Multiple - Antenna System for Mobile Phones

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Abstract— The Multiple Antenna System proposed in the following paper is based upon two types of patch antennas working in different frequency ranges. The antennas are classified into Main and Subsidiary antenna. The Main antenna shall work for the GSM ranges of 2G, 3G and 4G covering the bandwidth from 0.7 to 2.5 GHz. A subsidiary antenna is dedicated to work in the range of 2200-2600 MHz hence providing assistance in the LTE 2350 MHz and 2550 MHz bands and also in Bluetooth range. The whole system is designed on a PCB of dimensions 135x66.1x1.5 mm^3. Effectively increasing the isolation between the antennas the system may be optimal for modern day wireless communications.

Keywords- *GSM, 2G, 3G, 4G, LTE, UMTS, MHz, GHz, PCB, WLAN, VSWR, HFSS.*

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I. INTRODUCTION

Wireless communication has successfully moved on from the 2G era to 3G and now 4G eras. It paves a way for the antenna developers to model the antennas which are highly compatible with the ongoing systems as well as to suffice the needs of next transition. The antennas designed should thus have a wide range of compatibility i.e. they should not only work in the 2G or 3G range but should fit easily into the 4G and 5G environment as well. Along with these basic characteristics they should also work efficiently for other devices used by the modern day mobile users like Bluetooth, Wi-Fi, WLAN, etc.

MIMO System has been proposed for mobile phones. The Four antenna system has a Main antenna along with three Auxiliary antennas. The main antenna works for GSM, UMTS and LTE bands and the auxiliary antennas work on a frequency range of 1880-2690 MHz [1].A two L-shaped antenna system has been proposed which divides the frequency ranges to be covered into two bands 700-960 MHz and 1580-2700 MHz [2]. The system may burden the antennas resulting in less efficient output and thus less isolation between the working antennas. The existing commercial bands include the 2G and 3G networks are GSM-850, GSM-900, DSCS-1800, PCS-1900 & UMTS. 4G which is also known as the LTE covers LTE-700, LTE-2300 & LTE-2500.

The antenna system in this paper is modeled on a FR4 epoxy substrate having the dimensions of 135x66.1x1.5 cubic mm. The antennas proposed in the paper are rectangular patch antennas. The system comprises of a Main antenna along with the other Subsidiary antenna. The Main antenna is set to work in the GSM 2G, 3G & 4G range which extend from 700 MHz to 2500 MHz. A subsidiary antenna works in the frequency range between 2200-2600 MHz. The Subsidiary antennas help in the efficient working of the antenna system. The Subsidiary Antenna would provide assistance in the LTE 2350 MHz and 2550 MHz bands which are used for 4G in the Indian subcontinent. In addition to that the Subsidiary Antenna would be helpful in assisting in Bluetooth range i.e. 2400 MHz. By controlling the isolation levels between the antennas the working system may be very effective in communication fields.

Figure 1. Proposed Antenna System.

II. ANTENNA DESIGN

The proposed design is modeled and simulated on the HFSS platform. The purpose of this paper is to simulate the antennas on the HFSS platform and to maximize the isolation levels thereby. The designed system should be having more than 12dB of isolation between each other. In order to attain higher isolation levels the simulated sizes of the patch antennas should be the least among the optimized ones.

More emphasis is laid on the high isolation levels of the antennas which otherwise render the system inappropriate for usage in mobile systems.

A. Design Specifications of the Main Antenna

The patch antenna proposed as the Main antenna is designed on a FR4 Epoxy substrate having dimensions of 53.4x66.1x1.5 mm^3.The FR4 epoxy is chosen due to its fire resistant nature and other qualities. The antenna is simulated as of Copper material. The volume occupied by the antenna itself is 29.4x42.1x0.005 mm^3. The proposed design for the Main Antenna is given in the Figure 2.

TABLE 1 : DESIGN SPECIFICATIONS OF MAIN ANTENNA

Parameters	**a**	**b**	**c**	**d**
Dimensions(mm)	42.1	29.4	53.4	66.1
Parameters	**e**	**f**	**g**	**h**
Dimensions(mm)	11.9	2.85	1.5	17.4

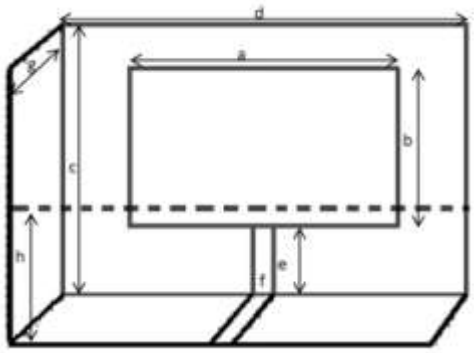

Figure 2. Proposed Main Antenna Design.

