

TF 151

IN-CIRCUIT
FET AND
TRANSISTOR TESTER

S E R V I C E M A N U A L



SENCORE SERVICE MANUAL

3200 SENCORE DRIVE, SIOUX FALLS, S. DAKOTA 57107

Safety Precautions

When testing electronic equipment, there is always a danger present. Unexpected high voltages can be present at unusual locations in defective equipment. The technician should become familiar with the device that he is working on and observe the following precautions.

1. An isolation transformer should always be used on equipment having the chassis tied to one side of the AC power line.
2. When making test lead connections to high voltage points, remove the power. If this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket as a safety precaution and stand on an insulated floor to reduce the possibility of shock.
3. Discharge filter capacitors before connecting test leads to them. Capacitors can store a charge that could be dangerous to the technician.
4. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose the technician to dangerous potentials.
5. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.
6. Do not work alone when working on hazardous circuits. Always have another person close by in case of accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with higher voltages.

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INSTRUCTION MANUAL FOR THE SENCORE TF151
DYNAMIC IN AND OUT OF CIRCUIT TRANSISTOR
AND FIELD EFFECT TRANSISTOR TESTER

The transistor has revolutionized the electronic industry and has made inroads into many devices. Now, the transistor has a new partner to aid in this revolution, the Field Effect Transistor. This new semiconductor device has been widely accepted by the designers of electronic devices. The need for a transistor tester to test both the FET and the regular transistor both in and out of circuit has developed. Sencore has met this need with the new TF151. It can check regular transistors for AC beta and FET's for Gm, both in and out of circuit, as well as check for that critical leakage in each device. The TF151 will fill the bill in the service industry and also in industrial applications, with ease. Here are a few of the features found on the TF151:

- * Checks high power, low power and the critical RF types in or out of circuit for actual AC beta.
- * Checks these regular transistors for leakage or I_{CBO} .
- * Checks Field Effect Transistors in or out of circuit for Gm or transconductance.
- * Checks Field Effect Transistors for gate leakage or I_{GSS} .
- * Checks diodes in or out of circuit
- * Large Six inch meter for easy reading

SPECIFICATIONS

Regular Transistor (Bi-polar) Testing

Beta (h_{fe}) measured at 60 Hertz

| | <u>RANGE</u> | <u>BETA</u> | <u>I_C</u> |
|------------|--------------|-------------|-------------------------|
| Lo Power | X1 | 1-50 | 2.0 Ma |
| | X10 | 10-500 | 2.0 Ma |
| Hi Power | X1 | 1-50 | 20 Ma |
| | X10 | 10-500 | 20 Ma |
| Special RF | X1 | 1-50 | 0.2 Ma |

Leakage (I_{CBO}) measured at $V_{CB} = 4V$, $I_E = 0$

One range 0-100 microamps lower 1/2 of scale.

100-5000 microamps upper 1/2 of scale.

Field Effect Transistors

Transconductance (Gm) measured at $V_{DS} = 5V$, $V_{GS} = 0$

| <u>RANGE</u> | <u>Gm</u> |
|--------------|--------------------|
| X1 | 0-5000 Micromhos |
| X10 | 0-50,000 Micromhos |

Gate Leakage (I_{GSS}) measured at $V_{GS} = 4V$, $V_{DS} = 0$
One range 0-100 microamps lower 1/2 of scale
100-5000 microamps upper 1/2 of scale
Zero Bias Drain Current (I_{DSS})
Measured at $V_{DS} = 5V$, $V_{GS} = 0$

General

Electrical: 105/130 VAC, 50/60 Hertz at 10 watts
Physical: 9 1/2" High x 7 1/2" wide X 6" deep
Weight: 9 pounds

COMMON TRANSISTOR TERMINOLOGY

The terms used in describing transistors, both bi-polar and FET types are fairly new to the service industry. By knowing the standard format of the terms, such as I_{CBO} or I_{GSS} , the technician can figure out what each term means. The main letters are I and V and stand for current and voltage. The sub letters are the elements of the device and tell between which elements the voltage is applied or the current flows. The sub letters C, B, and E stand for the collector, base, and emitter of a bipolar transistor. The term I_{CBO} therefore stands for Current between the collector and base. The O indicates that the third element, the emitter in this case, is left open. The I_{CBO} is the term used to designate leakage current in the bi-polar transistor.

In the field effect transistors, the term I_{GSS} is the leakage current from the gate to the source. The third sub letter indicates that the third element, the drain, is shorted to the second element or source. I_{DSS} is referred to as the zero bias drain current. It is of course current from drain to the source. The third letter indicates the gate is shorted to the source for a condition of zero or no bias.

When the third letter is missing from the sub letters such as I_{DS} , then the term must have a condition listed with it to tell what bias is applied to the gate or under what conditions the current is flowing.

Knowing that the subletters indicate the elements in question and that the third letter when used indicates the condition of the third element, the technician can readily figure out most of the transistor terms that he will encounter.

CONTROLS ON THE TF151 IN-CIRCUIT TRANSISTOR AND FET TESTER

'N' CHAN/NPN - 'P' CHAN/PNP Switch. Selects the proper polarity of voltage applied to the collector or drain of the transistor under test and is used when checking the forward and reverse currents of a diode.

Gm ZERO and BETA CAL Control. Is adjusted for each transistor to compensate for various internal impedance differences found in transistors and insures an accurate beta or Gm reading.

GAIN button. Used only for beta and Gm checks and is not used for leakage measurements.

I_{DSS} Button. Used for the zero bias drain current check and for matching and pairing of field effect transistors.

BIAS Switch. Selects either NORM bias for depletion type field effect transistors or POS for the enhancement type field effect transistors.

FUNCTION SWITCH. Selects the proper tests for regular transistors or field effect transistors.

ON-OFF Switch. Controls the AC power to the TF151 and glows in the ON position to act as a pilot light.

TEST JACKS

SOURCE/E: Black lead connects to the emitter of a regular transistor or to the source of a field effect transistor.

GATE 1/B: Yellow lead connects to the base of a regular transistor or to the gate of a field effect transistor.

DRAIN/C: Red lead connects to the collector of a regular transistor, or to the drain of a field effect transistor.

GATE 2: Blue lead connects to the second gate of a dual gate field effect transistor.

USING THE SENCORE FET AND TRANSISTOR REFERENCE BOOK

The Transistor Reference Book supplied with the TF151 is a unique book, listing more transistor and field effect transistor than any other one source of information in the field. The Transistor Reference Book is in three parts; regular transistor listings, field effect transistor listings, and manufacturers part numbers. The transistor section has the field effect transistor numbers in the same listing. If you don't know if it is a regular (bi-polar) transistor or FET, the book will tell you. If it is a regular transistor, the information will follow the transistor number. If it is an FET, you will be told to look under the FET section of the book. The manufacturers part numbers will be listed under the manufacturers name. The manufacturers are listed alphabetically in the back section of the book. Figure 1 shows a section of the regular transistor chart.

| 1 | 2 | 3 | 4 | 5 | 6 | | | |
|------------|-------------------|--------------------|--------------|-------------|------|------|---------------------------|-----|
| TRANSISTOR | LO PW | N = NPN P = PNP | BASE DIAG | GAIN (BETA) | | | LEAKAGE ICBO MAX uA | |
| | HI PW | P M O A T L | | | | | | |
| | * SPEC'L RF | | | MIN. | AVE. | MAX. | | |
| 2N2440 | | NS | 32 | 185 | | | .001 | |
| 2N2443 | | NS | 32 | 50 | | | | .01 |
| 2N2444 | ✓ | PG | 500 | 75 | 120 | | | 150 |
| 2N2445 | ✓ | PG | 56 | 20 | 60 | | | 200 |

Figure 1.

