Thyristor and Rectifier Testing Using Curve Tracers

Introduction

One of the most useful and versatile instruments for testing semiconductor devices is the curve tracer (CT). Tektronix is the best known manufacturer of curve tracers and produces four basic models: 575, 576, 577 and 370. These instruments are specially adapted CRT display screens with associated electronics such as power supplies, amplifiers, and variable input and output functions that allow the user to display the operating characteristics of a device in an easy-to-read, standard graph form. Operation of Tektronix CTs is simple and straightforward and easily taught to non-technical personnel. Although widely used by semiconductor manufacturers for design and analytical work, the device consumer will find many uses for the curve tracer, such as incoming quality control, failure analysis, and supplier comparison. Curve tracers may be easily adapted for go-no go production testing. Tektronix also supplies optional accessories for specific applications along with other useful hardware.

Tektronix Equipment

Although Tektronix no longer produces curve tracer model 575, many of the units are still operating in the field, and it is still an extremely useful instrument. The 576, 577 and 370 are current curve tracer models and are more streamlined in their appearance and operation. The 577 is a less elaborate version of the 576, yet retains all necessary test functions.

The following basic functions are common to all curve tracers:

- **Power supply** supplies positive DC voltage, negative DC voltage, or AC voltage to bias the device. Available power is varied by limiting resistors.
- **Step generator** supplies current or voltage in precise steps to control the electrode of the device. The number, polarity, and frequency of steps are selectable.
- **Horizontal amplifier** displays power supply voltage as applied to the device. Scale calibration is selectable.
- **Vertical amplifier** displays current drawn from the supply by the device. Scale calibration is selectable.

Curve tracer controls for beam position, calibration, pulse operation, and other functions vary from model to model. The basic theory of operation is that for each curve one terminal is driven with a constant voltage or current and the other one is swept with a half sinewave of voltage. The driving voltage is stepped through several values, and a different trace is drawn on each sweep to generate a family of curves.

Limitations, Accuracy, and Correlation

Although the curve tracer is a highly versatile device, it is not capable of every test that one may wish to perform on semiconductor devices such as dv/dt, secondary reverse breakdown, switching speeds, and others. Also, tests at very high currents and/or voltages are difficult to conduct accurately and without damaging the devices. A special high-current test fixture available from Tektronix can extend operation to 200 A pulsed peak. Kelvin contacts available on the 576 and 577 eliminate inaccuracy in voltage measured at high current (V_{TM}) by sensing voltage drop due to contact resistance and subtracting from the reading.

Accuracy of the unit is within the published manufacturer's specification. Allow the curve tracer to warm up and stabilize before testing begins. Always expand the horizontal or vertical scale as far as possible to increase the resolution. Be judicious in recording data from the screen, as the trace line width and scale resolution factor somewhat limit the accuracy of what may be read. Regular calibration checks of the instrument are recommended. Some users keep a selection of calibrated devices on hand to verify instrument operation when in doubt. Re-calibration or adjustment should be performed only by qualified personnel.

Often discrepancies exist between measurements taken on different types of instrument. In particular, most semiconductor manufacturers use high-speed, computerized test equipment to test devices. They test using very short pulses. If a borderline unit is then measured on a curve tracer, it may appear to be out of specification. The most common culprit here is heat. When a semiconductor device increases in temperature due to current flow, certain characteristics may change, notably gate characteristics on SCRs, gain on transistors, leakage, and so on. It is very difficult to operate the curve tracer in such a way as to eliminate the heating effect. Pulsed or single-trace operation helps reduce this problem, but care should be taken in comparing curve tracer measurements to computer tests. Other factors such as stray capacitances, impedance matching, noise, and device oscillation also may create differences.

Safety (Cautions and Warnings)

Adhere rigidly to Tektronix safety rules supplied with each curve tracer. No attempt should be made to defeat any of the safety interlocks on the device as the curve tracer can produce a lethal shock. Also, older 575 models do not have the safety interlocks as do the new models. Take care never to touch any device or open the terminal while energized.

WARNING: Devices on the curve tracer may be easily damaged from electrical overstress.

Follow these rules to avoid destroying devices:

- Familiarize yourself with the expected maximum limits of the device.
- Limit the current with the variable resistor to the minimum necessary to conduct the test.
- Increase power slowly to the specified limit.
- Watch for device "runaway" due to heating.
- Apply and increase gate or base drive slowly and in small steps.
- Conduct tests in the minimum time required.

General Test Procedures

Read all manuals before operating a curve tracer.

Perform the following manufacturer's equipment check:

1. Turn on and warm up curve tracer, but turn off, or down, all power supplies.
2. Correctly identify terminals of the device to be tested. Refer to the manufacturer's guide if necessary.
3. Insert the device into the test fixture, matching the device and test terminals.
4. Remove hands from the device and/or close interlock cover.
5. Apply required bias and/or drive.
6. Record results as required.
7. Disconnect all power to the device before removing.

Model 576 Curve Tracer Procedures

The following test procedures are written for use with the model 576 curve tracer. (Figure AN1006.1)

See "Model 370 Curve Tracer Procedure Notes" on page AN1006-16 and "Model 577 Curve Tracer Procedure Notes" on page AN1006-18 for setting adjustments required when using model 370 and 577 curve tracers.

The standard 575 model lacks AC mode, voltage greater than 200 V, pulse operations, DC mode, and step offset controls. The 575 MOD122C does allow voltage up to 400 V, including 1500 V in an AC mode. Remember that at the time of design, the 575 was built to test only transistors and diodes. Some ingenuity, experience, and external hardware may be required to test other types of devices.

For further information or assistance in device testing on Tektronix curve tracers, contact the Littelfuse Applications Engineering group.

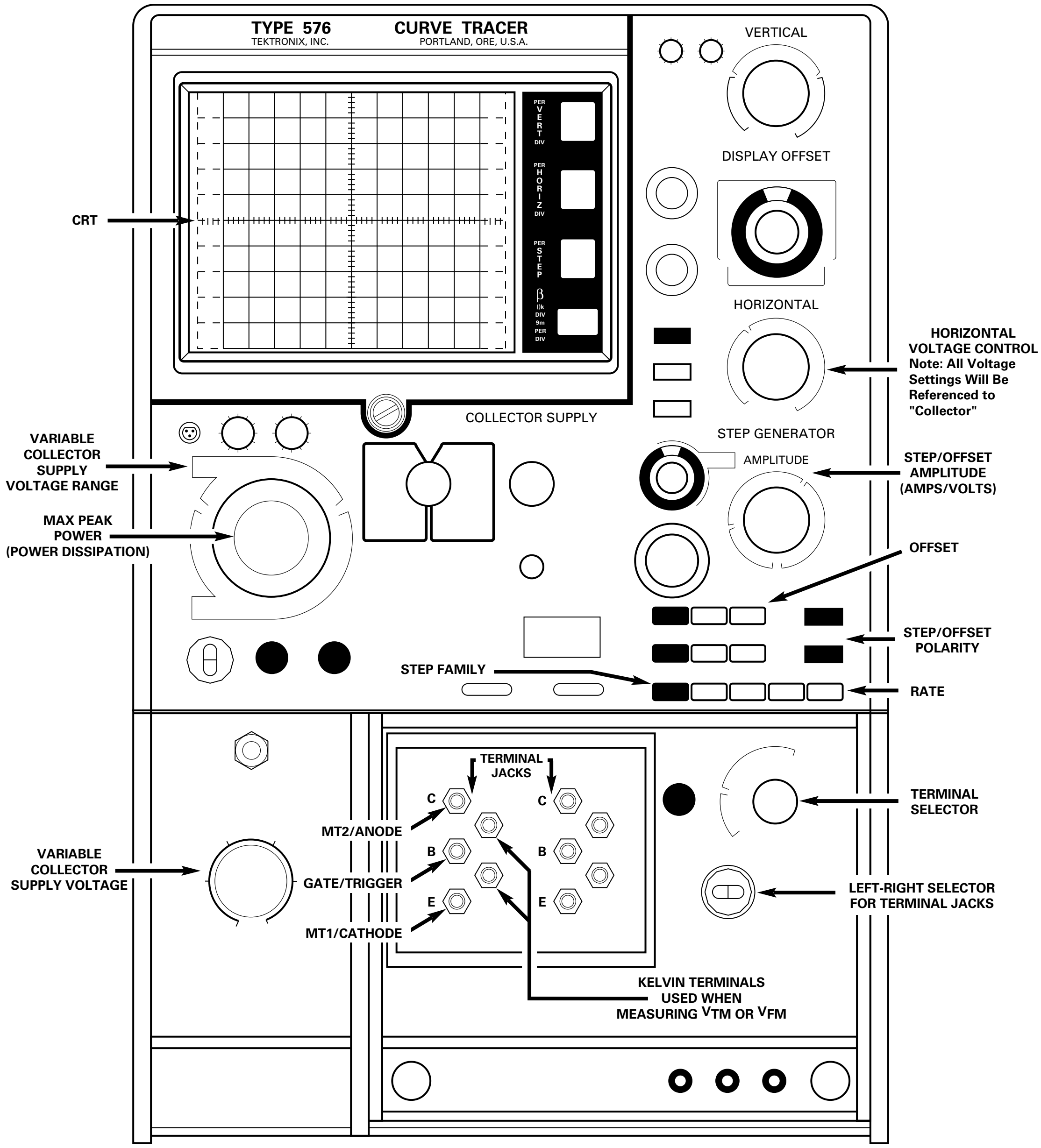

Figure AN1006.1 Tektronix Model 576 Curve Tracer

Power Rectifiers

The rectifier is a unidirectional device which conducts when forward voltage (above 0.7 V) is applied.

To connect the rectifier:

1. Connect *Anode to Collector Terminal (C).*
2. Connect *Cathode to Emitter Terminal (E).*

To begin testing, perform the following procedures.

