Errata

Title & Document Type: 3312A Operating and Service Manual

Manual Part Number: 03312-90004

Revision Date: March 1990

HP References in this Manual

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

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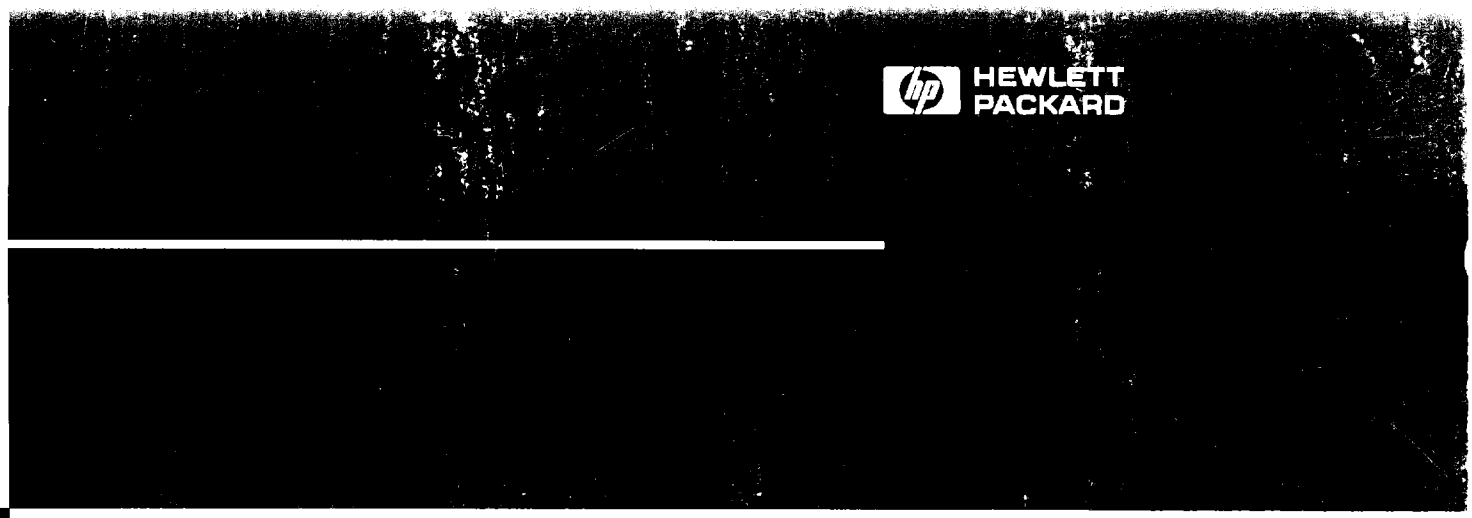
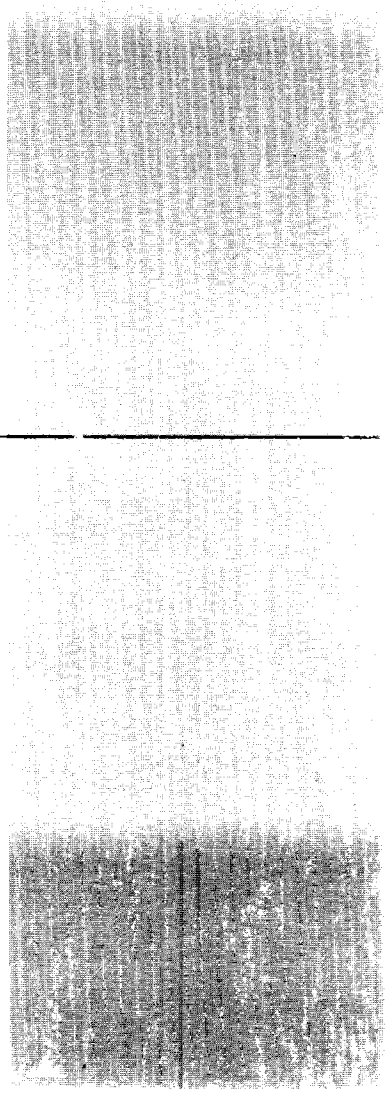
Agilent Technologies



HP 3312A
Operating and Service Manual
Function Generator



Warranty

The information contained in this document is subject to change without notice.

Hewlett-Packard makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties or merchantability and fitness for a particular purpose.

Hewlett-Packard shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

Safety Summmary

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

Ground the Instrument

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

Do Not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Keep Away from Live Circuits

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

Do Not Service or Adjust Alone

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

Do Not Substitute Parts or Modify Instrument

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure the safety features are maintained.

Dangerous Procedure Warnings

Warnings accompany potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

Safety Symbols

The following safety symbols are used throughout this manual and in the instrument. Familiarize yourself with each symbol and its meaning before operating this instrument.

General Definitions of Safety Symbols Used on Equipment or in Manuals

Instruction manual symbol. The product is marked with this symbol when it is necessary for the user to refer to the instruction manual to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).

Protective ground (earth) terminal. Used to identify any terminal which is intended for connection to an external protective conductor for protection against electrical shock in case of a fault, or to the terminal of a protective ground (earth) electrode.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.

Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

Alternating or direct current (power line).

Warning

The warning sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which if not correctly performed or adhered to, could result in injury or death to personnel.

Caution

The caution sign denotes a hazard. It calls attention to an operating procedure, practice, condition 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 or the user's data.

Hewlett-Packard
8600 Soper Hill Road
Everett, Washington 98205-1298

Printed in U.S.A

Operating and Service Manual

MODEL HP 3312A Function Generator

Serial Numbers
1432A01246 to 1432A06631

HEWLETT PACKARD

HP Part Number 03312-90004
Microfiche Part Number 03312-90054
Printed in U.S.A.

Print Date: March 1990

8600 Soper Hill Road, Everett, WA 98205-1298

Warning

To prevent potential fire or shock hazard, do not expose equipment to rain or moisture.

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HEWLETT PACKARD

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

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Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

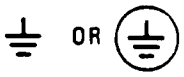
Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

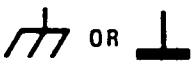
Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

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The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition 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.

NOTE: The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This manual contains installation procedures, operating instructions and maintenance information for the Model 3312A Function Generator. Instrument specifications and procedures for adjusting the instrument to those specifications, schematic diagrams, theory of operation, and troubleshooting information are provided for use in maintaining the instrument.

1-3. This section of the manual contains a description of the Model 3312A, the performance specifications and characteristics, and instrument identification information.

1-4. DESCRIPTION.

1-5. The Hewlett-Packard Model 3312A Function Generator is a compact, wide range, dual function generator consisting of a main generator and a modulation generator. The main generator provides sine, square, or triangle wave outputs over the frequency range of 0.1 Hz to 13 MHz. The modulation generator produces sine, square and triangle waveforms with a frequency range of 0.01 Hz to 10 kHz. The modulation generator can be used to Amplitude Modulate (AM) or Frequency Modulate (FM) the output signal of the main generator. The AM envelope can be adjusted from 0% to 100%; FM can change the carrier frequency up to ± 5%.

1-6. SWEEP OUTPUT.

1-7. For added versatility, the 3312A has a built-in sweep generator which can be used to sweep the frequency of the main generator. The frequency of the main generator can be swept as much as 100:1 on any range.

1-8. OUTPUT LEVEL.

1-9. The output voltage of the 3312A can be varied from 0 V to 10 V peak-to-peak into 50 ohms in four voltage ranges. A front panel control permits continuous adjustment within each voltage range. The dc level of the main generator output can be adjusted within the range of ± 10 volts using the front panel offset control. With the OFFSET in the CAL position the dc offset is eliminated.

1-10. BURST.

1-11. The burst is either a single pulse or a series of pulses which are rear panel selectable by a slide switch labeled SINGLE and MULTIPLE. The TRIGGER PHASE control adjusts the phase of the signal. FREE RUN disables the burst.

1-12. SYMMETRY.

1-13. The main and the modulation generators have separate front panel symmetry adjustments which will vary the symmetry of the output waveforms. The CAL position of each SYM knob will produce symmetrical waveforms. In the SWEEP mode, the SYM adjusts the sweep rate, and CAL selects a 90:10 ramp.

1-14. SPECIFICATIONS.

1-15. Table 1-1 is a complete list of the Model 3312A critical specifications. These specifications are the performance standards or limits against which the instrument can be tested. Table 1-2 lists some supplemental performance characteristics which are not specifications, but are typical characteristics included as additional information for the user.

1-16. Any changes in specifications due to manufacturing, design or traceability to the U.S. National Bureau of Standards are included in Table 1-1 of this manual. Specifications listed in this manual supersede all previous specifications for the Model 3312A.

1-17. INSTRUMENT AND MANUAL IDENTIFICATION.

1-18. The instrument serial number is located on the rear panel. Hewlett-Packard uses a two-section serial number consisting of a four-digit prefix and a five-digit suffix. A letter between the suffix and prefix identifies the country in which the instrument was manufactured (A = USA, G = West Germany, J = Japan, U = United Kingdom). All correspondence with Hewlett-Packard should include the complete serial number.

1-19. If the serial number of your instrument is lower than the one on the title page of this manual, refer to Section VIII for backdating information that will adapt this manual to your instrument.

Table 1-1. Specifications.

Dial Accuracy: ± 5% of full scale (After 1-hour warm-up.)
Square Wave Rise or Fall Time (10% to 90%): < ~~18~~ 20 nsec at 3 MHz and full rated output.
Abberations: < 10%.
Triangle Linearity Error: < 1% of rated amplitude at 100 Hz.
Variable Symmetry: 80:20 to 20:80 to 1 MHz.

Spectral Purity:
Sine Wave Distortion: < 0.5% THD from 10 Hz to 50 kHz. (X1 thru X10 k ranges).
> 30 dB below fundamental from 50 kHz to 13 MHz.

OUTPUT CHARACTERISTICS.

Impedance: 50Ω ± 10%.
Level: 20 V p-p into open circuit, 10 V p-p into 50 Ω at 1 kHz.
Level Flatness (Sine Wave): < ± 3% from 10 Hz to 100 kHz at full rated output (1 kHz reference). < ± 10% from 100 kHz to 10 MHz at full rated output.
Step Attenuator Accuracy: better than 5%.
Sync Output: Impedance: 50 Ω ± 10%, > 1 V p-p square wave into open circuit.
Rise or Fall Time (10% to 90%): < 10 nsec.
DC Offset: ± 10 volts maximum (subject to coarse amplitude attenuator setting).

MODULATION CHARACTERISTICS.

Internal Modulation Source
Output Level: > 1.0 V p-p into 10 kΩ.

Spectral Purity: Sine Wave Distortion: < 2% THD from 10 Hz to 10 kHz.

Amplitude Modulation
Carrier 3 dB Bandwidth: < 100 Hz to > 5 MHz.
Carrier Envelope Distortion: < 2% at 70% sine wave modulation with f_c = 1 MHz, f_m = 1 kHz.
External Sensitivity: < 10 V p-p for 100% modulation.
Frequency Modulation: ± 5%.
Deviation: 0 to 5% (internal).
Modulation Frequency:
Internal: 0.01 Hz to 10 kHz.
External: DC to > 50 kHz.
Distortion: < -35 dB at f_c = 10 MHz, f_m = 1 kHz, ~~10%~~ 1% modulation. (100 KHz peak deviation

Sweep
Ramp Linearity Error: < 1% at 100 Hz.

EXTERNAL FREQUENCY CONTROL.

Input Requirement: With dial set to 10, application of 0 to -2 V dc ± 20% to the VCO input will linearly decrease frequency by more than 1000:1. An ac voltage will FM the frequency about a dial setting within the limits of (.1<f<10) x range setting.

Linearity: The frequency vs voltage curve will be linear within 0.5% ~~over a 100:1 frequency range~~ of peak freq. for $f_{peak} \leq$ 1MHz over a 100:1 freq range. 5% of peak freq. for f_{peak} > 1MHz over a 100:1 freq. range)

Table 1-2. General Information.

MAIN GENERATOR CHARACTERISTICS.

General:
Sine, Square, triangle, ramp, and pulse.

Variable Symmetry.
Range is 80:20 to 20:80.

Frequency Characteristics
Range: 0.1 Hz to 13 MHz in 8 decade ranges.

Output Characteristics
Attenuator: 1:1, 10:1, 100:1, 1000:1 and > 10:1 continuous control.

MODULATION CHARACTERISTICS.

General:
Types: Internal AM, FM, Sweep, Trigger, Gate or Burst.
External AM, FM, Sweep, Trigger, Gate or Burst.

Amplitude Modulation:
Depth: 0 to 100%.
Modulation Frequency: 0.01 Hz to 10 kHz (internal).
DC to > 1 MHz (external).

Frequency Modulation:
Modulation Frequency: 0.01 Hz to 10 kHz (internal).
DC to > 50 kHz (external).

Sweep Characteristics
Sweep Width: < Range: 100:1 on any range.
Sweep Rate: 90:10 ramp, (0 Hz provides manual setting of "Sweep Start" without Modulation Generator oscillating).
Sweep Mode: Repetitive linear sweep between start and stop frequency settings. Retrace time can be increased with symmetry control.

Gate Characteristics
Frequency Range: 0.1 Hz to 1 MHz (useful to 10 MHz).
Start/Stop Phase Range: + 90° to - 80°.
Gating Signal Frequency Range (External): DC to 1 MHz. (TTL compatible input level.)

External Frequency Control
Range: 1000:1 on any range.

General:
Operating Temperature: 0°C to + 55°C; specifications apply from 0°C to 40°C.
Storage Temperature: - 40°C to + 75°C.
Power: 100/120/220/240 V + 5%, - 10%, switchable; 48 Hz to 440 Hz; ≤ 25 VA.

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section explains how to prepare the Model 3312A Function Generator for use. Included are initial inspection procedures, power and grounding requirements, environmental information, mounting instructions and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. If the shipping container is damaged it should be kept until the contents of the shipment have been checked mechanically and electrically. If the instrument does not pass a mechanical inspection or the electrical performance tests given in Section V, notify the carrier and refer to the warranty on the front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 3312A can be operated from any source of 100, 120, 220 or 240 volts ac + 5% −10%, of 48 Hz to 440 Hz frequency. The instrument can be easily adapted to the available line voltage by changing the position of the slide switches on the rear panel.

2-7. Figure 2-1 illustrates the standard power plug configurations that are used throughout the United States and in other countries. The -hp- part number shown directly below each plug drawing is the part number for a 3312A power cord equipped with the proper plug. If the appropriate power cord is not included with the instrument, notify the nearest Hewlett-Packard office and a replacement cord will be provided.

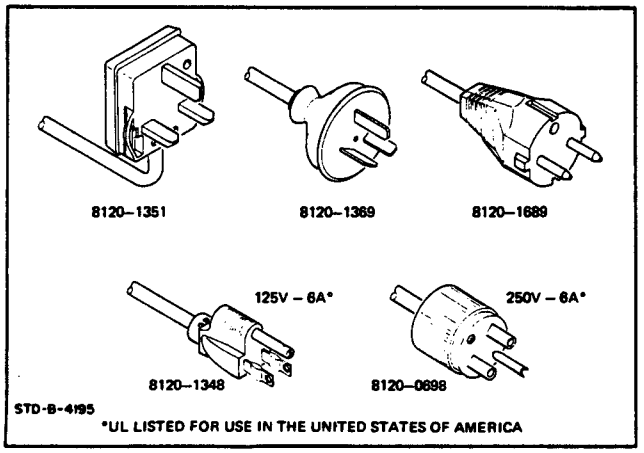


Figure 2-1. Power Plugs.

2-8. GROUNDING REQUIREMENTS.

2-9. For the safety of operating personnel, the instrument must be grounded. The offset pin on the power cable grounds the instrument when plugged into the proper receptacle.

2-10. INSTRUMENT MOUNTING.

2-11. Bench Use.

2-12. The front of the 3312A may be elevated for operating convenience by flipping down the bails which are attached to the two front feet of the instrument.

2-13. REPACKAGING FOR SHIPMENT.

2-14. The following paragraphs contain a general guide for repackaging the instrument for shipment. Refer to Paragraph 2-15 if the original container is to be used or 2-16 if it is not. If you have any questions, contact the nearest -hp- Sales and Service Office (see Appendix A for office locations).

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number and full serial number.

2-15. Place instrument in original container with appropriate packing material and seal well with strong tape or metal bands. If original container is not available, one can be acquired from your nearest -hp- Sales and Service Office.

2-16. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper, or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container "DELICATE INSTRUMENT," "FRAGILE," etc.

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains complete operating instructions for the Model 3312A Function Generator. Included is a brief description of the instrument, a description of controls and connectors, general operating information, and a basic operating procedure.

3-3. DESCRIPTION.

3-4. The 3312A Function Generator combines two separate function generators in one instrument - a main generator and a modulation generator. The frequency range of the main generator is 0.1 Hz to 13 MHz in eight decade ranges. The modulation generator frequency range is 0.01 Hz to 10 kHz. Both the main generator and the modulation generator provide sine, triangle, square, pulse and ramp outputs. The symmetry of all waveforms can be varied over a range of 80:20 to 20:80 on the main generator and is set at 10:90 on the modulation generator.

3-5. The main generator can be modulated or triggered by the modulation generator to provide AM, FM, sweep or burst. The main generator can also be modulated by an external source connected to the MOD connector on the modulation generator. The frequency of the main generator can be externally controlled by applying an ac or dc voltage to the VCO input.

3-6. The output attenuator has a range of more than 1000:1 so that output levels ranging from 1 mV p-p to 10 V p-p into 50 ohms can be obtained.

3-7. The 3312A has a dc offset capability which allows the dc operating point of the main generator output to be adjusted from - 10 V to + 10 V dc (as long as the dc offset plus instantaneous ac does not exceed ± 10 V). The dc offset can be adjusted using the front panel OFFSET control or set to 0 V by pushing the associated CAL button.

3-8. CONTROLS AND INDICATORS.

3-9. Figures 3-1 and 3-2 illustrate and describe the function of all front and rear panel controls, connectors and indicators. The description of each item is keyed to the drawing within the figure.

3-10. GENERAL OPERATING INFORMATION.

3-11. Grounding.

3-12. To protect operating personnel, the 3312A chassis must be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cord, which, when plugged into the proper receptical, grounds the instrument. The offset pin of the power plug is the ground connection. All input and output commons are connected directly to outer chassis (frame) ground through the offset pin on the power cord.

WARNING

The outer shells of all input and output BNC jacks are connected to the chassis. To protect the operator from electrical shock, DO NOT float this instrument.

3-13. Main Generator Outputs.

3-14. The main generator has two outputs, a main signal output and a sync output. The main signal output (labeled V p-p) provides the sine, square and triangle outputs. The sync output (Paragraph 3-19) provides a pulse which can be used for external timing purposes. Both outputs are BNC connectors located on the front panel of the instrument.

3-15. Main Signal Output.

3-16. The output of the main generator is dc coupled to supply both ac and dc components of the output waveform. The main generator output level is 10 V p-p into 50 ohms. The SYNC output level is .25 V p-p into 50 ohms. Output impedance of both outputs is 50 ohms nominal.

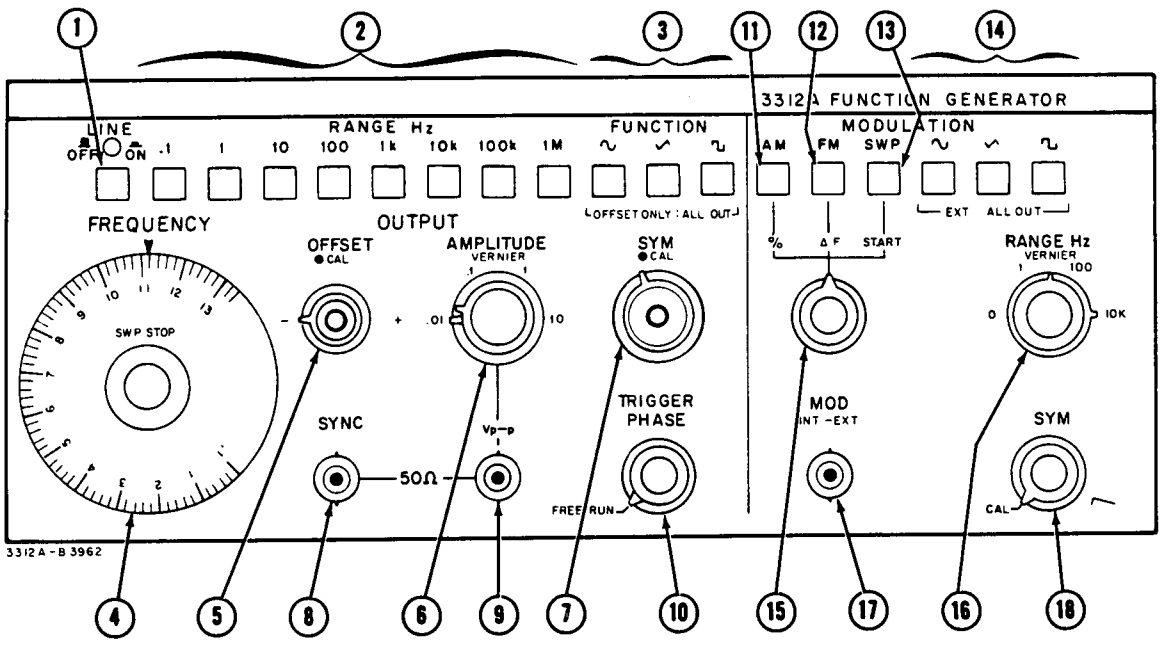
3-17. Connections to this output should be made using shielded cables equipped with BNC connectors. Table 3-1 is a list of recommended -hp- cables. In order for the 3312A to meet the specifications listed in Table 1-1, the main signal output must be terminated into 50 ohms. The -hp- Model 11048C 50 ohm Feedthru Termination is recommended. Always place the termination at the load *end* of the transmission line.

Table 3-1. Cable Assemblies.

10502A 9" Cable Assembly
11086A 24" Cable Assembly
10519A 72" Cable Assembly

3-18. SYNC Output.

3-19. The SYNC output supplies a one volt rectangular wave which is 180° out of phase with the main generator output signal. The leading edge and the trailing edge of the SYNC pulse occur at the zero crossing point of the output waveform. The frequency and duty cycle of this pulse vary with the main output signal.



(1) LINE: S18 switch applies or removes ac power. The green LED is lit when ON.

(2) RANGE Hz: S1 through S8, pushbuttons select frequency range. RANGE selection times the reading on the FREQUENCY dial determines the output frequency of the main generator.

(3) FUNCTION: Interlocked buttons select one of three functions. When they are all out, the dc level may be set accurately (S9, S10, S11).

(4) FREQUENCY: Sets the desired frequency within the range of any of the RANGE pushbuttons.

(5) OFFSET: R616 sets the dc operating point of any function. CAL position removes the dc offset. $E_{ac} + E_{dc}$ must be less than 10 V or clipping of the waveform will occur.

(6) AMPLITUDE: S22, R613(a), (b), adjust the peak-to-peak amplitude of the waveform. It is attenuated in steps of 1:1, 10:1, 100:1, 1000:1; the VERNIER adjusts from zero to maximum output volts for the particular range selected.

(7) SYM: R608 varies the symmetry of output waveforms and the SYNC output. CAL is symmetrical.

(8) SYNC: A square wave 180° out of phase with the main generator. Useful for synchronizing external instruments or driving a counter.

(9) OUTPUT: Terminal for all main generator functions. 20 V p-p into open circuit or 10 V p-p into 50 ohms, in the 1:1 attenuator position.

(10) TRIGGER PHASE: R615 sets the starting phase of the output signal in the burst mode. FREE RUN disables the burst.

(11) AM: Selects amplitude modulation. Functional for internal or external modulation.

(12) FM: S13 selects frequency modulation. Functional for internal or external modulation.

(13) SWP: S14 selects sweep mode. This function overrides AM and FM.

(14) ~ ⋀ ⊓ : S15, S16, S17 select the modulating function. External modulation is possible when all buttons are out, and the modulating signal is applied to the MOD INT-EXT jack.

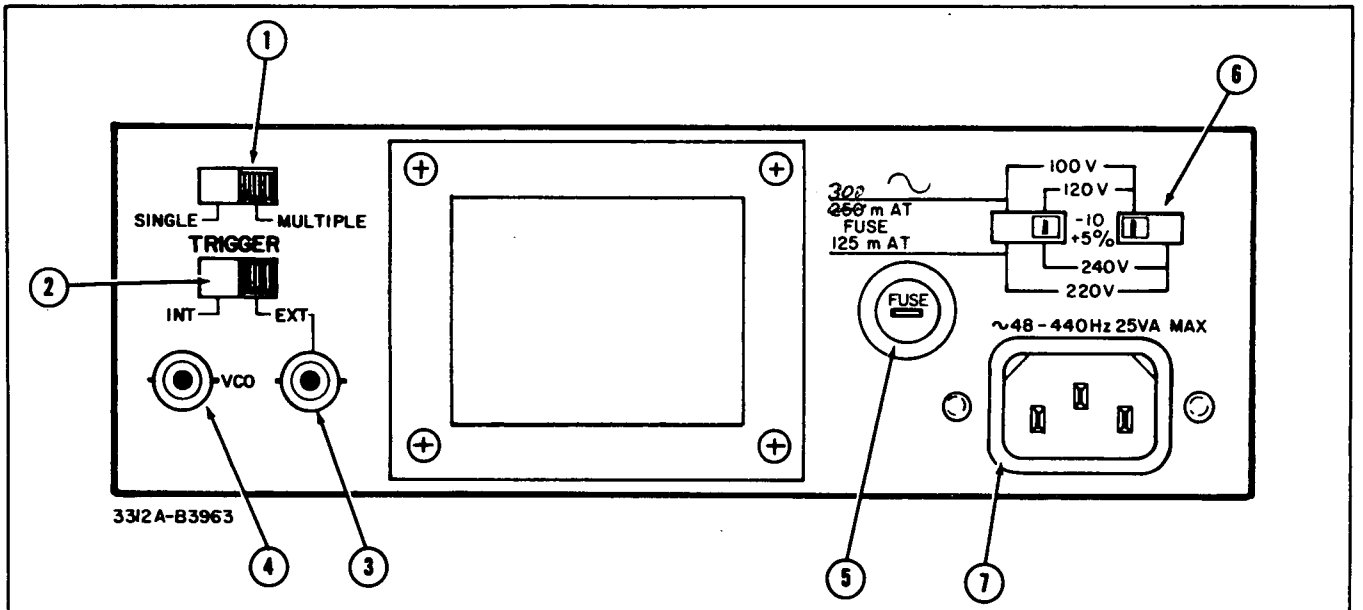
(15) % Δ F START: R612 selects the percent of AM, the deviation in FM, or the start frequency of the SWP.

(16) RANGE Hz: R602, S21 select one of the three ranges of modulating frequencies with continuous control within each range via the VERNIER. The 0 position is used to set the start sweep frequency.

(17) MOD INT-EXT: Input for external AM or FM. Waveforms of the modulation generator are also available at this output when internal modulation is used.

(18) SYM: R601 varies the symmetry of the modulation output waveform. CAL selects a 90:10 ramp for SWP and symmetrical for all other functions.

Figure 3-1. Front Panel.



1. SINGLE/MULTIPLE: S19 selects single cycle or multiple cycles in the burst mode.
2. TRIGGER: S20 selects either an internal or external trigger.
3. EXTERNAL TRIGGER INPUT: for external burst control.
4. VCO: Input for an external frequency control voltage (Paragraph 3-66).
5. FUSE: F1 protects the instrument from current overloading.
6. 100/120/220/240: S23, S24 slide switches to match the instrument to ac line voltage being used.
7. POWER RECEPTACLE: Primary power is connected to the instrument via the power cord.

Figure 3-2. Rear Panel.

By connecting the SYNC output to the input of an appropriate frequency measuring device, the output frequency can be set with greater accuracy and resolution. The SYNC output can also be used to trigger an oscilloscope or synchronize an external oscillator.

3-20. Input Constraints.

3-21. The 3312A inputs and outputs are dc coupled. The maximum instantaneous ac plus dc voltages which can be safely applied to the inputs are ± 10 V. In some applications it may be necessary to connect one of the 3312A outputs to an ac or dc source node in a circuit. In these cases, the dc plus instantaneous value of external signal level applied to the 3312A outputs must not exceed ± 10 V.

CAUTION

Exceeding input or output voltages of ±10 V (dc plus instantaneous ac) can cause damage to the input or output circuitry of the 3312A.

3-22. Modulation Generator Input/Output.

3-23. The BNC connector of the modulation generator (labeled MOD) serves as both an input and an output. The waveforms from the internal modulation generator (sine, square or triangle) are available at the MOD connector and are useful for synchronizing an oscilloscope when using the AM, FM, or sweep modes. When none of the modulation generator's function buttons is pressed, an external modulation source can be applied through the MOD connector. Refer to Paragraph 3-46 for information concerning external operation.

3-24. The modulation generator input/output is dc coupled and the impedance is a nominal 8 kilohms. Refer to Table 3-1 for recommended cable assemblies to use with the modulation generator.

3-25. Output Characteristics.

3-26. The main generator and the modulation generator supply five different output waveforms.

a. Sine
b. Square
c. Triangle
d. Ramp
e. Pulse

3-27. Sine Wave Output.

3-28. The Total Harmonic Distortion (THD) of the main sine wave, including spurious and harmonics, is less than 0.5% from 10 Hz to 50 kHz and greater than 30 dB below fundamental from 50 kHz to 13 MHz. The modulation sine wave distortion is less than 2% THD from 10 Hz to 10 kHz.

3-29. Square Wave Output.

3-30. The RMS value of a symmetrical (50% duty cycle) square waveform is equal to its peak value. The rise or fall time is less than 18 nanoseconds between the 10% and 90% points of the p-p output square wave. The aberrations, or deviations from the final settling amplitude of the square wave after overshoot, will not vary more than ± 10% of the final value.

3-31. Triangle Output.

3-32. The RMS value of the triangle waveform is 0.557 times the peak value. The triangle ramp will not deviate from a straight line any more than 1% of the total peak-to-peak value of the ramp. Non-linearity is, therefore, negligible.

3-33. Ramp.

3-34. A ramp output can be obtained from the main generator by selecting the triangle waveform and adjusting the symmetry control knob. The ramp output of the main generator can be varied in amplitude with the AMPLITUDE knob. The ramp output of the modulation generator has a fixed amplitude, however, the slope or retrace time can be varied with the SYM knob on the modulation generator.

3-35. Pulse.

3-36. A pulse with a variable amplitude from 0 V to 20 V p-p into an open circuit, is possible with the main generator. This involves selecting single cycle burst set to start at the zero point with the TRIGGER PHASE knob, and determining the pulse width with the FREQUENCY dial. The SYNC output can deliver a <10 nsec rise time pulse by changing the symmetry of the main generator.

3-37. Gate or Burst.

3-38. The usable frequency range of the burst function is from 0.1 Hz to 10 MHz. The trigger phase can be started anywhere from - 80° to + 90°. The stop will be at that point at the termination of the burst (see Figure 3-3).

3-39. AM.

3-40. The Main Generator output can be amplitude modulated up to 100%. The modulation frequency ranges from 0.01 Hz to 10 kHz. Any of the modulation generator's functions can be used to AM.

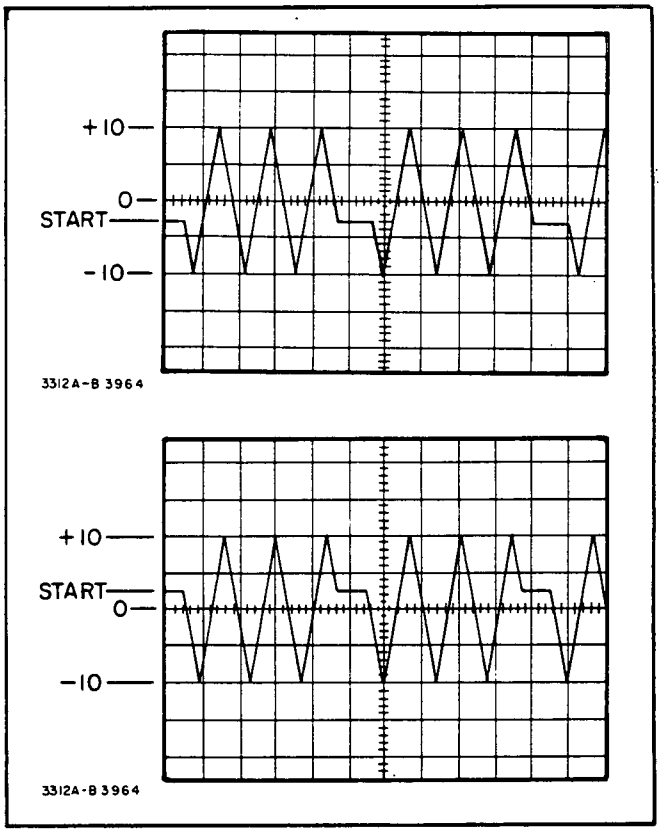


Figure 3-3. Phase Control of Burst.

