EMC-ESD In de Praktijk

Speeding your device through EMC compliance

EMI/EMC Definitions

- EMI/EMC
- Regulations
 - Country/Region
 - Industrial/Consumer
 - Military
- Conducted Emissions
 - Unwanted signals coupled to AC mains
- Radiated Emissions
 - Unwanted signals broadcast from DUT
- Intentional Radiator
 - Spectrum Emission Mask
 - Power Limits
 - Harmonic Content
- Susceptibility/Immunity
 - Region dependent





Figure 1. This EMI test report shows a failure at around 90 MHz

Pre-Compliance Scan \rightarrow **Tektronix RSA306B**



- 30 MHz 6.2 GHz
- Shaded area = limit
- 128,004 Trace Points
 Auto ID limit failures
- ~ 7s (CISPR Peak)

Pre-Compliance Scan → Frequency Ranges

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ĸ		0.000000	0.000000	REW	1.000M		-Pest	1M .		56.99	60	Abs	56.99	56.99	-30.000	-30.000		
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0		0.000000	0.000000	REW	1.000M		+Peak	1M		56.95	60	Abs	56.99	56.99	-30.000	-30.000		
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5		0.000000	0.000000	85%	1 D00N		-Feek	156		55.99	6.0	Asc	56.99	56.99	30.000	30.000		
		0.000000	0.000000	204	1.000M		-Past	156		55.99	6.0	Aire	56.99	55.99	.32.002	.30.000		Dan

Spurious	Parameters		ers	Reference Ranges and L		imits Trace Scale		e Pre	Prefs								
Settings			On	Start (Hz)	Stop (Hz)	Filter Shape	BW (Hz)	Auto	Detector	VBW (Hz)	-	Mask	Abs Start	Abs Stop	Abs Same	^	Expand
	┢	Δ	\checkmark	30.000000M	88.000000M	CISPR	120.000k	√	CISPR +Pk	1k	A	bs	90.00u	90.00u	√		Reset
		В	√	88.000000M	216.0000	CISPR	120.000k	√	CISPR +Pk	9k	A	bs	150.0u	150.0u	√		layout
		С	√	216.0000	960.0000	CISPR	120.000k	√	CISPR +Pk	3k	A	bs	210.0u	210.0u	√	•	Load
Restore		D	√	960.0000	6.200000G	CISPR	1.000M	\checkmark	CISPR +Pk	30k	A	bs	300.0u	300.0u	\checkmark	• 🗸	Cauco
Defaults	<			Frequenc	y bands		Scan	ning	filter				Powe	r limit	>	,	Save

- Up to 20 ranges
- CISPR/MIL RBW
- Variable detection thresholds

- Absolute measurements
- Relative measurements
- Standards pre-defined

Pre-Compliance Scan → Path Loss/Gain

			I 2-5 I
Table Editor - Ext Loss Table 1			
Add Point Delete	Undo	X: Frequency	Y: Loss (Atten)
		30.00000 MHz	8.000000 dB
		100.0000 MHz	8.600000 dB
Frequency Interpolation		2.000000 GHz	10.00000 dB
: 💿 Linear			
Log (affects only Trace Correction)			
-			
-			
New Table Load	Save As	Apply	OK
rnal Gain/Loss Correction Internal Settings			
	External Loss 1	Tables (Loss > 0 , Gain < 0)	
External Gain value: 20.0 dB	External Loss T	Tables (Loss > 0, Gain < 0) Table 1 Edit.	
External Gain value: 20.0 dB external corrections to:	External Loss T	Tables (Loss > 0, Gain < 0)	-
External Gain value: 20.0 dB vexternal corrections to: All acquired data (filter method)	External Loss 1	Tables (Loss > 0, Gain < 0)	•

- Compensate for path gain/loss
- Be careful of antenna factor vs gain/loss
- Up to 3 different tables at one time

EMI Testing Work Flow SCHEDULE TIME AT TESTING LAB



EMI Pre-Compliance testing will save time/money by identifying problem areas before they become expensive re-design issues

Do I Need An EMI Receiver ?

