ALCIOM
3 Rue des Vignes
78220 VIROFLAY

Tel : 01 47 09 30 51
contact@alciom.com

www.alciom.com

Project :

White paper

DOCUMENT :

3D-Printed shields
An experimentation

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14/03/2014	**1A**	**Robert Lacoste / ALCIOM**

SUMMARY:

This white paper presents the results of an evaluation of RF performance of 3D-printed shields.

DOCUMENT HISTORY

DATE	VERSION	AUTHOR	COMMENT
14/03/14	1A	R.Lacoste / ALCIOM	Initial version

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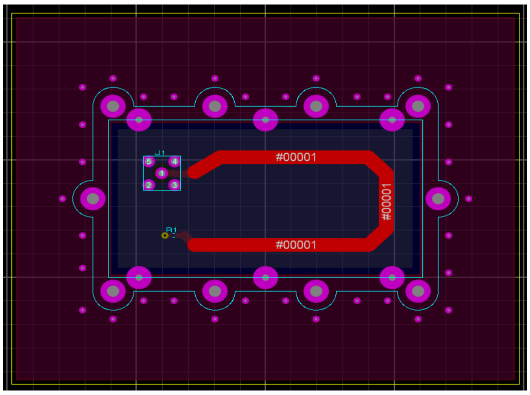
1 Introduction

3D printers are now very easily available. As a design house quite specialized in wireless devices and mixed-signal projets, we wanted to investigate the potential usages of standard 3D printers in our field. This white paper presents the results of our experimentations regarding 3D printed shields and their RF performances.

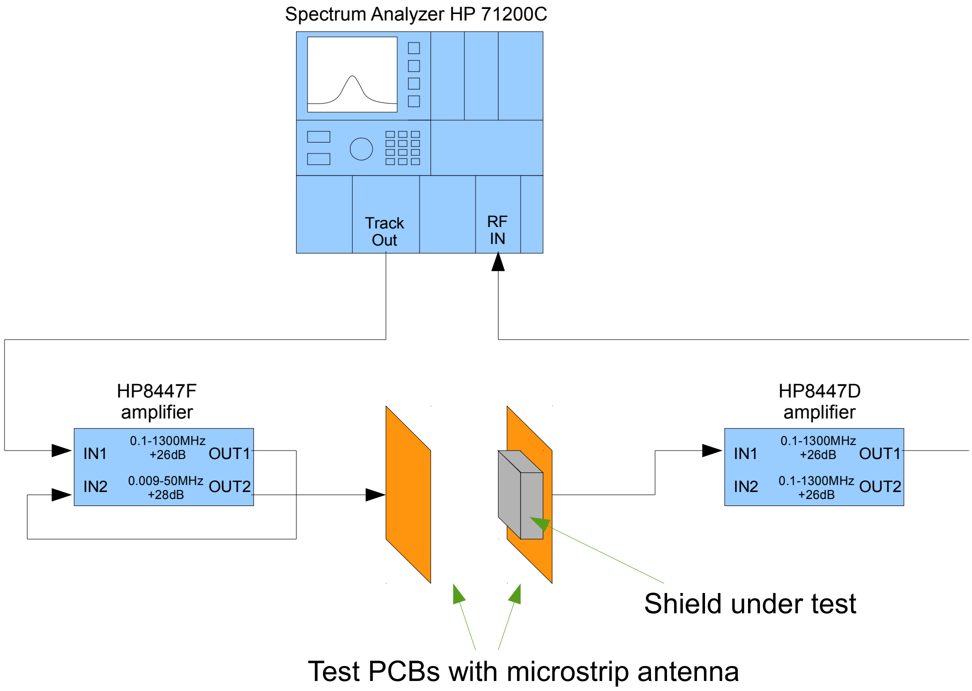
Warning : these results are experimental results, and are provided just for information. We will be glad to receive your feedback !

