# 10514A/B MIXERS

HEWLETT hp PACKARD

OPERATING AND SERVICE MANUAL

# HEWLETT **hp** PACKARD

## 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

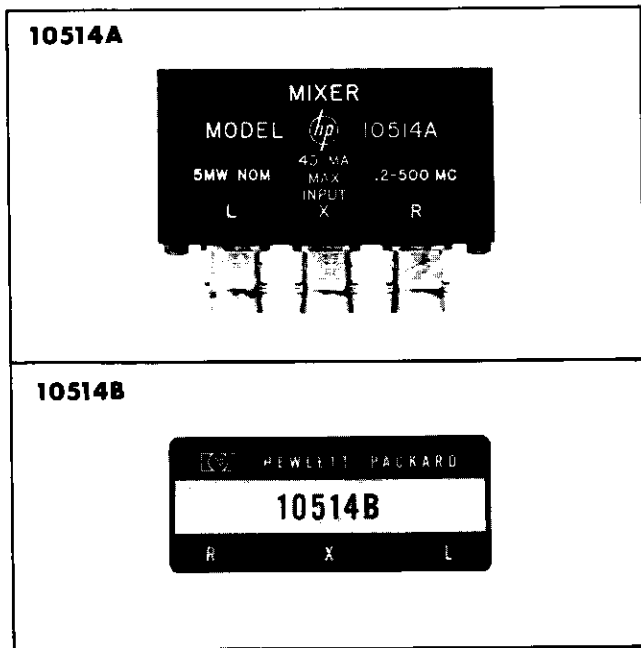# OPERATING AND SERVICE MANUAL

# MODEL 10514A,B
# MIXERS

Figure 1.   Model 10514A, 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.
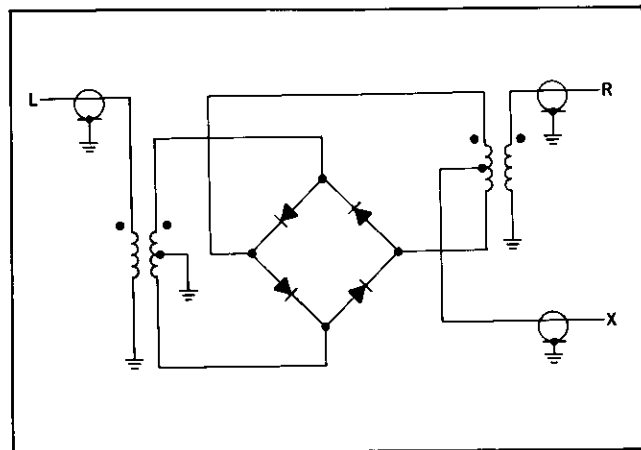


Figure 2.   Schematic Diagram

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# 1. GENERAL INFORMATION.

2.     The Hewlett-Packard Model 10514A, B Mixer operates between 0.2 MHz and 500 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. All connectors are standard female BNC. 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.
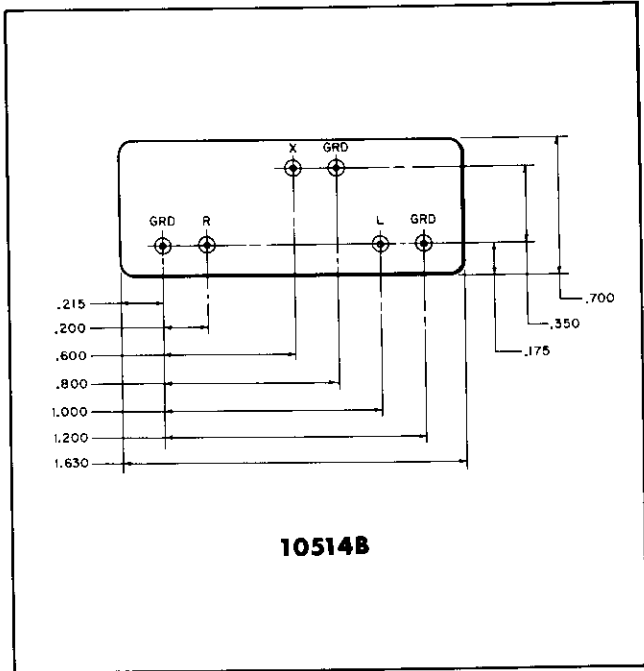
8.     For full compliance with specifications, conditions during operation should be limited as follows:

   a.  Minimum temperature: $0°C$ ($+32°F$).

   b.  Maximum temperature: $+55°C$ ($+131°F$).

