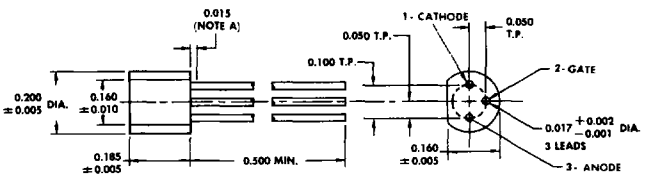
TYPES TIC44, TIC45, TIC46, TIC47
BULLETIN NO. DL-S 7111669, DECEMBER 1971
REPLACES BULLETIN NO. DL-S 669051, SEPTEMBER 1966

## SILECT† THYRISTORS‡
## 600 mA DC • 30 thru 200 VOLTS

### Rugged, One-Piece Construction with Standard TO-18 100-mil Pin-Circle Configuration

### mechanical data

These thyristors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C method 106B. The thyristors are insensitive to light.




NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

THE GATE IS CONNECTED TO A P REGION

### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

| | TIC44 | TIC45 | TIC46 | TIC47 | UNIT |
|---|---|---|---|---|---|
| Static Off-State Voltage, $V_D$ (See Note 1) | 30 | 60 | 100 | 200 | V |
| Repetitive Peak Off-State Voltage, $V_{DRM}$ (See Note 1) | 30 | 60 | 100 | 200 | V |
| Static Reverse Voltage, $V_R$ (See Note 1) | 30 | 60 | 100 | 200 | V |
| Repetitive Peak Reverse Voltage, $V_{RRM}$ (See Note 1) | 30 | 60 | 100 | 200 | V |
| Continuous or RMS On-State Current at (or below) 55°C Case Temperature (See Note 2) | 600 | | | | mA |
| Continuous or RMS On-State Current at (or below) 25°C Free-Air Temperature (See Note 3) | 300 | | | | mA |
| Average On-State Current (180° Conduction Angle) at (or below) 55°C Case Temperature (See Note 4) | 430 | | | | mA |
| Surge On-State Current (See Note 5) | 6 | | | | A |
| Peak Negative Gate Voltage | 8 | | | | V |
| Peak Positive Gate Current (Pulse Width ≤ 300 μs) | 1 | | | | A |
| Peak Gate Power Dissipation (Pulse Width ≤ 300 μs) | 4 | | | | W |
| Operating Free-Air Temperature Range | −55 to 125 | | | | °C |
| Storage Temperature Range | −55 to 150 | | | | °C |
| Lead Temperature 1/16 Inch from Case for 10 Seconds | 260 | | | | °C |

NOTES: 1. These values apply when the gate-cathode resistance $R_{GK} \leq 1\ k\Omega$.
2. These values apply for continuous d-c operation with resistive load. Above 55°C derate according to Figure 5.
3. These values apply for continuous d-c operation with resistive load. Above 25°C derate according to Figure 6.
4. This value may be applied continuously under single-phase, 60-Hz, half-sine-wave operation with resistive load. Above 55°C derate according to Figure 5.
5. This value applies for one 60-Hz half sine wave when the device is operating at (or below) rated values of peak reverse voltage and on-state current. Surge may be repeated after the device has returned to original thermal equilibrium.

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‡U. S. Patent No. 3,439,238

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## electrical characteristics at 25°C free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $I_D$ | Static Off-State Current | $V_D$ = Rated $V_D$, | $R_{GK}$ = 1 kΩ, | $T_A$ = 125°C | | | 50 | μA |
| $I_R$ | Static Reverse Current | $V_R$ = Rated $V_R$, | $R_{GK}$ = 1 kΩ, | $T_A$ = 125°C | | | 50 | μA |
| $I_{GT}$ | Gate Trigger Current (See Note 6) | $V_{AA}$ = 6 V, | $R_L$ = 100 Ω, | $t_{p(g)} \geq 20$ μs | | | 200 | μA |
| $V_{GT}$ | Gate Trigger Voltage (See Note 6) | $V_{AA}$ = 6 V, | $R_L$ = 100 Ω, | $t_{p(g)} \geq 20$ μs | | | 0.8 | V |
| | | $V_{AA}$ = 6 V, | $R_L$ = 100 Ω, | $t_{p(g)} \geq 20$ μs, | $T_A$ = 125°C | 0.2 | | |
| $I_H$ | Holding Current | $R_L$ = 100 Ω, | $R_{GK}$ = 1 kΩ | | | | 5 | mA |
| $V_T$ | On-State Voltage | $I_T$ = 300 mA, | $R_{GK} \geq$ 1 kΩ, | See Note 7 | | | 1.4 | V |