NOTE

The 3312A is capable of > 100% modulation, ie., the strength of the modulating signal can be greater than needed to just bring the carrier level to zero. Overmodulation may cause distortion of the modulating information.

3-41. The extent of the amplitude variation is expressed as the percentage of modulation. The following formula defines the relationship between F_c and F_m (see Figure 3-4).

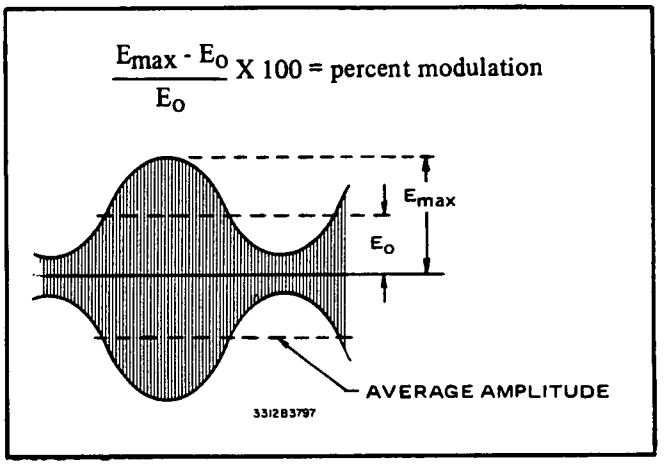


Figure 3-4. Percent Modulation.

3-42. FM.

3-43. The frequency of the main generator can be varied up to ± 5% by the modulation generator. The modulation frequency can be set from 0.01 Hz to 10 kHz, and any of the modulation waveforms can be used to FM.

3-44. SWP.

3-45. When the SWP button is pressed, the modulation generator produces a linear ramp which sweeps the frequency of the main generator. With the RANGE Hz knob in the 0 Hz position, the "Sweep Start" frequency can be set. The stop frequency, or the frequency at which the sweep terminates, is set with the main frequency dial. The rate of sweep is governed by the SYM knob.

3-46. External Control.

3-47. The front panel MOD INT-EXT input/output connector is to be used for external amplitude modulating or frequency modulating the main generator. For AM operation, an external input of less than 10 V p-p will give 100% modulation. For FM operation, the external frequency may be varied from dc to greater than 50 kHz. The AM and FM pushbuttons must still be used.

3-48. The frequency of the main generator can be tuned remotely by applying 0 V to - 2 V dc to the VCO connector on the rear panel. With the dial set to 10, any range can be varied over the entire dial range within the limit set by the range pushbuttons. Frequency modulation can also be accomplished by applying an ac voltage to the VCO terminal. Simultaneous AM and FM is possible with the VCO input used to vary frequency and the MOD input used for the AM signal.

3-49. Frequency.

3-50. The frequency range of the main generator is 0.1 Hz to 13 MHz in eight overlapping ranges. The dial accuracy is ± 5% of full scale which means that the greatest accuracy will be obtained at the high end of the dial. For instance, if the dial were set to "1" on the 1 kHz range, the output frequency would be 1 kHz ±650 Hz. If, on the other hand, the dial were set to "10" on the 100 Hz range, the output frequency would be 1 kHz ± 65 Hz.

3-51. The frequency range of the modulation generator is 0.01 Hz to 10 kHz. The RANGE Hz knob selects the upper frequency limit and the VERNIER is used to select frequencies within the selected range.

3-52. Amplitude.

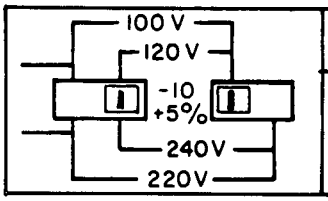
3-53. The amplitude of the main generator can be adjusted from 0 to 20 V p-p into an open circuit or from 0 to 10 V p-p into 50 ohms. Amplitude of the modulation generator is fixed at 1 V p-p into an open circuit, except in SWP operation (Paragraph 3-45).

3-54. BASIC OPERATING PROCEDURES.

3-55. Instrument Turn-On.

a. Check the line voltage at the point of installation.

b. Refer to Figure 3-5. Set the rear panel Line Selector switches to the setting that corresponds with the line voltage to be used. Line voltage must be within - 10% to + 5% of the selected voltage setting. Line frequency must be within the range of 48 Hz to 66 Hz.



Line Voltage	S1	S2
100	Left	Left
120	Right	Left
220	Left	Right
240	Right	Right

Figure 3-5. Line Selector Switches.

c. Verify that the proper fuse is installed in the rear panel fuse holder.

Line Setting	Fuse Type	-hp- Part No.
100 V/120 V	~~.25~~ .30 A 250 V Slo Blow	2110-0201
220 V/240 V	.125 V 250 V Slo Blow	2110-0318

d. Connect the detachable ac power cord to the rear panel power receptacle.

e. Set the LINE switch to the ON position. The green light will illuminate.

3-56. Fuse Replacement.

3-57. The main ac line fuse is located on the rear panel next to the line power receptacle. Remove the line power cord before attempting to remove the fuse. Figure 3-6 shows how to replace the fuse.

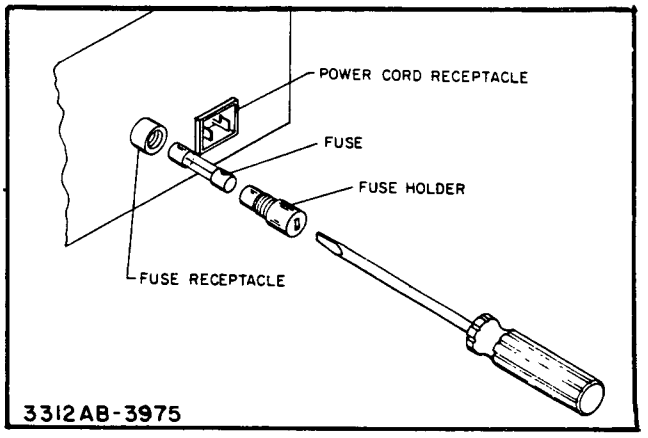


Figure 3-6. Fuse Replacement.

3-58. Main Generator Operation.

3-59. The sine triangle and square waveforms, selected with interlocking pushbuttons, are available at the BNC output jack. The RANGE Hz pushbuttons and frequency dial select frequencies from 0.1 Hz to 13 MHz in eight overlapping ranges. The frequency dial scale must be multiplied by the RANGE Hz setting to obtain the frequency.

3-60. With the AMPLITUDE knob in the 10 position and no load, a 10 volt peak signal is selected. The VERNIER control adjusts the voltage from greater than 10 volts to 1 volt at that setting. In the 1 position the voltage is adjustable from 1 volt to .1 volts; in the .1 position the voltage is adjustable from .1 volts to .01 volts; and in the .01 position from .01 volts to 0.

3-61. The symmetry of any waveform can be varied with the SYM knob. The square waveform can be varied from symmetrical to a ratio of 80:20 to 20:80 up to 1 MHz.

3-62. OFFSET changes the dc level of the waveform. The CAL button eliminates dc offset. The peak ac voltage plus the dc offset should not exceed 10 V to avoid clipping of the output waveform.

3-63. Burst.

3-64. With the rear panel TRIGGER switch (2) set to INT, the upper slide switch (1) set to either SINGLE or MULTIPLE, and TRIGGER PHASE (10) out of the FREE RUN position, internal burst is initiated. The TRIGGER PHASE knob controls the starting and stopping phase of the output waveform. The SINGLE-MULTIPLE switch selects a single cycle or multiple cycles respectively. Pulses are obtained only when the square wave function is pushed.

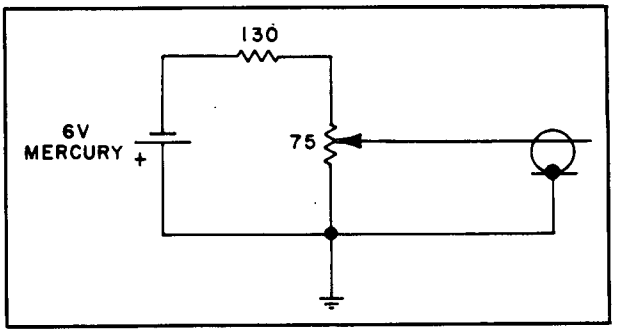


Figure 3-7. External VCO.

The pulse width is set by the main generator's FREQUENCY dial and the modulation generator's RANGE Hz knob sets the repetition rate. The TRIGGER PHASE knob in the FREE RUN position disables the burst (see Figure 3-11 for burst operation).

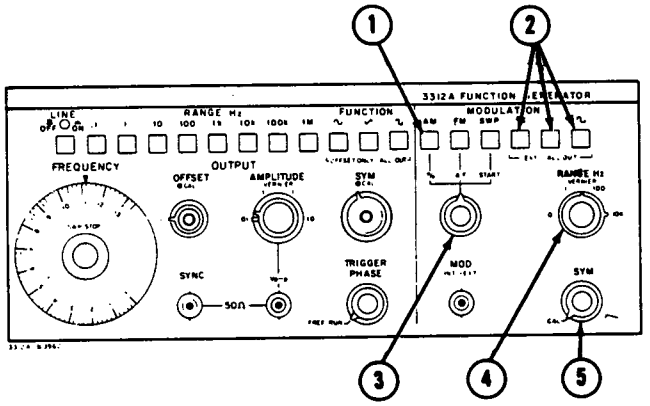
3-65. With the rear panel slide switch (2) set to EXT, an external burst may be applied in either single or multiple cycles. TRIGGER PHASE is still operational. The external gating signal frequency range is from dc to 1 MHz. The input voltages must be TTL compatible.

3-66. VCO.

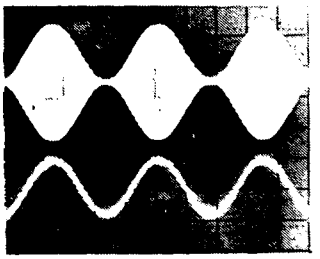
3-67. A dc voltage from 0 V to - 2 V applied to the rear panel VCO connector is sufficient to vary the frequency of the main generator over three decades. Since some dc power supplies induce some noise, a supply similar to the one in Figure 3-7 works well.

3-68. Modulation Generator Operation.

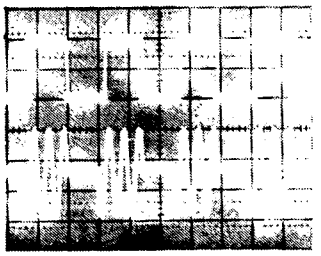
3-69. Figures 3-8 through 3-10 are operating illustrations containing step-by-step operating procedures indexed to the



1. Press AM pushbutton.
2. Select a function.
3. Set the percent modulation.
4. Set the modulation frequency.
5. SYM in the CAL position.



AM with sine wave

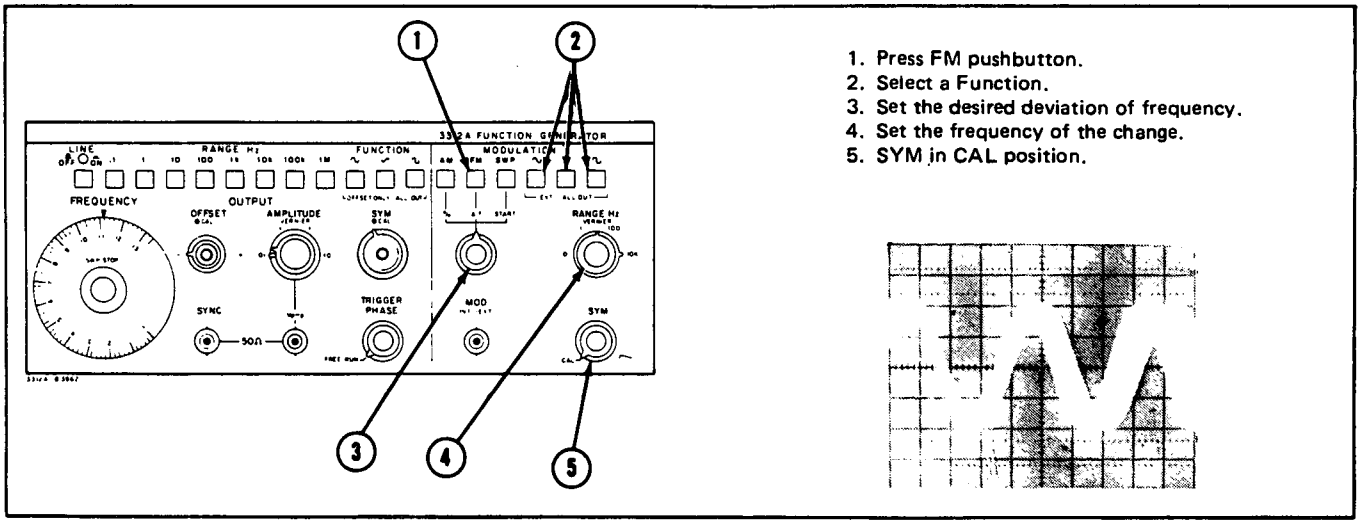


AM with square wave

Figure 3-8. AM Operation.

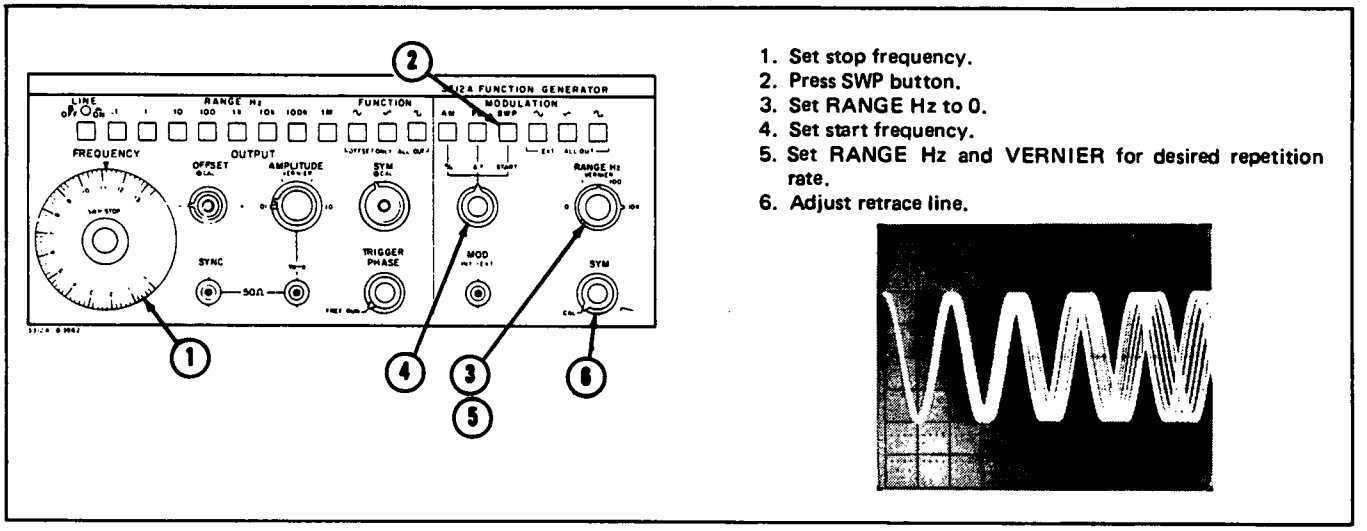
illustrations. The figures describe the operations to be accomplished in achieving the different modes of operation.

3-70. The operating procedure must be performed in the sequence given, as succeeding steps may depend on control settings and results of previous steps. In all cases, it is assumed that the main generator is set to the frequency and amplitude desired and that *all* modulation generator function pushbuttons are in the OUT position.



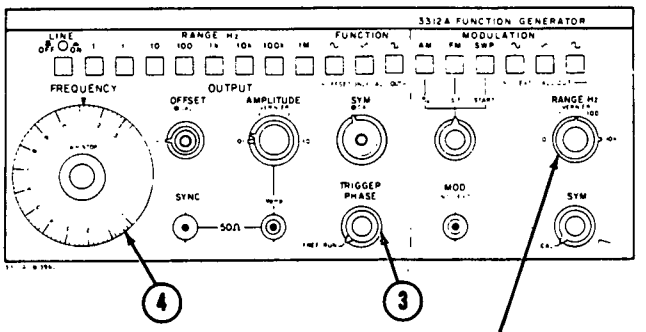
1. Press FM pushbutton.
2. Select a Function.
3. Set the desired deviation of frequency.
4. Set the frequency of the change.
5. SYM in CAL position.

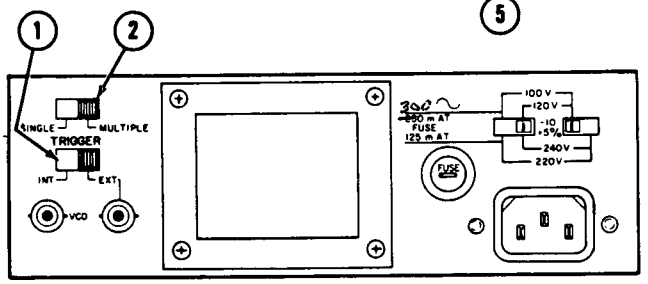
Figure 3-9. FM Operation.



1. Set stop frequency.
2. Press SWP button.
3. Set RANGE Hz to 0.
4. Set start frequency.
5. Set RANGE Hz and VERNIER for desired repetition rate.
6. Adjust retrace line.

Figure 3-10. Sweep Operation.

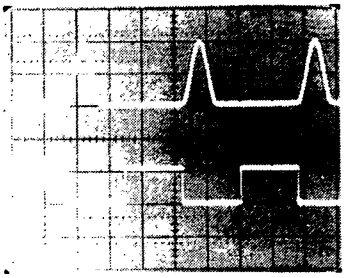




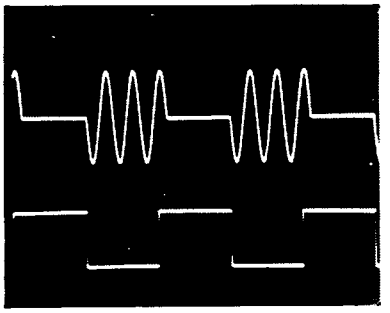
3312A-83983

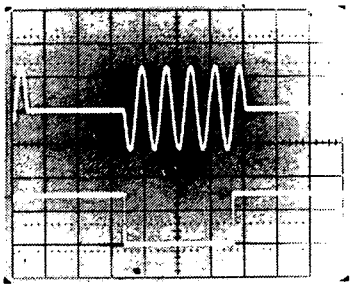
1. Set rear panel slide switch to INT.
2. Select either MULTIPLE or SINGLE with rear panel slide switch.
3. Rotate TRIGGER PHASE clockwise to desired phase.
4. Set frequency of burst.
5. Set repetition rate.

NOTE The phase of the square function is unaffected by TRIGGER PHASE.

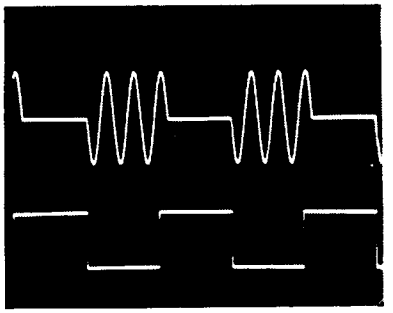


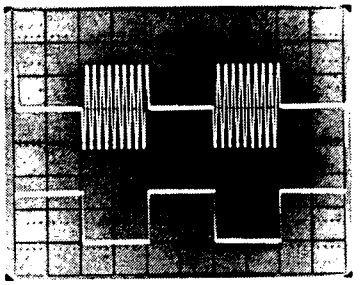
TRIGGER PHASE fully CW, SINGLE mode.





Repetition rate varied, MULTIPLE.





Frequency of burst varied, MULTIPLE mode.

Figure 3-11. Burst Operation.

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains a complete theory of operation for the Model 3312A Function Generator. The theory is divided into two levels:

1. Basic Block Diagram Description
2. Functional Block Diagram Description

Detailed circuit descriptions are given for unique complex circuits. These descriptions may be helpful when troubleshooting the instrument.

4-3. DESCRIPTION.

4-4. The 3312A combines two separate, independent function generators referred to as the main generator and the modulation generator. The main generator output can be controlled by the modulation generator. The major features of the 3312A are the 0.1 Hz to 13 MHz frequency range of the main generator and the AM, FM, sweep and tone burst capabilities of the modulation generator. A basic block diagram of the 3312A is shown in Figure 4-1.

4-5. BASIC BLOCK DIAGRAM DESCRIPTION.

4-6. The main generator of the 3312A uses a voltage to frequency conversion technique. A triangle waveform is generated by charging and discharging a capacitor from a constant current source. The time required to charge and discharge the capacitor determines the period of one cycle and, therefore, the frequency.

4-7. The triangle waveform from the Triangle Generator is applied to the Voltage Comparator which acts as an amplitude limiter. As the triangle waveform alternately crosses the upper and lower switching levels of the limiter input, a square wave is generated at the output of the Voltage Comparator. This square wave is fed back to the Triangle Generator where it controls the charge/discharge cycle of the triangle output.

4-8. To obtain a sine wave, the triangle wave is shaped by a diode network in the Sine Shaper. The diode network serves as a non-linear load which varies the attenuation of the input triangle according to its level.

4-9. The modulation generator can amplitude modulate, frequency modulate, sweep, or initiate a burst from, the main generator output. Sweep and frequency modulation modes control the voltage output of the tuning amplifier which determines the frequency. In amplitude modulation, the main signal is routed through a balanced modulator where it is mixed with the modulating signal. The percent of modulation is controlled by the level of the modulating signal.

4-10. The tone burst is accomplished by gating the main generator output on and off. Multiple or single cycle operation is determined by the duration of the low state of the Burst Control.

4-11. The output amplifier has separate parallel paths for the high and low frequencies. This gives it wide bandwidth and a high slew rate to maintain good square and triangle wave shape without compromising dc stability and low offset. An integrated-circuit operational amplifier is used

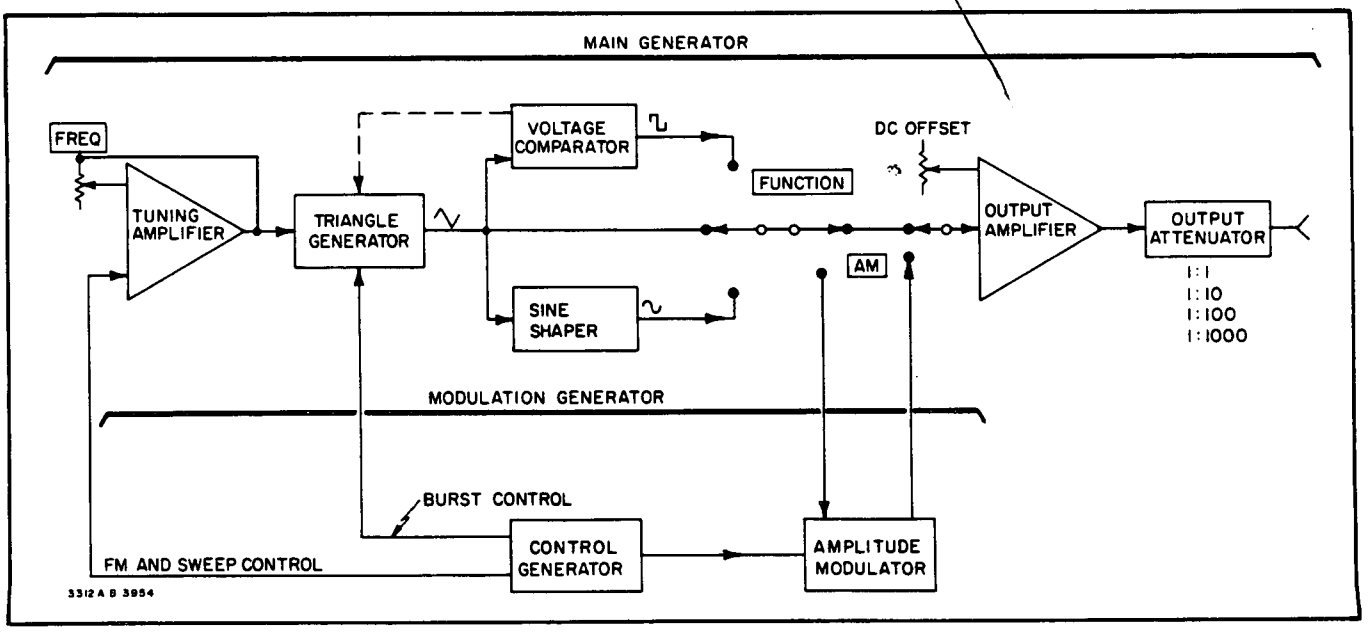


Figure 4-1. Basic Block Diagram.

for the low frequencies while the ac-coupled high-frequency path is optimized for wide bandwidth. The two paths are summed in the final gain stage and then buffered through cascaded emitter-followers to the output.

4-12. The Output Attenuator provides selectable attenuation for the output and an impedance match to the 50 ohm output terminal. The attenuator reduces the amplitude of the output signal by factors of 1, 10, 100, or 1000.

4-13. FUNCTIONAL BLOCK DIAGRAM DESCRIPTION.

4-14. Refer to the Functional Block diagram, Figure 7-1 for the following discussion. Detailed circuit descriptions are referenced to figures or to the circuit diagrams of Section VII.

4-15. The 3312A can be divided into three major sections:

1. Main Generator Section (Paragraph 4-16)
2. Output Section (Paragraph 4-29)
3. Modulation Section (Paragraph 4-33)

4-16. Main Generator Section.

4-17. Tuning Amplifier. The Tuning Amplifier is a summing amplifier which sums any current from the VCO INPUT or the modulation source with the current present at the input of the amplifier. The output voltage of the amplifier is a weighted average of the input signal voltages. The Frequency Control (Dial) varies the amount of voltage seen at the output of the Tuning Amplifier, which determines the frequency.

4-18. Symmetry Switch and Vernier. The front panel Symmetry Switch operates in two modes. With the front panel control in the CAL position (Figure 4-2) the output of the Tuning Amplifier is connected, through two nominal 5 kΩ resistors, to the non-inverting input of U102 and the inverting input of U103. Because the gain of U102 is equal to that of U103, the magnitude of the voltage at the emitters of Q101 and Q102 is equal, but due to the inversion of U103, the emitter of Q101 is positive with respect to ground and the emitter of Q102 is negative with respect to ground. In the calibrated position, equal currents flow through R122 and R123.

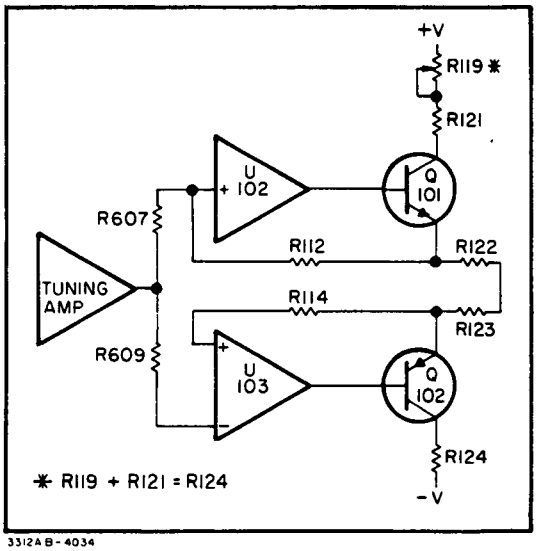


Figure 4-2. Calibrated Symmetry.

4-19. During variable symmetry operation (Figure 4-3), the output of the Tuning Amplifier goes to the wiper arm of the symmetry Vernier, and the junction of R122 and R123 is grounded. Adjusting the position of the wiper arm varies the input resistance of U102 and U103 and, therefore, the gain. The emitters of Q101 and Q102 will remain opposite in polarity, but the magnitude of the voltage will differ. In addition, different currents will flow through R122 and R123, which means different currents in the integrating capacitance, so that the output waveform will no longer have a 50% duty cycle. Instead, the duty cycle may be varied from 80% to 20% or 20% to 80%.

4-20. Positive and Negative Current Sources. The voltages set up by the symmetry stage are transferred to the integrating current sources through two operational amplifiers. Since amplifier input impedance is near infinity, zero current flows into the amplifier, consequently the voltage across R119 + R121 and R124 will appear across R117 and R126 respectively. The collector diodes of Q106 and Q107 (Figures 7-2) are current sources controlled by the emitter current established by R117 and R126. The RANGE Hz switches change the parallel resistances of R117 and R126 which influence the ramp time of the integrating capacitance and, therefore, the frequency.

4-21. Diode Switch. The gating circuit of the Diode Switch (Figure 7-2) allows for the charge or discharge of the integrating capacitance. The high speed comparator, U201 (Figure 7-3), controls the signal path through the switch. When pin 2 of U201 is high, CR204 and CR206 are conducting, CR203 and CR207 are reverse biased, and the integrating capacitor charges. When pin 2 goes low, CR203 and CR207 conduct, CR204 and CR206 are reverse biased, and the integrating capacitor discharges.

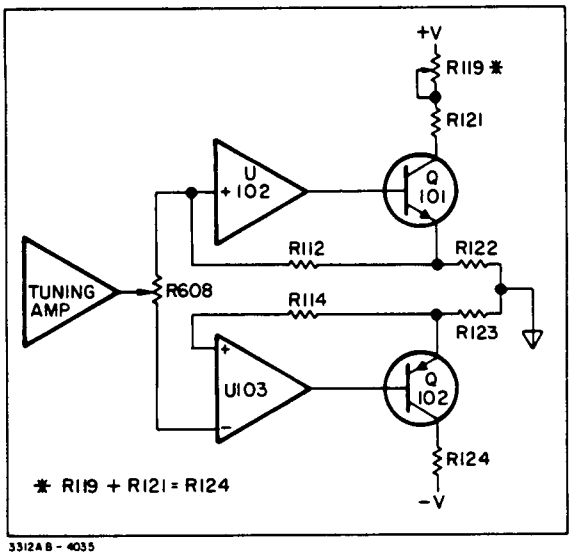


Figure 4-3. Variable Symmetry.

4-22. When the diode switch is reverse biased there is a diode capacitance which distorts the peak of the triangle (see Figure 4-4). This distortion is removed by the level shifting circuit of Q401 and C404. The square wave at the collector of Q401 is passed through the ac voltage divider of C404 and C205 and added to the triangle wave to eliminate the "drop-off" caused by diode capacitance.

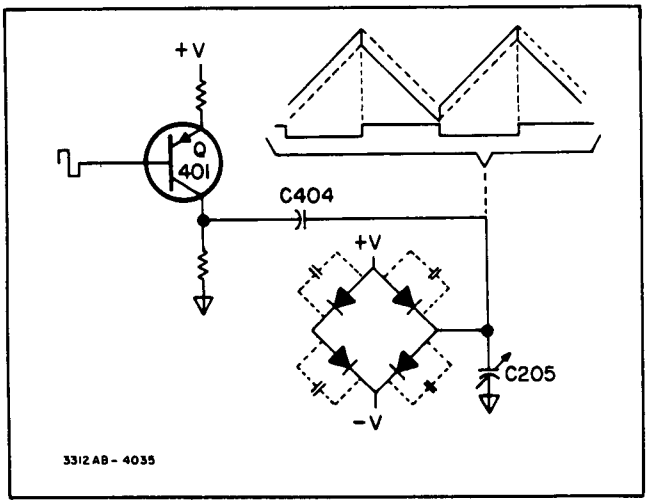


Figure 4-4. Level Shifter.

4-23. Integrating Capacitance. The integrating capacitors are C205, C201, C202, C203, C204, and C206. Because the current charging and discharging is constant, except for direction, the voltage across the integrating capacitance will be triangular. The resulting waveform is varied in frequency by changing the current and capacitance with connections through the RANGE Hz switches and the FREQUENCY dial.

4-24. Buffer Amplifier. The Buffer Amplifier (Figure 7-2) has a gain of one and consists of a FET input and a push-pull output. The high input impedance of the FET provides isolation, and the emitter followers Q202 and Q203, form a push-pull circuit. Diodes CR209 and CR211 are temperature compensating diodes.

4-25. Comparator. While the integrating capacitor is charging, the positive-going ramp is applied to pin 4 of U201 (Figure 7-3). The positive-going ramp is compared in magnitude, to the square wave on pin 2. Upon coincidence, the Comparator changes state, reversing the biasing of the gating diodes, and the integrating capacitance discharges. Coincidence of the negative-going ramp with the square wave now at its negative limit, switches the Comparator back to the original state, completing one cycle of operation.

4-26. The square wave output of U201 pin 5 is processed by a ± 5 V diode clamping network to provide the square wave output.

4-27. Sync Generator. The Sync Generator is a simple divider network which attenuates the output of the ± 5 V clamp. The sync output is, therefore, always a square wave in phase with the main generator (180° out of phase with the square wave output due to output amplifier inversion) and under the control of the Symmetry Switch.

