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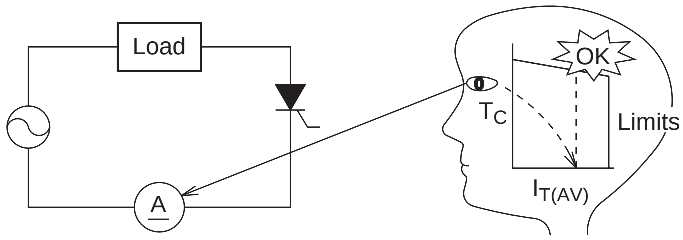
Thyristors • Triacs

Precautions for Use

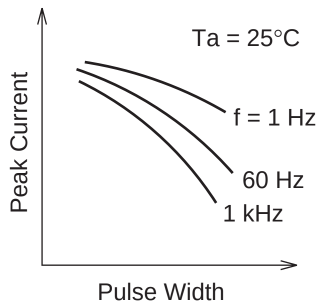
1. Use of Thyristors

(1) Determination of the current

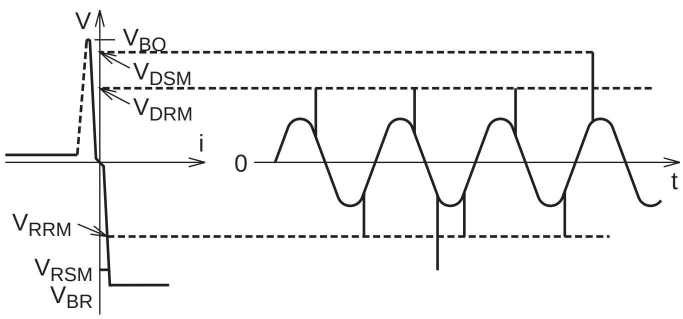
The permissible currents for thyristors is shown by the average value.



- When no rush current flows (heater, solenoid load)
  Load current × 1.3 to 1.5 ≤ permissible current for thyristor
  Example: 1 A × 1.5 / Applicable to 2 A class thyristors
  Determine the size of heatsink fin from the catalog.
- When the rush current flows (lamp, transformer, motor load)
  The rush current should be measured and a detailed heat calculation should be made. The current is roughly estimated to be twice the calculated value when no rush current flows.
- When pulses are used (capacitor discharge, LC oscillation, short-duration application (less than 10 seconds))
  For appropriate data on thyristors used for pulse applications (gas ignition, leakage protector, CDI, strobe), contact Renesas.



(2) Selection of withstanding voltage class



Note: V_{DRM} = supply voltage × 2.5 to 3

Selection of voltage items

Supply voltage	Location of use	Withstanding voltage class	V_{DRM} (V)	V_{DSM} (V)
100 V line	Domestic use (home use)	8	400	—
120 V line	U.S.A.			
100 V line	Earth leakage breaker	8	400	500
200 V line	Domestic use (factory use)	12	600	—
240 V line	Europe			
240 V line (240 V)	Earth leakage breaker	12	600	800

(3) Measures for dv/dt
When large voltage dv/dt is applied to thyristors, CR absorbers should be connected in parallel to the thyristors to lighten the dv/dt applied to the device.

A capacitor of 0.047 µF and a resistor of 33 Ω are generally used for low power thyristors.

It is generally recommended to insert a resistor of 1 kΩ between the gate and cathode for high-sensitivity low-current thyristors to lighten the dv/dt.

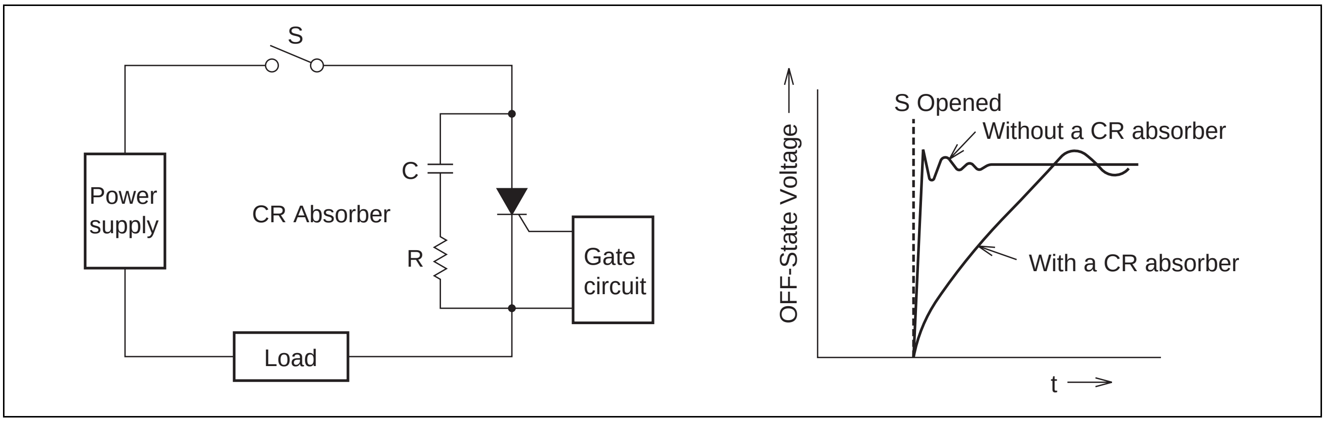
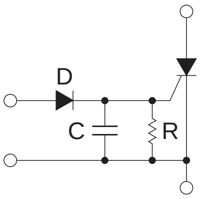


Figure1 To lighten the dv/dt with a CR absorber

(4) Cautions on the di/dt
If the current rate-of-rise di/dt exceeds the limit when a thyristor is turned on, the device may be damaged. In applications for invertors and choppers which discharge large currents when the thyristor is turned on, the di/dt causes a problem and, therefore, should be lightened by connecting and anode reactor.

(5) Measures for error prevention

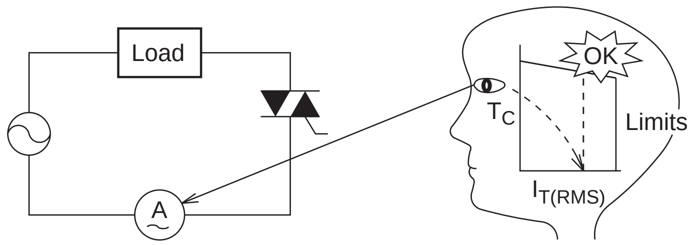
The cause and preventive measures of errors in the trigger circuit are shown in the table below.

Cause	Preventive measures
Noise to trigger circuit	(1) Stabilize the supply voltage (2) Insert a surge voltage absorber. (3) Avoid the use of a differentiation circuit which can be easily affected by the noise voltage resulting from the design of trigger circuits. (4) Provide electromagnetic shields to avoid external noise from the chassis.
Noise voltage induced in relation to the wiring from the trigger circuit to the gate of the thyristor.	(1) Use shielded wires to transmit the trigger signals. (2) Keep the wires as far apart as possible from the main circuit wires to avoid electromagnetic complications.
Feedback noise from the main circuit	(1) Insert an absorber at the gate (see below). (2) Insert a diode (see below).  Valves of general use R : 100 to 1 kΩ C : 0.01 to 0.1 μF Absorber for the gate

2. Use of Triacs

(1) Determination of the current

The permissible currents for triacs are shown by the effective values.



