

# EMC in Industrial electronics

## PE:Region

EMC/EMI in overview – basic principles, current state of technology

Flensburg, Per Thåstrup Jensen – February 2018



## Agenda

- Why bother with EMC?
- The basic EMC parameters
- International standardisation on EMC
- Accreditation, 3. party
- Approval Management and assessment
- Europe, CE mark, Notified Body
- USA, Canada, Japan, CB scheme, Korea
- RISK, extended requirements, EMC HALT
- Related approvals, other than EMC



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## Why bother with EMC?

### Conclusion:

You **MUST** comply with EMC requirements! Both EU- and international requirements.

### The benefit:

It makes sense to establish good EMC performance

– and properly applied, the EMC requirements can even improve your position on the market and reduce your costs on field return of defective products.



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## FORCE Technology

1600 employees  
60% export  
95% commercial



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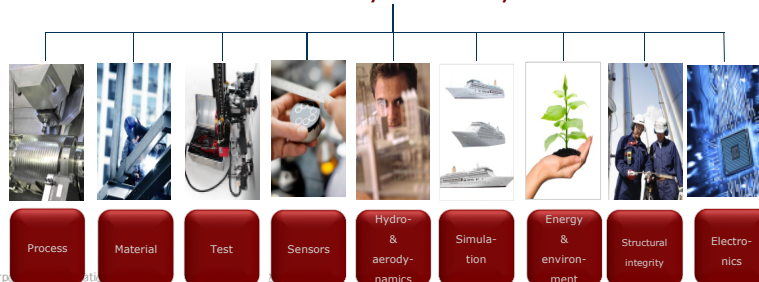
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## FORCE Technology

- Turnover of DKK 1.4 billion per year. 75 years background.
- About 30 employees working with EMC at 3 locations in Denmark and 1 in Sweden.
- Since 2017, DELTA is merged with FORCE Technology.

### Industry & society

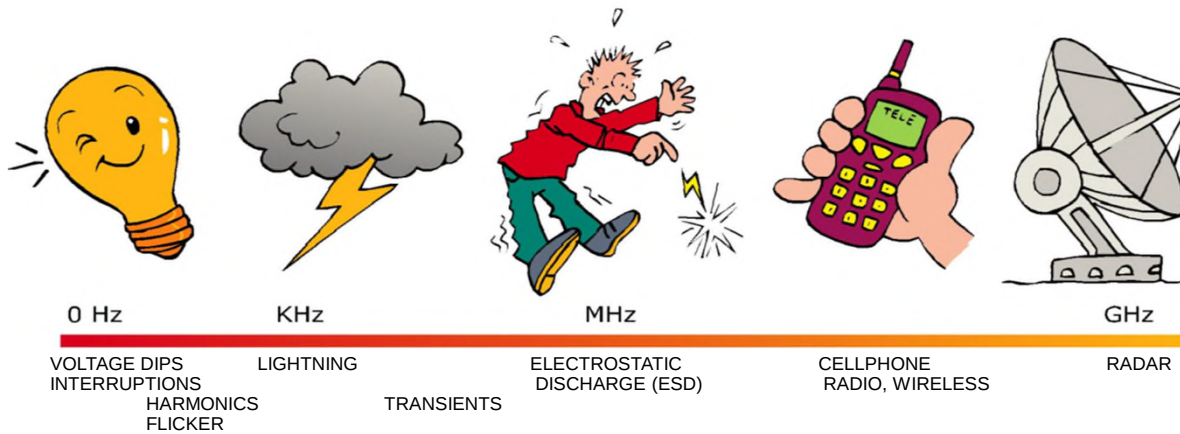


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## Basic electrical phenomena



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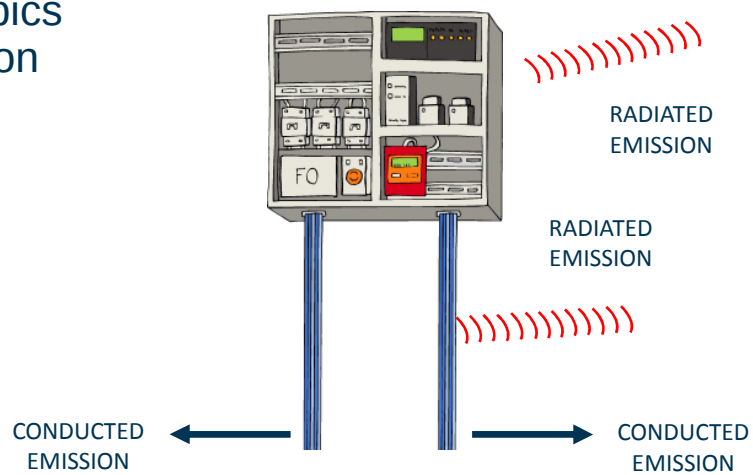
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## Basic electrical phenomena

### EMC topics - emission



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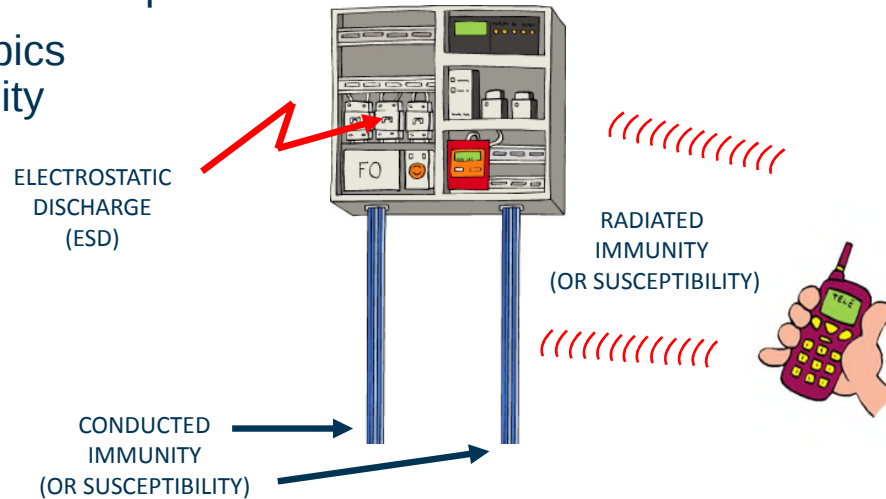
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## Basic electrical phenomena

### EMC topics - immunity



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## MIL-STD 461G

TABLE IV. Emission and susceptibility requirements.

