IN-HOUSE EMC TESTING

WHERE TO START, AND WHERE CAN IT GO

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Application Engineer

ROHDE&SCHWARZ
Make ideas real

ABSTRACT

In the face of product failures during EMC testing, the question arises:

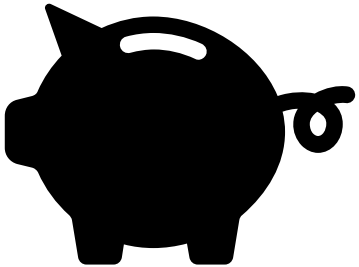
"When does it make economic sense to perform EMC testing in-house?“

This presentation aims to provide insights into initiating in-house EMC testing by identifying the most accessible tests to begin with. Additionally, we will explore diverse pathways for expanding testing capabilities, ultimately leading to comprehensive EMC compliance.

Join us to discover how to embark on cost-effective in-house EMC testing and explore its potential for your organization.

WHY IN-HOUSE TESTING - GOAL

- Goal 1 – Save Money
  - Reduce the cost of external testing (Test House)
    - Less retest and less trips
  - Reduce time and resource for testing.
    - Reduce multiple test and/or retest time
    - Reduce project downtime from shipping and waiting.
    - Reduce resource downtime for employees traveling



WHY IN-HOUSE TESTING - GOAL

- Goal 1 – Save Money

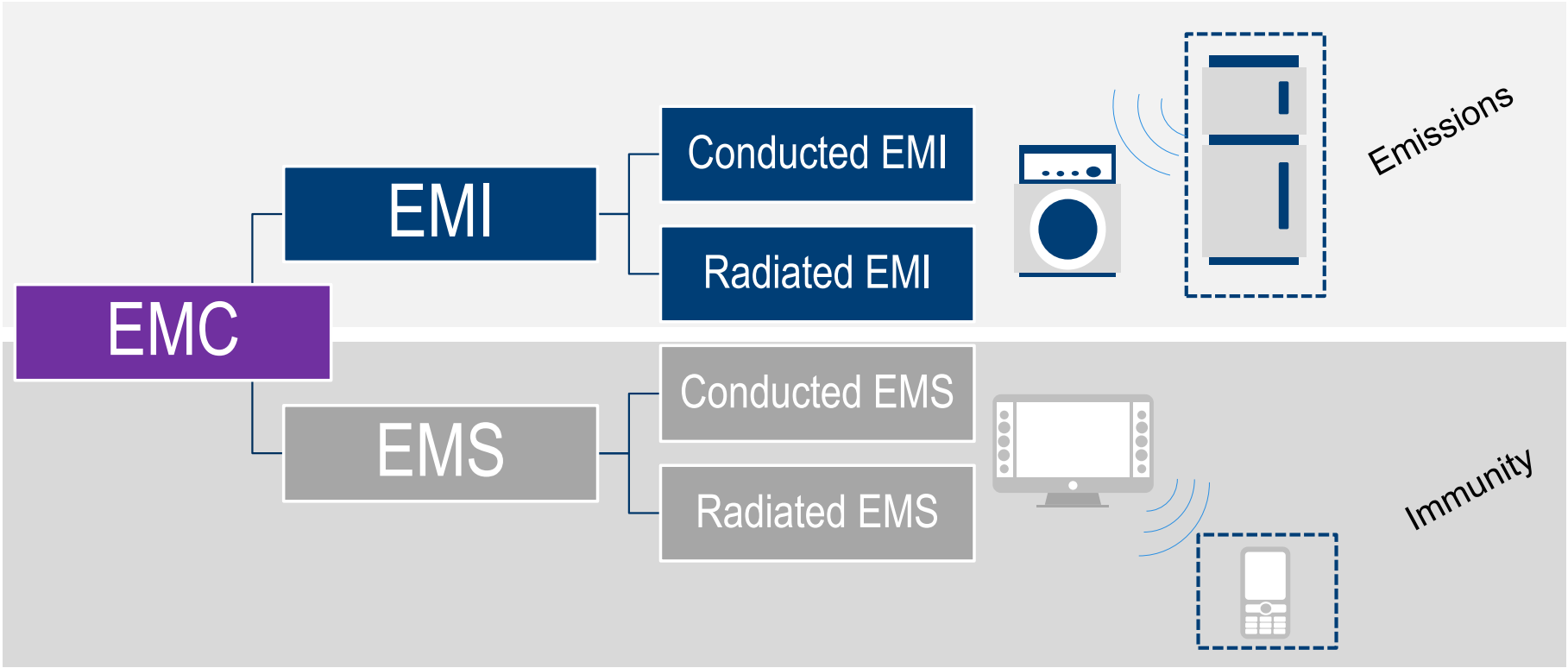
- Goal 2 – Increase in-house knowledge
  - Prevent repeat issues
    - Reduce testing cost
    - Prevent project delays
  - Improve product design
    - Improves quality
    - Improves functions and features
  - Provides development path for employees
    - Development opportunities help with employee retention.

EMC TESTING COVERED

- Electrical noise testing (EMC Electromagnetic compatibility)
  - Testing Noise that is generated by the DUT
    - Emissions = EMI (Electromagnetic Interference)
  - Noise added to connected lines
    - Conducted Emission (CE)
  - Noise broadcast over-the-air (OTA)
    - Radiated Emission (RE)
  - Testing the Effects of noise from the environment on DUT
    - Immunity = EMS (Electromagnetic Susceptibility)
  - Noise coming in on the connect lines
    - Conducted Immunity (CI) or Conducted Susceptibility (CS)
  - Noise coming in over-the-air (OTA)
    - Radiated Immunity (RI) or Radiated Susceptibility (RS)

- Testing not covered
  - Voltage or current test
  - Electrostatic Discharge
    - ESD
  - Electrical Fast Transient
    - EFT

EMC TESTING – TYPES



PRODUCT TESTING – LEVELS

Concept → Design → Prototype → Verify → Pre-production

First level - Debugging

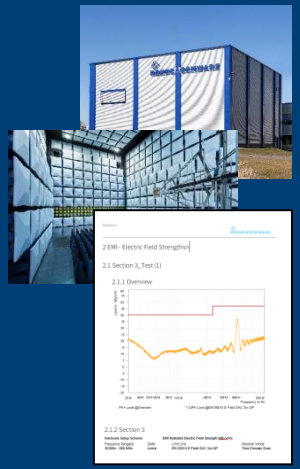
Oscilloscopes
- Near field
- Time/freq correlation
- Reference masking
- Serial/parallal/protocol test

