



**Fast Thyristor
Type TFI473-1600-40**

Low switching losses
Low reverse recovery charge
Distributed amplified gate for high di_T/dt

| | | |
|-----------------------------------|------------|---------------|
| Mean on-state current | I_{TAV} | 1600 A |
| Repetitive peak off-state voltage | V_{DRM} | 3800 ÷ 4000 V |
| Repetitive peak reverse voltage | V_{RRM} | |
| Turn-off time | t_q | 125 μ s |
| V_{DRM}, V_{RRM}, V | 3800 | 4000 |
| Voltage code | 38 | 40 |
| $T_j, ^\circ C$ | - 60 ÷ 125 | |

MAXIMUM ALLOWABLE RATINGS

| Symbols and parameters | | Units | Values | Test conditions |
|------------------------|--|-------------------|--|--|
| ON-STATE | | | | |
| I_{TAV} | Mean on-state current | A | 1600 2340 | $T_c=85^\circ C$; Double side cooled; $T_c=55^\circ C$; Double side cooled; 180° half-sine wave; 50 Hz |
| I_{TRMS} | RMS on-state current | A | 2512 | $T_c=85^\circ C$; Double side cooled; 180° half-sine wave; 50 Hz |
| I_{TSM} | Surge on-state current | kA | 30.0 35.0 | $T_j=T_{j\max}$ $T_j=25^\circ C$ 180° half-sine wave; $t_p=10$ ms; single pulse; $V_D=V_R=0$ V; Gate pulse: $I_G=I_{FGM}$; $V_G=20$ V; $t_{GP}=50$ μ s; $di_G/dt=2$ A/ μ s |
| | | | 32.0 37.0 | $T_j=T_{j\max}$ $T_j=25^\circ C$ 180° half-sine wave; $t_p=8.3$ ms; single pulse; $V_D=V_R=0$ V; Gate pulse: $I_G=I_{FGM}$; $V_G=20$ V; $t_{GP}=50$ μ s; $di_G/dt=2$ A/ μ s |
| I^2t | Safety factor | $A^2s \cdot 10^3$ | 4500 6100 | $T_j=T_{j\max}$ $T_j=25^\circ C$ 180° half-sine wave; $t_p=10$ ms; single pulse; $V_D=V_R=0$ V; Gate pulse: $I_G=I_{FGM}$; $V_G=20$ V; $t_{GP}=50$ μ s; $di_G/dt=2$ A/ μ s |
| | | | 4200 5600 | $T_j=T_{j\max}$ $T_j=25^\circ C$ 180° half-sine wave; $t_p=8.3$ ms; single pulse; $V_D=V_R=0$ V; Gate pulse: $I_G=I_{FGM}$; $V_G=20$ V; $t_{GP}=50$ μ s; $di_G/dt=2$ A/ μ s |
| BLOCKING | | | | |
| V_{DRM}, V_{RRM} | Repetitive peak off-state and Repetitive peak reverse voltages | V | 3800÷4000 | $T_{j\min} < T_j < T_{j\max}$; 180° half-sine wave; 50 Hz; Gate open |
| V_{DSM}, V_{RSM} | Non-repetitive peak off-state and Non-repetitive peak reverse voltages | V | 3900÷4100 | $T_{j\min} < T_j < T_{j\max}$; 180° half-sine wave; single pulse; Gate open |
| V_D, V_R | Direct off-state and Direct reverse voltages | V | $0.6 \cdot V_{DRM}$ $0.6 \cdot V_{RRM}$ | $T_j=T_{j\max}$; Gate open |

| TRIGGERING | | | | |
|--------------------|---|------------------|------------------|---|
| I_{FGM} | Peak forward gate current | A | 10 | $T_j = T_{j\ max}$ |
| V_{RGM} | Peak reverse gate voltage | V | 5 | |
| P_G | Gate power dissipation | W | 8 | $T_j = T_{j\ max}$ for DC gate current |
| SWITCHING | | | | |
| $(di_T/dt)_{crit}$ | Critical rate of rise of on-state current non-repetitive (f=1 Hz) | A/ μ s | 2000 | $T_j = T_{j\ max}$; $V_D = 0.67 \cdot V_{DRM}$; $I_{TM} = 2 I_{TAV}$; Gate pulse: $I_G = 2$ A; $V_G = 20$ V; $t_{GP} = 50$ μ s; $di_G/dt = 2$ A/ μ s |
| THERMAL | | | | |
| T_{stg} | Storage temperature | $^{\circ}$ C | -60 \div 50 | |
| T_j | Operating junction temperature | $^{\circ}$ C | -60 \div 125 | |
| MECHANICAL | | | | |
| F | Mounting force | kN | 40.0 \div 50.0 | |
| a | Acceleration | m/s ² | 50 | Device clamped |

CHARACTERISTICS

| Symbols and parameters | | Units | Values | Conditions | |
|------------------------|---|------------|---------------------------|--|---|
| ON-STATE | | | | | |
| V_{TM} | Peak on-state voltage, max | V | 2.40 2.70 | $T_j = T_{j\ max}$; $I_{TM} = 4000$ A $T_j = 25$ $^{\circ}$ C; $I_{TM} = 5024$ A | |
| $V_{T(TO)}$ | On-state threshold voltage, max | V | 1.44 | $T_j = T_{j\ max}$; | |
| r_T | On-state slope resistance, max | m Ω | 0.270 | $0.5 \pi I_{TAV} < I_T < 1.5 \pi I_{TAV}$ | |
| I_H | Holding current, max | mA | 1000 | $T_j = 25$ $^{\circ}$ C; $V_D = 12$ V; Gate open | |
| BLOCKING | | | | | |
| I_{DRM}, I_{RRM} | Repetitive peak off-state and Repetitive peak reverse currents, max | mA | 300 | $T_j = T_{j\ max}$; $V_D = V_{DRM}$; $V_R = V_{RRM}$ | |
| $(dv_D/dt)_{crit}$ | Critical rate of rise of off-state voltage ¹⁾ , min | V/ μ s | 200, 320, 500, 1000 | $T_j = T_{j\ max}$; $V_D = 0.67 \cdot V_{DRM}$; Gate open | |
| TRIGGERING | | | | | |
| V_{GT} | Gate trigger direct voltage, max | V | 5.00 3.00 2.00 | $T_j = T_{j\ min}$ $T_j = 25$ $^{\circ}$ C $T_j = T_{j\ max}$ | $V_D = 12$ V; $I_D = 3$ A; Direct gate current |
| I_{GT} | Gate trigger direct current, max | mA | 500 300 200 | $T_j = T_{j\ min}$ $T_j = 25$ $^{\circ}$ C $T_j = T_{j\ max}$ | |
| V_{GD} | Gate non-trigger direct voltage, min | V | 0.35 | $T_j = T_{j\ max}$; $V_D = 0.67 \cdot V_{DRM}$; | |
| I_{GD} | Gate non-trigger direct current, min | mA | 15.00 | Direct gate current | |
| SWITCHING | | | | | |
| t_{gd} | Delay time, max | μ s | 1.22 | $T_j = 25$ $^{\circ}$ C; $V_D = 1500$ V; $I_{TM} = I_{TAV}$; $di/dt = 200$ A/ μ s; | |
| t_{gt} | Turn-on time ²⁾ | μ s | 4.00, 6.30, 8.00, 10.0 | Gate pulse: $I_G = 2$ A; $V_G = 20$ V; $t_{GP} = 50$ μ s; $di_G/dt = 2$ A/ μ s | |
| t_q | Turn-off time ³⁾ , max | μ s | 125 160 | $dv_D/dt = 50$ V/ μ s; $dv_D/dt = 200$ V/ μ s; | $T_j = T_{j\ max}$; $I_{TM} = I_{TAV}$; $di_R/dt = -10$ A/ μ s; $V_R = 100$ V; $V_D = 0.67 V_{DRM}$ |
| Q_{rr} | Total recovered charge(linear), max | μ C | 3000 | $T_j = T_{j\ max}$; $I_{TM} = 2000$ A; | |
| t_{rr} | Reverse recovery time, max | μ s | 14 | $di_R/dt = -50$ A/ μ s; | |
| I_{rrM} | Peak reverse recovery current, max | A | 430 | $V_R = 100$ V | |

| THERMAL | | | | | |
|--------------|---|--------------|------------------|----------------|---------------------|
| R_{thjc} | Thermal resistance, junction to case, max | °C/W | 0.0100 | Direct current | Double side cooled |
| R_{thjc-A} | | | 0.0220 | | Anode side cooled |
| R_{thjc-K} | | | 0.0180 | | Cathode side cooled |
| R_{thck} | Thermal resistance, case to heatsink, max | °C/W | 0.0020 | Direct current | |
| MECHANICAL | | | | | |
| w | Weight, typ | g | 1600 | | |
| D_s | Surface creepage distance | mm (inch) | 55.13 (2.170) | | |
| D_a | Air strike distance | mm (inch) | 25.10 (0.988) | | |

| PART NUMBERING GUIDE | | | | | | | | NOTES | | | | | | |
|--|-----|------|----|----|----|----|---|--|------|------|------|------|--|--|
| TFI | 473 | 1600 | 40 | A2 | X2 | H4 | N | 1) Critical rate of rise of off-state voltage | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Symbol of group | P2 | K2 | E2 | A2 | | |
| 1. TFI — Fast Thyristor TFIS — Fast Thyristor with Distributed Amplified Gate. Design version 3. Mean on-state current, A 4. Voltage code 5. Critical rate of rise of off-state voltage 6. Group of turn-off time ($dv_D/dt=50\text{ V}/\mu\text{s}$) 7. Group of turn-on time 8. Ambient conditions: N – normal; T – tropical | | | | | | | | $(dv_D/dt)_{crit}, \text{ V}/\mu\text{s}$ | 200 | 320 | 500 | 1000 | | |
| | | | | | | | | 2) Turn-on time | | | | | | |
| | | | | | | | | Symbol of group | H4 | C4 | B4 | A4 | | |
| | | | | | | | | $t_{gt}, \mu\text{s}$ | 4.00 | 6.30 | 8.00 | 10.0 | | |
| | | | | | | | | 3) Turn-off time ($dv_D/dt=50\text{ V}/\mu\text{s}$) | | | | | | |
| | | | | | | | | Symbol of group | X2 | | | | | |
| | | | | | | | | $t_{qr}, \mu\text{s}$ | 125 | | | | | |

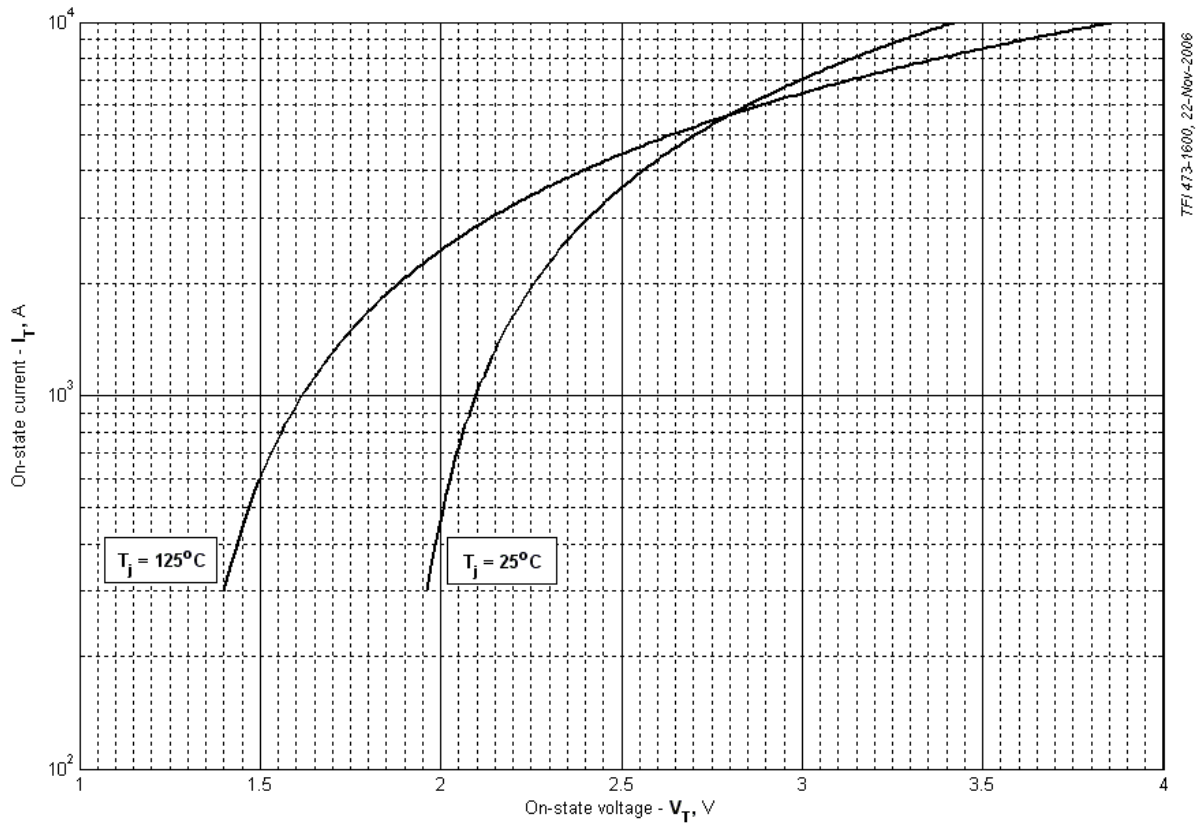


Fig 1 – On-state characteristics of Limit device

Analytical function for On-state characteristic:

$$V_T = A + B \cdot i_T + C \cdot \ln(i_T + 1) + D \cdot \sqrt{i_T}$$

| | Coefficients | |
|----------|--------------------------|-------------------------|
| | $T_j = 25^\circ\text{C}$ | $T_j = T_{j\text{max}}$ |
| A | 1.799223 | 1.165741 |
| B | 0.106392 | 0.195115 |
| C | -0.227901 | -0.304378 |
| D | 0.350140 | 0.467637 |

On-state characteristic model (see Fig. 1).

