



AEROSPACE RECOMMENDED PRACTICE

ARP6248™

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Stripline Test Method to Characterize the Shielding Effectiveness
of Conductive EMI Gaskets up to 40 GHz

RATIONALE

This new standard is intended to provide a test method to characterize the shielding effectiveness of conductive EMI gaskets, up to the frequency of 40 GHz. FCC recently published EMC emission limits up to this frequency.

At this moment (February 2015), standardized methods are only available up to a maximum frequency of 18 GHz.

Methods addressing small samples of gaskets are limited up to 10 GHz and are not giving a shielding effectiveness value, but a related parameter called transfer impedance.

This standard will directly provide shielding effectiveness values up to 40 GHz, and will also be applicable for small samples of conductive EMI gaskets.

A more detailed rationale concerning the validity of some standards is given in Appendix C of this document.

INTRODUCTION

Due to the impact of higher and higher frequencies, characterization of shielding materials and components is needed up to the frequency range as occurring in actual electronic applications and products. Consequently, FCC recently published EMC emission limits up to the frequency of 40 GHz.

In more, the direct radiated effects of small subassemblies and components such as the ones found on a PCB are becoming important. For this reason, an appropriate SE characterization of small in-circuit enclosures and the accompanying shielding gaskets at frequencies above 1 GHz is needed.

The standard IEEE Std 1302™ is a guidance document on choosing appropriate test methods for conductive EMI gaskets, and refers to the standardized methods such as MIL-DTL-83528C, ARP1173, and ARP1705. MIL-DTL-83528C and ARP1173 are dealing with SE measurements up to 18 GHz, but the methods proposed in these standards are not applicable for samples of small shielding components.

The standard ARP1705B is dealing with the related parameter transfer impedance for conductive EMI gaskets up to the frequency of 10 GHz. But there is no clear and firm relationship between transfer impedance of conductive gaskets and the forthcoming shielding effectiveness.

A method overcoming these problems is proposed in this document, and is furthermore also in line with the recently published standards IEC 61967-8 and IEC 62132-8 on the characterization of integrated circuits for EMI emission and immunity.

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1. SCOPE

1.1 Purpose

The purpose of this procedure is to establish a technique for reliably and repeatedly measuring the RF shielding characteristics of EMI conductive gasket materials and EMI conductive gaskets. Depending on the materials used for the construction of the measuring setup, the EMI conductive gaskets can be characterized against various joint surfaces. This standard will directly provide shielding effectiveness values up to 40 GHz, and will also be applicable for small samples of conductive EMI gaskets.

1.2 Background

MIL-DTL-83528C and ARP1173 are existing methods for accomplishing the goals expressed in 1.1, but are limited to an upper frequency of 18 GHz.

Both methods consists of a larger (MIL-DTL-83528C) or smaller (ARP1173) enclosure with an open window in one of the metallic walls of the enclosure. A solid metal clamping plate is used to close the window, and to clamp the gasket under test between this clamping plate and the enclosure wall. The gasket is placed around the periphery of the window. A source is placed within the enclosure and a receiving antenna located outside the enclosure.

Beside the limited frequency range, there is the fact that the utility of data from measurements made using these techniques is limited, since the results depend upon the dimensions and construction of the enclosure, the details of the antennas used for both source and receiver, the size of the open window, the measuring environment (such as the location of the measuring enclosure in or outside a shielded room), as well as the performance of the gasket under test. Since the data is so dependent upon the test setup, it cannot be accurately used in equipment design analysis.

ARP1705 is using another measuring test setup in order to define a parameter related to the shielding effectiveness of EMI conductive gaskets. The method was originally limited to an upper frequency of 1 GHz and has recently been expanded up to 10 GHz. Although there is a close relationship between the global conductivity of the complete system of the two surfaces and the clamped gasket in between and the provided shielding effectiveness, there is no firm one-to-one relationship which makes it not possible to be accurately used in equipment design analysis.

The stripline test method presented in this document offers an attractive alternative to any of the radiated field methods and to the transfer impedance method for evaluating EMI conductive gaskets, over a wide frequency range from 100 MHz up to 40 GHz in one measuring sweep.

The method yields data which are directly related to the design and test procedures of small subassemblies, shielding compartments and cavities of larger systems, and components such as the ones found on a PCB. Additional theory can be found in the publications referenced in 2.2 of this document.