In-house

Pre-compliance

External Lab

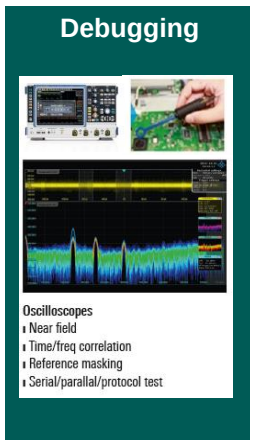
Final level – Full Compliance

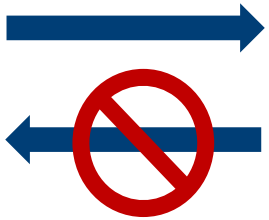


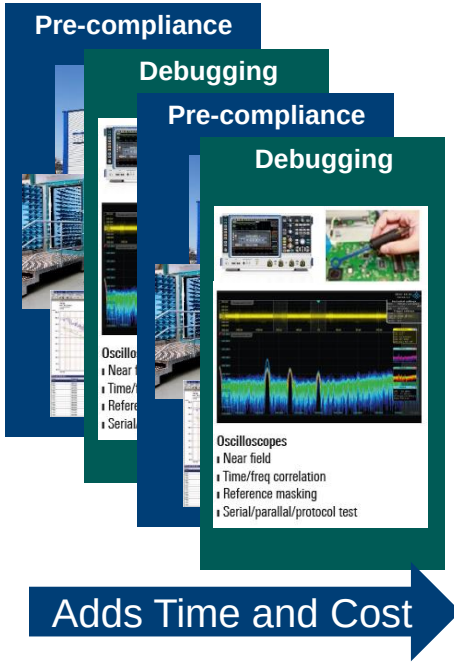
External Lab

PRODUCT TESTING – LEVELS

Concept → Design → Prototype → Verify → Pre-production







Adds Time and Cost

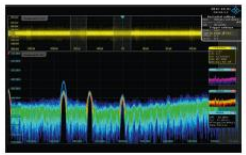
Adds Time and Cost

PRODUCT TESTING – LEVELS

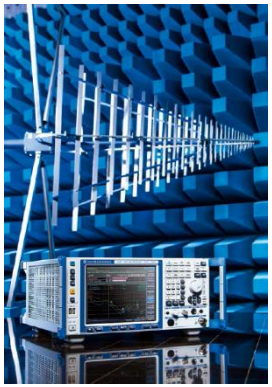
Concept → Design → Prototype → Verify → Pre-production

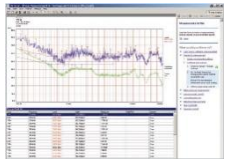
Debugging | **Pre-compliance** | **Full Compliance**

Spectrum Analyzer
| Near field
| Weighted detector
| Interference analysis
| Excellent Sensitivity



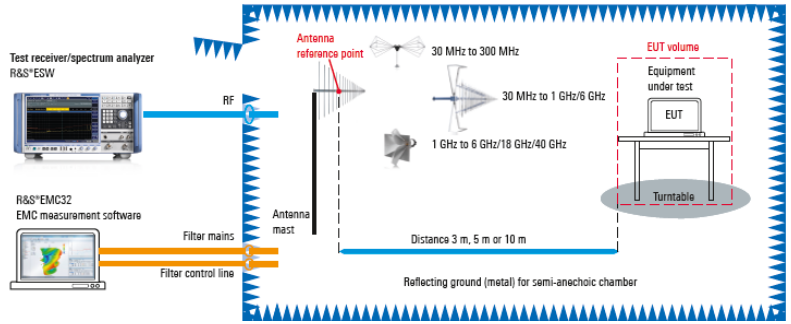
Oscilloscopes
- Near field
- Time/freq correlation
- Reference masking
- Serial/parallal/protocol test





R&S®ESL and FSL

R&S®ESRP and FSV3000

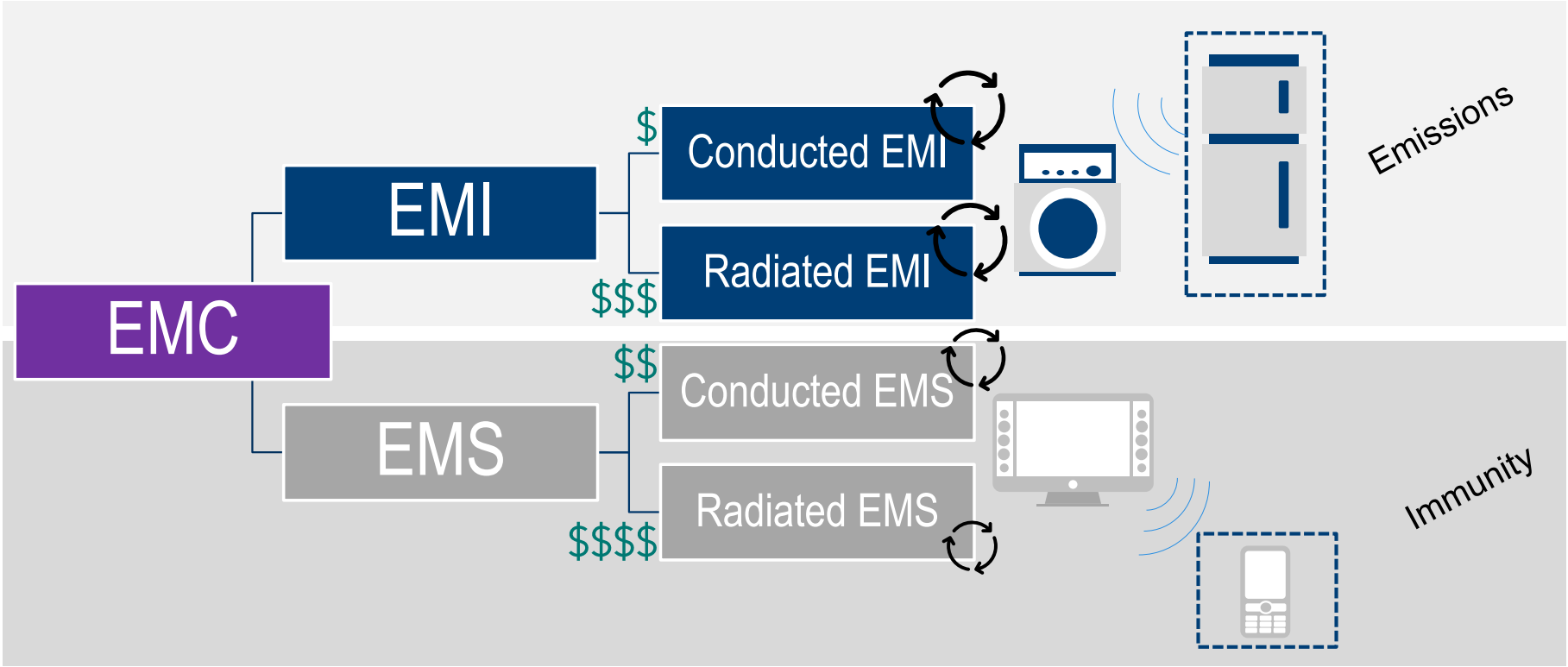


EMI Test Receiver
| Conducted and radiated measurement
| Precompliance and compliance acc. to CISPR/EN/MIL/etc. standard
| High measurement speed
| Disturbance measurement

