ELECTROMAGNETIC SCANNING

Root-Cause Diagnostics

EM SCANNING

Demonstration

The Need

Solution – EM Scanning

Continuing Role

Electromagnetic Scanning

Applications

Optimal Configuration

Return on Investment

Future of EM Scanning

H vs E - Near Field Scanning

FF Prediction/Wireless

Emscan Corporation

A DEMONSTRATION

A demonstration was conducted using Emscan's Electromagnetic Scanning system to find frequencies of interest and to show where the current loops were flowing on the devices under test.

THE NEED

Today's designers need to Design-in EMC and Identify EMC Problems early in the design cycle to:

- Optimize designer productivity
- Reduce design and compliance cost
- Get to market fast

THE SOLUTION

ELECTROMAGNETIC SCANNING

- Maximize designer productivity
- Focus on solving not finding EMC problems
- Get immediate feedback of effectiveness of corrective measures
- Reduce the number of board spins

CONTINUING ROLE

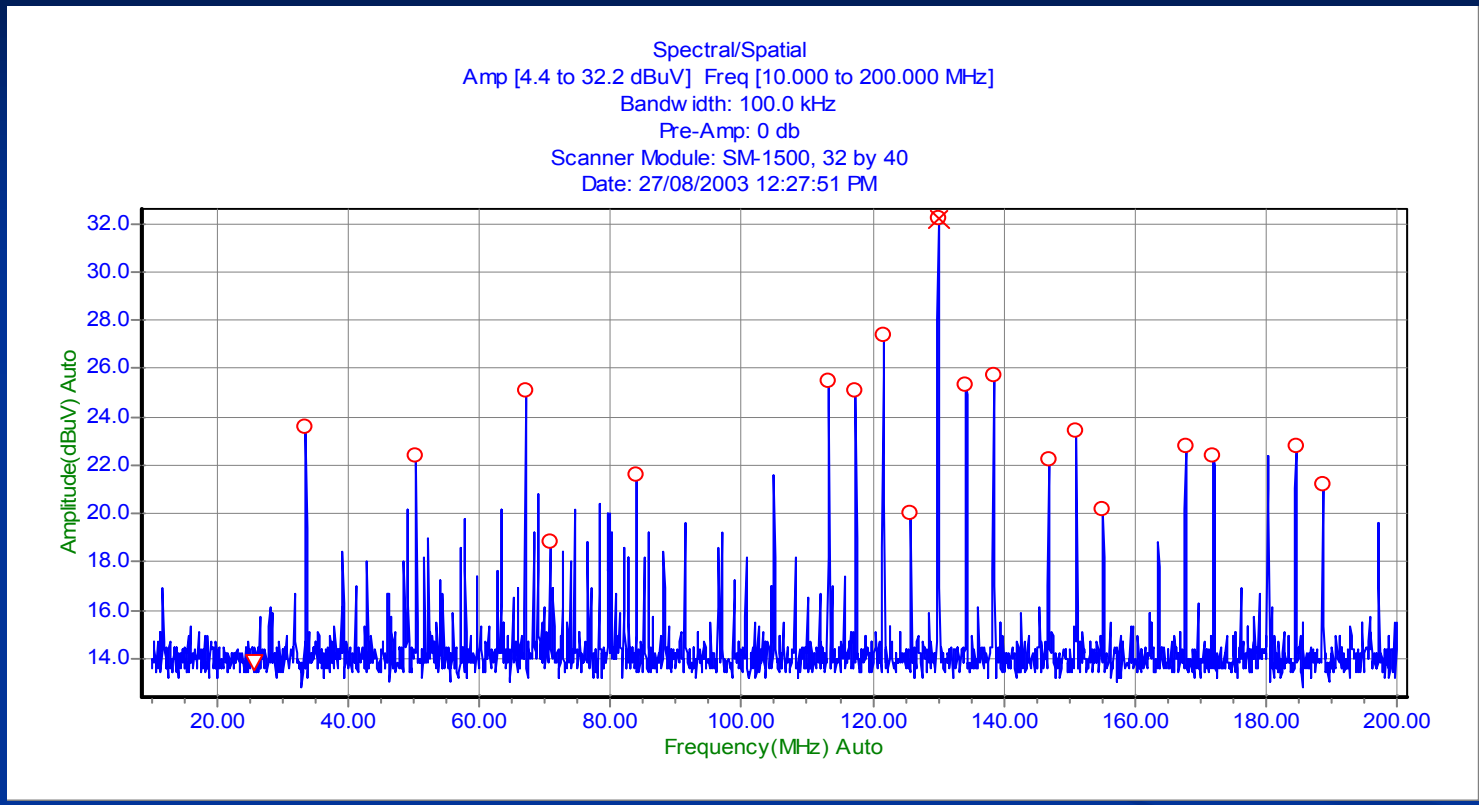
Electromagnetic Scanning can play a vital role during the:

- Design Development Phase
- Cost Reduction Phase
- Sustaining Phase

EM SCANNING

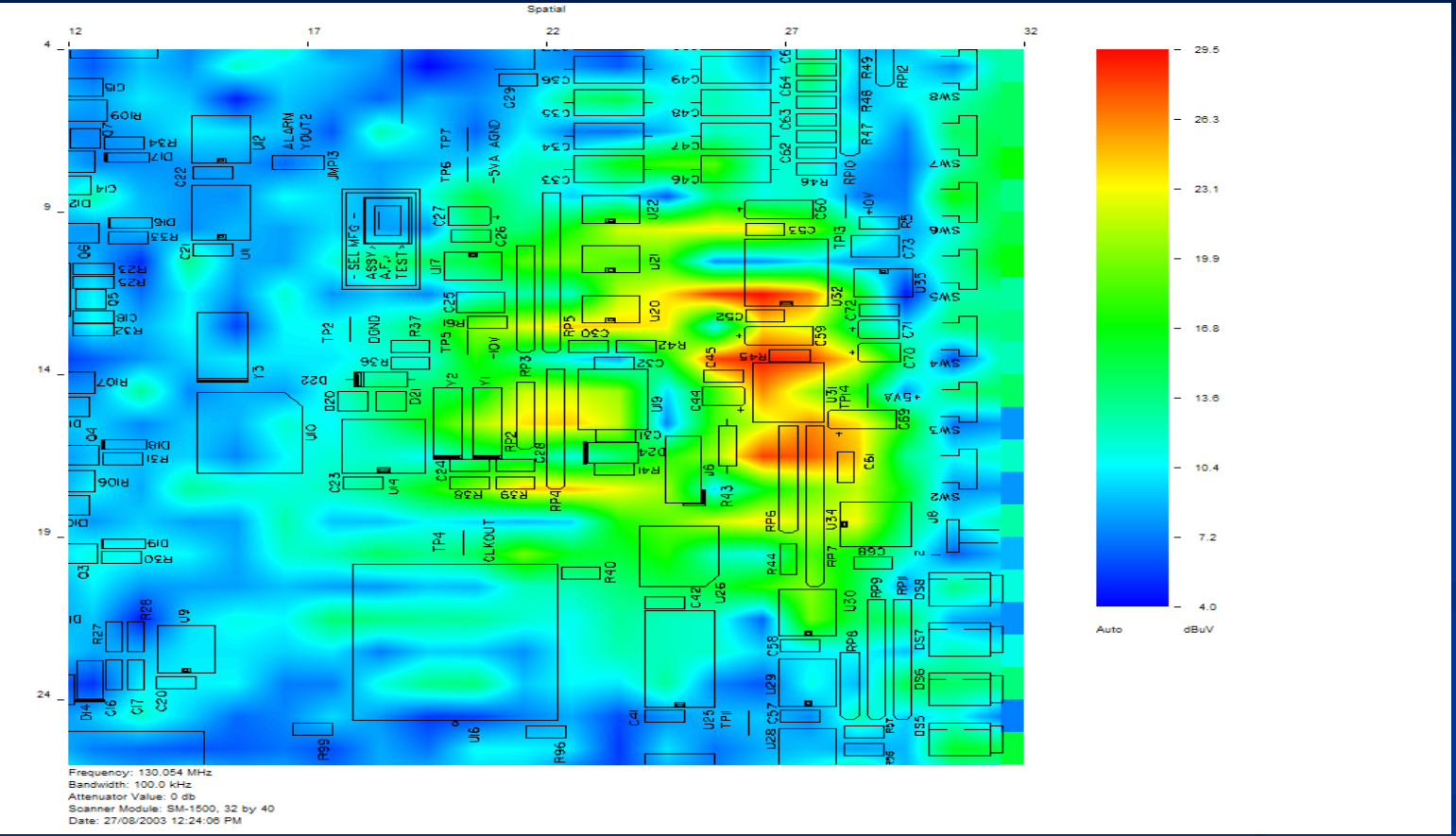
- Frequencies of Interest
- Location
- Analysis
- Archiving
- Reporting
- Visualization
- Speed and Time

