TR 139

TRANSISTOR TESTER

SENCORE

SENCORE SERVICE MANUAL

426 S. WESTGATE DRIVE, ADDISON, ILLINOIS

OPERATING INSTRUCTIONS FOR THE SENCORE TR139

IN-CIRCUIT TRANSISTOR TESTER

"Transistorized - completely solid state - no tubes." This is the trend of present day consumer products; radios, tape recorders, hi-fi, and even TV receivers have gone the route of the transistor. The need for a transistor tester that will check the transistors right in the circuit has been met by Sencore with the TR139. The TR139 is the first in-circuit transistor checker that really works; making it a great time saver for the serviceman, lab, production line, or wherever transistors need to be tested. Very accurate out of circuit testing of transistors and diodes is also provided with the TR139. Following are some of the outstanding features of the TR139:

* Checks high power and low power transistors in-circuit for AC beta.

* Checks high power and low power transistors out of circuit for AC beta and leakage or I_{CBO}.

* Checks diodes and rectifiers in-circuit for opens and shorts.

* Checks diodes and rectifiers out of circuit for actual forward and reverse currents.

* Has large 6 inch meter for easy viewing.

* Housed in an attractive modern vinyl clad steel case.

* Cannot become obsolete.

SPECIFICATIONS

Transistor Testing

Beta (h_{fe}) measured at f=60 cycles, I_C=2.0MA, $V_{CE} \approx$ 0V

Range	Beta	Accuracy
LO	2-100	$\pm$5%
HI	10-500	$\pm$5%

Percent accuracy will be slightly higher than shown, on in-circuit testing, depending on the circuit loading of the transistor.

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.

Diodes and Rectifier Testing

In-circuit - checked for shorts and opens, can be detected with loads of 20 ohms paralleling the device.
Out of circuit - checked for forward to reverse current ratio.

Electrical

117VAC 60∿@ 2.5 watts

Physical

Dimensions - 9-1/2" high x 7-1/2" wide x 6" deep
Weight - 7 pounds

CONTROLS ON THE TR139 IN-CIRCUIT TRANSISTOR CHECKER

NPN-PNP Switch. Selects the proper polarity of DC voltage applied to the collector of the transistor under test and is used when checking the forward and reverse currents of a diode.

Off-Beta-Leakage Switch. Turns the power off and selects the HI or LO Beta range for the AC beta checks and the leakage range for LEAKAGE checks on both transistors and diodes.

Beta Test Switch. Is used only when checking the beta of a transistor and is not used in the LEAKAGE position of the function switch.

Beta Cal Control. Is adjusted for each transistor to compensate for the various internal impedance differences found in transistors and insures an accurate beta reading.

Test Jacks. E or black jack connects to the emitter of the transistor.

B or yellow jack connects to the base of the transistor.

C or red jack connects to the collector of the transistor.

