IXYS UK WESTCODE

**Date:- 2nd June, 2015**

**Data Sheet Issue:- P2**

# Phase Control Thyristor

# Types N5715EE240 & N5715EE280

## Absolute Maximum Ratings

| | VOLTAGE RATINGS | MAXIMUM LIMITS | UNITS |
|---|---|---|---|
| $V_{DRM}$ | Repetitive peak off-state voltage, (note 1) | 2400-2800 | V |
| $V_{DSM}$ | Non-repetitive peak off-state voltage, (note 1) | 2400-2800 | V |
| $V_{RRM}$ | Repetitive peak reverse voltage, (note 1) | 2400-2800 | V |
| $V_{RSM}$ | Non-repetitive peak reverse voltage, (note 1) | 2500-2900 | V |

| | OTHER RATINGS | MAXIMUM LIMITS | UNITS |
|---|---|---|---|
| $I_{T(AV)}$ | Mean on-state current. $T_{sink}$=55°C, (note 2) | 5715 | A |
| $I_{T(AV)}$ | Mean on-state current. $T_{sink}$=85°C, (note 2) | 3975 | A |
| $I_{T(AV)}$ | Mean on-state current. $T_{sink}$=85°C, (note 3) | 2315 | A |
| $I_{T(RMS)}$ | Nominal RMS on-state current. $T_{sink}$=25°C, (note 2) | 11200 | A |
| $I_{T(d.c.)}$ | D.C. on-state current. $T_{sink}$=25°C, (note 4) | 9910 | A |
| $I_{TSM}$ | Peak non-repetitive surge $t_p$=10ms, $V_{RM}$=0.6$V_{RRM}$, (note 5) | 80 | kA |
| $I_{TSM2}$ | Peak non-repetitive surge $t_p$=10ms, $V_{RM}$≤10V, (note 5) | 88 | kA |
| $I^2t$ | $I^2t$ capacity for fusing $t_p$=10ms, $V_{RM}$=0.6$V_{RRM}$, (note 5) | $32.0\times10^6$ | $A^2s$ |
| $I^2t$ | $I^2t$ capacity for fusing $t_p$=10ms, $V_{RM}$≤10V, (note 5) | $38.7\times10^6$ | $A^2s$ |
| $di_T/dt$ | 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 |
| $V_{RGM}$ | Peak reverse gate voltage | 5 | V |
| $P_{G(AV)}$ | Mean forward gate power | 5 | W |
| $P_{GM}$ | Peak forward gate power | 30 | W |
| $V_{GD}$ | Non-trigger gate voltage, (Note 7) | 0.25 | V |
| $T_{HS}$ | Operating temperature range | -40 to +125 | °C |
| $T_{stg}$ | Storage temperature range | -40 to +150 | °C |

Notes: -

1) De-rating factor of 0.13% per °C is applicable for $T_j$ 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 $T_j$ initial.
6) $V_D$=67% $V_{DRM}$, $I_{TM}$=4000A, $I_{FG}$=2A, $t_r$≤0.5µs, $T_{case}$=125°C.
7) Rated $V_{DRM}$.

## Characteristics

| | PARAMETER | MIN. | TYP. | MAX. | TEST CONDITIONS (Note 1) | UNITS |
|---|---|---|---|---|---|---|
| $V_{TM}$ | Maximum peak on-state voltage | - | - | 1.35 | $I_{TM}$=6000A | V |
| $V_0$ | Threshold voltage | - | - | 0.84 | | V |
| $r_T$ | Slope resistance | - | - | 0.085 | | mΩ |
| dv/dt | Critical rate of rise of off-state voltage | 1000 | - | - | $V_D$=80% $V_{DRM}$, Linear ramp, gate o/c | V/µs |
| $I_{DRM}$ | Peak off-state current | - | - | 300 | Rated $V_{DRM}$ | mA |
| $I_{RRM}$ | Peak reverse current | - | - | 300 | Rated $V_{RRM}$ | mA |
| $V_{GT}$ | Gate trigger voltage | - | - | 3.0 | $T_j$=25°C, $V_D$=10V, $I_T$=3A | V |
| $I_{GT}$ | Gate trigger current | - | - | 300 | | mA |
| $I_H$ | Holding current | - | - | 1000 | $T_j$=25°C | mA |
| $t_{gd}$ | Gate controlled turn-on delay time | - | 0.7 | 1.0 | $I_{FG}$=2A, $t_r$=0.5µs, $V_D$=67%$V_{DRM}$, $I_{TM}$=2000A, di/dt=10A/µs, $T_j$=25°C | µs |
| $t_{gt}$ | Turn-on time | - | 1.2 | 3.0 | | |
| $Q_{rr}$ | Recovered Charge | - | 8000 | 10500 | $I_{TM}$=3000A, $t_p$=1ms, di/dt=10A/µs, $V_r$=50V | µC |
| $Q_{ra}$ | Recovered Charge, 50% chord | - | 5460 | - | | µC |
| $I_{rm}$ | Reverse recovery current | - | 260 | - | | A |
| $t_{rr}$ | Reverse recovery time, 50% chord | - | 42 | - | | µs |
| $R_\theta$ | Thermal resistance, junction to heatsink | - | - | 0.006 | Double side cooled | K/W |
| | | - | - | 0.013 | Cathode side cooled | K/W |
| | | - | - | 0.012 | Anode side cooled | K/W |
| F | Mounting force | 76 | - | 93 | | kN |
| $W_t$ | Weight | - | 2.0 | - | | kg |

