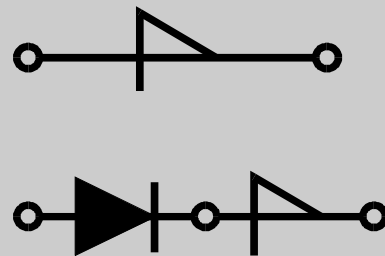


## Applications

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



Application Note H - 6



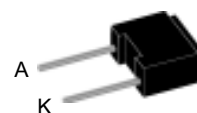
**Remark:** For special selection of more than 2 pieces IXBOD 1-... for every break down voltage of  $V_{BO} > 2000 \text{ V}$  please contact us.

# Single Breakover Diode

$$V_{BO} = 600-1000V$$

$$I_{AVM} = 0.9 A$$

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

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

Dimensions in mm (1 mm = 0.0394")

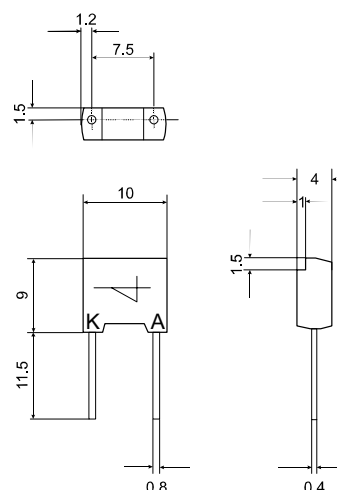




Fig. 1 Energy per pulse for trapezoidal current waveforms (see waveform definition).



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



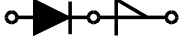
Fig. 3 On-state voltage



Fig. 4 Transient thermal resistance.

