

# Measurement methods and equipment EMC TEST LAB IN GRÅSTEN and FLENSBURG

Tim Flinholm Fink, 27. February, 2018



# Overview

- Short overview of typical drive application
- EMC EMISSION AND IMMUNITY STANDARDS
- EMC TEST LAB AND EQUIPMENT
- Equipment and calibration

# Danfoss Drives Application examples



# Marine and Offshore

Expand your efficiency horizons with powerful drive and grid systems

**Total**  
range for  
Marine and  
Offshore needs

**Enjoy full flexibility to create tomorrow's outstanding clean power systems, today:**

- Ruggedize your drive-grid systems
- Manage heat loss intelligently
- Reduce emissions and fuel consumption, and save space
- Optimize vessel-wide applications
- Utilize power conversion and shore supply

**Draw on our global network:**

- Extensive lifecycle services
- Know-how that is second to none
- No matter which platform or port of call, we are there to help

**Benefit from application-optimized products with global marine certifications**

**Top performers:**

- VACON® NXP Liquid Cooled Drive
- VACON® NXP,  
VACON® NXP Grid Converter



# Food and Beverage

Unsurpassed fit and variant reduction improve line productivity

**Feeding a growing population demands innovation in hygiene, traceability and cutting-edge control**

**Reinvent system efficiency**

- 30% energy savings is typical
- Most competitive total cost of ownership, TCO
- Innovative motors, efficiency class > IE4

**We champion your cause with intelligent product lifecycle services**

**Globally-compatible AC drives, optimized for food and beverage:**

- Unique synchronization and positioning with Integrated Motion Controller. No servo drive required.
- Leaner warehousing thanks to variant reduction
- European Hygienic Engineering & Design Group (EHEDG) certification

**Top performers:**

- VLT® AutomationDrive FC 302
- VLT® OneGearDrive
- VLT® Decentral Drive FCD 302
- VLT® Integrated Servo Drive ISD 510

**90%**

**overall system  
efficiency**



# Water and Wastewater

Get the ultimate in cost-efficient system optimization from the market leader

190%

power  
generation,  
for water  
management that  
powers itself

**Achieve energy neutrality in your water and wastewater systems**

**Eliminate one of the largest drains on the municipal electricity budget**

**Preserve precious drinking water, and let waste be a thing of the past.**

**World-class expert services**

**Achieve more with less:**

- Use the most cost- and energy-efficient application-optimized AC drives on the planet
- Enjoy uniform water-dedicated technology for compatibility, ease of training and service
- Unsurpassed fit to your system, with universal adaptability and connectivity

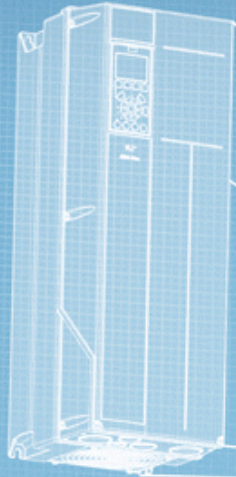
**Top performer:**

- VLT® AQUA Drive FC 202



# HVAC/Building automation

## Maximizing comfort and building efficiency



2.5M

global installed  
base of  
dedicated HVAC  
drives

**Achieve world-class asset protection, control and energy savings, whilst creating comfort**

**Look no further for high-quality, application-optimized AC-drives answers you can trust:**

- Most competitive total cost of ownership, TCO
- Seamless BMS integration including BACnet IP
- Draw upon expert services to reach your goals

**World leader in HVAC since 1986**

- Unique HVAC-dedicated features, which are integrated as standard
- Global installed base of 2.5 million dedicated HVAC drives

**Top performers:**

- VLT® HVAC Drive FC 102
- VLT® DriveMotor FCM 106
- VLT® DriveMotor FCP 106



# Refrigeration

Accelerate system payback with best-practice speed control

**<1 year**

best case  
payback time

Drive down total cost of ownership for reefers, cold rooms and all kinds of compressors

