EMC ANTENNAS

Recommendations for emissions and immunity
EMC Antennas

10Hz to 40GHz
EMC Antennas

Let’s look at the typical EMC antennas for Emissions and Immunity

We are not trying to cover every single standard, but the most common

Our EMC antennas cover from 20Hz up to 40GHz
EMISSION ANTENNAS

Antennas intended to receive signals radiated by unintentional radiations
IEEE/ANSI C63.4 and CISPR 16

- 30MHz to 18GHz (currently limits only up to 6GHz in CISPR 22)
- Preferred antennas is the dipole, however
  - Dipoles are narrow banded and need to be adjusted continuously
  - It is always good to show correlation to dipoles
  - So a Dipole set like a 3121D should be in every Lab.
Dipole Set is a tool to have

- Correlation to dipoles under 1GHz is something that both CISPR 16 and ANSI C63.4 demand.
- In case of questions on results it is good for a lab to keep a set to verify results.
Biconicals 30MHz to 200MHz

- Biconical Antennas
- Two models 3110C and 3104C
- 3104C has a 50 ohm balun, it can handle more power (50W) but not recommended.
- 3110C is more delicate (500mW) but it is better balanced. And it has a stinger (rear rod) mount.
LPDA 200MHz to 1GHz

- LPDA
- Great VSWR
- Flexible mounting

Ideal antenna for the 200MHz to 1GHz range
Hybrids (30MHz to 1GHz)Background

For radiated emissions measurement specified in ANSI C63.4, unlike monopole, bicon, dipole, log or horn antennas, bicon/log hybrid antennas are not listed explicitly.

Great deal of confusions on whether it is allowed per C63.4.

The interpretation published on C63.org website states that

- Based on C63.4-2004, they can be used as long as you can show correlation to a dipole
- According to C63.4-2009, hybrids are not preferred.

Per CISPR 16-1-4:2007-02, hybrids can be used. Correlations to dipoles are still needed per C63.4.
Correlation is the key
Requirements and Criteria

- Maximum hybrid antenna size: 1.5 m x 1.5 m
- Emissions Antenna only, no “bat-wing”, “T-loading” or “L-loading”. Removable loading elements are allowed provided they are removed during emissions test.
- VSWR less than 10:1 or used with attenuator pads (helpful but not critical).
30-200 MHz The difference must be
- for d=3 m, ≤ ±2.5 dB H and V pol
- for d=10 m, ≤ ±2.4 dB H and V pol

Similarly at 200 – 300 MHz, comparison is made with LPDAs
- for d=3 or 10 m, ≤ ±2.9 dB H and V pol
Transition Frequencies are Critical we are better than the competition

3142E Antenna Factor competitor comparison
Requirements and Criteria

- Maximum hybrid antenna size: 1.5 m x 1.5 m
- Emissions Antenna only, no “bat-wing”, “T-loading” or “L-loading”. Removable loading elements are allowed provided they are removed during emissions test.
- VSWR less than 10:1 or used with attenuator pads (helpful but not critical).
3142E and 3143B

- Two options recommended
- 30MHz to 6GHz (3142E)
- 30MHz to 1GHz (3143B)
- At 1GHz there is a change to the chamber, so having the range up to 6GHz may not be necessary
3142E-PA

- 3142E available now with preamplifier option (3142E-PA)
- All PA options the antenna is calibrated with the preamplifier to include amplifier mismatch with the antenna factor and reduce uncertainty
- 3142E-PA designed to mount to mast
Above 1GHz

Our 3117 is probably one of the best antennas in the market for this range.

It has a very nice pattern all the way up to 18GHz and now is available with a PA option for better AF.
3117 1 to 18GHz

3117-PA option
CISPR 16 potential turn

- CISPR 16 may want to choose a LPDA as their antenna for 1 to 18GHz
- IEEE/ANSI will stay with horns so 3117 is secure there
- CISPR 16 is looking for a more constant beamwidth antenna (potentially)
- 3186 is process of design for this application
MIL STD and CISPR 25

- MIL STD 461 F
- RE 101
- Pick up coil for magnetic fields.
- This is the required antenna and is built per the standard

7604
MIL STD and CISPR 25

- MIL STD 461 F
- RE 102 and 103

Antennas
- 3301C active rod
- 3110B
- 3106B
- 3115/3117
- 3116C
MIL STD and CISPR 25

- **CISPR 25**
- **Antennas**
  - 3301C active rod
  - 3110B
  - 3148B
  - 3117
IMMUNITY ANTENNAS

Antennas intended to radiate signals to affect electronic equipment
Things to consider

- Higher gain, less EUT coverage!!!

