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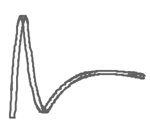
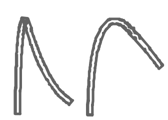
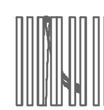
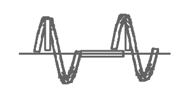
Overview Transients

Partners for HV and EMC Solutions

Characteristics	Static Discharge	Switching Operations	Lightning	Power Trip Out
Phenomenon	"ESD"	"EFT Burst"	"Surge"	"DIPS"
Voltage U	up to 15kV	up to 4kV	up to 6kV	Supply Voltage
Energies at Maximum Charging Voltage	Below 10mJ	300mJ	300J	-
Repetition Rate	Single Impulse	Multiple Pulses 5kHz	Maximum 6 Impulses/Min	Related to the power frequency
Application Equipment Under Test	Metal Parts which can be touched by persons	Power-, Signal-, Measuring and Data Lines	Power-, Signal-, Measuring and Data Lines	Power Supply ac,dc
Upper Frequency Limit	Approx. 1GHz	Approx. 100MHz	Approx. 350kHz	Approx. 100kHz
Wave Forms	 IEC 61000-4-2	 IEC 61000-4-4	 IEC 61000-4-5	 IEC 61000-4-11

Maintenance of IEC 61000-4-5, WG11

- **Date of Adoption: January 2007**
- **Date of Withdrawal: October 2009**

Rationale

- Decoupling <1.5 mH for CDN > 20 A
- New High Speed Telecom CDN, Coupling Method

Reasons

- For line current higher approximate 20 A the voltage drop gets too high (power line voltage >10%)
- Waveform is not defined for coupling L/N to PE (9 µF, 10 Ohm)

New Specifications in Standard

- Decoupling inductance between up to maximum 1.5 mH in function of the line current
- Half value time for L/N to PE coupling
- New proposal for High speed CDN

Voltage Wave Form:

Surge voltage parameters:	Coupling impedance	
	18 µF	9 µF + 10 Ohm
Front time	1.2 µs ± 30%	1.2 µs ± 30%
Time to half value:		
current rating < 25 A	50 µs + 10 µs/ - 10 µs	50 µs + 10 µs/ - 25 µs
current rating 25 A up to 60 A	50 µs + 10 µs/ - 15 µs	50 µs + 10 µs/ - 30 µs
current rating 60 A up to 100 A	50 µs + 10 µs/ - 20 µs	50 µs + 10 µs/ - 35 µs

Current Wave Form:

Surge current parameters:	Coupling impedance	
	18 µF	9 µF + 10 Ohm
Front time	8 µs ± 20%	2.5 µs ± 30%
Time to half value:	20 µs ± 20%	25 µs ± 30%

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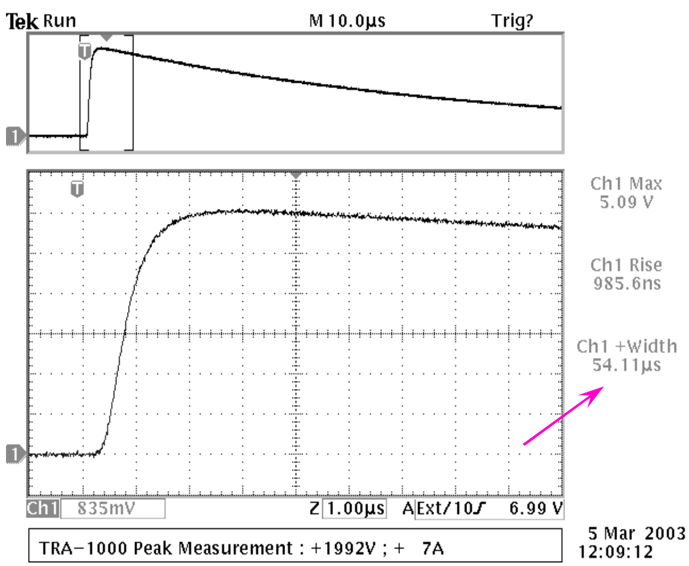
Waveform at Different Outputs

