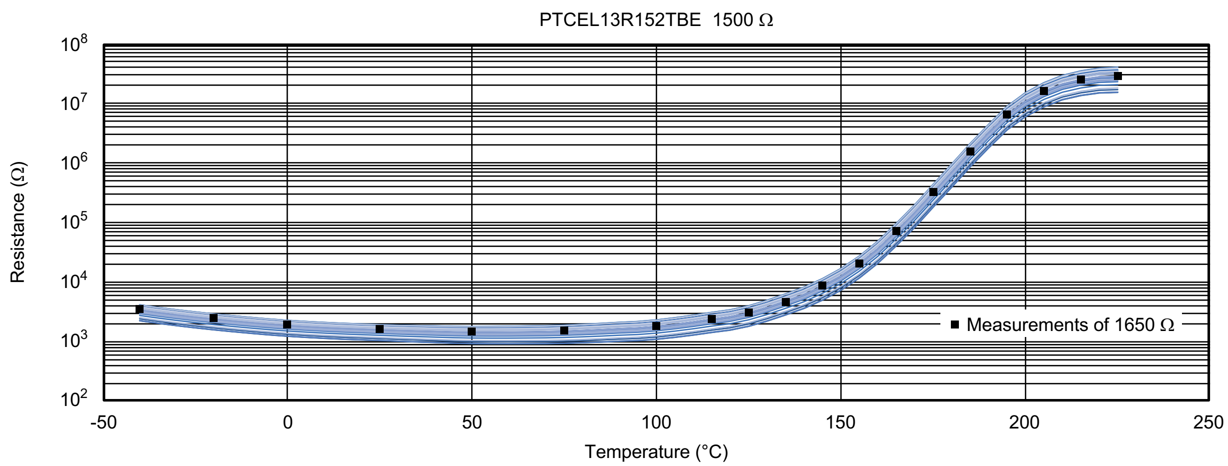
Simulation Notes for SPICE Modelling the PTCTL, PTCCL, and PTCEL

By Alain Stas

1. RESISTANCE TEMPERATURE CURVE



In blue: the simulation results / in black: the measurements

2. TRIP TIME AS A FUNCTION OF TRIP CURRENT

When a fixed DC voltage is applied to a PTC, the current starts up at a defined value depending on the ambient PTC resistance value. The current can then increase a bit if the resistance temperature curve of the PTC presents a minimum, and then decays when the PTC switches.

A characteristic of a PTC is the trip time, i.e. the time elapsed between the time when the current is maximal and when it has decreased to 50 % of this value.

The simulation below reproduces the needed circuit (Fig. 1), and the SPICE directives measure the maximum current and trip time for a number of runs spread throughout the PTC tolerances. Fig. 2 presents the current decrease in time through the PTC.

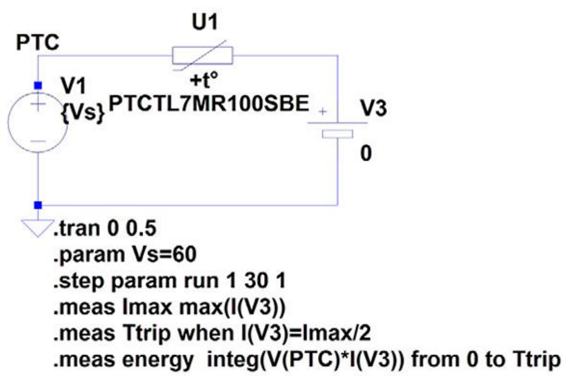


Fig. 1

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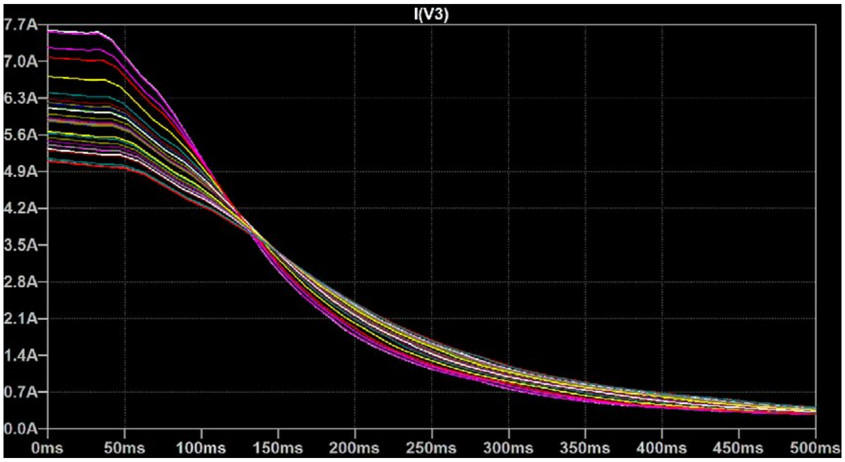

Fig. 2

The simulation results of trip time vs trip current are compared to the measurements in Fig. 2b.