4-28. Sine Shaper. The triangle wave from the Buffer Amplifier (Figure 7-3) is connected through R257 to the sine synthesizing diodes. The diodes of the sine network are reverse biased by the resistive dividers made up of R259, R262, R263, etc. As the triangle ramp goes positive, the bias is overcome and the diodes in the lower half turn on to produce a non-linear loading effect on the triangle wave. When the ramp reaches a negative level, the upper half of the sine shaping network begins to load the triangle wave thus shaping the negative half of the wave. The diodes in this section are selected for their soft turn-on characteristics to insure a smooth sine-shaped curve.

4-29. Transistors Q216, Q217, Q218 and Q219 compensate for thermal changes. This insures that the proper bias level is maintained over a wide temperature range. In the Model 3312A, the sine shaper is followed by a low-pass LC filter that has a sharp cutoff at 14 MHz. This filter attenuates third harmonics substantially at generator frequencies above 5 MHz, enabling the instrument to produce sine waves with all harmonics more than 30 dB below the fundamental up to its maximum frequency.

4-30. Output Section.

4-31. The output section consists of the Output Amplifier and the Output Attenuator (Figure 7-4).

4-32. The amplifier system has a voltage gain of - X16 and has been impedance matched on both sides. The ac signal is coupled through Q501 to Q502 and Q503. To obtain a frequency response that extends to zero, the main output is direct coupled to U501 and then to the complementary stage of Q504 and Q507. The dc offset is summed into pin 2 of U501 via R504. In the CAL position, R504 is opened and no offset is summed into the output amplifier.

4-33. The output is dc coupled to the output attenuator. The step attenuator consists of resistive attenuator sections of 20 dB steps with an impedance of 50 ohms.

4-34. Modulation Generator.

4-35. Signal Generator. Basic to this circuit are the integrator U301 and the comparator U302 (Figure 4-5). By integrating the square wave at its input the integrator generates a triangle wave. The level of the triangle is then compared to the square wave and when the voltage at the input node to the comparator equals zero $[R_1 (E_3 - E_2 / R_1 + R_2) = E_2]$ the comparator output switches states. The square wave output from the comparator is then inverted, clamped and fed back to the inverter to control the generation of the triangle wave.

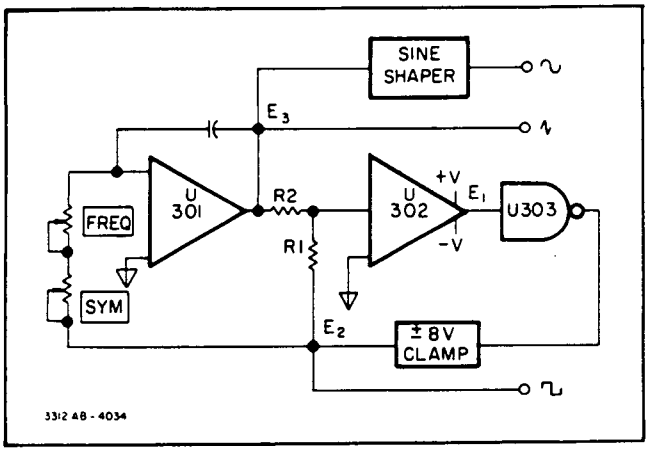


Figure 4-5. Signal Generator.

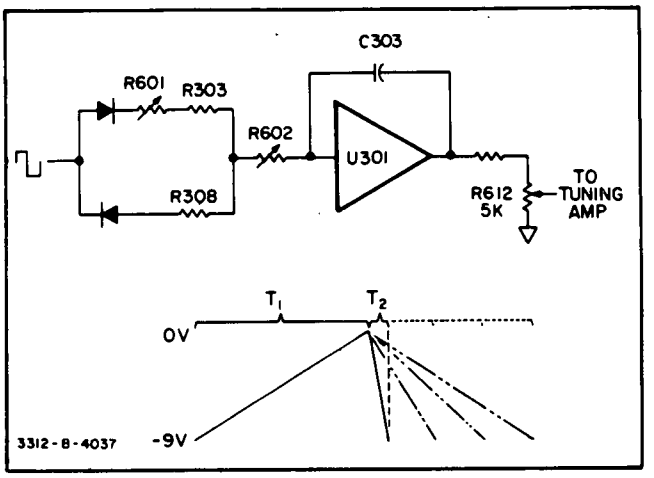


Figure 4-7. Sweep Operation.

4-36. Amplitude Modulation. The AM modulator (Figure 7-4) is a balanced modulator which mixes the carrier signal from the main generator with the modulation signal from the modulation generator. The carrier frequency is applied to pin 7 of U404 and the modulation signal is input to pin 4. Modulation amplitude control resistor R612 attenuates the modulation signal to control the envelope of the output signal.

4-37. Frequency Modulation and Sweep. During FM and sweep operation the output of the modulation generator is applied directly to the Tuning Amplifier of the main generator. In FM operation (Figure 4-6), R612 controls the percent of deviation in frequency of the carrier waveform. The change in frequency is limited to ±5% of the carrier frequency by current limiting resistor A1R426. All three functions of the modulation generator are available for modulating the main generator output frequency.

4-38. When the SWP pushbutton is pressed, resistors R303 and R308 are selected. If R601 is in the CAL position, the output of U301 is a 90:10 ramp (Figure 4-7). As R601 is rotated clockwise, t_2 increases and flyback time is increased.

4-39. The 0 Hz position of the RANGE Hz knob allows pin 5 of U303 (Figure 7-5) to go high producing a low at pin 6 of U303 and at the emitter of Q302. Q302 begins to conduct, turning Q301 on and forming a loop with U302, Q302, Q301 and U301. In SWP the square wave is held at its high level and the triangle wave ramps to - 10 V then stops. Start frequency, for the sweep of the main generator output, can then be selected with R162. R162 affects the frequency of the main generator by determining the negative voltage level at which the ramp starts. Taking the RANGE Hz knob out of the 0 Hz position starts the modulation generator running and, as the ramp voltage approaches zero volts, the output frequency of the main generator approaches the frequency of the dial setting.

4-40. Burst. At any setting other than FREE RUN, the tone burst gate is operable. The start/stop phase of the tone burst is determined by R615 (Figure 4-8) and the transistor array U403. The signal always stops in the same phase as it started.

4-41. When TRIGGER PHASE is in FREE RUN the line from the Burst Control is open and U402A pin 2 is pulled low by the negative supply causing a high at the output of U402A. As a result Q402 and U403(c) turn on and U403(a) and (b) turn off. With U403(a) off, CR408 is reverse biased and no charge is drawn off the integrating capacitor allowing the main generator to free run.

4-42. In TRIGGER PHASE a low from the burst control appears on U402A pin 2 forcing the output of U402A high and starting the burst. When the burst control line goes high again followed by a positive transition of the square wave (at U402A pin 1) the output of U402A goes low. Q402 now turns off allowing TRIGGER PHASE POT, R615, to

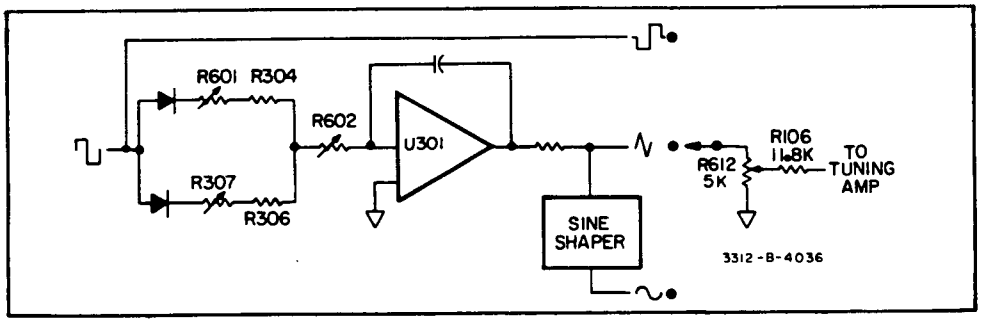


Figure 4-6. FM Operation.

determine the voltage at the base of U403(e) and in turn at the base of U403(c). When the voltage from the main generator (via the BUFFER AMPLIFIER) appearing at the base of U403(b) equals that at the base of U403(c), both U403(a) and (b) turn on and U403(c) turns off. CR408 forward biases and clamps the integrator output to the voltage at the base of U403(c) (which was originally determined by TRIGGER PHASE POT, R16). With the integrator output held at that level the comparator does not switch the current sources resulting in a dc level at the square wave output. When the burst control goes low again the voltage on the integrating capacitor will determine the phase at which the burst restarts. Thus, R615 controls the start/stop phase.

4-43. Multiple Cycle Burst Mode (Figure 7-3). The main generator is gated off when the burst logic sees a positive square wave transition *after* the burst input to U402 pin 2 goes high. If the main square wave is already high, the main generator will not be gated off until the main square wave first goes low then returns high. The waveforms in Figure 4-9 should serve to clarify the operation of the burst logic.

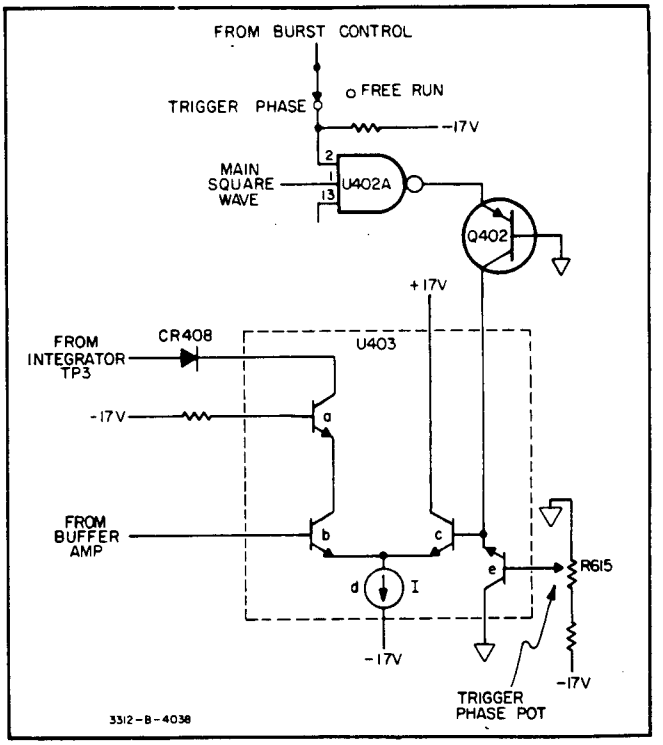


Figure 4-8. U403 Burst Amplifier Array.

4-44. Single Cycle Burst Mode. In single cycle operation (Figure 7-3), U402A pin 2 is driven from U401, a monostable one-shot multivibrator. After being inverted the output of U402 is normally high. Triggering of U401 causes U402A pin 2 to go low for 40 nanoseconds, after which it returns to its quiescent high state. This 40 nanosecond low pulse is sufficient to start the main generator. Since pin 2 almost immediately returns to a high state, the main generator runs until the triangle returns to its start/stop phase position, at which time the generator stops, completing one cycle of operation.

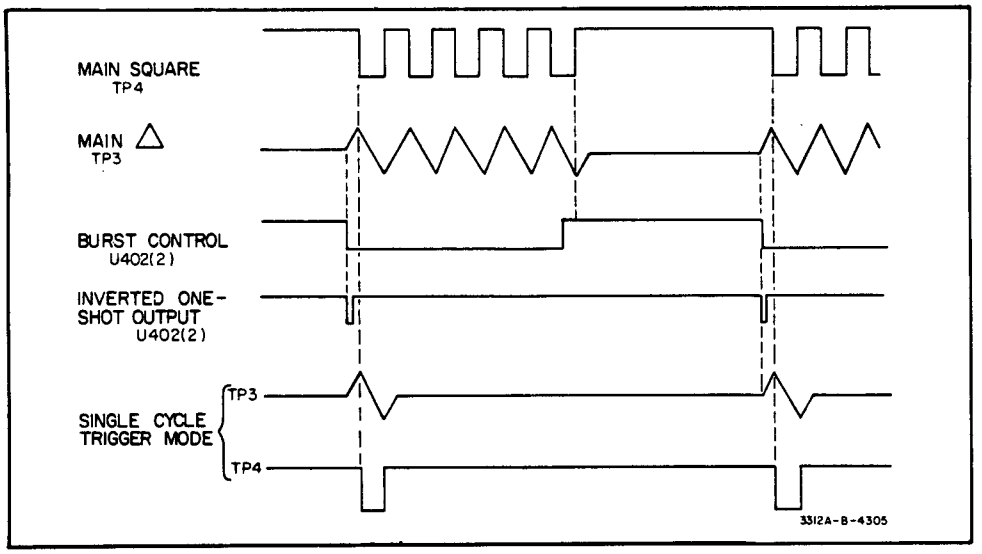


Figure 4-9. Burst Time Relation Waveforms.

WARNING

These servicing instructions are for use by trained service personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are trained to do so.

Table 5-1. Required Test Equipment.

Instrument Type	Required Specifications	Recommended Model
Electronic Counter	.1 Hz to 13 MHz with time interval capability	-hp- Model 5245L with a Model 5262A time interval plug-in
Oscilloscope	275 MHz bandwidth with dual channel (-hp- Model 1805A) and delay (-hp- Model 1821A Plug-in)	-hp- Model 1725A
Divider Probe	10 MΩ, 10:1 Divider < 10 pF shunt capability	-hp- Model 10004B
Distortion Analyzer	5 Hz to 600 kHz ± .1%	-hp- Model 332A
Feedthru Termination	50 Ω ± 1%, dc to 13 MHz	-hp- Model 11048C
DC Voltmeter/ Nullmeter	0 - 20 V range with null capability	-hp- Model 419A
Amplifier	1 kHz bandwidth, < 1% distortion at 1 MHz Gain: X10	-hp- Model 467A
DC Standard	0 to - 3 V in .1 V steps Accuracy: 0.1%	-hp- Model 740B with 11055B Output Cable
Function Generator	Output Frequency: 20 kHz Function: square wave with triggering capability	-hp- Model 3300A/3302A
Digital Voltmeter	10 mV sensitivity, 3 digits resolution with sample and hold option and dc measuring capability	-hp- Model 3480C/D/3484A with Option 001 (sample and hold)
Frequency Meter/ Discriminator	Bandwidth: 10 MHz Accuracy: .3%	-hp- Model 5210A with 10531A Filter
Oscillator	Function: Sine Frequency: to 50 kHz Output Level: > 5 V p-p	-hp- Model 204C
DC Nullmeter	Range: 50 mV to 20 V	-hp- Model 419A
Spectrum Analyzer	Bandwidth: to 13 MHz	-hp- Model 141T with 8552B/8553B Plug-ins
AC Voltmeter	Bandwidth: > 5 MHz Range: 1 V rms	-hp- Model 3400A

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary for proper maintenance of the Model 3312A. Included are Performance Tests and Adjustment Procedures. The Performance Tests may be used for incoming inspection and after adjustment or repair. Specifications are given in Table 1-1. If your instrument does not meet its specifications, refer to the Adjustment Procedures.

5-3. RECOMMENDED TEST EQUIPMENT.

5-4. The test equipment that is recommended for maintenance of the Model 3312A is listed in Table 5-1. If the recommended model is not available, use an instrument that has specifications equal to or better than those listed.

5-5. PERFORMANCE TEST RECORD.

5-6. A Performance Test Record form is provided at the end of this section to record the results of the Performance Tests. The form may be removed and retained as a permanent record of the incoming inspection or routine maintenance performed on the instrument. It may be reproduced without written permission from Hewlett-Packard.

PERFORMANCE TESTS

5-7. PERFORMANCE TESTS.

5-8. The following tests verify that the Model 3312A is operating properly and meets its specifications in Table 1-1 of this manual. These tests should be completed before attempting to adjust the instrument.

5-9. Dial Accuracy Test.

Specification: ± 5% FS

a. Connect the 3312A through a 50 Ω load to the input of a counter (connect a 50 Ω load to the SYNC output). Set the counter to read period. Set the 3312A controls as follows:

FUNCTION ..... ~
AMPLITUDE ..... AS REQUIRED
OFFSET ..... CAL
MODULATION .. ALL PUSHBUTTONS OUT
TRIGGER PHASE ..... FREE RUN

b. Set the RANGE and FREQUENCY dial to each of the settings indicated in Table 5-2 and check for the indicated tolerances for ranges .1 through 10. For the remaining ranges, set the counter to indicate frequency.

Table 5-2. Dial Accuracy Test.

Dial	Range Hz	Counter Indication
1	.1	6060 ms to 28,571 ms
6	.1	1504 ms to 1869 ms
13	.1	733 ms to 810 ms
1	1	606 ms to 2857 ms
6	1	150 ms to 187 ms
13	1	73 ms to 81 ms
1	10	61 ms to 286 ms
6	10	15 ms to 18.9 ms
13	10	7.3 ms to 8.1 ms
1	100	35 Hz to 165 Hz
6	100	535 Hz to 665 Hz
13	100	1235 Hz to 1365 Hz
1	1 K	350 Hz to 1650 Hz
6	1 K	5350 Hz to 6650 Hz
13	1 K	12,350 Hz to 13,650 Hz
1	10 K	3.5 K to 16.5 K
6	10 K	53.5 K to 66.5 K
13	10 K	123.5 K to 136.5 K
1	100 K	35 K to 165 K
6	100 K	535 K to 665 K
13	100 K	1.235 M to 1.365 M
1	1 M	.350 M to 1.65 M
6	1 M	5.35 M to 6.65 M
13	1 M	12.35 M to 13.65 M

5-10. Square Wave Rise and Fall Time.

Specification:

Square Wave Rise and Fall Time: less than 18 ns rise and fall times at 3 MHz and full output (10% and 90% Points)

NOTE

In the following tests all leads should be kept as short as possible.

a. Connect the 3312A as shown in Figure 5-1. Set the oscilloscope for a dc input.

b. Set AMPLITUDE to 10, the FUNCTION switch to square wave and OFFSET to CAL.

c. Set the 3312 FREQUENCY to 3 MHz and check the rise and fall times. Time required for the transition between 10% and 90% of the square wave amplitude should be less than 18 ns.

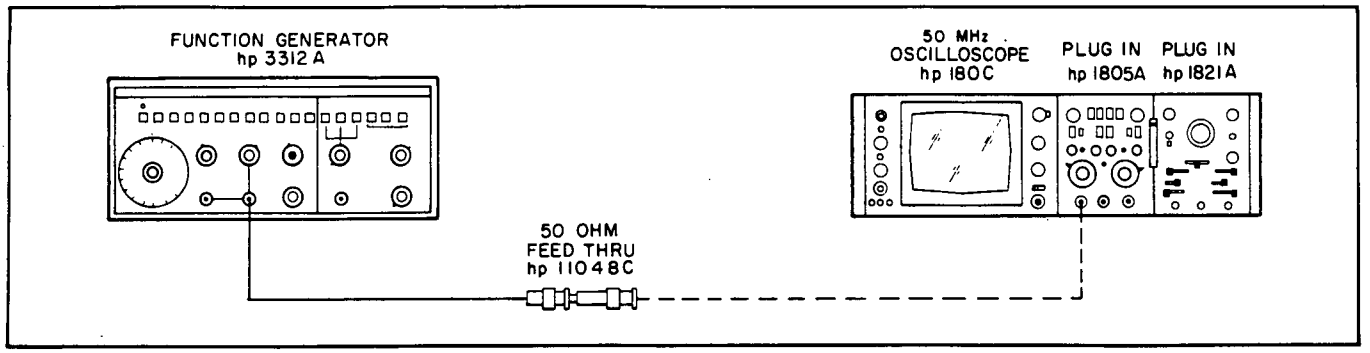


Figure 5-1. Rise Time Test.

5-11. Aberration Test.

Specification: < 10% of p-p

a. With the equipment still connected as in the Square Wave Rise and Fall test, check the aberration as follows.

b. Observe the oscilloscope and measure the voltage difference between the minimum and maximum voltage points at the top of the waveform (V_{ab}), at 1 MHz.

c. Measure the p-p voltage (V_{p-p}). See Figure 5-2.

d. Using the following formula calculate percent of aberration.

$$\text{Aberration (\%)} = V_{ab}/V_{p-p} \text{ X100}$$

This value should not exceed 10%.

e. Repeat Steps c and d except measure the voltage points at the bottom of the waveform. Aberration should not exceed 10%.

f. Repeat b through e at several different frequencies.

5-12. Triangle Linearity Test.

Specification: < 1% at 100 Hz

a. Set the 3312A for triangle output, the FREQUENCY dial to 10, and select the X10 frequency RANGE. Using an electronic counter to monitor the 3312A output, adjust the frequency dial for a period of 10.0 msec. Set the remaining 3312A controls as follows:

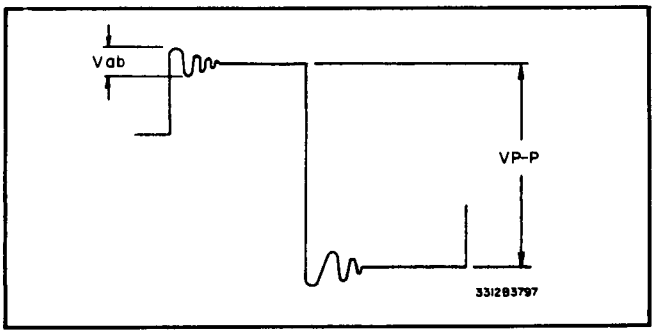


Figure 5-2. Aberration Test.

SYM ..... CAL
TRIGGER PHASE ..... FREE RUN
MODULATION ..... ALL BUTTONS OUT

b. Set the 3480C/D/3484A Voltmeter to measure ac voltage. Connect the voltmeter to the 3312A 50 Ω OUTPUT and adjust the AMPLITUDE control for 5.78 V rms as indicated on the voltmeter.

c. Connect the equipment as shown in Figure 5-3.

d. Set the controls of the 3480C/D/3484A Voltmeter as follows:

FUNCTION ..... V dc
SAMPLE RATE ..... HOLD
FILTER ..... OUT
TERMINAL ..... FRONT
RANGE 10

e. Set the MODE switch at the rear of the 3480C/D to the "ON" position and the DELAY switch to the "OFF" position.

f. Set the 5262A Time Interval unit to trigger on a + .3 V negative going transition in the START channel and on a + .6 V negative going transition in the STOP channel. Set the 5245L FUNCTION switch to "REMOTE OR TIME INT." and use the 1 μs TIME BASE. Set the 5262A for separate (SEP) channel operation.

g. Set the 3300A for a 20 kHz square wave triggered by the Model 180C DELAYED GATE OUTPUT. Set the channel B AMPLITUDE control of the 3300A to the fully clockwise position. Set the Model 3302A MODE to MULTIPLE, INPUT PHASE to -, and START/STOP PHASE to EXTERNAL.

h. Set the oscilloscope to trigger externally on the PULSE OUTPUT of the Model 3312A. The oscilloscope input should be dc coupled. Adjust the controls of the

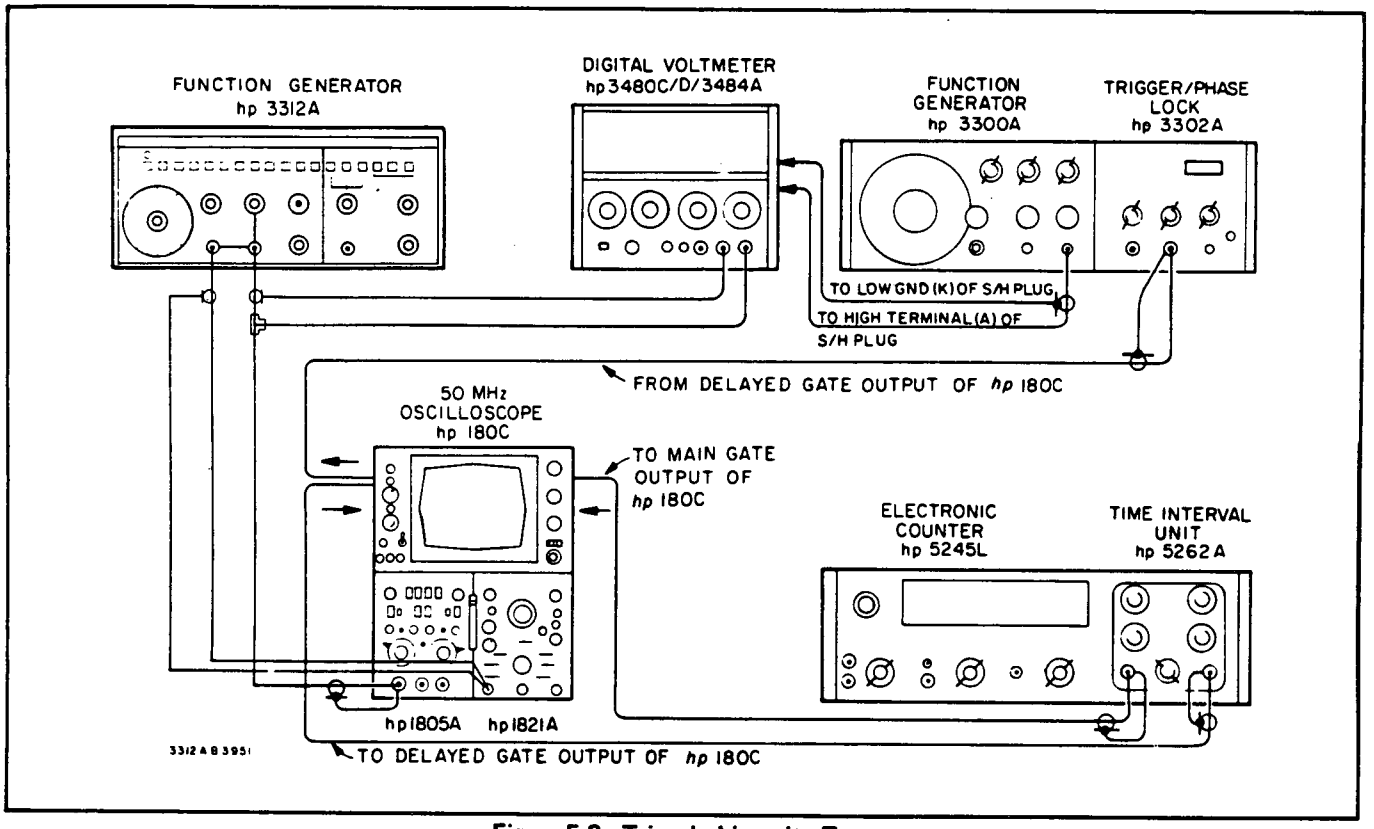


Figure 5-3. Triangle Linearity Test.

oscilloscope so that one cycle of the triangle wave occupies approximately the full length and height of the display area.

i. Set the oscilloscope delay time control to 5 μs/div.

j. Alternately set the bright dot on the trace precisely on the positive and negative peaks of the triangle wave by adjusting the oscilloscope delay control. Adjust DC OFFSET for peak voltages of ± 10 V.

NOTE

When checking linearity on the positive slope of the triangle waveform, set the oscilloscope time/div to .5 ms. When checking the negative slope, set the oscilloscope to 1 ms.

k. Adjust the oscilloscope delay control until the 3480C/D/3484A Voltmeter reads - 9.00 V. Note the indication of the electronic counter. This reading is the "relative zero" and must be subtracted from subsequent indications to obtain the values listed in Table 5-3(a). The relative zero for Table 5-3(b) is measured at + 9.00 V.

l. Verify linearity by checking the instrument at each point indicated in Table 5-3. Each reading should be within the limits given. Be sure to subtract the relative zero from each measurement to obtain the adjusted indications.

Table 5-3(a). Triangle Linearity (Positive Slope).

3480C/D/3484A Voltage Reading (V)	Adjusted 5245L Indication Limits (ms)
- 9.00	Relative Zero (noted in Step k)
- 7.00	.500 ± .050
- 5.00	1.000 ± .050
- 3.00	1.500 ± .050
- 1.00	2.000 ± .050
+ 1.00	2.500 ± .050
+ 3.00	3.000 ± .050
+ 5.00	3.500 ± .050
+ 7.00	4.000 ± .050
+ 9.00	4.500 ± .050

Table 5-3(b). Triangle Linearity (Negative Slope).

3480C/D/3484A Voltage Reading (V)	Adjusted 5245L Indication Limits (ms)
+ 9.00	Relative Zero (noted in Step k)
+ 7.00	.500 ± .050
+ 5.00	1.000 ± .050
+ 3.00	1.500 ± .050
+ 1.00	2.000 ± .050
- 1.00	2.500 ± .050
- 3.00	3.000 ± .050
- 5.00	3.500 ± .050
- 7.00	4.000 ± .050
- 9.00	4.500 ± .050

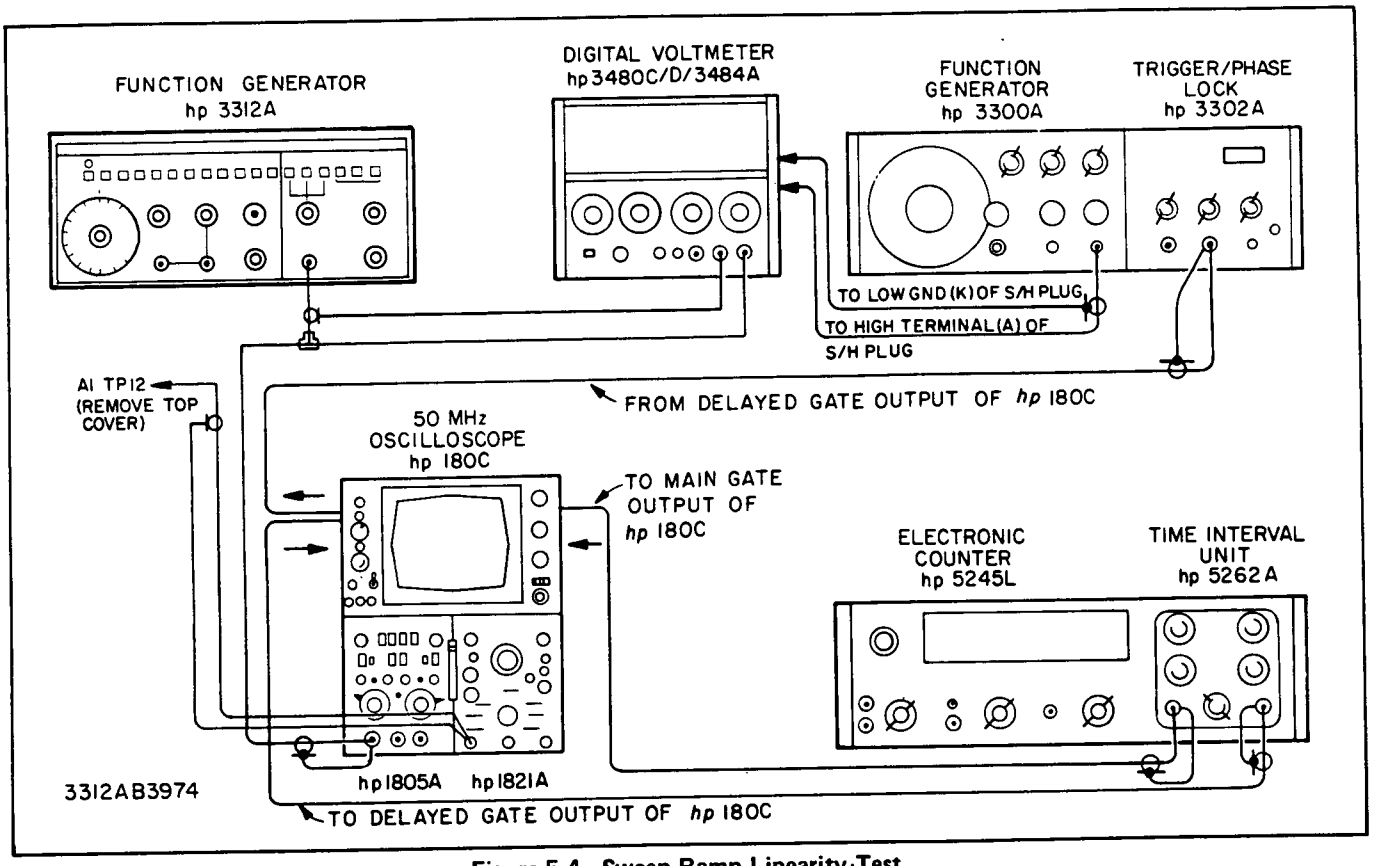


Figure 5-4. Sweep Ramp Linearity Test.

5-13. Sweep Ramp Linearity Error Test.

