Very-Near-Field Solutions to EMC Compliance Problems – Real World Case Study

Agenda

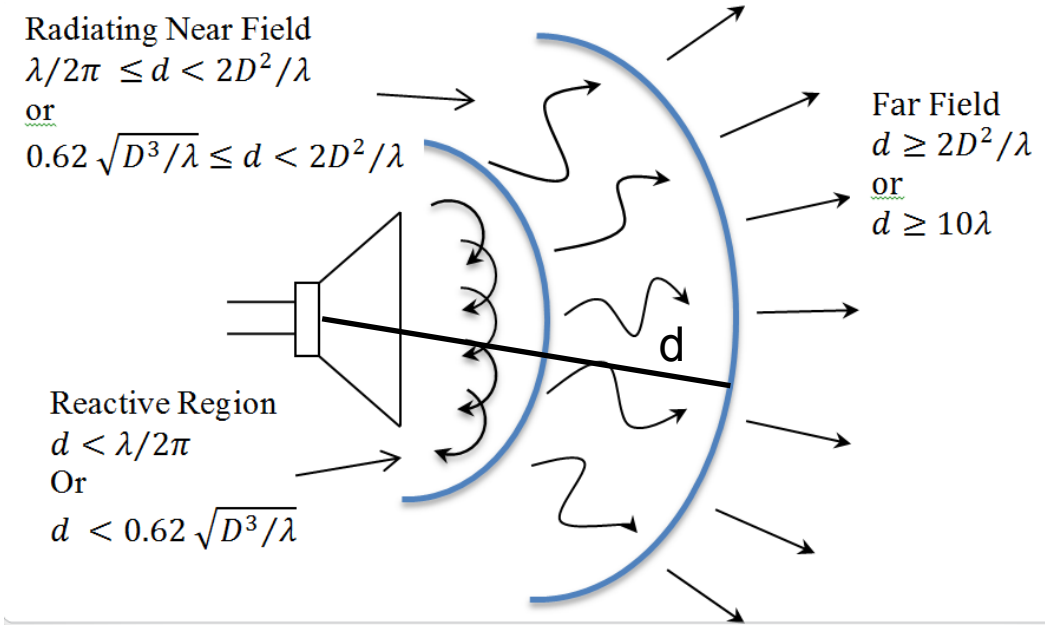
- Introduction to Very-Near-Field
- Very-Near-Field Implementation
- Case Study
- Other Applications
- Conclusion

Introduction to Very-Near-Field

Far-Field / Near-Field / Very-Near-Field

What is Very-Near-Field?

- What we call the very-near-field is the reactive region
- Interaction with device under test is unavoidable
- These are rules of thumb only



Far-Field (Chamber) Measurements

- Controlled somewhat repeatable tests
- Compliance or compliance like results
- Slow test time with possible queues for chamber time
- No information about location of emissions

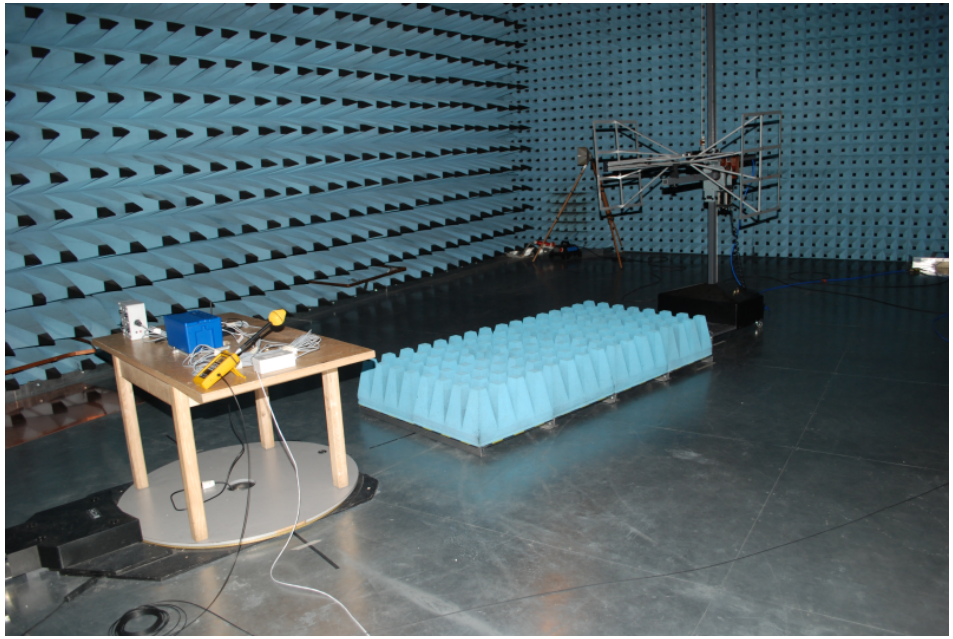


Image: www.geosig.com

Very-Near-Field Measurements

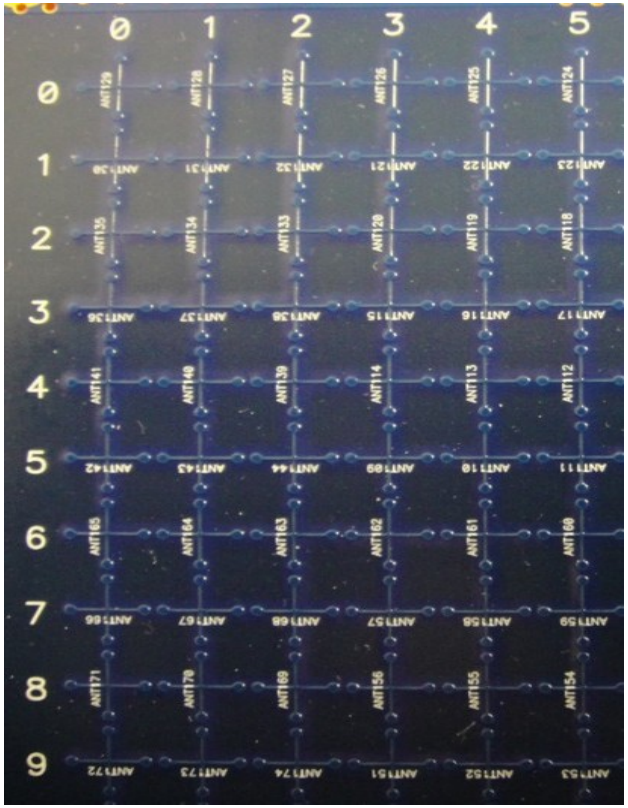
- Origin of all emissions
- Insight into root causes
- Best applied at board level
- Possible to extrapolate far-field from very-near-field
- Not repeatable and difficult to get whole picture

Very-Near-Field Implementation

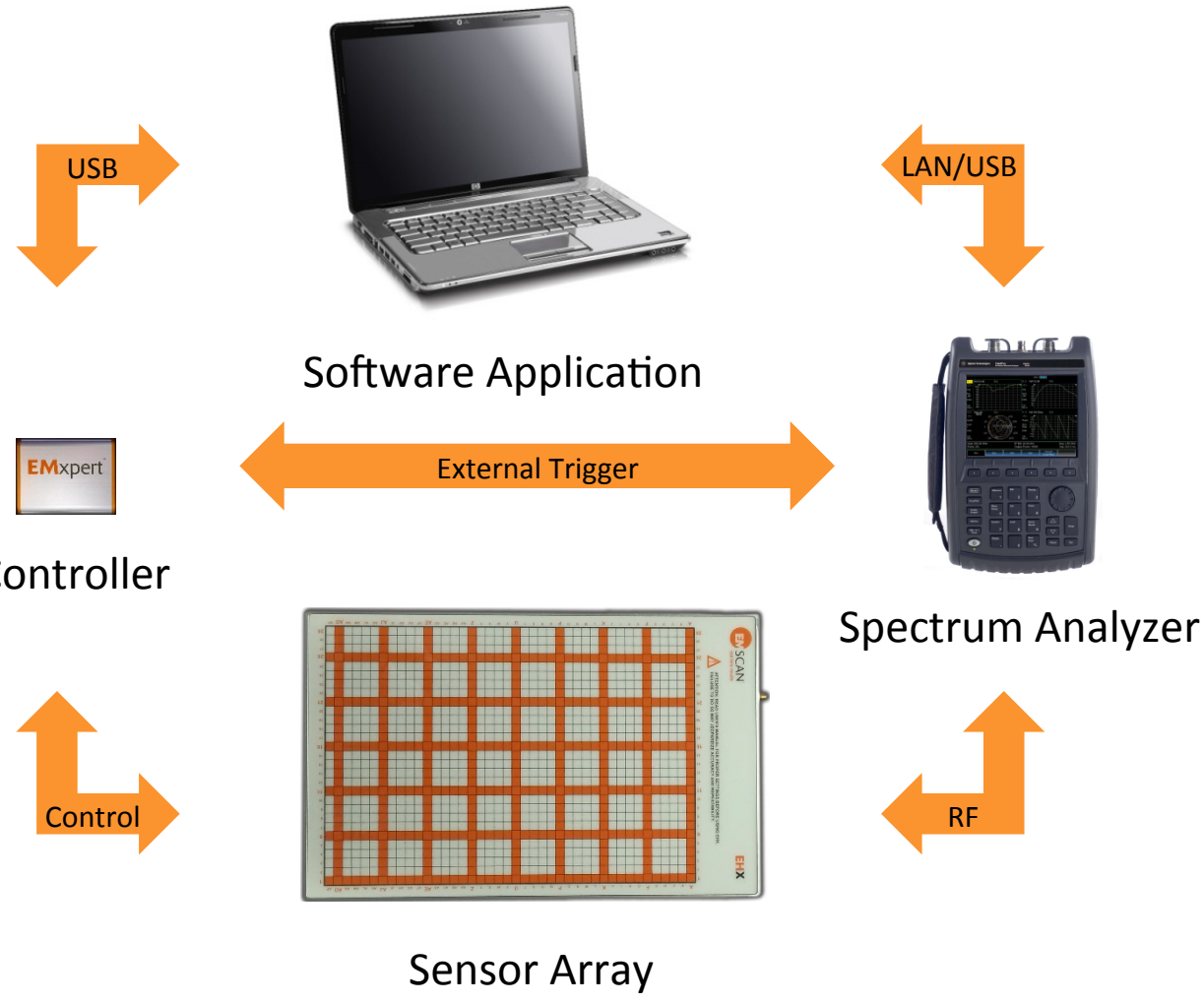
A Better Solution

Scanning Array of Probes

- 1218 probes in a 29 x 42 array
- Magnetic field loop probes
  - Sensitive down to -135 dBm
  - Inefficient for EMI isolation
  - Broadband
- 7.5 mm to 0.12 mm resolution
- Scan area 21.8cm x 31.6cm
- Real-time measurements (<1 sec)