Procedure 1: V_{RRM} and I_{RM}

To measure the V_{RRM} and I_{RM} parameter:

1. Set **Variable Collector Supply Voltage Range** to *1500 V.*(*2000 V on 370*)
2. Set **Horizontal** knob to sufficient scale to allow viewing of trace at the required voltage level (*100 V/DIV* for 400 V and 600 V devices and *50 V/DIV for 200 V devices*).
3. Set **Mode** to *Leakage.*
4. Set **Vertical** knob to *100 µA/DIV.* (Due to leakage setting, the CRT readout will be 100 nA per division.)
5. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
6. Set **Polarity** to (-).
7. Set **Power Dissipation** to *2.2 W.* (*2 W* on 370)
8. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
9. Increase **Variable Collector Supply Voltage** to the rated V_{RRM} of the device and observe the dot on the CRT. Read across horizontally from the dot to the vertical current scale. This measured value is the leakage current. (Figure AN1006.2)

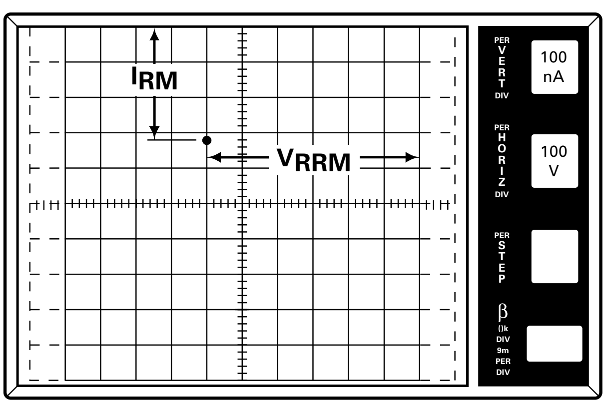

Figure AN1006.2 I_{RM} = 340 nA at V_{RRM} = 600 V

Procedure 2: V_{FM}

Before testing, note the following:

- A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of VFM will result due to voltage drop in fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin connections.
- Due to the current limitations of standard curve tracer model 576, V_{FM} cannot be tested at rated current without a Tektronix model 176 high-current module. The procedure below is done at $I_{T(RMS)}$ = 10 A (20 A_{PK}). This test parameter allows the use of a standard curve tracer and still provides an estimate of whether V_{FM} is within specification.

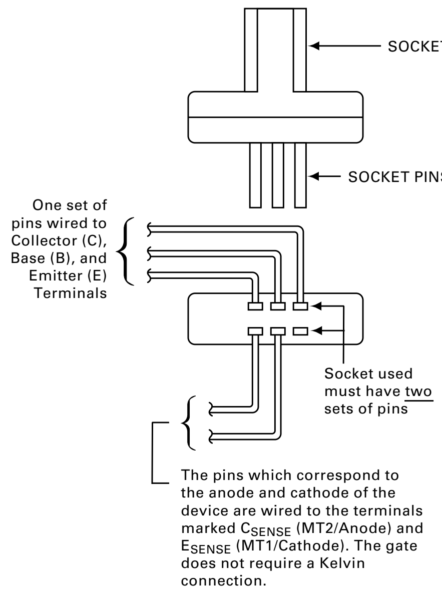

Figure AN1006.3 Instructions for Wiring Kelvin Socket

To measure the V_{FM} parameter:

1. Set **Variable Collector Supply Voltage Range** to *15 Max Peak Volts.* (*16 V on 370*)
2. Set **Horizontal** knob to *0.5 V/DIV.*
3. Set **Mode** to *Norm.*
4. Set **Vertical** knob to *2 A/DIV.*
5. Set **Power Dissipation** to *220 W* (*100 W on 577*).
6. Set **Polarity** to (+).
7. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
8. Increase **Variable Collector Supply Voltage** until current reaches 20 A.

WARNING: Limit test time to 15 seconds maximum.

To measure V_{FM}, follow along horizontal scale to the point where the trace crosses the 20 A axis. The distance from the left-hand side of scale to the crossing point is the V_{FM} value. (Figure AN1006.4)

Note: Model 370 current is limited to 10 A.

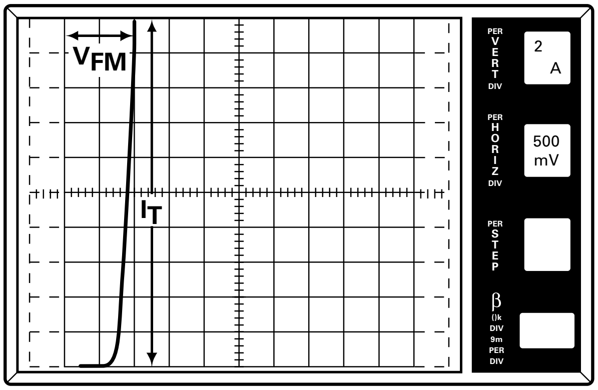

Figure AN1006.4 V_{FM} = 1 V at I_{PK} = 20 A

SCRs

SCRs are half-wave unidirectional rectifiers turned on when current is supplied to the gate terminal. If the current supplied to the gate is to be in the range of 12 μA and 500 μA, then a sensitive SCR is required; if the gate current is between 1 mA and 50 mA, then a non-sensitive SCR is required.

To connect the rectifier:

1. Connect *Anode to Collector Terminal (C).*
2. Connect *Cathode to Emitter Terminal (E).*

Note: When sensitive SCRs are being tested, a 1 kΩ resistor must be connected between the gate and the cathode, except when testing I_{GT}.

To begin testing, perform the following procedures.

Procedure 1: V_{DRM} / V_{RRM} / I_{DRM} / I_{RRM}

To measure the V_{DRM} / V_{RRM} / I_{DRM}, and I_{RRM} parameter:

1. Set **Variable Collector Supply Voltage Range** to appropriate *Max Peak Volts* for device under test. (Value selected should be equal to or greater than the device's V_{DRM} rating.)
2. Set **Horizontal** knob to sufficient scale to allow viewing of trace at the required voltage level. (The *100 V/DIV* scale should be used for testing devices having a V_{DRM} value of 600 V or greater; the *50 V/DIV* scale for testing parts rated from 300 V to 500 V, and so on.)
3. Set **Mode** to *Leakage*.
4. Set **Polarity** to (+).
5. Set **Power Dissipation** to *0.5 W*.(*0.4 W* on 370)
6. Set **Terminal Selector** to *Emitter Grounded-Open Base*.
7. Set **Vertical** knob to approximately ten times the maximum leakage current (I_{DRM}, I_{RRM}) specified for the device. (For sensitive SCRs, set to *50 μA*.)

Note: The CRT screen readout should show 1% of the maximum leakage current if the vertical scale is divided by 1,000 when leakage current mode is used.

Procedure 2: V_{DRM} / I_{DRM}

To measure the V_{DRM} and I_{DRM} parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
2. Set **Variable Collector Supply Voltage** to the rated V_{DRM} of the device and observe the dot on CRT. Read across horizontally from the dot to the vertical current scale. This measured value is the leakage current. (Figure AN1006.5)

WARNING: Do NOT exceed V_{DRM}/V_{RRM} rating of SCRs, Triacs, or Quadracs. These devices can be damaged.

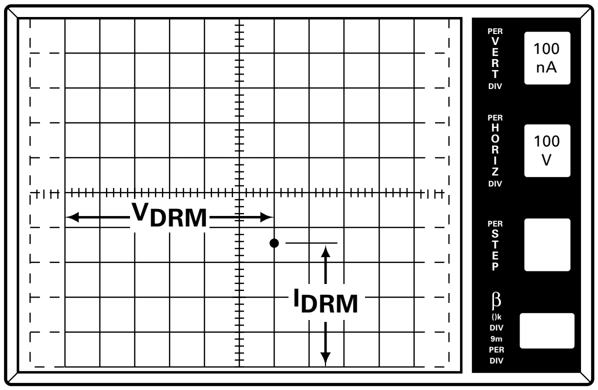

Figure AN1006.5 I_{DRM} = 350 nA at V_{DRM} = 600 V

Procedure 3: V_{RRM} / I_{RRM}

To measure the V_{RRM} and I_{RRM} parameter:

1. Set **Polarity** to (-).
2. Repeat Steps 1 and 2 (V_{DRM}, I_{DRM}) except substitute V_{RRM} value for V_{DRM}. (Figure AN1006.6)

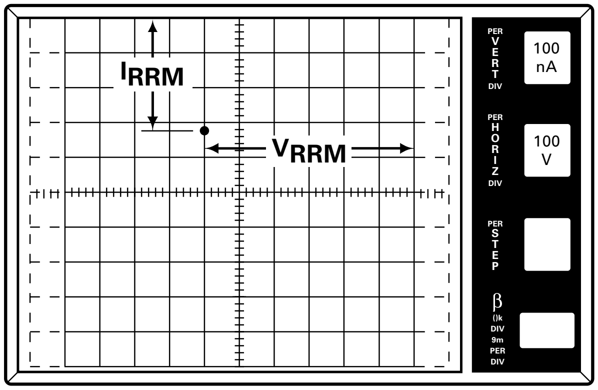

Figure AN1006.6 I_{RRM} = 340 nA at V_{RRM} = 600 V

Procedure 4: V_{TM}

To measure the V_{TM} parameter:

1. Set **Terminal Selector** to *Step Generator-Emitter Grounded.*
2. Set **Polarity** to *(+).*
3. Set **Step/Offset Amplitude** to twice the maximum I_{GT} rating of the device (to ensure the device turns on). For sensitive SCRs, set to *2 mA.*
4. Set **Max Peak Volts** to *15 V.* (*16 V* on 370)
5. Set **Offset** by depressing *0* (zero).
6. Set **Rate** by depressing *Norm.*
7. Set **Step Family** by depressing *Rep* (repetitive).
8. Set **Mode** to *DC.*
9. Set **Horizontal** knob to *0.5 V/DIV.*
10. Set **Power Dissipation** to *220 W* (*100 W on 577*).
11. Set **Number of Steps** to *1*. (Set steps to 0 (zero) on 370.)
12. Set **Vertical** knob to a sufficient setting to allow the viewing of 2 times the $I_{T(RMS)}$ rating of the device ($I_{T(peak)}$) on CRT.

    Before continuing with testing, note the following:

    (1) Due to the excessive amount of power that can be generated in this test, only parts with an $I_{T(RMS)}$ rating of 6 A or less should be tested on standard curve tracer. If testing devices above 6 A, a Tektronix model 176 high-current module is required.

    (2) A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of V_{TM} will result due to voltage drop in the fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin connectors.
13. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
14. Increase **Variable Collector Supply Voltage** until current reaches rated $I_{T(peak)}$, which is twice the $I_{T(RMS)}$ rating of theSCR under test.

Note: Model 370 current is limited to 10 A.