B. *Design Specifications of the Subsidiary Antenna*

The patch antenna proposed as the Subsidiary antenna is simulated on a FR4 Epoxy substrate as well. The substrate has the dimensions of 30x66.1x1.5 mm^3 whereas the antenna simulated on it takes the space of 9.5x11 mm^2. The antenna proposed if made of a Perfect-E material. The design specifications of the Subsidiary Antenna is given below

TABLE 2: DESIGN SPECIFICATIONS OF SUBSIDIARY ANTENNA

Parameters	**a**	**b**	**c**	**d**
Dimensions(mm)	30	66.1	9.5	11
Parameters	**e**	**f**	**g**	**h**
Dimensions(mm)	7	1	1.5	6

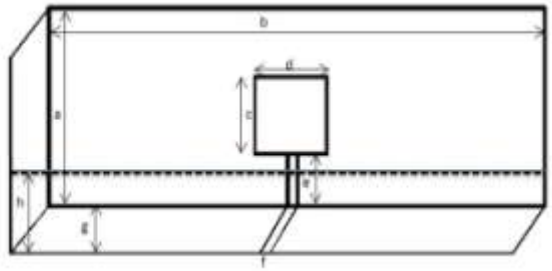

Figure 3. Proposed Subsidiary Antenna Design.

III. SIMULATED RESULTS AND ANALYSIS

Both the antennas are simulated on HFSS software. The Main Antenna is simulated in the frequency ranges of 0.5 -3 GHz which in turn covers all the frequencies to be covered by the proposed antenna. Figure 4 depicts the S-parameter versus the Frequency curve of the Main Antenna in the HFSS Software. The S(1,1) for the proposed antenna falls under the value of -10dB for the region 700 MHz to 2700 MHz which is the required frequency range for the Main Antenna.

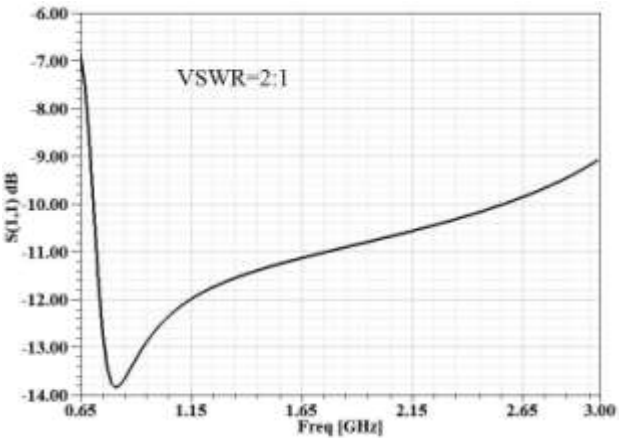

Figure 4. S-Parameter v/s Frequency of Main Antenna.

The VSWR characteristics of both the antenna are taken to be 2:1 fall well under 2dB for the required range. The results obtained for the Subsidiary Antenna in the frequency region of 2200-2600 MHz are shown in Figure 5. The VSWR needs to be under 2 dB.

Based upon the VSWR characteristics we conclude that the proposed Main Antenna works well for the desired frequency range. It will cover all the running GSM, UMTS PCTS and LTE bands. The return loss to be lesser than 2dB for the S-parameter values below -10db assures the high working capability of the main antenna designed. Also from the VSWR characteristics of the subsidiary antenna it is clear that the antenna works well in between the frequency ranges of 2200-2600 MHz.

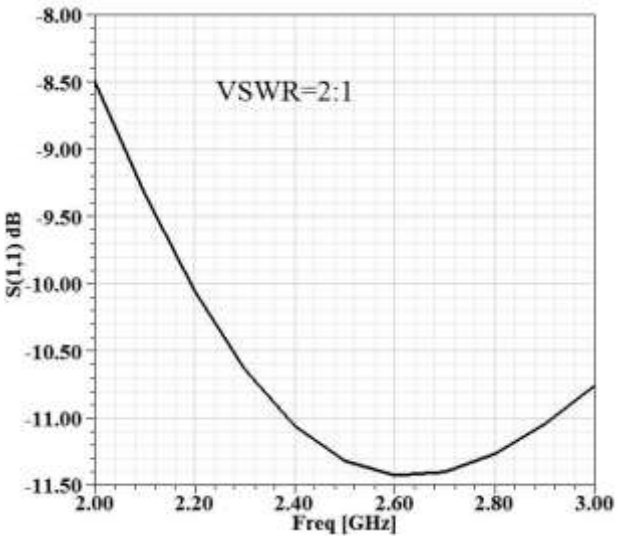

Figure 5. S-Parameter v/s Frequency of Subsidiary Antenna.

