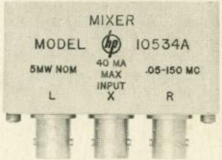
OPERATING AND SERVICE MANUAL

MIXERS

10534A/B



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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

MIXERS
10534A/B

02396-2 Printed: JUNE 1968

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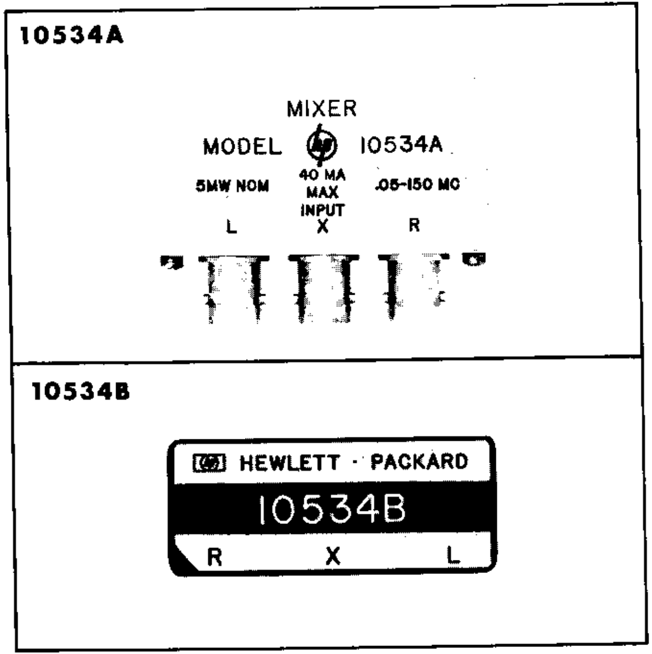


Figure 1. Model 10534A, B Mixers

CAUTION

Do not apply more than 40 milliamperes peak. Application of more than 40 milliamperes peak or any attempt to open the case and make repairs will void the warranty.

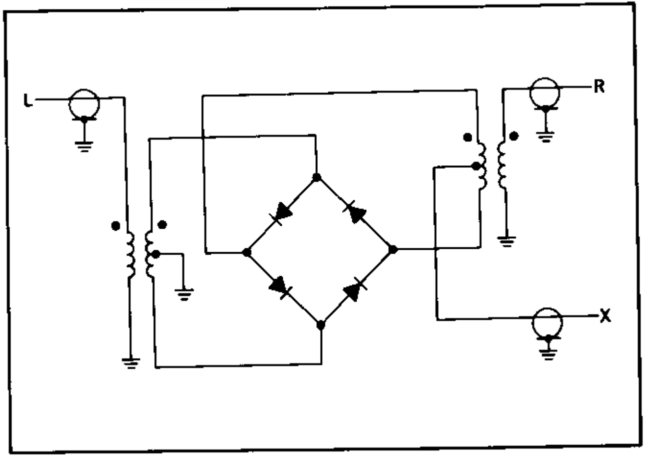


Figure 2. Schematic Diagram

10514-A-1

1. GENERAL INFORMATION.

2. The Hewlett-Packard Model 10534A, B Mixer operates between 50 kHz and 150 MHz, with capabilities as a mixer, phase detector, frequency doubler, current-controlled attenuator, balanced modulator, amplitude modulator, or pulse modulator. The Mixer is designed for use with 50-ohm systems, but use with a 75-ohm load at the "X" connector should give about the same results. The nominal input level at the "L" connector is 5 mw. Maximum input level at any connector is 40 ma. Mixer operating power is obtained from the input signals. The Mixer is sealed and is not repairable.

3. IDENTIFICATION.

4. The three digit number on each Mixer is a series number, for documentation purposes. The series number identifies a group of instruments and is not unique for any given Mixer within the series.

5. INITIAL INSPECTION.

6. If shipping package is damaged, ask that carrier's agent be present when package is opened. Inspect the Mixer for obvious physical damage (dents, scratches, etc.). If the Mixer is damaged or fails to meet specifications, notify carrier and nearest Hewlett-Packard field office immediately. (Field offices are listed at back of this manual.) Retain shipping package and padding material for carrier's inspection. The field office will arrange for replacement of your Mixer without waiting for the claim against the carrier to be settled. The Mixer case is sealed at the factory. Any attempt to open the Mixer case will void the warranty.