The stripline test method offers a great repeatability for evaluating EMI conductive gaskets, and has the advantage of requiring no specific measuring environment and less laboratory equipment such as antennas, and is very compact and easy to handle. It is also a broadband measuring setup, covering a frequency range from 100 MHz up to 40 GHz at once. By allowing a lower dynamic range, the lower frequency limit is even below 100 MHz.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP1173 Test Procedure to Measure the R.F. Shielding Characteristics of E.M.I. Gaskets

ARP1705 Coaxial Test Procedure to Measure the RF Shielding Characteristics of EMI Gasket Materials

ARP1705B Coaxial Test Procedure to Measure the RF Shielding Characteristics of EMI Gasket Materials

2.2 Other References and Publications

- 2.2.1 IEEE Std 1302™ - 2008, "IEEE Guide for the Electromagnetic Characterization of Conductive Gaskets in the Frequency Range of DC to 18 GHz," IEEE, November 2008.
- 2.2.2 MIL-DTL-83528C - 2001, "General Specification for Gasketing Material, Conductive, Shielding Gasket, Electronic, Elastomer, EMI/RFI," 2001.
- 2.2.3 J. Catrysse et al., "Towards a global approach for the characterization of IC's and on board shielding components," Proceedings EMC Europe 2010, Wroclaw, September 2010.
- 2.2.4 J. Catrysse et al., "Expanding the stripline measuring setup for the characterisation of conductive gaskets up to 40 GHz," Proceedings IEEE EMC International Symposium 2012.
- 2.2.5 J. Catrysse et al., "A measuring setup for the characterisation of 'in circuit' conductive gaskets up to 40 GHz," Proceedings EMC Europe 2012, Roma, September 2012.
- 2.2.6 J. Catrysse et al., "The importance of continuous and homogeneous gasket conductivity up to 40 GHz," Proceedings EMC Europe 2013, Brugge, September 2013.
- 2.2.7 D. Pissoort et al., "Correlating the High-Frequency shielding performance of 'on-board' gaskets when measured using a stripline or reverberation room method," Proceedings IEEE EMC International Symposium 2014.
- 2.2.8 B. Koerber et al., "IC-stripline: A new proposal for susceptibility and emission testing of IC's," Proceedings EMCcomp 2007.
- 2.2.9 IEC 61967-8 ed. 1, Integrated Circuits - measurements of electromagnetic emissions - part 8: measurement of radiated emissions - IC stripline method.
- 2.2.10 IEC 62132-8 ed. 1, Integrated Circuits - measurements of electromagnetic immunity - part 8: measurement of radiated immunity - IC stripline method.

2.3 Definitions

2.3.1 SHIELDING EFFECTIVENESS (EMC)

For a given external source, the ratio of the electric or magnetic field strength at a point before and after the placement of the shield in position (IEEE Standard Directory of Electrical and Electronic Terms, p. 528, 1972).

For the purpose of this measurement methodology, it is referred to the standard MIL-DTL-83528C (clause 4.5.12) which uses a same approach: *"Shielding Effectiveness is defined as the ability of a gasket to electrically bond a test cover panel to an enclosure flange such that radiated RF is attenuated."*

Consequently, the results of this measurement methodology includes contributions from the gasket material itself as well as the clamping plate.

3. BASIS OF THE TEST METHOD

Based on work by B. Koerber, a test methodology has been standardized for emission and susceptibility testing of ICs: IC stripline method (IEC 61967-8 ed. 1 and IEC 62132-8). See also References 2.2.8 through 2.2.10.

The method is based on putting a stripline over a PCB board with a full GND layer, so that susceptibility or emission of an integrated circuit may be characterized. The principle of the setup is sketched in Figure 1.