2 Test configuration

Several methods allows to measure the efficiency of a shield against RF signals. In order to simulate real life situations, where a shield is required between two sections of a design, we etched two identical test PCBs with a 5cm long 50-ohm microstrip terminated on a 50-ohm resistor to ground. Such a microstrip is a low efficiency but wideband antenna. The PCB is a standard FR4 substrate, 1,6mm, so the microstrip width is 3mm. An SMA connector on the bottom side allows to connect the RF source or analyzer. The PCB includes a full ground plane on the bottom side and ancilarry ground plane on the top side except inside the shield compartment :

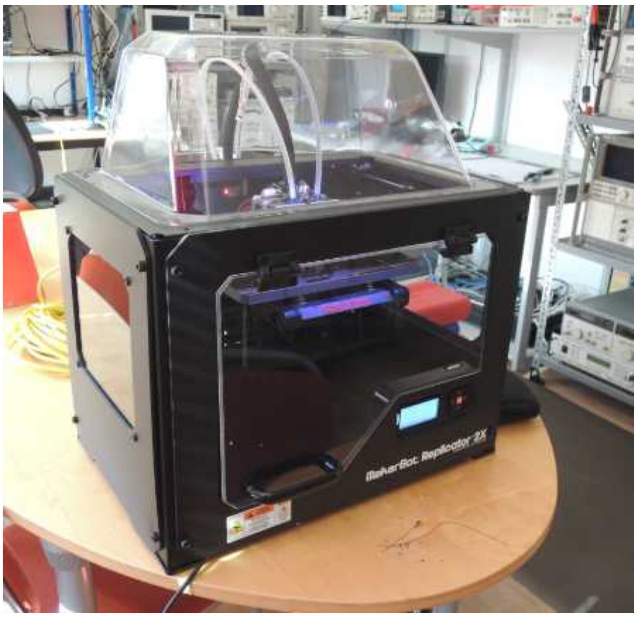


The two PCBs where installed face to face, with a 8cm distance, and we measured the RF coupling between each of them against frequency, from 1MHz up to 2GHz. The test setup was the following :

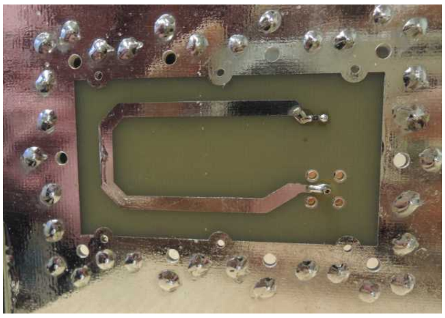
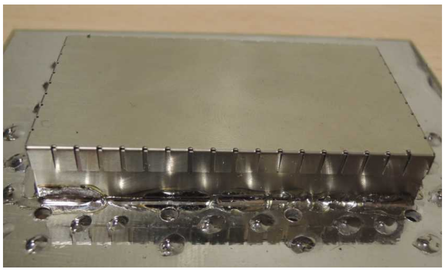


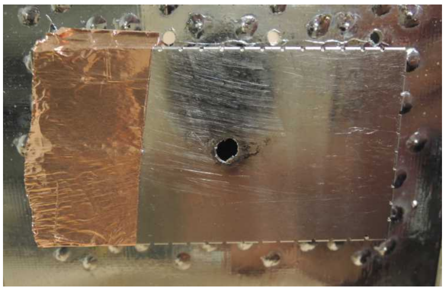
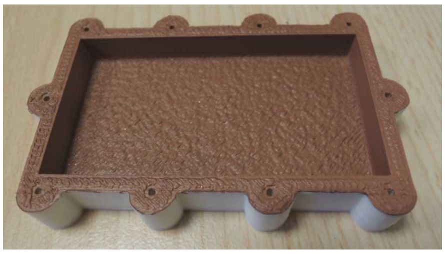
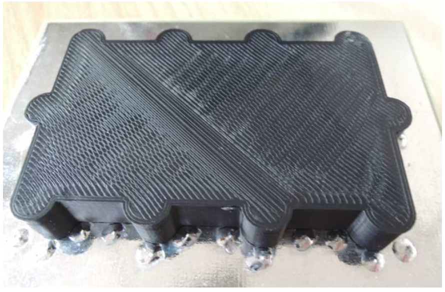
3 3D printed shields

For these experiments we used a REPLICATOR 2X printer from Makerbot. This experimental printer is optimized for ABS filaments which are more suitable than PLA for these kind of parts. Moreover conductive ABS filaments are now available on the market.