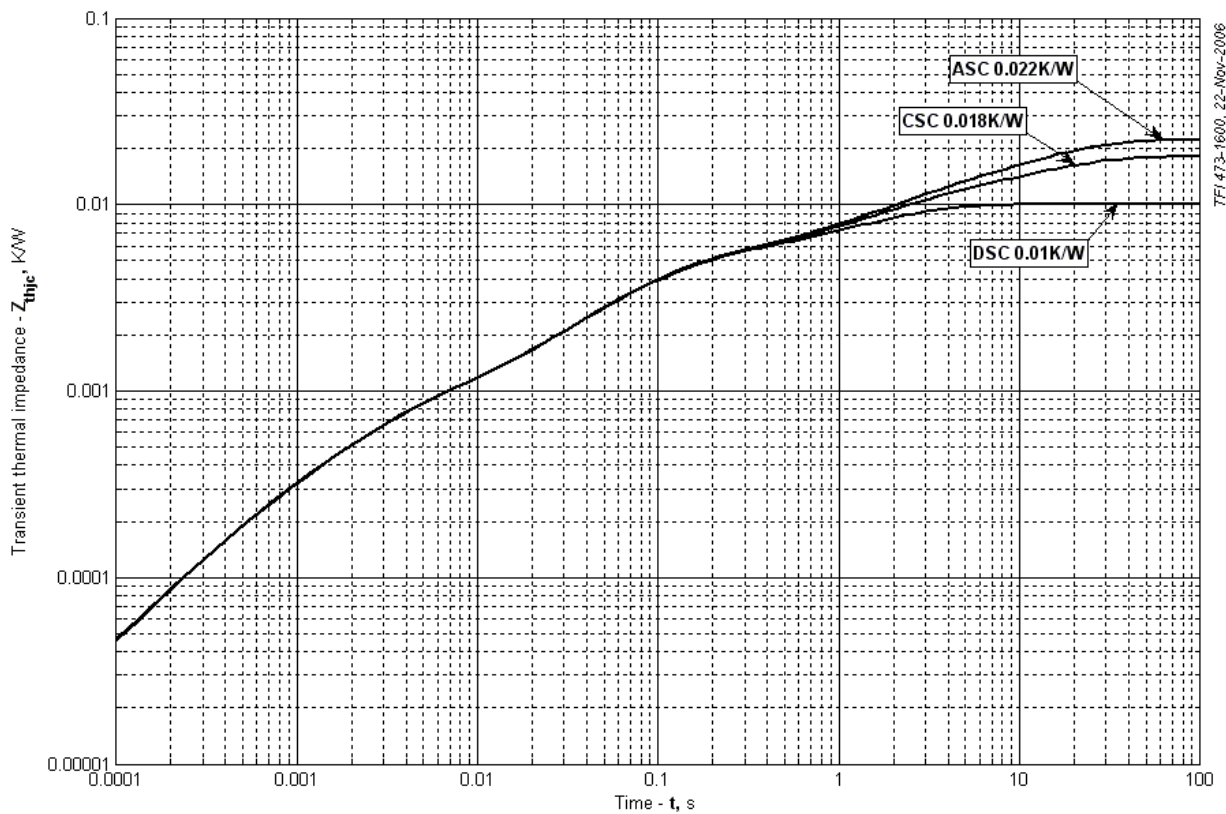


Fig 2 – Transient thermal impedance

Analytical function for Transient thermal impedance junction to case Z_{thjc} for DC:

$$Z_{thjc} = \sum_{i=1}^n R_i \left(1 - e^{-\frac{t}{\tau_i}} \right)$$

Where $i = 1$ to n , n is the number of terms in the series.

t = Duration of heating pulse in seconds.

Z_{thjc} = Thermal resistance at time t .

R_i = Amplitude of p_{th} term.

τ_i = Time constant of r_{th} term.

DC Double side cooled

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|--------------|----------|----------|-----------|-----------|------------|----------|
| R_i , K/W | 0.002785 | 0.003537 | 0.0005787 | 0.0006418 | 0.00009446 | 0.002362 |
| τ_i , s | 2.061 | 0.07354 | 0.002615 | 0.1375 | 0.0004601 | 1.210 |

DC Anode side cooled

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|--------------|---------|---------|-----------|----------|-----------|------------|
| R_i , K/W | 0.01246 | 0.00478 | 0.0006333 | 0.003716 | 0.0005969 | 0.00006119 |
| τ_i , s | 13.310 | 1.871 | 0.2261 | 0.07337 | 0.002363 | 0.0003248 |

DC Cathode side cooled

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|--------------|----------|----------|-----------|----------|-----------|------------|
| R_i , K/W | 0.008256 | 0.004771 | 0.0006239 | 0.003744 | 0.0005969 | 0.00006164 |
| τ_i , s | 13.250 | 1.783 | 0.2371 | 0.07347 | 0.002367 | 0.000327 |

Transient thermal impedance junction to case Z_{thjc} model (see Fig. 2).

