



## Phase Control Thyristor

### Types N4845E#320 & N4845E#360

#### Absolute Maximum Ratings

|                  | VOLTAGE RATINGS                                 | MAXIMUM LIMITS | UNITS |
|------------------|-------------------------------------------------|----------------|-------|
| V <sub>DRM</sub> | Repetitive peak off-state voltage, (note 1)     | 3200-3600      | V     |
| V <sub>DSM</sub> | Non-repetitive peak off-state voltage, (note 1) | 3200-3600      | V     |
| V <sub>RRM</sub> | Repetitive peak reverse voltage, (note 1)       | 3200-3600      | V     |
| V <sub>RSM</sub> | Non-repetitive peak reverse voltage, (note 1)   | 3300-3700      | V     |

|                      | OTHER RATINGS                                                                                              | MAXIMUM LIMITS       | UNITS            |
|----------------------|------------------------------------------------------------------------------------------------------------|----------------------|------------------|
| I <sub>T(AV)</sub>   | Mean on-state current. T <sub>sink</sub> =55°C, (note 2)                                                   | 4865                 | A                |
| I <sub>T(AV)</sub>   | Mean on-state current. T <sub>sink</sub> =85°C, (note 2)                                                   | 3405                 | A                |
| I <sub>T(AV)</sub>   | Mean on-state current. T <sub>sink</sub> =85°C, (note 3)                                                   | 2060                 | A                |
| I <sub>T(RMS)</sub>  | Nominal RMS on-state current. T <sub>sink</sub> =25°C, (note 2)                                            | 9505                 | A                |
| I <sub>T(d.c.)</sub> | D.C. on-state current. T <sub>sink</sub> =25°C, (note 4)                                                   | 8480                 | A                |
| I <sub>TSM</sub>     | Peak non-repetitive surge t <sub>p</sub> =10ms, V <sub>RM</sub> =0.6V <sub>RRM</sub> , (note 5)            | 65                   | kA               |
| I <sub>TSM2</sub>    | Peak non-repetitive surge t <sub>p</sub> =10ms, V <sub>RM</sub> ≤10V, (note 5)                             | 72                   | kA               |
| I <sup>2</sup> t     | I <sup>2</sup> t capacity for fusing t <sub>p</sub> =10ms, V <sub>RM</sub> =0.6V <sub>RRM</sub> , (note 5) | 21.1×10 <sup>6</sup> | A <sup>2</sup> s |
| I <sup>2</sup> t     | I <sup>2</sup> t capacity for fusing t <sub>p</sub> =10ms, V <sub>RM</sub> ≤10V, (note 5)                  | 25.9×10 <sup>6</sup> | A <sup>2</sup> s |
| di <sub>T</sub> /dt  | Maximum rate of rise of on-state current (repetitive), (Note 6)                                            | 150                  | A/μs             |
|                      | Maximum rate of rise of on-state current (non-repetitive), (Note 6)                                        | 300                  | A/μs             |
| V <sub>RGM</sub>     | Peak reverse gate voltage                                                                                  | 5                    | V                |
| P <sub>G(AV)</sub>   | Mean forward gate power                                                                                    | 5                    | W                |
| P <sub>GM</sub>      | Peak forward gate power                                                                                    | 30                   | W                |
| V <sub>GD</sub>      | Non-trigger gate voltage, (Note 7)                                                                         | 0.25                 | V                |
| T <sub>HS</sub>      | Operating temperature range                                                                                | -40 to +125          | °C               |
| T <sub>stg</sub>     | Storage temperature range                                                                                  | -40 to +150          | °C               |

Notes: -

- 1) De-rating factor of 0.13% per °C is applicable for T<sub>j</sub> below 25°C.
- 2) Double side cooled, single phase; 50Hz, 180° half-sinewave.
- 3) Cathode side cooled, single phase; 50Hz, 180° half-sinewave.
- 4) Double side cooled.
- 5) Half-sinewave, 125°C T<sub>j</sub> initial.
- 6) V<sub>D</sub>=67% V<sub>DRM</sub>, I<sub>TM</sub>=5000A, I<sub>FG</sub>=2A, t<sub>r</sub>≤0.5μs, T<sub>case</sub>=125°C.
- 7) Rated V<sub>DRM</sub>.

## Characteristics

|                   | PARAMETER                                  | MIN. | TYP.  | MAX.   | TEST CONDITIONS (Note 1)                                                                                                                                   | UNITS |
|-------------------|--------------------------------------------|------|-------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| V <sub>TM</sub>   | Maximum peak on-state voltage              | -    | -     | 1.55   | I <sub>TM</sub> =5000A                                                                                                                                     | V     |
| V <sub>0</sub>    | Threshold voltage                          | -    | -     | 0.93   |                                                                                                                                                            | V     |
| r <sub>T</sub>    | Slope resistance                           | -    | -     | 0.122  |                                                                                                                                                            | mΩ    |
| dv/dt             | Critical rate of rise of off-state voltage | 1000 | -     | -      | V <sub>D</sub> =80% V <sub>DRM</sub> , Linear ramp, gate o/c                                                                                               | V/μs  |
| I <sub>DRM</sub>  | Peak off-state current                     | -    | -     | 200    | Rated V <sub>DRM</sub>                                                                                                                                     | mA    |
| I <sub>RRM</sub>  | Peak reverse current                       | -    | -     | 200    | Rated V <sub>RRM</sub>                                                                                                                                     | mA    |
| V <sub>GT</sub>   | Gate trigger voltage                       | -    | -     | 3.0    | T <sub>j</sub> =25°C, V <sub>D</sub> =10V, I <sub>T</sub> =3A                                                                                              | V     |
| I <sub>GT</sub>   | Gate trigger current                       | -    | -     | 300    |                                                                                                                                                            | mA    |
| I <sub>H</sub>    | Holding current                            | -    | -     | 1000   | T <sub>j</sub> =25°C                                                                                                                                       | mA    |
| t <sub>gd</sub>   | Gate controlled turn-on delay time         | -    | 0.9   | 1.3    | I <sub>FG</sub> =2A, t <sub>r</sub> =0.5μs, V <sub>D</sub> =67%V <sub>DRM</sub> ,<br>I <sub>TM</sub> =2000A, di/dt=10A/μs, T <sub>j</sub> =25°C            | μs    |
| t <sub>gt</sub>   | Turn-on time                               | -    | 2.4   | 4.0    |                                                                                                                                                            |       |
| Q <sub>rr</sub>   | Recovered Charge                           | -    | 10000 | 11000  |                                                                                                                                                            | μC    |
| Q <sub>ra</sub>   | Recovered Charge, 50% chord                | -    | 6625  | -      | I <sub>TM</sub> =2000A, t <sub>p</sub> =2000μs, di/dt=10A/μs,<br>V <sub>r</sub> =100V                                                                      | μC    |
| I <sub>rm</sub>   | Reverse recovery current                   | -    | 265   | -      |                                                                                                                                                            | A     |
| t <sub>rr</sub>   | Reverse recovery time, 50% chord           | -    | 50    | -      |                                                                                                                                                            | μs    |
| t <sub>q</sub>    | Turn-off time                              | -    | 530   | -      | I <sub>TM</sub> =2000A, t <sub>p</sub> =2000μs, di/dt=10A/μs,<br>V <sub>r</sub> =100V, V <sub>dr</sub> =80%V <sub>DRM</sub> , dV <sub>dr</sub> /dt=20V/μs  | μs    |
|                   |                                            | -    | 850   | -      | I <sub>TM</sub> =2000A, t <sub>p</sub> =2000μs, di/dt=10A/μs,<br>V <sub>r</sub> =100V, V <sub>dr</sub> =80%V <sub>DRM</sub> , dV <sub>dr</sub> /dt=200V/μs |       |
| R <sub>thJK</sub> | Thermal resistance, junction to heatsink   | -    | -     | 0.0060 | Double side cooled                                                                                                                                         | K/W   |
|                   |                                            | -    | -     | 0.0118 | Anode side cooled                                                                                                                                          | K/W   |
|                   |                                            | -    | -     | 0.0125 | Cathode side cooled                                                                                                                                        | K/W   |
| F                 | Mounting force                             | 76   | -     | 93     | Note 2                                                                                                                                                     | kN    |
| W <sub>t</sub>    | Weight                                     | -    | 2.0   | -      |                                                                                                                                                            | kg    |

