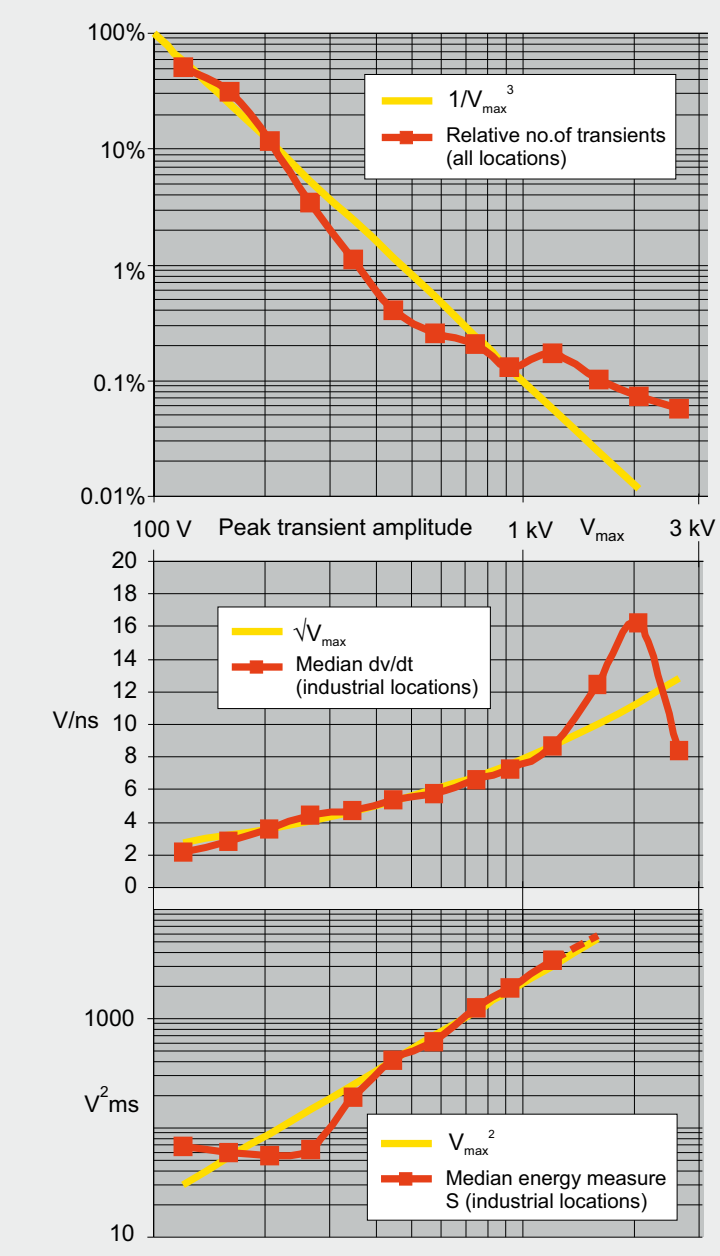


# Transient occurrence



## Transient occurrence in the real world

The data shown here are taken from a study carried out in Germany in the mid-1980s. Around 3,400 hours of recording captured 28,000 transients at 40 different measuring points. The transients were measured between live and protective earth of TN-type 230/380 V supply networks. Transient characteristics did not vary much between industrial, business, domestic or laboratory locations, although the total number of transients was much greater in the industrial locations than the others.