## Notes on Ratings and Characteristics

### 1.0 Voltage Grade Table

| Voltage Grade | $V_{DRM}$ $V_{DSM}$ $V_{RRM}$ V | $V_{RSM}$ V | $V_D$ $V_R$ DC V |
|---|---|---|---|
| 24 | 2400 | 2500 | 1450 |
| 28 | 2800 | 2900 | 1650 |

### 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

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

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

Where $V_0$=0.84V, $r_T$=0.085mΩ,

$R_{th}$ = 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 | 0.00675 | 0.00667 | 0.00660 | 0.00654 | 0.00642 | 0.00627 | 0.00600 |
| Square wave Cathode Side Cooled | 0.01353 | 0.01346 | 0.01340 | 0.01334 | 0.01323 | 0.01308 | 0.013 |
| Sine wave Double Side Cooled | 0.00669 | 0.00659 | 0.00653 | 0.00646 | 0.00628 | | |
| Sine wave Cathode Side Cooled | 0.01350 | 0.01339 | 0.01333 | 0.01326 | 0.01309 | | |

| 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 | 1.276146 | A | 0.6434688 |
| B | -0.08033478 | B | 0.004824459 |
| C | $2.7735 \times 10^{-05}$ | C | $4.47622 \times 10^{-05}$ |
| D | 0.009457305 | D | $5.10893 \times 10^{-03}$ |

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 |
| $r_p$ | $3.695834 \times 10^{-3}$ | $1.905657 \times 10^{-3}$ | $5.380699 \times 10^{-4}$ |
| $\tau_p$ | 1.373287 | 0.1494363 | 0.01265141 |

| D.C. Cathode Side Cooled | | | |
|---|---|---|---|
| Term | 1 | 2 | 3 |
| $r_p$ | $9.610370 \times 10^{-3}$ | $2.768420 \times 10^{-3}$ | $5.785389 \times 10^{-4}$ |
| $\tau_p$ | 7.357367 | 0.2197350 | 0.1392909 |