FREQUENCIES OF INTEREST



Plot the peak signal amplitudes at all frequencies in the scanned range for the PCB.

LOCATION



Isolate and map a problem frequency to determine the location and intensity of current loops and hot spots.

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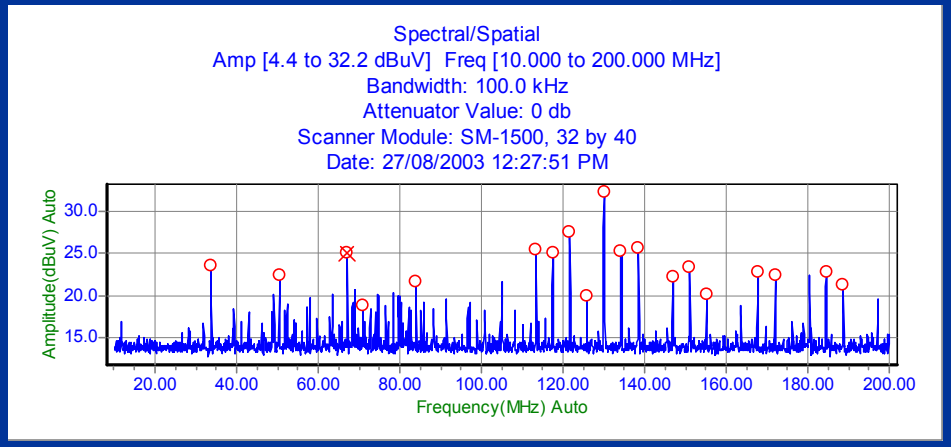
ANALYSIS

- Subtract the ambient signals
- Compare pre to post-remediation scans
- Multiple frequency analysis
- Multiple location analysis

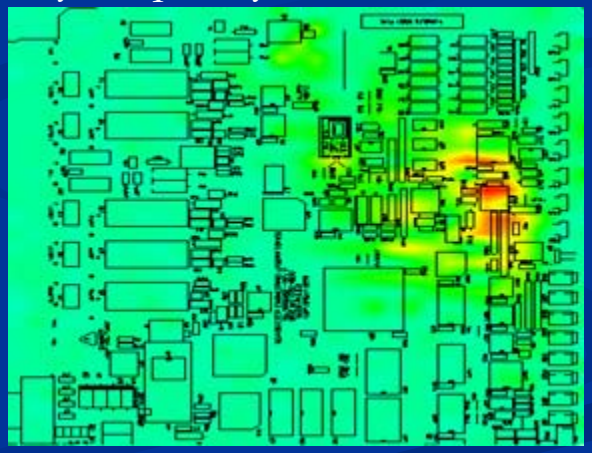
SPECTRAL/SPATIAL SCAN

Collects and archives all of the frequency, amplitude and location data in one scan

Composite Spectral – Highest amplitude at any location for each frequency



Composite Spatial – Highest amplitude at any frequency for each location



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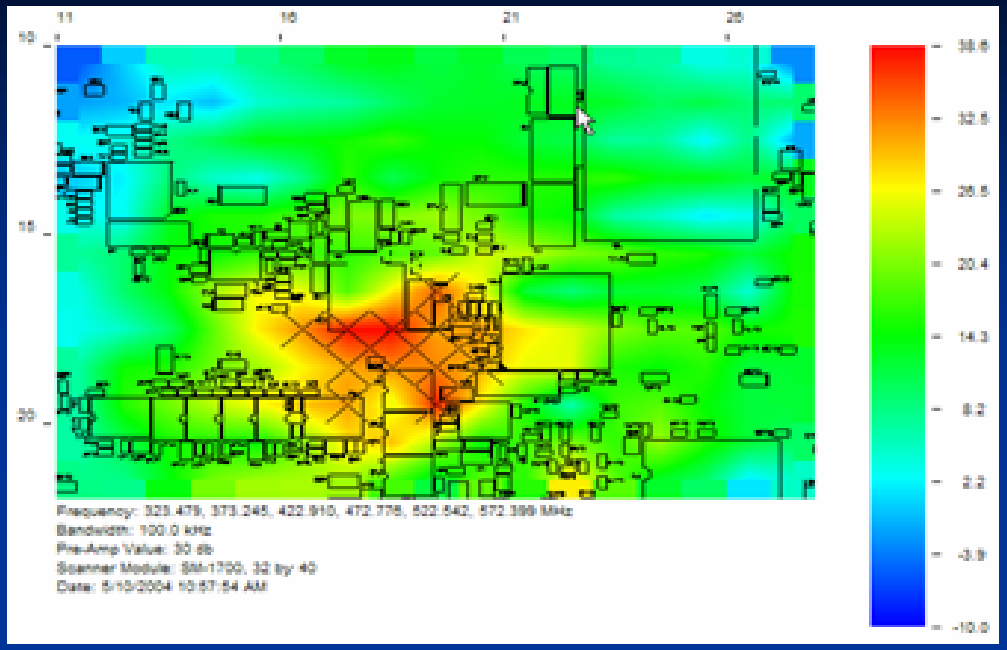
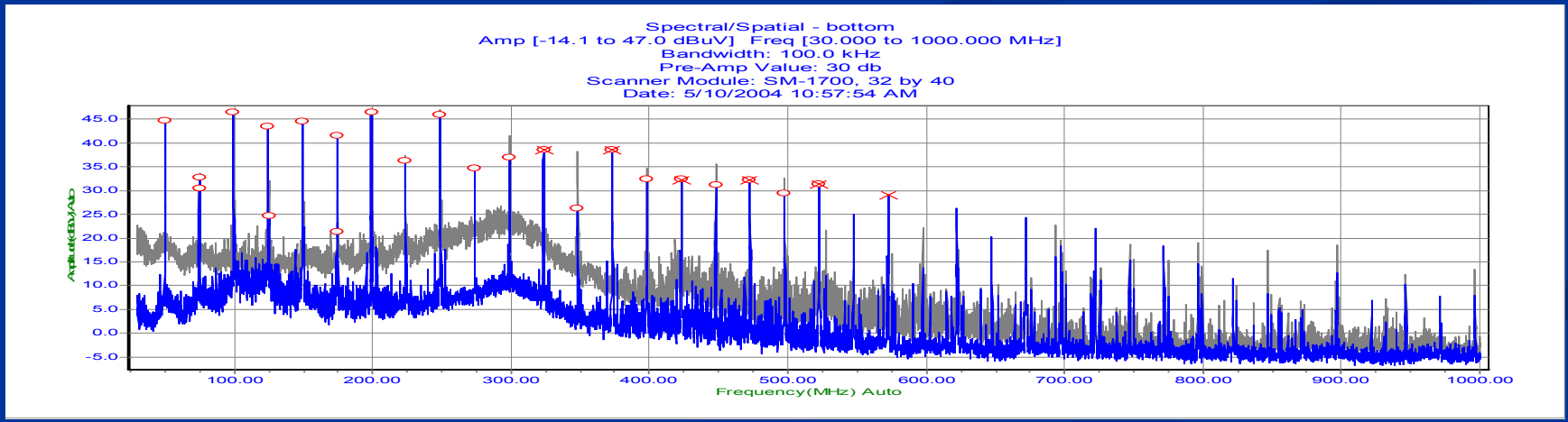
Multiple Locations Marked



