



SYNC POWER CORP.

*Technical Review of N-Channel
MOSFET Measurement*

*576 Curve Tracer
Testing Report*

April 2005

MOSFET Products

Ver. 1

AN002

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This application note describes methods for measuring N-Channel MOSFET Characteristics.

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Type 576 CURVE TRACER

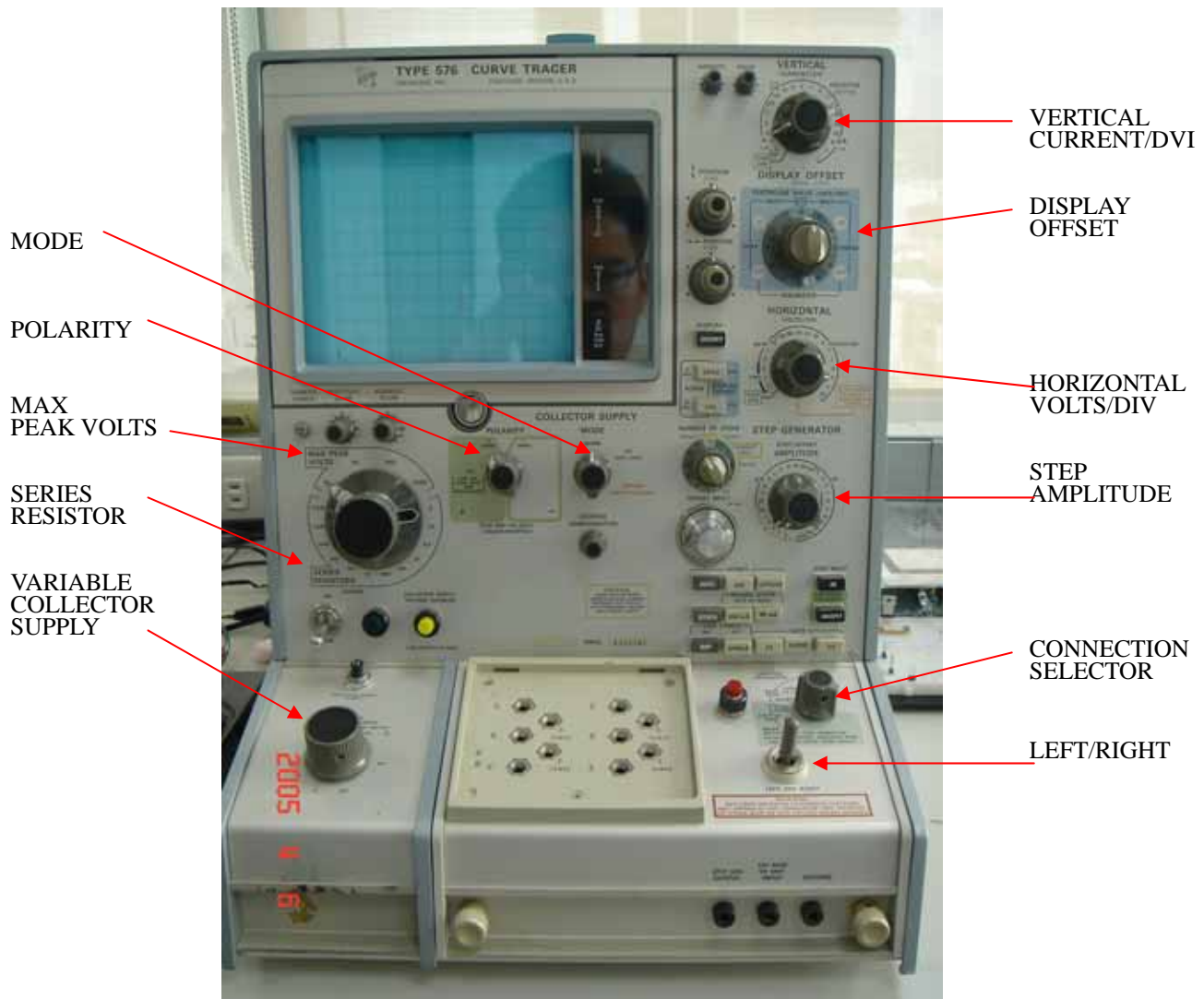


Figure 1.

The initial state of the curve tracer is assumed to be as follows:

- **LEFT/ RIGHT** switch in “off” position
- **VARIABLE COLLECTOR SUPPLY** at zero
- **DISPLAY** not inverted
- **DISPLAY OFFSET** set at zero
- **STEP/OFFSET POLARITY** button OUT (not inverted)
- **VERT/HORIZ DISPLAY MAGNIFIER** set at **NORM** (OFF)
- The **REP** button of the STEP FAMILY selector should be IN
- The **AID** button of the OFFSET selector should be IN
- The **NORM** button of the RATE SELECTOR should be IN

General Information



Figure 2.

