Test Note

EMC TESTS ON THE
ALSTOM AND MASTERFIP WORLDFIP MASTERS
FOLLOWING EMC NORM IEC 61000 4-4

Abstract

The document describes the setup and the results of the EMC tests performed on the Alstom WorldFIP master and the CERN masterFIP, following the IEC 61000 4-4 norm.

The tests compare the performance of the two boards.

They also compare different grounding technics on the Alstom board: direct grounding of the WorldFIP-shielding or capacitive connection.

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1 INTRODUCTION

This document describes the setup and the results of the EMC tests performed on the SPEC-masterFIP and Alstom WorldFIP master, following the IEC 61000 4-4 norm.

The object of the IEC 61000 4-4 standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to repetitive fast transients (bursts), on supply, signal and control ports. The test is intended to demonstrate the immunity of the electronic equipment when subjected to types of transient disturbances such as those originating from switching transients (interruption of inductive loads, relay contact bounce, etc).

For our system, we applied the repetitive fast transients to the WorldFIP communication port. We did not test the supply or ground ports, as they are application specific.

The standard defines the:

- test voltage waveform
- range of test levels
- test equipment
- test setup
- test procedure

2 Test Voltage Waveform and Range of Test Levels

The repetitive fast transient test is a test with bursts consisting of a number of fast transients, coupled into the signal under test, the WorldFIP communication port in this case. Significant for the test are the high amplitude, the short rise time, the high repetition rate, and the low energy of the transients. Figure 1 shows a general graph of the fast transient/ burst and Figure 2 the waveshape of a single pulse into a 50 Ω load.

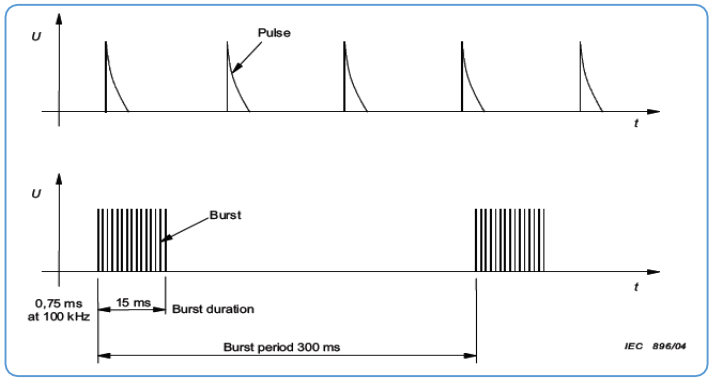


Figure 1: General graph of the fast transient/ burst

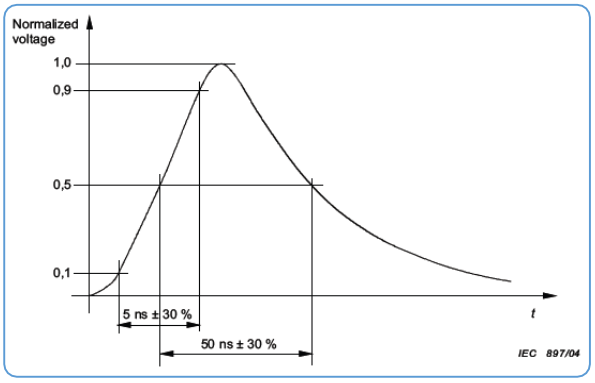


Figure 2: Waveshape of a single pulse into

According to the standard, the preferred test levels for the electrical fast transient test, applicable to the control/ communication port of the equipment are given in Table 1. We performed the tests from Level 1 up to Level 4.

Open circuit output test voltage and repetition rate of the impulses		
Level	On I/O (input/output) signal, data and control ports	
	Voltage peak kV	Repetition rate kHz
1	0,25	5 or 100
2	0,5	5 or 100
3	1	5 or 100
4	2	5 or 100
X [a]	Special	Special

NOTE 1 Use of 5 kHz repetition rates is traditional; however, 100 kHz is closer to reality. Product committees should determine which frequencies are relevant for specific products or product types.

NOTE 2 With some products, there may be no clear distinction between power ports and I/O ports, in which case it is up to product committees to make this determination for test purposes.

[a] "X" is an open level. The level has to be specified in the dedicated equipment specification.