SECTION OF TRANSISTOR CHART

1. TRANSISTOR column indicates the transistor number or manufacturers part number.
2. This column indicates the proper test position of the function switch. The check mark (✓) indicates a high power transistor and the function switch should be set to the HI POWER position. The asterisk (*) indicates that the transistor is a special RF type and that the SPECIAL RF check should be used. No mark indicates that the transistor is lo power and the LO POWER check on the TF151 should be used.
3. The POL/MAT column tells the polarity and the material of the transistor. The type switch should be set to NPN when the letter N is indicated and PNP when the letter P is indicated. The G stands for germanium material and S for silicon. This is handy when selecting a replacement type such as a general replacement line transistor.

4. BASE DIAG Column indicates the base diagram for that particular transistor. If the lead oonfiguration is not known, the base diagram number listed in this column should be consulted in the back of the book.
5. GAIN (BETA) section is divided into three sections, minimum, average and maximum, showing the gain or beta that should be expected with the transistor. The minimum and maximum figures are manufacturers' limits. The AVE column shows the average or typical figure. All three are listed when available. Circuit loading may affect the indicated beta of the transistor; when a figure below that listed is encountered, the transistor should be removed from the circuit and rechecked to be sure.
6. LEAKAGE column shows the maximum leakage or I_{CBO} of the transistor. Anything over this figure should be considered bad and the transistor rejected.

Note: The chart shows the maximum leakage at four volts, which is the TF151 test voltage. The manufacturers published figure is often given at voltages higher than four volts. To simplify leakage testing, the published figure was converted to that shown.

FET SECTION OF REFERENCE BOOK

The Field Effect Transistor section of the book is similar to the regular or bi-polar transistor information. The following section of the Field Effect Transistor chart shown in figure 2 shows how the chart can be used to check the FET:

| 1. | 2. | 3. | 4. | 5. | 6. | | | 7. |
|-------|------|------|-----------|-------------------|--------------------------------|------|-------|----------------------------|
| FET | CHAN | BIAS | BASE DIAG | IDSS MAX MA | GAIN G _m (uMHOS) | | | LEAKAGE |
| | | | | | MIN. | AVE. | MAX. | I _{GSS} MAX uA |
| UC807 | P | NORM | 500 | | 2500 | | 25000 | .002 |
| UC814 | P | NORM | 500 | 15 | 800 | | 5000 | .002 |
| UC850 | P | NORM | 500 | 1.0 | 110 | | | .002 |
| UC851 | P | NORM | 500 | 9.0 | 1000 | | | .004 |

Figure 2.
SECTION OF FET CHART

1. FET column lists the FET number or manufacturers number of the device.
2. CHAN column tells if the FET is an N channel or P channel transistor and the information is used to set the type switch to the proper polarity of voltage in the TF151 for the tests.
3. BIAS column shows the BIAS switch setting. NORM is for depletion type FETs that require zero bias, and POS is for enhancement type FETs, that require positive bias.
4. BASE DIAG column indicates the base diagram of the particular device in question. If the source, gate, and drain connections are not known, consult this drawing number in the back of the transistor manual.

5. $I_{DSS} \text{ MAX MA}$ is the maximum zero bias drain current for the listed FET. This is the maximum current and should not be exceeded when the I_{DSS} check is made on the FET. I_{DSS} measurements are not made on positive biased FET's.
6. $\text{GAIN } G_m (\mu\text{MHOS})$ shows the G_m limitations of the device. The minimum and maximum figures, when shown, are the manufacturing limits. The AVE figure is an average or typical gain figure. All three figures are listed when available.
7. $\text{LEAKAGE } I_{GSS} \text{ MAX } \mu\text{A}$ is the maximum leakage current of the FET as read on the LEAKAGE scale of the TF151 meter when making the GATE leakage test. Any reading above this figure can be considered as bad and the FET rejected.

If any transistor is not listed in the book, the information was not available at the time of printing. The Sencore FET and Transistor Reference Book is printed once each year. If you wish to receive each copy as it is printed, sign the warranty card and return it to the Sencore factory as soon as possible. Your name will be put on an automatic mailing list to receive the new transistor book for the TF151 as they are printed. A nominal charge will be made for each book.

TESTING REGULAR TRANSISTORS (BI-POLAR)

What should a regular transistor be tested for? The two most important parameters of a transistor are the beta, and leakage between the base and collector (I_{CBO}). Beta is the current amplification factor and can be either DC or AC beta. DC beta is the ratio of collector current divided by the base current and is referred to as h_{FE} in the transistor manual. AC beta is the ratio of change in the collector current divided by the change in base current while holding the collector voltage constant and is referred to as h_{fe} in the transistor manual. AC beta measured at low frequencies and DC beta are very nearly the same. However, AC beta is more revealing because it is measured under dynamic conditions.

The beta limits, or spread as it is called, is the extreme that may be expected with a particular transistor. This can be a ratio of as much as 2:1 or more for a given transistor. If only a single figure is given in a transistor manual, it is generally the minimum figure. In the Sencore Reference Book, the column the figure is in will tell you if it is minimum or an average figure.

The application of a transistor generally fits a beta pattern and the chart below is given as a rough guide to beta values of various transistors found in these circuits. A more exact figure can be found in the Sencore Reference book or a transistor manual.

| <u>Type</u> | <u>Beta Range</u> |
|-------------|-------------------|
| RF-IF | 2-50 |
| Power | 10-100 |
| Audio | 40-400 |

Leakage current or I_{CBO} is probably one of the most important parameters of a transistor. This is the current that flows between the base and collector in the reverse direction. This reverse current flow will cause the AC beta of the transistor to decrease and up-set the circuit the transistor is used in, if it becomes excessive. This leakage is similar to grid leakage in a vacuum tube.

Leakage current can increase with transistor age, especially if some slight impurities were left in the transistor at manufacture. Leakage will cause the most problems in circuits that operate at high and low temperatures, because leakage current will increase with heat. The current will approximately double for each 10 degrees centigrade increase for germanium devices and for each six degrees centigrade increase for silicon devices.

Silicon transistors have a very low leakage current while germanium may have a fairly low to quite high leakage depending upon the application. The chart below is a rough guide to help determine if the leakage is too high. When in doubt, consult the Sencore Reference Book.

| Transistor Type | Germanium Transistors Leakage Current (max) | Silicon Transistors Leakage Current (max) |
|-----------------|--|--|
| RF-IF | 0-5 microamps | 0-3 microamps |
| Audio | 5-50 microamps | 0-5 microamps |
| Power | 50-5000 microamps | 5-500 microamps |

CHECKING REGULAR TRANSISTORS FOR AC BETA IN OR OUT OF CIRCUIT

The regular or bi-polar type transistor can be easily checked in or out of circuit for actual AC beta with the TF151. Three ranges are provided, LO POWER, HI POWER and SPECIAL RF. Most transistors will fall in the LO POWER classification and most of the tests will be performed with the TF151 Function switch set to the LO POWER range. If the transistor has a power dissipation of one watt or more, it is generally considered a HI POWER transistor and should be tested with the Function switch in the HI POWER position. These transistors will be marked with a (✓) in the Sencore Reference book. The SPECIAL RF setting is for the low saturation drift field type transistors such as the GE9 replacement type and other critical RF transistors. These transistors will be marked with an asterisk (*) in the Sencore Reference book. If the transistor is used in an RF or IF application and is not marked for the SPECIAL RF check, it will normally be tested under the LO POWER check. If the beta appears too low or the meter reads a beta of less than one, the transistor may be saturating early. The transistor should then be checked at a lower current with the SPECIAL RF check position on the TF151. The connections for testing the transistor in or out of the circuit are the same. The only thing that will change is the Function switch position depending upon the type of transistor tested.

