Errata

Title & Document Type: 8901A Modulation Analyzer Operating Manual

Manual Part Number: 08901-90031

Revision Date: January 1980

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

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Agilent no longer sells or supports this product. You will find any other available product information on the Agilent Test & Measurement website:

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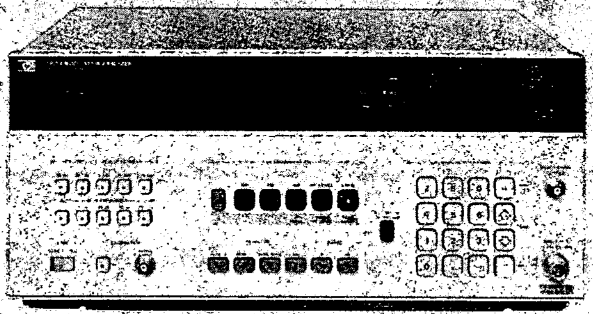
Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

OPERATING MANUAL

8901A Modulation Analyzer



General Information
Installation
Operation

HEWLETT
PACKARD

OPERATING MANUAL

8901A

Modulation Analyzer

(Including Options 001, 002, 003, 004, and 010)

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 1933A, 1925A 1921A, 1918A, 1916A, 1915A, 1911A, 1905A, 1903A, 1901A and 1836A.

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

HEWLETT
PACKARD

1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

OPERATING MANUAL PART NO. 08901-90031
Service Manual Part No. 08901-90032
Operating and Service Manuals Part No. 08901-90033
Operating and Service Manuals Microfiche Part No. 08901-90034

Printed: JANUARY 1980

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.

CAUTIONS 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.

WARNINGS

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.

CONTENTS

CONTENTS (Cont'd)

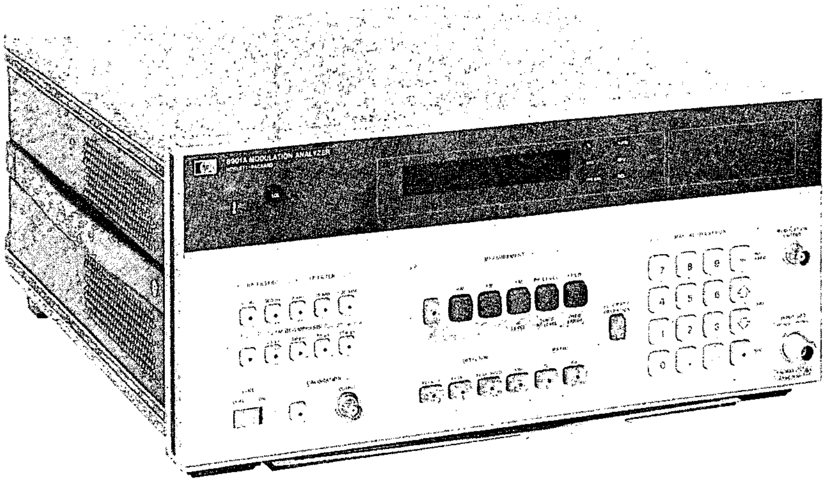
CONTENTS (Cont'd)

Sections IV through VIII
PERFORMANCE TESTS
ADJUSTMENTS
REPLACEABLE PARTS
MANUAL CHANGES
SERVICE

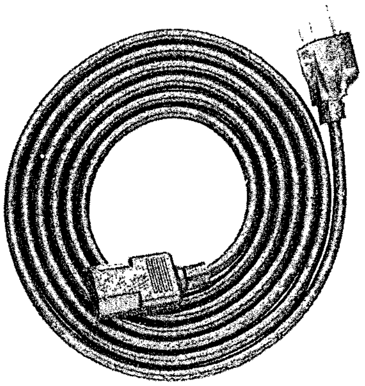
These sections are bound separately with a separate table of contents.

ILLUSTRATIONS

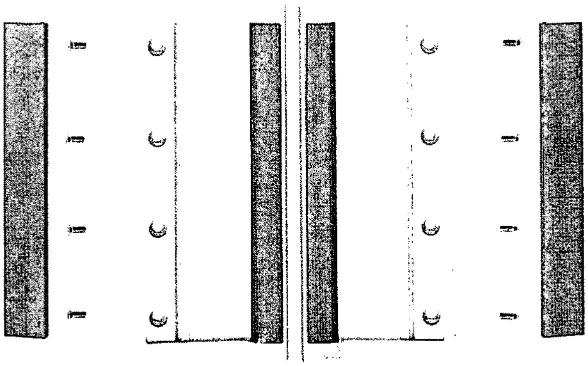
TABLES



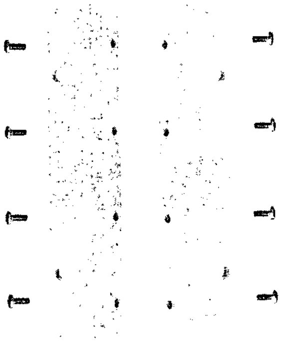
MODEL 8901A



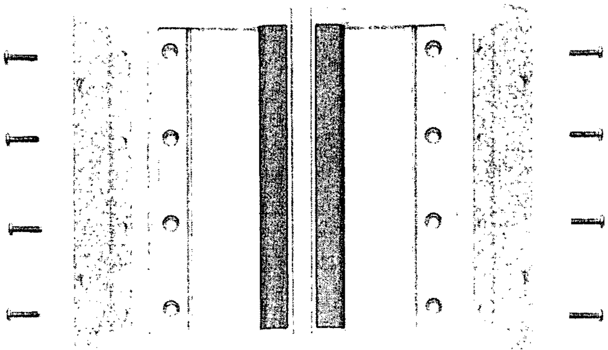
LINE POWER CABLE



OPTION 907
FRONT HANDLE KIT



OPTION 908
RACK FLANGE KIT



OPTION 909
RACK FLANGE AND FRONT
HANDLE COMBINATION KIT

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

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

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

This Operating Manual together with the Service Manual form a two manual set which contains information required to install, operate, test, adjust, and service the Hewlett-Packard Model 8901A Modulation Analyzer. The Modulation Analyzer (with the AM and FM Calibrators, Option 010) is shown in Figure 1-1 with all supplied accessories. These manuals document Modulation Analyzers supplied with Options 001, 002, 003, 004 and 010.

The information contained in both the Operating and Service Manuals is described below. Sections I through III are contained in this Operating Manual; Sections IV through VIII are contained in the 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, and a discussion of basic modulation theory.

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, operating instructions for both local and remote operation and maintenance information.

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 Service Manual title page. In addition, this section also contains recommended modifications for earlier instrument configurations.

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

Two copies of this Operating Manual are supplied with the Modulation Analyzer. One copy of the Operating Manual 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.

Also, on the title pages of each of these manuals below the manual part number, is a microfiche part number. This number may be used to order 100 x 150 mm (4 x 6-inch) microfilm transparencies of the two manual set. Each microfiche contains up to 96 photo-duplicates of the manual pages. The microfiche package also includes the latest Manual Changes supplements.

1-2. SPECIFICATIONS

Instrument specifications are listed in Table 1-1. These are the performance standards, or limits against which the instrument may be tested. Characteristics listed under Supplemental Information, Table 1-2, 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 CONSIDERATIONS (Cont'd)

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, 004, and 010 and various mechanical options are documented in these manuals. The differences are noted under the appropriate paragraph such as Options in Section I, the Replaceable Parts List, and the schematic diagrams.

Serial Numbers. Attached to the instrument is a serial number plate. The serial number is in the form 1234A00123. The first four digits and the letter are the serial prefix. The last five digits form the sequential suffix that is unique to each instrument. The contents of 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 Manual and the Service Manual each are supplied with a Manual Changes supplement for these newer instruments. Each supplement contains change instructions for its respective manual.

In addition to change information, the supplements may 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 pages of the two manuals. Complimentary copies of these supplements are available from Hewlett-Packard.

1-6. DESCRIPTION

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

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

The Modulation Analyzer is fully automatic and all major measurements can be made by pushing a single key. The Modulation Analyzer's large digital dislay 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).[1]

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

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[1] HP-IB is Hewlett-Packard's implementation of IEEE Standard 488 and ANSI Standard MC1.1.

DESCRIPTION (Cont'd)

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

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

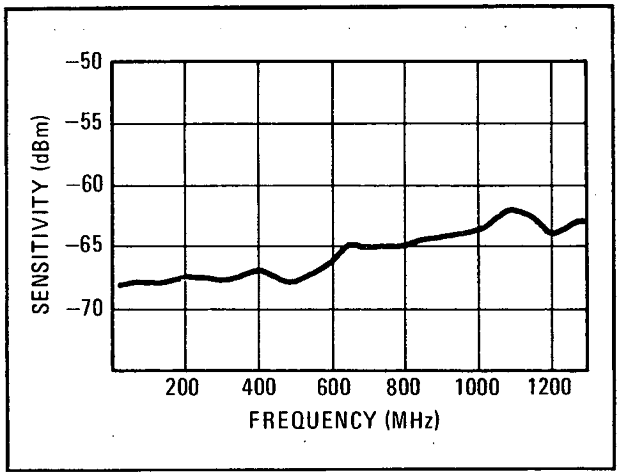


Figure 1-2. Typical Sensitivity of Frequency Measurements in Manual Operation

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

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

The Modulation Analyzer is equipped with input power protection to prevent damage from the accidental application of excessive power. (This is a common cause of damage in equipment used to measure transmitters.) The Modulation Analyzer is tested for inputs up to 25 watts. Protection is provided by 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. This technique is superior to fuses which, in many cases, are too slow for adequate protection and require replacement each time an overload occurs.

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

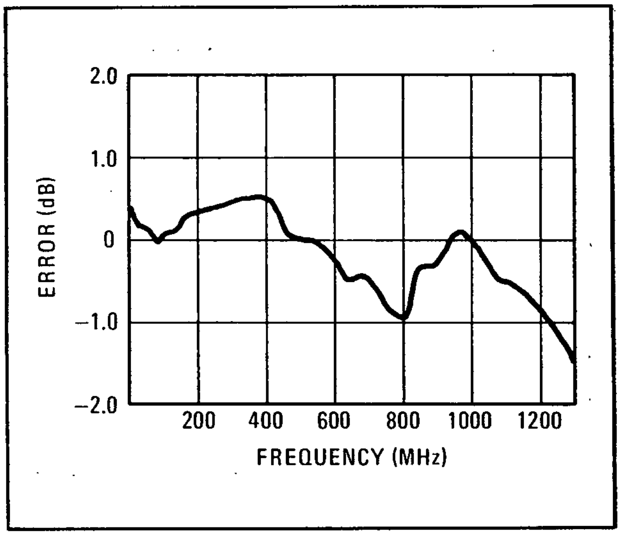


Figure 1-3. Typical Power Measurement Accuracy

DESCRIPTION (Cont'd)

allows some selectivity, one signal can be measured even when others are present.

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

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

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

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

For all AM depth and FM deviation measurements you can select from one of three detectors.

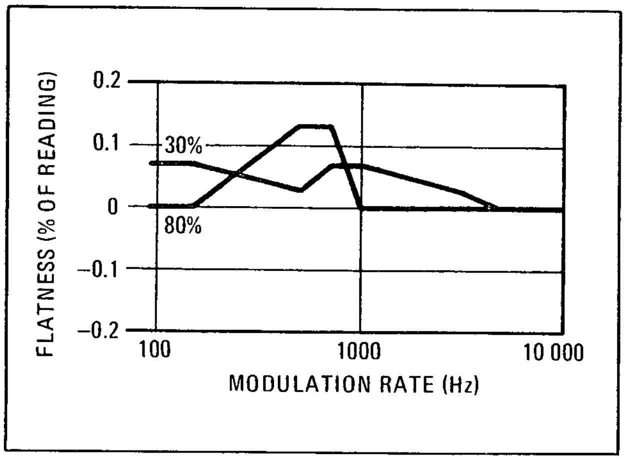


Figure 1-4. Typical AM Flatness

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

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

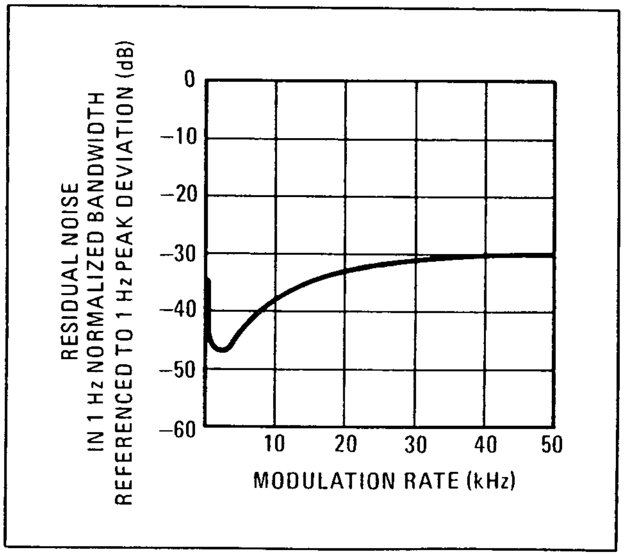


Figure 1-5. Typical Internal Noise Contribution to FM Measurements at 100 MHz Carrier Frequency

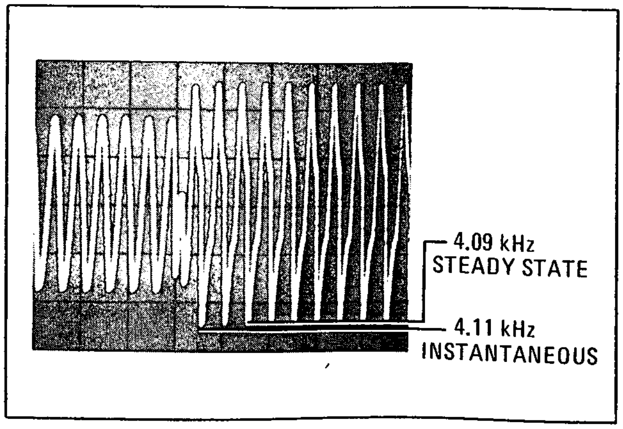


Figure 1-6. FM Mobile Radio Modulation Limiting Measurement Showing Demodulated Waveform and Measured Value of Transient and Steady-State Deviation

DESCRIPTION (Cont'd)

peak that occurs will be measured. Pushing the PEAK HOLD key resets the display and initiates a new measurement cycle.

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

The Modulation Analyzer contains four de-emphasis networks that can be used in addition to the audio filters. These are the ones commonly used in FM communications — 25, 50, 75, and 750 μs. When selected, the de-emphasis networks always affect the demodulated output. You can select whether or not the de-emphasis network affects the deviation measured and indicated by the display. The ability to select either the actual or "de-emphasized deviation" increases the usefulness of the Modulation Analyzer in many applications.

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

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

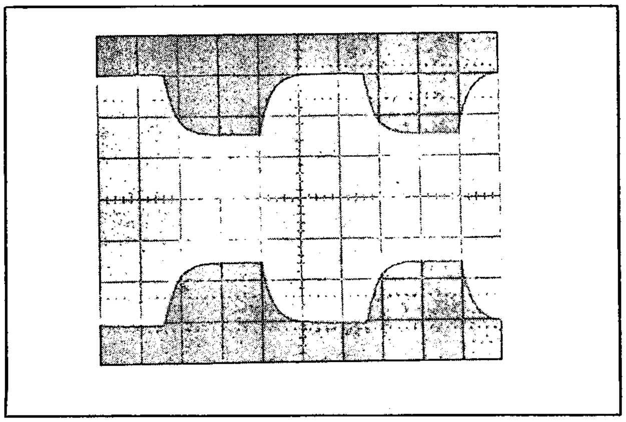


Figure 1-7. AM Calibrator Waveform

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

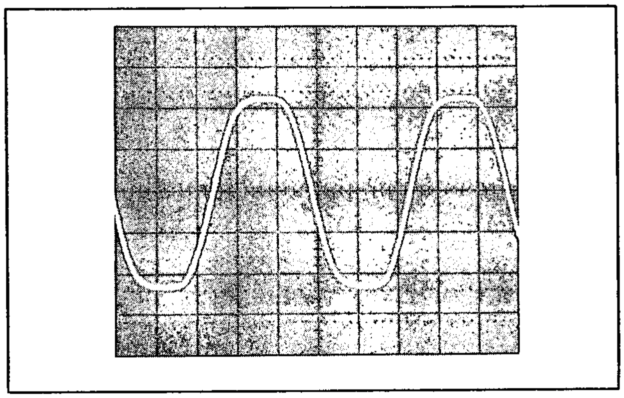


Figure 1-8. FM Calibrator Modulation Waveform

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

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

Operation. Often instruments with state-of-the-art accuracy require highly skilled operators in order to be used. This is not the case with the Modulation Analyzer. It provides excellent accuracy while remaining easy to use. Its front panel is simple, uncluttered, and easy to understand. You need only select the measurement to be made. There is no need to tune, adjust levels, or select the

DESCRIPTION (Cont'd)

appropriate range; the internal microprocessor does it all and quickly. Because the microprocessor determines the optimum instrument settings for you, most measurements require only a single keystroke.

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

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

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

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

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

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

Programmability. The Modulation Analyzer is completely programmable 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 annunciators make it very easy to determine what state the instrument is in.

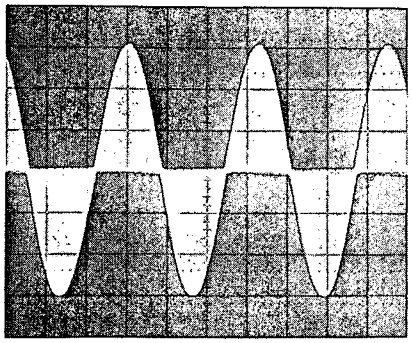


Figure 1-9. Demodulated FM Stereo Test Signal at 15 kHz Rate

1-7. OPTIONS

1-8. Electrical Options

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

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

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

Option 004. This option allows operation at line frequencies ranging from 48 to 440 Hz. Operation at frequencies greater than 66 Hz is restricted to ≤126.5 Vac line input.

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

1-9. Mechanical Options

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

Front Handle Kit (Option 907). Ease of handling is increased with the front-panel handles. Order HP part number 5061-0090.

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.

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 on page 3-26.

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 on page 2-2.

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 on page 2-1.

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

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.

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

ELECTRICAL EQUIPMENT AVAILABLE (Cont'd)

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, and, if installed, CALIBRATION OUTPUT to rear-panel connections. If the instrument to be converted is not equipped with AM and FM calibrators (Option 010), order HP part number 08901-60101. If the instrument has the calibrators, order HP part number 08901-60104. After installation and calibration, performance will be identical to the 8901A Option 001.

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

High Stability Internal Reference Retrofit Kit (HP 08901-60102). 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 8901A Option 003.

Conversion to 400 Hz Line Operation. Modulation Analyzers not equipped to operate at line power frequencies greater than 66 Hz may be converted to operate at line frequencies from 48 to 440 Hz. However, operation at line frequencies greater than 66 Hz will be restricted to line voltages less than or equal to 126.5 Vac. To convert to 400 Hz operation, order HP part number 08901-60095. After installation, performance will be identical to the 8901A Option 004.

AM and FM Calibrators Retrofit Kits. These kits contain all the necessary components and full instructions for installation of the AM and FM calibrators. If the instrument to be equipped with the calibrators has front-panel connectors, order HP part number 08901-60106. If the instrument has rear-panel connectors (Option 001), order HP part number 08901-60107. After installation and calibration, performance will be identical to the 8901A Option 010.

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. Note that the Modulation Analyzer listed in Table 1-3 is required only if the instrument being tested does not already contain the AM and FM Calibrators, Option 010. Table 1-3 also includes some alternate equipment listings. These alternate instruments are highlighted in Table 1-4 which also indicates the possible advantages of using them as substitutes. Table 1-5 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 most easily visualized as a calibrated, superheterodyne receiver; i.e., it is a receiver which converts the incoming signal to a fixed intermediate frequency (IF) which is then demodulated. Like a receiver, the Modulation Analyzer contains an RF input, local oscillator (LO), mixer, IF amplifier and filter, demodulator (detector), and audio filters (tone controls). Unlike a receiver, it has no tuned input, RF amplification, or audio power amplifier. Many other features are added to the instrument to make it more versatile. Some of these are automatic tuning, selectable measurement modes (signal frequency, level, or modulation — AM, FM, or ΦM), peak or average responding detectors, AM and FM calibrators (Option 010), and HP-IB programmability.

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

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

The LO has three main modes of operation:

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

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

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

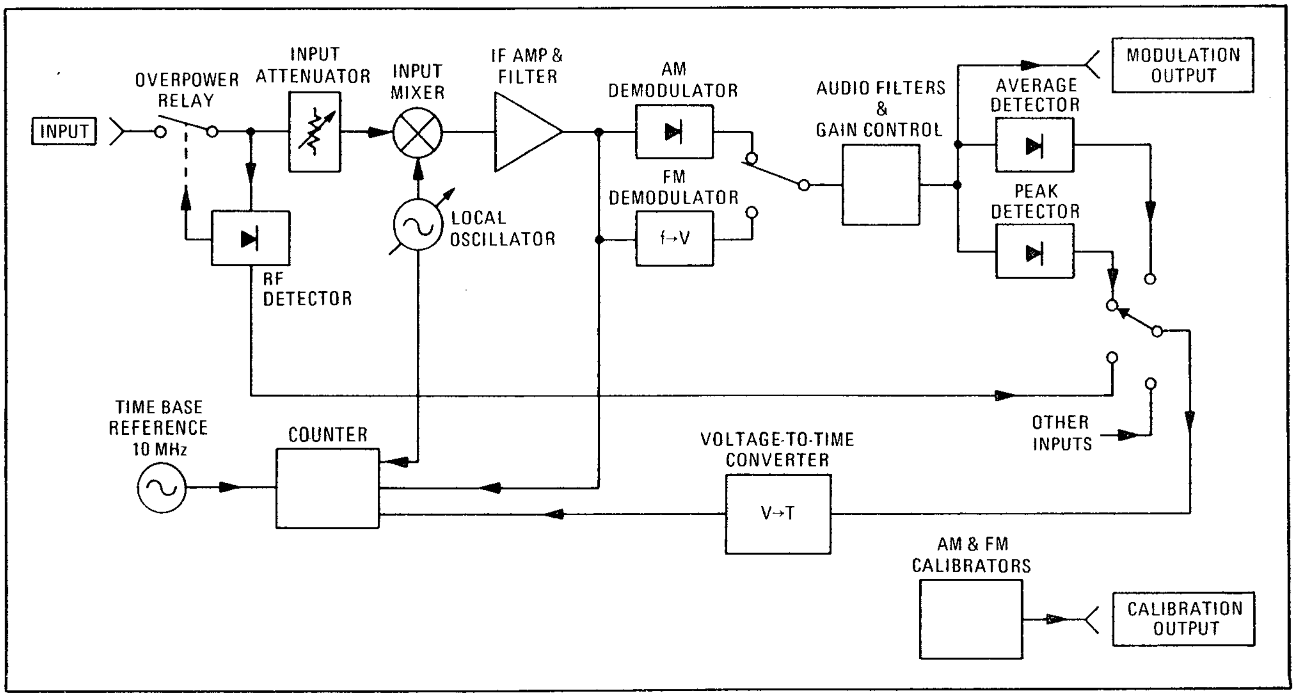


Figure 1-10. HP 8901A Modulation Analyzer Simplified Block Diagram

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

frequency of the LO and the IF, and the Controller subtracts the two. (Below 2.5 MHz, the IF is counted directly as the input frequency.)

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

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

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

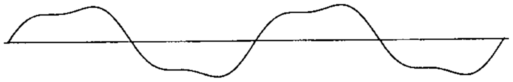
1-16. MODULATION BASICS

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

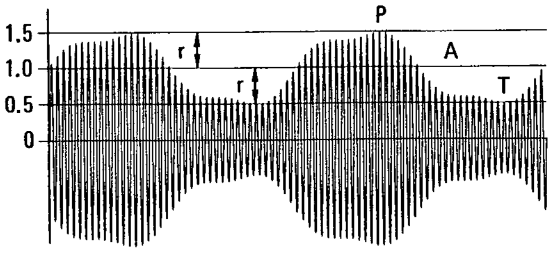
The RF signal which is modulated is called the carrier. The modulating signal is referred to as the baseband signal and can be of any arbitrary form (e.g., voice, tone, noise). Demodulation is the process of recovering the baseband signal from the modulated carrier. The Modulation Analyzer can measure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

1-17. Amplitude Modulation

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



(a) BASEBAND SIGNAL



(b) AMPLITUDE MODULATED CARRIER

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

A quantity which describes the amount of AM or the AM depth is the modulation index. If the peak amplitude is called *P* and the trough amplitude is

MODULATION BASICS (Cont'd)

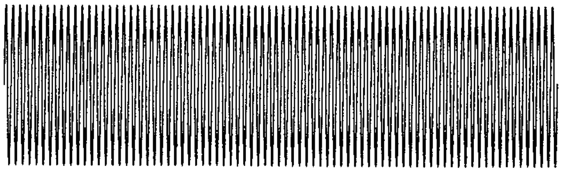
called T, the modulation index m (usually expressed in %) is defined as

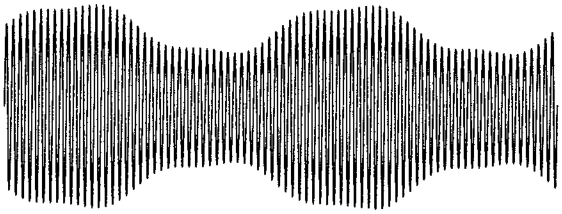
$$m = \frac{P-T}{P+T} \times 100\%.$$

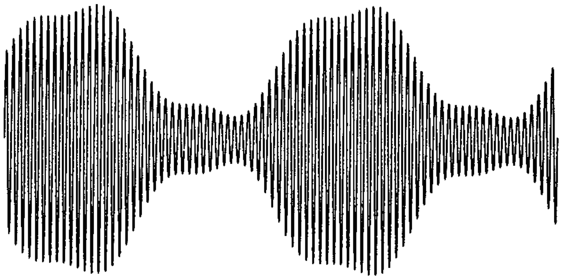
In the example of Figure 1-11, $P=1.5$ and $T=0.5$; therefore,

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

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


(a) 0% AM (CW)


(b) 30% AM


(c) 70% AM

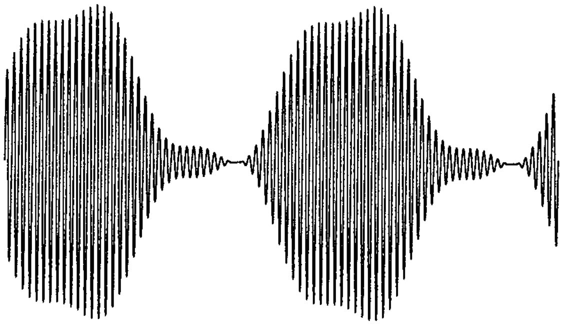

(d) 100% AM

Figure 1-12. AM for Various Depths

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

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

$$= \frac{2r}{2A} \times 100\%$$

$$= \frac{r}{A} \times 100\%.$$

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

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

as before.

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

Figure 1-13 illustrates an AM signal with an asymmetrical baseband source. The first definition of modulation index still applies here. For it,


(a) BASEBAND SIGNAL

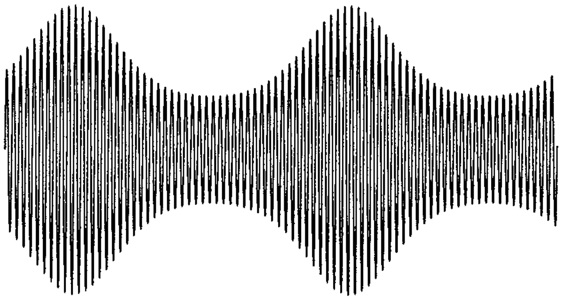

(b) AMPLITUDE MODULATED CARRIER

Figure 1-13. AM with an Asymmetrical Baseband Signal

MODULATION BASICS (Cont'd)

m = 46%. The second definition, however, does not apply since *P–A ≠ A–T*. The Modulation Analyzer detects a different value for *r* if the positive peak of the recovered signal is detected than if the negative peak is detected. Thus a different modulation index is measured in PEAK+ than PEAK–.

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

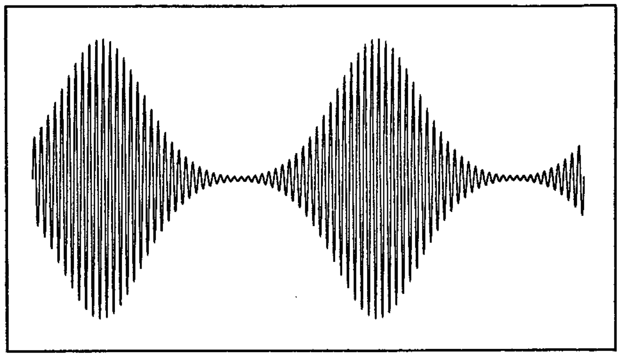
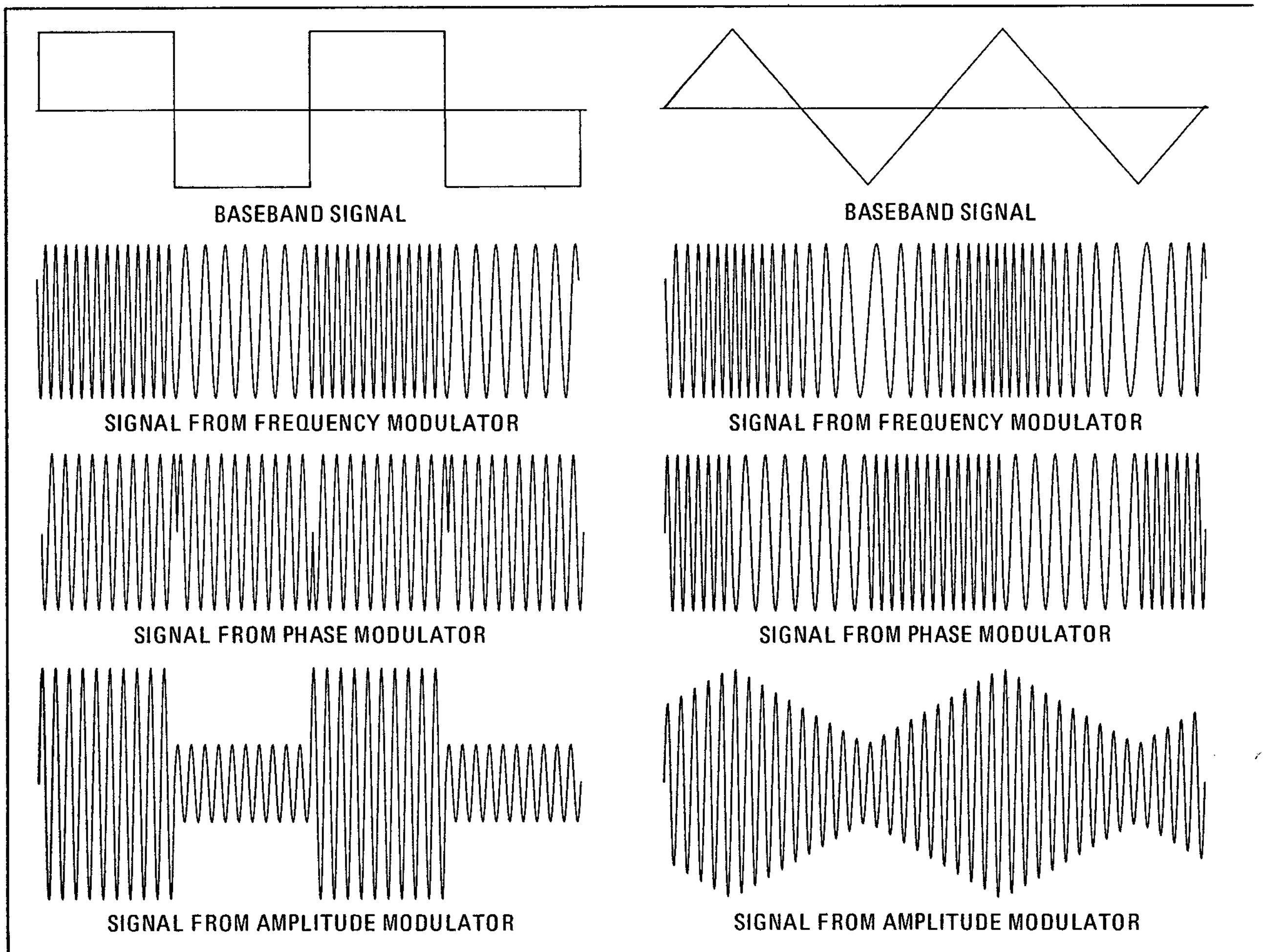


Figure 1-14. AM with Modulation Exceeding 100% as Measured by the PEAK+ Detector

1-18. Exponential Modulation

Exponential (or angular) modulation is the generic name given to modulation in which the frequency or phase of the carrier is varied. Frequency and phase modulation are very closely related.



(a) SQUARE WAVE BASEBAND SIGNAL

(b) TRIANGLE WAVE BASEBAND SIGNAL

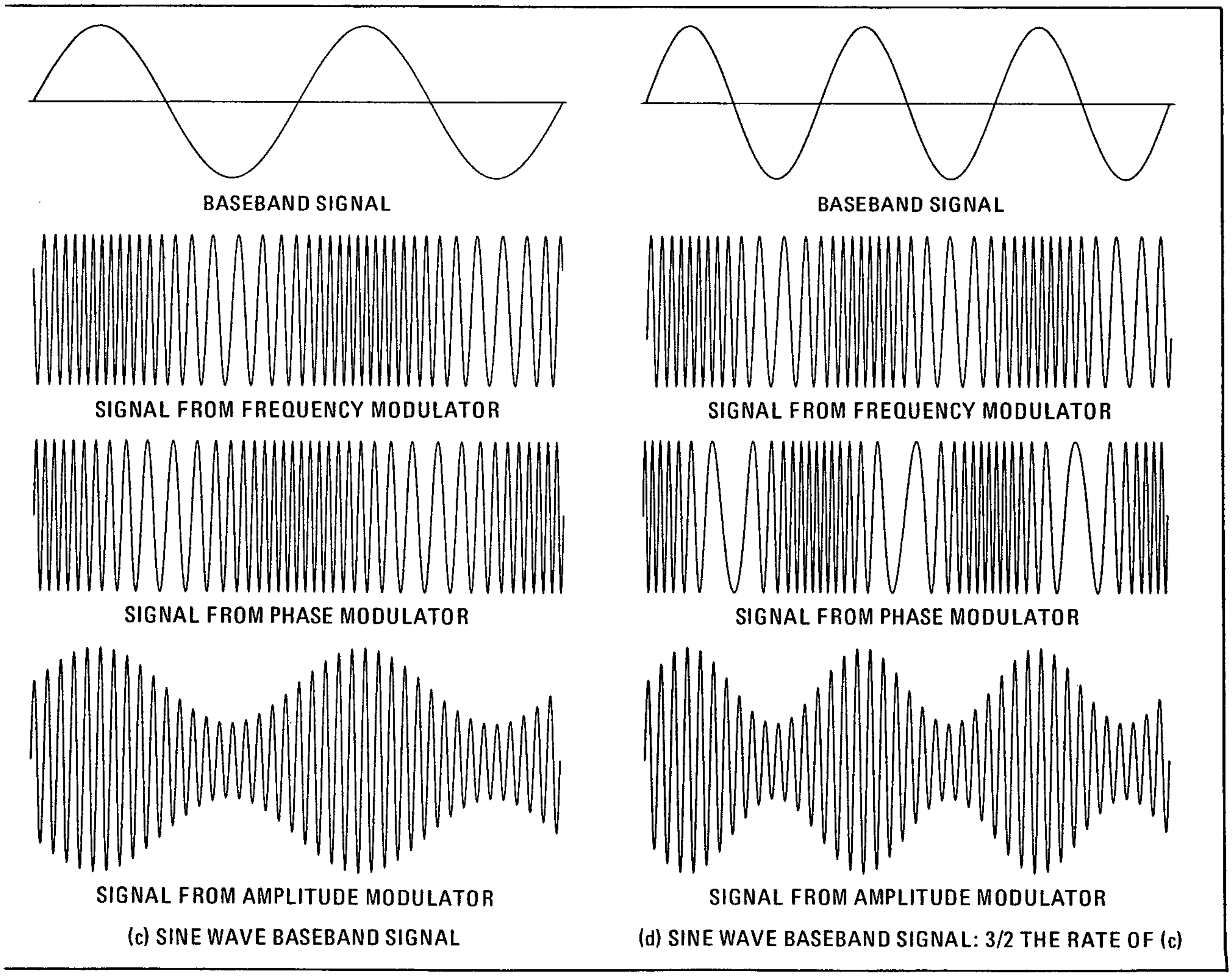
Figure 1-15. Signals from Frequency, Phase, and

In fact, it is impossible to tell whether the signal was produced by a frequency modulator or phase modulator by analyzing the received signal unless specific information about the baseband signal is given.

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

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

This relationship is most easily visualized by some examples. Look at Figure 1-15. The first baseband signal shown is a square wave. The three waveforms under it are the result of applying this signal to an FM, ΦM, and AM modulator respectively. (The AM waveform is included only for reference.) It is assumed that the phase modu-



(c) SINE WAVE BASEBAND SIGNAL

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

Amplitude Modulators for Various Baseband Signals

Exponential Modulation (Cont'd)

lator doesn't produce AM — only ΦM. The FM waveform is as expected. The frequency goes up on the positive peak of the baseband signal and down on the negative peak. The phase modulated signal, however, is peculiar. The frequency is generally constant throughout except for a discontinuity where the baseband signal switches amplitude. The waveform of the figure was contrived so that a 180 degree phase shift occurred exactly at a zero crossing of the carrier. In general, a discontinuity will occur when the baseband signal switches amplitude, but the phase shift is not necessarily 180 degrees and does not need to occur at a zero crossing of the carrier. Mathematically, the derivative of a square wave is the constant zero except for a positive spike (impulse) where the baseband signal switches positive and a negative spike where the square wave switches negative.

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

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

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

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

1-19. Other Considerations

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

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

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

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

Table 1-1. Specifications (1 of 4)

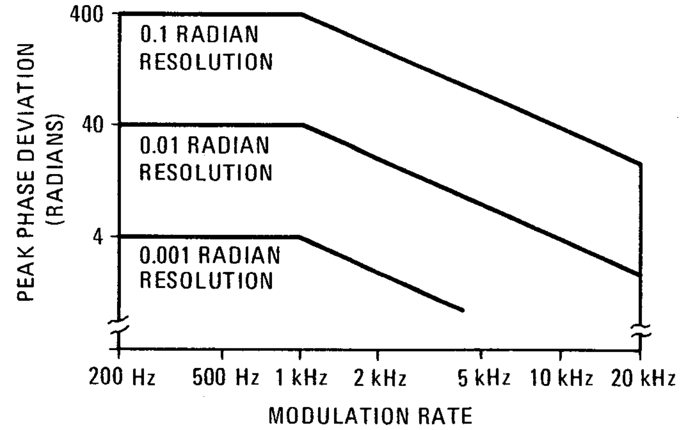
All parameters describe performance in automatic operation or with properly set manual controls.

Electrical Characteristic	Performance Limits	Conditions
RF INPUT		
Frequency Range	150 kHz to 1300 MHz	
Operating Level	12 mVrms (−25 dBm) to 7 Vrms (1W peak)	150 kHz to 650 MHz
	22 mVrms (−20 dBm) to 7 Vrms (1W peak)	650 to 1300 MHz
Input Impedance	50Ω nominal	
FREQUENCY MODULATION		
Rates	20 Hz to 10 kHz	150 kHz to 10 MHz carrier
	20 Hz to 200 kHz	10 to 1300 MHz carrier
	20 Hz to 20 kHz	10 to 1300 MHz carrier; 750 μs de-emphasis
Deviations	40 kHz peak maximum	150 kHz to 10 MHz carrier
	400 kHz peak maximum	10 to 1300 MHz carrier
	40 kHz peak maximum	10 to 1300 MHz carrier; 750 μs de-emphasis
Accuracy[1]	±2% of reading ±1 digit	250 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates
	±1% of reading ±1 digit	10 to 1300 MHz carrier; 50 Hz to 100 kHz rates
	±5% of reading ±1 digit	10 to 1300 MHz carrier; 20 Hz to 200 kHz rates
Demodulated Output Distortion[2]	<0.1% THD	400 kHz to 10 MHz carrier; deviations <10 kHz
	<0.1% THD	10 to 1300 MHz carrier; rates and deviations <100 kHz
AM Rejection[1]	<20 Hz peak deviation	50% AM at 400 Hz and 1 kHz rates; 50 Hz to 3 kHz BW
Residual FM	<8 Hz rms at 1300 MHz decreasing linearly with frequency to <1 Hz rms for 100 MHz and below	50 Hz to 3 kHz BW
PHASE MODULATION		
Carrier Frequency	10 to 1300 MHz	
Rates	200 Hz to 20 kHz	
Deviation and Maximum Resolution	Refer to Figure 1-16.	
Accuracy[1]	±3% of reading ±1 digit	
Demodulated Output Distortion	>0.1% THD	
AM Rejection[1]	<0.03 radians peak deviation	50% AM at 1 kHz rate, 50 Hz to 3 kHz BW

[1] Peak residuals must be accounted for in peak readings.

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

Table 1-1. Specifications (2 of 4)

Electrical Characteristic	Performance Limits	Conditions
PHASE MODULATION (cont'd)		
 Figure 1-16. Phase Modulation Deviation and Maximum Resolution		
AMPLITUDE MODULATION		
Rates	20 Hz to 10 kHz 20 Hz to 100 kHz	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier
Depth	To 99%	
Accuracy[1, 2]	±2% of reading ±1 digit	150 kHz to 10 MHz carrier; 50 Hz to 10 kHz rates; >5% depth
	±3% of reading ±1 digit	150 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates
	±1% of reading ±1 digit	10 to 1300 MHz carrier; 50 Hz to 50 kHz rates; >5% depth
	±3% of reading ±1 digit	10 to 1300 MHz carrier; 20 Hz to 100 kHz rates
Flatness (Variation in indicated AM depth for constant depth on input signal)	±0.3% of reading ±1 digit	10 to 1300 MHz carrier; 90 Hz to 10 kHz rates; 20 to 80% depth
Demodulated Output Distortion	<0.3% THD <0.6% THD	≤50% depth ≤95% depth
FM Rejection[1]	<0.2% AM	250 kHz to 10 MHz carrier; <5 kHz peak deviation at 400 Hz and 1 kHz rates; 50 Hz to 3 kHz BW
	<0.2% AM	10 to 1300 MHz carrier; <50 kHz peak deviation at 400 Hz and 1 kHz rates; 50 Hz to 3 kHz BW
Residual AM	<0.01% rms	50 Hz to 3 kHz BW

[1] Peak residuals must be accounted for in peak readings.

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

Table 1-1. Specifications (3 of 4)

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

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

Table 1-1. Specifications (4 of 4)

Electrical Characteristic	Performance Limits	Conditions
CALIBRATORS (Option 010) (cont'd)		
FM		
Deviation	34 kHz peak nominal	
Calibration Factor Accuracy	±0.1%	
GENERAL		
Power Requirements		
Line Voltage:		
100, 120, 220, or 240 Vac	+5%, −10%	48 to 66 Hz (including Option 004)
100, 120 Vac	+5%, −10%	48 to 440 Hz (Option 004 only)
Power Dissipation	200 V•A maximum	
Remote Operation (HP-IB)	IEEE STD 488-1978 Compatibility code: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0	The Hewlett-Packard Interface Bus (HP-IB) is Hewlett-Packard Company's implementation of IEEE Std 488-1978, "Digital Interface for Programmable Instrumentation". All functions except the line switch are remotely programmable.
Conducted and Radiated Electromagnetic Interference	MIL STD 461A, VDE 0871 (Level B), and CISPR publication 11	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.
Conducted and Radiated Electromagnetic Susceptibility	MIL STD 461A-1968	Meets the requirements of methods CS01, CS02, and RS03 (1 volt/metre) of MIL STD 461A dated 1968.
Net Weight	20 kg (44 lb) nominal	
Dimensions:		
Height	190 mn (7.5 in.) nominal	
Width	425 mm (16.8 in.) nominal	
Depth	468 mm (18.4 in.) nominal	
Temperature:		
Operating	0 to 55°C	
Storage	−55 to 75°C	

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

All parameters describe performance in automatic operation or with properly set manual controls.

RF INPUT

Tuning:

Manual Frequency Entry
Automatic
Track (frequencies >10 MHz only).

Acquisition Time (Automatic Operation):

~1.5 seconds.

Maximum Safe Input Level:

AC: 35 Vrms (25W for source SWR <4)
DC: 40V.

FREQUENCY MODULATION

Maximum Deviation Resolution:

1 Hz, < 4 kHz deviation
10 Hz, 4 to 40 kHz deviation
100 Hz, 40 to 400 kHz deviation
Resolution is increased one digit with 750 μs de-emphasis and pre-display "on".

Demodulated Output Distortion:

150 to 400 kHz carrier; deviations <10 kHz: <0.3% THD.

Detectors:

+Peak
–Peak
Average (rms sine wave calibrated).

Demodulated Output (600Ω) Across an Open Circuit:[1]

1 mV/Hz when resolution is 1 Hz
0.1 mV/Hz when resolution is 10 Hz
0.01 mV/Hz when resolution is 100 Hz.

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
Average (rms sine wave calibrated).

Demodulated Output (600Ω) Across an Open Circuit:[1]

1 V/radian when resolution is 0.001 radian
0.1 V/radian when resolution is 0.01 radian
0.01 V/radian when resolution is 0.1 radian.

AMPLITUDE MODULATION

Maximum Depth Resolution:

0.01% for depths <40%
0.1% for depths 40 to 100%.

Detectors:

+Peak (peak)
–Peak (trough)
Average (rms sine wave calibrated).

Demodulated Output (600Ω) Across an Open Circuit:[1]

0.1 V/percent when resolution is 0.01%
0.01 V/percent when resolution is 0.1%.

FREQUENCY COUNTER

Modes:

Frequency
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 via the keyboard):

0.22 mVrms (–60 dBm).

Maximum Resolution:

10 Hz for frequencies <1 GHz
100 Hz for frequencies ≥1 GHz.

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 LEVEL

Resolution:

0.1 mW for levels from 0.1 to 1W
0.01 mW for levels from 0.01 to 0.1W
0.001 mW for levels <0.01W.

---

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

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

AUDIO FILTERS AND FM DE-EMPHASIS

Overshoot on Square Wave Modulation with >20 kHz Low Pass Filter in: <1%.

>20 kHz Low Pass Filter 3 dB Frequency: 110 kHz typical.

High- and Low-Pass Filter 3 dB Frequency Accuracy: ±3%.

FM De-emphasis Filter 3 dB Frequencies:

25 μs: 6366 Hz
50 μs: 3183 Hz
75 μs: 2122 Hz
750 μs: 212 Hz.

FM De-emphasis Filter Time Constant Accuracy: ±3%.

REAR PANEL INPUTS/OUTPUTS

FM Output: 10 kΩ impedance, −9 to 6V into an open circuit, ~6 V/MHz, dc coupled, 16 kHz bandwidth (one pole).

AM Output: 10 kΩ impedance, −4 to 0V into an open circuit, ~8 mV/%, dc coupled, 16 kHz bandwidth (one pole).

Recorder Output: DC voltage proportional to peak voltage of the MODULATION OUTPUT, 1 kΩ impedance, 0 to 4V for each resolution range into an open circuit.

IF Output: 50Ω impedance, 150 kHz to 2.5 MHz, −27 to −3 dBm.

10 MHz Reference Output: 50Ω impedance, TTL levels (0 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: >500Ω impedance, 0.5V peak-to-peak minimum input level. (External reference accuracy affects accuracy of all measurements.)

LO Input (Option 003): 50Ω impedance, ~1.27 to 1301.5 MHz, 0 dBm.

CALIBRATORS (Option 010)

Carrier Frequency: 10.1 MHz nominal.

Modulation Rate: 10 kHz nominal

Output Level: −25 dBm nominal.

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

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
Audio Synthesizer	Frequency Range: 20 Hz to 400 kHz Output Level: +15 dBm (50Ω) maximum Frequency Accuracy: ±0.1% Level Flatness: ±0.01 dB from 90 Hz to 10 kHz; ±0.02 dB from 50 Hz to 100 kHz; ±0.05 dB from 20 Hz to 200 kHz. Distortion: <−50 dB from 20 Hz to 200 kHz	HP 3320B	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 (see Table 1-4)	C, P, T
Distortion Measurement Set	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 600Ω Oscillator Distortion: <−70 dB Oscillator Frequency Accuracy: ±2%	HP 339A	P, A, T

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

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

Instrument Type	Critical Specifications	Suggested Model	Use*
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 MΩ Ohms Accuracy: ±1%	HP 3455A	A, T
Frequency Standard	Accuracy: ±0.1 ppm recommended	House Standard	A
Modulation Analyzer (required only for Modulation Analyzers that do not contain Option 010)	AM Calibration Factor Accuracy ±0.1% FM Calibration Factor Accuracy ±0.1% Compatible with 8901A	HP 8901A Option 010	P, A
Oscilloscope	Bandwidth: less than 3 dB down 0 to 100 MHz Sensitivity: 5 mV per division minimum Input Impedance: 10 MΩ and 50 Ω Triggering: External and Internal	HP 1740A	C, A, T
Power Meter/ Power Sensor	Frequency Range: 150 kHz to 1300 MHz Impedance: 50Ω Instrumentation Accuracy: ±1% SWR: <1.1	HP 435A/8482A or HP 436A/8482A (see Table 1-4)	P
Power Splitter	Frequency Range: 150 kHz to 1300 MHz Impedance: 50Ω SWR: <1.1 Tracking: <0.25 dB	HP 11667A	P, A, T
Power Supply	Output Range: 0 to 25 Vdc	HP 6215A	T
RF Spectrum Analyzer	Frequency Range: 0 to 2 GHz Input Level: +10 dBm maximum Display Range: 60 dB	HP 8555A/8552B/141T or HP 8566A (see Table 1-4)	A, T
Service Accessory Kit	No substitution recommended.	HP 08901-60089	T
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%	HP 8640B Option 001/002	C,P,A T

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

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

Instrument Type	Critical Specifications	Suggested Model	Use*
Signal Generator (Cont'd)	AM Accuracy: ±10% FM Range: 0 to 400 kHz peak deviation FM Accuracy: ±10%		
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: 50Ω Directivity: >40 dB Connectors: Type N	Wiltron 60N50	P

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

Table 1-4. Recommended Alternate Test Equipment

Instrument Type	Suggested Alternate	Instrument Replaced	Advantages of Alternate
Computing Controller	HP 9835A/98034A/ 98332A	HP 9825A/98034A/98213A	CRT Display; ANSI Basic Larger Memory
Power Meter/ Power Sensor	HP 436A Option 022/ 8482A	HP 435A/8482A	HP-IB*
RF Spectrum Analyzer	HP 8566A	HP 8555A/8552A/ 141T	HP-IB*

*HP-IB is Hewlett-Packard's implementation of the IEEE Std. 488 and the identical ANSI Standard MC1.1

Table 1-5. 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 ping 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.

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.

WARNINGS

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 card 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 2110-0002, 2A (250V normal blow) for 100/120 Vac operation and 2110-0001, 1A (250V, normal blow) for 220/240 Vac operation.

2-6. Power Cables

WARNING

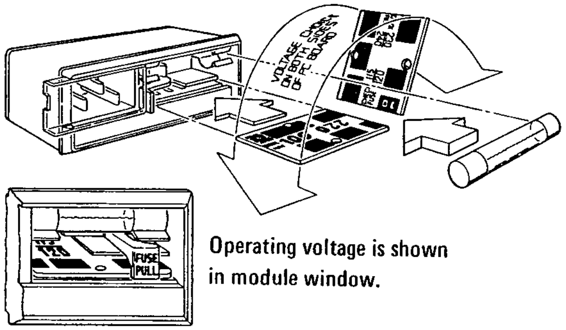
BEFORE CONNECTING THIS INSTRUMENT, the protective earth terminals of

(continued)

Power Cables (Cont'd)

WARNING

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).



Operating voltage is shown in module window.

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.

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).

Figure 2-1. Line Voltage and Fuse Selection

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

2-7. HP-IB Address Selection

WARNINGS

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

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

In the Modulation Analyzer, the HP-IB talk and listen addresses are selectable by an internal switch. The following procedure explains how the switches are to be set. Refer to Table 2-1 for a listing of the talk and listen addresses. The address 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.

a. Disconnect the line (Mains) power cable.

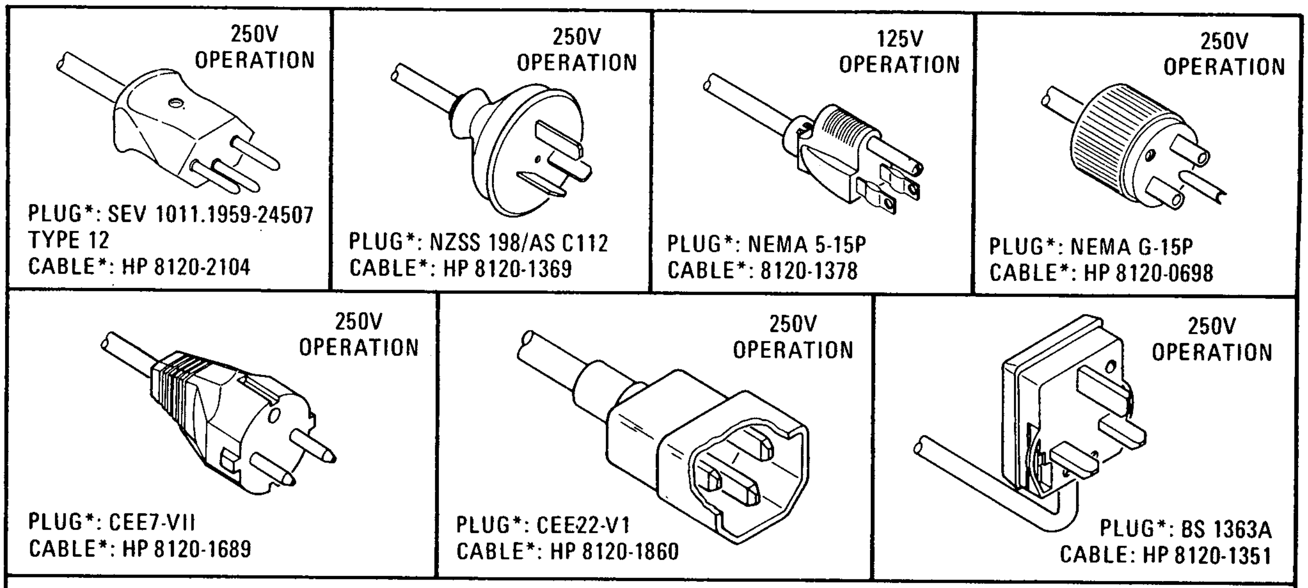
b. Remove any HP-IB cables or connectors from the HP-IB connector.

c. Remove the Modulation Analzyer's top cover.

1. Remove the two plastic feet from the rear of the top cover by removing the pan-head Pozidriv screw within each foot.
2. 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.
3. Lift off the top cover.

d. 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.

e. 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 2-3. Facing the board, the left hand switch (marked with a "5") is the most significant address



*The number shown for the plug is the industry identifier for the plug only.
The number shown for the cable is an HP part number for a complete cable including the plug.

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

HP-IB Address Selection (Cont'd) HP-IB

bit (A5 in Table 2-1). 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.)

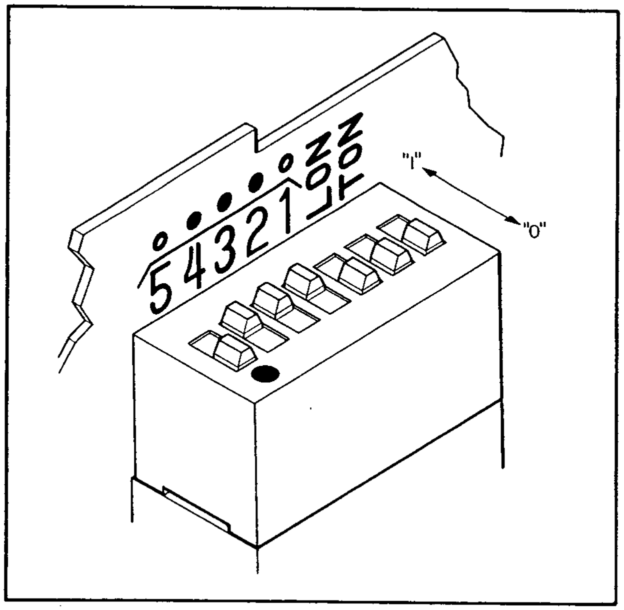


Figure 2-3. The HP-IB Address Switch Shown as Set by the Factory. The Address Shown is 01110 in Binary With Both Talk Only and Listen Only Off.

f. Reinstall the top cover by reversing the procedure in step c above.

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

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

2-8. Interconnections

Interconnection data for the Hewlett-Packard Interface Bus is provided in Figure 2-4.

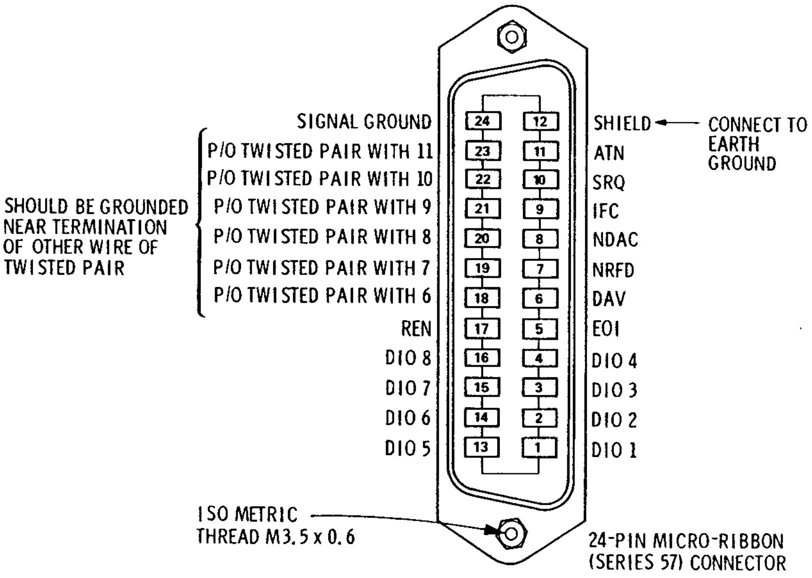
2-9. Mating Connectors

Interface Connector. The HP-IB mating connector is show in Figure 2-4. Note that two securing screws are metric.

Coaxial Connectors. Coaxial mating connectors used with the Modulation Analyzer should 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:



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 10631A, 1 metre (3.3 ft), HP 10631B, 2 metres (6.6 ft)
HP 10631C 4 metres (13.2 ft), HP 10631D, 0.5 metres (1.6 ft)

Cabling Restrictions

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6 ft) of connecting cable per instrument.
2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20.0 metres (65.6 ft).

Figure 2-4. Hewlett-Packard Interface Bus Connection

Operating Environment (Cont'd)

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

HP-IB Table 2-1. Allowable HP-IB Address Codes

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

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 (20 kg, 44 lb). Care must be exercised when lifting to avoid personal injury. Use equipment slides when rack mounting.

Rack mounting information is provided with the rack mounting kits. If the kits were not ordered with the instrument as options, they may be ordered through the nearest Hewlett-Packard office. Refer to 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 "a" and "b" of the pull-out card removal procedure below.

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

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

a. Remove the two front feet of the instrument.

b. Remove the Operating Information tray assembly by sliding the tray toward the rear of the instrument and then down.

c. Remove the information card by bowing it 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 card:

a. 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.

b. Push the information card all the way into the tray.

c. 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.

Removal and installation of Operating Information Pull-Out Card (Cont'd)

d. 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:

a. 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.)

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

c. 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.

d. Seal the shipping container securely.

e. 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. Also included is a basic exercise designed to acquaint the novice operator with the Modulation Analyzer's operating characteristics.

3-3. Operating Characteristics

Table 3-1 briefly summarizes the major operating characteristics of the Modulation Analyzer. The table is not intended to be an in-depth listing of all operations and ranges but gives a rough idea of the instrument's capabilities. For more information on Modulation Analyzer capabilities, refer to Description on page 1-2, Table 1-1, Specifications on page 1-15; and Table 1-2; Supplemental Information on page 1-19. For information on HP-IB capabilities, refer to the summary contained in Table 3-3, Message Reference Table on page 3-27.

3-4. Turn-On Procedure

WARNINGS

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.

CAUTIONS

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 page 2-1.

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

The Modulation Analyzer has a standby state and an on state. Whenever the power cable is plugged in, an internal power supply is activated. In instruments supplied with the high-stability reference (Option 002) the supply energizes the internal reference oven. If the Modulation Analyzer is already plugged in, set the LINE switch to ON. If the power cable is not plugged in, follow these instructions.

1. Check that the line voltage setting matches the power source (see Figure 2-1 on page 2-2).
2. Check that the fuse rating is appropriate for the line voltage used (see Figure 2-1 on page 2-2). Fuse ratings are given under Operator's Maintenance on this foldout.
3. Plug in the power cable.
4. Set the LINE switch to ON.

NOTE

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

3-5. Local Operation

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

Simplified Operation. Located on the inside of this fold, Simplified Operation provides a quick introduction to front-panel operation of the Modula-

Local Operation (Cont'd)

tion Analyzer. It is designed to rapidly orient the novice user with basic operating procedures and therefore is not an exhaustive listing of all Modulation Analyzer functions. However, an index to the Detailed Operating Instructions appears opposite the fold to guide the operator to the more complete discussion of the topic of interest.

Getting Acquainted. Located on page 3-4 is an informal exercise entitled Getting Acquainted. This exercise is intended to familiarize the first-time operator with basic Modulation Analyzer operating procedures. It provides a simple walk-through of many Modulation Analyzer functions and discusses a number of the instrument's capabilities. Only a signal generator, oscilloscope, and interconnecting cables and adapters are required.

Panel Features. Front-panel controls, indicators, and connectors are illustrated and described in Figures 3-3 to 3-5 beginning on page 3-10. These figures describe the functions of the various key groups and summarize briefly how to use them. Rear-panel features are shown in Figure 3-6 on page 3-13. The figure provides a good quick reference for rear-panel signal levels and frequencies and also includes the impedances at the rear-panel connections.

Detailed Operating Instructions. The Detailed Operating Instructions starting on page 3-44 provide the complete operating reference for the Modulation Analyzer user. The instructions are organized alphabetically by subject. Not only do the instructions contain information on the various measurements that can be made (listed under titles such as AM, FM, ΦM, Frequency, and Level) but there are also individual discussions of nearly all controls, inputs, and outputs (e.g., Filtering, FM De-emphasis, Ratio, IF Output, etc.). Also included are instructions for using the many User Special Functions (e.g., Attenuation, Input; Modulation Range; Error Disable; Special Functions; etc.).

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

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

**FRONT-PANEL FEATURES
AND SIMPLIFIED OPERATION** ➧

Supplemental Information. In addition to the information described above, several other discussions pertinent to operating the Modulation Analyzer to its fullest capabilities are contained in Section I of this manual. Principles of Operation for a Simplfied Block diagram (on page 1-9) is a fundamental description of what the Modulation Analyzer is and how it works. This information supplements the block diagrams given in the Detailed Operating Instructions and provides a basis for applying the Modulation Analyzer to various measurement situations. Modulation Basics (on page 1-10), covers the theory behind amplitude, frequency, and phase modulation. It contains numerous illustrations of the various types of modulation the Modulation Analyzer can measure and is intended to provide an intuitive grasp of carrier modulation rather than an in-depth mathematical analysis.

3-6. Remote Operation HP-IB

The Modulation Analyzer is capable of remote operation via the Hewlett-Packard Interface Bus (HP-IB). Instructions pertinent to HP-IB operation begin on page 3-26. Covered there are all considerations and instructions specific to remote operation including capabilities, addressing, input and output formats, the status byte, and service requests. At the end of the discussion is a complete summary of all codes and formats.

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

3-7. Operator's Checks

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

Basic Functional Checks. This procedure, beginning on page 3-14, requires only a signal generator, an oscilloscope, and interconnecting cables and adapters. It assures that most front-panel controlled functions are being properly executed by the Modulation Analyzer.

HP-IB Functional Checks. This series of procedures, beginning on page 3-18, require 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 (e.g., by performing the Basic Functional Checks). The procedures check all of the applicable bus messages summarized in Table 3-3.

3-8. Operator's Maintenance

WARNING

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

The only maintenance the operator should normally perform is the replacement of the primary power fuse located within the Line Power Module (A31). For instructions on how to change the fuse, refer to Figure 2-1, steps 1 and 3.