We printed and tested the following configurations :

Configuration	Shield configuration	Picture
NO_SHIELD	No shield on the test PCB	
TIN_PLAIN	Standard metallic shield soldered on the test PCB	

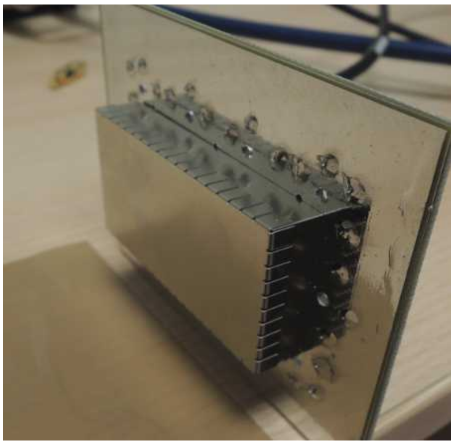
TIN_HOLE	Standard metallic shield with a 3mm hole on the cover	
ABS_PAINTED	3D printed standard ABS shield, full, plus two layers of 3M EMI paint	
ABS_COND	3D printed conductive ABS, full	
ABS_COND_PAINTED	3D printed conductive ABS plus two layers of 3M EMI paint	

4 Experimental results

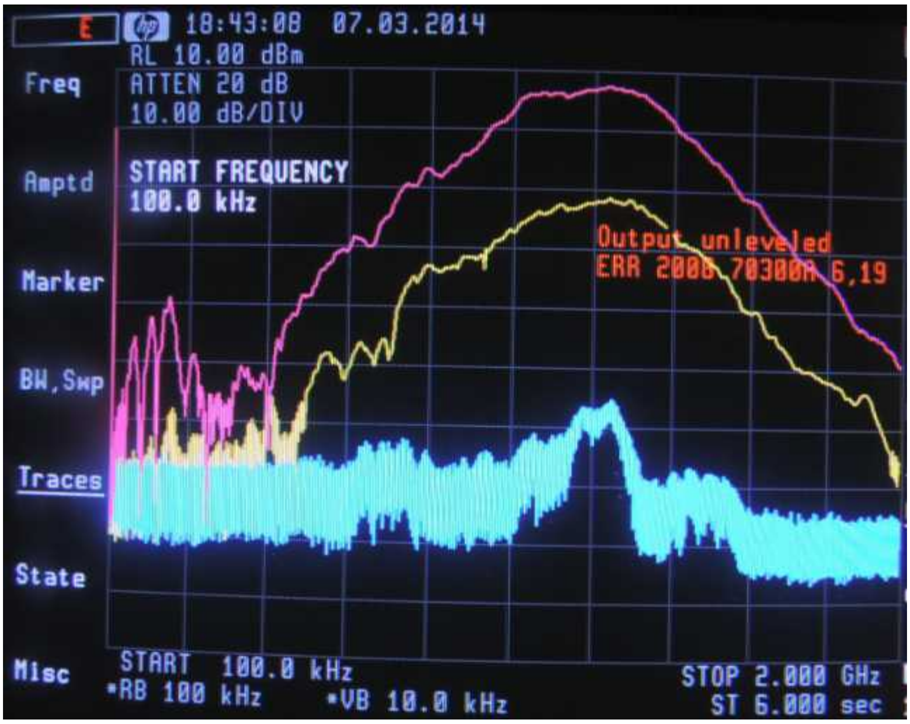
Here under the results of our experiments :