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

   a.  Minimum temperature: $-40°C$ ($-40°F$).

   b.  Maximum temperature: $+75°C$ ($+167°F$).

**10514B**

## SPECIFICATIONS

Input/Output Frequencies: "L" and "R" ports: 200 kHz to 500 MHz; "X" port: dc to 500 MHz.

Max. Input: 40 mA (damage level).

Impedance: Designed for, and specified in, a 50 ohm system.

Mixer Conversion Loss (Single Sideband):

(A) 7 dB max, for $f_L$ and $f_R$ in the 500 kHz to 50 MHz range and $f_X$ from dc to 50 MHz.

(B) 9 dB max, for $f_L$ and $f_R$ in the 200 kHz to 500 MHz range and $f_X$ from dc to 500 MHz.

Noise Performance (Single Sideband):

7 dB max. noise figure for conditions of (A) above except $f_X$ min. frequency of 50 kHz.

9 dB max. noise figure for conditions of (B) above except $f_X$ min. frequency of 50 kHz.

$10^{-7}$ volts per root cycle max. expected at output for conditions of (A) or (B) except $f_X$ at 10 cycles.

Mixer Balance:

| As In (A) | As In (B) | 10514B (as in (B)) | |
|---|---|---|---|
| 40 dB | 30 dB | 25 dB | $f_L$ at R with $f_L$ ref |
| 40 dB | 20 dB | 15 dB | $f_L$ at X with $f_L$ ref |
| 45 dB | 30 dB | 25 dB | $f_R$ at L with $f_R$ ref |
| 25 dB | 15 dB | 15 dB | $f_R$ at X with $f_R$ ref |
| 35 dB | 15 dB | 15 dB | $f_X$ at L with $f_X$ ref |
| 25 dB | 15 dB | 15 dB | $f_X$ at R with $f_X$ ref |

## 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
  production with $f_L$ level of 5 mw and $f_R$ at 70 mV:

| Product | Level Referred to $f_X$ level | Product | Level Referred to $f_X$ level |
|---------|------------------------------|---------|------------------------------|
| $2f_L - f_R$ | 30 dB | $2f_R - f_L$ | 65 dB |
| $3f_L - 2f_R$ | 70 dB | $3f_R - 2f_L$ | 65 dB |
| $4f_L - 3f_R$ | 70 dB | $4f_R - 3f_L$ | 85 dB |
| $5f_L - 4f_R$ | 90 dB | $5f_R - 4f_L$ | 90 dB |
| $6f_L - 5f_R$ | 95 dB | $6f_R - 5f_L$ | > 100 dB |
| $7f_L - 6f_R$ | > 100 dB | $7f_R - 6f_L$ | > 100 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 500 MHz; better at lower
  frequencies.

10514A
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: Specification for 50 Ω terminations and $F_L$
      level of 5 mW.  Special units available with
      improved noise specifications, or improved
      specific port-to-port balance specifications.

## SPECIFICATIONS (Cont'd)

### 10514B

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 50 Hz $\pm10$g's; shock simulated hammer test 1500g's; operating altitude 50,000 feet.

The 10514B 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.

Weight: 0.5 oz (14 grams).

Note: All 10514B specifications for 50 ohm termination and $F_L$ level of 5 milliwatts. Designed for printed circuit board mounting per dimension drawing on Page 4.

10. PERMANENT MOUNTING.

11. The 10514A 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, 1/2-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, 0.2 MHz to 500 MHz, 5 mw (0.5 Vrms into 50 ohms) to L.

b.  Connect second input signal, 0.2MHz to 500MHz, 1mw or less (0.22Vrms into 50 ohms) to R.

c.  Output (sum and difference frequencies of L and R inputs, dc to 500 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 10514A, 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 relative frequency response of a typical Model 10514A, B Mixer used as a mixer (Paragraph 14), or phase detector (Paragraph 15).  The lower frequency input is +7 dBm at L