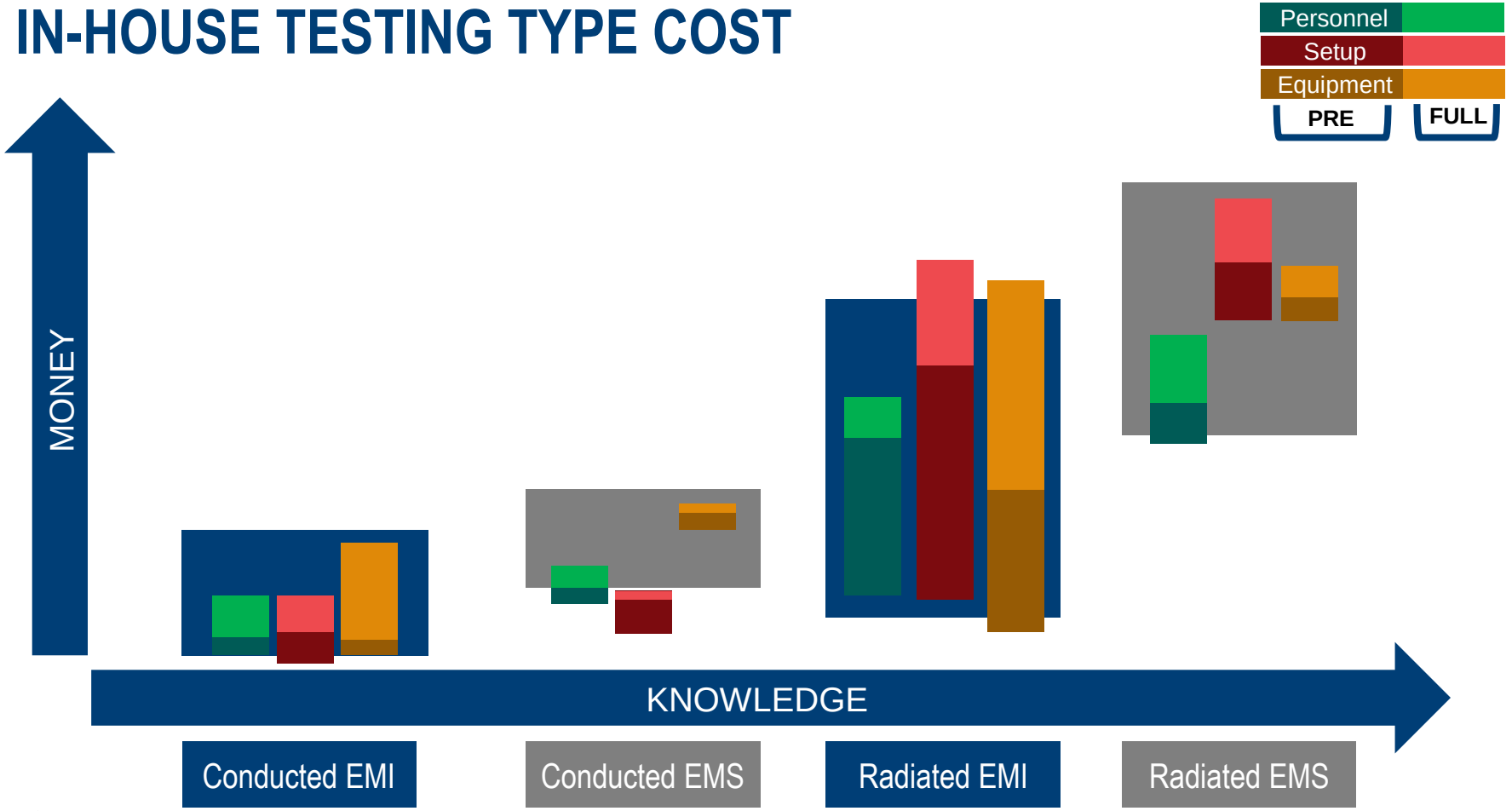
R&S®ESW

R&S®ESR

TESTING COST AND RETURN ON INVESTMENT



IN-HOUSE TESTING TYPE COST



CONDUCTED EMI

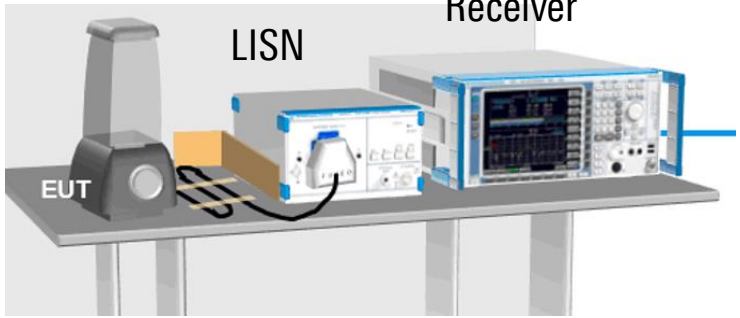
	PRE	FULL
Personnel		
Setup		
Equipment		

MONEY

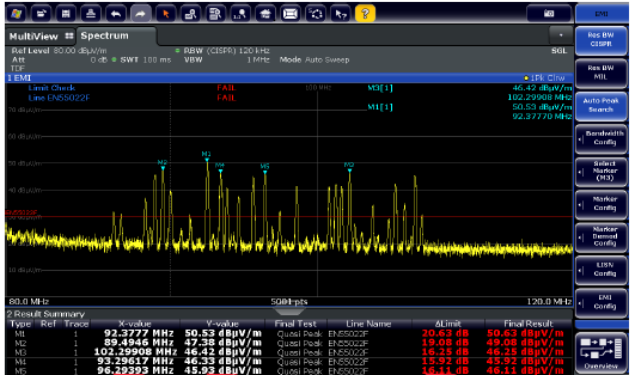
Conducted EMI

Manual operation Copy test house setup and limits	Paperwork – Documentation Standard knowledge & understanding Automation with software
Small area Table, Bench, or floor	Correct setup per standard. Table (height, dimension, grounding…)
Scope or Spectrum Analyzer Coil or LISN	Compliance EMI Receiver Calibrated Coil or LISN *Network Analyzer for calibration

