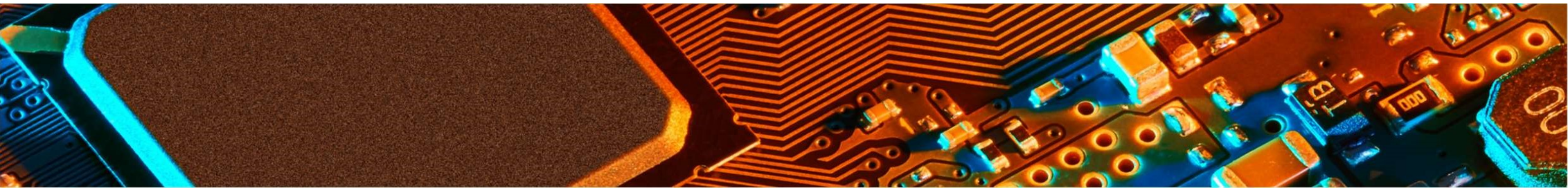
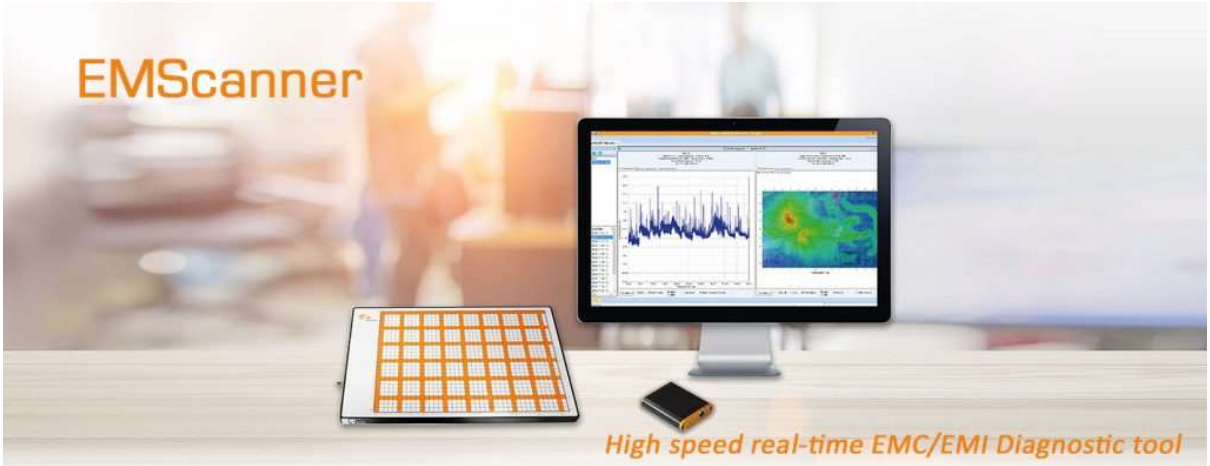


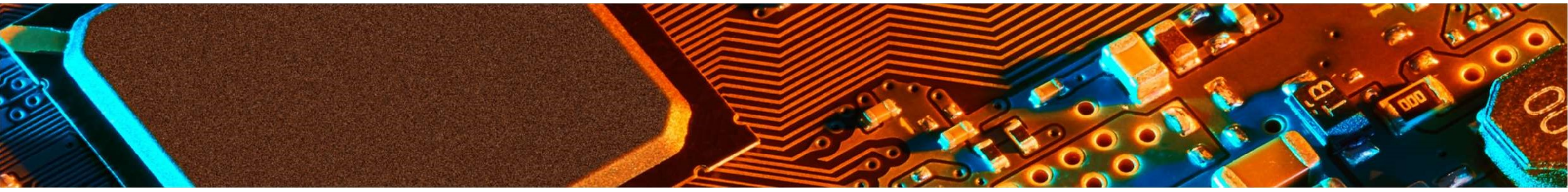
Application Note

May 2021

EMScanner

How to Diagnose Board-Level Design Issues Using Very-Near-Field Measurements





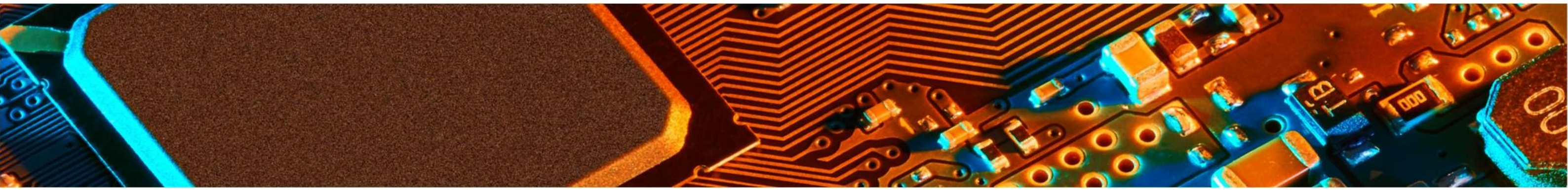
Application Note EMScanner
May 2021 – Yoram Shimoni

How EMScanner Diagnoses Board-Level EMC Design Issues

ABSTRACT

The EMScanner provides board-level design teams with world-leading fast magnetic very-near-field data to help diagnose EMC design challenges. The instrument captures and displays visual images of spectral and real-time spatial scan results in seconds. PCB designers can now scan any board to identify both constant and time-based emission sources in the range of 150 kHz to 8 GHz. This report provides examples of the following types of EMC design issues: filtering, shielding, common mode, current distributions, immunity, and broadband noise as well as non-EMC uses of the EMScanner.
Audience: PCB Design Teams including designers and verification engineers.

CONTENTS

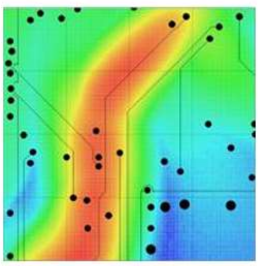
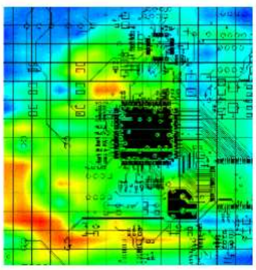
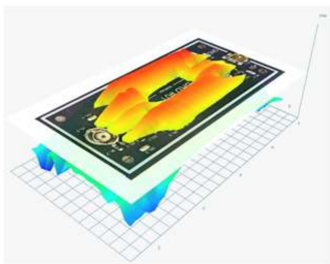
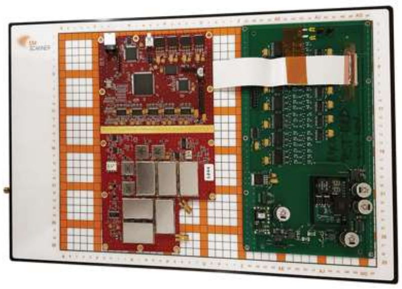


1. Introduction

The EMScanner provides unique pre- and post-EMC compliance testing that images emissions in less than a second. This allows the design team to immediately analyze and compare design iterations. During any new PCB development process, design engineers must find, characterize, and address unintended radiators or RF leakage to pass compliance testing. Ideal PCB projects for the EMScanner are boards designed for high speed, high power, and/or high density/complexity. Any PCB that places a premium on the board real-estate also qualifies as an excellent candidate. The EMScanner allows engineers to visualize the root causes of potential EMC and EMI problems. The patented scanner delivers repeatable and reliable results that pinpoint the cause of a design failure.

As a result, the user can personally test the design without having to rely on another department, test engineer, or time-consuming off-site testing. After diagnosing even an intermittent problem, the engineer can implement a design change and retest. The results provide concrete verification of the effectiveness (or not) of the design change. The EMScanner allows board designers to pre-test and resolve EMC and EMI problems, thus avoiding unexpected EMC compliance test results. The patented scanner's diagnostic capabilities allow design teams to reduce emission testing times dramatically.

EMScanner users have also documented 50 percent reductions in design cycle times. The compact EMScanner, provides PCB design teams with an easy-to-use, cost-effective, and proven tabletop solution.
The EMScanner also provides a unique view into non-EMC related issues at the PCB level such as self-interference or NFC performance.

If you can **see it**, You **can fix it**

2. System Description

The EMScanner used in this application report consists of a patented scanner and compact adaptor, and a customer supplied spectrum analyzer and PC running EMViewer software. The bench top scanner combines 2,436 loops into 1,218 H-field (magnetic) probes spaced every 7.5 mm into an electronically switched array, which provides an effective 3.75 mm resolution. The system operates from 150 kHz to 8 GHz.
Note: EMScanner operates with an external spectrum analyzer.

