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A New Hybrid Method for Analyzing the Electromagnetic Radiation from the Cable Attached to the Mobile Device

Monisha Mahalakshmi K[*1], Sharmila Banu[*2], Saranya N[*3], Janardhana Prabhu S[#4]
[*1,*2,*3]Student, Department of communication systems,[#4]Faculty of ECE
Regional office of Anna University, Madurai, Tamilnadu, India

***Abstract*- The electromagnetic radiation from the gadgets acts as a source of interference to the objects near by it and also the spurious radiation from these devices cause harm to the human beings and other living organisms. When the mobile device is connected to the source cable for charging or when it is connected to the data cable for transmitting data or when it is connected to the hybrid cable which acts as both the source cable and the data cable, the common-mode current flowing in the cable be a significant source of radiated emissions. The mechanism by which intentional signals induce common-mode current on the cable might be voltage-driven(coupled from signal's electric field) and current-driven(coupled from signal's magnetic field). This paper proposes hybrid method for estimating the electromagnetic radiation of the cable attached to the mobile device at the early stage of design without using expensive electromagnetic interference chambers. The method included radiation characterization of the box-source-cable geometry by using the hybrid method which combines transmission line method and the full wave simulation method. The electric field, magnetic field and far field radiation of the proposed geometry was measured using simulation method and also real common mode current measurement was done. The predicted results included simulation results and the measurement results. The accuracy of the predicted results was evaluated using feature selection validation technique to allow the objective, quantized, comparison of data for inter alia validation of computational electromagnetics.**

Index Terms—Attached cables, common-mode current, electro- magnetic interference (EMI), feature selective validation (FSV), mobile device, printed circuit board (PCB), radiated emission, radiation transfer function (RTF).

I.INTRODUCTION

As the density of the electromagnetic environment continues to increase, the concern about its effects from sources producing EMI also increases. Advances in technology and the number of products produced are having a significant effect on the efforts aimed at maintaining the required operation and interoperability of products and systems used in our society. These events had added challenges for those who are responsible for keeping pace with the effort needed to maintain the required level of electromagnetic compatibility (EMC) in these products and systems. There are several methods existing for the measurement of electromagnetic interference. They include laboratory methods like TEM cell method and anechoic chamber which are expensive and time consuming task. The simulation method of measurement of EMI included time domain and frequency domain measurements. Though these methods could measure electromagnetic radiation up to certain accuracy limit, It would be suitable for measuring the EMI for only single trace structure or bent trace or otherwise micro strip trace structures. But in gadget like mobile device there are several components which would result in interference and so it is necessary to propose the method which would be ideal for the measurement of interference in the design stage itself. This paper proposes hybrid method of measuring electromagnetic radiation of the mobile device connected to the source cable. Hybrid method is the combination of 3d full wave simulation method and 2d transmission line model method.

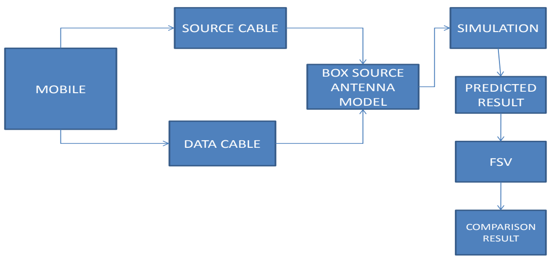
II COMMON MODE NOISE AND DIFFERENTIAL MODE NOISE

In a cable based transmission system the Common Mode signal is the unwanted signal because it carries no information. The potential of the cable pair varies with respect to ground. This varying potential gives rise to electromagnetic radiation from the cable. In a cable based transmission system the Differential Mode signal is the wanted signal that carries information. In our proposed method we measure the common mode signal.

III. RADIATION EMISSION FROM THE MOBILE DEVICE WITH AND WITHOUT CABLE ATTACHMENT

The radiated emission from the mobile device attached to the cable and detached to the cable [1] were studied and it was proved the horizontal polarization was dominant for lower frequencies and the vertical polarization was dominant at higher frequencies and when the cable was detached from the mobile device there were no vertical polarization which proves that the radiation from the mobile device is dominant at lower frequencies and the radiation from the cable is dominant at higher frequencies.

IV. BLOCK DIAGRAM OF BOX-SOURCE-ANTENNA MODEL



A. Mobile Device

When we charge the mobile phone using the source cable and the common mode current in the cable produce harmful radiation from the source cable and the mobile device. The radiation from the mobile depends upon the dimension of the mobile phone. So we are going to measure radiation in mobile phone of different dimension.

