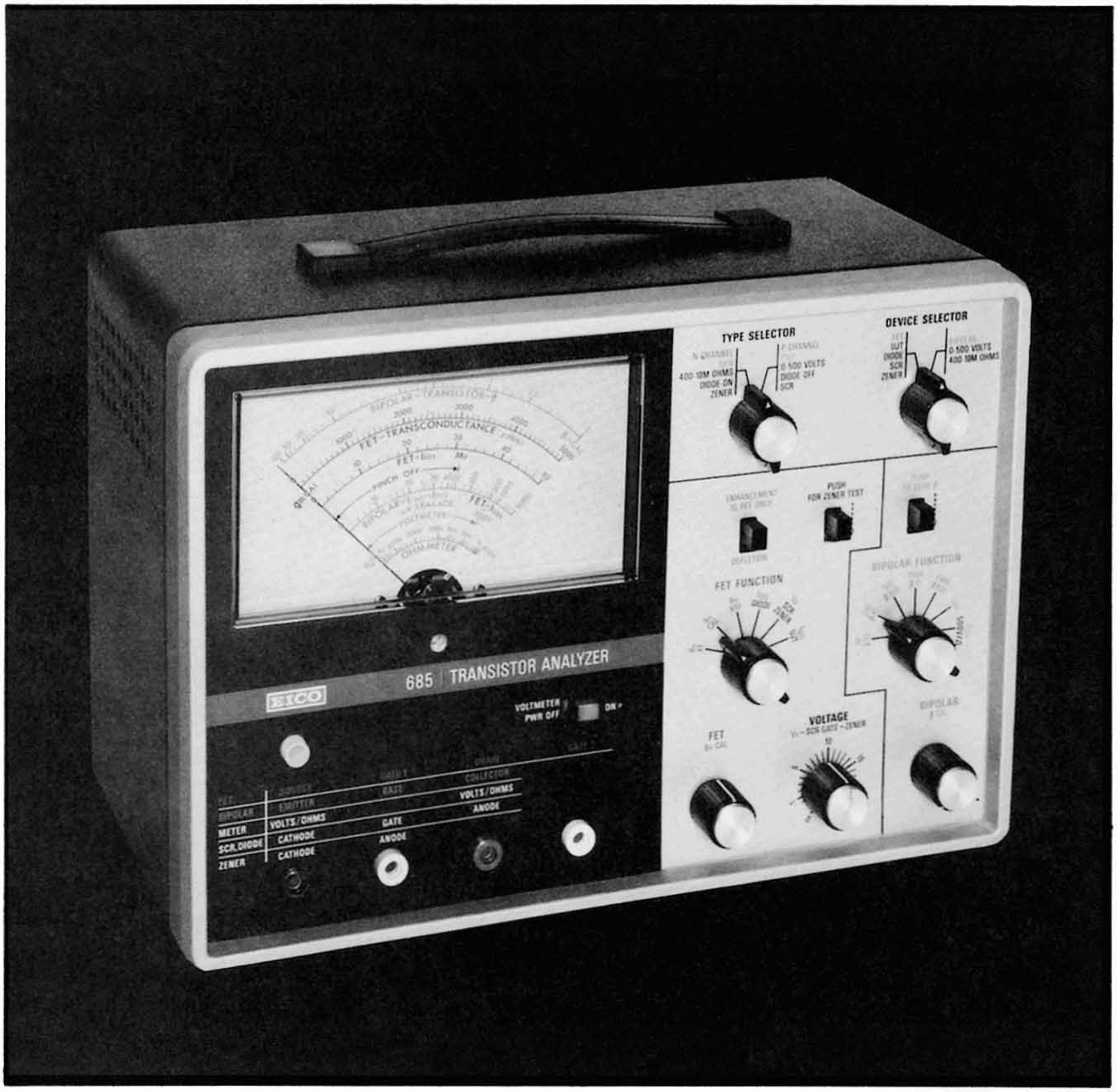
EICO®

685 | Transistor Analyzer



OPERATING MANUAL

GENERAL DESCRIPTION

The EICO Model 685 Dynamic Semiconductor and Circuit Analyzer is a "state of the art" instrument that tests bipolar transistors and field effect transistors (FET's) both in and out of circuit. It can also be used to test UJT's, SCR's, and many types of diodes. In addition, an accurate voltmeter and ohmmeter are integral parts of the Model 685. This tester has been designed to fulfill the technician's requirements of convenience and speed while satisfying the engineer's need for accuracy and versatility.

FEATURES

1. For bipolar transistors, checks power, signal and critical RF types in or out of circuit, reading a-c beta accurately. Measurement of leakage currents I_{CBO}, I_{CEO}, and I_{CES} can be made, with the results displayed on an accurate compressed meter scale.

2. FET's can be checked for a-c transconductance (g_m), as well as gate leakage (I_{GSS}), zero bias drain current (I_{DSS}), and pinch-off voltage (V_p). Both enhancement and depletion devices can be checked with equal ease and with equally accurate results.

3. The versatility of the instrument permits its use in performing significant tests on other semiconductor devices such as unijunction transistors, controlled rectifiers, power rectifiers, signal diodes, and zener diodes.

4. A built-in d-c voltmeter and ohmmeter, using a single knob setting, permits convenient testing of the circuit that contains the semiconductor being checked.

5. A 50-microampere 6" Taut Band meter used in combination with close tolerance (1%) resistors, ensures accurate readings and provides sufficient sensitivity to obtain meaningful leakage measurements.

SPECIFICATIONS

Bipolar Transistor Tests

AC Beta (in and out of circuit):	2-100 (readings to 1000) at $I_c = 0.2$ ma for RF devices
	2-100 and 2-1000 (readings to 10,000) at $I_c = 2$ ma for small signal devices
	2-100 and 2-1000 (readings to 10,000) at $I_c = 20$ ma for power devices
I_{CBO}:	0-5 ma
I_{CEO}:	0-5 ma
I_{CES}:	0-5 ma

FET Tests

AC Transconductance (g_m)(in and out of circuit):	0-5000 and 0-50,000 micromhos at $V_{DS} = 5v$ and $V_{GS} = 0$
I_{DSS}:	0-50 ma (linear scale)
I_{GSS}:	0-5 ma
V_p:	0-20v at $V_{DS} = 5v$

UJT Test:	Establishes condition of device
SCR and Triac Test:	Establishes condition of device and indicates gate turn-on voltage
Signal Diode and Rectifier Test:	Establishes condition of device from forward and reverse current tests.
Zener Diode Test:	Establishes condition of device and indicates zener breakdown voltage
Voltmeter:	0-500 volts (30 volts center scale), 1 megohm resistance
Ohmmeter:	400 ohms to 10 megohms (130 kilohms center scale).
Semiconductor Complement:	2 - 2N5172 1 - 1N3600 (selected) 1 - 1N662 2 - 1N34 5 - 100 PIV, 500 ma rectifiers 1 - 6.8-volt zener 1 - 9.1-volt zener 1 - 24-volt zener
Meter Movement:	50 μa 2% Taut Band
Power Requirements:	105-132 volts, 50/60 Hz, 10 watts
Size:	12-1/2" high, 8-1/2" wide, 6" deep
Weight:	10 pounds

TRANSISTOR BASICS

General. The following paragraphs will provide the user of the EICO Model 685 with useful transistor background information. Familiarity with this information will help the technician to make meaningful use of this instrument. For a more comprehensive description of the subject, the reader is referred to Howard W. Sams & Co. publication No. 20659, "Practical Design with Transistors."

Terminology. Since the Model 685 checks many parameters of both bipolar and FET type transistors, the user of this instrument should be familiar with the terms employed. The terminals of a bipolar transistor are designated C (collector), B (base), and E (emitter). In a field effect transistor (FET), the terminals are D (drain), G (gate), and S (source). By using these abbreviations as subletters, various terms can be designated. For example, bipolar transistor term I_{CBO} represents the leakage current flow between collector (C) and base (B), with the O indicating that the third element, the emitter (E) in this case, is open. Similarly, the bipolar transistor term I_{CEO} stands for the leakage current flow between collector and emitter, with the base open.

The terms I_{DSS} and I_{GSS} are used with FET's. I_{DSS} represents the current flow from drain (D) to source (S). The third subletter, S, indicates that the second element (the source) is shorted to the third element (the gate) so that zero bias exists. Thus, I_{DSS} is termed the zero bias drain current. I_{GSS} is gate-to-source leakage current. In this case, the second element (the source) is shorted to the third element (the drain).

Bipolar Transistor Tests. The Model 685 is designed to measure a-c beta, I_{CBO}, and I_{CEO} of bipolar transistors. Beta, represented by the Greek letter β , is the current amplification factor. It is the rate of change in the collector current divided by the change in the base current while maintaining the collector-emitter voltage constant. The range of β values varies with transistor types. The Model 685 provides five scales for measuring the β of r-f, signal, and power transistors.

I_{CBO}, the leakage current that flows between base and collector, is another significant parameter that can be measured. Leakage current is especially critical in circuits where large temperature variations are encountered, since the leakage current increases when the temperature rises.

I_{CEO}, collector-to-emitter leakage current with the base lead open, is another bipolar transistor parameter of interest. Transistors characterized by excessive values of leakage current I_{CEO} are undesirable for many applications. I_{CES}, collector-to-emitter current with the base lead connected to the emitter, can also be measured.

FET's. The FET is somewhat similar to the vacuum tube in that the input terminal (gate) is reverse biased and the output (drain) current depends upon the gate voltage. Characterized by a high-impedance input, the gain of an FET is a function of its transconductance (g_m). Its characteristic curves resemble those of pentode vacuum tubes. The two basic FET types are the junction FET (JFET) and the metal-oxide semiconductor gate FET (MOSFET). The latter is also known as the insulated gate FET (IGFET). Both devices may have either a P-channel or an N-channel.

Three modes of operation are associated with FET's: the depletion mode, the enhancement mode, and the depletion-enhancement mode. JFET's operate in the depletion mode; i.e., drain current flows even in the absence of a gate-to-source voltage, V_{GS}. For the N-channel JFET, a negative gate voltage lowers channel conduction. A positive gate voltage has a similar effect on the P-channel JFET. The amount of voltage required to reduce channel conduction to zero is called the pinch-off voltage, V_p.

Only IGFET's are used as enhancement devices. Here, zero bias cuts off drain current. For N-channel FET's, drain current increases as V_{GS} is made more positive. In P-channel FET's, more negative values of V_{GS} cause drain current to increase. IGFET's are made in both the enhancement and depletion types. An ENHANCEMENT-DEPLETION switch on the Model 685 selects the proper bias for the type of FET to be tested.

FET Tests. The Model 685 provides readings of ac transconductance (g_m) as well as I_{DSS}, I_{GSS}, and pinch-off voltage. I_{DSS} is zero bias drain current. I_{GSS} is gate leakage current. These four tests represent the most significant FET parameters. When used in balanced circuits, FET's must be carefully matched for g_m.