Notes:-

- 1) Unless otherwise indicated T<sub>j</sub>=125°C.
- 2) For other clamp forces, please consult factory.

Notes on rupture rated packages.

This product is available with a non-rupture rated package.

For additional details on these products, please consult factory.

## Notes on Ratings and Characteristics

### 1.0 Voltage Grade Table

| Voltage Grade | $V_{DRM}$ $V_{DSM}$ $V_{RRM}$<br>V | $V_{RSM}$<br>V | $V_D$ $V_R$<br>DC V |
|---------------|------------------------------------|----------------|---------------------|
| 32            | 3200                               | 3300           | 1920                |
| 36            | 3600                               | 3700           | 2160                |

### 2.0 Extension of Voltage Grades

This report is applicable to other and higher voltage grades when supply has been agreed by Sales/Production.

### 3.0 De-rating Factor

A blocking voltage de-rating factor of 0.13%/°C is applicable to this device for  $T_j$  below 25°C.

### 4.0 Repetitive dv/dt

Standard dv/dt is 1000V/μs.

### 5.0 Computer Modelling Parameters

#### 5.1 Device Dissipation Calculations

$$I_{AV} = \frac{-V_0 + \sqrt{V_0^2 + 4 \cdot ff^2 \cdot r_s \cdot W_{AV}}}{2 \cdot ff^2 \cdot r_s} \quad \text{and:} \quad W_{AV} = \frac{\Delta T}{R_{th}}$$

$$\Delta T = T_{j\max} - T_{Hs}$$

Where  $V_0=0.93V$ ,  $r_s=0.122m\Omega$ ,

$R_{th}$  = Supplementary thermal impedance, see table below.

$ff$  = Form factor, see table below.

| Supplementary Thermal Impedance |         |         |         |         |         |         |         |
|---------------------------------|---------|---------|---------|---------|---------|---------|---------|
| Conduction Angle                | 30°     | 60°     | 90°     | 120°    | 180°    | 270°    | d.c.    |
| Square wave Double Side Cooled  | 0.00661 | 0.00653 | 0.00645 | 0.00639 | 0.00627 | 0.00613 | 0.00600 |
| Square wave Anode Side Cooled   | 0.01242 | 0.01234 | 0.01226 | 0.01220 | 0.01208 | 0.01194 | 0.01180 |
| Square wave Cathode Side Cooled | 0.01314 | 0.01307 | 0.01300 | 0.01295 | 0.01285 | 0.01271 | 0.01250 |
| Sine wave Double Side Cooled    | 0.00654 | 0.00644 | 0.00637 | 0.00630 | 0.00613 |         |         |
| Sine wave Anode Side Cooled     | 0.01235 | 0.01225 | 0.01218 | 0.01212 | 0.01194 |         |         |
| Sine wave Cathode Side Cooled   | 0.01308 | 0.01300 | 0.01294 | 0.01288 | 0.01272 |         |         |

| Form Factors     |      |      |      |      |      |      |      |
|------------------|------|------|------|------|------|------|------|
| Conduction Angle | 30°  | 60°  | 90°  | 120° | 180° | 270° | d.c. |
| Square wave      | 3.46 | 2.45 | 2    | 1.73 | 1.41 | 1.15 | 1    |
| Sine wave        | 3.98 | 2.78 | 2.22 | 1.88 | 1.57 |      |      |

## 5.2 Calculating $V_T$ using ABCD Coefficients

The on-state characteristic  $I_T$  vs.  $V_T$ , on page 5 is represented in two ways;

- (i) the well established  $V_o$  and  $r_s$  tangent used for rating purposes and
- (ii) a set of constants A, B, C, D, forming the coefficients of the representative equation for  $V_T$  in terms of  $I_T$  given below:

$$V_T = A + B \cdot \ln(I_T) + C \cdot I_T + D \cdot \sqrt{I_T}$$

The constants, derived by curve fitting software, are given below for both hot and cold characteristics. The resulting values for  $V_T$  agree with the true device characteristic over a current range, which is limited to that plotted.

| 25°C Coefficients |                           | 125°C Coefficients |                           |
|-------------------|---------------------------|--------------------|---------------------------|
| A                 | 1.197091                  | A                  | 0.8600505                 |
| B                 | -0.03714521               | B                  | -0.02173266               |
| C                 | $5.2376 \times 10^{-5}$   | C                  | $6.36509 \times 10^{-5}$  |
| D                 | $4.888255 \times 10^{-3}$ | D                  | $7.866687 \times 10^{-3}$ |

## 5.3 D.C. Thermal Impedance Calculation

$$r_t = \sum_{p=1}^{p=n} r_p \cdot \left( 1 - e^{\frac{-t}{\tau_p}} \right)$$

Where  $p = 1$  to  $n$ ,  $n$  is the number of terms in the series and:

$t$  = Duration of heating pulse in seconds.

