

## GTEM-CELL TESTING FOR ELECTROMAGNETIC MEASUREMENTS

**K. Malaric, J. Bartolic and B. Modlic**

Faculty of Electrical Engineering and Computing  
Department for Radiocommunications and Microwave Engineering  
University of Zagreb, HR-10000 Zagreb, Croatia

*Abstract: Use and application of the GTEM-cell, which is a transmission structure based on a TEM-cell approach, has been described. The cell can be used for calibrating small antennas, for immunity and emission testing. Its broadband frequency response from DC up to app. 20 GHz enables laboratory experiments as well as commercial testing of the equipment such as cellular phone, IC boards, or small electronic devices up to 0.2 m x 0.2 m in size. It provides homogenous electromagnetic fields with TEM (transversal electromagnetic mode) distribution, similar to the free space. It has a shield to prevent radiation from the outside, which would interfere with our measurement. Electric and magnetic field inside the cell can be accurately predicted using numerical methods. GTEM-cell designed and made at the University of Zagreb, Croatia was presented in this paper as well as the measurements in frequency domain; return loss and standing voltage ratio. Measurement setup and the method have been explained.*

*Keywords: GTEM-cell, EMC, EMI*

### 1 INTRODUCTION

GTEM-cell is a transmission structure based on a TEM-cell approach. Slightly spherical wave propagates from the source into a  $50 \Omega$  rectangular coaxial transmission line and its distributed hybrid termination without geometrical distortion of the TEM wave. Since the opening angle of the waveguide is small, the undistorted spherical wave can be considered as a plane wave. GTEM-cell is a tapered section of rectangular  $50 \Omega$  transmission line. The GTEM-cell (Fig. 1) begins with a precision craft apex, where transition from the standard  $50 \Omega$  coaxial connector (or the N type connector) to the asymmetric rectangular waveguide is done. The distributed load section uses absorbing material for electromagnetic wave termination and a distributed resistive load for current termination. At low frequencies, it operates as a circuit  $50 \Omega$  load. At high frequencies, the absorber attenuates the incident wave as in an anechoic chamber. In this way, a termination from DC to several GHz is achieved. The TEM mode excited by either a CW source or a pulse generator simulates an incident plane wave for immunity and emission tests [1].

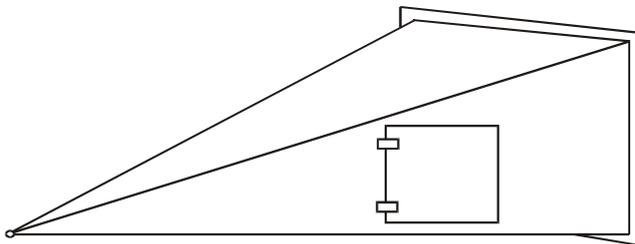


Figure 1. GTEM-cell

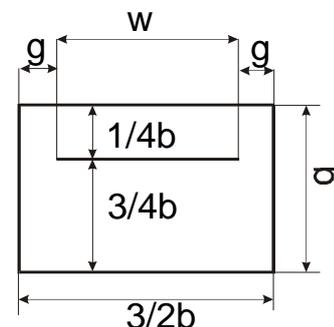


Figure 2. GTEM-cell cross section

The characteristics [2] of GTEM-cell (Fig 2.) are:  $50 \Omega$  impedance, inner conductor at  $3/4$  height, inner height to width ratio equals 2 to 3 and angle septum/bottom plate equals  $15^\circ$ , with angle septum/top plate of  $5^\circ$ . Septum as well as coating is made of copper. The N type connector is at the

end of the tapered section. Septum is supported with dielectric material. At the other end of 1,15m long GTEM cell, there are pyramidal absorbers 25 cm long for electromagnetic wave termination and the distributed resistive load for current termination. An object of approximately 20 cm x 20 cm can be inserted for testing. Figure 3. shows electric and magnetic field distribution in GTEM cell using numerical analysis with the program "MAFIA".

