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A Novel Fixed Multiband Micro strip Patch Antenna Design for New Generation Wireless Communication Systems

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***Abstract* - This paper presents the design of a fixed antenna of multiple frequency bands. The antenna proposed here will be used in new generation wireless communication devices. This antenna has the ability to radiate multiple bandwidths with a less return loss and improved antenna gain. This model is highly compact and cost effective one. The fixed model is simulated and implemented in hardware and the results are compared.**

Keywords – fixed multiband antenna; wireless communication; return loss; antenna gain

I. INTRODUCTION

Antennas for mobile and wireless terminals supporting several standards simultaneously are currently receiving a lot of interest. Therefore, there is an increasing demand for multiband antennas, which can be easily integrated, in a wireless device supporting multiple standards. The term fixed means that the operating frequencies, radiation patterns and polarization are fixed upon the designer goal and once the antenna is fabricated and placed in the system, the performances of the antenna cannot be changed. Printed antennas, monopole antennas and Planar Inverted-F Antennas (PIFA) [1] are the most suitable antennas to be used in wireless systems due to their low profile, low fabrication cost, and simple feeding structures.

Modern wireless devices or systems are getting smaller and thinner in addition to the increase in the number of services required to be integrated in one device. Therefore, antennas are required to fulfill these needs with multiple bands capabilities and with small and slim overall size [2]. Different techniques have investigated to achieve multiband operation for printed antennas and for PIFA as discussed earlier. In PIFA, the ground plane can play an important role to enhance the performance of the antenna. For example, for low frequency operation such as for the GSM 900/800 bands, the ground plane has to be used as a radiating part.

However, if the ground plane also acts as a radiating part, the effect of the user's hand is likely to degrade the antenna performance when the antenna is fitted inside the mobile phone. It causes several practical engineering problems. In some designs, the location of the antenna on the substrate is also an important factor to be considered as it can enhance the bandwidth of the antenna by few more percentages.

This paper includes the design of a multi band antenna for new generation wireless communication [1]. This design basically has a patch, substrate and ground plane. The patches are of different types such as rectangular patch, rectangular patch with triangular slots, and rectangular patch with c slots. The patches are given individual feed lines with the help of a main feed line.

The fixed multiband antennas can widely be used in different systems or devices and they are not reliable to accept new services as compared with reconfigurable antennas. These antennas can be considered as one of the major elements in future wireless communication systems. The microstrip reconfigurable antenna has the ability to operate in multiple bands where the total antenna size can be reused and further reducing the overall size. New Generation wireless communication systems relying on multiband reconfigurable antennas are becoming more popular for their ability to serve multiple standards. Devices using a single compact antenna allow reduction in the dimensions of the device and more space to integrate other electronic components.

This paper is a further study of [1]. This further study includes the design methodology, frequency setting in the fixed design, and independent tuning in the reconfigurable design [2]. It also includes the radiation patterns for the reconfigurable design, and the efficiency and gain comparison for the fixed and reconfigurable designs.

II. PROPOSED ANTENNA DESIGN

A. Antenna Design

The designed fixed antenna is a hybrid structure [2], [3], [5] of five patch antennas given a single feed. Each patch has been further modified in order to achieve multiple frequency bands [2]. The frequency of operation of the microstrip patch antenna is determined by the length *L*. The center frequency can be given by the relation.

$$f_{c\approx\frac{c}{2L\sqrt{\varepsilon_r}}} = \frac{1}{2L\sqrt{\varepsilon_0\varepsilon_r\varepsilon_0}}$$

For microstrip antennas, the width W and length L of the radiating patch and the effective permittivity of the microstrip structure ε_{re} which support the operation at the required resonant frequency or the free-space wavelength λ0 can be designed as follows.