7. ENVIRONMENT.

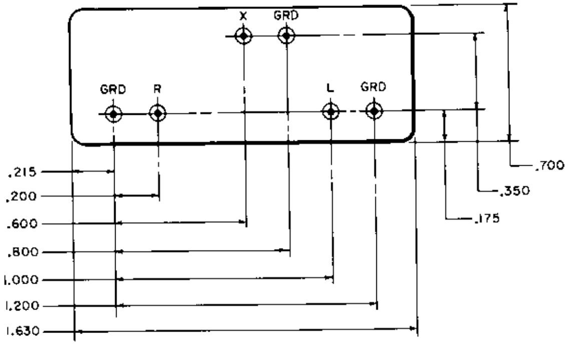
8. Mixers type tested to meet specifications as outlined on Page 5.

9. Temperature during storage and shipment should be limited as follows:

a. Minimum temperature: -62°C (-80°F).

b. Maximum temperature: +85°C (+85°F).

SPECIFICATIONS



10534B

(BOTTOM VIEW)

Input/Output Frequencies: "L" and "R" ports: 50 kHz to 150 MHz; "X" port: dc to 150 MHz.

Max. Input: 40 mA (damage level).

Impedance: Specified for a 50 ohm system.

Mixer Conversion Loss (Single Sideband):

(A) 6.5dB max, for f_L and f_R in the 200 kHz to 35 MHz range and f_X from dc to 35 MHz.

(B) 8 dB max, for f_L and f_R in the 100kHz to 150 MHz range and f_X from dc to 150 MHz.

Noise Performance (Single Sideband):

6.5 dB max for f_L and f_R in 200 kHz to 35 MHz range and f_X from 50 kHz to 35 MHz.

8 dB max. for f_L and f_R in 50 kHz to 150 MHz range and f_X from 50 kHz to 150 MHz.

Less than 100 nV per root cycle at output for f_X at 10 Hz.

Mixer Balance:

I. f_L and f_R 50 kHz to 35MHz; f_X dc to 35 MHz

II. f_L and f_R 35MHz to 150 MHz; f_X dc to 150 MHz

As In I.	As in II.	
40 dB	30 dB	f_L at R with f_L ref.
35 dB	20 dB	f_L at X with f_L ref.
40 dB	30 dB	f_R at L with f_R ref.
20 dB	15 dB	f_R at X with f_R ref.
35 dB	20 dB	f_X at L with f_X ref.
20 dB	12 dB	f_X at R with f_X ref.

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SPECIFICATIONS (Cont'd)

Typical Conversion Compression:
By f_R alone: 0.3 dB for 1 mw level.
By f_{R2} signal presence interfering with f_{R1} signal (F_L level at 5 mw):
1 dB for f_{R2} level of 1 mw.
10 dB for f_{R2} level of 10 mw.

Intermodulation: Typical intermodulation product with f_L level of 5 mw and f_R at 70 mV (f_L=21MHz and f_R=20MHz):

Product	Level Referred to f_X level	Product	Level Referred to f_X level
$2f_L-f_R$	40 dB	$2f_R-f_L$	65 dB
$3f_L-2f_R$	65 dB	$3f_R-2f_L$	65 dB
$4f_L-3f_R$	65 dB	$4f_R-3f_L$	90 dB
$5f_L-4f_R$	85 dB	$5f_R-4f_L$	90 dB
$6f_L-5f_R$	90 dB	$6f_R-5f_L$	> 95 dB
$7f_L-6f_R$	95 dB	$7f_R-6f_L$	> 95 dB

Typical Pulse Modulation Performance (Pulse Input at "X", output at "R"):
Rise and Fall Times: < 1 nanosecond.
Pulse Width: No restriction.
On-Off Ratio: 35 dB.
Saturation Pulse Amplitude: 10 mA with f_L=5mw.
Maximum Input: 40 mA peak (damage level).
Modulation Source: Either + or - polarity turns switch on. Amplitude between pulses, within 2 mV of 0V.
Linearity: Output is linear over a 30 dB input current range at 150 MHz. Better at lower frequencies.

10534A

Connectors: Female BNC.

