

PROTECT YOUR TRIACS

By P. RAULT

In most of their applications, triacs are directly exposed to overvoltages transmitted by the mains. When used to drive resistive loads (temperature regulation), it is indispensable to provide them with efficient protection.

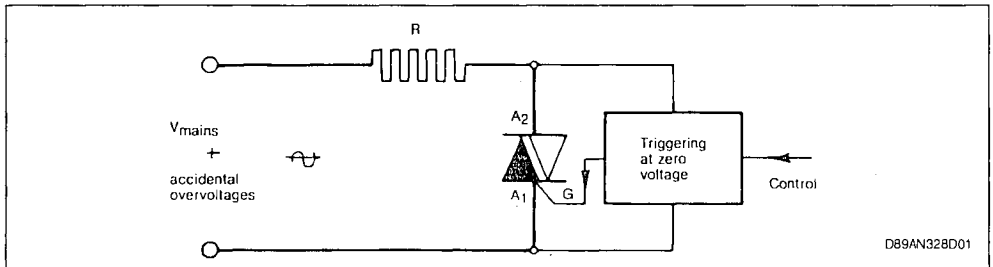
WHY PROTECTION ?

In a typical utilization circuit (figure 1), an overvoltage superimposed on the network voltage can turn on the triac by exceeding its avalanche voltage. Un-

der these conditions, because of its internal structure, only part of triac is effectively turned on and can thus withstand only very low di/dt . This explains the considerable danger of damage to the component when used to drive purely resistive loads. In reality, the di/dt when turning on can, in this case, reach very high values ($> 100 A/\mu s$) since only the inductance of the connections limits the rate at which the current can increase.

Figure 1 : Typical Circuit.

The Triac is directly connected to the distribution network : risk of damage.



WHAT WE PROPOSE

The principle of the protection which we have studied consists in turning on the triac by the gate, as soon as the voltage across it exceeds a certain value (figure 2), thus under conditions which ensure a high level of safety. To do this we use a bidirectional

TRANSIL diode whose current/voltage characteristic is recalled in figure 3.

When the voltage applied to the triac reaches the VBR voltage of the TRANSIL, the latter conducts, producing a current in the triac gate and turning it on (figure 4). The triac continues to conduct till the half cycle current passes through zero (figure 5).

Figure 2 : Protection of the Triac by a Bidirectional TRANSIL Diode.

The Triac is turned on by gate (current i) as soon as voltage A_2 exceeds the voltage V_{BR} of the TRANSIL.

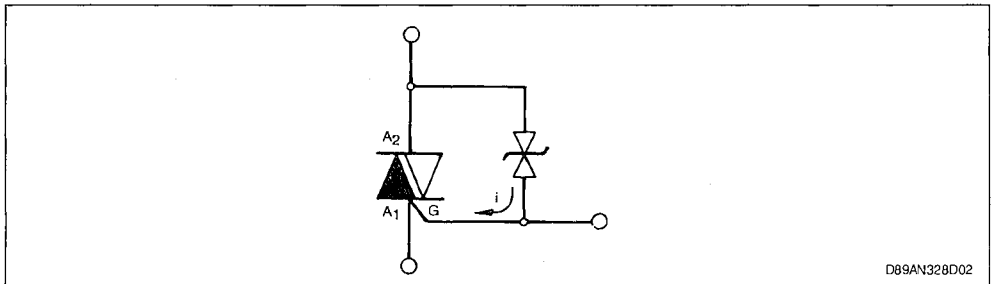


Figure 3 : Voltage-current Characteristic of a TRANSIL Diode.

V_{BR} Specified at 1mA (tolerance 5 or 10%)

V_{CL} limitation voltage, given for a high I_{PP} current level (from several amperes to several tens of amperes, depending of the type).

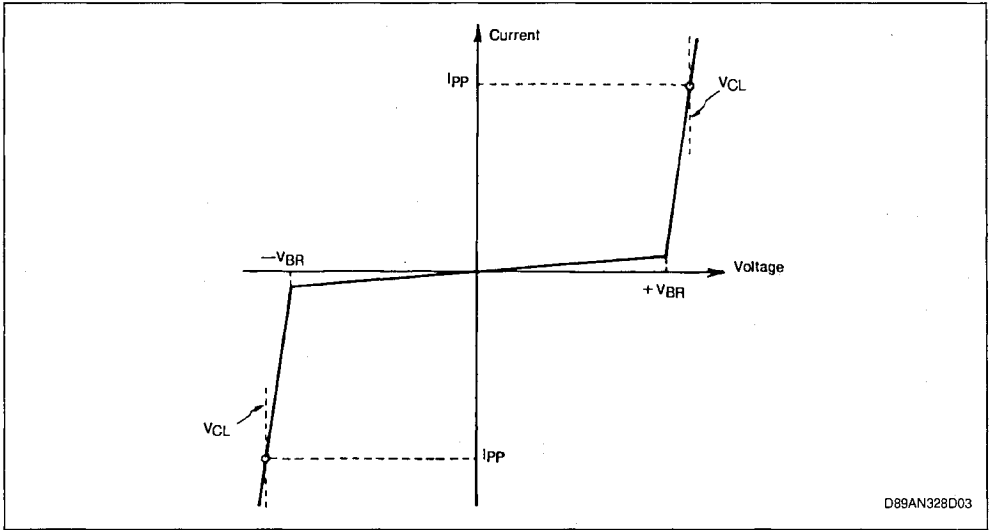


Figure 4 : Characteristic of the TRIAC + TRANSIL Assembly.