BJT		MOSFET
Collector	→	Drain
Base	→	Gate
Emitter	→	Source

- Socket as follow

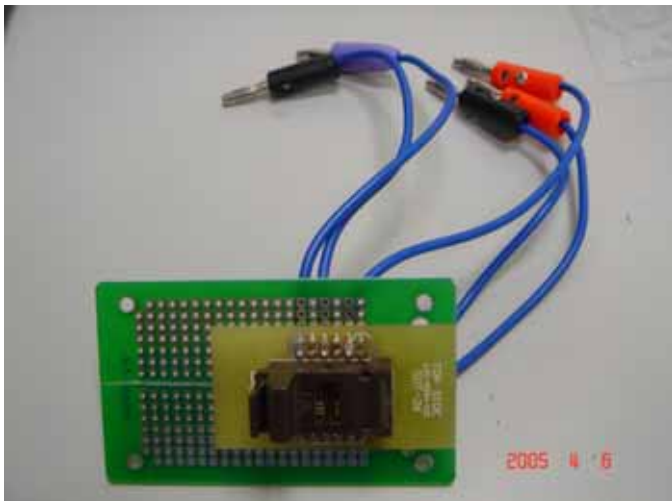


Figure 4.



Figure 3.

Connect the device using the **LEFT/RIGHT** switch

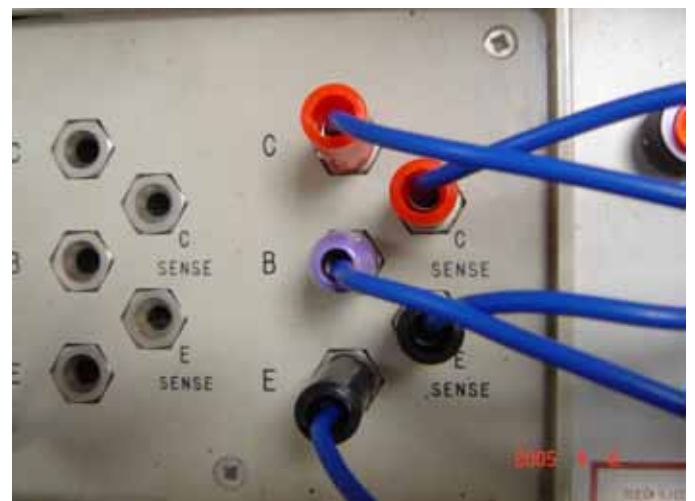


Figure 5.

Drain-Source Breakdown Voltage

1. Drain-Source Breakdown Voltage ($V_{(BR)}$, V_{DSS})

- Set the **MAX PEAK VOLTS** to **75V**.
- Set the **SERIES RESISTOR** to limit the avalanche current to a safe Value (i.e., tens of milliamps). A suitable value in this case would be **14k** Ohms.



Figure 6.

- Set the **POLARITY** switch to **NPN**.
- The **MODE** control should be set to **NORM**.



Figure 7.

- Not set the **DISPLAY** to **INVERT**.



Figure 8.

Drain-Source Breakdown Voltage

- f. **HORIZONTAL VOLTS/DIV** should be set at 5 V/div on the “collector” range.



Figure 9.

- g. **VERTICAL CURRENT/DIV** should be set at 50 $\mu\text{A}/\text{div}$.



Figure 10.

- h. On the plug-in fixture, the **CONNECTION SELECTOR** should be set to “**SHORT**” in the “**EMITTER GROUNDED**” sector. This action grounds the gate and disables the step generator.



Figure 11.

Drain-Source Breakdown Voltage

- i. Connect the device using the **LEFT/RIGHT** switch.



Figure 12.

- j. Increase the collector supply voltage using the **VARIABLE COLLECTOR SUPPLY** control until the current (as indicated by the trace on the screen) reaches 250 μA . Read V_{DSS} from the screen.



Figure 13.

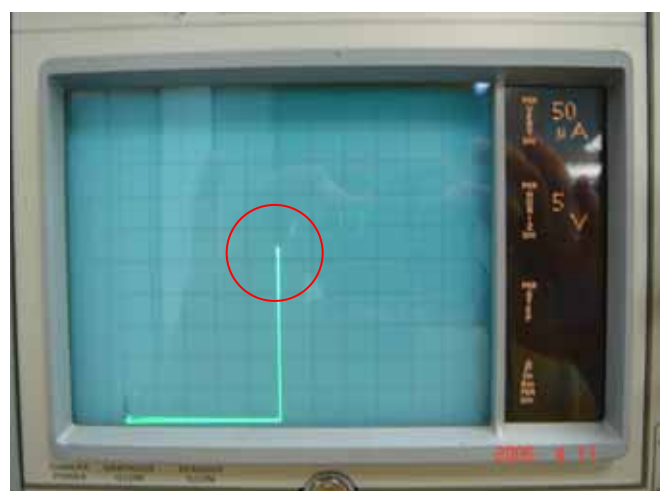


Figure 14.