Partners for HV and EMC Solutions

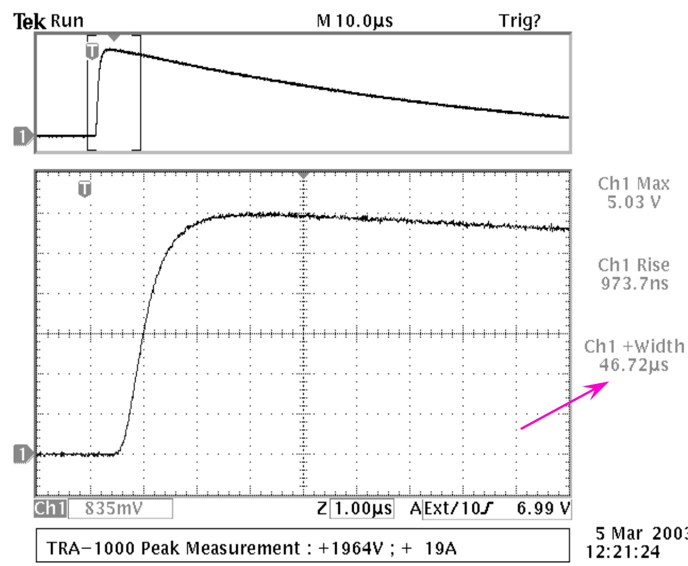
Voc, direct output

- TRA2000 System



Voc, L to N

- TRA2000 System

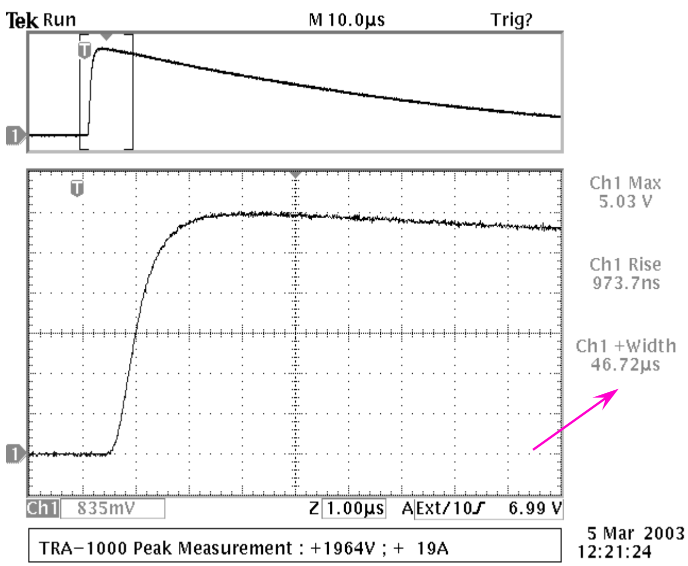


Waveform at Different Outputs

Partners for HV and EMC Solutions

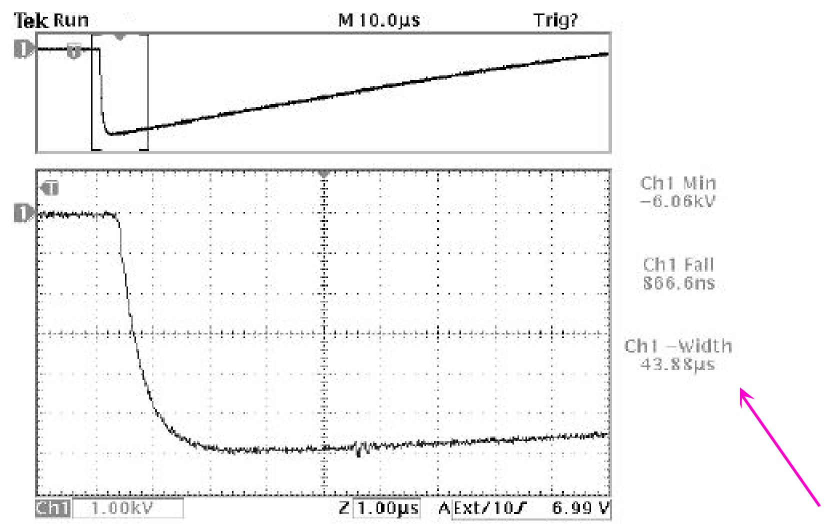
Voc, coupling L-N

- TRA2000 System



Voc, L/N to PE

- TRA2000 System



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TRA2000 Surge Outputs

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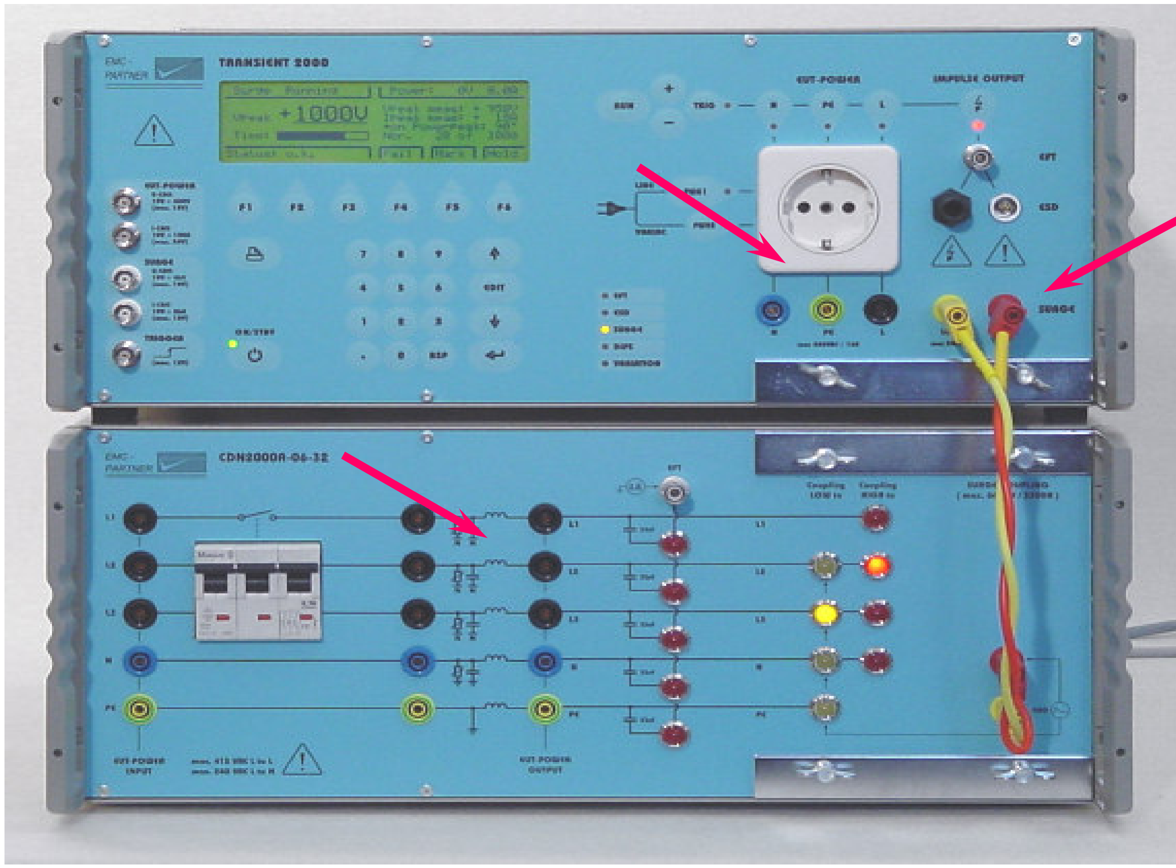
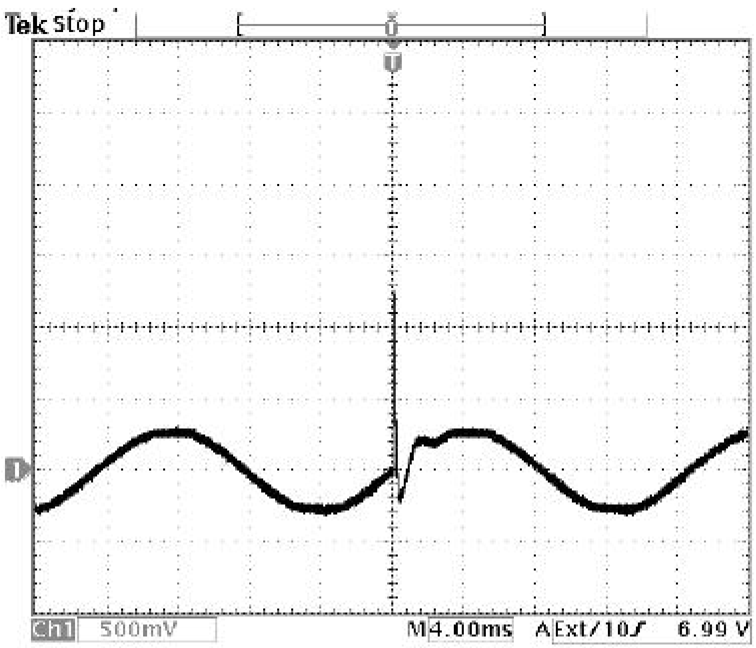


Synchronization Effects

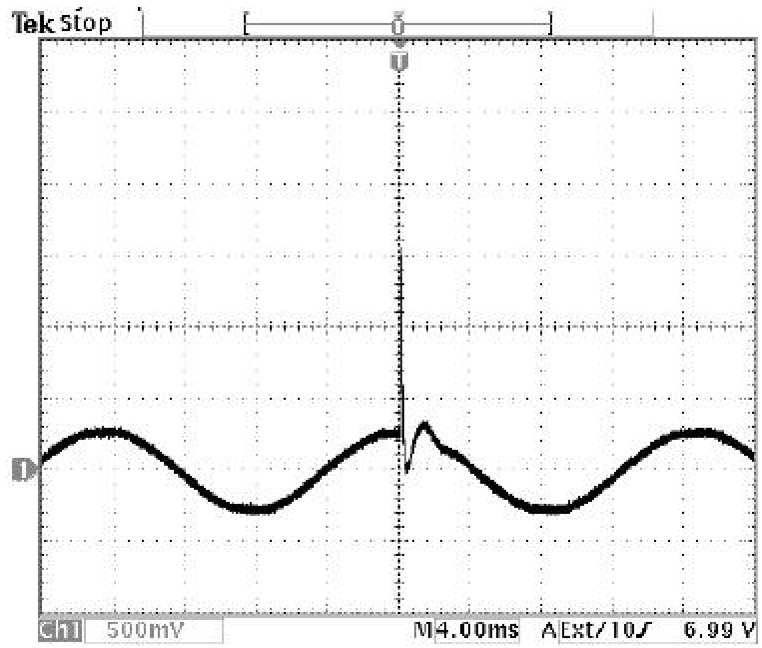
Partners for HV and EMC Solutions

Surge Impulse
Zero Degree Phase Angle



Surge Impulse

90 Degree Phase Angle



IEC 61000-4-2 Edition 2
DOA – June 2009 DOW -- 2014

Relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, directly from operators.

It additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures.

The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges.

Reasons for Revision of IEC 61000-4-2

Partners for HV and EMC Solutions

Rationale

- Previously pass/fail greatly influenced by generator used
- New high speed technology is in use → >GHz

IEC61000-4-2 Ed2 changes

- Calibration and verification of measurement equipment clearly defined
- Standard current waveform defined as a mathematical equation
- Uncertainty defined for different parameters
- No tests at lower level for contact discharge

The “Good Old Days”

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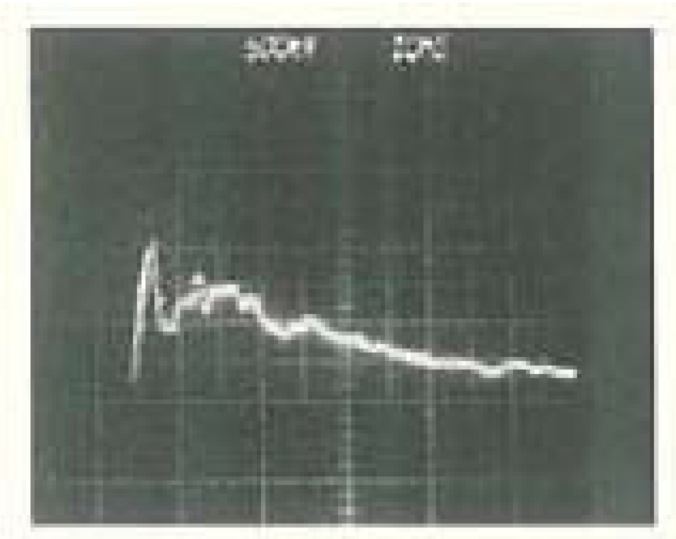
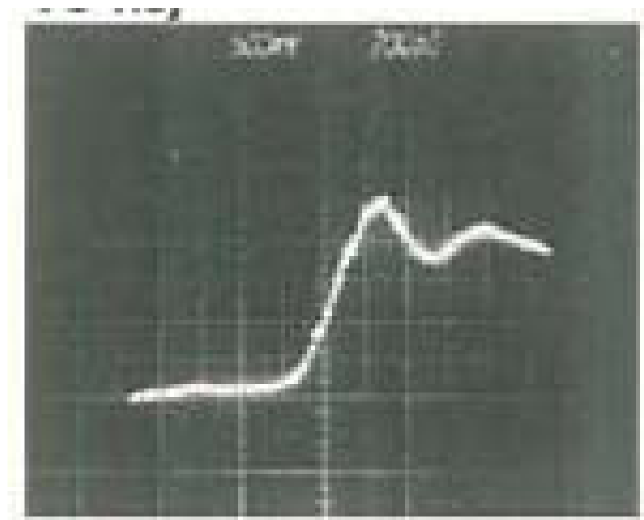
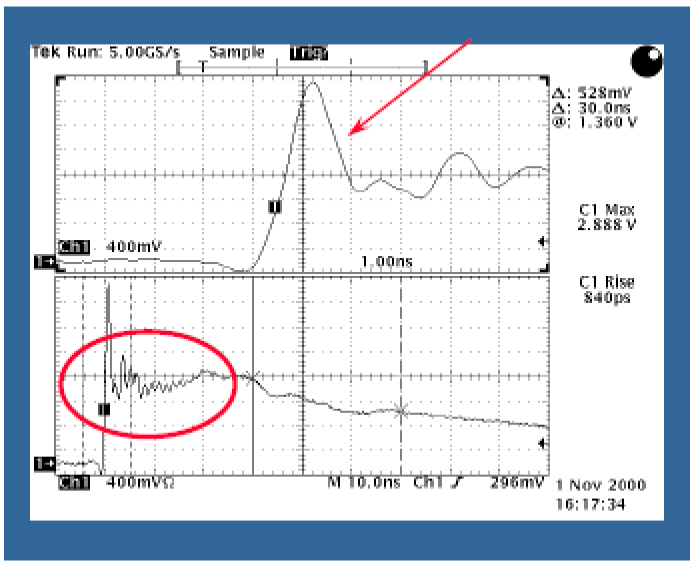