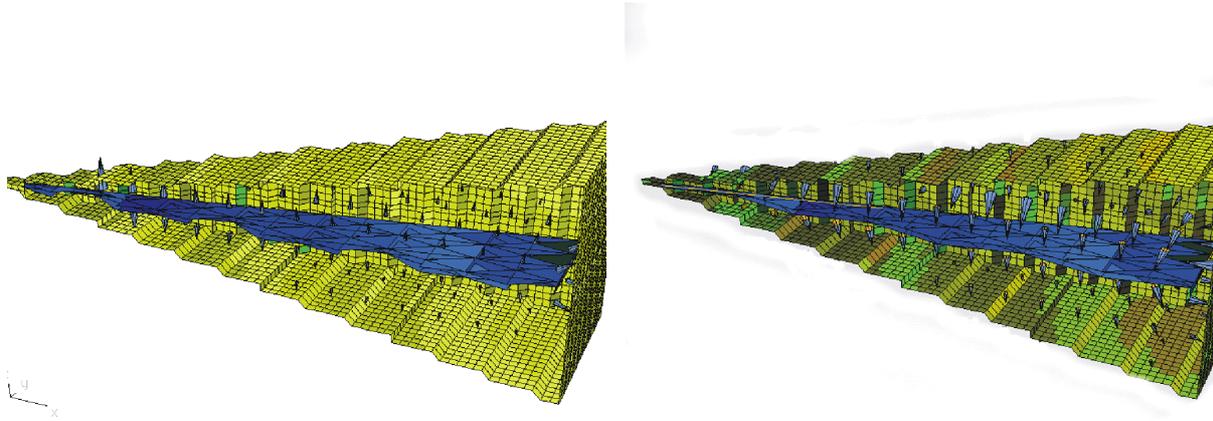


Figure 3. Electric and magnetic field distribution in GTEM-cell using numerical analysis

