Application Note: Surge Testing of unshielded Control and Data Lines

Surge testing on unshielded data and control lines is a very complex topic. This application note will help you to get an overview, to select the suitable test equipment and to perform a test properly.

Overview Coupling and Decoupling Networks for data- and control lines

Standard	**IEC 61000-4-5**			**IEC 61000-4-12**	
Operating Mode of the EUT Lines	asymmetrical	symmetrical		asymmetrical / symmetrical (*)	
Impulse Shapes	1,2/50µs-8/20µs	1,2/50µs-8/20µs	10/700µs-5/320µs	Ring wave 100kHz with Z=12Ω, 30Ω and 200Ω	Damped Oscillatory Wave 100kHz & 1MHz; Ring wave 100kHz with Z=200Ω
Coupling Network	PCD 126	PCD 121	PCD 120 PCD 122	PCD 126	PCD 150
Decoupling Network	DEC 7	DEC 5	DEC 5	DEC 7	included in PCD 150

(*) Communication ports with fast operating signals are tested without any CDN. The test voltage is applied directly between the cabinets of the equipment interconnected.

Standard	**ITU K.44**	**TIA-968-A** (FCC Part 68)	**Telcordia (Bellcore) GR-1089-CORE**		
Operating Mode of the EUT Lines	symmetrical	symmetrical	symmetrical		
Impulse Shapes	10/700µs	10/160µs 10/560µs 9/720µs	10/1000µs 10/360µs 2/10µs	10/360µs 12 pair	
Coupling Network	PCD 120 (PCD 122)	PCD 800	PCD 900	PIM 930	
Decoupling Network	DEC 5 DEC 6	DEC 5 DEC 6	(DEC 5) (**)	(DEC 5) (**)	

(**) Test impulses are applied with the system in an idle condition, that is not transmitting or receiving data. However DC may be present on the EUT line. The DEC 5 is used to decouple the auxiliary equipment in this idle state.

Coupling onto data and control lines

Several common standards describe the surge testing of control and data lines. Such standards are e.g. IEC / EN 61000-4-5, IEC / EN 61000-4-12 and ITU-T K.44. These basic standards only contain little information about selecting a suitable coupling element. The following information will help you to decide which coupling element should be used.

The given information can be used for symmetrical or asymmetrical operated lines.

There are some reasons to use coupling elements:
- to protect the generator from the signals (AC and / or DC) present on the lines to be tested
- to isolate the lines to be tested from the load caused by the generator
- to form a defined impulse shape and / or amplitude

As data rates in communication systems increase, the coupling element for superimposing the surge onto control and data lines must be selected carefully. For this reason it is necessary to know the characteristics of the most common coupling elements.

	Capacitors	**Transzorbdiodes (Avalanche Breakdown Diodes)**	**Gas Arrestors**
Advantages	no nonlinear distortion	small capacitive load to the lines to be tested	nearly no capacitive load to the lines to be tested
Disadvantages	heavy capacitive load to the lines to be tested	nonlinear distortion	Nonlinear distortion. Causes short circuit when ignited.
Influence on Impulse Amplitude	If the proper value is selected (often given in the standards) no amplitude drop occurs.	The diodes are limiting elements. The voltage drop must be taken into account to select the impulse voltage at the generator.	Since the voltage across the ignited arrestor is very low, nearly no voltage drop occur.
Application Fields	control and signal lines with low frequencies (data rates)	control and signal lines with medium frequencies (data rates)	signal lines with high data rates

Which coupling element is used for a specific application should be defined in the relevant product standard. If no information is given and the preferred type of coupling element given in the basic standard does not work, the user has to decide which one he will use. The table above gives guidance but no absolute rules to select a coupling element. When the surge test system is connected to the EUT and it does not work any more, try it with another coupling element.

The used coupling element has to be documented in the test protocol because different types of coupling elements may produce different test results

Decoupling Auxiliary equipment from the EUT being tested

As data rates in communication systems increase, surge testing with a decoupling unit between the EUT and the auxiliary equipment becomes more and more difficult or even impossible. The following information helps you to decide which decoupling unit should be used and what has to be done if no suitable decoupling unit exist.