4.1 TIN_PLAIN

First test was done with a soldering of the shield only through the 6 pin holes :



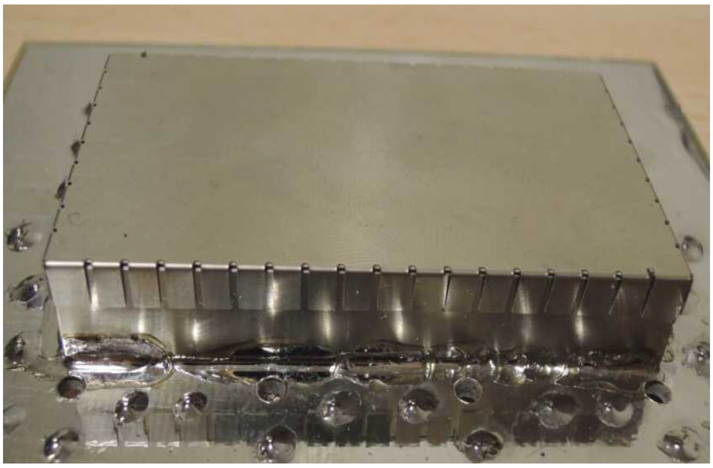
Measurement results :



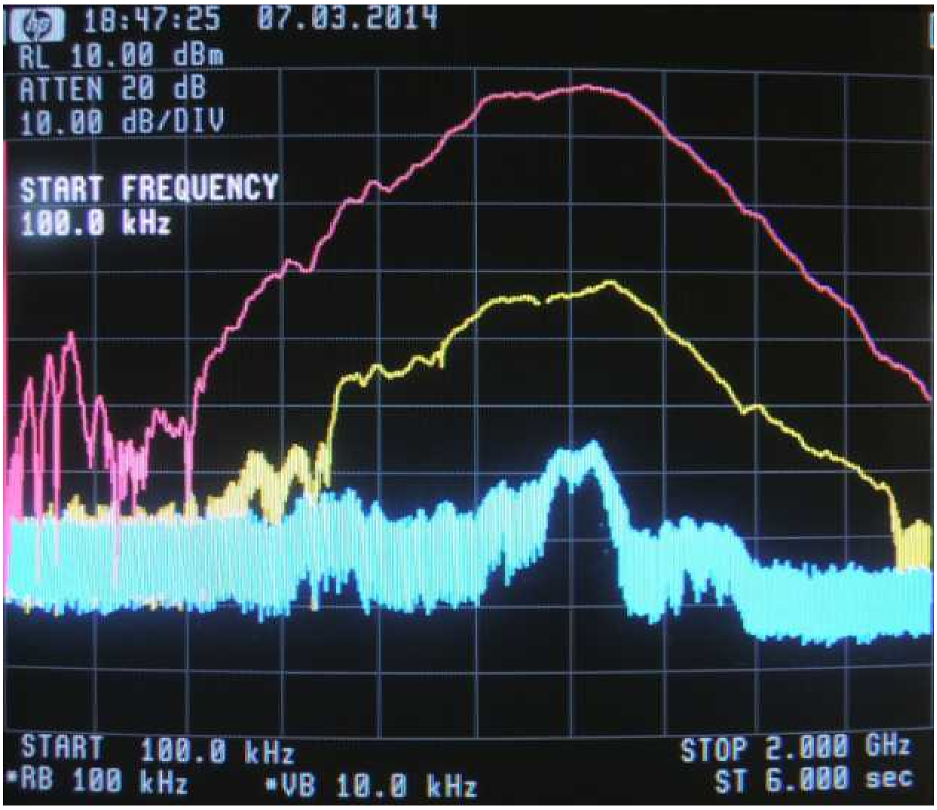
(pink : reference without any shield, yellow : with shield in place, blue : sensitivity baseline measured with a 50-ohm load in place of the transmitting antenna).