Specification: Less than 1% at 100 Hz

WARNING

The following test requires that the top cover be removed. Removal of the cover exposes lethal voltages. Use caution, especially in the vicinity of the LINE ON/OFF switch (left front corner of PC board).

a. Connect the equipment as shown in Figure 5-4 and set the 3312A modulation control to SWP. Set the SYM control to CAL.

b. Adjust the 3312A MODULATION RANGE Hz control for a 100 Hz ramp at the MOD INT/EXT jack. Use the high end of the 100 Hz range.

c. Set the 5262A Time Interval Unit to trigger on a 0.3 V negative pulse in the START channel, on a 0.6 V negative going pulse in the STOP channel, and set the function control for separate (SEP) channel operation. Set the 5245L FUNCTION switch to "Remote or Time INT" and use the 1 μs TIME BASE.

d. Set the 3300A for a 20 kHz square wave triggered by the Model 180C delayed gate output. Set the Model 3302A to MULTIPLE cycle, - INPUT PHASE.

e. Set the oscilloscope controls so that the positive going ramp of the triangle wave occupies approximately the full length and height of the oscilloscope graticule. Both a positive and negative crest should be visible.

f. Set the oscilloscope delay time control to 5 μsec/div.

g. Note the bright dot which occurs on the trace and adjust the delay control on the oscilloscope so that the 3480C/D indicates - 9.0 V. (This will be near the start of the positive-going ramp.)

h. Record the indication on the digital voltmeter and the counter.

i. Turn the oscilloscope delay control until the dot occurs 0.50 ms later than the counter indication recorded in Step h, on the positive portion of the waveform.

j. Repeat Steps h and i for at least eight more points on the positive going portion of the ramp.

k. Repeat Steps g through j except check the negative going portion of the waveform. In Step g begin at the right of the positive peak of the negative going waveform.

l. The following formulas define a method of determining the ideal "best fit" straight line for a given set of points lying on an X-Y or "cartesian plane." In this instance the points used should be those recorded in Step h through k of this procedure, first checking positive and then negative slope.

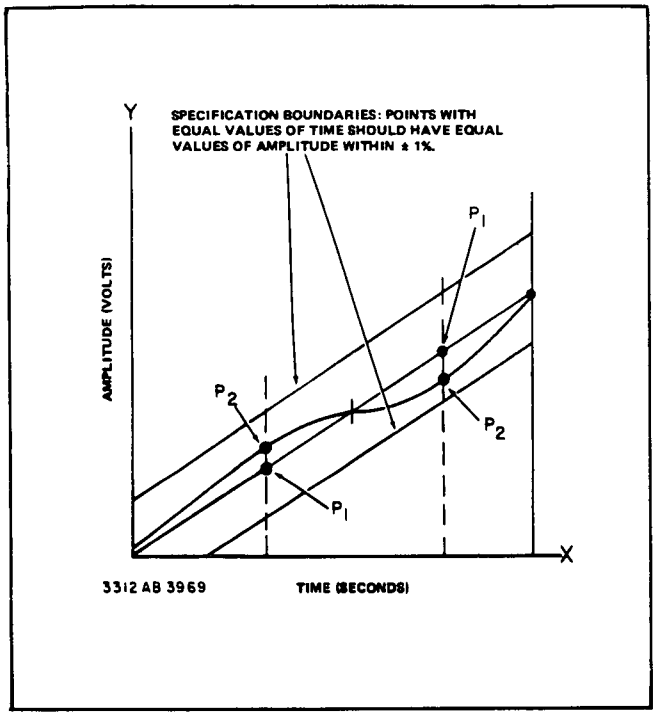


Figure 5-5. Linearity (Example).

$a_0 = (AD - CB)/(ND - B^2)$
$a_1 = (NC - AB)/(ND - B^2)$

Where:
a_0 = intercept of line with y-axis
a_1 = slope of the line
$A = Y_0 + Y_1 + Y_2 \ldots . + Y_n$
$B = X_0 + X_1 + X_2 \ldots . + X_n$
$C = (X_0)(Y_0) + (X_1)(Y_1) + (X_2)(Y_2) \ldots + (X_n)(Y_n)$
$D = X_0^2 + X_1^2 X_2^2 \ldots . X_n^2$
N = Number of points chosed.
X_i = Time coordinate of a data point (msec).
Y_i = Voltage coordinate of a data point (volts).

NOTE

X_i and Y_i are the values recorded in Steps h through k.

m. Using the following slope-intercept formula calculate the theoretical value of Y for each value of X recorded in Steps h through k. Do this first for positive slope and then negative slope:

$Y = a_0 + a_1 X$

n. Determine the percent deviation of Y for each of the corresponding values of X by the following formulas:

$\%\ \text{dev.} = 100 - \left(\frac{10(Y_1 - Y_0)}{Y_0/Y_1 \times 100}\right)$ when $Y_1 > Y_0$
$\%\ \text{dev.} = \left(\frac{Y_0/Y_1 \times 100}{10(Y_1 - Y_0)}\right) - 100$ when $Y_1 < Y_0$

Where:
Y_0 is the value of Y recorded in Steps h through k.
Y_1 is the value of Y calculated in Step m.
This value should not exceed 1% at any point.

5-14. Sine Wave Distortion Test.

Specification
Less than 0.5% (46 dB) THD from 10 Hz to 50 kHz.
Less than - 30 dB below fundamental from 50 kHz to 13 MHz.

a. Connect the equipment as shown in Figure 5-6. Set the 3312A to SINE function at 10 Hz. Set the AMPLITUDE control to 10 V. All modulation pushbuttons should be out and TRIGGER PHASE set to FREE RUN. SYM control *must* be set to CAL.

b. Measure the distortion at several frequencies between 10 Hz and 50 kHz. At each frequency, the distortion must be more than 0.5% (46 dB) below the fundamental.

c. Substitute a spectrum analyzer for the distortion analyzer shown in Figure 5-6.

d. Measure the distortion at several frequencies between 50 kHz and 13 MHz. Each harmonic must be at least 30 dB below the fundamental frequency.

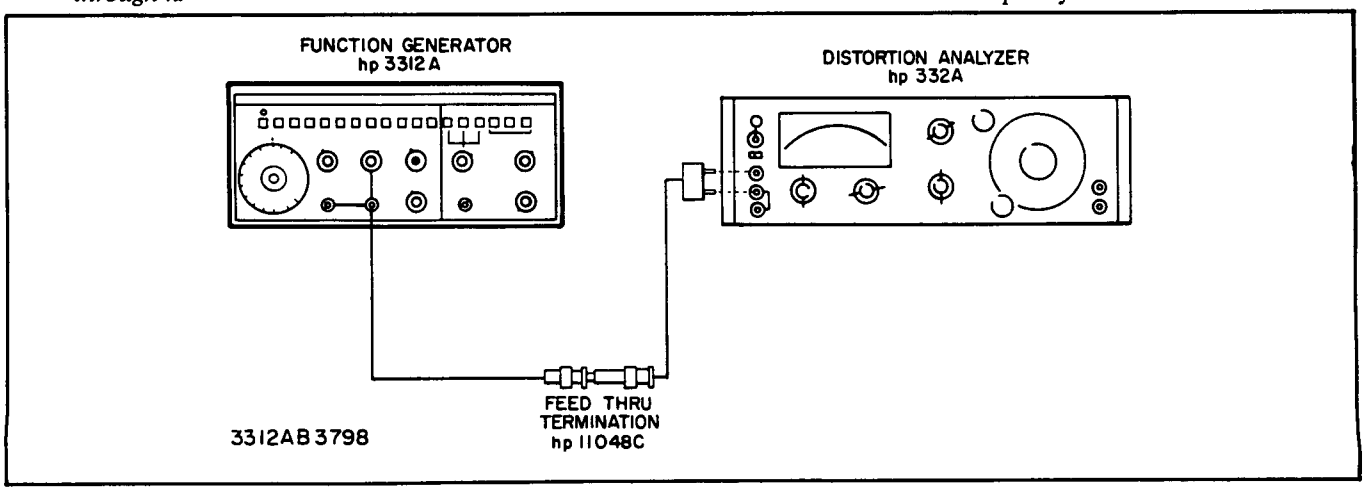


Figure 5-6. Sine Wave Distortion Test.

5-15. Output Impedance Test.
Specification: 50 Ω ± 10%

a. Set the 3312A for a 1 kHz sine wave output.

b. Connect a true rms voltmeter to the output of the 3312A (unterminated). Keep cable as short as possible. Set the AMPLITUDE control to 10 and adjust the VERNIER control for an indication of 5 V rms on the voltmeter.

c. Terminate the 3312A with a 50 Ω load (11048C) and again measure the output of the 3312A. The voltage should be between 2.37 V and 2.62 V.

5-16. Attenuator Accuracy Test.
Specification: Accuracy greater than 95%

a. Connect the 3312A output through a 50 Ω load to the input of an rms voltmeter. Set the 3312A controls as follows:

FUNCTION	~
RANGE Hz	1 M
FREQUENCY Dial	10
AMPLITUDE	10 V
OFFSET	CAL
SYM	CAL
TRIGGER PHASE	FREE RUN
MODULATION	ALL BUTTONS OUT

b. Adjust the 3312A AMPLITUDE Vernier for an indication of exactly 3.0 volts rms on the voltmeter.

c. Downrange the 3312A to the 1 V range and downrange the voltmeter. The voltmeter should indicate between 0.285 and 0.315 V rms.

d. Repeat the procedure for the 0.1 V and 0.01 V ranges of the 3312A. The voltmeter should indicate between 28.5 mV and 31.5 mV for the 0.1 V range and between 2.85 mV and 3.15 mV for the 0.01 V range.

5-17. Sine Wave Level Flatness Test.
Specification
Less than ± 3% 10 Hz to 100 kHz at full output (1 kHz reference)
Less than 10% from 100 kHz to 10 MHz at full output

a. Connect the equipment as shown in Figure 5-7.

b. Set the 3312A controls as follows:

RANGE Hz	1 K
FREQUENCY Dial	1
AMPLITUDE	10 V
AMPLITUDE Vernier	CW
OFFSET	CAL
TRIGGER PHASE	FREE RUN
SYM	CAL
MODULATION	ALL BUTTONS OUT

c. Using the oscilloscope, measure the peak-to-peak amplitude of the 3312A output. Multiply this value by 0.015 to determine the maximum permissible deviation (Vdev) in volts.

d. Set the oscilloscope vertical sensitivity to 0.2 V/div. Set the sweep time to 2 ms/div.

NOTE

The following procedure requires the oscilloscope display be offset in order to view the top of the displayed waveform. This is accomplished with the vertical position and DC OFFSET controls of the Model 1805A Vertical Amplifier. If you have a Model 1801A Vertical Amplifier the DC Bal Control can be used to offset the waveforms. The Model 1801A should be readjusted after this test is completed.

e. Using the vertical position and DC Offset controls of the oscilloscope, position the display so that the positive peaks of the signal just touchsd the horizontal center line of the graticule.

f. Check several frequencies from 10 Hz to 100 kHz. The positive peaks of the oscilloscope display should vary no more than the value of Vdev calculated in Step c.

g. Check several frequencies between 100 kHz and 10 MHz. The maximum allowable deviation for these frequencies will be the peak-to-peak voltage measured in Step c multiplied by 0.05.

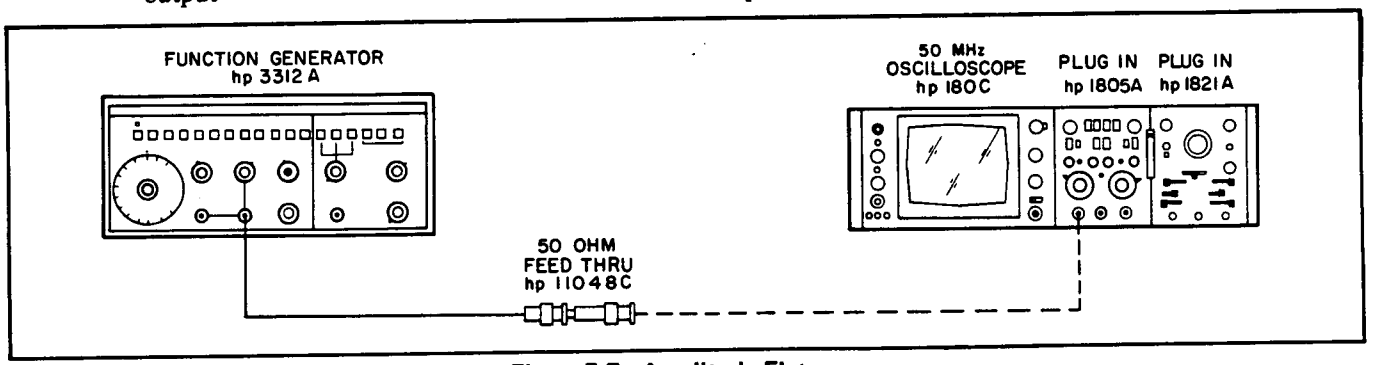


Figure 5-7. Amplitude Flatness.

5-18. Sync Output Impedance and Amplitude Test.
Specification: 50 Ω ± 5% to 10 MHz, > 1 V p-p into open circuit.

a. Set the 3312A for a 10 MHz sine wave. Set SYM to CAL and TRIGGER PHASE to FREE RUN. All modulation pushbuttons should be out.

b. Using a short cable, connect the SYNC output of the 3312A to the vertical input of the oscilloscope and measure the amplitude of the SYNC output voltage. This voltage must be greater than 1 V p-p.

c. Adjust the vertical sensitivity of the oscilloscope for exactly 1 V p-p display.

d. Connect a 50 Ω feedthru termination across the SYNC output terminal and again measure the SYNC output amplitude. This amplitude should be between 0.488 V p-p and 0.513 V p-p.

NOTE

Because of the resolution required in this test, two methods may be used:

1) Increase the vertical sensitivity of the oscilloscope and change the vertical position so that only the top of the waveform is visible.

or

2) Use a true rms voltmeter with a bandwidth of 10 MHz. If a true rms voltmeter is used, the values in Step b should be greater than 0.5 V. In Step c, set the output for exactly 0.5 V rms. In Step d, the limits should be 244 mV and 257 mV.

5-19. Sync Output Rise and Fall Time Test.
Specification: (10% and 90%): less than 10 nsec into open circuit

a. Set the 3312A for a 10 MHz sine wave, TRIGGER PHASE to FREE RUN and SYM to CAL, all modulation pushbuttons out; connect the SYNC output (terminated) to the dc coupled vertical input of an oscilloscope.

b. Adjust the oscilloscope vertical controls for 8 cm vertical display. Measure the time between the 10% and 90% points of the leading and trailing edges of the waveform. This time must be less than 10 nsec.

5-20. DC Offset Test.
Specification: Maximum V_{ac} + V_{dc} offset without clipping is ± 10 volts.

a. Connect the 3312A output (unterminated) to the vertical input of an oscilloscope. Set the 3312A controls as follows:

RANGE Hz	1 K
FREQUENCY Dial	1
FUNCTION	~
TRIGGER PHASE	FREE RUN
SYM	CAL
MODULATION	ALL BUTTONS OUT
AMPLITUDE	10 V

NOTE

Since the vertical input of the oscilloscope will be used in both the ac and dc coupled modes, ensure that there is no offset in the reference when switching between the two.

b. With the oscilloscope in the ac coupled mode, adjust the horizontal reference trace for a convenient reference. Adjust the 3312A AMPLITUDE VERNIER for a 5 V peak ac display on the scope.

c. Change the oscilloscope input coupling to dc and adjust the 3312A OFFSET (CAL pushbutton out) for a + 5 V dc offset. There should be no clipping on the positive peaks of the waveform.

d. Repeat Step c except use a negative dc offset of 5 volts. There should be no clipping on the negative peaks of the waveform.

e. With all of the main generator FUNCTION pushbuttons out, measure the maximum plus and minus offset voltage with the offset control, first max CW and then max CCW. These must be at least ± 10 V dc.

5-21. Internal Modulation Source Output Level Test.
Specification: Greater than 1.0 V p-p into 10 kΩ with MODULATION control fully CW.

a. Connect the MOD INT/EXT output of the 3312A to the input of an oscilloscope using a 10 kΩ load across the output of the 3312A. Turn the modulation control fully CW.

b. Press the AM MODULATION pushbutton and the sinewave pushbutton (all other pushbuttons out). The amplitude on the oscilloscope should be greater than 1.0 V p-p.

c. Also check the square and triangle function amplitudes. These should be greater than 1.0 V p-p.

d. Check Steps b and c at several frequencies up to 10 kHz.

5-22. Internal Modulation Source Spectral Purity Test.

a. Connect the 3312A MOD INT/EXT jack to the input of a distortion analyzer (unterminated).

b. Set the 3312A MODULATION pushbutton to ~, and set the modulation SYM control to CAL.

Specification: Spectral purity (sine wave distortion), less than 2%(- 34 dB) THD from 10 Hz to 10 kHz

c. Measure the distortion at several frequencies between 10 Hz and 10 kHz. Distortion must be less than 2%(- 34 dB) over the entire frequency range.

5-23. Variable Symmetry Test.

Specification: 80:20:80

a. Connect the output of the 3312A through a 50 Ω feedthru termination to the input of an oscilloscope. Set the 3312A controls as follows:

RANGE ..... 1 K
FREQUENCY Dial 1
SYM CAL ..... OUT (NOT CAL)
AMPLITUDE 10
FUNCTION ..... ⊓⊔
OFFSET ..... CAL
MODULATION ..... ALL BUTTONS OUT

b. Adjust the oscilloscope for a stable display of the 1 kHz rectangular wave. Adjust the horizontal display so that one cycle exactly equals 10 cm (.1 msec/cm). If necessary, adjust frequency dial slightly for 10 cm on horizontal display.

c. Vary the SYM control over its entire range. The symmetry ratio should vary from a minimum of 8:2 in the CCW position to 2:8 in the CW position.

5-24. Carrier Envelope Distortion Test.

Specification: Less than 2% (- 34 dB) at Fm = 1 kHz, F_C = 1 MHz at 70% modulation

a. Set the 3312A controls as follows:

RANGE Hz ..... 1 M
FREQUENCY Dial 1
FUNCTION ..... ~
AMPLITUDE ..... 10 V
SYM ..... CAL
TRIGGER PHASE ..... FREE RUN
OFFSET ..... CAL
MODULATION FUNCTION ..... AM~
% MODULATION ..... MAX CCW

b. Set the MODULATION RANGE Hz to 10 K and adjust the vernier control for a 1 kHz signal at the MOD INT/EXT jack. Use either a counter or an oscilloscope (1 ms/cm) to set the frequency.

c. Connect the output of the 3312A through a 50 Ω feedthru termination to set the input of an oscilloscope. Adjust the AMPLITUDE VERNIER on the main generator for an output of 4 V p-p on the scope.

d. Adjust the % modulation control so that the amplitude modulated envelope is 6.8 V p-p. This represents 70% modulation.

e. Without changing any controls, disconnect the 3312A from the input of the oscilloscope and connect it to the RF Detector input of the distortion analyzer.

f. Measure the carrier envelope distortion at 1 kHz. The distortion must be less than 2% (- 34 dB).

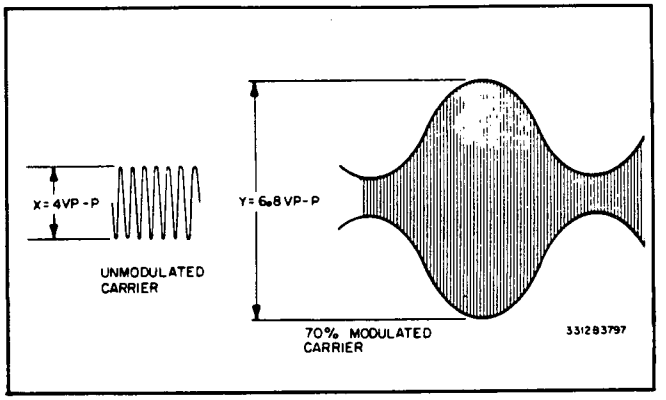


Figure 5-8. 70% Modulation Waveform.

5-25. External Amplitude Modulation Sensitivity Test.

Specification: Less than 10 V p-p for 100% modulation

a. Connect a sine wave source at 1 kHz to the MOD INT/EXT jack on the 3312A. Set the 3312A controls as follows:

RANGE Hz ..... 100 K
FREQUENCY Dial 5
OFFSET ..... CAL
TRIGGER PHASE ..... FREE RUN
FUNCTION ..... ~
MODULATION ..... AM
% MODULATION ..... CW
All other modulation pushbuttons should be out.

b. Connect the 3312A output to the vertical input of an oscilloscope. Adjust the output of the sinewave source for a 100% modulation pattern on the oscilloscope.

c. Measure the amplitude of the sinewave required to 100% modulate the 3312A output. This voltage should be less than 10 V p-p.

5-26. FM Distortion Test.

Specification: <-35 dB at F_C = 10 MHz, F_m = 1 kHz at ~~10~~ 1% modulation (100KHz peak deviation)

a. Connect the equipment as shown in Figure 5-9. Set the 3312A controls as follows:

RANGE Hz ..... 1 M
FREQUENCY Dial 10
OFFSET ..... CAL
FUNCTION ..... ~
AMPLITUDE ..... 10 V
VERNIER ..... CW

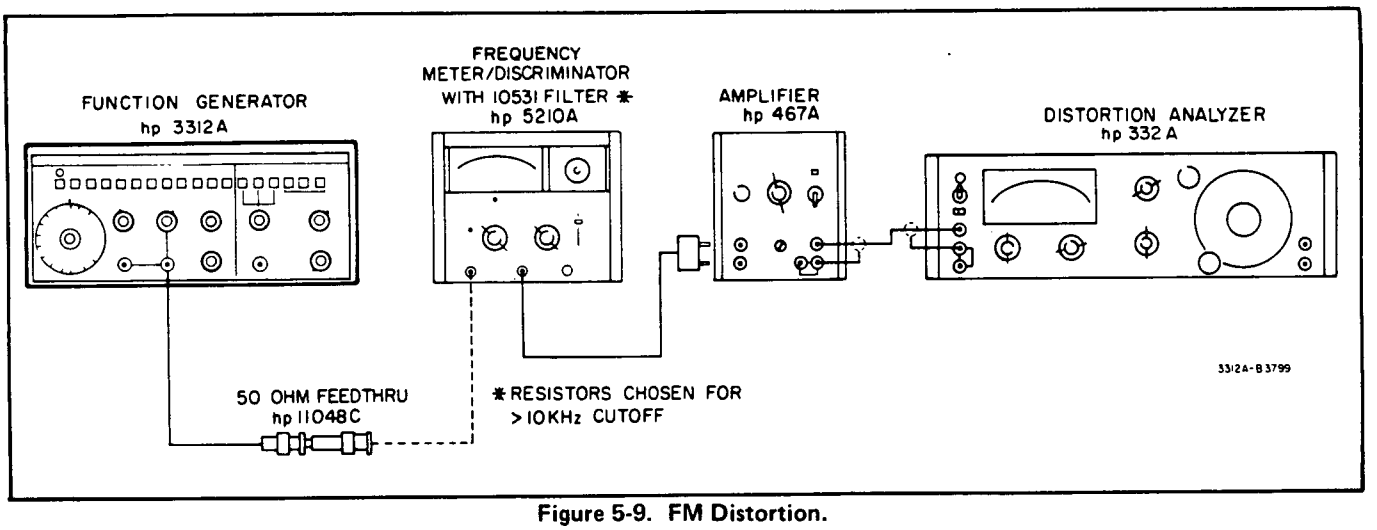


Figure 5-9. FM Distortion.

ΔF	CW
TRIGGER PHASE	FREE RUN
MODULATION	~FM
MODULATION SYM	CAL
MODULATION RANGE Hz	10 K
RANGE Hz VERNIER	Adjust for 1 kHz measured at MOD INT/EXT jack

b. Set the amplifier for a gain of 10 and measure the distortion of the detected 1 kHz signal out of the discriminator. The distortion must be less than - 35 dB.

5-27. Carrier 3 dB Bandwidth Test (Amplitude Modulation).

Specification: Less than 100 Hz to greater than 5 MHz

a. Connect the 3312A output through a 50 ohm termination to the input of the 3400A RMS Voltmeter and set the 3312A controls as follows:

RANGE Hz	1 K
FREQUENCY Hz	1
FUNCTION	~
OFFSET	CAL
SYM	CAL
AMPLITUDE	10 V
TRIGGER PHASE	FREE RUN
MODULATION	AM
MODULATION FUNCTION	ALL BUTTONS OUT

b. Adjust the AMPLITUDE VERNIER control for a 0 dB indication on the 1 volt range of the voltmeter.

c. Tune the 3312A between 100 Hz and 5 MHz. The indication on the voltmeter must not be below 3 dB at 100 Hz and 5 MHz.

5-28. Frequency Deviation Test.

Specification: 0 to 5% internal

a. Connect the 3312A output to the input of an oscilloscope. Set the 3312A controls as follows:

RANGE Hz	100 K
FREQUENCY Dial	10
FUNCTION	~
TRIGGER PHASE	FREE RUN
SYM	CAL
OFFSET	CAL
MODULATION FUNCTION	ALL BUTTONS OUT
MODULATION RANGE Hz	10 K
MODULATION RANGE Hz Vernier	CW
ΔF	CW

b. Use either an oscilloscope or a counter to monitor the output of the 3312A and adjust the frequency dial for exactly 1 MHz (1 μsec).

c. Set the oscilloscope for a sweep time of 0.2 μsec/div. One cycle should fill 5 cm of horizontal deflection.

d. Press the FM~ pushbutton. The presentation on the oscilloscope should be like the one shown in Figure 5-10. Measure the + and - deviation as shown. $2T_{dev}$ should be at least .1 μsec (.5 cm).

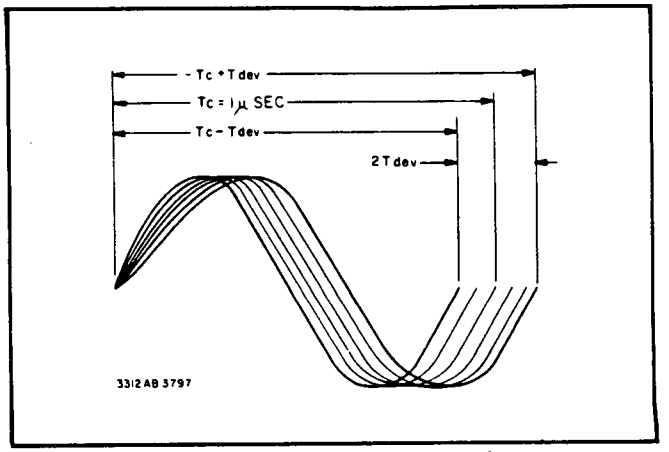


Figure 5-10. Frequency Deviation Test.

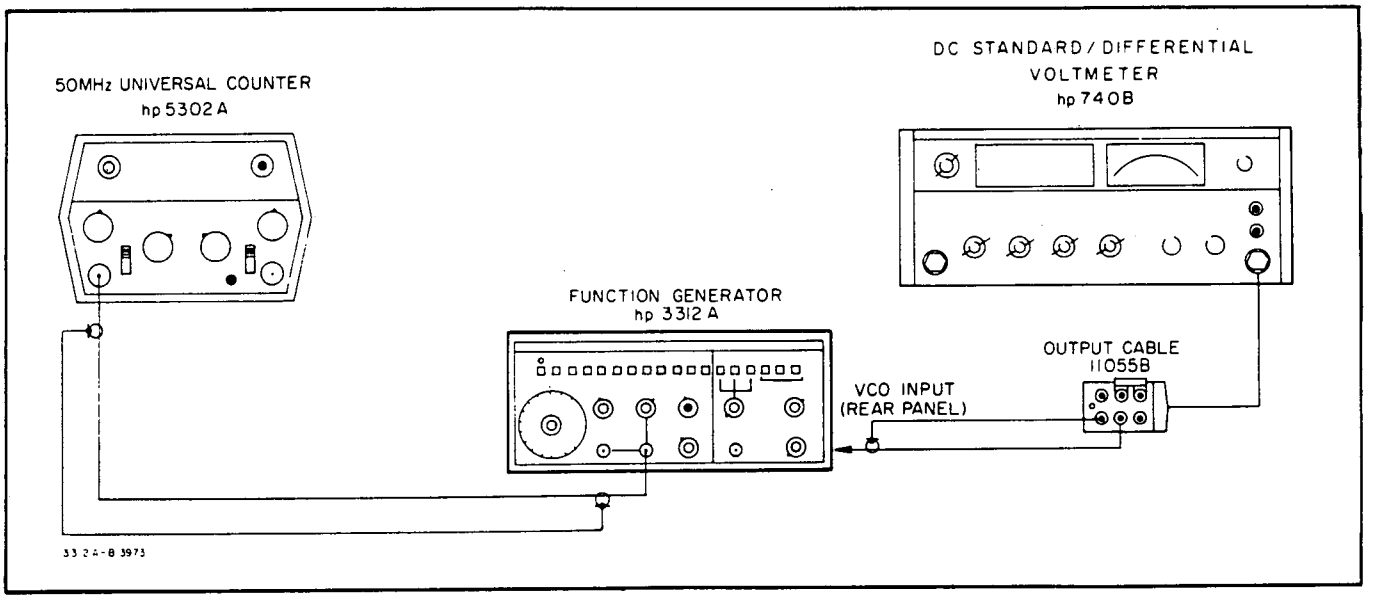


Figure 5-11. VCO Linearity Test.

5-29. External Frequency Control Input Requirements, VCO Linearity Tests.

Specifications: With dial set to 10, application of 0 to - 2 V dc ± 20% to the VCO input will linearly decrease frequency by more than 1000:1. An ac voltage will FM the frequency about a dial setting within the limits of (.1 <f<10) x range setting. The frequency vs voltage curve will be linear within ~~0.5%~~ 5.0% over a 100:1 frequency range.

a. Connect equipment as shown in Figure 5-11 and set the 3312A controls as follows:

RANGE Hz	1 M
FREQUENCY Dial	10
FUNCTION	~
SYM	CAL
AMPLITUDE	10 V
AMPLITUDE Vernier	CW
TRIGGER PHASE	FREE RUN
MODULATION	All buttons out
Other Mod Settings	Any

b. After a 1 hour warm-up, set the DC Standard for 0 volts output and measure the output frequency of the 3312A. If necessary, adjust the dial for exactly 10 MHz display.

c. Set the DC Standard for a counter indication of 10 kHz. The DC Standard output should fall between the limits of - 1.6 V and - 2.4 V.

d. Set the DC Standard for a counter indication of 100 kHz and record the dc voltage to four decimal places.

e. Set the DC Standard eight more times for even values of frequency over the entire range between 10 MHz and 100 kHz (i.e., 9 MHz, 8 MHz, 7 MHz . . .). Record the voltage values to four decimal places.

f. The following formulae define the "best fit" straight line for a given set of points. Using these formulae, a straight line will be obtained which represents the VCO frequency vs voltage characteristics. VCO linearity specifications will be met if ~~for each VCO input voltage~~ the frequency actually produced varies from the ~~value indicated by the~~ "best fit" line by less than ~~5%~~ 5.0% of the upper frequency of the two decades tested. (See Figure 5-12.)

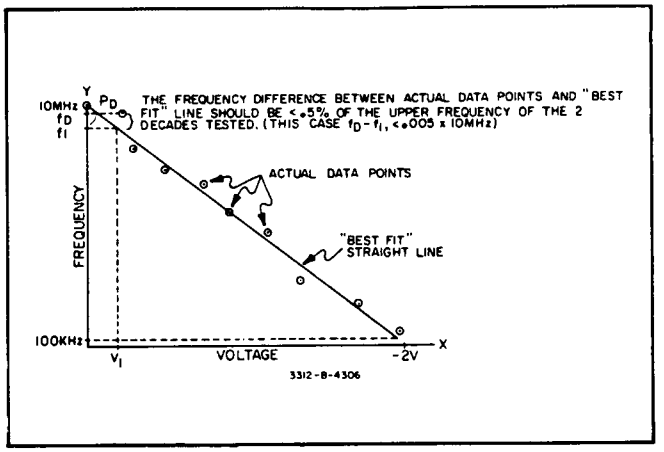


Figure 5-12. VCO Linearity Graph.

$a_0 = (AD - CB)/(ND - B^2)$

$a_1 = (NC - AB)/(ND - B^2)$

Where:

a_0 = intercept of line with y-axis (frequency)

a_1 = slope of the line

$A = Y_0 + Y_1 + Y_2 + \ldots . Y_N$

$B = X_0 + X_1 + X_2 + \ldots . X_N$

$C = (X_0 Y_0) + (X_1 Y_1) + \ldots . (X_N Y_N)$

$D = X_0^2 + X_1^2 + X_2^2 + \ldots . X_N^2$

N = Number of points chosen (N = 10 recommended)
X_i = VCO input voltage coordinate of a data point (volts)
Y_i = Frequency coordinate of a data point (MHz).

NOTE

X_i and Y_i are the values recorded in Steps (b), (d) and (e).

g. Using the following slope-intercept formula calculate the Y value (frequency) on the "best fit" line for each value of X (voltage) recorded in Steps (b), (d) and (e).

$Y = a_0 + a_1 X$

h. Determine the deviation of Y (frequency) for each corresponding value of X (voltage) by the following formulae:

$Y_0 - Y_1$ = deviation (for $Y_0 > Y_1$)
$Y_1 - Y_0$ = deviation (for $Y_1 > Y_0$)

Where:
Y_0 is the value of Y recorded in Steps (b), (d) and (e)
Y_1 is the value of Y calculated in Step (g).

The deviation should not exceed 500 kHz (5% of 10 MHz).

ADJUSTMENT PROCEDURES

5-30. ADJUSTMENT PROCEDURE.

