Section

Operating Instruction:

2-1. INTRODUCTION

2-2. To use your Fluke multimeter fully, there are some additional factors to be considered, such as measurement techniques, the maximum signal input levels that will not damage your instrument, and common applications. Section 2 presents this information. For example, a simple circuit plugged into the front panel will provide direct reading dc-current gain (Beta) measurements for both NPN and PNP transistors, and the dB function can be used to measure the relative Q of two devices.

2-3. OPERATING NOTES

2-4. The operating notes present the capabilities and limitations of your 8050A and routine operator maintenance instructions. Everyone using an 8050A should be familiar with the operating notes.

2-5. Input Overload Protection

CAUTION

Exceeding the maximum input overload limits can damage your instrument. The transient overload protection circuit is intended to protect against short duration high energy pulses. The components used limit the protection to approximately five pulses per second for 6 kV 10 microsecond pulses, and about 0.6 watts average for lower amplitude pulses. Fast repetition rate pulses as from a TV set can damage the protection components; RV1 - RV3, R1 and R2*. If replaced, use only Fluke replacement parts to maintain product safety.

* R2 is a fusible resistor. Use exact replacement to insure safety.

2-6. Each measurement function is equipped with inpı overload protection. Table 2-1 lists the overload limi for each function.

2-7. Input Connections to Common

WARNING

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, DO NOT CONNECT THE COMMON INPUT TERMINAL TO ANY SOURCE OF MORE THAN 500 VOLTS DC OR PEAK AC ABOVE EARTH GROUND.

2-8. Your 8050A may be operated with the commo input terminal at a potential of up to 500V dc or ac pea with respect to earth ground. If this limit is exceede instrument damage or an operator safety hazard ma occur.

2-9. Operating Power

2-10. The Model 8050A is available in standard ve sions that use 100V, 120V, or 220/240V ac at 47 to 44 Hz. The optional battery version of the 8050A (-0 Option) can operate on internal rechargeable batteries line power. See Section 4 of this manual for input pow selection procedure. The voltage set at the factory will b marked on the decal on the bottom of your 8050A. Se Section 6 of this manual for more information about th battery version of the 8050A.

2-11. Extending the Life of the LCD

2-12. The liquid crystal display used in your instrume is rugged and reliable. With proper care, it will give yo years of satisfactory service. The chemicals that make th advanced type of display possible require certain consi erations. To extend the life of the display and to mak

Table 2-1. Maximum Input Signal Limits

FUNCTION SELECTED		RANGE SELECTED	INPUT TERMINALS	MAXIMUM INPUT OVERLOAD
V dB	DC	ALL RANGES	V/kΩ/S and COMMON	1000V dc or peak ac
	AC	20V, 200V, 750V		750V rms continuous
		2V, 200 mV		750V rms for no longer than 15 seconds.
mA	DC or AC	ALL RANGES	mA and COMMON	Double fuse protected: 2A, 250V fuse in series with a 3A, 600V fuse
kΩ or S		ALL RANGES	V/kΩ/S and COMMON	500V dc or ac rms

ure that the display will be ready to operate at a moment's notice, observe the following practices:

1. Keep the instrument out of high temperature and high humidity environments such as the dash-board of a car on a hot, sunny day.

2. Keep the instrument out of low temperature environments. Operation or storage at tempera-tures below -15°C (5°F) may result in the display being sluggish until the instrument is returned to normal operating temperature.

2-13. MEASUREMENT TECHNIQUES

2-14. The information in this portion of Section 2 offers you techniques in measurement and interpretation of measurements that may extend the usefulness of your 8050A. These techniques — common throughout the electronics industry — have been tailored specifically for your 8050A. Except for some common ac considerations, the techniques have been separated by instrument func-tion. The ac considerations are presented last.

2-15. Voltage Measurement Techniques

2-16. In Section 1 we discussed the operation of the controls and terminals used to make voltage measure-ments (V or dB). To use your 8050A effectively, there are other factors of which you should be aware.

2-17. dB TECHNIQUES

2-18. This discussion assumes that you have a general knowledge of dB and dBm for both voltage and power.

2-19. dB Landmarks

2-20. While your 8050A makes it easy for you to deter-mine the gain or loss of a circuit or a system and provides you with a convenient way to convert from dB to volts (simply select the V function and read the display), the mental picture of what is happening with these logarith-mic measurements may still be unclear. Table 2-2 pro-vides you with convenient dB landmarks to help you approximate a change in dB to a change in voltage. Just locate the dB change in voltage (in the appropriate column) and multiply the original signal by the corres-ponding multiplication factor to get the output signal level. These figures are not exact, but are close enough for most quick mental calculations.

2-21. Referencing dBm to Any Impedance

2-22. The REF Z switch on your 8050A allows you to automatically select 1-of-16 common circuit impedances to use as a reference impedance when making dBm meas-urements. Not all circuits have an impedance equal to one of these selectable reference impedances. Use the follow-ing procedure to reference dBm measurement to any impedance:

1. Do you have a voltage standard?

   YES: Proceed to Step 2

   NO: Proceed to Step 8

2. Convert the circuit impedance into a reference level using the following formula:

$$\text{Reference Voltage} = \sqrt{0.001 \text{ X (circuit impedance)}}$$

Table 2-2. dB Landmarks

CHANGE IN dB	MULTIPLICATION FACTOR TO GET OUTPUT RELATIVE TO INPUT
+20 dB	10
+10	3.2
+6	2
+3	1.4
+2	1.3
+1	1.1
0	1.0
-1	0.9
-2	0.8
-3	0.7
-6	0.5
-10	0.32
-20	0.1

3. Connect your 8050A to the voltage standard: HI to the V/kΩ/S terminal and LO to COMMON.

4. Select the V function and the appropriate range on your 8050A. Make sure that the RELATIVE switch is at the OFF position.

5. Program the voltage standard for an output that causes your 8050A to display the reference voltage calculated in Step 2.

6. Set the RELATIVE switch to the ON position. In the dB function all 8050A measurements will now be in dBm referenced to the circuit impedance.

7. Go to the following paragraph: (dBV)

8. Select the REF Z closest to the impedance of your circuit, make your measurements and add the correction factor below to the measured value.

Correction Factor (in dB) =

$$10 \log \frac{\text{circuit impedance}}{\text{REF Z}}$$

2-23. dBV Measurements

2-24. dBV measurements are especially useful since they are voltage relationships that are independent of impedance, dBV is referenced to 1V. At a reference impedance of 1000Ω, 1V dissipates 1 mW so 0 dBV = 0 dBm when the REF Z = 1000Ω.

2-25. CONVERTING VOLTAGE MEASUREMENTS

2-26. Your instrument is one of the new family of Fluke meters that actually measure the true rms value of an ac signal. This is a feature that allows accurate measurement of common waveforms like distorted or mixed frequency sine waves, square waves, sawtooths, noise, pulse trains (with a duty cycle of at least 10%), etc. In the past, the methods of ac measurement used have introduced large errors in the readings. Unfortunately, we've all grown used to these erroneous voltage readings and depend upon them to indicate whether or not a piece of equipment is working correctly. The data contained in Figure 2-1 should help you to convert between measurement methods.

