


KEYSIGHT TECHNOLOGIES

EMC Back to Basics



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EMC LIVE




Agenda

- EMC Overview
← You are here!
- Emissions
 - Receiver Architecture
 - Measurement Fundamentals
 - Making an Emissions Measurement
- Other Equipment Considerations
- Q+A

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Sources of Electromagnetic Interference

- **Natural Sources**
 - Lightning
 - Sun Spots
- **Unintentional emitting products**
 - Power lines
 - Motors (mixers, hair dryers etc)
 - Lighting, appliances
- **Devices that intentionally emit signals**
 - Most computers
 - Hand held communication devices
 - Radar, transceivers, broadcast equipment etc

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EMC Market Segmentation

Measurement Type:

Emissions
 Radiated & Conducted
 - Compliance
 - Pre-Compliance

Immunity
 Radiated & Conducted
 Compliance

Application:

Commercial

Military

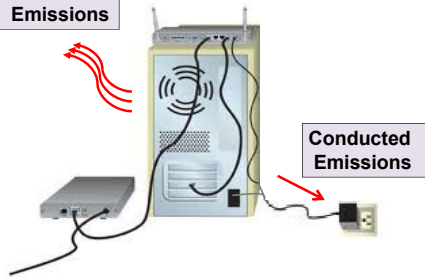
Sub-segments:

- Product Type
- Product Class
- Country

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Definitions: Emissions

Radiated Emissions



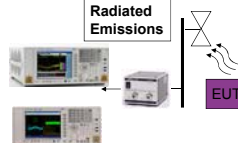
Conducted Emissions

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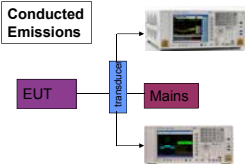
Measurement Equipment

Emissions

Radiated Emissions



Conducted Emissions



Measuring Equipment	Ancillary	Environment
<ul style="list-style-type: none"> • Compliance receivers • Spectrum Analyzers • Preamps • Measurement SW 	<ul style="list-style-type: none"> • Artificial Mains Networks • LISN • Conducted Transducers • Antennas • Towers • Turntables • Control SW 	<ul style="list-style-type: none"> • Open Sites • Anechoic Chambers • Semi-Anechoic Chambers • TEM Cells • Reverberation Chamber

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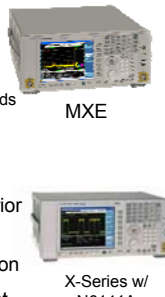
Compliance vs. Precompliance Measurements

Full Compliance

- Pass/Fail final regulatory testing
- Requires specific equipment and test site
 - must comply to specific Mil or Comm'l standards
- Expensive and time consuming

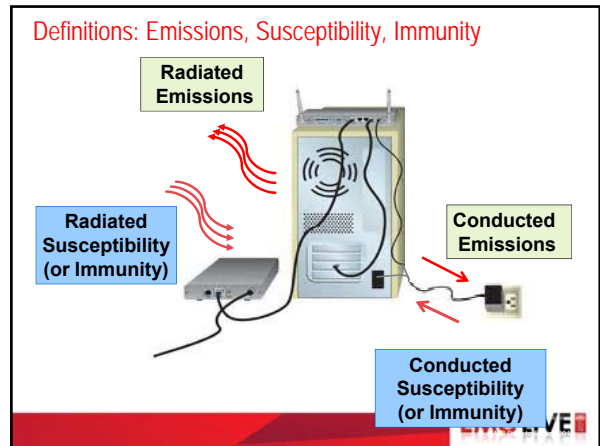
Precompliance Measurements

- "Unofficial" performance estimate done prior to Full Compliance test
- Typically done with SA on available location
- Purpose is to minimize chance of failure at Compliance test.