CIRCUIT DESCRIPTION

The following paragraphs provide a brief description of the circuits used when each of its various test functions is being performed by the Model 685. In each case, a simplified schematic diagram of the circuit is presented as an aid to understanding the associated description. For purposes of simplification, N-channel FET's and NPN transistors are described in the text. However, the drawings also show the circuit variations for testing P-channel FET's and PNP transistors.

a. <u>FET g_m Calibration</u> (See figures 1A and 1B.)

In general, the upper winding of T1 develops the basic drain voltage required for testing FET's while the bottom winding performs a similar function for the FET gate. The a-c voltage developed across the upper winding performs a second function. In conjunction with diodes D1 and D2, it provides a full-wave rectified voltage that is filtered by R3 and C1. A constant +6.8-volt level is developed across zener diode D5. This d-c voltage serves as the collector supply for balance transistors Q1 and Q2. It is also divided down by R4 and R5 for use in other circuits of the Model 685.

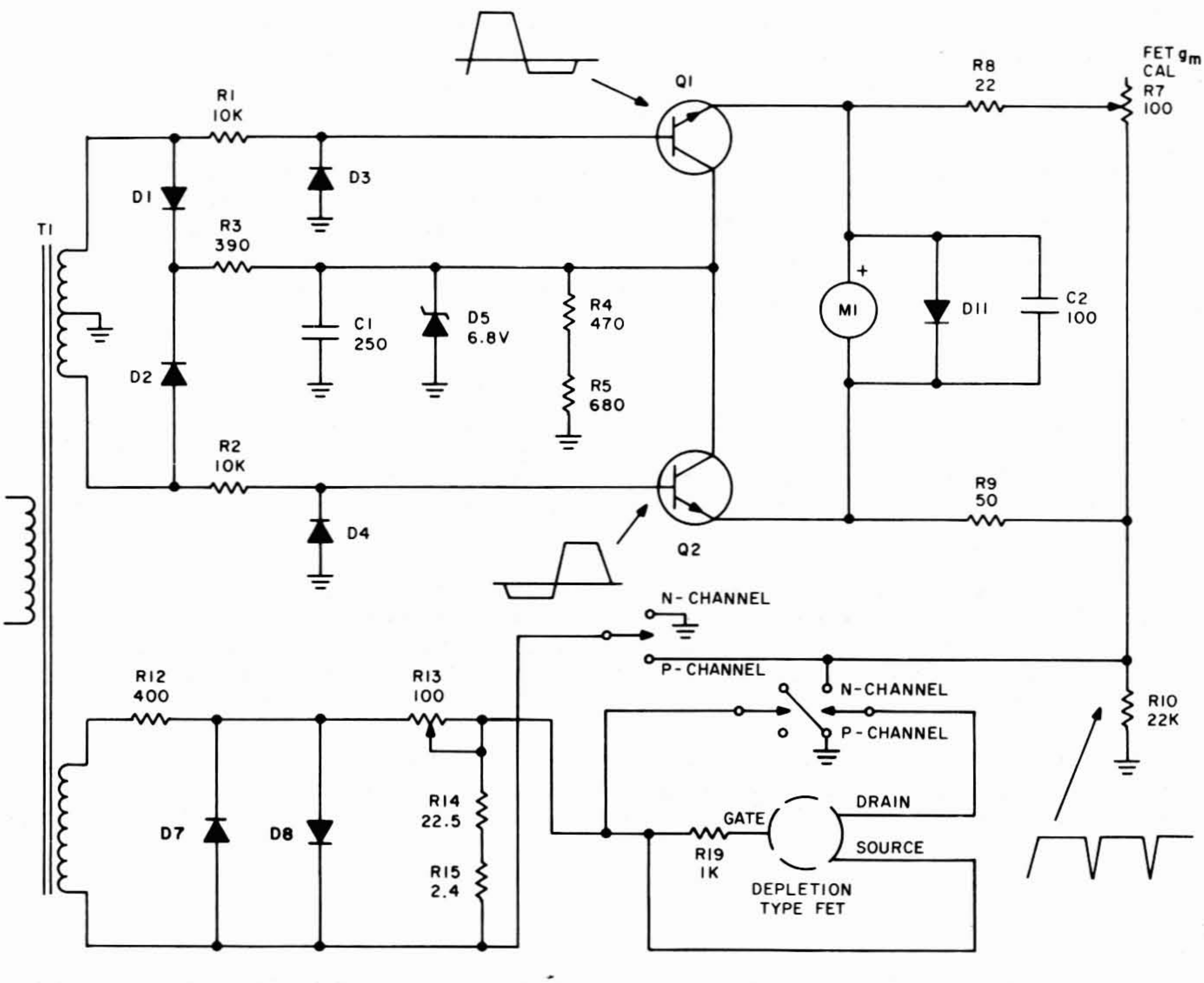


Figure 1A. g_m CAL Circuit, Depletion Mode FET

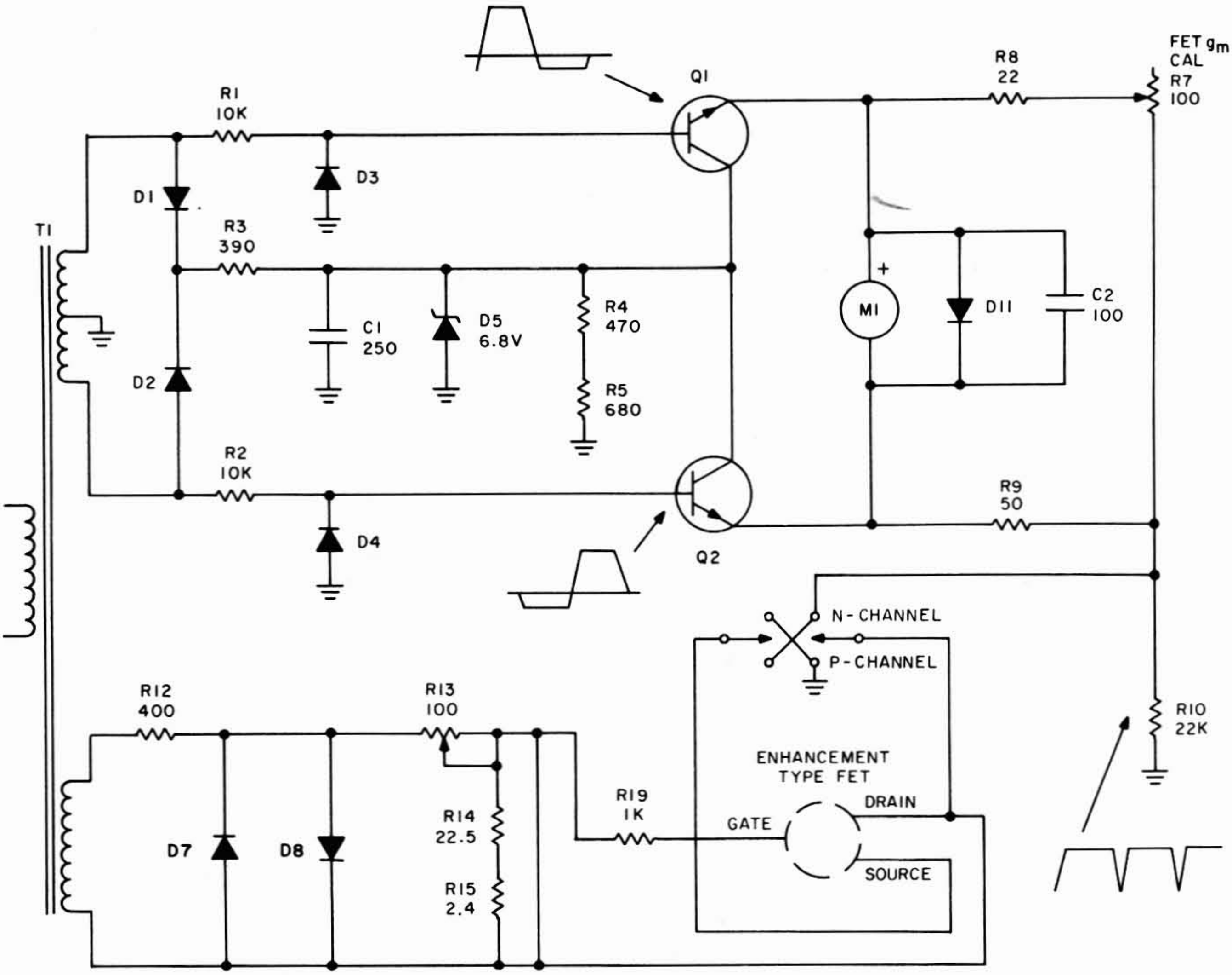


Figure 1B. g_m CAL Circuit, Enhancement Mode FET

Diodes D3 and D4, in conjunction with resistors R1 and R2, clip the negative-going voltage excursions supplied by the same transformer winding. The waveform at the base of each transistor is developed as follows: When the a-c input is positive going, that transistor is forced into saturation. At saturation, the collector-to-base voltage drops to a low value. This causes the base voltage to rise almost to the 6.8 collector voltage, producing the positive portion of the waveform shown at the base. When the a-c input goes negative at the end of the first half-cycle, it forward biases the diodes connected at the bases, clipping the a-c voltage at about 0.2 volt. (The 0.2 volt is the negative portion of the waveform shown.) The associated transistor is turned off as a result of the low base voltage. Thus, Q1 and Q2 conduct on alternate half cycles, switching on and off.

When Q1 conducts, its collector current passes through M1 in series with R9 (the combination of which is shunted by R7 and R8) and then through series resistor R10. When Q2 conducts, it causes current to flow through the series combination of M1, R8, and R7, shunt-connected R9, and series resistor R10. In this case, the direction of current flow through M1 is reversed. Since the value of R10 is much higher than the other resistors, most of the voltage developed at the emitters of Q1 and Q2 appears across R10, producing the waveform shown. This constitutes the drain voltage supply for the FET under test.

When the front panel FET FUNCTION switch is set to the g_m CAL position and a depletion mode FET is being tested, the gate of the FET under test is shorted to the source via R19 (figure 1A). For enhancement mode FET's, the gate is similarly shorted to the drain via R19 (figure 1B). Therefore, the drain current of the FET is controlled mainly by the drain voltage pulses applied from the Q1-Q2 switching circuit. The FET g_m CAL control R7, is adjusted so that equal currents flow through the meter on alternate half cycles. Since equal current flows in both directions, when adjusted, balancing the circuit produces a zero meter reading. This calibrates the FET g_m circuit.

N-channel or P-channel FET's operating in either the depletion or enhancement mode can be calibrated for test. The switching circuits in the Model 685 set up the proper polarities and voltages for the particular type selected, as shown.

b. <u>FET g_m X 1 Operation.</u>

When the FET FUNCTION switch is set to the g_m X1 position, the circuit assumes the form shown in figures 2A and 2B. At this time, a constant amplitude (0.4 volt peak-to-peak) square wave developed across R14 and R15 is applied to the gate of the FET under test. The square wave is derived from the lower winding of transformer T1. The combination of diodes D7 and D8 in series with R12 clips the a-c waveform, which then appears across R13, R14, and R15. Potentiometer R13 is adjusted so that precisely 0.4 volt peak-to-peak is developed across R14 and R15.