Case of a 600V/12A triac protected by a 440V TRANSIL diode (the dotted line gives the characteristic of the triac alone).

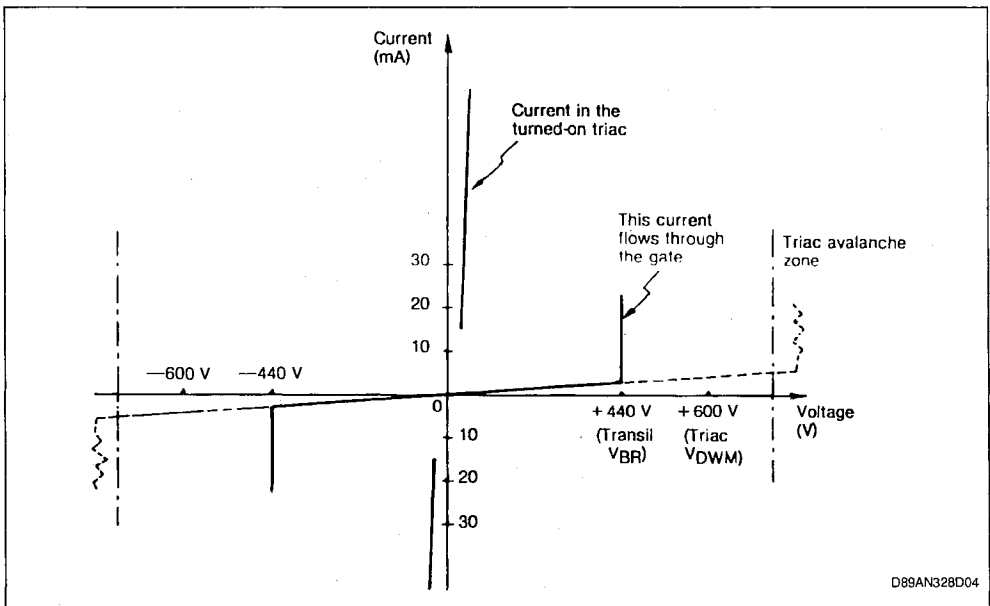
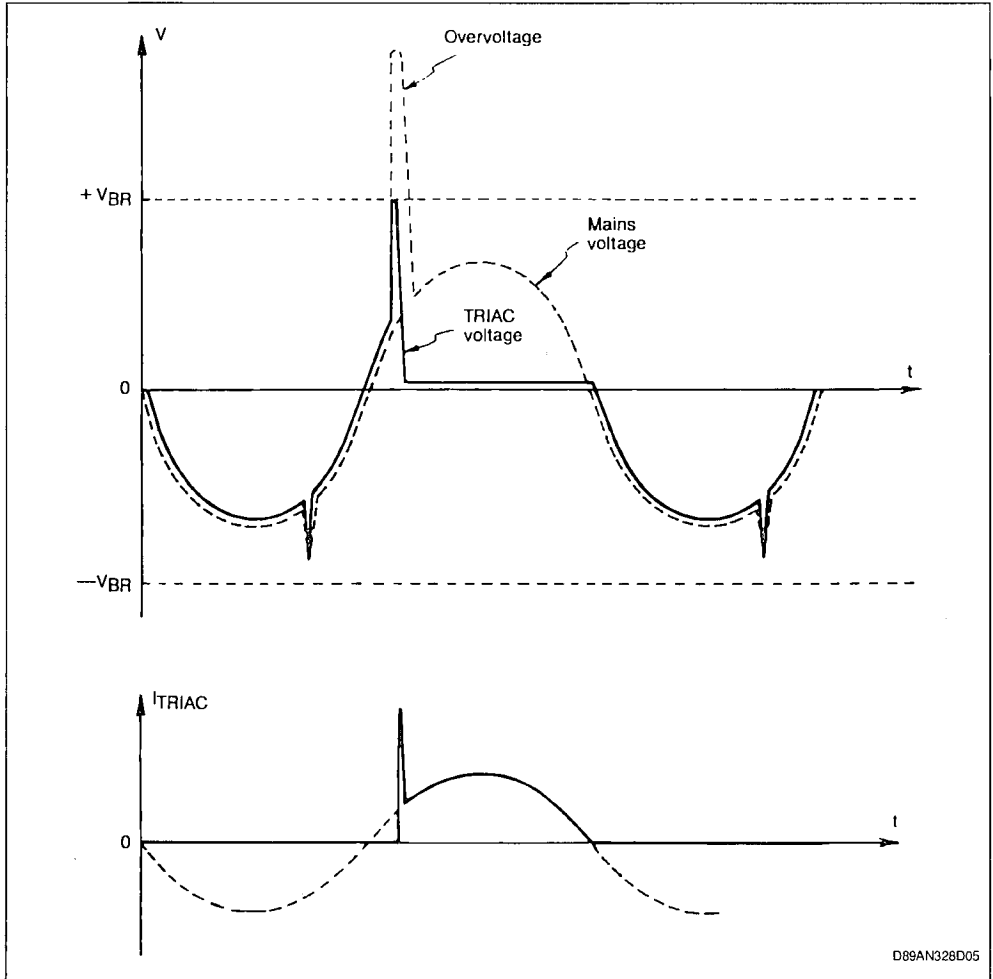