WARNING: Limit test time to 15 seconds maximum after the *Variable Collector Supply* has been set to $I_{T(peak)}$. After the *Variable Collector Supply Voltage* has been set to $I_{T(peak)}$, the test time can automatically be shortened by changing *Step Family* from repetitive to single by depressing the *Single button.*

To measure V_{TM}, follow along horizontal scale to the point where the trace crosses the $I_{T(peak)}$ value. The distance from the left-hand side of scale to the intersection point is the V_{TM} value. (Figure AN1006.7)

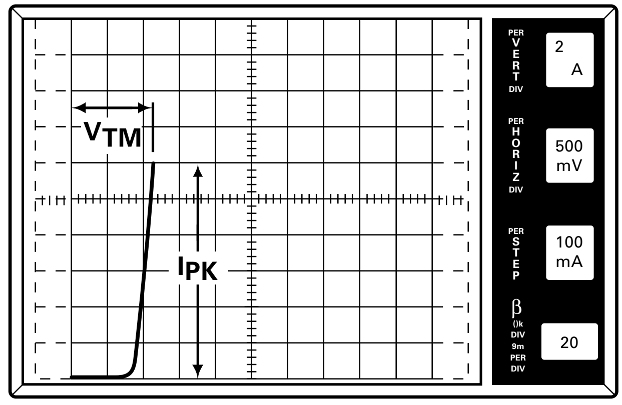

Figure AN1006.7 V_{TM} = 1.15 V at $I_{T(peak)}$ = 12 A

Procedure 5: I_H

To measure the I_H parameter:

1. Set **Polarity** to (+).
2. Set **Power Dissipation** to *2.2 W.* (*2 W* on 370)
3. Set **Max Peak Volts** to *75 V.* (80 V on 370)
4. Set **Mode** to *DC.*
5. Set **Horizontal** knob to *Step Generator.*
6. Set **Vertical** knob to approximately 10 percent of the maximum I_H specified.

Note: Due to large variation of holding current values, the scale may have to be adjusted to observe holding current.

7. Set **Number of Steps** to *1.*
8. Set **Offset** by depressing *0*(zero). (Press *Aid* and Oppose at the same time on 370.)
9. Set **Step/Offset Amplitude** to twice the maximum I_{GT} of the device.
10. Set **Terminal Selector** to *Step Generator-Emitter Grounded.*
11. Set **Step Family** by depressing *Single.*
12. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
13. Increase **Variable Collector Supply Voltage** to maximum position (*100*).
14. Set **Step Family** by depressing *Single*. (This could possibly cause the dot on CRT to disappear, depending on the vertical scale selected.)
15. Change **Terminal Selector** from *Step Generator-Emitter Grounded* to *Open Base-Emitter Grounded.*
16. Decrease **Variable Collector Supply Voltage** to the point where the line on the CRT changes to a dot. The position of the beginning point of the line, just before the line becomes a dot, represents the holding current value. (Figure AN1006.8)

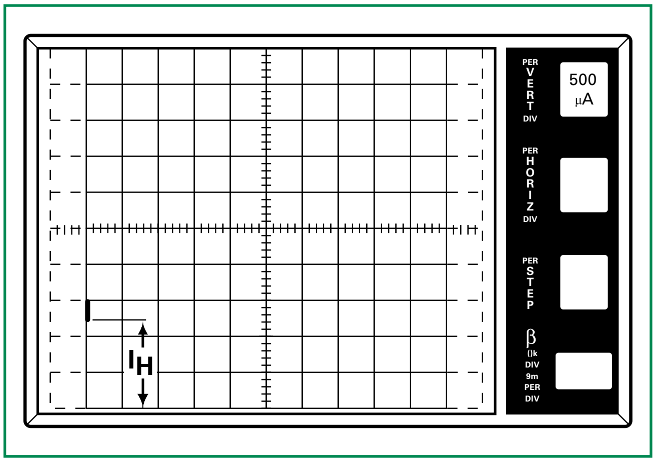

Figure AN1006.8 I_H = 1.2 mA

Procedure 6: I_{GT} and V_{GT}

To measure the I_{GT} and V_{GT} parameter:

1. Set **Polarity** to (+).
2. Set **Number of Steps** to 1.
3. Set **Offset** by depressing *Aid.*
4. Set **Offset Multiplier** to *0* (zero). (Press *Aid* and *Oppose* at the same time on 370.)
5. Set *Terminal Selector* to *Step Generator-Emitter Grounded.*
6. Set **Mode** to *Norm.*
7. Set **Max Peak Volts** to *15 V.* (*16 V* on 370)
8. Set **Power Dissipation** to *2.2 W.* (*2 W* on 370) For sensitive SCRs, set at 0.5 W. (*0.4 W* on 370)
9. Set **Horizontal** knob to *2 V/DIV.*
10. Set **Vertical** knob to *50 mA/DIV.*
11. Increase **Variable Collector Supply Voltage** until voltage reaches 12 V on CRT.
12. After 12 V setting is completed, change **Horizontal** knob to *Step Generator.*

Procedure 7: I_{GT}

To measure the I_{GT} parameter:

1. Set **Step/Offset Amplitude** to 20% of maximum rated I_{GT}.

   Note: R_{GK} should be removed when testing I_{GT}
2. Set **Left-Right Terminal Jack Selector** to correspond with location of the test fixture.
3. Gradually increase **Offset Multiplier** until device reaches the conduction point. (Figure AN1006.9) Measure I_{GT} by following horizontal axis to the point where the vertical line crosses axis. This measured value is I_{GT}. (On 370, I_{GT} will be numerically displayed on screen under offset value.)

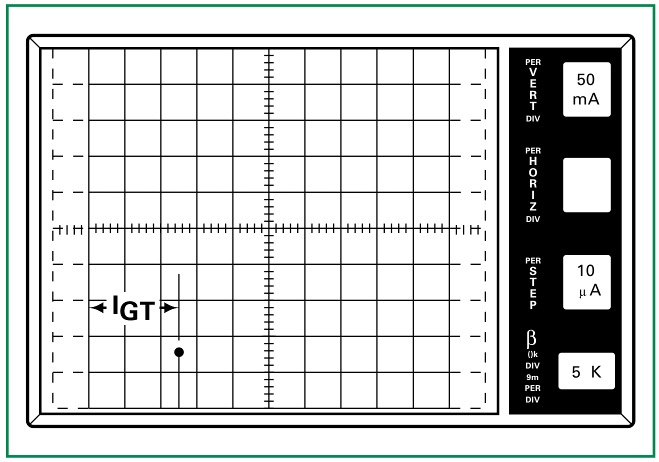

Figure AN1006.9 I_{GT} = 25 µA

Procedure 8: V_{GT}

To measure the V_{GT} parameter:

1. Set **Offset Multiplier** to *0* (zero). (Press *Aid* and *Oppose* at the same time on 370.)
2. Set **Step Offset Amplitude** to 20% rated V_{GT}.
3. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
4. Gradually increase **Offset Multiplier** until device reaches the conduction point. (Figure AN1006.10) Measure V_{GT} by following horizontal axis to the point where the vertical line crosses axis. This measured value is V_{GT}. (On 370, V_{GT} will be numerically displayed on screen, under offset value.)

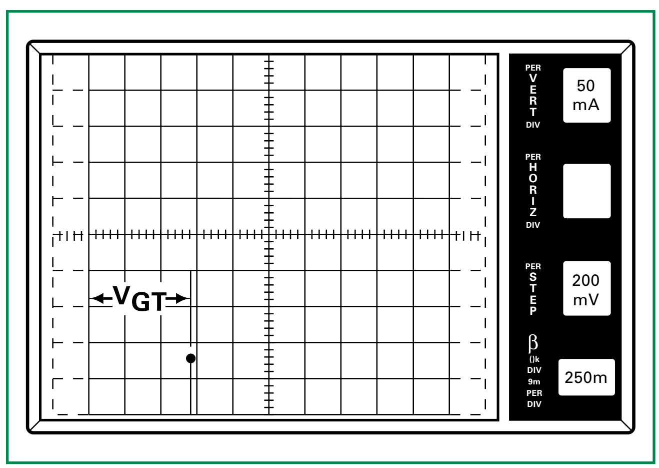

Figure AN1006.10 V_{GT} = 580 mV

Triacs

Triacs are full-wave bidirectional AC switches turned on when current is supplied to the gate terminal of the device. If gate control in all four quadrants is required, then a sensitive gate Triac is needed, whereas a standard Triac can be used if gate control is only required in Quadrants I through III.

To connect the Triac:

1. Connect the *Gate* to the *Base Terminal* (B).
2. Connect *MT1* to the *Emitter Terminal* (E).
3. Connect *MT2* to the *Collector Terminal* (C).

To begin testing, perform the following procedures.

Procedure 1: (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, (-)I_{DRM}

Note: The (+) and (-) symbols are used to designate the polarity MT2 with reference to MT1.

To measure the (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, and (-)I_{DRM} parameter:

1. Set **Variable Collector Supply Voltage Range** to appropriate *Max Peak Volts* for device under test. (Value selected should be equal to the device's V_{DRM} rating.)

   WARNING: DO NOT exceed V_{DRM}/V_{RRM} rating of SCRs, Triacs, or Quadracs. These devices can be damaged.
2. Set **Horizontal** knob to sufficient scale to allow viewing of trace at the required voltage level. (The *100 V/DIV* scale should be used for testing devices having a V_{DRM} rating of 600 V or greater; the *50 V/DIV* scale for testing parts rated from 30 V to 500 V, and so on.)
3. Set **Mode** to *Leakage.*
4. Set **Polarity** to (+).
5. Set **Power Dissipation** to *0.5 W.* (*0.4 W* on 370)
6. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
7. Set **Vertical** knob to ten times the maximum leakage current (I_{DRM}) specified for the device.

Note: The CRT screen readout should show 1% of the maximum leakage current. The vertical scale is divided by 1,000 when leakage mode is used.