When the square wave signal is fed to the gate of the FET being tested, it causes the FET to conduct more heavily on one half of the cycle than the other. Current flow through the meter then becomes unequal, producing a meter reading. The signal polarity is arranged so that meter current in the forward direction exceeds the meter current in the reverse direction for the particular FET under test, producing a normal up-direction meter deflection. Since $g_m = \frac{\Delta I_D}{\Delta V_G}$ and ΔV_G is maintained constant, the meter reading produced by the change in drain current is proportional to the g_m of the FET and is calibrated accordingly (0-5000 μ mhos).

c. <u>FET g_m X 10.</u>

When the FET FUNCTION switch is set to the g_m X10 position, the voltage applied to the gate of the FET under test is reduced from 0.4 volt to 0.04 volt peak-to-peak. Since $g_m = \frac{\Delta I_D}{\Delta V_G}$ and the constant ΔV_G is 1/10 the value used for the g_m X1 measurement, the meter reading becomes g_m X10, providing a maximum reading of 50,000 μ mhos.

d. <u>Measurement of I_{DSS}.</u> (See figure 3.)

When measuring I_{DSS} (zero bias drain current), the gate is shorted to the source for the depletion type FET as described for g_m calibration. This test does not apply to enhancement type FET's. For the I_{DSS} measurement, meter M1 is shunted by 1.87-ohm resistor R11. Resistor R9, in the emitter circuit of Q2, is shorted. When power is applied to the circuit, a pulsed voltage again appears at the drain of the FET under test. However, current flows through meter M1 only when Q1 is turned on. (When Q2 conducts, no current flows thru M1.) The meter is calibrated with the shunt to read 50 ma of I_{DSS} at full scale.

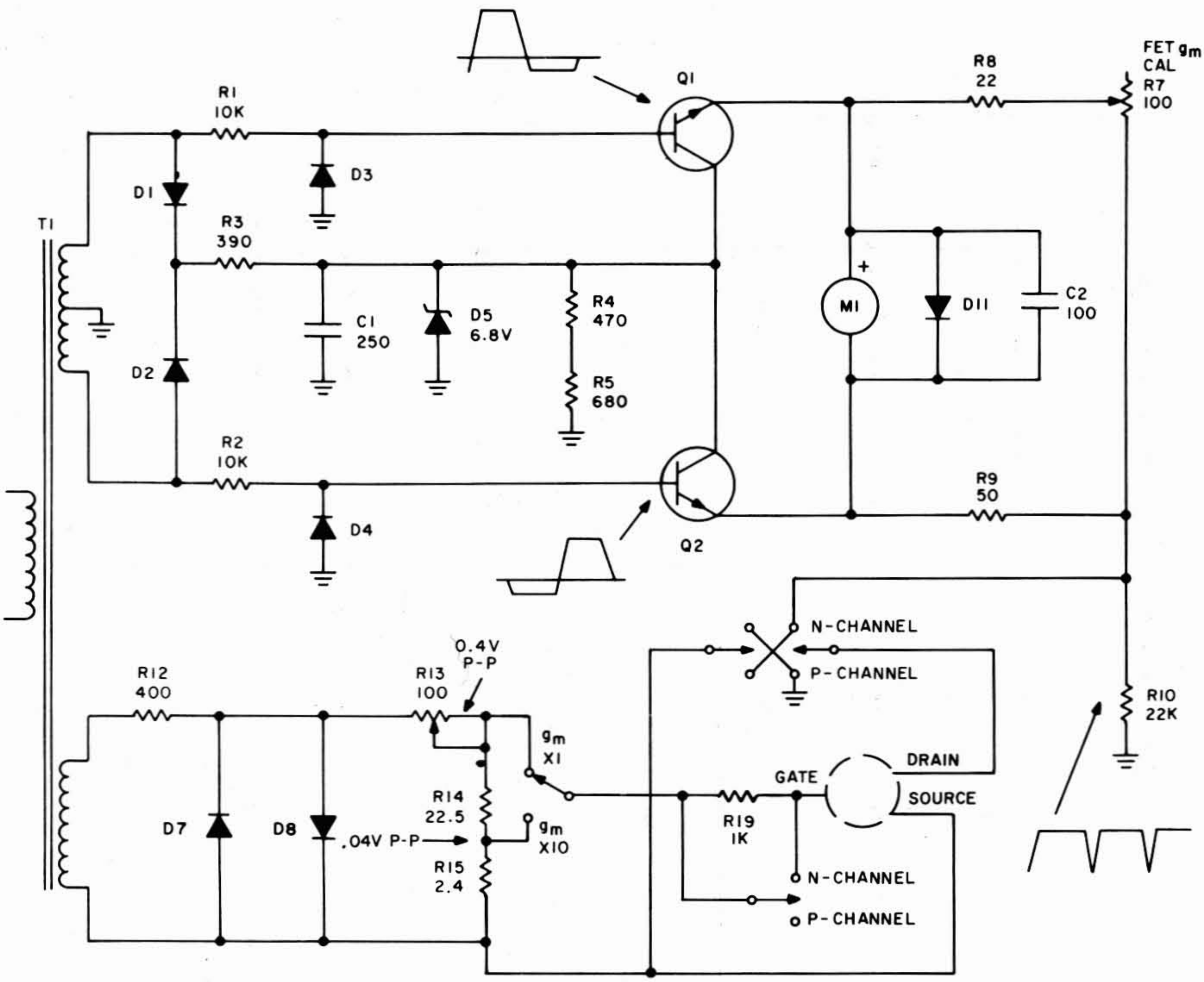


Figure 2A. g_m X1 - g_m X10 Circuit, Depletion Mode FET

e. Diode Testing.

The diode test circuit is the same as that used for measuring I_{DSS}. (See figure 3.) In this case, the diode under test rather than an FET is connected between the drain and source terminals. When the TYPE SELECTOR switch is set to the DIODE-ON source position, the anode of the diode is connected to the drain connection and the cathode to the source connection (ground terminal).

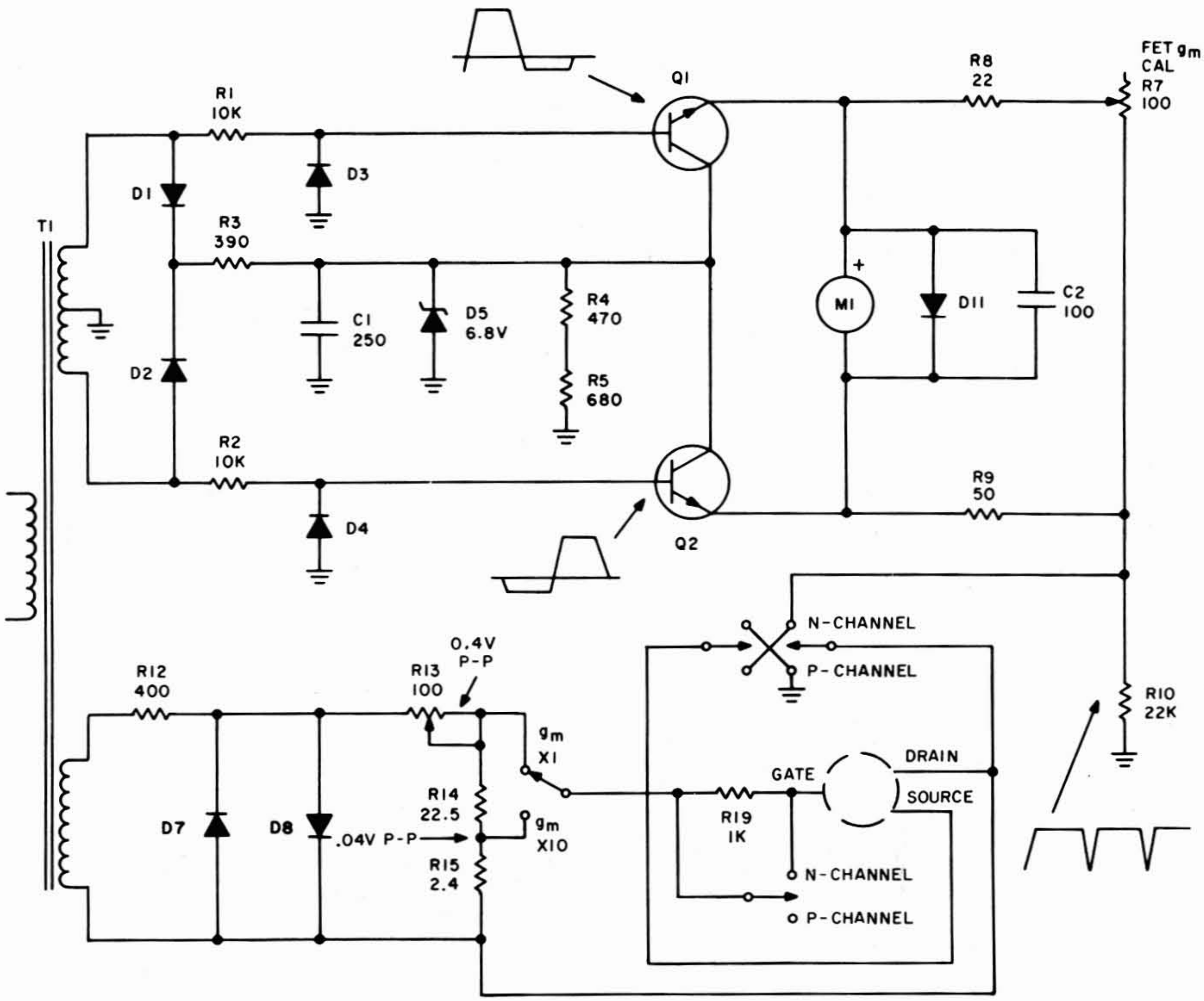


Figure 2B. g_m X1 - g_m X10 Circuit, Enhancement Mode FET

Since the diode is forward biased, current flow through the meter (a function of the Q1 collector current) is relatively high, and an up-meter deflection is produced. When the TYPE SELECTOR switch is set to the DIODE-OFF position, the diode connections are reversed, the diode is back biased, and no (or very little) meter deflection occurs. The ratio of the diode-on to diode-off meter readings is an indication of the quality of the device. Higher ratios are, of course, more desirable.