Compare sections of the PCB against the overall composite

Locations compared to Composite



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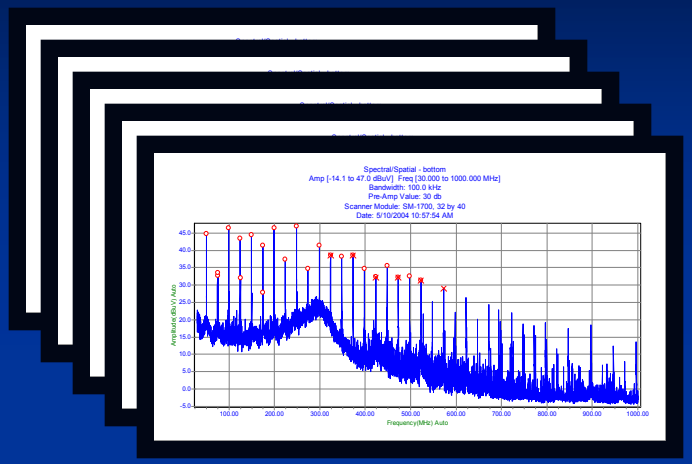
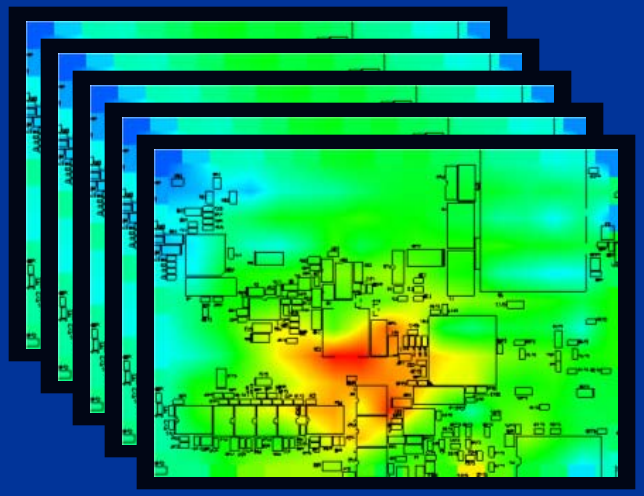
ARCHIVING





- Ability to view the amplitude at each probe throughout a range of frequencies and archive this data for further investigation.
- Particularly valuable for:
  - EMI integrity of component substitutions
  - Development of Technical Construction Files for self-declaration.
- Electromagnetic database for future design changes.

REPORTING

Data is easily exportable as:

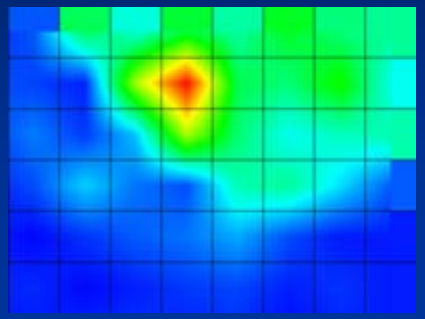
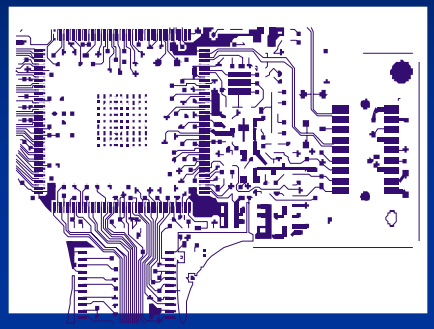
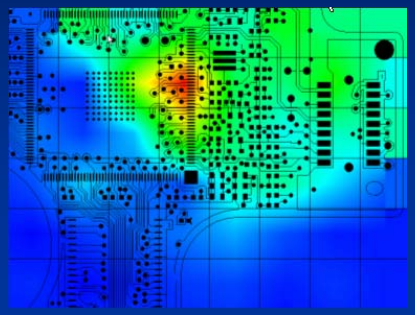
- Bitmaps
- Or spreadsheets by frequency, amplitude and location

POWERFUL VISUALIZATION

Powerful Visualization Tools allow you to:

- View frequencies of interest
- View current loops and hot spots
- Overlays correlate with design features
- Zoom, cross reference, compare
- See time based circuit activity

OVERLAYS

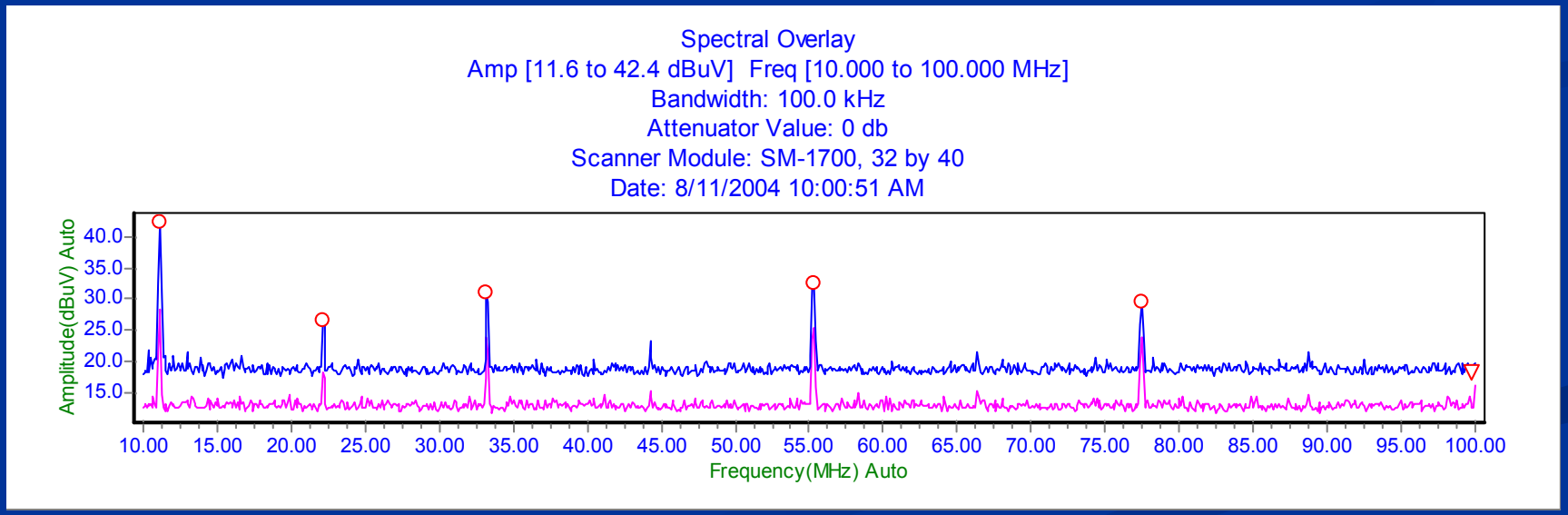




The ability to view the spatial data in direct relation to the board features is a valuable tool.

