FIELD DISTRIBUTIONS WITHIN A RECTANGULAR CAVITY WITH VEHICLE-LIKE FEATURES

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Abstract

A model vehicle cabin is constructed to investigate 3D field distributions generated by an on-board transmitter within the large partial cavity. Simulations performed using FEKO and CST Microwave Studio (CST MWS) are found to be in good agreement with internal field measurements acquired using a low disturbance automated probe positioner at 870 MHz. Results show vehicle furnishings change field distribution within the cavity and should be included for electromagnetic modelling and field exposure assessments. The study enhances understanding of complex field behavior within a vehicle. The results (e.g. E-field hotspots) can be used to optimize placement locations of on-board transmitters and introduce field mitigation techniques in appropriate locations if required.

1. Introduction

The modern vehicle incorporates numerous electronics devices to provide communications services and an intelligent environment for the driver. Devices such as mobile telephones, Bluetooth transmitters, tyre pressure monitoring system and many other wireless transmitters are increasingly being installed in a vehicle. Optimizing the performance of transmitters and at the same time ensuring compliance to radiation safety standards [1] is a challenging task for the automotive engineer. Earlier studies have reported external 2D field studies due to a TETRA transmitter [2] and 1D field radiation levels due to mobile transmitter within and outside the vehicle [3]. Field distributions within an empty vehicle cabin due to a micro-strip patch antenna were also described using a scaled vehicle model in [4]. However, limited literature describes the effects to internal 3D field distributions due to on-board transmitters within a vehicle cabin with furnishings included. This study is important as the vehicle cabin is a resonant cavity with a complex propagation environment. It is highly reflective and can cause spatial field variations. Availability of 3D field data will be helpful in identifying regions of high field strength and allow for field mitigation if required. In this paper, we compare the internal field distributions of a model vehicle cabin with furnishings to one without furnishings at 870 MHz. The work reported herewith is on-going and results presented will be incorporated for future study within an actual sedan vehicle.

2. Cabin model and field measurements validation

The vehicle cabin model is a rectangular partial cavity made out of aluminium sheets. It measures 1200 mm x 1000 mm x 1200 mm. The partial cavity populated with model interior furnishings is shown in Fig. 1. The entire 3D field distributions in the cavity volume are mapped using a low disturbance field probe positioner developed within The University of Sheffield. The on-board transmitter is represented by a simple dipole fed with a 15 dBm source inserted via the left aperture. Although 3D fields can be plotted, only three 2D field
amplitude cut planes are shown in Fig. 1 for clarity. The cut-planes shown are 950 mm, 650 mm and 350 mm from the bottom of the cavity. Herewith, these three cut planes will be named cut-plane 1, 2 and 3 respectively. The measured results acquired within an empty cavity are compared with simulated data obtained using FEKO and CST MWS. Fig. 2a and Fig. 2b shows simulated field profile compares well with measurements for cut plane 1. This observation is seen for all cut-planes within the cavity. Using a fixed co-ordinate in the X and Z directions, Fig. 3 gives a representative indication of field level difference between measurements and simulations using a 1D cut along the Y-direction. The origin for this graph is located in the middle of the cavity. It shows that both CST MWS and FEKO give very similar results. Hence only results from FEKO will be presented in the following section where field data for an empty cavity is compared to one with furnishings.
3. Effects of furnishings on field distributions within vehicle cabin

Fig. 4 shows the measurement set up used to acquire field amplitude data from the cabin model. The scan area is located where the driver and passenger will normally be seated. Each individual item within the cavity (i.e. dashboard, steering wheel and seat) can be easily removed from the model cavity. 3D field measurements performed within the cavity at 870 MHz with furnishing compare reasonably well with those obtained from simulations. However, it should be noted that although different simulators gave similar field distributions, small variations have been observed between simulated and measured data. This could be due to positional error of the furnishings within the cavity. Having established confidence in the electromagnetic model, we use simulated results obtained from FEKO to compare field profiles of a model vehicle cabin with interior furnishings to a model without interior furnishings.

Fig. 5 shows the changes in field profile within the cavity when furnishings were introduced. Fig 5a and Fig. 5b show the changes in cut-plane 3 which is close to the base of the seat. Changes in field distributions are observed in the entire cavity volume. Although not shown in this paper, individual furniture was inserted into the cavity to evaluate changes in measured field distribution. Small field level variations were observed when the dashboard made out of ABS plastic was inserted into the cavity. However, the field profile remains relatively similar. The introduction of the steering wheel model has enhanced field levels but did not significantly change the field profile within the cavity. When the seat was introduced field distribution changed within the cavity and consistent high field amplitude was observed along the vertical frames. High field levels were also observed at the base of the seat indicating that there is possible reflection of fields from the horizontal components. Hence, it can be concluded that field distribution within the cavity changed primarily due to the introduction of the seat. These field distribution changes can cause impedance and possible radiation pattern variations to conformal antennas mounted on windscreens. The effects of seats on simulated radiation patterns for such conformal antennas on a vehicle were compared to measurements in [5]. The results show changes in radiation patterns when seats are included at 100 MHz.
4. Conclusions

It is shown that the introduction of furnishings within the cavity can cause field distribution variations within the cavity. These variations can have an affect on the performance of on-board transmitters and also field exposure assessments. Future studies will concentrate on investigating effects of various other details within the vehicle at higher frequencies. The study enhances understanding of complex field behavior within a vehicle. The locations of E-field hotspots can be useful to vehicle designers in optimizing the placement location of on-board transmitters and introduce field mitigation techniques in appropriate areas if required.

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References