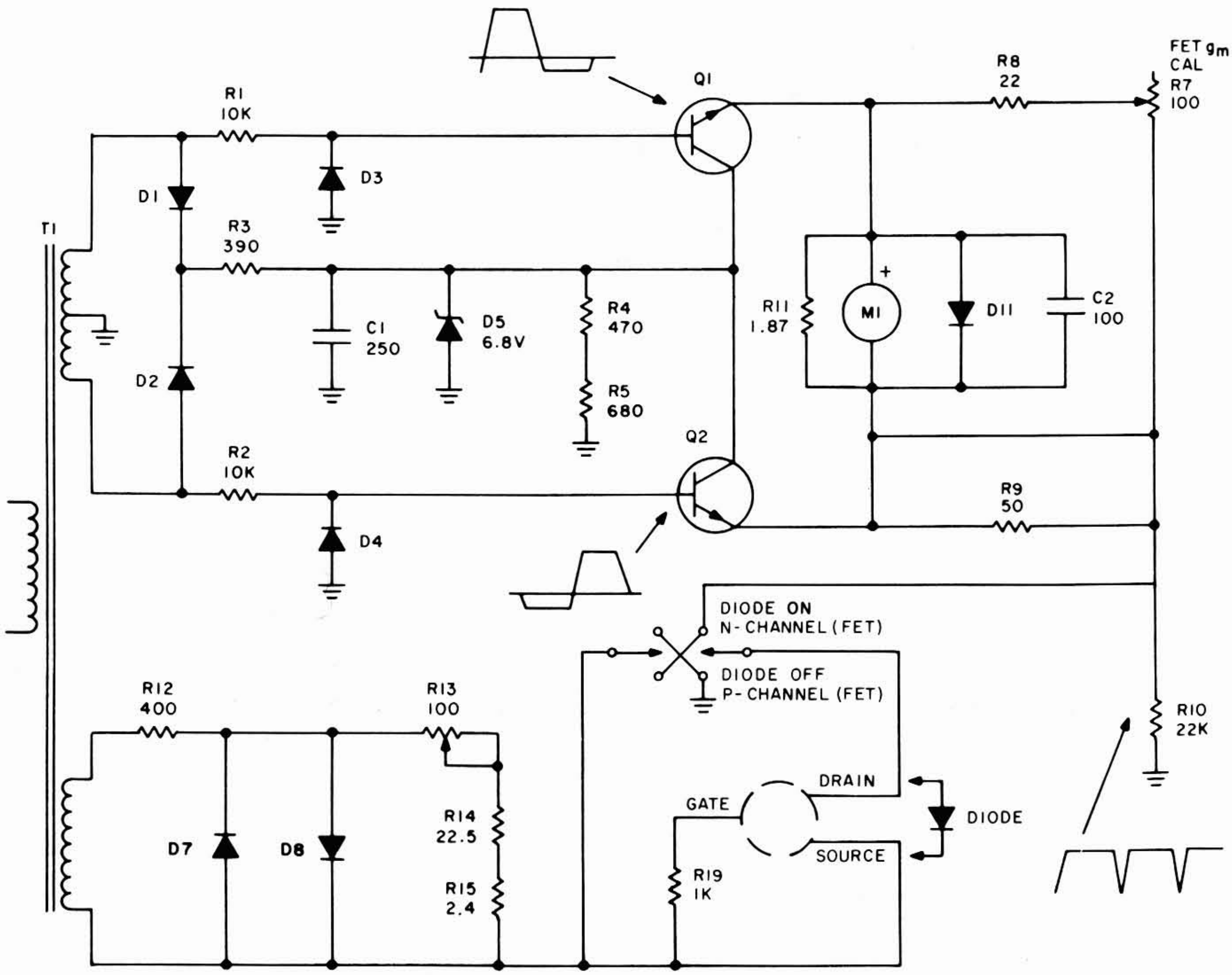


Figure 3. I_{DSS} Measurement (Depletion Only) and Diode Testing

f. Measurement of I_{CBO}.

When measuring I_{CBO} in a bipolar transistor, the collector and base are connected to a metering circuit driven by a 4-volt d-c supply, as shown in figure 4A. Diode D6 shunts current around the meter circuit at higher leakage current values, effectively compressing the upper end of the 0-5000 μa leakage scale. At low leakage values, the diode opens, resulting in a linear scale at the low end of the dial. Thus, low values of leakage can be accurately read, while still permitting high-leakage measurement, all on one scale and one knob setting. The NPN or PNP setting of the TYPE SELECTOR switch determines the connections for the transistor under test.

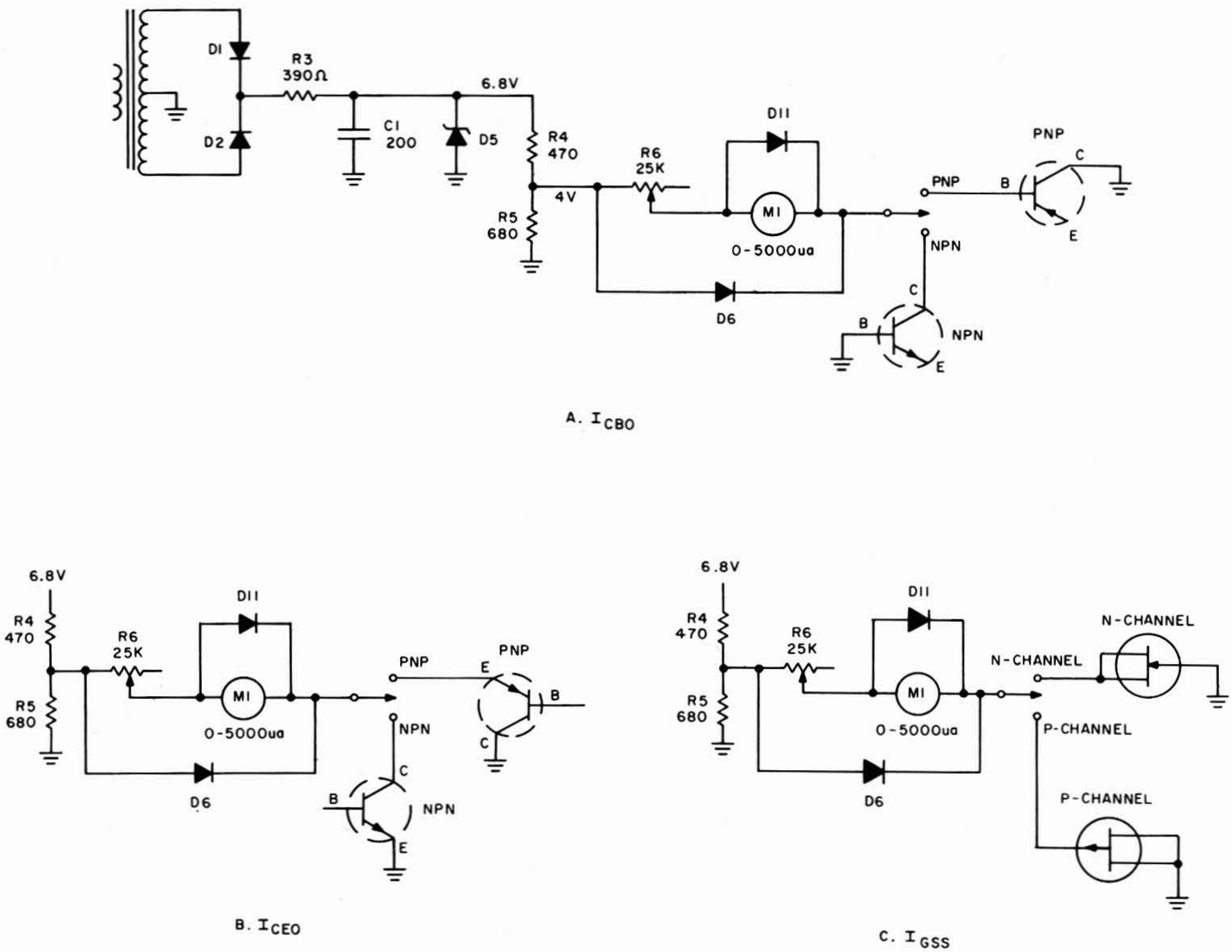


Figure 4. I_{CBO}, I_{CEO}, and I_{GSS} Measurement

g. Measurement of I_{CEO} and I_{CES}.

I_{CEO} measurements are made in a similar fashion as I_{CBO}. (See figure 4B.) In this case, the base of the bipolar transistor under test is open, and the collector-emitter leakage is measured in the same d-c circuit. I_{CES} is measured using the identical circuit, but in this case the base lead of the transistor is connected to the emitter lead of the transistor.

h. Measurement of I_{GSS}.

When measuring I_{GSS} in an FET, the source and drain are shorted by the Model 685 and the same basic circuit described in "f" above, is used to measure leakage current. (See figure 4C.) The N-

CHANNEL or P-CHANNEL setting of the TYPE SELECTOR switch determines the connections required for the FET under test.

i. Measurement of V_p.

When measuring V_p, a calibrated negative voltage is fed from the arm of VOLTAGE control R18 to the gate of the FET under test. (See figure 5.) Drain current is then monitored by meter M1, which is connected in a shunt diode configuration as previously described for the leakage measurement circuits. As the arm of the control is turned up, the FET gate is driven more negative and the drain current reading on the leakage scale is reduced. When current has decreased to the pinch-off level (generally taken as 50 μa), the V_p voltage is read off the 0-20V calibrated VOLTAGE control dial.

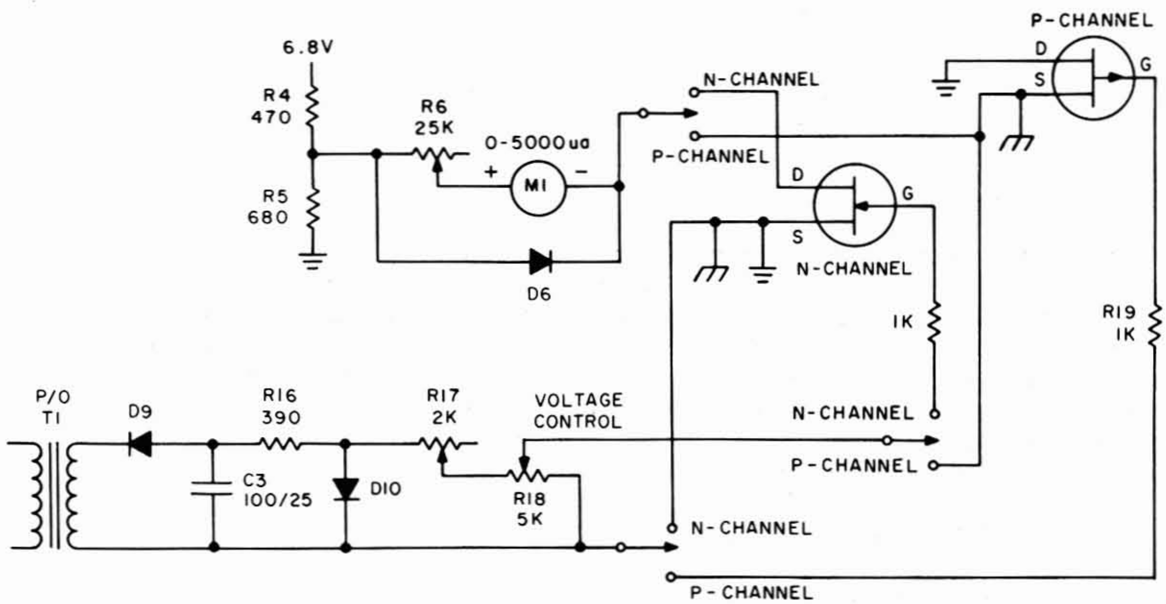


Figure 5. V_p Measurement

j. SCR and Triac Testing.