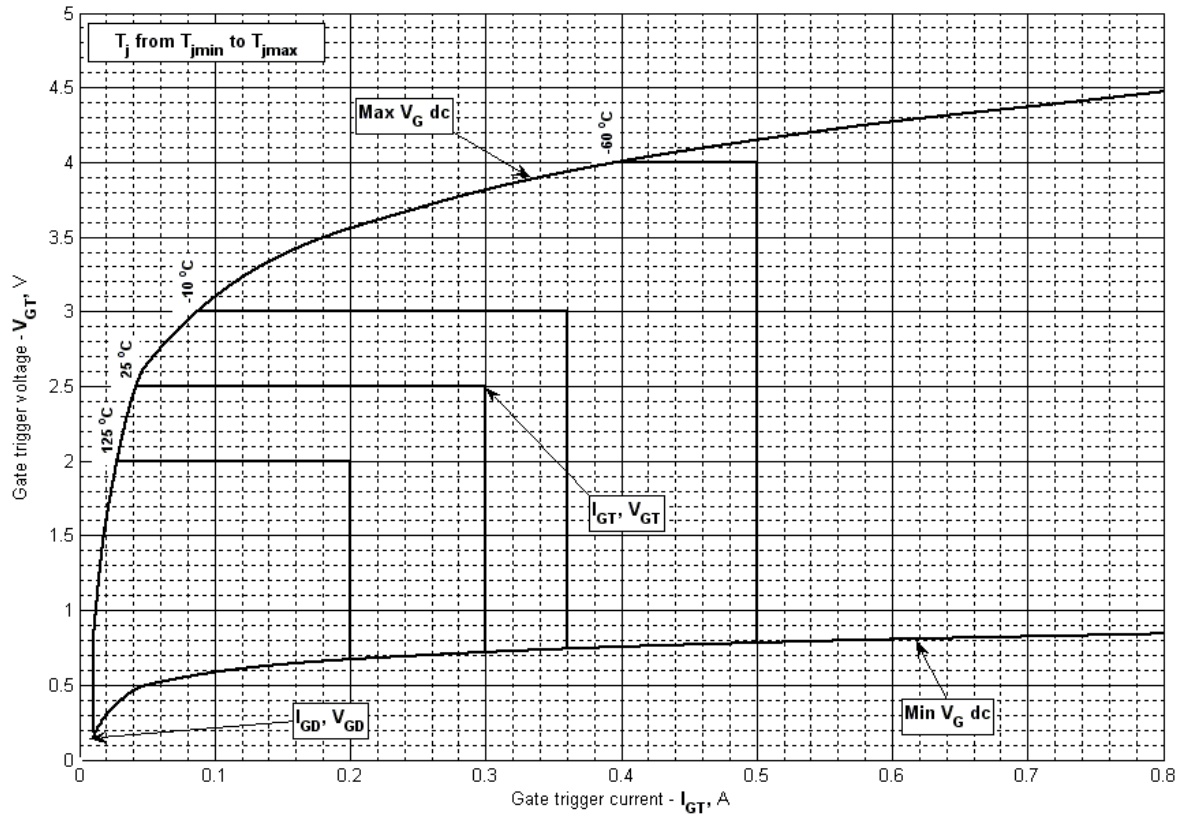


Fig 3 – Gate characteristics – Trigger limits

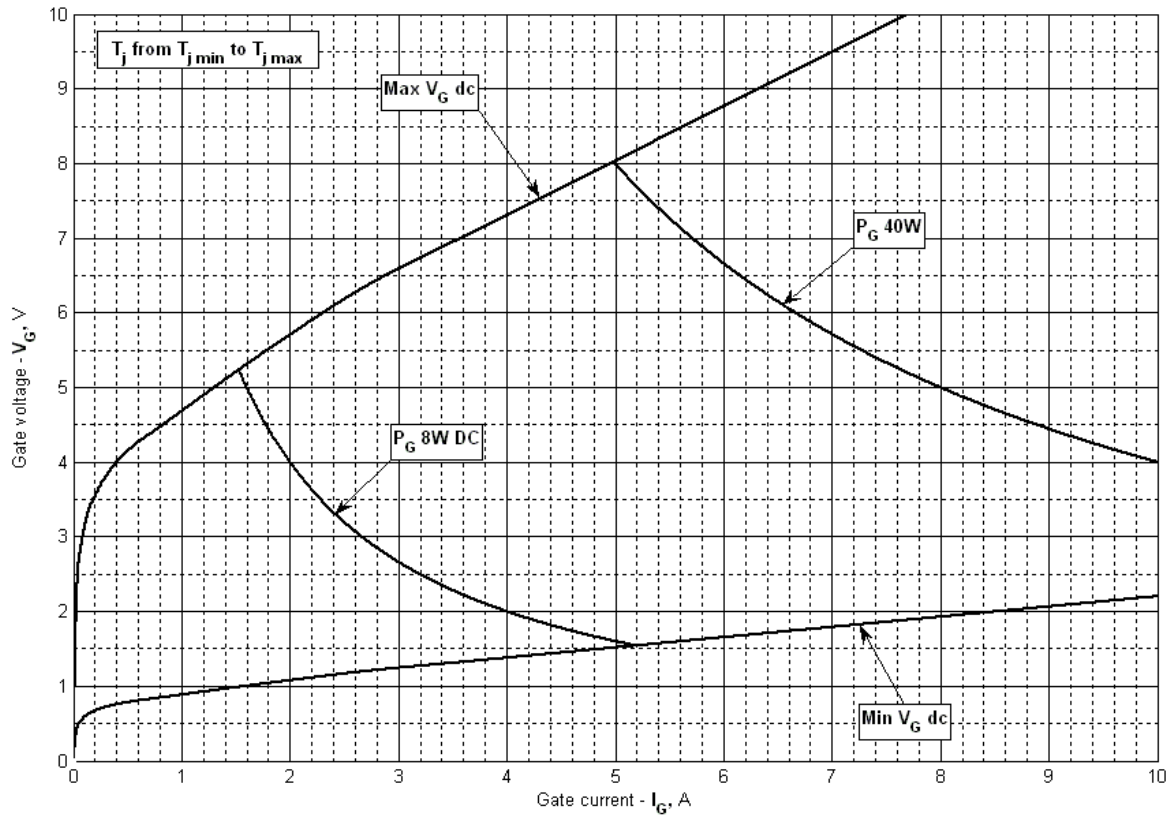


Fig 4 - Gate characteristics –Power curves

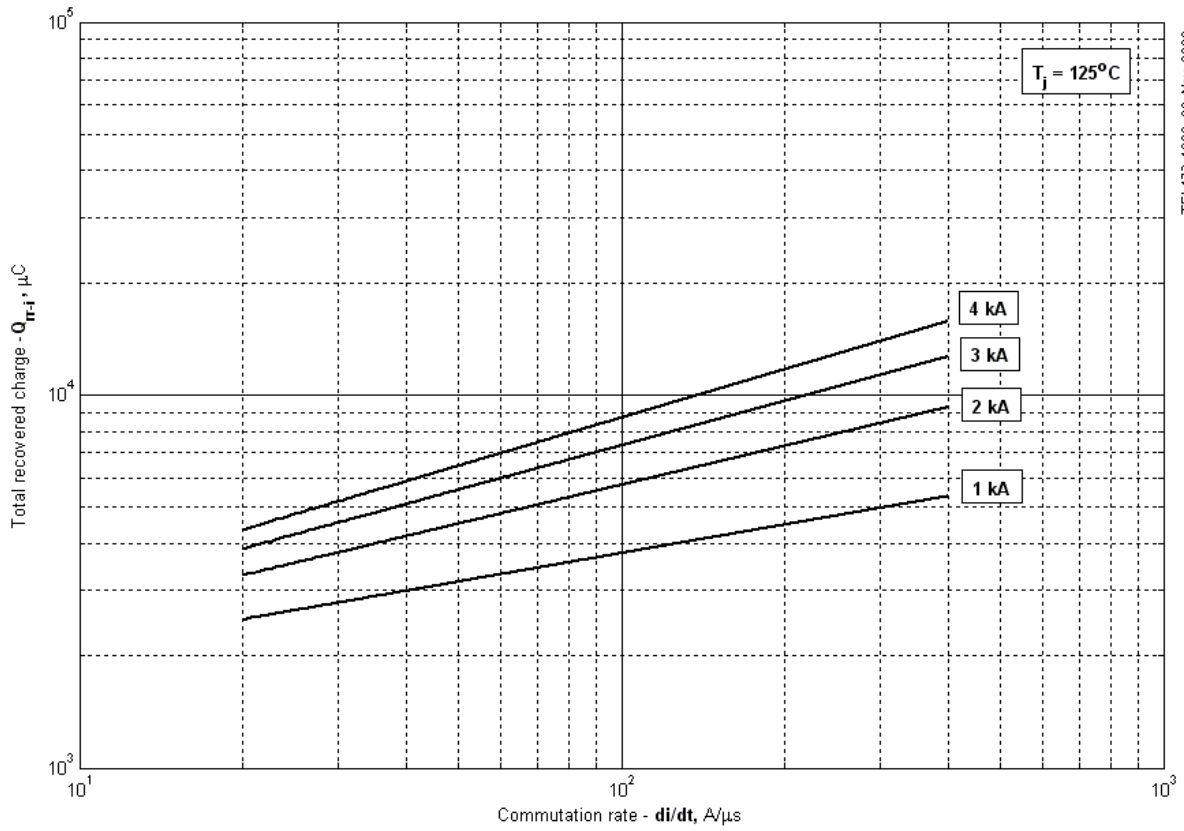


Fig 5 – Total recovered charge, Q_{rr-i} (integral)

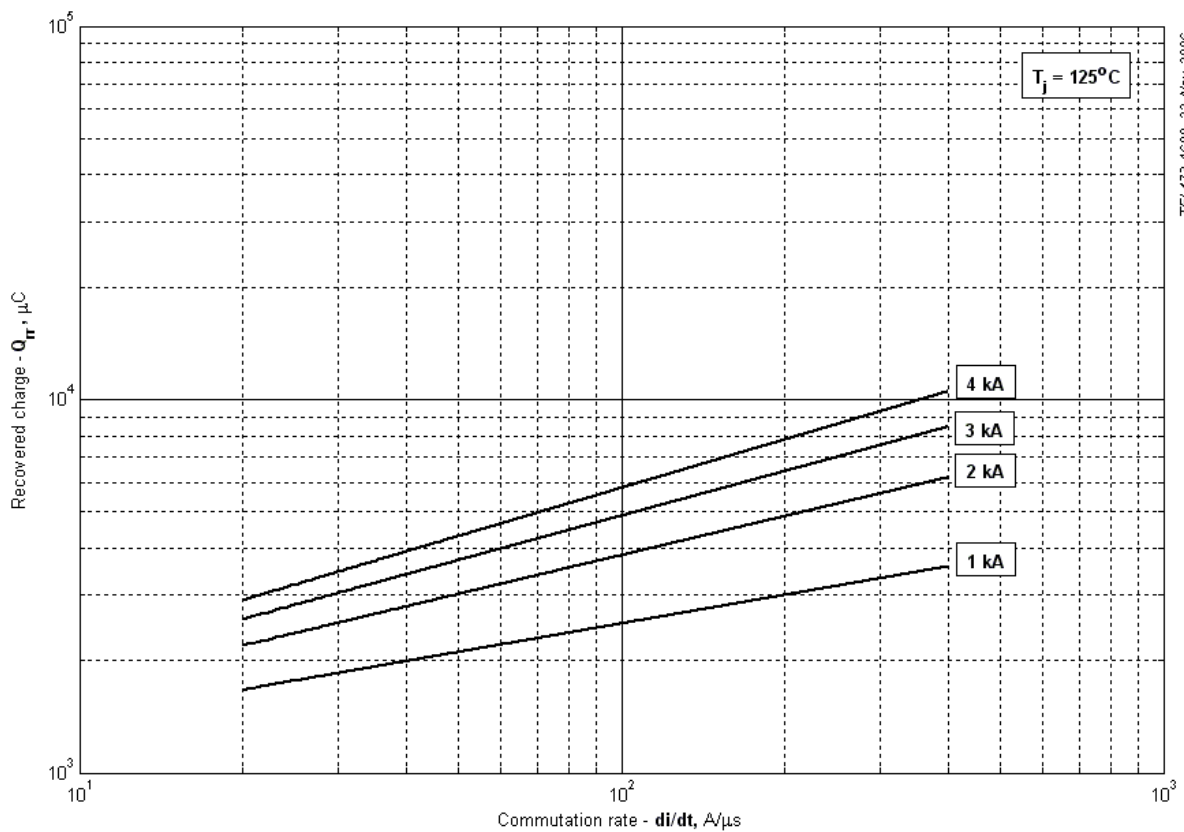


Fig 6 - Recovered charge, Q_{rr} (25% chord)

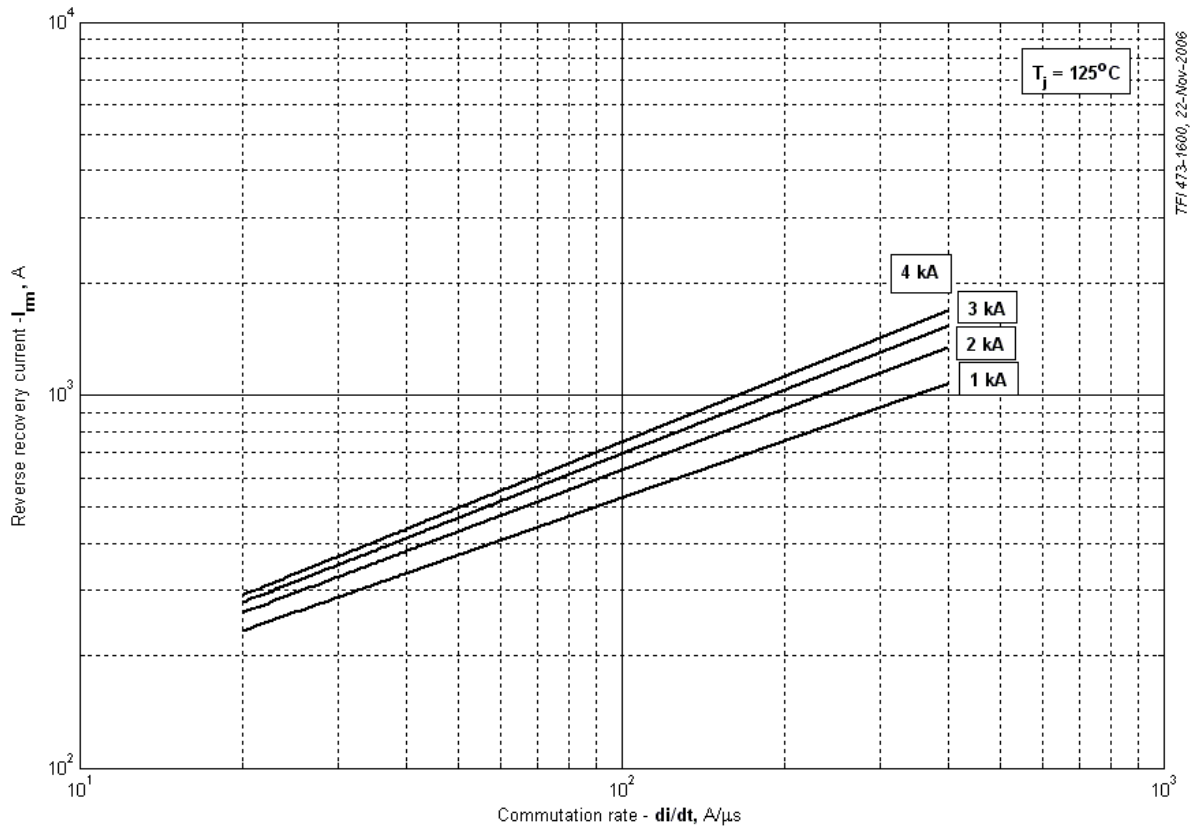


Fig 7 – Peak reverse recovery current, I_{fm}

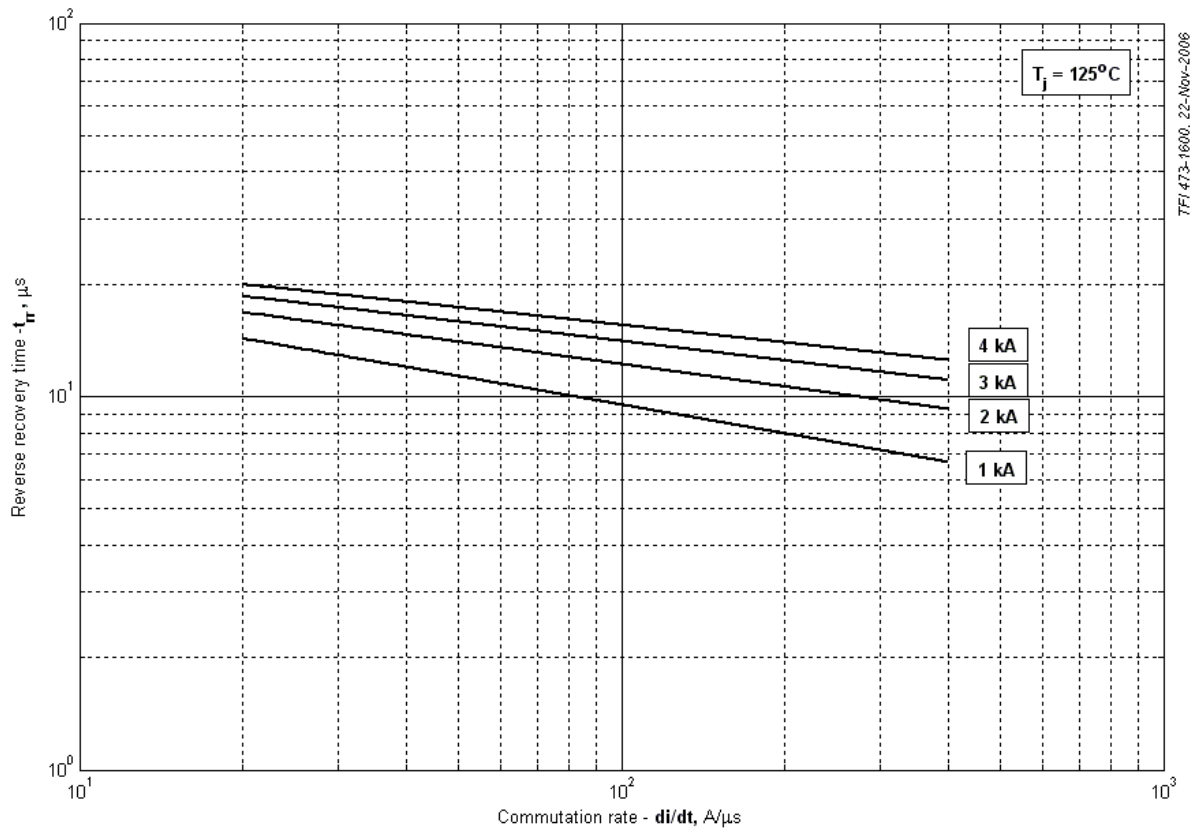


Fig 8 – Maximum recovery time, t_{tr} (25% chord)