- Basic equations may not apply in a chamber environment

- Full wave simulations may get close to the actual results (within 3dB)

- Measured data is the key
Outline II

Immunity Antennas

- Measured and computed vs. Calculated
- IEC 61000-4-3
- MIL STD 461F
- Automotive components
- Full Automotive
- 200V/m
There is no far field, there is no free space in most immunity set-ups

As the field is incident onto the metallic top bench both polarizations are affected very differently in some cases the top helps in other it does not.
Do not use the FF equation

Field achieved at different distances and frequencies. Free space.

\[ |\vec{E}| = \frac{30 \cdot P_t \cdot G_t}{r} \]

- 1GHz using Far field gain and eq.
- 1.5GHz using Far Field gain and eq.
- 2GHz using Far field gain and eq.
- 1GHz full wave analysis
- 1.5GHz full wave analysis
- 2GHz full wave analysis
Case #1

- Dual Ridge Horn (200MHz to 1GHz) Horizontal and Vertical Polarization, probe at 15cm over Metallic bench
3106B power requirements 1m from metallic topped test bench

<table>
<thead>
<tr>
<th></th>
<th>V 100 V/m</th>
<th>H 100 V/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computed V</td>
<td></td>
<td></td>
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<tr>
<td>Computed H</td>
<td></td>
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Power (W)

Frequency (MHz)
Understanding the difference

- Similar trend, Better agreement on vertical
- About 3dB difference for Horizontal (50 vs. 100 watts)
- Model does not include the absorber (to make it simpler), not the wood bench, (but a conductive sheet as the top).
- Absorber treatment are horizontal wedges, they are
  More reflective on the horz. pol.
Case #2

- Larger chamber, to approach better the model with perfectly matched layers
- Chamber has better absorber
- Probe at 1m from antenna tip and 30cm over bench
3150B test data

Field probe 30cm over a 90cm bench. Antenna 1m away and 1.5m centerline above ground.
Understanding the difference

- Similar trend for computed and measured.
- At higher frequencies the difference increases but that is related to the feed implementation of the dual stacked LPDA.
- But at frequencies under 800MHz there is less than 1dB difference in required power.
- We also see a measurement error caused by the sampling time as the software reads the field probe values.
- The two cases have validated the models, while showing their possible limitations.
Outline II

- Immunity Antennas
  - Measured and computed vs. Calculated
  - IEC 61000-4-3
  - MIL STD 461F
  - Automotive components
  - Full Automotive
  - 200V/m
Low level immunity IEC 61000-4-3

- 10v/m with 80%AM modulation
- Equivalent to 18V/m CW
- 3143B can do this from 80MHz to 1GHz
- 3142E can do this from 80MHz to 6GHz, but above 1GHz is not ideal
3142E average of 16 points

3142E power requirements in FACT™ 3 chamber with ferrite floor

Horizontal Polarization, Scaled from Measured Data
average of the power required for each of the 16 points on the grid

Vertical Polarization, Scaled from Measured Data
average of the power required for each of the 16 points on the grid
3143B average of 16 points

3143B power requirements in FACT™ 3 chamber with ferrite floor
Horizontal Polarization, Scaled from Measured Data
average of the power required for each of the 16 points on the grid

3143B power requirements in FACT™ 3 chamber with ferrite floor
Vertical Polarization, Scaled from Measured Data
average of the power required for each of the 16 points on the grid
3142E in a 26H center of grid

3142E inside Spacesaver 26H 18V/m immunity level at 3m distance

Power ( Watts )

Frequency (MHz)

80 100 200 300 400 500 700 1000 2000 3000

Contor @1.31 H
Center @1.3 V
higher level immunity IEC 61000-4-3

- 30v/m with 80%AM modulation
- Equivalent to 54V/m CW
- 3150B can do this from 80MHz to 1GHz
- 3119 can do this from 1GHz to 6GHz
3150B center of grid

3150B antenna power requirements
Horizontal polarization 3m distance. Antenna 1.5m over ground, probe 1m over ground

3150B antenna power requirements
Vertical polarization 3m distance. Antenna 1.5m over ground, probe 1m over ground
3119 center of grid

Do not have data for 3m above 1GHz, but based on the gain and the below 1GHz data the antenna should be able to generate the 30V/m with 80 AM mod with under 200Watts
Outline II

Immunity Antennas
- Measured and computed vs. Calculated
- IEC 61000-4-3
- MIL STD 461F
- Automotive components
- Full Automotive
- 200V/m

Now we get in the High field immunity we will go over our recommended solutions, some of these will apply mainly to one standard, some other will apply to several standards. We will start with the 1m testing required in automotive components and Mil STD 461 F
1M IMMUNITY
MIL STD 461 F RS 101/ ISO 11452-8

- MIL STD 461 F
- RS 101 and ISO 11452-8
- Magnetic field coils.
- Helmholtz Coil

7605/7606
MIL STD 461 F/RS 103 immunity under 30MHz

- MIL STD 461 F RS 101 and ISO 11452-2
- 100kHz to 30MHz
- 200V/m
- 1m distance
- 5503-3m
- 1kW input (3kW input balun available)
- V-pol only
Measured data 5503-3m
MIL STD 461 F/RS 103 immunity 30 to 100MHz

- Most difficult range
- Antennas not efficient
- TEM structures not efficient
- Recommend BCI for Automotive components
- For MIL STD 461 Biconicals
- 3109, 3158, 3159
3158 Measured inside a FACT 3 Chamber. Field for a 5kW input.
Mil Std 461F/RTCA DO 160 setup, no bench.
3159