To check an SCR, it is connected as shown in figure 6. The SCR cathode is connected back to the arm of the VOLTAGE control, and the SCR gate is returned to the bottom of the control as shown. If the arm of the control is set to the low end, gate voltage is zero with respect to the cathode, and the SCR remains off. As the arm of the control is raised, the gate-to-cathode voltage rises. When the turn-on voltage level is reached, the SCR conducts, producing a deflection on the meter. On a good SCR, the device can be turned on as the voltage is increased from zero and turned off as the voltage is reduced to zero.

A Triac is connected in a like manner. The gate connection is the same as for the SCR. One anode is connected to the cathode lead and the other to the anode lead of the SCR test. In one direction of connection, the Triac will conduct, regardless of the VOLTAGE control setting. Reversing the connections to the Triac anodes will produce deflection only as the VOLTAGE control is advanced, as in the case of the SCR.

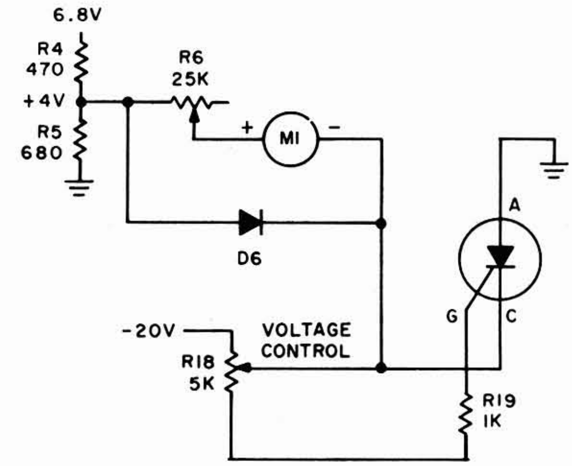


Figure 6. SCR Testing

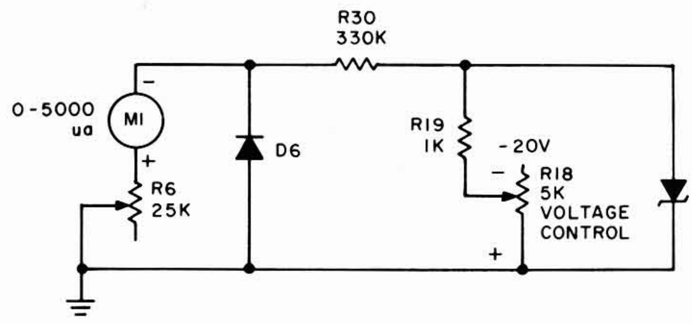


Figure 7. Zener Diode Testing

k. Zener Diode Testing.

In the test circuit shown in figure 7, the zener diode under test is connected across the 0-20-volt supply. When the VOLTAGE control arm is turned up from its minimum voltage position, the meter current through R30 increases and the d-c voltage across the diode rises. When the zener breakdown voltage is reached, the diode under test conducts, limiting the voltage across the series combination of R18 and R19 to the zener voltage. Further rotation of the VOLTAGE control arm does not increase the voltage across R18 and R19 and the meter reading does not change. The zener breakdown voltage can then be read off the VOLTAGE control dial as the lowest voltage reading that will not permit the meter to deflect further.

l. Measuring β in Bipolar Transistors.

Transformer T2 supplies the voltages necessary to measure a-c beta (β) in bipolar transistors. In the r-f transistor test circuit of figure 8A, diodes D12 and D13 clip the a-c voltage developed across the BIPOLAR β CAL control so that a square wave of fixed voltage is impressed across the primary of T2. This control sets the a-c input to T2 to a level that produces 0.2 ma of average collector current in the transistor under test. The meter shunt resistors are designed to provide full-scale deflection (corresponding to β = 2 on the Model 685) at 0.2 ma of collector current. (The circuit shown applies to NPN transistors; the PNP test circuit is similar, with meter polarity reversed.)

When the PUSH TO READ β switch is held down, the meter is transferred to the base circuit of the transistor to measure the average base current. (See figure 8B.) Since $\beta = \frac{\Delta I_C}{\Delta I_B}$ and I_C is maintained constant at 0.2 ma, β is proportional to $\frac{1}{\Delta I_B}$ and the meter is calibrated against the average base current reading. The β scale on the Model 685 is calibrated downward rather than upward because of the reciprocal function.

A similar circuit is used to measure β of signal transistors. (See figure 9.) In the SIG β X1 position of the BIPOLAR FUNCTION switch, the BIPOLAR β CAL control is adjusted for an average collector current of 2 ma. Operation of the β measuring circuit is the same as that described for the RF β X1 position of the BIPOLAR FUNCTION switch.

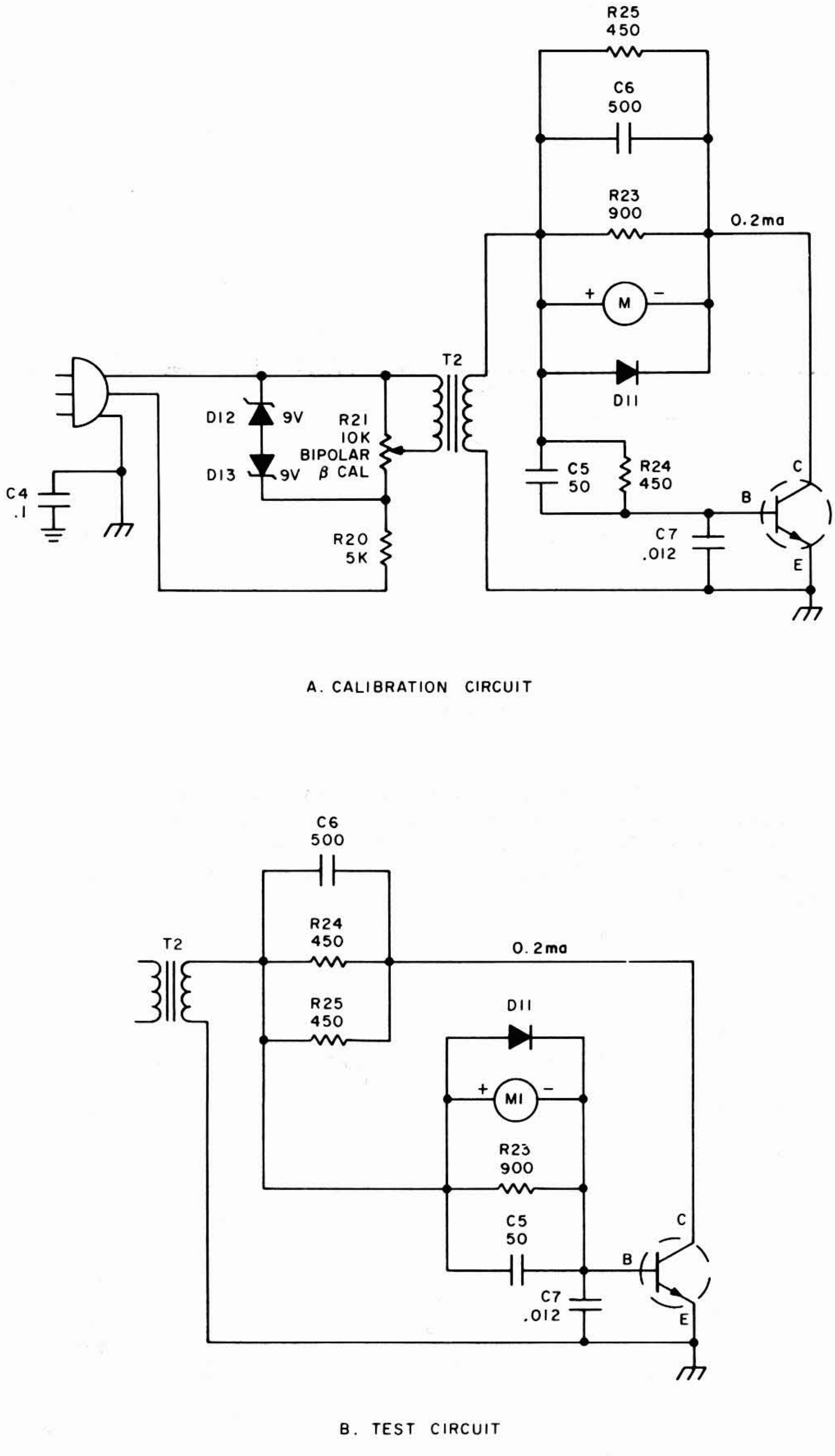
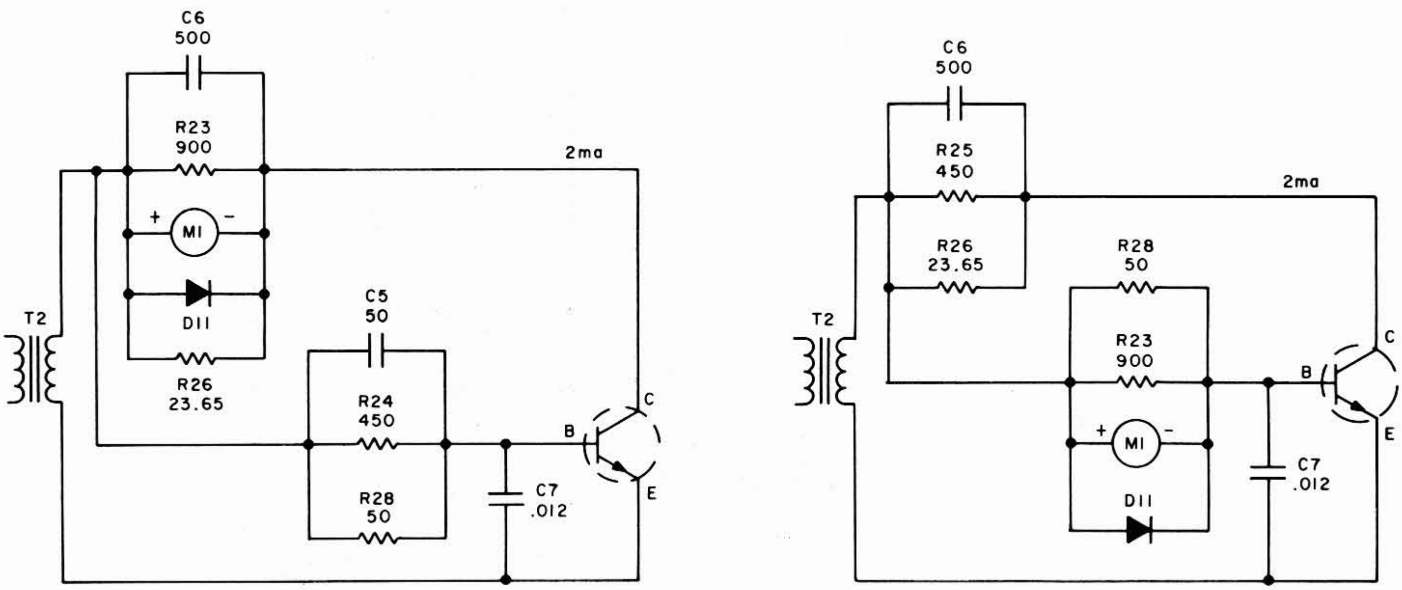