2-27. RELATIVE (AUTOMATIC OFFSET COMPENSATION)

NOTE

While in the relative mode of operation, the A/D and/or the display limitations may result in an overload indication. For example, with -1.5 volts displayed on the 2V range, if RELATIVE is pushed, the highest voltage that can be measured without overloading the display is +0.5V; 0.5-(-1.5)=2V = the full scale display reading. Any voltage more negative than -2V would overload the A/D while the display would stop at -0.5: -2-(-1.5)= -0.5V.

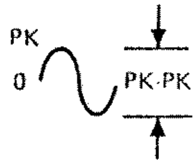
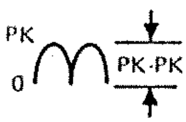
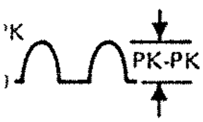
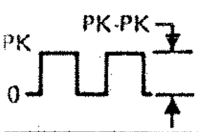
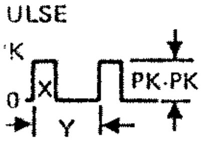
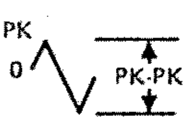
2-28. Usually, when there is an offset voltage, you must subtract (or add) the offset to your meter reading. With your 8050A, measure the offset voltage and set the RELATIVE switch to the ON position. Your 8050A will automatically remove the offset from subsequent measurements.

2-29. CIRCUIT LOADING ERROR

2-30. Connecting most voltmeters to a circuit may change the operating voltage of the circuit if it loads the circuit down. As long as the circuit resistance (source impedance) is small compared to the input impedance of the meter, the error is not significant. For example, when measuring voltage with your meter, as long as the source impedance is 1 kΩ or less, the error will be ≤.01%. If circuit loading does present a problem, the percentage of error can be calculated using the appropriate formula in Figure 2-2.

2-31. COMBINED AC AND DC SIGNAL MEASUREMENTS

2-32. The waveform shown in Figure 2-3 is a simple example of an ac signal riding on a dc level. To measure

AC-COUPLED INPUT WAVEFORM	PEAK VOLTAGES		METERED VOLTAGES			DC AND AC TOTAL RMS
			AC COMPONENT ONLY		DC COMPONENT ONLY	
	PK-PK	0-PK	RMS CAL*	8050A		TRUE RMS = $\sqrt{ac^2 + dc^2}$
INE 	2.828	1.414	1.000	1.000	0.000	1.000
ECTIFIED SINE FULL WAVE) 	1.414	1.414	0.421	0.435	0.900	1.000
ECTIFIED SINE HALF WAVE) 	2.000	2.000	0.764	0.771	0.636	1.000
QUARE 	2.000	1.000	1.110	1.000	0.000	1.000
ECTIFIED QUARE 	1.414	1.414	0.785	0.707	0.707	1.000
ECTANGULAR ULSE  D = X/Y K = $\sqrt{D - D^2}$	2.000	2.000	2.22K	2K	2D	$2\sqrt{D}$
RIANGLE AWTOOTH 	3.464	1.732	0.960	1.000	0.000	1.000

* RMS CAL IS THE DISPLAYED VALUE FOR AVERAGE RESPONDING METERS THAT ARE CALIBRATED TO DISPLAY RMS FOR SINE WAVES

Figure 2-1. Voltage Conversion

1. DC VOLTAGE MEASUREMENTS

Loading Error in % = 100 x Rs ÷ (Rs + 10^7)

Where: Rs = Source resistance in ohms of circuit being measured.

2. AC VOLTAGE MEASUREMENTS

First, determine input impedance, as follows:*

$$Zin = \frac{10^7}{\sqrt{1 + (2 \pi F \cdot Rin \cdot C)^2}}$$

Where: Zin = effective input impedance
Rin = 10^7 ohms
Cin = 100 x 10^{-12} Farads
F = frequency in Hz

Then, determine source loading error as follows:*

$$\text{Loading Error in \%} = 100 \times \frac{Zs}{Zs + Zin}$$

Where: Zs = source impedance
Zin = input impedance (calculated)

*Vector algebra required

Figure 2-2. Circuit Loading Error Calculations

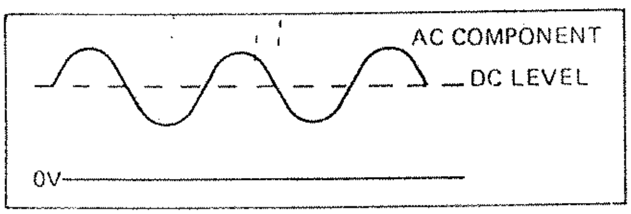


Figure 2-3. RMS Values

waveforms such as these, first measure the rms value of the ac component using the ac function of your meter. Measure the dc component using the dc function of your instrument. The relationship between the total rms value of the waveform and the ac component and the dc component is:

$$\text{RMS Total} = \sqrt{(\text{ac component rms})^2 + (\text{dc component})^2}$$

2-33. INSIGNIFICANCE OF INHERENT METER OFFSET

2-34. If you short the input of your meter while the ac voltage function is selected, you may have a reading of typically 10 to 20 digits on the display. This small offset is caused by the action of amplifier noise and offset of the true rms converter. This offset will not significantly affect any readings until you try to measure signals almost at the floor of the meter. For example:

GIVEN: An offset of 40 digits (.40 mV, 200 mV range).
Input signal = 10 mV, 200 mV range

$$\text{Total rms} = \sqrt{10^2 + 0.4^2} = \sqrt{100 + .16} = \sqrt{100.16} = 10.01 \text{ mV}$$

or using a realistic offset for your instrument,

GIVEN: A typical offset of 20 digits (.20 mV, 200 mV range).
Input signal = 10 mV, 200 mV range

$$\text{Total rms} = \sqrt{10^2 + 0.2^2} = \sqrt{100 + .04} = \sqrt{100.04} = 10.00$$

the meter will read this as 10.00 mV.

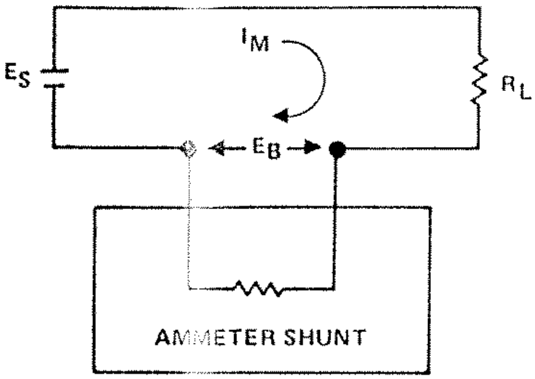
2-35. Current Measurement Techniques

WARNING

INSTRUMENT DAMAGE AND OPERATOR INJURY MAY RESULT IF THE FUSE BLOWS WHILE CURRENT IS BEING MEASURED IN A CIRCUIT WHICH EXHIBITS AN OPEN CIRCUIT VOLTAGE GREATER THAN 600 VOLTS.