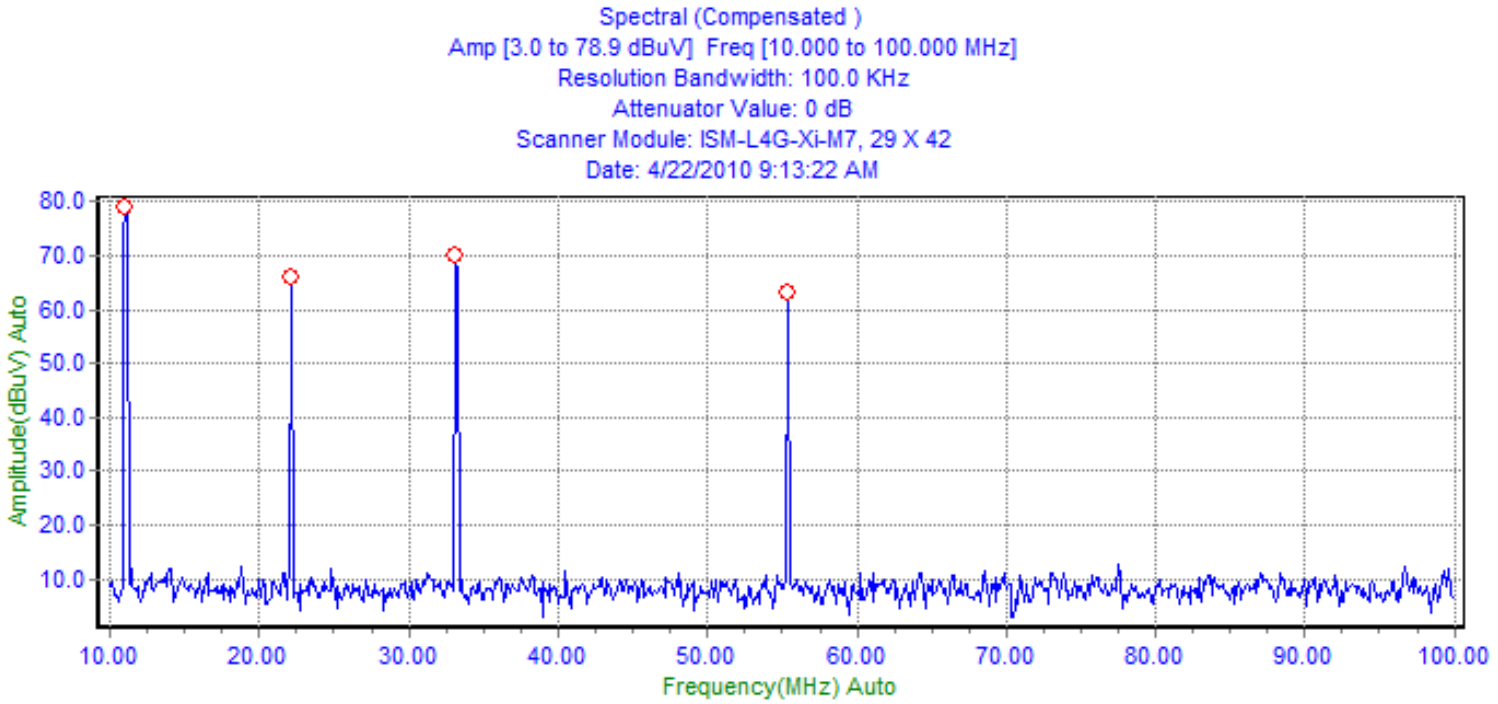


System Configuration



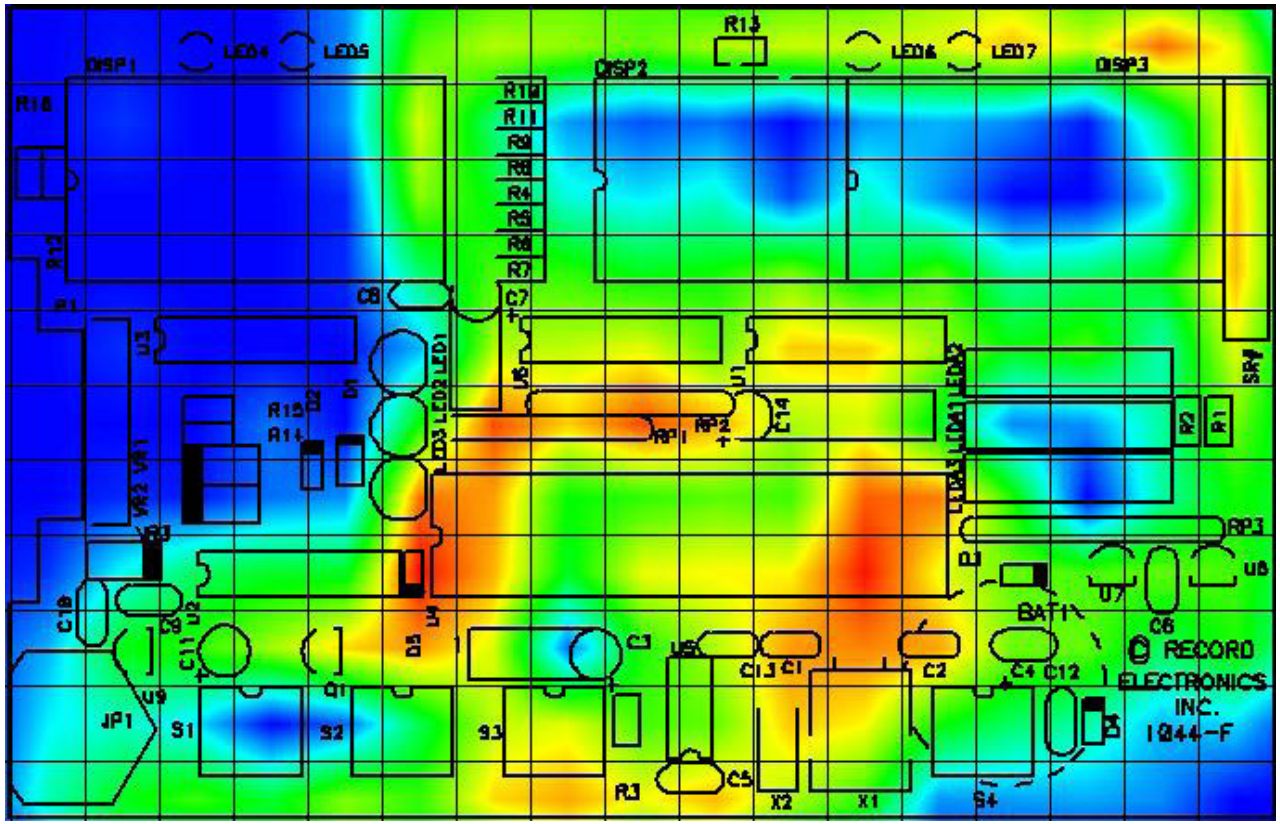
Spectral Scan

- Identify the frequencies of emission



Spatial Scan

- Visualize where the emissions are coming from

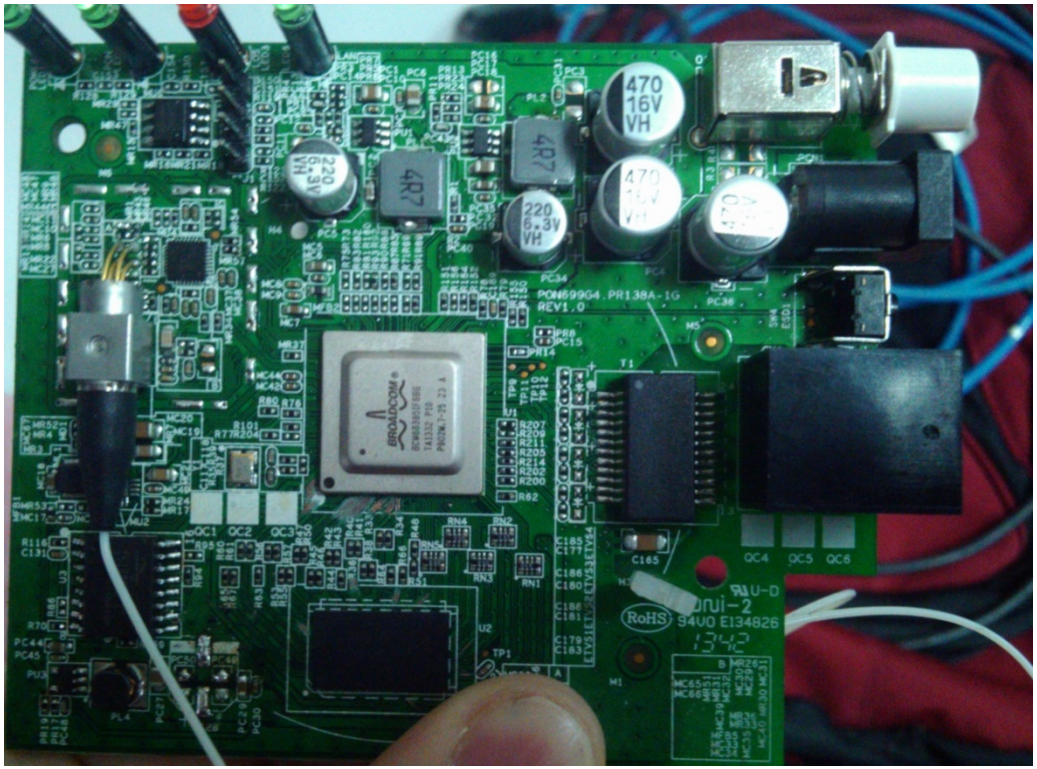


Debugging an Optical Networking Unit

Case Study courtesy of

Optical Networking Unit

- Passive optical network (PON)
- Onboard bi-directional optical subassembly (BOSA)
- Converts Wired LAN traffic to Optical Network

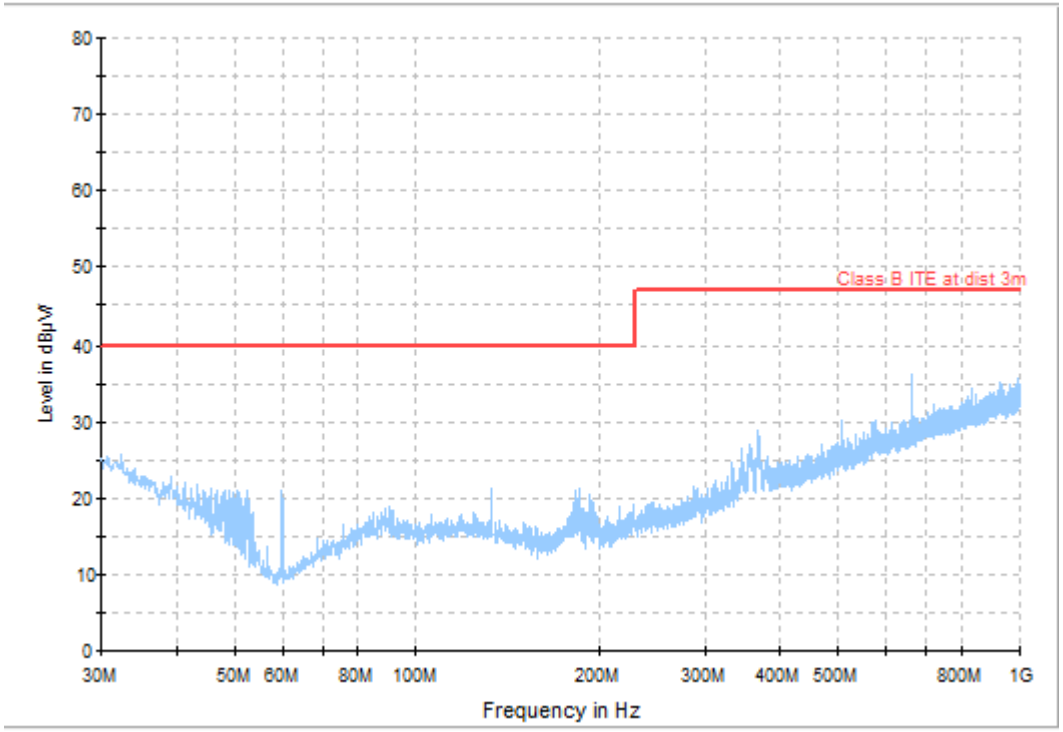


Introduction

- A SEMTECH customer is having difficulty achieving the required EMC performance
- Far field measurements in a chamber identified components that failed to meet requirements from their end customer.
- For GPON traffic the board will pass the directive, but EPON traffic fails.

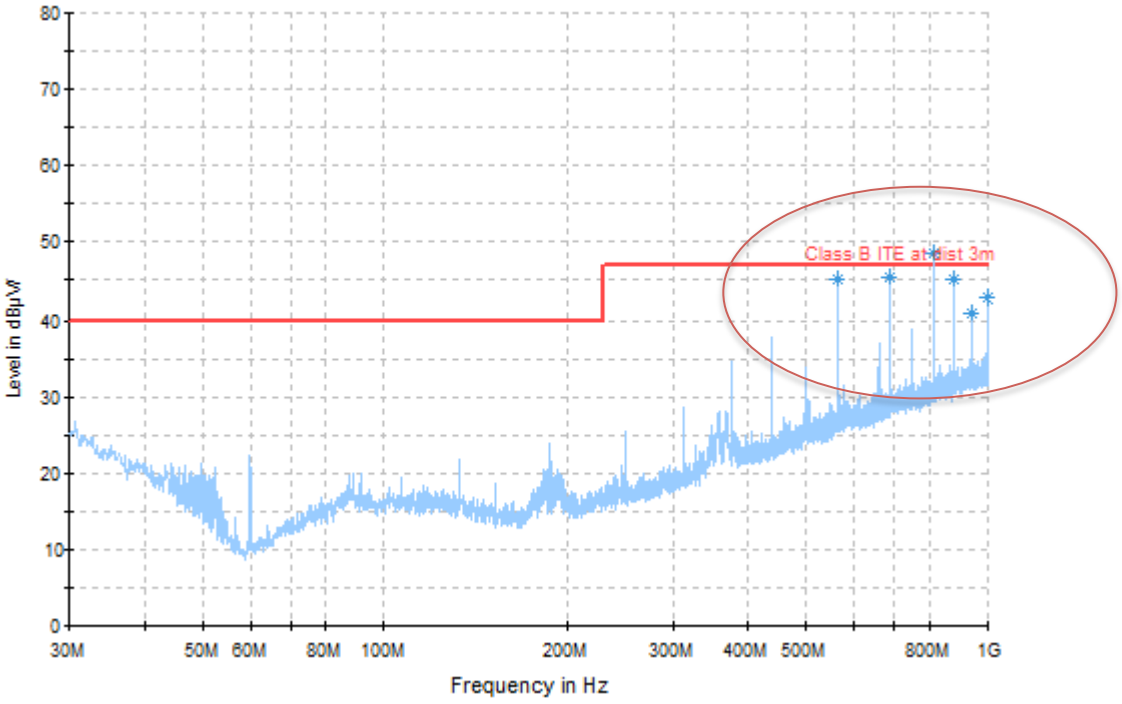
Chamber RE

- GN25L95 (ONU) with power on
- **No** data between GN25L95 and MAC



Chamber RE

- GN25L95 with power on
- **Full EPON** data between GN25L95 and MAC



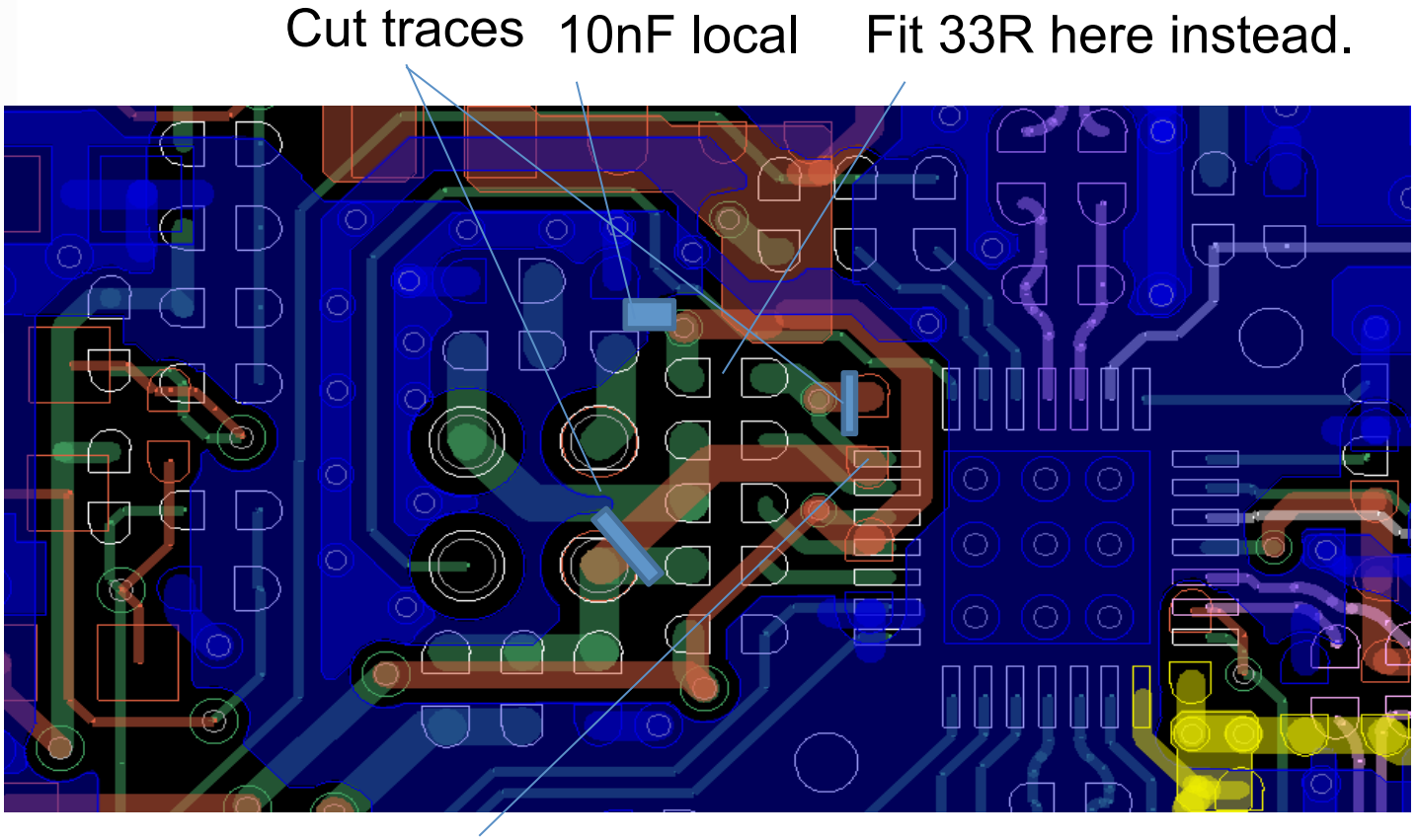
Analysis

- When MAC sends GPON PBRS23 to GN25L95 the RE test passes
- When running SmartBit dataflow the RE fails
- Changing RC filter near BOSA has some benefit but not enough

Questions

- The radiation source is not at a GN25L95 frequency. Is it coming from MAC?
- How is the MAC radiating? Does it go through the GN25L95?
- Is the BOSA pin radiating? Energy here would be high.
- Other options are burst control line, laser driver circuit or RF traces