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}} \times \sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{eff}\sqrt{\mu_0\varepsilon_0}}} - 2\Delta L$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\frac{h}{w}}}$$

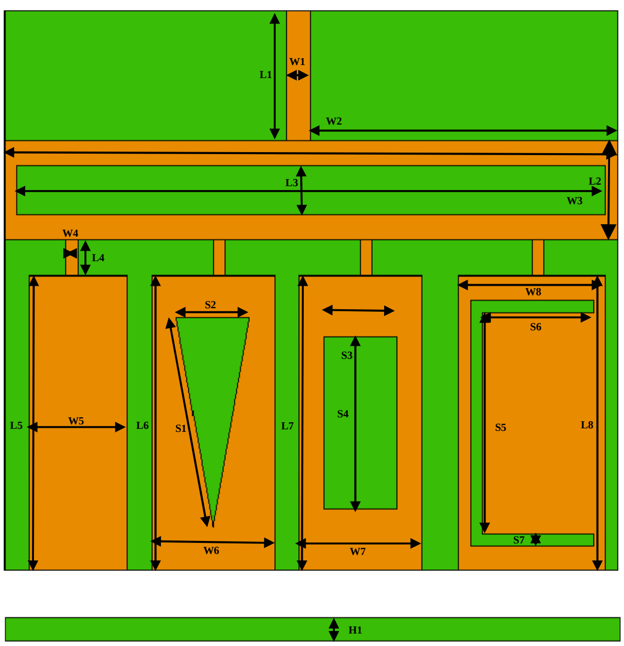

Fig 1: Structure of proposed antenna design.

The figure 1 shows the geometry of the antenna having five patches which will radiate five frequency bands (0.85 GHz – gsm 850,1.0 GHz – pcs,2.0 GHz – umts, 2.25 GHz – wi-max, 2.29 GHz – wi-fi,). The table 1 lists the key parameters. The antenna consists of one main patch and four sub patches and a ground plane and a feed line of 50Ω. The antenna designed on a FR-4 substrate with a thickness of 1.57 mm and a relative permittivity of 4.4, occupying an area of 45.6 X 50 mm on one side of the substrate and an area of 50 X 50 mm for the ground plane on the other side.

L1	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**
10.6	8	4	3	24	24	24	24
W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**
2	50	48	1	8	10	10	12
S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**H1**
8	20	8	20	10	9	19	1.57

Table 1: Dimension of Proposed Antenna (units in mm)

B. Scattering Parameter

S-parameters describe the input-output relationship between ports or terminals in an electrical system [1]. For instance, if we have two ports intelligently called Port one and Port two, then S12 represents the power transferred from Port two to Port one. S21 represents the power transferred from Port one to Port two. S11 represents the return loss in the two port network.

The antenna design will radiate five different freequency bands. Where 0.85 ghz for gsm 850 will give -10.5 db, 1.0 ghz for pcs will give -4 db, 2.0 ghz for umts will give -7.5 db, 2.25 ghz for wi-max will give -14 db, 2.29 ghz for wi-fi will give -10 db.

C. Current Distribution

The current must be zero at the end of the patch [1], and the voltage is out of phase with the current in the microstrip. Therefore the voltage is at a peak at the end of the microstrip patch, and a half-wavelength away from the start of the patch, the voltage has equal magnitude but different phase. The Phase difference in voltage in turn, which produces fringing fields that coherently add in phase and produce radiation. The current distribution must be zero at the ends of the microstrip patch. Current cannot flow out of the microstrip patch. The voltage is out of phase with the current in the microstrip patch.

The Surface Distribution Current at .85 GHz is along the main patch and along the sub feeds. For the frequency 1 GHz the distribution is along main patch sub feeds 2, 3 and triangular slot. For frequency 2 GHz the distribution is along main patch and c slot. For frequency 2.25 GHz the distribution is along c slot. For 2.95 GHz the current distribution is along the rectangular slot, c slot and main patch. The rectangular patch will act as a supporting patch for the current distribution in the rest of the five patches in the fixed antenna design.