Figure 8. RF Transistor Testing

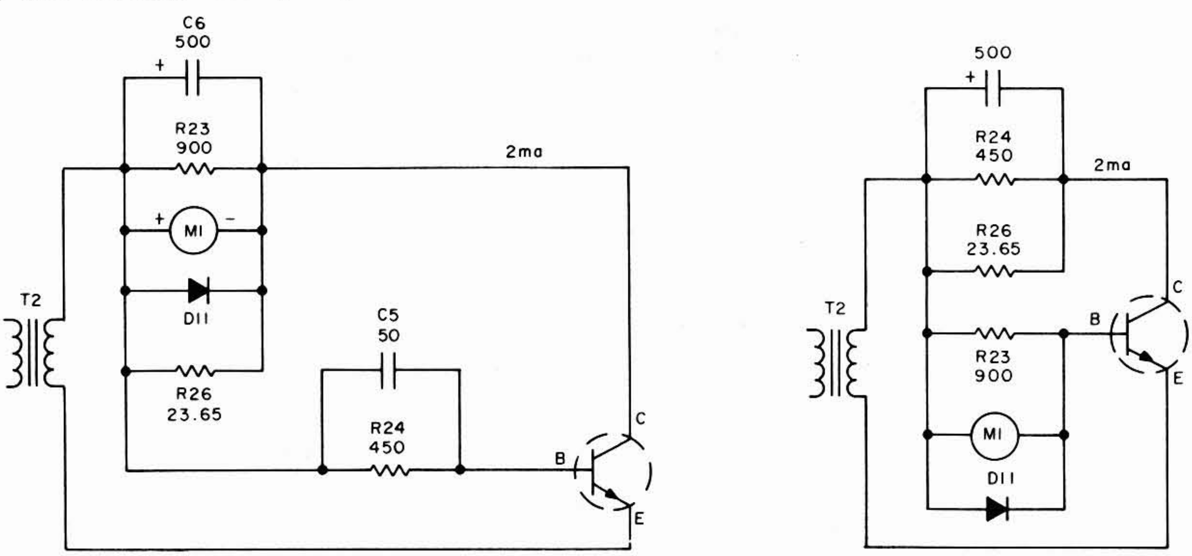


A. CALIBRATION CIRCUIT

B. TEST CIRCUIT

Figure 9. SIG β X1 Transistor Testing

In the SIG X10 position, the resistance in the base circuit is increased to 10 times its original value (from 45 ohms to 450 ohms) so that the same full-scale deflection of 2 ma (now corresponding to β = 20 on the Model 685) is produced by 1/10 the base current. (See figure 10.) In effect, the metering circuit is now 10 times more sensitive, measuring β values from 20 to 1000, with readings to 10,000.



A. CALIBRATION CIRCUIT

B. TEST CIRCUIT

Figure 10. SIG βX10 Transistor Testing

When using the PWR β X1 position of the BIPOLAR FUNCTION switch, full-scale meter deflection is produced by 20 ma of collector current. (See figure 11.) As in the other β positions, the meter is switched to the base circuit to measure the β of power transistors.

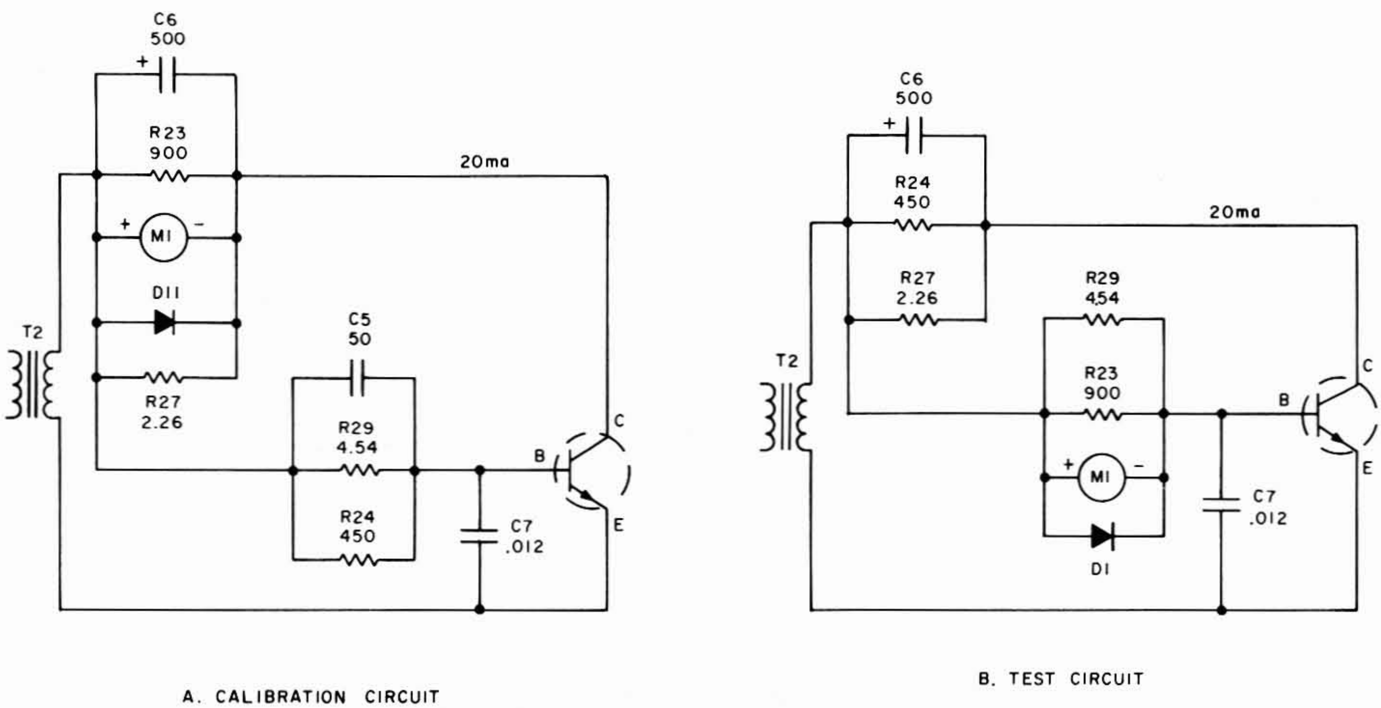


Figure 11. PWR β X1 Transistor Testing

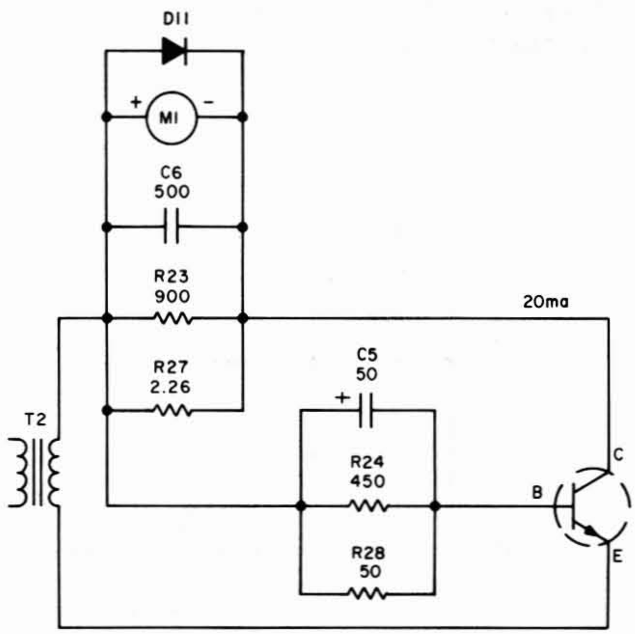
In the PWR β X10 position, the base resistance is again made 10 times its previous value, permitting β values between 20 and 1000 to be measured, with readings to 10,000. (See figure 12.)

m. Ohmmeter Operation.

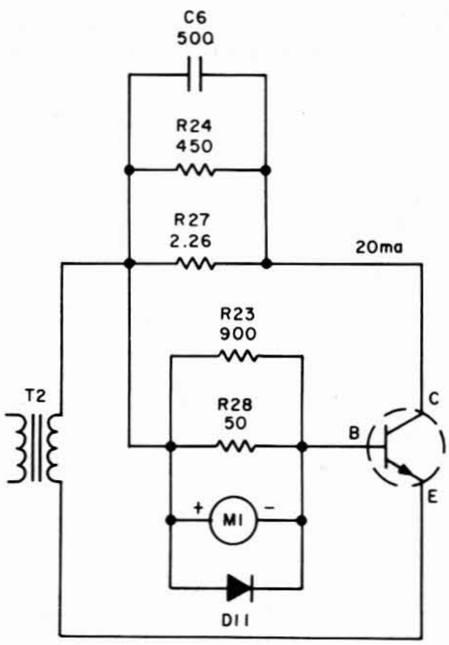
The ohmmeter circuit also makes use of the diode-controlled compressed scale circuit. (See figure 13.) The VOLTS/OHMS terminals can be used to measure resistance values ranging from 400 ohms to 10 megohms, all on one scale and at the same knob setting.

n. Voltmeter Operation.

In voltmeter operation, d-c power is removed from the metering circuit. (See figure 14.) Multiplier resistor R30 permits measurement up to 500 volts. Again, the compressed scale provides a linear calibration at lower voltages (normally used in transistor circuits), while permitting higher voltage measurements on the compressed end of the scale. All readings are made while using only one knob setting.



A. CALIBRATION CIRCUIT



B. TEST CIRCUIT

Figure 12. PWR β X10 Transistor Testing

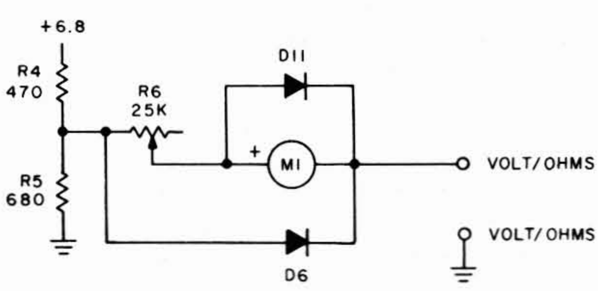


Figure 13. Ohmmeter Circuit

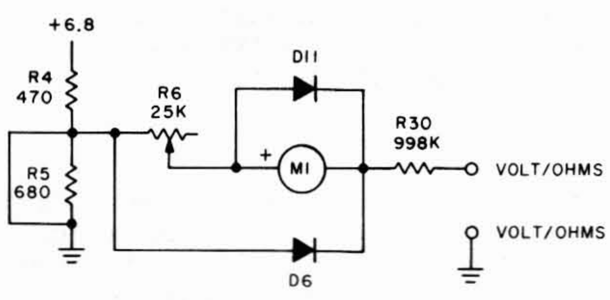


Figure 14. Voltmeter Circuit

OPERATING CONTROLS AND INDICATORS

Table 1 lists the operating controls on the Model 685 and indicates their functions.

