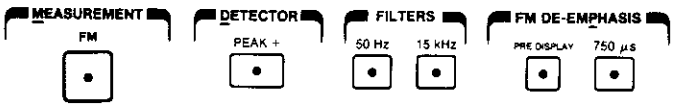
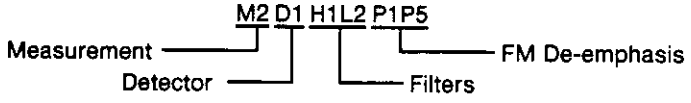
[1] With 750 μs de-emphasis, pre-display only.

To filter the demodulated signal, press the appropriate filter keys. (Refer to **Filters, Audio.**) If de-emphasis filtering is desired, select the appropriate time constant and display placement. (Refer to **FM De-emphasis.**)

If FM deviation is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to **Ratio.**)

Example

To measure the positive peak FM deviation of a signal in a 50 Hz to 15 kHz demodulated signal bandwidth, and place a 750 us time constant de-emphasis before the display:

LOCAL (keystrokes)	
HP-IB (program codes)	

FM (Cont'd)
(Includes Special Function 2)

HP-IB Program Codes

All HP-IB codes for setting range limits for FM measurements are provided in "Procedures".

FM = M2
SPCL = SP

Indications

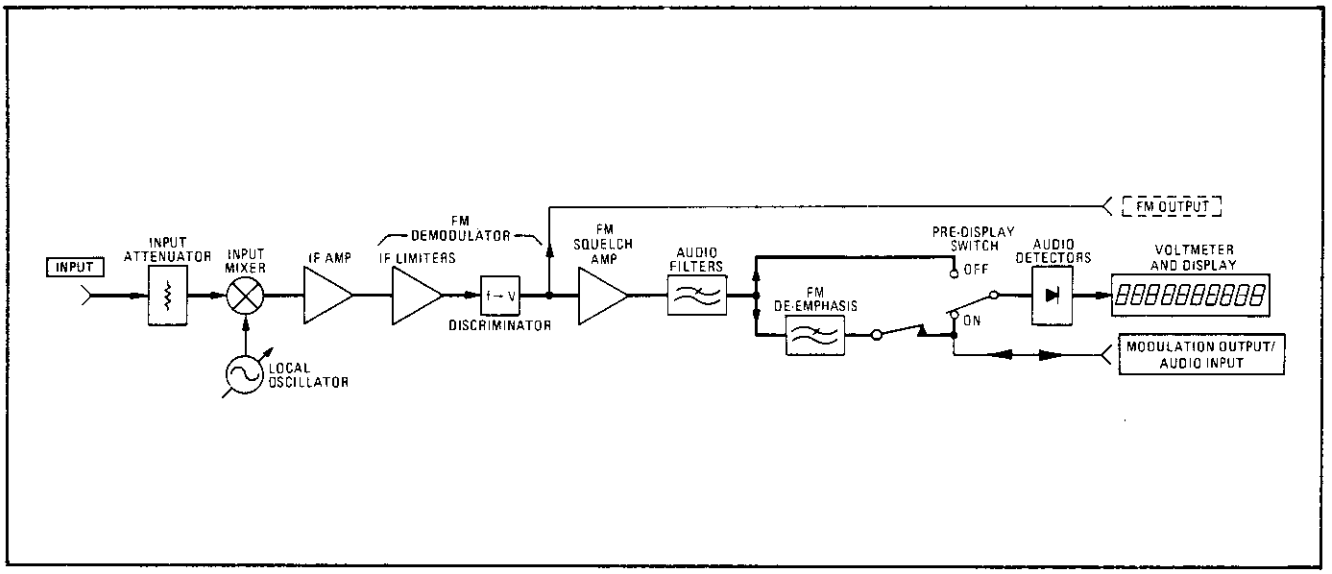
Display: When the FM key is pressed, the display shows the measured FM deviation (or the equivalent de-emphasized deviation). The kHz annunciator is displayed.

Front Panel: The LEDs within the selected functions light.

Measurement Technique

The FM on the IF is demodulated by a frequency discriminator. The amplitude of the discriminator's output signal is proportional to the frequency deviation. The demodulated signal is filtered, audio detected, and displayed as kHz deviation.

The FM de-emphasis filter can be inserted ahead of the audio detectors and display circuitry using the PRE DISPLAY key. The demodulated FM signal always passes through the FM de-emphasis filter to be made available at the output of MODULATION OUTPUT/AUDIO INPUT.



FM Measurement Block Diagram

FM (Cont'd)
(Includes Special Function 2)

Comments

The PEAK+ detector always detects the upward carrier frequency excursion while the PEAK- detector always detects the downward carrier frequency excursion. The PEAK ±/2 detector sums the upward and downward frequency excursion and divides the total by two to provide an average peak value. (This value should not to be confused with a detected average value.)

When operating with carrier frequencies below 2.5 MHz, the output signal at MODULATION OUTPUT/AUDIO INPUT is inverted unless using the 455 kHz IF. 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 modulation range contains regions of overlap between the following displayed peak deviations: 0.35 and 0.4 kHz (750 us de-emphasis, pre-display only), 3.5 and 4 kHz, and 35 and 40 kHz. When using the average detector, ranging occurs 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 **Audio Range**.

When the Modulation Analyzer is first powered up, demodulated FM, with a sensitivity of 0.01 Vac/MHz (≤400 kHz peak deviation range), is available at MODULATION OUTPUT/AUDIO INPUT. The instrument does not autorange to more sensitive ranges because the selection of the FREQ Measurement mode, at power up, automatically disables Error 04 (audio circuits overdriven). When Error 04 is disabled, the instrument only autoranges to less sensitive audio ranges.

AM conditions that cause the carrier signal to disappear either causes inaccuracies in the measurement of FM deviation, or Error 05 (FM squelched).

Related Functions

Audio Detectors
Audio Filters
Audio Frequency
Audio Range
FM De-Emphasis
FM Output
Ratio
Residual Noise Effects

FM Calibration
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 12 and 17)

Description

The accuracy of the Modulation Analyzer's FM demodulator can be checked with the internal FM calibrator. The calibration process generates a calibration factor that indicates the FM measurement error (within the accuracy limits of the calibrator). The calibration factor can then be enabled to automatically correct the known FM error in subsequent measurements (Special Function 17 or the Save Calibration function). With the calibration factor enabled, FM measurements can be made with an accuracy typically better than 0.5%. The calibration factor can be enabled, disabled, or displayed at any time.

Other instruments in the family of HP 8901 and 8902 RF signal analyzers can be calibrated or cross checked with the Modulation Analyzer's FM calibrator using Special Function 12.

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, then perform the following steps:

1. Connect the CALIBRATION AM/FM OUTPUT to the RF INPUT with a 50 ohm cable (or a sensor module with an internal switch such as the HP 11722A), and select FM.

2. Press the CALIBRATE key. After several seconds, the FM calibration factor will be displayed in % and stored.

The instrument displays 100.00% if no error is measured. A display of 100.17% means the Modulation Analyzer is reading 0.17% high. As long as the CALIBRATE 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 CALIBRATE 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 instrument power-up should not be used even if the instrument is already warm, since the circuits in the audio chain may not be fully settled.

FM Calibration (Cont'd)
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 12 and 17)

Procedures (cont'd)

Correcting Measurements with the FM Calibration Factor. Once a calibration factor has been determined, the instrument retains that value in its non-volatile memory. (Refer to **Instrument Preset.**) This factor can be enabled to automatically correct FM measurements. The calibration factor can also be disabled or displayed.

Enter the appropriate front-panel key or Special Function code for the desired action described in the following table:

Action: FM Calibration Factor	Measurement Mode	Front-Panel Key or Special Function Code	Program Code (HP-IB)
Disable	Any	17.0 SPCL	17.0SP
Enable	FM (From CALIBRATE mode)	(Blue Key) SAVE CAL	SC
	Any	17.1 SPCL	17.1SP
Display	FM	(Blue Key) % CAL FACTOR*	CF
	Any	17.2 SPCL	17.2SP

Calibrating or Cross Checking Another HP 8901 or 8902 RF Signal Analyzer. To compute an FM calibration factor for another RF signal analyzer that has no internal calibrator, or that has an internal calibrator that is to be cross checked, use the Modulation Analyzer and its calibrator as follows:

1. Connect the Modulation Analyzer's CALIBRATION AM/FM OUTPUT to the input of the RF signal analyzer.

2. Key 12.0 SPCL into the Modulation Analyzer. Record the reading that appears on the display. This is the computed, calibrated, peak FM deviation (excluding noise).

3. Key 12.1 SPCL into both instruments. Record the reading that appears on the display of the RF signal analyzer. (If display jitter makes readings difficult, key 5.1 SPCL.) The displayed value is the weighted, peak, residual FM deviation of the calibrator's unmodulated output as demodulated by the RF signal analyzer.

FM Calibration (Cont'd)
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 12 and 17)

Procedures (cont'd)

4. Key 12.2 SPCL into both instruments. Record the value that appears on the display of the RF signal analyzer. (If display jitter makes readings difficult, key 5.1 SPCL.) The displayed value is the demodulated, positive, peak FM deviation of the calibrator's modulated output (including noise).

5. On the RF signal analyzer, press the PEAK- key. Record the value that appears on the display of the RF signal analyzer. If the difference between the readings of steps 4 and 5 is 3 counts or less in the least significant digit, an average between the two need not be computed; use the result from step 4. If the difference between the two readings is greater than 3 counts in the least significant digit, compute the average as follows:

$$(12.2\ \text{result}) = \frac{(\text{result of step 4}) + (\text{result of step 5})}{2}$$

6. Compute the FM calibration factor of the RF signal analyzer as follows:

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

7. To use this FM calibration factor to correct FM measurements made with the RF signal analyzer, enter the value as a ratio reference and use the Ratio function in the RF signal analyzer.

The Special Function codes are summarized in the following 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	12.2 SP

FM Calibration (Cont'd)
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 12 and 17)

HP-IB Program Codes

The HP-IB codes for enabling, disabling, or displaying the internal FM calibration factor are provided in "Procedures". The HP-IB codes for the FM Calibrator Special Function used to calibrate another RF signal analyzer are also provided as part of "Procedures".

FM = M2
CALIBRATE on = C1
CALIBRATE off = C0
SPCL = SP

Indications

Self-calibration.
Display: When the CALIBRATE key is pressed, approximately 17 seconds pass during which the instrument configures itself and tunes to the calibrator's signal. The display indicates four dashes (----) and lights the % annunciator. Once the FM calibration factor has been computed, it is displayed. Subsequent updates occur approximately every 17 seconds.

Front Panel: The LEDs within the FM and CALIBRATE keys light. The LEDs within the FILTERS, FM DE-EMPHASIS, DETECTOR, DISPLAY, Blue Key, DISABLE ERROR, and SPCL keys are all disabled.

Correcting Measurements with the FM Calibration Factor (Self-calibrated).
Display: When the calibration factor is enabled, the FM deviation measurement is always a corrected measurement.

If 17.2 SPCL is keyed, the value of the calibration factor is displayed.

If % CAL FACTOR is keyed, and the FM calibration factor is enabled, the value of the % FM calibration factor is displayed. If % CAL FACTOR is keyed, and the FM calibration factor is disabled, 100% is displayed. (Note the resolution of 1%.)

The display times out after a few seconds and returns the previous display.

Front Panel: When the instrument displays a calibration factor, the SPCL key lights and all annunciators and other key lights are turned off.

FM Calibration (Cont'd)
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 12 and 17)

Indications (cont'd)

Calibrating Another RF Signal Analyzer.

Display: As the numeric Special Function codes are entered, they appear on the front-panel display. The Modulation Analyzer displays the computed FM deviation (Special Function 12.0), but shows two dashes (--) throughout the other measurements.

Front Panel: During these measurements, no measurement keys light, but the LEDs within the SPCL key, the selected DETECTOR key, and the CALIBRATE key of the Modulation Analyzer light.

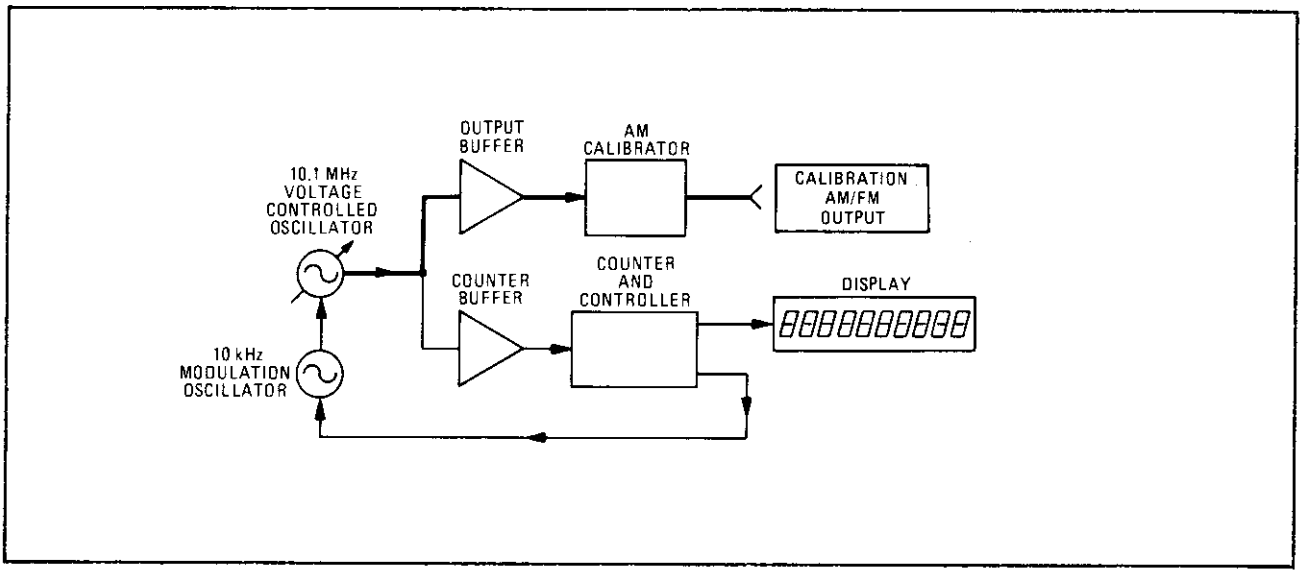
Measurement Technique

When FM is selected and the CALIBRATE 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 the oscillator is driven to the opposite end of its control range where it is counted again. The peak FM deviation is computed from these measurements.

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**.) The VCO is frequency modulated by a 10 kHz modulation oscillator, and the FM demodulator makes another FM measurement. (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. The accuracy of the internal FM demodulator is computed using the following equation:

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

FM Calibration (Cont'd)
(Includes the CALIBRATE, SAVE CAL, and % CAL FACTOR keys, and Special Functions 12 and 17)



Simplified Block Diagram of the FM Calibrator

Comments

If the instrument's non-volatile memory is erased, 100.00% is used as the default calibration factor.

Whenever FM calibration is performed, the FM calibration factor stored in the instrument is updated with the new factor.

Pressing the CALIBRATE key cancels all Special Functions.

The modulation waveform of the FM Calibrator is rounded squarewave. The RF signal analyzer that uses it as a calibration standard must have demodulation and audio processing circuits which preserve the full fidelity of the waveform.

When used to calibrate an RF signal analyzer, Special Functions 12.1 and 12.2 set the FM deviation range to that of 0 to 40 kHz (Special Function 2.2). Upon exiting the FM Calibrator Special Function, the audio ranging is not returned to automatic but remains fixed (thus leaving the SPCL light on). Key in 2.0 SPCL to return the audio ranging to automatic.

Related Functions

FM
Ratio
Residual Noise Effects
Special Functions

FM De-Emphasis

Description

The de-emphasis filters compensate for pre-emphasis on FM signals. (Pre-emphasis is a 6 dB per octave, high-frequency boost given to the audio signal before modulating the carrier.) The 3 dB corner frequency, f_o , is commonly expressed as a time constant τ_o , where $f_o = 1/2\pi\tau_o$.

When selected, the filters are inserted in the audio signal path following the modulation filters. They always affect the output signal at MODULATION OUTPUT/AUDIO INPUT and can be placed before the audio detector and display. (Refer to the block diagram in **FM**.) De-emphasis has no affect on the rear-panel FM OUTPUT. The 3 dB frequency of these filters (typically accurate to ±3%) are provided in the following table:

FM De-emphasis	
Time Constant (μs)	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 displayed deviation is measured before de-emphasis is performed (with the de-emphasized signal available at MODULATION OUTPUT/AUDIO INPUT unless AUDIO INPUT is selected). To display the deviation after it is de-emphasized, press the PRE DISPLAY key.

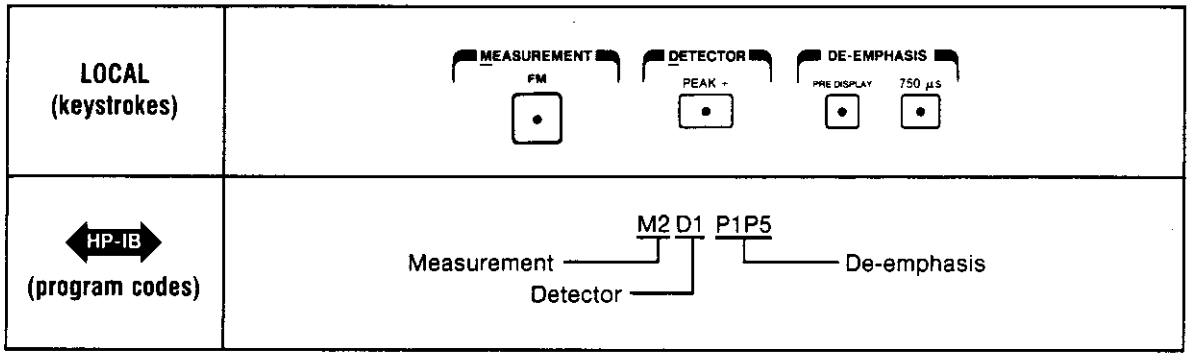
To change the de-emphasis time constant, press the key corresponding to the new time constant desired.

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 with code P0. (HP-IB code P0 also turns off the PRE DISPLAY function.)

FM De-emphasis (Cont'd)

Example

To measure the positive peak FM deviation of a carrier with 750 us de-emphasis inserted before the deviation measurement:



HP-IB Program Codes

FM De-emphasis		
Time Constant (µs)	PRE DISPLAY On	PRE DISPLAY Off
Filters off	P0P1	P0
25	P1P2	P0P2
50	P1P3	P0P3
75	P1P4	P0P4
750	P1P5	P0P5

Indications

Front Panel: When a de-emphasized signal is available at MODULATION OUTPUT/AUDIO INPUT, the LED within the selected filter's key lights. If the de-emphasized signal is being displayed, the light within the PRE DISPLAY key lights.

Comments

Until they are turned off, the de-emphasis filters are always active when demodulated FM is present at MODULATION OUTPUT/AUDIO INPUT.

FM De-emphasis (Cont'd)

Comments (cont'd)

When 750 us de-emphasis is selected, the FM sensitivity is increased by a factor of ten. The range of deviation measurements is restricted to 40 kHz peak deviation or less after de-emphasis. The modulation ranges are ten times more sensitive (the most sensitive range is 0.4 kHz) to provide greater resolution for measuring low deviation FM.

Related Functions

FM
Modulation Output
Recorder Output

FM Output

CAUTION

Do not apply greater than 10 Vpeak (ac + dc) into the FM OUTPUT connector or damage to the instrument could result.

Description

The rear-panel FM OUTPUT (dc-coupled, 10 kohm output impedance) provides an auxiliary output for the FM that is demodulated from the signal at the RF INPUT. This output is used to monitor FM when displaying other measurements (such as AM, ϕM, or audio signals) 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, 1 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 Vdc for the 1.5 MHz IF and -5.6 Vdc for the 455 kHz IF. The FM sensitivity is typically 6V/MHz or 6 mV/kHz. The dc voltage at FM OUTPUT can be calculated as follows:

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

Where,

Vdc = 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, or V/MHz, and
FREQ ERROR = the kHz error displayed when the FREQ ERROR key is pressed.

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

Procedure

To characterize the sensitivity of the FM OUTPUT, apply an unmodulated 2 MHz carrier at the RF INPUT (use the 1.5 MHz IF selected with Special Function 3 described in **Filters, RF and IF**). Measure the dc voltage at the output with a dc voltmeter. Move the carrier to 1 MHz and again note the dc voltage. The FM sensitivity (K) is:

(Vdc @ 2 MHz) - (Vdc @ 1 MHz) = V/MHz or mV/kHz

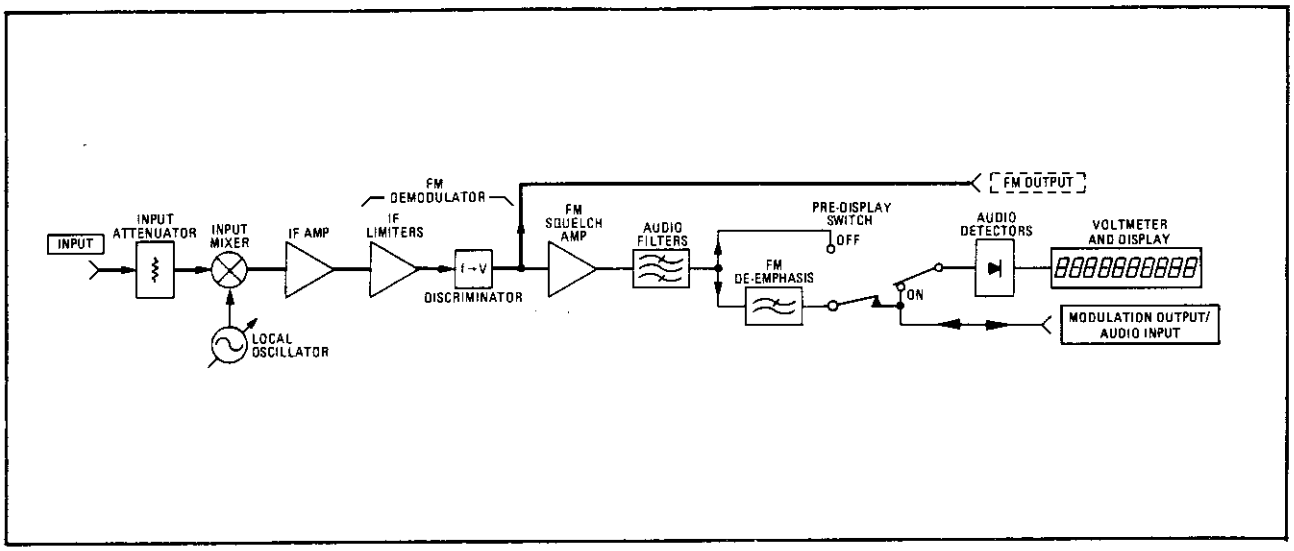
FM Output (Cont'd)

Example

A 2 MHz unmodulated signal is applied to the RF INPUT. A dc voltmeter connected to FM OUTPUT measures +3.89 Vdc. When the carrier is set to 1 MHz, -2.272 Vdc is measured. The FM sensitivity is:

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

Block Diagram



FM OUTPUT Block Diagram

Comments

FM OUTPUT is unsquelched and also contains a significant component at twice the IF frequency which is greatest when operating at a carrier of 150 kHz.

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

When RF Level measurements are made, automatic RF input attenuation overrides any manual settings that might have been selected with Special Function 1. The selected attenuation could degrade the accuracy of measurements made on the FM OUTPUT signal.

Related Functions

AM Output
FM
RF Frequency Error

Frequency Offset Control (Special Function 27)

Description

Frequency Offset Control can be used with an external LO and an external mixer to enable the Modulation Analyzer to make measurements on microwave input frequencies to 42 GHz. All normal instrument measurements can be made on this input signal. For most accurate measurements, the external LO should be a relatively pure signal from a synthesized signal source (such as the HP 8340A, 8671A, 8672A, or 8673A).

The Modulation Analyzer uses Special Function 27 to enter and display the frequency of the external LO. This Special Function is also used to enable the Frequency Offset mode.

When in Frequency Offset mode, the RF Power function has available a separate table of frequency/calibration factor entries. Frequency entries can range from 0 to 42 GHz. (Refer to **RF Power Calibration Factors**.)

Procedures

To make measurements on microwave input frequencies, connect a synthesized, high-frequency signal to the LO input connector of an external mixer. Also, connect the microwave input signal to the other input of the mixer. Connect the output of the mixer to the RF INPUT connector and/or the SENSOR input connector of the Modulation Analyzer.

Perform the actions required with the Special Functions in the following table:

Action Regarding Frequency Offset Control	Special Function Code	Program Code HP-IB
Exit Frequency Offset Mode	27.0 SPCL	27.0SP
Re-enter Frequency Offset Mode	27.1 SPCL	27.1SP
Display the External LO Frequency	27.2 SPCL	27.2SP
Enter and Enable the LO Frequency*	27.3 SPCL	27.3SP

*After Special Function 27.3 is entered, enter the frequency of the LO (in MHz). Frequencies from 0 to 40700 MHz can be entered.

Frequency Offset Control (Cont'd)
(Includes Special Function 27)

Procedures (cont'd)
Manually tune to the microwave input frequency by pressing the appropriate numeric keys followed by the MHz key.

Perform any normal instrument measurement; press the Blue Key and the DISPLAY FREQ key to display the microwave input frequency.

HP-IB Program Codes

All HP-IB codes for manipulating the frequency offset control using Special Function 27 are provided in "Procedures".

DISPLAY FREQ = FR
MHz = MZ

Indications

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display returns to the measurement previously selected.

When 27.0 SPCL is keyed, the f OFS annunciator turns off.
When 27.1 SPCL is keyed, the f OFS annunciator turns on.
When 27.3 SPCL is keyed, and the external LO entry is completed, the f OFS annunciator turns on.

When 27.2 SPCL is keyed, the value of the entered external LO frequency is displayed. This value is timed out.

Front Panel: Special Function 27.2 lights the SPCL key.
Special Function 27.3 lights the SPCL key (after MHz entry).

Measurement Technique

The external LO mixes with the microwave input signal to create a difference frequency. The microwave input is ± 1300 MHz (the normal frequency range of the instrument) from the external LO frequency. If the microwave input frequency is lower than the external LO, the Modulation Analyzer uses the LO minus the microwave input, and the sign of the external LO is positive. If the microwave input frequency is greater than the external LO, the Modulation Analyzer uses the LO plus the microwave input and the sign of the external LO is negative. The external LO frequency at the mixer port and the LO frequency that was entered into the Modulation Analyzer with Special Function 27.3 must be the same value.

Whenever a new external LO or a new microwave frequency is entered, the Modulation Analyzer retunes as if the indicated change was physically made externally.

Frequency Offset Control (Cont'd)
(Includes Special Function 27)

Comments

The Modulation Analyzer assumes the condition:
Displayed Microwave Frequency = External LO - Measured RF; unless manually tuned with a microwave frequency entry that is greater than the external LO.
The instrument will then assume the condition:
Displayed Microwave Frequency = External LO + Measured RF: until manually tuned with a microwave frequency entry less than the external LO.