NOTES: 6. When measuring these parameters, a 1-kΩ resistor should be used between gate and cathode to prevent triggering by random noise.

7. This parameter is measured using pulse techniques. $t_w$ = 1 ms, duty cycle ≤ 1%.

## switching characteristics at 25°C free-air temperature

| PARAMETER | | TEST CONDITIONS | | | | TYP | UNIT |
|---|---|---|---|---|---|---|---|
| $t_{gt}$ | Gate-Controlled Turn-On Time | $V_{AA}$ = 30 V, See Figure 1 | $R_L$ = 50 Ω, | $R_G$ = 20 kΩ, | $V_{in}$ = 20 V, | 3.5 | μs |
| $t_q$ | Circuit-Commutated Turn-Off Time | $V_{AA}$ = 30 V, See Figure 2 | $R_L$ = 50 Ω, | $I_{RM}$ = 1 A, | | 6.8 | μs |

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## thermal characteristics

| PARAMETER | | MAX | UNIT |
|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case Thermal Resistance | 75 | °C/W |
| $R_{\theta JA}$ | Junction-to-Free-Air Thermal Resistance | 275 | |



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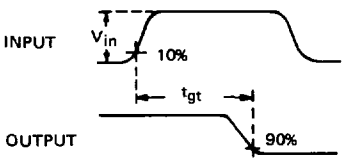
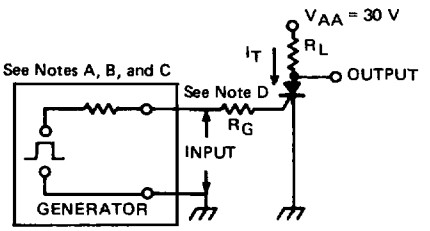
## PARAMETER MEASUREMENT INFORMATION

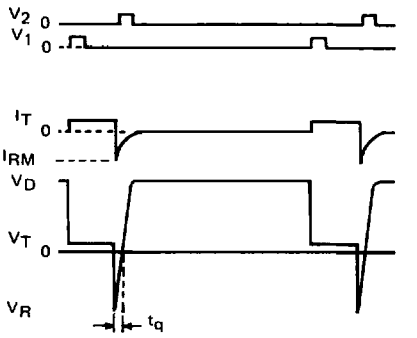



VOLTAGE WAVEFORMS

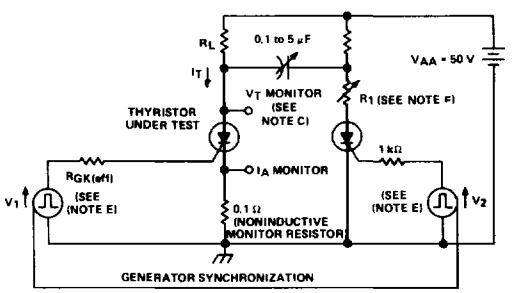



TEST CIRCUIT

FIGURE 1—TURN-ON TIME




WAVEFORMS




TEST CIRCUIT

FIGURE 2—COMMUTATING TURN-OFF TIME

NOTES: A. $V_{in}$ is measured with gate and cathode terminals connected as shown and anode terminal open.

B. The input waveform of Figure 1 has the following characteristics: $t_r \leq 40$ ns, $t_w \geq 20$ μs.

C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 14$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 12$ pF.

