

Applications

- Transient voltage protection
- High-voltage switches
- Crowbar
- Lasers
- Pulse generators



Application Note H - 6



Remark: For special selection of more than 2 pieces IXBOD 1-... for every break down voltage of $V_{BO} > 2000$ V please contact us.

Single Breakover Diode

$V_{BO} = 600-1000V$
 $I_{AVM} = 0.9 A$

| V_{BO} V | Standard Types |
|---------------|-------------------|
| 600 ±50 | IXBOD 1 -06 |
| 700 ±50 | IXBOD 1 -07 |
| 800 ±50 | IXBOD 1 -08 |
| 900 ±50 | IXBOD 1 -09 |
| 1000 ±50 | IXBOD 1 -10 |



| Symbol | Conditions | Rated Values |
|---------------|---|--------------------------|
| I_D | $T_{VJ} = 125^\circ C; V = 0,8x V_{BO}$ | 20 μA |
| V_{BO} | $V_{BO}(T_{VJ}) = V_{BO, 25^\circ C} [1 + K_T (T_{VJ} - 25^\circ C)]$ | |
| I_{RMS} | $f = 50 \text{ HZ}; T_{amb} = 50^\circ C$ connection pins soldered to printed circuit (conductor 0,035x2mm) | 1.4 A |
| I_{AVM} | | 0.9 A |
| I_{SM} | $t_p = 0.1 \text{ ms}; T_{amb} = 50^\circ C$ non repetitive | 200 A |
| I^2t | $t_p = 0.1 \text{ ms}; T_{amb} = 50^\circ C$ | 2 A^2s |
| T_{amb} | | -40...+125 $^\circ C$ |
| T_{stg} | | -40...+125 $^\circ C$ |
| T_{VJm} | | 125 $^\circ C$ |
| K_T | Temperatur coefficient of V_{BO} | $2 \cdot 10^{-3} K^{-1}$ |
| K_p | coefficient for energy per pulse E_p (material constant) | 700 K/Ws |
| R_{thJA} | - natural convection - with air speed 2 m/s | 60 K/W 45 K/W |
| Weight | | 1 g |

| Symbol | Conditions | Characteristic Values |
|--------------|---|-----------------------|
| I_{BO} | $T_{VJ} = 25^\circ C$ | 15 mA |
| I_H | $T_{VJ} = 25^\circ C$ | 30 mA |
| V_H | $T_{VJ} = 25^\circ C$ | 4 - 8 V |
| $(dv/dt)_c$ | $T_{VJ} = 50^\circ C; V_D = 0.67 \cdot (V_{BO} + 100V)$ | > 1000 $V/\mu s$ |
| $(di/dt)_c$ | $T_{VJ} = 125^\circ C; V_D = V_{BO}; I_T = 80A; f = 50 \text{ Hz}$ | 200 $A/\mu s$ |
| $t_{q(typ)}$ | $T_{VJ} = 125^\circ C; V_D = 0.67 \cdot V_{BO}; V_R = 0V$ $dV/dt_{(lin.)} = 200V/\mu s; I_T = 80A; di/dt = -10A/\mu s$ | 150 μs |
| V_T | $T_{VJ} = 125^\circ C; I_T = 5A$ | 1.7 V |
| $V_{(TO)}$ | For power-loss calculations only | 1.1 V |
| r_T | $T_{VJ} = 125^\circ C$ | 0.12 Ω |

Dimensions in mm (1 mm = 0.0394")





Fig. 1 Energy per pulse for trapezoidal current waveforms (see waveform definition).



Fig. 2 Energy per pulse for exponentially decaying current pulse (see waveform definition).



Fig. 3 On-state voltage



Fig. 4 Transient thermal resistance.

