# AN 6184

# Effective Thermal Resistance for Repetitive Waveforms

## Application Note

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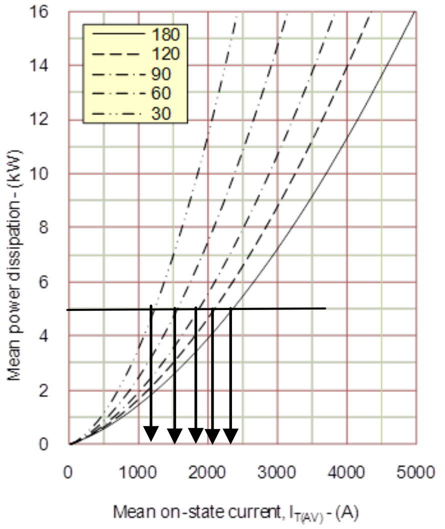


Fig.3 On-state power dissipation – sine wave

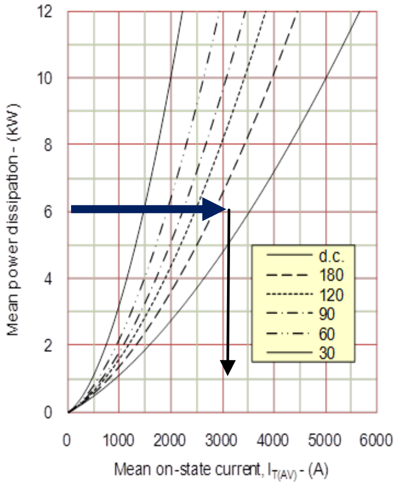


Fig.6 On-state power dissipation – rectangular wave

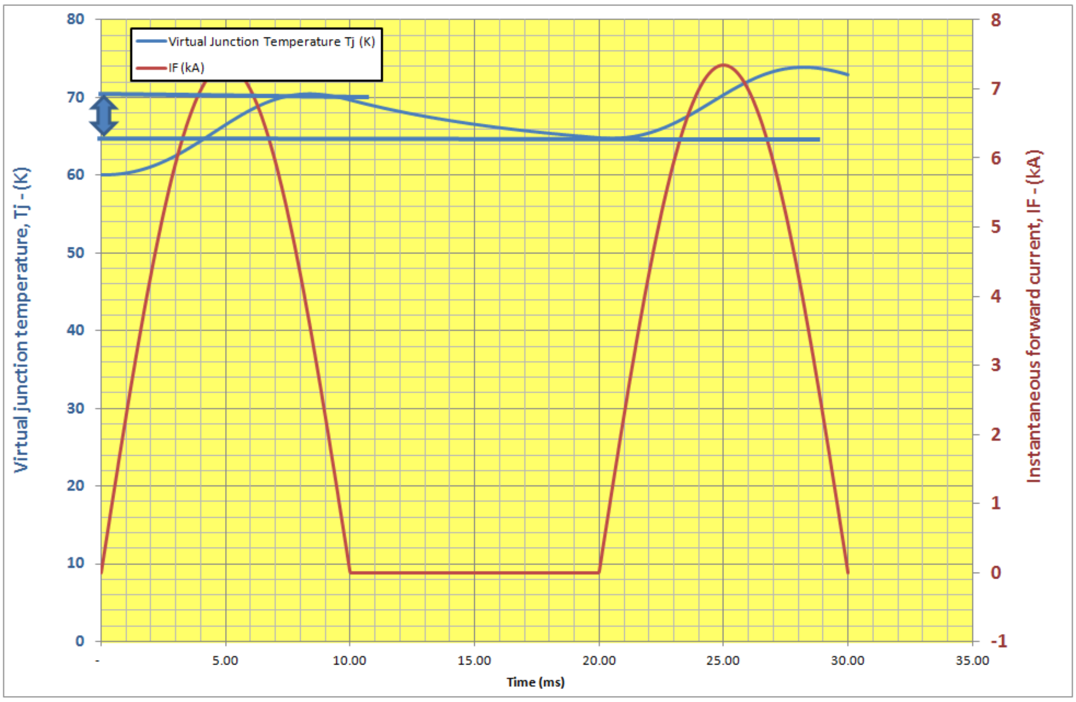
The above figures from a DCR3030V42 thyristor datasheet give the mean power dissipation for sine and square waves for a number of conduction angles. If we consider the square wave graph, fig 6, for d.c, we see that for a mean power of 5kW, the d.c. current is 3090A and for a case temperature of 60°C, the junction will be at 60°C + 5kW* Rth(dc)= 60°C + 5000W*0.00746°C/W or 97.3°C where 0.00746°C/W is the d.c. thermal resistance given in the datasheet under THERMAL AND MECHANICAL RATINGS.