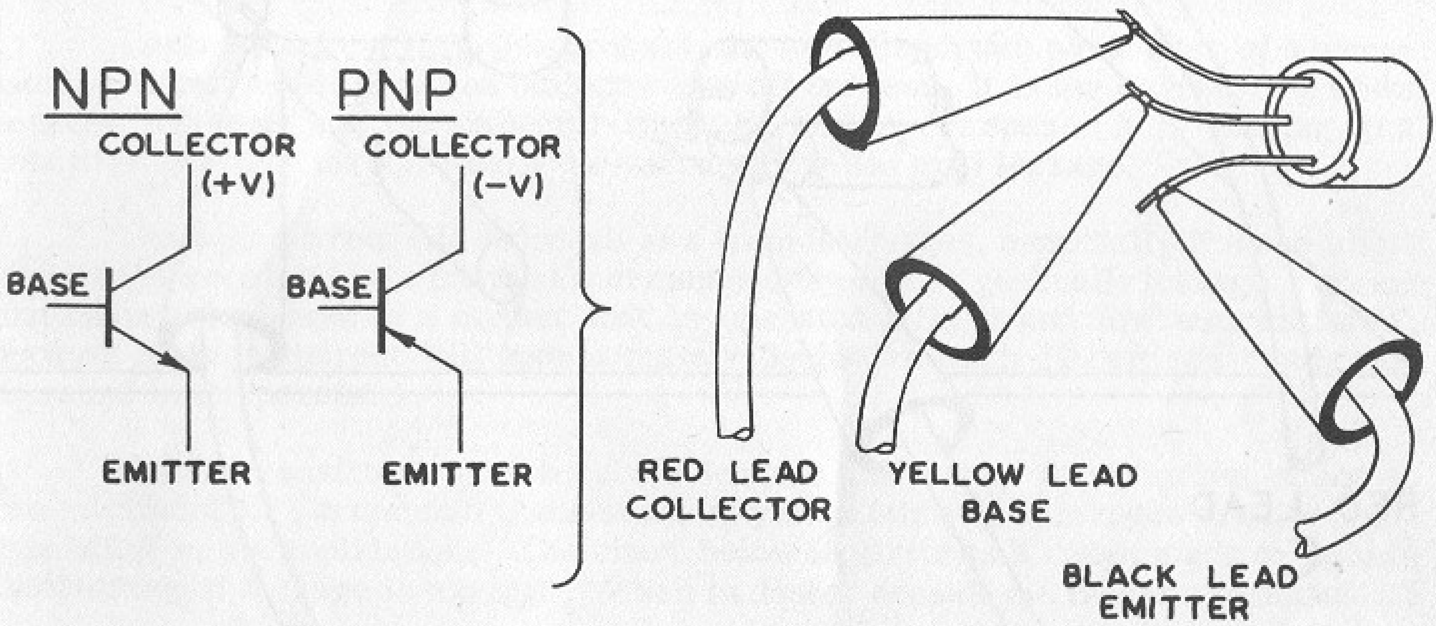


Figure 1. Connecting to transistor for in-circuit and out of circuit testing.

CONNECTING THE TR139 FOR TESTING TRANSISTORS

The TR139 is connected to the transistor the same for in-circuit and out of circuit checks.

1. Connect the red lead from the C jack (red) on the TR139 to the collector of the transistor to be tested.

2. Connect the yellow lead from the B jack (yellow) to the base of the transistor.

3. Connect the black lead from the E jack (black) to the emitter of the transistor. See Figure 1 for steps 1, 2 and 3.

When in doubt as to which lead is the base, which is the emitter, and which is the collector, consult Howard Sams transistor specifications manual HTA-1 supplied with the TR139.

Connecting the TR139 to a transistor out of circuit is very easy as the leads of the transistor are exposed. Connecting the TR139 to a transistor in-circuit may be difficult as the leads are either too short or are not accessable. It is very simple in most cases, however, to connect to the lead of another component that is connected to the transistor. See Figure 2. A light placed under the circuit board, for example, will allow you to trace down the leads of the transistor to a point whereby the clips may be connected to test the transistor. In the case of a board where this is found to be impractical, it is very easy to solder a short piece of wire to each of the transistor conductors to make the test. These may be left on, unsoldered, or simply clipped off after you are finished.

No damage will result to the transistor or circuit components if the TR 139 is accidently hooked up to the transistor improperly, unless it is left in this condition for an extended period of time.