| Requirement | Description                                                                    |
|-------------|--------------------------------------------------------------------------------|
| CE101       | Conducted Emissions, Audio Frequency Currents, Power Leads                     |
| CE102       | Conducted Emissions, Radio Frequency Potentials, Power Leads                   |
| CE106       | Conducted Emissions, Antenna Port                                              |
| CS101       | Conducted Susceptibility, Power Leads                                          |
| CS103       | Conducted Susceptibility, Antenna Port, Intermodulation                        |
| CS104       | Conducted Susceptibility, Antenna Port, Rejection of Undesired Signals         |
| CS105       | Conducted Susceptibility, Antenna Port, Cross-Modulation                       |
| CS109       | Conducted Susceptibility, Structure Current                                    |
| CS114       | Conducted Susceptibility, Bulk Cable Injection                                 |
| CS115       | Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation             |
| CS116       | Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads |
| CS117       | Conducted Susceptibility, Lightning Induced Transients, Cables and Power Leads |
| CS118       | Conducted Susceptibility, Personnel Borne Electrostatic Discharge              |
| RE101       | Radiated Emissions, Magnetic Field                                             |
| RE102       | Radiated Emissions, Electric Field                                             |
| RE103       | Radiated Emissions, Antenna Spurious and Harmonic Outputs                      |
| RS101       | Radiated Susceptibility, Magnetic Field                                        |
| RS103       | Radiated Susceptibility, Electric Field                                        |
| RS105       | Radiated Susceptibility, Transient Electromagnetic Field                       |

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## Radiated immunity test in 10 m chamber



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## Elevator disturbing ultrasound scanning

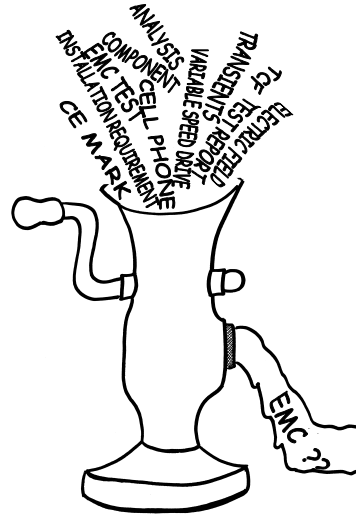


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## Standardization



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## International Standardization

- Standards are developed by technical experts
- Standards are approved by voting of National Committees



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## International standardization



**International Electrotechnical Commission (IEC)** Founded in 1906, National electrotechnical committees, More than 70 membership countries

**CISPR** International Special Committee on Radio Interference (part of IEC)



**International Telecommunications Union (ITU)** Founded in 1865, UN organisation Approx. 200 membership countries



**International Organisation for Standardisation (ISO).** Founded in i 1947, National standardisation organisations, more than 159 members

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## European standardization



**Comité Européen de Normalisation Electrotechnique (CENELEC)** Founded in 1973, national electro-technical committees 31 membership countries



**European Telecommunications Standards Institute (ETSI) founded in 1988,** European membership organisation Approx. 200 members



**Comité Européen de Normalisation (CEN)** Founded in 1961, National standardisation organisations, 31 membership countries

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## Standardization

### World

- IEC produces standards for electrical equipment
- ISO produces standards for non electrical equipment (!)
- CISPR produces standards for protection of the radio spectrum

### EU

- CENELEC produces standards for electrical equipment
- CEN produces standards for non electrical equipment
- ETSI produces standards for Telecom equipment

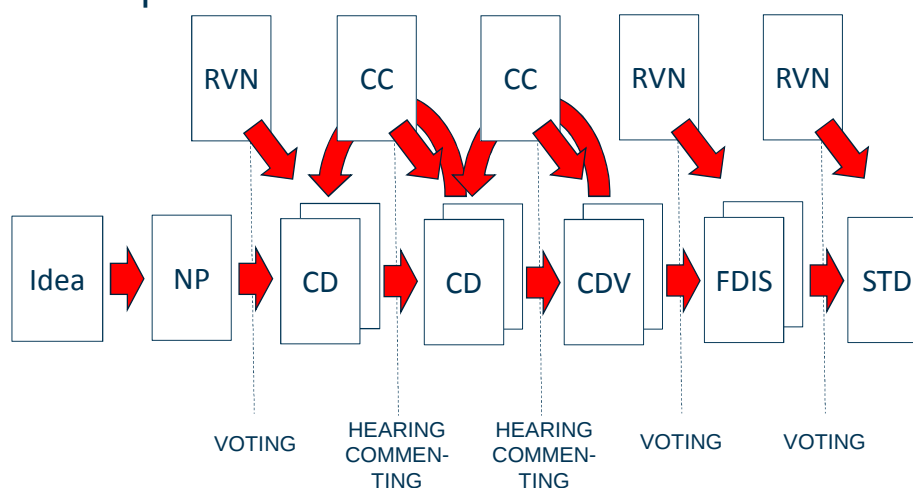
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## A possible path to a new standard



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## IEC immunity testing specialist, HF phenomena



Per Thåstrup



TC 77B, WG 10  
(Secretary)



S-650 og S-710  
(Chairman)

Basic standards. Test signals, test methods and uncertainty budgets:

IEC 61000-4-3 (Radiated RF immunity)

IEC 61000-4-6 (Conducted RF immunity)

(IEC 61000-4-22 (RF reverberation test))

IEC 61000-4-31 (Conducted wideband RF immunity)

IEC 61000-4-39 (RF immunity, Close Proximity test)

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## Who participates in the WGs?



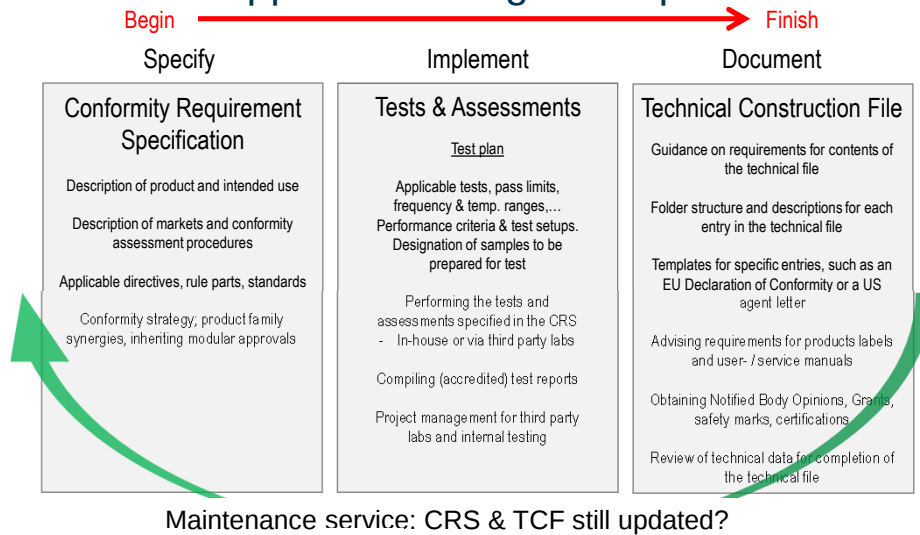
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## Contents of an Approval Management process