Procedure 2: (+)V_{DRM}, (+)I_{DRM}

To measure the (+)V_{DRM} and (+)I_{DRM} parameter:

1. Set Left-Right Terminal Jack Selector to correspond with location of the test fixture.
2. Increase Variable Collector Supply Voltage to the rated V_{DRM} of the device and observe the dot on the CRT. Read across horizontally from the dot to the vertical current scale. This measured value is the leakage current. (Figure AN1006.11)

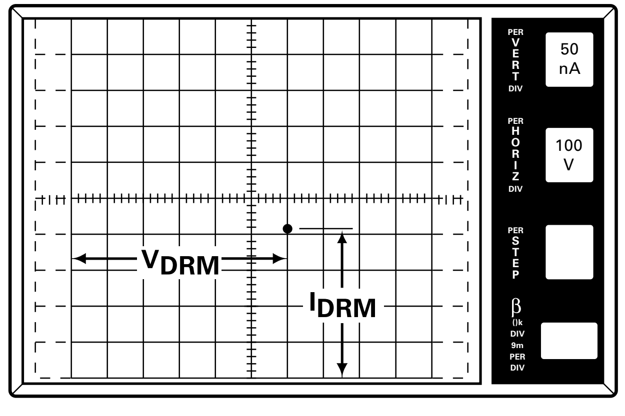

Figure AN1006.11 (+)I_{DRM} = 205 nA at (+)V_{DRM} = 600 V

Procedure 3: (-)V_{DRM}, (-)I_{DRM}

To measure the (-)V_{DRM} and (-)I_{DRM} parameter:

1. Set **Polarity** to (-).
2. Repeat Procedures 1 and 2. (Read measurements from upper right corner of the screen.)

Procedure 4: $V_{TM\ (Forward\ and\ Reverse)}$

To measure the $V_{TM\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Terminal Selector** to Step Generator-Emitter Grounded.
2. Set **Step/Offset Amplitude** to twice the maximum I_{GT} rating of the device (to insure the device turns on).
3. Set **Variable Collector Supply Voltage Range** to *15 V Max Peak volts.* (*16 V* on 370)
4. Set **Offset** by depressing *0* (zero).
5. Set **Rate** by depressing *Norm.*
6. Set **Step Family** by depressing *Rep* (Repetitive).
7. Set **Mode** to *Norm.*
8. Set **Horizontal** knob to *0.5 V/DIV.*
9. Set **Power Dissipation** to *220 W* (*100 W* on 577).
10. Set **Number of Steps** to *1.*
11. Set **Step/Offset Polarity** to non-inverted (button extended; on 577 button depressed).
12. Set **Vertical** knob to a sufficient setting to allow the viewing of 1.4 times the $I_{T(RMS)}$ rating of the device [$I_{T(peak)}$ on CRT].

Note the following:

- Due to the excessive amount of power that can be generated in this test, only parts with an $I_{T(RMS)}$ rating of 8 A or less should be tested on standard curve tracer. If testing devices above 8 A, a Tektronix model 176 high-current module is required.
- A Kelvin test fixture is required for this test. If a

Kelvin fixture is not used, an error in measurement of V_{TM} will result due to voltage drop in fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin connections.

Procedure 5: $V_{TM\ (Forward)}$

To measure the $V_{TM\ (Forward)}$ parameter:

1. Set **Polarity** to (+).
2. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
3. Increase **Variable Collector Supply Voltage** until current reaches rated $I_{T(peak)}$, which is 1.4 times $I_{T(RMS)}$ rating of the Triac under test.

   Note: Model 370 current is limited to 10 A.

WARNING: Limit test time to 15 seconds maximum. After the *Variable Collector Supply Voltage* has been set to $I_{T(peak)}$, the test time can automatically be set to a short test time by changing *Step Family* from repetitive to single by depressing the *Single* button.

To measure V_{TM}, follow along horizontal scale to the point where the trace crosses the $I_{T(peak)}$ value. The distance from the left-hand side of scale to the crossing point is the V_{TM} value. (Figure AN1006.12)

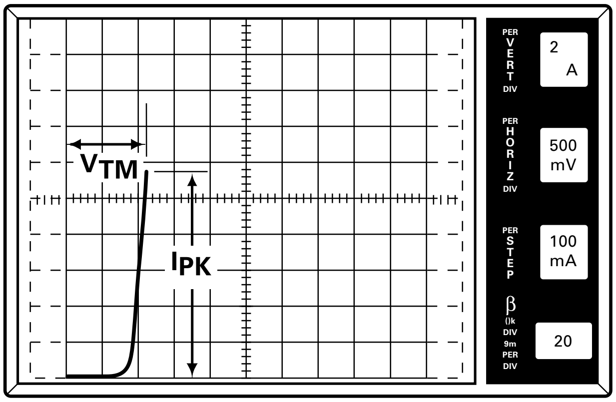

Figure AN1006.12 $V_{TM\ (forward)}$ = 1.1 V at I_{PK} = 11.3 A (8 A rms)

Procedure 6: $V_{TM\ (Reverse)}$

To measure the $V_{TM\ (Reverse)}$ parameter:

1. Set **Polarity** to (-).
2. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
3. Increase **Variable Collector Supply Voltage** until current reaches rated $I_{T(peak)}$.
4. Measure $V_{TM(Reverse)}$ similar to Figure AN1006.12, except from upper right hand corner of screen.

Procedure 7: $I_{H(Forward\ and\ Reverse)}$

To measure the $I_{H\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Step/Offset Amplitude** to twice the I_{GT} rating of the device.
2. Set **Power Dissipation** to *10 W*.
3. Set **Max Peak Volts** to *75 V*. (*80 V* on 370)
4. Set **Mode** to *DC*.
5. Set **Horizontal** knob to *Step Generator*.
6. Set **Vertical** knob to approximately 10% of the maximum I_H specified.

   Note: Due to large variation of holding current values, the scale may have to be adjusted to observe holding current.
7. Set **Number of Steps** to *1*.
8. Set **Step/Offset Polarity** to non-inverted (button extended, on 577 button depressed).
9. Set **Offset** by depressing *0* (zero). (Press *Aid* and *Oppose* at same time on 370.)
10. Set **Terminal Selector** to *Step Generator-Emitter Grounded*.

Procedure 8: $I_{H(Forward)}$

To measure the $I_{H\ (Forward)}$ parameter:

1. Set **Polarity** to (+).
2. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
3. Increase **Variable Collector Supply Voltage** to maximum position (*100*).
4. Set **Step Family** by depressing *Single*.

   This could possibly cause the dot on the CRT to disappear, depending on the vertical scale selected).
5. Decrease **Variable Collector Supply Voltage** to the point where the line on the CRT changes to a dot. The position of the beginning point of the line, just before the line becomes a dot, represents the holding current value. (Figure AN1006.13)

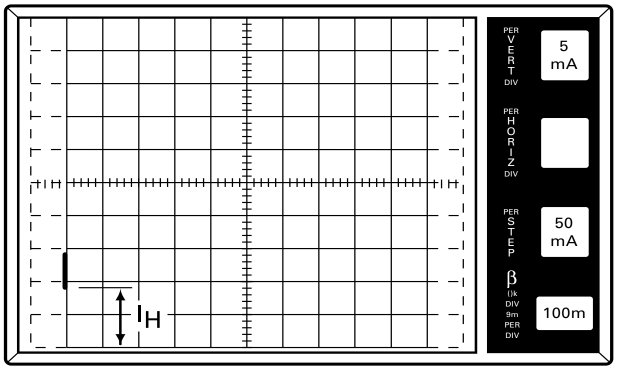

Figure AN1006.13 $I_{H\ (Forward)}$ = 8.2 mA

Procedure 9: $I_{H(Reverse)}$

To measure the $I_{H (Reverse)}$ parameter:

1. Set **Polarity** to (-).
2. Repeat Procedure 7 measuring $I_{H(Reverse)}$. (Read measurements from upper right corner of the screen.)

Procedure 10: I_{GT}

To measure the I_{GT} parameter:

1. Set **Polarity** to (+).
2. Set **Number of Steps**to *1*. (Set number of steps to *0* (zero) on 370.)
3. Set **Offset** by depressing *Aid*. (On 577, also set **Zero** button to *Offset*. Button is extended.)
4. Set **Offset Multiplier** to *0* (zero). (Press *Aid* and Oppose at same time on 370.)
5. Set **Terminal Selector** to *Step Generator-Emitter Grounded*.
6. Set **Mode** to **Norm.**
7. Set **Max Peak Volts** to *15 V*. (*16 V* on 370)
8. Set **Power Dissipation** to *10 W*.
9. Set **Step Family** by depressing *Single*.
10. Set **Horizontal** knob to *2 V/DIV*.
11. Set **Vertical** knob to *50 mA/DIV*.
12. Set **Step/Offset Polarity** to non-inverted position (button extended, on 577 button depressed).
13. Set **Variable Collector Supply Voltage** until voltage reaches 12 V on CRT.
14. After 12 V setting is completed, change **Horizontal** knob to *Step Generator*.

Procedure 11: I_{GT} - Quadrant I [MT2 (+) Gate (+)]

To measure the I_{GT} - Quadrant I parameter:

1. Set **Step/Offset Amplitude** to approximately 10% of rated I_{GT}
2. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
3. Gradually increase **Offset Multiplier** until device reaches conduction point. (Figure AN1006.14) Measure I_{GT} by following horizontal axis to the point where the vertical line passes through the axis. This measured value is I_{GT}. (On 370, I_{GT} is numerically displayed on screen under offset value.)

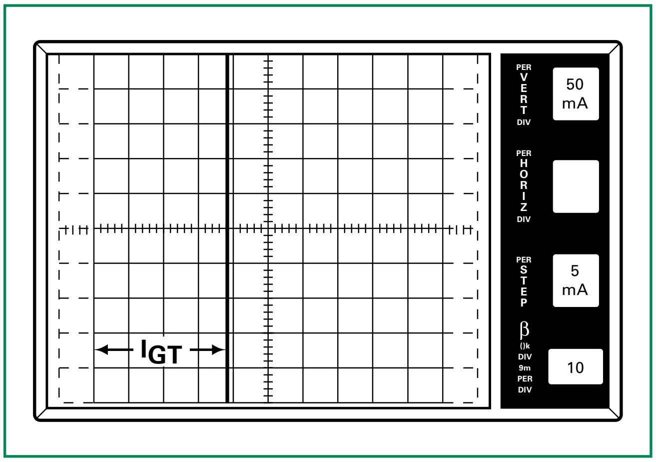

Figure AN1006.14 I_{GT} in Quadrant I = 18.8 mA

Procedure 12: I_{GT} - Quadrant II [MT2 (+) Gate (-)]

To measure the I_{GT} - Quadrant II parameter:

1. Set **Step/Offside Polarity** by depressing Invert (release button on 577).
2. Set **Polarity** to (+).
3. Set observed dot to bottom right corner of CRT grid by turning the horizontal position knob. When Quadrant II testing is complete, return dot to original position.
4. Repeat Procedure 11.