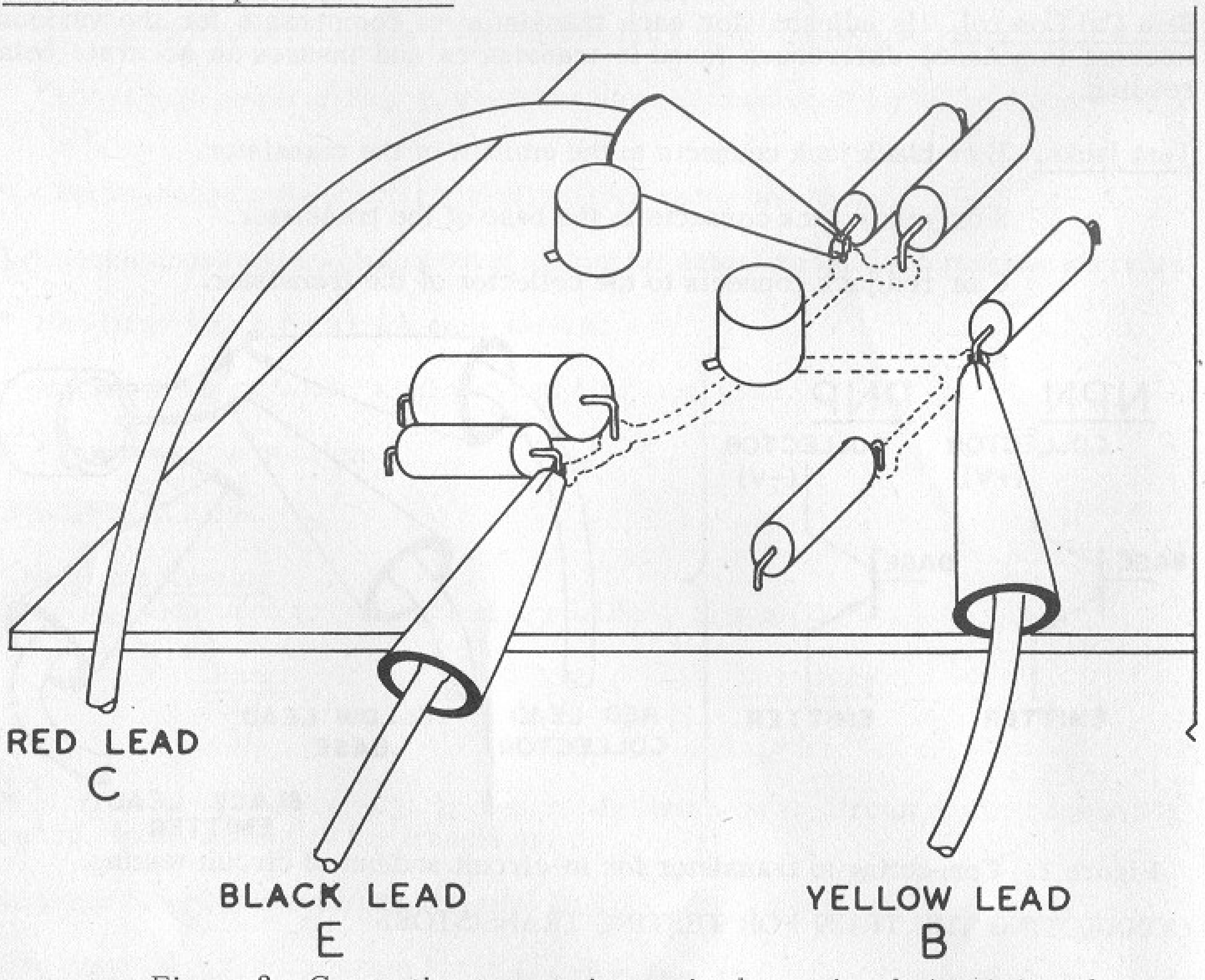


Figure 2. Connecting to transistor wired on printed circuit board.

OPERATION

The TR139 is a very versatile instrument that can be used with great success by anyone involved in the design, production or servicing of transistorized gear. It provides the answers needed in each of these areas. For example, the design engineer must know AC beta and leakage of a transistor. The production analyzer wants to know if a transistor wired in a set is shorted or open and also if the AC beta is below the minimum for that type. The service dealer, when trouble shooting, is primarily interested in whether transistors in a set are open or shorted. Any beta indication he gets is considered good, because beta does not change appreciably as a transistor gets older. Of course, if a service dealer is searching for a replacement for a defective transistor, then he will be interested in beta as well as leakage.

AC Beta and Leakage Measurements

Beta and leakage are two of the most important parameters of a transistor. Beta is the current amplification factor similar to the mu of a vacuum tube. DC beta is the ratio of collector current divided by the base current (it is referred to as h_{FE} in a transistor manual); AC beta is the ratio of the change in collector current divided by the change in base current while keeping collector voltage constant (it is referred to as h_{fe} in a transistor manual). AC beta measured at low frequencies and DC beta are very nearly the same; an AC beta measurement, however, is more revealing than a DC measurement because it is measured under dynamic conditions. Beta, unlike mu, may have a spread of 2:1 or more for a particular type transistor, and a designer will design his circuit for the low end of the beta range. When a single beta figure is given in a transistor manual it is usually the average or minimum figure.