Win full traceability, seamless system integration and full motor compatibility

We champion your cause in optimizing refrigeration applications

- Experts at your service
- Specialized range of refrigeration
  - optimized AC drives

**Top performer:**

- VLT® Refrigeration Drive FC 103



# Chemical

Enhanced reliability in a harsh environment



## Freedom

of choice in control  
system and motor  
type

**Surpass the competition with  
world-class precision, quality  
technology**

**Draw upon the know-how of our  
experts:**

- On-site project engineering
- Extensive lifecycle support services

**Do more with less:**

- Superior energy efficiency
- Application-optimized AC drives give you leaner machines and processes

**Top performers:**

- VACON® NXC
- VACON® 100 INDUSTRIAL



# Mining and Minerals

Save on CAPEX and OPEX with robust, reliable drives



**Intelligent**  
heat management  
drives down  
substation costs

**Boost productivity and extend equipment lifetime**

**Win high asset availability:**

- Heavy-duty, application-optimized AC drives
- Rugged high performance in the harshest of conditions
- Intelligent heat management

**Reap surprising savings in both CAPEX and OPEX:**

- World-class AC drive dedicated engineering
- Expert lifecycle support services
- On-site support to back you up

**Top performers:**

- VACON® 100 INDUSTRIAL
- VACON® NXP
- VACON® NXC



# Cranes and Hoists

The sky is the limit for safe and efficient performance



## Meet the challenges of safety and efficiency demands, using our:

- Extensive lifecycle services
- World-class application-optimized AC drives
- Heavy-duty reliability when it counts

## Achieve high availability and powerful efficiency:

- Hoisting and other crane movements
- Innovative hybrid energy storage

## Top performers:

- VACON® NXP Air Cooled
- VACON® NXP Common DC Bus
- VACON® 20 Cold Plate

**Global**  
service network

# Elevators and Escalators

World-class buildings demand cutting-edge convenience

## Intuitive

set-up, with  
graphical  
interface

Enjoy the ultimate in travel comfort,  
with no compromises

**Full range of market-leading AC  
drives with integrated elevator  
control:**

- Tailored solutions for large OEMs
- Extensive lifecycle services
- Versatile, seamless system integration

**Second life for hydraulic elevators  
via modernization with an AC drive:**

- Fast retrofit
- More rides per day
- High availability

**Top performer:**

- VACON® NXP Air Cooled



# Heavy industry

Supreme process availability and performance when it counts

Current ratings  
up to

**5000A**

Ensure best-practice process control and optimal efficiency to meet your performance targets, no matter how demanding the task is.

We offer heavy-duty expertise in both single-drive and system-drive applications encompassing the entire power range.

**Win competitive edge using tomorrow's technology today:**

- Expert services
- Broad range of air- and liquid-cooled AC drives
- Seamless system integration
- Rapid connectivity

**Top Performers:**

- VACON® 100
- VACON® NXP Liquid Cooled
- VACON® NXC
- VACON® NXP System Drive



# Oil and gas

Save energy and drive down operating costs



## Long

lifetime, top  
performance,  
and full-throttle  
process  
throughput

### Gain even more competitiveness via variable speed control

- Improve the productivity of your existing systems
- Save energy and drive down operating costs, thanks to extended product lifetime

### Combine the newest intelligent functionalities and high durability to win more sustainability

- Innovate better equipment with application-optimized AC drives

### Get fast response from the global service network:

- World-class AC-drive-dedicated engineering
- Extensive lifecycle services

### Top Performers:

- VACON® NXC
- VACON® NXP Liquid Cooled
- VACON® NXP System Drive
- VACON® 100



# EMC test of drives

## Application impact

- **User profile – how is the drive used**
  - Inertia
  - Start/Stop effects
  - Grid influence
  - Interference on communication cables
  - Cable length
- **Test purpose**
  - Drives testing and application simulation
  - Capture worst case scenario
  - Design margin towards requirements

# EMC Emission and Immunity Standards

The High Frequency (RF) standards we are capable of testing according to are:

**Product standard IEC/EN61800-3**  
**Generic Standard IEC/EN61000-6-X**

Emission:

**Conducted emission**  
**IEC/EN55011 (0,15-30MHz)**

**Radiated emission**  
**IEC/EN55011 (30-1.000MHz )**

Immunity:

**Conducted RF-CM**  
**IEC/EN61000-4-6 (0,15-80MHz)**

**Radiated EM-field**  
**IEC/EN61000-4-3 (80-1000MHz)**

**Burst**  
**IEC/EN61000-4-4 (5/50nS)**

**Surge**  
**IEC/EN61000-4-5 (1,2/50uS)**

**ESD**  
**IEC/EN61000-4-2 (1.2/5nS)**

**+ Ringwave (UL)**

**+ Marine Standards**

**+ VDE 0160 Pulse**



# EMC Emission and Immunity Standards

The Low Frequency (LF) standards we are capable of testing according to are:

**Product standard IEC/EN61800-3**  
**Generic Standard IEC/EN61000-6-X**

Emission:

**Harmonic Line Current Emission**  
**IEC/EN61000-3-2 / 3-12**

**Voltage Fluctuations and Flicker**  
**Emissions**  
**IEC/EN61000-3-3 / 3-11**

Immunity:

**Voltage Harmonic Distortion**  
**IEC/EN61000-4-13**

**Voltage Dips, Short Interruptions**  
**and Variations**  
**IEC/EN61000-4-11 / 4-34**

**Voltage Unbalance**  
**IEC/EN61000-4-27**

**Voltage Fluctuation Immunity**  
**IEC/EN61000-4-14**

**Commutation Notches**  
**IEC/EN60146-1-1**

**Power Frequency Variation**  
**IEC/EN61000-4-28**

**+ Marine, Ger.Lloyd, etc.**

# EMC TEST LAB AND EQUIPMENT

Test Benches:

EMC Chamber 1

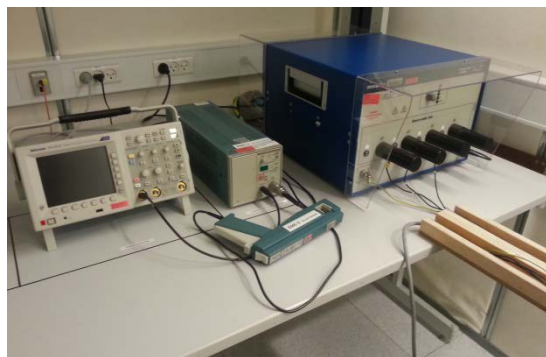
EMC Chamber 2

Test Lab

Conducted Emission 1

Conducted Emission 2

Conducted Emission 3



- Messtec 3 $\phi$ +N 150kHz-30MHz LISN
- Max 140 $\mu$ V level input
- EUT Supply: 3 $\phi$ +N 400VAC/200A
- Connections to shielded motor cable matrix:
  - 2x up to 35mm<sup>2</sup>
  - 1x up to 2,5mm<sup>2</sup>



- Messtec 3 $\phi$ +N 9kHz-30MHz LISN
- Max 140 $\mu$ V level input
- EUT Supply:
  - 3 $\phi$ +N 400VAC/200A
  - 3 $\phi$ +N 550VAC Variable transformer
  - 3 $\phi$ +N 690VAC
- Connections to shielded motor cable matrix:
  - 2x up to 35mm<sup>2</sup>
  - 1x up to 2,5mm<sup>2</sup>
- Schwarzbeck DC LISN 150kHz-30MHz



- Rohde & Schwarz 3 $\phi$ +N 150kHz-30MHz LISN
- Max 140 $\mu$ V level input
- EUT Supply:
  - 3 $\phi$ +N 400VAC/63A
- Connections to shielded motor cable matrix:
  - +17m (10mm<sup>2</sup> shielded motor cable)
  - +17m (2,5mm<sup>2</sup> shielded motor cable)



# EMC TEST LAB AND EQUIPMENT

Test Benches:

Mobile on trolley

EMC Chamber 2

Test Lab

Conducted RF-CM

Burst

Generators, etc.