To connect the TF151 for testing:

- 1. Connect the E, B, and C test leads to the transistor as shown in figure 3 or 4.

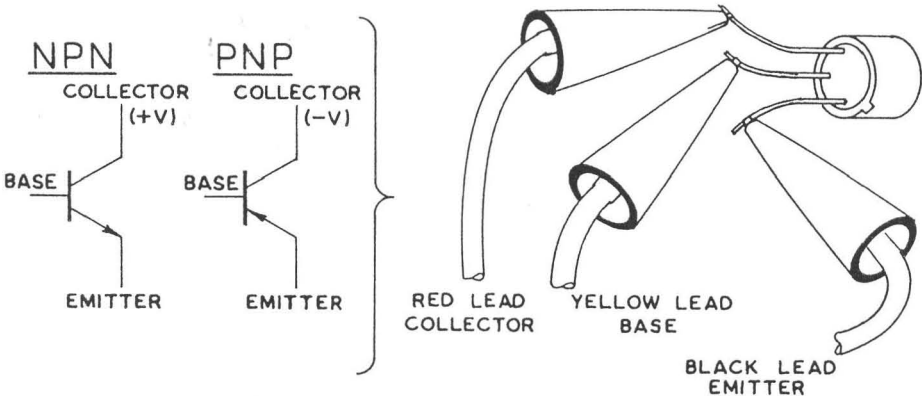


Figure 3. Connecting To A Transistor For In-Circuit And Out Of Circuit Testing

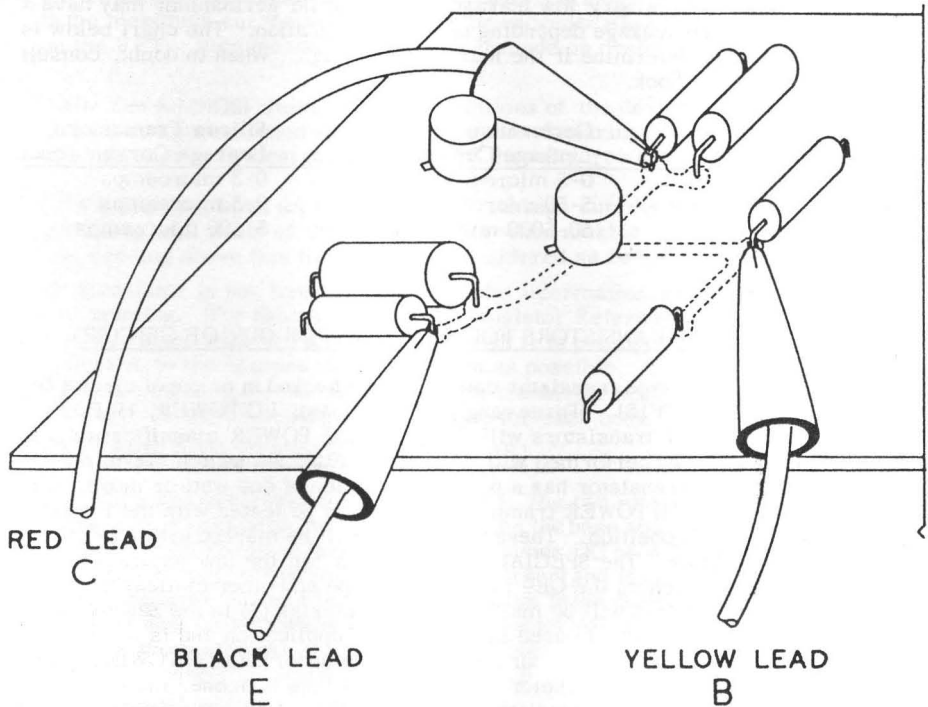


Figure 4. Connecting To A Transistor Wired On Printed Circuit Board

2. Set the function switch to LO POWER X10 (HI POWER X10 for High power transistors or SPECIAL RF X1 for low saturation transistors) and the TYPE switch to the desired type, NPN or PNP.
3. Rotate the BETA CAL control until the meter reads on the BETA CAL line on the meter. Push the GAIN button and read the actual AC beta of the transistor on the meter scale marked BETA. The reading will be multiplied by 10 for the actual beta figure, if the Function Switch is in the X10 position.

If the meter reads to the right of the BETA CAL line, or less than 10 when using the LO POWER X10 or HIPOWER X10, switch the Function switch to the X1 range, recalibrate the BETA CAL control, and push the GAIN button to read the beta. For the X1 ranges, the meter scale is read directly. The chart below gives the transistor problems that can occur and how they will look on the TF151.

REGULAR TRANSISTOR CHART

TROUBLE

AS APPEARS ON TF151

Open Base, Emitter or Collector

Cannot BETA CAL when transistor is tested out of circuit. In circuit TF151 may BETA CAL through circuit impedances but no beta reading can be obtained when GAIN button is depressed.

TROUBLE

AS APPEARS ON TF151

| | |
|--|--|
| Base to Emitter short | TF151 will BETA CAL, but TYPE switch must be in wrong position. Beta reading will be all the way to left or greater than infinity with meter pointer vibrating. |
| Base to Collector short | TF151 will BETA CAL, but when GAIN button is depressed, meter indication will not change. |
| Emitter to Collector short | If there is a dead short, TF151 will not BETA CAL. If there is a low resistance short the TF151 may BETA CAL, but the meter needle will vibrate rapidly when checking beta. |
| Collector and Base leads interchanged | TF151 will BETA CAL, but meter reads to right (a beta of less than one). |
| Emitter and Collector leads interchanged | TF151 will BETA CAL, but meter may read to right (a beta of less than one) indicate a very low beta figure. A few transistors may read the same as they are made to have the Emitter and Collector leads transposed. |
| Base and Emitter leads interchanged | Transistor will BETA CAL as opposite polarity transistor and no Beta reading is obtained when GAIN button is depressed. |

Sometimes if a transistor is shunted with another transistor or diode directly across one of the junctions, it may indicate as an open or shorted transistor. If there is any doubt, disconnect one or two of the leads and recheck the transistor. In this case, the base lead is the best to start with.

If a transistor checks defective in-circuit, but good out of circuit, be sure to check the other components in that circuit for defects, especially capacitors and diodes. It is a good idea to also check the other components in the circuit when the transistor checks bad both in and out of circuit. Very likely, the transistor defect was caused by the failure of some other component.

CHECKING REGULAR TRANSISTORS FOR LEAKAGE (I_{CBO})

The leakage between the base and collector (I_{CBO}) is one of the most important parameters of the transistor. This must be measured out of the circuit to prevent the circuit components from affecting the reading.

1. Connect the E, B, and C test leads to the transistor as previously described.
2. Set the Function switch to the LEAKAGE (I_{CBO}) position on the regular transistor section and the Type switch to the desired type, NPN or PNP.
3. Read the leakage in microamps directly on the red LEAKAGE scale of the meter.

TESTING FIELD EFFECT TRANSISTORS

The Field Effect transistor is fairly new in the electronic industry but its use has become quite wide spread. It is unlike the regular or bi-polar transistor that operates on a current principle and has its gain measure in current (beta). The FET is very much like a vacuum tube, it has high impedance input, is voltage operated, and its gain is measured in micromhos. The chart below gives a comparison between the different devices.

| PARAMETER | TRANSISTOR | FET | TUBE |
|-------------------|--|--|--|
| Input Impedance | Low | High | High |
| Gain measured in | $\frac{\text{Current out} = \text{Beta}}{\text{Current in}}$ | $\frac{\text{Current out} = G_m}{\text{Voltage in}}$ | $\frac{\text{Current out} = G_m}{\text{Voltage in}}$ |
| Warm up time | Short | Short | Long |
| Power Consumption | Small | Small | Large |

From the chart, you can see that the FET combines the advantages of the bi-polar transistor with that of the vacuum tube. To test the FET, the gain must be measured in G_m or micromhos and the gate leakage which is similar to grid leakage in a tube, must be measured.

