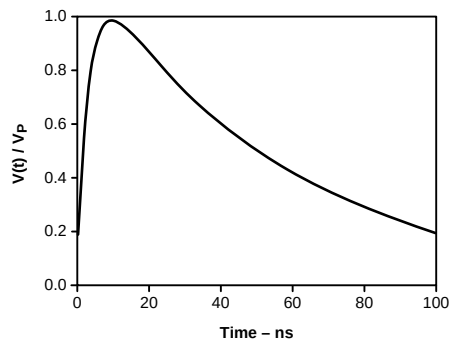


1) EFT and Surge Transient Waveform Equations



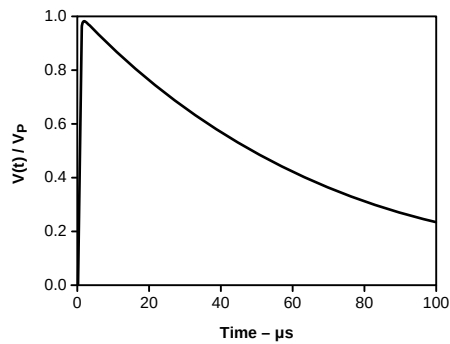
5 / 50 ns, EFT waveform:

$$V(t) = A \cdot V_P \cdot (1 - e^{-t/\tau_1}) \cdot e^{-t/\tau_2}$$

$$\tau_1 = 3.5 \text{ ns}$$

$$\tau_2 = 55.6 \text{ ns}$$

$$A = 1.27$$



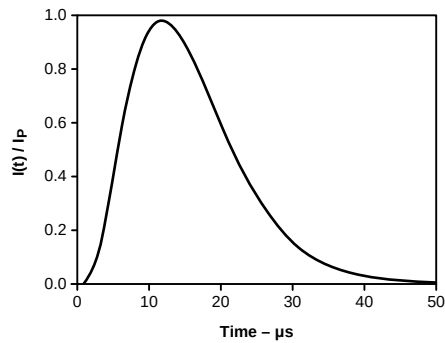
1.2 / 50 μs , Surge open-circuit waveform :

$$V(t) = A \cdot V_P \cdot (1 - e^{-t/\tau_1}) \cdot e^{-t/\tau_2}$$

$$\tau_1 = 0.4074 \text{ } \mu\text{s}$$

$$\tau_2 = 68.22 \text{ } \mu\text{s}$$

$$A = 1.037$$



8 / 20 μs , Surge short-circuit waveform:

$$I(t) = A \cdot I_P \cdot t^k \cdot e^{-t/\tau}$$

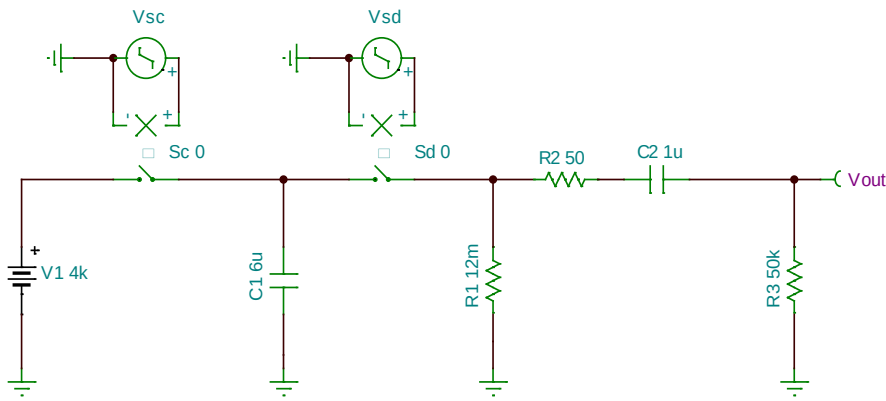
$$A = 0.1405 (\mu\text{s})^{-k}$$

$$k = 2.93$$

$$\tau = 3.977 \text{ } \mu\text{s}$$

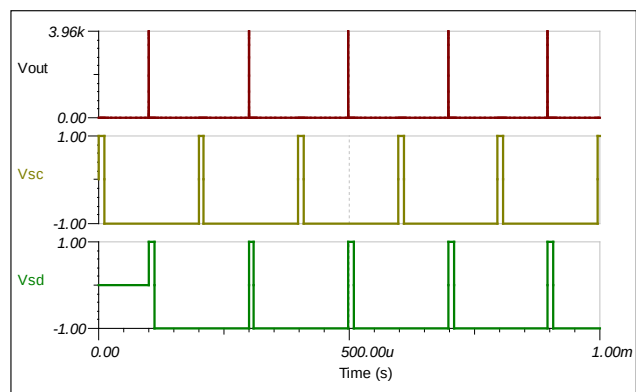
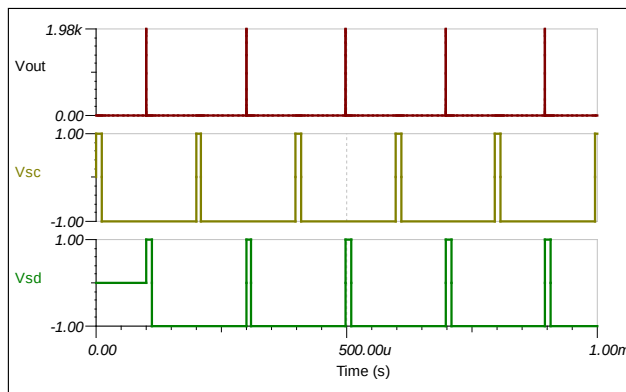
2) Simulation Models for EFT and Surge Generators

Because of the significantly higher energy content of an EFT transient versus an ESD transient, I have focused on the simulation of the EFT generator. Although slightly modified from the standard (I added a 2nd switch as charge switch, Sc) the output transient is in alignment with the EFT standard waveform.

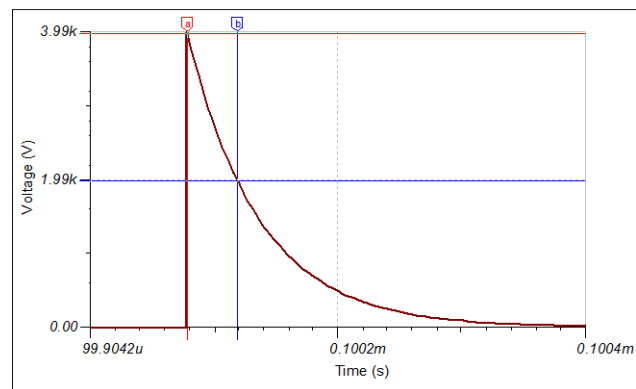
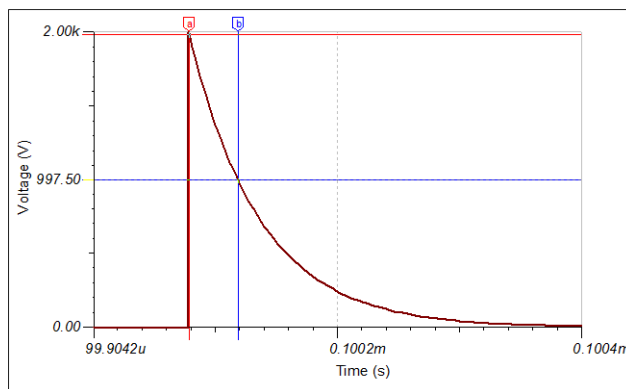


EFT Generator

The charge switch, Sc, and discharge switch, Sd, operate alternately. When Sc is closed, Sd is open, and the 6 μ F capacitor (C1) is charged by the high-voltage dc-supply (V1). When Sc is open, Sd is closed, and C1 discharges via the R-C output network. The 12 m Ω R1 serves as pulse-shaping resistor. The 50 Ω R2 provides impedance matching with the coaxial output, and the 1 μ F C2 blocks dc voltages. R3 is the actual load impedance, which is made 50 Ω during generator calibration only.