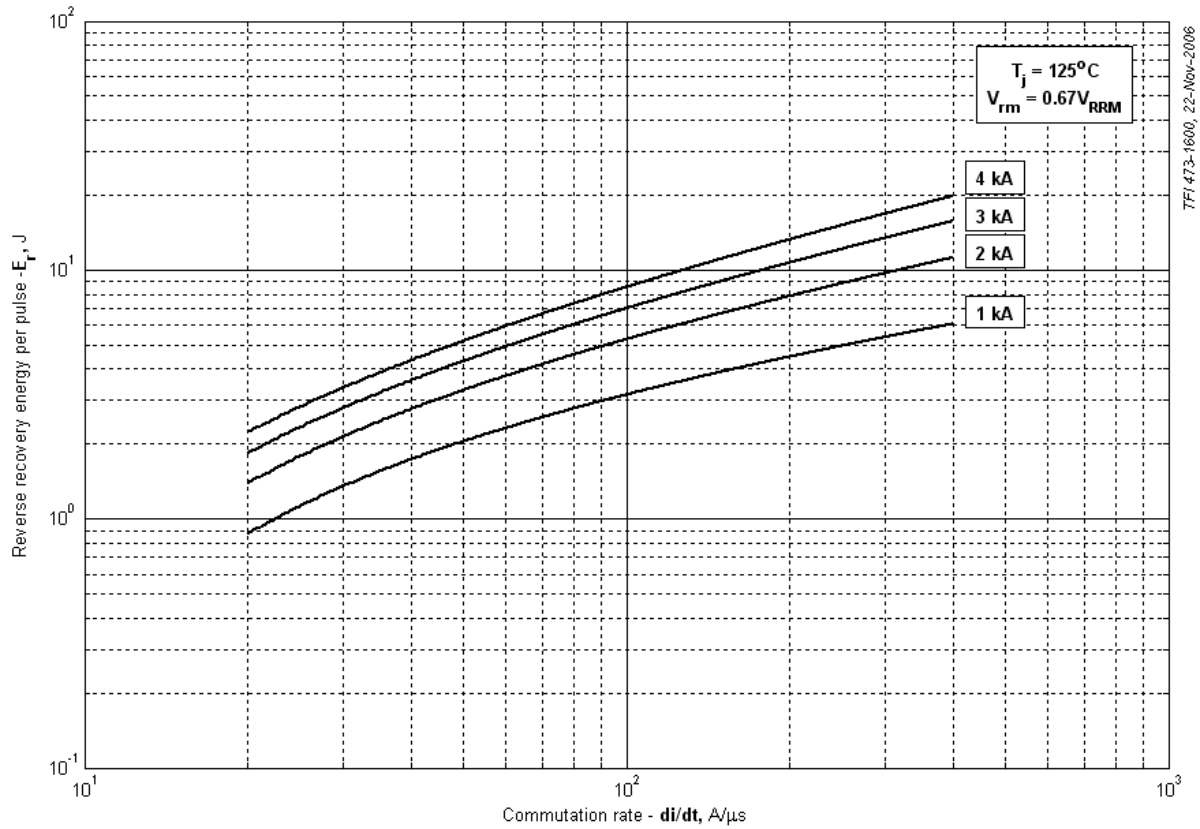


Fig 9 – Reverse recovery energy per pulse

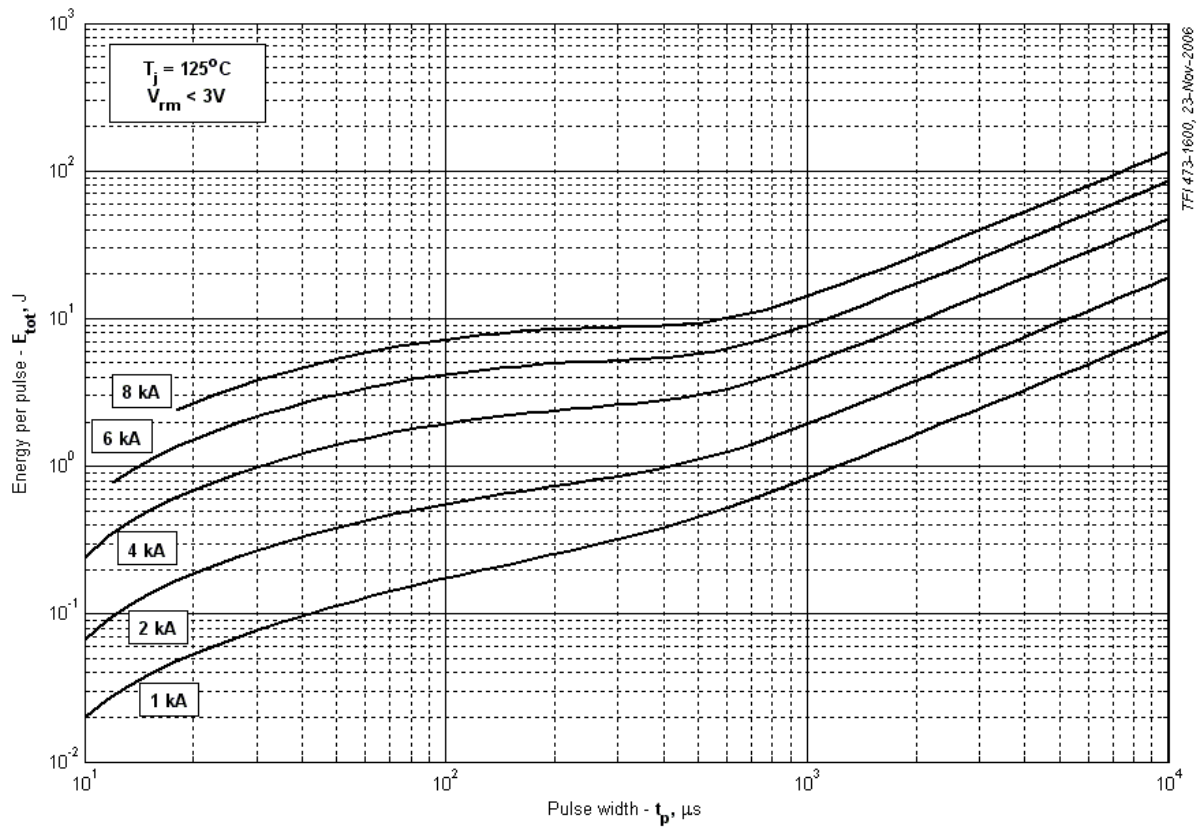


Fig 10 – Sine wave energy per pulse

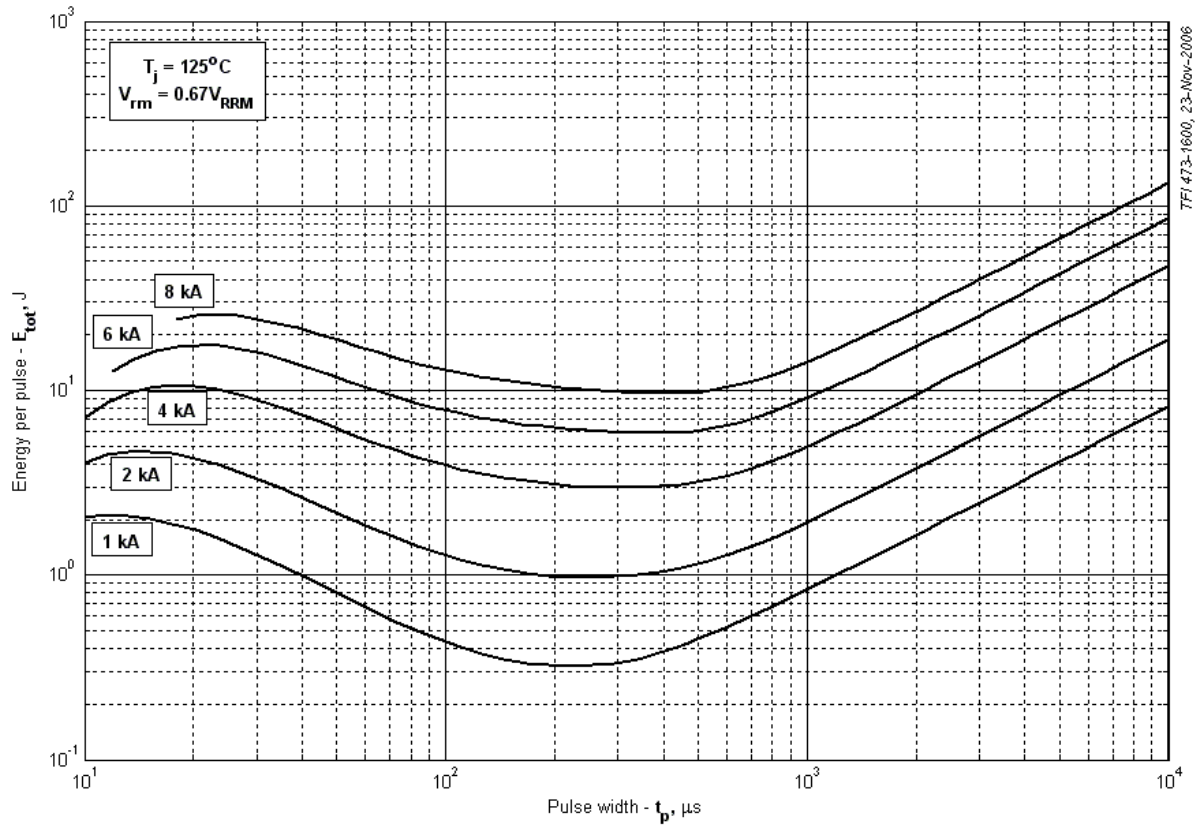


Fig 11 – Sine wave energy per pulse

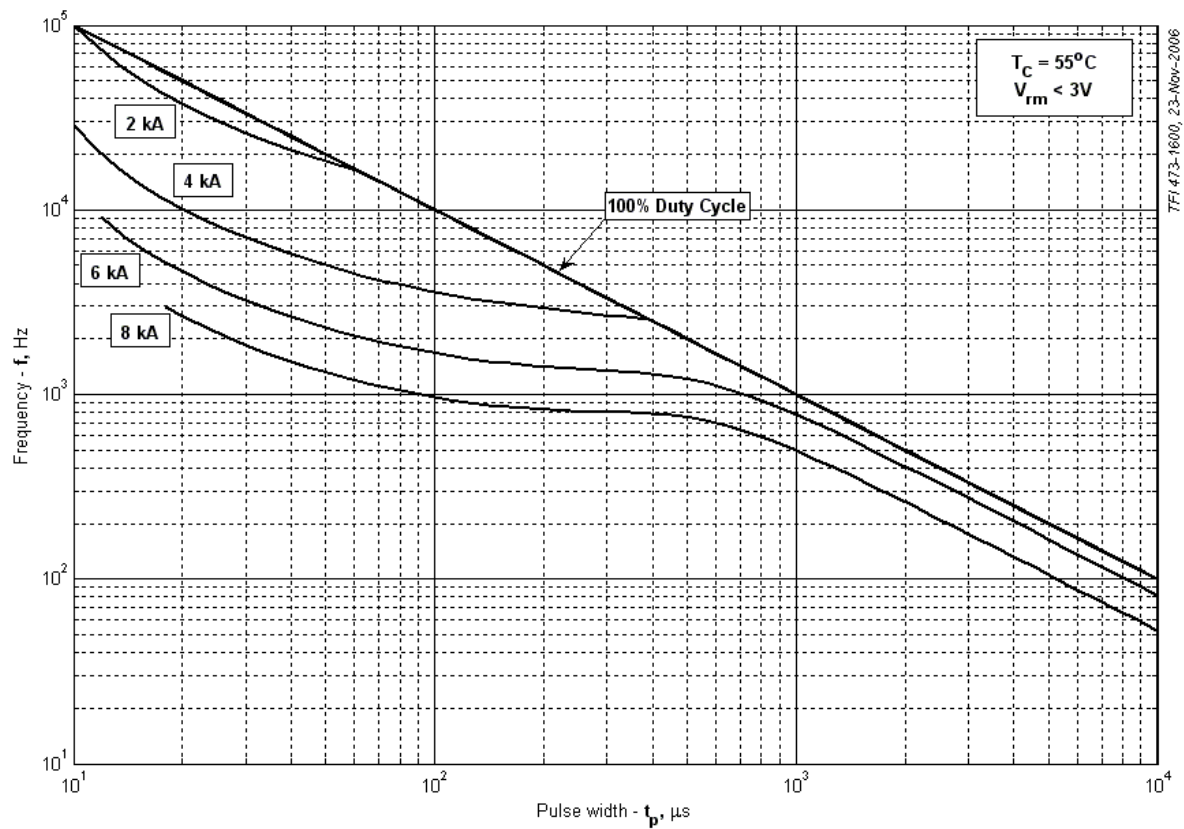
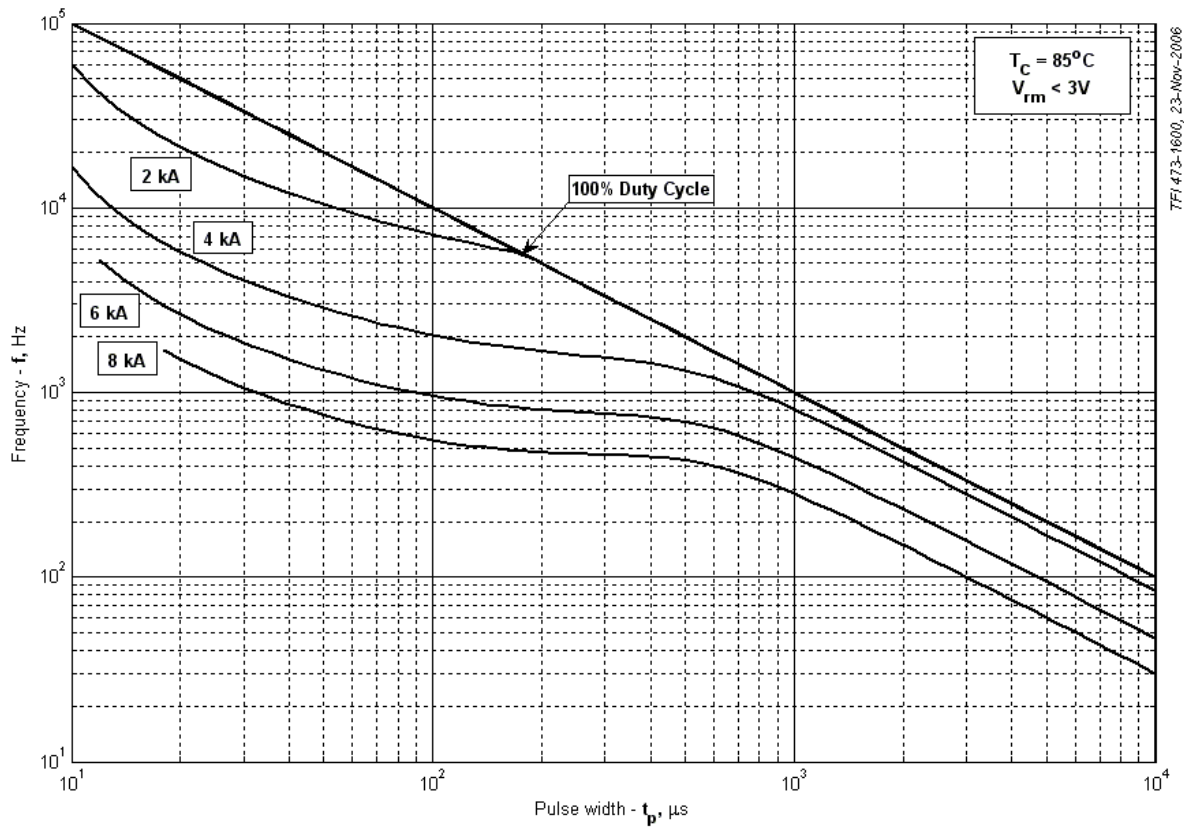
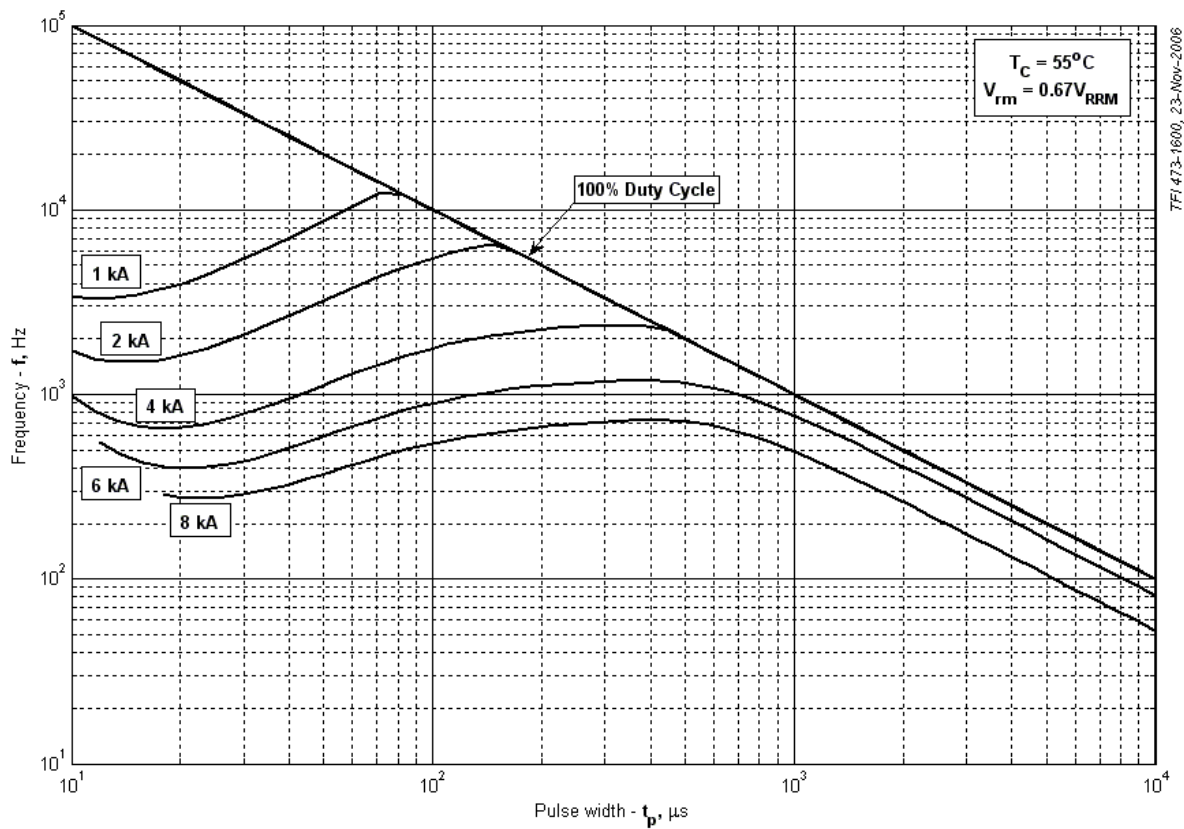