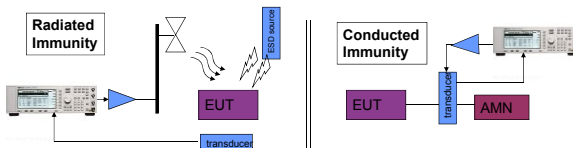


MXE
X-Series w/ N6141A

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Measurement Equipment Immunity



Measurement / Source	Other	Environment
<ul style="list-style-type: none"> • RF sources • Power amps • ESD sources • Power meters • Oscilloscope (EUT monitoring) 	<ul style="list-style-type: none"> • LISN • Coupling Transducers – clamps, etc. • Antennas • Measurement SW • Control SW 	<ul style="list-style-type: none"> • Screen rooms • TEM Cells • GTEM Cells

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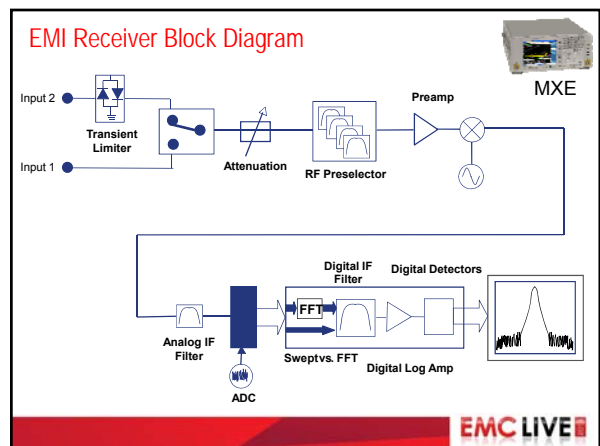
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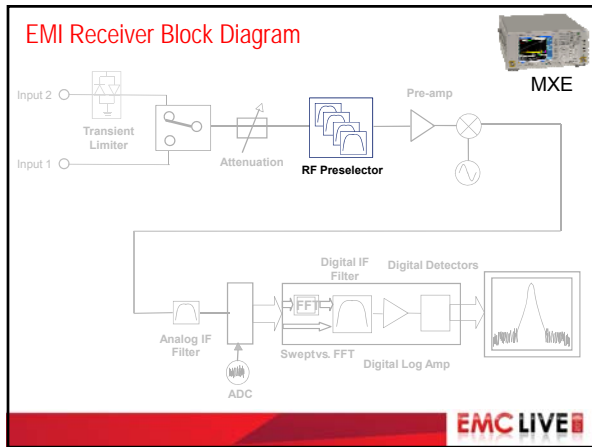
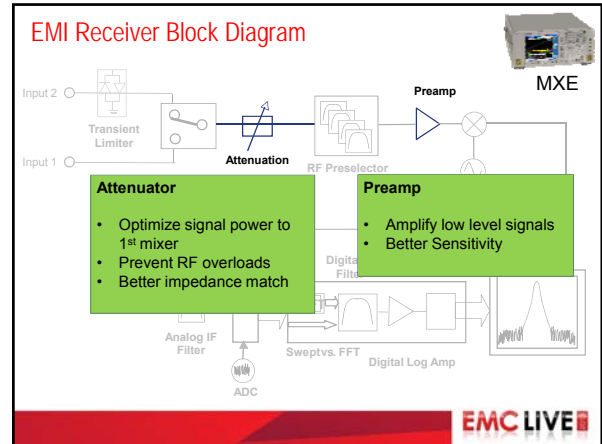
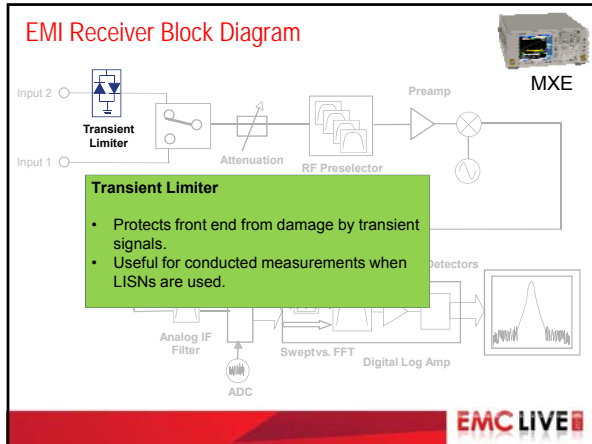
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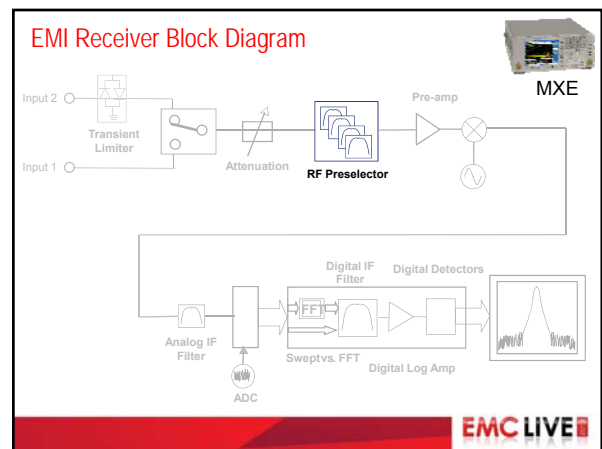
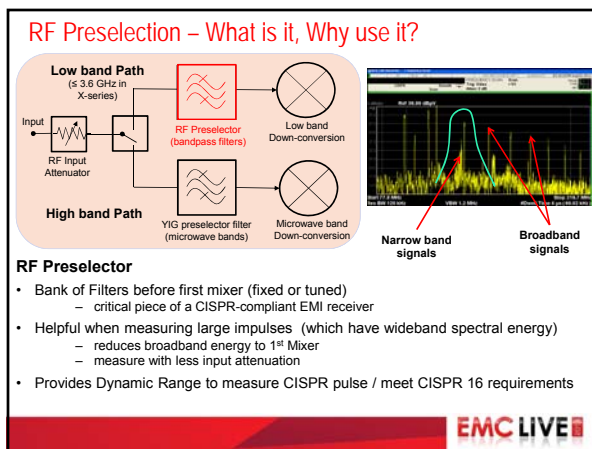