III. SIMULATION RESULTS

A. Scattering Parameter S11

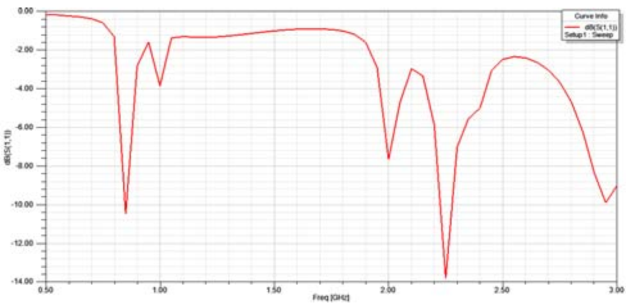

Figure 2: Return Loss of the proposed design

The Scattering parameter has been analyzed in the simulation. The return loss of the fixed multi band antenna is studied for the proposed model. An antenna should have minimum return loss in order to have a better efficiency. The proposed design is having a very minimum return loss as mentioned.

The antenna design will radiate five different freequency bands. Where 0.85 ghz for gsm 850 will give -10.5 db, 1.0 ghz for pcs will give -4 db, 2.0 ghz for umts will give -7.5 db, 2.25 ghz for wi-max will give -14 db, 2.29 ghz for wi-fi will give -10 db.

B. Voltage Standing wave Ratio

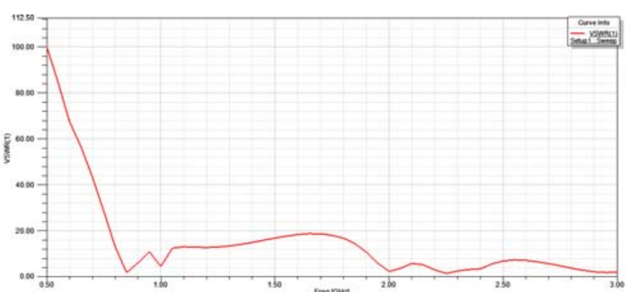

Figure 3: VSWR of the proposed design

Voltage Standing Wave Ratio is a function of a reflection coefficient; this describes the power reflected from the antenna. The reflection coefficient is given byΓ. The VSWR is always a real and positive number for microstrip antennas. The smaller the VSWR is, the better the microstrip antenna is matched to the transmission line and the more power is delivered to the microstrip antenna. The minimum VSWR is 1.0. Here no power is reflected from the ideal microstrip antenna.

In this design the antenna is giving a VSWR of range 1.0. So there is no power reflected from the antenna. Therefore the antenna is matched to transmission line and more power is delivered from the antenna.

C. Radiation Pattern

A radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the microstrip antenna. The power variation as a function of the arrival angle is observed in the antenna's far field.

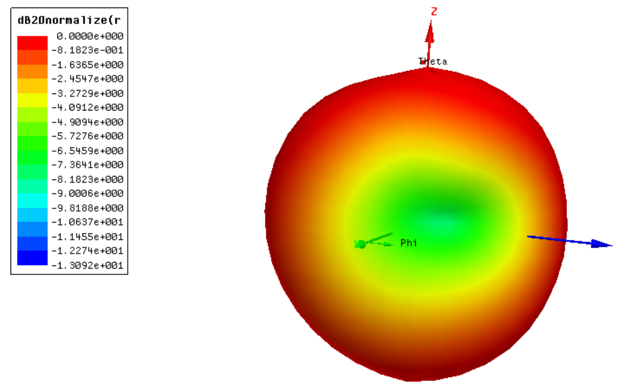

Figure 4: Radiation Pattern of the proposed design

D. Current Distribution

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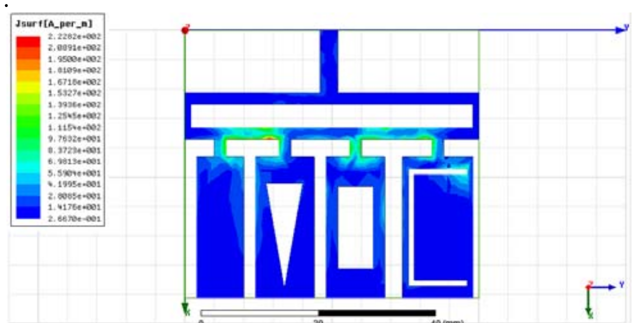