- Teseq NSG 4017C
- EM Test CDNs and FCC Clamps
- Voltage levels up to 30V RMS

- EM Test 30+N Generator
- Test Voltages up to 4,4kV Burst
- EUT Supply up to 690VAC



- ~5m tables with copper surfaces for immunity testing in both chambers

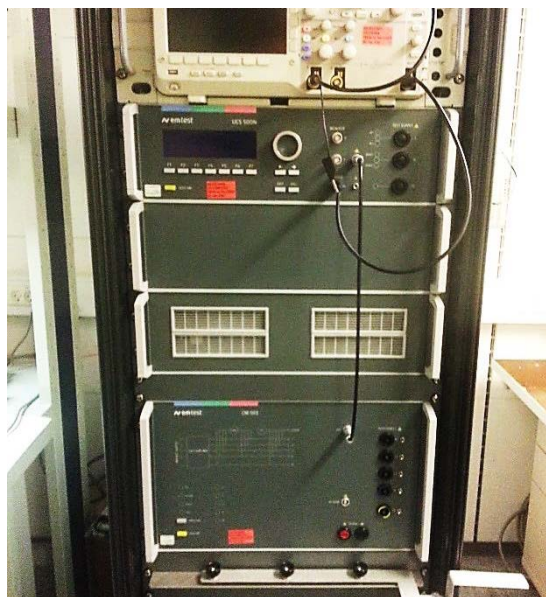


# EMC TEST LAB AND EQUIPMENT

Test Benches:

## EMC Chamber 1

### Burst/Surge/Ringwave



- EM Test Generator + Control SW
- Test Voltages up to 7kV Burst/Surge + Ringwave
- EUT Supply up to 690VAC (3 $\phi$ +N) / 1.000 VDC – 32A (+/-)

## EMC Chamber 2

### Burst/Surge



- EM Test 1 $\phi$ +N Burst/Surge Generator
- Test Voltages up to 4,4kV
- EUT Supply: 230VAC

### ESD



- 2 x EM Test Generators
- Test Voltages up to 16,5kV Air and 10kV Contact Discharge

## Test Lab

### Generators, etc.



- 3 $\phi$ +N Schaffner Surge generator – MAX EUT Voltage: 440VAC
- R&S RF Signal Generator
- Rolf Heine Antenna (possible to do inhouse radiated emission/immunity troubleshooting)
- 25W RF Amplifier
- R&S RF Power Meter
- EMC (Detectus) Scanner
- R&S and Agilent Spectrum Analyzers
- R&S RF-current probes
- Tektronix Oscilloscopes
- HP Current Clamps, Amplifiers
- Ferrites, Components, etc.