Table 1. Controls and Indicators

Item	Function
TYPE SELECTOR switch	Two-position switch that selects type of operation. <u>Left-hand position</u> N-CHANNEL - for FET transistors NPN - for bipolar transistors 400-10M OHMS - ohmmeter DIODE-ON - forward bias on diode under test ZENER - for zener diode tests <u>Right-hand position</u> P-CHANNEL - for FET transistors PNP - for bipolar transistors 0-500 VOLTS - d-c voltmeter DIODE-OFF - reverse bias on diode under test SCR - for SCR and Triac tests
DEVICE SELECTOR switch	Two-position switch that selects device or function tested. <u>Left-hand position</u> FET - for all Field Effect Transistor tests UJT - for Unijunction Transistor tests DIODE - for power rectifier and signal diode tests SCR - for SCR and Triac tests ZENER - for zener diode tests <u>Right-hand position</u> BIPOLAR - for bipolar transistor testing 0-500 VOLTS - d-c voltmeter 400-10M OHMS - ohmmeter
ENHANCEMENT-DEPLETION switch	Selects proper FET gate bias for enhancement mode (IGFET's only) or DEPLETION mode (JFET's and certain IGFET's)
PUSH FOR ZENER TEST momentary action switch	Depressed when performing zener diode tests

Table 1. Controls and Indicators (cont)

Item	Function
FET FUNCTION switch	Selects FET parameter or other device to be tested **Position** — **Function** g_m X1 — Reads 0-5000 μ mho FET transconductance g_m CAL — Used when zero calibrating g_m meter scale g_m X10 — Reads 0-50,000 μ mho FET transconductance I_{DSS} DIODE — Used for measuring I_{DSS} in FET's on 0-50 ma scale and for testing diodes V_p SCR, ZENER — Used for measuring V_p in FET's and for testing SCR's, Triacs and zener diodes on voltage scale printed on panel I_{GSS} UJT — Used for measuring I_{GSS} in FET's on 0-5000 μa scale and for testing UJT's
FET g_m CAL control (10 turn)	Zero sets meter prior to performing g_m measurements
VOLTAGE control	Used to determine V_p in FET's, allows for SCR gate turn-on and turn-off, and measures zener diode breakdown voltages. Calibrated from 0 to 20 volts
PUSH TO READ β momentary action switch	When depressed, permits β to be measured on upper scale when BIPOLAR FUNCTION switch is set to a β or β X10 position
BIPOLAR FUNCTION switch	In some positions, selects type of bipolar transistor for β measurement. Also sets up instrument for measuring leakage currents. **Position** — **Function** RF β X1 — Used for measuring β (2 to 100 range-readings to 1000) in r-f transistors at 0.2 ma collector current SIG β X1 — Used for measuring β (2 to 100 range-readings to 1000) in signal transistors at 2 ma collector current SIG β X10 — Used for measuring β (20 to 1000 range-readings to 10,000) in signal transistors at 2 ma collector current

Table 1. Controls and Indicators (cont)

Item	Function
	Position / **Function** PWR β X1 — Used for measuring β (2 to 100 range-readings to 1000) in power transistors at 20 ma collector current PWR β X10 — Used for measuring β (20 to 1000 range-readings to 10,000) in power transistors at 20 ma collector current I_{CBO} — Used for measuring I_{CBO} (0 to 5000 μa) I_{CEO} 500V/Ω — Used for measuring I_{CEO} and I_{CES} (0-5000 μa scale) and for setting up d-c voltmeter or ohmmeter
BIPOLAR β CAL control (10 turn)	Calibrates meter to full scale prior to making β measurements
FET jacks: SOURCE, GATE 1, DRAIN, and GATE 2	Used to connect Model 685 to FET or UJT under test
BIPOLAR jacks: EMITTER, BASE, and COLLECTOR	Used to connect Model 685 to bipolar transistor under test
METER jacks: VOLTS/OHMS	Connects external circuit to voltmeter or ohmmeter circuit in Model 685.
SCR DIODE jacks: CATHODE, GATE, ANODE	All three jacks are used to connect to SCR under test. When testing diodes, only cathode and anode connections are used.
ZENER jacks: CATHODE, ANODE	Connects Model 685 to zener diode under test
VOLTAGE switch	Placed in ON position for all functions except voltmeter operation, at which time it is set to PWR OFF.

OPERATING PROCEDURES

The markings on the meter scales and the nomenclature on the front panel of the Model 685 are color coded to simplify its operation. Red markings refer to bipolar transistors, blue markings apply to FET's, while silver on the panel signifies other components and functions (such as diodes, SCR's voltmeter, ohmmeter, etc.). In addition, the four test leads supplied with the unit and the associated jacks on the panel have different colors for the same reason. Although the Model 685 offers a wide variety of test functions, you will find that with a little practice, operation becomes quite simple. The normal precautions pertinent to transistors should be followed to prevent damaging them. Insulated gate FET's (IGFET's) must be handled in a special manner as outlined in the following paragraph. Before attempting to use the Model 685, be sure that you understand the operating instructions in this section.

a. Safety Precautions when Handling IGFET's.

Out of circuit, the IGFET (also known as MOSFET) is subject to static build-up on an open gate lead and is therefore subject to damage when handled. (When connected in circuit, it is quite rugged.) The IGFET is generally shipped with its leads shorted together to prevent such static build-up. When testing the IGFET out of circuit, connect the leads from the Model 685 to the IGFET BEFORE the short is removed. It is generally wise to take the following precautions.

1. If you are going to connect the IGFET to a circuit, keep the shorting clip on the leads until they are soldered to the circuit; then remove the clip. When removing an IGFET, short its leads together with a clip before unsoldering them.

2. When soldering or unsoldering the IGFET leads, ground the soldering iron tip. This can be accomplished by connecting a clip lead from the barrel of the soldering iron to the Model 685 case (assuming the unit is plugged into the a-c line) or to conduit ground. DO NOT use a soldering gun.

3. Remove power from a circuit before installing or removing an IGFET to prevent damage from voltage transients.

b. Measuring Beta (β) in Bipolar Transistors.

1. Determine in which of the following categories the transistor falls: rf, signal, or power. Transistor references contain this information. You must also determine whether the transistor is an NPN or PNP type.

2. Set the panel switches as follows:

TYPE SELECTOR:	NPN or PNP (as applicable)
DEVICE SELECTOR:	BIPOLAR
BIPOLAR FUNCTION:	To appropriate β position

3. Set the β CAL control to the maximum counterclockwise position.

4. Connect the EMITTER (black), BASE (yellow), and COLLECTOR (red) leads on the Model 685 to the corresponding transistor terminals.

   NOTE: You may check β with the transistor IN OR OUT of the circuit. You will get more accurate readings in the out-of-circuit test.

5. Adjust BIPOLAR β CAL control for a full-scale reading (to β -CAL mark) on the meter.

6. Press PUSH TO READ β switch and read value on top red scale. (If in a X10 position, multiply reading on meter by 10.)

c. Measuring I_{CBO} of Bipolar Transistor.

1. Set the panel switches as follows:

TYPE SELECTOR:	NPN or PNP
DEVICE SELECTOR:	BIPOLAR
BIPOLAR FUNCTION:	I_{CBO}

2. Connect the leads (as in step b.4 for β tests) to the transistor. Note that the transistor must be OUT OF CIRCUIT for this test.

3. Read I_{CBO} value on the 0-5000 μA LEAKAGE red scale.

d. Measuring I_{CEO} and I_{CES} of Bipolar Transistor.

I. For I_{CEO}

1. Set the panel switches as follows:

TYPE SELECTOR:	NPN or PNP
DEVICE SELECTOR:	BIPOLAR
BIPOLAR FUNCTION:	I_{CEO}

2. Connect leads (as in step b.4 for β test) to the transistor. Transistor must be OUT OF CIRCUIT for this test.

3. Read I_{CEO} value on the 0-5000 μA LEAKAGE red scale.

II. For I_{CES}

1. Set the panel switches as follows:

TYPE SELECTOR:	NPN or PNP
DEVICE SELECTOR:	BIPOLAR
BIPOLAR FUNCTION:	I_{CEO}

2. Connect collector lead to collector of transistor and connect emitter lead to both the base and emitter of transistor. Transistor must be OUT OF CIRCUIT for this test.

3. Read I_{CES} value on 0-5000 μA LEAKAGE red scale.

e. Measuring g_m of FET.

Before connecting the Model 685 to an FET, determine if that FET is N-channel or P-channel and if it is an enhancement type, depletion type, or a combination of both. All junction FET's (JFET's) are depletion types. Insulated gate FET's (IGFET's) may be enhancement or enhancement-depletion types. If an IGFET is to be tested, be sure to follow the safety precautions previously outlined.

1. Set the panel switches as follows:

TYPE SELECTOR:	N-CHANNEL or P-CHANNEL
DEVICE SELECTOR:	FET
ENHANCEMENT-DEPLETION:	As required
FET FUNCTION:	g_m CAL

NOTE: For enhancement-depletion types, you may check g_m separately in each of these modes.

2. Connect the source (black), gate 1 (yellow), drain (red), and gate 2 (white, if used) leads on the Model 685 to the corresponding FET terminals.

NOTE: You may check g_m with the FET IN OR OUT OF CIRCUIT.

3. Adjust FET g_m CAL for zero (g_m CAL) reading on Model 685.

4. Set FET FUNCTION switch to g_mX1 or g_mX10 (as appropriate) and read g_m value (in μmhos) on second scale (blue). (If in X10 position, multiply reading on meter scale by 10.)

NOTE: To check the g_m for gate 2, connect the leads as above to the transistor, except connect gate 2 to yellow and gate 1 to white.

f. Measuring I_{DSS} of FET. (Applies to depletion-type only.)

1. Set the FET FUNCTION switch to I_{DSS}, leaving the other switches as for g_m measurement.

2. Connect FET as for g_m measurement.

3. Read I_{DSS} (in ma) from blue FET I_{DSS} scale.

g. Measuring I_{GSS} of FET.

1. Set the FET FUNCTION switch to I_{GSS}, leaving the other switches as for g_m measurement.

2. Connect FET as for g_m measurement.

3. Read I_{GSS} (in μa) from red μA LEAKAGE scale.

h. Measuring V_p of FET.

1. Set VOLTAGE control to 0, then place FET FUNCTION switch in V_p position. Leave other switches in same positions as for g_m measurement.

