

# Corrigendum 2 to IEC 61000-4-4 ed. 2; 2004

## How to calibrate the transient waveform at the output of the CDN

Authors: H. Kunkel, Member of TC77B MT12, EM TEST Switzerland  
M. Fuhrer, Application Engineer, EM TEST Switzerland



- Warning to users, lab-managers and accredited laboratories

### 1. Introduction

In 2004 IEC had published the IEC 61000-4-4 ed.2 for testing Electrical Fast Transients. The standard did include some major technical changes in relation to testing and pulse verification & calibration.

- All lines of a power supply mains shall be tested simultaneously and no more one line after the other sequentially.
- The wave shape of the EFT burst transients is specified at the CDN output additionally and no more at the coaxial output only. Additionally as mentioned above the transients must be coupled to all lines simultaneously also during calibration.

The actual text in the standard is in some way misleading so that IEC had decided to publish a corrigendum which should explain this measuring procedure much better.

***Unfortunately this corrigendum will cause much more problems as it will solve!***

#### 1.1 Old IEC 61000-4-4

In IEC 61000-4-4 ed.1 the EFT transients were only specified and measured at the coaxial 50Ω output of the generator. Measurements at the CDN output (EUT) were not required but had shown significant differences between different manufacturers products.

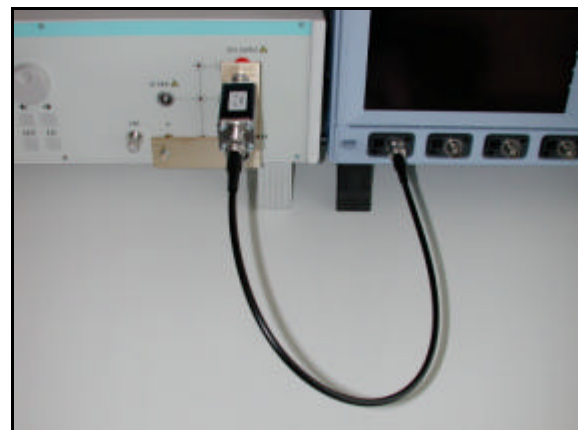
The transients were coupled to each individual line, one line after the other.



#### 1.2 New IEC 61000-4-4

In IEC 61000-4-4 ed.2 which was published in 2004, the EFT wave shape was additionally specified to be measured at the output of the CDN as well. The target is to increase the reproducibility between different generators from different manufacturers.

To speed up the test procedure itself, all lines of the EUT must be tested now simultaneously, in case of a 3 phase power mains supply the transients must be coupled to 5 lines simultaneously.



**Problem:** The standard does not specify in detail where and how to measure at the output of the CDN, specially where to connect the 50Ω termination.  
The requirement to connect at the „Common Mode Output“ is not precise enough.

The standard wording reads as follows:

**6.2.2 Verification of the characteristics of the coupling/decoupling network**

The requirements given in 6.1.2 also apply to the measurement equipment that is used for the verification of the characteristics of the coupling/decoupling network.

The waveform shall be verified at the common mode output of the coupling/decoupling network with a single 50 W termination.

The verification is performed with the generator output voltage set to a nominal voltage of 4 kV. The generator is connected to input of the coupling/decoupling network. The output of the CDN (normally connected to the EUT) is terminated with a 50 ohm load. The peak voltage and waveform are recorded.

The functionality verification of each single coupling/decoupling path is recommended.

Rise time of the pulses (10 % to 90 % value) shall be 5 ns ± 30 %.

Impulse duration (50 % value) shall be 50 ns ± 30 % with the 50 W load.

Peak Voltage +/-10% according to table 2.

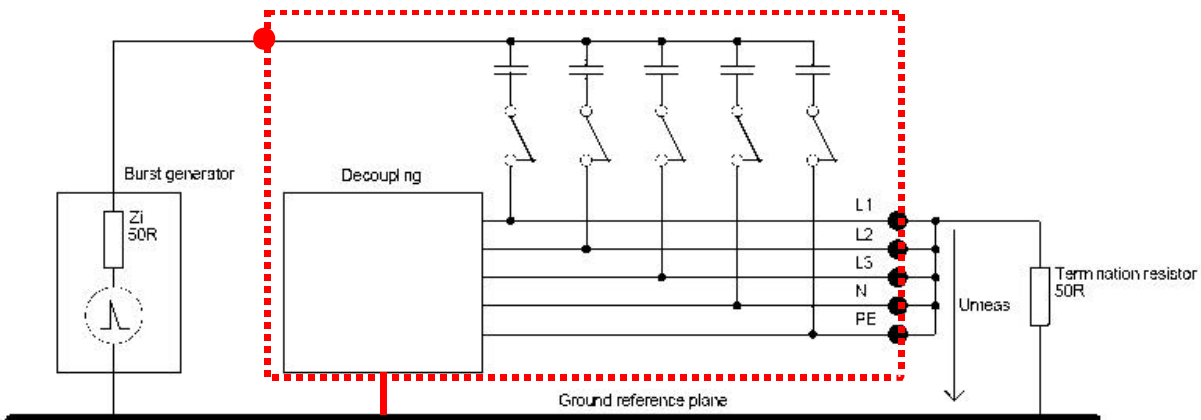
The residual test pulse voltage on the inputs of the coupling/decoupling network when the EUT and the power network are disconnected shall not exceed 10 % of applied test voltage.