# Breakover Diode Modules

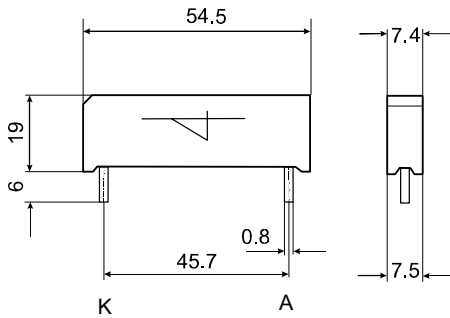
Version: R 

Version: RD 

| $V_{BO}$<br>V | Standard<br>Types | BOD -<br>Elements | $V_{BO}$<br>V | Standard<br>Types | BOD -<br>Elements | $V_{BO}$<br>V | Standard<br>Types | BOD -<br>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<br>D-Version                                                                 |
|------------|---------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------|-------------------|---------------------------------------------------------------------------------------|
| $I_D$      | $T_{VJ} = 125^{\circ}\text{C}; V = 0,8x V_{BO}$                                                                           | 100               | 100               | 100               | 100 $\mu\text{A}$                                                                     |
| $V_{BO}$   |                                                                                                                           |                   |                   |                   | $V_{BO}(T_{VJ}) = V_{BO, 25^{\circ}\text{C}} [1 + K_T (T_{VJ} - 25^{\circ}\text{C})]$ |
| $I_{RMS}$  | $f = 50 \text{ Hz}; T_{amb} = 50^{\circ}\text{C}$<br>connection pins soldered to printed circuit<br>(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 $\text{A}^2\text{s}$                                                            |
| $V_T$      | $T_{VJ} = 125^{\circ}\text{C}; I_T = 5 \text{ A}$                                                                         | 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 $\Omega$                                                                            |
| $T_{amb}$  |                                                                                                                           | -40...+125        | -40...+125        | -40...+125        | -40...+125 $^{\circ}\text{C}$                                                         |
| $T_{stg}$  |                                                                                                                           | -40...+125        | -40...+125        | -40...+125        | -40...+125 $^{\circ}\text{C}$                                                         |
| $T_{VJm}$  |                                                                                                                           | 125               | 125               | 125               | 125 $^{\circ}\text{C}$                                                                |
| $K_T$      | Temperatur coefficient of $V_{BO}$                                                                                        | $2 \cdot 10^{-3}$ | $2 \cdot 10^{-3}$ | $2 \cdot 10^{-3}$ | $2 \cdot 10^{-3} \text{ K}^{-1}$                                                      |
| $K_p$      | coefficient for energy per pulse $E_p$ (material constant)                                                                | 700               | 700               | 700               | 700 K/Ws                                                                              |
| $R_{thJA}$ | - natural convection<br>- with air speed 2 m/s                                                                            | 20<br>16          | 20<br>16          | 20<br>16          | 20<br>16 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                                               |
| $(dv/dt)_c$  | $T_{VJ} = 50^{\circ}\text{C}; V_D = 0.67 \cdot (V_{BO} + 100\text{V})$<br>- $V_{BO}$ bis 1500V<br>- $V_{BO}$ 1600 - 2000V<br>- $V_{BO}$ 2100 - 2500V<br>- $V_{BO}$ 2600 - 3000V<br>- $V_{BO}$ 3200 - 3400V<br>- $V_{BO}$ 3600 - 4200V |                                                   | > 1000<br>> 1500<br>-<br>-<br>-<br>- | -<br>-<br>> 2000<br>> 2500<br>-<br>- | -<br>-<br>-<br>-<br>> 3000<br>> 3500 V/ $\mu\text{s}$ |
| $(di/dt)_c$  | $T_{VJ} = 125^{\circ}\text{C}; V_D = V_{BO}; I_T = 80 \text{ A}; f = 50 \text{ Hz}$                                                                                                                                                   |                                                   | 200                                  | 200                                  | 200 A/ $\mu\text{s}$                                  |
| $t_{q(typ)}$ | $T_{VJ} = 125^{\circ}\text{C}; dv/dt_{(lin.)} = 200 \text{ V}/\mu\text{s}; I_T = 80 \text{ A}; di/dt = -10 \text{ A}/\mu\text{s}$                                                                                                     |                                                   | 150                                  | 150                                  | 150 $\mu\text{s}$                                     |



Dimensions in mm (1 mm = 0.0394")

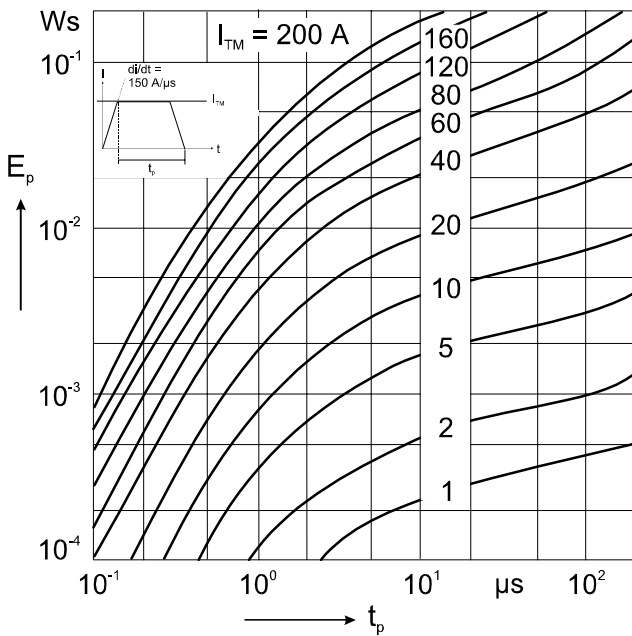
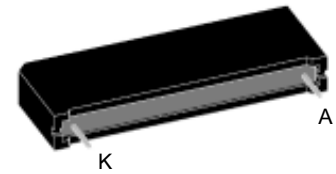


Fig. 5 Energy per pulse for single BOD element for trapezoidal wave current.  $E_p$  must be multiplied by number of elements for total energy.

