# Y.I.C. Technologies

## Comprehensive Application Note

## Cable Analysis with Near Field Scanners

## ABSTRACT


The analysis of cables using near-field scanners represents a pivotal aspect of modern electromagnetic compatibility (EMC) research and engineering. Near-field scanning techniques offer a non-intrusive means to assess cable performance, enabling detailed examination of electromagnetic field distributions and associated phenomena. This abstract explores the significance of cable analysis through near-field scanners, discussing its relevance in understanding electromagnetic interference (EMI) and immunity issues, as well as its utility in optimizing signal integrity. The abstract delves into the methodology and principles underlying near-field scanning, highlighting its applications in various domains, including automotive, aerospace, telecommunications, and consumer electronics. Additionally, it underscores the importance of leveraging near-field scanning technologies for efficient EMC compliance testing and troubleshooting, thereby enhancing the reliability and performance of electronic systems.



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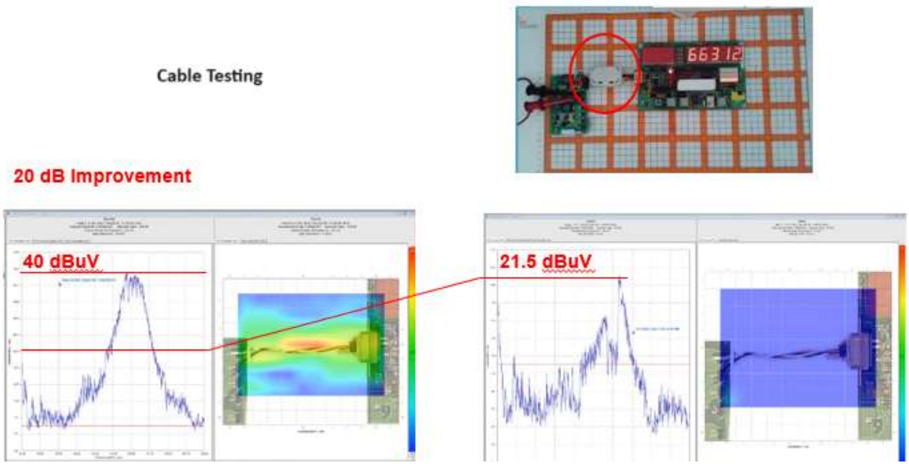

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# Introduction

Cables play a pivotal role in electronic systems, primarily due to their extended length within the system. They serve as significant conduits for electromagnetic signals, making them pivotal components for Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC). Furthermore, in Signal Integrity considerations, cables may serve as sources of waveform distortion. In various applications such as automotive or aerospace, where numerous cables transmit both analog and digital signals encompassing narrowband and broadband frequencies, their significance in shaping the EMC profile of the product cannot be overstated. Consequently, possessing tools for meticulous measurement and experimental evaluation of systems during both design and production stages becomes indispensable.

# Differential Mode and Common Mode

An essential concept pertaining to cables involves the distinction between differential and common modes of signal propagation.

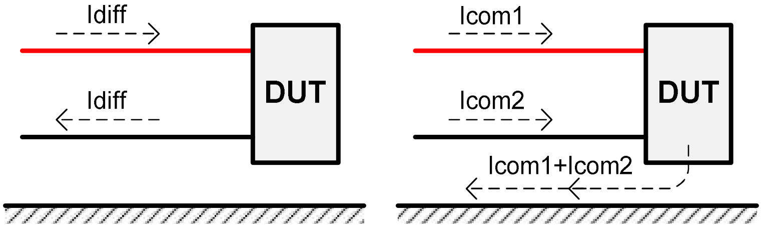



*Fig. 1. Current modes.*

In the preceding diagram (left), the concept of differential current is depicted, illustrating its flow through two wires with equal amplitudes but in opposite directions. On the other hand, common mode currents (right) are portrayed as currents injected into the ground plane (chassis, earth, etc.) or a third conductor, subsequently returning through the two wires in the same direction.

In the context of Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) radiated issues, differential currents typically do not pose a critical concern. This is attributed to the close proximity of both wires, which minimizes the size of the loop. Consequently, the radiated field generated by one wire at a certain distance is effectively countered by the radiated field emanating from the return wire, owing to their identical amplitudes and opposite directions.

However, common mode currents are associated with significantly larger, often undefined loops. Should the common mode current exceed approximately 10-15µA for typical cables spanning lengths of 1m to 3m, the resultant electric field at a distance of 3 meters surpasses the thresholds stipulated by EMC regulations.

## How to evaluate currents in cables

Three fundamental techniques are typically employed for evaluating currents in cables:

• Current probes

• Near field probes

• Near field scanners

Near field probes, such as magnetic loops positioned close to wires, can detect the magnetic field generated by currents in the cables. Analysis of the frequencies involved in the issue is possible using oscilloscopes or spectrum analyzers, although accurately measuring amplitude can be challenging due to the dependence of the magnetic pickup effect on position and orientation.

While the techniques are typically applied to measure one cable at a time, near field scanners offer the advantage of evaluating multiple cables and wires simultaneously. This facilitates real-time validation of design changes in systems with numerous cables.