The shield attenuation range from 10dB in low frequencies up to nearly 20dB at 1GHz.

The same measurement was then done with a proper soldering of the shield can all around the ground plane :



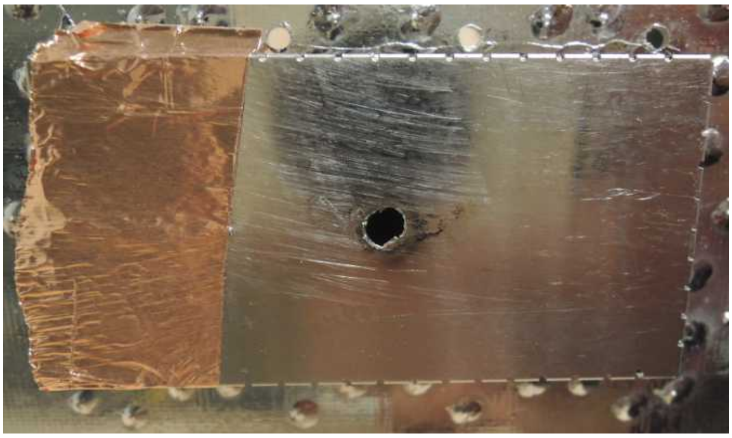
As expected, measured attenuation was greatly improved :



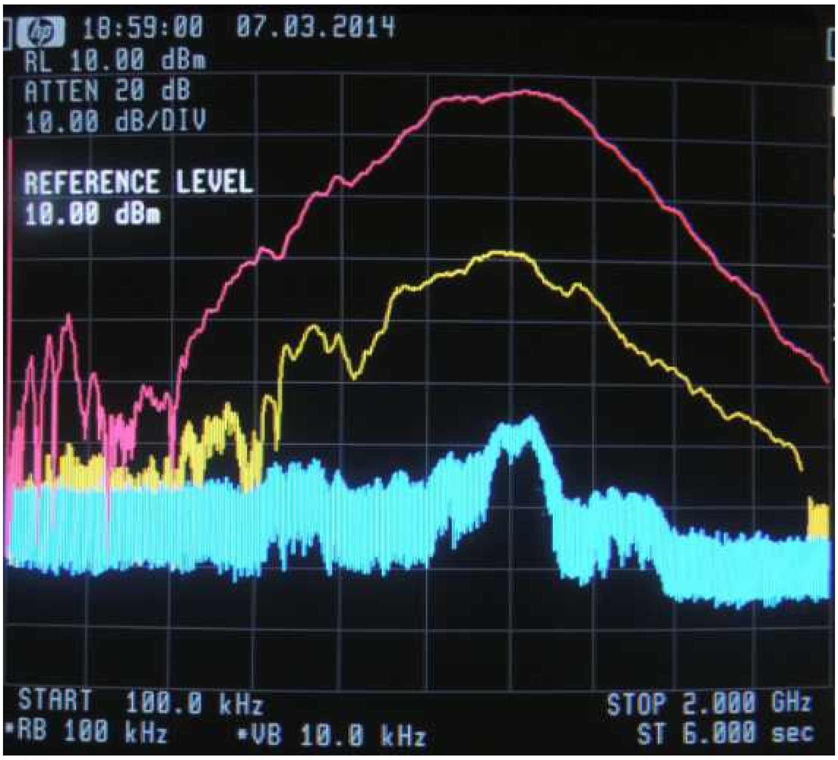
The measured attenuation in this optimal configuration is then around 25 to 30dB from 400MHz to 1,5GHz, down to 20dB up to 2GHz and at low frequencies.