COMPARISONS

The BLUE scan represents the PCB before a decoupling capacitor was placed next to the power supply.

The RED scan shows a a sizable reduction in amplitude.



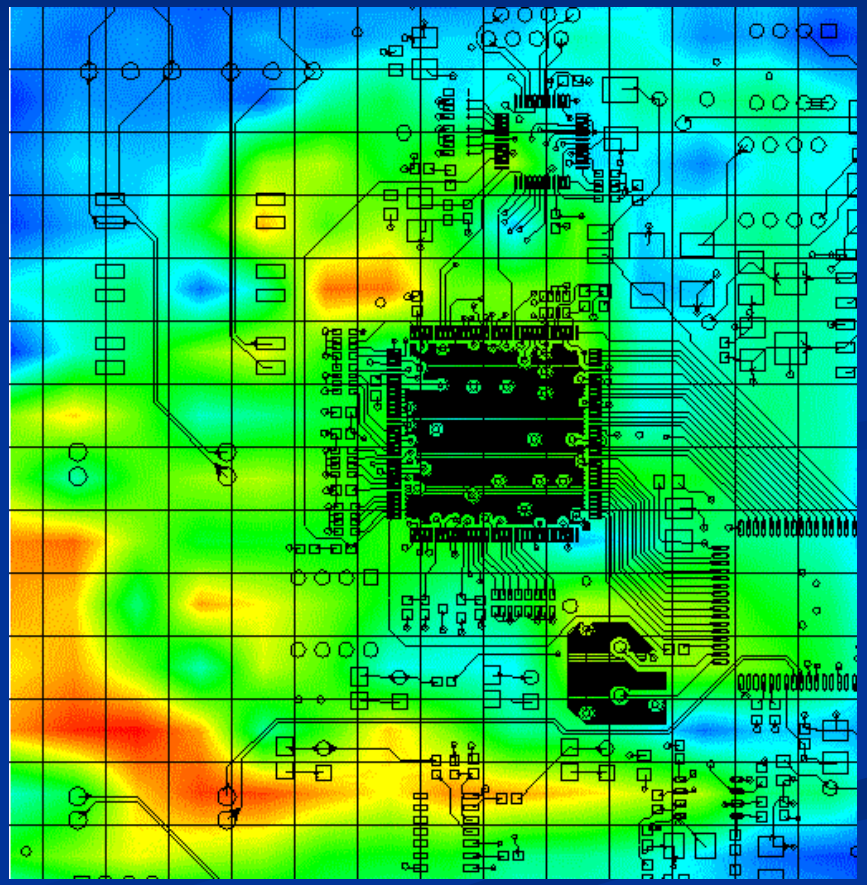
SPEED & TIME

Speed of data capture is a time saver but the real benefits of fast scanning are:

- Capturing time based events
  - Intermittent signals
  - Software based events
- Synchronizing the scan so that each location is scanned at the point in the software cycle
- Immediate feedback re: corrective measures
- Gathering a large archive of data, quickly

CONTINUOUS SCANNING

Creates an image that is refreshed 4 to 8 times per second.



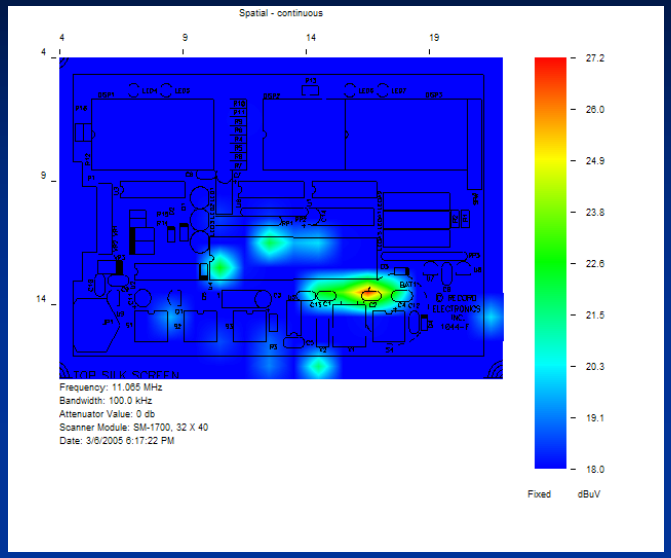
CAPTURING TIME BASED EVENTS

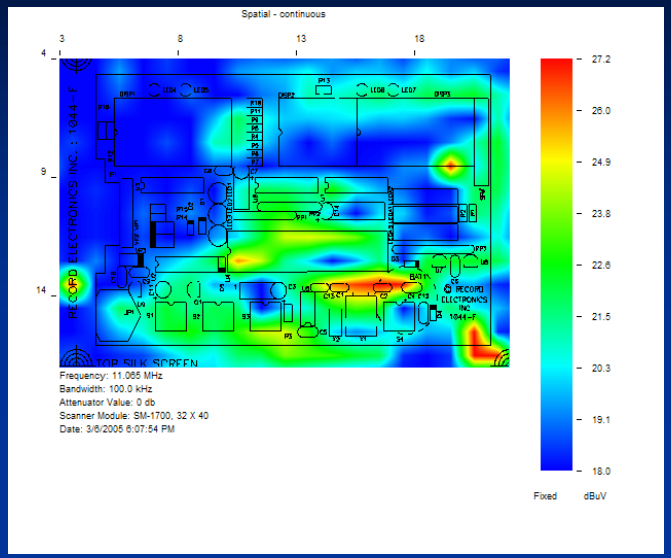
Peak hold enables you to quickly and reliably capture the cumulative picture of:

- continuous
- non continuous
- random or intermittent current loops

Once captured these events can be further investigated and compared.

