HP 8901A
MODULATION ANALYZER
Operation and Calibration Manual

SERIAL NUMBERS

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

1836A to 1933A and all *MAJOR* changes that apply to your in instrument.

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

First Edition

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

Operation and Calibration Manual HP Part 08901-90135

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

Printed in U.S.A. : June 1989

HEWLETT PACKARD

CERTIFICATION

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

WARRANTY

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

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

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

LIMITATION OF WARRANTY

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

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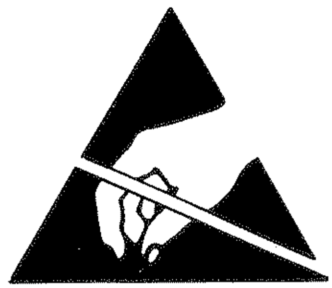

ATTENTION
Static Sensitive
Devices

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

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

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

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

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

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

SAFETY CONSIDERATIONS

GENERAL

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

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

BEFORE APPLYING POWER

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

SAFETY EARTH GROUND

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

SAFETY SYMBOLS

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

⚡ Indicates hazardous voltages.

⏚ Indicates earth (ground) terminal.

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

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

WARNING

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

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

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

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

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

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

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

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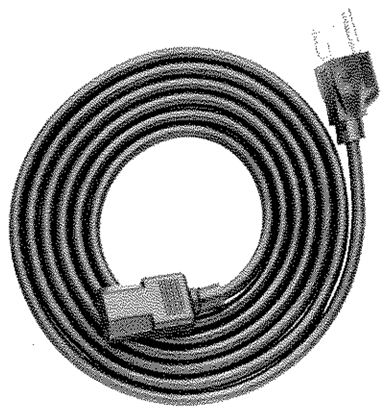
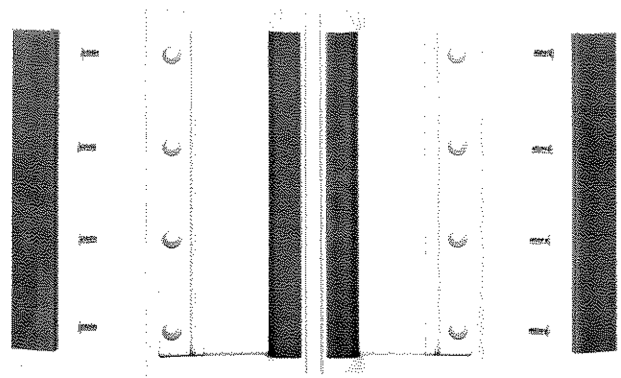
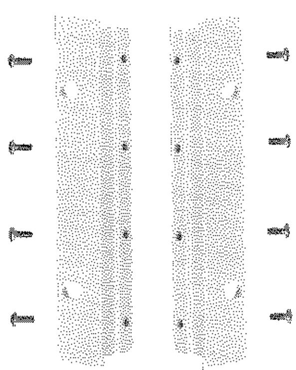
MODEL 8901A



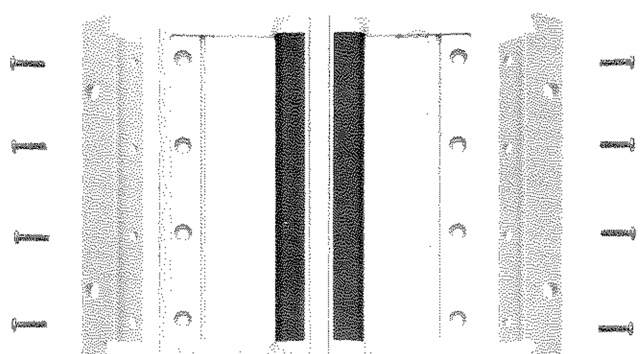
LINE POWER CABLE



OPTION 907
FRONT HANDLE KIT



OPTION 908
RACK FLANGE KIT



OPTION 909
RACK FLANGE AND FRONT
HANDLE COMBINATION KIT

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

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

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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.

[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.

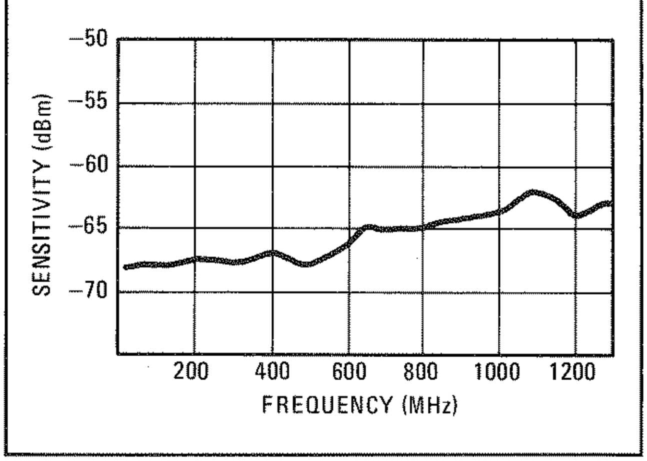


Figure 1-2. Typical Sensitivity of Frequency Measurements in Manual Operation

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

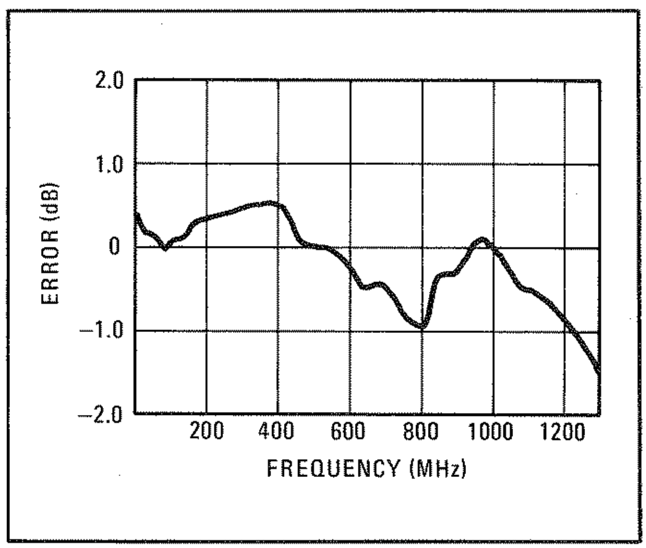


Figure 1-3. Typical Power Measurement Accuracy

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.

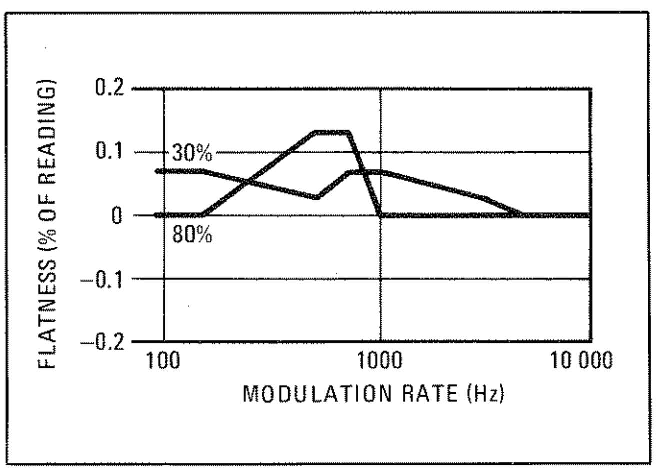


Figure 1-4. Typical AM Flatness

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

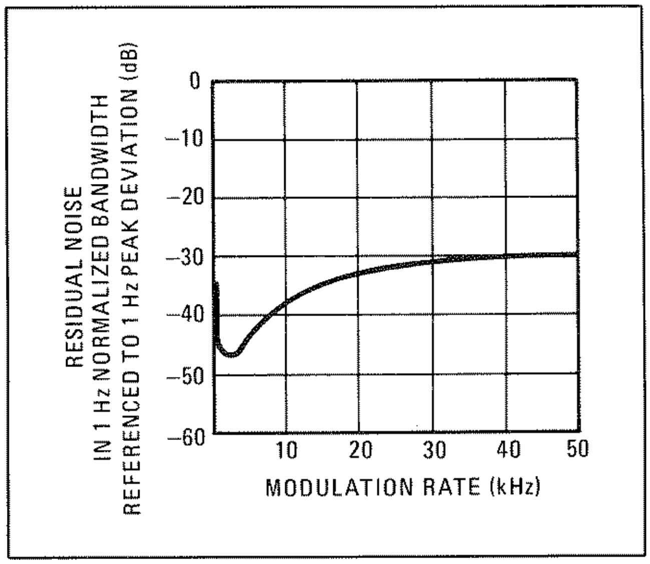


Figure 1-5. Typical Internal Noise Contribution to FM Measurements at 100 MHz Carrier Frequency

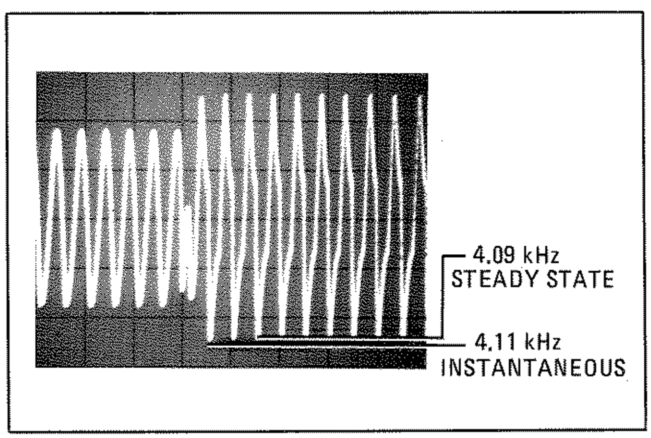


Figure 1-6. FM Mobile Radio Modulation Limiting Measurement Showing Demodulated Waveform and Measured Value of Transient and Steady-State Deviation

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.

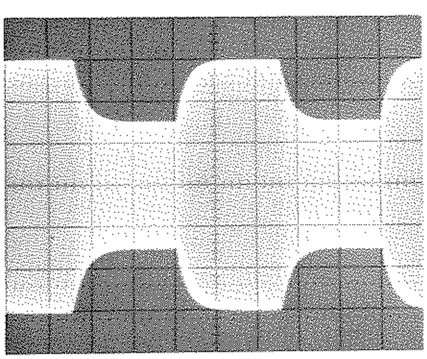


Figure 1-7. AM Calibrator Waveform

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.

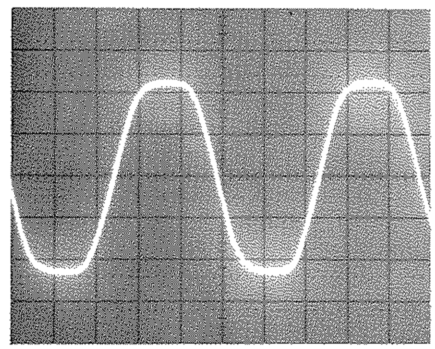


Figure 1-8. FM Calibrator Modulation Waveform

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.

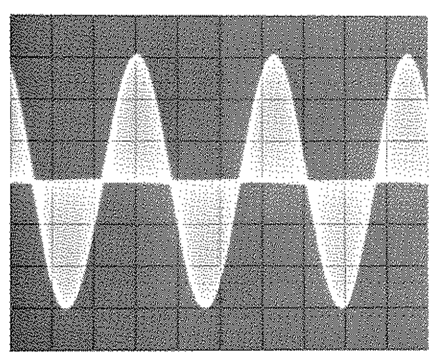


Figure 1-9. Demodulated FM Stereo Test Signal at 15 kHz Rate

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 (1×10^{-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 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.

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

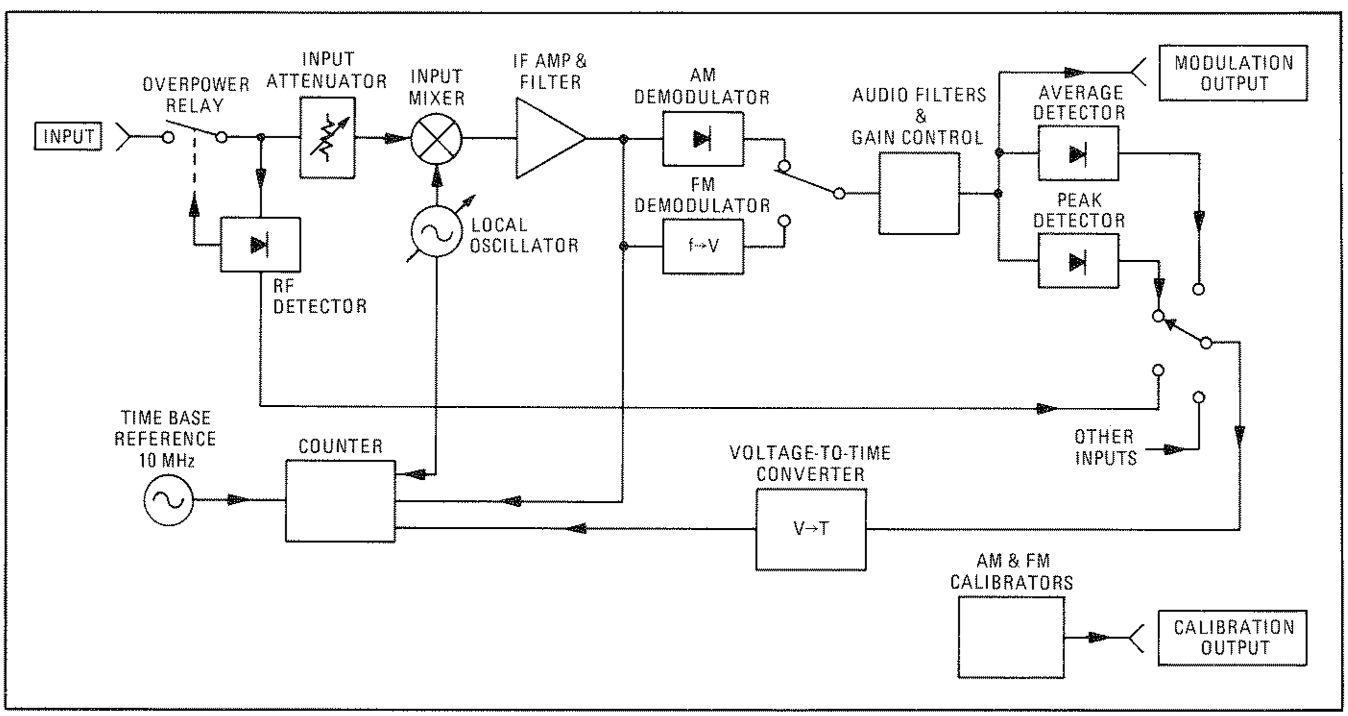


Figure 1-10. HP 8901A Modulation Analyzer Simplified Block Diagram

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.

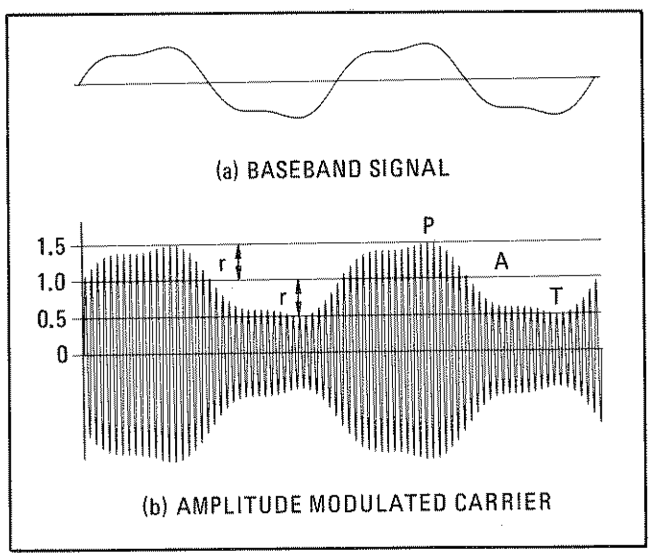


Figure 1-11. A Baseband Signal and the Correponding Amplitude Modulated Carrier

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%.

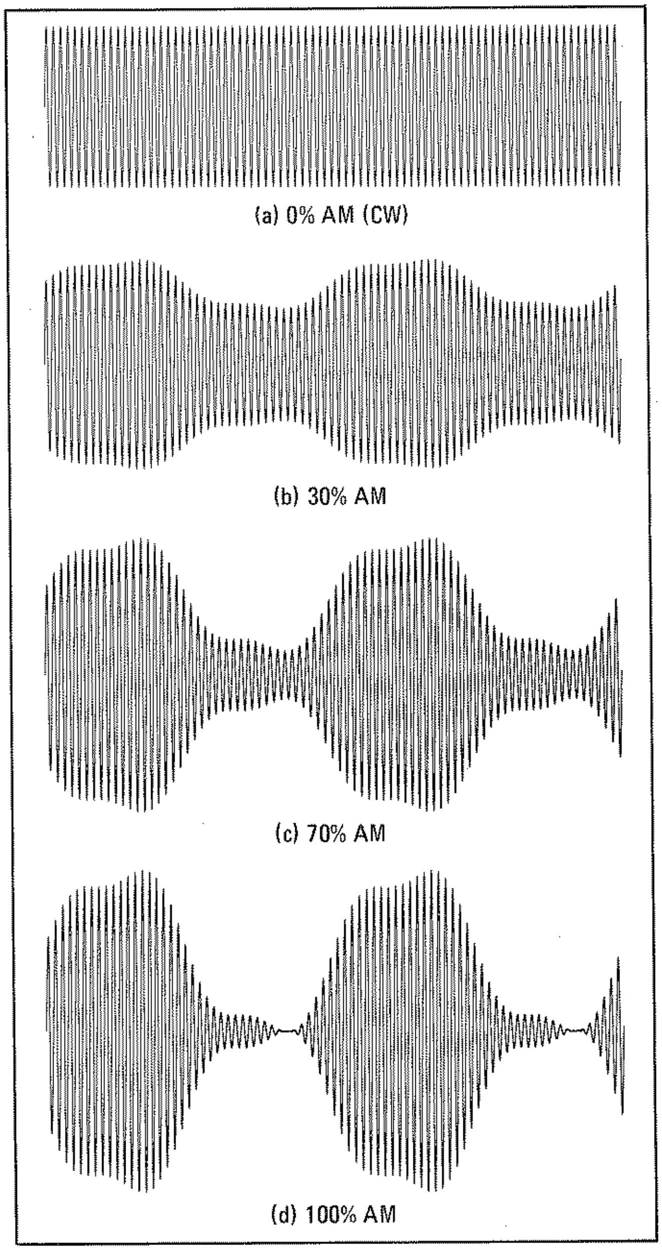


Figure 1-12. AM for Various Depths

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,

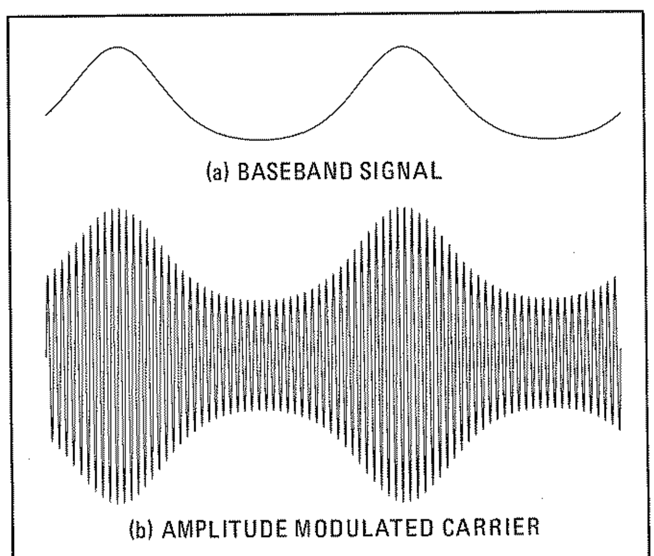


Figure 1-13. AM with an Asymmetrical Baseband Signal

MODULATION BASICS (Cont'd)

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

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.

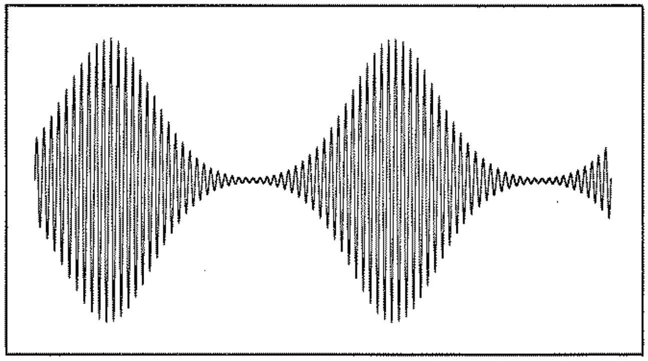


Figure 1-14. AM with Modulation Exceeding 100% as Measured by the PEAK+ Detector

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.

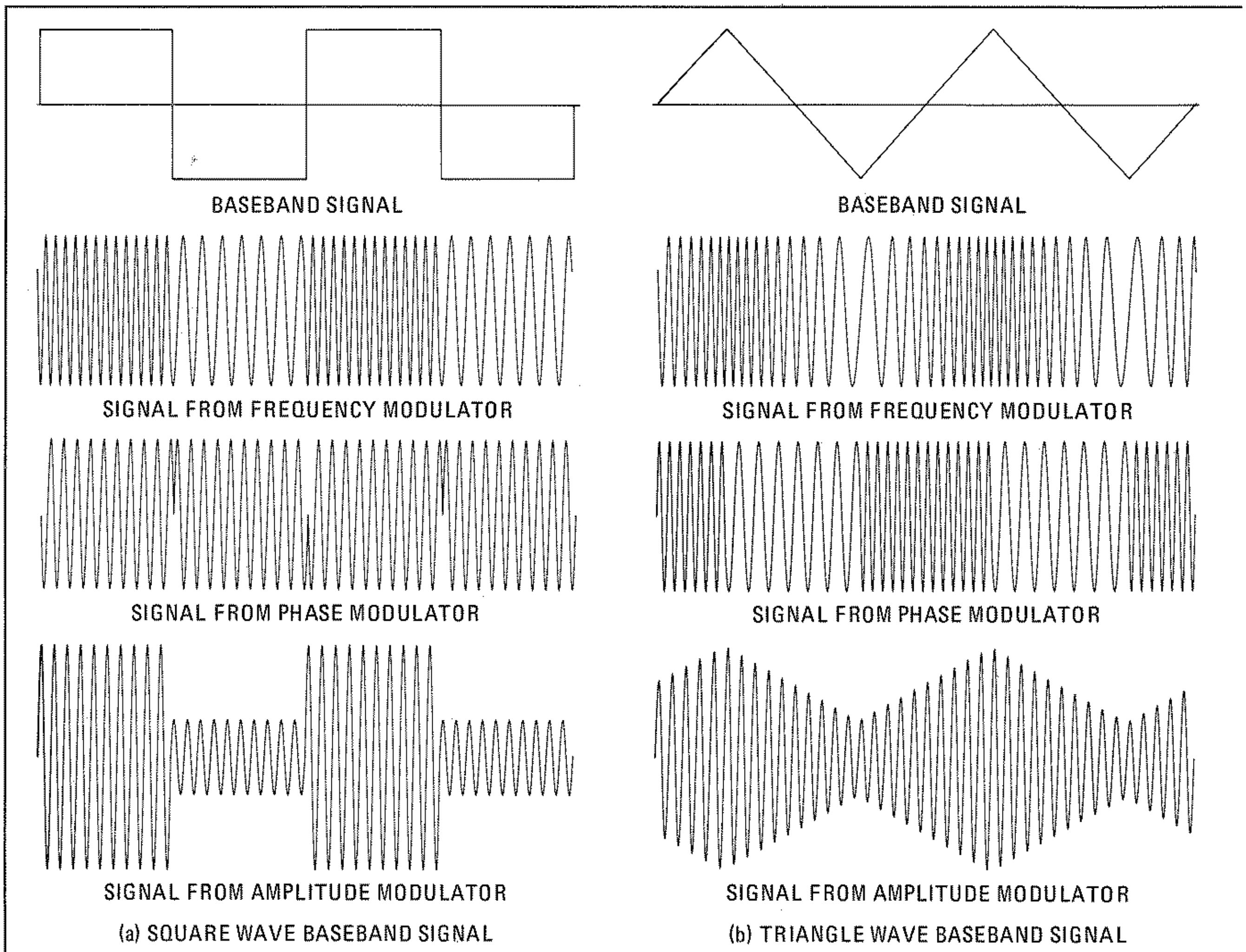


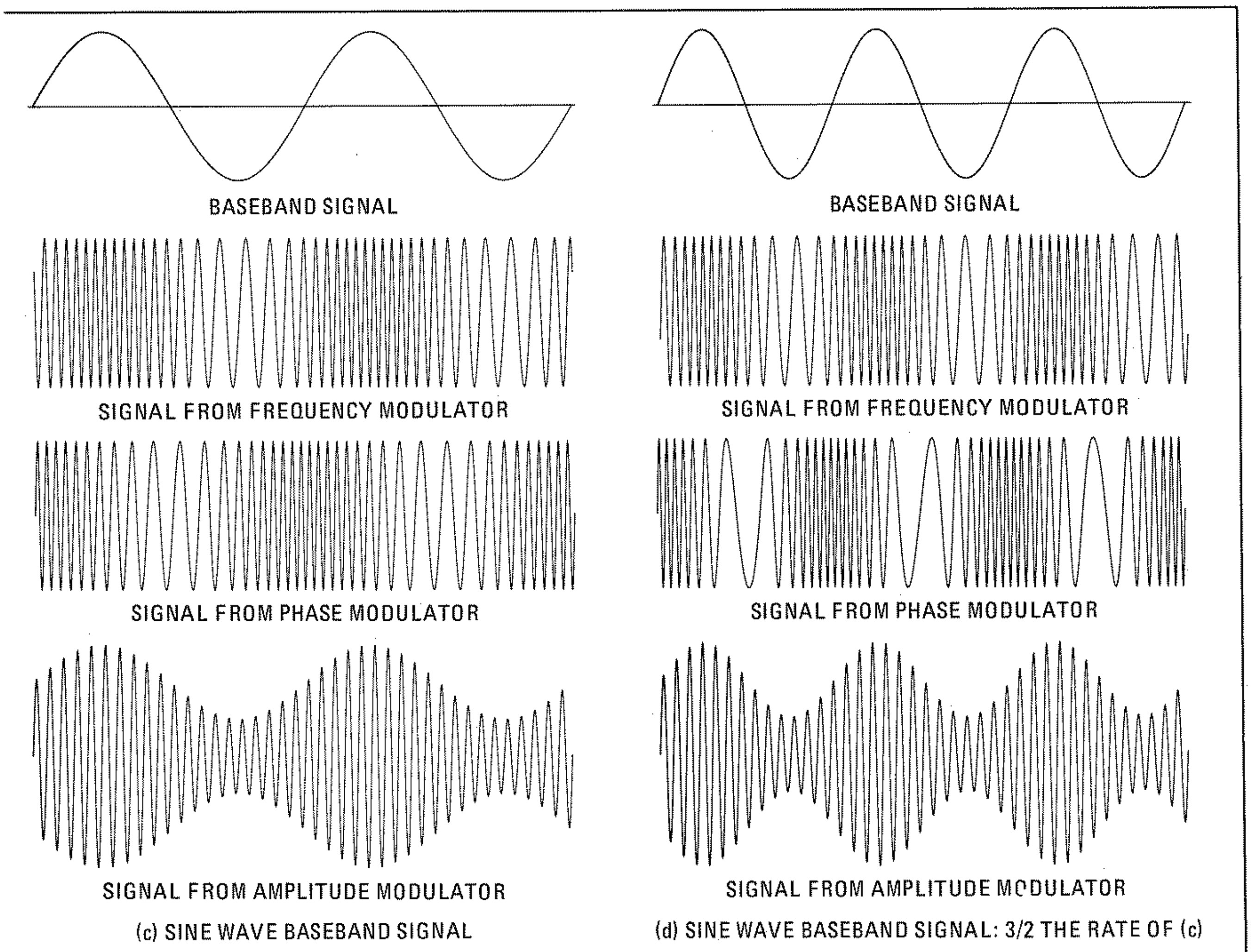
Figure 1-15. Signals from Frequency, Phase, and

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-



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)		

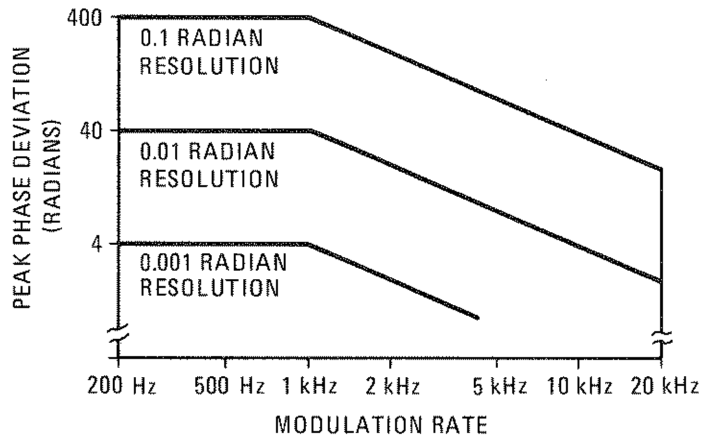


Figure 1-16. Phase Modulation Deviation and Maximum Resolution

Electrical Characteristic	Performance Limits	Conditions
AMPLITUDE MODULATION		
Rates	20 Hz to 10 kHz	150 kHz to 10 MHz carrier
	20 Hz to 100 kHz	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	≤50% depth
	<0.6% THD	≤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

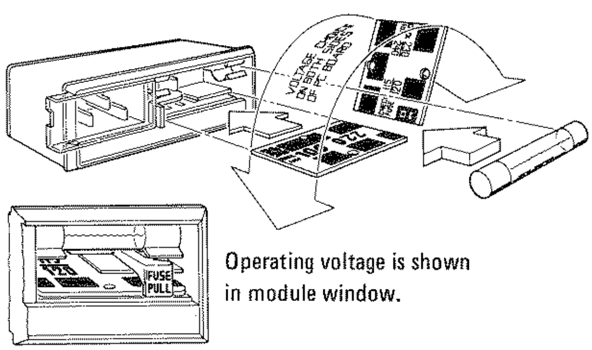
BEFORE CONNECTING THIS INSTRUMENT, the protective earth terminals of

(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).



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 HP-IB

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

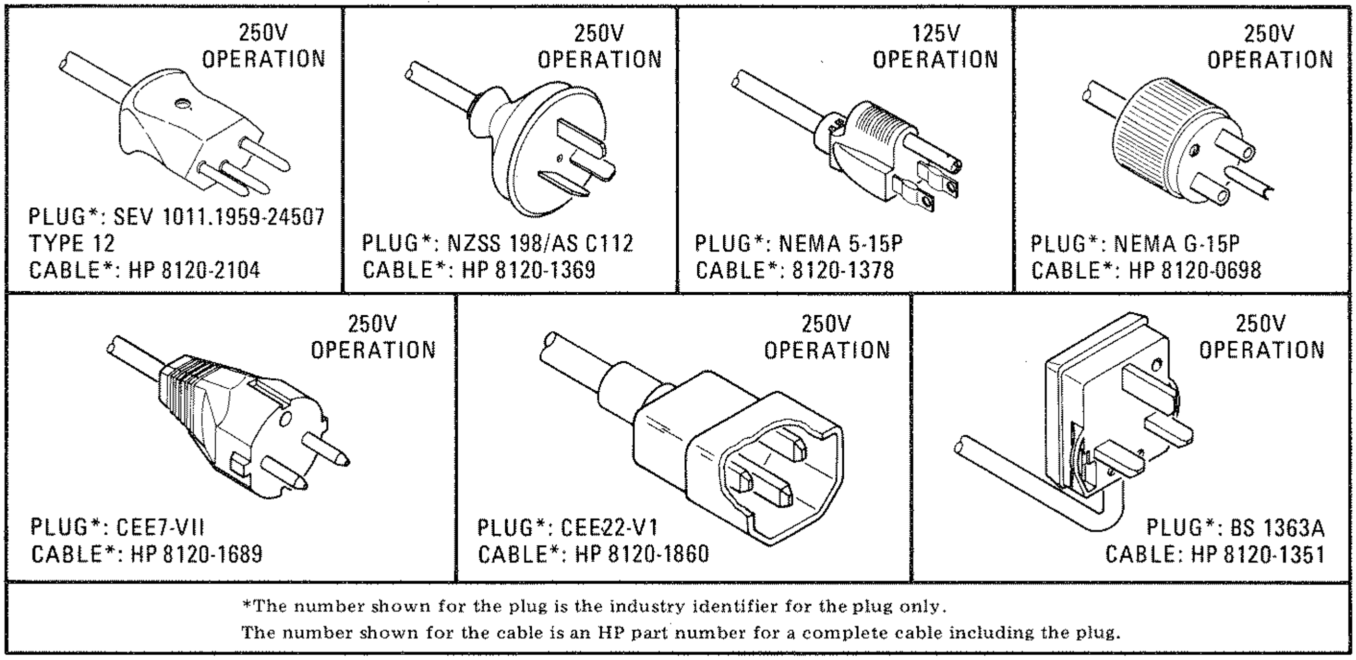


Figure 2-2. Power Cable and Mains Plug Part Numbers

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.)

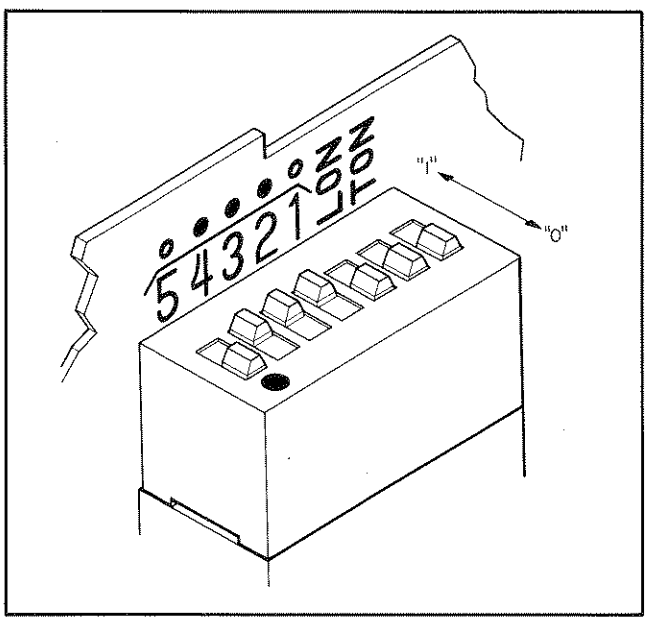


Figure 2-3. The HP-IB Address Switch Shown as Set by the Factory. The Address Shown is 01110 in Binary With Both Talk Only and Listen Only Off.

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.

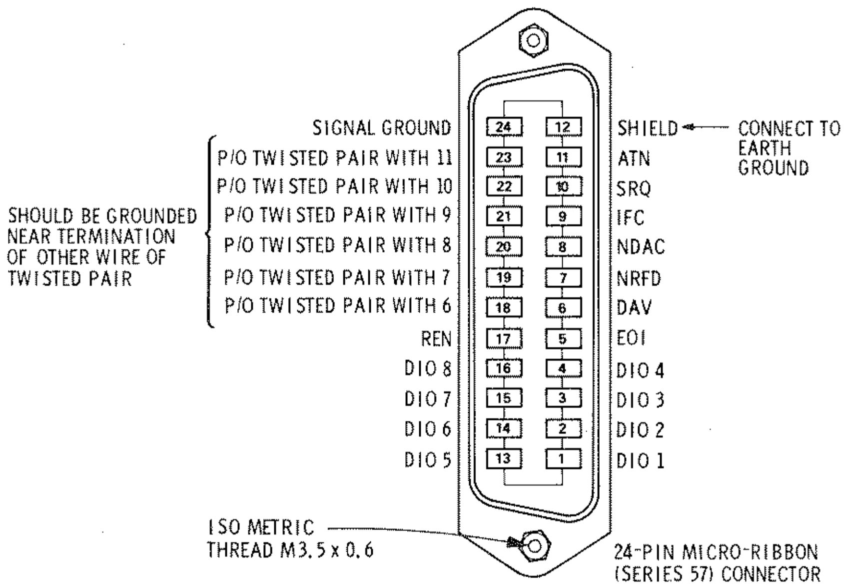
2-9. Mating Connectors

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 10833A, 1 metre (3.3 ft); HP 10833B, 2 metres (6.6 ft);
HP 10833C, 4 metres (13.2 ft); HP 10833D, 0.5 metres (1.6 ft).

Cabling Restrictions

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

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

Figure 2-4. 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-

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.

FRONT-PANEL FEATURES

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

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

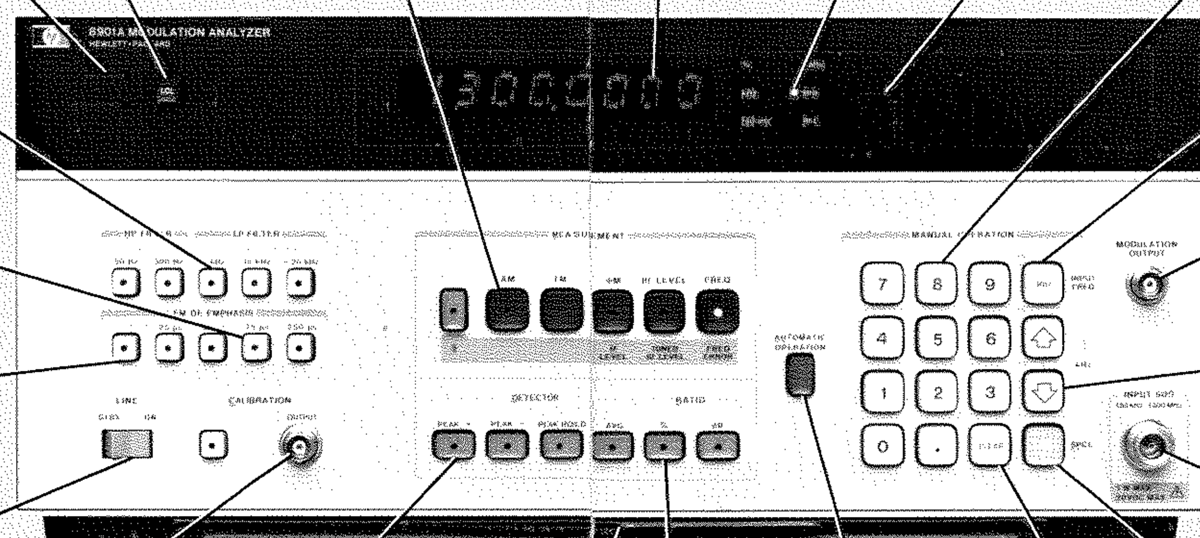
Display Annunciators indicate the measurement result units.

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

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

HP-IB Annunciators indicate remote operation status.

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



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

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

FM DE-EMPHASIS networks equalize pre-emphasized FM.

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

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

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

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

INPUT couples modulated signal into the instrument.

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

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

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.

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.

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

For more on panel features, see Figures 3-3 through 3-6 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 D EMPHASIS (FM only).

Level:

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

Frequency:

Tune, then press: [FREQ] or [$] [FREQ ERROR] ; or

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

then press: MZ [MHz] INPUT FREQ [$] [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]

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 250V normal blow fuse of the same rating. Do not use repaired fuses or short circuited fuseholders.

The only maintenance the operator should normally perform is the replacement of the primary power fuse located within the Line Power 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 b 100/120 Vac operation and 2110-0001, 1A (250V, normal blow) for 220/2 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 k inputs of 150 kHz to 10 MHz; deviation to 100 kHz pe 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 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 Analy 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 Modulation Analyzer's tuning. IF Frequency (Special Function 10): Frequency of signal in
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 c performed before the displayed measurement is made (Pr 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 measu ment results to a reference value. Display can be in % o Limit: Data may be entered as upper and lower limits. Lim annunciator lights when limits are exceeded.
Manual Operation	Input attenuation, ranges, tuning, IF frequency, frequency lution and many other operations may be manually con
Remote Operation	All Modulation Analyzer operations except the line switch be controlled via the Hewlett-Packard Interface Bus.

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.

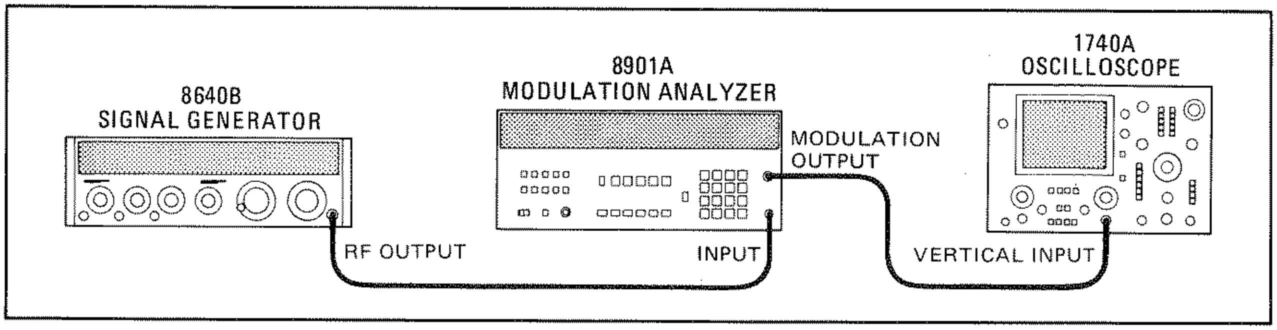
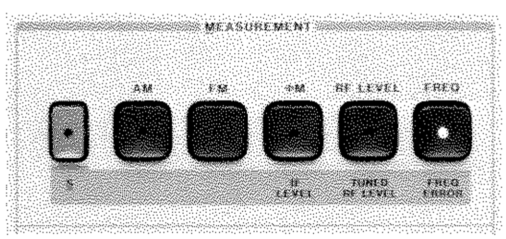


Figure 3-2. Getting Acquainted Setup

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.

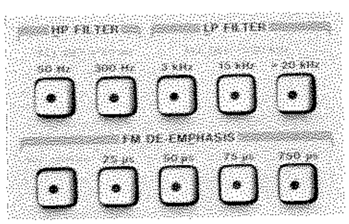
RF Level Measurement. Press RF LEVEL. The display now shows the generator's output power in watts using scientific notation. The "–03" at the right end of the display is the power-of-ten multiplier, i.e., "milli" watts.

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)

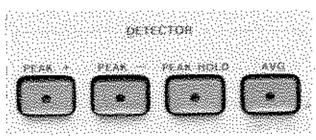
3 kHz without changing its deviation. As the rate goes above 3 kHz, the displayed FM drops. This is also true of the signal on the oscillosope.

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.

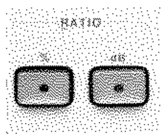
Average (RMS Calibrated). Press PEAK+ or PEAK− to turn PEAK HOLD off. Note the display, then press AVG. The reading should drop by about 30%. You are seeing the rms frequency deviation as measured by an average responding detector. This mode is normally reserved for measurement of

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*

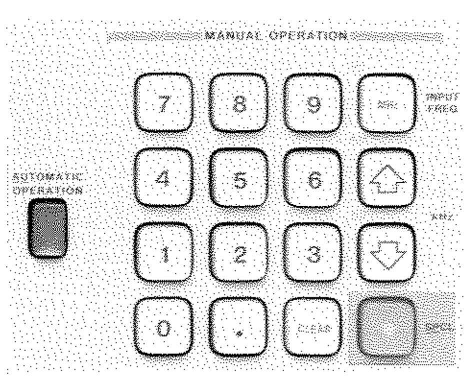
**If the carrier frequency at INPUT is below 10 MHz, the 15 kHz low-pass filter will remain on.*

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 1W*	*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.

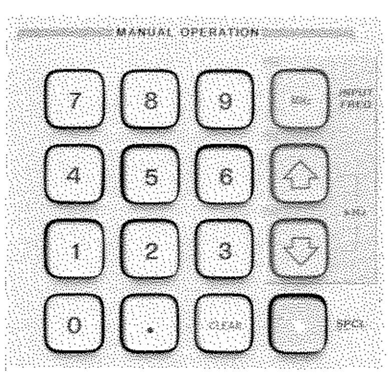
If the display reads E01, it is trying to tell you that your signal is not quite centered in the IF. Slowly tune the signal towards the frequency you keyed in until E01 disappears and the generator's frequency is displayed. (Normally, the signal must be within 50 kHz of the frequency keyed in when above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

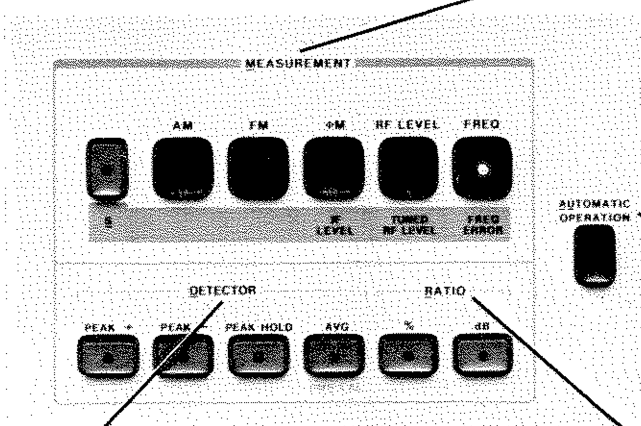
● **LCL** (local) key returns the Modulation Analyzer to local keyboard control from HP-IB (remote) control provided the instrument is not in Local Lockout.

● **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).



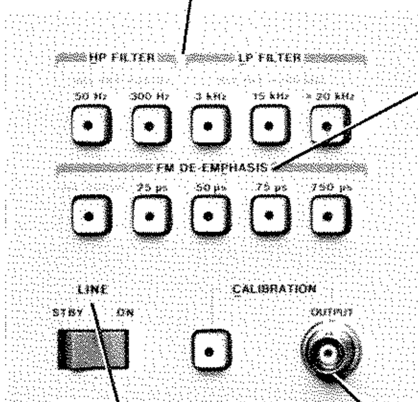
● **AUTOMATIC OPERATION** configures the Modulation Analyzer to automatically tune to the largest detectable input signal and make the measurement selected. This key also sets the Special Functions 1 through 8 to their zero-suffix mode and turns off many other Special Functions.

● **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.

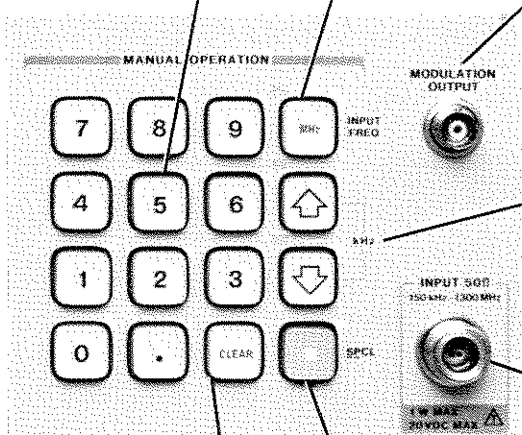
LINE switch applies power to the Modulation Analyzer when set to the ON position. In the STBY (standby) position, power is applied only to the high-stability reference oscillator oven (Option 002 only).

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 40V (ac + dc) to the INPUT jack or damage to the instrument may result.

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

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

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

REAR-PANEL FEATURES

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

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

CAUTION

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

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

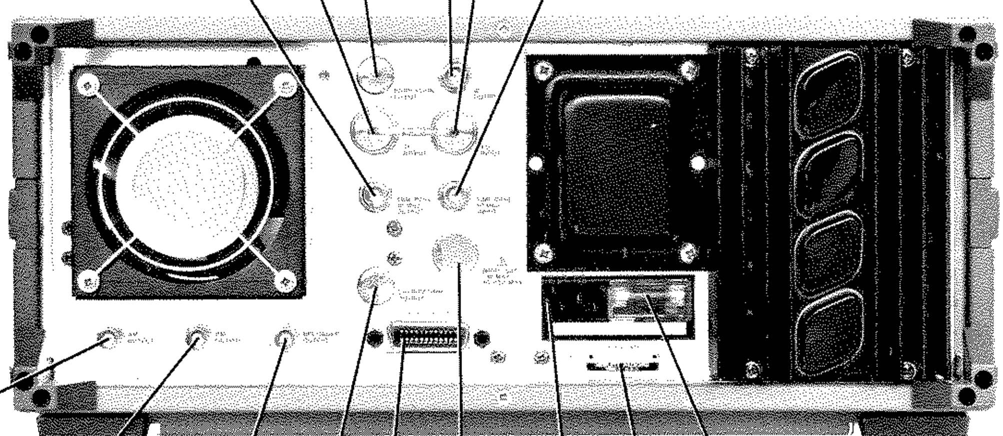
IF OUTPUT produces a 150 kHz to 2.5 MHz modulated IF signal. The output level ranges from −27 to −3 dBm (50Ω output impedance).

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

CAUTION

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

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



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

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

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

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

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

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

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

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

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

Figure 3-6. Rear-Panel Features

OPERATOR'S CHECKS

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.

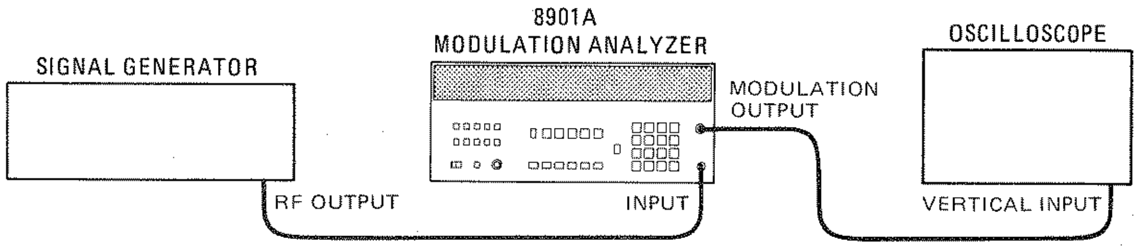


Figure 3-7. Basic Functional Checks Setup

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. -6

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.

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.

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.

OPERATOR'S CHECKS

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.

OPERATOR'S CHECKS

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	RESET 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

OPERATOR'S CHECKS

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

OPERATOR'S CHECKS

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.

OPERATOR'S CHECKS

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.

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

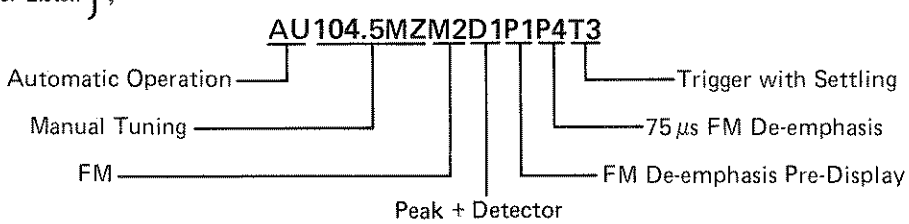
EXAMPLE 1: General Program Syntax and Protocol

{ 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 } ,



HP-IB

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
/		

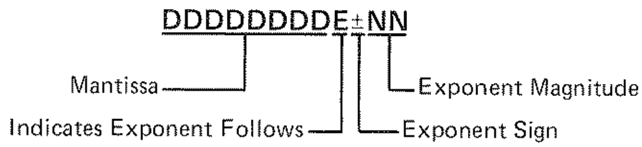
*Except when inserted between two characters of a program code.

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:

```
±DDDDDDDDE±NNCRLF
```

- ±DDDDDDDD — Signed Mantissa
- E — Indicates Exponent Follows
- ± — Exponent Sign
- NN — Exponent Magnitude
- CR — Carriage Return
- LF — Line Feed

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:

```
+900000DDE+02CRLF
```

- DD — Error Code
- CR — Carriage Return
- LF — Line Feed

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.

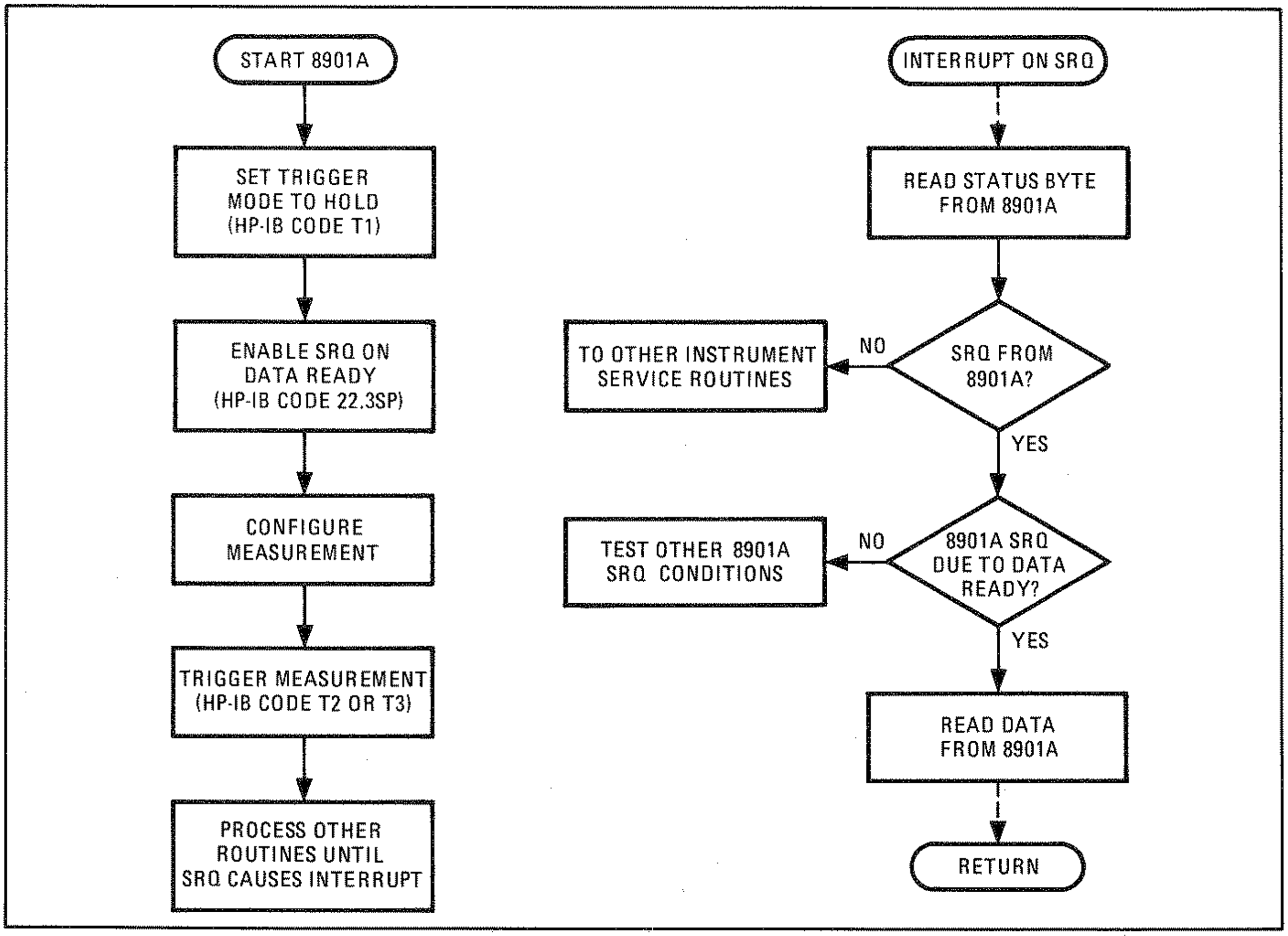


Figure 3-8. Example Flow Chart for Driving the Modulation Analyzer Using the Require Service Message (SRQ)

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:

DDDDDDDDE±NN

- DDDDDDDD — 8-Digit Mantissa (leading decimal not allowed)
- E — Indicates Exponent Follows
- ± — Exponent Sign
- NN — Exponent Magnitude

Output Formats:

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

±DDDDDDDDE±NNCRLF

- ±DDDDDDDD — Signed Mantissa
- E — Indicates Exponent Follows
- ± — Exponent Sign
- NN — Exponent Magnitude
- CR — Carriage Return
- LF — Line Feed

Errors:

+900000DDE+02CRLF

- DD — Error Code
- CR — Carriage Return
- LF — Line Feed

Return to Local:

Front panel LCL key if not locked out.

Manual Trigger:

Front panel CLEAR key initiates Trigger With Settling measurement cycle.

Status Byte:

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

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

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

Table 3-6. 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
		Average (RMS Calibrated)	D4 or U4
LP Filters			
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)

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

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 Time Constant		AM Calibrator	
Fast	5.0SP	Display Computed Peak AM Depth	13.0SP
Slow	5.1SP	Display Demodulated Peak Residual AM Depth	13.1SP
AM ALC Response Time		Display Demodulated Peak AM Depth	13.2SP
Slow	6.0SP	Set Limit	
Fast	6.1SP	Clear Limits; Turn Off LIMIT Annunciator	14.0SP
Open ALC	6.2SP	Set Lower Limit to Ratio Reference	14.1SP
Frequency Resolution		Set Upper Limit to Ratio Reference	14.2SP
Automatic Selection	7.0SP	Restore Lower Limit	14.3SP
10 Hz Resolution (f<1 GHz)	7.1SP	Restore Upper Limit	14.4SP
1000 Hz Resolution	7.2SP	Read Lower Limit	14.5SP
Error Disable		Read Upper Limit	14.6SP
Automatic Selection	8.0SP	Read Lower Limit Measurement Code	14.7SP
E01 disabled	8.1SP	Read Upper Limit Measurement Code	14.8SP
E02 & E03 disabled	8.2SP	Time Base Oven (Opt. 002)	
E01, E02, & E03 disabled	8.3SP	Display E12 If Oven Cold	15.0SP
E04 disabled	8.4SP	AM Calibration (Opt. 010	
E01 & E04 disabled	8.5SP	Disable AM Calibration Factor	16.0SP
E02, E03, & E04 disabled	8.6SP	Enable AM Calibration Factor	16.1SP
E01 through E04 disabled	8.7SP	Read AM Calibration Factor (0 if disabled)	16.2SP
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) Disable FM Calibration Factor Enable FM Calibration Factor Read FM Calibration Factor (0 if disabled)	 17.0SP 17.1SP 17.2SP	AAAAA.TLS AAAAA= address; T=1 means talk only; L=1 means Listen only; S=1 means SRQ.	
Tone Burst Receiver NN is delay in ms from signal detected at INPUT to activation of MODULATION OUTPUT	18.NNSP	Service Request 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 4 Instrument Error 8 Upper Limit 16 Lower Limit	22.NNSP
HP-IB Address Displays HP-IB Address in binary form:	21.0		

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	↓ Hz	S5	Frequency Error
HU	↑ Hz	T0	Free Run
HZ	Hz Input Frequency	T1	Hold
H0	HP Filters off	T2	Trigger Immediate
H1	50 Hz HP Filter on	T3	Trigger With Settling
H2	300 Hz HP Filter on	U1	Peak+
KD	↓kHz	U2	Peak−
KU	↑ kHz	U3	Peak Hold
K1	Clear	U4	Average (RMS Calibrated)
L0	LP Filters off	Z1	Hz Input Frequency
L1	3 kHz LP Filter on	Z2	↑ Hz
L2	15 kHz LP Filter on	Z3	↓ Hz
L3	>20 kHz LP Filter on	Z4	SPCL
MZ	MHz Input Frequency	Z5	SPCL SPCL
M1	AM	0—9	0
M2	FM		

Table 3-9. 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		
	IF Frequency and Input High-Pass Filter		
3.0SP	Automatic IF Selection; Filter Out		
	IF (MHz)	**Input HP Filter**	
3.1SP	0.455	Out	
3.2SP	1.5	Out	
3.3SP	0.455	In	
3.4SP	1.5	In	
	Tune Mode		
4.0SP	Automatic; Low-noise LO		
4.1SP	Automatic; Track		
4.2SP	Manual		
	Audio Peak Detector Time Constant		
5.0SP	Fast		
5.1SP	Slow		
	AM ALC Response Time		
6.0SP	Slow		
6.1SP	Fast		
6.2SP	Open ALC		
	Frequency Resolution		
7.0SP	Automatic Selection		
7.1SP	10 Hz Resolution (f<1 GHz)		
7.2SP	1000 Hz Resolution		

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

HP-IB

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

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

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

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: AM — Detector: PEAK + — Filters: 50 Hz, 15 kHz
HP-IB (program codes)	M1D1H1L2 (Measurement: M1, Detector: D1, Filters: H1L2)

Program Code HP-IB

M1 is the HP-IB code for AM.

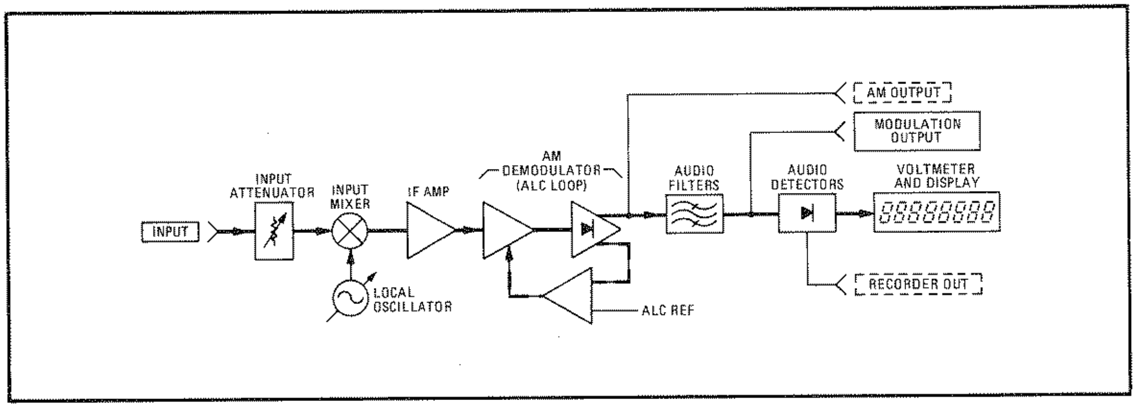
Indications

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

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

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.

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

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

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

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.

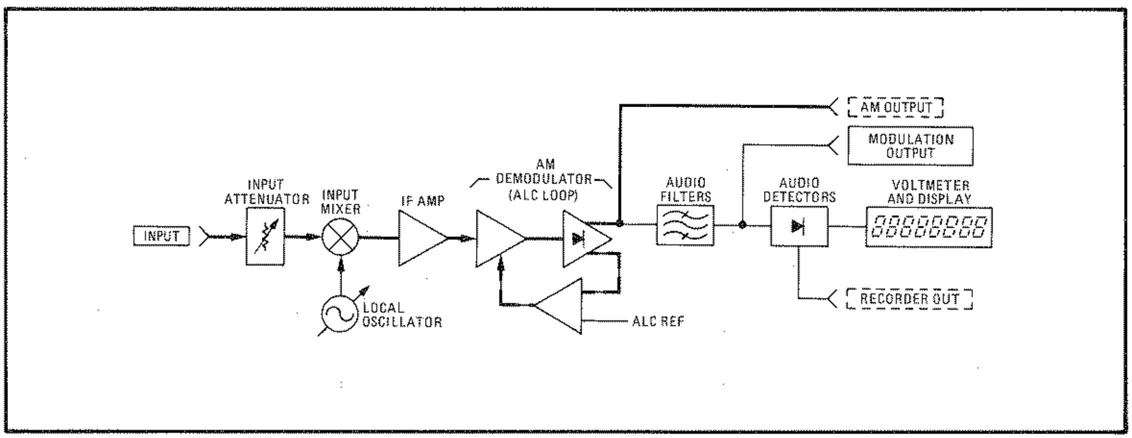
LOCAL (keystrokes)	Code: [6] [.] [2] Function: [•] SPCL
HP-IB (program codes)	6.2SP (Code: 6.2, Function: SP)

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:

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

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

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 [key]
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 ≤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 M1, Calibration C1)

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

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: 1 6 . 1 — Function: SPCL
HP-IB (program codes)	16.1SP (Code: 16.1; Function: SP)

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: 1 3 . 0 — Function: SPCL
HP-IB (program codes)	13.0SP (Code: 13.0; Function: SP)

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: 1 3 . 1 — Function: SPCL
HP-IB (program codes)	13.1SP (Code: 13.1; Function: SP)

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 — Function)

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

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

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

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

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

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

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)

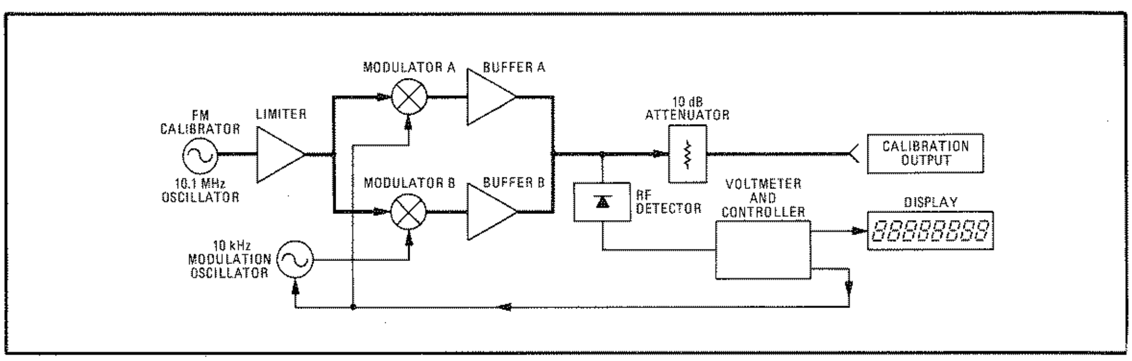
the Read AM Calibration Factor function is selected. If this function is selected and the AM Calibration Factor is enabled, the display will show the AM Calibration Factor, and the SPCL key will light. All annunciators and other key lights will turn off. The display will time out in about 2 seconds, 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 FM Calibrator sends an unmodulated 10.1 MHz carrier to the AM Calibrator. The AM Calibrator consists of two identical modulators in parallel whose outputs are summed. When the calibration cycle begins, each modulator is turned on individually and the level of its output is measured 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:

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

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

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

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

The Special Function codes are summarized in the table below:

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

Examples

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

LOCAL (keystrokes)	Measurement: FM [•] CALIBRATION [•]
HP-IB (program codes)	M2C1 (M2 = Measurement, C1 = 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: 1 7 . 1 Function: • SPCL
HP-IB (program codes)	17.1SP (Code: 17.1; Function: SP)

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

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

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

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

On both Modulation Analyzers:

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

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)

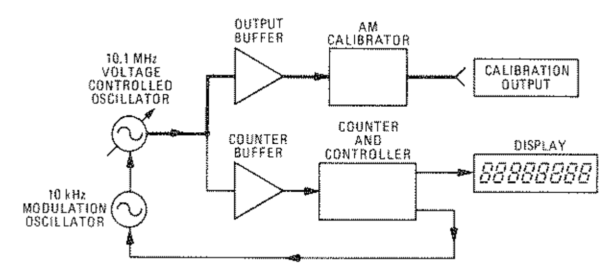
Indications (Cont'd)

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)
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: AM [•] Detector: PEAK – [•]
HP-IB (program codes)	M1D2 (Measurement: M1, Detector: D2)

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
Detector (Peak) Time Constant
Modulation Output
Ratio
Recorder 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: AM; Detector: PEAK+ PEAK HOLD
HP-IB (program codes)	M1D1D3 (Measurement: M1; Detector: D1D3)

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: 5 . 1 — Function: • SPCL
HP-IB (program codes)	5.1SP (Code: 5.1; 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. 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: [8] [.] [8] Function: [•] SPCL
HP-IB (program codes)	8.8SP (Code: 8.8, 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 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.

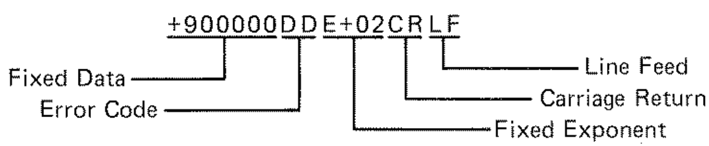
E20 through E29. These are Entry Errors which indicate that an invalid key sequence or keyboard entry has been made. These errors require that a new keyboard entry or function selection be made.