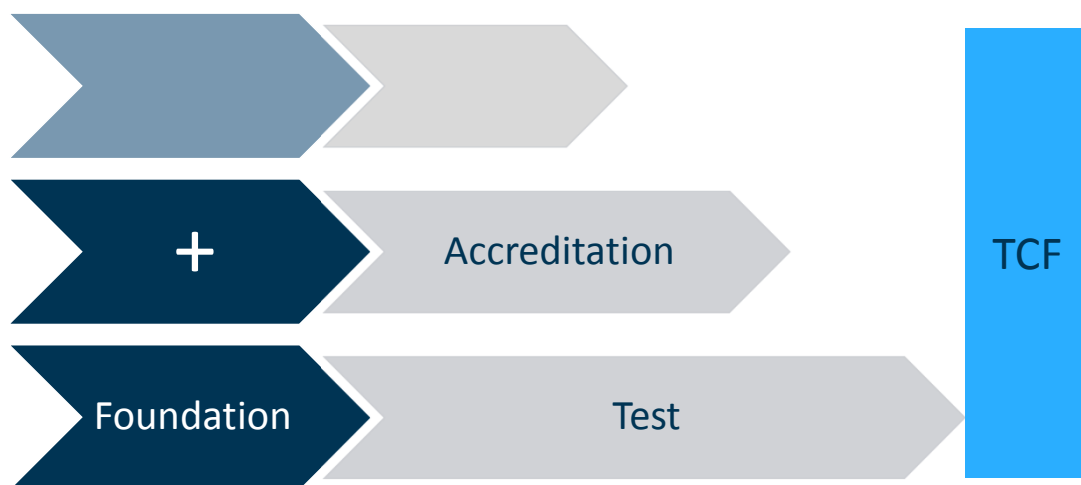
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## Test – and more?



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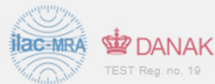
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## Accreditation, ILAC and DANAK

### FORCE Technology Test Report



**Selected EMC test of xxxxyy**

**Performed for ZZ-Company Ltd.**

Project no.: 118-12345-1

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## ILAC

International Laboratory Accreditation Cooperation

Why use an  
Accredited Laboratory?



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## Notified Body

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**GROWTH**  
Internal Market, Industry, Entrepreneurship and SMEs

European Commission > Growth > The European Single Market > Single Market for Goods > Building blocks of the Single Market > Notified bodies

Search

Single Market for Goods

View Legislative Framework

Building blocks of Single Market

- Conformity assessment
- Accreditation of conformity assessment bodies
- Notified bodies**
- Market Surveillance
- ICSMS
- Legal metrology
- Free movement in harmonised and non-harmonised sectors
- International aspects of the Single Market

Single Market and Standards - links

News

Events

Tools and Databases

### Notified bodies

A notified body is an organisation designated by an EU country to assess the conformity of certain products before being placed on the market. These bodies carry out tasks related to conformity assessment procedures set out in the applicable legislation, when a third party is required. The European Commission publishes a list of such notified bodies.

#### What the notified bodies do

Conformity assessment is a service to manufacturers in an area of public interest. It is the responsibility of the EU country to notify conformity assessment bodies within their jurisdiction according to principles laid down in [Decision 768/2009/EC](#). Notified bodies:

- are free to offer their conformity assessment services to any economic operator inside or outside the EU
- may carry out these activities on the territory of other EU countries or non-EU countries
- must operate in a non-discriminatory, transparent, neutral, independent, and impartial manner
- must employ the necessary personnel, with sufficient knowledge and experience to carry out the conformity assessment in accordance with the law(s) in question
- must make adequate arrangements to ensure the confidentiality of the information obtained in the course of conformity assessment
- must be adequately insured to cover their professional activities, unless liability is assured under the national legislation of the notifying EU country
- must provide information to their notifying authority, the market surveillance authorities, and other notified bodies.

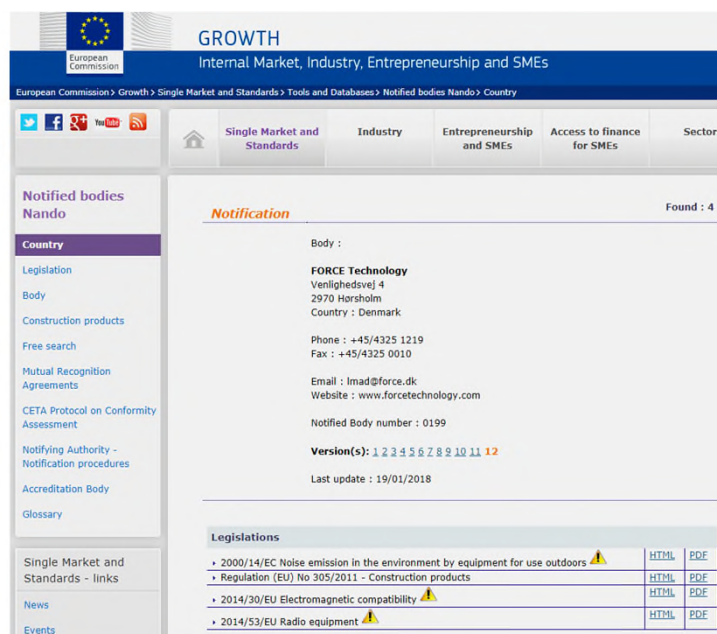
Manufacturers are free to choose any notified body that has been legally designated to carry out the conformity assessment procedure.



## NB NANDO

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**GROWTH**  
Internal Market, Industry, Entrepreneurship and SMEs

European Commission > Growth > Single Market and Standards > Tools and Databases > Notified bodies Nando > Country

Single Market and Standards

Industry

Entrepreneurship and SMEs

Access to finance for SMEs

Sectors

### Notified bodies Nando

Country

Legislation

Body

Construction products

Free search

Mutual Recognition Agreements

CETA Protocol on Conformity Assessment

Notifying Authority - Notification procedures

Accreditation Body

Glossary

Single Market and Standards - links

News

Events

### Notification

Found : 4

Body :

**FORCE Technology**  
Venlighedsvej 4  
2970 Hørsholm  
Country : Denmark

Phone : +45/4325 1219  
Fax : +45/4325 0010

Email : [Imad@force.dk](mailto:Imad@force.dk)  
Website : [www.forcetechnology.com](http://www.forcetechnology.com)