2-36. BURDEN VOLTAGE ERROR

2-37. When a meter is placed in series with a circuit to measure current, you may have to consider an error caused by the voltage drop across the meter (in this case, across the protective fuses and current shunts). This voltage drop is called burden voltage. The maximum full-scale burden voltages for your instrument are: 0.3V for the four lowest ranges, and 0.9V for the 2000 mA range. These voltage drops can affect the accuracy of a current measurement if the current source is unregulated and the resistance of the shunt and fuse represents a significant part (1/1000 or more) of the source resistance. If burden voltage does present a problem, the percentage error can be calculated using the formula in Figure 2-4. This error can be minimized by selecting the highest current range that provides the necessary resolution.



E_S = Source voltage

R_L = Load resistance + Source resistance

I_M = Measured current (display reading in amps)

E_B = Burden voltage (calculated), i.e.,

Display reading expressed as a % of full scale (100 x $\frac{\text{READING}}{\text{FULL SCALE}}$ times full scale burden voltage for selected range. See table.

RANGE	F.S. BURDEN VOLTAGE
200 µA to 200 mA	0.3V max.
2000 mA	0.9V max

Maximum current error due to Burden Voltage

IN % $= 100 \times \frac{E_B}{E_S - E_B}$

IN MILLIAMPS $= \frac{E_B \times I_M}{E_S - E_B}$

Examples: $E_S = 14V$, $R_L = 9\Omega$, $I_M = 1497.0$ mA,

$E_B = 100 \times \frac{1497.0}{2000.0} \times 0.9$ (from Table) =

74.9% of 0.9 = 0.674V

Maximum error in % $= 100 \frac{.674}{14-.674} = 100 \frac{.674}{13.326} = 5.06\%$

Increase displayed current by 5.06% to obtain true current.

Maximum error in milliamps $= \frac{.674 \times 1497.0}{14-.674} = \frac{1009.0}{13.326} = 75.7$ mA

Increase displayed current by 75.7 mA to obtain true current.

Figure 2-4. Calculating Burden Voltage Error

2-38. RELATIVE (AUTOMATIC OFFSET COMPENSATION)

NOTE

While in the relative mode of operation, the A/D and/or the display limitations may result in an overload indication. For example, with -1.5 mA displayed on the 2 mA range, if RELATIVE is pushed, the highest current that can be measured without overloading the display is +0.5 mA: 0.5-(-1.5)=2 mA = the full scale display reading. Any current more negative than -2 mA would overload the A/D while the display would stop at -0.5: -2-(-1.5)= -0.5 mA.

2-39. Usually when working with an offset, you have to add or subtract the offset to your meter reading. With your 8050A, however, measure the offset, set the RELATIVE switch to the ON position and the 8050A will automatically remove the offset from subsequent measurements.

2-40. Resistance Measurement Techniques

2-41. AUTOMATIC TEST LEAD COMPENSATION

2-42. When measuring low resistances, test lead resistance interferes with low resistance readings and usually has to be subtracted from resistance measurements for accuracy. With your 8050A, however, just select the resistance range desired, short the tips of the test leads together and set the RELATIVE switch to the ON position. The test lead resistance will automatically be subtracted from subsequent measurements by your 8050A.

2-43. RESISTANCE COMPARISON

2-44. When one resistance is needed for many measurements (such as when sorting resistors to find a matched set) simply connect the desired resistance to your 8050A and set the RELATIVE switch to the ON position. The display will go to zero. Subsequent measurements will display the difference between the resistance being measured and the desired resistance.

2-45. DIODE TEST

2-46. The three resistance ranges with a diode symbol beside the range value have a high enough measurement voltage to turn on a silicon junction. These ranges (2 kΩ, 200 kΩ, and 20 MΩ) can be used to check silicon diodes and transistors. The 2 kΩ range is preferred. It is marked with the largest diode symbol. On the unmarked ranges, the measurement voltage is too low to turn on silicon junctions. Use these ranges to make in-circuit resistance measurements.

2-47. Conductance Measurement Techniques

NOTE

When switching from kΩ to conductance, 200 nS range, the instrument will read -00.00 for a number of seconds. This settling time may be shortened considerably by momentarily shorting the test leads or by pushing the 200 nS range buttons before *pushing the kΩ/S function button.*

2-48. There are two conductance ranges on your meter; 2 mS and 200 nS. You can think of this function either as a new type of measurement or as another way to measure high resistances. As a high resistance meter, your 8050A offers many advantages over conventional measurement methods, including the ability to make these high resistance readings at voltages within the operating range of ICs and MOS devices. As a conductance meter, your instrument can directly measure inverse-function components. For example, the resistance of a photodiode decreases as the available light increases. Conductance and available light increase or decrease together allowing easier, less error prone applications. The display is in conductance units, siemens. If resistance readings are desired, refer to the conductance-to-resistance conversion information in Figure 2-5.

2-49. The 200 nS range can be used for making resistance measurements from 5 MΩ to 100,000 MΩ. Since conductance is the inverse of resistance, as the measured resistance increases, measurement readings decrease so noise problems decrease. Except for high voltage stress testing, this range of conductance replaces the megger and can be used to check high value resistors and low leakage components, like diodes or capacitors. For more information, refer to applications material presented later in this section.

2-50. The 2 mS range can be used for making resistance measurements from 500Ω to 10 MΩ. It can be used either for resistance measurements or for such things as direct-reading dc current gain (Beta) measurements on transistors. Beta measurements require a special test fixture presented in the applications material later in this section.

2-51. The two conductance ranges span an equivalent resistance range of 500Ω to 100,000 MΩ. When using Ohm's law to determine current or power, it is sometimes necessary to divide by the resistance of the circuit or component. You may find it more convenient to measure conductance and multiply. Residual input circuit conductance may be zeroed out by separating the probe tips, and when the reading settles, set the RELATIVE switch to ON.

2-52. AC Measurement Techniques

2-53. When making precise measurements of ac signals there are special parameters that must be considered such as the type of ac converter the meter uses (average, rms etc.), crest factor, bandwidth, noise etc.

2-54. TRUE RMS

2-55. In order to compare dissimilar waveforms, calculate Ohm's law statements or power relationships, you must know the effective value of a signal. If it is a dc signal, the effective value equals the dc level. If the signal is ac, however, we have to use the root mean square or rms value. The rms value of an ac current or ac voltage is defined as being numerically equal to the dc current or voltage that produces the same heating effect in a given resistance that the ac current or voltage produces.