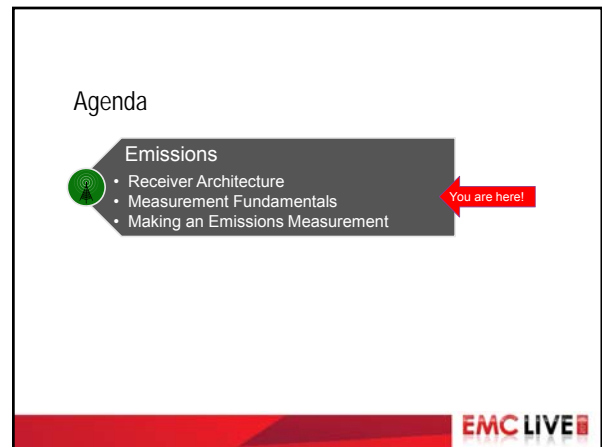
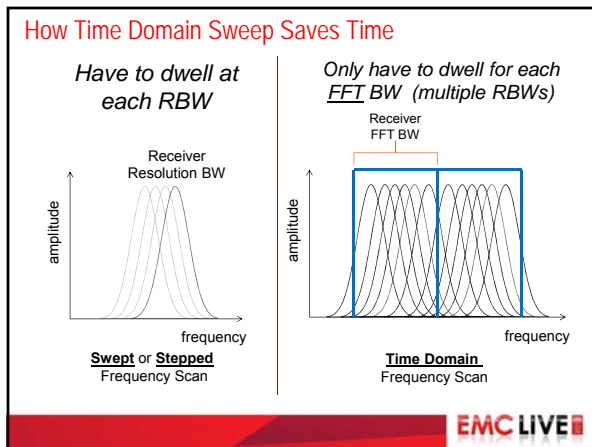
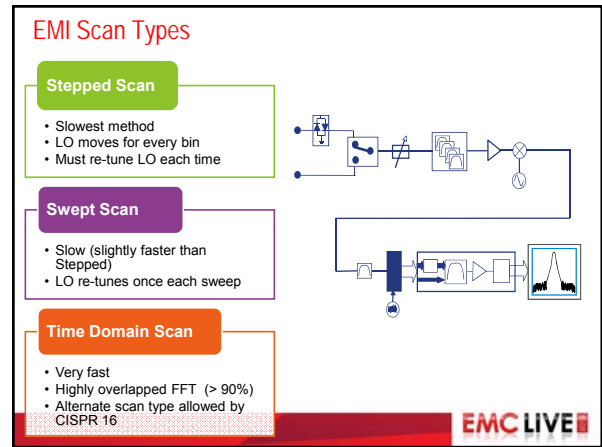
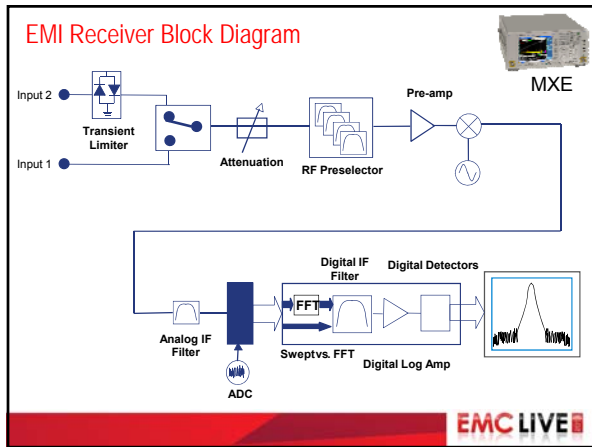
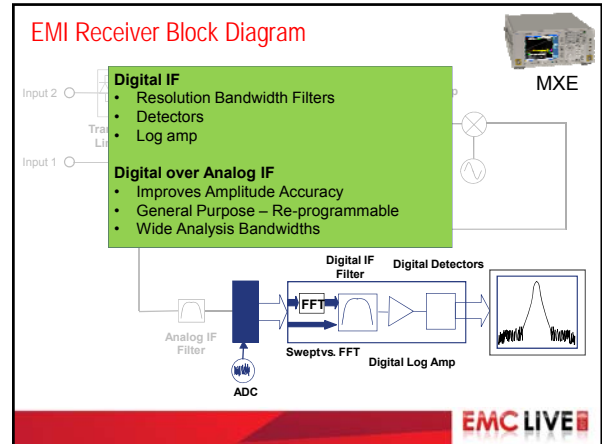
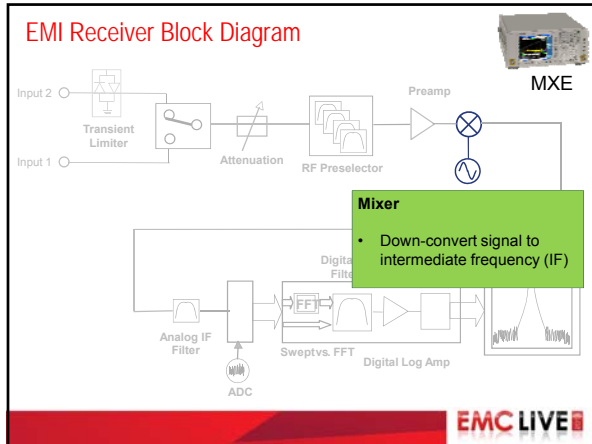
RF Preselector Bands