For sine waves the de-rate curves in figure 3 of the datasheet give the following values of Average or Mean current to give 5kW of conduction losses.

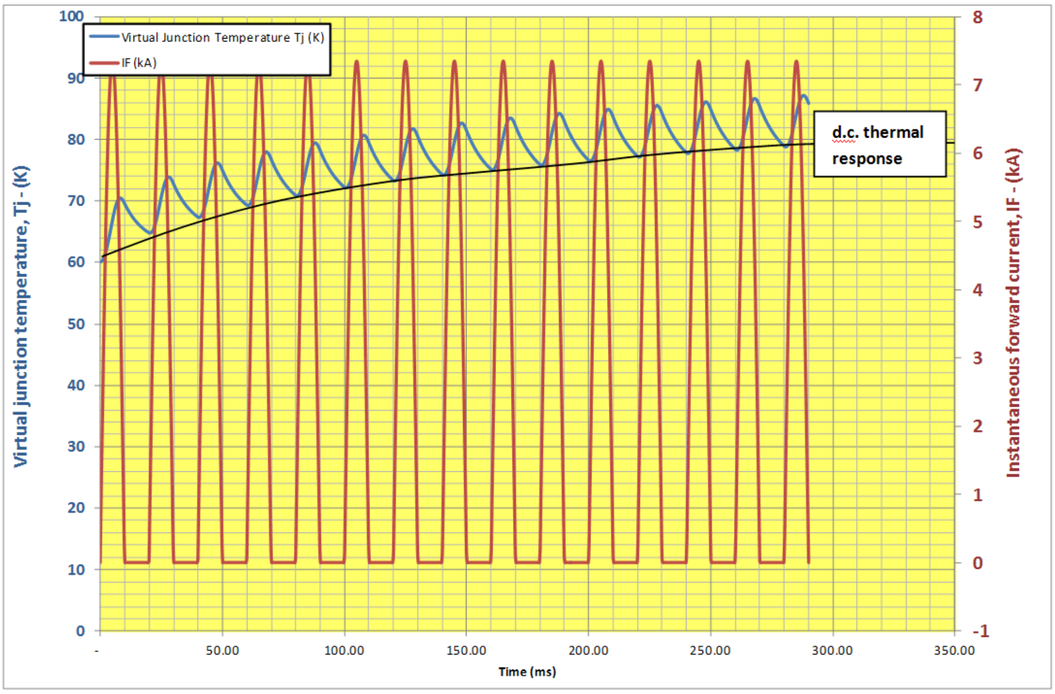
| Conduction angle | 180° | 120° | 90° | 60° | 30° | 15° |
|---|---|---|---|---|---|---|
| Mean current for 5kW | 2340 | 2080 | 1860 | 1550 | 1220 | 950 |
| Peak current at the delay angle for 5kW | 7.351kA | 8.713kA | 11.687kA | 16.827kA | 28.504kA | 44.626kA |

Note how, as the conduction angle decreases, the peak current, at the delay angle, necessary to give the mean current increases, leading to short pulses of power into the thyristor with longer time intervals between during which the thyristor will cool down.

If we look at the thermal response for the 180° case we see that the junction temperature vs time is variable with a ΔTj of ~ 6°C.