If the entered LO frequency and microwave input frequency ever differ by more than 1300 MHz (or less than 0.15 MHz), an out-of-range error is displayed (Error 10).

The automatic tune function does not work over the new measurement range of 0 to 42 GHz but can only tune across 1300 MHz greater than (or less than) the external LO.

Manual tuning uses the LO polarity required depending on whether the microwave input is less than or greater than the external LO frequency. Automatic tuning uses whatever LO polarity (positive or negative) that was in effect last (at power-up, the polarity is positive).

When FM or ϕM measurements are made, the Peak+ and Peak- functions can be interpreted as being reversed whenever the external LO frequency is greater than the microwave input frequency.

Special Function 22 can enable a service request to be pulled whenever the Frequency Offset mode changes state (bit weight 16), when the tuned frequency is changed, or when Special Function 27.0, 1, or 3 is used to enter or exit the mode. (Refer to **Service Request Condition**.)

TTL Output:
When the Modulation Analyzer is in the Frequency Offset mode, the TTL output is dependent upon the value entered as the external LO frequency. If the entered value is zero, the TTL output is 0V nominal. If the LO is greater than 0, but less than 18 GHz, the nominal output is 5V. For LO frequency values greater than 18 GHz, the TTL output is 3V nominal. When not in Frequency Offset mode, the output is 0V.

Related Functions

RF Frequency Tuning
Special Functions

HP-IB Address
(Special Function 21)

Description

The Modulation Analyzer's present HP-IB address can be displayed using Special Function 21. The binary code displays the HP-IB address, whether the instrument is set to talk only or to listen only, and whether it is currently issuing a service request.

The HP-IB address display does not time out, but it can be cleared by pressing any key (except the LOCAL, S (shift), Blue Key, or number keys).

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 provided in the following table:

Allowable HP-IB Address Codes

Address Swtiches					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	.	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
1	1	1	1	1	Invalid	Invalid	31

Indications

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the HP-IB code is displayed.

HP-IB Address (Cont'd)
(Special Function 21)

Indications (cont'd)

Display (cont'd): The display shows 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 digits AAAAA.TL are 1, but S is 0, the HP-IB board is not installed.)

Front Panel: The LED within the SPCL key lights and all measurement key lights and annunciators turn off.

Example

If 01110.001 is 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

SPCL = SP

Comments

The HP-IB address display is continuously updated. When the switch setting is changed, the result is immediately visible on the display.

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

The factory-set address is decimal 14.

Related Functions

Remote Operation, Hewlett-Packard Interface Bus (Section III)
Special Functions

IF Frequency
(Special Function 34.0)

Description

The Modulation Analyzer only characterizes RF input signals that can pass through its intermediate frequency (IF) filters. Three ways are used to pass the RF input signal through the IF:

When RF input signals less than 2.5 MHz are measured, the RF input signal passes directly into the IF; that is, the RF input frequency and the IF frequency are the same.

When RF input signals greater than 2.5 MHz, but less than 10 MHz are measured, the signal is down converted to a 455 kHz IF.

When RF input signals greater than 10 MHz are measured, the signal is down-converted to a 1.5 MHz IF.

Special Function 34.0 enables the Modulation Analyzer to display the IF signal being used with the selected measurement.

When the instrument is measuring IF frequency, the signal at MODULATION OUTPUT/AUDIO INPUT remains unchanged.

Procedures

To measure the IF frequency, enter the numeric code 34.0, then press the SPCL key.

If IF frequency is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to Ratio.)

HP-IB Program Code

SPCL = SP

Indications

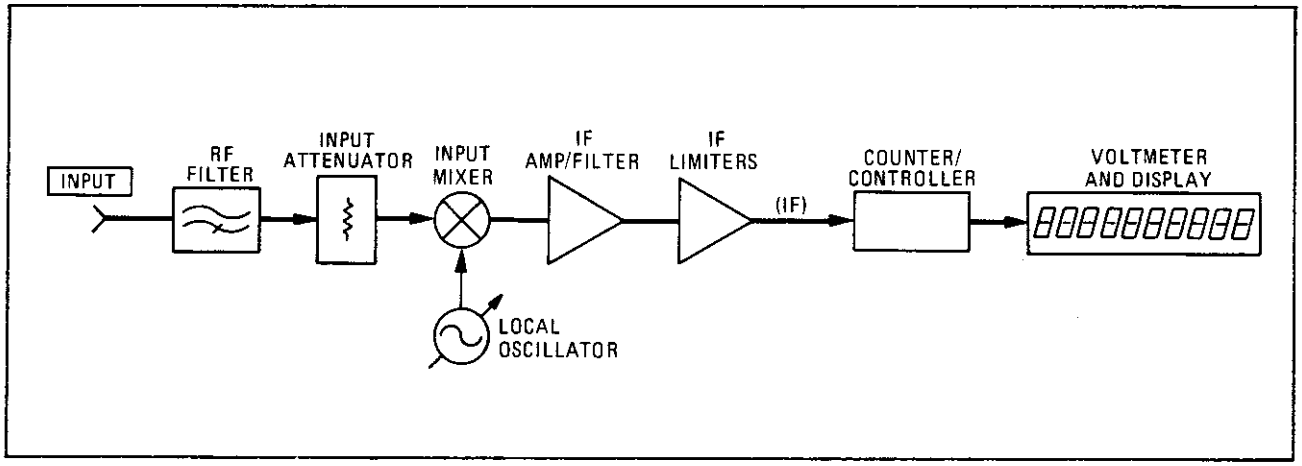
Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the IF frequency is displayed (in MHz). The MHz annunciator is also displayed.

Front Panel: All measurement key lights turn off and the LED within the SPCL key lights.

Measurement Technique

The IF signal, generated when the Local Oscillator and the RF input signal mix, is amplified by the IF Amplifier and FM Limiters. When measuring RF input frequencies greater than 2.5 MHz, the Measuring Receiver uses either the 455 kHz or 1.5 MHz IF. For RF input frequencies less than 2.5 MHz no down-conversion is necessary and the input signal is passed directly into the IF. The frequency of the IF signal is counted and displayed.

IF Frequency
(Special Function 34.0)



IF Frequency Measurement Block Diagram

Comments

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

RF filter selection is dependent on the selected IF Frequency. (Refer to **Filters, RF and IF**.)

When using the 455 kHz IF on input signals with frequencies greater than 300 MHz, AM due to FM increases substantially.

The Modulation Analyzer determines the frequency of the RF input signal by counting the frequencies of both the IF and LO, and calculating their difference.

When measuring frequencies less than 2.5 MHz, the value of the IF frequency is equal to the value of the RF input frequency.

The calibration of the output signal available at MODULATION OUTPUT/ AUDIO INPUT depends on the IF signal level and should be assumed only when all errors are enabled (Special Function 8.8).

Related Functions

Disable Error Message Control
Filters, RF and IF
LO Frequency
RF Frequency Resolution
RF Input Frequency
Special Functions

IF Level

Description

The IF LEVEL key enables the Modulation Analyzer to measure the signal level in its IF and display this value 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, the output at MODULATION OUTPUT/AUDIO INPUT 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.

Procedures

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, enter the value as a ratio reference using the RATIO key. (Refer to Ratio.)

HP-IB Program Code

IF LEVEL = S3

Indications

Display: When the IF LEVEL key is pressed, the optimum IF level is displayed in % or dB (as selected by the LOG/LIN key). The % or dB annunciator is also displayed.

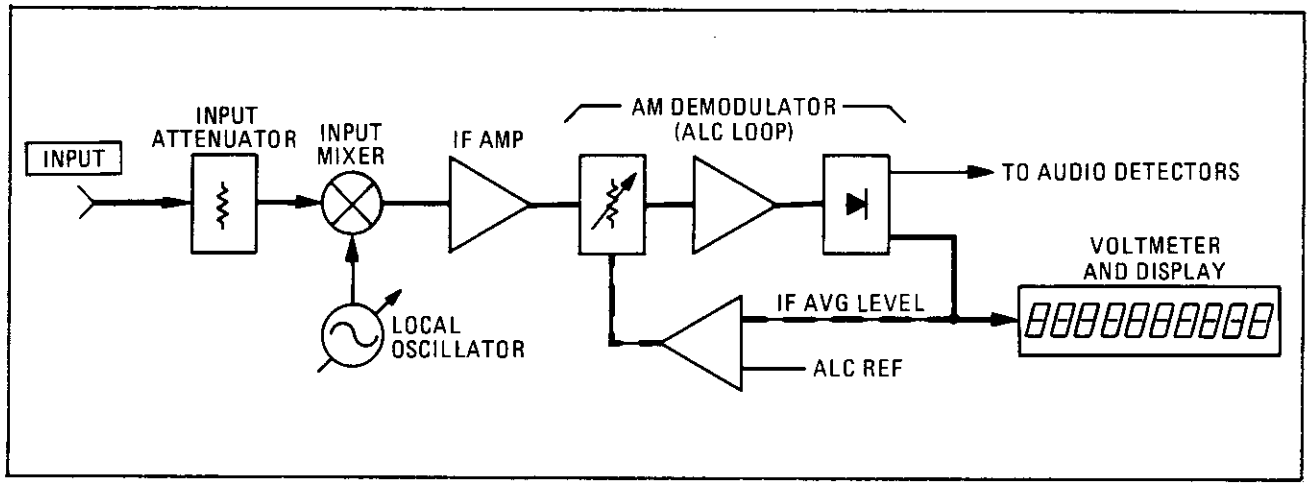
Front Panel: The LEDs within the S (shift) key and the IF LEVEL key light. The value in the display will show the percent of optimum IF Level.

Measurement Technique

Once the instrument is tuned and the IF Level function is selected, the automatic level control (ALC) loop of the AM Demodulator detects the average IF signal level. The measured IF Avg Level is compared to an ALC reference and then displayed as a percentage of the optimum level. If the ALC loop is closed and sufficient signal power is

IF Level (Cont'd)

Measurement Technique (cont'd)
available, the IF level is automatically adjusted to a preset ALC reference level to display 100%. If the ALC loop is open (Special Function 6.2), the input attenuator and the input signal level can be adjusted to achieve the 100% level.



IF Level Measurement Block Diagram

Comments

Error 03 (input circuits underdriven) is generated whenever the IF level is less than 100%. Override this error message using Special Function 8. (Refer to **Disable Error Message Control.**)

When operating with the AM ALC loop open, the displayed AM represents the demodulated ac riding on the carrier; the displayed IF level represents the average carrier level. Compute the AM depth with the following formula:

$$\frac{\text{demodulated ac}}{\text{average carrier level}} \times 100\% = \frac{\text{displayed AM}}{\text{displayed IF level}} \times 100\%$$

To enable the Modulation Analyzer to do this computation, first observe the IF level, press the AM key and enter the IF level on the numeric keys. Then press the RATIO key. AM is now displayed accurately although the measured IF level is not 100%.

In most circumstances, when the AM ALC is off (loop open), use IF levels greater than or equal to 100% for FM measurements and less than or equal to 100% for AM measurements.

Related Function

AM ALC Response Time

IF Output

CAUTION

Do not apply greater than 40 Vdc or greater than +15 dBm into the rear-panel IF OUTPUT connector.

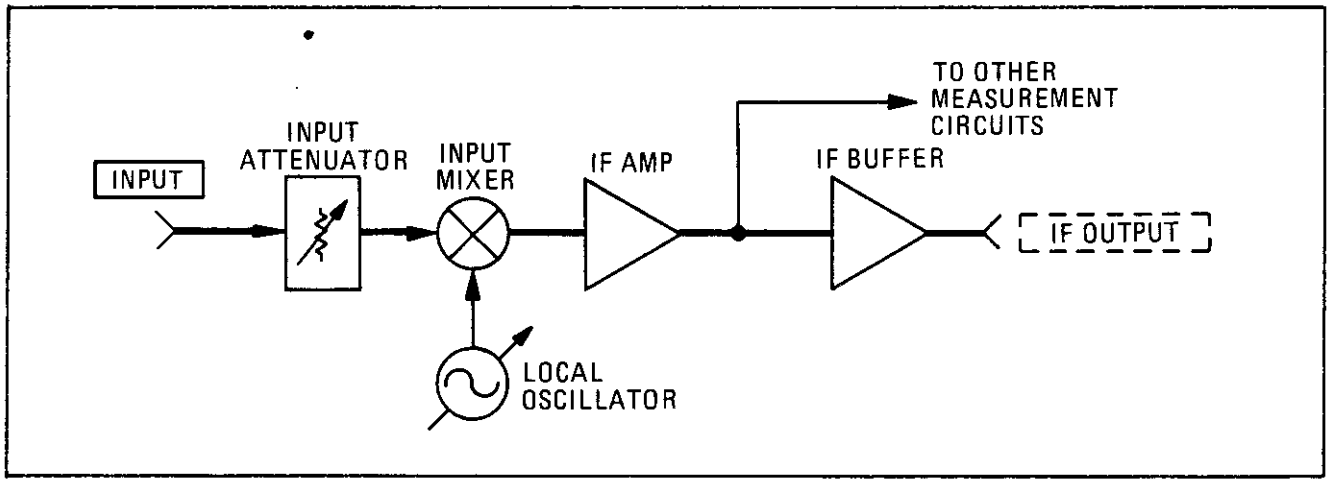
Description

The rear-panel IF OUTPUT (a female BNC connector) provides a buffered IF output to enable monitoring of the Modulation Analyzer's IF signal. The ac-coupled signal ranges from 150 kHz to 2.5 MHz and normally varies in level from -27 to -3 dBm (into 50 ohms). The level variation depends on the RF input signal level, RF input attenuation setting, and the measurement selected.

The 3 dB bandwidth of the signal at IF OUTPUT is approximately 3 MHz when the instrument uses the 2.5 MHz low-pass filter, and approximately 200 kHz when the instrument uses the 455 kHz bandpass filter.

At any particular input level and front-panel setting, the flatness of the IF OUTPUT, as input frequency varies, is typically ±5%.

Block Diagram



IF Output Block Diagram

Comments

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

Check for spurious signals in the IF by connecting a spectrum analyzer to IF OUTPUT.

IF Output (Cont'd)

Comments (cont'd)
Check that instruments (such as counters), connected to IF OUTPUT, do not inject spurious signals into the IF path. These spurious signals can cause spurs in the Modulation Analyzer's IF circuits which could result in measurement inaccuracies.

Related Functions

Filters, RF and IF
IF Frequency

Instrument Preset
(Includes all Power-Up and Default Conditions as well as Special Functions 40 and 41, and HP-IB Clear)

Description

When first turned on (during power-up), the Modulation Analyzer walks through a sequence of internal checks before it is ready to make measurements. The results of these checks are indicated internally to aid servicing. (Refer to Section VIII.) This power-up sequence is indicated to the user when all front-panel indicators are lighted (burned-out LEDs are evident at this time). After approximately 10 seconds, this sequence is completed. Special Function 40 also performs the power-up sequence.

When the INSTR PRESET key is pressed, or Special Function 41 (Device Clear) is keyed, the instrument configures itself the same as during power-up, but bypasses the internal checks.

The Modulation Analyzer contains a battery back-up to the RAMs which makes the internal memory non-volatile, enabling certain aspects of the instrument setup to be maintained after the power has been switched off (power-down).

Maintained during power-down:

- Storage of 8 instrument states using the Store and Recall function. (Refer to **Store/Recall**.)

- For RF Power:
  1. One set of zero and calibration data. (Refer to **RF Power Calibration**.)
  2. Two calibration factor tables: One table stores 16 frequency/calibration factor pairs and a reference calibration factor for use with RF power sensors. One table stores 22 frequency/calibration factor pairs for use with microwave power sensors. (Refer to **RF Power Calibration Factors**.)

- For AM and FM:
  An AM calibration factor and an FM calibration factor (both in disabled mode). (Refer to **AM Calibration** and **FM Calibration**.)

Instrument Preset (Cont'd)
(Includes all Power-up and Default Conditions as well as Special Functions 40 and 41, and HP-IB Clear)

Description (cont'd)
Default conditions after power-up:

Front-Panel Keys

HP FILTER	all off
LP FILTER	all off
FM DE-EMPHASIS	all off
PRE DISPLAY	off
CALIBRATION	all off
RF POWER ZERO	previous power-down value
RF POWER SAVE CAL	previous power-down value
MEASUREMENT	FREQ
DETECTOR	PEAK+
DISPLAY	off
RATIO	off
AUTOMATIC OPERATION	on
TRACK MODE	off
AUTO TUNING	on
RANGE HOLD	off
DISABLE ERROR	as appropriate for selected measurement
MHz	when pressed, 100 MHz
kHz ⇧ and kHz ⇩	0 kHz
MODULATION OUTPUT	FM

Special Functions

1-10	suffix is set to 0
11 Previous Ratio	off
Ratio Reference	100%
14 Limit	off
Upper Limit	1300
Lower Limit	0.150
Upper/Lower Limit Code	0.005 (FREQ)
16 AM Calibration Factors	100% or previous power-down value
17 FM Calibration Factors	100% or previous power-down value
22 Service Request	suffix set to 2
Status Byte	cleared
25 External Attenuation	0 dB
27 Frequency Offset Control	0 MHz
37 Calibration Factors, RF Power	Table #1 from previous power-down
Mode	Automatic Cal Factor Mode

Instrument Preset (Cont'd)
(Includes all Power-up and Default Conditions as well as Special Functions 40 and 41, and HP-IB Clear)

Procedures

To walk the instrument through its internal checks, key in 40.0 SPCL, or turn the Modulation Analyzer off, then on again.

To reset the Modulation Analyzer to its default conditions without going through the 10 second process of internal checks, press the Blue Key and INSTR PRESET (AUTOMATIC OPERATION) key, or key in 41.0 SPCL.

HP-IB Program Codes

Special Function 40.0 is not accessible from the HP-IB.

INSTR PRESET (Device Clear) = IP
SPCL = SP

Comments

After plugging in a new Memory Assembly, some or all of the instrument states stored through power-down may be non-existent. If this information is lost:

1. The Recall function selects the Instrument Preset state.
2. Error 15 is displayed and RF power calibration factors must be re-entered.
3. AM and FM calibration factors are 100% when enabled.

Limit
(Special Function 14)

Description

Using Special Function 14 and the RATIO key, lower and upper measurement limits can be entered into the Modulation Analyzer. Subsequent out-of-limit measurements will then cause the LIMIT annunciator to be displayed.

When the Limit function is enabled, the Modulation Analyzer can issue an HP-IB service request upon reaching an lower or upper limit. (Refer to **Service Request Condition.**) The LIMIT light turns off after 5 measurement cycles if further measurements are not out of limits; but the service request can only be cleared by serial polling or by a Device Clear or Instrument Preset message.

Only one lower and one upper limit can be set at a time. Each limit (lower or upper) can only be in effect in one Measurement mode. (The Measurement mode need not be the same for both the lower and upper limits.) Both limit references can be displayed, cleared and restored; the status of the Limit function can be displayed; and the Measurement modes for both limits can be displayed.

Procedures

First enter the desired limit reference as a ratio reference:

1. Select the measurement key in which the limit is to be used.

2. Key the limit value into the numeric keyboard. Use the Blue Key and the minus (-, decimal point) key to change the sign of the entered value.

3. Press the RATIO key.

The entered value is now stored as a ratio reference. To transform the ratio reference directly into a lower or upper limit reference, key in Special Function 14.1 or 14.2 (respectively).

Press the RATIO key again to re-display the measurement value.

Limit (Cont'd)
(Special Function 14)

Procedures (cont'd)
The Special Function codes pertaining to the Limit function are listed in the following table:

	Action	Special Function Code	Program Code HP-IB
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
	Display lower limit.	14.5 SPCL	14.5SP
	Display upper limit.	14.6 SPCL	14.6SP
	Display selected, lower limit measurement code.	14.7 SPCL	14.7SP
	Display selected, upper limit measurement code.	14.8 SPCL	14.8SP
	Display limit status in the format Lower.Upper; where 0=disabled and 1=enabled.	14.9 SPCL	14.9SP

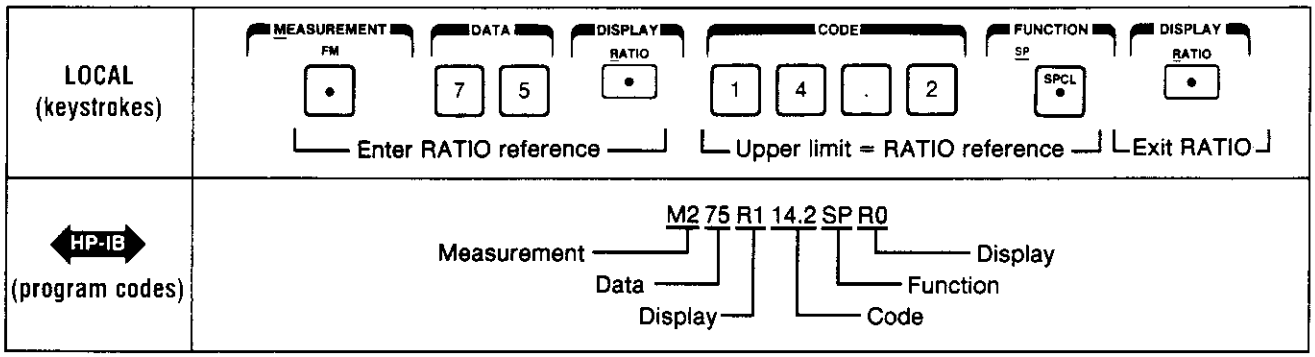
To determine the measurement in which a lower or upper limit is in effect, key in Special Function 14.7 or 14.8 (respectively). The display shows a code which represents the measurement in which the limit is in effect. These codes are indexed in the following table:

Display	Measurement	Display	Measurement
0.000	AM	0.011	AUDIO FREQ (external)
0.001	FM	2.003	RF LEVEL (35.0 SPCL)
0.002	ϕM	2.004	TUNED RF LEVEL
0.003	RF POWER	2.009	AUDIO DISTN (internal)
0.005	FREQ	2.010	LO FREQUENCY (33.0 SPCL)
0.006	FREQ ERROR	2.011	AUDIO DISTN (external)
0.008	IF LEVEL	4.009	SINAD (internal)
0.009	AUDIO FREQ (internal)	4.011	SINAD (external)
0.010	IF FREQUENCY (34.0 SPCL)	6.011	EXT AUDIO RMS LEVEL (30.0 SPCL)

Limit (Cont'd)
(Special Function 14)

Example

To set an upper limit of 75 kHz FM deviation:



Read the FM deviation in kHz with an upper limit set at 75 kHz.

HP-IB Program Codes

The codes for performing the various limit operations are provided in "Procedures".

RATIO off = R0
RATIO on = R1

Indications

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.

Display: When the RATIO key is pressed, the value displayed is a reference value that is compared to the ratio reference entered. When the RATIO key is pressed a second time, the display returns to the previous measurement with the Limit function enabled.

When numeric codes 14.0 through 14.4 are keyed in, they appear on the display. When the SPCL key is pressed, the display returns to the measurement previously selected.

When numeric codes 14.5 through 14.9 are keyed in, they appear on the display. When the SPCL key is pressed, the requested action is displayed.

If a measurement falls out of set limits, the LIMIT annunciator is displayed. After the measurement returns to within the set limits, the LIMIT annunciator continues to be displayed until five successive measurements are made that fall within the set limits.

Limit (Cont'd)
(Special Function 14)

Indications (cont'd)

Front Panel: The LED within the RATIO key lights when pressed; when pressed again, the LED is turned off.

When limits are cleared, set, or restored, the LED within the SPCL key does not light (Special Functions 14.0 through 14.4). When limits are displayed, or when the measurement code or the limit status is displayed, the LED within the SPCL key lights until the display times out (Special Functions 14.5 through 14.9).

Comments

The test for out-of-limit results is performed on the actual measurement results, not upon the displayed number. Thus, although the display shows 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.

If Special Function 14.1 or 14.2 is initiated with no previous numeric value, the ratio reference becomes the entered value. The desired limit must be entered before the Special Function numeric code.

Related Sections

Ratio
Service Request Condition
Special Functions

LO Frequency
(Special Function 33.0)

Description

Using the numeric keyboard and the SPCL key, the Modulation Analyzer can be set to display the local oscillator (LO) frequency.

When the instrument is measuring the LO frequency, the signal at MODULATION OUTPUT/AUDIO INPUT remains unchanged.

Procedures

To measure the LO frequency, enter the numeric code 33.0, then press the SPCL key.

If the LO frequency is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to Ratio.)

HP-IB Program Codes

LO FREQUENCY = 33.0
SPCL = SP

Indications

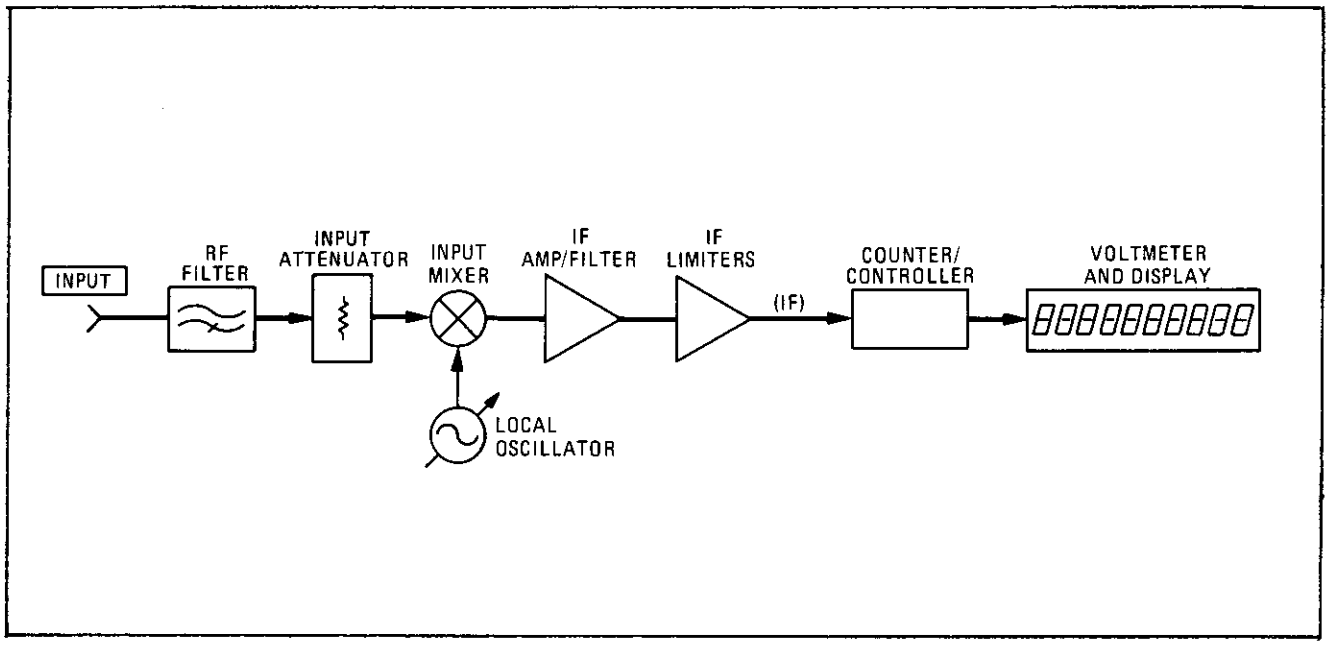
Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the LO frequency is displayed (in MHz). The MHz annunciator is also displayed.