**Curves**

Figure 1 - On-state characteristics of Limit device

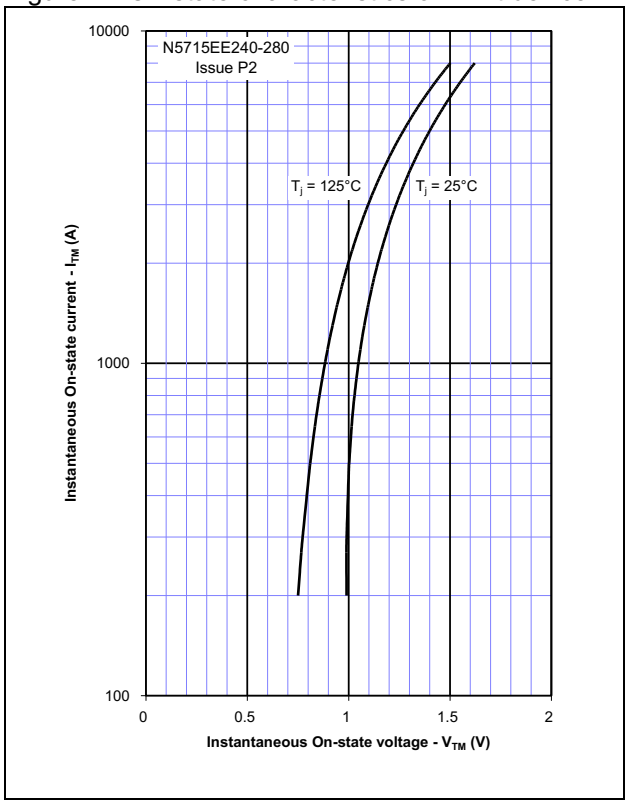



Figure 2 - Transient Thermal Impedance

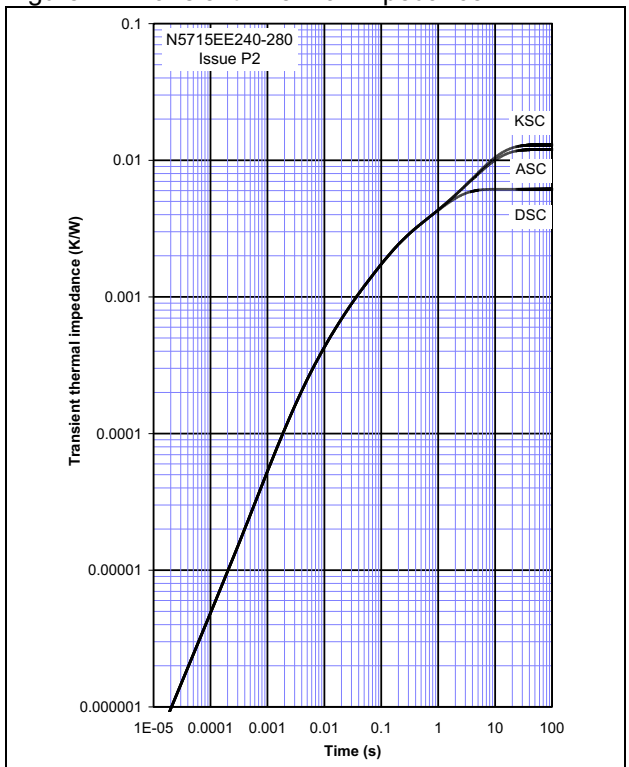



Figure 3 - Gate Characteristics - Trigger Limits

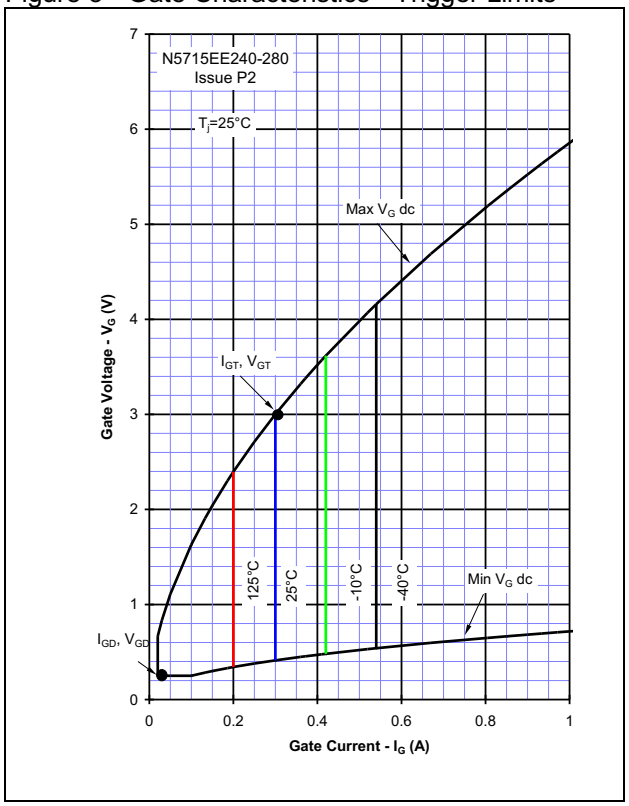



Figure 4 - Gate Characteristics - Power Curves

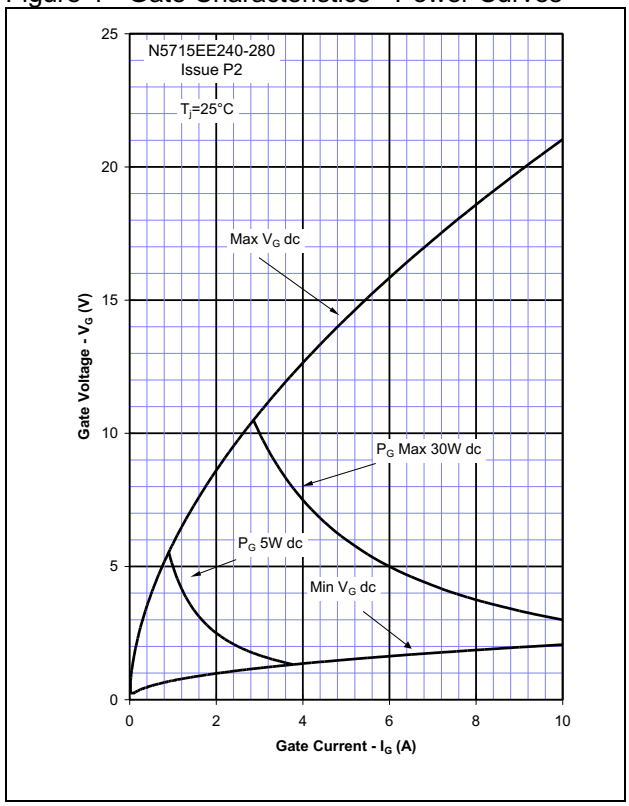


Figure 5 – Recovered Charge, $Q_{rr}$

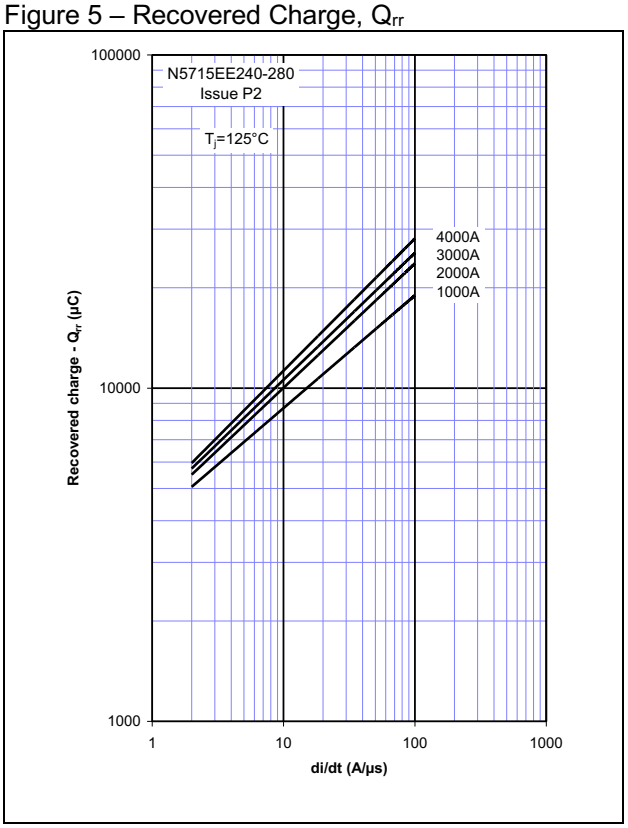



Figure 6 – Recovered charge, $Q_{ra}$ (50% chord)

