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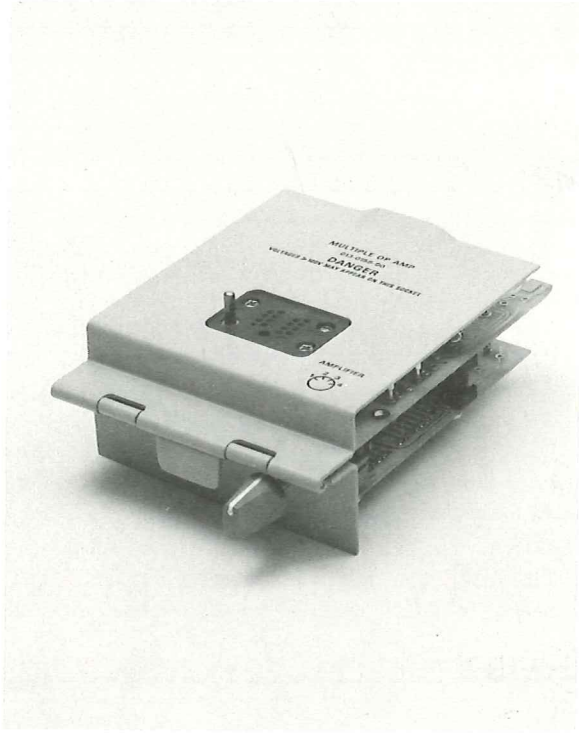
CDG – PARTS PUBLICATION

MULTIPLE OP AMP CARD

(Part No. 013-0155-00)



The Multiple Op Amp Card is a test card for use with the 178 Linear Test Fixture.

The Test Card performs the same tests as the Standard Op Amp Card, and has the capability of testing each of the op amps (up to four) in a common package.

NO. 062-1765-00
DATE Oct. 1974

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DESCRIPTION

The following description of each of the features of the card is illustrated by Fig. 1. The number in the diamond, ◇ , indicates the portion of the figure being considered.

◇1 A four-position switch selects the op amp (in a multiple op amp package) or the section of a linear integrated circuit to be tested.

◇2 A Device Under Test (DUT) socket into which several types of adapter sockets may be plugged, using the Amphenol-Barnes adapter system. The adapter system accomodates most of the package configurations (TO-5, DIP, flat pack, etc.) ZERO INSERTION sockets for 14 and 16-lead dual-in-line packages are available from Textool Products, Inc., 1410 W. Pioneer Drive, Irving, Texas 75061. Order ZIP DIP ADAPTER, 216-2812-0-061 for 16-lead dual-in-line packages, and ZIP DIP ADAPTOR, 214-2665-0-061 for 14-lead dual-in-line packages.

◇3 Connections from the adapter system are made via patch cords to the test circuits, ◇4 .

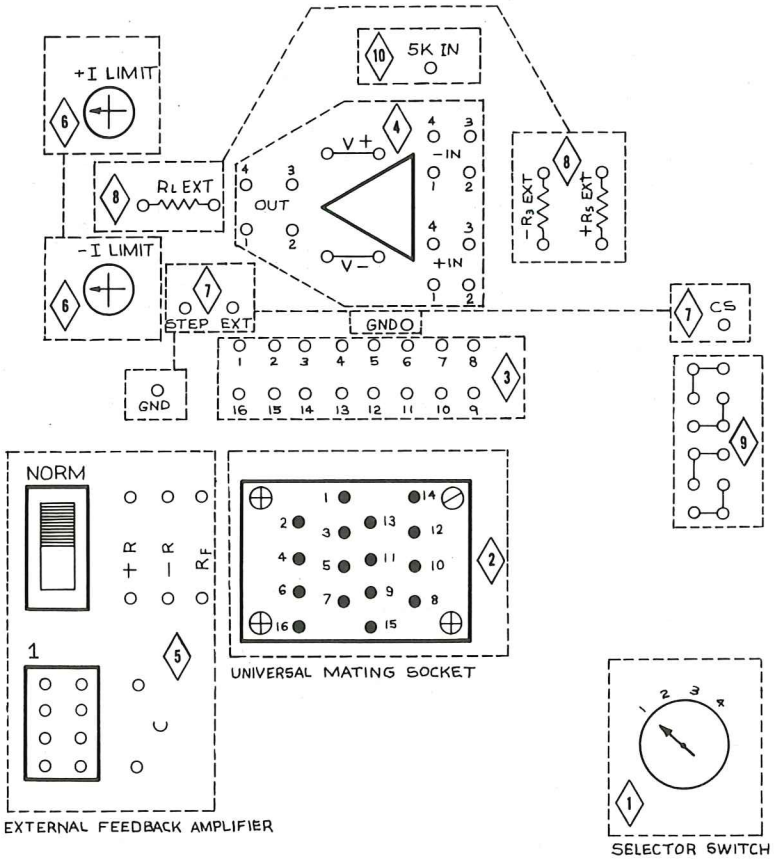

Figure 1. Multiple Op Amp Card

(4) The 178 test circuit for the DUT are brought out to pin jacks within this area. The regulated supplies are labeled V+ and V-.

Each op amp terminal is connected to a pin jack. For example, the output is labeled OUT, and consists of four pin jacks, one for each of the DUT outputs (up to four). Similarly, the the pin jacks connecting to the DUT's differential inputs are labeled +IN and -IN. Each of the inputs consists of four pin jacks, labeled 1, 2, 3, 4. Pin jack number 1, for -IN, +IN, and OUT is connected to the DUT when the selector switch is in position 1. Likewise, jacks labeled 2 are connected to the DUT when the selector switch is in position 2, etc.

(5) An external feedback amplifier (EXT FBA) is provided for additional closed loop gain, phase shift control, and other circuit applications when needed. The EXT FBA may be added to the closed loop test configuration by the switch shown in Fig.2. This added gain can be useful for testing low gain amplifiers, for example, in a test function such as CMRR or PSRR, where the DUT's output voltage should be held at zero volts. In these functions, the EXT FBA maintains the DUT's output closer to zero volts than would be possible if the loop gain were provided by only a low-gain DUT. If the output of a low-gain DUT is not held close to zero volts, an error signal appears at the input. This error signal due to gain adds to the input signal due to CMRR and PSRR and produces an erroneous measurement. With high gain DUT the error signal is directly reduced because a smaller signal is required at the input for a given output signal.

As a rule of thumb, this low DUT gain may cause significant measurement error when measuring CMRR and PSRR, if those parameters are 20 dB or more below the DUT gain. The EXT FBA has a gain of 40 dB, which is sufficient for most low gain, high CMRR-PSRR devices. This gain may be retailored if more than 60 dB is desired by the user.

For phase control the LM 301 is compensated with a 1000 pF capacitor for a first pole of $\leq$ 0.1 Hz, giving the EXT FBA a unit-gain bandwidth of $\leq$ 10 kHz.

The DUT will oscillate if a second pole in the system feedback loop cocurs before system unitygain bandwidth is reached. Therefore, if the DUT has unity gain bandwidth much greater than the 178 gain bandwidth, the LM 301 can be used to control the system gain bandwidth. To accomplish this system gain bandwidth control, increase the size of the LM 301 compensating capacitor, C, on the Multiple Op Amp Card. If the DUT has compensating terminals, compensate the DUT for unity-gain bandwidth to stop oscillations and do not use the EXT FBA.

With the EXT FBA switch in the NORM position, the EXT FBA may be used for other applications (i.e., EXT FBA can be patched into input, output, or power supply circuits to provide offset, power supply, common-mode amplifier phase control, etc.).

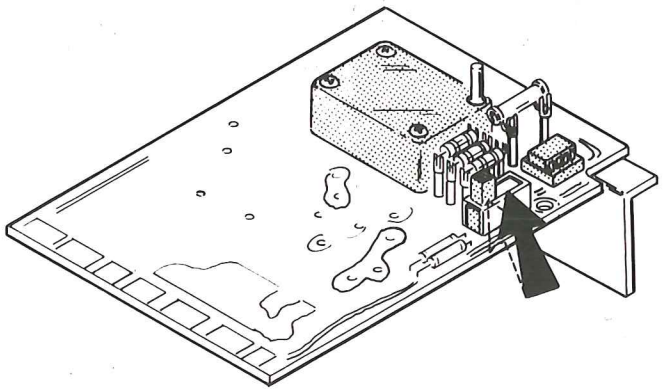

Figure 2 - External Feedback Amplifier and Switch

⑥ Two variable resistors, -I Limit and +I Limit can be set to limit the DUT supply current; see 178 manual.

⑦ Jacks STEP and CS provide access to the 577 Step Generator and Collector Supply. EXT connects to the 178 EXT SIGNAL IN jack (178 front panel).

Kelvin sensing is provided for the collector sweep. Open the run on the back side of the board; see Fig. 3. Patch from the solder pad directly to DUT terminal.

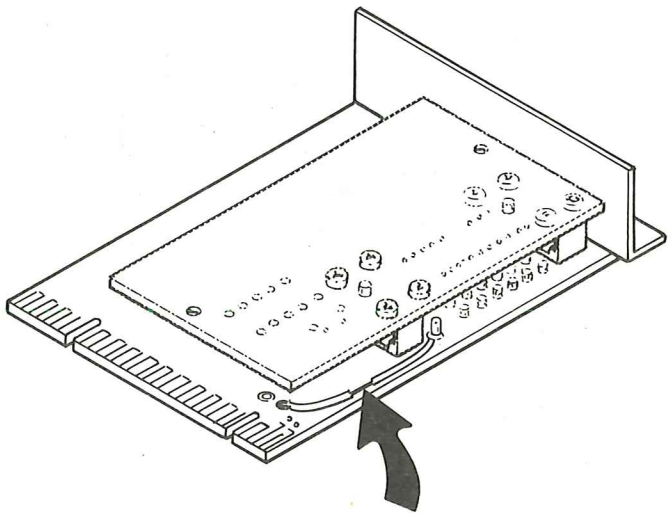

Figure 3
Breakpoint for collector Sweep Kelvin Sensing run.
The solder pad is to the left on the run.