Front Panel: All measurement key lights turn off, the LED within the SPCL key lights.

Measurement Technique

The LO signal is a combination of the RF input signal and the intermediate frequency (IF). The Modulation Analyzer counts the frequency of both the IF and the LO, and calculates their difference to determine the frequency of the RF input signal. RF input frequencies greater than 2.5 MHz are mixed with the LO to obtain either a 455 kHz or the 1.5 MHz IF. For RF input frequencies less than 2.5 MHz, although no down-conversion is necessary and the RF input signal is passed directly into the IF, the LO is tuned to 101.5 MHz to turn on the input mixer diodes.

LO Frequency (Cont'd)
(Special Function 33.0)



LO Frequency Measurement Block Diagram

Comments

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

When the RF input signal is less than 2.5 MHz, the LO frequency is set to 101.5 MHz.

Related Functions

LO Frequency
RF Frequency Resolution
RF Input Frequency
Special Functions

LO Input and LO Output (Option 003)

CAUTION

Do not apply greater than 40 Vdc 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.

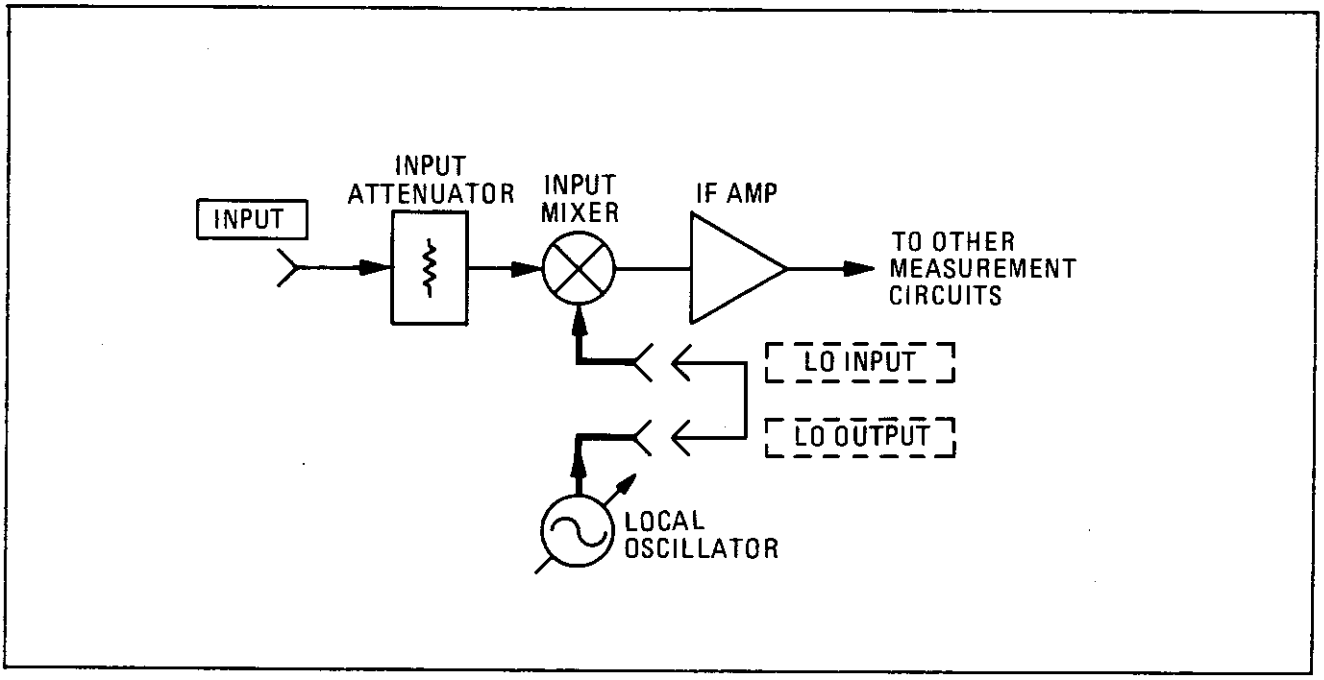
Description

In Measuring Receivers with Option 003, the internal local oscillator signal (LO) passes through the rear-panel LO OUTPUT and LO INPUT connectors. The range of the LO signal is 1.27 MHz to 1301.5 MHz, at approximately 0 dBm. Both connectors are 50 ohm, ac-coupled, female, Type-N connectors.

NOTE

The rear-panel LO OUTPUT must be connected to the rear-panel LO INPUT for normal Modulation Analyzer operation using the internal local oscillator.

Block Diagram



LO Input and LO Output Block Diagram

LO Input and LO Output (Cont'd)
(Option 003)

Procedure

To use LO OUTPUT as a signal source:

1. Select an IF frequency of either 1.5 MHz or 455 kHz using Special Function 3. (If the IF frequency is not specified, the Modulation Analyzer will assume the 1.5 MHz IF for keyboard-entered frequencies greater than 10 MHz and the 455 kHz IF for frequencies less than 10 MHz but greater than 2.5 MHz.)

2. Subtract the IF frequency from the frequency desired at LO OUTPUT, and enter the result, in MHz, via the numeric keys; then press the MHz key. (To tune the LO below 2.96 MHz, use the procedure as described, but select the 455 kHz IF using Special Function code 3.1, and disable Error 01 using Special Function code 8.1.)

To use LO INPUT to apply an external LO:

1. Select an IF frequency (1.5 MHz or 455 kHz) using Special Function 3.

2. Press the MHz key to enter manual tune mode (to prevent the internal LO from continuously tuning).

3. Add the IF frequency to the frequency to which the Modulation Analyzer is to be tuned, and set the external LO to that frequency.

4. 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 of the RF input signal is unnecessary.

When an external LO is used, measurements made using the FREQ or FREQ ERROR keys are not accurate. To determine input frequency, subtract the IF frequency (Special Function 34) 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 are possible. To avoid the problem, turn off the external LO when switching its frequency.

Related Functions

Disable Error Message Summary
Filters, RF and IF
IF Frequency
LO Frequency
RF Frequency Tuning

Modulation Output/Audio Input (Includes the AUDIO INPUT key)

CAUTION

Do not apply greater than 10 Vdc or greater than +30 dBm (1 watt) into MODULATION OUTPUT/AUDIO INPUT or damage to the instrument may result.

NOTE

For optimum signal flatness, cables attached to MODULATION OUTPUT/AUDIO INPUT should be terminated with their characteristic impedance.

Description

The output at MODULATION OUTPUT/AUDIO INPUT provides a calibrated output for signals demodulated by the Modulation Analyzer. The output signal available at the connector usually corresponds to the current modulation measurement. The dc-coupled output has a 600 ohm output impedance at the BNC female connector.

The input at MODULATION OUTPUT/AUDIO INPUT provides external access to the audio measurement circuits. The input has a 100 kohm input impedance at the connector.

Modulation Output/Audio Input (Cont'd)
(Includes the AUDIO INPUT key)

Description (cont'd)
Many measurements have a direct effect on MODULATION OUTPUT/AUDIO INPUT. The following table lists the Modulation Analyzer's response when the listed measurement functions are initiated (any measurements not listed do not have an effect):

Measurement	Measuring Receiver's Response
AM	Selects the demodulated AM signal (unless AUDIO INPUT is selected).
AUDIO DISTN	Measures signal available at MODULATION OUTPUT/AUDIO INPUT (depends on AUDIO INPUT key selection).
AUDIO FREQ	Measures signal available at MODULATION OUTPUT/AUDIO INPUT (depends on AUDIO INPUT key selection).
AUTOMATIC OPERATION	Selects the last-selected modulation measurement.
FM	Selects the demodulated FM signal (unless AUDIO INPUT is selected).
FREQ	Selects the last-selected modulation measurement.
FREQ ERROR	Selects the last-selected modulation measurement.
INSTR PRESET	Refer to **Instrument Preset**
ϕM	Selects the demodulated FM signal (unless AUDIO INPUT is selected).
RF POWER	Blanks output; turns off all Modulation Output, Audio Input keylights.
TUNED RF LEVEL	Blanks output; turns off all Modulation Output, Audio Input keylights.
29.0 SPCL (SINAD)	Selects the last-selected modulation measurement.
30.0 SPCL (Ext. Audio RMS Level)	Selects AUDIO INPUT.
33.0 SPCL (LO Frequency)	Selects the last-selected modulation measurement.
34.0 SPCL (IF Frequency)	Selects the last-selected modulation measurement.
35.0 SPCL (RF Level)	Blanks output; turns off all Modulation Output, Audio Input keylights.
HP and LP Filters, and FM De-emphasis affect the output, but not the input of MODULATION OUTPUT/AUDIO INPUT. (See the Modulation Output/Audio Input Block Diagram in this instruction.)	

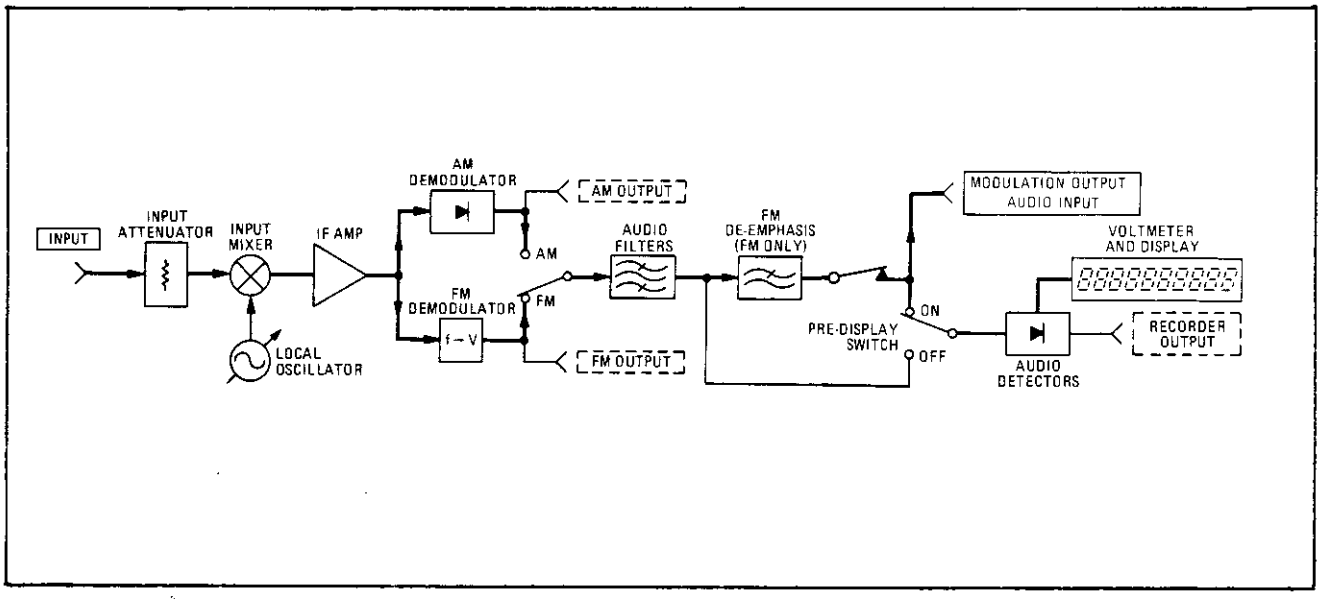
Modulation Output/Audio Input (Cont'd)
(Includes the AUDIO INPUT key)

Description (cont'd)
The level of the output signal at MODULATION OUTPUT/AUDIO INPUT auto-ranges; usually between 0 and 4 Vpeak into an open circuit. The modulation type and the displayed resolution determine the sensitivity at the output (into an open circuit). The following table examines this relationship. (Refer to Audio Range for more information on modulation ranges.)

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)
0.001	1	0.01*	100	0.0001	10
		0.1	10	0.001	1
0.01	0.1	1	1		
		10	0.1	0.01	0.1
0.1	0.01	100	0.01	0.1	0.01

*Available only with 750 μs de-emphasis, pre-display.

Block Diagram



Modulation Output/Audio Input Block Diagram

Modulation Output/Audio Input (Cont'd)
(Includes the AUDIO INPUT key)

Comments

Errors 01 through 03, 05, 10, and HP-IB Error 96 (corresponds to a display of two dashes) turn off the signal at MODULATION OUTPUT/AUDIO INPUT.

When the Modulation Analyzer is first powered up, the demodulated signal at MODULATION OUTPUT/AUDIO INPUT 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 Error 04 (audio circuits overdriven) is automatically disabled. When Error 04 is disabled, only autoranging to less sensitive audio ranges is allowed.

When Error 01 through Error 04 are always enabled (8.8 SPCL), the signal at MODULATION OUTPUT/AUDIO INPUT is entirely safeguarded. Under this condition an error is displayed when the signal at MODULATION OUTPUT/AUDIO INPUT is uncalibrated. (Refer to **Disable Error Message Control.**)

Related Functions

AM
Audio Filters
Audio Range
Disable Error Message Control
FM
ϕM

ϕM
(Includes Special Function 2)

Description

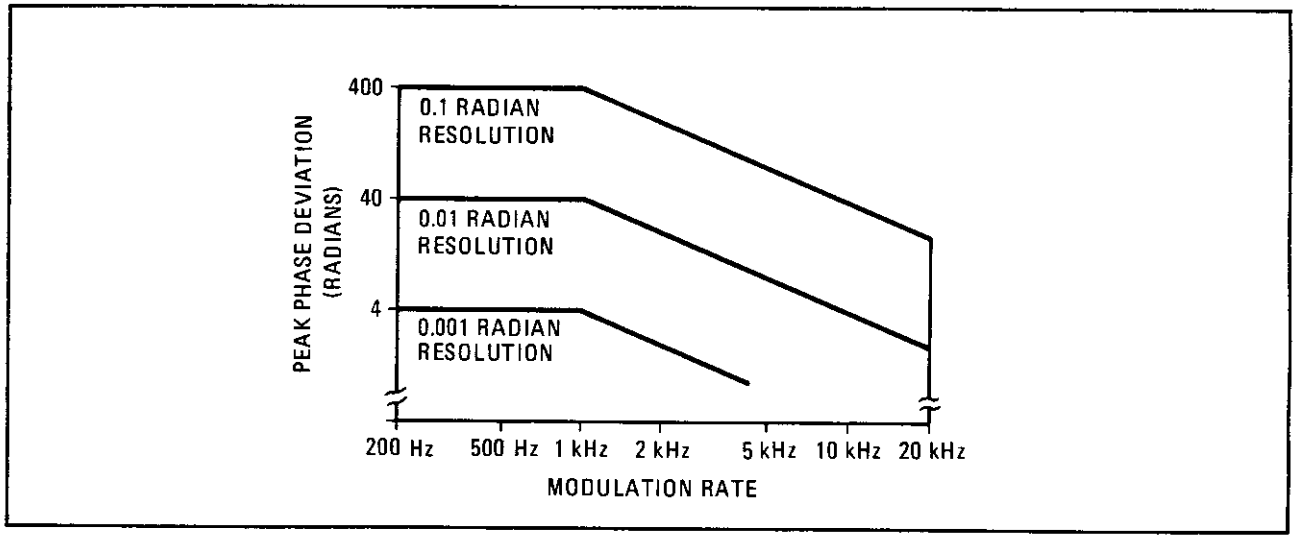
The ϕM key enables the Modulation Analyzer to measure the phase modulation deviation of the tuned input signal.

The demodulated ϕM is present at MODULATION OUTPUT/AUDIO INPUT (unless AUDIO INPUT is selected).

The ϕM measurement is specified only for carriers from 10 to 1300 MHz; however, ϕM measurements can be performed on carriers from 150 kHz to 10 MHz. Higher frequencies can be measured when an external LO is used. (Refer to **Frequency Offset Control**). 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.

The demodulated signal's frequency and distortion can also be characterized. (Refer to **Audio Distortion and Level** and to **Audio Frequency.**)

The following figure illustrates the display resolution for different combinations of peak phase deviation and modulation rate.



Procedure

To make a ϕM measurement, first tune the instrument to the input signal. (Refer to **RF Frequency Tuning** or press AUTOMATIC OPERATION.)

Press the ϕM key, and select an audio detector: PEAK+, PEAK-, or AVG. The RMS detector, selected by pressing the Blue Key and the RMS key, is not quite as accurate in measuring FM and is usually only used for audio distortion measurements. (Refer to **Audio Distortion and Level** and to **Audio Detectors**).

ϕM (Cont'd)
(Includes Special Function 2)

Procedure (cont'd)

The following table lists the different measurement range limits that can be selected with Special Function 2:

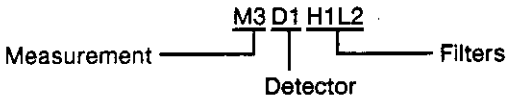
Modulation Range (Peak ± rad. dev.)	Detector Selected	Special Function Code	Program Code HP-IB	Display Resolution (radians)	MODULATION OUTPUT Sensitivity (mVac/radian)
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection	
≤0.4	RMS	2.4 SPCL	2.4SP	0.0001	10
≤4	Pk, Avg	2.4 SPCL	2.4SP	0.001	1
≤4	Pk, Avg, RMS	2.1 SPCL	2.1SP	0.001	1
≤40	Pk, Avg, RMS	2.2 SPCL	2.2SP	0.01	0.1
≤400	Pk, Avg, RMS	2.3 SPCL	2.3SP	0.1	0.01

To filter the demodulated signal, press the appropriate filter keys. (Refer to **Audio Filters**).

If ϕM deviation is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to Ratio.)

Example

To measure the positive-peak ϕM deviation of a signal in a 50 Hz to 15 kHz demodulated signal bandwidth:

LOCAL (keystrokes)	
HP-IB **(program codes)**	

ϕM (Cont'd)
(Includes Special Function 2)

HP-IB Program Code

All HP-IB codes for changing the limits of the phase modulation deviation are provided in "Procedures".

ϕM = M3

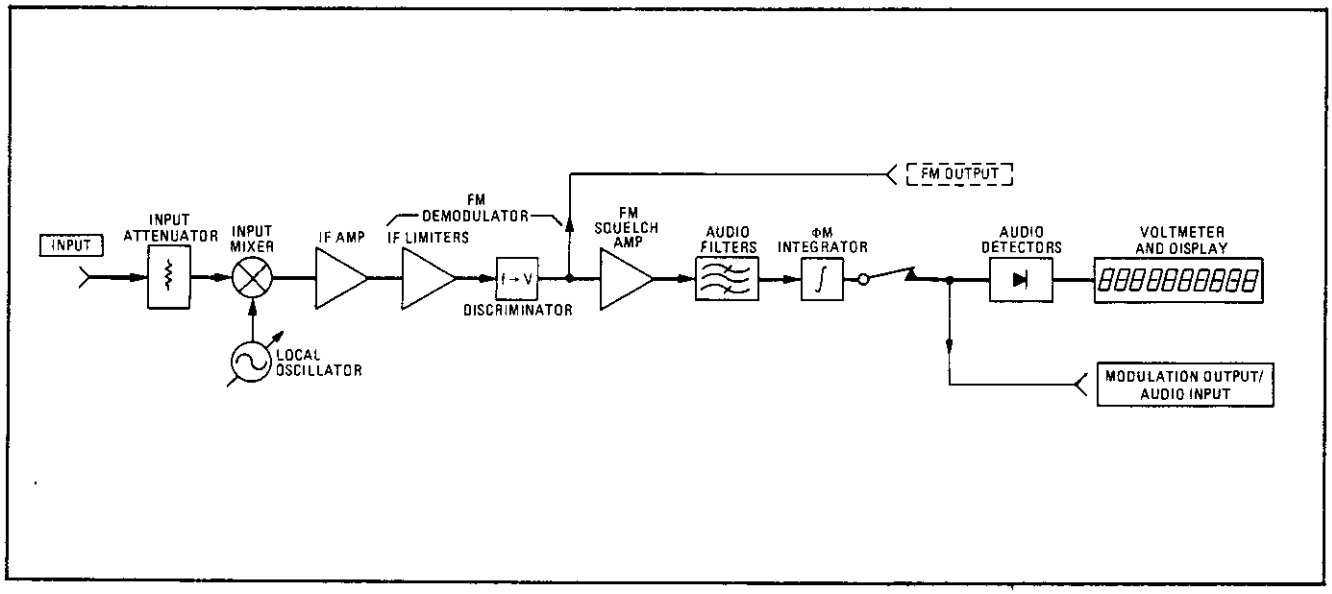
Indications

Display: When the ϕM key is pressed, the display shows the measured radian deviation on the carrier. The radian (rad) annunciator is displayed.

Front Panel: The LEDs within the keys representing the selected functions light.

Measurement Technique

The ϕM on the IF carrier is demodulated by a discriminator that produces a signal whose amplitude is proportional to the frequency deviation. The demodulated signal is filtered and passed through an integrator. The integrator's output is detected and displayed as phase deviation in radians. The integrator's output is made available at the output of MODULATION OUTPUT/AUDIO INPUT.



ϕM Measurement Block Diagram

ϕM (Cont'd)
(Includes Special Function 2)

Comments

The PEAK+ detector always detects the carrier's positive, phase deviation while the PEAK- detector always detects the carrier's negative, phase deviation. The PEAK ±/2 detector sums the positive and negative phase deviations and divides the total by two to provide an average peak value. (This value is not to be confused with a detected average value.)

The routine which automatically selects the modulation range contains regions of overlap between the following displayed peak deviations: 0.35 and .4 radians, 3.5 and 4 radians, and 35 and 40 radians. When using the average detector, ranging occurs 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 ϕM key a second time. To set the instrument to a selected modulation range, refer to **Audio Range**.

When operating above 2.5 MHz while using the 455 kHz IF, the upper limit of the modulation rate is that of the >20 kHz LP FILTER.

When operating with carrier frequencies below 2.5 MHz, the output signal at MODULATION OUTPUT/AUDIO INPUT is inverted unless using the 455 kHz IF.

AM conditions that cause the carrier signal to disappear will cause inaccuracies in the measurement of ϕM deviation, or they could cause Error 05 (FM squelched) to be displayed.

When ϕM is selected, the signal at the rear-panel FM OUTPUT still represents demodulated FM, not ϕM.

To display phase deviation in degrees instead of radians, enter 1.745 as a ratio reference and select the RATIO key. (Refer to **Ratio**.)

Pulsed phase modulation, such as phase shift keying, cannot be accurately demodulated or measured by the Modulation Analyzer.

Related Functions

Audio Detectors
Audio Filters
Audio Range
Ratio
Residual Noise Effects

Range Hold

Description

The RANGE HOLD key freezes the current ranges being used by the Modulation Analyzer. This function, the corollary to the AUTOMATIC OPERATION key, disables the automatic tuning function and places Special Functions prefixed 1, 2, 3, 7, 9, and 10 in non-automatic modes. The following functions are not affected by the Range Hold function: HP and LP Filters, FM De-emphasis, Measurement, Detectors, and Display. Any Special Functions prefixed 1 through 10 that are already in manual modes also remain unaffected. The table below summarizes the effect of the Range Hold function:

Special Function Prefix	Measurement Function	Effect of RANGE HOLD on Functions
1	RF Input Attenuation	Holds setting
2	Audio Range	Holds setting
3	RF and IF Filters	Holds setting
5	Audio Detector Response	No effect
6	AM ALC Response	No effect
7	RF Frequency Resolution	Holds setting
8	Error Message Disable	No effect
10	RF Power Range	Holds setting
	AUTO TUNING	Selects Manual Tuning

Procedures

To hold the special functions in a specific measurement state, set the Modulation Analyzer as desired, then press the RANGE HOLD key.

To exit the Range Hold mode, press the RANGE HOLD key a second time or press the AUTOMATIC OPERATION key.

HP-IB Program Code

Automatic Ranging = G0
RANGE HOLD = G1

Range Hold (Cont'd)

Indications

Display: When the RANGE HOLD key is pressed, the display returns to the measurement previously selected.

Front Panel: The light within the RANGE HOLD key lights. The light within the SPCL key also turns on.

Comments

Once settings are held with the Range Hold Function, one or more can be changed by manually entering the desired function. For example, the RANGE HOLD key places the instrument in the manual tune mode; press the Blue Key and AUTO TUNING (TRACK MODE) key to re-enter the automatic tuning mode.

Related Functions

Audio Range
Disable Error Message Control
Filters, RF and IF
RF Frequency Tuning
RF Input Attenuation
Special Functions

Ratio and Log/Lin
(Includes the PREVIOUS RATIO key and Special Function 11.2)

Description

The RATIO and PREVIOUS RATIO keys permit any measurement result to be compared to a reference value. The reference value may be the result of a previous measurement or a keyboard entry. Special Function 11.2 displays the current ratio reference.

The LOG/LIN key enables measurement results to be displayed linearly (%) or logarithmically (dB).

The ratio functions can be used with the following measurements:

AM	SINAD	(29.0 SPCL)
FM	Ext Audio RMS Level	(30.0 SPCL)
ϕM	LO Frequency	(33.0 SPCL)
RF POWER	IF Frequency	(34.0 SPCL)
FREQ	RF Level	(35.0 SPCL)
AUDIO FREQ		
AUDIO DISTN		
IF LEVEL		
TUNED RF LEVEL		
FREQ ERROR		

The Modulation Analyzer keeps the current ratio reference as the previous ratio reference. A current ratio is changed to previous ratio status whenever the following conditions occur:

- the RATIO key is pressed a second time,
- a new measurement is selected, or
- the variable units selectable by the Data keys are changed.

The output signal at MODULATION OUTPUT/AUDIO INPUT is unaffected by the ratio functions.

Procedures

Use the LOG/LIN key anytime during the measurements to change the display to either dB or % (respectively).

To use the Ratio function:

1. Select the desired Measurement mode. Measurements possible with the ratio function are listed in "Description."

2. Set the display to the desired reference value:

   - Adjust the signal parameter being measured to a reference setting, or
   - enter the reference on the numeric keys. If the reference is to be negative value, press the Blue Key and the minus key (- key under the decimal point key).

Ratio and Log/Lin (Cont'd)
(Includes the PREVIOUS RATIO key and Special Function 11.2)

Procedures (cont'd)

3. Press the RATIO key. The display will show the measurement result relative to the reference value.

To use the Previous Ratio function:

1. Perform the procedure to select a ratio reference.
2. Select the desired Measurement mode. (The Modulation Analyzer uses the same value as that entered in the Ratio mode regardless of the current measurement selected.)
3. Press the Blue Key and the PREVIOUS RATIO (RATIO) key. The display will show the measurement result relative to the original reference value.

To display the ratio (or previous ratio) reference, key in 11.2 SPCL.

Examples

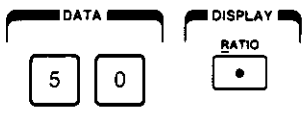
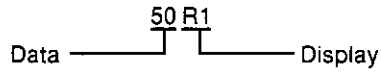
35.35 kHz FM deviation is displayed; to enter this value as the RATIO reference for future measurements:

LOCAL (keystrokes)	DISPLAY RATIO
HP-IB **(program codes)**	R1 Display

The result from this comparison is either 100% (if linear results are selected), or 0 dB (if logarithmic results are selected).