## 2 MEASUREMENT SETUP

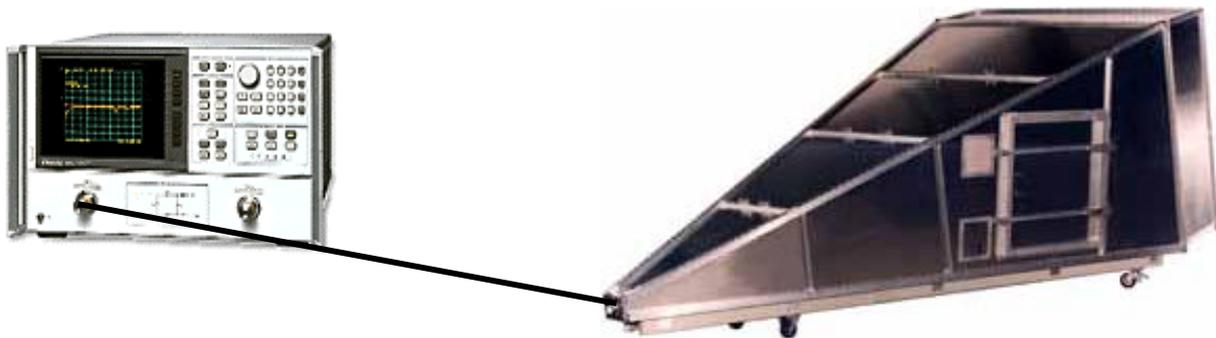


Figure 4. Measurement setup

The measurements were performed using HP 8720B Network Analyzer [3] and with gold plated N type connectors. Network Analyzer can excite frequencies from 135 MHz up to 20 GHz. Measurement results are stored into the computer via software developed at our Department. The results are then processed in Microsoft Excel. For the GTEM-cell it is not of utter importance to have laboratory free of outside interference as with other type of similar measurements, since the cell has an outer shield, so the impact of the surrounding fields have no effect on the measurements. That is true for the GTEM-cell itself, although the network analyzer itself can be under the influence of other fields that reside in the vicinity of the measurement setup. That is why the gold plated N type connectors have been used in the measurements to lower the signal loss and interference. Electromagnetic compatibility is basically finding out how much one electronic device influences the other electronic device, and if it does, what is the level when this event occurs. Immunity is the ability of a device to withstand the interference of other device still operating inside the characteristic boundaries guaranteed by the manufacturer. Biomedical exposure is the influence of the radiation to the living beings, whether they are mammalia cells, viruses, bacteria, animals or humans. Numerous comparisons of the GTEM-cell with OATS (open area test sites) have been performed, and the GTEM-cell has been accepted as a valid tool for the full compliance testing. This simplifies the measurements as well as significantly lowers the cost for a large variety of applications. That means that it is not necessary to have a large test area outside in the open, or full or semi anechoic room for the compliance measurements, if the smaller object has to be tested. The cell can be used for small antenna calibration, as well as for the immunity and emission testing.

### 3 MEASUREMENT RESULTS

The measurements were performed in Primary Electromagnetic Laboratory at the Department of Radiocommunications and Microwave Engineering. Standing wave ratio (SWR) and return loss are the parameters of GTEM-cell that have been measured. SWR shows how much is GTEM-cell matched. If the value of SWR is close to "1.0", then the cell is very well matched.