In the forthcoming demonstration, we will showcase a system that employs all three techniques to evaluate the activity in a set of cables.

# Examples

Using **EM**Scanner, an initial analysis was conducted on the PCB configured with a ground (GND) layer beneath the inductor. The findings revealed significant broadband activity centred around the 100MHz frequency, as depicted in Figure 5.

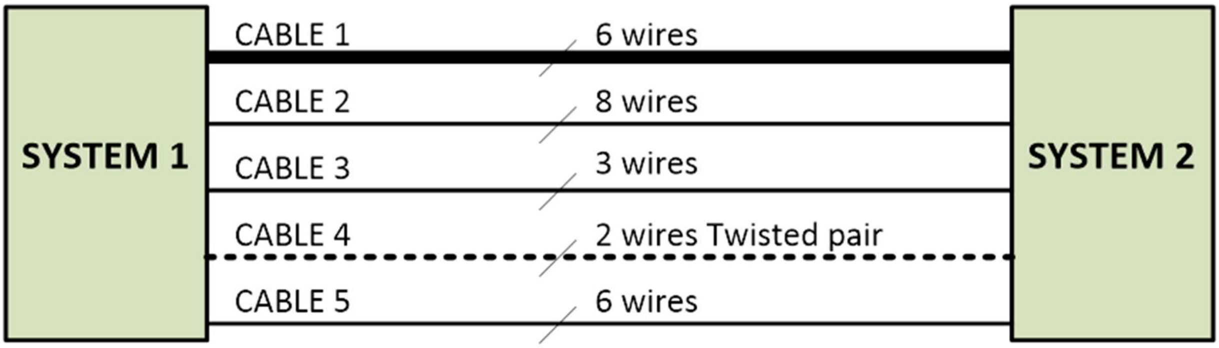



*Fig. 2. The system is under test.*

Long cables transmitting signals from System 1 to System 2 are causing electromagnetic interference (EMI) issues, prompting the need for analysis utilizing current probes, near field probes, and near field scanners.

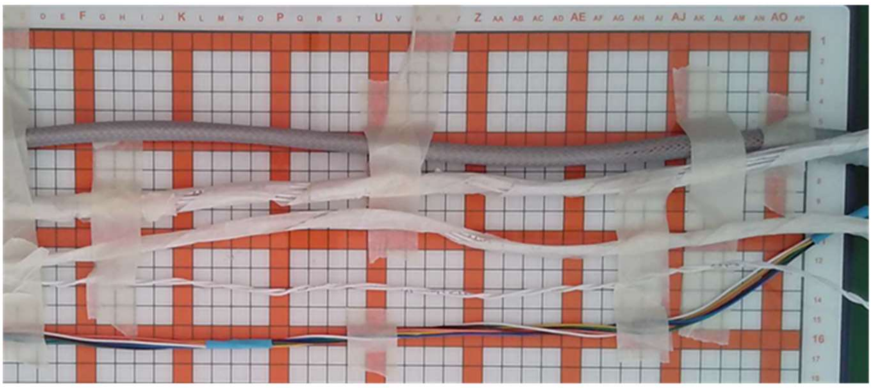


*Fig. 3. The cables on top of the table.*

We will elucidate certain signals within those cables. While such knowledge may not be initially imperative (as it occasionally forms part of the troubleshooting process), understanding these signals beforehand likely enhances comprehension of the example.

Cable 1 is carrying a quasi-sinusoidal (non-perfect) signal 20MHz in frequency.

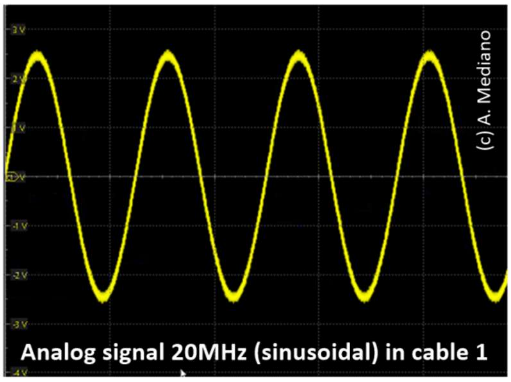



*Fig. 4.- Analog signal in cable 1*

Cable 4 is carrying a pseudo-random data through a twisted pair:

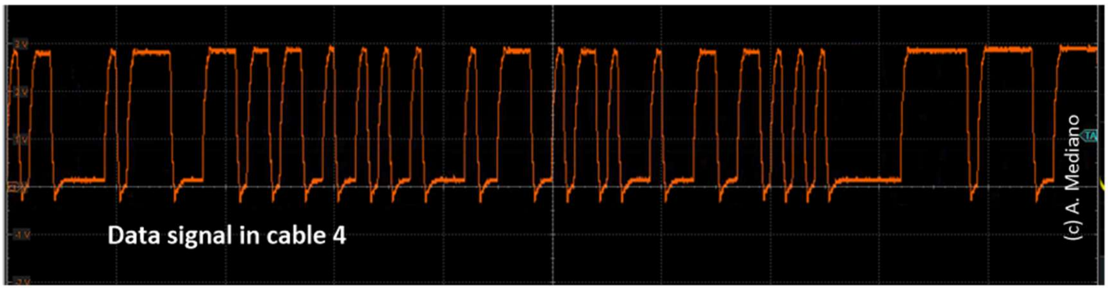



*Fig. 5.- Data sent through cable 4.*

Finally, cable 6 is carrying a clock 10MHz in frequency and rise time approximately 2.5ns.

