Comparative Analysis of Microstrip and Co-Planar Waveguide-Fed Printed Monopole Antenna for Ultra-Wideband Application

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1 Introduction

Ultra-wideband antennas (UWBs), which offer maximum bandwidth, rise in gain and narrow radiated power, are constantly rising as a result of the tremendous expansion in communication systems, from old-fashioned landlines to modern wireless gadgets. To meet demands for clear resolution and data rates, modern communication technology is always being improved. For maximum data rate wireless communication systems (WCS), antenna scientists must develop tiny antennas on printed circuit boards while maintaining essential broadband features. The advancement of various modern communication systems has increased the progress of multifunctional antennae. Earlier, wireless systems had a single antenna with defined radiation characteristics. The selection of resonant frequency is a theory that has given rise to new technologies for applications in tiny multiband systems. As a result, designing tunable and frequency tunable antennas have gained popularity [1]. In this communication, a small SWB polarization antenna with double-band capabilities has been examined. The suggested antenna has duplex band-rejection characteristics that encompass the WLAN band and X-band satellite communication, and it offers an unusually high impedance BW from 1.2 to 25 GHz. The suggested antenna is a strong option for polarization diversity applications since it has a minimal ECC

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of 0.025 for the SWB frequency range. This antenna may be utilized for the spectrum used in cognitive radio due to its huge bandwidth [2]. A novel microstrip-fed antenna with a planar shape of size $24 \times 28 \times 1.6\ \text{mm}^3$ is proposed. The V-structure patch, microstrip-fed line and partial ground plane construction make up the antenna structure. A frequency rejection feature that can reject the frequency range from 5.15 to 5.825 GHz is obtained by adding a U-structure slot to the patch [3]. Reference [4] describes the impact of a straightforward ground slot monopole antenna fed with microstrip. Its main purpose is for the UWB application's antenna. An antenna with a T-shape (gap) that is CPW-fed, one-step patched, and has filtering properties are developed for double resonating frequencies of 3.5 GHz and 5 GHz, covering the frequency ranges from 3.2 GHz to 3.5 GHz) and 4.7 GHz to 5.6 GHz, respectively [5]. Diego et al. [6] produced a wide band E structure printed antenna with an approximate impedance bandwidth of 29.8% by creating a zigzag groove in the patch. A U-shaped slot-loaded inverted disc antenna with a maximum bandwidth of 24.2 per cent was created by Kaur et al. [7]. Similar to a slot, fractal, or metamaterial, an ultra-wideband antenna can be made. There have been several published UWB antenna configurations [8] through [9]. Radiator with disc patches and a CPW-fed, concentrically filled antenna for UWB applications. With the installation of a flawed ground plane, it can improve the frequency quality of the antenna [10].

2 Proposed Antenna Configuration

The suggested antenna geometry is shown in Figs. 1 and 2. The FR-4 epoxy-coated substrate has the following measurements.

Optimized sizes for the ground plane are $L_{ge} = 19.5$ mm and $W_{ge} = 11.4$ m to enhance bandwidth for both microstrip fed and CPW fed. This comparative study of both the fed that is microstrip fed as well as CPW fed is going to analyse in terms of bandwidth and return loss.

The following equations, Eqs. (1) and (2), can be used to determine how the proposed monopole antenna with a circular disc-shaped patch should be constructed

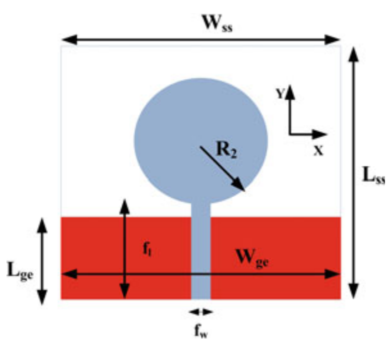


Fig. 1 Microstrip-fed printed monopole antenna

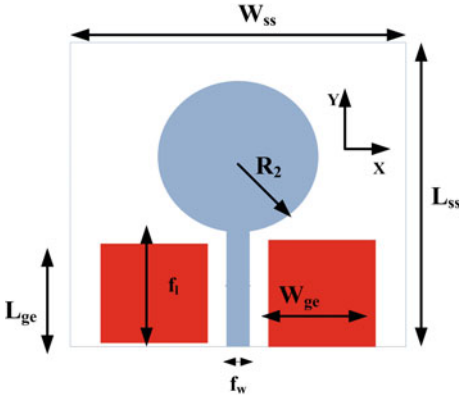


Fig. 2 CPW-fed printed monopole antenna

[6].

$$R_2 = \frac{R_{ef}}{\sqrt{1 + \frac{2h}{\pi \varepsilon_r R_{ef}}\left[\ln\left(\frac{1.57 R_{ef}}{h}\right) + 1.78\right]}} \quad (1)$$

$$R_{ef} = \frac{8.79 \times 10^9}{f_{sr}\sqrt{\varepsilon_r}}, \quad (2)$$

where h is the substrate's height in mm, ε_r is the substrate's dielectric constant, and f_{sr} is the resonance frequency.