Environmental: Type tested to meet specifications over -20°C to +65°C and thru five cycles of 40°C and 95% humidity. Compliance with the rigid MIL-I-6181D RFI specification has been demonstrated. Non-operating tests include -40°C to +75°C exposure, 0.060 inch peak-to-peak vibration of 55 cps, 4" bench drop, and altitude to 25,000 feet.

Dimensions: 2.3 in. (59 mm) wide, 0.6 in. (15 mm) thick, 1.7 in. (43 mm) deep.

Mounting: Tapped 4-40 NC hole pair on 2.062 in. (53 mm) centers on connector side.

Weight: 2.1 oz. (59 grams).

Note: Specified for 50 Ω terminations and F_L level of 5 mW. Special units available with improved noise specifications, port-to-port balance specifications or grounds isolated.

SPECIFICATIONS (Cont'd)

10534B

Connectors: 0.040 in. pins for printed circuit board mounting. All ground pins internally connected (see drawing Page 4).

Environmental: Type tested to meet environmental specifications of MIL-E-16400F class 1; MIL-T-21200 class 1; and MIL 5400D class 2. Conditions include: non-operating temp. -62°C to +85°C; operating temp. -54°C to +75°C; humidity 95% at +60°C; vibration to 500 Hz ±10g's; shock simulated hammer test 1500g's; operating altitude 50,000 feet.

The 10534B not designed to meet RFI requirements since its intended use is in other equipment.

Dimensions: 1.63 in. long, 0.700 in. wide, 0.430 in. seated height, 0.630 in. high with pins; Printed circuit board mounting per drawing on Page 4.

Weight: 0.35 oz (10 grams)

Lead temperature (during soldering): 265°C (509°F) max at not less than 1/32 inch from seating surface for 10 secs max.

10. PERMANENT MOUNTING.

11. The 10534A Mixer may be mounted on a panel as part of a permanent system as follows:

a. Cut opening in panel for connectors.

b. Drill two #33 holes (or notch opening to) 2.062 inches apart for mounting screws.

c. Remove two allen-drive screws on connector side of Mixer case. (Removing these screws does not allow the Mixer case to be opened.)

d. Mount Mixer on panel. Use two 4-40 screws, 1/4-inch longer than the panel thickness.

12. OPERATION.

13. The Mixers are designed for use in 50-ohm systems; but use with a 75-ohm load at the "X" connector should give about the same results. Connections for various applications are given in Paragraphs 14 through 26.

14. MIXER.

a. Connect one input signal, 50 kHz to 150 MHz, 5 mw (0.5 Vrms into 50 ohms) to L.

b. Connect second input signal, 50kHz to 105MHz, 1mw or less (0.22Vrms into 50 ohms) to R.

c. Output (sum and difference frequencies of L and R inputs, dc to 150 MHz) is available at X.

d. The load at X should present an impedance of 50 ohms at f_X.

e. Conversion efficiency is the ratio of power in one output sideband to the power available at R. Figure 3 represents the conversion efficiency as a function of the available power at L, of a typical Model 10534A, B Mixer used as a mixer (Paragraph 14), or phase detector (Paragraph 15). Input signals at L and R are 1MHz, with the signal level at R maintained at 10 mv. Note that the conversion efficiency decreases sharply as power available at L is reduced below 0 dBm.

f. Figure 4 represents the conversion loss of a typical Model 10534A, B Mixer used as a mixer (Paragraph 14), or phase detector (Paragraph 15). The lower frequency input is +7 dBm at L and the higher frequency input is -3 dBm at R. Response near the -3 dB points can be improved about 0.5 dB by increasing the signal at L a few dB (20 mw maximum input signal.)

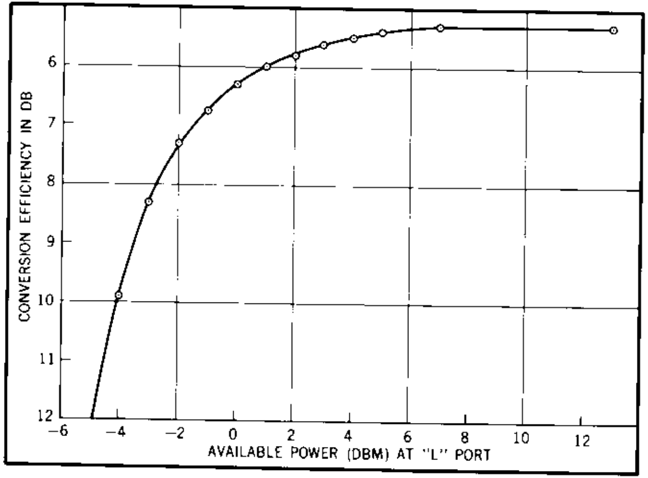

Figure 3. Conversion Efficiency

10514-B-1

15. PHASE DETECTOR.

a. Connect as for mixer (Paragraph 14). Input signals must be same frequency.