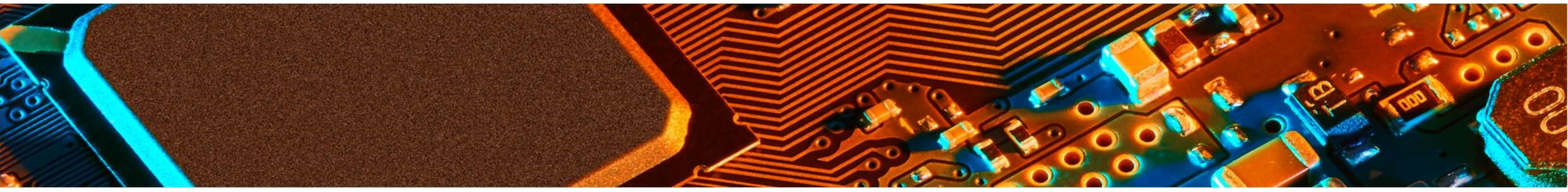
3. Filtering

Determine the effectiveness of a filter in real-time

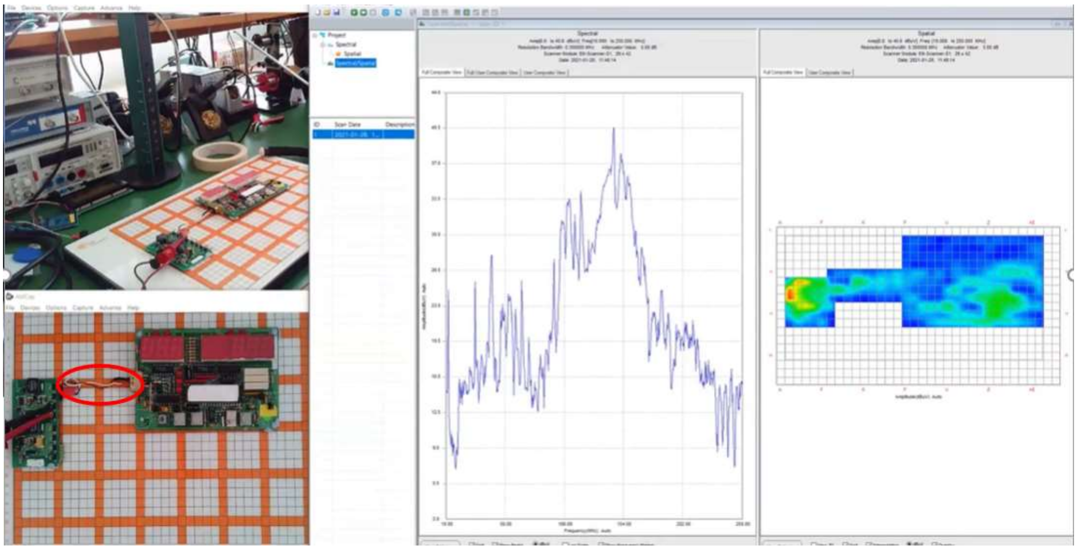
Objective: Identify and resolve EMI issues at their source and measure the effectiveness of filters in real-time.

The relentless trend towards miniaturization in electronic devices requires ever smaller and faster digital electronic devices - with their inherent design challenges. The smaller and more densely populated the board, the more difficult for the design team to control emissions and susceptibility. Ideally, the team can identify emission problems early in the design cycle and prevent unexpected and unpleasant problems later.
Early-stage testing with EMScanner identifies spurious signals in noise sensitive circuits. Strategies to resolve such signals include component filtering, filter-printed circuit board traces, and EMI filtering. By mapping very-near-field emissions generated by current flow on the surface of the board, EMScanner measures the effectiveness of filters. Measurements occur in real-time. This allows the design team to compare different design versions in seconds using the Spatial Comparison capabilities of the instrument.

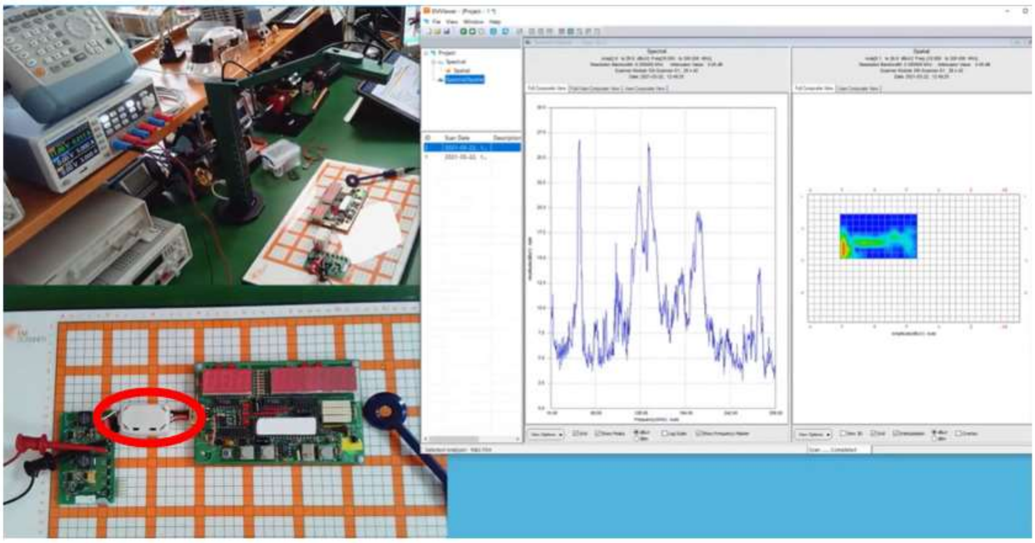
The example spatial imaging below evaluates a PCB from a satellite receiver. The device under test (DUT) is positioned on the patented scanner as shown below. This illustrates the effect of adding a filter on the cables between the power supply and the board. The noise from the mother board is completely gone, substantially improving the noise floor.

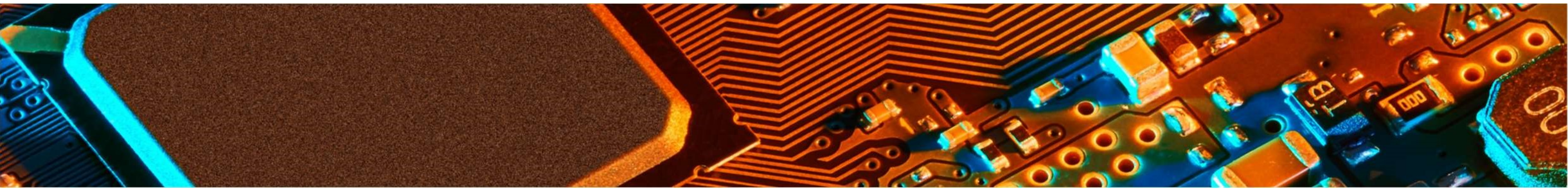


Unfiltered connection to power supply circled in red.