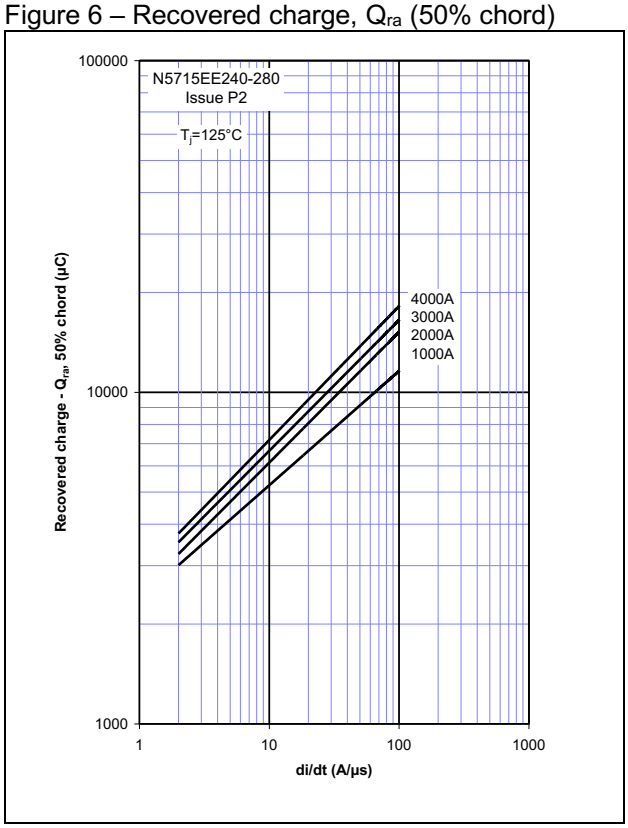



Figure 7 – Reverse recovery current, $I_{rm}$

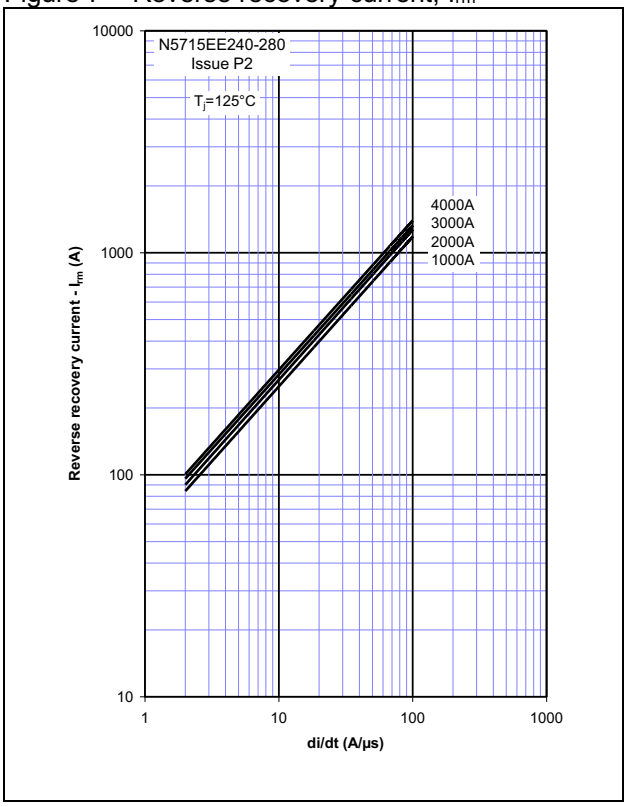



Figure 8 – Reverse recovery time, $t_{rr}$

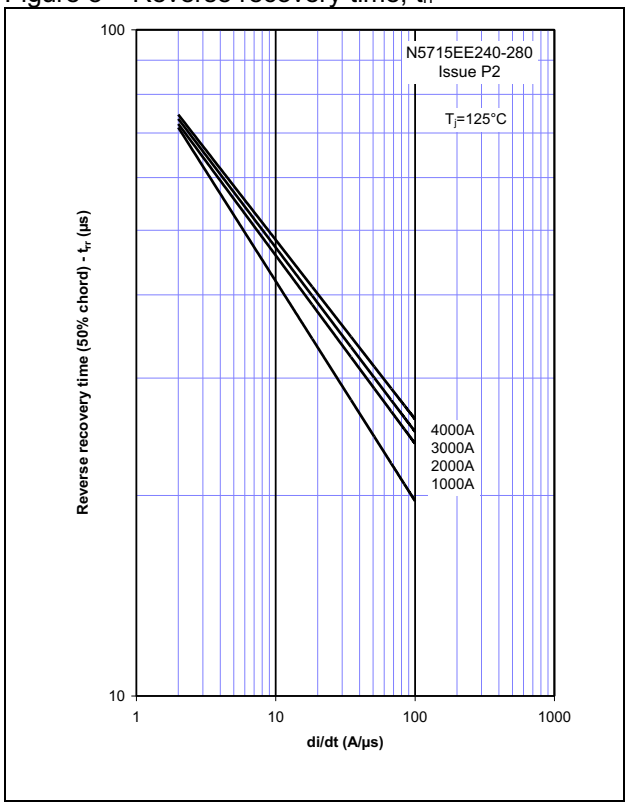


Figure 9 – On-state current vs. Power dissipation – Double Side Cooled (Sine wave)