b. Measure dc output from X. Output will be near zero when signals are 90° out of phase; maximum when signals are in phase or 180° out of phase.

c. The dc load on X may be a high impedance, but the ac load at X should be 50 ohms or less for the input frequency at L and R.

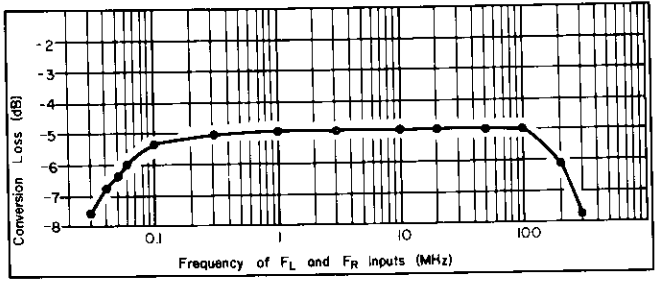

Figure 4. Frequency Response of Conversion Loss

16. FREQUENCY DOUBLER.

a. Connect same signal to L and R inputs with equal length lines from a Tee connection.

b. Take rf output from X, terminated with a 50-ohm resistive load.

17. CURRENT-CONTROLLED ATTENUATOR.

a. Connect series current limiting resistor at X. In calculating the value of this resistor, assume that the resistance at X is zero and the resistor must limit current to 40 mA at maximum possible supply voltage. (The discharge of a power supply output filter capacitor, or the capacitance of a length of coaxial cable, can cause a 40 mA peak current through the diodes, if the resistor is not in place.) Table 1 lists the appropriate minimum resistance values for power supply voltages from 1 volt to 500 volts. Current limiting resistors are needed for any source voltage above 0.5-volt peak

b. Connect dc control source through current limiting resistor to X.

Table 1. Current Limiting Resistors

Voltage	Minimum Resistance
1 volt	27 ohms
5 volts	150 ohms
10 volts	270 ohms
50 volts	1500 ohms
100 volts	2700 ohms
500 volts	15K ohms

c. Connect rf input signal, 50 kHz to 150 MHz, 5 mw (0.5 Vrms into 50 ohms) to L.

d. Take rf signal output from R.

18. Figure 5 shows attenuation and relative harmonic levels characteristic of a typical Model 10534A Mixer when used as a current-controlled attenuator. In this example input signals are 30 MHz at +0 dBm at L and 0 to 40 ma dc control current at X.

19. BALANCED MODULATOR.

a. Connect rf input signal, 50 kHz to 150 MHz, 5 mw (0.5 Vrms into 50 ohms) to L.

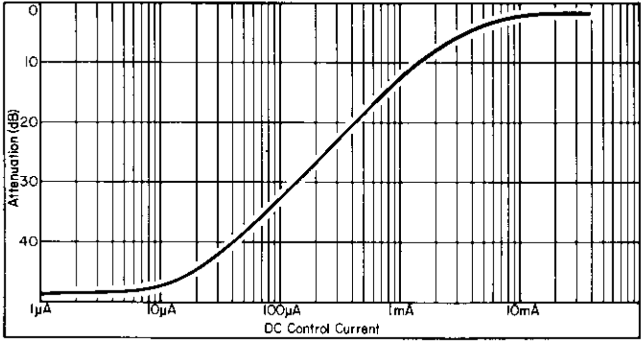

Figure 5. Typical Attenuation

b. Connect modulating signal (dc to 150 MHz) through current limiting resistor (described in Para 17a) to X.

c. Output modulation product of L and X inputs (above 50 kHz) is available at R. This output consists of sidebands displaced plus and minus the modulation frequency away from the carrier (rf input) frequency. The carrier (rf input) is suppressed.