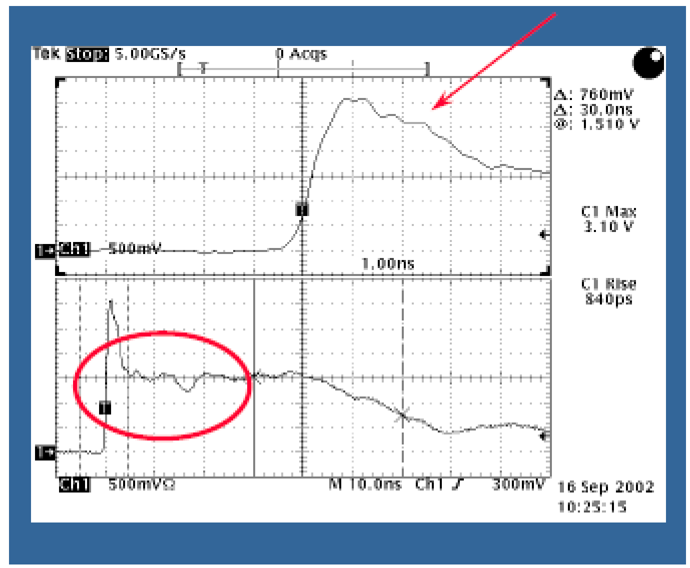
Round Robin Waveform

Partners for HV and EMC Solutions

Edition 1 Generators



Modified Ed. 2 Generators



Conclusion of the Round Robin

- It was difficult to find EUT failing with ESD Standard test levels. Some EUT have been modified to show failure.
- Large (typically 1:2.2) test result variations have been observed as a result of changing the ESD generator.
- The modified generators did not show smaller variations than the non-modified generators.
- **No direct correlation between current or field or frequency related parameters and EUT failure level could be found within the limited data set**
- **Test result variations were observed with same ESD generator on the same EUT**

Potential Causes of Test Result Variations

Steps to determine the source of differences

Verify the test setup; examine all the details, including the position of each cable and the condition of the EUT (e.g., covers, doors).

Verify the test procedure, including the EUT operation mode, position and location of auxiliary equipment, operator position, software state, application of discharges to the EUT.

Verify the test generator; is it operating correctly? When was it calibrated last ? Is it operating within specifications ? Are test result differences due to the use of different generators ?

Variation in Test Results

If differences in test results are caused by the use of different ESD generators, then the results with any generator that meets the requirements of 6.1 can be used for determining compliance with this standard.

Note: In terms of compliance with the standard, it is sufficient to consider only the results given by the ESD generator which is less aggressive to the EUT.

However, in terms of EUT quality/reliability and customer satisfaction, it may be advisable to ensure the EUT exhibits error-free performance with the ESD generator which is more aggressive to the EUT.

Escalation Strategy

1. **If 1 error** occurs in the first discharge set, **go to step 2**.

   If more than 1 error the EUT fails at that test point and test level.

2. **A second test** is run at that test point applying **Double the number of discharges of the first set**. If no error occurs in this set of discharges, the EUT passes the test at that test point. If more than one error occurs in the second set of discharges, the EUT fails the test. If exactly 1 error occurs in the second set of discharges, a third test is performed.

3. **The third test is a repetition of point 2** If no error occurs in this set of discharges, the EUT passes the test at that test point. If 1 or more errors occur in this set of 100 discharges, the EUT fails the test.

Immediate Effect of Escalation Strategy

Test time may increase significantly

Pass / Fail criteria less dependent on ESD generator model

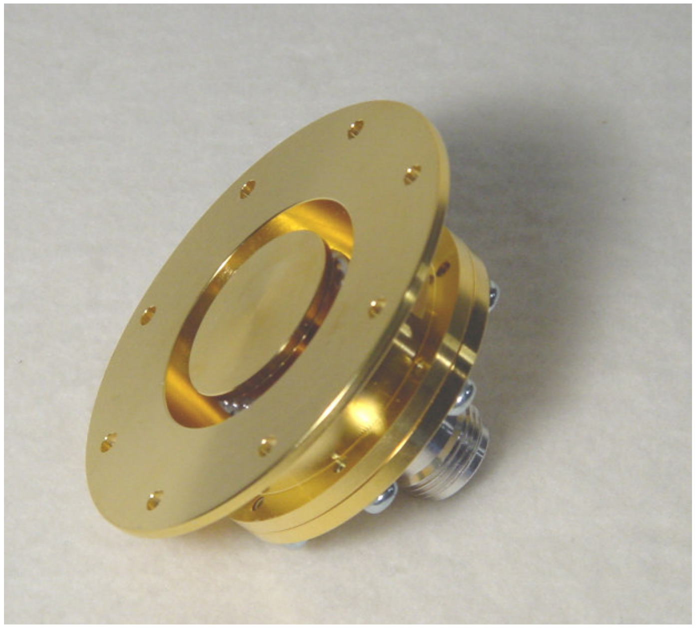
Justification procedures increase EUT Pass opportunities