WARNING

The following adjustment procedures require that the top and bottom covers be removed. Be extremely careful when performing these procedures since lethal voltages are exposed. Be especially careful around the LINE ON/OFF switch, located on the left front corner of the top PC board.

5-31. The following is a complete adjustment procedure for the Model 3312A. This procedure should be performed only if it has been determined by the Performance Tests that the 3312A does not meet its specifications.

5-32. Power Supply Adjustment.

a. Connect a dc voltmeter to J3 pin 2 and adjust A1R601 for + 17.1 V ± 50 mV.

b. Use an oscilloscope to measure the ac ripple on the + 17 V supply. It should be less than 50 mV p-p.

c. Connect the dc voltmeter to J3 pin 4 and adjust A1R602 for - 17.1 V ± 50 mV.

5-33. Frequency Adjustment.

a. Connect an electronic counter with a 50 Ω load on its input to the 3312A SYNC output. Set the 3312A main generator controls only as follows:

RANGE Hz ..... 1 K
SYM ..... CAL
OFFSET ..... CAL
FUNCTION ..... ~
AMPLITUDE ..... 10 V
AMPLITUDE VERNIER ..... CW

b. Set the FREQUENCY dial R606 to the maximum CCW position and measure the dc voltage across A2R124 (between J1 pin 6 and TP2). Connect the low side of the digital voltmeter to J1 pin 6. Record this voltage to 1 mV resolution.

c. Connect the dc voltmeter across the A2R119, A2R121 combination (between J1 pin 3 and TP1). Connect low side of digital voltmeter to J1 pin 3. Adjust A2R121 such that the voltmeter reading differs by < 1.5 mV from the voltage measured in Step b.

d. Set the FREQUENCY dial to 10. Adjust A2R102 for approximately 10 kHz reading.

e. Set FREQUENCY dial completely CW and measure the width of both positive and negative halves of the waveform by setting the counter to measure the time interval starting with the positive crossing and ending with the negative crossing for the positive half and starting with the negative crossing and ending with the positive crossing for the negative half. (Be sure the triggering levels are the same on both channels.) Each half should be 5 ms ± .5 ms. If the positive half is not 5 ms ± .5 ms adjust A2R127 until it is. If the negative half is not 5 ms ± .5 ms adjust A2R129 until it is.

f. Turn the FREQUENCY dial until counter indicates 1 kHz ± 50 Hz. Dial should be on 1. If not, slip dial to 1.

g. Set the FREQUENCY dial to 10 and adjust A2R102 for 10 kHz ± 30 Hz.

h. Repeat Steps e through g until all adjustments remain within tolerances.

i. Change the 3312A RANGE Hz to 100 K and the FREQUENCY dial to 10. Adjust A2C205 for 1 MHz ± 3 kHz.

j. As was done in Step e, determine if the negative and positive portions of the waveform are symmetrical within

± 5 ns. If the positive side is shorter, increase the value of A2C111. If the negative side is shorter, increase the value of A2C112.

k. Change the RANGE to 1 K and the dial to 5. Note the frequency and calculate the percentage deviation from 5 kHz.

l. Change the RANGE to 1 M. Adjust A2C217 so that the counter indicates 5 MHz plus or minus the percentage of deviation noted in Step k. For example, if the counter indicated 1% above 5 kHz in Step k, adjust A2C217 so that the counter indicates 1% above 5 MHz.

m. Change the FREQUENCY dial to 10 and adjust A2C216 for an indication of 10.2 MHz. The reason that A2C216 is adjusted for 10.2 MHz instead of 10 MHz exactly is that when the covers are replaced, the frequency will drift down. Replace the covers and allow 5 to 10 minutes for the termperature inside to stabilize. After warm-up, the frequency counter should indicate 10 MHz ± 100 kHz. If not, it may be necessary to readjust C216 either up or down so that the frequency will be 10 MHz ± 100 kHz when the covers are replaced.

n. After the covers are replaced, recheck the frequency at 1 MHz, 5 MHz and 10 MHz. Since C205, C216 and C217 interact, it may be necessary to repeat Steps i, k, l, and m.

5-34. Distortion Adjustment.

a. Connect the 3312A output to the input of a distortion analyzer and set the 3312A controls as follows:

FUNCTION	~
RANGE	1 K
FREQUENCY Dial	10
AMPLITUDE	10 V
AMPLITUDE Vernier	CENTER
TRIGGER PHASE	FREE RUN
SYM	CAL
MODULATION	ALL BUTTONS OUT
Other MOD settings	Any

b. Adjust the distortion analyzer to measure the distortion of the 3312A output. Alternately adjust A2R283 and A2R279 for minimum distortion on the analyzer. This distortion level must be better than - 46 dB.

c. Change the main RANGE Hz to 1 M and connect the 3312A output to the input of the spectrum analyzer and measure the distortion over the entire range of the FREQUENCY dial. All harmonics must be at least 32 dB below the fundamental over the entire range of the dial. If the harmonics are not down at least 32 dB, readjust C217 so that the harmonics are down at least 35 dB at the worst spot on the dial.

d. Connect the 3312A to the input of a counter and check the frequency at a dial setting of 5. It should be between 4.7 MHz and 5.3 MHz. If necessary, readjust C217. Check 1 MHz and 10 MHz. If necessary, readjust C205 and C216 as described in Paragraph 5-34, Steps i and m.

5-35. Rise Time and Aberration Adjustment.

a. Connect the 3312A main output through a 50 ohm termination to the dc coupled input of an oscilloscope. Place the 50 ohm termination at the oscilloscope end of the cable.

b. Set the 3312A controls as follows:

FUNCTION	⊓
Main RANGE Hz	1 M
FREQUENCY Dial	3
OFFSET	CAL
SYM	CAL
TRIGGER PHASE	FREE RUN
AMPLITUDE	10 V
AMPLITUDE Vernier	CENTER
MODULATION	ALL OUT
Other MOD settings	ANY

c. Adjust A1C505 for the best possible waveform. The best waveform should have minimum rise and fall time and minimum aberration.

5-36. Modulation Symmetry Adjustment.

a. Connect the 3312A MOD INT/EXT output to an electronic counter. Set the 3312A controls as follows:

FREQUENCY Dial	CW
Main RANGE Hz	1 K
OFFSET	CAL
Main FUNCTION	ALL BUTTONS OUT
Other Main Generator Settings	ANY
MODULATION FUNCTION	⊓
AM, FM, SWP	ALL BUTTONS OUT
MODULATION SYM	CAL
MODULATION RANGE Hz	100
MODULATION RANGE Hz Vernier	CW

b. Measure the width of both the positive and negative half cycles of the square wave. (Set the counter to measure the time interval beginning with the positive transition and ending with the negative transition for the positive half. For the negative half start the interval on the negative transition and end with the positive transition.) Adjust A1R307 for less than 10 μs difference between the two intervals.

c. Change the Modulation RANGE Hz to 10 K and turn the FREQUENCY Vernier completely CCW. Adjust A1R302 for less than 10 μs difference between the width of positive and negative half cycles.

5-37. Modulation Sinewave Distortion Adjustment.

a. Connect the MOD INT/EXT output to the input of a

distortion analyzer. Set the 3312A controls as follows:

FREQUENCY Dial ..... CW
Main RANGE Hz ..... 1 K
OFFSET ..... CAL
Other Main Generator Settings ..... ANY
MODULATION FUNCTION ..... ~
AM, FM, SWP ..... ALL BUTTONS OUT
MODULATION SYM ..... CAL
MODULATION RANGE Hz 100
MODULATION RANGE Hz Vernier ..... CW

b. Adjust the distortion analyzer to measure the distortion. Alternately adjust A1R342 and A1R348 for minimum distortion.

c. Adjust A1R307 for minimum distortion. Minimum distortion must be better than - 34 dB.

d. Change the Modulation RANGE Hz to 10 K and turn the Vernier completely CCW. Readjust A1R302 for minimum distortion. Distortion on the 10 K range must be better than - 34 dB.

e. Turn the FREQUENCY Vernier completely CW and measure the distortion. It should be better than - 34 dB.

5-38. Carrier Balance Adjustment.

a. Connect the 3312A main output to the vertical input of an oscilloscope. Set the 3312A controls as follows:

RANGE Hz 1
FREQUENCY Dial 1
OFFSET ..... CAL
SYM ..... CW UNCAL
TRIGGER PHASE ..... FREE RUN
FUNCTION ..... ALL BUTTONS OUT
AMPLITUDE ..... 1 V
AMPLITUDE Vernier ..... CENTER
MODULATION FUNCTION ..... AM⊓
FM AND SWP ..... OUT
PERCENT MODULATION ..... CW
MODULATION RANGE Hz ..... 10 K
MODULATION RANGE Hz Vernier ..... CW
MODULATION SYM ..... CAL

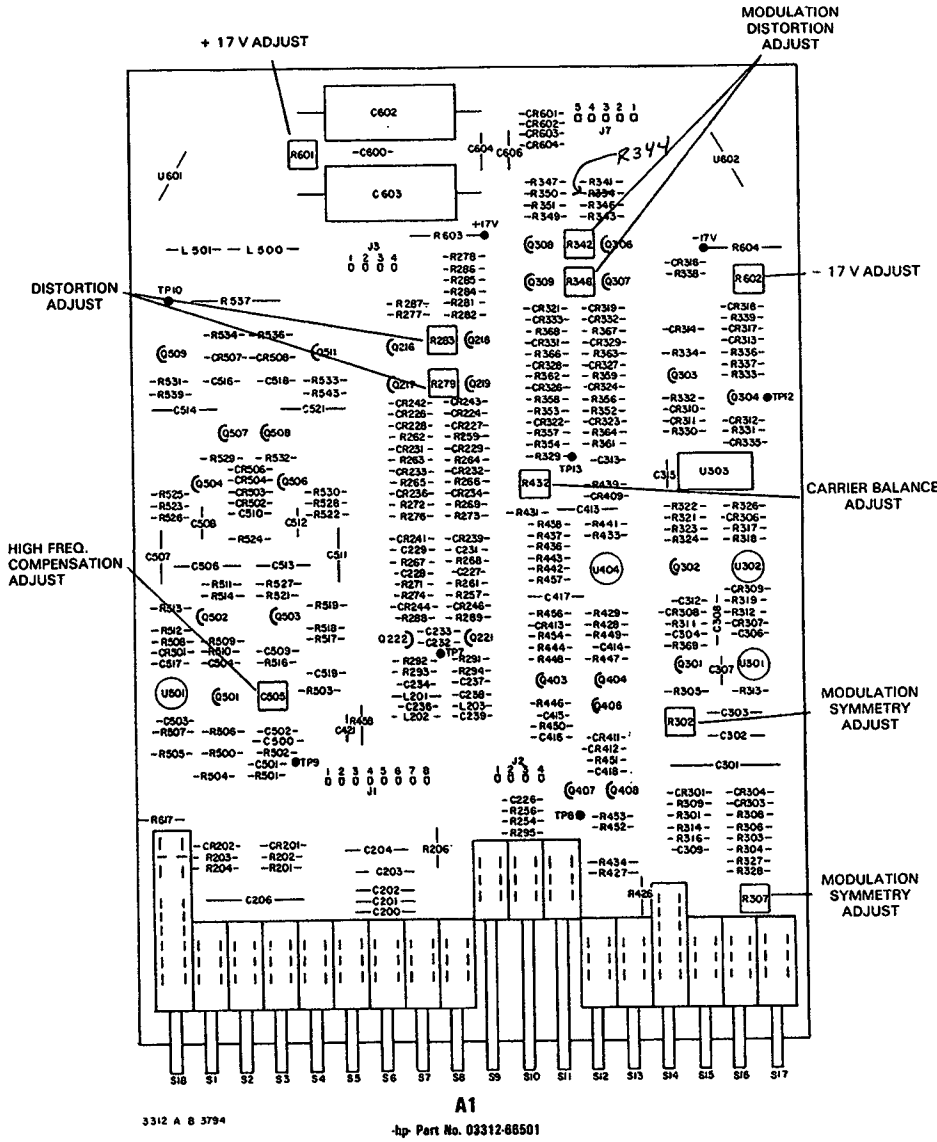
b. Set the oscilloscope for maximum vertical sensitivity and adjust R432 for minimum modulation signal on the oscilloscope.

5-39. FACTORY SELECTED VALUES.

5-40. Table 5-4 is a list of factory selected components in the Model 3312A. The table lists the purpose of each component, its nominal value and how to select the specific value.

Table 5-4. Factory Selected Components.

Designator	Purpose and How to Select	Nominal Value
C111	Square Wave Symmetry Adjust – Increasing the value of C111 increases the time of the positive portion of the waveform. Component may be missing.	Position may be blank. Nominal value is .68 pF.
C112	Square Wave Symmetry Adjust – Increasing the value of C112 increases the time of the negative portion of the waveform. Component may be missing.	Position may be blank. Nominal value is .68 pF.
R607, R609	Symmetry CAL adjust – Measure the resistance of the cal potentiometer. Divide this value by two and then add approximate value of the wiper arm contact resistance. This value represents the correct value of R607 and R609.	5.1 K
A2C103, A2-C104	If VCO linearity out of spec these values can be increased up to 100 pF.	200 pF
A2R213	If oscillation dies when SYM knob turned all the way CW, a 619 Ω resistor can be used.	1 KΩ
A2R103	Increase range of A2R127 and A2R129 so that symmetry can be adjusted within tolerance. Decrease A2R103 if period too short at end of pot. ranges.	100 Ω
A1R429	Compensates for gain variations of A1U404.	1 K



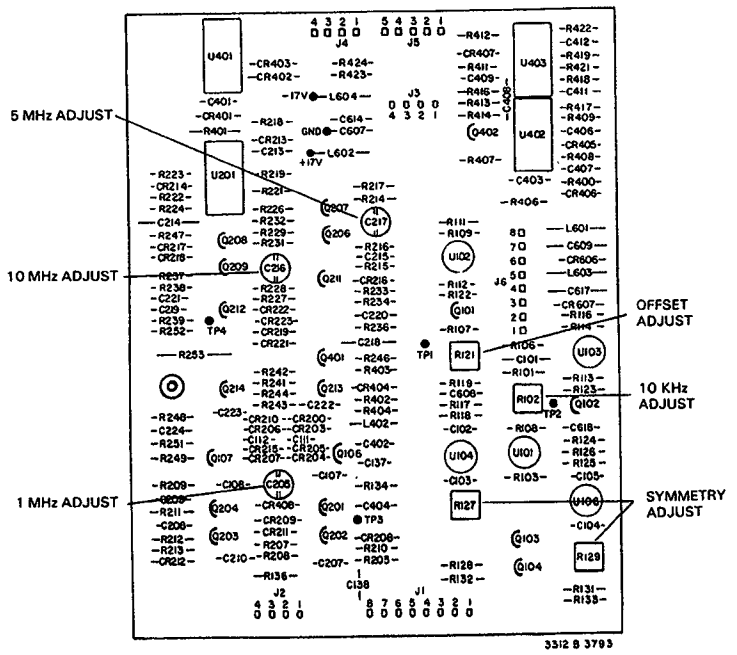


Figure 5-13. Adjustment Locator.

PERFORMANCE TEST CARD

Hewlett-Packard Model 3312A
Function Generator
Serial No. _____

Tests Performed By _____
Date _____

Test Description	Specification	Limit	Test Result
1. Dial Accuracy Test	5% F.S.		
	Dial / Range		
	1 / .1	6060 ms to 28,571 ms	_____
	6 / .1	1504 ms to 1869 ms	_____
	13 / .1	733 ms to 810 ms	_____
	1 / 1	606 ms to 2857 ms	_____
	6 / 1	150 ms to 187 ms	_____
	13 / 1	73 ms to 81 ms	_____
	1 / 10	61 ms to 286 ms	_____
	6 / 10	15 ms to 18.9 ms	_____
	13 / 10	7.3 ms to 8.1 ms	_____
	1 / 100	35 Hz to 165 Hz	_____
	6 / 100	535 Hz to 665 Hz	_____
	13 / 100	1235 Hz to 1365 Hz	_____
	1 / 1 K	350 Hz to 1650 Hz	_____
	6 / 1 K	5350 Hz to 6650 Hz	_____
	13 / 1 K	12.35 K to 13.65 K	_____
	1 / 10 K	3.5 K to 16.5 K	_____
	6 / 10 K	53.5 K to 66.5 K	_____
	13 / 10 K	123.5 K to 136.5 K	_____
	1 / 100 K	35 K to 165 K	_____
	6 / 100 K	535 K to 665 K	_____
	13 / 100 K	1.235 M to 1.365 M	_____
	1 / 1 M	.350 M to 1.65 M	_____
	6 / 1 M	5.35 M to 6.65 M	_____
	13 / 1 M	12.35 M to 13.65 M	_____
2. Square Wave Rise and Fall Time Test	Less than 18 ns	< 18 ns	_____
3. Aberration Test	Less than 10% p-p	< 10%	_____
4. Sine Wave Distortion Test	.5% THD. 10 Hz to 50 kHz > - 30 dB 50 kHz to 13 MHz	< .5% (46 dB) < - 30 dB	_____
5. Output Impedance Test	50 ohm ± 10% (2.37 V to 2.62 V)	2.37 V to 2.62 V	_____
6. Level Flatness Test	< 3%, 10 Hz to 100 kHz < 10%, 100 kHz to 10 MHz	< 3% < 10%	_____
7. Attenuator Accuracy Test	> 95%	.285 V to .315 V 28.5 mV to 31.5 mV 2.85 mV to 3.15 mV	_____
8. Sync Output Impedance and Amplitude Test	50 ohm ± 5% > 1 V p-p open circuit	.488 V to .513 V p-p > 1 V p-p	_____
9. Sync Output Rise and Fall Time Test	< 10 ns open circuit 10% and 90% points	< 10 ns	_____
10. DC Offset Test	± 10 V without clipping $V_{ac} + V_{dc}$	< 10 V ($V_{ac} + V_{dc}$)	_____

PERFORMANCE TEST CARD (Cont'd)

Test Description (Cont'd)	Specification (Cont'd)	Limit (Cont'd)	Test Result (Cont'd)
11. Internal Modulation Source Level Test	> 1.0 V p-p into 10 kΩ	> 1.0 V p-p	_____
12. Internal Modulation Source Spectral Purity Test	< 2% (- 34 dB) 10 Hz to 10 kHz	< 2% (- 34 dB)	_____
13. Variable Symmetry Test	80:20:80 to 1 MHz	> 80:20:80	_____
14. Carrier Envelope Distortion Test	2% (- 34 dB) F_m = 1 kHz, F_c = 1 MHz @ 70% modulation	< 2% (- 34 dB)	_____
15. Carrier 3 dB Bandwidth Test	< 100 Hz to > 5 MHz	< 3 dB	_____
16. External Modulation Amplitude Sensitivity Test	< 10 V p-p for 100% modulation	< 10 V p-p	_____
17. FM Distortion Test	< - 35 dB at F_c = 10 MHz, F_m = 1 kHz at 10% modulation	< - 35 dB	_____
18. External Frequency Control Input Test	0 to - 2 V will linearly decrease frequency > 1000:1 Linearity = .5% over a 100:1 range	< .5% error	_____
19. Triangle Linearity Error Test	< 1% at 100 Hz	< 1%	_____
20. Sweep Ramp Linearity Error Test	< 1% at 100 Hz	< 1%	_____
21. Frequency Deviation Test	0 to 5% internal	> 0.1 μsec	_____

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-3 lists the parts in alphameric order of their reference designators and provides the following information:

a. -hp- Part Number.

b. Total quantity used in the instrument (Qty Column). The total quantity of a part is given the first time the part number appears.

c. Description of the part. (See Table 6-1 for abbreviations.)

d. Typical manufacturer of the part in a five-digit code. (See Table 6-2 for list of manufacturers.)

e. Manufacturers part number.

6-3. Chassis Mounted and Miscellaneous Parts.

6-4. Chassis mounted components, mechanical parts and miscellaneous parts not having reference designators are listed near the end of Table 6-3.

6-5. ORDERING INFORMATION.

6-6. To obtain replacement parts, address your order or inquiry to the nearest Hewlett-Packard Sales and Service Office (Appendix A). Identify parts by their -hp- Part Numbers. Include the instrument model and serial number.

6-7. Non-Listed Parts.

6-8. To obtain a part that is not listed, include:

a. Instrument model number.
b. Instrument serial number.
c. Description of the part.
d. Function and location of the part.

Table 6-1. Standard Abbreviations.

ABBREVIATIONS

Ag ..... silver	Hz ..... hertz (cycle(s) per second)	NPO ..... negative positive zero (zero temperature coefficient)	sl ..... slide
Al ..... aluminum	ID ..... inside diameter	ns ..... nanosecond(s) = 10^{-9} seconds	SPDT ..... single-pole double-throw
A ..... ampere(s)	impg ..... impregnated	nsr ..... not separately replaceable	SPST ..... single-pole single-throw
Au ..... gold	incd ..... incandescent		Ta ..... tantalum
C ..... capacitor	ins ..... insulation(ed)	Ω ..... ohm(s)	TC ..... temperature coefficient
cer ..... ceramic		obd ..... order by description	TiO_2 ..... titanium dioxide
coef ..... coefficient	kΩ ..... kilohm(s) = 10^{+3} ohms	OD ..... outside diameter	tog ..... toggle
com ..... common	kHz ..... kilohertz = 10^{+3} hertz		tol ..... tolerance
comp ..... composition		p ..... peak	trim ..... trimmer
conn ..... connection	L ..... inductor	pA ..... picoampere(s)	TSTR ..... transistor
dep ..... deposited	lin ..... linear taper	pc ..... printed circuit	V ..... volt(s)
DPDT ..... double-pole double-throw	log ..... logarithmic taper	pF ..... picofarad(s) 10^{-12} farads	vacw ..... alternating current working voltage
DPST ..... double-pole single-throw	mA ..... milliampere(s) = 10^{-3} amperes	piv ..... peak inverse voltage	var ..... variable
elect ..... electrolytic	MHz ..... megahertz = 10^{+6} hertz	p/o ..... part of	vdcw ..... direct current working voltage
encap ..... encapsulated	MΩ ..... megohm(s) = 10^{+6} ohms	pos ..... position(s)	W ..... watt(s)
F ..... farad(s)	met flm ..... metal film	poly ..... polystyrene	w/ ..... with
FET ..... field effect transistor	mfr ..... manufacturer	pot ..... potentiometer	wiv ..... working inverse voltage
fxd ..... fixed	mtg ..... mounting	p-p ..... peak-to-peak	w/o ..... without
GaAs ..... gallium arsenide	mV ..... millivolt(s) = 10^{-3} volts	ppm ..... parts per million	ww ..... wirewound
GHz ..... gigahertz = 10^{+9} hertz	μF ..... microfarad(s)	prec ..... precision (temperature coeffient, long term stability and/or tolerance)	* ..... optimum value selected at factory, average value shown (part may be omitted)
gd ..... guard(ed)	μs ..... microsecond(s)	R ..... resistor	** ..... no standard type number assigned selected or special type
Ge ..... germanium	μV ..... microvolt(s) = 10^{-6} volts	Rh ..... rhodium	
gnd ..... ground(ed)	my ..... Mylar®	rms ..... root-mean-square	
H ..... henry(ies)	nA ..... nanoampere(s) = 10^{-9} amperes	rot ..... rotary	
Hg ..... mercury	NC ..... normally closed	Se ..... selenium	
	Ne ..... neon	sect ..... section(s)	
	NO ..... normally open	Si ..... silicon	

® Dupont de Nemours

DECIMAL MULTIPLIERS

Prefix	Symbols	Multiplier	Prefix	Symbols	Multiplier
tera	T	10^{12}	centi	c	10^{-2}
giga	G	10^{9}	milli	m	10^{-3}
mega	M or Meg	10^{6}	micro	μ	10^{-6}
kilo	K or k	10^{3}	nano	n	10^{-9}
hecto	h	10^{2}	pico	p	10^{-12}
deka	da	10	femto	f	10^{-15}
deci	d	10^{-1}	atto	a	10^{-18}

STD-B-2734

DESIGNATORS

A ..... assembly	FL ..... filter	Q ..... transistor	TS ..... terminal strip
B ..... motor	HR ..... heater	QCR ..... transistor-diode	U ..... microcircuit
BT ..... battery	IC ..... integrated circuit	R ..... resistor	V ..... vacuum tube, neon bulb, photocell, etc.
C ..... capacitor	J ..... jack	RT ..... thermistor	W ..... cable
CR ..... diode	K ..... relay	S ..... switch	X ..... socket
DL ..... delay line	L ..... inductor	T ..... transformer	XDS ..... lampholder
DS ..... lamp	M ..... meter	TB ..... terminal board	XF ..... fuseholder
E ..... misc electronic part	MP ..... mechanical part	TC ..... thermocouple	Y ..... crystal
F ..... fuse	P ..... plug	TP ..... test point	Z ..... network

Table 6-2. Code List of Manufacturers.

Manufacturer Number	Manufacturer Name	Address
00746	R-OHM Corporation	Irvine, CA 92716
00853	Sangamo Elec. Co., S. Carolina Division	Pickens, CA 29671
01121	Allen Bradley Co.	Milwaukee,WI 53212
01295	Texas Instruments Inc. Semiconductor Component Division	Dallas, TX 75231
01921	RCA Corporation Solid State Division	Sommerville, NJ 08876
02114	Ferroxcube Corporation	Saugerties, NY 12477
03888	Pyrofilm Corporation	Whippany, NJ 07981
04713	Motorola Semiconductor Products	Phoenix, AZ 85008
06560	Airco Speer Electronic Division Air RDCN Co.	Nogales, AZ 85621
07263	Fairchild Semiconductor Division	Mountain View, CA 94040
16299	Corning Glass Work Elec. Component Division	Raleigh, NC 27604
17856	Siliconix Inc.	Santa Clara, CA 95054
19701	Mepco/Electra Corporation	Mineral Wells, TX 76067
22753	U I D Electronics Corporation	Hollywood, FL 33021
24226	Gowanda Electronics Corporation	Gowanda. NY 14070
24546	Corning Glass Works	Bradford, PA 16701
24931	Specialty Connector Company, Inc.	Indianapolis, IN 46227
27014	National Semiconductor Corporation	Santa Clara, CA 95051
27264	Molex Products Company	Downers Grove, IL 60515
28480	Hewlett-Packard Company Corporate HQ	Palo Alto, CA 94304
32997	Bourns Inc. Trimpot Product Division	Riverside, CA 92507
55285	Bergquist Co.	Minneapolis, MN 55420
56289	Spraque Electric Company	North Adams, MA 01247
71590	Centralab Electronic Division Globe-Union Inc.	Milwaukee, WI 53201
72136	Electro Motive Manufacturing Company Inc.	Willimantic, CT 06226
73138	Beckman Instruments Inc. Helipot Division	Fullerton, CA 92634
73899	J F D Electronics Corporation	Brooklyn, NY 11219
74970	Johnson E F Company	Waseca, MN 56093
82389	Switchcraft Inc.	Chicago, IL 60630
91637	Dale Electronics Inc.	Columbus, NE 68601
95121	Quality Components Inc.	St. Marys, PA 15857

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1	03312-66501	1	PC ASSY, MAIN	28480	03312-66501
A1C200 Δ	0150-0015	1	CAPACITOR-FXD 2.2PF 500WVDC	95121	TYPE QC
A1C201-4,6	0160-4187	5	CAPACITOR SET	28480	0160-4187
A1C226	0150-0043	2	CAPACITOR-FXD 6.8PF +-5% 500WVDC TI DIOX	95121	TYPE QC
A1C227	0160-2198		CAPACITOR-FXD 20PF +-5% 300WVDC MICA O+	28480	0160-2198
A1C228	0160-2204	3	CAPACITOR-FXD 100PF +-5% 300WVDC MICA	28480	0160-2204
A1C229	0150-0121	14	CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C231	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C232	0180-0197	6	CAPACITOR-FXD: 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1C233	0180-0197		CAPACITOR-FXD: 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1C234	0160-2150	1	CAPACITOR-FXD 33PF +-5% 300WVDC MICA	28480	0160-2150
A1C236	0140-0191	2	CAPACITOR-FXD 56PF +-5% 300WVDC MICA	72136	DM15E560J0300WV1CR
A1C237	0140-0193	2	CAPACITOR-FXD 82PF +-5% 300WVDC MICA	72136	DM15E820J0300WV1CR
A1C238	0140-0193		CAPACITOR-FXD 82PF +-5% 300WVDC MICA	72136	DM15E820J0300WV1CR
A1C239	0140-0191		CAPACITOR-FXD 56PF +-5% 300WVDC MICA	72136	DM15E560J0300WV1CR
A1C301-3	0160-4188	3	CAPACITOR SET	28480	0160-4188
A1C321 Δ5	0140-0204		CAPACITOR:FXD MICA 47PF 5% 500VDCW	04522	DM15E470J0500WV1CR
A1C304	0150-0093	21	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A1C306	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A1C307	0140-0196	1	CAPACITOR-FXD 150PF +-5% 300WVDC MICA	72136	DM15F151J0300WV1CR
A1C308	0160-0205	1	CAPACITOR-FXD 10PF +-5% 500WVDC MICA O+	28480	0160-0205
A1C309	0160-2206	1	CAPACITOR-FXD 160PF +-5% 300WVDC MICA	28480	0160-2206
A1C312	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A1C313	0160-0945	1	CAPACITOR-FXD 910PF +-5% 100WVDC MICA	28480	0160-0945
A1C315	0150-0093	1	CAPACITOR-FXD .1UF 100WVDC	28480	0150-0093
A1C413	0180-0229	2	CAPACITOR-FXD: 33UF+-10% 10VDC TA-SOLID	56289	150D336X9010B2
A1C414	0160-2198	2	CAPACITOR-FXD 20PF +-5% 300WVDC MICA O+	28480	0160-2198
A1C415	0160-2199	1	CAPACITOR-FXD 30PF +-5% 300WVDC MICA	28480	0160-2199
A1C416	0180-0197		CAPACITOR-FXD: 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1C417	0180-0229		CAPACITOR-FXD: 33UF+-10% 10VDC TA-SOLID	56289	150D336X9010B2
A1C418	0180-0197		CAPACITOR-FXD: 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1C421	0140-0205	3	CAPACITOR-FXD 62PF +-5% 300WVDC MICA	72136	DM15E620J0300WV1CR
A1C500 Δ4	0150-0044	1	CAPACITOR-FXD TI 5.6PF 5% 500VDCW	78488	TYPE GA
A1C501	0140-0199	1	CAPACITOR-FXD 240PF +-5% 300WVDC MICA	72136	DM15F241J0300WV1CR
A1C502	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C503	0140-0202	1	CAPACITOR-FXD 15PF +-5% 500WVDC MICA O+	72136	DM15C150J0500WV1CR
A1C504	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C505	0121-0131	1	CAPACITOR: VAR: TRMR: AIR: 1.2/4.2PF	74970	189-0501-005
A1C506	0180-0374	2	CAPACITOR-FXD: 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A1C507	0180-0228	2	CAPACITOR-FXD: 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A1C508	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A1C509	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C510	0150-0011	1	CAPACITOR-FXD 1.5PF +-20% 500WVDC TI	95121	TYPE QC
A1C511	0180-0228		CAPACITOR-FXD: 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A1C512	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A1C513	0180-0374		CAPACITOR-FXD: 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A1C514	0180-1746	7	CAPACITOR-FXD: 15UF+-10% 20VDC TA-SOLID	56289	150D156X9020P2
A1C516	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C517	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C518	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C519	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A1C521	0180-1746		CAPACITOR-FXD: 15UF+-10% 20VDC TA-SOLID	56289	150D156X9020B2
A1C600 Δ	0180-0229		CAPACITOR-FXD: 33UF +-10% 10VDC	56289	150D336X901082
A1C602	0180-0533	2	CAPACITOR-FXD: 500UF +75-10% 40VDC AL	56289	39D507G040GJ4
A1C603	0180-0533		CAPACITOR-FXD: 500UF+75-10% 40VDC AL	56289	39D507G040GJ4
A1C604	0180-0197		CAPACITOR-FXD: 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1C606	0180-0197		CAPACITOR-FXD: 2.2UF +-10% 20VDC TA	56289	150D225X9020A2
A1CR201	1902-0025	6	DIODE-ZNR 10V 5% DO-7 PD=.4W TC=+.06%	04713	SZ 10939-182
A1CR202	1902-0025		DIODE-ZNR 10V 5% DO-7 PD=.4W TC=+.06%	04713	SZ 10939-182
A1CR224	1901-0040	53	DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR226	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR227	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR228	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR229	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR231	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR232	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR233	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR234	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR236	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR239	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR241	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR242	1902-0025		DIODE-ZNR 10V 5% DO-7 PD=.4W TC=+.06%	04713	SZ 10939-182

See introduction to this section for ordering information

Δ Serial No's. 1432A00351 and below do not contain these parts.