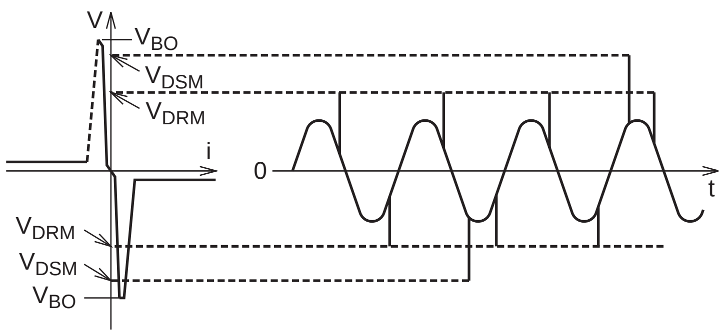
- When no rush current flows (heater load)
  Load current × 1.3 to 1.5 ≤ permissible current for triacs
  Example : 6 A × 1.5 = 9 → 10 A class thyristors
  Determine the size of heatsink fin from the catalog.
- When the rush current flows (lamp, transformer, motor load)
  The rush current should be measured and a detailed heat calculation should be made.
  Provide us with the following values and Renesas will do the calculation for you.

  Ambient temperature Ta =_______°C
  Peak value of rush current Ip = ______A Waveform if available.
  Constant current value $I_{T(RMS)}$ = ______A
  Operation sequence ___seconds during ON ___seconds during OFF
  Heatsink fin Material, size, painting, heat resistance $R_{th(f\;\;a)}$ if available.

The following triacs are applicable to the loads when the rush current flows (see Table below).

Load		Rush current	Applicable triacs
Incandescent lamp	100 V • 800 W	80 A	BCR16CM-12L
	100 V • 600 W	60 A	BCR12CM-12L
	100 V • 500 W	50 A	BCR10CM-12L
Halogen lamp	100 V • 600 W	72 A	BCR16CM-12L
Microwave oven	100 V • 600 W	80 A	BCR16CM-12L
General-use 3-phase induction motor	0.75 kW • 200 V	40 to 45 A	BCR16CM-12L

(2) Selection of withstanding voltage class



Note: Withstanding voltage of triac (V_{DRM}) =
Two or three times the supply volatage

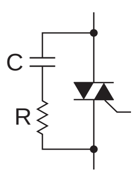
Selection of withstanding voltage items

	Supply voltage	Location of use	Withstanding voltage item	V_{DRM} (V)	V_{DSM} (V)
100 V line system	100 V line	Domestic use (home use)	8	400	500
	120 V line	U.S.A.			
	100 V line	Reversing operation of capacitor motor			
200 V line system	200 V line	Domestic use (factory use)	12	600	720
	240 V line	Europe			
	200 V line (240 V)	Reversing operation of capacitor motor	14	700	840

(3) Selection of CR absorber

In general, CR absorbers should be connected to suppress the (dv/dt)c value applied to the device when controlling the inductive load by triacs as shown below. The values for CR absorbers vary in accordance with the circuit conditions and sometimes they have to be determined by experimentation. In most cases, the (dv/dt)c value can be controlled to be less than 2.5 V/µs (supply voltage 100 V) and 5 V/µs (supply voltage 200 V) when C is 0.1 µF and R is 100 Ω.

In addition, please be sure to insert R (47 to 100 Ω) so that triacs does not do di/dt destruction of by the electric discharge current of capacitor.

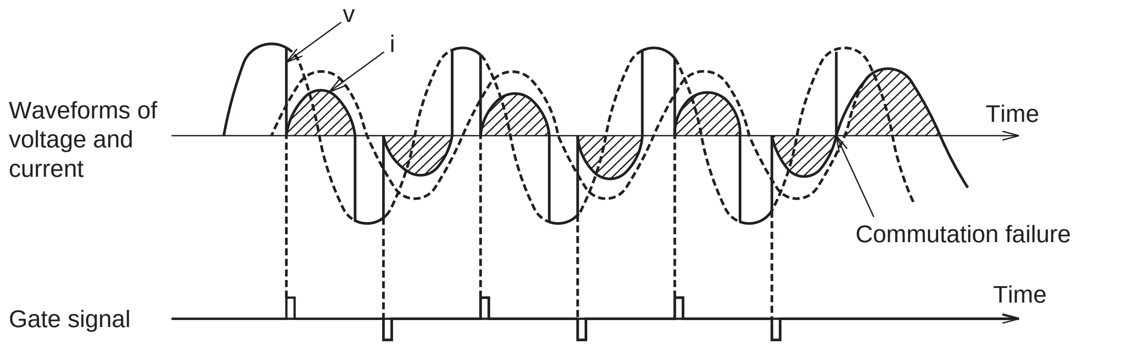


Recommended values of C and R

	100 V	200 W
C	0.1 µF, 400 W. V.	0.1 µF, 600 W. V.
R	100 Ω, 1/2 W	100 Ω, 1 W

(4) L load and R load

The commutation characteristics of triacs should be considered according to the load. (di/dt)c and (dv/dt)c shift to on-state without the gate signal and become uncontrollable as shown below, if they exceed certain values during commutation through the effect of current delay when the inductive load (L load) is controlled by triacs (commutation failure).



Waveforms of voltage and current applied to triacs when L load is used and when commutation fails.

Figure2 Waveforms of voltage and current applied to triacs during L load

To turn off the triacs, the appropriate device should be selected in accordance with the load. Also, C and R should be connected in series to the device to control the rise in voltage during commutation.

	Example of load
L Load (inductive load)	Motors, electromagnetic valves, transformers, solenoids
R Load (resistive load)	Heaters, lamps

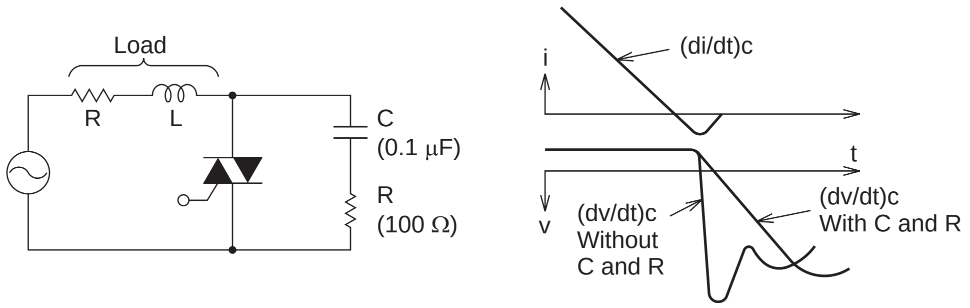


Figure 3 Waveforms during commutation

(5) Trigger mode of triacs

Triacs are turned on by applying either positive or negative gate signals. Thyristors are turned on by the gate signal when either forward or reverse voltages are applied.

