

# Thyristor Module

$$V_{RRM} = 2 \times 1400 \text{ V}$$

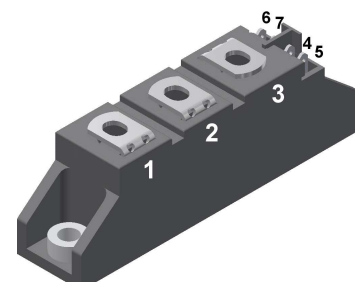
$$I_{TAV} = 116 \text{ A}$$

$$V_T = 1.28 \text{ V}$$

Phase leg

Part number

**MCC95-14io1B**



Backside: isolated

 E72873



## Features / Advantages:

- Thyristor for line frequency
- Planar passivated chip
- Long-term stability
- Direct Copper Bonded Al<sub>2</sub>O<sub>3</sub>-ceramic

## Applications:

- Line rectifying 50/60 Hz
- Softstart AC motor control
- DC Motor control
- Power converter
- AC power control
- Lighting and temperature control

## Package: TO-240AA

- Isolation Voltage: 4800 V~
- Industry standard outline
- RoHS compliant
- Soldering pins for PCB mounting
- Base plate: DCB ceramic
- Reduced weight
- Advanced power cycling

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| Thyristor      |                                                      |                                                                                                                                                                                                        |                                | Ratings |      |      |                   |
|----------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|---------|------|------|-------------------|
| Symbol         | Definition                                           | Conditions                                                                                                                                                                                             |                                | min.    | typ. | max. | Unit              |
| $V_{RSM/DSM}$  | max. non-repetitive reverse/forward blocking voltage | $T_{VJ} = 25^{\circ}\text{C}$                                                                                                                                                                          |                                |         |      | 1500 | V                 |
| $V_{RRM/DRM}$  | max. repetitive reverse/forward blocking voltage     | $T_{VJ} = 25^{\circ}\text{C}$                                                                                                                                                                          |                                |         |      | 1400 | V                 |
| $I_{R/D}$      | reverse current, drain current                       | $V_{R/D} = 1400\text{ V}$                                                                                                                                                                              | $T_{VJ} = 25^{\circ}\text{C}$  |         |      | 200  | $\mu\text{A}$     |
|                |                                                      | $V_{R/D} = 1400\text{ V}$                                                                                                                                                                              | $T_{VJ} = 125^{\circ}\text{C}$ |         |      | 5    | mA                |
| $V_T$          | forward voltage drop                                 | $I_T = 150\text{ A}$                                                                                                                                                                                   | $T_{VJ} = 25^{\circ}\text{C}$  |         |      | 1.29 | V                 |
|                |                                                      | $I_T = 300\text{ A}$                                                                                                                                                                                   |                                |         |      | 1.50 | V                 |
|                |                                                      | $I_T = 150\text{ A}$                                                                                                                                                                                   | $T_{VJ} = 125^{\circ}\text{C}$ |         |      | 1.28 | V                 |
|                |                                                      | $I_T = 300\text{ A}$                                                                                                                                                                                   |                                |         |      | 1.70 | V                 |
| $I_{TAV}$      | average forward current                              | $T_C = 85^{\circ}\text{C}$                                                                                                                                                                             | $T_{VJ} = 125^{\circ}\text{C}$ |         |      | 116  | A                 |
| $I_{T(RMS)}$   | RMS forward current                                  | 180° sine                                                                                                                                                                                              |                                |         |      | 182  | A                 |
| $V_{T0}$       | threshold voltage                                    | } for power loss calculation only                                                                                                                                                                      | $T_{VJ} = 125^{\circ}\text{C}$ |         |      | 0.85 | V                 |
| $r_T$          | slope resistance                                     |                                                                                                                                                                                                        |                                |         |      | 2.4  | m $\Omega$        |
| $R_{thJC}$     | thermal resistance junction to case                  |                                                                                                                                                                                                        |                                |         |      | 0.22 | K/W               |
| $R_{thCH}$     | thermal resistance case to heatsink                  |                                                                                                                                                                                                        |                                |         | 0.2  |      | K/W               |
| $P_{tot}$      | total power dissipation                              |                                                                                                                                                                                                        | $T_C = 25^{\circ}\text{C}$     |         |      | 455  | W                 |
| $I_{TSM}$      | max. forward surge current                           | $t = 10\text{ ms}; (50\text{ Hz}), \text{ sine}$                                                                                                                                                       | $T_{VJ} = 45^{\circ}\text{C}$  |         |      | 2.25 | kA                |
|                |                                                      | $t = 8,3\text{ ms}; (60\text{ Hz}), \text{ sine}$                                                                                                                                                      | $V_R = 0\text{ V}$             |         |      | 2.43 | kA                |
|                |                                                      | $t = 10\text{ ms}; (50\text{ Hz}), \text{ sine}$                                                                                                                                                       | $T_{VJ} = 125^{\circ}\text{C}$ |         |      | 1.92 | kA                |
|                |                                                      | $t = 8,3\text{ ms}; (60\text{ Hz}), \text{ sine}$                                                                                                                                                      | $V_R = 0\text{ V}$             |         |      | 2.07 | kA                |
