International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 3, March - 2014

A Dual – Layer Antenna Solution for Mobile Phones with GSM, UMTS and WLAN Operation

[1.] B. Sammunayak, [2.] G. Rajasekhar, [3.] K. Madhukar
[1,2,3.] Asst. Professor
GITAM University, Hyd.GITAM University, Hyd.GITAM University,Hyd

***Abstract*— Mobile communication devices consist of one antenna for EGSM & DCS, second a dual – band antenna for Transmitter and Receiver bands of UMTS and a third antenna for standards operating in the ISM band (WLAN & Bluetooth).A low – profile antenna solution for such devices is presented in this paper. The concept of this antenna is based on dual- layer approach. At the top and bottom layer, the λ/4 resonance of the radiators, are used. The advantage of this type structure is a very low profile antenna with no additional height above the substrate. This might be an issue for other multi-band antennas based on a folded Planar Inverted F- antenna. But in the future for mobile communication devices become even smaller than today. The main criteria are designing minimal height of these products. The performance of the antenna has been simulated using commercial FDTD/ FEM Software tools.**

Index Terms: FDTD/ FEM

I. INTRODUCTION

The mobile phone industry integrates more and more communication standards into their products – GSM850, EGSM900, DCS, PCS, UMTS, BT and WLAN and the communication devices become smaller i.e. the antenna designers have a challenging task to design integrated antenna solution. The approach presented here is particularly useful for devices with small height, since we use antennas printed on the substrate. The antenna arrangement consisting of three so-called dual-layer antennas is depicted in Fig.1 (prototype) and Fig. 2(FEM model). Such a dual-layer antenna was firstly introduced in [1]. The structure has been optimized with the FDTD tool EMPIRE™ [2] because of its excellent performance.

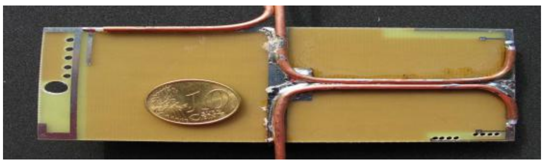


Fig.1 Prototype of the mobile phone mockup – feeding of the three low-profile antennas (EGSM/DCS left, UMTS upper right, WLAN/BLUETOOTH lower right) via semi rigidcables.

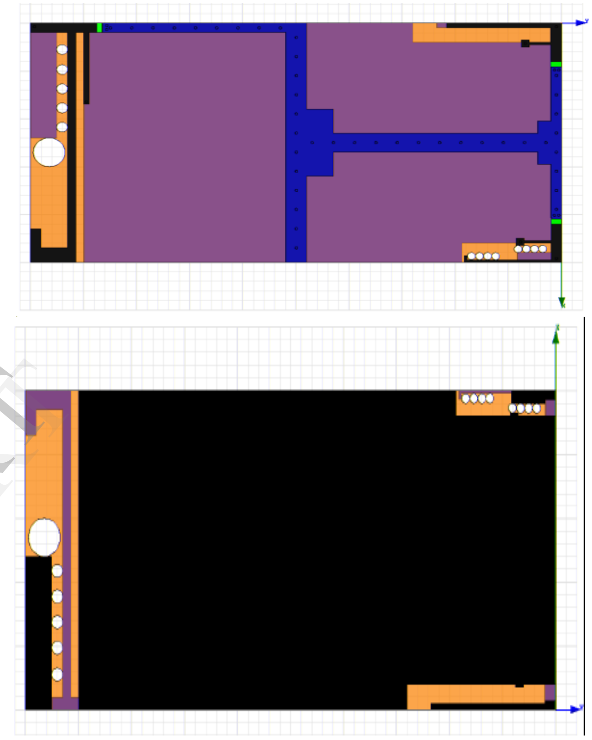


Fig.2: Top and Bottom view of FEM model with printed antennas for EGSM/DCS(left), UMTS and WLAN(right).

The fine-tuning taking into account dielectric and conductor losses of the antenna test board has been done with the FEM software HFSS™ [3]. The overall size of the antenna test board measures 100 x 50 x 1 mm^3.