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

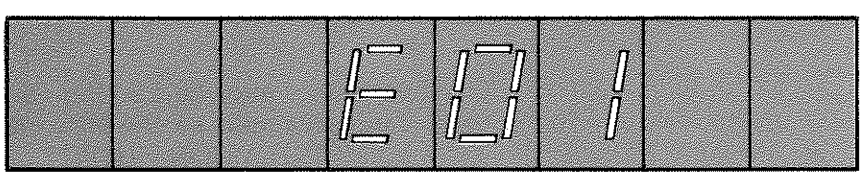
The HP-IB output format for errors is shown below:



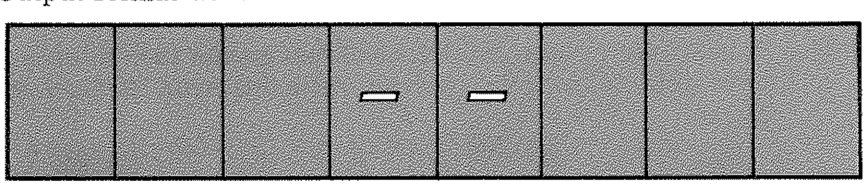
For example, error E01 is output to the HP-IB as +90000001E+02CRLF. This format differs from normal data outputs since normal data outputs will never exceed 4 x 10^9. Once an error has been input to the computing controller, the error code is simply derived by subtracting 9 x 10^9 from the input number,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



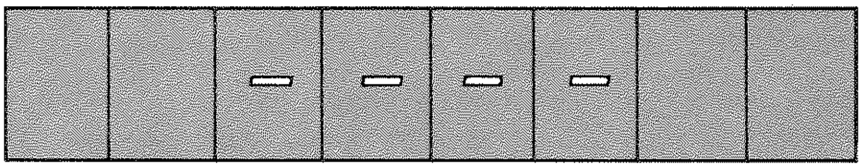
The above display exemplifies the general error display format. E means error while the number is the error code. These errors are output to the HP-IB as shown under HP-IB Output format above.



Error Message Summary (Cont'd)

Error Displays (Cont'd)

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.



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. 010 only).	Connect CALIBRATION OUTPUT to INPUT or turn off Calibrator.	4
E09	Option not installed.	Select another instrument function.	5
E10	Input frequency out of range.	Adjust input frequency to within specified limits.	6
E11	Calculated value out of range.	Enter new RATIO reference.	7
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 key; LP Filter: 15 kHz key
HP-IB (program codes)	H1L2 (H1 = High-Pass Filter, L2 = Low-Pass Filter)

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)

LOCAL (keystrokes)	Measurement: FM · Detector: PEAK + · Filters: 50 Hz, 15 kHz · De-emphasis: PRE-DISPLAY, 750 μs
HP-IB (program codes)	M2D1H1L2P1P5 — Measurement (M2), Detector (D1), Filters (H1L2), De-emphasis (P1P5)

Program Codes HP-IB

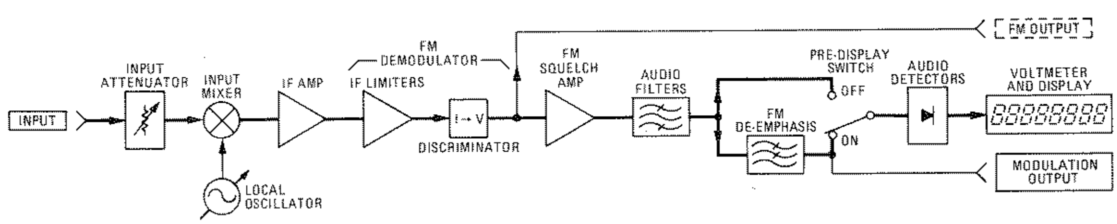
M2 is the HP-IB code for FM.

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	FM De-emphasis	Modulation Range
Detector, Peak Hold	FM Output	Ratio
Filters	Modulation Basics (Section 1—16)	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 $f_o = 1/(2\pi\tau_o)$. 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)	Measurement: FM; Detector: PEAK +; De-emphasis: PRE-DISPLAY, 750 μs
HP-IB (program codes)	M2D1P1P5 (Measurement: M2; Detector: D1; De-emphasis: P1P5)

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 FM OUTPUT jack or damage to the instrument may result.

Description

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

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

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:

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

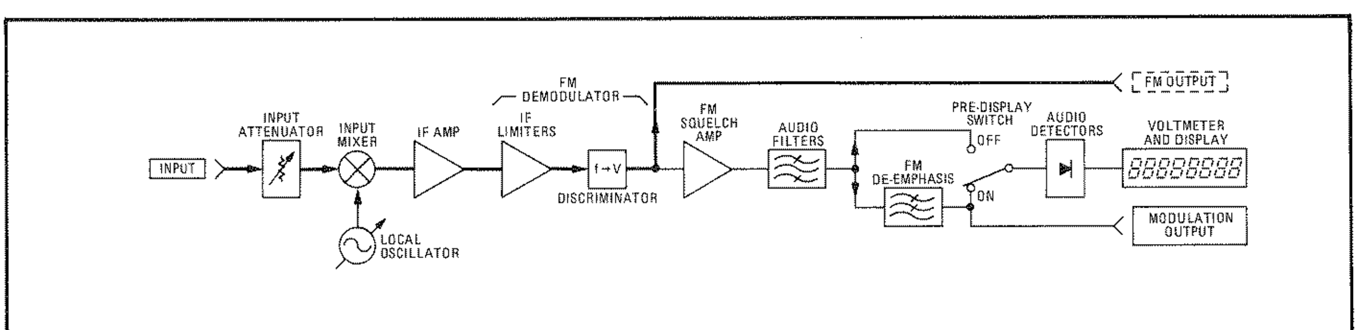
Example

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 [key]
HP-IB (program codes)	M5 — Measurement

Program Code HP-IB

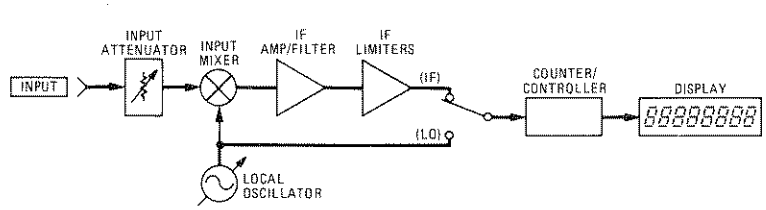
M5 is the HP-IB code for FREQ.

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, IF	Ratio
Frequency Error	Frequency Resolution	

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)	Measurement: [•] S, [•] FREQ ERROR — Data: [3] [0] — Function: MZ [MHz] INPUT FREQ
HP-IB (program codes)	S530MZ (Measurement: S5 — Data: 30 — Function: MZ)

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

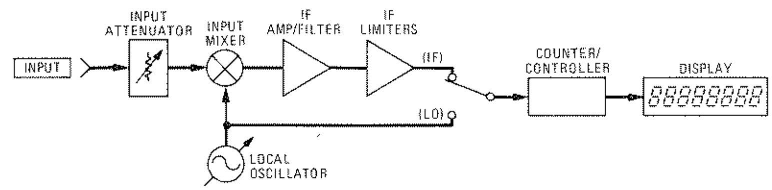
When the Modulation Analyzer is tuned, the IF signal is amplified and limited (>60 dB of gain). If manually tuned, the input frequency is determined (refer to *Frequency [Input]*) and compared to the keyboard-entered frequency or the frequency the moment MHz was pressed. The difference is displayed as 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: [1] [0] [.] [0] Function: [•] SPCL
HP-IB (program codes)	10.0SP (Code: 10.0, Function: SP)

Program Code HP-IB

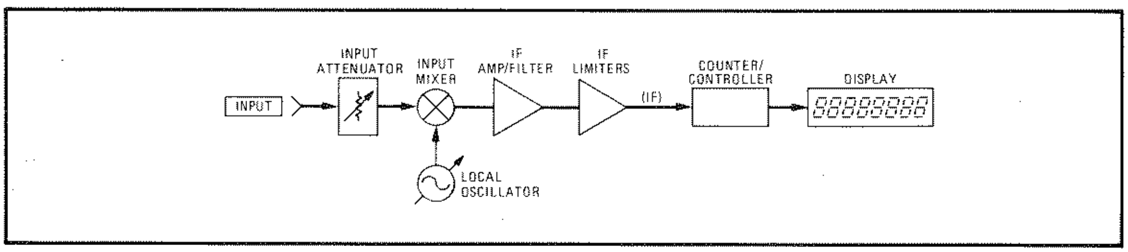
10.0 is the HP-IB code to measure IF frequency.

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

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

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

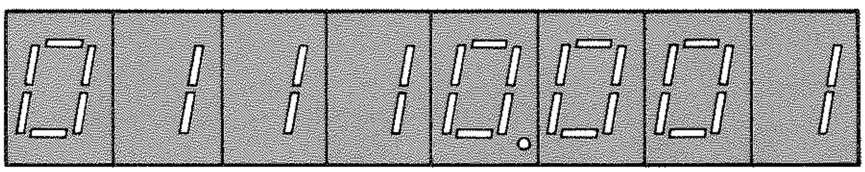
If T and L are both 1, the instrument is set to talk only (talk overrides listen). If all the A digits are set to 1 and T is 1, the instrument will talk status only (i.e., output the status byte only). (If all digits AAAAA.TL are 1 but S is 0, the HP-IB board is not installed.)

Example

Display the HP-IB address:

LOCAL (keystrokes)	Code: 2 1 . 0 — Function: • SPCL
HP-IB (program codes)	21.0SP (Code: 21.0 — Function: SP)

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: 3 . 3 — Function: • SPCL
HP-IB (program codes)	3.3SP (Code: 3.3, Function: SP)

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

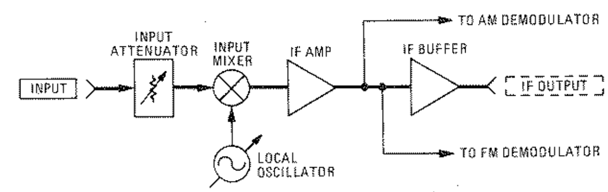
Do not apply greater than 40 Vdc or greater than +15 dBm into the rear-panel IF OUTPUT jack.

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:

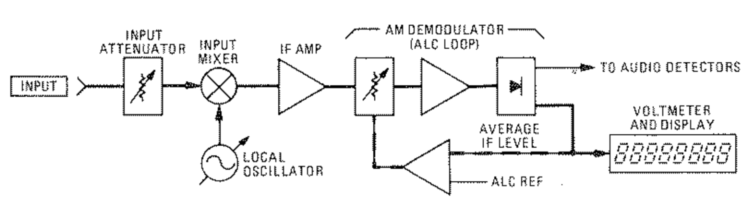
LOCAL (keystrokes)	Measurement: [S] [IF LEVEL]
HP-IB (program codes)	S3 — Measurement

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 ⩾100% for FM measurements and ⩽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:

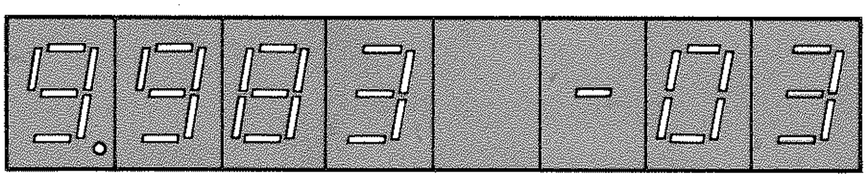
LOCAL (keystroke)	Measurement RF LEVEL [•]
HP-IB (program codes)	M4 Measurement

Program Code HP-IB

M4 is the HP-IB code for RF LEVEL.

Indications

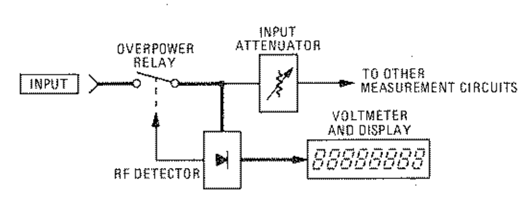
When RF level is selected, the LEDs within the RF LEVEL key and the watts annunciator will light. The display will be in scientific notation form; that is, a 4-digit number followed by a signed power-of-10 multiplier. For example, if the display shows:



then the power at INPUT is 9.983×10^{-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:

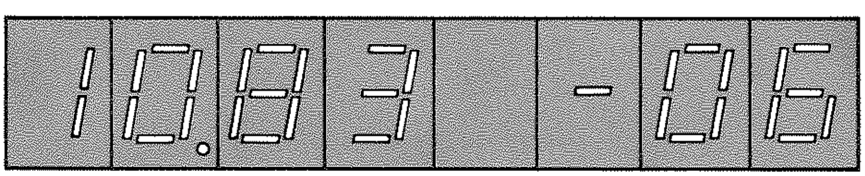
LOCAL (keystrokes)	Measurement: [S] [TUNED RF LEVEL]
HP-IB (program codes)	S4 (Measurement)

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



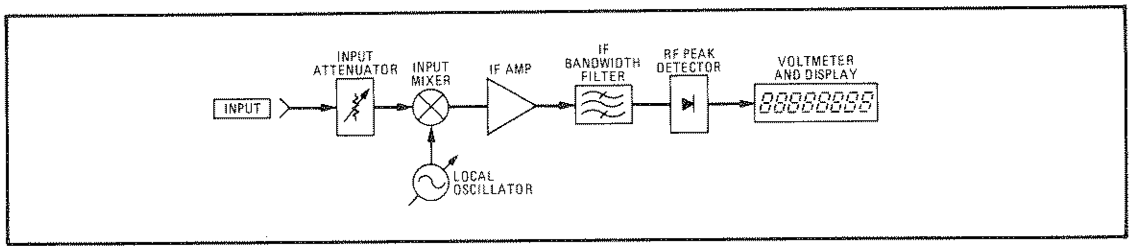
then the tuned RF level is 10.83×10^{-6} watts (10.83 μW).

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)



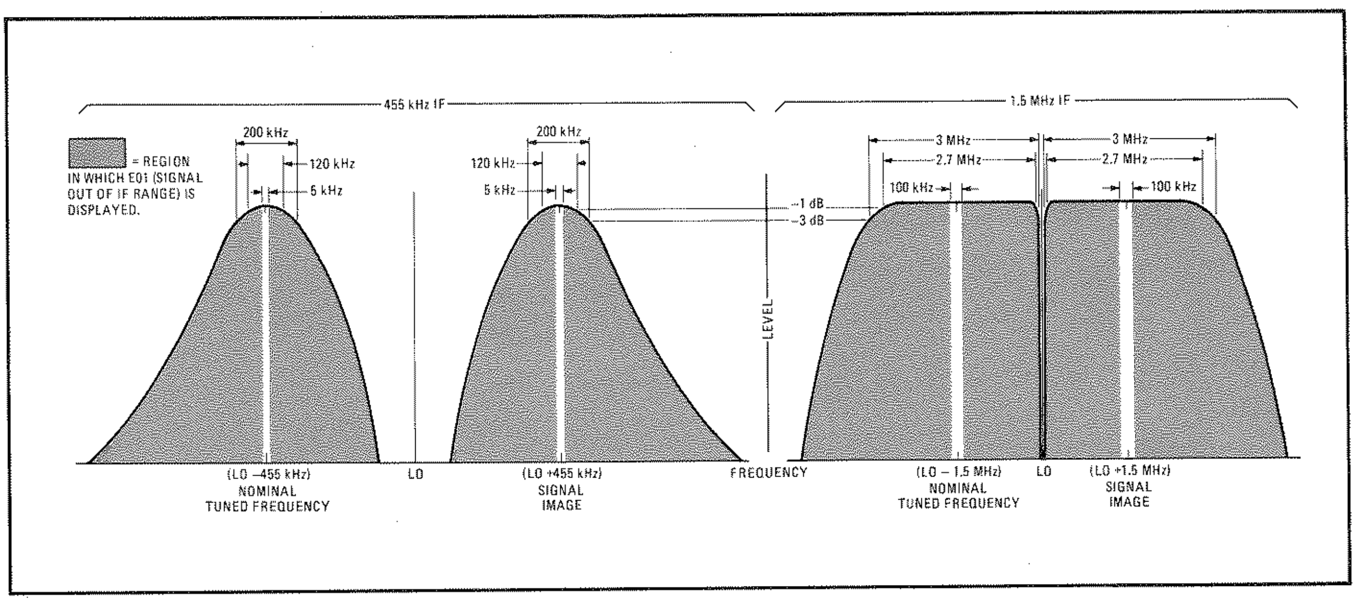
Tuned RF Level Measurement Block Diagram

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:

LOCAL (keystrokes)	Measurement: FM [•] — Data: [7] [5] — Ratio: dB [•] — Code: [1] [4] [.] [2] — Function: [•] SPCL Enter RATIO reference — Upper limit = RATIO reference
HP-IB (program codes)	M275R214.2SP Measurement (M2), Data (75), Ratio (R2), Code (14.2), Function (SP)

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:

LOCAL (keystrokes)	Measurement: [•] S, FREQ ERROR [•] — Data: [.] [6] [6] — Ratio: % [•] — Code: [1] [1] [.] [3] — Function: [•] SPCL Enter RATIO reference — Make RATIO reference negative
HP-IB (program codes)	S5.66R111.3SP Measurement (S5), Data (.66), Ratio (R1), Code (11.3), Function (SP)

LOCAL (keystrokes)	Code: [1] [4] [.] [1] — Function: [•] SPCL
HP-IB (program codes)	14.1SP Code (14.1), Function (SP)

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: [1] [4] [.] [7] Function: [•] SPCL
HP-IB (program codes)	14.7SP (Code: 14.7, Function: SP)

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

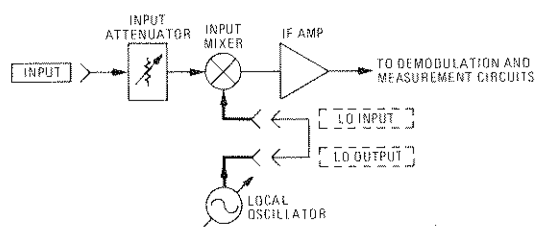
In Modulation Analyzers with Option 003, the internal local oscillator signal (LO) is brought out of and back into the instrument through the rear-panel LO OUTPUT and LO INPUT jacks. The signal at these jacks ranges from ~1.27 to 1301.5 MHz at approximately 0 dBm. Both jacks are 50Ω, ac coupled and furnished 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.*)

<table>
<tr><th colspan="2">AM</th><th colspan="2">FM</th><th colspan="2">ΦM</th></tr>
<tr><th>Display Resolution (%)</th><th>MODULATION OUTPUT Sensitivity (Vac/%)</th><th>Display Resolution (Hz)</th><th>MODULATION OUTPUT Sensitivity (mVac/Hz)</th><th>Display Resolution (radians)</th><th>MODULATION OUTPUT Sensitivity (mVac/radian)</th></tr>
<tr><td rowspan="2">0.01</td><td rowspan="2">0.1</td><td>0.1*</td><td>10*</td><td>0.001</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td rowspan="2">0.01</td><td rowspan="2">0.1</td></tr>
<tr><td rowspan="2">0.1</td><td rowspan="2">0.01</td><td>10</td><td>0.1</td></tr>
<tr><td>100**</td><td>0.01**</td><td>0.1</td><td>0.01</td></tr>
</table>

*Available only with 750 microsecond de-emphasis, pre-display.

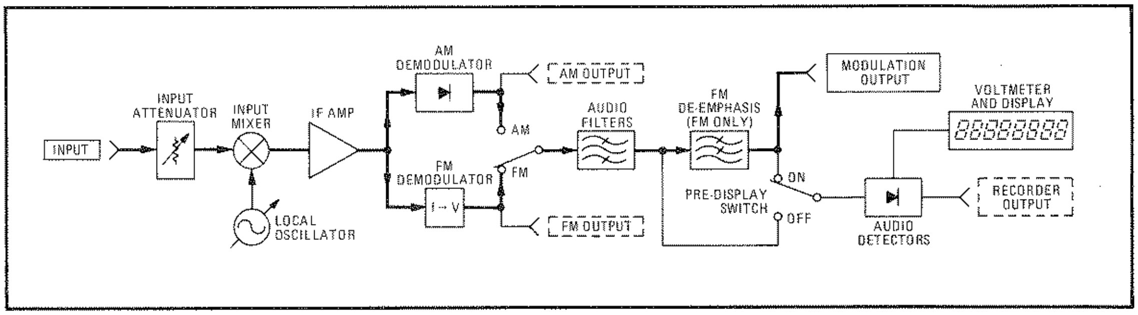
**Not available with 750 microsecond de-emphasis, pre-display.

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.

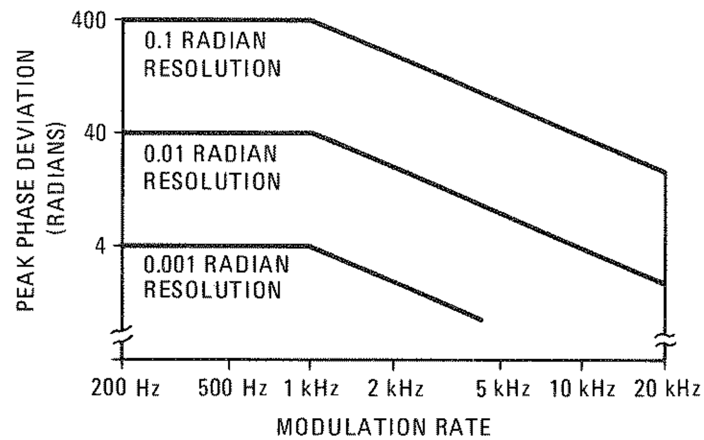
Related Sections

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: ΦM — Detector: PEAK + — Filters: 15 kHz
HP-IB (program codes)	M3D1H1L2 (Measurement: M3; Detector: D1; H1; Filters: L2)

Program Code HP-IB

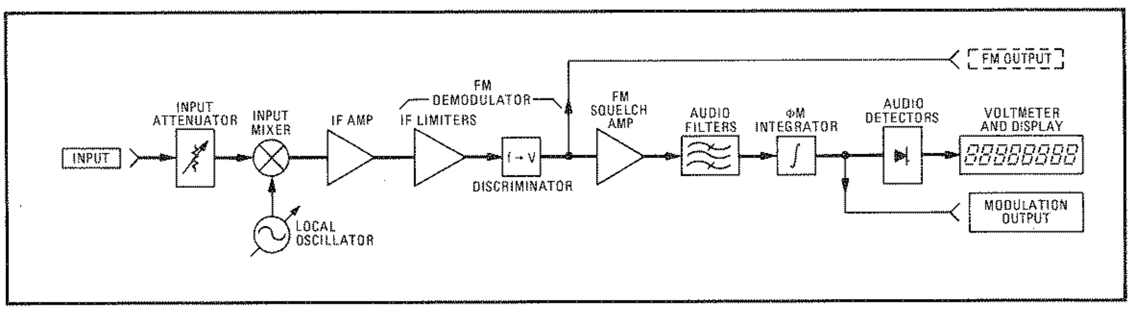
M3 is the HP-IB code for ΦM.

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: [5] [0] Ratio: [%]	or	Data: [5] [0] Ratio: [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: [FM] Code: [1] [1] [.] [1] Function: [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

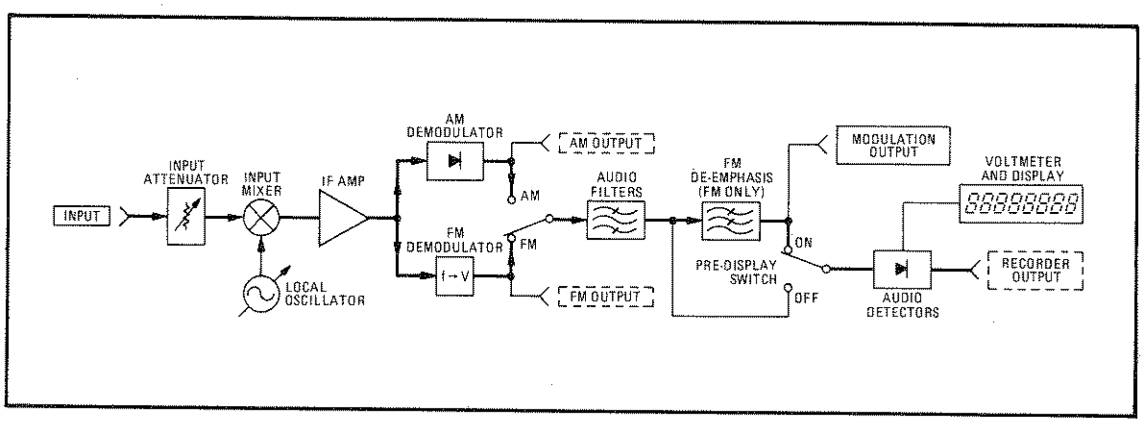
Do not apply greater than 10 Vdc or greater than +30 dBm into RECORDER OUTPUT or damage to the instrument may result.

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.

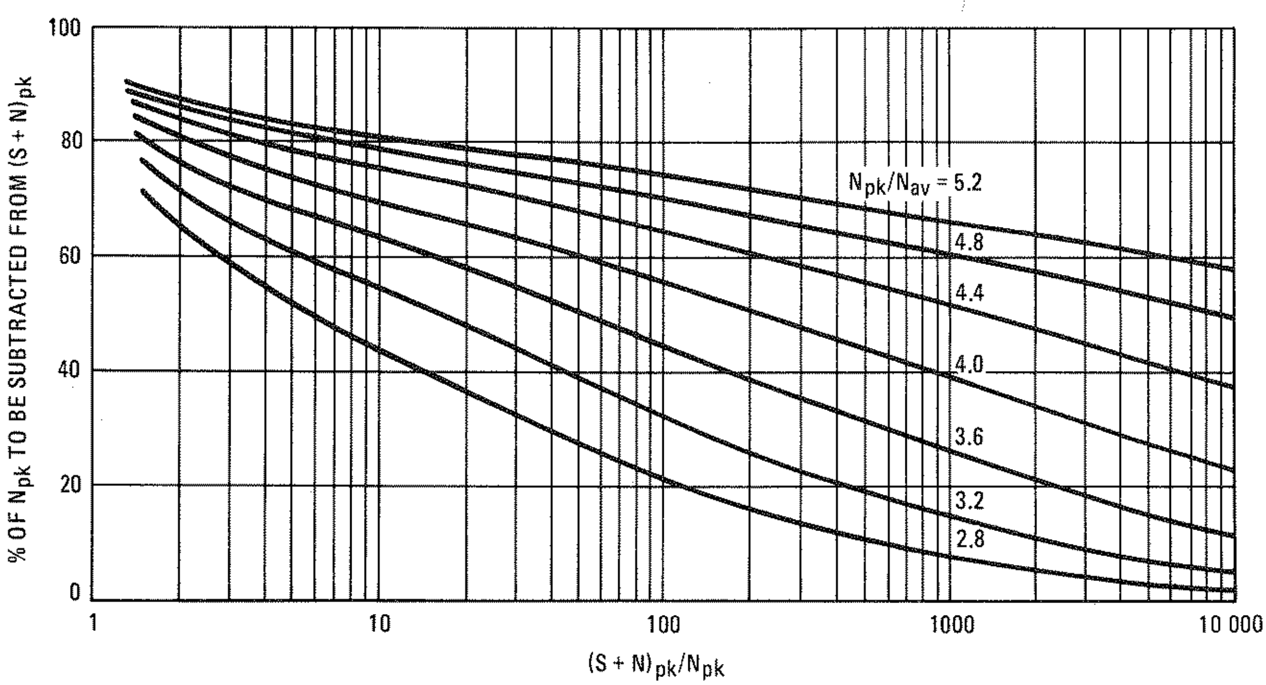
5. Compute $\frac{(S+N)_{pk}}{N_{pk}}$ and $\frac{N_{pk}}{N_{av}}$.

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.

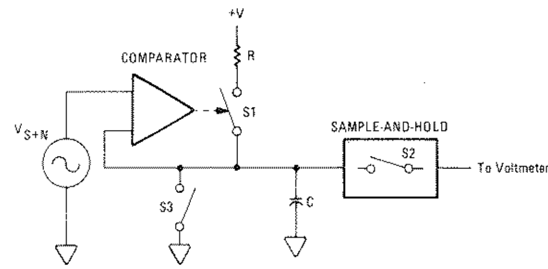
The effects of random noise on our measurement system are not nearly so straight forward. Truely random noise, when viewed in the frequency domain, is a continuous spectrum of frequencies at various amplitudes. Indeed, the frequency of the noise spectrum is limited only by the bandwidths of the observing 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: [2] [2] [.] [3] [0] Function: [•] SPCL
HP-IB (program codes)	22.30SP (Code: 22.30, Function: SP)

Program Codes
HP-IB

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	Instru-ment 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 Name	Special Function Code	Program Code (HP-IB)	Description	Disabled by: Lights SPCL key	Disabled by: AUTO. OP. key	Disabled by: Any MEAS. key	Disabled by: CLEAR key	Disabled by: All keys*	Display Timed	References and Comments
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 AM (%) / FM (kHz) / ΦM (rad)	N	—	—	—	—	—	Modulation Range Modulation Output
	2.1	2.1SP	AM ≤ 40 / FM ≤ 4, ≤ 0.4* / ΦM ≤ 4	Y	Y	N	N	N	—	
	2.2	2.2SP	AM ≤100 / FM ≤ 40, ≤ 4* / ΦM ≤ 40	Y	Y	N	N	N	—	
	2.3	2.3SP	AM ≤100 / FM ≤400, ≤ 40* / ΦM ≤400 *with 750 μs de-emphasis, pre-display	Y	Y	N	N	N	—	
IF Frequency and Input High-Pass Filter	3.0	3.0SP	Automatic IF selection; input high-pass filter out IF (MHz) / Input High-Pass Filter	N	—	—	—	—	—	Frequency, IF and 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 Name	Code	Program Code HP-IB	Description	Lights SPCL key	Disabled by AUTO. OP. key	Disabled by Any MEAS. key	Disabled by CLEAR key	Disabled by All keys*	Display Timed	References and Comments
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
	8.1	8.1SP	E01 disabled	Y	Y	N	N	N	—	Error Message Summary
	8.2	8.2SP	E02 and E03 disabled	Y	Y	N	N	N	—	Attenuation, Input
	8.3	8.3SP	E01, E02, and E03 disabled	Y	Y	N	N	N	—	Modulation Range
	8.4	8.4SP	E04 disabled	Y	Y	N	N	N	—	Tuning
	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
	12.1	12.1SP	Display demodulated peak residual FM deviation	Y	N	Y	N	N	N	NOTE: 12.1 and 12.2 set the Modulation Range to 2.2.
	12.2	12.2SP	Display demodulated peak FM deviation	Y	N	Y	N	N	N	
AM Calibrator	13.0	13.0SP	Display computed peak AM depth	Y	N	Y	N	N	N	Calibration, AM
(Continued on next page)										

N = No; — = Not applicable; Y = Yes; *Except the LCL, S (Shift), and Numeric Keys

Special Functions (Cont'd)

Special Function Summary (3 of 4)

Special Function Name	Special Function Code	Program Code (HP-IB)	Description	Lights SPCL key	Disabled by AUTO. OP. key	Disabled by Any MEAS. key	Disabled by CLEAR key	Disabled by All keys*	Display Timed	References and Comments
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 Name	Special Function Code	Program Code HP-IB	Description	Lights SPCL key	Disabled by AUTO. OP. key	Disabled by Any MEAS. key	Disabled by CLEAR key	Disabled by All keys*	Display Timed	References and Comments
Tone Burst Receiver	18.NN	18.NNSP	Configures the Modulation Analyzer as a tone burst receiver where a settling time is inserted between detecting a carrier and turning on MODULATION OUTPUT. NN is that time from 1 through 99 ms. If NN = 0, the delay is 99 ms.	Y	Y	Y	Y	Y	N	Tone Burst Receiver
HP-IB Address	21.0	21.0SP	Displays HP-IB address in form AAAAA.TLS. AAAAA is the binary address. T=1 means talk only, L=1 means listen only; S=1 means service request issued.	Y	Y	Y	Y	Y	N	HP-IB Address
Service Request	22.NN	22.NNSP	Enables a condition to cause a service request to be issued. NN is the sum of any combination of the weighted conditions below: 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)

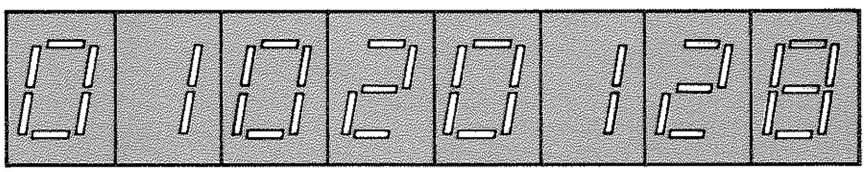
Special Special Display. To determine the actual instrument settings of Special Functions prefixed 1 through 8, press the SPCL key alone once while Special Display is still active. (If the Special Display described above is not in effect, press the SPCL key twice to get this display.) The digit position 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: 10.0; Function: SP)

Special Display. When SPCL is pressed alone once, the following display results.



1 2 3 4 5 6 7 8 (= PREFIXES)

(= SUFFIXES)

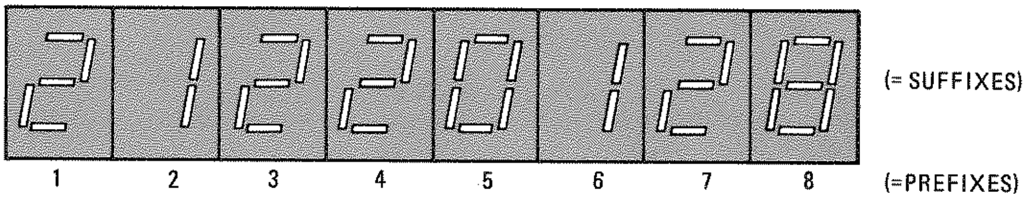
This display means:

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.

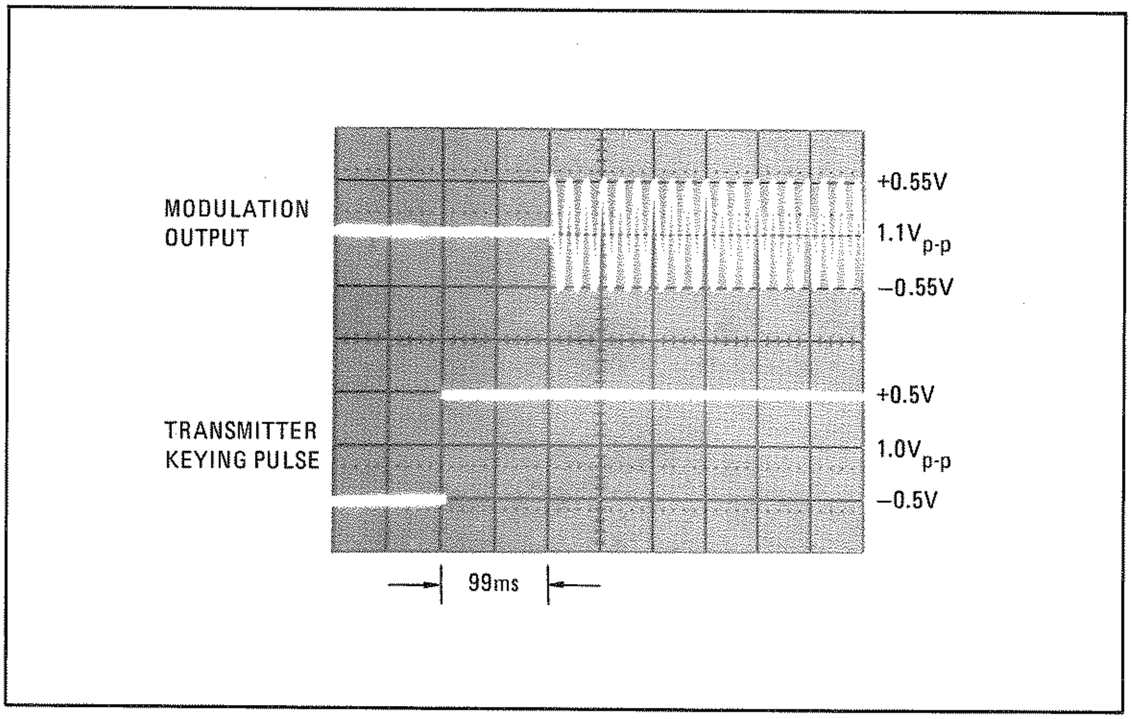
To determine whether the Modulation Analyzer has actually switched in the externally applied time base, key in 46.9 SPCL. The display should show 1 000 000 ±1 if the external time base is in. If the external signal was not switched in, the display will show 0 or 1 only.

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: 4 . 1 — Function: • SPCL
HP-IB (program codes)	4.1SP (Code: 4.1; Function: SP)

Manual Tuning by Keyboard Entry. To tune to a 934.5 MHz input signal:

LOCAL (keystrokes)	Code: 9 3 4 . 5 — Function: MZ MHz INPUT FREQ
HP-IB (program codes)	934.5MZ (Code: 934.5; Function: MZ)

To tune to a 1 MHz input signal using the 455 kHz IF:

LOCAL (keystrokes)	Code: 3 . 1 — Function: • SPCL (Select 455 kHz IF); Code: 8 . 1 — Function: • SPCL (Disable E01); Data: 1 — Function: MZ MHz INPUT FREQ (Tune to 1 MHz)
HP-IB (program codes)	3.1SP8.1SP1MZ (Code: 3.1; Function: SP; Code: 8.1; Function: SP; Data: 1; Function: MZ)

Frequency Stepping. To set a 10 kHz frequency step and to increase the tuning by that step size:

LOCAL (keystrokes)	Data: 1 0 — Function: ⇧ kHz
HP-IB (program codes)	10KU (Data: 10; Function: KU)

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.

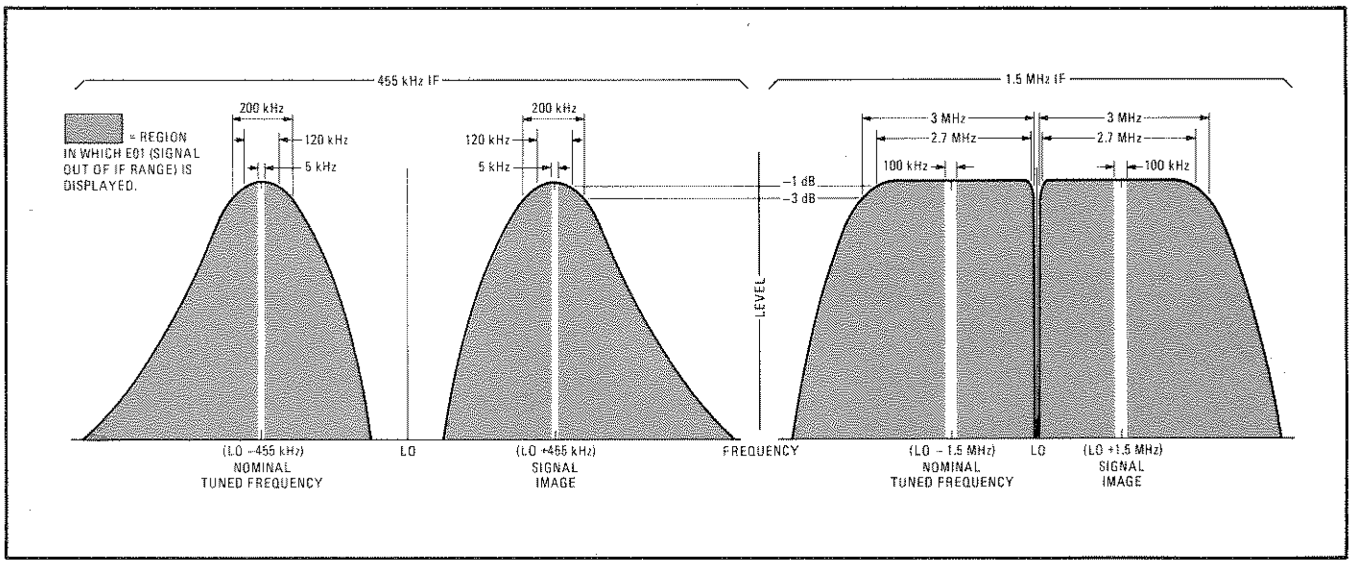
When the Modulation Analyzer tunes to an input signal (greater than 2.5 MHz), its internal local oscillator (LO) is positioned above the nominal tuning by the IF frequency. Since the image passband is not filtered out, image signals pass into the IF amplifier with the same ease as signals in the nominal 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)

Section 4
PERFORMANCE TESTS

4-1. INTRODUCTION

The procedures in this section test the instrument's electrical performance using the specifications of table 1-1 as the performance standards. All tests can be performed without access to the interior of the instrument. A simpler operational test is included in the Basic Functional Checks in section 3.

NOTE

Unless otherwise noted, no warm-up period is required for these tests.

Line voltage must be within +5% and −10% of nominal if the performance tests are to be considered valid.

4-2. EQUIPMENT REQUIRED

Equipment required for the performance tests is listed in table 1-3, "Recommended Test Equipment" in section 1. Any equipment that satisfies the critical specifications given in the table may be substituted for the recommended model(s).

4-3. TEST RECORD

Results of the performance tests may be tabulated on the test record at the end of the procedures. The test record lists all of the tested specifications and their acceptable limits. The results, recorded at incoming inspection, can be used for comparison in periodic maintenance and troubleshooting and after repairs or adjustments.

4-4. CALIBRATION CYCLE

This instrument required periodic verification of performance. Depending on the use and environmental conditions, the instrument should be checked using the following performance tests at least once every year.

4-5. ABBREVIATED PERFORMANCE TESTING

No abbreviation of performance testing is recommended.

Performance Test 1

AM TESTS (FOR HP 8901A EQUIPPED WITH OPTION 010)

Specifications

Characteristic	Performance Limits	Conditions
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 ±3% of reading ±1 digit ±1% of reading ±1 digit ±3% of reading ±1 digit	150 kHz to 10 MHz carrier; 50 Hz to 10 kHz rates; 5 to 99% depth 150 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates; 5 to 99% depth 10 to 1300 MHz carrier; 50 Hz to 50 kHz rates; 5 to 99% depth 10 to 1300 MHz carrier; 20 Hz to 100 kHz rates; 5 to 99% depth
Flatness[3,4]	±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
Residual AM[1]	< 0.01% rms	50 Hz to 3 kHz bandwidth
FREQUENCY MODULATION		
AM Rejection[1]	< 20 Hz peak deviation	50% AM depth; 400 Hz and 1 kHz rates; 50 Hz to 3 kHz bandwidth
PHASE MODULATION		
AM Rejection[1]	< 0.03 rad peak deviation	50% AM depth; 1 kHz rate; 50 Hz to 3 kHz bandwidth

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in *Detailed Operating Instructions* in section 3.)
(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.
(3) Flatness is the variation in indicated AM depth for constant depth on input signal.
(4) For optimum flatness, cables should be terminated with their characteristic impedance.

Description

AM accuracy is measured with the internal AM Calibrator (Option 010), which produces approximately 33% AM at a 10 kHz rate. A low-residual AM source is connected to the input and the internal residual AM is measured. A source, which can produce wide-band, linear AM, is modulated at various AM rates and depths to measure distortion, flatness, and incidental FM and ΦM. A special AM/FM test source is required for these tests to assure that the AM source has adequate bandwidth, low distortion, low residual AM, and low incidental FM and ΦM.

NOTE

This procedure is only for Modulation Analyzers equipped with the AM Calibrator (Option 010). For Modulation Analyzers not equipped with Option 010, use Performance Test 1A which uses the AM Calibrator from a second HP 8901A that is equipped with Option 010.

Equipment

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Audio Synthesizer .... HP 3336C (Opt. 005)

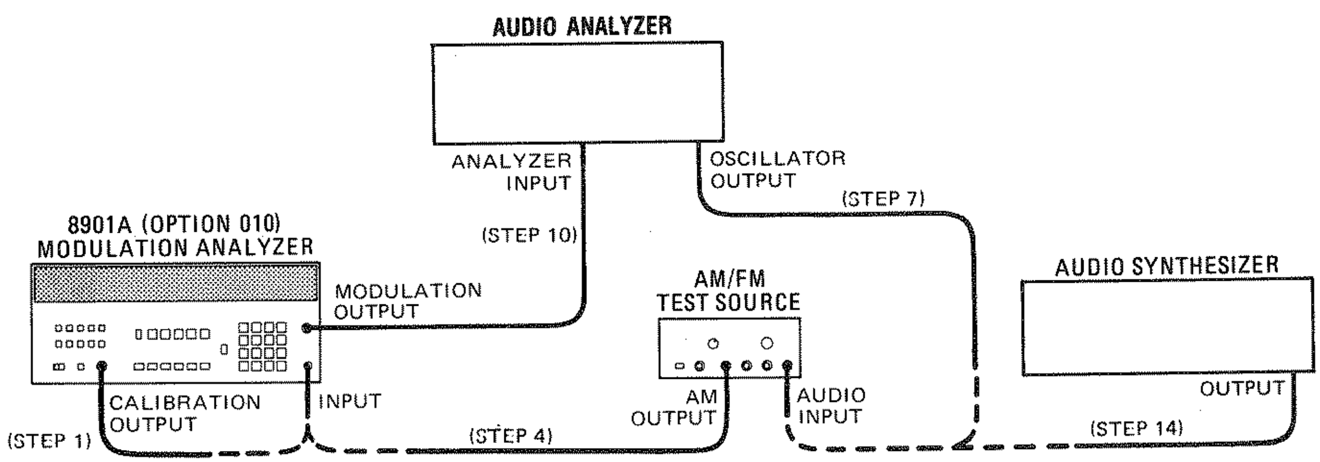


Figure 4–1. AM Performance Test Setup (for HP 8901A Equipped with Option 010)

Procedure

AM Accuracy at 10 kHz Rate

1. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Connect the Modulation Analyzer's CALIBRATION OUTPUT to its INPUT.

NOTE

For greatest accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

2. On the Modulation Analyzer, press AM and then press CALIBRATION. Allow at least two readings (approximately 40 seconds) to pass. The display should read between 99 and 101%.

AM Calibration Factor 40% AM Range: 99 ________________ 101%

3. Key in 2.2 SPCL to set the AM range to 100% AM. Allow at least two readings to pass . The display should read between 99 and 101%. Record this value for future reference.

AM Calibration Factor 100% AM Range: 99 ________________ 101%

Residual AM

4. On the AM/FM test source, set the test mode switch to AM. Connect the test source AM output to the Modulation Analyzer's INPUT. (See figure 4–1. Nothing should be connected to the test source's audio input.)
5. On the Modulation Analyzer, press FREQ and key in 4.1 SPCL to turn on Track Mode. Tune the AM/FM test source's carrier frequency to approximately 12.5 MHz. Key in 4.0 SPCL to turn off Track Mode.
6. On the Modulation Analyzer, press AM. Key in 2.0 SPCL to set the modulation range to automatic. Set the other controls as follows:

   HP Filter .... 50 Hz
   LP Filter .... 3 kHz
   Detector .... AVG

   The display should show 0.01% or less.

Residual AM: ________________ 0.01%

AM Distortion

7. Set the audio analyzer's source to 20 kHz. Connect its output to the audio input of the AM/FM test source. (See figure 4–1.)

NOTE

For this test, if the audio analyzer has floating input and output connectors, the low connector should be grounded. Connections should be made to the high input or high output connector.

8. Set the Modulation Analyzer controls as follows:

   HP Filter .... All Off
   LP Filter .... All Off
   Detector .... PEAK+

9. Adjust the level of the audio analyzer's source for a Modulation Analyzer display of 50% AM.

10. Connect the audio analyzer's input to the Modulation Analyzer's MODULATION OUTPUT. (See figure 4–1.) Set the audio analyzer to measure the distortion on the 20 kHz signal at the MODULATION OUTPUT with 80 kHz of low-pass filtering (on the audio analyzer). The distortion should be 0.3% or less (–50.5 dB or less).

    AM Distortion at 20 kHz Rate; 50% AM: ________ 0.3%

11. Increase the level of the audio analyzer's source until the Modulation Analyzer reads 95% AM. Measure the distortion. The distortion should be 0.6% or less (–44.4 dB or less).

    AM Distortion at 20 kHz Rate; 95% AM: ________ 0.6%

12. Set the frequency of the audio analyzer's source to 20 Hz. Readjust the level, if necessary, for a Modulation Analyzer display of 95% AM. Measure the distortion. The distortion should be 0.6% or less (–44.4 dB or less).

    AM Distortion at 20 Hz Rate; 95% AM: ________ 0.6%

13. Decrease the level of the audio analyzer's source until the Modulation Analyzer reads 50% AM. Measure the distortion. The distortion should be 0.3% or less (–50.5 dB or less).

    AM Distortion at 20 Hz Rate; 50% AM: ________ 0.3%

AM Flatness

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch it on.

14. Set the audio synthesizer to 1 kHz at +5 dBm. Connect its output to the audio input of the AM/FM test source. (See figure 4–1.) Fine adjust the audio synthesizer level for a Modulation Analyzer display of 80% AM.

15. On the Modulation Analyzer, press AVG. Set RATIO to %. Set the audio synthesizer frequency as listed in the following table. For each frequency setting, note the Modulation Analyzer's display. The difference in readings between any two frequencies should be less than 0.8% REL.

NOTE

±0.3% of reading is equivalent to a difference of 0.6% between any pair of readings. ±1 digit at a nominal reading of 80.0 is about ±0.1% of the reading in the RATIO mode or ±0.2% for any pair of readings. The total limit is then 0.8%.

Audio Synthesizer Frequency (Hz)	Displayed AM (% REL)
1 000	________
10 000	________
150	________
90	________

AM Flatness (Maximum Difference): ________ 0.8% REL

AM Accuracy

16. On the Modulation Analyzer, press RATIO % to turn it off. Press PEAK+. Key in 5.1 SPCL to set the audio detector time constant to slow.

17. Set the audio synthesizer frequency to 10 kHz. Set its level for a display of 80% AM times the calibration factor of step 3. (For example, if the calibration factor of step 3 is 100.4%, set the level for a display of 80.3% AM.)

18. On the Modulation Analyzer, key in 80 and press RATIO %. Set the audio synthesizer to the frequencies shown in the following table (without changing the level). For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	AM Limits (% REL)		
	Lower	Actual	Upper
50 000	98.9	______	101.1
100 000	96.9	______	103.1
50	98.9	______	101.1
20	96.9	______	103.1

NOTE

±1 digit at a nominal reading of 80.0 is about ±1% of the reading in the RATIO mode.

19. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 kHz. Set the audio synthesizer to the frequencies in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	AM Limits (% REL)		
	Lower	Actual	Upper
20	96.9	______	103.1
50	97.9	______	102.1
10 000	97.9	______	102.1

AM Rejection

20. On the Modulation Analyzer, press RATIO to turn it off. Set the HP FILTER to 50 Hz and the LP FILTER to 3 kHz.
21. Set the audio synthesizer frequency to 1 kHz. Set its level for a Modulation Analyzer display of 50% AM.
22. On the Modulation Analyzer, press FM. Momentarily disconnect the audio input to the AM/FM test source and note the residual FM displayed on the Modulation Analyzer.

Residual FM; 455 kHz IF: ________________ Hz

23. Reconnect the audio input of the AM/FM test source. Note the Modulation Analyzer's displayed FM. The displayed FM minus one-half the residual FM noted in step 22 should be 20 Hz peak or less.

AM Rejection (with FM); 455 kHz IF: ________________ 20 Hz

24. On the Modulation Analyzer, key in 3.0 SPCL to set the IF back to 1.5 MHz. Repeat steps 22 and 23.

Residual FM; 1.5 MHz IF: ________________ Hz

AM Rejection (with FM); 1.5 MHz IF: ________________ 20 Hz

25. On the Modulation Analyzer, press ΦM. Momentarily disconnect the audio input to the AM/FM test source and note the residual ΦM displayed on the Modulation Analyzer.

Residual ΦM; 1.5 MHz IF: ________________ rad

26. Reconnect the audio input of the AM/FM test source. Note the Modulation Analyzer's displayed ΦM. The displayed ΦM minus one-half the residual ΦM noted in step 25 should be 0.030 rad peak or less.

AM Rejection (with ΦM); 1.5 MHz IF: ________________ 0.030 rad

Performance Test 1A

AM TESTS (USING A SECOND HP 8901A EQUIPPED WITH OPTION 010)

Specifications

Characteristic	Performance Limits	Conditions
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 ±3% of reading ±1 digit ±1% of reading ±1 digit ±3% of reading ±1 digit	150 kHz to 10 MHz carrier; 50 Hz to 10 kHz rates; 5 to 99% depth 150 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates; 10 to 1300 MHz carrier; 50 Hz to 50 kHz rates; 5 to 99% depth 10 to 1300 MHz carrier; 20 Hz to 100 kHz rates
Flatness[3,4]	±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
Residual AM[1]	< 0.01% rms	50 Hz to 3 kHz bandwidth
FREQUENCY MODULATION		
AM Rejection[1]	< 20 Hz peak deviation	50% AM depth; 400 Hz and 1 kHz rates; 50 Hz to 3 kHz bandwidth
PHASE MODULATION		
AM Rejection[1]	< 0.03 rad peak deviation	50% AM depth; 1 kHz rate; 50 Hz to 3 kHz bandwidth

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in *Detailed Operating Instructions* in section 3.)
(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.
(3) Flatness is the variation in indicated AM depth for constant depth on input signal.
(4) For optimum flatness, cables should be terminated with their characteristic impedance.

Description

AM accuracy is measured with the internal AM Calibrator of a second HP 8901A equipped with Option 010. A low-residual AM source is connected to the input and the internal residual AM is measured. A source, which can produce wide-band, linear AM, is modulated at various AM rates and depths to measure distortion, flatness, and incidental FM and ΦM. A special AM/FM test source is required for these tests to assure that the AM source has adequate bandwidth, low distortion, low residual AM, and low incidental FM and ΦM.

NOTE

If the Modulation Analyzer under test is equipped with the AM Calibrator (Option 010), perform Performance Test 1, AM Tests (For HP 8901A Equipped with Option 010).

Equipment

Modulation Analyzer with AM Calibrator .... HP 8901A Option 010
AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Audio Synthesizer .... HP 3336C (Opt. 005)

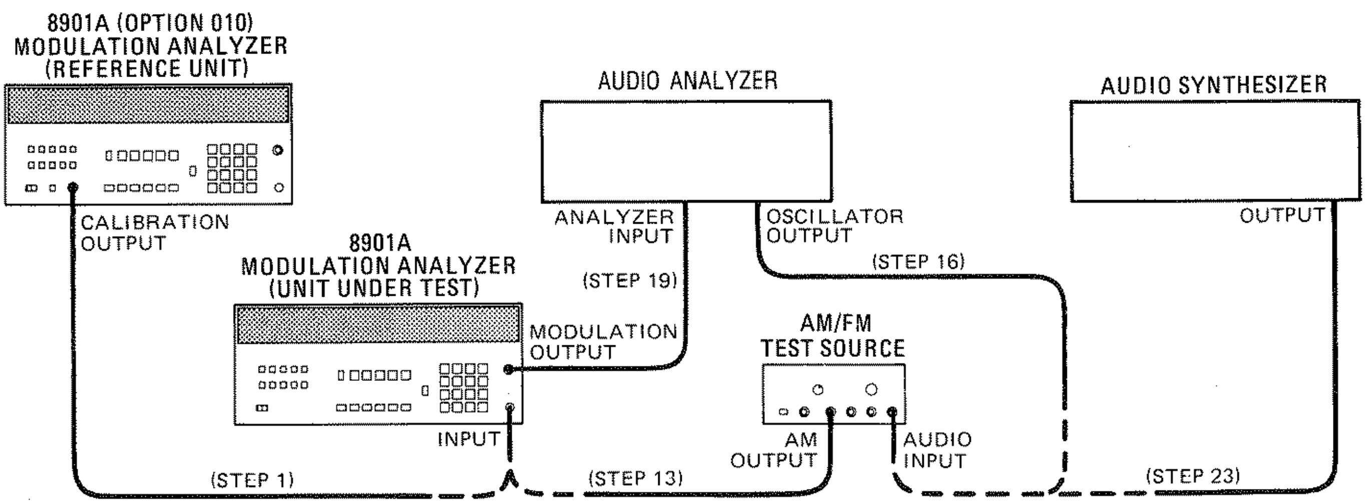


Figure 4-2. AM Performance Test Setup (Using a Second HP 8901A Equipped with Option 010)

Procedure

AM Accuracy at 10 kHz Rate

1. On both the Modulation Analyzers, key in 41.0 SPCL to preset the instruments. Connect the CALIBRATION OUTPUT from the Modulation Analyzer equipped with Option 010 AM calibrator (Reference Unit) to the INPUT of the Modulation Analyzer under test.

NOTE

For greatest accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

2. Key in 13.0 SPCL on the Reference Unit to display the computed peak AM depth and note the reading on its display. The computed AM Depth of the calibrator, excluding noise, is displayed.

Computed Peak AM Depth: ________ %

3. Key in 13.1 SPCL on both Modulation Analyzers to display the demodulated peak residual AM depth. Then, key in 5.1 SPCL on the Modulation Analyzer under test to set the peak detector time constant to slow. Note the reading on the display of the Modulation Analyzer under test. The measured and corrected noise of the AM calibrator in CW is displayed.

Weighted Peak Residual AM; 40% Range: ________ %

4. Add the results of steps 2 and 3 above.

Computed plus Residual AM; 40% Range: ________ %

5. Key in 2.2 SPCL on the Modulation Analyzer under test to set the AM range to 100%. Note the reading its display.

Weighted Peak Residual AM; 100% Range: ________ %

6. Add the results of steps 2 and 5 above.

Computed plus Residual AM: 100% Range: ________ %

7. Key in 13.2 SPCL on both Modulation Analyzers to display the demodulated peak residual AM depth. Then, key in 5.1 SPCL on the Modulation Analyzer under test. Note the reading on the display of the Modulation Analyzer under test. The AM depth, measured with the PEAK+ detector, is displayed.

   Measured Demodulated Positive Peak AM (Including Residual);

40% Range: ________ %

8. Press PEAK– on the Modulation Analyzer under test. Note the reading on its display.

   Measured Demodulated Negative Peak AM (Including Residual);

40% Range: ________ %

9. Make the following calculation:

$$\frac{(reading\ of\ step\ 7) + 2(reading\ of\ step\ 8)}{3}$$

   Measured Demodulated Peak AM (Averaged);

40% Range: ________ %

   This result should equal the result of step 4 ±0.334% AM.

10. Key in 2.2 SPCL on the Modulation Analyzer under test to set the AM range to 100%. Note the reading on its display.

   Measured Demodulated Negative Peak AM (Including Residual;

100% Range: ________ %

11. Press PEAK+ on the Modulation Analyzer under test. Note the reading on its display.

    Measured Demodulated Negative Peak AM (Including Residual);

    40% Range: ______________ %

12. Make the following calculation:

$$\frac{(reading\ of\ step\ 11) + 2(reading\ of\ step\ 10)}{3}$$

    Measured Demodulated Peak AM (Averaged); 100% Range: ______________ %

    This result should equal the result of step 6 ±0.34% AM.

Residual AM

13. On the AM/FM test source, set the test mode switch to AM. Connect the test source AM output to the INPUT of the Modulation Analyzer under test. (See figure 4–2. Nothing should be connected to the test source's audio input.)
14. On the Modulation Analyzer under test, key in 41.0 SPCL to initialize it. Tune the AM/FM test source's carrier frequency to approximately 12.5 MHz.
15. On the Modulation Analyzer under test, press AM. Set the other controls as follows:

    HP Filter .... 50 Hz
    LP Filter .... 3 kHz
    Detector .... AVG

    The display should show 0.01% or less.

    Residual AM: ______________ 0.01%

AM Distortion

16. Set the audio analyzer's source to 20 kHz. Connect its output to the audio input of the AM/FM test source (see figure 4–2).
17. Set the Modulation Analyzer controls as follows:

    HP Filter .... All Off
    LP Filter .... All Off
    Detector .... PEAK+

18. Adjust the level of the audio analyzer's source so that the Modulation Analyzer under test displays 50% AM.
19. Connect the audio analyzer's input to the MODULATION OUTPUT of the Modulation Analyzer under test. (See figure 4–2.) Set the audio analyzer to measure the distortion on the 20 kHz signal at the MODULATION OUTPUT with 80 kHz of low-pass filtering (on the audio analyzer). The distortion should be 0.3% or less (–50.5 dB or less).

    AM Distortion at 20 kHz Rate; 50% AM: ______________ 0.3%

20. Increase the level of the audio analyzer's source until the Modulation Analyzer under test reads 95% AM. Measure the distortion. The distortion should be 0.6% or less (–44.4 dB or less).

    AM Distortion at 20 kHz Rate; 95% AM: ______________ 0.6%

21. Set the audio analyzer's source frequency to 20 Hz. Readjust the level, if necessary, for a Modulation Analyzer display of 95% AM. Measure the distortion. The distortion should be 0.6% or less (−44.4 dB or less).

AM Distortion at 20 Hz Rate; 95% AM: ________________ 0.6%

22. Decrease the level of the audio analyzer's source until the Modulation Analyzer reads 50% AM. Measure the distortion. The distortion should be 0.3% or less (−50.5 dB or less).

AM Distortion at 20 Hz Rate; 50% AM: ________________ 0.3%

AM Flatness

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch the leveling on.

23. Set the audio synthesizer to 1 kHz at +5 dBm. Connect its output to the audio input of the AM/FM test source. (See figure 4–2.) Fine adjust the audio synthesizer level for a Modulation Analyzer under test display of 80% AM.

24. On the Modulation Analyzer, press AVG. Set RATIO to %. Set the audio synthesizer frequency as listed in the following table. For each frequency setting, note the Modulation Analyzer's display. The difference in readings between any two frequencies should be less than 0.8% REL.

NOTE

±0.3% of reading is equivalent to a difference of 0.6% between any pair of readings. ±1 digit at a nominal reading of 80.0 is about ±0.1% of the reading in the RATIO mode or ±0.2% for any pair of readings. The total limit is then 0.8%.

Audio Synthesizer Frequency (Hz)	Displayed AM (% REL)
1 000	________
10 000	________
150	________
90	________

AM Flatness (Maximum Difference): ________________ 0.8% REL

AM Accuracy

25. On the Modulation Analyzer, press RATIO % to turn ratio off. Press PEAK+. Key in 5.1 SPCL to set the audio detector time constant to slow.

26. Set the audio synthesizer frequency to 10 kHz. Set its level for a Modulation Analyzer under test display of 80% AM times the result of step 10 divided by the result of step 4. (For example if the result of step 10 is 33.40% and the result of step 4 is 33.33%, set the level for 80% × 33.40 ÷ 33.33 = 80.2%).

27. On the Modulation Analyzer, key in 80 and press RATIO %. Set the audio synthesizer to the frequencies shown in the following table (without changing the level). For each setting, the Modulation Analyzer display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	AM Limits (% REL)		
	Lower	Actual	Upper
50 000	98.9	______	101.1
100 000	96.9	______	103.1
50	98.9	______	101.1
20	96.9	______	103.1

NOTE

±1 digit at a nominal reading of 80.0 is about ±1% of the reading in the RATIO mode.

28. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 kHz. Set the audio synthesizer to the frequencies in the following table. For each setting, the Modulation Analyzer display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	AM Limits (% REL)		
	Lower	Actual	Upper
20	96.9	______	103.1
50	97.9	______	102.1
10 000	97.9	______	102.1

AM Rejection

29. On the Modulation Analyzer, press RATIO to turn ratio off. Set the HP FILTER to 50 Hz and the LP FILTER to 3 kHz.

30. Set the audio synthesizer frequency to 1 kHz. Set its level for a Modulation Analyzer display of 50% AM.

31. On the Modulation Analyzer, press FM. Momentarily disconnect the audio input to the AM/FM test source and note the residual FM displayed on the Modulation Analyzer.

Residual FM; 455 kHz IF: ________ Hz

32. Reconnect the audio input of the AM/FM test source. Note the Modulation Analyzer's displayed FM. The displayed FM minus one-half the residual FM noted in step 31 should be 20 Hz peak or less.

AM Rejection (with FM); 455 kHz IF: ________ 20 Hz

33. On the Modulation Analyzer, key in 3.0 SPCL to set the IF back to 1.5 MHz. Repeat steps 31 and 32.

Residual FM; 1.5 MHz IF: ________ Hz

AM Rejection (with FM); 1.5 MHz IF: ________ 20 Hz

34. On the Modulation Analyzer, press ΦM. Momentarily disconnect the audio input to the AM/FM test source and note the residual ΦM displayed on the Modulation Analyzer.

Residual ΦM; 1.5 MHz IF: ________ radians

35. Reconnect the audio input of the AM/FM test source. Note the ΦM displayed on the Modulation Analyzer. The displayed ΦM minus one-half the residual ΦM noted in step 34 should be 0.030 radians peak or less.

AM Rejection (with ΦM); 1.5 MHz IF: ________ 0.030 rad

Performance Test 2

FM TESTS (FOR HP 8901A EQUIPPED WITH OPTION 010)

Specification

Characteristic	Performance Limits	Conditions
FREQUENCY MODULATION		
Rates	20 Hz to 10 kHz 20 Hz to 200 kHz 20 Hz to 20 kHz	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier 10 to 1300 MHz carrier; 750 μs de-emphasis
Deviations	40 kHz peak maximum 400 kHz peak maximum 40 kHz peak maximum	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier 10 to 1300 MHz carrier; 750 μs de-emphasis
Accuracy[1]	±2% of reading ±1 digit ±1% of reading ±1 digit ±5% of reading ±1 digit	250 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates; 10 to 1300 MHz carrier; 50 Hz to 100 kHz rates; 10 to 1300 MHz carrier; 20 Hz to 200 kHz rates;
Demodulated Output Distortion[2]	< 0.1% THD < 0.1% THD	400 kHz to 10 MHz carrier; deviations < 10 kHz 10 to 1300 MHz carrier; rates and deviations < 100 kHz

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in section 3.)
(2) With 750 μs de-emphasis and pre-display "off", distortion is not specified for modulation outputs >4 V (pk). This can occur near maximum deviation for a measurement range at rates < 2 kHz.

Characteristic	Performance Limits	Conditions
FREQUENCY MODULATION (cont'd)		
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 bandwidth
AMPLITUDE MODULATION		
FM Rejection[1]	< 0.2% AM	250 kHz to 10 MHz carrier; < 5 kHz peak deviation; 400 and 1 kHz rates; 50 Hz to 3 kHz bandwidth
	< 0.2% AM	10 to 1300 MHz carrier; < 50 kHz peak deviation; 400 Hz and 1 kHz rates; 50 Hz to 3 kHz bandwidth

[1] Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in section 3.)

Description

FM is measured with a very low-noise oscillator at the Modulation Analyzer's input. The resulting measured FM is the residual FM of the Modulation Analyzer's internal local oscillator. FM accuracy is measured with the internal FM Calibrator (Option 010), which produces approximately 34 kHz peak deviation at a 10 kHz rate. A source, which can produce wide-band, linear FM, is modulated at various FM rates and deviations to measure distortion, flatness, and incidental AM. A special AM/FM test source is required for these tests to assure that the FM source has adequate bandwidth, low distortion, low residual FM, and low incidental AM.

NOTE

This procedure is only for Modulation Analyzers equipped with the FM Calibrator (Option 010). For Modulation Analyzers not equipped with Option 010, use Performance Test 2A which uses a second HP 8901A that is equipped with Option 010.

Equipment

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Audio Synthesizer .... HP 3336C (Opt. 005)

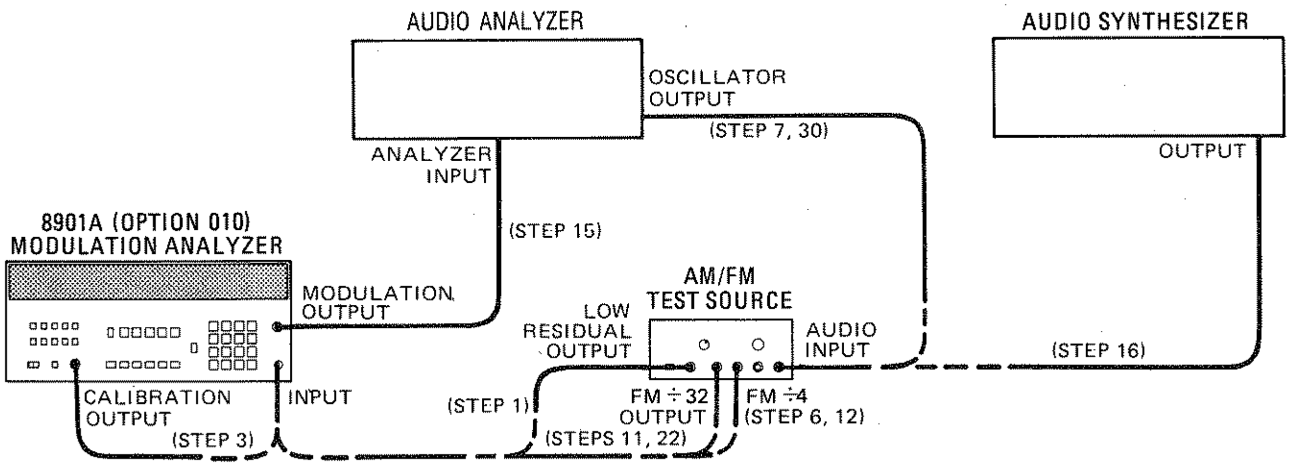


Figure 4–3. *FM Performance Test Setup*

Procedure

Residual FM

1. On the AM/FM test source, set the test mode to residual FM. Connect its low-residual (560 MHz) output to the Modulation Analyzer's INPUT. (See figure 4–3.)
2. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Set the other controls as follows:

   Measurement .... FM
   HP Filter .... 50 Hz
   LP Filter .... 3 kHz
   Detector .... AVG

   The display should read 4 Hz or less.