| $I^2t$         | value for fusing                                     | $t = 10\text{ ms}; (50\text{ Hz}), \text{ sine}$                                                                                                                                                       | $T_{VJ} = 45^{\circ}\text{C}$  |         |      | 25.3 | kA <sup>2</sup> s |
|                |                                                      | $t = 8,3\text{ ms}; (60\text{ Hz}), \text{ sine}$                                                                                                                                                      | $V_R = 0\text{ V}$             |         |      | 24.6 | kA <sup>2</sup> s |
|                |                                                      | $t = 10\text{ ms}; (50\text{ Hz}), \text{ sine}$                                                                                                                                                       | $T_{VJ} = 125^{\circ}\text{C}$ |         |      | 18.3 | kA <sup>2</sup> s |
|                |                                                      | $t = 8,3\text{ ms}; (60\text{ Hz}), \text{ sine}$                                                                                                                                                      | $V_R = 0\text{ V}$             |         |      | 17.7 | kA <sup>2</sup> s |
| $C_J$          | junction capacitance                                 | $V_R = 400\text{ V}$ $f = 1\text{ MHz}$                                                                                                                                                                | $T_{VJ} = 25^{\circ}\text{C}$  |         | 119  |      | pF                |
| $P_{GM}$       | max. gate power dissipation                          | $t_p = 30\text{ }\mu\text{s}$                                                                                                                                                                          | $T_C = 125^{\circ}\text{C}$    |         |      | 10   | W                 |
|                |                                                      | $t_p = 300\text{ }\mu\text{s}$                                                                                                                                                                         |                                |         |      | 5    | W                 |
| $P_{GAV}$      | average gate power dissipation                       |                                                                                                                                                                                                        |                                |         |      | 0.5  | W                 |
| $(di/dt)_{cr}$ | critical rate of rise of current                     | $T_{VJ} = 125^{\circ}\text{C}; f = 50\text{ Hz}$ repetitive, $I_T = 250\text{ A}$                                                                                                                      |                                |         |      | 150  | A/ $\mu\text{s}$  |
|                |                                                      | $t_p = 200\text{ }\mu\text{s}; di_G/dt = 0.45\text{ A}/\mu\text{s};$<br>$I_G = 0.45\text{ A}; V = \frac{2}{3} V_{DRM}$ non-repet., $I_T = 116\text{ A}$                                                |                                |         |      | 500  | A/ $\mu\text{s}$  |
| $(dv/dt)_{cr}$ | critical rate of rise of voltage                     | $V = \frac{2}{3} V_{DRM}$                                                                                                                                                                              | $T_{VJ} = 125^{\circ}\text{C}$ |         |      | 1000 | V/ $\mu\text{s}$  |
|                |                                                      | $R_{GK} = \infty$ ; method 1 (linear voltage rise)                                                                                                                                                     |                                |         |      |      |                   |
| $V_{GT}$       | gate trigger voltage                                 | $V_D = 6\text{ V}$                                                                                                                                                                                     | $T_{VJ} = 25^{\circ}\text{C}$  |         |      | 2.5  | V                 |
|                |                                                      |                                                                                                                                                                                                        | $T_{VJ} = -40^{\circ}\text{C}$ |         |      | 2.6  | V                 |
| $I_{GT}$       | gate trigger current                                 | $V_D = 6\text{ V}$                                                                                                                                                                                     | $T_{VJ} = 25^{\circ}\text{C}$  |         |      | 150  | mA                |
|                |                                                      |                                                                                                                                                                                                        | $T_{VJ} = -40^{\circ}\text{C}$ |         |      | 200  | mA                |
| $V_{GD}$       | gate non-trigger voltage                             | $V_D = \frac{2}{3} V_{DRM}$                                                                                                                                                                            | $T_{VJ} = 125^{\circ}\text{C}$ |         |      | 0.2  | V                 |
| $I_{GD}$       | gate non-trigger current                             |                                                                                                                                                                                                        |                                |         |      | 10   | mA                |
| $I_L$          | latching current                                     | $t_p = 10\text{ }\mu\text{s}$                                                                                                                                                                          | $T_{VJ} = 25^{\circ}\text{C}$  |         |      | 450  | mA                |
|                |                                                      | $I_G = 0.45\text{ A}; di_G/dt = 0.45\text{ A}/\mu\text{s}$                                                                                                                                             |                                |         |      |      |                   |
| $I_H$          | holding current                                      | $V_D = 6\text{ V}$ $R_{GK} = \infty$                                                                                                                                                                   | $T_{VJ} = 25^{\circ}\text{C}$  |         |      | 200  | mA                |
| $t_{gd}$       | gate controlled delay time                           | $V_D = \frac{1}{2} V_{DRM}$                                                                                                                                                                            | $T_{VJ} = 25^{\circ}\text{C}$  |         |      | 2    | $\mu\text{s}$     |
|                |                                                      | $I_G = 0.45\text{ A}; di_G/dt = 0.45\text{ A}/\mu\text{s}$                                                                                                                                             |                                |         |      |      |                   |
| $t_q$          | turn-off time                                        | $V_R = 100\text{ V}; I_T = 150\text{ A}; V = \frac{2}{3} V_{DRM}$ $T_{VJ} = 100^{\circ}\text{C}$<br>$di/dt = 10\text{ A}/\mu\text{s}$ $dv/dt = 20\text{ V}/\mu\text{s}$ $t_p = 200\text{ }\mu\text{s}$ |                                |         | 185  |      | $\mu\text{s}$     |