Notified Body number : 0199

**Version(s):** 1 2 3 4 5 6 7 8 9 10 11 12

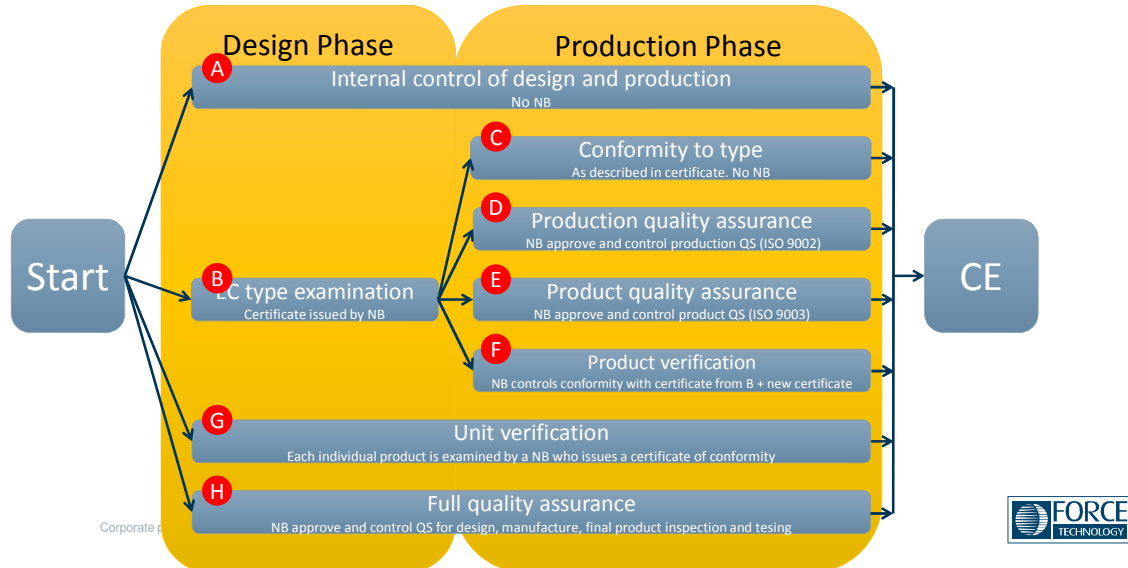
Last update : 19/01/2018

#### Legislations

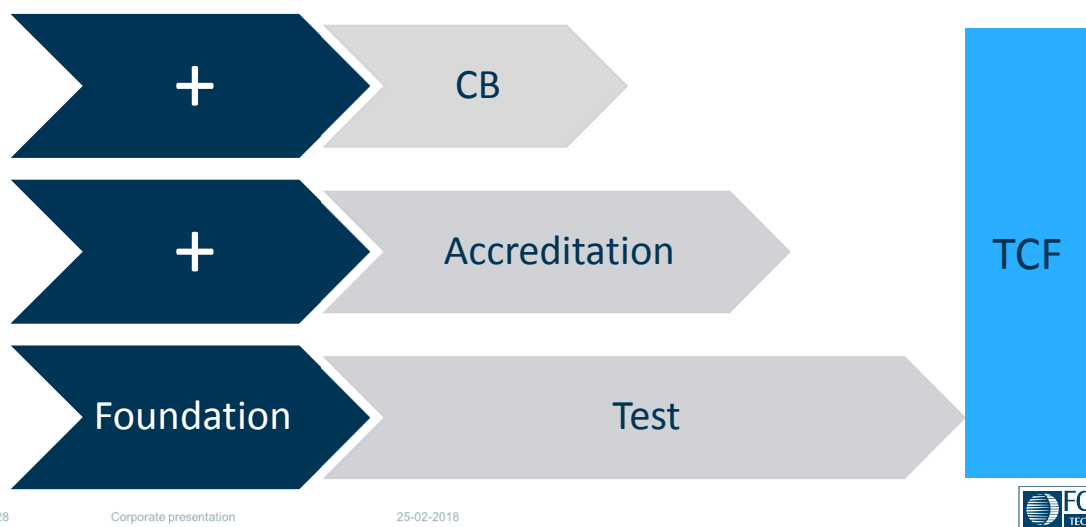
|                                                                              |                      |                     |
|------------------------------------------------------------------------------|----------------------|---------------------|
| • 2000/14/EC Noise emission in the environment by equipment for use outdoors | <a href="#">HTML</a> | <a href="#">PDF</a> |
| • Regulation (EU) No 305/2011 - Construction products                        | <a href="#">HTML</a> | <a href="#">PDF</a> |
| • 2014/30/EU Electromagnetic compatibility                                   | <a href="#">HTML</a> | <a href="#">PDF</a> |
| • 2014/53/EU Radio equipment                                                 | <a href="#">HTML</a> | <a href="#">PDF</a> |



## Conformity modules – CE marking



## Test, accreditation – and even more?



## CB Testing laboratories

IEC IECCEE IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE)

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Members > CB Testing Laboratories

### Testing Laboratories

CB Testing Laboratories (CBTLs) **Associated Testing Laboratories (ACTLs)** Customer Testing Facilities (CTFs)

List Statistics Map Total CB Testing Laboratories: 496

CB Testing Laboratories (CBTLs) Table search:  Excel PDF Print

| Laboratory Name                                 | Country/Location | Responsible National Certification Body |
|-------------------------------------------------|------------------|-----------------------------------------|
| FORCE Technology, Product Compliance - Aarhus   | Denmark          | FORCE Certification A/S                 |
| FORCE Technology, Product Compliance - Horsholm | Denmark          | FORCE Certification A/S                 |
| FORCE Technology, Product Compliance - Odense   | Denmark          | FORCE Certification A/S                 |

Showing 1 to 3 of 3 entries (filtered from 496 total entries) Previous 1 Next

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## CB National Certification Body NCB

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Members > National Certification Bodies > **FORCE Certification A/S**

### NCB FORCE Certification A/S

Home Documents Standards in Scope CB Test Labs **Assoc. Test Labs** Cust. Test Facilities

CB Testing Laboratories Table search:  Excel PDF Print

| Laboratory Name                                 | Country/Location | ACTLs | Standards in scope |
|-------------------------------------------------|------------------|-------|--------------------|
| FORCE Technology, Product Compliance - Aarhus   | Denmark          | 0     | 39                 |
| FORCE Technology, Product Compliance - Horsholm | Denmark          | 0     | 35                 |
| FORCE Technology, Product Compliance - Odense   | Denmark          | 0     | 3                  |

Showing 1 to 3 of 3 entries Previous 1 Next

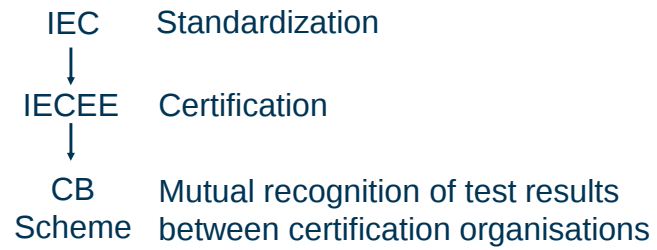
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## The CB scheme



Product Service



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## Outside Europe



CB  
and  
national approvals



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## Outside Europe

FCC (USA)  
Accredited.