Triacs can be triggered by the gate signal in the following four modes. However, the IV mode is guaranteed only by the BCR08AS and BCR1AM.

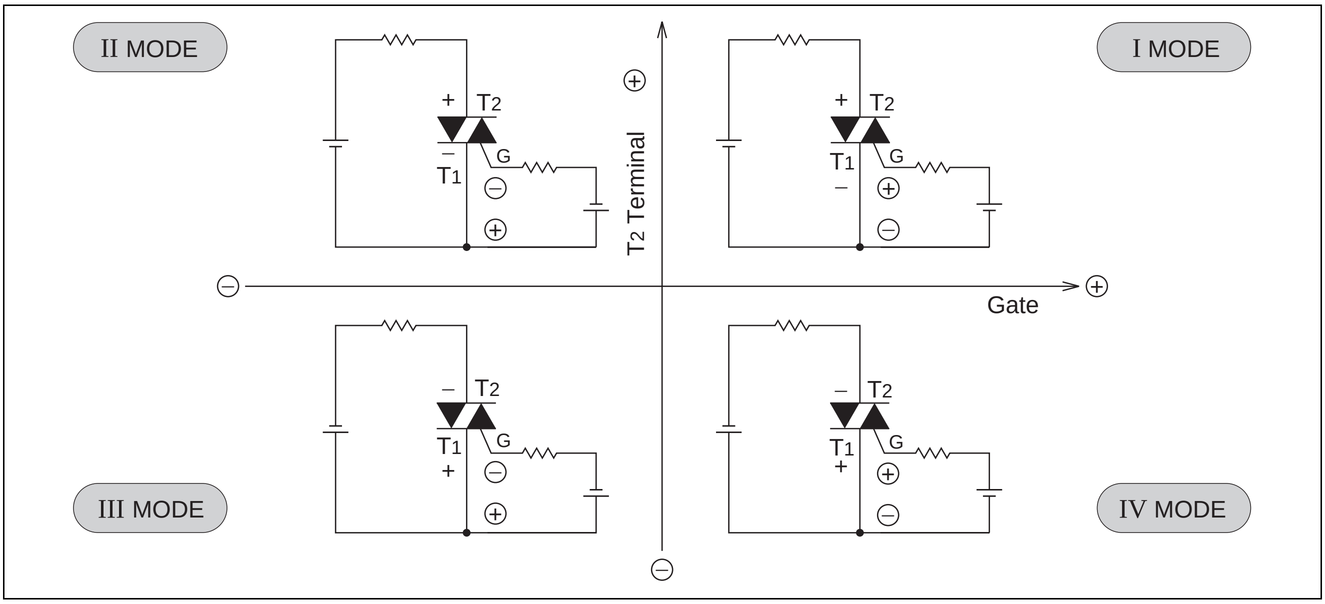
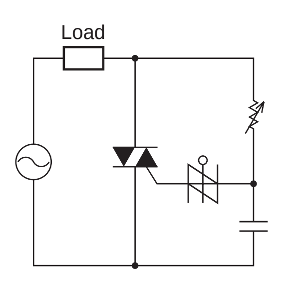
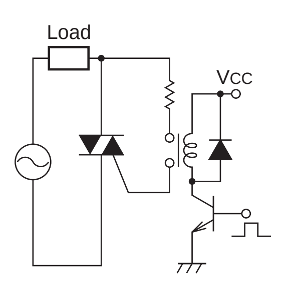
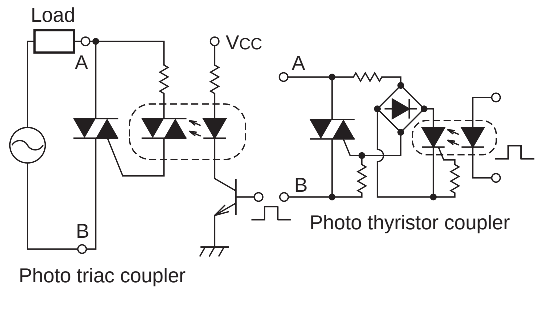
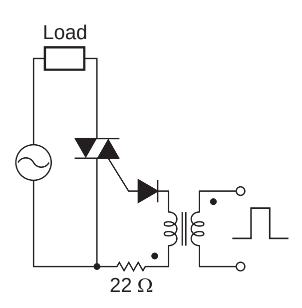
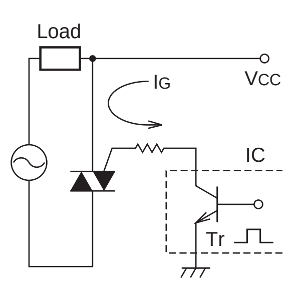
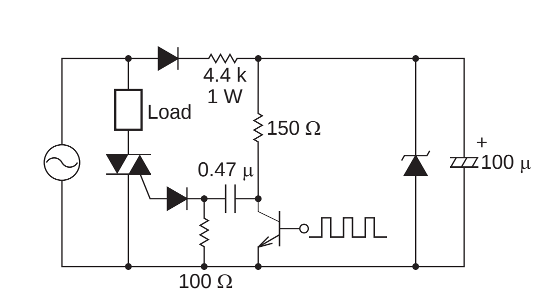
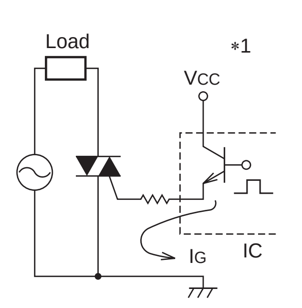
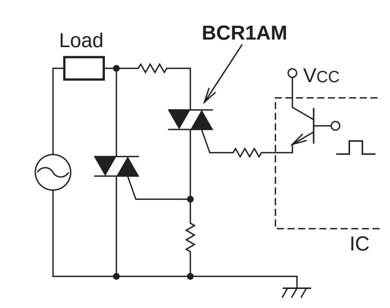


Figure 4 Trigger mode for triacs

(6) Gate circuit and gate trigger current

As stated earlier, triacs have four trigger modes and can be used in the following combinations.