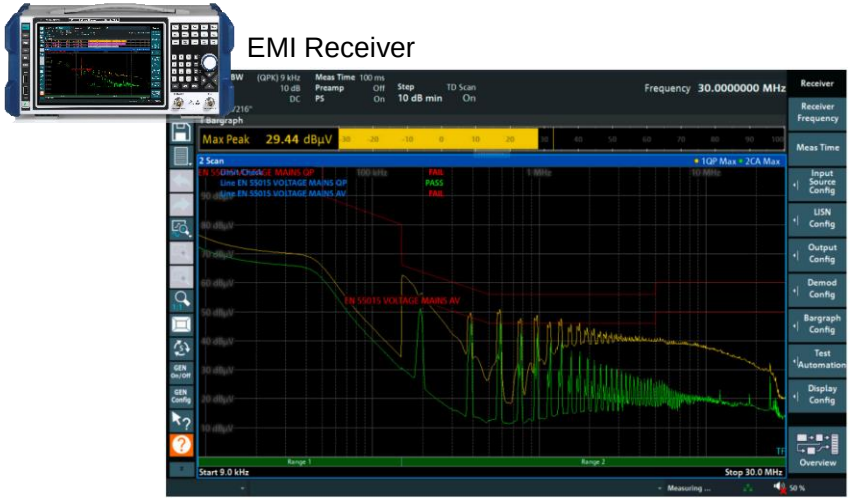
CONDUCTED EMI



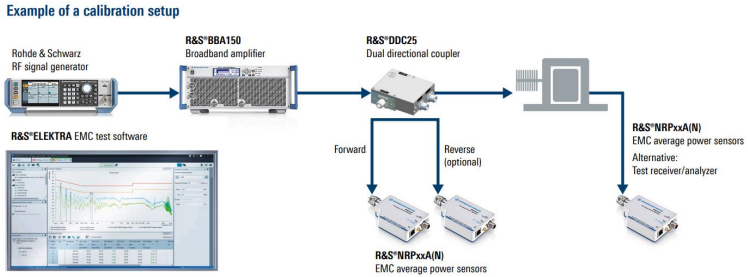
Spectrum Analyzer



EMI Receiver



CONDUCTED EMS



Personnel
Setup
Equipment

PRE | FULL

MONEY

Conducted EMS

Manual operation (getting harder) Maybe be a to copy test house	Paperwork – Documentation Standard knowledge & understanding Automation with software
Small area Table, Bench, or floor	Correct setup per standard. Table (height, dimension, grounding…)
Signal Generator Amplifier Power Sensors Coil	<- Same at Precompliance *Network Analyzer for calibration

CONDUCTED EMS – SIGNAL GENERATION

Example of a calibration setup

Rohde & Schwarz
RF signal generator

R&S®BBA150
Broadband amplifier

R&S®DDC25
Dual directional coupler

R&S®ELEKTRA EMC test software

Forward

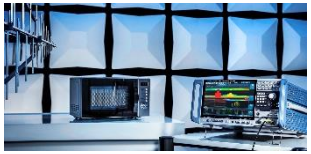
Reverse
(optional)