DEPLETION AND ENHANCEMENT MODES IN FIELD EFFECT TRANSISTORS

The field effect transistor is unlike the regular or bi-polar transistor in many ways. One of the differences is in the mode of operation or how the applied bias effects the drain current of the device. There are three modes of operation of the FET, the depletion mode, the enhancement mode, and the depletion enhancement mode. A depletion mode FET is the junction type. It is biased just like a tube, with the gate at the opposite polarity of the drain potential. At zero bias, the maximum drain current will be flowing, much like a tube. The enhancement mode is just the opposite of the tube, or much like that of the regular bi-polar transistor. The gate bias is of the same polarity as the drain or a forward bias. At zero bias, the enhancement FET it cut off and only a minute amount of drain current will be flowing. To get the proper bias on the FET for testing, the TF151 has a BIAS switch on the lower part of the panel. There are two positions, NORM for the depletion type FETs and POS for the enhancement type FETs. In the NORM position, zero bias is applied to the FET and in the POS, a forward bias is applied. Although the depletion type is the most popular and is widely used at present, the enhancement type will probably take its place among the leaders because of the ease of bias and coupling.

MEASURING G_m of the FIELD EFFECT TRANSISTOR IN OR OUT OF CIRCUIT

Both junction and insulated gates, sometimes referred to as MOSFET or IGFET can be checked in or out of the circuit with the TF151. If the FET is a dual gate type, both gates may be checked independently for greater accuracy.

To oonnect and make the test on an FET in or out of circuit:

1. Connect the Source, Drain, and Gate leads as shown in figure 5 or 6. The blue lead is connected to the second gate of dual gate FETs. (See the section on dual gate field effect transistors when testing these devices).
2. Set the function switch to GAIN (G_m) X1 range on the Field Effect Transistor side of the TF151 and the type switch to the type to be tested, either 'N' channel or 'P' channel.
3. Set the BIAS switch to NORM for most junction and insulated gate FETs, or to POS for the enhancement type FET. When in doubt, consult the Sencore Transistor manual that comes with the TF151.
4. Rotate the G_m ZERO control until the meter reads zero (0) and then depress the GAIN button and read the top scale of the meter directly in micromhos.

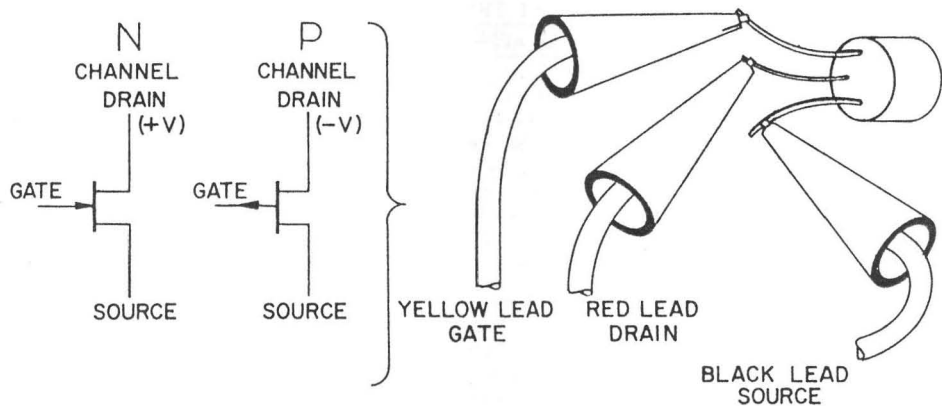


Figure 5. Connecting To A Field Effect Transistor For In-Circuit And Out Of

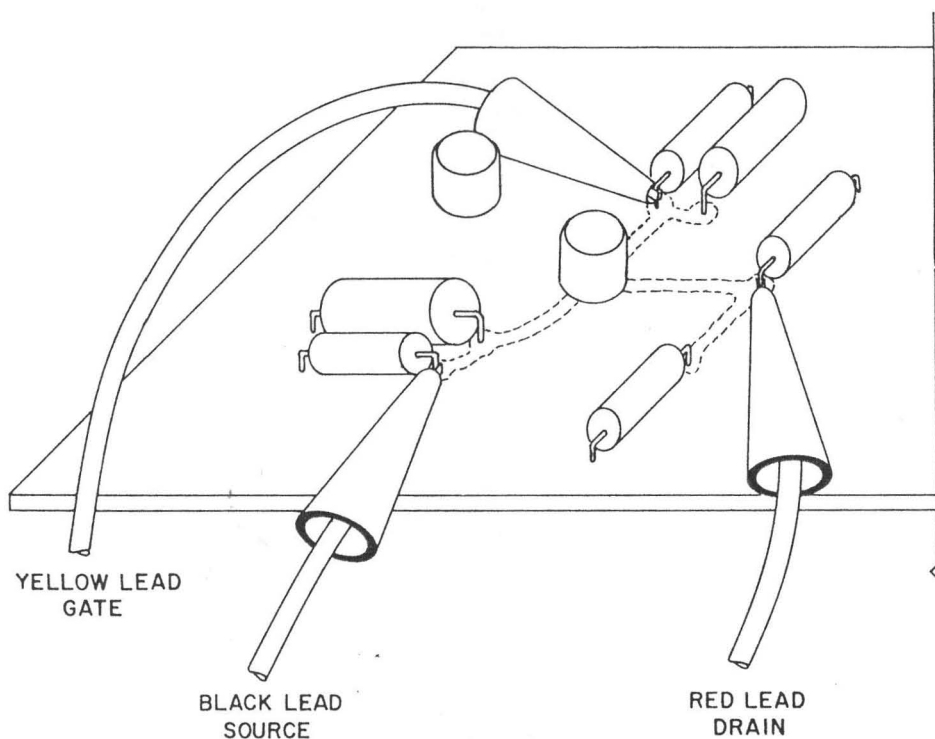


Figure 6. Connecting To A Field Effect Transistor Wired On Printed Circuit Board

If the meter reads to the right or a Gm of greater than 5000, set the Function switch to the GAIN (Gm) X10 position and multiply the reading obtained on the Gm scale of the meter by 10 for the actual Gm of the FET.

| <u>TROUBLE</u> | <u>FET TROUBLES</u> <u>AS APPEARS ON TF151</u> |
|--|--|
| Short, gate to Source | Meter can be zeroed but no Gm reading |
| Short, gate to Drain | Meter can be zeroed, but needle vibrates rapidly and changes only slightly when GAIN button is depressed |
| Short, Source to Drain | Meter can be zeroed but needle vibrates rapidly - no Gm reading when GAIN button is depressed |
| Gate open | Meter can not be zeroed and needle wanders around |
| Source open | Meter can be zeroed but no Gm reading when GAIN button is depressed |
| Drain open | Meter can be zeroed but no Gm reading when GAIN button is depressed |
| N Channel set for P channel or P channel set for N channel | Meter can be zeroed but needle vibrates rapidly. Meter reading is negative when GAIN button is depressed. Leakage position gives full scale deflection of meter. |
| Gate and Source leads interchanged | Meter can be zeroed but Gm reading is in the negative direction |
| Gate and Drain leads interchanged | Meter can be zeroed but Gm reading is in the negative direction |
| Source and Drain leads interchanged | Normal operation |
| BIAS switch in wrong position | No Gm reading on enhancement types. Depletion types may zero and give a Gm reading, but meter pointer vibrates rapidly indicating excessive current drain from power supply. |

CHECKING GATE LEAKAGE (I_{GSS}) OF FIELD EFFECT TRANSISTORS

Gate leakage (I_{GSS}) is a very important parameter in an FET. It is similar to the grid leakage in a vacuum tube and can cause somewhat the same type of problems in the circuit. In IF circuits, it can upset the gain of the system, and cause AGC problems. The leakage actually lowers the input impedance of the FET and can cause unbalance of bridge amplifiers using the FET. The TF151 can check the gate leakage of a junction or insulated gate FET and can also check both gates of a dual gate FET. The leakage should be checked out of circuit as the circuit impedances may cause a leakage reading on the meter, even though the FET has no leakage.

