Chapter 5

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Wideband CPW-fed patch Antenna with parasitic patches and slots

5.1 Wideband CPW-fed patch Antenna with Half U Slot Cut in Rectangular patch

Planar MSA are becoming very popular in wireless systems due to their Low fabrication cost, low profile and easy to integrate features. More over fast growing field of wireless communications has spurred increasing possibility of using various service applications with different frequency bands in the same equipment and is demanding a small antenna for all application in single device. These bands may be used in many systems simultaneously; there is a need for single antennas which covers all these bands Krishna [2008]. In literature several papers has been published on various key design configurations for wideband operation, including a monopole antenna fed with a meandered coplanar waveguide Liu [2004], CPW-fed monopole antenna with across slot for WLAN operation Wu[2007], CPW fed Koch- fractal slot antenna Krishna[2008], dual-band angular ring slot antenna Sze[2007], compact disc slit monopole antenna Liu[2008], and elevated CPW- fed slotted microstrip antenna for ultra-wideband application Chandan [2012] etc. The most popular methods for enhancing Broadband width is to use parasitic patches with stacked geometry or either coplanar geometry, increases the thickness or area of the antenna respectively. Presently a simply CPW fed single metallic layer monopole antenna is gaining popularity in wireless system

In this section a monopole antenna with CPW feed technique on single layer substrate, having a rectangular resonating patch embedded with half U slot is presented for WIMAX and wide band local area network services. U slot dimensions are optimized to improve the various parameters like return loss, gain etc. across the targeted frequency bands. Simulation of the antenna indicates that designed antenna having large bandwidth, gain & radiation characteristic over the operating bands. In the following section details of the design antenna are presented and various simulated results like return loss, directivity, efficiency and gain are discuss.
5.1.1 Antenna Design

The designed CPW feed antenna with half U slot is shown in figure 5.1. The substrate used for proposed antenna design was FR4 having substrate dielectric constant ($\varepsilon_r$) is 4.4 mm and the thickness of the dielectric substrate is 1.6 mm. Copper clad FR4 is available in a single side or double sided sheets. The proposed antenna is fabricated on single sided substrate. A transmission line, having width $W_f$ & distance of gap ‘d’ between the ground plane and transmission line used to feed the antenna. The dimensions for designed antenna are 62 mm X 47 mm X 1.6 mm. Two equal finite ground planes are placed in symmetrically to each side of feed line. The basis of this antenna structure having length $L_1$ and width $W_1$ of rectangular patch connected to CPW feed-line.

The optimize design parameters for the proposed CPW feed structure are $L_1 = 20$ mm length of rectangular patch, $W_1 = 29$ mm width of rectangular patch, $L_g = 21$ mm ground plane length, $W_g = 27$ mm ground plane width, $W_f = 3$ mm feed line width, $L_2 = 5$ mm slot length, slot length $L_3 = 13$ mm, slot length $L_4 = 27$ mm, slot width $W_2 = 24$ mm, slot width $W_3 = 1$ mm, slot width $W_4 = 2$ mm, Spacing between ground plane and feed length $d = 1$ mm, Spacing between rectangular patch and ground plane $S = 3$ mm, and Spacing between rectangular patch and rectangular strip $S_1 = 1$ mm. Total volumetric size of the designed antenna is 4.66 cm$^3$. Performance of the antenna is analyzed by IE3D simulator.
5.1.2 Results and Discussion

Fig. 5.2 represents the return loss for optimized proposed design. The simulated result has a bandwidth of 84.33 % across a range of freq 2.4 GHz to 5.9 GHz, below the -10 dB RL at central frequency at 4.15 GHz. The change in simulated value of VSWR Vs frequency is shown in fig
5.3 VSWR presented by antenna across a bandwidth area is less than 2:1 value which is good for matching between CPW feeding circuit and resonating antenna. The simulate value of VSWR at resonant freq is 1.62. Figure 5.4 depict the simulated graph of input impedance of design antenna with freq. At resonance freq 2.22 GHz the simulated input impedance of antenna is 58.3+ j 25 ohms which is in good agreement with the 50 ohms impedance of feeding network. maximum gain of antenna is about 2.8 dBi and directivity of 5.94 at 4.15 GHz frequency as shown in Fig.5.5and5.74.graph of antenna efficiency shows that both radiating and antenna efficiency is approximately 60%.
Fig 5.2- Variation of return loss Vs frequency
Fig 5.3- Variation of VSWR Vs. frequency
Fig 2.5- Graph of input impedance of antenna vs. frequency
Fig5.5 Impedance Loci
Fig5.6- gain vs. frequency
Fig5.7- Variation of directivity of antenna VS. Frequency
Fig-5.8 efficiency vs. frequency of antenna
5.1.3 Parametric study and effect of space gap between ground plane and patch.