Change Layout and Test in Chamber



Very Near Field Test Activities

1. Whole board (bottom layer) tested to identify magnitude and location of emissions.

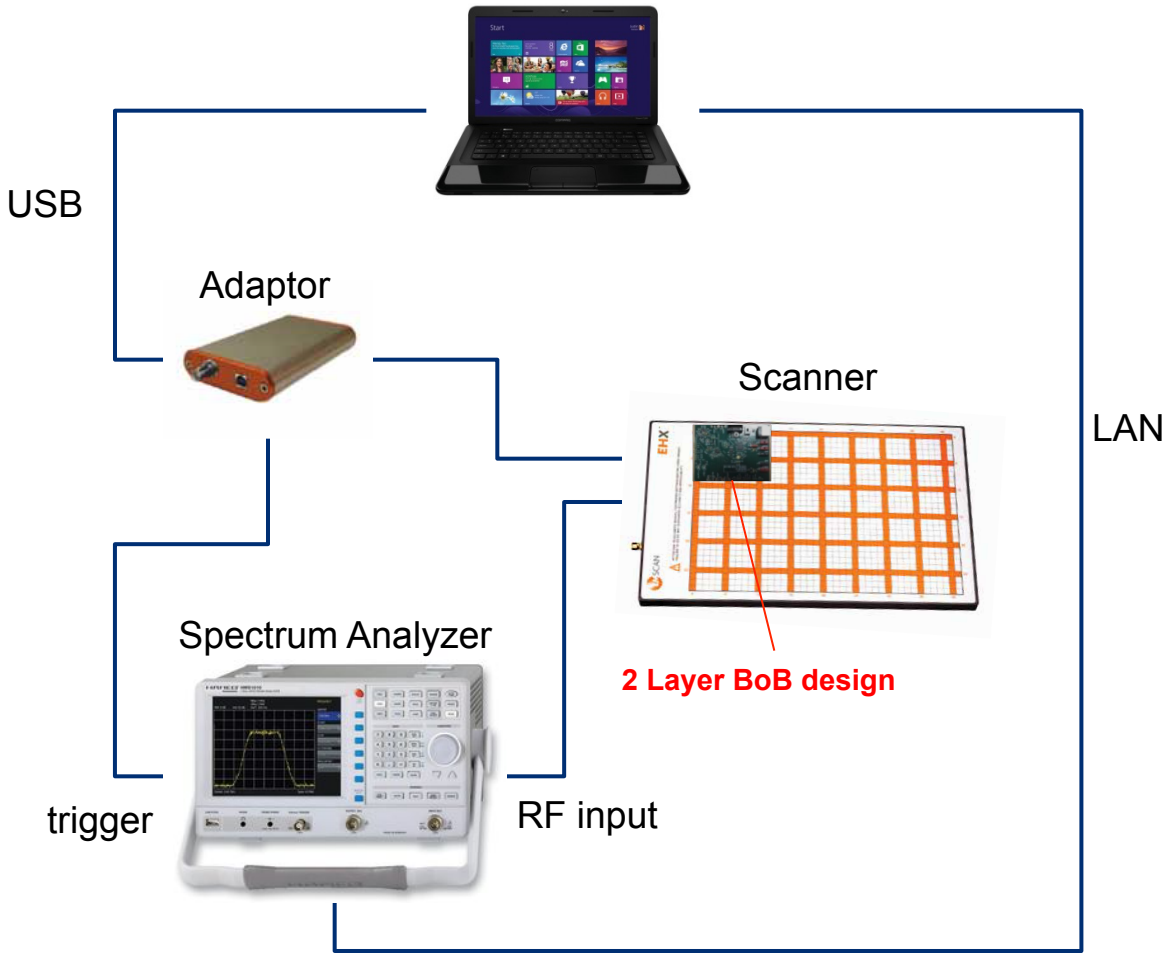
2. Region of interest (top layer) around the Tx leads , tested for spectral emissions . The whole board is tested for spatial scan.

3. Recreate the far field results and try to locate the source of highest spectral content for each test pattern.

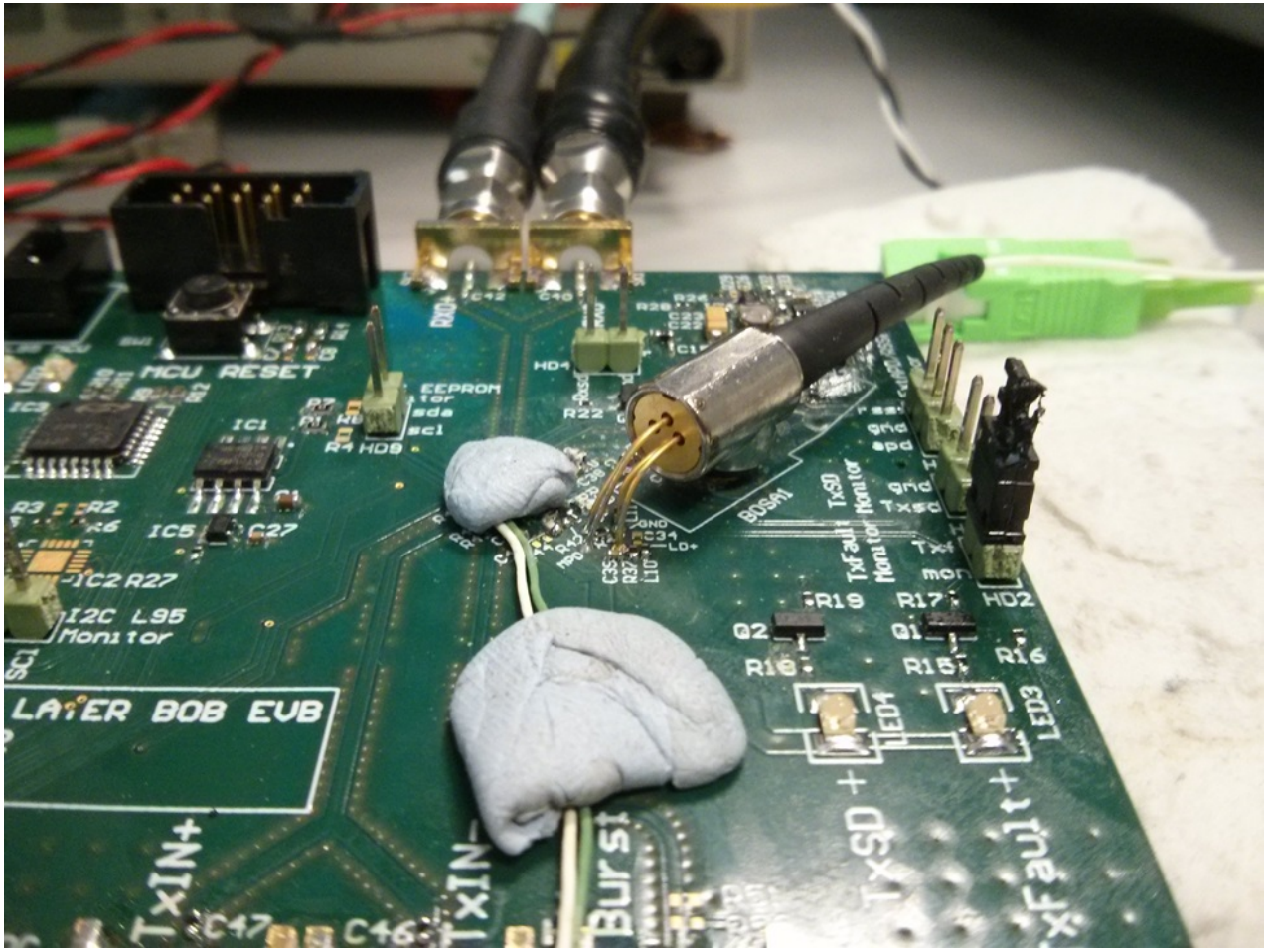
Test Conditions

- Input data rate : 1.25Gbps
- Wavelength : 1310nm
- Input data pattern : Continuous Waveform (CW), PRBS2^23-1, PRBS2^7-1, All Ones 8b10b, All zeros 8b10b, Idle (1010) 8b10b, Jitter 8b10b.

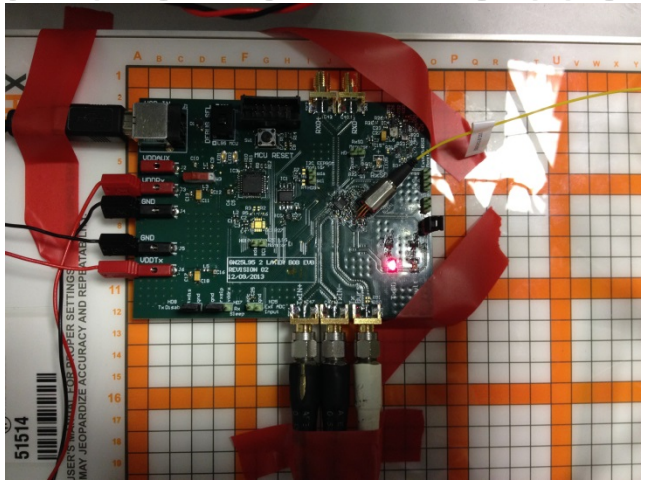
Test Setup

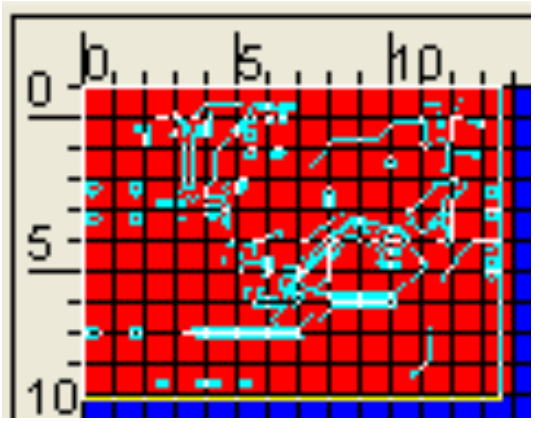

USB
Adaptor
Scanner
LAN
Spectrum Analyzer
2 Layer BoB design
trigger
RF input

BOSA On Board – 2 layer PCB

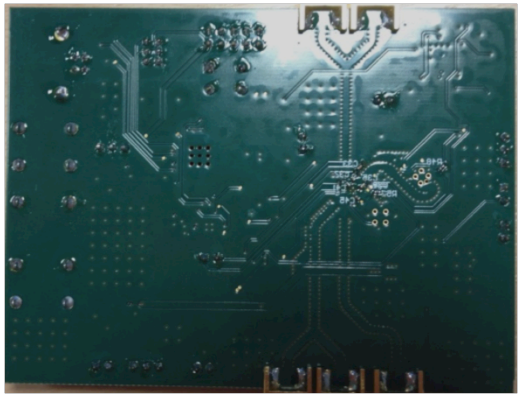


Scan Conditions – Bottom Layer





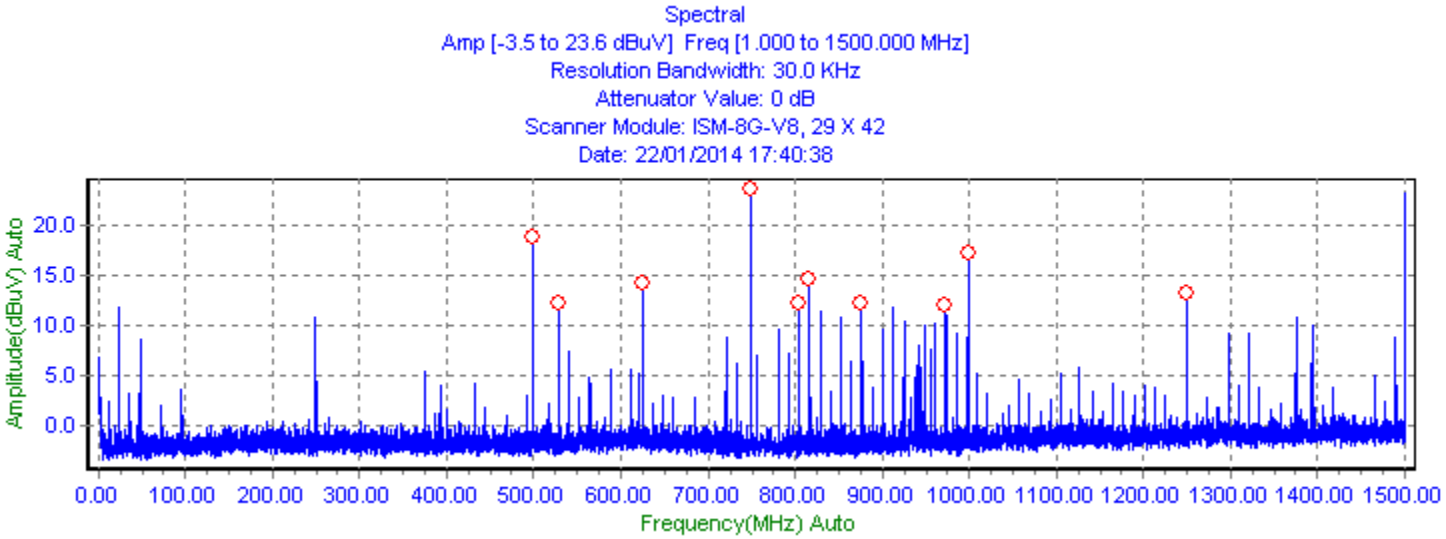
140 probes (in red) activated for both spectral scan and spatial scan