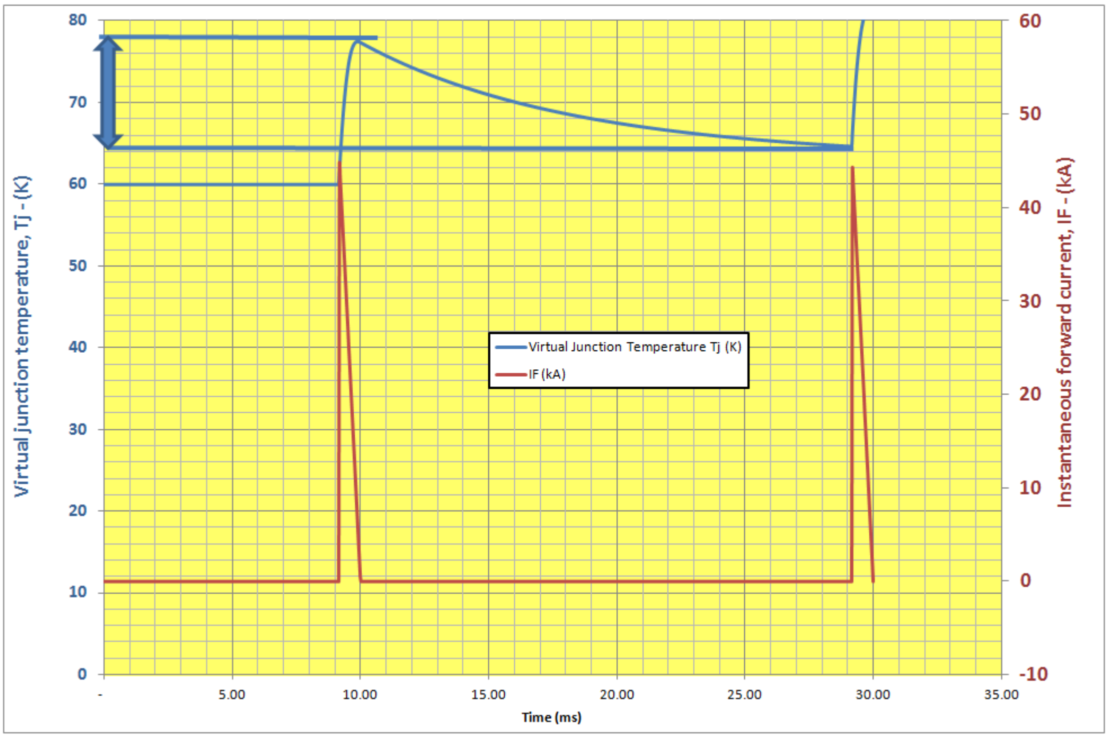


This continues to be seen when the device temperature has stabilised and the peak temperature is above the temperature that would be reached with 5kW d.c.



This gives rise to the concept of an Effective Thermal Resistance for repetitive waveforms.

For instance, consider a sine wave with 15° conduction angle. We now have a Δtj of ~14°C, so the Effective Thermal Resistance will be higher than for the 180° conduction angle case.



The Effective Thermal Resistance is usually presented in the data sheets in tables of actual values

| Conduction | Effective thermal resistance - junction to case °C/W | |
|---|---|---|
| d.c. | 0.00746 | 0.01300 |
| Half wave | 0.00880 | 0.01430 |
| 3 phase 120° | 0.00876 | 0.01426 |
| 6 phase 60° | 0.00927 | 0.01480 |

or increments on the d.c. value as below in the DCR3030V42 datasheet

| Double side cooling | | |
|---|---|---|
| | $\Delta Z_{th}$ (z) | |
| θ° | sine. | rect. |
| 180 | 1.34 | 0.88 |
| 120 | 1.57 | 1.30 |
| 90 | 1.83 | 1.54 |
| 60 | 2.08 | 1.81 |
| 30 | 2.27 | 2.11 |
| 15 | 2.36 | 2.28 |

| Anode Side Cooling | | |
|---|---|---|
| | $\Delta Z_{th}$ (z) | |
| θ° | sine. | rect. |
| 180 | 1.34 | 0.88 |
| 120 | 1.57 | 1.30 |
| 90 | 1.84 | 1.54 |
| 60 | 2.08 | 1.81 |
| 30 | 2.28 | 2.11 |
| 15 | 2.37 | 2.28 |

| Cathode Sided Cooling | | |
|---|---|---|
| | $\Delta Z_{th}$ (z) | |
| θ° | sine. | rect. |
| 180 | 1.33 | 0.88 |
| 120 | 1.57 | 1.29 |
| 90 | 1.83 | 1.53 |
| 60 | 2.07 | 1.80 |
| 30 | 2.26 | 2.10 |
| 15 | 2.35 | 2.26 |

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