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April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (http://www.renesas.com)

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# Thyristors • Triacs

## Symbology

## 1. Power semiconductor devices, general use

| Symbol | Parameter | Definition/description |
|---|---|---|
| $R_{th}$ | Thermal resistance | Defined when junction power dissipation results in a balanced state of thermal flow. Specifies the degree of temperature rise per unit of power, measuring junction temperature from a specified external point. |
| $R_{th(j-a)}$ | Junction-to-ambient thermal resistance | The thermal resistance between the junction and ambient atmosphere. |
| $R_{th(j-c)}$ | Junction-to-case thermal resistance | The thermal resistance between the junction and surface of the case. |
| $R_{th(j-f)}$ | Junction-to-fin thermal resistance | The thermal resistance between the junction and the fin. |
| $R_{th(c-f)}$ | Contact thermal resistance (Case-to-fin thermal resistance) | The thermal resistance between the surface of the case and the fin. |
| $Z_{th}$ | Transient thermal impedance | Defined when case temperature (stud temperature) is constant, and power dissipation at the junction is pulsating. Specifies the degree of temperature rise per unit of power, measuring junction temperature from a specified external point. |
| $Z_{th(j-a)}$ | Junction-to-ambient transient thermal impedance | The transient thermal impedance between the junction and ambient atmosphere. |
| $Z_{th(j-c)}$ | Junction-to-case transient thermal impedance | The transient thermal impedance between the junction and surface of the case. |
| $Z_{th(j-f)}$ | Junction-to-fin transient thermal impedance | The transient thermal impedance between the junction and the fin. |
| $T_a$ | Ambient temperature | When used in the natural cooling or forced-air cooling, it is the temperature of the surrounding atmosphere of a device that is dependent on geographical location and season, and is not influenced by heat dissipation of the device. |
| $T_f$ | Fin temperature | The temperature at a specified point of the device heatsink. |
| $T_c$ | Case temperature | The temperature at a specified point of the device case. |
| $T_j$ | Junction temperature rating | The device junction temperature rating. Indicates the maximum and minimum allowable operation temperatures. |
| $T_{stg}$ | Storage temperature rating | The device storage temperature (with no electrical connection). Indicates the maximum and minimum allowable temperatures. |

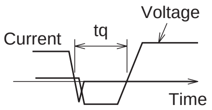
## 2. Thyristors

| Symbol | Parameter | Definition/description |
|---|---|---|
| $V_{RRM}$ | Repetitive peak reverse voltage | Within the rated junction temperature range, and when there is no signal between the gate and cathode, specifies the repetitive peak reverse voltage applicable on each cycle.<br>For low power devices, tested with a specified resistance between the gate and cathode. |
| $V_{RSM}$ | Non-repetitive peak reverse voltage | Within the rated junction temperature range, and when there is no signal between the gate and cathode, specifies the non-repetitive peak reverse voltage applicable for time width equivalent to less than a half of a sine wave at commercial frequency.<br>For low power devices, tested with a specified resistance between the gate and cathode. |
| $V_{R(DC)}$ | DC reverse voltage | Within the rated junction temperature range, and when there is no signal between the gate and cathode, specifies the maximum value for DC voltage applicable in reverse direction. |
| $V_{DRM}$ | Repetitive peak off-state voltage | Within the rated junction temperature range, and when there is no signal between the gate and cathode, specifies the repetitive peak off-state voltage applicable for each cycle. Includes the maximum instantaneous value for repetitive transient off-state voltage. |
| $V_{DSM}$ | Non-repetitive peak off-state voltage | Within the rated junction temperature range, and when there is no signal between the gate and cathode, specifies the non-repetitive peak off-state voltage applicable for time width equivalent to less than a half of a sine wave at commercial frequency. Indicates the maximum instantaneous value for non-repetitive transient off-state voltage.<br>For low power devices, tested with a specified resistance between the gate and cathode. |
| $V_{D(DC)}$ | DC off-state voltage | Within the rated junction temperature range, and when there is no signal between the gate and cathode, specifies the maximum value for DC voltage applicable in forward direction.<br>For low power devices, tested with a specified resistance between the gate and cathode. |
| dv/dt | Critical rate-of-rise of off-state voltage | At maximum rated junction temperature, and when there is no signal between the gate and cathode, specifies the maximum rate-of-rise of off-state voltage that will not cause the device change from an off-state to an on-state when an exponential function waveform off-state voltage of specified amplitude is applied to the device,<br>$\frac{dv}{dt} = \frac{0.632V_D}{\tau}$<br>Here, $V_D$: Specified off-state voltage<br>$\tau$: Time constant for the exponential function waveform<br>For low power devices, tested with a specified resistance between the gate and cathode. |
| $V_{TM}$ | On-state voltage | At specified case (or point) temperature, and when on-state current (commercial frequency, half sine wave of specified amplitude) is applied to the device, indicates peak value for the resulting voltage drop. |