Table 6-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1CR243	1902-0025		DIODE-ZNR 10V 5% DO-7 PD=.4W TC=+.06%	04713	SZ 10939-182
A1CR244	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR246	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR301	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR303	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR304	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR306	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR307	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR308	1902-0041	4	DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=	04713	SZ 10939-98
A1CR309	1902-3190	1	DIODE-ZNR 13V 5% DO-7 PD=.4W TC=+.06%	04713	SZ 10939-215
A1CR310	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR311	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR312	1902-3139	1	DIODE-ZNR 8.25V 5% DO-7 PD=.4W	04713	SZ 10939-158
A1CR313	1902-0048	1	DIODE-ZNR 6.81V 5% DO-7 PD=.4W	28480	1902-0048
A1CR314	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR316	1902-0064	2	DIODE-ZNR 7.5V 5% DO-7 PD=.4W TC=	04713	SZ 10939-146
A1CR317	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR318	1902-0064		DIODE-ZNR 7.5V 5% DO-7 PD=.4W TC=	04713	SZ 10939-146
A1CR319	1902-0025		DIODE-ZNR 10V 5% DO-7 PD=.4W TC=+.06%	04713	SZ 10939-182
A1CR321	1902-0025		DIODE-ZNR 10V 5% DO-7 PD=.4W TC=+.06%	04713	SZ 10939-182
A1CR322	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR323	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR324	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR326	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR327	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR328	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR329	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR331	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR332	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR333	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR335	1902-0041		DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=	04713	SZ 10939-98
A1CR409	1902-3136	2	DIODE-ZNR 8.06V 5% DO-7 PD=.4W	04713	SZ 10939-155
A1CR411	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR412	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR413	1902-3182	1	DIODE-ZNR 12.1V 5% DO-7 PD=.4W	04713	SZ 10939-206
A1CR501	1902-3073	1	DIODE-ZNR 4.32V 5% DO-7 PD=.4W TC=	04713	SZ 10939-77
A1CR502	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR503	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR504	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR506	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR507	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR508	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR601	1901-0028	4	DIODE-PWR RECT 400V 750MA	04713	SR1358-9
A1CR602	1901-0028		DIODE-PWR RECT 400V 750MA	04713	SR1358-9
A1CR603	1901-0028		DIODE-PWR RECT 400V 750MA	04713	SR1358-9
A1CR604	1901-0028		DIODE-PWR RECT 400V 750MA	04713	SR1358-9
A1J1	1251-3829	2	CONNECTOR, 8-PIN	27264	OBD NO.
A1J2, J3	1251-3827	2	CONNECTOR, 4-PIN	27264	OBD NO.
A1J7	1251-3825	1	CONNECTOR, 5-PIN M POST TYPE	27264	09-65-1061
A1L201	9100-3546	2	COIL: FXD; MOLDED RF CHOKE; .0000013UH	06560	15A1R3J
A1L202	9100-3546		COIL: FXD; MOLDED RF CHOKE; .0000013UH	06560	15A1R3J
A1L203	9100-3547	1	COIL: FXD; MOLDED RF CHOKE; .0000043UH	06560	15A4R3J
A1L500/501 & 8	9100-3458	1	WIDE BAND CHOKE	28480	9100-3458
A10216	1854-0215	12	TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10217	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10218	1853-0020	10	TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A10219	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A10221	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10222	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A10301	1855-0082	1	TRANSISTOR: J-FET P-CHAN, D-MODE SI	28480	1855-0082
A10302	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10303	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A10304	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A10306	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A10307	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A10308	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10309	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10403	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10404	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10406	1853-0010	1	TRANSISTOR PNP SI CHIP TO-18 PD=360MW	28480	1853-0010
A10407	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A10408	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A10501	1854-0345	2	TRANSISTOR NPN 2N5179 SI PD=200MW	04713	2N5179
A10502	1853-~~0288~~ 0405	1	TRANSISTOR PNP SI PD=360MW TO-18 2N4209	28480	~~1853-0203~~
A10503	1854-0345		TRANSISTOR NPN 2N5179 SI PD=200MW	04713	2N5179
A10504	1853-0258	3	TRANSISTOR PNP 2N4035 SI CHIP	07263	2N4035
A10506	1854-0351	2	TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0351
A10507	1854-0351		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0351

Table 6-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1Q508	1853-0258		TRANSISTOR PNP 2N4035 SI CHIP	07263	2N4035
A1Q509	1854-0053	1	TRANSISTOR NPN 2N2218 SI PD=800MW	04713	2N2218
A1Q511	1853-0012	1	TRANSISTOR PNP 2N2904A SI CHIP	01295	2N2904A
A1R201	0698-6582	2	RESISTOR 2.222K .1% .125W F TUBULAR	03888	PME55
A1R202	0698-6583	2	RESISTOR 202 OHM .1% .125W F TUBULAR	03888	PME55
A1R203	0698-6583		RESISTOR 202 OHM .1% .125W F TUBULAR	03888	PME55
A1R204	0698-6582		RESISTOR 2.222K .1% .125W F TUBULAR	03888	PME55
A1R206	0683-2005		RESISTOR-FXD 20 OHM 5%	01607	CB2005
A1R254	0698-4450	1	RESISTOR 324 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-324R-F
A1R256	0698-4455	2	RESISTOR 536 OHM 1% .125W	28480	0698-4455
A1R257	0683-2015	4	RESISTOR 200 OHM 5% .25W CC TUBULAR	01121	CB2015
A1R259	0683-1315	2	RESISTOR 130 OHM 5% .25W CC TUBULAR	01121	CB1315
A1R261	0683-1025	7	RESISTOR 1K 5% .25W CC TUBULAR	01121	CB1025
A1R262	0683-1315		RESISTOR 130 OHM 5% .25W CC TUBULAR	01121	CB1315
A1R263	0683-8205	2	RESISTOR 82 OHM 5% .25W CC TUBULAR	01121	CB8205
A1R264	0683-8205	9	RESISTOR 82 OHM 5% .25W CC TUBULAR	01121	CB8205
A1R265	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A1R266	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A1R267	0683-4715	2	RESISTOR 470 OHM 5% .25W CC TUBULAR	01121	CB4715
A1R268	0698-2025	2	RESISTOR 2K OHM 5% .25W	01121	CB 2025
A1R269	0683-3005	2	RESISTOR 30 OHM 5% .25W CC TUBULAR	01121	CB3005
A1R271	0683-3315	4	RESISTOR 330 OHM 5% .25W CC TUBULAR	01121	CB3315
A1R272	0683-3005		RESISTOR 30 OHM 5% .25W CC TUBULAR	01121	CB3005
A1R273	0683-3905	4	RESISTOR 39 OHM 5% .25W CC TUBULAR	01121	CB3905
A1R274	0683-1215	5	RESISTOR 120 OHM 5% .25W CC TUBULAR	01121	CB1215
A1R276	0683-3905		RESISTOR 39 OHM 5% .25W CC TUBULAR	01121	CB3905
A1R277	0757-0433	2	RESISTOR 3.32K 1% .125W F TUBULAR	24546	C4-1/8-T0-3321-F
A1R278	0683-1525	3	RESISTOR 1.5K 5% .25W CC TUBULAR	01121	CB1525
A1R279	2100-3252	4	RESISTOR-VAR TRMR 5KOHM 10% C TOP ADJ	32997	3389P-1-502
A1P281	0757-0448	2	RESISTOR 18.2K 1% .125W F TUBULAR	24546	C4-1/8-T0-1822-F
A1R282	0683-1035	12	RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R283	2100-3252		RESISTOR-VAR TRMR 5KOHM 10% C TOP ADJ	32997	3389P-1-502
A1R284	0757-0448		RESISTOR 18.2K 1% .125W F TUBULAR	24546	C4-1/8-T0-1822-F
A1R285	0757-0433		RESISTOR 3.32K 1% .125W F TUBULAR	24546	C4-1/8-T0-3321-F
A1R286	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R287	0683-1525		RESISTOR 1.5K 5% .25W CC TUBULAR	01121	CB1525
A1R288	0698-3558	4	RESISTOR 4.02K 1% .125W F TUBULAR	16299	C4-1/8-T0-4021-F
A1R289	0698-3558		RESISTOR 4.02K 1% .125W F TUBULAR	16299	C4-1/8-T0-4021-F
A1R291	0683-1005	10	RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A1R292	0683-1005		RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A1R293	0698-3444	1	RESISTOR 316 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-316R-F
A1R294	0698-4455		RESISTOR 536 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-536R-F
A1R295	0683-2415	3	RESISTOR 240 OHM 5% .25W CC TUBULAR	01121	CB2415
A1R301	0683-8235	1	RESISTOR 82K 5% .25W CC TUBULAR	01121	CB8235
A1R302	2100-3210	3	RESISTOR-VAR TRMR 10KOHM 10% C SIDE ADJ	32997	3389P-1-103
A1R303 Δ2	0698-4472	1	RESISTOR 7.68K 1% .125W F TUBULAR	24546	C4-1/8-T0-7681-F
A1R304 Δ2	0698-3572	1	RESISTOR 60.4K 1% .125W F TUBULAR	16299	C4-1/8-T0-6042-F
A1R305	0683-2255	1	RESISTOR 2.2M 5% .25W CC TUBULAR	01121	CB2255
A1R306 Δ2	0698-3228	1	RESISTOR 49.9K 1% .125W F TUBULAR	28480	0698-3228
A1R307	2100-0558		RESISTOR-VAR 20K 10%	73138	72P
A1R308 Δ2	0698-4542	1	RESISTOR 453K 1% .125W F TUBULAR	19701	MF4C1/8-T0-4533-F
A1R309	0757-0161	1	RESISTOR 604 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-604R-F
A1R311, R312	0683-1005		RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A1R313	0683-1015	10	RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
A1R314	0683-8225	6	RESISTOR 8.2K 5% .25W CC TUBULAR	01121	CB8225
A1R316	0683-1335	2	RESISTOR 13K 5% .25W CC TUBULAR	01121	CB1335
A1R317 Δ2	0757-0446	2	RESISTOR 15K 1% .125W F TUBULAR	24546	C4-1/8-T0- 1502-F
A1R318 Δ2	0757-0440	1	RESISTOR 7.5K 1% .125W F TUBULAR	24546	C4-1/8-T0-7501-F
A1P319	0757-0442		RESISTOR 10K 1% .125W F TUBULAR	24546	C4-1/8-T0-1002-F
A1R321	0683-4735	3	RESISTOR 47K 5% .25W CC TUBULAR	01121	CB4735
A1P322	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R323	0683-1045		RESISTOR 100K 5% .25W	01121	CB1045
A1R324	0683-2445	1	RESISTOR 240K 5% .25W CC TUBULAR	01121	CB2445
A1R326	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R327	0683-1535		RESISTOR 15K 5% .25W CC TUBULAR	01121	CB1535
A1R328	0683-1335	1	RESISTOR:FXD 13K 5%	01607	CB1335
A1R329	0683-5125	3	RESISTOR 5.1K 5% .25W CC TUBULAR	01121	CB5125
A1R330	0683-1825	7	RESISTOR 1.8K 5% .25W CC TUBULAR	01121	CB1825
A1R331	0683-3335	1	RESISTOR 33K 5% .25W CC TUBULAR	01121	CB3335
A1R332	0683-3015	1	RESISTOR 300 OHM 5% .25W CC TUBULAR	01121	CB3015
A1R333	0683-2025	7	RESISTOR 2K 5% .25W CC TUBULAR	01121	CB2025
A1R334	0683-6815	1	RESISTOR 680 OHM 5% .25W CC TUBULAR	01121	CB6815
A1R336	0683-5125		RESISTOR 5.1K 5% .25W CC TUBULAR	01121	CB5125
A1R337	0683-1825		RESISTOR 1.8K .25W CC TUBULAR	01121	CB1825

See introduction to this section for ordering information

Δ2 Refer to Section VIII

Table 6-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1R338	0683-1035	2	RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R339	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R341	0757-0447	2	RESISTOR 16.2K 1% .125W F TUBULAR	24546	C4-1/8-T0-1622-F
A1R342	2100-3252		RESISTOR-VAR TRMR 5KOHM 10% C TOP ADJ	32997	3389P-1-502
A1R343	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R344	0698-3153	2	RESISTOR 3.83K 1% .125W F TUBULAR	16299	C4-1/8-T0-3831-F
A1R346	0683-1825		RESISTOR 1.8K 5% .25W CC TUBULAR	01121	CB1825
A1R347	0757-0447		RESISTOR 16.2K 1% .125W F TUBULAR	24546	C4-1/8-T0-1622-F
A1R348	2100-3252		RESISTOR-VAR TRMR 5KOHM 10% C TOP ADJ	32997	3389P-1-502
A1R349	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R350	0698-3153		RESISTOR 3.83K 1% .125W F TUBULAR	16299	C4-1/8-T0-3831-F
A1R351	0683-1825		RESISTOR 1.8K 5% .25W CC TUBULAR	01121	CB1825
A1R352	0683-1515	2	RESISTOR 150 OHM 5% .25W CC TUBULAR	01121	CB1515
A1R353	0683-1515		RESISTOR 150 OHM 5% .25W CC TUBULAR	01121	CB1515
A1R354	0683-4715		RESISTOR 470 OHM 5% .25W CC TUBULAR	01121	CB4715
A1R356	0683-1215		RESISTOR 120 OHM 5% .25W CC TUBULAR	01121	CB1215
A1R357	0683-1325	2	RESISTOR 1.3K 5% .25W CC TUBULAR	01121	CB1325
A1R358	0683-1215		RESISTOR 120 OHM 5% .25W CC TUBULAR	01121	CB1215
A1R359	0683-1815	4	RESISTOR 180 OHM 5% .25W CC TUBULAR	01121	CB1815
A1R361	0683-1825		RESISTOR 1.8K 5% .25W CC TUBULAR	01121	CB1825
A1R362	0683-1815		RESISTOR 180 OHM 5% .25W CC TUBULAR	01121	CB1815
A1R363	0683-3315		RESISTOR 330 OHM 5% .25W CC TUBULAR	01121	CB3315
A1R364	0683-4325	1	RESISTOR 4.3K 5% .25W CC TUBULAR	01121	CB4325
A1R366	0683-3315		RESISTOR 330 OHM 5% .25W CC TUBULAR	01121	CB3315
A1R367, 368	0683-5615	2	RESISTOR 560 OHM 5% .25W CC TUBULAR	01121	CB5615
A1R369	0683-8215	1	RESISTOR 820 OHM 5% .25W CC TUBULAR	01121	CB8215
A1R370 Δ5	0757-0280	1	RESISTOR:FXD 1000 OHM 1%	03292	C4-1/8-T0-1001-F
A1R371 Δ5	0698-3499	1	RESISTOR:FXD 40.2KOHMS 1%	03292	C4-1/8-T0-4022-F
A1R426	0698-4478	2	RESISTOR 10.7K 1% .125W F TUBULAR	24546	C4-1/8-T0-1072-F
A1R427	0683-1235	2	RESISTOR 12K 5% .25W CC TUBULAR	01121	CB1235
A1R428	0683-8225		RESISTOR 8.2K 5% .25W CC TUBULAR	01121	CB8225
A1R429 ::	0757-0280	3	RESISTOR 1K 1% .125W F TUBULAR	24546	C4-1/8-T0-1001-F
A1R431	0683-8225		RESISTOR 8.2K 5% .25W CC TUBULAR	01121	CB8225
A1R432	2100-3210		RESISTOR-VAR TRMR 10KOHM 10% C SIDE ADJ	32997	3389P-1-103
A1R433	0683-3625	1	RESISTOR 3.6K 5% .25W CC TUBULAR	01121	CB3625
A1R434	0757-0416	1	RESISTOR 511 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-511R-F
A1R436	0757-0346	1	RESISTOR 10 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-10R0-F
A1R437	0683-5115	6	RESISTOR 510 OHM 5% .25W CC TUBULAR	01121	CB5115
A1R438	0683-7525		RESISTOR 7.5K 5% .25W CC TUBULAR	01121	CB7545
A1R439	0683-1025		RESISTOR 1K 5% .25W CC TUBULAR	01121	CB1025
A1R441	0683-6825	1	RESISTOR 6.8K 5% .25W CC TUBULAR	01121	CB6825
A1R442	0698-4123		RESISTOR 499 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-499R-F
A1R443	0698-4123		RESISTOR 499 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-499R-F
A1R444	0698-4422	2	RESISTOR 1.27K 1% .125W F TUBULAR	16299	C4-1/8-T0-1271-F
A1R446	0683-5115		RESISTOR 510 OHM 5% .25W CC TUBULAR	01121	CB5115
A1R447	0683-5115		RESISTOR 510 OHM 5% .25W CC TUBULAR	01121	CB5115
A1R448	0686-2225	1	RESISTOR 2.2K 5% .5W CC TUBULAR	01607	EB2225
A1R449	0698-4422		RESISTOR 1.27K 1% .125W F TUBULAR	16299	C4-1/8-T0-1271-F
A1R450	0683-2415		RESISTOR 240 OHM 5% .25W CC TUBULAR	01121	CB2415
A1R451	0683-1825		RESISTOR 1.8K 5% .25W CC TUBULAR	01121	CB1825
A1R452, R453	0683-2205	4	RESISTOR 22 OHM 5% .25W CC TUBULAR	01121	CB2205
A1R454	0683-2415	4	RESISTOR 240 OHM 5%	01121	CB2415
A1R456	0683-2025		RESISTOR 2K 5% .25W CC TUBULAR	01121	CB2025
A1R457	0683-2025		RESISTOR 2K 5% .25W CC TUBULAR	01121	CB2025
A1R458	0683-2005	1	RESISTOR 20 OHM 5% .25W CC TUBULAR	01121	CB2005
A1R500 Δ8	0698-3153	9	RESISTOR 3.83K 1% .125W F TC=0 +-100	00746	CRB14 OR CRB25
A1R501	0683-1045		RESISTOR 100K 5% .25W CC TUBULAR	01121	CB1045
A1R502	0698-4123		RESISTOR 499 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-499R-F
A1R503	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R504 Δ8	0698-3619	1	RESISTOR 12.4K 1% .125W F TC=0 +-100	00746	CRB14 OR CRB25
A1R505 Δ8	0698-3153	9	RESISTOR 3.83K 1% .125W F TC = 0 +-100	00746	CRB14 OR CRB25
A1R506	0683-2235	2	RESISTOR 22K 5% .25W CC TUBULAR	01121	CB2235
A1R507	0683-2235		RESISTOR 22K 5% .25W CC TUBULAR	01121	CB2235
A1R508	0683-9125	2	RESISTOR 9.1K 5% .25W CC TUBULAR	01121	CB9125
A1R509	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A1R510	0683-3035	1	RESISTOR 30K 5% .25W CC TUBULAR	01121	CB3035
A1R511	0683-3905		RESISTOR 39 OHM 5% .25W CC TUBULAR	01121	CB3905
A1R512	0683-1525		RESISTOR 1.5K 5% .25W CC TUBULAR	01121	CB1525
A1R513	0683-1625	2	RESISTOR 1.6K 5% .25W CC TUBULAR	01121	CB1625
A1R514	0683-1825		RESISTOR 1.8K 5% .25W CC TUBULAR	01121	CB1825
A1R516	0683-3025	3	RESISTOR 3K 5% .25W CC TUBULAR	01121	CB3025
A1R517	0683-9125		RESISTOR 9.1K 5% .25W CC TUBULAR	01121	CB9125
A1R518	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A1R519	0683-1625		RESISTOR 1.6K 5% .25W CC TUBULAR	01121	CB1625
A1R521	0683-1825		RESISTOR 1.8K 5% .25W CC TUBULAR	01121	CB1825

See introduction to this section for ordering information

Table 6-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1R522	0683-1025		RESISTOR 1K 5% .25W CC TUBULAR	01121	CB1025
A1R523	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A1R524	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A1R525	0683-1815		RESISTOR 180 OHM 5% .25W CC TUBULAR	01121	CB1815
A1R526	0683-1025		RESISTOR 1K 5% .25W CC TUBULAR	01121	CB1025
A1R527	0683-3905		RESISTOR 39 OHM 5% .25W CC TUBULAR	01121	CB3905
A1R528	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A1R529	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A1R530	0683-2415		RESISTOR 240 OHM 5% .25W CC TUBULAR	01121	CB2415
A1R531	0683-1505	2	RESISTOR 15 OHM 5% .25W CC TUBULAR	01121	CB1505
A1R532	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A1R533	0683-1505		RESISTOR 15 OHM 5% .25W CC TUBULAR	01121	CB1505
A1R534	0683-0625	2	RESISTOR 6.2 OHM 5% .25W CC TUBULAR	01121	CB62G5
A1R536	0683-0625		RESISTOR 6.2 OHM 5% .25W CC TUBULAR	01121	CB62G5
A1R537	0698-8501	1	RESISTOR 50 OHM 2% 2W MO TUBULAR	24546	FP42
A1R539	0683-1005		RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A1R543	0683-1005		RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A1R601, R602	2100-3212		RESISTOR-VAR TRMR 200 OHM 10% C SIDE ADJ	32997	3389P-1-201
A1R603, R604	0757-0159	2	RESISTOR 1K 1% .5W F TUBULAR LAR	19701	MF7C1/2-TO-1R0-F
A1R617	0686-1025	1	RESISTOR 1K 5% .5W CC TUBULAR	01121	EB1025
*A1S1	3101-1865	1	SWITCH-PB 18STA .394 IN-CTRS 1A 300VAC (SWITCH S18, 1(TQ), ~~3101-0614~~) 3101-2443 1865 (SWITCH S1-S8, S12-S17, 14(TQ), 3101-0600)	28480	3101-1865
*A1S2	3101-1866	1	SWITCH-PB 3STA DPDT INTLH .394 IN-CTRS (SWITCH S9-S11, 3(TQ) 3101-0600)	28480	3101-1866
A1U301	1820-0223	1	IC LIN LM301AH AMPLIFIER	27014	LM301AH
A1U302	1820-0321	1	IC DGTL COMPARATOR (ANALOG)	07263	710HC
A1U303	1820-1197	1	IC DGTL SN74LS00 N GATE	01295	SN74LS00N
A1U404	1820-0427	1	IC LIN MC 1496G MODULATOR	04713	MC1496G
A1U501	1820-0203	4	IC LIN AMPLIFIER	28480	1820-0203
A1U601	1826-0203	1	IC LIN REGULATOR	07263	7815KC
A1U602	1826-0169	1	IC LIN LM320K-15 REGULATOR	27014	LM320K-15
*A1XU303	1200-~~0477~~ 0638		SOCKET: IC 14 Pin	04610	C931402
A1X601/602	0340-0583	6	INSULATOR -XSTR THRM - CNDCT	55285	7403-09FR-03
A2	03312-66502	1	PC ASSY, MODULATION	28480	03312-66502
A2C101	0180-1746		CAPACITOR-FXD; 15UF+-10% 20VDC TA-SOLID	56289	150D156X902082
A2C102	0160-2204		CAPACITOR-FXD 100PF +-5% 300WVDC MICA	28480	0160-2204
A2C103*C104*	0140-~~0198~~ 0199		CAPACITOR-FXD ~~200PF~~ 290 +-5% 300WVDC MICA	00853	RDM15E620J3C
A2C105	0160-2204		CAPACITOR-FXD 100PF +-5% 300WVDC MICA	28480	0160-2204
A2C107	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C108	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
		2			
A2C111	0150-~~0046~~ *		CAPACITOR-FXD .68PF +-5% 500WVDC TI DIOX	95121	TYPE QC
A2C112	0150-~~0046~~ *		CAPACITOR-FXD. .68PF +-5% 500WVDC TIDIOX	95121	TYPE QC
A2C115 Δg	0140-0198	5	CAPACITOR -FXD 200PF +-5% 300VDC MICA	00853	RDM15F201J3C
A2C137	0150-0071		CAPACITOR-FXD 400PF +-5% 1000WVDC CER	28480	0150-0071
A2C138	0150-0071		CAPACITOR-FXD 400PF +-5% 1000WVDC CER	28480	0150-0071
A2C205	0121-0046		CAPACITOR; VAR; TRMR; CER; 9/35PF	73899	DV11PS35D
A2C207	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C208	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C209	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C210	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C213	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A2C214	0180-1746		CAPACITOR-FXD; 15UF+-10% 20VDC TA-SOLID	56289	150D156X902082
*A2C215	0160-2198		CAPACITOR; FXD 20PF +-5% 300WVDC MICA 0+	28480	0160-2198
A2C216	0121-0046		CAPACITOR; VAR; TRMR; CER; 9/35PF	73899	DV11PS35D
A2C217	0121-0046		CAPACITOR; VAR; TRMR; CER; 9/35PF	73899	DV11PS35D
A2C218	0180-1746		CAPACITOR-FXD; 15UF+-10% 20VDC TA-SOLID	56289	150D156X902082
A2C219	0150-0072	3	CAPACITOR-FXD 200PF +-5% 1000WVDC CER	28480	0150-0072
A2C220	0150-0072		CAPACITOR-FXD 200PF +-5% 1000WVDC CER	28480	0150-0072
A2C221	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C222	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C223	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C224	0150-0022	1	CAPACITOR-FXD 3.3PF +-10% 500WVDC TI	95121	TYPE QC
A2C401	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C402	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C403	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C404	0150-0043		CAPACITOR-FXD 6.8PF +-5% 500WVDC TI DIOX	95121	TYPE QC
A2C406	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C407	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093

* see change sheet.

Table 6-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2C408	0150-0072		CAPACITOR-FXD 200PF +-5% 1000WVDC CER	28480	0150-0072
A2C409	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C411	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
A2C412	0160-0763	1	CAPACITOR-FXD 5PF +-10% 500WVDC MICA 0+	28480	0160-0763
A2C607	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A2C608	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A2C609	0180-1746		CAPACITOR-FXD: 15UF+-10% 20VDC TA-SOLID	56289	150D156X9020B2
A2C614	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A2C617	0180-1746		CAPACITOR-FXD: 15UF+-10% 20VDC TA-SOLID	56289	150D156X9020B2
A2C618	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A2CR200 Δ	1901-0376	4	DIODE-GEN PRP 35V 50MA	28480	1901-0376
A2CR203, CR204	1901-0535	4	DIODE-SCHOTTKY	28480	1901-0535
A2CR205 Δ	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A2CR206, CR207	1901-0535		DIODE-SCHOTTKY	28480	1901-0535
A2CR208	1902-3128	2	DIODE-ZNR 7.32V 5% DO-7 PD=.4W	04713	SZ 10939-143
A2CR209	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR210 Δ	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A2CR211	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR212	1902-3128		DIODE-ZNR 7.32V 5% DO-7 PD=.4W	04713	SZ 10939-143
A2CR213	1902-3136		DIODE-ZNR 8.06V 5% DO-7 PD=.4W	04713	SZ 10939-155
A2CR214	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR215 Δ	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A2CR216	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR217	1902-3205	1	DIODE-ZNR 15V 5% DO-7 PD=.4W TC=+.057%	04713	SZ 10939-233
A2CR218	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR219	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR221	1902-0901	2	DIODE-ZNR 5.4V 1%	28480	1902-0901
A2CR222	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR223	1902-0901		DIODE-ZNR 5.4V 1%	28480	1902-0901
A2CR401	1902-0041		DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=	04713	SZ 10939-98
A2CR402	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR403	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR404	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR405	1902-3171	1	DIODE-ZNR 11V 5% DO-7 PD=.4W TC=+.062%	04713	SZ 10939-194
A2CR406	1902-0041		DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=	04713	SZ 10939-93
A2CR407	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR408	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR606 Δ7	1902-3048	7	DIODE-ZNR 3.48V 5% DO-7 PD=.4W TC=-.058%	04713	SZ 30016-50
A2CR607 Δ7	1902-3048	7	DIODE-ZNR 3.48V 5% DO-7 PD=.4W TC=-.058%	04713	SZ 30016-50
A2J1	1251-3829		CONNECTOR, 8-PIN	27264	OBD NO.
A2J2, J3	1251-3827	2	CONNECTOR, 4-PIN	27264	OBD NO.
A2J4	1251-3305		CONNECTOR, 4-PIN M POST TYPE	27264	09-65-1041 (2244-4A)
A2J5	1251-3825	1	CONNECTOR, 5-PIN M POST TYPE	27264	09-65-1061
A2J6	1251-3751		CONNECTOR, 3-PIN M POST TYPE	27264	09-65-1081
A2L201	1855-0410		TRANSISTOR J-FET N-CHAN D-MODE TO -18 SI	17856	FN 2761
A2L402	9100-3548	1	COIL; FXD; MOLDED RF CHOKE; .0000004UH	06560	4425-2J
A2L403	9170-0894		CORE:MAG;SHIELDING BEAD .138 OD .047	02114	56-590-65/4A6
A2L601	9140-0137	2	COIL: FXD: MOLDED RF CHOKE: 1MH 5%	24225	19/104
A2L602	9100-3458	2	CHOKE,WIDE BAND	28480	9100-3458
A2L603	9140-0137		COIL: FXD: MOLDED RF CHOKE: 1MH 5%	24226	19/104
A2L604	9100-3458		CHOKE, WIDE BAND	28480	9100-3458
A20101	1854-0409	2	TRANSISTOR NPN 2N5210 SI TO-18 PD=310MW	04713	2N5210
A20102	1853-0050	2	TRANSISTOR PNP SI CHIP TO-18 PD=360MW	28480	1853-0050
A20103	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A20104	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A20106	1853-0050		TRANSISTOR PNP SI CHIP TO-18 PD=360MW	28480	1853-0050
A20107	1854-0409		TRANSISTOR NPN 2N5210 SI TO-18 PD=310MW	04713	2N5210
A20201	1855-0410	1	TRANSISTOR; J-FET N-CHAN, D-MODE SI	28480	1855-0410
A20202	1854-0092	2	TRANSISTOR NPN SI PD=200MW FT=600MHZ	28480	1854-0092
A20203	1853-0089		TRANSISTOR PNP 2N4917 SI PD=200MW	07263	2N4917
A20204	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A20206	1854-0019	2	TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0019
A20207	1854-0019		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0019
A20208	1853-~~0203~~ 0405	2	TRANSISTOR PNP SI CHIP TO-18 PD=360MW	28480	1853-~~0203~~ = 2N4209
A20209	1853-~~0203~~ 0405		TRANSISTOR PNP SI CHIP TO-18 PD=360MW	28480	1853-~~0203~~
A20211	1853-0258		TRANSISTOR PNP 2N4035 SI CHIP	07263	2N4035
A20212	1854-0092		TRANSISTOR NPN SI PD=200MW FT=600MHZ	28480	1854-0092
A20213	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A20214	1853-0020		TRANSISTOR PNP SI CHIP PD=300MW	28480	1853-0020
A20401	1853-0086		TRANSISTOR PNP SI PD=310MW FT=40MHZ	07263	3PS3322
A20402	1853-0089		TRANSISTOR PNP SI 2N4917 PD=200MW	07263	2N4917
A2R101	0698-3157	1	RESISTOR 19.6K 1% .125W F TUBULAR	16299	C4-1/8-TO-1962-F
				24546	C4-1/8-TO-2262-F
A2R102	2100-0558	1	RESISTOR-VAR TRMR 20KOHM 10% C TOP ADJ	73138	72P
A2R103 *	0757-~~0401~~		RESISTOR 100 1% .125 W R TC = 0 +-100	00746	CRB14 OR CRB25
A2R106	0698-3264	1	RESISTOR 11.8K 1% .125W F TUBULAR	16299	C4-1/8-TO-1182-F
A2R107	0698-4437	1	RESISTOR 2.94K 1% .125W F TUBULAR	16299	C4-1/8-TO-2941-F
A2R108	0683-8225		RESISTOR 8.2K 5% .25W CC TUBULAR	01121	CB8225
A2R109	0698-4432	3	RESISTOR 2.1K 1% .125W F TUBULAR	16299	C4-1/8-TO-2101-F
A2R111	0683-2025		RESISTOR 2K 5% .25W CC TUBULAR	01121	CB2025

See introduction to this section for ordering information

Δ Serial NO's. 1432A00351 and below do not contain these parts.