Procedure 13: I_{GT} - Quadrant III [MT2 (-) Gate (-)]

To measure the I_{GT} - Quadrant III parameter:

1. Set **Polarity** to (-).
2. Set **Step/Offset Polarity** to non-inverted position (button extended, on 577 button depressed).
3. Repeat Procedure 11. (Figure AN1006.15)

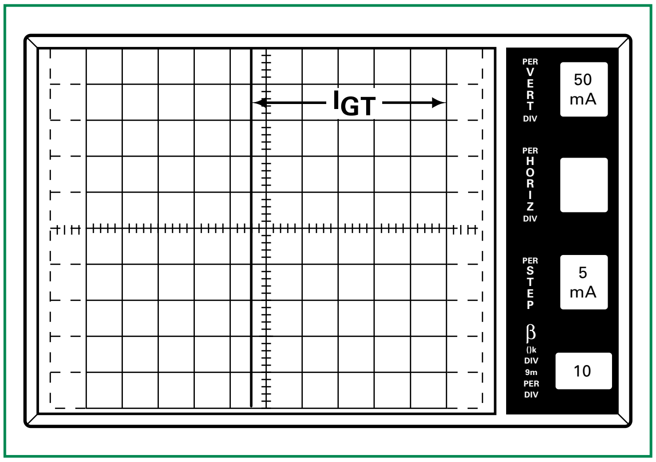

Figure AN1006.15 I_{GT} in Quadrant III = 27 mA

Procedure 14: I_{GT} - Quadrant IV [MT2 (-) Gate (+)]

To measure the I_{GT} - Quadrant IV parameter:

1. Set **Polarity** to (-).
2. Set **Step/Offset Polarity** by depressing *Invert* (release button on 577).
3. Set observed dot to top left corner of CRT grid by turning the **Horizontal** position knob. When Quadrant IV testing is complete, return dot to original position.
4. Repeat Procedure 11.

Procedure 15: V_{GT}

To measure the V_{GT} parameter:

1. Set **Polarity** to (+).
2. Set **Number of Steps** to *1*. (Set steps to *0* (zero) on 370.)
3. Set **Offset** by depressing *Aid*. (On 577, also set *0* (zero) button to *Offset*. Button is extended.)
4. Set **Offset Multiplier** to *0* (zero). (Press *Aid* and *Oppose* at same time on 370.)
5. Set **Terminal Selector** to *Step Generator-Emitter Grounded*.
6. Set **Mode** to *Norm*.
7. Set **Max Peak Volts** to *15 V*. (*16 V* on 370)
8. Set **Power Dissipation** to *10 W*.
9. Set **Step Family** by depressing *Single*.
10. Set **Horizontal** knob to *2 V/DIV*.
11. Set **Step/Offset Polarity** to non-inverted position (button extended, on 577 button depressed).
12. Set **Current Limit** to 500 mA (not available on 577).
13. Increase **Variable Collector Supply Voltage** until voltage reaches 12 V on CRT.
14. After 12 V setting is complete, change **Horizontal** knob to *Step Generator*.

Procedure 16: V_{GT} - Quadrant I [MT2 (+) Gate (+)]

To measure the V_{GT} - Quadrant I parameter:

1. Set **Step/Offset Amplitude** to 20% of rated V_{GT}.
2. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
3. Gradually increase **Offset Multiplier** until device reaches conduction point. (Figure AN1006.16) Measure V_{GT} by following horizontal axis to the point where the vertical line passes through the axis. This measured value will be V_{GT}. (On 370, V_{GT} will be numerically displayed on screen under offset value.)

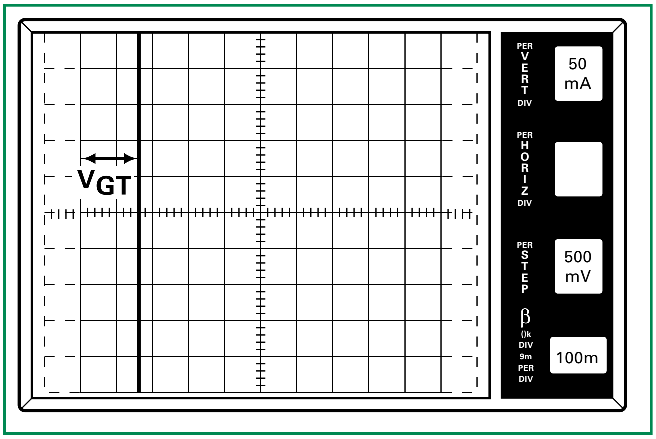

Figure AN1006.16 V_{GT} in Quadrant I = 780 mV

Procedure 17: V_{GT} - Quadrant II [MT2 (+) Gate (-)]

To measure the V_{GT} - Quadrant II parameter:

1. Set **Step/Offset Polarity** by depressing *Invert* (release button on 577).
2. Set **Polarity** to (+).
3. Set observed dot to bottom right corner of CRT grid by turning the **Horizontal** position knob. When Quadrant II testing is complete, return dot to original position.
4. Repeat Procedure 16.

Procedure 18: V_{GT} - Quadrant III [MT2 (-) Gate (-)]

To measure the V_{GT} - Quadrant III parameter:

1. Set **Polarity** to (-).
2. Set **Step/Offset Polarity** to non-inverted position (button extended, on 577 button depressed).
3. Repeat Procedure 16. (Figure AN1006.17)

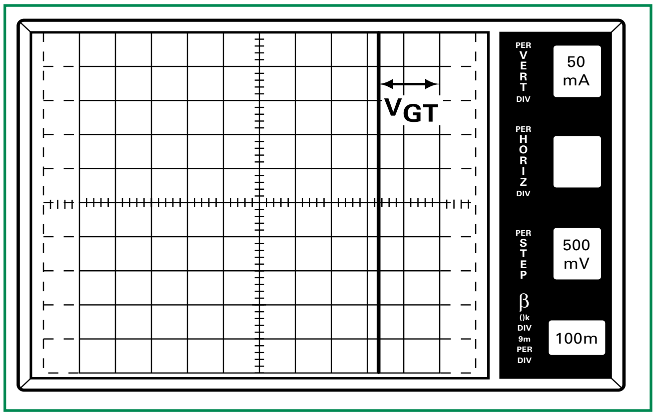

Figure AN1006.17 V_{GT} in Quadrant III = 820 mV

Procedure 19: V_{GT} - Quadrant IV [MT2 (-) Gate (+)]

To measure the V_{GT} - Quadrant IV parameter:

1. Set **Polarity** to (-).
2. Set **Step/Offset Polarity** by depressing *Invert* (release button on 577).

3. Set observed dot to top left corner of CRT grid by turning the **Horizontal** position knob. When testing is complete in Quadrant IV, return dot to original position.
4. Repeat Procedure 16.

Quadracs

Quadracs are simply Triacs with an internally-mounted DIAC. As with Triacs, Quadracs are bidirectional AC switches which are gate controlled for either polarity of main terminal voltage.

To connect the Quadrac:

1. Connect *Trigger* to *Base Terminal* (B).
2. Connect *MT1* to *Emitter Terminal* (E).
3. Connect *MT2* to *Collector Terminal* (C).

To begin testing, perform the following procedures.

Procedure 1: (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, (-)I_{DRM}

Note: The (+) and (-) symbols are used to designate the polarity of MT2 with reference to MT1.

To measure the (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, and (-)I_{DRM} parameter:

1. Set **Variable Collector Supply Voltage Range** to appropriate *Max Peak Volts* for device under test. (Value selected should be equal to or greater than the device's V_{DRM} rating).
2. Set **Horizontal** knob to sufficient scale to allow *viewing of trace at the required voltage level. (The* 100 V/DIV scale should be used for testing devices having a V_{DRM} rating of 600 V or greater; the *50 V/DIV* scale for testing parts rated from 300 V to 500 V, and so on).
3. Set **Mode** to Leakage.
4. Set **Polarity** to (+).
5. Set **Power Dissipation** to *0.5 W*. (*0.4 W* on 370)
6. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
7. Set **Vertical** knob to ten times the maximum leakage current (I_{DRM}) specified for the device.

   Note: The CRT readout should show 1% of the maximum leakage current. The vertical scale is divided by 1,000 when the leakage mode is used.

Procedure 2: (+)V_{DRM} and (+)I_{DRM}

To measure the (+)V_{DRM} and (+)I_{DRM} parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Increase **Variable Collector Supply Voltage** to the rated V_{DRM} of the device and observe the dot on the CRT. (Read across horizontally from the dot to the vertical current scale.) This measured value is the leakage current. (Figure AN1006.18)

WARNING: Do NOT exceed V_{DRM}/V_{RRM} rating of SCRs, Triacs, or Quadracs. These devices can be damaged.

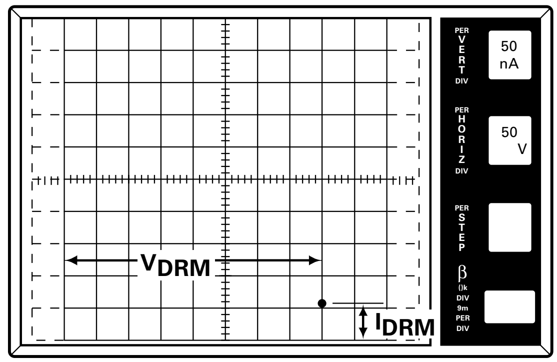

Figure AN1006.18 (+)I_{DRM} = 51 nA at (+)V_{DRM} = 400 V

Procedure 3: (-)V_{DRM} and (-)I_{DRM}

To measure the (-)V_{DRM} and (-)I_{DRM} parameter:

1. Set **Polarity** to (-).
2. Repeat Procedures 1 and 2. (Read measurements from upper right corner of screen).

Procedure 4: V_{BO}, I_{BO}, V_{BO}

(Quadrac Trigger DIAC or Discrete DIAC)

To connect the Quadrac:

1. Connect *MT1 to Emitter Terminal* (E).
2. Connect *MT2 to Collector Terminal* (C).
3. Connect *Trigger Terminal* to *MT2 Terminal* through a 10 Ω resistor.

To measure the V_{BO}, I_{BO}, and ΔV_{BO} parameter:

1. Set **Variable Collector Supply Voltage Range** to *75 Max Peak Volts.*(*80 V* on 370)
2. Set **Horizontal** knob to *10 V/DIV.*
3. Set **Vertical** knob to *50 μA/DIV.*
4. Set **Polarity** to *AC.*
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *0.5 W*. (*0.4 W* on 370)
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*

Procedure 5: V_{BO} (Positive and Negative)

To measure the $V_{BO\ (Positive\ and\ Negative)}$ parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Set **Variable Collector Supply Voltage** to *55 V* (*65 V* on 370) and apply voltage to the device under test (D.U.T.) using the **Left Hand Selector Switch**. The peak voltage at which current begins to flow is the V_{BO} value. (Figure AN1006.19)

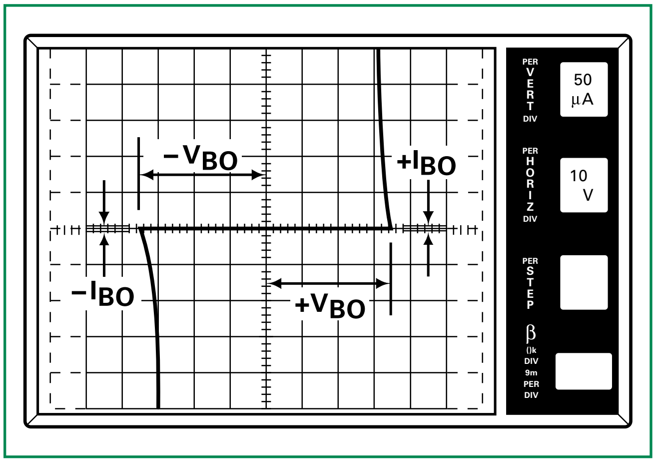

Figure AN1006.19 (+)V_{BO} = 35 V; (-)V_{BO} = 36 V; (±)I_{BO} < 10 A

Procedure 6: I_{BO} (Positive and Negative)

To measure the $I_{BO\ (Positive\ and\ Negative)}$ parameter, at the V_{BO} point, measure the amount of device current just before the device reaches the breakover point. The measured current at this point is the I_{BO} value.

