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Shielding Effectiveness in Coaxial Cable Connectors in Ultra High Frequency — UHF — 1 GHz to 3 GHz

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Abstract— Cables and connectors are responsible to efficiently transfer energy and data between systems and so have an important role on EMI and EMC problems. The purpose of the shield of coaxial cables and connectors is the mitigation of the energy fluxes into and/or out of the circuits. There is no universally applied test method, due to the complexity of all systems and working conditions. A method to measure the electric field with and without solder on connectors in ultra-high frequency is proposed. The testing methodology is based on the integration software that controls both injected signals and measured parameters, where a constant power level is injected into the cable and then the electric field is measured.

1. INTRODUCTION

Nowadays, numerous electro-electronic system designers and product development engineers use shielded cable and connectors to protect against electromagnetic interference and comply with the strict electromagnetic compatibility requirements. Although Transfer Impedance (Z_t) is an extensively used and important parameter to test a coaxial cable, EMC engineers prefer working with the Shielding Effectiveness (SE) parameter of cables and connectors [1, 2]. The SE in terms of electric field is defined by Equation (1):

$$\mathrm{SE_{dB}} = 20 \log \frac{E\ (\text{electric field without shielding})}{E\ (\text{electric field with shielding})} \tag{1}$$

The attenuation of semi anechoic chambers and shielded chambers are expressed in dB and the technical specification is described using the Shielding Effectiveness. Although all these procedures to measure the SE are cited in many current standards, the basic demonstration for a universal calibration of the setup measurement is frequently missing. The shielding effectiveness is a significant factor to ensure the electromagnetic compatibility of the electro-electronic systems, but there is not a universal accepted methodology to measure the SE of cable and connectors together [2].

2. PROBLEM FORMUATION AND METHODOLOGY UTILIZED

A RF connector with a poor SE can present some complications when used in the vicinity of sensitive devices or in an electromagnetic contaminated environment [4]. For instance, if conducting lines and connectors are installed near to inverters used for AC motor speed control or nearby an electric motor, they become susceptible to receive the noise emitted by these components. Such disturbs can generate frequency and amplitude variation within the conductor, which might cause errors in the communication with the electronic centrals connected to it [5]. For decreasing EMI and EMC problems, it is more efficient to act on the cause, on the receiver or on the coupling environment [3, 4]. In this paper, the connector is the component that will be investigated in order to mitigate the radiated electromagnetic energy.

In a semi-anechoic chamber, RF signal in UHF Band (1 GHz to 3 GHz) with a constant power level of 50 Watts is injected into a cable and connectors with matched 50 Ω load. The measurement setup consists of an electric field probe, the coaxial cable and connectors. Both the electric field amplitude and the voltage standing wave ratio (VSWR) are measured [5]. In order to reduce the radiated electromagnetic interference in the transmission line, a coaxial cable with a copper tube enclosing the outer conductor is used. Figure 1 and Figure 2 illustrate the measurement setup and the regions where will be soldiers in the connector, respectively.

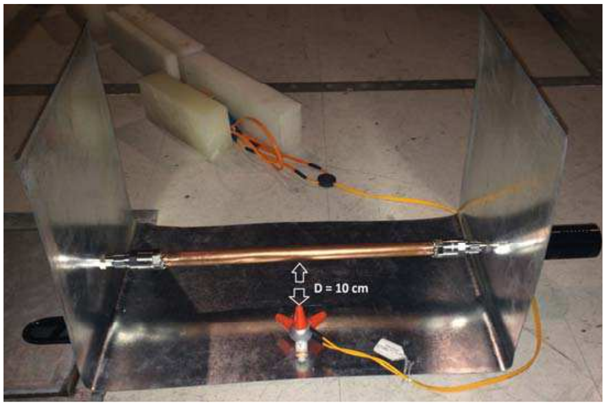

Figure 1: Measurement setup.

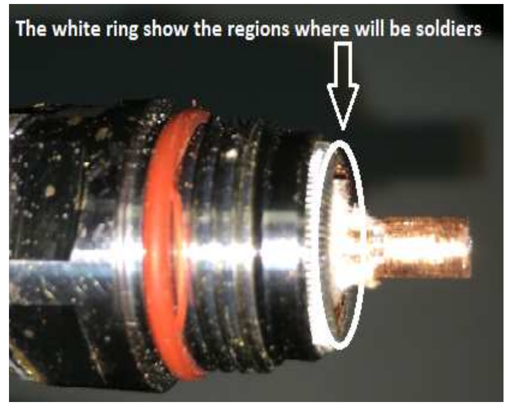

Figure 2: Connector without solder.

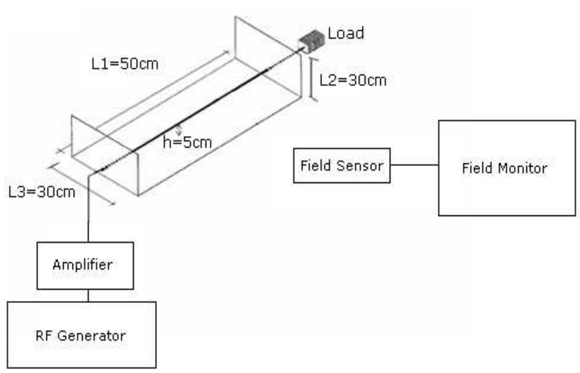

Figure 3: Measurement setup synoptic [4].