More quantified Pass / Fail justification process

Verification Target Changes

Edition 1 Target

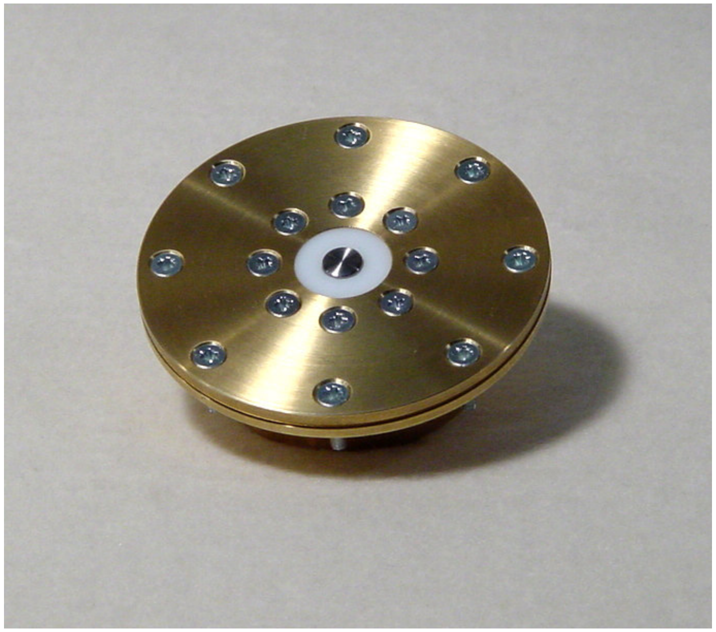
- **ESD-TARGET1 (2 Ohm)**



f upper limit approx. >1Ghz

Edition 2 Target

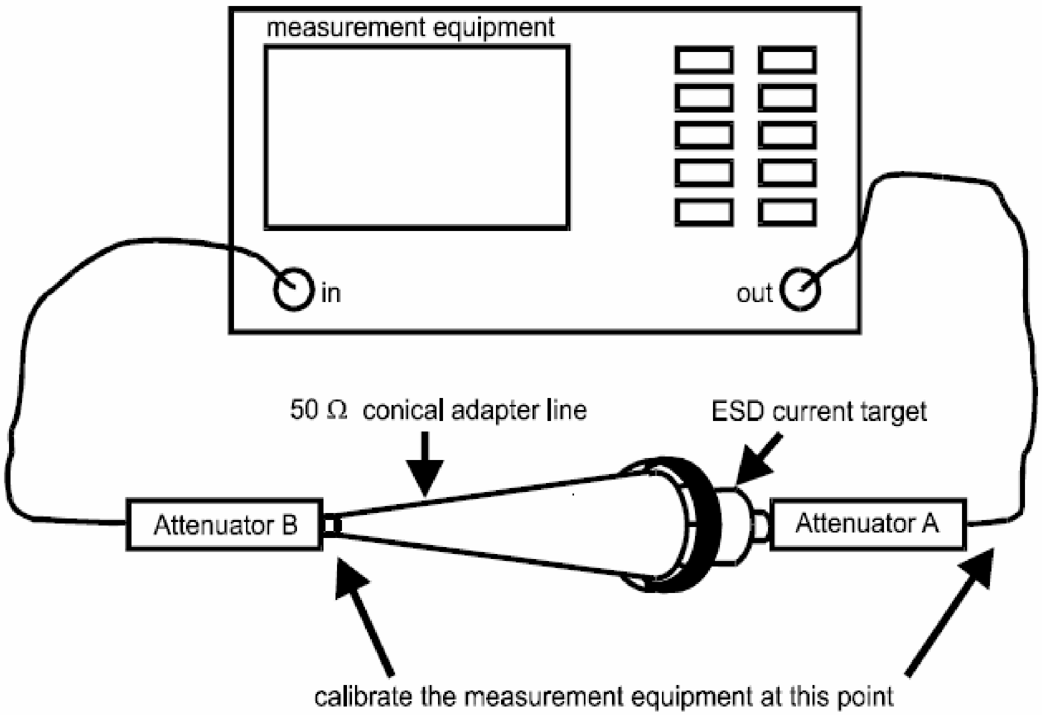
- **ESD-TARGET2 (2 Ohm)**



f upper limit approx. 4Ghz

Target Calibration

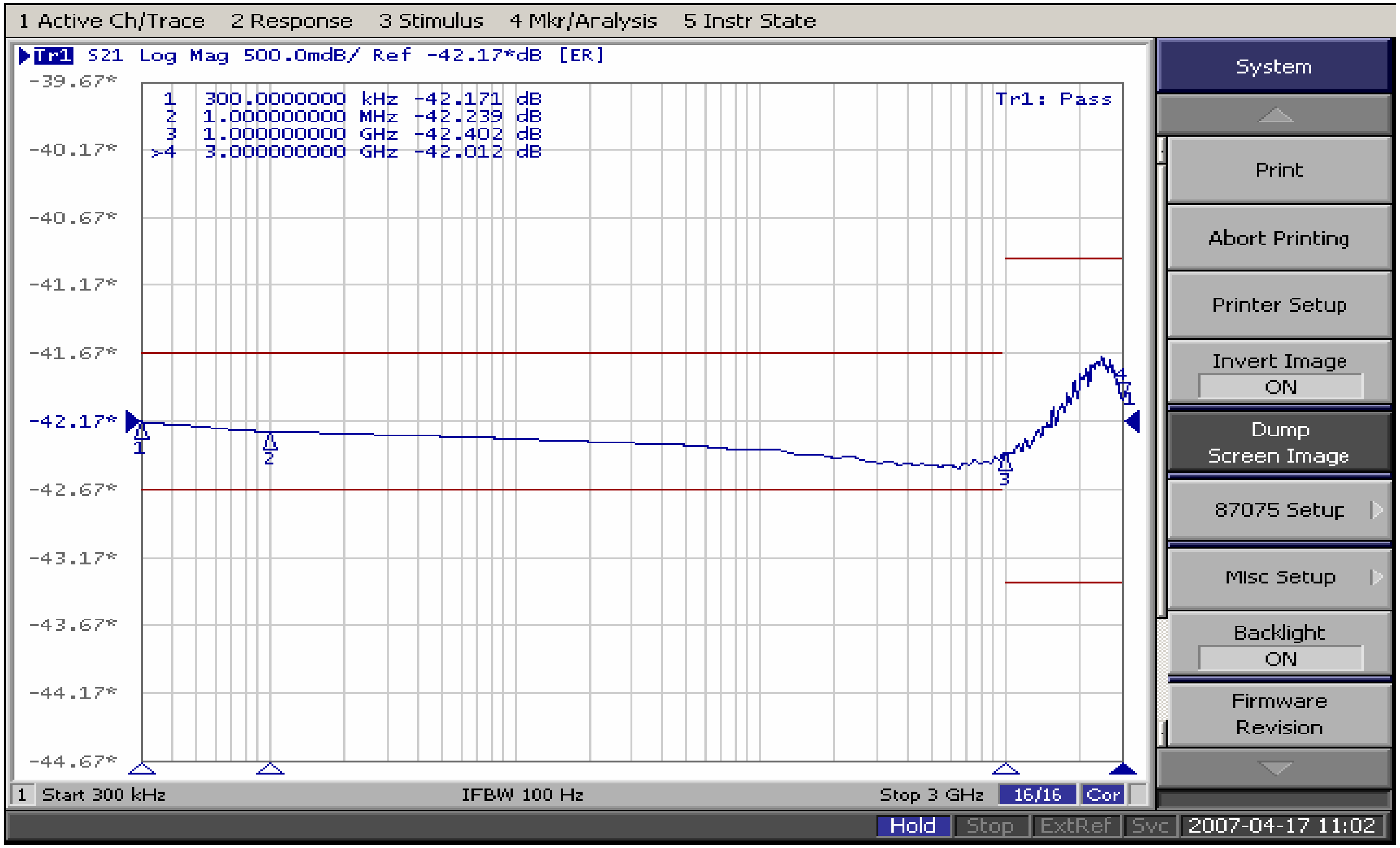
61000-4-2 Ed2/CDV © IEC:200X – 34 –



Note: adapters other than conical are also acceptable

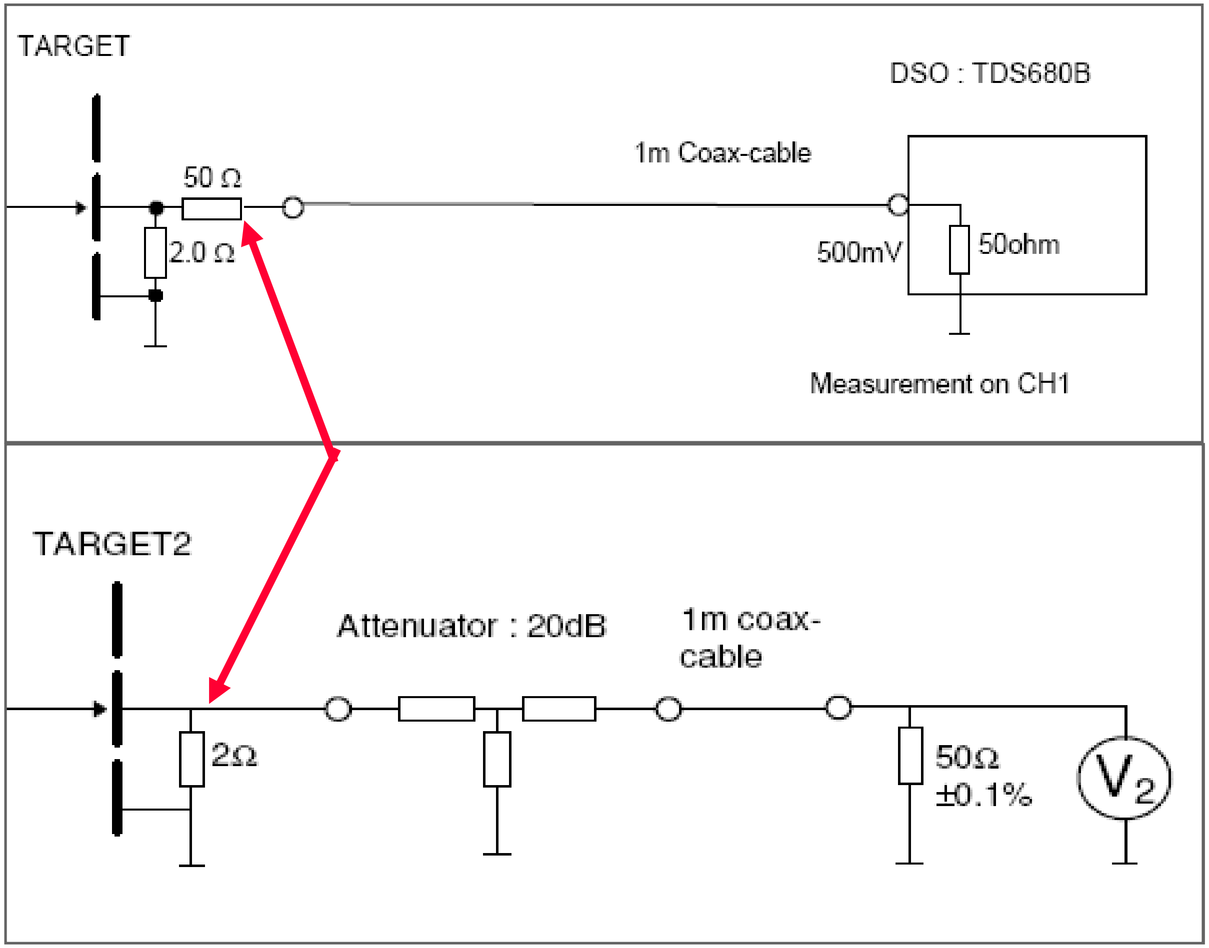
Insertion Loss Measurement

Partners for HV and EMC Solutions



Difference between existing and new targets

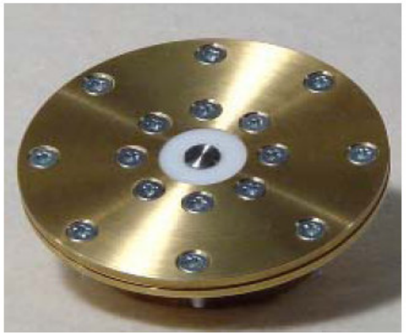
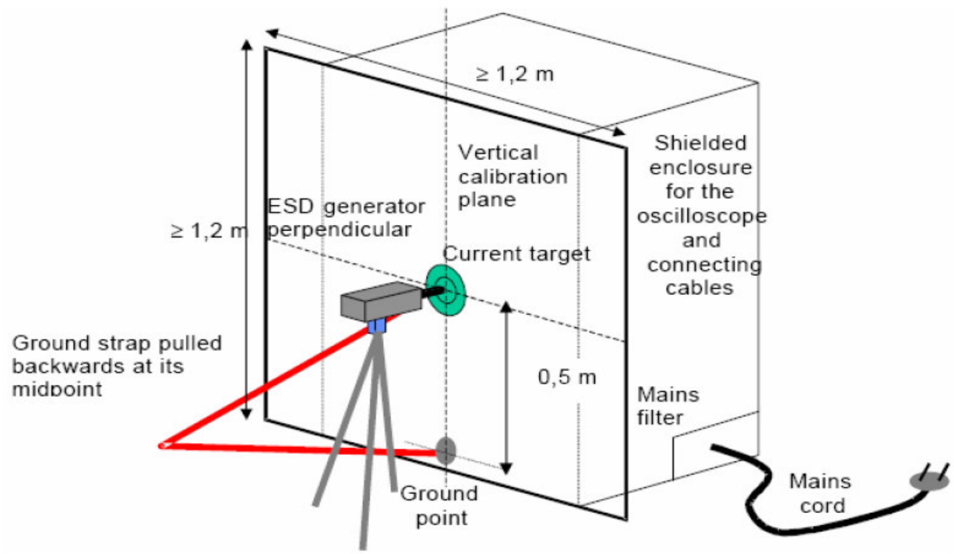
Partners for HV and EMC Solutions



Zsys must be used to calculate the ESD current V2 factor 2 higher Because of missing 50 OHM

1 General Information

The target - attenuator - cable chain always should be considered as one entity. As soon as one element gets exchanged, or even when it gets disassembled and re assembled, the whole chain needs re-calibration in order to insure compliance with the specification.