Drain-Source Breakdown Voltage

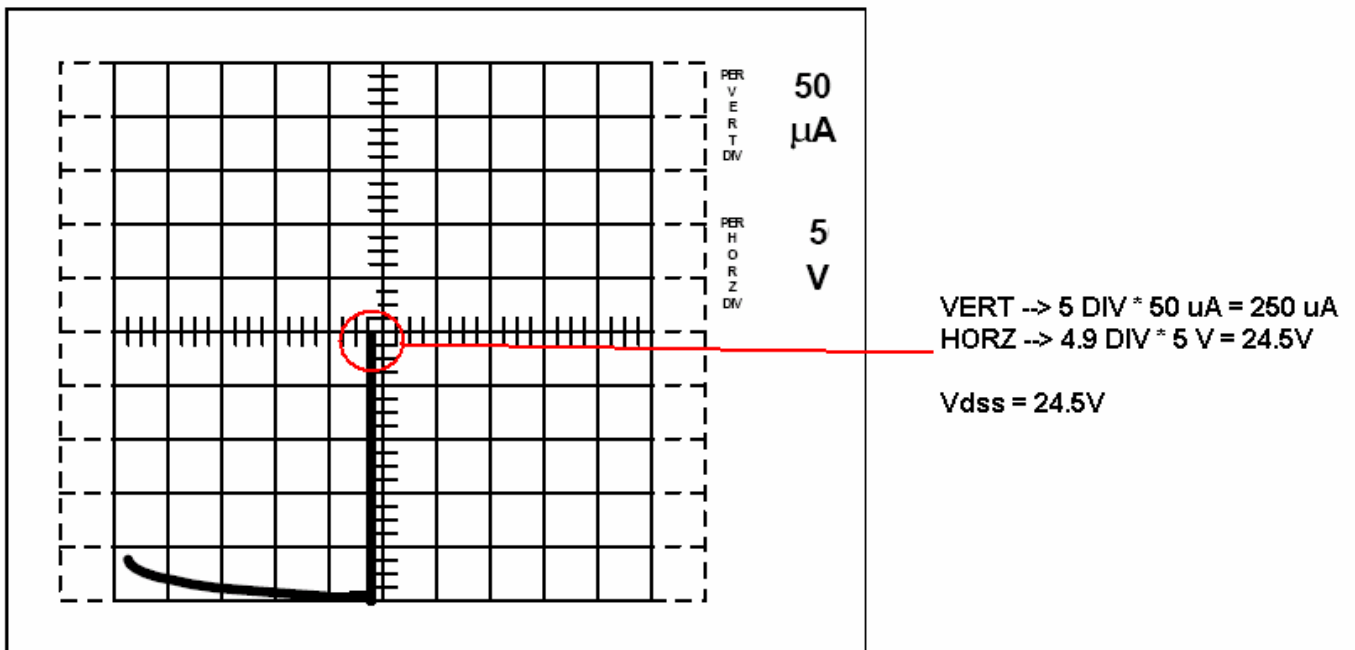


Figure 15.

Zero Gate Voltage Drain Current Current (I_{DSS})

2. Zero Gate Voltage Drain Current Current (I_{DSS})

- a. The **MODE** switch is set to "LEAKAGE".



Figure 16.

- b. **VERTICAL CURRENT/DIV** should be set at 1 nA/div.



Figure 17.

- c. Connect the device using the **LEFT/RIGHT** switch and adjust the collector supply voltage to the rated voltage of the Power . Read the value of **I_{DSS}** from the display. The vertical sensitivity may need altering to obtain an appropriately sized display. Often I_{DSS} will be in the nanoamp range and the current observed will be capacitor currents due to minute variations in collector supply voltage



Figure 18.

Zero Gate Voltage Drain Current Current (I_{DSS})

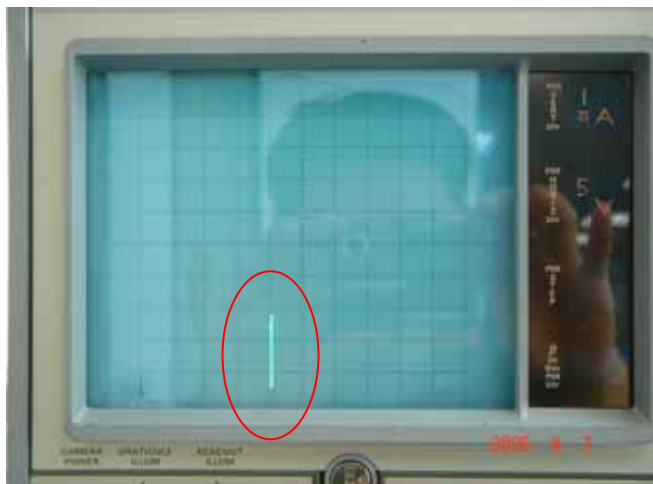


Figure 19.