SINGLE VS CONTINUOUS

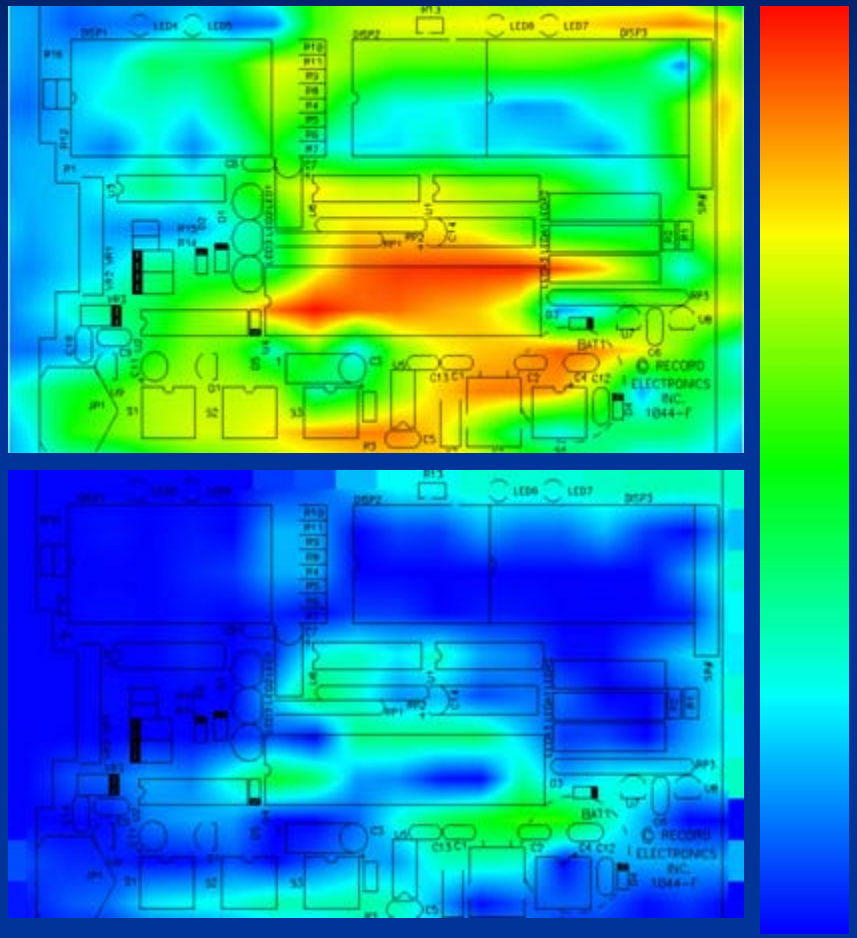




- Peak Hold
- At many locations the single scan does not capture the high amplitude data that is present on a periodic basis
- All PCB's have software events this feature is vitally important to gather the highest quality data possible

IMMEDIATE FEEDBACK

BEFORE



AFTER

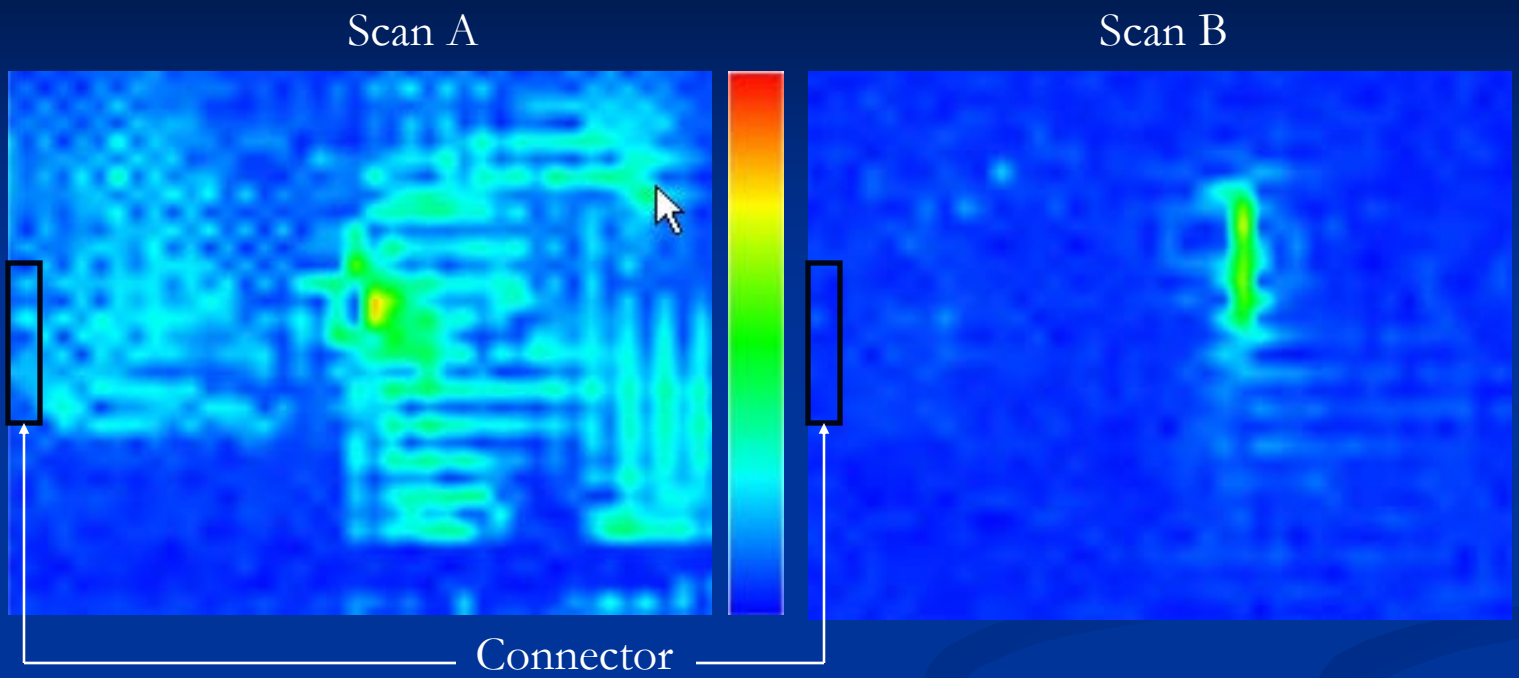
Changes to the PCB can be assessed immediately and completely.

APPLICATIONS

APPLICATIONS

- Evaluating Filters
- Switching Power Supplies
- Common Harmonics
- Evaluating Shielding
- Common Mode Radiation
- Multi-layer Boards
- Conducted Immunity
- Radiated Immunity

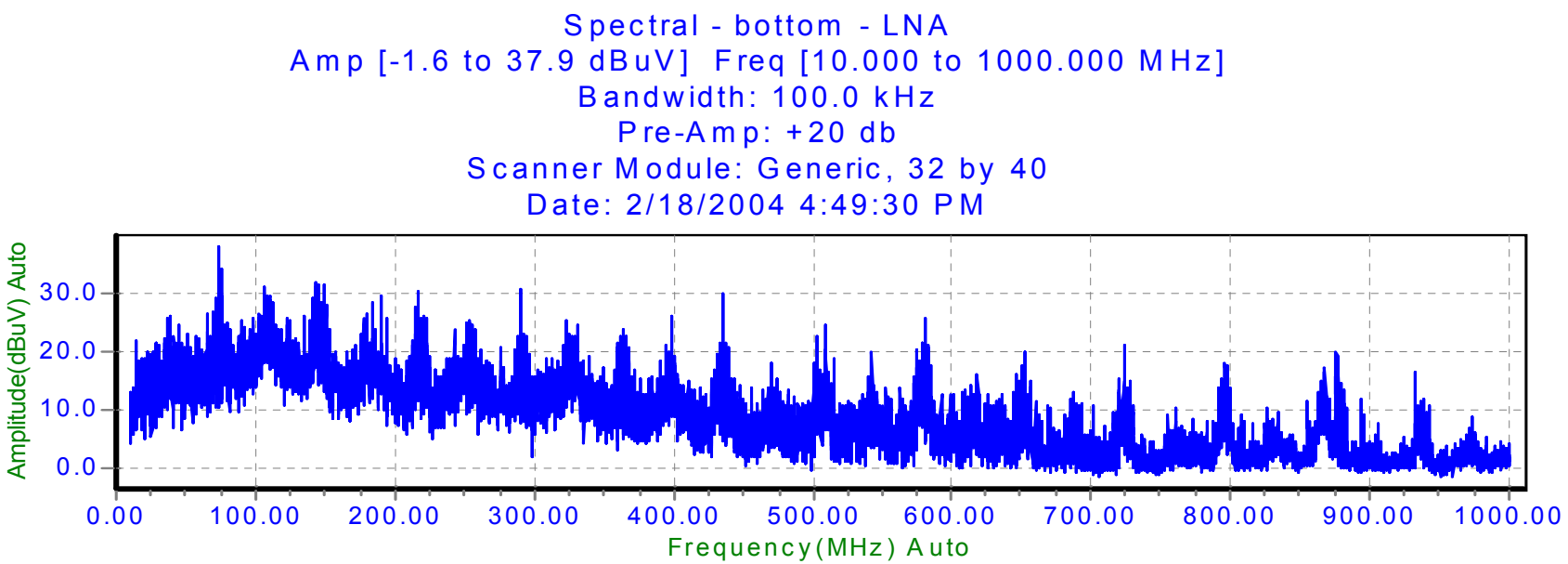
EVALUATING FILTERS



The the filter used in Scan A is inadequate. The filter in Scan B is better.