   Residual FM at 560 MHz; 50 Hz to 3 kHz bandwidth: ________ 4 Hz

   The equation for determining the residual FM limits is:

   $$residual\ FM\ in\ Hz = 5.83 \times carrier\ frequency\ in\ GHz + 0.42\ Hz$$

   For a carrier of 560 MHz, the residual FM limit is 3.7 Hz. Allowing for one digit of uncertainty gives a limit of approximately 4 Hz.

FM Accuracy at 10 kHz Rate

3. Connect the Modulation Analyzer's CALIBRATION OUTPUT to the INPUT. (See figure 4–3.)

NOTE

For greatest accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

4. On the Modulation Analyzer, press CALIBRATION. Allow at least two readings (approximately 40 seconds) to pass . The display should read between 99 and 101%. Record this value for future reference.

   FM Calibration Factor; 40 kHz Modulation Range: 99 ________________ 101%

5. On the Modulation Analyzer, key in 2.3 SPCL to set the modulation range to 400 kHz. Allow at least two readings to pass. The display should read between 99 and 101%.

   FM Calibration Factor; 400 kHz Modulation Range: 99 ________________ 101%

6. On the AM/FM test source, set the test mode to FM. Connect its FM÷4 output to the Modulation Analyzer's INPUT. (See figure 4–3.)
7. Set the audio analyzer's source to 10 kHz at 0.5 V. Connect its output to the audio input of the AM/FM test source. (See figure 4–3.)

NOTE

For this test, if the audio analyzer has floating input and output connectors, the low connector should be grounded. Connections should be made to the high input or high output connector.

8. On the Modulation Analyzer, key in 4.1 SPCL to turn on Track Mode. Tune the AM/FM test source's carrier frequency to approximately 100 MHz. Key in 4.0 SPCL to turn Track Mode off.
9. On the Modulation Analyzer, press FM. Set LP FILTER to 15 kHz and DETECTOR to AVG. Key in 2.0 SPCL to set the modulation range to automatic.
10. Adjust the level of the audio analyzer's source for a Modulation Analyzer display of 20 kHz average deviation. On the Modulation Analyzer, set RATIO to %.
11. Connect the FM÷32 output of the AM/FM test source to the Modulation Analyzer's INPUT without disturbing the AM/FM test source's controls. (See figure 4–3.) Multiply the displayed ratio on the Modulation Analyzer by the calibration factor of step 4. (For example, if the display reads 12.52% REL and the calibration factor of step 4 is 100.4%, the result is 12.52 × 100.4 = 12.57% REL.) The result should be between 12.35 and 12.65% REL.

    FM Accuracy; 4 kHz Modulation Range: 12.35 ________________ 12.65% REL

FM Distortion, Accuracy, and Rejection (1.5 MHz IF)

12. Connect the FM÷4 output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4–3.)
13. On the Modulation Analyzer, set all LP FILTERs to off, DETECTOR to PEAK+, and RATIO off.
14. Set the frequency of the audio analyzer's source to 100 kHz. Set the level of the audio analyzer for a Modulation Analyzer display of 100 kHz peak deviation.

15. Connect the audio analyzer's input to the Modulation Analyzer's MODULATION OUTPUT. (See figure 4-3.) Set the audio analyzer to measure the distortion on the 100 kHz signal at the MODULATION OUTPUT (all audio analyzer filters should be off). The distortion should be 0.1% or less (−60 dB or less).

FM Distortion at 100 kHz Rate; 100 kHz Peak Deviation: ________________ 0.1%

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch it on.

16. Set the audio synthesizer to 10 kHz at +5 dBm. Connect its output to the audio input of the AM/FM test source. (See figure 4-3.) Fine adjust the level for a Modulation Analyzer display of 100 kHz times the calibration factor of step 5. (For example, if the calibration factor of step 5 is 100.4%, set the level for a display of 100.4 kHz.)
17. Set the audio synthesizer to the frequencies in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	FM Limits (kHz)		
	Lower	Actual	Upper
100 000	98.9	______	101.1
200 000	94.9	______	105.1
50	98.9	______	101.1
20	94.9	______	105.1

18. On the Modulation Analyzer, set HP FILTER to 50 Hz and LP FILTER to 3 kHz.
19. Set the audio synthesizer frequency to 1 kHz. Set the level for a Modulation Analyzer display of 50 kHz peak deviation.
20. On the Modulation Analyzer, press AM. Momentarily disconnect the audio input to the AM/FM test source and note the residual AM displayed on the Modulation Analyzer.

Residual AM: ________________ %

21. Reconnect the audio input of the AM/FM test source. Note the AM displayed on the Modulation Analyzer. The displayed AM minus one-half the residual AM noted in step 20 should be 0.2% or less.

FM Rejection at 1 kHz Rate; 50 kHz Peak Deviation: ________________ 0.2%

FM Distortion, Accuracy, and Rejection (455 kHz IF)

22. Connect the FM÷32 output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4-3.)
23. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 kHz. Press FM.
24. Set the audio synthesizer level for a Modulation Analyzer display of 5 kHz peak deviation.

25. On the Modulation Analyzer, press AM. Momentarily disconnect the audio input to the AM/FM test source and note the residual AM displayed on the Modulation Analyzer.

Residual AM: ________________ %

26. Reconnect the audio input of the AM/FM test source. Note the AM displayed on the Modulation Analyzer. The displayed AM minus one-half the residual AM noted in step 25 should be 0.2% or less.

FM Rejection at 1 kHz Rate; 5 kHz Peak Deviation: ________________ 0.2%

27. On the Modulation Analyzer, press FM. Set all HP FILTERs to off and LP FILTER to >20 kHz.

28. Set the audio synthesizer level for a Modulation Analyzer display of 10 kHz peak deviation times the calibration factor of step 4. (For example, if the calibration factor of step 4 is 100.4%, set the level for a display of 10.04 kHz.)

29. Set the audio synthesizer to the frequencies shown in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	FM Limits (kHz)		
	Lower	Actual	Upper
10 000	9.79	______	10.21
20	9.79	______	10.21

30. Set the audio analyzer's source to 10 kHz at 2 V. Connect its output to the audio input of the AM/FM test source. (See figure 4–3.) Fine adjust the oscillator level for a Modulation Analyzer display of 10 kHz peak deviation.

31. Set the audio analyzer to measure the distortion on the 10 kHz signal at the MODULATION OUTPUT of the Modulation Analyzer. Set the audio analyzer's low-pass filter to 30 kHz and the high-pass filter to 400 Hz. The distortion should be less than 0.1% (–60 dB or less).

FM Distortion at 10 kHz Rate; 10 kHz Peak Deviation: ________________ 0.1%

Performance Test 2A

FM TESTS (USING A SECOND HP 8901A EQUIPPED WITH OPTION 010)

Specification

Characteristic	Performance Limits	Conditions
FREQUENCY MODULATION		
Rates	20 Hz to 10 kHz 20 Hz to 200 kHz 20 Hz to 20 kHz	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier 10 to 1300 MHz carrier; 750 μs de-emphasis
Deviations	40 kHz peak maximum 400 kHz peak maximum 40 kHz peak maximum	150 kHz to 10 MHz carrier 10 to 1300 MHz carrier 10 to 1300 MHz carrier; 750 μs de-emphasis
Accuracy(1)	±2% of reading ±1 digit ±1% of reading ±1 digit ±5% of reading ±1 digit	250 kHz to 10 MHz carrier; 20 Hz to 10 kHz rates; 10 to 1300 MHz carrier; 50 Hz to 100 kHz rates; 10 to 1300 MHz carrier; 20 Hz to 200 kHz rates;
Demodulated Output Distortion(2)	< 0.1% THD < 0.1% THD	400 kHz to 10 MHz carrier; deviations < 10 kHz 10 to 1300 MHz carrier; rates and deviations < 100 kHz
FREQUENCY MODULATION (cont'd)		
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 bandwidth
AMPLITUDE MODULATION		
FM Rejection(1)	<0.2% AM <0.2% AM	250 kHz to 10 MHz carrier; <5 kHz peak deviation; 400 and 1 kHz rates; 50 Hz to 3 kHz bandwidth 10 to 1300 MHz carrier; <50 kHz peak deviation; 400 Hz and 1 kHz rates; 50 Hz to 3 kHz bandwidth

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in section 3.)
(2) With 750 μs de-emphasis and pre-display "off", distortion is not specified for modulation outputs >4 V (pk). This can occur near maximum deviation for a measurement range at rates < 2 kHz.

Description

FM is measured with a very low-noise oscillator at the Modulation Analyzer's input. The resulting measured FM is the residual FM of the Modulation Analyzer's internal local oscillator. FM accuracy is measured using the FM Calibrator from a second HP 8901A equipped with Option 010. A source, which can produce wide-band, linear FM, is modulated at various FM rates and deviations to measure distortion, flatness, and incidental AM. A special AM/FM test source is required for these tests to assure that the FM source has adequate bandwidth, low distortion, low residual FM, and low incidental AM.

NOTE

If the Modulation Analyzer under test is equipped with the FM Calibrator (Option 010), perform Performance Test 2, FM Tests (For HP 8901A Equipped with Option 010).

Equipment

Modulation Analyzer with FM Calibrator .... HP 8901A Option 010
AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Audio Synthesizer .... HP 3336C (Opt. 005)

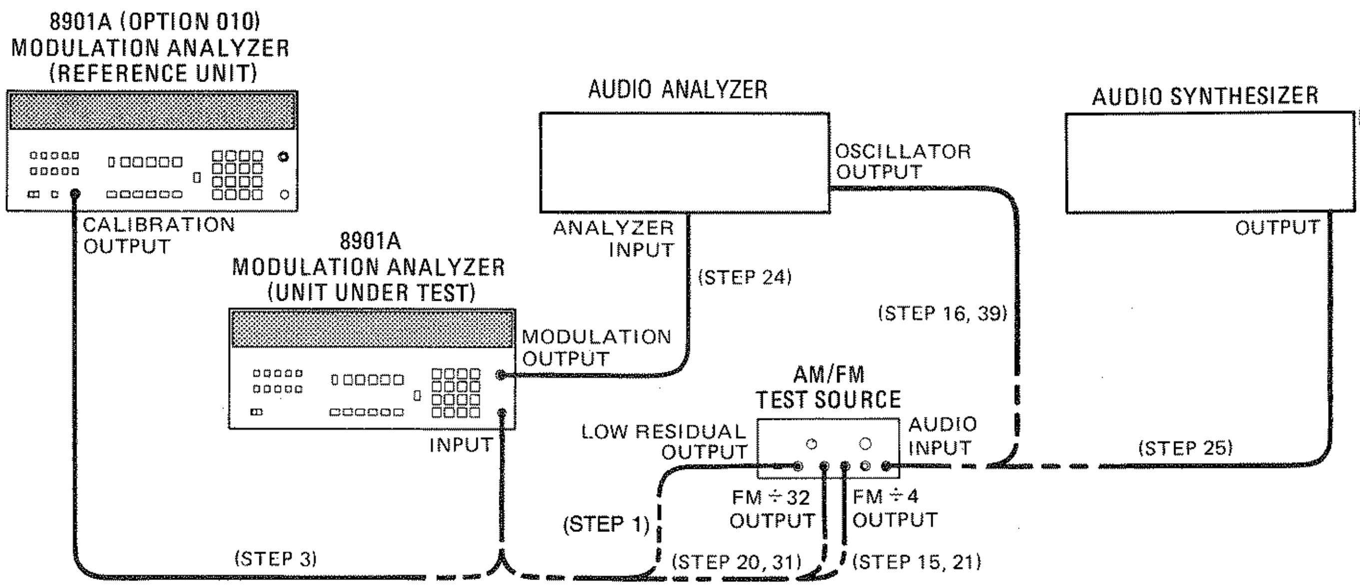


Figure 4–4. FM Performance Test Setup (Using a Second HP 8901A Equipped with Option 010)

Procedure

Residual FM

1. On the AM/FM test source, set the test mode to residual FM. Connect its low-residual (560 MHz) output to the Modulation Analyzer's INPUT. (See figure 4–4.)
2. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Set the other controls as follows:

   Measurement .... FM
   HP Filter .... 50 Hz
   LP Filter .... 3 kHz
   Detector .... AVG

   The display should read 4 Hz or less.

   The equation for determining the residual FM limits is:

   $$residual\ FM\ in\ Hz = 5.83 \times carrier\ frequency\ in\ GHz + 0.42\ Hz$$

   For a carrier of 560 MHz, the residual FM limit is 3.7 Hz. Allowing for one digit of uncertainty gives a limit of approximately 4 Hz.

   Residual FM at 560 MHz; 50 Hz to 3 kHz bandwidth: ________________ 4 Hz

FM Accuracy at 10 kHz Rate

3. Connect the CALIBRATION OUTPUT of the HP 8901A with Option 010 (Reference Unit) to the INPUT of the Modulation Analyzer under test. (See figure 4–4.)

   NOTE

   For greatest accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

4. Key in 12.0 SPCL on the Reference Unit to display the computed peak FM deviation and note the reading on its display. The computed FM depth of the calibrator, exluding noise is displayed.

   Computed Peak FM: ________________ Hz

5. Key in 12.1 SPCL on both Modulation Analyzers to display the demodulated peak residual FM deviation. Then key in 5.1 SPCL on the Modulation Analyzer under test to set the peak detector time constant to slow. Note the reading on the display of the Modulation Analyzer under test. The measured and corrected noise of the FM calibrator in CW is being displayed.

   Weighted Peak Residual FM; 40 kHz Range: ________________ Hz

6. Add the results of steps 4 and 5.

   Computed plus Residual FM; 40 kHz Range: ________________ Hz

7. On the Modulation Analyzer under test, key in 2.3 SPCL to set the modulation range to 400 kHz, and note the reading on its display.

   Weighted Peak Residual FM; 400 kHz Range: ________________ Hz

8. Add the results of steps 4 and 7 above.

   Computed plus Residual FM; 400 kHz Range: ________________ Hz

9. Key in 12.2 SPCL on both Modulation Analyzers to display the demodulated peak FM deviation. Then key in 5.1 SPCL on the Modulation Analyzer under test. Note the reading on the display of the Modulation Analyzer under test. The peak deviation, measured with the PEAK+ detector is being displayed.

   Measured Demodulated Positive Peak FM (Including Residual);

   40 kHz Range: ________________ kHz

10. On the Modulation Analyzer under test, press PEAK–. Note the reading on its display.

    Measured Demodulated Negative Peak FM (Including Residual);

    40 kHz Range: ________________ kHz

11. Make the following calculation:

$$\frac{(reading\ of\ step\ 9) + (reading\ of\ step\ 10)}{2}$$

    Measured Demodulated Peak FM (Averaged);

    40 kHz Range: ________________ kHz

    This result should equal the result of step 6 ±0.334 kHz.

12. Key in 2.3 SPCL on the Modulation Analyzer under test. Note the reading on its display.

    Measured Demodulated Negative Peak FM (Including Residual);

    400 kHz Range: ________________ kHz

13. On the Modulation Analyzer under test, press PEAK+. Note the reading on its display.

    Measured Demodulated Positive Peak FM (Including Residual);

    400 kHz Range: ________________ kHz

14. Make the following calculation:

$$\frac{(reading\ of\ step\ 12) + (reading\ of\ step\ 13)}{2}$$

    Measured Demodulated Peak FM (Averaged);

    400 kHz Range: ________________ kHz

    This result should equal the result of step 8 ±0.34 kHz.

15. On the AM/FM test source, set the test mode to FM. Connect its FM÷4 output to the Modulation Analyzer's INPUT. (See figure 4–4.)
16. Set the audio analyzer's source to 10 kHz at 0.5 V. Connect its output to the audio input of the AM/FM test source. (See figure 4–4.)

NOTE

For this test, if the audio analyzer has floating input and output connectors, the low connector should be grounded. Connections should be made to the high input or high output connector.

17. On the Modulation Analyzer under test, key in 41.0 SPCL initialize it. Tune the AM/FM test source's carrier frequency to approximately 100 MHz.
18. On the Modulation Analyzer under test, press FM. Set LP FILTER to 15 kHz and DETECTOR to AVG.
19. Adjust the level of the audio analyzer's source for a display of 20 kHz average deviation on the Modulation Analyzer under test. On the Modulation Analyzer under test, set RATIO to %.
20. Connect the FM÷32 output of the AM/FM test source to the Modulation Analyzer's INPUT without disturbing the AM/FM test source's controls. (See figure 4–4.) Multiply the displayed ratio on the Modulation Analyzer by the result of step 11 divided by the result of step 6. (For example, if the display reads 12.52% REL and the result of step 11 is 33.400 kHz and the result of step 6 is 33.333 kHz, the desired result is (12.52 × 33.4) ÷ 33.333 = 12.55.) The result should be between 12.35 and 12.65% REL.

FM Accuracy; 4 kHz Modulation Range: 12.35 ________________ 12.65% REL

FM Distortion, Accuracy, and Rejection (1.5 MHz IF)

21. Connect the FM÷4 output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4–4.)
22. On the Modulation Analyzer, set all LP FILTERs to off, DETECTOR to PEAK+, and RATIO off.
23. Set the frequency of the audio analyzer's source to 100 kHz. Set the level of the oscillator for a Modulation Analyzer display of 100 kHz peak deviation.
24. Connect the audio analyzer's input to the MODULATION OUTPUT of the Modulation Analyzer under test. (See figure 4–4.) Set the audio analyzer to measure the distortion on the 100 kHz signal at the MODULATION OUTPUT (all audio analyzer filters should be off). The distortion should be 0.1% or less (–60 dB or less).

FM Distortion at 100 kHz Rate; 100 kHz Peak Deviation: ________________ 0.1%

25. Set the audio synthesizer to 10 kHz at +15 dBm. Connect its output to the audio input of the AM/FM test source. (See figure 4–4.) Fine adjust the level for a Modulation Analyzer display of 100 kHz times the result of step 11 divided by the result of step 6. (For example, if the result of step 11 is 33.400 kHz, and the result of step 6 is 33.333 kHz, set the level for a display of (100 kHz × 33.400) ÷ 33.333 = 100.2 kHz.))

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch it on.

26. Set the audio synthesizer to the frequencies in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the following table.

Audio Synthesizer Frequency (Hz)	FM Limits (kHz)		
	Lower	Actual	Upper
100 000	98.9	______	101.1
200 000	94.9	______	105.1
50	98.9	______	101.1
20	94.9	______	105.1

27. On the Modulation Analyzer, set HP FILTER to 50 Hz and LP FILTER to 3 kHz.
28. Set the audio synthesizer frequency to 1 kHz. Set the level for a Modulation Analyzer display of 50 kHz peak deviation.
29. On the Modulation Analyzer, press AM. Momentarily disconnect the audio input to the AM/FM test source and note the residual AM displayed on the Modulation Analyzer.

Residual AM: ______________ %

30. Reconnect the audio input of the AM/FM test source. Note the AM displayed on the Modulation Analyzer. The displayed AM minus one-half the residual AM noted in step 20 should be 0.2% or less.

FM Rejection at 1 kHz Rate; 50 kHz Peak Deviation: ______________ 0.2%

FM Distortion, Accuracy, and Rejection (455 kHz IF)

31. Connect the FM÷32 output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4–4.)
32. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 kHz. Press FM.
33. Set the audio synthesizer level for a Modulation Analyzer display of 5 kHz peak deviation.
34. On the Modulation Analyzer, press AM. Momentarily disconnect the audio input to the AM/FM test source and note the residual AM displayed on the Modulation Analyzer.

Residual AM: ______________ %

35. Reconnect the audio input of the AM/FM test source. Note the AM displayed on the Modulation Analyzer. The displayed AM minus one-half the residual AM noted in step 34 should be 0.2% or less.

FM Rejection at 1 kHz Rate; 5 kHz Peak Deviation: ________ 0.2%

36. On the Modulation Analyzer, press FM. Set all HP FILTERs to Off and LP FILTER to >20 kHz.

37. Set the audio synthesizer frequency to 1 kHz. Set the audio synthesizer level for a Modulation Analyzer display of 0.1 times the display set in step 25. (For example, if the display set in step 25 is 100.2 kHz, set the level for a display of 10.02 kHz.)

38. Set the audio synthesizer to the frequencies shown in the following table. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	FM Limits (kHz)		
	Lower	Actual	Upper
10 000	9.79	______	10.21
20	9.79	______	10.21

39. Set the audio analyzer's source to 10 kHz at 2 V. Connect its output to the audio input of the AM/FM test source. (See figure 4–4.) Fine adjust the oscillator level for a Modulation Analyzer display of 10 kHz peak deviation.

40. Set the audio analyzer to measure the distortion on the 10 kHz signal at the MODULATION OUTPUT of the Modulation Analyzer. Set the audio analyzer's low pass filter to 30 kHz and the high pass filter to 400 Hz. The distortion should be less than 0.1% or less. (–60 dB or less).

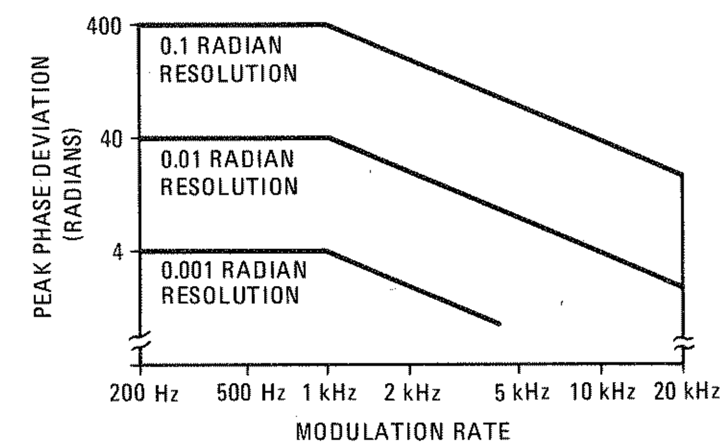
FM Distortion at 10 kHz Rate; 10 kHz Peak Deviation: ________ 0.1%

Performance Test 3

ΦM TESTS

Specification

Characteristic	Performance Limits	Conditions
PHASE MODULATION		
Carrier Frequency	10 to 1300 MHz	
Deviation and Maximum Resolution	Refer to figure below.	
Rates	200 Hz to 20 kHz	
Accuracy[1]	±3% of reading ±1 digit	
Demodulated Output Distortion	<0.1% THD	



Phase Modulation Deviation and Maximum Resolution

(1) Peak residuals must be accounted for in peak readings. (Refer to *Residual Noise Effects* in section 3.)

Description

A signal with a known amount of phase modulation is generated by frequency modulating a carrier at a known peak deviation (as measured by the previously-calibrated Modulation Analyzer) and rate. The relationship between the peak phase deviation and peak frequency deviation is:

$$\text{peak phase deviation} = \frac{\text{peak frequency deviation}}{\text{modulation rate}}.$$

The measured deviation is compared with the calculated deviation for several combinations of FM deviation and rate. The distortion is also measured. A special AM/FM test source is required for these tests to assure that the FM source has adequate bandwidth, low-distortion, and low residual ΦM.

Equipment

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Audio Synthesizer .... HP 3336C

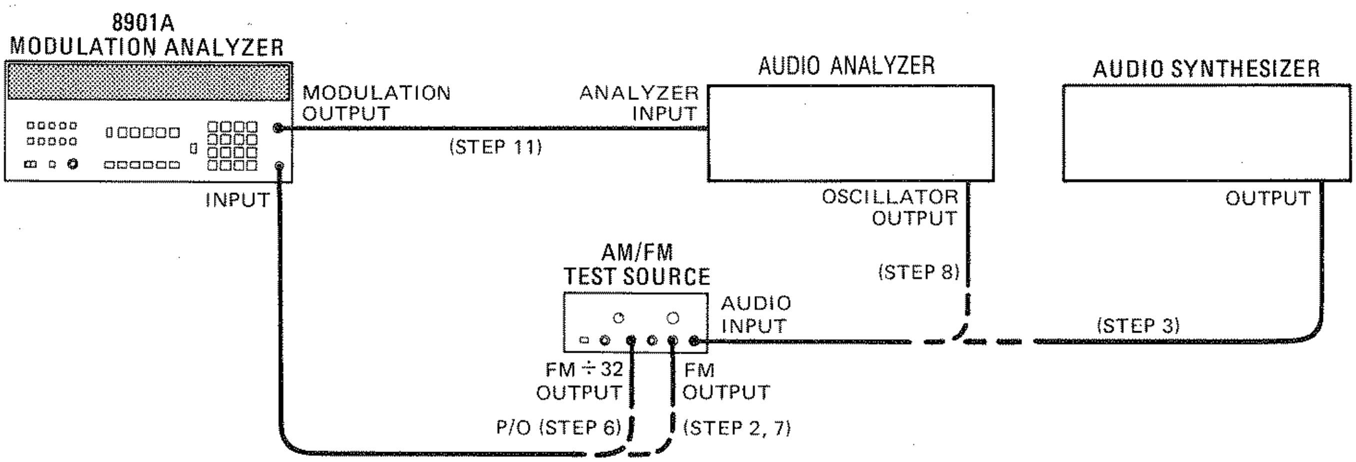


Figure 4–5. *ΦM Performance Test Setup*

Procedure

ΦM Accuracy

1. Make the tests in *Performance Test 2,* FM Tests.
2. On the AM/FM test source, set the test mode to FM. Connect its FM output to the Modulation Analyzer's INPUT. (See figure 4–5.)
3. Set the audio synthesizer to 200 Hz at –10 dBm. Connect its output to the audio input of the AM/FM test source. (See figure 4–5.)
4. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Press FREQ and then key in 4.1 SPCL to turn on Track Mode. Tune the AM/FM test source's carrier frequency to approximately 400 MHz. Key in 4.0 SPCL to turn off Track Mode.

5. On the Modulation Analyzer, press MHz to center its tuning. Set the other controls as follows:

   Measurement .... FM
   LP Filter .... >20 kHz
   Detector .... AVG

6. Set the audio synthesizer frequency as shown in the following table. Set the Modulation Analyzer high pass filter as shown in the table. Set the audio synthesizer level to give the FM deviation shown in the table (as read on the Modulation Analyzer). After setting each FM deviation, press ΦM. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	High Pass Filter	Average FM Deviation (kHz)	ΦM Limits (rad)		
			Lower	Actual	Upper
200	50	50	242.4	______	257.6
1 000	300	250	242.4	______	257.6
20 000	300	250	12.1	______	13.0
20 000	300	4*	0.193	______	0.207

* Connect the FM÷32 output of the AM/FM test source to the Modulation Analyzer's INPUT to make this measurement. (See figure 4-5.) Press AUTOMATIC OPERATION, then MHz to retune the Measuring Receiver. If the resolution is not 0.001 rad, press ΦM again.

ΦM Distortion

7. Connect the FM output of the AM/FM test source to the Modulation Analyzer's INPUT. (See figure 4-5.) Press AUTOMATIC OPERATION on the Modulation Analyzer.

8. Set the audio analyzer's source to 1 kHz. Connect its output to the audio input of the AM/FM test source. (See figure 4-5.)

NOTE

For this test, if the audio analyzer has floating input and output connectors, the low connector should be grounded. Connections should be made to the high input or high output connector.

9. On the Modulation Analyzer, press ΦM. Set DETECTOR to PEAK+. Set HP FILTER to 300 Hz. Set LP FILTER to 15 kHz.

10. Adjust the audio analyzer's source level to give a display of 400 rad peak deviation.

11. Connect the audio analyzer's input to the Modulation Analyzer's MODULATION OUTPUT. (See figure 4–5.) Set the audio analyzer to measure the distortion on the 1 kHz signal at the MODULATION OUTPUT. Set the high-pass filter on the audio analyzer to 400 Hz. (All audio analyzer filters should be off.) The distortion should be 0.1% (–60 dB or less).

    ΦM Distortion at 1 kHz Rate; 400 rad Peak Deviation;

    1.5 MHz IF: ________________ 0.1%

12. Reduce the level of the audio analyzer's source to give a display of 40 rad peak deviation.

13. On the Modulation Analyzer, key in 3.1 SPCL. The distortion measured on the audio analyzer should be 0.1% or less.

    ΦM Distortion at 1 kHz Rate; 40 rad Peak Deviation;

    455 kHz IF: ________________ 0.1%

Performance Test 4

AUDIO FILTERS TEST

Specification

Characteristic	Performance Limits	Conditions
AUDIO FILTERS		
50 Hz High Pass (2 Pole)		
3 dB Cutoff Frequency	50 Hz nominal	
Flatness	< 1%	> 200 Hz rates
300 Hz High Pass (2 Pole)		
3 dB Cutoff Frequency	300 Hz nominal	
Flatness	< 1%	> 1 kHz rates
3 kHz Low Pass (5 Pole)		
3 dB Cutoff Frequency	3 kHz nominal	
Flatness	< 1%	< 1 kHz rates
15 kHz Low Pass (5 Pole)		
3 dB Cutoff Frequency	15 kHz nominal	
Flatness	< 1%	< 10 kHz rates
>20 kHz Low Pass (9 Pole Bessel)[1]		
3 dB cutoff frequency	> 20 kHz nominal	
Flatness	< 1%	< 10 kHz rates

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

Description

A signal is frequency modulated by a source which is known to have FM which is flat with rate. The flatness of the demodulated signal is then measured for various modulation filters.

NOTE

Flatness of the audio synthesizer is critical for this test. If the audio synthesizer has leveling capability, switch it on.

Equipment

AM/FM Test Source .... HP 11715A
Audio Synthesizer .... HP 3336C (Opt. 005)

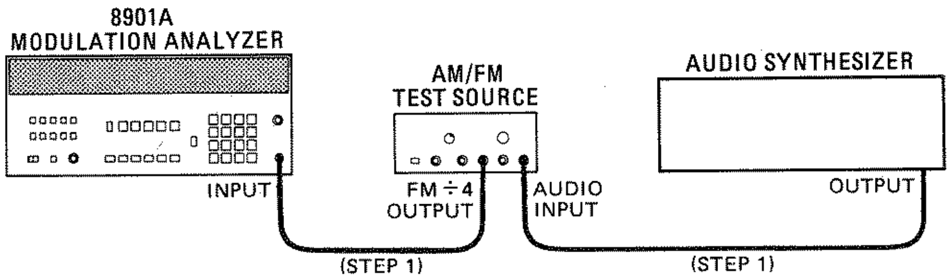


Figure 4–6. *Audio Filters Performance Test Setup*

Procedure

1. Connect the equipment as shown in figure 4–6.
2. On the AM/FM test source, set the test mode to FM.
3. Set the audio synthesizer to 200 Hz at +6 dBm.
4. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Press FREQ and then key in 4.1 SPCL to turn on Track Mode. Tune the AM/FM test source's carrier frequency to approximately 100 MHz. Key in 4.0 SPCL to turn off Track Mode.
5. On the Modulation Analyzer, press MHz to center the instrument's tuning. Set the other controls as follows:

   Measurement .... FM
   Detector .... AVG

6. Set the audio synthesizer level to give a display of approximately 25 kHz average deviation.

7. Set the audio synthesizer frequency to the frequencies shown in the following table. For each setting, set RATIO on the Modulation Analyzer to off, set all HP or LP FILTERs to off, then set RATIO to %, and insert the filter indicated. For each setting, the Modulation Analyzer's display should read between the limits indicated in the table.

Audio Synthesizer Frequency (Hz)	Filter	Ratio Limits (% REL)		
		Lower	Actual	Upper
200	50 Hz HP FILTER	98.99	________	101.01
2 000	50 Hz HP FILTER	98.99	________	101.01
1 000	300 Hz HP FILTER	98.99	________	101.01
10 000	300 Hz HP FILTER	98.99	________	101.01
1 000	3 kHz LP FILTER	98.99	________	101.01
100	3 kHz LP FILTER	98.99	________	101.01
10 000	15 kHz LP FILTER	98.99	________	101.01
1 000	15 kHz LP FILTER	98.99	________	101.01
10 000	> 20 kHz LP FILTER	98.99	________	101.01
1 000	> 20 kHz LP FILTER	98.99	________	101.01

Performance Test 5

RF LEVEL PERFORMANCE TEST

Specifications

Serial Prefix: 1933A to 2212A

Characteristic	Performance Limits	Conditions
RF LEVEL		Peak voltage responding, rms sine wave calibrated.
Range	1 mW to 1 W	
Instrumentation Accuracy	±2 dB ±3 dB	150 kHz to 650 MHz 650 to 1300 MHz
SWR	< 1.5	50Ω system

Serial Prefix: 2227A and above

Characteristic	Performance Limits	Conditions
RF LEVEL		Peak voltage responding, rms sine wave calibrated.
Range	1 mW to 1 W	
Instrumentation Accuracy	±1.5 dB	150 kHz to 650 MHz
SWR	< 1.3 < 1.5	50Ω system; 150 kHz to 650 MHz 50Ω system; 650 MHz to 1300 MHz

Description

Power from a signal generator is applied through a power splitter to the Modulation Analyzer's input and a power meter. The power level reading between the power meter and the Modulation Analyzer are compared for various settings of power level and frequency. SWR is measured at several frequencies by driving the input of the Modulation Analyzer through an SWR Bridge. The reflected power is measured by a power meter. A reference point is first made by disconnecting the Modulation Analyzer's input to give an open circuit (high reflection).

NOTE

For the accuracy measurement, the output of the signal generator must be filtered (if its harmonics or spurious signals are less than 30 down from the carrier) to prevent discrepancies between readings of the peak-responding Modulation Analyzer and the average-responding power meter.

Equipment

Bandpass Filter 512 to 674 MHz .... Telonic TBA 593-218-5FE
Bandpass Filter 800 to 1100 MHz .... Telonic TBA 950-375-5FE1
Power Meter and Sensor .... HP 436A/8482A
Power Splitter .... HP 11667A
Signal Generator .... HP 8640B with Option 002
SWR Bridge .... Wiltron 60N50

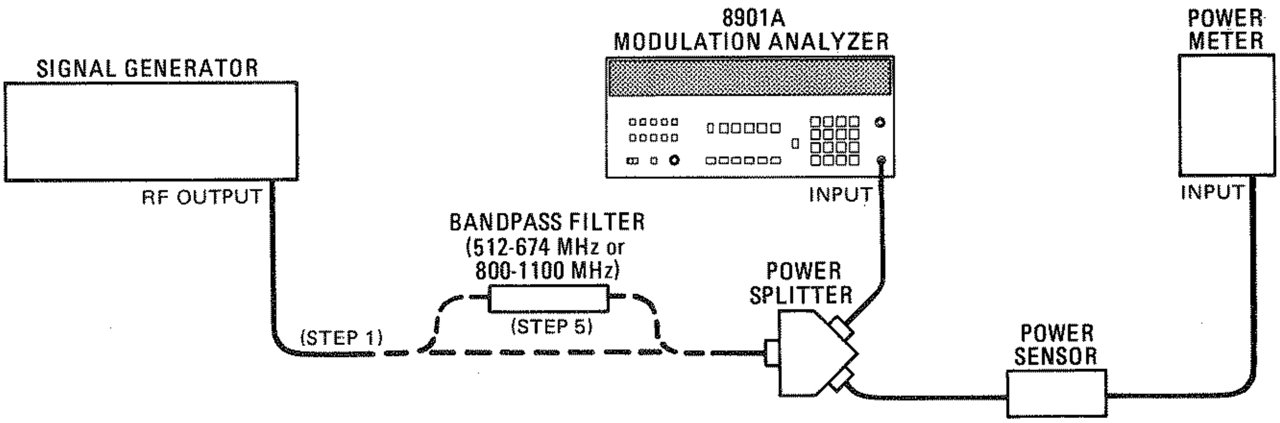


Figure 4–7. *RF Level Accuracy Performance Test Setup*

Procedure

RF Level Accuracy

1. Calibrate and zero the power meter and sensor.
2. Connect equipment as shown in figure 4–7.
3. Press RF LEVEL.
4. Set the signal generator to 50 MHz CW. Set its level for the power meter readings shown below. For each setting, the Modulation Analyzer's display should read between the limits shown below.

Serial Prefix: 1933A to 2212A

Power Meter Reading (mW)	RF Level Limits (mW)		
	Lower	Actual	Upper
10	6.31	______	15.8
3	1.89	______	4.75
1	0.631	______	1.58

Serial Prefix: 2227A and above

Power Meter Reading (mW)	RF Level Limits (mW)		
	Lower	Actual	Upper
10	7.08	______	14.1
3	2.12	______	4.24
1	0.708	______	1.41

5. Set the frequency of the signal generator to those shown in the table below. For each frequency setting, adjust the power level to give a power meter reading of 3 mW. The Modulation Analyzer should read between the limits shown in the table.

Serial Prefix: 1933A to 2212A

Signal Generator Frequency (MHz)	RF Level Limits (mW)		
	Lower	Actual	Upper
1000*	1.50	______	5.99
650*	1.89	______	4.75
100	1.89	______	4.75
10	1.89	______	4.75
0.5	1.89	______	4.75

* If a signal generator with a doubler is being used, insert the appropriate bandpass filter at the generator's output to suppress harmonic and subharmonic signals.

Serial Prefix: 2227A and above

Signal Generator Frequency (MHz)	RF Level Limits (mW)		
	Lower	Actual	Upper
1000*	2.12	______	4.24
650*	2.12	______	4.24
100	2.12	______	4.24
10	2.12	______	4.24
0.5	2.12	______	4.24

* If a signal generator with a doubler is being used, insert the appropriate bandpass filter at the generator's output to suppress harmonic and subharmonic signals.

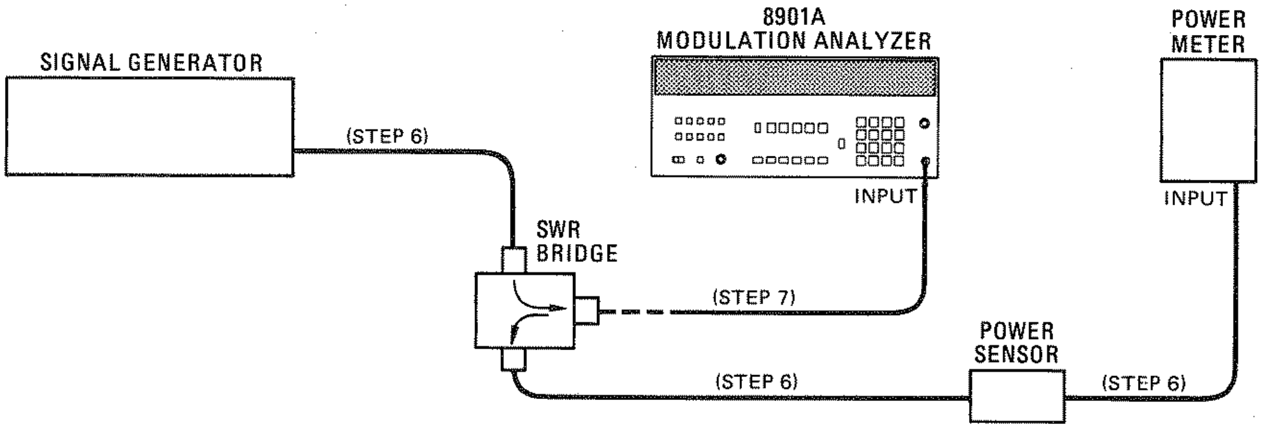


Figure 4-8. *SWR Performance Test Setup*

SWR Performance

6. Connect the equipment as shown in figure 4-8.
7. Set the signal generator frequency as listed in the following table. For each frequency disconnect the load from the test port of the SWR bridge and adjust the signal generator level for a power meter reading of −5 dBm. Then connect the test port of the SWR bridge directly to the Modulation Analyzer's INPUT. The power meter reading should drop by at least 14 dB.

Serial Prefix: 1933A to 2212A

Signal Generator Frequency (MHz)	Power Meter Reading (dBm)	
	Actual	Maximum
1000	________	−19
300	________	−19
100	________	−19
30	________	−19
10	________	−19

Serial Prefix: 2227A and above

Signal Generator Frequency (MHz)	Power Meter Reading (dBm)	
	Actual	Maximum
1000	________	−19
650	________	−23
300	________	−23
100	________	−23
30	________	−23
10	________	−23

Section 5
ADJUSTMENTS

5-1. INTRODUCTION

This section contains adjustments and checks that assure peak performance of the Modulation Analyzer. The instrument should be readjusted after repair or failure to pass a performance test. Allow a 30 minute warm-up prior to performing the adjustments. Removing the top cover is the only disassembly required for all adjustments.

To determine which performance tests and adjustments to perform after a repair, refer to paragraph 5-5, Post-Repair Tests, Adjustments, and Checks.

5-2. SAFETY CONSIDERATIONS

This section contains information, cautions, and warnings which must be followed for your protection and to avoid damage to the equipment.

WARNING

Adjustments described in this section are performed with power supplied to the instrument and with protective covers removed. Maintenance should be performed only by service trained personnel who are aware of the hazard involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

Removal of the Modulation Analyzer's bottom cover is not necessary to perform these adjustments. However, if the bottom cover is removed, hazardous voltage (≈120 V ac) is accessible.

A pin-to-pin voltage difference of 55 V dc may be found on many of the Modulation Analyzer's circuit board connectors. Be careful while working on the circuit boards with power supplied to the instrument.

If a circuit board is placed on an extender board, the possibility of coming in contact with 55 V dc is greatly increased. Be careful while working on the circuit boards with power supplied. Work with one hand. Do not touch the extender board.

5-3. EQUIPMENT REQUIRED

Each adjustment procedure contains a list of required test equipment. The test equipment is identified by callouts in the test setup diagrams where included.

If substitutions must be made for the specified test equipment, refer to table 1-3 for the minimum specifications. It is important that the test equipment meet the critical specifications listed in the table if the Modulation Analyzer is to meet its performance requirements.

5-4. FACTORY-SELECTED COMPONENTS

Factory-selected components are identified on the schematics and parts list by an asterisk which follows the reference designator. The normal value or range of the components is shown. Table 5-1 lists the reference designator, the criterion used for selecting a particular value, the normal value range, and the service sheet where the component part is shown.

Table 5-1. *Factory Selected Components*

Reference Designator	Service Sheet	Range of Values	Basis of Selection
Serial Prefixes: 2212A to 2410A (08901-60183)			
A15R10	*1*	*42.2Ω 68.1Ω*	*Refer to RF Detector Offset Adjustment (Adjustment 3).*
A15R47	*1*	*196Ω 383Ω*	*Refer to RF Detector Offset Adjustment (Adjustment 3).*
A19C43	11	4.7p to 15p	See LO Doubler Power Output and Balance Adjustment (Adjustment 5).
A19R63	11	38.1Ω to 110Ω	See LO Doubler Power Output and Balance Adjustment (Adjustment 5).
A19R72, R74	11	619Ω to 1210Ω	See LO Doubler Power Output and Balance Adjustment (Adjustment 5).
A20R1, R2	14	21.5 kΩ to ∞	See Track-Tune Mode Offset Adjustment (Adjustment 19).
A23R55	12	511Ω to 1780Ω	See Sampler Efficiency and Offset Adjustment (Adjustment 4).
A23C45	12	1.8p to 2.7p	See Sampler Efficiency and Offset Adjustment (Adjustment 4).
A51C20 A51R32	28	9.09 kΩ or 11.0 kΩ	If A51C20 cannot be adjusted for a display within listed limits, then R32 can be selected to shift nominal readings on the display. Increasing R32 one adjustment value will increase the nominal reading by approximately 3%. The only values available are 9.09 k ohms and 11.0 k ohms.
A51R24	28	—	If the FM deviation of the FM Calibrator Option 010 exceeds the peak deviation limits of 30 to 38 kHz, error E08 will be displayed. (If service errors have been enabled by Special Function 43.1, error E74 or E75 will be displayed instead.) To measure the actual peak deviation, connect the CALIBRATION OUTPUT to the INPUT and key in 12.2 SPCL. If the deviation is only slightly out of limits, alter the value of A51R24. Increasing the value of A51R24 by 10% will decrease the peak deviation by approximately 2.5 kHz.

5-5. POST-REPAIR TESTS, ADJUSTMENTS, AND CHECKS

Table 5-2 lists the performance tests, adjustments, and checks needed to calibrate or verify calibration of a repaired assembly. The tests, adjustments, and checks are classified by assembly repaired.

The table is also useful as a cross reference between performance tests and assemblies when the failure is a specification that is slightly out of limits.

For all repairs, perform the Basic Functional Checks, the Power Supply Adjustment (but only adjust the +15 V supply if it is out of limits), and the Internal Reference Frequency Adjustment. The Basic Functional Check utilizes automatic tuning and measurement which exercises nearly every circuit in the instrument (except the Remote Interface Assembly).

5-6. RELATED ADJUSTMENTS

The procedures in this section can be done in any order, but it is advisable to check the power supply voltages and time base reference first.

Table 5-2. *Post-Repair Tests, Adjustments, and Checks (1 of 3)*

Assembly Repaired	Test, Adjustment, or Check	Refer to Page
A1 Keyboard and Display	Power-Up Checks Service Special Functions (use 60.0 SPCL, Key Scan, and exercise all keys)	8-17 8-11
A2 Audio Filter	AM Performance Test AM Sensitivity Adjustment 15 kHz and >20 kHz Low-Pass Filter Gain Adjustments	4-2 5-29 5-16
A3 Audio De-emphasis and Output	FM Performance Test (FM Distortion 1.5 MHz IF only) ΦM Performance Test Audio Filters Performance Test ΦM Sensitivity Adjustment	4-15, (4-21) 4-28 4-32 5-26
A4 FM Demodulator	FM Performance Test FM Sensitivity Adjustment FM Flatness Adjustment	4-15 5-19 5-22
A5 Voltmeter	Voltmeter Offset and Sensitivity Adjustment Service Special Functions (use 49.N and 50.N SPCL, Display Internal Voltages, and check for reasonable readings)	5-14 8-7
A6 AM Demodulator	AM Performance Test FM Distortion and Incidental AM Adjustment (1.5 MHz IF) AM Sensitivity Adjustment ALC Reference Adjustment	4-2 5-24 5-29 5-17

Table 5-2. Post-Repair Tests, Adjustments, and Checks (2 of 3)

Assembly Repaired	Test, Adjustment, or Check	Refer to Page
A10 Power Supply Regulators	Power Supply Adjustment	5-6
A11 Counter	Internal Reference Frequency Adjustment Power-up Checks	5-7 8-17
A13 Controller	Power-Up Checks	8-17
A14 Remote Interface	HP-IB Functional Checks Power-Up Checks	3-18 8-17
A15 RF Input	RF Level Performance Test RF Detector Offset Adjustment	4-35 5-9
A17 Input Mixer	FM Distortion and Incidental AM Adjustment (1.5 MHz IF) FM Distortion and Incidental AM Adjustment (455 kHz IF)	5-24 5-32
A18 IF Amplifier	FM Distortion and Incidental AM Adjustment (1.5 MHz IF) FM Distortion and Incidental AM Adjustment (455 kHz IF)	5-24 5-32
A19 LO Divider	LO Doubler Balance Adjustment (only for Doubler repairs) Power-Up Checks	5-12 8-17
A20 LO Control	FM Performance Test (Residual FM only) Power-Up Checks	4-15, (4-21) 8-17
A21 Low Frequency VCXO Filter	Power-Up Checks	8-17
A22 Low Frequency VCXO	FM Performance Test (Residual FM Only) Power-Up Checks	4-15, (4-21) 8-17
A23 Sampler	FM Performance Test (Residual FM only) Sampler Efficiency and Offset Adjustment Power-Up Checks	4-15. (4-21) 5-10 8-17
A24 High Frequency VCO	FM Performance Test (Residual FM only) Power-Up Checks	4-15, (4-21) 8-17
A25 Audio Motherboard A26 Power Supply Motherboard A27 Digital Mother Board A28 RF Mother Board A29 Series Regulator Heat Sink A30 Line Power Module	Power-Up Checks	8-17

Table 5-2. Post-Repair Tests, Adjustments, and Checks (3 of 3)

Assembly Repaired	Test, Adjustment, or Check	Refer to Page
A31 Remote Interface Connector	HP-IB Functional Checks	3–18
A50 AM Calibrator	AM Performance Test (AM Accuracy at 10 kHz only) AM Calibrator Adjustment	4–4 5–28
A51 FM Calibrator	FM Performance Test (FM Accuracy at 10 kHz only) FM Calibrator Adjustment	4–17 5–18

Adjustment 1

POWER SUPPLY ADJUSTMENT

Reference

- **Service Sheets 23 and 24**

Description

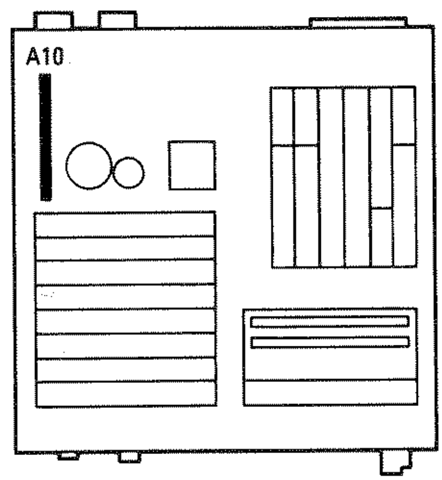
The +15 V supply is adjusted, and the other supplies, which are dependent upon it, are checked.

Equipment

Digital Multimeter .... HP 3478A

Procedure

1. Set voltmeter to measure +15 V dc. Connect input to A10TP3 (+15 V).
2. Adjust A10R24 (+15 V ADJ) for +14.9 to +15.1 V dc at A10TP3.
3. Check the other supplies with voltmeter as shown below.



Supply	Test Point	Voltage Limits (V dc)	
		Minimum	Maximum
−15 V	A10TP7	−15.2	−14.8
+5 V	A10TP5	+5.1	+5.3
−5 V	A10TP4	−5.3	−5.1
+40 V	A10TP6	+40.5	+42.5

Adjustment 2

INTERNAL REFERENCE FREQUENCY ADJUSTMENT

Reference

- **Service Sheet 16**

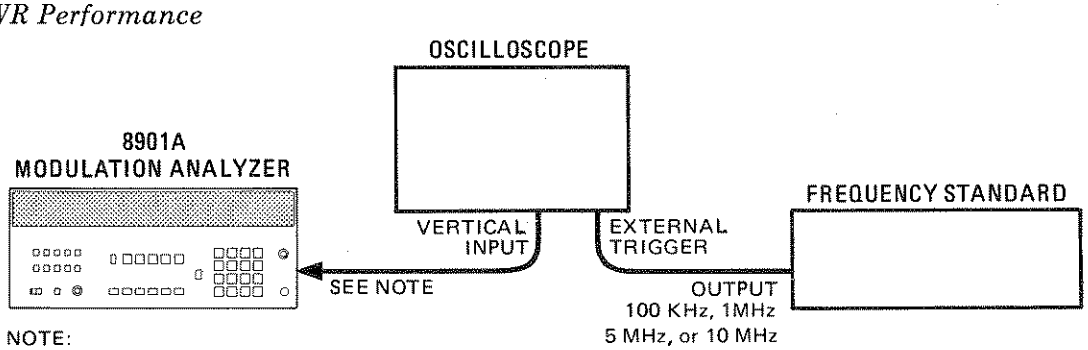
Description

An oscilloscope, triggered by an external reference, is used to monitor the internal reference frequency while it is adjusted.

Equipment

Frequency Standard . . . . House Standard
Oscilloscope . . . . HP 54201A

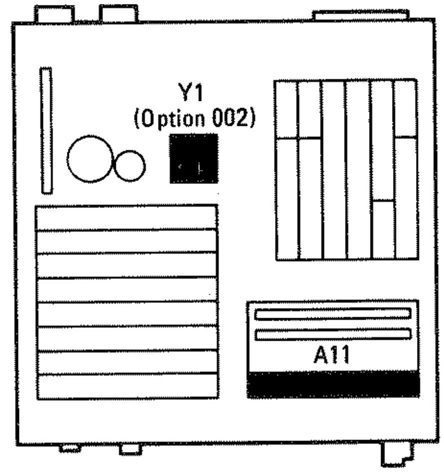
SWR Performance



NOTE:
CONNECT OSCILLOSCOPE VERTICAL INPUT TO A11J5 (INT 10 MHz OUT) IN THE 8901A OR (OPTION 002 ONLY) THE REAR-PANEL TIME BASE 10 MHz OUTPUT.

Figure 5–1. *Internal Reference Frequency Adjustment Test Setup*

Procedure



1. Allow equipment to warm up for 15 minutes. For Option 002, a warm-up of the Modulation Analyzer of several days with covers on is recommended.
2. Connect equipment as shown in figure 5–1.
3. Set oscilloscope's vertical sensitivity to view the Modulation Analyzer's time base output. Set its horizontal scale for 0.1 μs per division. Set oscilloscope to trigger externally.
4. Adjust A11C14 (10 MHz REF) or, for Option 002, Y1 (COARSE and FINE) for a stationary waveform. If adjusting A11C14, use a totally non-metallic adjustment tool.

NOTE

Movement of the waveform to the right at a rate of one division per second means that the Modulation Analyzer's time base frequency is low by 0.1 p/m.

If the frequency of the internal reference is quite far off, the oscilloscope display may be difficult to interpret. In that case, connect the frequency standard directly to the Modulation Analyzer's INPUT, press FREQ, and adjust the internal reference frequency for a display equal to the standard's frequency. Then begin again at step 2.

Adjustment 3

RF DETECTOR OFFSET ADJUSTMENT

Reference

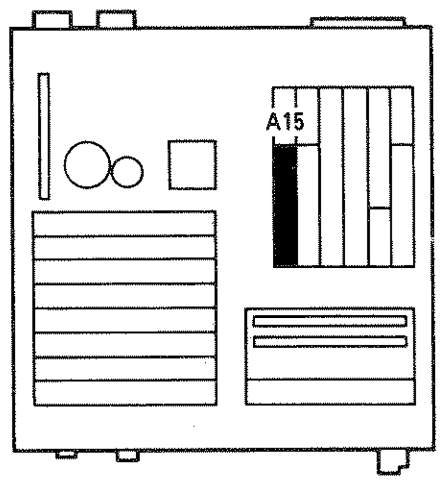
- **Service Sheet 1**

Description

With no RF input, the output from the RF detector is adjusted for 0 V dc while monitoring it with the internal voltmeter.

Procedure

1. Remove any cable from the Modulation Analyzer's INPUT.
2. Press RF LEVEL.
3. Key in 41.0 SPCL to preset the instrument. Then, key in 49.31 SPCL to display the RF level with respect to RF ground. These steps set the input for an RF level measurement and connect the internal voltmeter to the RF detector output.
4. Adjust A15R42 (DET OFS) for a display between −0.001 and 0.001.



Serial Prefixes: 2212A to 2410A only (08901-60183)

5. ***A15R10 and A15R47 Selection:*** If the instrument slightly exceeds the limits of step 5 of the RF Level Performance Test (Performance Test 5 in section 4), make an adjustment to the level accuracy versus input frequency by altering the value of A15R10 and A15R47.
   a. If the level accuracy is uniformly high or low, change A15R47. Increasing the value of A15R47 by 10% will lower the indicated level by 0.1 dB.
   b. If the level increases or decreases with frequency, change A15R10. Increasing the value of A15R10 by 10% will decrease, by 0.2 dB, the indicated level at 1000 MHz relative to the level at low frequencies.

After altering the resistor values, repeat the test, making additional measurements at frequencies between those indicated in step 5 of the RF Level Performance Test (Performance Test 5 in section 4),. The effects of changing the two resistors are slightly interactive. A large change in one resistor value may require a slight change in the value of the other resistor.

Adjustment 4

SAMPLER EFFICIENCY AND OFFSET ADJUSTMENT

Reference

Service Sheet 18.

Description

Using the track mode special function (4.1 SPCL), the two signals into the sampler are configured so that the low-frequency VCXO is at a set frequency and the high-frequency VCO tracks the RF input signal. The output of the sampler is observed on an oscilloscope. The RF input is tuned to locate a zero-beat frequency at the sampler output then tuned for a 1 MHz beat. The sampler offset and efficiency (or frequency response) are then adjusted so that the dc offset is zero and the amplitude of the 1 MHz waveform is the same for the zero beat.

NOTE

Improper adjustment of efficiency may result in the loop easily breaking or not attaining phase lock.

Equipment

Oscilloscope .... HP 54201A
Signal Source .... HP 8640B

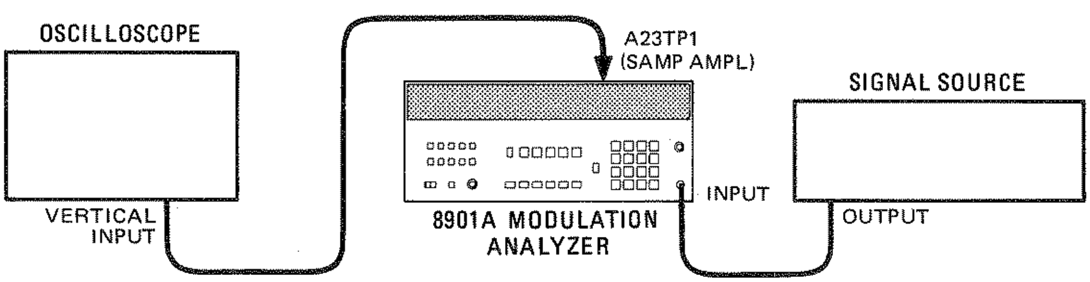
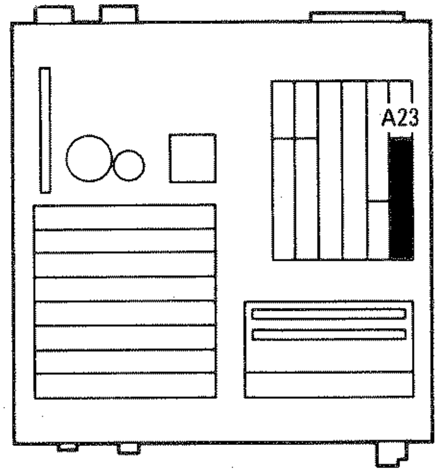


Figure 5–2. *Sampler Efficiency and Offset Adjustment Test Setup*

Procedure



1. Set the signal source to 18 MHz CW at 0 dBm.
2. Connect the equipment as shown in figure 5-2. (The oscilloscope input should be ac coupled.)
3. Set the oscilloscope's vertical sensitivity to 0.2 V/division and horizontal scale for 10 μs/division.
4. On the Modulation Analyzer, key in 41.0 SPCL to preset the instrument. Key in 4.1 SPCL to set the instrument to TRACK MODE. If the instrument fails to tune to the 18 MHz signal, key in 18 MHz then key in 4.1 SPCL.
5. Fine tune the signal source up slowly until a zero beat signal appears on the oscilloscope. Then increase the signal source frequency for a period of 30 μs. Note the frequency of the signal source. Note the peak-to-peak amplitude on the oscilloscope.

   Signal Source Frequency: ________ MHz

   Waveform Amplitude: ________ mV (p-p)
6. Tune the signal source up by 30.0 kHz. This tunes the high frequency VCO up 32 x 30 kHz ≈ 1 MHz since the LO frequency is the HF VCO frequency divided by 32 on this band.
7. Adjust A23R34 (OFS) for a waveform that does not shift on the oscilloscope display as the input coupling to the oscilloscope is changed from ac to dc. Make adjustments only when the input coupling is set to dc.
8. Adjust A23R54 (EFF) for the same peak-to-peak amplitude on the oscilloscope as noted in step 5. If the adjustment has not enough range:
   a. Set A23R54 fully ccw and repeat steps 5 to 7.
   b. The signal amplitude should now be less than in step 5. If it is not, replace A23R55 by higher values of resistance as listed in table 5–2. If this still does not have enough effect, replace A23C45 with 2.7 pF (HP Part Number 0160-4619).
   c. Adjust A23R54 for the same amplitude as noted in step 5.
9. Repeat step 7.

Table 5–2. *Part Numbers for A23R55*

Resistance (ohms)	HP Part Number
511	0757-0416
750	0757-0420
1000	0757-0280
1210	0757-0274
1470	0757-1094
1780	0757-0278

Adjustment 5

LO DOUBLER POWER OUTPUT AND BALANCE ADJUSTMENT

Reference

- **Service Sheet 11**

Description

The power output of the LO is monitored with a power meter while the LO is stepped through its doubler band. The bias and coupling components are changed as necessary to obtain the required power output. The output of the LO is then monitored with a spectrum analyzer as the VCO is swept slowly over its doubler band. The doubler balance is adjusted for minimum 1/2 and 3/2 harmonics of the doubled frequency.

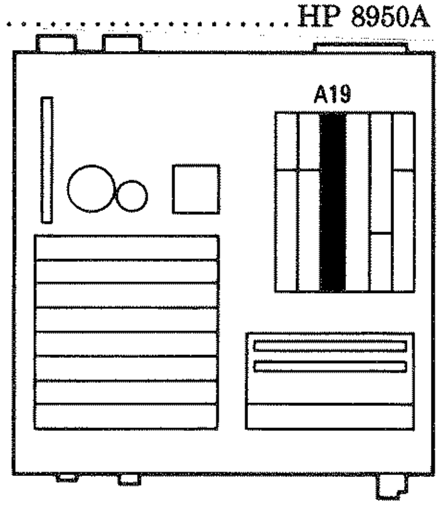
NOTE

Excessive subharmonics may cause the LO to tune to a wrong frequency when automatically tuning.

Equipment

RF Power Meter . . . . HP 435/8482A
RF Spectrum Analyzer . . . . HP 8950A

Procedure



1. Connect the power sensor of the power meter directly to A19J3 (LO OUT), or for Option 003, the rear panel LO OUTPUT jack.
2. On the Modulation Analyzer, key in 650 MHz to set the LO to the bottom of its doubler band.
3. Step the LO up in 50,000 kHz increments and record the power obtained at each frequency. The Modulation Analyzer will display error message E20 when the LO reaches the top of its range.
4. The power output of the LO should be between +1.4 dBm and +3.0 dBm at all frequencies prior to the display of error message E20. If the power output is within range, continue with step 6. If the power output is not within range, perform step 5.

   Resistors R63, R72, and R74 and capacitor C43 are changed to obtain the correct power output from the LO. Use the following guidelines when changing these components:

   a. To increase the power throughout the entire doubler band decrease the value of R63.

   b. To eliminate low frequency roll-off, increase the value of C43. Do not use a value for C43 that is larger than necessary or the effectiveness of the high-pass filter is reduced.

c. To eliminate high frequency roll-off, increase the value of R72 and R74. Note that the value of R72 must equal R74 at all times.

d. The effect of changing these components is interactive, therefore, whenever a component is changed, the entire adjustment must be repeated.

e. Any standard value component between the ranges shown in table 5-1 can be used during this procedure.

5. Replace components as required and repeat steps 1 through 4 until the power output of the LO is within range over the entire doubler band.
6. Set the spectrum analyzer to view a +10 dBm signal with a 0 to 2 GHz span width and log display. Connect its RF input to A19J3 (LO OUT) or, for Option 003, the rear panel LO OUTPUT jack.
7. On the Modulation Analyzer, key in 41.0 SPCL and the 55.0 SPCL to initialize the instrument and cause the LO to sweep slowly over its doubler range.
8. Adjust A19R41 (DBLR BAL) for minimum level of 1/2 and 3/2 harmonics of the doubled signal over the swept range. The 1/2 and 3/2 harmonics should be more than 30 dB below the doubled signal. The doubled signal sweeps from approximately 600 to 1300 MHz with a level of approximately +2 dBm.

NOTE

To ease adjustment, note the frequency of the fundamental where harmonics are worst, manually tune to that frequency (use the frequency increment keys to assist in fine tuning), make the adjustment, then key in 55.0 SPCL and recheck the entire range. The sweep can be halted at any time by pressing the SPCL key.

Adjustment 6

VOLTMETER OFFSET AND SENSITIVITY ADJUSTMENT

Reference

- **Service Sheets 9 and 10**

Description

First the dc offsets of the peak and average detectors are adjusted. The voltmeter sensitivity is then adjusted while comparing the displayed reading to the level read by an external dc voltmeter. The sensitivity of the average detector is adjusted while comparing the average mode to the peak mode when detecting a sinusoidal signal.

Equipment

Audio Analyzer . . . . HP 8903A
Digital Multimeter . . . . HP 3478A
Signal Source . . . . HP 8640B

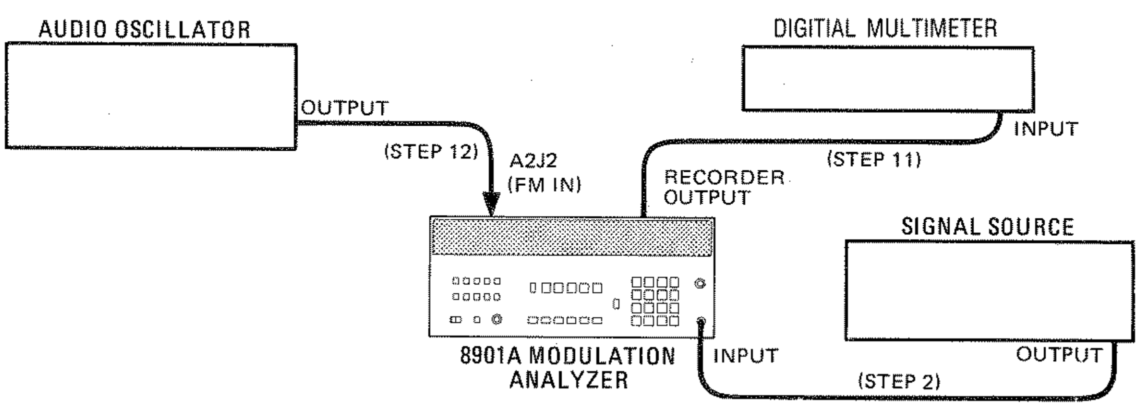
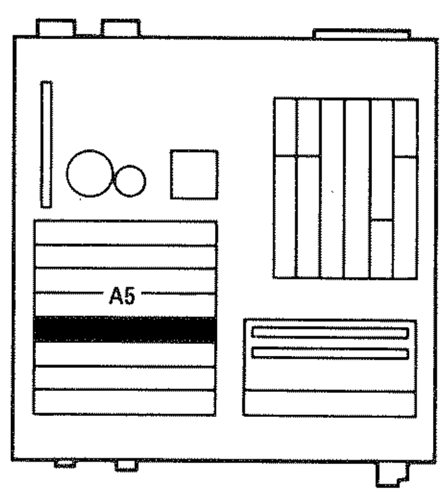


Figure 5–3. *Voltmeter Offset and Sensitivity Adjustment Test Setup*

Procedure



1. Set signal source to 11 MHz CW at 0 dBm.
2. Connect the signal source output to the Modulation Analyzer's INPUT as shown in figure 5–3.
3. On the Modulation Analyzer, key in 41.0 to initialize it.
4. Set HP FILTER to 300 Hz and LP FILTER to 3 kHz.

5. Key in 2.3 SPCL to set the audio gain to minimum. Next, key in 0.110 SPCL to set the audio input select and audio overvoltage detector to no input and no reset. Then key in 49. S(Shift) 0 SPCL to set the voltmeter to measure and display the peak detector output.
6. Adjust A5R49 (PK DET OFS) for a display of 0.0003 to 0.0007.
7. Key in 49.9 SPCL. This sets the voltmeter to read the output of the average detector.
8. Set A5R7 (RECT OFS) fully ccw. This shuts off A5U2.
9. Adjust A5R29 (AVG OFS) for a display of −0.0001 to 0.0001.
10. Set A5R7 (RECT OFS) fully cw then slowly ccw until display reads between 0.0004 and 0.0006.
11. Set external voltmeter to read 2.5 V dc. Connect its input to the Modulation Analyzer's rear-panel RECORDER OUTPUT as shown in figure 5–3.
12. Set audio analyzer's source for 2 kHz at 1 V. Connect its output to A2J2 (FM IN) of the Modulation Analyzer as shown in figure 5–3.
13. On the Modulation Analyzer, press FM. Set DETECTOR to PEAK+.
14. Adjust level of the audio analyzer's source until external voltmeter reads between +1.999 and +2.001 V dc.
15. Adjust A5R76 (VM SENS) for a display on the Modulation Analyzer of between 199.9 and 200.1 kHz, or if the level has drifted slightly, until the four digits of the display agree with the first four digits of the voltmeter reading to within ±1 digit.
16. Press AVG.
17. Adjust A5R35 (AVG SENS) for a display on the Modulation Analyzer of between 141.3 and 141.5 kHz, or if the level has drifted slightly, until the four digits of the display equals the voltmeter reading times 0.7071 to within ±1 digit.
18. Press PEAK+. Note the display. Press PEAK−. The two readings of the display should agree within ±1 digit.
19. Perform the FM Sensitivity, ΦM Sensitivity, and AM Sensitivity Adjustments.