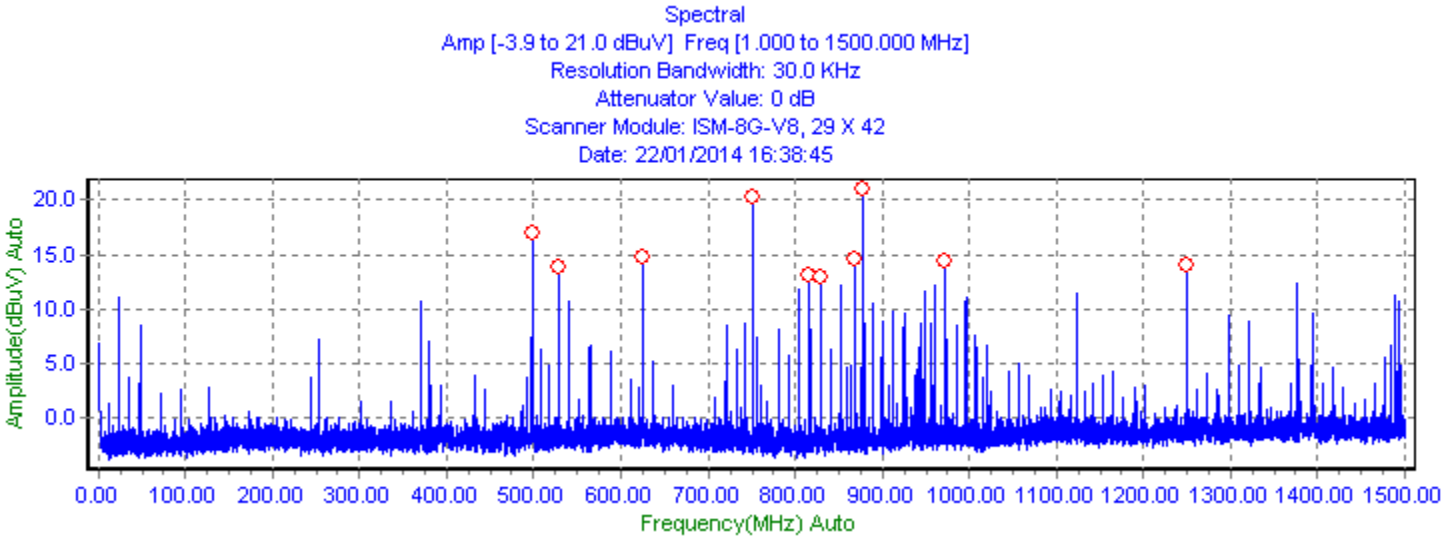
Bottom view of 2 Layer BoB Design

Spectral Scan Results

All Ones

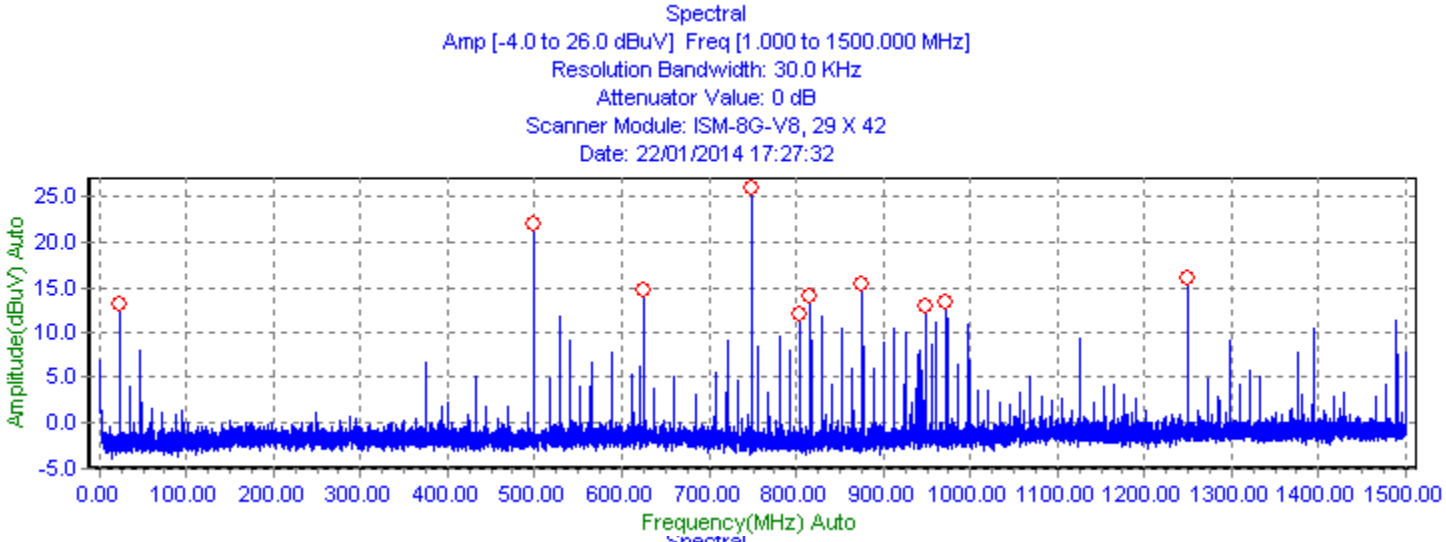


All Zeroes

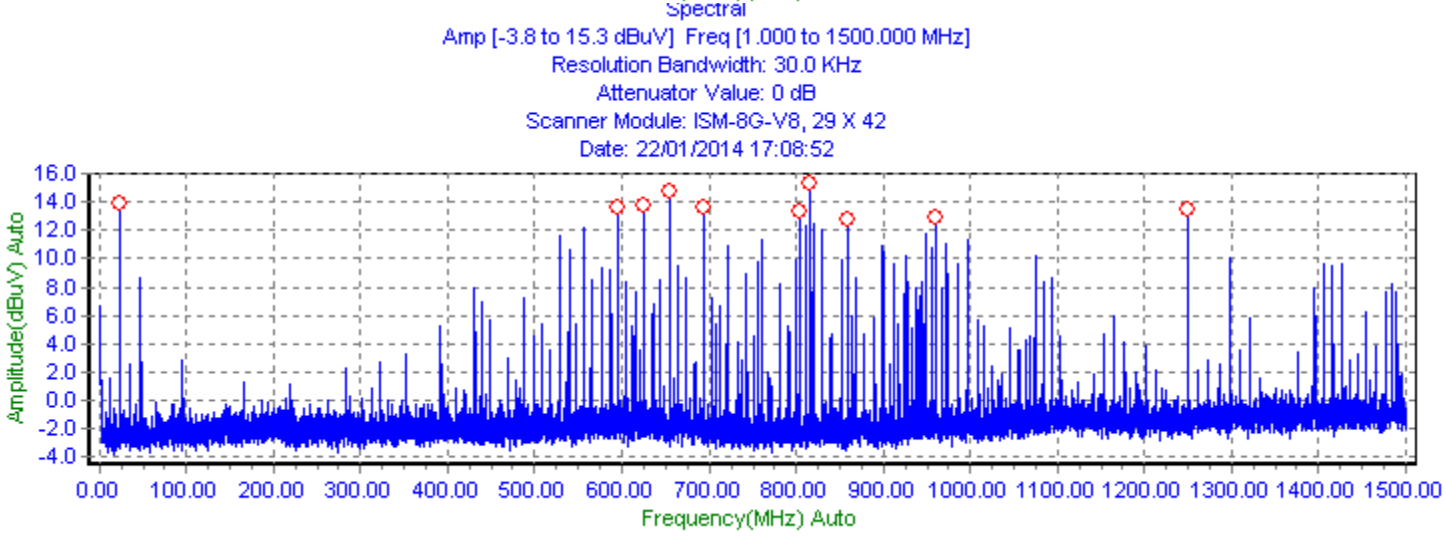


Spectral Scan Results

Idle (1010)

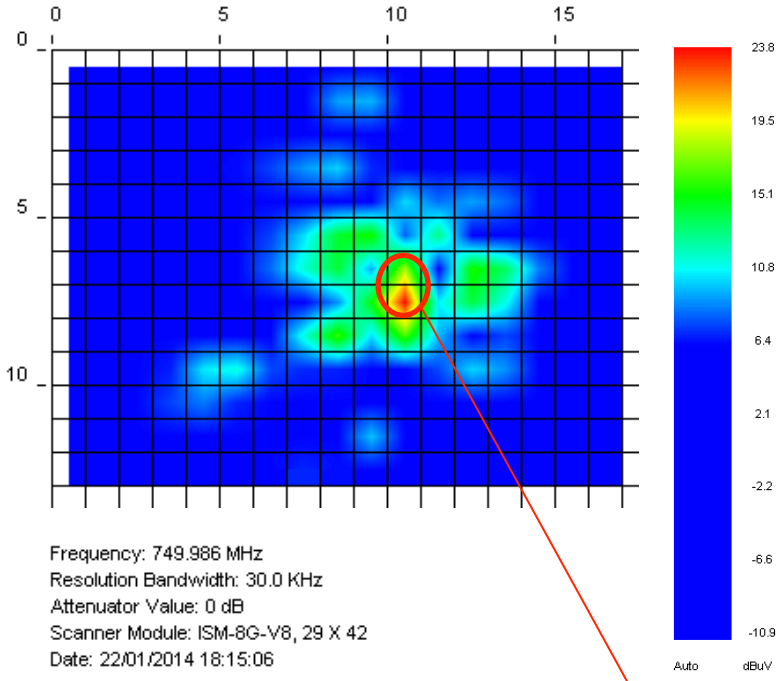


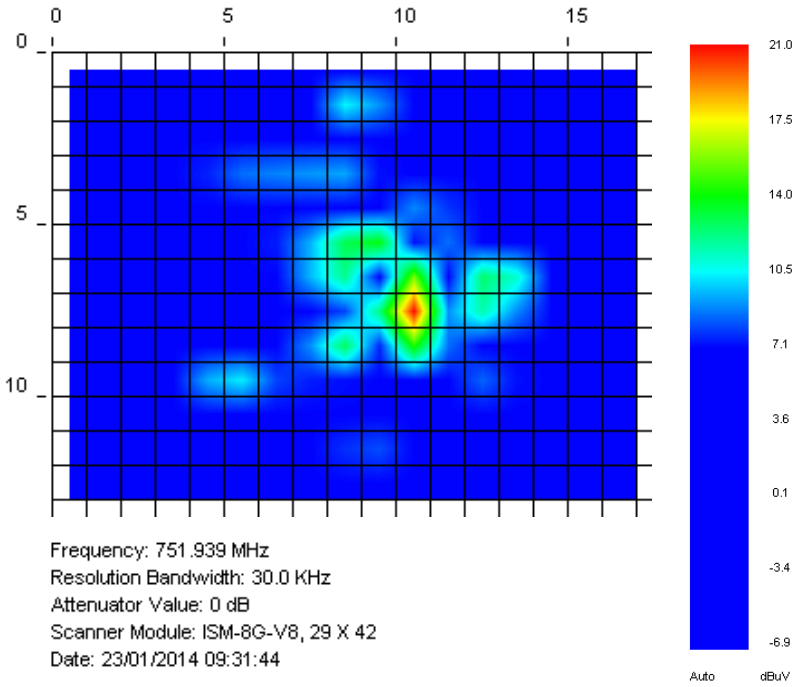
Jitter pattern



Spatial Scan Results

Hotspots indicate high emission area.



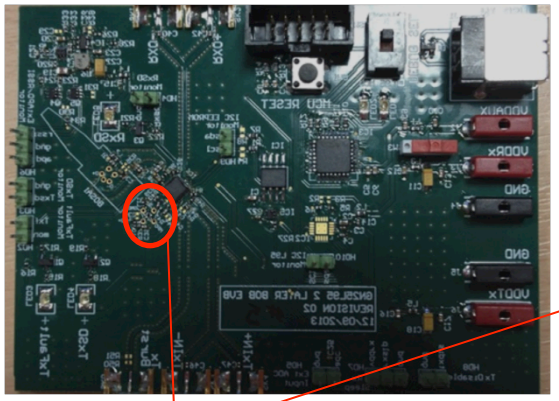


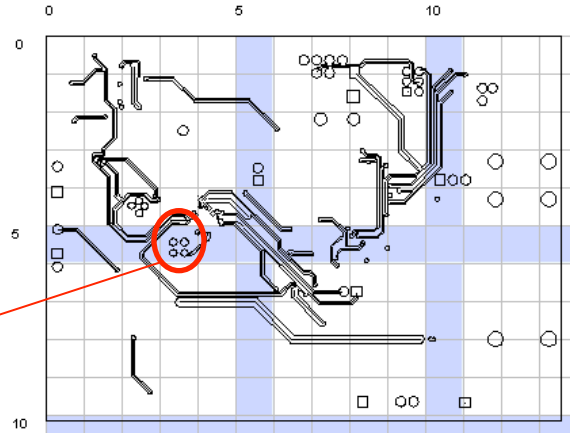
All Ones 8b10b

Tx leads to BOSA

All Zeroes 8b10b

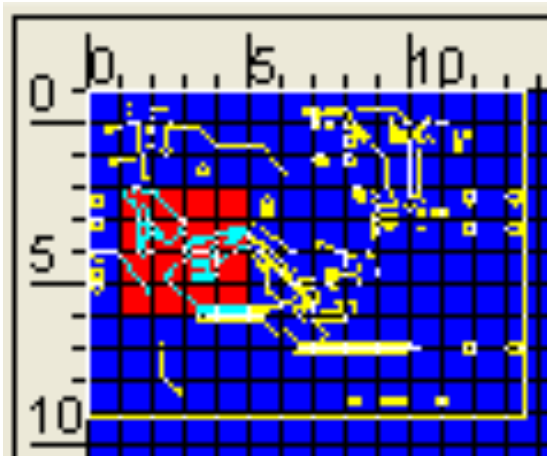
Scan Conditions – Top Layer



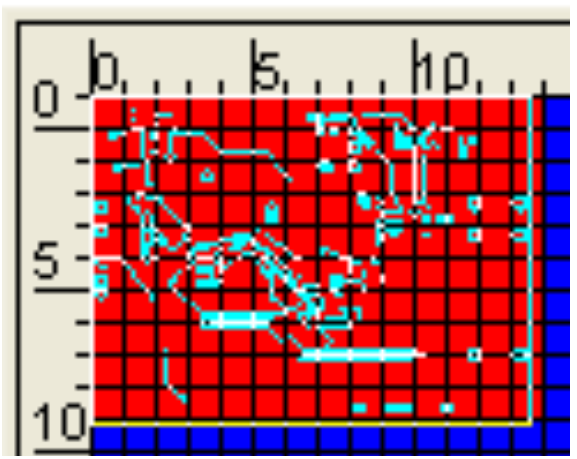


Tx leads

GERBER file has been imported to pinpoint the high energy emission area for the top later scan.