Fig 12 – Sine wave frequency ratings



TFI473-1600, 23-Nov-2006

Fig 13 – Sine wave frequency ratings



TFI473-1600, 23-Nov-2006

Fig 14 – Sine wave frequency ratings

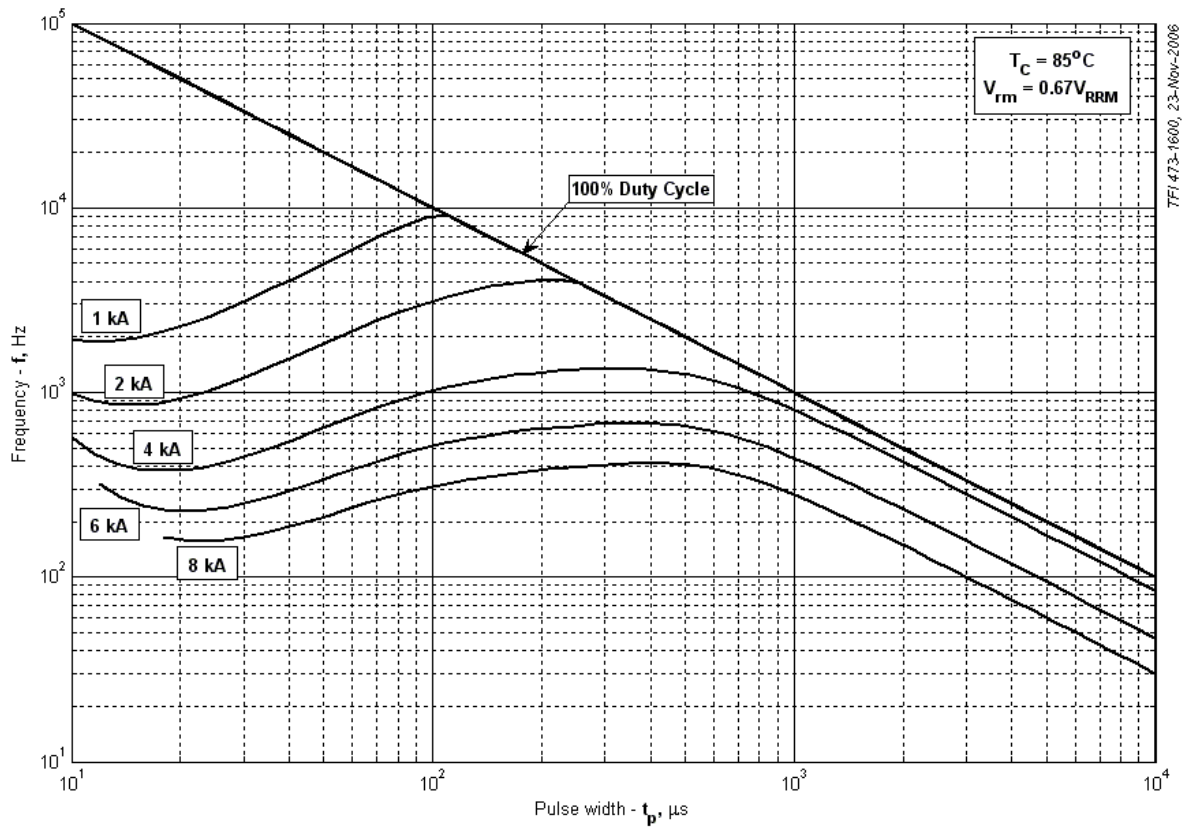


Fig 15 – Sine wave frequency ratings

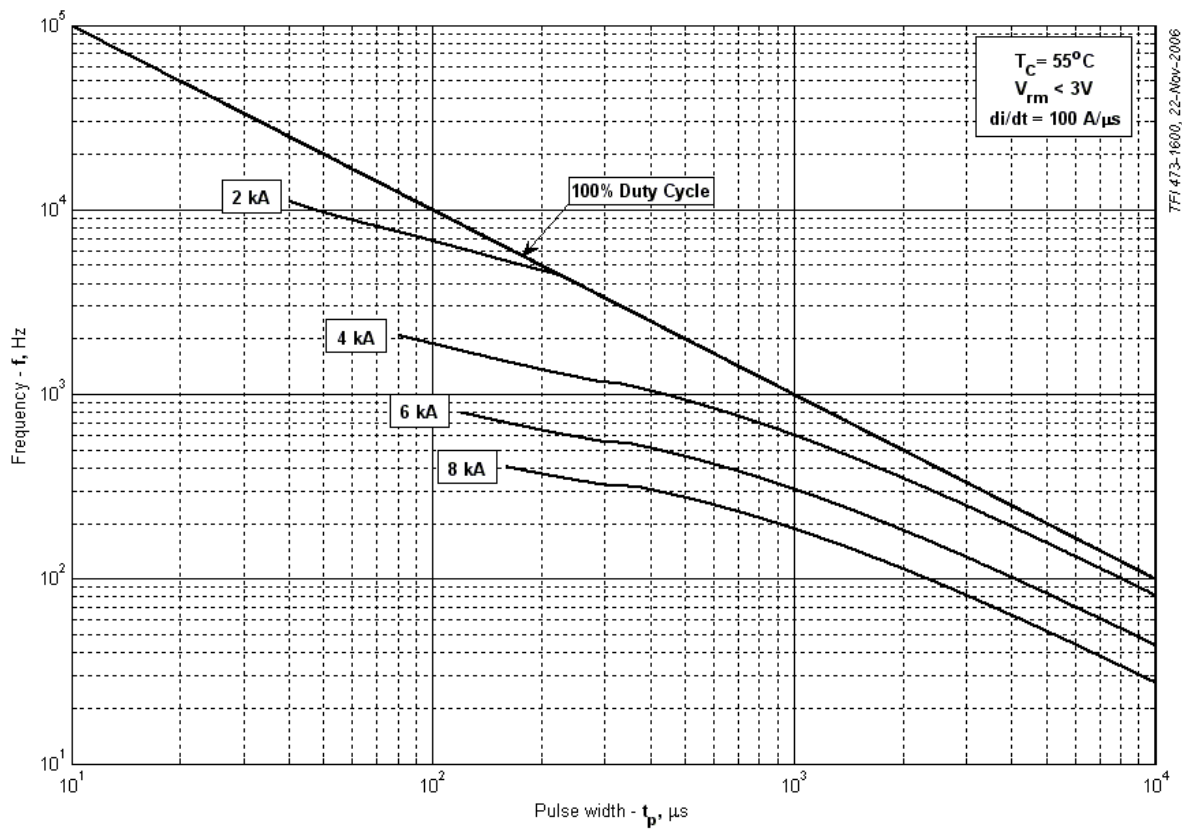


Fig 16 – Square wave frequency ratings