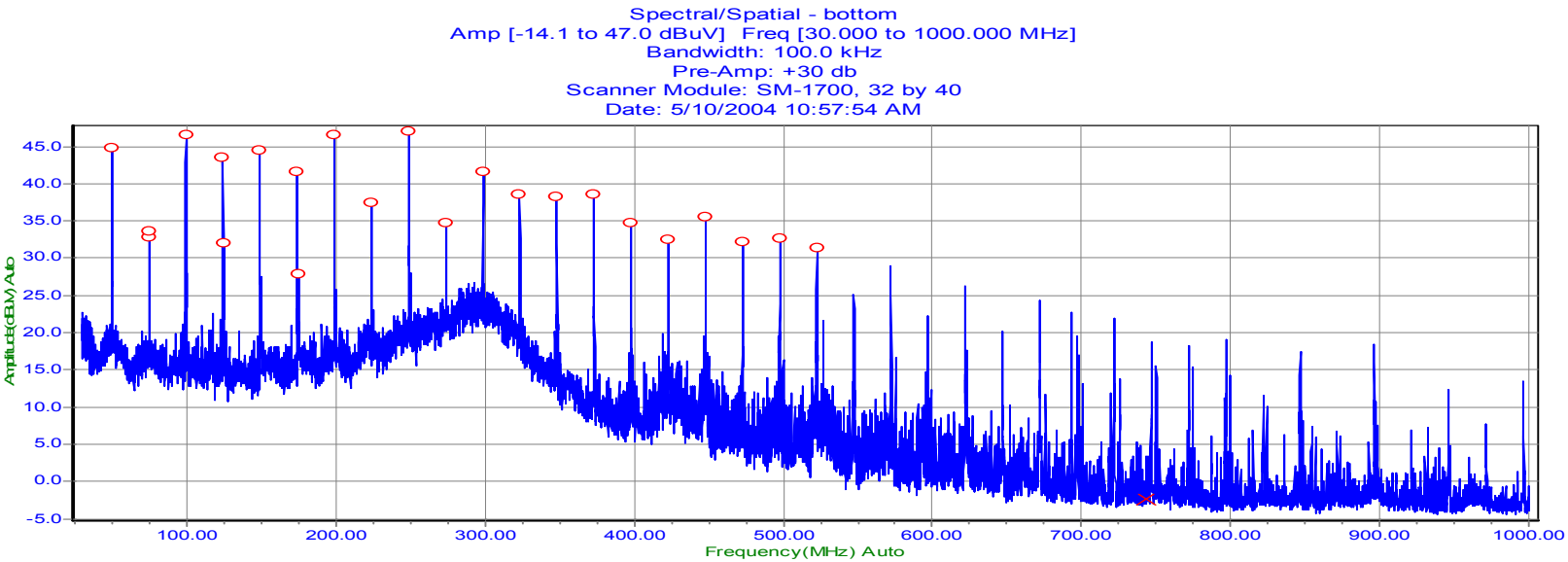
- It reduces the low amplitude noise
- It does not allow this noise to couple onto connectors causing common mode problems

SWITCHING POWER SUPPLY



A noisy SMPS can create a broadband signal on which the fundamental and harmonics of higher frequency clocks are added

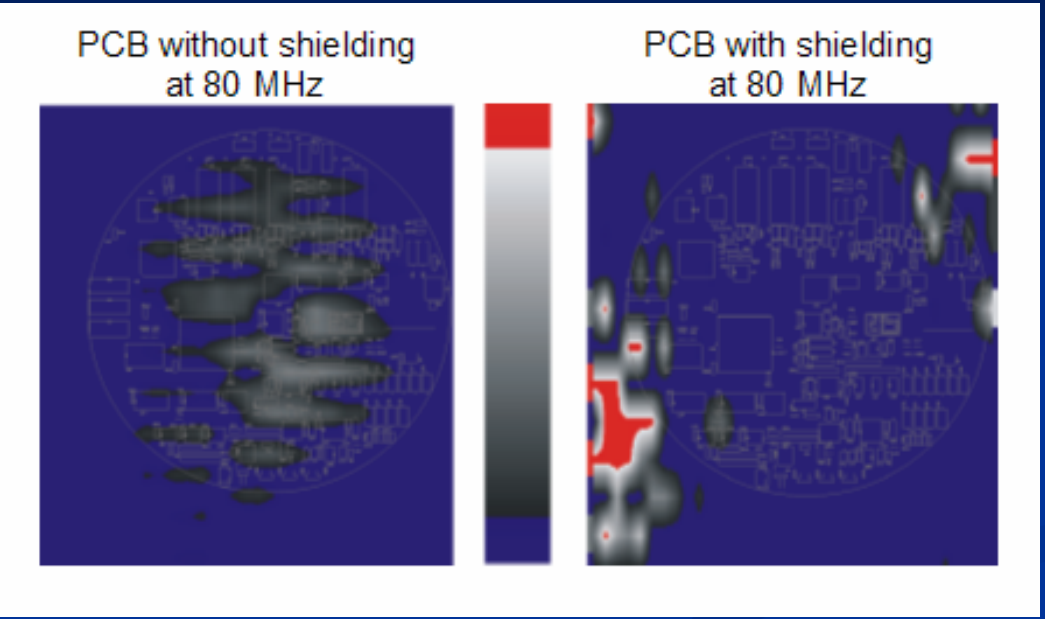
COMMON HARMONICS



In this example clocks at 25 MHz and 50 MHz cause a cumulative effect at the odd harmonics of the 25 MHz signal.

This cumulative effect can be as much as a 6 dB increase

EVALUATING SHIELDING



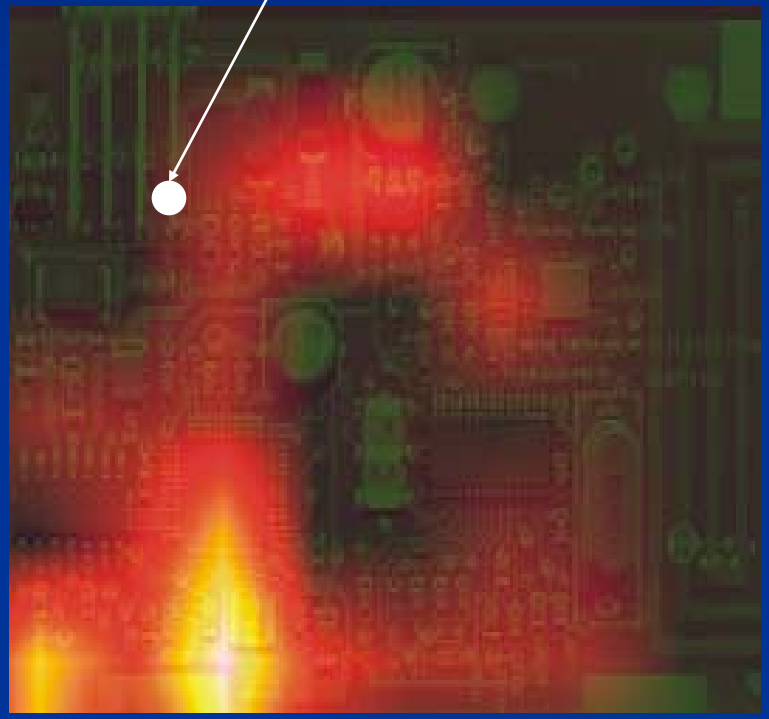
- Shielding effectively blocked most emissions across a broad span
- At 80 MHz an edge effect caused emissions of 38 dBuV at the connectors
- This was 12 dB higher than the board without shielding

COMMON MODE RADIATION

- When differential mode signals couple onto connectors they create common mode emissions on the cables
- The cables create a very large antenna
- CM far greater impact (up to 100,000 times) than DM
- Finding the current path from the source to the cables is paramount in solving EMI problems

COMMON MODE CONT'D

Noise being coupled on to the connectors



Low amplitude emissions coupling onto connectors

High speed EM Scanning shows:

- where and how Differential Mode currents are coupling onto connectors
- creating Common Mode radiation on cables or back planes.