The data show that:

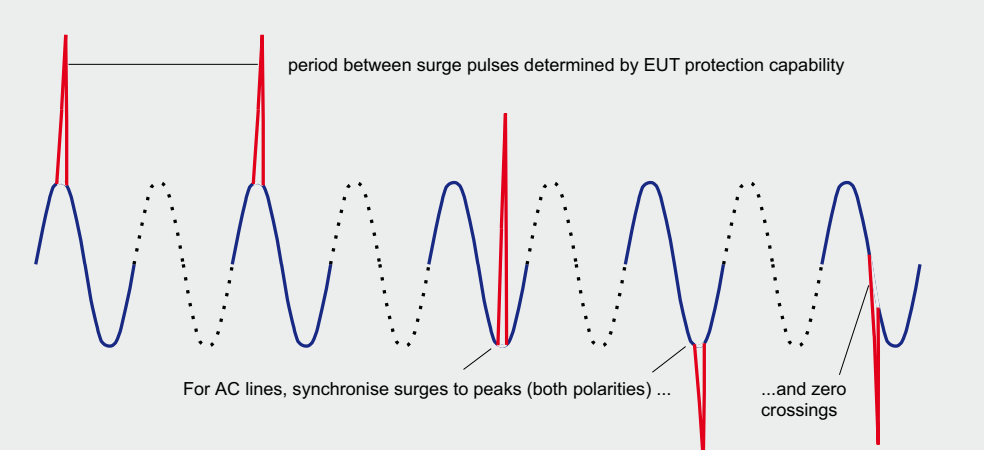
- the relative rate of occurrence of a given transient varies roughly proportionally to the inverse of the cube of its peak amplitude;
- the rate of rise (dV/dt) of the transient increases roughly proportionally to the square root of its peak amplitude, as does its rise time;
- the energy measure of a transient is more or less constant up to 200 V and then increases roughly proportionally to the square of its peak amplitude at higher voltages; this suggests that the waveshape of transients is fairly constant over a range of amplitudes.

For peak voltages above 1 kV, the number of recorded transients was insufficient to give a high degree of statistical coverage.