$r_t$  = Thermal resistance at time  $t$ .

$r_p$  = Amplitude of  $p$ th term.

$\tau_p$  = Time Constant of  $r$ th term.

| D.C. Double Side Cooled |                           |                           |                           |                           |
|-------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Term                    | 1                         | 2                         | 3                         | 4                         |
| $r_p$                   | $3.543719 \times 10^{-3}$ | $1.677583 \times 10^{-3}$ | $6.679909 \times 10^{-4}$ | $1.256405 \times 10^{-4}$ |
| $\tau_p$                | 1.365469                  | 0.1841105                 | 0.02837475                | $6.118678 \times 10^{-3}$ |

| D.C. Anode Side Cooled |                           |                           |                           |                           |
|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Term                   | 1                         | 2                         | 3                         | 4                         |
| $r_p$                  | $8.378160 \times 10^{-3}$ | $2.441365 \times 10^{-3}$ | $8.566744 \times 10^{-4}$ | $1.497242 \times 10^{-4}$ |
| $\tau_p$               | 6.749137                  | 0.3199177                 | 0.03601898                | $6.471704 \times 10^{-3}$ |

| D.C. Cathode Side Cooled |                           |                           |                           |                           |
|--------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Term                     | 1                         | 2                         | 3                         | 4                         |
| $r_p$                    | $9.319408 \times 10^{-3}$ | $2.558027 \times 10^{-3}$ | $6.224641 \times 10^{-4}$ | $9.787425 \times 10^{-5}$ |
| $\tau_p$                 | 7.197878                  | 0.2406578                 | 0.02322995                | $7.393157 \times 10^{-3}$ |