ESD-TARGET2	Proposed test set-up
 	

New ESD Simulator Calibration Procedure

Partners for HV and EMC Solutions

Table B.1 Contact discharge calibration procedure

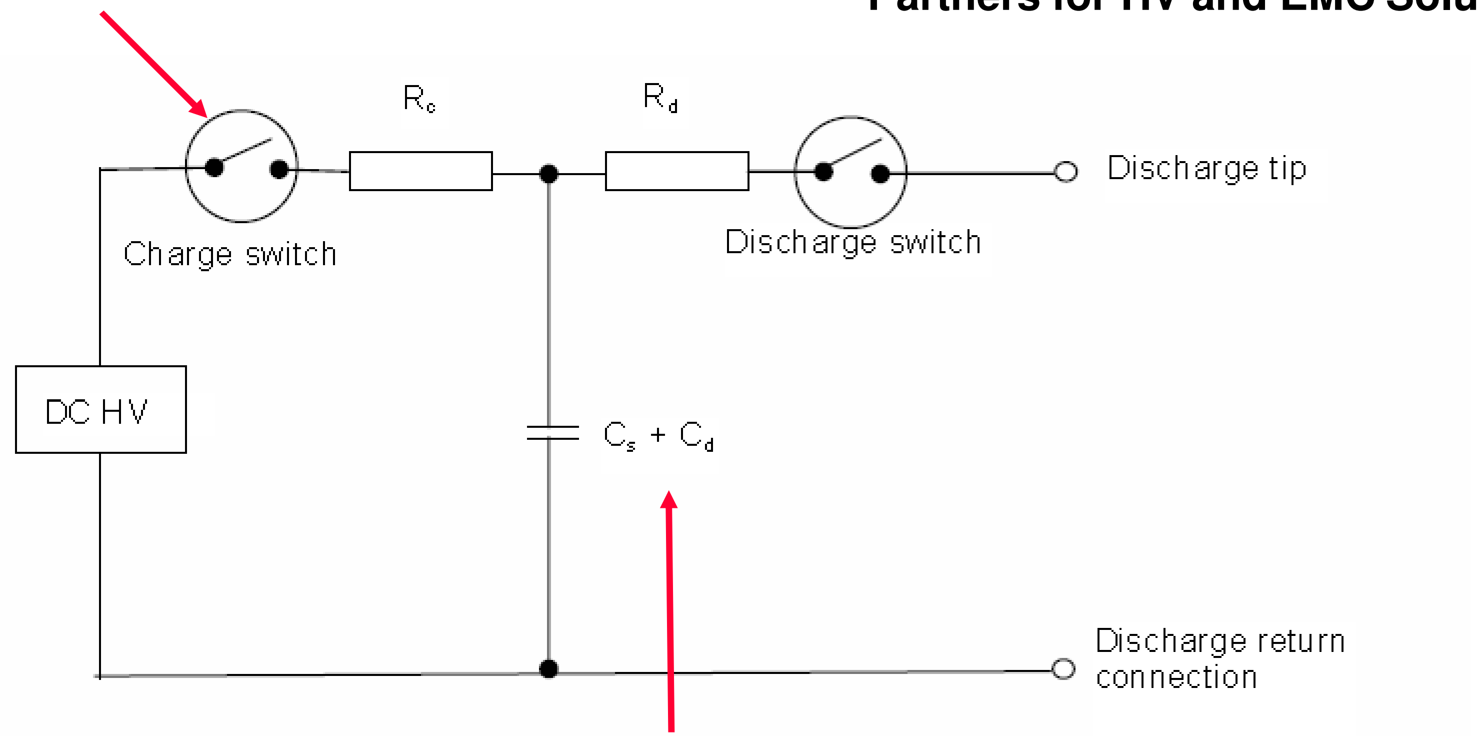
Step	Explanation
Discharge the ESD generator at each test level as defined in Table 1 five times for both polarities, store each result.	The specifications shall be met for all 5 discharges.
Measure I_p, I_{30}, I_{60}, t_r on each waveform.	The parameters have to be checked at each test level
Current at 30 ns Check if I_{30} is 2 A ± 30 %	The parameters have to be checked at each test level [1)]
Current at 60 ns Check if I_{60} is 1 A ± 30 %	The parameters have to be checked at each test level[1)]
Peak current Check if I_P is 3,75 A ± 15 %	The parameters have to be checked at each test level[1)]
Rise time Check if t_r is 0.8 ns ± 25 %	The parameters have to be checked at each test level

[1)] The value of the current given in the table corresponds to a voltage of 1 kV. This measured value changes proportionally to the generator voltage.

Calibration time will increase -> calibration cost will increase

Simplified Generator Diagram

Partners for HV and EMC Solutions



The generator shall meet the requirements given in 6.1 when evaluated according to the procedures in Annex B. Therefore, neither the diagram in Figure 1, nor the element values are specified in detail.
Existing ESD simulators should comply !

Measurement uncertainty (MU) considerations

- **The calibration laboratory has to show the following MU:**

	IEC 61000-4-2 Ed.2	MU of EMCP Calibration Place
Peak	≤ 7%	5.56%
Rise time	≤ 15%	7.03%
Current @ 30ns	≤ 7%	5.56%
Current @ 60ns	≤ 7%	5.56%

ESD3000 System Ready for Ed.2

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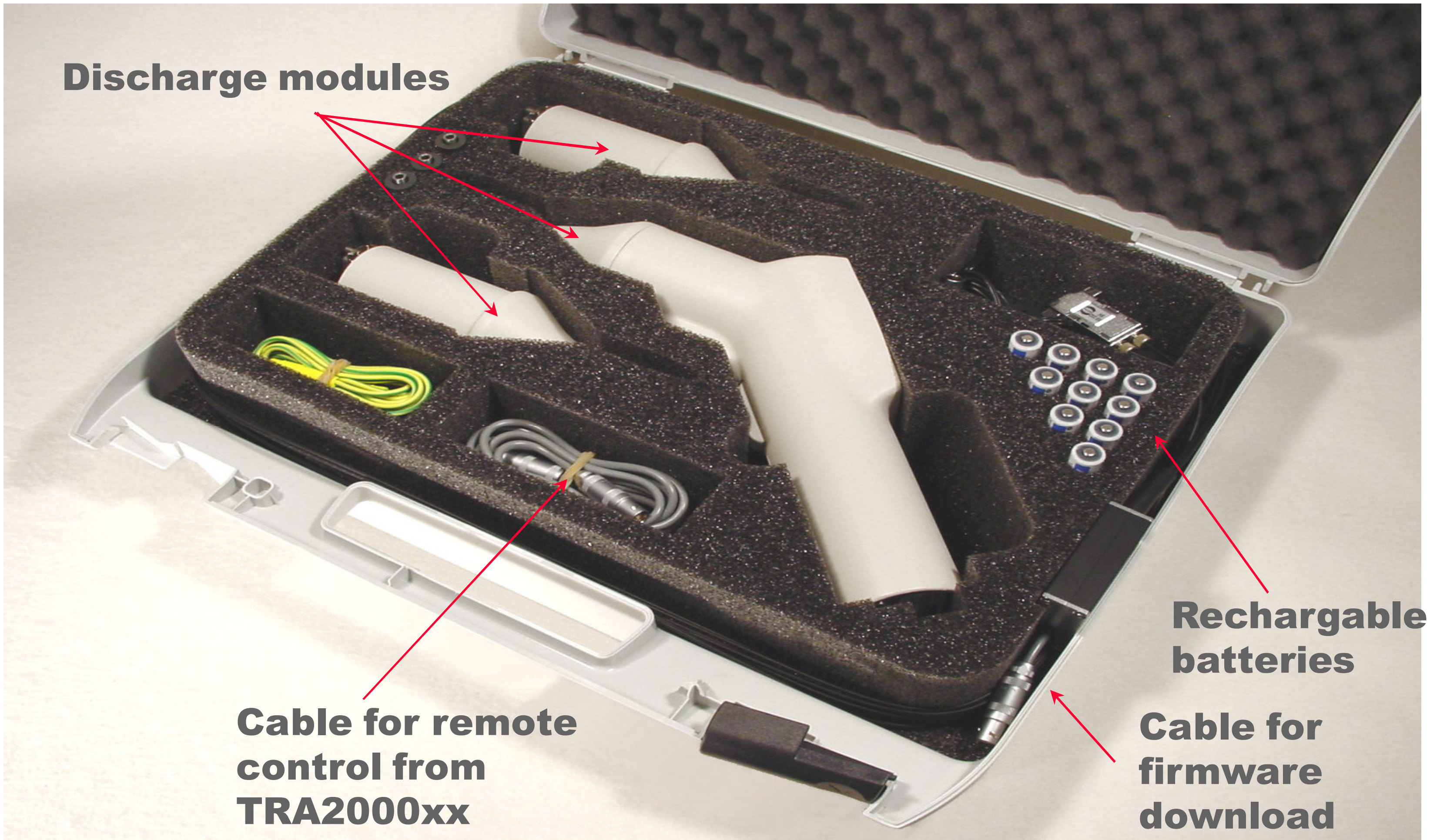