See change sheet

Table 6-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2R112	0698-4436	1	RESISTOR 2.8K 1% .125W F TUBULAR	16299	C4-1/8-T0-2801-F
A2R113	0698-4461	1	RESISTOR 698 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-698R-F
A2R114	0698-4432		RESISTOR 2.1K 1% .125W F TUBULAR	16299	C4-1/8-T0-2101-F
A2R116	0698-4432		RESISTOR 2.1K 1% .125W F TUBULAR	16299	C4-1/8-T0-2101-F
A2R117	0698-6943	2	RESISTOR 20K .1% .125W F TUBULAR	19701	MF4C1/8-T2-2002-P
A2R118	0683-1015		RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
A2R119	0757-0415	1	RESISTOR 475 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-475R-F
A2R121	2100-3383	1	RESISTOR-VAR TRMR 50 OHM 10% C TOP ADJ	32997	3389P
A2R122	0757-0161	2	RESISTOR 604 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-604R-F
A2R123	0757-0161		RESISTOR 604 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-604R-F
A2R124	0698-4123		RESISTOR 499 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-499R-F
A2R125	0683-1015		RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
A2R126	0698-6943		RESISTOR 20K .1% .125W F TUBULAR	19701	MF4C1/8-T2-2002-B
A2R127	2100-0569	2	RESISTOR-VAR TRMR 1MOHM 20% C TOP ADJ	73138	72PR105M
A2R128 Δ6	0683-2455	1	RESISTOR 2.4M 5% .25W FC TC =-900/+1100	00746	R-25J
	See service note 3312A-3				
A2R129	2100-0569		RESISTOR-VAR TRMR 1MOHM 20% C TOP ADJ	73138	72PR105M
A2R131 Δ6	0683-2455		RESISTOR 2.4M 5% .25W FC TC =-900/+1100	00746	R-25J
A2R132	0683-1025		RESISTOR 1K 5% .25W CC TUBULAR	01121	CB1025
A2R133	0683-1025		RESISTOR 1K 5% .25W CC TUBULAR	01121	CB1025
A2R134	0757-0408	2	RESISTOR 243 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-243R-F
A2R136	0757-0408		RESISTOR 243 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-243R-F
A2R205	0683-1015		RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
A2R207	0683-1005		RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A2R208	0683-1005		RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A2R209	0698-3518	1	RESISTOR 7.32K 1% .125W F TUBULAR	16299	C4-1/8-T0-7321-F
A2R210	0683-7525	1	RESISTOR 7.5K 5% .25W CC TUBULAR	01121	CB7525
A2R211	0698-4478		RESISTOR 10.7K 1% .125W F TUBULAR	24546	C4-1/8-T0-1072-F
A2R212	0683-1015		RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
A2R213*	0683-1025		RESISTOR 1K 5% .25W CC TUBULAR	01121	CB1025
*A2R214	0757-0280		RESISTOR 1K 1% .125W F TUBULAR	24546	C4-1/8-T0-1001-F
*A2R215	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A2R216	0683-1015		RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
*A2R217	0757-0280		RESISTOR 1K 1% .125W F TUBULAR	24546	C4-1/8-T0-1001-F
A2R218	0683-6215	1	RESISTOR 620 OHM 5% .25W CC TUBULAR	01121	CB6215
A2R219	0683-2015		RESISTOR 200 OHM 5% .25W CC TUBULAR	01121	CB2015
A2R221	0683-2015		RESISTOR 200 OHM 5% .25W CC TUBULAR	01121	CB2015
A2R222	0698-4442	1	RESISTOR 4.42K 1% .125W F TUBULAR	16299	C4-1/8-T0-4421-F
A2R223	0757-0289	1	RESISTOR 13.3K 1% .125W F TUBULAR	19701	MF4C1/8-T0-1332-F
A2R224	0683-1325		RESISTOR 1.3K 5% .25W CC TUBULAR	01121	CB1325
A2R226	0683-1015		RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
*A2R227	0757-1094	1	RESISTOR 1.47K 1% .125W F TUBULAR	24546	C4-1/8-T0-1471-F
*A2R228	0757-0420	1	RESISTOR 750 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-751-F
A2R229	0698-0082	1	RESISTOR 464 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-4640-F
A2R231	0683-2015		RESISTOR 200 OHM 5% .25W CC TUBULAR	01121	CB2015
A2R232	0698-4460	1	RESISTOR 649 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-649R-F
A2R233	0757-0407	4	RESISTOR 200 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-201-F
A2R234	0683-1215		RESISTOR 120 OHM 5% .25W CC TUBULAR	01121	CB1215
A2R236	0683-2205		RESISTOR 22 OHM 5% .25W CC TUBULAR	01121	CB2205
A2R237	0757-0407		RESISTOR 200 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-201-F
A2R238	0683-1215		RESISTOR 120 OHM 5% .25W CC TUBULAR	01121	CB1215
A2R239	0683-2205		RESISTOR 22 OHM 5% .25W CC TUBULAR	01121	CB2205
A2R241	0683-1015		RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
A2R242	0683-1015		RESISTOR 100 OHM 5% .25W CC TUBULAR	01121	CB1015
A2R243	0683-1005		RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A2R244	0683-1005		RESISTOR 10 OHM 5% .25W CC TUBULAR	01121	CB1005
A2R246	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A2R247	0683-1035		RESISTOR 10K 5% .25W CC TUBULAR	01121	CB1035
A2R248	0698-3557	1	RESISTOR 806 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-806R-F
A2R249	0698-4446	1	RESISTOR 267 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-267R-F
A2R251	0683-3315		RESISTOR 330 OHM 5% .25W CC TUBULAR	01121	CB3315
A2R252	0683-5115		RESISTOR 510 OHM 5% .25W CC TUBULAR	01121	CB5115
A2R253	0764-0013	1	RESISTOR 56 OHM 5% 2W MO TUBULAR	24546	FP42-2-T00-56R0-J
A2R400	0683-4725		RESISTOR 4.7K 5% .25W CC TUBULAR	01121	CB4725
A2R401	0687-5611	2	RESISTOR 560 OHM 10% .5W CC TUBULAR	01121	EB5611
A2R402	0757-0407		RESISTOR 200 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-201-F
A2R403	0757-0407		RESISTOR 200 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-201-F
A2R404	0683-1815		RESISTOR 180 OHM 5% .25W CC TUBULAR	01121	CB1815
A2R406	0687-5611		RESISTOR 560 OHM 10% .5W CC TUBULAR	01121	EB5611
A2R407	0698-4451	1	RESISTOR 340 OHM 1% .125W F TUBULAR	24546	C4-1/8-T0-340R-F
A2R408	0683-5115		RESISTOR 510 OHM 5% .25W CC TUBULAR	01121	CB5115
A2R409	0683-2025		RESISTOR 2K 5% .25W CC TUBULAR	01121	CB2025
A2R411	0683-2025		RESISTOR 2K 5% .25W CC TUBULAR	01121	CB2025
A2R412	0683-5115		RESISTOR 510 OHM 5% .25W CC TUBULAR	01121	CB5115
A2R413	0698-4416	1	RESISTOR 169 OHM 1% .125W F TUBULAR	16299	C4-1/8-T0-169R-F
A2R414	0698-3484	1	RESISTOR 6.65K 1% .125W F TUBULAR	16299	C4-1/8-T0-6651-F
A2R416	0698-4430	1	RESISTOR 1.91K 1% .125W F TUBULAR	16299	C4-1/8-T0-1911-F

Table 6-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2R417	0683-6225	1	RESISTOR 6.2K 5% .25W CC TUBULAR	01121	CB6225
A2R418	0683-1235		RESISTOR 12K 5% .25W CC TUBULAR	01121	CB1235
A2R419	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A2R421	0683-3025		RESISTOR 3K 5% .25W CC TUBULAR	01121	CB3025
A2R422	0683-4725		RESISTOR 4.7K 5% .25W CC TUBULAR	01121	CB4725
A2R423	0683-2725	1	RESISTOR 2.7K 5% .25W CC TUBULAR	01121	CB2725
A2R424	0683-2425		RESISTOR 2.4K 5% .25W CC TUBULAR	01121	CB2425
A2TP1	0360-1653	5	TERMINAL; SLDR STUD	28480	0360-1653
A2TP2	0360-1653		TERMINAL; SLDR STUD	28480	0360-1653
A2TP3	0360-1653		TERMINAL; SLDR STUD	28480	0360-1653
A2TP4	0360-1653		TERMINAL; SLDR STUD	28480	0360-1653
A2TP5	0360-1653		TERMINAL; SLDR STUD	28480	0360-1653
A2U101	1820-0203		IC LIN AMPLIFIER	28480	1820-0203
A2U102	1820-0203		IC LIN AMPLIFIER	28480	1820-0203
A2U103	1820-0203		IC LIN AMPLIFIER	28480	1820-0203
A2U104	1826-0560 } see	2	Note 3312A-3 Note-560 is no longer available by The		
A2U106	1826-0560 } service		but 1826-0567 should replace 1826-0066		
A2U201	1821-0001	1	IC LIN CA3046 TRANSISTOR ARRAY	02735	CA3046
A2U401	1820-0261	1	IC DGTL SN74 121 N MULTIVIBRATOR	01295	SN74121N
A2U402	1820-0371	1	IC DGTL SN74H 10 N GATE	01295	SN74H10N
A2U403	1858-0032	1	IC LIN CA3146E TRANSISTOR ARRAY	02735	CA3146E
A4	03312-61901		PC ASS'Y:AMPLITUDE		03312-61901
A4R613A, 613B	3100-3314		RESISTOR-VAR, AMPLITUDE NOT AVAILABLE SEPARATELY	91637	CMF-60-1
A4R618	0698-8387	1	RESISTOR 247.5 OHM .1% .25W F TUBULAR	19701	MF52C1/4-T2-247R5-B
A4R619	0698-7984	1	RESISTOR 61.1 OHM .1% .5W F TUBULAR	19701	MF7C1/2-T2-61R1-B
A4R620	0698-6594	1	RESISTOR 493 OHM .1% .25W F TUBULAR	91637	CMF-60-1
A4R621	0698-6595	1	RESISTOR 69 OHM .1% .25W F TUBULAR	91637	CMF-60-1
A4R622	0698-6598		RESISTOR 499 OHM 1% 1/4W TUBULAR	28480	3100-3314
A4R623	0698-6596	1	RESISTOR 61.2 OHM .1% .25W F TUBULAR	91637	CMF-60-1
A4R624	0698-6597	1	RESISTOR 54.9 OHM .1% .25W F TUBULAR	91637	CMF-60-1
A4S22			SWITCH: 4-POLE ROTARY-NOT AVAILABLE SEPARATELY CHASSIS MOUNTED COMPONENTS		
C601	0150-0024	1	CAPACITOR-FXD .02UF +80-20% 600WVDC CER	71590	DD203-Z5U-+80-20
CR605	1990-0485	1	LED, OFF/ON INDICATOR	28480	0570-1170
	1250-0083	5	CONNECTOR-RF BNC FEM SGL HOLE FR	24931	28JS-130-1
R601	2100-2087	1	RESISTOR-VAR W/SWITCH 1M 10% SYM:MOD	28480	2100-2087
R602/S21	3100-3295		SWITCH:ROTARY 100 K RANGE HZ	28480	3100-3295
R606	2100-3400	1	RESISTOR-VAR 10K 10%, FREQUENCY	01121	CJP4040A03U
R608	03312-61603	1	RESISTOR-VAR 10K 20%, DC OFFSET	28480	03312-61603
R611	0683-5125	1	RESISTOR-VAR 10K		CB5125
R612	2100-3421	1	RESISTOR-VAR 5K 20%, MOD LEVEL	01121	WA4G0405502MZ
R615	2100-3420		RESISTOR-VAR W/SW 2K, TRIGGER PHASE	28480	2100-3420
R616		1			
* see change sheet for additions					
S19, 20	3101-0110	2	SWITCH-SL: TRIGGER INT/EXT, SINGLE-MULTIPLE	05057	11A-1039A
S23, 24	3101-1609		SWITCH-SL: LINE POWER	82389	11E-1036
T1	9100-3456		XFMR-POWER	28480	9100-3456
W1	03312-61601	1	CABLE ASS'Y, SYNC	28480	03312-61601
W2	03312-61605	1	CABLE ASS'Y, VCO	28480	03312-61605
	03312-44001	1	DIAL:FREQUENCY	28480	03312-44001
	0370-2633	1	KNOB:DC OFFSET, SYM (MAIN)	28480	0370-2633
	0370-2634	2	KNOB:MOD LEVEL	28480	0370-2634
	0370-1100		KNOB:AMPL, RANGE HZ	28480	0370-1100
	0370-1005		KNOB:TRIGGER PHASE, SYM (MOD)	28480	0370-1005
	0370-1125	2	KNOB:VERNIER	28480	0370-1125
	0370-2631	1	PUSHBUTTON:WHITE	28480	0370-2631
	0370-0604	11	PUSHBUTTON:LT GREY	28480	0370-0604
	0370-0668	6	PUSHBUTTON:GREY	28480	0370-0668
	0370-2781		CAP, BLUE	28480	0370-2781
J1	1251-3823	2	CONNECTOR, 8-PIN	27264	OBD NO.
J2,J3	1251-3827	4	CONNECTOR, 4-PIN	27264	OBD NO.
J4	1251-3305	1	CONNECTOR, 4-PIN	28480	1251-3305
J5	1251-3825	2	LOCKWAFER ASS'Y (5 PIN)	28480	1251-3825
J6	1251-3751		CONNECTOR, 8-PIN	28480	1251-3751
J7	1251-3825		LOCKWAFER ASS'Y (5 PIN)	28480	1251-3825
F1	2110-0044		FUSE, .30 AMP SLOW BLOW (115 V)	04703	313.300
	2110-0320		FUSE, .15 AMP SLOW BLOW (230 V)	04703	313.150
J8-J12	1250-0083	5	CONNECTOR, RF BNC	02660	31-221-1020
	1400-0083	1	FUSEHOLDER; EXTR POST; SLT SCR CAP; 15A	28480	1400-0083
	5020-8813	1	FRAME, FRONT	28480	5020-8813
	5020-8814	1	FRAME, REAR	28480	5020-8814
	03312-00203 Δ_2	1	PANEL, FRONT	28480	03312-00203
	03312-00202	1	PANEL, REAR	28480	03312-00202
	03312-01201	1	BRACKET, FRONT	28480	03312-01201
	03312-01203	1	BRACKET, SHIELD	28480	03312-01203
	03312-04101	1	TOP COVER	28480	03312-04101
	5060-9841	1	BTM COVER	28480	5060-9841
	03312-01202	1	BRACKET, REAR	28480	03312-01202
	03312-20101	1	SIDE STRUT, LEFT	28480	03312-20101
	5060-9850	1	SIDE COVER, RT	28480	5060-9850
	5060-9874	1	SIDE COVER (HANDLE)	28480	5060-9874
	5060-9802	1	HANDLE	28480	5060-9802
	9100-3121		FILTER-ELEC 2A	28480	9100-3121

Δ_2 Refer to Section VIII

Table 6-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2R417	0683-6225	1	RESISTOR 6.25K 5% .25W CC TUBULAR	01121	CB6225
A2R418	0683-1235		RESISTOR 12K 5% .25W CC TUBULAR	01121	CB1235
A2R419	0683-4705		RESISTOR 47 OHM 5% .25W CC TUBULAR	01121	CB4705
A2R421	0683-3025		RESISTOR 3K 5% .25W CC TUBULAR	01121	CB3025
A2R422	0683-4725		RESISTOR 4.7K 5% .25W CC TUBULAR	01121	CB4725
A2R423	0683-2725	1	RESISTOR 2.7K 5% .25W CC TUBULAR	01121	CB2725
A2R424	0683-2425		RESISTOR 2.4K 5% .25W CC TUBULAR	01121	CB2425
A2TP1	0360-1653	5	TERMINAL: SLDR STUD	28480	0360-1653
A2TP2	0360-1653		TERMINAL: SLDR STUD	28480	0360-1653
A2TP3	0360-1653		TERMINAL: SLDR STUD	28480	0360-1653
A2TP4	0360-1653		TERMINAL: SLDR STUD	28480	0360-1653
A2TP5	0360-1653		TERMINAL: SLDR STUD	28480	0360-1653
A2U101	1820-0203		IC LIN AMPLIFIER	28480	1820-0203
A2U102	1820-0203		IC LIN AMPLIFIER	28480	1820-0203
A2U103	1820-0203		IC LIN AMPLIFIER	28480	1820-0203
A2U104	1826-0679	2	IC OP AMP LOW-BIAS-H-IMPD TO-99	01921	CA3140AT
A2U106	1826-0679		IC OP AMP LOW-BIAS-H-IMPD TO-99	01921	CA3140AT
A2U201	1821-0001	1	IC LIN CA3046 TRANSISTOR ARRAY	02735	CA3046
A2U401	1820-0261	1	IC DGTL SN74 121 N MULTIVIBRATOR	01295	SN74121N
A2U402	1820-0371	1	IC DGTL SN74H 10 N GATE	01295	SN74H10N
A2U403	1858-0032	1	IC LIN CA3146E TRANSISTOR ARRAY	02735	CA3146F
A4	03321-61901		PC ASS'Y:AMPLITUDE		03312-61901
A4R613A,613B	3100-3314		RESISTOR-VAR, AMPLITUDE NOT AVAILABLE SEPARATELY	91637	CMF-60-1
A4R618	0698-8387	1	RESISTOR 247.5 OHM .1% .25W F TUBULAR	19701	MF52C1/4-T2-247R5-B
A4R619	0698-7984	1	RESISTOR 61.1 OHM .1% .5W F TUBULAR	19701	MF7C1/2-T2-61R1-B
A4R620	0698-6594	1	RESISTOR 493 OHM .1% .25W F TUBULAR	91637	CMF-60-1
A4R621	0698-6595	1	RESISTOR 69 OHM .1% .25W F TUBULAR	91637	CMF-60-1
A4R622	0698-6598		RESISTOR 499 OHM 1% 1/4W TUBULAR	28480	3100-3314
A4R623	0698-6596	1	RESISTOR 61.2 OHM .1% .25W F TUBULAR	91637	CMF-60-1
A4R624	0698-6597	1	RESISTOR 54.9 OHM .1% .25W F TUBULAR	91637	CMF-60-1
A4S22			SWITCH: 4-POLE ROTARY-NOT AVAILABLE SEPARATELY		
			CHASSIS MOUNTED COMPONENTS		
C601	0150-0024	1	CAPACITOR-FXD. .02UF +80-20% 600WVDC CER	71590	DD203-Z5U-+80-20
CR605	1990-0485	1	LED. OFF/ON INDICATOR	28480	0570-1170
	1250-0083	5	CONNECTOR-RF BNC FEM SGL HOLE FR	24931	28JS-130-1
R601	2100-2087	1	RESISTOR-VAR W/SWITCH 1M 10% SYM:MOD	28480	2100-2087
R602/S21	3100-3295		SWITCH:ROTARY 100 K RANGE HZ	28480	3100-3295
R606	2100-3400	1	RESISTOR-VAR 10K 10% FREQUENCY	01121	CJP4040A03U
R608	03312-61603	1	RESISTOR-VAR 10K 20% DC OFFSET	28480	03312-61603
R611	0683-5125	1	RESISTOR-VAR 10K	01121	CB5125
R612	2100-3421	1	RESISTOR-VAR 5K 20% MOD LEVEL	01121	WA4G0405502M
R615	2100-3420		RESISTOR-VAR W/SW 2K, TRIGGER PHASE	28480	2100-3420
R616	03312-61902	8	SWITCH ASS'Y	28480	03312-61902
S19,20	3101-0110	2	SWITCH-SL: TRIGGER INT/EXT. SINGLE-MULTIPLE	05057	11A-1039A
S32,24	3101-1609		SWITCH-SL: LINE POWER	82389	11E-1036
T1	9100-3456		XFMR-POWER	28480	9100-3456
W1	03312-61601	1	CABLE ASS'Y SYNC	28480	03312-61601
W2	03312-61605	1	CABLE ASS'Y VCO	28480	03312-61605
	03312-44001	1	DIAL:FREQUENCY	28480	03312-44001
	0370-2633	1	KNOB:DC OFFSET, SYM (MAIN)	28480	0370-2633
	0370-2634	2	KNOB:MOD LEVEL	28480	0370-2634
	0370-1100		KNOB:AMPL, RANGE HZ	28480	0370-1100
	0370-1005		KNOB:TRIGGER PHASE, SYM (MOD)	28480	0370-1005
	0370-1125	2	KNOB:VERNIER	28480	0370-1125
	0370-2631	1	PUSHBUTTON:WHITE	28480	0370-2631
	0370-0604	11	PUSHBUTTON:LT GREY	28480	0370-0604
	0370-0668	6	PUSHBUTTON:GREY	28480	0370-0668
	0370-2781		CAP, BLUE	28480	0370-2781
J1	1251-3823	2	CONNECTOR, 8-PIN	27264	OBD NO.
J2,J3	1251-3827	4	CONNECTOR, 4-PIN	27264	OBD NO.
J4	1251-3305	1	CONNECTOR, 4-PIN	28480	1251-3305
J5	1251-3825	2	LOCKWAFER ASS'Y (5 PIN)	28480	1251-3825
J6	1251-3751		CONNECTOR, 8-PIN	28480	1251-3751
J7	1251-3825		LOCKWAFER ASS'Y (5 PIN)	28480	1251-3825
F1	2110-0044		FUSE, .30 AMP SLOW BLOW (115V)	04703	313.300
	2110-0320		FUSE, .15 AMP SLOW BLOW (230 V)	04703	313.150
J8-J12	1250-0083	5	CONNECTOR, RF BNC	02660	31-221-1020
	1400-0083	1	FUSEHOLDER: EXTR POST: SLT SCR CAP: 15A	28480	1400-0083
	*5020-8813	1	FRAME, FRONT	28480	5020-8813
	*5020-8814	1	FRAME, REAR	28480	5020-8814
	*03312-00203Δ_2	1	PANEL, FRONT	28480	03312-00203
	03312-00202	1	PANEL, REAR	28480	03312-00202
	03312-01201	1	BRACKET, FRONT	28480	03312-01201
	03312-01203	1	BRACKET, SHIELD	28480	03312-01203
	*03312-04101	1	TOP COVER	28480	03312-04101
	*5060-9841	1	BTM COVER	28480	5060-9841
	03312-01202	1	BRACKET, REAR	28480	03312-01202
	03312-20101	1	SIDE STRUT, LEFT	28480	03312-20101
	*5060-9850	1	SIDE COVER, RT	28480	5060-9850
	5060-9874	1	SIDE COVER, (HANDLE)	28480	5060-9874
	5060-9802	1	HANDLE	28480	5060-9802
	9100-3121	1	FILTER-ELEC 2A	28480	9100-3121
	5040-7675		PUSH-ROD-SW	28480	5040-7675
	5040-7203		TRIM: TOP 1/2	28480	5040-7203

* see change sheet

Δ_2 REFER TO SECTION VIII

4.74K

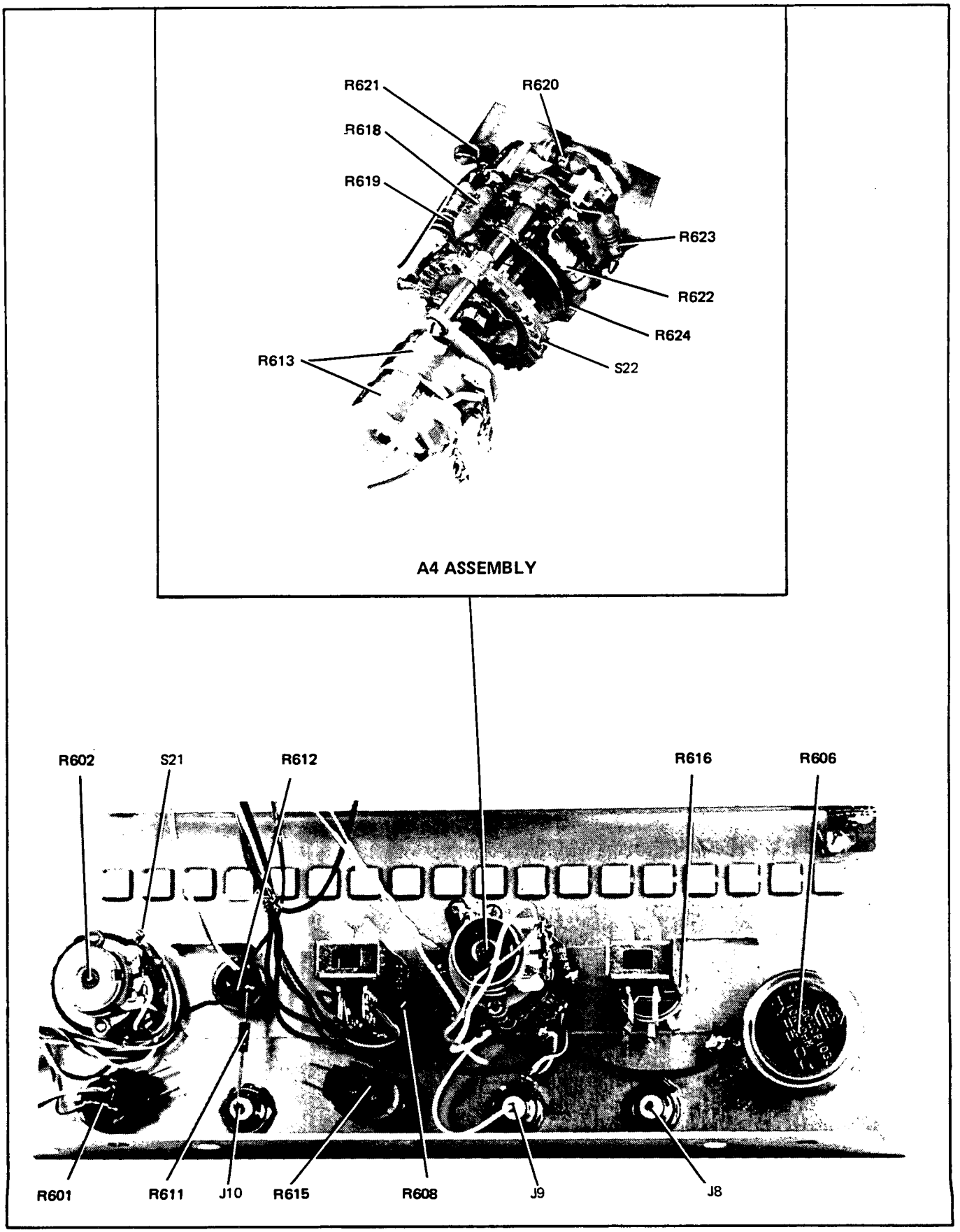


Figure 6-1. Chassis Mounted Components.

Table 7-1. 3312A Jack Connections.

A1 Board Connections	Pin No.	A2 Board Connections
J1		J1
CR201	1	Q103 (b)
R201, 202	2	R134, C137, R118
CR202, S1 (4)	3	U101 (7)
C204	4	Q104 (b)
C203, 202	5	R125/126, and C138, R136
S18	6	R126, 124
⏚	7	⏚
R206	8	TP3
J2		J2
C226, R256, R257	1	R207, 208
⏚	2	⏚
S11(3, 6)	3	R249, 251, 248
S9 (4)	4	
J3		J3
NC	1	R107
U601(Output)	2	C607, L602, R406
⏚	3	⏚
U602 (Output)	4	C614, L604, R424
R439, Q403, R341, R351		

A1 Board Connections	Pin No.	A2 Board Connections
J4		J4
R107	1	94
U401, 7	2	93
U401, 5	3	92
U401, 6	4	91
J5		J5
Q402/C409/C408	1	90
U402, pins 2,3,4	2	98
R412	3	97
R423	4	946
R424	5	945
J6		
R106	1	
U101 pin 6	2	
R127	3	
R122/R123	4	
R111	5	
R116	6	
R109	7	
NC	8	
J7		J7
CR311, U303 (10)	1	957
U303 (4)	2	956
CR604, CR602	3	1
	4	6
CR603, CR601	5	1

GENERAL SCHEMATIC NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.

2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
   INDUCTANCE IN MILLIHENRYS

3. ⏚ DENOTES EARTH GROUND. USED FOR TERMINALS WITH NO LESS THAN A NO. 18 GAUGE WIRE CONNECTED BETWEEN TERMINAL AND EARTH GROUND TERMINAL OR AC POWER RECEPTACLE.

4. ⏚ DENOTES FRAME GROUND. USED FOR TERMINALS WHICH ARE PERMANENTLY CONNECTED WITHIN APPROXIMATELY 0.1 OHM OF EARTH GROUND.

5. ⏚ DENOTES GROUND ON PRINTED CIRCUIT ASSEMBLY. (PERMANENTLY CONNECTED TO FRAME GROUND).

6. ——— DENOTES ASSEMBLY.

7. ——— DENOTES MAIN SIGNAL PATH.

9. ——— DENOTES FEEDBACK PATH.

10. ▭ DENOTES FRONT PANEL MARKING.

11. ▭ DENOTES REAR PANEL MARKING.

12. DENOTES SCREWDRIVER ADJUST.

13. ✱ AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY. THE VALUE OF THESE COMPONENTS MAY VARY FROM ONE INSTRUMENT TO ANOTHER. THE METHOD OF SELECTING THESE COMPONENTS IS DESCRIBED IN SECTION V OF THIS MANUAL.

14. DENOTES SECOND APPEARANCE OF A CONNECTOR PIN.

15. 924 DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e.g. 924 = WHITE, RED, YELLOW.)

17. WAVEFORMS AND AC VOLTAGE MEASUREMENTS WERE MADE WITH RESPECT TO CHASSIS GROUND USING AN OSCILLOSCOPE WITH A 10:1 DIVIDER PROBE (10 MEGOHM, 10 pF). THE VOLTAGE LEVELS SHOWN ON THE WAVEFORMS ARE ACTUAL VOLTAGE LEVELS AND ARE NOT TO BE CONFUSED WITH OSCILLOSCOPE SETTING. THE VOLTAGE LEVELS SHOWN ARE NOMINAL AND MAY VARY FROM ONE INSTRUMENT TO ANOTHER. A VARIATION OF ± 10 % IN MEASUREMENTS SHOULD BE ALLOWED.

SECTION VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section of the manual contains troubleshooting information and circuit diagrams for the Model 3312A Function Generator. Included are a functional block diagram, schematic diagrams and component location diagrams.

7-3. REFERENCE DESIGNATORS.

7-4. The reference designators were chosen in order to classify the circuitry of the 3312A according to the operation performed. The numbering series and corresponding operation category is as follows:

100 Series	Tuning Amplifier, Symmetry, and Current Sources
200 Series	Main Signal Generation
300 Series	Modulation Signal Generation
400 Series	Amplitude Modulation and Burst Operation
500 Series	Output Amplifier
600 Series	Power Supply and Chassis Mounted Components

7-5. TROUBLESHOOTING.

7-6. The following troubleshooting information is designed to eliminate needless unrelated checks in locating instrument malfunctions. It should first be determined that a malfunction does exist and that it does not exist external to the 3312A. Before troubleshooting the 3312A, become familiar with the principles of operation (Section III) and the functional composition (Section IV) of the instrument.

7-7. To isolate the malfunction to a functional block, use the Function Block Diagram (Figure 7-1). To further isolate the malfunction to a component, use the schematic diagrams (Figures 7-2 through 7-6).

7-8. FUNCTIONAL BLOCK DIAGRAM.

7-9. The block diagram (Figure 7-1) is a simplified functional diagram. It is designed to aid in troubleshooting to an assembly or a circuit level. Waveforms and voltages are given for the test points in one of four operating modes A, B, C or D. The mode of operation under which the waveform or voltage is specified is located above each waveform in Figure 7-1. Be sure that the instrument is in one of the given modes before attempting to correlate the actual waveform with the specified voltage or waveform shown. Modes of operation are given on the apron page of the Functional Block Diagram.

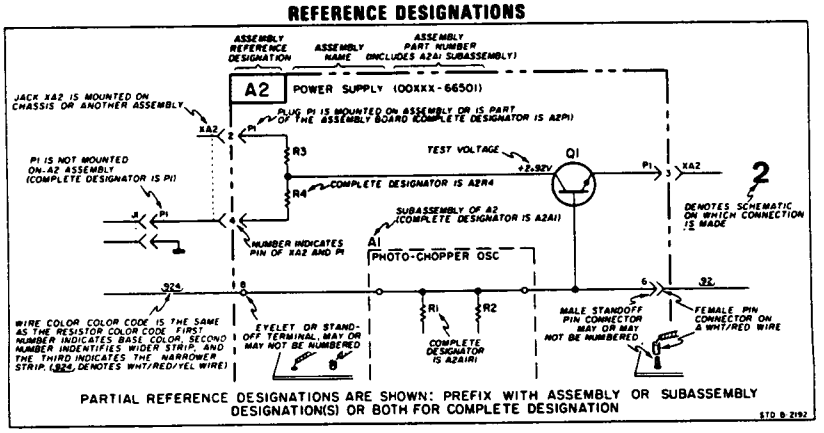
NOTE

A1TP10 is the left-hand side (as viewed from the front of the instrument) of R537, 51 Ω 2W.

7-10. The large number with a schematic name on each outlined assembly indicates the schematic number where the circuit diagram for that assembly can be found.

7-11. Schematic Diagrams.

7-12. The schematic diagrams, Figures 7-2 through 7-6, show the detailed circuits of the standard Model 3312A. Each schematic is assigned a numerical callout (Figures 7-2 through 7-6) which is used for referencing. The schematics are arranged to provide as much signal continuity as possible and assemblies do not necessarily appear in the order of their reference designations.