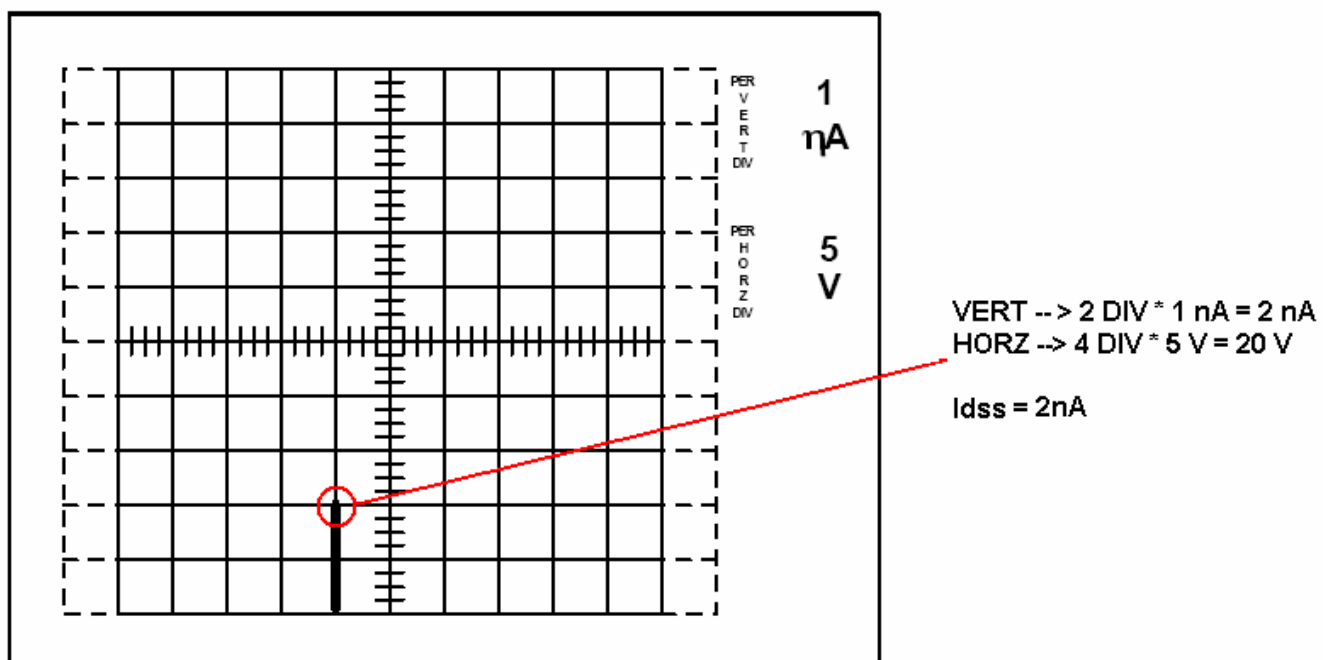


Figure 20.

Gate Threshold Voltage ($V_{GS(th)}$)

3. Gate Threshold Voltage ($V_{GS(th)}$)

- Connect the device as follows: source to “E”, gate to “B”, drain to “C”. This connection arrangement may require the construction of a special test fixture. Bending of the device leads can cause mechanical stress which results in the failure of the device.

Set the **MAX PEAK VOLTS** to **15V**.

- Set the **SERIES RESISTOR** to **30 ohms**.



Figure 21.

- Set **POLARITY** to **PNP**.
- Set the **MODE CONTROL** to **NORM**.
- Set the **DISPLAY** to **INVERT**.



Figure 22.

- Set the **VERTICAL CURRENT/DIV** to **50 uA/div**.



Figure 23.

Gate Threshold Voltage ($V_{GS(th)}$)

- g. Set the **HORIZONTAL VOLTS/DIV** to **200mV/div**.



Figure 24.

- h. Set the **CONNECTION SELECTOR** to **“SHORT”** in the **“EMITTER GROUNDED”** sector.



Figure 25.

- i. Connect the device using the **LEFT/ RIGHT** switch. Increase the **VARIABLE COLLECTOR VOLTAGE** until the drain current reaches 250 μA as indicated by the trace on the screen. Read the voltage on the horizontal center line (since this line corresponds to $I_D = 250 \mu\text{A}$).



Figure 26.



Figure 27.

Gate Threshold Voltage ($V_{GS(th)}$)

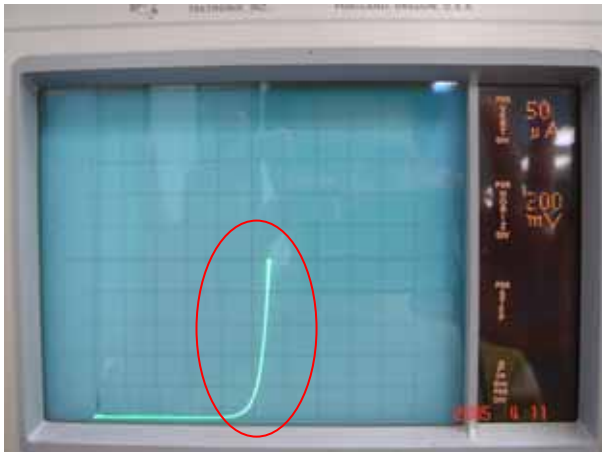


Figure 28.