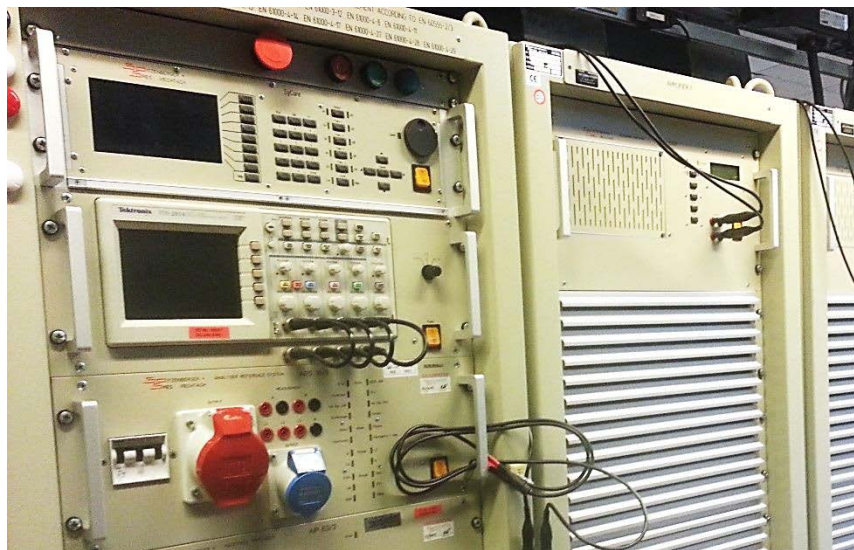


# EMC TEST LAB AND EQUIPMENT

## Test Lab

### Spitzenberger & Spies PAS

- LOW FREQUENCY EMISSION
- LOW FREQUENCY IMMUNITY



- 3 $\phi$ +N Power Amplifier System
- EUT Voltage: up to 690VAC
- EUT Power: 45kW (Higher loads possible for shorter periods of time)
- 3 $\phi$  rack with reactors for eg. Harmonic Emission
- Software option for Product Standard EN61800-3

### California Instr. RS90 PAS

- LOW FREQUENCY EMISSION
- LOW FREQUENCY IMMUNITY



- 3 $\phi$ +N Power Amplifier System
- EUT Voltage: up to 690VAC
- EUT Power: 90kVA
- Harmonic & Flicker measurement unit

# 10m SaC – the Facility on high level

- SAC (Semi Anechoic Chamber) with up to 10 meter measurement distance
- Chamber, load room and control room with total external dimensions of 25m length, 12m width and 9m height.
- Radiated Immunity from 80Mhz to 6GHz
- Radiated emissions from 9kHz to 18GHz (receiver up to 44GHz)
- Prepared for liquid cooled products
- Turntable for test objects has a diameter of 5m and capacity up to 10 tons.
- Door to the chamber is 4x4 meter and in level with surroundings.
- Motor load setup with maximum power of 90 kW





# EMC equipment procedures

- **Calibration**
  - **All instruments calibrated with traceability**
  - **Calibration reports must be reviewed and drift must be evaluated**
  - **Based on this, next calibration period can be determined**
  - If issues are found, all affected tests must be re-analyzed

# Calibration example – EMC analyzer

- 2016

EMI Detector.							
Note:	Res.BW:		Input:	Display:	Error:	Uncert.:	Spec.:
	200 Hz	Peak	-25.0 dBm	-24.99 dBm	0.01dBm	±0.1dB	2dB
	200 Hz	Q-Peak	-25.0 dBm	-24.95 dBm	0.05dBm	±0.1dB	2dB
	200 Hz	AVG	-25.0 dBm	-24.96 dBm	0.04dBm	±0.1dB	2dB
	9 kHz	Peak	-25.0 dBm	-25.47 dBm	-0.47dBm	±0.1dB	2dB
	9 kHz	Q-Peak	-25.0 dBm	-25.38 dBm	-0.38dBm	±0.1dB	2dB
	9 kHz	AVG	-25.0 dBm	-25.38 dBm	-0.38dBm	±0.1dB	2dB
	120 kHz	Peak	-25.0 dBm	-25.10 dBm	-0.10dBm	±0.1dB	2dB
	120 kHz	Q-Peak	-25.0 dBm	-24.91 dBm	0.09dBm	±0.1dB	2dB
	120 kHz	AVG	-25.0 dBm	-24.95 dBm	0.05dBm	±0.1dB	2dB

- 2017

EMI Detector.							
Note:	Res.BW:		Input:	Display:	Error:	Uncert.:	Spec.:
	200 Hz	Peak	-25.0 dBm	-24.85 dBm	0.15dBm	±0.1dB	2dB
	200 Hz	Q-Peak	-25.0 dBm	-24.86 dBm	0.14dBm	±0.1dB	2dB
	200 Hz	AVG	-25.0 dBm	-24.86 dBm	0.14dBm	±0.1dB	2dB
	9 kHz	Peak	-25.0 dBm	-24.90 dBm	0.10dBm	±0.1dB	2dB
	9 kHz	Q-Peak	-25.0 dBm	-24.92 dBm	0.08dBm	±0.1dB	2dB
	9 kHz	AVG	-25.0 dBm	-24.85 dBm	0.15dBm	±0.1dB	2dB
	120 kHz	Peak	-25.0 dBm	-25.10 dBm	-0.10dBm	±0.1dB	2dB
	120 kHz	Q-Peak	-25.0 dBm	-25.12 dBm	-0.12dBm	±0.1dB	2dB
	120 kHz	AVG	-25.0 dBm	-25.05 dBm	-0.05dBm	±0.1dB	2dB