Breakover Diode Modules

Version: R

Version: RD

| V_{BO} V | Standard Types | BOD - Elements | V_{BO} V | Standard Types | BOD - Elements | V_{BO} V | Standard Types | BOD - Elements |
|---------------|-------------------|-------------------|---------------|-------------------|-------------------|---------------|-------------------|-------------------|
| 1200 ±50 | IXBOD 1 -12R(D) | 2 | 2000 ±50 | IXBOD 1 -20R(D) | 3 | 3400 ±100 | IXBOD 1 -34R | 4 |
| 1300 ±50 | IXBOD 1 -13R(D) | 2 | 2100 ±50 | IXBOD 1 -21R(D) | 3 | 3600 ±100 | IXBOD 1 -36R | 4 |
| 1400 ±50 | IXBOD 1 -14R(D) | 2 | 2200 ±50 | IXBOD 1 -22R(D) | 3 | 3800 ±100 | IXBOD 1 -38R | 4 |
| 1500 ±50 | IXBOD 1 -15R(D) | 2 | 2300 ±50 | IXBOD 1 -23R(D) | 3 | 4000 ±100 | IXBOD 1 -40R | 4 |
| 1600 ±50 | IXBOD 1 -16R(D) | 2 | 2400 ±50 | IXBOD 1 -24R(D) | 3 | 4200 ±100 | IXBOD 1 -42R | 4 |
| 1700 ±50 | IXBOD 1 -17R(D) | 2 | 2500 ±50 | IXBOD 1 -25R(D) | 3 | | | |
| 1800 ±50 | IXBOD 1 -18R(D) | 2 | 2600 ±100 | IXBOD 1 -26R(D) | 3 | | | |
| 1900 ±50 | IXBOD 1 -19R(D) | 2 | 2800 ±100 | IXBOD 1 -28R(D) | 3 | | | |
| | | | 3000 ±100 | IXBOD 1 -30R(D) | 3 | | | |
| | | | 3200 ±100 | IXBOD 1 -32R(D) | 3 | | | |

| Symbol | Test Conditions | 2 BODs | 3 BODs | 4 BODs | 2-3 BODs D-Version | |
|---------------|---|-------------------|-------------------|-------------------|---|------------------|
| I_D | $T_{VJ} = 125^\circ\text{C}; V = 0,8x V_{BO}$ | 100 | 100 | 100 | 100 | µA |
| V_{BO} | | | | | $V_{BO}(T_{VJ}) = V_{BO, 25^\circ\text{C}} [1 + K_T (T_{VJ} - 25^\circ\text{C})]$ | |
| I_{RMS} | f = 50 HZ; $T_{amb} = 50^\circ\text{C}$ connection pins soldered to printed circuit (conductor 0,035x2mm) | 2.0 | 1.4 | 1.1 | 0.3 | A |
| I_{AVM} | | 1.25 | 0.9 | 0.7 | 0.2 | A |
| I_{SM} | $t_p = 0.1 \text{ ms}; T_{amb} = 50^\circ\text{C}$ non repetitive | 200 | 200 | 200 | 50 | A |
| I^2t | $t_p = 0.1 \text{ ms}; T_{amb} = 50^\circ\text{C}$ | 2 | 2 | 2 | 0.125 | A ² s |
| V_T | $T_{VJ} = 125^\circ\text{C}; I_T = 5\text{A}$ | 3.4 | 5.1 | 6.8 | 27 | V |
| $V_{(TO)}$ | For power-loss calculations only | 2.2 | 3.3 | 4.4 | 17.5 | V |
| r_T | $T_{VJ} = 125^\circ\text{C}$ | 0.24 | 0.36 | 0.48 | 3 | Ω |
| T_{amb} | | -40...+125 | -40...+125 | -40...+125 | -40...+125 | °C |
| T_{stg} | | -40...+125 | -40...+125 | -40...+125 | -40...+125 | °C |
| T_{VJm} | | 125 | 125 | 125 | 125 | °C |
| K_T | Temperatur coefficient of V_{BO} | $2 \cdot 10^{-3}$ | $2 \cdot 10^{-3}$ | $2 \cdot 10^{-3}$ | $2 \cdot 10^{-3}$ | K ⁻¹ |
| K_p | coefficient for energy per pulse E_p (material constant) | 700 | 700 | 700 | 700 | K/Ws |
| R_{thJA} | - natural convection - with air speed 2 m/s | 20 16 | 20 16 | 20 16 | 20 16 | K/W K/W |
| Weight | typical | 14 | 14 | 14 | 14 | g |