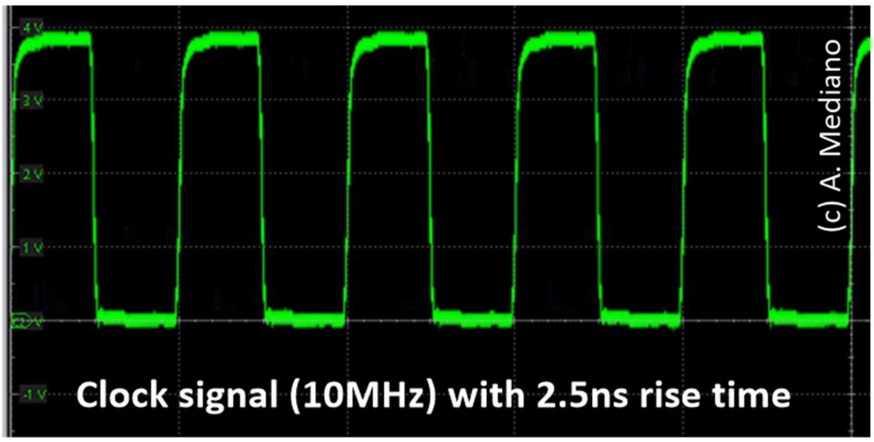



*Fig. 6.- Clock signal in cable 5.*

## Testing cables with current with Near Field Probes

We will assess the activity of the twisted pair cable using a current probe (R&S EZ-17 probe) in conjunction with one of the VHF-UHF near field probes from Y.I.C. Technologies.

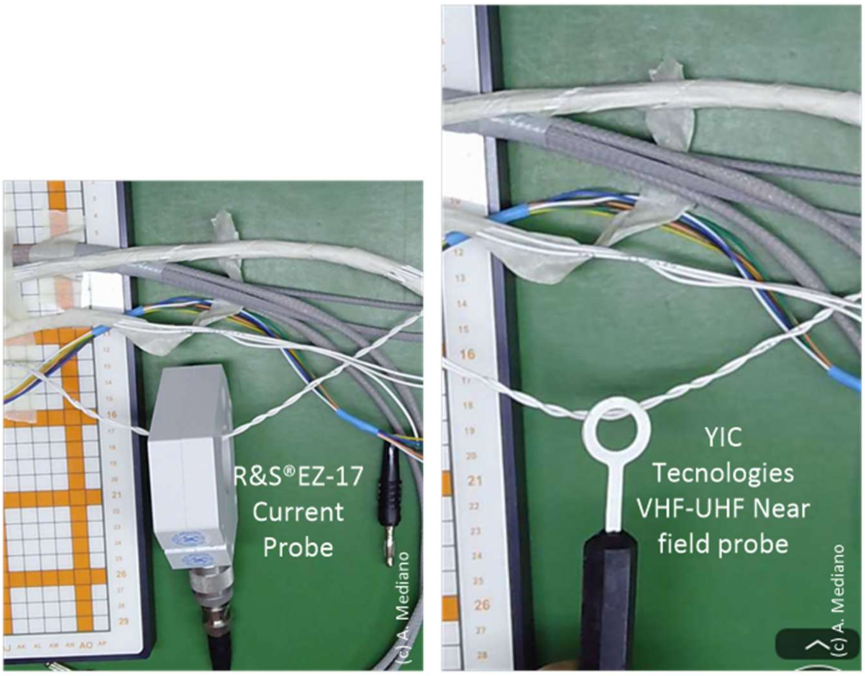
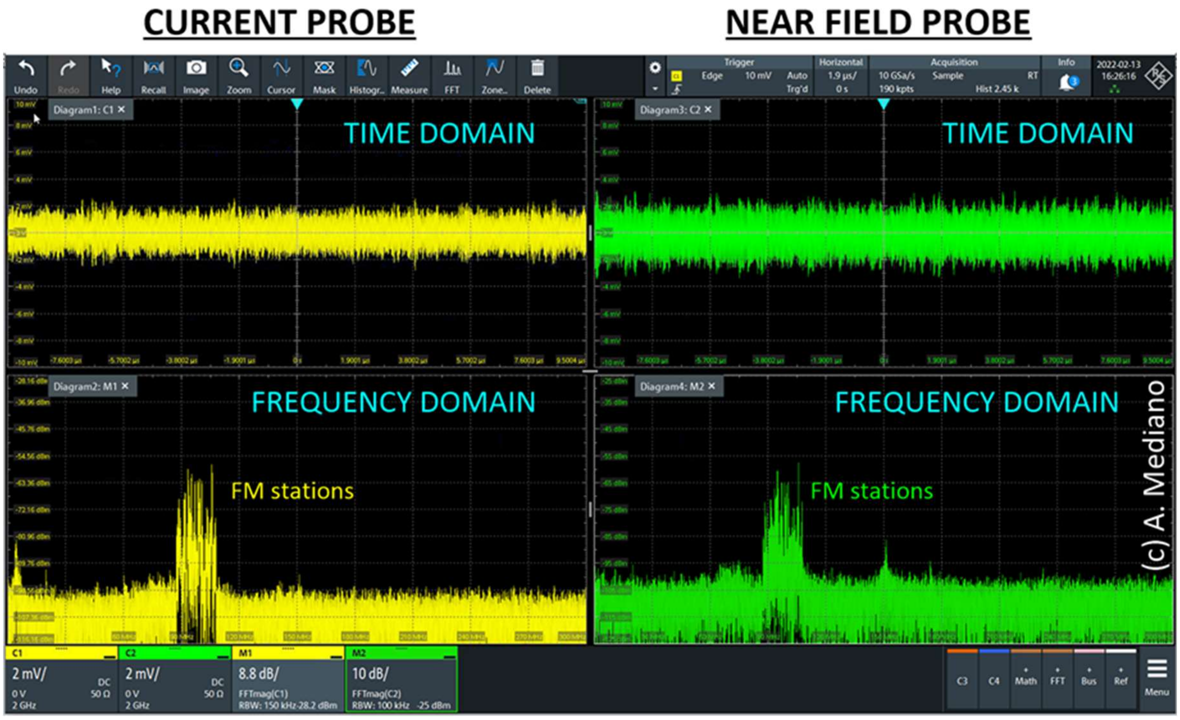