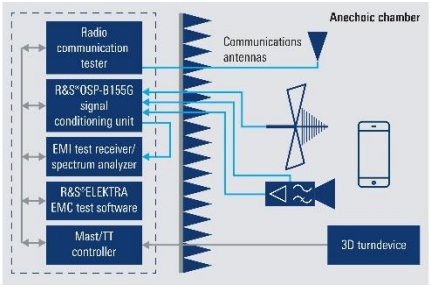
R&S®NRPxxA(N)
EMC average power sensors

R&S®NRPxxA(N)
EMC average power sensors

Alternative:
Test receiver/analyzer

RADIATED EMI

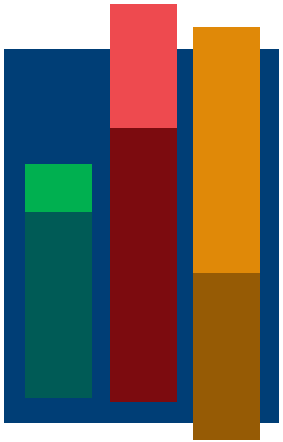




Personnel
Setup
Equipment

PRE | FULL

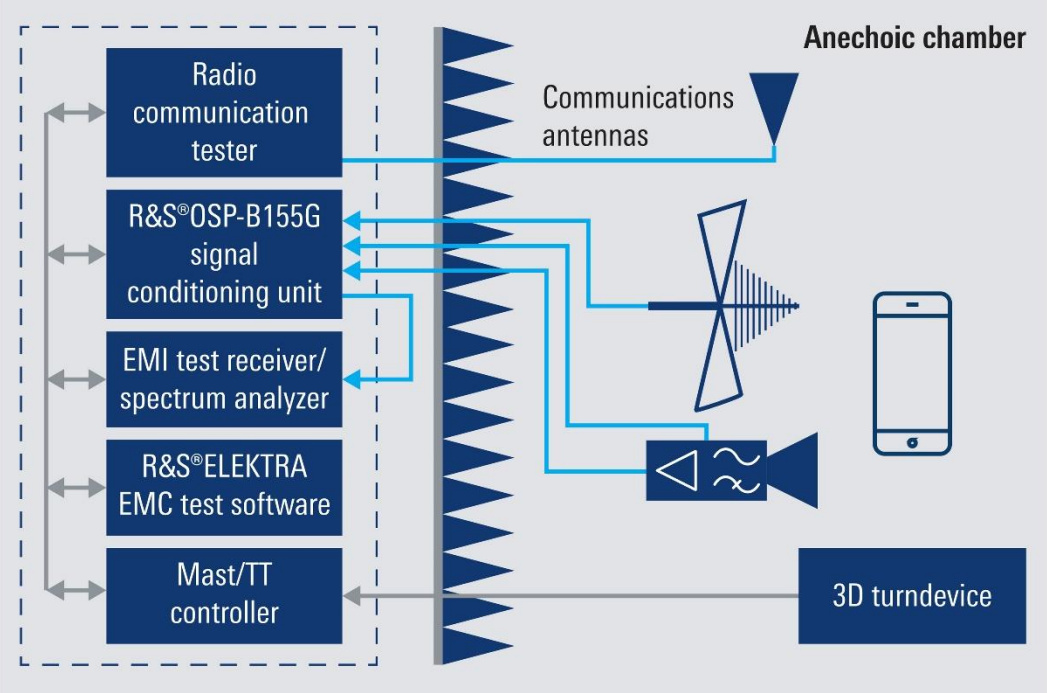
MONEY

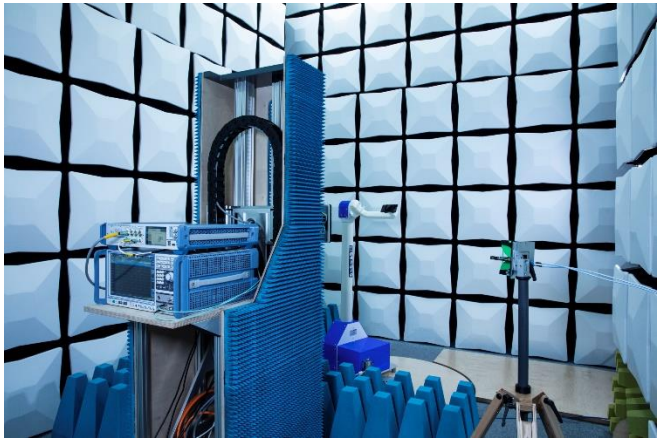


Radiated EMI

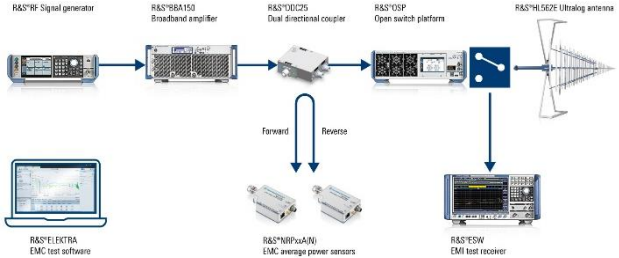
Manual operation (very long) Need EMC expertise if not in Chamber Copy test house setup and limits	Paperwork – Documentation Standard knowledge & understanding Automation with software Understanding path calibration
Open area (large room or outdoors) Smaller Chamber * If not chamber harder to read measurement	Correct setup per standard. Correct Chamber size – quiet zone Fit Antenna with mast Turntable. Chamber HVAC Control room or bench/rack outside chamber
Spectrum Analyzer Smaller Antenna	Compliance EMI Receiver Antenna with LNA Switching system/unit Turntable and mast controller

