

## CALCULATION OF TRANSIL APPARENT DYNAMIC RESISTANCE

B. Rivet

### 1 - INTRODUCTION

To estimate the clamping voltage  $V_{CL}$  and the dissipated power in a TRANSIL we need the apparent dynamic resistance of the device,  $rd$ .

This value depends on :

- The thermal impedance and therefore the package
- The breakdown voltage  $V_{BR}$
- The pulse current duration  $tp$  (standard exponential pulse).

The purpose of this note is to explain the means of calculating  $rd$ .

### 2 - EXPRESSION OF THE DYNAMIC RESISTANCE $R_d$

$rd$  is defined by the formula :

$$rd = (V_{CL} - V_{BR}) / I_{pp}$$

Where  $V_{CL}$  is the peak voltage at  $I_{pp}$  and  $V_{BR}$  is the breakdown voltage of the TRANSIL measured at a low level of current ( 1mA)

There are two distinct cases :

- $tp$  lower than 1 ms
- $tp$  higher than 1 ms

#### a) $rd(tp)$ with $tp < 1$ ms

In the data sheet  $V_{CL\ max}$  is specified at  $tp = 20\ \mu s$  and 1 ms.

We can thus estimate  $rd_{20\ \mu s}$  and  $rd_{1ms}$  with the following formula :

$$rd_{20\ \mu s} = \frac{V_{CL\ max}(20\ \mu s) - V_{BR\ nom}}{I_{pp}(20\ \mu s)} \quad (1)$$

$$rd_{1ms} = \frac{V_{CL\ max}(1\ ms) - V_{BR\ nom}}{I_{pp}(1\ ms)} \quad (2)$$

For  $tp$  between 20  $\mu s$  and 1ms we can calculate  $rd(tp)$  as

$$(3) \quad rd(tp) = \frac{rd_{1ms} - rd_{20\ \mu s}}{980} [tp - 20] + rd_{20\ \mu s}$$

with  $rd$  in ohms and  $tp$  in  $\mu s$ .

The apparent dynamic resistance decreases when the duration decreases. For  $tp < 20\ \mu s$  we can use a constant value equal to  $rd$  calculated for 20  $\mu s$  (relation (1)). This is a pessimistic rule.

#### b) $rd(tp)$ with $tp > 1$ ms

SGS-THOMSON TRANSILS are built with one chip for the low voltage parts and with two chips in series for the high voltage ones. The two cases need to be considered separately.

##### b.1. Low voltage devices

(Up to 213 V for BZW series and up to 220 V for KE series).

Using thermal criteria we obtain the typical dynamic resistance  $rd_{TYP}$  for  $tp$  higher than 1ms:

$$(4) \quad rd_{typ} = \alpha_T R_{th} [1 - \exp(-tp/\tau)]^B V_{BR}^2 nom$$

**Where:**

- $\alpha_T$  is the temperature coefficient of  $V_{BR}$ . It can be found in the protection devices databook.
- $R_{th}$ ,  $\tau$ ,  $B$  define the transient thermal impedance  $Z_{th}$ .

The curve  $Z_{th} = f(tp)$  is given in the data sheet.

## APPLICATION NOTE

$R_{th}$ ,  $\tau$ ,  $B$  depend on the package. Their values, assuming that the device is mounted on a printed circuit board, are grouped together in the following table.

PACKAGE	FAMILY	B	T (s)	$R_{th}$ (°C/W)
F126	BZW04	0.41	150	100
F126	BZW06	0.43	150	100
CB429	1.5KE	0.49	150	75
AG	BZW50	0.63	120	65

### b.2. High voltage devices

(Over 213 V for BZW series and over 220 V for KE series)

In this case, the following formula is used :

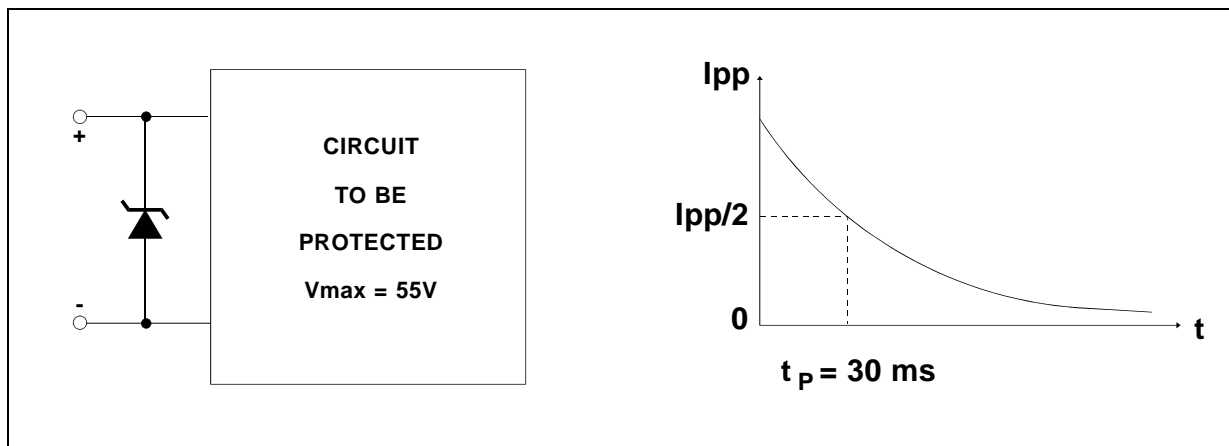
$$rd_{TYP} = \frac{\alpha_T}{2} R_{th} \left[ 1 - \exp\left(\frac{-t_p}{T}\right) \right]^B V_{BR}^2 nom \quad (5)$$

**Note :** To estimate the maximum value of  $V_{CL}$  and the peak power in the TRANSIL we have to use a coefficient  $k$  to take into account the dispersion of the various parameters ( $rd_{max} = k rd_{TYP}$ ).  $k = 2$  is recommended.

### 3 - EXAMPLE OF APPLICATION : CHOICE OF A TRANSIL

Assume the surge current in the TRANSIL is an exponential pulse with  $I_{pp} = 3A$  and  $t_p = 30ms$ . In the application (Fig.2) we have to check that

**Figure 2 : Application Diagram**



$V_{RM} > V_{CC} = 30V$  and  $V_{CL} max < 55V$  with a maximum ambient temperature of  $50\text{ }^{\circ}C$ .

Try to use a 1.5KE36 P  
The data sheet gives :

$$\begin{aligned} V_{RM} &= 30.8V (>30V) \\ V_{BR} max &= 39.6V \\ V_{BR} nom &= 36V \\ \alpha_T &= 9.9 \times 10^{-4} /^{\circ}C \end{aligned}$$

The table Fig.1 gives :

$$\begin{aligned} R_{th} &= 75^{\circ}C/W \\ \tau &= 150s \\ B &= 0.49 \end{aligned}$$

With the relation (4) we find :

$$\begin{aligned} rd_{TYP} &= 1.5 \text{ Ohm} \\ rd_{max} &= 3 \text{ Ohms} \end{aligned}$$

$$V_{CL} max = V_{BR} max (1 + \alpha_T (T_{amb} max - 25)) + rd_{max} I_{pp} = 50.2V$$

$$V_{CL} max = 50.2V < 55V$$

$$P_P = V_{CL} max \times I_{pp} = 148.8W$$

The 1.5KE TRANSIL datasheet (curves Fig.1 and Fig.3) indicates (at  $50^{\circ}C$  for a duration of 30ms) a maximum dissipation of  $90\% \times 200W = 180W$

So a 1.5KE36P can be used in this application.

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