Required CW Amplifier Output Power
in order to achieve 200V/m in 1m distance
Horizontal and Vertical Polarization

- FP height 2.26m

Amplifier Output Power [W]

Frequency [MHz]

- d=1m, H=2.26m CL Pout / H
  w/o ferrites

- d=1m, H=2.26m CL Pout / V
  w/o ferrites

- d=1m, H=2.26m CL Pout / H
  with ferrites

- d=1m, H=1.16m CL Pout / V
  with ferrites
MIL STD 461 F/RS 103 1m immunity

- MIL STD 461 F
- RS 101 and ISO 11452-2
- 200MHz to 2GHz or 1GHz
- 200V/m
- 1m distance
- 3106B
3106B in MIL STD and ISO set ups

3106B ISO 11452-2

3106B power requirements 1m from metallic topped test bench
3150B Automotive components

- ISO 11452-2
- 80MHz to 1GHz
  - 200V/m
- 1m distance
- 3150B
3150B Measured Power Requirements
with test bench and probe 30cm above.

Power (W)

Frequency (MHz)

- 3150B power for 200V/m H
- 3150B power for 200V/m V
3119 Automotive Components

- ISO 11452-2
- 400MHz to 6GHz 200V/m
- 1m distance
- 3119
3119 at 1m

Power requirements 3119 1m distance per ISO 11452-2
with a metal top bench

- V pol. 200 V/m
- H pol. 200 V/m

Power (watts)

Frequency (MHz)
2M IMMUNITY

Full vehicle testing
For full vehicle immunity

- Look at the line of solutions from 100kHz to 18GHz
- 100kHz to 30MHz
- 30MHz to 100MHz (and 20 to 200MHz LPDAs)
- 100MHz to 1000MHz
- 1GHz to 6GHz or 18GHz
100kHz to 30MHz

- 5502 chamber supported
  Vertical and Horizontal fields
  10kW input, continuous adjustment

- 5503-5m self supported,
  3kW input 100V/m discrete heights and separation horizontal and vertical

- 5504 chamber supported,
  continuous adjustment,
  10kW vertical field only
About TEM field generators

- The TEM fixtures will radiate and couple to the chamber.
- Resonant behavior will appear that will affect the performance.
- This behavior is very chamber dependent.
- It is usually impossible to fix, only possible to attenuate slightly.
5503-5m 150V/m 2m high elements
5503-5m 110V/m 2.5m high elements
5504 Measured data

5504 Chamber supported E field TLS generator
Field achieved with 10kW input power in several configurations in a chamber with no ferrite
Chamber size is 28m long by 15m wide by 11.5m tall lined with EHP-72PCL pyramidal absorber (no ferrite)
30MHZ TO 100MHZ

Bicons
Immunity 30 to 100MHz

- Most difficult range
- Antennas not efficient
- TEM structures not efficient
- 10kW highly recommended
- 3159
Required CW Amplifier Output Power in order to achieve 200V/m and 100V/m in 2m distance. Field Probe height 1m and 2m
Horizontal Polarization

Distance: 2m; 4 x 3 ferrites
Required CW Amplifier Output Power in order to achieve 200V/m and 100V/m in 2m distance. Field Probe height 1m and 2m Vertical Polarization

Distance: 2m; 4 x 3 ferrites
How about large LPDAs?

- FSA, and possibly Schwarzbeck make a large 20MHz-220MHz LPDA
- Comparable to our 3151
Comparison of 3151 and FSA eqv. at 5kW

FSA Horizontal

FSA vertical

3151 over ferrite on the floor
2m distance
scaled for a 5kW input power

Field levels (V/m)

Frequency (MHz)

Horizontal probe at 1m height
Vertical Probe at 1m height
100MHZ TO 1000MHZ

DRHA and LPDAs
100MHz to 1GHz

- We have 2 options
- 3150B and 3112
- 3112 is a ridge horn
- 3150B is a Stacked log
- Roughly same volume
3150B antenna power requirements
Horizontal polarization 2m distance, probe 1m over ground. ISO 11451-2 setup

3150B antenna power requirements
Vertical polarization 2m distance, probe 1m over ground. ISO 11451-2 setup
3112 ISO 11451-2
3112 Power Required for 200v/m at 2m distance

Vertical Pol
Horizontal Pol

Power (watts)

Frequency (MHz)

100 200 300 400 500 600 700 800 900 1000
BEYOND 1GHZ

DRHA and Octave Horns and future developments
Above 1GHz

- We recommend the 3119 (up to 6GHz) for 100V/m but also Octave horns 3161 series

- We are in the process of developing new above 1GHz immunity antennas
3119 per ISO 11451-2

3119 ISO 11451-2 with probe at 1m over ground
Power for 100V/m over conductive ground
CONCLUSION

Thank you for your attention
Conclusion

- We have a very complete line of EMC antennas
- While some of our antennas have less gain than competitors, we provide wider coverage
- A lot of our antennas are comparable and sometimes (emissions) better than our competitors
- We are in the process of measuring the complete line of immunity antennas to understand better their capabilities