Kelvin sensing (GND) is provided for the return path. Open the run on front side of board; see Fig. 4. Patch from the solder pad shown, directly to ground terminal of DUT.

⑧ R_L EXT provides the means to connect an external load resistor to the DUT output. The jack at the right end of R_L EXT is connected to the OUT jack selected by the four-position switch when the LOAD RESISTANCE switch on the 178 is in the EXT position. The left end of R_L EXT is grounded when FUNCTION switch is in OFFSET V, GAIN, and COLLECTOR SUPPLY I. The maximum external load resistance is always in parallel with a 50K ohm resistor.

$-R_S$ EXT and $+R_S$ EXT provide values of source resistance other than those selected by the SOURCE RESISTANCE switch (switch to EXT position). The lower ends of pin jacks $+R_S$ EXT and $-R_S$ EXT are connected to the IN jacks selected by the four-position switch (with SOURCE RESISTANCE switch to 50 ohm position). If the SOURCE RESISTANCE switch is in a position other than 50 ohm, the resistance selected is between lower end of R_S EXT and DUT Input terminal. In EXT position of SOURCE RESISTANCE switch, the top of R_S EXT (pin jack) connects to Input terminal selected by the four-position switch.

⑨ Four sets of pin jacks are provided to patch additional components into the test circuits.

⑩ The 5K ohm Input terminal is used to offset the output terminal voltage for devices that require the output at some voltage other than ground. The 5K ohm input voltage must be of the opposite polarity and be one-tenth of the desired output voltage. Generally, the Step Generator can be used in the OFFSET voltage mode to provide this voltage. For an example, see Norton Amplifier Application.

The 50K ohm Input terminal is used the same as the 5K ohm input. The offset voltage must be of the opposite polarity and equal to the desired voltage. The 50K ohm Input terminal is a solder pad, rather than a pin jack. The 50K ohm Input is grounded when not used to reduce noise in the 178. A run between the solder pad and ground must be opened to use this input. Resolder the run when this input is not being used. See Fig. 5 for location of solder pad and run.

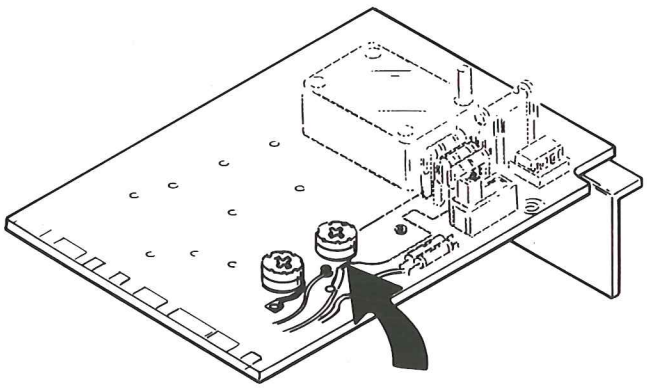

Figure 4

Breakpoint for Kelving Sensing return path. The solder pad is to the left on the run.

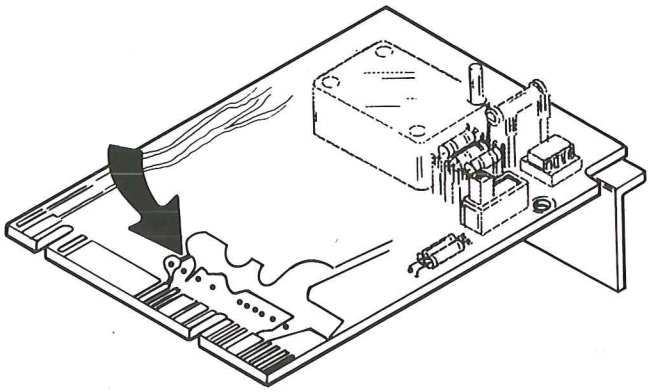

Figure 5
Breakpoint for 50K OHM INPUT run. The solder pad is on the left of the breakpoint.

APPLICATIONS

SPECIFICATION FOR LM 324 QUAD OPERATIONAL AMPLIFIERS

ELECTRICAL CHARACTERISTICS

V+ = +5 V_{DC} and T_A = 250 C unless otherwise noted

EXAMPLE: LM 324 Quad Op Amp

	Min	Typ	Max	Units
1. Input Offset Voltage		2	7	m_{VDC}
2. Output Voltage Swing R_L = 2 kΩ	0		V+ -1.5	V_{DC}
3. +Input Bias Current (Note 1)		45	500	n_{ADC}
4. -Input Bias Current (Note 1)		45	500	n_{ADC}
5. Input Offset Current		±5	±50	n_{ADC}
6. Input CMRR		85		dB
Input Common-Mode Range (note 2)	0		V+ -1.5	V_{DC}
7. Large Signal Voltage Gain $R_L \geq$ 2 kΩ		100		V/mV
8. PSRR DC		100		dB
9. Supply Current		0.8	2	mA_{DC}
10. Output Current Sink	10	20		mA_{DC}
11. Output Current Source	20	40		mA_{DC}

Note 1. Direction of input current is out of the ic due to PNP input stage. This current is independent of the output state, so no loading exists on input lines.

Note 2. Neither the commonmode voltage nor the input-signal voltage (either input) should be permitted to go negative by more than 0.3 V. The upper limit of commonmode voltage is V+ 1.5 V, but either (or both) inputs may go to +30 V_{DC} without damage.

Example: LM 324

General Description

The LM 324 consists of four independent, internally frequency compensated, high gain op amps designed to operate from a single power supply. Operation from split (+ and -) power supplies is possible and the low power-supply drain is independent of the power-supply voltage.

013-0155-00

LM 324 QUAD OP AMP

Absolute Maximum Ratings

Supply Voltage, V+	32 V_{DC}, or + and -16 V_{DC}
Differential Input Voltage	32 V_{DC}
Input Voltage	-0.3 V_{DC} to +32 V_{DC}
Output Short-Circuit to GND (See Note 3)	Continuous

Note 3. The Maximum output current is approximately 40 mA and is independent of the magnitude of V+. At supply voltages exceeding +15 V_{DC}, continuous short circuits (output to V+) can exceed power-dissipation ratings and cause eventual destruction.

Preliminary Setup for Testing Multiple Operational Amplifiers

Set controls as follows:

577

DISPLAY	STORE (if comparison between of amp sections is desired)
VARIABLE COLLECTOR %	0
COLLECTOR POLARITY	+
MAX PEAK VOLTS	25
MAX PEAK POWER-WATTS	.6
All Dark Gray Knobs and Buttons in except:	
STEP FAMILY SINGLE	press
OFFSET ZERO	out
STEP/OFFSET AMPL	.1 V
OFFSET MULT	10
OFFSET AID	in
PULSED 300 µs	out
HORIZ VOLTS/DIV	1 V COLLECTOR
Horizontal POSITION	centered
Vertical POSITION	centered

LM 324 QUAD OP AMP

178

DUT SUPPLIES	OFF
LOAD RESISTANCE	2K ohm
SOURCE RESISTANCE	50 ohm
+ SUPPLY	5 V
SWEEP AMPLITUDE	ccw
SWEEP FREQUENCY	1 Hz
FUNCTION	OFFSET V
VERT UNITS/DIV	2 mV

Multiple Op Amp Card

External Feedback Amplifier (Ext FBA switch)	NORM
+Supply Limit	cw
-Supply Limit	ccw
Amplifier Section	1

1. Check Input-Offset Voltage

Connect an LM 324 Quad Op Amp; see Fig. 6, into test fixture using patch cords as shown in Fig. 7.

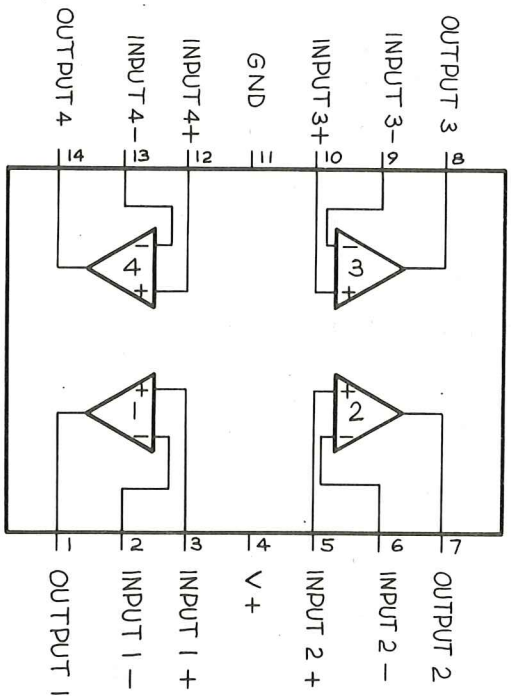

Figure 6. Dual-in line package pin connections for LM324.

LM 324 QUAD OP AMP

Procedure:

a. Set DUT SUPPLIES switch to ON.
b. Press and hold DISPLAY ZERO button while positioning spot to graticule center vertically and horizontally.
c. Turn SWEEP AMPLITUDE slowly clockwise until the display indicates the +Power Supply level has been reached (right edge of display moves straight down screen). See Fig. 8.
d. CHECK-input offset voltage. Maximum for this example, 7 mV (maximum vertical deflect-ion from graticule center line is $\geq$ 3.5 divisions).
e. Switch to Amplifier Section 2.
f. CHECK-input offset voltage.
g. CHECK-sections 3 and 4 in the same manner.