Table 1: Test levels according to the IEC 61000 4-4 standard

Level 4 corresponds to a severe industrial environment. The installation is characterized by the following attributes:

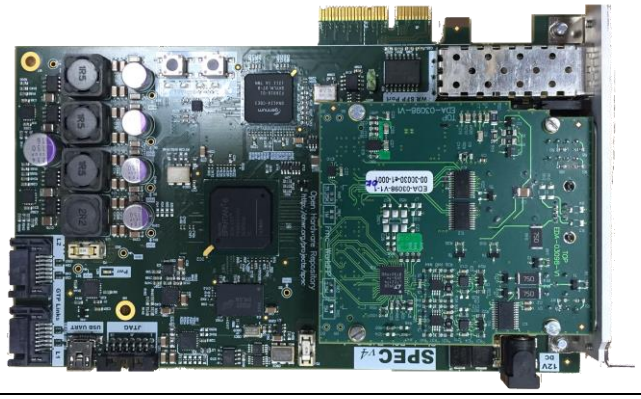
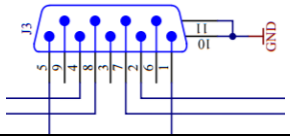
- no suppression of EFT/B in the power supply and control and power circuits which are switched by relays and contactors;
- no separation of the industrial circuits belonging to the severe industrial environment from other circuits associated with environments of higher severity levels;
- no separation between power supply, control, signal and communication cables;
- use of multicore cables in common for control and signal lines.

The outdoor area of industrial process equipment where no specific installation practice has been adopted, power plants, the relay rooms of open-air H.V. substations and gas insulated substations of up to 500 kV operating voltage (with typical installation practice) may be representative of this environment.

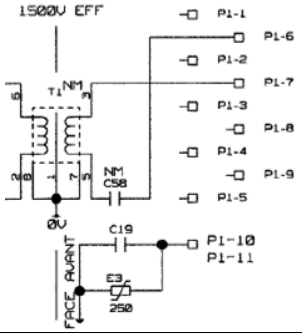
As comparison, programmable logic controllers (PLC) are compliant within level 3 of the standard.

3 Test Equipment and Test Setup

The Equipment Under Test, EUT, is the WorldFIP master, Alstom or masterFIP in the following configurations:

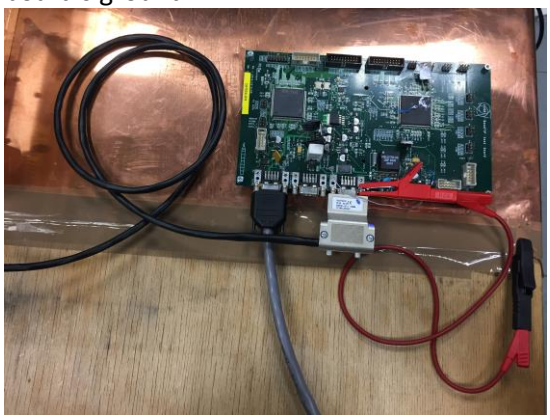
EUT 1	
Board	masterFIP V1 2M5 on SPEC V4 carrier 
Form factor	PCIe
Grounding	By design in this board the WorldFIP cable shielding is directly connected to the masterFIP board ground. In turn, the masterFIP board ground is connected to the SPEC ground and to the Kontron chassis. 

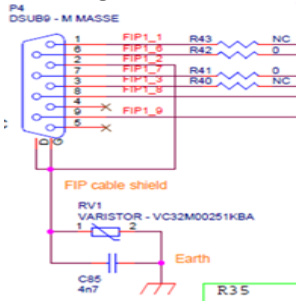
EUT 2	
Board	Alstom 2M5 PMC on PMC-to-PCI carrier 
Form factor	PCI
Grounding	The Alstom master is designed to provide capacitive coupling between the WorldFIP cable shielding and the board's ground. However, we noticed that if the Alstom board is screwed on the PMC-to-PCI adaptor, the isolation is lost and there is one single ground. In this configuration, the Alstom board is screwed on the adaptor and there is only one ground.

EUT 3	
Board	Alstom 2M5 PMC on PMC-to-PCI carrier 
Form factor	PCI
Grounding	The Alstom master is designed to provide capacitive coupling between the WorldFIP cable shielding and the board's ground. However, we noticed that if the Alstom board is screwed on the PMC-to-PCI adaptor, the isolation is lost and there is one single ground. In this configuration, we removed the front panel of the Alstom board to maintain the capacitive connection.  