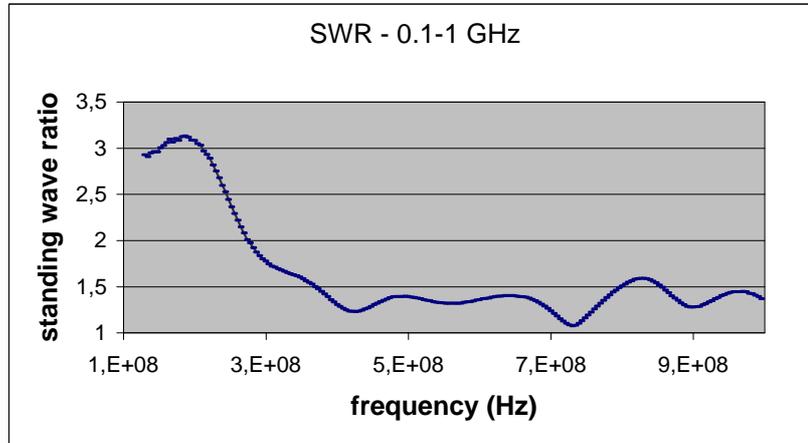


Figure 5. SWR

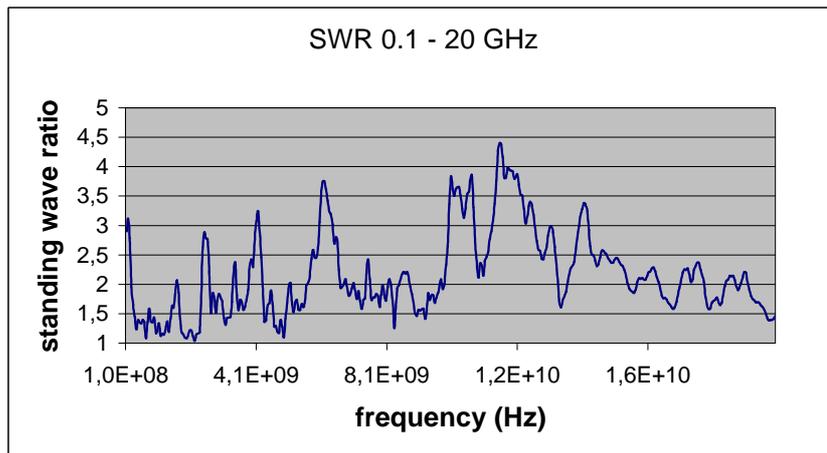


Figure 6. SWR up to 20 GHz

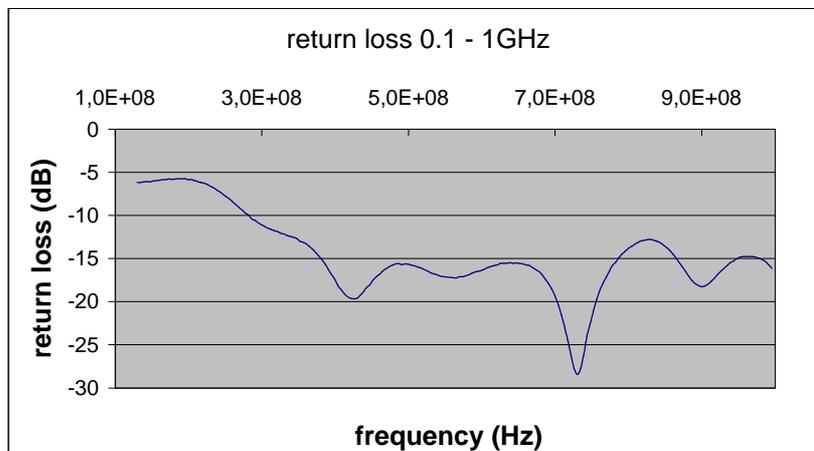


Figure 7. Return loss

Figure 5 is showing SWR up to frequencies of 1GHz. It can be seen that above app. 200 MHz, the value of SWR falls below 2.0, and that the cell is quite well matched. Figure 6. shows the expanded range up to 20 GHz, and it can be seen that with the exceptions of certain frequencies, the GTEM-cell can be used. Figures 7. and 8. depict the return loss in the ranges up to 1GHz and up to 20 GHz. The lower the value (in dB), the weaker signal is reflected back from the end of the cell, which means that the cell is better matched.

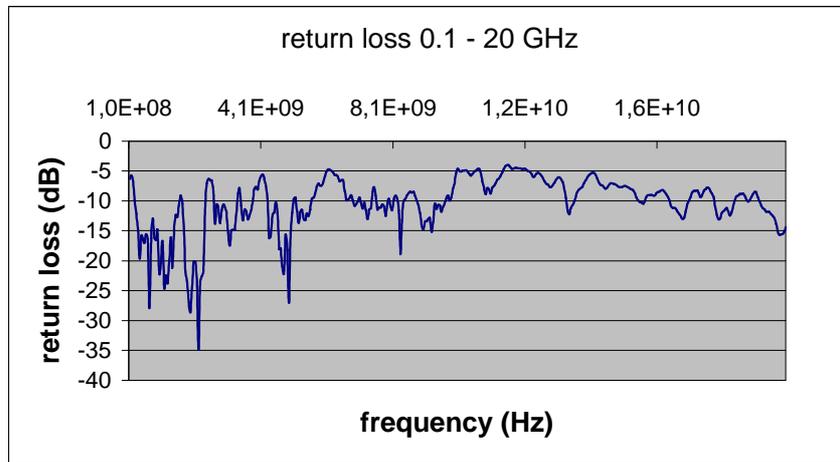


Figure 8. Return loss - up to 20 GHz

#### 4 CONCLUSION

GTEM-cell was designed and modeled at the Faculty of Electrical Engineering in Zagreb. General outlines of the cell have been given with the reference to the previous work. The results of the numerical analysis have been shown. The cell has been tested with the network analyzer HP 8720B. SWR and return loss were measured and the obtained results showed that the GTEM-cell can be used for the EMC measurements, the calibration of antennas, the immunity and emission testing as well as for biomedical exposure.

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**AUTHORS:** Mr.sc. Krešimir MALARIĆ, dipl.ing., Prof.dr.sc. Juraj BARTOLIĆ and prof.dr.sc. Borivoj MODLIĆ, Faculty of Electrical Engineering and Computing, Department for Radiocommunications and Microwave Engineering, University of Zagreb, Unska 3, HR-10000 Zagreb, Croatia  
Tel: +385 1 6129 789, e-mail: kresimir.malaric@fer.hr