RADIATED EMI – MEASURMENT





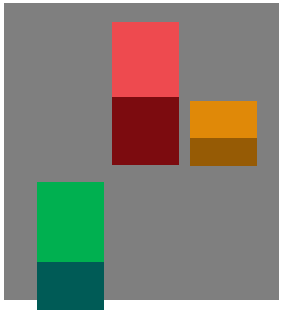
RADIATED EMS



Personnel
Setup
Equipment

PRE | FULL

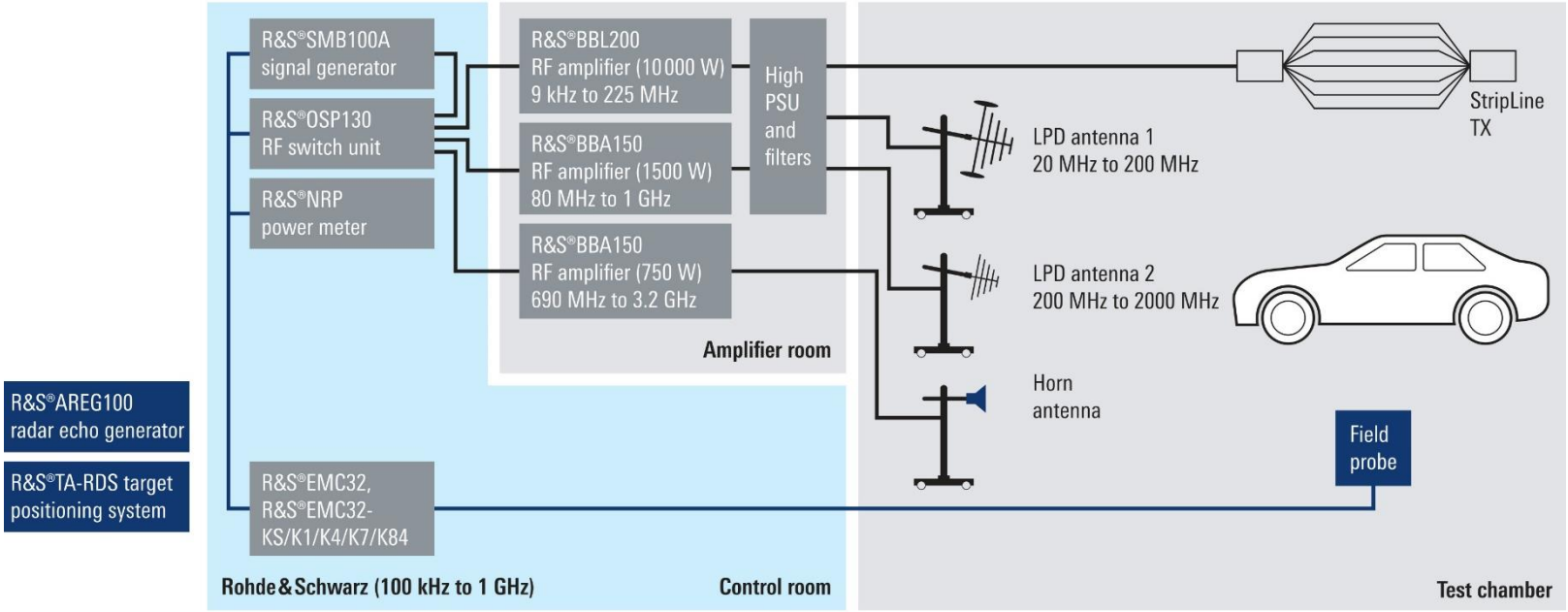
MONEY



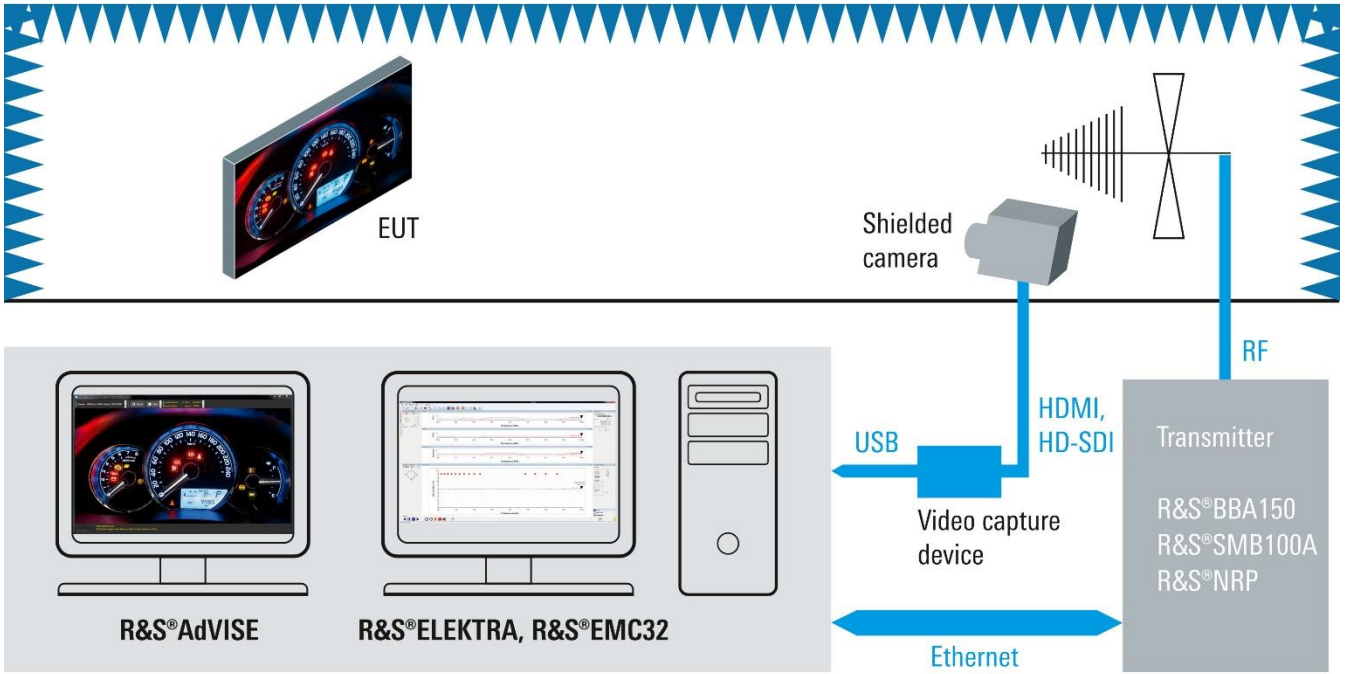
Radiated EMS

Manual operation not likely Hard to monitor signal and DUT without Software	Paperwork – Documentation Standard knowledge & understanding Automation with software High Power RF knowledge and safety
Smaller Chamber (but must be in chamber) Control room or bench/rack outside chamber to fit amplifiers	Correct setup per standard. Correct Chamber size – quiet zone Fit Antenna with mast Turntable. Chamber HVAC
Automation Software Signal generator, Amplifier(s) Power sensors, Field Probe, Spectrum Analyzer (or Receiver) Camera or IO monitoring	<- Same and precompliance but Larger amplifier for correct chamber size DUT Monitoring Software