3312A SETTINGS

OPERATION MODE A

MAIN GENERATOR

FREQUENCY ..... 1 kHz IN RANGE 1 kHz
OFFSET ..... CAL
AMPLITUDE ..... ATTENUATOR POSITION 1
..... VERNIER FULLY CW
SYM ..... CAL
FUNCTION ..... ~
TRIGGER PHASE ..... FREE RUN

MODULATION GENERATOR

AM, FM & SWP ..... IN OUT POSITION

OPERATION MODE B

MAIN GENERATOR

FREQUENCY ..... 1 MHz
OFFSET ..... CAL
AMPLITUDE ..... ATTENUATOR POSITION 1
..... VERNIER FULLY CW
SYM ..... CAL
FUNCTION ..... ~
TRIGGER PHASE ..... FREE RUN

MODULATION GENERATOR

AM ..... PRESSED IN
FM & SWP ..... OUT
FUNCTION ..... ~
PERCENT MOD 100%
FREQUENCY ..... 10 K RANGE
..... VERNIER FULLY CW
SYM ..... CAL

OPERATION MODE C

MAIN GENERATOR

FREQUENCY ..... 1 MHz
OFFSET ..... CAL
AMPLITUDE ..... ATTENUATOR POSITION 1
..... VERNIER FULLY CW
SYM ..... CAL
FUNCTION ..... ~
TRIGGER PHASE ..... FREE RUN

MODULATION GENERATOR

AM, FM & SWP ..... IN OUT POSITION
FUNCTION ..... ~
PERCENT MODULATION 100%
FREQUENCY ..... 10 K RANGE
..... VERNIER FULLY CW
SYM ..... CAL

OPERATION MODE D

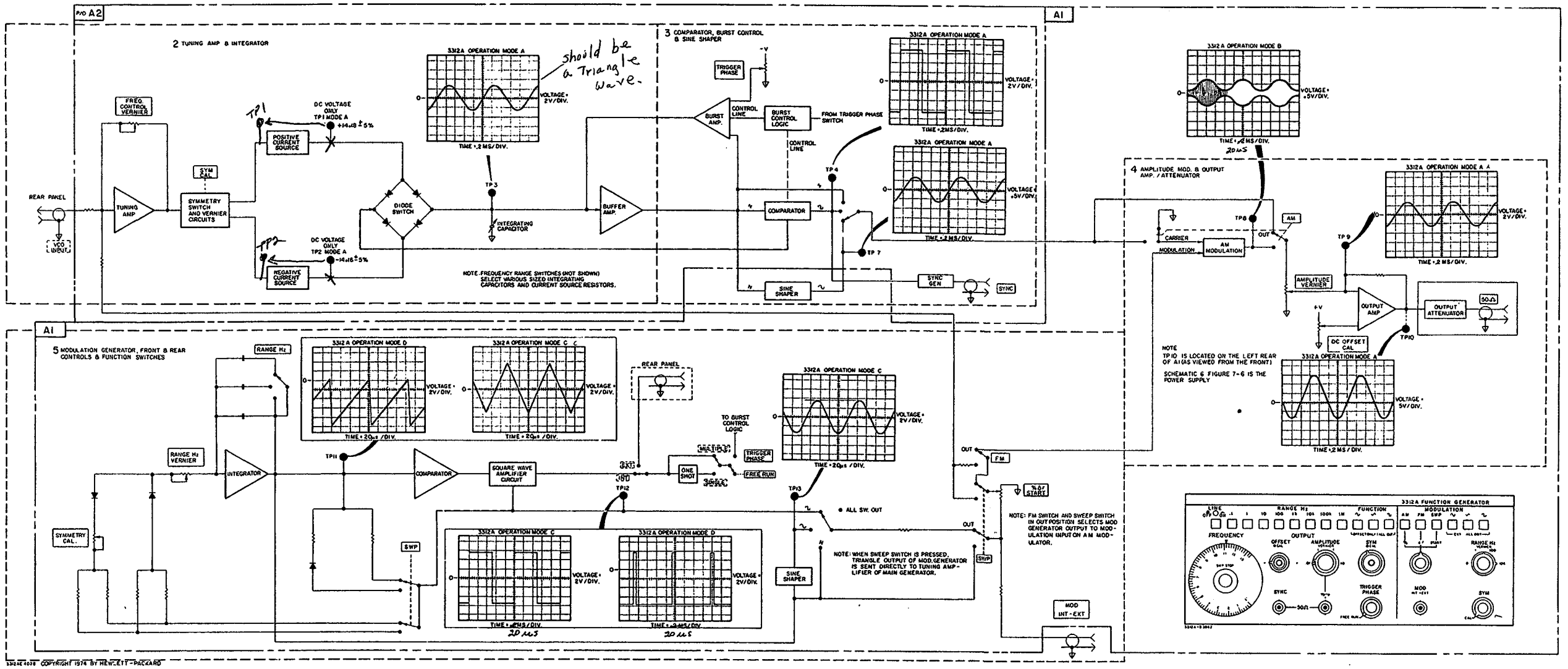
MAIN GENERATOR

FREQUENCY ..... 1 MHz
OFFSET ..... CAL
AMPLITUDE ..... ATTENUATOR POSITION 1
..... VERNIER FULLY CW
SYM ..... CAL
FUNCTION ..... ~
TRIGGER PHASE ..... FREE RUN

MODULATION GENERATOR

SWP ..... PRESSED IN
AM & FM °..... OUT POSITION
FUNCTION ..... ~
PERCENT MOD 100%
FREQUENCY ..... 10 K RANGE
..... VERNIER FULLY CW
SYM ..... CAL

NOTE: TP10 LOCATED ON LEFT SIDE (AS VIEWED FROM FRONT) OF 51 Ω, 2 W OUTPUT RESISTOR.



1

Figure 7-1. Functional Block Diagram.

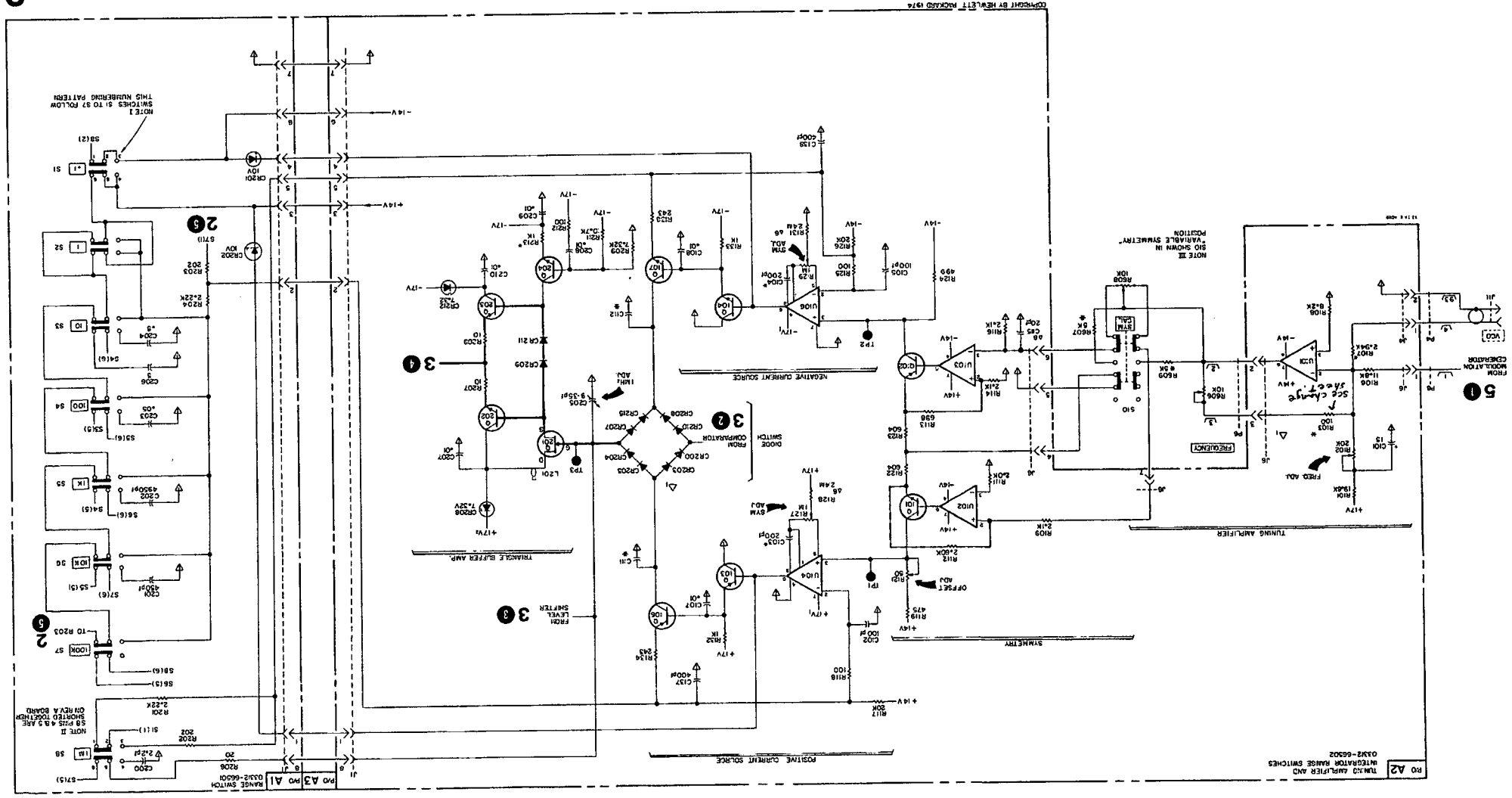
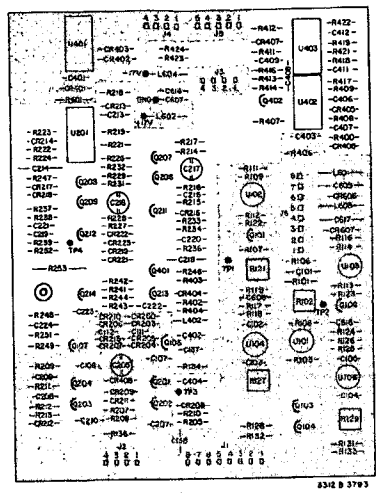
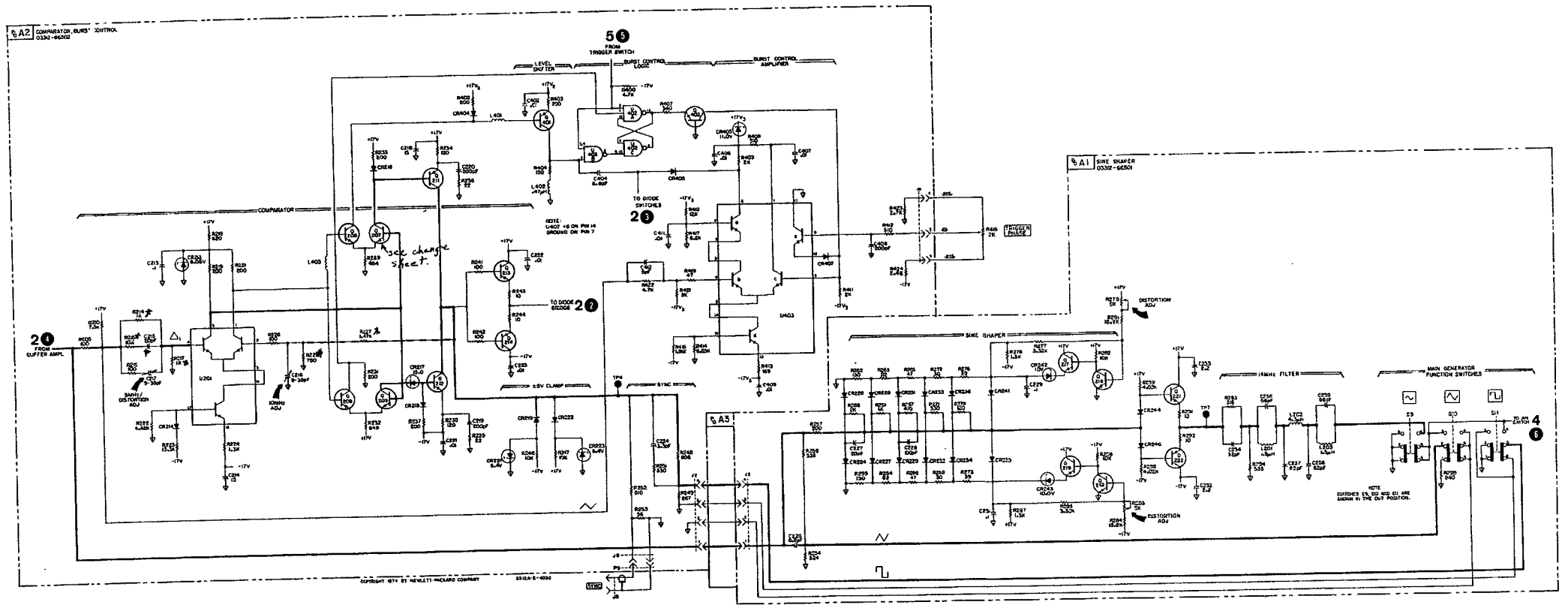


Figure 7-2. Tuning Amplifier Integrator and Range Switches.



A2

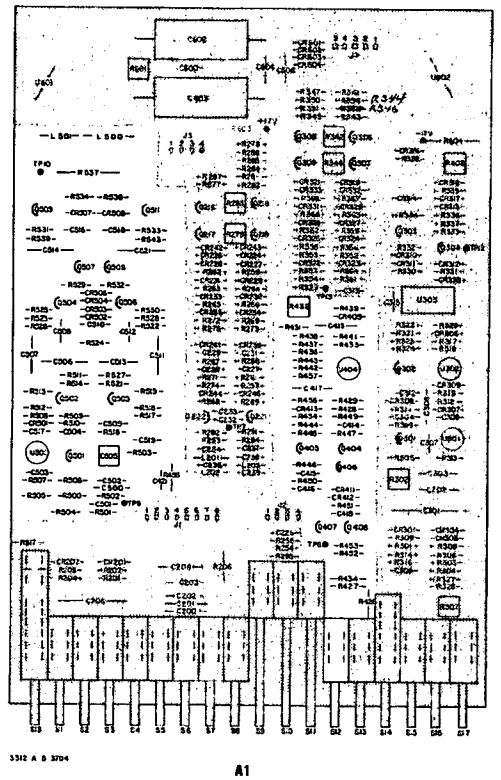
-hp- Part No. 03312-66502



* see change sheet

3

Figure 7-3. Comparator, Burst Control Logic and Amplifier, Sine Shaper and Front Panel Function Switches.



A1

4p Part No. 03312-60501

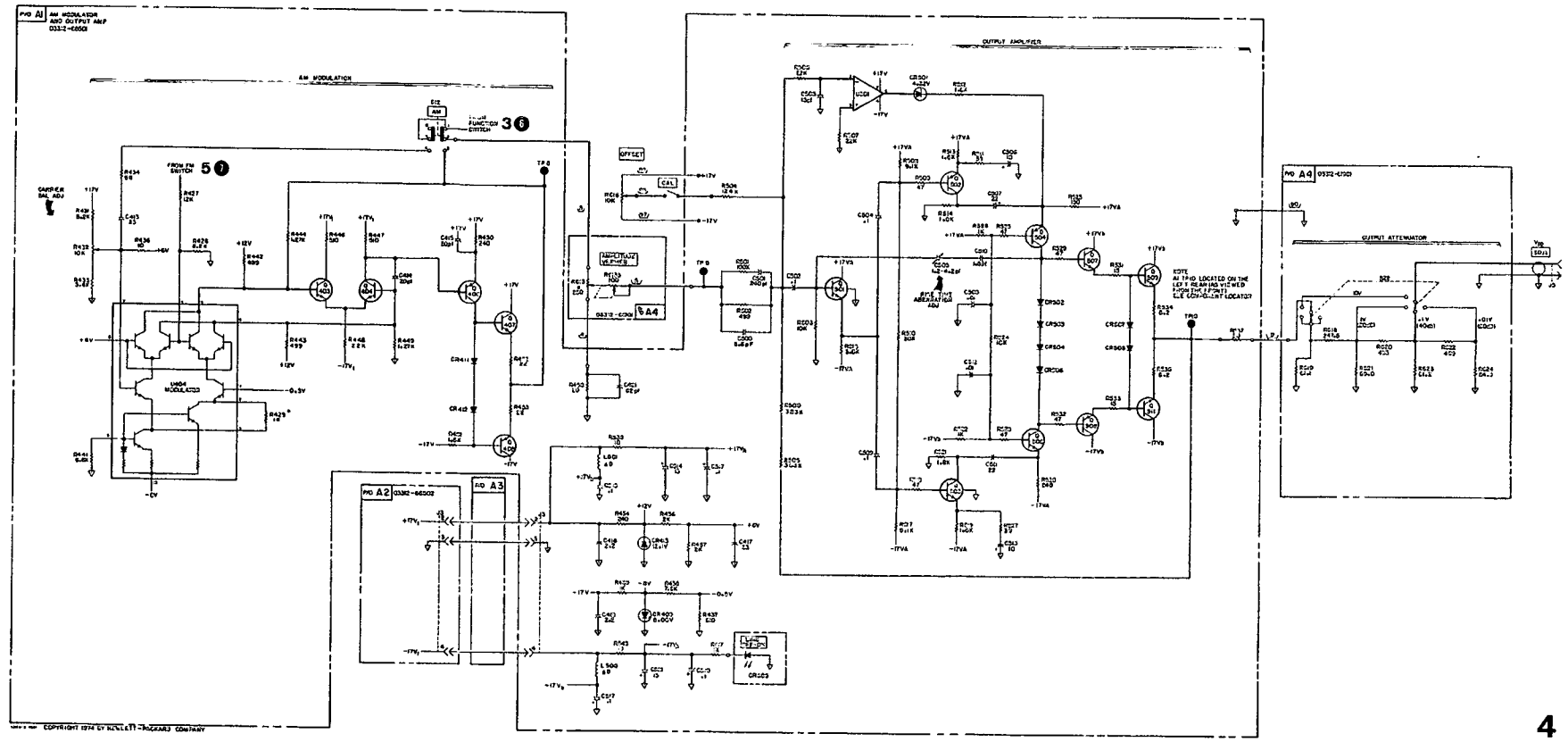
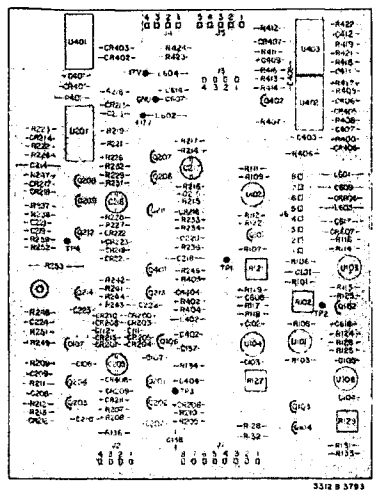


Figure 7-4. Amplitude Modulator and Output Amplifier Attenuator.



A2
-hp- Part No. 03312-66502

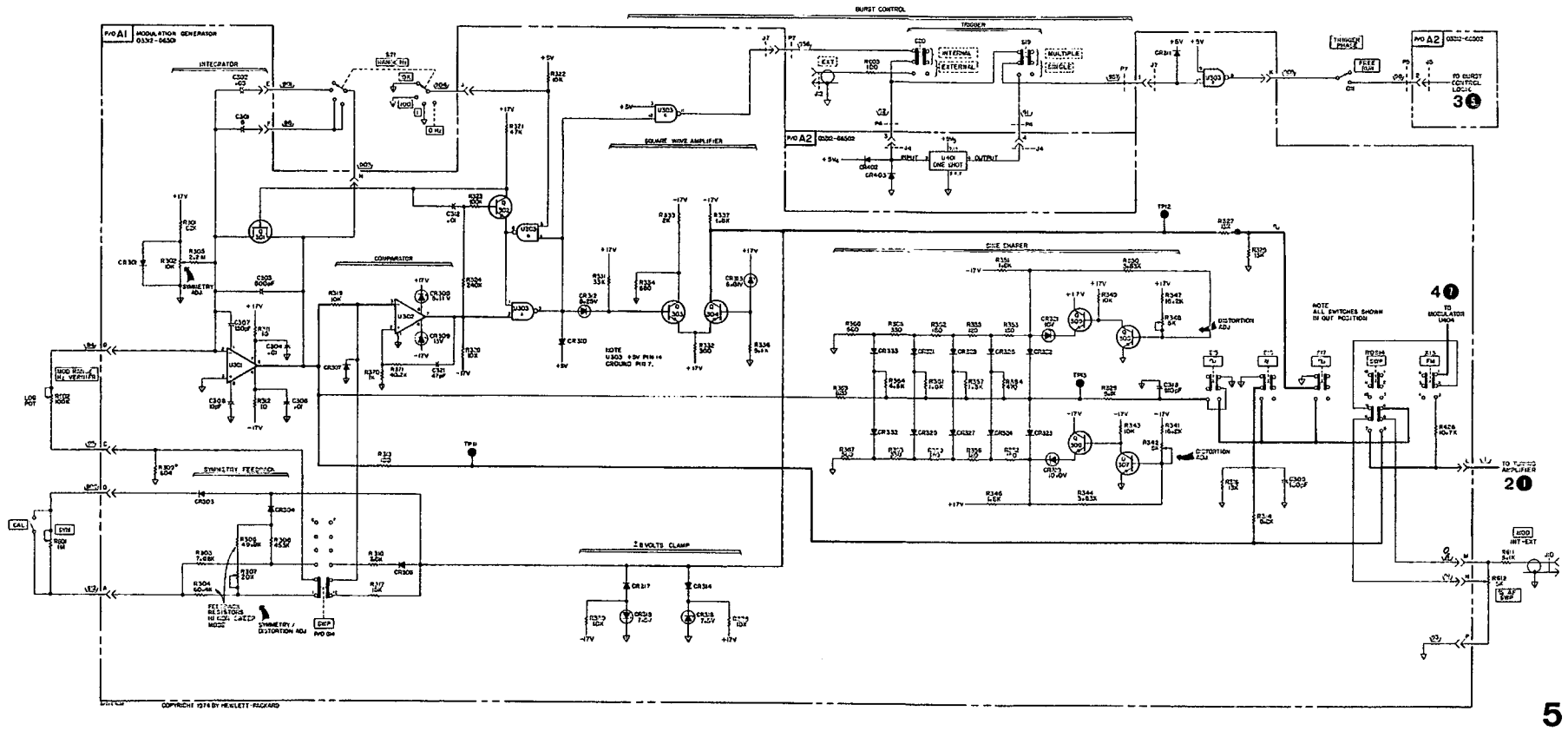


Figure 7-5. Modulation Generator, Burst Control, Front and Rear Panel Controls and Function Switches.

3312A SETTINGS

OPERATION MODE A

MAIN GENERATOR

FREQUENCY ..... 1 kHz IN RANGE 1 kHz
OFFSET ..... CAL
AMPLITUDE ..... ATTENUATOR POSITION 1
..... VERNIER FULLY CW
SYM ..... CAL
FUNCTION ..... ~
TRIGGER PHASE ..... FREE RUN

MODULATION GENERATOR

AM, FM & SWP ..... IN OUT POSITION

OPERATION MODE B

MAIN GENERATOR

FREQUENCY ..... 1 MHz
OFFSET ..... CAL
AMPLITUDE ..... ATTENUATOR POSITION 1
..... VERNIER FULLY CW
SYM ..... CAL
FUNCTION ..... ~
TRIGGER PHASE ..... FREE RUN

MODULATION GENERATOR

AM ..... PRESSED IN
FM & SWP ..... OUT
FUNCTION ..... ~
PERCENT MOD 100%
FREQUENCY ..... 10 K RANGE
..... VERNIER FULLY CW
SYM ..... CAL

OPERATION MODE C

MAIN GENERATOR

FREQUENCY ..... 1 MHz
OFFSET ..... CAL
AMPLITUDE ..... ATTENUATOR POSITION 1
..... VERNIER FULLY CW
SYM ..... CAL
FUNCTION ..... ~
TRIGGER PHASE ..... FREE RUN

MODULATION GENERATOR

AM, FM & SWP ..... IN OUT POSITION
FUNCTION ..... ~
PERCENT MODULATION 100%
FREQUENCY ..... 10 K RANGE
..... VERNIER FULLY CW
SYM ..... CAL

OPERATION MODE D

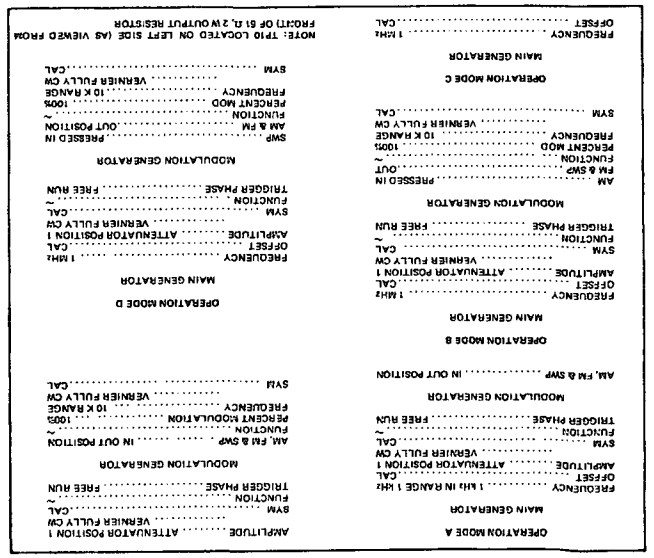
MAIN GENERATOR

FREQUENCY ..... 1 MHz
OFFSET ..... CAL
AMPLITUDE ..... ATTENUATOR POSITION 1
..... VERNIER FULLY CW
SYM ..... CAL
FUNCTION ..... ~
TRIGGER PHASE ..... FREE RUN

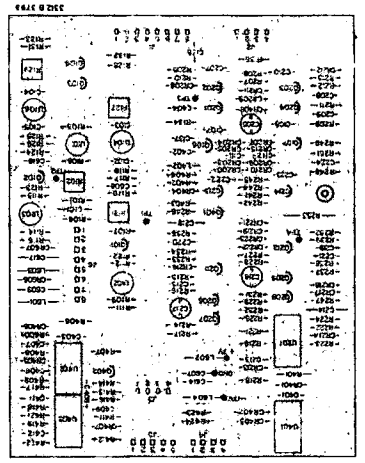
MODULATION GENERATOR

SWP ..... PRESSED IN
AM & FM ..... OUT POSITION
FUNCTION ..... ~
PERCENT MOD 100%
FREQUENCY ..... 10 K RANGE
..... VERNIER FULLY CW
SYM ..... CAL

NOTE: TP10 LOCATED ON LEFT SIDE (AS VIEWED FROM FRONT) OF 51 Ω, 2 W OUTPUT RESISTOR.



3312A SETTINGS



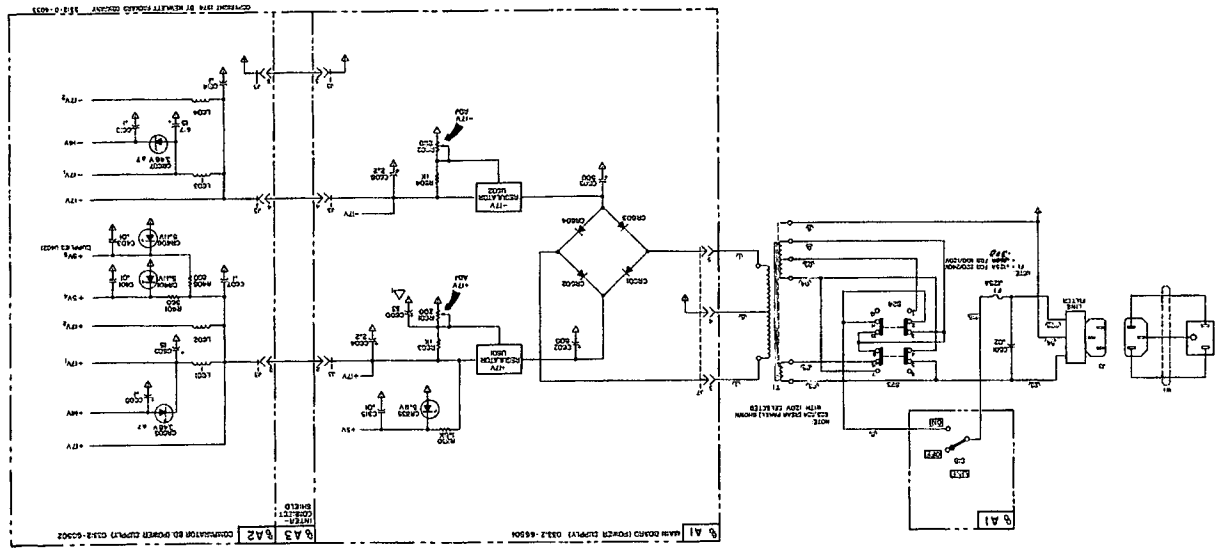


Figure 7-6. Power Supply.

SECTION VIII
BACKDATING

8-1. INTRODUCTION.

8-2. This section makes your manual applicable to earlier instruments. Where component values or part numbers in an instrument differ from the replaceable parts list, yet are not listed in this backdating section, the part numbers and values in the Replaceable Parts List should be used for replacement.

8-3. Where practical, backdating entries have been incorporated into the text of the manual rather than into this backdating section. If a backdating change is too long or otherwise impractical to incorporate into the text, the entry to be changed will be flagged with a delta (Δ_1). The numbered delta refers to the corresponding numbered delta in the backdating section. The subscript refers to the number of the corresponding change in backdating. Make all changes listed in this backdating which apply to your instrument.

Δ_1 Applies to serial numbers 1432A00350 and below.

Table 6-1:
Delete: A1C200, A1C600, A2CR200, A2CR205, A2CR210, and A2CR215.

Add: A2R104, part number 2100-3415, Resistor:Var 20 ohm 20%.

NOTE

Instruments with serial numbers 1432A00350 and below had an adjustment R104 on the 03312-66502 board. Set R104 to the maximum CW position and perform the frequency adjustments as outlined in Section V of this manual.

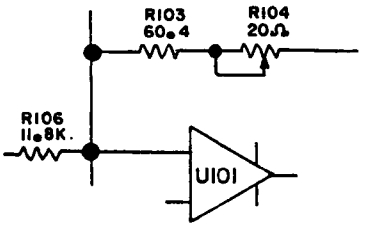


Figure 7-2:
Change the X1M switch as follows:
Delete CR200, CR205, CR210, and CR215

Figure 7-3:
Delete R215 and C215.

Figure 7-3:
Delete C600.

Δ_2 Applies to serial numbers 1432A00266 and below.

Table 6-1:
Change Panel, Front to part number 03312-00201.
Change A1CR318, CR316 to part number 1902-3085; 7.5 V.

Change A1R303 to part number 0757-0438; 5.11 K.
A1R304 to part number 0698-3499; 40.2 K.
A1R306 to part number 0757-0123; 34.8 K.
A1R307 to part number 2100-3210; 10 K.
A1R308 to part number 0698-4534; 309 K.
A1R317 to part number 0757-0442; 10 K.
A1R318 to part number 0698-0420; 750Ω.

Δ_3 Applies to serial numbers 1432A00430 and below.

Page 6-3:
Delete C605.

Page 7-11/7-12:
Delete C605.

Δ_4 Applies to serial numbers 1432A01037 and below.

Page 6-3:
Add A1C605
Delete A1C320.

Page 6-5:
Delete A1R325.

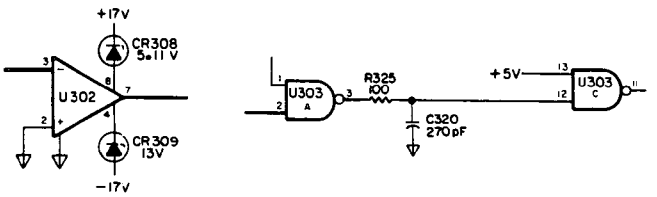
Δ_5 Applies to serial numbers 1432A01245 and below.

Page 6-3:
Add A1C320, 0140-0206, C:Fxd 270 pF
Delete A1C321

Page 6-5:
Add A1R325, 0683-1015 R:Fxd 100 ohm 5%

Page 6-6:
Delete A1R370, R371

Page 7-11:
Delete A1C321, A1R370, A1R371 and add A1C320, A1R325 as follows:



Δ_6 Applies to serial numbers 1432A05505 and below.
Page 6-9:
Change A2R128 and A2R131 to 0698-5094, R-F5.1M, ±.05%.

NOTE

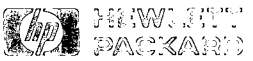
If A24104 or A2106 are replaced, change A2R128and/or AR131 to 0683-2455, R-F, 2.4 M ± .05%.

Δ_7 Applies to serial numbers 1432A04515 and below.
Page 6-9:
Change A2CR606 and A2CR607 to 3.01 V, 1902-3030.

Δ_8 Applies to serial numbers 1432A-06405 and below.
Page 6-7:
Add A1R538 and A1R542, 33 OHM .05, 0764-0033.
Change A1R500 and A1R505, to 4020 OHM, 0698-3558.

Page 6-4:
Delete A1L500 and A1L501
A1R538 is mounted where L500 was located.
A1R540 is mounted where L501 was located.

Δ_9 Applies to serial numbers 1432A-06630 and below.
Delete A2C115.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PACKARD