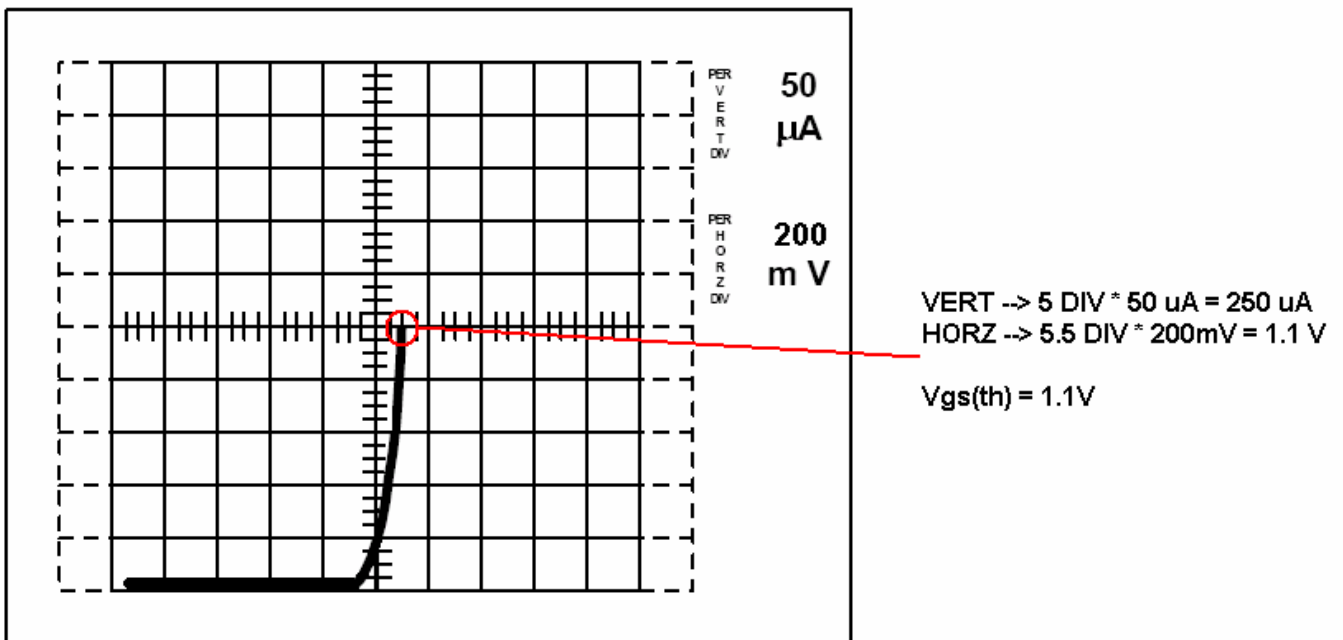


Figure 29.

Gate Leakage Current (I_{GSS})

4. Gate Leakage Current (I_{GSS})

- a. The device is connected as follows: gate to “C”, drain to “B”, source to “E”. This is not the usual connection sequence, and a special test fixture will be required if bending of the leads is to be avoided.
- b. Set **MAX PEAK** VOLTS to 15V.
- c. Set the **SERIES RESISTOR** to 30 ohms .



Figure 30.

- d. Set **POLARITY** to NPN.
- e. Set the **MODE** switch to LEAKAGE.
- f. Not set the **DISPLAY** to INVERT.



Figure 31.

- g. Set the **CONNECTION SELECTOR** to the “SHORT” position in the “EMITTER GROUNDED” sector.



Figure 32.

Gate Leakage Current (I_{GSS})

- h. **HORIZONTAL VOLTS/DIV** should be set at **2V/div**.



Figure 33.

- i. **VERTICAL CURRENT/DIV** should be set to an appropriately low range.
- j. Connect the device using the **LEFT/RIGHT** switch. Increase the collector supply voltage using the **VARIABLE COLLECTOR SUPPLY** control, but do not exceed 20V, the maximum allowable gate voltage. It may be necessary to adjust the vertical sensitivity. Read the leakage current from the display. In many cases, the leakage current will be in the nanoamp range, in which case the trace will be dominated by currents which flow through the device capacitance as a result of minute fluctuations in the collector supply voltage.
- k. The above procedure is for determining gate leakage current with a positive gate voltage. To make the same measurement using a negative voltage, reduce the **VARIABLE COLLECTOR SUPPLY** voltage to zero, change the **POLARITY** switch to the PNP position, and reapply the voltage. The trace will take time to settle because of the gate-source capacitance.



Figure 34.



Figure 35.

Gate Leakage Current (I_{GSS})



Figure 36.