The parametric studies are done by changing one design parameter of geometry while remaining parameters of geometry are fixed w.r.t reference design. Fig 5.9 represents the simulated graph of return loss for proposed design w.r.t freq for various values of spacing ‘S’ between ground plane and rectangular patch element. From simulated results it is observed that if the gap spacing ‘S’ decreases from the optimum value, there is decrease in Bandwidth with Slightly change of frequency band near to higher freq side. It is observed too that by increasing gap space bandwidth is decreased approximately by 30%. The optimal performance is obtained for S = 3 mm as shown in figure 5.1.

![Graph of return loss by changing gap between ground plane and patch](image)

Fig 5.9 –Effect on return loss by changing gap between ground plane and patch
radiation patterns of azimuth and elevation for designed antenna are represent in figure 5.10 (a) and 5.10(b) which points that the antenna is strongly radiating normal to the patch at resonant frequency 4.15 GHz. The radiation pattern obtained is nearly close to omni-directional.

Fig5.10(a) - Display of Azimuth pattern of antenna.
Fig 5.10 (b)- Display of Elevation pattern of antenna
The proposed CPW-Fed broadband antenna with half U slot cut in rectangular patch has simulated and designed for WIMAX/WLAN services. The result shows that it gives broadband bandwidth of 84.33% covering a range of frequency 2.4 GHz to 5.9 GHz at central frequency 4.15 GHz.

In the next section an effort are made to improve the bandwidth with same volumetric antenna with cpw feed.

5.2 Broadband CPW-fed Rectangular Antenna with parasitic patches

In this chapter a broadband Rectangular microstrip Antenna with parasitic patches on coplanar waveguide (CPW) feed is presented. The antenna having a planar rectangular fed patch with two parasitic patches for broad banding. Parametric study is performed to analyze the characteristics of the antenna. The total dimensions for designed antenna are 62 mm X 47 mm X 1.6 mm. and total volumetric size of the designed antenna is 4.66cm$^3$. The antenna operates across frequency range from 2.39 GHz to 7.42 GHz covering worldwide interoperability for microwave access (WIMAX) and WLAN bands. Good antenna characteristics such as radiation patterns, antenna gain and radiating efficiency across a band of operation are observed. Maximum peak gain of 7.72 dBi is obtained for the designed antenna.

In this section a wide band planar CPW feed rectangular microstrip antenna on single layer substrate coupled by two parasitic patches is presented for wireless applications. Nearby Patches, gets excited through the air gap by fed patch, such a patches is known as a parasitic patches. If the resonance frequencies of these patches are close to each other than broad band can be achieved.

By arranging the gap between patches the performance of antenna can be improved. Gap dimensions between the patches are optimized to improve the various parameters like return loss, gain, directivity etc. across the targeted frequency bands.
5.2.1 Antenna design

The designed CPW-fed Rectangular Antenna with parasitic patches is shown in Figure 5.10. The substrate used for proposed antenna design was FR4 having substrate dielectric constant (Er) is 4.4 mm and the thickness of the dielectric substrate is 1.6 mm. Copper clad FR4 is available in a single side or double sided sheets. The proposed antenna is fabricated on single sided substrate. A transmission line, having width Wf & distance of gap ‘d’ between the ground plane and transmission line used to feed the antenna. The dimensions for designed antenna are 62 mm X 47 mm X 1.6 mm. Two equal finite ground planes are placed in symmetrically to each side of feed line. The basis of this antenna structure having length L2 and width W2 of rectangular patch connected to CPW feed-line.