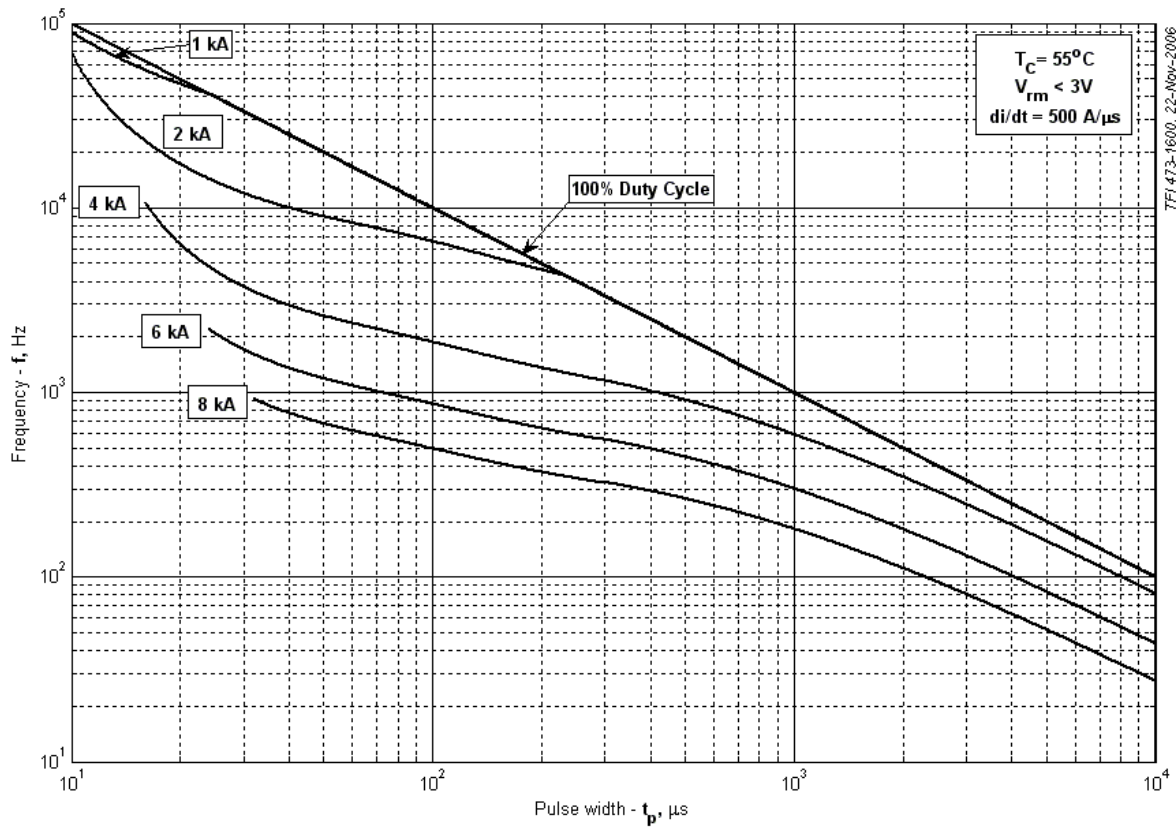


Fig 17 – Square wave frequency ratings

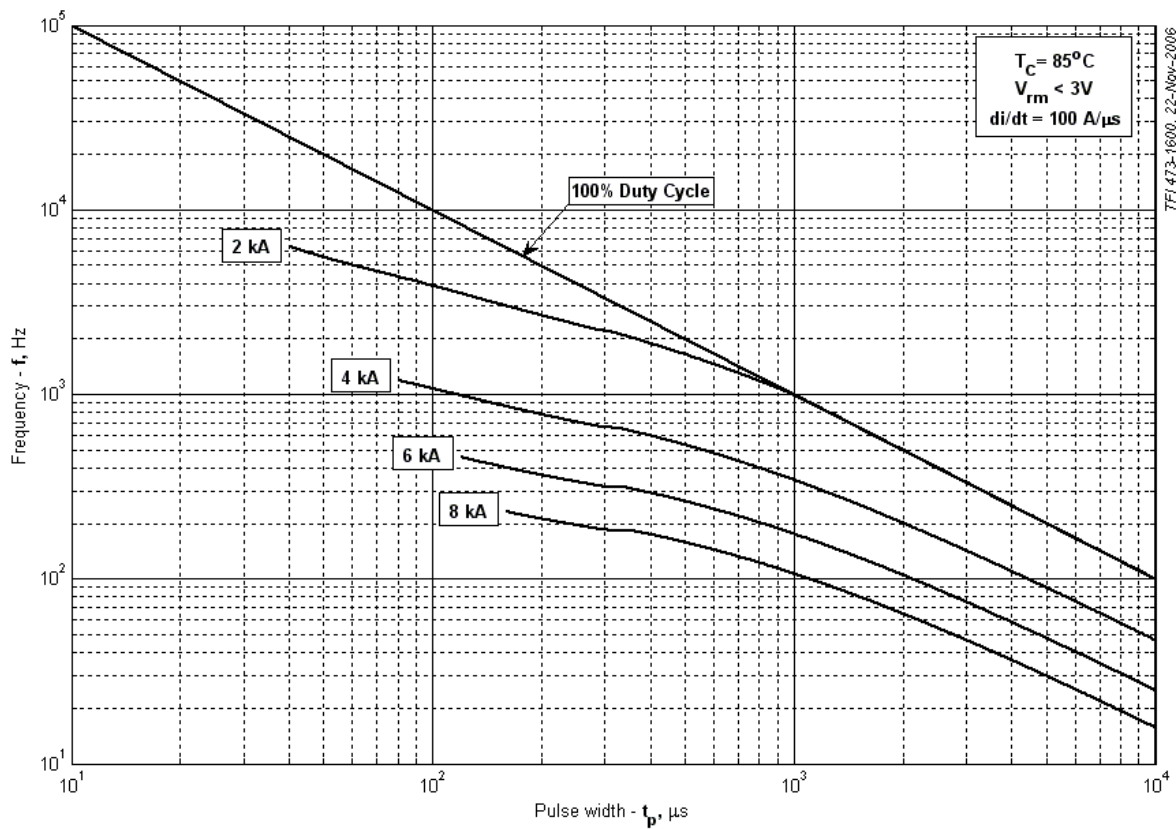


Fig 18 – Square wave frequency ratings

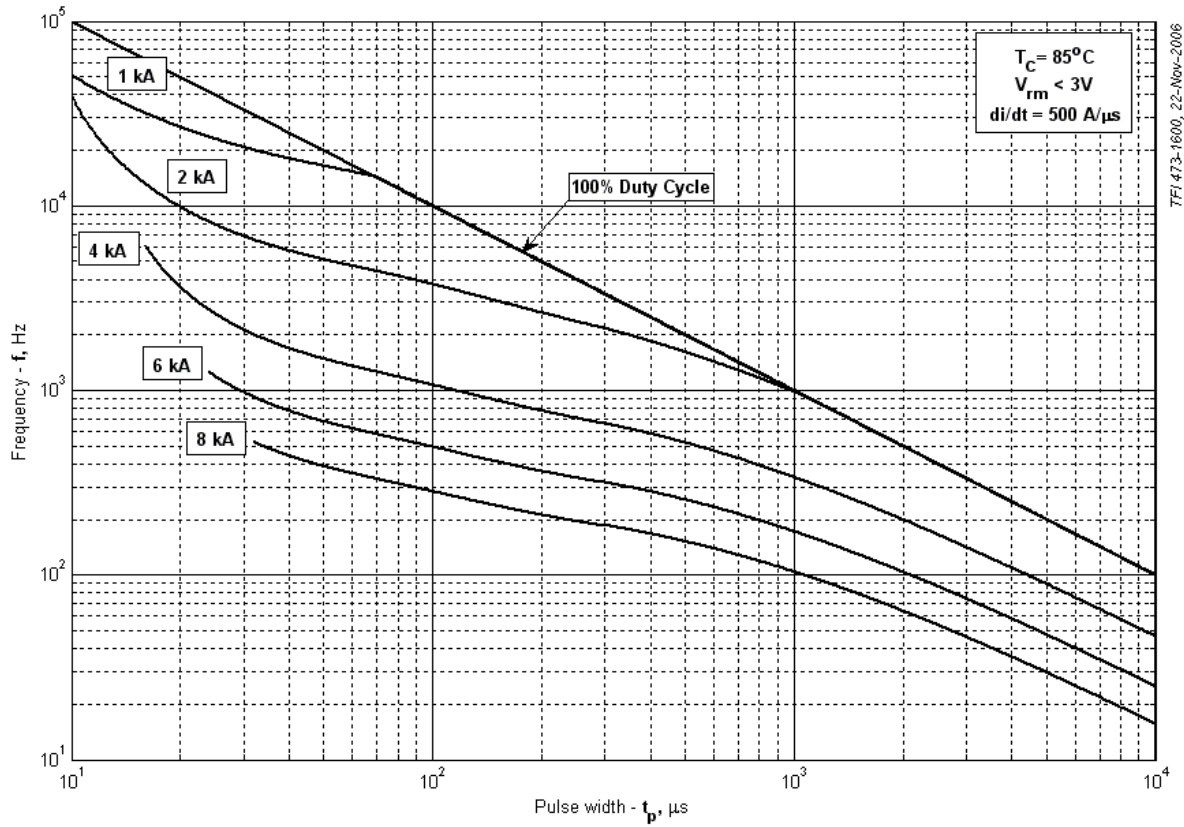


Fig 19 – Square wave frequency ratings

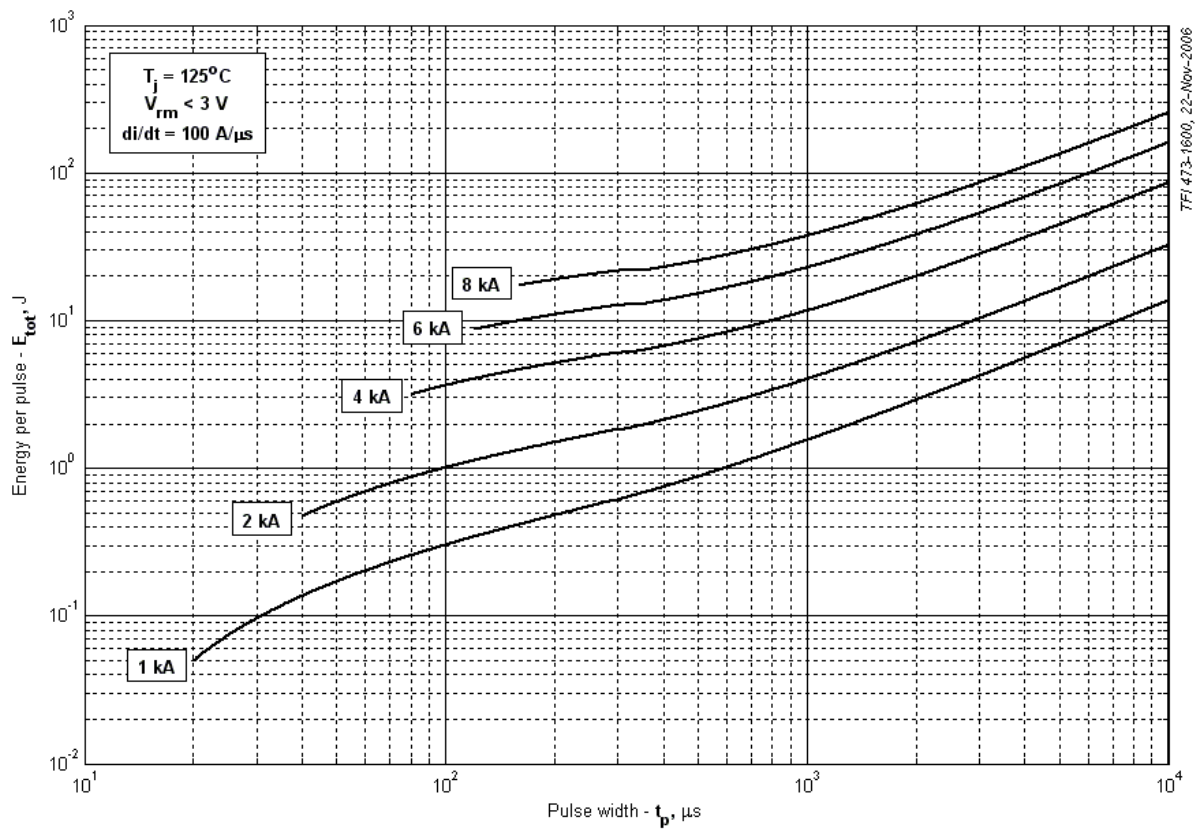


Fig 20 – Square wave energy per pulse

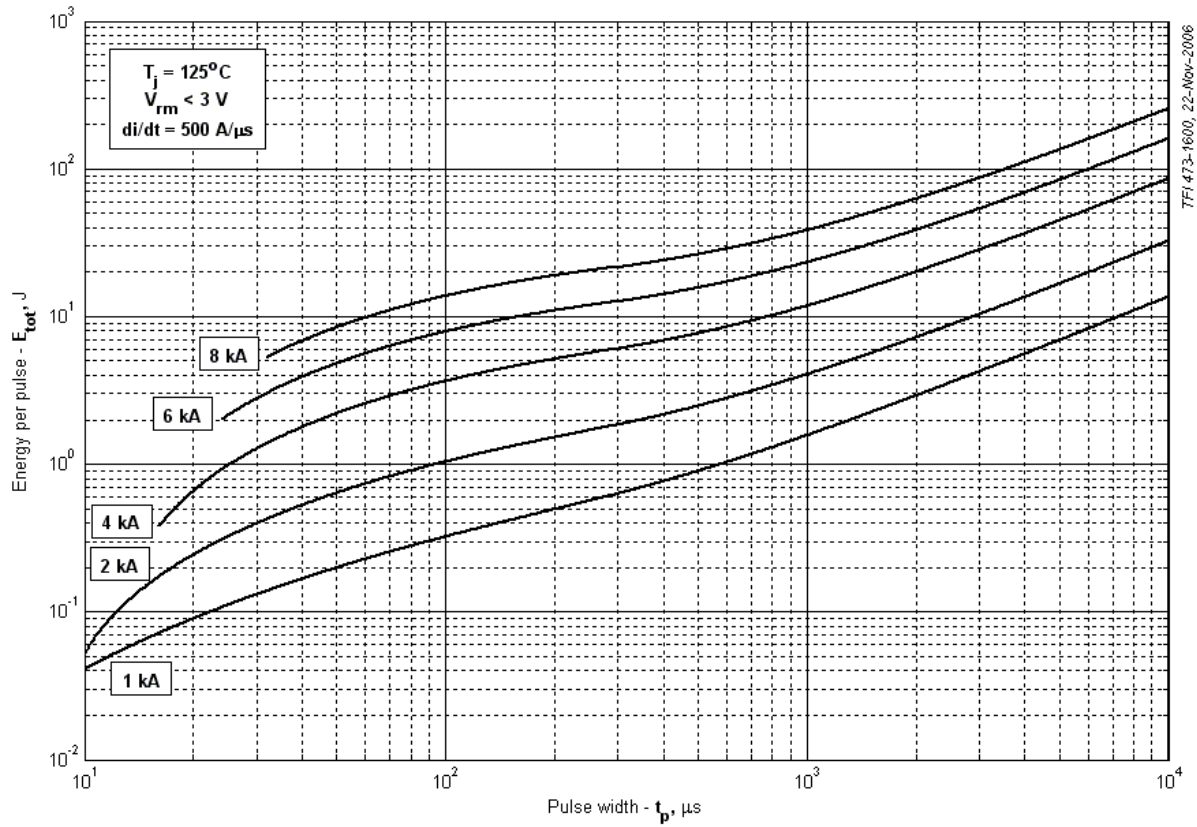