Note: Coupling/decoupling networks designed in accordance with Edition 1 of IEC 61000-4-4 may need minor modifications to meet the common mode requirements of this document.

**2. The Corrigendum**

To clarify this matter in IEC 61000-4-4 ed.2 IEC publishes a so called „Corrigendum 2“, which works as normative information.

- The EFT transients are coupled to all lines of the CDN simultaneously.
- **All output of the CDN are short circuited.**
- **The EFT transient wave shape shall be measured across the 50W termination.**



Version 3: Coupling into all coupling paths, measuring all coupling paths (short circuited together)

Fig. 1 Measuring setup as per Corrigendum

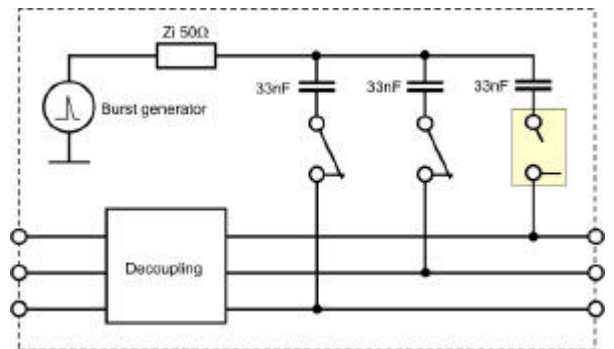
## 2.1 Technical problems

### General:

- A short circuit at the output of the CDN, the above figure shows a 3 phase CDN, does not rely on the real test situation in the field. In reality this would lead to a short circuit in the power supply mains.
  - Normally the transients shall be measured in the same configuration as it used for testing (without short circuit).
  - The safety problem for the operator, to make a short circuit across power mains output sockets, is not further discussed in here.
- In the above shown configuration, using a short circuit across the CDN output, all lines will be tied together and measured together.
  - It is false to believe that, if all lines tied together and measured across the 50Ω termination are within the specified tolerance range, also each individual line is working correctly.

➔ **Example 1: Coupling relay defect**

The coupling relay of one line (e.g. L) does not close anymore. The EFT/burst transients are therefore no more coupled to L.



- This failure **can not** be detected by using the short circuit across all CDN output. The correct working coupling paths will dominate the measurement, see table 2.

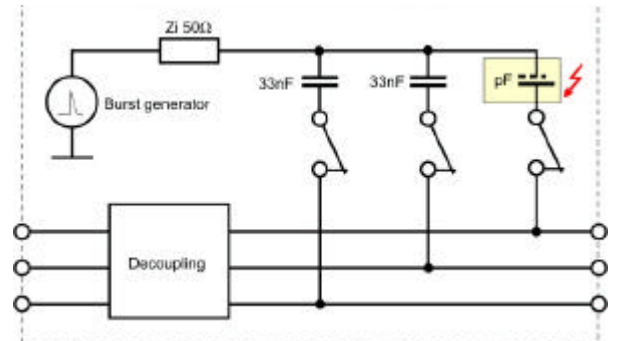
Output	Upeak	tr ns	Td ns	Remark
L+N+PE	4064	5.61	45.54	Short circuit across the output. <b>Wave shape in tolerance!</b> <b>No EFT transients on line L</b> due to relay failure. Can not be detected with this measurement.

Table 2

- ➔ For this case the standard tells you to check the function of each individual line additionally. This means that each individual output must be measured again, additionally to the measurement across the short circuited output !!!!!

➔ **Example 2: Coupling capacitor defect** (realistic failure occurring in a CDN)

The coupling capacitor of 33nF in one coupling path (e.g. L) is damaged. The capacitor no longer has 33nF but is significantly smaller e.g. 33pF (internally broken).



