COMPACT MULTI BAND STUB LOADED SLOT ANTENNA FOR WIRELESS APPLICATIONS

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Abstract—The design of a multi-band slot antenna is to serve the different wireless standards like Global Positioning System, Wireless Local Area Network, Worldwide Interoperability for Microwave Access, satellite communication and Long Term Evolution networks. The antenna consists of a rectangular slot with an area of 0.37λg0.14λg=48x18mm2 (where λg is the guide wavelength), a primary T-shaped feed patch, a secondary T shaped feed patch, an inverted T-shaped stub and two E-shaped stubs to generate six frequency bands. The multi-band slot antenna is studied and designed using computer simulation by HFSS software. The analysis of the antenna has been done and the return loss graph and the radiation pattern graph has been attached in this paper. Since it has dual feed it ,the antenna is capable of generating the frequency bands that operate independently. The frequency bands generated along with its applications has been shown in the antenna design section.

Index Terms—Dual feed, LTE, radiation pattern, Stubs.

I. INTRODUCTION

With the evolution of various wireless communication standards, it is required to integrate those standards into a single wireless device. For this reason multiband antenna was studied to integrate various bands like the Global-Positioning System (GPS), Worldwide Interoperability for Microwave Access (WIMAX) and Wireless-Area Network (WLAN) in a single device. The slot antenna has various advantages such as compact size, wide bandwidth and easy integration with other devices therefore it stands as an apt device. The previous studies in the development of the multi band are dual-band, tri-band and quad-band. The modification was increase in the number of bands and also reduced size. In this paper, we are presenting the design of antenna which can integrate Global-Positioning system (GPS), Worldwide Interoperability for Microwave Access (WIMAX), Wireless-Area Network (WLAN),c band(satellite communication) and Long Term Evolution (LTE). The proposed antenna consists of a rectangular slot, two T-shaped feed patch, an inverted T-shaped stub and two E-shaped stubs to generate about six frequency bands. We use the harmonics of the T-shaped feed patch to generate two frequency bands. Then by using a double-folded stub in the T-shaped feed patch, the two harmonic resonant frequencies can be tuned independently. With the other feed patch other two bands are generated. By this method we have generated six bands and a smaller size antenna. The proposed multi band slot antenna is studied and designed using the HFSS 13.0 software. The results on reflection coefficient, radiation pattern and efficiency are presented.

II. ANTENNA DESIGN

In this multiband slot antenna we have made use of two coaxial feed that makes it different from that of the existing multi band slot antenna, also in this we have made use of the following stubs which are the two Inverted T stub, two E stubs and a T stub. It is also to be noted that it consists of a slot which is essential part for generation of the frequency bands. The advantage of using the two coaxial feeds is that it can be used to generate two frequency bands which can operate simultaneously which is a phenomenal advantage of this antenna. In this antenna we have named the central feed line T patch along with the Inverted T shaped feed patch and the Two E shaped stubs together as the primary structure. While the feed is slightly away from the centre which is attached to another small T shaped stub has been named as the secondary structure. To speak of the location of the stubs relative to that of the slot antenna, it consists of the two E stubs placed at the either side of the slot antenna; it also consists of a inverted t stub placed at the upper edge of the antenna. It has two T stubs placed at the lower edge of the slot antenna, the structure of the T stub has been folded horizontally at the top to make it compact .The proposed multiband slot antenna consists of a rectangular slot with a size of L1*W1=48*18mm^2.The feed line has a width of WF=WF2=1.76mm to achieve impedance of 50 ohm. The T stub has an extended structure downwards to achieve perfect impedance matching. With this antenna we are able to generate six frequency bands ,the bands are as followed 1.575GHz, 2.45GHz, 3.5GHz, 5.4GHz, 3.4GHz and 4.1GHz.The frequency bands can be segregated as two main groups based on radiation elements that are used to produce them. The 1.575GHz, 2.45GHz, 3.5GHz and 5.4GHz are grouped as Set1 group that are produced by the primary structure, these bands are being generated by the E stubs, inverted T stubs and primary T shaped stubs .The Set 2 group which consists of 3.4GHz and 4.1GHz,these bands are generated using the...
secondary structure, these are generated by the small T shaped stubs. The substrate has a relative permittivity of 3.5 and a thickness of 0.8mm and a loss tangent of 0.004.

We have placed the feed line symmetrically on the ground plane. The primary T shaped feed patch with micro strip-fed on the other side of the substrate is used to feed the rectangular slot.

Now I am about to discuss about the generation of bands. The rectangular slot and the inverted T-shaped stub together generate band at about 1.575GHz for GPS system. The two E shaped Stubs operating as monopole radiators generate band at about 2.45GHz for the IEEE 802.11b and g WLAN systems. The large T shaped feed patch and inverted T shaped stub generate band at about 3.5GHz for the WiMAX applications. The large T shaped feed patch in the higher modes generates band at about 5.4GHz for IEEE 802.11 a WLAN system. The next is that the secondary small T shaped stub shown in the below figure is separately given power supply from a separate coaxial cable has a width of WF2, this structure is being used to generate the bands at about 3.4GHz for LTE applications and the band at 4.1GHz for the C band applications that is for satellite communications.