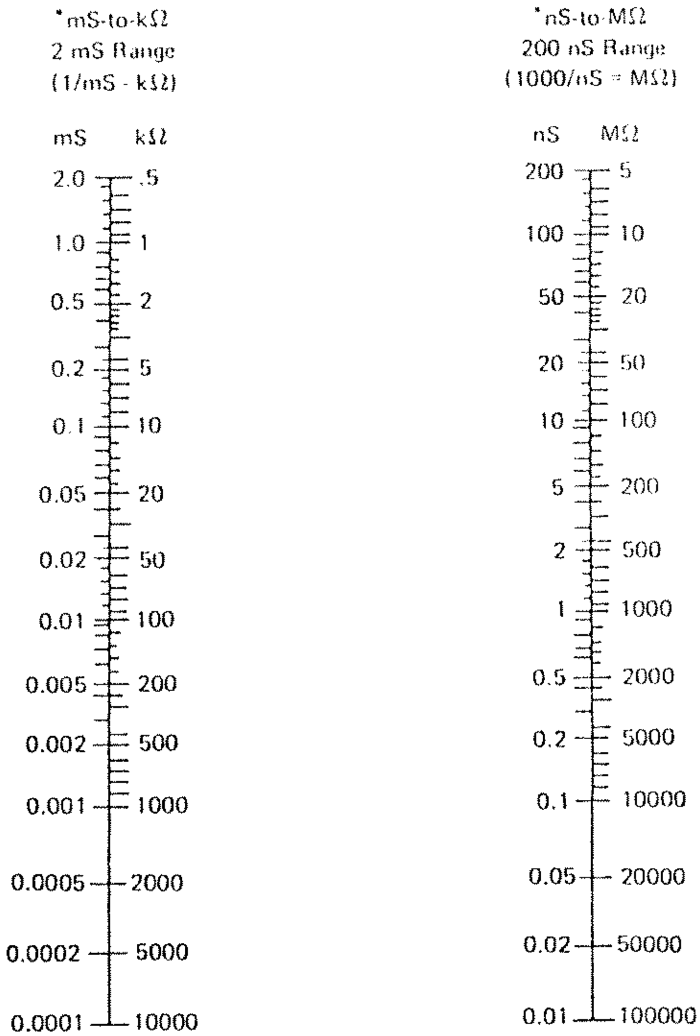
2-56. In the past, average responding converters were the type of converter most widely used. Theoretically, the rms value of a pure sine wave is $1/\sqrt{2}$ of the peak value and the average value is 2/pi of the peak value. Since the meters converted to the average value, the rms value was $1/\sqrt{2} \div 2/\text{pi} = \text{pi}/(2\sqrt{2}) = 1.11$ of the average value when measuring a sine wave. Most meters used an average responding converter and multiplied by 1.11 to present true rms measurements of sine waves. As the signal being measured deviated from a pure sine wave, the errors in measurement rose sharply. Signals such as square waves, mixed frequencies, white noise, modulated signals, etc., could not be accurately measured. Rough correction factors could be calculated for ideal waveforms if the signal being measured was distortion free, noise-free, and a standard waveform. The true rms converter in your meter provides direct, accurate measurement of these and other signals. Since the 8050A is ac coupled, refer to the section on Voltage Measurement Techniques for combined ac and dc signal measurements.

2-57. CREST FACTOR

2-58. Crest factor range is one of the parameters used to describe the dynamic range of a voltmeter's amplifiers. The crest factor of a waveform is the ratio of the peak to the rms voltage. In waveforms where the positive and negative half cycles have different peak voltages, the higher voltage is used in computing crest factor. Crest factors start at 1.0 for a square wave (peak voltage equals rms voltage).

2-59. Your instrument has a crest factor range of 1.0 to 3.0 at full-scale. Going down from full-scale, the crest factor capability increases from 3.0 to:

$$\frac{\text{Full-Scale X3}}{\text{RMS Value}} \text{ (i.e., 6 at half-scale)}$$



Conversion Scales

**S = siemens = 1/Ω = International unit of conductance formerly known as the mho.*

Find the approximate resistance value using one of the conversion scales. Then, on the Interpolation Table, **locate the most** significant digit of the display reading on the vertical NO. column, and the next digit on the **horizontal NO.** row. The number at the intersecting coordinates represents the unknown resistance value. **For example,** a reading of 52.0 nS is equal to 19.2 MΩ. Decimal point location is determined from the **scale approximation.**

Interpolation Table (l/no.)

NO.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1	1	.909	.833	.769	.714	.667	.625	.588	.556	.526
2	.500	.476	.455	.435	.417	.400	.385	.370	.375	.345
3	.333	.323	.313	.303	.294	.286	.278	.270	.263	.256
4	.250	.244	.238	.233	.227	.222	.217	.213	.208	.204
5	.200	.196	.192	.187	.185	.182	.179	.175	.172	.169
6	.167	.164	.161	.159	.156	.154	.152	.149	.147	.145
7	.143	.141	.139	.137	.135	.133	.132	.130	.128	.127
8	.125	.123	.122	.121	.119	.118	.116	.115	.114	.112
9	.111	.110	.109	.108	.106	.105	.104	.103	.102	.101

Figure 2-5. Conductance - to - Resistance Conversion

If an input signal has a crest factor of 3.0 or less, voltage measurements will not be in error due to dynamic range limitations at full-scale. If the crest factor of a waveform is not known, and you wish to know if it falls within the crest factor of your meter, measure the signal with both your meter and an ac coupled oscilloscope. If the rms reading on your meter is 1/3 of the peak voltage on the waveform or less, then the crest is 3.0. For readings at less than full-scale, use the preceding formula to determine the maximum crest factor. At half-scale the maximum crest factor is:

$$\frac{2 \times 3}{1} = 6$$

2-60. The waveforms in Figure 2-6 show signals with increasing values of crest factor. As you can see from the series of waveforms, a signal with a crest factor above 3.0 is unusual.

2-61. For an ac coupled pulse train:

$$\text{Crest Factor} = \sqrt{1/D - 1}$$

Where D = duty cycle or the ratio of pulse width to cycle length. Reversing this formula, we find that your meter can accurately measure pulse trains at full-scale with a duty cycle above 10% without being limited by crest factor.

$$\text{Crest Factor} = 3.0 = \sqrt{1/D - 1}$$
$$9.0 = 1/D - 1$$
$$10.0 = 1/D$$
$$D = 1/10 = 10\%$$

2-62. BANDWIDTH

2-63. Bandwidth defines the range of frequencies where the response by the voltmeter's amplifiers is no more than 3 dB down (half-power levels). Your instrument has a bandwidth of greater than 200 kHz.

2-64. SLEW RATE

2-65. Slew rate is also called the rate limit or the voltage velocity limit. It defines the maximum rate of change of the output of the amplifiers for a large input signal. Slew rate limitations are not a factor in measuring voltages within specified frequencies and amplitude limits of the 8050A.

2-66. RISE AND FALL TIME EFFECT ON ACCURACY

2-67. The rise and fall time of a waveform are the length of time it takes a waveform to change between the points that are 10% and 90% of the peak value. When discussing these periods, we'll only mention rise time. Errors due to rise or fall time can be caused either by bandwidth or slew rate limitations. Slew rate should not affect your measurement with the 8050A.