Filter Band	Filter Type	6 dB Bandwidth
20 Hz to 150 kHz	Fixed lowpass	310 kHz
150 kHz to 1 MHz	Fixed bandpass	1.7 MHz
1 to 2 MHz	↓	2.4 MHz
2 to 5 MHz	↓	7.5 MHz
...
30 to 70 MHz	Tracking bandpass	10 MHz
70 to 150 MHz	↓	24 MHz
...
1 to 2 GHz	↓	180 MHz
2 to 3.6 GHz	Fixed highpass	1.89 GHz (-3 dB corner freq)

Total 18 Filters.
Not all filters shown in table


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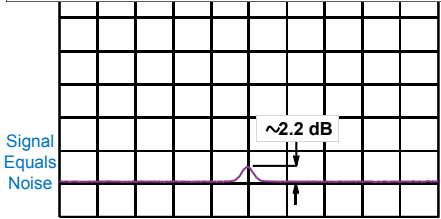
Measurement Fundamentals

- Sensitivity / DANL
- Attenuation / Preamp
- Resolution Bandwidth
- Detectors
- Measurement Time




Sensitivity / DANL

Sensitivity is the Smallest Signal That Can Be Measured

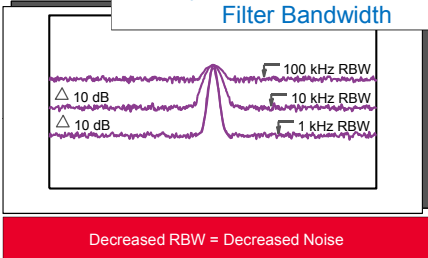


DANL: Displayed Average Noise Level (dBm/Hz)




Sensitivity/DANL: IF Filter (RBW)

Displayed Noise is a Function of IF Filter Bandwidth




Decreased RBW = Decreased Noise



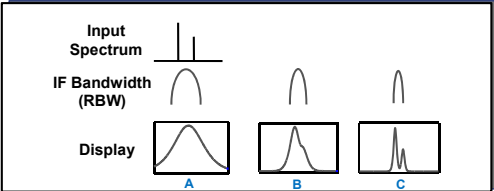
RBWs for CISPR & MIL

Commercial (CISPR)		
Bands	Frequency Range	CISPR reference bandwidth
A	9 to 150 kHz	200 Hz
B	150 kHz to 30 MHz	9 kHz
C	30 to 300 MHz	120 kHz
D	300 MHz to 1 GHz	120 kHz
E	1 to 18 GHz	1 MHz


Military (MIL-STD-461)		
	Frequency Range	RBW (6 dB BW)
	30 Hz to 1 kHz	10 Hz
	1 to 10 kHz	100 Hz
	10 to 150 kHz	1 kHz
	150 kHz to 30 MHz	10 kHz
	30 MHz to 1 GHz	100 kHz
	Above 1 GHz	1 MHz



IF Filter (RBW)

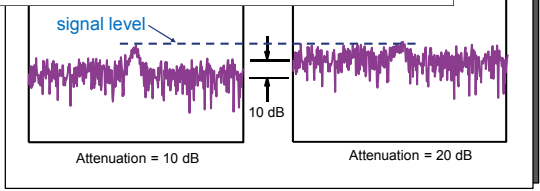


Smaller RBW = Better Frequency Resolution
Slower Sweep Time




Sensitivity / DANL

Effective Level of Displayed Noise is a Function of RF Input Attenuation



SNR decreases as Attenuation is Increased

Attenuation ↑ and SNR ↓



Sensitivity/DANL: Summary

For Best Sensitivity Use:

- Narrowest Resolution BW allowed
- Minimum RF Input Attenuation
- Using the Preamp also improves sensitivity

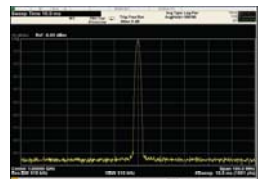


Measurement Fundamentals

- Sensitivity / DANL
- Attenuation / Preamp
- Resolution Bandwidth
- **Detectors**
- Measurement Time



Detectors

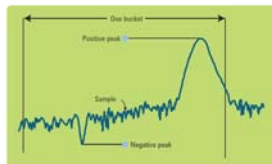


$$\text{Frequency Bucket Width} = \frac{\text{span}}{(\text{trace points} - 1)}$$

$$\text{Time Bucket Width} = \frac{\text{average time}}{(\text{trace points} - 1)}$$

Each of the 1001 trace points (buckets) covers a 100 kHz frequency span and a 0.01 millisecond time span.

- Sample
- Positive Peak
- Negative Peak
- Normal
- Average
- Quasipeak



The trace point saved in memory is based on the detector type algorithm.



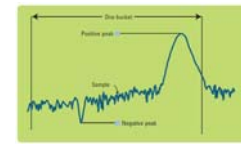
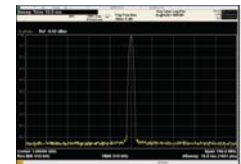
Detectors

CISPR and MIL

- Peak (positive) detection

CISPR only

- Average
- Quasipeak
- Fast charge time
- Slow discharge time
- Output is a function of amplitude and pulse repetition rate.