Table 1 Gate circuit

<table>
<tr><th></th><th colspan="3">Examples of gate trigger circuit</th></tr>
<tr><td rowspan="2">I • III Mode</td><td></td><td></td><td></td></tr>
<tr><td>SBS • diac</td><td>Lead relay</td><td>Photo coupler</td></tr>
<tr><td rowspan="2">II • III Mode</td><td></td><td></td><td></td></tr>
<tr><td>Pulse transformer</td><td>IC. Transistor</td><td>Transistor oscillation</td></tr>
<tr><td rowspan="2">I • IV Mode</td><td></td><td colspan="2">
BCR1AM Guarantees the IGT (10 mA) of the IV mode. Use the circuit as shown on left.</td></tr>
<tr><td>IC. Transistor</td><td colspan="2">Auxiliary trigger of BCR1AM</td></tr>
</table>

***1: The IV mode (G^+, T_2 –) is not generally guaranteed except those of BCR08AS and BCR1AM.**

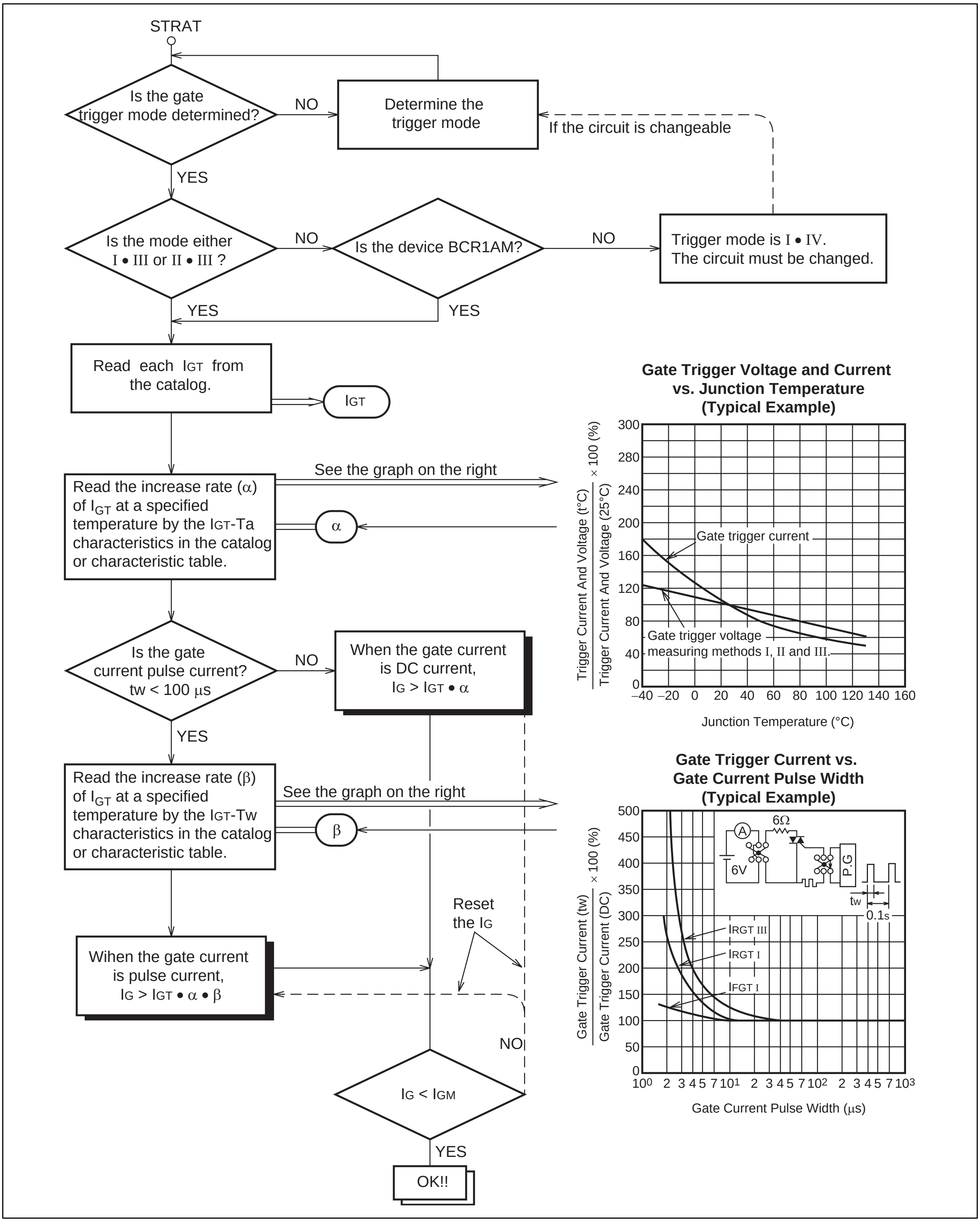


Figure 5 Determination of Gate Current

3. Introduction

This section explains thyristor-gate circuits, including the determination of circuit time-constants, methods of preventing erroneous operation, and precautionary measures for circuits with a high rate-of-rise di/dt of on-state current.

3.1 Determining Thyristor-Gate Circuit Time-Constants

When designing trigger circuits using thyristors, one of the first concerns is to assure that the device to be triggered is triggered completely, each time the control signal is applied to the gate. However, attempts to achieve this are hindered by gate losses (peak value, average value), restrictions in peak gate forward current and voltage, as well as varying values in gate input resistance (gate-to-cathode resistance) that range from a few 10 ohms to a few kiloohms. Thus determining circuit time-constants becomes an important task.

A graph similar to the one shown in Figure 6 can be used to help determine time-constants. Here, the gate forward current is shown on the horizontal axis, and the gate forward voltage on the vertical axis. These two points are connected by a hyperbolic curve that represents allowable gate losses with respect to the range of trigger variations and gate duty interval. In all areas above and to the right of the hatched box, the device will always trigger. The boundary represents the maximum gate trigger current and voltage for the operating temperature range (minimum junction temperature). By contrast, in all areas below and to the left of the hatched box, the device will not trigger. Here, the boundary represents the minimum gate non-triggering current and voltage for the operating temperature range (maximum junction temperature). The graph in Figure 6 is for the thyristor CR20F (a double logarithmic scale graph is used in the catalog). The maximum gate trigger current for that device is 50 mA (Tj = 25°C), maximum gate trigger voltage is 3.0 V (Tj = 25°C), and the minimum gate non-trigger voltage is 0.25 V (Tj = 125°C).

A basic triggering circuit is shown in Figure 7. Here, the gate circuit can be considered as a series-connected constant voltage power supply, current limiting resistor, and gate.