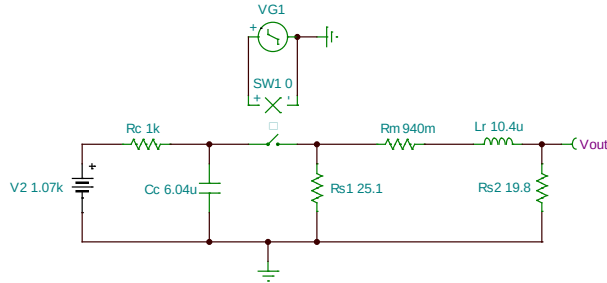
Output transients and switching cycles of Sc and Sd for R3 = 50 Ω (left) and R3 = 50 k Ω (right)



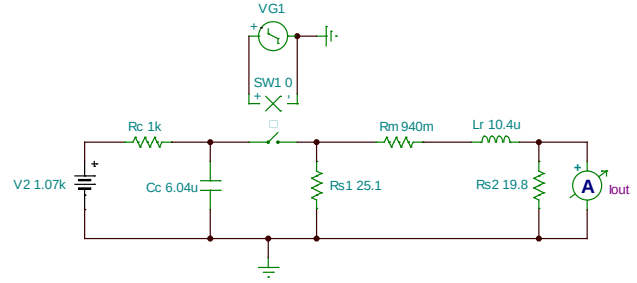
EFT waveform for R3 = 50 Ω (left) and R3 = 50 k Ω (right). The output peak voltage halves when terminated with 50 ohms. The time between the red and blue cursor lines at half the peak output voltage = 49 ns (left) and 50 ns (right). The IEC 61000-4-4 standard allows for a variation of 50 ns $\pm$ 30 %.

The IEC 61000-4-5 specified surge generator is a combination waveform generator (CWG) because under open-circuit conditions it provides an output voltage transient with 1.2 μ s front time and a time-to-half-value (0.5 V_{PK}) of 50 μ s, while under short-circuit conditions the output provides an output current transient with 8 μ s front time and a time-to-half-value (0.5 I_{PK}) of 20 μ s.

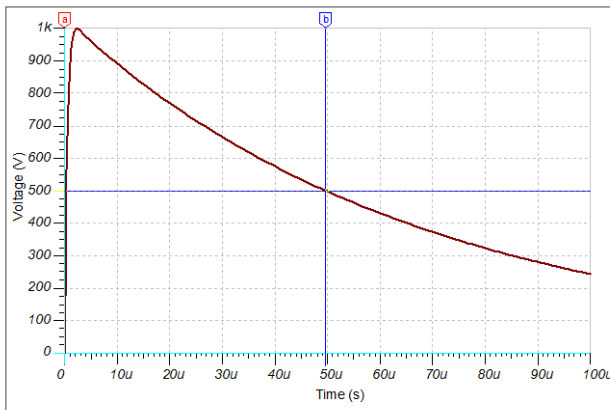
The following graphs show the CWG configurations and their corresponding output transient waveforms.



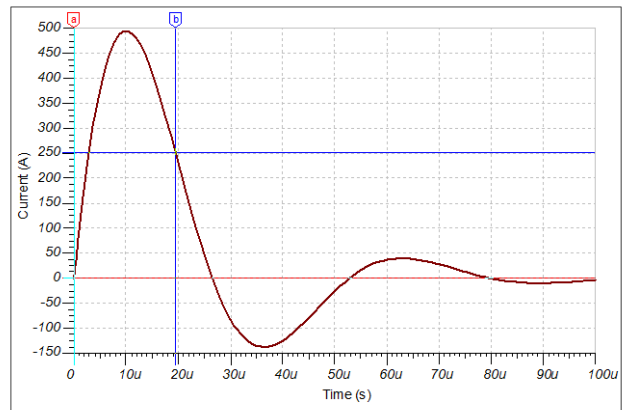
CWG with $R_L = \infty$ for measuring the 1.2/50 μ s open-circuit output voltage transient



CWG with $R_L = 0 \Omega$ for measuring the 8/20 μ s short-circuit output current transient



1.2/50 μ s open-circuit output voltage transient



8/20 μ s short-circuit output current transient

The cursor lines of the 1.2/50 μ s open-circuit output voltage transient show a time-to-half-value of 49.5 μ s and thus sit perfectly in the middle of the 50 μ s $\pm$ 20 % specified in the IEC 61000-4-5 standard.

The cursor lines of the 8/20 μ s short-circuit output current transient show a time-to-half-value of 19.5 μ s and thus sit perfectly in the middle of the 20 μ s $\pm$ 20 % specified in the IEC 61000-4-5 standard. Also, the negative overshoot of - 27.6 % is well within the standard-specified maximum of - 30 %.