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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).
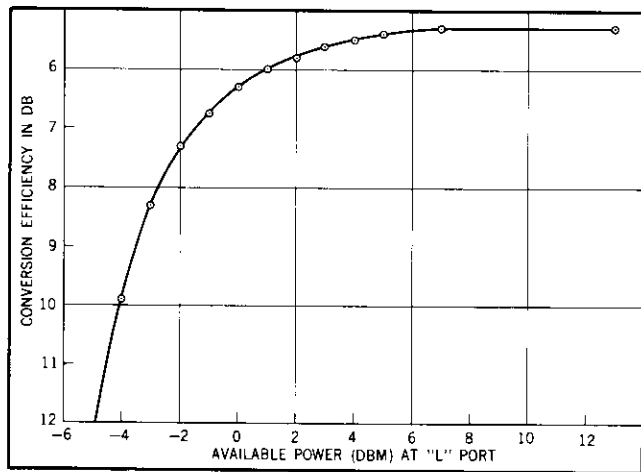


Figure 3.  Conversion Efficiency

## 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 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.
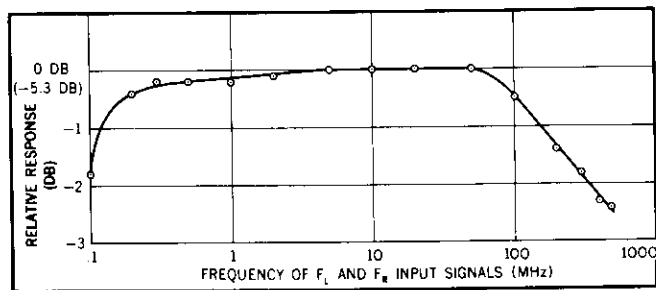


**Figure 4.** Relative Frequency Response

## 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, 0.2 MHz to 500 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 10514A Mixer when used as a current-controlled attenuator. In this example input signals are 50 MHz at +3 dBm at L and 0 to 40 ma dc control current at X.

19. BALANCED MODULATOR.

a. Connect rf input signal, 0.2 MHz to 500 MHz, 5 mw (0.5 Vrms into 50 ohms) to L.

b. Connect modulating signal (dc to 500 MHz) through current limiting resistor (described in Para 17a) to X.
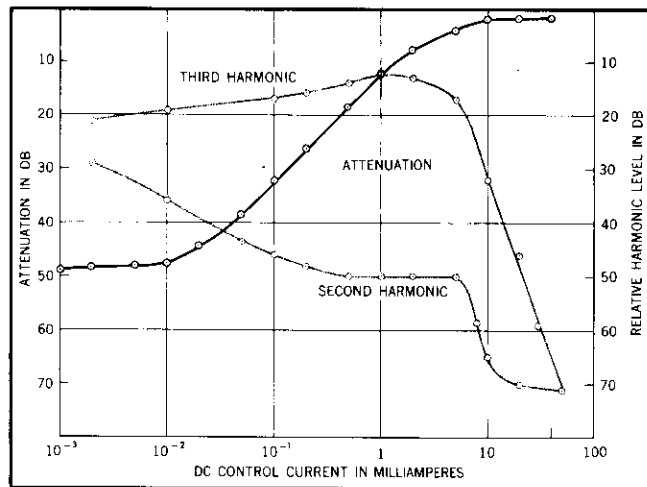
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Figure 5. Typical Attenuation

c. Output modulation product of L and X inputs (above 0.2 MHz) 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 10514A, B Mixer when used as a balanced modulator, displayed on a ⓗⓟ Model 851A/8551A Spectrum Analyzer. A 50 MHz signal is being modulated by a 1 MHz signal. Vertical scale is 10 dB/cm. Horizontal scale is 1 MHz/cm. The 50 MHz signal is centered on the display and is shown to be more than 40 dB down from the sideband output.

## 21. AMPLITUDE MODULATOR.

a. Connect rf input signal, 0.2 MHz to 500 MHz, 5 mw (0.5 Vrms into 50 ohms) to L.

b. Connect modulating signal (dc to 500 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 0.2 MHz) from R.
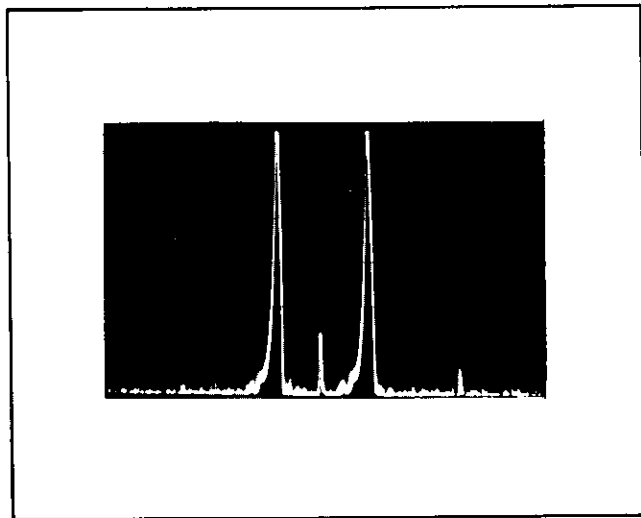