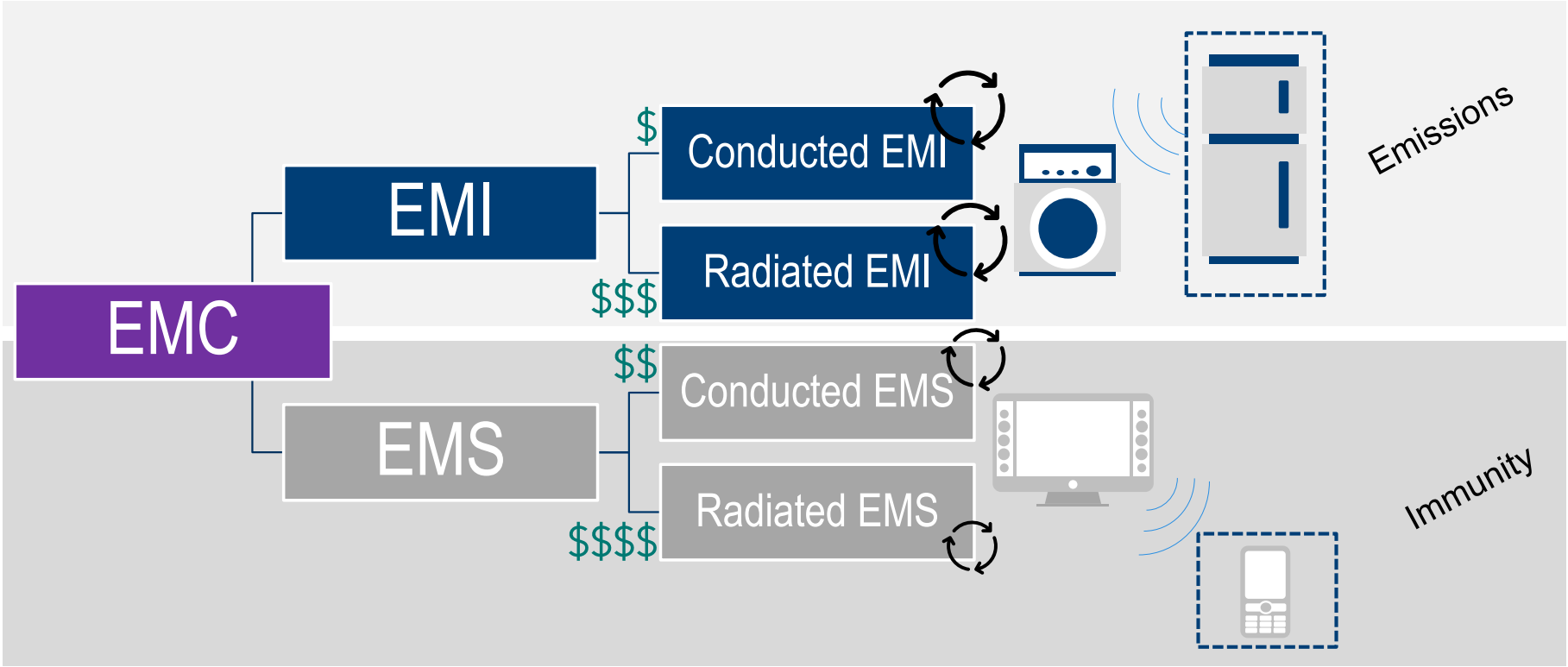
RADIATED EMS – SIGNAL GENERATION



RADIATED EMS – EUT MONITORING



TESTING COST AND RETURN ON INVESTMENT



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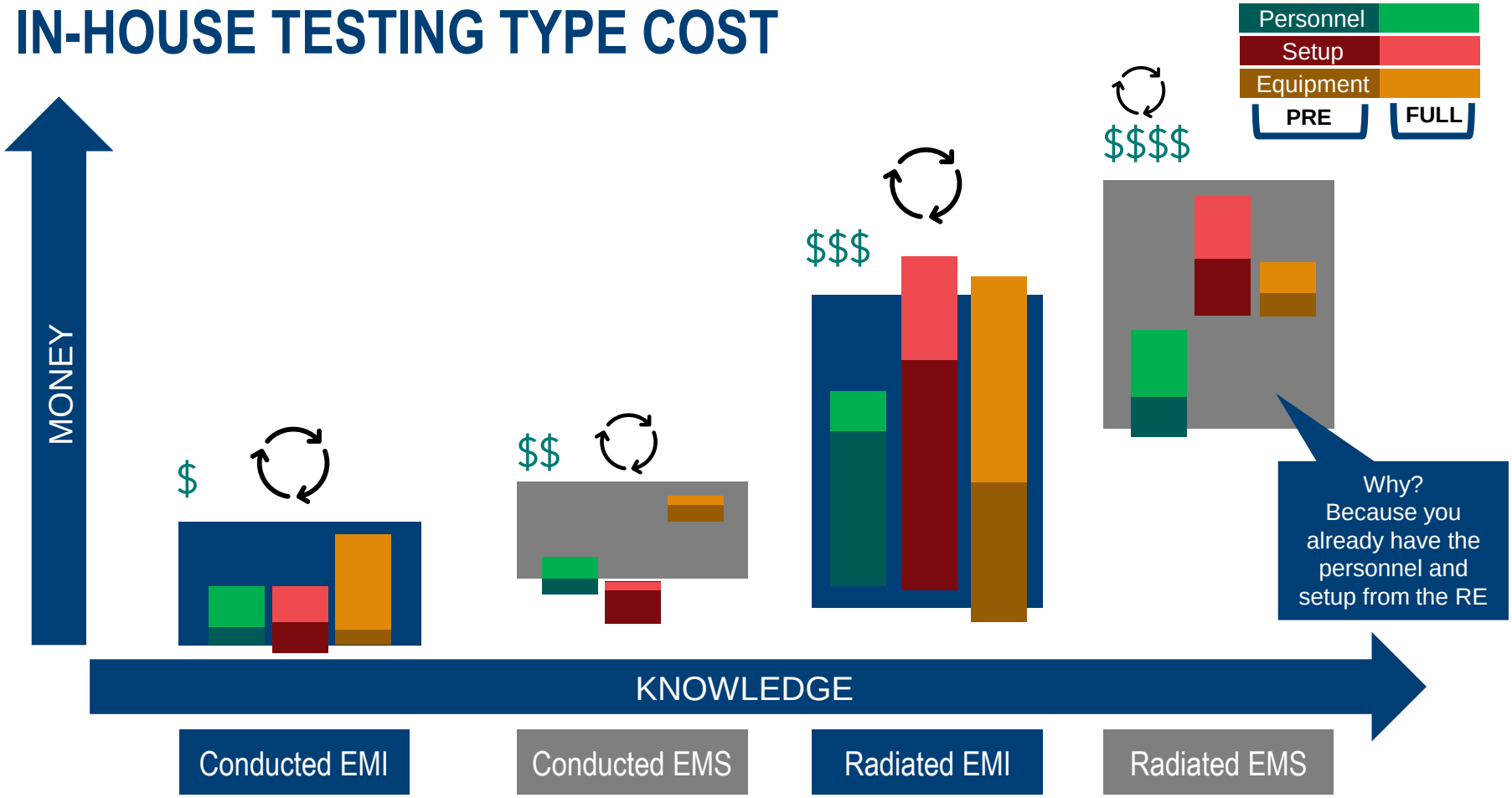
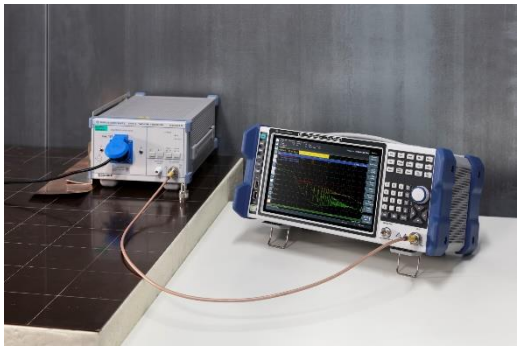


START WITH CONDUCTED EMISSIONS (CE)

- Require very little space
- Likely already have a Scope or Spectrum Analyzer
- May only need to purchase a Coil or LISN.

- If using scope or spectrum analyzer may need a personal is EMC or RF experience.
- If using a EMI Test Receiver, less experience need, and less chance for human error.



THANK YOU

FREQUENTLY ASKED QUESTION

How to learn from EMI test results reported by a test house?

Perform comparisons on EUTs returning form the test house / test lab.

LEARNING FROM TEST RESULTS

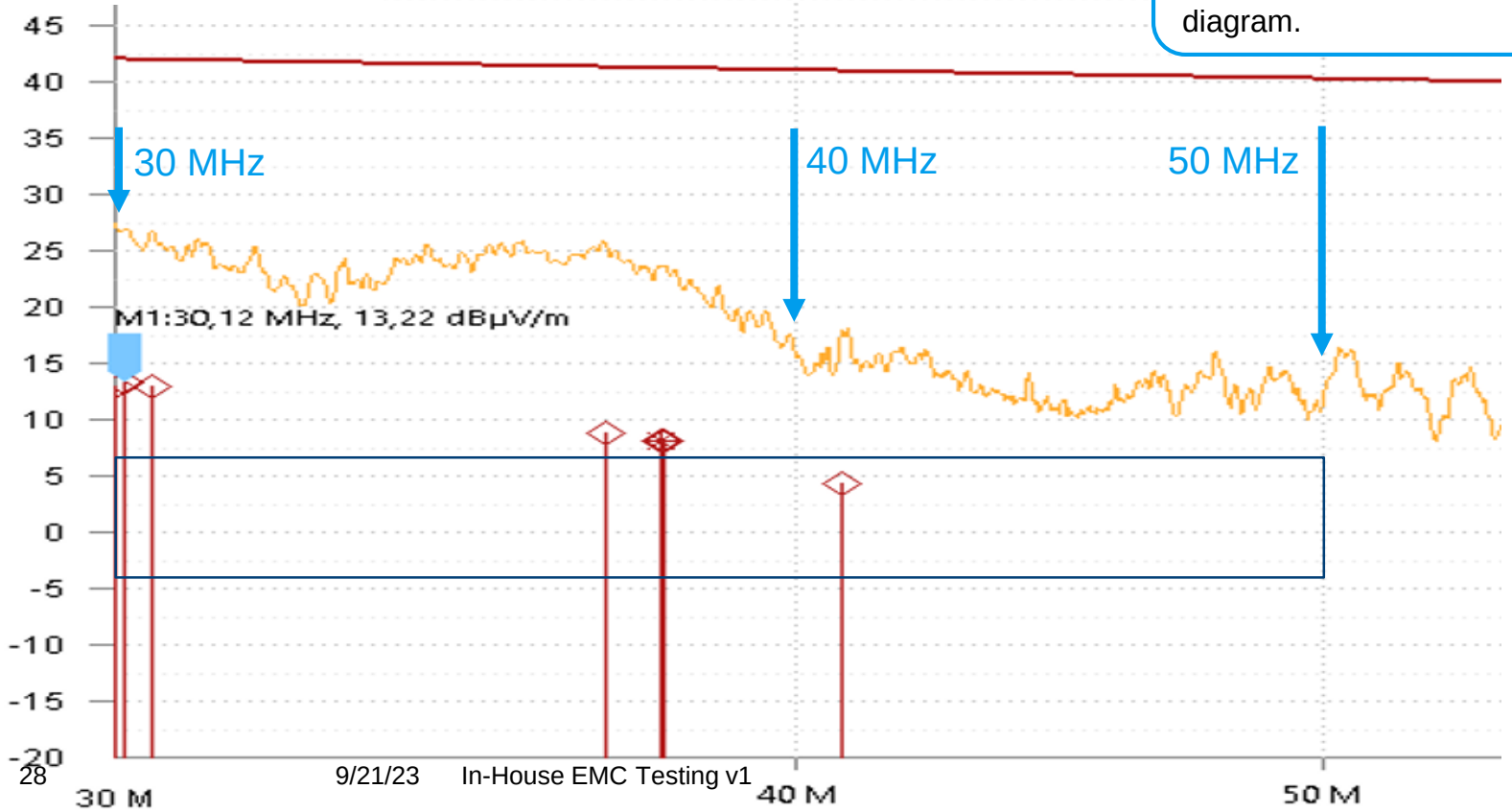
Result comparison: "Test House vs. Bench Top"