- EMI receiver are designed specifically for spectrum sweeping
 - RBW
 - Shape
 - Bandwidth
 - Detectors
 - Peak
 - Average
 - Quasi-Peak

Frequency Range	Bandwidth (6 dB)	Reference BW
9 kHz to 150 kHz (Band A)	100 Hz to 300 Hz	200 Hz
0.15 MHz to 30 MHz (Band B)	8 kHz to 10 kHz	9 kHz
30 MHz to 1000 MHz (Bands C and D)	100 kHz to 500 kHz	120 kHz
1 GHz to 18 GHz (Band E)	300 kHz to 2 MHz	1 MHz

Table 1. Measurement Bandwidth versus Frequency specified by CISPR 16-1-1.

- Pre-selected RF tuning stages
- User defined dwell time per step
- Detailed requirements in CISPR 16-1-1
- For Pre-Compliance You Don't Have To Use A Special Receiver
 - We are making an accurate approximation
 - Understand the compromises in the measurements

Spectrum Analyzer Sweep Speed

- EMI Detector types
 - EMI-Peak (or Peak)
 - Worst case
 - Safest detector
 - EMI-Average
 - Incorporates dwell
 - ~100ms common
 - EMI-Quasi-Peak
 - Incorporates dwell
 - ~1second
 - VERY long sweep times
- Filter Shape Factor
 - EMI RBW More selective
 - BW measured at -6dB points





Calculated response of the QP detector and meter to pulse stimulus

Quasi Peak Detector example







10dB differenz between Peak and QP, 8us Pulse width 10ms repetition rate

Setting Up A Pre-Compliance Test

CONDUCTED EMISSIONS <30 MHZ

- Utilize a metallic surface which can be grounded
- Line Impedance Stabilization Network (LISN)
- Pre-amp (Optional)
- Limiter (Optional)
- Make sure the instrument can accommodate gain/loss corrections



Setting Up A Pre-Compliance Test

RADIATED EMISSIONS >30 MHZ

- Identify an area with natural RF shielding
 - Basements
 - Parking garages
- Watch out for DAS
 - Used to help cellular coverage

- Non metallic platform for DUT
- We need to look at 360 around DUT
- Tripod/pre-amp optional but recommended





Pre-Compliance Test WHERE TO MEASURE ?

Measurement in Far Field with adequate distance to DUT





Open Area Test Site

Anechoic Chamber

- Shield from external signals, RF quiet area
- Avoid reflections

De-Bugging EMI Issues

- Switching Power Supplies
 - Switching frequencies and harmonics
 - Load-dependent emissions
- Clock and Data
 - High speed clocks, data, edges
 - High speed interfaces
 - Switching controls
- Resonances
 - Board and conductor geometries
 - Wiring lengths, routing, termination
 - Shielding and mechanical connections
- Radiated EMI problems are defined by
 - Sources
 - Antenna's





De-Bugging EMI Issues NEAR FIELD PROBING

- E-Field
 - Stub
 - High voltage, low current source
 - Max sensitivity perpendicular to source
- H-Field
 - Loop
 - Low voltage, high current source
 - Max sensitivity parallel to source
- Isolate sources of energy
- Measure relative changes
- Be Careful









Example: Switched Class D Amp



• RF: H-field probe

Amp vs. Time

M 100µs

Spectrum display

Power Vs. Time Peaks Correlated To Spectrum Content



Example: Switched Class D Amp



- RF: H-field probe
- Ch1 = Switch signal (HR)
- Spectrum
- Direct Correlation

4.00µs

250MS/s 10k points



Bandwidth

RBW Mode Auto Manual

RBW 3.00MHz (Auto) Span : RBW

(1000 : 1) Window

Kaiser

ALL WALL ALL &

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Example: USB Interference

- RF: H-field probe (USB cable interface)
- CH1: USB HS line
- Direct Correlation