*Fig. 7.- Testing the twisted pair with current probe and near field probe.*

The current probe offers the advantage of providing measurements with greater repeatability and precision in determining the current amplitude. Conversely, the near field probe provides the advantage of enhanced flexibility in positioning, enabling easy movement around the cable for comprehensive assessment.

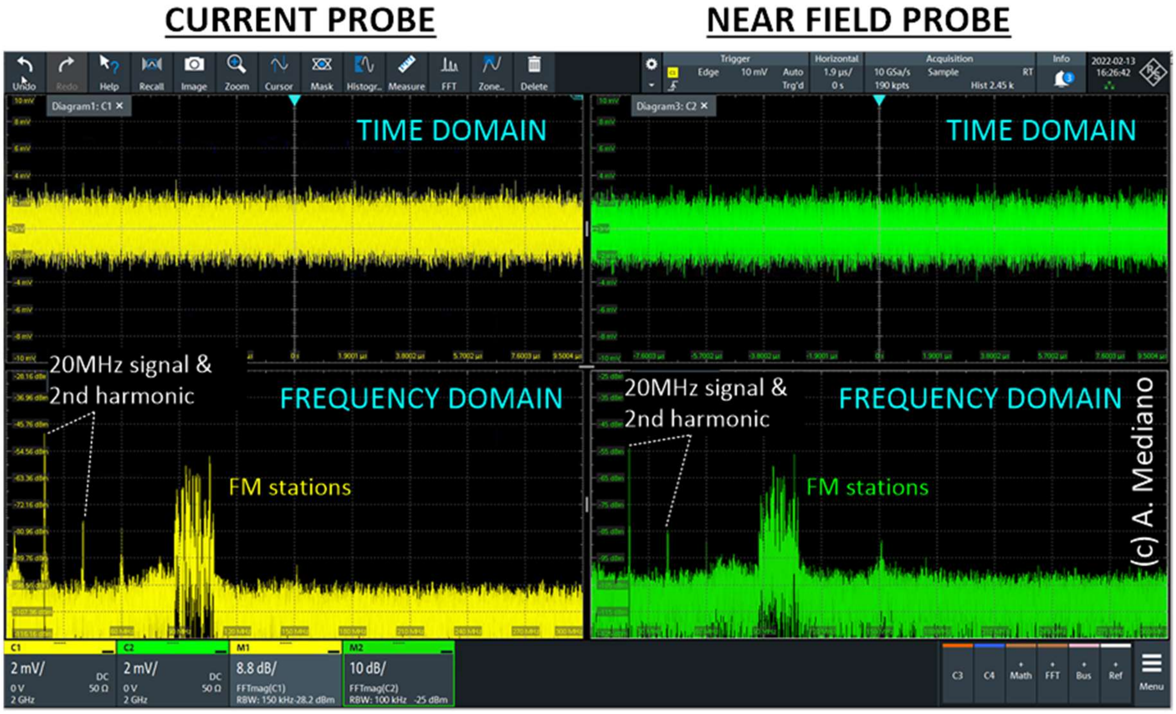
The results were saved for four different cases:

a) <u>SYSTEM 1 electronics is OFF</u>




Observe how FM broadcasting stations are detected due to the cable functioning as a receiving antenna. While this effect can be mitigated by conducting measurements in a shielded tent, such measures are often unnecessary for many debugging tasks.

b) <u>Only Sinusoidal signal in Cable 1 is ON</u>




Please take note that the analog signal is present in cable 1, whereas our measurement is being conducted on cable 4. This discrepancy arises from the occurrence of crosstalk between cables. To confirm the absence of signal detection by the probes, we performed a null experiment.