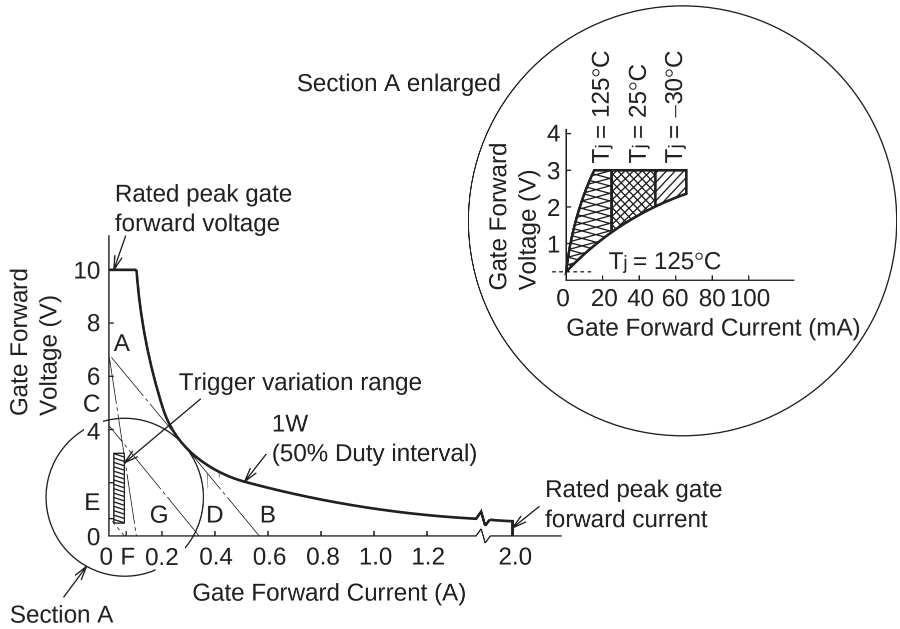


Figure 6 Gate triggerring conditions

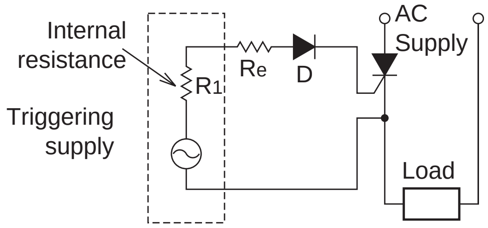


Figure 7 Basic trigger circuit

The main concerns in designing a trigger circuit center around determining proper values for power supply voltage, power supply internal resistance, and current-limiting resistors. However, these can be determined using the graph in Figure 6, by marking the triggering source voltage value for an open output terminal on the vertical axis, and the value for short-circuit current, when the output terminal is closed, on the horizontal axis, and then connecting the two points. This straight line is called the "gate load line", and no matter how much gate input resistance varies, the voltage and current applied to the gate will not influence formation of this gate load line. Consequently, as long as this line does not cross into the hatched box, and remains below the rated gate loss curve, all devices will trigger regularly and safely. If the hatched box is entered, some devices may not always trigger, and if the rated gate loss curve is crossed, power dissipation at the gate of some devices will be exceeded.

3.2 Methods of Preventing Erroneous Operation

Gate control gain values are high in thyristors, with small current values (at highest, not more than several hundred milliamperes) capable of turning on devices that conduct current values ranging from a few amperes to several kilo-amperes. On the other hand, these gates are extremely sensitive, and occasionally electrical noise will inadvertently open them. One cause of such spurious triggers in high current-carrying circuits located near to a gate circuit. The electromagnetic effect tends to induce voltage into the gate line and the resultant noise voltage triggers the thyristor to conducting state. This problem is particularly prevalent with multiple phase circuits, so extra caution is advised. The following methods are recommended for preventing erroneous operation.

(1) Keep gate lead lines far enough away from the main circuit conductors to prevent voltage induction.
(2) Insert a capacitor (0.01 to 0.1 µF) between the gate and cathode to absorb noise voltage.
(3) Avoid using common lines to main circuit cathodes and gate circuit cathodes. Take the extra time to connect a separate line to the device cathode.
(4) Use shielded wires for gate lines, or use two-conductor flat cables to inhibit the electromagnetic induction effect.

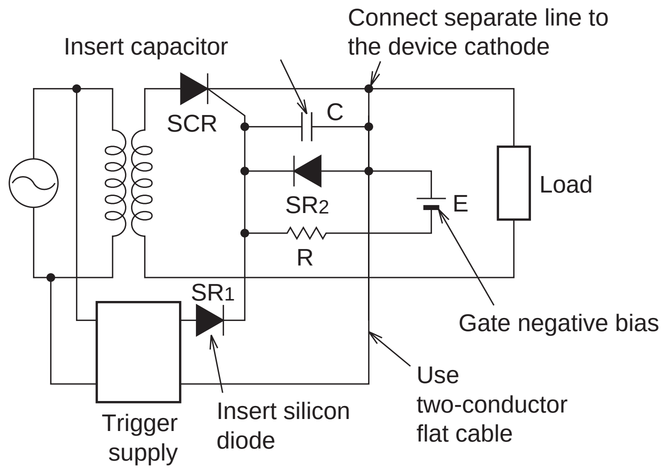


Figure 8 Trigger circuit

(5) Connect a silicon diode in series with the gate and use the voltage rise (approx. 0.7 V) to block the noise voltage.
(6) Apply bias to the gate, negative with respect to the cathode to block noise voltage.
The above points summarize the various methods available. Figure 8 shows these points diagramatically.

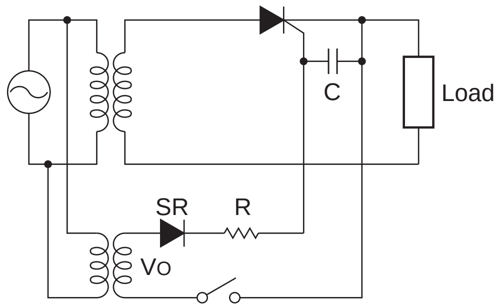


Figure 9 Trigger circuit wiring diagram

3.3 Gate Circuit Design Example

The trigger circuit described here is illustrated in Figure 9. The voltage used to trigger the thyristor CR20F is synchronized with the main circuit. The silicon diode (SR) shown in the circuit functions to block the negative cycle of the trigger supply. Unlike germanium diodes, silicon diodes have a voltage rise of 0.7 V, and so this diode helps prevent unwanted triggering. The trigger voltage supply is also half-wave rectified by the silicon diode SR, so the duty period of the gate is 50%. Referring back to Figure 6 and drawing the allowable power dissipation curve for a gate load line with a duty interval of 50%, and the average gate power dissipation for CR20F is 0.5 W, and the resultant curve for a 50% duty interval will correspond to the 1 W line. In other words, the value for

$$\text{Average gate input} \times \frac{100}{\text{duty interval (\%)}}$$

is used. When this value exceeds peak gate power loss (5 W with CR20F), use 5 W.

For example, when the RMS value for trigger supply voltage is 7 V, drawing the gate load line $\overline{AB}$ down from 7 V on the vertical axis as a tangent to the allowable power dissipation curve (for 50% duty interval), it will intersect the horizontal axis at 0.56. 0.56 A is thus the short circuit current. The gradient of this line (7 V/ 0.56 A) indicates that the resistance value must be over 12.5 Ω. Therefore, assuming a resistance value of 12.5 Ω, we draw another line representing the gate load line for another trigger supply voltage, parallel with line $\overline{AB}$, but outside of the hatched box. As trigger supply voltage rises from zero, any device will fire, as long as its gate load line lies along this line, and does not encroach into the hatched box. This line is marked $\overline{CD}$ on the graph, indicating a trigger supply voltage of 3 V. However, line $\overline{EF}$ indicates that in some case, some devices will trigger at a voltage of 0.5 V.

The triggering voltage used here is a sine wave, and depending on the individual characteristics of the device, the firing angle can vary between 1.5° and 24°. Using a voltage with a fast rate-of-rise reduces these variations, so normally a higher triggering voltage is used, with a Zener diode used to clip it below 10 V.