Results in Seconds, after applying the filter





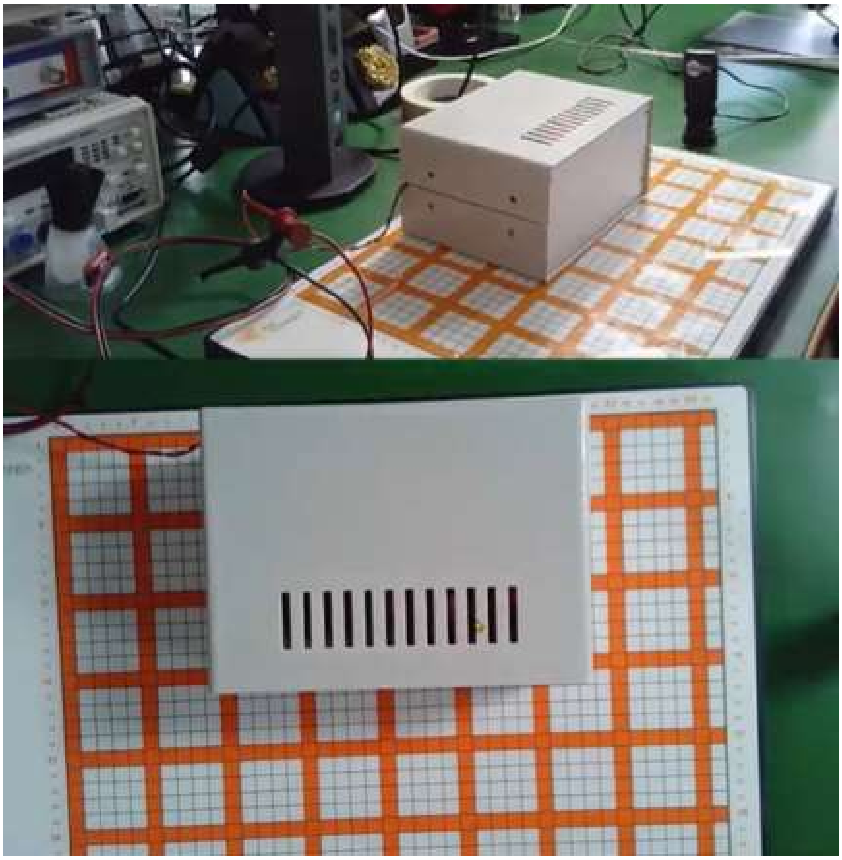
4. Shielding

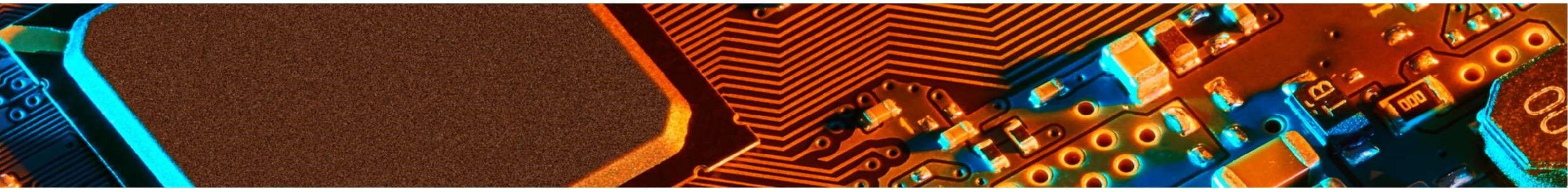
Minimize the susceptibility of noise sensitive circuits in seconds

Objective: Identify EMI problems at the source and measure the effectiveness of shields in real-time.

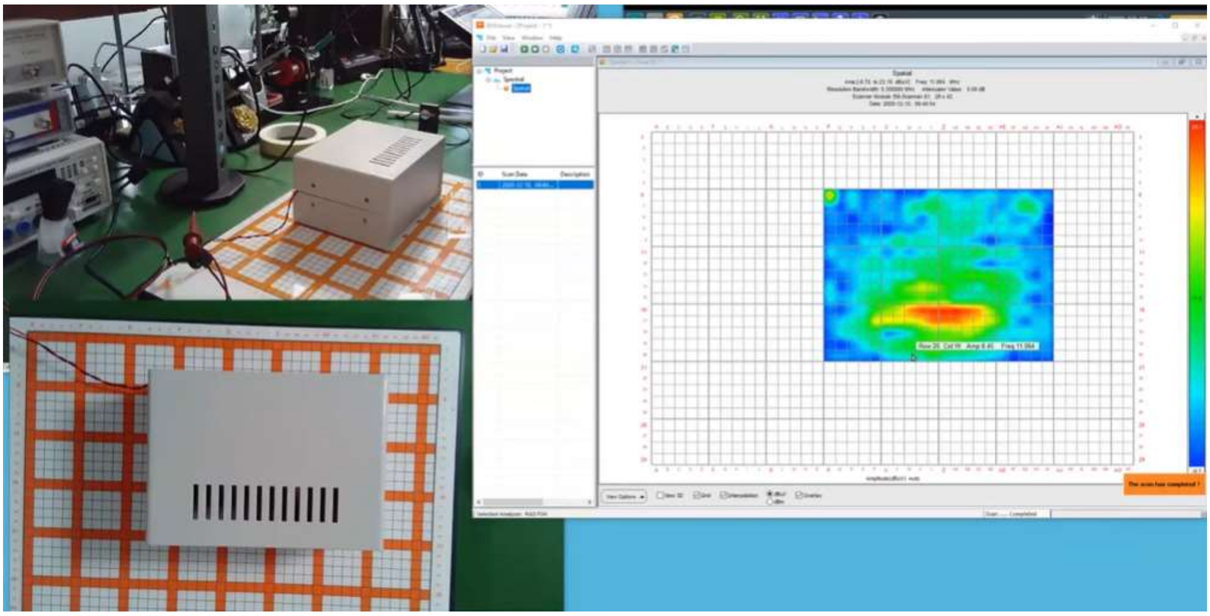
EMI shielding, another noise reduction method, constrains radiating emissions. EMScanner maps very-near-field emissions generated by current flow on the board's surface in seconds. As a result, design teams diagnose and quickly address any unexpected emission problems. The Spatial Comparison tool then facilitates immediate comparison between the shielded and unshielded solutions.

DUT with Shielding

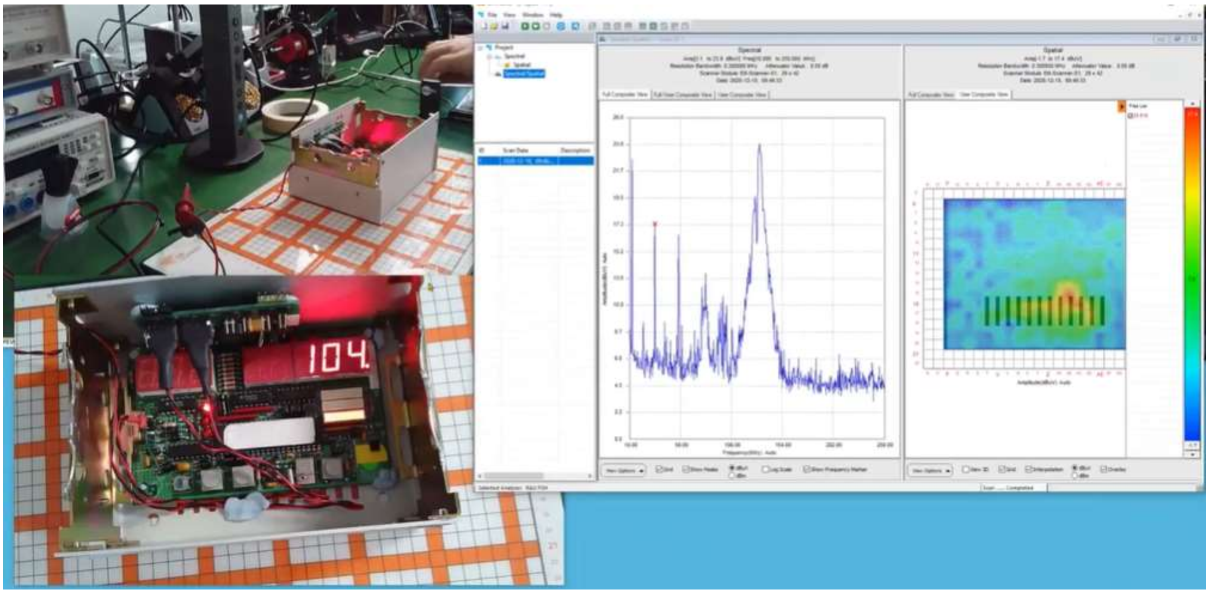




DUT with shielding showing results of a Spatial Scan.



DUT without shielding showing results of a Spatial Scan.

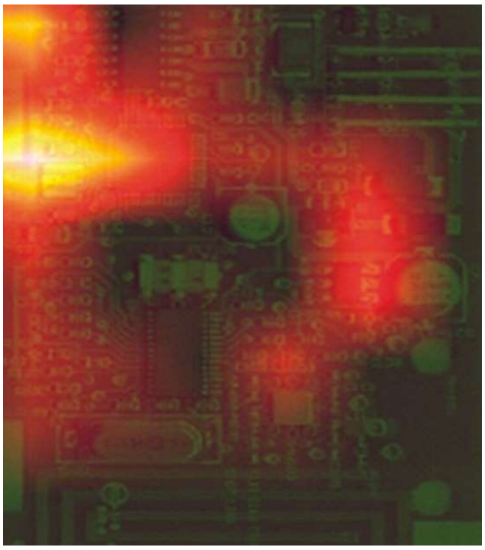


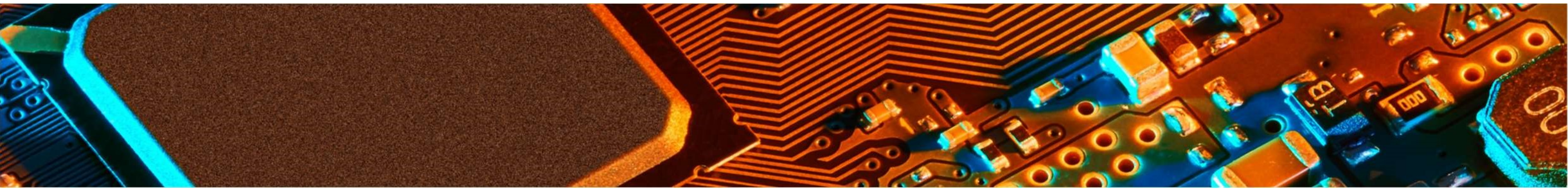
5. Common Mode

Address the coupling at its source in real-time
Objective: Display the common mode current on prototypes prior to EMC compliance testing since common mode current most frequently impacts cables and connectors.