1. Connect the Source, Drain, and Gate leads as described before.
2. Set the function switch to the LEAKAGE (I_{GSS}) position on the Field Effect Transistor side of the TF151 and the TYPE switch to the desired type, 'N' or 'P' Channel.
3. Read the leakage in microamps directly on the red LEAKAGE scale of the meter.

Leakage in an FET is extremely low, and any indication of leakage on the TF151 can be considered bad, indicating, a defective FET. The actual maximum leakage rating can be found in the Sencore FET and Transistor Reference Book supplied with the TF151.

If the Field Effect transistor is a dual gate type, the leakage of the second gate can be easily checked by simply setting the Function switch to the LEAKAGE (I_{G2SS}) position and reading the meter on the leakage scale for leakage of the second gate.

The gate leakage of an FET is extremely small and may not appear to move the pointer of the meter at all. If the meter moves any amount on an FET, the FET can be considered defective and should be replaced. To check to see if the meter has moved you may disconnect the gate lead from the FET while watching the meter needle when checking for leakage. Any movement of the meter when connecting or disconnecting the gate lead indicates a leakage and a defective FET.

ZERO BIAS DRAIN CURRENT (I_{DSS})

Zero bias drain current or I_{DSS} is a very important parameter to the FET. This test is used to match and "CULL" FETs for various circuits and on the production line. An FET may have a very wide range of I_{DSS} and will have to be selected to work in the various circuits designed by the different manufacturers. In a balanced bridge circuit or differential amplifier, the two FETs must be matched for G_m and I_{DSS} for the circuit to be balanced and work properly. In a cascode amplifier circuit, the upper FET should have a zero bias drain current of two to four times that of the lower FET for best gain and stability of the circuit. Thus, the manufacturers will select the FETs to match the circuit and will generally color code them. When ordering replacement FETs from the manufacturers, be sure to specify the color code of the FET for best operation of the circuit.

With the TF151, the I_{DSS} check will give you the actual zero bias drain current for depletion type FET's. Enhancement type FET's are forward biased and I_{DSS} is not measured. However, the drain test current that is indicated when the I_{DSS} button is pushed is useful for matching, culling, etc.

The following example shows how the zero bias drain current can affect the circuit and if the wrong value is chosen, the possibility of failure in a very short period of time is great. The example is with the depletion type FET, but the readings obtained with the enhancement mode FET can be used for similar calculations as well as FET matching.

If a replacement type FET is put into a circuit, the zero bias drain current should be checked with the TF151 and the power dissipated across the FET calculated, to be sure that you do not exceed the maximum rating of the device. In the example of figure 7, three FET's with different I_{DSS} are considered for replacement in the circuit. If the FET has a maximum dissipation of 100 milliwatts, all three could be used. However, FET B would be running at its maximum dissipation and would have a good chance of failure in a short period of time as compared to FET A. To compute the dissipation, follow these simple steps:

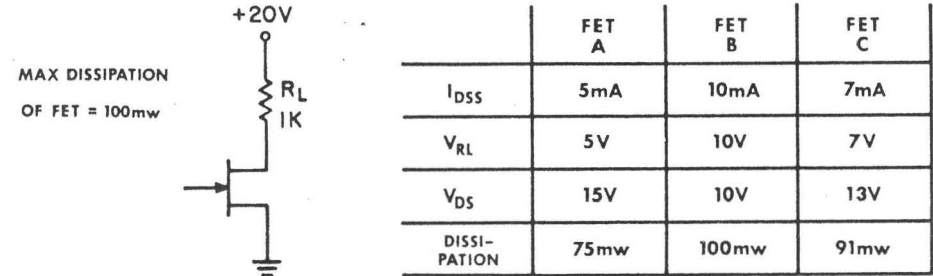


Figure 7. Field Effect Transistor Replacement In A Circuit

1. Measure the I_{DSS} with the TF151
2. Multiply the current in step one by the value of the drain load resistor.
3. Subtract the voltage across the load resistor from the drain supply voltage.
4. Multiply the voltage across the FET from step three by the I_{DSS} measured in step one. This is the dissipation across the FET in watts.

DUAL GATE FIELD EFFECT TRANSISTORS

The dual gate FET can easily be checked with the TF151 in or out of circuit for G_m , and out of circuit for leakage. When connecting MOS or IG dual gate FETs to the TF151, the second gate is connected to the TF151 with the GATE 2 lead. The yellow lead is for gate 1 and the blue lead for gate 2. The first test listed in the Sencore Reference Book is for the first gate. The second test, listed as GATE 2, is for the second gate. Make the tests on Gate 1 and then set the function switch to the GATE 2 tests and repeat the test to completely check out the dual gate FET. Most dual gate FETs are of the insulated gate type. If the dual gate FET is a junction type, such as 3N124, it must be checked as a regular, single gate FET. The first and second gate leads of the FET must be shorted together and connected to the TF151 with the yellow lead (Gate 1). The blue lead (Gate 2) is not used for this test.

DUAL FIELD EFFECT TRANSISTORS

There are also dual FETs, that is, one package that contains a matched pair of FETs with independent leads for each element. To check these properly, both FETs should be checked and the readings compared. If they do not match within 10%, the entire unit is probably defective and should be replaced. These units are used in differential amplifiers and bridge circuits where the FETs must be matched.

SAFETY PRECAUTIONS WITH THE MOSFET OR IGFET

The insulated gate, often called the IGFET or MOSFET are very delicate devices out of the circuit. In circuit, they are just as rugged as the junction type FET. Out of circuit, the insulated gate type is subject to damage from static charges when handled. The insulated gate FET is generally shipped with the leads all shorted together to prevent damage in shipment and handling. To test the insulated gate out of circuit, the leads from the TF151 should be connected before the short is removed from the FET leads. The following points should be followed when checking the MOSFET or insulated gate FET.

1. When a MOSFET is to be unplugged from a unit for testing, your body should be at the same potential as the unit. This can be easily accomplished by placing one hand on the chassis before you unplug the FET. Before the FET is connected to the TF151, put the hand holding the FET against the front panel of the TF151 and connect the source lead from the TF151 to the source of the FET. This procedure prevents possible damage from static charges to the FET. A lead clipped from the TF151 case to your watch band or ring is quite useful when a large quantity of FETs are to be tested.
2. When handling the insulated gate FET, the leads must be shorted together. This is generally done in shipment by a shorting ring or piece of wire. Connect the test leads of the TF151, with the source lead being first, to the FET. The shorting ring or wire may then be removed without fear of damage.
3. When soldering or unsoldering the insulated gate FET, the iron tip must be at ground potential. Connect a clip lead from the barrel of the soldering iron to the TF151 case or to conduit ground. Do not use a soldering gun.
4. Turn the power to the circuit off before inserting or removing an FET. The voltage transients that are generated may damage the FET.