Fig 21 – Square wave energy per pulse

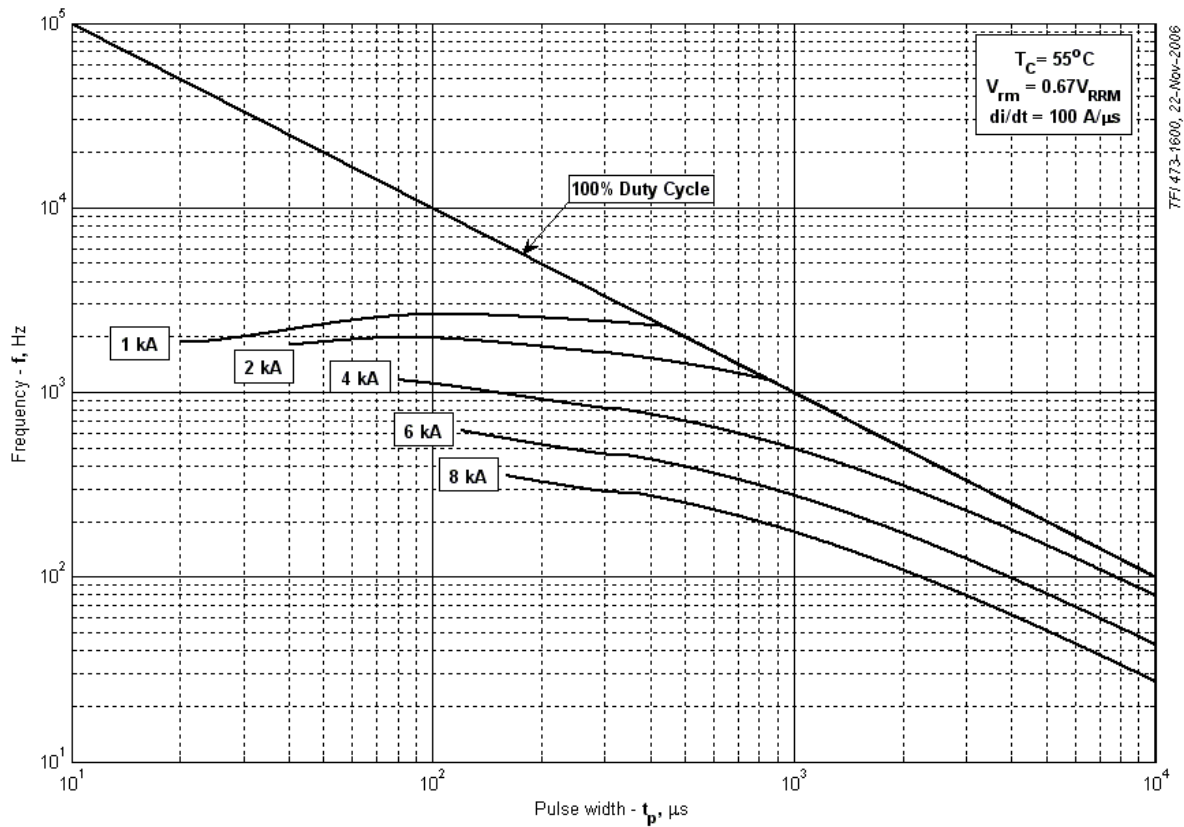


Fig 22 – Square wave frequency ratings

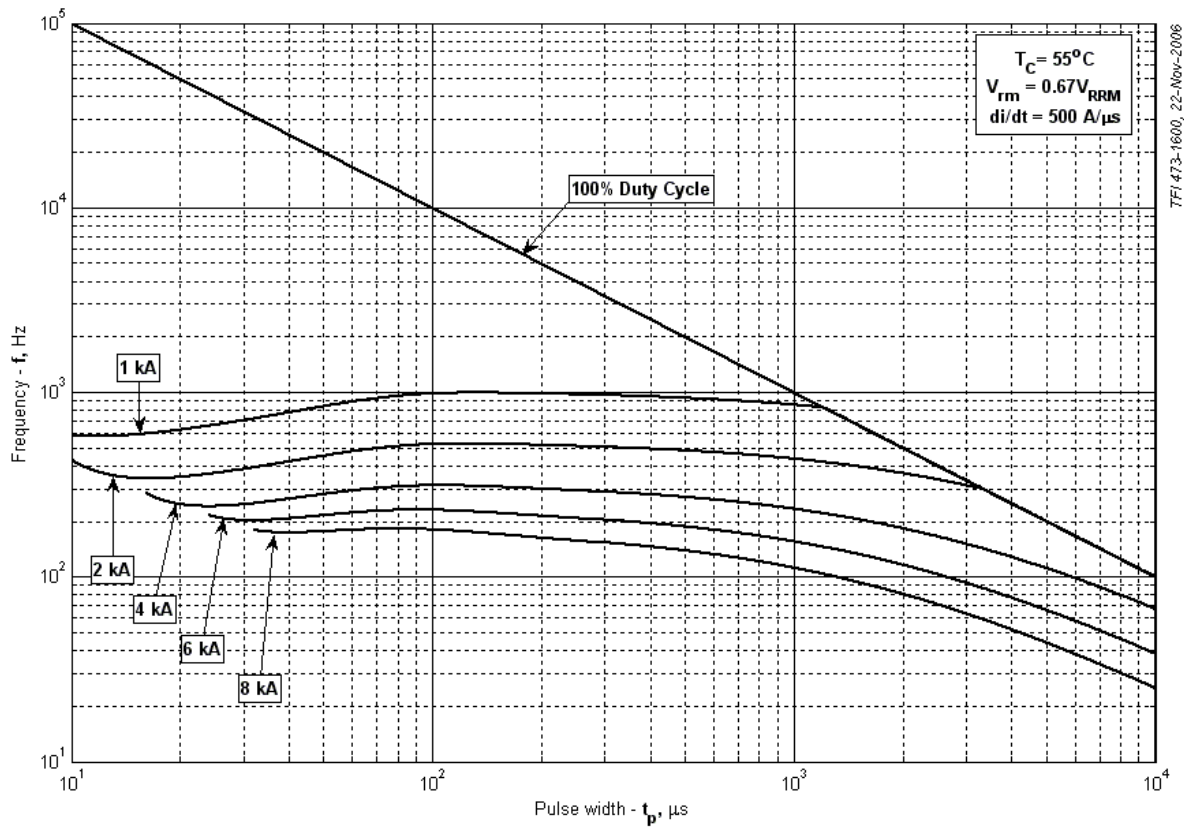


Fig 23 – Square wave frequency ratings

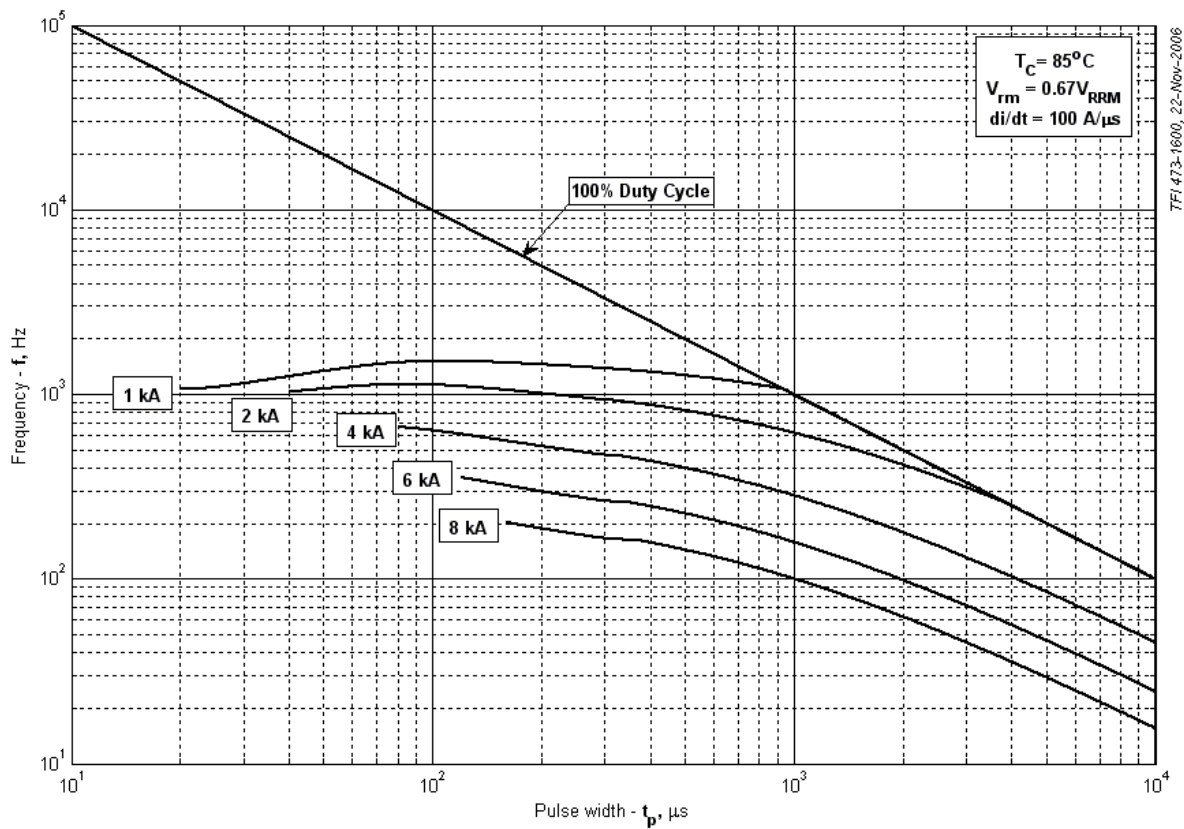


Fig 24 – Square wave frequency ratings

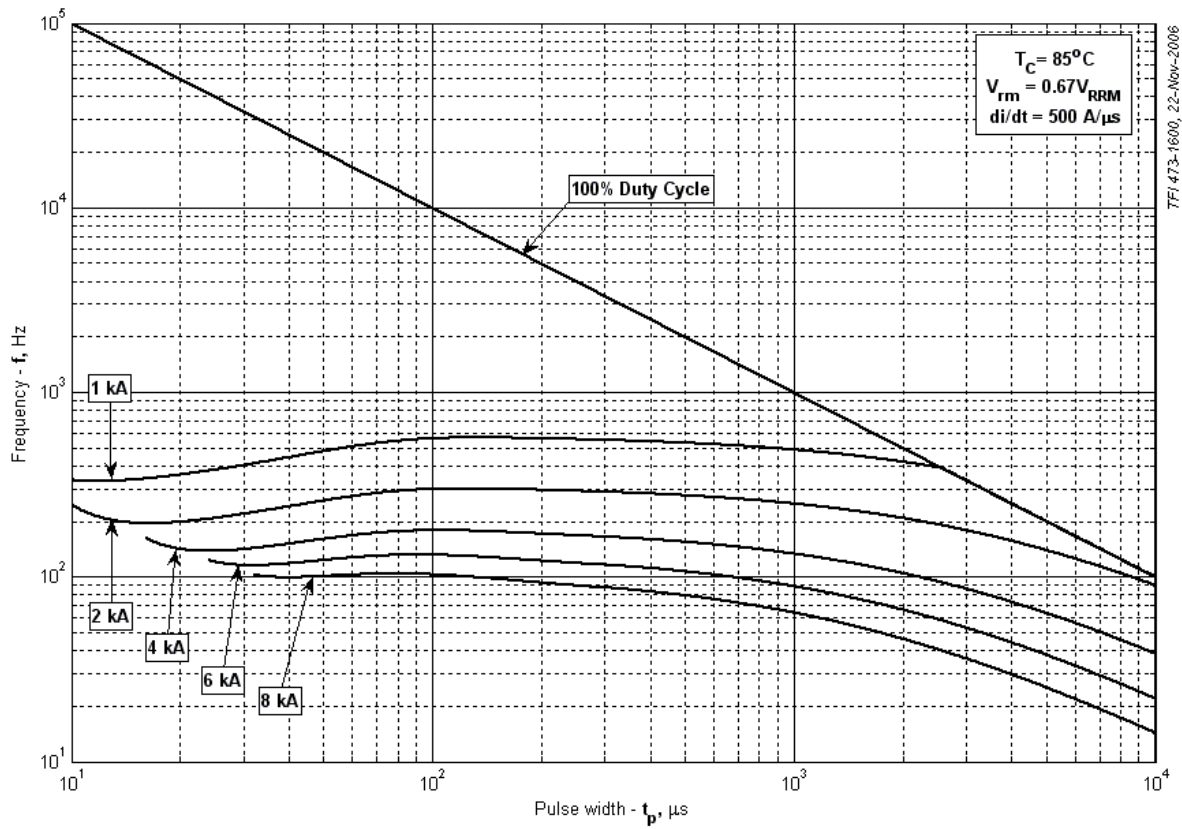