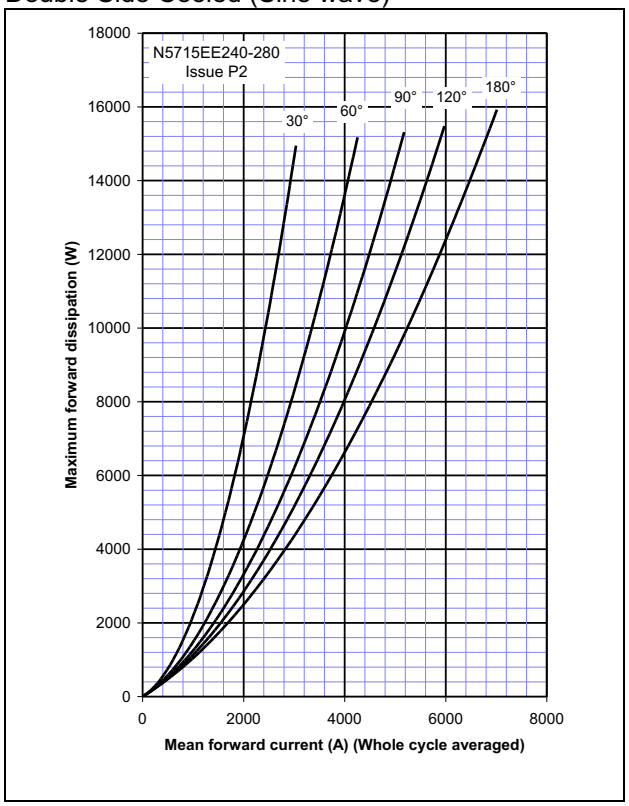



Figure 10 – On-state current vs. Heatsink temperature - Double Side Cooled (Sine wave)

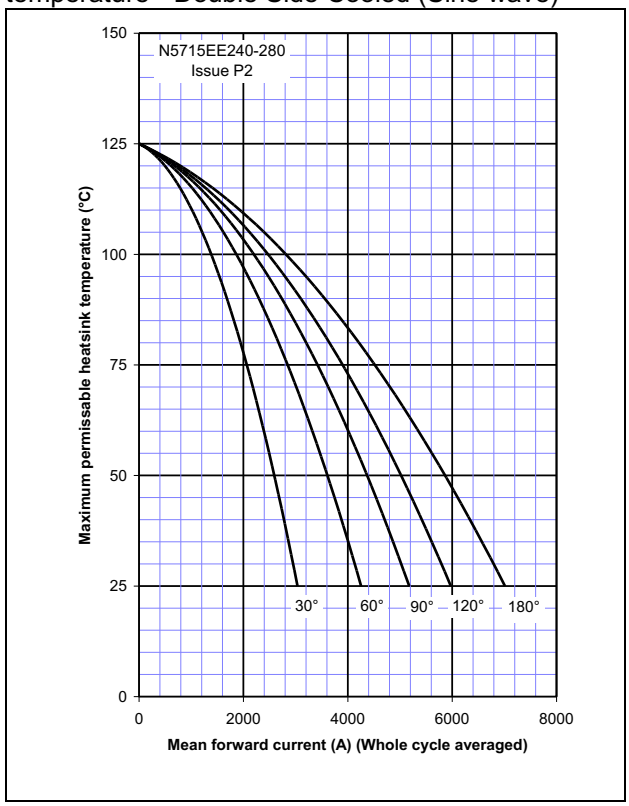



Figure 11 – On-state current vs. Power dissipation – Double Side Cooled (Square wave)

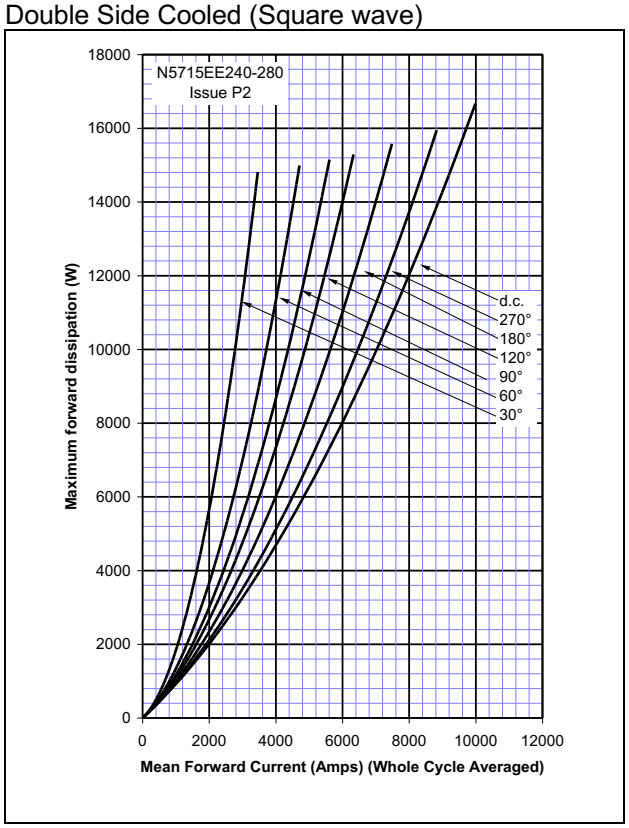



Figure 12 – On-state current vs. Heatsink temperature - Double Side Cooled (Square wave)