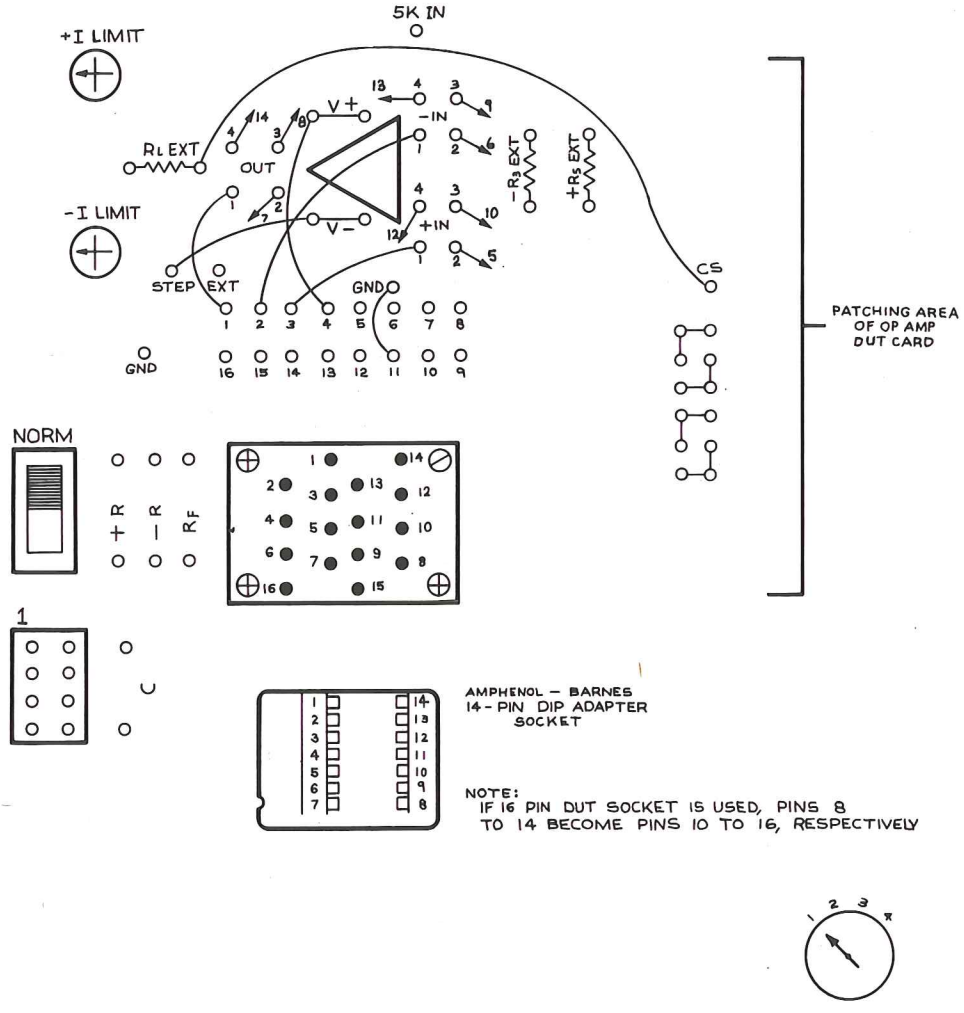

Figure 7. Test setup for four sections - multiple op amp. Section one is shown patched. Other three sections are shown using arrow and terminal number. Example O⟶ indicates this terminal connects to terminal 6 of the 16-terminal patch field of the adapter socket.

LM 324 QUAD OP AMP

2. Check Output Voltage Swing

Using the setup, procedure and display in Fig. 8 for input offset voltage test,

a. Set amplifier section switch to 1.
b. CHECK-the output voltage maximum swing (horizontal deflection from graticule center line. Maximum swing for this example, ≥ 3.5 volts (≥ 3.5 divisions) of horizontal deflection.
c. Repeat for sections 2, 3 and 4.

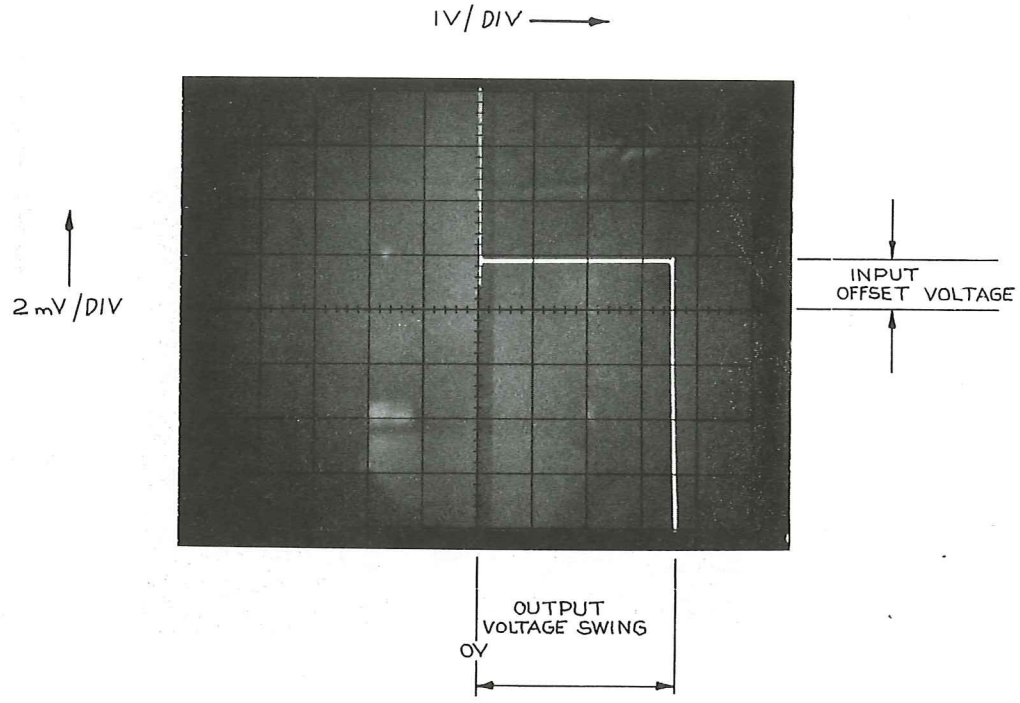

Figure 8. Typical display of input offset voltage and output voltage swing.

3. Check +Input Bias Current

Reset controls as follows:

577

ERASE	press

178

SWEEP AMPLITUDE	ccw
FUNCTION	+ INPUT I
VERTS UNITS/DIV	.1 μA

Multiple Op Amp Test Unit

Amplifier Section	1

LM 324 QUAD OP AMP

Procedure:

a. Press ERASE button.
b. Turn SWEEP AMPLITUDE (on 178) slowly clockwise unitl the display sweeps horizontally through five volts (five divisions).
c. CHECK-that vertical display is $\leq$5 divisions from graticule center ($\leq$500 nA); see Fig. 9. Reset Vert Volts/Div if better resolution is needed.
d. Repeat this test for amplifier sections 2, 3 and 4.
e. Erase the stored display.
f. Turn SWEEP AMPLITUDE control fully counterclockwise.

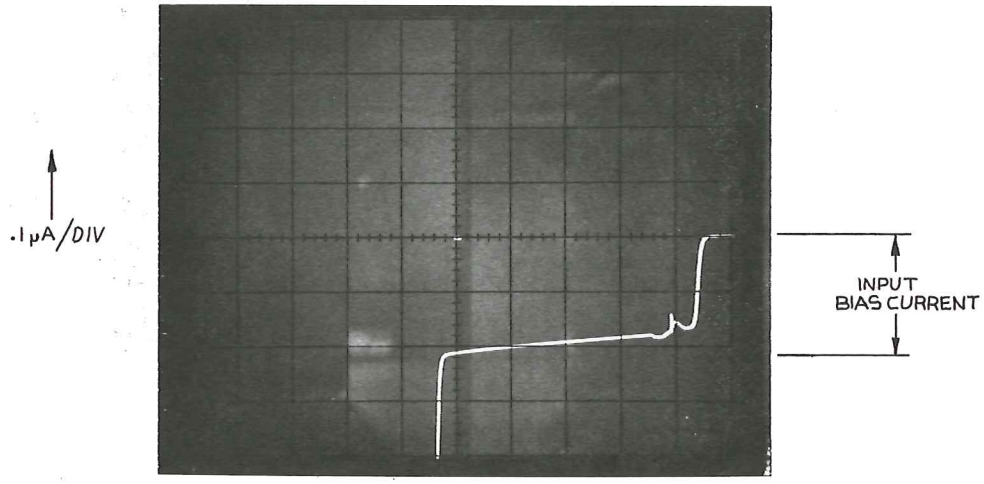

Figure 9. Typical display at input bias current.

4. Check-Input Bias Current

a. Reset FUNCTION to - INPUT I, Amplifier section to 1.
b. Press ERASE button.
c. Turn SWEEP AMPLITUDE slowly clockwise until the display sweeps horizontally through 5 volts.
d. CHECK-that vertical display is $\leq$5 divisions from graticule center ($\leq$500 nA). Increase vertical sensitivity as necessary.
e. Repeat for amplifier sections 2, 3 and 4.
f. Erase stored display.

5. Check Input Offset I

Reset controls as follows:

577

X10 VERT MAG	pull
Vertical POSITION	center display

LM 324 QUAD OP AMP

178

FUNCTION	+ INPUT I
VERT UNITS/DIV	.2 μA

Multiple Op Amp Test Unit

Amplifier Section	1

Procedure:

a. Erase once, then store display.
b. Switch FUNCTION to - INPUT I
c. Compare the two displays (parts 1 and 2).
d. CHECK-that input offset (vertical separation between + INPUT I and - INPUT I ≤ 2.5 divisions (≤ 50 nA). If greater resolution is needed, switch VERT UNITS/DIV to more sensitive setting. and repeat parts a. through d.
e. Repeat for amplifier sections 2, 3 and 4.

6. Check Input Common-Mode Rejection Ratio and Input Common-Mode Range.

Reset controls as follows:

577

X10 VERT MAG	in

178

FUNCTION	CMRR
VERT UNITS/DIV	.2 mV
SWEEP AMPLITUDE	ccw
DISPLAY ZERO	press

Multiple Op Amp Test Unit

Amplifier Section	1

Procedure:

a. Increase SWEEP AMPLITUDE until display indicates maximum swing of common-mode voltage; see Fig. 10.
b. CHECK-input common-mode rejection ratio, ratio of horizontal to vertical (slope), as in the example:

$$\frac{1 \text{ V (horizontal)}}{.1 \text{ mV (vertical)}} = 10{,}000 = 80 \text{ dB}.$$

(typical CMRR for this device is about 85 dB).
c. Switch VERT UNITS/DIV to 1 mV.
d. CHECK-input common-mode range (horizontal voltage swing to knee of curve. Minimum voltage range, V+ minus 1.5 volts.
e. Repeat for amplifier sections 2, 3 and 4.