Note: If I_{BO} is less than 10 µA, the current cannot readily be seen on curve tracer.

Procedure 7: $\Delta V_{BO\ (Voltage\ Breakover\ Symmetry)}$

To measure the $\Delta V_{BO\ (Voltage\ Breakover\ Symmetry)}$ parameter:

1. Measure positive and negative V_{BO} values per Procedure 5.
2. Subtract the absolute value of V_{BO} (-) from V_{BO} (+).

   The absolute value of the result is:

   $\Delta V_{BO} = [\ |+V_{BO}| - |-V_{BO}|\ ]$

Procedure 8: $V_{TM\ (Forward\ and\ Reverse)}$

To test V_{TM}, the Quadrac must be connected the same as when testing V_{BO}, I_{BO}, and ΔV_{BO}.

To connect the Quadrac:

1. Connect *MT1* to *Emitter Terminal* (E).
2. Connect *MT2* to *Collector Terminal* (C).
3. Connect *Trigger Terminal* to *MT2 Terminal* through a 10 Ω resistor.

Note the following:

Due to the excessive amount of power that can be generated in this test, only parts with an $I_{T(RMS)}$ rating of 8 A or less should be tested on standard curve tracer. If testing devices above 8 A, a Tektronix model 176 high-current module is required.

A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of V_{TM} will result due to voltage drop in fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin connections.

To measure the $V_{TM\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
2. Set **Max Peak Volts** to *75 V.* (*80 V* on 370)
3. Set **Mode** to *Norm.*
4. Set **Horizontal** knob to *0.5 V/DIV.*
5. Set **Power Dissipation** to *220 watts* (*100 watts* on a 577).
6. Set **Vertical** knob to a sufficient setting to allow the viewing of 1.4 times the $I_{T(RMS)}$ rating of the device $I_{T(peak)}$ on the CRT.

Procedure 9: $V_{TM(Forward)}$

To measure the $V_{TM\ (Forward)}$ parameter:

1. Set **Polarity** to (+).
2. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
3. Increase **Variable** Collector **Supply Voltage** until current reaches rated $I_{T(peak)}$, which is 1.4 times the $I_{T(RMS)}$ rating of the Triac under test.

   Note: Model 370 current is limited to 10 A.

   WARNING: Limit test time to 15 seconds maximum.
4. To measure V_{TM}, follow along horizontal scale to the point where the trace crosses the $I_{T(peak)}$ value. This horizontal distance is the V_{TM} value. (Figure AN1006.20)

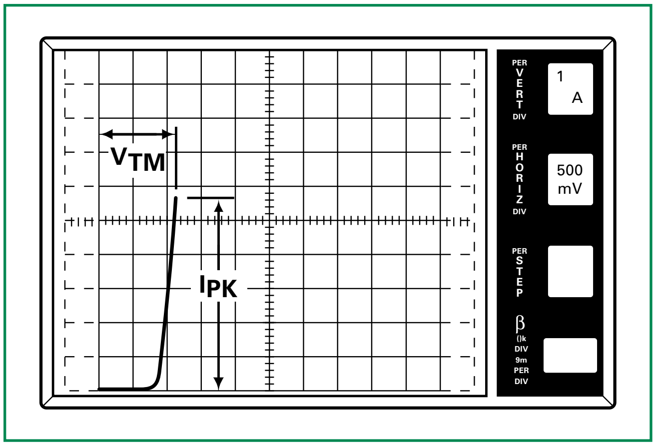

Figure AN1006.20 $V_{TM\ (Forward)}$ = 1.1 V at I_{PK} = 5.6 A

Procedure 10: $V_{TM(Reverse)}$

To measure the $V_{TM\ (Reverse)}$ parameter:

1. Set **Polarity** to (-).
2. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
3. Increase **Variable** Collector **Supply Voltage** until current reaches rated $I_{T(peak)}$.
4. Measure $V_{TM(Reverse)}$ the same as in Procedure 8. (Read measurements from upper right corner of screen).

Procedure 11: $I_{H(Forward\ and\ Reverse)}$

For these steps, it is again necessary to connect the *Trigger* to *MT2* through a 10 Ω resistor. The other connections remain the same.

To measure the $I_{H\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Power Dissipation** to *50 W*.
2. Set **Max Peak Volts** to *75 V*. (*80 V* on 370)
3. Set **Mode** to *DC*.
4. Set **Horizontal** knob to *5 V/DIV*.
5. Set **Vertical** knob to approximately 10% of the maximum I_H specified.

   Note: Due to large variations of holding current values, the scale may have to be adjusted to observe holding current.
6. Set **Terminal Selector** to *Emitter Grounded-Open Base*.

Procedure 12: $I_{H(Forward)}$

To measure the $I_{H\ (Forward)}$ parameter:

1. Set **Polarity** to (+).
2. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
3. Increase **Variable** Collector **Supply Voltage** to maximum position (*100*).

   Note: Depending on the vertical scale being used, the dot may disappear completely from the screen.
4. Decrease **Variable Collector Supply Voltage** to the point where the line on the CRT changes to a dot. The position of the beginning point of the line, just before the line changes to a dot, represents the I_H value. (Figure AN1006.21)

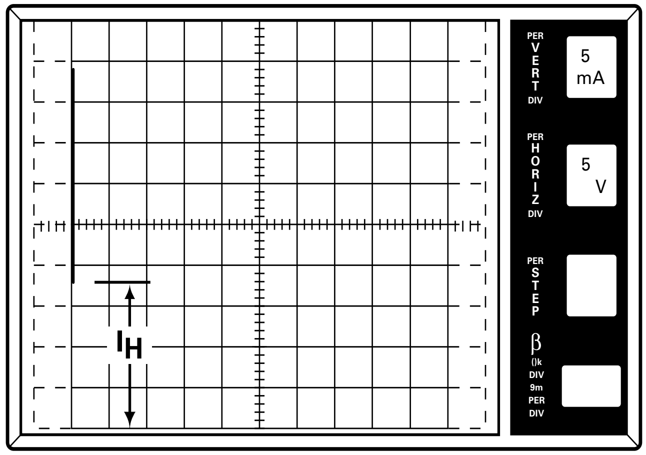

Figure AN1006.21 $I_{H\ (Forward)}$ = 18 mA

Procedure 13: $I_{H(Reverse)}$

To measure the $I_{H\ (Reverse)}$ parameter:

1. Set **Polarity** to (-).
2. Continue testing per Procedure 12 for measuring $I_{H\ (Reverse)}$.

SIDACs

The SIDAC is a bidirectional voltage-triggered switch. Upon application of a voltage exceeding the SIDAC breakover voltage point, the SIDAC switches on through a negative resistance region (similar to a DIAC) to a low on-state voltage. Conduction continues until current is interrupted or drops below minimum required holding current.

To connect the SIDAC:

1. Connect *MT1* to *the Emitter Terminal* (E).
2. Connect *MT2* to *the Collector Terminal* (C).

To begin testing, perform the following procedures.

Procedure 1: (+) V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, (-)I_{DRM}

Note: The (+) and (-) symbols are used to designate the polarity of MT2 with reference to MT1.

To measure the (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, and (-)I_{DRM} parameter:

1. Set **Variable Collector Supply Voltage Range** to *1500 Max Peak Volts*.
2. Set **Horizontal** knob to *50 V/DIV*.
3. Set **Mode** to *Leakage*.
4. Set **Polarity** to (+).
5. Set **Power Dissipation** to *2.2 W*. (*2 W* on 370)
6. Set **Terminal Selector** to *Emitter Grounded-Open Base*.
7. Set **Vertical** knob to *50 μA/DIV*. (Due to leakage mode, the CRT readout will show 50 nA.)

Procedure 2: (+)V_{DRM} and (+)I_{DRM}

To measure the (+)V_{DRM} and (+)I_{DRM} parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Increase **Variable Collector Supply Voltage** to the rated V_{DRM} of the device and observe the dot on the CRT. Read across horizontally from the dot to the vertical current scale. This measured value is the leakage current. (Figure AN1006.22)

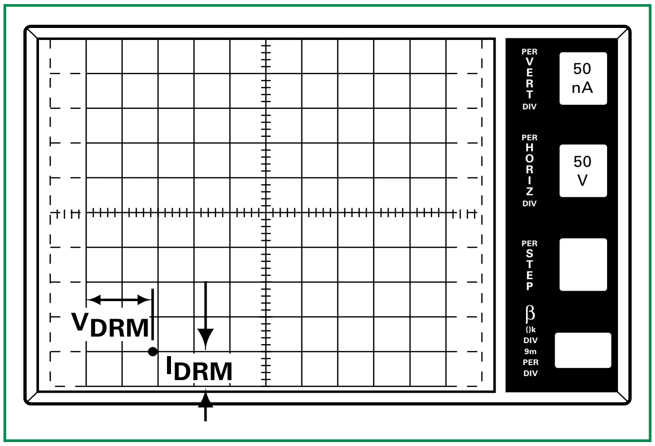

Figure AN1006.22 I_{DRM} = 50 nA at V_{DRM} = 90 V

Procedure 3: (-) V_{DRM} and (-) I_{DRM}

To measure the (-)V_{DRM} and (-)I_{DRM} parameter:

1. Set **Polarity** to (-).
2. Repeat Procedures 1 and 2. (Read measurements from upper right corner of the screen).

Procedure 4: V_{BO} and I_{BO}

To measure the V_{BO} and I_{BO} parameter:

1. Set **Variable Collector Supply Voltage Range** to *1500 Max Peak Volts*. (*2000 V* on 370)
2. Set **Horizontal** knob to a sufficient scale to allow viewing of trace at the required voltage level (*50 V/DIV* for 95 V to 215 V V_{BO} range devices and *100 V/DIV* for devices having V_{BO} ≥ 15 V).
3. Set **Vertical** knob to *50 A/DIV.*
4. Set **Polarity** to *AC.*
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *10 W.*
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
8. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.