Common mode currents are one of the primary causes of EMI emissions. They appear where they were never intended. EMScanner captures and displays images of the source of common mode current emissions. The instrumentation allows the design team to observe the path and mechanism leading to the creation of common mode currents. If these common mode currents couple onto one or more nearby I/O cables or connectors, it can cause compliance failure by strongly radiating into the far-field. By identifying the coupling at its source in real-time, the engineer can implement mitigation measures. Retesting can confirm the effectiveness of the mitigation.

EMScanner spatial scan showing low level noise coupling onto a connector at the top right.



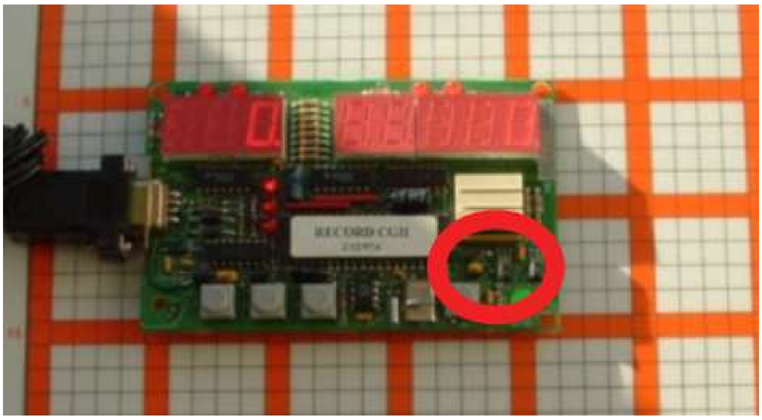


6. Current Distributions

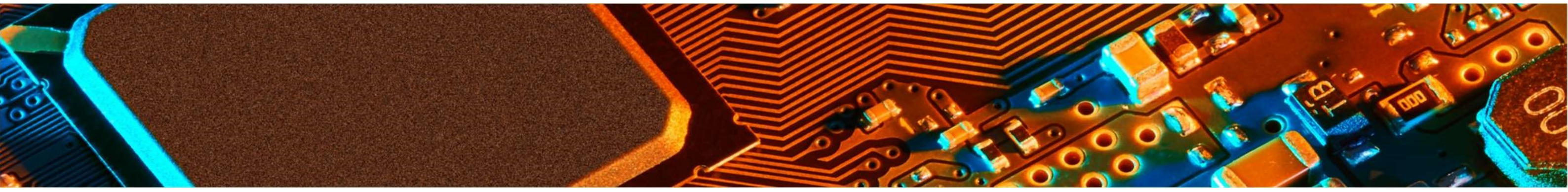
Unexpected EMC compliance test failure increases time-to-market dramatically. Imaging current distributions, the source of EMI emissions, early in the design cycle demonstrably reduces time-to-market.
Objective: Determine how different design modifications affect the total EMI emission in seconds.

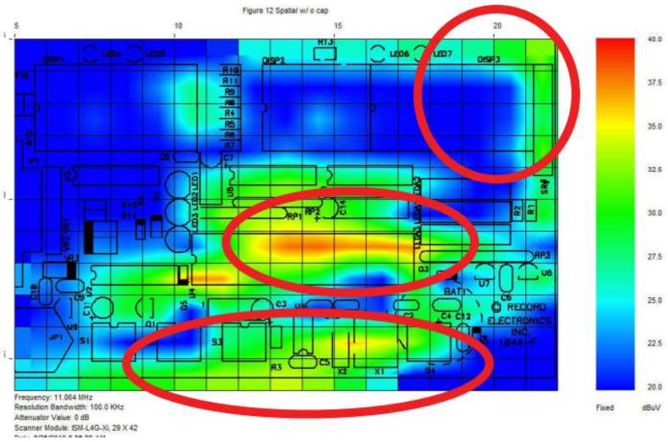
EMScanner quickly identifies emission sources from internal circuit boards, interconnecting cables, or connectors. Following a design modification, the design teams can visually document and measure reductions in the level of undesirable emissions in the design.

The spatial scan provides a detailed map of emission sources and current loops in real-time. The design team can test using either a single frequency or multiple frequencies by using the composite spatial display function. After implementing one or more design modifications, a subsequent scan provides a measurable and visually compelling comparison (as shown below).

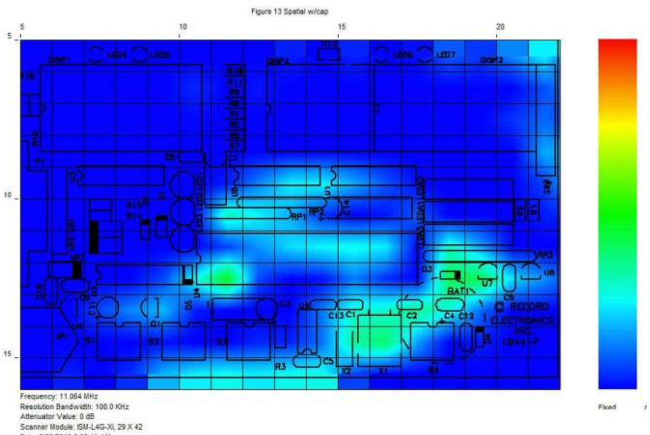


Taximeter PCB positioned on the patented scanner and tested at 11.06 MHz. The test measures noise without and then with a capacitor added (location in red circle)





Taximeter PCB test with no capacitor – noise circled in red.



Taximeter PCB test with capacitor reduces Noise by at least 8dBuV.

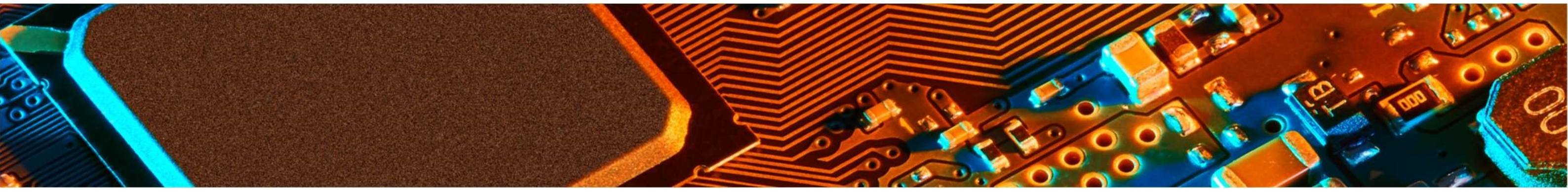
7. Immunity

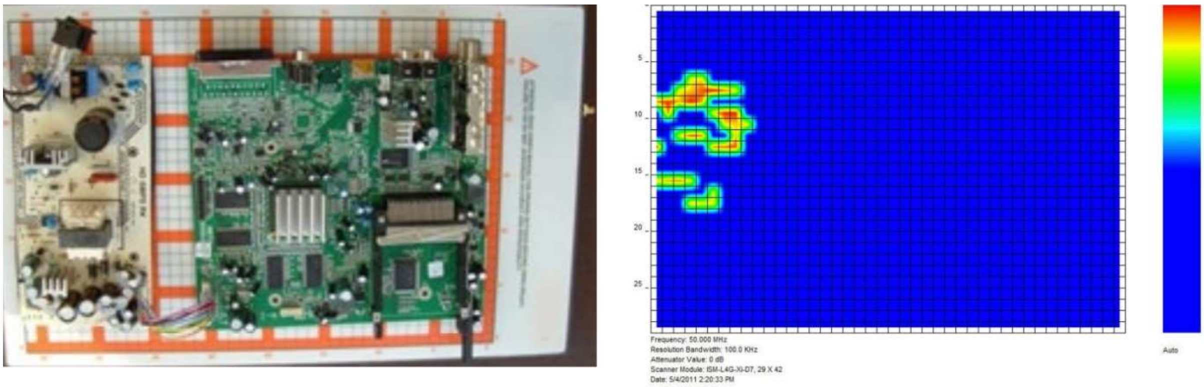
Visualize how injected RF signals flow through a PCB

Objective: Improve product reliability by identifying the source(s) and path(s) of any high currents generated during a conducted immunity test. Ensure that the current on the board is not impacting susceptible components on the board, causing system failure. If they are, quantify and compare the effects of different mitigation tactics.