| Symbol | Test Conditions | Characteristic Values <u>both</u> Versions R & RD | 2 BODs | 3 BODs | 4 BODs | |
|----------------------------|---|---|--------------------------------------|--------------------------------------|--------------------------------------|--|
| I_{BO} | $T_{VJ} = 25^\circ\text{C}$ | | 15 | 15 | 15 | mA |
| I_H | $T_{VJ} = 25^\circ\text{C}$ | | 30 | 30 | 30 | mA |
| V_H | $T_{VJ} = 25^\circ\text{C}$ | | 4 - 8 | 4 - 8 | 4 - 8 | V |
| (dv/dt)_c | $T_{VJ} = 50^\circ\text{C}; V_D = 0.67 \cdot (V_{BO} + 100\text{V})$ - V_{BO} bis 1500V - V_{BO} 1600 - 2000V - V_{BO} 2100 - 2500V - V_{BO} 2600 - 3000V - V_{BO} 3200 - 3400V - V_{BO} 3600 - 4200V | | > 1000 > 1500 - - - - | - - > 2000 > 2500 - - | - - - - > 3000 > 3500 | V/µs V/µs V/µs V/µs V/µs V/µs |
| (di/dt)_c | $T_{VJ} = 125^\circ\text{C}; V_D = V_{BO}; I_T = 80\text{A}; f = 50 \text{ Hz}$ | | 200 | 200 | 200 | A/µs |
| $t_{q(\text{typ})}$ | $T_{VJ} = 125^\circ\text{C}; V_D = 0.67 \cdot V_{BO}; V_R = 0\text{V}$ $dv/dt_{(\text{lin.})} = 200\text{V}/\mu\text{s}; I_T = 80\text{A}; di/dt = -10\text{A}/\mu\text{s}$ | | 150 | 150 | 150 | µs |



Dimensions in mm (1 mm = 0.0394")



Fig. 5 Energy per pulse for single BOD element for trapezoidal wave current. E_p must be multiplied by number of elements for total energy.



Fig. 6 Energy per pulse for single BOD element for exponentially decaying current pulse. E_p must be multiplied by number of elements for total energy.



Fig. 7 On-state voltage at $T_{VJ} = 125^\circ\text{C}$.



Fig. 8 Transient thermal resistance.

Application

Protection of thyristors against overvoltages in forward direction.

$$V_{BO}(T_{VJ}) = V_{BO, 25^{\circ}C} [1 + KT(T_{VJ} - 25^{\circ}C)]$$



Calculation example

a. The maximum junction temperature shall be calculated for a module IXBOD 1 -30R at an ambient temperature $T_a = 60^{\circ}C$, an exponentially decaying current $I_{TM} = 40A$, a pulsewidth $t_p = 2 \mu s$, an operating frequency $f = 50 \text{ Hz}$ and natural convection. From the diagram Fig. 6 the energy per pulse is obtained:

$$E_{p1} = 6 \times 10^{-3} \text{ Ws}$$

For a module IXBOD1-30R the number of single IXBOD elements is:

$$n = 3$$

At natural air cooling the thermal resistance junction to ambient amounts to (Fig.8):

$$R_{thJA} = 20K/W$$

and the unknown temperature can be calculated as:

$$T_{VJmax1} = T_a + n \cdot f \cdot E_p \cdot R_{thJA} + K_p \cdot E_p$$

$$T_{VJmax1} = 60 + 18 + 4.2 = 82.2^{\circ}C$$

b. If following these steady-state conditions an overload for 1 minute occurs with $I_{TM} = 60 \text{ A}$ and a pulse-width $t_p = 4 \mu s$ at the same operating frequency $f = 50 \text{ Hz}$, then the resulting maximum junction temperature is calculating as follows:

$$T_{VJmax2} = T_{VJmax1} + (E_{p2} - E_{p1}) \cdot n \cdot f \cdot Z_{thJA}(t) + K_p \cdot (E_{p2} - E_{p1})$$

The diagrams Fig. 11 and Fig. 8 show

$$E_{p2} = 14 \times 10^{-3} \text{ Ws}$$

$$Z_{thJA}(t = 1\text{min}) = 12K/W$$

From what follows:

$$T_{VJmax2} = 82.2 + 14.4 + 5.6 = 102.2^{\circ}C$$

which is allowed because the maximum admissible junction temperature $T_{VJM} = 125^{\circ}C$.

Example of a circuit

A simple emergency triggering circuit.

- T : Thyristor
- R_1 : Current limiting resistance (0 - 200 Ω)
- D_1 : Series-diode (fast recovery diode)
- D_3 : Protection diode
- D_4 : Zener diode, typical V_Z : 3-6 V
- R_2, C_2 : Protection against parasitic triggering;
recommended values:
 R_2 : 100 - 1000 Ω
 C_2 : 22 - 47 nF
- R_3, C_3 : Snubber network of the thyristor



Notice

1. A IXBOD element has a maximum reverse blocking voltage of 10V.
2. For higher reverse voltages a fast, soft recovery diode must be connected in series (Fig. 9). This diode must fulfill the conditions of Fig. 10.



Fig. 9 IXBOD protection by a fast recovery diode.



Fig. 10 Maximum peak value of the reverse current admissible for a given pulse-width t_B , which is required for the suitable fast recovery series-diode.



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