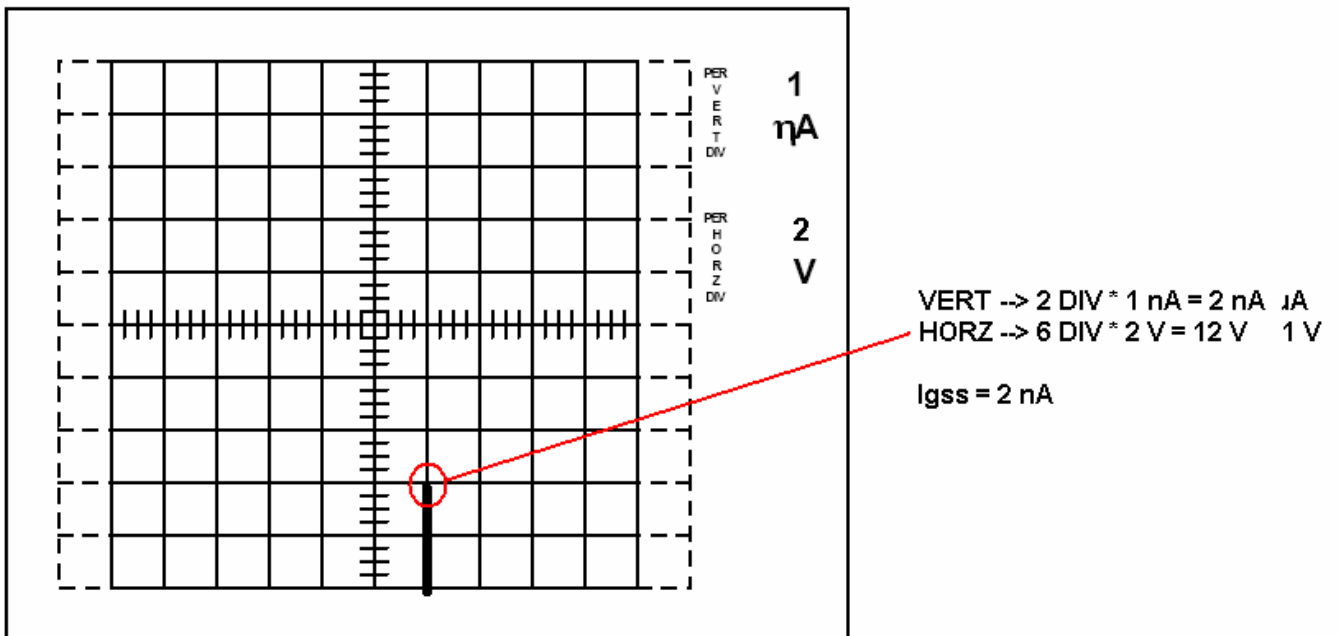


Figure 37.

5. Drain-Source On-Resistance $R_{DS(ON)}$

- a. Connect the device as follows: gate to “B”, drain to “C”, source to “E”.
- b. Set the **MAX PEAK VOLTS** to 15 V.
- c. Set the **SERIES RESISTOR** to 1.4 Ohms.



Figure 38.

- d. The **POLARITY** switch should be set to **NPN**.
- e. The **MODE** switch should be set to “**NORM**”



Figure 39.

- f. Not set the **DISPLAY** to **INVERT**.



Figure 40.

Drain-Source On-Resistance $R_{DS(ON)}$

Set the **STEP AMPLITUDE** to **0.5V**.

g. Set **NUMBER OF STEPS** to **5**.

h. Set **OFFSET MULT** to **0**.

$$V_{GS} = \text{STEP AMPLITUDE} \times (\text{NUMBER OF STEPS} + \text{OFFSET MULT})$$

$$= -0.5 \times (5+0) = -2.5V$$

if $V_{GS} = -4.5V$,

Set **NUMBER OF STEPS** to **9**.



Figure 41.

i. Set the **HORIZONTAL VOLTS/DIV** to **200mV/div**.

j. The **STEP MULTIPLIER** button should be **OUT**—that is, 0.1X not selected.

k. On the **PULSED STEPS** selector, the **80 microsec** button should be **IN** (or the 300 microsec, if the 80 is not available).

l. On the **RATE** selector, the **NORM** button should be **IN**.



Figure 42.

m. Set **VERTICAL CURRENT/DIV** at **1 A/div**. This scale should be chosen according to the on-resistance of the device being tested



Figure 43.

Drain-Source On-Resistance $R_{DS(ON)}$

- n. **HORIZONTAL VOLTS/DIV** should be set at **50mV/div**



Figure 44.

- o. Set the **CONNECTION SELECTOR** to the “**STEP GEN**” position in the “**EMITTER GROUNDED**” sector.



Figure 45.

- p. Connect the device using the **LEFT/RIGHT** switch and raise the **VARIABLE COLLECTOR SUPPLY** voltage until the desired value of drain current is obtained. $R_{DS(on)}$ is obtained from the trace by reading the peak values of current and voltage.



Figure 46.



Figure 47.

q. $R_{DS(on)} = V_{DS} / I_D$



Figure 48.