Ratio and Log/Lin (cont'd)
(Includes the PREVIOUS RATIO key and Special Function 11.2)

Example (cont'd)
35.35 kHz FM deviation is displayed, to compare this to an FM deviation of 50 kHz:

LOCAL (keystrokes)	
HP-IB (program codes)	

The result from this comparison is either 70.7% (if linear results are selected, or -3.01 dB (if logarithmic results are selected).

HP-IB Program Codes

LOG display = LG
LIN display = LN
PREVIOUS RATIO = R2
RATIO off = R0
RATIO on = R1
SPCL = SP

Indications

Display: When the LOG/LIN key is pressed, the displayed measurement changes to reflect the new value.

When the instrument is displaying a ratio or previous ratio comparison, the REL (relative) annunciator lights and the dB or % annunciator is displayed (as appropriate). The displayed value is the measurement result relative to the reference in % or dB.

When 11.2 SPCL is keyed, the last-entered ratio reference value is displayed.

Front Panel: When the instrument is displaying a ratio or previous ratio comparison, the RATIO key lights. The LEDs of all previously-selected annunciators remain on.

When Special Function 11.2 is selected, only the LED within the SPCL key lights.

Ratio and Log/Lin (Cont'd)
(Includes the PREVIOUS RATIO key and Special Function 11.2)

Measurement Technique

When in the Ratio mode, measurements are made in the same way as when not in the Ratio mode; however, before the result is displayed, the internal controller converts it to ratio. The following equations are used for computing ratio:

(M/R) (100%) = % ratio for all measurements,

(20) log (M/R) = dB ratio for the following measurements[1]: AM, FM, ϕM, AUDIO DISTN, IF LEVEL, SINAD (29.0 SPCL), Ext Audio RMS Level.

(10) log (M/R) = dB ratio for the following measurements[2]: FREQ, AUDIO FREQ, FREQ ERROR, LO Frequency (33.0 SPCL), IF Frequency (34.0 SPCL).

Comments

When using dB ratio; any ratio reference or measurement result that causes the value of M/R (see equations above) to approach 0 causes the instrument to display Error 11.

The RATIO keys are convenient when used to check modulation or RF level flatness throughout an RF frequency range (use Track Mode tuning described in **RF Frequency Tuning**) or throughout the audio range.

The reference that is kept for a ratio measurement can be entered as a limit reference (refer to **Limit**).

The following list provides some useful reference values for making ratio measurements:

- 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 peak, use 70.7 and % ratio.

Related Functions

Error Message Summary
Limit
Special Functions
RF Frequency Tuning

[1] When watts units are used, this equation provides the ratio result for RF POWER, TUNED RF LEVEL, and RF LEVEL (35.0 SPCL) measurements.

[2] When uV, mV, or V units are used, this equation provides the ratio result for RF POWER, TUNED RF LEVEL, and RF LEVEL (35.0 SPCL) measurements.

Recorder Output
(Includes Special Function 49)

Description

The RECORDER output yields the voltage that is being read by the internal voltmeter.

Since the internal voltmeter takes many different readings to interpret a measurement, only pulses are available at this output under normal conditions. An oscilloscope, connected to this output, could prove to be very useful in monitoring the signal or in troubleshooting an instrument malfunction.

Using Special Function 49, specific measurement voltages can be delivered out the RECORDER output to be read by an external, high-accuracy, linear voltmeter. This method enables better resolution on all measurements and better accuracy in RF power measurements because the slight, dc offset and non-linearity of the internal voltmeter can be bypassed.

The following Special Functions can be used to effectively "freeze" the instrument (no ranging, retuning, etc.) and deliver a dc level that is proportional to a particular measurement value:

Special Function	Measurement Voltage Delivered Out Recorder Output
49.00 SPCL	Ground
49.01 SPCL	RF Peak Detector Ground
49.02 SPCL	RF Peak Detector Output/2.96
49.03 SPCL	RF Peak Detector
49.04 SPCL	10 x AM Calibrator Level
49.05 SPCL	AM Calibrator Level
49.06 SPCL	Audio Range Detector
49.07 SPCL	Audio RMS Detector
49.08 SPCL	Ground
49.09 SPCL	Audio AVG Detector
49.0A SPCL (A = S (shift), 0)	Audio PEAK Detector
49.0B SPCL (b = S (shift), 1)	IF Average Detector
49.0D SPCL (d = S (shift), 3)	IF Peak Detector
49.0E SPCL (E = S (shift), 4)	ALC Current
49.0F SPCL (F = S (shift), 5)	Power Meter*

*Power Meter: Preceed with 0.211 SPCL to read sensor-type voltage, 0.212 SPCL to read voltage from the output filter on the Power Meter Assembly. Note these 0. Special Functions also determine the state of the RF power calibrator and sensor module input switch reed relays.

Procedure

To make an RF power measurement at the RECORDER output, connect a high-accuracy, linear voltmeter to that output. Connect the RF signal to be tested to the RF INPUT and SENSOR input. (This assumes use of the HP 11722A Sensor Module.

Recorder Output (Cont'd)
(Includes Special Function 49)

Procedure (cont'd)

CAUTION

When using the RECORDER output to measure RF power, care must be taken to note the effects of voltmeter load impedance and Operational Amplifier bias currents on the Voltmeter Assembly; depending on required accuracy, these factors might scale or offset the voltage read from what the instrument would use to calculate RF power measurements.

Key in the appropriate Special Function as listed in "Description".

The voltage that is proportional to the input power is displayed on the external voltmeter. To interpret the output voltage, a few measurements should be taken to characterize the measurement circuitry before an actual measurement is taken. Measure the voltage out the RECORDER output when zero input power is at the SENSOR input. Note the voltage value. Press the RANGE HOLD key. Now measure the voltage at the RECORDER output with a known input power (for example, 1 mW). Once these two voltages are known, any voltage obtained from an unknown input level can be interpolated.

Comments

For any value 49.PQ, if P is not equal to 0 or 8 (normal operation), the Modulation Analyzer displays $V_p - V_q$ and the controller saves V_q as V_{ref} for the P = 0 or 8 case: If P = 0 or 8, ("recorder" operation), the Modulation Analyzer displays $V_q - V_{ref}$ and delivers Vq out the RECORDER output for user access.

Normally, the Modulation Analyzer will measure voltages, apply an appropriate formula, and massage the number to display the appropriate measurement value in the appropriate units. Instead of using these formulas, the user can take a ratio of any two measurements to obtain relative measurement information.

Related Functions

RF Power
RF Power Calibration
RF Power Calibration Factors

Remote Control RF Switch

Description

An external power sensor is required for making accurate RF power measurements. A standard HP Power Sensor (HP 8480 series) can be configured in any of the following ways:

A power sensor alone.

A sensor module (such as the HP 11722A) that contains a power sensor (a specific power sensor depending on the HP Model Number of the sensor module) and an RF coaxial, type-N connector/cable. The Modulation Analyzer controls an RF switch in the sensor module to automatically switch between RF INPUT and SENSOR as selected measurements require.

A sensor module, built by the user, that includes any HP 8480 series power sensor, an RF cable, and an HP switch (HP 33311 or HP 8761[1]). The REMOTE CONTROL RF SWITCH rear-panel outputs enable the Modulation Analyzer to drive the external switch in the user-built sensor module. This user-built module also enables the Modulation Analyzer to automatically switch between RF INPUT and SENSOR as selected measurements require.

Procedure

The following procedure enables the user to create a remotely-controlled sensor module:

Select a control switch. Either the HP 33311B, Option 011 (5V solenoid) or the HP 8761A (12-15V solenoid) can be used[1].

Connect the Modulation Analyzer's REMOTE CONTROL RF SWITCH outputs to the control switch:

For the HP 33311B, Option 011:

Connect REMOTE CONTROL RF SWITCH 1 to the switch (1-).
Connect REMOTE CONTROL RF SWITCH 2 to the switch (2-).
Connect REMOTE CONTROL RF SWITCH GND to the switch (C+).

For the HP 8671A:

Connect REMOTE CONTROL RF SWITCH 1 to the switch (+).
Connect REMOTE CONTROL RF SWITCH 2 to the switch (-).
Leave REMOTE CONTROL RF GND disconnected.

Connect the power sensor input to port 1 of the selected switch.

Connect the RF coaxial cable to port 2 of the selected switch.

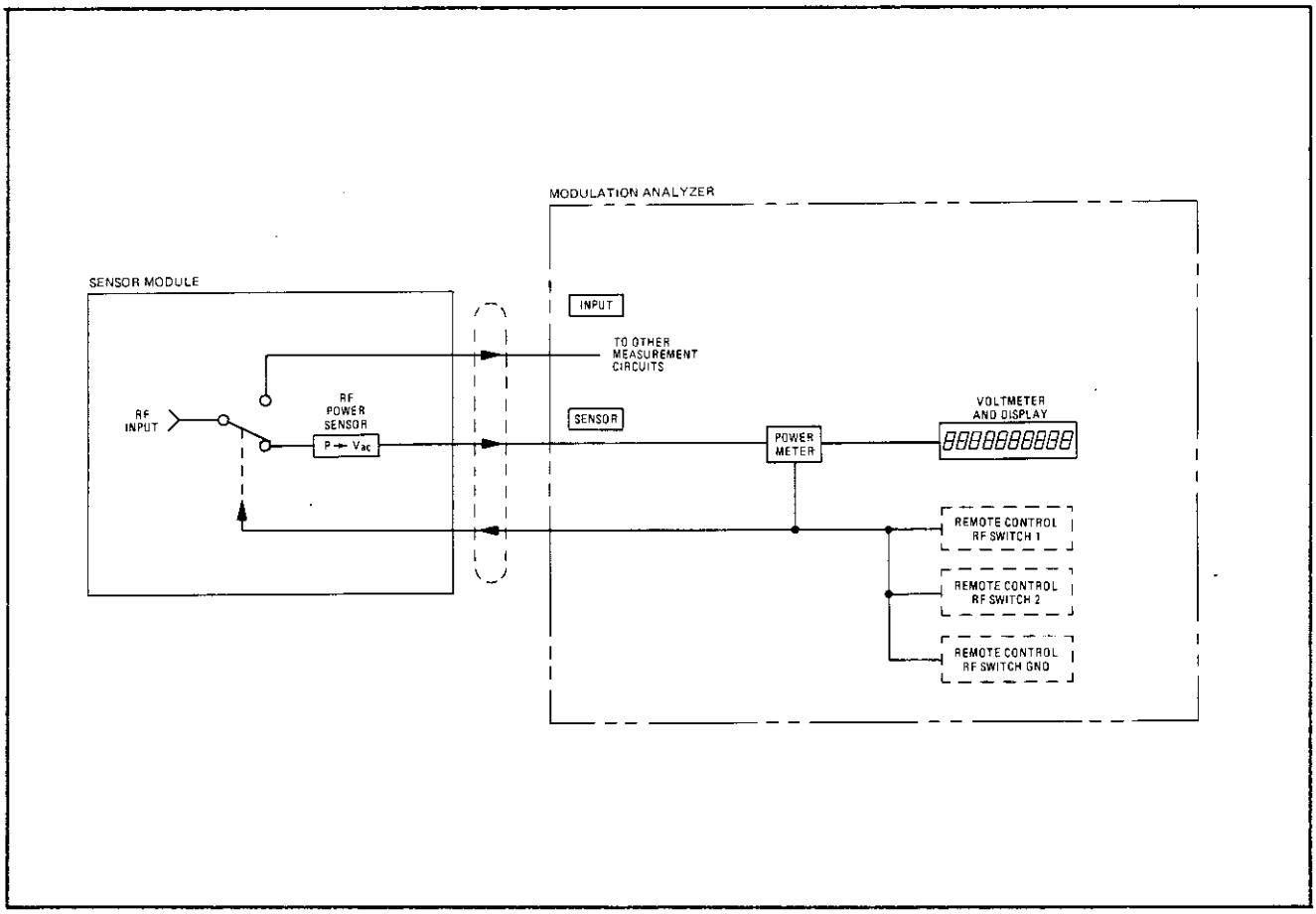
(The switch's port C is intended as an input from the device-under-test.)

Remote Control RF Switch (Cont'd)

Procedure (cont'd)
Connect the power sensor to the SENSOR input, and the other end of the RF coaxial cable to the RF INPUT of the Modulation Analyzer.

Proceed with selected measurements. This user-built module will enable the Modulation Analyzer to automatically switch between its inputs as selected measurements require.

Block Diagram



Remote Control RF Switch Block Diagram

Comments

These rear-panel voltages are not intended as "general purpose" switch drives. The connectors are to be used only for user-built sensor modules.

Related Function RF Power

1 The switches listed are those available at the time of the copyright date of this manual.

Residual Noise Effects

Description

When making peak-modulation measurements of the highest accuracy, it is necessary to characterize and factor out the effects of residual noise on the measurement. The procedure outlined in this Detailed Operating Instruction describes a technique for quantifying and removing residual noise effects on peak modulation measurements.

Procedure

The following procedure enables the user to make a corrected, peak-modulation measurement.

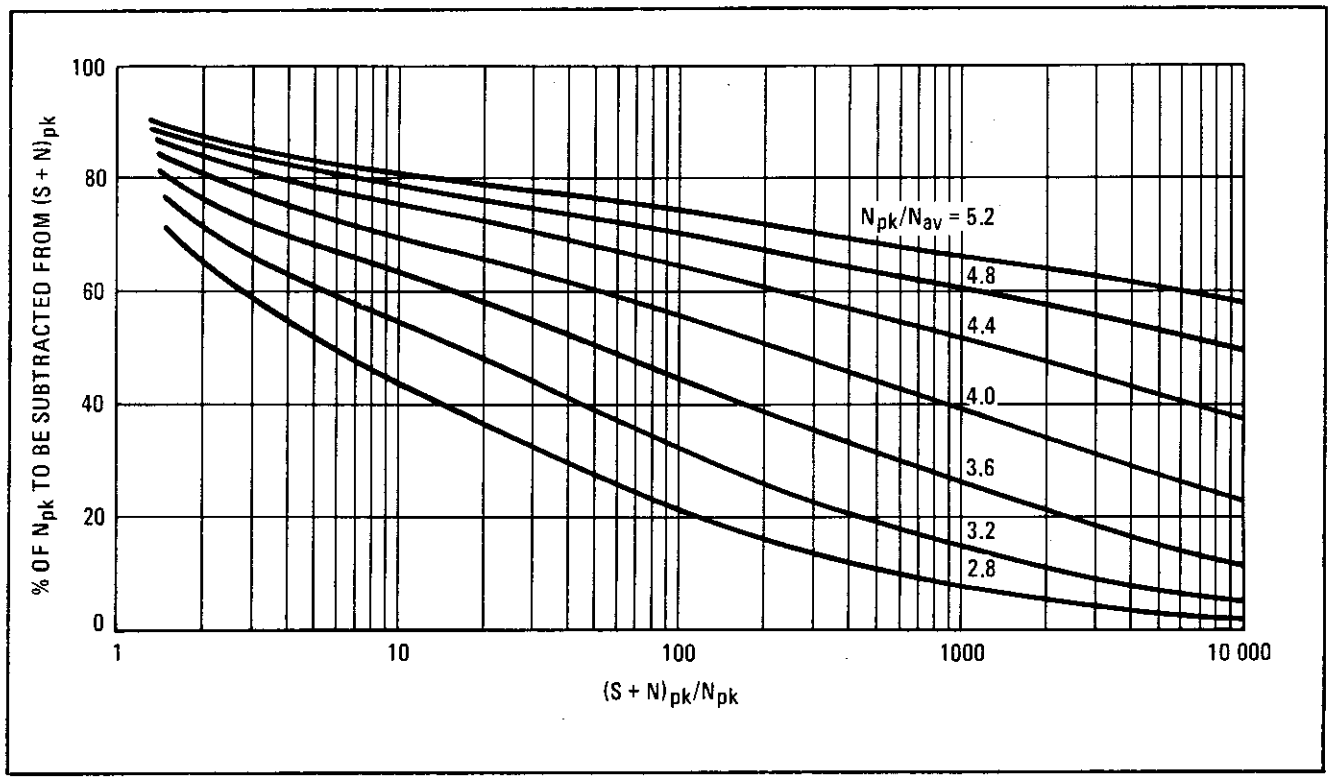
1. Set up and make a normal signal-plus-noise peak measurement, $(S+N)_{pk}$.
2. Press the RANGE HOLD key to prevent autoranging. If filtering and (or) de-emphasis was used in step one, make all the following measurements with the same settings.
3. Remove the baseband drive to the modulator, and measure the peak residual noise level, N_{pk}.
4. Measure the average residual noise level, N_{av}, using the average detector.
5. Compute $\frac{(S+N)_{pk}}{N_{pk}}$ and $\frac{N_{pk}}{N_{av}}$.
6. Use the nomograph to determine the percent, N%, of the peak residual noise level, N_{pk}, to be subtracted from the peak-measured signal plus noise, $(S+N)_{pk}$.
7. Compute the true, peak signal where:

$$S_{pk} = (S+N)_{pk} - N_{pk}\ (N\%),$$

and N% is expressed as a ratio.

Residual Noise Effects (Cont'd)

Procedure (cont'd)



Nomograph for Calculating Percentage of N_{pk} to be Subtracted from $(S+N)_{pk}$ to obtain S_{pk} (Sine Wave)

Example

To determine the actual peak AM depth (measured in a 15 kHz bandwidth) resulting from the application of a 1 Vpk, 1 kHz baseband signal to the modulation input of a signal generator:

1. Measure the peak modulation depth, $(S+N)_{pk}$:

LOCAL (keystrokes)	AUTOMATIC OPERATION; MEASUREMENT: AM; DETECTOR: PEAK +; FILTER: 15 kHz
HP-IB (program codes)	AU M1 D1 L2 (Measurement, Detector, Filter)

For example, 30.80% might be displayed.

Residual Noise Effects (Cont'd)

Example (cont'd)

2. Disable auto-ranging by pressing the RANGE HOLD key:

LOCAL (keystrokes)	RANGE HOLD
HP-IB **(program codes)**	G1 — Range Hold

3. Remove the baseband signal from the modulation input of the signal generator and read the peak residual modulation, N_{pk}; for example, 0.07%.

4. Measure the average residual modulation:

LOCAL (keystrokes)	DETECTOR RMS CAL AVG
HP-IB **(program codes)**	D4 — Detector

For example, the average residual modulation might read 0.02%.

5. Compute $\frac{N_{pk}}{N_{pk}} = \frac{0.07\%}{0.02\%} = 3.5$

6. Compute $\frac{(S+N)_{pk}}{N_{pk}} = \frac{30.80\%}{0.07\%} = 440$

7. Using the nomograph, N% is found to be 26%.

Compute $S_{pk} = (S+N)_{pk} - N_{pk}\ (N\%) = 30.80\% - 0.07\% \times 0.26 = 30.78\%$

NOTE

This correction factor of <0.1% of the peak reading is typical of a modulation measurement of a quality modulation source measured with the 15 kHz low-pass filter.

Residual Noise Effects (Cont'd)

Theory

Residual noise is a measurement of the short-term amplitude or phase (and thus frequency) instability inherent in any CW signal source. In a measurement system composed of a signal source and the Modulation Analyzer, residual noise is contributed by both instruments. When modulation is measured with the Modulation Analyzer, both the intended modulation and the residual modulation are measured in combined form. To determine the precise amount of modulation produced by a signal source as a result of the application of a baseband or modulating signal, the effects of residual noise must be factored out of the measurement results.

Two noise components are commonly encountered in modulation measurements: periodic (often line related) and gaussian (random). Periodic noise and the baseband signal behave identically. Thus the Modulation Analyzer measures the arithmetic sum of the peak or average levels of the two signals (according to the detector selected). To determine the actual modulation that can be attributed to the baseband input, simply subtract out the peak-periodic residual.

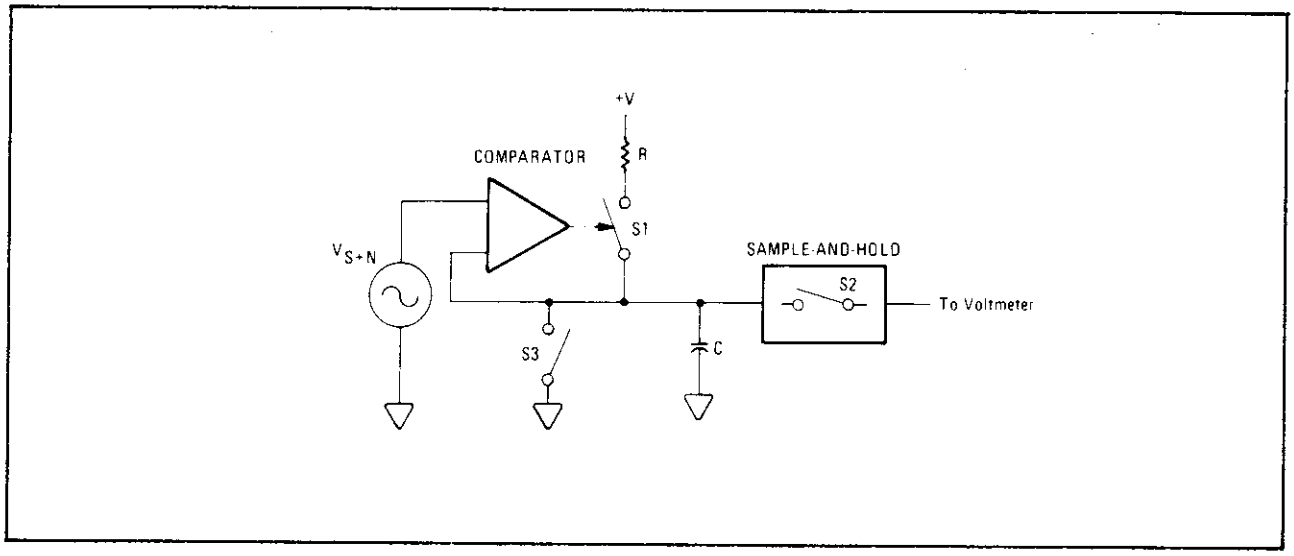
The effects of random noise on our measurement system are not nearly so straight forward. True random noise, when viewed in the frequency domain, is a continuous spectrum of frequencies at various amplitudes. Indeed, the frequency of the noise spectrum is limited only by the bandwidths of the observing and/or generating devices. In the time domain, noise of this kind appears as random amplitude spikes (or fuzz) riding on top of the recovered baseband signal. The amplitude of these spikes is limited by the slow rate of the observing and/or generating devices. Peak detecting these spikes exaggerates the amount of energy present in the noise spectrum so noise measurements are typically made with average-responding detectors and with limited bandwidths.

The measurement problem arises because we typically express modulation level as a peak function. To account for residuals in these peak measurements, the actual effects of the noise on the Modulation Analyzer's peak detector must be determined.

A simplified diagram of the Modulation Analyzer's peak detector is shown in the following figure. Whenever the signal-plus-noise voltage into the comparator exceeds the voltage stored on the output capacitor, C, the comparator closes the switch, S1. The capacitor is then charged via the path from +V through resistor, R. When the capacitor's charge exceeds the incoming signal voltage, the comparator opens the switch again. This process continues until the voltage on the capacitor is transferred to the voltmeter through the sample-and-hold switch, S2. C is then discharged by S3. When very narrow noise spikes are imposed on the comparator's input, the circuit's RC time constant will not allow the capacitor to fully charge before the noise peak has passed.

Residual Noise Effects (Cont'd)

Theory (con't)



Simplified Modulation Analyzer Peak Detector Output

When noise alone is imposed on the detector, it is very probable that, as C begins to charge, a noise spike will exceed the charge that exists on the peak detector capacitor. However, as the capacitor's charge more closely approximates 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 of a chance that the total input signal will exceed the charge on the capacitor (already set to the peak sinewave amplitude) when measuring a sinewave than when measuring only noise. Thus, the contribution of noise on the measured peak modulation level decreases with an increase in the signal-to-noise ratio.[1] To simply measure the peak residual noise present when the baseband drive is removed and subtract the result directly from the peak reading of the combined input, over-compensates the measurement results.

The residual noise reading made by the peak detector depends on the signal-to-noise ratio, as well as the statistics of the noise spikes and the response time of the specific peak detector. These factors are characterized by taking the ratio of the peak noise reading to the average noise reading. The average noise level is a truer determination of the actual amount of noise energy present, while the peak reading characterizes the peak detector and the statistics of the noise spikes.

Residual Noise Effects (Cont'd)

Comments

The primary restriction placed on this method of accounting for residuals 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.

Noise-peak-to-noise-average ratios greater than 4.4 indicate that there is probably a periodic component in the residual noise.

Both the modulation measurement to be corrected and the peak and average residual measurements to be used with the nomograph should be made on the same modulation range and with the same peak-detector-time-constant setting. Use the RANGE HOLD key while the instrument is measuring the modulated carrier; then measure the residuals once the ranges are held.

When factoring residual noise from peak ϕM measurements made while using the 3 kHz LP FILTER, the readings may jump considerably. If this jumping occurs, use the highest of 10 successive readings (for both noise and signal-plus-noise) for the computations. (Use the PEAK HOLD key to hold the highest reading over a 2 second period.)

The residual noise contributions of the AM and FM calibrators and the Modulation Analyzer are accounted for in the calibration procedures. It is <u>not</u> necessary to factor residual noise corrections into the calibration procedures described in this manual.

[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.

RF Frequency Error

Description

The FREQ ERROR key enables the Modulation Analyzer to measure the difference (in kHz) between the RF input signal frequency and the frequency to which the instrument is tuned. This function can be used to observe frequency drift of input signals, or to compare input frequencies against a keyboard-entered reference.

For down-converted signals, the down-converted RF 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 output signal available at MODULATION OUTPUT/AUDIO INPUT represents the last modulation measurement made.

Display resolution is controlled by Special Function 7. (Refer to **RF Frequency Resolution**.)

Procedures

To make any frequency error measurement, connect the test signal to the Modulation Analyzer's RF INPUT connector.

If a frequency drift measurement is to be made, first allow the Modulation Analyzer to automatically tune to the signal, then press MHz to prevent retuning. Press the S (shift) and FREQ ERROR keys to display the frequency drift.