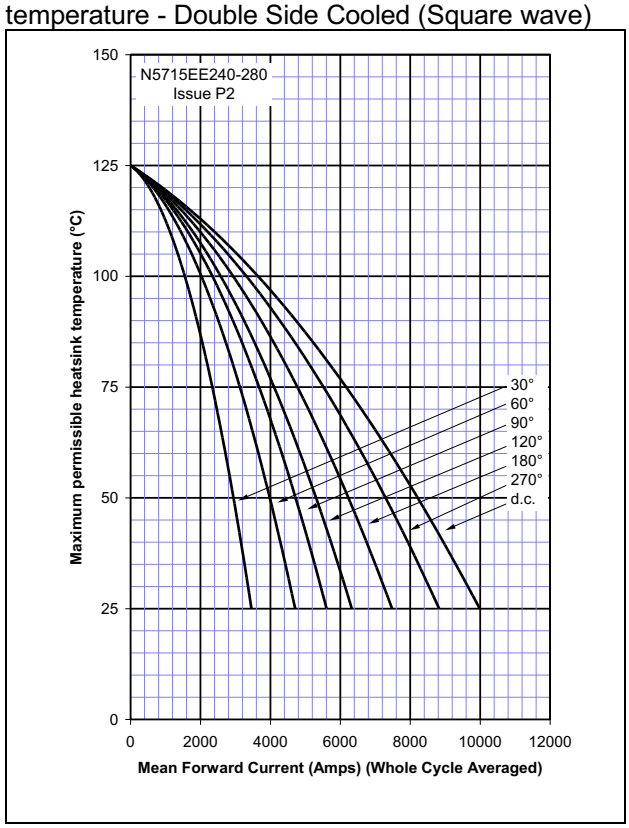


Figure 13 – On-state current vs. Power dissipation – Cathode Side Cooled (Sine wave)

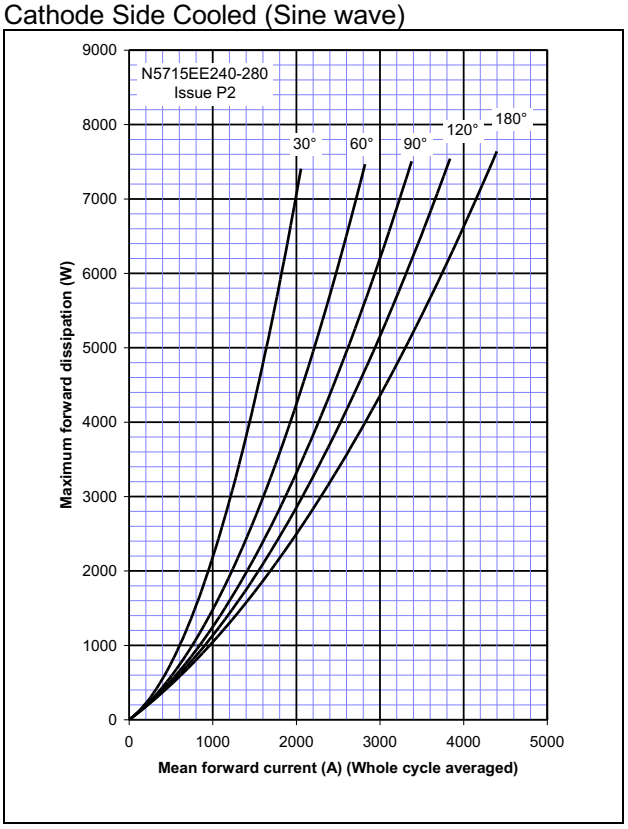



Figure 14 – On-state current vs. Heatsink temperature - Cathode Side Cooled (Sine wave)

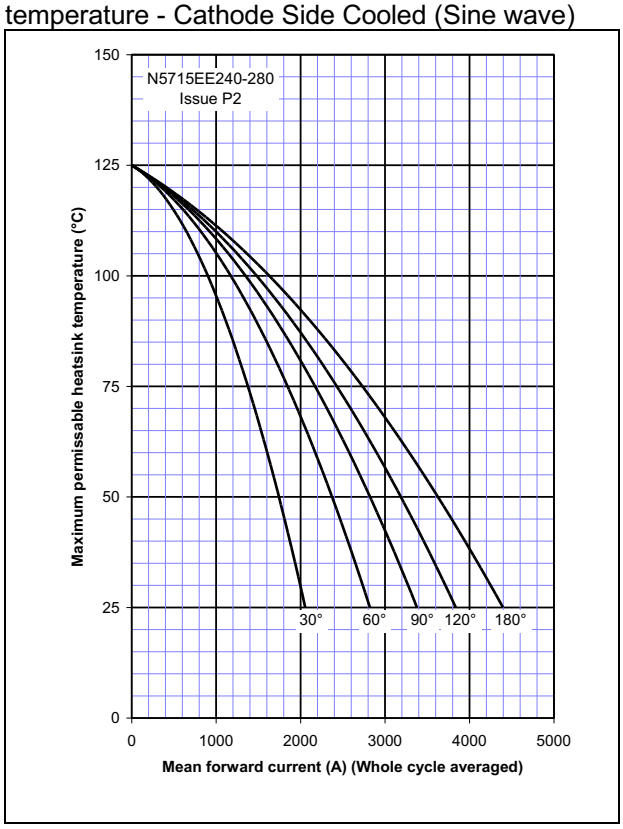



Figure 15 – On-state current vs. Power dissipation – Cathode Side Cooled (Square wave)