ICED registered  
(Canada).

Organization: Industry Canada, Certification and Engineering Bureau  
Registration Number: IC4187A-5  
Facilities: EMI room Hørsholm (EMC-5)

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The screenshot shows the FCC E-filing website interface. The header includes the FCC logo and navigation links. The main content area displays search results for test firms. Two firms are listed: FORCE Technology and DELTA Development Technology AB. The table includes columns for Display, Firm Name, Location, Accreditation, MRA Designation, Expiration, Contact, and Address. A 'Get Exportable Results' button is visible at the bottom right of the table.

| Display | Firm Name                       | Location                                         | Accreditation                                                      | MRA Designation | Expiration | Contact     | Address                                               | P.O. Box |
|---------|---------------------------------|--------------------------------------------------|--------------------------------------------------------------------|-----------------|------------|-------------|-------------------------------------------------------|----------|
| Scopes  | FORCE Technology                | Hørsholm, Denmark (hq) - Aarhus N, Denmark (dpt) | Danish Energy Agency                                               | US- EU DK0001   | 09/03/2019 | Lelf Hadsen | Venlighedsvej 4, Hørsholm Agro Food Park 13, Aarhus N | N/A      |
| Scopes  | DELTA Development Technology AB | Sweden                                           | Swedish Board for Accreditation and Conformity Assessment (SWEDAC) | US- EU SE0004   | 06/21/2018 | Ulf Bjerke  | Finnsnätten Elektronnikgatan 47                       | N/A      |

## Outside Europe

Japan  
VCCI  
recognized

Korea

Measurement Facilities Registered (as of February 13, 2018)

R: Radiated Field strength measurement facility  
G: Radiated Field strength measurement facility above 1GHz  
C: Mains Port interference measurement facility  
T: Telecommunication Port interference measurement facility  
A: Laboratory

| No    | Company                                     | Facility | Open Field |     |     |     | Chamber | Reg. No.   | Valid until | Place                            | Contact |
|-------|---------------------------------------------|----------|------------|-----|-----|-----|---------|------------|-------------|----------------------------------|---------|
|       |                                             |          | 3m         | 10m | 30m | 10m |         |            |             |                                  |         |
| 11078 | DELTA Danish Electronics, Light & Acoustics | EMC-5    | -          | -   | -   | -   | R-1180  | 2018/04/09 |             | Venlighedsvej 4 DK-2970 Hørsholm |         |
| 11080 | DELTA Danish Electronics, Light & Acoustics | EMC-3    | -          | -   | -   | -   | C-2532  | 2018/03/16 |             | Venlighedsvej 4 DK-2970 Hørsholm |         |
| 11081 | DELTA Danish Electronics, Light & Acoustics | EMC-4    | -          | -   | -   | -   | C-2533  | 2018/03/16 |             | Venlighedsvej 4 DK-2970 Hørsholm |         |
| 11079 | DELTA Danish Electronics, Light & Acoustics | EMC-5    | -          | -   | -   | -   | C-706   | 2018/04/09 |             | Venlighedsvej 4 DK-2970 Hørsholm |         |
| 11082 | DELTA Danish Electronics, Light & Acoustics | EMC-3    | -          | -   | -   | -   | T-1548  | 2018/03/25 |             | Venlighedsvej 4 DK-2970 Hørsholm |         |
| 11083 | DELTA Danish Electronics, Light & Acoustics | EMC-4    | -          | -   | -   | -   | T-1549  | 2018/03/25 |             | Venlighedsvej 4 DK-2970 Hørsholm |         |
| 11084 | DELTA Danish Electronics, Light & Acoustics | EMC-5    | -          | -   | -   | -   | T-1550  | 2018/03/25 |             | Venlighedsvej 4 DK-2970 Hørsholm |         |

| 지정번호<br>Designation No. | 시험기관명<br>Name of test laboratory      | 지정 분야<br>Designated area | 주소/전화/팩스<br>Address/Tel(T)/Fax(F)                     | 홈페이지<br>Website |
|-------------------------|---------------------------------------|--------------------------|-------------------------------------------------------|-----------------|
| EU0039                  | DELTA Dansk Elektronik, Lys & Akustik | EMC (Denmark)            | Venlighedsvej 4<br>2970 Hørsholm<br>Denmark<br>EMC 19 | N/A             |

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Co

## Vehicles

KBA (D) E1 marking of vehicles etc.

Transportstyrelsen (S)  
E5 marking of vehicles etc.



### Benannte Prüflabore (UNECE) Designated test laboratories (UNECE)

1/CI FORCE Technology Product Compliance, EMC-Test-Centre Aarhus

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Transportstyrelsen utser härmed  
(The Swedish Transport Agency hereby designates)



med beteckning  
(with reference number)

som teknisk tjänst inom kategorierna A för att utföra provningar eller inspektioner, enligt rättsakterna: 72/245/EEG, 2009/64/EG, 97/24/EG kapitel 8 och ECE-reglemente Nr 10.  
(as a technical service in category A for testing and inspections according to the regulatory acts 72/245/EEG, 2009/64/EG, 97/24/EG Chapter 8 and ECE-regulation No. 10.)

Den tekniska tjänsten har uppvisat relevant kompetens, särskild tekniskt kunskap och styrkt erfarenhet i enlighet med Transportstyrelsens föreskrifter (TSFS 2010:72) om utseende och anmälan av organisation för Transportstyrelsens räkning som teknisk tjänst<sup>1</sup>.  
(The technical service has demonstrated appropriate skills, specific technical knowledge and proven experience according to TSFS 2010:72<sup>1</sup>.)

Tidpunkt då tjänsten utsågs  
(Date of designation)

**Force Technology**  
**DELTA Product Compliance**  
Agro Food Park 13  
DK-8240 Aarhus N

Earlier:  
DELTA, Dansk Elektronik, Lys & Akustik

([www.madebydelta.com](http://www.madebydelta.com))

TT 0010

2014-09-23

2020-08-28

*[Signature]*  
Pär Nörling

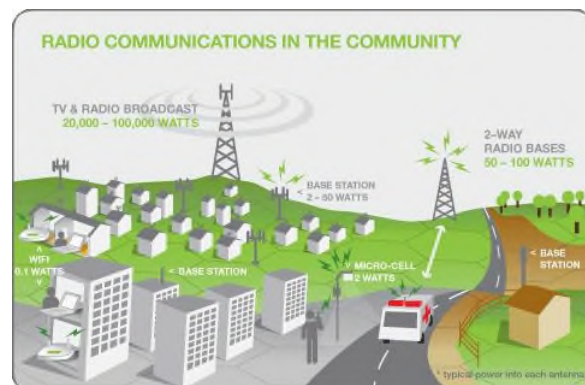


## Beyond the approval requirements

Real world radiated signals:

- Pulsed fields
- From multiple sides
- Broadbanded with complex modulation
- Non-homogenous
- Possibility of high field strength

Quite different from the  
immunity test environment!