## Curves

Figure 1 - On-state characteristics of Limit device

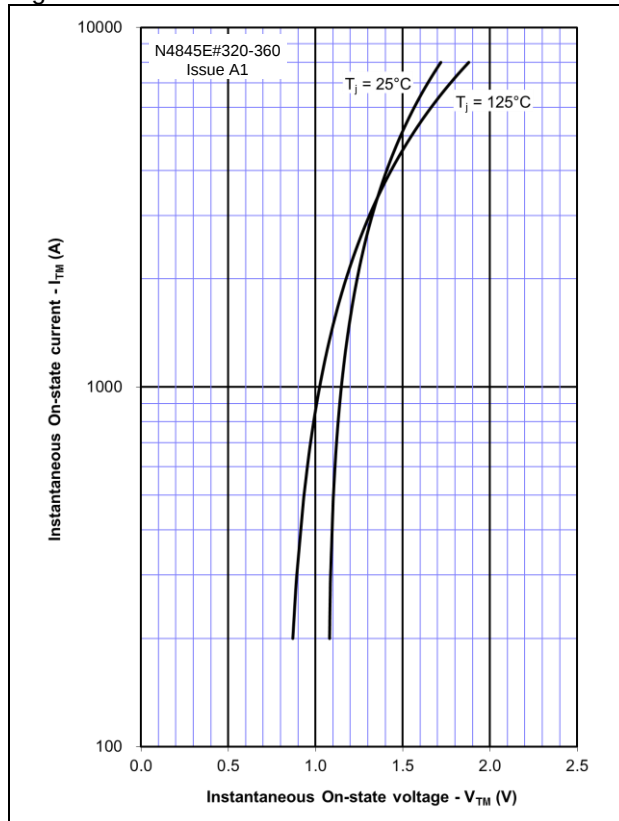


Figure 2 - Transient Thermal Impedance

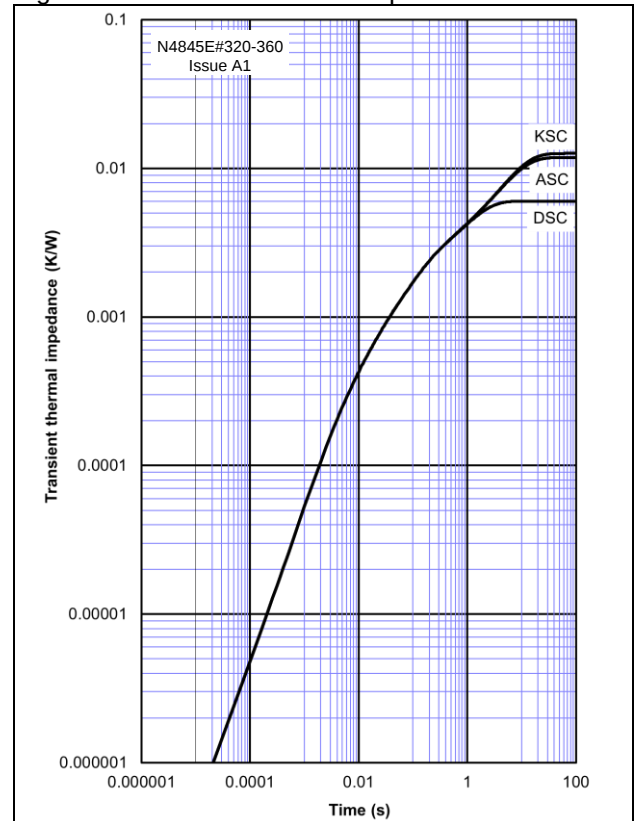


Figure 3 - Gate Characteristics - Trigger Limits

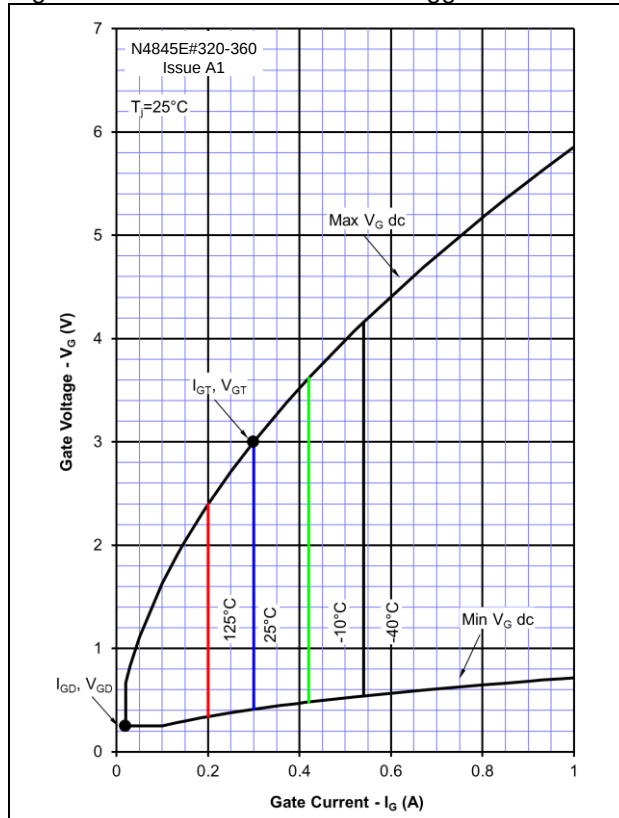


Figure 4 - Gate Characteristics - Power Curves

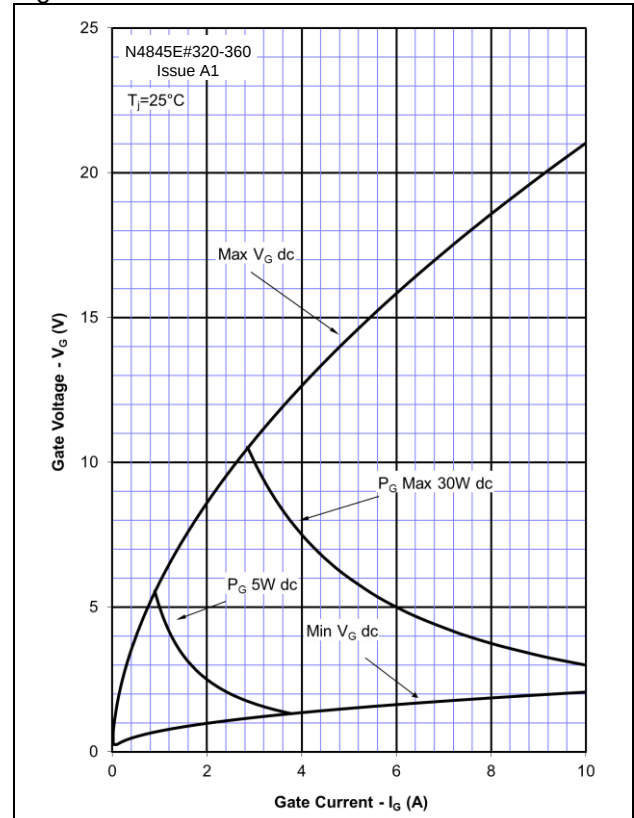


Figure 5 – Recovered Charge,  $Q_{rr}$

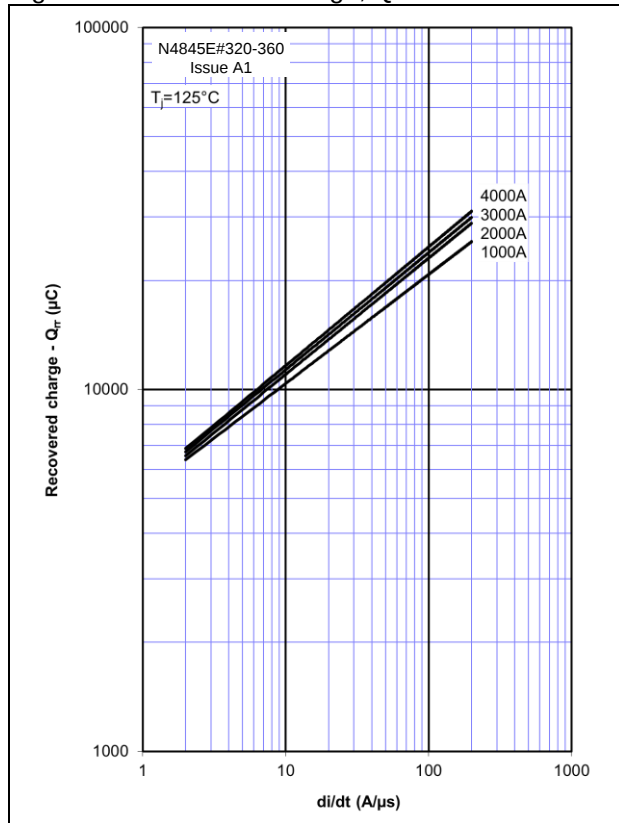


Figure 6 – Recovered charge,  $Q_{ra}$  (50% chord)