c) Sinusoidal signal in Cable 1 and Data in Cable 4 are ON

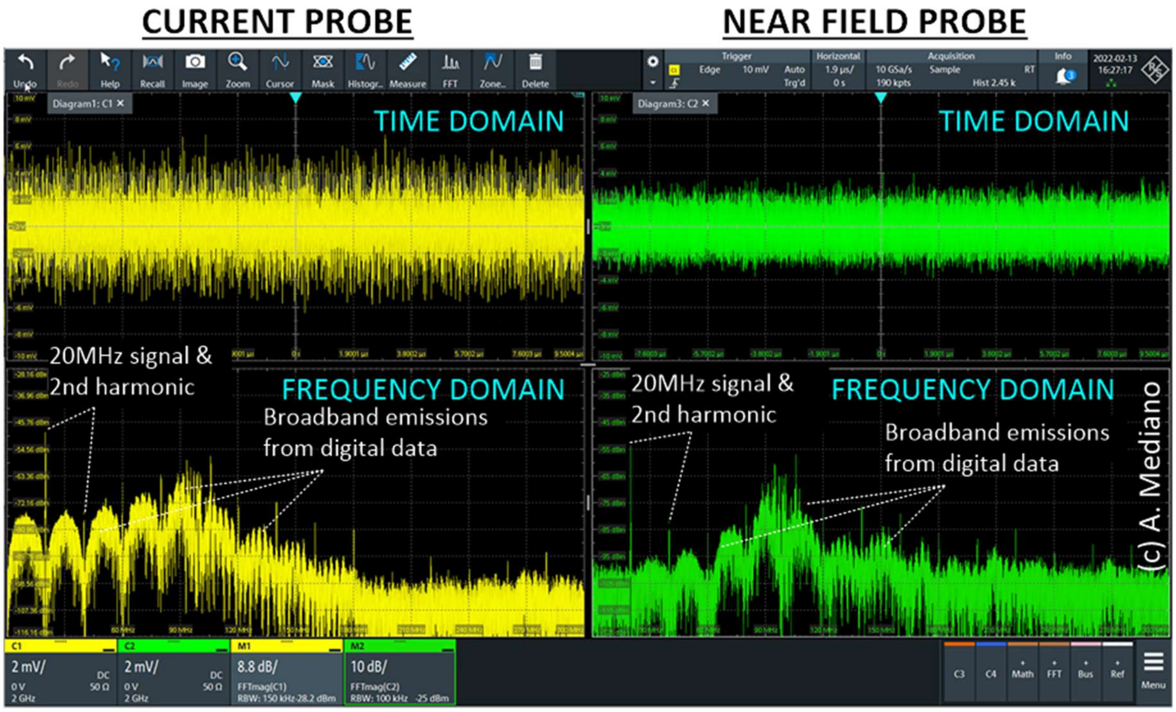



*Fig. 10.- Measurements when the analog signal (cable 1) and data (cable 4) are activated.*

Presently, the twisted pair activity intensifies due to the pseudo-random data it carries. Evidently, the analog signal from cable 1 remains present, while FM broadcasting stations are concealed within the broadband digital emissions.

d) <u>Sinusoidal signal in Cable 1, Data in Cable 4, and Clock in Cable 6 are ON</u>