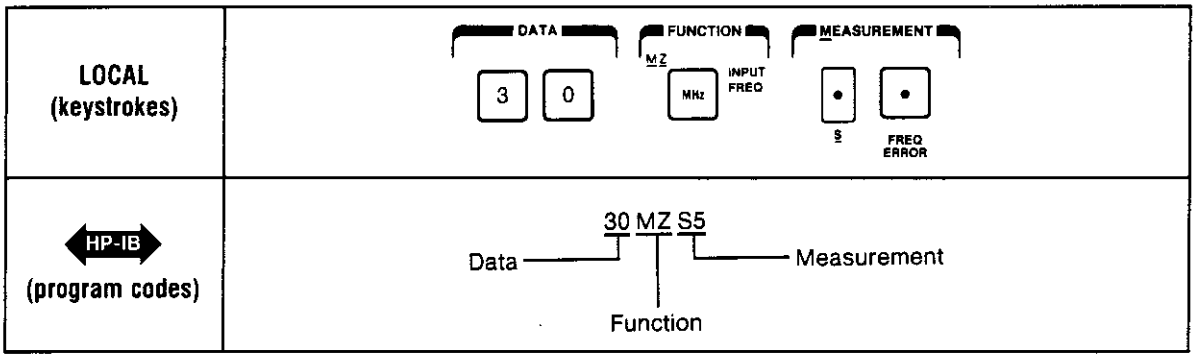
To make a frequency comparison, enter the reference frequency (in MHz) on the keyboard, then press the MHz key. Press the S (shift) and FREQ ERROR keys to display the difference frequency. The number is negative if the signal frequency is lower than the reference, and positive if the signal frequency is higher than the reference. Valid frequency error measurements are made as long as the down-converted signal remains in the IF passband. (Refer to **RF Frequency Tuning**.)

If frequency error is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to **Ratio**.)

RF Frequency Error (Cont'd)

Example

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



Indications

Display: When the FREQ ERROR key is pressed, the frequency error is displayed. The kHz annunciator lights.

Front Panel: The LEDs within the S (shift) and FREQ ERROR keys light.

HP-IB Program Codes

FREQ ERROR = S5
MHz = MZ

Measurement Technique

When the Modulation Analyzer is tuned, the IF signal is amplified and limited (when it has greater than 60 dB of gain). If manually tuned, the RF input frequency is determined (refer to **RF Input Frequency**) and compared to the keyboard-entered frequency, or to the frequency present when MHz was pressed. The difference is displayed as frequency error.

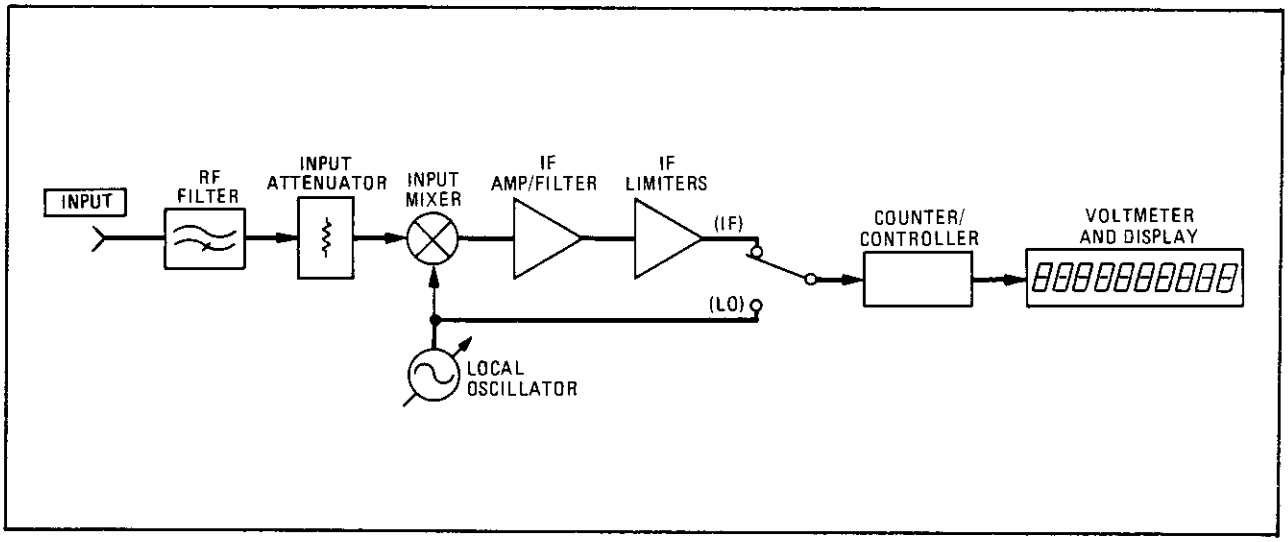
If the Modulation Analyzer is automatically tuned, two methods of determining frequency error are used:

When the input signal is greater than 2.5 MHz, the frequency of the actual IF signal is subtracted from the selected IF frequency (455 kHz or 1.5 MHz) to determine the frequency error.

RF Frequency Error (Cont'd)

Measurement Technique (cont'd)

When the input signal is less than 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 FREQ ERROR key 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 (normal or Track Mode). It is not recommended that frequency error be used when in automatic tuning track mode, since an inherent tuning offset exists in this mode.

Check channel accuracy on multichannel transmitters using the frequency error function in conjunction with the kHz ⇧ and kHz ⇩ keys. Set the step frequency to the channel spacing to quickly determine the accuracy of evenly-spaced channels.

When tuning manually, it is possible to accidentally adjust the LO so that the input falls in the image passband; for example, when using the kHz ⇧ and kHz ⇩ keys. Frequency error measurements are inaccurate when the input image enters the IF passband. Refer to **RF Frequency 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 **RF Frequency Resolution**. Counter accuracy is the reference accuracy ±3 counts.

RF Frequency Error (Cont'd)

Comments (cont'd)

When the FREQ ERROR key is pressed, MODULATION OUTPUT/AUDIO INPUT continues to output the last-selected modulation signal, filtered, and (or) de-emphasized (except PRE DISPLAY) as previously selected (unless AUDIO INPUT is selected). The calibration of this output depends on 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 shows the frequency error in parts per million.

Related Functions

Disable Error Message Control
IF Frequency
RF Frequency Resolution
RF Frequency Tuning
RF Input Frequency

RF Frequency Resolution (Special Function 7)

Description

When making RF measurements, the frequency resolution can be manually set using Special Function 7.

When RF frequency measurements are made, the Modulation Analyzer normally updates the display five times each second. The instrument automatically selects 10 Hz resolution for frequencies below approximately 2.5 MHz; 100 Hz resolution for frequencies from approximately 2.5 to approximately 320 MHz; and 1000 Hz resolution for frequencies greater than approximately 320 MHz. Use the numeric keyboard and the SPCL key to set the frequency resolution to either 10, 100, or 1000 Hz.

Special Function 7 sets the measurement resolution for RF input frequency, RF frequency error, IF frequency, and LO frequency measurements.

Procedure

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

RF Frequency Resolution	Special Function Code	Program Code HP-IB
Automatic Selection	7.0 SPCL	7.0SP
10 Hz*	7.1 SPCL	7.1SP
100 Hz	7.2 SPCL	7.2SP
1 kHz	7.3 SPCL	7.3SP

*7.1 selects 100 Hz resolution for RF frequency measurements when using an external LO value greater than 20 GHz. Refer to **Frequency Offset Mode.**

HP-IB Program Codes

The HP-IB codes for the various frequency resolution settings are provided in "Procedure".

RF Frequency Resolution (Cont'd)
(Special Function 7)

Indications

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display returns to the measurement previously selected.

Front Panel: The LED within the SPCL key lights (unless 6.0 SPCL is entered).

Comments

When the Modulation Analyzer is first powered up, or when AUTOMATIC OPERATION or INSTR PRESET is selected, the RF frequency resolution is placed in the automatic selection mode (Special Function 7.0).

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

Related Functions

IF Frequency
RF Frequency Error
RF Input Frequency
Special Functions

RF Frequency Tuning
(Includes the TRACK MODE, and AUTO TUNING, and DISPLAY FREQ INCR keys, and the kHz ⇧ and kHz ⇩ keys)

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 the LO frequency is placed either 1.5 MHz or 455 kHz higher than the input frequency, depending on which IF is selected. The LO is tuned to 100 MHz when the RF input frequency is less than 2.5 MHz; the input then passes directly into the IF.

The Modulation Analyzer is able to automatically tune or to be manually tuned to the RF input frequency:

> In automatic tuning, the instrument searches for the presence of a signal over the entire input spectrum. 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 or kHz ⇧ and kHz ⇩ keys, and the instrument tunes the LO to receive that frequecy.

The Blue Key and AUTO TUNING key enable the LO to be configured to a fixed frequency mode that is used for low-noise measurements. The TRACK MODE key enables the LO to be configured to a tracking mode in which the LO follows a moving input signal. The two frequency selection techniques and LO configurations combine to produce four tuning modes: Automatic Tuning - Low-noise LO, Automatic Tuning - Track Mode, Manual Tuning - Low-noise LO, and Manual Tuning - Track Mode.

Automatic Tuning -- Low-Noise LO. If not already tuned, the Modulation Analyzer searches throughout its frequency range for the input signal of greatest amplitude. If two input signals have similar power levels, the higher frequency signal is usually selected. The RF input signal's second and third harmonic levels must be at least 10 dB below the level of the fundamental, and all other signals at the input must be at least 30 dB below the level of the desired signal. 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. The instrument powers-up in this mode.

Automatic Tuning -- Track Mode. The instrument searches for the input signal in the same way as described in the previous paragraph; however, it does not lock to the internal reference oscillator.

RF Frequency Tuning (Cont'd)
(Includes the TRACK MODE, and AUTO TUNING, and DISPLAY FREQ INCR keys, and the kHz ⇧ and kHz ⇩ keys)

Description (cont'd)
Instead, the LO is locked to the input signal itself so it can track that signal as it varies in frequency. This function 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 searches for, and re-acquires the input signal. Track Mode tuning is not allowed with the 455 kHz IF or with input signals below 10 MHz. Track Mode tuning somewhat attenuates low-rate FM 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 required.

Manual Tuning - Low-Noise LO. The instrument tunes to the frequency keyed into it, via the keyboard, regardless of whether a signal is found. Once tuned, the LO is locked to an internal voltage-controlled crystal oscillator for high stability and low noise. Once locked, tuning does not change unless a new frequency is entered, the TRACK MODE key is pressed, the tuning is stepped up or down using the kHz ⇧ or kHz ⇩ keys, or AUTOMATIC OPERATION or INSTR PRESET is keyed. This manual tune mode is entered immediately when either the MHz, kHz ⇧, or kHz ⇩ key is pressed; or if the RANGE HOLD key is pressed.

Manual Tuning - Track Mode. The Modulation Analyzer tunes to the keyed frequency in the same way as described in the previous paragraph. However, the LO is not locked to an internal oscillator; instead the LO is locked to the input signal itself and tracks that signal as it varies in frequency. This function is useful when measuring second or third harmonic frequencies or when measuring spurious signals.

RF Frequency Stepping. Using the kHz ⇧ and kHz ⇩ keys, the tuning of the Modulation Analyzer can be changed by a selectable frequency step (in kHz). These keys are most often used in conjunction with the frequency error function. The kHz keys can be used regardless of the tune mode the instrument is in; but when pressed, they always set the tune mode to manual. If these keys are pressed while in one of the automatic tuning modes, they will set the tuning to the last successfully tuned frequency plus or minus the frequency step. Once a frequency step is entered on the keyboard (refer to "Procedure"), either the kHz ⇧ or kHz ⇩ key pressed alone will change tuning by that step size until a new step frequency is defined. At power-up, the step size is zero.

HP-IB

RF frequencies can be changed in fundamental (Hz) steps only via the HP-IB:

Hz Step Up = HU
Hz Step Down = HD

RF Frequency Tuning (Cont'd)
(Includes the TRACK MODE, and AUTO TUNING, and DISPLAY FREQ INCR keys, and the kHz ⇧ and kHz ⇩ keys)

Procedures

Tune Mode Selection:

- To select automatic tuning, press AUTOMATIC OPERATION or press the Blue Key and AUTO TUNING key.
- To select manual tuning, press either MHz or one of the kHz keys (with or without a preceding keyboard entry), or press the RANGE HOLD key.
- To select track mode, press the TRACK MODE key.

Manual Tuning by Keyboard Entry:

To manually tune to a specific signal frequency, enter the frequency in MHz via the numeric keyboard, then press the MHz key. The MHz key can also be used alone to aid in tuning. If the Modulation Analyzer is tuned close but not exactly to the input signal, press the MHz key to center the signal in the IF passband. If in automatic tuning mode, and no signal is present, press the MHz key alone to tune the Modulation Analyzer to the last frequency at which a signal was successfully tuned. (If no previous successful tuning has been made, the Modulation Analyzer tunes to 100 MHz.)

RF Frequency Stepping:

To step the tuning of the Modulation Analyzer, enter the desired frequency step size in kHz, via the numeric keyboard, then press either kHz ⇧ or kHz ⇩. Once the step size has been set, either kHz key will change the tuning by that step size each time the key is pressed. (At power-up, the step size is set to 0 kHz.)

HP-IB Program Codes

Note that when remotely operating the Modulation Analyzer, the programmer has the option to enter frequencies in fundamental units (Hz).

```
AUTO TUNING = AT
AUTOMATIC OPERATION = AU
Display Frequency = FR
Display Increment = FN
Hz, Input Frequency Entry = HZ
MHz, Input Frequency Entry = MZ
Ranging Automatic = G0
Range Hold = G1
Step Up (Hz) = HU
Step Down (Hz) = HD
Step Up (kHz) = KU
Step Down (kHz) = KD
TRACK MODE off = K0
TRACK MODE on = K1
```

RF Frequency Tuning (Cont'd)
(Includes the TRACK MODE, and AUTO TUNING, and DISPLAY FREQ INCR keys, and the kHz ⇧ and kHz ⇩ keys)

Indications

Display: When any of the tune modes are initiated, four dashes (----) are displayed. If the input signal meets the criteria necessary for tuning when a tune mode is initiated, the display returns to show the result of the measurement previously selected. Error 01 is displayed if the input signal does not meet tuning criteria except when a FREQ measurement is being made, then two dashes (--) are displayed.

Front Panel: The different tuning modes are indicated as follows:

Tuning Mode	TRACK MODE LED	AUTO TUNING LED
Automatic Tuning - Low-Noise LO	off	on
Automatic Tuning - Track Mode	on	on
Manual Tuning - Low-Noise LO	off	off
Manual Tuning - Track Mode	on	off

Comments

The instrument will not automatically tune to a signal that has low-rate, high deviation FM. Use a manual tune mode to measure such signals.

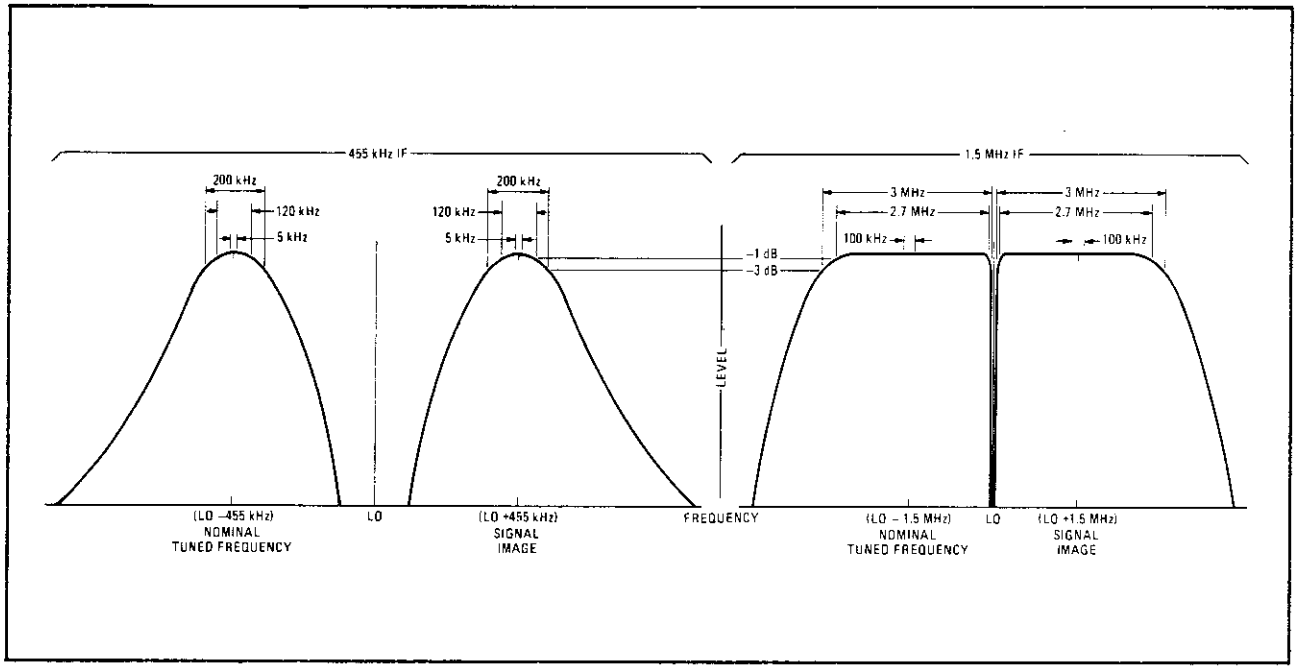
The automatic tuning - low-noise LO mode is adequate for most common signal measurements. It should always be used for measuring narrow deviation FM and ϕM. Automatic tuning - track mode is useful for determining AM, FM, ϕM, or TUNED RF LEVEL flatness as a function of carrier frequency. Manual tuning - low-noise mode should be used whenever drops in signal level may occur that could otherwise cause retuning. (For example, when counting frequency, manual tuning allows measurements to be made on very low-level signals.) Manual tuning - track mode is useful when measuring harmonic frequencies that might drift, or when measuring spurious signals.

When manually tuning or frequency stepping, use the frequency error measurement to determine tuning accuracy.

When the Modulation Analyzer tunes to an input signal (greater than 2.5 MHz), the IF frequency positions the internal LO above the nominal tuning. Since the image passband is not filtered out, image signals pass into the IF amplifier with the same ease as signals in

RF Frequency Tuning (Cont'd)
(Includes the TRACK MODE, and AUTO TUNING, and DISPLAY FREQ INCR keys, and the kHz ⇧ and kHz ⇩ keys)

Comments (cont'd)
the nominal passband. When signals other than those on which measurements are to be made fall into the image passband, measurement errors may result. One way to solve this problem is to step the tuning down by twice the IF frequency. This causes the desired frequency to pass through the image passband and often places the nominal passband in a portion of the input spectrum where interfering signals do not exist. The following spectrum diagram illustrates the relative position of the LO and both the nominal and image passbands for each IF frequency.



Spectrum Diagram of the 455 kHz and 1.5 MHz Passbands

Whenever tuning to signals less than 2.5 MHz, the LO is placed at 100 MHz and the input signal is allowed to pass directly through the IF. (The LO serves only to turn the input mixer on.) Note, however, that this also creates a passband from 97.5 to 102.5 MHz. If this is a problem, manually tune the LO so the passbands fall in some unoccupied region of the input spectrum. (Error 01 must be disabled.) Also, as a result, input frequency measurements will be incorrect, but the IF frequency function (Special Function 34) can be used to measure the RF input frequency. (Refer to IF Frequency.)

When making measurements on inputs with frequencies greater than 10 MHz, signals less than 2.5 MHz that are present in the spectrum, appear directly in the IF. These low-frequency signals can be removed by inserting the RF input high-pass filter. (Refer to **Filters, RF and IF**).

RF Frequency Tuning (Cont'd)
(Includes the TRACK MODE, and AUTO TUNING, and DISPLAY FREQ INCR keys, and the kHz ⇧ and kHz ⇩ keys)

Comments (cont'd)
When manually tuning, often the exact input frequency is unknown. If during tuning, Error 01 (signal out of IF range) is displayed, press the MHz key alone to center the signal in the IF. Also, if searching for a signal using the kHz keys, it is best to search down from above the signal frequency while monitoring IF LEVEL. (Refer to IF Level.) When the IF level rises significantly, switch to FREQ ERROR and enter the displayed value as a frequency step and complete tuning using the kHz keys.

When the INSTR PRESET key is pressed, or on power-up, the Modulation Analyzer selects the automatic tuning - low-noise LO mode.

Using the automatic tune mode, the Modulation Analyzer might not retune when the frequency changes, but its spectrum still has sufficient power within the tuned passband of the Modulation Analyzer's RF INPUT. It will appear that the carrier simply dropped in power. If the instrument does not retune, frequency and level measurement results might not be as expected. Use a manual tune mode if possible in the following situations:

When working with frequency agile sources (such as frequency synthesizers) that have a frequency hopping function.

When changing frequency in harmonic steps.

Related Functions

Default Conditions and Power-up Sequence
Filters, RF and IF
Instrument Preset
Range Hold

RF Input Attenuation (Special Function 1)

Description

The RF input attenuation is usually automatically selected, but can be manually set, by keyboard entry, using Special Function 1.

Procedure

To set the input attenuation to a selected range, or to enter an automatic selection mode, key the corresponding Special Function code; then press the SPCL key:

RF Input Attenuation	Special Function Code	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

HP-IB Program Codes

For HP-IB codes, refer to "Procedure".

Indications

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display returns to the measurement previously selected.

Front Panel: The LED within the SPCL key lights (unless Special Function 1.0 is entered).

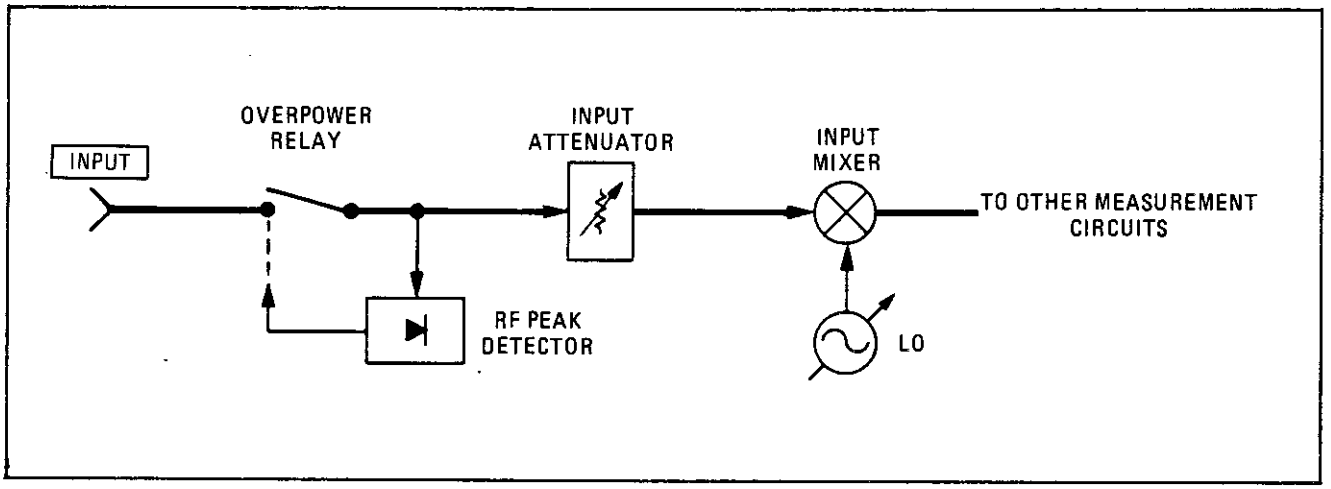
RF Input Attenuation (Cont'd)
(Special Function 1)

Comments

When the Modulation Analyzer is first powered up, or when AUTOMATIC OPERATION or INSTR PRESET is selected, the RF input attenuation is placed in the automatic selection mode (Special Function 1.0).

If the RF input attenuation is manually set to a range that causes the input signal level to overdrive the input mixer, Error 02 is displayed. If the RF input attenuation is manually set so the signal level reaching the IF circuits is too low for accurate measurements, Error 03 is displayed.

Manual setting of RF input attenuation is overridden when RF Level measurements are selected.



Block Diagram of RF Input Attenuation

Related Functions

Range Hold
RF Level
RF Power
Special Functions

RF Input Frequency

Description

The FREQ key enables the Modulation Analyzer to measure RF input signals from 150 kHz to 1300 MHz. (Higher frequencies can be measured using an external mixer as described in **Frequency Offset Control**).

To count input frequencies between 2.5 and 1300 MHz, the instrument uses heterodyning; to count input frequencies from 150 kHz to 2.5 MHz, it counts the input directly.

In most circumstances, when using manual tuning, the instrument can count signals with power levels greater than or equal to -60 dBm.

When the instrument is measuring input frequency, the output signal at MODULATION OUTPUT/AUDIO INPUT represents the last modulation measurement made.

Procedures

To make an input frequency measurement, first tune the instrument to the input signal (refer to **RF Frequency 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).

If RF frequency is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to **Ratio**.)

HP-IB Program Code

FREQ = M5

Indications

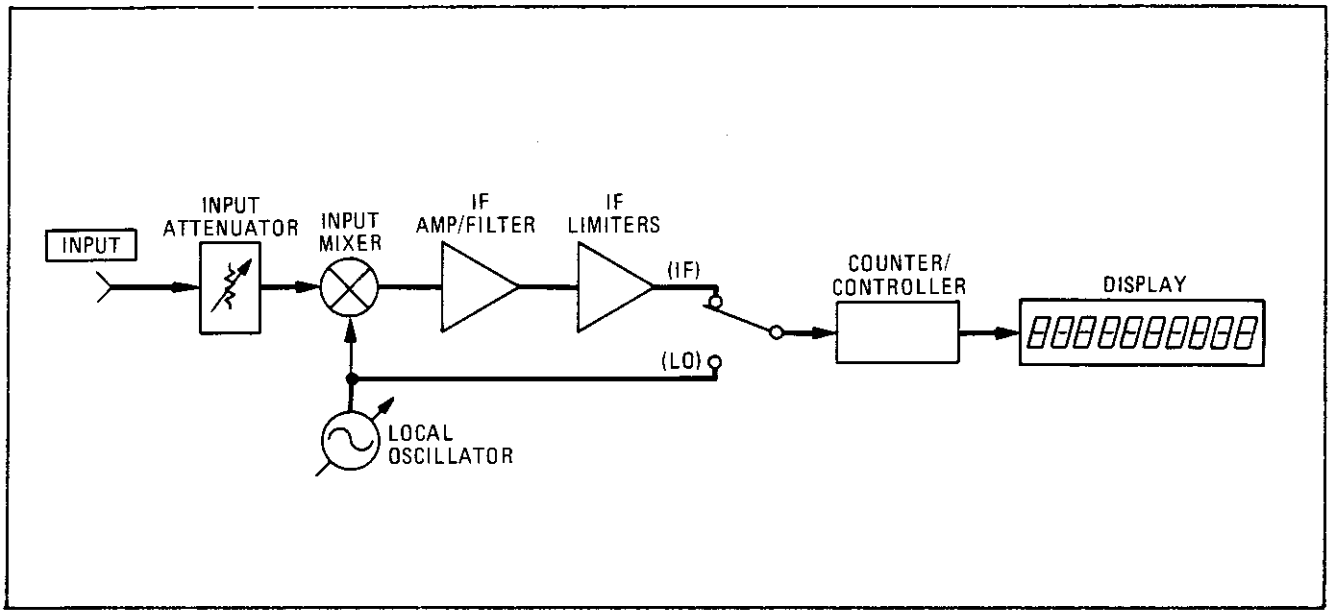
Display: When the FREQ key is pressed, the RF input frequency is displayed (in MHz). The MHz annunciator is also displayed.

Front Panel: The LED within the FREQ key lights.