LM 324 QUAD OP AMP

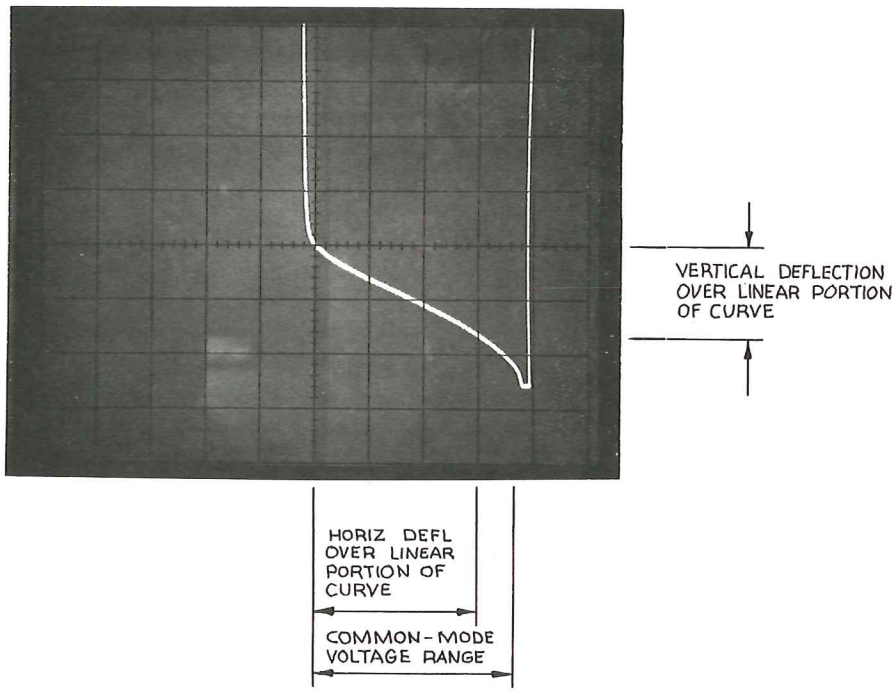

Figure 10. Typical display of common-mode range.

7. Check Large-Signal Voltage Gain

Following is a complete setup. The controls that are changed from the proceeding step are underlined. Reset controls as follows:

577

DISPLAY	STORE
VARIABLE COLLECTOR %	0
COLLECTOR POLARITY	+
MAX PEAK VOLTS	25
MAX PEAK POWER-WATTS	.6
All Dark Gray Knobs and Buttons in except:	
STEP FAMILY SINGLE	press
OFFSET ZERO	out
STEP/OFFSET AMPL	.1 V
OFFSET MULT	10
OFFSET AID	in

LM 324 QUAD OP AMP

PULSED 300 µs	out
DISPLAY FILTER (see note 1)	in (off)
HORIZ VOLTS/DIV	1 V COLLECTOR

178

DUT SUPPLIES	OFF
LOAD RESISTANCE	2K ohm
SOURCE RESISTANCE	50 ohm
+ SUPPLY	5 V
SWEEP AMPLITUDE	≈1/4 turn from full ccw
SWEEP FREQUENCY	.1 Hz
FUNCTION	GAIN
VERT UNITS/DIV	10 µV

Multiple Op Amp Test Unit

Amplifier Section	1

Procedure:

a. Set DUT SUPPLIES switch to ON.
b. Press and hold DISPLAY ZERO while positioning spot to graticule center (horizontallly and vertically). Release DISPLAY ZERO.
c. Increase SWEEP AMPLITUDE until one full sweep is displayed horizontally; see note 1 and Fig. 11. Calculate gain from horizontal voltage change divided by vertical voltage change.

8. Check Power Supply Rejection Ratio

Reset controls as follows:

577

DISPLAY FILTER	in (OFF)

178

SWEEP FREQUENCY	.1 Hz
FUNCTION	+ PSRR
VERT UNITS/DIV	10 µV
SWEEP AMPLITUDE	ccw

[1]After display is stored, set DISPLAY FILTER button out and press ERASE button. If a display without high frequency noise is desired. Store display as the sweep moves from bottom to top (and right to left).

LM 324 QUAD OP AMP

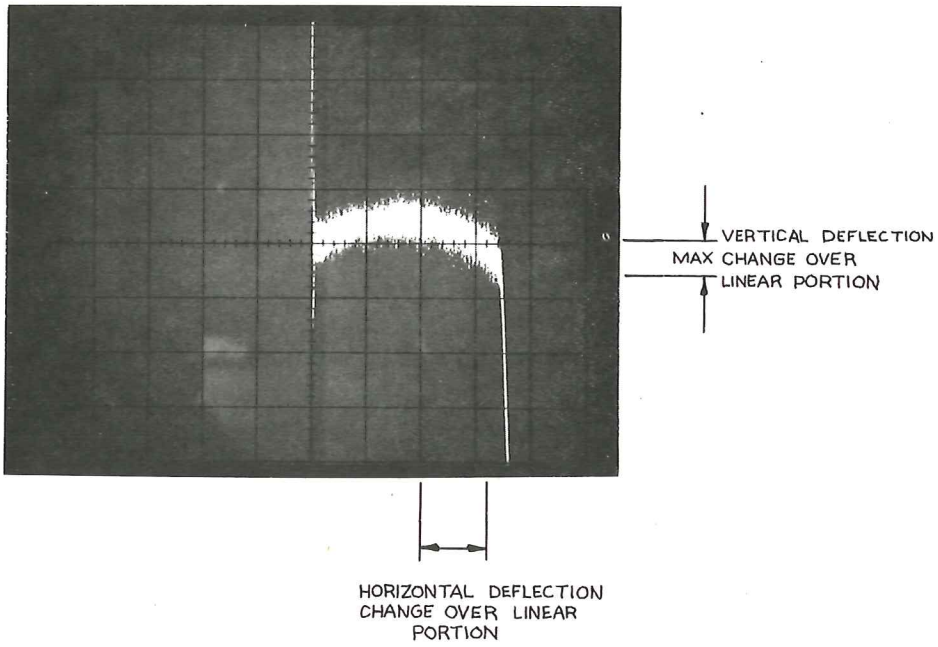

Figure 11. Typical display of large-signal voltage gain.

Procedure:

a. Press ERASE button.
b. Press DISPLAY ZERO.
c. Turn SWEEP AMPLITUDE slowly clockwise until five volts of sweep is displayed horizontally.
d. CHECK-power supply rejection ratio (PSRR); see Fig. 12. PSRR is power supply voltage swing (horizontal) divided by change in input voltage due to power supply variation (vertical).
e. CHECK-Op amp sections 2, 3 and 4.

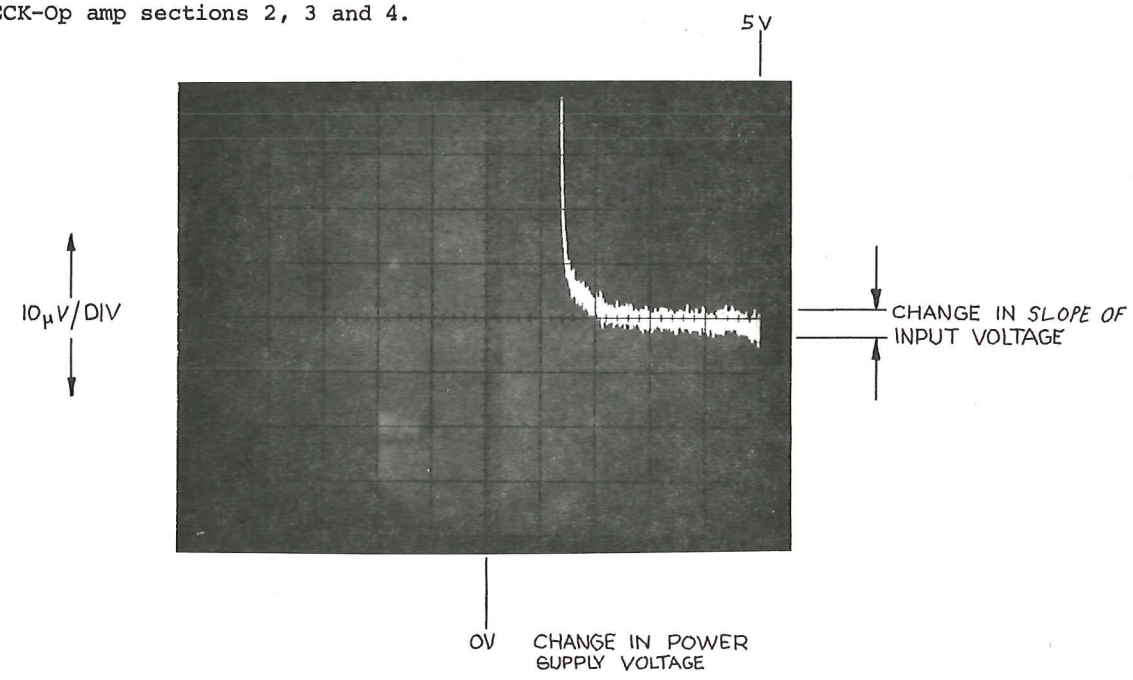

Figure 12. Typical display of power-supply rejection ratio.

LM 324 QUAD OP AMP

9. Check Supply Current (Maximum)

Reset controls as follows:

178

DUT SUPPLIES	OFF
FUNCTION	+ SUPPLY I
VERT UNITS/DIV	.5 mA
SWEEP AMPLITUDE	ccw

Procedure:

a. Turn SWEEP AMPLITUDE to give horizontal sweep between 0 and 5 volts.
b. Set DUT SUPPLIES switch to ON.
c. CHECK-supply current at 5 volts for ≤four vertical divisions; see Fig. 13.