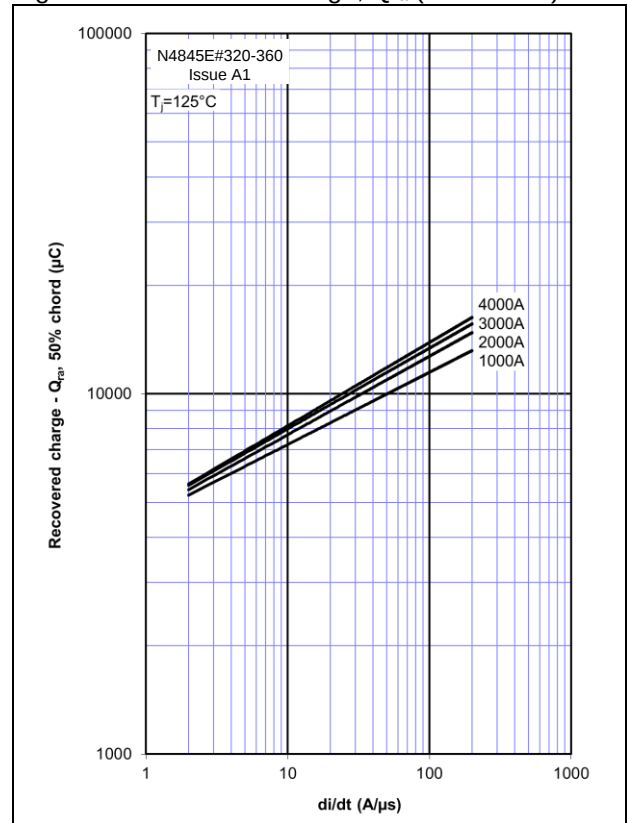


Figure 7 – Reverse recovery current,  $I_{rm}$

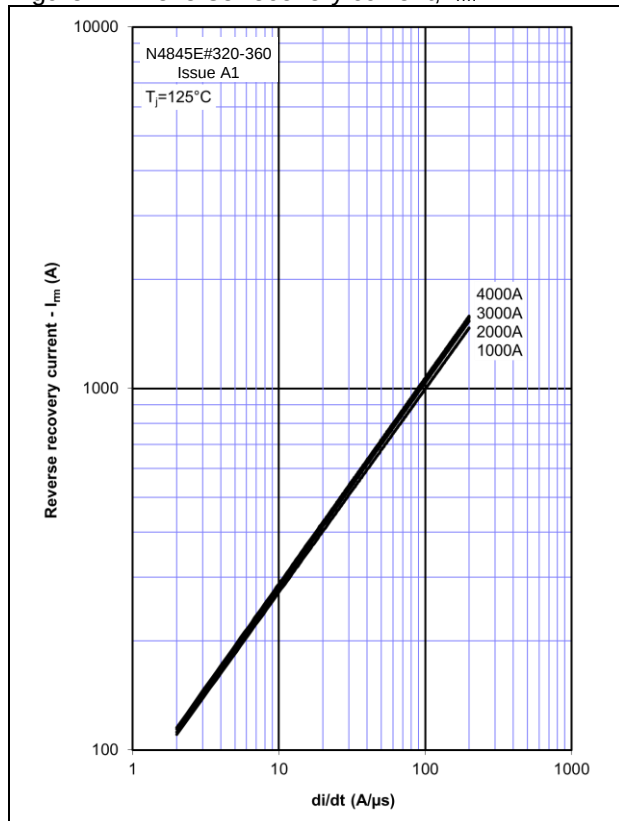


Figure 8 – Reverse recovery time,  $t_{rr}$

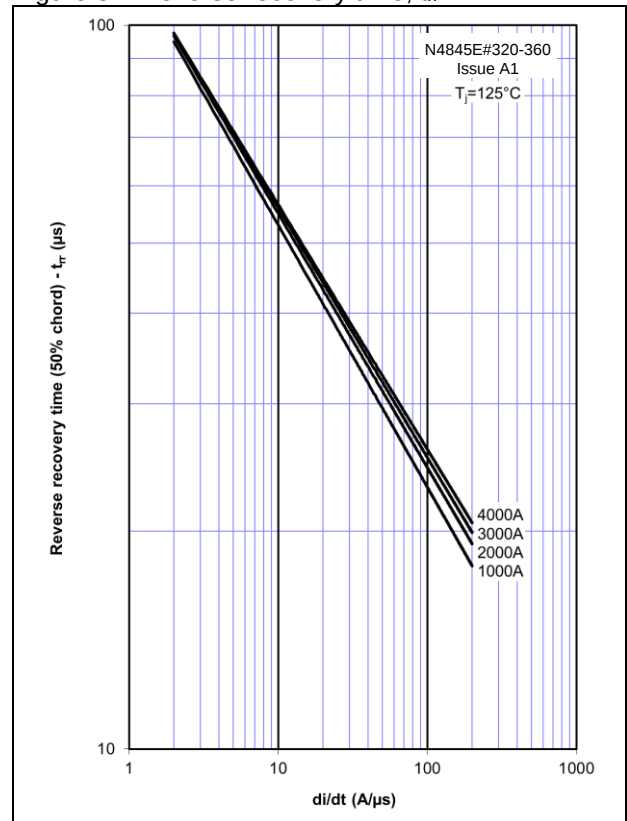


Figure 9 – On-state current vs. Power dissipation – Double Side Cooled (Sine wave)

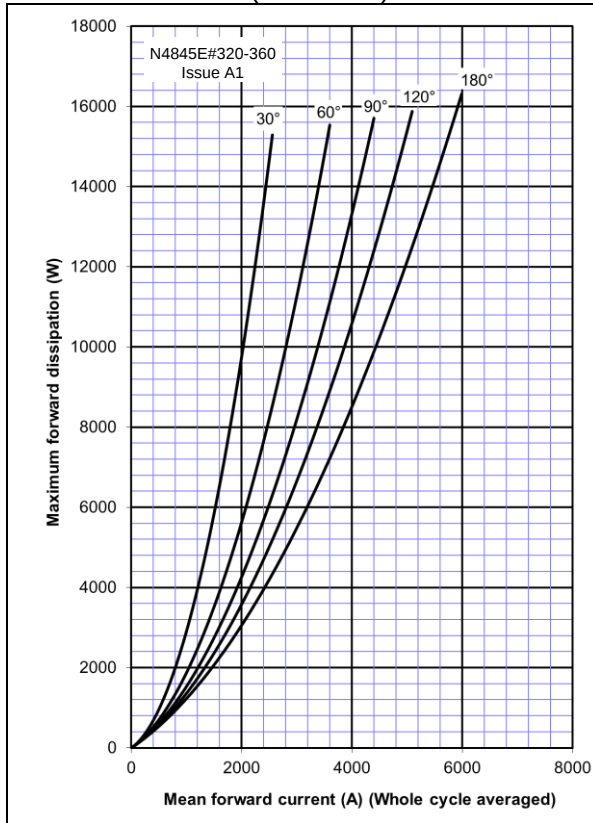


Figure 10 – On-state current vs. Heatsink temperature - Double Side Cooled (Sine wave)

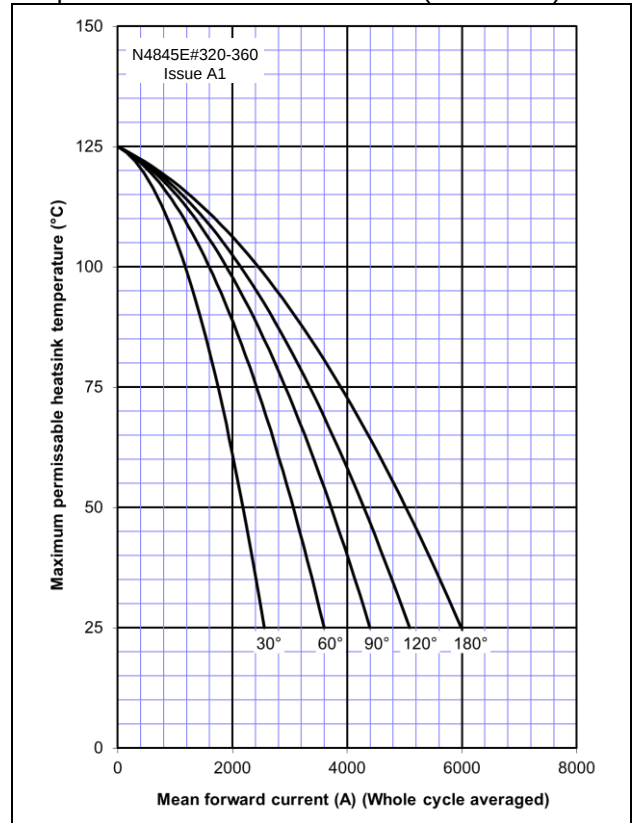


Figure 11 – On-state current vs. Power dissipation – Double Side Cooled (Square wave)