When a magnetic amplifier or similar device is used as the triggering supply, the voltage waveform applied to the gate is close to a square wave in shape, so differences in firing angles become quite small. When these types of waveforms are used, their peak-values are used to construct the gate load line.

Circuit constants are determined by using the above procedures. Inserting a capacitor (approx. 0.047 µF) between the gate and cathode will prevent spurious triggers. Since the trigger supply voltage for this circuit is half-wave rectified, use of a silicon diode helps suppress noise voltage that could also cause unwanted triggering. The gate line should be either a two-conductor flat cable, or shielded cable, and the gate and cathode terminal of device should have separate lines to minimize the electromagnetic induction effect.

3.4 Designing Gate Circuits for High Rate-of-Rise of On-state Current Values

In this section, gate circuit design will be covered for thyristors requiring high load current and high rate-of-rise of current (di/dt). Such characteristics are typical in motor-controllers, inverters, and DC choppers, and triggering is generally followed by large rush currents.

Thyristor turn-on time is a factor in the amount of current flow and width at the gate, on-current, anode-to cathode voltage level of the thyristor, and the characteristics of the load. However, a thyristor will always trigger if the current and voltage applied exceed the gate trigger current rating and voltage. The problem lies with the fact that since a high di/dt is accompanied by a large current flow, local heating will occur at turn-on, and this tends to cause unstable characteristics, and in some cases can even result in performance deterioration. However, these problems can be solved through trigger circuit design, and reliable operation can still be achieved.

3.5 Current Concentration at Turn-on

When the events occurring at thyristor turn-on are considered, the time required for conduction to spread across all junctions from the point that the signal enters the gate is considerably longer than turn-on-time. During the process of initial spreading, carriers are injected into the gate from the immediately surrounding areas, and the local portions of the gate start the turn-on process. At this time, the current will concentrate in these small spots, resulting in localized heating. The affects of this can degrade the characteristics of the device. The solution is to prevent localized current concentrations by holding load current rate-of-rise below a certain value. In applications where load current rate-of-rise di/dt is low, local hotspots are not a problem. In applications where the rate-of-rise di/dt is high, for example, with motor control ,inverter and DC choppers during triggering of the device, the hot-spots become a problem. Extra care should be taken to solve high di/dt problems during turn-on, when using devices designed to handle large switching currents.

3.6 Gate Construction and Spreading from the Initial Turn-On Area

The speed of conduction spread from the initial turn-on area is generally considered to be approximately 0.1 mm/µs. However, the amount of time required for spreading to cover the full effective conducting area depends on gate electrode construction, and the level of gate drive current.

The turn-on of thyristor starts at a junction where it is most easily triggered.

Where gate drive currents are small, there is little difference in the two types concerning the area occupied by initial turn-on, but for large gate drive currents, this difference increases significantly. It is obvious that for large gate drive currents in Figure 10, the conducting area for a center-gate becomes a circle around that gate, so not only is the initial conducting area increased, but spreading is also much more rapid than with corner-gates. An obvious advantage is that there are fewer problems with localized heating at the junction. Consequently, using center-gate thyristors with high gate drive currents will take care of most di/dt problems, and dramatically improve conduction spreading from the initial turn-on area as well.

In general, applying a current or voltage that exceeds gate trigger values to the thyristor gate will turn the device on, and unless di/dt is a particular problem, the device will continue to operate stably under these conditions alone. However, when the temperature-dependency characteristics of the gate and current concentration at gate turn-on are considered, from the standpoint of device reliability, it is better to reduce turn-on time by increasing gate drive current to a slightly excess level than to extend turn-on time with the minimum required current or voltage level.

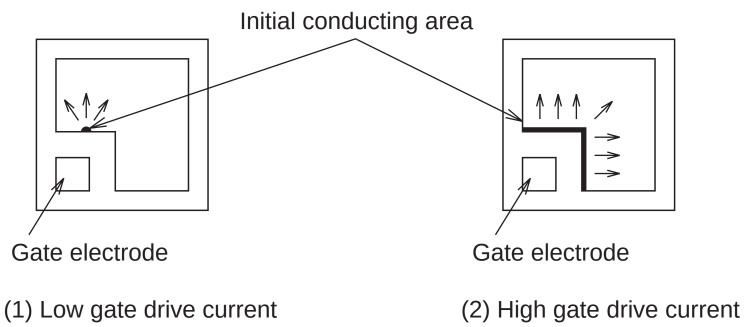


Figure 10 Turn-on area spreading

4. Designing Heatsinks for Power Rectifier Devices

Due to the heat generated internally in semiconductor power devices, special methods must be used to cool them. Natural heat radiation form the case of the device is insufficient, and so junction temperatures will exceed their allowable limits. Normal methods of cooling are self- cooling, air cooling water-cooling oil cooling and boiling-condensing cooling. However, the problems of thermal cooling are akin to those in an electrical circuit, and the resistance to the flow of heat (thermal resistance must be considered). An analogy between an electrical circuit and a thermal radiation circuit is given in Table 2.

Table 2 Comparing an electrical circuit with a thermal radiation circuit

Electrical circuit	Thermal radiation circuit
Voltage (V)	Temperature (°C)
Current (A)	Power dissipation (W)
Resistance (Ω)	Thermal resistance (°C/W)

If the problem of heat radiation is considered analogous to an electrical circuit, then the heat radiation circuit can be illustrated as shown in Figure 11. This equivalent circuit shows that the heat generated at the device junction meets thermal resistance between the junction and case, between the case and heatsink, and between the heatsink fins and ambient, before being radiated into the atmosphere or surrounding substance.

Considering P(W) to be the heat generated at the junction, the following equation can be derived.

$$Tj - Ta = P(R_{th(j-c)} + R_{th(c-f)} + R_{th(f-a)})$$

Tj: Junction temperature (°C)
Ta: Ambient temperature (°C)
P: Power dissipation within the device (W)
$R_{th(j\ c)}$: Junction-to-case thermal resistance (°C /W)
$R_{th(c\ f)}$: Case-to-heatsink thermal resistance (°C /W)
$R_{th(f\ a)}$: Heatsink-to-ambient thermal resistance (°C /W)

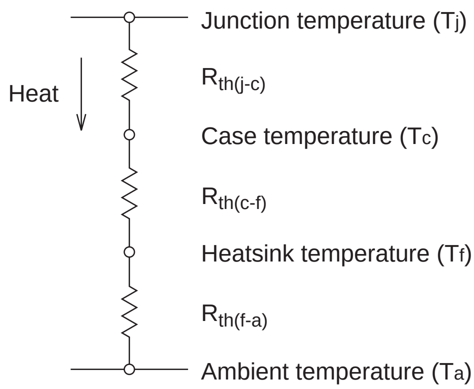


Figure 11 Equivalent circuit for thermal radiation

In designing the method of heatsinking, first the rectifier circuit must be designed, and then devices must be selected based on the various electrical conditions that must be met.