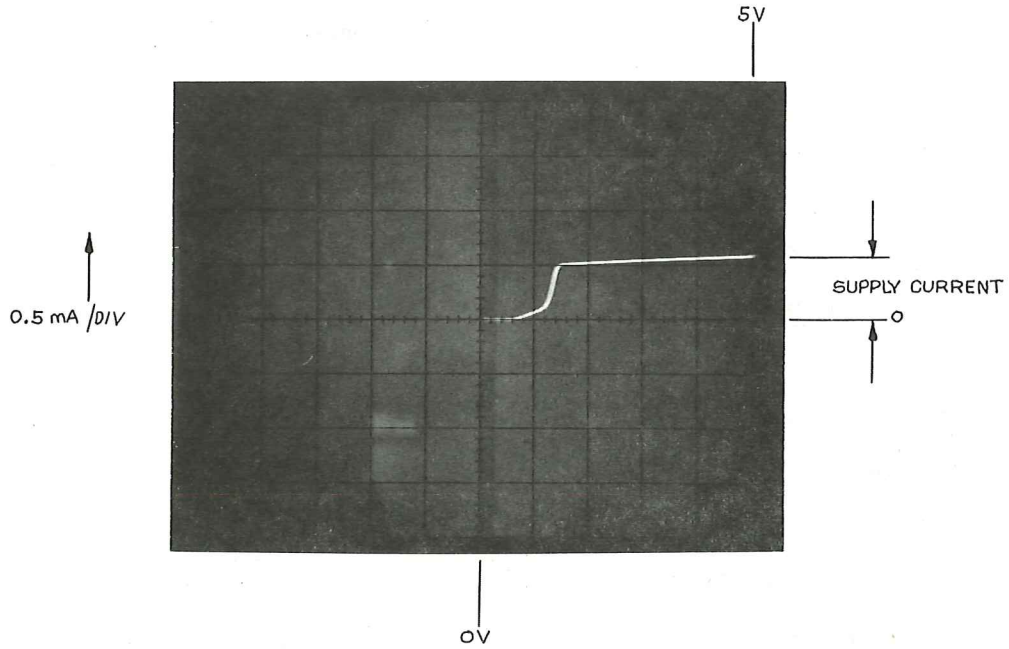

Figure 13. Typical display of supply-current (maximum).

10. Check Output Current Sink

Following is a complete setup. The controls are changed from the proceeding step are underlined. Reset controls as follows:

577

VARIABLE COLLECTOR %	0
COLLECTOR POLARITY	+
MAX PEAK VOLTS	25
MAX PEAK POWER-WATTS	.6

LM 324 QUAD OP AMP

All Dark Gray Buttons and Knobs in except:

STEP FAMILY SINGLE	press
OFFSET ZERO	out
STEP/OFFSET AMPL	.1 V
OFFSET MULT	10
PULSED 300 µs	out
DISPLAY FILTER	in
HORIZ VOLTS/DIV	1 V COLLECTOR
Horizontal POSITION	centered
Vertical POSITION	centered

178

DUT SUPPLIES	OFF
LOAD RESISTANCE	EXT
SOURCE RESISTANCE	EXT
+ SUPPLY	5 V
SWEEP AMPLITUDE	ccw
FUNCTION	COLLECTOR SUPPLY I
VERT UNITS/DIV	10 mA

Multiple Op Amp Test Unit

Op Amp Section	1

Procedure:

a. Place patch cords as shown in Fig. 14.
b. Set DUT SUPPLIES switch to ON.
c. Turn VARIABLE COLLECTOR % clockwise until the display reaches five volts (divisions) horizontally.
d. CHECK-vertical current output (minimum, 10 mA at 5 volts); see FIG. 15.

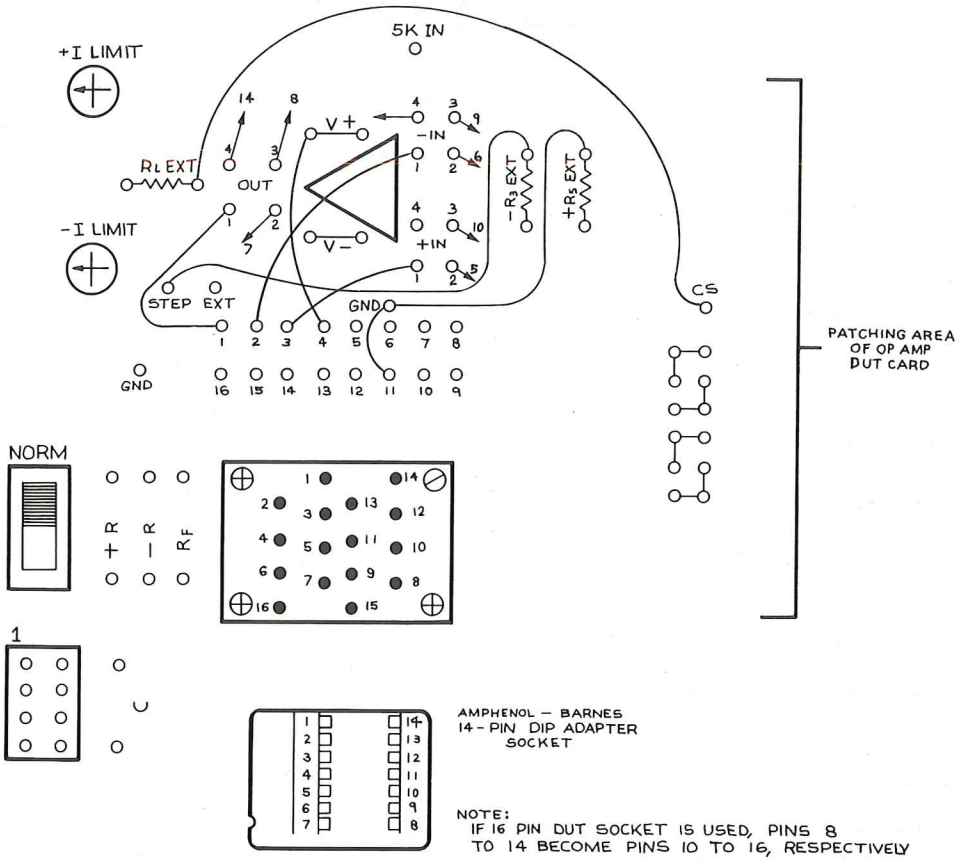

Figure 14. Test setup for measuring output current sink.

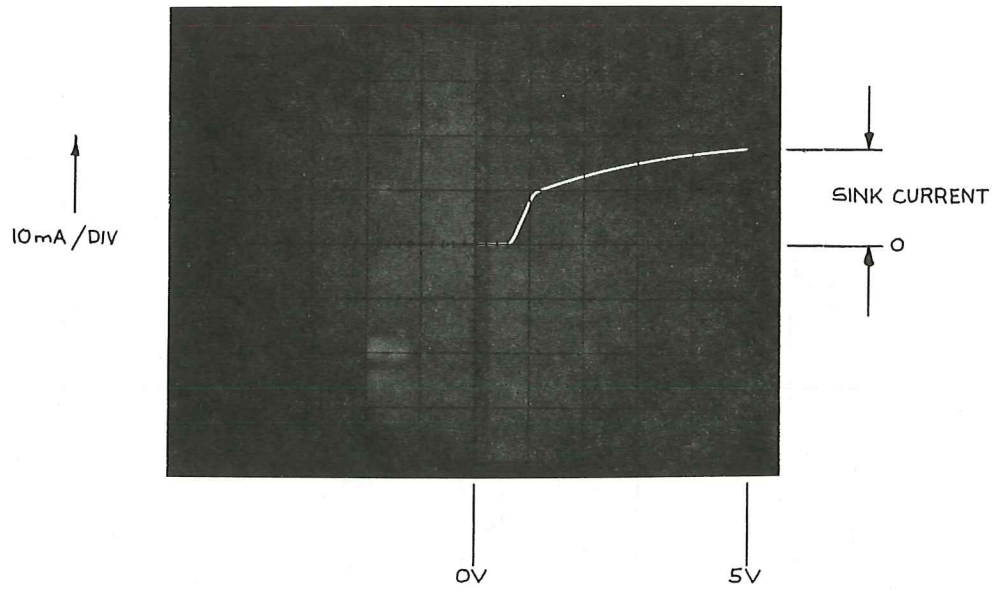

Figure 15. Typical display of minimum sink current.

LM 324 QUAD OP AMP

Check Output Current Source

Reset controls asfollows:

577

COLLECTOR SUPPLY POLARITY	-
VARIABLE COLLECTOR %	0

178

DUT SUPPLIES	OFF
VERT UNITS/DIV	20 mA

Multiple Op Amp Card

Op Amplifier Section	1

Procedure:

a. Remove patch cords from $-R_S$ EXT and $+R_S$ EXT.
b. Connect top of $-R_S$ EXT to GND. Connect top of $+R_S$ EXT to STEP, as shown in Fig. 16.
c. Set DUT SUPPLIES switch to ON.
d. Turn VARIABLE COLLECTOR % clockwise until sweep reaches zero volts.
e. CHECK-output current source on the vertical display; see Fig. 17.