The test setup included:

- Kontron KISS 762 host computer, same for all EUTs
- Reference ground plane made with copper foil of thickness 0.3mm and dimensions 2m x 0.50 m
- Fast transient/ burst generator SCHAFFNER Modula 6050 compliant to IEC 61000 4-4 controlled through a laptop; we verified the characteristics of the generator prior to testing
- Capacitive coupling clamp SCHAFFNER CDN 125
- As WorldFIP slave we used either the NFTC board or the nanoFIPdiag. The NFTC is providing exchange of large amount of bytes, which increases the probability of a pulse from the Schaffner generator to fall into the transmission/reception window, but it does not have a metallic enclosure. The nanoFIPdiag offers only exchange of 2 bytes but it is properly enclosed.

WorldFIP slave #1	
Board	NFTC; no enclosure
Configuration	124 bytes exchange, 5 us macrocycle
Grounding	WorldFIP cable shielding directly connected to the board's ground.  Note that the NFTC has also been tested for EMC (EDMS Doc number: 1171030)

WorldFIP slave #2	
Board	nanoFIPdiag; metalic enclosure
Configuration	2 bytes exchange, 1 us macrocycle
Grounding	Capacitive coupling between the WorldFIP cable shielding and the board's ground.  

The test setup was prepared following the rules of the standard. Figure 3 and Figure 4 show the arrangement of the test equipment on the ground reference plane. The WorldFIP master, Alstom or masterFIP, is connected to the slave, NFTC or nanoFIPdiag, through the standard WorldFIP cable. The clamp is placed around the WorldFIP cable, in short distance from the master (<0.5m). The gateway application is the standard “data loopback” of 2-byte, 1 us (nanoFIPdiag) or 124-byte, 5us (NFTC). The burst generator is connected to the clamp with a high voltage coaxial cable; the side of the clamp that is closer to the master is used for this connection.

During the test no probing with an oscilloscope/multimeter was possible, as we realised probing was altering the results (we were having several data mismatches on the gateway that when the oscilloscope was disconnected were not appearing at all).