- 2018

EMI Detector.							
Note:	Res.BW:		Input:	Display:	Error:	Uncert.:	Spec.:
	200 Hz	Peak	-25.0 dBm	-25.01 dBm	-0.01dBm	±0.1dB	2dB
	200 Hz	Q-Peak	-25.0 dBm	-25.00 dBm	0.00dBm	±0.1dB	2dB
	200 Hz	AVG	-25.0 dBm	-25.03 dBm	-0.03dBm	±0.1dB	2dB
	9 kHz	Peak	-25.0 dBm	-25.03 dBm	-0.03dBm	±0.1dB	2dB
	9 kHz	Q-Peak	-25.0 dBm	-25.03 dBm	-0.03dBm	±0.1dB	2dB
	9 kHz	AVG	-25.0 dBm	-25.04 dBm	-0.04dBm	±0.1dB	2dB
	120 kHz	Peak	-25.0 dBm	-24.84 dBm	0.16dBm	±0.1dB	2dB
	120 kHz	Q-Peak	-25.0 dBm	-24.93 dBm	0.07dBm	±0.1dB	2dB
	120 kHz	AVG	-25.0 dBm	-24.84 dBm	0.16dBm	±0.1dB	2dB



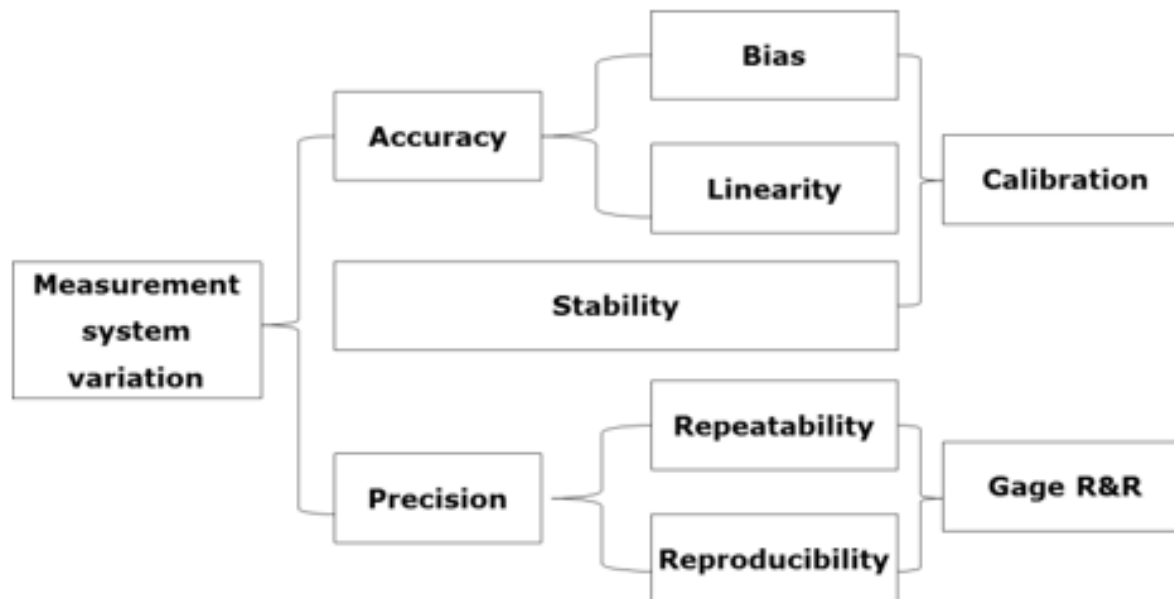
# What is MSA?