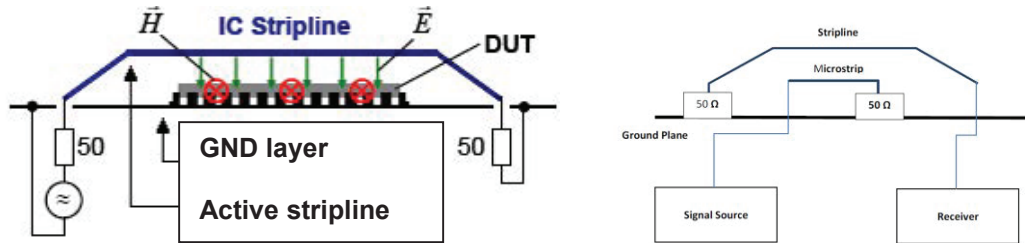


Figure 1 - Principle setup of the stripline method in order to characterize ICs (left) and the resulting stripline method for gaskets (right)

By replacing the IC under test by a 50 ohm microstrip, and a plate to clamp and compress a gasket to the chassis of the system, a basically matched measuring setup is obtained. Principally, matching is not an essential issue in this concept, but it will avoid the occurrence of high standing waves over the whole frequency range, although good matching is only obtained in the lower frequency range.

A picture of the setup is shown in Figure 2.

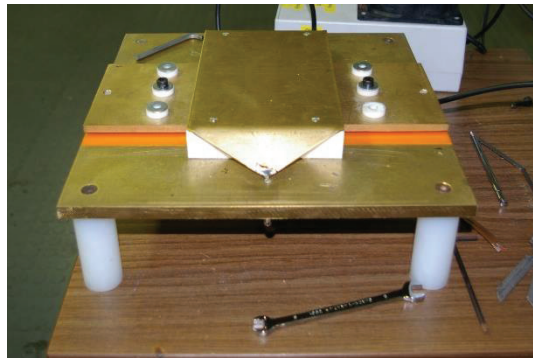


Figure 2 - Overall view of the stripline setup

Both the microstrip and the stripline have one load of 50 ohm, so that the setup may be considered as a 2-port circuit.

The open structure can be modelled as a set of two asymmetrical coupled lines, with a common reference GND conductor, as sketched in Figure 3.

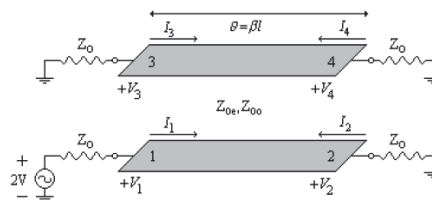


Figure 3 - Schematic figure of a directional coupler

It is a well-known characteristic of these geometries that sharp uncoupling at one of the ports may occur at a given frequency. This means that some sharp resonant effects may occur in the measurement graphs, and they should be disregarded with respect to the characteristic properties of the gasket.

To overcome these problems, absorbing materials are inserted in the setup in order to damp some resonant peaks and an appropriate data processing algorithm is under development.

By inserting shielding material between the stripline and the embedded microstrip, the coupling between both transmission lines is attenuated and gives a measure of the shielding effectiveness provided.

Complementary to the basic characterization of the shielding effectiveness of conductive EMI gaskets, the stripline test method holds a direct relationship to the physical and mechanical environment of small subassemblies, shielding cavities, compartments and partitions on larger boards and on-board shielding components on a PCB. This property is discussed in Reference 2.2.3 of this document.

4. TEST FIXTURE

Figures B1 through B20 illustrate the construction and the mechanical dimensions of the test fixture. The frame is made from brass which provide stable measurements in time. The frame can also be made from other materials or an appropriate plated surface, so that the influence of the gasket joint surfaces can be observed, in which case published test results should refer to the present document with the mention "modified - surface XXX."

4.1 Fixture Assembly

Figures 4 illustrate the setup, consisting of the base plate, the embedded microstrip, the stripline, the clamping plate and a typical sample of the gasket to be tested.