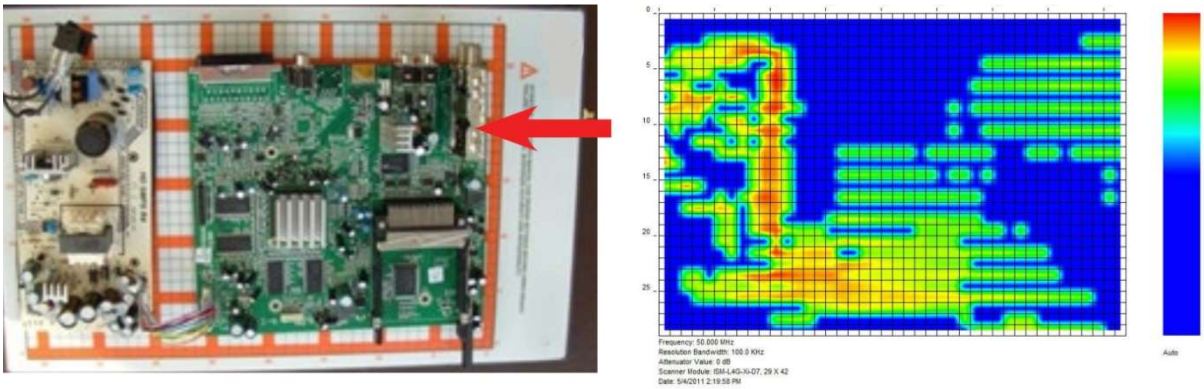
EMScanner displays the resulting very-near-field disturbance caused by injected RF signals flowing through a PCB or by signals radiated onto a PCB. The resulting scan identifies sensitive components on the board impacted by these high amplitude currents. The design engineers can then implement one or more mitigation measures and conduct “before” and “after” scans. These scans quantify the effectiveness of each mitigation tactic, facilitating easy comparison.

Using the scans from EMScanner, the design team can improve the immunity of susceptible components in early design stages. This significantly reduces costly board respins, which could otherwise result in significant delays in the design cycle.

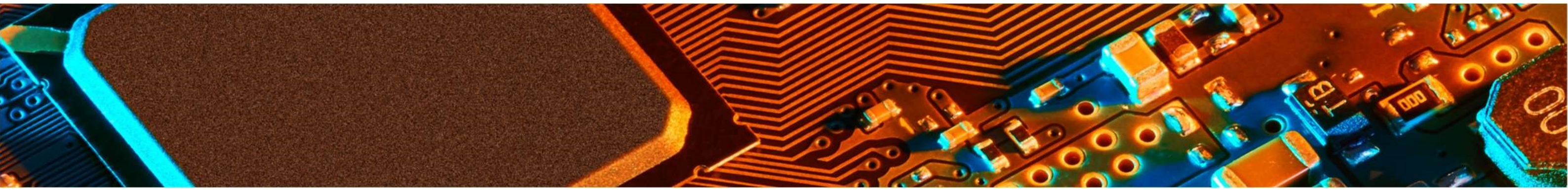




EMScanner spatial scan at 50MHz with no noise injection.



EMScanner spatial scan at 50MHz with noise injection at right edge of board.

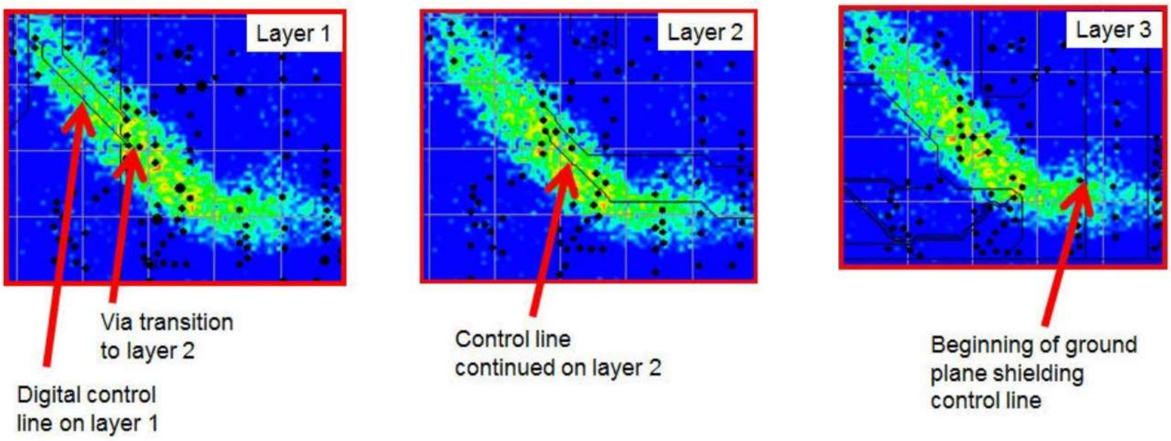


8. Emissions along Traces

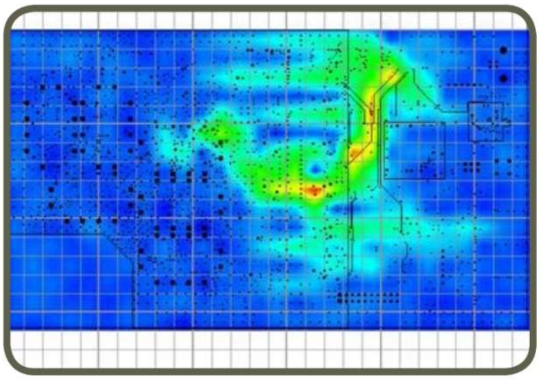
Follow the signals on traces

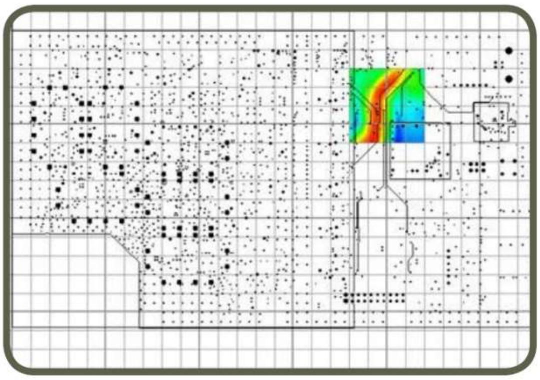
Objective: Identify the emission source and the path down to a single trace and via across multiple PCB layers.

The high-resolution EMScanner spatial scan available from the EMScannerR gives users the ability to find the source of emissions and the path taken by the problem emissions down to a single trace and via across multiple PCB layers.
An example is shown below.



Spatial Scan results of the PCB by EMScannerR

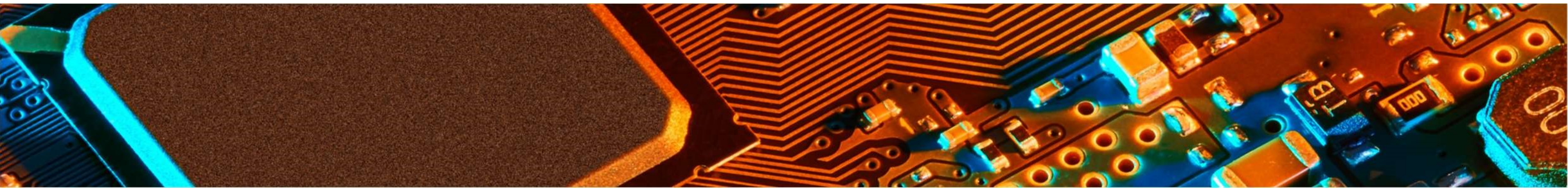




Spatial Scan results by EMScannerR

Run real-time spatial scan to see the emissions on the whole board.