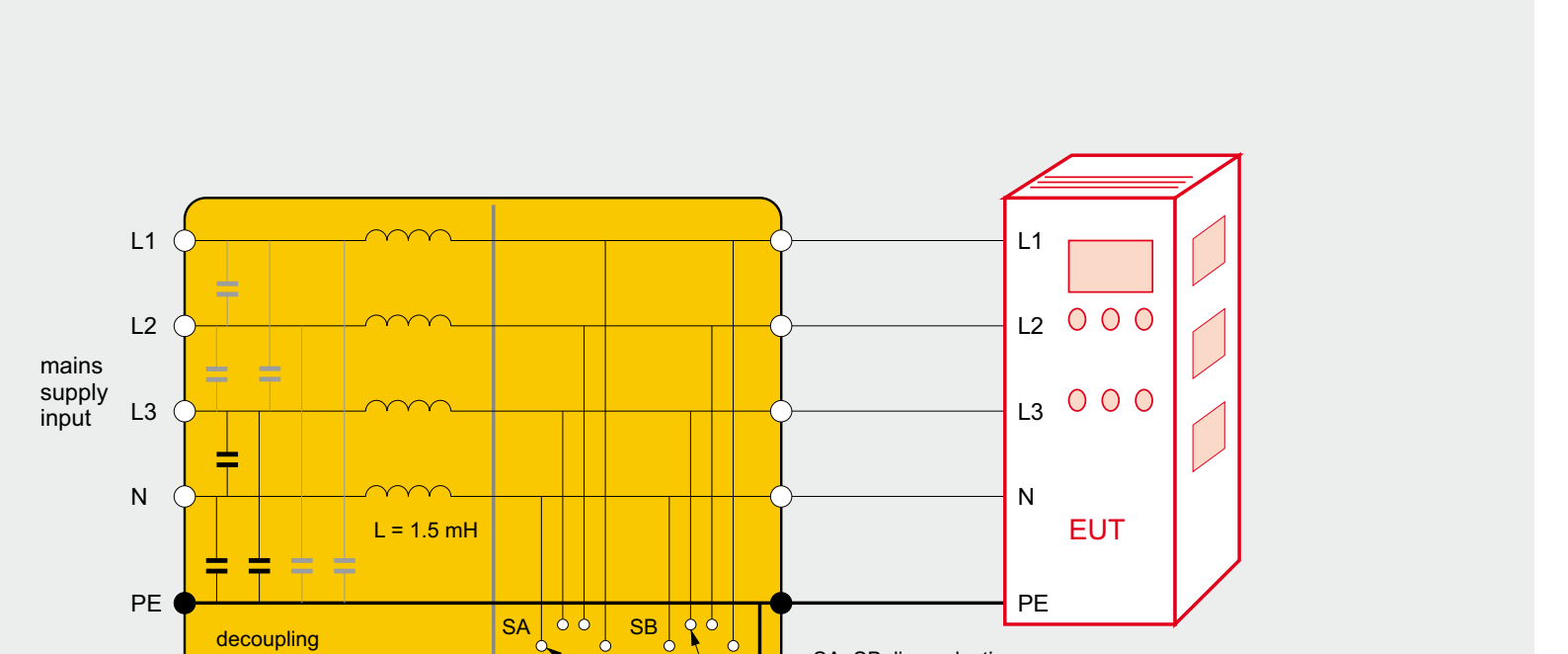
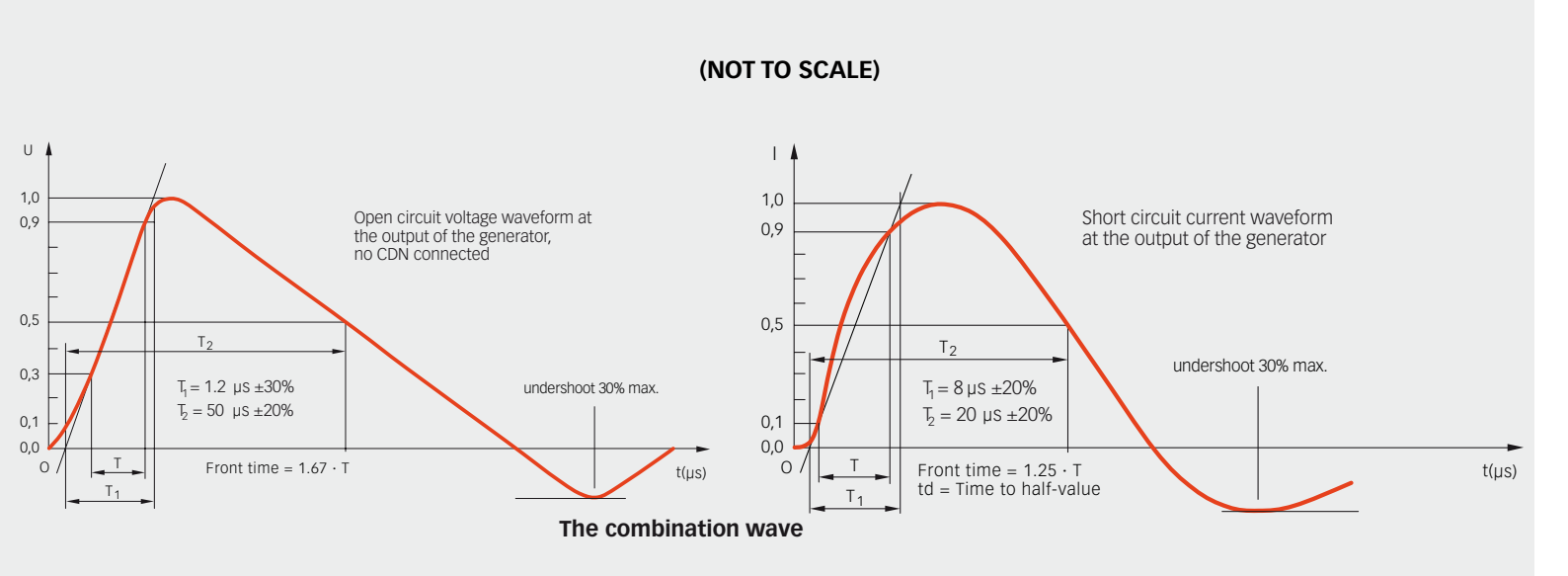
Reference: Transients in Low-Voltage Supply Networks, J. Gostfried, IEEE Transactions on EMC, Vol. EMC-20 No. 2, May 1987, pp. 104-115