4.2 TIN_HOLE

With the same setup a 3mm hole was added in the center of the shield can :



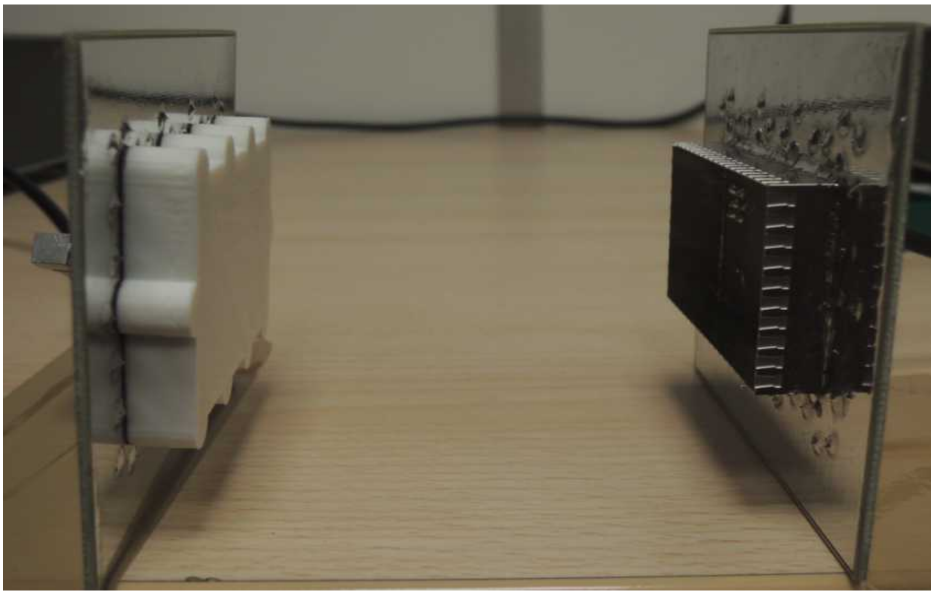
Measurement results :



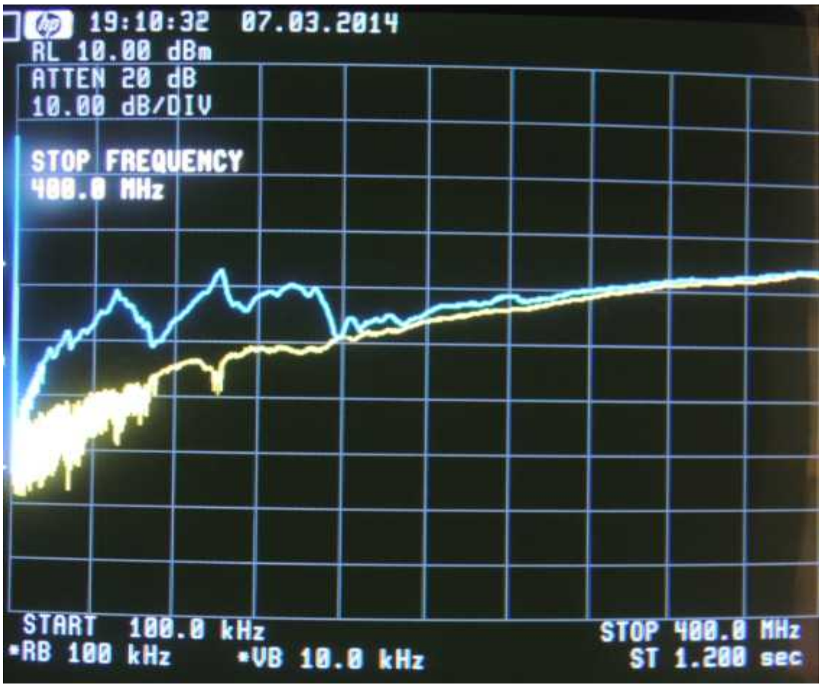
An overall 5dB degradation in the shield efficiency is measured from 200MHz upward.