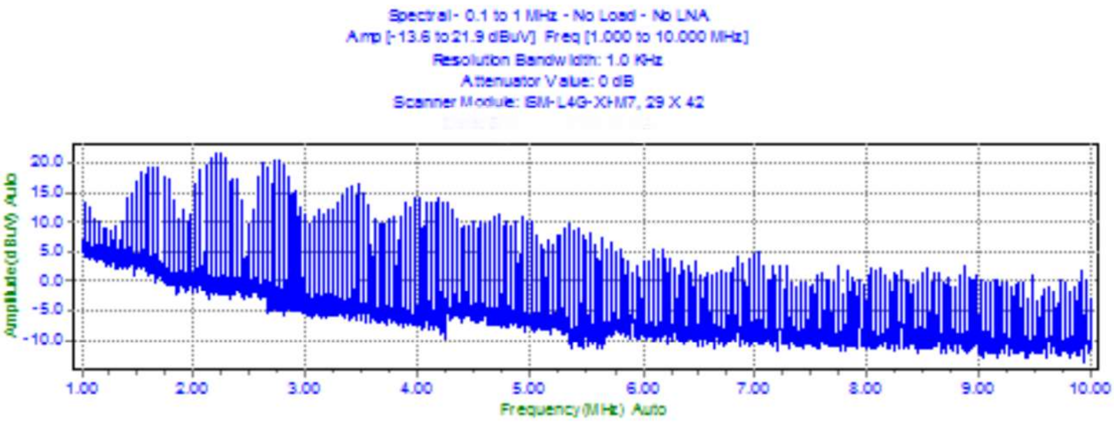
Then zoom into the problem area for Further analysis



9. Broadband Noise

Find the source of emissions and the path taken by the problem emissions
Objective: Characterize typical broadband noise in real-time.

As an example, a Switched Mode Power Supply (SMPS) can cause broadband noise in control electronics, other components, and the PCB itself. To characterize such emissions, EMScanner quickly scans the board across a broad frequency range. The user can then select and characterize specific frequencies to observe how the noise evolves spatially across the frequency range. This allows the design team to map the noise, confirm its source, and implement appropriate mitigation. The software's limit line feature serves as a key descriptor and allows project engineer(s) to distribute this test to less-experienced technicians.

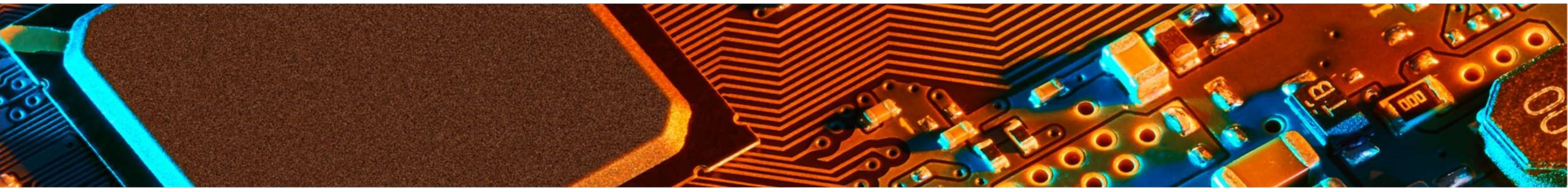


Spectral scan of the broadband noise from a power supply

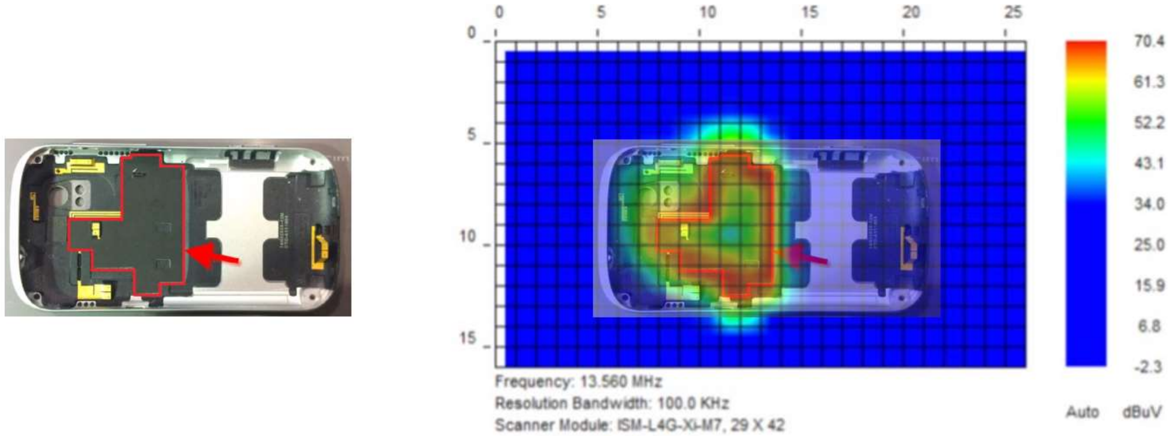
10. NFC Antenna Testing

Verify that the NFC antenna is operating as expected.
Objective: Validate the NFC antenna's emission level versus calculated results.

Considering the size, frequency and distance, antenna radiation pattern is not a meaningful parameter for NFC designers. Amplitude and distribution of the signal are important. The EMScanner is a fast and effective tool that measure and displays the emissions from an NFC antenna using very-near-field technology. The peak-hold mode of the EMScanner can still create a full image of the antenna's emission in seconds even with a burst NFC signal. These results allow a designer or a tester to verify that the antenna is operating as expected and to validate the antenna's emission level versus calculated specifications.

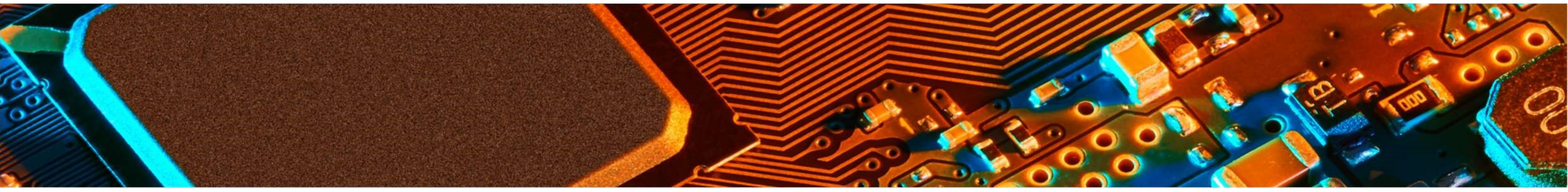


In the example below a phone has a back case which comes off and exposes every antenna used for GSM, Wi-Fi, NFC etc. The NFC antenna section is highlighted in red. The results from the near-field scan show strong currents in an area like the shape of the highlighted antenna (right image below).



Spatial Scan of the smart phone at 13.560 MHz

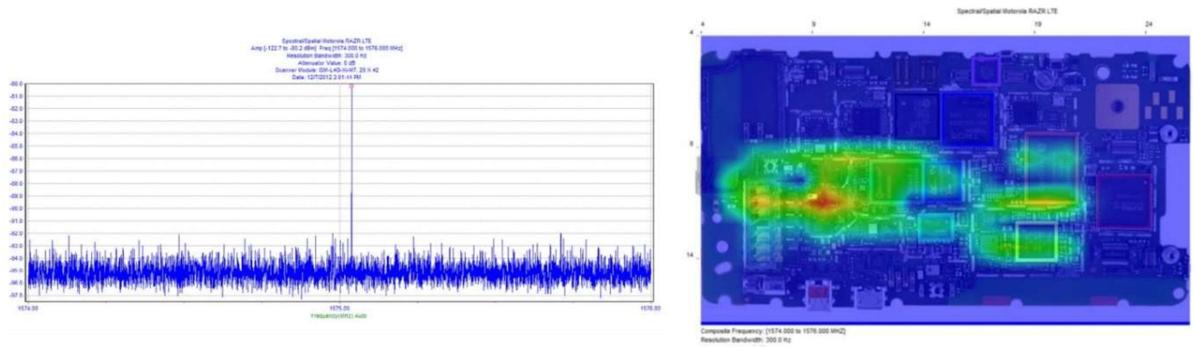
When the very-near-field result is overlaid on top of the photograph of the phone case itself, the image clearly shows the strong correlation between the NFC antenna emissions and the antenna's physical location.



11. GPS Self-Interference

Diagnose GPS self-interference problems.
Objective: Measure the emission of a mobile phone around the GPS bands.

When the camera is turned on, we can see a massive peak emission around the GPS band interfering with the GPS antenna in an otherwise well designed EMC-wise device. When the camera is running, the EMScanner spatial scan shows that the noise from the camera is coupling with the radio chipset and spreading to the SDRAM.