# Surge - IEC/EN 61000-4-5

Test standard	Peak V	Voltage Front time	Voltage time to half-value	Peak I	Current $t_r$	Current $t_d$	Number of pulses
IEC/EN 61000-4-5	1.2/50 $\mu$ s combination wave						
AC power line-to-line	0.5 - 4 kV $\pm$ 10%	1.2 $\mu$ s $\pm$ 30%	50 $\mu$ s $\pm$ 20%	0.25 - 2 kA $\pm$ 10%	8 $\mu$ s $\pm$ 20%	20 $\mu$ s $\pm$ 20%	Minimum 5 each polarity
AC power line-to-earth				Limited by additional 10 D in series			
Other lines, line-to-earth				Limited by additional 40 D in series			
ITU-T K.20, K.44	10/700 $\mu$ s wave						
Communication lines	0.5 - 5 kV	10 $\mu$ s	700 $\mu$ s	12.5 - 125 A	Defined by circuit components		10, polarity reversed between pulses



- ### Surge application
- ground reference plane is not essential, provided care is taken with earth connections, except for tests to shielded lines
  - physically isolate the EUT, disconnect it from other equipment where possible and insulate the whole setup to prevent flashover during the test
  - synchronise each surge to the peak of the AC supply waveform to give maximum stress, and to the zero crossing to induce maximum follow-on energy in case this occurs: five negative and five positive applications each at 0°, 90°, 180° and 270° phases are required in most cases
  - all lower test levels must also be satisfied - Increase the stress voltage in steps up to the maximum, to check that the protective devices do not allow upset or damage at lower levels of applied voltage despite satisfactorily clamping high levels
  - replace protective devices after testing if the EUT is to be re-used, in case of degradation; if tests done faster than one pulse per minute cause failure due to damaged protective devices, testing at one pulse per minute prevails



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# Transient immunity testing

## Ring wave - IEC/EN 61000-4-12

**Ring wave application**

Generator output impedance Z	Minimum repetition period	Application
12 $\Omega$	10 s	EUT supply ports connected to major feeders Application between communication ports on cabinets interconnected with 10 m long screened data comms cables
30 $\Omega$	6 s	EUT supply ports connected to outlets
200 $\Omega$	1 s	I/O ports, unless the test involves protection devices or filters, in which case 12 $\Omega$ or 30 $\Omega$ is applicable

A minimum of 5 positive and 5 negative transients are to be applied, both line to ground (common mode, symmetrical between all terminals and ground) and line to line (differential mode), and/or between cabinets (communication ports)