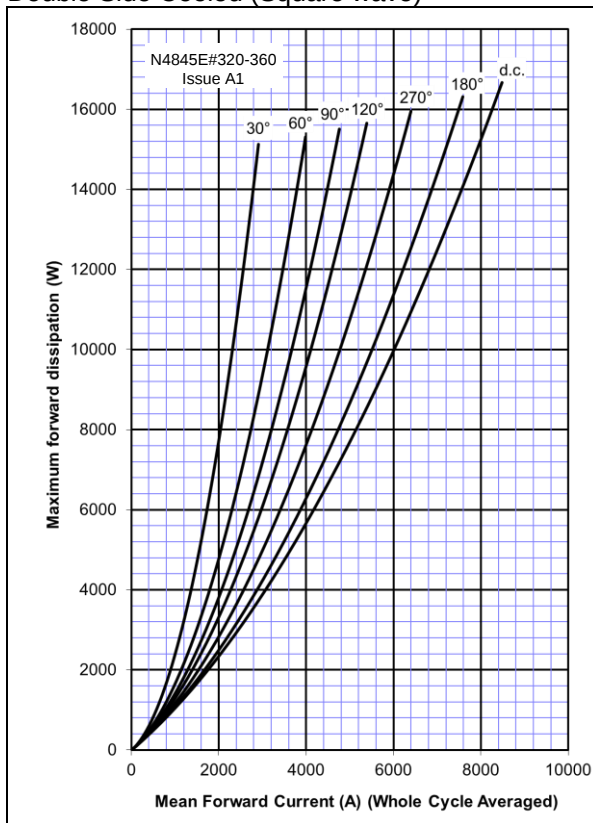


Figure 12 – On-state current vs. Heatsink temperature - Double Side Cooled (Square wave)

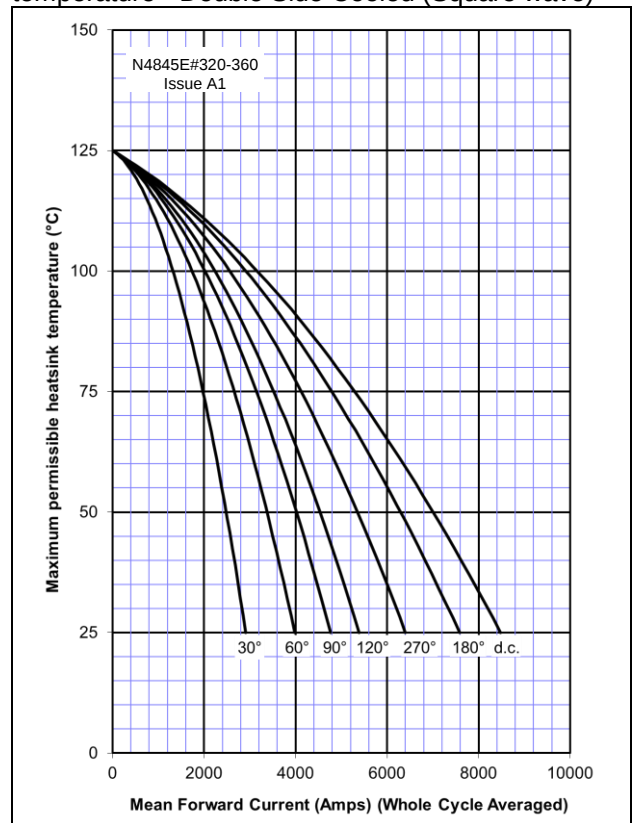


Figure 13 – On-state current vs. Power dissipation – Cathode Side Cooled (Sine wave)

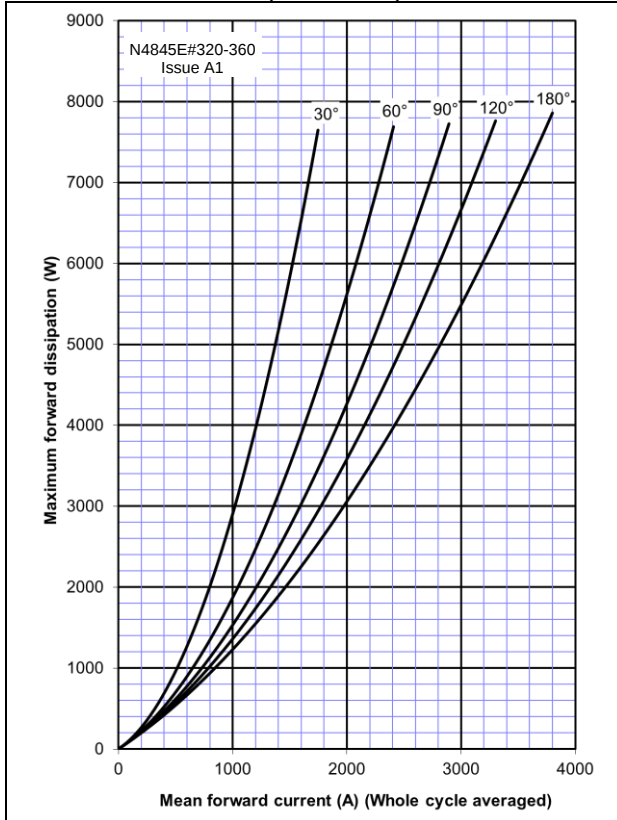


Figure 14 – On-state current vs. Heatsink temperature - Cathode Side Cooled (Sine wave)

