



AN575

APPLICATION NOTE

CALCULATION OF TRANSIL APPARENT DYNAMIC RESISTANCE

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 .

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 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_{CLmax} 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:

(1)

$$rd_{20\mu s} = \frac{V_{CLmax}(20\mu s) - V_{BRnom}}{I_{pp}(20\mu s)}$$

(2)

$$rd_{1ms} = \frac{V_{CLmax}(1ms) - V_{BRnom}}{I_{pp}(1ms)}$$

For tp between 20 ms and 1ms we can calculate $rd(tp)$ as:

(3)

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

with rd in ohms and tp in μs .

AN575 APPLICATION NOTE

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

b) $r_d(t_p)$ with $t_p > 1ms$

STMicroelectronics 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 r_d TYP for t_p higher than 1ms:

(4)

$$r_{d\text{ typ}} = \alpha_T R_{th} [1 - \exp(-t_p / \tau)]^B V_{BR}^2 \text{ nom}$$

Where:

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

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

R_{th} , 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.

Table 1.

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:

(5)

$$r_{d\text{ typ}} = \frac{\alpha_T}{2} R_{th} \left[1 - \exp\left(\frac{-t_p}{T}\right) \right]^B V_{BR}^2 \text{ nom}$$

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 ($r_{d\text{ max}} = k r_{d\text{ TYP}}$). $k = 2$ is recommended.

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 (Figure 1) we have to check that $V_{RM} > V_{CC} = 30V$ and $V_{CL\ max} < 55V$ with a maximum ambient temperature of $50\ ^\circ C$.

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 Figure1 gives:

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

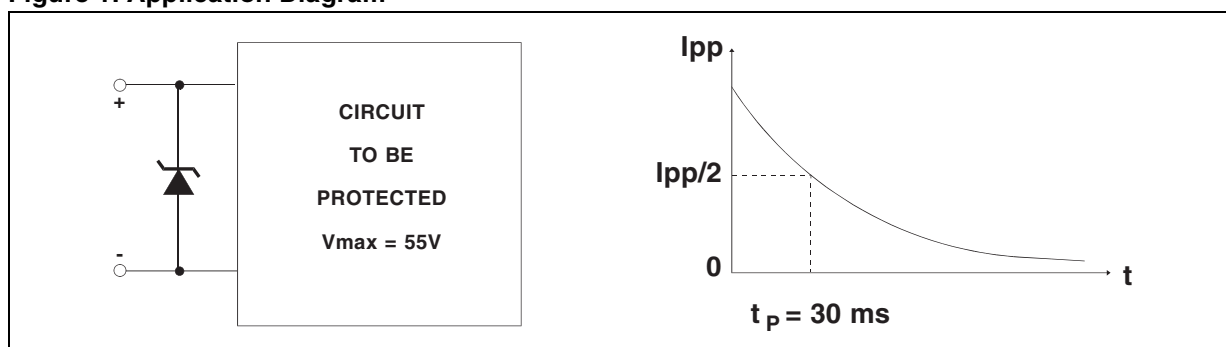
With the relation (4) we find:

$$\begin{aligned} r_{d\ TYP} &= 1.5\ \text{Ohm} \\ r_{d\ max} &= 3\ \text{Ohms} \\ V_{CL\ max} &= V_{BR\ max} (1 + \alpha_T (T_{amb\ max} - 25)) + r_{d\ max} I_{pp} = 50.2V \\ V_{CL\ max} &= 50.2V < 55V \\ P_P &= V_{CL\ max} \times I_{pp} = 148.8W \end{aligned}$$

The 1.5KE TRANSIL datasheet (curves Figure 1 and Figure 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.

Figure 1. Application Diagram



AN575 APPLICATION NOTE

REVISION HISTORY

Table 2. Revision History

Date	Revision	Description of Changes
March-1993	1	First Issue
13-May-2004	2	Stylesheet update. No content change.

Information furnished is believed to be accurate and reliable. However, STMicroelectronics assumes no responsibility for the consequences of use of such information nor for any infringement of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of STMicroelectronics. Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. STMicroelectronics products are not authorized for use as critical components in life support devices or systems without express written approval of STMicroelectronics.

The ST logo is a registered trademark of STMicroelectronics.
All other names are the property of their respective owners

© 2004 STMicroelectronics - All rights reserved

STMicroelectronics GROUP OF COMPANIES

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan -
Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States

www.st.com