1 bucket displayed over time



Measurement Fundamentals

- Sensitivity / DANL
- Attenuation / Preamp
- Resolution Bandwidth
- Detectors
- **Measurement Time**



Measurement Time

- Need to **reduce test time**
 - DUTs that require short measurement time (ex. motor starter)
 - Test more devices
 - Shorter turn-around-time
- **Minimum measurement (dwell) time** specified by both CISPR and MIL standards
- May need to measure longer if emission amplitude varies
- Ensures impulsive signals are detected
- **Parallel processing** to reduce test time
 - Time Domain Scan (FFT)
 - Alternate scan type allowed by CISPR 16



Measurement Time (Minimum)

Commercial (CISPR)		
Frequency Range	Scan time for Peak	Scan time for QPD
9 to 150 kHz	~14 s	47 min
150 kHz to 30 MHz	~3 s	1 h 39 min
30 MHz to 1 GHz	~1 s	5 h 23 min

Military (MIL-STD-461)		
Frequency Range	Scan time for Peak	QPD not accepted for MIL Testing
30 Hz to 1 kHz	.015 sec/Hz	
1 to 10 kHz	0.15 sec/kHz	
10 to 150 kHz	.015 sec/kHz	
150 kHz to 30 MHz	1.5 sec/MHz	
30 MHz to 1 GHz	0.15 sec/MHz	
Above 1 GHz	15 sec/GHz	

Agenda

- Emissions
 - Receiver Architecture
 - Measurement Fundamentals
 - Making an Emissions Measurement ← You are here!

Making an emissions measurement

- Recommended by CISPR
- Measurement methodology found in CISPR 16-2-3
- Typically the **fastest** way to make the measurement
- MIL Measurements*



Pre-Scan

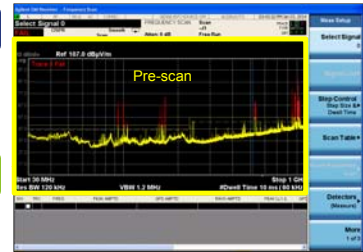
Preview spectrum using Peak Detector

Scan Types

- Stepped
- Swept
- Time Domain

Measurement Parameters

- Frequency range
- Limit Lines
- Margins
- Transducer Factors
- Scan Type



Data Reduction

Signals exceeding the limit are automatically:

- Marked in red
- Peaks are indicated with white "x"
- Added to signal list

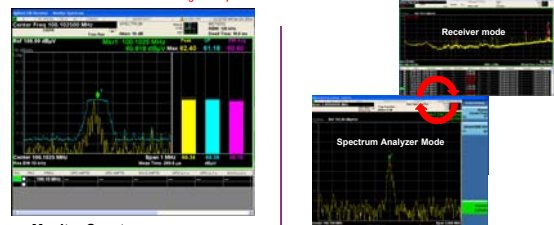
Maximization and Final Measurement on signals exceeding limit and margin

- Eliminate signals not failing limit
- Saves time



Maximization Techniques

Maximize signal amplitude before final measurement



Monitor Spectrum

- Simultaneous spectrum and meter measurements
- Access to signal (suspect) list
- Meter max hold

Spectrum Analyzer mode

- Switch between EMI receiver and SA modes using global center frequency
- Powerful analyzer mode



Final Measurement

Signals in list are automatically measured

Measure suspect signals with Quasi-peak, average detector, etc.

EUT still failing? Start troubleshooting?

Pre-scan → Data Reduction → Maximization → **Final Measurement** → Report Generation

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Report Generation

Report Generator

- Settings
- Screenshots
- Tables

Report Format: PDF or HTML

Pre-scan → Data Reduction → Maximization → Final Measurement → **Report Generation**

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- Other Equipment Considerations** ← You are here!
- Q+A

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Other Equipment Considerations

- Other Equipment Considerations ← You are here!
 - Automation Software
 - Transducers for EMI measurements
 - Test Environments

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Automation Software

Measurement and Control

- Reasons for Automation
 - Supplement skill and knowledge of the tester
 - Measurements **repeatability**
 - Results are presented in a common format
 - Reduce test time** by automating setups
 - Run **turntables** and antenna **towers**
- Types of Automation
 - Internally executed application (e.g. Keysight N6141A EMI App)
 - PC based applications
- Software

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Automation Software

- Automation software typically communicates with the receiver over **LAN or GPIB**
- Uses **SCPI commands**

TDK RF Solutions


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Other Equipment Considerations

Other Equipment Considerations

- Automation Software
- Transducers for EMI measurements
- Test Environments



You are here!