Figure 5 : Behaviour of a Triac Protected by a TRANSIL Diode:
(the triac is turned on by the gate at the beginning of the overvoltage and continues conduction through the rest of the half-wave).



THE ADVANTAGES OF THIS SOLUTION

- The triac will always operate within the voltage limits given by the manufacturer (\pm VDWM) and thus far from the avalanche zone.
- Not much power is dissipated in the triac during the disturbance : when it is turned on, the dissipated power is localized in the protection component (the TRANSIL is made for that !).
- The triac is turned on by a gate current which will ensure optimal di/dt conditions.

THE RESULT OBTAINED

We have carried out tests with repetitive overloads (1Hz) under various conditions : Exponential shock waves of about 1ms, calibrated in voltage (up to 2000V) and controlled in di/dt (500A/ μ S maxi).

The tests were carried out with steep-edged voltage pulses ($dV/dt > 1000V/\mu s$) and also with gradual slopes ($< 50V/ms$).

All these tests were successful : zero failure.

SELECTION OF THE TRANSIL DIODE REQUIRED FOR PROTECTING A TRIAC

VOLTAGE : VR

Obviously the triac associated with the TRANSIL diode should not be turned on by the maximum mains voltage. An additional safety margin should be given to prevent untimely turning on by the small

voltage spikes, often repetitive, which are always present on a «normally» disturbed mains line.

$$VR > V_{mains} \times \sqrt{2} + \text{safety margin}$$

In the absence of accurate specifications, add 20% for the safety margin.

Example : 220V network :

$$VR > 220\sqrt{2} + 20\% = 375V$$

POWER

The TRANSIL only conducts when turning on the triac ($t \approx 1\mu s$).

The current, during this time, can reach very high levels (several tens of amperes) in the case of disturbances with steep edges ($> 1000V/\mu s$), however the dissipated power remains well within the possibilities of TRANSILS.

The BZW 04 (400W/1ms) suffices in all cases.

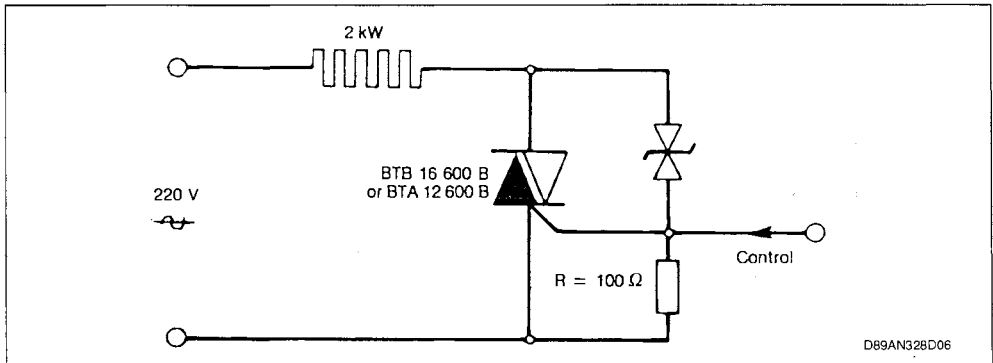
PRACTICAL EXAMPLE

Drive circuit for a 2kW heating element on 220V mains (figure 6).

The BZW 04.376 type TRANSIL perfectly protects the BTB 16.600 B triac (VDWM = $\pm 600V$).

The 100 - Ω resistor, R, between the gate and A1 is not absolutely indispensable but it enables preserving the dV/dt characteristic of the triac which is reduced (by about 20%) by the junction capacitance of the TRANSIL between anode and gate.

Figure 6 : Practical Example of the Protection of a 12 or 16A Triac against Overvoltages.



CONCLUSION

With the protection circuit proposed by us, the triac always operates under perfectly defined conditions in case of overvoltages :

- The voltage remains limited to the maximum specified for the triac.

- Turn-on is ensured by a gate current.

This circuit, which we have tested in a number of different setups (different loads, high amplitude overvoltages, disturbances of long duration, etc...), enables a considerable increase in the reliability of circuits using triacs and is indispensable for driving resistive loads on highly disturbed networks.