At that point, maximum junction temperature, junction-to-case thermal resistance and internal power dissipation can be determined, along with an approximate idea of the case-to-heatsink thermal resistance. And since maximum ambient temperature ($T_{a(max)}$) will be determined by other factors, the only variable free to work with is heatsink-to-ambient thermal resistance. This value is determined by the about of heatsink fin surface exposed to ambient, hence the size of the heatsink itself. Consequently, if the heatsink size is insufficient, the only alternative is to use a device with a different current capacity rating, or to use a different method of heatsinking.

4.1 Heatsink Thermal Resistance

The thermal resistance of a heatsink depends not only on its size, but also on shape, material, surface configuration (surface finish, painted or bare, etc.) and orientation. Other factors such as the difference between heatsink and ambient temperature, the speed of the air striking the heatsink surface, air-current conditions and the temperature of surrounding objects also influence thermal resistance.

Thermal resistance data of flat heat sinks are given in figure 12. For example, when $R_{th(f-a)}$ of 3°C/W is required, the data indicates that an unpainted aluminum plate with a thickness of t2.3 mm and an area of 220 cm^2, that is, about 15-cm square, is suitable.

Measured data for heat sinks on the market is available from the individual manufacturers. Thermal resistance values for several types of heatsink, including plain aluminum are illustrated in Figure 13.

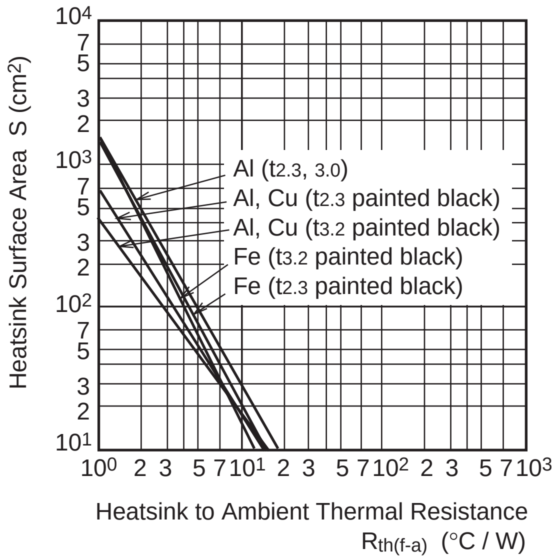


Figure 12 Heatsink Surface Area–Heatsink to Ambient Thermal Resistance Characteristics

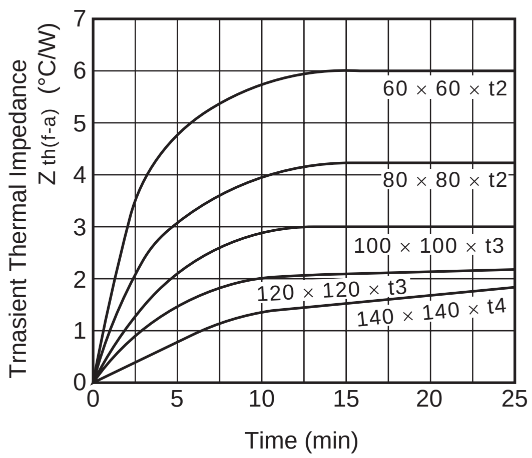


Figure 13 Transient thermal impedance for aluminum plate heatsinks
(single plate mounted perpendicular, painted black, self-cooling, temperature in center of fin 60°C)
(actual measurements)

4.2 Device Setting

The thermal resistance $R_{th(c-f)}$ between the device and heatsink (contact thermal resistance) depends heavily on factors such as the type of material used, contact surface finish, area of contact, nature of any material interposed at the contact surface, and contact pressure. Minimizing $R_{th(c-f)}$ should thus be the primary consideration whenever mounting a device.

When mounting the device to the heatsink, applying grease to the contact surfaces not only reduces contact thermal resistance, but also retards the growth of corrosion at the joint as well. However, note that the grease selected must not break down at device operation temperature, and it should be resistant to chemical changes occurring over time.

When using an aluminum heatsink, the oxidation layer should be knocked off of the contact surface using a wire brush. Grease should normally be applied only to the contact surfaces, not the device threads.

The contact thermal resistance in each package becomes as it is shown in Table 3.

A torque wrench must be used to mount the device tightening the nut to proper torque specifications.

Table 3 Contact thermal resistance information Package type

Package Type	Thread Diameter	Recommended torque		Contact thermal resistance (°C/W)
		N • m	(kg • cm)	
TO-3P	M3	0.59	(6)	0.3
TO-220	M3	0.49	(5)	1
TO-220F	M3	0.49	(5)	0.5
TO-220FN	M3	0.49	(5)	0.5

Notes: Values for contact thermal resistance applicable for mounting, using joint compound and torque to recommended values.

5. Cautions for mounting

5.1 Cautions for mounting

(1) The heatsink surface should be smooth without burrs or metal chips (6 S: ∇∇∇ finishing) when mounting heatsink fins to the flat-base and TO-220 package thyristors and triacs.
(2) A torque wrench, torque driver or box spanner must be used to mount the device, tightening the nuts to the proper torque specifications.
(3) Apply silicon grease to the contact surface to improve heat conductivity from the device to heatsink fin.
(4) Lead terminals of through-hall thyristors and triacs should be soldered according to the following conditions.
 1) Soldering should be completed at a location more than 4mm away from the molded part.
 2) Soldering temperature should be 260°C for a maximum of 10 s or 350°C for a maximum of 3 s.
 3) Recommended solder and flux are as follows:
  Solder: PbSn (4:6) Kyosho solder (melting point 180°C)
  Example: H63A
  Flux: Solderite
(5) The mounting hole diameter of the heatsink fin should be smaller than ϕ3.2 or ϕ3.8 when the heatsink fin is mounted to TO-220 non-insulated thyristors or triacs by the conducting method, or when mounting the insulating type triacs.

5.2 Cautions for using a through-hall type devices

Care should be given as follows when using a through-hall type device.

(1) Stress to electrode leads
Excessive stress given to electrode leads in a device may damage the device. The load as shown by the arrow in Figure 14 should be less than 9.8 N.

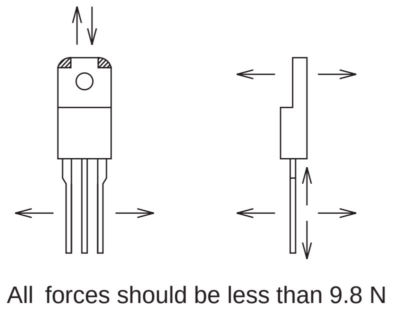


Figure 14 Stress to electrode leads

(2) Cautions for lead forming

Care should be given to the following when a lead is formed regarding parts arrangement of equipment.

(a) Provide a fixing device so as not to apply stress as shown in Figure 14 or take two needlenose pliers, and while one pliers is holding the lead, bend the rest of the lead using the other.