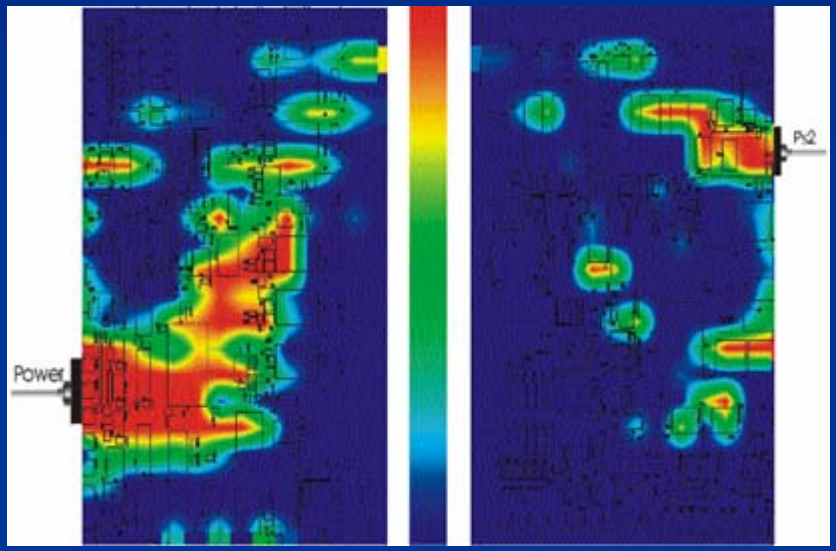
MULTI LAYER BOARDS

- RF current flows originate at a source and flow through a load then return to the current source via the path of least impedance
- Problem EMI will always appear on the primary or secondary surfaces at the source and the load.
- The current loop may travel into the hidden layers to the load or back to source.
- Emscan systems will show the resulting current loops as they exit the hidden layers and are coupled onto the source or the load.

CONDUCTED IMMUNITY

Signal Coupled to Transformer Output

Signal Coupled to the ps2 Cable

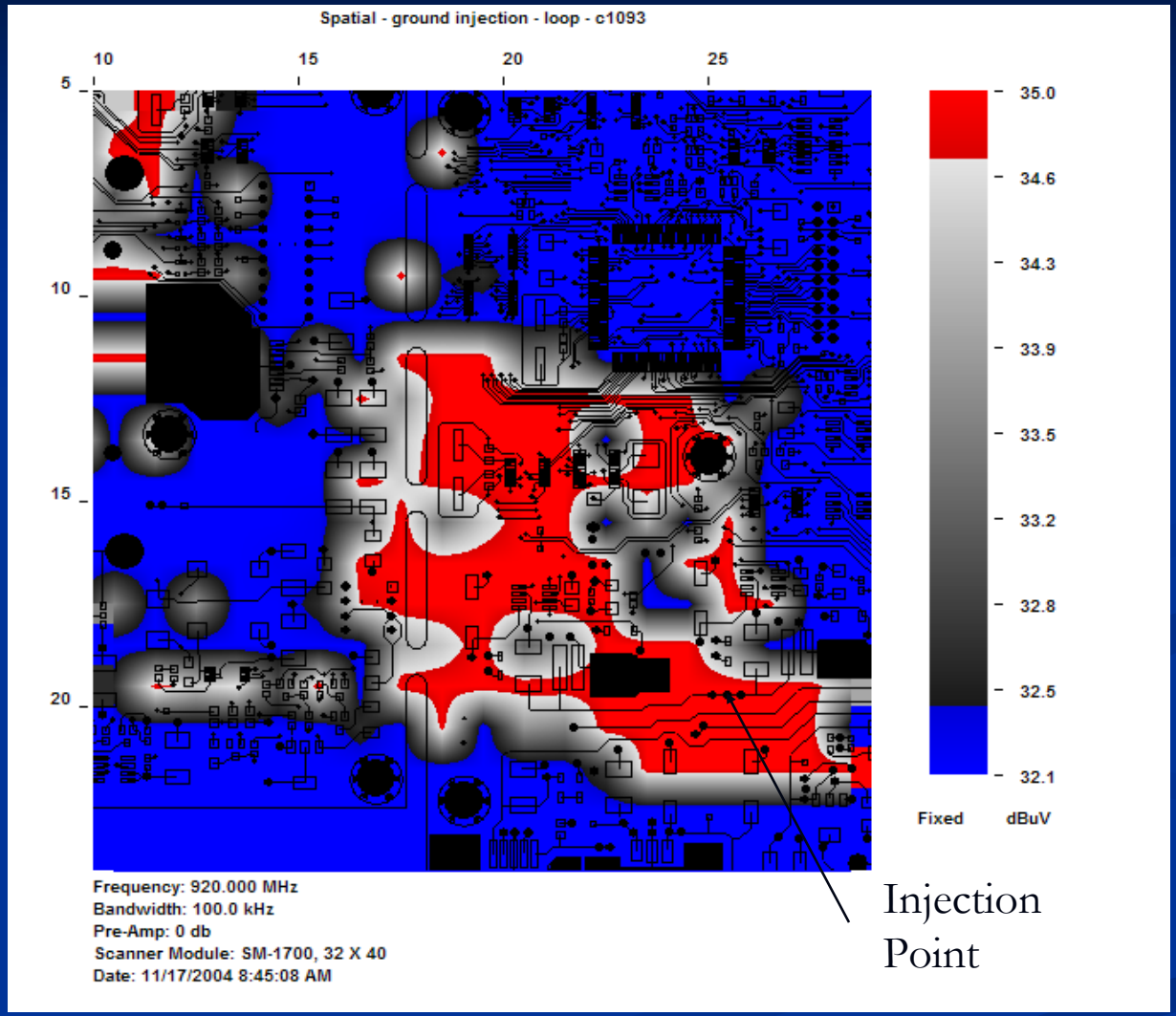


High speed EM scanning shows how injected RF signals flow onto a PCB.

The designer can then relate these high amplitude currents to sensitive structures (microprocessor latch up and reset)

High speed EM Scanning provides you with an archive of the resultant current flows across a wide frequency span.