Transducers for EMI measurements

“ a device that receives a signal in the form of one type of energy and converts it to a signal in another form ”
-dictionary.com

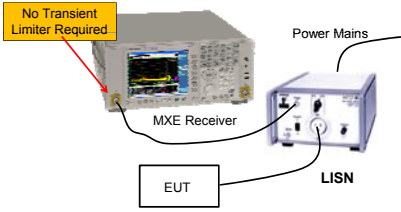
- Line Impedance Stabilization Network (LISN)
- Near Field Probe
- Antennas
- Other devices?

LISN: Line Impedance Stabilization Network

- Typically used for conducted emission measurements
- Isolates the power mains from the EUT
- Isolates EUT from the power mains
- Powers the EUT and couples signals to EMI receiver

No Transient Limiter Required



Power Mains


MXE Receiver

EUT


LISN

Types of LISNs


- V-LISN
- Delta LISN
- T-LISN




Antennas and Near Field Probes



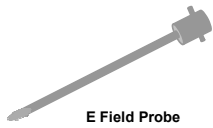
VS



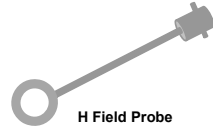


Near Field Probes – E & H Field


- Use Cases
 - Pre-compliance
 - Diagnostics
- Characteristics
 - Frequency Range
 - Spatial Resolution
 - Sensitivity
- Measure or Generate Fields
 - Emissions or Susceptibility




E Field Probe




H Field Probe




EMI Broadband Antenna Examples




Double ridged horn




Biconical




Log Periodic



Hybrid Log Periodic



Hybrid Log Periodic



Understanding Antenna Factors


"Ratio of the electric field to the voltage out of the antenna"

Linear Units

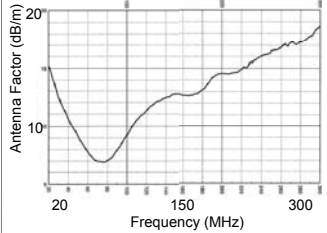
$$AF = \frac{E_{\text{inc}}}{V_{\text{ant}}}$$

AF = Antenna Factor (1/m)
 E = Electric Field units (V/m)
 V = Voltage output from antenna (V)

Log Units

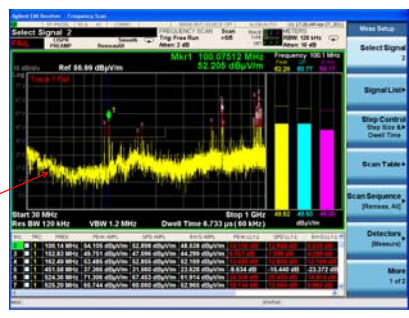
$$AF(\text{dB/m}) = E(\text{dB}\mu\text{V/m}) - V(\text{dB}\mu\text{V})$$


Typical biconical antenna factors



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Antenna Factors on a Typical Display



Corrected for a broadband antenna

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Other Equipment Considerations

Other Equipment Considerations

- Automation Software
- Transducers for EMI measurements
- Test Environments

You are here!

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Examples of Test Facilities



Anechoic Chamber

(Located on the Keysight Santa Rosa site)

- Anechoic**
an- (not) + echoic (echo)

Anechoic material is made of carbon impregnated rubberized cones or ferrite tiles or both

- This chamber uses 2 antenna towers, one for measuring vertical and one for horizontal polarization.

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Examples of Test Facilities

- Open Area Test Site (OATS)**
 - Useful in low ambient signal environments
- Reverberation Chamber**
 - Uses a mode stirring tuner to generate a uniform field (no absorption material on the walls)
- GHz Transverse Electro-Magnetic Cell (GTEM Cell)**
 - Used for smaller devices. Can be used for immunity and emissions.

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Questions?
Please type them in the chat box now



N9038A **MXE** EMI Receiver
Compliance Testing
www.keysight.com/find/mxe



X-Series Signal/Spectrum Analyzers
Pre-compliance Testing
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www.emclive2014.com