- This failure **can not** be detected by using the short circuit across all CDN output. The correct working coupling paths will dominate the measurement (see table 3)

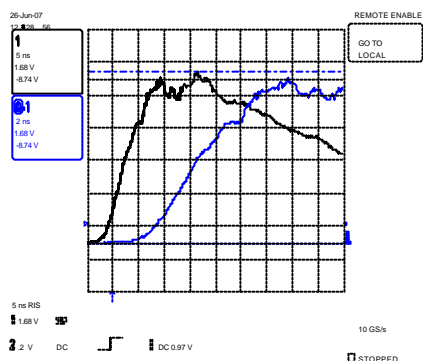
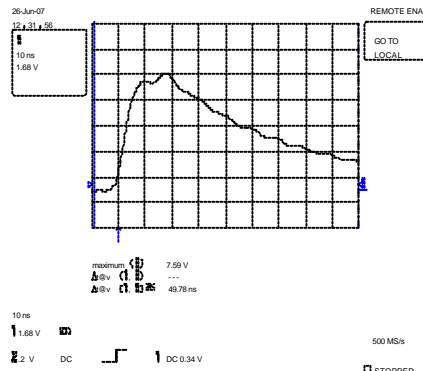
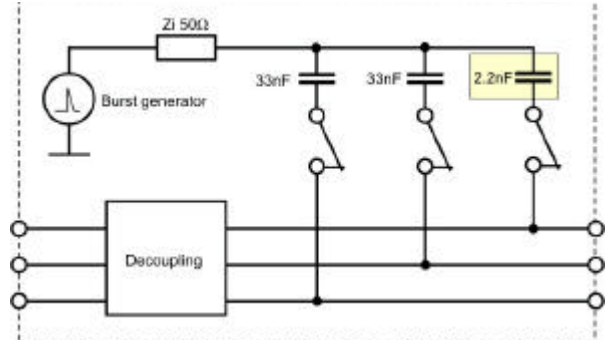
Output	Upeak	tr ns	td ns	Remark
L+N+PE	4040	5.14	45.1	Short circuit across the output. <b>Wave shape in tolerance!</b>
L only	<b>3496</b>	<b>7.68</b>	47.8	 <p><b>Coupling capacitor is partially broken.</b></p>
L only	<b>3096</b>	<b>8.38</b>	49.78	 <p>After some testing time the capacitor is completely damaged. <b>The EFT waveshape is completely distorted!!</b></p>

Table 3

- ➔ For this case the standard tells you to check the function of each individual line additionally. This means that each individual output must be measured, additionally to the measurement across the short circuited output !!!!!

➔ **Example 3: Coupling capacitor wrong value** (realistic failure occurring in a CDN)

The coupling capacitor in one coupling path (e.g. L) has the wrong value,  $C_c = 2.2\text{nF}$ . Might be a failure in manufacturing.



The coupling capacitor in one coupling path (e.g. L) has the wrong value,  $C_c=2.2\text{nF}$ . Might be a failure in manufacturing.

- This failure **can not** be detected by using the short circuit across all CDN output. The correct working coupling paths will dominate the measurement (see table 4).

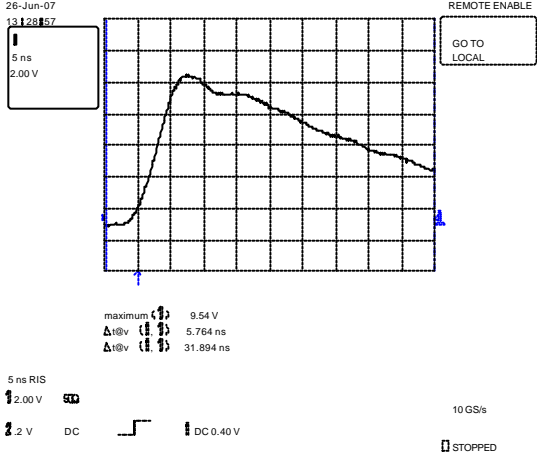
Output	Upeak	tr ns	td ns	Remark
L+N+PE	4016	5.57	45.57	Short circuit across the output. <b>Wave shape in tolerance!</b>
L only	3816	5.76	<b>31.89</b>	 <p>The test level is reduced and the pulse duration is out of tolerance.</p>

Table 4

- ➔ For this case the standard tells you to check the function of each individual line additionally. This means that each individual output must be measured, additionally to the measurement across the short circuited output !!!!!