4.3 ABS_PAINTED

The first 3D-printed test was done using a standard ABS filament, and two layers of conductive 3M EMI 35 paint :



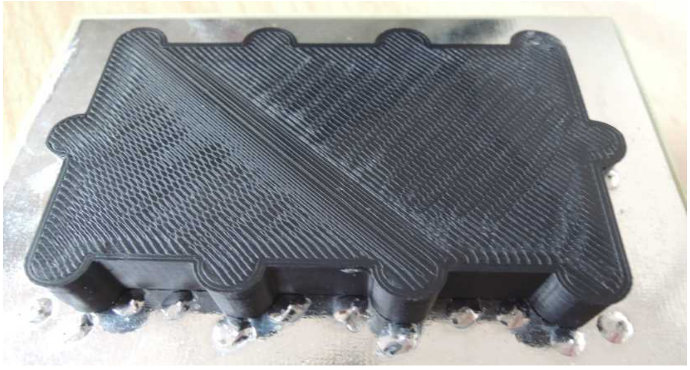
Measurement results :



A small attenuation of 10 to 15dB is measured in low frequencies, up to 180MHz. Attenuation is close to 0dB for upper frequencies up to 2GHz at least.

4.4 ABS_COND

The same shield was theen printed using a so-called conductive ABS filament. These filaments produce parts with quite high resistance so we expected low performances for RF shielding even if this material could be interesting for ESD dissipation.

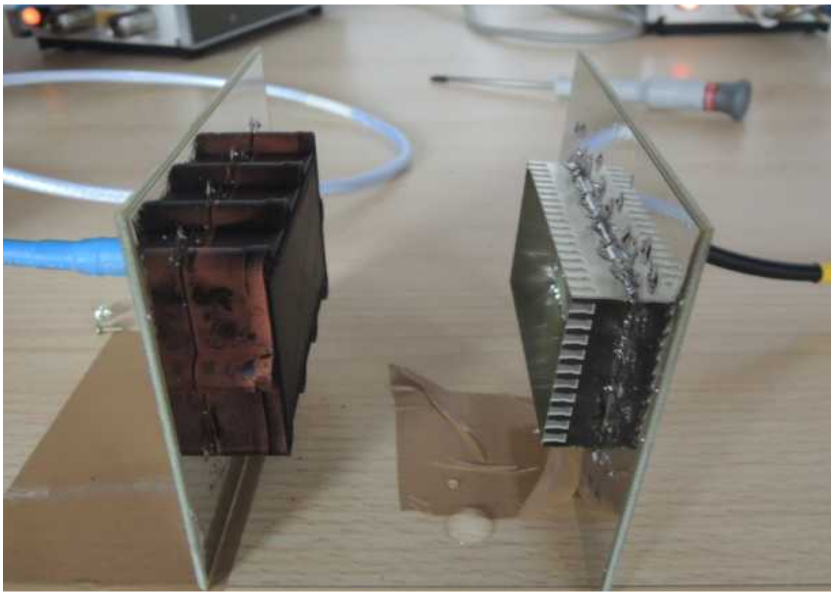


Measurement results :

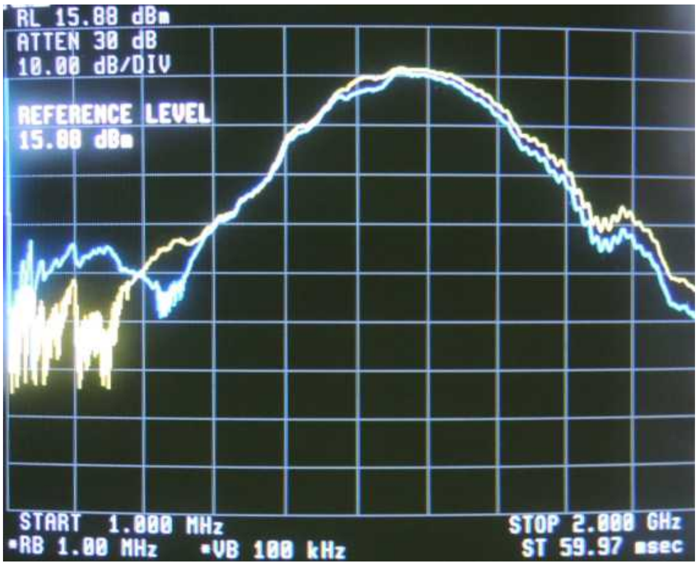
No significant shield efficiency was measured for frequencies above 200MHz. Even a negative efficiency was observed from 200 to 300MHz, probably due to multipath effect on the test setup. A 10dB attenuation is measured for lower frequencies