Procedure 5: V_{BO}

To measure the V_{BO} parameter, increase **Variable Collector Supply Voltage** until breakover occurs. (Figure AN1006.23) The voltage at which current begins to flow and voltage on CRT does not increase is the V_{BO} value.

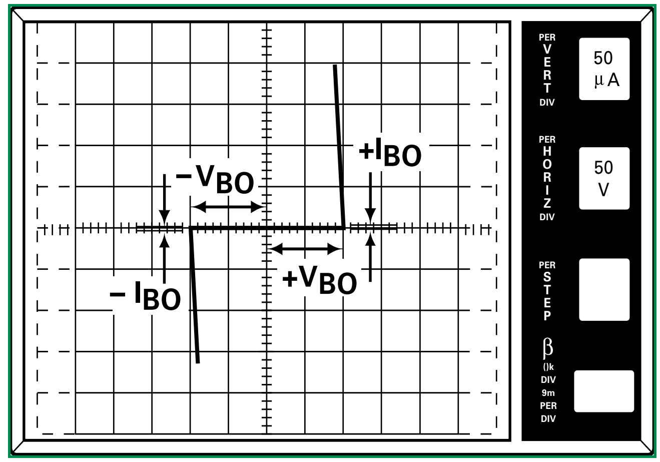

Figure AN1006.23 (+)V_{BO} = 100 V; (-)V_{BO} = 100 V; (±)I_{BO} < 10 μA

Procedure 6: I_{BO}

To measure the I_{BO} parameter, at the V_{BO} point, measure the amount of device current just before the device reaches the breakover mode. The measured current at this point is the I_{BO} value.

Note: If I_{BO} is less than 10 μA, the current cannot readily be seen on the curve tracer.

Procedure 7: $I_{H(Forward\ and\ Reverse)}$

To measure the $I_{H\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Variable Collector Supply Voltage Range** to *1500 Max Peak Volts* (*400 V* on 577; *2000 V* on 370).
2. Set **Horizontal** knob to a sufficient scale to allow viewing of trace at the required voltage level (50 V/DIV for devices with V_{BO} range from 95 V to 215 V and 100 V/DIV for devices having V_{BO} ≥ 215 V).
3. Set **Vertical** knob to 20% of maximum holding current specified.
4. Set **Polarity** to *AC.*
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *220 W* (*100 W* on 577).
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
8. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.

   WARNING: Limit test time to 15 seconds maximum.
9. Increase **Variable Collector Supply Voltage** until device breaks over and turns on. (Figure AN1006.24)

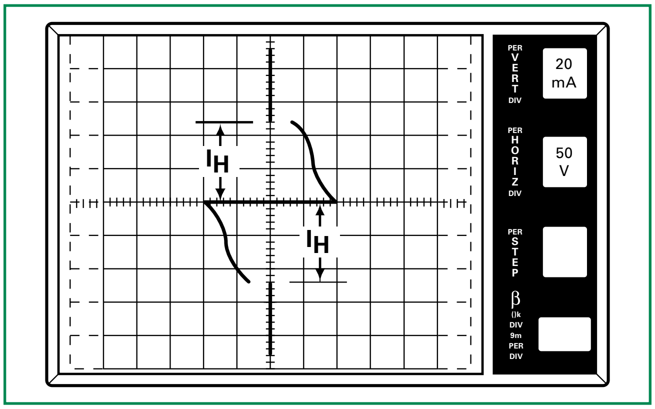

Figure AN1006.24 I_H = 48 mA in both forward and reverse directions

I_H is the vertical distance between the center horizontal axis and the beginning of the line located on center vertical axis.

Procedure 8: $V_{TM(Forward\ and\ Reverse)}$

To measure the $V_{TM\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Variable Collector Supply Voltage Range** to *350 Max Peak Volts*. (*400 V* on 370)
2. Set **Horizontal** knob to *0.5 V/DIV.*
3. Set **Vertical** knob to *0.5 A/DIV.*
4. Set **Polarity** to (+).
5. Set **Mode** to *Norm*.
6. Set **Power Dissipation** to *220 W* (*100 W* on 577).
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*

Before continuing with testing, note the following:

- A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of V_{TM} will result due to voltage drop in fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin Connections.

To continue testing, perform the following procedures.

Procedure 9: $V_{TM(Forward)}$

To measure the $V_{TM\ (Forward)}$ parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Increase **Variable Collector Supply Voltage** until current reaches rated $I_{T(peak)}$, which is 1.4 times the $I_{T(RMS)}$ rating of the SIDAC.

   Note: Model 370 current is limited. Set to 400 mA. Check for 1.1 V MAX.

   WARNING: Limit test time to 15 seconds.

3. To measure V_{TM}, follow along horizontal scale to the point where the trace crosses the $I_{T(peak)}$ value. This horizontal distance is the V_{TM} value. (Figure AN1006.25)

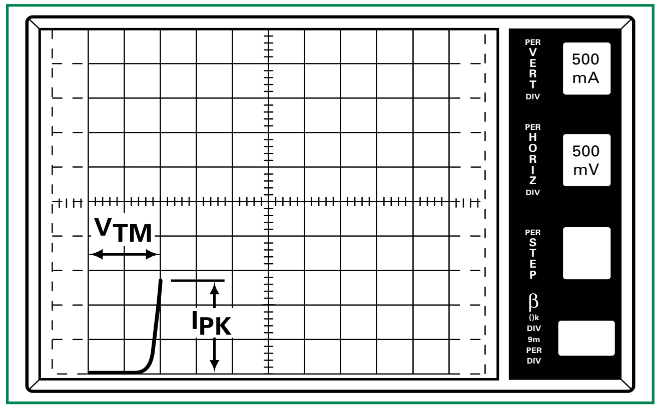

Figure AN1006.25 $V_{TM\ (Forward)}$ = 950 mV at I_{PK} = 1.4 A

Procedure 10: $V_{TM(Reverse)}$

To measure the $V_{TM\ (Reverse)}$ parameter:

Set **Polarity** to (-).

Repeat Procedure 8 to measure $V_{TM(Reverse)}$.

DIACs

DIACs are voltage breakdown switches used to trigger-on Triacs and non-sensitive SCRs in phase control circuits.

Note: DIACs are bi-directional devices and can be connected in either direction.

To connect the DIAC:

Connect one side of the DIAC to the Collector Terminal (C).

Connect other side of the DIAC to the Emitter Terminal (E).

To begin testing, perform the following procedures.

Procedure 1: Curve Tracer Setup

To set the curve tracer and begin testing:

1 Set **Variable Collector Supply Voltage Range** to *75 Max Peak Volts*. (*80 V* on 370)
2. Set **Horizontal** knob to sufficient scale to allow viewing of trace at the required voltage level (*10 V* to *20 V/DIV* depending on device being tested).
3. Set **Vertical** knob to *50 µA/DIV.*
4. Set **Polarity** to *AC.*
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *0.5 W.* (*0.4 W* on 370)
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*

Procedure 2: V_{BO}

To measure the V_{BO} parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Set **Variable Collector Supply Voltage** to *55 V* (*65 V* for 370) and apply voltage to device under test (D.U.T.), using **Left-Right-Selector Switch**. The peak voltage at which current begins to flow is the V_{BO} value. (Figure AN1006.26)

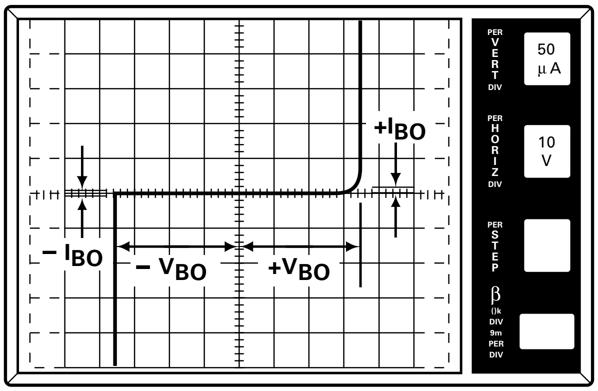

Figure AN1006.26 (+)V_{BO} = 35 V; (-)V_{BO} = 36 V; (±)I_{BO} < 15 µA; (-) I_{BO} < 10 µA and Cannot Be Read Easily

Procedure 3: I_{BO}

To measure the I_{BO} parameter, at the V_{BO} point, measure the amount of device current just before the device reaches the breakover mode. The measured current at this point is the I_{BO} value.

Note: If I_{BO} is less than 10 µA, the current cannot readily be seen on the curve tracer.

Procedure 4: $\Delta V_{BO(Voltage\ Breakover\ Symmetry)}$

To measure the $\Delta V_{BO\ (Voltage\ Breakover\ Symmetry)}$ parameter:

1. Measure positive and negative values of V_{BO} as shown in Figure AN1006.26.
2. Subtract the absolute value of V_{BO}(-) from V_{BO}(+).

   The absolute value of the result is:

   $\Delta V_{BO} = [\ |+V_{BO}| - |-V_{BO}|\ ]$

Model 370 Curve Tracer Procedure Notes

Because the curve tracer procedures in this application note are written for the Tektronix model 576 curve tracer, certain settings must be adjusted when using model 370. Variable Collector Supply Voltage Range and Power Dissipation controls have different scales than model 576. The following table shows the guidelines for setting Power Dissipation when using model 370. (Figure AN1006.27)

Model 576	Model 370
If power dissipation is 0.1 W,	set at 0.08 W.
If power dissipation is 0.5 W,	set at 0.4 W.
If power dissipation is 2.2 W,	set at 2 W.
If power dissipation is 10 W,	set at 10 W.
If power dissipation is 50 W,	set at 50 W.
If power dissipation is 220 W,	set at 220 W.

Although the maximum power setting on the model 370 curve tracer is 200 W, the maximum collector voltage available is only 400 V at 220 W. The following table shows the guidelines for adapting Collector Supply Voltage Range settings for model 370 curve tracer procedures:

Model 576	Model 370
If voltage range is 15 V	set at 16 V.
If voltage range is 75 V	set at 80 V.
If voltage range is 350 V	set at 400 V.
If voltage range is 1500 V	set at 2000 V

The following table shows the guidelines for adapting terminal selector knob settings for model 370 curve tracer procedures:

Model 576	Model 370
If Step generator (base) is emitter grounded	then Base Step generator is emitter common.
If Emitter grounded is open base	then Base open is emitter common.