20. Figure 6 shows the output of a typical ⓗⓟ Model 10534A, B Mixer when used as a balanced modulator, displayed on a ⓗⓟ Model 851A/8551A Spectrum Analyzer. A 30 MHz signal is being modulated by a 1 MHz signal. Vertical scale is 10dB/cm. Horizontal scale is 1 MHz/cm. The 30 MHz signal is centered on the display and is shown to be about 40 dB down from the sideband output.

21. AMPLITUDE MODULATOR.

a. Connect rf input signal, 50 kHz to 150 MHz, 5 mw (0.5 Vrms into 50 ohms) to L.

b. Connect modulating signal (dc to 150 MHz) to X.

c. Connect dc control current through current limiting resistor (described in Paragraph 17a) to X.

d. For 100% modulation, modulating signal should be approximately 150 mv rms and dc control current should be approximately 4 ma. (These are typical values.)

e. Take modulated signal output (above 50 kHz) from R.

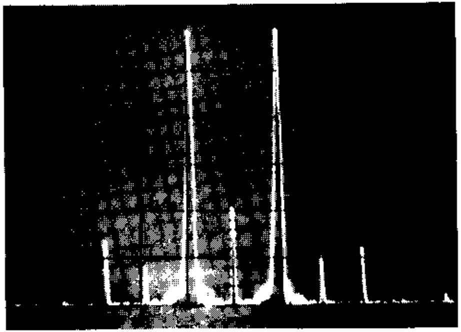

Figure 6. Balanced Modulator Output

22. Figure 7 is the presentation on a dual-trace oscilloscope of the output of a typical Model 10534A, B Mixer used as an amplitude modulator. Upper trace is modulating waveform. Lower trace is output of Mixer. In

this case, the carrier was re-inserted at the balanced modulation output to obtain ordinary amplitude modulation. However, ordinary modulation could also be obtained by applying a dc current with the modulating signal, as described in Paragraph 21c.

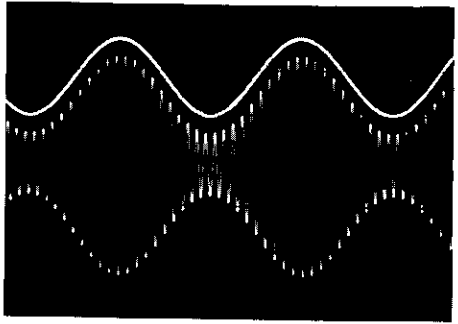

Figure 7. Amplitude Modulator Output

23. PULSE MODULATION.

a. Connect rf input signal, 50 kHz to 150 MHz, 5 mw (0.5 Vrms into 50 ohms) to L.

b. Connect modulating signal through current limiting resistor if necessary (described in Paragraph 17a) (pulse, 0 ma = off, 10 ma = saturated on) to X.

c. Take modulated signal output (above 50 kHz) from R.

24. Figure 8 shows the output of a typical Model 10534A, B Mixer used as a pulse modulator. Input signals to the Mixer are 30 MHz, 5 mw at L and pulses .165 μsec wide, 300 mv high, repetition rate 1 MHz at X. The oscilloscope presentation, Figure 8a, is made with a sweep speed of 0.02 μsec/cm, and shows the clean rf pulses obtainable. The spectrum analyzer display, Figure 8b, presents the pulse modulator output on a log vertical scale as a function of frequency, with a horizontal scale of 3.5 MHz/cm, showing dispersion and envelope of the output. Figure 8b shows that when connected as a pulse modulator, the Mixer may be used as a spectrum or "comb" generator.

a

b

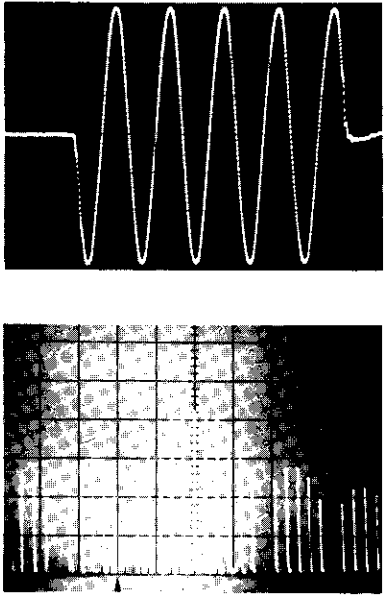

Figure 8. Pulse Modulator Output

10534-A-8

10534-A-6

25. THEORY OF OPERATION.

26. The circuit of the Model 10534A,B Mixer (Figure 9) is commonly known as a double-balanced, or ring modulator. Note that the diodes are all connected with the cathode of one connected to the anode of the next, "short-circuiting" the transformer secondaries; this is not the same circuit as a rectifier bridge.