Adjustment 7

15 KHZ AND >20 KHZ LOW-PASS FILTER GAIN ADJUSTMENTS

Reference

- **Service Sheet 7**

Description

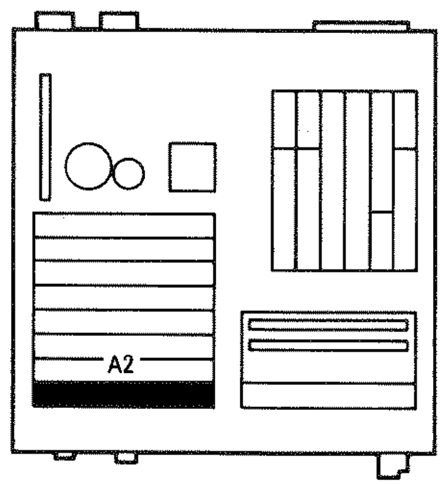
A signal generator is amplitude modulated at a 1 kHz rate. The signal is demodulated by the Modulation Analyzer with no low-pass filtering. Using the ratio feature, the demodulated signal is referenced to 100%. The low-pass filtering is then set to >20 kHz and 15 kHz, and the filter gain for each is adjusted for a reading of 100%.

Equipment

Signal Generator .... HP 8640B

Procedure

1. Set signal generator to 11 MHz at 0 dBm with 30% AM at a 1 kHz rate. Connect its RF output to the Modulation Analyzer's INPUT.
2. On the Modulation Analyzer, key in 41.0 SPCL to initialize it. Press AM. Set DETECTOR to AVG.
3. Set RATIO to %. The display should show between 99.95 and 100.05% REL.
4. Set LP FILTER to >20 kHz. Adjust A2R44 (>20 kHz LPF GAIN) for a display of 99.95 to 100.05% REL.
5. Set LP FILTER to 15 kHz. Adjust A2R40 (15 kHz LPF GAIN) for a display of 99.95 to 100.05% REL.



Adjustment 8

ALC REFERENCE ADJUSTMENT

Reference

- **Service Sheet 3**

Description

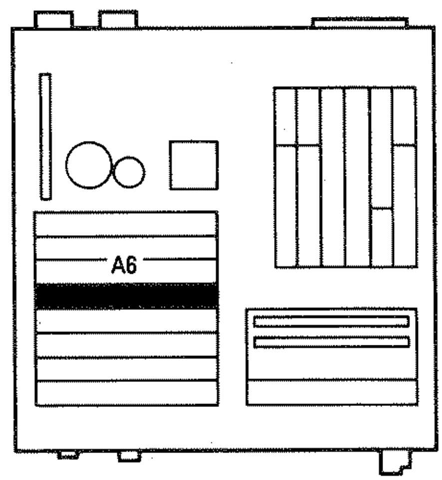
The ALC reference voltage is adjusted while monitoring it with the internal voltmeter.

Equipment

Signal Source .... HP 8640B

Procedure

1. Set signal source to 11 MHz CW at 0 dBm. Connect its output to the Modulation Analyzer's INPUT.
2. On the Modulation Analyzer, key in 41.0 SPCL and then 49. S(Shift) 1 SPCL to initialize the instrument and connect the internal voltmeter to a node which represents the average IF level which the ALC loop forces to equal the ALC reference.
3. Adjust A6R65 (ALC REF) for a display of 2.0970 to 2.1030.
4. If A51C20 cannot be adjusted for a display within listed limits, then A51R32 can be selected to shift nominal readings on the display. Increasing A51R32 one adjustment value will increase the nominal reading by approximately 3%. The only values available are 9.09 k Ω and 11.0 k Ω .



Adjustment 9

FM CALIBRATOR ADJUSTMENT (OPTION 010)

Reference

- **Service Sheet 28**

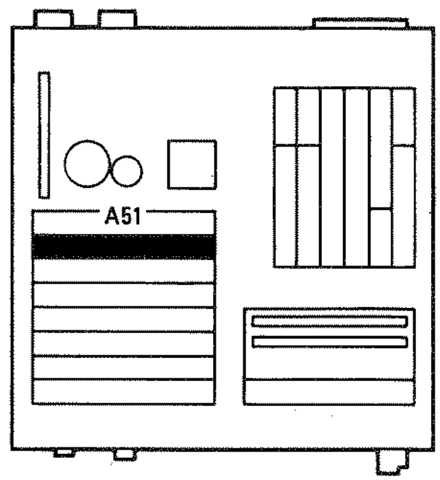
Description

The FM Calibrator is set to CW and its frequency is adjusted while monitoring it with the internal counter. The calibrator is then set to modulate and the symmetry adjusted as the demodulated signal is measured with the PEAK+ and PEAK− detectors.

NOTE

This calibration adjustment is not critical. An erroneous calibration cannot be made because if conditions exist that are out of calibration, the Modulation Analyzer dislays an error message.

Procedure



1. Connect CALIBRATION OUTPUT to INPUT.
2. Key in 12.1 SPCL and 46.3 SPCL. This sets the FM Calibrator to CW and connects the internal counter to measure the calibrator frequency.
3. Using a non-metallic tool, adjust A51C20 (FREQ) for a display of 1009000 to 1011000.
4. Key in 12.2 SPCL then 5.1 SPCL. This sets the instrument to display the demodulated FM from the calibrator and sets the peak detector time constant to slow.
5. Alternately set the DETECTOR to PEAK+ and PEAK− and note the display for each setting. Adjust A51R12 (TRAPEZOID SYMM) until the readings are the same for both detectors within ±0.010 kHz.
6. If the FM deviation of the FM Calibrator, Option 010, exceeds the peak deviation limits of 30 to 38 kHz, error E08 will be displayed. (If servcie errors have been enabled by Special Function 43.1, error E74 or E75 will be displayed instead.) To measure the actual peak deviation, connect the CALIBRATION OUTPUT to the INPUT and key in 12.2 SPCL.

   If the peak deviation is only slightly out of limits, alter the value of A51R24. increasing the value of A51R24 by 10% will decrease the peak deviation by approximately 2.5 kHz.

Adjustment 10

FM SENSITIVITY ADJUSTMENT (OPTION 010)

Reference

- **Service Sheet 6**

Description

The FM sensitivity is adjusted for a calibration factor of 100% while the Modulation Analyzer measures the output of its FM Calibrator (Option 010).

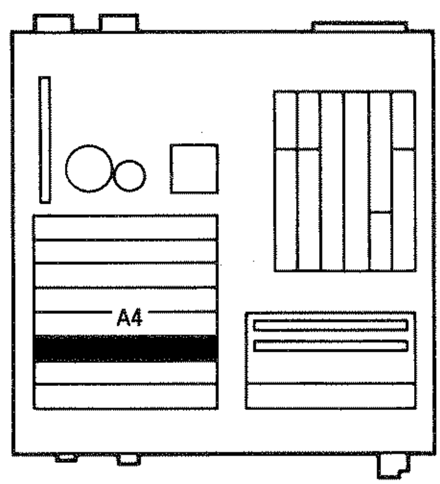
NOTE

This procedure is only for Modulation Analyzers equipped with the FM Calibrator (Option 010). For Modulation Analyzers not equipped with Option 010, perform the FM Sensitivity Adjustment which uses the FM Calibrator from a second HP 8901A Option 010 (Adjustment 11).

Procedure

NOTE

For best accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.



1. Perform the FM Calibrator Adjustment.
2. Connect CALIBRATION OUTPUT to INPUT.
3. Press FM then CALIBRATION. Allow at least two readings (approximately 40 seconds) to pass, then adjust A4R50 (FM SENS) for a display of 99.95 to 100.05%.

Adjustment 11

FM SENSITIVITY ADJUSTMENT (USING ANOTHER 8901A WITH OPTION 010)

Reference

- **Service Sheet 6**

Description

The FM calibrator from a second HP 8901A that is equipped with Option 010 is connected to the Modulation Analyzer's input. The FM is measured and adjusted to equal the FM produced by the calibrator.

NOTE

If the Modulation Analyzer is already equipped with the FM Calibrator (Option 010), perform the FM Sensitivity Adjustment (Adjustment 10) instead.

Equipment

Modulation Analyzer with FM Calibrator .... HP 8901A Opt. 010

Procedure

NOTE

For best accuracy, allow both Modulation Analyzers to warm up for at least one-half hour.

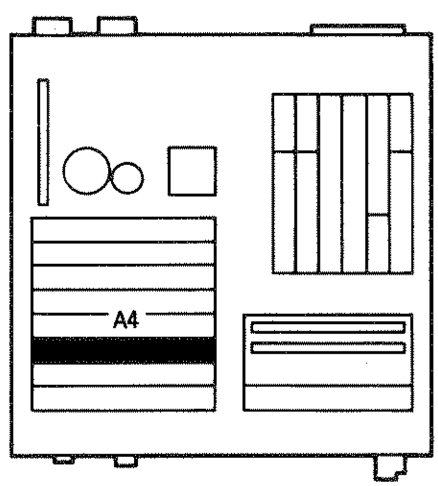
1. Connect the CALIBRATION OUTPUT from the Modulation Analyzer equipped with an FM calibrator (reference unit) to the INPUT of the Modulation Analyzer under test.

2. Key in 12.0 SPCL on the reference unit and note the reading on its display. The computed FM of the calibrator excluding noise is being displayed.

   Computed FM: 30.950 kHz

3. Key in 12.1 SPCL on both Modulation Analyzers to display the demodulated peak residual FM deviation. Then, key in 5.1 SPCL on the Modulation Analyzer under test (to set the peak detector time constant to slow). Note the reading on the display of the Modulation Analyzer under test. The measured and corrected noise of the FM calibrator in CW is being displayed.

   Corrected Noise: ______ kHz



4. Add the results of steps 2 and 3.

31.050

Sum: ______ kHz

5. Key in 12.2 SPCL on both Modulation Analyzers to display the demodulated peak FM deviation. Then, key in 5.1 SPCL on the Modulation Analyzer under test. Note the display of the Modulation Analyzer under test. The peak deviation, measured with the PEAK+ detector, is being displayed. 30.959

6. On the Modulation Analyzer under test, adjust A4R50 (FM SENS) for a display equal to the deviation computed in step 4 within ±0.015 kHz.

7. Press PEAK– on the Modulation Analyzer under test. If the display does not read within ±0.015 kHz of the display in step 6, readjust A4R50 (FM SENS) for a display on the Modulation Analyzer under test of half way between its present display and the result of step 4. Now note the display for both PEAK+ and PEAK–. The FM sensitivity is properly adjusted when

$$\frac{(display\ for\ PEAK+) + (display\ for\ PEAK-)}{2} = result\ of\ step\ 4\ within\ \pm 0.015\ kHz$$

Adjustment 12

FM FLATNESS ADJUSTMENT

Reference

- **Service Sheet 6**

Description

The AM/FM test source is frequency modulated at a 1 kHz rate with 400 kHz peak deviation. The demodulated FM is used as a reference. The modulation rate is increased to 150 kHz and the FM flatness is adjusted to bring the display back to the reference. The AM/FM test source is required to assure that the FM source has adequate bandwidth.

Equipment

AM/FM Test Source .... HP 11715A
Audio Synthesizer .... HP 3336C Opt. 005

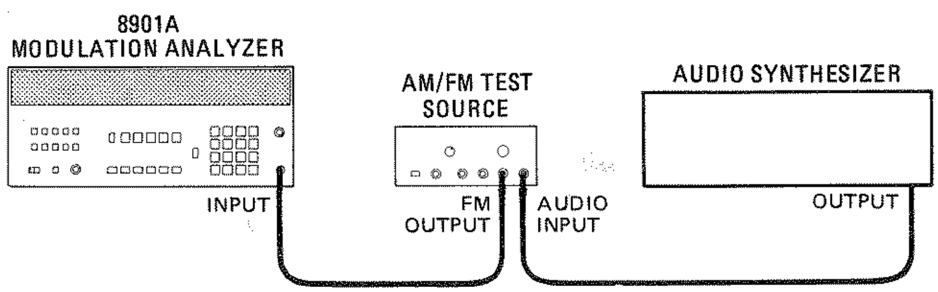
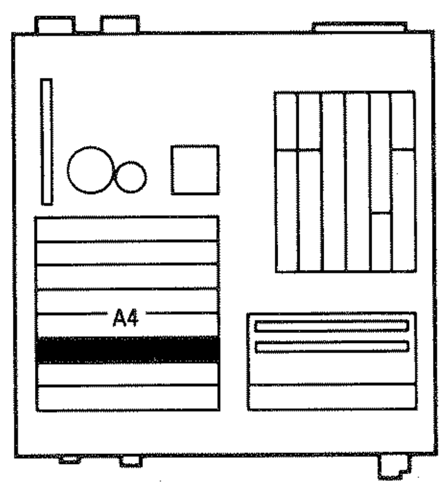


Figure 5–4. *FM Flatness Adjustment Test Setup*

Procedure



1. Connect equipment as shown in figure 5–4 using a short cable, approximately 0.3 metre (1 foot), to connect the audio synthesizer.
2. With the leveling on, set the audio synthesizer to 1 kHz at +5 dBm. On the AM/FM test source, set the test mode to FM.
3. On the Modulation Analyzer, key in 41.0 SPCL to initialize it.
4. Tune the AM/FM test source's carrier frequency to approximately 400 MHz.

5. Press MHz to center the Modulation Analyzer's tuning. Press FM. Set DETECTOR to AVG. Adjust audio synthesizer level for a display of approximately 280 kHz average deviation. Set RATIO to %.
6. Set audio synthesizer frequency to 150 kHz without changing the level. Adjust A4R85 (FM FLATNESS) for a reading of 99.9 to 100.1% REL on the Modulation Analyzer.

NOTE

If flatness does not adjust properly, try performing FM Distortion and Incidental AM Adjustments (1.5 MHz IF) (Adjustment 13).

Adjustment 13

FM DISTORTION AND INCIDENTAL AM ADJUSTMENT (1.5 MHZ IF)

Reference

- **Service Sheet 2**

Description

The AM/FM test source is frequency modulated at a 100 kHz rate with 400 kHz peak deviation. The peak deviation is measured with both the positive and negative peak detectors when the Modulation Analyzer is tuned first to the signal and then its image. The IF is then adjusted so that the difference between the detector readings is the same for both signals. This method permits proper adjustment of distortion even in the presence of a small amount of distortion from the FM source. Next, the (incidental) AM is measured at a 1 kHz rate and 50 kHz peak deviation and adjusted for a minimum.

Equipment

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B

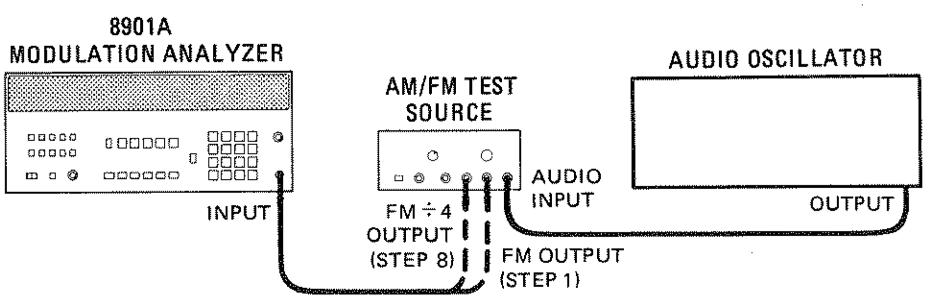
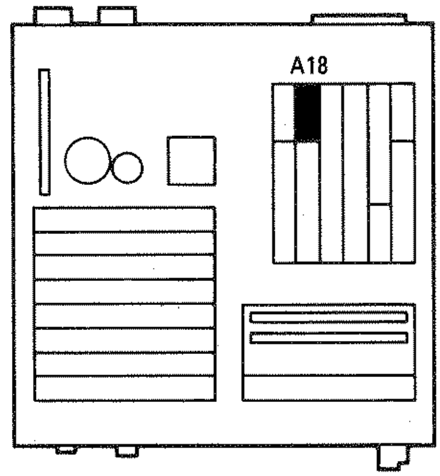


Figure 5–5. FM Distortion and Incidental AM Adjustment (1.5 MHz IF) Test Setup

Procedure



1. Connect equipment as shown in figure 5–5.
2. Set the audio analyzer's source to 100 kHz at 2 V. On the AM/FM test source, set the test mode to FM.
3. On the Modulation Analyzer, key in 41.0 SPCL to initialize it. Set HP FILTER to 50 Hz.
4. Tune the AM/FM test source's carrier frequency to approximately 400 MHz.
5. On the Modulation Analyzer, press MHz to center tuning. Press FM. Adjust level of the audio analyzer's source for a display on the Modulation Analyzer of 400 kHz peak deviation.
6. Switch the DETECTOR between PEAK+ and PEAK– and note the difference between the two readings. Adjust A18R23 (FM DISTN 1.5 MHz IF) for equal readings in PEAK+ and PEAK–.
7. Key in 3000 ⇩kHz to tune the Modulation Analyzer to the signal image. Again switch between PEAK+ and PEAK–. The difference between the two readings should be less than 1.6 kHz. If it is not, adjust A18R23 again to diminish the difference by one half. Now note the reading for PEAK+ (PK_{+1}) and PEAK– (PK_{-1}). Press ⇧ kHz. Note the reading for PEAK+ (PK_{+2}) and PEAK– (PK_{-2}). The instrument is adjusted properly when:

$$|(PK_{+1} - PK_{-1}) + (PK_{+2} - PK_{-2})| < 1.6\ kHz$$

   (Ideally, PK_{+1} should equal PK_{-2}, and PK_{-1} should equal PK_{+2}.)
8. Connect the FM ÷ 4 output of the AM/FM test source to the Modulation Analyzer's INPUT.
9. On the Modulation Analyzer, set LP FILTER to 3 kHz. Press AUTOMATIC OPERATION.
10. Set the frequency of the audio analyzer's source to 1 kHz and level for 50 kHz peak deviation.
11. On the Modulation Analyzer, press AM. Adjust A18R19 (INC AM 1.5 MHz IF) for a minimum display (but less than 0.2%).

NOTE

The specification for incidental AM requires that 0.5 times the residual AM be subtracted out. The residual AM can be measured by momentarily disconnecting the audio input to the AM/FM test source and noting the displayed AM. Subtracting 0.5 times displayed AM from the AM measured in step 11 gives the actual incidental AM.

Adjustment 14

ΦM SENSITIVITY ADJUSTMENT

Reference

- Service Sheet 8

Description

The AM/FM test source is frequency modulated with a sinusoidal signal at a 1 kHz rate and 100 kHz peak deviation. This is equivalent to 100 radians peak phase deviation since

$$\textit{phase deviation} = \frac{\textit{frequency deviation}}{\textit{modulation rate}}$$

The ΦM sensitivity is then adjusted for a reading of 100 radians.

Equipment

AM/FM Test Source .... HP 11715A
Audio Synthesizer .... HP 3336C Opt. 005

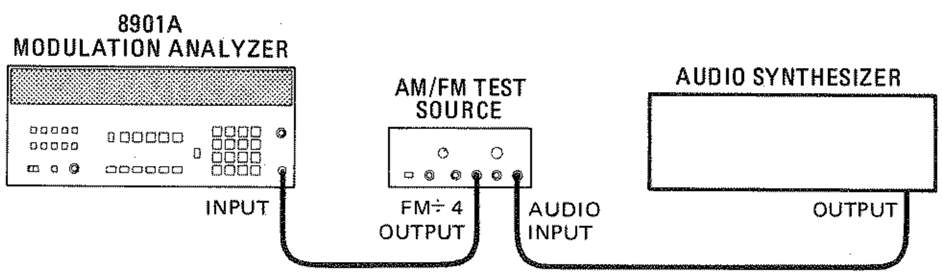
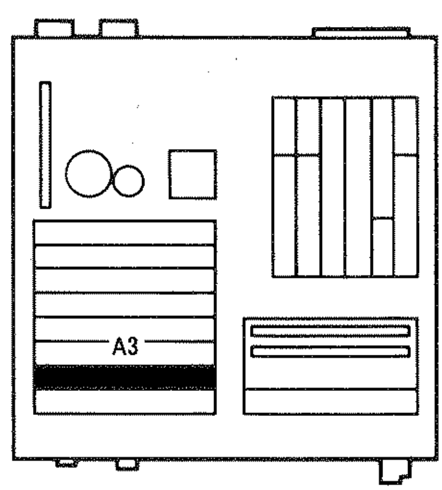


Figure 5–6. *ΦM Sensitivity Adjustment Test Setup*

Procedure



1. Connect equipment as shown in figure 5–6.
2. Set audio synthesizer to 1 kHz at +4 dBm. On the AM/FM test source, set the test mode to FM.
3. On the Modulation Analyzer, key in 41.0 SPCL to initialize it. Set HP FILTER to 300 Hz and LP FILTER to 3 kHz.
4. Tune the AM/FM test source's carrier frequency to approximately 100 MHz.

5. Press MHz to center the Modulation Analyzer tuning. Press FM. Adjust audio synthesizer level for a display of 100 kHz peak deviation.
6. On the Modulation Analyzer, press ΦM. Adjust A3R27 (ΦM SENS) for a display in radians of the same numerical value as the display in kHz of step 5 within ±0.02 radian.

NOTE

If a test oscillator is used in place of the audio synthesizer, the modulation rate must be measured with a counter. The adjustment is then made to give a display equal to the ratio (frequency deviation)/(modulation rate).

Adjustment 15

AM CALIBRATOR ADJUSTMENT (OPTION 010)

Reference

- **Service Sheet 29**

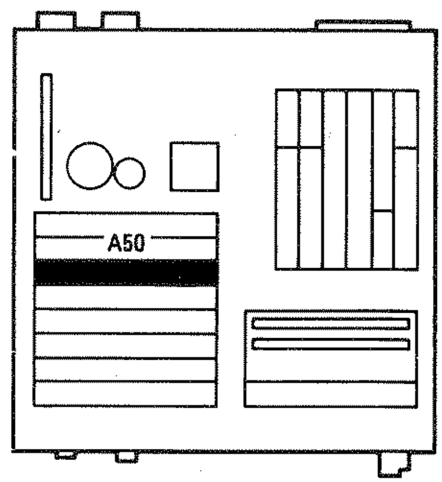
Description

The Modulation Analyzer is set to read the % AM as computed from internal measurements. The AM depth is adjusted for 33.33%. The AM is then demodulated and the symmetry is adjusted as the signal is measured with the PEAK+ and PEAK− detectors.

NOTE

This calibration adjustment is not critical. An erroneous calibration cannot be made because, if conditions exist that are out of calibration, the Modulation Analyzer displays an error message.

1. Connect CALIBRATION OUTPUT to INPUT.
2. Key in 13.0 SPCL. This sets the instrument to display the AM computed from internal measurements.
3. Adjust A50R45 ("A" LVL) for a display of 33.330 to 33.336%.
4. Key in 49.5 SPCL. This connects the internal voltmeter to measure the output level from the AM Calibrator. The display should read between 1.8 and 2.2.
5. Key in 13.2 SPCL then 5.1 SPCL. This sets the instrument to display the demodulated AM from the calibrator and sets the peak detector time constant to slow.



6. Alternately set the DETECTOR to PEAK+ and PEAK− and note the display for each setting. Adjust A50R39 (SYMM) until the readings are the same for both detectors within ±0.015%.

Adjustment 16

AM SENSITIVITY ADJUSTMENT (OPTION 010)

Reference

- **Service Sheet 7**

Description

The AM sensitivity is adjusted for a calibration factor of 100% while the Modulation Analyzer measures the output of its AM Calibrator (Option 010).

NOTE

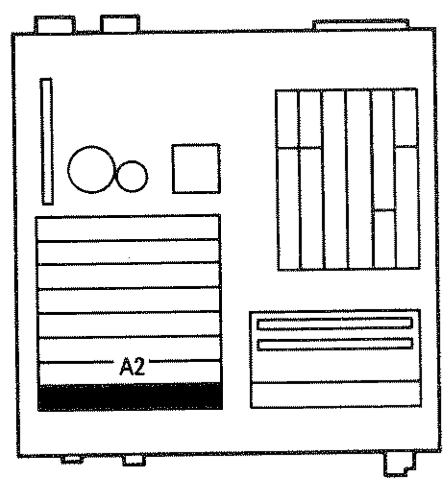
This procedure is only for Modulation Analyzers equipped with the AM Calibrator (Option 010). For Modulation Analyzers not equipped with Option 010, perform the AM Sensitivity Adjustment which uses the AM Calibrator from a second 8901A Option 010 (Adjustment 17).

Procedure

NOTE

For best accuracy, allow the Modulation Analyzer to warm up for at least one-half hour.

1. Perform the AM Calibrator Adjustment (Adjustment 15).
2. Connect CALIBRATION OUTPUT to INPUT.
3. Press AM, then CALIBRATION. Allow at least two readings to pass (approximately 40 seconds), then adjust A2R6 (AM SENS) for a display of 99.95 to 100.05%.



Adjustment 17

AM SENSITIVITY ADJUSTMENT (USING ANOTHER 8901A WITH OPTION 010)

Reference

- **Service Sheet 7**

Description

The AM calibrator from a second HP 8901A equipped with Option 010 is connected to the Modulation Analyzer's input. The AM is measured and adjusted to equal the AM produced by the calibrator.

NOTE

If the Modulation Analyzer is already equipped with the AM Calibrator (Option 010), perform the AM Sensitivity Adjustment (Adjustment 16) instead.

Equipment

Modulation Analyzer with AM Calibrator .... HP 8901A Opt. 010

Procedure

NOTE

For best accuracy, allow both Modulation Analyzers to warm up for at least one-half hour.

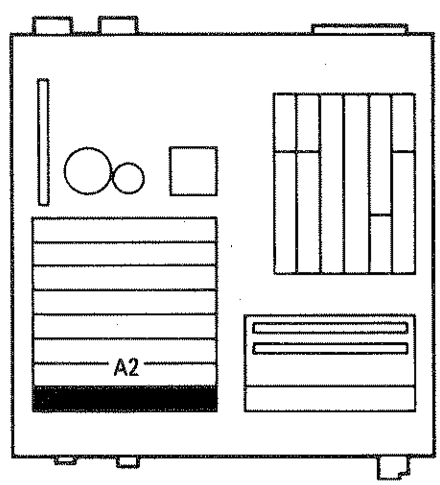
1. Connect the CALIBRATION OUTPUT from the Modulation Analyzer equipped with an AM calibrator (reference unit) to the INPUT of the Modulation Analyzer under test.

2. Key in 13.0 SPCL on the reference unit and note the reading on its display. The computed AM depth of the calibrator excluding noise is being displayed.

   Computed AM: ______ %

3. Key in 13.1 SPCL on both Modulation Analyzers, then key in 5.1 SPCL on the Modulation Analyzer under test (to set the peak detector time constant to slow). Note the reading on the display of the Modulation Analyzer under test. The measured and corrected noise of the AM calibrator in CW is being displayed.

   Corrected Noise: ______ %



4. Add the results of steps 2 and 3.

Sum: ______ %

5. Key in 13.2 SPCL on both Modulation Analyzers, then key in 5.1 SPCL on the Modulation Analyzer under test. Note the display of the Modulation Analyzer under test. The AM depth, measured with the PEAK+ detector, is being displayed.

6. Adjust A2R6 (AM SENS) for a display on the Modulation Analyzer under test equal to the deviation computed in step 4 within ±0.015%.

7. Press PEAK− on the Modulation Analyzer under test. If the display does not read within ±0.015% of the display in step 6, readjust A2R6 (AM SENS) for a display on the Modulation Analyzer under test of 1/3 the way between its present display and the result of step 4. Now note the display for both PEAK+ and PEAK−. The AM sensitivity is properly adjusted when

$$\frac{(display\ for\ PEAK+) + 2(display\ for\ PEAK-)}{3} = result\ of\ step\ 4\ within \pm 0.015\%$$

Adjustment 18

FM DISTORTION AND INCIDENTAL AM ADJUSTMENT (455 KHZ IF)

Reference

- **Service Sheets 2 and 3**

Description

The signal generator is set to 2.45 MHz and frequency modulated at a 1 kHz rate with 10 kHz peak deviation. The signal generator is used to reach the 2.45 MHz frequency. The (incidental) AM on the signal is measured and adjusted for a minimum. At 2.45 MHz the signal is not down converted by the Modulation Analyzer but goes directly into the IF. (2.45 MHz is near the top of the IF passband.)

Then the AM/FM test source is frequency modulated at a 10 kHz rate with 10 kHz peak deviation. The demodulated FM is measured with a distortion analyzer and FM distortion is adjusted for a minimum. The (incidental) AM is measured at a 1 kHz rate and 5 kHz deviation and adjusted for a minimum.

Equipemnt

AM/FM Test Source .... HP 11715A
Audio Analyzer .... HP 8903B
Signal Generator .... HP 8640B Opt. 001 and 002

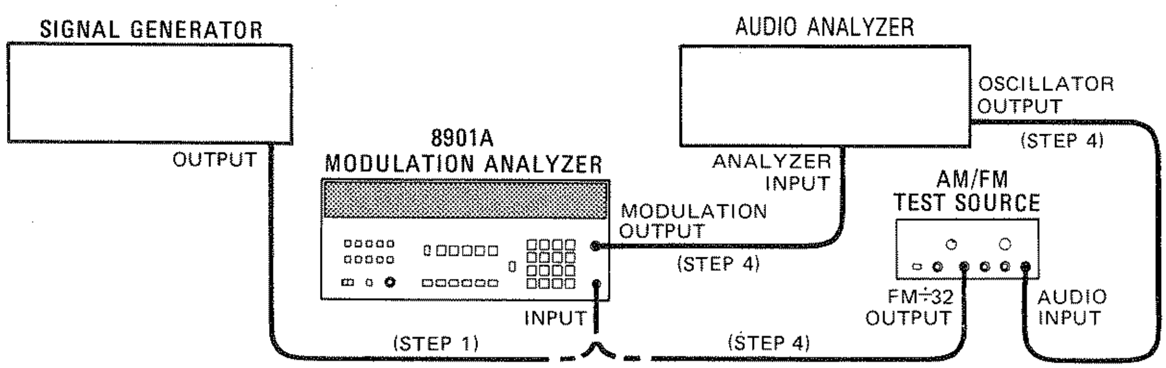
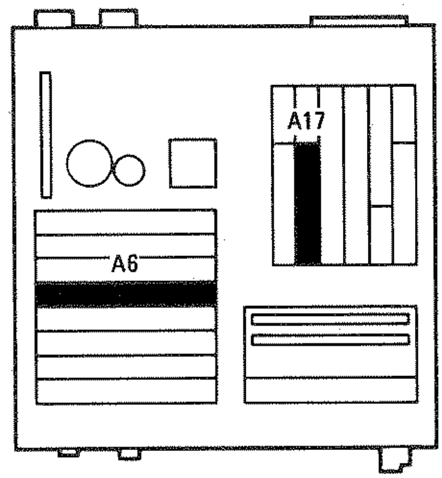


Figure 5–7. *FM Distortion and Incidental AM Adjustment (455 kHz IF) Test Setup*

Procedure



1. Set the signal generator to 2.45 MHz at 0 dBm with 10 kHz peak FM deviation at a 1 kHz rate. Connect its RF output to the Modulation Analyzer's INPUT as shown in figure 5–7.
2. On the Modulation Analyzer, key in 41.1 SPCL and 10.0 SPCL to initialize the instrument and measure the IF frequency. The IF frequency should be approximately 2.45 MHz. If it reads approximately 0.455 MHz, tune the frequency of the signal generator down slightly until a reading of 2.45 MHz is obtained.
3. Press AM on the Modulation Analyzer. Set HP FILTER to 50 Hz, LP FILTER to 3 kHz, and DETECTOR to AVG. Adjust A6C8 (IF FLATNESS) for a minimum display (but less than 0.2%).
4. Disconnect the signal generator and connect the remaining equipment as shown in figure 5–7.
5. Set audio analyzer's source to 10 kHz at 2 V. On the AM/FM test source, set test mode to FM.
6. On the Modulation Analyzer, press FREQ. Set LP FILTERS to < 20 kHz and DETECTOR to PEAK+.
7. Tune the AM/FM test source's carrier frequency to approximately 12.5 MHz.
8. On the Modulation Analyzer, key in 3.1 SPCL to set the IF to 455 kHz.
9. Press FM. Adjust the level of the audio analyzer's source for a Modulation Analyzer display of 10 kHz peak deviation.
10. Set the audio analyzer to measure the distortion on the 10 kHz signal at the MODULATION OUTPUT with 30 kHz of low-pass filtering on the distortion analyzer.
11. Adjust A17L11 (FM DISTN 455 kHz IF) for minimum distortion but less than 0.1% (less than −60 dB).
12. On the Modulation Analyzer, set LP FILTER to 3 kHz.
13. Set frequency of the audio analyzer's source to 1 kHz and set the level for 5 kHz peak deviation on the Modulation Analyzer.
14. Press AM. Adjust A17L8 (INC AM 455 kHz IF) for a minimum display (but less than 0.2%).

NOTE

The specification for incidental AM requires that 0.5 times the residual AM be subtracted out. The residual AM can be measured by momentarily disconnecting the audio input to the AM/FM test source and noting the displayed AM on the Modulation Analyzer. Subtracting 0.5 times the displayed AM from the AM measured in step 14 gives the actual incidental AM.

15. If a significant adjustment was made in either step 11 or step 14, repeat steps 9 through 14.

Adjustment 19

TRACK-TUNE MODE OFFSET ADJUSTMENT

Reference

- **Service Sheet 14**

Description

The Modulation Analyzer is tuned to a signal and put in the track-tune mode. The frequency error is measured and two resistors selected to bring the frequency error to within ±50 kHz.

Equipment

Signal Source .... HP 8640B or HP 3320B

Procedure

1. Set signal source to 11 MHz CW at 0 dBm. Connect its output to the Modulation Analyzer's INPUT.
2. On the Modulation Analyzer, key in 41.0 SPCL to initialize it. Allow the Modulation Analyzer to tune to the signal, then press S (Shift) FREQ ERROR.
3. Key in 4.1 SPCL to put the Modulation Analyzer in the track-tune mode. If the display does not read between ±50 kHz, replace resistors A20R1 and R2 with resistors of the value shown in table 5-3. (Choose the nearest error frequency.) Table 5-4 lists the HP part number for each resistor.
4. If A20R1 and R2 were replaced, recheck by repeating steps 1 to 3.

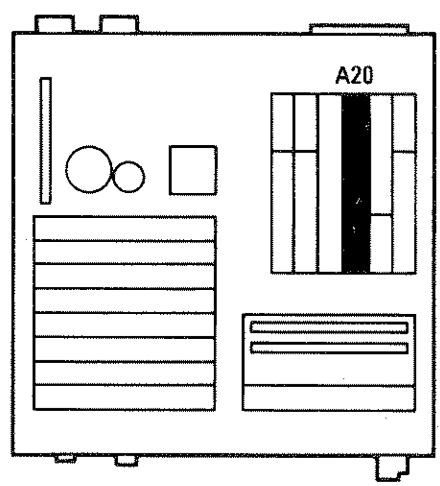


Table 5–3. *Frequency Error Resistor Selection (±1%, 1/8W, Metal Film)*

FREQ ERROR (kHz)	A20R1 (kΩ)	A20R2 (kΩ)
183	21.5	omit
166	23.7	omit
124	26.1	147.0
81	31.6	90.9
39	38.3	61.9
0	46.4	46.4
−39	61.9	38.3
−81	90.9	31.6
−124	147.0	26.1

Table 5–4. *Standard Value Resistors*

Resistance (kΩ)	HP Part Number
21.5	0757-0199
23.7	0698-3158
26.1	0698-3159
31.6	0698-3160
38.3	0698-3161
46.4	0698-3162
61.9	0757-0460
90.9	0757-0464

MANUAL CHANGES

MANUAL IDENTIFICATION
Model Number: 8901A
Date Printed: March 1980
Part Number: 08901-90032

MODULATION ANALYZER
SERVICE MANUAL

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
2009A	1
2012A	1-2
2021A	1-3
2026A	1-4
2031A	1-5
2032A	1-6
2051A	1-7
2052A	1-8
2105A	1-9
2119A	1-10
2126A	1-11
2128A	1-12
2133A	1-13
2134A	1-14
2138A	1-15
2142A	1-16
2201A	1-17
2212A	1-18
2227A	1-19
2229A	1-20

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
2238A	1-21
2239A	1-22
2244A	1-23
2251A	1-24
2302A	1-26
2303A	1-24, 26
2308A	1-27
2309A	1-28
2312A	1-29
2313A	1-30
2324A	1-31
2342A	1-32
2346A	1-33
2350A	1-34
2410A	1-35
2412A, 2416A	1-36
2421A	1-37
2424A	1-38
2426A	1-39
2432A	1-40

>> 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
55 Pages Text
32 Pages Illustrations
08 Foldouts

MANUAL CHANGES

MODULATION ANALYZER
SERVICE MANUAL

MANUAL IDENTIFICATION

Model Number: 8901A
Date Printed: March 1980
Part Number: 08901-90032

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
2439A	1-41
2443A	1-42
2447A	1-43
2450A	1-44
2505A	1-45
2518A	1-46
2521A	1-47
2542A	1-48
2543A	1-49
2545A	1-50
2606A	1-51
2607A	1-52
2609A	1-53
>> 2616A	1-54
>> 2617A	1-55
>> 2618A	1-56
>> 2623A	1-57
>> 2629A,2634A	1-58
>> 2705A	1-59

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES

>> NEW ITEM

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Printed in U.S.A.

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The following table lists all components affected by this Manual Changes supplement.

In the change column:

1. "E" indicates Errata information.
2. Numeric value is the manual change number.
3. "(r)" indicates the change describing the recommended replacement or action for that component.

NOTE: Recommended replacement information applies to instruments of all serial prefixes unless otherwise noted.

SUMMARY OF CHANGES BY COMPONENT

Assy	Component	Change
A1	--------	43
	DS5	18
	R20--27	E
	R21	18
A2	C14	E
	C32,33	1
	C38	E
	L5	E
	L10,12--14	1
	Q1	E
	R6	8
	R51	59
A3	C3,49,52	25(r)
	C4,6	E,46
	C12,14	E
	C47,48,53	46
	L2,3	E
	R1,4	22,46
	R29,36	46
	R49	8,9(r)
	U4,9	31(r)
	U7,8,10,11	8,9(r)
A4	--------	39
	C6,15,18,20,27, 31--33,35,38, 42--47,49,50,51	39
	CR6--9	39
	Q23,26,28,33,35	39
	R51	E
	R80,81,105,106	39
A5	C2,4,5,29	25(r)
	C8,9,11	17
	C21--25	58
	CR10,11	E
	R7,29	E
	R9,24	17,44
	R27,59,63	2
	R49,84	7
	R73,75	4
	R85	7,19(r)
	U1	16E
	U2	E,17,58
	U3	E
	U5	E,7
	U7	58
	U10--12	E
	VR6	2
	W1	58

Assy	Component	Change
A6	--------	28,30
	C46	E
	C51	22,32,E
	C54,57	28
	CR22	30
	L8	E
	Q6	40E
	Q17	E
	R89,92,93,102,122	28
	U4	E,23(r)
A10	C14,22	E
	CR13	E
	Q1,5,11	27(r)
	Q7,9	2
	R15,17,19	2
	R43	E
	TP8	E
	VR10,11	E
A11	--------	57
	J4,5	E
	MP1	57
	U14	E
A13	C10,11	57
	L1	57
	U3	6,15,18
	U4	6,18
	U9	15
A14	--------	38
	MP6,7	38
	R10	38,E
	U8	38
	U12,18	15,18
	U14	6
	U22F	38
A15	--------	18,37
	AT1,2,3	37
	C2	18,27,31
	C4,13	25(r)
	C10,12,14,16	18
	C13	37
	C28	18,27,31
	C29	37
	CR4	E
	K1	18
	L1--4	18
	MP1	E

Assy	Component	Change
A15	R10	E,18,37
	R15,19--21,27, 29,30,38,40,45	37
	R16,46,47,62	18
	U3	E
A17	--------	53
	L5	E,10
	L8,11	35
	T1	E
A18	CR6,7	E
	E1	42
	Q4	19(r)
	R23,24	25
A19	--------	56
	C17	56
	C38	34
	C43	E
	C64--70	56
	CR2--5	36
	MP1	56
	R16,17	56
	R21	34,56
	R27	34,56
	R63	E,56
	R72,74,75	E
	R86	34
	R87	56
	R111--116	56
	U7,8	56
	VR1	E
A20	--------	55
	E1	31
	R57	55
	U2,13,14	E
A22	CR2,4,6,8	E
	CR9--12	36
	Y1,2	E,51
A23	C45	5,E
	Q4,6	5
	R55	E
	T1	E
A24	C17	29
	CR3,4	2
	CR3,4	36
	R7	E
	U3	31(r)

SUMMARY OF CHANGES BY COMPONENT

Assy	Component	Change	Assy	Component	Change	Assy	Component	Change
A25	--------	3						
	C1,2	E,54						
	XA2-XA6	E						
	X7-X9	E						
A26	C2	E						
	C5	18						
	J5A	E						
	MP3	E						
	XA10	E						
	VR1,2	E						
A27	XA11	E						
	XA13A,B-XA14A,B	E						
	X12A,B	E						
A28	--------	12						
	XA15,XA17-XA24	E						
	X16	E						
A29	Q1--4	E,3						
A30	C1	13						
	TB1	E						
A31	MP1	24(r)						
A50	Q2--5	20						
	Q9	14						
	R90,109	20						
A51	C10	18						
	C18,19	E						
	C20	E						
	CR3,5,6	E,36						
	R32	E						
	R24	E						
	U4	18						
	No Prefix							
	B1	E						
	J1,6,7,10	11						
	MP1,2,5,6,9,10							
	MP16,18	47						
	MP17,19	21,45,54						
	MP23,24	57						
	MP28	26						
	MP30,40	E						
	MP32	E						
	MP38	E,12						
	MP36,37	12						
	MP41--44,46	E						
	MP48	12,21,45, 54						
	MP50	21,45,54, 57						
	MP54,57	21,45,54						
	MP66	41						
	MP67	45						
	MP70	E,47						
	T1	E						
	W1	E,11						
	W3	E						
	W4,8,36	11						
	W15	E						
	W27	E						
	W31	E						
	Y1	E						

ERRATA

Foldout 2 in this Manual Changes Supplement:
Change the value of R34 to 4.22k.

Page 4-36, Table 4-1:
In the bottom block under Residual FM, change the line to read: "560 MHz/50 Hz to 3 kHz bandwidth".

Page 5-1, Paragraph 5-4:
Add the following paragraphs to the end of paragraph 5-4:

5-4a. A51R24 Selection. If the FM deviation of the FM Calibrator Option 010 exceeds the peak deviation limits of 30 to 38 kHz, error E08 will be displayed. (If service errors have been enabled by Special Function 43.1, error E74 or E75 will be displayed instead.) To measure the actual peak deviation connect the CALIBRATION OUTPUT to the INPUT and key in 12.2 SPCL.

If the peak deviation is only slightly out of limits, alter the value of A51R24. Increasing the value of A51R24 by 10% will decrease the peak deviation by approximately 2.5 kHz.

Page 5-2, Table 5-1:
Add the following information to Table 5-1:

Reference Designator	Service Sheet	Range of Values	Basis of Selection
A19R63	11	38.1 to 110 ohms	Doubler output power
A19R72, R74	11	619 to 1210 ohms	Doubler high frequency roll-off
A19C43	11	4.7 to 15 pF	Doubler low frequency roll-off
A51R24	28	26.1k to 38.3k ohms	See paragraph 5-4a
A51R32	28	9.09k to 11.0k ohms	See addition to paragraph 5-15 in this manual changes supplement
A23R55	12	511 to 1780 ohms	Sampler Efficiency and Offset Adjustment
A23C45	12	1.8 to 2.7 pF	Refer to paragraph 5-10 step 8b.
See paragraph 5-11 for A19R63, R72, R74 and C43			

Pages 5-7 and 5-8, Paragraph 5-10:
Replace paragraph 5-10 with the attached "**5-10. SAMPLER EFFICIENCY AND OFFSET ADJUSTMENT**" (P/O ERRATA).

ERRATA (cont'd)

Page 5-8, Paragraph 5-10, step 8:
Under step 8 add the following:
If the minimum deflection is greater than 0.8Vpp, increase A23R55 to the next larger value as listed below.

Resistance (ohms)	HP Part Number
511	0757-0416
750	0757-0420
1000	0757-0280
1210	0757-0274
1470	0757-1094
1780	0757-0278

Page 5-9, Paragraph 5-11:
Delete the entire present procedure and add the attached procedure **5-11. LO DOUBLER POWER OUTPUT AND BALANCE ADJUSTMENT (P/O ERRATA)** in its place (the board location figure remains the same).

Page 5-14, Paragraph 5-15:
Add step 3.1 as follows:

3.1 If A51C20 cannot be adjusted for a display within listed limits, then R32 can be selected to shift nominal readings on the display. Increasing R32 one adjustment value will increase the nominal reading by approximately 3%. The only values available are
9.09k ohms and 11.0k ohms.

Page 5-16, Paragraph 5-17:
In step 2, change "13.0 SPCL" to "12.0 SPCL".

Page 5-18, Paragraph 5-19, step 7:
Change "300 (down arrow) kHz" to "3000 (down arrow) kHz".

Page 5-20, Paragraph 5-20, step 6:
Change "within ±0.02 radian" to "within ±0.2 radian".

Page 6-5, Table 6-2:
Change A1R20, R22, R23, R26, and R27 to HP Part Number 1810-0229 CD5 NETWORK-RES 8-SIP 330 OHM X 7.
Change A1R21, R24, and R25 to HP Part Number 0698-3445 CD2 RESISTOR 348 1% 0.125W F TC=0±100.

Page 6-7, Table 6-2:
Change A2C14 to 0160-3539 CD6 CAPACITOR-FXD 820PF +-5% 100VDC MICA.
Change A2C38 to HP Part Number 0160-3068 CD6 CAPACITOR-FXD 1500PF +-5% 300VDC MICA.

Page 6-8, Table 6-2:
Change A2L5 to 9100-1653 CD4 INDUCTOR RF-CH-MLD 910UH 5% .2DX.45LG.
Change A2Q1 to 1854-0830 CD6 TRANSISTOR-DUAL NPN PD=500MW X-ND LM394-05.

ERRATA (cont'd)

Page 6-14, Table 6-2:
Change A4R51 to 0698-3904 CD8 RESISTOR 14.7K 0.1% 0.1W F TC=0±100.
Page 6-17, Table 6-2:
Add an asterisk(*) to A6C43, A6C51 and A6L8 to indicate factory selected components.
Change A5U10-12 to 1820-1547 CD3 IC MULTIPLXR 8-CHAN-ANL 16-DIP-C PKG 04713 MC14051
Page 6-18, Table 6-2:
Change A6C55 to 0160-5469 CD5 CAPACITOR-FXD 1UF 10% 50VDC MPE
Page 6-19, Table 6-2:
Change A6Q17 to 1855-0597 CD4
CHANGE A6Q6 TO 1855-0265 CD3 TRANSISTOR J-FET N-CHAN D-MODE TO-18 SI.
Page 6-21, Table 6-2:
Change A10C14 to 0180-3701 CD6 CAPACITOR-FXD 2.2UF 75VDC TA
Change A6U2 to 1826-0989 CD7 IC OP AMP GP8 8-DIP-C PKG LM307J
Change A6U4 to HP Part Number 1990-0643 CD0 OPTO-ISOLATOR LED-PCNDCT IF=40MA MAX.
Change A6U7 to 1826-0065 CD0 IC COMPARATOR PCRIN 8-DIP-C PKG LM311N
Page 6-23, Table 6-2:
Add A10TP8, HP Part Number 1251-0600 CD0 CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ.
Change A10VR10 and VR11 to HP Part Number 1902-0943 CD5 DIODE-ZNR 2.37V 5% DO=7 PD=0.4W TC=-0.074%
Page 6-26, Table 6-2:
Change the following:
A13U5 ROM #3 TO 08901-80011 CD3
A13U6 ROM #4 TO 08901-80012 CD4
A13U7 ROM #5 TO 08901-80013 CD5
Page 6-27, Table 6-2:
Change A14R10 to 0698-7260 CD7 RESISTOR 10K 1% .05W F TC=0+-100
>> Page 6-28, Table 6-2:
Under A15MP1, add 3050-0016 CD8 QNTY 1 WASHER-FL MTLC NO.6 .147-IN-ID.
Page 6-29, Table 6-2:
Change A15R10 to 0699-0252 CD5 RESISTOR-FXD 52.8 +-5% .2W C TC=0=+-200.
Change A15R10* to 0699-1213 CD2 RESISTOR 61.59 1% .05W F TC=0+-100
Page 6-30, Table 6-2:
Change A17L5 to 9100-1641 CD0 INDUCTOR RF-CH-MLD 240 uH 5% 0.166D x 0.385LG.
Change A15U3 to 1826-0141 CD3 IC COMPARITOR GP DUAL 14-DIP-C-PKG LM319J.
Page 6-31, Table 6-2:
Change A17T1 to HP Part Number 08901-80031 CD7 TRANSFORMER ENCAPSULATED.
Page 6-32, Table 6-2:
Change A18CR6 and CR7 to HP Part Number 1901-0518 CD8 DIODE-SM SIG SCHOTTKY.
Page 6-33, Table 6-2:
Change A19C43 to 0160-4491 CD1 CAPACITOR FXD 8.2 pF ±5% 200VDC CER (add an asterisk after A19C43).

ERRATA (cont'd)

Page 6-35, Table 6-2:
Make the following changes to the A19 LO Divider Assembly:
Change A19R63* to 0757-0398 CD4 RESISTOR 75 1% .05W F TC=0+-100
Change A19R72 to 0757-0422 CD5 RESISTOR 909 1% 0.125W F TC=0±100 (add an asterisk after A19R72).
Change A19R74 to 0757-0422 CD5 RESISTOR 909 1% 0.125W F TC=0±100 (add an asterisk after A19R74).
Change A19R75 TO 0757-0416 CD7 RESISTOR 511 1% 0.125W F TC=0±100.

Page 6-36, Table 6-2:
Change A19VR1 to HP Part Number 1902-0943 CD5 DIODE-ZNR 2.37V 5% DO=7 PD=0.4W TC=-0.074%.

Page 6-39, Table 6-2:
Change A20U2 to 1820-1547 CD3 IC MULTIPLXR 8-CHAN-ANL 16-DIP-C PKG 04713 MC14051
Change A20U13 and U14 to HP Part Number 1990-0729 CD0 OPTO-ISOLATOR LED-PCNDCT IF=40MA MAX.
Under A20U13 and U14 add HP Part Number 1990-0643 CD7 OPTO-ISOLATOR LED-PCNDCT IF=40 MA-MAX (ALTERNATE). This is the recommended replacement part for A20U13 and U14.

Page 6-39, Table 6-2:
Change A20U1 to 1826-0989 CD7 IC OP AMP GP8 8-DIP-C PKG LM307J.
Change A20U4 to 1826-0328 CD8 IC OP AMP GP DUAL 8-DIP PKG RV4558DE.

Page 6-41, Table 6-2:
›› On the A22 Low Frequency VCXO Assembly board (08901-60007), for serial prefixes 2606A and below use the following part numbers:
Change A22Y1 to 0410-1181 CD1 CRYSTAL, 9.26 MHz.
Change A22Y2 to 1410-1182 CD2 CRYSTAL, 11.26 MHz.
Change A23C45* to 0160-3568 CD1 CAPACITOR-FXD 2.7PF +-5% 500VDC CER, add an asterisk (*) to indicate factory selected component.

Page 6-43, Table 6-2:
Change A23T1 to HP Part Number 08901-80042 CD0 SAMPLER TRANSFORMER.
Add an asterisk (*) to A23R55.

Page 6-45, Table 6-2:
Change A25C1 to 0160-4832 CD4 CAPACITOR-FXD .01UF +-10% 100VDC CER.
Change A25C2 to 0160-4801 CD7 CAPACITOR-FXD 100PF +-5% 100VDC CER.
Change A26C2 to 0180-2990 CD3 CAPACITOR-FXD 7500 UF +75 -10% 20 VDC AL.
Change A25XA5, XA7, XA8, XA9, to 1251-1365 CD6 CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS.
Change A25XA2, XA3, XA4, XA6, to 1251-2035 CD9 CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS.

Page 6-46, Table 6-2:
Add, as part of A26MP3, HP Part Number 3050-0227 CD3 WASHER-FL MTLC NO. 6 .149-IN-ID.
Change A26XA10 to 1251-1365 CD6 CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS.
Change A27XA11, XA12A, XA13A, XA14A, to 1251-1365 CD6 CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS.
Change A27XA12B, XA13B, XA14B, to 1251-2035 CD9 CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS.

ERRATA (cont'd)

Page 6-47, Table 6-2:
Change A30TB1 to NSR P/O A30.
Under A29Q1, Q2, Q3 and Q4 delete the following:
0340-0833 INSULATOR-XSTR POLYE.
0340-0875 CD9 INSULATOR-XSTR THRM=CNDCT.
Under A29Q1, Q2, Q3 and Q4 add the following:
0340-0486 8 1 INSULATOR-COVER NYLON.
5001-5501 5 1 TRANS SPACER (TO3).
2190-0006 1 2 WASHER-LK HLCL NO.6 .141-1N-ID.
Change A28XA20 to 1251-1365 CD6 CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS.
Change A28XA15, XA19, to 1251-2035 CD9 CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS.
Change A28XA16, XA17, XA18, XA21-XA24 to 1251-0472 CD4 CONNECTOR-PC EDGE 6-CONT/ROW 2-ROWS.

Page 6-50, Table 6-2:
Change A30TB1 to 0960-0736 CD5 LINE VOLTAGE SELECTOR CARD.

Page 6-53, Table 6-2:
Change A51CR3,5,6 to 0122-0173 CD8 DIODE-VVC 29 PF 10% C3/C25-MIN=5 30V.

Page 6-54, Table 6-2:
Add an asterisk to A51R24.
Add an asterisk to A51R32.

Page 6-55, Table 6-2:
>> Change B1 to 08901-60306 CD7 FAN ASSEMBLY, 115V-50/60 HZ (EXCEPT OPTION 004).
Change B1 to 08901-60307 CD8 FAN ASSEMBLY, 115V-48/480 HZ (OPTION 004 ONLY).
Change T1 to 9100-4052 CD3 TRANSFORMER-POWER 100/120/220/240V.
Under T1, add 7100-1283 CD4 QNTY 1 COVER-TRANSFORMER.
Under T1, delete 1251-4283 CD3 CONTACT-CONN U/W-POST-TYPE FEM CRP.
Under T1, delete 1251-3278 CD4 QNTY 1 CONNECTOR 8-PIN F POST TYPE.
Under T1, delete 2360-0203 CD1 QNTY 4 SCREW-MACH 6-32 .625-IN-LG.
Under T1, delete 2190-0006 CD1 QNTY 4 WASHER-LK HLCL NO. 6 .141-IN-ID.

Page 6-56, Figure 6-1:
Exchange references W1 and W3.
Add, under MP48 EXTRUSION ASSY, arrow to the same point as that of MP48. Title this point as "MP38 (GASKET UNDER MP48)".

Page 6-57, Table 6-2:
>> Change W15 to 08901-60163 CD4 CABLE ASSEMBLY, A11J5 to J10 (Option 002).
Change W27 to 08901-60296 CD4 CABLE ASSEMBLY, A26J3 to A27J4 (MOLEX).
>> Change W31 to 08901-60169 CD0 CABLE ASSEMBLY, Y1 to A11J4 (Option 002).
Under Y1, change the quantity of 2360-0203 from 4 to 2.
Under Y1, add 2360-0205 CD3 QNTY 2 SCREW-MACH 6-32 .750-IN-LG.

Page 6-59, Table 6-2:
Add, as part of MP15, HP Part Number 5040-6928 CD4 STRIP DIVIDER.

ERRATA (cont'd)

Page 6-60, Figure 6-3:
Change MP30 FRONT WINDOW to MP40 FRONT WINDOW.

Page 6-61, Table 6-2:
Add MP34 1600-0692 CD1 RETAINING CLIP(HOLDING FRONT WINDOW).
Change MP32 to 8160-0072 CD4 RFI ROUND STRIP MNL-MSH .062-IN-OD.Change MP40 to the following HP Part Numbers:
08901-20181 CD2 PANEL, FRONT WINDOW.
08901-20182 CD3 WINDOW-FRONT PANEL.
Delete MP41-44, MP46, MP70.
Change MP50 to HP Part Number 08901-20043 CD5 EXTRUSION (FOR COUNTER ASSEMBLY).
Change MP60 to 0590-1251 CD6 NUT-SPCLY 15/32-32-THD .1-IN-THK .562-WD.
Add, as MP65, HP Part Number 08901-00148 CD9 COVER, RF SECTION BLANK.

Page 8-9, Figure 8-4:
Change U1A, U1B, and U1C to U12A, U12B, and U12C respectively.
Change U7A and U7B to U14A and U14B.

Page 8-9, Paragraph 8-27:
In example #1, change references from U1A, U1B and U1C to U12A, U12B, and U12C respectively; and change references from U7A and U7B to U14A and U14B.

Page 8-11, Paragraph 8-28:
Under 50.N Display Internal Voltages, change N=4 to "+15V Supply. The display should read between 2.8500 and 3.1500. See Service Sheet 10."

Page 8-14, Table 8-5:
Change HP 9825A program line 3 to "red 714, A".

Page 8-16, Paragraph 8-31:
In E75, second line, change "3.0" to "30".

Page 8-50, Bottom line of right column:
Change "input bytes" to "input bits."

Page 8-50, (Remote Interface Assembly [A14]):
Lower right side of text, third paragraph from the bottom of page in the second sentence, change "Handshake Control Logic" to "Interface Control Logic".

Page 8-71, (Power Supply Decoupling):
Change Q5 to C5.

Page 8-88, Figure 8-59:
Note that there is now a cover over the empty circuit-board slot in the RF Section. The reference designator for this cover is MP65.

Page 8-95, Service Sheet 1 (schematic):
Reverse the polarity of the diode symbol for CR4.
On the A15 Assembly, change the value of R10* to 61.59 ohms.
Change R10 to 52.8 (ohms).

Page 8-97, Service Sheet 2 (schematic):
In A17 Input Mixer Assembly schematic, change the value of L5 to 240 uH.

ERRATA (cont'd)

Page 8-98, Service Sheet 3, (Other References):
In fourth line from the top, change "1.5 MHz" to 455 KHz, and change "Page 5-18" to Page 5-24.

Page 8-98, Service Sheet 3, (Troubleshooting):
In Check 4, ALC Reference, BW Control and Level Comparison Amplifier, Inverting Amplifier, and Control Current Source Check, step 8:
Replace last sentence with : It should take about 8 seconds for the level at pin 6 of U1 to drift from the negative to the positive extreme when the signal level is rapidly switched from +1 to +3 Vdc at TP2.
Step 12, Hint: Delete the word "present" from the sentence, "Reference present at pin 3 of U1."
Change "input bytes" to "input bits".

Page 8-98, Service Sheet 3 (NOTES):
In table of Transistor and Integrated Circuit Part Numbers, change U4 to 1990-0729.

Page 8-99, Service Sheet 3 (schematic):
On the A6 Assembly, add an asterisk(*) to C46, C51 and L8 to indicate factory selected components.

Page 8-99, Service Sheet 3 (NOTES):
In the table of Transistor and Integrated Circuit part numbers, change A6Q17 part number to 1855-0597

Page 8-99, Service Sheet 3 (NOTES):
In the Table of Transistor and Integrated Circuit Part Numbers, under A6 change U2 to 1826-0989.

Page 8-101, Service Sheet 4 (NOTES):
In the Table of Transistor and Integrated Circuit Part Numbers, under A6 change U7 to 1826-0065.

Page 8-107, Service Sheet 7 (schematic):
On the A2 Assembly change the value of L5 to 910 uH.
Under the AMPLIFIER I bracket, change C14 to 820PF.
Under NOTES, in the table of Transistor and Integrated Circuit Part Numbers, change Q1 to 1854-0830.

Page 8-109, Service Sheet 8 (component locations):
Exchange the location labels for L2 and L3.
Exchange the location labels for C12 and C14 and for C4 and C6.

Page 8-109, Service Sheet 8 (schematic diagram):
Change the following signal names:
From U23 Pin 15, change 3 kHz LPF(H) to 3 kHz LPF(L).
From U23 Pin 14, change 3 kHz LPF(L) to 3 kHz LPF(H).
At U13A pin 1 change 3 kHz LPF(H) to 3 kHz LPF(L).
At U12D pin 16 change 3 kHz LPF(L) to 3 kHz LPF(H).

Page 8-111, Service Sheet 9 (component locations):
In Figure 8-84:
Change location labels CR10 to CR11 and CR11 to CR10.
Change location labels R7 to R29 and R29 to R7.

Page 8-111, Service Sheet 9 (schematic):
A5U2, U3 or U5. If A5U2, U3 or U5 are replaced, change A5R85 to HP Part Number 0698-3452 as described in CHANGE 19.
In the Table of Transistor and Integrated Circuit Part Numbers, change A5U1 to 1826-1048.

ERRATA (cont'd)

Page 8-113, Service Sheet 10 (NOTES):
In the table of Transistor and Integrated Circuit part numbers, change A5U10-12 part number to 1820-1547.

Page 8-113, Service Sheet 10 (schematic):
Change voltage values next to CR13J to "+2.85 to +3.15 Vdc."

Page 8-115, Service Sheet 11 (schematic):
On the A19 Assembly, change the value of R63* to 75 ohms.
Change the value of C43 to 8.2 pF (add an asterisk after C43).
Change the value of R63 to 61.9 ohms (add an asterisk after R63).
Change the value of R72 to 909 ohms (add an asterisk after R72).
Change the value of R74 to 909 ohms (add an asterisk after R74).

Page 8-117, Service Sheet 12 (schematic):
In the lower right portion of the A23 Sampler Assembly schematic, add an asterisk (*) to A23R55.
Change the voltage connection for A24R7 to -15V(F1).

Page 8-119, Service Sheet 13 (schematic):
Change the symbols for A22CR2 and CR6 and A22CR4 and CR8 to normal diode symbols. These are not schottkey diodes.

Page 8-121, Service Sheet 14 (NOTES):
In table of Transistor and Integrated Circuit Part Numbers, change U13 and U14 to 1990-0729.

Page 8-121, Service Sheet 14 (NOTES):
In the Table of Transistor and Integrated Circuit Part Numbers, under A20 change the following:
U1 to 1826-0989
U4 to 1826-0328.

Page 8-125, Service Sheet 16 (schematic):
Between A27 and A11, add the circuit in P/O Figure 8-101 included in this Manual Changes supplement.

Page 8-126, Service Sheet 17 (troubleshooting):
In /1 **Stage 1 Check**, step 1: Change A11J5 to A11J4
In /2 **Stage 2, 3, and 4, Count Transfer Logic, and Counter Gate Control Check**, step 7: Change A13U14 to A11U14.

Page 8-131, Service Sheet 19 (NOTES):
In the Table of Transistor and Integrated Circuit Part Numbers, under A13 change the following:
U5 to 08901-80011
U6 to 08901-80012
U7 to 08901-80013.

Page 8-135, Service Sheet 21 (schematic):
On the lower half of the schematic, change the values of R20, R22, R23, R26, and R27 to 330 ohms.
Change the values of R21, R24, and R25 to 348 ohms.

Page 8-140, Figure 8-121:
Between R6 and R2 is an unmarked capacitor. Label this capacitor C22.

ERRATA (cont'd)

Page 8-141, Service Sheet 23 (component locations):
In Figure 8-122, change the following location labels:
CR6 to CR7
CR7 to CR9
CR9 to CR6
VR1 to VR2
VR2 to VR1.

Page 8-141, Service Sheet 23 (schematic):
On the top left side of the A26 Power Supply Motherboard Assembly, change the top line from J5A PIN 7 to PIN 8. Change the wire color from 0 to 04. Connect the same line to E on the A30 Line Power Assembly.
Change the next line from J5A PIN 8 to PIN 7, and change the wire color from 04 to 0. Connect the line to C on A30.
In the upper left corner of the schematic, correct the drawing as shown below to indicate the safety ground from the fan cover to chassis ground.

Page 8-143, Service Sheet 24 (component locations):
In Figure 8-125, change R43 to CR13 and CR13 to R43.
In Figure 8-125, add a Test-Point 8 flag to TP8, which is located right of center.

Page 8-143, Service Sheet 24 (schematic):
Add a Test-Point 8 (TP8) flag to the base of A10Q17.

Page 8-143, Service Sheet 24 (NOTES):
In the Reference Designations table, add A10TP8.

Page 8-145, SS25 (SCHEMATIC):
In the lower right corner of the schematic, change C1 to .01UF, change C2 to 100PF.

Page 8-155, Service Sheet A:
In the Table add the following:
Item 8, MP34, Retaining Clip.
On the Exploded View Illustration add the following:
Item Number 8 and the retaining clip (industrial tape is no longer used).

Page 8-151, Service Sheet 28 (schematic):
Change reference designators C18 to C19 and C19 to C18.
Add an asterisk to A51R24.

Page 8-157, Service Sheet B:
In the reference chart, change the following:
Item 54; Machine Screw (6-32 X 2.50)
Item 56; Machine Screw (6-32 X 2.25)

Page 8-159, Service Sheet C (Service Special Functions):
Under 46.N Count Internal Signals, change "N=2 FM Calibrator" to "N=3 FM Calibrator".

CHANGE 1 - Serial Prefix 2009A

<u>Pages 6-7, and 6-8, Table 6-2</u>:
Make the following changes to the A2 assembly listings:
Change A2C32 to 0160-3538 CD5 CAPACITOR-FXD 750 PF ±5% 100 VDC MICA.
Change A2C33 to 0160-3536 CD3 CAPACITOR-FXD 620 PF ±5% 100 VDC MICA.
Change A2L10 to 9100-1660 CD3 INDUCTOR RF-CH-MLD 2 MH 5% .2DX.57LG.
Change A2L12 to 9100-1654 CD5 INDUCTOR RF-CH-MLD 1.1 MH 5% .23DX.57LG.
Change A2L13 to 9100-1651 CD2 INDUCTOR RF-CH-MLD 750 UH 5% .2DX.45LG.
Change A2L14 to 9100-1648 CD7 INDUCTOR RF-CH-MLD 560 UH 5% .2DX.45LG.

<u>Page 8-107, Service Sheet 7 (schematic)</u>:
Make the following value changes to the A2 Audio Filter Assembly:
Change C32 to 750 pF.
Change C33 to 620 pF.
Change L10 to 2 mH.
Change L12 to 1.1 mH.
Change L13 to 750 uH.
Change L14 to 560 uH.

CHANGE 2 - Serial Prefix 2012A

<u>Pages 6-16 and 6-17, Table 6-2</u>:
Make the following changes to the A5 Voltmeter Assembly listings:
Delete A5R27.
Change A5R59 to 0698-6360 CD6 RESISTOR 10K .1% .125W F TC=0±25.
Change A5R63 to 0698-6631 CD4 RESISTOR 2.5K .1% .125W F TC=0±25.
Add A5VR6 1902-0946 CD8 DIODE-ZNR 3.3V 5% DO-35 PD=.4W TC=-.039%.

<u>Page 6-22, Table 6-2</u>:
Make the following changes to the A10 Power Supply Regulators Assembly listings:
Change A10Q7 and Q9 to 1854-0811 CD3 TRANSISTOR NPN SI PD=625 MW FT=100 MHz.
Change A10R15 to 0757-0280 CD3 RESISTOR 1K 1% .125W F TC=0±100.
Change A10R17 to 0757-0421 CD4 RESISTOR 825 1% .125W F TC=0±100.
Change A10R19 to 0757-0424 CD7 RESISTOR 1.1K 1% .125W F TC=0±100.

<u>Page 6-44, Table 6-2</u>:
Make the following changes to the A24 High Frequency VCO Assembly.
Change A24CR3 to 0122-0326 CD3 DIODE-VVC 43 PF 5%.
Change A24CR4 to 0122-0326 CD3 DIODE-VVC 43 PF 5%.

