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Shieldex®
EMC Cabinet

Technical Note

Introduction

MESA Solutions and Shieldex® have formed a partnership in the development of a lightweight, portable, conductive-fabric enclosure which we call our EMC Cabinet. Our aim is to let you measure what you intend to measure, and nothing else! Modern spectrum analyzers (SAs) are packed with features, and it is these very features that lead to self-generated electromagnetic interference (EMI) which is visible during high sensitivity measurements. Analyzer touch screens can be considered as EM apertures and plastic equipment housings have no EM shielding properties at all. In addition to this, a typical SA, cable, and probe combination form an antenna which couples environmental EMI into the analyzer along paths other than through the RF input connector!

Why is an EMC Cabinet needed?

Two simple experiments highlight issues associated with SA measurements which need to be addressed. The first tackles EMI which comes from high-speed processors and touch-screen technologies. The second examines pick-up from the environment, which is commonly detected, but goes unnoticed by unsuspecting users.

Statex Produktions- und Vertriebs GmbH
Kleiner Ort 9-11
28357 Bremen, Germany

Contact
Tel. +49 421 27 50 47
Fax +49 421 27 36 43
info@shieldex.de

Self-EMI reduction

As implied in Figure 1 below, the SA's self-EMI can both be measured, and prevented from appearing above the system noise floor.

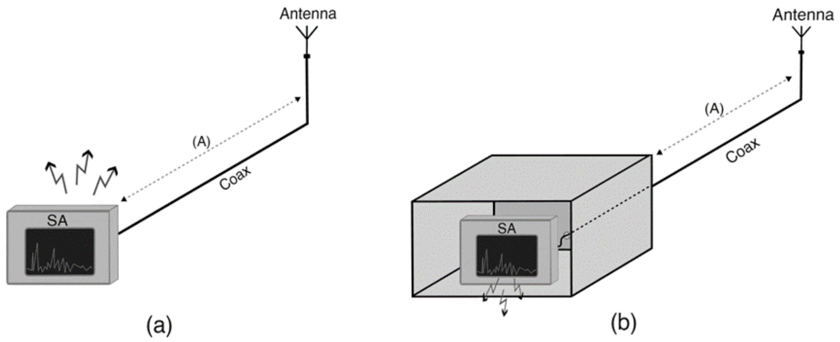

Figure 1: Spectrum analyzer setup with (a) antenna alone, and (b) EMC cabinet and well-defined interface.

An experiment was undertaken in the lowest noise environment available with the settings outlined in Table 1. The purpose is to evaluate typical EMI from a modern SA detected by a connected antenna with an average length coaxial cable (e.g., 2 m) with and without the EMC Cabinet.

Table 1: Spectrum analyzer settings for radiated measurements.

Variable	Value
RBW	10 kHz
Detector	Positive Peak
Internal pre-amp	ON

The EMI for both configurations can be determined from Figure 2.

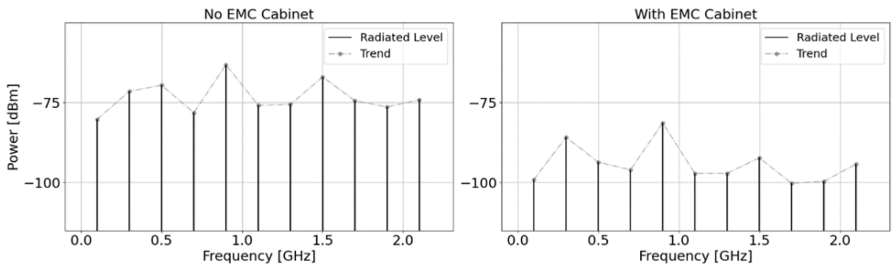

Figure 2: SA received power without and with the EMC Cabinet.

The SA power readings are not corrected for antenna factor or cable loss as the purpose is to show the relative reduction in received EMI power when using EMC Cabinet. With the SA settings given, the system noise floor is close to – 120 dBm, which is impressive for this class of instrument. At the same time, this low noise floor makes the internally generated EMI obvious. This could be reduced in several ways such as longer cables, more directional antennas, etc., but this is not simple to arrange in practice.

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The EMC Cabinet is easy to use and leads to the reduced levels of between 15 and 20 dB as seen on the right of Figure 2. The full reduction was not possible to determine because of the EMI levels and system noise floor.

To focus on a better estimation of the cabinet shielding of the self-generated EMI, we set up the following controlled experiment, Figure 3, using a terminated coaxial cable. The terminated cable attempts to represent the cable and probe environmental pickup mechanism. Placing a comb generator inside the cabinet gives clear definition to an imaginary SA EMI source.