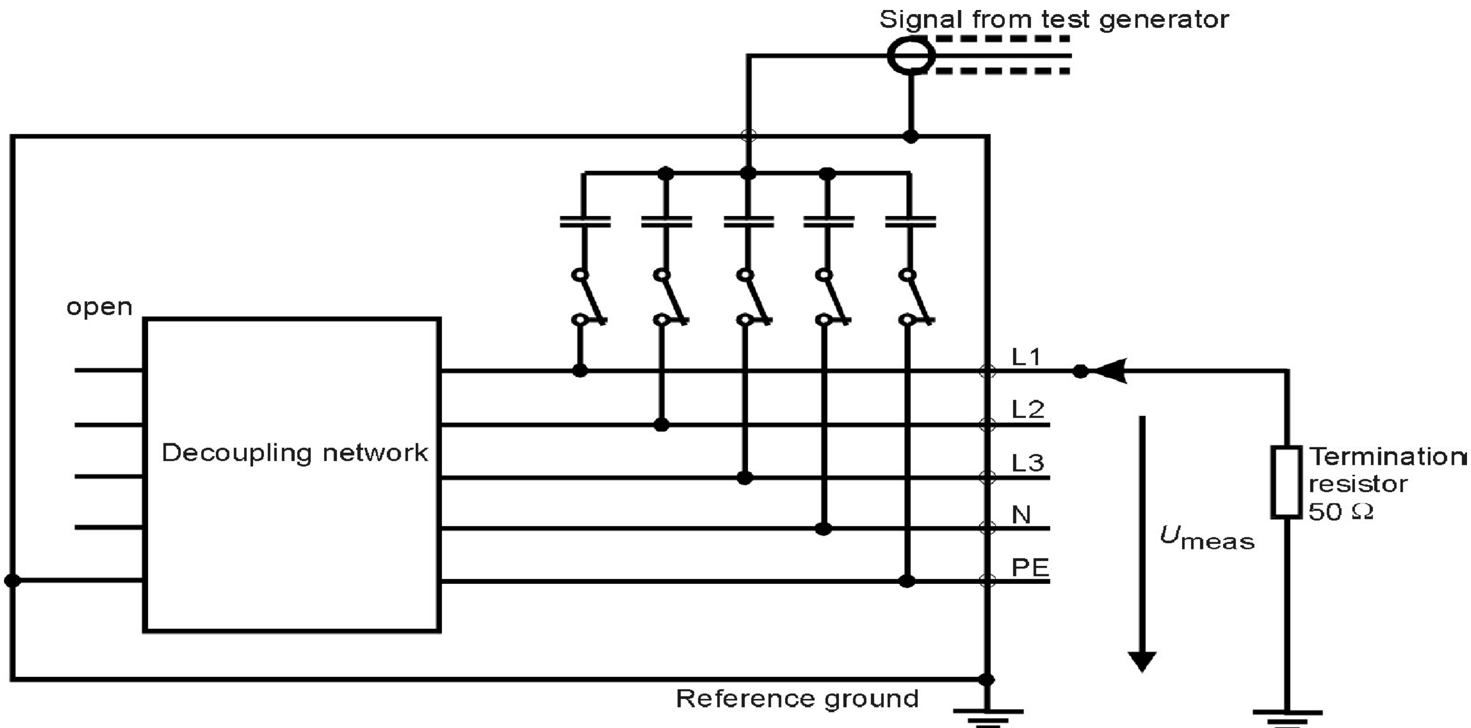
IEC 61000-4-4 Ed. 2.0 EFT

Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test

- Establishes a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to electrical fast transient/bursts on supply, signal, control and earth ports. The test method documented in this part of IEC 61000-4 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon. The standard defines: - test voltage waveform; - range of test levels; - test equipment; - verification procedures of test equipment; - test set-up; - test procedure. The standard gives specifications for laboratory and post-installation tests. **The contents of the corrigenda of August 2006 and June 2007 have been included in this copy.**

EFT Waveform Verification at CDN Output as Decided by IEC

Partners for HV and EMC Solutions



Status CDV May 2009 Written into FDIS (Final Draft International Standard)

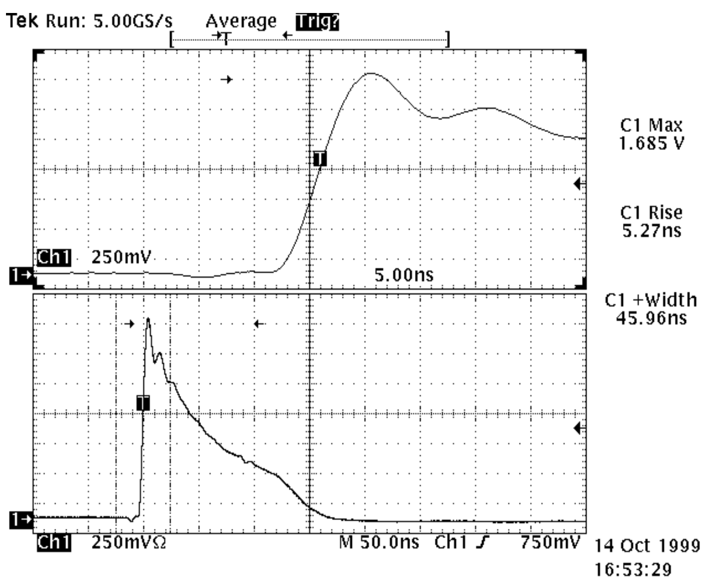
- **A possible disconnection of an individual line will be discovered.**
- **Not all generators on the market will comply with this calibration**

Outputs “Direct”or “CDN 1or 3p”

Partners for HV and EMC Solutions

<u>HV Direct Output Waveform</u>

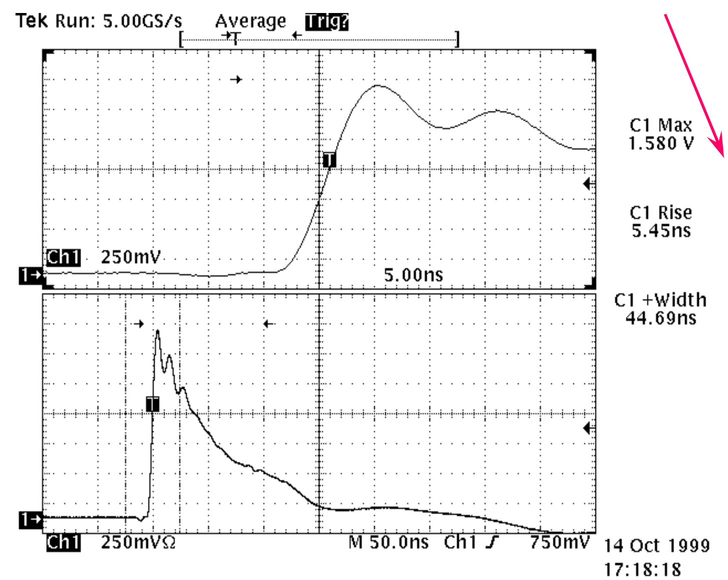
- TRA2000 System



50 +1000 Ohm calibration

<u>1 or 3 Phase CDN Output Waveform</u>

- TRA2000 System



EMCP
50 Ohm calibration phase by phase or all to PE

6.2.2 Verification of the CDN

- The waveform shall be verified at the common output of the CDN with a single 50 Ohm termination. The verification is performed with the generator output voltage of 4 kV.
- **The functionality verification of each single CDN path is recommended.**
- Rise time of the pulse 10 to 90% shall be 5 ns +/-30%
- Impulse duration shall be 50 ns +/-30% with the 50 Ohm load.
- The residual test pulse voltage on the inputs shall not exceed 10 % of the applied test voltage.
- **NOTE: CDN designed in accordance with Ed1 may need modification.**

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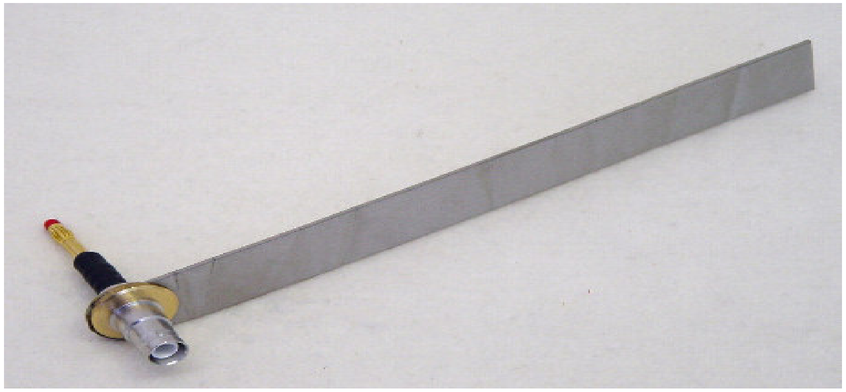
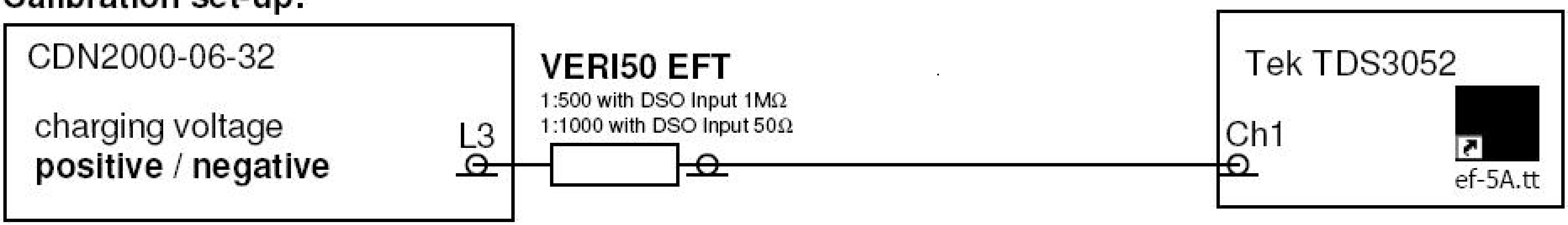
CDN Calibration Adapter