- MSA is a Six Sigma tool and stands for: "Measurement System Analysis"
- The purpose of MSA is to find and reduce/eliminate variation, producing a repeatable, precise and accurate measurement system.
- It is value adding to incorporate correct passing criteria's which incorporates products variations and measurement uncertainty.
- The consequence of not knowing the uncertainty's can have a critical impact on projects.



# What to considered during MSA

- It is important that a MSA study is reflecting a real test/test situation in order to cover all the uncertainties coming from the measurement system.





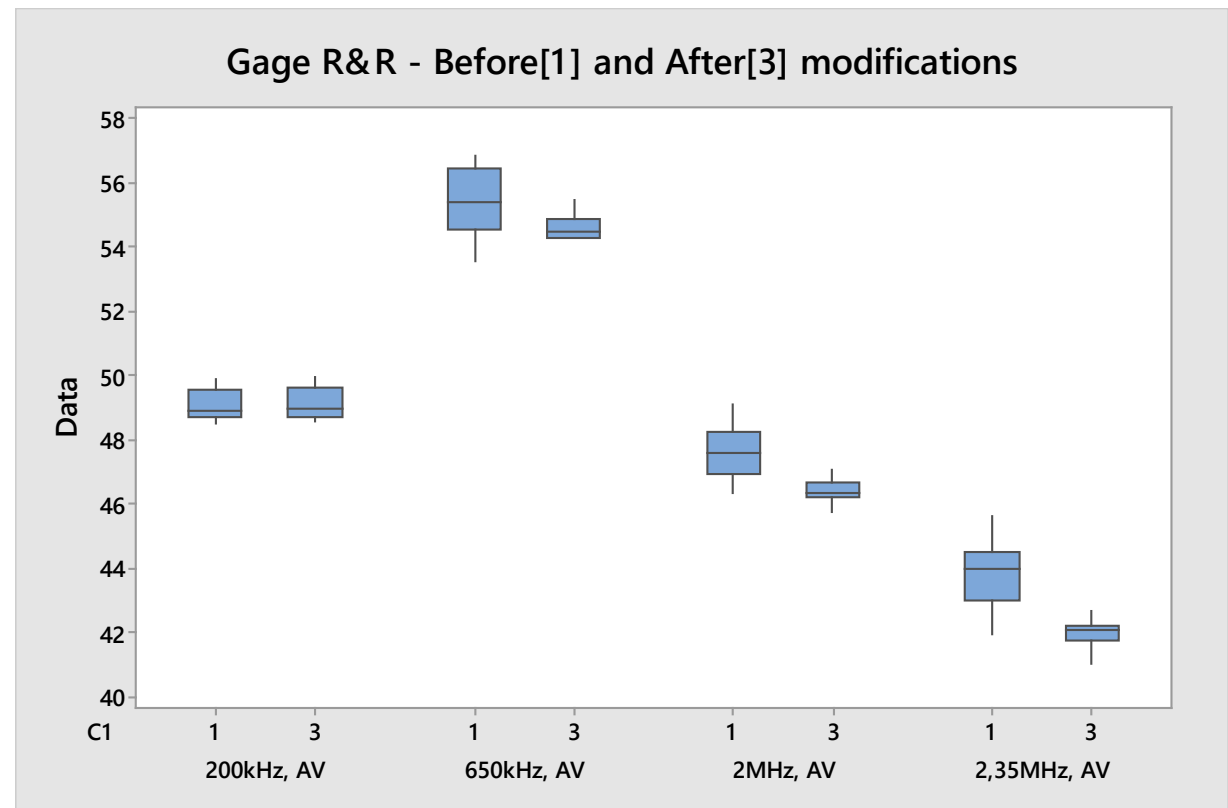
# Gage R&R study for Cond. Emission

- Measurement variations have been reduced by implementing a fixture to the LISN.
- Improvement of repeatability and reproducibility
- Measurement variation: Before 3,7dB ➡ Now 1,6dB

Before:



Now:





ENGINEERING  
**TOMORROW**