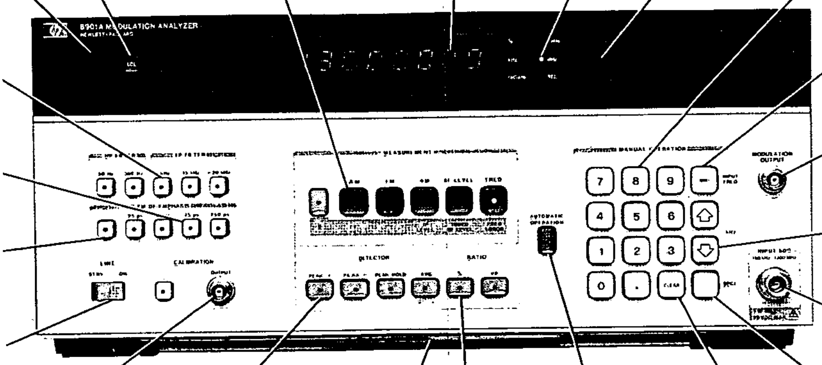
Operator's Maintenance (Cont'd)

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

Table 3-1. Operating Characteristics Summary

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

FRONT-PANEL FEATURES



HP-IB Annunciators indicate remote operation status.

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

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

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

Display Annunciators indicate the measurement result units.

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

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

FM DE-EMPHASIS networks equalize pre-emphasized FM.

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

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

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

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

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

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

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

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

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

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

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

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

INPUT couples modulated signal into the instrument.

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

For more on panel features, see Figures 3-3 through 3-6 on pages 3-10 through 3-13.

Figure 3-1. Front Panel Features

SIMPLIFIED OPERATION

TUNING

Automatic:

Press: AUTOMATIC OPERATION .

Manual:

Input Frequency:

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

MZ MHz INPUT FREQ

Frequency Step:

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

⇧ kHz , or ⇩ kHz .

MEASUREMENT

Modulation:

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

Level:

Press. RF LEVEL ● ; or tune, then press: ● S ● IF LEVEL , or ● S ● TUNED RF LEVEL .

Frequency:

Tune, then press: FREQ ● or ● S ● FREQ ERROR ; or

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

then press: MZ MHz INPUT FREQ ● S ● FREQ ERROR .

DETECTOR

In general:

Press: AM ● , FM ● , or ΦM ● , then PEAK + ● , PEAK − ● , or AVG ● RMS CAL .

Peak Hold:

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

FILTERS

High-Pass or Low-Pass:

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

FM De-emphasis (FM only):

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

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

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

RATIO

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

Press: % ⊡ for 100% or dB ⊡ for 0.00 dB

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

Enter the value using the numeric keyboard, then press:

% ⊡ or dB ⊡.

CALIBRATION (Option 010 only)

Connect a 50Ω cable from CALIBRATION OUTPUT to INPUT.

AM:

Press: AM ⊡ CALIBRATION ⊡.

FM:

Press: FM ⊡ CALIBRATION ⊡.

Table 3-2. Detailed Operating Instructions Table of Contents (Functional)

GETTING ACQUAINTED

3-9. GETTING ACQUAINTED WITH THE 8901A MODULATION ANALYZER

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

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

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

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

CAUTION

Before the Modulation Analyzer is switched on, it must be set to the voltage of the power source, or damage to the instrument may result. Refer to page 2-1.

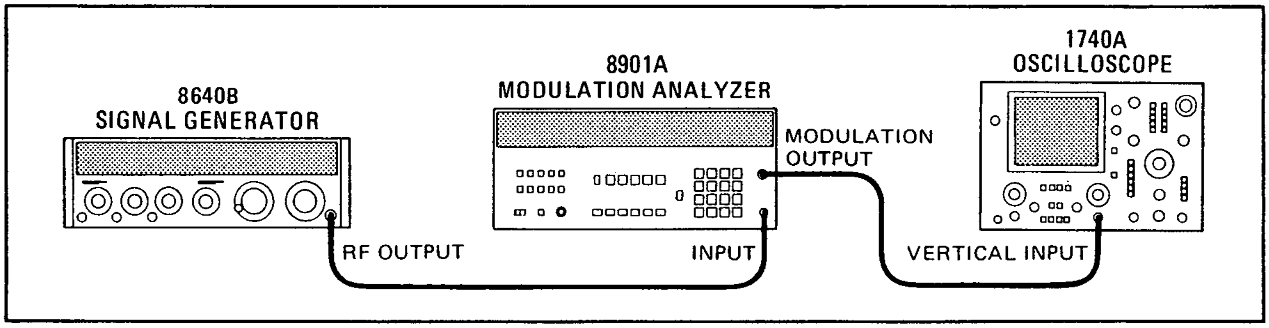
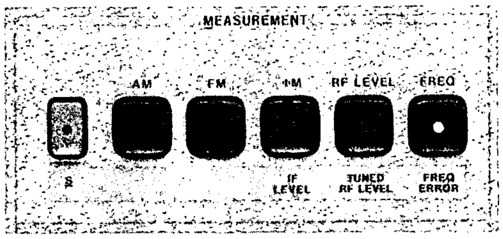


Figure 3-2. Getting Acquainted Setup

Measurements



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

At power-up, the Modulation Analyzer goes through a series of operational self-checks. One of the checks is to turn on all front-panel LEDs for a few seconds. After completing the self-checks, "— —"

GETTING ACQUAINTED

Measurements (cont'd)

may appear in the display, indicating that the Modulation Analyzer is searching for a signal; then "— — — —" will appear, indicating that the signal has been found but measurement results are not yet ready.

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

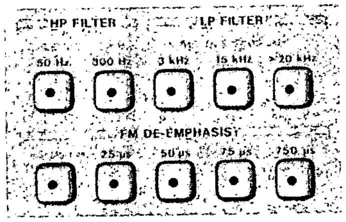
RF Level Measurement. Press RF LEVEL. The display now shows the generator's output power in watts using scientific notation. The "–03" at the right end of the display is the power-of-ten multiplier, i.e., "milli" watts.

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

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

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

Audio Filters and FM De-emphasis



NOTE

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

Signal Generator		*Modulation Analyzer*	
Output Level	*1 mW to 1 W*	*MEASUREMENT*	*FM*
Frequency	*150 kHz to 1300 MHz*	*DETECTOR*	*PEAK+*
Modulation	*FM only*	*HP & LP FILTERS**	*ALL OFF*
		FM DE-EMPHASIS	*off*
		RATIO	*off*

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

Audio Filters. The power-up mode for the Modulation Analyzer is with all filters and de-emphasis off unless the carrier frequency is less than 10 MHz, in which case the 15 kHz low-pass filter is in. Adding filters limits the bandwidth of the demodulated signal, and hence, may reduce the displayed modulation level. To see this, press 3 kHz. Now change the generator's modulation rate above and below

GETTING ACQUAINTED

Audio Filters and FM De-emphasis (cont'd)

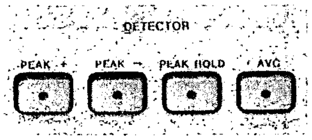
3 kHz without changing its deviation. As the rate goes above 3 kHz, the displayed FM drops. This is also true of the signal on the oscillosope.

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

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

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

Detectors



NOTE

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

Signal Generator		*Modulation Analyzer*	
Output Level	*1 mW to 1 W*	*MEASUREMENT*	*FM*
Frequency	*150 kHz to 1300 MHz*	*DETECTOR*	*PEAK+*
Modulation	*FM only*	*HP & LP FILTERS**	*ALL OFF*
		FM DE-EMPHASIS	*off*
		RATIO	*off*

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

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

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

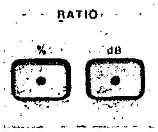
Average (RMS Calibrated). Press PEAK+ or PEAK− to turn PEAK HOLD off. Note the display, then press AVG. The reading should drop by about 30%. You are seeing the rms frequency deviation as measured by an average responding detector. This mode is normally reserved for measurement of

GETTING ACQUAINTED

Detectors (cont'd)

carrier noise because peak detectors appear to exaggerate noise. Switch the FM off and compare readings of carrier noise in PEAK+ and AVG.

Ratio



NOTE

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

Signal Generator		*Modulation Analyzer*	
Output Level	*1 mW to 1W*	*MEASUREMENT*	*FM*
Frequency	*150 kHz to 1300 MHz*	*DETECTOR*	*AVG (RMS CAL)*
Modulation	*off*	*HP & LP FILTERS**	*ALL OFF*
		FM DE-EMPHASIS	*off*
		RATIO	*off*

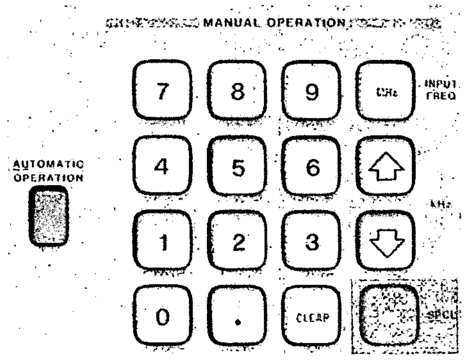
**If the carrier frequency at INPUT is below 10 MHz, the 15 kHz low-pass filter will remain on.*

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

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

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

Tuning



(see note next page)

GETTING ACQUAINTED

NOTE

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

Signal Generator		*Modulation Analyzer*	
Output Level	*1 mW to 1 W*	*MEASUREMENT*	*FM*
Frequency	*150 kHz to 1300 MHz*	*DETECTOR*	*PEAK+*
Modulation	*FM*	*HP & LP FILTERS**	*ALL OFF*
		FM DE-EMPHASIS	*off*
		RATIO	*off*

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

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

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

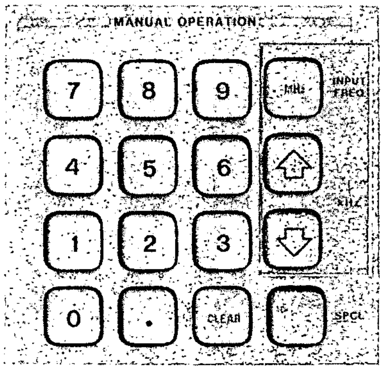
If the display reads E01, it is trying to tell you that your signal is not quite centered in the IF. Slowly tune the signal towards the frequency you keyed in until E01 disappears and the generator's frequency is displayed. (Normally, the signal must be within 50 kHz of the frequency keyed in when above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

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

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

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

Other Features



GETTING ACQUAINTED

Other Features (cont'd)

NOTE

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

Signal Generator		*Modulation Analyzer*	
Output Level	*1 mW to W*	*MEASUREMENT*	*FREQ ERROR*
Frequency	*150 kHz to 1300 MHz*	*DETECTOR*	*PEAK+*
Modulation	*FM*	*HP & LP FILTERS**	*ALL OFF*
		FM DE-EMPHASIS	*off*
		RATIO	*off*

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

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

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

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

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

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

For More Information

Overall instrument operation is summarized in Simplified Operation located on page 3-2 (the inside of the foldout at the front of this section).

Panel features are described in Figures 3-3 to 3-6, pages 3-10 to 3-13.

Remote operation is described under Remote Operation, Hewlett-Packard Interface Bus on page 3-26.

Your most complete operating reference is the Detailed Operating Instructions beginning with page 3-44. They are also indexed on page 3-3 (on the inside of the foldout at the beginning of this section).

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

If you wish to know more about how the Modulation Analyzer works, read Principles of Operation for Simplified Block Diagram on page 1-9. If you wish to know more about modulation, read Modulation Basics on page 1-10.

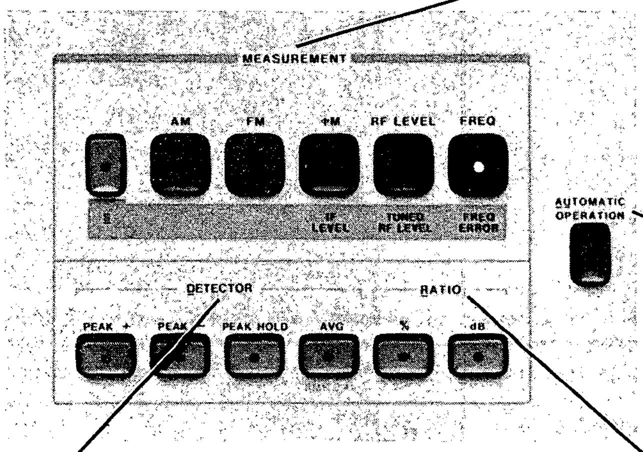
LCL (local) key returns the Modulation Analyzer to local keyboard control from HP-IB (remote) control provided the instrument is not in Local Lockout.

Numeric Display shows measurement results, error codes, instrument or Special Function status, HP-IB address, or service information.

HP-IB Annunciators display remote operation status. The REMOTE annunciator lights when the instrument is in remote mode. The ADDRESSED annunciator lights whenever the instrument is addressed via the HP-IB (regardless of whether or not the instrument is in remote).

Display Annunciators light to imndicate the units in which the measurement results are displayed. When results are displayed relative to a RATIO reference, units annunciators do not light, but the REL annunciator lights. The LIMIT annunciator lights when either the upper or lower limit reference is reached.

MEASUREMENT keys automatically configure the Modulation Analyzer to make and display the measurement selected. To select a measurement labeled above a key, press the key. To select a measurement labeled below a key, press the S (Shift) key, then the MEASUREMENT key. MEASUREMENT keys turn off many Special Funcions and always turn off CALIBRATION OUTPUT (Option 010).

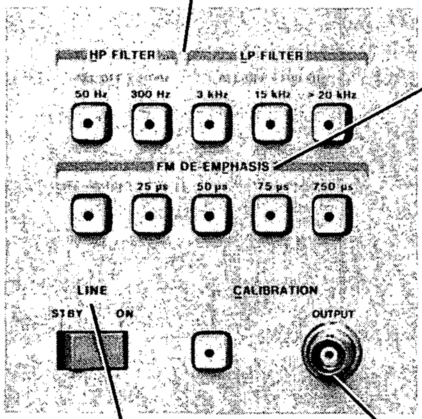


AUTOMATIC OPERATION configures the Modulation Analyzer to automatically tune to the largest detectable input signal and make the measurement selected. This key also sets the Special Functions 1 through 8 to their zero-suffix mode and turns off many other Special Functions.

DETECTOR keys select whether positive peak, negative peak, or average (rms calibrated) value of the modulation is measured. To hold indefinitely the greatest peak reading, select PEAK+ or PEAK−, then press the PEAK HOLD key. Pressing PEAK HOLD again will initiate a new peak hold measurement cycle. To turn off PEAK HOLD, press any DETECTOR key other than PEAK HOLD.

RATIO keys cause measurements to be compared in % or dB to a reference. To enter RATIO, press the % or dB key while the desired reference is displayed. The displayed reference can be either a measurement result or a keyboard entry. To exit RATIO, press the selected RATIO key again or select a new MEASUREMENT key. The RATIO keys are also used to enter upper and lower limit values into the instrument.

Figure 3-3. Display, MEASUREMENT, DETECTOR, RATIO, and AUTOMATIC OPERATION Features



HP (High-Pass) and LP (Low-Pass) FILTERS limit the demodulatd signal bandwidth. Press the appropriate key once to insert or change a filter. Press the key again to remove the filter. Only one high-pass and one low-pass filter may be active at a time. Filters affect both displayed modulation measurements and the signal at MODULATION OUTPUT but not those at the rear panel AM OUTPUT or FM OUTPUT. Tuning below 10 MHz or using the 455 kHz IF causes the 15 kHz LP FILTER to be inserted. Selecting ΦM causes the 50 Hz HP FILTER to be inserted.

FM DE-EMPHASIS affects FM measurements only. Press the appropriate key to insert or change de-emphasis. Press the key again to remove de-emphasis. If the PRE-DISPLAY key is not lighted, the display shows the deviation before de-emphasis. If the PRE-DISPLAY key is lighted, de-emphasis is performed before the displayed measurement is made. De-emphasis always affects demodulated FM at MODULATION OUTPUT, but never affects the signal at the rear-panel FM OUTPUT.

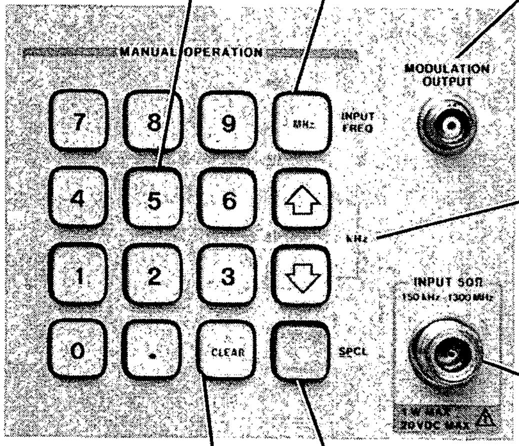
CALIBRATION OUTPUT (Option 010 only) when active, produces a 10 MHz signal with calibrated AM or FM. Connect CALIBRATION OUTPUT to INPUT, select AM or FM, then press the CALIBRATION key. The accuracy of the internal demodulator is normalized to 100%, displayed, and stored. This Calibration Factor can be enabled to correct measurement results automatically. To turn off CALIBRATION OUTPUT, press the CALIBRATION key or any MEASUREMENT key.

LINE switch applies power to the Modulation Analyzer when set to the ON position. In the STBY (standby) position, power is applied only to the high-stability reference oscillator oven (Option 002 only).

Figure 3-4. HP and LP FILTERS, FM DE-EMPHASIS, LINE, and CALIBRATION OUTPUT Features

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

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



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

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

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

⚠ CAUTION

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

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

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

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

REAR-PANEL FEATURES

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

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

CAUTION

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

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

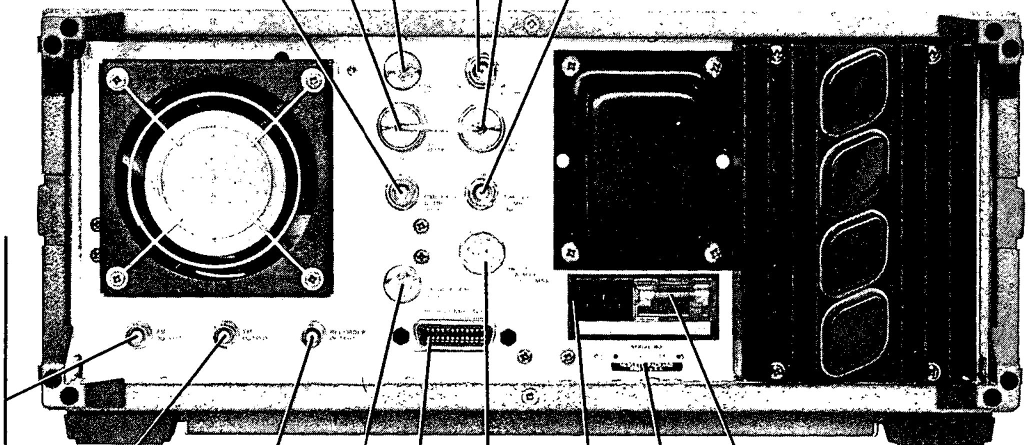
IF OUTPUT produces a 150 kHz to 2.5 MHz modulated IF signal. The output level ranges from −27 to −3 dBm (50Ω output impedance).

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

CAUTION

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

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



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

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

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

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

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

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

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

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

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

Figure 3-6. Rear-Panel Features

3-10. OPERATOR'S CHECKS

3-11. Basic Functional Checks

DESCRIPTION: Using only a signal generator and oscilloscope, the overall operation of the Modulation Analyzer is verified.

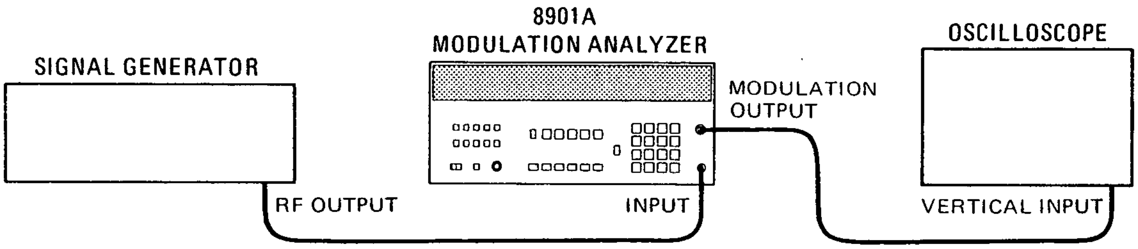


Figure 3-7. Basic Functional Checks Setup

EQUIPMENT: Oscilloscope ....HP 1740A
Signal Generator ....HP 8640B Options 001 and 002

PROCEDURE: **Preliminary Check**

1. Remove any cable from the Modulation Analyzer's INPUT. Set LINE switch to STBY, then back to ON and note the front-panel LED annunciators, display segments and decimal points, and key lights at turn on. 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 display should show "— —", the MHz annunciator should light, and the FREQ key should light.

RF LEVEL Check

3. Press the RF LEVEL key. The display should read between −0.003 and 0.003 mW.
4. Set signal generator to 10 MHz CW at +10 dBm (as measured on its level meter).
5. Connect the equipment as shown in Figure 3-7.
6. The Modulation Analyzer display should read between 6.5 and 16 mW.

Frequency Check

7. Press the FREQ key. Set the signal generator's frequency as shown below. 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

OPERATOR'S CHECKS

3-11. Basic Functional Checks (Cont'd)

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

9. Key in 100 then press ↑ kHz. The display should read between −102 and −98 kHz.

AM Check

10. Press the Modulation Analyzer's MHz key, and set the signal generator for 50% AM (as measured on its AM meter) at a 1 kHz rate.

11. Press AM. The display should read between 46 and 54%.

12. Set the signal generator's AM to 25% (as measured on its AM meter). The display should read between 22 and 28% with 0.01% resolution.

FM and ΦM Checks

13. Set signal generator's AM off, and set FM to 50 kHz deviation (as measured on its FM meter) at a 1 kHz rate. Press FM. The display should read between 45 and 55 kHz.

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

15. Press ΦM. The display should read between 45 and 55 radians.

FM De-emphasis Check

16. Press FM. Set RATIO to %. The display should read between 99.8 and 100.2% REL.

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

18. Set FM DE-EMPHASIS to PRE-DISPLAY. Set FM DE-EMPHASIS time constant as shown below. The display should read within the limits shown. Also, the oscilloscope waveform should change proportionately to the display. (Allow for a x10 autorange at the MODULATION OUTPUT when FM DE-EMPHASIS is set to 750 μs.)

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

OPERATOR'S CHECKS

3-11. Basic Functional Checks (Cont'd)

Filter Check

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

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

Detector Check

20. Set RATIO off, set filters to ALL OFF. Set the signal generator's FM rate to 1 kHz. Set RATIO to % and set DETECTORS to PEAK−. The display should read between 95 and 105% REL depending upon the signal generator's distortion.

21. Set DETECTOR to AVG. The display should read between 69.3 and 72.1% REL.

22. Set DETECTOR to PEAK+ then press PEAK HOLD. Switch the signal generator's FM off. The display should hold the value displayed just prior to pressing PEAK HOLD.

IF and Tuned RF Level Check

23. Press S (Shift) IF LEVEL. The display should read between 99.9 and 100.1%.

24. Press AUTOMATIC OPERATION then key in 10.0 and press the SPCL key. The display should read between 1.45 and 1.55 MHz.

25. Key in 3.1 and press the SPCL key. The display should read between 0.4425 and 0.4575 MHz.

26. Tune the signal generator to 5.25 MHz. Press S (Shift) TUNED RF LEVEL. The display should read between 6.5 and 16 mW.

27. Set RATIO to dB then key in 3.3 and press the SPCL key. The display should read between −2 and −4 dB REL.

Error Check

28. Tune the signal generator to 50 MHz at 0 dBm. On the Modulation Analyzer, press AUTOMATIC OPERATION then FM. Set DETECTOR to PEAK+. After the Modulation Analyzer is tuned, key in 9.0 and press the SPCL key. Key in 100 then press ↑ kHz. The display should read E01.

OPERATOR'S CHECKS

3-11. Basic Functional Checks (Cont'd)

29. Press ↓ kHz. Set the generator's FM on and adjust the peak deviation for 5 kHz (as read on its FM meter). The Modulation Analyzer's display should read E04.

30. Key in 8.4 and press the SPCL key. The display should read E07.

31. Set the signal generator's FM off. Set the output level to +20 dBm. The Modulation Analyzer's display should read E02.

32. Set the signal generator's output level to −20 dBm. The Modulation Analyzer's display should read E03.

Calibrator Check (Option 010 only)

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

34. Press FM, then CALIBRATION. After about 20 seconds, the FM Calibration Factor will be displayed. The display should read between 99.0 to 101.0%.

OPERATOR'S CHECKS

3-12. 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 on pages 3-27 and 3-28. In addition, the Modulation Analyzer's ability to recognize its HP-IB address is checked and all of the bus data, handshake, and control lines except DIO8 (the most significant data line which is not used by the Modulation Analyzer) are set to both their true and false states. These procedures do not check whether or not all Modulation Analyzer program codes are being properly interpreted and executed by the instrument, however, if the front-panel operation is good, the program codes, in all likelihood will be correctly implemented.

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

- The Modulation Analyzer performs properly when operated via the front-panel keys (that is, in local mode). This can be verified with the preceding Local Operator's Checks beginning on page 3-14.
- 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 the Modulation Analyzer's INPUT.

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 LINE switch to STBY, then to ON.

OPERATOR'S CHECKS

3-12. HP-IB Functional Checks (Cont'd)

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 REMOTE annunciator is off and that its ADDRESSED annunciator is on.

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

OPERATOR'S RESPONSE Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are off.

Remote and Local Messages and the LCL Key

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

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

OPERATOR'S RESPONSE Check that both the Modulation Analyzer's REMOTE and ADDRESSED 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 ADDRESSED annunciator is on.

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

OPERATOR'S RESPONSE Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. Press the LCL key on the Modulation Analyzer. Check that the Modulation Analyzer's REMOTE annunciator is now off, but that its ADDRESSED annunciator remains on.

OPERATOR'S CHECKS

3-12. 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 LINE 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 E96 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 REMOTE annunciator is off but that its ADDRESSED annunciator is on. The controller's display should read 9000009600.00 (HP 9825A) or 9000009600 (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 LINE 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 (manually tuning the Modulation Analyzer to 1 MHz).	wrt 714,"1MZ"	OUTPUT 714;"1MZ"

OPERATOR'S RESPONSE Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. Check also that its 15 kHz LP FILTER and SPCL key lights are both on.

Local Lockout and Clear Lockout/Set Local Messages

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 LINE switch to STBY, then to ON.

3-12. HP-IB Functional Checks (Cont'd)

Local Lockout and Clear Lockout/Set Local (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 both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on. Press the Modulation Analyzer's LCL key. Both its REMOTE and ADDRESSED annunciators should 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 ADDRESSED annunciator is 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 LINE 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 that sets the Modulation Analyzer's tuning to manual (lighting the SPCL light).	wrt 714,"MZ"	OUTPUT 714;"MZ"

OPERATOR'S RESPONSE Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on and that the SPCL key light is also on.

3-12. HP-IB Functional Checks (Cont'd)

Clear Message (Cont'd)

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

OPERATOR'S RESPONSE Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on and that the SPCL key light is off.

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 LINE switch to STBY, then to ON.

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 both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are on.

Send the Abort message, unaddressing the Modulation Analyzer to listen.	cli 7	ABORTIO 7

OPERATOR'S RESPONSE Check that the Modulation Analyzer's ADDRESSED 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 REMOTE annunciator is off but that its ADDRESSED annunciator is on.

Send the Abort message, unaddressing the Modulation Analyzer to talk.	cli 7	ABORTIO 7

3-12. HP-IB Functional Checks (Cont'd)

Abort Message (Cont'd)

OPERATOR'S RESPONSE Check that both the Modulation Analyzer's REMOTE and ADDRESSED annunciators are off.

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

OPERATOR'S RESPONSE On the Modulation Analyzer, key in 61.3 SPCL. The display should show 1.0. This indicates the Modulation Analyzer is in serial-poll mode (indicated by the "1").

Send the Abort message, removing the Modulation Analyzer from serial-poll mode.	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 LINE switch to STBY, then to ON.

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 Check that Modulation Analyzer's REMOTE annunciator is off. Depending upon the vintage of the HP-IB interface (HP 98034A) used, the Modulation Analyzer's ADDRESSED 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

3-12. HP-IB Functional Checks (Cont'd)

Status Byte Message (Cont'd)

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 ADDRESSED 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 LINE 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 (enabling a Require Service message 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 to send the Require Service 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 (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 SRQ value is 1, indicating the Modulation Analyzer issued the Require Service message.

3-12. 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 LINE 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 Modulation Analyzer 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 ADDRESSED annunciators are on. The controller's display should read 9000009600.00 (HP 9825A) or 9000009600 (HP 9835A and HP 9845A).

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

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 and the controller's display should read 9000009600.00 (HP 9825A) or 9000009600 (HP 9835A or HP 9845A).

3-13. 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 LINE 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 (Section 3-45). These checks verify that the Modulation Analyzer can respond to or send each of the applicable bus messages described in Table 3-3.

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).

3-14. HP-IB Compatibility

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

3-15. Remote Mode

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

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

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

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

3-16. Local Mode

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

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

3-17. 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 (whether in local or remote), the ADDRESSED annunciator on the front panel will turn on.

The Modulation analyzer's talk and listen addresses are switch selectable as described in paragraph 2-7. Refer to Table 2-1 for a comprehensive listing of all valid HP-IB address codes. To determine the present address setting, refer to the discussion titled HP-IB Address on page 3-91 in the Detailed Operating Instructions near the end of this section.

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

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

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

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

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

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

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

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

Addressing (Cont'd)

the LCL key, the data could be lost. This would leave the Modulation Analyzer in an unknown state. To prevent this, a local lockout is recommended. Local lockout disables the LCL key (and the CLEAR key) and allows return-to-local only under program control.

NOTE

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

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

3-18. Data Messages

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

3-19. 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

Receiving the Data Message (Cont'd)
until it receives an Abort message or until it's talk address or a universal unlisten command is sent by the controller.

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

Listen Only mode is provided to allow the Modulation Analyzer to accept programming from devices other than controllers (e.g., 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 on page 3-31. All functions can be programmed together as a continuous string as typified in Example 2. The string in Example 2 triggers a settled measurement cycle in which the Modulation Analyzer determines the positive peak de-emphasized (75 μs) FM deviation of an input signal at 104.5 MHz.

Program Codes. All of the valid HP-IB codes for controlling Modulation Analyzer functions are summarized in Table 3-6. All front-panel keys except the LCL key have corresponding program codes. Some of the tuning functions have additional codes which terminate the numeric data entry in Hz rather than MHz or kHz as indicated on the front panel. Where more than one code is given for a function, either code will serve equally. However, the first code given is recommended since its mnemonic more closely represents the function selected, and it will therefore make deciphering program code strings easier. The first codes given are the codes used in all programming examples in this manual.

Table 3-4 shows the Modulation Analyzer's response to various ASCII characters not used in its code set. The characters in the left-hand column will be ignored unless they appear between two characters of a program code. The characters in the right-hand columns, if received by the Modulation Analyzer, will always cause Error E24 (invalid HP-IB code) and a Require Service message to be generated. As a convenience, all lower case alpha characters are treated as upper case.

Turning Off Functions. When operating in local mode, the High-Pass and Low-Pass Filters, FM De-emphasis, Calibration, and Ratio functions

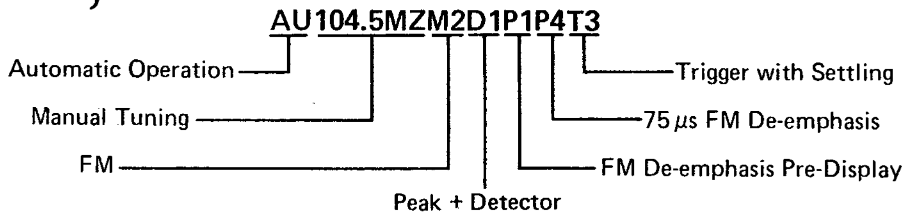
EXAMPLE 1: General Program Syntax and Protocol

{ Controller Talk
Modulation Analyzer Listen } ,

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

EXAMPLE 2: Typical Program String

{ Controller Talk
Modulation Analyzer Listen } ,



Receiving The Data Message (Cont'd)

Table 3-4. Modulation Analyzer Response to Unused ASCII Codes

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

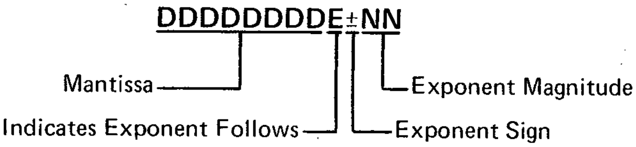
*Except when inserted between two characters of a program code.

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

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

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

General Numeric Data Input Format:



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

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

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

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

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 signal at MODULATION OUTPUT CAN CHANGE. However, the instrument is inhibited from outputting any data to the front-panel key lights and display or to the HP-IB except as

Receiving The Data Message (Cont'd)

follows. The instrument will issue the Require Service message if a LIMIT is reached (and if enabled to do so) or if a HP-IB code error occurs. The instrument will issue the Status Byte message if serial polled. (A serial poll, however, will trigger a new measurement, update displays and return the instrument to Hold.) If a momentary error condition occurs while the instrument is in Hold, the signal at MODULATION OUTPUT may be temporarily invalid with no indication from the instrument.

Upon leaving Hold, the front-panel indications are updated as the new measurement cycle begins. The Status Byte will be affected (and the Require Service message issued) by the events that occur during the new measurement cycle. The Modulation Analyzer leaves Hold when it receives either the Free Run, Trigger Immediate, 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 AM or FM Calibrator. Refer to the procedures under Calibration, AM, or Calibration, FM in the Detailed Operating Instructions.

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

Special Considerations for Triggered Operation. When in free-run mode, the Modulation Analyzer must pay attention to all universal bus commands, for example, serial poll enable (SPE), 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 reinitated 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.

Receiving The Data Message (Cont'd)

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

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

PEAK HOLD (D3). As in local, once PEAK HOLD is specified any ensuring 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.

3-20. Sending The Data Message

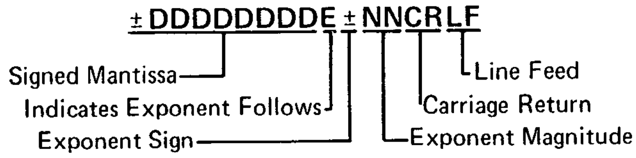
Depending on how the internal address switches are set, the Modulation Analyzer can either talk only, talk status only, listen only, or talk and listen both (normal operation). If set to both talk and listen, the instrument sends Data messages when addressed to talk. The instrument then remains configured 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) hand-shake line is pulsed each time the one-byte Data message is sent.

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

Data Output Format:



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

Error Output Format:

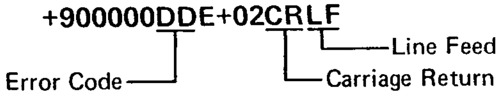


Table 3-5. Response to a Clear Message

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

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

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

Sending The Data Message (Cont'd)

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.

3-21. Receiving the Clear Message

The Modulation Analyzer responds to the Clear message by assuming the settings detailed in Table 3-5. The Modulation Analyzer responds equally to the Selected Device Clear (SDC) bus command when addressed to listen, and the Device Clear (DCL) bus command whether addressed or not. The Clear message clears any pending Require Service message and resets the Service Request Condition (Special Function 22) such that the Require Service message will be issued on HP-IB code errors only (22.2 SPCL).

3-22. 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, page 3-30.

3-23. Receiving the Remote Message

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

3-24. Receiving The Local Message

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

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

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

3-25. Receiving the Local Lockout Message

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

3-26. 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.

3-27. Receiving the Pass Control Message

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

3-28. Sending the Require Service Message

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

Sending the Require Service Message (Cont'd)

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

3-29. Selecting the Service Request Condition

Use Special Function 22, Service Request Condition, to enable the Modulation Analyzer to issue the Require Service message on any of the conditions above (except HP-IB code errors which always cause the Require Service message to be sent). The Service Request Condition Special Function is entered from either the front panel or 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 given 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. Figure 3-8 illustrates a flow chart for developing device subroutines using the instrument's ability to issue the Require Service message when data is ready. This subroutine structure frees the controller to process other routines until the Modulation Analyzer is ready with data.

3-30. Sending the Status Byte Message

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

If one or more of the five conditions described above are both enabled and present, all the bits corresponding to the conditions and also bit 7, the RQS bit, will be set true (and the Require Service message is sent). If one of the above conditions occurs but has not been enabled by Special Function 22, neither the bit corresponding to the condition nor the RQS bit will be set (and the Require Service message will not be sent). The bit pattern of the Status Byte is shown on page 3-37.

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

NOTE

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

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

3-31. 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.

3-32. Receiving the Abort Message

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

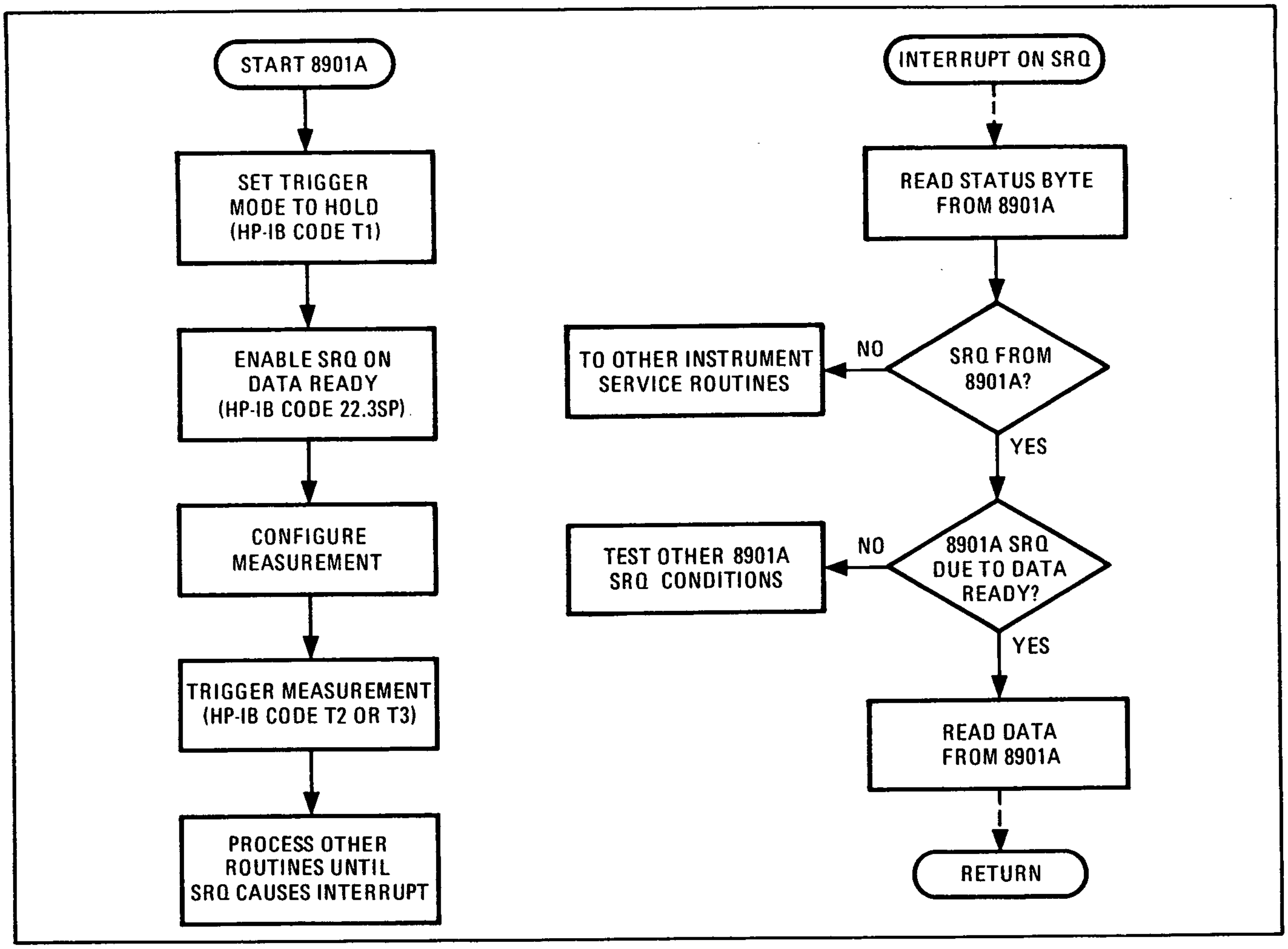


Figure 3-8. Example Flow Chart for Driving the Modulation Analyzer Using the Require Service Message (SRQ)

HP-IB SYNTAX AND CHARACTERISTICS SUMMARY

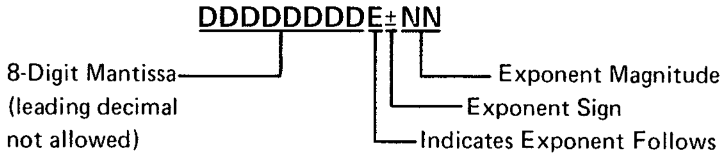
Address:

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

General Operating Syntax:

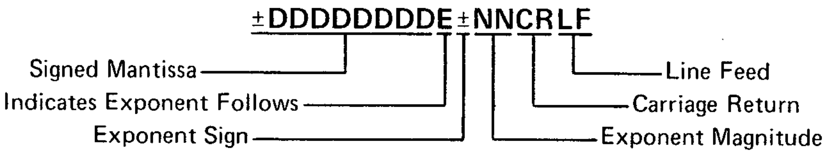
[Automatic Operation] [Tuning] [Measurement] [Detector] [Filter] [FM De-emphasis] [Special Functions] [Ratio] [Calibration] [Trigger]

Numeric Data Input Format:

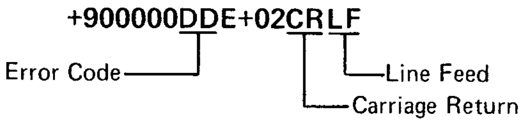


Output Formats:

Data (valid data output value always <9 x 10^9 and in fundamental units):



Errors:



Return to Local:

Front panel LCL key if not locked out.

Manual Trigger:

Front panel CLEAR key initiates Trigger With Settling measurement cycle.

Status Byte:

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

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

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

Table 3-6. Modulation Analyzer Parameter to HP-IB Code Summary

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

Table 3-7. Modulation Analyzer Special Function to HP-IB Code Summary (1 of 3)

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

Table 3-7. Modulation Analyzer Special Function to HP-IB Code Summary (2 of 3)

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

Table 3-7. Modulation Analyzer Special Function to HP-IB Code Summary (3 of 3)

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

Table 3-8. Modulation Analyzer HP-IB Code to Parameter Summary

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

Table 3-9. Modulation Analyzer HP-IB Code to Special Function Summary (1 of 2)

Program Code	Special Function
	Input Attenuation
1.0SP	Automatic Selection
1.1SP	0 dB
1.2SP	10 dB
1.3SP	20 dB
1.4SP	30 dB
1.5SP	40 dB
1.6SP	50 dB
	Modulation Range
2.0SP	Automatic Selection

	AM (%)	FM* (kHz)	ΦM (rad)
2.1SP	<40	<4	<4
2.2SP	<100	<40	<40
2.3SP	<100	<400	<400

*1/10 Range with 750 μs de-emphasis, pre-display

Program Code	Special Function
	IF Frequency and Input High-Pass Filter
3.0SP	Automatic IF Selection; Filter Out

	IF (MHz)	Input HP Filter
3.1SP	0.455	Out
3.2SP	1.5	Out
3.3SP	0.455	In
3.4SP	1.5	In

Program Code	Special Function
	Tune Mode
4.0SP	Automatic; Low-noise LO
4.1SP	Automatic; Track
4.2SP	Manual
	Audio Peak Detector Time Constant
5.0SP	Fast
5.1SP	Slow
	AM ALC Response Time
6.0SP	Slow
6.1SP	Fast
6.2SP	Open ALC
	Frequency Resolution
7.0SP	Automatic Selection
7.1SP	10 Hz Resolution (f<1 GHz)
7.2SP	1000 Hz Resolution

Program Code	Special Function
	Error Disable
8.0SP	Automatic Selection
8.1SP	E01 disabled
8.2SP	E02 & E03 disabled
8.3SP	E01, E02, & E03 disabled
8.4SP	E04 disabled
8.5SP	E01 & E04 disabled
8.6SP	E02, E03, & E04 disabled
8.7SP	E01 through E04 disabled
8.8SP	E01 through E04 enabled
9.0SP	Hold Settings
10.0SP	IF Frequency Measurement
	Re-enter Ratio With Previous Reference
11.0SP	Re-enter % Ratio
11.1SP	Re-enter dB Ratio
11.2SP	Read Ratio Reference
11.3SP	Make Ratio Reference Negative
	FM Calibrator
12.0SP	Display Computed Peak FM Deviation
12.1SP	Display Demodulated Peak Residual FM Deviation
12.2SP	Display Demodulated Peak FM Deviation
	AM Calibrator
13.0SP	Display Computed Peak AM Depth
13.1SP	Display Demodulated Peak Residual AM Depth
13.2SP	Display Demodulated Peak AM Depth
	Set Limit
14.0SP	Clear Limits; Turn Off LIMIT Annunciator
14.1SP	Set Lower Limit to Ratio Reference
14.2SP	Set Upper Limit to Ratio Reference
14.3SP	Restore Lower Limit
14.4SP	Restore Upper Limit
14.5SP	Read Lower Limit
14.6SP	Read Upper Limit
14.7SP	Read Lower Limit Measurement Code
14.8SP	Read Upper Limit Measurement Code

Table 3-9. Modulation Analyzer HP-IB Code to Special Function Summary (2 of 2)

Program Code	Special Function	Program Code	Special Function
	Time Base Oven (Opt. 002)	21.0SP	HP-IB Address Displays HP-IB Address in binary form: AAAAA.TLS AAAAA = address; T = 1 means talk only; L = 1 means listen only; S = 1 means SRQ.
15.0SP	Display E12 if Oven Cold		
	AM Calibration (Opt. 010)		
16.0SP	Disable AM Calibration Factor		
16.1SP	Enable AM Calibration Factor		
16.2SP	Read AM Calibration Factor (0 if disabled)		
	FM Calibration (Opt. 010)	22.NNSP	Service Request 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 4 Instrument Error 8 Upper Limit 16 Lower Limit
17.0SP	Disable FM Calibration Factor		
17.1SP	Enable FM Calibration Factor		
17.2SP	Read FM Calibration Factor (0 if disabled)		
18.NNSP	Tone Burst Receiver NN is delay in ms from signal detected at INPUT and activation of MODULATION OUTPUT.		

Table 3-10. 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
@	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.

AM

Description

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

Output Ranges

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

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

Procedure

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

Example

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

LOCAL (keystrokes)	Measurement — Detector — Filters AM PEAK + 50 Hz 15 kHz
HP-IB (program codes)	M1D1H1L2 Measurement — Detector — Filters

Program Code HP-IB

M1 is the HP-IB code for AM.

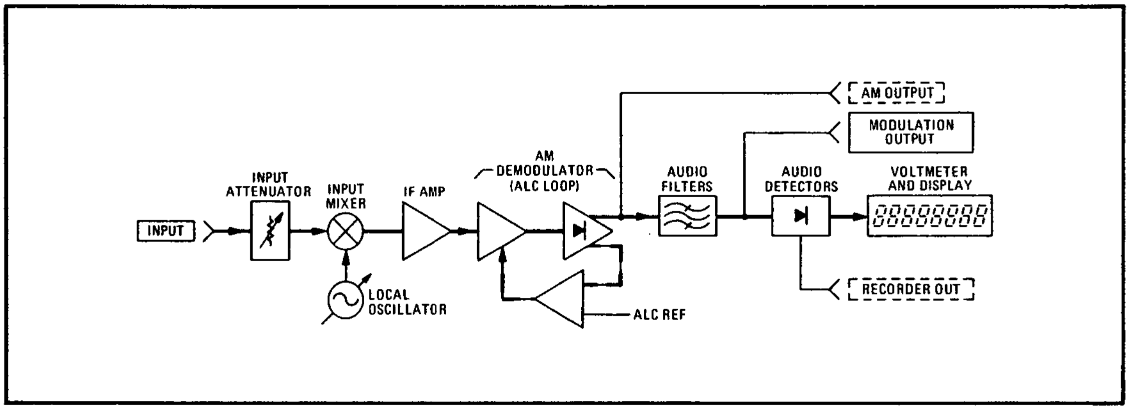
Indications

The LEDs within the keys representing the selected functions will light. The % annunciator to the right of the numerical display will light and the display will show the % AM on the carrier.

AM (Cont'd)

Measurement Technique

The instrument measures AM as a ratio of the demodulated audio signal level to the average tuned carrier level. An ALC loop within the demodulator holds the carrier level constant so that the percent AM is proportional to the amplitude of the demodulated audio output. This audio output is then filtered, and displayed as % AM.



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 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 will occur with lower modulation levels displayed. If the modulation level is reduced from above 40% into this overlap region, only 0.1% resolution may 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 *Modulation Range.*

When operating above 2.5 MHz while using the 455 kHz IF, the modulation bandwidth's upper limit is that of the >20 kHz low-pass filter. Note that the 15 kHz low-pass 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 the >20 kHz low-pass filter. The modulation bandwidth's lower limit 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 which cause the carrier signal to disappear will cause inaccuracies in measurement of FM, Φ M, or input frequency, or they may cause E05 (FM squelched) to be displayed when these measurements are selected.

Related Sections

AM Output
AM ALC Response Time
Detectors
Detector, Peak Hold
Filters
Modulation Basics (Section 1—16)
Modulation Range
Ratio
Residual Noise Effects

AM ALC Response Time

(Special Function 6)

Descripton 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 *AM, AM Measurement Block Diagram*). However,a fast ALC response time may be selected to quicken the response to changing carrier levels. Accuracy at AM rates <200 Hz is affected when the faster ALC response is selected. It is possible to disable the ALC entirely.

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

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

Example To enter a fast AM ALC response mode:

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

Program Code HP-IB For HP-IB codes, refer to Procedure above.

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

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

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

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

Related Sections

AM
AM Output
Level, IF
Special Functions

AM Output

CAUTION

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

Description

The rear-panel AM OUTPUT (dc coupled, 10 kΩ output impedance) provides an auxiliary output for the AM demodulated from the signal at INPUT. This output is useful for monitoring AM when displaying FM or ΦM or when the modulation rate is very low. (Use the AM ALC off setting described under *AM ALC Response Time.*) The output signal comprises a dc voltage related to the detected IF level and an ac voltage (bandwidth 16 kHz, one pole) 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.

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

where Vpk is the peak 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

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

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

Procedure

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 jack and remove any signal at INPUT. Press MHz to fix the tuning. Read the offset voltage on the voltmeter. Now disable the AM ALC loop (6.2 SPCL) and apply the carrier to INPUT. Measure the dc and peak ac signals at AM OUTPUT. Use the first equation under description above 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 INPUT and connect a dc voltmeter to AM OUTPUT.

LOCAL (keystrokes)	AUTOMATIC OPERATION ⎍ MZ [MHz] INPUT FREQ
HP-IB (program codes)	AUMZ

AM Output (Cont'd)

Example (Cont'd)

For this example, assume the voltmeter reads an offset voltage of —0.36 Vdc. Connect an AM signal to INPUT and tune the Modulation Analyzer to it. Now disable the AM ALC.

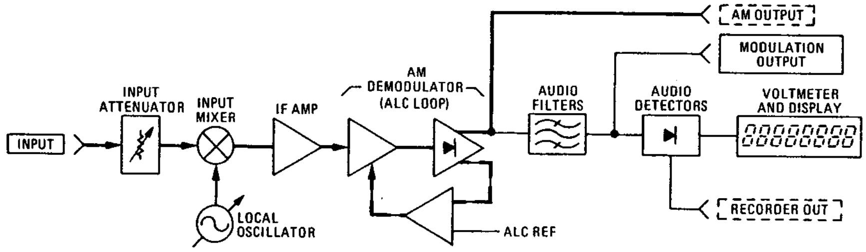
LOCAL **(keystrokes)**	Code Function 6 . 2 • SPCL
HP-IB **(program codes)**	6.2SP Code Function

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:

$$\% \text{ AM} = \frac{\text{Vpk x } 100\%}{|\text{Vdc} - \text{V}_{\text{off}}|} = \frac{0.02 \text{ x } 100\%}{|(-0.46) - (-0.36)|} = 20\% \text{ AM}$$

Block Diagram

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



AM OUTPUT Block Diagram

Comments

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

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

Related Sections

AM
AM ALC Response Time
FM Output

Attenuation, Input

(Special Function 1)

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

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

Input Attenuation Range	Special Function 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

Example To set the input attenuation to the 20 dB range:

LOCAL (keystrokes)	Code Function 1 . 3 • SPCL
HP-IB (program codes)	1.3SP Code Function

Program Code HP-IB For HP-IB codes, refer to Procedure above.

Indications As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Unless Special Function code 1.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

Comments When the Modulation Analyzer first powered up or when AUTOMATIC OPERATION is selected, the input attenuation is placed in the automatic selection mode.

If the input attenuation is set such that the input signal level causes the input mixer to be overdriven, E02 will be displayed. If the input attenuation is set such that the signal level reaching the circuits is too low for an accurate measurement, E03 will be displayed.

Attenuation, Input (Cont'd)

(Special Function 1)

Comments (Cont'd)

The following table is a guide for manually selecting the appropriate input attenuation for various input signal levels. The values given are approximate only. Typically, conversion loss through the input mixer increases linearly from 150 kHz to 1300 MHz with the higher frequency requiring approximately 5 dB more power for equal performance.

Input attenuation is always 50 dB when RF LEVEL is selected; Special Functions 1.1 to 1.5 are overridden.

Input Signal Level (dBm)		Input Attenuation* (dB)	
150 kHz to 650 MHz	650 to 1300 MHz	FM & ΦM Measurements	Other Measurements
−25 to −16	−20 to −13	0 (1.1 SPCL)	0 (1.1 SPCL)
−16 to −6	−13 to −3	0 (1.1 SPCL)	10 (1.2 SPCL)
−6 to 4	−3 to 7	10 (1.2 SPCL)	20 (1.3 SPCL)
4 to 14	7 to 17	20 (1.3 SPCL)	30 (1.4 SPCL)
14 to 24	17 to 27	30 (1.4 SPCL)	40 (1.5 SPCL)
24 to 30	27 to 30	40 (1.5 SPCL)	50 (1.6 SPCL)

*For measurements other than modulation measurements (except RF LEVEL) use attenuation from either column. RF level over rides manual setting of input attenuation and sets it to 50 dB.

Related Sections

Hold Settings
Level, RF
Special Functions

Automatic Operation

Description

The AUTOMATIC OPERATION key configures the Modulation Analyzer to automatically tune to the largest detectable input carrier (refer to Tuning for qualifications) and make the measurement selected. MODULATION OUTPUT is blanked while the instrument tunes. AUTOMATIC OPERATION sets Special Functions with prefixes 1 through 8 to their 0-suffix mode, turns off many Special Functions with prefixes greater than 8, and overrides all Service Special Functions (prefixes 0, 40, or greater). AUTOMATIC OPERATION does not affect HP/LP FILTERs, FM DE-EMPHASIS, MEASUREMENT, CALIBRATION DETECTOR, RATIO, or Limit settings. The instrument powers up in the automatic operation mode.

Procedure

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

Example

To enter automatic operation mode:

LOCAL **(keystroke)**	AUTOMATIC OPERATION ⊓
HP-IB **(program codes)**	AU

Program Code **HP-IB**

AU is the HP-IB code for AUTOMATIC OPERATION.

Indications

When AUTOMATIC OPERATION is pressed, the instrument initiates an automatic tuning sequence generally indicated by four dashes on the display. When tuned, the instrument displays the measurement selected and the appropriate key lights will be on. If a MEASUREMENT key light is on, the SPCL key light will be off. If all MEASUREMENT key lights are off, the SPCL key light will be on (the instrument is making a measurement such as IF frequency selected by the SPCL key).

Comments

The AUTOMATIC OPERATION key is the easiest way to make measurement in applications where only a single carrier is present at 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 Hold Settings Special Function (prefixed 9). Refer to *Hold Settings.*

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

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

Related Sections

Hold Settings
Special Functions
Tuning

Calibration, AM

(Includes Special Functions 13 and 16)

Description

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

Procedures

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

NOTE

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

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

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

Calibrating Another 8901A Modulation Analyzer. By duplicating the Modulation Analyzer's internal calibration process step by step with another Modulation Analyzer that does not have an internal calibrator, an AM Calibration Factor can be computed for that instrument. First, connect the CALIBRATION OUTPUT of the instrument with Option 010 (Modulation Analyzer A) to the INPUT of the other instrument (Modulation Analyzer B). Then perform the following:

Calibration, AM (Cont'd)

(Includes Special Functions 13 and 16)

Procedures (Cont'd)

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

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

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

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

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

The Special Function codes are summarized in the table below:

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

Examples

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

LOCAL (keystrokes)	Measurement AM ⌐•¬ CALIBRATION ⊡
HP-IB (program codes)	M1C1 Measurement — — Calibration

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

Calibration, AM (Cont'd)

(Includes Special Functions 13 and 16)

Examples (Cont'd)

Correcting Measurements with the AM Cal Factor (Self-Calibrated). To enable the AM Calibration Factor to correct AM measurements:

LOCAL (keystrokes)	Code Function 1 6 . 1 • SPCL
HP-IB (program codes)	16.1SP Code Function

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

On Modulation Analyzer A:

LOCAL (keystrokes)	Code Function 1 3 . 0 • SPCL
HP-IB (program codes)	13.0SP Code Function

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

On both Modulation Analyzers:

LOCAL (keystrokes)	Code Function 1 3 . 1 • SPCL
HP-IB (program codes)	13.1SP Code Function

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

Calibration, AM (Cont'd)

(Includes Special Functions 13 and 16)

Examples (Cont'd)

On both Modulation Analyzers:

LOCAL **(keystrokes)**	Code: 1 3 . 2 Function: • SPCL
HP-IB **(program codes)**	13.2SP Code: 13.2 Function: SP

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

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

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

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

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

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

Program Codes

HP-IB

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

Key	Program Code HP-IB
CALIBRATION on	C1
CALIBRATION off	C0
AM	M1
SPCL	SP

Indications

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

Correcting Measurements with the AM Calibration Factor (Self-calibrated). As the numeric Special Function code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display will return to showing the measurement selected unless

Calibration, AM (Cont'd)

(Includes Special Functions 13 and 16)

Indications (Cont'd)

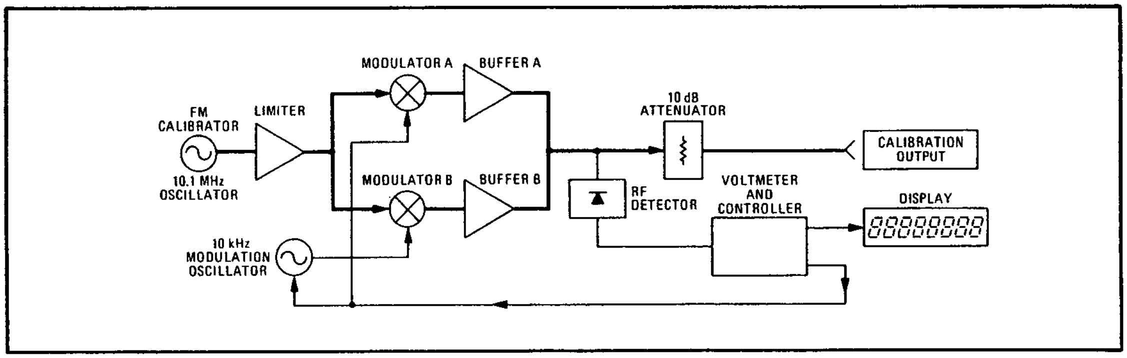
the Read AM Calibration Factor function is selected. If this function is selected and the AM Calibration Factor is enabled, the display will show the AM Calibration Factor, and the SPCL key will light. All annunciators and other key lights will turn off. The display will time out in about 2 seconds,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

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

Measurement Technique

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

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



Simplified Block Diagram of the AM Calibrator

Comments

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

Pressing the CALIBRATION key cancels all Special Functions.

Calibration, AM (Cont'd)

(Includes Special Functions 13 and 16)

Comments (Cont'd)

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

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

Related Functions

AM
Calibration, FM
Ratio
Residual Noise Effects
Special Functions

Calibration, FM

(Includes Special Functions 12 and 17)

Description

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

Procedures

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

NOTE

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

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

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

Calibrating Another 8901A Modulation Analyzer. By duplicating the Modulation Analyzer's internal calibration process step by step with another Modulation Analyzer that does not have an internal calibrator, an FM Calibration Factor can be computed for that instrument. First, connect the CALIBRATION OUTPUT of the instrument with Option 010 (Modulation Analyzer A) to the INPUT of the other instrument (Modulation Analyzer B). Then perform the following.

Calibration, FM (Cont'd)

(Includes Special Functions 12 and 17)

Procedures (Cont'd)

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

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

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

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

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

The Special Function codes are summarized in the table below:

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

Examples

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

LOCAL **(keystrokes)**	Measurement FM ⌈•⌉ CALIBRATION ⊡
HP-IB **(program codes)**	M2C1 Measurement — Calibration

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

Correcting Measurements with the FM Calibration Factor (Self-calibrated). To enable the FM Calibration Factor to correct FM measurements:

Calibration, FM (Cont'd)

(Includes Special Functions 12 and 17)

Examples (Cont'd)

LOCAL (keystrokes)	Code Function 1 7 . 1 • SPCL
HP-IB (program codes)	17.1SP Code Function

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

On Modulation Analyzer A:

LOCAL (keystrokes)	Code Function 1 2 . 0 • SPCL
HP-IB (program codes)	12.0SP Code Function

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

LOCAL (keystrokes)	Code Function 1 2 . 1 • SPCL
HP-IB (program codes)	12.1SP Code Function

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

On both Modulation Analyzers:

LOCAL (keystrokes)	Code Function 1 2 . 2 • SPCL
HP-IB (program codes)	12.2SP Code Function

Calibration, FM (Cont'd)

(Includes Special Functions 12 and 17)

Examples (Cont'd)

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

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

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

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

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

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

Program Codes

HP-IB

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

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

Indications

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

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

Calibrating Another Modulation Analyzer. As the numeric Special Function codes are entered, they will appear on the front panel display. The instrument with Option 010 (A) displays the computed FM deviation (code 12.0), but shows two dashes (——) throughout

Calibration, FM (Cont'd)

(Includes Special Functions 12 and 17)

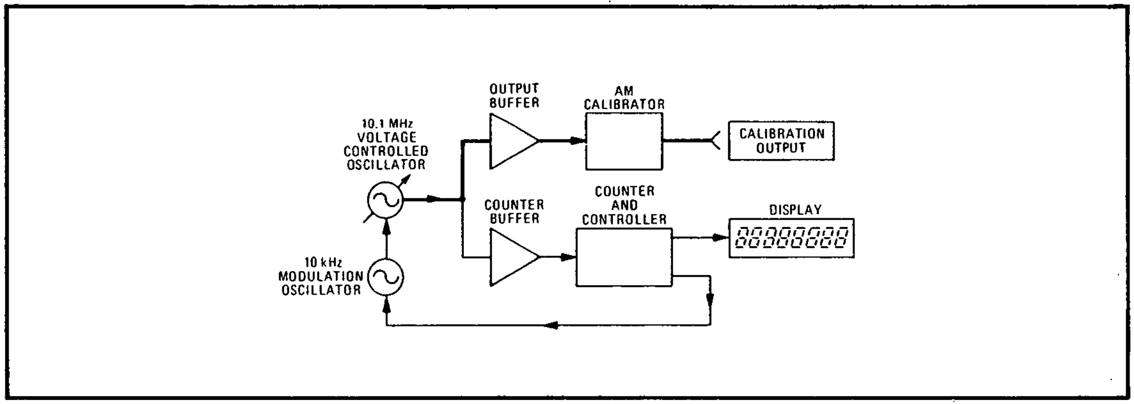
Indications (Cont'd)

the other measurements. The other instrument (B) displays the demodulated measurements (codes 12.1 and 12.2). During these measurements no measurement keys will be lighted, but the SPCL and selected DETECTOR keys of both instruments and the CALIBRATION key of the instrument with Option 010 will light.

Measurement Technique

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

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



Simplified Block Diagram of the FM Calibrator

Comments

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

Pressing the CALIBRATION key cancels all Special Functions.

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

When Special Functions 12.1 and 12.2 are used to calibrate another 8901A Modulation Analyzer they set the FM deviation range to 0 to 40 kHz (Special Function 2.2). Upon exiting the FM Calibrator Special Function, the modulation ranging is not returned to automatic but remains fixed (thus leaving the SPCL light on).