27. MIXER, PHASE DETECTOR, FREQUENCY DOUBLER.

28. The voltage at the left transformer secondary winding causes current to flow through diode pair ABD or ACD, depending on polarity. The dc voltage of B or C is held at ground potential by voltage divider action of the conducting diode pair. The diode pairs (ABD and ACD) alternate conduction, causing the ends of the right transformer secondary winding (B and C) to be alternately at ground potential, switching at a rate equal to the frequency of the input signal at L. The instantaneous voltage at X is determined by: 1) the level and polarity of the instantaneous voltage at the right transformer secondary winding, and 2) which terminal of the secondary is at ground potential at that instant. With rf input signals at L and R, the output at X contains the sum and difference frequencies of the input signals. For phase detection and frequency

doubling, the rf input signals at L and R are the same frequency. Their sum is twice either input frequency and their difference is zero Hz, or dc. A high-pass, low-pass, or bandpass filter may be used at the Mixer output (X) to select the desired signal.

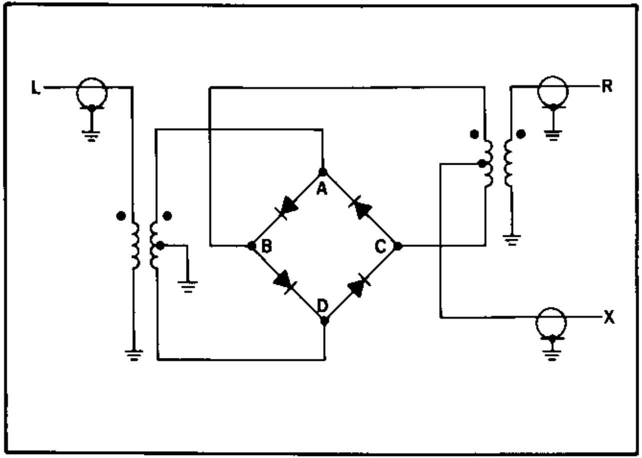

Figure 9. Schematic Diagram

29. CURRENT CONTROLLED ATTENUATOR, BALANCED MODULATOR, AMPLITUDE MODULATOR, OR PULSE MODULATOR.

30. To use the Mixer as a current controlled attenuator, balanced modulator, amplitude modulator, or pulse modulator the rf input signal is connected at L, the control or modulating signal at X, and the output taken from R.

31. With no input at X, an input signal at L appears greatly attenuated at R. Applying a dc control current at X causes conduction of a pair of diodes, which then act like resistors in series in a link-coupling circuit. When sufficient dc current is applied at X to cause a pair of diodes to act like small resistors, the secondary windings of the left and right transformers (refer to schematic diagram Figure 9) are connected together and the input at L will be available at the output R. Attenuation is inversely proportional to the dc current applied at X.

32. With an rf signal applied at L and a modulating signal at X, the output at R is the rf frequency plus and minus the modulating frequency; the carrier is suppressed. The modulating signal appears at terminals B and C of the rectifier (ring). B and C are

alternately switched toward ground potential at the frequency of the rf input signal at L. The small voltage at the X input is not sufficient to cause the diodes to conduct heavily. Switching the signal at L, however, switches current paths toward ground potential through the right transformer secondary. This causes the signal at X to be sampled at the rate of the signal at L. The sampled signal is induced into the right transformer primary winding, and may be coupled out through R.

33. By combining the action of the Mixer as a voltage controlled attenuator and a balanced modulator, an amplitude modulator is obtained. For this application, a signal containing both ac and dc components is applied at X. The ac components produce sidebands as described in Paragraph 32. The dc acts as a modulating signal of zero cycles, and its amplitude controls the amplitude of the carrier that will appear at R, as in the current controlled attenuator described in Paragraph 31. This combination provides the desired amplitude modulation output.