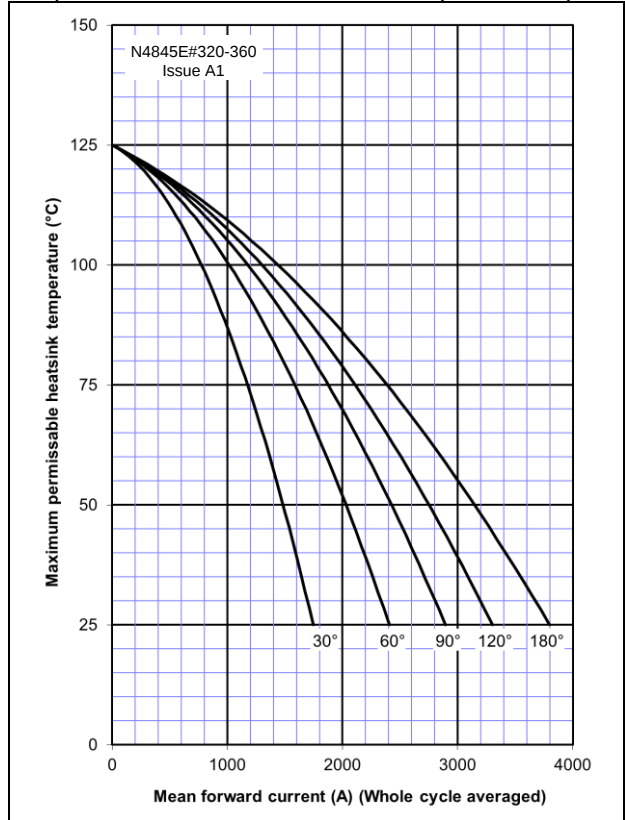


Figure 15 – On-state current vs. Power dissipation – Cathode Side Cooled (Square wave)

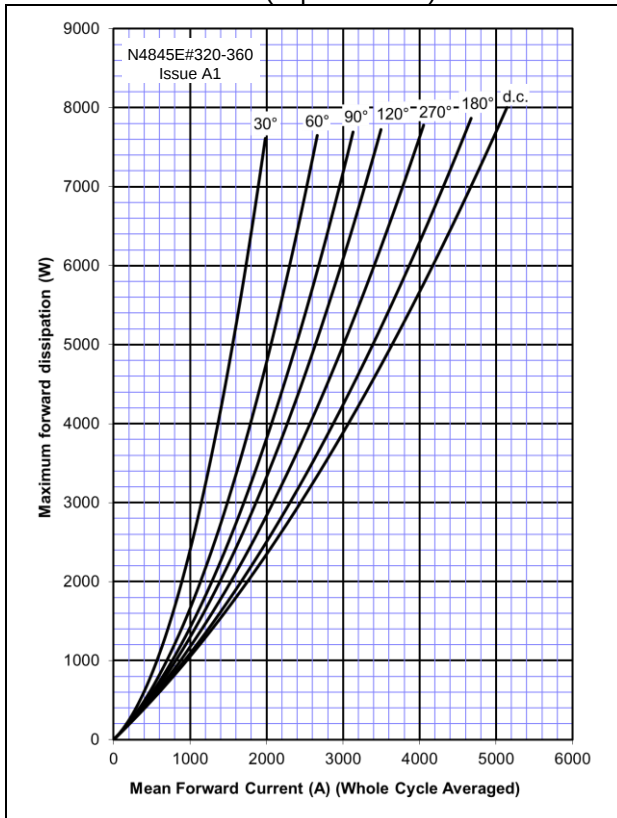


Figure 16 – On-state current vs. Heatsink temperature - Cathode Side Cooled (Square wave)