The application of transistors also fits a general beta pattern and the chart below is given as a rough guide to the beta values of transistors found in various circuits. For more exact beta figures refer to the transistor specifications manual. You can keep your manual up to date by purchasing new editions from your distributor as they are released by Howard W. Sams Co., Inc.

Type	Beta Range
RF-IF	2-50
Power	10-100
Audio	40-400

Leakage current (I_{CBO}) is probably the most important parameter of a transistor. Sometimes it is called collector cut-off current. It is the current that flows between the base and the collector when the emitter is open. It is similar to a condition in a tube circuit where the vacuum tube has grid leakage.

Leakage current can increase as a transistor ages, especially if some slight impurities were left in the transistor at manufacture. It is generally leakage current that causes problems in a circuit that is operated at high and low temperatures, because leakage current will approximately double for each 10 degrees centigrade increase in temperature.

Silicon transistors have very low leakage currents - in the order of one to two microamps. Germanium transistors may have fairly low leakages to quite high, depending on the application. The chart below is given as a rough guide to help in determining if leakage is too high. When in doubt, consult the transistor manual.

Germanium Transistor	Leakage Current (max.)
RF-IF	0-5 microamps
Audio	5-50 microamps
Power	50-5000 microamps

Checking Transistors for AC Beta In or Out of Circuit

1. Connect the E, B and C test leads to the transistor as described above.

2. Set the function switch to HI BETA position and the NPN-PNP switch to the desired type.

3. Rotate the BETA CAL control until the meter reads on the CAL line. Push the BETA TEST button and read the actual beta of the transistor on the HI BETA meter scale.

If the meter reads to the right of the CAL line, or less than a beta of 10, when the BETA TEST button is pushed, then switch the function switch to the LO BETA range, recalibrate the BETA CAL control, and push the BETA TEST button to read beta on the LO BETA meter scale.

Open or Shorted Transistors

Open or shorted transistors are easily located in circuit or out of circuit, because the TR139 will not calibrate properly, or it will calibrate, but will not give a beta reading when the BETA TEST switch is pushed. Sometimes if a transistor is shunted with another transistor or diode directly across it, it may indicate as an open or shorted transistor. If there is any doubt, disconnect one or two leads and check the transistor out of circuit.

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. Also check the other components in a circuit when a transistor checks defective, both in-circuit and out of circuit, because very likely the transistor defect was caused by the failure of some other component.

Checking Transistors for Leakage Out of Circuit

Checking the leakage of a transistor (I_{CBO}) must be done out of circuit to prevent circuit components from affecting the reading.

1. Connect the E, B and C test leads to the transistor as described above.

2. Set the function switch to the LEAKAGE position and the NPN-PNP switch to the desired type.

3. Read the leakage in microamps directly from the LEAKAGE scale on the meter.

Checking Power Transistors

When checking power transistors out of circuit, it may be noted that there is a difference in beta when checked on the LO BETA range versus the HI BETA range. If the leakage current of the transistor is high, it will cause an increase in the beta reading on the HI BETA range. When this occurs, the transistor should be checked on the LO BETA range for the most accurate beta check.

Matching Transistors and Diodes

The TR139 can be used to pair up or match several transistors for the more critical circuits. Simply measure AC beta and leakage on several transistors of the type to be used, and select two (or more) that have the same beta and leakage. Both beta and leakage should be matched as close as possible for the best circuit action. Germanium diodes can also be matched for leakage where it is deemed necessary, by measuring the reverse leakage of each diode with the TR139. To match diodes, use the out of circuit diode check as described later in this manual.

Transistor Substitution

The TR139 will enable you to compare different substitution types of transistors and compare them against the original types. The TR139 will also enable you to compare the beta and leakage to get the best replacement transistor. When choosing a substitute transistor, a manufacturer's guide should be consulted as to a replacement type. A good reference is the Howard Sams "Transistor Substitution Handbook."

You will find substitutes as well as the base configurations listed. Below is a list of manufacturers making a substitution line of transistors where five to twenty types are used to replace thousands. A list of the transistors that can be substituted, can be obtained from your local distributor or the manufacturer.