Figure 5: Surface Distribution Current at .85Ghz

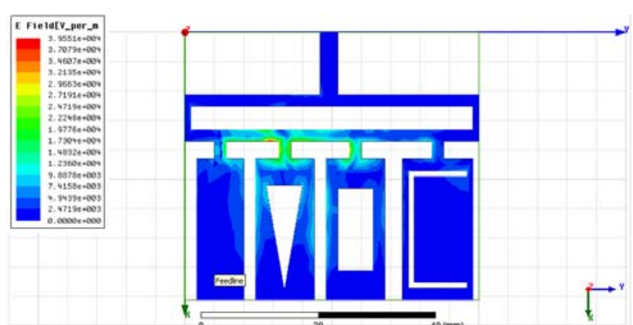

Figure 6: Surface Distribution Current at 1 Ghz

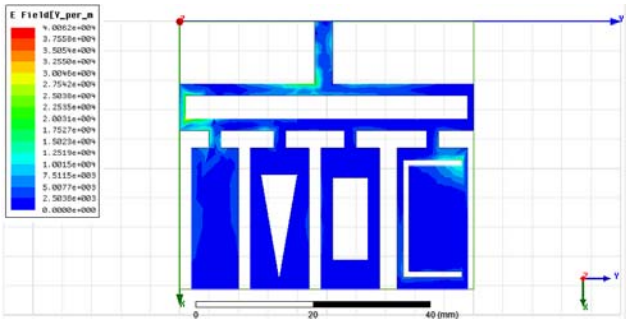

Figure 7: Surface Distribution Current at 2 Ghz

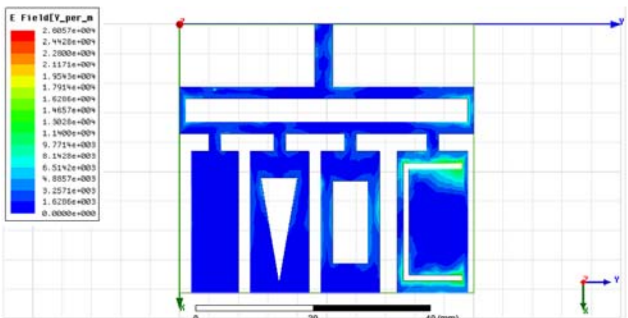

Figure 8: Surface Distribution Current at 2.25 Ghz

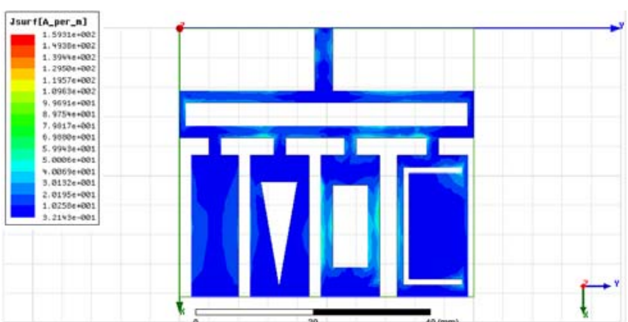

Figure 9:Surface Distribution Current at 2.95Ghz

The Surface Distribution Current at .85 GHz is along the main patch and along the sub feeds. For the frequency 1 GHz the distribution is along main patch sub feeds 2, 3 and triangular slot. For frequency 2 GHz the distribution is along main patch and c slot. For frequency 2.25 GHz the distribution is along c slot. For 2.95 GHz the current distribution is along the rectangular slot, c slot and main patch. The rectangular patch will act as a supporting patch for the current distribution in the rest of the five patches in the fixed antenna design.

IV. CONCLUSION

This paper aims to develop and design a fixed antenna of the five frequency bands. This antenna will be used in new generation wireless communication devices. This antenna has ability to radiate multiple bandwidths with a less return loss and improved gain. This model is highly compact and cost effective one. The fixed model is simulated and implemented in hardware and the results are compared.

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