<u>Page 8-111, Service Sheet 9 (schematic)</u>:
Change R27 to VR6, a 3.3V zener diode with the cathode connected to the +15V supply.

<u>Page 8-113, Service Sheet 10 (schematic)</u>:
Change R59 to 10 k ohms.
Change R63 to 2500 ohms.

<u>Page 8-141, Service Sheet 23 (schematic)</u>:
Change the value of R15 to 1000 ohms.
Change the value of R17 to 825 ohms.
Change the value of R19 to 1100 ohms.

<u>Page 8-143, Service Sheet 23 (NOTES)</u>:
In table of Transistor and Integrated Circuit Part Numbers, change Q7 and Q9 to 1854-0811.

CHANGE 3 - Serial Prefix 2021A

Page 6-45, Table 6-2:
Change the HP Part Number for A25 to 08901-60120.

Page 6-47, Table 6-2:
Make the following changes to the A29 Series Regulator Heat Sink Assembly.
Under A29Q1, Q2, Q3 and Q4, delete the following:
0340-0486 INSULATOR-COVER NYLON
2190-0006 WASHER LK.
Under A29Q1, Q2, Q3 and Q4, add the following:
0340-0833 INSULATOR-XSTR POLYE.

Page 8-145/146, Service Sheet 25 (schematic):
Add a line connecting XA5-28, STOP COUNT (H), to X7-8, X8-8 and X9-8 (these pins are currently labeled NC). Label the three pins STOP COUNT (H). On the right side of the schematic, at cable W23, make the circuit change illustrated in P/O Figure 8-129 included in this Manual Changes supplement.
Add a line connecting J2-7, e=2(L), to X7-30, X8-30, and X9-30 (these pins are currently labeled NC). Label the three pins e=2(L).
Change the assembly part number of A25 in the upper left portion of the schematic to 08901-60120.

Service Sheets 3, 4, 5, 6, 7, 8, 9, 10, 28, and 29 (schematics):
Change the assembly part number of the A25 Audio Motherboard Assembly to 08901-60120.

CHANGE 4 - Serial Prefix 2026A

Page 6-16, Table 6-2:
Make the following changes to the A5 Voltmeter Assembly listings:
Change A5R73 to 0757-0419 CD0 RESISTOR 681 1% .125W F TC=0+100.
Change A5R75 to 0757-0405 CD4 RESISTOR 162 1% .125W F TC=0±100.

Page 8-113, Service Sheet 10 (schematic):
Change the value of R73 to 681 ohms.
Change the value of R75 to 162 ohms.

CHANGE 5 - Serial Prefix 2031A

Page 6-42, Table 6-2:
Add A23C45 0160-4490 CD0 CAPACITOR-FXD 1.8 PF ±.25 PF 200 VDC CER.
Change A23Q6 to 1853-0281 CD9 TRANSISTOR PNP 2N2907A SI TO-18 PD=400 MW.

Page 8-117, Service Sheet 12 (schematic):
In the A23 Sampler Assembly (08901-60022) add C45, 1.8 pf, from the junction of CR8 and CR9, to ground.

Page 8-117, Service Sheet 12 (NOTES):
In the table of Transistor and Integrated Circuit Part Numbers, make the following changes:
Change "Q4, Q6" to "Q4".
Add "Q6 1853-0281".

CHANGE 6 - Serial Prefix 2032A

Page 6-26, Table 6-2:
Make the following changes to the A13 Controller Assembly:
Change A13U3 to 08901-80035 CD1 ROM#1.
Change A13U4 to 1818-1363 CD6 ROM#2.
Under A13U4, add 08901-80034 CD0 ROM#2 (ALTERNATE).

Page 6-28, Table 6-2:
Make the following changes to the A14 Remote Interface Assembly:
Change A14U14 to 1818-1364 CD7 ROM#11.
Under A14U14, change 08901-80023 to 08901-80033 CD9 ROM#11 (ALTERNATE).

Page 8-93, Service Sheet BD4 (troubleshooting):
In /3 Controller Kernel Check, step 7:
Replace the signature analysis and part number tables with the following tables:

With A14 Plugged In		With A14 Not Plugged In	
Test Point	Signature	Test Point	Signature
DATA 0	1864	DATA 0	2790
DATA 1	AHH4	DATA 1	437U
DATA 2	U264	DATA 2	U0UC
DATA 3	H26U	DATA 3	0U6C
DATA 4	AC5U	DATA 4	AP8F
DATA 5	54P0	DATA 5	C4CU
DATA 6	H0HU	DATA 6	71A8
DATA 7	AAA8	DATA 7	HP8H

Valid software date 180.1980. Valid ROM part numbers:

ROM Number	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

CHANGE 6 (cont'd)

Page 8-129, Service Sheet 18 (troubleshooting):
In /2 Memory Select Decoders and ROM Check, step 3:
Replace the signature analysis and part number tables with the following tables:

ROM	Start/Stop IC	Start/Stop Pin	Signature on CONTROL BUS DATA Test Point* 0	1	2	3	4	5	6	7
1	A13U12	15	F580	6H56	FFAF	FA62	5AU4	A36U	6F17	7731
2	A13U12	14	UCP4	4P18	4594	4UPF	75U4	F9AH	A8CA	C73F
3	A13U12	13	FUUH	4071	P1U9	86A5	89HC	HC04	UP6U	P675
4	A13U12	12	PF63	CH3C	H738	FFU3	5085	P57A	69FU	HF09
5	A13U12	11	H5C4	U937	86CP	A58F	A136	FC40	9834	A624
6	A13U12	10	0959	U952	FHUF	P0U9	65UU	29UP	CP7H	A0U8
7	A13U12	9	U80C	1A8H	C898	76AA	UC8A	588A	F71A	8627
8	A13U12	7	U451	U20U	P807	HC50	0967	CPU1	84C6	H63A
11	A14U18	9	3378	673F	3250	AFC9	5A23	PC30	5475	9FU9

*Valid software date 180.1980. Valid ROM part numbers:

ROM Number	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

CHANGE 7 - Serial Prefix 2051A

Page 6-16, Table 6-2:
Change A5R49 to 2100-3353 CD8 RESISTOR-TRMR 20K 10% C SIDE-ADJ 1-TRN.
Page 6-17, Table 6-2:
Add the following resistors:
A5R84 0757-0401 CD0 RESISTOR 100 1% .125W F TC=0+100.
A5R85 0698-3457 CD6 RESISTOR 316K 1% .125W F TC=0+100.
Change A5U5 to 1826-0266 IC OP AMP TO-99.
Page 8-111, Service Sheet 9 (component locations):
R84 and R85 are added as illustrated in P/O Figure 8-84 included in this Manual Changes supplement.
Page 8-111, Service Sheet 9 (schematic):
Change the table in upper right portion of the schematic as shown in P/O Figure 8-85 included in this Manual Changes supplement.

CHANGE 8 - Serial Prefix 2052A

Page 8-111, Service Sheet 9 (NOTES):
In the table of Transistor and Integrated Circuit Part Numbers, change U5 to 1826-0266.

Page 6-8, Table 6-2:
Change A2R6 to 2100-3052 CD4 RESISTOR-TRMR 50 10% C SIDE-ADJ 17-TRN.

Page 6-11, Table 6-2:
Change A3U7, U8, U10 and U11 to 1826-0644. However, if any one of these fail, replace all four (and A3R49 with the parts described in **Change** 9).

Page 8-109, Service Sheet 8 (NOTES):
In the table of Transistor and Integrated Circuit Part Numbers change A3U7, U8, U10 and U11 to 1826-0644. However, if any one of these fail, replace all four (and A3R49 with the parts described in **Change** 9).

CHANGE 9 - Serial Prefix 2105

r Page 6-11, Table 6-2:
Change A3R49 to 0698-3159 CD5 RESISTOR 26.1K 1% .125W F TC=0±100.
Change A3U7, U8, U10 and U11 to 1826-0783 CD9 IC OP AMP LOW-NOISE 8-DIP-C PKG.

r Page 8-109, Service Sheet 8 (schematic):
Change the value of R49 to 26.1k ohms.

r Page 8-109, Service Sheet 8 (NOTES):
In the table of Transistor and Integrated Circuit Part Numbers, change U7, U8, U10 and U11 to 1826-0783.

CHANGE 10 - Serial Prefix 2119

Page 6-30, Table 6-2:
Change A17L5 to 9100-1641 CD0 COIL-MLD 240 UH 5% Q=65 .155 D x .375 LG-NUM.

Page 8-109, Service Sheet 8 (schematic):
Change the value of L5 to 240 uH.

CHANGE 11 - Serial Prefix 2126

Page 6-55, Table 6-2:
Change J1, J6, J7 and J10 to HP Part Number 1250-1772 CD7 ADAPTER-COAX STR F-N F-SMA. Add, as part of Description of J1, "(INPUT)"; of J6, "(LO OUTPUT)"; of J7, "(LO INPUT)"; and of J10, "(INPUT)".
Add as part of J1, HP Part Number 0590-0505 CD1 NUT-KNRLD-R 5/8-24-THD .125-IN-THK.

Page 6-57, Table 6-2:
Change W1 to HP Part Number 08901-60118 CD9 CABLE ASSEMBLY J1 to A15J1 (EXCEPT OPTION 001).
Change W4 to HP Part Number 08901-60168 CD9 CABLE ASSEMBLY J7 to A17J3 (OPTION 003 ONLY).
Change W8 to HP Part Number 08901-60167 CD8 CABLE ASSEMBLY A19J3 to J6 (OPTION 003 ONLY).
Change W36 to HP Part Number 08901-60118 CD9 CABLE ASSEMBLY J10 to A15J1 (OPTION 001 ONLY).

Page 8-155, Service Sheet A (Figure 8-141):
In the table, the Reference Designator in Item Number 31 should be changed to "W1 and J1"

CHANGE 12 - Serial Prefix 2128

Page 6-47, Table 6-2:
Change A28 to HP Part Number 08901-60139 CD4 RF MOTHERBOARD ASSEMBLY.
Page 6-61, Table 6-2:
Change MP36 to HP Part Number 08901-00086 CD4 SUPPORT BRACKET, SHOCK MOUNT, FRONT.
Change MP37 to HP Part Number 08901-00087 CD5 SUPPORT BRACKET, SHOCK MOUNT, REAR.
Change MP38 to HP Part Number 08901-00095 CD5 GASKET, EXTRUSON, RF SECTION.
Change MP48 to HP Part Number 08901-20158 CD3 EXTRUSION ASSEMBLY, RF SECTION.
Service Sheets 1, 2, 11, 12, 13, 14, 15 and 27 (schematics):
Change all part number references of A28 RF Mother Board Assembly to 08901-60139.

CHANGE 13 - Serial Prefix 2133

Page 6-47, Table 6-2:
Add A30C1 as HP Part Number 0160-4065 CD5 CAPACITOR-FXD .1 UF ±20% 250 VAC (RMS).
Page 8-141, Service Sheet 23 (schematic):
In A30 Line Power Assembly, add C1, .1 uF, between points labeled "L" and "N".

CHANGE 14 - Serial Prefix 2134

Page 6-50, Table 6-2:
Change A50Q9 to HP Part Number 1854-0811 CD3 TRANSISTOR NPN S1, PD=625 MW FT=100 MHZ.
Page 8-153, Service Sheet 29 (NOTES):
In table of Transistor and Integrated Circuit Part Numbers, change A50Q9 to 1854-0811.

CHANGE 15 - Serial Prefix 2138A

Page 6-26, Table 6-2:
Change A13U3 to HP Part Number 08901-80038 CD4 ROM#1.
Change A13U9 to HP Part Number 08901-80039 CD5 ROM#7.
Under A13U9, delete HP Part Number 08901-80015.

CHANGE 15 (cont'd)

Page 9-93, Service Sheet BD4 (troubleshooting):
In /3 Controller Kernel Check, step 7:
Replace the signature analysis and part number tables with the following tables:

With A14 Plugged In		With A14 Not Plugged In	
Test Point	**Signature**	**Test Point**	**Signature**
DATA 0	1P3F	DATA 0	21F8
DATA 1	H59U	DATA 1	3C34
DATA 2	6762	DATA 2	65UH
DATA 3	F942	DATA 3	1446
DATA 4	2CF7	DATA 4	2P14
DATA 5	7766	DATA 5	9739
DATA 6	19UA	DATA 6	C88H
DATA 7	0237	DATA 7	7612

Valid software date 338.1981. Valid ROM part numbers:

ROM Number	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

Page 8-129, Service Sheet 18 (troubleshooting):
In /2 Memory Select Decoders and ROM Check, step 3:
Replace the signature analysis and part number tables with the following tables:

ROM	Start/Stop		Signature on CONTROL BUS DATA Test Point*							
	IC	Pin	0	1	2	3	4	5	6	7
1	A13U12	15	8927	343C	7017	UUF6	9497	P64P	2692	U8HP
2	A13U12	14	UCP4	4P18	4594	4UPF	75U4	F9AH	A8CA	C73F
3	A13U12	13	FUUH	4071	P1U9	86A5	89HC	HC04	UP6U	P675
4	A13U12	12	PF63	CH3C	H738	FFU3	5085	P57A	69FU	HF09
5	A13U12	11	H5C4	U937	86CP	A58F	A136	FC40	9834	A624
6	A13U12	10	0959	U952	FHUF	P0U9	65UU	29UP	CP7H	A0U8
7	A13U12	9	2CA4	1A8H	C898	76AA	UC8A	588A	F71A	8627
8	A13U12	7	U451	U20U	P807	HC50	0967	CPU1	84C6	H63A
11	A14U18	9	3378	673F	3250	AFC9	5A23	PC30	5475	9FU9

CHANGE 15 (cont'd)

*Valid software date 180.1980. Valid ROM part numbers:

ROM Number	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

CHANGE 16 - Serial Prefix 2142

Page 6-17, Table 6-2:
Change A5U1 to HP Part Number 1826-0471 CD2 IC OP AMP LOW-DRIFT TO-99.
Page 8-111, Service Sheet 9 (NOTES):
In table of Transistor and Integrated Circuit Part Numbers, change U1 to 1826-0471.

CHANGE 17 - Serial Prefix 2201A

Page 6-15, Table 6-2:
Change A5C8 to HP Part Number 0160-2202 CD0 CAPACITOR-FXD 75 PF ±5% 300 VDC.
Change A5C9 and A5C11 to NOT ASSIGNED.
Page 6-16, Table 6-2:
Change A5R9 and A5R24 to 0683-1565 CD2 RESISTOR 15M 5% .25W FC.
Page 6-17, Table 6-3:
Change A5U2 to 1826-0371 CD1 IC OP AMP TO-99.
Page 8-111, Service Sheet 9 (schematic):
Change the value of C8 to 75 pF.
Delete C9 and C11 and their connection to U2. Change U2 pin 1 output to NC.
Change the values of both R9 and R24 to 15M ohms.
Under NOTES, in the table of Transistor and Integrated Circuit Part Numbers, change U2 to 1826-0371.

CHANGE 18 - Serial Prefix 2212A

Page 5-1, paragraph 5-4:
Add the following paragraphs to the end of paragraph 5-4a (see ERRATA with the same page reference for 5-4a information):

5-4b. A15R10 and A15R47 Selection. If the instrument slightly exceeds the limits of step 5 of the RF Level Performance Test make an adjust- ment of the level accuracy vs. input frequency by altering the value of A15R10 and A15R47.

CHANGE 18 (cont'd)

If the level accuracy is uniformly high or low, change A15R47. Increasing the value of A15R47 by 10% will lower the indicated level by 0.1 dB. If the level increases or decreases with frequency, change A15R10. Increasing the value of A15R10 by 10% will decrease, by 0.2 dB, the indicated level at 1000 MHz relative to the level at low frequencies.

After altering the resistor values, repeat the test, making additional measurements at frequencies between those indicated in step 5. The effects of changing the two resistors are slightly interactive. A large change in one resistor value may require a slight change in the value of the other resistor.

Page 5-2, Table 5-1:
Add the following information to Table 5-1:

Reference Designator	Service Sheet	Range of Values	Basis of Selection
A15R10	1	42.2 to 68.1 ohms	See paragraph 5-4b.
A15R47	1	196 to 383 ohms	See paragraph 5-4b.

Page 6-4, Table 6-2:
Change A1DS5 to NOT ASSIGNED.
Page 6-5, Table 6-2:
Change A1R21 to NOT ASSIGNED.
Page 6-26, Table 6-2:
Change A13U3 to HP Part Number 08901-80040 CD8 ROM #1.
Change A13U4 to HP Part Number 08901-80041 CD9 ROM #2.
Delete HP Part Number 08901-80034 ROM #2 (ALTERNATE) (added in Change 6).

NOTE:
If either U3 or U4 is replaced in instruments with earlier serial prefixes, both should be replaced with parts from the same software date code.

Page 6-28, Table 6-2:
Change A15 to HP Part Number 08901-60183 CD8 RF INPUT ASSEMBLY.
Change A15C2 to HP Part Number 0160-4106 CD5 CAPACITOR-FXD .1 UF ±20% 50 VDC CER.
Change A15C10 to HP Part Number 0160-3878 CD6 CAPACITOR-FXD 1000 PF ±20% 100 VDC CER.
Change A15C12 to HP Part Number 0160-4502 CD2 CAPACITOR-FXD 390 PF ±5% 100 VDC CER.
Change A15C14 to HP Part Number 0160-4768 CD5 CAPACITOR-FXD 470 PF ±5% 100 VDC CER.
Change A15C16 to HP Part Number 0160-3878 CD6 CAPACITOR-FXD 1000 PF ±20% 100 VDC CER.
Add A15C28 as HP Part Number 0160-4106 CD5 CAPACITOR-FXD .1 UF +-20% 50 VDC CER.
Change A15K1 to HP Part Number 0490-1185 CD3 RELAY REED 1A 500 MA 100 VDC 5 VDC-COIL
Change A15L1 to HP Part Number 9100-2257 CD6 INDUCTOR RF-CH-MLD 820 NH 10% .105 D X .26 LG.

CHANGE 18 (cont'd)

Page 6-28, Table 6-2 (cont'd):
Change A15L2 to HP Part Number 9100-2261 CD2 INDUCTOR RF-CH-MLD 2.7 UH 10% .105 D X .26 LG.
Change A15L3 to HP Part Number 9140-0142 CD8 INDUCTOR RF-CH-MLD 2.2 UH 10% .105 D X .26 LG.
Add A15L4 as HP Part Number 9100-2258 CD7 INDUCTOR RF-CH-MLD 1.2 UH 10% .105 D X .26 LG.

Page 6-29, Table 6-2:
Change A15R10 to HP Part Number 0698-7205 CD9 RESISTOR 51.1 1% .05W F TC=0+100 (add an asterisk to A15R10).
Add A15R16 as HP Part Number 0757-0394 CD0 RESISTOR 51.1 1% .125W F TC=0+100.
Add A15R46 as HP Part Number 0698-7242 CD5 RESISTOR 1.78K 1% .05W F TC=0+100.
Add an asterisk to A15R47 and change it to HP Part Number 0698-3442 CD9 RESISTOR 237 1% .125W F TC=0+-100.

Page 6-30, Table 6-2:
Add A15R62 as HP Part Number 0698-7212 CD9 RESISTOR 100 1% .05W F TC=0+100.

Page 6-46, Table 6-2:
Add the following at the end of the Description for A26C5: (Option 004 only)

Page 8-89, Service Sheet BD2 (block diagram):
Replace A15 RF Input Assembly (SS1), in upper left portion of schematic, with P/O Figure 8-61 in this Manual Changes supplement.

Page 8-93, Service Sheet BD4 (troubleshooting):
In /3 Controller Kernel Check, step 7:
Replace the signature analysis and part number tables with the following tables:

With A14 Plugged In		With A14 Not Plugged In	
Test Point	**Signature**	**Test Point**	**Signature**
DATA 0	9AUP	DATA 0	A50A
DATA 1	907U	DATA 1	7PH4
DATA 2	15F9	DATA 2	1756
DATA 3	H5FA	DATA 3	08FP
DATA 4	H2P8	DATA 4	H73C
DATA 5	A2C1	DATA 5	4C7P
DATA 6	A086	DATA 6	01U1
DATA 7	04C2	DATA 7	7097

CHANGE 18 (cont'd)

Valid software date 67.1982. Valid ROM part numbers:

ROM Number	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

Page 8-95, Service Sheet 1 (component locations):
Replace with new Figure 8-67 "A15 RF Input Assembly, Component Locations" in this Manual Changes supplement.

Page 8-95, Service Sheet 1 (schematic):
Replace with new Figure 8-68 "RF Input Schematic Diagram" in this Manual Changes supplement. This figure supercedes Figure 8-68 provided in 19 May 1982 Manual Changes supplement.

Page 8-129, Service Sheet 18 (troubleshooting):
In /2 Memory Select Decoders and ROM Check, step 3:
Replace the signature analysis and part number tables with the following tables:

ROM	Start/Stop		Signature on CONTROL BUS DATA Test Point*							
	IC	Pin	0	1	2	3	4	5	6	7
1	A13U12	15	1PU9	4H0C	U93P	76PU	3919	P64P	167F	4119
2	A13U12	14	4P82	4P18	9U27	22C5	18AH	A678	A075	025A
3	A13U12	13	FUUH	4071	P1U9	86A5	89HC	HC04	UP6U	P675
4	A13U12	12	PF63	CH3C	H738	FFU3	5085	P57A	69FU	HF09
5	A13U12	11	H5C4	U937	86CP	A58F	A136	FC40	9834	A624
6	A13U12	10	0959	U952	FHUF	P0U9	65UU	29UP	CP7H	A0U8
7	A13U12	9	2CA4	1A8H	C898	76AA	UC8A	588A	F71A	8627
8	A13U12	7	U451	U20U	P807	HC50	0967	CPU1	84C6	H63A
11	A14U18	9	3378	673F	3250	AFC9	5A23	PC30	5475	9FU9

*Valid software date 67.1982. Valid ROM part numbers:

ROM Number	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

CHANGE 18 (cont'd)

Page 8-135, Service Sheet 21 (schematic):
In lower, left portion of schematic delete DS5 and R21 and their connection to +5V.

Page 8-141, Service Sheet 23 (schematic):
In left portion of service sheet, in P/O A26 Power Supply Motherboard Assembly, show a dashed line connected to C5. This capacitor is inserted in Option 004 instruments only.

Page 8-151, Service Sheet 28 (schematic):
In the center portion of the schematic, delete C10 and change U4 pin 1 to NC.

CHANGE 19 - Serial Prefix 2227A

Page 8-151, Service Sheet 28 (NOTES):
In the table of Transistor and Integrated Circuit Part Numbers, change U4 to 1826-0371.

Page 4-30, paragraph 4-12, SPECIFICATION table:
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 4-31, paragraph 4-12, PROCEDURE step 4:
Replace the table in step 4 with the table that follows:

Power Meter Reading (mW)	RF Level Limits (mW)		
	Lower	Actual	Upper
10	7.08	______	14.1
3	2.12	______	4.24
1	0.708	______	1.41

Page 4-31, paragraph 4-12, PROCEDURE step 5:
Replace the table in step 5 with the table that follows:

Signal Generator Frequency (MHz)	RF Level Limits (mW)		
	Lower	Actual	Upper
1000*	2.12	______	4.24
650*	2.12	______	4.24
100	2.12	______	4.24
10	2.12	______	4.24
0.5	2.12	______	4.24

* If a signal generator with a doubler is being used, insert the appropriate bandpass filter at the generator's output to suppress harmonic and sub-harmonic signals.

CHANGE 19 (cont'd)

Page 4-32, paragraph 4-12, PROCEDURE step 7:
Replace the table in step 7 with the table that follows:

Signal Generator Frequency (MHz)	Power Meter Reading (dBm)	
	Actual	Maximum
1000	______	-19
650	______	-23
300	______	-23
100	______	-23
30	______	-23
10	______	-23

Page 4-39, Table 4-1:
Replace the portion of the table for Section No. 4-12 with the table that follows:

Section No.	Test Description	Results		
		Min.	Actual	Max.
4-12.	RF LEVEL PERFORMANCE TEST			
	RF Level Accuracy			
	Power Meter Reading			
	10 mW	7.08	______	14.1
	3 mW	2.12	______	4.24
	1 mW	0.708	______	1.41
	Frequency			
	1000 MHz	2.12	______	4.24
	650 MHz	2.12	______	4.24
	100 MHz	2.12	______	4.24
	10 MHz	2.12	______	4.24
	0.5 MHz	2.12	______	4.24
	SWR			
	Frequency			
	1000 MHz		______	-19
	650 MHz		______	-23
	300 MHz		______	-23
	100 MHz		______	-23
	30 MHz		______	-23
	10 MHz		______	-23

CHANGE 19 (cont'd)

r Page 6-17, Table 6-2:
Change A5R85 to HP Part Number 0698-3452 CD1 RESISTOR 147K 1% .125W F TC=0+100. This change is backward compatible with all insrtuments with prefix 2051A and newer and any instruments to which revision "C" of the Voltmeter Assembly (08901-60010) A5, has been retrofitted.

r Page 6-32, Table 6-2:
Change A18Q4 to HP Part Number 1854-0477 CD7 TRANSISTOR NPN 2N2222A SI TO-18 PD=500 MW.

Page 8-97, Service Sheet 2 (schematic):
In A18 IF Amplifier Assembly, on A18Q4, delete the transistor ground connection.

r Page 8-97, Service Sheet 2 (NOTES):
In the table of Transistor and IC Part Numbers, change A18Q4 to 1854-0477.

r Page 8-111, Service Sheet 9 (schematic):
Change the value of A5R85 to 147k.

CHANGE 20 - Serial Prefix 2229A

Page 6-50, Table 6-2:
Change A50Q5 to HP Part Number 1854-0475 CD5 TRANSISTOR-DUAL NPN PD=750MW.

Page 6-51, Table 6-2:
Change A50R90 to HP Part Number 0698-3441 CD8 RESISTOR 215 1% .125W F TC=0+100.
Add A50R109 as HP Part Number 0698-3441 CD8 RESISTOR 215 1% .125W F TC=0+100.

Page 8-153, Service Sheet 29 (component locations):
The locations for components Q2 through Q5 and R109 are shown in new figure 8-136, A50 AM Calibrator Assembly Component Locations (Option 010) included in this Manual Changes supplement.

Page 8-153, Service Sheet 29 (schematic):
Change the LIMITER circuitry as illustrated in P/O Service Sheet 29 (schematic) included in this Manual Changes supplement (addition of Q2 and R109).
Change the reference designators of the following transistors:
From Q2 to Q3,
from Q3 to Q4,
from Q4 to Q5A, and
from Q5 to Q5B.
Change the value of R90 to 215 ohms.

Page 8-153, Service Sheet 29 (NOTES):
In the table of Transistor and Integrated Circuit Part Numbers, change Q5 to 1854-0475.

CHANGE 21 - Serial Prefix 2238A

Page 6-59, Table 6-2:
Under MP17 and MP19, change HP Part Numbers from 0624-0281 to 0624-0100 CD5 SCREW-TPG 4-40 .5-IN-LG PAN-HD-POZI STL.

Page 6-61, Table 6-2:
Under MP48, MP50, MP54, and MP57, change HP Part Numbers from 0624-0281 to 0624-0100 CD5 SCREW-TPG 4-40 .5-IN-LG PAN-HD-POZI STL.

CHANGE 22 - Serial Prefix 2239A

Page 6-10, Table 6-2:
Change A3R1| to HP Part Number 0698-7353 CD9 RESISTOR 19K 1% .125W F TC=0+100.
Change A3R4| to HP Part Number 0698-6343 CD5 RESISTOR 9K .1% .125W F TC=0+25.

Page 6-18, Table 6-2:
Change A6C51 to HP Part Number 0160-3535 CD2 CAPACITOR-FXD 560PF ±5% 300VDC MICA

Page 8-99, Service Sheet 3 (schematic):
In the lower right portion of the schematic, change the value of A6C51 to 560 pF.

Page 8-111, Service Sheet 8 (schematic):
In the upper left portion of the schematic:
Change the value of A3R1| to 19k.
Change the value of A3R4| to 9K.

CHANGE 23 - Serial Prefix 2244A

r Page 6-21, Table 6-2:
Change A6U4 to HP Part Number 1990-0643 CD7 OPTO-ISOLATOR LED-PCNDCT IF=40 MA-MAX.

r Page 8-99, Service Sheet 3, (schematic):
In TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS chart:
Change A6U4 Part Number to 1990-0643.

CHANGE 24 - Serial Prefix 2251A:

r Page 6-48, Table 6-2:
Change MP1 to HP Part Number 0380-0644 CD4 STANDOFF-HEX .327-IN-LG 6-32 THD and HP Part Number 2190-0034 9CD50 WASHER-LK HLCL NO.10 .194-IN-ID.

CHANGE 25 - Serial Prefix 2302A

r Page 6-9, Table 6-2:
Change A3C3 to HP Part Number 0180-2929 CD8 CAPACITOR-FXD 68 UF ±10% 10 VDC TA.
Change A3C49 and C52 to HP Part Number 0160-5201 CD3 CAPACITOR-FXD .01 UF ±1% 100 VDC.

r Page 6-15, Table 6-2:
Change A5C2, C4, C5, and C29 to HP Part Number 0180-2929 CD8 CAPCITOR-FXD 68 UF ±10% 10 VDC TA.

r Page 6-28, Table 6-2:
Change A15C4 to HP Part Number 0180-2929 CD8 CAPACITOR-FXD 68 UF ±10% 10 VDC TA.
Change A15C13 to HP Part Number 0160-4768 CD5 CAPACITOR-FXD 470 PF ±5% 100 VDC CER.

Page 6-32, Table 6-2:
Change A18R23 to HP Part Number 2100-3351 CD6 RESISTOR-TRMR 500 10% C SIDE-ADJ 1-TRN.
Change A18R24 to HP Part Number 0698-3446 CD3 RESISTOR 383 1% .125W F TC=0 +100.

r Page 8-94, Service Sheet 1 (schematic):
Change the value of C4 to 68 uF.

CHANGE 25 (cont'd)

Page 8-96, Service Sheet 2 (schematic):
Change A18R23 to 500 ohms and A18R24 to 383 ohms.

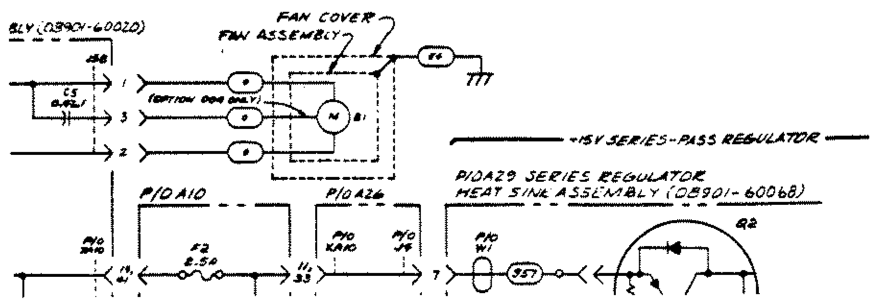
r Page 8-108, Service Sheet 8 (schematic):
Change the value of C3 to 68 uF.

r Page 8-110, Service Sheet 9 (schematic):
Change the value of C2, C4, and C5 to 68 uF.

r Page 8-112, Service Sheet 10 (schematic):
Change the value of C29 to 68 uF.

CHANGE 26 - Serial Prefix 2303A

Page 8-141, Service Sheet 23 (schematic):
In the upper left corner of the schematic, change the drawing as shown below to reflect the safety ground added from the fan cover to chassis ground.



Page 8-157, Service Sheet B (Figure 8-142):
In Figure 8-142, Rear Panel Illustrated Parts Breakdown, show a star washer between 2 (Fan Cover) and 3 (Fan Assembly) and in-line with 54 (Machine Screw). Designate the washer as call-out 58. This action is recommended for all instruments with prefix 2251A or below.
Add the following information to the reference chart.

Item Number	Reference Designator	Description
58	MP28	Star Washer

Page 6-60, Table 6-2:
Under MP28 add HP Part Number 2190-0008 CD3 WASHER-LK EXT. T NO.6 .141-IN-ID.

CHANGE 27 - Serial Prefix 2308A

r Page 6-22, Table 6-2:
Change Q1, 5, and 11 to HP Part Number 1884-0244 CD9 THYRISTOR-SCR VRRM=400.
Under Q1, 5, and 11, add HP Part Number 1205-0361 CD3 HT SK SGL TO-5/TO-39-CS.

Page 6-28, Table 6-2:
Change A15C2 to HP Part Number 0160-5630 CD2 CAPACITOR-FXD .15 UF ±20% 50 VDC CER.
Delete A15C28 added in CHANGE 18 of this Manual Changes Supplement.

CHANGE 27 (cont'd)

Page 8-94, Service Sheet 1 (component locations):
In "CHANGE 18, P/O **Figure 8-67, A15 Input Assembly Component Locations**" of this Manual Changes Supplement, delete A15C28 from the upper left corner.

Page 8-94, Service Sheet 1 (schematic):
In "**CHANGE 18, P/O Figure 8-68, A15 Input Assembly Schematic Diagram**" of this Manual Changes Supplement, delete C28 from the upper left corner and replace it with an open circuit.

r Page 8-140, Service Sheet 23 (schematic):
In the TRANSISTOR PART NUMBERS chart, change Q1 and Q5 to HP Part Number 1884-0244.

r Page 8-142, Service Sheet 24 (schematic):
In the TRANSISTOR PART NUMBERS chart, change Q11 to Hp Part Number 1884-0244.

CHANGE 28

Pages 6-17, 6-18, 6-19, 6-20, 6-21, Table 6-2:
Replace the entire A6 (08901-60114) assembly parts list with the attached **A6 AM DEMODULATOR ASSEMBLY (08901-60240) REPLACEABLE PARTS LIST (P/O CHANGE 28)**.

Pages 8-53, 8-55, and 8-56, paragraph 8-72:
Replace paragraph 8-72 with the new paragraph 8-72. **AM Demodulator (A6) - Service Sheet 3 (P/O CHANGE 28)**, contained in this manual supplement.

Page 8-99, Service Sheet 3 (component locations):
Replace Figure 8-72 with the new **Figure 8-72. P/O A6 AM Demodulator Assembly Component Locations (ALC Loop) (P/O CHANGE 28)** contained in this manual supplement

Page 8-99, Service Sheet 3 (schematic):
Replace Figure 8-73 with the new **Figure 8-73. AM Demodulator - ALC Loop Schematic Diagram (P/O CHANGE 28)** contained is this manual supplement.

Page 8-99, Service Sheet 3 (troubleshooting):
In </2>, Voltage-Variable Amplifier Check:
Delete "CAUTION" and the caution message.
Replace steps 1 through 8 with the attached **<Check 2> Voltage Variable Amplifier Check (P/O CHANGE 28)**.
In </4>, ALC Reference, BW Control and Level Comparison Amplifier, Inverting Amplifier, and Control Current Source Check:
Step 8, "Hint": Delete the sentence "Q27 and Q3 should be on."
Change Q2 to U5B.
Replace the sentence, "The collector of Q3 should be between -15 and -14 Vdc" with: Pin 8 of U5B should be a TTL high.
Step 11: Change the phrase "the collector of Q26" to: Pin 3 of U5A.
Change "+5 Vdc" to: +12 Vdc.
Step 11, "Hint": Replace the existing text with the following: U5A should be on with a TTL low at pin 1. U5C should be off.
Step 13, "Hint":In the last sentence delete the words, "U4 or" and change the word "Loop" to Circuit.

Page 8-101, Service Sheet 4 (component locations):
Replace Figure 8-74 with the new **Figure 8-74. P/O A6 AM Demodulator Assembly Component Locations (Control) (P/O CHANGE 28)** contained in this manual supplement.

CHANGE 28 (cont'd)

Page 8-101, Service Sheet 4 (schematic):
Change the value of C54 and C57 to .022u.
Change the value of R89 to 100 ohms, R92 to 464 ohms, R93 to 196 ohms, R102 to 26.1 ohms, and R122 to 5.11k.
In the upper left portion of the schematic, change the off-page indicator bullets from L to C; change the off-page indicator bullets at U8 pins 1 and 14 to E and D respectively; change in U8 pin 16 from no connection (NC) to an off-page indicator labeled, H,3.
Page 8-101, Service Sheet 4 (troubleshooting):
In </3> Select Decoder and Data Latch Check, add the following pin check for U8B.

Direct Control Special Function	Level (TTL) at U8 Pin
	16
0.0D0	L
0.0D3	H

CHANGE 29 - Serial Prefix 2312A

Page 6-44, Table 6-2:
Change A24C17 to HP Part Number 0160-4304 CD5 CAPACITOR-FXD 10-PF +-10% 100 VDC CER.
Page 8-117, Service Sheet 12 (schematic):
In the upper right portion of the A24 schematic, change the value of A24C17 to 10pF.

CHANGE 30 - Serial Prefix 2313A

Page 6-17, Table 6-2:
Change A6 to HP Part Number 08901-60246 CD4 AM DEMODULATOR ASSEMBLY.
Page 6-18, Table 6-2:
Add A6CR22 1901-0518 CD8 DIODE-SM SIG SCHOTTKY.
Page 8-99, Service Sheet 3 (schematic):
Change the A6 AM Demodulator Assembly number to (08901-60246).
Add a schottky diode symbol, labeled CR22, parallel to R79; anode to ground 1, cathode to pin 3 on U3.
In the table of Reference Designations, add CR22.
Page 8-101, Service Sheet 4 (schematic):
Change the A6 AM Demodulator Assembly number to (08901-60246).

CHANGE 31 - Serial Prefix 2324A

r Page 6-11, Table 6-2:
Change A3U4 and U9 to HP Part Number 1826-0753 CD3 IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C.
Page 6-28, Table 6-2:
Change A15C2 and add A15C28 as described in Change 18 of this Manual Changes Supplement. These capacitors were changed in Change 27 and are now changed back to their original configuration.

CHANGE 31 (cont'd)

Page 6-37, table 6-2:
Add A20E1 as HP Part Number 9170-0847 CD3 CORE-SHIELDING BEAD.

r Page 6-45, Table 6-2:
Change A24U3 to HP Part Number 1826-0785 CD1 IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-C.

Page 8-94, Service Sheet 1 (component locations):
In "CHANGE 18, P/O Figure 8-67. A15 Input Assembly, Component Locations" of this Manual Changes supplement, replace A15C28 as in original circuit layout (this part was removed in Change 27).

Page 8-95, Service Sheet 1 (schematic):
In "CHANGE 18, P/O Figure 8-68, A15 Input Assembly Schematic Diagram" of this Manual Changes Supplement, replace C28 as in original circuit configuration. A15C2 and C28 both have a value of 0.1uF.

Page 8-97, Service Sheet 14 (schematic):
In upper, left portion of schematic, add ferrite bead E1 to the base of Q9. The lead from the base goes through E1.

r Page 8-109, Service Sheet 8 (NOTES):
In the table of Transistor and IC Part Numbers", change the part number for U4,9 to 1826-0753.

r Page 8-117, Service Sheet 12 (NOTES):
In the table of Transistor and IC Part Numbers, under A24, change the part number for U3 to 1826-0785.

CHANGE 32 - Serial Prefix 2342A

In the Manual Changes Supplement:
Page 7 of Illustration/Tables, Table 6-2. Replaceable Parts (P/O CHANGE 28):
Change A6C51 to HP Part Number 0160-4678 CD6 CAPACITOR-FXD 560 PF +-1% 100VDC MICA.
Service Sheet 3, CHANGE 28, P/O Figure 8-73:
Change the value of C51 to 560p.

CHANGE 33 - Serial Prefix 2346A

Page 6-55, Table 6-2:
Change the first entry of B1 to 08901-60247 (CD5) FAN ASSEMBLY, 115V-50/60 MZ (EXCEPT OPTION 004).
Delete the following part numbers from the B1 entry:
1251-3201
1251-4283
0890-0007
0400-0009
Add the following part numbers to the B1 entry:
0624-0216 (CD4) SCREW-TPG 8-32 .375-IN-LG PAN-HD-POZI.
3160-0300 (CD6) FINGERGUARD

Page 6-59, Table 6-2:
Change MP16 to 08901-20233 (CD5) PANEL, REAR

CHANGE 34 - Serial Prefix 2350A

Pages 6-33, and 6-35, Table 6-2:

Change A19C38 to HP Part Number 0160-4389 (CD6) CAPACITOR-FXD 100PF +-5PF 200VDC CER.
Change A19R21 to HP Part Number 0698-7214 (CD1) RESISTOR 121 1% .05W F TC=0+-100.
Change A19R27 and A19R86 To HP Part Number 0698-7205 (CD0) RESISTOR 51.1 1% .05W F TC=0+-100.

Page 8-115, Service Sheet 11, (schematic):

Change the value of A19R21 to 121 ohms. Change the value of both A19R27 and A19R86 to 51.1 ohms. Change the value of A19C38 to 100pF.

CHANGE 35 - Serial Prefix 2410A

Page 6-30, Table 6-2:

Change A17L8 to HP Part Number 9140-0840 (CD3) INDUCR VARIABLE.
Change A17L11 to HP Part Number 9140-0841 (CD4) INDUCR VARIABLE.

CHANGE 36 - Serial Prefix 2412A

Page 6-34, Table 6-2:

Change A19CR2 through CR5 to HP Part Number 0122-0161 (CD4) DIODE-VVC 2.2PF 7%.

Page 6-40, Table 6-2:

Change A22CR9 through CR12 to HP Part Number 0122-0162 (CD5) DIODE-VVC 29PF 10%.

Page 6-44, Table 6-2:

Change A24CR3 and CR4 to HP Part Number 0122-0162 (CD5) DIODE-VVC 29PF 10%.

Page 6-53, Table 6-2:

Change A51CR3, CR5, and CR6 to HP Part Number 0122-0162 (CD5) DIODE-VVC 29PF 10%.

CHANGE 37 - Serial Prefix 2421A

Page 5-1, paragraph 5-4:

Delete the information regarding A15R10 that was added in Change 18 of the Manual Changes supplement.

Page 5-2, Table 5-1:

Delete A15R10 from this table that was added in Change 18 of the Manual Changes supplement.

Page 6-28, Table 6-2:

Change A15 to HP Part Number 08901-60256 (CD6) RF INPUT CONTROL ASSEMBLY.
Add A15AT1 and AT3 as HP Part Number 0699-1289 (CD0) 20 dB ATTEN.
Add A15AT2 as HP Part Number 0699-1288 (CD9) 10 dB ATTEN.
Change A15C13 to HP Part Number 0160-4062 (CD2) CAPACITOR-FXD 470PF +-10% 50VDC CER.
Add A15C29 as HP Part Number 0160-4616 (CD2) CAPACITOR-FXD 560PF +-5% 200VDC CER.

CHANGE 37 (cont'd)

Page 6-29, Table 6-2:

Change A15R10 to HP Part Number 0699-1213 (CD0) RESISTOR 61.59 1% .1W F TC=0+-200.

Change the following parts to NOT ASSIGNED:

A15R15
A15R19
A15R20
A15R21
A15R27
A15R29
A15R30
A15R38
A15R40
A15R45

Foldout 1 of the Manual Changes Supplement:

In the upper, left portion the foldout, change the part number listed after the label "A15 RF INPUT ASSEMBLY" to (08901-60256).

Change the value of A15R10 to 61.59. Remove the asterisk from R10.

Add capacitor C29 at the junction of R46 and CR4 anode.

Delete R15, R19, R20, and R21 and replace with AT1.

Delete R27, R29, and R30 and replace with AT2.

Delete R38, R40, and R45 and replace with AT3.

CHANGE 38 - Serial Prefix 2424A

Page 6-27, Table 6-2:

Change A14 to HP Part Number 08901-60257 (CD7) REMOTE INTERFACE ASSEMBLY.

Add A14R10 as HP Part Number 0757-0442 (CD9) RESISTOR 10K 1% .125W F TC=0+-100.

Change A14U8 to HP Part Number 1820-2740 (CD0) IC COMPTR TTL LS MAGTD 2-INP 8-BIT.

Page 6-29, Table 6-2:

Add MP6 and MP7 as HP Part Number 0363-0205 (CD7) CONNECTOR FINGER.

Page 8-95, Figure 8-67 (component locations):

Replace this figure with attached diagram, "**CHANGE 38. A15 RF Input Assembly Component Locations**".

Page 8-139, Figure 8-120 (schematic):

Change part number after the label A14 REMOTE INTERFACE ASSEMBLY to 08901-60257.

Change A14U8 and add A14U22F as shown in illustration "CHANGE 38. P/O Figure 8-120; A14 Remote Interface Assembly".

Page 8-139, Figure 8-120 (NOTES):

In the table of Integrated Circuit Part Numbers, change U8 to 1820-2740.

In the table of Digital Integrated Circuit Voltage and Ground Connections, show U8 +5V connection to pin 20; show U8 ground connection to pin 10.

CHANGE 39 - Serial Prefix 2426A

Pages 6-11 through 6-14, Table 6-2:

Change the following components:

A4	08901-60184	9	FM DEMODULATOR ASSEMBLY
A4C6	0160-4492	2	CAPACITOR-FXD 18PF +-5% 200VDC CER 0+-30
A4C15	0160-4806	2	CAPACITOR-FXD 39PF +-5% 100VDC CER 0+-30
A4C18	0160-4832	4	CAPACITOR-FXD .01UF +-10% 100VDC CER
A4C20	0160-4832	4	CAPACITOR-FXD .01UF +-10% 100VDC CER
A4C27	0160-5699	3	CAPACITOR-FXD 20PF +-5% 100VDC CER 0+-30
A4C31	0160-4805	1	CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30
A4C32	0160-4808	4	CAPACITOR-FXD 470PF +-5% 100VDC CER
A4C33	0160-5491	3	CAPACITOR-FXD 240PF +-5% 100VDC CER
A4C35	0160-4799	2	CAPACITOR-FXD 2.2PF +-.25PF 100VDC CER
A4C38	0160-4801	7	CAPACITOR-FXD 100PF +-5% 100VDC CER
A4C42	0160-4812	0	CAPACITOR-FXD 220PF +-5% 100VDC
A4C43	0160-4791	4	CAPACITOR-FXD 10PF +-5% 100VDC CER 0+-30
A4C44	0160-4795	8	CAPACITOR-FXD 4.7PF +-.5PF 100VDC CER
A4C45	0160-5719	8	CAPACITOR-FXD 620PF +-5% 100VDC CER
A4C46	0160-4832	4	CAPACITOR-FXD .01UF +-10% 100VDC CER
A4C47	0160-4822	2	CAPACITOR-FXD 1000PF +-5% 100VDC CER
A4C49	0160-4832	4	CAPACITOR-FXD .01UF +-10% 100VDC CER
A4C50	0160-4819	7	CAPACITOR-FXD 220PF +-5% 100VDC CER

Change A4CR6 through A4CR9:			
	08901-80037	3	MATCHED DIODE SET
Change A4Q23, A4Q26, A4Q28, and A4Q33:			
	1854-0637	1	TRANSISTOR NPN 2N2219A SI TO-5 PD=800MW
	1200-0173	5	INSULATOR-XSTR DAP-GL
Under A4Q28 and A4Q33:			
	1205-0361	3	HEAT SINK SGL TO-5/TO-39-CS
Change A4R80 and A4R81:			
	0698-3432	7	RESISTOR 26.1 1% .125W F TC=0+-100

Add the following components:

A4C51	0160-4819	7	CAPACITOR-FXD 2200PF +-5% 10VDC CER
A4Q35	1855-0020	8	TRANSISTOR J-FET N-CHAN D-MODE TO-18 SI
A4R105	0698-3155	1	RESISTOR 4.64K 1% .125W F TC=0+-100
A4R106	0698-3446	3	RESISTOR 383 1% .125W F TC=0+-100

Page 8-103, Figure 8-77, Service Sheet 5 (schematic):

Change the label in the upper, left corner to P/O A4 FM DEMODULATOR ASSEMBLY (08901-60184).

Page 8-105, Figure 8-79, Service Sheet 6 (schematic):

Change the label in the upper, left corner to P/O A4 FM DEMODULATOR ASSEMBLY (08901-60184).

Change the values of A4R80 and R81 to 26.1 ohms.

CHANGE 39 (cont'd)

Page 8-105, Figure 8-79, Service Sheet 6 (schematic) (cont'd):

In the lower, right portion, add C51 (2200pF) in parallel with C50, to the right of C50. Add R105 (4.64 kohms) between C50 and C51. Below C39, add N-channel FET Q35. Connect its source to ground 1, connect its gate to the gate of Q21, and connect its drain through new resistor R106 (215 ohms) which should be connected to the top of R86.

Page 8-105, Figure 8-79, Service Sheet 6 (NOTES):

In the table of Transistor Part Numbers, change Q23, Q26, Q28, and Q33 to 1854-0637.

CHANGE 40 - Serial Prefix 2432A

In Illustration Page 6 of the Manual Changes Supplement, Change 28:

Change A6Q6 to HP Part Number 1855-0265 (CD3) TRANSISTOR J-FET N-CHAN D-MODE TO-18 SI.

In SS3, P/O A6, in Change 28 of the Manual Changes Supplement (NOTES):

In the table of Transistor and Integrated Circuit Part Numbers, change Q6 to 1855-0265.

CHANGE 41 - Serial Prefix 2439A

Page 6-61, Table 6-2:

Add as MP66, HP Part Number 08901-00157 (CD0) COVER, AUDIO SECTION, FULL BLANK.

Page 8-91, Figure 8-62 (component locations)

Draw a blank cover over the open slot in the Audio Section. Refer to this cover as MP66. (This cover will cover a different slot depending on the option selected. For example, if no options are ordered, the cover will be over the A50 slot.)

CHANGE 42 - Serial Prefix 2443A

Page 6-32, Table 6-2:

Add A18E1 as HP Part Number 9170-0029 (CD3) CORE-SHIELDING BEAD.

Page 8-97, Service Sheet 2 (schematic):

In A18 Input Mixer Assembly, add a ferrite bead, E1, to the base of Q7.

CHANGE 43 - SERIAL PREFIX 2447A

Page 6-4, Table 6-2:

Change the A1 Keyboard and Display Assembly 08901-60001 (Option 010 only) to 08901-60261.

Change the A1 Keyboard and Display Assembly 08901-60034 (except Option 010) to 08901-60275.

Change A1C2-4, and A1C6-13 to 0160-4832 CD4 CAPACITOR-FXD .01UF +-10% 100VDC CER.
Delete A1C14-23.

CHANGE 43 (cont'd)

Page 6-5, Table 6-2:
Add A1R28-35 1810-0402 CD6 NETWORK-RES 16-DIP330.0 OHM X 8
Page 6-6, Table 6-2:
Change A1U1-8 to 1990-0574 CD3 DISPLAY-NUM-SEG 1-CHAR .43-H
Page 6-7, Table 6-2:
Add A1U40 08901-80074 CD8 PROGRAMMED ROM
Add A1U41-48 1820-2757 CD9 IC FF TTL ALS D-TYPE POS-EDGE-TRIG OCTL SN74LS574N
Page 8-76, Paragraph 8-91:
Replace Paragraph 8-91 with the following paragraph:

The Keyboard and Display Assembly contains the front-panel displays, annunciators, key lights, and the decoders and latches that control them. Lighting of a display is accomplished by straight-forward decoding of the Instrument Bus. For example, to display the digit 3 in display U2, the controller issues esd=613 to the Instrument Bus. Output 1G of Select Decoder U24 goes low (uniquely) and enables latch U42. The data code (d=3) is decoded by ROM U40, which is programmed to be a seven-segment decoder that is always enabled. In this example, U40 places lows on lines a, b, c, d, g, and highs on lines e and f. U40 drives U42, which lights the appropriate segments of U2. (A "low" lights the corresponding segment.) In this example, a "3" is displayed. The segment information is latched in U42 when a different e, s, or es code is issued to the instrument bus. For a discussion of the Instrument Bus, see Instrument Bus, page 8-48.

Page 8-133, Figure 8-109.
Replace this component locator with the attached component locator on illustration page 14.
Page 8-135, Figure 8-111.
Replace this component locator with the attached component locator on illustration page 15.
Page 8-135, Service Sheet 21 (schematic).
Replace Figure 8-112 with the new **Figure 8-112. Keyboard and Display -Decoder and Display Circuits Schematic Diagram** (P/O CHANGE 43) contained in this manual supplememt.

r CHANGE 44 - **Serial Prefix 2450A**

Page 6-16, Table 6-2:
Change A5R9 and A5R24 to 0699-0073 CD8 RESISTOR 10M 1% .125W F TC=0+-150.
Page 8-111, Service Sheet 9 (schematic):
In A5 Voltmeter Assembly, change the value of R9 and R24 to 10M.

CHANGE 45 - **Serial Prefix 2505A**

Page 6-59, Table 6-2:
Under MP17 and MP19 change screw 0626-0100 (See CHANGE 21) to 0624-0653 (3) SCREW 440X1/2 TAPTITE T-10 PNTX.
Page 6-61, Table 6-2:
Under MP48, 50, 54, and MP57, change screw 0626-0100 (see CHANGE 21) to 0624-0653 (3) SCREW 440X1/2 TAPTITE T-10 PNTX.
Add MP67 8710-1637 (CD6) TORX BIT, T-10.
Under MP67 add 1400-0510 (CD8) CLAMP-CABLE .15-DIA .62-WD NYL.

CHANGE 46 - Serial Prefix 2518A

r Page 6-9, Table 6-2:
Change A3C4, 6, 47 to 0160-5340 CD1 CAPACITOR-FXD .03UF +-1% 200VDC.
Change A3C48, 53 to 0160-4217 CD9 CAPACITOR-FXD 3900PF +-1% MICA.
Page 6-10, Table 6-2
Change A3R1, 29 to 0698-6942 CD0 RESISTOR 25K .1% .125W F TC=0+-50.
Change A3R4 to 0698-8191 CD5 RESISTOR 12.5K .1% .125W F TC=0+-25.
Page 6-11, Table 6-2:
Change A3R36 to 0698-8307 CD5 RESISTOR 7.4K .25% .25W F TC=0+-50
Page 8-109, Service Sheet 8 (schematic):
On the A3 Assembly, change the following values:

C3, C6, C47 to .03 uF
C48, C53 to 3900 pF
R1, R29 to 25k
R4 to 12.5k
R36 to 7.4k

CHANGE 47 - Serial Prefix 2521A

Page 1-7:
Change part number of Front Handle Kit (Option 907) to 5061-9690.
Change part number of Rack Flange Kit (Option 908) to 5061-9678.
Change part number of Rack Flange and Front Handle Kit (Option 909) to 5061-9684.
Change part number of lockwashers (quantity 8) to 2190-9609.
Page 6-59, Table 6-2:
Change MP1 to 5021-5805 CD4
Change MP2 to 5021-5836 CD1
Change MP5 to 5061-9434 CD7
Change MP6 to 5062-9446 CD3
Change MP9 to 5041-6819 CD4
Change MP10 to 5041-6820 CD7
Change MP16 to 08901-20273 CD3
Under MP2, change screw 2360-0197 to 0515-1331 CD5 M4X0.7X6 FLATHEAD
Under MP10, add screw 0515-1239 CD2 M5X0.8X12 FLATHEAD
Under MP18, add screw 0515-1232 CD5 M3.5X0.6X8 PANHEAD
Page 6-68, Table 6-3:
Add MP70 to 7120-8607 CD2 LABEL..."THIS INSTRUMENT USES METRIC AND ENGLISH HARDWARE..."
>> Page 6-22, Table 6-2:
Change A10R3 to 0698-3447 CD4 RESISTOR 422 1% .125W F TC=0+-100.
Change A10R7 to 0811-1662 CD3 RESISTOR .47 5% 2W PW TC=0+-800.
>> Page 8-141, Service Sheet 23 (schematic):
On the A10 Assembly, change R3 value to 422 ohms; change R7 value to 0.47 ohms.

>> CHANGE 48 - **Serial Prefix 2542A**

Page 6-37, Table 6-2:
Change A20Q24 to 1853-0594 CD7 TRANSISTOR-DUAL PNP 2N3808 TO-78.
Delete A20Q25.

Page 8-121, Service Sheet 14 (schematic):
In the middle of the A20 schematic, under the LF VCXO TUNE Amplifier bracket, change the reference designation of Q24 to Q24A and the reference designation of Q25 to Q24B.

Number Q24A as follows:
Collector is pin 1.
Base is pin 2.
Emitter is pin 3.

Number Q24B as follow:
Collector is pin 7.
Base is pin 6.
Emitter is pin 5.

Page 8-121, Service Sheet 14 (NOTES):
Pin-out for A20Q24 is as follows: When looking at the top of Q24, starting to the left of the tab (reading counterclockwise) the pin numbers are: 1, 2, 3, 4, 5, 6, 7.
In the Table of Transistor and Integrated Circuit Part Numbers, delete Q25 and change Q24 to 1853-0594.

Page 8-121, Figure 8-96 (component locations):
In the lower left corner of the drawing, change the reference designation of Q25 to Q24B and change the reference designation of Q24 to Q24A. Q24 is a dual package PNP transistor.

>> CHANGE 49 - **Serial Prefix 2543A**

Page 6-8, Table 6-2:
Change A2Q1 to 1854-0295 CD7 TRANSISTOR-DUAL NPN PD=400MW.

Page 6-13, Table 6-2:
Change A4Q18 to 1854-0830 CD6 TRANSISTOR-DUAL NPN PD=500MW.

Page 6-15, Table 6-2:
Change A5CR15 to 1901-0880 CD7 DIODE-GEN PRP 125MA DO-35.

Page 6-22, Table 6-2:
Change A10MP1 to 5001-0178 CD2 QTY 2 BRACKET ANGLE.
Under A10MP1 list the following:
2190-0007 CD2 WASHER-LOCK INTL T NO.6 .141-ID.
2360-0191 CD6 QTY 2 SCREW-MACH 6-32 .188 PNPD.

Page 6-28, Table 6-2:
Change A15K1 to 0490-1452 RELAY-REED 1A 500MA 100VDC 5VDC-COIL.

Page 6-30, Table 6-2:
Delete A15L5 and A15R62.
Add A15W1 8150-4819 CD4 WIRE JUMPER.

Page 6-32, Table 6-2:
Change A18CR4 and CR5 to 1901-0880 CD7 DIODE-GEN PRP 125MA DO-35.

Page 6-44, Table 6-2:
Change A24C10 to 0160-3531 CD8 CAPACITOR-FXD 2UF +-5% 50VDC MET POLYC.
Change A24CR1, CR2, CR5, CR6 to 1901-0880 CD7 DIODE-GEN PRP 125MA DO-35.

Page 6-53, Table 6-2:
Change A51Q9 to 1854-0295 CD7 TRANSISTOR-DUAL NPN PD=400MW.

CHANGE 49 (cont'd)

Page 6-61, Table 6-2:
Delete MP34.
Add MP68 08901-00108 CD1 QTY 1 POWER ASSEMBLY BRACKET SUPPORT.

Page 8-95, Service Sheet 1 (schematic):
On the A15 Assembly, on the line between K1 and Q1 (between the nodes of C6 and R49) insert jumper wire W1.
On the A15 Assembly, delete R62 and L5.
On the A15 Assembly, change U3A pin-outs as follows:
Change pin 1 to pin 12
Change pin 3 to pin 4.
Change pin 4 to pin 5.
Change pins 2,5,7 to pins 3,6,8.
Change pin 10 to pin 11.
On the A15 Assembly, change U3B pin-outs as follows:
Change pin 6 to pin 7.
Change pin 8 to pin 9.
Change pin 9 to pin 10.
Pins 1,2,13,14 are not connected.

Page 8-105, Service Sheet 6 (NOTES):
In the Table of Transistor and Integrated Circuit Part Numbers, change Q18 to 1854-0830.

Page 8-107, Service Sheet 7 (NOTES):
In the Table of Transistor and Integrated Circuit Part Numbers, change Q1 to 1854-0295.

Page 8-151, Service Sheet 28 (NOTES):
In the Table of Transistor and Integrated Circuit Part Numbers, change Q9 to 1854-0295.

Page 8-155, Service Sheet A:
In the table, delete Item Number 8, MP34, and Retaining Clip.
On the exploded view illustration, Delete Item Number 8, and the drawing of the retaining clip. (A clear industrial tape is now used to secure the LED Display window.)

>> CHANGE 50 - Serial Prefix 2545A

Page 6-41, Table 6-2:
Change A23 to 08901-60144 CD1 SAMPLER ASSEMBLY.
Change A23C30 to 0160-5699 CD3 CAPACITOR-FXD 20PF +-5% 100VDC CER 0+-30.
Change A23CR14 to 1901-0033 CD2 DIODE-GEN PRP 180V 200MA DO-7.
Change A23Q11, and Q12 to 1855-0420 CD2 TRANSISTOR J-FET 2N4391 N-CHAN D-MODE.

Page 6-26, Table 6-2:
Change A13U10 to 08901-80025 CD9 ROM #8.

Page 8-116, (component locations):
Replace the A23 Sampler Assembly Component Locations with the attached "A23 Sampler Assembly Component Locations (P/O CHANGE 50)".

Page 8-117, Service Sheet 12 (schematic):
Change the part number of the A23 Assembly to 08901-60144.
In the Table of Transistor and Integrated Circuit Part Numbers, under A23, change Q11 and Q12 part number to 1855-0420.

Page 8-131, Service Sheet 19, (schematic):
In the Table of Transistor and Integrated Circuit Part Numbers, change U10 part number to 08901-80025.

>> **CHANGE 51 - Serial Prefix 2606A**

Page 6-15, Table 6-2:
Change A5 to 08901-60293 CD1 VOLTMETER ASSEMBLY.
Page 8-111, Service Sheet 9 (schematic):
In the upper lefthand corner of the schematic, change the part number of the A5 Voltmeter Assembly to 08901-60293.
Page 8-113, Service Sheet 10 (schematic):
In the upper lefthand corner of the schematic, change the part number of the A5 Voltmeter Assembly to 08901-60293.

>> **CHANGE 52 - Serial Prefix 2607A**

Page 6-21, Table 6-2:
Change A10C9,C10 to 0180-0491 CD5 CAPACITOR-FXD 10UF +-20% 25VDC TA.
Change A10C21,C22 to 0160-0574 CD3 CAPACITOR-FXD .022UF +-20% 100VDC CER.
Page 6-41, Table 6-2:
Change A22Y1 to 0410-1615 CD6 CRYSTAL, 9.26 MHz.
Under A22Y1, change 1200-0758 to 1400-0973 CD7 CLIP CMPNT .139D .154 DIA STL.
Change A22Y2 to 1410-1616 CD7 CRYSTAL, 11.26 MHz.
Under A22Y2, change 1200-0758 to 1400-0973 CD7 CLIP CMPNT .139D .154 DIA STL.
Page 8-141, Service Sheet 23 (schematic):
Under P/O A10 Power Supply Regulators Assembly change:
In the upper corner next to Q12, change C21 to .022uf
Looking straight down from C21 to the bottom of the schematic, change C22 to .022uf.
On the right side of the schematic under OVER VOLTAGE PROTECTION, change C9 to 10uf.
Looking straight down from C9, change C10 to 10uf.

>> **CHANGE 53 - Serial Prefix 2609A**

Page 6-30, Table 6-2:
Replace the entire A17 Input Mixer parts list with the attached A17 Input Mixer parts list "P/O Table 6-2. Replaceable Parts (P/O CHANGE 53).
Page 8-96, Service Sheet 2 (component locator):
Replace the A17 Input Mixer Assembly Component Locations with the attached "A17 Input Mixer Assembly Component Locations (P/O CHANGE 53).
Page 8-97, Service Sheet 2 (schematic):
Replace SS2, A17 Input Mixer and A18 IF Amplifier with the attached "SS2 A17 Input Mixer and A18 IF Amplifier (P/O CHANGE 53)" schematic foldout.

CHANGE 54 - Serial Prefix 2616A

Page 6-45, Table 6-2:
Change A25 to 08901-60286 CD2 AUDIO MOTHERBOARD ASSEMBLY.

Page 6-56, Figure 6-1:
Replace Figure 6-1. Top Chassis Parts, Mechanical Parts, and Cable Identification with the attached " Figure 6-1. Top Chassis Parts, Mechanical Parts, and Cable Identification (P/O CHANGE 54)."

Page 6-59, Table 6-2:
Change MP17 to 08901-00167 CD2 STRUT, CENTER
Change MP19 to 08901-00168 CD3 BRACKET SUPPORT, AUDIO SECTION.

Page 6-61, Table 6-2:
Change MP48 to 08901-20276 CD6 EXTRUSION ASSEMBLY, RF SECTION.
Change MP54 to 08901-20277 CD7 EXTRUSION ASSEMBLY, AUDIO SECTION.
Delete MP55 and MP56.

Page 8-145, SS25 (SCHEMATIC):
In the upper left-hand corner of the schematic, change the A25 Audio Motherboard Assembly part number to 08901-60286.

CHANGE 55 - Serial Prefix 2617A

Page 6-36, Table 6-2:
Change A20 to 08901-60285 CD1 LO CONTROL ASSEMBLY.
Replace the entire A20 LO Control parts list with the attached A20 LO Control parts list "P/O Table 6-2. Replaceable Parts (P/O CHANGE 55)."

Page 8-121, Component Locations:
Replace the P/O A20 LO Control Assembly Component Locations (Analog Circuits) with the attached "A20 LO Control Assembly Component Locations (P/O CHANGE 55)."

Page 8-123, Component Locations:
Replace the P/O A20 LO Control Assembly Component Locations (Digital Circuits) with the attached "A20 LO Control Assembly Component Locations (P/O CHANGE 55)."

Page 8-121, SS14 (SCHEMATIC):
Replace SS14 P/O A20 LO Control with the attached "SS14 P/O A20 LO Control Assembly (1 of 2) (P/O CHANGE 55)" schematic foldout.

Page 8-123, SS15 (SCHEMATIC):
Replace SS15 P/O A20 LO Control with the attached "SS15 P/O A20 LO Control Assembly (2 of 2) (P/O CHANGE 55)" schematic foldout.

CHANGE 56 - Serial Prefix 2618A

Page 6-33, Table 6-2:
Change A19 to 08901-60274 CD8 LO DIVIDER ASSEMBLY.
Change A19C17 to 0160-0576 CD5 CAPACITOR-FXD .1UF +-20% 50VDC CER.

Page 6-34, Table 6-2:
Add A19C64,66,68-70 0160-3878 CD6 CAPACITOR-FXD 1000pf +-20% 100VDC CER.
Add A19C65,67 0160-4835 CD7 CAPACITOR-FXD .1UF +-10% 50VDC CER.
Change A19MP1 to 08901-00166 CD1 COVER LO DIVIDER.
Change A19R16 to 0757-0280 CD3 RESISTOR 1k 1% .125W F TC=0+-100.
Change A19R17 to 0698-3151 CD7 RESISTOR 2.87k 1% .125W F TC=0+-100.

CHANGE 56 cont'd.

Page 6-35, Table 6-2:
Change A19R21 to 0698-7205 CD0 RESISTOR 51.1 1% .05W F TC=0+-100.
Change A19R27,33,34 to 0698-3132 CD4 RESISTOR 261 1% .125W F TC=0+-100.
Change A19R63 to 0757-0398 CD4 RESISTOR 75 1% .125W F TC=0+-100.
Change A19R87 to 0698-7205 CD0 RESISTOR 51.1 1% .05W F TC=0+-100.
Page 6-36, Table 6-2:
Change A19R111,113-116 to 0698-3132 CD4 RESISTOR 261 1% .125W F TC=0+-100.
Change A19R112 to 0698-7205 CD0 RESISTOR 51.1 1% .05W F TC=0+-100.
Change A19U7,8 to 1820-3485 CD2 IC PRESCR ECL MC12090L.
Change A20R57 part number to 0698-3162 RESISTOR 46.4K 1% .125W F TC=0+-100 24546 C4-1/8-T0-4642-F.
Page 8-115, Service Sheet 11 (COMPONENT LOCATIONS):
Replace the A19 LO Divider Assembly Component Locations with the attached A19 LO Divider Assembly Component Locations (P/O CHANGE 56).
Page 8-115, Service Sheet 11 (SCHEMATIC):
Replace the appropriate portions of the A19 LO Divider Assembly with the attached "P/O A19 LO Divider Assembly (P/O CHANGE 56). "
In the upper left corner of the schematic, change the part number of the A19 LO Divider Assembly to 08901-60274.
Under NOTES, in the Table of Transistor and Integrated Circuit Part Numbers, change U7, U8 to 1820-3485.