2. Connect FET as for g_m measurement.

3. Meter on Model 685 will read up scale. Turn up Vp control slowly and note that meter reading decreases. When reading on red μA LEAKAGE scale drops to 50 μa (or to lower value, if desired), read value of V_p from calibrated dial at VOLTAGE control knob.

NOTE: 50 μa is a generally recommended value of drain current that corresponds to V_p. In general, a value that lies between 1/100 and 1/1000 of I_{DSS} may be used to establish V_p.

i. Checking Diodes.

The Model 685 provides a forward-to-reverse current test that will establish whether or not a diode is operating properly, as described below.

NOTE: This test is most accurate when checking OUT OF CIRCUIT. If the diode is shunted by a low resistance element in the circuit, the results will be meaningless.

1. Set the panel switches as follows:

TYPE SELECTOR:	DIODE ON
DEVICE SELECTOR:	DIODE
FET FUNCTION:	DIODE

2. Connect the cathode (black) and anode (red) leads on the Model 685 to the diode under test and note the relative reading on the blue 0-50-ma scale.

3. Turn the TYPE SELECTOR switch to the DIODE-OFF position. Meter deflection should now be very low or nonexistent. If it is not, the diode should be discarded.

j. Checking SCR's.

The SCR test will indicate the condition of the device. This test should be performed with the SCR OUT OF CIRCUIT.

1. Set the panel controls as follows:

TYPE SELECTOR:	SCR
DEVICE SELECTOR:	SCR
FET FUNCTION:	SCR
VOLTAGE potentiometer:	0

2. Connect cathode (black), gate (yellow), and anode (red) leads on the Model 685 to the SCR under test. There should be no deflection on the meter.

3. Slowly turn up VOLTAGE pot until a meter deflection occurs. This indicates that the gate can turn on the SCR.

4. Turn the VOLTAGE control back to 0. The meter should not deflect, indicating that the SCR will cut off when the diode is reverse biased.

k. Checking Triacs.

The Triac test will indicate the condition of the device. This test should be performed with the Triac OUT OF CIRCUIT.

1. Set the panel controls as follows:

TYPE SELECTOR:	SCR
DEVICE SELECTOR:	SCR
FET FUNCTION:	SCR
VOLTAGE potentiometer:	0

2. Connect gate (yellow) lead on the Model 685 to the gate of the Triac under test. Connect the cathode (black) lead to one anode and the anode (red) lead to the second anode. If there is no deflection on the meter, reverse the leads to the anodes on the Triac. When it has been established that the Triac conducts in one direction, reverse the leads to the Triac. Now, there should be no deflection on the meter.

3. Slowly turn up VOLTAGE pot until a meter deflection occurs. This indicates that the gate can turn on the Triac.

4. Turn the VOLTAGE control back to 0. The meter should not deflect, indicating that the Triac will cut off when the diode is reverse biased.

l. Checking Zener Diodes.

The zener diode test establishes the breakdown voltage of any zener diode in the 0-20-volt operating range.

1. Set the panel controls as follows:

TYPE SELECTOR:	ZENER
DEVICE SELECTOR:	ZENER
FET FUNCTION:	ZENER
VOLTAGE potentiometer:	0

2. Connect the cathode (black) and anode (yellow) leads on the Model 685 to the zener diode under test. The diode should be checked OUT OF CIRCUIT.

3. Push the PUSH FOR ZENER TEST switch and hold it down.

4. Slowly turn up the VOLTAGE control until a deflection stabilizes. Now rotate the control counterclockwise until the meter reading just starts to fall from its stable region. Read the zener breakdown voltage from the calibrated VOLTAGE dial.

m. Checking UJT's.

1. Set panel switches as follows:

TYPE SELECTOR:	N-CHANNEL or P-CHANNEL (as appropriate)
DEVICE SELECTOR:	UJT
FET FUNCTION:	UJT

2. Connect source (black) and gate 1 (yellow) leads on Model 685 to base 1 and base 2, respectively, of UJT under test.

3. Note reading on red I_{GSS} scale. It should be between 200 and 1500 μa.

4. Disconnect leads from UJT. Then, connect gate 1 (yellow) lead to emitter of UJT and source (black) lead to each base (in turn) of the UJT. In each case, reading on red I_{GSS} scale should be higher than that noted in step 3.

5. Disconnect leads from UJT. Connect source (black) lead to emitter of UJT and gate 1 (yellow) lead to each base (in turn) of the UJT. In each case, meter should read 0-10 μa on the red I_{GSS} scale.

n. Ohmmeter.

The Model 685 can be used to measure resistance values between 400 ohms and 10 megohms on a scale that is conveniently expanded at the low end of the dial.

1. Set the panel switches as follows:

TYPE SELECTOR:	400-10M OHMS
DEVICE SELECTOR:	400-10M OHMS
BIPOLAR FUNCTION:	500V/Ω

2. Connect the red and black VOLT/OHMS leads on the Model 685 across the circuit to be measured and read resistance from bottom red scale.

o. Voltmeter.

The voltmeter uses the 0-500 segment that corresponds to the μA LEAKAGE scale. The lower end of the dial is conveniently expanded to accurately read the lower voltage values generally encountered in transistor circuits.

1. Set panel switches as follows:

TYPE SELECTOR:	0-500 VOLTS
DEVICE SELECTOR:	0-500 VOLTS
BIPOLAR FUNCTION:	500V/Ω
VOLTMETER:	POWER OFF

2. Connect the red (+) and black (-) leads on the Model 685 across the d-c voltage to be measured.

CAUTION: If unit on which voltage measurement is to be made does not have a floating power supply, pull the a-c plug on the Model 685 out of the line before performing measurement.

CALIBRATION (See figure 15.)

Three potentiometers on the PC board must be calibrated prior to operation. Several items of test equipment are required: a standard VTVM and either an a-c VTVM or a scope for measuring peak-to-peak voltages. The EICO Models 232, 235, 240, or 242 may be used here.

Preliminary Procedure

Set the controls on the Model 685 as follows:

TYPE SELECTOR:	N-CHANNEL
DEVICE SELECTOR:	FET
ENHANCEMENT-DEPLETION:	DEPLETION
FET FUNCTION:	g_m X1
BIPOLAR FUNCTION:	I_{CEO}
VOLTAGE pot:	20 (max. clockwise)
FET g_m CAL pot:	fully counterclockwise
BIPOLAR β CAL pot:	fully counterclockwise
VOLTMETER:	ON

Calibration of R13

1. Connect GATE 1 (yellow) and SOURCE (black) leads of Model 685 to peak-to-peak reading a-c vtvm or scope.

2. Adjust R13 (top potentiometer near 250 mfd capacitor) for reading of 0.4 volt peak-to-peak.

Calibration of R17

1. Connect d-c vtvm between terminals F (+) and G (-) on PC board.

2. Adjust R17 (top potentiometer near 100 mfd capacitor) for reading of 20 volts dc.

Calibration of R6

1. Set DEVICE SELECTOR switch to 400-10M OHMS.

2. Connect the red and black VOLT/OHMS leads across the 1K, 1% resistor (11080), supplied with kits only.

3. Adjust R6 (near bottom of PC board) so bottom red ohms scale on Model 685 reads at 1K.

MAINTENANCE

To gain access to the chassis, remove the four screws at the rear of the cabinet. (Two of these support the line cord while in storage.) Slide the chassis from the front of the cabinet.

Visually check the parts on the printed circuit board for evidence of arcing or overheating. Make sure that the wiring between panel switches and the board is intact.

If trouble should occur in the unit, a thorough understanding of circuit operation (see CIRCUIT DESCRIPTION) will facilitate trouble localization. Some troubleshooting hints are outlined below. Use the overall schematic diagram as a troubleshooting aid. Each part on the PC board is identified by a reference designation which relates to the designations on the schematic diagram.

TROUBLESHOOTING CHART

Symptom	Probable Cause	Remedy
No g_m reading can be made. β and leakage tests are normal.	D7 or D8 shorted.	Check both diodes out of circuit with Model 685.
g_m readings too high or too low.	Potentiometer R13 not calibrated.	Calibrate R13 per instructions in this manual.
Leakage and g_m tests normal, but β cannot be measured.	R22 open.	Check for open resistor R22 with ohmmeter and replace if necessary.
Meter swings to left or right when measuring g_m. Beta and leakage tests normal.	Diodes D3 or D4, or transistors Q1 or Q2 defective.	Check diodes and transistors and replace if necessary.
g_m, leakage, diode, V_p, SCR, and ohmmeter functions abnormal. Beta and zener diode recordings are normal.	D5 or C1 shorted, or R3 open.	There should be 6.8 volts at + end of C1. Check D5 and C1 for short and R3 for open circuit.

TROUBLESHOOTING CHART (cont)

Symptom	Probable Cause	Remedy
Meter reading is abnormal for all leakage measurements, V_p, zener diode tests, and ohmmeter; g_m and β readings normal.	Potentiometer R6 not calibrated.	Recalibrate R6 per instructions in this manual.
V_p, zener diode, and SCR tests cannot be made. All other functions are normal.	Defective component in 20-volt power supply section.	Check for 20 volts across VOLTAGE control. If abnormal, check diodes D9 and D10, C3, R16, and potentiometer R17.
Calibration of VOLTAGE control is inaccurate.	Potentiometer R17 not calibrated.	Recalibrate R17 per instructions in this manual.

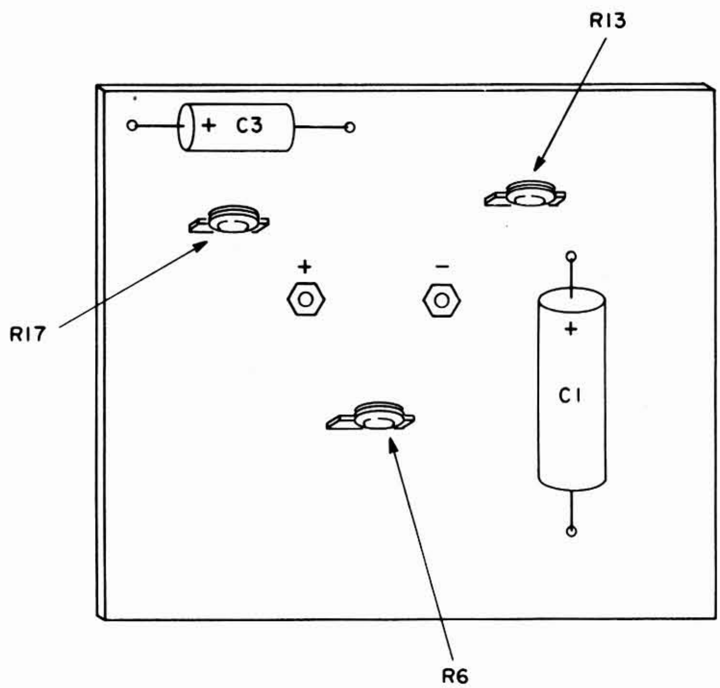


Figure 15. Location of Calibration Controls

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