| Package TO-240AA     |                                                              |                      |                                         | Ratings |      |      |      |
|----------------------|--------------------------------------------------------------|----------------------|-----------------------------------------|---------|------|------|------|
| Symbol               | Definition                                                   | Conditions           |                                         | min.    | typ. | max. | Unit |
| I <sub>RMS</sub>     | RMS current                                                  | per terminal         |                                         |         |      | 200  | A    |
| T <sub>VJ</sub>      | virtual junction temperature                                 |                      |                                         | -40     |      | 125  | °C   |
| T <sub>op</sub>      | operation temperature                                        |                      |                                         | -40     |      | 100  | °C   |
| T <sub>stg</sub>     | storage temperature                                          |                      |                                         | -40     |      | 125  | °C   |
| Weight               |                                                              |                      |                                         |         | 81   |      | g    |
| M <sub>D</sub>       | mounting torque                                              |                      |                                         | 2.5     |      | 4    | Nm   |
| M <sub>T</sub>       | terminal torque                                              |                      |                                         | 2.5     |      | 4    | Nm   |
| d <sub>Spp/App</sub> | creepage distance on surface   striking distance through air | terminal to terminal | 13.0                                    | 9.7     |      |      | mm   |
| d <sub>Spb/Apb</sub> |                                                              | terminal to backside | 16.0                                    | 16.0    |      |      | mm   |
| V <sub>ISOL</sub>    | isolation voltage                                            | t = 1 second         | 50/60 Hz, RMS; I <sub>ISOL</sub> ≤ 1 mA |         | 4800 |      | V    |
|                      |                                                              | t = 1 minute         |                                         |         | 4000 |      | V    |



| Ordering | Ordering Number | Marking on Product | Delivery Mode | Quantity | Code No. |
|----------|-----------------|--------------------|---------------|----------|----------|
| Standard | MCC95-14io1B    | MCC95-14io1B       | Box           | 36       | 458171   |

| Similar Part   | Package     | Voltage class |
|----------------|-------------|---------------|
| MCMA110P1600TA | TO-240AA-1B | 1600          |
| MCMA140P1400TA | TO-240AA-1B | 1400          |

### Equivalent Circuits for Simulation

\* on die level

$T_{VJ} = 125^{\circ}\text{C}$

|                                                                                     |                    |           |    |
|-------------------------------------------------------------------------------------|--------------------|-----------|----|
|  |                    | Thyristor |    |
| $V_{0\max}$                                                                         | threshold voltage  | 0.85      | V  |
| $R_{0\max}$                                                                         | slope resistance * | 1.2       | mΩ |



Keyed gate/cathode twin plugs with wire length = 350 mm, gate = white, cathode = red

Type ZY 200L (L = Left for pin pair 4/5)

Type ZY 200R (R = Right for pin pair 6/7)

- UL 758, style 3751



## Thyristor



Fig. 1 Surge overload current  $I_{TSM}$ ,  
 $I_{FSM}$ : Crest value,  $t$ : duration



Fig. 2  $I^2t$  versus time (1-10 ms)

