Modified Cross Dipole Antenna for Ku Band Satellite Application

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Abstract— **The aim of this research is to achieve a compact, reduced size antenna with high gain, high directivity and beam scanning capability by introducing dipole element for satellite application. A modified crossed dipole antenna element for Ku band satellite application is presented in this paper. The antenna covers the Ku frequency band ranging from (12GHz-18GHz) is designed on FR4 substrate with thickness of 1.6 mm. The proposed antenna shows the overall gain of 10.8dBi with return loss >-10dB.**

Keywords— Satellite communication; Ku band; dipole antenna; FR4 substrate; balun

I. INTRODUCTION

The rapid growth in telecommunication & radar technology is placing increasing demands on wireless system performance & functionality. The antenna is the most visible part of the satellite communication. Many of today's satellite communication and radar systems necessitate miniaturized, phased and high gain antennas that are capable of wideband /multiband operation. The need to maintain the antenna performance stable over a very large frequency band sets very demanding requirements on the antenna system and poses several technological challenges. Ku band antenna applications include mobile radars, Direct Broadcast Systems, satellite tracking, VSAT, radiometric ground based fire detection and micro electro mechanical Systems. The Ku band is a portion of the electromagnetic spectrum in the microwave range of frequencies ranging from 11.7 to 12.7GHz (downlink frequencies) and 14 to 14.5GHz (uplink frequencies). The ITU has allocated the 11.7GHz to 12.2GHz band to broadcasting services and the 12.2GHz to 12.75GHz band to fixed satellite services.

A variety of antennas can be used for satellite communication, of which parabolic reflector is the most common type of antenna which can be used for broadcasting services. But the parabolic reflector antenna requires a feed system and it has to be manufactured with care. Also the reflector antenna is not as small when compared to the other existing antennas. Therefore depending upon the requirements of the satellite antennas dipole antenna has been widely used in many communication applications, because of their broad bandwidth, simple structure & stable gain. The existing design for satellite antenna includes the Radial Line Slotted Antenna (RLSA) [2] which consists of 4 layers of dielectrics which are sandwiched between the metal and copper plate with several slots. The antenna shows an acceptable gain and directivity but the performance was greatly affected by changing the structural parameters. Also the air gap height greatly affects its resonance.

The conventional structure includes a series fed dipole antenna [1] having different lengths and a ground reflector and is serially connected with a transmission line-3. The proposed antenna consists of four dipoles with different lengths and a modified ground plane. The lengths of the short and long dipoles control the upper & lower operating frequencies. The distance between the dipoles and ground plane controls the return loss level.

II. ANTENNA GEOMETRY AND DESIGN PROCEDURE

The structure of the proposed antenna is shown in figure.1.The antenna occupies the overall size of 72×92 mm on a FR4 substrate with dielectric constant of 4.4 & thickness of 1.6 mm. The choice of substrate depends upon dielectric constant (ε_r), loss tangent (tanδ), substrate height (h), conductivity, cost, thermal expansion and manufacturability. In this design, FR-4 is chosen as a substrate because of its characteristics such as low cost, cheapest material, ease of fabrication which provides optimum performance for most of the applications**.** The designed antenna is comprised of two modified double dipole antennas which are crossed to form a single element antenna.

TABLE I. DESIGN PARAMETERS

S.NO	PARAMETER NAME	DESIGNED VALUE
1.	Dielectric constant, ε_r	4.4
2.	Loss tangent , tanδ	0.007
3.	Patch length, L	72 mm
4.	Patch width, W	92 mm
5.	Substrate height	1.6 mm

First the conventional series fed dipole antenna1 [1] is designed with reduced size. It consists of two strip dipole (D1&D2) elements having different lengths and a ground reflector. The height of the modified ground plane is chosen as 12mm. The length and width of the dipole (D1) are *L1* and *W1*, respectively and those of (D2) are *L2* and *W2*, respectively. The distance between the two dipoles controls the resonant frequencies

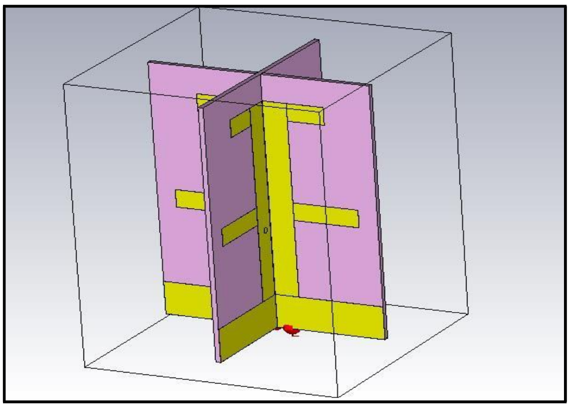

Fig. 1. Geometry of proposed antenna

The design is carried out using CST Microwave studio. An integrated balun between the Micro-Strip (MS) and Coplanar strip (CPS) lines is designed on the CPS line to match the input impedance of the antenna with the 50Ω feed line, and the end of the MS line is shorted with a shorting pin at the feed point. The widths of the CPS line and slot line are denoted as w_{CPL} and w_{SL}. Similarly the antenna 2 is designed with the same dimensions. The design is optimized by trial and error method in order to obtain the required resonance. High frequency is achieved by reducing the size of the antenna to a scale factor of 0.8 from the conventional design [1]. The optimized design parameters are listed in the table II. In order to obtain high gain and more bandwidth a new structure is implemented and it is modified to form a single element antenna. So a crossed dipole antenna is formed by cutting the first antenna from the top till 5.4mm along the length of the dipole and the second antenna is cut from the bottom till 4.7mm respectively, so as to intersect both the antennas as shown in fig.1. The width of the Micro-Strip feed line is w_{FD}.