Measurement Technique

The IF carrier is amplified by the IF Amplifier and Limiters (more than 60 dB of gain). For input frequencies below 2.5 MHz the RF input signal is counted directly since no down-conversion is necessary. (The input signal acts as the IF. Refer to **RF Frequency Tuning** for an exception.) For input frequencies from 2.5 to 1300 MHz, the RF input frequency is derived by down-converting (heterodyning) the input and then subtracting the IF frequency from the local oscillator frequency.

RF Input Frequency (Cont'd)



RF Input Frequency Measurement Block Diagram

Comments

When the instrument is first powered up, or when INSTR PRESET is selected, the Modulation Analyzer measures the RF input frequency.

When the Disable Error Message Control Special Function is in the automatic selection mode (Special Function 8.0), very low-level signals can be counted without generating errors (Error 03 for example). However, other modes of Special Function 8 will allow errors to be generated at much higher signal levels. (Refer to **Disable Error Message Control**.)

It is important to note that when FREQ is selected, the frequency displayed is the RF input signal frequency regardless of whether the LO is properly tuned. 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 frequency error function can demonstrate the changed tuning. Typically, the instrument must be tuned to within 50 kHz of the input frequency or Error 01 is displayed. Defeat the tuning error (Error 01) with Special Function 8.1 to increase the usable IF bandwidth.

When working with agile frequency sources (such as frequency synthesizers), it is possible for the carrier to hop to a frequency near the current, tuned frequency. The spectrum of the new frequency could have sufficient power within the tuned passband of the Modulation Analyzer's input to cause the instrument to 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 level measurement results may not be as expected. For best results, use the manual-tune mode when working with frequency agile sources.

RF Input Frequency (Cont'd)

Comments (Cont'd)
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 input 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 passband falls in some unoccupied region of the input spectrum. This requires that Error 01 must be disabled. Also, as a result, input frequency measurements will be incorrect, but the IF frequency function (Special Function 34) can be used to measure the input frequency instead.

When tuning manually, it is possible to accidentally adjust the LO so that the input signal falls in the image passband; for example, when using the kHz ⇧ and kHz ⇩ keys. Frequency measurements are inaccurate when the input passes through this image passband. See **RF Frequency Tuning** for an illustration of the image passbands.

The large gain in the IF Amplifier and Limiters enables frequency measurements on input signal levels less than -60 dBm. When automatically tuning, the instrument tunes to the strongest signal at the input. When manually tuned to the approximate input frequency, the instrument ignores the more powerful signals and their images if they fall outside the passband of the IF amplifier.

When the FREQ key is pressed, the output available at MODULATION OUTPUT/AUDIO INPUT continues to be the last selected modulation signal, filtered, and (or) de-emphasized (except PRE DISPLAY) as previously selected. The calibration of this output depends on the IF signal level and should be assumed only when all errors are enabled (Special Function 8.8).

Related Functions

Audio Frequency
IF Frequency
Ratio
RF Frequency Error
RF Frequency Resolution
RF Frequency Tuning

RF Level
(Includes Special Function 35)

Description

The RF Level function enables the Modulation Analyzer to measure and display the peak, broadband RF power. RF level measurements are initiated with Special Function 35, or with the RF POWER key (when there is no sensor at the Modulation Analyzer's SENSOR input).

RF level measurements are not calibrated, so they are not as accurate as measurements made with an external power sensor. (Refer to RF Power.)

MODULATION OUTPUT/AUDIO INPUT is turned off during this measurement, however, AM OUTPUT and FM OUTPUT (rear panel) remain active but uncalibrated. The tuning of the instrument remains unchanged.

Procedures

To make a broadband RF power measurement when the external power sensor is disconnected, but an RF cable is connected to RF INPUT, press the RF POWER key.

To make the measurement when the power sensor is connected, key in 35.0, then press the SPCL key.

If RF level is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to Ratio.)

HP-IB Program Codes

LIN = LN
LOG = LG
SPCL = SP
VOLTS units = VL
mV units = MV
uV units = UV
WATTS units = WT

Indications

Display: When a measured value is displayed, the selected units annunciator lights, and if the units are linear, the display indicates the measurement in scientific notation; that is, the measured value is followed by a signed, power-of-ten multiplier. The following table shows the annunciator units for linear and logarithmic formats:

Linear Unit	Logarithmic Unit
W	dBm
V	dBV
mV	dB mV
μV	dB μV

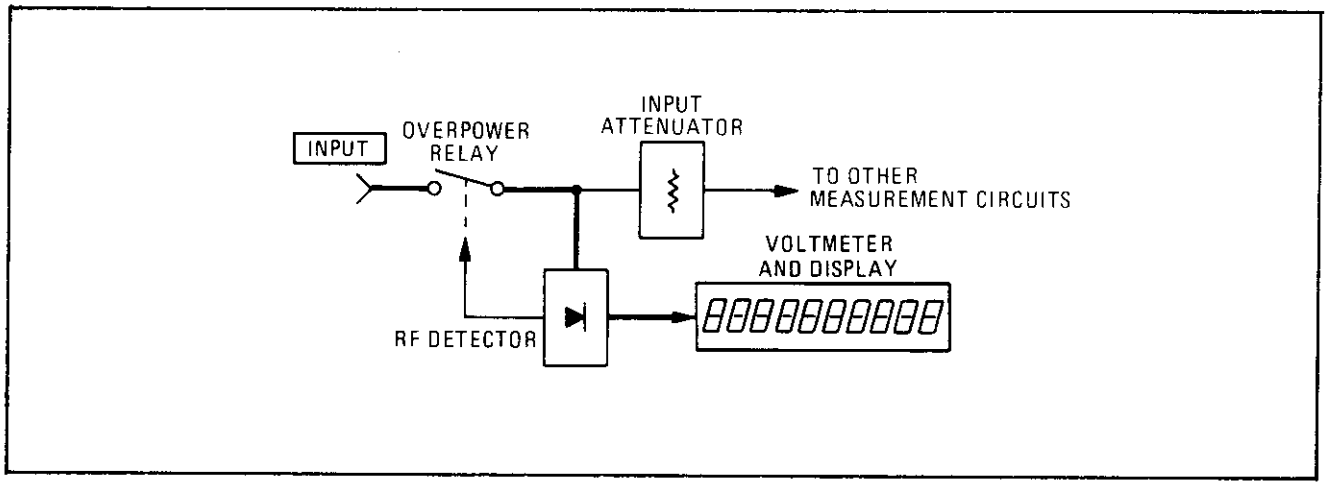
RF Level (Cont'd)
(Includes Special Function 35)

Indications (cont'd)
Front Panel: When the RF level function is selected, the LED within the SPCL key lights.

Measurement Technique

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

When RF Level is selected, the Modulation Analyzer sets its RF input attenuation to 50 dB to minimize SWR. Any manual setting of RF input attenuation (Special Function 1) is overridden.



RF Level Measurement Block Diagram

Comments

If the RF input signal has AM, the peak envelope power is measured.

The input high-pass filter (Special Function 3) remains inserted if previously selected.

The maximum allowable input level is 1 watt into 50 ohms. Input levels greater than 1 watt cause the overpower relay to open and the display to show Error 06. To reset the relay, remove the input signal and press any measurement key.

Related Functions

IF Level
RF Power

RF Power
(Includes Special Function 10)

Description

The RF POWER key enables the Modulation Analyzer to make calibrated, broadband measurements of RF and microwave power. The instrument is compatible with several power sensors and sensor modules. (Refer to Table 1-1, "Specifications".) If the instrument is not connected to a power sensor, pressing the RF POWER key configures the instrument to make uncalibrated, RF level measurements. (Refer to **RF Level**.)

The RF power sensor measures power over a 50 dB range. The absolute level accuracy and sensitivity of the range is determined by the particular power sensor selected and the SWR of the source being measured. The Modulation Analyzer automatically selects between five internal power ranges. Special Function 10 enables manual selection of the ranges.

To assure specified measurement accuracy, unique calibration information must be entered into the Modulation Analyzer for each power sensor. Calibration consists of four steps:

1. Enter the 50 MHz reference calibration factor from the power sensor's calibration label.
2. Zero the power sensor.
3. Calibrate the power sensor at 50 MHz using the Modulation Analyzer's 1 mW calibrator.
4. Enter the frequency-dependent calibration factors from the power sensor's calibration label.

In addition to the above steps, frequent re-zeroing of the power sensor is especially recommended at low power levels or when ambient conditions change. Refer to **RF Power Calibration** for steps 1, 2, and 3. Refer to **RF Power Calibration Factors** for step 4.

MODULATION OUTPUT/AUDIO INPUT is disabled during RF power measurements.

Procedures

To make calibrated, broadband RF power measurements, connect an external power sensor or sensor module to the Modulation Analyzer's SENSOR input. Press the RF POWER key.

NOTE

If the Modulation Analyzer has not previously been calibrated to the power sensor, perform the calibration procedure described in **RF Power Calibration** and **RF Power Calibration Factors** before making power measurements.

RF Power (Cont'd)
(Includes Special Function 10)

Procedures (cont'd)
To manually set the RF power range, or to re-enter the automatic selection mode, key the corresponding Special Function code; then press the SPCL key.

RF Power Range Selected	Special Function Code	Program Code HP-IB
Automatic Selection	10.0 SPCL	10.0SP
Range #1 (most sensitive range)	10.1 SPCL	10.1SP
Range #2	10.2 SPCL	10.2SP
Range #3	10.3 SPCL	10.3SP
Range #4	10.4 SPCL	10.4SP
Range #5 (least sensitive range)	10.5 SPCL	10.5SP

If RF power is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to Ratio.)

HP-IB Program Codes

The HP-IB codes for selecting RF power ranges are provided in "Procedures".

LIN results = LN
LOG results = LG
RF POWER = M4
SPCL = SP
VOLTS units = VL
mV units = MV
uV units = UV
WATTS units = WT

Indications

Display: When a measured value is displayed, the selected units annunciator lights, and if the units are linear, the display indicates the measurement in scientific notation;

RF Power (Cont'd)
(Includes Special Function 10)

Indications (cont'd)

Display: (cont'd) that is, the measured value is followed by a signed, power-of-ten multiplier. The following table shows the annunciator units for linear and logarithmic formats.

Linear Unit	Logarithmic Unit
W	dBm
V	dBV
mV	dB mV
μV	dB μV

Front Panel: The LED within the RF POWER key will light.

Measurement Technique

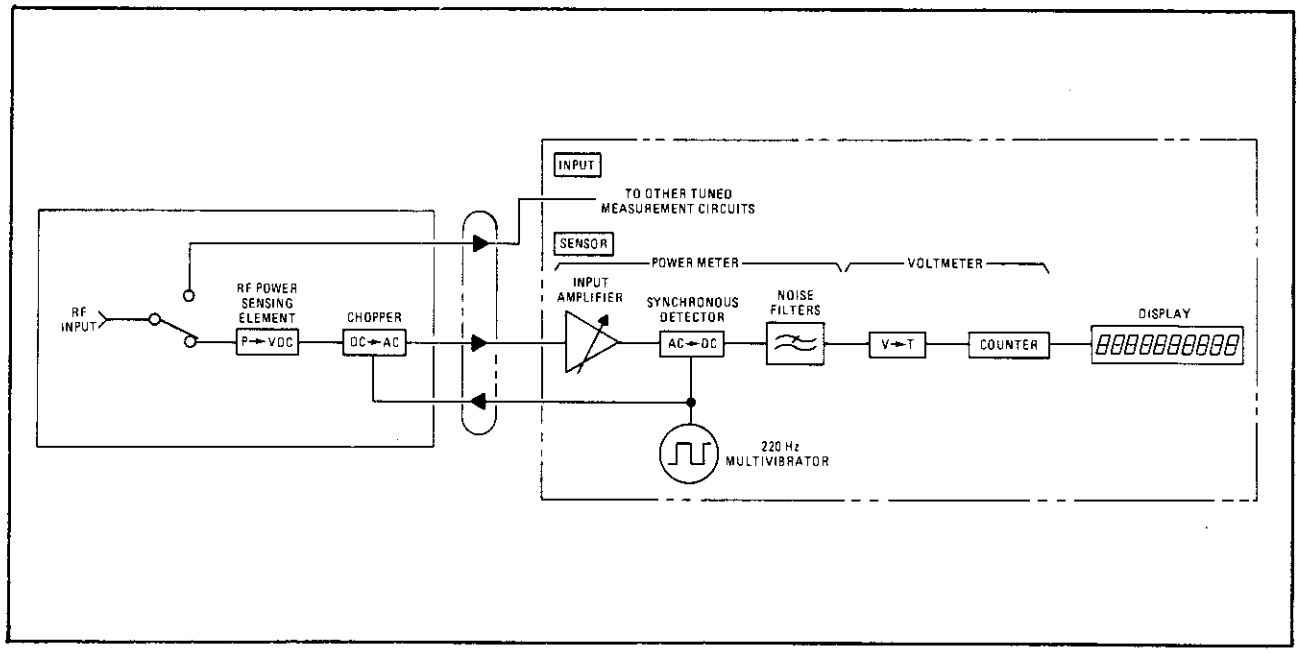
When the RF Power Measurement mode is selected, the internal power meter amplifies and detects the small ac signal from the external power sensor to be measured by the voltmeter.

Five ranges of amplification are used to encompass the power sensor's wide dynamic range. Special Function 10 permits manual selection of the five ranges: Range 1 (10.1 SPCL) has the most amplification (the most sensitive range), while Range 5 (10.5 SPCL) has the least amplification (the least sensitive range). The ranges are not specified in terms of absolute power since the selected power sensor determines the sensitivity.

The chopper in the power sensor converts the dc voltage (generated by the power sensing element) to a chopped, ac signal. The amplified ac signal is rectified by a synchronous detector whose output alternates, at a 220 Hz rate, between a non-inverting and an inverting configuration. (The 220 Hz Multivibrator is the source for both chopping signals.) The result is a rechopped, dc level proportional to the dc output of the RF power sensing element of the power sensor. This chopping and rechopping method reduces any measurement error generated by the power meter circuitry.

The dc level from the Synchronous Detector is filtered to reduce the noise level, then measured by the Voltmeter. On the more sensitive ranges, filtering is increased to smooth out the large noise component on the signal and thus stabilize the displayed reading.

RF Power (Cont'd)
(Includes Special Function 10)



RF Power Block Diagram

Comments

Any compatible power sensor can be configured as a sensor module using an external switch wired to the control connectors on the rear panel. (Refer to **Remote Control RF Switch.**)

To make relative power measurements from the RF Power mode, use the **Ratio** function.

All measurement units assume a source impedance of 50 ohms.

The instrument exits the automatic tuning mode when in the RF Power function is selected. The RF, LO and IF sections are inactive since power is being measured at the external sensor.

Related Functions

RF Level
RF Power Calibration
RF Power Calibration Factors
Tuned RF Level

RF Power Calibration
(Includes ZERO, CALIBRATE, and SAVE CAL keys)

Description

The internal 50 MHz Power Reference Oscillator, used in RF power calibration, is an extremely amplitude-stable RF power source that has been set to 1 mW (0 dBm), traceable to the National Bureau of Standards (NBS). This power reference enables the Modulation Analyzer to precisely determine the sensitivity of the external power sensor at 50 MHz (power in vs. voltage out).

The ZERO, CALIBRATE, and SAVE CAL functions are used during calibration of the power sensor. Variations in the sensitivity of the power sensor, at frequencies other than 50 MHz, are corrected through the use of calibration factors (which are supplied with the sensor and entered via the keyboard). (Refer to **RF Power Calibration Factors.**)

Procedures

To make an RF power measurement, press the RF POWER key. If Error 15 is displayed, no calibration factors have been entered. Enter calibration factors as described in **RF Power Calibration Factors.**

If a new power sensor or sensor module is being calibrated, or if it is not known whether the Modulation Analyzer has been previously calibrated to the sensor, the reference calibration factor must first be checked and/or entered. To view the reference calibration factor currently being used, press the CALIBRATE, Blue Key, and % CAL FACTOR keys.

The reference calibration factor will appear in the display for a few seconds. This display should agree with the Reference Calibration Factor usually printed on the power sensor. If the reference calibration factor is different, the power sensor's reference calibration factor (and other calibration factors) can be entered using Special Function 37.3. (Refer to **RF Power Calibration Factors.**) After entering calibration factors into the table, be sure that the instrument is using the Automatic Cal Factors by keying AUTOMATIC OPERATION or 37.0 SPCL before proceeding with the calibration procedure. When not using the tables, the Reference Calibration Factor is just entered and "held" (in manual mode) for the SAVE CAL function.

To calibrate the instrument with its power sensor, connect the power sensor's output to the SENSOR input of the Modulation Analyzer. Connect the RF input of the sensor to the CALIBRATION RF POWER OUTPUT connector. Allow at least a half-hour continuous operation. Press ZERO. After several seconds, 0 is displayed. Press CALIBRATE. The instrument displays a measured value of power. Press Blue Key, then SAVE CAL. Read 1.000 mW. (If desired, press LOG/LIN to display 0.00 dBm.) The reference calibration factor stays in effect until another SAVE CAL operation is done. Press the CALIBRATE key again (or any Measurement key) to turn off the calibrator.

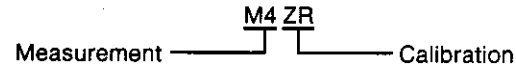
RF Power Calibration (Cont'd)
(Includes ZERO, CALIBRATE, and SAVE CAL keys)

Procedure (cont'd)
If RF power is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to Ratio.)

Example

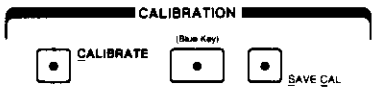
To calibrate the Modulation Analyzer to the power sensor at the SENSOR connector, connect the sensor to RF POWER OUTPUT, then perform the following steps. (The reference calibration factor is assumed to have been entered.)

Zero:

LOCAL (keystrokes)	
HP-IB (program codes)	

When making local entries, wait for 0 to be displayed before proceeding with the steps that follow. When making HP-IB entries, enter a read statement before the Calibrate statement that follows. (The read statement for a controller that uses BASIC would be: "read 714;".)

Calibrate:

LOCAL (keystrokes)	
HP-IB (program codes)	

RF Power Calibration (Cont'd)
(Includes ZERO, CALIBRATE, and SAVE CAL keys)

Program Codes HP-IB

CALIBRATE on = C1
CALIBRATE off = C0
LIN results = LN
LOG results = LG
RF POWER = M4
SAVE CAL = SC
VOLTS units = VL
mV units = MV
uV units = UV
WATTS units = WT
ZERO = ZR

Indications

Display: When a measured value is displayed, the selected units annunciator lights, and if the units are linear, the display indicates the measurement in scientific notation; that is, the measured value is followed by a signed, power-of-ten multiplier. The following table shows the annunciator units for linear and logarithmic formats.

Linear Unit	Logarithmic Unit
W	dBm
V	dBV
mV	dB mV
μV	dB μV

Front Panel: The LEDs within the keys representing the selected functions light. The LED in the RF POWER key remains lighted throughout the calibration process. The LED in the ZERO key remains lighted during the zeroing process. The LED in the Blue Key blinks (at the current measurement rate) when pressed, until the SAVE CAL key is pressed. Pressing the CALIBRATE key will turn off the ZERO function, but pressing the ZERO key will not turn off the calibrator.

Measurement Technique

With the external power sensor properly connected to the Modulation Analyzer, and the sensor's RF input connected to the CALIBRATION RF POWER OUTPUT, calibration begins by first determining the sensor type. (See the Simplified Block Diagram of RF Power Calibration.) A switch at the output of the power meter connects the power sensor's resistor to the Voltmeter. The voltage across the resistor indicates, to the Modulation Analyzer, the type of power sensor being used. UNCAL and RECAL annunciators are displayed if the sensor type differs from that used in a previous calibration.

RF Power Calibration (Cont'd)
(Includes ZERO, CALIBRATE, and SAVE CAL keys)

Measurement Technique (cont'd)
When the ZERO key is pressed, the internal controller sends out a signal to the sensor module to switch out the RF input to the power sensor and directs the power meter to make a power measurement (with 0 watts at the power sensor input). The controller uses the zeroing digital-to-analog converter (DAC) in the power meter to output a dc voltage that cancels any dc offset that may be present in the power sensor. The zeroing process persists until the reading is zero, which may take several seconds to complete.

When the CALIBRATE key is pressed, the power reference oscillator outputs a calibrated, 1 mW signal at 50 MHz. When the SAVE CAL key is pressed, the controller equates the output from the power meter to 1 mW.

The calibration procedure allows the instrument to set the power-measurement transfer function so the displayed power correctly represents the actual power. This procedure can be visualized as a process that adjusts the intercept and slope of the sensor's transfer characteristic. The ZERO key sets the zero crossing (intercept), and the SAVE CAL key sets the gain (slope). (See the following figure.) The displayed power is given by the equation:

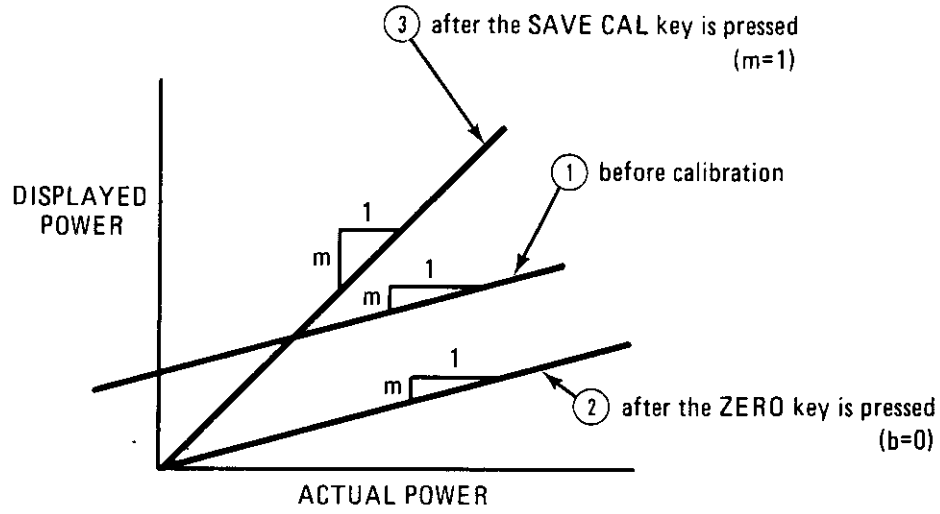
$$P_{dis} = m\,P_{act} + b$$

where; P_{dis} is the Displayed Power,
P_{act} is the Actual Power,
b is the zero crossing, and
m is the slope.

The calibration routine forces b = 0 and m = 1.

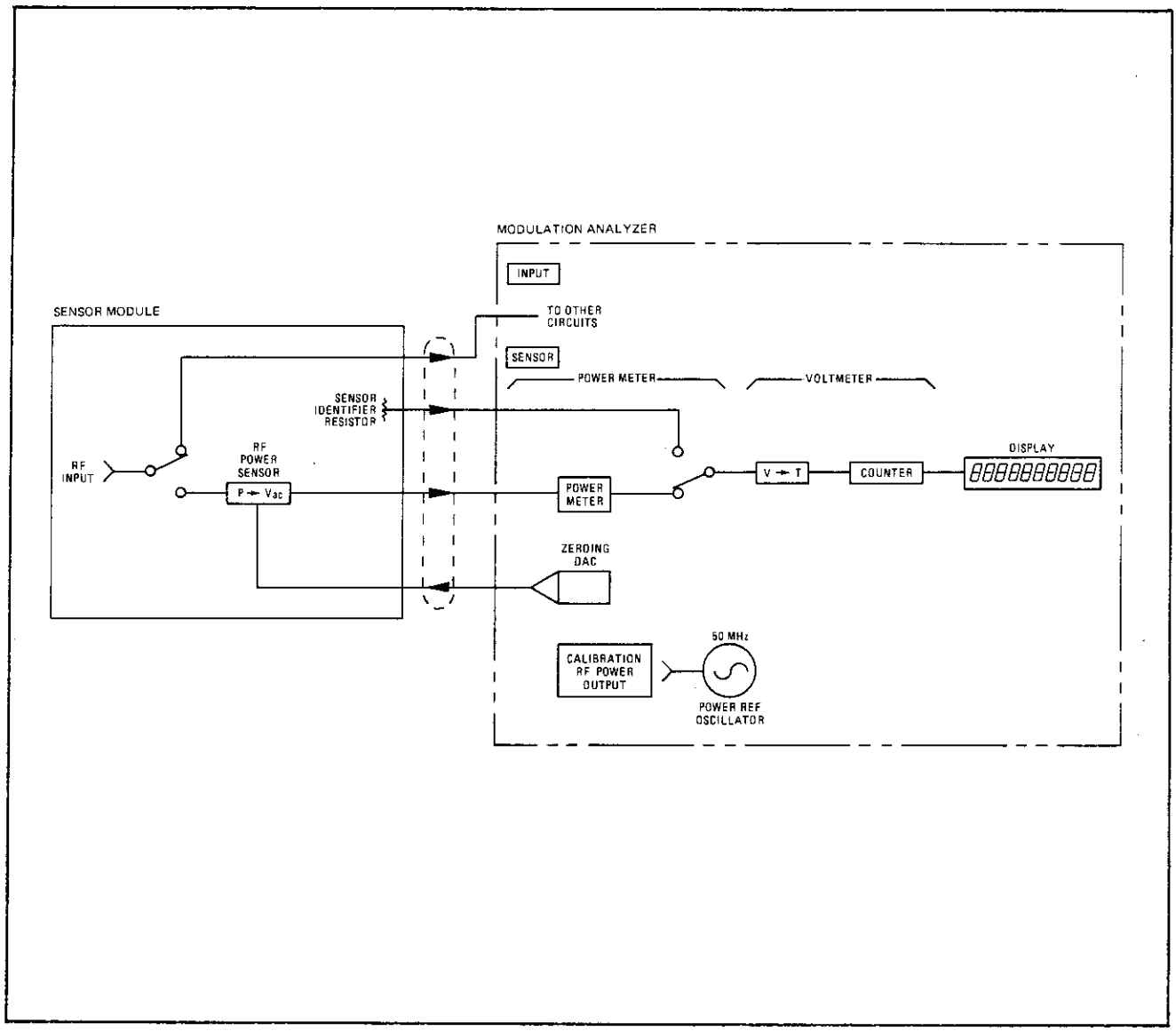
RF Power Calibration (Cont'd)
(Includes ZERO, CALIBRATE, and SAVE CAL keys)

Measurement Technique (cont'd)
The following example shows the different responses that occur during calibration:



Minor adjustments in the slope are made by the controller, based on the calibration factors, to correct for variations in the power sensor's sensitivity due to frequency and mismatch. (Refer to **RF Power Calibration Factors**.)

RF Power Calibration (Cont'd)
(Includes ZERO, CALIBRATE, and SAVE CAL keys)



Simplified Block Diagram of RF Power Calibration

Comments

RF power calibration is performed only once, each time the power sensor is changed. The calibration information is retained in the Modulation Analyzer's non-volatile memory even when the instrument is disconnected from its power source. (Refer to Instrument Preset.)

Press the ZERO key before making power measurements whenever there is a change in ambient operating conditions; for example, when temperature or humidity variations occur.