1. General Electric
2. Motorola (HEP line)
3. RCA (SK Top of the Line series)
4. Semitronics
5. Workman (Miracle Five)

Transistor Socket Adaptor for the TR139

The TR139 is ideally suited for production line testing of transistors. The test jacks are spaced on 3/4 inch centers to allow for the use of a transistor socket adapter, such as the Pomona type 1472, for testing large quantities of transistors.

This permits the transistors to be plugged in, eliminating the need to hook up three individual test leads to the transistor terminals.

Connecting the TR139 for Testing Diodes

In-Circuit: (see figure 3)

1. Connect a lead from the E jack (black) to the cathode or positive lead of the diode.
2. Connect a lead from the C jack (red) to the anode lead of the diode.

Out of Circuit: (see figure 4)

1. Connect a lead from the C jack (red) to the anode lead of the diode.
2. Connect a lead from the B jack (yellow) to the cathode or positive lead of the diode.

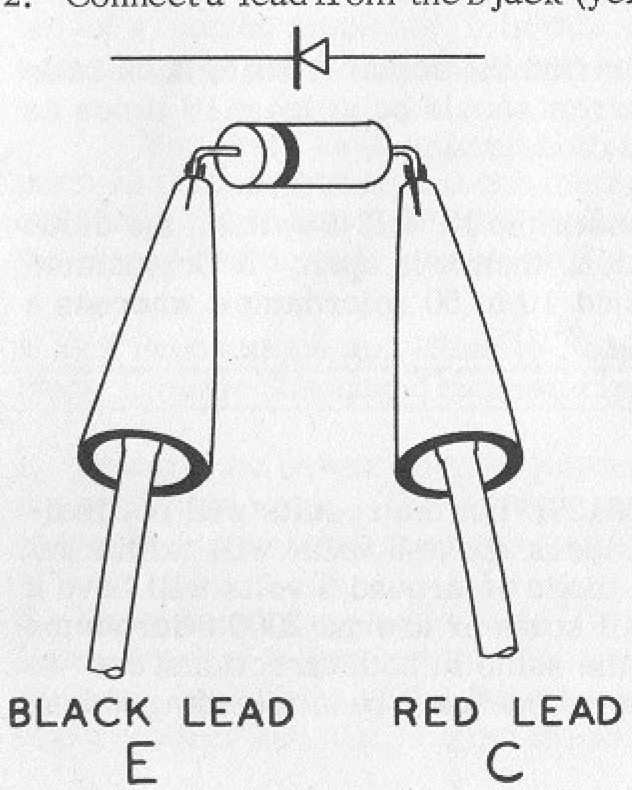


Figure 3. Connecting diode or rectifier for in-circuit testing.

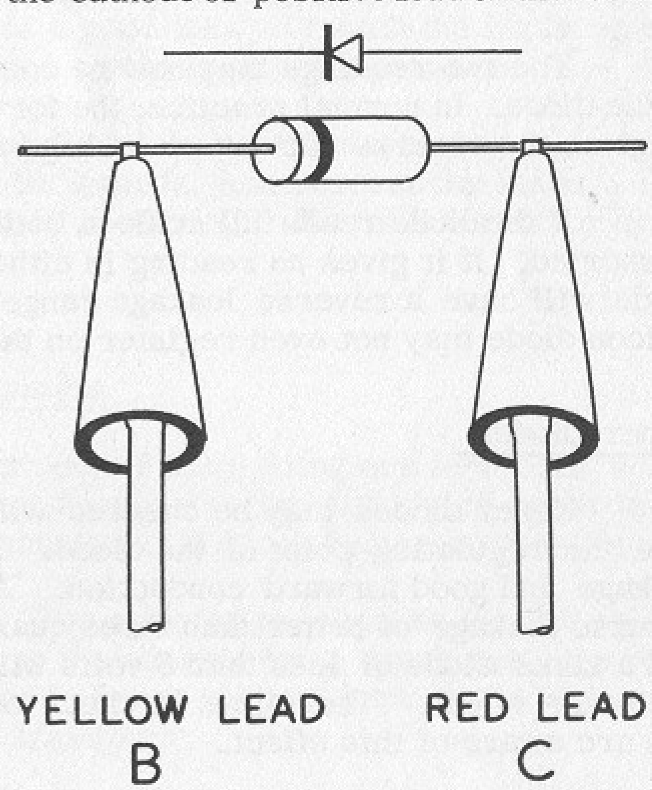


Figure 4. Connecting diode or rectifier for out of circuit testing.