MATCHING OF TRANSISTORS, FIELD EFFECT TRANSISTORS AND DIODES

The TF151 is ideal for matching of transistors, field effect transistors and diodes. In such circuits as a ring demodulator, audio output stage, bridge circuits and others,

the devices used must be matched for the best operation of the circuit. If only one device is to be replaced, the TF151 can be used to measure the important parameters of the good device and then measure the replacement device to find one that matches. In bi-polar transistors, the beta and I_{CBO} should be matched for the best operation. This is especially true in power stages such as an audio out put stage. If the leakage is not matched, the circuit can be unbalanced and cause trouble again in the near future.

For the best demodulation in the new diode demodulators used in color TV or in a ring type demodulator, the diodes should be matched for forward and reverse currents. The reverse current is often referred to as the leakage of the diode. An unbalance of leakage in a demodulator circuit can cause an upset in the color on the receiver screen.

The field effect transistor should be matched for I_{DSS} (zero bias drain current) as well as G_m for proper operation in its circuit. In many cases, the I_{DSS} is extremely important as it can determine the proper operating point as well as the stability of the circuit.

TRANSISTOR SUBSTITUTION

Many replacement lines of transistors are now available to the service industry. They run from as few as six to as many as 24 different types to replace the different types used in television and radio. Each of these manufacturers print a replacement guide for common transistors you may encounter. These can be obtained from your local electronic parts distributor.

When the transistor number is not listed in the replacement guide, it becomes very difficult to guess just what type should be put in place of the defective transistor.

In most cases, it can be narrowed down to an IF, RF, or audio type. To simplify matters, find a similar number transistor in the set you are working on and measure the parameters with the TF151 and check the replacement list in the back of the Sencore Reference Book that comes with the TF151 to find a transistor that comes close. The manufacturers replacement guide should be consulted to determine if the type is for RF, IF, or audio applications. By making a comparison check with the TF151, much time can be saved in waiting for a direct replacement type from the manufacturer. This may not work in all cases due to the critical nature of some circuits, but should be tried when you need a fast substitute to get things going.

Be sure to check the collector breakdown voltage so that the replacement type will not break down in the circuit. A good rule to follow is that the collector breakdown of the replacement transistor should be equal to or greater than the applied voltage to that stage it is replaced in.

CHECKING DIODES AND RECTIFIERS IN-CIRCUIT

The TF151 will check diodes and power rectifiers in circuit for both open or shorts with a very low impedances across it. To connect the diode for in-circuit checks see figure 8 and use the following steps:

1. Connect the black lead to the cathode or positive lead of the diode.
2. Connect the red lead to the anode of the diode.
3. Set the Type switch to NPN and the function switch to LO POWER X10 position. If the diode is a power rectifier, set the function switch to HI POWER X10.
4. Rotate the BETA CAL control fully clockwise. If the meter reads up scale to the right, the diode is good and has diode action. If the meter does not move, the diode is either open or shorted. However, it may be shunted by a defective component. Remove the diode from the circuit and recheck using the out of circuit check described below to determine if it is the diode or some other component.

CHECKING DIODE AND RECTIFIERS OUT OF CIRCUIT

A more accurate check out of the circuit may be made on a diode or rectifier with the leakage position on the TF151. The actual reverse current or leakage can be measured and compared with the forward current to find the actual front to back ratio of the diode. To connect the diode for the out of circuit test, see figure 9 and use the following steps:

1. Connect the red lead to the anode of the diode.
2. Connect the yellow lead to the cathode or positive lead of the diode.
3. Set the function switch to LEAKAGE position and the Type switch to NPN. The meter should indicate forward current and read at or near full scale.
4. Switch the Type switch to the PNP position and read the reverse current of the diode on the meter on the MICROAMP scale of the meter.

The two readings may now be compared to find the actual front to back ratio of the diode. In normal practice, the forward current should be at least 10 times as large as the reverse current or leakage for good diode action. A germanium diode will have a reverse leakage range around 10 to 50 microamps whereas a silicon diode may not register on the TF151 meter.

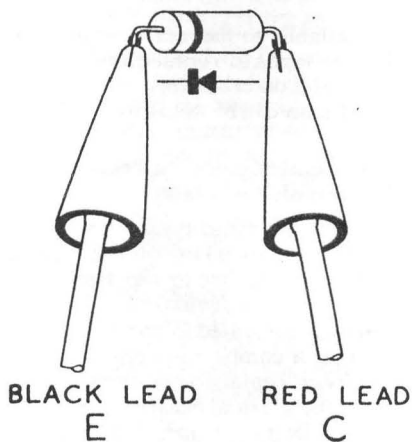


Figure 8. Connecting Diode Or Rectifier For In-Circuit Testing

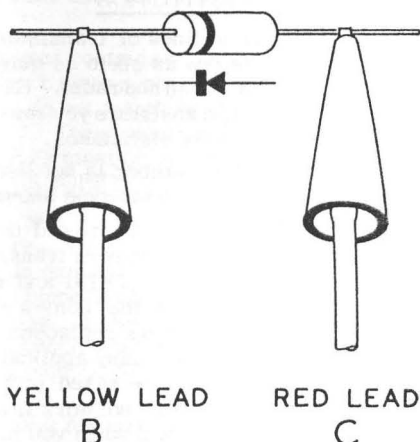


Figure 9. Connecting Diode Or Rectifier For Out-Of-Circuit Testing

ZENER DIODES

Zener diodes may be checked with the TF151, but the results will not indicate the regulating point of the diode. Zener diodes above eight volts will exhibit no leakage and will show good forward conduction on the out of circuit test. A Zener diode of around six volts will have a reverse leakage of better than three quarters full scale or around 2000 microamps and a zener diode of less than five volts will read the same in both directions, due to the zener effect. Therefore, a check on a zener diode may be misleading unless you are aware of this effect.

VARICAP DIODES

A varicap diode is just like a regular silicon diode. The only difference between the two is that the varicap diode has a controlled capacity effect. The varicap diode, when checked on the TF151 will appear the same as a regular silicon diode. The reverse current or leakage will be one of the most important checks on this type of diode. Excessive reverse leakage current will cause the Q of the varicap to be lower than normal which will reduce the sensitivity of a receiver or reduce the output of an oscillator circuit.

CHECKING OTHER SEMICONDUCTOR DEVICES

There are many other semiconductor devices other than the transistor, FET, or the diode. Such things as the unijunction transistor, SCRs DIACs, TRICAS, and others are being used in industrial applications. These devices require a very elaborate test which can not be performed on the Sencore TF151 accurately or with the voltages and currents available.

SOLID STATE SERVICING HINTS

1. Be sure the power to the equipment is turned off or the line cord is removed from the AC receptical when making in-circuit tests or repair work. Transistors can be damaged from the transients developed when changing components or inserting new transistors.
2. When servicing solid state TV receivers, use a meter and high voltage probe to measure the 2nd anode potential. If you arc the 2nd anode lead to the chassis for a spark test as done in tube circuits, you can destroy the high voltage rectifier and possibly the horizontal output transistor. The transient spikes developed may also destroy some of the small signal transistors in the receiver.
3. When working on Solid state TV or radios, do not operate them with any parts disconnected, such as the yoke or speaker. If you do, you are removing the load from the transistor and it can draw excessive current and destroy itself in a short period of time.
4. When replacing power transistors, be sure to use silicon grease to insure maximum heat transfer from the transistor. Both sides of the mica insulation should be covered for best results. Be sure also that no foreign matter such as metal shavings adhere to the mica insulator. This can cause a breakdown at a later time.
5. If an FM stereo receiver still has poor separation after the multiplex section has been realigned, check the switching transistors or demodulator diodes. The transistors should have approximately the same beta figure and the diodes should have the same front to back ratio for best separation and circuit operation. If the devices are not matched, it will cause an unbalance in the circuit and maximum separation will not be obtained.
6. Transistors and FET's are "solid" devices, but there are some cases where an intermittent can occur. If you run across a "tough dog" and suspect that you may have an intermittent, you can check the transistor or FET in-circuit and tap it lightly while watching the gain on the TF151 meter. Any changes will indicate a defective device. A can of freeze spray will also prove to be quite helpful. If the transistor changes its gain drastically or no gain indication is obtained after spraying the suspected transistor, it is an indication of a defective or intermittent transistor.
7. If you work on a particular make or model of set, log the beta or Gm readings from a good working unit on the schematic for future reference. You can take the minimum figures from the Sencore Transistor manual or get them from the manufacturer as a speed and time saving servicing convenience. Then, you merely look at the schematic to get all your necessary information. In-circuit leakage readings may also be logged in the same manner. Although the readings taken will include the circuit impedances, they can show up a defective stage quite readily if the readings are drastically different than those from a good working set.
8. When servicing transistor radios or amplifiers, be sure that the volume control is set to mid-range. If the control is set to minimum, the first audio transistor will appear to be shorted and cause a misleading reading on the in-circuit transistor tester.