### 2.1 What does it mean „to make a functional check“ ?

- Either the standard nor the Corrigendum tells the user what to do or in which case a functional check is pass or fail.
  - Would it be ok if “a” pulse can be detected at this output ?
  - Or does this pulse shall be within the waveshape specification and tolerance ?
- In the above example a damaged coupling capacitor will still work in “some way” and inject some noise into the line.
- With the wrong component built into the CDN the energy will be reduced because the capacitor has a higher impedance. The result is that the required pulse duration of 50ns (pulse energy) will be reduced significantly and the injected peak voltage as well (see table 4).
- Is this function ok now ?

#### → Consequence:

- with the short circuit across the output of a CDN it can not be determined whether all individual lines are operating correctly as intended.
- In any case to be sure, a functional check must be done, this means each individual output must be measured again.

#### → Question:

- For what is the required measurement with the short circuit bridge good for, except confusing the users and increasing the measuring problems.
- Or does the individual CDN output must no more show the EFT/burst pulses to be in tolerance ?

### 2.2 Additional problems for calibration labs and for real testing:

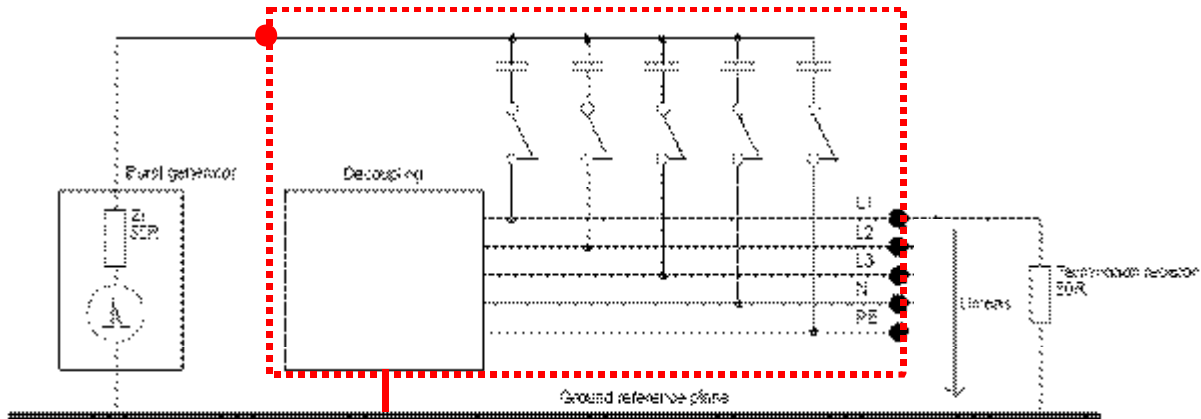
- EFT/ burst generators calibrated according to the actual corrigendum 2, using the “short circuit measuring setup” can be called conform to the standard. Anyway it can not be guaranteed that all coupling paths of the CDN are working properly. Lets stay with our coupling problems with L. This line will definitely not deliver the EFT transient as specified in IEC 61000-4-4
- In case of a 3phasen CDN the following applications are possible:
  - Coupling to 5 lines in a 3phase star system
  - Coupling to 4 lines in a 3phase delta system with neutral.
  - Coupling to 3 lines in a 1ph or 3phase delta-system without neutral.
  - Coupling to 2 lines in a DC power supply.
  - Coupling to a ground wire.

Because it is technically clear the „short circuit“ method does not allow the user or the lab to decide whether the generator and its CDN works properly all above shown application cases must be calibrated individually what finally again results in a measurement of each individual line.

### 3. Solution:

The measuring setup must be corrected as shown in the following figure.

- The EFT transients are coupled to all lines of the CDN simultaneously.
- **The output of the CDN shall not be short circuited.**
- **The EFT transients shall be measured at each individual output of the CDN.**
- **Each individual output must show the transients within the tolerances as specified.**



Version 3: Coupling into all coupling paths, measuring all coupling points **Individually (one after the other)**

Fig. 2 Proposed and correct measuring setup to be included into a new Corrigendum

### 4. Conclusion

1. The actual published Corrigendum 2 for IEC 61000-4-4ed.2 of 2004 is misleading and is technically incorrect.
2. To approve an EFT generator/CDN combination to be compliant to the standard each individual output of the CDN shall be measured separately with a 50Ω termination connected to this output.
3. Each individual output must show the correct wave shape within the specified tolerances.
4. Accredited laboratories will relate to misleading calibration setup and procedure and will state compliance to equipment which may not work properly.
5. Laboratories using their test equipment can not be sure that EFT/burst testing was performed correctly because the test equipment may not work as intended.
6. **These facts are technically clear and undoubted and it is known to the responsible working group within IEC. Anyway the corrigendum is published.**

Why that ???



**The Corrigendum 2 shall be withdrawn and needs further discussions in MT12 which is the responsible maintenance team for IEC 61000-4-4.**