II. DESIGN, FDTD/FEM- SIMULATIONAND MEASUREMENT

The design of the EGSM/DCS antenna depicted on the left-hand side in Fig.1 was the most complicated one, since our goal was to fit this antenna in the shorter edge of the PCB. The longer EGSM resonator with bended tip acts like a coupling element to the ground plane of the PCB rather than a radiator. The λ/2 board resonance excited by the bended line is the main source for the radiation at around 900MHz. The radiation pattern at this frequency presented later. In Fig.3 the dual- layer antenna is depicted together with the λ/4 current distributions in the top-layer radiator for EGSM and the bottom-layer radiator for DCS. A PCB area of 50 x 10 mm^{2}without backside metallization has been used for EGSM/DCS antenna.

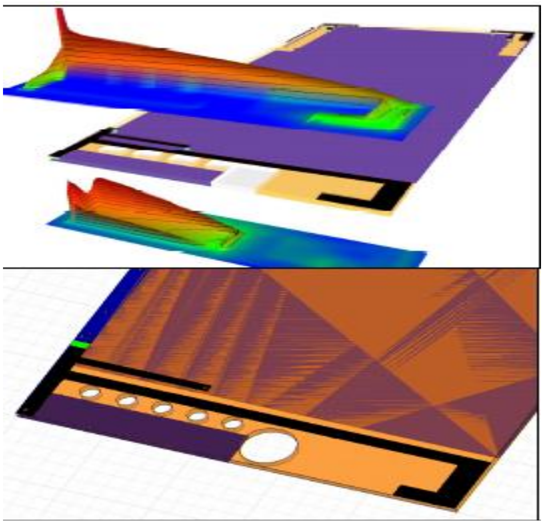


Fig.3: FDTD model with λ/4 current distribution(top) and detailed FEM model(bottom) of the EGSM/DCS antenna.

The radiator for DCS band has a larger width, since this resonator was optimized for maximum bandwidth. With further optimization it might be possible to include also the band ofthe PCSstandard. A simultaneous matching for EGSM and DCS band has been obtained by using a short circuited matching line close to the feeding point. For the UMTS antenna depicted in the top of Fig. 4 a PCB area of 28 x 4 mm^2 has been used. The length of the radiator on top and bottom layer have been adjusted to shift their resonance frequencies to the center frequencies of the Tx and Rx bands of UMTS – 1950 MHz and 2140MHz, respectively. The final design step here was the adjustment of the length of the short circuited matching line to achieve simultaneous matching at the two mentioned frequencies. For the dual – band WLAN antenna that radiates in the two ISM frequency bands at 2.4 GHz and 5 GHz a PCB area of 20 x 4 mm^2 was needed. The design was similar to the one of the UMTS antenna explained before, since the antennas have more or less the same general shape.

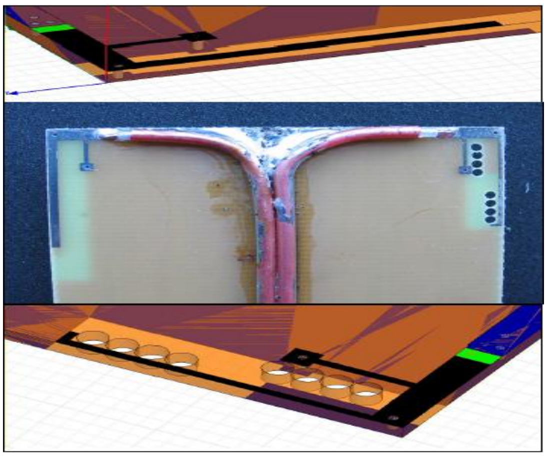


Fig. 4: UMTS antenna model (top), WLAN antenna model (bottom) and a cut-out of one prototype with these antennas together with the semi-rigid cables used for feeding (middle).

In the next plots the scattering parameters obtained from the FEM simulation with HFSS^{TM} [3] are presented. Fig. 6 shows the return loss behaviour for the frequency bands of the EGSM- antenna (port 1). The return loss for other antenna ports, except the 5 GHz band, is plotted in Fig. 7. These antennas operate inDCS(S_{11}), UMTS (S_{22}) and WLAN/BT (S_{33}) frequency bands.