The radiated power from an antenna is analyzed usually on the basis of radiation pattern emerging from an antenna. Radiated power usually depends on the angular position and radial distance from the circuit. Generally a Far-fields report on a specific frequency is computed in all directions. The following figures depict the Radiation pattern for the specified frequency range of the main antenna in dB valued for 1 GHz and 1.5 GHz as well as for the Subsidiary antenna in the 2.5 GHz in the E and H Planes.

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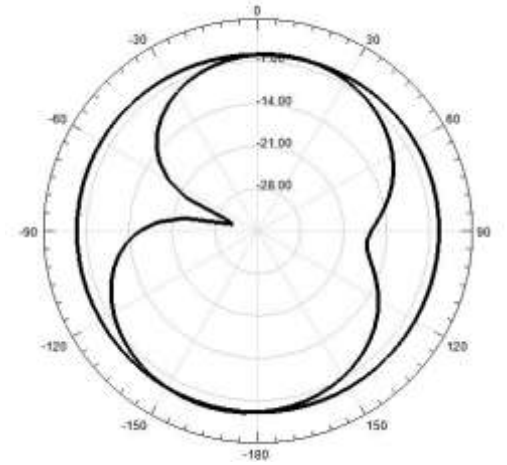
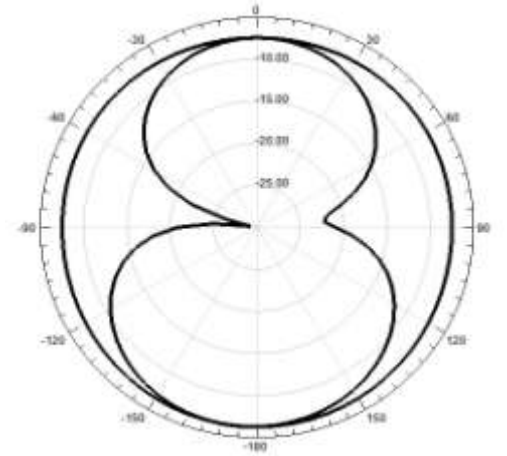


(a)



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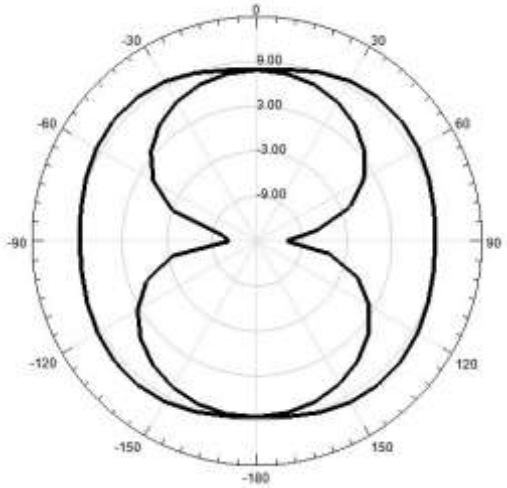

(c)

Figure 6. Radiation plots of (a) Main Antenna at 1 GHz (b) Main Antenna at 1.5GHz (c) Subsidiary Antenna at 2.5 GHz.

The Radiation patterns of the Main antenna and the Subsidiary antennas depict that the antennas is almost bidirectional at all frequencies. Thus by the proper placement of the antenna on the substrate the SAR values may be kept under check.

IV. CONCLUSIONS

A Multiple Antenna system was proposed for mobile phones constituting two antennas. The simulated results are analyzed. We thus reach to the conclusion that the Main antenna and the Subsidiary antenna for the Antenna system works properly in the required frequency ranges as was specified. The simulated antennas fit on the top and bottom of the Mobile Phone PCB. The next step would be to simulate two more Subsidiary antennas which thus shall constitute the Multiple Antenna System with 4 antennas. The antennas must be similar as they should work for same frequency range i.e. 1700-2500MHz. And to check the effective isolation levels between the system of antennas.

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