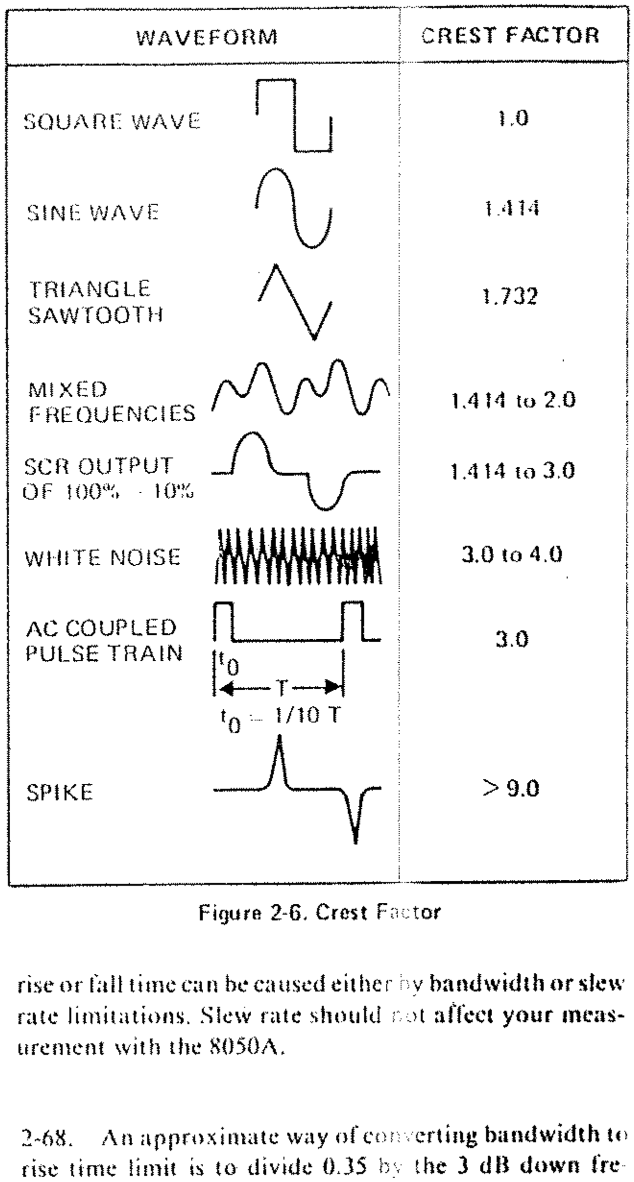


Figure 2-6. Crest Factor

2-68. An approximate way of converting bandwidth to rise time limit is to divide 0.35 by the 3 dB down frequency. For your instrument this will be 0.35/200 kHz = 1.75 μsec. The following example will help you to calculate errors due to this limitation when measuring rectangular pulses. These calculations will be rough because ideal waveforms are used in analysis.

2-69. Ideally, the rectangular pulses would have zero rise and fall time and would be the right angled waveform shown in Figure 2-7, Part A. In practice, every waveform has a rise and fall time and looks more like the waveform in Figure 2-7, Part B. When calculating the error caused by the bandwidth of your instrument, we will assume that the rise and fall time equals the slew rate of 1.75 μsec. To do this, we will calculate the values for the theoretical signal with zero rise and fall time, then calculate the values for a signal with the same period but with total slope periods equal to 1.75 μsec. A comparison of the results will show the measurement error due to the finite

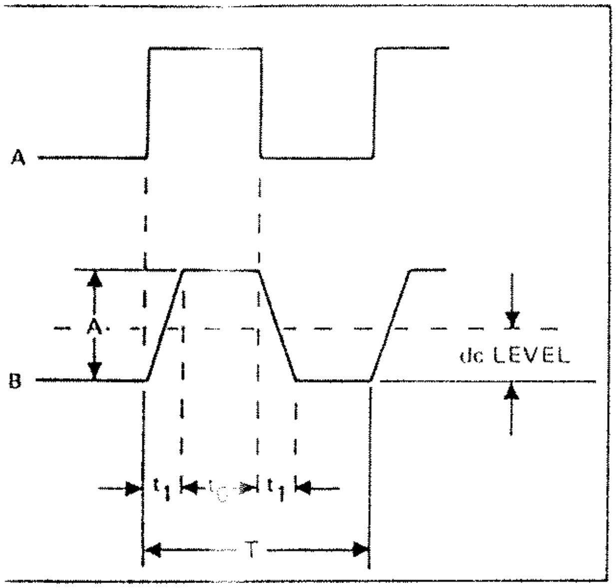


Figure 2-7. Components of a Rectangular Waveform

andwidth. Using Figure 2-7, Part B, for a reference, the otal rms and dc levels are:

$$E\ total\ rms = A\sqrt{\frac{3t_0 + 2t1}{3T}}$$

$$E\ dc = A\left[\frac{(t_0 + t1)}{T}\right]$$

70. Since we can calculate two values, to find what our meter measures, use the formula:

$$E\ ac\ rms = \sqrt{(E\ total\ rms)^2 - (E\ dc)^2}$$

71. Let's look at the waveform in Figure 2-7, Part B. When using your meter to measure the ac component of e signal, the display will indicate the rms value of the ac gnal riding on the dc level. (This dc level is the average lue of the waveform relative to the baseline.) The total ns value of the waveform can be calculated using the lationship:

$$E\ total\ rms = \sqrt{E\ ac\ rms^2 + E\ dc^2}$$

72. For our example let's use a 10 kHz pulse train of μsec pulses with a peak value of 1V. Ideally, the pulses ould have a zero rise time as shown in Figure 2-8, Part

$$E\ total\ rms = 1\sqrt{\frac{3(50) + 2(0)}{3(100)}} = \sqrt{\frac{150 + 0}{300}} = \sqrt{\frac{1}{2}}$$

$$E\ total\ rms = 0.707$$

$$E\ dc = 1\left(\frac{50 + 0}{100}\right) = \frac{50}{100} = 0.5$$

$$So,\ the\ E\ ac\ rms = \sqrt{(0.707)^2 - (0.5)^2} = \sqrt{0.50 - 0.25}$$

$$E\ ac\ rms = \sqrt{0.25} = 0.5$$

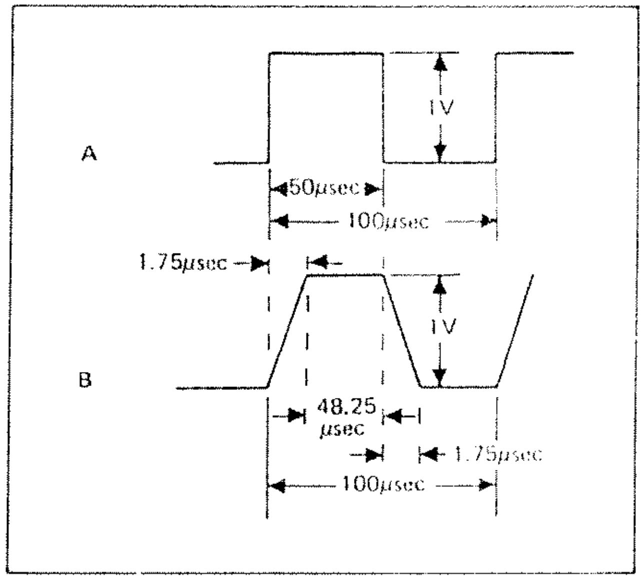


Figure 2-8. Rise Time/Fall Time Example

2-73. When the maximum distortion in rise time of 1.75 μsec is assumed, the signal becomes the isoceles trapezoid waveform shown in Figure 2-8, Part B. In this case,