**IEC/EN 61000-4-12 Ring wave**

**AC, DC and 3-phase supply ring wave coupling**

**EFT - IEC/EN 61000-4-4**

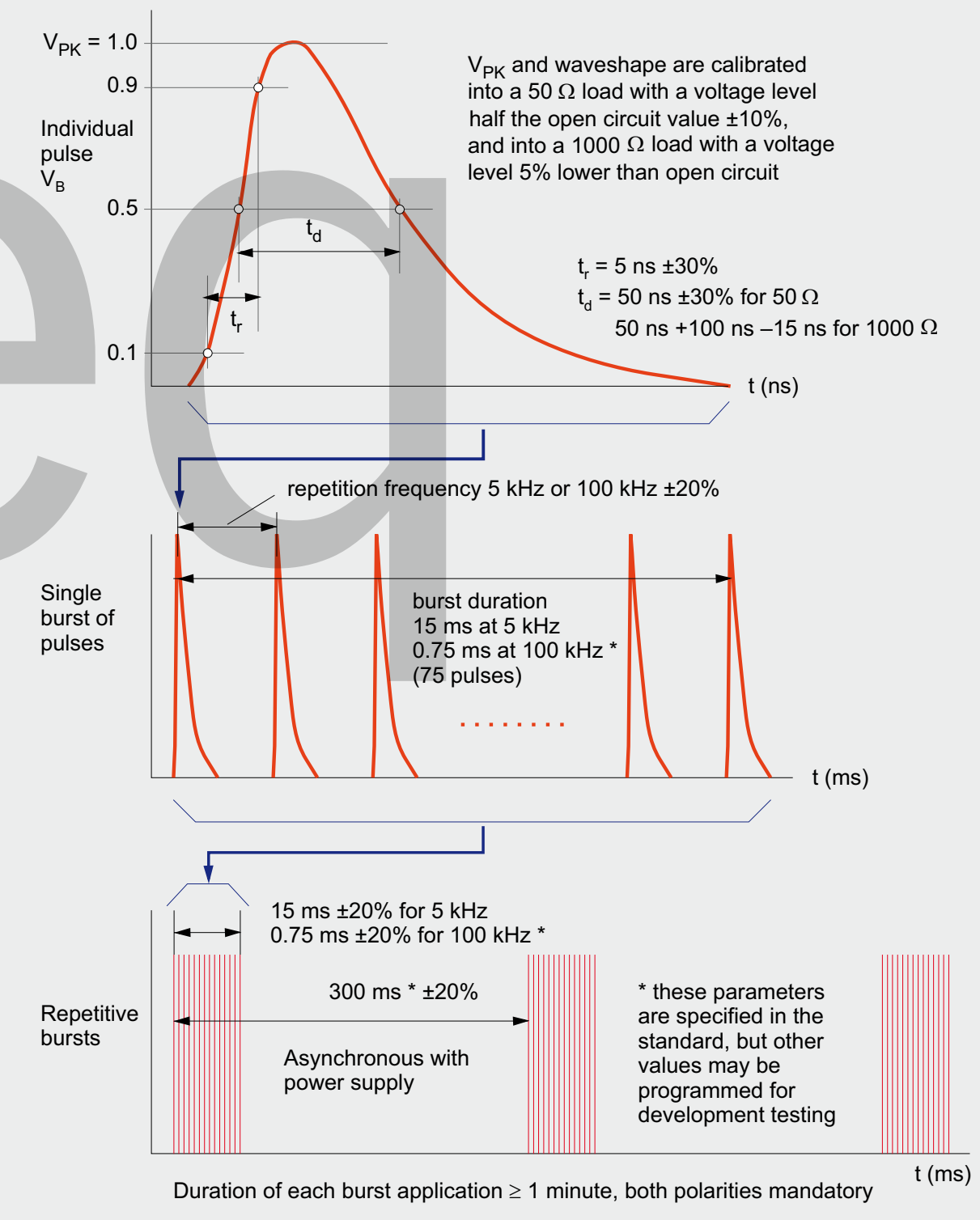
Common mode coupling only (2nd edition IEC/EN 61000-4-4)