D. $R_G$ includes the total resistance of the generator and the external resistor.

E. Pulse generators for $V_1$ and $V_2$ are synchronized to provide an anode current waveform with the following characteristics: $t_w = 50$ to 300 μs, duty cycle = 1%. The pulse widths of $V_1$ and $V_2$ are $\geq 10$ μs.

F. Resistor $R_1$ is adjusted for $I_{RM} = 1$ A.

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## THERMAL INFORMATION

The minimum heat-sink requirements may be calculated for any on-state current, heat-sink combination by the following procedure:

1. Determine worst-case power dissipation from Figure 3.
2. Calculate maximum allowable case-to-free-air thermal resistance by use of the equation.

$$R_{\theta CA} = \frac{T_J - T_A}{P_{A(av)}} - R_{\theta JC}$$

where: $T_J$ = Junction temperature

$T_A$ = Free-air temperature

$P_{A(av)}$ = Average anode power dissipation (see Figure 3 for worst-case values)

$R_{\theta JC}$ = Junction-to-case thermal resistance = 75°C/W maximum.

3. Determine area of heat sink from Figure 4.

EXAMPLE

Determine: Minimum size of 1/16"-thick aluminum heat sink for safe operation of thyristor at an average current of 0.4 A with a conduction angle of 180°

Given: Maximum $T_J$ = 125°C

$T_A$ = 35°C

$R_{\theta JC}$ = 75°C

Solution: From Figure 3, $P_{A(av)}$ = 0.84 W for 0.4 A with 180° conduction angle. *Using the equation of step 2 above:*

$$R_{\theta CA} = \frac{125^\circ C - 35^\circ C}{0.84\ W} - 75^\circ C/W = 32^\circ C/W$$

*Figure 4 shows that for* $R_{\theta CA}$ of 32°C/W, *the area* is 18 sq. in. The minimum dimensions of the sides should be:

$$\sqrt{\frac{area}{2}} \times \sqrt{\frac{area}{2}} = \sqrt{\frac{18}{2}} \times \sqrt{\frac{18}{2}} = 3'' \times 3''$$

MAXIMUM AVERAGE ANODE POWER DISSIPATED
vs
AVERAGE ON-STATE CURRENT

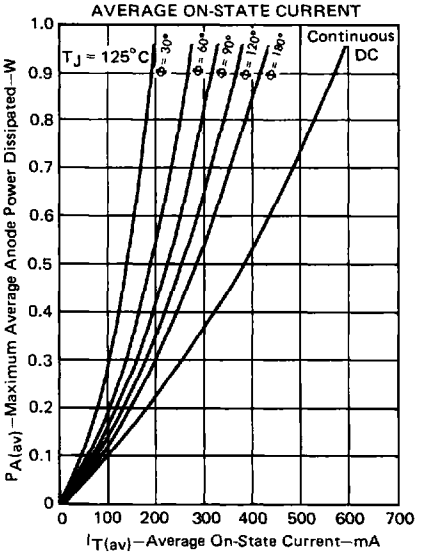


FIGURE 3

TYPICAL HEAT-SINK AREA
vs
CASE-TO-FREE-AIR THERMAL RESISTANCE
1/16"-THICK ALUMINUM HEAT SINK

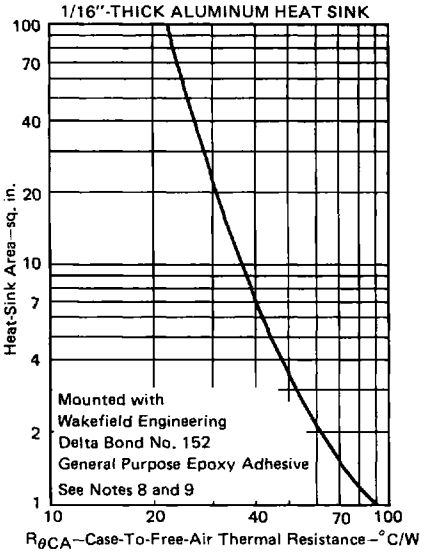


FIGURE 4

NOTES: 8. The thyristor is mounted in the center of a square heat sink vertically positioned in still free air with both sides exposed. The heat-sink area is twice the area of one side.