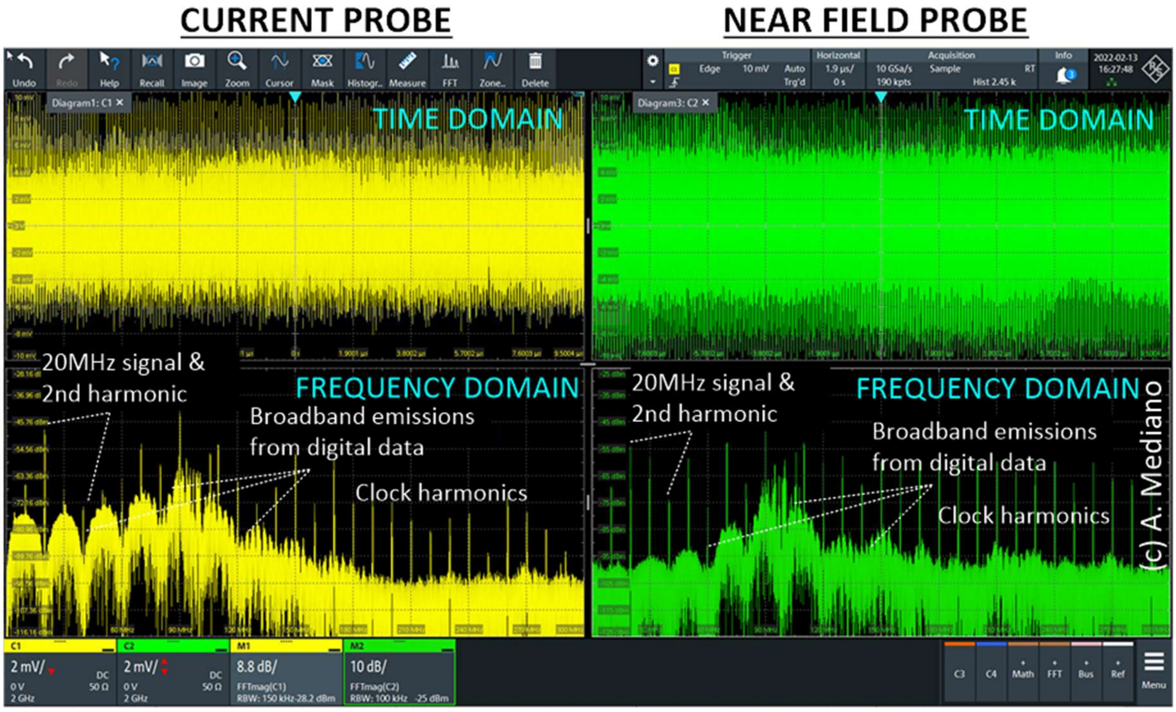



*Fig. 11.- Measurements when analog signal (cable 1), data (cable 4), and clock (cable 5) are activated in System 1.*

Within the twisted pair configuration, the earlier activity is discernible, yet presently, the harmonics of the clock signal in cable 5 have become coupled to cable 4.

Armed with this information, the designer can endeavour to investigate and mitigate emissions through various techniques, such as employing ferrites, enhancing rise-times, implementing filtering, and so forth.

# Testing cables with the EMScanner

Employing a near field scanner provides a potent method to analyze the preceding information from a different perspective, conducting spatial and spectral scans. Initially, the set of cables is positioned atop the scanner. Identifying the cables involves discerning their positions via row and column identification, followed by capturing an image to serve as an overlay during the scan process.

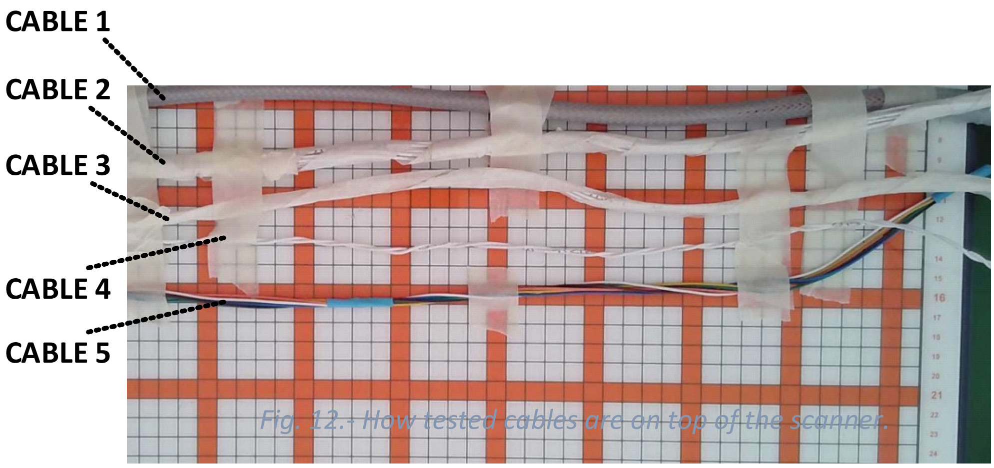



*Fig. 12.- How tested cables are on top of the scanner.*

First, the frequencies from the set of cables are detected in the range 10MHz to 300MHz:

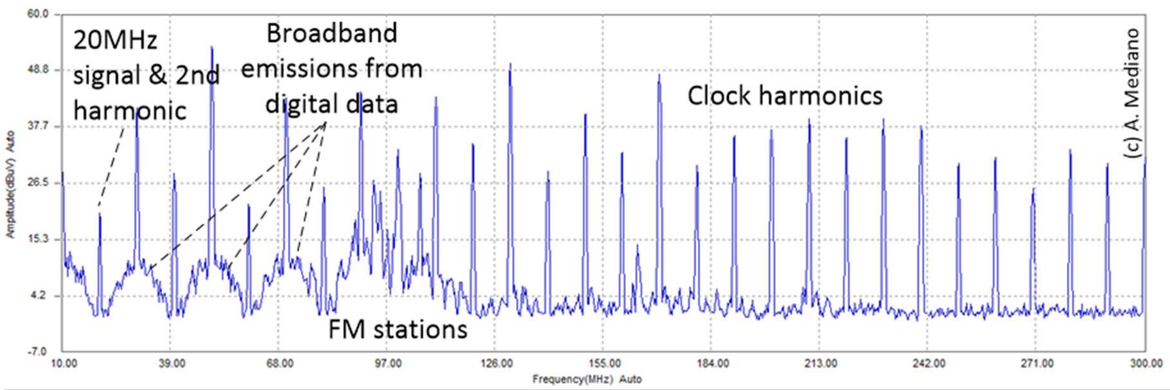



*Fig. 13.- The full spectrum radiated from the cable set.*

We confirm the previous results. From the full pack of cables we identify different signals:

a) FM broadcasting noise; b) the 20MHz analog signal (cable 1); c) the broadband emissions from the digital data (cable 4); and d) the 10MHz clock and its harmonics (cable 5).