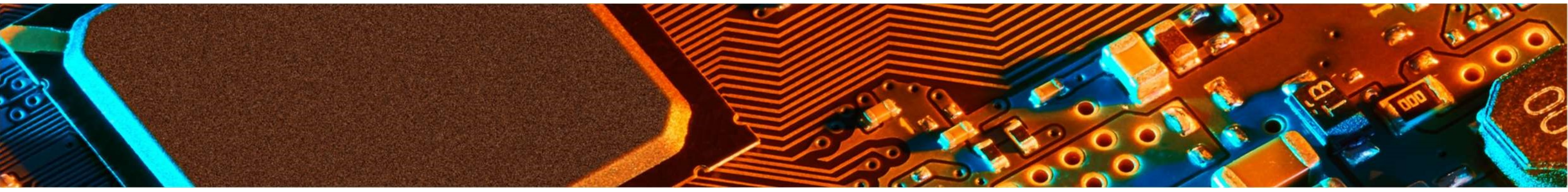


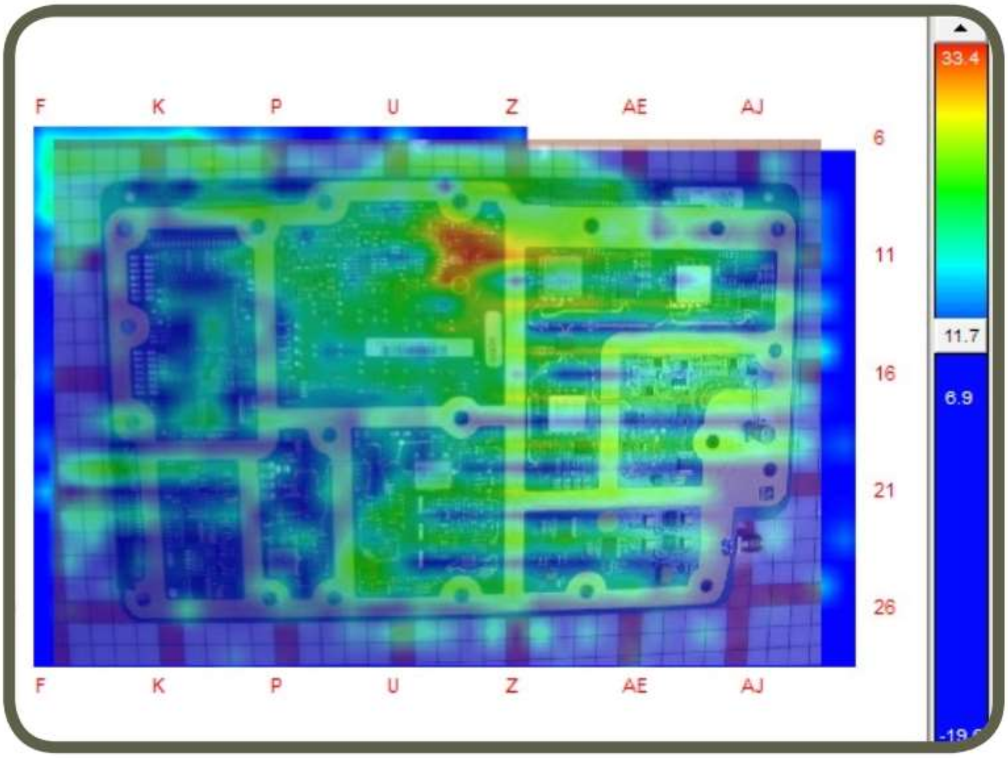
Spectral Scan (left) and Spatial Scan (right) of the mobile phone.

12. Manufacturing Problem Troubleshooting

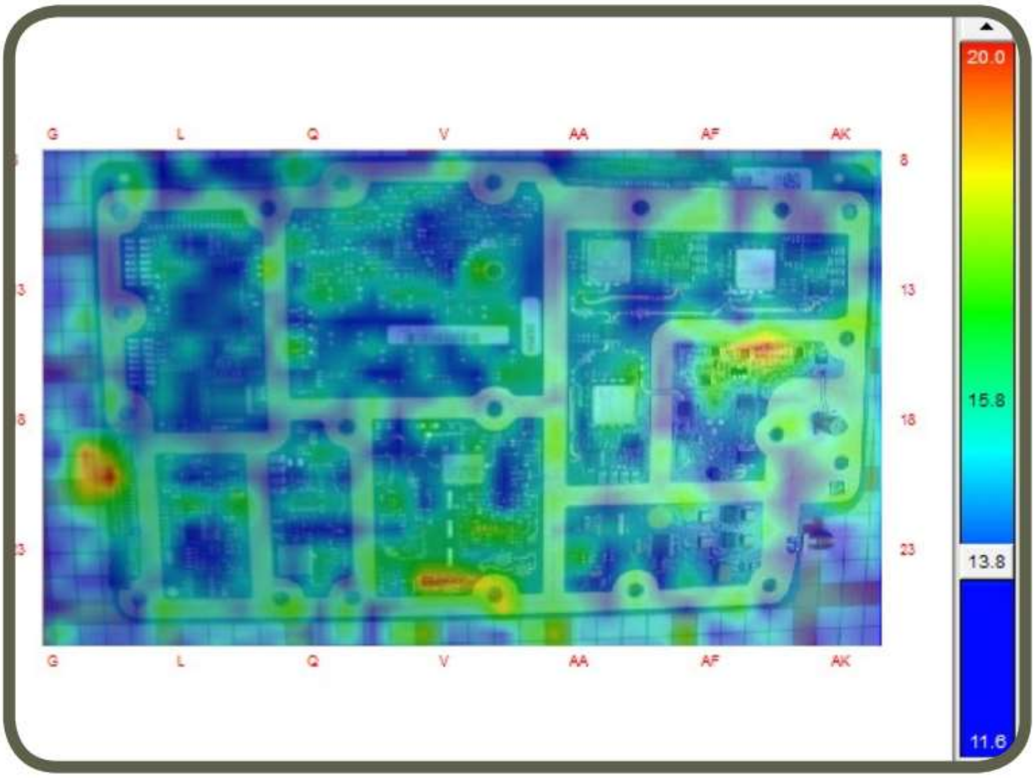
Reduce debugging time and improve manufacturing yield with Golden Sample comparison test
Objective: Identify defective PCBs.

Tests were done at a manufacturing facility in Europe to determine if problems could be identified when comparing the very-near-field emissions of good boards and problem boards. There was an issue that had been eluding detection; it showed as a poor RSSI reading and had been isolated to the IF chain. An EMScanner spatial scan comparison of the IF currents between a good board and the problem board indicated an issue at a location different from where the manufacturer had assumed the problem was. Further investigation uncovered a soldering issue with a single component. A scan of the entire board at the IF frequency clearly showed a difference in the spatial profile.