Select easy-to-read frequency points which allow a quick and direct comparison of levels. Please note: the frequency axis' are scaled in different manners. A spectrum analyzer uses linear scaling whereas a typical EMI receiver in the test house applies logarithmic scaling.

LEARNING FROM TEST RESULTS

Result comparison: "TestHouse vs. BrandeTool"

Field strength in dBµV/m



Logarithmic frequency scaling in test lab. A difference of 10 MHz appears differently in size within the diagram.

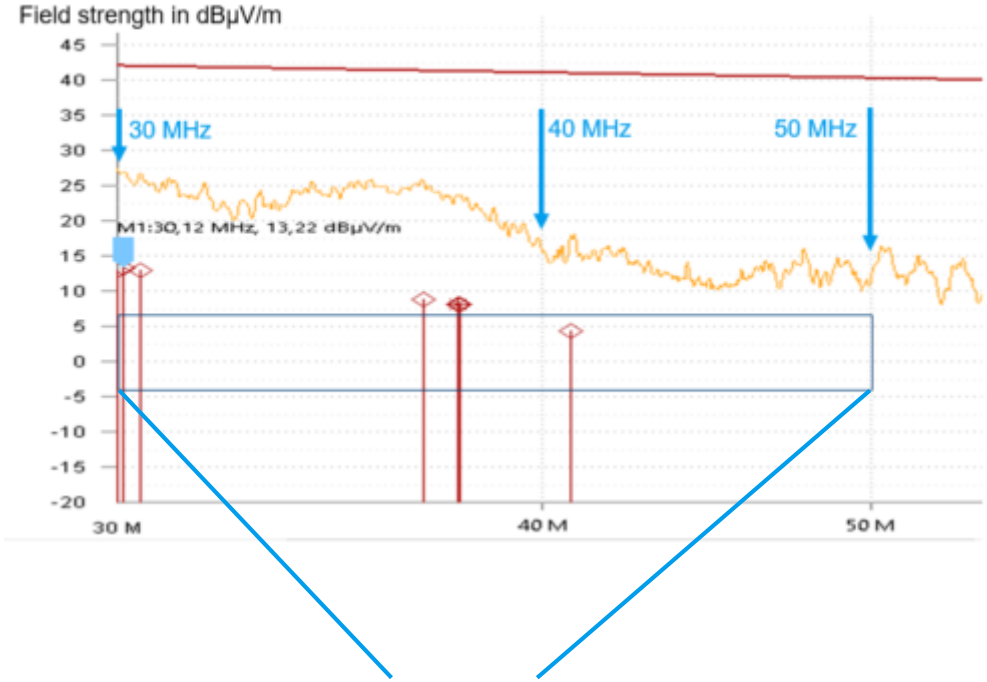
FREQUENTLY ASKED QUESTION

How to convert a frequency axis from logarithmic scaling into linear scaling?

Load the graph / diagram into a presentation program, put rectangles on top and take the dimensions

CONVERSION

Formula with logarithmic linear frequency scaling



16.67 cm

30 MHz to 50 MHz

		f	log(f / MHz)	Horizontal position in diaram
Reference	Start frequenc	30 MHz	1.477	0.00 cm
	Stop frequenc	50 MHz	1.699	16.67 cm
	Distance	20 MHz	0.222	16.67 cm
	Decade	300 MHz	2.477	75.14 cm
	Distance	270 MHz	1.000	75.14 cm

Converting frequencies into positions within the diagram

f	Distance
30 MHz	0.00 cm
31 MHz	1.07 cm
32 MHz	2.11 cm
33 MHz	3.11 cm
34 MHz	4.08 cm
35 MHz	5.03 cm
36 MHz	5.95 cm
37 MHz	6.84 cm
38 MHz	7.71 cm
39 MHz	8.56 cm
40 MHz	9.39 cm
41 MHz	10.19 cm
42 MHz	10.98 cm
43 MHz	11.75 cm
44 MHz	12.50 cm
45 MHz	13.23 cm
46 MHz	13.95 cm
47 MHz	14.65 cm
48 MHz	15.34 cm
49 MHz	16.01 cm
50 MHz	16.67 cm

Converting positions within the diagram into frequencies

Distanz	f
0.0 cm	30.00 MHz
1.0 cm	30.93 MHz
2.0 cm	31.90 MHz
3.0 cm	32.89 MHz
4.0 cm	33.91 MHz
5.0 cm	34.97 MHz
6.0 cm	36.06 MHz
7.0 cm	37.18 MHz
8.0 cm	38.33 MHz
9.0 cm	39.53 MHz
10.0 cm	40.76 MHz
11.0 cm	42.03 MHz
12.0 cm	43.33 MHz
13.0 cm	44.68 MHz
14.0 cm	46.07 MHz
15.0 cm	47.51 MHz
16.0 cm	48.98 MHz
17.0 cm	50.51 MHz

CONVERSION

From logarithmic to linear frequency scaling

Side effect:

Bending of slope sections of limit lines

Example limit line with logarithmic scaling of the frequency axis.

The same example limit line with linear scaling of the frequency axis