excess length folded (not coiled), 0.1 m from GRP

EFT burst test set-up and coupling

**AC, DC and 3-phase supply surge coupling**

## IEC/EN 61000-4-4: 2004 Electrical fast transient burst Waveform specifications



## Generic and product standards

Standard	Scope	ESD	EFT-burst	Surge
IEC/EN 61000-6-1:2001	Residential, commercial & light industrial generic	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power, 0.5 kV DC power > 10 m, signal and functional earth > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC power input, 0.5 kV L-L & L-E DC power > 10 m, to IEC/EN 61000-4-5
IEC/EN 61000-6-2:2005	Industrial generic	4 kV contact, 8 kV air to IEC/EN 61000-4-2	2 kV AC power, DC power > 3 m, 1 kV signal and functional earth > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC power; 0.5 kV L-L & L-E DC power connected to a distribution network; 1 kV L-E signal > 30 m, to IEC/EN 61000-4-5
EN 55014-2: 1997 + A1: 2001	Household appliances etc.	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power, 0.5 kV DC power, signal and control > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC mains, to IEC/EN 61000-4-5
EN 55020:2002	Broadcast receivers etc.	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power to IEC/EN 61000-4-4	Not required
EN 55024: 1998	Information technology equipment	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power, 0.5 kV DC power, signal and telecom > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC mains, 0.5 kV L-L & L-E DC power with outdoor cables, to IEC/EN 61000-4-5; 1.5 kV/10/700 $\mu$ s on signal/telecom ports with outdoor cables, to IEC/EN 61000-4-5
EN 50130-4: 1995 + A2: 2003	Fire, intruder and social alarm systems	6 kV contact, 8 kV air to IEC/EN 61000-4-2	2 kV AC mains supply, 1 kV other supply/signal lines to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC mains supply; 1 kV L-E other supply/signal lines, to IEC/EN 61000-4-5
EN 61326-1:2006	Measurement, control and lab equipment, min. requirements	4 kV contact, 4 kV air to IEC/EN 61000-4-2	1 kV AC & DC power, 0.5 kV I/O signal/control > 3 m to IEC/EN 61000-4-4	0.5 kV L-L, 1 kV L-E on AC power; 0.5 kV L-L, 1 kV L-E on AC power, to IEC/EN 61000-4-5
EN 61547: 1995 + A1: 2000	General lighting equipment	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power, 0.5 kV DC power, signal and control > 3 m to IEC/EN 61000-4-4	0.5 kV L-L, 1 kV L-E on AC power, to IEC/EN 61000-4-5
EN 300386	Telecom network equipment, immunity only	4 kV contact, 4 kV air to IEC/EN 61000-4-2	1 kV AC power, 0.5 kV DC power, outdoor signal and indoor signal > 3 m to IEC/EN 61000-4-4	0.5 kV L-L, 1 kV L-E on AC power; 0.5 kV L-E indoor signal lines > 10 m, 1 kV on outdoor signal lines, to IEC/EN 61000-4-5
	Telecom centres	6 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power and DC power > 3 m, 0.5 kV outdoor signal and indoor signal > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC power; 0.5 kV L-E outdoor signal lines, to IEC/EN 61000-4-5

# ESD - IEC/EN 61000-4-2

**The discharge event**

**Applying the ESD test**

Points of application - all points that are accessible to the user in normal operation, not necessarily parts of open connectors nor points accessible only during maintenance or servicing.

Application method - contact discharge is preferred, air discharge is used where contact cannot be applied, both direct discharges to the EUT and indirect discharges to the coupling plane, are required.

Non-earthed apparatus - should be deliberately discharged between each pulse, e.g. via connection of bleed resistor or by air ionisation.

Number of discharges - normally ten in each polarity to each point of application - EN 55084 requires a total of 200, @ at each point.

Mode of application - test generator must be perpendicular to the surface of the EUT. For air discharge, the nozzle approach the EUT as far as possible without causing mechanical damage; for contact, the nozzle must touch the EUT before the discharge switch is connected.

Test levels - all lower test levels must also be satisfied, i.e. if the test specification is 6 kV contact, then 2 and 4 kV must also be applied.