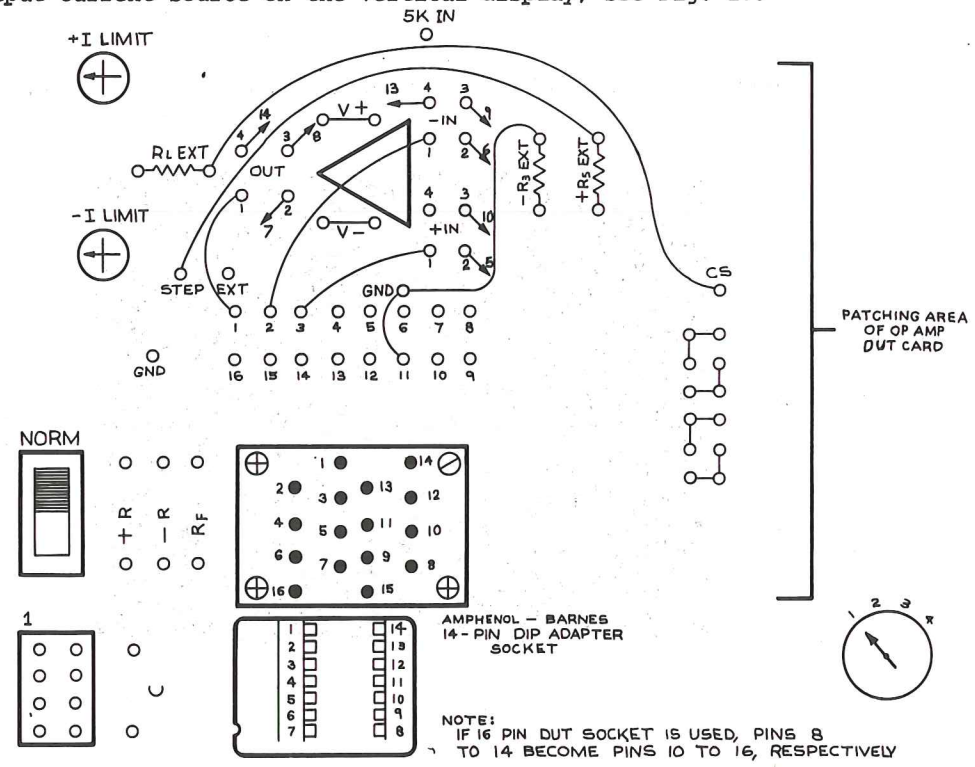

Figure 16. Test setup for measuring current source.

LM 324 QUAD OP AMP

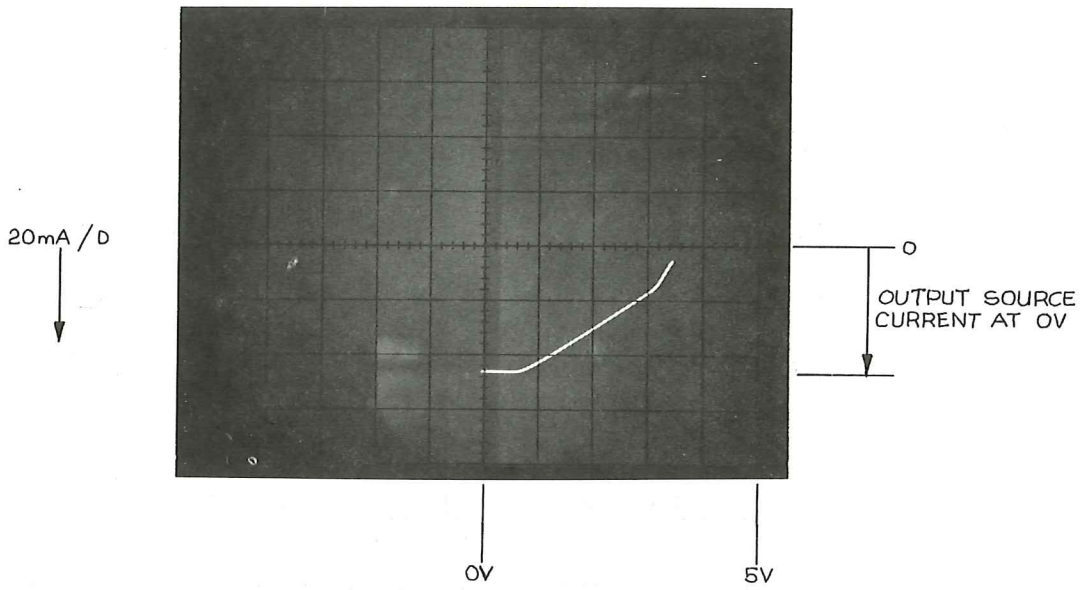

Figure 17. Typical display of output source current.

3900 NORTON AMP

TYPICAL SPECIFICATION FOR NORTON AMPLIFIER

Example: 3900 (See Fig. 18 for package configuration)

General Description

The 3900 consists of four independent, dual-input, internally compensated amplifiers that were designed to operate from a single supply voltage. The amplifier provides a large output voltage swing and makes use of a current mirror to achieve the non-inverting input function.

Electrical Characteristics ($V+ = +15\ V_{DC}$ and $T_A = 25^{\circ}C$)

	Min	Typ	Max	Units
1. Open Loop Voltage Gain f = 100 Hz	1200	2800		V/V
2. Supply Current RL = 50 kΩ		6.2	10	mA_{DC}
3. Power-Supply Rejection f = 100 Hz			70	dB
4. Mirror Gain $+I_{IN}$ = 200 µA	0.9	1	1.1	µA/µA
5. Mirror Current (See Note 1)		10	500	μA_{DC}

Note 1. Input V_{BE} match between non-inverting and inverting inputs occurs for a mirror-current (non-inverting input) of approximately 10 µA. This is, therefore, a typical design center for many circuits.

TESTING THE 3900 NORTON AMPLIFIER

(See Fig. 19 for a diagram of the circuit test setup and Fig. 20 for connections to Multiple Op Amp Card)

The circuitry between the V- supply and the ground terminal of the DUT is used to hold the V- terminal at one diode drop below ground to permit the inputs to be at real ground level. The divider gives high resolution to the V- supply. The HA-911 is used for stability, in the follower mode. The non-inverting input of the DUT is fed by the STEP GEN to force the mirror current desired.

The 200K ohm resistor between -30 volts and 5K IN is used to set the device output at +7.5 volts in quiescent condition.

The V+ supply must be set to 14.3 V instead of 15 V to adjust for the -0.7 V at the ground terminal; however, this voltage is not critical.

3900 NORTON AMP

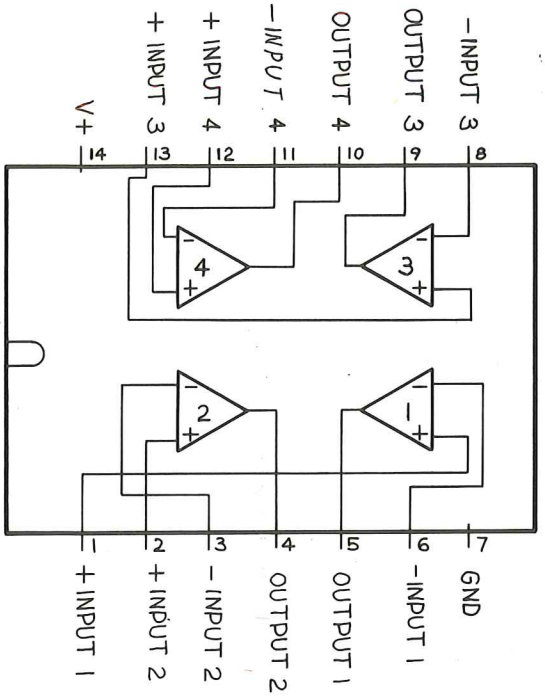

Figure 18. 3900 quad amplifier (Norton)

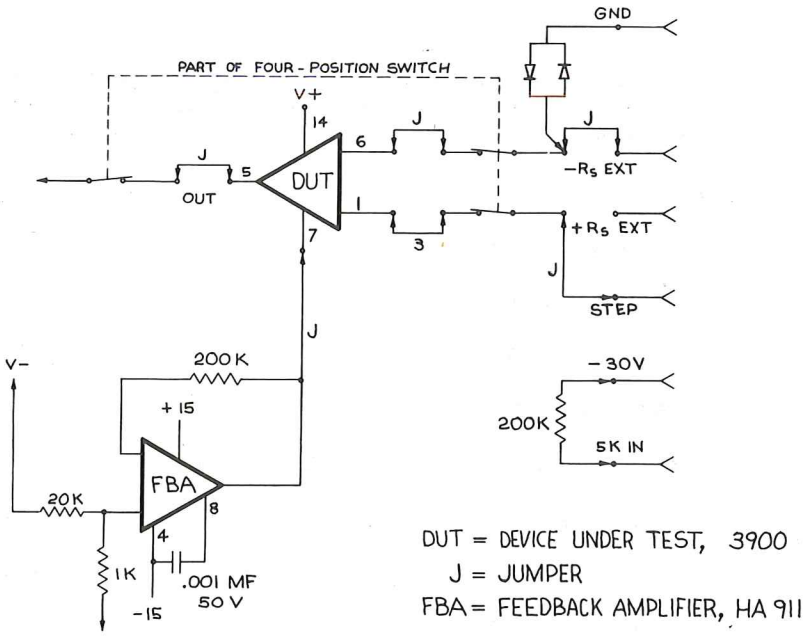

Figure 19. Diagram of circuit setup shown in Figure 19.