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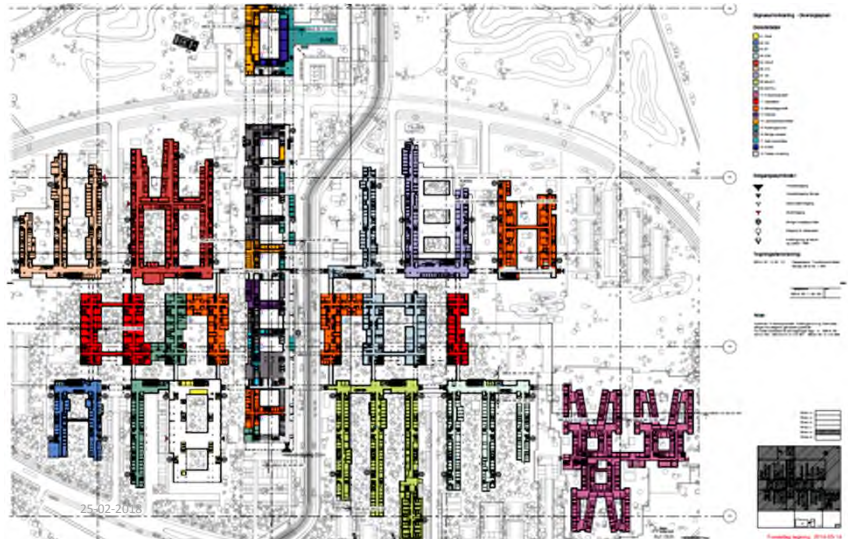
## EMC assessment – mission profile

Example: tramway through a hospital.

Risk assessment – is required for EMCD and RED directives.

Does the user environment match the approval?

What happens in extreme conditions?



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## EMC assessment – also on-site

Gathering information for an EMC assessment:

- In-situ testing
- On-site recording troubleshooting etc.

Maritime, off-shore, industry, client premises



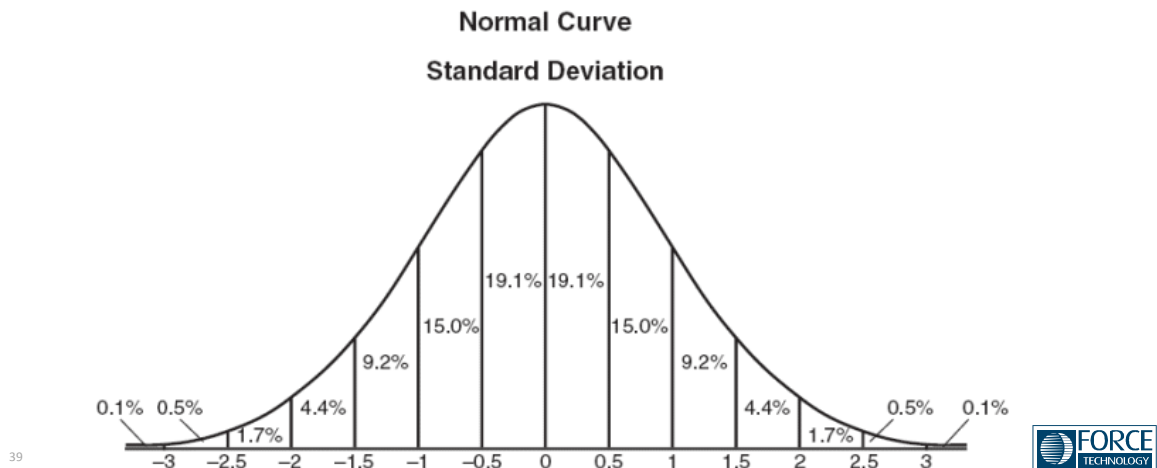
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User environment. "Normal"? 95%? 99.7%?  
 Mission profile – how long time outside "normal"?



## Essential requirements New approach EU directives

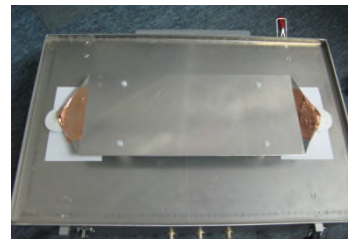
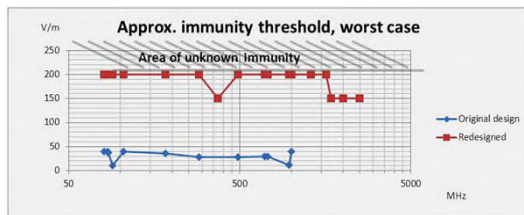
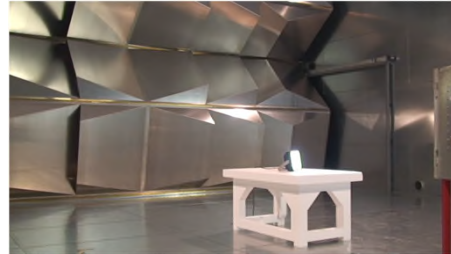
All of the directives require a risk assessment of the product.  
 The essential requirements are usually given in Annex 1 of directive text

- EMC directive: ½ page
- Radio Equipment Directive (RED): 1 page
- LVD directive: 1 page
- Machinery directive: Risk analysis + 30 pages
- Medical Device directive: 82 essential requirements

## EMC HALT (Highly Accelerated Limit Testing)

To know the failures due to Electrical disturbance:

- Radiated fields
- Burst/surge
- ESD
- UWB pulses



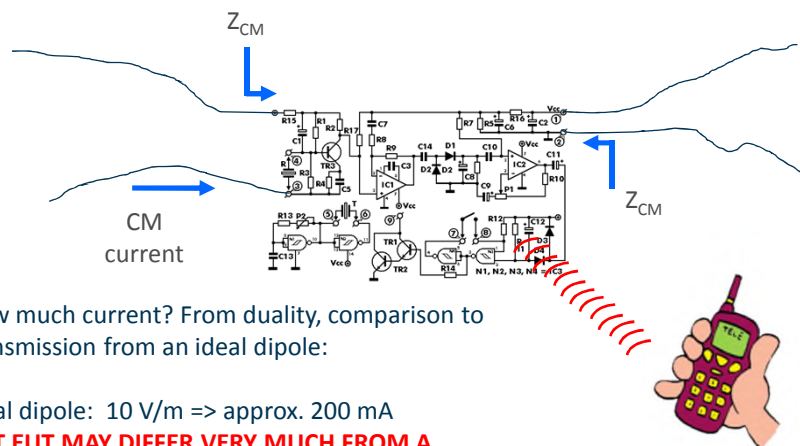
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## EMC HALT (Highly Accelerated Limit Testing)