34. The steep sides and sharp corners of a good pulse indicate high frequency components (harmonics) while the pulse duration reflects low frequency components. When the Model 10534A is modulated by a pulse, the output represents the sum and difference of the rf signal and the modulating signal, including the harmonics. A square pulse, to have a good shape, requires components at least to the 10th harmonic. In the example given in Figure 8 the 1 MHz repetition rate causes harmonics of 1 MHz and up; the rectangular pulse 10^{-7} second wide causes the signal to have components of 10 MHz at least through 100 MHz. The spectrum presented in Figure 8b shows the relative levels of the carrier and signals to ±17.5 MHz away from carrier frequency.

35. PERFORMANCE CHECKS.

36. CONVERSION LOSS.

a. Set output levels of Signal Generator before connecting them to the Mixer. Use the following procedure for each generator:

1) Set Signal Generator to desired frequency.

2) Set output level to be as shown in Figure 10 using RF Millivoltmeter (hp Model 411A or equivalent) terminated with 50-ohm resistive load.

Note: 5 mw = 0.5 Vrms into 50 ohms.
1 mw = 0.22 Vrms into 50 ohms.

b. Make connections as shown in Figure 10.

c. Measuring Device used at X must present 50-ohm resistive load at X. The measuring device should be a tuned voltmeter, spectrum analyzer, wave analyzer, or other type of receiver capable of providing a calibrated indication of signal level of one of the sidebands (only) at X.

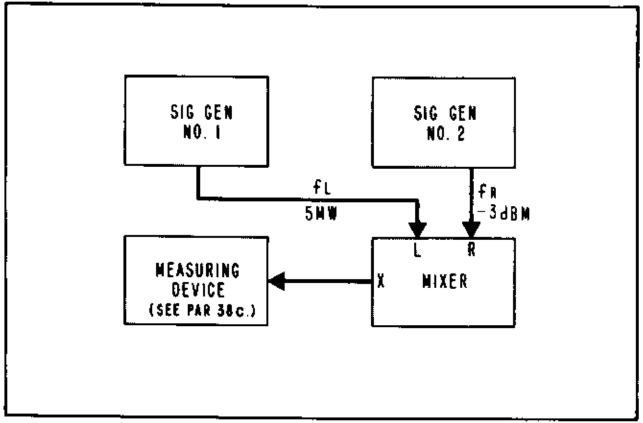

Figure 10. Test Setup-Conversion Loss

d. Measure power in one of the sidebands, f_L+f_R or f_L-f_R at X.

e. Conversion loss is the difference in level, in dB, between the input signal at R (-3 dBm, set in step a.2) and one of the sideband signals output at X. Refer to specification table to determine whether Mixer is within specification for the frequencies of f_L and f_R used. If the conversion loss is within specifications, this is an indication that the noise figure is satisfactory.

37. MIXER BALANCE.

a. f_L or f_R at X.

1) Set Signal Generator #1 to f_L.

2) Using RF Millivoltmeter terminated with 50-ohm resistive load, measure Signal Generator output level. Set f_L level to 5 mw (0.5 Vrms into 50 ohms).

3) Connect Signal Generator #1 to L.

4) Set Signal Generator #2 to f_R.

5) Using RF Millivoltmeter terminated with 50-ohm resistive load, measure Signal Generator output level. Set f_R level to 1 mw or less (0.22 Vrms or less into 50 ohms).

6) Connect Signal Generator #2 to R.

7) Connect Measuring Device to X. Measuring Device should be a tuned voltmeter, spectrum analyzer, wave analyzer, or other type of receiver capable of providing a calibrated indication of signal level at the desired frequency. The Measuring Device should present a 50-ohm load to its signal source.

8) Tune the Measuring Device to the frequencies of f_L and f_R. These levels, measured at X, referred to their input levels, should be within the appropriate specification listed on Page 4.

b. f_R or f_X at L.

1) Set Signal Generator #1 to f_L.

2) Connect Signal Generator #1 to Power Splitter shown in Figure 11. The values for the Power Splitter resistors are chosen so a 50-ohm load is presented at any terminal when the other two terminals are terminated with 50-ohm loads.

