

TRANSISTOR PROTECTION BY TRANSIL : DISSIPATION POWER AND SURGE CURRENT DURATION

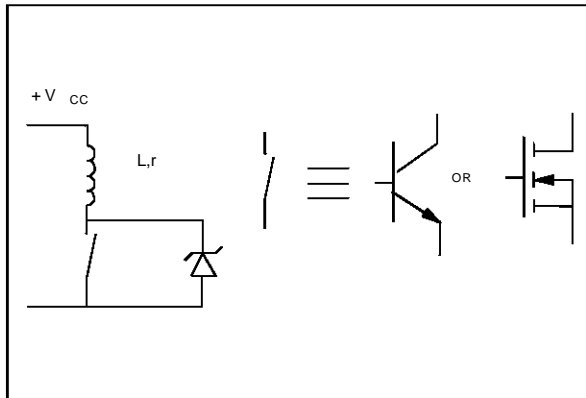
B. RIVET

I - INTRODUCTION

In a great number of applications, we find the diagram FIG.1 where a TRANSIL is used to protect a switch which 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.

Figure 1 : BASIC DIAGRAM

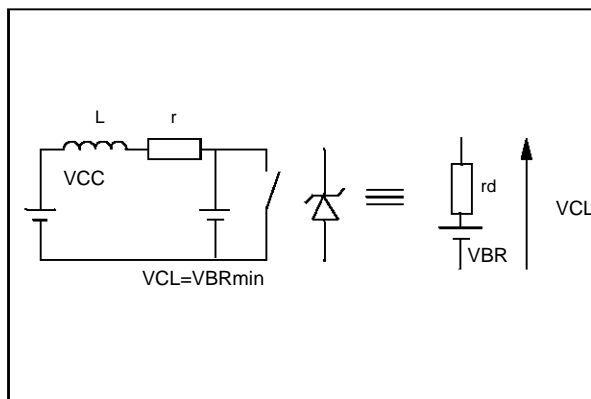


II - CIRCUIT MODELISATION

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

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

Figure 2 : EQUIVALENT CIRCUIT



V_{CL} : clamping voltage
 V_{BR} : breakdown voltage
 r_d : apparent resistance

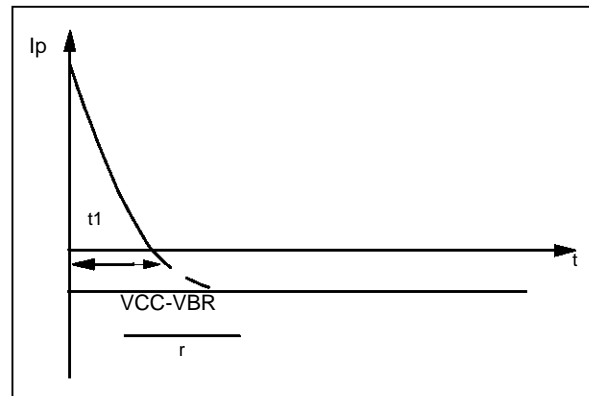
III - CURRENT IN THE TRANSIL

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

$$i = (I_p + \frac{V_{BR \text{ min}} - V_{CC}}{r}) \exp(-r \frac{t}{L}) + (\frac{V_{BR \text{ min}} - V_{CC}}{r})$$

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

Figure 3 : CURRENT WAVEFORM



t_1 can be calculated by

$$t_1 = -\frac{L}{r} \ln\left(\frac{V_{BR \text{ min}} - V_{CC}}{V_{BR \text{ min}} - V_{CC} - r I_p}\right)$$

IV - TRANSIL POWER DISSIPATION

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

a) Single pulse operation

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

P_p is given by

$$P_p = V_{BR \text{ min}} \times I_p$$

APPLICATION NOTE

If we assimilate the pulse current with a triangle the standard exponential pulse duration t_p is calculated by the formula :

$$t_p = - \left(\frac{1,4L}{2r} \right) \ln \left(\frac{V_{BRmin} - V_{CC}}{V_{BRmin} - V_{CC} + rI_p} \right)$$

The energy in the Transil can be expressed by :

$$W = \frac{V_{BRmin} \cdot L}{r} \left[I_p + \left(\frac{V_{BRmin} - V_{CC}}{r} \right) \ln \left(\frac{V_{BRmin} - V_{CC}}{V_{BRmin} - V_{CC} + rI_p} \right) \right]$$

When r tends to zero we find :

$$W = \frac{1}{2} L I_p^2 \left(\frac{V_{BRmin}}{V_{BRmin} - V_{CC}} \right)$$

b) Repetitive pulses operation

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

$$P = F \times \frac{V_{BRmin} \cdot L}{r} \left[I_p + \left(\frac{V_{BRmin} - V_{CC}}{r} \right) \ln \left(\frac{V_{BRmin} - V_{CC}}{V_{BRmin} - V_{CC} + rI_p} \right) \right]$$

When r tends to zero we find :

$$P = \frac{1}{2} L F I_p^2 \left(\frac{V_{BRmin}}{V_{BRmin} - V_{CC}} \right)$$

Where F is the commutation frequency.

V - EXAMPLE OF APPLICATION

Commutation of a coil supplied by a battery. The different parameters of the application are :

$$V_{CC} = 14V \quad L = 10mH \quad r = 3 \text{ Ohms} \quad I_p = 4A$$

TRANSIL : 1.5KE36P $V_{BRmin} = 34.2V$ (cf data sheet)

a) Single pulse

We find

$$P_p = 34.2 \times 4 = 136.8W$$

$$t_p = - \left(\frac{-1.4 \cdot 10 \cdot 10^{-3}}{2 \times 3} \right) \ln \left(\frac{34.2 - 14}{34.2 - 14 + 3 \times 4} \right)$$

$$t_p = 1.08ms$$

The data sheet gives P_p 1500W for $t_p = 1.08ms$ then this 1.5KE36P can be used in this application.

b) Repetitive pulse operation

The commutation frequency is equal to 10HZ so

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

$$= 980mW$$

$$R_{th} = 75^\circ C/W \text{ and } T_j \text{ max.} = 175^\circ C$$

$$\text{So } T_j = P \times R_{th} + T_{amb. \text{ max.}}$$

With $T_{amb. \text{ max.}} = 50^\circ C$ we find :

$$T_j = 0.98 \times 75 + 50 = 123.5^\circ C < T_j \text{ max}$$

So we can also use this Transil in repetitive pulse operation.

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