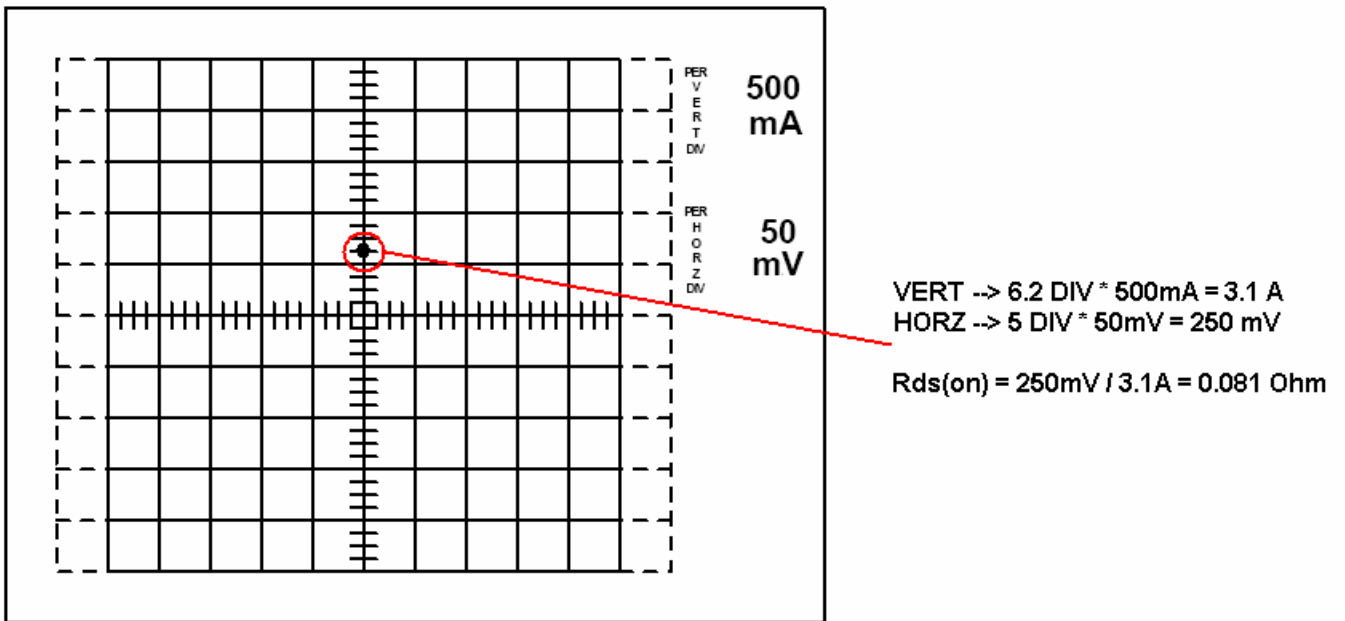


Figure 49.

6. **On-State Drain Current $I_{D(ON)}$**

- a. Connect the device as follows: gate to “B”, drain to “C”, source to “E”.
- b. Set the **MAX PEAK VOLTS** to **15 V**.
- c. Set the **SERIES RESISTOR** to **1.4 Ohms**.



Figure 50.

- d. The **POLARITY** switch should be set to **NPN**.
- e. The **MODE** switch should be set to “**NORM**”.
- f. Not set the **DISPLAY** to **INVERT**.



Figure 51.

- g. Set the **STEP AMPLITUDE** to **0.5V**.
- h. Set **NUMBER OF STEPS** to **5**.
- i. Set **OFFSET MULT** to **0**.
- j. $V_{GS} = \text{STEP AMPLITUDE} \times (\text{NUMBER OF STEPS} + \text{OFFSET MULT})$
 $= -0.5 \times (5 + 0) = -2.5V$
 if $V_{GS} = -4.5V$
 Set **NUMBER OF STEPS** to **9**.



Figure 52.

On-State Drain Current $I_{D(ON)}$

Set **VERTICAL CURRENT/DIV** at **500 mA/div**.

This scale should be chosen according to the on-resistance of the device being tested.



Figure 53.

- l. **HORIZONTAL VOLTS/DIV** should be set at **1V/div**.



Figure 54.

- m. Set the **CONNECTION SELECTOR** to the **“STEP GEN”** position in the **“EMITTER GROUNDED”** sector.



Figure 55.

On-State Drain Current $I_{D(ON)}$

- n. Connect the device using the **LEFT/RIGHT** switch and raise the **VARIABLE COLLECTOR SUPPLY** voltage until the desired value of drain current is obtained. $R_{DS(on)}$ is obtained from the trace by reading the peak values of current and voltage.



Figure 56.



Figure 57.



Figure 58.

On-State Drain Current $I_{D(ON)}$

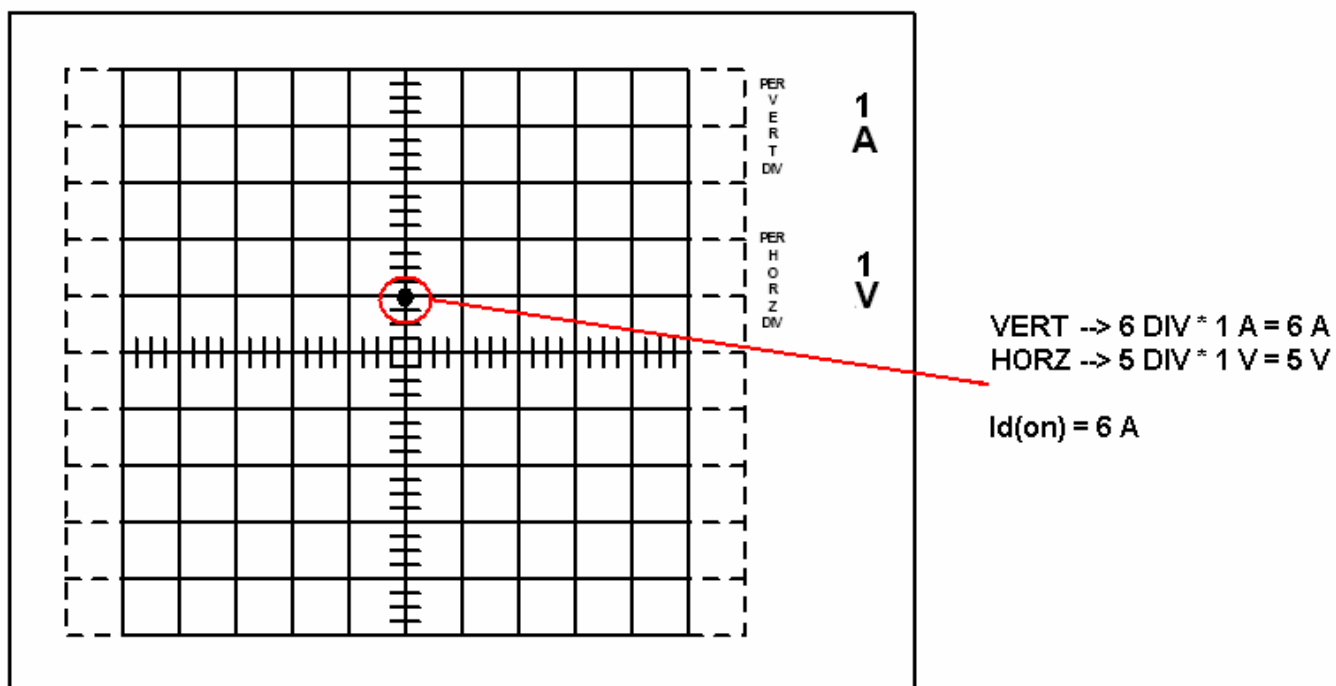


Figure 59.