We model the mobile phone as rectangular box of the dimension depend upon the size of the mobile phone and we connect it to the source cable or data cable and the point of connection acts as a source of interference and it may be the voltage source or current source. The source of interference is considered to be the Gaussian pulse and we are modeling mobile phone as a perfect electric conductor(PEC material) which is suitable for easy simulation.

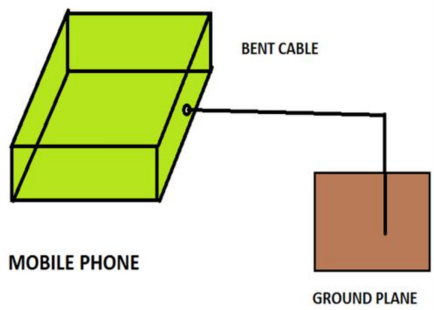
B. Source Cable

The source cable is the one which carries power signal used for charging mobile phones. We are going to model the source cable as the bent cable which is the flat ribbon cable and hence it makes the simulation faster without reducing the accuracy. The common mode current in the source cable would result in unwanted electromagnetic radiation. The common mode noise could also be measured in the hybrid cable which acts as both source cable and data cable. In the hybrid cable not only the common mode noise that matter but also the crosstalk from the signal wires which has more than two wires and the signal integrity problem should be considered.

C. Box-Source-Antenna Model

To model the phone body, we used a rectangular cubic conducting box that was similar in shape to a real mobile phone. The common-mode current on the cable could be modeled as an impressed voltage or current source, which is provided by measurement. This kind of modeling approximation originated from previous studies which show that the noise coupling of integrated circuit, traces, or other components on a printed circuit board and an attached cable can be effectively modeled by placing equivalent voltage or current source between the board and the cable.

BOX-SOURCE ANTENNA MODEL



V.HYBRID METHOD OF RADIATION OF BOX-SOURCE-ANTENNA MODEL

The hybrid method combines the advantage of the full wave simulation method and the transmission line modeling method. The cable is modeled using 2D transmission line modeling method and then connected to the rectangular box and then simulated using 3D full wave simulation method.

VI. HYBRID METHOD OF IRRADIATION OF BOX-SOURCE-ANTENNA MODEL

When we expose the box-source-antenna model to radiation by plane wave excitation the voltage induced would be calcutaed. The type of polarisation of the plane wave is linear.

VII. SIMULATION OF BOX-SOURCE-ANTENNA MODEL IN CST CABLE STUDIO

The box-source-antenna model was simulated in CST cable studio and the electric field radiation and magnetic field radiation was measured and also the common-mode current was simulated using the CST software. The hybrid method we used to measure the radiation and the radiation transfer function was calculated by using the formula given below.

RTFp[dBΩ/m]=Epmea(ro)[dBμV/m]ICM(rs)[dBμA]=Epsim(ro) (1)

where p is h or v, which signifies horizontal or vertical polarization, respectively;Ep mea(ro) is the measured radiated electric field at a specific position ro in the far-field region; ICM(rs) is the common-mode current in the cable. Epsim(ro) is the simulated electric field at a specific position ro in the far-field region.

VIII FEATURE SELECTIVE VALIDATION TECHNIQUE

The FSV method was initially developed to provide an objective quantification of the data typical to the validation of computational electromagnetics in EMC application. FSV is based on the creation of a number of quanta from the original data. The basis is that a majority of comparisons undertaken by humans rely on the assessment of the overall shape / envelope of the data and the comparison of the individual, fast moving, features. The FSV measures are the Amplitude Difference Measure (ADM) and the Feature Difference Measure (FDM) which can be combined into a Global Difference Measure (GDM) which is an overall goodness-of-fit measure. The average value of these provides single value summaries that are helpful to attribute an overall quality to the comparison and use as the basis for rank-ordering several comparisons.

IX. RESULTS AND DISCUSSION

In this paper the electric field and magnetic field radiation of the mobile device attached to the source cable is simulated and the common mode current of box-source-cable geometry had been simulated and the comparison result need to be provided by using FSV technique.