9. $R_{\theta CA}$ includes the case-to-heat sink thermal resistance, $R_{\theta CHS}$, in addition to the heat-sink-to-free-air thermal resistance, $R_{\theta HSA}$ and is defined by the equation, $R_{\theta CA} = R_{\theta CHS} + R_{\theta HSA}$.



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## THERMAL INFORMATION

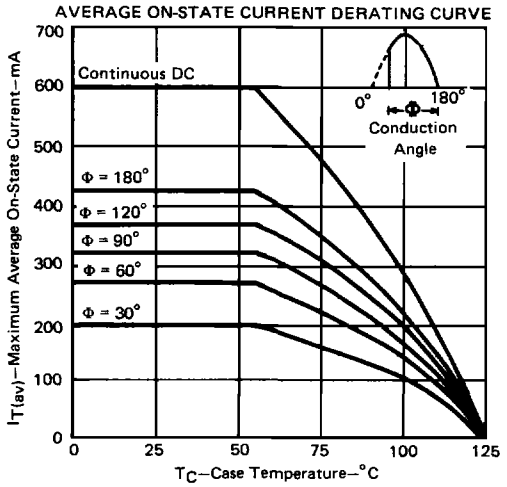


FIGURE 5

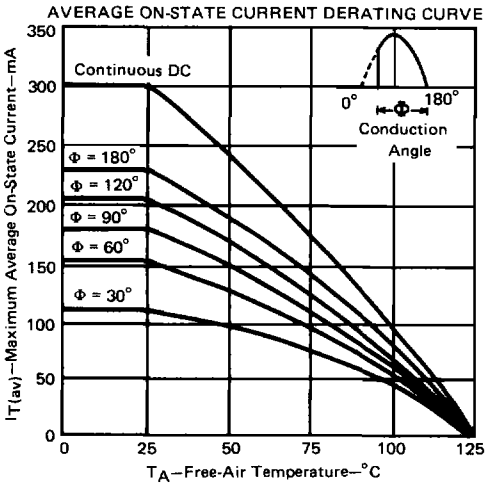


FIGURE 6

## TYPICAL CHARACTERISTICS

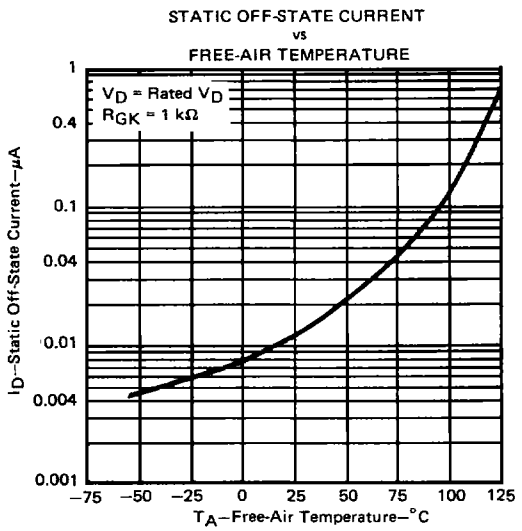


FIGURE 7

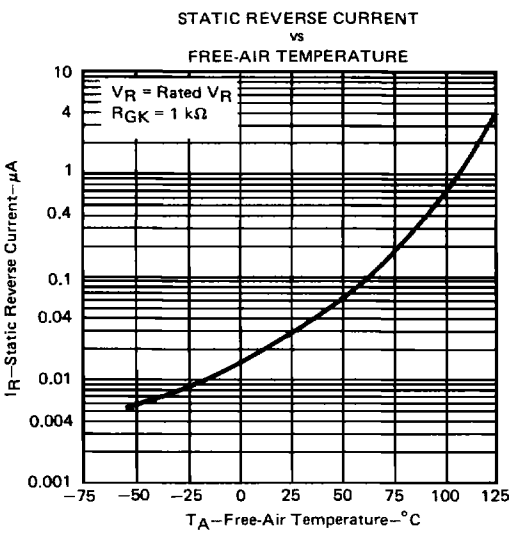


FIGURE 8

## TYPICAL CHARACTERISTICS

GATE TRIGGER CURRENT