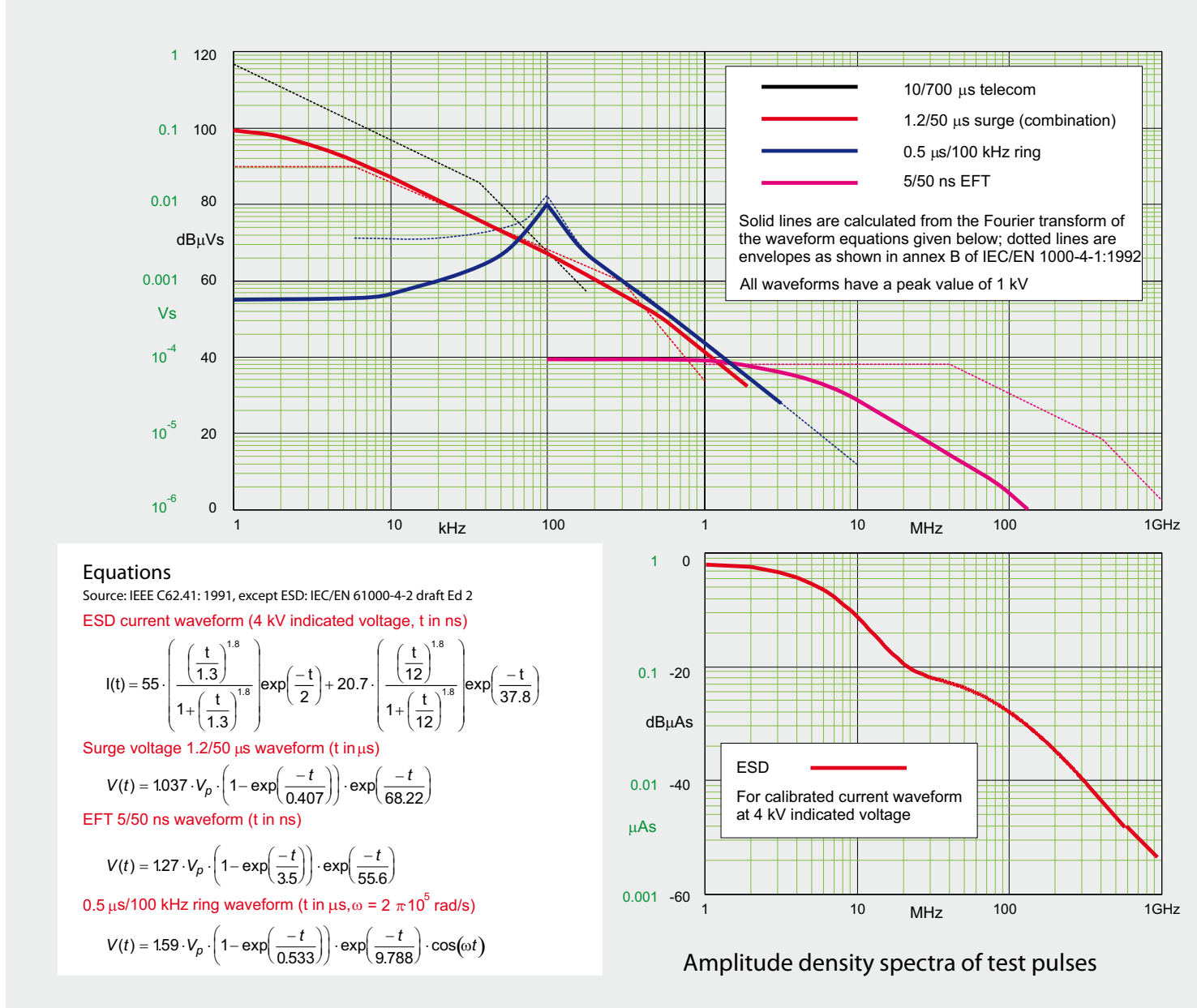
**ESD generator equivalent circuit**

**IEC/EN 61000-4-2 Electrostatic discharge specification**

Severity level (environment)	Test voltage (contact)	Test voltage (air)
1 (55% RH, antistatic)	2 kV	2 kV
2 (10% RH, antistatic)	4 kV	4 kV
3 (50% RH, synthetic)	8 kV	8 kV
4 (10% RH, synthetic)	15 kV	15 kV

**ESD test set-up for table-top and floor-standing EUTs**

## Amplitude density spectra



## Energy content