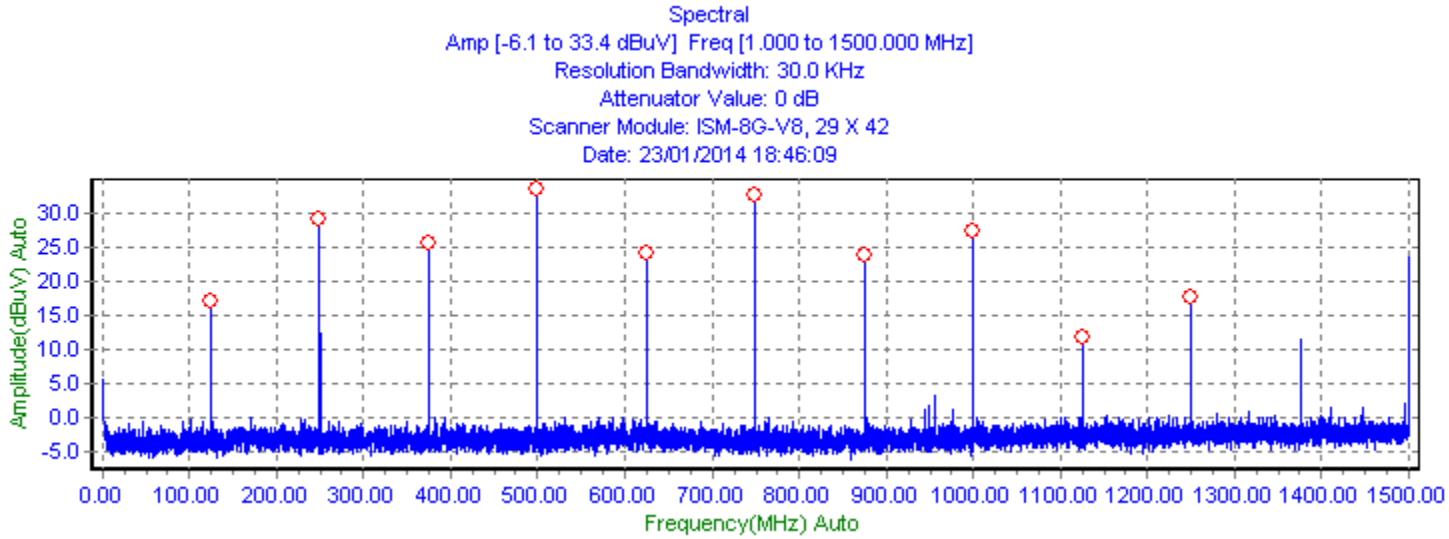
16 probes (in red)
activated for spectral scan



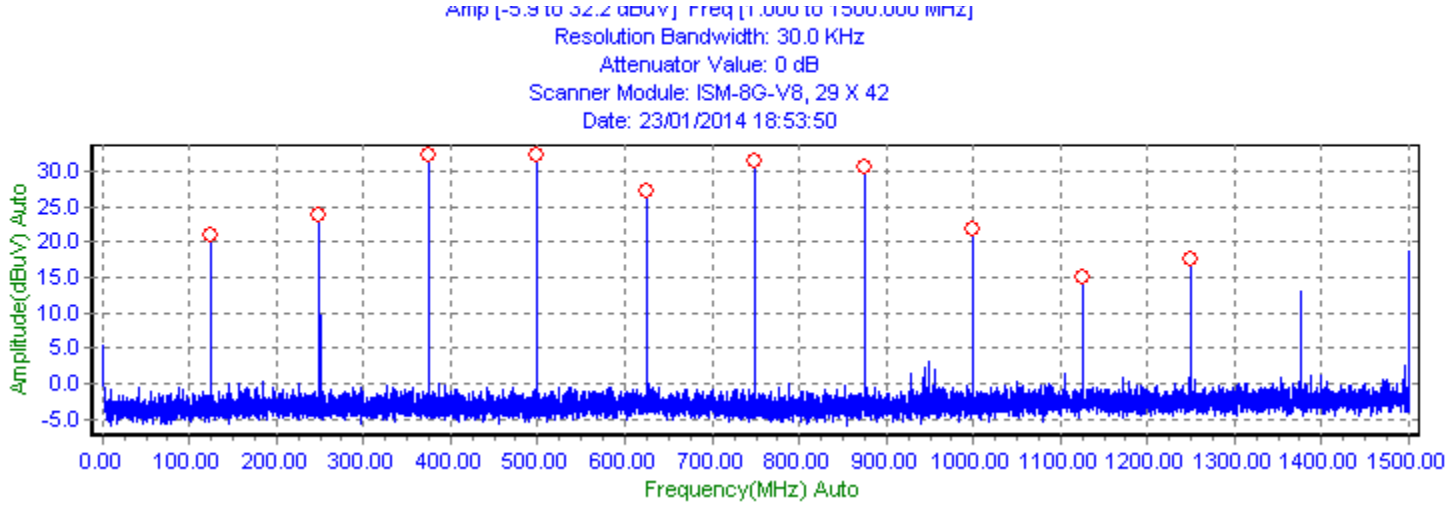
140 probes (in red)
activated for spatial scan

Spectral Scan Results

All Ones

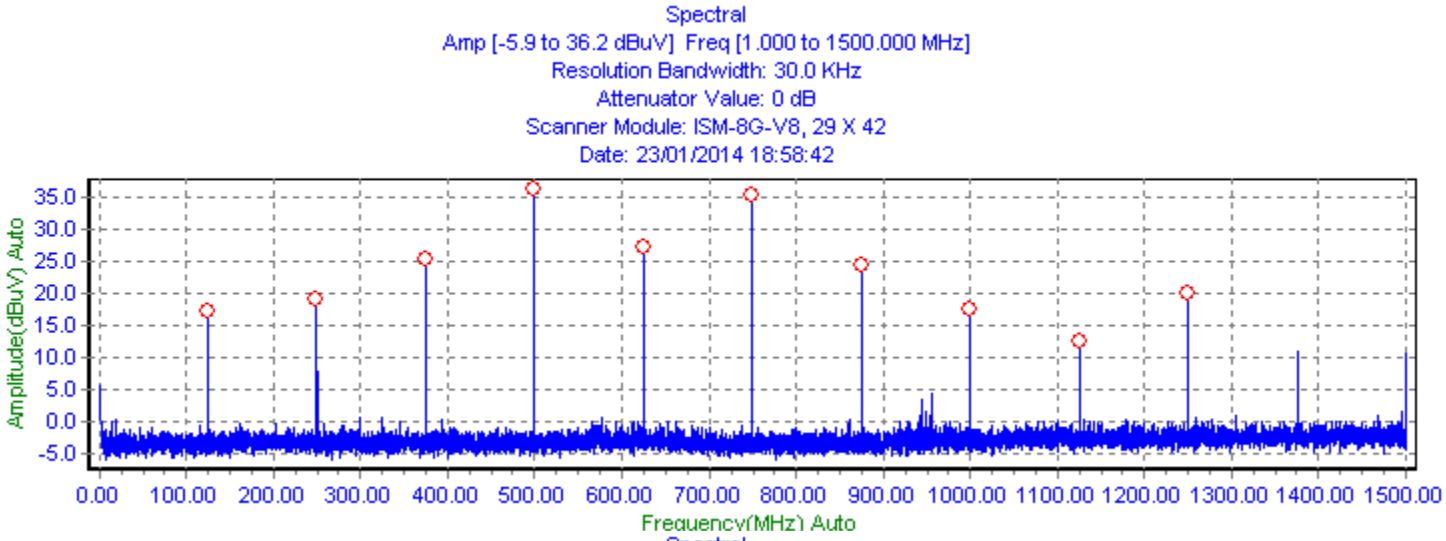


All Zeroes

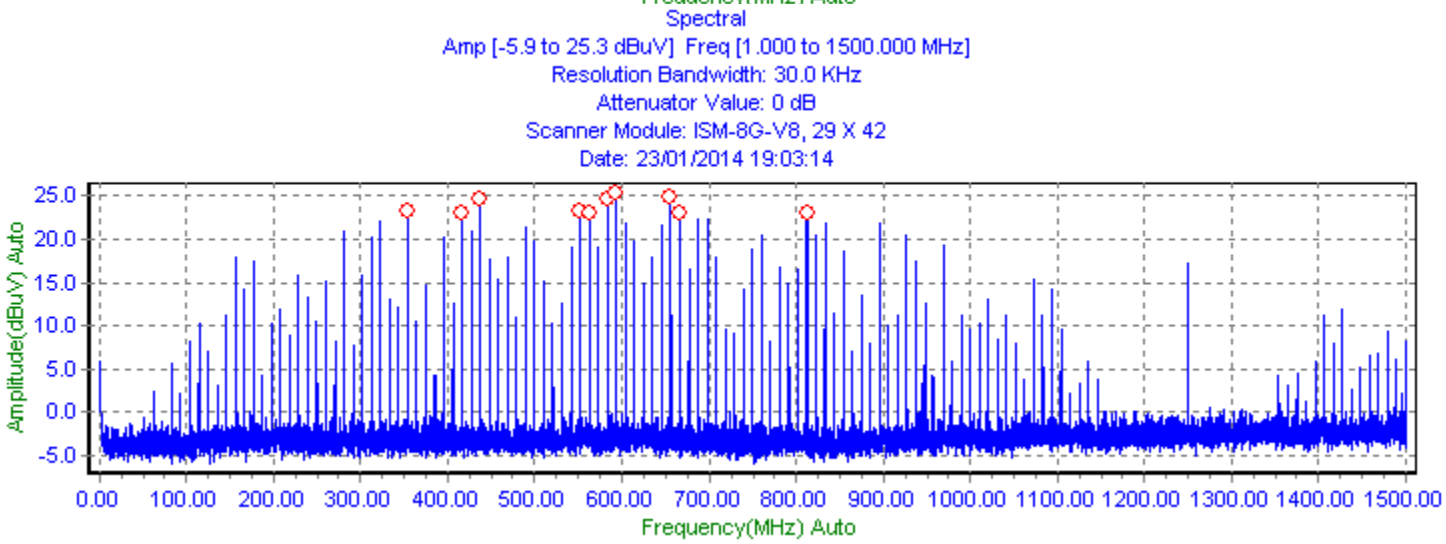


Spectral Scan Results

Idle (1010)