vs
FREE-AIR TEMPERATURE

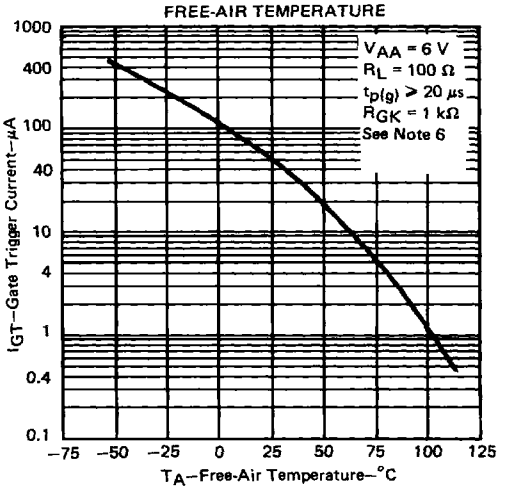


FIGURE 9

GATE TRIGGER VOLTAGE
vs
FREE-AIR TEMPERATURE

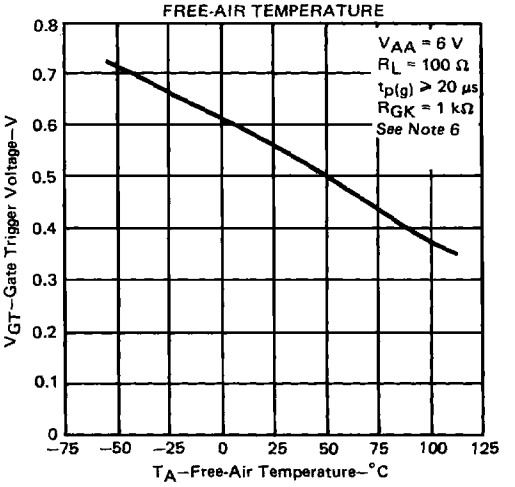


FIGURE 10

NOTE 6: When measuring these parameters, a 1-kΩ resistor should be used between gate and cathode to prevent triggering by random noise.

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HOLDING CURRENT
vs
FREE-AIR TEMPERATURE

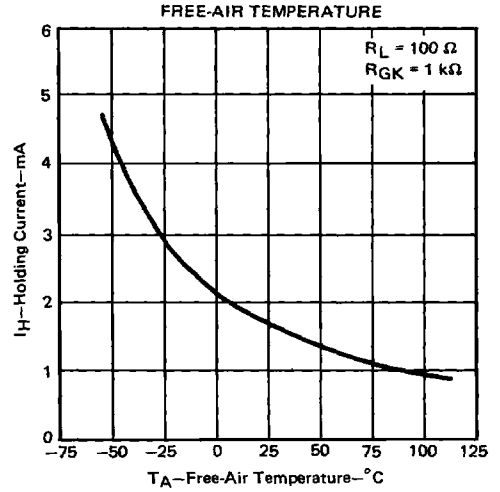


FIGURE 11

GATE-CONTROLLED TURN-ON TIME
vs
GATE CURRENT

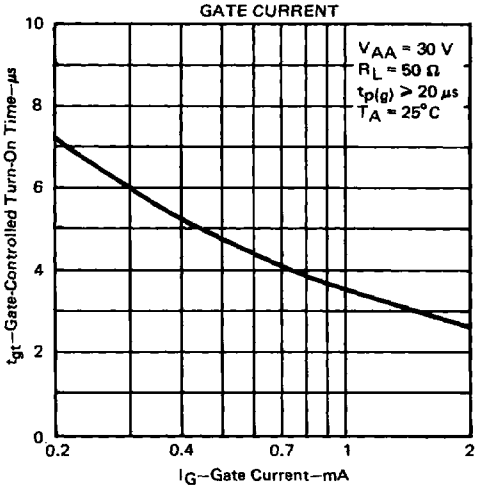


FIGURE 12

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