Fig 25 – Square wave frequency ratings

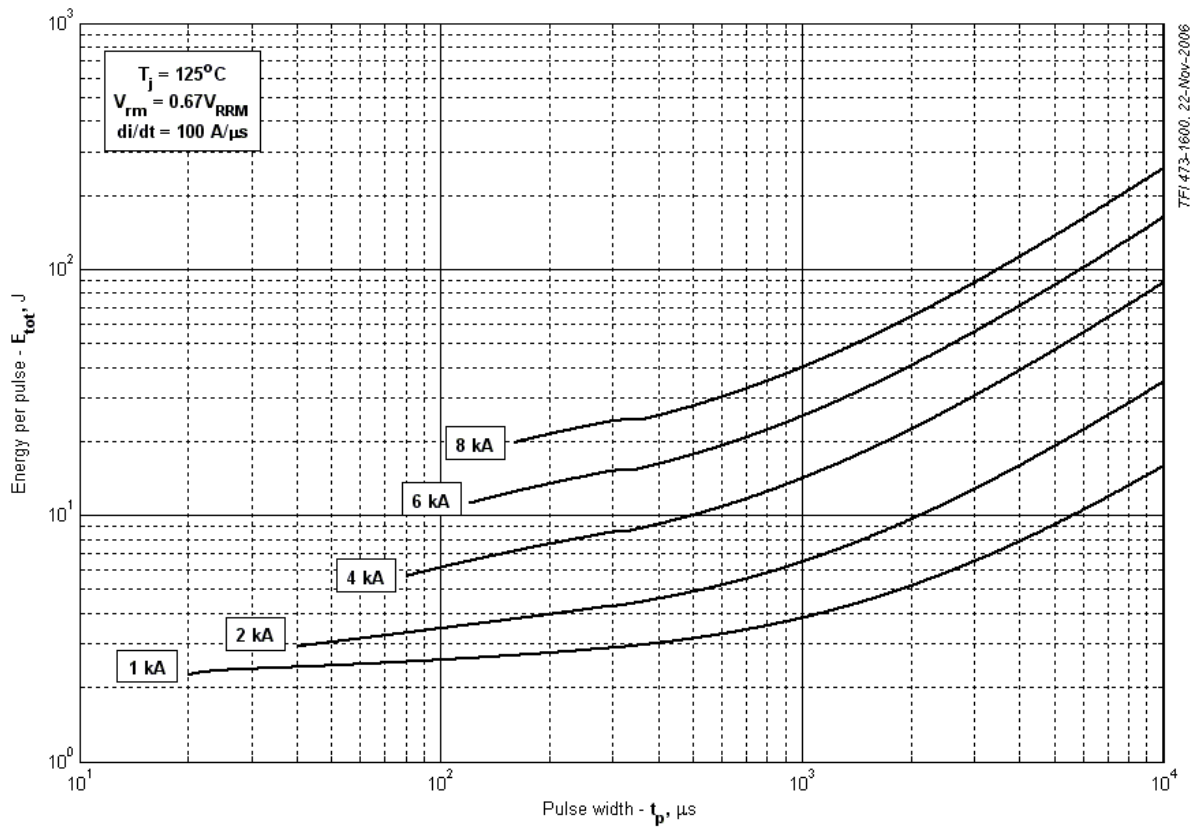


Fig 26 – Square wave energy per pulse

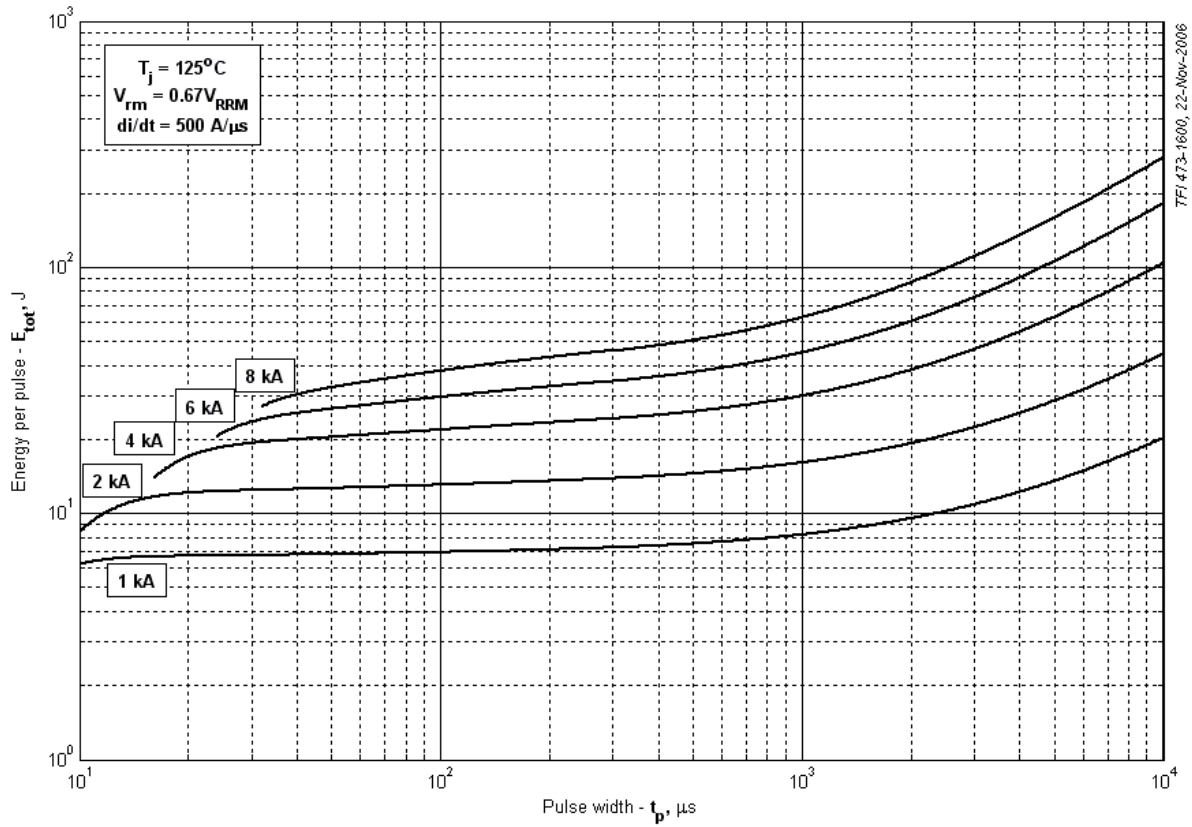


Fig 27 – Square wave energy per pulse

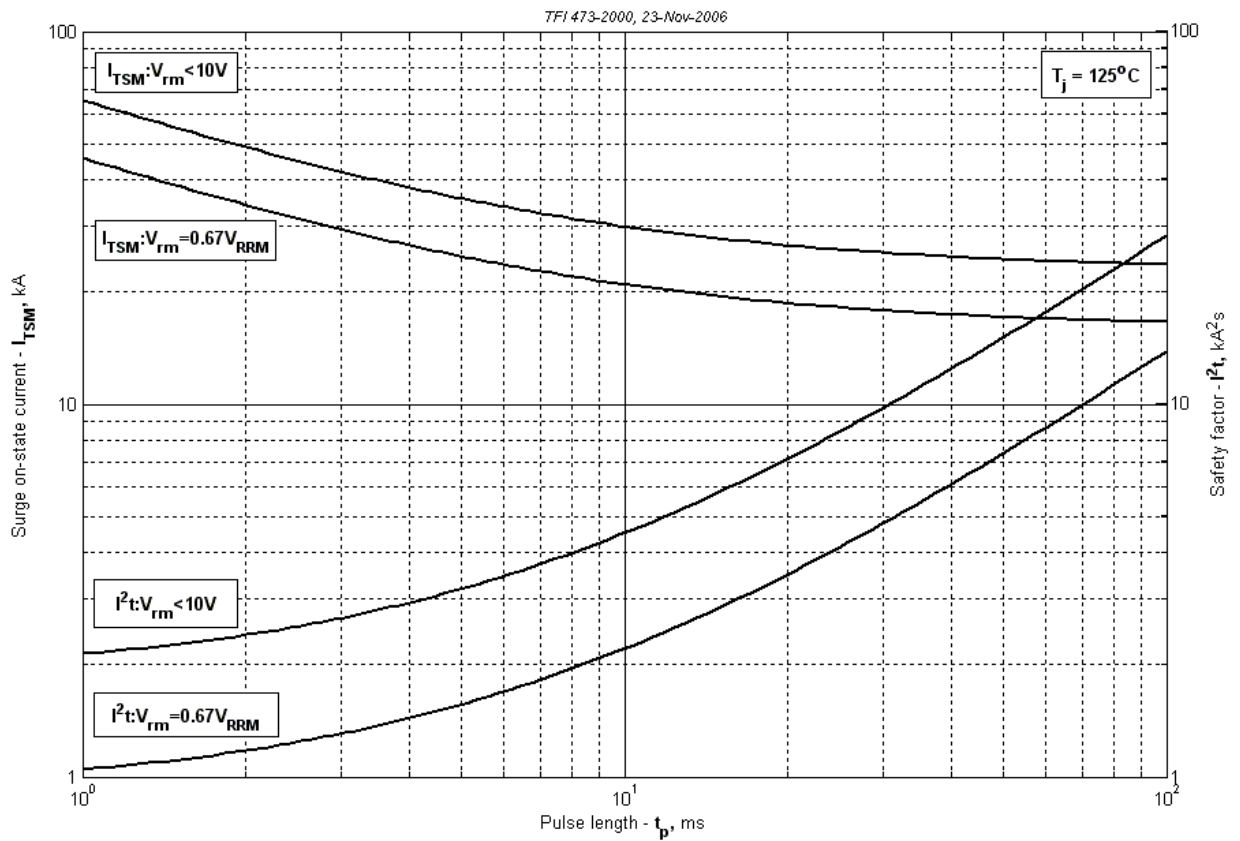


Fig 28 – Maximum surge and I^2t ratings

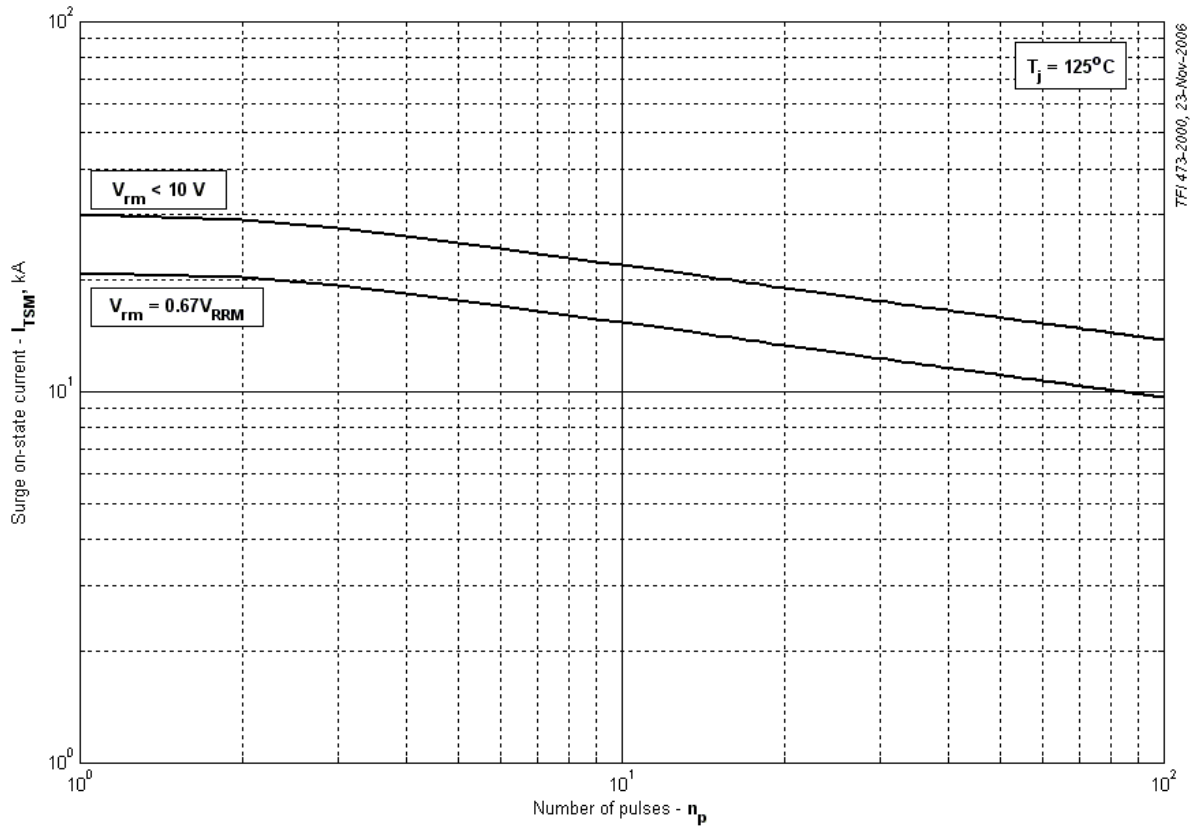


Fig 29 – Maximum surge ratings