SGS-THOMSON MICROELECTRONICS

APPLICATION NOTE

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 Rd

rd is defined by the formula :

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

Where V_{CL} is the peak voltage at Ipp 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 µs 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 µs 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 µs.

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

b) rd(tp) with tp > 1ms

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:

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

Where:

- α_T is the temperature coefficient of V_{BR}. It can be found in the protection devices databook.
- Rth, τ, B define the transient thermal impedance Zth.

The curve Zth = f(tp) is given in the data sheet.

Rth, τ, 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)	Rth (°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 tp = 30ms. In the application (Fig.2) we have to check that $V_{RM} > V_{CC}$ = 30V and V_{CL} max < 55V with a maximum ambient temperature of 50 °C.

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

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

The table Fig.1 gives :

R_{th} = 75°C/W
τ = 150s
B = 0.49

With the relation (4) we find :

rd $_{TYP}$ = 1.5 Ohm
rd max = 3 Ohms

V_{CL} max = V_{BR} max (1+α_T (T_{amb} max -25)) + rd max I_{pp} = 50.2V

V_{CL} max = 50.2V < 55V

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

The 1.5KE TRANSIL datasheet (curves Fig.1 and Fig.3) indicates (at 50C for a duration of 30ms) a maximum dissipation of 90% x 200W = 180W

So a 1.5KE36P can be used in this application.

Figure 2 : Application Diagram