CHANGE 57 - Serial Prefix 2623A

Page 6-23, Table 6-2:
Change A11 to 08901-60291 CD9 COUNTER ASSEMBLY (OPTION 002 ONLY).
Change A11 to 08901-60292 CD0 COUNTER ASSEMBLY (EXCEPT OPTION 002).
Page 6-24, Table 6-2:
Change A11MP1 to 08901-00180 CD9 COVER, COUNTER ASSEMBLY.
Page 6-25, Table 6-2:
Delete A13C10, C11.
Page 6-26, Table 6-2:
Delete A13L1.
Page 6-59, Table 6-2:
Delete MP23.
Change MP24 to 08901-00174 CD1 GUIDE, PC, DIGITAL.
Page 6-61, Table 6-2:
Change MP50 to 08901-20275 CD5 EXTRUSION (for COUNTER ASSEMBLY).
Under MP50, add 08662-20028 CD6 PLUG HOLE, .500-DIA.(This part holds the mounting screw in place.)
Page 8-125, Service Sheet 16 (SCHEMATIC):
In the upper left corner of the schematic, change the part number of the P/O A11 COUNTER ASSEMBLY (08901-60292)(Option 002: 08901-60291).
Page 8-127, Service Sheet 17 (SCHEMATIC):
In the upper left corner of the schematic, change the part number of the P/O A11 COUNTER ASSEMBLY (08901-60292)(Option 002: 08901-60291).
Page 8-129, Service Sheet 18 (SCHEMATIC):
Near the C. P. U., Delete C10, C11, and L1.

CHANGE 58 - Serial Prefix 2629A

Page 6-15, Table 6-2:
Delete A5C21 through A5C25.

Page 6-17, Table 6-2:
Delete A5U2 and A5U7.
Add A5W1 8159-0005 CD6 RESISTOR ZERO OHMS 22AWG LEAD DIA.

Page 8-111, Component Locations:
Replace the P/O A5 Voltmeter Assembly Component Locations (1 of 2) with the attached "A5 Voltmeter Assembly Component Locations (P/O CHANGE 58)."

Page 8-111, Service Sheet 9 (Schematic):
Replace SS9 P/O A5 Voltmeter with the attached "SS9 P/O A5 Voltmeter Assembly (1 of 2) (P/O CHANGE 58)" schematic foldout.

Page 8-113, Component Locations:
Replace the P/O A5 Voltmeter Assembly Component Locations (2 of 2) with the attached "A5 Voltmeter Assembly Component Locations (P/O CHANGE 58)."

Page 8-113, Service Sheet 10 (Schematic):
Replace SS10 P/O A5 Voltmeter with the attached "SS10 P/O A5 Voltmeter Assembly (2 of 2) (P/O CHANGE 58)" schematic foldout.

\>> **CHANGE 59 - Serial Prefix 2705A**

Page 6-9, Table 6-2:
Change A2R51 to 0757-0401 CD0 RESISTOR 100 1% .125W F TC=0+-100

Page 8-107, Service Sheet 7:
Under 15 KHz LOW-PASS FILTER, change the value of R51 to 100 ohm.

5-11. LO DOUBLER POWER OUTPUT AND BALANCE ADJUSTMENT (P/O ERRATA)

REFERENCE: Service Sheet 11.

DESCRIPTION: The power output of the LO is monitored with a power meter while the LO is stepped through its doubler band. The bias and coupling components are changed as necessary to obtain the required power output. The output of the LO is then monitored with a spectrum analyzer as the VCO is swept slowly over its doubler band. The doubler balance is adjusted for minimum 1/2 and 3/2 harmonics of the doubled frequency.

NOTE

Excessive subharmonics may cause the LO to tune to a wrong frequency when automatically tuning.

EQUIPMENT:

RF Power Meter	HP 435/8482A
RF Spectrum Analyzer	HP 8555A/8552B/141T

PROCEDURE:

1. Connect the power sensor of the power meter directly to A19J3 (LO OUT), or for Option 003, the rear panel LO OUTPUT jack.

2. On the Modulation Analyzer, key in 650 MHz to set the LO to the bottom of its doubler band.

3. Step the LO up in 50,000 kHz increments and record the power obtained at each frequency. The Modulation Analyzer will display error message E20 when the LO reaches the top of its range.

4. The power output of the LO should be between +1.4 dBm and +3.0 dBm at all frequencies prior to the display of error message E20. If the power output is within range, continue with step 6. If the power output is not within range, perform step 5.

NOTE

Resistors R63, R72, and R74 and capacitor C43 are changed to obtain the correct power output from the LO. Use the following guidelines when changing these components:

a. To increase the power throughout the entire doubler band decrease the value of R63.

PROCEDURE (cont'd)

b. To eliminate low frequency roll-off, increase the value of C43. Do not use a value for C43 that is larger than necessary or the effectiveness of the high-pass filter is reduced.

c. To eliminate high frequency roll-off, increase the value of R72 and R74. Note that the value of R72 must equal R74 at all times.

d. The effect of changing these components is interactive, therefore, whenever a component is changed, the entire adjustment must be repeated.

e. Any standard value component between the ranges shown in Table 5-1 can be used during this procedure.

5. Replace components as required and repeat steps 1 through 4 until the power output of the LO is within range over the entire doubler band.

6. Set the spectrum analyzer to view a +10 dBm signal with a 0 to 2 GHz span width and log display. Connect its RF input to A19J3 (LO OUT) or, for Option 003, the rear panel LO OUTPUT jack.

7. On the Modulation Analyzer, key in 41.0 SPCL and the 55.0 SPCL to initialize the instrument and cause the LO to sweep slowly over its doubler range.

8. Adjust A19R41 (DBLR BAL) for minimum level of 1/2 and 3/2 harmonics of the doubled signal over the swept range. The 1/2 and 3/2 harmonics should be more than 30 dB below the doubled signal. The doubled signal sweeps from approximately 600 to 1300 MHz with a level of approximately +2 dBm.

NOTE

To ease adjustment, note the frequency of the fundamental where harmonics are worst, manually tune to that frequency (use the frequency increment keys to assist in fine tuning), make the adjustment, then key in 55.0 SPCL and recheck the entire range. The sweep can be halted at any time by pressing the SPCL key.

8-72. AM Demodulator (A6) Service Sheet 3 (P/O CHANGE 28)

General. AM is demodulated by rectifying the IF signal and by forcing the average of the IF signal to be a constant level by means of an automatic level control (ALC) loop. The rectified IF, after filtering the IF carrier, accurately represents the carrier average plus its AM envelope. In fact, the % AM equals the level of the ac component divided by the level of the dc component times 100%. Since the averge carrier level is forced to be constant, the % AM is proportional to the level of the ac component alone. The demodulation process is illustrated in Figure 8-45.

2.5 MHz Low Pass Filter and AM IF Buffer. The 2.5 MHz Low-Pass Filter determines the IF frequency response when using the 1.5 MHz IF or when the input signal is not down-converted. The filter has six poles and is designed for best flatness up to 2.5 MHz. At 2.5 MHz the flatness can be fine adjusted with C8 (IF FLATNESS) for minimum incidental AM. The filtered IF is routed to the AM IF Buffer and an FM IF Buffer (see Service Sheet 4) where it is further routed to the FM Demodulator, IF Level and IF Present Detectors, and the rear-panel IF OUTPUT.

Voltage Variable Amplifier. The Voltage-Variable Amplifier adjusts its gain in response to the dc output from the AM and Level Detector. The amplifier is, then, the "leveler" of the ALC loop and, as shown in Figure 8-44, it is an ac-coupled, variable-gain, non-inverting operational amplifier.

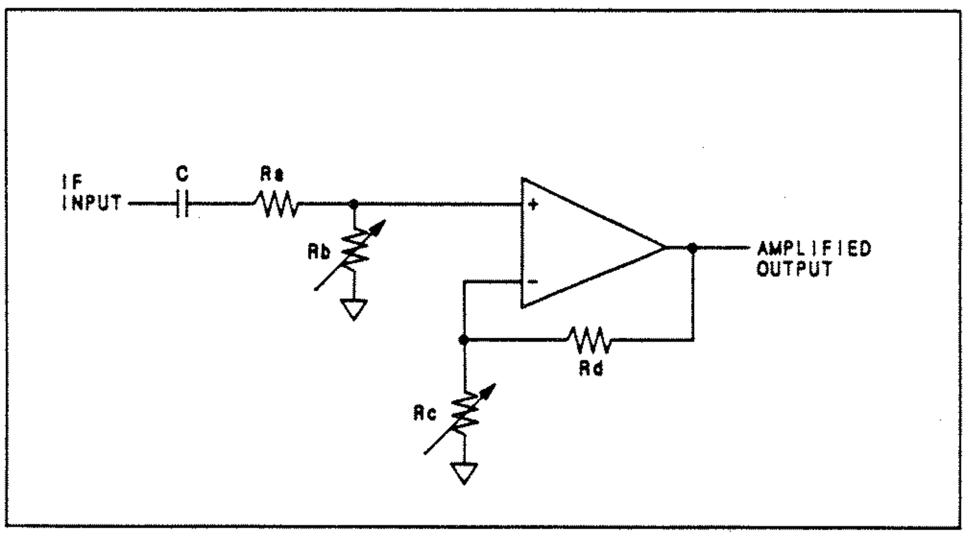


Figure 8-44. Simplified Diagram of the Voltage-Variable Amplifier

8-72. (cont'd)

The gain of the Voltage-Variable Amplifier is

$$\frac{Rb}{Ra+Rb} \times \frac{Rc+Rd}{Rc} .$$

Ra is R10. Rb is the parallel combination of R16 and the resistance of the channel of FET Q7, which predominates. Rc is the parallel combination of R37, R22, R21, and the resistance of Q6, which predominates. Rd is R34.

The R-Setting (that is, Resistance-Setting) Circuit adjusts the input attenuation and feedback division ratio of the Voltage-Variable Amplifier in proportion to the output voltage of U2. The output of U2, in turn, is proportional to the amplitude error of the IF signal.

Figure 8-45. AM Demodulation Process
(as shown in manual)

The variable resistors (FETs Q6 and Q7), which set the gain of the Voltage-Variable Amplifier, are controlled by two matched current sources Q2C and Q2D, and two local feedback amplifiers U4A and U4B. U4A drives n-channel FET Q6 in such a way as to hold the dc voltage at the drain of Q6 at the same potential as the reference voltage at the inverting input of U4A. The reference voltage, determined by the voltage divider R23 and R25, is approximately +50 mV. If the current from the collector of Q2D changes, the voltage at the drain of Q6 changes proportionally. The change is sensed by U4A. U4A drives Q6 which changes the channel resistance and brings the drain voltage back to +50 mV. The operation of Q2C, Q7, and U4B is similar to Q2D, Q6, and U4A except that Q7 is a p-channel FET and U4A is referenced to -50 mV. Another difference is that Q2C must supply the current to R13 as well as to Q7. Thus the FETs work in opposition--the resistance of Q6 decreases when Q7 increases (resulting in an increase in gain of the Voltage-Variable Amplifier).

To clarify the action of the R-Setting Circuit, suppose that a change in IF level (in this case a decrease) causes the output of U2 to decrease. The reduction in voltage at the bases of transistors Q2C and Q2D causes an increase in their collector currents. As the drain voltage of Q6 rises, U4A responds by increasing the gate voltage of Q6 (that is, making it less negative) which reduces the resistance of the FET's channel and brings the drain voltage back to a nominal +50 mV. At the same time, as the drain voltage of Q7 rises (that is, becomes less negative), U4B responds by increasing the gate voltage of Q7 (making it more positive) which increases the resistance of the FET's channel and brings the drain voltage back to a nominal -50 mV.

The reduction in channel resistance of Q6 reduces the negative feedback around the amplifier formed by Q4 and Q5 and increases its gain. The increase in channel resistance of Q7 decreases the attenuation of the voltage divider between the output of Q8 and the base of Q5. Thus the gain of the overall Voltage-Variable Amplifier is increased which is the desired effect since in this example, the IF level was too low.

8-72. (cont'd)

The Voltage-Variable Amplifier is designed to operate over a gain ranging from unity (0 dB) to at least 16 (24 dB). Q4 and Q5 provide the forward gain of the amplifier with well-defined performance at 1.5 MHz. Two RC networks, R14 and C16 and R28 and C23, aid in canceling distortion created in the FET channels by the IF frequency. The networks inject a small amount of IF signal into the gates of the FETs. C17 and C21 set the response time of the local feedback amplifiers U4B and U4A.

Q21 and Q20 form a unity-gain, IF buffer amplifier which drives the AM and Level Detector. Q31 improves the symmetry of the overdrive characteristics of the buffer amplifier. This improvement is needed because the ALC loop initially receives signals when its ALC gain is maximum (the no-signal condition).

AM and Level Detector. The AM and Level Detector rectifies the IF carrier. Q13 to Q16, CR9 and CR10, and associated components form a precision, active, half-wave rectifier. A simplified diagram of the rectifier is shown in Figure 8-46. The circuit is essentially an inverting operational amplifier with two parallel feedback paths. Each path conducts current in a different direction as determined by CR9 and CR10. The path through CR9 can produce only negative voltages at the output to the Level Amplifier and Carrier Filter. This feedback path contains the network R73, R74, C43, and L8 which acts as a constant resistance (equal to R73) between CR9 and the amplifier's inverting (-) input, but low-pass filters the IF going to the AM Output Buffer.

Figure 8-46. Simplified Diagram of AM and Level Detector
(as shown in manual)

The emitter of Q13 is the amplifier's common-base inverting input. The base of Q13 is the ac grounded, non-inverting input of the amplifier. Q13 is followed by a cascade stage (a common-emitter transistor driving a common-base transistor) Q15 and Q14. R58 and C40 frequency compensate the amplifier. Q16 is a +13.8V regulator and RF decoupling circuit. CR6 and CR7 protect the amplifier in the event of unusual conditions at the input.

AM Output Buffer. Q17, Q18, and Q19 form a unity-gain buffer amplifier which interfaces the demodulated AM with the rear-panel AM OUTPUT jack and the audio circuits. R87 and C50 further filter the IF carrier. R88 and C51 form the first two elements of a complex 260 kHz Low-Pass Filter (see Service Sheet 7).

Level Amplifier and Carrier Filter. U3 and associated components form an inverting amplifier and IF carrier and AM ripple filter. Note that the non-inverting (+) input of U3 connects through R75 to the inverting input (namely, the emitter of Q13) of the AM and Level Detector which is its "virtual" ground. Thus the two amplifiers have a common signal-ground reference.

BW Control and Level Comparison Amplifier. The dc output of U3 represents the IF carrier's average level. This output is compared against a stable reference voltage. Differences between the two voltages are amplified by

8-72. (cont'd)

U1 to alter the drive voltage (via U2) to the bases of Q2C and Q2D of the R-Setting Circuit. U1 adds more filtering to the detected IF and determines the response time of the ALC loop to variations in IF level (that is, it determines the ALC bandwidth). U5B permits selection of the 0.1 dB bandwidth of either 20 Hz when open or 200 Hz when closed. When U5B is closed, the time constant of the integrator U1 is the product of R55 and C31. When U5B is open, the time constant is the product of R51+R54+R55 and C31; C36 adds even more filtering.

ALC Reference. The very stable voltage reference for the ALC loop is supplied by the voltage-reference diode VR3. VR3 is biased on by a regulated current source formed by Q1, VR4, and associated components. The reference output is divided by R69, R65, and R66. Fine adjustment of the ALC Reference is via R65 (ALC REF).

Resistor Drive Amplifier. U2 amplifies (with a gain of 1.1) and inverts the output of U1. Switch U5A is normally closed, and U5C is normally open. U2, then normally drives the bases of Q2C and Q2D of the R-Setting Circuit. The output of U2 works against the +15V supply through R26, R31, R32, and Q2A, which is wired as a diode to temperature compensate the base-emitter voltages of Q2C and Q2D.

Q2B produces a voltage at its collector that is proportional to the control currents of Q2C and Q2D. This voltage is monitored by the Voltmeter to check that the ALC loop is operating within its proper range. The automatic leveling can be defeated, if desired, by opening U5A and closing U5C (user Special Function 6.2). The bases of Q2C and Q2D are then biased by voltage divider R26, Q2A, and R27.

</2> Voltage Variable Amplifier Check (P/O CHANGE 28)

1. Set the signal generator to 1.5 MHz CW at -7 dBm. Connect its RF output to A6J2 (IF IN).

2. Connect a high-impedance, ac coupled oscilloscope to the emitter of Q8. The oscilloscope should have a low-capacitance 10:1 divider probe. Adjust the signal generator level for a waveform of 200 mVpp.

3. Key in 0.0D0 SPCL to switch the ALC off.

4. Measure pin 11 of U5C with a dc voltmeter. The voltage should be between -15 and -13 Vdc.

Hint: U5C should be on. U5A should be off. Pin 9 of U5C should be a TTL low.

5. Measure pin 7 (the collector) of Q2B with a dc voltmeter. The voltage should be between +1.66 and +1.69 Vdc.

6. Connect the oscilloscope (with divider probe) to the collector of Q4. The waveform of the 1.5 MHz signal should be sinusoidal with an amplitude between 400 and 600 mVpp.

Hint: If this step fails, check the R-Setting Circuits as follows:

a. Measure the drains of Q6 and Q7 with a dc voltmeter. The voltages should be within the limits shown in the schematic.

Hint: The voltage at pins 2 and 6 of U4 should be within the limits shown in the schematic. The polarity at the output of U4A (pin 1) should conform to the polarity of its differential inputs. (For example, if pin 3 is more positive than pin 2, pin 1 should be positive and may be as high as +15V.) Similarly for U4B.

b. Connect the oscilloscope (with divider probe) to the base of Q5 and observe the ac waveform on the oscilloscope. Momentarily ground pin 8 (the collector) of Q2C and observe the waveform. Then momentarily place a 1k ohm resistor in parallel with R8 and observe the waveform. The amplitude of the waveform should be as follows:

Condition	Waveform Amplitude Limits (mVpp)	
	Minimum	Maximum
Unmodified circuit	20	50
Pin 8 of Q2C grounded	10	30
1 k@ resistor in parallel with R8	150	200

</2> (cont'd)

c. Connect the oscilloscope to the collect ~ of Q4 and observe the ac waveform on the oscilloscope. Momentarily ground pin 14 (the collector) of Q2D and observe the ac waveform on the oscilloscope. Momentarily place a 1k ohm resistor in parallel with R20 and observe the waveform. The amplitude of the waveform should be as follows:

Condition	Waveform Amplitude Limits (mVpp)	
	Minimum	Maximum
Unmodified circuit	200	400
Pin 14 of Q2D grounded	30	70
1 k@ resistor in parallel with R20	2000	3000

Hint: Check the bias of Q4 and Q5.

7. If necessary, fine adjust the signal generator level for a waveform of 500 mVpp.

8. Connect the oscilloscope to the collector of Q20. The waveform should be sinusoidal with an amplitude between 450 and 550 mVpp.

5-10. SAMPLER EFFICIENCY AND OFFSET ADJUSTMENT (P/O ERRATA)

REFERENCE: Service Sheet 18.

DESCRIPTION:

Using the track-tune mode, the two signals into the sampler are configured so that the low-frequency VCXO is at a set frequency and the high-frequency VCO tracks the RF input signal. The output of the sampler is observed on an oscilloscope. The RF input is tuned to locate a zero-beat frequency at the sampler output then tuned for a 1 MHz beat. The sampler offset and efficiency (or frequency response) are then adjusted so that the dc offset is zero and the amplitude of the 1 MHz waveform is the same for the zero beat.

NOTE

Improper adjustment of efficiency may result in the loop easily breaking or not attaining phase lock.

EQUIPMENT:

Oscilloscope..................HP 1740A Signal
Source..................HP 8640B or HP 3325A

```
                         +-------------+            SIGNAL SOURCE
                         |             | A23TP1     +-------------------+
OSCILLOSCOPE             |             V (SAMP AMPL)|                   |
+----------------+       |   +---------------------+|                   |
| +-----+        |       |   |                     ||                 o |
| |     |        |       |   +---------------------+ +----------------+-+
| |     |        |       |   |                   o |           OUTPUT |
| +-----+        |       |   |                   o | INPUT            |
|  o    o        |       |   | o o               o-+------------------+
+--+-------------+       |   +---------------------+
   | VERTICAL            |            8901A
   | INPUT               |     MODULATION ANALYZER
   +---------------------+
```

Figure 5-2. Sampler Efficiency and Offset Adjustment Test Setup

PROCEDURE:

1. Set the signal source to 18 MHz CW at 0 dBm.

2. Connect the equipment as shown in Figure 5-2. (The oscilloscope input should be ac coupled. The signal source can be connected either to a sensor module or directly the the Modulation Analyzer's INPUT.)

3. Set the oscilloscope's vertical sensitivity to 0.2 V/division and horizontal scale for 10 us/division.

4. On the Modulation Analyzer, press the blue key then press INSTR PRESET (the AUTOMATIC OPERATION key) to preset the instrument. Press TRACK MODE. If the instrument fails to tune to the 18 MHz signal, key in 18 MHz then press TRACK MODE.

5. Fine tune the signal source up slowly until a zero beat signal appears on the oscilloscope. Then increase the signal source frequency for a period of 30 us. Note the frequency of the signal source. Note the peak-to-peak amplitude on the oscilloscope.

Signal Source Frequency: __________ MHz
Waveform Amplitude: __________ mVpp

6. Tune the signal source up by 30.0 kHz. This tunes the high-frequency VCO up 32 x 30 kHz ~ 1 MHz since the LO frequency is the HF VCO frequency divided by 32 on this band.

```
                A23--+
                      \
+======================\=========+
| |                     \        |
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| |        +---+    | | | \ | | ||
| |        |   |    | | | |\| | ||
| |        +---+    | +-+ | \ +-+|
| |                 | | | | |\| ||
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|                   | | | | | | ||
|+------+------+    | | | | +-+ ||
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|+-------------+  ==-----------==|
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|+-------------+  +-------------+|
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|+-------------+                 |
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+================================+
     U   U                     U
```

7. Adjust A23R34 (OFS) for a waveform that does not shift on the oscilloscope display as the input coupling to the oscilloscope is changed from ac to dc. Make adjustments only when the input coupling is set to dc.

8. Adjust A23R54 (EFF) for the same peak-to-peak amplitude on the oscilloscope as noted in step 5. If the adjustment has not enough range:

a. Set A23R54 fully ccw and repeat steps 5 to 7.

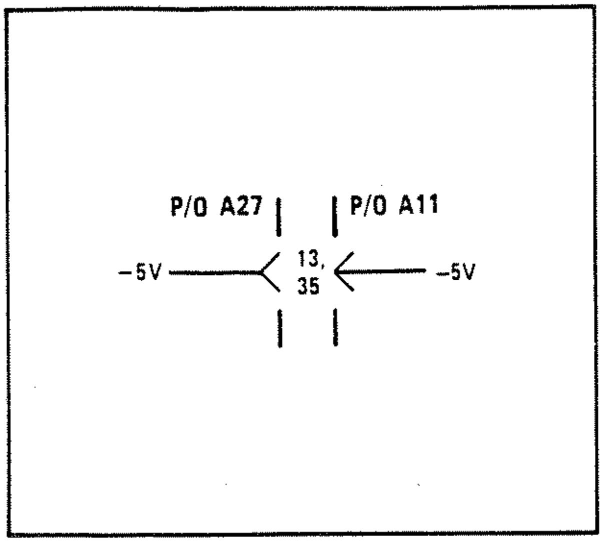
b. The signal amplitude should now be less than in step 5. If it is not, replace A23R55 by higher values of resistance as listed in Table 5-2a. If this still does not have enough effect, replace A23C45 with 2.7 pF (HP Part Number 0160-4619).

c. Adjust A23R54 for the same amplitude as noted in step 5.

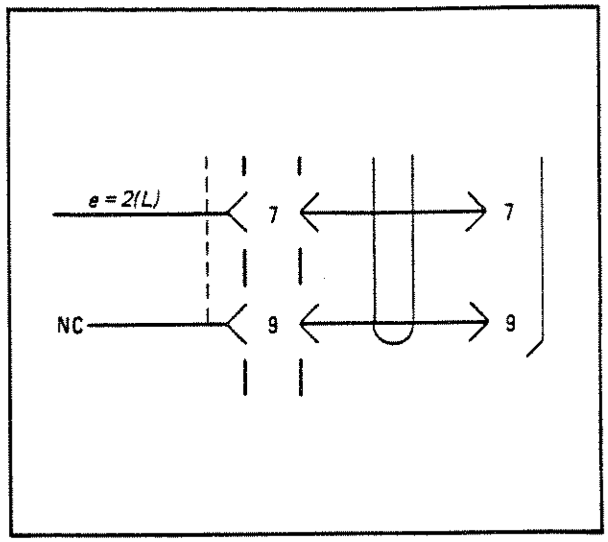
9. Repeat step 7.

Table 5-2a. Part Numbers for A23R55

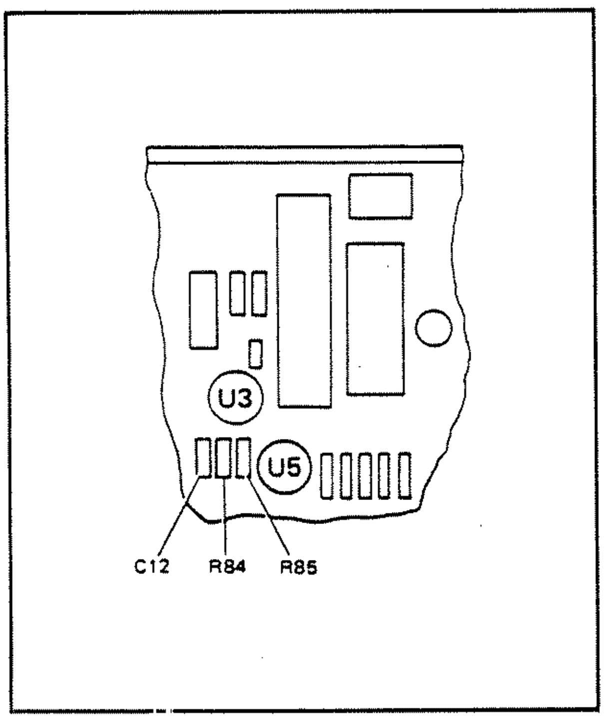
Resistance (ohms)	HP Part Number
511	0757-0416
750	0757-0420
1000	0757-0280
1210	0757-0274
1470	0757-1094
1780	0757-0278



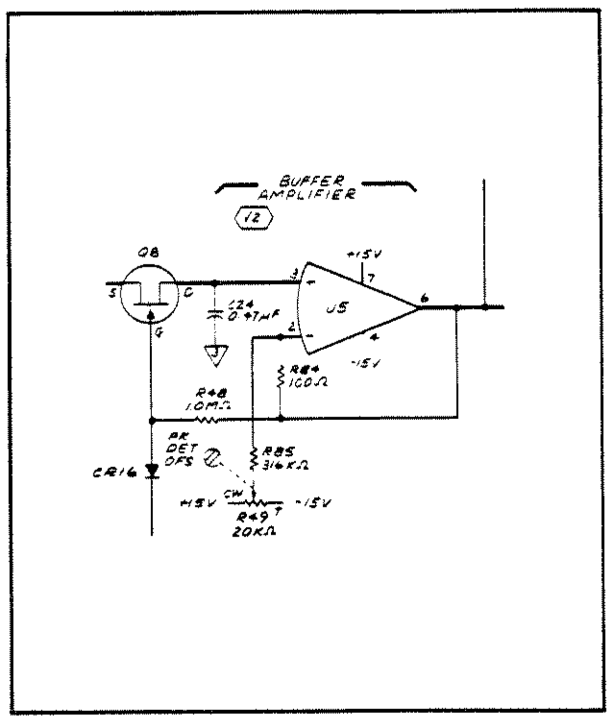
ERRATA, P/O Figure 8-101.
Counter - Time Base Circuits Schematic Diagram.



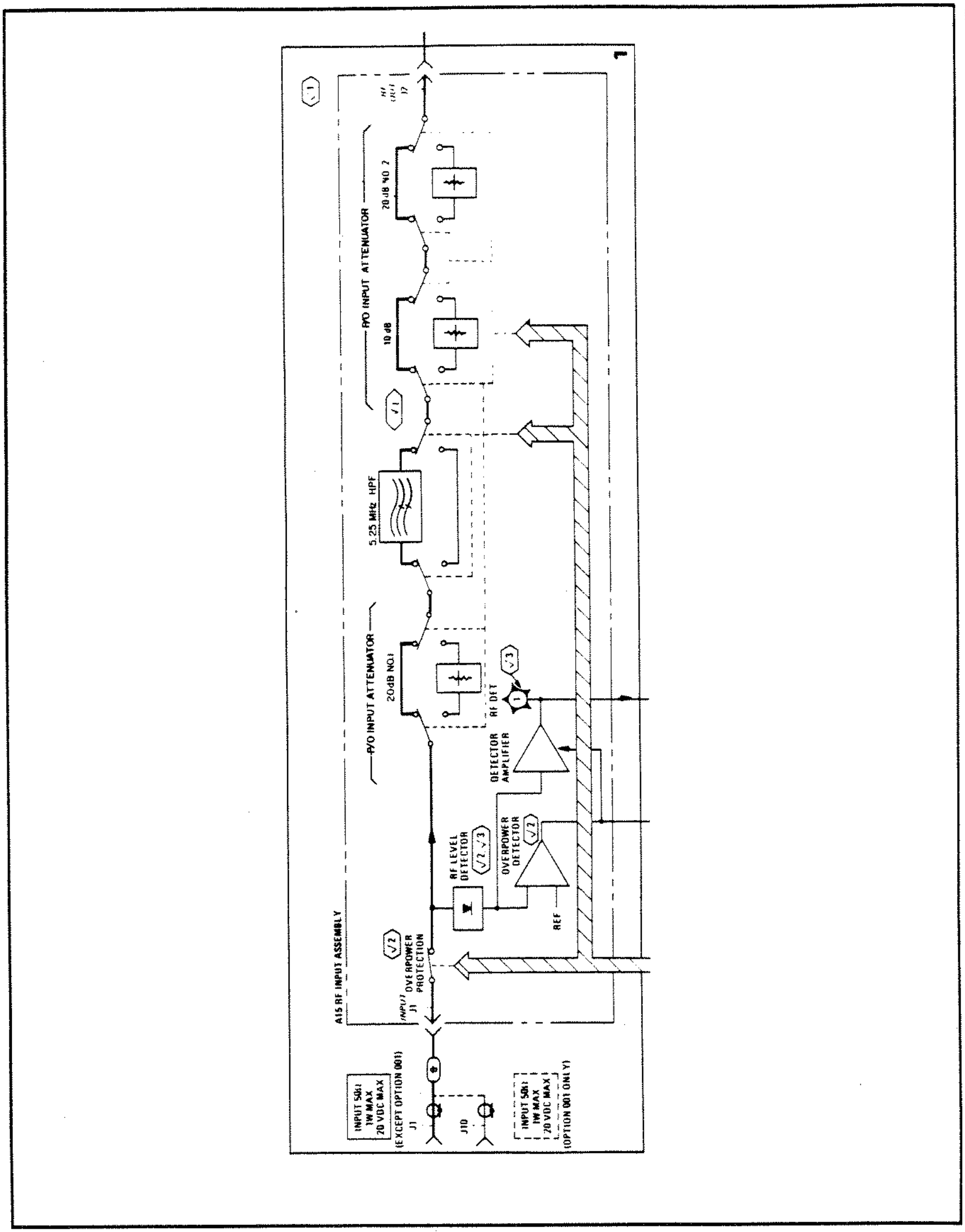
CHANGE 3, P/O Figure 8-129.
Audio Motherboard Schematic Diagram.



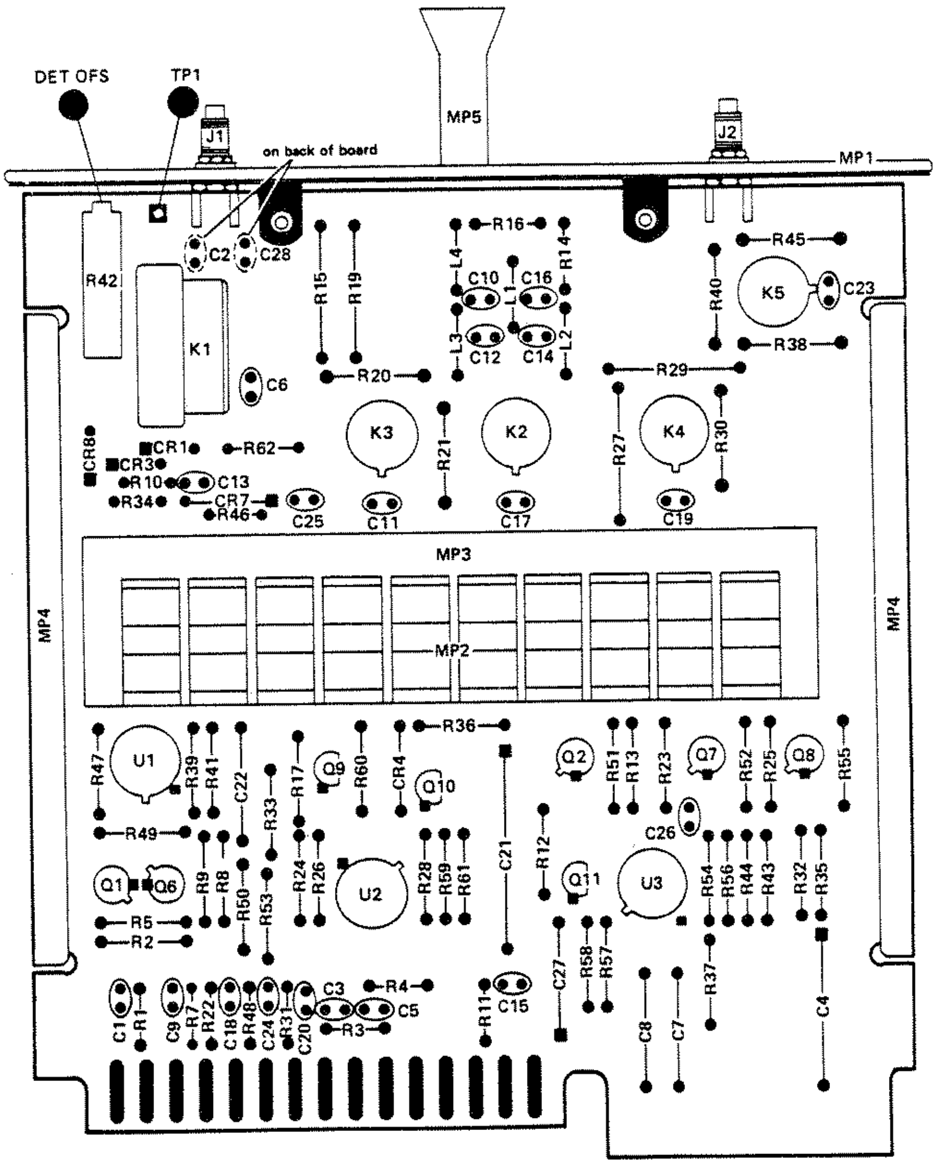
CHANGE 7, P/O Figure 8-84.
A5 Voltmeter Assembly, Component Locations (Audio Detectors).



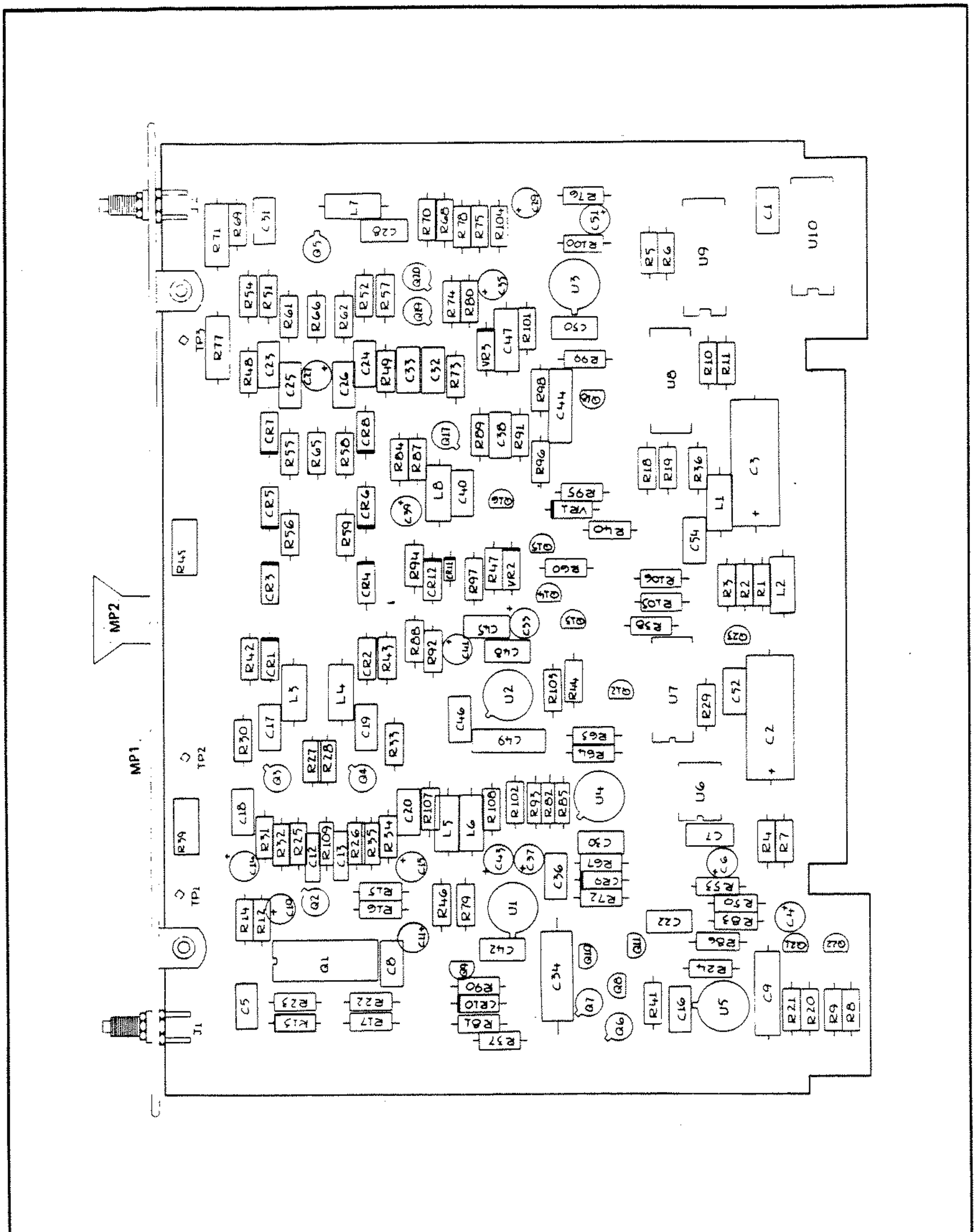
CHANGE 7, P/O Figure 8-85.
Voltmeter - Audio Detectors Schematic Diagram.



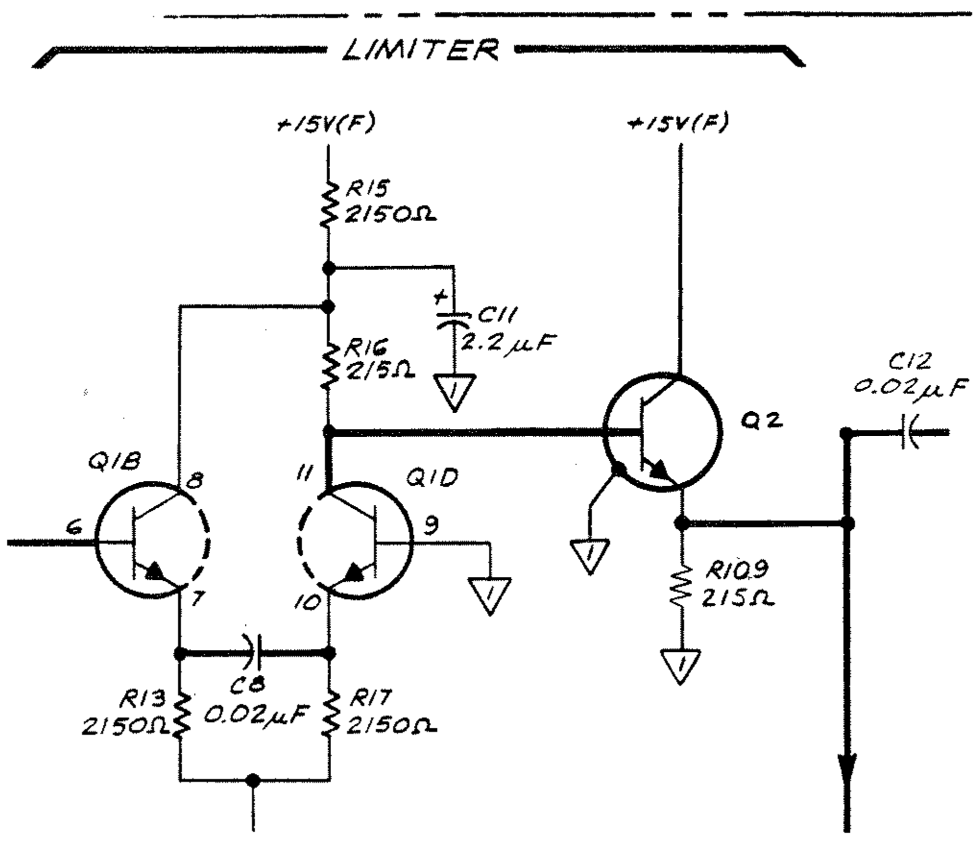
CHANGE 18, P/O Figure 8-61. RF and Power Supply Sections Block Diagram



CHANGE 18, P/O Figure 8-67. A15 Input Assembly, Component Locations



CHANGE 20. Figure 8-136. A50 AM Calibrator Assembly Component Locations (Option 010)



CHANGE 20. P/O Service Sheet 29. A50 AM Calibrator Assembly, Schematic Diagram (Option 010)

Table 6-2. Replaceable Parts (P/O Change 28)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A6	08901-60240	8	1	AM DEMODULATOR BOARD ASSEMBLY	28480	08901-60240
A6C1	0180-0058	0	2	CAPACITOR-FXD 50UF+75-10% 25VDC AL	56289	30D506G025CC2
A6C2	0180-0058	0		CAPACITOR-FXD 50UF+75-10% 25VDC AL	56289	30D506G025CC2
A6C3	0160-4636	6	1	CAPACITOR-FXD 255PF +-1% 100VDC MICA	28480	0160-4636
A6C4	0160-2660	2	1	CAPACITOR-FXD 20PF +-2% 500VDC CER 0+-30	28480	0160-2660
A6C5	0160-4635	5	1	CAPACITOR-FXD 212PF +-1% 100VDC MICA	28480	0160-4635
A6C6	0160-4775	8	1	CAPACITOR-FXD 4.7PF +-.5PF 100VDC CER	28480	0160-4775
A6C7	0160-4807	3	3	CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A6C8	0121-0105	4	1	CAPACITOR-V TRMR-CER 9-35PF 200V PC MTG	52763	304324 9/35PF N650
A6C9	0160-4833	5	5	CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A6C11	0180-0197	8	6	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C14	0160-4832	4	3	CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A6C15	0160-4835	7	5	CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A6C16	0160-4812	0	3	CAPACITOR-FXD 220PF +-5% 100VDC CER	28480	0160-4812
A6C17	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A6C18	0160-4822	2	4	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A6C19	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A6C20	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A6C21	0160-4833	5		CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A6C22	0160-4833	5		CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A6C23	0160-4812	0		CAPACITOR-FXD 220PF +-5% 100VDC CER	28480	0160-4812
A6C24	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C25	0180-1746	5	8	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C26	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A6C29	0160-4807	3		CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A6C30	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A6C31	0160-3501	2	1	CAPACITOR-FXD 4UF +-10% 50VDC MET-POLYC	28480	0160-3501
A6C32	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C34	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C36	0180-0228	6	1	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A6C37	0160-5528	7	1	C MPC .22U 100V	28480	0160-5528
A6C38	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C39	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C40	0160-3539	6	1	CAPACITOR-FXD 820PF +-5% 100VDC MICA	28480	0160-3539
A6C41	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C42	0160-4807	3		CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A6C43	0160-4334	1	1	CAPACITOR-FXD 290PF +-1% 300VDC MICA	28480	0160-4334
A6C44	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C45	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C46	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A6C47	0180-2929	8	1	CAPACITOR-FXD 60UF+-10% 10VDC TA	28480	0180-2929
A6C50	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A6C51	0160-0340	1	1	CAPACITOR-FXD 600PF +-1% 300VDC MICA	28480	0160-0340
A6C52	0180-2613	7	1	CAPACITOR-FXD 390UF+-10% 6VDC TA	56289	150D397X9006R2-DJB
A6C53	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C54	0160-4833	5		CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A6C55	0160-4535	4	1	CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535
A6C56	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A6C57	0160-4833	5		CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A6C58	0160-4825	5	2	CAPACITOR-FXD 560PF +-5% 100VDC CER	28480	0160-4825
A6C59	0160-4825	5		CAPACITOR-FXD 560PF +-5% 100VDC CER	28480	0160-4825
A6C60	0160-4810	8	1	CAPACITOR-FXD 330PF +-5% 100VDC CER	28480	0160-4810
A6C61	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A6C62	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C63	0160-4812	0		CAPACITOR-FXD 220PF +-5% 100VDC CER	28480	0160-4812
A6C64	0160-4801	7	1	CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A6C65	0180-0376	5	1	CAPACITOR-FXD .47UF+-10% 35VDC TA	56289	150D474X9035A2
A6C66	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A6C67	0160-0166	9	1	CAPACITOR-FXD .068UF +-10% 200VDC POLYE	28480	0160-0166
A6C68	0160-4789	0	1	CAPACITOR-FXD 15PF +-5% 100VDC CER 0+-30	28480	0160-4789
A6C69	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C70	0160-4509	2	1	CAPACITOR-FXD .033UF +-5% 50VDC	28480	0160-4509
A6CR5	1901-0050	3	6	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR6	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR7	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR9	1901-0539	3	3	DIODE-SM SIG SCHOTTKY	28480	1901-0539
A6CR10	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539
A6CR13	1901-0518	8	4	DIODE-SM SIG SCHOTTKY	28480	1901-0518
A6CR14	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A6CR15	08901-80024	8	2	DET DIODES-MATCH	28480	08901-80024
A6CR16	08901-80024	8		DET DIODES-MATCH	28480	08901-80024

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts (P/O Change 28)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A6CR17	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A6CR18	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR19	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A6CR20	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A6CR21	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539
A6J1	1250-1220	0	4	CONNECTOR-RF SMC M PC 50-OHM	28480	1250-1220
	2190-0124	4	4	WSHR LK .195 ID 10	28480	2190-0124
	2950-0078	9	4	NU-HEX 10-32	28480	2950-0078
A6J2	1250-1220	0		CONNECTOR-RF SMC M PC 50-OHM	28480	1250-1220
	2190-0124	4		WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0124
	2950-0078	9		NUT-HEX-DBL-CHAM 10-32-THD .067-IN-THK	28480	2950-0078
A6J3	1250-1220	0		CONNECTOR-RF SMC M PC 50 OHM	28480	1250-1220
	2190-0124	4		WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0124
	2950-0078	9		NUT-HEX-DBL-CHAM 10-32-THD .067-IN-THK	28480	2950-0078
A6J4	1250-1220	0		CONNECTOR-RF SMC M PC 50-OHM	28480	1250-1220
	2190-0124	4		WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0124
	2950-0078	9		NUT-HEX-DBL-CHAM 10-32-THD .067-IN-THK	28480	2950-0078
A6L1	9140-0210	1	2	INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A6L2	9140-0210	1		INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A6L3	9140-0271	4	1	INDUCTOR RF-CH-MLD 13.3UH 2%	28480	9140-0271
A6L4	9140-0272	5	1	INDUCTOR RF-CH-MLD 32UH 2% .166DX.385LG	28480	9140-0272
A6L5	9140-0273	6	1	INDUCTOR RF-CH-MLD 47.6UH 2%	28480	9140-0273
A6L7	9100-1652	3	1	INDUCTOR RF-CH-MLD 820UH 5% .20X.45LG	28480	9100-1652
A6L8	9140-0274	7	1	INDUCTOR RF-CH-MLD 80UH 2% .166DX.385LG	28480	9140-0274
A6L9	9100-1666	9	1	INDUCTOR RF-CH-MLD 3.6MH 5% .23DX.57LG	28480	9100-1666
A6L10	9140-0131	5	1	INDUCTOR RF-CH-MLD 10MH 5% .25DX.75LG	28480	9140-0131
A6MP1	08901-00018	2	1	COVER AM DE MOD	28480	08901-00018
	2360-0113	2	2	SM 632 .250 PNPD	00000	ORDER BY DESCRIPTION
A6Q1	1853-0007	7	5	TRANSISTOR PNP2N3251 SI TO-18 PD=360MW	04713	2N3251
A6Q2	1858-0010	2	1	TRANSISTOR ARRAY 14-PIN PLSTC DIP	04713	MPQ2906
A6Q4	1853-0007	7		TRANSISTOR PNP 2N3251 SI TO-18 PD=360MW	04713	2N3251
A6Q5	1854-0404	0	7	TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A6Q6	1855-0420	2	1	TRANSISTOR J-FET 2N4391 N-CHAN D-MODE	01295	2N4391
A6Q7	1855-0421	3	1	TRANSISTOR J-FET 2N5114 P-CHAN D-MODE	17856	2N5114
A6Q8	1854-0404	0		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A6Q9	1854-0404	0		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A6Q10	1853-0281	9	3	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A6Q11	1853-0007	7		TRANSISTOR PNP 2N3251 SI TO-18 PD=360MW	04713	2N3251
A6Q12	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
A6Q13	1853-0007	7		TRANSISTOR PNP 2N3251 SI TO-18 PD=360MW	04713	2N3251
A6Q14	1854-0637	1	1	TRANSISTOR NPN 2N2219A SI TO-5 PD=800MW	01295	2N2219A
A6Q15	1854-0404	0		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A6Q16	1854-0404	0		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A6Q17	1855-0082	2	1	TRANSISTOR J-FET P-CHAN D-MODE SI	28480	1855-0082
A6Q18	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A6Q19	1854-0477	7	2	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A6Q20	1853-0007	7		TRANSISTOR PNP 2N3251 SI TO-18 PD=360MW	04713	2N3251
A6Q21	1854-0404	0		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A6Q29	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A6Q30	1854-0404	0		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A6Q31	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A6R1	0757-1108	6	1	RESISTOR 300 1% .125W F TC=0+-100	24546	C4-1/8-T0-301-F
A6R2	0698-3157	3	3	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A6R3	0698-3446	3	1	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
A6R4	0698-3447	4	2	RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A6R5	0757-0401	0	8	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R6	0757-0280	3	4	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R7	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R8	0757-0441	8	2	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A6R9	0757-0442	9	9	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R10	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R13	0698-3160	8	1	RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A6R14	0757-0458	7	4	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A6R15	0757-0458	7		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A6R16	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R17	0757-0438	3	8	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R18	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R19	0698-3445	2	2	RESISTOR 348 1% .125W F TC=0+-100	24546	C4-1/8-T0-348R-F
A6R20	0757-0441	8		RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A6R21	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R22	0698-3150	6	2	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A6R23	0757-0465	6	4	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A6R24	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A6R25	0698-3445	2		RESISTOR 348 1% .125W F TC=0+-100	24546	C4-1/8-T0-348R-F
A6R26	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R27	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts (P/O Change 28)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A6R28	0757-0458	7		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A6R29	0757-0458	7		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A6R30	0698-3444	1	2	RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
A6R31	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A6R32	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A6R33	0757-0416	7	4	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R34	0698-3154	0	1	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A6R35	0757-0338	2	3	RESISTOR 1K 1% .25W F TC=0+-100	24546	C5-1/4-T0-1001-F
A6R36	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R37	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R38	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R39	0757-0443	0	2	RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
A6R41	0698-3444	1		RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
A6R42	0757-0338	2		RESISTOR 1K 1% .25W F TC=0+-100	24546	C5-1/4-T0-1001-F
A6R44	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R46	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R49	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R50	0698-3152	8	4	RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A6R51	0698-4488	5	1	RESISTOR 26.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2672-F
A6R52	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R54	0698-4472	7	1	RESISTOR 7.68K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7681-F
A6R55	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A6R56	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R57	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R58	0698-3432	7	2	RESISTOR 26.1 1% .125W F TC=0+-100	03888	PME55-1/8-T0-26R1-F
A6R60	0699-0148	8	2	RESISTOR 31.6K .1% .1W F TC=0+-15	28480	0699-0148
A6R61	0757-0200	7	1	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A6R62	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R63	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A6R64	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R65	2100-3207	1	1	RESISTOR-TRMR 5K 10% C SIDE-ADJ 1-TRN	28480	2100-3207
A6R66	0698-8955	9	1	RESISTOR 13.5K .1% .1W F TC=0+-10	28480	0698-8955
A6R67	0698-0082	7	3	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A6R68	0757-0419	0	1	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R69	0699-0149	9	1	RESISTOR 28.7K .1% .1W F TC=0+-15	28480	0699-0149
A6R70	0698-3447	4		RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A6R71	0757-0346	2	1	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A6R72	0699-0096	5	2	RESISTOR 12K .1% .1W F TC=0+-10	28480	0699-0096
A6R73	0698-4454	5	3	RESISTOR 523 1% .125W F TC=0+-100	24546	C4-1/8-T0-523R-F
A6R74	0698-4454	5		RESISTOR 523 1% .125W F TC=0+-100	24546	C4-1/8-T0-523R-F
A6R75	0699-0096	5		RESISTOR 12K .1% .1W F TC=0+-10	28480	0699-0096
A6R76	0698-4454	5		RESISTOR 523 1% .125W F TC=0+-100	24546	C4-1/8-T0-523R-F
A6R77	0757-0444	1	1	RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A6R78	0757-0443	0		RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
A6R79	0699-0148	8		RESISTOR 31.6K .1% .1W F TC=0+-15	28480	0699-0148
A6R80	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A6R81	0698-4626	3	1	RESISTOR 1.47K 1% .25W F TC=0+-100	24546	C5-1/4-T0-1471-F
A6R82	0698-3440	7	4	RESISTOR 196 1% .125W F TC=0+-100	24546	C4-1/8-T0-196R-F
A6R87	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R88	0699-0143	3	1	RESISTOR 825 .1% .1W F TC=0+-15	28480	0699-0143
A6R89	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R90	0757-0447	4	1	RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A6R91	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R92	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A6R93	0698-3440	7		RESISTOR 196 1% .125W F TC=0+-100	24546	C4-1/8-T0-196R-F
A6R94	0757-0338	2		RESISTOR 1K 1% .25W F TC=0+-100	24546	C5-1/4-T0-1001-F
A6R95	0757-0394	0	1	RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
A6R96	0698-8979	7	1	RESISTOR 11.6K 1% .125W F TC=0+-100	28480	0698-8979
A6R97	0698-3153	9	1	RESISTOR 3.83K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3831-F
A6R98	0757-0440	7	1	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A6R99	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R100	0698-3132	4	1	RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F
A6R101	0757-1094	9	1	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A6R102	0698-3432	7		RESISTOR 26.1 1% .125W F TC=0+-100	03888	PME55-1/8-T0-26R1-F
A6R103	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A6R104	0698-3454	3	2	RESISTOR 215K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2153-F
A6R105	0757-0199	3	3	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A6R107	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A6R108	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A6R109	0698-8825	2	1	RESISTOR 681K 1% .125W F TC=0+-100	28480	0698-8825
A6R110	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R112	0698-8827	4	1	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A6R113	0683-2265	1	2	RESISTOR 22M 5% .25W FC TC=-900/+1200	01121	CB2265
A6R114	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R115	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-2. Replaceable Parts (P/O Change 28)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A6R117	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R118	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A6R119	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A6R120	0757-0317	7	1	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
A6R121	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A6R122	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R124	0698-3440	7		RESISTOR 196 1% .125W F TC=0+-100	24546	C4-1/8-T0-196R-F
A6R125	0683-2265	1		RESISTOR 22M 5% .25W FC TC=-900/+1200	01121	CB2265
A6R126	0698-3440	7		RESISTOR 196 1% .125W F TC=0+-100	24546	C4-1/8-T0-196R-F
A6R128	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A6R129	0698-3454	3		RESISTOR 215K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2153-F
A6TP1	1251-0600	0	2	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A6TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A6U1	1826-0035	4	2	IC OP AMP LOW-DRIFT TO-99 PKG	27014	LM308AH
A6U2	1826-0043	4	1	IC OP AMP GP TO-99 PKG	3L585	CA307T
A6U3	1826-0035	4		IC OP AMP LOW-DRIFT TO-99 PKG	27014	LM308AH
A6U4	1826-0716	8	1	IC OP AMP LOW-NOISE DUAL 8-DIP-C PKG	18324	NE5532AFE
A6U5	1826-0606	5	1	IC SWITCH ANLG QUAD 16-DIP-C PKG	17856	DG201BK
A6U6	1826-0102	6	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	27014	LM312H
A6U7	1826-0026	3	1	IC COMPARATOR PRCN TO-99 PKG	01295	LM311L
A6U8	1820-1411	0	1	IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A6U9	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A6U10	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A6VR2	1902-0072	1	1	DIODE-ZNR 7.87V 2% DO-35 PD=.4W	28480	1902-0072
A6VR3	1902-0680	7	1	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827
A6VR4	1902-3059	8	1	DIODE-ZNR 3.83V 5% DO-35 PD=.4W	28480	1902-3059
	7120-8043	8	1	LABEL-IC	28480	7120-8043

See introduction to this section for ordering information
*Indicates factory selected value

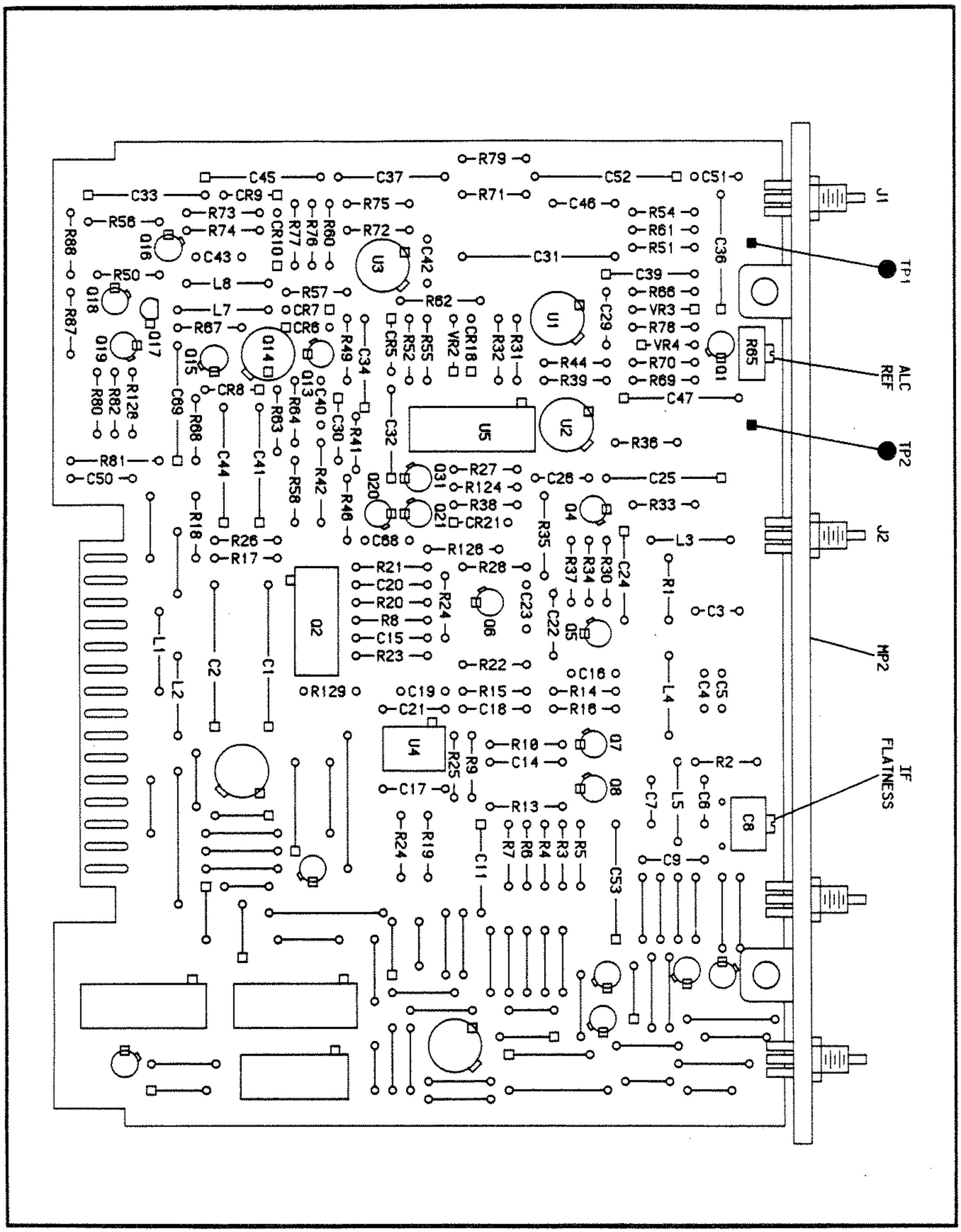


Figure 8-72. P/O A6 AM Demodulator Assembly Component Locations (ALC Loop)(P/O Change 28)

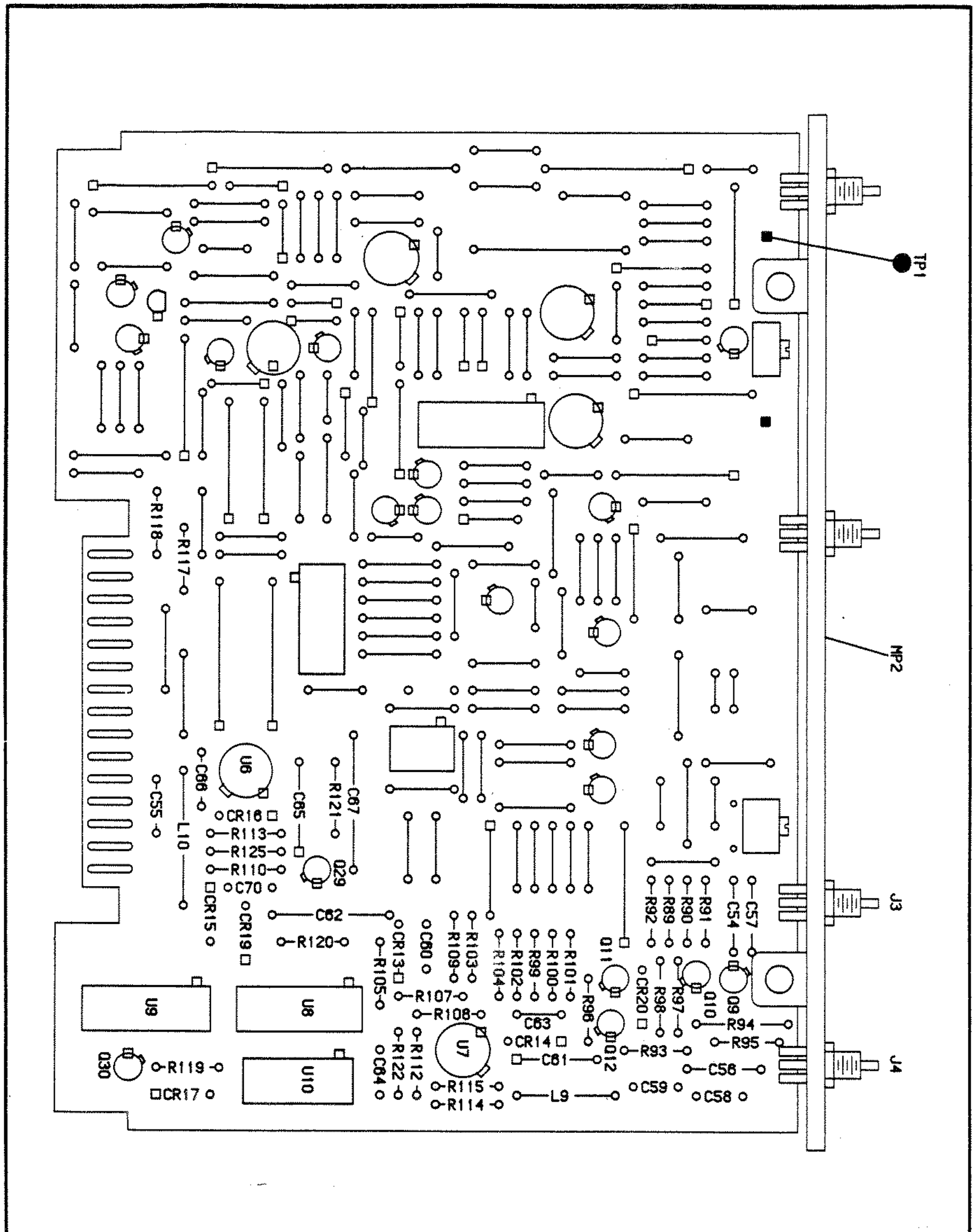
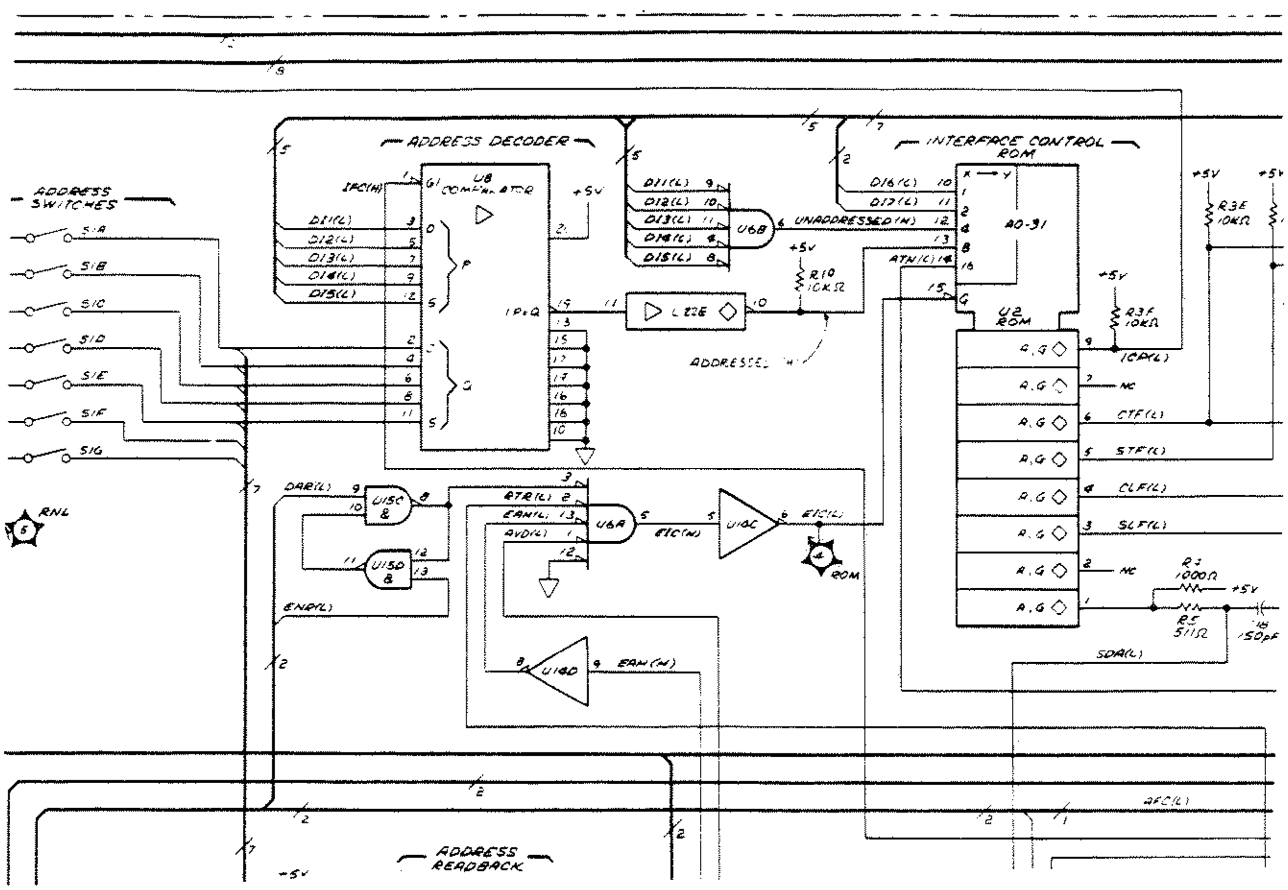
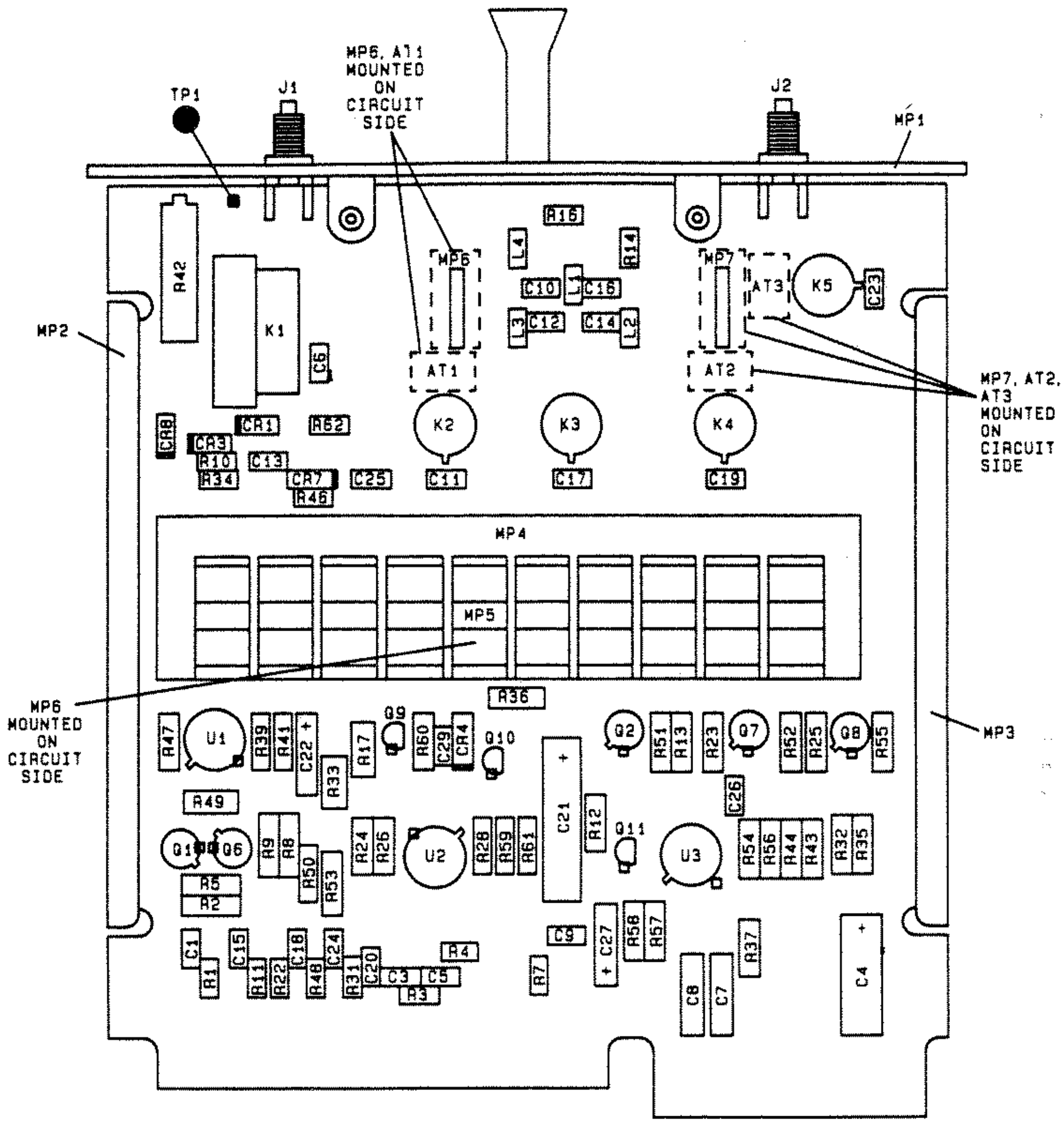