Note: The TR139 is connected differently for in-circuit checks than it is for out of circuit checks on diodes and rectifiers. If the diode is connected wrong or backwards for any of these checks, no damage will result to the diode or circuit components.

Checking Diodes In-Circuit

Diodes or rectifiers may be checked quickly and easily in-circuit with the TR139. Simply connect the diode to the TR139 as described above for in-circuit checking.

1. Set the NPN-PNP switch to NPN and the function switch to HI BETA position.

2. 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 shorted or open. However, it may be shunted by a defective component. Remove the diode from the circuit and recheck to determine if it is the diode or a defective component.

Checking Diodes Out of Circuit

A more accurate out of circuit check may be made on a diode or rectifier with the TR139. 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.

1. Connect the diode to the TR139 as described above for out of circuit checking. Note, if the diode is connected for the in-circuit test and the out of circuit test is attempted, no damage will result.

2. Set the function switch to the LEAKAGE position, the NPN-PNP switch to NPN and read the forward conduction of the diode on the microamp scale of the meter. The diode should read at or near full scale or approximately 5 milliamps.

3. Switch the NPN-PNP switch to PNP position and read the reverse current or leakage of the diode 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.

If the diode reads full scale in both positions of the NPN-PNP switch, the diode is shorted. If it gives no reading in either position, then it is open. A Germanium diode will have a reverse leakage range of around 10 to 50 microamps whereas a silicon diode may not even register on the meter.

Zener Diodes

Zener diodes may be checked with the TR139, but the results will not indicate the regulating point of the diode. Zener diodes above 8 volts will exhibit no leakage and good forward conduction. A zener diode of around 6 volts will have a reverse leakage of better than three quarters full scale or around 2000 microamps and a zener diode of less than 5 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.

The TR139 in Action

To trouble shoot transistorized equipment with the TR139, all a serviceman has to know is how to hook up the leads and where he can buy replacement transistors. The TR139 does all the rest. A schematic to follow isn't even necessary when checking transistors, although it is certainly helpful when tracing out a circuit.

How does the TR139 do all of this? Easy. Merely connect the TR139 test leads to the transistor (see Fig. 2). The function switch is set to HI BETA and the BETA CAL control is adjusted clockwise until the meter CAL's. If the meter reads to the left, the NPN-PNP switch is set wrong for that transistor type. Switch to the other position and then CAL the meter. Push the BETA TEST button and read the gain (AC BETA). Does the transistor have an AC BETA? If it shows any AC BETA at all, it is probably a good transistor, because beta does not change appreciably as a transistor ages, and what you are reading is probably the same reading that it left the factory with.

On to the next transistor! Hint - it would be nice if you could isolate the trouble to a certain stage or section, because you do not have to check as many transistors that way - even if it is so simple and easy with the TR139. Back to the second transistor. It CAL's all right, but when you push the BETA TEST button the needle just sits there. When we remove the transistor from the circuit and recheck it the needle still just sits there - obviously a bad transistor, probably a shorted base. Incidently, when we took the transistor out of the circuit and rechecked it, we didn't even have to re-cal the TR139, which just goes to show that the TR139 practically ignores circuit loading. (Occasionally, you may find a transistor that reads off scale to the left when you check for beta. If the circuit is examined closely, you will probably find that another transistor is cascaded with the one you are checking or that there is a diode connected between the emitter-base junction, giving this effect.) Since we have obviously found the bad transistor, all we have to do is look up the transistor in one of the many substitution lists (see page 7) and put in the replacement. We could check the replacement transistor for beta and leakage, but it isn't always necessary, unless the transistor is in a critical multivibrator circuit or in one channel of a stereo amplifier. In that case it is a good idea to match the replacement transistor to the other transistor in the set for the best circuit operation.

You don't have to know the polarity of diodes or rectifiers, either, to check them in circuit, because if the meter reads backwards, just reverse the leads. The only time the meter will read is if the diode is rectifying. If it is shorted or open the meter needle will just sit still.