With the spatial scan we can see how the highest signal is coming from the cable 4 with the clock signal:

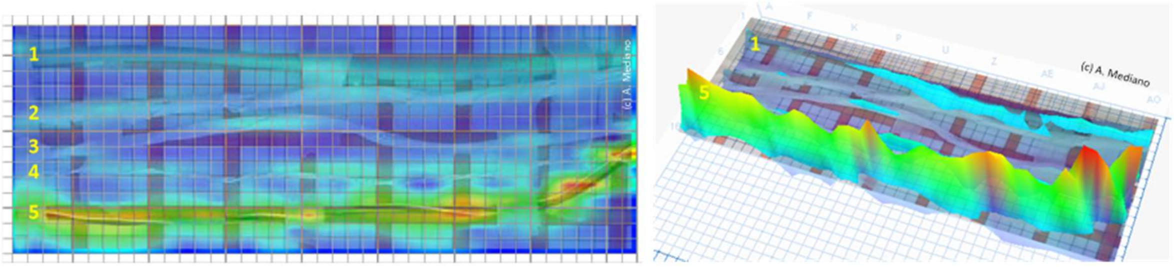



*Fig. 14.- With the used scale we can see that maximum amplitudes are detected in cable 5.*

However, we have the capability to instruct the system to pinpoint the location of specific frequencies. For instance, we can direct EMViewer to identify the 20MHz analog signal within Cable 1:

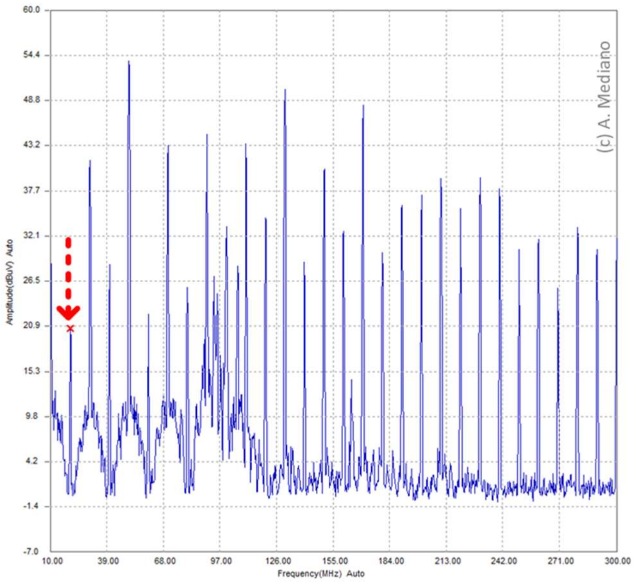



*Fig. 15.- With a click of the mouse we can ask for the frequency of interest.*

The outcome is evident: the signal predominantly surrounds Cable 1. However, it's worth noting that some energy is detected around other cables as well. This occurrence can be attributed to the fact that 20MHz serves as the second harmonic of the 10MHz digital clock.

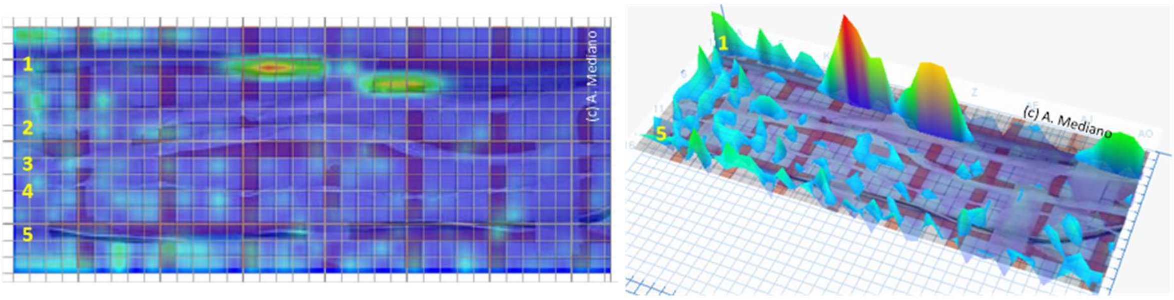



*Fig. 16.- Where the 20MHz energy is detected. Basically, in cable number 1 but note second harmonic in 10MHz clock signal (cable 5) has some contribution for energy in that frequency.*

We can endeavor to determine the specific location of the broadband signal:

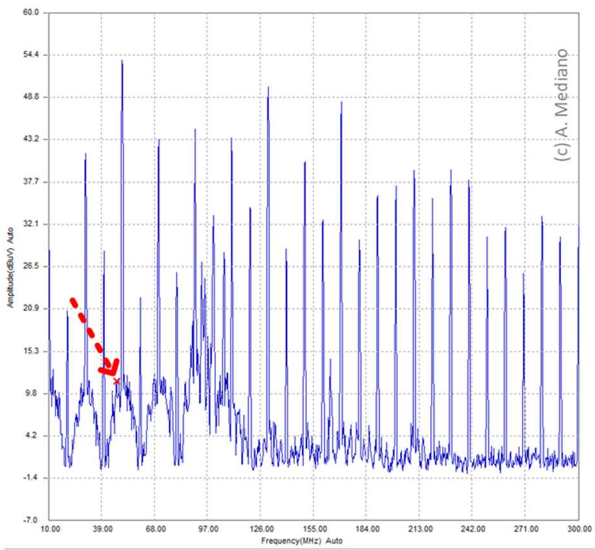



*Fig. 17.- Specifying where the energy for the broadband emission is located.*

And, as one might expect, the region of interest corresponds to cable 4:

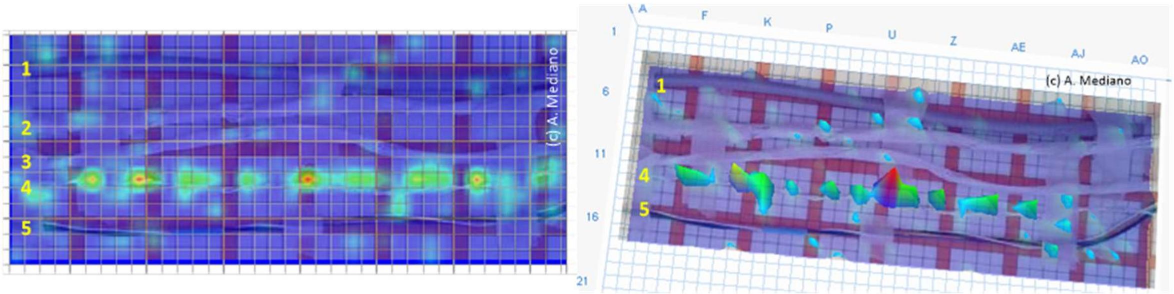



*Fig. 18.- The energy from digital data is clearly located around cable 4.*

Finally, we can try to detect any of the harmonics of our clock:

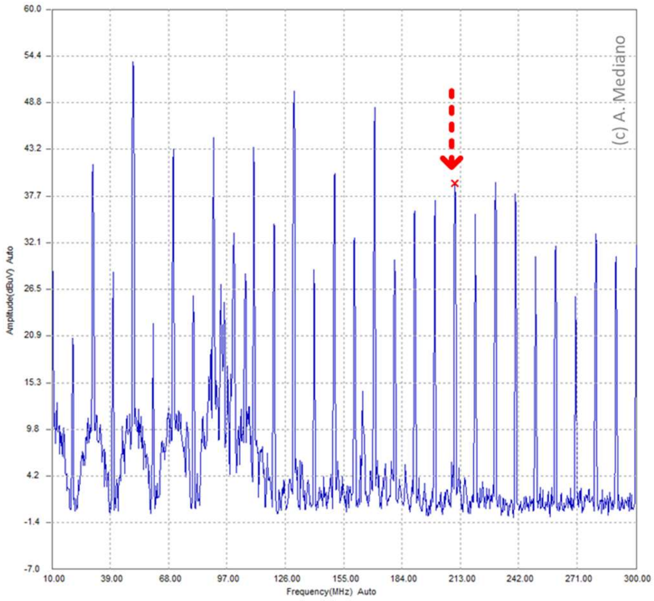
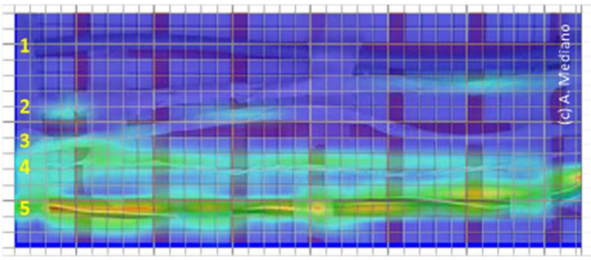
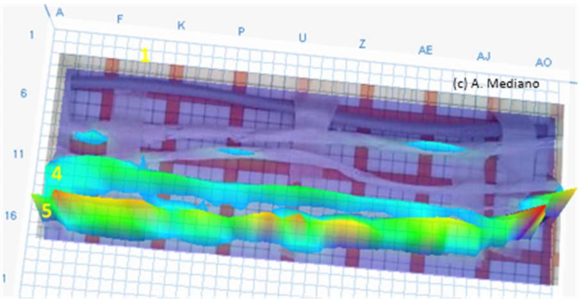



*Fig. 19.- How to specify interest to locate where 210MHz energy is located (21th clock harmonic).*

The result is clearly located around cable number 5 (as expected):






Note how you can identify with the EMScanner:

What frequencies emanate from the Device Under Test (our cable set)

- The specific frequencies' locations in 2D
- The specific frequencies' locations in 3D
- How signals are coupled to other wires through crosstalk

Moreover, you can conduct comparisons between different scenarios to assess the effectiveness of various remedies: such as alterations in software, adjustment of rise times, signal filtering, diverse grounding connections, and so forth. A visual analysis of the system can prove highly beneficial in identifying anomalies or unexpected outcomes deviating from the nominal design.

In production, the scanner can be useful to validate the complaint with some specific limits or to detect manufacturing failures.

Y.I.C. Technologies solutions offer a powerful way to look at your product design by offering desktop solutions with fast and reliable results.

**For more information, please contact us:**

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