Figure 8-74. P/O A6 AM Demodulator Assembly Component Locations (Control) (P/O Change 28)



CHANGE 38. P/O Figure 8-120; A14 Remote Interface Assembly



CHANGE 38. A15 RF Input Assembly Component Locations

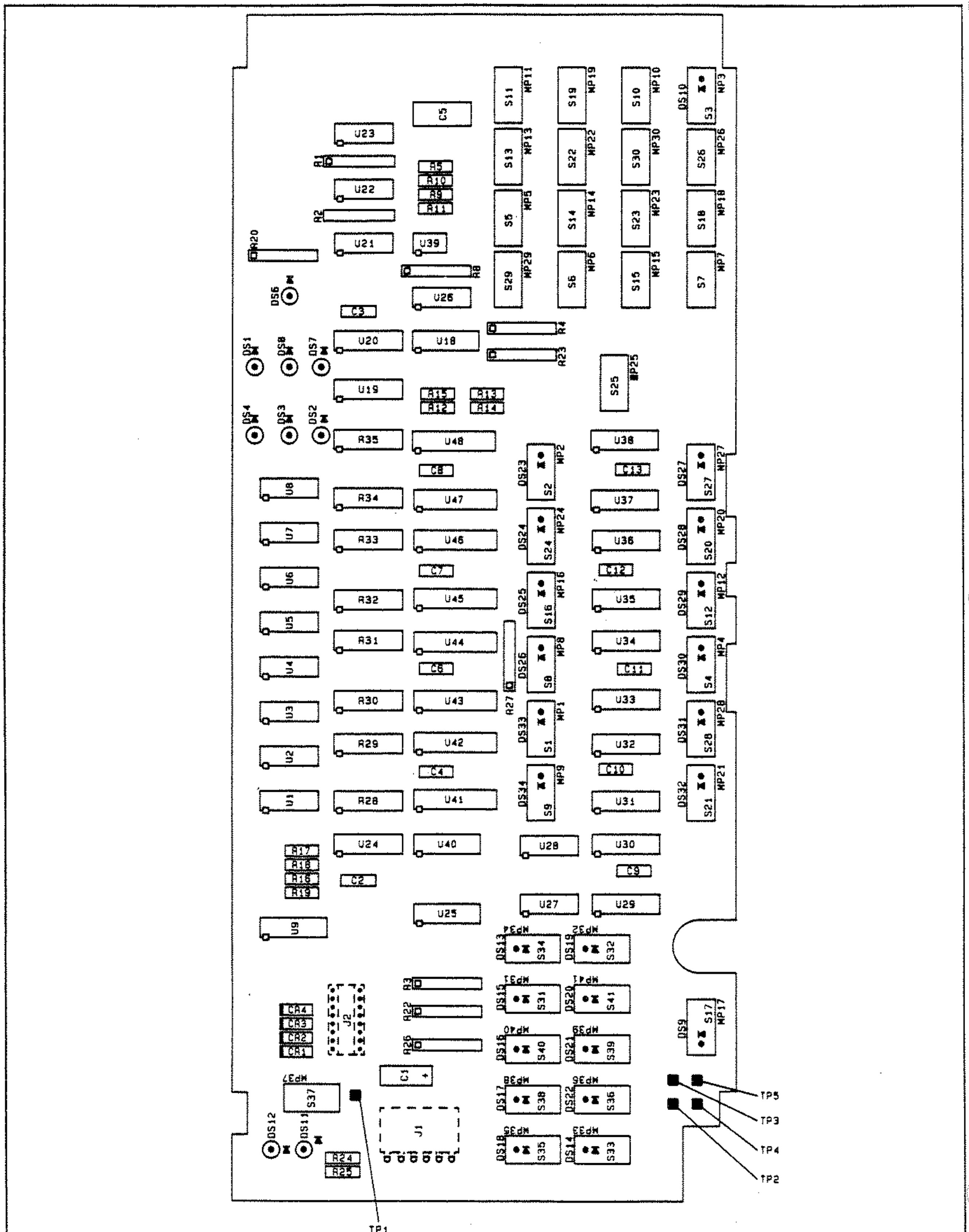


Figure 8-109. P/O A1 Keyboard and Display Assembly Component Locations (Keyboard Circuits) (P/O CHANGE 43)

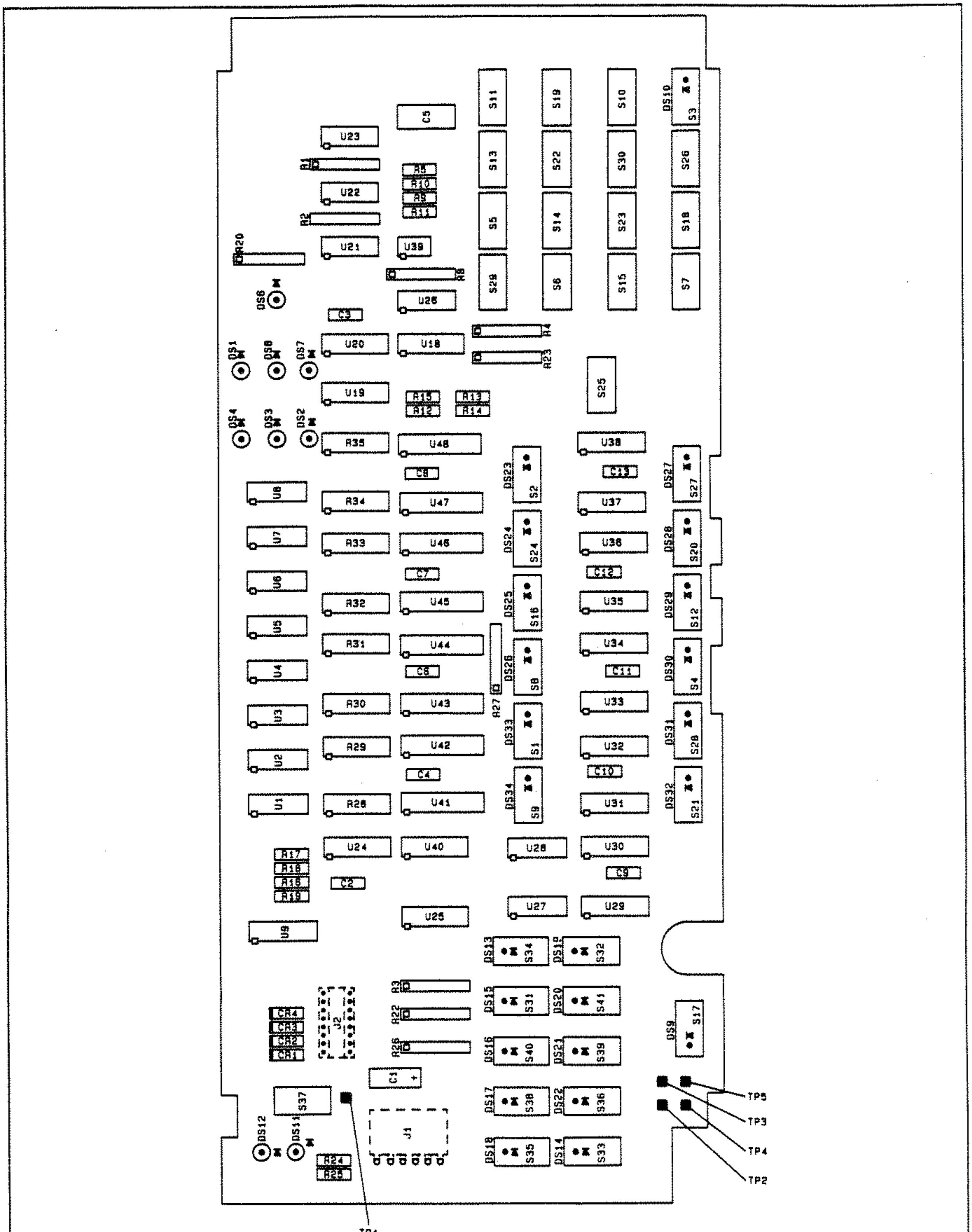
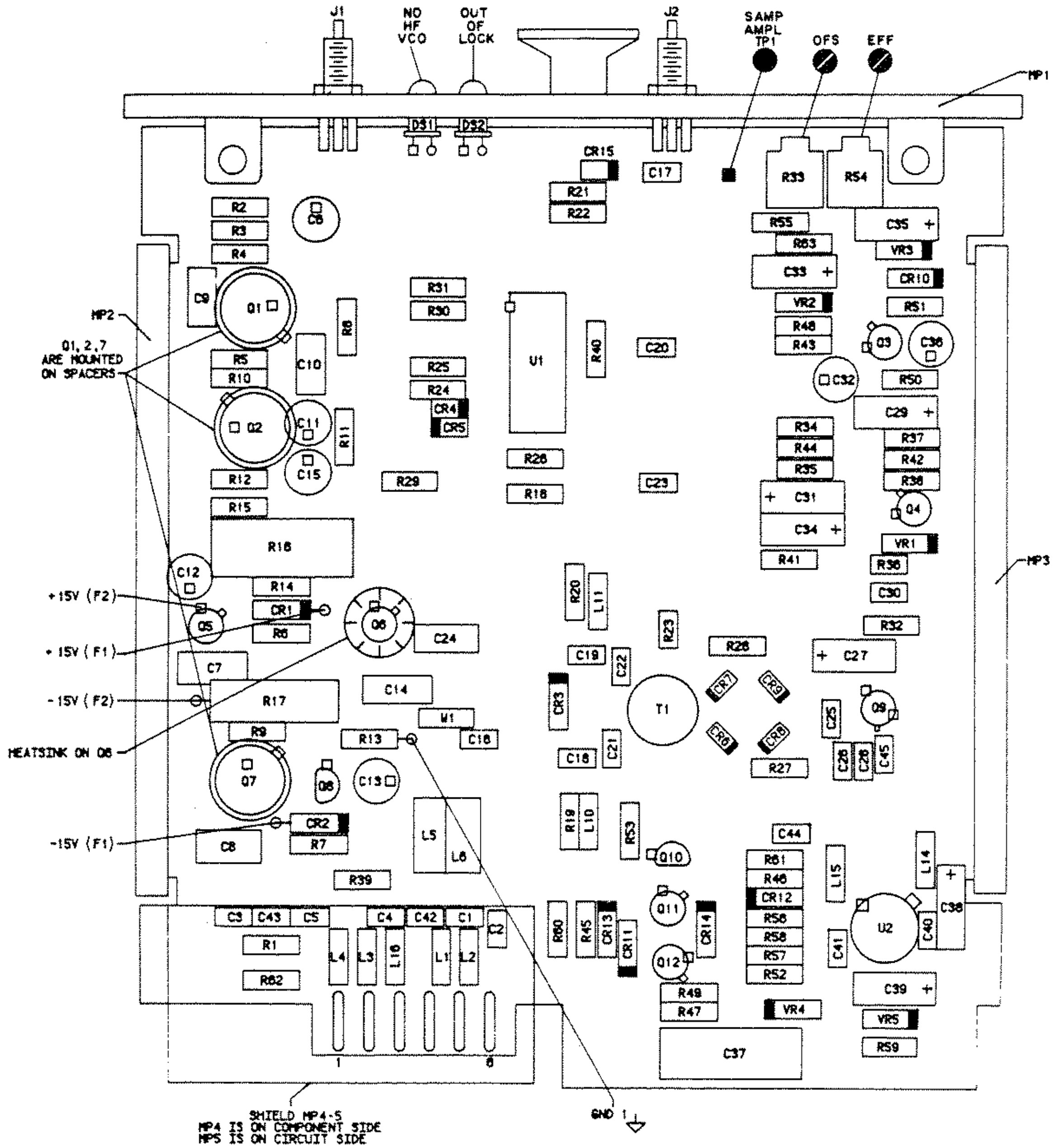


Figure 8-111. P/O A1 Keyboard and Display Assembly Component Locations (Decoder and Display Circuits) (P/O CHANGE 43)



A23 Sampler Assembly Component Locations (P/O CHANGE 50)

P/O Table 6-2. Replaceable Parts (P/O CHANGE 53)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A17						
A17	08902-60104	4	1	INPUT MIXER ASSEMBLY	28480	08902-60104
A17C1	0160-3879	7	8	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A17C2	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A17C3	0160-3873	1	1	CAPACITOR-FXD 4.7PF +-.5PF 200VDC CER	28480	0160-3873
A17C4	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A17C5	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A17C6	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A17C7	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A17C8	0180-0197	8	2	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A17C9	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A17C10	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A17C11	0160-4535	4	5	CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535
A17C12	0160-4835	7	5	CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A17C13	0160-4812	0	1	CAPACITOR-FXD 220PF +-5% 100VDC CER	28480	0160-4812
A17C14	0160-4652	6	1	CAPACITOR-FXD 960PF +-1% 500VDC MICA	00853	RDM19F961F5C
A17C15	0160-4647	9	1	CAPACITOR-FXD 154PF +-1% 500VDC MICA	28480	0160-4647
A17C16	0180-2929	8	1	CAPACITOR-FXD 68UF+-10% 10VDC TA	28480	0180-2929
A17C17	0160-4646	8	1	CAPACITOR-FXD 444PF +-1% 500VDC MICA	28480	0160-4646
A17C18	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A17C19	0160-4814	2	1	CAPACITOR-FXD 150PF +-5% 100VDC CER	28480	0160-4814
A17C20	0160-4641	3	1	CAPACITOR-FXD 3520PF +-1% 50VDC	28480	0160-4641
A17C21	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A17C22	0160-4651	5	1	CAPACITOR-FXD 817PF +-1% 500VDC MICA	00853	RDM19F(817)F5C
A17C23	0160-0576	5	2	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A17C24	0160-4535	4		CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535
A17C25	0160-4801	7	1	CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A17C26	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A17C27	08901-00064	8	1	STRAP/CAPACITOR	28480	08901-00064
A17C28	0160-4512	7	2	CAPACITOR-FXD 120PF +-5% 200VDC CER	28480	0160-4512
A17C29	0160-4535	4		CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535
A17C30	0160-4535	4		CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535
A17C31	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A17C32	0160-4822	2	1	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A17C33	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A17C34	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A17C35	0160-4512	7		CAPACITOR-FXD 120PF +-5% 200VDC CER	28480	0160-4512
A17C36	0160-4535	4		CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535
A17CR1	1901-0050	3	7	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A17CR2	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A17CR3	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A17CR4	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A17CR5	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A17CR6	1901-0518	8	2	DIODE-SM SIG SCHOTTKY	28480	1901-0518
A17CR7	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A17CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A17CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A17DS1	1990-0524	3	1	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4550
A17E1	9170-0847	3	1	CORE-SHIELDING BEAD	02114	56-590-65/3B PARYLENE
A17J1	1250-1425	7	2	CONNECTOR-RF SMC M SGL-HOLE-RR 50-OHM	28480	1250-1425
A17J2	1250-1220	0	2	CONNECTOR-RF SMC M PC 50-OHM	28480	1250-1220
	2190-0124	4	2	WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0124
	2950-0078	9	2	NUT-HEX-DBL-CHAM 10-32-THD .067-IN-THK	28480	2950-0078
A17J3	1250-1220	0		CONNECTOR-RF SMC M PC 50-OHM	28480	1250-1220
	2190-0124	4		WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0124
	2950-0078	9		NUT-HEX-DBL-CHAM 10-32-THD .067-IN-THK	28480	2950-0078
A17J4	1250-1425	7		CONNECTOR-RF SMC M SGL-HOLE-RR 50-OHM	28480	1250-1425
A17L1	9100-3922	4	4	INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A17L2	9100-3922	4		INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A17L3	9100-3922	4		INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A17L4	9100-3922	4		INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A17L5	9100-4434	5	1	INDUCTOR 240UH 2% .165DX.385LF Q=65	28480	9100-4434

See introduction to this section for ordering information.

* Indicates factory selected value

P/O Table 6-2. Replaceable Parts (P/O CHANGE 53)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A17L6	9100-3313	7	1	INDUCTOR RF-CH-MLD 22UH 5% .166DX.385LG	28480	9100-3313
A17L7	9100-1625	0	1	INDUCTOR RF-CH-MLD 33UH 5% .166DX.385LG	28480	9100-1625
A17L8	9140-0840	3	1	COIL-VAR 18UH-56.3UH Q=20 PC-MTG	28480	9140-0840
A17L10	9100-1626	1	1	INDUCTOR RF-CH-MLD 36UH 5% .166DX.385LG	28480	9100-1626
A17L11	9140-0841	4	1	COIL-VAR 6.1UH-19.1UH Q=20 PC-MTG	28480	9140-0841
A17L12	9140-0303	3	2	INDUCTOR RF-CH-MLD 89.3UH 2%	28480	9140-0303
A17L14	9140-0454	5	1	INDUCTOR RF-CH-MLD 18UH 5% .166DX.385LG	28480	9140-0454
A17MP1	08902-00026	3	1	COVER-MIXER	28480	08902-00026
	2360-0113	2	1	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
A17MP2	5001-0176	0	2	GROUND STRAP	28480	5001-0176
A17MP3	0363-0159	0	1	RFI STRIP-FINGERS BE-CU ZINC PLATED	28480	0363-0159
A17Q1	1853-0281	9	4	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A17Q2	1853-0314	9	2	TRANSISTOR PNP 2N2905A SI TO-39 PD=600MW	04713	2N2905A
A17Q3	1854-0404	0	1	TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A17Q4	1854-0632	6	1	TRANSISTOR NPN SI PD=180MW FT=4GHZ	25403	BFR-91
A17Q5	1853-0020	4	2	TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A17Q6	1854-0720	3	1	TRANSISTOR NPN SI PD=500MW FT=4GHZ	28480	1854-0720
A17Q7	1853-0020	4		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A17Q8	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A17Q9	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A17Q10	1853-0314	9		TRANSISTOR PNP 2N2905A SI TO-39 PD=600MW	04713	2N2905A
A17Q11	1854-0610	0	1	TRANSISTOR NPN SI TO-46 FT=800MHZ	28480	1854-0610
A17Q12	1858-0008	8	1	TRANSISTOR ARRAY 14-PIN PLSTC DIP	04713	MHQ6001
A17Q13	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A17R1	0757-0442	9	1	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A17R2	0757-0200	7	1	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A17R3	0698-3154	0	5	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A17R4	0698-8821	8	3	RESISTOR 5.62 1% .125W F TC=0+-100	28480	0698-8821
A17R5	0698-8821	8		RESISTOR 5.62 1% .125W F TC=0+-100	28480	0698-8821
A17R6	0698-0087	2	1	RESISTOR 316 1% .25W F TC=0+-100	24546	C5-1/4-T0-3160-F
A17R7	0698-0085	0	2	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A17R8	0699-0135	3	2	RESISTOR 71.2 1% .25W F TC=0+-100	28480	0699-0135
A17R9	0699-0135	3		RESISTOR 71.2 1% .25W F TC=0+-100	28480	0699-0135
A17R10	0698-7204	9	3	RESISTOR 46.4 1% .05W F TC=0+-100	24546	C3-1/8-T0-46R4-F
A17R11	0698-7220	9	1	RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A17R12	0698-7204	9		RESISTOR 46.4 1% .05W F TC=0+-100	24546	C3-1/8-T0-46R4-F
A17R13	0757-0421	4	1	RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A17R14	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A17R15	0757-0422	5	2	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A17R16	0699-0392	4	1	RESISTOR 34.8 1% .125W F TC=0+-100	28480	0699-0392
A17R17	0757-0439	4	1	RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A17R18	0757-0441	8	1	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A17R19	0698-7204	9		RESISTOR 46.4 1% .05W F TC=0+-100	24546	C3-1/8-T0-46R4-F
A17R20	0757-0799	9	1	RESISTOR 121 1% .5W F TC=0+-100	28480	0757-0799
A17R21	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A17R22	0698-7205	0	3	RESISTOR 51.1 1% .05W F TC=0+-100	24546	C3-1/8-T0-51R1-F
A17R23	0698-7205	0		RESISTOR 51.1 1% .05W F TC=0+-100	24546	C3-1/8-T0-51R1-F
A17R24	0698-7216	3	1	RESISTOR 147 1% .05W F TC=0+-100	24546	C3-1/8-T0-147R-F
A17R25	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A17R26	0757-0274	5	1	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A17R27	0698-7205	0		RESISTOR 51.1 1% .05W F TC=0+-100	24546	C3-1/8-T0-51R1-F
A17R28	0757-0278	9	1	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A17R29	0757-0294	9	2	RESISTOR 17.8 1% .125W F TC=0+-100	19701	MF4C1/8-T0-17R8-F
A17R30	0698-3441	8	1	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F

See introduction to this section for ordering information.

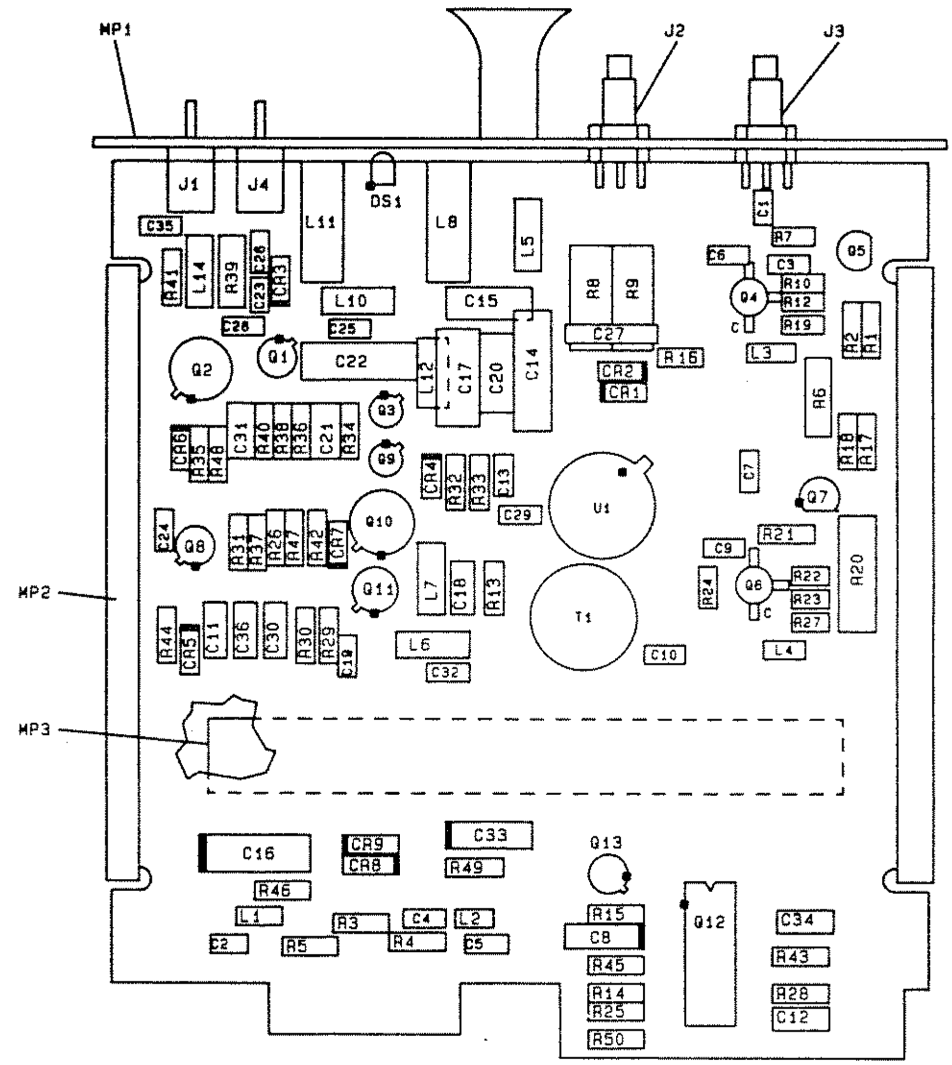
* Indicates factory selected value

P/O Table 6-2. Replaceable Parts (P/O CHANGE 53)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A17R31	0698-3431	6	1	RESISTOR 23.7 1% .125W F TC=0+-100	03888	PME55-1/8-T0-23R7-F
A17R32	0757-0418	9	3	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A17R33	0698-3443	0	3	RESISTOR 287 1% .125W F TC=0+-100	24546	C4-1/8-T0-287R-F
A17R34	0698-3443	0		RESISTOR 287 1% .125W F TC=0+-100	24546	C4-1/8-T0-287R-F
A17R35	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A17R36	0757-0294	9		RESISTOR 17.8 1% .125W F TC=0+-100	19701	MF4C1/8-T0-17R8-F
A17R37	0757-0394	0	2	RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
A17R38	0757-0180	2	1	RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0180
A17R39	0757-0394	0		RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
A17R40	0757-0418	9		RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A17R41	0698-3443	0		RESISTOR 287 1% .125W F TC=0+-100	24546	C4-1/8-T0-287R-F
A17R42	0757-0401	0	2	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A17R43	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A17R44	0757-0418	9		RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A17R45	0698-4037	0	2	RESISTOR 46.4 1% .125W F TC=0+-100	24546	C4-1/8-T0-46R4-F
A17R46	0698-8821	8		RESISTOR 5.62 1% .125W F TC=0+-100	28480	0698-8821
A17R47	0698-4037	0		RESISTOR 46.4 1% .125W F TC=0+-100	24546	C4-1/8-T0-46R4-F
A17R48	0698-3438	3	1	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
A17R49	0757-0422	5		RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A17R50	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A17T1	08901-80031	7	1	XFMR TORD14.0TRN	28480	08901-80031
A17U1	08901-67001	3	1	MIXER CIRCUIT	28480	08901-67001
	0340-0850	0	1	INSULATOR-XSTR TFE	28480	0340-0850
	1251-1556	7	12	CONNECTOR-SGL CONT SKT .018-IN-BSC-SZ	28480	1251-1556

See introduction to this section for ordering information.

* Indicates factory selected value



A17 Input Mixer Assembly Component Locations (P/O CHANGE 53)

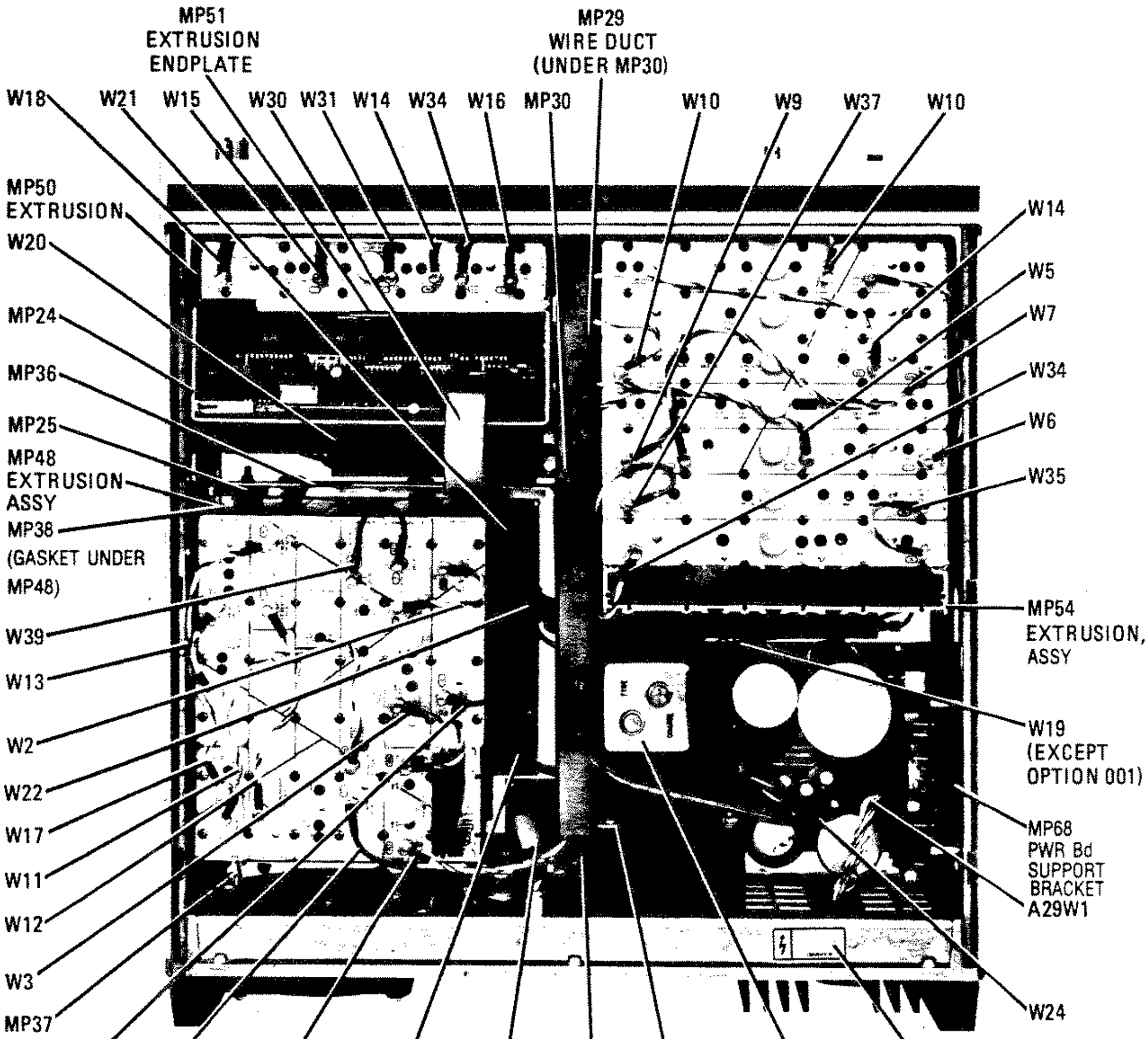


Figure 6-1. Top Chassis Parts, Mechanical Parts, and Cable Identification (P/O CHANGE 54).

P/O Table 6-2. Replaceable Parts (P/O CHANGE 55)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A20	**08901-60285 – SERIAL PREFIX 2617A AND ABOVE**					
A20	08901-60285	1	1	LO CONTROL ASSEMBLY	28480	08901-60285
A20C1	0160-4835	7	3	CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A20C2	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A20C3	0180-1746	5	2	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A20C4	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A20C5	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A20C6	0180-0269	5	1	CAPACITOR-FXD 1UF+50-10% 150VDC AL	56289	30D105G150BA2
A20C7	0160-4801	7	2	CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A20C8	0160-4832	4	8	CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A20C9	0160-4801	7		CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A20C10	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A20C11	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A20C12	0160-4807	3	1	CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A20C13	0180-0197	8	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A20C14	0160-4814	2	1	CAPACITOR-FXD 150PF +-5% 100VDC CER	28480	0160-4814
A20C15	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A20C16	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A20C17	0160-0161	4	1	CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A20C18	0160-3324	7	1	CAPACITOR-FXD 1UF +-5% 100VDC MET-POLYC	28480	0160-3324
A20C19	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A20C20	0180-1997	8	1	CAPACITOR-FXD 20UF+50-10% 150VDC AL	28480	0180-1997
A20C21	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A20C22	0160-4822	2	2	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A20C23	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A20C24	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A20CR1	1901-1085	6	2	DIODE-SM SIG SCHOTTKY	28480	1901-1085
A20CR2	1901-1085	6		DIODE-SM SIG SCHOTTKY	28480	1901-1085
A20CR3				NOT ASSIGNED		
A20CR4				NOT ASSIGNED		
A20CR5	1901-0050	3	13	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR6	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR7	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR10	1901-0518	8	6	DIODE-SM SIG SCHOTTKY	28480	1901-0518
A20CR11	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A20CR12	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR13	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR14	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR15	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR16	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR17	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A20CR18	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A20CR19	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A20CR20	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR21				NOT ASSIGNED		
A20CR22	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20CR23				NOT ASSIGNED		
A20CR24	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A20CR25	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A20DS1				NOT ASSIGNED		
A20DS2				NOT ASSIGNED		
A20DS3	1990-0717	6	2	LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	HLMP-1501
A20DS4	1990-0717	6		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	HLMP-1501
A20L1	9100-3922	4	3	INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A20L2	9100-3922	4		INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A20L3	9100-3922	4		INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922

See introduction to this section for ordering information. * Indicates factory selected value

P/O Table 6-2. Replaceable Parts (P/O CHANGE 55)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A20	**08901-60285 – SERIAL PREFIX 2617A AND ABOVE**					
A20MP1	08901-00104	7	1	CVR LO CONT BD	28480	08901-00104
	2360-0113	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
A20Q1	1854-0477	7	5	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A20Q2	1853-0034	0	3	TRANSISTOR PNP SI TO-18 PD=360MW	28480	1853-0034
A20Q3	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A20Q4	1853-0034	0		TRANSISTOR PNP SI TO-18 PD=360MW	28480	1853-0034
A20Q5	1854-0378	7	1	TRANSISTOR NPN 2N5109 SI TO-39 PD=800MW	3L585	2N5109
A20Q6	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A20Q7	1853-0034	0		TRANSISTOR PNP SI TO-18 PD=360MW	28480	1853-0034
A20Q8				NOT ASSIGNED		
A20Q9				NOT ASSIGNED		
A20Q10				NOT ASSIGNED		
A20Q11				NOT ASSIGNED		
A20Q12	1854-0813	5	3	TRANSISTOR NPN 2N3501S SI TO-39 PD=1W	28480	1854-0813
A20Q13	1853-0462	8	2	TRANSISTOR PNP 2N3635 SI TO-39 PD=1W	28480	1853-0462
A20Q14				NOT ASSIGNED		
A20Q15				NOT ASSIGNED		
A20Q16	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A20Q17				NOT ASSIGNED		
A20Q18				NOT ASSIGEND		
A20Q19	1853-0594	7		TRANSISTOR-DUAL PNP 2N3808 TO-78	28480	1853-0594
A20Q20	1854-0474	4	3	TRANSISTOR NPN SI PD=310MW FT=100MHZ	04713	2N5551
A20Q21	1854-0474	4		TRANSISTOR NPN SI PD=310MW FT=100MHZ	04713	2N5551
A20Q22	1854-0813	5	3	TRANSISTOR NPN 2N3501S SI TO-39 PD=1W	28480	1854-0813
A20Q23	1853-0462	8	2	TRANSISTOR PNP 2N3635 SI TO-39 PD=1W	28480	1853-0462
A20Q24	1853-0594	7		TRANSISTOR-DUAL PNP 2N3808 TO-78	28480	1853-0594
A20Q25				NOT ASSIGNED		
A20Q26	1854-0813	5	3	TRANSISTOR NPN 2N3501S SI TO-39 PD=1W	28480	1854-0813
A20Q27	1854-0474	4		TRANSISTOR NPN SI PD=310MW FT=100MHZ	04713	2N5551
A20Q28	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A20R1	2100-3161	6	1	RESISTOR-TRMR 20K 10% C SIDE-ADJ 17-TRN	02111	43P203
A20R2	0757-0463	4	1	RESISTOR 82.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8252-F
A20R3	0698-7284	5	2	RESISTOR 100K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1003-F
A20R4	0698-7284	5		RESISTOR 100K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1003-F
A20R5	0698-7260	7	4	RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A20R6	0699-0381	1	1	RESISTOR 40K .1% .1W F TC=0+-15	28480	0699-0381
A20R7	0699-0122	8	2	RESISTOR 4.8K .1% .125W F TC=0+-25	28480	0699-0122
A20R8	0699-0122	8		RESISTOR 4.8K .1% .125W F TC=0+-25	28480	0699-0122
A20R9	0698-6360	6	1	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A20R10	0698-8049	2	1	RESISTOR 64K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-6402-B
A20R11	0757-0289	2	3	RESISTOR 13.3K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-1332-F
A20R12	0698-3152	8	2	RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A20R13	0698-3154	0	4	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A20R14	0698-8212	1	1	RESISTOR 6K .25% .125W F TC=0+-25	19701	MF4C1/4-T9-6001-C
A20R15	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A20R16	1810-0204	6	1	NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102
A20R17	0698-7244	7	4	RESISTOR 2.15K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2151-F
A20R18	0698-7244	7		RESISTOR 2.15K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2151-F
A20R19	0698-7279	8	1	RESISTOR 61.9K 1% .05W F TC=0+-100	24546	C3-1/8-T0-6192-F
A20R20	0698-3449	6	1	RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F
A20R21	0757-0289	2		RESISTOR 13.3K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-1332-F
A20R22	0757-0290	5	1	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A20R23	0698-0085	0	2	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A20R24	0698-3260	9	1	RESISTOR 464K 1% .125W F TC=0+-100	28480	0698-3260
A20R25	0698-3266	5	1	RESISTOR 237K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2373-F
A20R26	0698-7286	7	2	RESISTOR 121K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1213-F
A20R27				NOT ASSIGNED		
A20R28				NOT ASSIGNED		
A20R29	0698-3438	3	1	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
A20R30	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F

See introduction to this section for ordering information. * Indicates factory selected value

P/O Table 6-2. Replaceable Parts (P/O CHANGE 55)

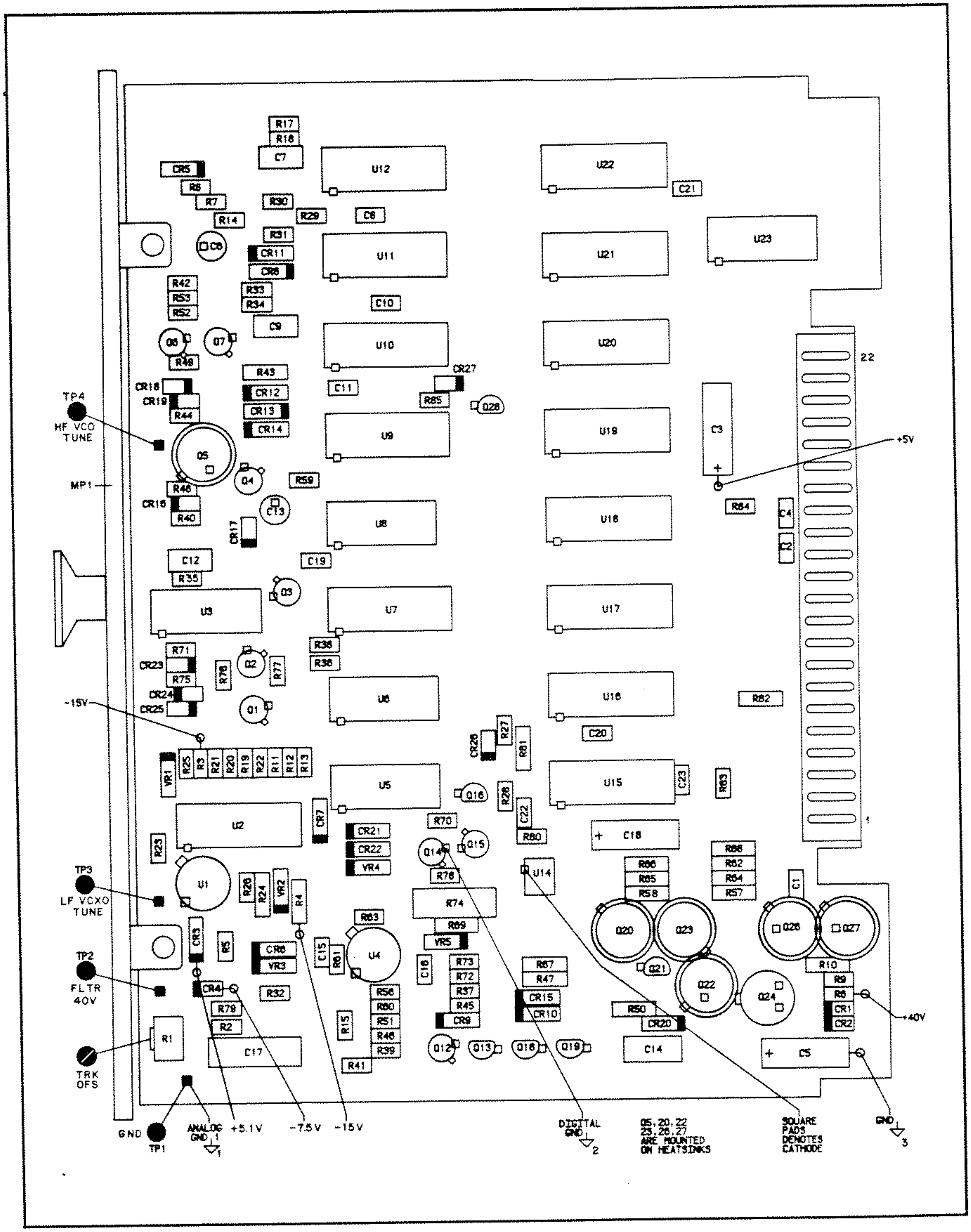
Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A20	**08901-60285 - SERIAL PREFIX 2617A AND ABOVE**					
A20R31	0698-7259	4	2	RESISTOR 9.09K 1% .05W F TC=0+-100	24546	C3-1/8-T0-9091-F
A20R32	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A20R33	0698-7244	7		RESISTOR 2.15K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2151-F
A20R34	0698-7244	7		RESISTOR 2.15K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2151-F
A20R35	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A20R36	0757-0289	2		RESISTOR 13.3K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-1332-F
A20R37	1810-0206	8	1	NETWORK-RES 8-SIP10.0K OHM X 7	01121	208A103
A20R38				NOT ASSIGNED		
A20R39				NOT ASSIGNED		
A20R40	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A20R41				NOT ASSIGNED		
A20R42	0757-0123	3	4	RESISTOR 34.8K 1% .125W F TC=0+-100	28480	0757-0123
A20R43	0698-7248	1	2	RESISTOR 3.16K 1% .05W F TC=0+-100	24546	C3-1/8-T0-3161-F
A20R44	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A20R45	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A20R46	0698-7276	5	1	RESISTOR 46.4K 1% .05W F TC=0+-100	24546	C3-1/8-T0-4642-F
A20R47	0698-3159	5		RESISTOR 26.1K 1% .125W F TC=0+-100	28480	0698-3159
A20R48	0757-0123	3		RESISTOR 34.8K 1% .125W F TC=0+-100	28480	0757-0123
A20R49				NOT ASSIGNED		
A20R50				NOT ASSIGNED		
A20R51	0698-7261	8	1	RESISTOR 11K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1102-F
A20R52	0698-7258	3	1	RESISTOR 8.25K 1% .05W F TC=0+-100	24546	C3-1/8-T0-8251-F
A20R53				NOT ASSIGNED		
A20R54				NOT ASSIGNED		
A20R55				NOT ASSIGNED		
A20R56	0698-7236	7	7	RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A20R57	0757-0123	3		RESISTOR 34.8K 1% .125W F TC=0+-100	28480	0757-0123
A20R58	0757-0199	3	1	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A20R59	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A20R60	0698-7259	4		RESISTOR 9.09K 1% .05W F TC=0+-100	24546	C3-1/8-T0-9091-F
A20R61	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A20R60-R69				NOT ASSIGNED		
A20R70	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A20R71	0698-3439	4	1	RESISTOR 178 1% .125W F TC=0+-100	24546	C4-1/8-T0-178R-F
A20R72	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A20R73	0698-0082	7	1	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A20R74	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A20R75	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A20R76	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A20R77	0698-7286	7		RESISTOR 121K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1213-F
A20R78	0699-0069	2	1	RESISTOR 2.15M 1% .125W F TC=0+-100	28480	0699-0069
A20R79				NOT ASSIGNED		
A20R80				NOT ASSIGNED		
A20R81				NOT ASSIGNED		
A20R82	0698-7248	1		RESISTOR 3.16K 1% .05W F TC=0+-100	24546	C3-1/8-T0-3161-F
A20TP1	1251-0600	0	4	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A20TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A20TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A20TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A20U1	1826-0989	7	4	IC OP AMP GP 8-DIP-C PKG	27014	LM307J
A20U2	1826-0605	4	1	IC MULTIPLXR 8-CHAN-ANLG 16-DIP-C PKG	17856	DG508BK
A20U3	1820-1198	0	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS03N
A20U4	1826-0990	0	1	IC OP AMP GP DUAL 8-DIP-C PKG	04713	MC1458U
A20U5	1826-0716	8	1	IC OP AMP LOW-NOISE DUAL 8-DIP-C PKG	18324	NE5532AFE
A20U6	1820-1199	1	2	IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A20U7	1820-1195	7	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N
A20U8	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A20U9	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A20U10	1826-0188	8	2	IC CONV 8-B-D/A 16-DIP-C PKG	04713	MC1408L-8

See introduction to this section for ordering information. * Indicates factory selected value

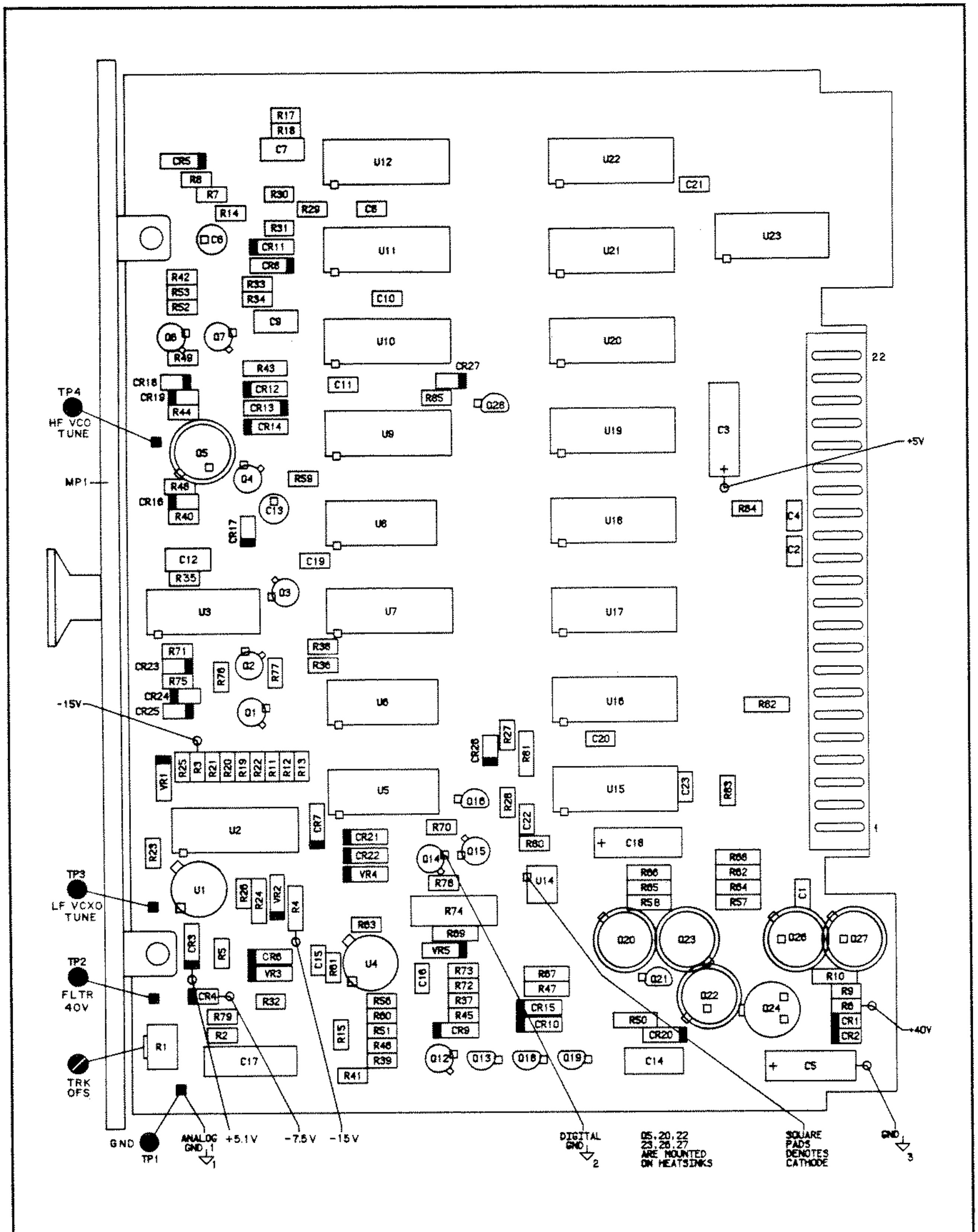
P/O Table 6-2. Replaceable Parts (P/O CHANGE 55)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A20	**08901-60285 – SERIAL PREFIX 2617A AND ABOVE**					
A20U11	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A20U12	1826-0188	8		IC CONV 8-B-D/A 16-DIP-C PKG	04713	MC1408L-8
A20U13				NOT ASSIGNED		
A20U14	1826-0606	5	2	IC SWITCH ANLG QUAD 16-DIP-C PKG	17856	DG201BK
A20U15	1820-1195	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N
A20U16	1820-1411	0	7	IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A20U17	1820-1411	0		IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A20U18	1820-1411	0		IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A20U19	1820-1411	0		IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A20U20	1820-1411	0		IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A20U21	1820-1411	0		IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A20U22	1820-1411	0		IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A20U23	1826-0606	5		IC SWITCH ANLG QUAD 16-DIP-C PKG	17856	DG201BK
A20VR1	1902-0955	9	1	DIODE-ZNR 7.5V 5% DO-35 PD=.4W TC=+.062%	28480	1902-0955
A20W1	8159-0005	0	1	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005

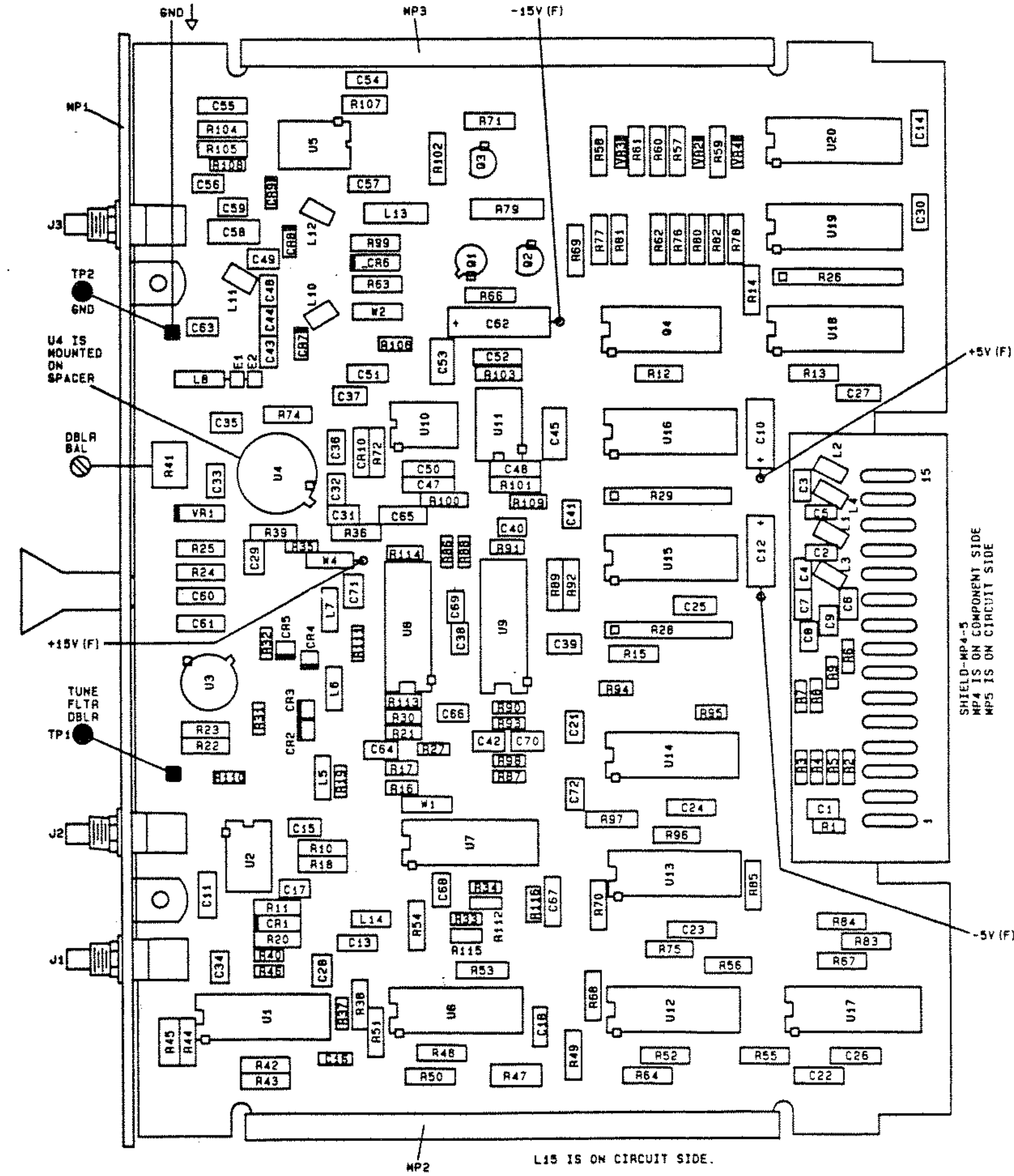
See introduction to this section for ordering information.   * Indicates factory selected value



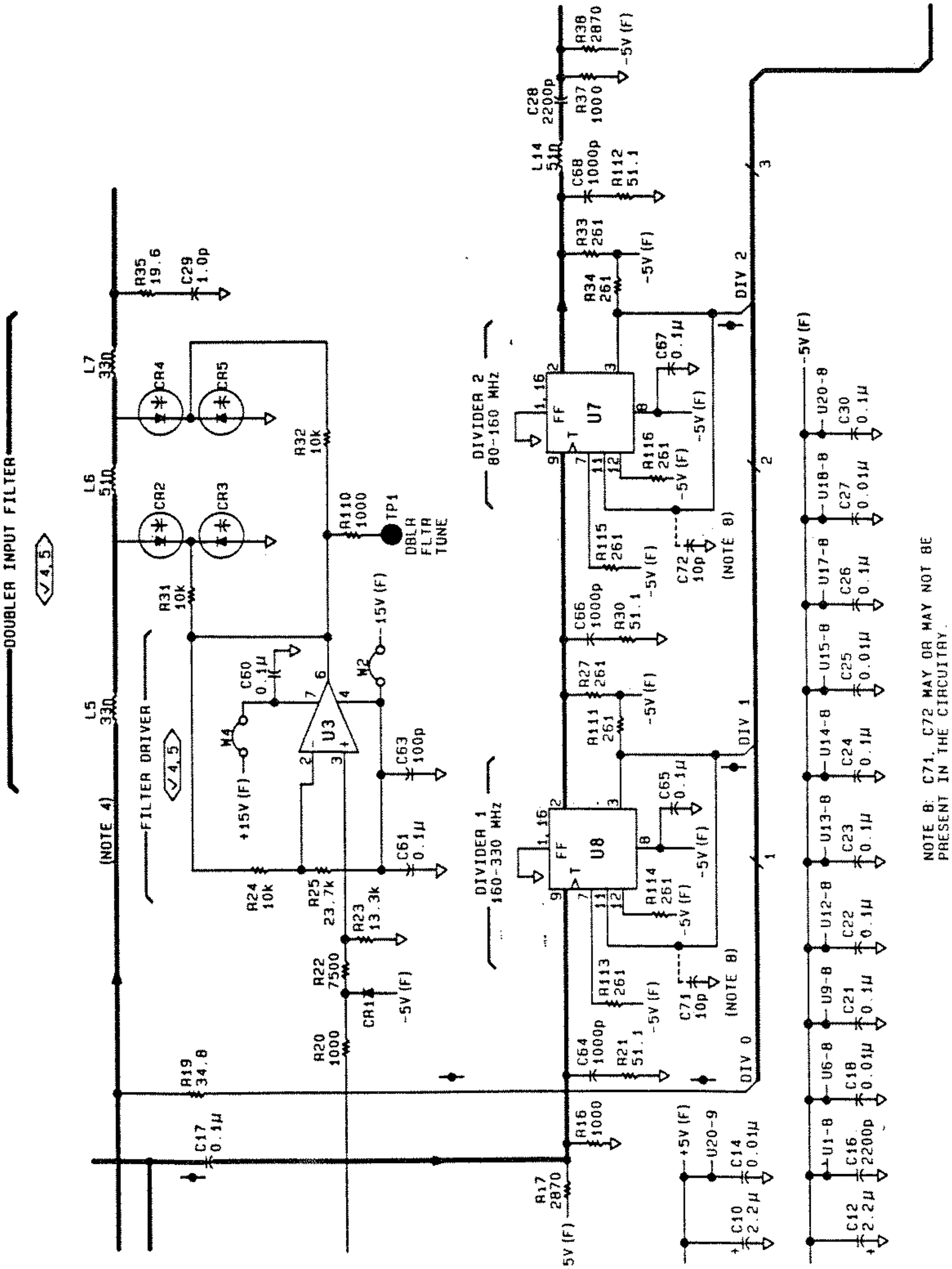
A20 LO Control Assembly Component Locations (P/O CHANGE 55).



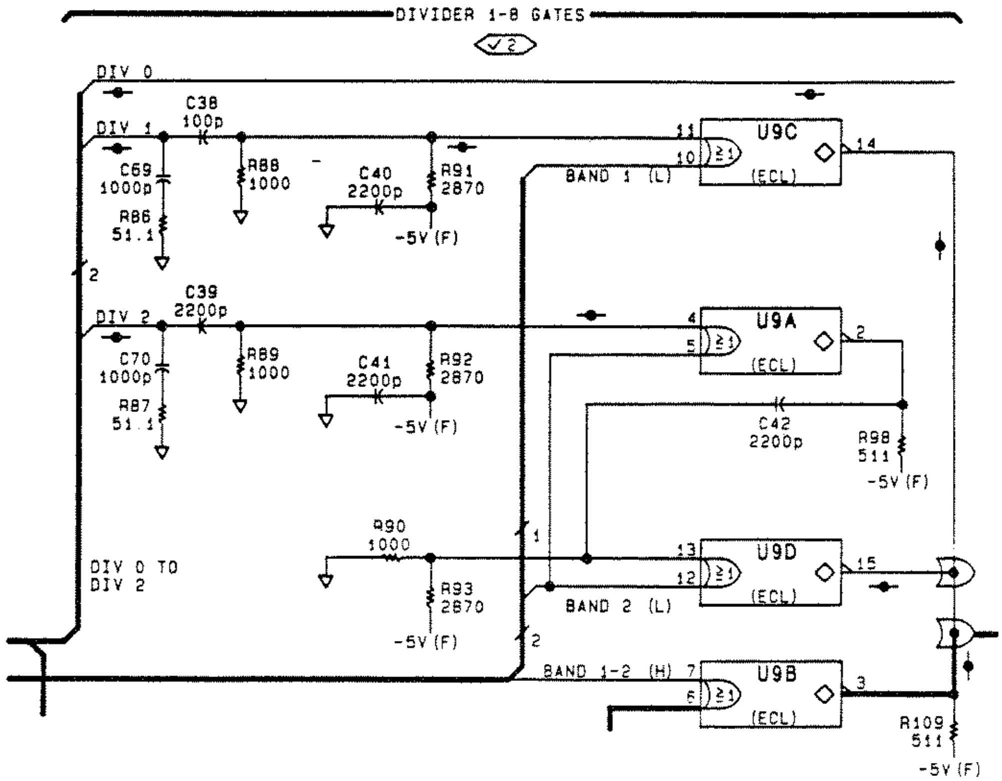
A20 LO Control Assembly Component Locations (P/O CHANGE 55).



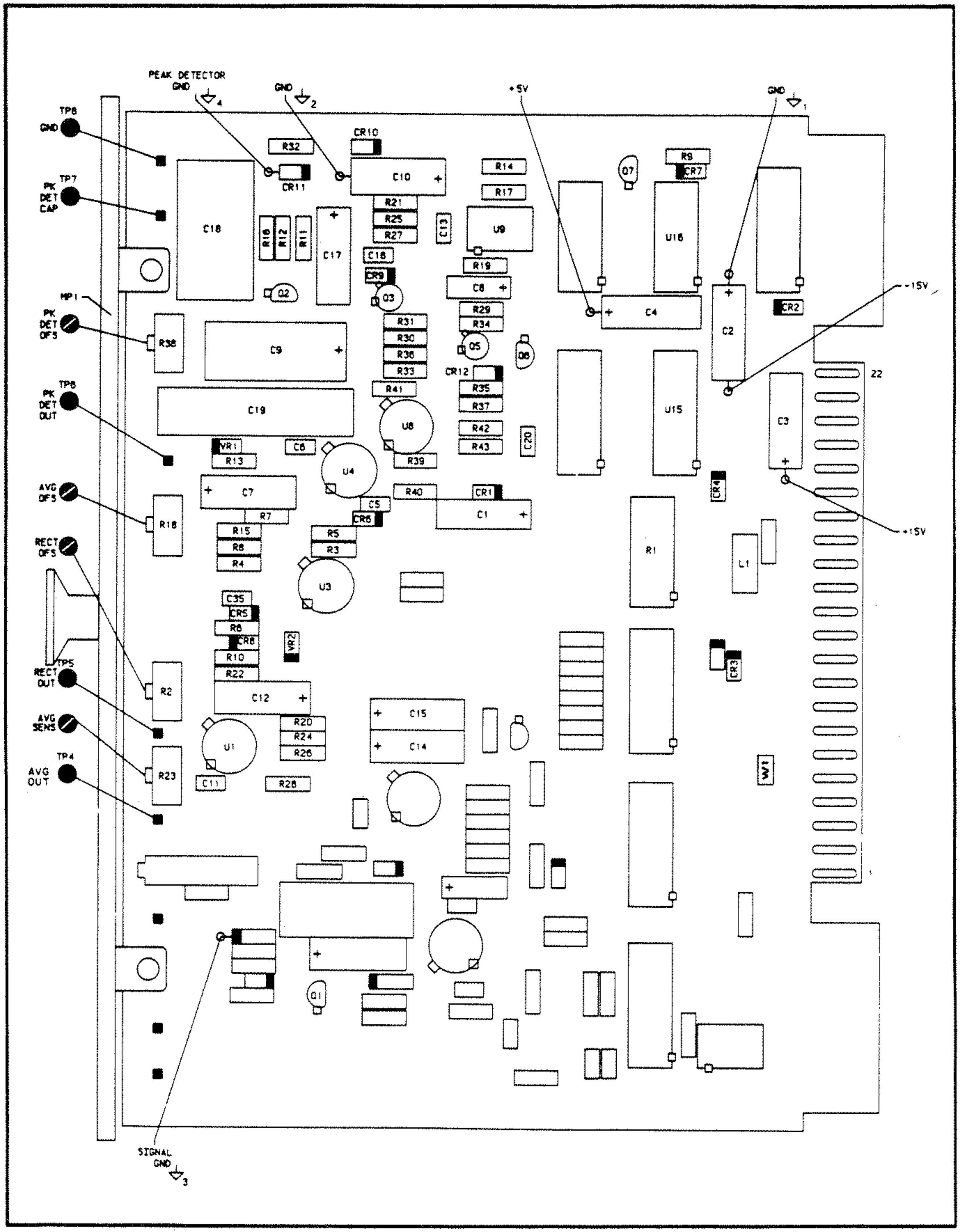
A19 LO Divider Assembly Component Locations (P/O CHANGE 56).



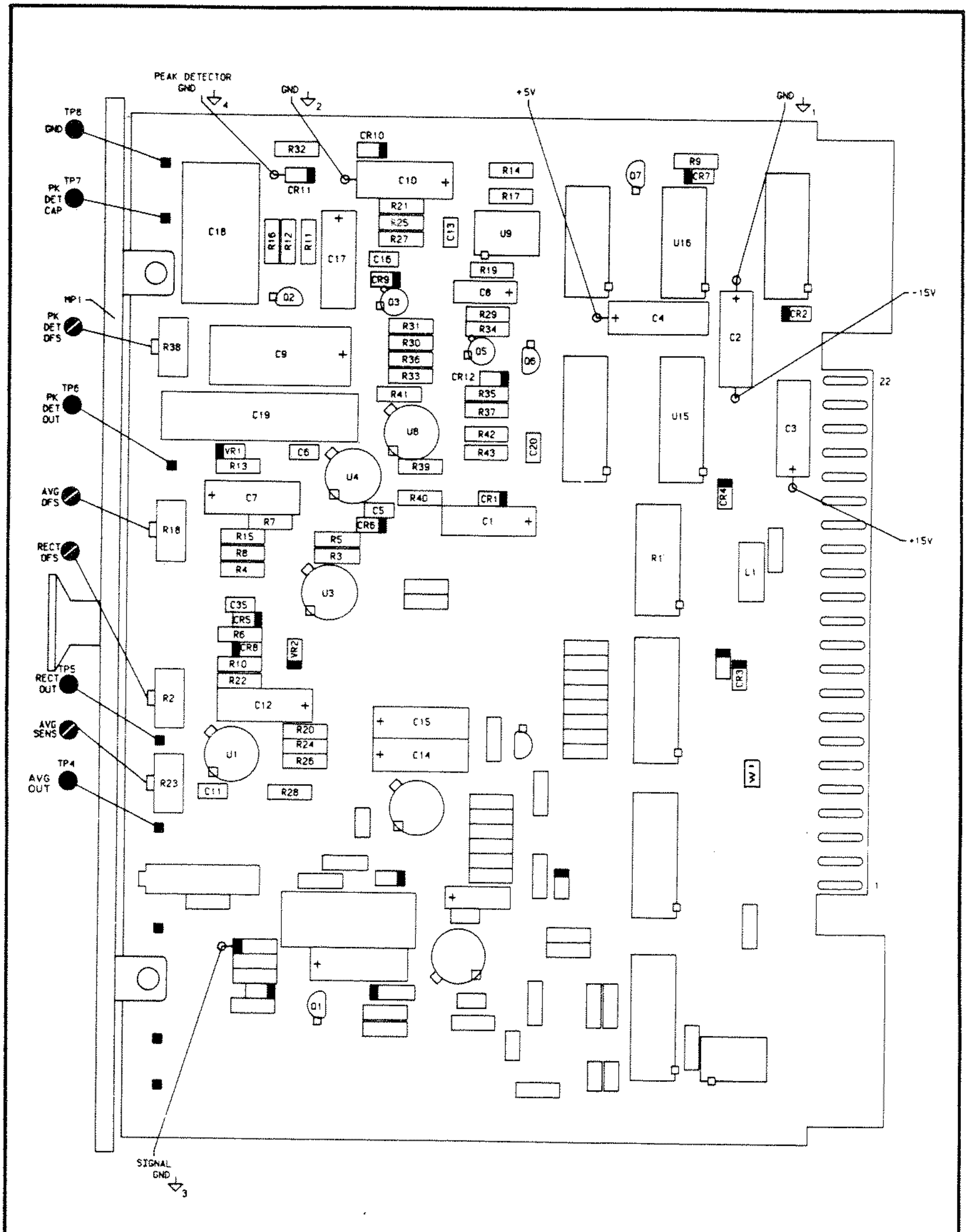
P/O A19 LO Divider Assembly (P/O CHANGE 56).