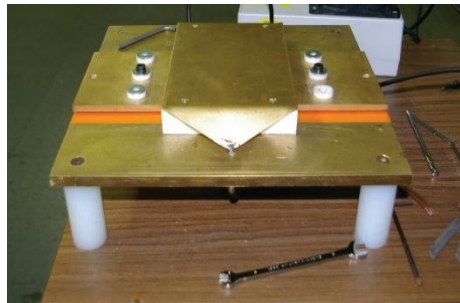


Figure 4A - Global view of the complete setup

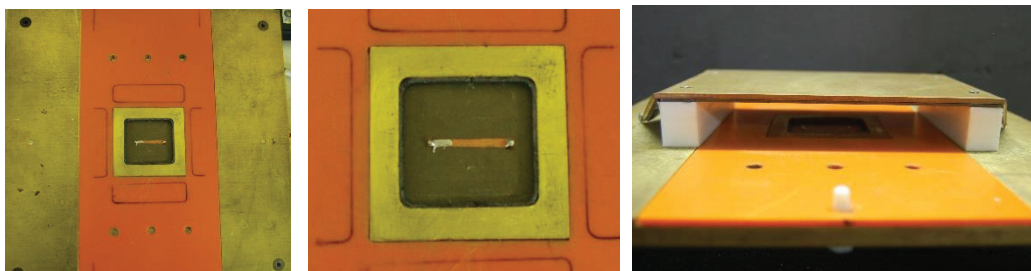


Figure 4B - Embedded microstrip in the base plate

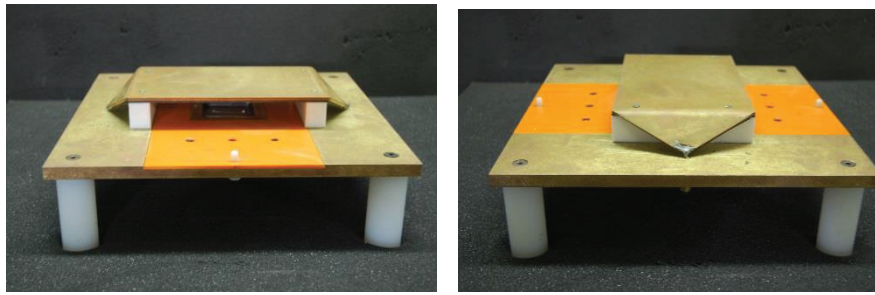


Figure 4C - The stripline, and insulating surfaces on top of the base plate

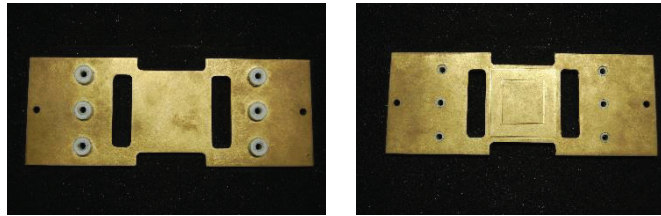


Figure 4D - The clamping plate in order to compress the gasket under test



Figure 4E - Typical size of a sample of gasket to be tested

A stripline has been designed to fit a characteristic impedance of 50 ohm (Figure 4C). The width of the stripline is 12 cm and the height above the solid GND brass base plate is 2.6 cm. The active length of the stripline is 9 cm, and both tapering sections are 3 cm each. The inner side of the stripline is covered with an absorbing ferrite sheet, to avoid too much influence of the short tapering and other resonances. Typical characteristics for this sheet are a thickness of 1 mm and a reflectivity coefficient of minimal - 5 dB.

Coaxial 2.4 mm connectors appropriate for the proposed frequency range are mounted through the solid GND base plate. The use of other connectors might give rise to a reduced frequency range. Panel socket connectors are preferred, mating perfectly to the flat surface of the GND base plate. If necessary, the circumference could be soldered to the GND base plate, in order to guarantee a perfectly conductive and tightened transition between GND base plate and panel socket connector.

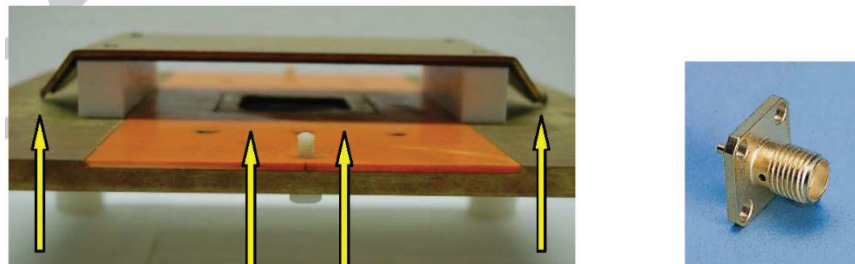


Figure 5 - Position of the 4 coaxial panel socket connectors with respect to the setup, and example of panel socket connector

Another solid brass plate with a central positioning area of 5 cm x 5 cm (Figure 4D) is intended to hold the gasket, and is inserted in the open area of the stripline (see Figure 4A).