RF Power Calibration (Cont'd)
(Includes ZERO, CALIBRATE and SAVE CAL keys)

Comments (cont'd)
Any time the power-sensor type is changed (for example, from an HP 8482A to an HP 8484A), the instrument must be recalibrated. The Modulation Analyzer displays the need for recalibration by lighting the RECAL annunciator. If power sensors are interchanged frequently, use the Store/Recall function to hold calibration information for each power sensor. (Refer to Store/Recall.)

Any time power sensors are exchanged (for example, from one HP 11722A to another), the instrument must be recalibrated. The Modulation Analyzer WILL NOT recognize the need for recalibration.

Depending on the power-sensor type, the CALIBRATE key automatically sets the power meter to the range that is full-scale for a 1 mW input. (Refer to RF Power.)

C0 aborts ZR, but when ZR is timed out, C1 is not aborted.

Related Functions

Frequency Offset Control
Instrument Preset
RF Level
RF Power
RF Power Calibration Factors
Store/Recall

RF Power Calibration Factors (Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Description

Calibration factors are used to compensate the external power sensor's frequency response, relative to the reference calibration made at 50 MHz with the Power Reference Oscillator. (Refer to **RF Power Calibration**.) Calibration factor data, including the reference calibration factor, is usually available on a label affixed to the power sensor or sensor module.

Calibration factors can be entered and stored in an internal table (Automatic Cal Factors). The table is routinely accessed during RF power measurements to correct frequency response errors in the power sensor. If no entry in the table directly corresponds to the input frequency, the Modulation Analyzer derives an appropriate calibration factor using linear interpolation. Sixteen pairs of frequency/calibration factor combinations can be entered (plus a reference calibration factor).

A second table, that has an entry capability of 22 pairs of frequency/calibration factor combinations (plus a reference calibration factor), is available for use with Special Function 27. (Refer to **Frequency Offset Control**).

Calibration factors can be entered, reviewed, and altered manually from the front panel (Manual Cal Factors). Automatic selection of calibration factors can be manually overridden without alteration of the table.

Procedures

To view the calibration factor being used, tune the instrument to the frequency of interest (using a procedure outlined in **RF Frequency Tuning**), then press the RF POWER, Blue Key, and % CAL FACTOR keys.

Automatic Cal Factors.
The Modulation Analyzer allows entry and review of the Automatic Cal Factor tables with Special Function 37. The following information describes the Modulation Analyzer's reaction as the different suffixes of Special Function 37 are initiated. For more detailed information regarding each individual suffix of this Special Function, refer to "Comments".

Table Review
37.0 Enter Automatic Cal Factor mode.

37.1 Enter Manual Cal Factor mode.

37.2 Display Cal Factor Status (0 = Automatic, 1 = Manual).

RF Power Calibration Factors (Cont'd)
(Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Procedures (cont'd)

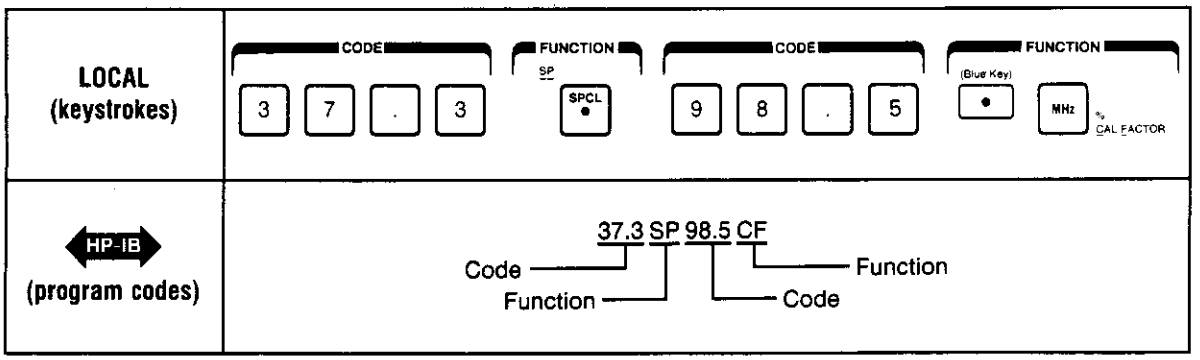
Table Review (cont'd)

37.3 Prepare to accept a reference calibration factor or a frequency/calibration-factor pair and to enter this input into the appropriate table.

- o The reference calibration factor is entered by keying 37.3 SPCL, then the value, followed by the Blue Key and % CAL FACTOR key.
- o A frequency/calibration-factor pair is entered by keying 37.3 SPCL, the frequency value (in MHz) and the MHz key. Next, the calibration factor value is entered, followed by the Blue Key and % CAL FACTOR key.

Examples

To enter a reference calibration factor of 98.5% into the Automatic Cal Factor table:



To invoke the new reference calibration factor, press the AUTOMATIC OPERATION key or key in 37.0 SPCL, and perform the calibration procedure as described in **RF Power Calibration**. The reference calibration factor is defined during calibration and stays in effect until another SAVE CAL operation is done.

RF Power Calibration Factors (Cont'd)
(Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Procedures (cont'd)

Examples (cont'd)
To enter an Automatic Cal Factor of 99.0% at 1 MHz:

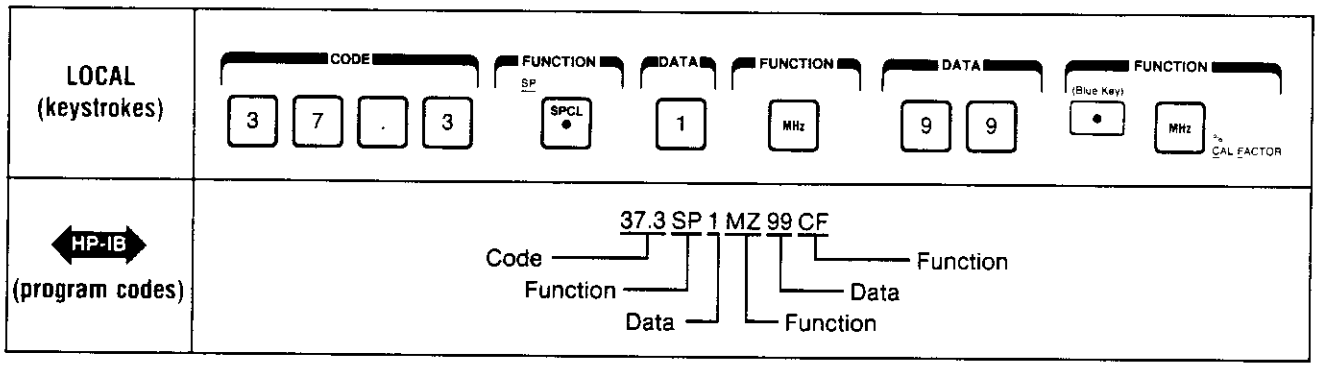


Table Review (cont'd)

37.4 Display the number of entries in the table.

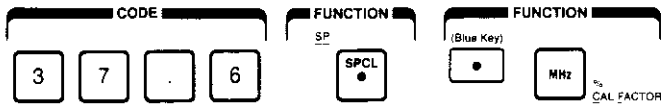
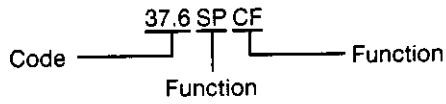
37.5 Recall the reference calibration factor from the table. Display this value by keying 37.5 SPCL, and pressing the Blue Key and % CAL FACTOR key. Key 37.0 SPCL or AUTOMATIC OPERATION to return to the Automatic Cal Factor mode.

37.6 Recall the next frequency/calibration-factor pair from the table. After 37.6 SPCL is entered, pressing the Blue Key and DISPLAY FREQ key displays the frequency at which the calibration factor was entered. Pressing the Blue Key and % CAL FACTOR key displays the calibration factor. Key 37.0 SPCL or AUTOMATIC OPERATION to return to the Automatic Cal Factor mode.

RF Power Calibration Factors (Cont'd)
(Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Procedures (cont'd)

Example
To display the calibration factor of the first frequency/calibration factor pair after entering the RF Power Measurement mode and keying in 37.5 SPCL (HP-IB program codes M437.5SPCF):

LOCAL (keystrokes)	
HP-IB (program codes)	

To display the frequency in addition to the calibration factor of the entered pair in the example, press the Blue Key and DISPLAY FREQ key.

To display the third frequency/calibration factor pair in the table, follow the procedure as described in the example above, but enter 37.6 SPCL three times before using the DISPLAY FREQ key or % CAL FACTOR key.

Table Review (cont'd)
37.9 Clear the table.

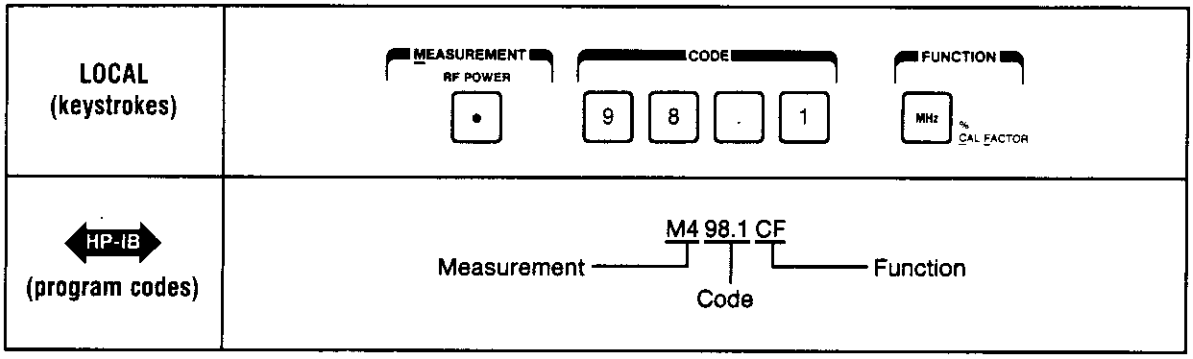
To select the second table used for the Frequency Offset Control, use Special Function 27. (Refer to **Frequency Offset Control**.)

Manual Cal Factors. To enter a Manual Cal Factor, first press the RF POWER key. Next, press the numbered keys that correspond to the calibration factor value, then the Blue Key and % CAL FACTOR key.

RF Power Calibration Factors (Cont'd)
(Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Procedures (cont'd)

Example
To enter a Manual Cal Factor of 98.1%:



HP-IB Program Codes

% CAL FACTOR = CF
DISPLAY FREQ = FR
Hz = HZ
MHz = MZ
RF POWER = M4
SPCL = SP

Indications

Automatic Cal Factors.

37.0 The display returns to the current measurement. The LED of the selected measurement key remains lighted.

37.1 The display returns to the current measurement. The LED within the RF POWER key remains lighted.

37.2 The display indicates the calibration factor status for a few seconds. The LED within the SPCL key is lighted.

37.3 The display returns to the current measurement. Entries are made into the table regardless of the value in the display. The LED within the key of the selected Measurement mode remains lighted. The Blue Key blinks at the selected measurement rate when pressed until the % CAL FACTOR key is pressed.

RF Power Calibration Factors (Cont'd)
(Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Indications (cont'd)

Automatic Cal Factors (cont'd)

37.4 The display indicates the number of entries in the table for a few seconds. The LED within the SPCL key is lighted.

37.5 The display returns to the current RF power measurement. When % CAL FACTOR is keyed, the % annunciator and the calibration factor value are displayed for a few seconds. The LED within the SPCL key is lighted.

37.6 The display returns to the current RF power measurement. When DISPLAY FREQ is keyed, the MHz annunciator and the frequency entry are displayed for a few seconds. When % CAL FACTOR is keyed, the % annunciator and the calibration factor value are displayed for approximately two seconds. When either % CAL FACTOR or DISPLAY FREQ is keyed, the LED within the SPCL key is lighted.

37.9 The display returns to the current measurement. The key-cap LED of the selected, Measurement mode remains lighted.

Manual Cal Factors.

Display: After a Manual Cal Factor is entered, the measurement in the display changes to reflect the effect of the new calibration factor entry. When the calibration factor is recalled and displayed, the % annunciator and the calibration factor value are displayed and then timed out.

Front Panel: The LEDs within the keys representing the selected functions light. The Blue Key flashes when pressed until the % CAL FACTOR key is pressed.

Comments

Keying AUTOMATIC OPERATION, INSTR PRESET, or 37.0 SPCL configures the instrument to its Automatic Cal Factor mode. (Refer to **Automatic Operation** or **Instrument Preset**.)

The SAVE CAL key saves the current reference calibration factor. Changing the Cal Factor mode does not change the reference calibration factor; for example, if the Automatic Cal Factor mode is selected, the instrument could continue to use a manually-entered reference calibration factor that was previously entered, until another SAVE CAL operation is initiated from the Automatic Cal Factor mode. (Refer to **RF Power Calibration**.)

RF Power Calibration Factors (Cont'd)
(Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Comments (cont'd)
Two calibration factors must be available for the Modulation Analyzer to make RF power measurements; a reference calibration factor, and a calibration factor at the frequency to be measured (entered manually or from the Automatic Cal Factor table). During calibration, the Modulation Analyzer equates the second calibration factor to the current reference calibration factor. This allows viewing of the current reference calibration factor by pressing the CALIBRATE key, then the Blue Key and % CAL FACTOR key.

Calibration factors have a resolution of 0.1%.

Automatic Cal Factors.
After entering a table of calibration factors, check the table size (37.4 SPCL) and display each entry (37.5 SPCL and 37.6 SPCL) to verify that the table was entered correctly.

To be sure RF power measurements are valid, the Modulation Analyzer must be retuned each time frequency is changed. (Refer to **RF Frequency Tuning**.)

If RF power measurements are attempted at frequencies greater than any frequency in the table, interpolation is not possible and Error 15 is displayed.

When the power sensor is changed, a new calibration-factor table should be entered. The new table supercedes the table used with the previous power sensor. To avoid re-entering tables when frequent interchanging of power sensors is necessary, either use Manual Cal Factors, or use the two available tables for two different power sensors. Key Special Function 27 and use 0 Hz as the external, Local Oscillator (LO) value. (Refer to **Frequency Offset Control**.)

The Automatic Cal Factor tables are retained in the instrument's non-volatile memory for use in all subsequent RF power measurements. (Refer to **Instrument Preset**.)
Special Function 37:

37.0 This Special Function can be keyed from any Measurement mode.

37.1 - This Special Function can be accessed only after entering the RF Power Measurement mode.
- The instrument uses the current calibration factor as the Manual Cal Factor.

RF Power Calibration Factors (Cont'd)
(Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Comments (cont'd)

37.3 - The Modulation Analyzer will display an error unless entries into its calibration factor tables meet the following criteria:

RF Frequency Range.....0-42 GHz
RF Frequency Resolution.....50 kHz
Calibration Factor Range.....70-120%
Calibration Factor Resolution.....0.1%
Maximum number of entries/table...17 for first table, 23 for second table

- Special Function 37.3 must be used to enter every calibration factor input.
- The table entries can be entered from any Measurement mode since Special Function 37.3 disables the MHz key from its usual function of manual frequency tuning.
- The frequency must be entered before the calibration factor; if the opposite order is followed, a reference calibration factor could be entered mistakenly.
- Calibration factors are accepted in any order with respect to their corresponding frequencies.
- If an error is made in entering any value, pressing the CLEAR key allows the user to immediately re-enter the correct value rather than starting the process at the beginning.
- To replace an existing calibration factor entry, enter the new calibration factor at the frequency previously used in the entry.
- To delete an existing calibration factor entry, enter 0% as the calibration factor at the frequency previously used in the entry.

37.4 The number of table entries displayed include the reference calibration factor.

37.5 - This Special Function is accessed only after the RF Power Measurement mode is entered.
- Keying 37.5 SPCL configures the instrument to use Manual Cal Factors with the reference calibration factor in the table as the manual entry. (To enter the Automatic Cal Factor mode, key AUTOMATIC OPERATION or 37.0 SPCL.)

37.6 - This Special Function is accessed only after the RF Power Measurement mode is entered.
- Frequency/calibration-factor pairs should only be displayed after 37.5 has been entered.
- 37.6 SPCL is entered before each frequency/calibration factor pair is recalled.

RF Power Calibration Factors (Cont'd)
(Includes the % CAL FACTOR and DISPLAY FREQ keys and Special Function 37)

Comments (cont'd)

37.6 (cont'd)
- The table entries are recalled from the lowest frequency to the highest. The table can be thought of as a list with the reference calibration factor at the top and frequency/calibration factor entries ascending in frequency after the reference. Entries always appear in the list and are recalled in numerical frequency order even when entries are made out of order.
- An attempt to read beyond the end of the table results in Error 26.
- This Special Function configures the instrument to use Manual Cal Factors and manual tune frequency. The frequency/calibration factor pair recalled last becomes the manual entry. (To enter the Automatic Cal Factor mode, key AUTOMATIC OPERATION or 37.0 SPCL.)

Manual Cal Factors.
Manual Cal Factors are not frequency selective; that is, as frequency is changed, the instrument will continue to use the calibration factor entered last. To obtain accurate measurements when using Manual Cal Factors, a new calibration factor should be entered each time the frequency is changed.

The Manual Cal Factor is not retained in the Modulation Analyzer's non-volatile memory and therefore, must be re-entered after AUTOMATIC OPERATION or INSTR PRESET is keyed. (Refer to **Automatic Operation** or **Instrument Preset**.)

Related Functions

Automatic Operation
RF Power Calibration
Frequency Offset Control
RF Frequency Tuning
Instrument Preset
RF Level
RF Power

Service Request Condition (Special Function 22)

Description

Various circumstances cause the Modulation Analyzer to issue a Require Service message. (An HP-IB code error is one circumstance that causes a Require Service message.)

Using the keyboard and the SPCL key, the operator can enable one or more conditions to cause the Require Service message to be issued. The occurrance of an enabled condition sets both the bit corresponding to the condition and bit 7 (RQS bit) in the Status Byte.

The bits set in the status byte and the Require Service message are not cleared unless the status byte is read (by serial polling), a Clear message is received and executed by the Modulation Analyzer, or a Controller Reset or Controller Clear Service Special Function is performed. The enabled Service Request conditions are always disabled again whenever a Clear message is received and executed by the Modulation Analyzer or whenever a Controller Reset or Controller Clear Service Special Function is performed.

Procedure

To enable one or more conditions to cause the Modulation Analyzer to issue a Require Service message, sum the weights of the conditions to be enabled (from the following table). This sum becomes the code suffix of Special Function 22. Enter the Special Function code (prefix, decimal, and suffix) via the numeric keyboard, then press the SPCL key. An HP-IB code error (weight = 2) will always cause a Require Service message. This condition cannot be disabled, and if the weight is not summed in, it will be assumed by the instrument.

Condition	Weight
Data Ready	1
HP-IB Code Error	2
Instrument Error	4
Limit Exceeded	8
Frequency Offset Mode Change	16
Recalibrate	32
SRQ Mask Set	64

Service Request Condition (Cont'd) (Special Function 22)

Example

To set the Modulation Analyzer to send a Require Service message for all conditions, first compute the Special Function suffix by summing all the weights.

$$(2+)\ 4 + 8 + 16 + 32 + 64 = 126$$

Key in 22.126 SPCL.

HP-IB Program Codes

Compute the Special Function code as described in "Procedure".

SPCL = SP

Indications

When any enabled condition occurs, both the RQS bit and the bit corresponding to the enabled condition are set in the status byte, and the SRQ control line on the HP-IB is set true. For reference, the Modulation Analyzer's status byte is listed in the following table:

	MSB							LSB
Bit	8	7	6	5	4	3	2	1
Weight	128	64	32	16	8	4	2	1
Condition	0 (always)	SRQ Mask Set	Recalibrate	Frequency Offset Mode Change	Limit Exceeded	Instrument Error	HP-IB Code Error	Data Ready

Modulation Analyzer's Status Byte

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display returns to show the measurement previously selected.

The SRQ LED next to the LOCAL key lights when a service request message is sent.

Front Panel: Special Function 22 has no effect on the SPCL key light.

Service Request Conditon (Cont'd)
(Special Function 22)

Comments

HP-IB

For more information on the HP-IB operation, serial polling, and the Status Byte message, refer to the discussion, "HP-IB Operation" that appears earlier in Section III of this manual.

HP-IB

The HP-IB Address Special Function provides a convenient means to determine, at any time, whether a Require Service message is being issued by the Modulation Analyzer.

Related Functions

HP-IB Address
HP-IB Operation (appears earlier in Section III)

SINAD
(Special Function 29.0)

Description

Special Function 29.0 enables the Modulation Analyzer to make SINAD (SIgnal to Noise And Distortion) measurements that help determine the sensitivity of receivers. SINAD measurements are made identically to audio distortion measurements; but the result is calculated differently.

SINAD measurements can be made at frequencies of either 1 kHz or 400 Hz using the 1 kHz DISTN or 400 Hz DISTN keys (respectively).

SINAD can be measured on external audio signals using the AUDIO INPUT key when the input signal is applied to MODULATION OUTPUT/AUDIO INPUT. When the AUDIO INPUT key is not selected, the Modulation Analyzer makes the measurement on the audio signal that is demodulated from the signal at the RF INPUT connector.

If AUDIO INPUT is not selected, the output available at MODULATION OUTPUT/AUDIO INPUT is not affected by this measurement.

Procedures

To make a SINAD measurement, first set the audio frequency under test to 400 Hz or 1 kHz.

Either external audio signals or internally demodulated signals can be measured.

To measure an external audio signal:
- Connect the signal to MODULATION OUTPUT/AUDIO INPUT.
- Press the AUDIO INPUT key on the front panel of the Modulation Analyzer.

To measure an internally demodulated audio signal:
- Connect the frequency to be measured to RF INPUT.
- To change the bandwidth of the audio signal, press the appropriate filter keys. (Refer to **Audio Filters**.)

Select AM or FM as appropriate.

Key in 29.0 SPCL.

If the frequency-under-test is 400 Hz, press the Blue Key and 400 Hz DISTN (PEAK-) key. If the frequency-under-test is 1 kHz, no keys are pressed since the instrument defaults to this frequency.

Press the LOG/LIN key to display the result logarithmically.

If SINAD measurements are to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to Ratio.)

SINAD (Cont'd)
(Special Function 29.0)

HP-IB Program Codes

AUDIO INPUT = A1
MODULATION OUTPUT = A0
1 kHz DISTN = D5
400 Hz DISTN = D6
LIN results = LN
LOG results = LG
SPCL = SP

Indications

Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the SINAD value is displayed along with the % or dB annunciator. The 1 kHz or 400 Hz annunciator is also displayed.

Front Panel: The LED within the SPCL key lights. The LED next to RMS lights. All measurement keys are turned off.

If FILTER or DE-EMPHASIS keys have been selected, the LEDs within these keys remain on. They are turned off if AUDIO INPUT is selected.

When AUDIO INPUT is selected, the LED within the key lights and the LEDs under MODULATION OUTPUT are turned off. If AUDIO INPUT is not selected or is turned off, the appropriate LED under MODULATION OUTPUT lights.

Related Functions

Audio Distortion and Level
Audio Frequency
Special Functions

Special Functions

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. Technicians can gain arbitrary control of the instrument as an aid in troubleshooting.

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 VIII). 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 VIII). 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.

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

Special Functions (Cont'd)

Description (cont'd)
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) keys. (While either display is active, pressing the SPCL key selects the other display.)

A summary of User Special Functions is provided in the nine-page table in this instruction. Also included in this instruction are procedures for using Special Functions and for obtaining the Special Display and the Special Special Display.