The dual-band WLAN antenna has the port number3. Its simulated return loss is depicted in Fig. 5. This antenna can be used for Bluetooth^{TM}or the IEEE 802.11 b/g standard operating in the ISM 2.4 GHz band and for IEEE 802.11a standard implemented in the ISM 5 GHz band. In terms of return loss (8dB) the antennas fulfill the requirements for all of the aimed communication standards – IEEE 802.11a is a exception caused by radiation efficiency issues at 5 GHz. The isolation between the three antenna ports is plotted in Fig.8. An minimal isolation of 16 dB at around 2.15 GHz has been predicted by FEM simulation between UMTS and WLAN antenna ports. In view of the fact that the two antennas are quite close to each other, the isolation of 16 dB is considered a good result.

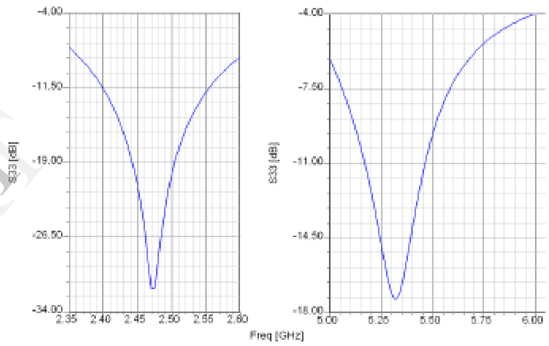


Fig. 5: Simulated return loss for the ISM 2.4 GHz and 5.2GHz frequency bands.

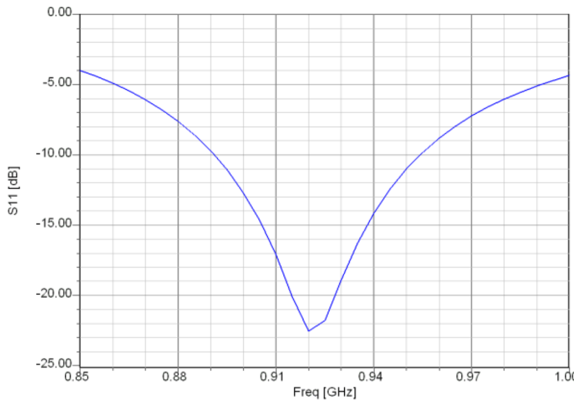


Fig. 6:Simulated return loss for the EGSM frequency band

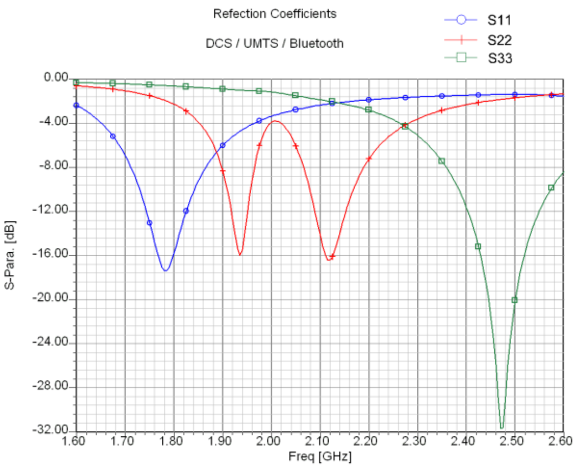


Fig. 7:Simulated return loss for DCS (S11), UMTS(S22) and WLAN/BT (S33) frequency bands

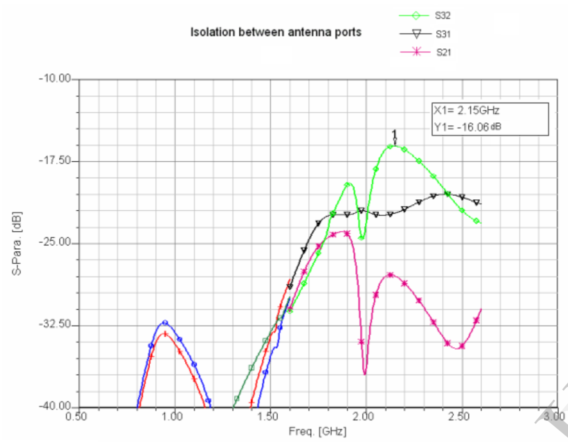


Fig. 8:Simulated isolation between the ports of the three antennas in the critical frequency range.

The scattering parameters have been measured with the HP NWA 8722C to validate the design. The agreement in terms of resonance frequencies and matching is sufficient, keeping in mind the quite high tolerances of the substrate material FR4. Due to the radiation efficiency was too low, the measurement in the 5GHz band has been skipped.