3) Terminate one Power Splitter output with 50-ohm resistive load.

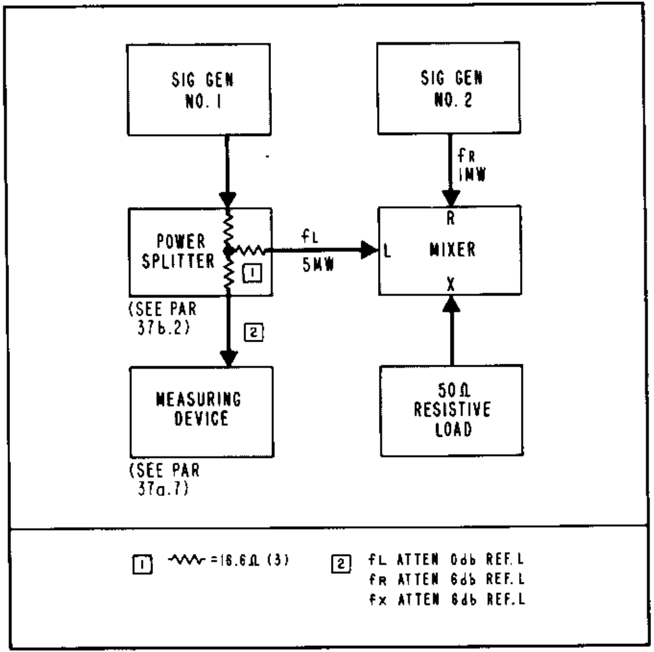

Figure 11. Test Setup-Mixer Balance

4) Using RF Millivoltmeter terminated with 50-ohm resistive load, measure signal level at remaining Power Splitter output terminal. Set this f_L level to be 5 mw (0.5 Vrms into 50-ohms).

5) Disconnect 50-ohm termination and RF Millivoltmeter from Power Splitter outputs, and con- connect output terminal to L.

6) Using RF Millivoltmeter terminated with 50-ohm resistive load, measure Signal Generator #2 output level. Set f_R level to 1 mw or less (0.22 Vrms or less into 50-ohms).

7) Connect Signal Generator #2 to R.

8) Terminate X with a 50-ohm resistive load. A Measuring Device such as the one described in Paragraph 37, step a7, may be used when f_X is being measured. The signal f_X is either one of the sidebands (f_L+f_R or f_L-f_R) obtainable at X.

9) Connect a Measuring Device such as the one described in Paragraph 37, step a7, to the Power Splitter output as shown in Figure 11.

10) Tune the Measuring Device to the frequencies of f_R and f_X. These levels measured at the Power Splitter output, increased 6 dB to compensate for Power Splitter attenuation, and then referred to their input levels, should be within the appropriate specification listed on Page 4.

c. f_L or f_X at R.

1) Using RF Millivoltmeter terminated with 50-ohm resistive load, measure Signal Generator output level. Set f_L level to 5 mw (0.5 Vrms into 50-ohms).

2) Connect Signal Generator #1 to L.

3) Connect Signal Generator #2 to Power Splitter.

4) Terminate one Power Splitter output with 50-ohm resistive load.

5) Using RF Millivoltmeter terminated with 50-ohm resistive load, measure level at remaining Power Splitter output terminals. Set this f_R level to be 1 mw or less (0.22 Vrms or less into 50-ohms).

6) Disconnect 50-ohm termination and RF Millivoltmeter from Power Splitter outputs and connect one Power Splitter output terminal to R.

7) Terminate X with a 50-ohm resistive load. A Measuring Device such as the one described in Paragraph 37, step a7, may be used when f_X is being measured. The signal f_X is either one of the sidebands (f_L+f_R or f_L-f_R) obtainable at X.

8) Connect a Measuring Device such as the one described in Paragraph 37, step a7, to the Power Splitter output.

9) Tune the Measuring Device to the frequencies of f_L and f_X. These levels measured at the Power Splitter output, increased 6 dB to compensate for Power Splitter attenuation, and then referred to their input levels, should be within the appropriate specification listed on Page 4.

38. MAINTENANCE

39. The Models 10534A, B Mixers are sealed at the factory. Any attempt to open the case or make repairs voids the warranty. For assistance of any kind, contact the nearest HP field office (see list inside back cover).

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