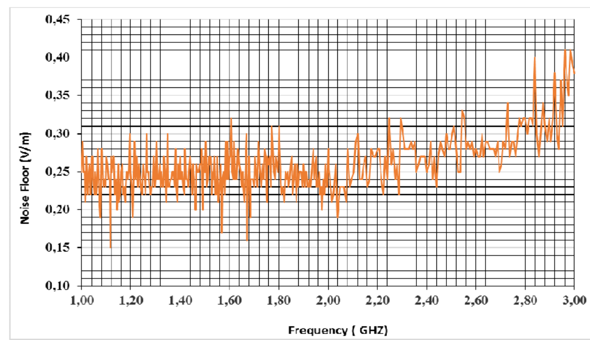

Figure 4: Noise floor of the semi-anechoic chamber.

The experimental setup shown in Figures 1 and 3 are based on the following parameters: $L_1 = 50\,\mathrm{cm}$, $L_2 = 30\,\mathrm{cm}$, $L_3 = 30\,\mathrm{cm}$, $h = 5\,\mathrm{cm}$, and load impedance of $50\,\Omega$ [3]. The connector under test is a 7/8” $50\,\Omega$ connector for 1/2” coaxial cable.

By using the EMC32 software that controls both injected signals and measured parameters, a 50 W constant power is injected into the cable. Both radiated electric field and the Voltage Standing Wave Ratio (VSWR) are measured with and without solder in the connector. The distance between the probe and the cable center was set to 10 cm.

3. RESULTS

In order to only measure the radiated electric field by the coaxial cable connector, and ensure consistency and repeatability of the test, the noise floor of the semi-anechoic chamber is measured. The Figure 4 shows the result for the noise floor measured with a electric field probe. The environment radio frequency levels at a test site shall be sufficiently low compared to the levels of measurements to be performed (to provide enough signal to noise ratio). In the present tests, the ambient radio frequencies had levels of at least 6 dB below the measurement levels to be performed [6].

Figure 5 illustrates the measured VSWR. The measured noise floor level shows that it can be neglected, considering that there is a good signal to noise ratio. The connector with solder has a lower VSWR and therefore it presents better performance in almost all frequency range (1 GHz to 3 GHz).

Figure 6 shows that the amplitude of the radiated electric field by the connector with solder is lower than without solder in the whole frequency range. At the frequency of 1.48 GHz, the amplitude electric field reaches values equal to 135 V/m. At the same frequency but with the connector soldered, the electric field drops to 4.7 V/m. In 1.79 GHz there is a variation of about 21.2 V/m in the electric field. At the frequency of 2.1 GHz the field level is 7.3 V/m with solder and 70 V/m without it. For frequencies higher than 2.7 GHz the difference with and without the solder is not relevant, pointing that the coupling mechanism is not anymore controlled by the solder.

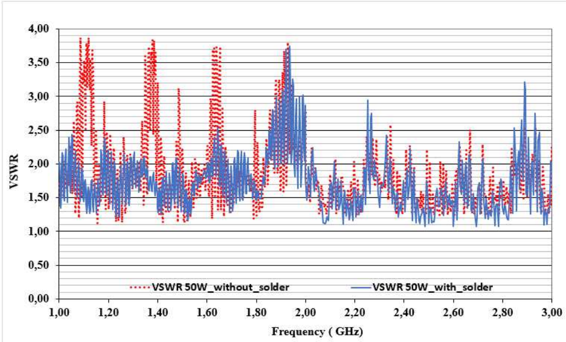

Figure 5: Voltage standing wave ratio (VSWR) with and without solder.

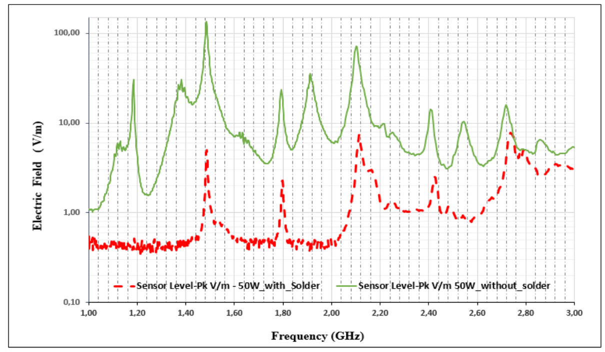

Figure 6: Electric field radiated by the connector with and without solder.

4. CONCLUSION

Differences between the measures of the electric field amplitudes in ultra-high frequency with and without solder are considerably high. For frequencies above 2.7 GHz this difference on the radiated electric field is not relevant. This article clearly shows the importance of a proper installation of RF Connectors in the UHF band. In this case even following the manufacturer recommendations it was necessary solder the connector to minimize both the VSWR and the radiated electric field. It should be also noted that in the UHF band, considering the performed measurements, there are still many challenges to determine the transfer impedance, as well as the shielding effectiveness of coaxial cables and connectors in the microwave range [7].

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