AN587
APPLICATION NOTE

TRANSISTOR PROTECTION BY TRANSIL™

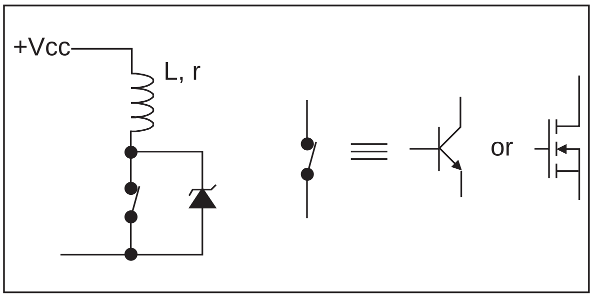
B.RIVET

INTRODUCTION

In a large number of applications, we find the circuit in Fig. 1 where a TRANSIL™ is used to protect a switch that controls an inductive load. The switch can be a bipolar or a MOS transistor.

The purpose of this paper is to calculate the dissipated power in the TRANSIL™ and the pulse current duration.

Fig. 1: Basic diagram

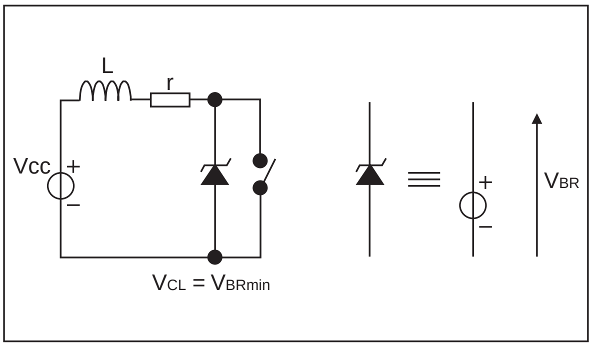


1. CIRCUIT MODELLING

When the switch turns off we use the equivalent circuit represented in Fig. 2.

The worst case is to consider $V_{CL} = V_{BR\ min}$. This hypothesis will be used in all formulae.

Fig. 2: Equivalent Circuit



V_{CL}	Clamping voltage
V_{BR}	Breakdown voltage

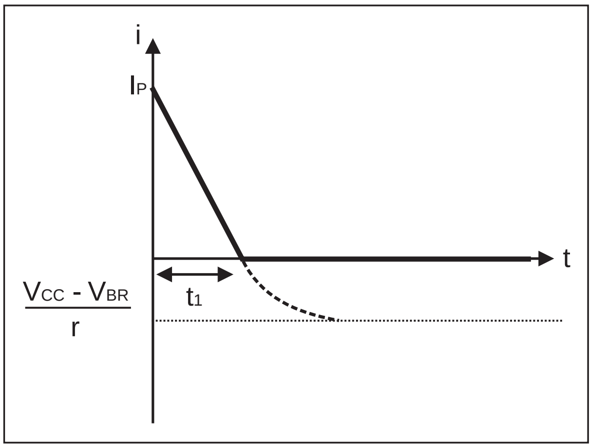
2. CURRENT IN THE TRANSIL

We can express the current i through the TRANSIL by the following formula:

$$i = \left(I_P + \frac{V_{BR\ min} - V_{cc}}{r}\right)\exp\left(-r \times t/L\right) + \left(\frac{V_{cc} - V_{BR\ min}}{r}\right)$$

I_p is the current through the coil when the transistor switches off. Fig. 3 shows the current variation versus time.

Fig. 3: Current Waveform



t_1 can be calculated by:

$$t_1 = -\frac{L}{r} \times ln\left(\frac{V_{BR\ min} - V_{cc}}{V_{BR\ min} - V_{cc} + rI_p}\right)$$

3. TRANSIL POWER DISSIPATION

We can consider two cases, single pulse operation and repetitive pulse operation.

3.1. Single pulse operation

In this case, in order to define a TRANSIL we need the peak power P_P and the pulse current standard duration t_P.

Pp is given by: $P_P = V_{BR\ min} \times I_P$

If we approximate the pulse current with a triangle, the standard exponential equivalent pulse duration tp is calculated by the formula:

$$t_P = -\left(14\frac{L}{2r}\right) \times ln\left(\frac{V_{BR\ min} - V_{cc}}{V_{BR\ min} - V_{cc} + rI_P}\right)$$

The energy in the TRANSIL can be expressed by:

$$W = \left(\frac{V_{BR\ min} \times L}{r}\right) \times \left[I_P + \left(\frac{V_{BR\ min} - V_{cc}}{r}\right) ln\left(\frac{V_{BR\ min} - V_{cc}}{V_{BR\ min} - V_{cc} + rI_P}\right)\right]$$

When r tends to zero we find:

$$W = \frac{1}{2} L I_P^2 \left(\frac{V_{BR\ min}}{V_{BR\ min} - V_{cc}}\right)$$

3.2. Repetitive pulse operation

In repetitive pulse operation the power dissipation can be calculated by the following formula:

$$P = F \times \left(\frac{V_{BR\ min} \times L}{r}\right) \times \left[I_P + \left(\frac{V_{BR\ min} - V_{cc}}{r}\right) ln\left(\frac{V_{BR\ min} - V_{cc}}{V_{BR\ min} - V_{cc} + rI_P}\right)\right]$$

When r tends to zero we find:

$$P = \frac{1}{2} F L I_P^2 \left(\frac{V_{BR\ min}}{V_{BR\ min} - V_{cc}}\right)$$

Where F is the switching frequency.

4. EXAMPLE OF APPLICATION

A typical application would be a switched coil supplied by a battery. The different parameters of the application are:

V_{CC} = 14V, L = 10mH, r = 3, I_P = 4A

TRANSIL: SM6HT36A**,** $V_{BR\ min}$ = 34.2V

4.1. Single pulse

We find

$$P_P = 32.4 \times 4 = 136.8W$$

$$t_P = \frac{-14 \times 10 \times 10^{-3}}{2 \times 3} ln\left(\frac{34.2 - 14}{34.2 - 14 + 3 \times 4}\right)$$

$$t_P = 108ms$$

The datasheet gives $P_P \approx$ 450W for t_P = 2ms, so the SM6HT36A can be used in this application.

4.2. Repetitive pulse operation

The switching frequency is equal to 10Hz so

$$P = 10 \times \frac{34.2 \times 10 \times 10^{-3}}{3} \times \left[4 + \left(\frac{34.2 - 14}{3}\right) ln\left(\frac{34.2 - 14}{34.2 - 14 + 3 \times 4}\right)\right]$$

$$P = 980mW$$

We have:

$T_j = P.R_{th(j-a)} + T_{amb\ max}$

With $T_{amb\ max}$ = 50°C, $R_{th(j-a)}$ = 75°C/W (with copper surface under each lead equal to 2.5cm^2) we find:

T_j = 0.98 x 75 + 50 = 123.5°C

Tj max beeing equal to 175°C we can also use this TRANSIL in repetitive pulse operation.