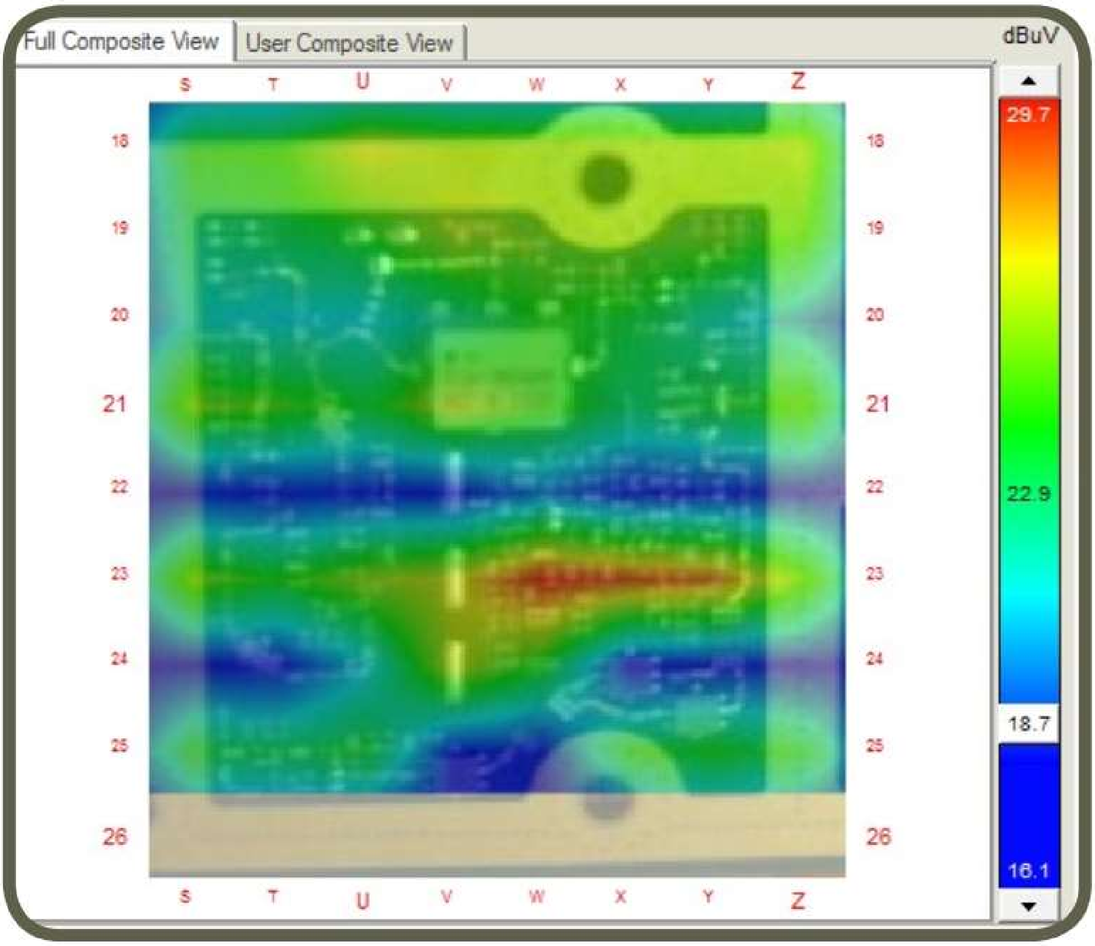


Spatial Scan of the Good Board at the IF frequency

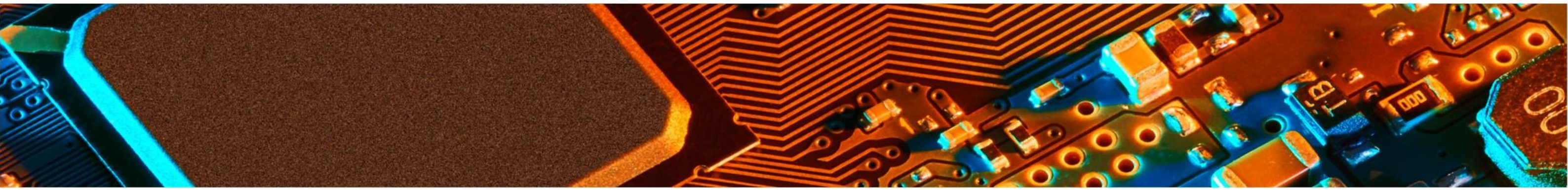


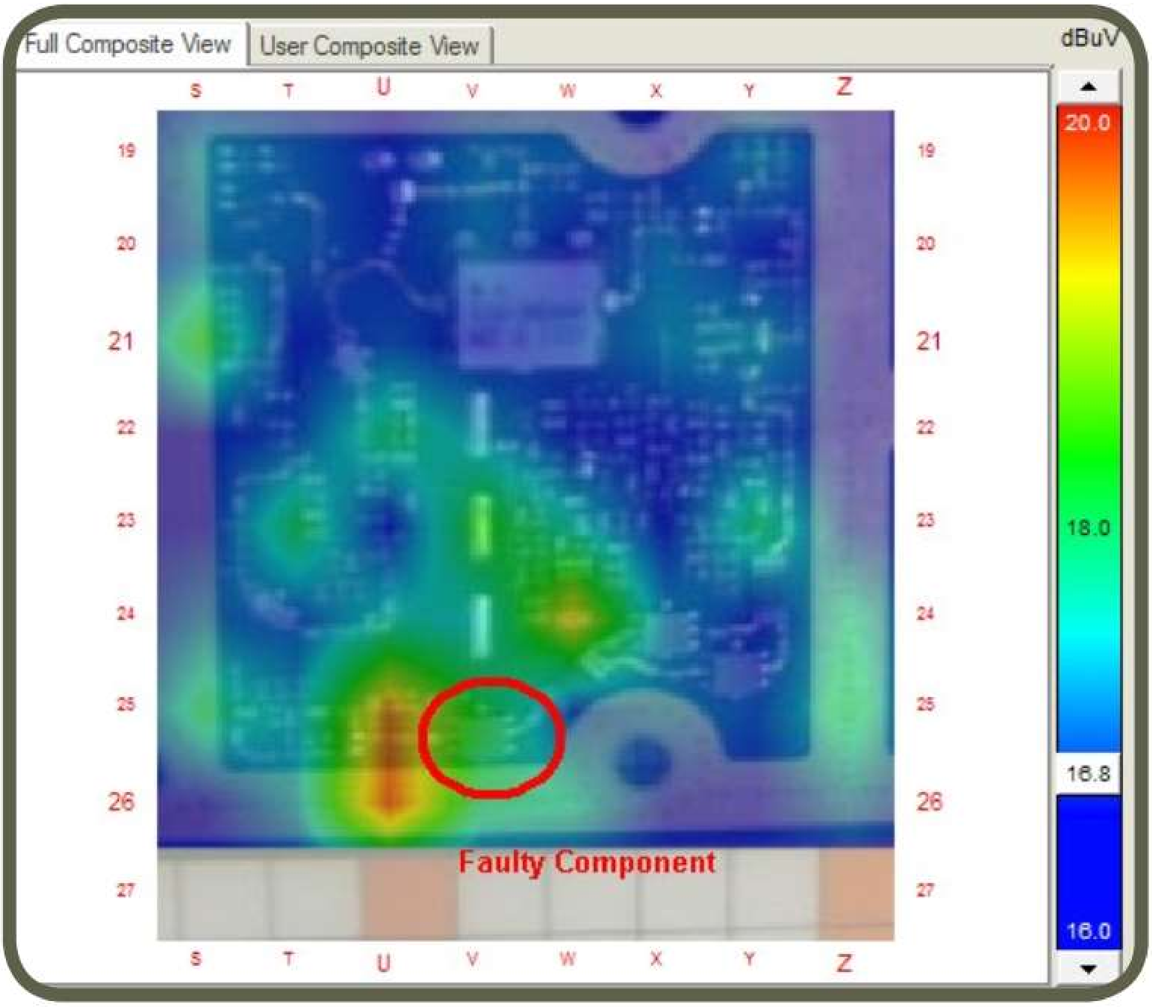
Spatial Scan of the Bad Board at the IF frequency

Once it was confirmed that there was a problem at the IF frequency a focused analysis on the IF chain was done. Zooming in on the area of the IF right as it exited the first mixer showed a very-near-field variation immediately after the SAW filters.



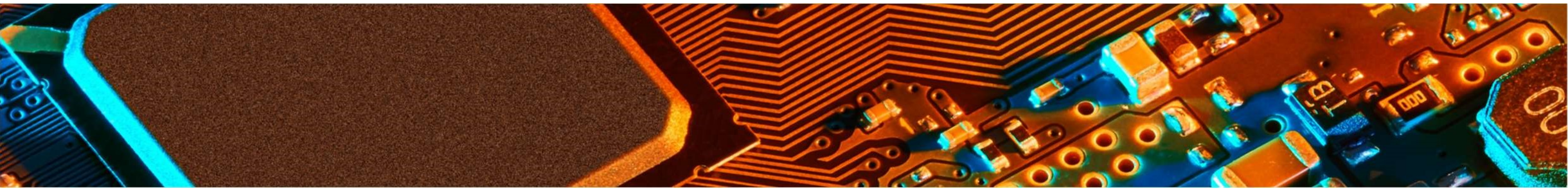
Spatial Scan of the IF Chain of the Good Board Showing Strong Emissions Throughout





Spatial Scan of the Bad Board at the IF Frequency

After viewing the large variation in the very-near-field emissions at this location, a visual inspection of the board revealed the SAW filter highlighted in the image above was populated with a 90° rotation meaning no signal would pass through.



13. Summary

The prior examples demonstrate the EMScanner in action, presenting real-time scans in seconds to identify spurious and continuous EM emissions. The instrument provides spatial and spectral scans that allow design teams to cut one to two design cycles out of their product development process.
It also reduces their EMI testing time by up to two orders of magnitude.

About Y.I.C. Technologies

Y.I.C. Technologies is the world leading developer of FAST magnetic very-near-field measurement technologies and applications, providing real-time test solutions to antenna and PCB designers and verification engineers, without the need for a chamber. The EMScanner, a compact EMC and EMI diagnostic tool enable engineers to quickly optimize their designs. Y.I.C. Technologies solutions dramatically increase designer productivity and substantially, reduce time-to-market and project development costs.

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