Partners for HV and EMC Solutions



EMCP supports with the adapter only line to reference earth calibration

Calibration set-up:



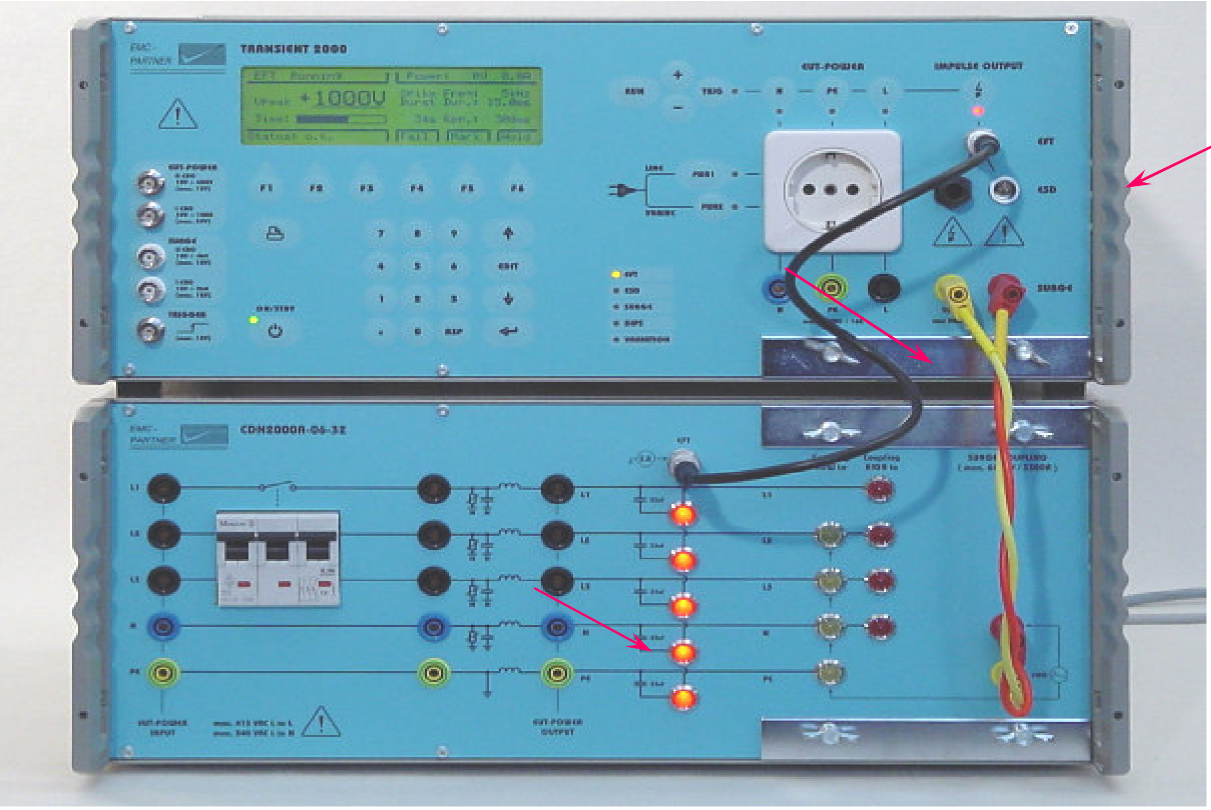
TRANSIENT 2000 Output:
Impulse output EFT
No power on EUT power inputs

COUPLING PATH
ALL to GND
VERI50-EFT on L3

CH 1: VERI50 EFT
DSO terminated with 50Ω
PC control file ef-5L3.tt

TRA2000 EFT Outputs

Partners for HV and EMC Solutions



TRA2000 EFT Complies with CDV and FDIS calibration method

IEC 61000-4-11 Ed. 2
Published 2004-03-24

Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests

- This second edition cancels and replaces the first edition published in 1994 and its amendment 1 (2000). This second edition constitutes a technical revision in which:

  1) preferred test values and durations have been added for the different environment classes;

  2) the tests for the three-phase systems have been specified.

Maintenance of IEC 61000-4-11

Rationale for Changes

- Three phase application was not clearly defined
- V-variations as defined were not real world

Reasons

- Generator was not clearly defined e.g. overswing and underswing in % of what; DIP voltage or nominal voltage?
- Three phase test sequence was not clear
- Interruption and Dips >16 A were not not addressed

Changes

- Overswing and underswing in % of U_T (nominal voltage)
- Three phase test sequence now specified
- Interrutption and Dips >16 in a new standard IEC 61000-4-34

Agreed Changes

Voltage change with load at the output of the generator

- 100% output, 0 to 16 A   less than 5% **of UT**
- **80% output 0 to 20 A   less than 5% of UT**
- 70% output, 0 to 23 A   less than 5% **of UT**
- 40% output, 0 to 40 A   less than 5% **of UT**

The test set-ups for the three types of phenomena described in this standard are:

- voltage dips
- short interruptions;
- **voltage variations with gradual transition between the rated voltage and the reduced voltage (optional).**

Verification Of The Switching Time

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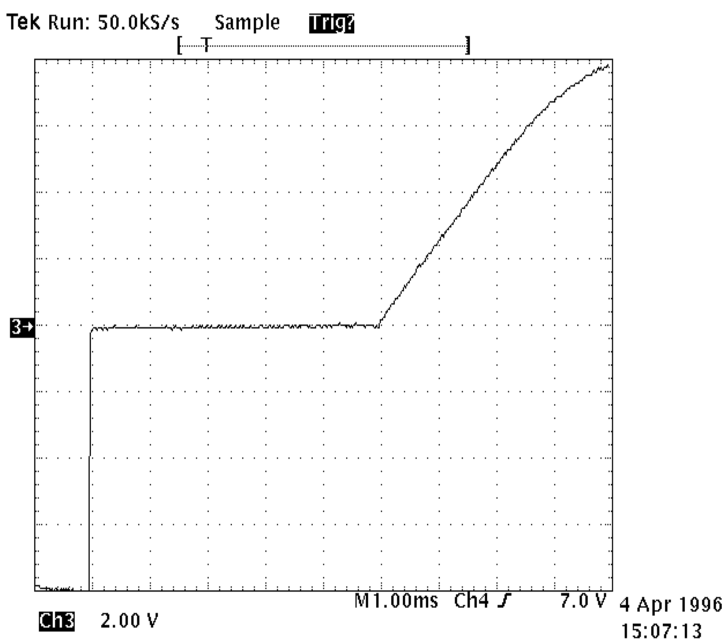
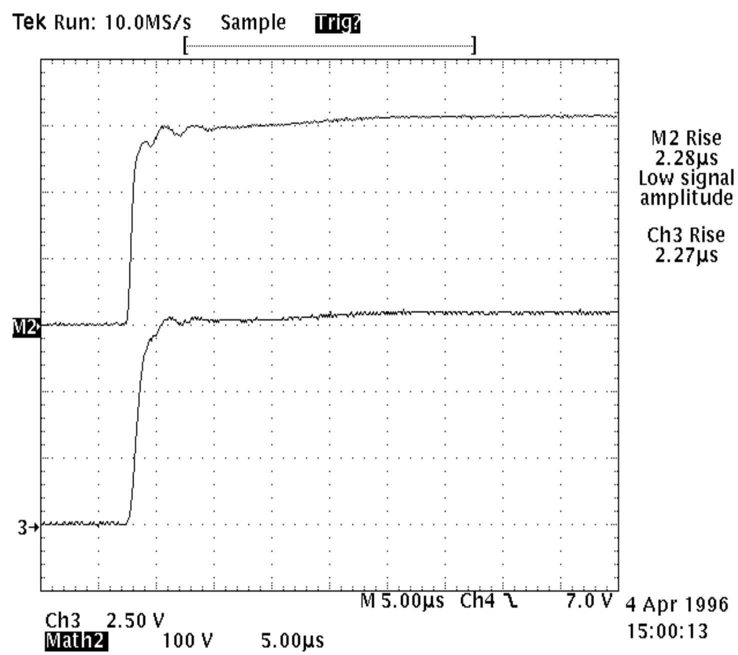