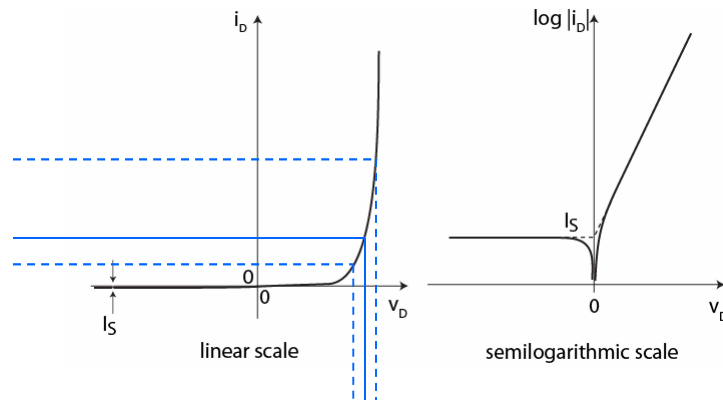
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## What does the current do?



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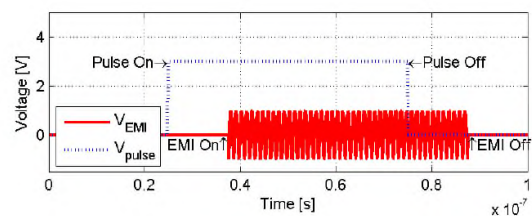


## What does the current do?

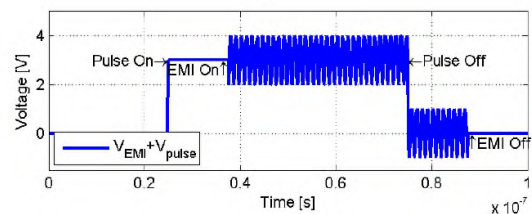
Field strengths:

>200 V/m, 80-40000 GHz

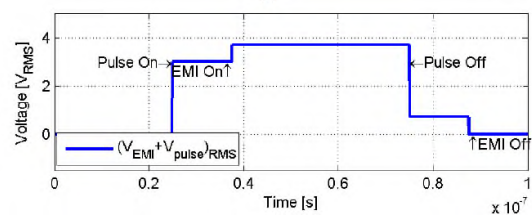
In some frequency ranges up to near 1000 V/m



(a)



(b)

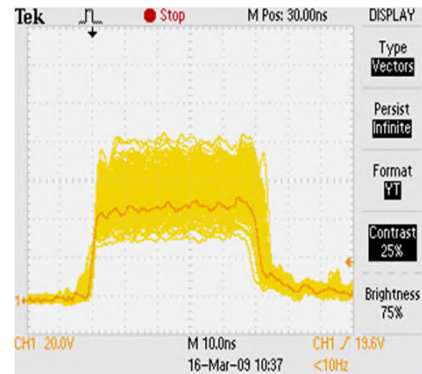


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## 18 kV trapezoidal pulse from FORCE test generator



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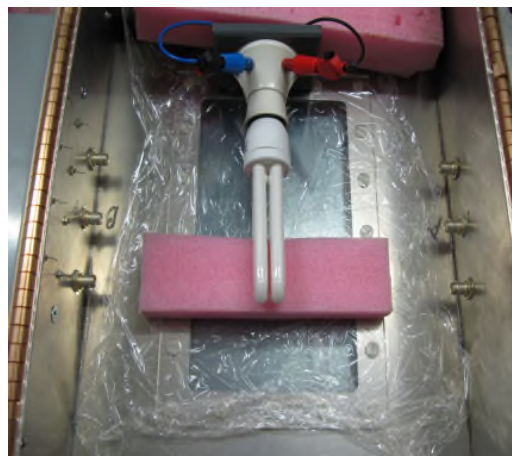
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## EMC HALT on compact fluorescent lamp

The lamp short-circuits and is destroyed using a 18 kV UWB puls

(around 100 kV/m pulse amplitude).



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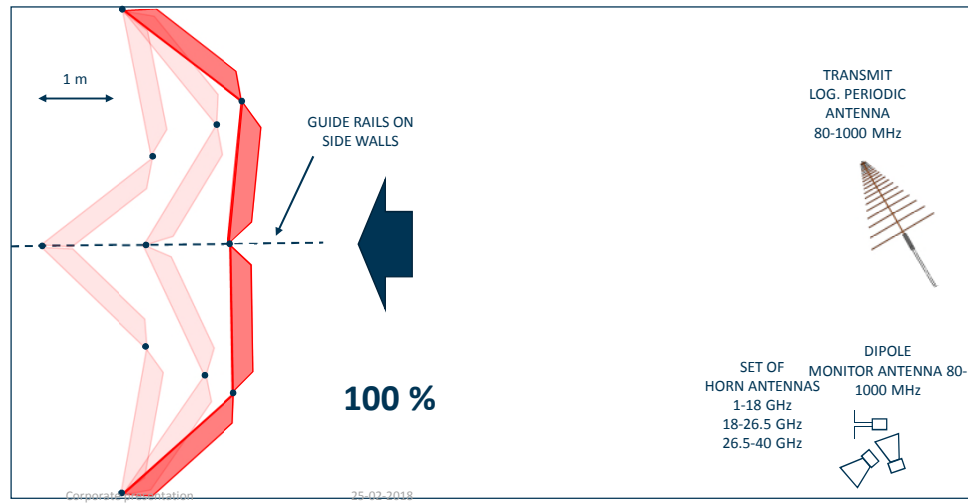
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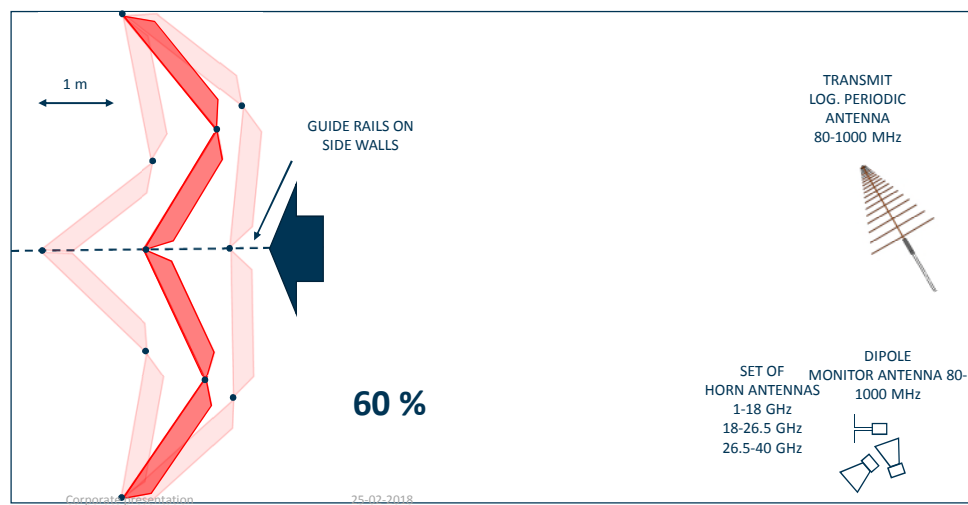
## Reverberation chamber for high field strength

The stirrer is an oscillating stirrer wall with a stroke of approx. 2.6 m.