Related Functions

Calibration, AM
FM

Ratio
Residual Noise Effects
Special Functions

Default Conditions and Power-Up Sequence

Description

When first turned on, the Modulation Analyzer walks through a sequence of internal checks after which the instrument is ready to make measurements. The results of these checks are indicated internally to aid servicing. The power-up sequence is visible to the operator only in that all front-panel indicators are lighted. This allows the operator to determine if any of the LEDs are burned out. After approximately 10 seconds this sequence is completed. At that time the instrument will be configured as follows:

HP FILTER	ALL OFF
LP FILTER	ALL OFF
FM DE-EMPHASIS	Off
PRE-DISPLAY	Off
CALIBRATION (Option 010 only)	Off
MEASUREMENT	FREQ
DETECTOR	Off*
RATIO	Off
Ratio Reference	0
Limit	Off
Lower Limit Reference	150 kHz
Upper Limit Reference	1300 MHz
Limit Measurement Mode	Frequency
AUTOMATIC OPERATION	On
MANUAL OPERATION	
MHz INPUT FREQ	Automatic tuning**
↑↓kHz (step size)	0 kHz
SPCL	Special Functions prefixed 1 through 8 in zero-suffix mode; all others off except Service Request Condition (see below).
MODULATION OUTPUT	FM (Least sensitive range)
HP-IB Service Request Condition	HP-IB Error Only (22.2)
Status Byte	Cleared

*DETECTOR will be PEAK+ if a modulation measurement is selected immediately after power-up.

**If MHz is pressed immediately after power-up the instrument will tune to 100 MHz.

Related Sections

Calibration, AM
Calibration, FM
Tuning

Detectors

Description The Modulation Analyzer provides two types of audio detectors; peak and average (rms calibrated). (The peak hold function also provided is covered under *Detector, Peak Hold.)* The two peak detector keys select whether the positive peak (PEAK +) or the negative peak (PEAK—) of the demodulated signal is measured. The average detector is calibrated to read rms values with a sine wave input and is suitable for noise and residual measurements. The selected detector at turn on is PEAK +. Once selected, the detector remains unchanged and will be automatically activated each time modulation measurements are made until another detector is selected. The signals at MODULATION OUTPUT or at AM OUTPUT or FM OUTPUT are not affected by the DETECTOR keys.

Procedure When a modulation measurement is selected, a detector will automatically be activated. To select a different detector, press the appropriate key.

Example To measure negative peak AM modulation:

LOCAL (keystrokes)	Measurement Detector AM PEAK –
HP-IB (program codes)	M1D2 Measurement Detector

Program Codes HP-IB

Key	Program Code HP-IB
PEAK+	D1
PEAK—	D2
AVG (RMS CAL)	D4

Indications The LED in the selected DETECTOR key will light.

Comments The response time of the audio peak detectors can be slowed down; refer to *Detector (Peak) Time Constant.*

The PEAK+ detector is selected at power-up.

To display measurements made with the AVG (RMS CAL) detector as true average (not rms calibrated), key in 111.07, then press the % RATIO key.

Related Sections

Detector, Peak Hold	Ratio
Detector (Peak) Time Constant	Recorder Output
Modulation Output	

Detector, Peak Hold

Description The Modulation Analyzer provides a PEAK HOLD key to be used in conjunction with either of the two audio peak detectors, PEAK+ or PEAK− (refer to *Detectors*). When active, PEAK HOLD causes the Modulation Analyzer to hold and display indefinitely the greatest peak reading (+ or −) made.

Procedure Peak hold must be used with one of the peak detectors. To initiate peak hold, press the PEAK HOLD key. The instrument will now hold and display the greatest peak reading. To re-initiate a new peak hold cycle, press PEAK HOLD again. The display will now be updated with the new peak. To turn off peak hold, press any DETECTOR key other than the PEAK HOLD key or select a different MEASUREMENT.

Example To set up the Modulation Analyzer to measure the modulation transient on the output of a signal generator when the generator's AM switch is turned on:

LOCAL (keystrokes)	Measurement — Detector AM — PEAK+ PEAK HOLD
HP-IB (program codes)	M1D1D3 Measurement — Detector

Program Codes **HP-IB** D3 is the HP-IB code for PEAK HOLD. (For more HP-IB information on PEAK HOLD, refer to comments below.)

Indications When the PEAK HOLD key is pressed, the light within the PEAK HOLD key will turn on. The display will then show the greatest measurement value acquired since the PEAK HOLD key was pressed.

Comments Since the peak detector circuitry has a limited rise time, narrow one-time peaks may yield PEAK HOLD readings that are slightly low. To prevent errors when measuring narrow peaks, repeat the peak-generating process several times while leaving PEAK HOLD active. This assures the accuracy of the displayed results.

If PEAK HOLD is pressed while the average detector is active, the detector will switch to last peak detector previously selected.

RECORDER OUTPUT is directly linked to the peak detector output and will also hold the peak. Its output will deteriorate over a period of time after the signal is removed. The displayed peak, however, is stored in memory and does not deteriorate after the signal is removed.

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 Sections

Detectors
Detector (Peak) Time Constant
Recorder Output

Detector (Peak) Time Constant

(Special Function 5)

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

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

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

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

Example To enter a slow audio peak-detector response mode:

LOCAL (keystrokes)	Code Function 5 . 1 • SPCL
HP-IB (program codes)	5.1SP Code Function

Program Codes HP-IB For HP-IB codes, refer to Procedure above.

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

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

Related Sections
Detectors
Detector, Peak Hold
Recorder Output

Error Disable

(Special Function 8)

Description

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

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

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

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

Procedure

To selectively enable or disable the various errors listed under description above, enter the Special Function code corresponding to the condition desired, then press the SPCL key. The codes for the various conditions are given below.

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

Error Disable (Cont'd)

(Special Function 8)

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

LOCAL (keystrokes)	Code Function 8 . 8 • SPCL
HP-IB (program codes)	8.8SP Code Function

Program Codes **HP-IB** For HP-IB codes refer to Procedure above.

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

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

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

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

Related Sections

Error Message Summary
Special Functions

Error Message Summary

Description

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

Error messages are grouped by error code as follows:

E01 through E19 and E90 through E99. These are Operating Errors which indicate that not all conditions have been met to assure a calibrated measurement. Operating Errors can usually be cleared by a readjustment of front-panel controls (usually, the easiest way is to press AUTOMATIC OPERATION). The Error Disable Special Function (8.N) can be used to selectively disable certain Operating Errors.

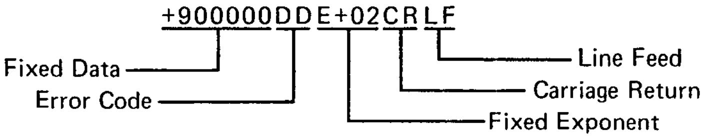
E20 through E29. These are Entry Errors which indicate that an invalid key sequence or keyboard entry has been made. These errors require that a new keyboard entry or function selection be made.

E30 through E89. These are Service Errors and are generated to give service information or because a service function has been accessed and has generated a message. Service errors do not necessarily represent failures within the instrument and must be enabled to appear. Service Errors are discussed in the Service Section (VIII) of this manual.

HP-IB Output Format

HP-IB

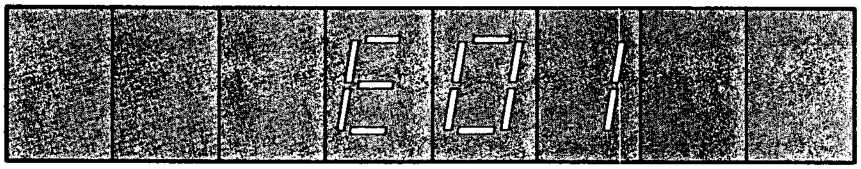
The HP-IB output format for errors is shown below:



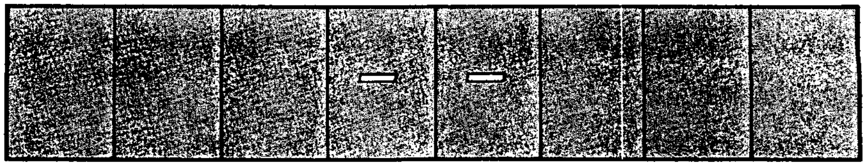
For example, error E01 is output to the HP-IB as +90000001E+02CRLF. This format differs from normal data outputs since normal data outputs will never exceed 4 x 10^9. Once an error has been input to the computing controller, the error code is simply derived by subtracting 9 x 10^9 from the input number, then dividing the result by 100.

Error Displays

Shown below are three types of error displays. The first is typical of most error displays and is shown as a general case. The second and third have specific meaning and occur often



The above display exemplifies the general error display format. E means error while the number is the error code. These errors are output to the HP-IB as shown under HP-IB Output format above.

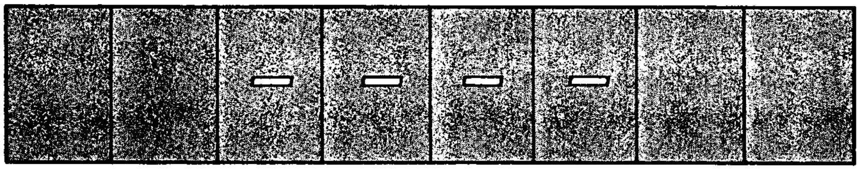


Error Message Summary (Cont'd)

Error Displays (Cont'd)

HP-IB

The display above means that 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 may be manually tuned far enough away from an input signal that no power can be detected in the IF.) This display is output to the HP-IB as E96 using the HP-IB output format above.



HP-IB

This display means that 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, manual settings may prevent a measurement from being completed (for example, frequency measurements made on a low-level input signal with high AM depth, or when the 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

The table below describes all Operating and Entry errors. The error code, message, and the action typically required to remove the error-causing condition are given. The Comments column gives additional information and references pertaining to particular errors.

ERROR CODE	MESSAGE	ACTION REQUIRED	COMMENTS
		Operating Errors	
E01	Signal out of IF range.	Re-tune to signal at input.	1
E02	Input circuits overdriven.	Increase input attenuation range or press AUTOMATIC OPERATION.	2
E03	Input circuits underdriven.	Decrease input attenuation range or press AUTOMATIC OPERATION	3
E04	Audio circuits overdriven.	Increase modulation range or press AUTOMATIC OPERATION	4

Comments:

1. 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 MHz ±2.5 kHz. Refer to *Tuning*. E01 turns off MODULATION OUTPUT.
2. Refer to *Attenuation, Input* for nominal input levels. E02 turns off MODULATION OUTPUT.
3. Refer to *Attenuation, Input* for nominal input levels. E03 turns off MODULATION OUTPUT.
4. Attempts to measure modulation levels greater than those specified or improperly set modulation range cause this error. Refer to *Modulation Range.*

Error Message Summary (Cont'd)

Error Messages (Cont'd)

ERROR CODE	MESSAGE	ACTION REQUIRED	COMMENTS
Operating Errors			
E05	FM squelched	Reduce signal level variations (AM) at INPUT.	1
E06	INPUT power protect relay open.	Reduce signal level at INPUT; then press any key.	2
E07	Display overrange.	Increase range or press AUTOMATIC OPERATION.	3
E08	CALIBRATOR signal not at INPUT (Opt. 001 only).	Connect CALIBRATION OUTPUT to INPUT or turn off Calibrator.	4
E09	Option not installed.	Select another instrument function.	5
E10	Input frequency out of range.	Adjust input frequency to within specified limits.	6
E11	Calculated value out of range.	Enter new RATIO reference.	
E12	Timebase oven cold (only Opt. 002).	For highest accuracy, wait until oven is warm.	8
E96 HP-IB	No input signal sensed by instrument (HP-IB only).	Increase level of signal at INPUT or decrease input attenuation.	9

Comments:

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

Error Message Summary (Cont'd)

Error Messages (Cont'd)

ERROR CODE	MESSAGE	ACTION REQUIRED	COMMENTS
		Entry Errors	
E20	Entered value out of range.	Re-enter new value.	–
E21	Invalid key sequence.	Check for compatibility of functions selected.	1
E22	Invalid Special Function prefix.	Check, then re-enter correct Special Function code.	2
E23	Invalid Special Function suffix.	Check, then re-enter correct Special Function Code	3
E24 HP-IB	Invalid HP-IB code.	Check, then re-enter correct HP-IB code.	4
		Service Errors	
E30 through 89	Service related errors.	Refer to service section of Manual.	5

Comments:

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

Filters

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

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

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

LOCAL (keystrokes)	HP Filter: 50 Hz ⊡ LP Filter: 15 kHz ⊡
HP-IB (program codes)	H1L2 High-Pass Filter — H1 Low-Pass Filter — L2

Program Codes HP-IB

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

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

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

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

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

Filters (Cont'd)

Comments (Cont'd)

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

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

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

When the Modulation Analyzer powers up no filters are inserted.

Related Sections

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

FM

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

Output Ranges

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

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

[2] With 750 microsecond de-emphasis, pre-display only.

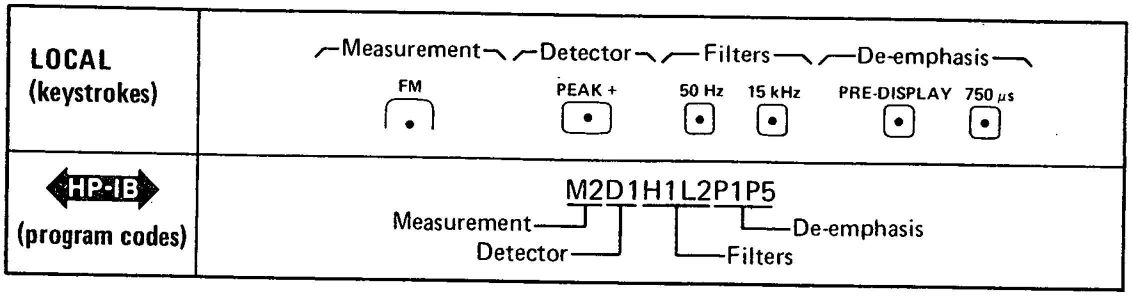
[3] Except 750 microsecond de-emphasis, pre-display.

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

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

FM (Cont'd)

Example (Cont'd)



Program Codes HP-IB

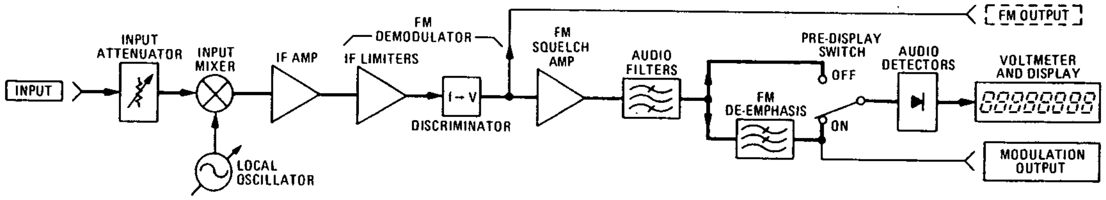
M2 is the HP-IB code for FM.

Indications

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

Measurement Technique

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



FM Measurement Block Diagram

Comments

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

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

The routine which automatically selects the audio range contains regions of overlap between 0.35 and 0.4 kHz (750 µs de-emphasis, pre-display only), 3.5 and 4 kHz, and 35

FM (Cont'd)

Comments (Cont'd)

and 40 kHz peak deviation as read on the display. When using the average detector ranging will occur with lower modulation levels displayed. If the modulation level is reduced from a higher range into an overlap region, the range may not change. To display the increased resolution, press the FM key a second time. To set the instrument to a selected modulation range, refer to *Modulation Range.*

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

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

Related Sections

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

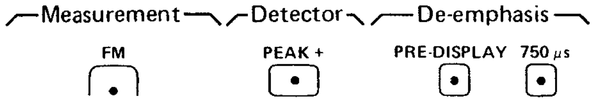
FM De-emphasis

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

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

Example To measure the positive peak FM deviation of a carrier with 750 μs de-emphasis inserted before the deviation measurement.

LOCAL (keystrokes)	
HP-IB (program codes)	M2D1P1P5 Measurement De-emphasis Detector

Program Codes HP-IB

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

FM De-emphasis (Cont'd)

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

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

Related Sections

FM
Modulation Output
Recorder Output

FM Output

CAUTION

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

Description

The rear-panel FM OUTPUT (dc coupled, 10 kΩ output impedance) provides an auxiliary output for the FM demodulated from the signal at the INPUT. This output is useful for monitoring FM while displaying AM or ΦM or when the modulation rate is very low. The output signal comprises a dc voltage related to the detected IF frequency and an ac voltage (bandwidth 16 kHz, 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 may be calculated as follows:

$$\text{Vdc} = \text{V}_{\text{off}} - \frac{\text{(K) (FREQ ERROR)}}{1000}$$

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,
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 may be measured by the procedure below.

Procedure

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

$$\text{(Vdc @ 2 MHz)} - \text{(Vdc @ 1 MHz)} = \text{V/MHz} = \text{mV/kHz}$$

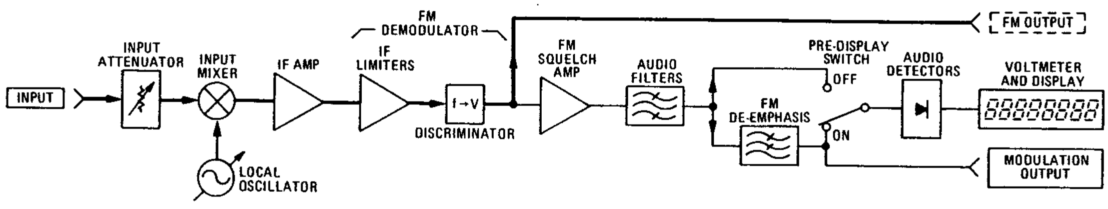
Example

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

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

Block Diagram

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



FM OUTPUT Block Diagram

FM Output (Cont'd)

Comments	FM OUTPUT is unsquelched and also contains a significant IF component which is greatest when operating at 150 kHz. Note that the sense of the ac output component (corresponding to the demodulated FM) is inverted for carriers with frequencies above 2.5 MHz. When RF LEVEL is selected, 50 dB of input attenuation is inserted. This degrades the accuracy of measurements made on the FM OUTPUT signal.
Related Sections	AM Output FM Frequency Error

Frequency (Input)

Description

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

Procedure

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

Example

To measure the frequency at INPUT:

LOCAL **(keystroke)**	FREQ .
HP-IB **(program codes)**	M5 Measurement

Program Code

HP-IB

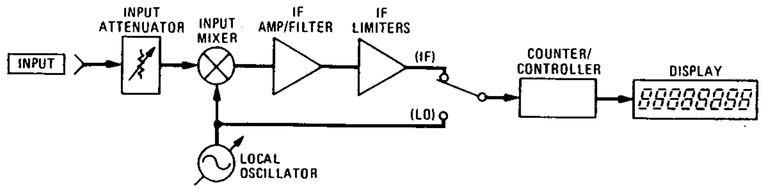
M5 is the HP-IB code for FREQ.

Indications

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

Measurement Technique

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



Input Frequency Measurement Block Diagram

Frequency (Input) (Cont'd)

Comments

The Modulation Analyzer powers up measuring the input frequency.

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

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

It is important to note that the frequency displayed when FREQ selected is the input signal frequency regardless of whether the LO is properly tuned or not as long as a signal is present in the IF. Thus, when using the ↑ kHz or ↓ kHz functions, the displayed input frequency will not change although tuning has been altered. The FREQ ERROR function will demonstrate the changed tuning. Typically, the instrument must be tuned within 50 kHz of the input frequency or E01 will be displayed. Use Special Function 8.1 to defeat the tuning error, E01, to increase the usable IF bandwidth.

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

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

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

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

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

Related Sections

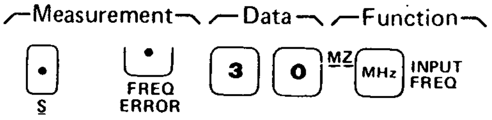
Error Disable
Frequency Error
Frequency, IF
Frequency Resolution
Ratio

Frequency Error

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

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

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

LOCAL (keystrokes)	
HP-IB (program codes)	S530MZ Measurement — Data — Function

Program Code HP-IB S5 is the HP-IB code for FREQ ERROR.

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

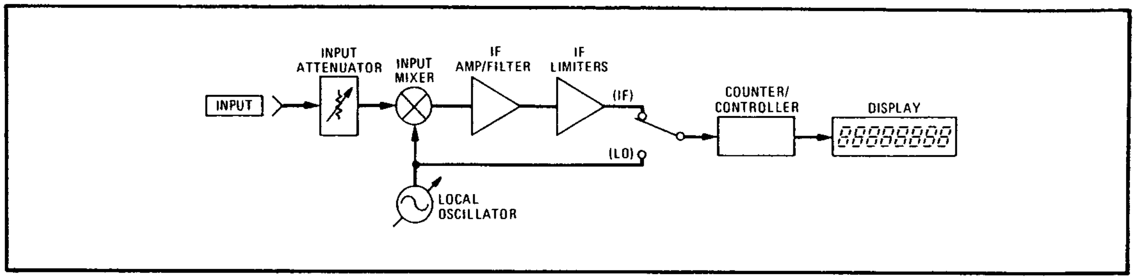
Measurement Technique When the Modulation Analyzer is tuned, the IF signal is amplified and limited (>60 dB of gain). If manually tuned, the input frequency is determined (refer to *Frequency [Input]*) and compared to the keyboard-entered frequency or the frequency the moment MHz was pressed. The difference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

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

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

Frequency Error (Cont'd)

Measurement Technique (Cont'd)



Frequency Error Measurement Block Diagram

Comments

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

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

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

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

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

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

Related Sections

Error Disable
Frequency, IF
Frequency, Input
Frequency Resolution
Tuning

Frequency, IF

(Special Function 10)

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

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

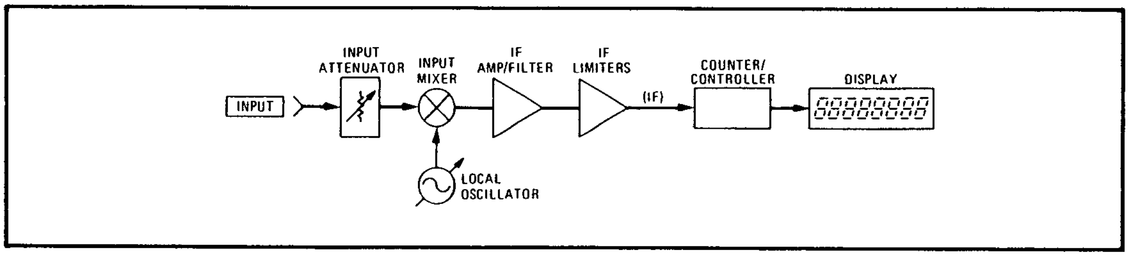
Example To display the frequency of the signal in the IF:

LOCAL **(keystrokes)**	Code Function 1 0 . 0 • SPCL
HP-IB **(program codes)**	10.0SP Code Function

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

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

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



IF Frequency Measurement Block Diagram

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

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

Related Sections

Error Disable	Frequency Resolution
Frequency (Input)	Special Functions

Frequency Resolution

(Special Function 7)

Description

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

Procedure

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

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

Example

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

LOCAL (keystrokes)	Code: 7 . 1 Function: • SPCL
HP-IB (program codes)	7.1SP Code: 7.1 Function: SP

Program Codes HP-IB

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

Indications

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

Comments

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

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

Related Sections

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

Hold Settings

(Special Function 9)

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

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

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

Example To hold settings:

LOCAL **(keystrokes)**	Code: 9 . 0 Function: • SPCL
HP-IB **(program codes)**	9.0SP Code: 9.0 Function: SP

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

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

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

Related Sections

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

HP-IB Address

(Special Function 21)

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

Allowable HP-IB Address Codes

Address Switches					Talk Address Character	Listen Address Character	Decimal Equivalent
A5	A4	A3	A2	A1			
0	0	0	0	0	@	SP	0
0	0	0	0	1	A	!	1
0	0	0	1	0	B	"	2
0	0	0	1	1	C	#	3
0	0	1	0	0	D	$	4
0	0	1	0	1	E	%	5
0	0	1	1	0	F	&	6
0	0	1	1	1	G	'	7
0	1	0	0	0	H	(	8
0	1	0	0	1	I	)	9
0	1	0	1	0	J	*	10
0	1	0	1	1	K	+	11
0	1	1	0	0	L	,	12
0	1	1	0	1	M	–	13
0	1	1	1	0	N	.	14
0	1	1	1	1	O	/	15
1	0	0	0	0	P	0	16
1	0	0	0	1	Q	1	17
1	0	0	1	0	R	2	18
1	0	0	1	1	S	3	19
1	0	1	0	0	T	4	20
1	0	1	0	1	U	5	21
1	0	1	1	0	V	6	22
1	0	1	1	1	W	7	23
1	1	0	0	0	X	8	24
1	1	0	0	1	Y	9	25
1	1	0	1	0	Z	:	26
1	1	0	1	1	[	;	27
1	1	1	0	0	\	<	28
1	1	1	0	1	]	=	29
1	1	1	1	0	⌒	>	30

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

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

HP-IB Address (Cont'd)

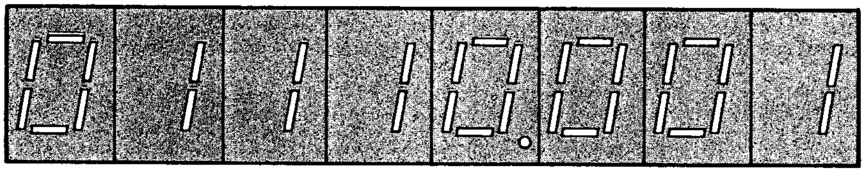
(Special Function 21)

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

Example Display the HP-IB address:

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

If the following was displayed:



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

Program Code HP-IB

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

Comments

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

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

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

Related Sections

Special Functions
Remote Operation, Hewlett-Packard Interface Bus (page 3-26)

IF Frequency, and Input High-Pass Filter Selection

(Special Function 3)

Description

The Modulation analyzer uses one of two IF frequencies. A 1.5 MHz IF is automatically selected for input frequencies below 2.5 MHz or above 10 MHz, while a 455 kHz IF is selected for inputs between 2.5 and 10 MHz. The IF, however, may be manually set to either 455 kHz or 1.5 MHz. In addition, an input high-pass filter can be manually inserted to reject low frequencies, if present, when measurements are to be made on higher frequencies (signals greater than 10 MHz). Use the numeric keyboard and the SPCL key to manually select both the IF frequency and the input high-pass filter.

The IF 3 dB bandwidth is approximately 3.0 MHz for the 1.5 MHz IF and 200 kHz for the 455 kHz IF. (Refer to the bandwidth diagram in *Tuning.*) Whenever the 455 kHz IF is selected, the Modulation Analyzer automatically inserts the 15 kHz low-pass modulation filter Under these conditions, only the 3 kHz or >20 kHz low-pass filters will override that filter. Whenever the 1.5 MHz IF is used below 2.5 MHz the 15 kHz low-pass is again selected; however, under these conditions only the 3 kHz low-pass overrides it. The following procedure selects the IF frequency and input high-pass filter combination, however, using the 455 kHz IF below 2.5 MHz requires a special procedure which can be found in the *Tuning* section.

Procedure

To manually select the IF frequency and input high-pass filter combination, key in the corresponding Special Function code, then press the SPCL key.

IF Frequency (MHz)	Input High-Pass Filter	Special Function Code	Program Code HP-IB
Automatic IF frequency selection	Out	3.0 SPCL	3.0SP
0.455	Out	3.1 SPCL	3.1SP
1.5	Out	3.2 SPCL	3.2SP
0.455	In	3.3 SPCL	3.3SP
1.5	In	3.4 SPCL	3.4SP

Example

To use the 455 kHz IF above 10 MHz (input high-pass filter in):

LOCAL (keystrokes)	Code Function 3 . 3 • SPCL
HP-IB (program codes)	3.3SP Code Function

Program Codes HP-IB

The HP-IB codes for setting various IF frequency and input high-pass filter combinations are given under Procedure above.

IF Frequency, and Input High-Pass Filter Selection (Cont'd)

(Special Function 3)

Indications As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Unless Special Function code 3.0 was entered, the light within the SPCL key will turn on if not already on. If the light is already on, it will remain on.

Comments When a new IF frequency is selected, the instrument immediately retunes to accommodate it.

Frequency and tuned RF level measurements may typically be made on very low-level signals (to —60 dBm). Using the narrow bandwidth of the 455 kHz IF for signal frequencies below 2.5 MHz or above 10 MHz increases the sensitivity and selectivity of the Modulation Analyzer in these modes.

When using the 455 kHz IF on input signals with frequencies above 300 MHz, AM due to FM increases substantially.

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

Related Sections

Frequency, IF
Hold Settings
Level, IF
Special Functions
Tuning

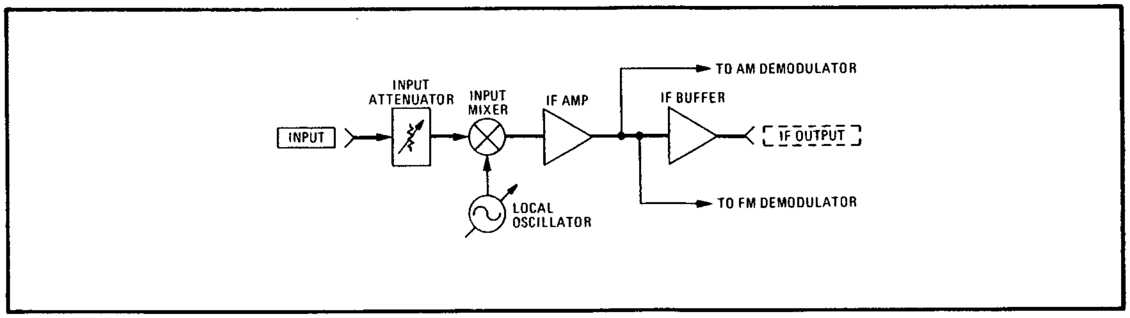
IF Output

CAUTION

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

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

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



IF OUTPUT Block Diagram

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

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

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

Level, IF

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

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

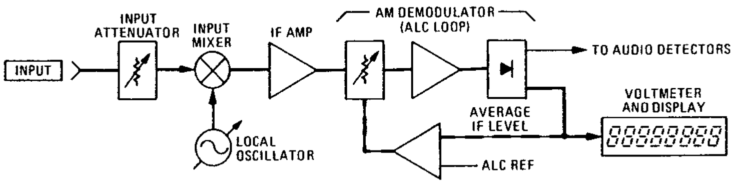
Example To measure IF Level:

LOCAL (keystrokes)	Measurement S IF LEVEL
HP-IB (program codes)	S3 Measurement

Program Code HP-IB S3 is the HP-IB code for IF LEVEL.

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

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



IF Level Measurement Block Diagram

Level, IF (Cont'd)

Comments

When enabled, E03 (input circuits underdriven) will be generated whenever IF level is less than 100% optimum.

When operating with the AM ALC loop open, the AM displayed represents the demodulated ac riding on the carrier while the IF level displayed represents the average carrier level. The AM % can be computed by the following formula:

$$\frac{\text{demodulated ac}}{\text{average carrier level}} \times 100\% = \frac{\text{AM \% displayed}}{\text{IF level displayed}} \times 100\%$$

An easy way to make the Modulation Analyzer do the computation for you is to first observe the IF level, then switch to AM and enter the IF level on the numeric keys. Now press the % RATIO key. AM will now be displayed accurately although the IF level was not 100%.

In general when the AM ALC is off (loop open), use IF levels $\geqslant$100% for FM measurements and $\leqslant$100% for AM measurements.

Related Sections

AM ALC Response Time
Level, Tuned RF
Level, RF

Level, RF

Description The RF LEVEL key causes the Modulation Analyzer to measure the peak broadband RF power at INPUT in watts. In addition, MODULATION OUTPUT 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.

Measurement Range 1 milliwatt to 1 watt into 50Ω. (0 to +30 dBm or 0.22 Vrms to 7 Vrms.) 1 μW maximum resolution.

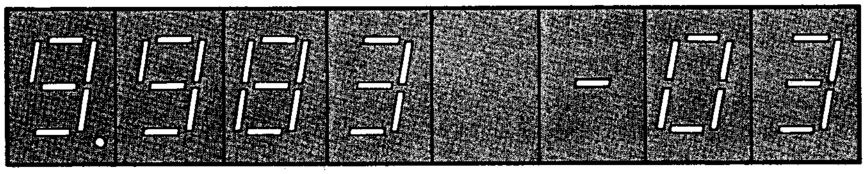
Procedure To make a broadband RF power measurement, press the RF LEVEL key. (If the RF level is to be displayed relative to some reference level refer to *Ratio.*)

Example To measure the peak envelope power of an RF input signal:

LOCAL **(keystroke)**	Measurement RF LEVEL
HP-IB **(program codes)**	M4 Measurement

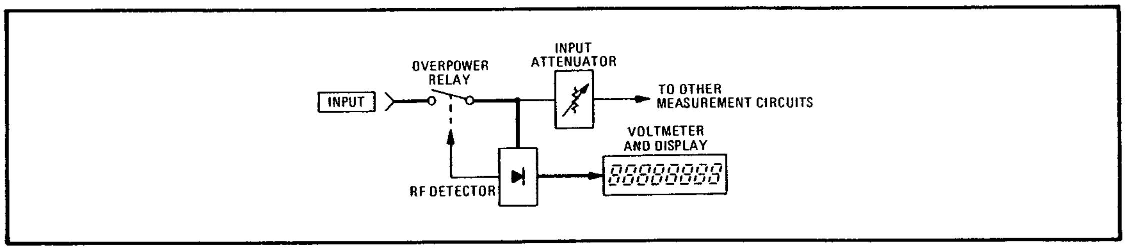
Program Code **HP-IB** M4 is the HP-IB code for RF LEVEL.

Indications When RF level is selected, the LEDs within the RF LEVEL key and the watts annunciator will light. The display will be in scientific notation form; that is, a 4-digit number followed by a signed power-of-10 multiplier. For example, if the display shows:



then the power at INPUT is 9.983 x 10^{-3} watts (9.983 mW).

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



RF Level Measurement Block Diagram

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

Level, RF (Cont'd)

Comments (Cont'd)

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

To display power in dBm, enter the number .001, then press the dB key.

Related Sections

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

Level, Tuned RF

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

NOTE

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

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

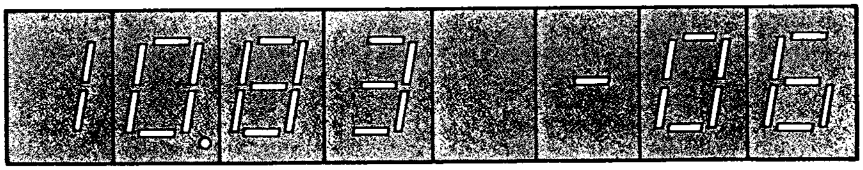
Procedure To make a tuned RF level measurement, first tune the instrument to the input signal (refer to *Tuning* or press AUTOMATIC OPERATION). Manual tuning will be necessary when measuring low-level signals (inputs <−25 dBm from 150 kHz to 650 MHz or <−20 dBm from 650 to 1300 MHz). Press the S (shift)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

Example To measure the tuned RF level of an input signal:

LOCAL (keystrokes)	Measurement S TUNED RF LEVEL
HP-IB (program codes)	S4 Measurement

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

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

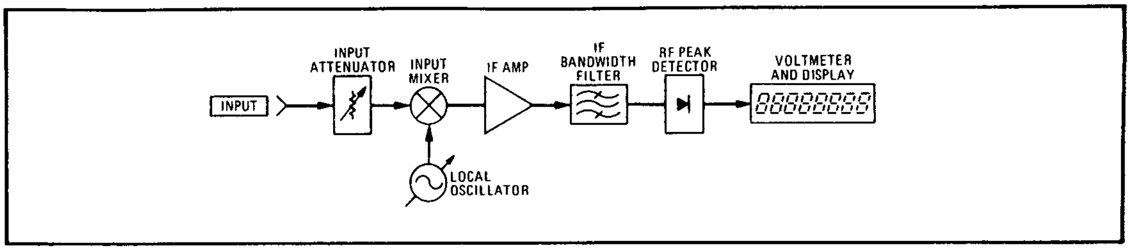


then the tuned RF level is 10.83 x 10^{-6} watts (10.83 μW).

Measurement Technique When the Modulation Analyzer is tuned, all the power falling within the IF is amplified and peak detected. It is then measured by the voltmeter and displayed in watts.

Level, Tuned RF (Cont'd)

Measurement Technique (Cont'd)



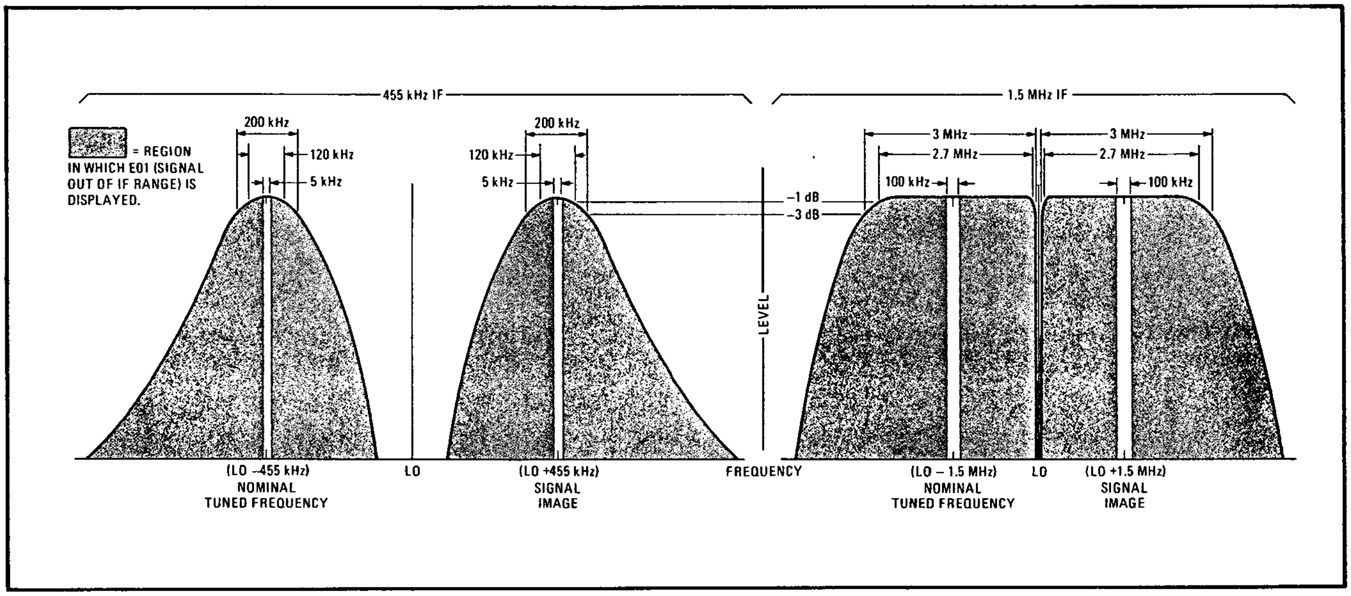
Tuned RF Level Measurement Block Diagram

Comments

The bandwidth of the 455 kHz IF (normally used for input frequencies between 2.5 and 10 MHz) is approximately 200 kHz. The bandwidth of the 1.5 MHz IF (normally used for input frequencies below 2.5 MHz or above 10 MHz) is approximately 3 MHz. However, each nominal IF passband also has an image passband which may contain signals with significant power. The IF and image bandwidths and their relationships to the local oscillator signal (LO) are illustrated for each IF in the spectrum diagram given below.

To display power in dBm, enter the number .001, then press the dB key.

Absolute power measurements are most accurate in RF level, however, power measurements have greater dynamic range in tuned RF level.



Spectrum Diagram of the 455 kHz and 1.5 MHz Tuned Bandwidths

Related Sections

Level, IF
Level, RF
Ratio

Limit

(Special Function 14)

Description

Using the numeric keyboard and the SPCL and RATIO keys, upper and lower measurement limits may be entered into the Modulation Analyzer. Subsequent out-of-limit measurements will then cause the LIMIT annunciator to light. If enabled, reaching an upper or lower limit will also cause the Modulation Analyzer to issue an HP-IB service request. (Refer to *Service Request Condition.*) The LIMIT light will turn off after 5 measurement cycles if further measurements are not out of limits, however, the service request can only be cleared by serial polling or by a Device Clear message. Only one upper and one lower limit can be set at a time and each limit (upper or lower) can only be in effect in one measurement mode. The measurement mode need not be the same for both the upper and lower limits. Both limit references can be displayed, cleared, and restored, and the measurement modes for both limits may be displayed.

Procedures

A limit reference must first be entered as a RATIO reference. To do this, first select the MEASUREMENT in which the limit is to be used, then key in the value of the limit on the numeric keyboard, and press either the % or dB key. (Since the RATIO keys are used here simply to enter the limit into the instrument it does not matter which key, % or dB, is used.) The entered value is now stored as a RATIO reference. To make this reference negative or to transform it directly into either an upper or lower limit reference, key in the corresponding Special Function code, then press the SPCL key. The Special Function codes most useful when working with the limit functions are listed below:

	Action	Special Function Code	Program Code HP-IB
Ratio	Read RATIO reference	11.2 SPCL	11.2SP
	Make RATIO reference negative	11.3 SPCL	11.3SP
Limit	Clear limits; turn off LIMIT annunciator	14.0 SPCL	14.0SP
	Set lower limit to RATIO reference	14.1 SPCL	14.1SP
	Set upper limit to RATIO reference	14.2 SPCL	14.2SP
	Restore lower limit	14.3 SPCL	14.3SP
	Restore upper limit	14.4 SPCL	14.4SP
	Read lower limit	14.5 SPCL	14.5SP
	Read upper limit	14.6 SPCL	14.6SP
	Read lower limit measurement mode	14.7 SPCL	14.7SP
	Read upper limit measurement mode	14.8 SPCL	14.8SP

To determine the measurement in which an upper or lower limit is in effect key in the corresponding Special Function code, then press the SPCL key. The display shows a code which represents the measurement in which the limit is in effect. These codes are indexed below.

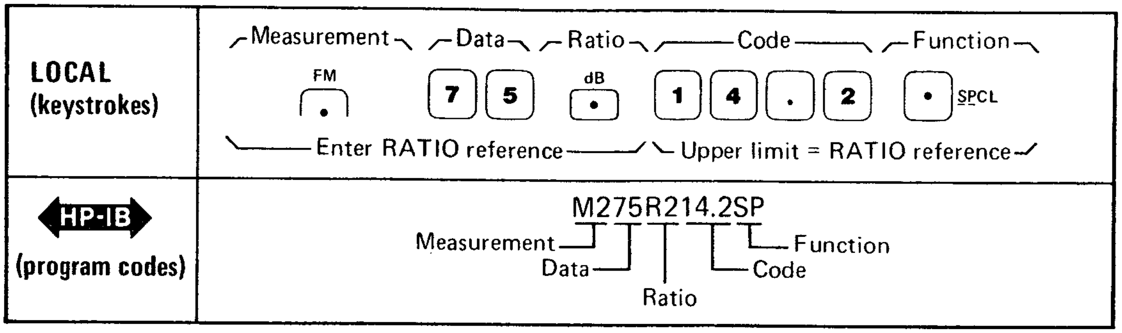
Display	Measurement	Display	Measurement
0.000	AM	0.006	FREQ ERROR
0.001	FM	0.007	Spare
0.002	ΦM	0.008	IF LEVEL
0.003	RF LEVEL	0.009	Spare
0.004	TUNED RF LEVEL	0.010	IF Frequency
0.005	FREQ	0.011	Spare

Limit (Cont'd)

(Special Function 14)

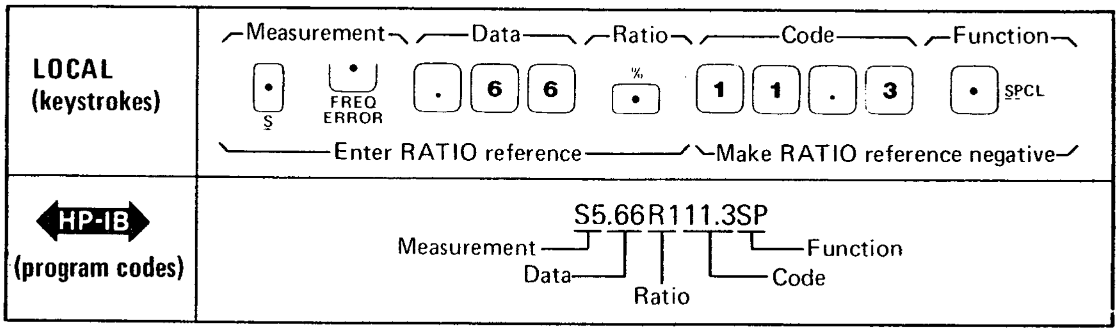
Examples

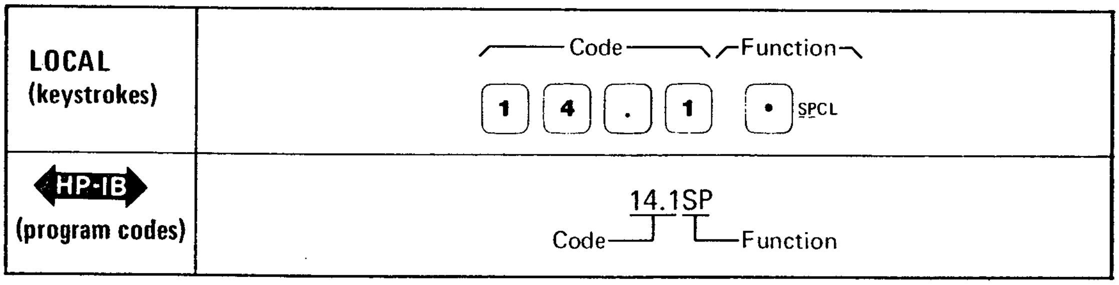
To set an upper limit of 75 kHz FM deviation:



This leaves the Modulation Analyzer in dB RATIO mode. Press the dB key to exit RATIO and to read the FM deviation in kHz with an upper limit set at 75 kHz. Notice that this example could have used the % RATIO key with equal results.

To set a lower FREQ ERROR limit of —660 Hz:





This leaves the Modulation Analyzer in % RATIO mode. Press the % key to read the frequency error in kHz with the lower limit set to —660 Hz.

Limit (Cont'd)

(Special Function 14)

Examples (Cont'd)

To determine in which measurement the lower limit is set:

LOCAL **(keystrokes)**	Code — Function 1 4 . 7 • SPCL
HP-IB **(program codes)**	14.7SP Code — Function

If, for example, the display shows 0.006, the lower limit is set for the FREQ ERROR measurement.

Program Codes HP-IB

The codes for performing the various limit and ratio operations are given above. The codes for the RATIO keys are given below for reference.

Key or Function	Program Code HP-IB
Turn off RATIO	R0
%	R1
dB	R2

Indications

As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. If limits are being cleared or set, the SPCL key will not turn on if not already on. However, if limits or their measurement modes are being read, the key will turn on if not already on and remain lighted while the limit value or mode is displayed. When operating with limits set, the other key lights and the display behaves as they normally would, however, if a measurement falls out of set limits, the LIMIT annunciator lights. The light remains on until 5 successive measurements are made that fall within the set limits. Thus, the LIMIT light will normally remain on for approximately 1 second after the last out-of-limit measurement result. If the Modulation Analyzer is set to issue a service request when an out-of-limit measurement occurs, the service request may be cleared by serial polling.

Comments

It does not matter which RATIO key is used to enter the RATIO reference before transforming it into a limit.

The test for out-of-limit results is performed on the actual measurement results, not upon the displayed number. Thus, although the display may show a relative measurement result (i.e., using the ratio functions) the limit test is still made upon the result before the ratio is computed. Limits cannot be set in terms of relative measurement results.

Related Sections

Service Request Condition
Special Functions
Ratio

LO Input and LO Output

CAUTION

Do not apply greater than 40 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

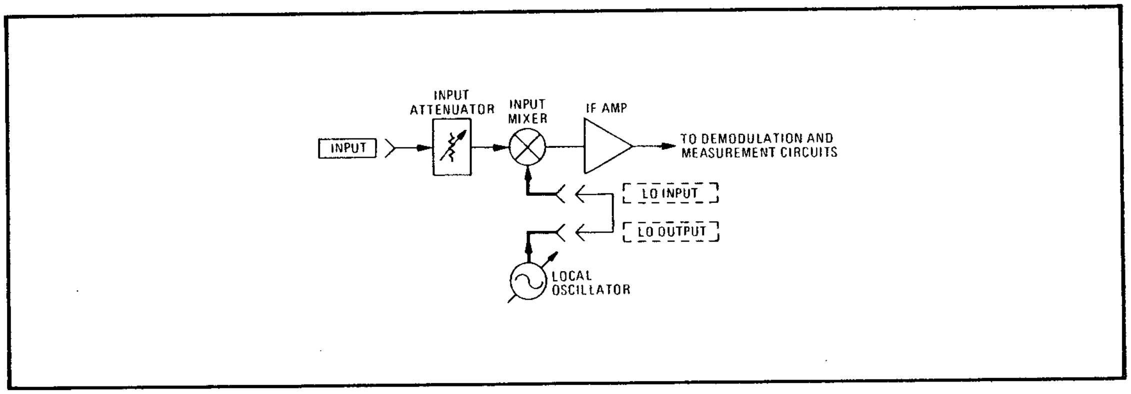
In Modulation Analyzers with Option 003, the internal local oscillator signal (LO) is brought out of and back into the instrument through the rear-panel LO OUTPUT and LO INPUT jacks. The signal at these jacks ranges from ~1.27 to 1301.5 MHz at approximately 0 dBm. Both jacks are 50Ω, ac coupled and furnished with female Type N connectors.

NOTE

For normal Modulation Analyzer operation using the internal local oscillator, the rear-panel LO OUTPUT must be connected to the rear-panel LO INPUT.

Block Diagram

A block diagram illustrating the relationships between the LO INPUT and LO OUTPUT jacks and the Modulation Analyzer's input circuits is given below.



LO INPUT and LO OUTPUT Block Diagram

Procedure

To use LO OUTPUT as a signal source, select an IF frequency (1.5 MHz or 455 kHz) using Special Function 3. The Modulation Analyzer will assume 1.5 MHz IF above 10 MHz (as entered on the keyboard) and 455 kHz IF below 10 MHz if the IF frequency is not specified. Subtract the IF frequency from the frequency desired at LO OUTPUT and enter the result in MHz via the numeric keys, then press MHz.

To tune the LO below 2.96 MHz use the procedure above, but select the 455 kHz IF (Special Function code 3.1) and disable error E01 (Special Function code 8.1).

To use LO INPUT to apply an external LO, select an IF frequency (1.5 MHz or 455 kHz) using Special Function 3. Press the MHz key to enter manual tune mode (this keeps the internal LO from tuning continuously). Add the IF frequency to the frequency to which the Modulation Analyzer is to be tuned and set the external LO to that frequency. Adjust the external LO to 0 dBm and apply the signal to LO INPUT.

Comments

To tune to inputs below 2.5 MHz with an external LO, select the 1.5 MHz IF, but set the LO to ~100 MHz. The LO must be present to bias the Input Mixer on, but down-conversion is not necessary.

LO Input and LO Output (Cont'd)

Comments (Cont'd)

When an external LO is used, measurements made using the FREQ or FREQ ERROR keys will not be accurate. To determine input frequency, subtract the IF frequency (Special Function 10) from the LO frequency used.

When using an external LO, rapid changes in LO frequency within the IF passband cause FM transients. Several seconds are then required before accurate measurements will be possible. To avoid the problem, turn off the external LO when switching its frequency.

Related Sections

IF Frequency and Input High-Pass Filter Selection
Tuning

Modulation Output

CAUTION

Do not apply greater than 10 Vdc or greater than +30 dBm (1 watt) into MODULATION OUTPUT or damage to the instrument may result.

NOTE

For optimum signal flatness, cables attached to MODULATION OUTPUT should be terminated with their characteristic impedance.

Description MODULATION OUTPUT provides a calibrated output for signals demodulated by the Modulation Analyzer. The output is dc coupled with a 600Ω output impedance and a BNC female connector. The signal at MODULATION OUTPUT always corresponds to the modulation measurement being made. If FREQ, IF LEVEL, TUNED RF LEVEL, FREQ ERROR or IF frequency is selected, the signal at MODULATION OUTPUT corresponds to the last selected modulation measurement. If RF LEVEL is selected, MODULATION OUTPUT is turned off (i.e., set to 0V). If high-pass or low-pass filters are selected, they always affect the signal at MODULATION OUTPUT. If FM de-emphasis is selected, it always affects demodulated FM at MODULATION OUTPUT, regardless of the PRE-DISPLAY setting. The output level of the signal at MODULATION OUTPUT is autoranging and usually is between 0 and 4V peak into an open circuit. The output sensitivity (into an open circuit) depends upon both the modulation type and the displayed resolution as given in the table below. (More information on other outputs and the setting of modulation ranges may be found in *Modulation Range.*)

AM		FM		ΦM	
Display Resolution (%)	MODULATION OUTPUT Sensitivity (Vac/%)	Display Resolution (Hz)	MODULATION OUTPUT Sensitivity (mVac/Hz)	Display Resolution (radians)	MODULATION OUTPUT Sensitivity (mVac/radian)
0.01	0.1	0.1*	10*	0.001	1
		1	1	0.01	0.1
0.1	0.01	10	0.1		
		100**	0.01**	0.1	0.01

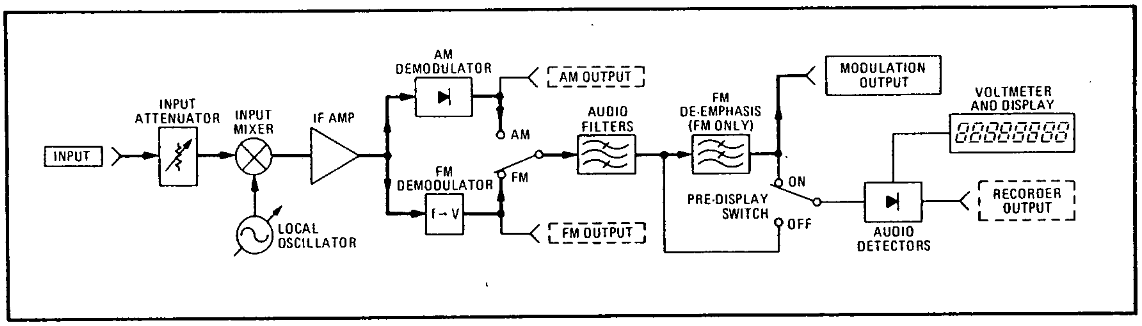
*Available only with 750 microsecond de-emphasis, pre-display.

**Not available with 750 microsecond de-emphasis, pre-display.

Block Diagram A simplified block diagram of the Modulation Analyzer's measurement circuits illustrating the relationships between MODULATION OUTPUT and the other outputs and circuit blocks is given below.

Modulation Output (Cont'd)

Block Diagram (Cont'd)



Modulation Output Block Diagram

Comments

The sense of the demodulated FM and ΦM at MODULATION OUTPUT is inverted for carriers with frequencies below 2.5 MHz.

Errors E01 through E03, E05, E10, and HP-IB error E96 (corresponds to a display of two dashes) turn off the signal at MODULATION OUTPUT.

When the Modulation Analyzer is first powered up, the demodulated signal at MODULATION OUTPUT is FM. The sensitivity is 0.01 mVac/Hz and will not autorange to more sensitive ranges. This is because at power up, FREQ is selected, and thus E04 (audio circuits overdriven) is automatically disabled. When E04 is disabled, only autoranging to less sensitive audio ranges is allowed.

When E01 through E04 are always enabled (8.8 SPCL), the signal at MODULATION OUTPUT is entirely safeguarded. Under this condition an error will be displayed when the signal at MODULATION OUTPUT is uncalibrated. Refer to *Error Disable.*

Related Sections

AM
Error Disable
Filters
FM
Modulation Range
ΦM

Modulation Range

(Special Function 2)

Description When first tuned on, the Modulation Analyzer is set to automatically select the modulation range appropriate for the desired measurement. However, using the numeric keyboard and the SPCL key, the modulation range can be manually set.

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

AM

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

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

FM

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

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

[2] With 750 microsecond de-emphasis, pre-display only.

[3] Except 750 microsecond de-emphasis, pre-display.

Modulation Range (Cont'd)

(Special Function 2)

Procedure (Cont'd)

Phase Modulation (Φ M)						
Modulation Range[1]				Display Resolution (radians)	MODULATION OUTPUT Sensitivity (mVac/radian)	RECORDER OUTPUT (Rear Panel) (Vdc/rad. peak dev.)
PEAK ± (rad. dev.)	AVG[2] (rad. dev.)	Special Function Code	Program Code HP-IB			
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection		
⩽4	⩽2.8	2.1 SPCL	2.1SP	0.001	1	1
⩽40	⩽28	2.2 SPCL	2.2SP	0.01	0.1	0.1
⩽400	⩽280	2.3 SPCL	2.3SP	0.1	0.01	0.01

[1] Range limits are nominal. Refer to figure under Phase Modulation for relationship between deviation, rate, and resolution.

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

Example To set the modulation range to the ⩽40% AM setting (also ⩽4 kHz deviation for FM and ⩽4 radians deviation for ΦM):

LOCAL (keystrokes)	Code: 2 . 1 Function: • SPCL
HP-IB (program codes)	2.1SP Code: 2.1 Function: SP

Program Codes HP-IB For HP-IB codes, refer to Procedure above.

Indications As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Unless Special Function code 2.0 was entered, the light within the SPCL key will turn on, if not already on. If the light is already on it will remain on.

Comments When the instrument is first turned on or when AUTOMATIC OPERATION is selected, the modulation range is placed in the automatic selection mode.

If the modulation range selected is too high, no error will be generated, and both MODULATION OUTPUT and RECORDER OUTPUT will track the displayed values. If the modulation range is too low (i.e., the audio signal level is too high), error E04 will be generated. The point at which error E04 is generated may not be exactly at the nominal level at which ranges are switched.

Modulation Range (Cont'd)

(Special Function 2)

Comments (Cont'd)

When E04 is disabled (Special Function code 8.4), autoranging is to higher modulation ranges only. This feature is used most often when modulation varies widely with time such as off-the-air demodulation of a broadcast signal.

Refer to *Phase Modulation (ΦM)* for more information on ΦM modulation ranges.

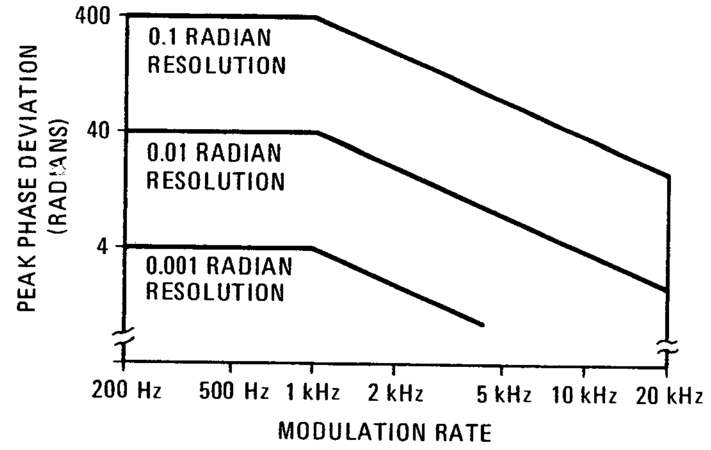
Related Sections

Error Disable
Hold Settings
Special Functions

ΦM

Description

The Φ M key causes the Modulation Analyzer to measure the phase modulation deviation of the input signal to which the instrument is tuned. In addition, demodulated ΦM is present at MODULATION OUTPUT. The ΦM measurement is only specified for carriers from 10 to 1300 MHz, however, ΦM measurements are allowed on carriers from 150 kHz to 10 MHz. The ΦM measurement is only specified for modulation rates from 200 Hz to 20 kHz, however, the low frequency 3 db limit is typically 7 Hz.



Phase Modulation Peak Phase Deviation and Modulation Rate vs. Display Resolution

Phase Modulation (Φ M)

Modulation Range[1]				Display Resolution (radians)	MODULATION OUTPUT Sensitivity (mVac/radian)	RECORDER OUTPUT (Rear Panel) (Vdc/rad. peak dev.)
PEAK± (rad. dev.)	AVG[2] (rad. dev.)	Special Function Code	Program Code HP-IB			
Automatic Selection		2.0 SPCL	2.0SP	Automatic Selection		
≤4	≤2.8	2.1 SPCL	2.1SP	0.001	1	1
≤40	≤28	2.2 SPCL	2.2SP	0.01	0.1	0.1
≤400	≤280	2.3 SPCL	2.3SP	0.1	0.01	0.01

[1] Range limits are nominal. Refer to figure under Phase Modulation for relationship between deviation, rate, and resolution.

[2] Values are for sine wave modulation signal only

Procedure

To make a ΦM measurement, first tune the instrument to the input signal (refer to *Tuning* or press AUTOMATIC OPERATION). Press the ΦM key, and selet an audio detector: PEAK+, PEAK—, or AVG (refer to *Detectors*). To limit the demodulated signal measurement bandwidth, press the appropriate filter keys (refer to *Filters*). When ΦM is selected, the 50 Hz high-pass filter is automatically inserted which limits the low frequency response. This filter may be removed if desired by pressing the 50 Hz key, however, residual ΦM will increase and measurement inaccuracies may result. If ΦM deviation is to be displayed relative to a reference, refer to *Ratio*.

ΦM (Cont'd)

Example

To measure the positive peak ΦM deviation of a signal in a 50 Hz (filter automatically inserted) to 15 kHz demodulated signal bandwidth:

LOCAL (keystrokes)	Measurement — Detector — Filters ΦM PEAK + 15 kHz
HP-IB (program codes)	M3D1H1L2 Measurement — Detector — Filters

Program Code **HP-IB**

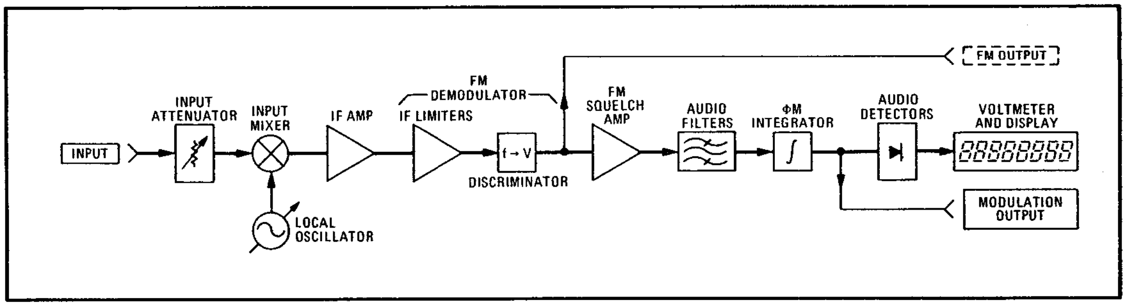
M3 is the HP-IB code for ΦM.

Indications

The LEDs within the keys representing the selected functions will light. The radians annunciator will light and ΦM on the display will show the radian deviation on the carrier.

Measurement Technique

Once the instrument is tuned to the input signal, 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 then detected and displayed as phase deviation in radians.



ΦM Measurement Block Diagram

Comments

The PEAK+ detector always detects the carrier's positive phase deviation while the PEAK- detector always detects its negative phase deviation.

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

When operating above 2.5 MHz while using the 455 kHz IF, the modulation bandwidth's upper limit is that of the >20 kHz low-pass filter. Note that the 15 kHz low-pass 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 the >20 kHz low-pass filter.

The 50 Hz high-pass filter, automatically inserted when ΦM is selected, remains on as long as the signal at MODULATION OUTPUT is the demodulated ΦM signal or until the filter is manually turned off.

ΦM (Cont'd)

Comments (Cont'd)

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

AM conditions which cause the carrier signal to disappear will cause inaccuracies in the measurement of ΦM deviation, or they may cause E05 (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 % RATIO (refer to *Ratio).*

Pulsed phase modulation such as phase shift keying cannot be accurately demodulated or measured by the Modulation Analyzer.

Related Sections

Detectors
Filters
Modulation Basics (Section 1—16)
Modulation Range
Ratio
Residual Noise Effects

Ratio

(Includes Special Function 11)

Description

The RATIO keys permit any measurement result to be compared in % or dB to a reference value. The reference value may be the result of a previous measurement or a keyboard entry. The RATIO keys can be used with any MEASUREMENT function and with IF Frequency (Special Function 10).