A Few Precautions and Hints to Follow When Trouble Shooting Transistorized Equipment

1. Be sure the power on the equipment is turned off when doing any in-circuit testing or repair work. The voltages may be low enough to eliminate shock hazards to yourself, but you may generate spikes and transients that can damage the transistors.

2. When servicing a solid state TV receiver, use a meter to measure the 2nd anode high voltage. If you arc the 2nd anode lead to the chassis for a spark test, the way you have been doing with tube circuits, you are almost sure to destroy the high voltage rectifier and also the horizontal output transistor.

3. When servicing transistor radios, turn the volume control up to mid-range, otherwise the audio input transistor, when checked in-circuit, may appear to be shorted.

4. If poor separation of an FM stereo receiver is still a problem after the multiplex section has been aligned, try checking the switching transistors. The beta of these transistors should be almost identical. If one has a high beta and the other has a low beta, it will cause an upset in the circuit and maximum separation will not be obtained.

5. It is true that transistors are "solid" devices, but there are some cases where intermittent transistors have been found. If you have a real "tough dog" intermittent set on the bench and cannot find any bad solder joints on the PC board, try tapping the transistors while you are testing them, and watch for any changes in the beta reading.

6. If you work on a particular type or make of set, log the beta readings from a good working set on the schematic for future reference and servicing speed. You might also get these minimum or average beta figures from the manufacturers of the set. Some manufacturers, such as Motorola, are starting to include beta figures on their schematics.

It is helpful to know the minimum beta requirement of each transistor, because a replacement transistor can then be checked to be sure that it is in the range of normal beta for the circuit.

Disassembly Instructions

To remove the TR139 from its case for recalibration of the microamp scale or any repairs that may be necessary:

1. Remove the two screws on the bottom of the panel holding the panel to the case.

2. Remove the two screws holding the cord wrapper to the rear of the case.

3. Lift the front panel away from the case. This will expose the calibration control and the chassis of the TR139.

Calibration of the TR139

The microamp scale of the TR139 may be periodically checked and recalibrated with the following procedure. To recalibrate the TR139, it must be removed from its case.

1. Set the NPN-PNP switch to NPN and the FUNCTION switch to LEAKAGE.

2. Connect the positive lead of a 5 milliamp meter to the C jack of the TR139 and the negative lead to one side of a 2,000 ohm pot.

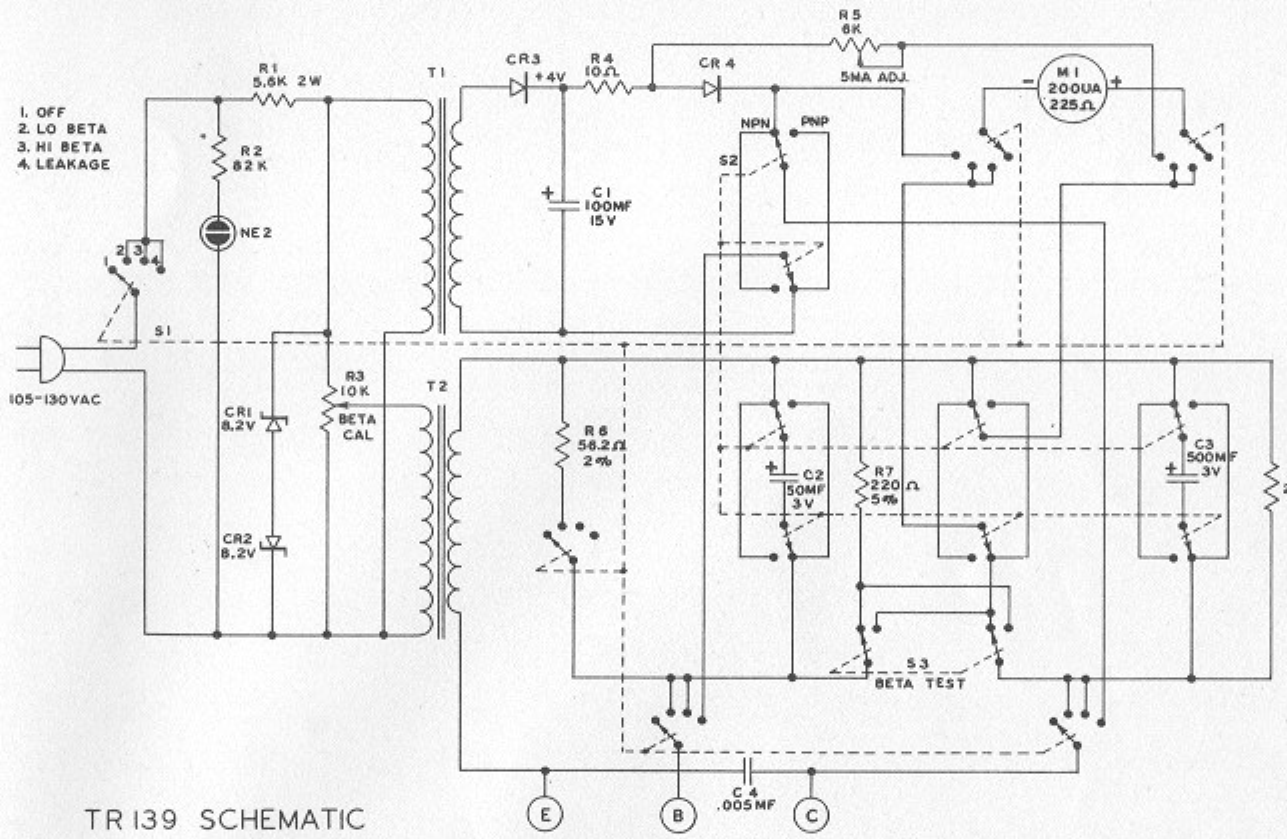
3. Connect the other side of the 2,000 ohm pot to the B jack of the TR139. Adjust this 2,000 ohm pot for a reading of 5 milliamps on the 5 milliamp meter.