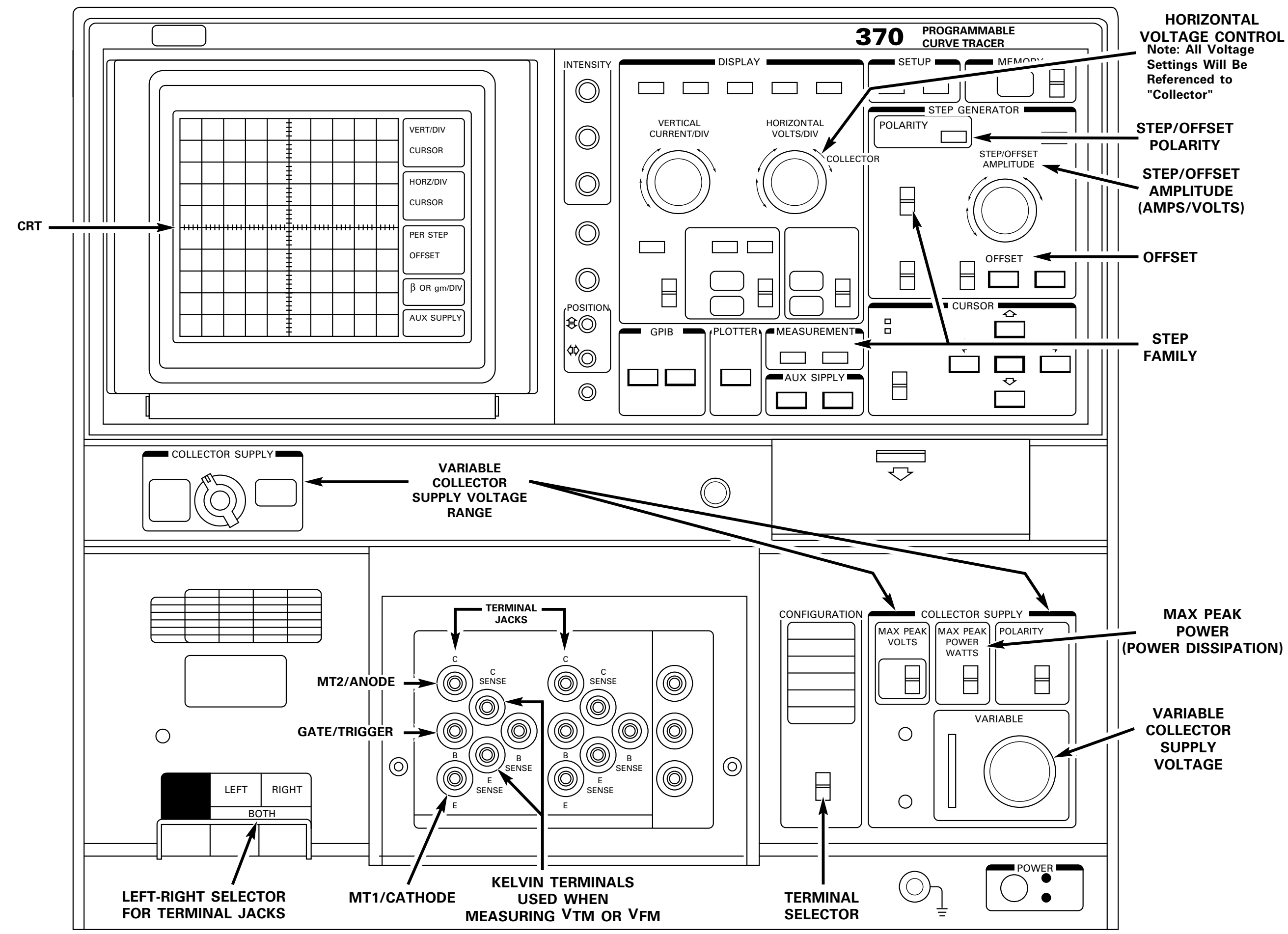

Figure AN1006.27 Tektronix Model 370 Curve Tracer

Model 577 Curve Tracer Procedure Notes

Because the curve tracer procedures in this application note are written for the Tektronix model 576 curve tracer, certain settings must be adjusted when using model 577. Model 576 curve tracer has separate controls for polarity (AC,+,-) and mode (Norm, DC, Leakage), whereas Model 577 has only a polarity control. The following table shows the guidelines for setting Collector Supply Polarity when using model 577. (Figure AN1006.28)

Model 576	Model 577
If using Leakage mode along with polarity setting of +(NPN) and -(PNP),[vertical scale divided by 1,000],	set **Collector Supply Polarity** to either *+DC* or *-DC*, depending on polarity setting specified in the procedure. The vertical scale is read directly from the scale on the control knob.
If using DC mode along with either +(NPN) or -(PNP) polarity,	set **Collector Supply Polarity** to either *+DC* or *-DC* depending on polarity specified.
If using Norm mode along with either +(NPN) or -(PNP) polarity,	set **Collector Supply Polarity** to either *+(NPN)* or *-(PNP)* per specified procedure.
If using Norm mode with *AC* polarity,	set **Collector Supply Polarity** to *AC*.

One difference between models 576 and 577 is the Step/Offset Polarity setting. The polarity is inverted when the button is depressed on the Model 576 curve tracer. The Model 577 is opposite — the Step/Offset Polarity is "inverted" when the button is extended and "Normal" when the button is depressed. The Step/Offset Polarity is used only when measuring I_{GT} and V_{GT} of Triacs and Quadracs in Quadrants I through IV.

Also, the Variable Collector Supply Voltage Range and Power Dissipation controls have different scales than model 576. The following table shows the guidelines for setting Power Dissipation when using model 577.

Model 576	Model 577
If power dissipation is 0.1 W,	set at 0.15 W.
If power dissipation is 0.5 W,	set at 0.6 W.
If power dissipation is 2.2 W,	set at 2.3 W.
If power dissipation is 10 W,	set at 9 W.
If power dissipation is 50 W,	set at 30 W.
If power dissipation is 220 W,	set at 100 W.

Although the maximum power setting on model 576 curve tracer is 220 W (compared to 100 W for model 577), the maximum collector current available is approximately the same. This is due to the minimum voltage range on model 577 curve tracer being 6.5 V compared to 15 V for model 576. The following table shows the guidelines for adapting Collector Voltage Supply Range settings for model 577 curve tracer procedures:

Model 576	Model 577
If voltage range is 15 V	set at either 6.5 V or 25 V, depending on parameter being tested. Set at 6.5 V when measuring V_{TM} (to allow maximum collector current) and set at 25 V when measuring I_{GT} and V_{GT}
If voltage range is 75 V	set at 100 V.
If voltage range is 1500 V,	set at 1600 V.

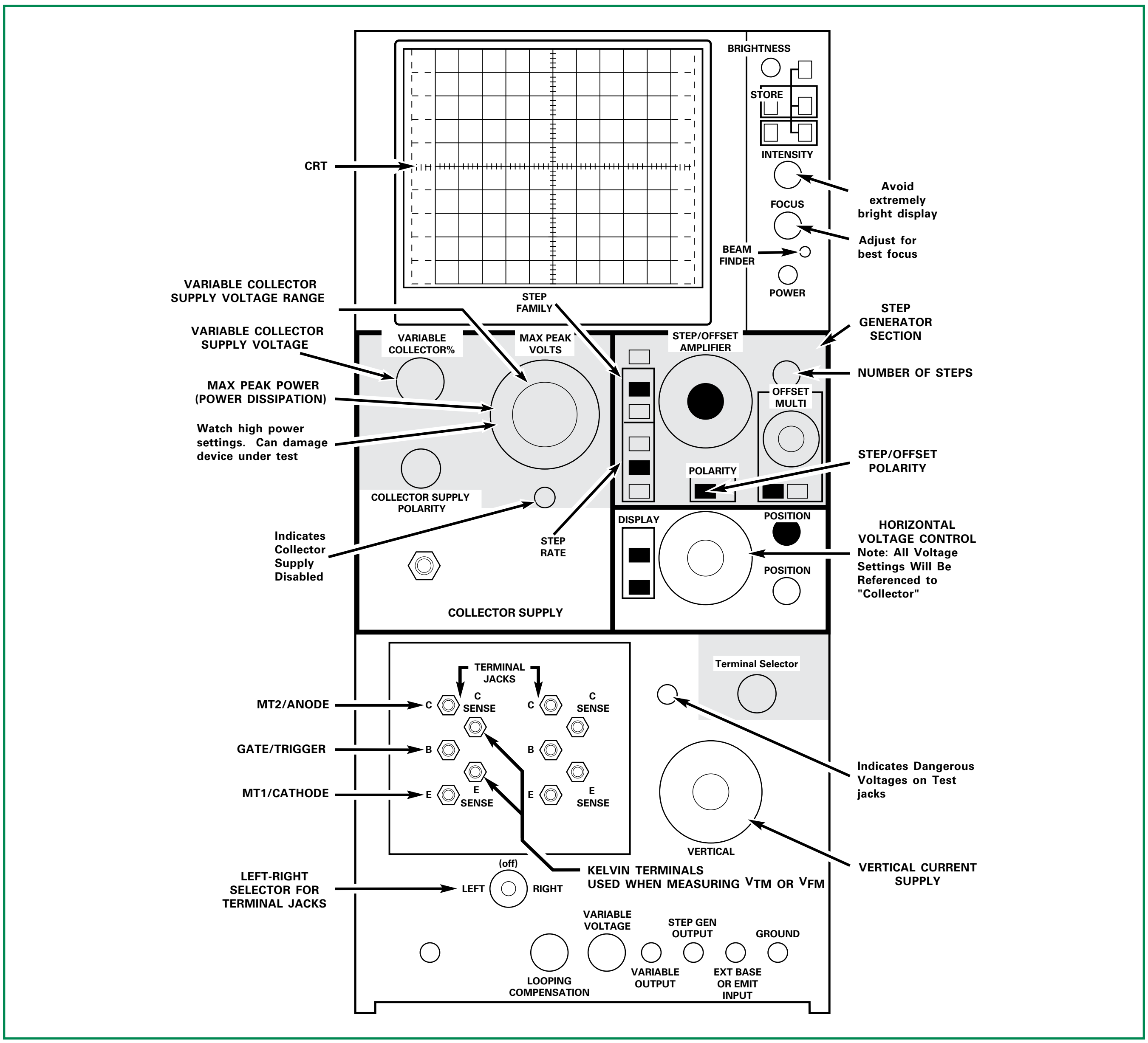

Figure AN1006.28 Tektronix Model 577 Curve Tracer