## Thyristors (continued)

| Symbol | Parameter | Definition/description |
|---|---|---|
| $I_{T(RMS)}$ | RMS on-state current | At specified case (or point) temperature, indicates the RMS value for on-state current that can be continuously applied to the device. |
| $I_{T(AV)}$ | Average on-state current | At specified case (or point) temperature, and with the device connected to a resistive or inductive load, indicates the average value for forward current (sine half wave, commercial frequency) that can be continuously applied to the device. |
| $I_{TSM}$ | Surge-on current | Within the rated junction temperature range, indicates the peak value for non-repetitive on-state current (sine half wave, commercial frequency). This value is defined at one cycle, or as a function of multiple cycles. |
| $I^2t$ | Current-squared, time integration | Indicates peak value for surge-on current as the square of a half of a current sine wave, time integrated over a half of a cycle.<br>$I^2t = \int_0^{\frac{\pi}{\omega}} I_{TSM}{}^2 \sin^2 \omega t \, dt$ |
| di/dt | Critical rate-of-rise of on-state current | At specified case (or point) temperature, specified off-state voltage, specified gate conditions, and at a frequency of less than 60Hz, indicates the maximum rate-of-rise of on-state current that the thyristor will withstand after switching from an off-state to an on-state. |
| $I_H$ | Holding current | At specified junction temperature, gate conditions and off-state voltage, indicates the minimum anode current required holding the thyristor in an on-state. |
| $I_L$ | Latching current | At specified junction temperature, off-state voltage and gate conditions, and when the gate trigger current is lifted immediately following switching from an off-to on-state, indicates the minimum anode current required to hold the thyristor in an on-state. |
| $I_{RRM}$ | Reverse current | At maximum rated junction temperature, indicates the peak value for reverse current flow when a voltage (sine half wave, commercial frequency, and with a peak value as specified for repetitive peak reverse voltage rating) is applied in a reverse direction to the device<br>For low power devices, tested with a specified resistance between the gate and cathode. |
| $I_{DRM}$ | Off-state current | At maximum rated junction temperature, indicates the peak value for off-state current flow when a voltage (sine half wave, commercial frequency, and with a peak value as specified for repetitive peak off-state voltage rating) is applied in a forward direction to the device.<br>For low power devices, tested with a specified resistance between the gate and cathode. |
| $P_{GM}$ | Peak gate power dissipation | Within the rated junction temperature range, indicates the peak value for maximum allowable power dissipation over a specified time period, when the device is forward-conducting between the gate and cathode. |
| $P_{G(AV)}$ | Average gate power dissipation | Within the rated junction temperature range, indicates the average value for maximum allowable power dissipation over a specified period of time, when the device is forward-conducting between the gate and cathode. |
| $I_{FGM}$ | Peak gate forward current | Within the rated junction temperature range, indicates the peak value for forward current flow between the gate and cathode. |

## Thyristors (continued)

| Symbol | Parameter | Definition/description |
|---|---|---|
| $V_{RGM}$ | Peak gate reverse voltage | Within the rated junction temperature range, indicates the peak value for reverse voltage applied between the gate and cathode. |
| $V_{FGM}$ | Peak gate forward voltage | Within the rated junction temperature range, indicates the peak value for forward voltage applied between the gate and cathode. |
| $I_{GT}$ | Gate trigger current | At a junction temperature of 25°C, with an off-state voltage of 6 V, and a specified load resistance, indicates the minimum gate DC current required switching the thyristor from an off-state to an on-state. |
| $V_{GT}$ | Gate trigger voltage | At a junction temperature of 25°C, with an off-state voltage of 6 V, and a specified load resistance, indicates the minimum gate DC voltage required to switch the thyristor from an off-state to an on-state. For low power devices, does not include current flow through the connected gate resistor, current flow through the connected gate resistor. |
| $V_{GD}$ | Gate non-trigger voltage | At maximum rated junction temperature, and with a specified off-state voltage applied to the device, indicates the maximum gate DC voltage that will not switch the device from an off-state to an on-state. |
| $P_{T(AV)}$ | On-state power dissipation | At a specified conducting angle, and with on-state current of specified waveform applied to the device, indicates the average value for internal power dissipation occurring over a one-cycle interval. |
| $t_{gt}$ | Turn-on time | At specified junction temperature, and with a peak repetitive off-state voltage of a half of the rated value, followed by device turn-on using specified gate current, when specified on-state current of specified di/dt flows, indicated as the time required for the applied off-state voltage to drop to 10% of its initial value after gate current application. "Delay time" is the term used to define the time required for applied voltage to drop to 90% of its initial value following gate current application, and the time required for the level to drop from 90% to 10% is referred to as "rise time". The sum of both of these defines turn-on time. |
| $t_q$ | Turn-off time | Specified at maximum rated junction temperature. Device set up to conduct on-state current, followed by application of specified reverse voltage to quench the on-state current, and then increasing voltage at a specified rate-of-rise as determined by circuit conditions controlling the point where specified off-state voltage is reached. Turn-off time defines the minimum time that the device will hold its off-state, starting from the point when on-state current reached zero, and after forward voltage is again applied.<br><br> |
| Qrr | Reverse recovery charge | Indicates the total amount of reverse recovery charge due to current integrated time in a reverse direction (as part of the internally stored charge). Specified at a certain junction temperature, and time measured starting at the point when the device switched from forward to reverse, following specified current flow, and after current has decreased at a specified rate-of-fall. |