DISASSEMBLY INSTRUCTIONS

To remove the TF151 from its case for recalibration of the leakage or Gm scales of the meter or any repairs that may be necessary, it is a simple matter to remove the four screws holding the chassis in the case as follows:

1. Remove the two screws on the bottom of the panel holding the panel to the case.
2. Remove the two screws at the top of the book holder on the rear of the case.
3. Lift the front panel away from the case. This will expose the Leakage and Gm calibration controls on the top of the chassis.

To reassemble the TF151, simply reverse the above procedure.

CALIBRATION OF THE TF151

Calibration of the TF151 is extremely simple and easy. There are only two calibration controls inside of the TF151, the leakage calibration and the Gm signal calibration. Both are on the top of the chassis and are accessible when the TF151 is removed from its case.

Leakage Calibration:

1. Set the TYPE switch to the NPN or 'N' channel position and the function switch to the LEAKAGE position on the regular transistor side of the switch.
2. Connect the positive lead of a 1 milliamp meter to the C or collector jack of the TF151 and the negative lead to one side of a 2K pot.
3. Connect the other side of the 2K pot to the B jack of the TF151. Adjust the 2K pot for a reading of 1 milliamps on the external meter.
4. The TF151 meter should now read 1 milliamp. If it does not, adjust the LEAKAGE CAL control on the top of the chassis until the TF151 meter reads 1 milliamps. See figure 10 for location of control.

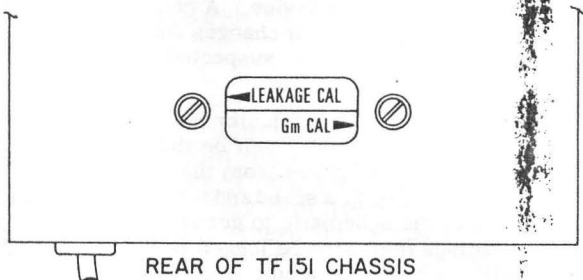
Gm Calibration:

1. Connect an oscilloscope such as the Sencore PS148 ground lead to the S or source jack of the TF151 and the vertical input to the G1 or gate jack.
2. Set the function switch to the GATE 1 section on Gm X1 and depress the GAIN button. The signal should be a square wave and be 0.34 volts peak to peak. If the signal is not 0.34 volts peak to peak, adjust the Gm CAL control on top of the TF151 chassis until the signal output is 0.34 volts peak to peak. The Gm X10 range signal is taken from the X1 range through a precision resistor and needs no adjustment.

*BIAS
SW. IN NORM!*

Figure 10.

Location Of Leakage And G_m
Cal Controls In The TF151



CIRCUIT DESCRIPTION

The Sencore TF151 is a unique breakthrough in solid state servicing equipment. It incorporates a regular transistor tester and a field effect transistor tester in one piece of equipment.

The regular transistor section is used to measure the AC beta of a transistor. This is accomplished by applying a 60 Hertz signal simultaneously between the collector and the emitter and between the base and the emitter. The ratio of average collector current to average base current as the transistor conducts on each half cycle is the beta.

The amount of AC signal applied to the transistor by T1 is controlled with the BETA CAL control R1. It is adjusted for each transistor under test so that the average collector current will be .2 milliamps, 2 milliamps, or 20 milliamps depending upon the setting of the FUNCTION switch. The .2 mA is for low saturation type transistors, the 2 mA for low power transistors, and 20 mA for power transistors for a more accurate check. The average collector current is indicated on the meter and is adjusted for the proper value by setting the meter to full scale with the BETA CAL control at the level selected by the FUNCTION switch. When the GAIN button is depressed, the meter is transferred to the base circuit to measure the average base current. In the X1 ranges, the meter has the same sensitivity and will measure .2, 2, or 20 mA of base current. In the X10 range, the meter is 10 times more sensitive and will measure one tenth of the collector current as full scale base current. Zener diodes CR1 and CR2 are used to keep the applied AC signal from changing due to line voltage variations. Capacitors C3 and C4 in the collector and base circuits provide the "short circuit" to the AC signal that is required in making the AC beta measurements. The TYPE switch S2 controls the meter polarity and applies the correct polarity of voltage to the transistor in the leakage test. Capacitor C5 prevents the transistor under test from developing spurious high frequency oscillations.

Leakage is measured by applying four volts DC between the collector and base and measuring the current that flows. The DC voltage is developed from transformer T2, diodes CR5 and CR6 and is regulated to six volts by zener diode CR7. The four volts for the leakage test is divided down from the six volt supply by R6 and R5. R4 and CR4 are in parallel with the meter and are used to set up the full scale deflection of 5000 microamps on the 200 microamp meter. The nonlinearity of the diode and series resistor allow the meter to read directly for the first one half of the scale; Then the diode begins to conduct and shunt some of the current around the meter giving the nonlinear Leakage scale on the meter. This reduces the need for switching to various current ranges and reduces the confusion. The leakage section is the same for both regular transistors and field effect transistors. The function switch selects the test so that the voltage is applied to the different elements of the transistor, and the TYPE switch selects the correct polarity of voltage to be applied as well as the correct meter polarity.

The field effect transistor test section is independent of the regular transistor test section. The field effect transistor or FET must be checked just like a vacuum tube, for Gm. The unique system used in the Sencore TF151 consists of a bridge arrangement consisting of TR1, TR2, R10, R11, R12, and R14. The transistors act like a switch and are turned on or off by the AC signal applied from the transformer T2. With this system connected between the drain and source of the FET, R11, the Gm ZERO control is adjusted so that equal currents flow in the bridge and the meter reading is zero. The impedance of the bridge system is kept very low and the voltage applied to the drain of the FET under test is held constant to conform to the Gm formula so that accurate Gm measurements can be made. The signal developed by the other secondary of T2 is a constant amplitude square wave formed by diodes CR10, CR11 and resistor R16. The signal is divided down by R17, R18, and R19. R17 is adjusted so that the signal applied when the function switch is in the Gm X1 range is .34 volts peak to peak. In the Gm X10 range, the signal is taken from a precision resistor and is .034 volts peak to peak to give a ten times multiplier up to 50,000 micromhos. When the square wave signal is applied to the gate of the FET under test, it causes it to conduct heavier on one half of the cycle than the other. This causes an unbalance of current in the bridge circuit and the meter will read the unbalance. The amount that the FET will conduct is dependent upon the Gm of the device and therefore the meter can be calibrated in Gm. Switch S6 selects either NORM or reverse bias for depletion type FETs or POS or forward bias for enhancement type FETs for proper testing. The three prong line cord is connected so that the case is automatically at ground potential to conform to Underwriters Laboratories specifications. This is also done to help prevent damage to the insulated gate type FETs when checking them out of circuit.