Special Function		Program Code (HP-IB)	Description	Default Parameter	Lights SPCL Key	Display Timed	Volatile Memory Storage	Non-Volatile Memory Storage	AUTO OP. Key	Disabled By: Any Meas. Key	Disabled By: Clear Key	Disabled By: All Keys	Comments	Related Detailed Operating Instructions
Name	Code													
RF Input Attenuation	1.0	1.0SP	Automatic selection	Y	N	–	–	–	–	–	–	–		RF Input Attenuation
	1.1	1.1SP	0 dB input attenuation	–	Y	–	N	N	Y	N	N	N		
	1.2	1.2SP	10 dB input attenuation	–	Y	–	N	N	Y	N	N	N		
	1.3	1.3SP	20 dB input attenuation	–	Y	–	N	N	Y	N	N	N		
	1.4	1.4SP	30 dB input attenuation	–	Y	–	N	N	Y	N	N	N		
	1.5	1.5SP	40 dB input attenuation		Y	–	N	N	Y	N	N	N		
	1.6	1.6SP	50 dB input attenuation		Y	–	N	N	Y	N	N	N		
Audio Range	2.0	2.0SP	Automatic Selection	Y	N		–	–	–	–	–	–		AM Audio Range FM ϕM (Phase Modulation)
			AM (%) / FM (kHz) / ϕM (rad)											
	2.4[1]	2.4SP	≤4 / ≤0.4 / ≤0.04[2] / ≤0.4	–	Y	–	N	N	Y	N	N	N		
[1]using true rms detector.	2.4	2.4SP	≤40 / ≤4 / ≤0.4[2] / ≤4	–	Y		N	N	Y	N	N	N		
[2]with 750 μs de-emphasis pre-display	2.1	2.1SP												
	2.2	2.2SP	≤100 / ≤40 / ≤4[2] / ≤40	–	Y	–	N	N	Y	N	N	N		
	2.3	2.3SP	≤100 / ≤400 / ≤40[2] / ≤400	–	Y	–	N	N	Y	N	N	N		
RF and IF Filters	3.0	3.0SP	Automatic Selection	Y	N	–	–	–	–	–	–	–		Filters, RF and IF
			IF Freq (MHz) / IF Filter / RF High-Pass Filter											
	3.1	3.1SP	0.455 / 200 kHz BW / OUT		Y	–	N	N	Y	N	N	N		
	3.2	3.2SP	1.5 / 2.5 MHz BW / OUT		Y	–	N	N	Y	N	N	N		
	3.3	3.3SP	0.455 / 200 kHz BW / IN	–	Y		N	N	Y	N	N	N		
	3.4	3.4SP	1.5 / 2.5 MHz BW / IN		Y	–	N	N	Y	N	N	N		
	3.6	3.6SP	0.455 / 2.5 MHz BW / OUT	–	Y	–	N	N	Y	N	N	N		
	3.8	3.8SP	0.455 / 2.5 MHz BW / IN	–	Y	–	N	N	Y	N	N	N		

N = No; – Not applicable; Y = Yes; *Except the LOCAL, S (Shift), Blue Key, and Numeric Keys

Special Function		Program Code (HP-IB)	Description	Default Parameter	Lights SPCL Key	Display Timed	Volatile Memory Storage	Non-Volatile Memory Storage	AUTO OP. Key	Disabled By: Any Meas. Key	Disabled By: Clear Key	Disabled By: All Keys	Comments	Related Detailed Operating Instructions
Name	Code													
Audio Detector Response: Audio Peak Det. Response and RMS Detector Digital Averaging Response	5.0	5.0SP	Fast	Y	N	–	–	–	–	–	–	–		Audio Detector Response
	5.1	5.1SP	Slow	–	Y	–	N	N	Y	N	N	N		
AM ALC Response	6.0	6.0SP	Slow AM ALC (AM rates >20 Hz)	Y	N	–	–	–	–	–	–	–		AM ALC Response Time
	6.1	6.1SP	Fast AM ALC (AM rates >1 kHz)	–	Y	–	N	N	Y	N	N	N		
	6.2	6.2SP	AM ALC off	–	Y	–	N	N	Y	N	N	N		
RF Frequency Resolution	7.0	7.0SP	Automatic Selection	Y	N	–	–	–	–	–	–	–		RF Frequency Resolution
	7.1	7.1SP	10 Hz	–	Y	–	N	N	Y	N	N	N		
	7.2	7.2SP	100 Hz	–	Y	–	N	N	Y	N	N	N		
	7.3	7.3SP	1 kHz	–	Y	–	N	N	Y	N	N	N		
Error Message Disable	8.0	8.0SP	Automatic Selection	Y	N	–	–	–	–	–	–	–		Disable Error Message Control
			Errors Disabled:											
	8.1	8.1SP	01	–	Y	–	N	N	Y	N	N	N		
	8.2	8.2SP	02 03	–	Y	–	N	N	Y	N	N	N		
	8.3	8.3SP	01 02 03	–	Y	–	N	N	Y	N	N	N		
	8.4	8.4SP	04	–	Y	–	N	N	Y	N	N	N		
	8.5	8.5SP	01 04	–	Y	–	N	N	Y	N	N	N		
	8.6	8.6SP	02 03 04	–	Y	–	N	N	Y	N	N	N		
	8.7	8.7SP	01 02 03 04	–	Y	–	N	N	Y	N	N	N		
	8.8	8.8SP	All Errors Enabled	–	Y	–	N	N	Y	N	N	N		

N = No; – = Not applicable; Y = Yes; *Except the LOCAL, S (Shift), Blue Key, and Numeric Keys

Special Function		Program Code (HP-IB)	Description	Default Parameter	Lights SPCL Key	Display Timed	Volatile Memory Storage	Non-Volatile Memory Storage	AUTO OP. Key	Disabled By: Any Meas. Key	Disabled By: Clear Key	Disabled By: All Keys	Comments	Related Detailed Operating Instructions
Name	Code													
RF Power Range	10.0	10.0SP	Automatic Selection	Y	N	–	–	–	–	–	–	–		RF Power
	10.1	10.0SP	Range #1 (most sensitive range)	–	Y	–	N	N	Y	N	N	N		
	10.2	10.2SP	Range #2	–	Y	–	N	N	Y	N	N	N		
	10.3	10.3SP	Range #3	–	Y	–	N	N	Y	N	N	N		
	10.4	10.4SP	Range #4	–	Y	–	N	N	Y	N	N	N		
	10.5	10.5SP	Range #5 (least sensitive range)	–	Y	–	N	N	Y	N	N	N		
Previous Ratio	11.2	11.2SP	Display previous ratio reference	100%	Y	Y	Y	N	Y	Y	Y	Y		Ratio and Log/Lin
FM Calibration	12.0	12.0SP	Display computed peak FM deviation	–	Y	N	N	N	N	Y	N	N	Lights CALIBRATE	FM Calibration
	12.1	12.1SP	Display demodulatted peak residual FM deviation	–	Y	N	N	N	N	Y	N	N	Lights CALIBRATE Fixes 2.2 SPCL	
	12.2	12.2SP	Display demodulated peak FM deviation	-	Y	N	N	N	N	Y	N	N	Lights CALIBRATE Fixes 2.2 SPCL	
AM Calibration	13.0	13.0SP	Display computed peak AM depth	–	Y	N	N	N	N	Y	N	N	Lights CALIBRATE	AM Calibration
	13.1	13.1SP	Display demodulated peak residual AM depth	–	Y	N	N	N	N	Y	N	N	Lights CALIBRATE Fixes 2.2 SPCL	
	13.2	13.2SP	Display demodulated peak AM depth	–	Y	N	N	N	N	Y	N	N	Lights CALIBRATE Fixes 2.2 SPCL	

N = No; – = Not applicable; Y = Yes; *Except the LOCAL, S (Shift), Blue Key, and Numeric Keys

Special Function		Program Code (HP-IB)	Description	Default Parameter	Lights SPCL Key	Display Timed	Volatile Memory Storage	Non-Volatile Memory Storage	Disabled By: AUTO OP. Key	Disabled By: Any Meas. Key	Disabled By: Clear Key	Disabled By: All Keys	Comments	Related Detailed Operating Instructions
Name	Code													
Limit	14.0	14.0SP	Clear limits; turn off LIMIT annunciator	–	N	–	Y	N	–	–	–	–		Limit
	14.1	14.1SP	Set lower limit to RATIO reference	0.15 kHz	N	–	Y	N	–	–	–	–		
	14.2	14.2SP	Set upper limit to RATIO reference	1300 MHz	N	–	Y	N	–	–	–	–		
	14.3	14.3SP	Restore lower limit	–	N	–	Y	N	–	–	–	–		
	14.4	14.4SP	Restore upper limit	–	N	–	Y	N	–	–	–	–		
	14.5	14.5SP	Display lower limit	0.15 kHz	Y	Y	Y	N	Y	Y	Y	Y		
	14.6	14.6SP	Display upper limit	1300 MHz	Y	Y	Y	N	Y	Y	Y	Y		
	14.7	14.7SP	Display measurement code in which lower limit was selected	0.005	Y	Y	Y	N	Y	Y	Y	Y		
	14.8	14.8SP	Display measurement code in which upper limit was selected	0.005	Y	Y	Y	N	Y	Y	Y	Y		
	14.9	14.9SP	Display limit status in the format Lower. Upper where 0=disabled and 1=enabled.	0.0	Y	Y	Y	N	Y	Y	Y	Y		
Time Base Check	15.0	15.0SP	Display Error 12 if Option 002 installed and oven cold. Display 0 if Option 002 installed and oven warm, or if Option 002 not installed.	–	Y	Y	N	N	Y	Y	Y	Y		
	15.1	15.1SP	Displayed 0 if internal time base is being used. Display 1 if external time base is being used.	–	Y	Y	N	N	Y	Y	Y	Y		

N = No; – = Not applicable; Y = Yes; *Except the LOCAL, S (Shift), Blue Key, and Numeric Keys

Special Function		Program Code (HP IB)	Description	Default Parameter	Lights SPCL Key	Display Timed	Volatile Memory Storage	Non-Volatile Memory Storage	AUTO OP. Key	Disabled By: Any Meas. Key	Disabled By: Clear Key	Disabled By: All Keys	Comments	Related Detailed Operating Instructions
Name	Code													
AM Calibration Factor	16.0	16.0SP	Disable AM calibration factor	–	N	–	Y	N	–	–	–	–	Blue Key, % CAL FACTOR displays status: If disabled, 100% (note 1% resolution). If enabled, calibration factor value displayed (resolution of 0.01%).	AM Calibration
	16.1	16.1SP	Enable AM calibration factor	100%	N	–	Y	N	–	–	–	–		
	16.2	16.2SP	Display AM calibration factor (0 if not enabled)	100%	Y	Y	Y	Y	Y	Y	Y	Y		
FM Calibration Factor	17.0	17.0SP	Disable FM calibration factor	–	N	–	Y	N	–	–	–	–	Blue key, % CAL FACTOR displays status: if disabled, 100% (note 1% resolution). If enabled, calibration factor value displayed (resolution of 0.01%).	FM Calibration
	17.1	17.1SP	Enable FM calibration factor	100%	N	–	Y	N	–	–	–	–		
	17.2	17.2SP	Display FM calibration factor (0 if not enabled)	100%	Y	Y	Y	Y	Y	Y	Y	Y		
Tone-Burst Receiver	18.NN	18.NNSP	Configures instrument as a tone-burst receiver. A time delay of NN ms is inserted between detection of a carrier and unsquelching of the output at MODULATION OUTPUT/AUDIO INPUT. Range of NN is 1 to 99 ms. If NN is 0, delay is 99 ms.	99 ms	Y	N	N	N	N	Y	N	N		Tone Burst Receiver
HP-IB Address	21.0	21.0SP	Displays HP-IB address in form AAAAAAA.TLS. AAAAAAA=binary address. T=1=talk only. L=1=listen only. S=1=requesting service.	–	Y	N	N	N	Y	Y	Y	Y		HP-IB Address

N = No; – = Not applicable; Y = Yes; *Except the LOCAL, S (Shift), Blue Key, and Numeric Keys

Special Function Name	Code	Program Code (HP-IB)	Description	Default Parameter	Lights SPCL Key	Display Timed	Volatile Memory Storage	Non-Volatile Memory Storage	Disabled By: AUTO OP. Key	Disabled By: Any Meas. Key	Disabled By: Clear Key	Disabled By: All Keys	Comments	Related Detailed Operating Instructions
Service Request	22.NN	22.NNSP	Enables a condition to cause a service request. NN is the sum of any combination of the weighted conditions below: 1 Data ready 2 HP-IB error (cannot be disabled) 4 Instrument error 8 Limit exceeded 16 Desire external controller attention 32 Recalibrate 64 Readback SRQ mask	22.2 SPCL	N	–	Y	N	N	N	N	N		Service Request Condition
External Attenuation	25.2	25.2SP	Display value of external attenuation in dB	0 dBm	Y	–	Y	N	Y	Y	Y	Y		External Attenuation
Frequency Offset Control	27.0	27.0SP	Exit Frequency Offset Mode	–	N	–	Y	N	–	–	–	–		Frequency Offset Control
	27.1	27.1SP	Re-enter Frequency Offset Mode	–	N	–	Y	N	–	–	–	–		
	27.2	27.2SP	Display external LO frequency	0 MHz	Y	N	Y	N	Y	Y	Y	Y		
	27.3	27.3SP	Enter and enable external LO frequency	–	N	–	Y	N	–	–	–	–		
SINAD Measurement	29.0	29.0SP	Make an audio SINAD measurement	–	Y	N	N	N	N	Y	N	N		SINAD
External Audio RMS Level Measurement	30.0	30.0SP	Measure the rms level of an external audio input at MODULATION OUTPUT/ AUDIO INPUT	–	Y	N	N	N	N	Y	N	N	Measurements can only be made on inputs to MODULATION OUTPUT/AUDIO INPUT.	Audio Distortion and Level

N = No; – = Not applicable; Y = Yes; *Except the LOCAL, S (Shift), Blue Key, and Numeric Keys

Special Function Name	Code	Program Code (HP-IB)	Description	Default Parameter	Lights SPCL Key	Display Timed	Volatile Memory Storage	Non-Volatile Memory Storage	AUTO OP. Key	Disabled By: Any Meas. Key	Disabled By: Clear Key	Disabled By: All Keys	Comments	Related Detailed Operating Instructions
LO Frequency	33.0	33.0SP	Measure the LO frequency	–	Y	N	N	N	N	Y	N	N		LO Frequency
IF Frequency	34.0	34.0SP	Measure the IF frequency	–	Y	N	N	N	N	Y	N	N		IF Frequency
RF Level	35.0	35.0SP	Measure the RF level of the RF input signal at INPUT using the RF peak detector.	–	Y	N	N	N	N	Y	N	N		RF Level
RF Power[1] Calibration Factors	37.0	37.0SP	Use automatic calibration factors	Y	N	–	N	N	–	–	–	–	% CAL FACTOR shows the value currently being used. *The appropriate keys must be pressed for listed action to occur; refer to RF Power.	RF Power Calibration Factors
	37.1	37.1SP	Use manual calibration factors	–	N	–	N	N	–	–	–	–		
	37.2	37.2SP	Display calibration factor status; 0=automatic 1=manual	0	Y	Y	N	N	Y	Y	Y	Y		
	37.3	37.3SP	Enter automatic calibration factor	–	N	–	Y	Y	–	–	–	–		
[1]Two tables are available. The table being used is determined by the status of Frequency Offset Mode (Special Function 27).	37.4	37.4SP	Display table size	–	Y	Y	Y	Y	Y	Y	Y	Y		
	37.5*	37.5SP	Recall reference calibration factor	–	Y	Y	Y	Y	Y	Y	Y	Y		
	37.6*	37.6SP	Recall next frequency/ calibration factor	–	Y	Y	Y	Y	Y	Y	Y	Y		
	37.9	37.9SP	Clear table	–	N	–	Y	Y	–	–	–	–		

N = No; – = Not applicable; Y = Yes; *Except the LOCAL, S (Shift), Blue Key, and Numeric Keys

Special Functions (Cont'd)

Procedures

Entering Special Functions. To use a Special Function, key in the corresponding code, then press the SPCL key.

Special Display. To display the user-requested modes of Special Functions prefixed 1 through 10, press the SPCL key 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.

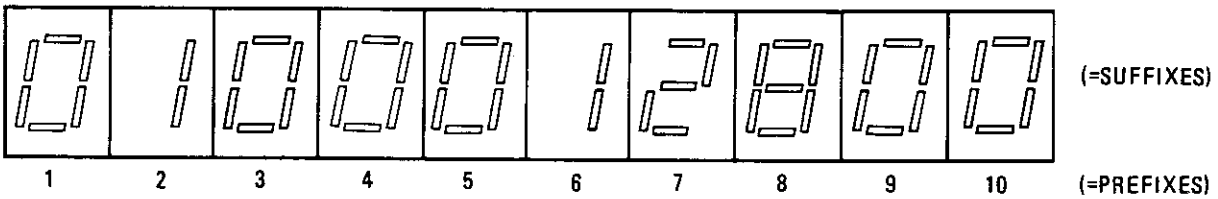
Special Special Display. To determine the actual instrument settings of Special Functions prefixed 1 through 10, press the SPCL key alone once while the Special Display is still active. (If the Special Display described above is not in effect, press the SPCL key twice to get this display.) The digit position corresponds to the Special Function prefix, and the number displayed in that digit corresponds to the Special Function suffix.

Examples

Entering Special Functions. To display the frequency of the signal in the IF (Special Function 34):

LOCAL (keystrokes)	CODE: 3 4 . 0 — FUNCTION SP: SPCL
HP-IB (program codes)	34.0 SP (Code — Function)

Viewing the Special Display. When SPCL is pressed alone once, the following display might result:

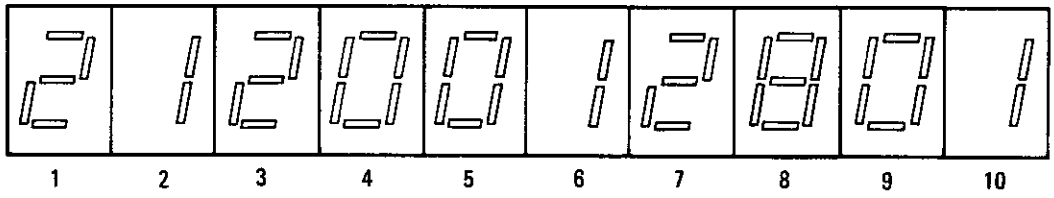


Special Functions (Cont'd)

Examples (cont'd)
This display is interpreted as follows:

Special Function		User-Requested Setting
Code	Name	
1.0	RF Input Attenuation and Gain	Automatic Selection
2.1	Audio Range	40% AM; 4 kHz FM; 4 radians ϕM
3.0	RF and IF Filters	Automatic Selection (RF High-Pass Filter Out)
5.0	Audio Detector Response	Fast Response
6.1	Automatic Level Control	Fast Response
7.2	RF Frequency Resolution	100 Hz
8.8	Error Message Disable	All Errors Enabled
10.0	RF Power Range	Automatic Selection

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.)



Special Functions (Cont'd)

Procedures (cont'd)
This display is interpreted as follows:

Special Function		Actual Instrument Setting
Code	Name	
1.2	RF Input Attenuation and Gain	10 dB Attenuation
2.1	Audio Range	40% AM; 4 kHz FM; 4 radians ϕM
3.2	RF and IF Filters	1.5 MHz IF Frequency; 2.5 MHz IF Bandwidth; Narrow Filter Out; RF High-Pass Filter Out
5.0	Audio Detector Response	Fast Response
6.1	Automatic Level Control	Fast Response
7.2	RF Frequency Resolution	100 Hz
8.8	Error Message Disable	All Errors Enabled
10.1	RF Power Range	Range #1

HP-IB Program Code

SPCL = SP

Indications

Entering Special Functions.
Display: As the numeric code is entered, it appears on the display. When the SPCL key is pressed, the display shows the measurement result or the information requested, or, if none has been requested, the display returns to the measurement previously selected.

Front Panel: Most Special Functions with a non-zero suffix will turn on the LED within the SPCL key. (Refer to the Special Function Summary for exceptions.)

Special Functions (Cont'd)

Comments

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 when entering a Special Function code, Error 21 (invalid key sequence) is displayed, the Special Function requested has not been executed.

Related Functions

Instrument Preset
Special Function Summary table (in "Description" of this instruction)

Store/Recall

Description

The STORE key enables the Modulation Analyzer to store a complete instrument state (including all front-panel functions and most Special Functions) in any of its eight storage registers. Any of these stored states can then be re-initiated using the RECALL key.

Procedures

To store the current instrument state, press the Blue Key and the STORE (7) key. Then enter a register number (1-8).

To recall a previously-stored instrument state, press the Blue Key and the RECALL (8) key. Then enter the appropriate register number (1-8).

HP-IB Program Codes

RECALL = RC
STORE = TR

Indications

Display: When the Blue Key, STORE key, and storage register number are pressed, the display blanks briefly. After each key is pressed, the display returns to the measurement previously selected.

After the RECALL key is pressed, the display blanks briefly. A measurement is then made on the current input signal with the instrument set to the state existing in the selected storage register.

Front Panel: The STORE key does not affect the LEDs within the front-panel keys.

When the RECALL key is pressed, the LEDs within the appropriate keys light.

Comments

Regarding storage of RF power calibration factors:
- The current reference calibration factor and the frequency/calibration factor pair can be stored.
- Manual calibration factors can be stored.
- The table of calibration factors cannot be stored with this function, but two tables of calibration factors can be separately stored in the instrument's non-volatile memory. (Refer to **RF Power Calibration Factors**.)

If the input frequency has changed when a previously-stored state is recalled, the Modulation Analyzer will retune.

Related Function Instrument Preset

Time Base 10 MHz Input and Time Base 10 MHz Output

CAUTION

Do not apply greater than 20V peak (ac + dc) into the TIME BASE 10 MHz INPUT or damage to the instrument may result.

Do not apply greater than 3 Vdc 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 input for an external 10 MHz time base reference. This input is ac coupled and requires an input signal level greater than 0.5 Vp-p. The input impedance is approximately 500 ohms.

TIME BASE 10 MHz OUTPUT (available only with the high stability reference, Option 002) provides an output for the internal 10 MHz reference. The output is a 50 ohm, TTL compatible output (0V to greater than 2.2V into an open circuit).

Comments

An Option 002 (high stability reference) Modulation Analyzer, that is driven from an external reference, will only output the signal from 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 external time base to TIME BASE 10 MHz INPUT, then switch the instrument's POWER switch to STBY and back to ON.

To drive several instruments from a single external reference, simply use a BNC tee at the Modulation Analyzer's TIME BASE 10 MHz INPUT.

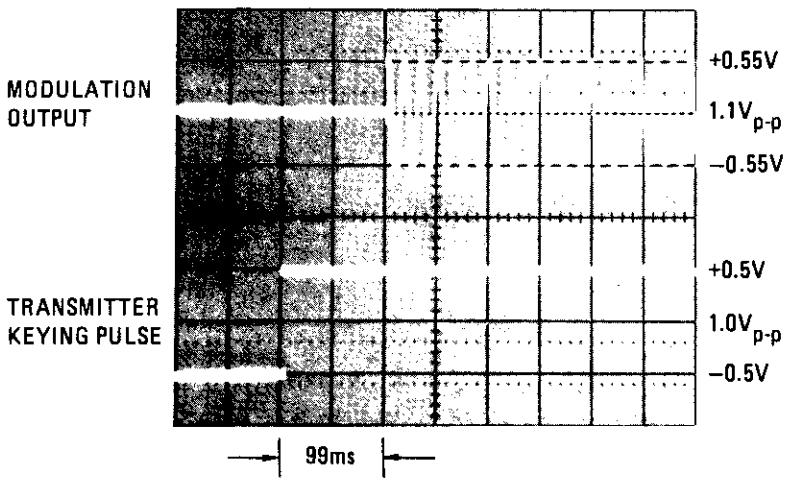
Tc determine whether the Modulation Analyzer has actually switched in the externally applied time base, key in 46.9 SPCL. The display should show 1 000 000 $\pm$1 if the external time base is in. If the external signal was not switched in, the display will show 0 or 1 only.

Tone Burst Receiver (Special Function 18)

Description

In some FM applications (mobile radio, 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. It is difficult to measure this frequency due to the audio noise present in the demodulated signal that occurs in the short delay between the keying of the transmitter and the appearance of the 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 RF INPUT and the time when it turns on the output of MODULATION OUTPUT/AUDIO INPUT. Only the valid audio tone can reach the external counter on a repeatable basis. The time delay is selectable from 1 through 99 milliseconds. The photo in the following figure 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/AUDIO INPUT

Tone Burst Receiver (Cont'd)
(Special Function 18)

Procedures

In order to successfully measure tone bursts, tune and range the Modulation Analyzer:

1. Select FM.
2. Select a detector, and if desired, filters and de-emphasis.
3. Key on the transmitter and allow the Modulation Analyzer to range and tune automatically.
4. Press the RANGE HOLD key to hold all ranges and tuning.
5. Select the time delay to be inserted between the moment the transmitter is keyed and when MODULATION OUTPUT/AUDIO INPUT 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.)
6. Enter the Special Function code 18.NN where NN is the selected delay in milliseconds, then press the SPCL key. (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, press any key except the Blue Key, S (shift), numeric, and LOCAL keys.

Program Codes

The Special Function code suffix is derived from the time delay as described in "Procedure".

SPCL = SP

Indications

Display: As the numeric code is entered, it appears on the front panel display. When the SPCL key is pressed, 18.NN is displayed (NN is the delay in milliseconds). If no RF is at the RF INPUT connector, two dashes (--) are displayed.

Front Panel: The LED next to LISTEN in the upper, left portion of the front panel lights.

The LED next to FM in the upper, right portion of the front panel remains lighted signifying that demodulated FM is available at the MODULATION OUTPUT/AUDIO INPUT.

The LEDs within the Measurement, Detector, and Display keys are turned off. Note that if the PRE DISPLAY key was selected, it is also turned off since FM is not being displayed.

Tone Burst Receiver (Cont'd)
(Special Function 18)

Comments

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 oscillate at a frequency other than the nominal IF frequency. When RF first enters the instrument, the IF frequency shifts sharply 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 created when the transmitter is keyed is close to, or equal to the IF frequency inherent in the particular instrument's behavior.

This function is best used when operating in remote mode since the counting instrument connected to the output of MODULATION OUTPUT/ AUDIO INPUT may need to acquire several sets of data in rapid succession (when counting multiple tones, for example).

Ranges can be held for this function using the individual Special Functions for each parameter instead of using the RANGE HOLD key.

Special Function code 18.0 provides a 99 ms delay.

Related Functions

Audio Range
FM
Range Hold
RF Frequency Tuning
RF Input Attenuation
Special Functions

Tuned RF Level

Description

The Tuned RF Level function enables the Modulation Analyzer to measure the peak RF power falling within its tuned IF range. (See the block diagam in "Measurement Technique".) The Tuned RF Level function is not calibrated, and so it is not as accurate or sensitive as the RF Power function. The Tuned RF Level function enables the instrument to measure the level of frequencies that are drifting, or to determine flatness as a function of carrier frequency.

When the peak tuned RF level measurement is selected, MODULATION OUTPUT/AUDIO INPUT continues to output the demodulated signal corresponding to the last modulation type selected (unless AUDIO INPUT is selected). AM OUTPUT and FM OUTPUT (rear panel) remain active during this measurement.

Procedures

To make a peak tuned RF level measurement, first tune the instrument to the input signal. (Refer to **RF Frequency Tuning** or press AUTOMATIC OPERATION). Press the TUNED RF LEVEL key.

If peak tuned RF level is to be displayed relative to a reference, enter the value as a ratio reference using the RATIO key. (Refer to **Ratio**.)

HP-IB Program Code

LIN results = LN
LOG results = LG
SPCL = SP
VOLTS units = VL
mV units = MV
uV units = UV
WATTS units = WT

Indications

Display: When the TUNED RF LEVEL key is pressed, the peak tuned RF level is displayed. When a measured value is displayed, the selected units annunciator lights, and if the units are linear, the display indicates the measurement in scientific notation; that is, the measured value is followed by a signed, power-of-ten multiplier. The following table shows the annunciator units for linear and logarithmic formats:

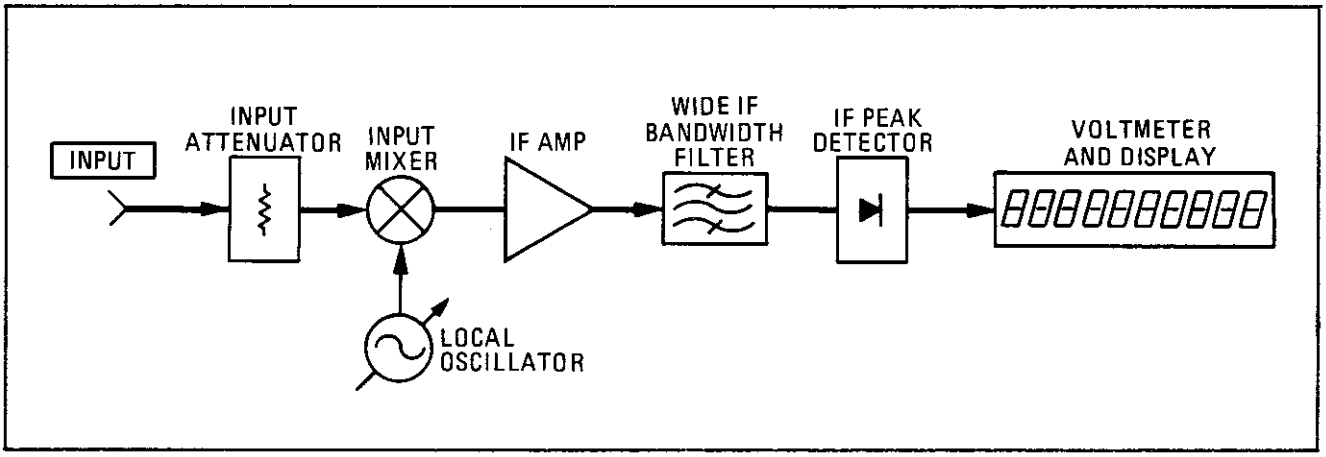
Tuned RF Level (Cont'd)
(Special Function 36)

Linear Unit	Logarithmic Unit
W	dBm
V	dBV
mV	dB mV
μV	dB μV

Front Panel: The LED within the SPCL key lights.

Measurement Technique

When the Modulation Analyzer is tuned, all the power falling within the IF bandpass filter is amplified and peak detected. The power is then measured by the voltmeter and displayed in the selected measurement units.



Tuned RF Level Measurement Block Diagram

Comments

Use an external power sensor to make accurate, absolute power measurements. (Refer to RF Power.)

Related Functions

IF Level
RF Frequency Tuning
RF Power

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