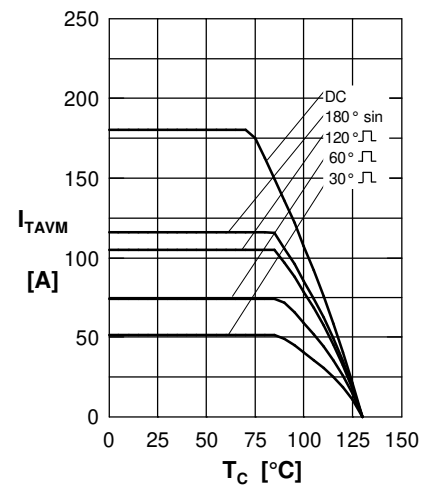


Fig. 3 Max. forward current at case temperature



Fig. 4 Power dissipation vs. on-state current & ambient temperature (per thyristor or diode)

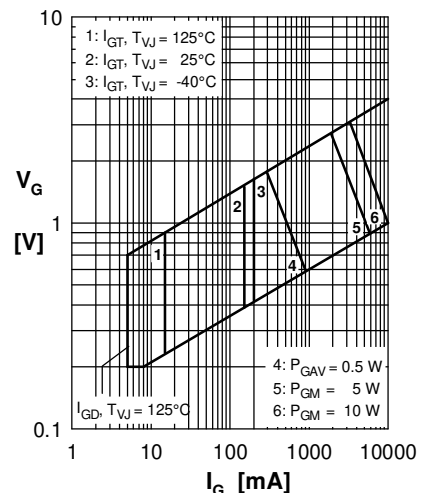


Fig. 5 Gate trigger characteristics

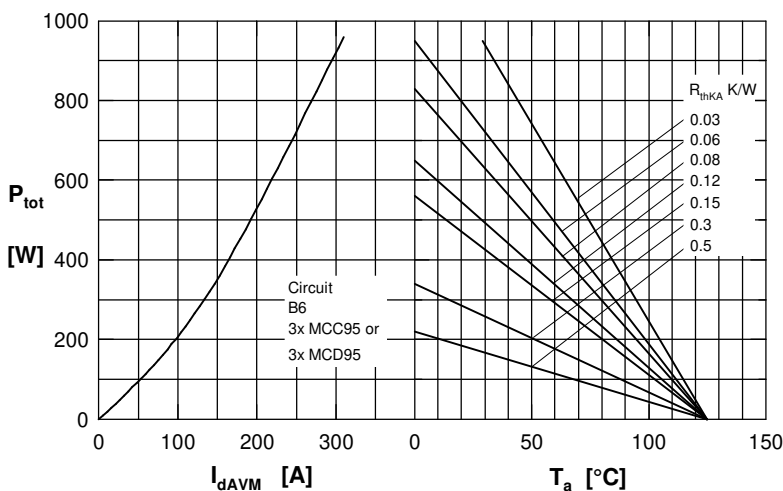


Fig. 6 Three phase rectifier bridge: Power dissipation vs. direct output current and ambient temperature



Fig. 7 Gate controlled delay time

## Thyristor



Fig. 8 Three phase AC-controller: Power dissipation versus RMS output current and ambient temperature



Fig. 9 Transient thermal impedance junction to case (per thyristor/diode)

$R_{\theta JC}$  for various conduction angles d:

| d    | $R_{\theta JC}$ [K/W] |
|------|-----------------------|
| DC   | 0.22                  |
| 180° | 0.23                  |
| 120° | 0.25                  |
| 60°  | 0.27                  |
| 30°  | 0.28                  |

Constants for  $Z_{\theta JC}$  calculation:

| i | $R_{\theta i}$ [K/W] | $t_i$ [s] |
|---|----------------------|-----------|
| 1 | 0.0066               | 0.0019    |
| 2 | 0.0678               | 0.0477    |
| 3 | 0.1456               | 0.3440    |



Fig. 10 Transient thermal impedance junction to heatsink (per thyristor/diode)

$R_{\theta JK}$  for various conduction angles d:

| d    | $R_{\theta JK}$ [K/W] |
|------|-----------------------|
| DC   | 0.42                  |
| 180° | 0.43                  |
| 120° | 0.45                  |
| 60°  | 0.47                  |
| 30°  | 0.48                  |

Constants for  $Z_{\theta JK}$  calculation:

| i | $R_{\theta i}$ [K/W] | $t_i$ [s] |
|---|----------------------|-----------|
| 1 | 0.0066               | 0.0019    |
| 2 | 0.0678               | 0.0477    |
| 3 | 0.1456               | 0.3440    |
| 4 | 0.2000               | 1.3200    |