TROUBLE CHART

The TF151 can be broken down into three sections, the regular transistor or beta reading section, the FET or Gm reading section and the leakage section. The leakage section is common to both regular transistors and FETs. If it ever becomes necessary to trouble shoot the TF151, check to see what section is giving the trouble. This will narrow down the checking to the section that is faulty.

| SYMPTOM | PROBABLE CAUSE | CORRECTIVE MEASURE |
|---|------------------------------|---|
| Leakage and Gm OK, but no beta cal | R2 open | Check with ohm meter and replace if necessary |
| Meter pegs to left or right on Gm readings. Leakage and beta OK | CR8, CR9, TR1 or TR2 | Check diodes and transistors |
| Gm zero no effect and no leakage readings. Beta OK | CR7 or C1 shorted or R8 open | Check for +6 volts at positive end of C1. Check CR7 and C1 for shorts and R8 for open |
| No Gm readings, beta and leakage OK | CR10 or CR11 shorted | Check both diodes out of circuit with TF151 for short |
| Gm readings to high or to low | Gm cal off | See calibration information and recal Gm pot |
| No leakage readings, Gm and beta OK | CR4 shorted | Check CR4 and replace if necessary |
| Meter vibrates rapidly in Gm and beta with type switch in P or PNP position. In FET leakage, meter pegs with type switch set to N | C7 shorted | Check C7 and replace if necessary |

TF 151 PARTS LIST

| REFERENCE NO. | PART NO. | DESCRIPTION | PRICE |
|----------------|----------|------------------------------------|--------|
| R10 | 14G176 | 82 OHM 1/2W 5% | \$.30 |
| R14 | 14G265 | 100 OHM 1/2W 1% | .75 |
| R15 | 14G319 | 1.85 OHM 1/2W 2% | .65 |
| R18 | 14G317 | 20.5 OHM 1/2W 2% | .65 |
| R19, R20, R23 | 14G318 | 2.26 OHM 1/2W 2% | .65 |
| R21, R24 | 14G248 | 24.9 OHM 1/2W 2% | .65 |
| R1, R11 | 15A76 | 10K, 100 OHM Dual Control | 2.25 |
| R4 | 15S15A | 6K Linear Control | 1.50 |
| R17 | 15G26 | 100 OHM Linear Control | 1.50 |
| CR1, CR2 | 19G18 | 8 Volt Zener Diode | 1.95 |
| CR3 | 19G28A | IN695 Diode | .65 |
| CR4 | 19G16 | IN816 Diode | .75 |
| CR5, CR6, CR10 | | | |
| CR11 | 16S5 | Rectifier .5AMP @400 PIV | 1.50 |
| CR7 | 50G3 | 6.2 Volt Zener Diode | 1.95 |
| CR8, CR9 | 19G13 | IN34A Diode | .50 |
| TR1, TR2 | 19G29 | 2N5172 Transistor | .75 |
| M1 | 23C29 | 6" meter, 200 microamp, 225 ohm 5% | 22.00 |
| S1 | 25G4 | Slide Switch SPDT | .50 |
| S2 | 25A113 | Rotary Switch 8P2P | 3.00 |

| REFERENCE NO. | PART NO. | DESCRIPTION |
|---|----------|--|
| S3 | 25B114 | Rotary Switch 8P12P |
| S4 | 25A109 | Push Switch 2P2P |
| S5 | 25A110 | Push Switch 4P2P |
| S6 | 25G4 | Slide Switch SPDT |
| TR1 | 28S21 | Transformer 115 VAC PRIMARY 14.5 VAC Secondary |
| TR2 | 28B36 | Transformer 115 VAC PRIMARY 44VAC and 22VAC Secondary |
| Case Complete | | |
| TF151 Test Lead set | | |
| (PRICES SUBJECT TO CHANGE WITHOUT NOTICE) | | |

ITEMS INCLUDED WITH THE TF151

- | | |
|---|----------------------|
| 1 - Instruction Manual | 1 - Red Test Lead |
| 1 - Warranty Registration Card | 1 - Yellow Test Lead |
| 1 - Sencore Transistor - FET Reference Book | 1 - Black Test Lead |
| | 1 - Blue Test Lead |

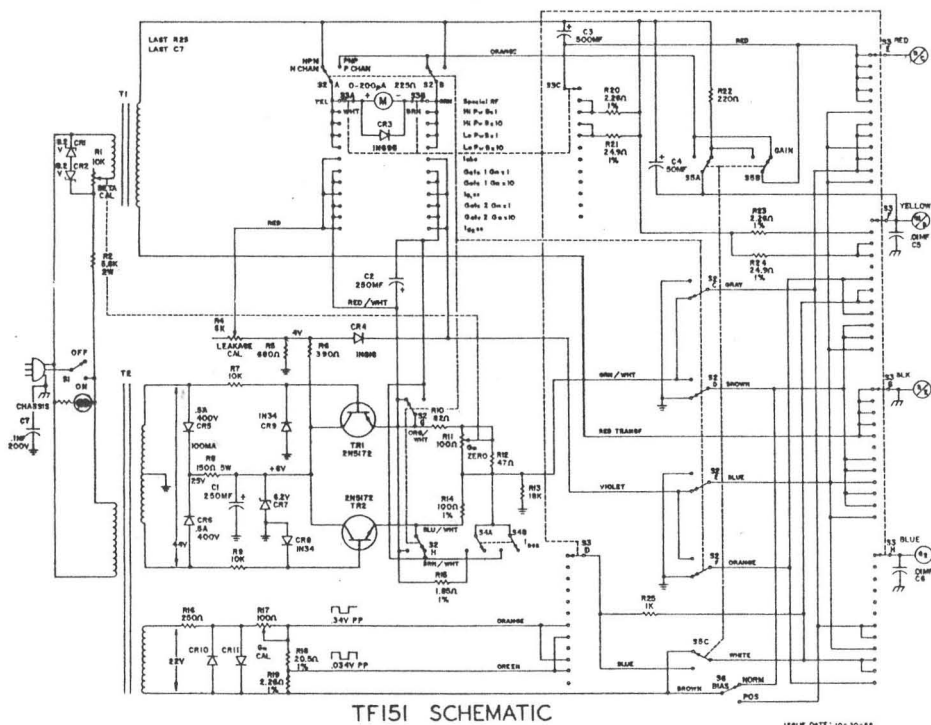


Figure 11.

Notes: 4/3/00 AC hum on FET cal procedure
No sq wave - Repaired Bias Switch
Orig Mfg Design Flaw - Switch was Shimmed
By Washer on one Side (Bracket on other)
And Riveted. Bracket Shim was Between
Sw and chassis wall. Washer Shim was on
Outside Preventing Full Switch Movement.
The Switch was Making Minimal Contact
+ Needed Freq Cleaning - Trimmed Washer

SERVICE AND WARRANTY

You have just purchased one of the finest transistor testers on the market today. The TF151 has been inspected and tested twice at the factory to insure the best quality instrument to you. If something should happen, the TF151 is covered by a standard 90 day warranty as explained on the warranty policy enclosed with your instrument.

For the best service on out of warranty work, send the TF151 directly to the factory service department. Be sure to state the nature of your problem to insure faster service.

If you wish to repair your own transistor tester, we have included a schematic, parts list, and trouble chart. Any of these parts may be ordered directly from the factory service department.

We reserve the right to examine defective components before an in warranty replacement part is issued.



SENCORE, INC.

3200 SENCORE DRIVE, SIOUX FALLS, S. DAKOTA 57107