Figure 6. Balanced Modulator Output

22. Figure 7 is the presentation on a dual-trace oscilloscope of the output of a typical Model 10514A,B Mixer used as an amplitude modulator. Upper trace is modulating waveform. Lower trace is output of Mixer. In

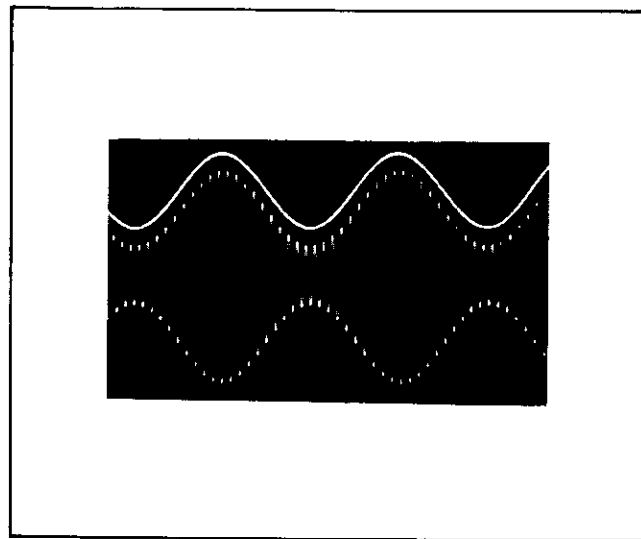this case, the carrier was re-inserted at the balanced modulation output to obtain ordinary amplitude modulation. However, ordinary modulation could also be obtained by applying a dc current with the modulating signal, as described in Paragraph 21c.

### 23. PULSE MODULATION.

a. Connect rf input signal, 0.2 MHz to 500 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 0.2 MHz) from R.

24. Figure 8 shows the output of a typical Model 10514A, B Mixer used as a pulse modulator. Input signals to the Mixer are 50 MHz, 5 mw at L and pulses 0.1 $\mu$sec wide, 300 mv high, repetition rate 1 MHz at X. The oscilloscope presentation, Figure 8a, is made with a sweep speed of 0.02 $\mu$sec/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 7 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.
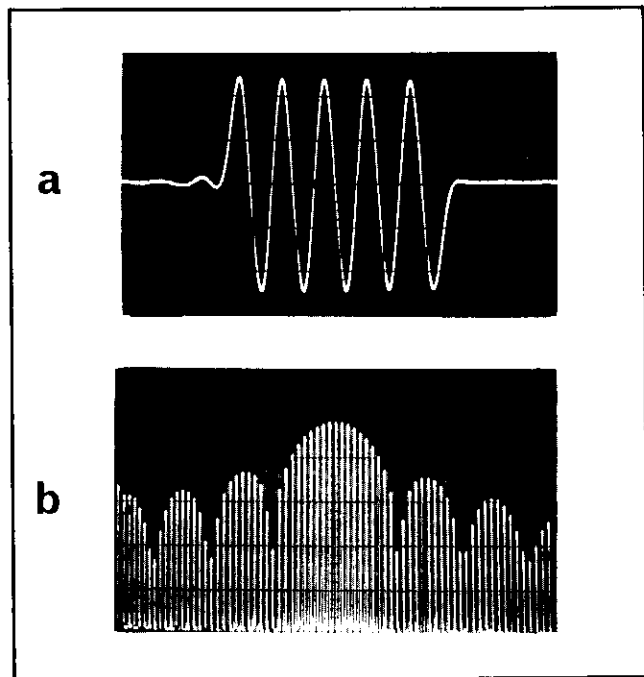