Embedded in the solid GND base plate, there is a small 50 ohm microstrip (Figure 4B), with a load of 50 ohm connected via a coaxial connector through the GND base plate. This microstrip is used as the transmitting antenna and simulates the radiating traces on a PCB. The sidewalls of the embedded space are also covered with a typical absorbing ferrite sheet, as used in practice to damp cavity resonances.

The microstrip has a length of 4 cm and is made on a substrate of microwave PCB material, and is embedded in a 5 cm x 5 cm x 0.5 cm cavity, in the central area of the solid GND base plate (thickness of minimum 10 mm).

By covering this embedded microstrip with a plate or sheet, the Shielding Effectiveness (SE) of this material can be evaluated, by performing two measurements: a first coupling between microstrip and stripline in an open structure and a second one when covered with the material.

Using a solid brass plate to cover the embedded microstrip, and inserting a gasket in between this plate and the solid GND base plate of the stripline structure, the SE of the gasket can be measured. In this way, the brass plate can act as a gasket sample holder, and the gasket may be carefully positioned on this solid plate. This is shown in Figure 4D. When placing this sample holder in place, the embedded microstrip is exactly within the inner surface area limited by the gasket.

The clamping plate is fastened to the GND brass base plate with 2 x 3 bolts, which are isolated from the clamping plate by plastic non-conductive rings. Neither the size of the bolts (ex. M8), nor the placement of the bolts and the non-conductive rings are critical. The bolts are screwed in the GND base plate, due to the appropriate screw threads provided in the GND base plate. Details are shown in the Figure 6A.

An alternative version uses a non-conductive clamping plate, with an appropriate conductive area at the gasket position, in order to avoid the need of the non-conductive rings. More details as given in Appendix D.

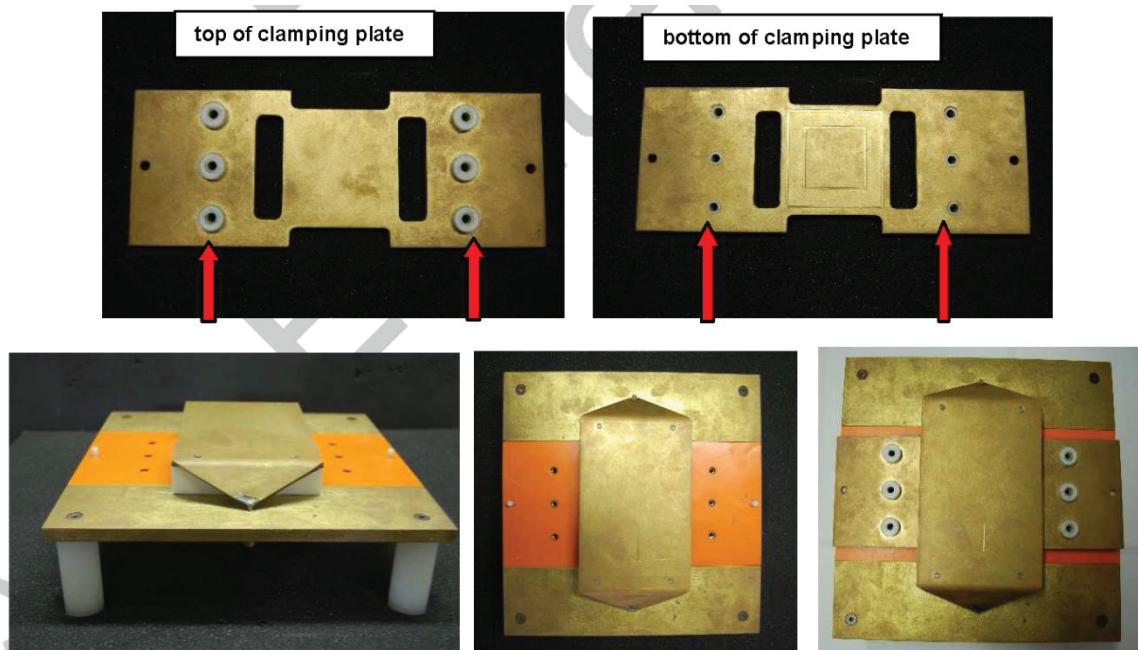


Figure 6A - Details for fixing the clamping plate (upper) on the GND base plate (lower)