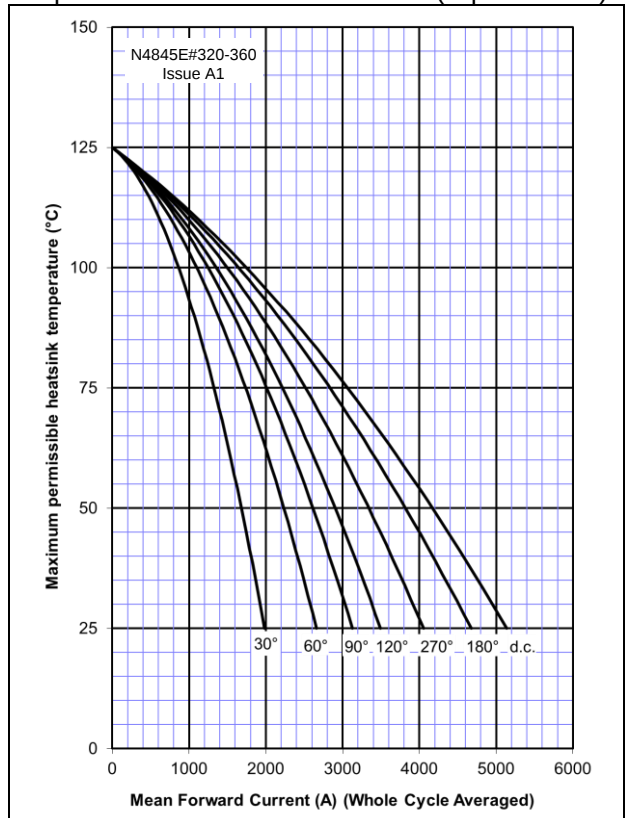
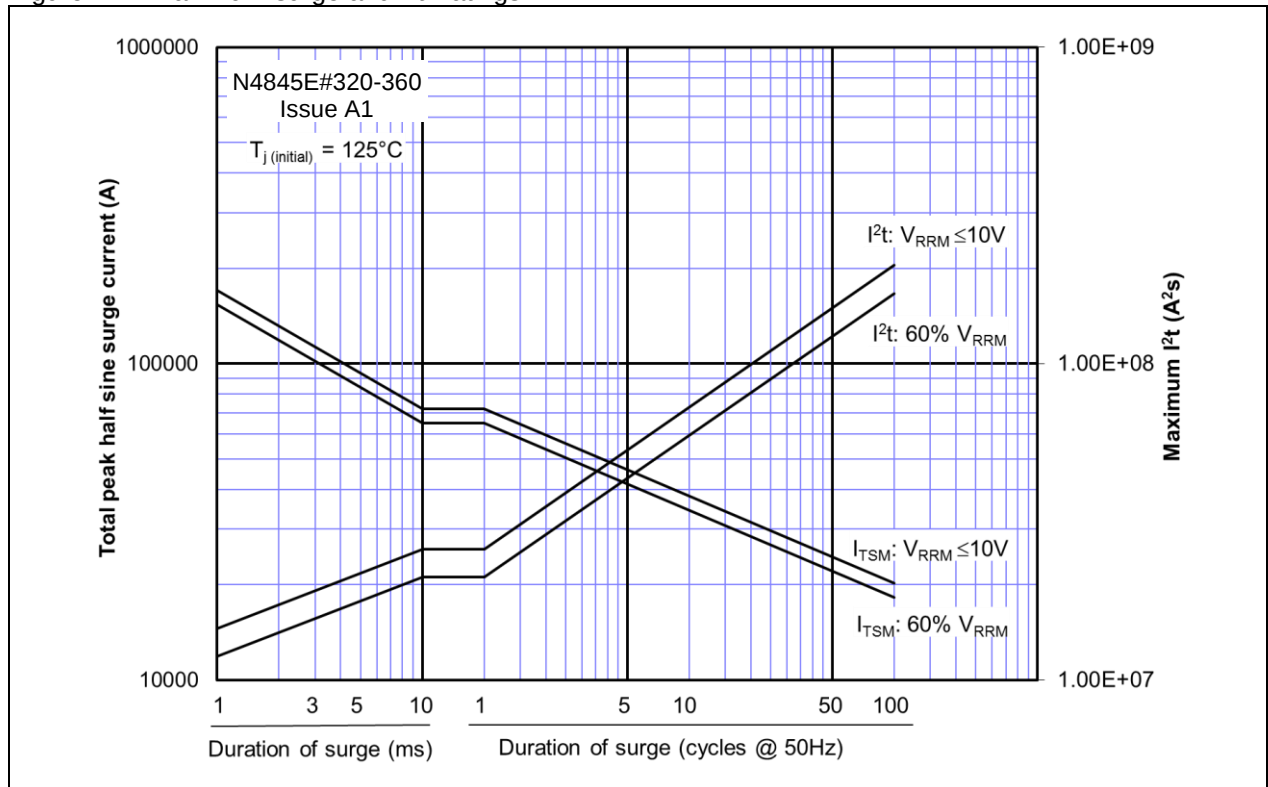
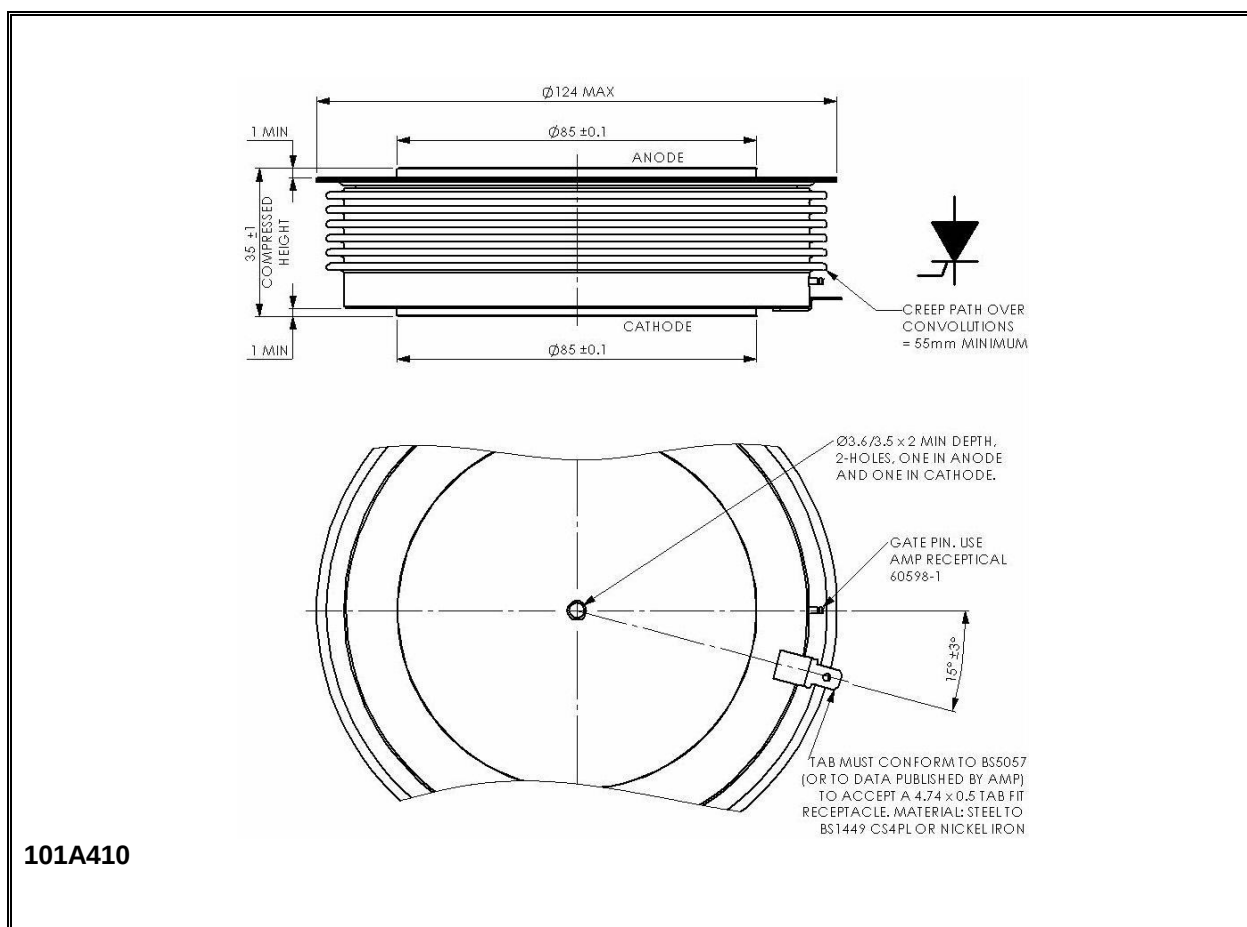


Figure 17 – Maximum surge and  $I^2t$  Ratings



## Outline Drawing & Ordering Information



### ORDERING INFORMATION

(Please quote 10 digit code as below)

| N4845           | E#                                                                                                   | ◆ ◆                     | 0                        |
|-----------------|------------------------------------------------------------------------------------------------------|-------------------------|--------------------------|
| Fixed Type Code | Fixed Outline Code<br>EE 35mm clamp height capsule<br>EY 35mm clamp height non-rupture rated capsule | Voltage Code<br>32 & 36 | Fixed turn-off time code |

 Typical order code: N4845EE360 – 3600V  $V_{\text{DRM}}$ ,  $V_{\text{RRM}}$ , 1000V/ $\mu\text{s}$  dv/dt, 35mm clamp height capsule.

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