TRANSISTOR PROTECTION BY TRANSIL : DISSIPATION POWER AND SURGE CURRENT DURATION

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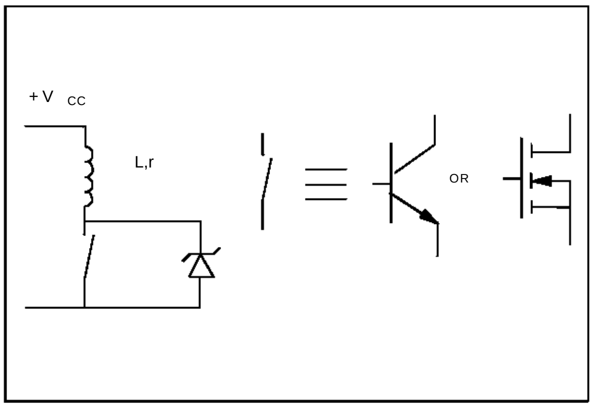
I - INTRODUCTION

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

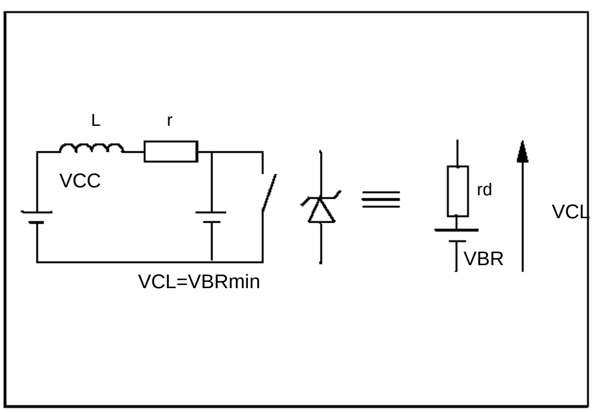


II - CIRCUIT MODELISATION

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

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

Figure 2 : EQUIVALENT CIRCUIT



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

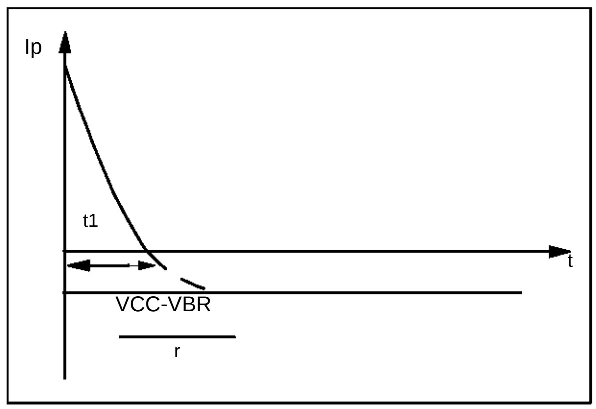
III - CURRENT IN THE TRANSIL

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

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

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

Figure 3 : CURRENT WAVEFORM



t1 can be calculated by

$$t1 = -\frac{L}{r}\ln\left(\frac{V_{BR}min - V_{CC}}{V_{BR}min - V_{CC} - rIp}\right)$$

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 Pp and the pulse current standard duration tp.

Pp is given by

Pp = V_{BR} min x Ip

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

$$tp = -\left(\frac{1{,}4L}{2r}\right)\ln\left(\frac{V_{BR}\min - V_{CC}}{V_{BR}\min - V_{CC} + rIp}\right)$$

The energy in the Transil can be expressed by :

$$W = \frac{V_{BR}\min.L}{r}\left[Ip + \left(\frac{V_{BR}\min - V_{CC}}{r}\right) ln\left(\frac{V_{BR}\min - V_{CC}}{V_{BR}\min - V_{CC} + rIp}\right)\right]$$

When r tends to zero we find :

$$W = \frac{1}{2}\, LIp^2\left(\frac{V_{BR}\min}{V_{BR}\min - V_{CC}}\right)$$

b) Repetitive pulses operation

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

$$P = F\,x\,\frac{V_{BR}min.L}{r}\left[Ip + \left(\frac{V_{BR}min - V_{CC}}{r}\right) ln\left(\frac{V_{BR}\min - V_{CC}}{V_{BR}\min - V_{CC} + rIp}\right)\right]$$

When r tends to zero we find :

$$P = \frac{1}{2}\, LFIp^2\left(\frac{V_{BR}\min}{V_{BR}\min - V_{CC}}\right)$$

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 L = 10mH r = 3 0hms Ip = 4A

TRANSIL : 1.5KE36P V_{BR}min = 34.2V (cf data sheet)

a) Single pulse

We find

Pp = 34.2 x 4 = 136.8W

$$tp = -\left(\frac{-1.4.10.10^{-3}}{2x3}\right)\ln\left(\frac{34.2-14}{34.2-14+3x4}\right)$$

tp = 1.08ms

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

b) Repetitive pulse operation

The commutation frequency is equal to 10HZ so

$$P = 10x\left(\frac{34.2x10.10^{-3}}{3}\right)\left[4 + \left(\frac{34.2-14}{3}\right)\ln\left(\frac{34.2-14}{34.2-14+3x4}\right)\right]$$

= 980mW

Rth = 75°C/W and Tj max. = 175°C

So Tj = P x Rth + Tamb.max.

With Tamb.max. = 50°C we find :

Tj = 0.98 x 75 + 50 = 123.5°C < Tj max

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