$$E\ total\ rms = 1\sqrt{\frac{3(48.25) + 2(1.75)}{3(100)}} = \sqrt{\frac{144.75 + 3.50}{300}}$$

$$E\ total\ rms = \sqrt{\frac{148.25}{300}} = \sqrt{0.494} = 0.703$$

$$E\ dc = 1\ \frac{48.25 + 1.75}{100} = \frac{50}{100} = 0.50$$

$$So,\ E\ ac\ rms = \sqrt{(0.703)^2 - (0.50)^2} = \sqrt{0.494 - 0.25}$$

$$E\ ac\ rms = \sqrt{0.244} = 0.494$$

Note that the E dc stayed the same.

So, the errors are:

In E total rms: 0.6%

In E ac rms: 1.2%

2-74. OPERATION

2-75. Use the following procedure to operate your 8050A:

1. Connect your 8050A to operating power and set the POWER switch to the ON position.

2. Select the desired instrument function and range.

3. Connect the test leads to the circuit to be measured. Be sure that you do not connect your 8050A to a source that exceeds the maximum safe operating limits presented in the operating notes in this section.

2-76. APPLICATIONS

2-77. The test applications described in the following paragraphs are suggested as useful extensions of your meter's capabilities. They are not meant to be the equivalent of manufacturer's recommended test methods. They are intended to provide you with repeatable, meaningful indications which allow you to decide whether the device being tested is good, marginal, or defective.

2-78. Measuring the Response of Frequency Sensitive Devices

2-79. With your 8050A you can easily determine the bandwidth of an amplifier, of a filter, the notch of a band-reject filter, etc. Use the following procedure to find the bandwidth of an amplifier:

1. Connect the amplifier (test device) as shown in Figure 2-9.

2. Select the AC V measurement function and be sure the RELATIVE switch is at the OFF position.

3. Starting at a low frequency, (45 Hz) sweep the band of interest.

4. As the input frequency enters the bandpass area of the amplifier, the meter readings will begin to rise. Continue to increase frequency to determine the highest point in the bandpass area.

5. Select the AC dB measurement function.

6. Set the RELATIVE switch to the ON position. You have now established the highest point in the bandpass as a 0 dB relative reference level. (See the top waveform in Figure 2-9.)

7. Continue to increase frequency until the 8050A displays -3.01 dB.

8. Record the frequency. This is the upper bandwidth limit (half-power point).

9. Decrease frequency. The display will increase to 0.00 dB.

10. Continue to decrease frequency until the display drops to -3.01 dB.

11. Record the frequency. This is the lower bandwidth limit (half-power point).

2-80. The response of other frequency sensitive device can be found using similar techniques. Figure 2-9 has waveforms for some types of frequency sensitive devices.

2-81. Relative dB Uses

2-82. The RELATIVE function of your 8050A allows you to make any voltage level the 0 dB reference point for dB measurements. Once the reference level is established (input the reference level and set the REFERENCE switch to the ON position), subsequent measurements show the difference (in dB) between that reference and the point being measured. An application of this function is shown in Figure 2-10. System gain checks are easily made referenced to TP1. The actual gain (in dB) is displayed, no mental math is necessary.

2-83. Your 8050A as a Q Meter

2-84. FINDING THE Q OF A SINGLE TUNED CIRCUIT

2-85. Use the technique presented earlier to determine the resonant frequency and bandwidth of a single tuned circuit. Calculate the Q of the circuit using the following formula:

$$Q = \frac{\text{Resonant Frequency}}{\text{2X Bandwidth}}$$

2-86. RELATIVE Q

2-87. Often you are interested in Q as a comparison between two devices or as a standard in passing or failing a device in an assembly situation. As Figure 2-11 shows your 8050A can provide a direct indication of the Q of the device in question as compared to a known device (Relative Q). Use the following procedure:

1. Connect the known device in a test circuit.

2. Select the AC dB function of your 8050A.

3. Connect the 8050A across the test device load.

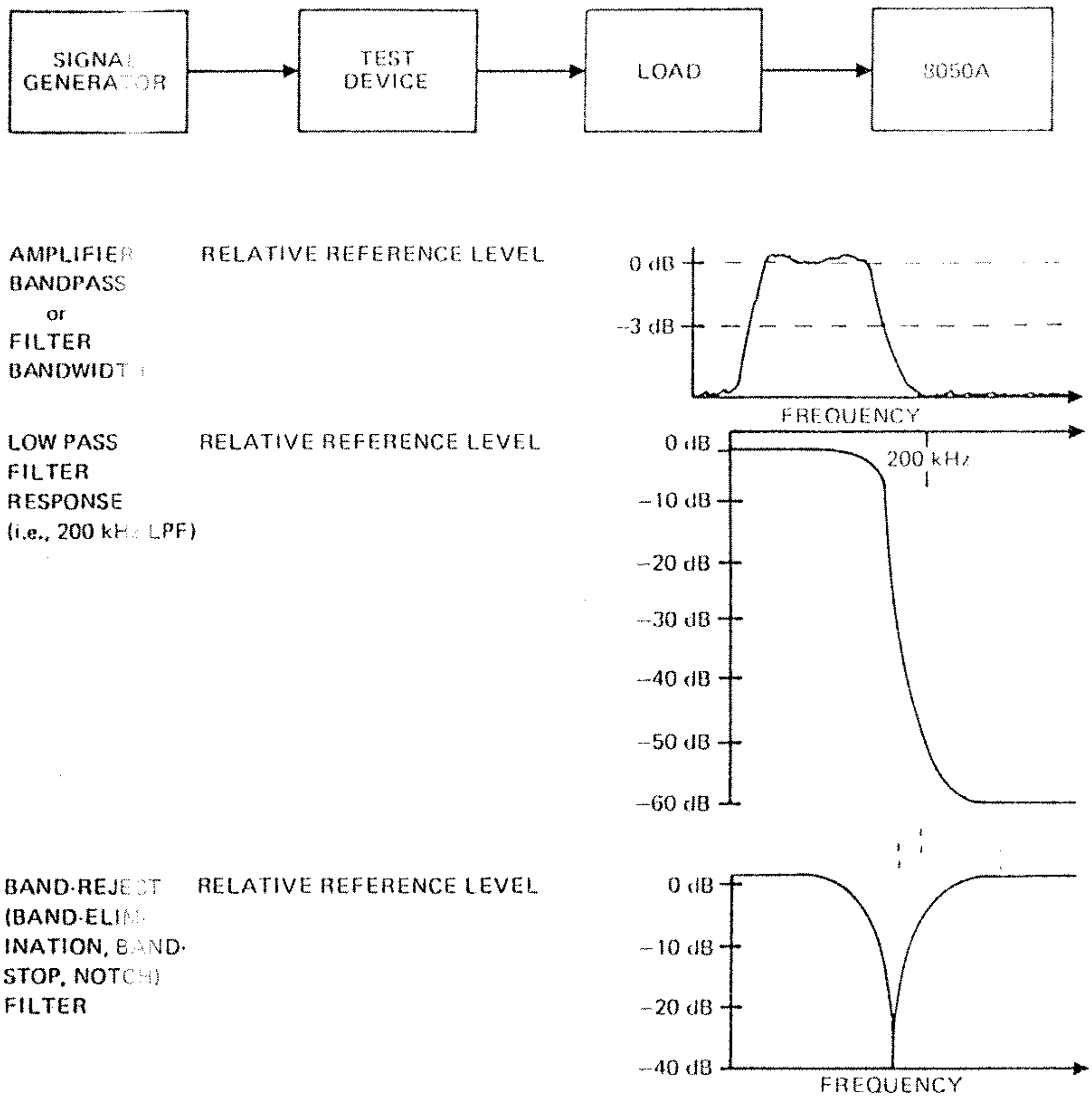


Figure 2-9. Frequency Sensitive Devices

4. Set the RELATIVE switch to the ON position.

5. Replace the known device with a device in question.

6. The 8050A will display the relative Q of the device in question. The relative Q measurement will be logarithmic and must be interpreted in the same manner as dB. For example, a device that has the same Q as the reference device will produce a display of 0.00. A device with 1/2 the Q of the reference device will produce a display of -3.01 dB, while a device with twice the Q of the reference device will produce a display of +3.01 dB.

NOTE

If more resolution in ACV is desired, the 20 mV linear AC range, which is used in dB, is accessible from the front panel. It has 1 μV resolution and is typically within ±2.5% from 20 Hz to 50 kHz, although this is not a guaranteed specification. To obtain this resolution, select AC, V and push the 200 mV and 2 V range buttons simultaneously (same as selecting the 2 mS range).

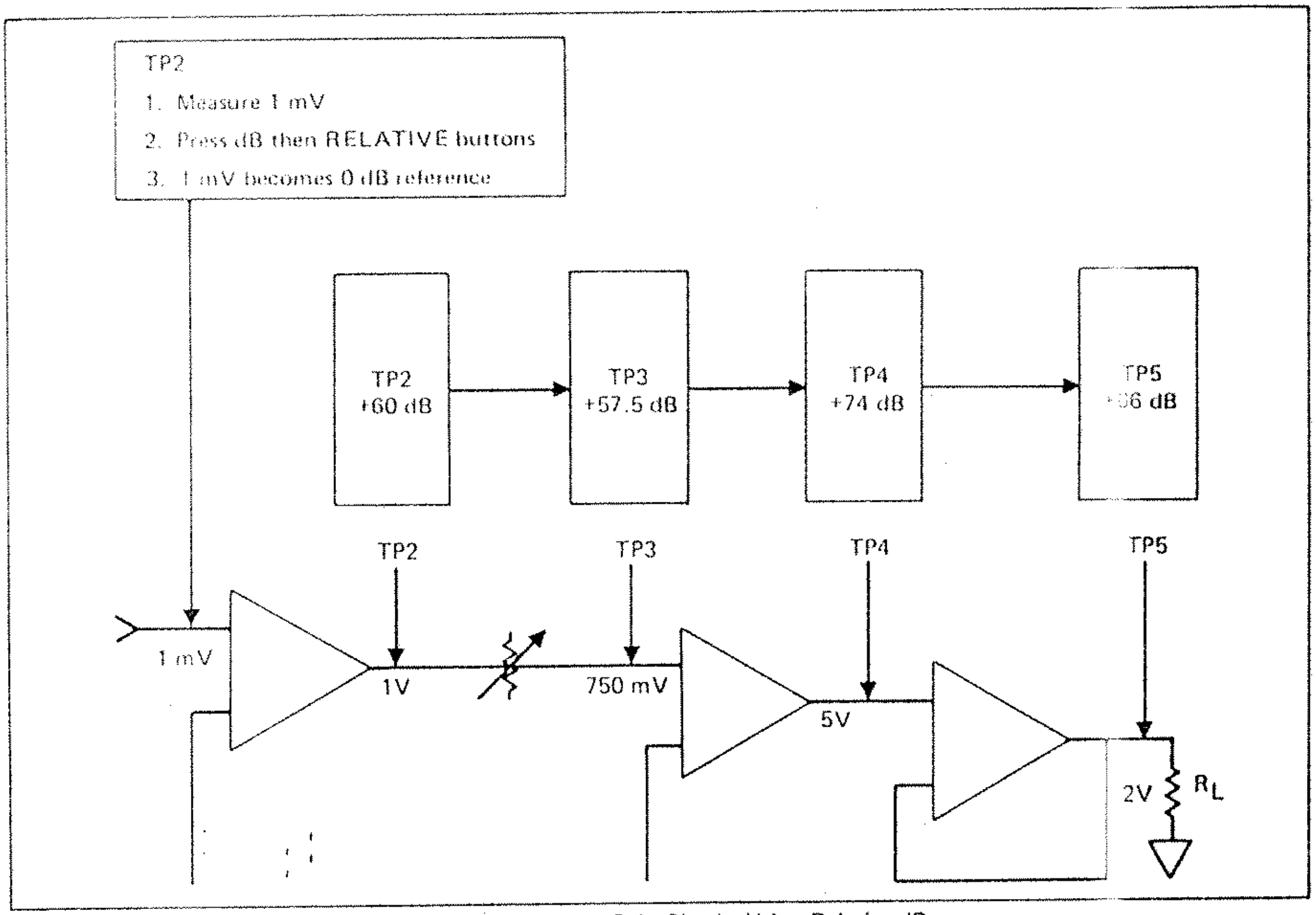


Figure 2-10. System Gain Checks Using Relative dB

2-88. Transistor Tester

NOTE

The transistor tester described in the following paragraphs provides approximate test information. Beta is measured using V_{CE} of about 2V and an I_C of about 200 μA. It is very useful in comparative measurements and matching.

2-89. Select the 2 mS range then plug the fixture shown in Figure 2-12 into the V/kΩ/S and COMMON input terminals, and you have transformed your instrument into a transistor tester. Now, plug a transistor into the test socket and your meter will determine the following:

1. Transistor type (NPN or PNP).
2. Collector-to-emitter leakage (I_{CES}).
3. Beta from 10 to 1000 without changing range.