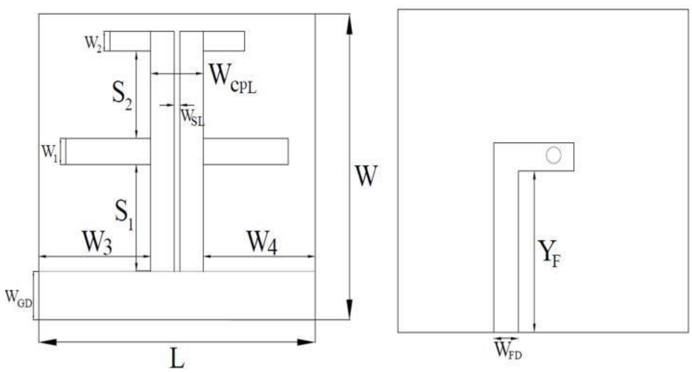

Fig. 2. Front & back view of the single antenna

TABLE II. DESIGN PARAMETERS OF THE SINGLE ELEMENT

PARAMETER	VALUE(mm)	PARAMETER	VALUE(mm)
L	72	W_{SL}	1.6
W	92	W_{CPL}	17.6
S_1	29	h	1.6
S_2	28.6	W_{FD}	3
W_1	6.4	Y_F	31
W_2	6.4	W_3	27.36
W_{GD}	12	W_4	27.36

III. RESULTS AND DISCUSSION

A. *Return loss:*

The modified dipole antenna element was designed and simulated in CST microwave studio. Figure 3 shows a plot of the simulated return loss of the antenna. The result shows that the antenna resonates at 11.9GHz, 14.6GHz and 15.9GHz frequency bands with low return loss of -19.6dB, -23dB and -34dB, respectively.

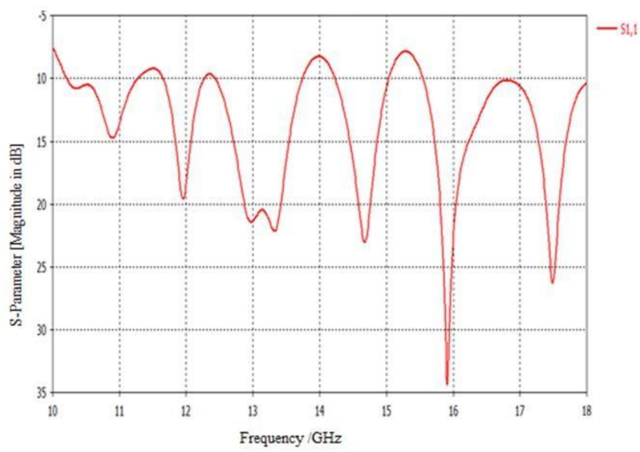

Fig. 3. Return loss of the proposed antenna

B. *Radiation pattern:*

The radiation pattern of the antenna has been simulated at 16GHz and 14 GHz in the xz-plane and is depicted in fig 4. The measured maximum gains in the normal direction of the antenna are also presented in the figure 4. The proposed antenna shows the overall gain of 12.18dBi at 16GHz and 10.8dBi at 14GHz.

C. *Bandwidth:*

The term bandwidth refers to the range of frequencies the antenna will perform satisfactorily throughout the size of frequencies. The observed -10dB bandwidths are 1.09GHz at (10.2GHz-11.2GHz), 1.3GHz at (12.4GHz-13.7GHz), 1.25GHz at (15.5GHz-16.8GHz) and 1.13GHz at (16.8GHz-17.9GHz) as shown in fig.3. This shows that the designed antenna works on more number of resonant frequencies and has more bandwidth as compared to existing antennas in the literature.

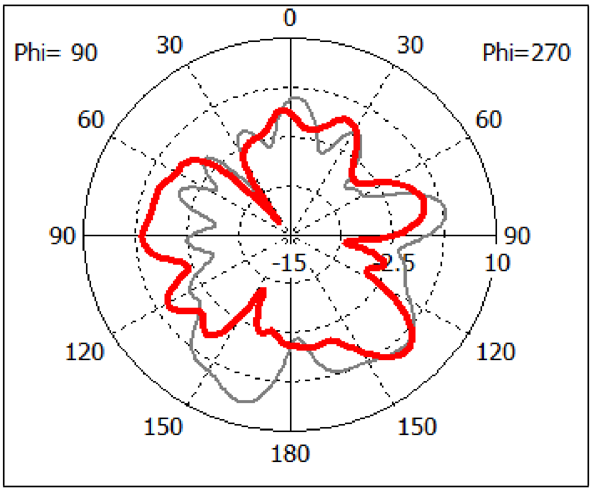

Fig. 4 Radiation pattern of the proposed antenna

IV. CONCLUSION

A new antenna design of crossed dipoles is presented for wideband satellite applications. The proposed antenna design provides the overall gain of 10.8dBi with low return loss level over the Ku band frequencies. The antenna is stable for transmitting and receiving applications in wideband systems because of its larger bandwidth. The proposed antenna is an excellent candidate for many satellite applications such as direct broadcast services and for tracking purposes.

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