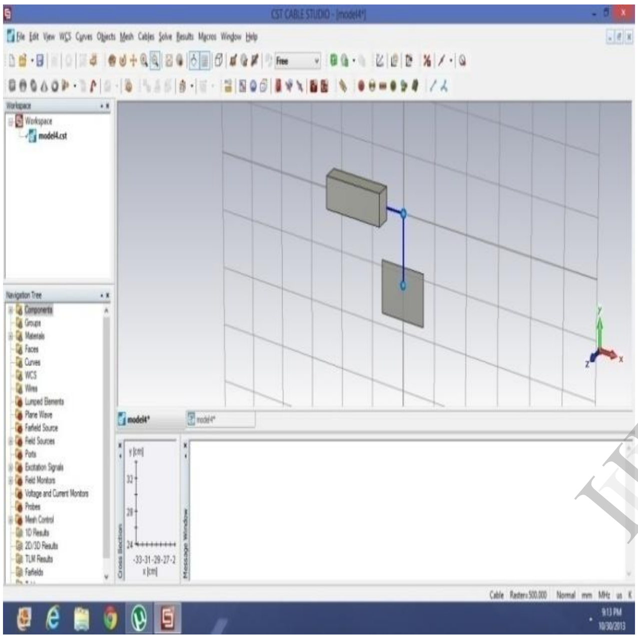


Fig.1.Box-source-cable geometry

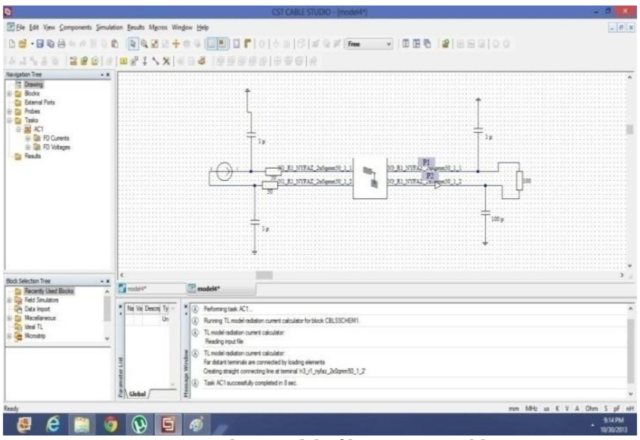


Fig.2. Transmission line model of box-source-cable geometry

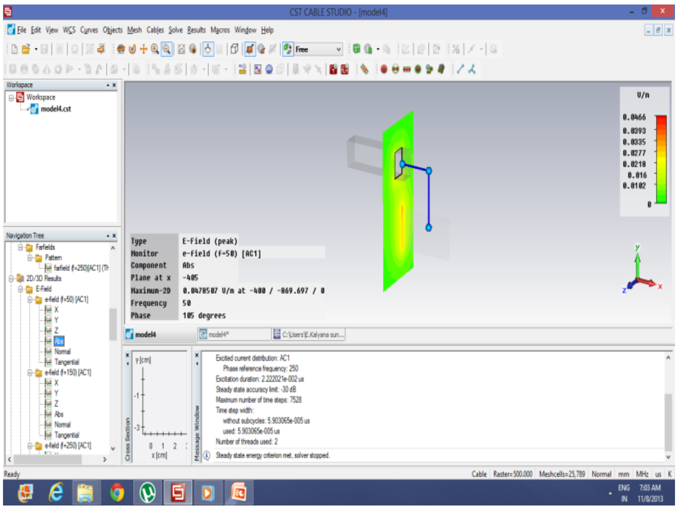


Fig.3. E-field radiation of box-source-cable geometry at 50MHz

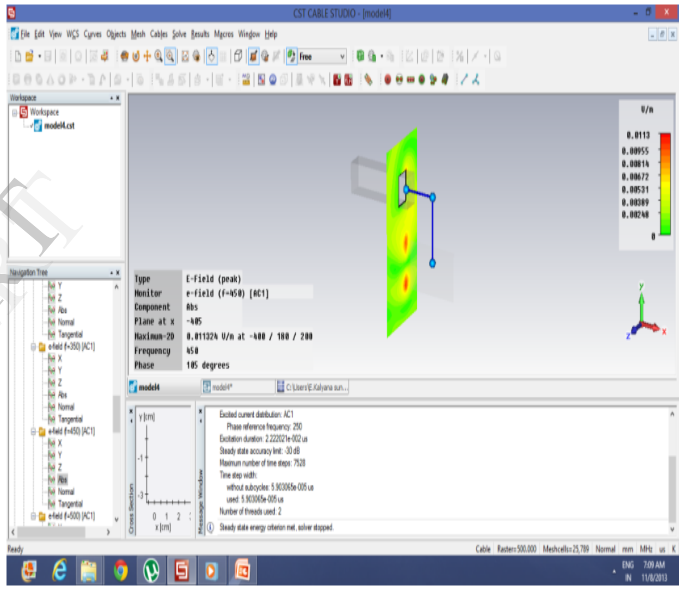


Fig.4. E-field radiation at 450MHz

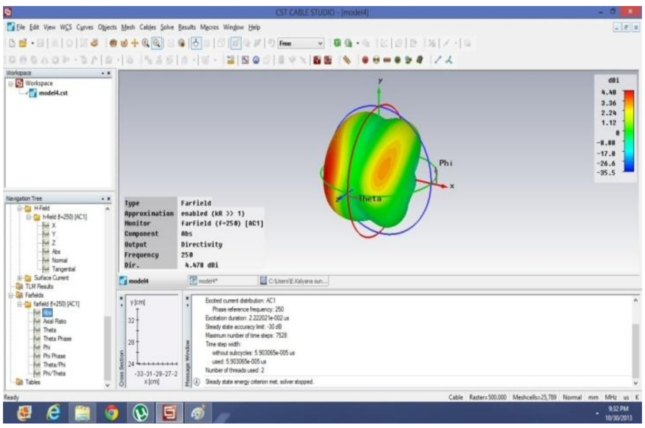


Fig.5.Far-field plot at 250 MHz

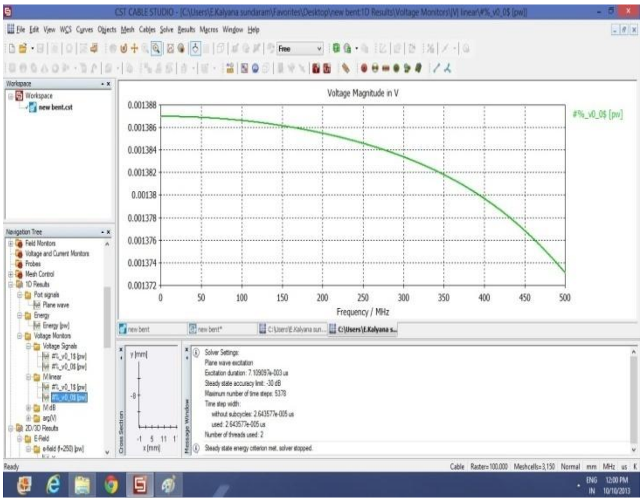


Fig.6. Voltage curve

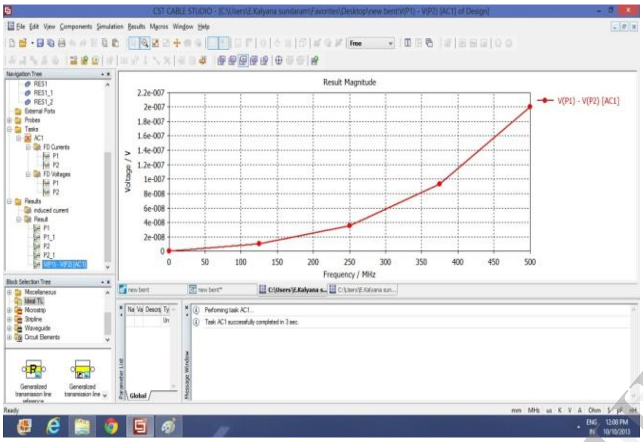


Fig.7.Induced Voltage in the box-source-cable geometry

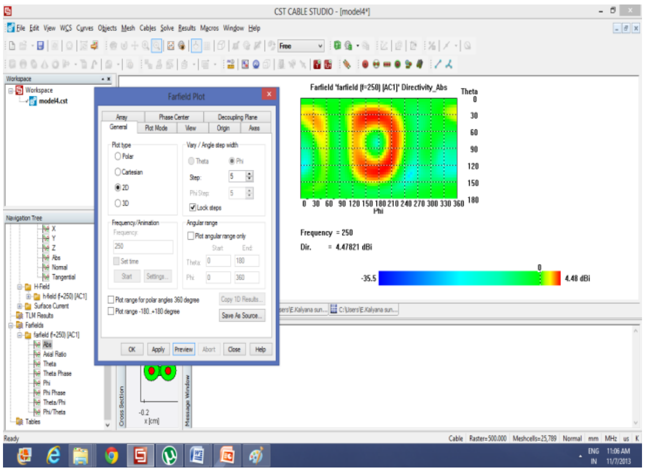


Fig.8.Far-field plot at 250MHz

TABLE 1 RADIATED E-FIELD RESULTS OF DIFFERENT FREQUENCY RANGE

FREQUENCY(MHz)	RADIATED ELECTRIC FIELD(V/M)
50	0.0478507
150	0.1884567
250	0.1600634
350	0.0529614
450	0.0113245
500	0.0013467

TABLE 2 RADIATED H-FIELD RESULTS OF DIFFERENT FREQUENCY RANGE

FREQUENCY(MHz)	RADIATED MAGNETIC FIELD(V/M)
50	0.000121374
150	0.000402317
250	0.000122256
350	0.000112547
400	0.000010958
500	0.000001346

IX CONCLUSION

In this paper, a simple hybrid method had been proposed which combines the transmission line method and full wave simulation in order to improve the accuracy of electromagnetic interference analysis of the cable connected to the mobile device. The box-source-cable geometry model had been created to measure the field created when the source or data cable is connected to the mobile device. The electric field, magnetic field and the far-field radiation measurement was done and we used the computer simulation technology studio suite to measure the above fields.