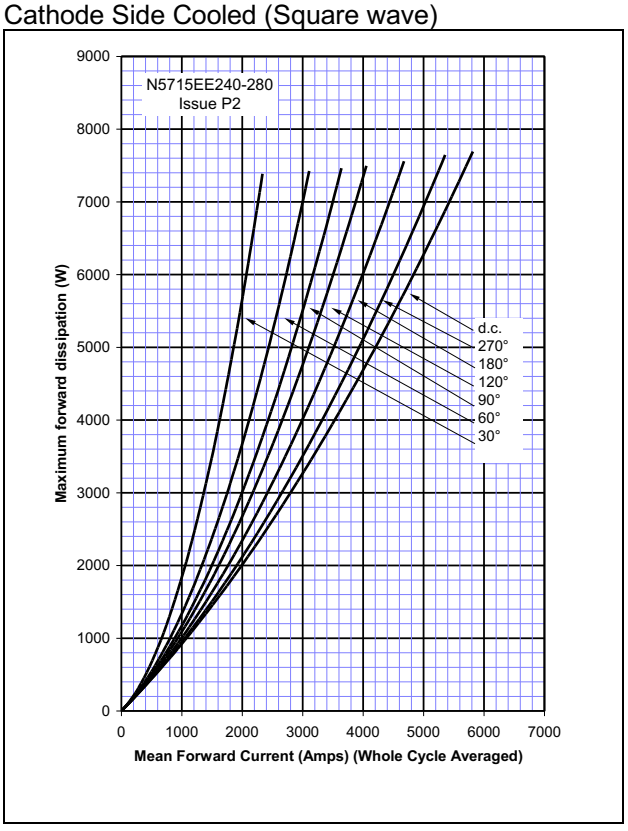



Figure 16 – On-state current vs. Heatsink temperature - Cathode Side Cooled (Square wave)