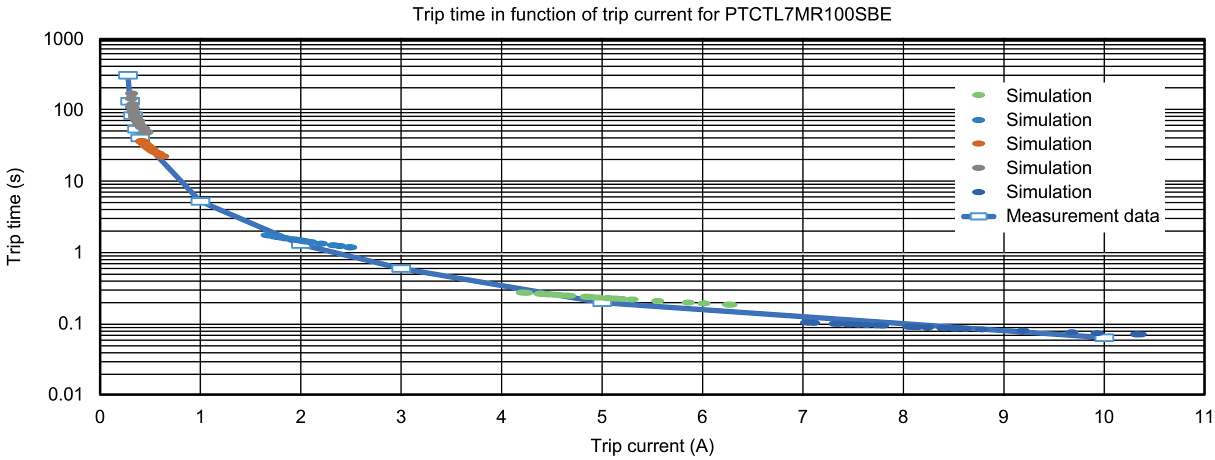

Fig. 2b

3. CURRENT VOLTAGE CURVE

Fig. 3 shows the circuit used to reproduce the current voltage relation for the PTCEL13R600LBE. The right section of the circuit is used to introduce the real physical measurements to which the simulation results are compared. Fig. 4 provides a comparison between the simulation results (white) and some measurements (in green).

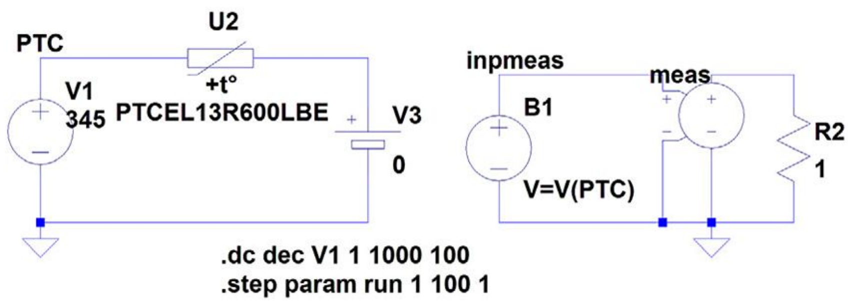

Fig. 3

TECHNICAL NOTE

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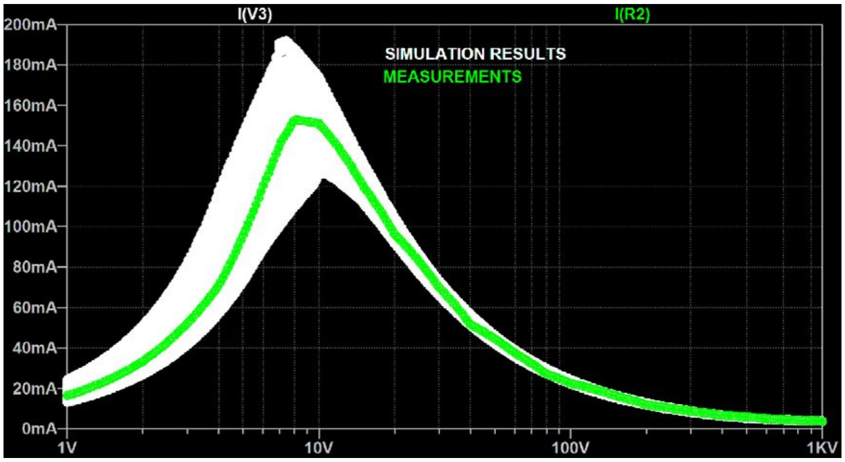

Fig. 4

In white, the simulation of a current-voltage curve for the PTCEL13R600LBE for a R25 of 60 Ω, ± 30 %.