The optimize design parameters for the proposed CPW feed structure are L2 = 16 mm length of rectangular patch, W2= 16mm width of rectangular patch, Lg = 21 mm ground plane length, Wg = 28mm ground plane width, Wf = 3mm feed line width, [L1] = 16mm , [W1] = 16mm, Space gap of feed length and ground plane d = 1mm , Space of rectangular patch and ground plane S = 2mm, and Spacing between rectangular patch and rectangular parasitic patches S1 =1mm. Total volumetric size of the designed antenna is 4.66cm³. Performance of the antenna is analyzed by IE3D simulator.
Fig 5.11- Geometry of CPW-fed Rectangular Antenna with parasitic patches
5.2.2 Results and discussion

Fig. 5.11 represents the return loss for optimized proposed design. The simulated result has a bandwidth of 102.6 % across a range of freq 2.39 GHz to 7.42 GHz, below the -10 dB RL at central frequency at 4.9 GHz. The change in simulated value of VSWR Vs frequency is shown in fig 5.12 VSWR presented by antenna across a bandwidth area is less than 2:1 value which is good for matching between CPW feeding circuit and resonating antenna. The simulate value of VSWR at resonant freq is 1.62. Figure 5.4 depict the simulated graph of input impedance of design antenna with freq. At resonance freq 4.9 GHz the simulated input impedance of antenna is 58.3+ j 25 ohms which is in good agreement with the 50 ohms impedance of feeding network. maximum gain of antenna is about 7.72 dBi and directivity of 5.94 at 4.9 GHz frequency as shown in Fig.5.12and5.13 and maximum radiating efficiency of 100% at 5.87 GHz frequency band is obtained as shown in Figure5.14.
Fig 5.12- Variation of return loss Vs frequency
Fig 5.13  Variation of VSWR Vs. frequency
Fig 2.5- Graph of input impedance of antenna vs. frequency
Fig 2.4 Impedance Loci
Fig 5.16- change in simulated value of gain of antenna vs. frequency
Fig-5.17 Antenna efficiency
5.2.3 Parametric study and effect of space gap between ground plane and patch.

The parametric studies are performed by changing one design parameter of geometry while remaining parameters of geometry are fixed w.r.t reference design. Fig5.14 represents the simulated graph of return loss for the proposed design w.r.t freq for various values of spacing ‘S’ between ground plane and rectangular patch element. From simulated results, it is observed that with the decrease or increase in gap spacing ‘S’ from the optimum value, there is a decrease in Bandwidth. The optimal performance is obtained for spacing $S = 2\text{mm}$.

Fig 5.18 – Effect on return loss by changing gap between ground plane and patch
radiation patterns of azimuth and elevation for designed antenna are represent in figure 5.15 (a) and 5.15(b) which points that the antenna is strongly radiating normal to the patch at resonant frequency 4.9 GHz. The radiation pattern obtained is nearly close to omni-directional. The antenna radiation characteristics are identical at all the frequency bands.

Fig 5.19 (a) – Display of Azimuth pattern of antenna.
Fig 15 (b) - Display of Elevation pattern of antenna
5.3 Conclusions & Discussion

In this chapter a broadband monopole antenna with half u cut slot in rectangular patch on a coplanar wave guide (CPW) fed and radiation performance of parasitic patches gap couple rectangular antenna with CPW fed are presented and compared.

In first step the antenna composed of a rectangular patch inserted with U slot, simulated results having a wide bandwidth of 84.33% covering a frequency range of 2.4 to 5.9 GHz covering wi-fi and Wi-max bands. Result shows this antenna is very promising in WIMAX application.

In the second part the radiation performance of a single layer assembly of gap coupled patches is presented to achieve broadband performance. By properly choosing the space gap between patches and tuning their dimensions broader bandwidth is obtained. The antenna gives broader bandwidth of 102.6% over the range of frequency from 2.39 to 7.42 GHz at centre frequency 4.9GHz. Throughout the bandwidth the radiation pattern is identical in shape and antenna is strongly radiating normal to the patch.