RADIATED IMMUNITY



OPTIMAL PRE-COMPLIANCE CONFIGURATION

OPTIMAL PRE-COMPLIANCE CONFIGURATION

- Chamber – or other source of far field measurement
- Emscan – to locate the source of the emissions
- Current Clamp – measure the field strength that has coupled onto cables

Together these 3 elements present the optimal pre-compliance configuration for solving radiated emission problems

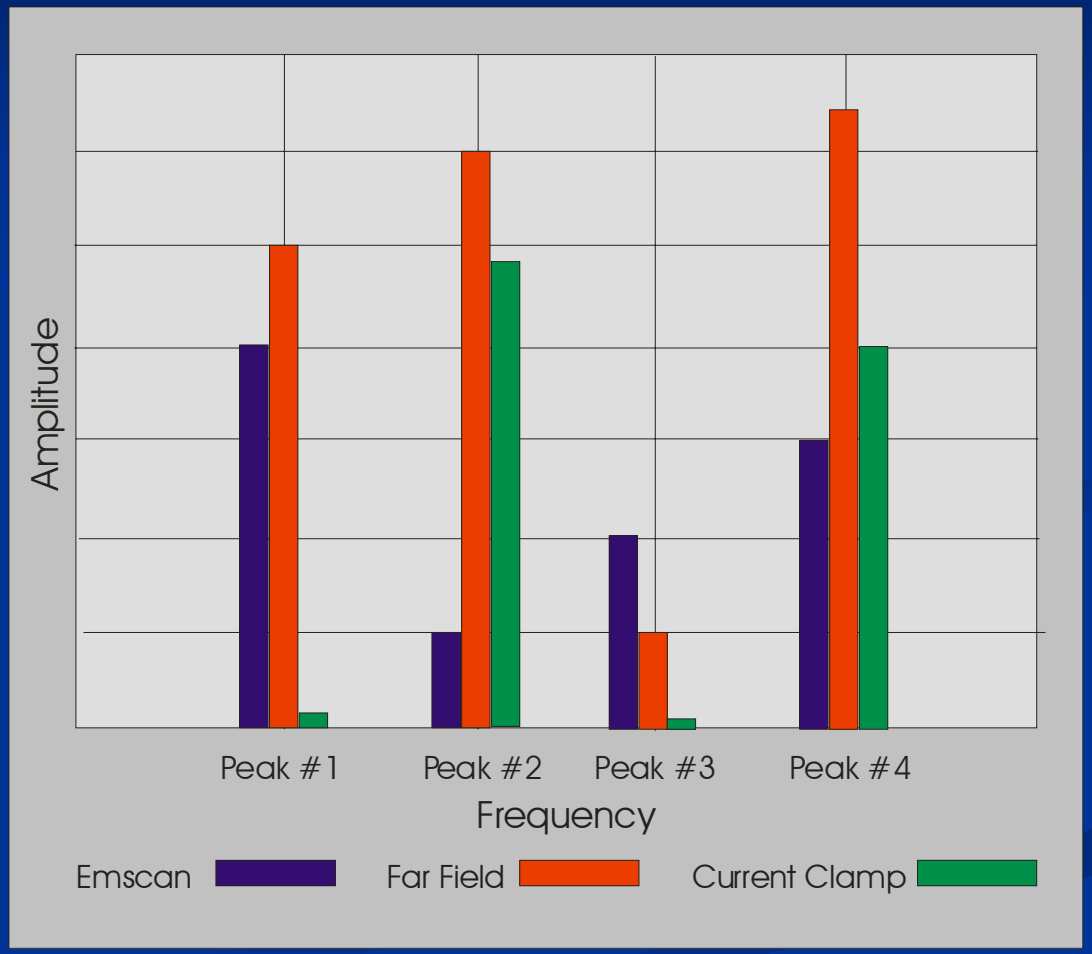
SAMPLE OUTCOMES

Peak #1 – strong radiator on PCB

Peak #2 – low amplitude PCB radiator coupling to connectors

Peak #3 – single radiator on PCB dissipates before far field

Peak #4 – radiator on PCB and couples to connectors



EMSCAN RETURN ON INVESTMENT

Save Money - Protect Your Profits - Keep Top Designers

COST REDUCTION

- **Design and development phase**
  - 1 board spin – savings $10,000 to $65,000
- **Cost reduction phase**
  - 1 board spin – savings $10,000 to $65,000
- **Sustaining phase**
  - avoid regulatory retesting due to component changes, process changes and supplier substitutions $10,000 to $30,000
- **Total Savings - $30,000 to $160,000**
- **Payback Based on Design and Cost Reduction Savings**
  - Payback on 1 design (average Emscan cost is $30,000)

ENGINEERING COSTS

- Faster identification of potential problems faster
- Saving board spins in the design phase, cost reduction phase and sustaining phase
- Result - at least 1 man month of engineering is saved.

What is your fully loaded cost for 1 man month of a top design engineer?

TIME TO MARKET SAVINGS

- The Law of Life Cycle Profits
  - a 4 week delay getting to the market results in a loss of profit margin equal to the 4 most profitable weeks of the entire life cycle of your product
- Estimate – Protect 8% of your profit margin
  - For a 2 year life cycle if the 4 most profitable weeks are twice as profitable as the average week, a $30,000 investment in an Emscan would protect 1/24 x 2 = 8% of your profit margin

PRODUCTIVITY & CREDIBILITY

Delays due to EMC cause:

- Increased pressure
- Lost credibility for the design engineer and the department
- Reduced job satisfaction which could lead to turnover

FUTURE OF EM SCANNING

- Automate collection of current clamp data
- Insert-able scanner
- System level scanning
- Higher and lower frequency
- Far field prediction for wireless devices (very precise)
- Report generation

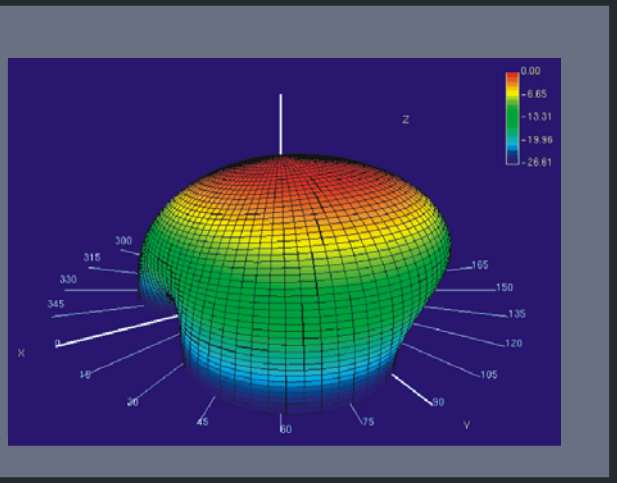
Near Field to Far Field

- Correlation – varies with
  - Distance
  - Phase
  - Common Mode
- Ideal combination – Emscan + current clamp + far field measurement (chamber or antenna) =
  - optimal NF/FF correlation
  - location of offending signals
  - insight toward correction

H vs E Field for Near Field Scanning

- Our scanners detect predominately H field emissions. Some E field emissions are sensed.
  - H field measurements provide much more comprehensive spatial mapping
  - H field probes provide greater sensitivity
  - Both probe types are likely to detect problem frequencies except that: unintended current sources (and their associated spatial maps) leading to common mode radiation, may not show up with an e field probe.
- E Field Probes have the following limitations:
  - Most simple single e field probes pick up only Ez –whose contribution in the far field is minimal.
  - More complex E field probes have larger dimensions, must be rotated to capture Ex and Ey, and don't lend themselves to higher-resolution applications
- To date we have felt that our H field measurements are the best choice and therefore have not built an array of e field probes.

NEAR AND FAR FIELD MEASUREMENT OF WIRELESS DEVICES



- Production and Designer Testing
- High accuracy/high repeatability
- Optimize integrated radio/ antenna designs
- Measure
  - ⇨ Radiated Power
  - ⇨ EIRP, Directed Gain
  - ⇨ 2D/3D NF Patterns (polarization)
  - ⇨ 2D/3D FF Patterns
  - ⇨ F/B Ratio, Beam Width