Figure 7. Amplitude Modulator Output

Figure 8.   Pulse Modulator Output

## 25.  THEORY OF OPERATION.

26.  The circuit of the Model 10514A, 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.
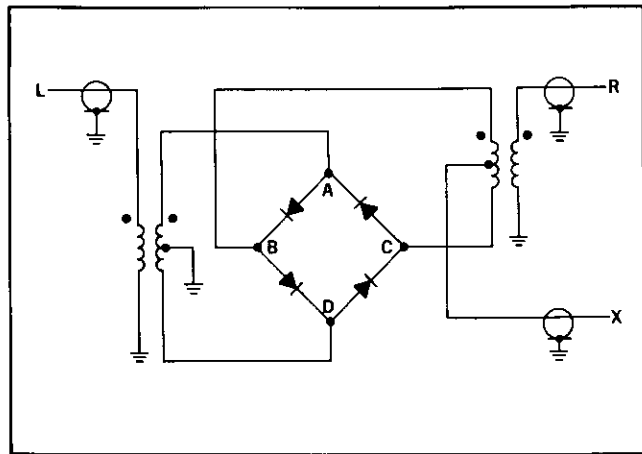
Figure 9.   Schematic Diagram

### 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 10514A 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 ±35 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 (⊕ 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.
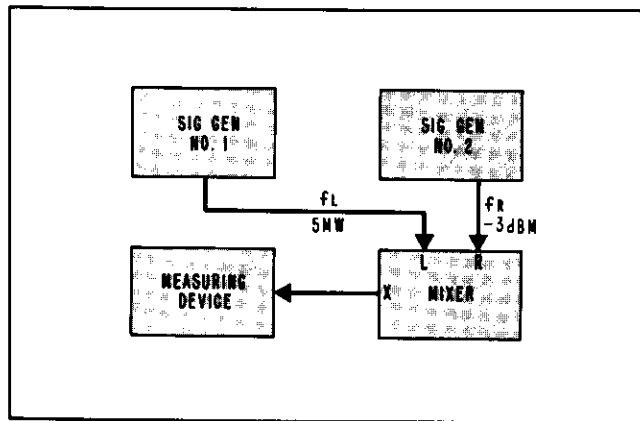


Figure 10.   Test Setup-Conversion Loss

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

e. Conversion efficiency 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 efficiency is within specifications, this is a good indication that the noise figure is satisfactory.
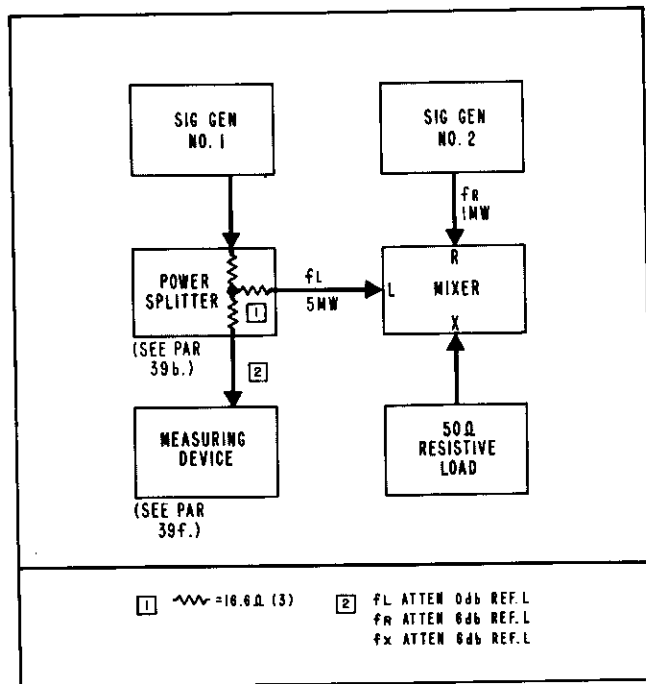
37. MIXER BALANCE.

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).

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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

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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 Milli-voltmeter 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 10514A, 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).

# ELECTRONIC INSTRUMENTATION SALES AND SERVICE

## UNITED STATES

### ALABAMA
P.O. Box 4207
2003 Byrd Spring Road S.W.
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TWX: 910-950-1282

232 South Tucson Boulevard
Tucson 85716
Tel: 602-623-2554
TWX: 910-952-1162

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TWX: 910-499-2170

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Palo Alto 94303
Tel: 415-327-6500
TWX: 910-373-1280

2591 Carlsbad Avenue
Sacramento 95821
Tel: 916-482-1463
TWX: 910-367-2092

1055 Shafter Street
San Diego 92106
Tel: 714-223-8103
TWX: 910-335-2000

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