4. The meter on the TR139 should now also read full scale or 5 milliamps. If it does not, adjust the milliamp cal control found on the top of the TR139 chassis until the TR139 meter reads 5 milliamps.

Circuit Description

The TR139 measures AC beta of a transistor by applying a 60 cycle 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 beta. The amount of AC signal applied to the transistor by T2 is controlled with the BETA CAL control R3. It is adjusted for each transistor under test so that the average collector current will be 2 milliamps. This is the current that the meter indicates before the BETA TEST button is pushed. When the BETA TEST button is pushed the meter is transferred to the base circuit to measure average base current. The circuit is designed so that in the HI BETA position one tenth of the collector current (0. 2MA) will give full scale meter indication (beta=10) and in the LO BETA position one half of the collector current is needed for full scale indication (beta=2). The AC signal applied to the transistor is regulated with zener diodes CR1 and CR2 to prevent AC line variations from affecting the beta readings. Capacitors C2 and C3 in the base and collector circuits provide the "short circuit" to the AC signal; that is one of the requirements of measuring AC beta. They are switched with the NPN-PNP switch, S2, so they always have the correct polarity. S2 also controls the meter polarity and applies the correct polarity of voltage to the transistor in the leakage test. Capacitor C4 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 by half wave rectifier CR3 and filter capacitor C1. R5 and CR4 are used to compress the upper half scale of the meter so that only one leakage range is needed.



TR 139 SCHEMATIC

Reference	Description	Part No.	Price
CR1, CR2	Zener diode 8. 2V	19G18	$ 1.95
CR3, CR4	Silicon rectifier	16S5	1. 50
M1	Meter, 0-200 microamp	23C22	20. 00
R3	Control, 10K ww	15G12A	3. 00
R5	Control, 6K carbon	15S15A	.75
S1	Switch, 6P4P	25A87	5. 95
S2	Switch, 8P2P	25A86	4. 95
S3	Switch, 2P2P snap action	25G88	1. 50
T1	Transformer	28B27	3. 95
T2	Transformer	28S21	3. 25
	Panel	10C178	5. 00
	Case	10C180	7. 50
	Cord wrapper	10A181	.75

Service and Warranty

You have just purchased one of the finest pieces of test equipment on the market today. The TR139 has been inspected and tested twice at the factory to insure the best in quality to you. If something should happen, the TR139 is covered by a standard 90 day warranty as explained on the warranty policy enclosed with your instrument.

For best service on out of warranty work, send the TR139 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 TR139, we have included a schematic and parts list. 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.

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Form #314