7. Diode Forward Voltage V_{SD}

- a. Connect the device as follows: gate to “B”, drain to “C”, source to “E”.
- b. Set the **MAX PEAK VOLTS** to 15V.
- c. Set the **SERIES RESISTOR** at 1.4 ohms or a value sufficiently low that rated current can be obtained.



Figure 60.

- d. Set **POLARITY** to PNP.
- e. Set **MODE** to "NORM".
- f. Set the **DISPLAY** to **INVERT**.



Figure 61.

- g. The 80 microsec button of the **PULSED STEPS** selector should be IN (or the 300 microsec, if the 80 is not available).



Figure 62.

Diode Forward Voltage V_{SD}

- h. The **CONNECTION SELECTOR** should be set to the "SHORT" position in the "EMITTER GROUNDED" sector.



Figure 62.

- i. **HORIZONTAL VOLTS/DIV** should be on 100 mV/div.



Figure 63.

- j. **VERTICAL CURRENT DIV** should be on 200 mA/div.



Figure 64.

Diode Forward Voltage V_{SD}

- k. The device is connected using the **LEFT/RIGHT** switch. Increase the **VARIABLE COLLECTOR SUPPLY** voltage until rated current is reached . Read V_{SD} from the trace .



Figure 65.



Figure 66.

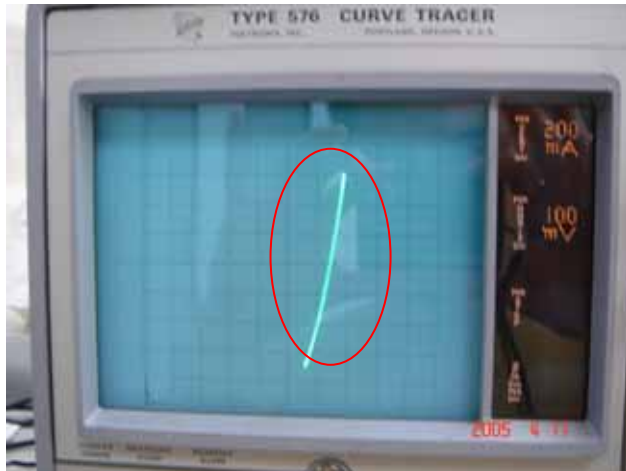


Figure 67

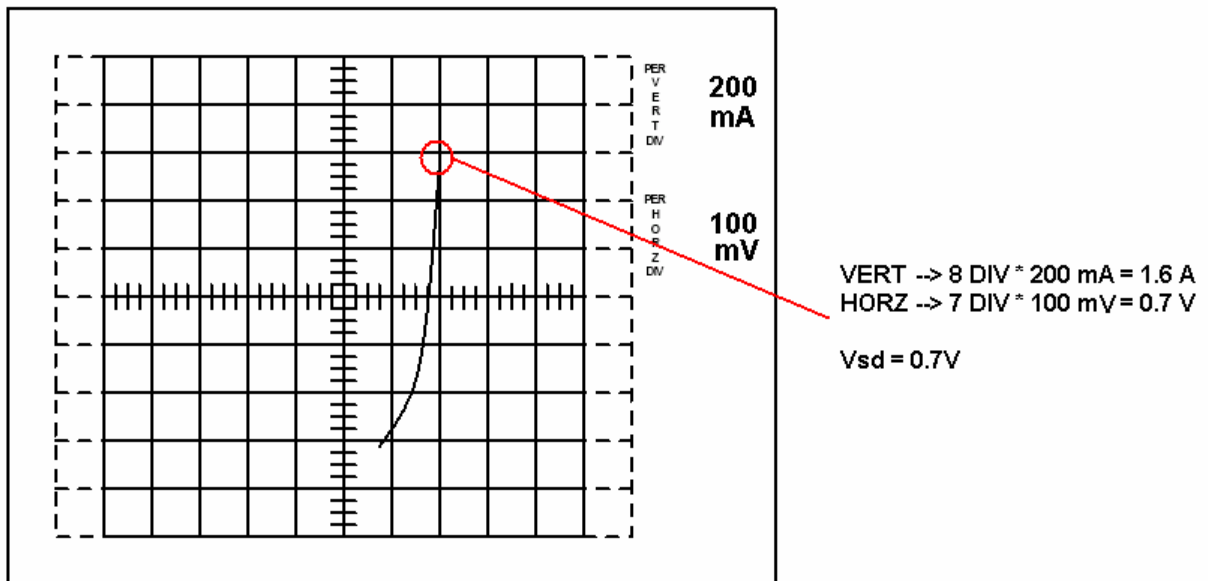


Figure 68.

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