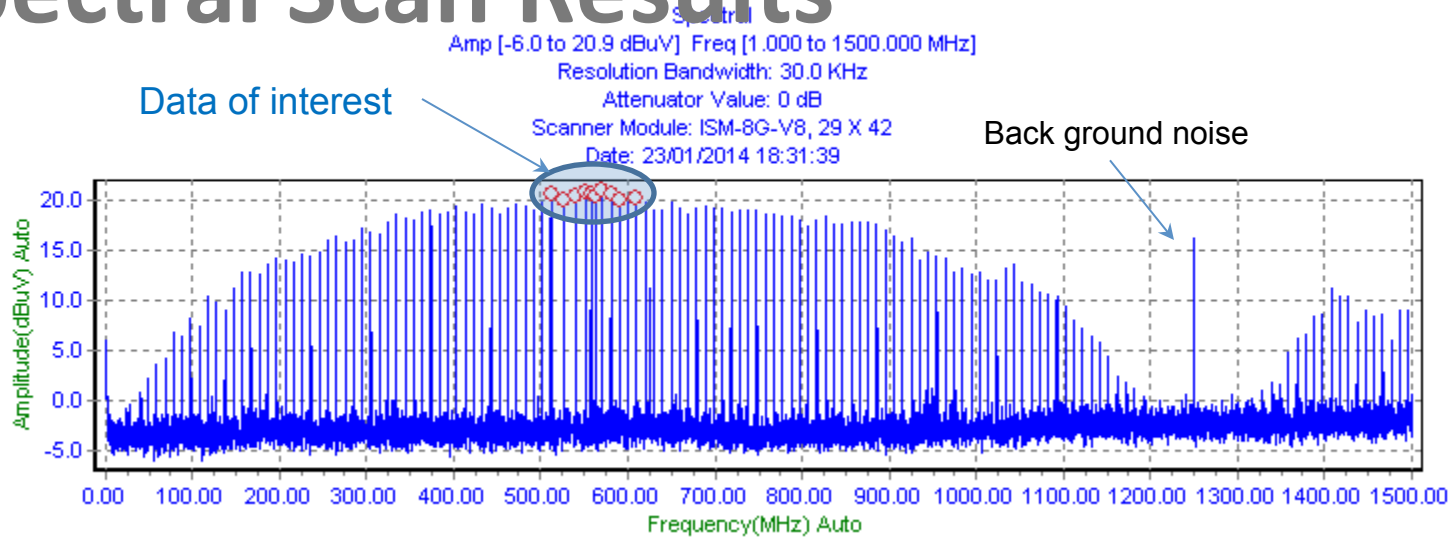


Jitter Pattern

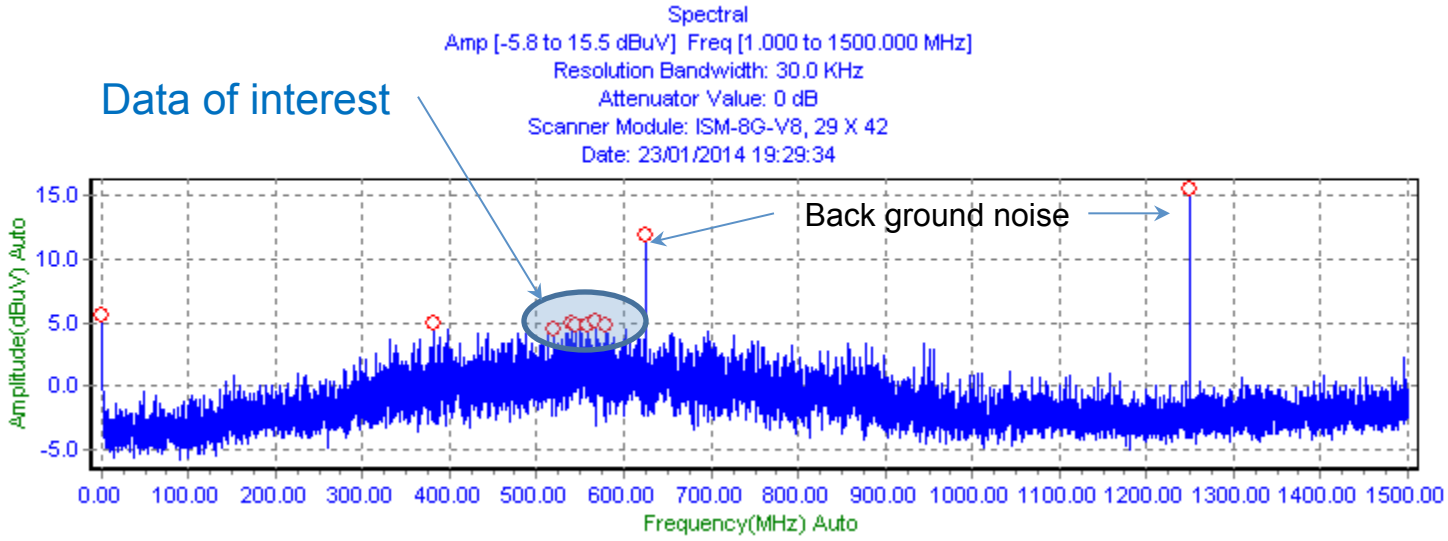


Spectral Scan Results

PRBS2^7-1

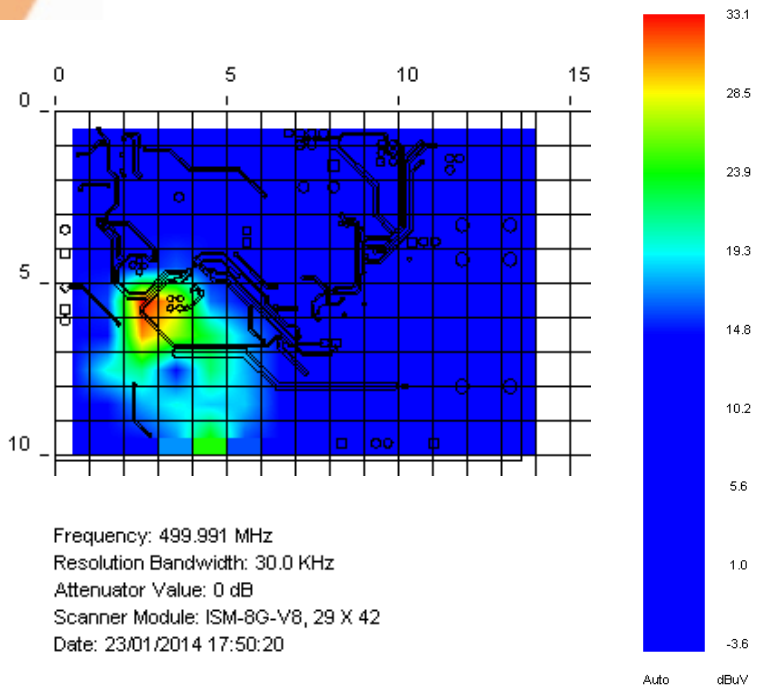


PRBS2^23-1

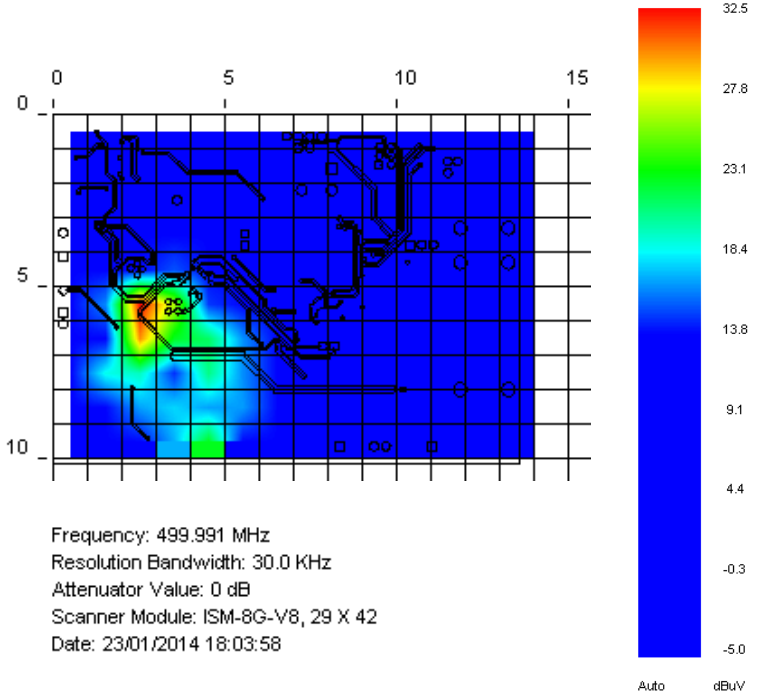


Spatial Scan Results

Hotspots indicate high emission area



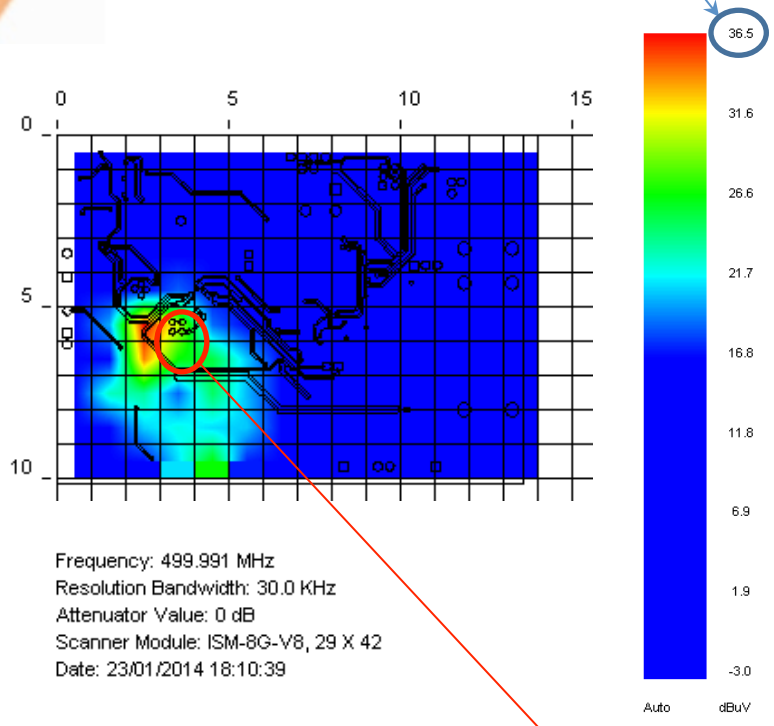
All Ones 8b10b



All Zeroes 8b10b

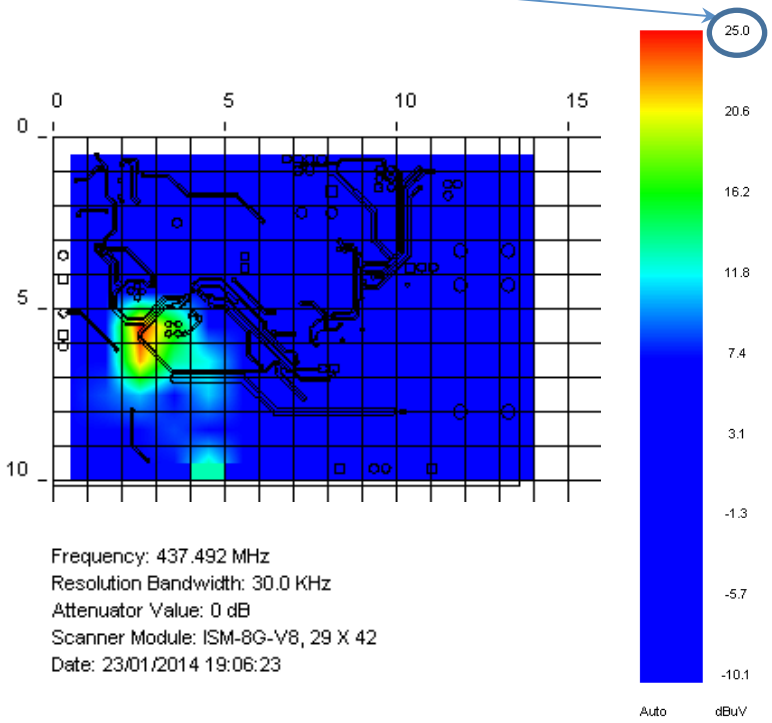
Spatial Scan Results

The magnitude is much smaller



Idle 8b10b

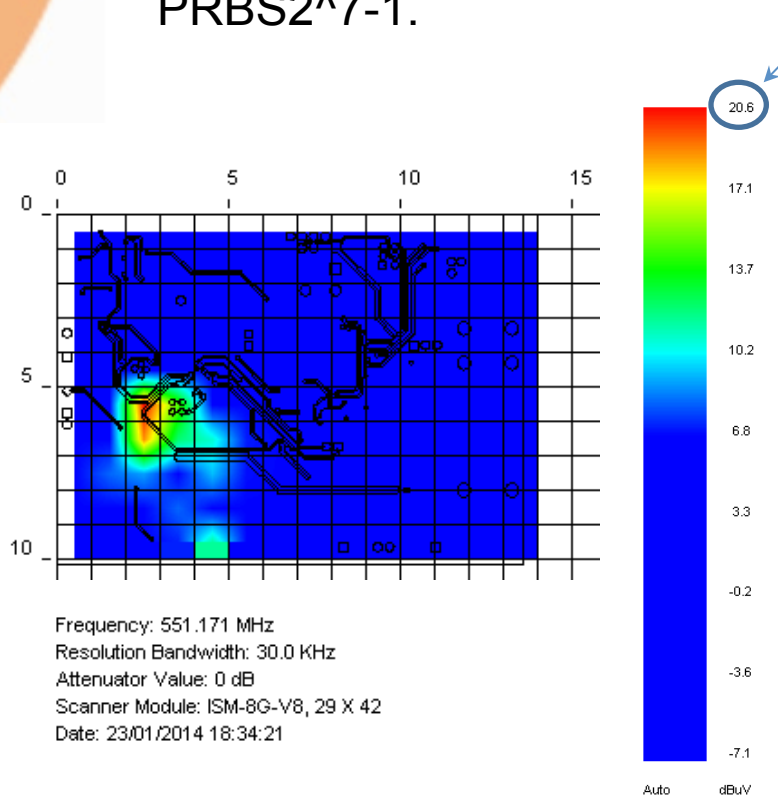
Tx leads to BOSA

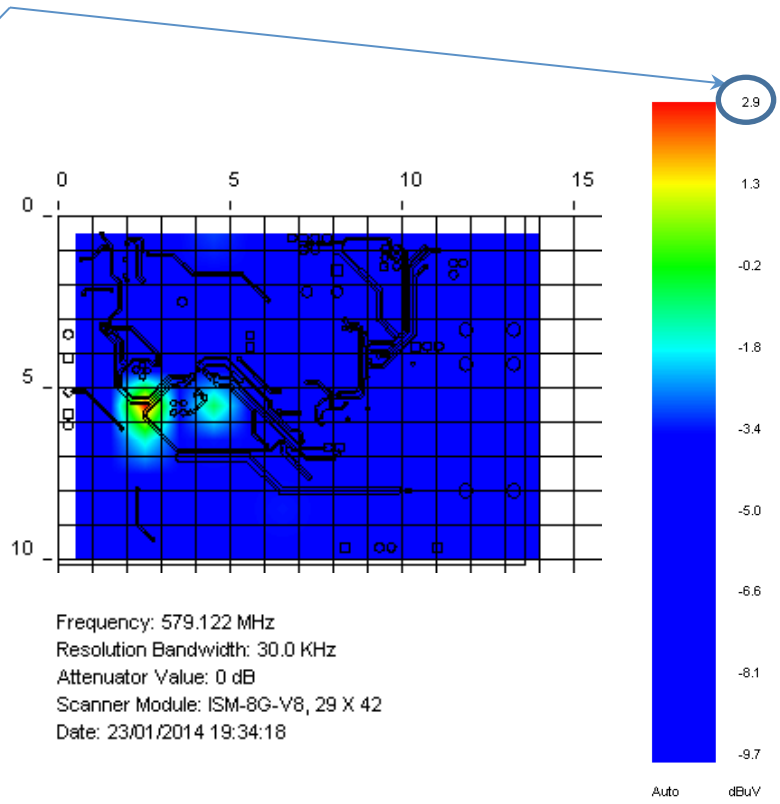


Jitter 8b10b

Spatial Scan Results

The magnitude of PRBS2^23-1 is much smaller than for PRBS2^7-1.





PRBS2^7-1

PRBS2^23-1

Summary

- The higher spectral content in the failed RE tests are due to the patterns used for EMC compliance testing
- The measured spectral content in the very-near-field scans aligns with the theoretical FFT expectation and with chamber results
- The emissions “hotspot” is the tx leads to the BOSA

Follow up

- The very-near-field scan results will show the customer exactly what the problem is

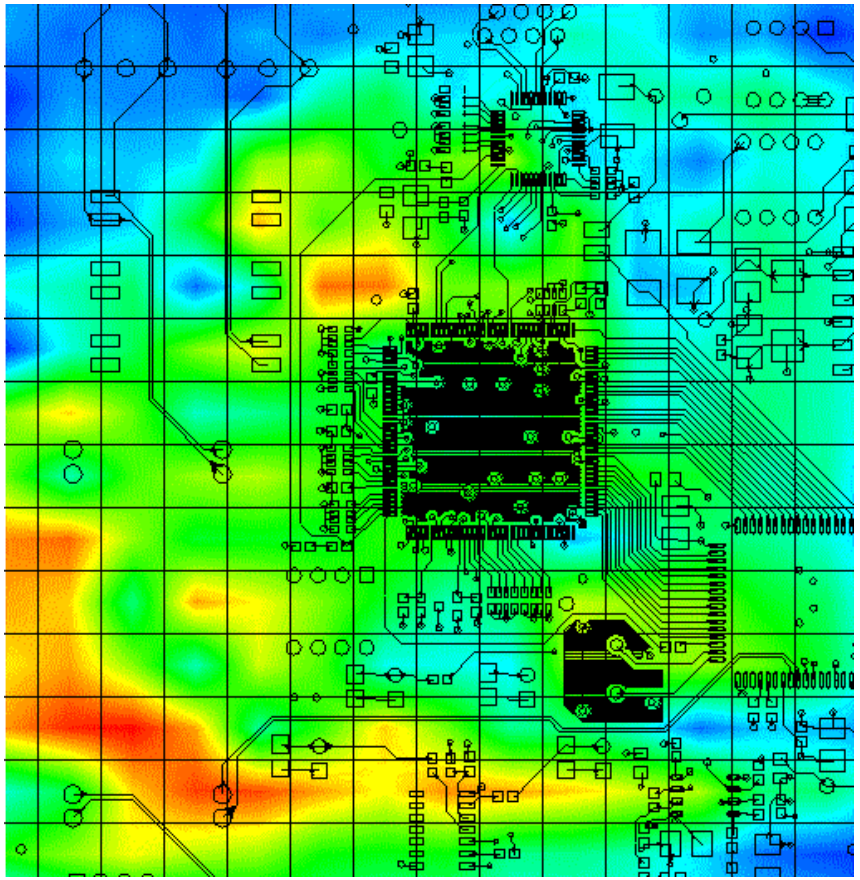
- Suggested solutions to customer will include
  - Absorption plate attached to the BOSA to capture emissions
  - Altering BOSA design to shorten Tx lead lengths
  - Reduce ride/fall time (filter) laser drive signals

Other Applications

Typical EMC Concerns

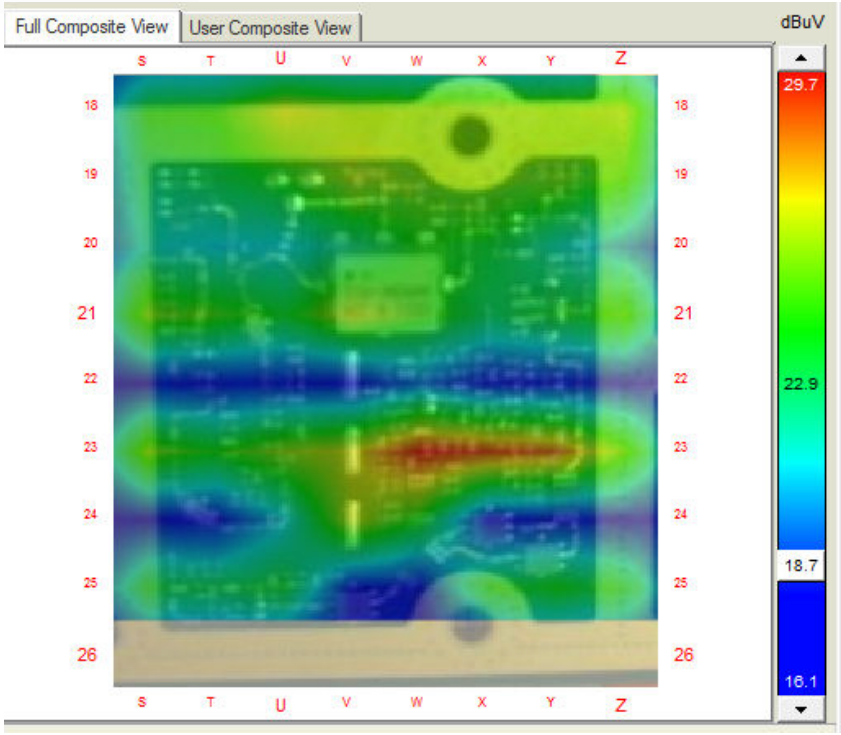
Real-Time

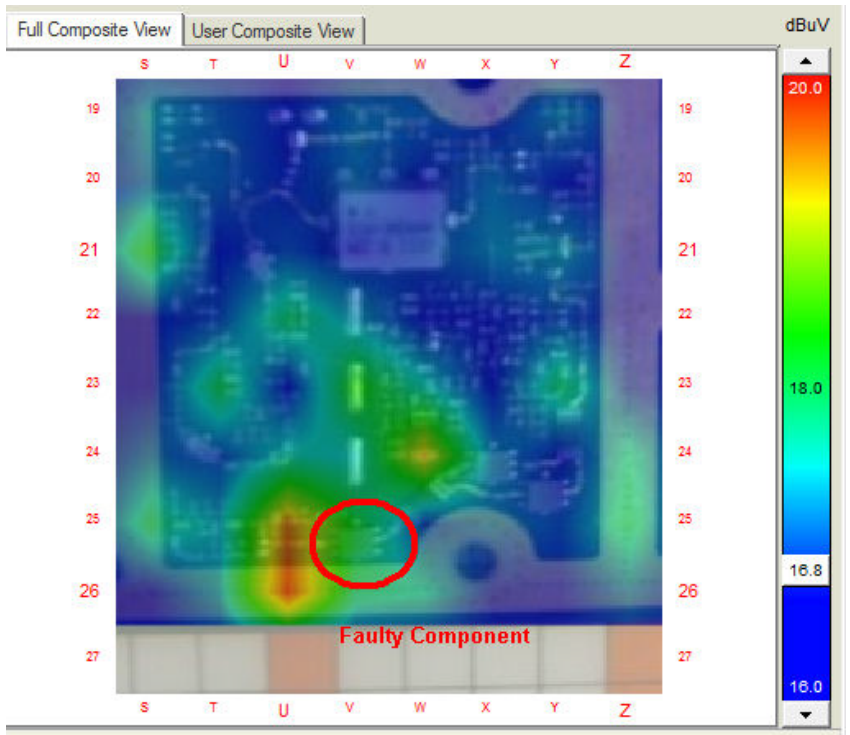
- Changes in real-time
- Intermittent events
- Functional testing
- Different operating modes
- Firmware modifications