![Fig. 1 Top View](image1)

![Fig. 2 Bottom view1](image2)

![Fig. 3 Bottom view 2](image3)

### TABLE 1

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<th>L1</th>
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<th>L5</th>
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<td>4</td>
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<td>W5</td>
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### III. ANTENNA ANALYSIS

To study the different effect of radiating components on the bands of frequency, the proposed multi-band antenna is simulated and carried out by considering only the specified parts of antenna as below, so as to know how different bands have been generated.

So we need to consider only the specified radiating elements and then view the radiation pattern for them. 1) Only the first T-shaped feed patch (primary), or first T-shaped feed patch (primary) and the inverted T-shaped stub, 3) only the T-shaped feed patch (primary) and two E-stubs, 4) the secondary T-shaped feed patch (secondary) alone. The simulation design of proposed antenna is completed and Software result is obtained. That obtained result are in condition 1) only when T-shaped feed patch is used in slot, the antenna can produce the three bands of frequencies such as bands 1,3 and 4, at about 1.8GHz, 3.5GHz and 5.2 GHz respectively. In condition 2) when the inverted T-shaped stub is added, band is moved slightly down from 1.8 to 1.575GHz, but still band 3 and band 4 are the same it does change. The four bands of frequencies, 1.57 to 1.665GHz for GPS system, 2.368-2.56GHz IEEE 802.11b&g WLAN systems, 3.19-3.829GHz for WiMAX systems, 5.123-5.234GHz frequency band for WLAN IEEE 802.11a system, are generated by using first four conditions with a first port known as first T-shaped feed patch. Then the next condition is for generating band 5 and band 6 such as 3.3-3.4GHz for LTE and 3.6-4.2GHz for MMDS with a help of port 2 or called second feed patch. Thus the proposed can cover the nearly all these WiMAX bands and though the GPS system works as circularly polarized signal and most commercial wireless devices has worked as a linearly polarized antennas to receive the GPS signal. The second T-shaped feed patch bands also are be polarized by the circular polarization.

There are many parameters that affected by the frequency bands such a parameters are L1, L3, L10, w1, w5 and g1. These parameters have to be changed in order to get required frequency bands. In first port or first T-shaped feed patch the bands are ordered by band 3, 4, 1 and 2 using the following parameters:

Band 3: using L3 (the length of the inverted T-shaped stub) and W5 (width of the T-shaped feed patch).

Band 4: using L12 (the length of the double-folded stub in the T-shaped feed patch).

Band 1: using L6 (the gap between the inverted T-shaped stub and the upper edge of the slot), and

Band 2: using L6 (the height of the E-shaped stub)

These all the four bands of frequency in first T-shaped feed patch that obtained by measuring with a different length and width of the proposed antenna. Thereby the best required result has been taken in account. In second T-shaped feed patch parameters are following: L13, L14, L15, g3 and the W2 are affected by the band 5 and band 6 and by changing this length and width, these two required bands of...
frequency are achieved. The operation of the proposed antenna is studied further using the current distribution at the resonant frequency.

![Fig. 4 Frequency bands](image4)

![Fig. 5 Frequency bands](image5)

![Fig. 6 Antenna](image6)

**IV. SIMULATION RESULTS**

The computer simulation is used to study proposed antenna. In this simulation six frequency bands are generated. In which one port produce four frequency band and another one (secondary) produce two frequency band. The frequency bands are 1.57-1.67 GHz (bandwidth of 90 MHz) for the GPS, 2.4-2.9 GHz for the IEEE 802.11b & g WLAN system, 3.5 GHz for the WiMAX system and 5.4GHz for the IEEE 802.11a WLAN system. These bands are shown in Fig. 4 (return loss graph), which are the Set1 group generated by the Primary structure. The Set2 group are shown in Fig. 5 (return loss graph) which are produced by the secondary structure, this Set 2 band consists of two frequency which are the 3.4GHz for LTE band and 4.1GHz for the C band. It is simulated using the HFSS software. With S22 port four frequencies reflection loss co-efficient are calculated, which has been shown in the Fig: 4. With S33 port other two frequencies reflection co-efficient are calculated, which has been shown in figure 5. Note that the s33 (Fig: 5) is being generated by the secondary T shaped feed patch alone. Also in Fig. 7 the radiation pattern using primary structure is alone shown and in Fig. 8 the radiation pattern using secondary structure is shown. The 3D polar plot gives information about the intensity of radiation pattern.

![Fig. 7 Radiation Pattern](image7)

![Fig. 8 Radiation Pattern](image8)

![Fig. 9 Three Dimensional Plot](image9)
CONCLUSION

From this designed multiband slot antenna six frequency bands are generated. The main advantage of this antenna is that it could work at two different groups of frequency bands independently and simultaneously. These bands are used for GPS/WIMAX/WLAN/SATELLITE/LTE application. In this paper all antenna parameters are studied using the simulator. With this performance of the antenna system is evaluated. The Gain, Directivity, Reflection co-efficient are measured. Hardware can be implemented using this data. Fabrication is done using the simulation results of HFSS software.

REFERENCES