(b) To bend a lead sideways, bend the thin part of a lead or at a point which is more than 2 mm apart from the capsulated body and the angle of bending should be within 30 degrees, as shown in Figure 15.

(c) To bend the lead in vertical direction to the display surface of the device type name, bend it 2 mm away from the case, as shown in Figure 16.

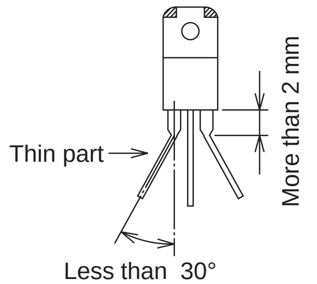


Figure 15 Bending a lead sideways

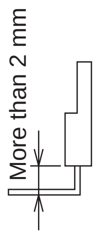


Figure 16 Bending a lead in vertical direction

5.3 Confirmation of allowable dissipation

(1) Because allowable dissipation of surface-mounted device depends on mounting plate and wiring pattern, so that test of dissipation is necessary after mounting.

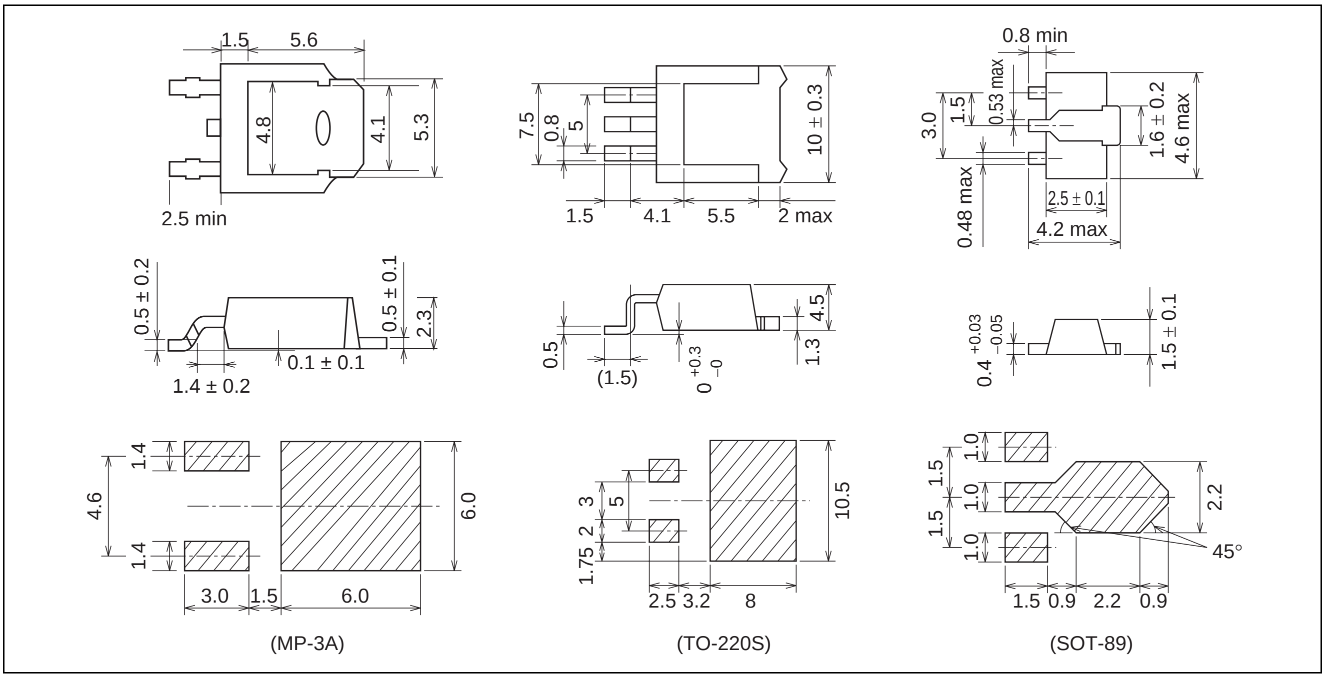


Figure 17 Recommended mounting pad

(2) Reflow method

Temperature profile of IR rays reflow is shown in Figure 18

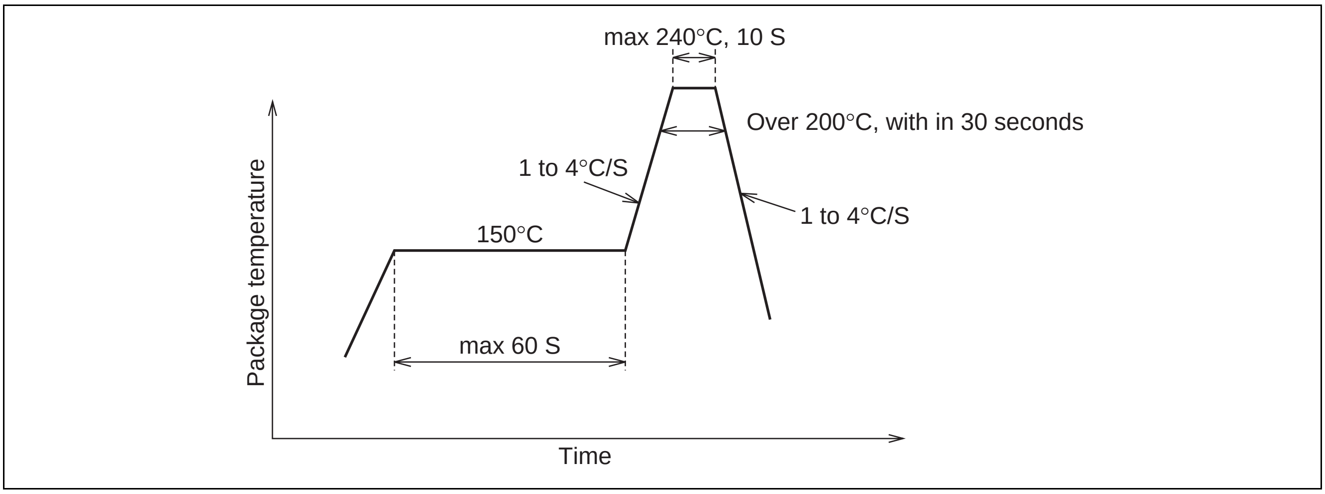


Figure 18 Temperature profile of IR rays reflow (Recommended conditions)

(3) Cleaning PCB (Printed Circuit Board)

In case of necessity of the cleaning PCB to remove flux after the soldering, following items should be taken care.

1) Please do not scrub the type names on the device neither by hand nor with brush, if the devices are on washing process.

2) Following conditions should be applied for the ultrasonic cleaning of devices.

- Recommended conditions
  Frequency 28 kHz or less
  Output of ultrasonic 20 W/*l* or less
  Cleaning time 30 sec or less
- Neither vibrating element of ultrasonic, PCB nor device should be contacted. Furthermore resonance frequency and devices should be avoided.

Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	Jan.26.05	—	First edition issued