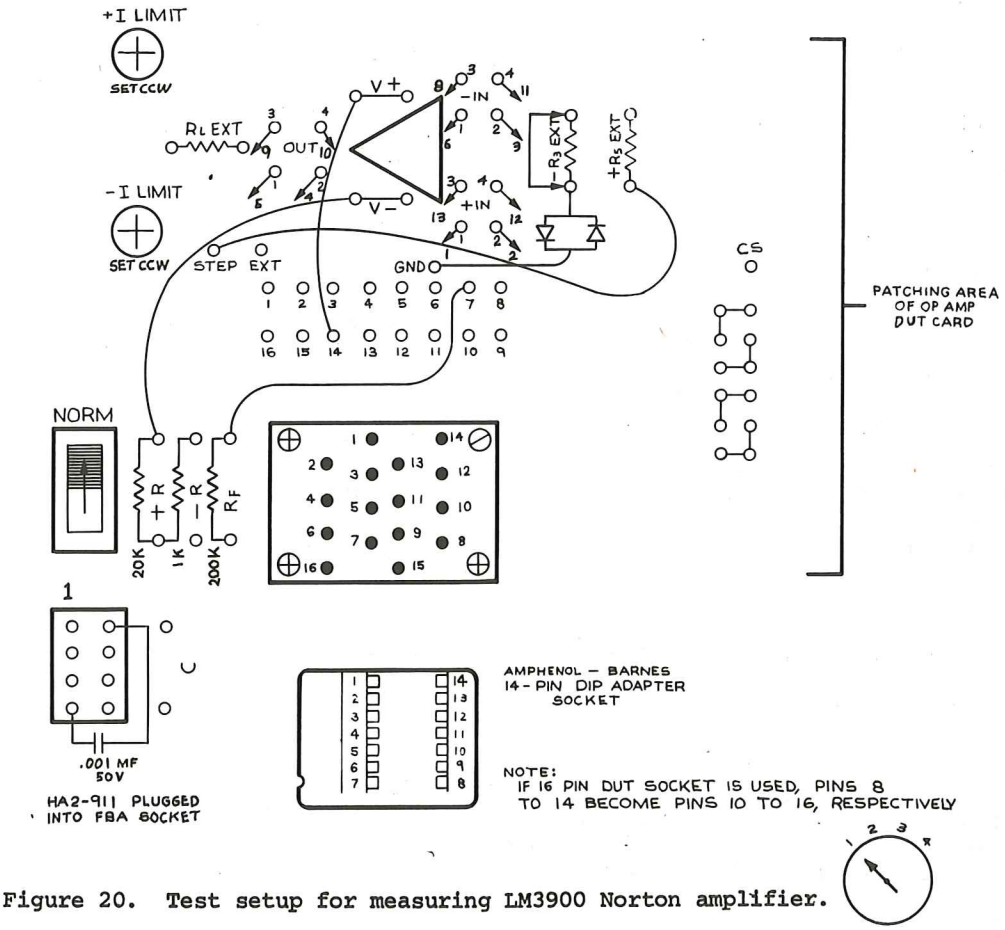

Figure 20. Test setup for measuring LM3900 Norton amplifier.

3900 NORTON AMP

The diodes at the inverting input are to protect the device during the mirror current test if the 178 sweep amplitude should not be at zero.

To measure GAIN, +PSRR, and $+I_C$ set controls as follows:

577

COLLECTOR SUPPLY POLARITY	+DC
VARIABLE COLLECTOR %	ccw
MAX PEAK VOLTS	25
MAX PEAK POWER-WATTS	.6 or lower
All Dark Gray Buttons and Knobs in except:	
STEP X.1	out
STEP FAMILY SINGLE	press
OFFSET ZERO	in
STEP/OFFSET AMPL	5 uA
OFFSET AID	in
PULSED 300 uA	out
HORIZ VOLTS/DIV	5 V, COLLECTOR

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+SUPPLY	14.3
-SUPPLY	out of detent, ccw
VERT UNITS/DIV	5 mV
LOAD RESISTANCE	50K ohm
SOURCE RESISTANCE	50 ohm
SWEEP FREQUENCY	100 Hz
SWEEP AMPLITUDE	½ turn from full ccw

Multiple Op Amp Card

Section	1
External Feedback Amplifier Switch	NORM

1. Check Gain in OFFSET V

   a. Set FUNCTION switch to OFFSET V.
   b. Turn V- until gain curve is displayed; see Fig. 21
   c. CHECK-gain from display. Gain equals change in output voltage (horizontal) divided by change in input voltage (vertical).
   d. CHECK-Op Amp section 2, 3, and 4.

3900 NORTON AMP

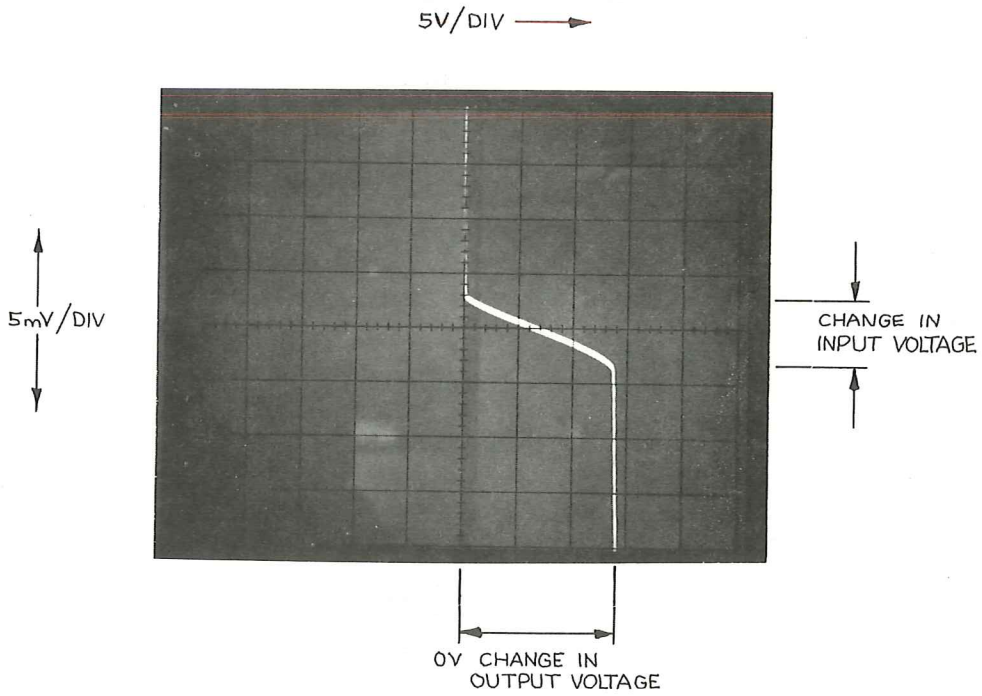

Figure 21. Typical display of gain characteristics.

2. Check +PSRR

   a. Set FUNCTION switch to +PSRR.
   b. CHECK-power supply rejection ratio. PSRR equals change in +supply voltage (horizontal) divided by change in input voltage (vertical) caused by supply voltage change.

3. Check Positive Supply Current

   a. Set FUNCTION to + SUPPLY I.
   b. CHECK-positive supply current change as a function of +supply voltage change.

4. Check Mirror Current

   Reset controls as follows:
   Following is a complete setup. The controls that are changed from the proceeding steps are underlined.

   577

STORE	in
VARIABLE COLLECTOR %	0
COLLECTOR SUPPLY POLARITY	+DC
MAX PEAK VOLTS	25
MAX PEAK POWER-WATTS	.6

   All Dark Gray Button and Knobs in except:

STEP FAMILY SINGLE	press

3900 NORTON AMP

OFFSET ZERO	in
PULSED 300 µs	out
HORIZ VOLTS/DIV	50 mV, COLLECTOR

178

DUT SUPPLIES	OFF
LOAD RESISTANCE	50k ohm
SOURCE RESISTANCE	50 ohm
+SUPPLY	14.3
SWEEP AMPLITUDE	ccw
SWEEP FREQUENCY	.1 Hz
FUNCTION	+ INPUT I
VERT UNITS/DIV	10 µA

Multiple Op Amp Card

SECTION	1
External Feedback Amplifier switch	NORM

Procedure:

a. Switch DUT SUPPLIES to ON.
b. Press and hold DISPLAY ZERO while positioning spot horizontally and vertically to graticule center.
c. Press ERAXE button.
d. Adjust -SUPPLY for a 2 µA to 40 µA (o.2 division to four division, 0.5 divisions recommended) vertical display.
e. Turn SWEEP AMPLITUDE slowly clockwise to approximately 1/8 turn or less and not more than one-fourth turn clockwise from detent, see note) until effect of sweep is seen on display.

NOTE

If for any reason the SWEEP AMPLITUDE control must be turned mored than one-fourth turn clockwise from detent, place 500 ohm resistors in $-R_S$ EXT and $+R_S$ EXT and switch SOURCE RESISTANCE to EXT to stay within input current specifications.

f. Store display, then turn INTENSITY control counterclockwise (decrease intensity).
g. Set FUNCTION switch to -INPUT I.
h. Increase Intensity to store _Input I curve.

NOTE

The point at which -Input I and +Input I cross is the mirror current Input V_{BE} match (see note in mirror current specification). See Fig. 22 for typical display.

i. CHECK-mirror current at Input V_{BE} match (crossover point in Fig. 22).

3900 NORTON AP AMP

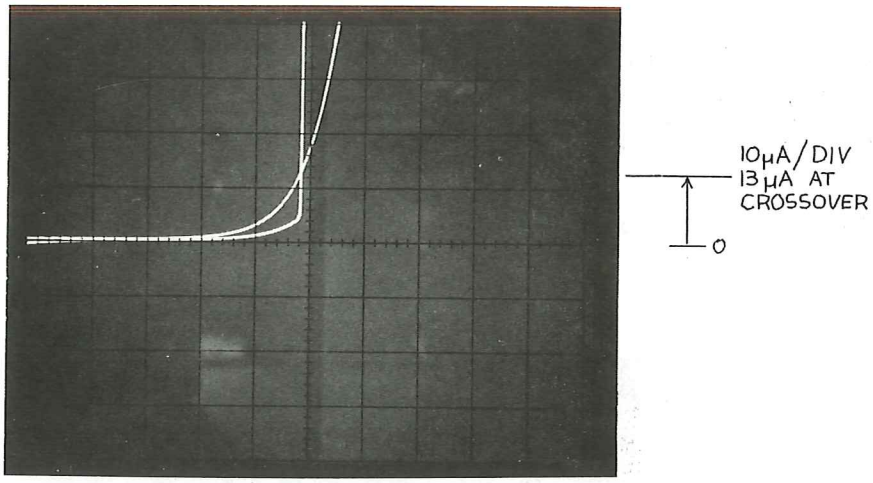

Figure 22. Typical display on Norton amplifier mirror current.

5. Check Mirror Gain

Change control as follows:

577

HORIZ VOLTS/DIV	STEP GEN
STEP X.1	out
STEP/OFFSET AMPL	5 μA/STEP with STEP X.1 out
STEP/OFFSET ZERO	in
STEP FAMILY	REP
STEP RATE	NORM
NUMBER OF STEPS	cw

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FUNCTION	-INPUT I
VERT UNITS/DIV	100 μA (may need more vertical sensitivity for better resolution)
SWEEP AMPLITUDE	0
SWEEP FREQUENCY	100 Hz
SOURCE RESISTANCE	EXT

3900 NORTON AMP

Procedure:

a. Adjust V- clockwise to put display offscreeen. Then turn V- counterclockwise until display start is at zero; see Fig. 23. V- must not be less than one-fourth turn clockwise from detent.
b. Erase display and re-store display and measure gain. Gain is change in horizontal deflection divided by change in vertical deflection at 200 µA (40 steps at 5 µA/Step). See Fig. 23.
c. Calculate mirror gain from display in Fig. 23.