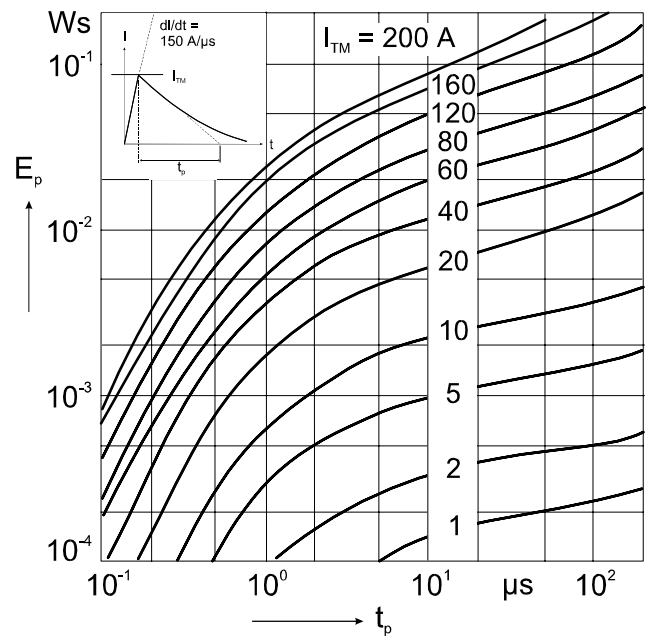


Fig. 6 Energy per pulse for single BOD element for exponentially decaying current pulse.  $E_p$  must be multiplied by number of elements for total energy.

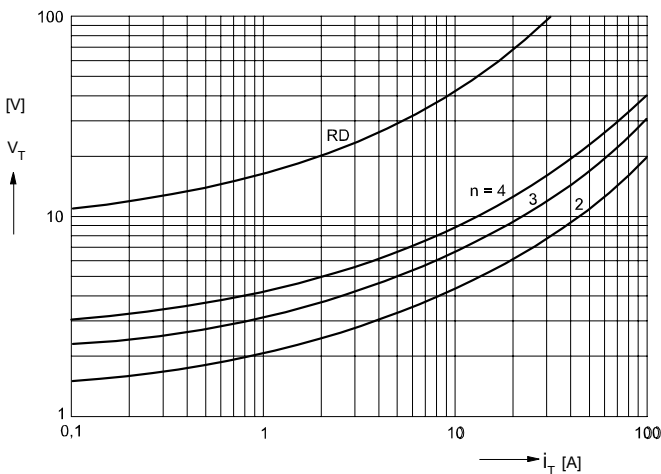


Fig. 7 On-state voltage at  $T_{VJ} = 125^\circ\text{C}$ .

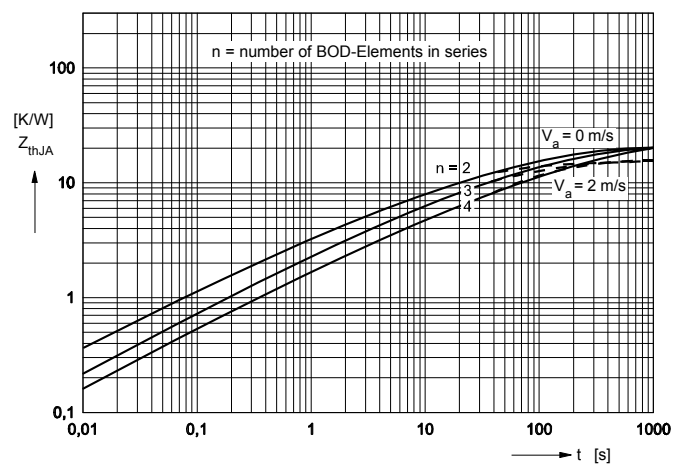


Fig. 8 Transient thermal resistance.

## 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  $I_{TM} = 60 A$  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  $\Omega$ )  
 $D_1$  : 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  $\Omega$   
 $C_2$ : 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.

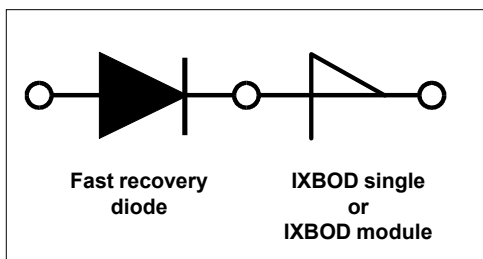


Fig. 9 IXBOD protection by a fast recovery diode.



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.