With decoupling between EUT and Auxiliary Equipment according to e.g. IEC 61000-4-5 or ITU-T K.44				
asymmetrically operated lines		symmetrically operated lines		
control lines up to few 100Hz e.g. control lines for relays or 20mA current interface	data lines above some 100Baud e.g. RS-232 or 20mA current interface	low data transfer rate up to 10kBaud e.g. analog telecom lines	medium data transfer rate up to 100kBaud e.g. RS-422 or RS-485	high data transfer rate up to 10MBaud e.g. ISDN or Ethernet lines
DEC 7 PCD 150	DEC 6	DEC 5 PCD 150 (*)	DEC 5	DEC 6

(*) The PCD 150 can be used only up to some 100Baud

If the system is not working correctly with a decoupling unit between the EUT and auxiliary equipment, surge tests must be made without any decoupling as described below.

Surge Tests without Decoupling between the EUT and the Auxiliary Equipment
The standards Telcordia (Bellcore) GR-1089-CORE and IEC 61000-4-5 Edition 2 describe test procedures when no suitable decoupling unit is available. Such tests may be performed as described below.

EUT survival test
Surges have high energy and can destroy insufficient protected electric equipment. It is important to ensure that the protection circuits of the EUT are working properly. This is verified with this test. No information about the system behavior due to surges can be gained from this test.

Test procedure:
- Functional test of the whole system (EUT connected with auxiliary equipment)
- Testing the EUT alone (no connection to the auxiliary equipment) with surges
- Functional test of the whole system (EUT connected with auxiliary equipment again)

Test result: The EUT has survived / not survived the test

System test
The data will always be interrupted or corrupted when a surge is applied. Data bits are typically a few volts or lower, and a surge is up to several thousand volts. Therefore it is important to know how the system response to the surge is, e.g. are there any software latch-ups?

Test procedure:
- Whole system in action, EUT is connected to the auxiliary equipment without a decoupling unit
- Testing the whole system with surges through a coupling network

Test result: The system has passed / not passed the test

Ordering Information for Haefely Equipment

Type	Article No.	Short description
PCD 120	249941	Automatic coupling network for symmetrical lines. Optimized for ITU-T K.44. Can also be used for IEC 61000-4-5 (impulse shape 10/700us).
PCD 121	249801	Manually coupling network for symmetrical lines according IEC 61000-4-5 (combination wave 1.2/50us - 8/20us).
PCD 122	249802	Manually coupling network for symmetrical lines. Optimized for IEC 61000-4-5 (impulse shape 10/700us). Can also be used for ITU K.44
PCD 126	249803	Manually coupling network for asymmetrical lines according to IEC 61000-4-5 (combination wave 1.2/50us - 8/20us) and IEC 61000-4-12 (ring wave 100kHz).
PCD 150	249804	Manually coupling and decoupling network according IEC 61000-4-12 (damped oscillatory waves 100kHz and 1MHz).
PCD 800	249908	Automatic coupling network for symmetrical lines according TIA-968-A (FCC Part 68)
PCD 900	249930	Automatic coupling network for symmetrical lines according Telcordia (Bellcore) GR-1089-CORE
PIM 930	249933	Impulse module with integrated automatic coupling network for symmetrical lines (12 pair) according Telcordia (Bellcore) GR-1089-CORE
DEC 5	249014	Decoupling network with current compensated inductors for symmetrical lines according IEC 61000-4-5 (combination wave 1.2/50us - 8/20us and 10/700us) and ITU-T K.44
DEC 6	249015	Decoupling network with resistors for symmetrical lines according ITU-T K.44
DEC 7	249016	Decoupling network with single inductors for asymmetrical lines according IEC 61000-4-5 (1.2/50us - 8/20us) and IEC 61000-4-12 (ring wave 100kHz).

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