REFERENCES

[1] W. Cui, M. Li, X. Luo*, J. L. Drewniak, T. H.Hubing, T. P. VanDoren,R. E. DuBroff (1999)'Anticipating EM1 From Coupling Between High-speed Digital and 1/0 Lines', *Electromagnetic Compatibility* Laboratory Department of Electrical and Computer Engineering University of Missouri-Rolla.

[2] S.Deng,T.Hubing,andD.Beetner(2008)'Estimating maximum radiated Emissions from printed circuit boards with an attached cable', *IEEE Trans. Electromagn. Compat*., vol. 50,no. 1, pp. 215–218.

[3] S.Deng,T.Hubing and D.Beetner (2008) 'Using TEM cell Measurements to estimate the maximum radiation from PCBs wit cables due to magnetic field coupling' *IEEE Trans. Electromagn.Compat*.,vol. 50, no. 2, pp. 419– 423.

[4] Dong-yeon Kim, Jae W. Lee, Choon Sik Cho,Haeng S. Lee, and Yeon Choon Chung (2011)'Indirect evaluation of radiated emission from a bent signal line on a printed circuit board with two attached cables',Microwave and optical technology letters / Vol. 53, No. 8.

[5] J. L. Drewniak, Fei Sha, T. P. Van Doren, T.H.Hubing(1995) 'Diagnosing and Modeling Common-Mode Radiation from Printed Circuit Boards with Attached Cables', Department of Electrical Engineering Electromagnetic Compatibility Laboratory University of Missouri-Rolla Rolla, Missouri, 65401.

[6] Garrett McCormick, Zulfiqar A.Khan ,Vijay Devabhaktuni, Mansoor Alam (2010)'Estimating Radiated Emissions from Printed Circuit Boards and Cables inside EMC Chambers', *IEEE Trans*. 978-14244- 6307- 7/10/.

[7] D. M. Hockanson, J. L. Drewniak, T. H.Hubing, T. P. V. Doren, F. Sha, and M.Wilhelm(1996) 'Investigation of fundamental EMI Source mechanisms driving common-mode radiation from printed Circuit boards with attached cables', *IEEE Trans.Electromagn. Compat*., vol. 38, no. 4, pp.557–5662 .

[8] H. Shim and T. Hubing (2005),'Model for estimating radiated Emissions from a printed circuit board with attached cables driven by voltage-driven sources', *IEEETrans.Electromagn.Compat*., vol. 47, no. 4, pp. 899– 907.

[9] Hyun Ho Park, Member, IEEE, Hark-Byeong Park, and Haeng Seon Lee (2013)'A Simple Method of Estimating the Radiated Emission From a Cable Attached to a Mobile Device',*IEEE Trans* , VOL. 55,NO. 2.

[10] Jiri Misurec, Milos Orgon (2011)' Modeling of Power Line Transfer Of Data for Computer Simulation',*Department of elecommunication* BrnoUniversity of Technology, Purkynova 118, 612 00 Brno,Czech Republic, Department of Telecommunications, Slovak Technical University, Ilkovičova 3, 812 19 Bratislava, Slovak Republic .

[11] J.Wang(2002),'Asimple method for predicting common-mode radiation from a cable attache to a conducting enclosure', vol. E85-B, no. 7.

[12] Tvrtko Mandic (2012)'Electric and Magnetic Field Coupling to PCB Transmission Lines and IC Packages', University of Zagre.

[13] un Ho Park, Jae Wook Lee, Jong-Hwa Kwon, and Hyung-Soo Lee (2002) 'Common-Mode Current on a Wire through a Corrugated Aperture', *ETRI Journal*, Volume 24.

[14] Yan Fu and Todd Hubing, Fellow, IEEE (2007)' Analysis of Radiated Emissions From a Printed Circuit Board Using Expert System Algorithms', *IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY*,VOL.49.

[15] Zulfiqar A. Khan, John. L. Volakis (2006)' Experimental and Analytical Study of EMC/EMI effects on PCBs and cables enclosed within metallic enclosures', ElectroScience Lab, *Electrical and Computer Engineering*, The Ohio State University.