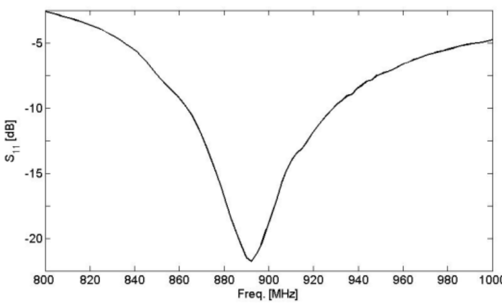


Fig. 9: Measured return loss for the EGSM frequency band

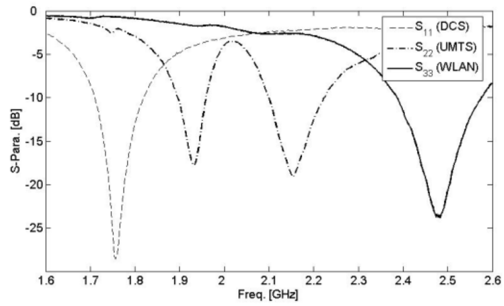


Fig. 10: Measured return loss for the DCS (S11), UMTS (S22) and WLAN/BT (S33) frequency bands

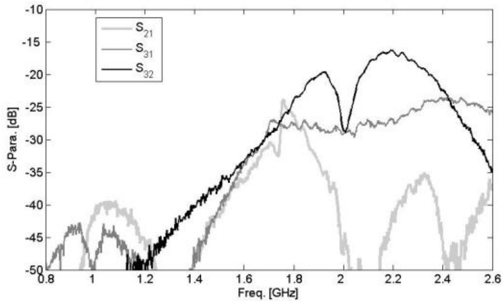


Fig. 11: Measured isolation between the ports of the three antennas in the critical frequency range

In Fig. 12 the measured radiation pattern of the EGSM/DCS antenna in the E-plane is depicted. At 892 MHz a dipole-like pattern has been observed. Therefore the λ/2 board mode must be the main source of radiation. The pattern at 1.756 GHz has a weak null between 300° and 330°. The above mentioned measured pattern shapes have been predicted by FEM simulations. The 3D pattern in dB for the six frequency bands under investigation have been summarized in Tab. 1. For the EGSM band the typical "donut"-shaped pattern has been achieved. For the DCS frequency (upper right in Tab.1) the weak nullcan also be find in the 3D pattern.

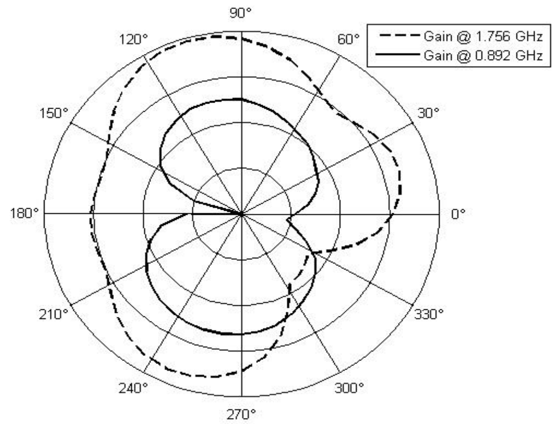
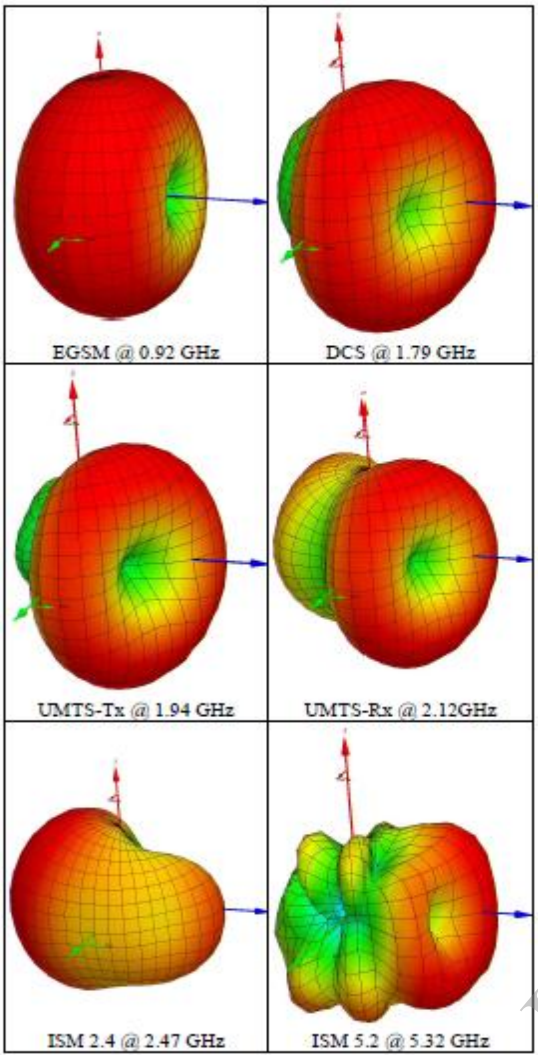