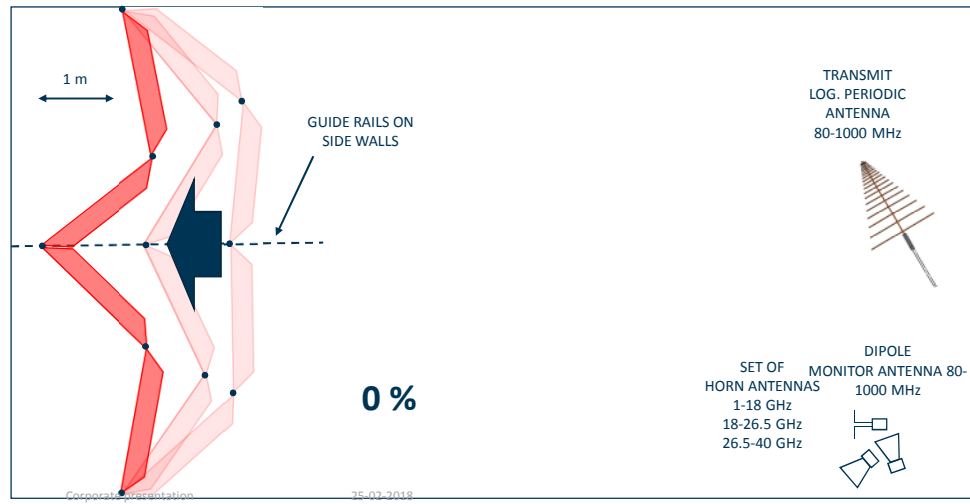
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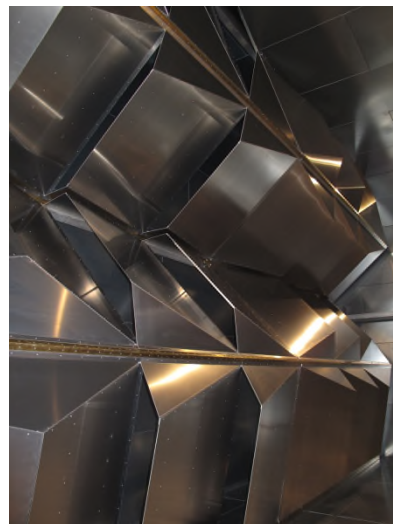
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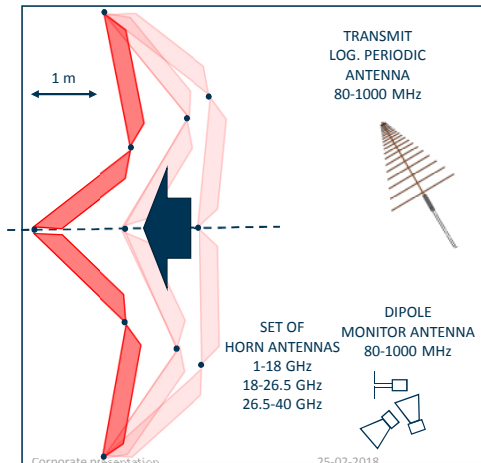
## Reverberation chamber

The stirrer is an oscillating stirrer wall with a stroke of approx. 2.6 m.



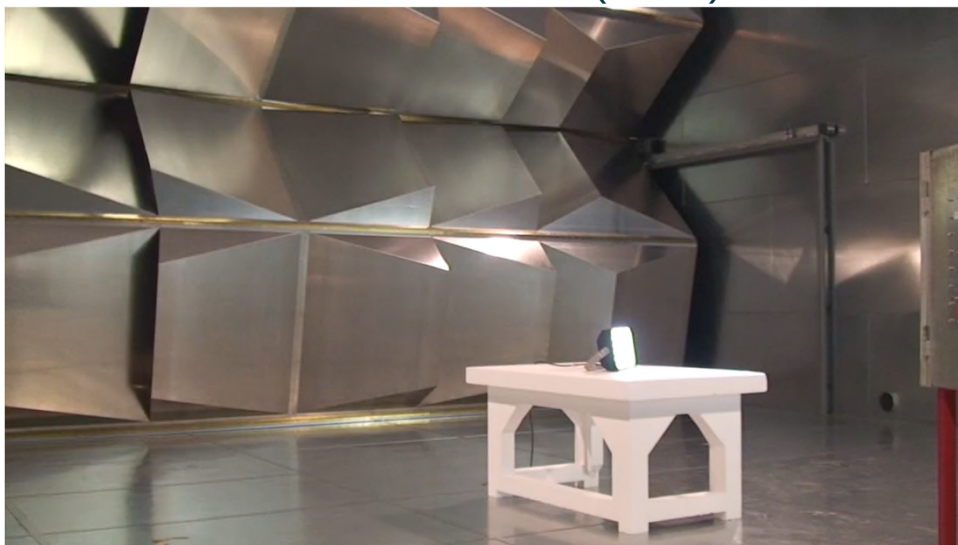
## Antennas in the chamber

Photos of the installed antennas placed on the end wall opposite the stirrer.



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## Reverberation chamber HALT test (video)



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## Findings from EMC HALT activities

- EMC HALT analysis includes extreme cases of the user environment.
- The extreme cases can reveal circuit behavior that may not have been anticipated by even an experienced designer.
- "Anything can happen" – but the EMC HALT testing shows some examples of what happens first – or gives even the full picture of failure responses.
- Risks can be more easily assessed when they are identified.

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## Summary

- The fundamental EMC parameters.
- Test requirements, Accreditation.
- Approvals in EU – Notified Bodies (NB).
- National approvals, IECEE CB scheme, NCB.
- Approval Management process, including risk assessment.
- Mission profile. Extreme use cases. Risk.
- EMC HALT using reverb chamber for high field strength.
- EMC HALT using UWB pulses (and other test signals).
- (And a full palette of environmental tests, failure analysis, calibration, approval, technical services etc.)

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