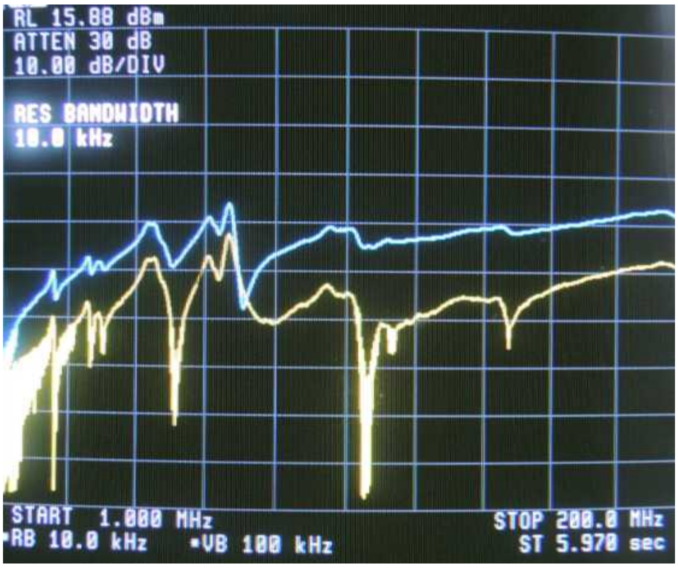
4.5 ABS_COND_PAINTED

Finaly the same test was done with two layers of 3M EMI paint on the 3D printed ABS conductive shield :



Once again, no significant shield efficiency was measured for frequencies above 200MHz. However for lower frequencies a reasonnable shield efficiency was measured, ranging from 5-8dB (<80Mhz) to 10-15dB (80Mhz to 200MHz) :





5 Wrapping up

These experiments were very partial results. In particular the shield efficiencies where measured in a barely controlled environment and using a very close field coupling. Far field shield efficiencies could be very different. Therefore these results should be used with great caution.

Anyway these tests allow to get some order of magnitudes :

- A well soldered metallic shield can easily provides an attenuation of the close-field coupling between two circuits of 25 to 30dB around 1GHz, and more than 20dB at any RF frequency except very low frequencies where magnetic coupling is the main contributor. Gettig a far higher attenuation would need more care in the PCB design, soldering, etc.

- Small defects in such a metallic shield (small holes or bad solder joins) quite degrade the atttenuation down to 10-20dB only.

- The usage of conductive ABS filament alone doesn't allow to provide an effective shielding against RF fields, at least using the currently available filaments. Due to their high impedance a shield efficiency of 10dB is at best obtained from 80Mhz up to 200MHz

- The addition of conductive ABS filament and conductive EMI paint allows to get a slightly better shield efficiency, but still limited : from 5-8dB (<80Mhz) to 10-15dB up to 200MHz. No shield effect is measured for higher frequencies

Therefore a metallic shield is still the only viable solution except where a very light shield is required (for example for a plastic packaging if a product fails to the EMC certification test only by a couple of dB... A last solution would be to use a silver-based paint for increased surface conductivity, but the extra cost would be significant.

6 Who is ALCIOM ?

ALCIOM is a consultancy and design house company specialized in mixed signal devices, from radiofrequencies and microwaves to high speed electronic systems, digital signal processing and ultra-low power embedded systems. Based in France, near Paris, we served more than 100 customers worldwide since 2003. We are Microchip certified wireless design center and gold partners, Cypress gold partners, Texas Instruments low power RF specialists and accredited Analog Devices experts.

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