Fig. 12: Measured radiation pattern in dB for the EGSM/DCS antenna in the E-plane (yz-cut)

ISSN: 2278-0181
Vol. 3 Issue 3, March - 2014



Tab. 1: 3D radiation patterns predicted by FEM simulations

Standard	EGSM	DCS	UMTS-TX	UMTS-TX	ISM 2.4	ISM 5.2
f_o in GHz	0.92	1.79	1.94	2.12	2.47	5.32
Peak Gain	93	71	63	39	47	61
Rad. Effi(%)	82	92	91	86	67	15

Tab.2: Simulated peak gain (linear) and radiation efficiency for the six frequency bands under investigation.

Finally the simulated linear peak gain and the radiation efficiency for the six frequency bands under investigation have been summarized in Tab. 2. Up to the UMTS-Rx band the efficiencies are excellent. At 2.4 GHz a value of67 % has been achieved and is acceptable. Not acceptable on the other hand is an efficiency of 15 % at 5.32 GHz. It seems that a better substrate material is needed for such a high frequency. In the future we will remove more or less all the FR4-material around this antenna, especially in regions with a strong electric fieldConcentration.

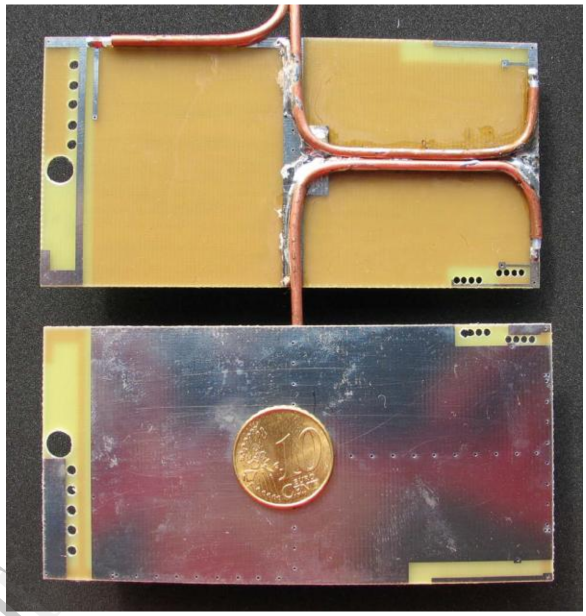


Fig. 13: Front and backside of two prototypes

III. CONCLUSION

A low profile antenna setup for mobile communications has been presented, with the advantage that very flat devices can be designed from an antenna point of view. In terms of return loss of the antenna arrangement fulfills the requirements for all of the aimed communication standards-EGSM, DCS, UMTS and WLAN – except the IEEE 802.11a standard caused by efficiency issues in the 5 GHz band.

REFERENCES

[1] A.Rennings, M.Rauf, P.Waldow, I.wolff,"A dual layerPrinted antenna system for DCS/PCS/UMTS "Proceedings of 2004 European Microwave Co-nferenceAmsterdam,The Netherlands, pages1249 - 1252, October 11 – 15, 2004.
[2] IMST GmbH, " User manual for the 3D EM time domain Simulator Empire", www.empire.de, jan 2004.
[3] Ansoft, "User Manual for HFSS", www.ansoft.de.
[4] A. Rennings, S.Otto, A.Pimpertz, P.Waldow, "A low – Profile antenna solution for Mobile Com-munications with GSM, UMTS and WLAN Oper-ation".