The Modulation Analyzer stores only one RATIO reference at a time. When in RATIO, if a new measurement is selected, RATIO is disabled. This may be inconvenient, especially, when it is necessary to switch between measurements often (for example, to check input frequency while measuring AM). When returning to the previous measurement, it is possible to re-enter RATIO mode with the same factor used before, using Special Function 11.0 or 11.1. Additionally, the RATIO reference may be displayed or made negative (useful for setting frequency error limits), using Special Function 11.2 or 11.3.

Procedures

To use the RATIO keys, set the display to the desired reference value. This can be done by adjusting the signal parameter being measured to a reference setting or by entering the reference on the numeric keys. If % RATIO is desired, press the % key; if dB RATIO is desired, press the dB key. The display will show the measurement result relative to the reference value.

To re-enter RATIO with the previous RATIO reference or to read the reference or make the reference negative, key in the corresponding Special Function code, and press the SPCL key. The Special Function codes are listed below.

RATIO Operation	Special Function Code	Program Code HP-IB
Re-enter % RATIO with the previous reference.	11.0 SPCL	11.0SP
Re-enter dB RATIO with the previous reference.	11.1 SPCL	11.1SP
Read RATIO reference.	11.2 SPCL	11.2SP
Make RATIO reference negative.	11.3 SPCL	11.3SP

Examples

If the display shows 35.35 kHz FM deviation, to enter this value as the RATIO reference for future measurement:

LOCAL (keystroke)	Ratio % •	or	Ratio dB •
HP-IB (program codes)	R1 Ratio	or	R2 Ratio
Resulting Display	100.0 REL (% key light on)	or	0.00 REL (dB key light on)

Ratio (Cont'd)

(Includes Special Function 11)

Examples (Cont'd)

If the display shows 35.35 kHz FM deviation, to compare this to an FM deviation of 50 kHz:

LOCAL (keystrokes)	Data — Ratio [5] [0] [•] (%)	or	Data — Ratio [5] [0] [•] (dB)
HP-IB (program codes)	50R1 Data — Ratio	or	50R2 Data — Ratio
Resulting Display	70.7 REL (% key light on)	or	−3.01 REL (dB key light on)

If after setting up the RATIO reference in the example above, the frequency is checked, RATIO will be disabled. If it is desired to return to FM with the previous (dB) RATIO reference:

LOCAL (keystrokes)	Measurement — Code — Function FM [•] [1] [1] [.] [1] [•] SPCL
HP-IB (program codes)	M211.1SP Measurement — Code — Function

Program Codes HP-IB

The HP-IB codes for re-entering RATIO or for reading or changing the reference are given above. The HP-IB codes for the RATIO keys are given below:

RATIO Function	Program Code HP-IB
off	R0
%	R1
dB	R2

Indications

When the instrument is displaying a RATIO measurement, the REL (relative) annunciator and the appropriate RATIO key both light. Other units annunciators turn off. The displayed value is the measurement result relative to the reference in % or dB.

Measurement Technique

When in RATIO, measurements are made in the same fashion as when not in RATIO, however before the result is displayed, the internal controller converts it to ratio. The following formulas are used for computing ratio:

Ratio (Cont'd)

(Includes Special Function 11)

Measurement Technique (Cont'd)

$\left(\frac{M}{R}\right)$ (100%) = % RATIO for all measurements,

(20) log $\left(\frac{M}{R}\right)$ = dB RATIO for all modulation and IF level measurements

(10) log $\left(\frac{M}{R}\right)$ = dB RATIO for frequency and level measurements except IF level

where M = the current measurements result, and
R = the RATIO reference.

Comments

When using dB RATIO, if a ratio reference is entered or a measurement result occurs that causes the value of M/R (see equations above) to approach 0, E11 will be displayed. This typically occurs when a measurement result goes to 0.

If already in RATIO, pressing the opposing RATIO key causes the Modulation Analyzer to acquire a new reference from the present measurement result. To convert from dB to % (or vice versa) with the same reference, use the re-enter RATIO function (Special Function 11.0 or 11.1).

The RATIO keys are convenient when used to check modulation or RF level flatness across an RF frequency range (use track mode tuning, Special Function 4.1) or across the audio range.

The reference that is stored for ratio measurements may be entered as a limit reference (refer to *Limit*).

Some useful reference values for making ratio measurements are given below:

To display power in dBm, use 0.001 and dB RATIO.
To display broadcast FM relative to 75 kHz use 75 and % RATIO.
To display ΦM in degrees, use 1.745 and % RATIO.
To display AM as dB down from the carrier, use 200 and dB RATIO.
To display rms calibrated average as true average, use 111.07 and % RATIO.
To display rms calibrated average as peak, use 70.7 and % RATIO.

Related Sections

Error Message Summary
Limit
Special Functions
Tuning

Recorder Output

CAUTION

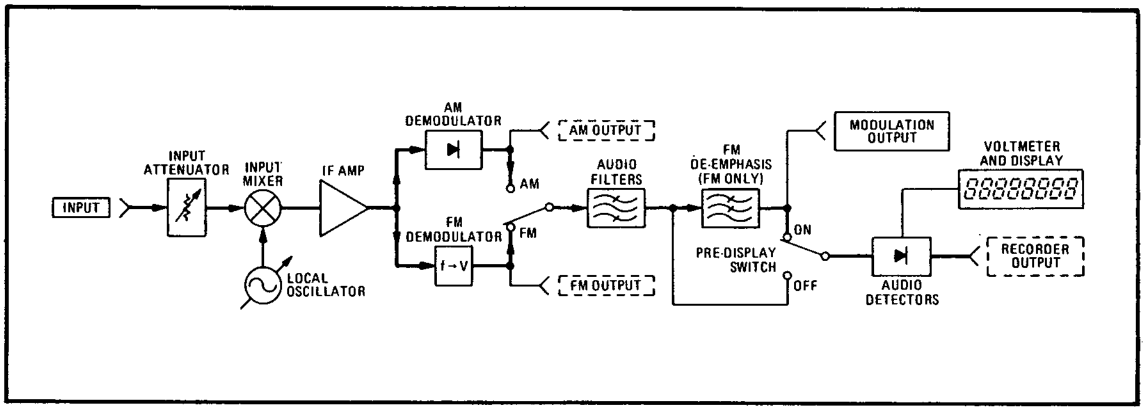
Do not apply greater than 10 Vdc or greater than +30 dBm into RECORDER OUTPUT or damage to the instrument may result.

Description

The rear-panel RECORDER OUTPUT produces a dc voltage equal to the peak level of the signal at MODULATION OUTPUT. The single exception to the above occurs when FM de-emphasis, pre-display "off" is selected. In this case, RECORDER OUTPUT produces a dc voltage proportional to the peak FM deviation before de-emphasis, while MODULATION OUTPUT produces de-emphasized FM. RECORDER OUTPUT switches with the signal at MODULATION OUTPUT so that it always corresponds to the modulation measurement being made. If FREQ, FREQ ERROR, TUNED RF LEVEL, or IF frequency (Special Function 10) is selected, the signal at RECORDER OUTPUT is derived from the last selected modulation measurement. If RF LEVEL is selected, RECORDER OUTPUT is turned off (i.e. set to 0 Vdc). The dc level at RECORDER OUTPUT ranges from 0 to 4 Vdc into an open circuit for each modulation display range (output impedance is 1 kΩ). For more information on output ranges and setting modulation ranges, refer to *Modulation Range.*

Block Diagram

A simplified block diagram of the Modulation Analyzer's measurement circuits illustrating the relationships between RECORDER OUTPUT and the other outputs and circuit blocks is given below.



Recorder Output Block Diagram

Comments

The signal at RECORDER OUTPUT represents the last peak detector selected, and it still reflects peak levels when the AVG (RMS CAL) detector is selected.

The dc offset at RECORDER OUTPUT is small (typically 0.001 Vdc).

When PEAK HOLD is selected, RECORDER OUTPUT holds the highest peak, but unlike the display, the voltage level at recorder output represents a stored charge which may discharge over a period of time, if not refreshed by new peaks.

Related Sections

Detectors
Detector (Peak) Time Constant
Detector, Peak Hold
FM De-emphasis
Modulation Output

Residual Noise Effects

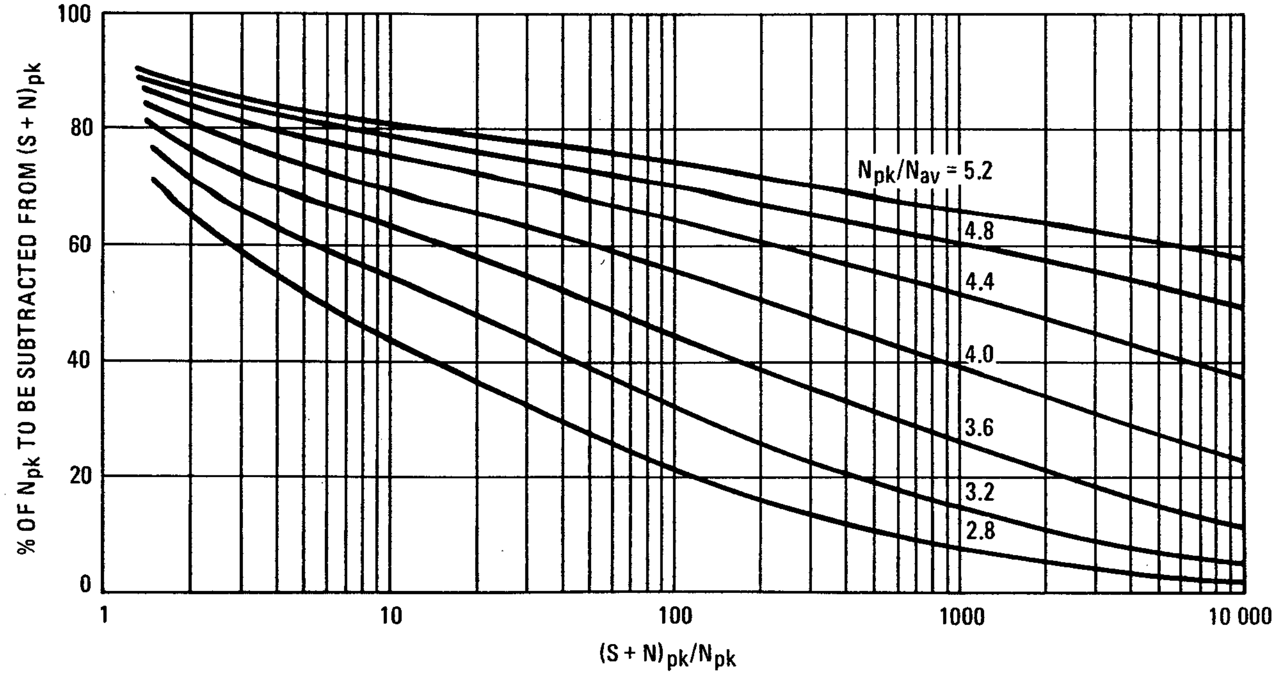
Description When peak modulation measurements of the highest accuracy are to be made, it becomes necessary to characterize and factor out the effects of residual noise on the measurement. The procedure outlined in this section describes a technique for quantifying and removing residual noise effects on peak modulation measurements.

Procedure The complete procedure for making a corrected peak modulation measurement follows below.

1. Set up and make a normal signal-plus-noise peak measurement, $(S+N)_{pk}$.
2. Key in 9.0 SPCL (Hold Settings Special Function) 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 subtract 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.



Nomograph for Calculating Percentage of N_{pk} to be Subtracted from $(S+N)_{pk}$ to get S_{pk} (Sine Wave).

Residual Noise Effects (Cont'd)

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:

LOCAL (keystrokes)	AUTOMATIC OPERATION ☐ — Measurement: AM ● — Detector: PEAK + ● — Filter: 15 kHz ●
HP-IB (program codes)	AUM1D1L2 Measurement (M1) Detector (D1) Filter (L2)

Read the peak modulation depth, $(S+N)_{pk}$; for example, 30.80%.

Now disable auto-ranging using the Hold Settings Special Function:

LOCAL (keystrokes)	Code: 9 . 0 — Function: ● SPCL
HP-IB (program codes)	9.0 SP Code (9.0) Function (SP)

Remove the baseband signal from the modulation input of the signal generator and read the peak residual modulation, N_{pk}; for example, 0.07%.

Now measure the average residual modulation:

LOCAL (keystrokes)	Detector: AVG ● RMS CAL
HP-IB (program codes)	D4 Detector

For example, the average residual modulation reads 0.02%.

Compute $\frac{N_{pk}}{N_{pk}} = \frac{0.07\%}{0.02\%} = 3.5.$

Compute $\frac{(S+N)_{pk}}{N_{pk}} = \frac{30.80\%}{0.07\%} = 440.$

Residual Noise Effects (Cont'd)

Example (Cont'd)

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.

Theory

Residual noise is a measure 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 measurements are made with the Modulation Analyzer, both the intended modulation and the residual modulation are mesured in combined form. In order 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 attributable to the baseband input simply subtract out the peak periodic residual.

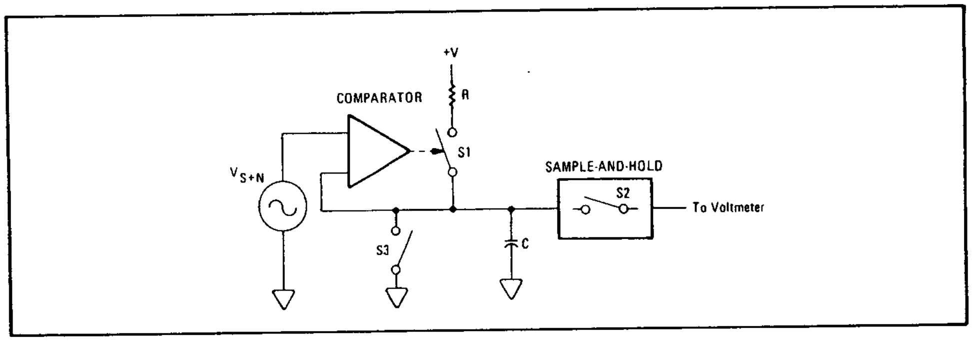
The effects of random noise on our measurement system are not nearly so straight forward. Truely random noise, when viewed in the frequency domain, is a continuous spectrum of frequencies at various amplitudes. Indeed, the frequency of the noise spectrum is limited only by the bandwidths of the observing 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 slew 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.

Our 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 below. 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. As soon as 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)

Comments (Cont'd)



Simplified Modulation Analyzer Peak Detector Output

When noise alone is imposed on the detector, the probability that a noise spike will exceed the charge already existing on the peak detector capacitor is great as C begins to charge. 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 top of a sinewave, only the signal-plus-noise peaks exceeding the sinusoid's peak level can add charge to the peak detector capacitor. Statistically, the chances of the charge on the capacitor (already set to the peak sinewave amplitude) being exceeded by the total input signal are much less than when only noise is being measured. 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 this directly from the peak reading of the combined input over-compensates the mesurement results.

Since the residual noise reading made by the peak detector not only depends upon the signal to noise ratio but also upon the statistics of the noise spikes and the response time of the specific peak detector, these factors must be characterized. To do this, the ratio of the peak noise reading to the average noise reading is used. 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 present.

Comments

The primary restriction placed on this method of accounting for residuals is that the noise must be gaussian (i.e., 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 Hold Settings Special Function (9.0 SPCL) while the instrument is measuring the modulated carrier; then measure the residuals once the ranges are held.

---

[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.

Residual Noise Effects (Cont'd)

Comments (Cont'd)

When factoring residual noise from peak ΦM measurements made while using the 3 kHz LP FILTER, the readings may jump considerably. If this occurs, use the highest of 10 successive readings (for both noise and signal-plus-noise) for the computations. An easy way to do this is to use PEAK HOLD to hold the highest reading over a 2 second period.

The residual noise contributions of the AM and FM calibrators (Option 010) and the Modulation Analyzer are accounted for in the calibration procedures. It is *not* necessary to factor residual noise corrections into the calibration procedures described in this book.

Service Request Condition

(Special Function 22)

Description

The Modulation Analyzer will issue a Require Service message under various circumstances. For example, a Require Service message will always be issued if an HP-IB code error occurs. Using the keyboard and the SPCL key, the operator may enable one or more conditions to cause the Require Service message to be issued. Whenever the enabled condition occurs, it 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 table below). 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
Upper limit reached	8
Lower limit reached	16

Example

To set the Modulation Analyzer to send a Require Service message when an instrument error occurs, or when either an upper or lower limit is reached (or when an HP-IB code error occurs), first compute the Special Function suffix by summing the weights corresponding to those conditions:

(2+) 4 + 8 + 16 = 30

Enter the code:

LOCAL (keystrokes)	Code Function 2 2 . 3 0 • SPCL
HP-IB (program codes)	22.30SP Code Function

Program Codes

Compute the Special Function code as described under Procedure above. SP is the HP-IB code for the SPCL key.

Service Request Condition (Cont'd)

(Special Function 22)

Indications

As the numeric code is entered, it will appear on the front panel display. When the SPCL key is pressed, the display returns to show the measurement previously selected. Special Function 22 has no effect on the SPCL key light. 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 will be set true. The Modulation Analyzer's status byte is shown below for reference.

MSB LSB

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

Modulation Analyzer's Status Byte

Comments

HP-IB

For more information on HP-IB operation, serial polling, and the Status Byte message, refer to the discussion titled HP-IB Operation appearing 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 Sections

HP-IB Address
HP-IB Operation (appears earlier in Section III)
Limit

Special Functions

Description

General Information. Special Functions extend user control of the instrument beyond that normally available from dedicated front panel keys. They are intended for the user who has an understanding of the instrument and the service technician who needs arbitrary control of the instrument. Special functions are accessed via keyboard entry of the appropriate numeric code terminated by the SPCL key (refer to Procedures below). The codes comprise a prefix, decimal, and suffix. Special Functions are disabled by a variety of means, depending upon the function. Refer to the comprehensive listings below for actions which clear or disable any Special Function. Special Functions are grouped by their prefixes into three categories as follows:

Prefix 0

This is the Direct Control Special Function and is intended for use in servicing the Modulation Analyzer. All instrument error messages and safeguards are inactive. This is discussed in detail in Section VIII. If the Direct Control Special Function is entered inadvertently, press AUTOMATIC OPERATION.

Prefixes 1 to 39

These are the User Special Functions which 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 below.

Prefixes 40 to 99

These are the Service Special Functions used to assist in troubleshooting an instrument fault. The functions available are quite diverse — special internal measurements, software control, and special service tests and configurations. Most instrument safeguards are relinquished. These Special Functions are discussed in detail in Section VIII. 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 allows viewing of some Special Function settings. The operator-requested settings of Special Functions prefixed 1 through 8 may be viewed by pressing the SPCL key once (following no numeric entry). This display is called the Special Display. If some of these Special Functions are in automatic modes (generally the 0-suffix setting), the actual instrument settings of these functions may 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 are timed, and the display returns to the previous measurement at time-out. If desired, these displays may be cleared by pressing any key except the LCL, numeric, or S (Shift) keys. (While either display is active, pressing the SPCL key will switch to the other display.)

A summary of User Special Functions is given below. Following the summary are procedures for using Special Functions and for obtaining the Special Display and the Special Special Display. These displays are also illustrated and explained.

Special Functions (Cont'd)

Special Function Summary (1 of 4)

Special Function		Program Code HP-IB	Description		Disabled by					References and Comments
Name	Code			Lights SPCL key	AUTO. OP. key	Any MEAS. key	CLEAR key	All keys*	Display Timed	
Input Attenuation	1.0	1.0SP	Automatic selection	N	—	—	—	—	—	Attenuation, Input
	1.1	1.1SP	0 dB input attenuation	Y	Y	N	N	N	—	
	1.2	1.2SP	10 dB input attenuation	Y	Y	N	N	N	—	
	1.3	1.3SP	20 dB input attenuation	Y	Y	N	N	N	—	
	1.4	1.4SP	30 dB input attenuation	Y	Y	N	N	N	—	
	1.5	1.5SP	40 dB input attenuation	Y	Y	N	N	N	—	
	1.6	1.6SP	50 dB input attenuation	Y	Y	N	N	N	—	
Modulation Range	2.0	2.0SP	Automatic selection	N	—	—	—	—	—	Modulation Range Modulation Output
			AM (%) FM (kHz) ΦM (rad)							
	2.1	2.1SP	≤ 40 ≤ 4 ≤ 0.4* ≤ 4	Y	Y	N	N	N	—	
	2.2	2.2SP	≤100 ≤ 40 ≤ 4* ≤ 40	Y	Y	N	N	N	—	
	2.3	2.3SP	≤100 ≤400 ≤ 40* ≤400	Y	Y	N	N	N	—	
			*with 750 μs de-emphasis, pre-display							
IF Frequency and Input High-Pass Filter	3.0	3.0SP	Automatic IF selection; input high-pass filter out	N	—	—	—	—	—	Frequency, IF and Input High-Pass Filter
			IF (MHz) Input High-Pass Filter							
	3.1	3.1SP	0.455 Out	Y	Y	N	N	N	—	
	3.2	3.2SP	1.5 Out	Y	Y	N	N	N	—	
	3.3	3.3SP	0.455 In	Y	Y	N	N	N	—	
	3.4	3.4SP	1.5 In	Y	Y	N	N	N	—	
Tune Mode	4.0	4.0SP	Automatic tuning; low noise LO	N	—	—	—	—	—	Tuning
	4.1	4.1SP	Automatic tuning; track mode	Y	Y	N	N	N	—	
	4.2	4.2SP	Manual tuning via keyboard entry	Y	Y	N	N	N	—	
Audio Peak Detector Time Constant	5.0	5.0SP	Fast peak detector	N	—	—	—	—	—	Detector (Peak) Time Constant
	5.1	5.1SP	Slow peak detector	Y	Y	N	N	N	—	
AM ALC Response	6.0	6.0SP	Slow AM ALC response	N	—	—	—	—	—	AM ALC Response Time
	6.1	6.1SP	Fast AM ALC response	Y	Y	N	N	N	—	
	6.2	6.2SP	AM ALC off	Y	Y	N	N	N	—	

N = No; — = Not Applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

Special Functions (Cont'd)

Special Function Summary (2 of 4)

Special Function		Program Code	Description	Lights SPCL key	Disabled by				Display Timed	References and Comments
Name	Code	HP-IB			AUTO. OP. key	Any MEAS. key	CLEAR key	All keys*		
Frequency Resolution	7.0	7.0SP	Automatic selection	N	—	—	—	—	—	Frequency Resolution
	7.1	7.1SP	10 Hz resolution (f<1 GHz)	Y	Y	N	N	N	—	
	7.2	7.2SP	1000 Hz resolution	Y	Y	N	N	N	—	
Error Disable	8.0	8.0SP	Automatic selection	N	—	—	—	—	—	Error Disable Error Message Summary Attenuation, Input Modulation Range Tuning
	8.1	8.1SP	E01 disabled	Y	Y	N	N	N	—	
	8.2	8.2SP	E02 and E03 disabled	Y	Y	N	N	N	—	
	8.3	8.3SP	E01, E02, and E03 disabled	Y	Y	N	N	N	—	
	8.4	8.4SP	E04 disabled	Y	Y	N	N	N	—	
	8.5	8.5SP	E01 and E04 disabled	Y	Y	N	N	N	—	
	8.6	8.6SP	E02, E03, and E04 disabled	Y	Y	N	N	N	—	
	8.7	8.7SP	E01 through E04 disabled	Y	Y	N	N	N	—	
	8.8	8.8SP	E01 through E04 enabled	Y	Y	N	N	N	—	
Hold Settings	9.0	9.0SP	Holds ranges, tuning, and error modes at present settings; disables automatic functions	Y	Y	N	N	N	—	Hold Settings
IF Frequency Measurement	10.0	10.0SP	Measures IF signal frequency	Y	N	Y	N	N	N	Frequency, IF
Re-enter RATIO with Previous Reference	11.0	11.0SP	Re-enter % RATIO	N	—	—	—	—	—	Ratio
	11.1	11.1SP	Re-enter dB RATIO	N	—	—	—	—	—	
	11.2	11.2SP	Read RATIO reference	Y	Y	Y	Y	Y	Y	
	11.3	11.3SP	Make RATIO reference negative	N	—	—	—	—	—	
FM Calibrator	12.0	12.0SP	Display computed peak FM deviation	Y	N	Y	N	N	N	Calibration, FM NOTE: 12.1 and 12.2 set the Modulation Range to 2.2.
	12.1	12.1SP	Display demodulated peak residual FM deviation	Y	N	Y	N	N	N	
	12.2	12.2SP	Display demodulated peak FM deviation	Y	N	Y	N	N	N	
AM Calibrator (Continued on next page)	13.0	13.0SP	Display computed peak AM depth	Y	N	Y	N	N	N	Calibration, AM

N = No; — = Not applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

Special Functions (Cont'd)

Special Function Summary (3 of 4)

Special Function		Program Code HP-IB	Description	Lights SPCL key	Disabled by				Display Timed	References and Comments
Name	Code				AUTO. OP. key	Any MEAS. key	CLEAR key	All keys*		
AM Calibrator (Cont'd)	13.1	13.1SP	Display demodulated peak residual AM depth	Y	N	Y	N	N	N	NOTE: 13.1 and 13.2 set the Modulation Range to 2.1.
	13.2	13.2SP	Display demodulated peak AM depth	Y	N	Y	N	N	N	
Set Limit	14.0	14.0SP	Clear limits; turn off LIMIT annunciator	N	—	—	—	—	—	Limit, Ratio
	14.1	14.1SP	Set lower limit to RATIO reference	N	N	N	N	N	—	NOTE: 14.5 and 14.6 Special Functions will display 0 if the limit is not enabled.
	14.2	14.2SP	Set upper limit to RATIO reference	N	N	N	N	N	—	
	14.3	14.3SP	Restore lower limit	N	N	N	N	N	—	
	14.4	14.4SP	Restore upper limit	N	N	N	N	N	—	
	14.5	14.5SP	Read lower limit	Y	Y	Y	Y	Y	Y	
	14.6	14.6SP	Read upper limit	Y	Y	Y	Y	Y	Y	
	14.7	14.7SP	Read lower limit measurement code	Y	Y	Y	Y	Y	Y	
	14.8	14.8SP	Read upper limit measurement code	Y	Y	Y	Y	Y	Y	
Time Base Oven (Option 002 only)	15.0	15.0SP	Display E12 if internal reference oven is cold	Y	Y	Y	Y	Y	N	If the oven is warm or if the high stability reference oscillator is not installed; no display change occurs.
AM Calibration (Option 010 only)	16.0	16.0SP	Disable AM calibration factor	N	—	—	—	—	—	Calibration, AM
	16.1	16.1SP	Enable AM calibration factor	N	N	N	N	N	—	
	16.2	16.2SP	Read AM calibration factor (0 if not enabled)	Y	Y	Y	Y	Y	Y	
FM Calibration (Option 010 only)	17.0	17.0SP	Disable FM calibration factor	N	—	—	—	—	—	Calibration, FM
	17.1	17.1SP	Enable FM calibration factor	N	N	N	N	N	—	
	17.2	17.2SP	Read FM calibration factor (0 if not enabled)	Y	Y	Y	Y	Y	Y	

N = No; — = Not applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

Special Functions (Cont'd)

Special Function Summary (4 of 4)

Special Function		Program Code	Description	Lights SPCL key	Disabled by				Display Timed	References and Comments
Name	Code	HP-IB			AUTO. OP. key	Any MEAS. key	CLEAR key	All keys*		
Tone Burst Receiver	18.NN	18.NNSP	Configures the Modulation Analyzer as a tone burst receiver where a settling time is inserted between detecting a carrier and turning on MODULATION OUTPUT. NN is that time from 1 through 99 ms. If NN = 0, the delay is 99 ms.	Y	N	Y	N	N	N	Tone Burst Receiver
HP-IB Address	21.0	21.0SP	Displays HP-IB address in form AAAAA.TLS. AAAAA is the binary address. T=1 means talk only, L=1 means listen only; S=1 means service request issued.	Y	Y	Y	Y	Y	N	HP-IB Address
Service Request	22.NN	22.NNSP	Enables a condition to cause a service request to be issued. NN is the sum of any combination of the weighted conditions below: 1 Data ready 2 HP-IB error 4 Instrument error 8 Upper limit reached 16 Lower limit reached Instrument powers up in the 22.2 state.	N	N	N	N	N	N	Service Request Condition. This function is set to zero suffix by a HP-IB Clear message or by Service Special Functions 40 and 41.

N = No; — = Not Applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

Procedure

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 8, 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 Functions (Cont'd)

Procedure (Cont'd)

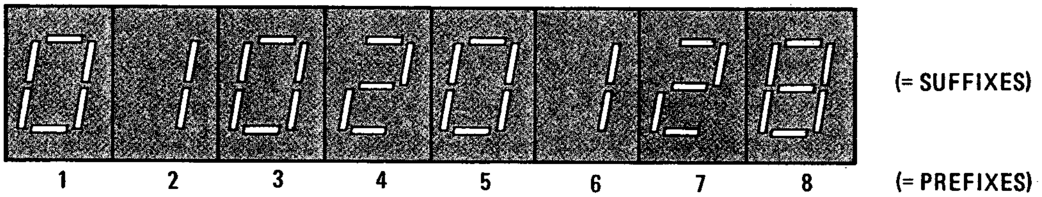
Special Special Display. To determine the actual instrument settings of Special Functions prefixed 1 through 8, press the SPCL key alone once while Special Display is still active. (If the Special Display described above is not in effect, press the SPCL key twice to get this display.) The digit position 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 10):

LOCAL (keystrokes)	Code: 1 0 . 0 Function: • SPCL
HP-IB (program codes)	10.0SP Code Function

Special Display. When SPCL is pressed alone once, the following display results.



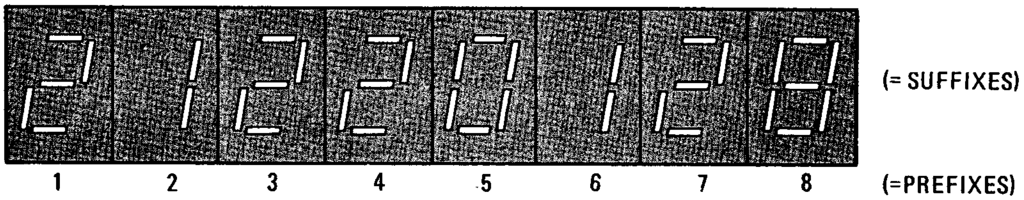
This display means:

Special Function		User-Requested Setting
Code	Name	
1.0	Input Attenuation	Automatic Selection
2.1	Modulation Range	40% AM; 4 kHz FM; 4 radians ΦM
3.0	IF Frequency and Input High-Pass Filter	Automatic Selection; no Input High-Pass Filter
4.2	Tune Mode	Manual Tuning
5.0	Audio Peak Detector Time Constant	Fast Peak Detector
6.1	AM ALC Response	Fast AM ALC
7.2	Frequency Resolution	1000 Hz Resolution
8.8	Measurement Error Disable	E01 through E04 enabled

Special Special Display. When SPCL is pressed before the Special Display (described in the previous example) times out, the following display results:

Special Functions (Cont'd)

Examples (Cont'd)



This display means:

Special Function		Actual Instrument Setting
Code	Name	
1.2	Input Attenuation	10 dB Attenuation
2.1	Modulation Range	40% AM; 4 kHz FM; 4 radians ΦM
3.2	IF Frequency and Input High-Pass Filter	1.5 MHz IF Frequency; no Input High-Pass Filter
4.2	Tune Mode	Manual Tuning
5.0	Audio Peak Detector Time Constant	Fast Peak Detector
6.1	AM ALC Response	Fast AM ALC
7.2	Frequency Resolution	1000 Hz Resolution
8.8	Measurement Error Disable	E01 through E04 Enabled

Program Codes HP-IB

HP-IB Codes for the special functions are summarized in the Special Function Summary above.

Indications

Entering Special Functions. As the numeric code is entered, it will appear on the front-panel display. When the SPCL key is pressed, the display will either show the measurement results or the information requested, or, if none has been requested, it will return to show the measurement previously selected. Most Special Functions with a non-zero suffix will turn on the SPCL key light if not already on. If the light is already on, it will remain on. (Refer to the Special Function Summary above for exceptions.)

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, E21 (invalid key sequence) is displayed, the Special Function requested has not been executed.

Related Sections

Default Conditions and Power-up Sequence
Special Function Summary table (under Description above)

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 500Ω. TIME BASE 10 MHZ OUTPUT (available only with the high stability reference, Option 002) provides an output for the internal 10 MHz reference. This is a 50Ω, TTL compatible output (0V to >2.2V into an open circuit).

Comments

An Option 002 (high stability reference) Modulation Analyzer 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 upon 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 LINE 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.

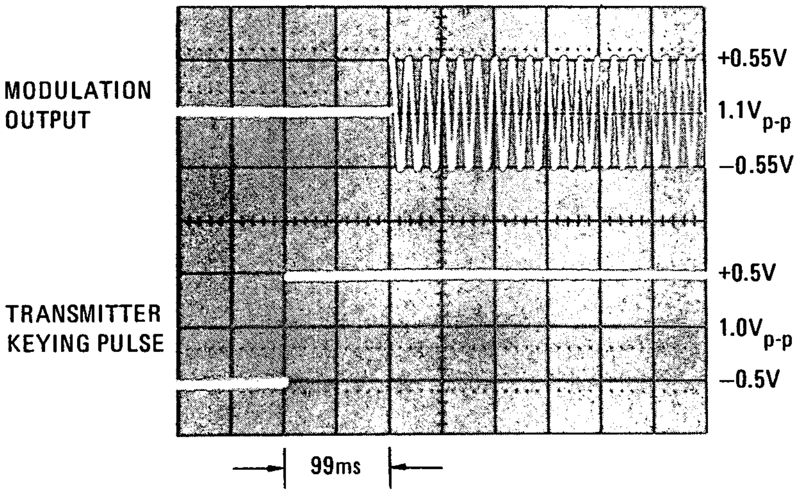
To determine whether the Modulation Analyzer has actually switched in the externally applied time base, key in 46.9 SPCL. The display should show 1 000 000 ±1 if the external time base is in. If the external signal was not switched in, the display will show 0 or 1 only

Tone Burst Receiver

(Special Function 18)

Description

In some FM applications (mobile radio, for example), the transmitter issues one or more squelch tones during a brief interval after it is keyed. Often, it is necessary to capture these tones and count their frequency. Under normal operation this can be difficult since there is a short delay between the keying of the transmitter and the appearance of the tones. During that delay the counter receiving the demodulated signal counts audio noise and readings become difficult to interpret or repeat. By means of keyboard entry using the SPCL key the Modulation Analyzer can be configured as a tone burst receiver. This function inserts a user-selectable delay between the instant the instrument senses an RF signal at its INPUT and the time when it turns on MODULATION OUTPUT. This allows only the valid audio tone to reach the counter and assures repeatability. The time delay is selectable from 1 through 99 milliseconds. The photo below illustrates a 99 ms delay between transmitter keying (lower trace).



Oscilloscope Photo Depicting a 99 ms Delay Between Transmitter Keying Pulse (Lower Trace) and Activation of MODULATION OUTPUT

Procedure

In order to successfully measure tone bursts, the Modulation Analyzer must already be tuned and ranged. The easiest way to do this is to select FM, a detector, and, if desired, filters and de-emphasis, then key on the transmitter and allow the Modulation Analyzer to range and tune automatically. Use the Hold Settings Special Function (9.0 SPCL) to hold all ranges and tuning. Select the time delay to be inserted between the moment the transmitter is keyed and when MODULATION OUTPUT is to be turned on. This delay becomes the Special Function suffix. (If a 0 suffix is selected, the Modulation Analyzer executes a 99 ms delay.) 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 S (Shift), numeric, and LCL keys.

Tone Burst Receiver (Cont'd)

(Special Function 18)

Example

A 50 ms delay is to be inserted by the Modulation Analyzer between the keying of an FM mobile radio transmitter and measuring the frequency of its squelch tone. It is assumed that the Modulation Analyzer is tuned to the transmitter frequency and that the input attenuation, modulation range, and tuning are fixed.

LOCAL (keystrokes)	Code: 1 8 . 5 0 Function: • SPCL
HP-IB (program codes)	18.50SP Code: 18.50 Function: SP

Program Codes **HP-IB**

The Special Function code suffix is derived from the time delay as described under procedure above. The HP-IB code for the SPCL key is SP.

Indications

As the numeric code is entered, it will appear on the front panel display. When the SPCL key is pressed, the display will show two dashes (— —) if no RF is at the INPUT jack or 18.NN if RF is present (NN is the delay in milliseconds). All key lights will be turned off (including the FM and DETECTOR keys) except the filter and de-emphasis keys, if selected, and the SPCL key. Note that if DE-EMPHASIS PRE-DISPLAY is selected, the PRE-DISPLAY key will be turned off since FM is not being displayed.

Comments

When using the Tone Burst Receiver Special Function use the 99 ms delay for best results. Shorter delays require very careful setup. This is because 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 or equal to that inherent in the particular instruments behavior.

This function is best used when operating in remote mode since the counting instrument connected to MODULATION OUTPUT may need to acquire several sets of data in rapid succession (when counting multiple tones, for example).

Holding ranges for this function may be done using the individual Special Functions for each parameter rather than using the Hold Settings Special Function.

Special Function code 18.0 gives a 99 ms delay.

Related Sections

Attenuation, Input
FM
Hold Settings
Modulation Range
Special Functions
Tuning

Tuning

(Includes Special Function 4)

Description

The Modulation Analyzer is considered tuned to an input signal when the frequency of the Local Oscillator (LO) is adjusted to produce an IF signal that is centered in the IF passband. Normally, this occurs when the LO frequency is placed either 1.5 MHz or 455 kHz above the input frequency, depending upon which IF is selected. The only exception to the above is when the 1.5 MHz IF is selected for input frequencies below 2.5 MHz. Under these conditions, the LO is tuned to 101.5 MHz and the low-frequency input passes directly into the IF.

The Modulation Analyzer employs two techniques to determine what frequency to tune to. In automatic tuning, the entire input spectrum is searched for the presence of a signal. Once found, the LO is tuned so that the signal is received. In manual tuning, the desired input frequency is entered via the numeric keyboard, and the LO is tuned so that that frequency is received.

The LO can be configured in two ways: a fixed frequency mode that is used for low-noise measurements, and a tracking mode in which the LO follows a moving input signal. The two frequency selection techniques and LO configurations combine to produce three tuning modes: Automatic Tuning — Low-Noise LO, Automatic Tuning — Track Mode, and Manual Tuning. Two kinds of manual tuning are allowed: keyboard entry of input frequency and frequency stepping. All of these tuning modes are described in more detail below.

Automatic Tuning — Low-Noise LO. In this mode, if not already tuned, the Modulation Analyzer searches through out its frequency range for an input signal and tunes to it. To successfully tune to the desired signal, the signal's second and third harmonic levels must be at least 10 dB below the level of the fundamental. All other signals at the input must be at least 30 dB below the level of the desired signal. If two input signals have similar power levels, the higher frequency signal is usually selected. Once tuned, the LO is locked to an internal voltage controlled crystal oscillator for highly-stable, low-noise measurements. This tuning is maintained as long as a detectable signal is present. If the input signal disappears (drops below —20 to —25 dBm), the Modulation Analyzer returns to the searching process. This mode of tuning is selected whenever AUTOMATIC OPERATION is pressed, and may be used with either the 1.5 MHz or 455 kHz IF.

Automatic Tuning — Track Mode. In this mode, the instrument searches for the input signal as described above; however, it does not lock to the internal reference oscillator. Instead, the LO is locked to the input signal itself and thus tracks that signal as it moves. This is extremely useful for checking modulation or level as a function of carrier frequency. If the input signal disappears (for example, while switching bands) the Modulation Analyzer will search for, and will re-acquire the input signal. Track mode tuning is not allowed with the 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 by Keyboard Entry. In this mode, the instrument tunes to receive the frequency keyed into it via the keyboard regardless of whether a signal is found there or not. Once tuned, it locks to an internal voltage-controlled crystal oscillator for high stability and low noise. Once locked, tuning will not change unless a new frequency is entered, the tuning is stepped up or down using the kHz (↑) or kHz (↓) keys, or an automatic tuning mode is selected. The manual tune mode is entered immediately when either the MHz, kHz (↑), or kHz (↓) key is pressed or if either the Manual Tuning by Keyboard Entry, (4.2 SPCL) Hold Settings (9.0 SPCL) Special Function is selected.

Tuning (Cont'd)

(Includes Special Function 4)

Description (Cont'd)

Frequency Stepping. Using the kHz (↑) and kHz (↓) keys the tuning of the Modulation Analyzer can be changed by a selectable frequency step. These keys are most often used in conjunction with the frequency error function. The kHz keys may 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 below), either the kHz (↑) or kHz (↓) key pressed alone will change tuning by that step size until a new step frequency is defined. At turn-on, the step size is zero.

Procedures

Tune Mode Selection. To select the automatic tuning — low-noise LO mode, press AUTOMATIC OPERATION or key in 4.0 SPCL. To select automatic tuning — track mode, key in 4.1 SPCL. To select manual tuning by keyboard entry, press either MHz or one of the kHz keys (with or without a preceding keyboard entry), key in 4.2 SPCL, or use the Hold Settings Special Function (code 9.0). The Special Function and HP-IB codes for tune mode selection are summarized below.

Tune Mode	Special Function Code	Program Code HP-IB
Automatic tuning; low noise lock	4.0 SPCL	4.0SP
Automatic tuning; track mode	4.1 SPCL	4.1SP
Manual tuning by keyboard entry	4.2 SPCL	4.2SP

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 may 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, pressing the MHz key alone tunes 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 will tune to 100 MHz.)

When only using the 455 kHz IF, the Modulation Analyzer does not normally tune to input frequencies below 2.5 MHz. If error E01 is disabled, however, the instrument can be manually tuned down to 815 kHz. First select the 455 kHz IF by keying in 3.1 SPCL. Then disable error E01 by keying in 8.1 SPCL. Now, manually tune by keyboard entry as described above.

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 turn-on, the step size is set to 0 kHz.)

Tuning (Cont'd)

(Includes Special Function 4)

Examples

Tune Mode Selection. To enter the automatic tuning — track mode:

LOCAL (keystrokes)	Code — Function 4 . 1 • SPCL
HP-IB (program codes)	4.1SP Code — Function

Manual Tuning by Keyboard Entry. To tune to a 934.5 MHz input signal:

LOCAL (keystrokes)	Code — Function 9 3 4 . 5 MZ MHz INPUT FREQ
HP-IB (program codes)	934.5MZ Code — Function

To tune to a 1 MHz input signal using the 455 kHz IF:

LOCAL (keystrokes)	Code — Function — Code — Function — Data — Function 3 . 1 • SPCL 8 . 1 • SPCL 1 MZ MHz INPUT FREQ Select 455 kHz IF — Disable E01 — Tune to 1 MHz
HP-IB (program codes)	3.1SP8.1SP1MZ Code — Function — Code — Function — Data — Function

Frequency Stepping. To set a 10 kHz frequency step and to increase the tuning by that step size:

LOCAL (keystrokes)	Data — Function 1 0 ⇧ kHz
HP-IB (program codes)	10KU Data — Function

Tuning (Cont'd)

(Includes Special Function 4)

Program Codes HP-IB

The HP-IB codes for selecting the different tune modes are given under Procedure above. The HP-IB codes for manual tuning are given below. Note that when operating the Modulation Analyzer in remote, the programmer may optionally enter frequencies in fundamental units (Hz).

Key or Function	Program Code HP-IB
MHz (INPUT FREQ)	MZ
Hz (INPUT FREQ)	HZ
kHz (↑)	KU
Hz (↑)	HU
kHz (↓)	KD
Hz (↓)	HD

Indications

When numeric codes or data are entered via the keyboard they will appear on the display. When a terminating key is pressed (MHz, kHz, or SPCL), the display returns to show the result of the measurement previously selected. If the automatic tuning — low-noise LO mode is selected, the SPCL key will not turn on (unless already on). All other tuning modes will light that key.

Comments

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 mode should be used whenever drops in signal level may occur that may otherwise cause retuning (for example AM in excess of 99%). For example, when making TUNED RF LEVEL measurements or when counting frequency, manual tuning allows measurements to be made on very low-level signals.

When manually tuning or frequency stepping, use the FREQ ERROR measurement to determine tuning accuracy.

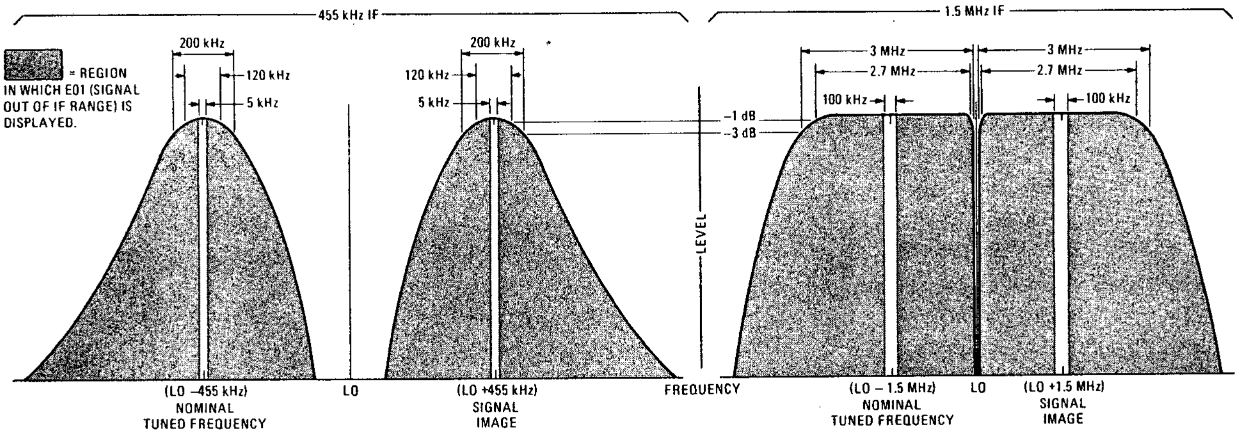
When the Modulation Analyzer tunes to an input signal (greater than 2.5 MHz), its internal local oscillator (LO) is positioned above the nominal tuning by the IF frequency. Since the image passband is not filtered out, image signals pass into the IF amplifier with the same ease as signals in the nominal 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 spectrum diagram below illustrates the relative position of the LO and both the nominal and image passbands for each IF frequency.

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

Tuning (Cont'd)

(Includes Special Function 4)

Comments (Cont'd)



Spectrum Diagram of the 455 kHz and 1.5 MHz Passbands

When making measurements on inputs with frequencies greater than 10 MHz, if signals below 2.5 MHz are present in the spectrum, they appear directly in the IF. These low-frequency signals can be removed by inserting the input high-pass filter. Refer to *Frequency, IF, and Input High-Pass Filter.*

When manually tuning, often the exact input frequency is not known. If upon tuning, error E01 (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. 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 1.5 MHz IF is used for inputs below 2.5 MHz, FM at MODULATION OUTPUT is inverted.

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

Related Sections

Default Conditions and Power-up Sequence
Hold Settings
IF Frequency and Input High-Pass Filter Selection
Special Functions

Table 3-11. Detailed Operating Instructions Table of Contents

ALPHABETICAL LISTING

FUNCTIONAL LISTING

Table 3-11. Detailed Operating Instructions Table of Contents

FUNCTIONAL LISTING (Cont'd)

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HEWLETT
PACKARD

HP Part No. 08901-90031

Printed in U.S.A.

Change Notice

MANUAL CHANGES

MODULATION ANALYZER
OPERATING MANUAL

MANUAL IDENTIFICATION
Model Number: 8901A
Date Printed: Oct. 1982
Part Number: 08901-90031

update file

This supplement contains important information for correcting manual errors and for adapting the manual to instruments containing improvements made after printing the manual.

To use this supplement, first, make all ERRATA corrections and then all appropriate serial number related changes indicated in the tables below.

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
1934A, 1935A	Errata Only
2009A, 2012A	Errata Only
2021A, 2026A	Errata Only
2031A, 2032A	Errata Only
2051A, 2052A	Errata Only
2105A, 2119A	Errata Only
2126A, 2128A	Errata Only
2133A, 2134A	Errata Only
2138A, 2142A	Errata Only
2201A,	Errata Only
2212A	18
2227A, 2229A	18-19
2238A, 2239A	18-19
2244A, 2251A	18-19
2302A, 2303A	18-19
2308A, 2309A	18-19
2312A, 2313A	18-19
2324A, 2342A	18-19
2346A, 2350A	18-19
2410A, 2412A	18-19
2416A, 2421A	18-19

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
2424A, 2426A	18-19
2432A, 2439A	18-19
2443A, 2447A	18-19
2450A	18-19
2505A, 2518A	18-19
2521A	18-19
2542A, 2543A	18-19
2545A	18-19
2606A	18-19
2607A	18-19
2609A	18-19
2616A	18-19
2617A	18-19
2618A	18-19
2623A	18-19
2629A, 2634A	18-19
>> 2705A	18-19

>> NEW ITEM

NOTE:
Manual change supplements are revised as often as necessary to keep manuals as current and accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies, quote the manual identification information from your supplement or the model number and print date from the title page of the manual.

Printed in U.S.A.

HEWLETT PACKARD

5 October 1987
5 Pages Text
2 Pages Illustrations

ERRATA

Page 1-1:

In the right-hand column, the second paragraph under "Section VIII, Service", should read: "This copy of the Operating Manual should stay with the Modulation Analyzer for use by the operator. Additional copies can be ordered separately through your nearest Hewlett-Packard Sales Office. The part number is listed on the title page of this manual."

Page 1-8, paragraph 1-12:

Change the following option retrofit kit HP Part Numbers:

08901-60101 to 08901-60234
08901-60104 to 08901-60235
08901-60106 to 08901-60236
08901-60107 to 08901-60237

Page 1-8, High Stability Internal Reference Retrofit Kit (HP 08901-60102):

Delete the present paragraph and add the following two paragraphs in its place.

High Stability Internal Reference Retrofit Kit (HP 08901-60102). This kit contains all the necessary components and full instructions for installation of the high-stability internal reference oscillator. After installation and calibration, performance will be identical to the 8901A Option 002.

Rear Panel Local Oscillator Connections Retrofit Kit (HP 08901-60103). This kit contains all the necessary components and full instructions for installation of rear-panel local oscillator connections. After installation and calibration, performance will be identical to the 8901A Option 003.

Page 1-18, Table 1-1. Specifications (4 of 4):

Under GENERAL, change the "Conducted and Radiated Electromagnetic Interference" specification to read as follows:

Electrical Characteristic	Performance Limits	Conditions
Conducted and Radiated Electromagnetic Interference	VDE 0871 (Level B) and CISPR publication 11	Conducted and radiated interference is within the requirements of VDE 0871 (Level B), and CISPR publication 11.

Under GENERAL, delete the entire "Conducted and Radiated Electromagnetic Susceptibility" specification.

Page 1-21, Table 1-3:

Add the attached **Table 1-3. Recommended Test Equipment** (P/O 1 of 3),(P/O ERRATA).

ERRATA (cont'd)

Page 2-1, paragraph 2-5:
Add the following sentences to paragraph 2-5:

Two fuses are supplied with each instrument. One fuse has the proper rating for 110/120 Vac line operation; the other fuse is rated for 200/220 Vac operation.

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

Page 2-3, Figure 2-2:
Replace Figure 2-2. Power Cable and Mains Plug Part Numbers with the attached **Figure 2-2. Power Cable and Mains Plug Part Numbers (P/O ERRATA).**

Page 2-4, Figure 2-4:
Replace the text under Mating Cables Available with the following:
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).

Page 2-6, paragraph 2-16:
Replace the text under Other Packaging, Step b with the following:
Use a strong shipping container. A double-wall carton made of 1.9 MPa (275 psi) is adequate.

Page 3-15, paragraph 3-11, step 18:
In the table under step 18, change the minimum limit for 25 us FM De-emphasis Time Constant to 97.0%.

Page 3-16, paragraph 3-11, step 27:
Change the second sentence to read as follows:
The display should read between -2 and -8 dB REL.

Page 3-22, HP-IB Functional Checks:
In the table at the top of the page, change "CLEAR 714" to "RESET 714".

Page 3-25, HP-IB Functional Checks:
Under **Trigger Message and Clear Key Triggering**, change the last sentence under the second OPERATOR'S RESPONSE to read as follows:
The controller's "run" indicator should turn off.

Page 3-40, Table 3-8:
Change the "HD (down arrow) 1 kHz" entry to "HD (down arrow) 1 Hz".

Page 3-56, **Calibration, AM (cont'd)**:
In MEASUREMENT TECHNIQUE, change the first sentence to read "When AM is selected and the CALIBRATION key is pressed, the FM Calibrator sends an unmodulated 10.1 MHz carrier to the AM Calibrator."

Page 3-71, **Error Messages Table**:
For Error Code E08, change MESSAGE to read "Calibrator Signal not at INPUT (Option 010 only)."

Page 3-78, **FM, De-emphasis**:
Change the formula in the fourth line under DESCRIPTION to read as follows: f_o=1/(   ).

Page 3-80, **FM OUTPUT**:
In the caution, change "AM OUTPUT" to "FM OUTPUT".

ERRATA (cont'd)

Page 3-89, HP-IB Address:
In the second half of the Allowable HP-IB Address Codes table, change A2 for decimal equivalent 26 to "1".

Page 3-128, Special Functions (cont'd):
Change the Special Function "Tone Burst Receiver","Disabled by" entry to read:

AUTO. OP. key=Y
CLEAR key=Y
All keys*=Y

CHANGE 18 - Serial Prefix 2212A

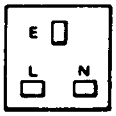
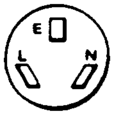
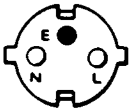
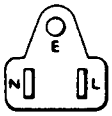
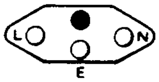
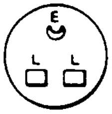
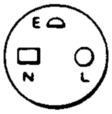
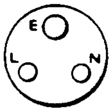
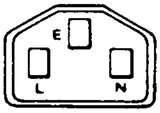
Page 1-8, paragraph 1-12, "ELECTRICAL EQUIPMENT AVAILABLE":
Under paragraph entitled "Conversion to 400 Hz Line Operation", change the second to the last sentence (at the top of the second column) to read: To convert to 400 Hz operation, order HP Part Number 08901-60226.
Page 3-16, paragraph 3-11, step 27:
Change the last sentence of this step to read, "The display should read between -2 and -8 dB REL."

CHANGE 19 - Serial Prefix 2227A

Page 1-8, paragraph 1-12, "ELECTRICAL EQUIPMENT AVAILABLE":
Under paragraph entitled "Conversion to 400 Hz Line Operation", change the second to the last sentence (at the top of the second column) to read: To convert to 400 Hz operation, order HP Part Number 08901-60226.
Page 1-17, Table 1-1:
Change the Performance Limits for RF LEVEL Instrumentation Accuracy to ±1.5 dB for the Conditions 150 kHz to 1300 MHz.
Change the Performance Limits for RF LEVEL SWR to <1.3 for the Conditions 150 kHz to 650 MHz, 50 ohm system, and to <1.5 for the Conditions 650 to 1300 MHz, 50 ohm system.
Page 1-22, Table 1-3:
Add to the Critical Specifications for the Signal Generator: Harmonics: <-30 dBc.

Table 1-3. Recommended Test Equipment (P/O 1 of 3), (P/O ERRATA).

Bandpass Filters	Passband Frequency: 512 to 674 MHz Passband SWR: ≤ 1.4 Passband insertion loss: ≤ 0.4 dB Midband insertion loss: ≤ 0.5 dB Stop band rejection: Below Passband: Frequency: ≤ 337 MHz Attenuation: ≥ 21 dB Above Passband: Frequency: 768 to 3000 MHz Attenuation: ≥ 21 dB	Telonic TBA 593-218-5FE	P
	Passband Frequency: 800 to 1100 MHz Passband SWR: ≤ 1.4 Passband insertion loss: ≤ 0.4 dB Midband insertion loss: ≤ 0.5 dB Stop band rejection: Below Passband: Frequency: ≤ 550 MHz Attenuation: ≥ 21 dB Above Passband: Frequency: 1333 to 3000 MHz Attenuation: ≥ 21 dB	Telonic TBA 950-375-5FE1	P

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

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

Figure 2-2. Power Cables and Mains Plug Part Numbers (P/O ERRATA)

Service Notes

ENGLEWOOD NSR 2411

INST SERVICE MGR

Supercedes:
8901A-1

HP MODEL 8901A MODULATION ANALYZER

Serial Prefix 2201A and Below

SOFTWARE CHANGE SUMMARY

INTRODUCTION

The HP 8901A has undergone several changes in software. This service note summarizes the changes and gives guidance in deciding whether to update software to a more recent edition. This note also documents the troubleshooting data that are affected by the changes.

Software is changed whenever anomalies are found in the instrument's operation which can be corrected by altering the Controller's program. Since the program resides in the ROMs, one or more ROMs are altered each time the software is changed. When the software is changed, the affected ROMs are given new part numbers, the software date is changed, and the instrument is given a new serial prefix.

The software date is displayed when Special Function 42.0 is keyed in. The software date is stored in ROM 1. In cases where the software is partially updated, however, the software date does not uniquely identify the software edition. The most positive means of identifying the software edition is by comparing the part numbers of the ROMs with those listed for a given software edition.

Partially updated software may also affect the ROM checksums verified by Special Function 52 (Read Only Memory Verification) and by the Power-Up Checks. The expected checksums are stored in ROM 1.

When the Controller fails, it must usually be troubleshot by signature analysis as documented in the Controller Kernel Check of Service Sheet BD4 and the Memory Select Decoders and ROM Check of Service Sheet 15. When the ROMs are altered, the signatures in some of the checks are also altered. This service note documents the signatures for factory-issued combinations of ROMs.

SUMMARY OF SOFTWARE EDITIONS

Software Date 124.1979. This is the first edition of software in production instruments.

Software Date 284.1979. This edition of software corrects the following anomaly:

Anomaly 1. Under some conditions when error message E07 or E11 occurs, the RF Level Detector causes a slight loading of the signal which, in combination with the error, can cause a display that alternates between two errors (E07 and E04) or between an error (E11) and a measurement result, and it can induce a slight residual AM on the MODULATION OUTPUT jack. In either case the measurement is invalid as indicated by the error message.

Changing ROM 1 to HP 08901-80032 corrects Anomaly 1, but the preferred replacement is HP 08901-80040. (See Software Date 67.1982.)

Software Date 180.1980. This edition of software corrects Anomaly 1 and the following anomalies:

Anomaly 2. Under some conditions of input overpower (usually at frequencies above 100 MHz) the Input Attenuator will alternate between 0 and 50 dB, putting unnecessary wear on the attenuator relays. The Overpower Protection relay, however, remains open to protect the input circuits, and error E06 is displayed until the overpower condition is removed and the instrument is reset.

Anomaly 3. When tuning to low-level signals (below −25 dBm) with a 1.5 MHz IF, the tuning routine may require two attempts to find the signal. If the signal is approximately 10.1 MHz, the signal may not be found at all.

Anomaly 4. During the Local Oscillator Test, which occurs at power up or when Special Function 54.0 is keyed in, the operation of the Counter is checked by counting the time base reference. (Specifically, this is Test 3 which is checked by Special Function 54.1.) The Counter is good if the reading is 1000000 ±1. The test, however, sets the limit to exactly 1000000. Thus, a properly operating counter may fail the test. (Use Special Function 46.8 to verify that the Counter is working properly.)

Anomaly 5. If the instrument is set to generate a service request when data is ready (for example, Special Function 22.3) and to trigger with settling (HP-IB code T3), the service request condition will be cleared (properly) by the serial poll disable command from the HP-IB controller. However, the instrument then reasserts the service request for about 1 ms then clears it. Some HP-IB controllers (for example, HP controllers) are unaffected by the reassertion of service request; those that are affected require a wait statement after serial polling the instrument.

Changing ROM 1 to HP 08901-80035 corrects Anomalies 1, 2, and 3, but the preferred replacement is HP 08901-80040. (See Software Date 67.1982.) Changing ROM 2 to HP 1818-1363 or HP 08901-80034 corrects Anomaly 4, but the preferred replacement for ROM 2 is HP 08901-80041. (See Software Date 67.1982.) Changing ROM 2 does not affect the software date. Changing ROM 11 to HP 1818-1364 or HP 08901-80033 corrects Anomaly 5. Changing ROM 11 does not affect the software date.

Software Date 338.1981. This edition of software corrects Anomalies 1 through 5 and the following anomaly:

Anomaly 6. At input frequencies between about 3 and 4 MHz, levels at the low end of a range of the Input Attenuator, and sometimes with 30% or more AM, one of the following sequences may be indicated even though the signal is valid. (The situations described assume that the signal has been applied then the AUTOMATIC OPERATION key has been pressed.)

> The display shows error message E10, indicating that the signal frequency is out of range.
>
> The display continually alternates between "--" and "----", indicating that the instrument repeatedly finds the signal but then retunes the LO and looses the signal.
>
> After the AUTOMATIC OPERATION key has been pressed, the displayed sequence is "----", a measurement result, "----", and measurement results thereafter, indicating that the instrument found the signal, made a measurement, but had to readjust the tuning of the LO before the second measurement. All measurement results after the first one will be valid.
>
> The display continually shows "--", indicating that the instrument never finds the signal.
>
> After the AUTOMATIC OPERATION key has been pressed, "--" is displayed momentarily followed by "----" then the measurement result. This indicates that the instrument had difficulty in finding the signal. All measurement results are valid.

Changing ROM 1 to HP 08901-80038 corrects Anomalies 1, 2, and 3, partially corrects Anomaly 6, and changes the software date to 338.1981; but the preferred replacement for ROM 1 is 08901-80040. (See Software Date 67.1982.) Changing ROM 7 to HP 08901-80039 completes the correction of Anomaly 6.

Software Date 67.1982. This edition of software corrects Anomalies 1 through 6 and adds a slight refinement to the RF Level measurement mode (misnamed "Anomaly 7" for consistency) as follows:

Anomaly 7. Beginning with serial prefix 2212A, the A15 RF Input Assembly was modified to improve the accuracy of the RF Level measurement. At that time, the constants which convert the voltage reading from the RF Level Detector to RF power were slightly modified.

Changing ROM 1 to HP 08901-80040 corrects Anomalies 1, 2, and 3, partially corrects Anomaly 6, and changes the software date to 67.1982. Changing ROM 2 to HP 08901-80041 adds the improvement described in Anomaly 7. Changing ROM 2 does not affect the software date. Changing ROM 2 on instruments with the older A15 assembly (HP 08901-60116) will slightly affect the RF Level measurement but the measurement will remain well within the specification for that configuration.

Table 1. Summary of Software Editions and ROM Part Numbers.
(ROMs 3, 4, 5, 6, and 8 remain as originally issued; there is no ROM 9 or 10.)

Software Date (First Serial Prefix)	Part Number			
	ROM 1	ROM 2	ROM 7	ROM 11
124.1979 (1836A)	08901-80029	08901-80030	1818-0923 or 08901-80015	1818-0924 or 08901-80023
284.1979 (1933A)	08901-80032	08901-80030	1818-0923 or 08901-80015	1818-0924 or 08901-80023
180.1980 (2032A)	08901-80035	1818-1363 or 08901-80034	1818-0923 or 08901-80015	1818-1364 or 08901-80033
338.1981 (2138A)	08901-80038	1818-1363 or 08901-80034	08901-80039	1818-1364 or 08901-80033
67.1982 (2212A)	08901-80040	08901-80041	08901-80039	1818-1364 or 08901-80033

SIGNATURES FOR TROUBLESHOOTING THE CONTROLLER

Two tables in the procedures for troubleshooting of the Controller are altered by software changes. The first table is in the Controller Kernel Check (on Service Sheet BD4). The signatures for the Control Bus address lines remain the same.

The signatures for the Control Bus data lines for factory-issued combinations of ROMs are as follows:

Software Date: 124.1979.

ROM	Part Number
1	08901-80029
2	08901-80030
3	1818-0920 or 08901-80011
4	1818-0921 or 08901-80012
5	1818-0922 or 08901-80013
6	1818-0926 or 08901-80014
7	1818-0923 or 08901-80015
8	1818-0925 or 08901-80025
11	1818-0924 or 08901-80023

Signature Test Point	Signature With A14 Plugged In	Signature Without A14 Plugged In
DATA 0	0C02	A51P
DATA 1	7C7C	9922
DATA 2	807C	2P82
DATA 3	3690	A1PU
DATA 4	1PU9	F10F
DATA 5	A035	2H94
DATA 6	6906	261A
DATA 7	7CUP	60FU

Software Date: 284.1979.