P/O A19 LO Divider Assembly (P/O CHANGE 56).

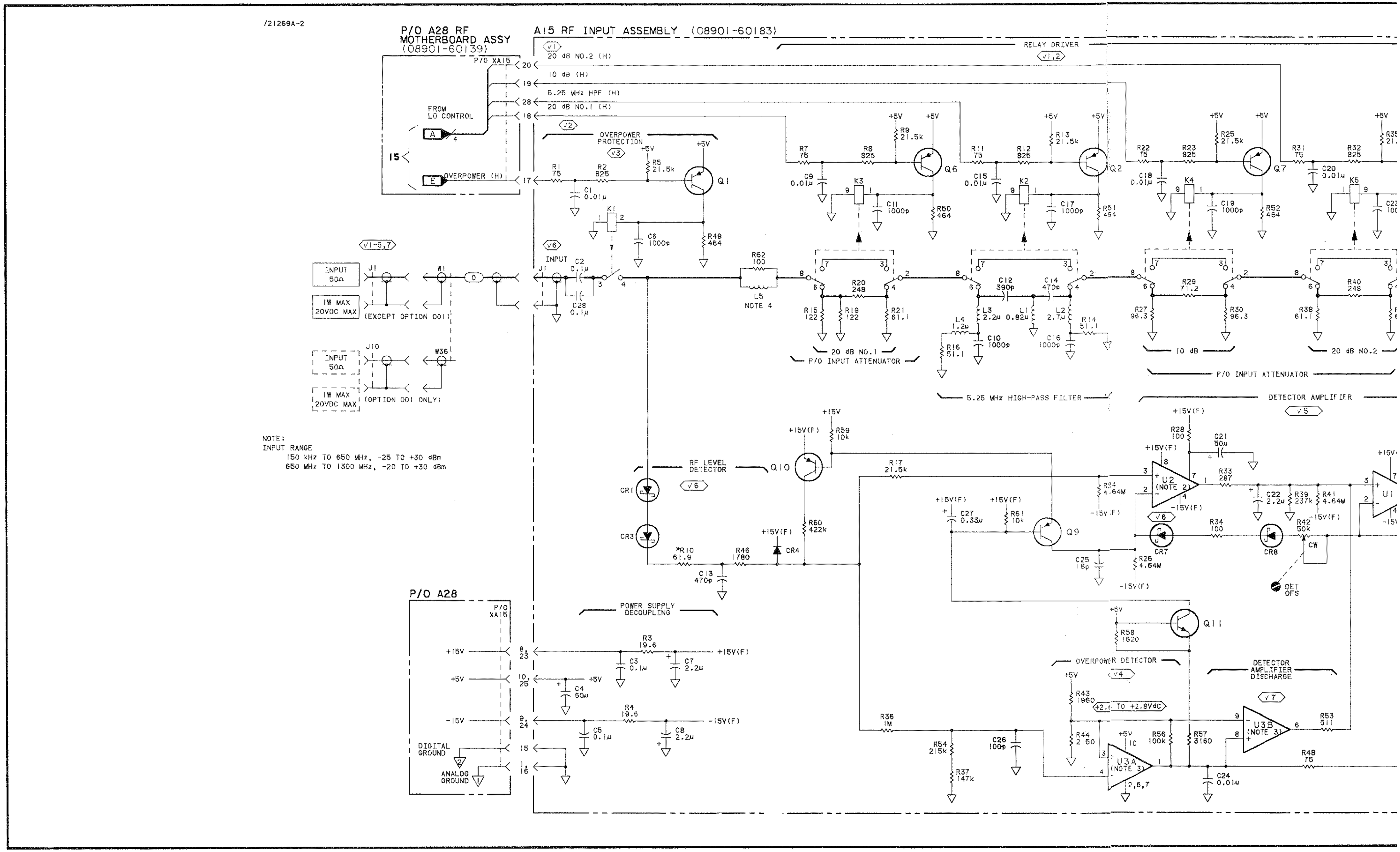


P/O A5 Voltmeter Assembly Component Locations (1 Of 2) (P/O CHANGE 58).

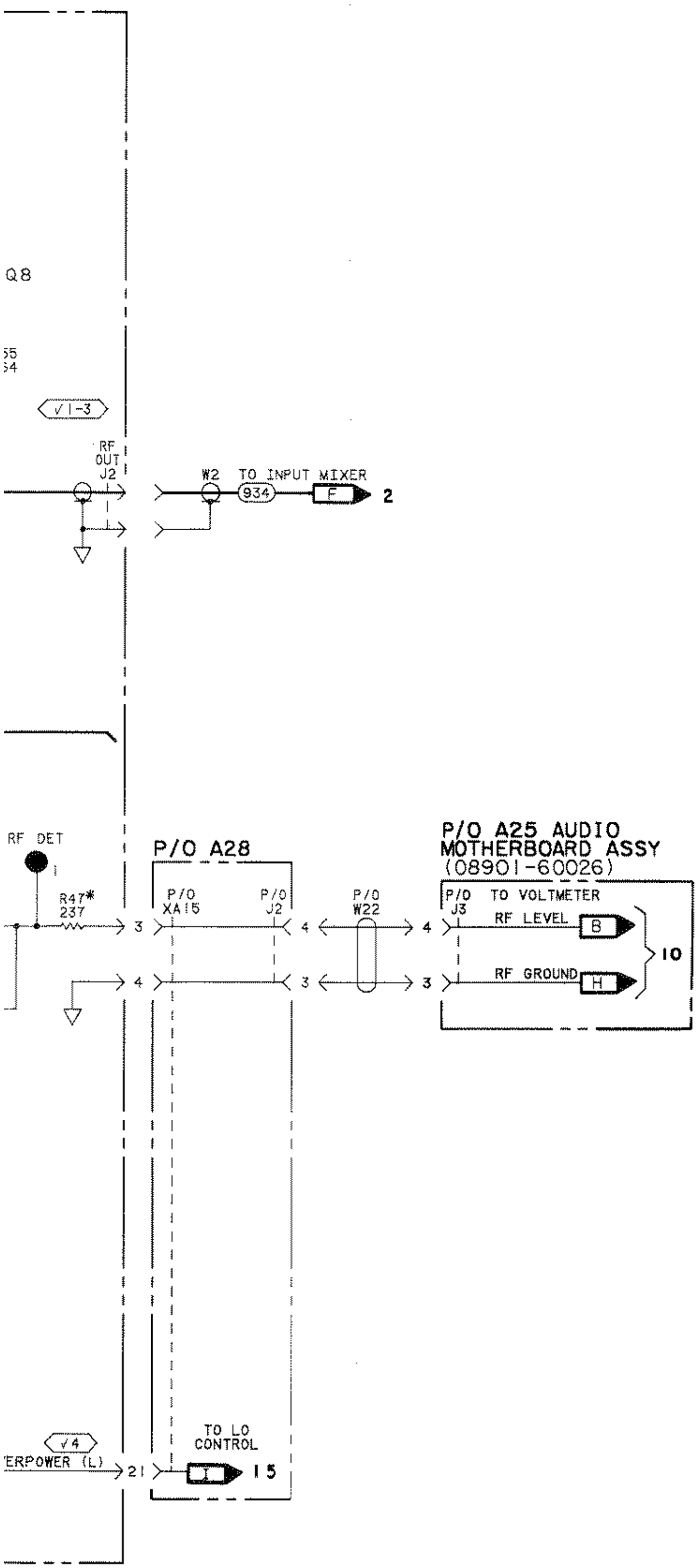


P/O A5 Voltmeter Assembly Component Locations (2 of 2) (P/O CHANGE 58).

08901-90032



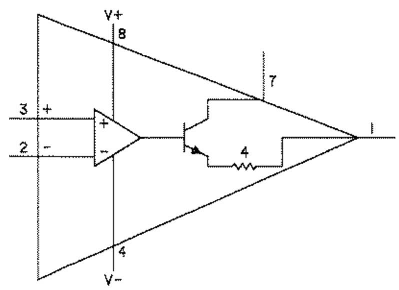
/21269A-2
P/O A28 RF MOTHERBOARD ASSY (08901-60139)
A15 RF INPUT ASSEMBLY (08901-60183)
RELAY DRIVER
OVERPOWER PROTECTION
FROM LO CONTROL
OVERPOWER (H)
20 dB NO.2 (H)
10 dB (H)
5.25 MHz HPF (H)
20 dB NO.1 (H)
INPUT 50Ω
1W MAX 20VDC MAX
(EXCEPT OPTION 001)
(OPTION 001 ONLY)
20 dB NO.1
P/O INPUT ATTENUATOR
10 dB
20 dB NO.2
5.25 MHz HIGH-PASS FILTER
DETECTOR AMPLIFIER
RF LEVEL DETECTOR
POWER SUPPLY DECOUPLING
OVERPOWER DETECTOR
DETECTOR AMPLIFIER DISCHARGE
DET OFS
P/O A28
DIGITAL GROUND
ANALOG GROUND
NOTE:
INPUT RANGE
150 kHz TO 650 MHz, -25 TO +30 dBm
650 MHz TO 1300 MHz, -20 TO +30 dBm



/212698-2

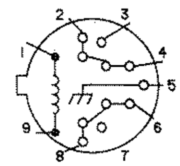
NOTES

1. SEE TABLE 8-6 FOR SCHEMATIC DIAGRAM NOTES.
2. THE DIAGRAM BELOW SHOWS THE OUTPUT STAGE OF COMPARATOR A15U2 IN DETAIL.



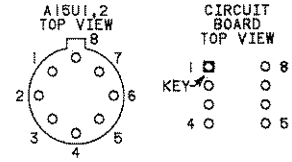
3. OPEN COLLECTOR OUTPUT.
4. PC TRACE INDUCTOR

A15K2-5 BOTTOM VIEW



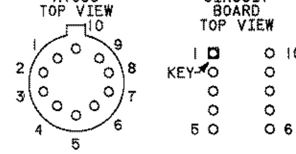
A15U1,2 TOP VIEW

CIRCUIT BOARD TOP VIEW



A15U3 TOP VIEW

CIRCUIT BOARD TOP VIEW



REFERENCE DESIGNATIONS

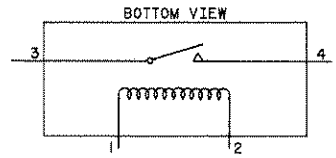
NO PREFIX	A25
J1,10 W1,2,22,36	J3
	A28
A15	J2 XA15
C1-28 CR1,3,4,7,8 J1,2 K1-5 L1-L5 Q1,2,6-11 R1-5,7-17,19-62 TP1 U1-3	

NOT ASSIGNED: A15 CR2,5,6;Q3-5; R6,18

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1,2,6-8	1853-0281
Q9,10	1853-0020
Q11	1854-0071
U1	1826-0013
U2	1826-0098
U3	1826-0191

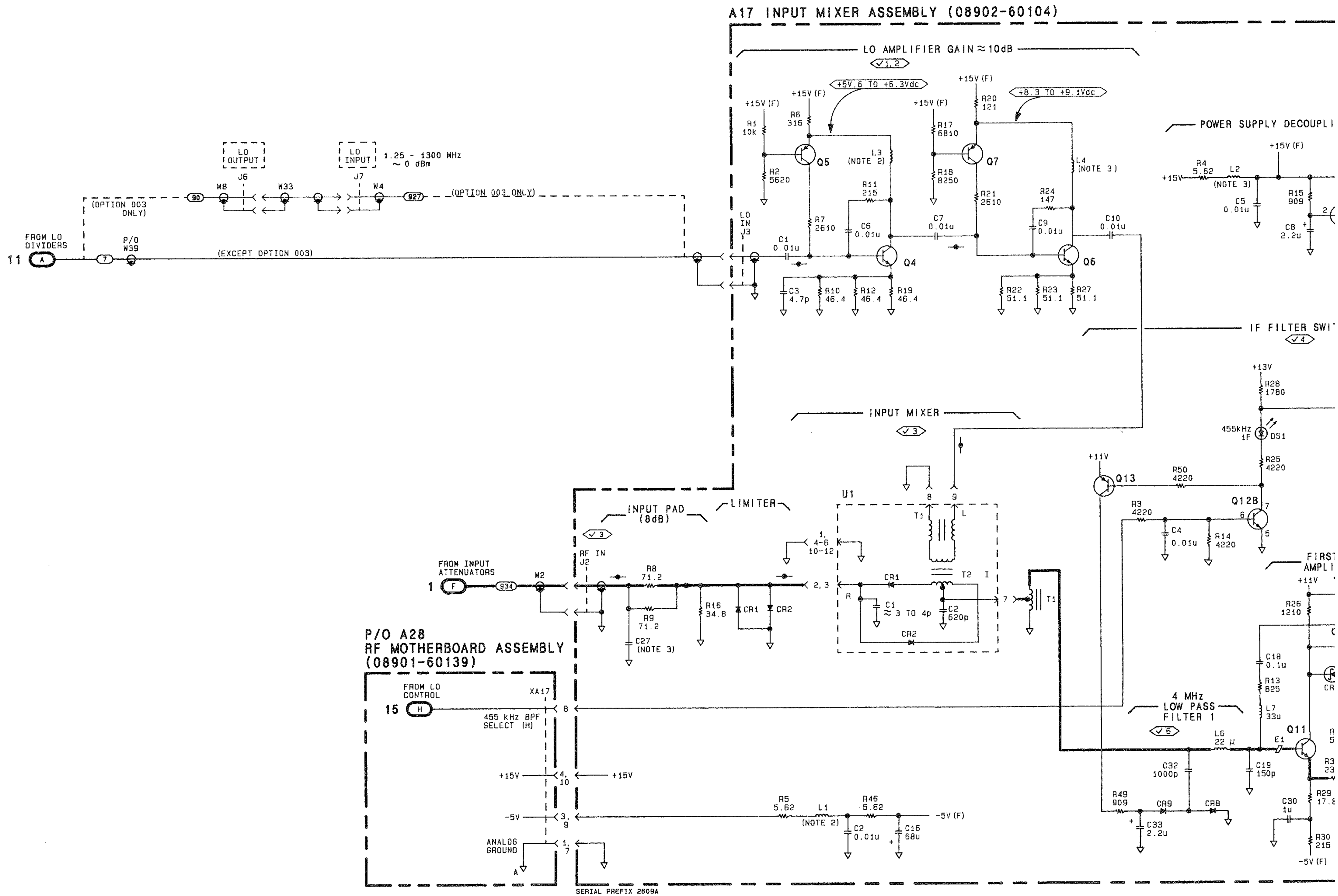
A15K1 BOTTOM VIEW



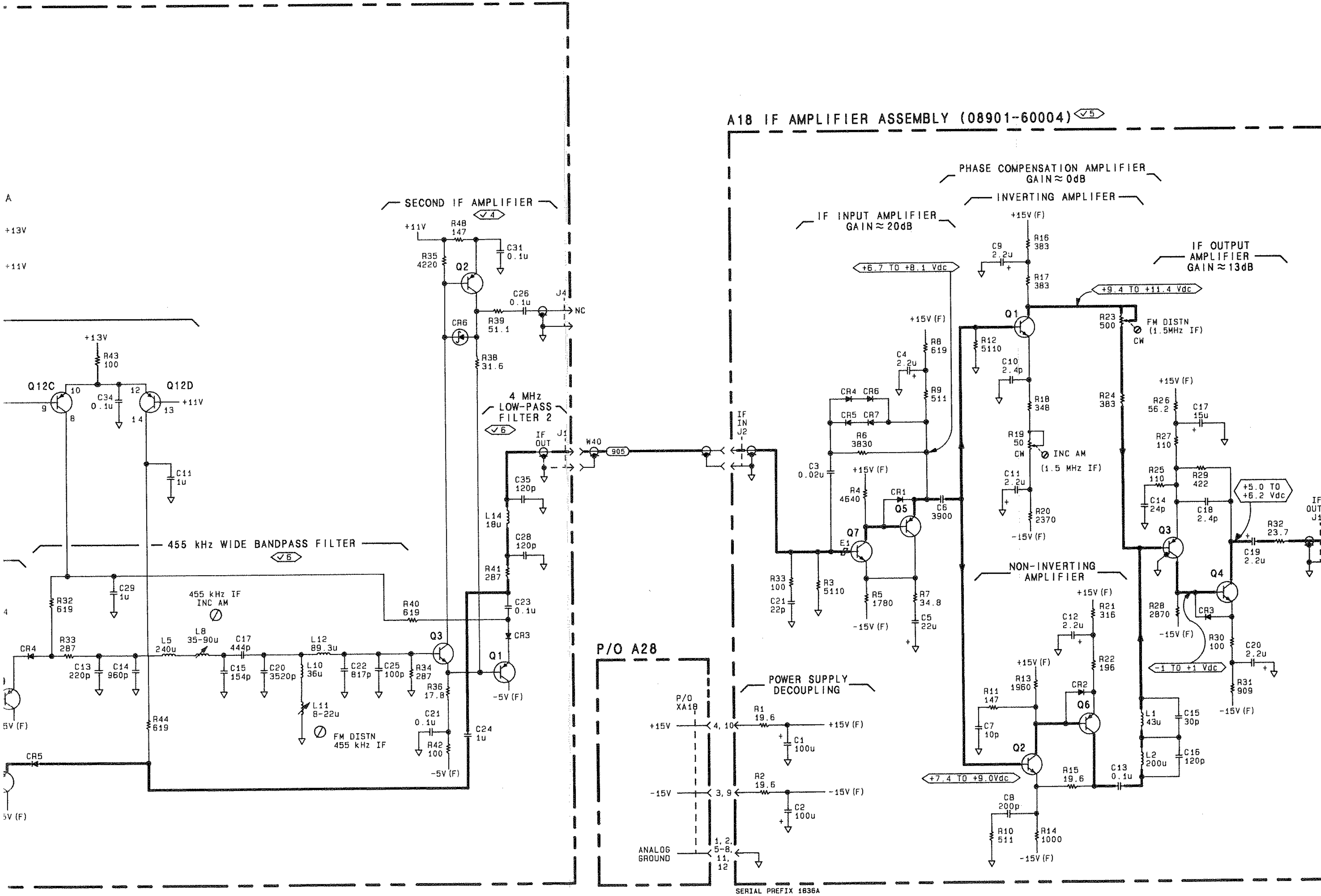
A1

Figure 8-68. RF Input Schematic Diag

CHANGE 18, P/O Figure 8-68 . A15 RF Input Assembly, Schematic Diagram



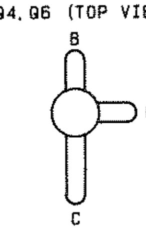
A17 INPUT MIXER ASSEMBLY (08902-60104)
LO AMPLIFIER GAIN ≈ 10dB
POWER SUPPLY DECOUPLI
IF FILTER SWI
INPUT MIXER
INPUT PAD (8dB)
LIMITER
4 MHz LOW PASS FILTER 1
FIRST AMPLI
LO OUTPUT
LO INPUT
1.25 - 1300 MHz ~ 0 dBm
(OPTION 003 ONLY)
(EXCEPT OPTION 003)
FROM LO DIVIDERS
FROM INPUT ATTENUATORS
RF IN J2
LO IN J3
P/O A28 RF MOTHERBOARD ASSEMBLY (08901-60139)
FROM LO CONTROL
455 kHz BPF SELECT (H)
ANALOG GROUND
SERIAL PREFIX 2609A



NOTES

1. SEE TABLE 8-6 SCHEMATIC DIAGRAM NOTES.
2. INDUCTANCE IS APPROXIMATEL 4.5 μH AT 1MHz
3. A17C27 IS A METAL STRIP OVER R8 AND R9.
4. RELAYS IN S4 ARE LATCHING TYPE. A MOMENTARY TTL LOW INPUT WILL ACTUATE THE INDICATED SEGMENT, AND THE DEACTIVATE THE SWITCHING SOLENOID.

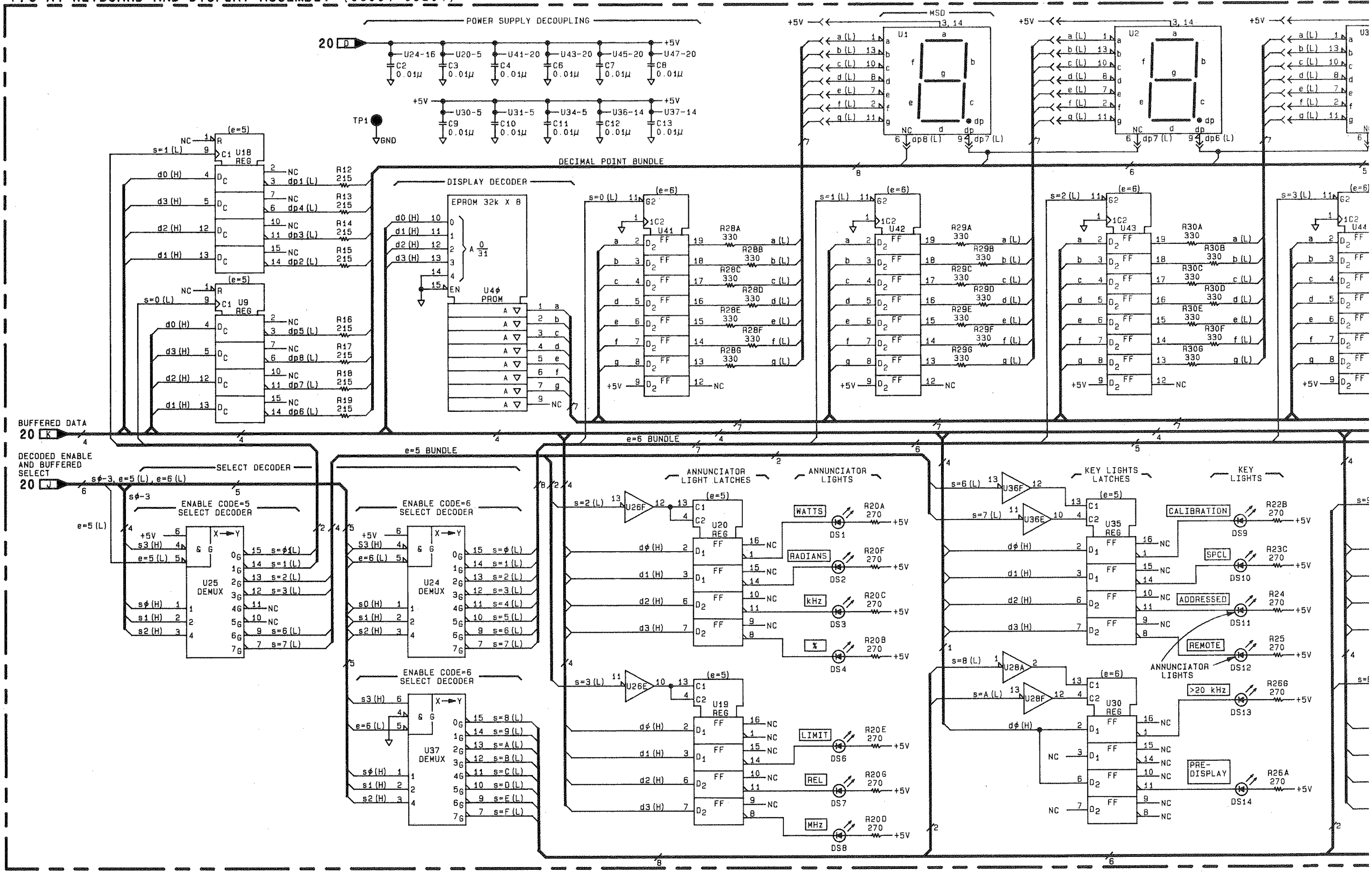
Q4, Q6 (TOP VIEW)

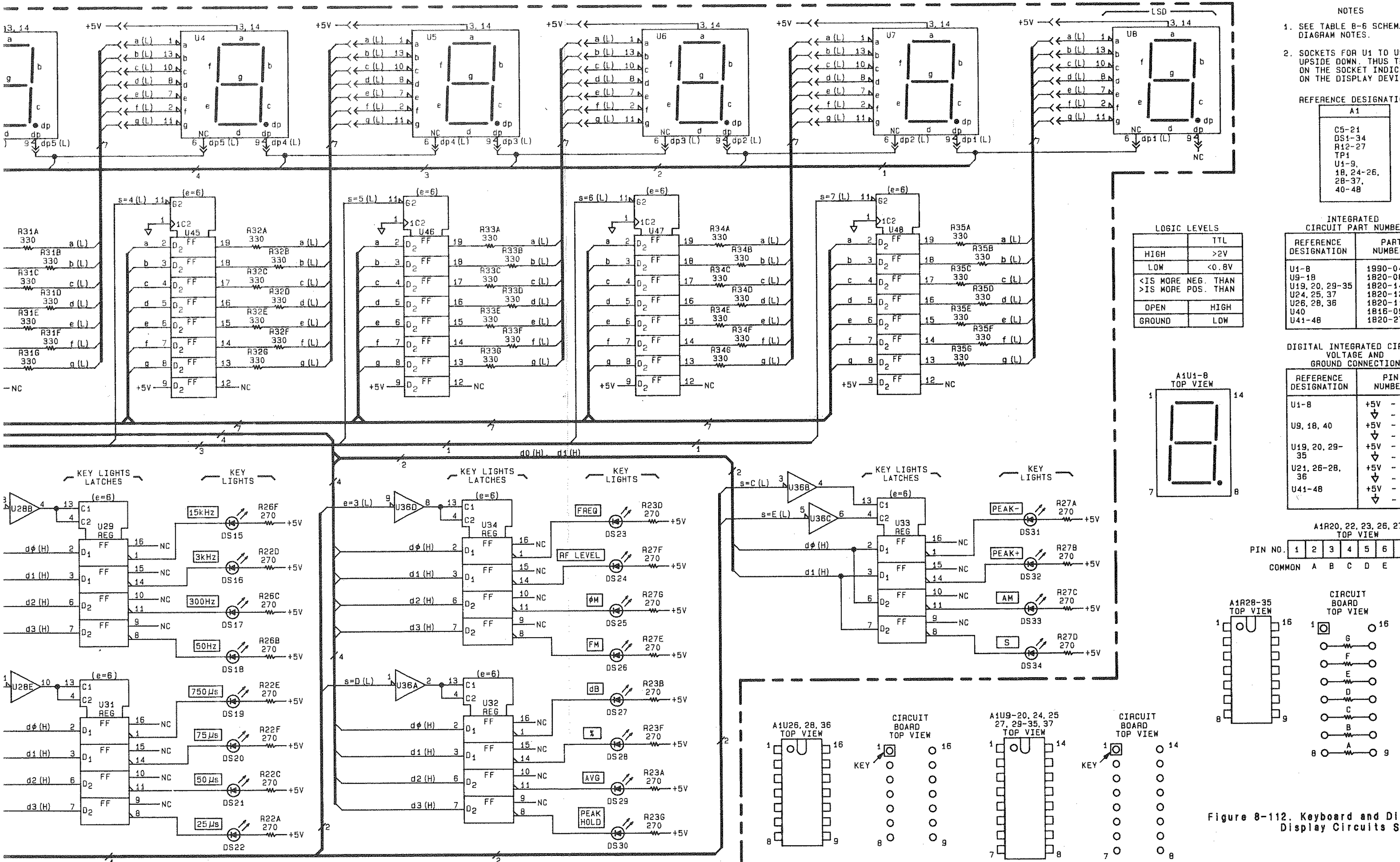


SS2

A17 INPUT MIXER
A18 IF AMPLIFIER
P/O CHANGE 53

P/O A1 KEYBOARD AND DISPLAY ASSEMBLY (08901-60261)





NOTES

1. SEE TABLE 8-6 SCHEMATIC DIAGRAM NOTES.
2. SOCKETS FOR U1 TO U8 ARE UPSIDE DOWN. THUS THE PIN 1 MARK ON THE SOCKET INDICATES PIN 8 ON THE DISPLAY DEVICE.

REFERENCE DESIGNATION

A1
C5-21 DS1-34 R12-27 TP1 U1-9, 18, 24-26, 28-37, 40-48

LOGIC LEVELS

	TTL
HIGH	>2V
LOW	<0.8V
<IS MORE NEG. THAN >IS MORE POS. THAN	
OPEN	HIGH
GROUND	LOW

INTEGRATED CIRCUIT PART NUMBER

REFERENCE DESIGNATION	PART NUMBERS
U1-8	1990-0437
U9-18	1820-0839
U19, 20, 29-35	1820-1411
U24, 25, 37	1820-1216
U26, 28, 36	1820-1199
U40	1816-0916
U41-48	1820-2757

DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTION

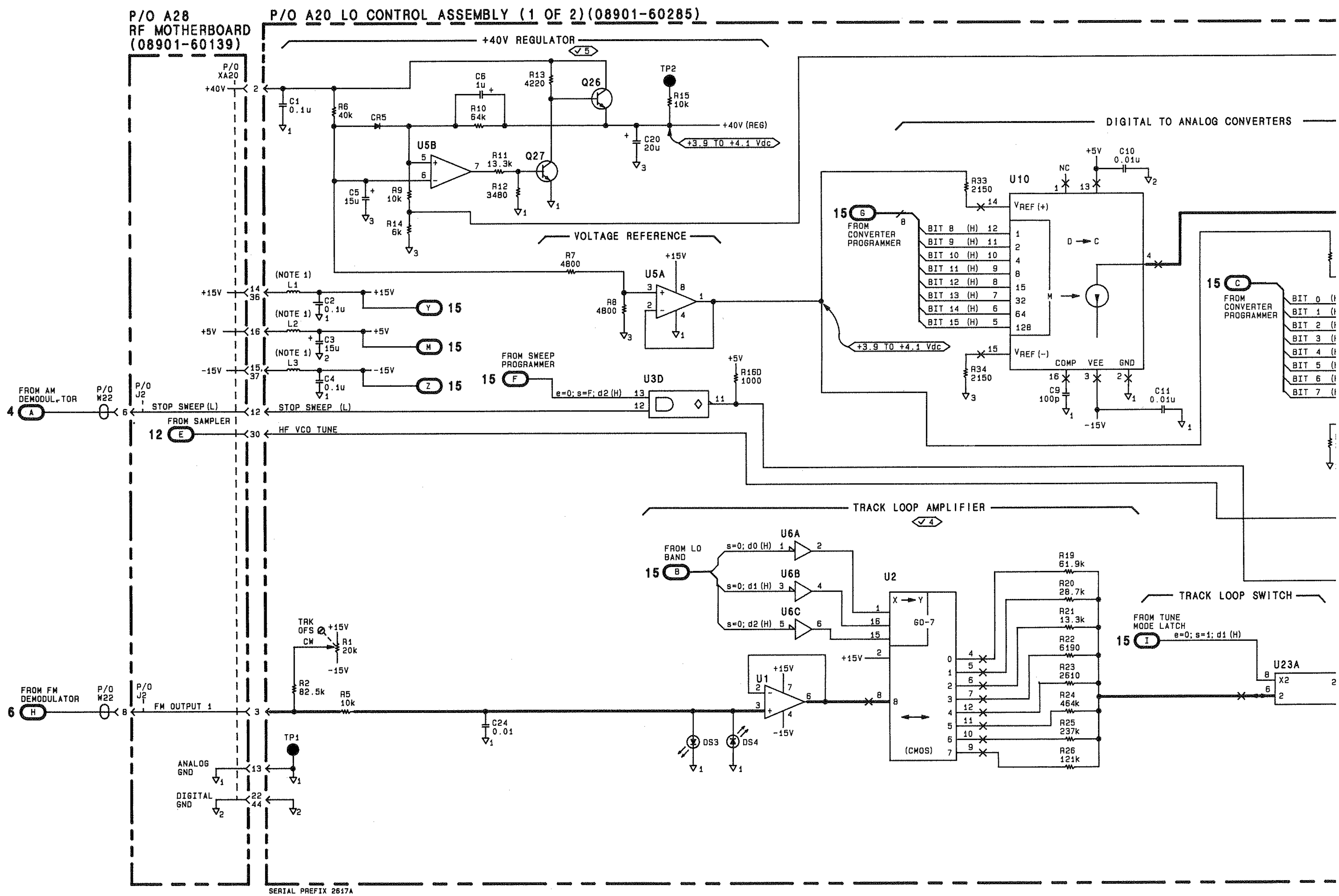
REFERENCE DESIGNATION	PIN NUMBERS
U1-8	+5V - 3 ⏚ - 6
U9, 18, 40	+5V - 16 ⏚ - 8
U19, 20, 29-35	+5V - 6 ⏚ - 12
U21, 26-28, 36	+5V - 14 ⏚ - 7
U41-48	+5V - 20 ⏚ - 10

A1R20, 22, 23, 26, 27 TOP VIEW

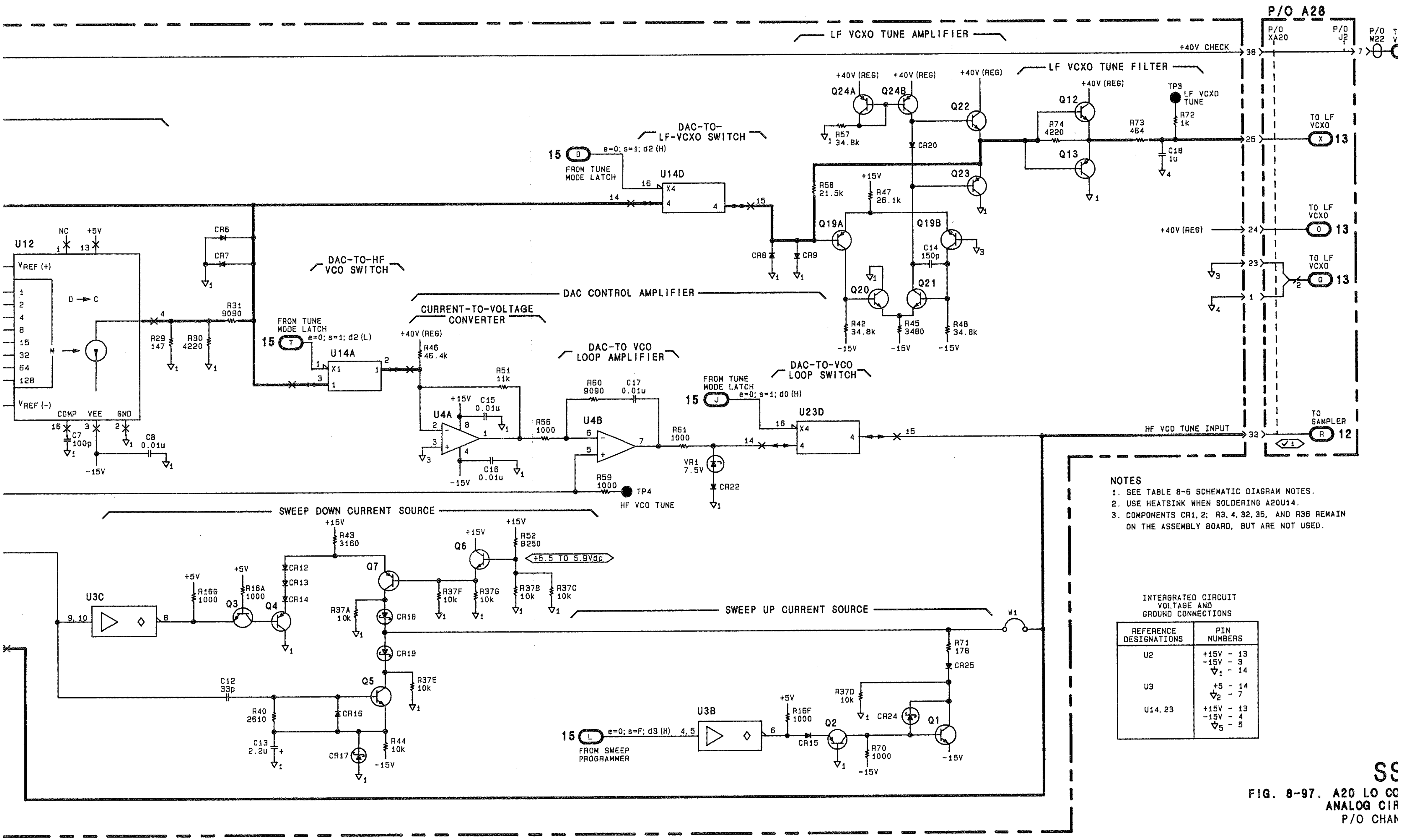
PIN NO.	1	2	3	4	5	6	7	8
COMMON	A	B	C	D	E	F	G	

P/O

Figure 8-112. Keyboard and Display-Decoder Display Circuits Schematic Diag (Change



P/O A28
RF MOTHERBOARD
(08901-60139)
P/O A20 LO CONTROL ASSEMBLY (1 OF 2)(08901-60285)
+40V REGULATOR
VOLTAGE REFERENCE
DIGITAL TO ANALOG CONVERTERS
TRACK LOOP AMPLIFIER
TRACK LOOP SWITCH
FROM AM DEMODULATOR
FROM FM DEMODULATOR
FROM SAMPLER
FROM SWEEP PROGRAMMER
FROM CONVERTER PROGRAMMER
FROM LO BAND
FROM TUNE MODE LATCH
STOP SWEEP (L)
HF VCO TUNE
FM OUTPUT 1
ANALOG GND
DIGITAL GND
+40V (REG)
+3.9 TO +4.1 Vdc
TRK OFS
U5B
U5A
U10
U3D
U6A
U6B
U6C
U1
U2
U23A
Q26
Q27
TP1
TP2
DS3
DS4
(CMOS)
SERIAL PREFIX 2617A



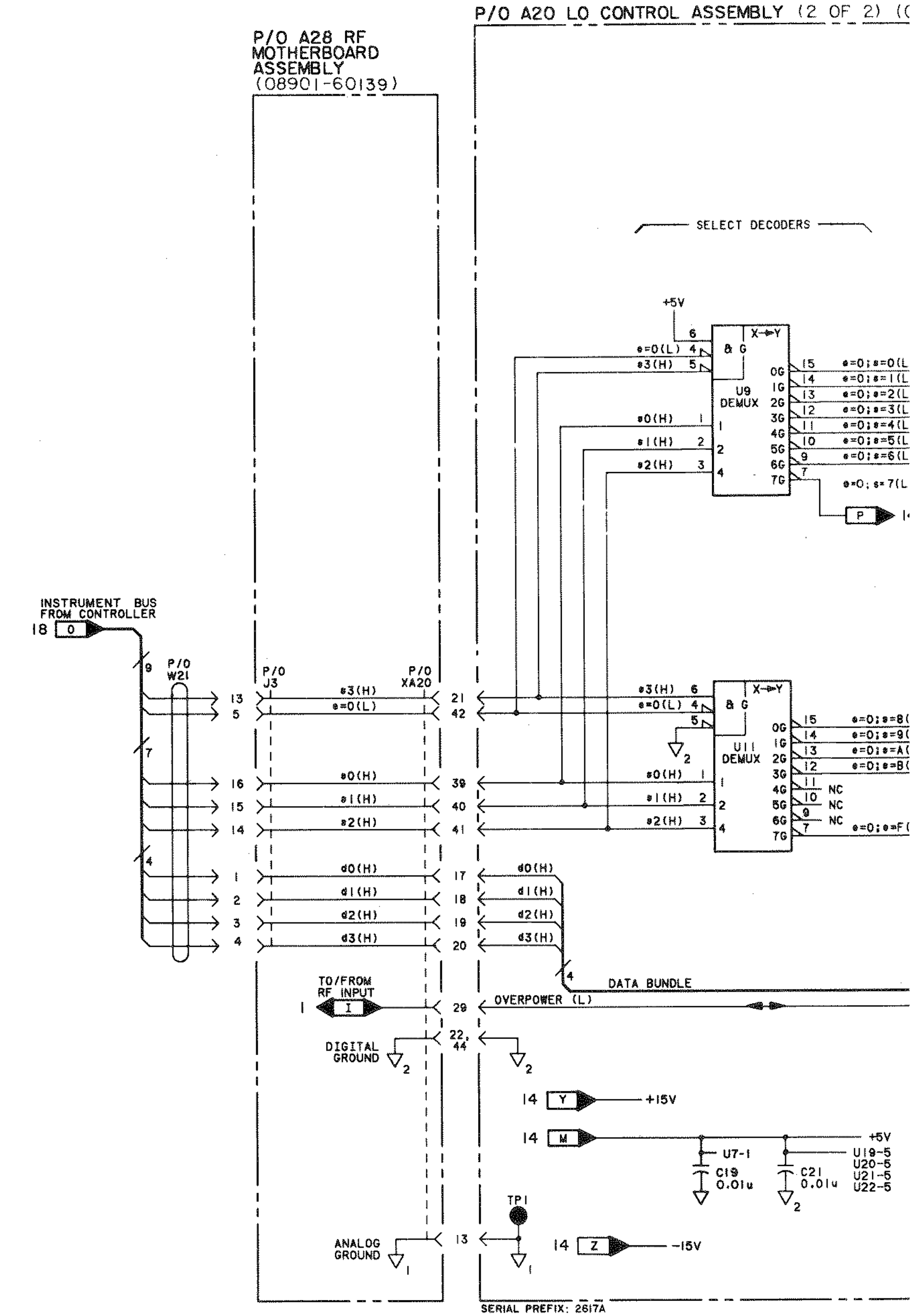
NOTES
1. SEE TABLE 8-6 SCHEMATIC DIAGRAM NOTES.
2. USE HEATSINK WHEN SOLDERING A20U14.
3. COMPONENTS CR1, 2; R3, 4, 32, 35, AND R36 REMAIN ON THE ASSEMBLY BOARD, BUT ARE NOT USED.

INTERGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
U2	+15V - 13 -15V - 3 ▽1 - 14
U3	+5 - 14 ▽2 - 7
U14, 23	+15V - 13 -15V - 4 ▽5 - 5

SS

FIG. 8-97. A20 LO CO
ANALOG CIR
P/O CHAN

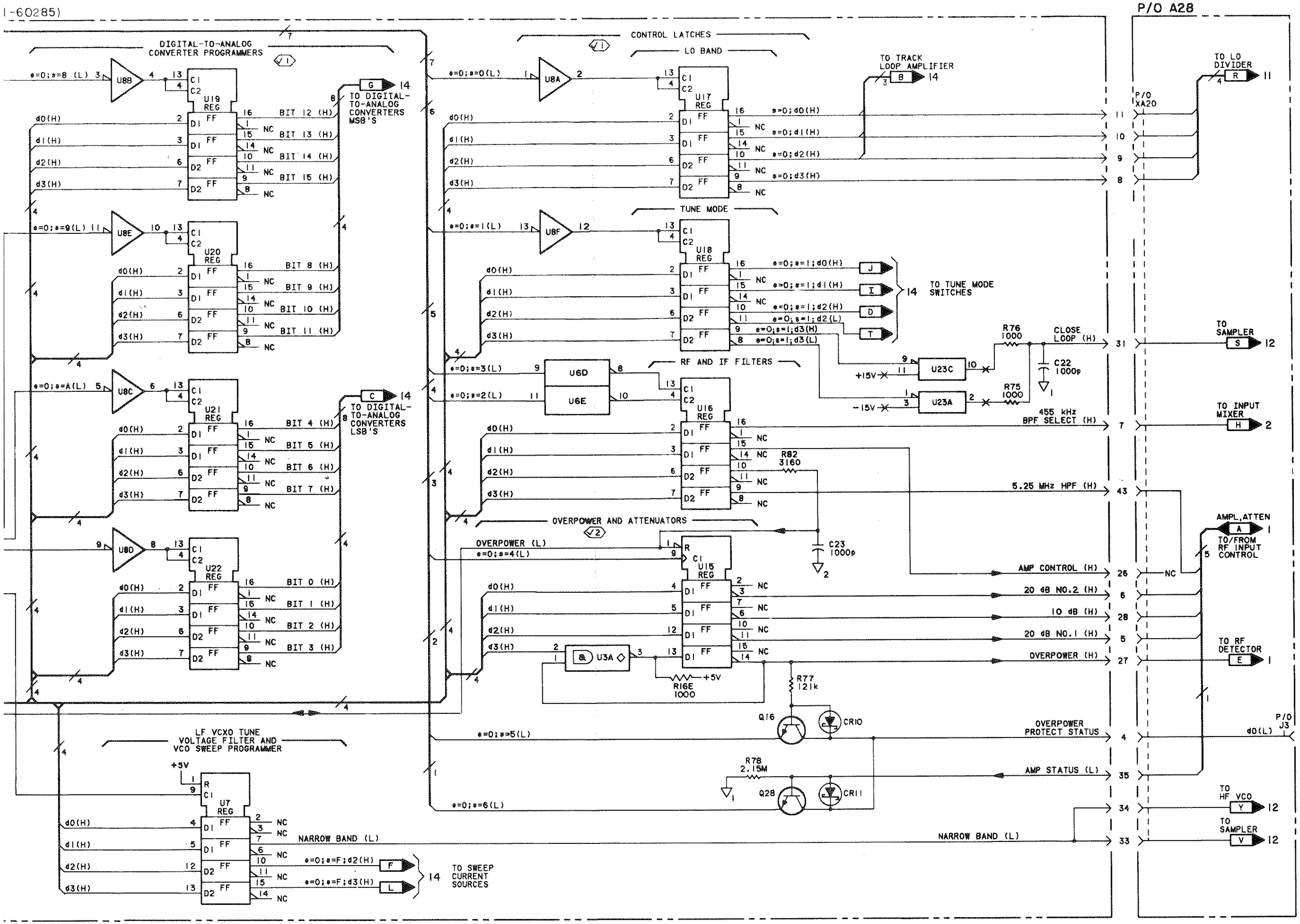


P/O A20 LO CONTROL ASSEMBLY (2 OF 2)
P/O A28 RF MOTHERBOARD ASSEMBLY (08901-60139)
SELECT DECODERS
U9 DEMUX
U11 DEMUX
INSTRUMENT BUS FROM CONTROLLER
P/O W21
P/O J3
P/O XA20
DATA BUNDLE
OVERPOWER (L)
TO/FROM RF INPUT
DIGITAL GROUND
ANALOG GROUND
+15V
+5V
-15V
U7-1
C19 0.01u
C21 0.01u
U19-5
U20-5
U21-5
U22-5
TP1
SERIAL PREFIX: 2617A

NOTES

1. SEE TABLE 8-6 DIAGRAM NOTES.

SCHEMATIC

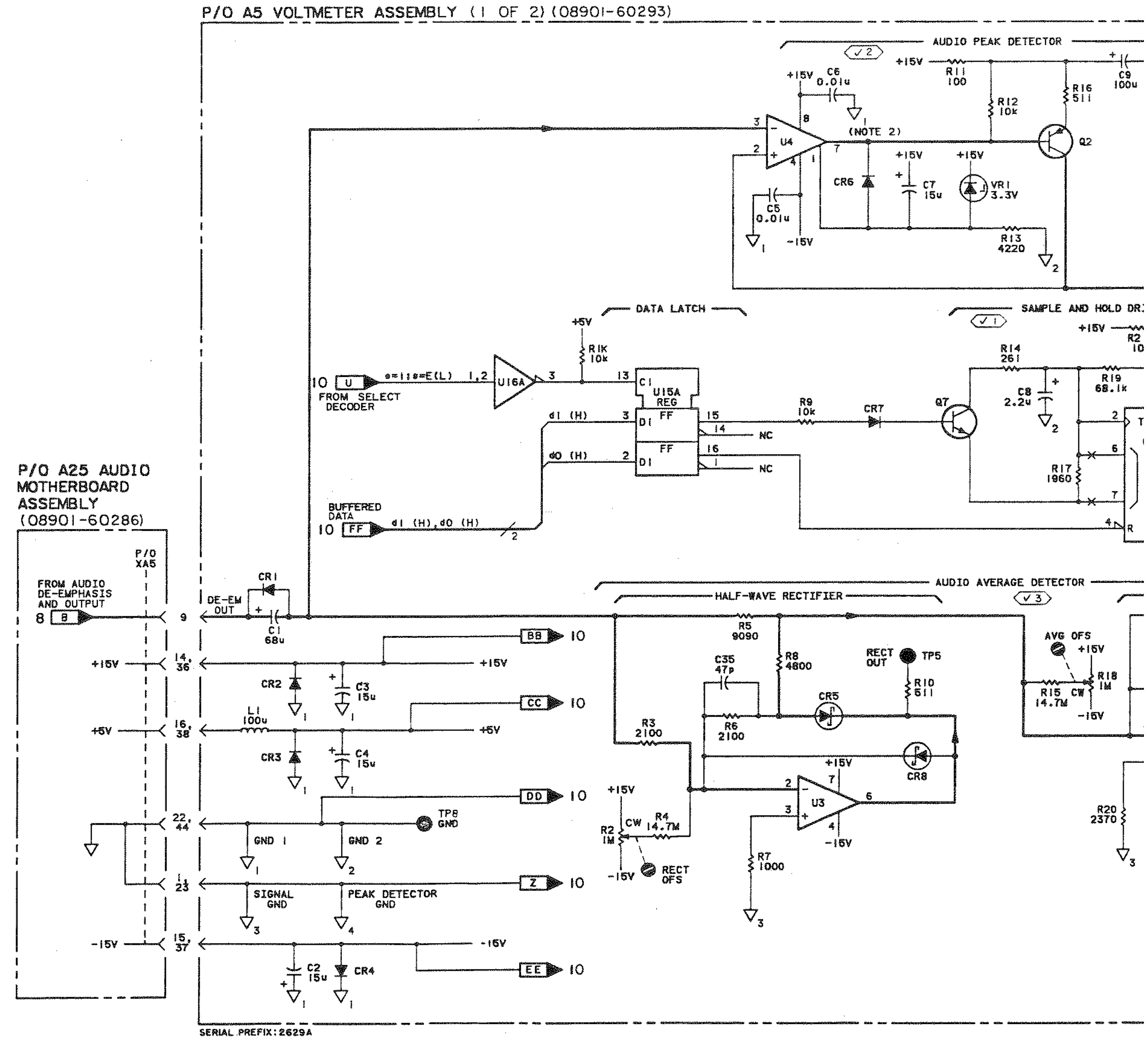


DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

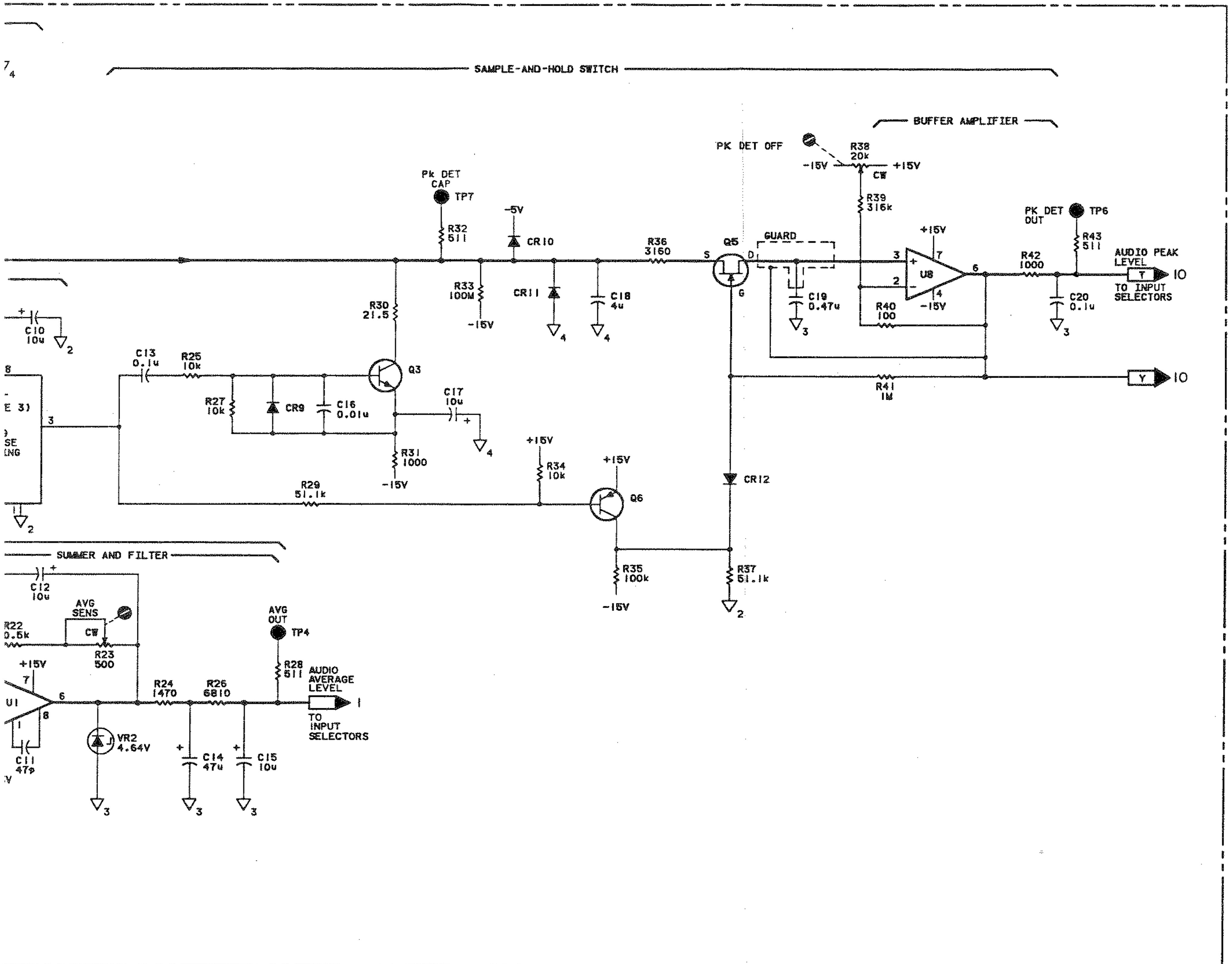
REFERENCE DESIGNATIONS	PIN NUMBERS
U16-22	+5V - 5 ▽2 - 12
U3,6,8,23	+5V - 14 ▽2 - 7
U7,9,11,15	+5V - 16 ▽2 - 8
U23	+15 - 13 -15 - 4 ▽1 - 5

SS

FIG. 8-99. LO CON DIGITAL CIRC (P/O CHANGE

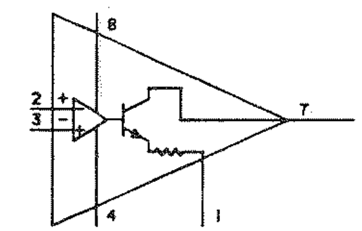


P/O A5 VOLTMETER ASSEMBLY (1 OF 2) (08901-60293)
AUDIO PEAK DETECTOR
DATA LATCH
SAMPLE AND HOLD DR
AUDIO AVERAGE DETECTOR
HALF-WAVE RECTIFIER
P/O A25 AUDIO MOTHERBOARD ASSEMBLY (08901-60286)
P/O XA5
FROM AUDIO DE-EMPHASIS AND OUTPUT
FROM SELECT DECODER
BUFFERED DATA
DE-EM OUT
RECT OUT
RECT OFS
AVG OFS
GND 1
GND 2
SIGNAL GND
PEAK DETECTOR GND
TP8 GND
TP5
(NOTE 2)
SERIAL PREFIX: 2629A

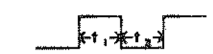


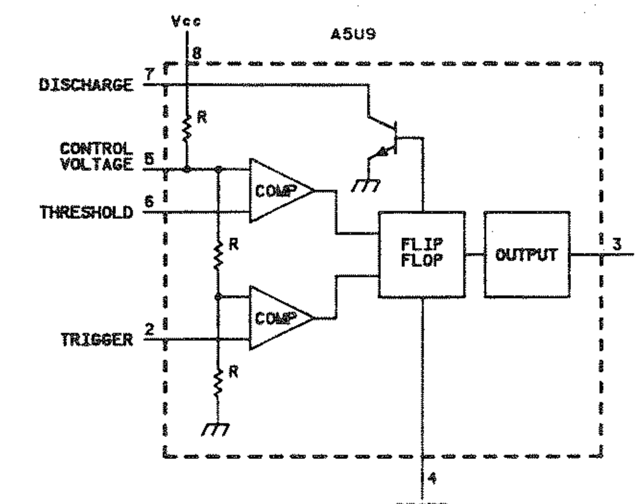
NOTES

1. SEE TABLE 8-6 SCHEMATIC DIAGRAM NOTES.
2. THE DIAGRAM BELOW SHOWS THE OUTPUT STAGE OF COMPARATOR A5U4 IN DETAIL.



3. PULSE TIMING FOR MONOSTABLE MULTIVIBRATOR A5U9 (SHOWN BELOW) IS AS FOLLOWS:
Q7 OFF: t_1 = 131ms t_2 = 9.4ms
Q7 ON : t_1 = 106ms; t_2 = 2.4ms

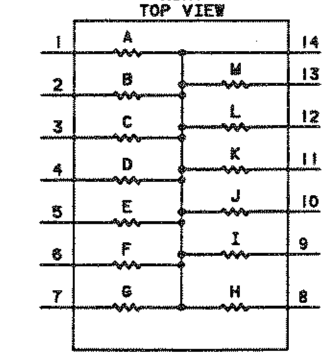




DIGITAL INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

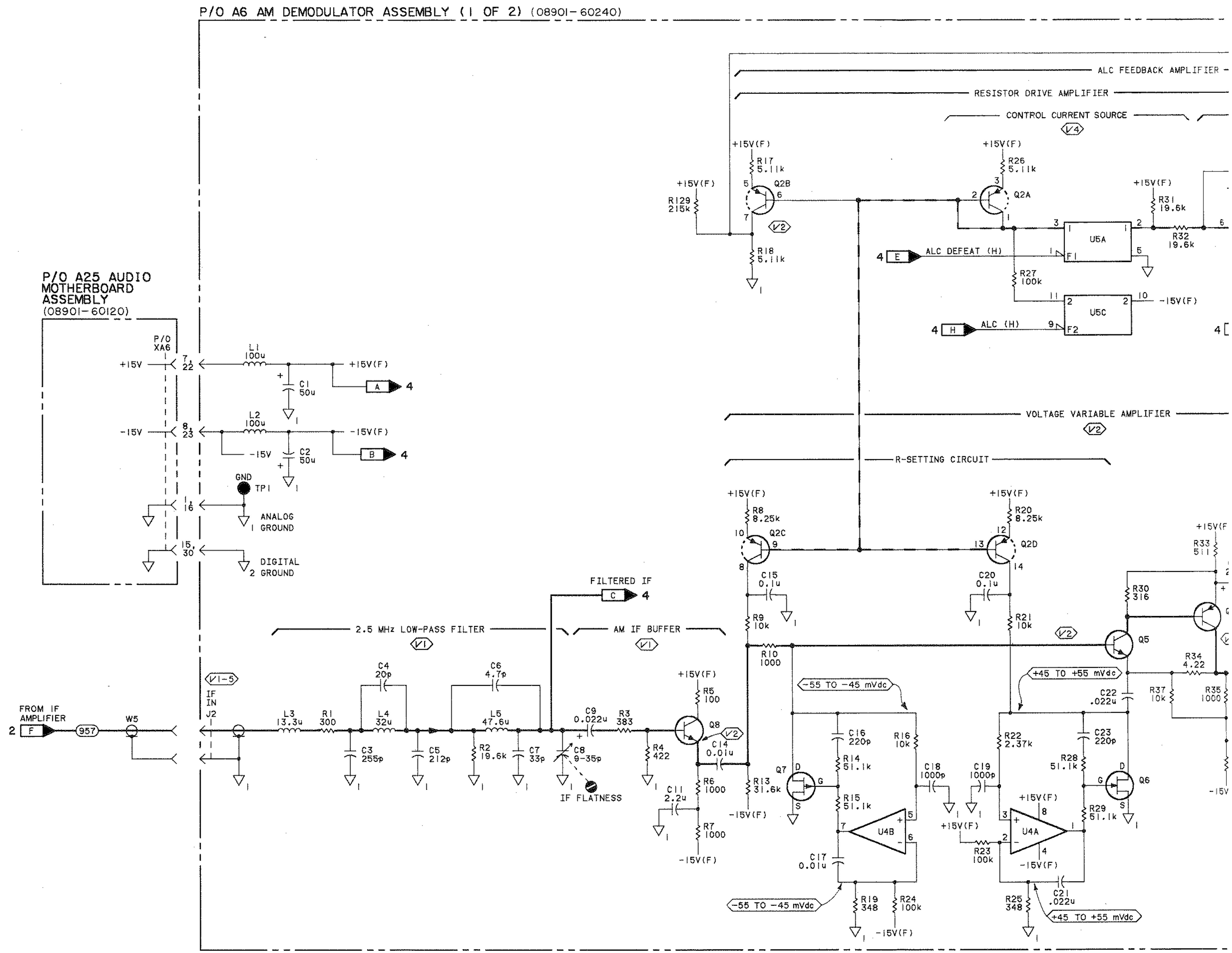
REFERENCE DESIGNATIONS	PIN NUMBERS
U15	+5V - 5
	∇_2 - 12
U16	+5V - 14
	∇_2 - 7

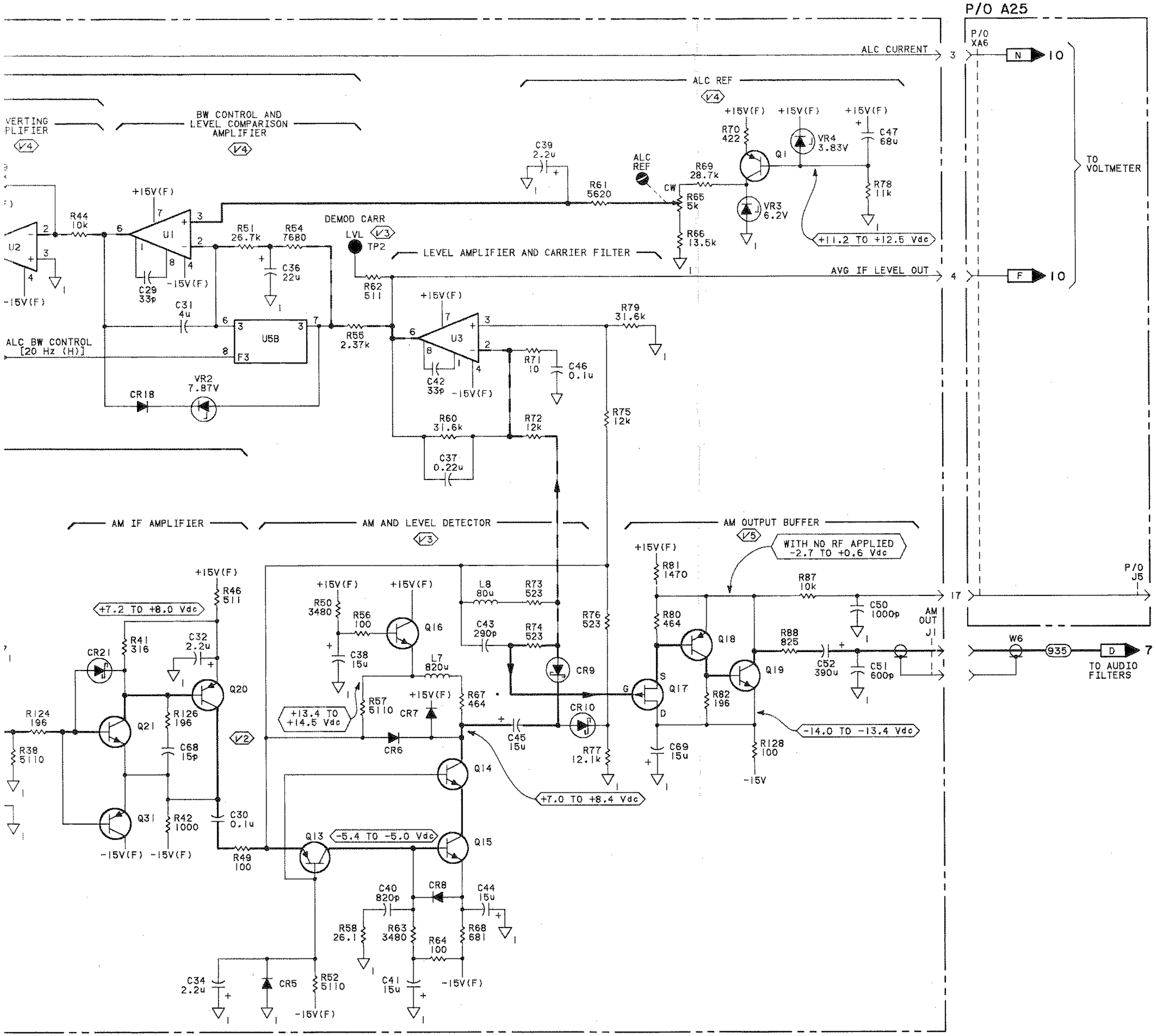
A5R1
TOP VIEW



SS9
P/O A5

Figure 8-85. Voltmeter-AUDIO Circuits (P/O Change 58)


P/O A6 AM DEMODULATOR ASSEMBLY (1 OF 2) (08901-60240)
P/O A25 AUDIO MOTHERBOARD ASSEMBLY (08901-60120)
ALC FEEDBACK AMPLIFIER
RESISTOR DRIVE AMPLIFIER
CONTROL CURRENT SOURCE
VOLTAGE VARIABLE AMPLIFIER
R-SETTING CIRCUIT
2.5 MHz LOW-PASS FILTER
AM IF BUFFER
ALC DEFEAT (H)
ALC (H)
FILTERED IF
FROM IF AMPLIFIER
IF IN
GND
TP1
ANALOG GROUND
DIGITAL GROUND
IF FLATNESS
-55 TO -45 mVdc
+45 TO +55 mVdc
8901A AM DEMODULATOR ASSEMBLY: 2309A



NOTES

1. SEE TABLE 8-6 FOR SCHEMATIC DIAGRAM NOTES.
2. ALL CAPACITOR VALUES IN FARADS.
3. ALL INDUCTOR VALUES IN HENRIES.

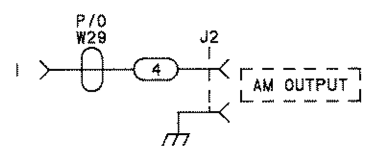
REFERENCE DESIGNATIONS

NO PREFIX	A6 CONT.
J12 W5,6,29	R1-10,13-39, 41,42,44, 46,49-52, 54-58,60- 82,87,88, 124,126, 128,129 TP2 U1-5 VR2-4
A6	
C1-9,11,14- 26,29-32, 34,36-47, 50-52,68, 69 CR5-10,18,21 J1,2 L1-5,7,8 Q1,2,4-8,13- 21,31	

NOT ASSIGNED: A6C10,12,13,27, 28,33,35,48,49; CR1-4,11,12; L6; Q3,22-28; R11,12,40,43, 45,47,48,53,59,83-86,127.

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1,4,13,20	1853-0007
Q2	1858-0010
Q5,8,15,16,21	1854-0404
Q6	1855-0420
Q7	1855-0421
Q14	1854-0637
Q17	1855-0082
Q18,31	1853-0281
Q19	1854-0477
U1,3	1826-0035
U2	1826-0043
U4	1826-0716
U5	1826-0606



P/O

Figure 8-73. AM Demodulator—ALC Loop Schematic Di

Change 28, P/O Figure 8-73. AM Demodulator-ALC Loop Schematic Diagram