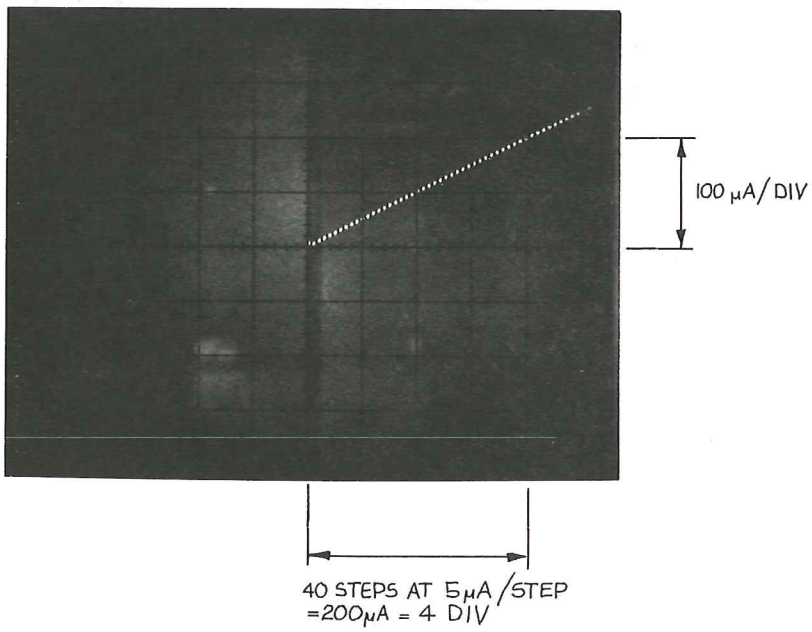
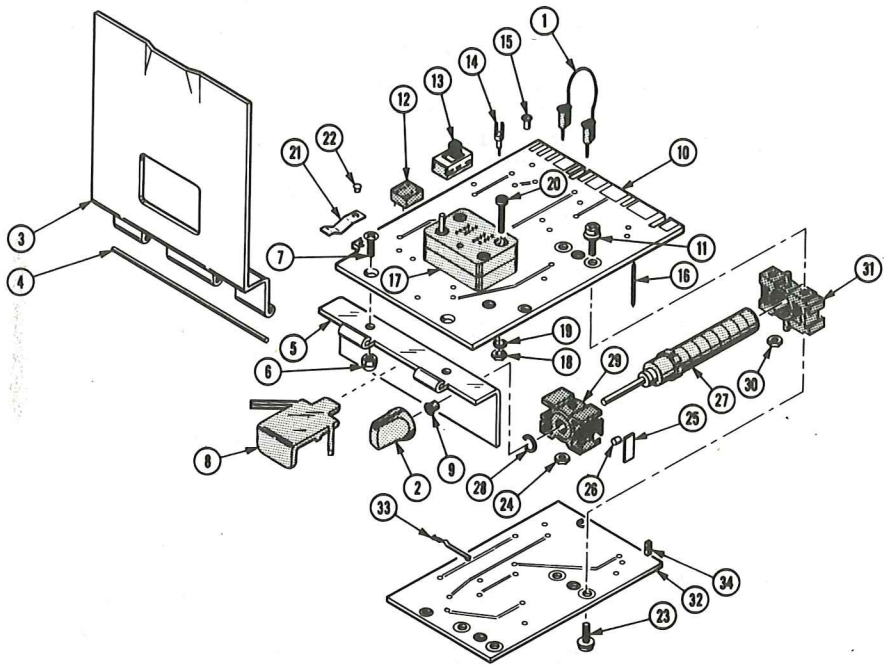


Figure 23. Typical display of mirror gain.

EXPLODED VIEW



REPLACEABLE PARTS LIST

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
1-1	012-0200-00			1	LEAD,TEST:	80009	012-0200-00
	012-0310-00			1	CABLE ASSY:	80009	012-0310-00
	672-0500-00			1	CKT BOARD ASSY:OPERATIONAL AMPLIFIER		
-2	366-0379-01			1	. KNOB:	80009	366-0379-01
	213-0153-00			1	. . SETSCREW:	56878	OBD
-3	200-1513-01			1	. COVER,CKT BOARD:DUT	80009	200-1513-01
					(ATTACHING PARTS)		
-4	214-1901-00			1	. PIN,HINGE:	80009	214-1901-00
					- - - * - - -		
-5	214-2229-00			1	. HINGE:CIRCUIT BOARD COVER	80009	214-2229-00
					(ATTACHING PARTS)		
-6	220-0601-00			2	. NUT,PLAIN,CAP:	27827	3261-0718
-7	211-0101-00			2	. SCREW,MACHINE:4-40 X 0.25" 100 DEG,FLH STL	83385	OBD

REPLACEABLE PARTS LIST

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
-8	367-0185-00			1	. PULL,CKT CARD:	80009	367-0185-00
-9	348-0031-00			1	. GROMMET,PLASTIC:0.156 INCH DIA	80009	348-0031-00
-10	----- -----			1	. CKT CARD ASSY:MULTIPLE OP AMP		
					(ATTACHING PARTS)		
-11	211-0116-00			2	. SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
-12	136-0514-00			1	. . SOCKET,PLUG-IN:MICROCIRCUIT,8 CONTACT	82647	C930802
-13	260-1641-00			1	. . SWITCH,SLIDE:DPDT,0.5A,125VAC	10389	23-021-114
-14	131-1497-00			12	. . CONTACT,ELEC:0.04 DIA PIN 1 END	88245	15409
-15	136-0388-00			64	. . SOCKET,PIN TERM:	71279	3704-1-03
-16	131-0590-00			16	. . CONTACT,ELEC:0.71 INCH LONG	22526	47351
-17	131-1373-00			1	. . CON,RCPT,ELEC:	29587	699-70021-161
					(ATTACHING PARTS)		
-18	210-0406-00			2	. . NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
-19	210-0054-00			2	. . WASHER,LOCK:SPLIT,0.118 ID X 0.212"OD STL	83385	OBD
-20	211-0126-00			2	. . SCREW,MACHINE:4-40 X 0.625,FILH STL	70318	OBD
					- - - * - - -		
-21	214-1974-00			1	. . SPRING,GROUND:	80009	214-1974-00
					(ATTACHING PARTS)		
-22	210-0702-00			1	. . EYELET,METALLIC:0.047 OD X 0.125 INCH LONG	07707	S6127
					- - - * - - -		
	263-1119-00			1	. ACTR ASSY,CAM S:OPERATIONAL AMPLIFIER	80009	263-1119-00
					(ATTACHING PARTS)		
-23	211-0116-00			4	. SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
					- - - * - - -		
-24	210-0406-00			2	. . NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
-25	214-1704-00			1	. . SPRING,FLAT:CAM SW DETENT,0.006 INCH THK	80009	214-1704-00
	214-1704-01			1	. . SPRING,FLAT:CAM SW DETENT,0.008 INCH THK	80009	214-1704-01
-26	214-1127-00			2	. . ROLLER,DETENT:0.125 DIA X 0.125 INCH L	80009	214-1127-00
-27	105-0662-00			1	. . ACTUATOR,CAM S:OPERATIONAL AMPLIFIER	80009	015-0662-00
					(ATTACHING PARTS)		
-28	354-0219-00			1	. . RING,RETAINING:FOR 0.25 INCH SHAFT	79136	5103-25-MD-R
					- - - * - - -		
-29	401-0155-00			1	. . BEARING,CAM SW:	80009	401-0155-00
-30	210-0406-00			4	. . NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
-31	401-0051-01			1	. . BEARING,CAM SW:	80009	401-0051-01
-32	----- -----			1	. CKT CARD ASSY:MULTIPLE OP AMP D.U.T.		
-33	131-0604-00			12	. . CONTACT,ELEC:0.025 SQ X 0.365 INCH LONG	80009	131-0604-00
-34	136-0263-04			16	. . CONTACT,ELEC:FOR 0.025 INCH SQUARE PIN	22526	75377-001

CROSS INDEX MFR. CODE NUMBER TO MANUFACTURER

MFR.CODE	MANUFACTURER	ADDRESS	CITY,STATE,ZIP
07707	USM Corp., USM Fastener Div.	510 River Rd.	Shelton, CT 06484
10389	Chicago Switch, Inc.	2035 Wabansia Ave.	Chicago, IL 60647
22526	Berg Electronics, Inc.	Youk Expressway	New Cumberland, PA 17070
27827	Fischer Mfg. Co.	5332 Santa Fe Ave.	Los Angeles, CA 90058
29587	Bunker-Ramo Corp., The, Amphenol Industrial Div.	1830 S. 54th Ave.	Chicago, IL 60650
56878	Standard Pressed Steel Co.	Box 608 Benson East	Jenkintown, PA 19046
70318	Allmetal Screw Products Co., Inc.	821 Stewart Ave.	Garden City, NY 11530
71279	Cambridge Thermionic Corp.	445 Concord Ave.	Cambridge, MA 02138
73743	Fischer Special Mfg. Co.	446 Morgan St.	Cincinnati, OH 45206
79136	Waldes, Kohinoor, Inc.	47-16 Austel Place	Long Island City, NY 11101
80009	Tektronix, Inc.	P. O. Box 500	Beaverton, OR 97077
82647	Texas Instruments, Inc., Control Products Div.	34 Forest St.	Attleboro, MA 02703
83385	Central Screw Co.	2530 Crescent Dr.	Broadview, IL 60153
88245	Litton Systems, Inc., USECO Div.	13536 Saticoy St.	Van Nuys, CA 91409

SCHEMATIC