## 3. Triacs

| Symbol | Parameter | Definition/description |
|---|---|---|
| $V_{DRM}$ | Repetitive peak off-state voltage | Within the rated junction temperature range, and with no signal between the gate and T1 terminal, indicates the applicable peak repetitive off-state voltage value. Indicated as maximum instantaneous value that includes repetitive transient voltage, but excludes non-repetitive transient voltage. |
| $V_{DSM}$ | Non-repetitive peak off-state voltage | Within the rated junction temperature range, and when there is no signal between the gate and T1 terminal, specifies the non-repetitive peak off-state voltage applicable for a time width equivalent to less than a half of a sine wave at commercial frequency.<br>Indicates the maximum instantaneous value for non-repetitive transient off-state voltage. |
| $V_{TM}$ | On-state voltage | At specified case (or point) temperature, and when current having a specified amplitude (commercial frequency, sine half wave) is applied in both directions, indicates the peak value of the resulting on-state voltage in the direction producing the larger voltage. |
| $I_{T(RMS)}$ | RMS on-state current | At a specified case (or point) temperature, indicates the RMS value for commercial frequency sine wave (360 degree) current that can be continually applied to the device. |
| $I_{TSM}$ | Surge on-current | Within the rated junction temperature range, indicates the peak value for a non-repetitive type current sine wave at commercial frequency. Indicated for one cycle, or as a function of multiple cycles. |
| $I^2t$ | Current squared, time integration | Indicates peak value for surge on-current rating as the square of a half of a current since wave, time integrated over a half cycle. |
| di/dt | Critical rate-of-rise for on-state current | At specified case (or point) temperature, specifies a half of repetitive peak off-state voltage, specified gate conditions, and at a frequency of less than 60Hz, indicates the maximum rate-of-rise for on-current which the triac will withstand after switching from an off-state to an on-state. |
| dv/dt | Critical rate-of-rise of off-voltage | At maximum rated junction temperature, and when there is no signal between the gate and T1 terminal specified the maximum rate-of-rise of off-state voltage that will not drive the device from an off-state to an on-state when an exponential function from off-state voltage of specified amplitude is applied to the device.<br>$\frac{dv}{dt} = \frac{0.632V_D}{\tau}$<br>Here, $V_D$: Specified off-state voltage<br>$\tau$: Time constant for the exponential function waveform |
| $I_{DRM}$ | Off-state current | At maximum rated junction temperature, and indicates the peak value for off-state current flow when voltage (commercial frequency, sine half wave) have a peak value equal to peak repetitive off-state voltage rating is applied in both directions. |
| $P_{GM}$ | Peak gate dissipation | Within the rated junction temperature range, indicates peak value of the maximum allowable power dissipation for both directions between the gate and T1 terminal over a specified time period. |
| $P_{G(AV)}$ | Average gate dissipation | Within the rated junction temperature range, indicates average value of the maximum allowable power dissipation for both directions between the gate and T1 terminal. |

## Triacs (continued)

| Symbol | Parameter | Definition/description |
|---|---|---|
| $V_{GM}$ | Peak gate voltage | Within the rated junction temperature range, indicates the peak value of voltage (commercial frequency, sine half wave) applicable in both directions between the gate and T1 terminal. |
| $I_{GM}$ | Peak gate current | Within the rated junction temperature range, indicates the peak value of current (commercial frequency, sine half wave) applicable in both directions between the gate and T1 terminal. |
| $V_{GT}$ | Gate trigger voltage | With a junction temperature of 25°C, 6V of off-voltage, and a specified load resistance, indicates the minimum gate DC voltage required to switch the triac from an off-state to an on-state. There are up to four values, depending on the polarity of the T1 terminal and gate. |
| $I_{GT}$ | Gate trigger current | With a junction temperature of 25°C, 6V of off-voltage, and a specified load resistance, indicates the minimum gate DC current required switching the triac from off-state to an on-state. There are up to four values, depending on the polarity of the T1 terminal and gate. |
| $V_{GD}$ | Gate non-trigger voltage | At maximum rated junction temperature, and with specified off-state voltage applied, indicates the maximum gate DC voltage that will not switch the device from an off-state to an on-state. |
| $P_{T(AV)}$ | On-state power dissipation | With an on-state current sine wave of specified conducting angle, specifies the average value for internal power dissipation occurring over one cycle. |
| (dv/dt)c | Critical rate-of-rise of off-state voltage at commutation | At maximum rated junction temperature, and when conducting a specified on-state current, followed by reversing the current at a specified rate-of-fall, indicates the maximum rate-of-rise of off-state voltage which will not cause the device to conduct in the opposite direction when a specified voltage is applied to the opposite of the previously conducting direction. Specifies the smaller value for the two conducting directions. |

## Revision Record

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