2-90. Transistor type is determined by setting the switch on the fixture to BETA and observing the display. If a low reading (≤.0100) is obtained, reverse the test fixture at the input terminals. If the collector is now positioned at the COMMON input terminal, the transistor is a PNP type. An NPN type will have its collector positioned at the V/kΩ/S input terminal. If the transistor is defective, the indications will be as follows regardless of fixture position:

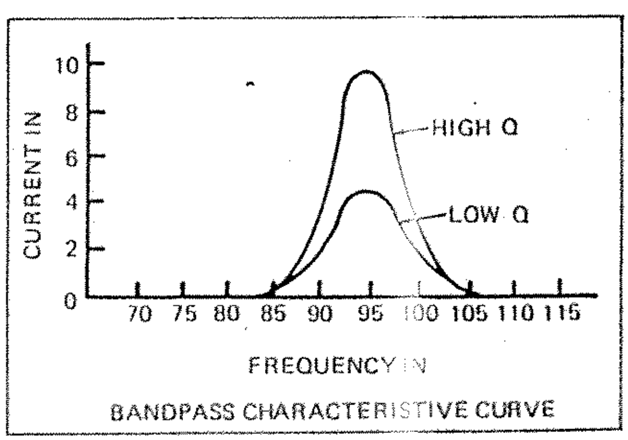


Figure 2-11. Relative Q

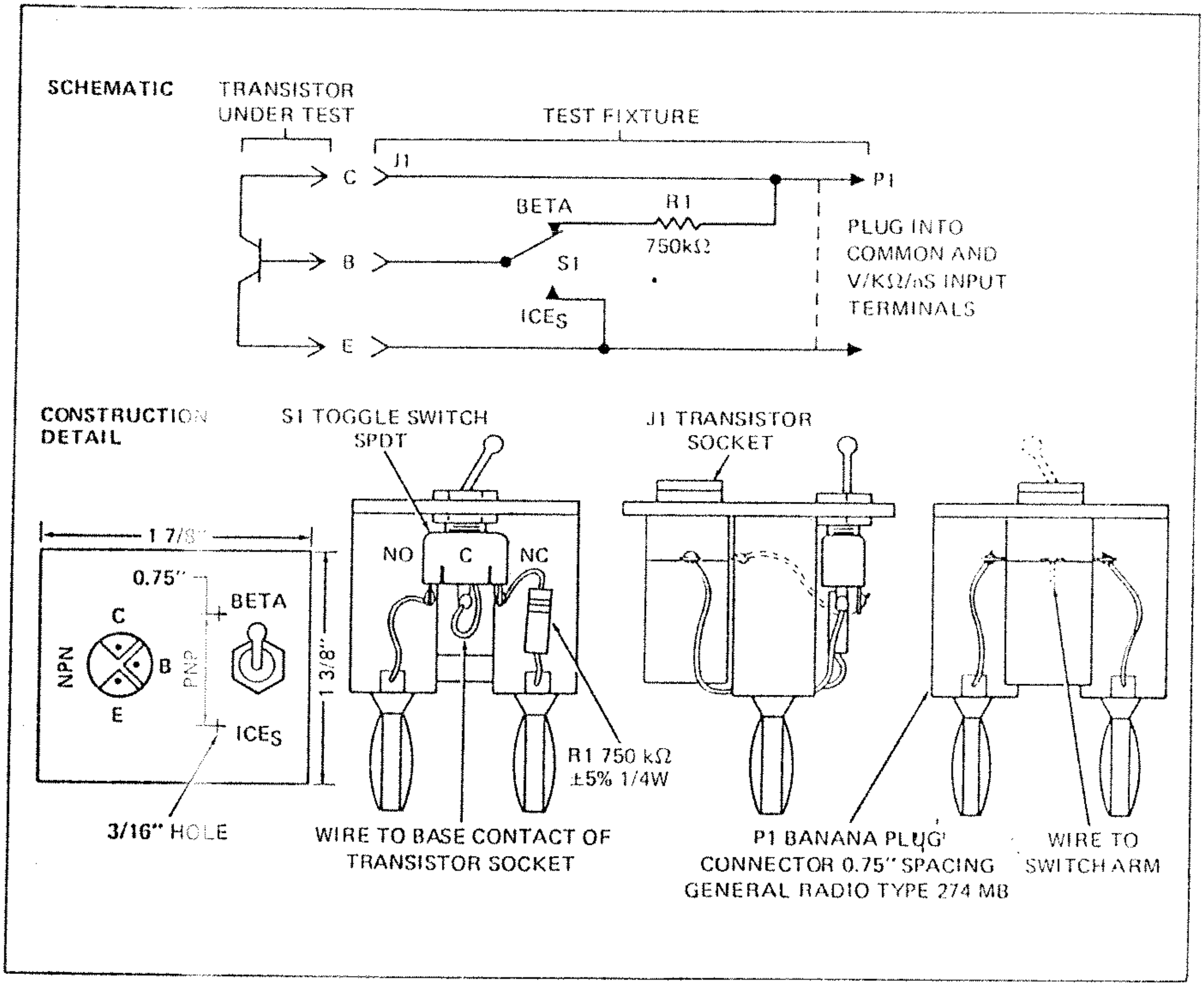


Figure 2-12. Transistor Beta Test Fixture

1. A shorted transistor will cause an overload indication.

2. An open transistor will read .0005 or less.

2-91. After the transistor fixture is properly positioned, set the switch to I_{CES} for the leakage test. The transistor is turned off in this test (base shorted to emitter), and should appear as a very low conductance (high resistance) from collector-to-emitter. Therefore, the lower the reading, the lower the leakage. Silicon transistors that read more than .0020 (6 μA) should be considered questionable.

2-92. Beta is determined by setting the fixture switch to BETA and observing the display. Mentally shift the decimal point three places to the right and read beta directly. For example, a display reading of .1273 indicates a dc current gain (beta) of 127.3.

NOTE

Beta is a temperature sensitive parameter. Therefore, repeatable readings can only be obtained by allowing the transistor to stabilize at the ambient temperature while being tested. Avoid touching the transistor's case with your fingers.

2-93. Leakage Tester

2-94. The 200 nS conductance range effectively extends the resistance measurement capability of the instrument up to 100,000 MΩ where it can be used to provide useful leakage measurements on passive components. For example, you can detect leaky capacitors, diodes, cables, connectors, printed circuit boards (pcbs), etc. In all cases, the test voltage is <3.5V dc.

2-95. RESISTIVE COMPONENTS

2-96. Leakage testing on purely resistive components such as cables and pcbs is straightforward. Select the 200 nS range and install the test leads in the V/kΩ/S and COMMON input terminals. With the test leads open, wait until the reading settles and zero out the residual conductivity by setting the RELATIVE switch to ON. Connect the leads to the desired points on the unit-under-test, and read leakage conductance. If an overrange occurs, select the resistance range that provides an on-scale reading.

NOTE

Under high humidity conditions, fingerprints and other residual surface contaminants can create leakage paths of their own. Use clean test leads to minimize their contribution to the readings.

2-97. DIODES

2-98. Diode leakage (I_R) tests require that the diode junction be reverse biased when being measured. This is accomplished by connecting the diode's anode to the COMMON input terminal. Leakage can then be read in terms of conductance. Normally, a silicon diode should result in an in-range reading on the 200 nS range.