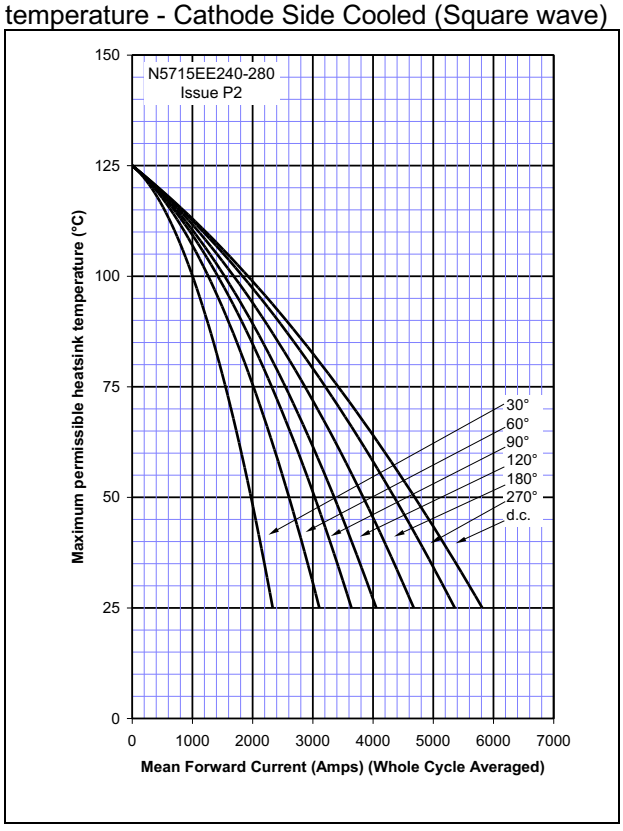
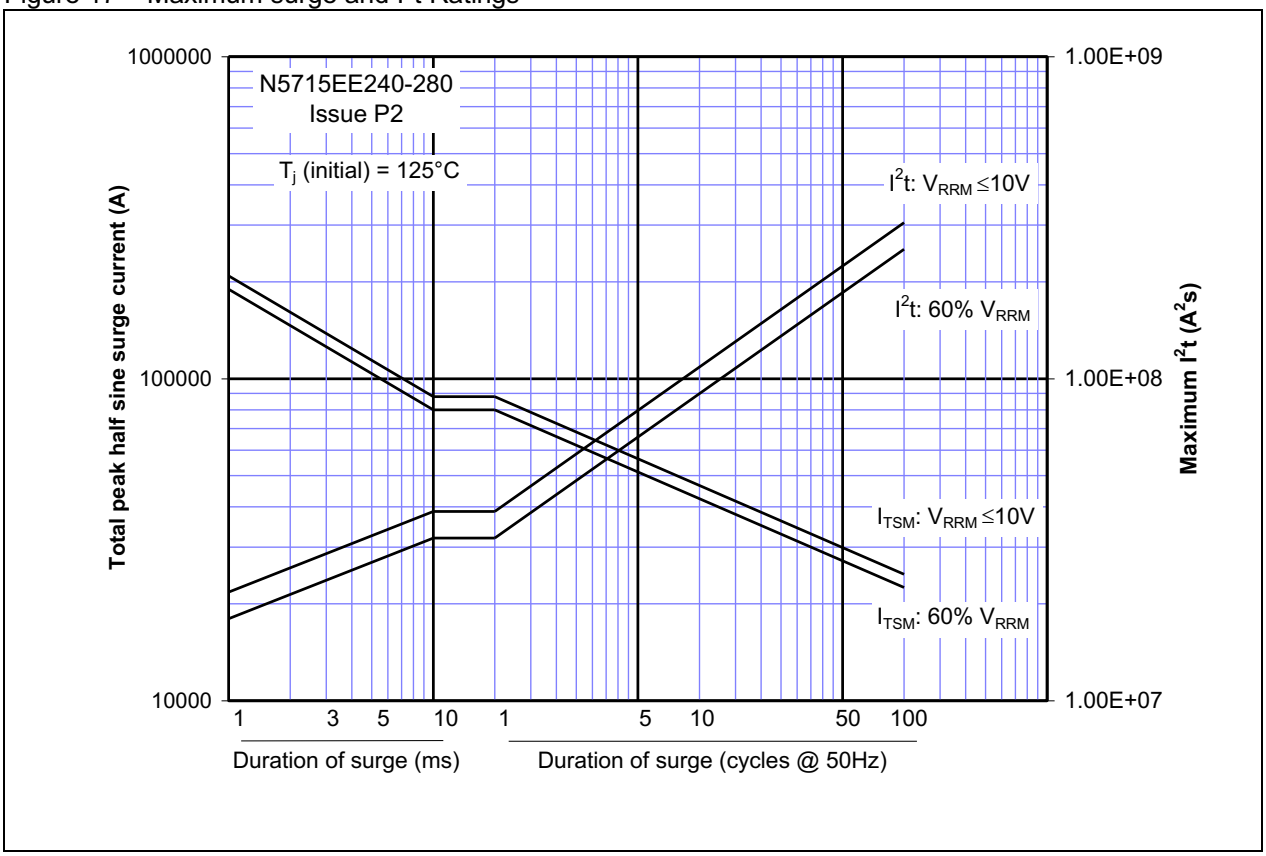
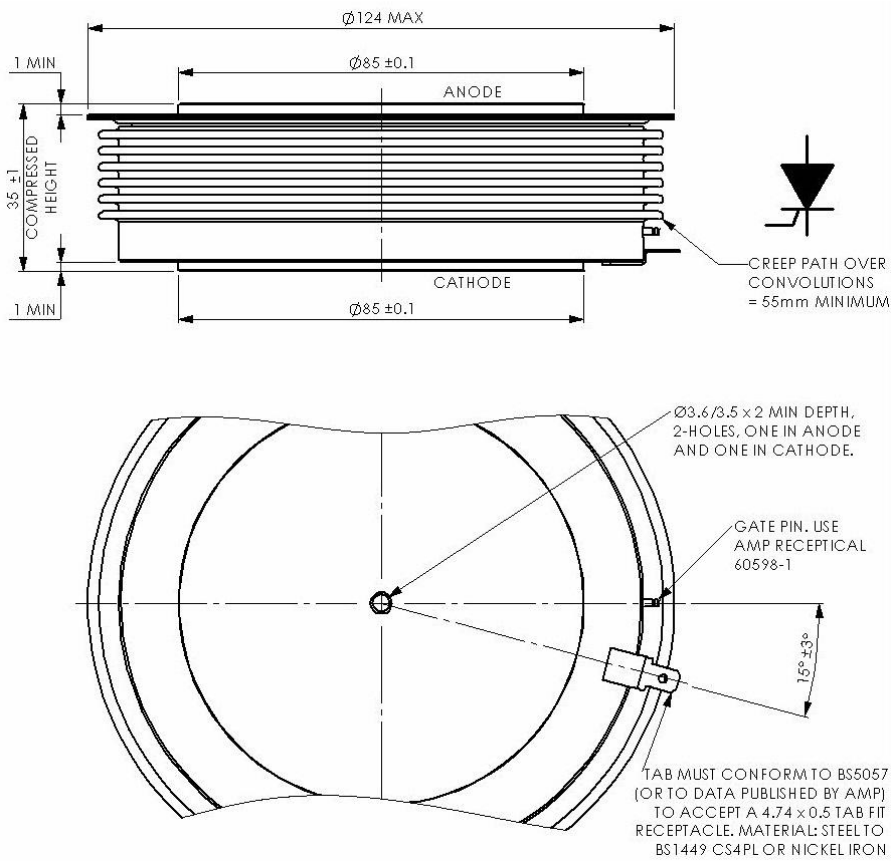


Figure 17 – Maximum surge and $I^2t$ Ratings



## Outline Drawing & Ordering Information




**101A410**

| ORDERING INFORMATION (Please quote 10 digit code as below) | | | |
|---|---|---|---|
| **N5715** | **EE** | **♦ ♦** | **0** |
| Fixed Type Code | Fixed Outline Code | Voltage Code 24 & 28 | Fixed turn-off time code |

Typical order code: N5715EE240 – 2400V $V_{DRM}$, $V_{RRM}$, 1000V/µs dv/dt, 35mm clamp height capsule.

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