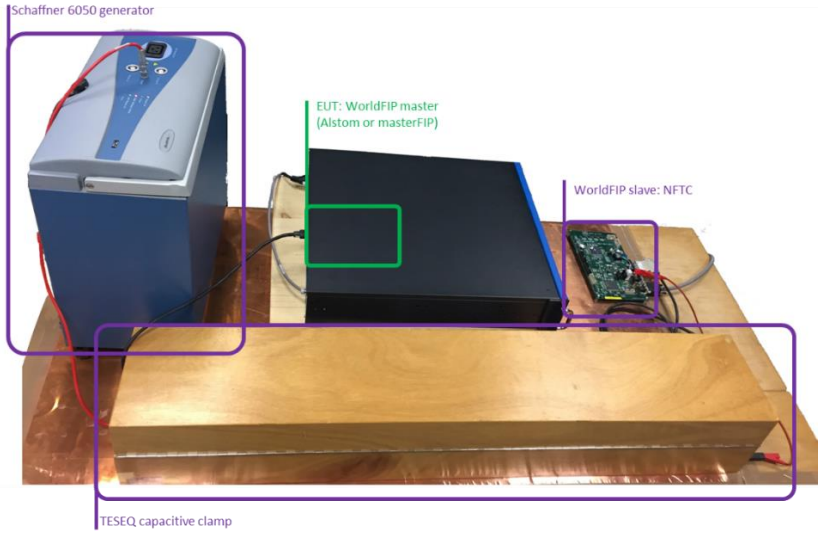


Figure 3: Test Setup with NFTC board

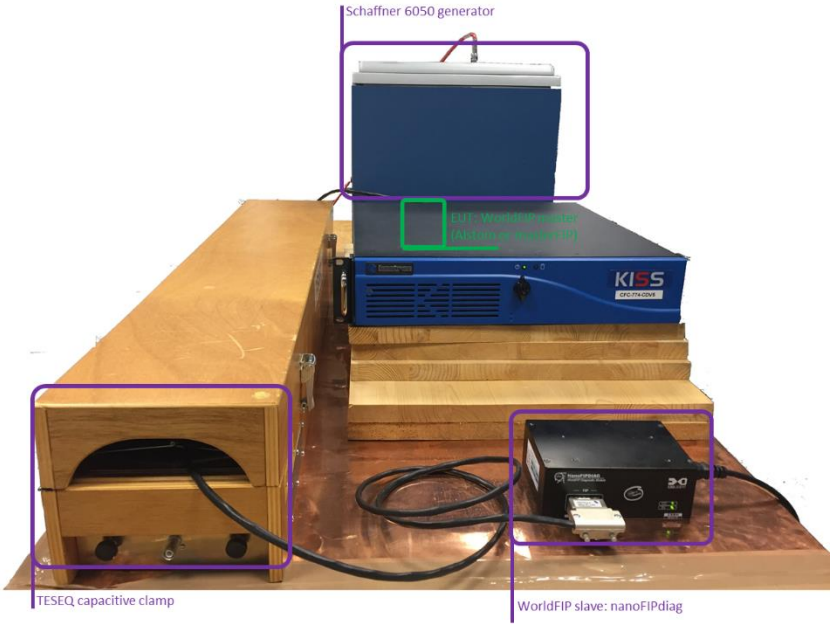


Figure 4: Test Setup with nanoFIPdiag

4 Test Results

The following table describes the test results for each setup.

EUT	WorldFIP slave	IEC 61000 4-4 Test Type	# Test Repetitions	Result
EUT #1	nanoFIPdiag	Level 1: ±0.25KV, 5KHz, 120s	5	no error
EUT #1	nanoFIPdiag	Level 2: ±0.5KV, 5KHz, 120s	5	no error
EUT #1	nanoFIPdiag	Level 3: ±0.1KV, 5KHz, 120s	5	no error
EUT #1	nanoFIPdiag	Level 4: ±2KV, 5KHz, 120s	5	no error
EUT #1	NFTC	Level 1: ±0.25KV, 5KHz, 120s	5	no error
EUT #1	NFTC	Level 2: ±0.5KV, 5KHz, 120s	5	no error
EUT #1	NFTC	Level 3: ±0.1KV, 5KHz, 120s	5	no error
EUT #1	NFTC	Level 4: ±2KV, 5KHz, 120s	5	no error
EUT #2	nanoFIPdiag	Level 1: ±0.25KV, 5KHz, 120s	5	no error
EUT #2	nanoFIPdiag	Level 2: ±0.5KV, 5KHz, 120s	5	no error
EUT #2	nanoFIPdiag	Level 3: ±0.1KV, 5KHz, 120s	5	no error
EUT #2	nanoFIPdiag	Level 4: ±2KV, 5KHz, 120s	5	no error
EUT #2	NFTC	Level 1: ±0.25KV, 5KHz, 120s	5	no error
EUT #2	NFTC	Level 2: ±0.5KV, 5KHz, 120s	5	no error
EUT #2	NFTC	Level 3: ±0.1KV, 5KHz, 120s	5	no error
EUT #2	NFTC	Level 4: ±2KV, 5KHz, 120s	5	no error
EUT #3	nanoFIPdiag	Level 1: ±0.25KV, 5KHz, 120s	5	no error
EUT #3	nanoFIPdiag	Level 2: ±0.5KV, 5KHz, 120s	5	no error
EUT #3	nanoFIPdiag	Level 3: ±0.1KV, 5KHz, 120s	5	no error
EUT #3	nanoFIPdiag	Level 4: ±2KV, 5KHz, 120s	5	4 errors (data mismatch and com lost)
EUT #3	NFTC	Level 1: ±0.25KV, 5KHz, 120s	5	no error
EUT #3	NFTC	Level 2: ±0.5KV, 5KHz, 120s	5	no error
EUT #3	NFTC	Level 3: ±0.1KV, 5KHz, 120s	5	no error
EUT #3	NFTC	Level 4: ±2KV, 5KHz, 120s	5	51 errors (data mismatch and com lost)

Table 2: Test Results

5 Conclusions

Throughout the IEC 61000 4-4 testing no WorldFIP communication or data errors occurred to the masterFIP board; this confirms the good grounding and deglitching technics.

The Alstom board with isolated grounds, EUT#3, showed errors during the Level 4 (±2KV) testing; this reveals that the capacitive coupling between the WorldFIP cable shielding and the board's ground is a weak option regarding EMC.

As in the LHC tunnel there is a big infrastructure of creating a common reference ground (around the tunnel till up to the control rooms) and the WorldFIP cable shielding is being grounded ever few meters (on every TAP), it is clear that the direct grounding of the WorldFIP cable shielding on the masterFIP board is the best solution.

Note finally that throughout the testing no probing with an oscilloscope/multimeter was possible, as probing was interfering to the testing.