A/B Comparison

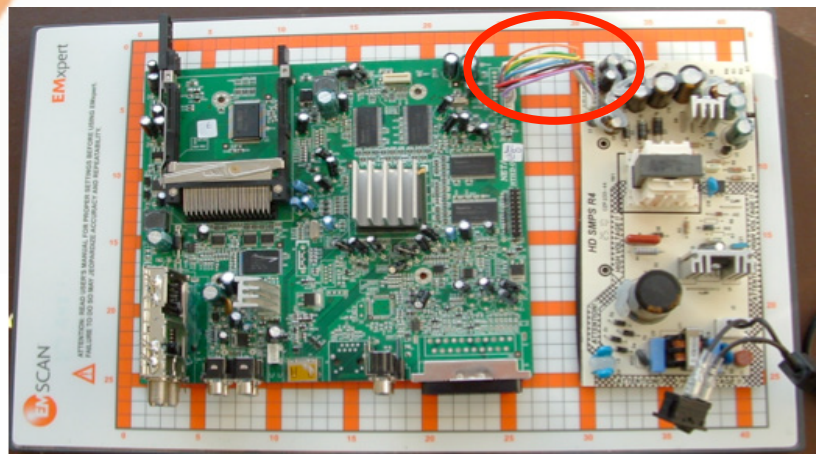
- Obsolescence management
- Production unit versus gold standard
- Fault diagnosis

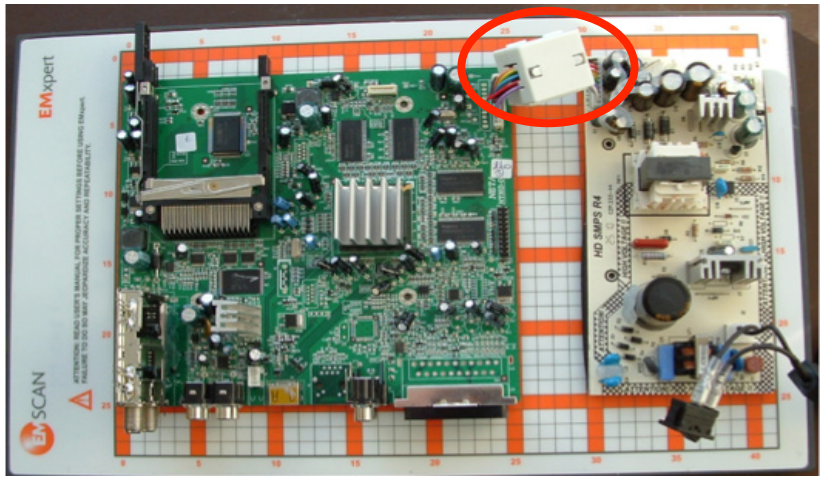


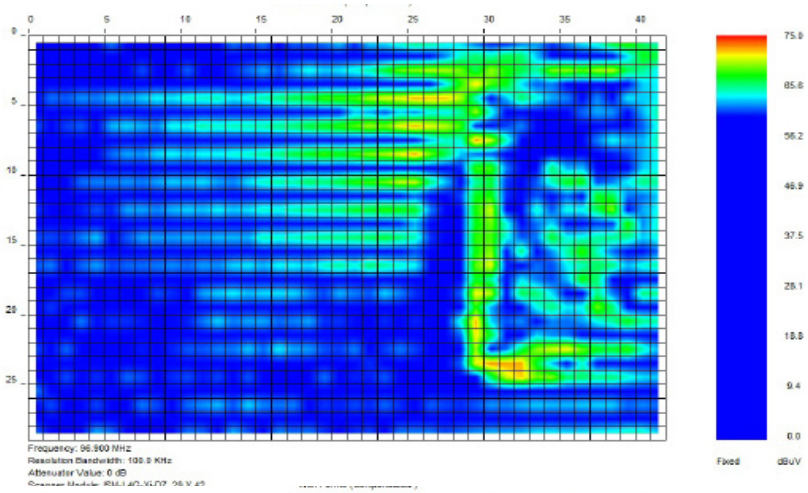


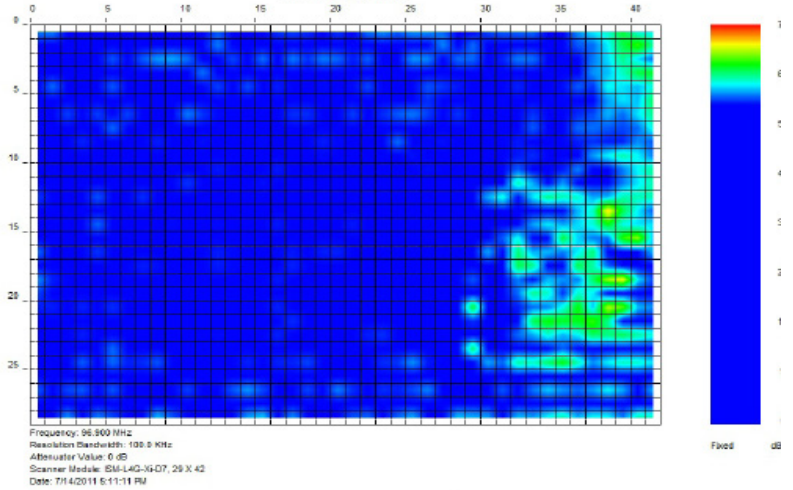
Effectiveness of Filters

- Immediate feedback means trial and error can be used



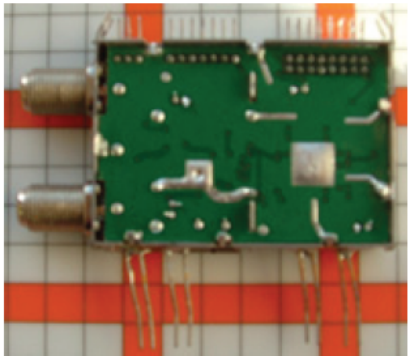


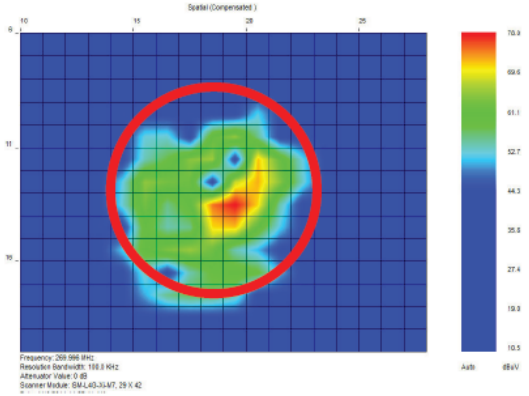


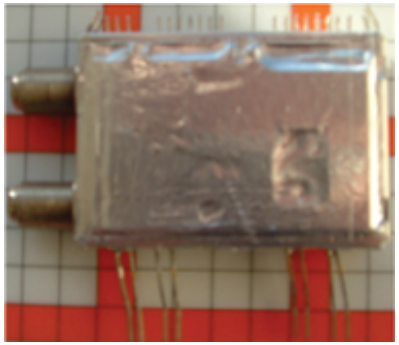


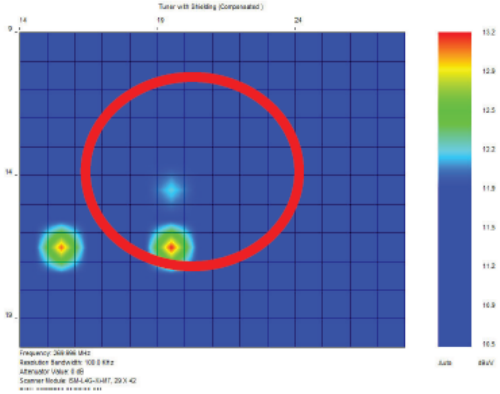
Testing Shielding or Absorbers

- Look for leakage points or new radiation mechanisms
- Test uniformity and effectiveness







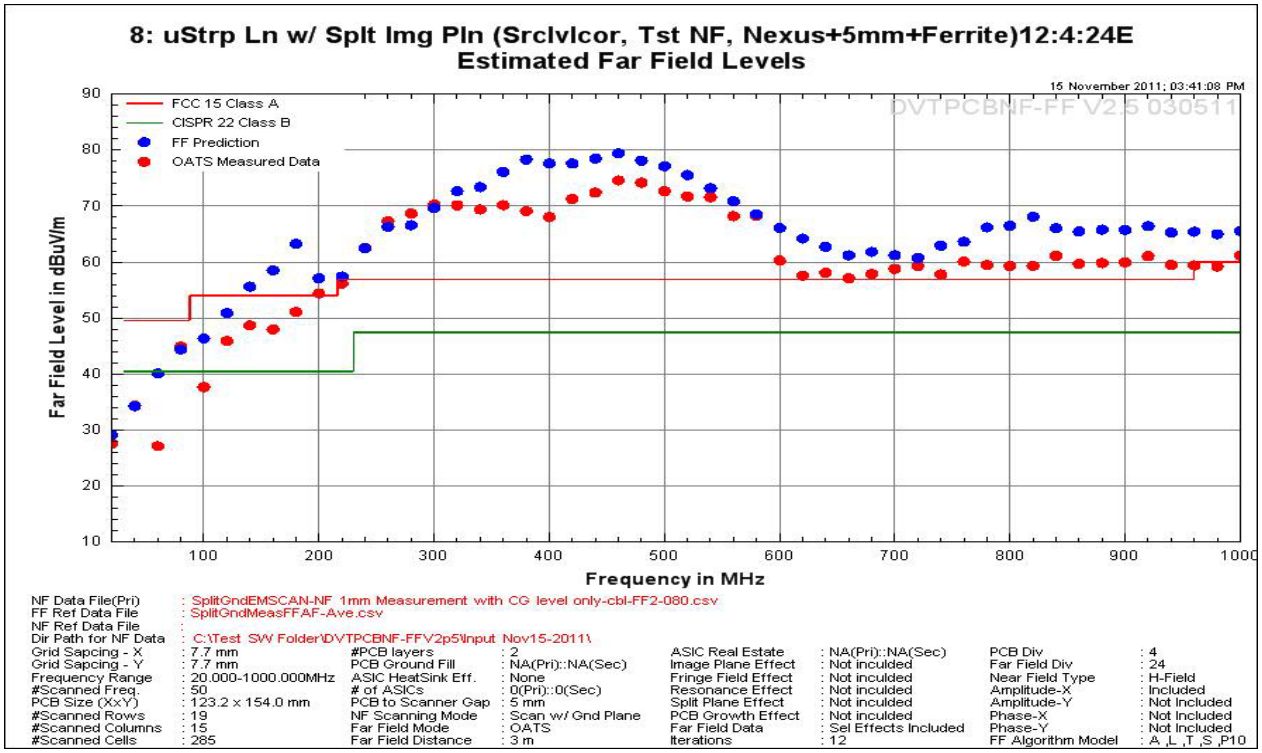


Other Applications

Chamber Predictions

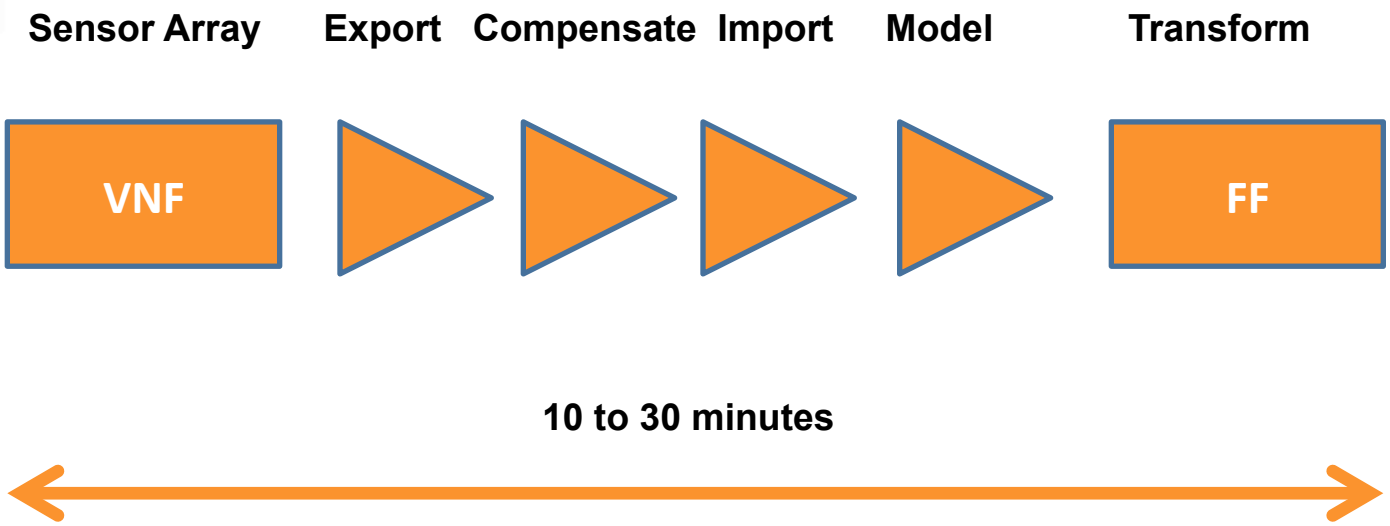
Far-Field Prediction

- VNF results to predict Open Area Test Site (OATS) or free space radiated EMI of PCB



Methodology

- Measure very-near-field emissions and apply a model based prediction algorithm to them
- Some user expertise is still needed