DIPS: Angle 270° 100% to 0%
Overshoot: < 5%
Rise time: 1 to 5 µs



DIPS: Angle 270° 100% to 0%
Overshoot: < 5%
Rise time: 1 to 5 µs

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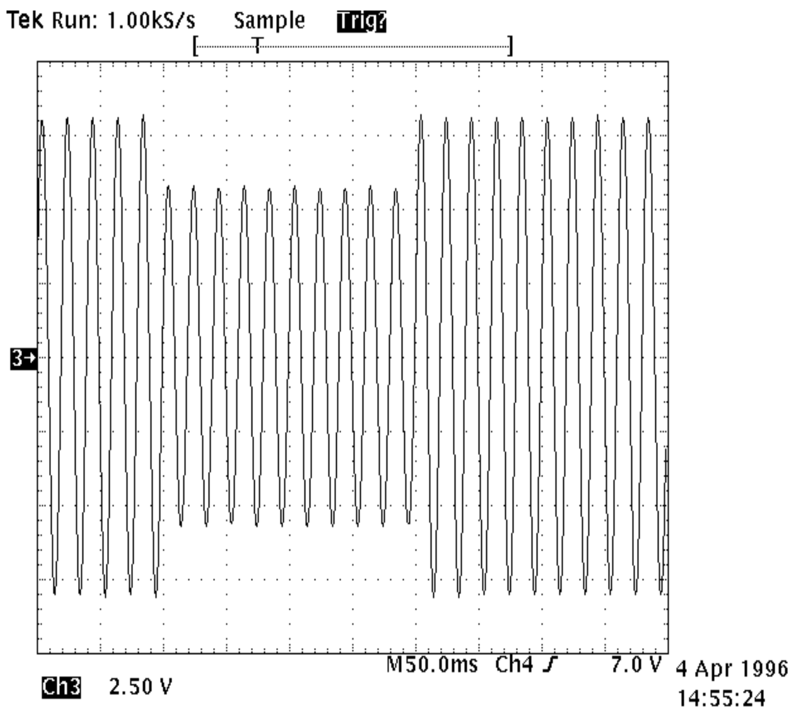
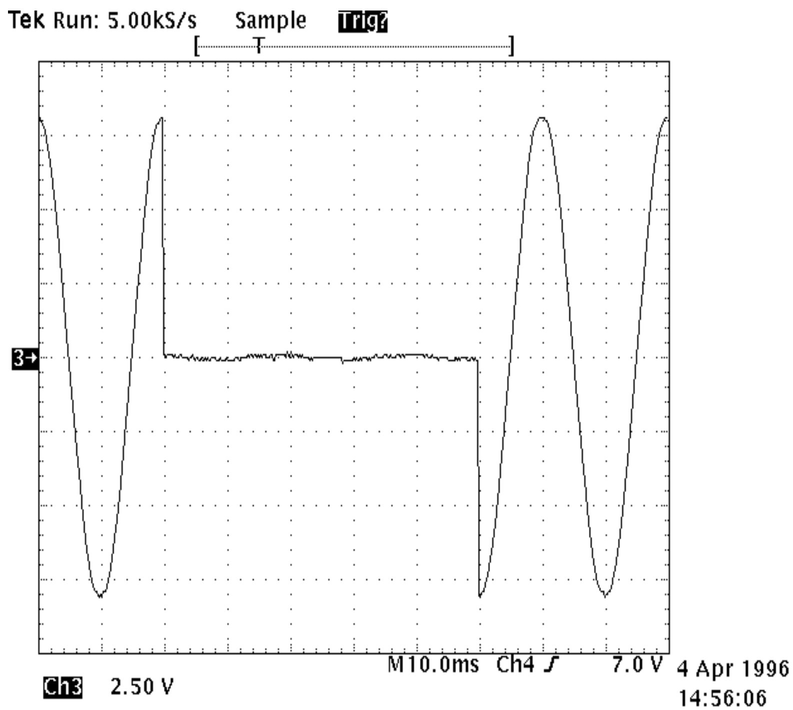
Verification Of the Switching Angle

Partners for HV and EMC Solutions



DIPS: 70%, 200 ms, Begin = 0°, End = 0°



DIPS: 0%, 50 ms, Begin = 90°, End = 270°

New Test Sequence < 16A

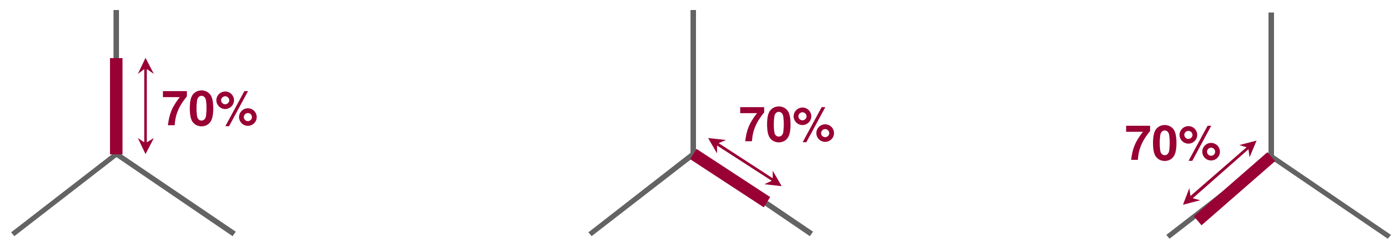
- The EUT shall be tested for each selected combination of test level and duration with a sequence of three dips/interruptions with intervals of 10 s minimum (between each test event).
- Abrupt changes in supply voltage shall occur at zero crossings of the voltage, and at additional angles considered critical by product committees or individual product specifications preferably selected from 45°, 90°, 135°, 180°, 225°, 270° and 315° on each phase.
- **For short interruption test of three-phase systems, all the three phases must be simultaneously tested as per 5.1.**

- For voltage dips test of three-phase systems **with neutral**, each individual voltage (phase-to neutral and phase-to-phase) must be tested, one at a time, as per 5.1. **This implies six different series of tests.**

- For voltage dips test of three-phase systems **without neutral**, each phase-to-phase voltage must be tested, one at a time, as per 5.1. **This implies three different series of tests**.

Example 70% Dips

3 tests phase to neutral

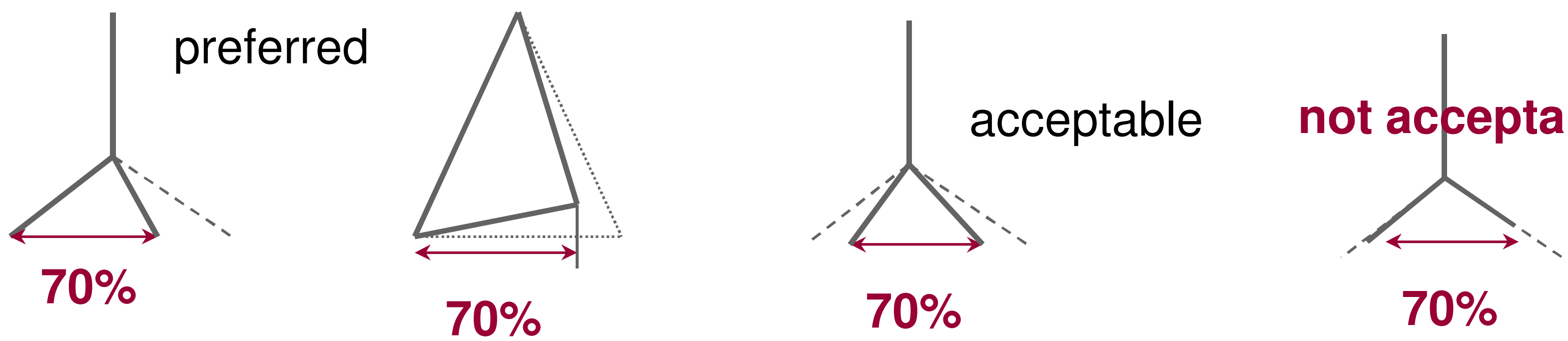


3 tests phase to phase

preferred

acceptable

not acceptable



critical for motors

critical for rectifiers

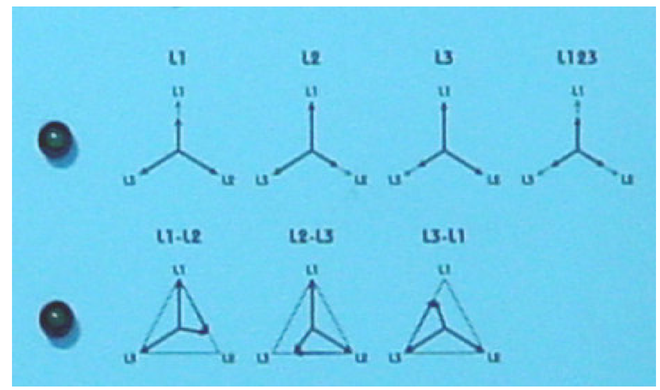
EMCP Solution Dip & Interrupt on Three Phase Power Supplies

Partners for HV and EMC Solutions

TRA2000

EXT-PFS32

SRC32



DIPS >16 A, Standard IEC 61000-4-34

Rated current 16 A to 100 A

- 16 A up to 50 A per phase same calibration procedure as -11, 100 Ohm, 50 Ohm for the range 50 to 100 A
- Inrush current 500 A measured with same circuit (VERI-DIPS)
- 50A up to 100 A inrush current 1000 A measured with same circuit (VERI-DIPS2)

Rated current per phase >100 A

- Instead of a calibration procedure a power line voltage measurement per half cycle is specified
- Switching time is measured with a 25 Ohm resistor instead of 100 Ohm
- No inrush current measurement is specified