ROM	Part Number
1	08901-80032
2	08901-80030
3	1818-0920 or 08901-80011
4	1818-0921 or 08901-80012
5	1818-0922 or 08901-80013
6	1818-0926 or 08901-80014
7	1818-0923 or 08901-80015
8	1818-0925 or 08901-80025
11	1818-0924 or 08901-80023

Signature Test Point	Signature With A14 Plugged In	Signature Without A14 Plugged In
DATA 0	A466	0A7A
DATA 1	2HPH	FUC4
DATA 2	U4A0	5A59
DATA 3	36C1	A1FP
DATA 4	821H	5HP8
DATA 5	P24F	6UPH
DATA 6	90A9	HUC5
DATA 7	1160	UA51

Software Date: 180.1980.

ROM	Part Number
1	08901-80035
2	1818-1363 or 08901-80034
3	1818-0920 or 08901-80011
4	1818-0921 or 08901-80012
5	1818-0922 or 08901-80013
6	1818-0926 or 08901-80014
7	1818-0923 or 08901-80015
8	1818-0925 or 08901-80025
11	1818-1364 or 08901-80033

Signature Test Point	Signature With A14 Plugged In	Signature Without A14 Plugged In
DATA 0	1864	2790
DATA 1	AHH4	437U
DATA 2	U264	U0UC
DATA 3	H26U	0U6C
DATA 4	AC5U	AP8F
DATA 5	54P0	C4CU
DATA 6	H0HU	71A8
DATA 7	AAA8	HP8H

Software Date: 338.1981.

ROM	Part Number
1	08901-80038
2	1818-1363 or 08901-80034
3	1818-0920 or 08901-80011
4	1818-0921 or 08901-80012
5	1818-0922 or 08901-80013
6	1818-0926 or 08901-80014
7	08901-80039
8	1818-0925 or 08901-80025
11	1818-1364 or 08901-80033

Signature Test Point	Signature With A14 Plugged In	Signature Without A14 Plugged In
DATA 0	1P3F	21F8
DATA 1	H59U	3C34
DATA 2	6762	65UH
DATA 3	F942	1446
DATA 4	2CF7	2P14
DATA 5	7766	9739
DATA 6	19UA	C88H
DATA 7	0237	7612

Software Date: 67.1982.

ROM	Part Number
1	08901-80040
2	08901-80041
3	1818-0920 or 08901-80011
4	1818-0921 or 08901-80012
5	1818-0922 or 08901-80013
6	1818-0926 or 08901-80014
7	08901-80039
8	1818-0925 or 08901-80025
11	1818-1364 or 08901-80033

Signature Test Point	Signature With A14 Plugged In	Signature Without A14 Plugged In
DATA 0	9AUP	A50A
DATA 1	907U	7PH4
DATA 2	15F9	1756
DATA 3	H5FA	08FP
DATA 4	H2P8	H73C
DATA 5	A2C1	4C7P
DATA 6	A086	01U1
DATA 7	04C2	7097

The second table is in the Memory Select Decoders and ROM Check (on Service Sheet 18). The signatures for the Memory Select Decoder outputs remain the same. The signatures for the Control Bus data lines are as follows:

ROM	Part Number	Reference	Start/Stop		Signature on CONTROL BUS DATA Test Point							
			IC	Pin	0	1	2	3	4	5	6	7
1	08901-80029	A13U3	A13U12	15	F5P8	659H	37FH	9C81	42U8	HU27	P0CC	0440
1	08901-80032	A13U3	A13U12	15	0P97	H1A3	F272	C5H9	F361	H97H	H97H	A31H
1	08901-80035	A13U3	A13U12	15	F580	6H56	FFAF	FA62	5AU4	A36U	6F17	7731
1	08901-80038	A13U3	A13U12	15	8927	343C	7017	UUF6	9497	P64P	2692	U8HP
1	08901-80040	A13A3	A13A12	15	1PU9	4H0C	U93P	76PU	3919	P64P	167F	4119
2	08901-80030	A13U4	A13U12	14	1CU9	H04A	4FPF	11F5	7127	9436	3198	221C
2	1818-1363 or 08901-80034	A13U4	A13U12	14	UCP4	4P18	4594	4UPF	75U4	F9AH	A8CA	C73F
2	08901-80041	A13U4	A13U12	14	4P82	4P18	9U27	22C5	18AH	A678	A075	025A
3	1818-0920 or 08901-80011	A13U5	A13U12	13	FUUH	4071	P1U9	86A5	89HC	HC04	UP6U	P675
4	1818-0921 or 08901-80012	A13U6	A13U12	12	PF63	CH3C	H738	FFU3	5085	P57A	69FU	HF09
5	1818-0922 or 08901-80013	A13U7	A13U12	11	H5C4	U937	86CP	A58F	A136	FC40	9834	A624
6	1818-0926 or 08901-80014	A13U8	A13U12	10	0959	U952	FHUF	P0U9	65UU	29UP	CP7H	A0U8
7	1818-0923 or 08901-80015	A13U9	A13U12	9	U80C	1A8H	C898	76AA	UC8A	588A	F71A	8627
7	08901-80039	A13U9	A13U12	9	2CA4	1A8H	C898	76AA	UC8A	588A	F71A	8627
8	1818-0925 or 08901-80025	A13U10	A13U12	7	U451	U20U	P807	HC50	0967	CPU1	84C6	H63A
11	1818-0924 or 08901-80023	A14U14	A14U18	9	0147	PFC8	2U9A	4019	9UF0	39H3	F064	6A59
11	1818-1364 or 08901-80033	A14U14	A14U18	9	3378	673F	3250	AFC9	5A23	PC30	5475	9FU9

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HP Part No. 08901-90070

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ENGLEWOOD NSR 2411

INST SERVICE MGR

8901A-2-S

PRODU VICE NOTE

Supercedes:
None

HP MODEL 8901A MODULATION ANALYZER

Serial Prefix 2251A and Below

FAN ASSEMBLY SHOCK HAZARD

WARNING

The fan in the 8901A Modulation Analyzer is mounted to the rear panel with rubber vibration isolation mounts. The fan cover is grounded to the chassis via one of the mounting screws which is electrically connected to the chassis by a wire and two solder lugs. Grounding of the anodized cover is assured by grinding away a clear area around the mounting location. However, the fan frame is not reliably grounded because all surfaces of the frame, including the inside of the mounting holes, are painted. Should the fan wiring, including the motor windings, make contact with the fan frame, a voltage of line potential could be present on the frame. The fan frame is painted and partially shielded by a finger guard, but it is still possible for fingers to touch the frame and thus presents a shock hazard.

INTRODUCTION

The potential shock hazard can be eliminated by establishing electrical continuity between the fan frame and fan cover. The ground wire should also be changed from 22 gauge to 18 gauge.

Instruments with serial prefix 2238A and below should be modified to eliminate the shock hazard. Some instruments with serial prefixes 2239A, 2244A, and 2251A, and all instruments with serial prefix 2302A and above have already been modified.

Instruments which have been modified can be identified by removing the instrument top cover and checking the color of the wire connected between the solder lug (item 17 of Service Sheet B in the Service Manual) fastened to a fan mounting screw and the lug which is riveted to the rear-panel assembly (item 29). If the color of the wire is green/yellow, the instrument has the 18 gauge wire and the fan modification and no modification of the instrument is necessary. If the wire color is black, however, the wire is 24 gauge and the fan should be modified.

D/PM,OF/WA

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The modification to correct the shock hazard consists of scraping clear an area on the inside of the fan cover and around a mounting hole on the fan frame, then sandwiching a star washer between the frame and cover, and reassembling the fan. The following items (or their equivalents) are needed:

Description	HP Part Number	Quantity	CD
Insulated Wire, 18 Guage	8150-2919	0.5 ft	1
Star Washer	2190-0008	1	3

CORRECTION PROCEDURE

NOTE

Refer to Service Sheet B, Figure 8-142 of the Service Manual with HP Part Number 08901-90032. The Item Number, Reference Designator, and Description table associated with Figure 8-142 is in error in that the descriptions for items 54 and 56 are transposed. Before proceeding, change the description for item 54 to read "Machine Screw (6-32 × 2.50)" and the Description for item 56 to read "Machine Screw (6-32 × 2.25)". Also, two parts are missing. A lock washer identical to item 19 and a hex nut identical to item 20 should be placed between items 15 and 17 with the hex nut being next to item 15.

With the above corrections, use Figure 8-142 and its associated table to identify the parts referred to in the procedure below.

1. Disconnect the power cord from the line receptacle on the rear panel.

2. Remove the instrument top cover by removing the top two plastic standoffs on the rear panel. Each standoff is held in place by a Pozidriv screw. Next, loosen the screw in the center of the rear edge of the top cover. This is a captive screw and turning it counterclockwise will cause the cover to push away from the rear panel. Once the screw is free, lift the cover off the instrument.

3. Locate the two black fan wires exiting from a rubber grommet (item 4) mounted on the inside of the rear panel. These wires terminate at a white plastic connector (item 6). Unplug this connector from the A26 Power Supply Motherboard Assembly.

4. Remove the 5/16 inch hex nut (item 20), the first lock washer (item 19), the solder lug (item 17), and the second lock washer (not shown) from the end of the 6-32 × 2.50 machine screw (item 54). Use a wrench to hold the second hex nut (not shown) stationary while loosening the machine screw (item 54) with a Pozidriv screwdriver until the compression on the rubber shock mount (item 15) is relieved. Now remove the nut.

5. Remove the 6-32 × 2.50 machine screw and flat washer (items 54 and 55) by unscrewing the screw from the threaded insert in the rubber shock mount (item 15).

6. Support the finger guard (item 1), fan cover (item 2), and fan assembly (item 3) at the rear of the instrument and unscrew the three remaining 6-32 × 2.25 machine screws (items 56) and flat washers (items 57) from their respective shock mounts (items 14).

7. Slide the fan wire grommet (item 4) out of its slot in the rear panel assembly and remove the fan, fan cover, and finger guard from the rear of the instrument.

8. Using a soldering iron and de-soldering tool, unsolder the 22 gauge black wire from each of the solder lugs to which it is attached. Remove any excess solder from the lugs.

9. Cut a 2-3/4 inch length of 18 gauge, green/yellow wire. Strip approximately 1/2 inch of insulation from each end, and resolder the lug (item 17) to one end after first establishing a good mechanical connection. In similar manner, resolder the other end of the wire to the lug which is riveted to the rear panel assembly.

10. Using a small file, screwdriver, knife, or similar sharp object, scrape away the anodization from the inside of the fan cover (item 2) around the mounting screw hole which is in the corner of the fan cover where a similar area has been scraped away on the outside. Remove the anodization completely from a circular area approximately 3/8 inch in diameter.

11. Locate the two fan wires which exit from the rear of the fan assembly (item 3) immediately below one of the four drilled mounting tabs. Using a small file, knife, or similar sharp object, completely remove the paint from the area around the mounting hole in this tab on the surface that faces the fan cover.

12. Insert the 6-32 × 2.50 machine screw (item 54) and flat washer (item 55) through a mounting hole in the finger guard (item 1) and through the hole in the fan cover from which the anodization was removed. Place an external star washer on the screw so that upon reassembly, the star washer will be sandwiched between the fan cover and the fan frame.

13. Place the fan assembly back into the fan cover so that the screw is in the mounting hole in the fan housing from which the paint has been removed.

14. Place the remaining three 6-32 × 2.25 machine screws and flat washers (items 56 and 57) through the mounting holes in the finger guard, fan cover, and fan (items 1, 2, and 3).

15. Position the fan assembly at the rear of the instrument so that the two black fan wires are at the upper right corner of the assembly when viewed from the rear. Slide the grommet (item 4) back into the slot in the rear-panel assembly and position each of the four mounting screws in its respective threaded shock mount (items 14 and 15).

16. While supporting the fan assembly from the rear, thread each of the four mounting screws in a few turns to position and secure the fan to the rear panel. Using a Pozidriv screwdriver, tighten each of the three shorter 6-32 × 2.25 screws (items 56) until 1/8 inch of thread is exposed on the inboard side of the rubber shock mounts (items 14).

17. Tighten the 6-32 × 2.50 machine screw (item 54) until the shock mount (item 15) is compressed about the same as the other three shock mounts.

18. Reconnect the fan plug (item 6) to J5B of the A26 Power Supply Motherboard Assembly.

19. Screw the 5/16 inch hex nut (not shown) onto the longer 6-32 × 2.50 machine screw (item 54). Secure the screw with a screwdriver while tightening the nut snug against the shock mount with a wrench.

20. Re-install the lock washer (not shown), the solder lug (item 17) with the green/yellow wire attached, and the second lock washer (item 19) to the 6-32 × 2.50 screw (item 54) and secure them with the second hex nut (item 20).

21. Replace the instrument top cover.

22. Plug in the line cord, set the LINE switch to ON, and check the operation of the fan.

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8901A-03

SERVICE NOTE

SUPERSEDES None

8901A Modulation Analyzer

Serial Numbers: 2925A05414/2950A05587

A14 Remote Interface Assembly/A14R5

Modification to Prevent HP-IB Hang-Up

To Be Performed By: HP-Qualified Personnel

Parts required:

HP P/N	Description	Qty.
0698-0084	Resistor, 2150 ohms, 1%, 0.125W	1

Note:

> This modification should be performed only on A14 Remote Interface assembly HP P/N 08901-60257.

Situation:

Some instruments with serial numbers noted above may cause the HP-IB to hang-up for long periods of time. The problem is caused by insufficient time delay on the reset line of handshake logic (DAC) flip-flop A14U15B (pin 13). Increasing the value of A14R5 will prevent this failure mechanism.

Continued

DATE 23 May 1990

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:

MODIFICATION RECOMMENDED

ACTION CATEGORY:	☐ IMMEDIATELY ■ ON SPECIFIED FAILURE ☐ AGREEABLE TIME	STANDARDS:	LABOR: 1.00 Hours		
LOCATION CATEGORY:	☐ CUSTOMER INSTALLABLE ☐ ON-SITE ■ HP LOCATION	SERVICE INVENTORY:	☐ RETURN ■ SCRAP ☐ SEE TEXT	USED PARTS:	☐ RETURN ■ SCRAP ☐ SEE TEXT
AVAILABILITY:	PRODUCT'S SUPPORT LIFE	RESPONSIBLE ENTITY: 1000		UNTIL: 01 June 1995	
AUTHOR: LHL	ENTITY: 1000	ADDITIONAL INFORMATION:			

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Solution/Action:

Replace A14R5 with with the HP part number noted above. Re-calibration of the instrument is not required.

P-08901-60089A

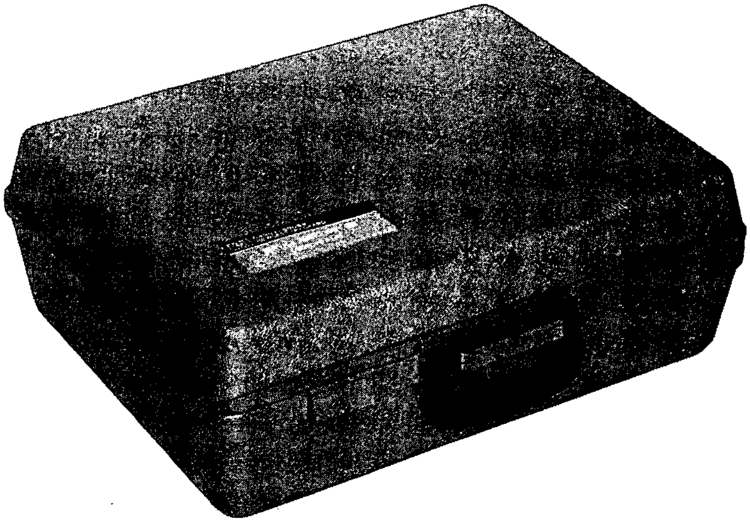
SERVICE NOTE

Supersedes:
P-08901-60089

HP MODEL 8901A MODULATION ANALYZER

All Serials

SERVICE ACCESSORY KIT



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DESCRIPTION

The HP 08901-60089 Service Accessory Kit contains extender boards, extender cables, and other accessories useful for servicing the HP Model 8901A Modulation Analyzer. Table 1 lists the contents (and replaceable parts) of the kit. (Check digit for the kit is 3.) Figure 2 is a schematic diagram of the HP 08901-60081 Digital Test/Extender Board contained in the kit.

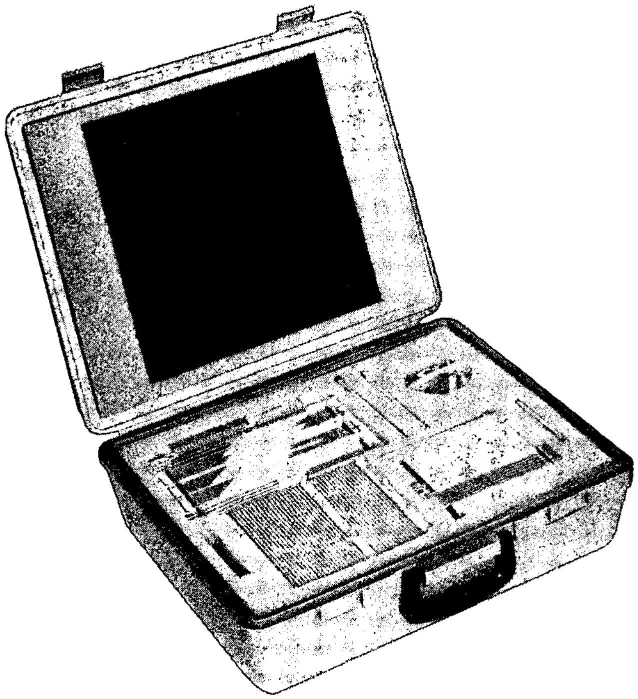
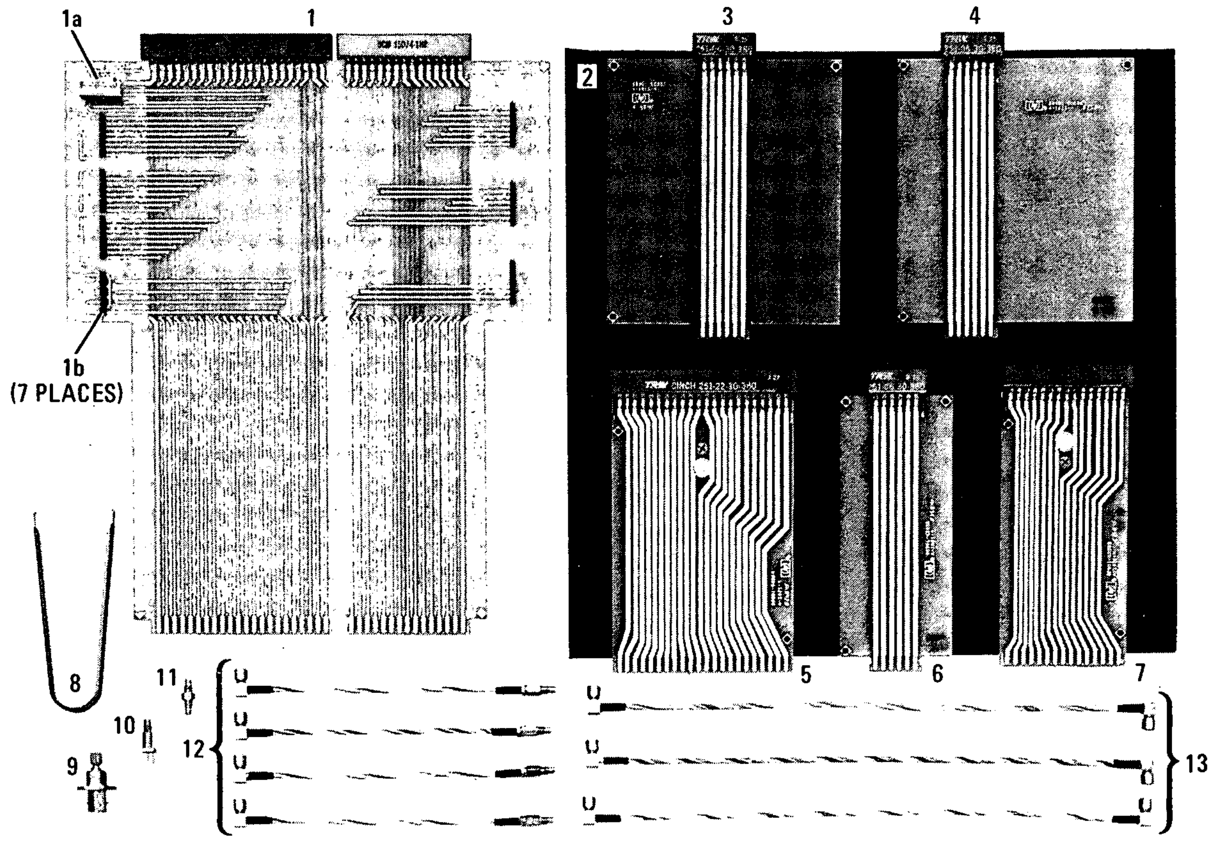


Figure 1. Internal View of the Service Accessory Kit

Table 1. Contents of the HP 08901-60089 Service Accessory Kit

Item Number	Description	Qty	HP Part Number	Check Digit
1	Digital Test/Extender Board	1	08901-60081	5
1a	7-Pole Switch	1	3101-1973	7
1b	8-Pin Connector	7	1251-4335	6
2	Conductive Foam	1	4208-0094	8
3	Extender Board (2 x 6 pins)	1	08901-60087	1
4	Extender Board (2 x 6 pins)	1	08901-60088	2
5	Extender Board (2 x 22 pins)	1	08901-60084	8
6	Extender Board (2 x 6 pins)	1	08901-60086	0
7	Extender Board (2 x 15 pins)	1	08901-60085	9
8	IC Extractor	1	8710-0585	1
9	SMC-BNC Adapter	1	1250-0832	8
10	SMC RF Test Probe	1	1250-1598	5
11	SMC-SMC Adapter	1	1250-0827	1
12	Cable Assembly	4	08901-60090	6
13	Cable Assembly	3	08901-60056	4



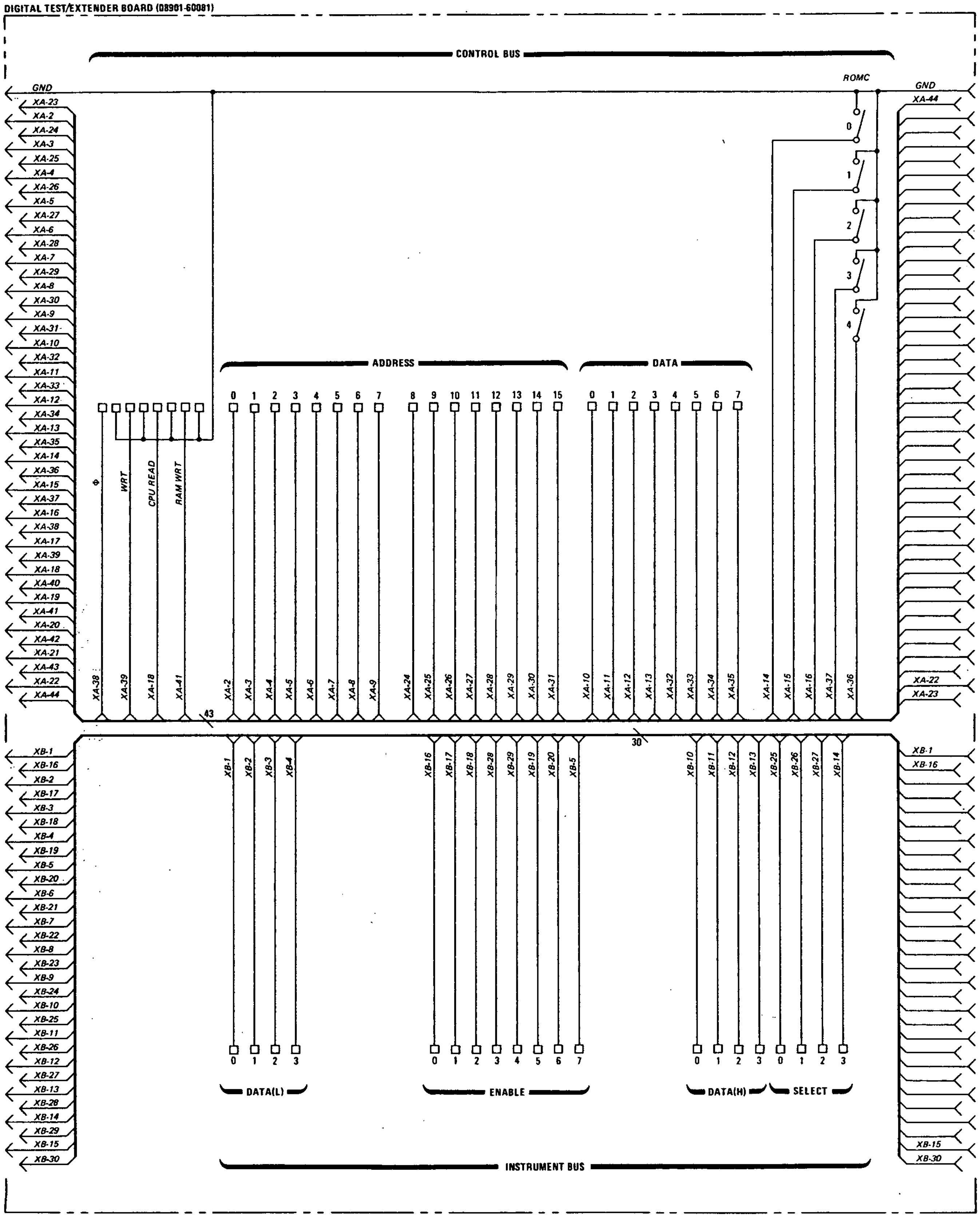


Figure 2. Schematic Diagram of HP 08901-60081 Digital Test/Extender Board

P-08901-60095

SERVICE NOTE

Supersedes:

None

HP MODEL 8901A MODULATION ANALYZER

All Serials

400 Hz LINE OPERATION FAN REPLACEMENT

INTRODUCTION

The HP Part Number 08901-60095 400 Hz Line Operation Fan when installed in an HP 8901A Modulation Analyzer allows operation at line frequencies ranging from 48 to 440 Hz. Operation at frequencies greater than 66 Hz is restricted to ≤126.5 Vac line input. If used to replace the standard fan, performance will be identical to the 8901A Option 004.

The fan is easy to install and requires no special tools.

INSTALLATION PROCEDURE

1. Turn the instrument off and unplug the power cord.
2. Remove the 4 plastic standoffs (MP18) on the rear panel by unscrewing the Pozidriv screw in each standoff.
3. Remove the top cover by unscrewing the Pozidriv screw in the middle of the rear edge of the top cover. This is a captive screw and will cause the top cover to push away from the frame.
4. Remove the bottom cover in the same manner as the top cover (see step 3 above).
5. Remove the fan power supply plug (connected to J5B) on the Power Supply Mother Board (A26).
6. While keeping the upper right fan cover screw from turning, remove the hex nut, the lock washer, and the grounding lug from the screw.
7. Remove the four pan-head screws located at the four corners of the fan cover. Note the positions of the wire finger guard, the fan cover, and the fan cable insulating grommet. Pull the fan assembly (B1) away from the instrument.
8. Install the 400 Hz fan, the fan cover, and the wire finger guard in the same position as the old fan assembly. The airflow arrow should point in towards the instrument. Replace the four pan-head screws at the four corners of the fan cover. Be sure the grommet and grounding lug are properly placed. When tightening the 4 screws, be careful not to overtighten as it will compress the rubber shock mounts and defeat their purpose. Only 3 mm (1/8 inch) of the screw should be exposed past the end of the rubber shock mount.
9. Connect the fan plug to the socket (J5B) on the Power Supply Mother Board.
10. Replace the top and bottom cover.
11. If the fan is being replaced to convert the instrument to Option 004, Type "Opt. 004" and the numbers of any other options still installed in the instrument on a blank label (HP 7120-1927). Place the label on the lip of the rear panel. Remove any existing option labels.
12. Apply power to the instrument and confirm the fan is operating properly.

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SERVICE NOTE

Supersedes:

None

HP MODEL 8901A MODULATION ANALYZER

All Serials

REAR TO FRONT PANEL CONNECTORS RETROFIT KIT (EXCEPT OPTION 010)

INTRODUCTION

The HP Part Number 08901-60100 Rear to Front Panel Connectors Retrofit Kit when installed in an HP 8901A Modulation Analyzer will move the rear-panel INPUT jack (J10), and the MODULATION OUTPUT jack (J4) to the front panel. The kit is installed by removing the front-panel assembly, replacing the INPUT, MODULATION OUTPUT, and CALIBRATION OUTPUT cables, moving the jacks to the front-panel assembly and installing a new front dress panel.

The kit is easy to install and requires no special tools.

NOTE

This retrofit kit does not apply to instruments with Option 010 AM and FM Calibrators installed.

The contents of the kit are listed in Table 1.

Table 1. Parts List for HP 08901-60100 Rear to Front Panel Connectors Retrofit Kit

Qty	Description	HP Part No.	CD
2	Clip, 0.138 ID	0510-1148	2
1	Plug hole 0.50D	6960-0002	4
1	Plug hole 0.62D	6960-0010	4
1	Panel Front STD	08901-00060	4
1	Cable Assembly W1	08901-60041	7
1	Cable Assembly W19	08901-60049	5

INSTALLATION PROCEDURE

Removing Top and Bottom Cover

1. Turn the instrument off and unplug the power cord.
2. Remove the four plastic standoffs (MP 18) on the rear panel by unscrewing the Pozidriv screw in each standoff.
3. Remove the top cover by unscrewing the Pozidriv screw in the middle of the rear edge of the top cover. This is a captive screw and will cause the top cover to push away from the frame.
4. Remove the bottom cover in the same manner as the top cover (see step 3 above).

Removing Cable Assemblies

5. Remove the wire duct cover (MP30) by sliding the cover toward the rear of instrument.
6. Remove the INPUT cable (black) from the instrument by disconnecting the SMC plug at A15J1 and removing the nut on the INPUT jack (J10) on the rear panel.
7. Remove the MODULATION OUTPUT cable (brown) from the instrument by disconnecting the SMC plug at A25J1 and removing the nut on the MODULATION OUTPUT jack (J4) on the rear panel. A25J1 is located behind the left side of the last extrusion in the audio section.

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Replacing Front-Dress Panel

8. Remove the top plastic trim strip (MP3) just above the front-panel assembly by prying it up with a small screwdriver.

9. Remove the 6 Pozidriv screws holding the front-panel assembly in place (3 screws on the top of the front frame and 3 screws on the bottom of the front frame). Remove only the 2 outside screws and the middle screw on the bottom of the front frame.

10. Slide the front-panel assembly out from the frame. Locate and remove the 3 small stud clips holding the front-dress panel in place. A pair of needle-nose pliers can be used to remove the clips.

11. Remove the old dress panel and replace it with the new dress panel (HP 08901-00060). Install the 2 stud clips (HP 0510-1148) on the dress panel studs (the backside of the front-panel assembly).

Installing New Cable Assemblies

12. Route the new cables (SMC end first) through the front frame along the wire duct. Connect the INPUT cable (black) SMC plug to A15J1. Connect the MODULATION OUTPUT cable (brown) SMC plug to A25J1.

CAUTION

Do not torque the SMC plug to more than 0.6 N·m (5 inch-pounds).

13. Connect the INPUT jack (J1) to the front-panel assembly using the hardware supplied in the kit. The lockwasher goes behind the front-panel assembly. Use caution not to scratch the front-dress panel or scar the knurl on the knurled nut.

14. Connect the MODULATION OUTPUT jack (J2) to the front-panel assembly (see step 13 above).

Replacing Front-Panel Assembly

15. Slide the front-panel assembly back into the frame. Make sure the IC socket plug (connected to J2) and the 6-pin connector (connected to J1) are secure and the cables are not pinched when the front-panel assembly is in place. Replace the 6 Pozidriv screws.

16. Install the hole plugs (HP 6960-0002 and 6960-0010) in the rear panel.

17. Replace the plastic trim strip, the wire duct cover, the top and bottom covers, and the 4 plastic standoffs on the rear panel.

18. Delete "Opt. 001" on the rear panel option label.

19. Verify the INPUT jack (J1) and the MODULATION OUTPUT jack (J2) route signals properly.

Supersedes:

None

HP MODEL 8901A MODULATION ANALYZER

All Serials

REAR-PANEL LOCAL OSCILLATOR CONNECTORS RETROFIT KIT

INTRODUCTION

The HP Part Number 08901-60103 Rear-Panel Local Oscillator Connectors Retrofit Kit when installed in an HP 8901A Modulation Analyzer provides an output for the internal local oscillator and an input for an external local oscillator signal. Both Type N connectors are located on the rear panel. After installation, performance will be identical to the 8901A Option 003. The kit is easy to install and requires no special tools.

The contents of the kit are listed in Table 1.

Table 1. Parts List for HP 08901-60103 Rear-Panel Local Oscillator Connectors Retrofit Kit

Qty	Description	HP Part No.	CD
1	Label	7120-1927	5
1	Cable Assy Semi-Rgd W33	08901-20083	3
1	Cable Assy W8	08901-60048	4
1	Cable Assy W4	08901-60062	2

INSTALLATION PROCEDURE

1. Turn the instrument off and unplug the power cord.
2. Remove the 2 top plastic standoffs (MP18) on the rear panel by unscrewing the Pozidriv screw in each standoff.
3. Remove the top cover by unscrewing the Pozidriv screw in the middle of the rear edge of the top cover. This is a captive screw and will cause the top cover to push away from the frame.
4. Remove the right side cover by unscrewing the 2 Pozidriv screws on each end of the side strap. Slide the cover towards the rear of the instrument.
5. Remove the wire duct cover (MP30) by sliding the cover towards the rear of the instrument.
6. Remove the 2 hole-plugs from the LO OUTPUT and the LO INPUT positions on the rear panel.
7. Locate and remove the violet cable (W39) between LO OUT (A19J3) and LO IN (A17J3).
8. The RF Section must be moved foward to install the Type N connector in the LO OUTPUT position on the rear panel. To move the RF section, the RF section shock mounting brackets must be disconnected from the main frame. Locate and remove the 2 screws near the middle of the bottom center strut, the 4 screws on the left side frame, and the 4 screws on the rear panel.
9. Carefully slide the RF section towards the front of the instrument. Install the white/-black cable (W8) supplied in the kit between LO OUT (A19J3) and LO OUTPUT (on the

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rear panel). The hardware for the Type N connector goes towards the outside of the instrument.

CAUTION

Do not torque the SMC plugs to more than 0.6 N·m (5 inch-pounds).

10. After the connector is installed, replace the 10 screws securing the RF section shock mounting brackets.

11. Install the white/red/violet cable (W4) supplied in the kit between LO IN (A17J3) and LO INPUT (on the rear panel). Hardware for the jack is installed towards the outside of the rear panel. Route both cables neatly along the wire duct.

12. Connect the semi-rigid cable (W33) between LO OUTPUT (J6) and LO INPUT (J7) on the rear panel.

13. Replace the wire duct cover (MP30), the top cover, and the 2 plastic standoffs.

14. Type "Opt. 003" and the numbers of any other options installed on the instrument on the blank label (HP 7120-1927) and place the label on the lip on the rear panel. Remove any other existing option labels.

15. Verify the internal local oscillator signal is being properly routed when the semi-rigid coaxial cable between J6 and J7 is in place, by applying a signal of appropriate level to the INPUT jack and checking that the Modulation Analyzer can tune to it. Try several frequencies between 10 and 1300 MHz.

SERVICE NOTE

Supersedes:

None

HP MODEL 8901A MODULATION ANALYZER

All Serials

FRONT TO REAR PANEL CONNECTORS RETROFIT KIT (WITH OPTION 010)

INTRODUCTION

The HP Part Number 08901-60104 Front to Rear Panel Connectors Retrofit Kit when installed in an HP 8901A Modulation Analyzer (with Option 010) will move the front panel INPUT jack (J1), the MODULATION OUTPUT jack (J2), and the CALIBRATION OUTPUT jack (J3) to the rear panel.

The kit is installed by removing the front-panel assembly, replacing the INPUT, MODULATION OUTPUT, and CALIBRATION OUTPUT cables, moving the jacks to the rear-panel assembly and installing a new front dress panel.

The kit is easy to install and requires no special tools.

NOTE

This retrofit kit applies to instruments with Option 010 AM and FM Calibrators installed.

The contents of the kit are listed in Table 1.

Table 1. Parts List for HP 08901-60104 Front to Rear Panel Connectors Retrofit Kit

Qty	Description	HP Part No.	CD
3	Clip 0.138ID	0510-1148	2
1	Label	7120-1927	5
1	Panel Front Opt. 001/010	08901-00062	6
1	Cable Assy W36	08901-60045	1
1	Cable Assy W37	08901-60046	2
1	Cable Assy W38	08901-60047	3

INSTALLATION PROCEDURE

Removing Top and Bottom Cover

1. Turn the instrument off and unplug the power cord.
2. Remove the four plastic standoffs (MP18) on the rear panel by unscrewing the Pozidriv screw in each standoff.
3. Remove the top cover by unscrewing the Pozidriv screw in the middle of the rear edge of the top cover. This is a captive screw and will cause the top cover to push away from the frame.
4. Remove the bottom cover in the same manner as the top cover (see step 3 above).

Removing Cable Assemblies

5. Remove the top plastic trim strip (MP3) just above the front panel by prying it up with a small screwdriver.
6. Remove the wire duct cover (MP30) by sliding the cover toward the rear of the instrument.
7. Disconnect the SMC plug at A15J1 (the black cable between the INPUT jack and A15J1), the SMC plug at A50J2 (the blue cable between the CALIBRATION OUTPUT jack and A50J2), and the SMC plug at A25J1 (the brown cable between the MODULATION OUTPUT jack and A25J1). A25J1 is located

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Removing Cable Assemblies (cont'd)

behind the left side of the last extrusion in the audio section.

Removing Front-Panel Assembly

8. Remove the knurled nuts on the front panel from the INPUT jack (J1), the CALIBRATION OUTPUT jack (J3), and the MODULATION OUTPUT jack (J2) using either knurled nut wrench if available or a pair of pliers. Use caution not to scratch the front-dress panel.

9. Remove the 6 Pozidriv screws holding the front-panel assembly in place (3 screws on the top of the front frame and 3 screws on the bottom of the front frame). Remove only the two outside screws and the middle screw on the bottom of the front frame.

10. Slide the front-panel assembly out from the frame and remove the INPUT jack (J1), the CALIBRATION OUTPUT jack (J3), and the MODULATION OUTPUT jack (J2) from the front-panel assembly. Carefully pull the cables through the front frame, out of the instrument.

11. Locate and remove the 2 small stud clips (the backside of the front-panel assembly) still holding the front-dress panel in place. A pair of needle-nose pliers can be used to remove the clips. After the clips are removed, slide the front-dress panel away from the front panel assembly.

Installing New Dress-Panel and Front-Panel Assemblies

12. Put the new front-dress panel (HP 08901-00062) in place and install the 3 small stud clips (HP 0510-1148) on the front-dress panel studs (the backside of the front-panel assembly).

13. Slide the front-panel assembly back into the frame. Make sure the IC socket plug (connected to J2) and the 6-pin connector (connected to J1) are secure and the cables are not pinched when the front-panel assembly is in place. Replace the 6 Pozidriv screws.

Installing New Cable Assemblies

14. Remove the hole plugs on the rear panel marked INPUT, CALIBRATION OUTPUT, and MODULATION OUTPUT.

15. Connect the black cable (W36) supplied in the kit between A15J1 and INPUT (on the rear panel). The hardware on the rear panel jacks goes towards the outside of the rear panel. Route the cable neatly along the wire duct.

CAUTION

Do not torque the SMC plugs to more than 0.6 N·m (5 inch-pounds).

16. Connect the blue cable (W37) supplied in the kit between A50J2 and CALIBRATION OUTPUT (on the rear panel).

17. Connect the brown cable (W38) supplied in the kit between A25J1 and MODULATION OUTPUT (on the rear panel).

18. Replace the wire duct cover, the top and bottom covers, the top plastic trim strip, and the four plastic standoffs.

19. Type "OPT. 001-010" and the numbers of any other options still installed in the instrument on the blank label (HP 7120-1927). Place the label on the lip of the rear panel. Remove any other existing option labels.

20. Verify the INPUT jack (J10), the MODULATION OUTPUT jack (J4) and the CALIBRATION OUTPUT jack (J11) route signals properly.

P-08901-60101

SERVICE NOTE

Supersedes:

None

HP MODEL 8901A MODULATION ANALYZER

All Serials

FRONT TO REAR PANEL CONNECTOR CONVERSION
(Except Option 010)

INTRODUCTION

The HP part number 08901-60101 Front To Rear Panel Connectors Conversion Kit when installed in an HP 8901A will move the front-panel INPUT jack (J1) and the MODULATION OUTPUT jack (J2) to the rear panel.

The kit is installed by removing the front-panel assembly, replacing the INPUT and MODULATION OUTPUT cables, moving the jacks to the rear-panel assembly, and installing a new front-dress panel.

The kit is easy to install and requires no special tools.

NOTE

This conversion kit does not apply to instruments with Option 010 AM and FM Calibrator installed.

The contents of the kit are listed in Table 1.

Table 1. Parts List for HP 08901-60101 Front To Rear Panel Connectors Conversion Kit

Qty	Description	HP Part Number	CD
3	Clip, 0.138 ID	0510-1148	2
1	Panel, Front Opt. 001	08901-00061	5
1	Cable Assy. W36	08901-60045	1
1	Cable Assy. W38	08901-60047	3
1	Label	7120-1927	5

INSTALLATION PROCEDURE

Removing Top and Bottom Cover

1. Turn the instrument off and unplug the power cord.
2. Remove the four plastic standoffs on the rear panel by unscrewing the Pozidriv screw in each standoff.
3. Remove the top cover by unscrewing the Pozidriv screw in the middle of the rear edge of the top cover. This is a captive screw and will cause the top cover to push away from the frame.
4. Remove the bottom cover in the same manner as the top cover (see step 3 above).

Removing Cable Assembly

5. Remove the top plastic trim strip just above the front panel by prying it up with a small screwdriver.
6. Remove the wire duct cover by sliding the cover toward the rear of the instrument.
7. Disconnect the SMC plug at A15J1 (the black cable between INPUT jack and A15J1) and the SMC plug at A25J1 (the brown cable between MODULATION OUTPUT jack and A25J1). A25J1 is located behind the left side of the last extrusion in the audio section.

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Removing Cable Assembly (Cont'd)

8. Remove the knurled nuts on the front panel from the INPUT jack (J1) and the MODULATION OUTPUT jack (J2) using either a knurled nut wrench if available or a pair of pliers. Use caution not to scratch the front-dress panel.

9. Remove the 6 Pozidriv screws holding the front-panel assembly in place (3 screws on the top-front frame and 3 screws on the bottom-front frame). Remove only the two outside screws and the middle screw on the bottom-front frame.

10. Slide the front-panel assembly out from the frame and remove the INPUT jack (J1) and the MODULATION OUTPUT jack (J2) from the front-panel assembly. Carefully pull the cables through the front frame, out of the instrument.

11. Locate and remove the 2 small stud clips (lower half of front-panel assembly on the inside) still holding the front-dress panel in place. A pair of needle-nose pliers can be used to remove the clips. After the clips are removed, slide the front-dress panel away from the front-panel assembly.

Installing New Dress-Panel and Front-Panel Assembly

12. Put the new front-dress panel (HP 08901-00061) in place and install the 3 small stud clips (HP 0510-1148) on the studs (back of front-panel assembly).

13. Slide the front-panel assembly back into the frame. Make sure the wiring harness and ribbon cable are secure and are not pinched when the front-panel assembly is in place. Replace the 6 Pozidriv screws.

Installing New Cable Assembly

14. Remove the hole plugs on the rear panel marked INPUT (J10) and MODULATION OUTPUT (J4).

15. Connect W36 (black cable) between A15J1 and the INPUT jack (J10) on the rear-panel assembly. Connect W38 (brown cable) between A25J1 and the MODULATION OUTPUT jack (J4) on the rear-panel assembly. The hardware on the rear-panel jacks goes towards the outside.

CAUTION

Do not torque the SMC plugs to more than 0.6 N·m (5 inch-pounds).

16. Replace wire duct cover, bottom cover, top cover, the top plastic trim strip, and the four plastic standoffs.

17. Type "OPT. 001" on the label (HP 7120-1927) and place it on the lip of the rear panel near the heat sink.

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INSTRUMENT SERVICE MGR

P-08901-60106

SERVICE NOTE

Supersedes:
None

HP MODEL 8901A MODULATION ANALYZER

All Serials

AM AND FM CALIBRATORS RETROFIT KIT (EXCEPT OPTION 001)

INTRODUCTION

The HP Part Number 08901-60106 AM and FM Calibrators Retrofit Kit when installed in an HP 8901A Modulation Analyzer will provide internal AM and FM Calibrators. After installation and calibration, performance will be identical to the 8901A Option 010. The AM Calibrator provides a nominal output of 33.33% AM. The FM Calibrator provides a nominal output of 33 kHz peak deviation. The Modulation Analyzer can determine the modulation of each calibrator to ±0.1%.

The installation procedure requires installing the CALIBRATION switch on the Keyboard and Display Assembly A1 by heat staking the switch. This requires some skill and patience. Read through the switch installation section and familiarize yourself with the procedure. Two switches are included in the kit in case one is damaged and becomes unuseable.

The kit is otherwise easy to install and requires no special tools.

NOTE

This retrofit kit does not apply to instruments with Option 001 Rear-Panel Connectors installed.

The contents of the kit are listed in Table 1.

INSTALLATION PROCEDURE

Removing Top Cover, Trim Strip, and Wire Duct Cover

1. Turn the instrument off and unplug the power cord.

2. Remove the top two plastic standoffs (MP18) on the rear panel by unscrewing the Pozidriv screw in each standoff.

3. Remove the top cover by unscrewing the Pozidriv screw in the middle of the rear edge of the top cover. This is a captive screw and will cause the top cover to push away from the frame.

4. Remove the top plastic trim strip (MP3) just above the front panel by prying the trim strip up with a small screwdriver.

5. Remove the wire duct cover (MP30) by sliding the cover toward the rear of the instrument.

Installing AM and FM Calibrator Assemblies

6. Install the new AM Calibrator Assembly A50 behind the AM Demodulator Assembly A6 in the audio section.

7. Install the new FM Calibrator Assembly A51 behind the AM Calibrator Assembly in the

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Table 1. Parts List for HP 08901-60106 AM and FM Calibrators Retrofit Kit

Qty	Description	HP Part Number	CD
12	Screw, TPG 4-24 0.5 Inch	0624-0281	3
1	Keycap, Quarter A1MP17	5041-0252	7
2	Pushbutton Switch, PC Mount	5060-9436	7
1	Label, Blank	7120-1927	5
1	Panel, Front Opt 010	08901-00003	5
1	FM Calibrator Assy A51	08901-60013	3
1	AM Calibrator Assy A50	08901-60014	4
1	Cable Assy W32	08901-60050	8
1	Cable Assy W34	08901-60064	4
1	Cable Assy W35	08901-60076	8

Installing AM and FM Calibrator Assemblies (Cont'd)

audio section. Be sure the assembly covers on A50 and A51 are flush with the other assembly covers in the audio section.

8. Secure A50 and A51 with the self-tapping screws (4-24 0.5 inch) supplied in the kit.

Removing Keyboard and Display Assembly

9. Remove the six Pozidriv screws holding the front-panel assembly in place (3 screws on the top of the front frame and 3 screws on the bottom of the front frame). Remove only the two outside screws and the center screw on the bottom of the front frame.

10. Slide the front-panel assembly out from the front frame.

11. Disconnect the ribbon cable plug (A1J2) and the six-pin connector (A1J1) from the Keyboard and Display Assembly A1.

12. Remove the knurled nuts on the INPUT jack (J1) and the MODULATION jack (J2) on the front panel. Use either a knurled-nut wrench, if available, or a pair of pliers. Use caution not to scratch the front dress panel or scar the knurl on the knurled nuts.

13. Disconnect the ac line switch from the Keyboard and Display Assembly by unplugging the two black wires.

14. Remove the ten screws holding the Keyboard and Display Assembly to the front-panel assembly. Note the position of the red plastic shield, the circuit board cover, and the circuit board spacers. Remove A1 from the front-panel assembly.

Installing CALIBRATION Switch

15. Locate the position on the Keyboard and Display Assembly where the CALIBRATION switch will be installed (lower left corner of A1). Identify the holes for the switch posts and the switch pads (see Figure 1).

16. Make sure the contact pads on the circuit board are clean and free of surface imperfections.

17. Place the switch (HP 5060-9436) in the proper position on the circuit board (see Figure 1). You should see the LED inside the white stem of the switch if the switch is properly placed.

NOTE

The following operation should be done in a well ventilated area in case the staking tip (or soldering tip) temperature runs too high, causing the plastic to vaporize and emit fumes (non-toxic).

18. Push down firmly on the switch and carefully heat stake the two plastic posts using the soldering iron. If properly installed, the switch should not be any looser than the other switches on the circuit board.

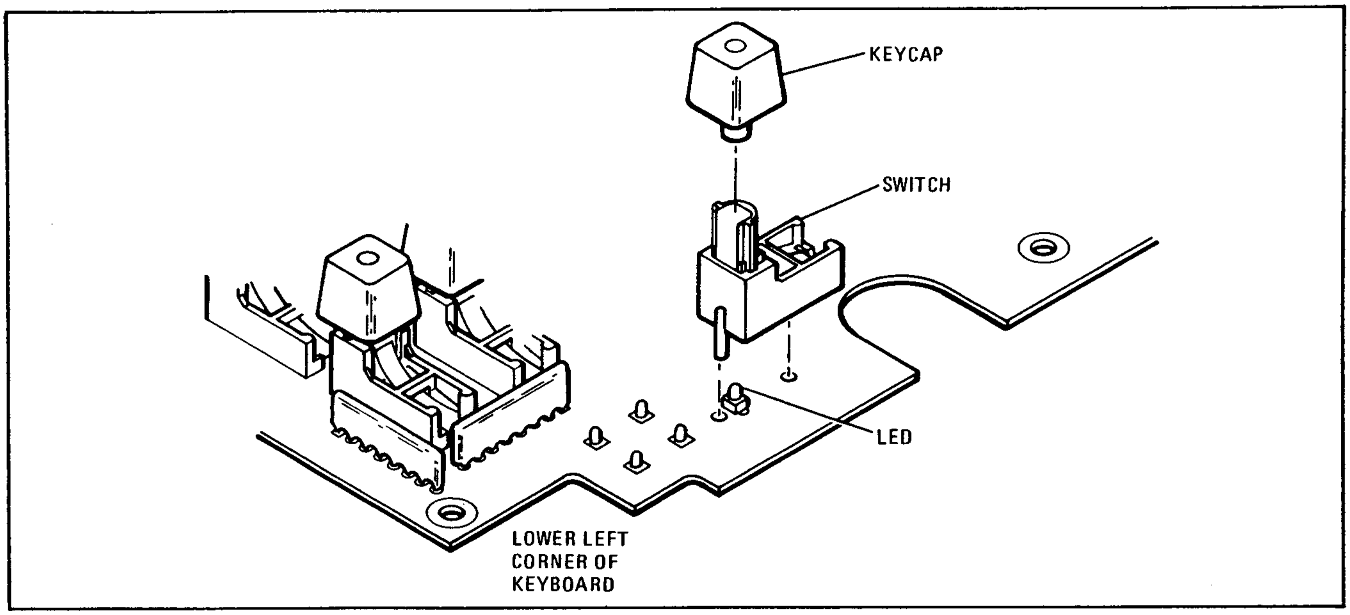

Figure 1. CALIBRATION Switch Location

Installing CALIBRATION Switch (Cont'd)

NOTE

The switch post can be heat staked using a soldering iron with either a staking tip if available or a regular flat tip. Best results will be achieved with a staking tip. To assure proper switch assembly make sure that the switch is pushed firmly against the circuit board and a tip temperature of approximately 440°C (825°F) is used. Too low a temperature will cause the plastic to stick to the tip of the soldering iron. Too much heat will cause the plastic to fume (non-toxic) profusely and possibly ruin the switch post. Each post should take about one second to stake. With the proper cycle the post should turn a darker color and in about 10 seconds, return to its original color.

19. Push the keycap (HP 5041-0252) on the switch stem and check the mechanical operation of the switch (it should have the same "feel" as the other keyboard switches).

Replacing Front Dress Panel

20. Remove the two small stud clips (back side of front-panel assembly) holding the front-dress panel in placed. A pair of needle-nose pliers can be used to remove the clips. Remove the front-dress panel.

21. Install the new front-dress panel (HP 08901-00003) and install the INPUT jack (J1) and the MODULATION OUTPUT jack (J2) in the front-panel assembly. Use caution not to scratch the front-dress panel or scar the knurl on the knurled nuts.

22. Install the CALIBRATION OUTPUT jack (J3) on the blue coaxial cable supplied in the kit on the front panel. The lock washer goes on the inside of the front-panel assembly. Route the cable neatly along the wire duct and connect the SMC plug on the cable to A50J2 on the FM Calibrator Assembly.

CAUTION

Do not torque the SMC plugs to more than 0.6 N·m (5 inch-pounds).

Replacing Keyboard and Display Assembly

23. Install the modified Keyboard and Display Assembly, the red plastic shield, the circuit board cover, and cover spacers. The seven longer screws are used to attach the red plastic shield and circuit board insulator. Make sure the annunciator LEDs adjacent to the displays match up with their respective holes and the front-panel buttons are centered before tightening the screws.

24. Plug in the two black wires for the line switch, the ribbon cable plug (A1J2), and the six-pin connector (A1J1).

Replacing Keyboard and Display Assembly (Cont'd)

25. Slide the front-panel assembly back into the frame. Make sure the cables are not pinched when the front-panel assembly is in place. Replace the six Pozidriv screws.

26. Connect the white/orange/yellow cable (W34) from A51J2 to A11J2 on the Counter Assembly A11. Route the cable neatly along the wire duct.

27. Connect the white/red cable (W35) from A50J1 to A51J1.

28. Replace the wire duct cover, the plastic trim strip, the top cover and the two plastic standoffs.

29. Type "OPT 010" and the numbers of any other options still installed in the instrument on the blank label (HP 7120-1927). Place the label on the lip of the rear panel. Remove any existing option labels.

30. Perform the FM CALIBRATOR ADJUSTMENTS and AM CALIBRATOR ADJUSTMENTS in the Operating and Service Manual and verify proper operation of the calibrators.

SERVICE NOTE

Supersedes:
None

HP MODEL 8901A MODULATION ANALYZER

All Serials

AM AND FM CALIBRATORS RETROFIT KIT (WITH OPTION 001)

INTRODUCTION

The HP Part Number 08901-60107 AM and FM Calibrators Retrofit Kit when installed in an HP 8901A Modulation Analyzer will provide internal AM and FM Calibrators. After installation and calibration, performance will be identical to the 8901A Option 010. The AM Calibrator provides a nominal output of 33.33% AM. The FM Calibrator provides a nominal output of 33 kHz peak deviation. The Modulation Analyzer can determine the modulation of each calibrator to ±0.1%.

The installation procedure requires installing the CALIBRATION switch on the Keyboard and Display Assembly A1 by heat staking the switch. This requires some skill and patience. Read through the switch installation section and familiarize yourself with the procedure. Two switches are included in the kit in case one is damaged and becomes unuseable.

The kit is otherwise easy to install and requires no special tools.

NOTE

This retrofit kit applies to instruments with Option 001 Rear-Panel Connectors installed.

The contents of the kit are listed in Table 1.

INSTALLATION PROCEDURE

Removing Top Cover, Trim Strip, and Wire Duct Cover

1. Turn the instrument off and unplug the power cord.

2. Remove the top two plastic standoffs (MP18) on the rear panel by unscrewing the Pozidriv screw in each standoff.

3. Remove the top cover by unscrewing the Pozidriv screw in the middle of the rear edge of the top cover. This is a captive screw and will cause the top cover to push away from the frame.

4. Remove the top plastic trim strip (MP3) just above the front panel by prying the trim strip up with a small screwdriver.

5. Remove the wire duct cover (MP30) by sliding the cover toward the rear of the instrument.

Installing AM and FM Calibrator Assemblies

6. Install the new AM Calibrator Assembly A50 behind the AM Demodulator Assembly A6 in the audio section.

7. Install the new FM Calibrator Assembly A51 behind the AM Calibrator Assembly in the

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Table 1. Parts List for HP 08901-60107 AM and FM Calibrators Retrofit Kit

Qty	Description	HP Part Number	CD
3	Clip, 0.138 ID	0510-1148	2
12	Screw, TPG 4-24 0.5 Inch	0624-0281	3
1	Keycap, Quarter A1MP17	5041-0252	7
2	Pushbutton Switch, PC Mount	5060-9436	7
1	Label, Blank	7120-1927	5
1	Panel, Front Opt 001 & 010	08901-00062	6
1	FM Calibrator Assy A51	08901-60013	3
1	AM Calibrator Assy A50	08901-60014	4
1	Cable Assy W37	08901-60046	2
1	Cable Assy W34	08901-60064	4
1	Cable Assy W35	08901-60076	8

Installing AM and FM Calibrators Assemblies (Cont'd)

audio section. Be sure the assembly covers on A50 and A51 are flush with the other assembly covers in the audio section.

8. Secure A50 and A51 with the self-tapping screws (4-24 0.5 inch) supplied in the kit.

Removing Keyboard and Display Assembly

9. Remove the six Pozidriv screws holding the front-panel assembly in place (3 screws on the top of the front frame and 3 screws on the bottom of the front frame). Remove only the two outside screws and the center screw on the bottom of the front frame.

10. Slide the front-panel assembly out from the front frame.

11. Disconnect the ribbon cable plug (A1J2) and the six-pin connector (A1J1) from the Keyboard and Display Assembly A1.

12. Disconnect the ac line switch from the Keyboard and Display Assembly by unplugging the two black wires.

13. Remove the 10 screws holding the Keyboard and Display Assembly to the front-panel assembly. Note the position of the red plastic shield, the circuit board cover, and the circuit board spacers. Remove A1 from the front-panel assembly.

Installing CALIBRATION Switch

14. Locate the position on the Keyboard and Display Assembly where the CALIBRATION switch will be installed (lower left corner of A1). Identify the holes for the switch posts, the holes for the LED, and the switch pads (see Figure 1).

15. Make sure the contact pads on the circuit board are clean and free of surface imperfections.

16. Place the switch (HP 5060-9436) in the proper position on the circuit board (see Figure 1). You should see the LED inside the white stem of the switch if the switch is properly placed.

NOTE

The following operation should be done in a well ventilated area in case the staking tip (or soldering tip) temperature runs too high, causing the plastic to vaporize and emit fumes (non-toxic).

17. Push down firmly on the switch and carefully heat stake the two plastic posts using the soldering iron. If properly installed, the switch should not be any looser than the other switches on the circuit board.

NOTE

The switch post can be heat staked using a soldering iron with either a staking tip if available or a regular flat tip. Best results will be achieved with a staking tip.

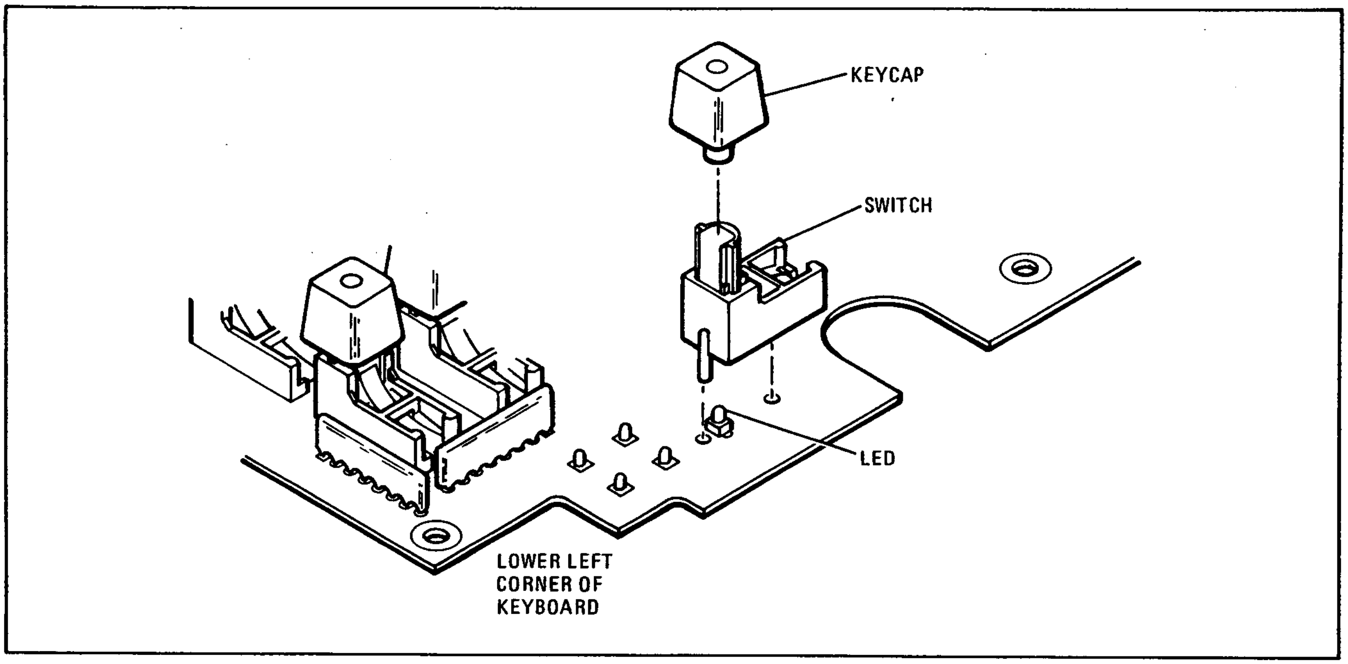


Figure 1. CALIBRATION Switch Location

NOTE (Cont'd)

To assure proper switch assembly make sure that the switch is pushed firmly against the circuit board and a tip temperature of approximately 440°C (825°F) is used. Too low a temperature will cause the plastic to stick to the tip of the soldering iron. Too much heat will cause the plastic to fume (non-toxic) profusely and possibly ruin the switch post. Each post should take about one second to stake. With the proper cycle the post should turn a darker color and in about 10 seconds, return to its original color.

18. Push the keycap (HP 5041-0252) on the switch stem and check the mechanical operation of the switch (it should have the same "feel" as the other keyboard switches).

Replacing Front-Dress Panel

19. Remove the three small stud clips (back side of front-panel assembly) holding the front-dress panel in place. A pair of needle-nose pliers can be used to remove the clips. Remove the front-dress panel.

20. Install the new front-dress panel (HP 08901-00062) and replace the three small stud clips (HP 0510-1148).

Replacing Keyboard and Display Assembly

21. Install the modified Keyboard and Display Assembly, the red plastic shield, the circuit board cover, and cover spacers. The seven longer screws are used to attach the red plastic shield and circuit board insulator. Make sure the annunciator LEDs adjacent to the display match up with their respective holes and the front-panel buttons are centered before tightening the screws.

22. Plug in the two black wires for the line switch, the ribbon cable plug (A1J2), and the six-pin connector (A1J1).

23. Slide the front-panel assembly back into the frame. Make sure the cables are not pinched when the front-panel assembly is in place. Replace the six Pozidriv screws.

24. Connect the white/orange/yellow cable (W34) from A51J2 to A11J2 on the Counter Assembly A11. Route the cable neatly along the wire duct.

CAUTION

Do not torque the SMC plugs to more than 0.6 N•m (5 inch-pounds).

25. Connect the white/red cable (W35) from A50J1 to A51J1.

26. Connect the blue cable (W37) from A50J2 to the CALIBRATION OUTPUT jack (J11)

Replacing Keyboard and Display Assembly (Cont'd)

on the rear panel. The hardware goes towards the outside of the rear panel. Route the cables neatly along the wire duct.

27. Replace the wire duct cover, the plastic trim strip, the top cover and the two plastic stand-offs.

28. Type "OPT 001, 010" and the numbers of any other options still installed in the instrument on the blank label (HP 7120-1927). Place the label on the lip of the rear panel. Remove any existing option labels.

29. Perform the FM CALIBRATOR ADJUSTMENTS and AM CALIBRATOR ADJUSTMENTS in the Operating and Service Manual and verify proper operation of the calibrators.