Very-Near-Field Array Based Measurement

Conclusion

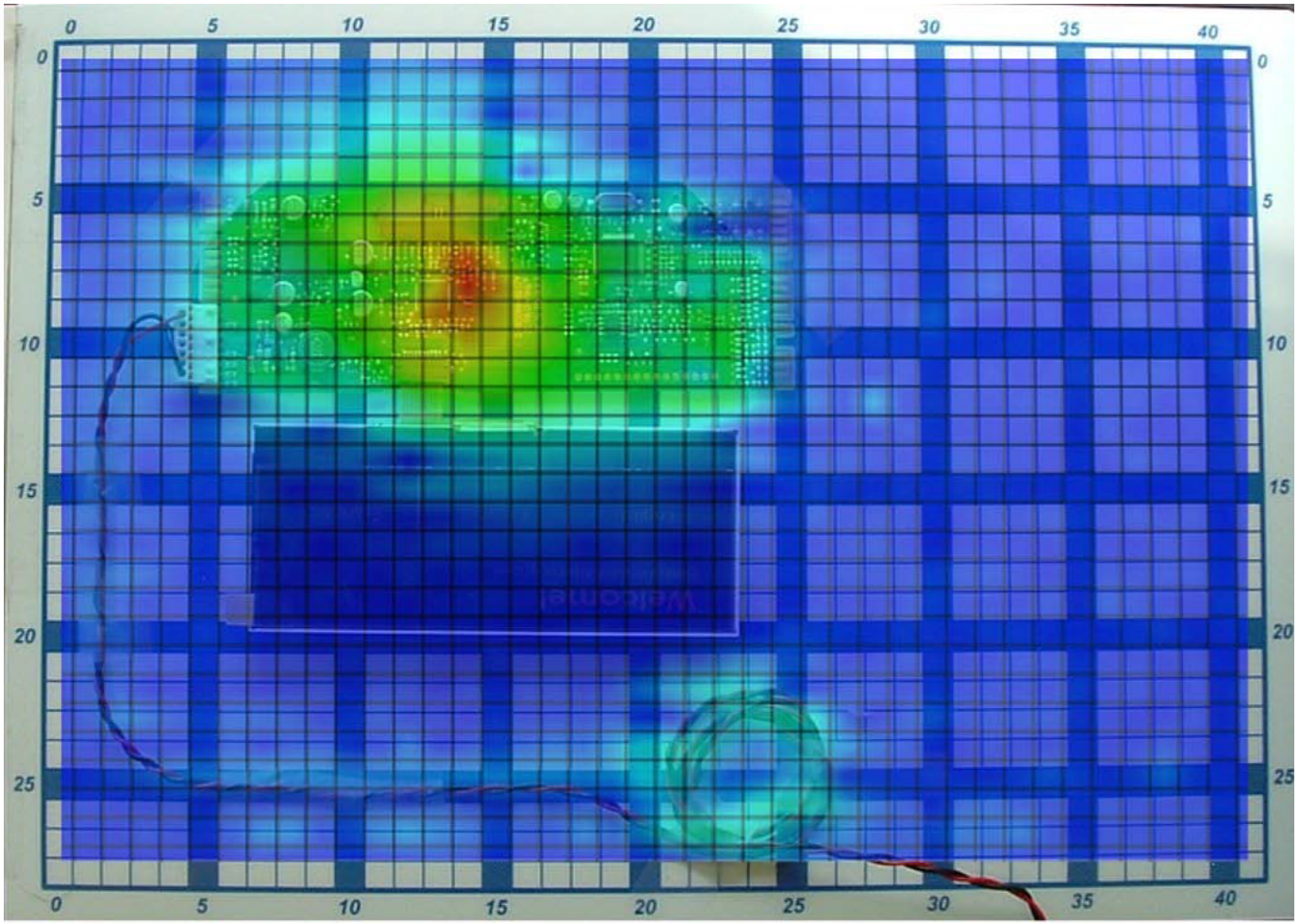
Very-Near-Field Pros and Cons

- Array based very-near-field testing can identify source of emissions quickly
- Changes in the lab can be validated before going to the chamber
- Intermittent or changing events can be captured
- PCB diagnostic not product compliance
- Some shapes not appropriate for testing

Thank You

www.emscan.com
info@emscan.com

Very-Near-Field = Magic Goggles



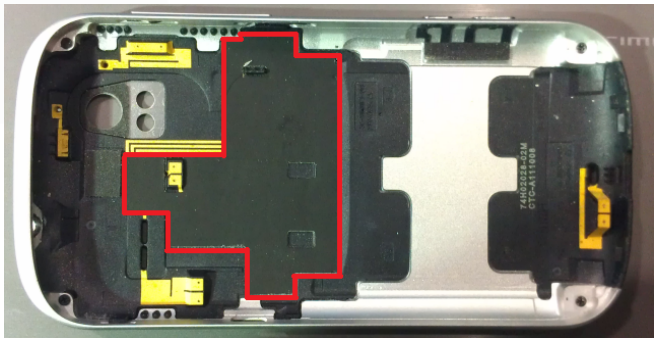
- EPON passive optical network
- ONU optical networking unit
- BoB – BOSA on board
- BOSA – bidirectional optical subassembly

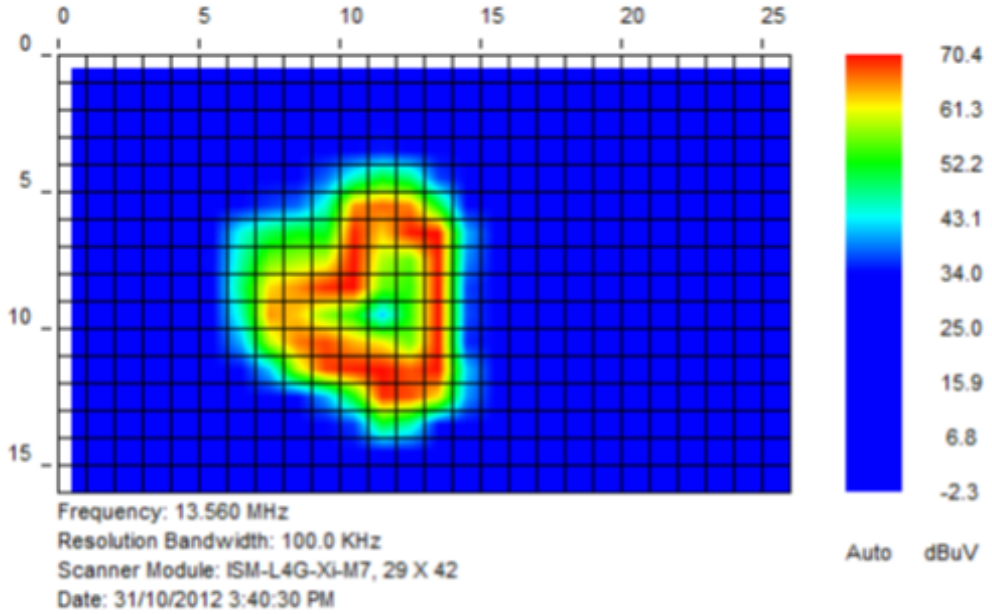
Other Applications

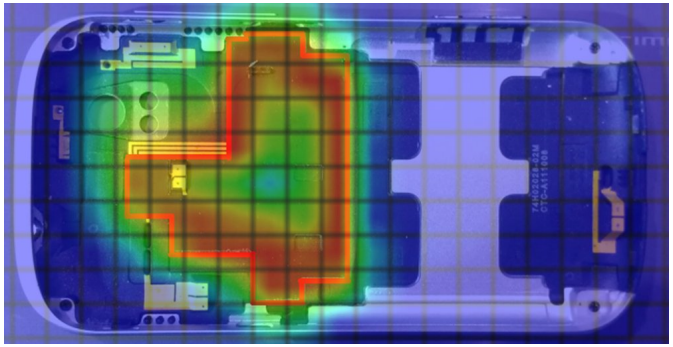
Beyond EMC Compliance

NFC Antennas

- Measure the field strength at specific distances

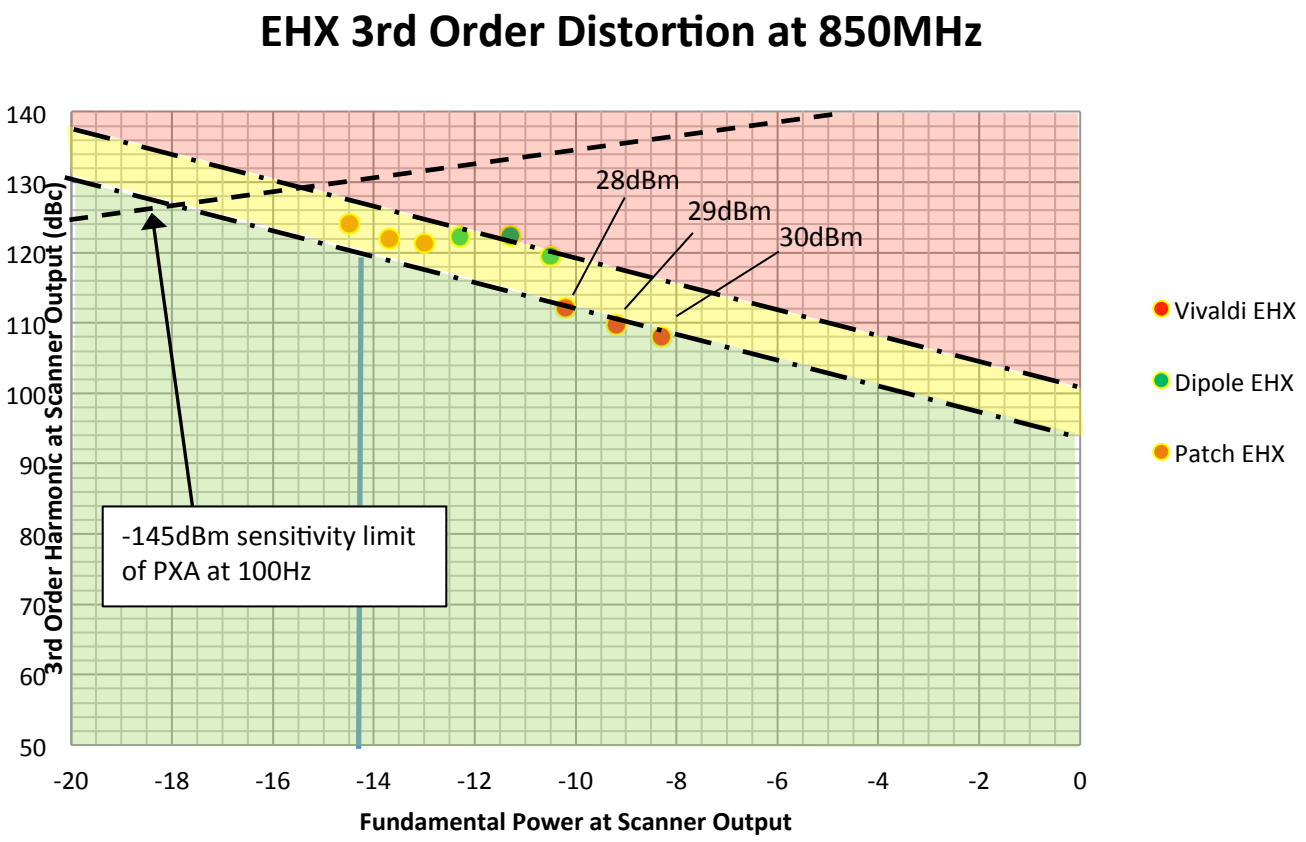






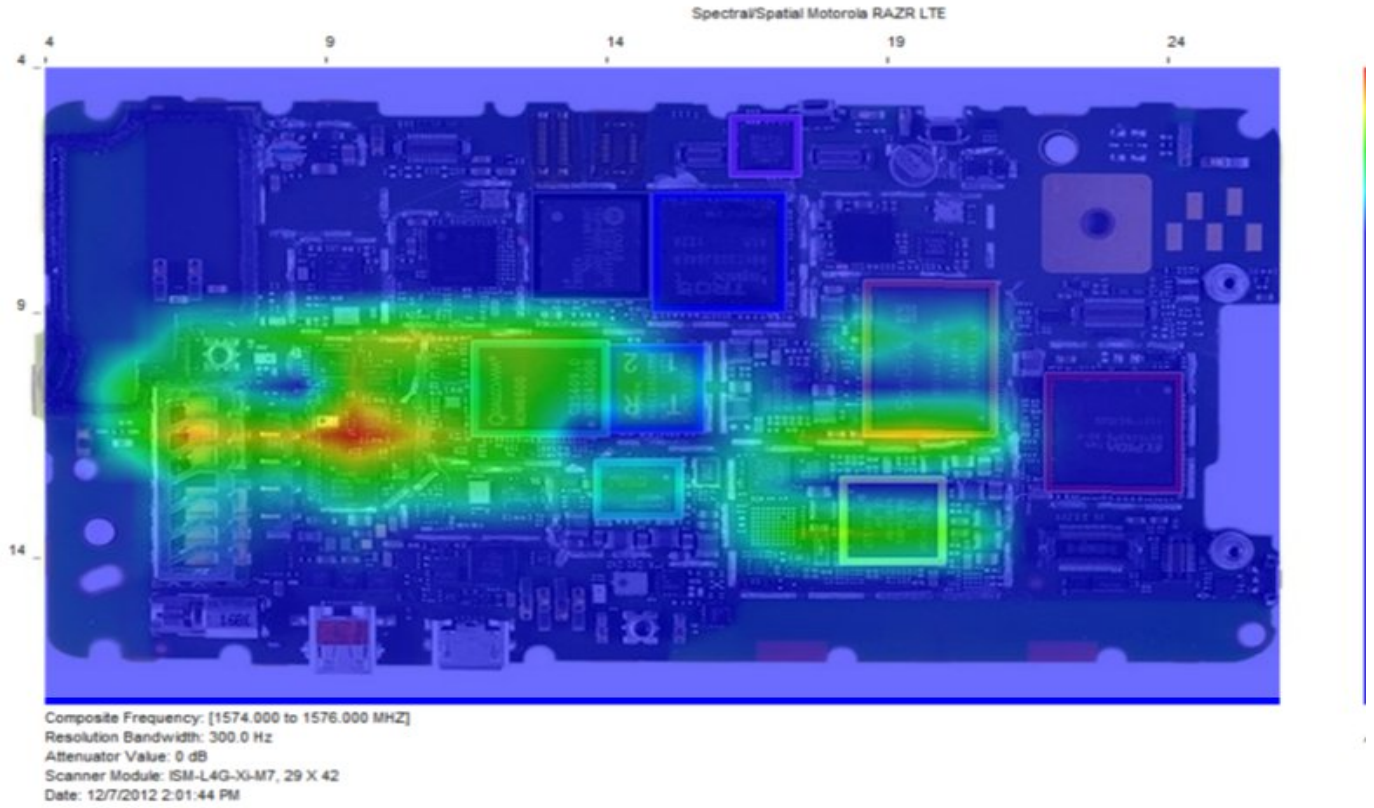
Distortion and PIM Testing

- Scanner linearity can be better than -120dBc



Measure Self-Interference (Desense)

- Sensitivity of the system can detect emissions from a conducted power as low as -135dBm



Noise generated at 1575.039 MHz while camera is active harms GPS performance