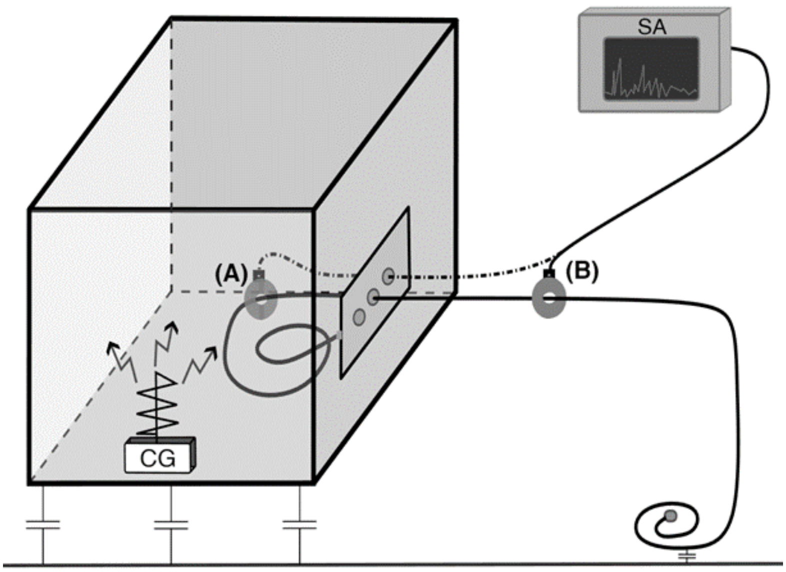

Figure 3: A comb-generator acts as a controlled SA EMI source. Common-mode currents inside and outside the EMC Cabinet allow a better definition of cabinet shielding performance.

The results seen in Figure 4 are achieved using a common-mode current probe to measure at (A), inside the cabinet, and (B) outside the cabinet.

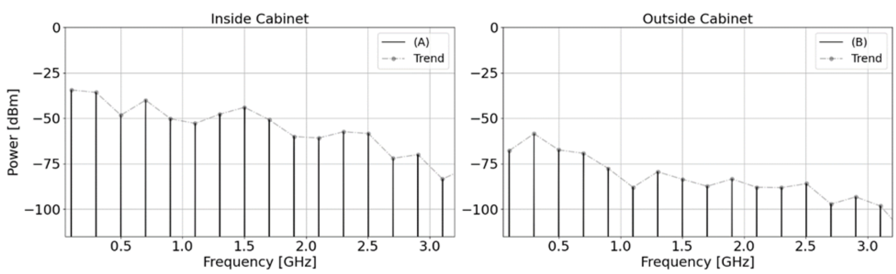

Figure 4: Conducted measurement results shown for (A) inside the cabinet, and (B) outside the cabinet.

The SA settings for this measurement are given in Table 2.

Variable	Value
RBW (kHz)	10 kHz
Detector	Positive Peak

The EMC Cabinet shielding effectiveness (SE) results from both the real self-generated EMI and from the controlled comb generator source can be seen in Figure 5 below.

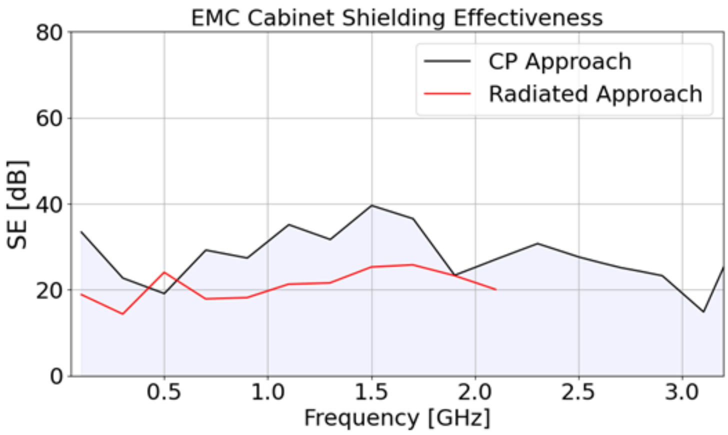

Figure 5: EMC Cabinet SE determined through both the current probe (CP) and self-generated EMI approaches.

The differences in findings are simply due to the CP approach not being placed at various positions along a wavelength-dependent cable. The minimum points of the CP method should coincide with the estimated radiated results. The latter can suffer from signal-to-noise issues and so the CP technique acts as a double-check.

The conclusion here is that the EMC Cabinet reduces SA self-generated EMI by 15 dB and more to at least 3 GHz, without hindering the use of the analyzer.

Antenna-mode EMI reduction

To illustrate the significance of antenna-mode coupling the second experiment was constructed. The primary purpose was to correlate the level of current flowing on the outside of cables (known as common-mode current) to levels of radiation detected at the EMC standards' distance of 10 m. It can be shown that 5 µA of common-mode current will give rise to an electric field (E-field) of 37 dBµV/m at 10 m if the cabling forms antenna resonance. For reference this value of E-field is quoted in the well-known CISPR standards, such as 11 and 32, linked to Class B emissions. The experiment confirms the relationship between the common-mode (CM) current and the measured fields.