ENGLEWOOD NSR 2411

PEDERSEN,HARRY H

P-08901-60287

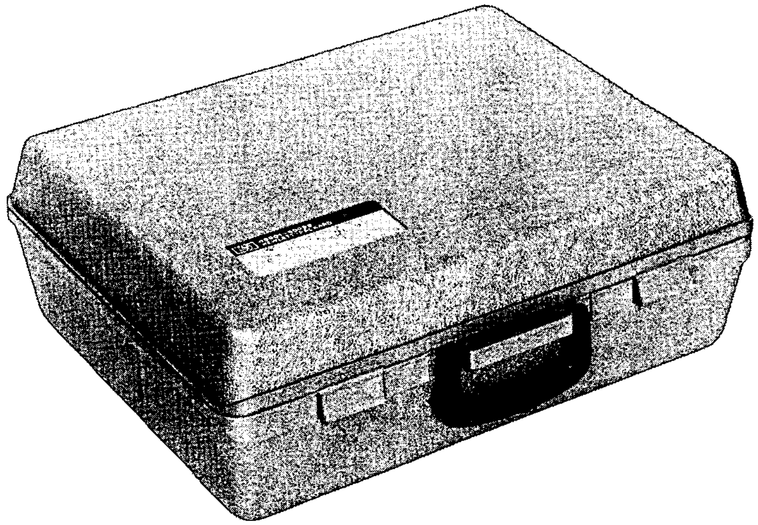
RVICE NOTE

Supersedes:
P-08901-60089A

HP MODEL 8901A AND 8901B MODULATION ANALYZER AND HP MODEL 8902A MEASURING RECIEVER

All Serials

SERVICE ACCESSORY KIT
(HP Part Number 08901-60287)



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HP Part No. 08901-90112

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DESCRIPTION

The HP 08901-60287 Service Accessory Kit contains extender boards, extender cables, and other accessories useful for servicing the HP Model 8901A, 8901B Modulation Analyzers and the HP Model 8902A Measuring Receiver. Table 1 lists the contents (and replaceable parts) of the kit. (Check digit for the kit is 3.) Figure 2 is a schematic diagram for the HP 08901-60081 Digital Test/Extender Board contained in the kit.

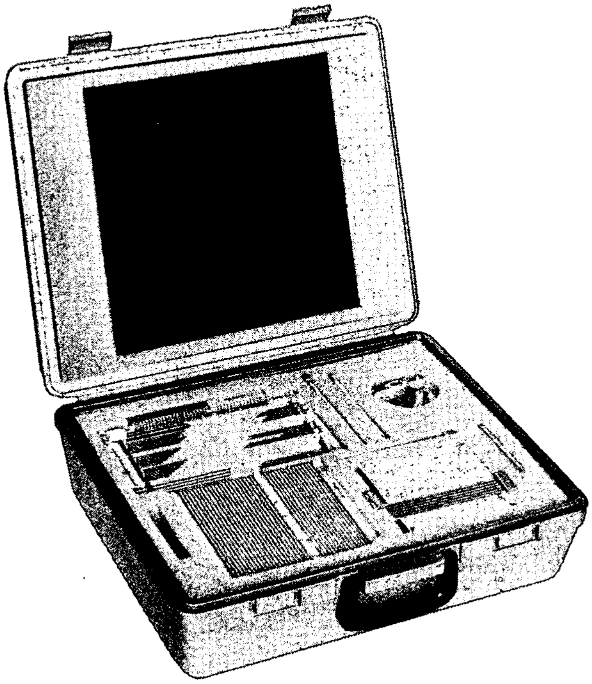
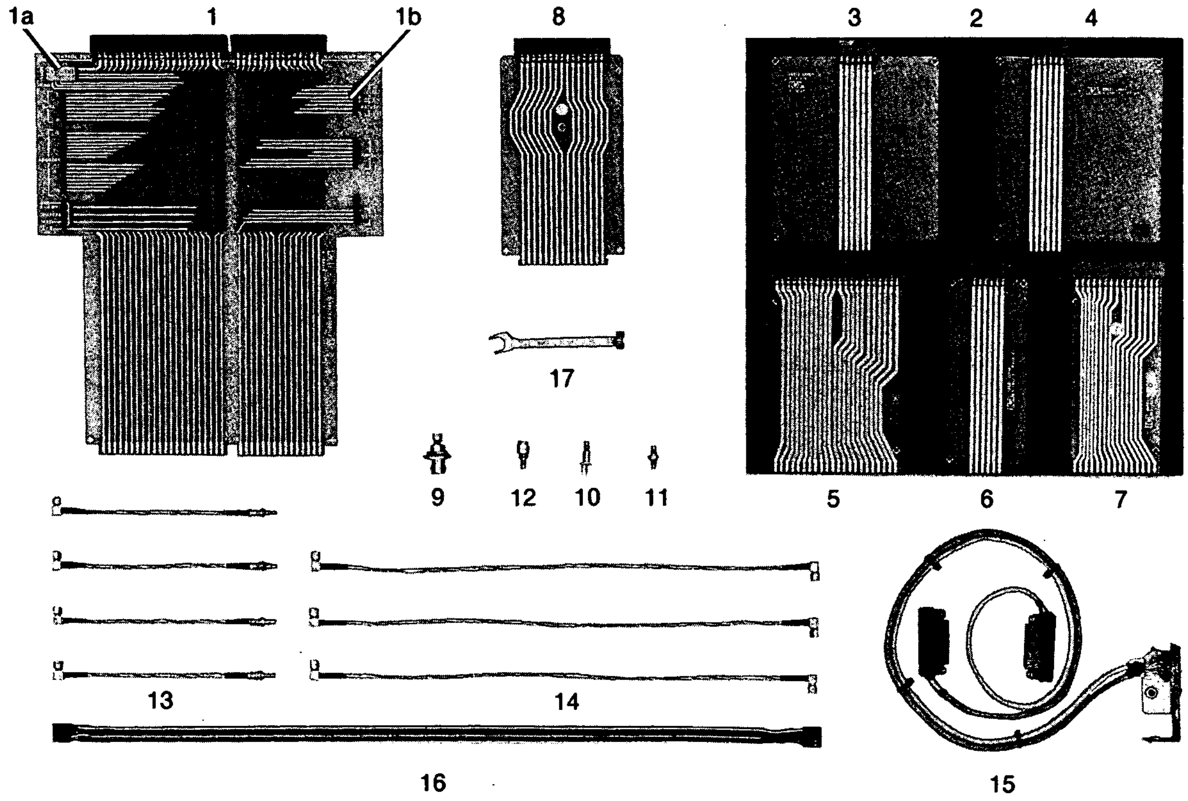


Figure 1. Internal View of the Service Accessory Kit

Table 1. Contents of the HP 08901-60287 Service Accessory Kit

Item Number	Description	Qty	HP Part Number	Check Digit
1	Digital Test/Extender Board	1	08901-60081	5
1a	7-Pole Switch	1	3101-1973	7
1b	8-Pin Connector	7	1251-4335	6
2	Conductive Foam	1	4208-0094	8
3	Extender Board (2 x 6 pins)	1	08901-60087	1
4	Extender Board (2 x 6 pins)	1	08901-60088	2
5	Extender Board (2 x 22 pins)	1	08901-60084	8
6	Extender Board (2 x 6 pins)	1	08901-60086	0
7	Extender Board (2 x 15 pins)	1	08901-60085	9
8	Extender Board (2 x 15 pins)	1	08662-60276	0
9	SMC-BNC Adapter	1	1250-0832	8
10	SMC RF Test Probe	1	1250-1598	5
11	SMC-SMC Adapter	1	1250-0827	1
12	SMA-SMC Adapter	1	1250-1693	1
13	Cable Assembly (coax SMC)	4	08901-60090	6
14	Cable Assembly (coax SMC)	3	08901-60056	4
15	Cable Assembly (RF Power)	1	08901-60290	2
16	Cable Assembly (Ribbon)	1	08902-60025	7
17	Wrench (5/16 inch)	1	5021-2810	5



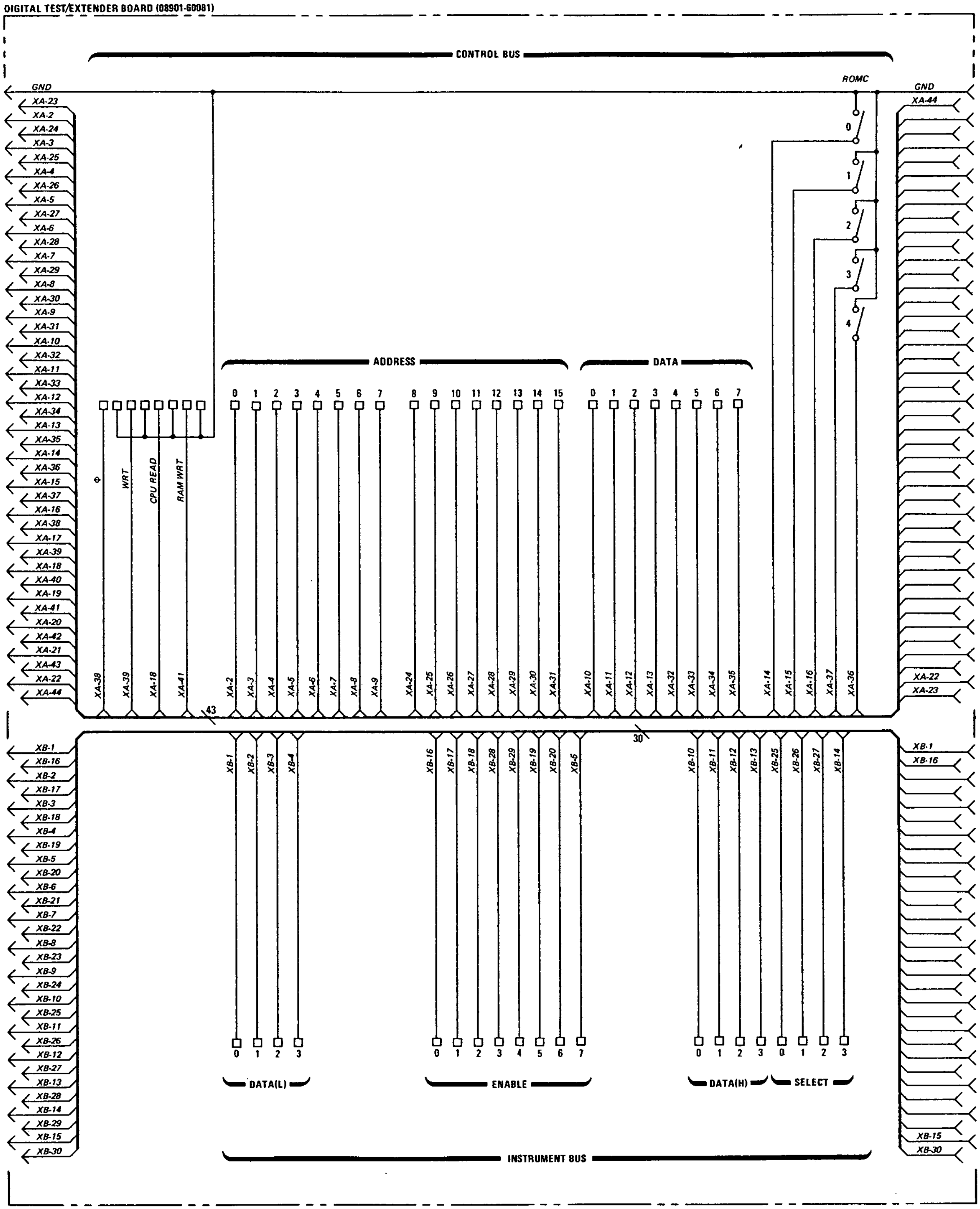
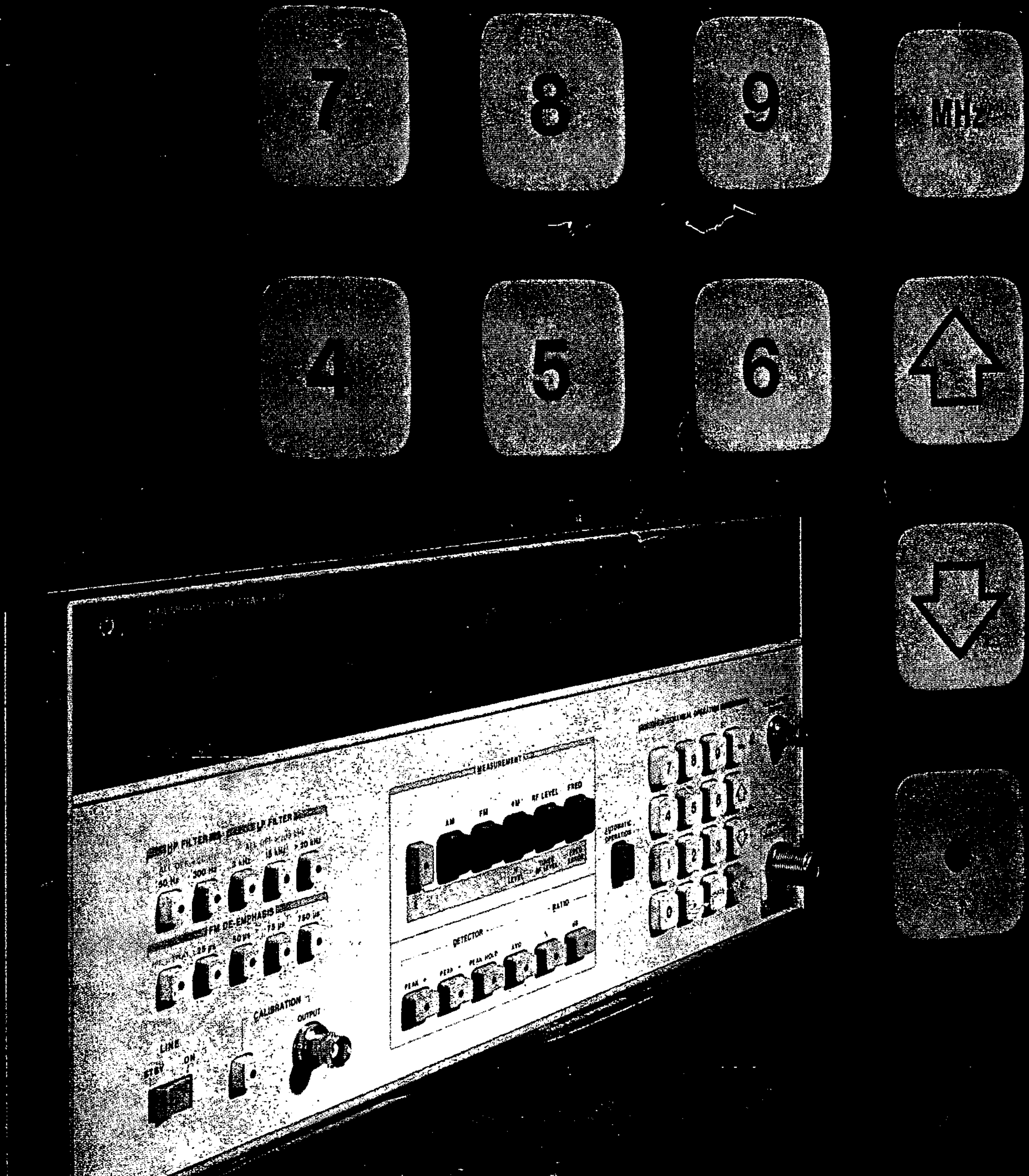


Figure 2. Schematic Diagram of HP 08901-60081 Test/Extender Board

App Note

Applications and Operation of the 8901A Modulation Analyzer



Application Note 286-1

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Application Note 286-1

Applications and Operation of the 8901A Modulation Analyzer

Contents

1. Introduction

The 8901A Modulation Analyzer is a calibrated receiver that combines several RF measurement capabilities in one instrument. It measures modulation (AM, FM, ΦM), frequency, and power automatically, with all major functions requiring only a single keystroke. Once the function is selected, the 8901A automatically tunes to the input signal, selects the appropriate range, makes the measurement, and displays the result. Accuracy for AM and FM is 1% of reading for most rates and depths, or deviations. Low internal noise and high separation between AM and FM demodulators make possible measurement of small amounts of residual or incidental modulation. Several front panel keys put the analyzer in special measurement modes. For example, the FM de-emphasis PRE-DISPLAY mode greatly simplifies measuring flatness of pre-emphasized FM transmitters; the PEAK HOLD mode captures modulation transients for broadcast monitoring, and the percent and dB ratio modes provide flexible display formats. These features and capabilities make the 8901A ideal for demanding applications such as signal generator calibration and transmitter testing.

This application note contains information for making full use of the analyzer's capabilities. It includes step-by-step procedures for calibrating signal generators, measuring VCO linearity, and testing FM transmitters (section 2); brief theory of operation (section 3); descriptions and uses of the special functions (section 4); theory and operation of the optional calibrators (section 5); and remote HP-IB[1] operation with various Hewlett-Packard controllers (section 6).

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[1] HP-IB is Hewlett-Packard's implementation of IEEE Standard 488.

2. Applications

The performance and features of the Modulation Analyzer make it a versatile RF measurement tool. As a bench instrument used with an audio oscillator the 8901A performs most mobile radio transmitter tests in several keystrokes. The percent and dB relative ratio modes provide flexible display formats. These features along with standard de-emphasis and audio filters simplify many measurements that are presently tedious. For example, flatness of pre-emphasized FM transmitters can be measured directly in dB by merely sweeping audio frequency into the transmitter microphone input. Besides ease of use, unprecedented accuracy and the internal calibrator option make the 8901A ideal for calibrating signal generators. High AM and FM separation and a low noise local oscillator make the 8901A useful as a general purpose lab instrument for incidental and residual modulation measurements and in characterizing crystal oscillators. Other applications include IC testing, broadcast monitoring, and testing ILS transmitters. This section describes several major applications of the 8901A Modulation Analyzer.

Mobile Radio Transmitter Testing

In the design of the Modulation Analyzer careful attention was given to testing requirements of mobile transmitters. Three of the most important measurements commonly made are

Power output
Frequency error
Modulation limiting

These measurements are important because they have a direct bearing on the transmitter's operating range and because of government regulations. The 8901A measures power, frequency, and modulation with single keystrokes. Besides these basic measurement capabilities, the Modulation Analyzer contains the appropriate FM de-emphasis filters, post detection measurement bandwidth filters, and detectors required for performing almost all of the standard mobile transmitter tests as specified in EIA Standards RS-152B and RS-382A, and CEPT Recommendation TR/17 Annex I, II, and III. The 8901A meets the vast majority of transmitter testing requirements when used with an audio source to provide test tones for the transmitter microphone input. In tables 2-1 through 2-4 the 8901A test capabilities are compared with the most widely accepted industry standards.

Table 2-1. FM mobile transmitter tests per CEPT Recommendation TR/17 Annex I, II, and III

Test	Can 8901A Test?	Comments
Frequency Tolerance	Yes	
Carrier Power	Yes	Requires a power attenuator for levels > 1 watt.
Adjacent Channel Power	No	
Conducted Spurious Emission	No	
Maximum Permissible Frequency Deviation	Yes	
Transmitter Modulator Limiting Characteristic	Yes	
Frequency Deviation Reduction for Modulation Frequency > 3 kHz	Yes	The 8901A dB ratio mode provides direct display of measurement results according to the specification.
Modulator Sensitivity, Including the Microphone	Yes	An acoustic transducer is required.
Transmitter Audio Frequency Response	Yes	
Audio Frequency Harmonic Distortion	Yes	Requires a distortion analyzer connected to the MODULATION OUTPUT.
Residual Transmitter Modulation	Yes	

Table 2-2. AM transmitter tests per EIA RS-382A

Test	Can 8901A Test?	Comments
Carrier Output Power	Yes	Requires a power attenuator for levels > 1 watt.
Conducted Spurious Emissions	Limited	8901A can measure carrier harmonics to approximately −50 dBc (or minimum absolute levels of −50 dBm).
Radiated Spurious Emissions	No	
Audio Frequency Harmonic Distortion	Yes	Requires a distortion analyzer.
Audio Frequency Response	Yes	
Hum and Noise Level	Yes	
Transmitter Frequency Stability	Yes	
Transmitter Modulation Spectrum	No	Requires a spectrum analyzer.

Table 2-3. FM mobile transmitter tests per EIA RS-152B

Test	Can 8901A Test?	Comments
Carrier Power	Yes	Requires a power attenuator for levels > 1 watt.
Conducted Spurious Emission	No	
Radiated Spurious Emission	No	
Audio Frequency Harmonic Distortion	Yes	Requires a distortion analyzer connected to MODULATION OUTPUT of 8901A.
Audio Frequency Response	Yes	
FM Hum and Noise	Yes	
Modulation Limiting		
Instantaneous	Yes	
Steady State	Yes	
Carrier Frequency Stability	Yes	8901A measures frequency to 10 Hz resolution. External test chambers must provide varying temperature and humidity.
AM Hum & Noise	Yes	
Transmitter Sideband Spectrum	No	Requires a spectrum analyzer.
Carrier Attack Time	Yes	Requires a storage oscilloscope connected to 8901A IF OUTPUT.

Table 2-4. Single sideband (SSB) transmitter tests per EIA RS-424

Test	Can 8901A Test?	Comments
Peak Envelope Power Output (Two Tone)	Yes	Requires power attenuator for levels > 1 watt.
Conducted Spurious Emissions	Limited	8901A can measure carrier harmonics to approximately −50 dBc (or minimum absolute levels of −50 dBm).
Radiated Spurious Emissions	No	
Audio Frequency Response	Yes	
Frequency Stability	Yes	
Intermodulation Distortion	No	Requires a spectrum analyzer.

Common Transmitter Tests with the 8901A

With the 8901A most transmitter tests require only a few keystrokes. Several features like PEAK HOLD and PRE-DISPLAY really simplify measurements that are presently difficult or tedious to perform. The percent and dB ratio modes allow the 8901A to display measurement results in the units that are most often used. For example, FM hum and noise can be displayed in dB down from a user-entered reference deviation. The following procedures show how to perform the most common transmitter tests with the 8901A. Some of the examples shown are for FM transmitters. However, the 8901A works equally well with AM or ΦM transmitters.

Power

The 8901A measures power in watts in RF level mode. Sometimes dBm is preferred to watts. Since 0 dBm is 1 milliwatt the keystrokes to display power in dBm are

dB
. 0 0 1 •

The 8901A measures power for inputs up to 1 watt (+30 dBm), and is relay protected for overloads up to 25 watts. The error message "E06" is displayed when an overload occurs. Normal operation resumes after any key is pressed and the overload condition is no longer present.

Frequency Error

The Analyzer measures the transmitter frequency in frequency mode. In normal operation the 8901A automatically adjusts the counter resolution as a function of input frequency to obtain a display rate of 3.6 readings/second. This constant display rate can be overridden with special functions in favor of better resolution. For maximum resolution (10 Hz) use the 7.1 special function. The keystrokes are

SPCL
7 . 1 •

Special functions are described further in sections 4 and 6. The 8901A can also display frequency error. The keystrokes to measure the frequency error of a 464.55 MHz transmitter are

4 6 4 . 5 5 MHz • •
S FREQ ERROR

The display indicates the frequency error. Frequency error can also be displayed in parts per million (ppm) using percent ratio mode. After the previous keystrokes enter 0.1 times the frequency input in MHz (46.455 for this example) and press the percent ratio key.

Microphone Sensitivity

Microphone sensitivity is the audio level at the transmitter microphone input that produces standard test modulation on the transmitter output. Standard test modulation is defined as a 1 kHz rate and 30% depth for AM transmitters or 3 kHz peak deviation for FM mobile transmitters. For an FM transmitter the keystrokes are

FM ● 15 kHz ● PEAK+ ●

The audio level is adjusted until the 8901A indicates standard modulation (Figure 2-1). This audio level is used as the reference microphone input for several of the following tests.

Incidental AM

Incidental AM is the amount of AM modulation produced when the transmitter is frequency modulated to standard test deviation. Incidental AM is measured by pressing the AM key.

Audio Distortion

Transmitter audio distortion is measured with the equipment setup of Figure 2-1 with a distortion analyzer connected to the 8901A MODULATION OUTPUT. The audio source level should be adjusted to produce standard test modulation. The recovered modulation is available at the MODULATION OUTPUT. Most FM transmitters employ pre-emphasis which boosts the level of high frequency audio signals at the microphone input. FM receivers low-pass filter the recovered audio with de-emphasis to reproduce the original microphone input signal. The 8901A has four de-emphasis networks including 25 μs for Dolby FM broadcast, 50 μs for European FM broadcast, 75 μs for U.S. FM broadcast, and 750 μs for mobile radio transmitters. When selected these de-emphasis networks low-pass filter the MODULATION OUTPUT signal. The appropriate network should always be used when measuring FM transmitter distortion.

Audio Flatness

Transmitter audio flatness is the change in modulation as the frequency of the microphone audio input signal is varied. For FM transmitters the change in modulation is measured with respect to the appropriate pre-emphasis characteristic. FM mobile transmitter flatness is normally measured (per EIA Standard RS-152B) by monitoring the audio input level required to produce 30% rated deviation as the audio source frequency is varied from 300 Hz to 3 kHz. This procedure is time consuming since it requires level adjustment at each frequency. The 8901A features a special de-emphasis mode called PRE-DISPLAY which greatly simplifies measuring FM flatness. PRE-DISPLAY mode positions the de-emphasis network before the modulation measurement detectors and the 8901A performs as a standard receiver for measuring flatness directly (Figure 2-2). Furthermore, in dB ratio mode the analyzer displays the response in dB relative to a desired reference rate (usually 1 kHz). The 8901A measures FM mobile transmitter audio flatness with the following procedure:

1. Press

   FM ● PEAK+ ●

2. Set the audio source to 1 kHz and adjust the level to produce 20% rated deviation.

   Note: 20% is used rather than 30% to avoid possible audio limiting problems near 3 kHz rates.

3. Press

   PRE-DISPLAY ● 750μs ● dB ●

4. Vary the audio frequency between 300 Hz and 3 kHz. The 8901A indicates the transmitter audio frequency response in dB.

Modulation Limiting

Modulation limiting is a measure of the ability of the audio limiters to prevent the transmitter from overmodulating and disrupting communication in nearby channels. Both instantaneous and steady state limiting are measurements of interest. The 8901A features a special detector mode called PEAK HOLD that greatly simplifies measuring instantaneous limiting. In PEAK HOLD mode the peak detector decay time constant is greatly increased and the display is updated only by larger measurement results. PEAK HOLD is usable with either the PEAK + or PEAK − detectors and in AM, FM,

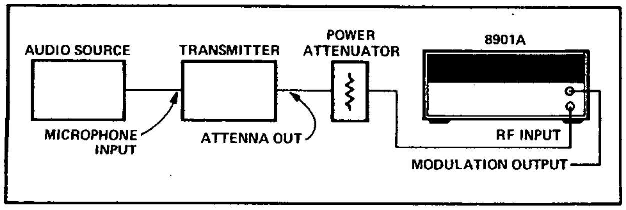


Figure 2-1. Transmitter test setup.

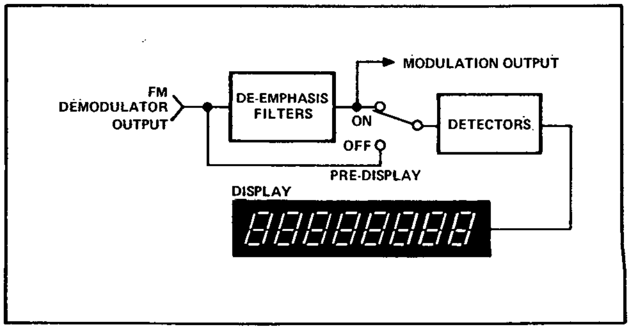
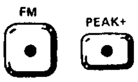


Figure 2-2. 8901A PRE-DISPLAY de-emphasis mode.

or ΦM mode. The 8901A measures instantaneous limiting of FM mobile transmitters with the following procedure:

1. Press



and adjust for standard test deviation.

2. Press

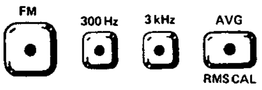
and suddenly increase and decrease the audio level 20 dB. Repeat the transient several times to ensure that the 8901A captures the largest transient. The display indicates the instantaneous limiting in kHz.

3. Steady state limiting can also be measured. With the audio level increased 20 dB press either PEAK + or PEAK −. This takes the 8901A out of PEAK HOLD mode.

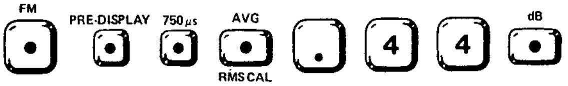
Before the 8901A, the most common method of measuring instantaneous modulation limiting was using a calibrated storage oscilloscope technique with a modulation meter demodulated output. The scope method takes longer to set up, provides limited accuracy, and cannot be automated.

Residual Modulation (Hum and Noise)

Residual modulation is a measure of the hum and noise of the unmodulated transmitter. The 8901A has an average responding detector that is helpful in making noise measurements. The AVG detector is average responding but rms sinewave calibrated. It is used when measuring residual modulation because average or rms reading of noise is more appropriate than peak measurements. Residual FM is often measured in a 300 Hz to 3 kHz bandwidth. To make this measurement the audio source is removed from the microphone input and the following keystrokes made:



The display indicates the residual FM. For FM mobile transmitters hum and noise is defined as the ratio of the output of a standard receiver with de-emphasis when the transmitter is modulated and unmodulated. Hum and noise is usually expressed in dB referenced to 3 kHz peak deviation. This can be displayed directly with the 8901A using the dB ratio mode. The 750 µs filter attenuates a 1 kHz signal by 13.66 dB (a factor of 0.2076). Also, since the average detector is used the rms value of the reference deviation is used. For standard modulation the ratio reference is 0.440 ($3.0 \times 1/\sqrt{2} \times 0.2076 = 0.440$) and the keystrokes are



The display now indicates FM hum and noise in dB relative to 3 kHz peak deviation. The 50 Hz high-pass filter is also recommended for this measurement. The 8901A residual FM is low enough (<8 Hz @ 1300 MHz in a 50 Hz to 3 kHz bandwidth decreasing linearly with RF frequency) that it can measure directly the hum and noise of most transmitters. Section 4 contains typical curves of the 8901A residual FM.

Automatic Transmitter Testing

The Modulation Analyzer is fully programmable and HP-IB operation is standard. All of the common tests just described (except distortion) can be automated with the Modulation Analyzer, a programmable audio source, desktop computer, and plotter (Figure 2-3). An example program using this equipment performs a comprehensive characterization of the transmitter automatically. Figure 2-4 shows a sample output. The program takes approximately 4 minutes to run—2½ minutes to label the titles and graphs, and 1½ minutes to perform the measurements. A listing and description of the program is included in section 6.

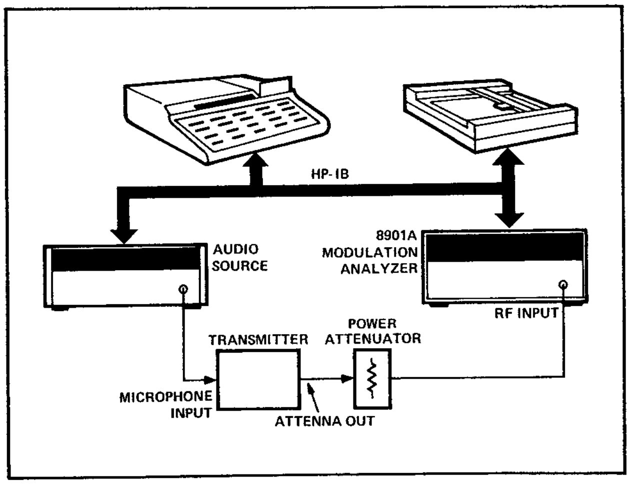
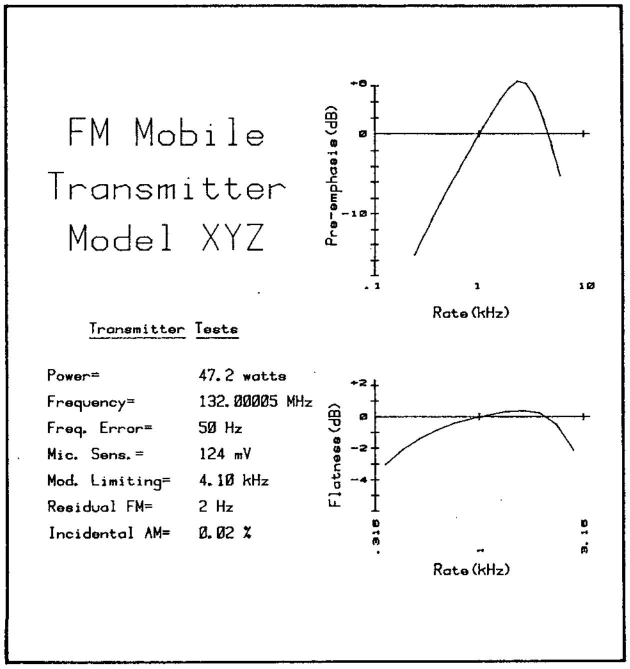


Figure 2-3. Automated FM transmitter testing

Signal Generator Calibration

Signal Generator calibration is another major application of the 8901A Modulation Analyzer. The 8901A is ideally suited for testing signal generators because it is the electrical dual of a signal generator; signal generators are calibrated transmitters and the Modulation Analyzer is a calibrated receiver. The outstanding accuracy and low noise of the 8901A enable it to test the modulation performance characteristics of the finest signal generators. This accuracy is easily verified with the optional calibrators which are essentially a secondary modulation standard. Because the 8901A makes modulation measurements directly it substantially reduces the amount of test equipment required to perform modulation calibration (Table 2-5). Calibration time is also significantly reduced because many adjustments on other instruments are eliminated. Table 2-6 compares the time required to calibrate the modulation of the HP 8640B Signal Generator with and without the 8901A. The test times listed include time to read, perform, and record the results for each procedure. Although the tests were performed on an 8640B Signal Generator, they are typical for many other signal generators. Using the 8901A the measurements are made six times faster than present techniques, saving over four hours. Also, to keep test times within reason, measurements made in the conventional way are often limited to only a few RF frequencies. In contrast, the 8901A in auto-track mode can continuously measure modulation as the generator under test is tuned through octave bands. Hence, tests made with the 8901A are much more thorough, yet they are performed in much less time. In summary, the 8901A is a valuable tool for anyone testing, repairing, or calibrating signal generators. The test procedures on pages 8 to 10 compare older methods and 8901A methods for several 8640B performance tests.



```
FM Mobile
Transmitter
Model XYZ

   Transmitter Tests

Power=            47.2 watts
Frequency=        132.00005 MHz
Freq. Error=      50 Hz
Mic. Sens.=       124 mV
Mod. Limiting=    4.10 kHz
Residual FM=      2 Hz
Incidental AM=    0.02 %
```

Figure 2-4. Example output of transmitter test program

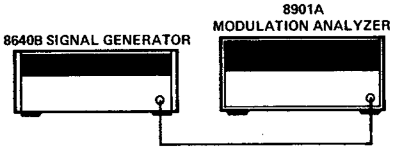
Table 2-5. 8640B Signal generator modulation calibration equipment comparison

With 8901A	Without 8901A
8901A Modulation Analyzer 3336A Audio Synthesizer Distortion Analyzer 11715A AM/FM Test Source 3455A Digital Voltmeter	8554B Spectrum Analyzer 8640B Reference Signal Generator 8405A Vector Voltmeter 5327C Frequency Counter 3310A Function Generator 180A Oscilloscope 331A Distortion Analyzer 3490A Digital Voltmeter 651A Test Oscillator 3400A Voltmeter 5210A Frequency Discriminator 465A Amplifier 355D Step Attenuator 8471A Crystal Detector 423A Crystal Detector Assorted filters, loads, and mixer

Table 2-6. 8640B Signal generator modulation calibration time comparison

Test	Test Time		Comments
	with 8901A	without 8901A	
AM Tests			
AM Accuracy	3	30	
Residual AM	2	15	
AM Distortion	5	15	Requires distortion analyzer.
AM Bandwidth	5	15	
AM Sensitivity	2	15	Requires audio synthesizer.
Incidental FM	2	90	
FM Tests			
FM Accuracy	3	30	
Residual FM	2	15	
FM Distortion	5	15	Requires distortion analyzer.
FM Bandwidth	10	30	Requires calibrating 8901A with the HP 11715A AM/FM Test Source and audio synthesizer if rates >200 kHz are tested.
FM Sensitivity	5	15	Requires audio synthesizer.
Incidental AM	2	15	
Total Time	46 min	5 hours	

AM Accuracy



TIME: 3 minutes with 8901A.

PROCEDURE: To measure indicated AM accuracy, connect the 8901A to the 8640B Signal Generator. Using the internal 8640B audio oscillator at 400 Hz and 1 kHz rates, set various AM depths on the 8640B meter and read accuracy on the 8901A by entering the same depth on the keyboard and pressing the % ratio key. For example, with the signal generator AM depth set to 30%, key in

AM			%
•	3	0	•

The 8901A now displays the accuracy in percent.

ADDITIONAL CAPABILITY

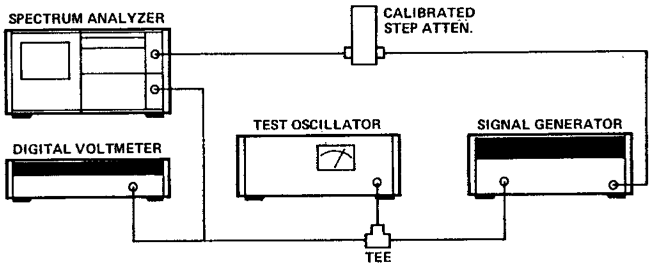
Variable RF Frequency Using Track Mode

Additional time: 3 minutes.

The 8901A can also measure modulation flatness (usually measured in dB) as RF frequency is continuously varied using track mode. Set the 8640 audio oscillator to 1 kHz or greater and key in

			SPCL	dB
4	.	1	•	•

Now vary the RF frequency. The 8901A tracks the changing RF signal and displays modulation sensitivity in dB as carrier frequency varies.



TIME: 30 minutes without 8901A.

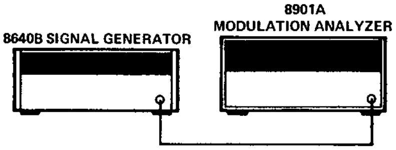
PROCEDURE: Connect the equipment as shown. Use the spectrum analyzer as a single-frequency receiver by adjusting the analyzer to zero frequency span, linear mode, and peaking the signal using the fine frequency tune. Next, calibrate the spectrum analyzer detector so that it can be used to measure AM depth. With the step attenuator set at 0 dB adjust the reference level until the vertical output is −500mV dc. Then set 20 dB of attenuation and measure the vertical output V_{dc}. Calculate the detector offset V_{off} using

$$V_{off(mV)} = \frac{V_{dc} + 50\,.}{0.9}$$

Reset the step attenuator to 0 dB and adjust the reference level to −282.8 mV + V_{off}. The detector is now calibrated and % AM depth is ½ the detector ac voltage in mV.

Note: The spectrum analyzer must be periodically readjusted because of drift.

FM Accuracy



TIME: 3 minutes with 8901A.

PROCEDURE: To measure indicated FM accuracy, connect the 8901A to the 8640B. Using the internal 8640B audio oscillator at 400 Hz and 1 kHz set various FM deviations. Check the 8640B meter accuracy with the 8901A by entering the same deviation on the 8901A keyboard and pressing the % ratio key. For example, adjust the FM deviation to 5 kHz using the 8640B meter and key in

FM ● 15 kHz ● PEAK+ ● 5 % ●

The 8901A now displays the accuracy in percent.

ADDITIONAL CAPABILITY

Variable Audio Rates

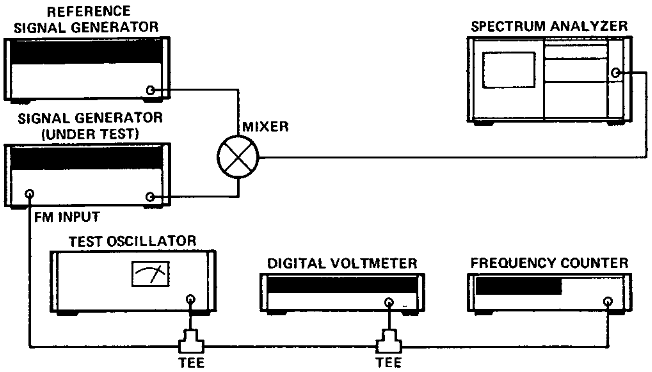
Additional time: 3 minutes.

This same test can be performed at any audio rate by simply changing the frequency of the 8640B internal audio oscillator or using an external source and the EXT FM mode.

Variable RF Frequency

Additional time: 3 minutes.

Using track mode, FM modulation flatness is also easily measured (same keystrokes as AM Accuracy).

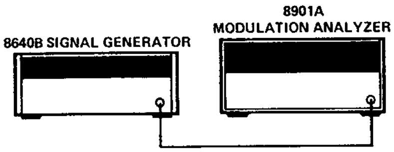


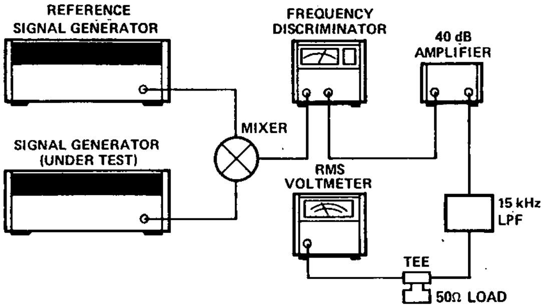
TIME: 30 minutes without 8901A.

PROCEDURE: The 8640B FM accuracy is measured using the carrier (Bessel) null technique. Apply an external 2.079 kHz signal to the FM input. Adjust the modulating signal amplitude for a first order carrier null. 5 kHz deviation is now set. Determine the panel meter accuracy by comparing the meter indication to the 5 kHz peak deviation. The reference generator and mixer convert the signal to the range of the spectrum analyzer. Test various carrier frequencies by re-setting both 8640Bs. This tests only one deviation (5 kHz) at one rate (2.079 kHz) and does not check at specified 400 Hz and 1 kHz rates.

Note: Measurement accuracy using the Bessel null technique is sensitive to incidental AM and FM distortion since either of these causes the null to shift and degrades accuracy.

Residual FM

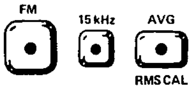




TIME: 2 minutes with 8901A.

20 Hz to 15 kHz Bandwidth

PROCEDURE: Connect the 8901A to the 8640B and set the 8640B AM off and FM to AC with the vernier fully clockwise. Measure residual FM by pressing



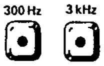
The display now indicates the residual FM.

ADDITIONAL CAPABILITY

300 Hz to 3 kHz Bandwidth

Additional time: 1 minute.

Residual FM for the 8640B is also specified for a measurement bandwidth of 300 Hz to 3 kHz. This measurement is accomplished with the 8901A by keying in



TIME: 15 minutes without 8901A.

20 Hz to 15 kHz Bandwidth

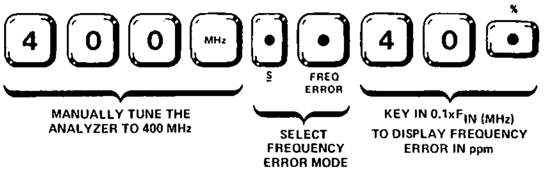
PROCEDURE: Connect the equipment as shown. Turn the 8640B AM off, FM to AC (vernier fully CW). Set the reference 8640B 100 kHz lower in frequency than the generator under test. Calibrate the frequency discriminator for 1 volt output for a full scale meter deflection. Measure residual FM using the RMS voltmeter (0.5mVrms/1 Hz residual FM).

Note: This procedure does not measure the 300 Hz to 3 kHz specification.

In addition to calibration of modulation the 8901A is also quite useful in checking proper operation of other generator parameters. Here are some examples.

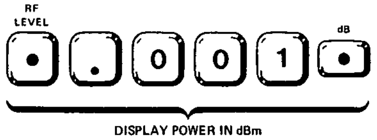
Frequency Accuracy

The 8901A measures and displays frequency or frequency error. Ratio mode along with FREQ ERROR mode allows frequency error to be displayed in parts per million (ppm). For example, if the signal generator is set to 400.0 MHz, press:



RF Level Functional Check

The signal generator output level can be checked from +30 dBm to −20 dBm using RF LEVEL mode as follows:



Typical accuracy is ± 1 dB (Figure 4-17, section 4). If the analyzer is manually tuned as above the RF level can be checked to −50 dBm using TUNED RF LEVEL mode with typical accuracy ± 2 dB (± 3 dB for frequencies >300 MHz).

General R&D Use

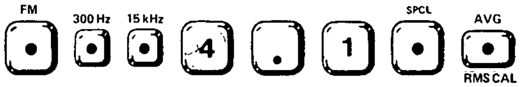
Since the 8901A is basically a calibrated receiver, another major application is general use as a bench instrument in RF design. Here are some examples.

Oscillator Characterization

Voltage-controlled oscillator (VCO) linearity is often measured by measuring frequency as dc input voltage is varied. The 8901A can be used in frequency mode along with a variable dc source to measure VCO linearity (Figure 2-5). Another common VCO measurement is differential nonlinearity. Differential nonlinearity is a plot of VCO modulation sensitivity (Δf/ΔV) as a function of control input voltage (V). This plot is the derivative of the VCO's linearity transfer characteristic. Since changes in the slope of the VCO transfer characteristic are readily apparent in a modulation sensitivity curve, the plot gives useful information concerning VCO linearity. Ideally, VCO modulation sensitivity is constant, resulting in a horizontal line when plotted over the frequency range of the VCO.

The 8901A has a special tuning mode called track mode that simplifies measuring modulation sensitivity. In track mode the 8901A tracks the changing VCO frequency while still measuring FM. The benefit is that the 8901A provides excellent modulation sensitivity over a wide range of input frequency. Previously FM discriminators were used in place of the 8901A. The VCO signal was then heterodyned to the operating frequency of the discriminator. Because of the narrow operating range of most discriminators, this technique required frequent readjustment. The 8901A measures modulation sensitivity as shown in Figure 2-5 as follows:

1. With the 8901A set to measure frequency, adjust the function generator dc off-set until the VCO is in the middle of the frequency range of interest.
2. Stimulate the VCO with a fixed-frequency sinewave (≈10 kHz) of small amplitude and put the 8901A in FM mode using the 300 Hz high-pass, 15 kHz low-pass filter, track mode, and the average detector by pressing



3. Establish a relative reference using either the % or dB ratio key.
4. Vary the dc offset until the VCO has covered the full frequency range of interest.

The 8901A displays the relative change in modulation sensitivity as the dc control voltage is varied. The recorder output on the rear can be used with an x-y recorder to produce a hard copy. The recorder output provides a dc voltage proportional to the peak demodulated voltage. Note that the recorder output does not give results in dB since the dB display is calculated in software.

A real time display of modulation sensitivity can also be obtained using the track mode of the 8901A. This real time linearity display capability permits oscillator designers to evaluate circuit changes quickly and accurately. The procedure is very similar to the previous one except that a second function generator is required. Adjust the dc offset of function generator #1 until the

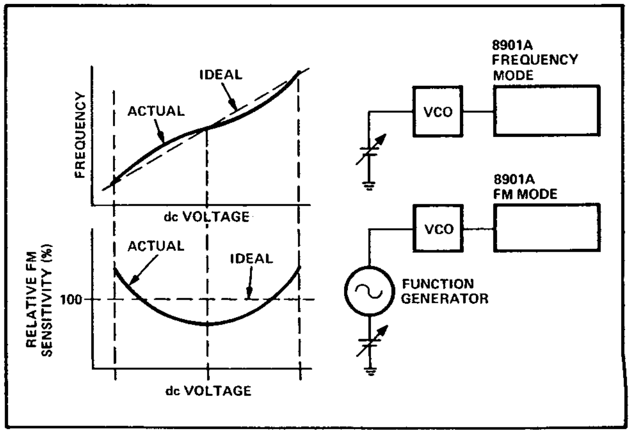


Figure 2-5. Voltage controlled oscillator characterization.

VCO frequency is in the middle of the frequency range of interest (Figure 2-6). Then set function generator #1 to a 1 Hz sinewave and adjust the amplitude for the desired VCO input voltage swing. Use this signal to calibrate the X input of the oscilloscope. Function generator #2 should be set to a 10 kHz sinewave. Adjust the amplitude to produce a reference FM deviation. Then, with the 8901A set up as before, gradually increase the frequency of generator #1 to about 50 Hz. For best results an oscilloscope with variable persistence is recommended. The 8901A can track continuously over octave bands. The band limits and other information regarding track mode are discussed further in section 4. The oscilloscope display in Figure 2-7 shows the FM modulation sensitivity of a VCO being swept from 265 to 285 MHz at a 50 Hz rate. The horizontal scale is 2 MHz/division and the vertical scale is 20 kHz/division.

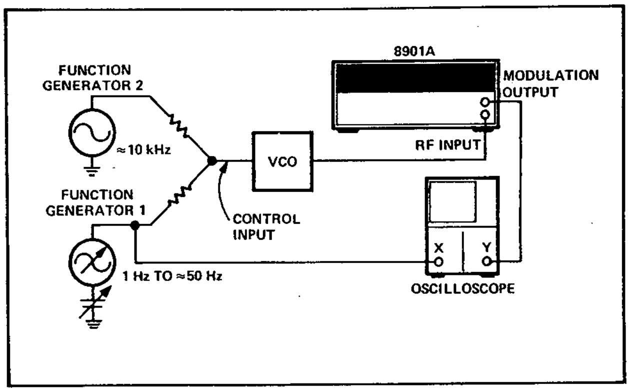


Figure 2-6. Equipment setup to measure real time VCO modulation sensitivity.

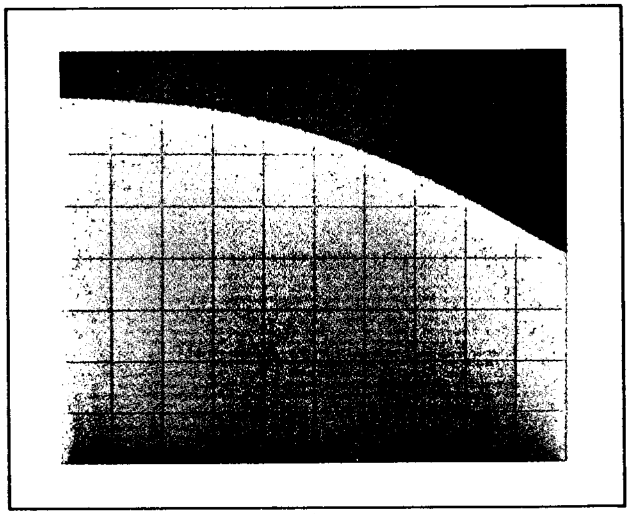


Figure 2-7. Real time display of modulation sensitivity.

Receiver Design

Another example of general purpose use of the 8901A is in the design of receivers. Because the Modulation Analyzer is a calibrated receiver it can simulate portions of prototype receivers. This is very useful in isolating problems. Take for example an FM receiver. If the audio output is distorted when an RF signal is applied at the antenna input, there is a question of which element may be causing the problem. The 8901A can monitor the signals at the points indicated by the arrows in Figure 2-8 to isolate the problem. At each point, the residual noise, AM content, FM content, signal level, and frequency is checked. Distortion can also be monitored with a distortion analyzer connected to the MODULATION OUTPUT. Thus, any element that causes AM to FM conversion, additional noise, or additional distortion is isolated.

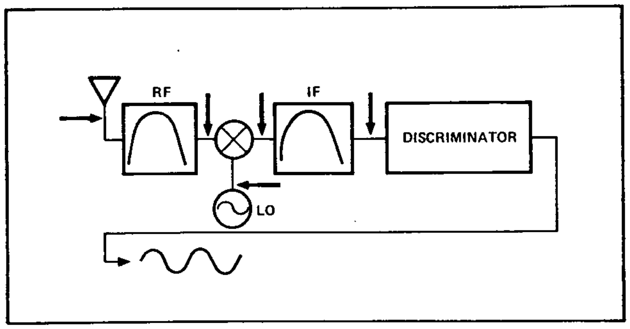


Figure 2-8. FM receiver design using the 8901A.

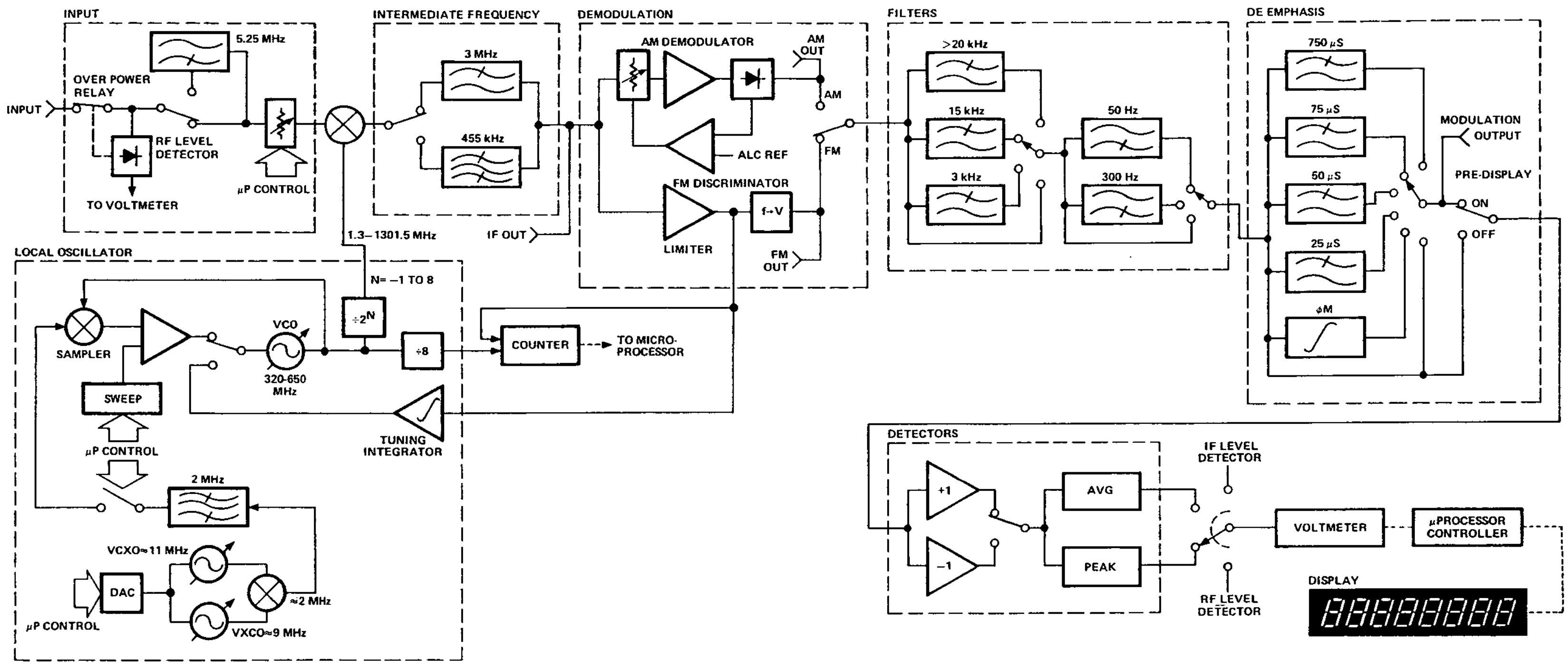
Extending the 8901A Frequency Range

The frequency range of the 8901A Modulation Analyzer is 150 kHz to 1300 MHz. This range can be extended higher using a spectrum analyzer as a fixed-tuned receiver and connecting the spectrum analyzer IF output to the Modulation Analyzer RF input. The spectrum analyzer should be in the linear detector mode and in zero span with a 3 MHz resolution bandwidth. This frequency translation technique permits the 8901A to make accurate modulation measurements on AM, FM, and ΦM signals above 1300 MHz. Because the 8901A has very low noise, the measurement of residual FM is usually limited by the phase noise characteristic of the spectrum analyzer local oscillators. Other performance such as incidental AM or FM measurements may also be affected.

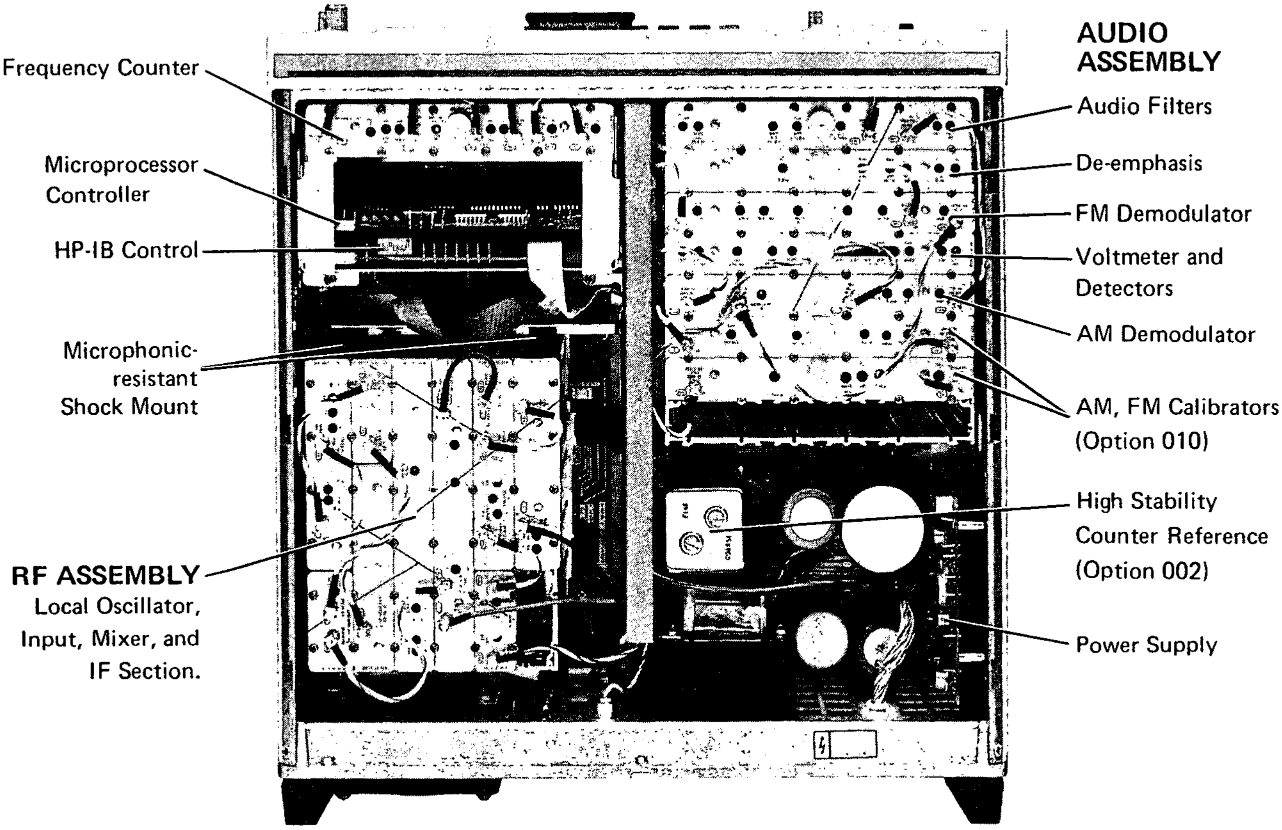
Another method of extending the frequency range is to use a mixer and local oscillator to down-convert the signal to be measured into the frequency range of the 8901A. The best performance results if the frequency input to the 8901A is between 10 MHz and 100 MHz.

8901A Block Diagram and Interior Layout ⇨

8901A Block Diagram



Interior Layout



3. Theory of Operation

The 8901A Modulation Analyzer is most easily visualized as a calibrated, superheterodyne receiver. Like a receiver, it converts the incoming signal to a fixed intermediate frequency (IF) which is then demodulated and appropriately filtered. However, unlike most receivers, the Modulation Analyzer has no tuned RF amplification and the recovered modulation is measured and displayed rather than applied to an audio amplifier and speaker. A discussion of the signal flow in the 8901A follows. (Refer to block diagram.)

Input

The signal at the RF input is sensed by the input diode detector. If the signal level exceeds one watt, the over-power relay opens immediately to protect the input circuits. For signal levels less than 1W the programmable attenuator sets the optimum level into the mixer. When RF level is being measured, the microprocessor determines the input power from the RF detector voltage and displays the result on the front panel. For signals above 10 MHz, the 5.25 MHz high-pass filter can be inserted to eliminate any extraneous signals, such as AM broadcast signals, that might otherwise pass through to the IF.

Intermediate Frequency (IF)

The mixer and local oscillator (LO) convert the signal to the intermediate frequency (IF). The IF is normally 1.5 MHz for signals above 10 MHz and 455 kHz for signals between 2.5 and 10 MHz, but the user has the option of selecting the 455 kHz IF above 10 MHz. Selecting the 455 kHz IF increases selectivity but modulation rates and FM deviations are restricted. For signals below 2.5 MHz the input passes directly through the mixer without frequency conversion. The IF level is detected to make sure there is sufficient signal for the modulation measurement selected. The IF detector is also used for making tuned RF level measurements and for automatic tuning. The IF signal is buffered and available at a connector on the back panel.

AM and FM Demodulators

The AM demodulator detects the instantaneous amplitude of the IF signal and separates the detected signal into its ac and dc components. The dc component controls an ALC amplifier preceding the AM detector to maintain a constant average signal level to the detector. The ac component is the recovered amplitude modulation.

The first stage of the FM demodulator is the limiter which amplifies and limits the IF signal, removing any AM. The FM discriminator demodulates all angle modulation. Phase modulation is recovered by integrating the demodulated FM in the audio circuitry.

The limiter output can be counted by the internal counter to measure the IF frequency. In frequency mode the analyzer measures the input signal frequency by counting the LO and IF and displaying the difference between the two. Because of the large limiter gain it is possible to measure the frequency of very low-level input signals.

Audio Filters

The post-detection bandwidth of the recovered modulation is determined by the high-pass and low-pass filters. These audio filters are independently selectable.

De-emphasis

After filtering, the modulation signal passes through the de-emphasis block. This block is by-passed for AM signals. ΦM is recovered by integrating the signal from the FM discriminator. For FM signals, either no de-emphasis or any one of four standard networks may be selected. These are single-pole, low-pass filters that attenuate high modulation rates. The de-emphasized modulation is available at the front panel MODULATION OUTPUT. With PRE-DISPLAY mode off, the analyzer measures and displays absolute FM deviation. With PRE-DISPLAY on, the deviation displayed is scaled by one of the de-emphasis filters to simulate the audio output of an FM receiver.

Detectors

After de-emphasis the modulation signal passes through an inverting or non-inverting amplifier and is converted to a dc level by either the average or peak detector. The amplifiers allow the peak detector to measure either the positive or negative peak of the modulation waveform. The dc voltmeter measures the output from whichever detector is selected and the front panel displays the corresponding modulation. In PEAK HOLD mode the peak detector decay time constant is greatly increased and the front panel reading is updated only in the upwards direction.

Local Oscillator

The local oscillator (LO) mixes with the input signal and converts it to the IF. The 8901A has three modes for tuning the LO frequency: manual keyboard entry, automatic track tuning, and automatic low-noise tuning. In manual mode the microprocessor adjusts the LO 1.5 MHz higher than the entered frequency (455 kHz for frequencies <10 MHz). Because the 8901A employs fundamental mixing, the receive frequency is settable over the full frequency range of 150 kHz to 1300 MHz. In automatic track mode the analyzer frequency locks to the input signal. The LO tracks as the input signal frequency varies to maintain a constant IF. Normal operation uses the automatic low-noise tuning mode which phase locks the LO to a low noise, voltage-controlled crystal oscillator (VCXO). For both automatic modes the 8901A tunes to the input signal if the second and third harmonics are <−10 dBc, all other signals are <−30 dBc, and AM and FM are within specified limits. Track mode is discussed further in section 4. A discussion of automatic low noise tuning follows.

Automatic tuning is a two step process. First the input signal frequency is determined. Then the microprocessor adjusts the VCXO's and the 320-651 MHz VCO is phase-locked to the VCXO's. The 8901A searches for the input signal by sweeping the LO downward from 1301.5 MHz in octaves until a signal is detected in the IF. Then the LO is moved to check whether the signal is a second or third harmonic. Next the LO and IF are counted to determine the input signal frequency. Then the microprocessor tunes the 320-651 MHz VCO close to the desired frequency. The 320-651 MHz VCO is then phaselocked to a harmonic of the 2 MHz signal from the VCXO's and the divide number of the LO output is set. The microprocessor fine tunes the VCXO's to achieve the correct LO frequency. The result is a stable, low noise, LO signal for down-converting the input signal.

The low noise of the 2 MHz signal used to phase-lock the VCO is achieved by using two VCXO's which tune in opposite directions as the control voltage varies. This method allows the use of high Q oscillators with limited tuning ranges. The result is a spectrally pure 2 MHz signal of higher quality than would be possible using a single 2 MHz VCXO.