4. CURRENT DECAY SIMULATION (INCLUDING THE VDR EFFECT)

When a high amplitude sinusoidal voltage is applied to a PTC with a serial resistor, the current decays as the PTC trips and takes over the voltage itself. The lower the ambient temperature is, the longer it will take for the PTC to trip. The current waveform shows the VDR effect, as the PTC resistance is as the PTC instantaneous resistance decreases at a high voltage. Fig. 6 shows the current decay for ambient temperatures going from 0 °C to 70 °C.

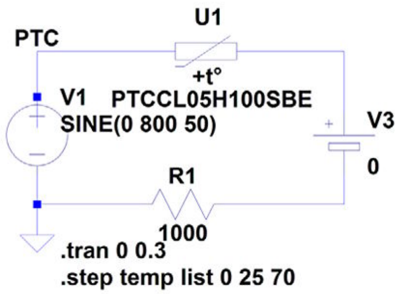

Fig. 5

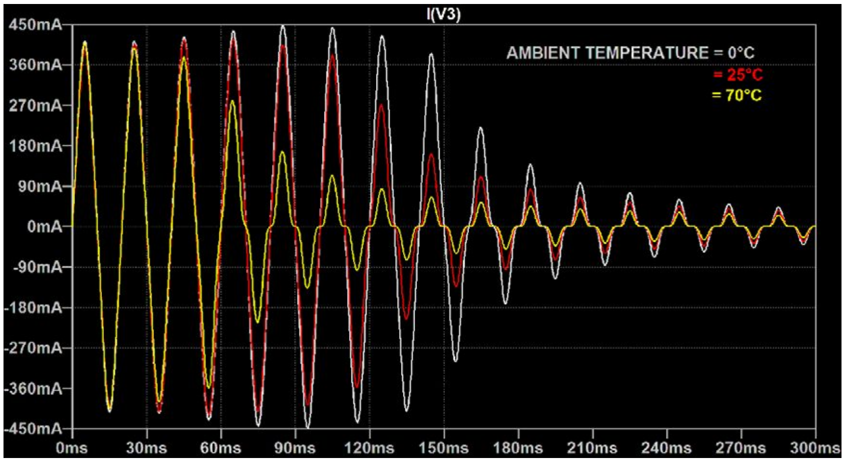

Fig. 6

TECHNICAL NOTE

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5. ILLUSTRATION OF A PTC AS A RESETTABLE FUSE

In this simulation (Fig. 7 and Fig. 8), we apply a PWL voltage going from 220 V to 500 V, going back to 220 V, then tune it down to 10 V, and at last bring it back to the nominal 220 V. When the voltage increases from 220 V to 500 V (Fig. 8, lower pane), the current exceeds the non-trip current and the PTC switches. We see that the PTC remains switched (high voltage and low current) even when the voltage comes back to 220 V. We need to tune down the voltage to low values (here 10 V) for some time to let the PTC cool down. The resistance decreases (Fig. 8, mid pane) and then the nominal voltage 220 V can be reapplied without PTC tripping.

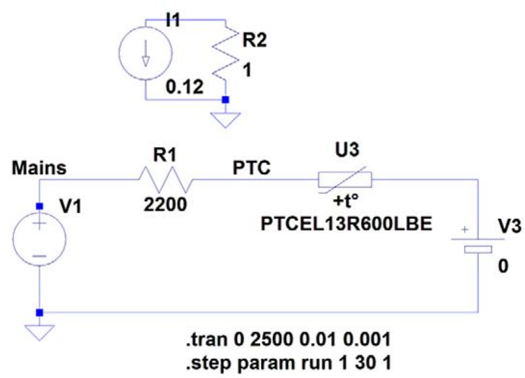

Fig. 7

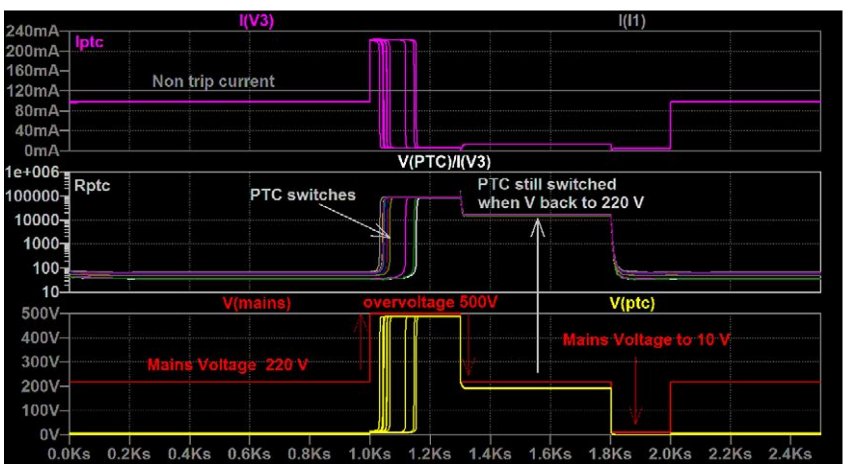

Fig. 8

TECHNICAL NOTE