Relevant to this technical note, though, is what goes wrong in the experiment when antenna-mode coupling is not considered. When the investigation was first undertaken with a group of post-graduate students engaged in a course on EMC, the expected current/field correlations could not be found. As is often the case in sophisticated SA measurements, the details are at first confusing. Once the issues are examined and understood, then everything seems so simple!

Three separates, but related, matters lead to metrological errors encountered here. For clarity they are elaborated separately:

Coupling from Exterior of Antenna Cable

With reference to Figure 6 below, consider the controlled signal generator exciting a CM signal on the outside of a typical 2 m representative power cable. The level of excitation is determined by the generator settings and an accurate variable attenuator. The cable is then either configured as an E-field antenna by holding it up with a wooden support, or as a magnetic loop antenna by connecting it to the simple ground plane beneath.

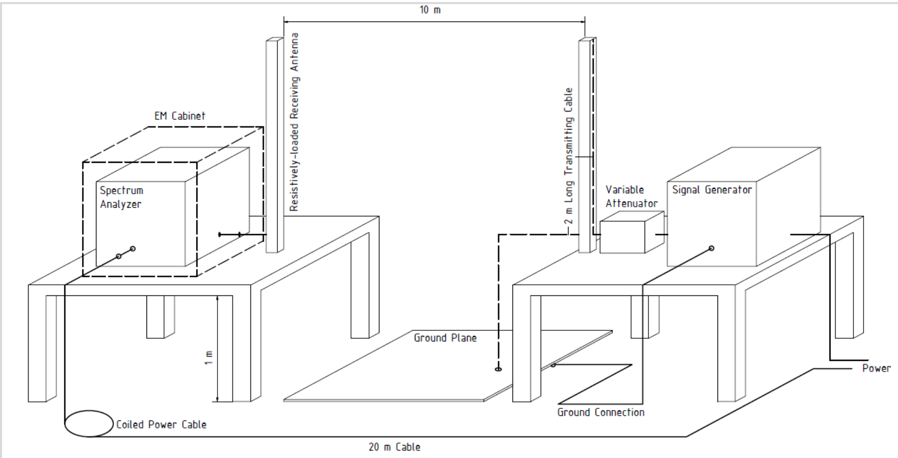

Figure 6: Antenna-mode coupling, common-mode cable currents and measured E-field

When recording the E-field levels with the broadband, resistively-loaded antenna placed 10 m away, shown in Figure 6, values across a frequency range within the power cable “antenna behavior” range around 30 – 40 MHz were confusing.

It transpired that, apart from the corrected emission levels being detected, CM energy was being picked up on the exterior of the antenna cable too, and this was entering through the plastic enclosure of the SA into receiver circuitry. This is called antenna-mode coupling.

Effect of SA Ground-connection	The antenna-mode coupling was worsened when the power supply was connected to the battery-driven SA. This is because the CM current has an additional path to ground which includes the power cord. This effectively increases the pickup mechanism which previously only included the antenna cable and SA.
Effect of 20 m Power Extension Cable	A further most un-expected finding was that the results on the SA can be influenced by removing the power cable coil depicted in Figure 6 and also by lifting the power cable up and down. This occurs when the power supply is connected to the SA and can be explained by additional CM current paths which now occur on the considerably lengthened cabling system. On a professional antenna measurement site, this additional coupling path is eliminated by placing the power cabling under the ground plane. However, unwary SA users in field often overlook these points as they are subtle.
How does the EMC Cabinet work?	When the SA is placed into the EMC Cabinet, all the unintentional CM current paths identified in Sections 2.1 to 2.3 are removed as the CM current is prevented from entering the SA in the first place. When the EMC Cabinet is included in the setup, the externally created CM energy is diverted away from the SA front-end connector. A grounding strap at the back of the EMC Cabinet improves the diversionary path, but if it is not possible to include the strap, CM currents couple capacitively to grounding structures as too much energy is required for them to flow over the EMC Cabinet open interface and into the SA. In the case of self-EMI from the SA itself entering the antenna, the EMC Cabinet reduces the coupling mechanism as shown in Section 1. By eliminating self and external EMI, your SA can be used over the full dynamic range without false detection of signals which are completely unrelated to the device-under-test.
Shieldex Quality	The EMC Cabinet by Shieldex are high-quality shielding enclosures made from specially manufactured Shieldex textiles. These textiles are produced in Bremen, Germany, adhering to the highest quality standards. The EMC Cabinet stands out for its high cost-effectiveness and durability. Shieldex materials, that are used for the EMC cabinet, exhibit an abrasion resistance of up to 20.000 cycles. With Shieldex's EMC Cabinet, customers receive reliable shielding solutions that meet the highest standards.

Did we spark your interest ?

More information can be found on our detailed data sheets.
Please do not hesitate to contact us at any time.

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