4. Performance and Operation

Frequency Measurement

The 8901A measures input frequency automatically from 150 kHz to 1300 MHz for levels between 22mVrms and 7Vrms (12mVrms to 7Vrms for input frequencies <650 MHz). The internal configuration of the Modulation Analyzer in frequency mode is shown in Figure 4-1. The input frequency is measured by first counting the local oscillator and then the IF frequency. The input frequency F_{in} is calculated by $F_{in} = F_{lo} - F_{if}$. The accuracy is equal to the reference accuracy ± 3 counts. (Reference aging is $<1 \times 10^{-6}$/month, $<1 \times 10^{-9}$/day optional.)

In automatic mode the count time of the LO and the display resolution are adjusted by the microprocessor to produce approximately 3.6 readings/second. Resolution is 10 Hz for $F_{in} \leqslant 18.5$ MHz, 100 Hz for $F_{in} \leqslant 325$ MHz, and 1 kHz for $F_{in} > 325$ MHz. Special function 7.1 provides increased resolution of 10 Hz for $F_{in} < 1000$ MHz and 100 Hz for $F_{in} \geqslant 1000$ MHz. Sometimes decreased resolution is desired when digit flickering becomes annoying and fine resolution is not important. Special function 7.2 sets the display resolution to 1 kHz for all input frequencies. Table 4-1 summarizes these resolution modes.

Example: To obtain maximum resolution when counting a 500 MHz signal, execute the following keystrokes:

FREQ SPCL

[•] [7] [.] [1] [•]

Example: To return the 8901A to auto resolution mode clear the 7.1 special function by pressing either the green AUTOMATIC OPERATION key or executing

SPCL

[7] [.] [0] [•]

High Sensitivity (0.22 mV) Count Mode

Keying in the approximate frequency of the desired signal (within ± 50 kHz) manually tunes the 8901A and improves the counter sensitivity. If error E01 (signal out of IF range) is disabled with the 8.1 special function the frequency may be entered within ± 1 MHz of the desired signal. In this mode the Modulation Analyzer typically counts signals over a 90 dB dynamic range from 0.22 mVrms to 7Vrms (−60 to +30 dBm). The high sensitivity

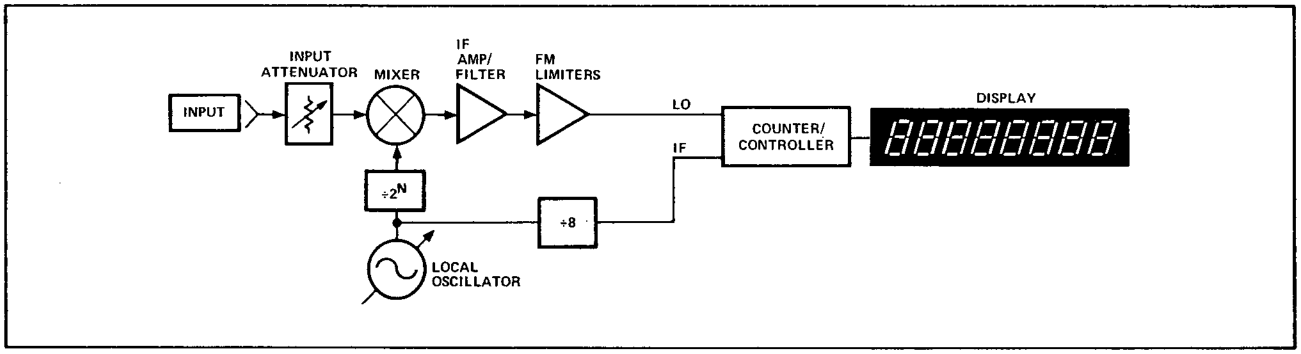


Figure 4-1. Input frequency measurement block diagram.

Table 4-1. 8901A frequency resolution modes.

Mode	Special Function	Resolution	Readings/ Second*
Auto	7.0	10 Hz, F_{in} <18.5 MHz 100 Hz, F_{in} <325 MHz 1 kHz, F_{in} >325 MHz	>3.6 >3.6 >3.6
High Resolution	7.1	10 Hz, F_{in} <1000 MHz 100 Hz, F_{in} >1000 MHz	>1 ⩽1
Low Resolution	7.2	1 kHz, for all F_{in}	⩾5

* The first reading may take up to 2 seconds (typically 1.3) because the 8901A must tune to the input signal.

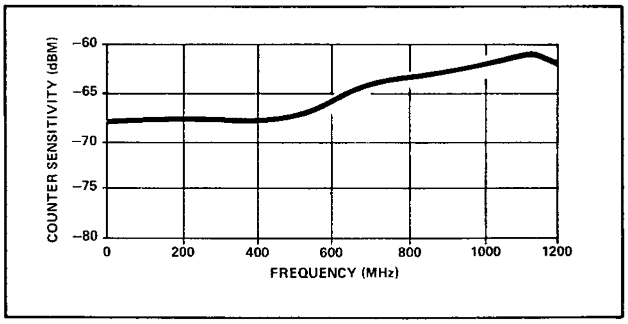


Figure 4-2. Typical 8901A counter sensitivity when manually tuned.

is due to the large IF gain, and the wide dynamic range results from 50 dB of attenuation automatically adjusted by the microprocessor. If the input signal level is too low to count the 8901A displays a single zero. Figure 4-2 shows typical performance in the high sensitivity count mode.

Example: To count a 0.5 mV signal near 450.52 MHz, key in

FREQ

[•] [4] [5] [0] [.] [5] [MHz]

Note: It is only necessary to set the frequency within 50 kHz. Automatic operation is resumed by pressing the green AUTOMATIC OPERATION key.

Amplitude Modulation Measurement

In AM mode the 8901A automatically measures percent depth with accuracy of 1% of reading ± 1 count to depths up to 99%. The internal configuration of the Modulation Analyzer in AM mode is shown in Figure 4-3. The analyzer measures AM as the ratio of the demodulated audio signal level to the average tuned carrier level. The ALC loop within the demodulator holds the carrier level E_{avg} constant so that the percent AM is proportional to the amplitude of demodulated audio output. This output is filtered, detected, and displayed as % AM. The 8901A measures E_{max} or E_{min} depending on whether the PEAK+ or PEAK− detector is selected (Figure 4-4). The peak positive m+ or negative m− percent AM is then computed and displayed using the formulas in Table 4-2.

When the AVG detector is selected, the demodulated audio signal amplitude V_{rms} is measured with an average responding detector that is rms calibrated for a sinewave. The percent AM displayed is computed using the formula in Table 4-2. Notice that for a sinusoidal modulation

Table 4-2. Internal 8901A amplitude modulation formulas.

Detector	Percent Modulation Formula
PEAK +	$m_+ = \frac{E_{max} - E_{avg}}{E_{avg}} \times 100$
PEAK −	$m_- = \frac{E_{avg} - E_{min}}{E_{avg}} \times 100$
AVG	$m = \frac{V_{rms}}{E_{avg}} \times 100$

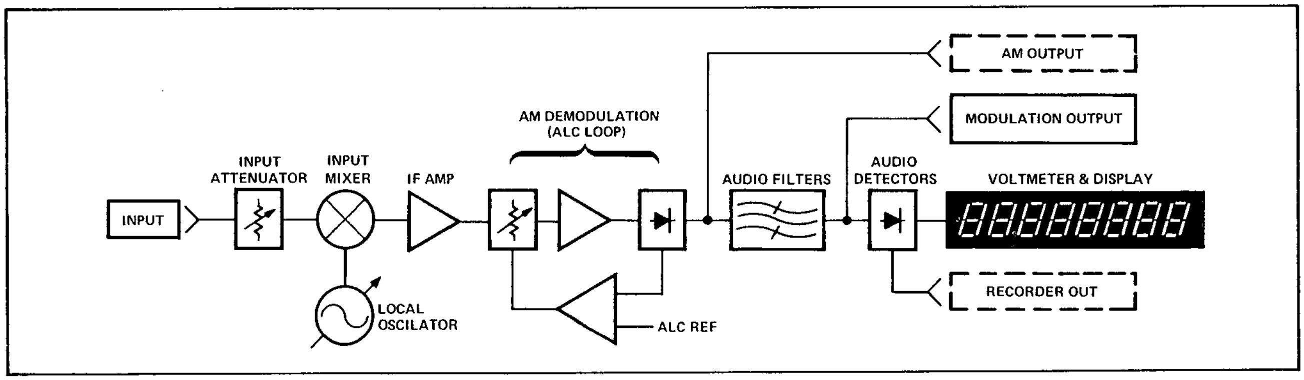


Figure 4-3. AM measurement block diagram.

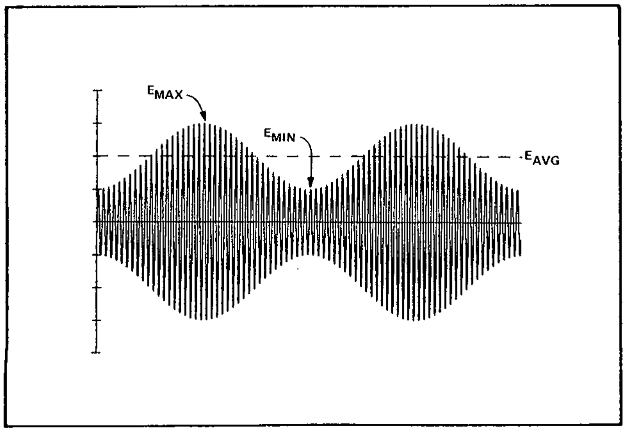


Figure 4-4. RF carrier modulated with 50% AM.

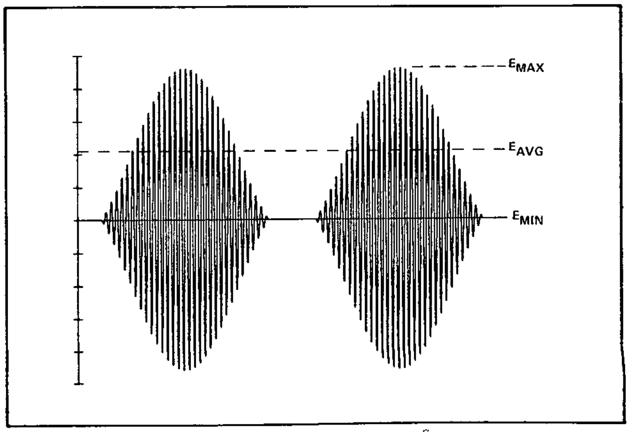


Figure 4-5. RF carrier modulated with 130% AM.

signal the percent AM displayed using the PEAK detector is 1.41 times that using the AVG detector since $E_{max} - E_{avg} = \sqrt{2}\, V_{rms}$.

Measuring AM Depths Greater than 100%

Often it is desired to measure percent AM for depths greater than 100%. Peak positive depths greater than 100% occur whenever the peak E_{max} is greater than twice the average level E_{avg} (Figure 4-5). The 8901A measures peak positive AM depth to greater than 300% with typical accuracy better than 3% of reading.

For AM depths greater than 100% the RF carrier may be pinched off for a portion of the negative half cycle of the modulating waveform. The theoretical limit from Table 4-2 for negative AM depth, m–, is 100 because $E_{min} = 0$ when the carrier is pinched off. The 8901A displays very close to 100 with the PEAK– detector selected. The Modulation Analyzer may lose "lock" on the input signal in automatic operation because the carrier level is pinched off. Fortunately, this problem is easily overcome using the manual tune mode by pressing the MHz key while the analyzer is properly tuned to the input signal. If the 8901A is not already tuned to the input signal, key in the frequency of the input signal. For example, if the frequency is 30.1 MHz the keystrokes required are

3 0 . 1 MHz

It may also be necessary to override errors with

SPCL
8 . 7 •

AM Flatness

AM flatness is very important in testing instrument landing system (ILS) transmitters. Figure 4-6 shows the typical AM flatness for low modulation rates. Between 90 Hz and 150 Hz rates the variation in flatness is typically better than 0.03%. For best flatness and repeatability it's helpful to average 10 readings. The slow peak detector time constant (special function 5.1) is also recommended.

Frequency Modulation Measurement

In FM mode the 8901A automatically measures the deviation to 1% accuracy for rates 20 Hz to 100 kHz. Figure 4-7 shows the internal configuration of the 8901A in FM mode. The analyzer displays the peak deviation from the average carrier frequency in kHz. The peak detectors allow either the positive or negative peak deviation to be measured.

Carrier Shift

When the modulating signal applied to an FM transmitter contains a non-zero dc component it causes a shift in the average carrier frequency. Carrier shift can be measured with the 8901A by measuring the transmitter frequency with and without the modulation signal applied. The difference represents the frequency shift from the unmodulated carrier. Another way to measure carrier shift is to manually enter the unmodulated carrier frequency. Then the 8901A displays the carrier shift of the modulated signal in frequency error mode. This difference can also be added to the peak deviation displayed to obtain the peak frequency deviation from the unmodulated carrier.

Residual FM

Low residual FM is one of the key contributions of the 8901A. Figures 4-8 and 4-9 show the residual FM of the 8901A for various post detection bandwidths. Note that the residual FM is significantly reduced when the 15 kHz

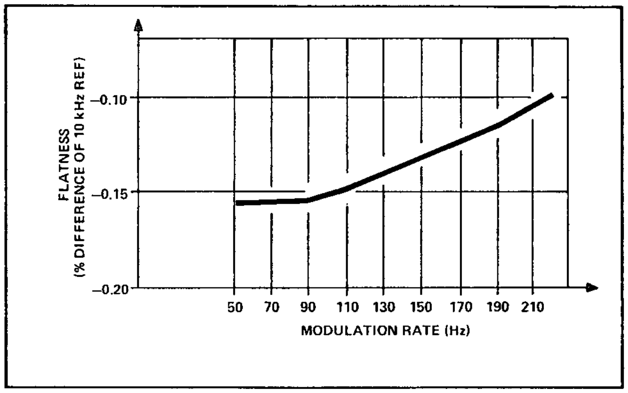


Figure 4-6. Typical AM flatness when averaging 10 readings (20 to 80% AM depth).

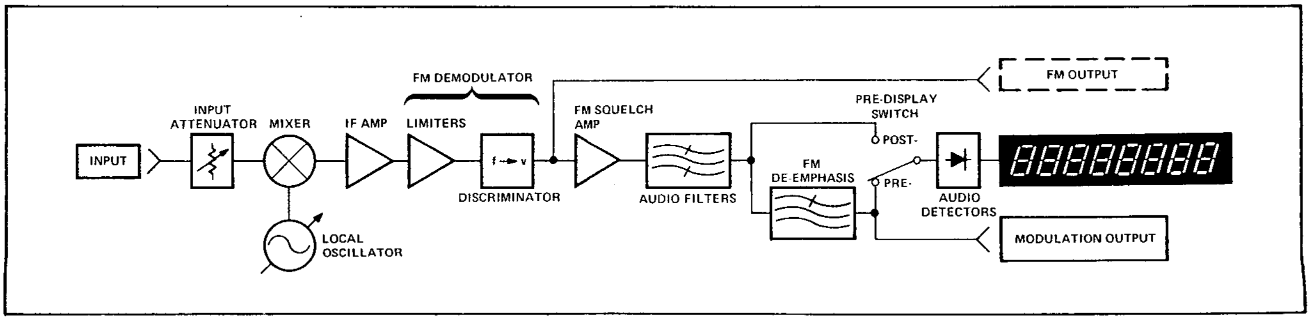


Figure 4-7. FM measurement block diagram.

and 3 kHz low-pass filters are used to restrict the measurement bandwidth. High-pass filters have little effect on the internal 8901A residual FM. The average responding detector (rms sinewave calibrated) is used to obtain the data in Figure 4-8 because the rms value of the residual noise is generally more desirable than the peak value.

For mobile transmitters residual FM is often expressed as hum and noise referred to a 1 kHz rate and a 3 kHz peak deviation. Figure 4-10 shows the typical 8901A hum and noise. The analyzer settings were FM mode, 750 μs pre-display de-emphasis, average detector, and dB ratio mode with a ratio reference of 0.440 (section 2 describes how to make hum and noise measurements in greater detail). Best hum and noise performance is achieved using the 50 Hz high-pass filter. For best hum and noise performance for high frequencies, the HP 8662A Synthesized Signal Generator can be used as a local oscillator.

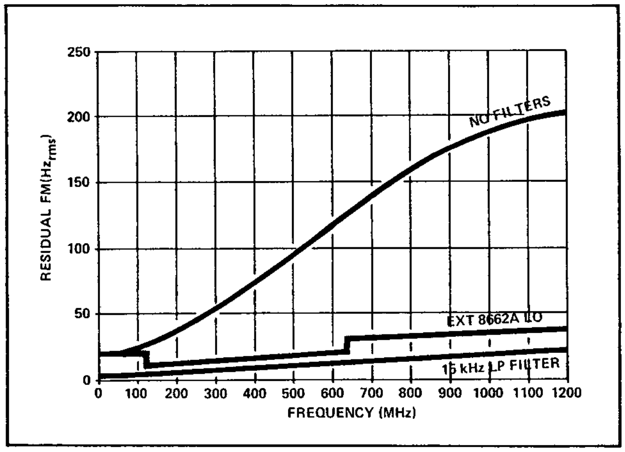


Figure 4-8. Typical 8901A residual FM.

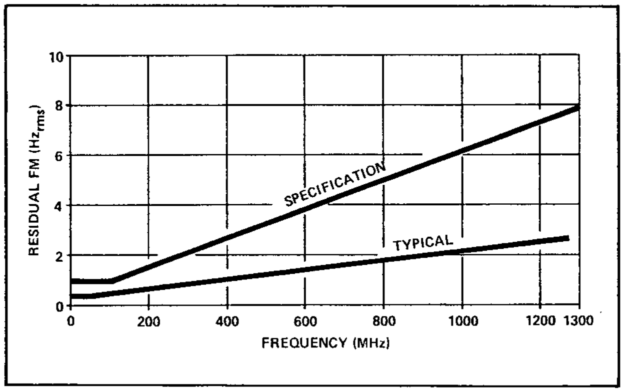


Figure 4-9. 8901A residual FM (50 Hz to 3 kHz BW).

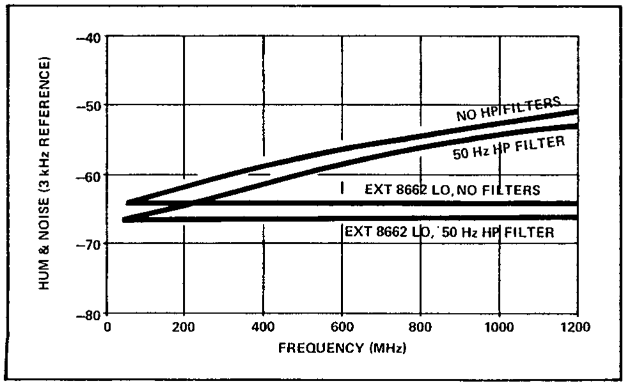


Figure 4-10. Typical 8901A hum & noise (750 μs pre-display mode).

Frequency-Shift Keying

Frequency-shift keying (FSK) is a popular digital modulation format used with FM transmitters. The 8901A contains a special post detection filter for accurately measuring FSK modulation. The >20 kHz filter is a nine pole Bessel low-pass filter. It minimizes overshoot on squarewave modulation typically to less than 1%.

Figure 4-11 is an oscillograph of the 8901A MODULATION OUTPUT for an RF test signal modulated by a 10 kHz squarewave to 5.0 kHz peak deviation. The ringing is due to the audio circuitry of the 8901A. The peak detector catches the peak of the ringing and indicates 6.61 kHz peak deviation. In Figure 4-12 the ringing is eliminated using the >20 kHz low-pass filter and the 8901A indicates the peak deviation correctly as 5.0 kHz.

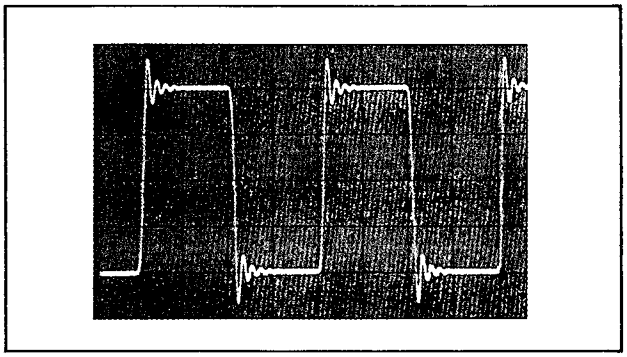


Figure 4-11. Demodulated 10 kHz FSK signal without >20 kHz low pass filter.

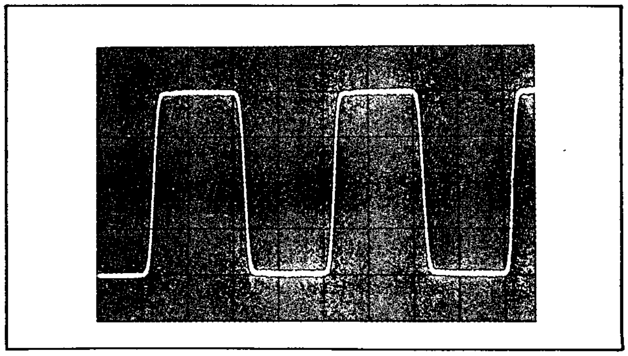


Figure 4-12. Demodulated 10 kHz FSK signal with >20 kHz low pass filter.

Stereo Separation

The 8901A accurately recovers FM stereo modulation for making measurements such as stereo separation (Figure 4-13). The left and right channels of stereo FM broadcast signals can be obtained by connecting a stereo decoder to the modulation output. Figure 4-14 shows typical 8901A stereo separation as audio rate is varied.

Accounting for Peak Residuals

To realize the maximum accuracy of the 8901A when making peak modulation measurements it is necessary to account for peak noise residuals. With the input RF signal modulated the 8901A measures the peak of the signal plus noise $(S + N)_{pk}$. The noise peak N_{pk} is measured by turning off the modulating signal to the signal generator or transmitter under test. Unfortunately, the true peak S_{pk} cannot be computed directly by subtracting N_{pk} from $(S + N)_{pk}$. The effect of the noise contribution N_{pk} on the total signal $(S + N)_{pk}$ measured by the peak detector varies with the waveform shape and signal-to-noise ratio $(S + N)_{pk}/N_{pk}$ of the modulating signal. For the special case of the calibrator output, the 8901A automatically compensates for the peak residual and the weighted residual peak modulation can be displayed using the 12.1 or 13.1 special functions for FM or AM. This is not possible for other input signals since the modulating waveform is arbitrary.

For sinusoidal modulation the nomograph in Figure 4-15 can be used to subtract the appropriate percentage of noise N_{pk} to obtain the true peak of S_{pk}. The following procedure and example illustrate the use of the nomograph.

1. Set up the measurement and read the $(S + N)_{pk}$ from the display. This may be noisy so gauge the correct reading visually. If any low pass filters are on, leave them on for the remainder of this procedure.
2. Freeze the modulation range using the 9.0 special function.
3. Turn off the modulating signal and measure the average noise N_{avg} using the average detector.
4. Measure the peak noise N_{pk} with the peak detector.
5. Compute $(S + N)_{pk}/N_{pk}$ and N_{pk}/N_{avg} and use the nomograph to calculate the percentage, N%, of N_{pk} to subtract from $(S + N)_{pk}$.
6. Compute the true peak, S_{pk}, using the formula

$$S_{pk} = (S + N)_{pk} - (N\%)(N_{pk})$$

Example: The following example shows how the procedure might be used to precisely measure AM depth of a signal generator set to 30% AM.

1. The peak modulation using the 15 kHz low pass filter is measured.

AM ● 15 kHz ● PEAK– ●

Result: 30.15%

2. The modulation range is frozen by pressing

9 . 0 SPCL ●

3. The modulation is turned off and the noise is measured:

AVG ● RMS CAL

Result: 0.02%

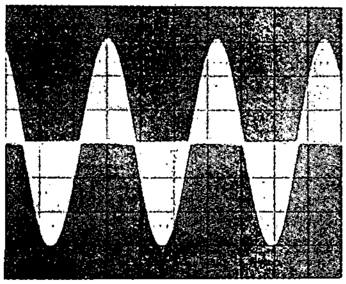


Figure 4-13. Demodulated 15 kHz FM stereo test signal.

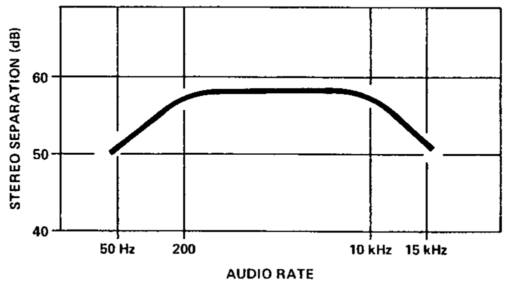


Figure 4-14. Typical 8901A stereo separation.

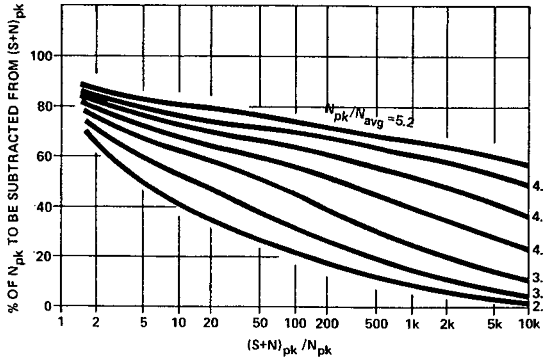


Figure 4-15. Nomograph for N% to calculate the true peak S_{pk}.

4. To simplify computing the ratio N_{pk}/N_{avg}, ratio mode is used:

Result: 300%

N_{pk}/N_{avg} is 3.

5. The noise peak N_{pk} is measured:

Result: 0.06%

6. $\frac{(S+N)_{pk}}{N_{pk}}$ is computed to be 502.5 since

$$\left(\frac{30.15}{0.06}\right) = 502.5$$

and the percentage N% to be subtracted from N_{pk} is obtained from the nomograph (Figure 4-15).

Result: N% = 15%

7. Therefore, the true peak is 30.14%, not 30.15%.

$$= 30.15 - (0.15)(0.06)$$
$$= 30.14$$

RF Level Measurement

The 8901A measures peak broadband RF power over the range 0 to +30 dBm (1 mW to 1W). The internal configuration of the Modulation Analyzer in RF LEVEL mode is shown in Figure 4-16. A diode detector senses the broadband RF power at the input. The internal voltmeter measures the detector output and the microprocessor converts the result to watts. Since the diode is a peak detector, the 8901A measures peak envelope power (PEP) and may be used to measure single sideband transmitter power. A plot of typical level accuracy as a function of RF input frequency is shown in Figure 4-17.

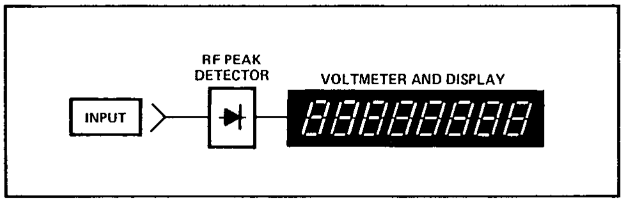


Figure 4-16. RF level measurement block diagram.

Reverse Power Protection

Since the 8901A is often connected to transmitters either directly or through an attenuator, the possibility of accidental application of too much power is quite real. To guard against damage to the 8901A a diode detector continuously monitors input signal levels. If the input level exceeds 1 watt (+30 dBm) the power protect relay automatically opens. The input protection is conservatively rated at 25 watts; however, the relay typically withstands overloads up to 100 watts. When an input overload occurs the display indicates the error message "EO6". Normal instrument operation resumes after any key is pressed and the overload condition is no longer present. In remote operation the analyzer requests service if desired. The remote operation section contains an example which illustrates recovering from errors in the event of an overload condition.

Tuned RF Level Measurement

In the TUNED RF LEVEL mode the Modulation Analyzer measures the peak RF level in the IF section for RF input levels in the range 10 nW to 1 W (−50 to +30 dBm). The internal configuration in TUNED RF LEVEL mode is shown in Figure 4-18.

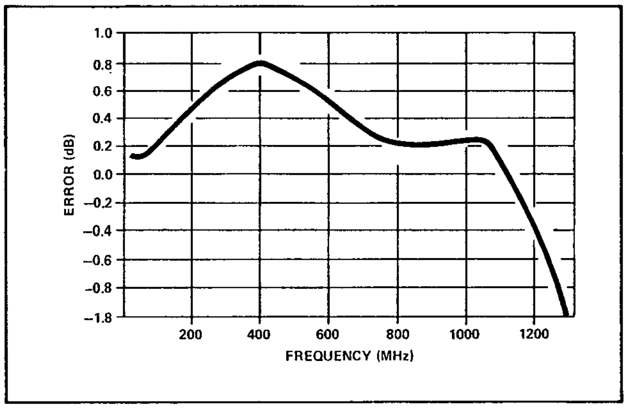


Figure 4-17. Typical 8901A RF level accuracy.

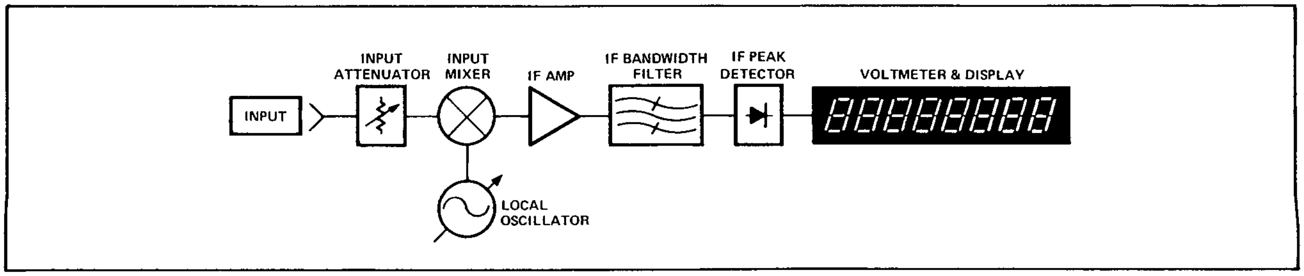


Figure 4-18. Tuned RF level measurement block diagram.

The measurement bandwidth is determined by the IF filter bandwidth. Either the 455 kHz filter or the 1.5 MHz filter may be selected using special functions 3.1 or 3.2, respectively. Figure 4-19 shows the portion of the spectrum to which the 8901A responds for each of the two possible IF bandwidths. Note that since the 8901A doesn't have tuned RF amplification, no image rejection is provided. However, many useful selective RF level measurements can be made in the presence of other undesired signals. In particular, for signals separated by more than 200 kHz, RF level can often be measured independently using the 455 kHz IF filter.

Measuring Carrier Harmonics

Tuned RF level mode is most useful in making relative power measurements. Typically, the 8901A can measure carrier harmonics to −50 dBc or a minimum absolute level of −50 dBm, with ± 2 dB accuracy (± 3 dB for frequencies >300 MHz).

Example: Measure the 2nd harmonic of a 100 MHz transmitter (or signal generator at 100 MHz, +10 dBm). Execute the following:

1. Select TUNED RF LEVEL mode.

   • •
   S TUNED RF LEVEL

2. Select 455 kHz IF.

   SPCL
   3 . 1 •

3. Disable automatic error display.

   SPCL
   8 . 7 •

4. Manually tune the analyzer to the transmitter frequency.

   1 0 0 MHz

5. Manually tune the analyzer 100 kHz lower. This positions the signal at the 3 dB point of the 455 kHz IF filter and minimizes the effect of local oscillator related spurious products in the IF.

   1 0 0 ⇩ MHz

6. Establish the carrier reference. The display now reads 0.00.

   dB
   •

7. Tune 100 kHz below the second harmonic. Note that the increment value need not be repeated because it remains constant until changed.

   2 0 0 MHz ⇩

   The display now indicates the 2nd harmonic level in dBc.

IF Level Mode

In IF level mode, the 8901A monitors the dc output of the AM detector after the automatic gain control amplifier (AGC) and displays it as a percent of the optimum level (Figure 4-20). Normally, in automatic operation the analyzer displays either 100%, indicating sufficient signal strength to guarantee accurate

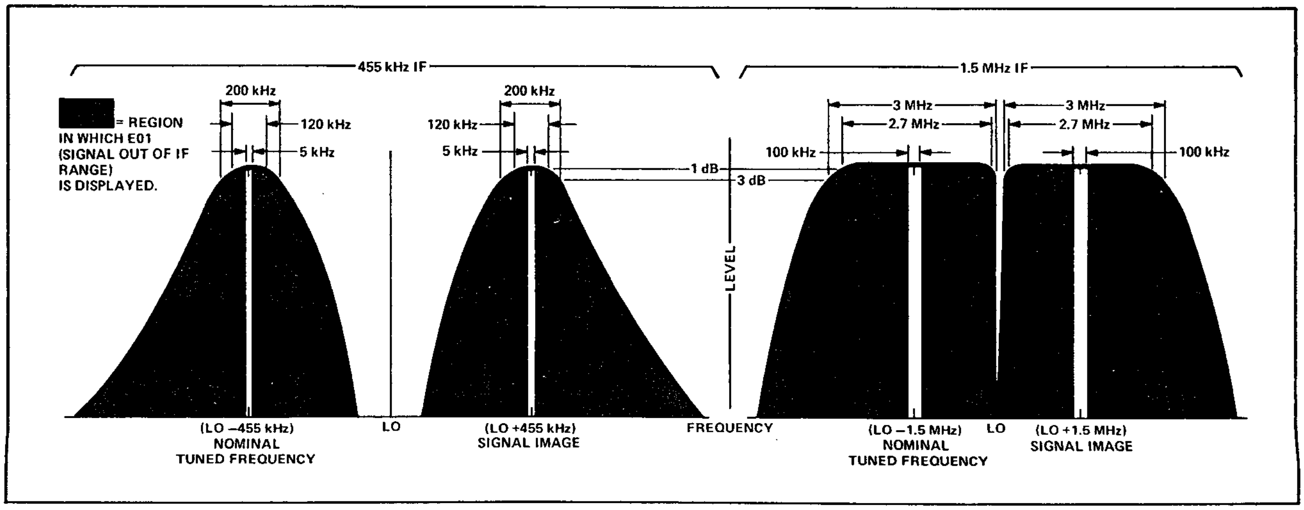


Figure 4-19. Typical 8901A IF bandwidth characteristics.

modulation measurements, or two dashes indicating that the analyzer cannot automatically tune to the input signal. However, if the analyzer is manually tuned the IF level can drop below 100%. A display of less than 100% means that the AGC amplifier has reached maximum gain (about 14 dB) and it still cannot provide the optimum signal level.

High Sensitivity FM Measurements

Certain applications such as off-the-air FM monitoring, require higher sensitivity than the −25 dBm the 8901A provides in automatic operation. For these applications meaningful FM measurements to −50 dBm are possible by manually tuning the 8901A and disabling error E03 (input circuits underdriven) with the 8.2 special function. The IF level can be used as a figure of merit for judging the validity of these measurements.

High Sensitivity AM Measurements

AM measurements can also be made to approximately −40 dBm. However, because AM measurements are proportional to (IF Level %)/100, the AM displayed changes as the IF level drops below 100%. The following procedure corrects for this:

1. Manually tune the 8901A to the desired frequency. For example, if the frequency is 35.3 MHz, the keystrokes are

3 5 . 3 MHz

2. Disable error E03 with

SPCL
8 . 2 •

3. Measure the IF level and establish a ratio reference by keying

%
• • •
S IF LEVEL

4. Select AM mode and scale measurements by the IF level reference.

AM SPCL
• 1 1 . •

The 11. special function re-enters % RATIO mode with the previous reference. This is necessary because RATIO is disabled when the measurement mode changes from IF Level to AM. The analyzer now displays AM depth correctly in percent. This procedure must be repeated if the input level changes.

AM Measurements Relative to the Unmodulated Carrier

The IF level mode may also be used with the AGC disabled to make AM measurements relative to the unmodulated carrier. The procedure is:

1. With the carrier unmodulated disable the AGC and establish an IF level reference

SPCL %
• • 6 . 2 • •
S IF LEVEL

2. Turn on the amplitude modulation and key in

AM SPCL
• 1 1 . •

The analyzer now displays AM depth in percent relative to the unmodulated carrier. This procedure must be repeated if the input level changes because the AGC leveling is defeated.

Track Mode

Track mode is enabled using the 4.1 special function. In this mode the 8901A automatically tunes to the input signal. However, it does not lock to the voltage controlled crystal oscillators (VCXOs) as in automatic operation. Instead it frequently locks to the input signal as shown in Figure 4-21. The FM discriminator output is used as an error signal to adjust the local oscillator frequency. Thus, the 8901A stays tuned as the input signal frequency varies.

Track mode is useful in applications where the input frequency is changing. One application is measuring modulation flatness of signal generators as center frequency is varied. Another application is measuring modulation sensitivity (linearity) of voltage-controlled oscillators (VCOs). A small amplitude sinewave (≈10 kHz) is combined with a low frequency sinewave (<60

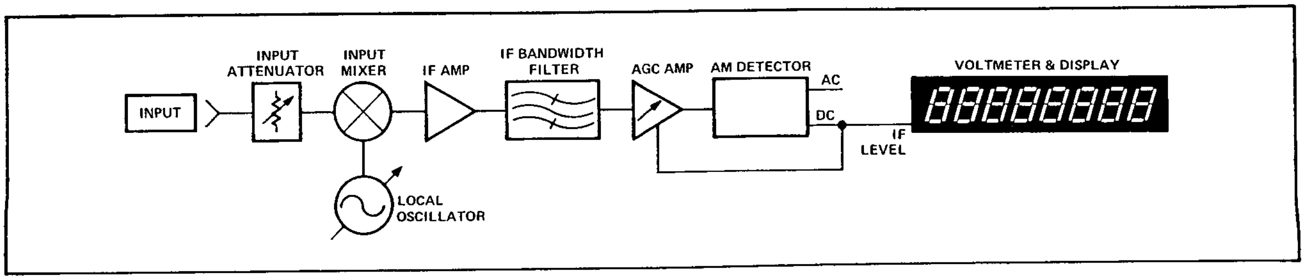


Figure 4-20. IF level measurement block diagram.

Hz) of larger amplitude and applied to the control input of the VCO. The small sinewave produces a reference FM deviation while the other varies the VCO center frequency. Track mode allows the 8901A to continue measuring FM while tracking the VCO. The 8901A can track VCOs in real time over a much greater frequency range than has been possible before. VCO linearity testing is covered in more detail in section 2.

AM measurements are essentially unaffected in track mode. However, for best FM measurement results several recommendations should be followed. First, the modulation rate should be 1 kHz or greater. This is because the track loop attenuates low rate FM as it tracks the input signal. FM accuracy is typically degraded 1% at 1 kHz and progressively less as rate increases. At a 10 kHz rate there is essentially no degradation due to the track loop. Second, the average responding detector is recommended in track mode. The average detector is less sensitive than the peak detectors to undesired FM deviation transients. Such transients are caused by discontinuities in the rate of change of the input signal frequency. For example, if the frequency tuning knob of a signal generator is turned in a jerky motion, large apparent peak deviations can result. The average detector smooths out these transients. Third, the residual FM degrades slightly in track mode typically to 12 to 20 Hz in a 3 kHz bandwidth for input frequencies less than 650 MHz. Much of the increase is due to 60 Hz line effects in the track loop. These line effects can be significantly reduced by selecting the 300 Hz high-pass filter. Residual FM is typically 3 to 11 Hz (300 Hz to 3 kHz bandwidth) for frequencies up to 650 MHz. Finally, auto-track should be used *within* the frequency bands listed in Table 4-3. The reason is that at the band limits frequency lock is broken and the search and lock cycle is repeated. Retuning can take as long as two seconds. Consequently, if the input frequency is changing rapidly, the 8901A may not be able to retune. The lowest frequency at which track mode can be used is 10 MHz.

Table 4-3. 8901A Continuous track mode bands.

Lower Band Edge (MHz)	Upper Band Edge (MHz)
10	18.8
18.5	39.2
38.5	79.9
78.5	161.2
158.5	324.0
318.5	649.5
638.5	1300

Table 4-4. 8901A IF and input filters.

IF Frequency (MHz)	Input High-Pass Filter	Special Function Code
Automatic IF	Out	3.0 SPCL
frequency selection 0.455	Out	3.1 SPCL
1.5	Out	3.2 SPCL
0.455	In	3.3 SPCL
1.5	In	3.4 SPCL

IF Filter Characteristics

The 8901A has two IF filters. One is 200 kHz wide (3 dB points) centered at 455 kHz and the other is 3 MHz wide with a 1.5 MHz center frequency. Figures 4-22 and 4-23 show the typical transfer characteristics of the IF filters. In automatic operation the 1.5 MHz filter is selected for input frequencies below 2.5 MHz or above 10 MHz, and the 455 kHz filter is selected for inputs between 2.5 and 10 MHz. Either filter may be selected manually using the special functions in Table 4-4.

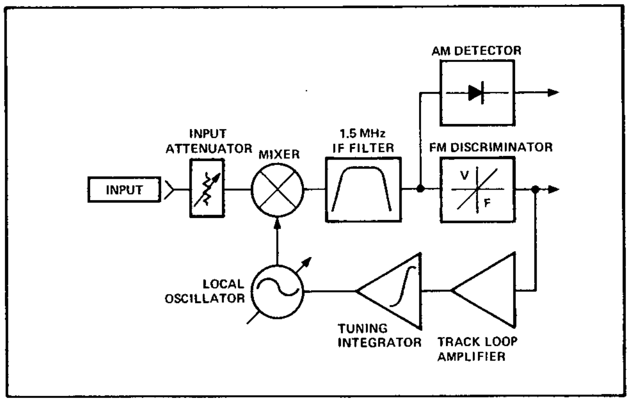


Figure 4-21. Track mode block diagram.

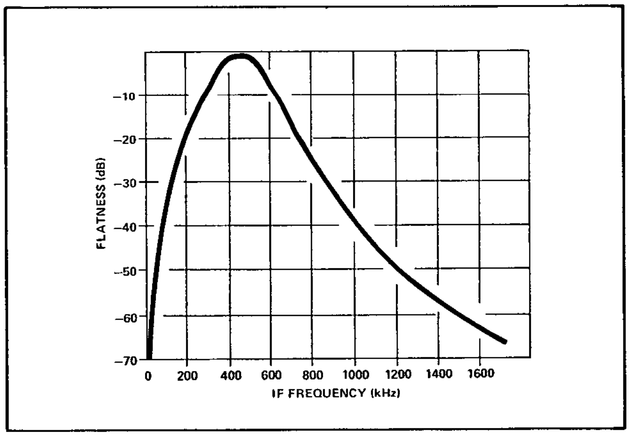


Figure 4-22. 455 kHz IF filter characteristic.

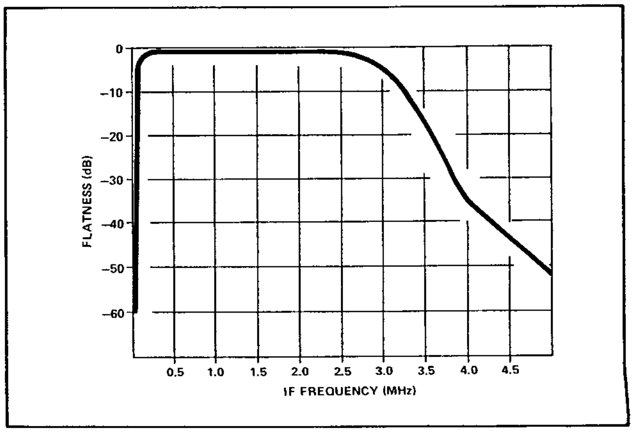


Figure 4-23. 1.5 MHz IF filter characteristic.

In addition to the IF filters, a 5.25 MHz high-pass input filter can be selected. Because the input mixer does not reject low frequency signals, extraneous signals such as AM broadcast pickup could affect measurements. These undesired low frequency signals can be rejected using the high-pass filter for measurements being made above 10 MHz.

Audio Filter Characteristics

The audio filters determine the post detection measurement bandwidth of the signals applied to the peak or average detectors. The 50 and 300 Hz high-pass filters are useful in filtering out hum and low frequency noise. The 3 kHz and 15 kHz low-pass filters reduce the effects of high frequency noise and are especially useful in making residual AM or FM measurements. The high-pass filters are two-poles and the low-pass filters are five-poles. This ensures sharp cutoffs yet allows testing at a 1 kHz rate to remain essentially unaffected. The >20 kHz low-pass filter is a nine-pole Bessel filter designed for minimum overshoot (ringing) on square wave modulation such as frequency shift keying (FSK). The transfer characteristics shown in Figures 4-24 through 4-28 were obtained using the 8901A in ratio mode while varying the modulation rate.

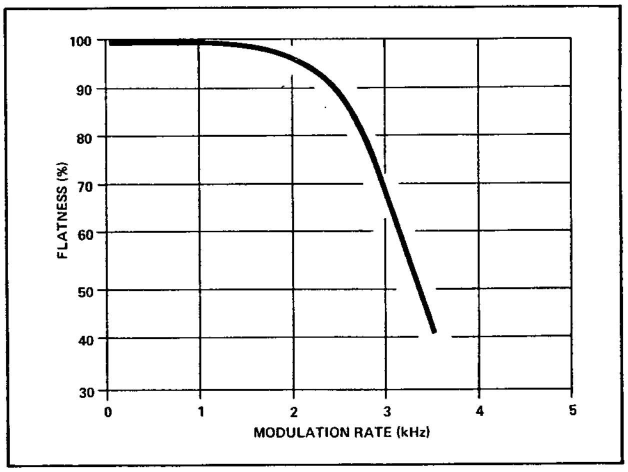


Figure 4-26. Typical 3 kHz low-pass filter response.

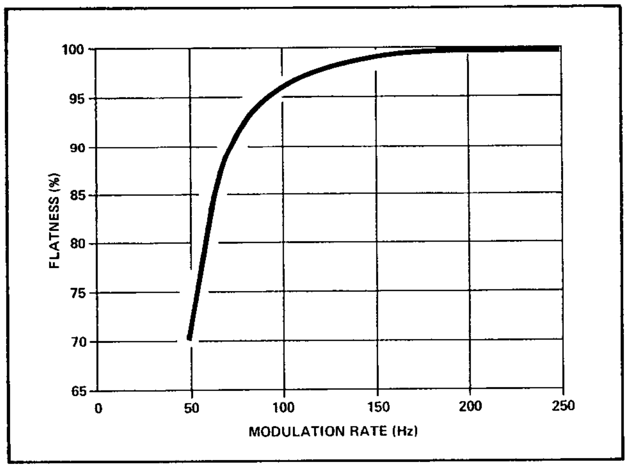


Figure 4-24. Typical 50 Hz high-pass filter response.

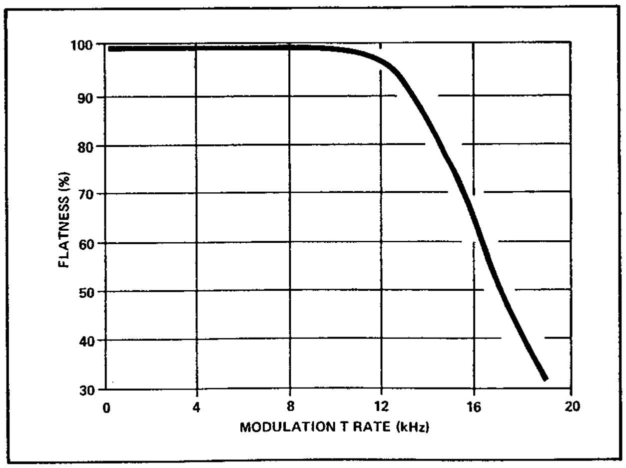


Figure 4-27. Typical 15 kHz low-pass filter response.

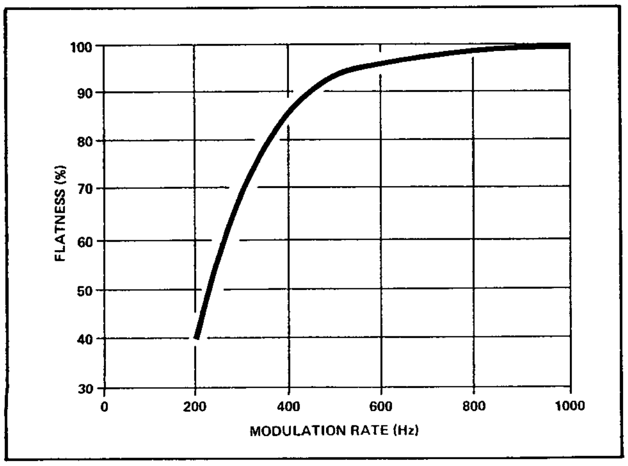


Figure 4-25. Typical 300 Hz high-pass response.

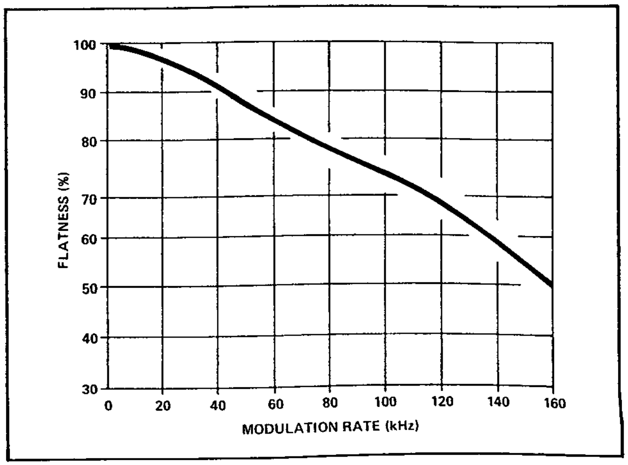


Figure 4-28. Typical >20 kHz low-pass filter response.

Peak Hold Detector

PEAK HOLD may be selected with either the positive (PEAK +) or negative (PEAK −) peak detector. In this mode the peak detector decay time constant is greatly increased and the displayed modulation is updated only in an increasing direction. Peak hold is ideal for detecting short modulation transients. For fast single transients less than 1 ms duration the peak hold detector captures approximately 90% of the true peak. If the transient is repeated after 10 ms the peak hold detector captures 90% of the new difference or 99% of the true peak. Therefore, it is recommended that the peak-generating process be repeated several times where possible.

Special Function Operation

Most measurements with the 8901A require only a single keystroke. There is no need to tune, adjust levels, or select the appropriate range because the microprocessor determines the optimum instrument settings automatically. However, in some applications it is desirable to override the automatic selection. Special functions provide manual control of instrument functions. There are eight groups of commonly used instrument control special functions (see Table 4-5). Special function modes are accessed by entering the appropriate code (prefix, decimal point, suffix) and then pressing the SPCL key. Pressing the SPCL key without entering a number causes the analyzer to shift to an eight digit status display. The digit position is the special function prefix and the displayed number is the suffix corresponding to the desired instrument setting. For example, if the modulation range is manually set to the 400 kHz FM range with the 2.3 special function, the status display shows a three in the second digit (Figure 4-29). The special display contains zeroes for the functions in automatic selection. The user can select any combination of manual or automatic operation. Pressing the SPCL key twice without entering a number causes the display to show the current instrument settings, including settings which have been automatically set by the microprocessor.

Besides providing manual control, special functions are used to set upper or lower limits, enable service requests, verify accuracy of other 8901A's not fitted with the calibrator option, and to troubleshoot the 8901A if a failure occurs.

The 14.2 special function sets the upper limit to the current ratio reference. For example, to establish 75 kHz as the upper deviation limit when the analyzer is in FM mode the keystrokes are

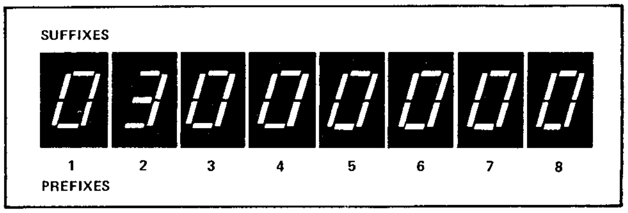


Figure 4-29. 8901A special function status display.

Table 4-5. 8901A manual control special functions.

Function	Code	Description
Input Attenuation	1.0	Automatic selection
	1.1	0 dB input attenuation
	1.2	10 dB input attenuation
	1.3	20 dB input attenuation
	1.4	30 dB input attenuation
	1.5	40 dB input attenuation
	1.6	50 dB input attenuation
Modulation Range	2.0	Automatic selection
		AM (%) FM (kHz) ΦM (rad)
	2.1	≤ 40 ≤ 4 ≤0.4* ≤ 4
	2.2	≤100 ≤ 40 ≤ 4* ≤ 40
	2.3	≤100 ≤400 ≤40* ≤400
		*with 750µs de-emphasis and pre-display
IF Frequency and Input High-Pass Filter	3.0	Automatic IF selection; input high-pass filter out
		IF (MHz) Input High-Pass Filter
	3.1	0.455 Out
	3.2	1.5 Out
	3.3	0.455 In
	3.4	1.5 In
Tune Mode	4.0	Automatic tuning; low noise LO
	4.1	Automatic tuning; track mode
	4.2	Manual tuning via keyboard entry
Audio Peak Detector Time Constant	5.0	Fast peak detector
	5.1	Slow peak detector
AM ALC Response	6.0	Slow AM ALC response
	6.1	Fast AM ALC response
	6.2	AM ALC off
Frequency Resolution	7.0	Automatic selection
	7.1	10 Hz resolution (f<1 GHz)
	7.2	1000 Hz resolution
Error Disable	8.0	Automatic selection
	8.1	E01 disabled
	8.2	E02 and E03 disabled
	8.3	E01, E02, & E03 disabled
	8.4	E04 disabled
	8.5	E01 and E04 disabled
	8.6	E02, E03, & E04 disabled
	8.7	E01 through E04 disabled
	8.8	E01 through E04 enabled

Then, whenever the FM deviation exceeds 75 kHz the limit light turns on. The limit function is most useful when used along with the 22. special function which generates a service request when the limit is reached. These two special functions enable the analyzer to become a remote modulation monitor. The most commonly used special functions are described in Table 6-3 and on the 8901A pullout information card. The green automatic operation key clears special functions with prefix numbers 1 through 8, 9, 15, and 21.

5. Calibrator Operation and Theory

Introduction

One of the unique features and contributions of the 8901A is the AM and FM calibrator option. The task of verifying and calibrating the Modulation Analyzer is formidable since the basic accuracy specification is ± 1% of reading. Precise AM signals are difficult to generate and the Bessel null technique which is often used to generate known FM deviations accurately is time consuming, requires extra test equipment (signal generator, audio source, frequency counter, and spectrum analyzer) and provides insufficient accuracy (≈1%), for calibrating the 8901A. These difficulties are overcome by the internal calibrators. They provide a 10 MHz, 10 kHz rate signal with either a nominal AM depth of 33.3% or 33 kHz peak FM deviation. The calibration output signal is generated by switching between two RF levels for AM or between two frequencies for FM. These two levels (or frequencies) are measured statically with high accuracy using the internal voltmeter (or counter). The calibrator modulation is then calculated from these measurements. The exact % AM (or peak FM deviation) generated can be displayed using the 12.0 (13.0) special function. The indicated modulation is accurate to ± 0.1% of reading. Thus, high accuracy is achieved by statically measuring the two levels (or frequencies) of the calibration output which is generated by dynamically switching between the same levels (frequencies).

With the calibrator signal connected to the 8901A RF input the accuracy of the Modulation Analyzer is measured directly and displayed in %. For example, 100.12% means the 8901A is reading 0.12% high. At recommended calibration cycles (1 year) the 8901A is adjusted to read 100%. The calibration factor can be incorporated in subsequent modulation measurements using special functions to achieve typical accuracy of ± 0.6% of reading. The calibrator output may also be used to calibrate other Modulation Analyzers not fitted with the calibrator option. Thus, users buying several 8901A's need not include the calibrators in every unit to keep them maintained.

AM Calibrator

Generating the AM Calibrator Signal

The 10 MHz signal is applied to two identical modulators (A and B) which are isolated by buffer amplifiers (Figure 5-1). When the CALIBRATION key is pressed the Modulation Analyzer statically measures the two carrier levels, V_A and V_B (Figure 5-2). The output signal used to calibrate the modulation analyzer is dynamically generated by closing modulator A and switching modulator B on and off with the shaped square wave drive signal (Figure 5-2b). The A and B signals are summed producing the composite waveform in Figure 5-2c and 5-3. The shaping prevents the demodulation circuitry from ringing when the CALIBRATION OUTPUT is measured.

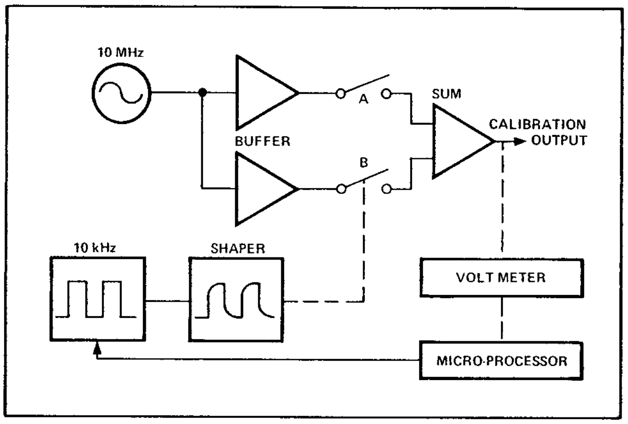


Figure 5-1. AM calibrator block diagram.

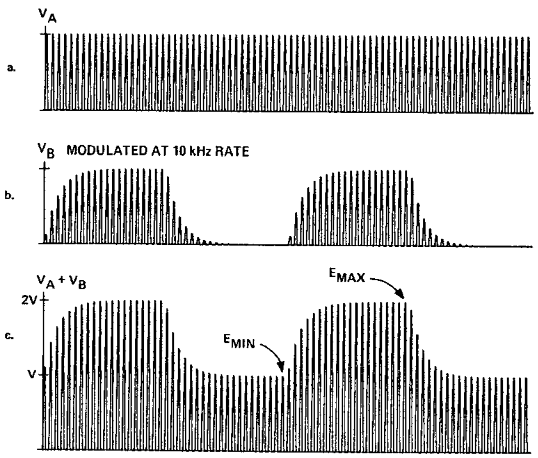


Figure 5-2. Forming the AM calibrator signal.

Calculating AM Calibrator Depth

AM depth is defined by[1]:

$$m+ = \frac{E_{max} - E_{avg}}{E_{avg}} \text{ X } 100, \quad m- = \frac{E_{avg} - E_{min}}{E_{avg}} \text{ X } 100 \qquad (5\text{-}1)$$

where m+ and m– are the positive and negative peak modulation depths and E_{max}, E_{min}, and E_{avg} are the maximum, minimum, and average carrier levels as shown in Figure 5-4. The 8901A and most other modulation meters measure AM depth using equations 5-1.

The average modulation m is given by:

$$m = \frac{m+ + m-}{2} \qquad (5\text{-}2)$$

If the modulation waveform is symmetrical as in Fig. 5-3 or 5-4, then

$$E_{avg} = \frac{E_{max} + E_{min}}{2} \qquad (5\text{-}3)$$

Substituting Eqs. 5-1 and 5-3 into 5-2 yields:

$$m = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \text{ X } 100 \qquad (5\text{-}4)$$

Equation 5-4 is an alternate definition of AM that is often used, particularly when AM is measured with oscilloscopes. Equation 5-4 is used to calculate the calibrator AM depth since E_{min} and E_{max} are determined to high accuracy statically. E_{min} is measured with modulator A closed and modulator B open. This is V_A shown in Figure 5-2a. Next, V_B is measured with modulator A open and modulator B closed. E_{max} is obtained by adding V_A and V_B.

$$E_{max} = V_A + V_B \qquad (5\text{-}5)$$

Because V_A is very nearly equal to V_B, the RF detector and voltmeter are operated over a very narrow range when V_A and V_B are measured separately. The result is excellent linearity. This linearity would not be possible if E_{max} were measured directly. However, this does require that the relative phase shift between the A path (consisting of modulator A and buffer A) and the B path (consisting of modulator B and buffer B) be minimal for Eq. 5-5 to be valid. Typically, the relative phase shift is less than two degrees. The actual phase shift can be verified easily using an HP 8405A Vector Voltmeter. For phase shifts this small, the error introduced in Eq. 5-5 is negligible. Substituting V_A for E_{min} and $V_A + V_B$ for E_{max} in Eq. 5-4 yields:

$$m = \frac{V_B}{2\,V_A + V_B} \text{ X } 100 \qquad (5\text{-}6)$$

This result can be displayed with the 13.0 special function. Notice that if $V_A = V_B$ then m = 33.33 from Eq. 5-6. However, this technique does not require that V_A equal V_B since both levels are measured. Thus, the calculated modulation may differ from 33.33 by several percent but the accuracy remains ± 0.1% of reading.

Comparing Measured with Calculated AM Depth

When the CALIBRATION OUTPUT is connected to the RF input, the 8901A measures the positive (m+) and negative (m–) AM depth. This intermediate result can be displayed using the 13.2 special function and selecting either PEAK + or PEAK –. If the 10 kHz signal driving modulator B is perfectly symmetrical, then m+ = m– = m. The 8901A does not depend on this, however, since drift may cause a small amount of asymmetry to occur. Asymmetry causes the average carrier level E_{avg} to shift, and changes both m+ and m–. Since the calculated modulation, m, is a function of E_{max} and E_{min} only, it is unaffected by asymmetry. The error due to asymmetry

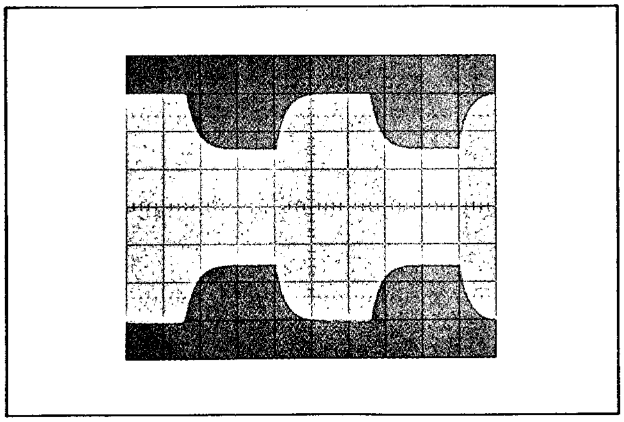


Figure 5-3. AM calibrator waveform.

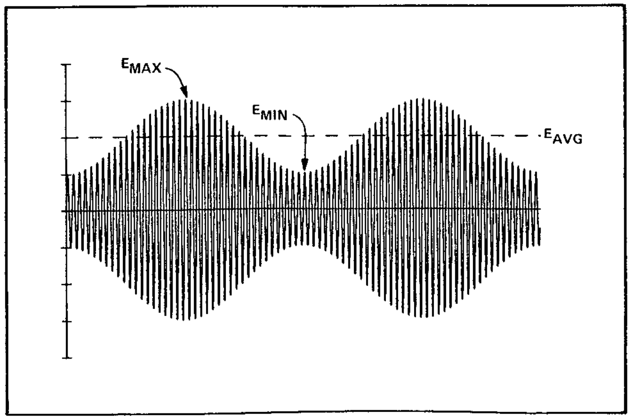


Figure 5-4. RF carrier modulated with 50% AM.

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[1] Frederick E. Terman, Electronic and Radio Engineering, McGraw Hill Book Co., fourth edition, page 523.

when comparing the measured AM depth m+ and m− to the calculated depth m is eliminated using the relation:

$$m = \frac{m+ + 2m-}{3} \tag{5-7}$$

The negative peak, m−, is given twice the weighting of m+ in Eq. 5-7 because the corrective action of the automatic gain control (AGC) in the AM detector in response to a shift in average carrier level changes the minimum level (and m−) only half as much as the maximum level (and m+). The measured AM depth, m, is automatically determined from Eq. 5-7 when the 8901A performs self-calibration. When one 8901A is calibrated with another, m is calculated manually as outlined in the calibration procedure in this section.

The only significant difference between the calculated AM depth from Eq. 5-6 and the measured value from Eq. 5-7 other than the error due to being out of calibration is due to the effect of residual noise. To correct for this noise, the 8901A measures the peak residual AM of the calibrator's unmodulated output and corrects the result with the appropriate weighting factor. The weighted residual AM can be displayed using the 13.1 special function. (Section 4 describes accounting for peak residuals further.) The AM cal factor displayed is the average measured AM depth corrected for noise effects divided by the calculated calibrator AM depth expressed in percent.

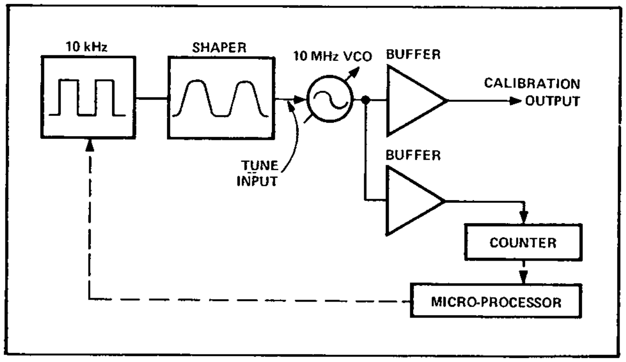


Figure 5-5. FM calibrator block diagram.

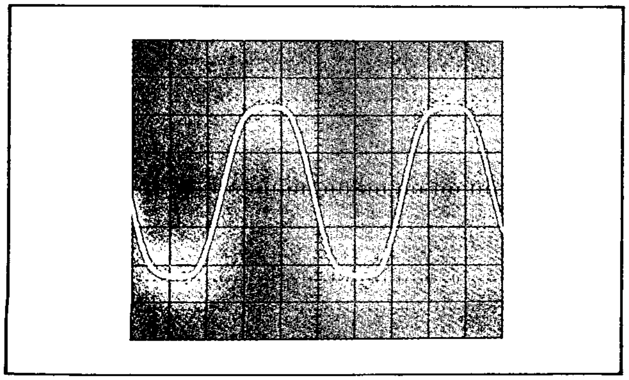


Figure 5-6. FM calibrator modulation waveform.

FM Calibrator

Generating the FM Calibrator Signal and Calculating Deviation

The FM calibrator is very analogous to the AM calibrator. The same 10 MHz source is switched between two discrete frequencies by a shaped square-wave to provide approximately 33 kHz of peak FM deviation (Figure 5-5). When the calibrator button is pressed, the VCO input is driven to the high frequency peak f_h, and the frequency is measured by the internal counter. Then the VCO is driven to the low frequency peak f_l and the frequency is counted again. The average peak deviation $\Delta f_{peak_{avg}}$ is calculated by:

$$\Delta f_{peak_{avg}} = \frac{f_h - f_l}{2} \tag{5-8}$$

This value can be displayed using the 12.0 special function. The calibrator signal used to verify the 8901A accuracy is switched at a 10 kHz rate (Figure 5-6). The shaping prevents the demodulation circuitry from ringing when the CALIBRATION OUTPUT is measured.

Comparing Measured with Calculated FM Deviation

The 8901A measures peak deviation as the difference between the peak and the average carrier frequency. The equations for positive and negative peak deviation are

$$\begin{aligned} \Delta f_{p+} &= f_h - f_{avg} \\ \Delta f_{p-} &= f_{avg} - f_l \end{aligned} \tag{5-9}$$

When the calibration output is connected to the RF input, the 8901A automatically measures Δf_{p+} and Δf_{p-}. These measurements can also be displayed using the 12.2 special function and selecting either PEAK+ or PEAK−. Next, the 8901A determines average measured peak deviation using

$$\Delta f_{peak_{avg}} = \frac{\Delta f_{p+} + \Delta f_{p-}}{2} = \frac{(f_h - f_{avg} + f_{avg} - f_l)}{2} \tag{5-10}$$

Eq. 5-10 shows that any shifts in the average frequency, f_{avg}, due to asymmetry in the modulation waveform are eliminated by calibrating using the average peak deviation. The average peak deviation is computed automatically except when one Modulation Analyzer is used to verify the accuracy of another. In this case, $\Delta f_{peak_{avg}}$ is calculated manually as indicated in the calibration procedure in this section.

The only significant difference between the calculated peak deviation and the average measured peak deviation just described other than the error due to being out of calibration, is due to the effect of residual noise. To correct for this noise the 8901A measures the peak residual deviation of the calibrator's unmodulated output and corrects the result with the appropriate weighting factor. The weighted residual deviation can be displayed with special function 12.1. The FM calibration factor displayed is the average measured peak deviation corrected for noise effects divided by the true calculated peak deviation. This is all performed automatically if the 8901A has the calibrator option installed.

Verifying Accuracy

Verifying the accuracy of the 8901A is a simple two step procedure:

1. Connect the CALIBRATION OUTPUT to the RF input.
2. To automatically perform AM or FM accuracy verification, press

AM ● CALIBRATION ●

or

FM ● CALIBRATION ●

When the CALIBRATION button is pressed the 8901A calculates the calibrator modulation. Next, the analyzer turns off all high-pass, low-pass, and de-emphasis filters. Then it tunes to the calibrator signal and measures the modulation. After approximately 22 seconds the 8901A displays a number close to 100%. Most of this time is spent averaging readings to reduce noise effects. The number is the calibration factor which represents the measured modulation expressed as a percentage of the calibrator modulation. For example, if after performing the calibration procedure the display indicates 100.12%, this means that the 8901A reads 0.12% high. Since specified accuracy is ± 1% of reading, the calibration factor displayed should always be within 99.0% and 101.0% between calibration cycles.

Calibrator Special Functions

Some of the intermediate results performed during calibration are available as special functions. Table 5-1 summarizes the special functions related to the calibrators. The AM (FM) calibration factor displayed is related to the 13. (12.) special functions by:

$$\text{AM Cal Factor} = \frac{(\text{13.2 reading} - \text{13.1 reading})}{(\text{13.0 reading})} \text{ X } 100\% \tag{5-11}$$

$$\text{FM Cal Factor} = \frac{(\text{12.2 reading} - \text{12.1 reading})}{(\text{12.0 reading})} \text{ X } 100\% \tag{5-12}$$

Verifying the Accuracy of a Second 8901A

Using the calibrator special functions described above, one 8901A equipped with calibrators (Option 010) may be used to verify the accuracy of a second 8901A.

The AM calibration procedure is:

1. Connect the CALIBRATION OUTPUT of Modulation Analyzer A to the RF input of Modulation Analyzer B (Figure 5-7).
2. Key in

   1 3 . 0 SPCL ●

   to Modulation Analyzer A and note the reading. This is the calibrator AM depth.
3. Key in

   1 3 . 1 SPCL ●

   to both instruments and note the displayed reading of analyzer B. This is the peak residual AM of the calibrator's unmodulated output measured with analyzer B. (If display jitter makes it difficult to read the display, key in 5.1 SPCL).
4. Key in

   1 3 . 2 SPCL ●

   to both instruments noting the reading on the display of analyzer B. This is the peak AM depth of the calibrator measured with Modulation Analyzer B.

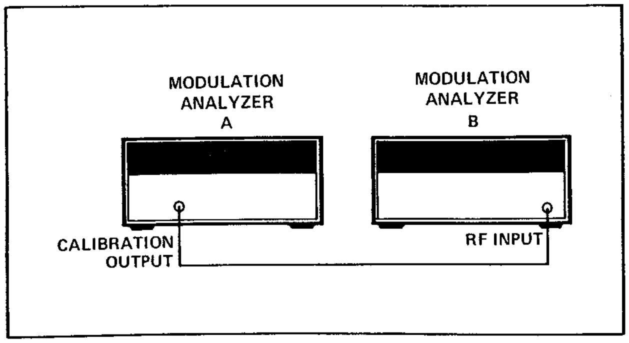


Figure 5-7. Verifying the accuracy of a second 8901A.

5. On Modulation Analyzer B, press PEAK−. Note the reading on the display of Modulation Analyzer B. If the difference between the readings of steps 4 and 5 is <3 in the least significant digit, use the reading from step 3. If the difference between the two readings is >3 in the least significant digit, compute the average as follows:

$$\text{13.2 reading} = \frac{\text{(reading of step 4)} + 2\text{x(reading of step 5)}}{3} \qquad (5\text{-}13)$$

For FM, if the difference is > 3 counts, compute the average as:

$$\text{12.2 reading} = \frac{\text{(reading of step 4)} + \text{(reading of step 5)}}{2} \qquad (5\text{-}14)$$

6. Compute the AM Cal Factor of Modulation Analyzer B using the AM Cal formula:

$$\text{AM Cal Factor} = \frac{\text{(13.2 reading} - \text{13.1 reading)}}{\text{13.0 reading}} \text{x } 100 \qquad (5\text{-}15)$$

The procedure for FM is identical except the 12. special function prefix is used whenever the 13. is used above.

Table 5-1. Calibration special functions.

Function	Special Function Code AM	FM
Display computed peak modulation (calibrator)	13.0 SPCL	12.0 SPCL
Display weighted demodulated peak residual modulation	13.1 SPCL	12.1 SPCL
Display demodulated peak modulation	13.2 SPCL	12.2 SPCL
Disable Cal Factor	16.0 SPCL	17.0 SPCL
Enable Cal Factor	16.1 SPCL	17.1 SPCL
Read Cal Factor	16.2 SPCL	17.2 SPCL

Improving Accuracy Using the Calibration Factor

Special functions allow the calibration factors to be incorporated in modulation measurements for improved accuracy. The 8901A modulation accuracy is ± 1% of reading for most rates, depths, and deviations even though the calibrator is accurate to 0.1% of reading. This is because the calibrator verifies accuracy at a single rate and for one AM depth or FM deviation. The ± 1% of reading specification includes the effects of flatness and linearity with rate and modulation and also environmental effects. The environmental effects are mostly temperature related and can be removed by verifying the accuracy at the operating temperature and using the calibration factors in subsequent measurements. Keying in special functions 16.1 and 17.1 causes all subsequent readings to be corrected using the AM or FM calibration factors (Table 5-1). For example, if the AM calibration factor is 100.12 all readings are scaled by 100/100.12 before displaying the result. With the calibration factors enabled typical accuracy is ± 0.6% of reading ± 1 digit.

6. Remote Operation

The 8901A Modulation Analyzer is fully programmable. All front panel functions, except the line switch, can be controlled using HP-IB. In addition, all special functions are programmable yielding increased measurement flexibility and serviceability. This section is an overview of programming the 8901A. In addition to addressing, program codes, and data message formats, specific examples are given using various HP instrument controllers including 9825A, 9835A, 9845B/T, and HP 1000 computers. Instrument subroutines are given and an example program to test FM mobile transmitters using a 9825 Desktop Computer is included.

Displaying and Setting the Address

The 8901A listen and talk addresses are preset to the ASCII symbols "." and "N". This corresponds to a decimal equivalent of 14. The 5 bit binary representation of the address is displayed on the front panel by keying in 21.SPCL (Figure 6-1). If the HP-IB interface board is not installed or all seven switches are set to 1, the display reads out 11111.110 and HP-IB operation is disabled.

The address is easily modified by sliding the top cover back and adjusting the binary switches (Figure 6-2). The display is updated immediately for any change in the address switches. The TALK ONLY (TON) and LISTEN ONLY (LON) bits should both be set to zero for normal (addressable) HP-IB operation. Table 6-1 lists the allowable address codes.

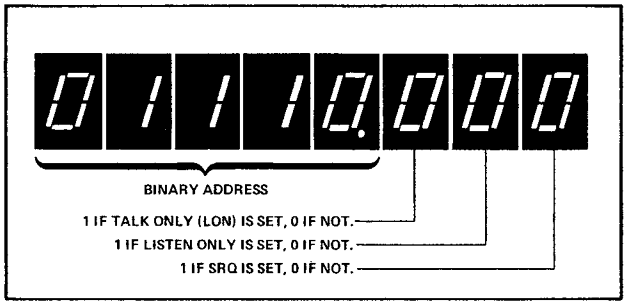


Figure 6-1. Remote address display.

Table 6-1. Allowable address codes.

Address Switches					Talk Address Character	Listen Address Character	Decimal Equivalent
A_3	A_4	A_1	A_2	A_1			
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
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

* 14 is factory preset address

** 21 is the 98034A HP-IB interface preset address. Therefore, the 8901A should not be set to 21.

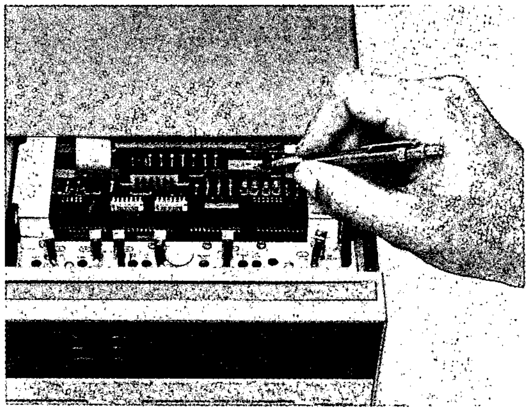


Figure 6-2. 8901A address setting.

Program Codes

The program code set for the 8901A is given in Table 6-2. The programming format consists of a program code prefix and a single digit argument. The prefix codes are single alphanumeric characters which are underlined in light grey on the front panel for quick reference.

The program codes for automatic and manual operation are two alphanumeric characters. The increment, decrement, and manual frequency input functions are suffix codes. A numerical argument must precede the suffix code. For example, the command string to set the 8901A input frequency to 454.5 MHz is "454.5MZ". Special functions can be programmed using the codes from Table 6-3 and the suffix "SP". For example, the command string for 10 Hz counter resolution is "7.1SP".

Code Simplifications and Conventions

The 8901A ignores: spaces ! " # $ % & ( ) * / ' (commas), carriage returns (CR), and line feeds (LF). As a convenience, all lower case alpha characters are treated as upper case, and the letter "O" is treated the same as zero. The Modulation Analyzer always outputs and displays E24 (bus code error) if it receives: @ B G I J N Q V W Y [/] — ^ {¦} ~ or DEL.

Table 6-2. 8901A program code set.

	Program Code
Measurement	
AM	M1
FM	M2
ΦM	M3
RF Level	M4
Frequency	M5
IF Level	S3
Tuned RF Level	S4
Frequency Error	S5
High-Pass Filters	
Off	H0
50 Hz	H1
300 Hz	H2
Low-Pass Filters	
Off	L0
3 kHz	L1
15 kHz	L2
>20 kHz	L3
FM De-emphasis	
De-emphasis and Pre-display Off	P0
Pre-display On	P1
25 μs	P2
50 μs	P3
75 μs	P4
750 μs	P5
Detector	
Peak +	D1
Peak −	D2
Peak Hold	D3
Average	D4
Ratio	
Off	R0
%	R1
dB	R2
Trigger	
Free Run	T0
Hold	T1
Immediate	T2
Trigger with Settling	T3
Automatic Operation	AU
Manual Operation	
MHz Input Frequency	MZ
Hz Input Frequency	HZ
Increment (↑kHz)	KU
(↑ Hz)	HU
Decrement (↓kHz)	KD
(↓ Hz)	HD
SPCL	SP
SPCL SPCL	SS
Clear	CL
Calibrator	
Off	C0
On	C1

Table 6-3. 8901A special function code set.

Function	Code	Description
Input Attenuation	1.0	Automatic selection
	1.1	0 dB input attenuation
	1.2	10 dB input attenuation
	1.3	20 dB input attenuation
	1.4	30 dB input attenuation
	1.5	40 dB input attenuation
	1.6	50 dB input attenuation
Modulation Range	2.0	Automatic selection AM (%) FM (kHz) ΦM (rad)
	2.1	≤ 40 ≤ 4 ≤0.4* ≤ 4
	2.2	≤100 ≤ 40 ≤ 4* ≤ 40
	2.3	≤100 ≤400 ≤40* ≤400 *with 750μs de-emphasis pre-display
IF Frequency and Input High-Pass Filter	3.0	Automatic IF selection; input high-pass filter out IF (MHz) Input High-Pass Filter
	3.1	0.455 Out
	3.2	1.5 Out
	3.3	0.455 In
	3.4	1.5 In
Tune Mode	4.0	Automatic tuning; low noise LO
	4.1	Automatic tuning; track mode
	4.2	Manual tuning via keyboard entry
Audio Peak Detector Time Constant	5.0	Fast peak detector
	5.1	Slow peak detector
AM ALC Response	6.0	Slow AM ALC response
	6.1	Fast AM ALC response
	6.2	AM ALC off
Frequency Resolution	7.0	Automatic selection
	7.1	10 Hz resolution (f<1GHz)
	7.2	1000 Hz resolution
Error Disable	8.0	Automatic selection
	8.1	E01 disabled
	8.2	E02 and E03 disabled
	8.3	E01, E02, & E03 disabled
	8.4	E04 disabled
	8.5	E01 and E04 disabled
	8.6	E02, E03, & E04 disabled
	8.7	E01 through E04 disabled
	8.8	E01 through E04 enabled
Hold Settings	9.0	Holds ranges, tuning and error modes at present settings; disables automatic functions
IF Frequency Measurement	10.0	Measures IF signal frequency
Re-enter RATIO with Previous Reference	11.0	Re-enter % RATIO
	11.1	Re-enter dB RATIO
	11.2	Read RATIO reference
	11.3	Make RATIO reference negative
FM Calibrator (Option 010)	12.0	Display computed peak FM deviation
	12.1	Display demodulated peak residual FM deviation
	12.2	Display demodulated peak FM deviation
AM Calibrator (Option 010)	13.0	Display computed peak AM depth
	13.1	Display demodulated peak residual AM depth
	13.2	Display demodulated peak AM depth
Set Limit	14.0	Clear Limits; turn off LIMIT annunciator
	14.1	Set lower limit to RATIO reference
	14.2	Set upper limit to RATIO reference
	14.3	Restore lower limit
	14.4	Restore upper limit
	14.5	Read lower limit
	14.6	Read upper limit
	14.7	Read lower limit measurement code
	14.8	Read upper limit measurement code
Time Base Oven (Option 002)	15.0	Display E12 if internal reference oven is cold
AM Calibration (Option 010)	16.0	Disable AM calibration factor
	16.1	Enable AM calibration factor
	16.2	Read AM calibration factor (0 if not enabled)
FM Calibration (Option 010)	17.0	Disable FM calibration factor
	17.1	Enable FM calibration factor
	17.2	Read FM calibration factor (0 if not enabled)
Tone Burst Receiver	18.NN	Configures the Modulation Analyzer as a tone burst receiver where a settling time is inserted between detecting a carrier and turning on MODULATION OUTPUT. NN is that time from 1 through 99 ms. If NN = 0, the delay is 99 ms.
HP-IB Address	21.0	Displays HP-IB address in form AAAAA.TLS. AAAAA is the binary address. T = 1 means talk only. L = 1 means listen only; S = 1 means service request issued.
Service Request	22.NN	Enables a condition to cause a service request to be issued. NN is the sum of any combination of the weighted conditions below: 1 Data ready 2 HP-IB error 4 Instrument error 8 Upper limit reached 16 Lower limit reached Instrument powers up in the 22.2 state.

Programming Order Considerations

Order is important when programming the 8901A. The code "AU" places the 8901A in automatic operation and clears all special functions with prefix numbers 1 through 8, 9, 15, and 21. Therefore, any desired special functions should be after "AU" in the program code sequence. Because measurement cycles are always executed immediately after a trigger command is received, trigger commands should always be last in a programming sequence. The code "P0" not only turns off pre-display mode but also all de-emphasis. Consequently, de-emphasis filter codes should be after pre-display on "P1" or off "P0". Peak hold mode works with either the positive or negative peak detector. Pressing either PEAK + or PEAK − or changing measurement modes (e.g., AM to FM) in local operation takes the 8901A out of peak hold mode. Pressing PEAK HOLD after PEAK + or PEAK − turns on peak hold mode. Remote operation is the same as local operation. Therefore, peak hold mode "D3" must be programmed after selecting PEAK + or PEAK −. The following rules should always be followed:

1. Any desired special functions should be **after** "AU".
2. De-emphasis filters code should be **after** selecting pre-display on or off.
3. PEAK HOLD should be **after** selecting PEAK + or PEAK − and **after** changing measurement modes.
4. Trigger commands should be last.

An easy way to remember rules 2 and 3 is that the arguments must be in ascending order. For example, the program sequence to set positive peak hold is "D1D3". The following examples clarify the use of these rules.

Example: A typical code sequence to set up the modulation analyzer for an instantaneous FM modulation limiting measurement is:

$\left\{\begin{array}{l}\text{controller talk}\\ \text{8901A listen}\end{array}\right\}$ "AU M2 2.2SP H1 P0 D1D3 T3"

AU — Automatic operation (clears special functions)

M2 — FM mode

2.2SP — fix 40 kHz deviation range (prevents autoranging)

H1 — 50 Hz high-pass filter

P0 — Turn off pre-display mode and de-emphasis

D1D3 — peak + detector and peak hold

T3 — trigger with settling time

Example: Select the 750 μs de-emphasis filter and PRE-DISPLAY on:

$\left\{\begin{array}{l}\text{controller talk}\\ \text{8901A listen}\end{array}\right\}$ "P1P5"

Example: Select the 75 μs de-emphasis filter and PRE-DISPLAY off:

$\left\{\begin{array}{l}\text{controller talk}\\ \text{8901A listen}\end{array}\right\}$ "P0P4"

Example: Select the PEAK − detector and turn off PEAK HOLD mode:

$\left\{\begin{array}{l}\text{controller talk}\\ \text{8901A listen}\end{array}\right\}$ "D2"

Triggered Operation

The 8901A has a full complement of triggered modes of operation (Table 6-4). The 8901A executes measurement cycles continuously in free run mode (T0) as it does in local. In hold mode (T1) the 8901A does not output to the display or to the bus. The trigger immediate command (T2) causes the 8901A to make one measurement cycle and wait to be read. Trigger with settling time (T3) causes the 8901A to execute one measurement cycle after delaying to allow internal circuits to settle. In both trigger immediate and trigger with settling modes the analyzer enters hold mode after the reading is output to the controller.

Trigger with settling (T3) is recommended for most applications. It provides a valid reading in the shortest time and eliminates the need to perform software checks for proper settling. The subroutines and examples in this section all use trigger with settling. Another advantage of trigger with settling mode is in debugging programs. The 8901A display holds the reading after it is output to the controller. Thus it is easy to check that program variables are assigned proper values as the program is stepped through. The CLEAR key is another debugging aid. Whenever CLEAR is pressed during remote operation, the 8901A executes a measurement cycle. This is useful for identifying timing problems in systems. For example, when the 8901A is triggered under program control, the input signal might not be settled or present due to system switching transients. Pressing CLEAR after a few seconds and noting the change in the new reading is a quick way to check for timing problems.

Table 6-4. 8901A trigger modes.

Trigger Mode	HP-IB Code
Free Run	T0
Hold	T1
Immediate	T2
Trigger with Settling	T3

Output Data Message Format

The Modulation Analyzer outputs readings in a 15 byte format (Figure 6-3). The output message is in exponential form. It begins with a + or − sign and ends with a carriage return (CR) and line feed (LF). Data is always output in fundamental units: Hz, watts, radians, % or dB. Error messages indicated on the display can also be read remotely. The error output format is +900000NNE+02CRLF where NN is the error number. When an error occurs, the instrument error (NN) is obtained by addressing the 8901A to talk, subtracting 9 x 10^9 from the reading returned, and dividing by 100. The operating information pull-out card lists all the error codes.

Example: Display reads: 969.21346 MHz
Data output: +96921346E+01CRLF

Example: Display reads: 34.92 kHz
Data output: +00003492E+01CRLF

Example: In the 9825A example program Figure 6-4, execution branches to the error trapping subroutine "trap" if an error occurs. The "trap" subroutine determines the error number and prints a diagnostic message if either E96 or E06 occurs. When no input signal is sensed by the 8901A, the display indicates two dashes and E96 is output to the bus. E06 occurs if the input power protect relay is tripped by an input overload.

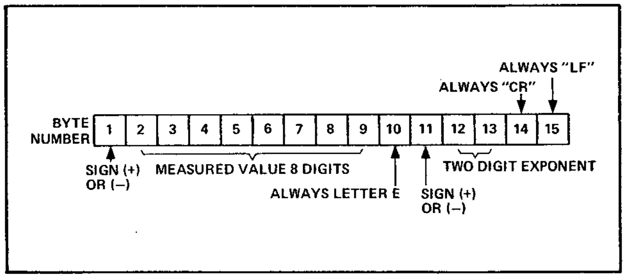


Figure 6-3. 8901A output message format.

Service Request and Status Reporting

The 8901A can request service via the interface SRQ for five conditions. These conditions are

1. Data ready
2. Invalid programming code error
3. Instrument error
4. Upper limit reached
5. Lower limit reached

When addressed to talk during a serial poll, the 8901A sends the status byte as shown in Figure 6-5. The operator has control over which conditions cause the 8901A to request service using special function 22.X. To enable an SRQ-generating condition, use the 22.X special function with argument X equal to the sum of the bit values for the desired service request condition. The bits in the status byte can be set to one only if they are enabled. The invalid programming code is an exception. An invalid program code always generates a service request even if an attempt is made to mask it off. The 8901A powers up in the 22.2 state. Bit 6 (SRQ) is set true whenever any of the other status bits are set. All bits remain set until the status byte is read. Bits 5 and 7 are always 0.

Bit	Bit Value	Function
0	1	Data Ready
1	2	Bus Code Error
2	4	Instrument Error
3	8	Upper Limit Reached
4	16	Lower Limit Reached
5	32	0
6	64	Service Request
7	128	0

Figure 6-5. 8901A status byte

```
 0: "Error trapping example":
 1:
 2: rem 7 ——————————————————————————————————————————— Set remote enable
 3: wtb 714,"M1T0"————————————————————————————————— Trigger an AM measurement
 4: "error could occur":—————————————— The 8901A will display E06 if an overload occurs.
 5: fmt ;red 714,A ——————————————————————————————————————————————— Read 8901A
 6: if A>9e9;cll 'trap';gto "Continue"————————— Branch to "trap" if an error has occurred
 7: prt "AM depth= ",A,"%" ————————————————————— If no error, print measurement result
 8: "Continue":
 9: stp ———————————————————————————————————————————————————————————————— Stop
10:
11: "trap":————————————————————————————————— Subroutine to determine error number
12: (A-9e9)/100→E ——————————————————————————————————— Determine error code (E)
13: if E=96;prt "No input signal";ret ——————————— Print error message if E96 occurs
14: if E=6;prt "Input power","protect relay","open"— Print error message if E06 occurs
15: ret —————————————————————————————————————————————————————————————— Return
```

Figure 6-4. 8901A error trapping example.

Example: Enable the 8901A to generate a service request when data is ready or lower limit is reached. The argument is 16 + 1 = 17, and the special function is 22.17. This could be programmed using the general form:

$$\left\{\begin{matrix}\text{controller talk}\\ \text{8901A listen}\end{matrix}\right\}\ \text{“22.17SP”}$$

or specifically with the 9825A: wtb 714, “22.17SP”,
or the 9835A or 9845B/T:
OUTPUT 714 USING “K”; “22.17SP”

Example: Using the equipment shown (Figure 6-6), the example subprogram “limit” (Figure 6-7) interrupts the main progam and prints the FM deviation with the 9825A strip printer whenever the source peak FM deviation is less than 60 kHz or greater than 70 kHz.

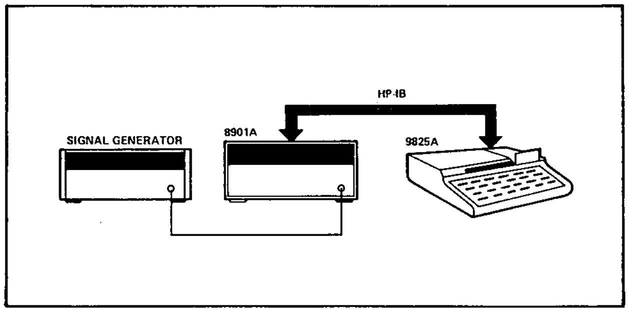


Figure 6-6. Example service request setup.

Programming Execution Time

The reading rate in remote operation is determined by two parameters: the rate at which data can be input to the 8901A via the HP-IB interface, and the time required for the 8901A to execute a measurement cycle and output the measurement result. Because the 8901A accepts data at a 273 bytes/second rate, data transfer is normally a small fraction of the total program run-time. Execution time is almost completely a function of internal hardware settling times. Table 6-5 lists typical execution times for various measurement functions and trigger modes. RF level is the fastest mode for the 8901A to return the first reading. This is because RF level is a broadband measurement and does not require the 8901A to tune. The remaining functions (AM, FM, ΦM, and frequency) all require the 8901A to tune to the input signal before measurements can be made. The times to return the first reading given in Table 6-5 vary with input frequency, modulation rate, and modulation deviation or depth. These times assume that the 8901A is not already tuned. Once tuned, the time to switch between any of the tuned functions is typically less than one second. When several measurement modes are used in succession, Table 6-5 suggests that the optimum sequence is RF level, frequency, AM, FM, and ΦM. Using the audio measurement bandwidth filters also results in faster readings. Particularly helpful is the 50 Hz high-pass filter in AM and FM modes and the 15 kHz low-pass filter in FM Mode for deviations less than 4 kHz.

```
0: "Service request example":
1: rem 7 ------------------------------------ Set remote enable true
2: oni 7,"limit" ---------------------------- Branch to "limit" when an interrupt occurs
3: wtb 714,"M2T070R114.2SP" ----------------- Put 8901A in FM mode, set lower limit to 60 kHz deviation
4: wtb 714,"60R114.1SPR0" ------------------- Set upper limit to 70 kHz, turn off ratio mode
5: wtb 714,"22.24SP" ------------------------ Set 8901A interrupt mask for upper or lower limit
6: eir 7 ------------------------------------ Enable interrupts
7:
8: for I=1 to 1000 \
9: dsp "I=",I       |
10: next I          |------------------------ Dummy main program
11: gto -3         /
12:
13: "limit":rds(714)→S ---------------------- Serial poll 8901A, read status byte into S
14: if bit(3,S)=0 and bit(4,S)=0;iret ------- Check status byte for upper or lower limit
15: fmt ;red 714,D -------------------------- Read FM deviation
16: prt "Dev=",D*1e-3,"kHz" ----------------- Print results
17: eir 7 ----------------------------------- Re-enable interrupts
18: iret ------------------------------------ Return to main program
```

Figure 6-7. 8901A service request example.

Free run trigger mode provides the fastest reading rate while trigger with settling provides the most consistent readings. In trigger with settling mode the reading rate varies with modulation rate, depth, or deviation, and can be improved as above using audio filters where possible.

Device Subroutines

When using an instrument in remote operation it is helpful to develop a set of device subroutines to control the main functions of the instrument. These subroutines eliminate the need to remember specific instrument program codes and greatly simplify writing application programs. A comprehensive set of device subroutines is included on pages 42-46 for the 9825A, 9835A, 9845B/T, and HP-1000 controllers. Making use of these subroutines requires the ROMs and interface cards listed in Table 6-6.

It is also necessary to assign the proper value to the subroutine variable which represents the 8901A address. Table 6-7 shows how to assign the address variable, assuming the 8901A address is 14 and the 98034A select code is 7.

The general calling syntax in the subroutines descriptions is given for the 9825A only. The calling syntax for the other controllers is very similar. Table 6-8 shows example calling statements for the audio filter subroutine, Flt. Notice that in the HP-1000 FORTRAN subroutines, the address variable IDLU must always appear first in the calling statement.

Table 6-5. Typical 8901A measurement rates.

Measurement Mode	Time to Autotune and Return First Reading (Seconds)	Readings/Second After First Reading		
		Trigger Mode		
		Free Run	Immediate	With Settling
AM	1.4 to 2.5	5.8	2.1 to 2.9	1.5 to 2.0
FM	1.6 to 2.5	5.8	1.8 to 3.1	1.4 to 2.2
ΦM	1.6 to 2.5	5.8	1.0 to 3.0	0.9 to 2.1
RF Level	0.40	5.4	4.3	2.5
Frequency resolution auto	0.6	3.6	2.3	1.5
10 Hz	0.6 to 0.9	1.0 to 2.75	0.8 to 2.0	0.5 to 1.2
1 kHz	0.6	5.0	3.1	2.0

Table 6-6. Hardware required for 8901A device subroutines.

Controller	Hardware Required
9825A	98210A String and Advanced Programming ROM 98213A General and Extended I/O ROM* 98034A HP-IB Interface Card
9835A	98332A I/O ROM 98034A HP-IB Interface Card
9845B/T	98412A I/O ROM (9845B, 9845T) or 98432A I/O ROM (9845A, 9845S) 98034A HP-IB Interface Card
HP-1000	59310B HP-IB Interface Card

* The 98214A or 98216A ROM can be substituted for the 98213A ROM.

Table 6-7. Example 8901A address variable assignment.

Controller	Variable Name	Assignment Statement
9825A	Ma	dev "Ma", 714
9835A, 9845B/T	Ma	COM Ma Ma = 714
HP-1000	IDLU	IDLU = 14

Table 6-8. Example call statements.

Controller	Call Statement
9825A	cll 'Flt' (a_1, a_2)
9835A, 9845B/T	CALL Flt (a_1, a_2)
HP-1000	CALL FLT (IDLU, a_1, a_2)

Am

AM Depth

Description: This subroutine measures AM depth.

Calling Syntax: cll 'Am' (a_1)

a_1—will contain measured AM depth, in %.

9825A Example: Measure AM depth

cll 'Am' (M)
prt "AM% = ", M

Comments: This subroutine assumes that the audio filters and detector are already set as desired. The detector and filters can be set using the "Det" and "Flt" subroutines.

Listing:

9825A

```
1: "Am":
2: fmt ;wrt "Ma","M1T3";red "Ma",p1
3: ret
*29114
```

9835A,9845B/T

```
400  SUB Am(A)
410  COM Ma
420  OUTPUT Ma USING "K";"M1T3"
430  ENTER Ma;A
440  SUBEND
```

HP-1000

```
      SUBROUTINE AM(IDLU,DEPTH)
      WRITE(IDLU,10)
10    FORMAT("M1T3")
      READ(IDLU,*) DEPTH
      RETURN
      END
```

Cnt

Frequency Count

Description: This subroutine sets the modulation analyzer to frequency mode, triggers it, and returns the measured frequency.

Calling Syntax: cll 'Cnt' (a_1)

a_1—will contain measured frequency in Hz.

9825A Example: Make a frequency measurement:

cll 'Cnt' (F)
prt "Freq = ", F*le-6, "MHz"

Comments: This subroutine uses 10 Hz resolution. In automatic low-noise tuning mode the 8901A takes several readings to return the correct frequency when it must tune to the input signal. The error occurs because the local oscillator is not fully settled by the first reading. To overcome this problem this subroutine uses track mode after tuning. This ensures that the frequency measured in "Cnt" is fully settled and correct. "Cnt" returns the 8901A to automatic low-noise tuning mode before execution returns to the main program. This is only necessary when 10 Hz resolution is requested. If 100 Hz resolution is adequate, the command string "M5T3" provides a faster count.

Listing:

9825A

```
15: "Cnt":
16: fmt ;wrt "Ma","M5AU7.1SP4.1SPT3";
    red "Ma",p1
17: wrt "Ma","AU";if (p1-9e9)/100=10;
    wrt "Ma","T3";red "Ma",p1
18: ret
*23503
```

9835A, 9845B/T

```
210  SUB Cnt(F)
220  COM Ma
230  OUTPUT Ma USING "K";"M5AU7.1SP4.1SPT3"
240  ENTER Ma;F
250  OUTPUT Ma USING "K";"AU"
260  IF (F-9E9)/100<>10 THEN SUBEXIT
270  OUTPUT Ma USING "K";"T3"
280  ENTER Ma;F
290  SUBEND
```

HP-1000

```
      SUBROUTINE CNT(IDLU,FREQ)
      DOUBLE PRECISION FREQ
      WRITE(IDLU,10)
10    FORMAT("M5AU7.1SP4.1SPT3")
      READ(IDLU,*) FREQ
      WRITE(IDLU,11)
11    FORMAT("AU")
      IF((FREQ-9.E9).NE.10.0) GO TO 99
      WRITE(IDLU,12)
12    FORMAT("T3")
      READ(IDLU,*)FREQ
99    RETURN
      END
```

Dem

De-emphasis Filters

Description: This subroutine sets the FM de-emphasis filters of the Modulation Analyzer.

Calling Syntax: cll 'Dem' (a_1, a_2)

a_1—set to desired de-emphasis, in μs.

a_2—If a_2 is non-zero the de-emphasis filters are placed before the measurement detector (pre-display). If a_2 is set to zero the modulation output is still de-emphasized but after the FM deviation is measured and displayed.

9825A Example: Set the 750 μs de-emphasis filter but do not use the PRE-DISPLAY mode.

cll 'Dem' (750, 0)

Comments: Pre-display mode is most helpful in measuring flatness of FM transmitters with pre-emphasis. If no de-emphasis is desired, set a_1 to zero. For the 9825A controller a_2 may be omitted rather than setting it equal to zero.

Listing:

9825A

```
8: "Dem":
9: p1→p0;if p0>=750;100→p0
10: fmt "P",f1.0,"P",f1.0;
    wrt "Ma",p2#0,p0/25+(p0>=25)
11: ret
*22157
```

9835A,9845B/T

```
140  SUB Dem(D,Pre)
150  COM Ma
160  Det=D
170  IF Det>=750 THEN Det=100
180  IMAGE 2("P",D)
190  OUTPUT Ma USING 180;
     Pre<>0,Det/25+(Det>=25)
200  SUBEND
```

HP-1000

```
       SUBROUTINE DEM(IDLU,IDIS,IDEM)
       J=0
       L=0
       IF(IDIS.NE.0) J=1
       IF(IDEM.EQ.750) IDEM=100
       IF(IDEM.GT.0)  L=IDEM/25+1
       WRITE(IDLU,10) J,L
10     FORMAT("P",I1,"P",I1)
       RETURN
       END
```

Det

Measurement Detectors

Description: This subroutine selects the measurement detector of the Modulation Analyzer.

Calling Syntax: cll 'Det' (a_1, a_2)

a_1—determines which detector is to be used.

Detector	a_1
PEAK +	1
PEAK −	2
AVG	4

a_2—If a_2 is non-zero the Modulation Analyzer is placed in the PEAK HOLD mode. If set to zero, PEAK HOLD mode is not used.

9825A Example: Set the Modulation Analyzer to the PEAK + mode with PEAK HOLD off:

cll 'Det' (1, 0)

Comments: The average detector is recommended for residual noise modulation measurements. Peak hold mode is useful in measuring instantaneous modulation transients. Peak hold mode is turned off when the 8901A changes measurement modes (e.g., AM to FM). Therefore, the 8901A must already be in the desired measurement mode (i.e., by a call to "Am" or "Fm") before "Det" is used to set peak hold mode.

Listing:

9825A

```
12: "Det":
13: fmt "D",f1.0,;wrt "Ma",p1;if p2#0;
    wtb "Ma","D3"
14: ret
*30313
```

9835A, 9845B/T

```
80   SUB Det(Detector,Pkhold)
90   COM Ma
100  IMAGE "D",D
110  OUTPUT Ma USING 100;Detector
120  IF Pkhold<>0 THEN OUTPUT Ma USING "K";"D3"
130  SUBEND
```

HP-1000

```
       SUBROUTINE DET(IDLU,IDET,IH)
       WRITE(IDLU,10) IDET
       IF(IH.NE.0) WRITE(IDLU,10) 3
10     FORMAT("D",I1)
       RETURN
       END
```

Flt

Audio Filters

Description: This subroutine sets the high and low-pass filters that determine the measurement bandwidth of the Modulation Analyzer.

Calling Syntax: cll 'Flt' (a_1, a_2)
a_1—set to desired high-pass filter, in Hz.
a_2—set to desired low-pass filter, in kHz.

9825A Example: Set the Modulation Analyzer measurement bandwidth to 300 Hz to 15 kHz:
cll 'Flt' (300, 15)

Comments: If no high-pass filter is desired, set a_1 to 0. Similarly, if no low-pass filter is desired, set a_2 to 0 (i.e., to turn all the filters off, use . . .
cll 'Flt' (0,0) . . .)

Listing:

9825A

```
15: "Flt":
16: (p1>0)+(p1>50)→p3;(p2>0)+(p2>3)+
    (p2>15)→p4
17: fmt "H",f1.0,"L",f1.0;wrt "Ma",p3,p4
18: ret
*20419
```

9835A,9845B/T

```
10    SUB Flt(H,L)
20    COM Ma
30    Hp=(H>0)+(H>50)
40    Lp=(L>0)+(L>3)+(L>15)
50    IMAGE "H",D,"L",D
60    OUTPUT Ma USING 50;Hp,Lp
70    SUBEND
```

HP-1000

```
      SUBROUTINE FLT(IDLU,HP,LP)
      IH=0
      IL=0
      IF(HP.GT.0)    IH=1
      IF(HP.GT.50)   IH=2
      IF(LP.GT.0)    IL=1
      IF(LP.GT.3)    IL=2
      IF(LP.GT.15)   IL=3
      WRITE(IDLU,10) IH,IL
10    FORMAT("H",I1,"L",I1)
      RETURN
      END
```

Fm

FM Deviation

Description: This subroutine measures FM deviation.

Calling Syntax: cll 'Fm' (a_1)
a_1—will contain measured deviation, in Hz.

9825A Example: Measure FM deviation (D) using the PEAK – detector:
cll 'Det' (2, 0)
cll 'Fm' (D)

Comments: Before this subroutine is called, the audio filters, de-emphasis filters, and detectors should be set as desired using the "Flt", "Dem", and "Det" subroutines.

Listing:

9825A

```
19: "Fm":
20: fmt ;wrt "Ma","M2T3";red "Ma",p1
21: ret
*24844
```

9835A, 9845B/T

```
450   SUB Fm(D)
460   COM Ma
470   OUTPUT Ma USING "K";"M2T3"
480   ENTER Ma;D
490   SUBEND
```

HP-1000

```
      SUBROUTINE FM(IDLU,DEV)
      WRITE(IDLU,10)
10    FORMAT("M2T3")
      READ(IDLU,*) DEV
      RETURN
      END
```

Mtf

Modulation Analyzer Receive Frequency

Description: This subroutine takes the Modulation Analyzer out of the autotuning mode and sets the receive frequency in the manual tune mode. This configures the instrument as a fixed-tuned receiver.

Calling Syntax: cll 'Mtf' (a_1)
a_1—set to desired frequency, in MHz.

9825A Example: Set the Modulation Analyzer receive frequency to 132.1 MHz.
cll 'Mtf' (132.1)

Comments: Normally, the analyzer can be operated in autotune mode. This subroutine is recommended only when undesired RF signals are present.
To return the Modulation Analyzer to the autotune mode, use: cll 'Mtf' (0).

Listing:

9825A

```
25: "Mtf":
26: if p1=0;wtb "Ma","4.0sp";ret
27: fmt f10.5,"MZ";wrt "Ma",p1;ret
*19597
```

9835A,9845B/T

```
320   SUB Mtf(F)
330   COM Ma
340   IF F<>0 THEN GOTO 370
350   OUTPUT Ma USING "K";"4.0SP"
360   SUBEXIT
370   IMAGE 10D.5D,"MZ"
380   OUTPUT Ma USING 370;F
390   SUBEND
```

HP-1000

```
      SUBROUTINE MTF(IDLU,FREQ)
      DOUBLE PRECISION FREQ
      IF(FREQ.LT.1E-3) GO TO 20
      WRITE(IDLU,10) FREQ
10    FORMAT(F10.5,"MZ")
      RETURN
20    WRITE(IDLU,30)
30    FORMAT("4.0SP")
      RETURN
      END
```

Pep

Peak Envelope Power

Description: This subroutine measures the peak envelope power using the diode detector of the Modulation Analyzer.

Calling Syntax: cll 'Pep' (a_1)
a_1—will contain the measured RF level, in watts.

9825A Example: Measure the RF level (P).
cll 'Pep' (P)
prt "Power =", P, "watts"

Comments: To save testing time (≈1.5s), this subroutine should be called at the beginning or end of a transmitter test sequence because the analyzer must retune after making RF Level measurements.

Listing:

9825A

```
22: "Pep":
23: fmt ;wrt "Ma","M4T3";red "Ma",p1
24: ret
*12285
```

9835A,9845B/T

```
270   SUB Pep(P)
280   COM Ma
290   OUTPUT Ma USING "K";"M4T3"
300   ENTER Ma;P
310   SUBEND
```

HP-1000

```
      SUBROUTINE PEP(IDLU,PWR)
      WRITE(IDLU,10)
10    FORMAT("M4T3")
      READ(IDLU,*) PWR
      RETURN
      END
```

Pm

Phase Deviation

Description: This subroutine measures transmitter phase deviation using the Modulation Analyzer.

Calling Syntax: cll 'Pm' (a_1)

a_1—will contain measured deviation, in radians.

9825A Example: Measure ΦM deviation (D) at a 1 kHz rate using the PEAK detector:

cll 'Pm' (D)

prt "phase dev.=", D*180/π, "Degrees"

Comments: Before this subroutine is called, the audio filters and detectors should be set as desired using the "Flt" and "Det" subroutines.

Because the 8901A recovers phase modulation by integrating the recovered FM, low frequency noise can cause significant display bouncing. Therefore using the 50 Hz or 300 Hz high-pass filter in ΦM mode is highly recommended. If no high-pass filters are specified the 8901A defaults to the 50 Hz high-pass filter when it enters ΦM mode. When the 50 Hz high-pass filter is turned on by default it is also turned off when the 8901A leaves ΦM mode. The subroutine returns the measured phase deviation in radians (a_1). To convert a_1 to degrees (D), use the following formula:

$$D = a_1\left(\frac{180}{\pi}\right)$$

Listing:

9825A

```
28: "Pm":
29: fmt ;wrt "Ma","M3T3";red "Ma",pl
30: ret
*30764
```

9835A, 9845B/T

```
500  SUB Pm(R)
510  COM Ma
520  OUTPUT Ma USING "K";"M3T3"
530  ENTER Ma;R
540  SUBEND
```

HP-1000

```
      SUBROUTINE PM(IDLU,RAD)
      WRITE(IDLU,10)
10    FORMAT("M3T3")
      READ(IDLU,*) RAD
      RETURN
      END
```

Example Program

The example program which follows uses the 8901A application subroutines to automatically test an FM mobile transmitter. Figure 6-8 shows the equipment setup. An HP 3325A Synthesizer is used as a programmable audio source to simulate voice signals at the microphone input. The transmitter output is attenuated to the operating level of the 8901A. The 8901A makes the transmitter measurements using the application subroutines. The program generates two plots. The first shows the transmitter pre-emphasis curve. Pre-emphais is the increase in FM deviation of the transmitter output as audio frequency is increased. For FM mobile transmitters the pre-emphasis is specified at 6 dB/octave between 300 Hz and 3 kHz. The second plot shows transmitter flatness which is the deviation from the ideal pre-emphasis curve. The program takes approximately 4 minutes to run: 2½ minutes to label the titles and graphs, and 1½ minutes to perform the measurements (Figure 6-9). The program also provides an alternate output using the 9825A thermal strip printer (Figure 6-10). The alternate version takes about 45 seconds to run.

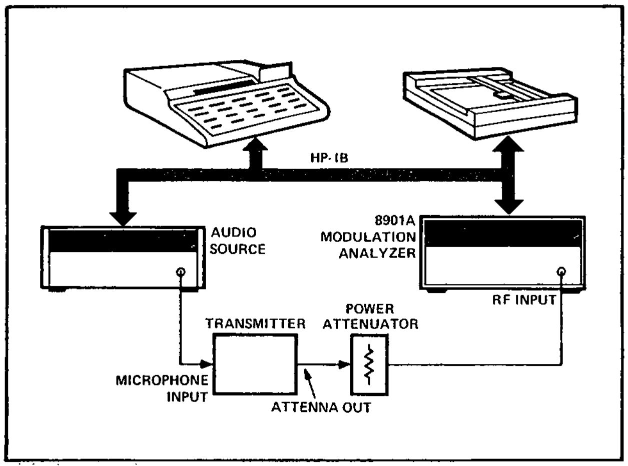
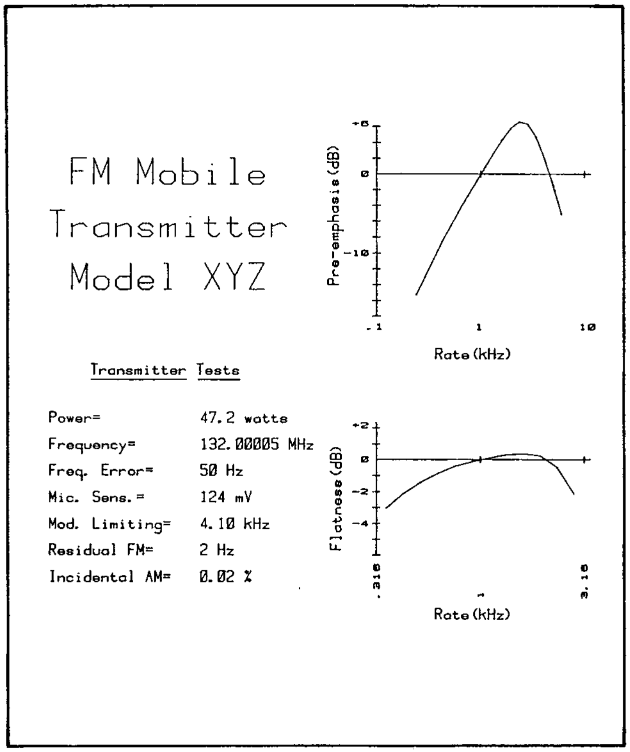


Figure 6-8. Automatic transmitter test equipment setup.

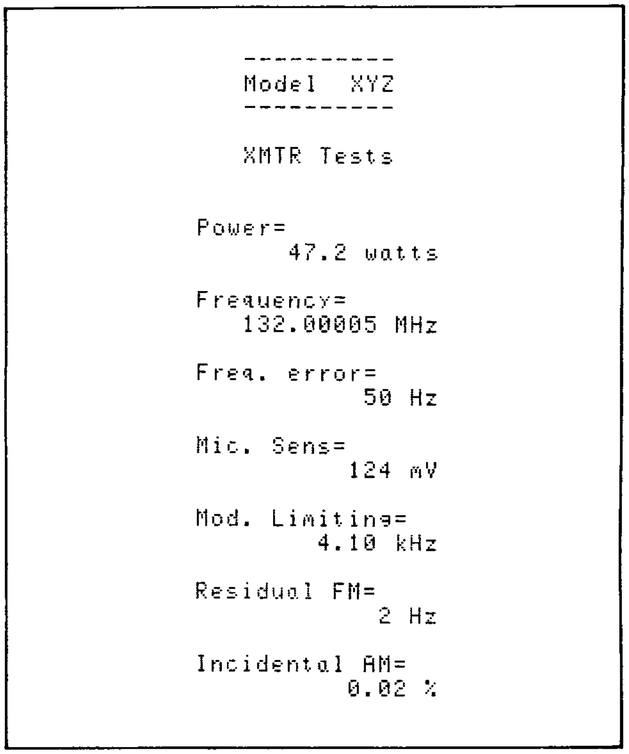


FM Mobile
Transmitter
Model XYZ

Transmitter Tests

```
Power=              47.2 watts
Frequency=          132.00005 MHz
Freq. Error=        50 Hz
Mic. Sens.=         124 mV
Mod. Limiting=      4.10 kHz
Residual FM=        2 Hz
Incidental AM=      0.02 %
```

Figure 6-9. Sample output of example application program.



```
         ----------
         Model  XYZ
         ----------

         XMTR Tests


    Power=
          47.2 watts

    Frequency=
       132.00005 MHz

    Freq. error=
               50 Hz

    Mic. Sens=
             124 mV

    Mod. Limiting=
            4.10 kHz

    Residual FM=
                2 Hz

    Incidental AM=
              0.02 %
```

Figure 6-10. Sample alternate output of example program.

Example Program

```
0: "AN 286-1 FM Mobile test program":
1: dev "3325",717,"Ma",714                               Assign address variables
2: gto "start"                                           Branch to "start" label
3: "Init":time 5000;rem 7;cli 7;clr 7
4: fmt ;wrt "Ma","CLAU7.1SPD1H0L0P0C0R0M2"               Set 5 second timeout, initialize
5: wrt "3325","FU1FR1KH-56DB";ret                        audio source and 8901A
6:
7: "3325A Device subroutines":
8: "Aff":fmt "FR",f.4,"KH";wrt "3325",p1;ret             Audio frequency (Aff) and
9: "Afl":fmt "AM",f.2,"DB";wrt "3325",p1;ret             level (Afl) subroutines
10:
11: "8901A Device subroutines":
12: "Am":
13: fmt ;wrt "Ma","M1T3";red "Ma",p1
14: ret
15: "Cnt":
16: fmt ;wrt "Ma","M5AU7.1SP4.1SPT3";red "Ma",p1
17: wrt "Ma","AU";if (p1-9e9)/100=10;wrt "Ma","T3";red "Ma",p1
18: ret
19: "Dem":
20: p1→p0;if p0>=750;100→p0
21: fmt "P",f1.0,"P",f1.0;wrt "Ma",p2#0,p0/25+(p0>=25)
22: ret
23: "Det":                                                8901A device subroutines
24: fmt "D",f1.0,;wrt "Ma",p1;if p2#0;wtb "Ma","D3"
25: ret
26: "Flt":
27: (p1>0)+(p1>50)→p3;(p2>0)+(p2>3)+(p2>15)→p4
28: fmt "H",f1.0,"L",f1.0;wrt "Ma",p3,p4
29: ret
30: "Fm":
31: fmt ;wrt "Ma","M2T3";red "Ma",p1
32: ret
33: "Pep":
34: fmt ;wrt "Ma","M4T3";red "Ma",p1
35: ret
36:
37: "Fm/lim":                                  FM modulation limiting subroutine
38: cll 'Afl'(p2)                              Set starting audio source level
39: fmt ;wrt "Ma","M2";wait 500                Select FM mode and settle for 500ms
40: cll 'Det'(1,1)                             Select PEAK HOLD and PEAK +
41: cll 'Afl'(p2+20);cll 'Afl'(p2);cll 'Afl'(p2+20)   Increase audio level 20 dB twice
42: wrt "Ma","T3";red "Ma",p1                  Trigger and read instantaneous peak deviation
43: cll 'Det'(1);cll 'Fm'(p4)                  Select PEAK + detector and read steady-state deviation
44: cll 'Afl'(p2)                              Reset starting audio level
45: ret
46: "Fmsens":                                  FM Microphone sensitivity subroutine
47: if p5=0 ;3000→p5                           Default to 3 kHz desired FM deviation
48: cll 'Aff'(p2);cll 'Afl'(p4);cll 'Flt'(0,15);cll 'Fm'(p6);p4→p1
49: p1+20log(p5/p6)→p1                         Calculate next audio level
50: if abs(p6-p5)<50;ret                       Return if measured deviation is within 50 Hz of desired
51: if p1>25 or p1<-56;prt "*fmsens failed*";ret
52: cll 'Afl'(p1);cll 'Fm'(p6);gto -3          Set new audio level and measure FM deviation
53:
54: "axis":ofs p1,p2
55: plt p3,0;plt p4,0,-1;plt 0,p5;plt 0,p6,-1
56: for I=-int(abs(p3/p7))*p7 to p4 by p7
57: if I#0;plt I,-.6;plt I,.6,-1                Subroutine to draw axes
58: next I
59: for I=-int(abs(p5/p8))*p8 to p6 by p8
60: if I#0;plt -.6,I;plt .6,I,-1
```

```
61: next I
62: ofs -p1,-p2;ret
63:
64: "label":ofs p1,p2;csiz 2
65: plt p3,p4,1;lbl A$;csiz 2,2,1,90                        X and Y axis label subroutine
66: plt p5,p6,1;lbl B$;csiz 2;ofs -p1,-p2;ret
67:
68: "start":                                                Start of main program
69: dim A$[20],B$[20],A[20,3],C$[10]                        Ask operator if a 9872A plotter
70: ent "Is a 9872A plotter connected",C$                   is connected. Press "continue"
71: if pos(cap(C$),"N")=0;gto "setup"                       for yes. If "n" or "no" is entered,
72: sfg 1;16→r0;gto "cont"                                  flag 1 is set and the thermal strip
73:                                                         printer becomes the output device.
74: "setup":
75: "Assign plotter address":dev "9872",705                 Assign plotter address, select pen #1,
76: psc 705;pclr;pen# 1;wrt "9872","VS20"                   and set writing speed to 20cm/s
77:
78: dsp "Setting up plot. Standby . . ."
79: scl 0,100,0,100                                         Scale paper in X and Y from 0 to 100
80: csiz 5,2,1,0                                            Select large character size
81: plt 5,85,1;cplt 1,0;lbl "FM Mobile";cplt -10,-1;lbl "Transmitter"
82: cplt -10,-1;lbl "Model XYZ"                             Print titles
83: csiz 2;plt 12,49,1;lbl "Transmitter Tests"
84: plt 12,48;plt 28,48,-1;plt 30,48;plt 37,48,-1           Underline previous title
85: plt 5,40,1;lbl "Power="
86: plt 5,35,1;lbl "Frequency="
87: plt 5,30,1;lbl "Freq. Error="
88: plt 5,25,1;lbl "Mic. Sens.="                            Print test headings
89: plt 5,20,1;lbl "Mod. Limiting="
90: plt 5,15,1;lbl "Residual FM="
91: plt 5,10,1;lbl "Incidental AM="
92: "Rate(kHz)"→A$;"Pre-emphasis(dB)"→B$                    Assign X and Y axis labels
93: cll ´axis´(60,87,0,36,-27,9,17.5,3)                     Draw axes for upper plot
94: cll ´label´(60,87,10,-35,-6.5,-21)                      Label axes for upper plot
95: plt 59,96,1;cplt -2,0;csiz 1,1,1;lbl "+6"
96: plt 59,86.5,1;cplt -1,0;lbl "0"                         Label Y-axis tic marks
97: plt 59,71.5,1;cplt -3,0;lbl "-10"
98: plt 60,60,1;cplt -1,-1.2;lbl ".1"
99: plt 77.5,60,1;cplt -.5,-1.2;lbl "1"                     Label X-axis tic marks
100: plt 95,60,1;cplt -.5,-1.2;lbl "10"
101: "Flatness(dB)"→B$                                      Reassign Y-axis label
102: cll ´axis´(60,33,0,36,-18,7,17.5,3)                    Draw axes for lower plot
103: cll ´label´(60,33,10,-30,-6,-17)                       Label axes for lower plot
104: plt 59,39,1;cplt -2,0;csiz 1,1,1;lbl "+2"
105: plt 59,32.5,1;cplt -1,0;lbl "0"                        Label Y-axis tic marks
106: plt 59,26.5,1;cplt -2,0;lbl "-2"
107: plt 59,20.5,1;cplt -2,0;lbl "-4"
108: plt 60.5,7,1;csiz 1,1,1,90;lbl ".316"
109: plt 78,7,1;lbl "1";plt 95.5,7,1;lbl "3.16";csiz 2       Label X-axis tic marks
110: "set plotter max. speed (36cm/s)":wrt "9872","VS36"
111: "Use pen #4":pen# 4
112: "Position pen in upper right corner":plt 100,100,1
113: "cont":dsp "Connect next transmitter";stp              Display prompt and wait for
114: cll ´Init´;cll ´Aff´(1)                                operator to connect the transmitter
115:
116: "Assign XMTR frequency in variable A (in MHz)":
117: 132→A
118:
119: if flg1=0;gto +4                                       Print test heading on the
120: fmt 2/,3x,"----------",/,3x,"Model  XYZ";wrt r0        strip printer if flag 1 is set
```

Example Program (continued)

```
121: fmt 3x,"----------",2/,3x,"XMTR Tests",2/;wrt r0
122:
123: cll ´Pep´(P)
124: "Compensate reading for 30db Pad (P*le3)":                    }
125: if flgl;fmt "Power=",/,5x,f5.1," watts",/;wrt r0,P*le3;gto +3 }— Measure power
126: plt 29,40,1;fxd 1;lbl P*le3," watts"                          }
127:
128: cll ´Cnt´(F);F-A*le6→E ——————————————————————————————————— Measure frequency
129: if flgl=0;gto +3
130: fmt "Frequency=",/,2x,f10.5," MHz",/;wrt r0,F*le-6     }
131: fmt "Freq. error=",/,8x,f5.0," Hz",/;wrt r0,E;gto +5   }——— Print frequency
132: plt 29,35,1;fxd 5;lbl F*le-6," MHz"                    }    and frequency error
133: plt 29,30,1;fxd 0;lbl E," Hz"                          }
134:
135: "Use -7 dBm for starting Mic. sens.' estimate":        ┌— Measure microphone sensitivity,
136: cll ´Fmsens´(M,1,F,-7);1000√.05tn^(M/20)→S ————————————┘  & convert dBm (50Ω) to mV
137: if flgl;fmt "Mic. Sens=",/,9x,f4.0," mV",/;wrt r0,S;gto +3 ———— Output result
138: plt 29,25,1;fxd 0;lbl S," mV"
139:
140: cll ´Fm/lim´(D,M) ——————————————————————— Measure instantaneous modulation limiting
141: if flgl;fmt "Mod. Limiting=",/,7x,f5.2," kHz",/;wrt r0,D*le-3;gto +3
142: plt 29,20,1;fxd 2;lbl D*le-3," kHz" ————————————————————————— Output result
143:
144: "Set Audio source to min level ":                   }
145: cll ´Afl´(-56);cll ´Aff´(100)                       }——————————— Measure residual FM
146: cll ´Flt´(300,3);cll ´Det´(4);cll ´Fm´(R)           }
147: fmt ;wrt "Ma","T3";red "Ma",R ————————— Take additional reading to ensure proper setting
148: if flgl;fmt "Residual FM=",/,9x,f4.0," Hz",/;wrt r0,R;gto +3 ———— Output result
149: plt 29,15,1;fxd 0;lbl R," Hz"
150:
151: cll ´Aff´(1);cll ´Afl´(M) ————————— Reset audio source to microphone sensitivity setting
152: cll ´Flt´(50,3);cll ´Det´(1);cll ´Am´(A) ———————————————— Measure incidental AM
153: if flgl;fmt "Incidental AM=",/,9x,f5.2," %",3/;wrt r0,A;gto "fin"——— Output
154: plt 29,10,1;fxd 2;lbl A," %"                                            Result
155:
156: "Measure reference data points":
157: cll ´Flt´(0,15);cll ´Dem´(0);cll ´Fmsens´(R,1,F,M-9,1000) ——— Measure pre-emphasis
158: cll ´Dem´(750,1);cll ´Fm´(S)
159:
160: "Set up logarithmic audio sweep":    }
161: .2→T;6→U;18→N;(U/T)^(1/N)→V;T/V→T    }———— Compute log increment (V) for an 18 point
162:                                              sweep from 200 Hz to 6 kHz
163: "Plot pre-emphasis curve":
164: ofs 60,87;cll ´Dem´(0) ——————————————————————— Offset pen, turn off PRE-DISPLAY
165: for I=1 to N+1
166: T*V→T→A[I,1];cll ´Aff´(A[I,1]) ——————————— Increment and store audio frequency
167: cll ´Fm´(A[I,2])
168: 20log(A[I,2]/1000)→X;if X<-16;gto +2 }———— Normalize measured deviation in dB (X)
169: plt log(A[I,1]/.1)*17.5,1.5*X        }        and plot if X is greater than −16
170: next I
171: pen;ofs -60,-87 ————————————————————————————————————— Lift pen, clear pen offset
172:
173: "Plot flatness":
174: ofs 60,33;1→I;cll      '750,1) ———————— Set new pen offset and 750µs PRE-DISPLAY mode
175: if A[I,1]<=.315;gto +3 ———————————— Skip to next point if frequency is less than 315 Hz
176: cll ´Aff´(A[I,1]);cll ´Fm´(A[I,3])
177: plt log(A[I,1]/.315)*35,20log(A[I,3]/S)*3 ———— Scale measurement in plotter units and plot
178: if A[I+1→I,1]<3.16;gto -3 ———————— Increment to next point if frequency is less than 3.16 kHz
179: pen# ;ofs -60,-33;plt 100,100,1 ———— Put pen away, position pen holder in upper right corner
180: "fin":dsp "done";stp
181: end
```

Bus Commands

Table 6-9 lists the IEEE 488 bus commands to which the 8901A responds. Hewlett-Packard instrument controllers automatically use these commands making them transparent to the programmer.

Table 6-9. Bus commands to which the 8901A responds.

	Function	Command	Response
Device control	Address	Talk Listen	8901A outputs measurement result and remains in local or remote. 8901A goes to remote and listens for data.
	Unaddress	UNT Untalk UNL Unlisten	If talking 8901A is unaddressed. 8901A ceases to listen to data.
	Clear	DCL Device Clear SDC Selective Device Clear	Sets 8901A to automatic operation, frequency measurement mode, and trigger to free run.
	Remote	REN Remote Enable GTL Go to local REN Remote Disable	8901A remains in local until first addressed to listen. 8901A returns to local control, all instrument functions and settings are unchanged.
	Local Lockout	LLO Local Lockout	Disables all front panel keys.
	Trigger	GET Group Execute Trigger	8901A makes a settled measurement (same as program code T3).
Interrupt/ Status	Require Service	SRQ Service Request	8901A requests service when service request mask conditions occur.
	Status Byte	SPE Serial Poll Enable SPD Serial Poll Disable	Sets serial poll mode and latches RQS in 8901A. Terminates serial poll mode.
Abort	Abort	IFC Interface Clear	8901A ceases to talk or listen.