The low cut-off frequency of the antenna can be calculated using the usual formula provided for predicting the low cut-off frequency of printed monopole antennas. A cylindrical monopole antenna may be utilized with the appropriate modifications [6–9, 11, 12]. These equations are valid for an antenna with a monopole structure and a planar model.

$$f_{ef} = \frac{c}{\lambda_{ll}} = \frac{7.2}{(H + R_{ef} + f_{ll})}\text{GHz} \quad (3)$$

Compared to planar antennas, which have a single sheet of dielectric on the antenna and have circularly formed monopole characteristics. Here, f_l stands for feed length to match the 50-Ω input impedance. The dielectric substrate increases the antenna's effective size, which lowers the lower band edge frequency.

3 Result

Initially, changing the dimensions of the ground plane makes a major contribution to monopole antennas.

Table 1 shows the various ground structures in terms of return loss and fractional bandwidth for CPW fed. Reducing the ground plane increases the bandwidth, and lowering the return loss after reaching a critical dimension will decrease the bandwidth and no improvement in bandwidth. Maximum fractional bandwidth of 89% is observed in the dimension of $L_{ge} = 15.9$ mm, $W_{ge} = 11.4$ mm with return loss −41 dB. From Table 2, it is noticed microstrip-fed antenna gives a lower performance in comparison to CPW fed. In microstrip fed, it gives fractional bandwidth of 87% which is lower when compared to CPW fed and return loss of −38 dB. In both the cases, optimized dimensions are $L_{ge} = 15.9$ mm and $W_{ge} = 11.4$ mm (Fig. 3).

The space in between the ground plane and patch provides for better improvement of the bandwidth. In Tables 2 and 3, it is showing that the smaller the gap, the more the bandwidth. Figure 4 shows VSWR frequencies result, and VSWR provides transmitted radiated wave and its returning wave. Its value should be the lowest as possible in order to promote fair radiation. CPW fed gives and microstrip-fed VSWR responses are good, but CPW fed gives better which value is 1.018 in contrast to microstrip fed that is 1.65.

Figure 5 shows the performance of gain for both the fed that microstrip fed and CPW fed, and the graph shows that the performance is better in the case of CPW fed reaching a maximum gain of 8.77 dBi, whereas for microstrip fed it only reaches upto 6.45 dBi.

Figures 6 and 7 show the radiation pattern of E-field and H-field for both the microstrip fed and CPW fed. A uniform omnidirectional pattern can be seen in CPW

Table 1 Optimized dimension of the proposed antenna

Parameters	Value(mm)	Parameters	Value(mm)
W_{ss}	35	W_{ge}	11.5
L_{ss}	30	f_l	18
R_2	8.5	f_w	1.6
L_{ge}	19.5	h	1.6

Table 2 Return loss for various ground dimensions for CPW-fed antenna

Ground plane dimension (mm)	Operating centre frequency (GHz)	$\|S_{11}\|$dB	−10 dB Bandwidth (GHz)	Fractional bandwidth (GHz)
$L_{ge} = 15.9$ $W_{ge} = 13.4$	$f_{cn1} = 7.4$ $f_{cn2} = 15.4$	−25.30 −17.97	(5.1–12.9) (14.2–19)	86.6 28.9
$L_{ge} = 15.9$ $W_{ge} = 12.4$	$f_{cn1} = 6$ $f_{cn2} = 16$	−27.69 −31.9	(5.2–12.8) (14.0–18.0)	84 25
$L_{ge} = 15.9$ $W_{ge} = 11.4$	$f_{cn1} = 6$ $f_{cn2} = 16$	−41.86 −39.91	(5.2–13.6) (14.1–18.2)	89 25
$L_{ge} = 15.9$ $W_{ge} = 10.4$	$f_{cn1} = 6$ $f_{cn2} = 17.4$	−41.58 −26.68	(5.3–13.5) (14.4–19.7)	87 29.5
$L_{gg} = 15.9$ $W_{gg} = 9.4$	$f_{cen1} = 6$ $f_{cen2} = 15.8$	−21.97 −21.97	(5.4–13.4) (14.6–17.0)	85 15

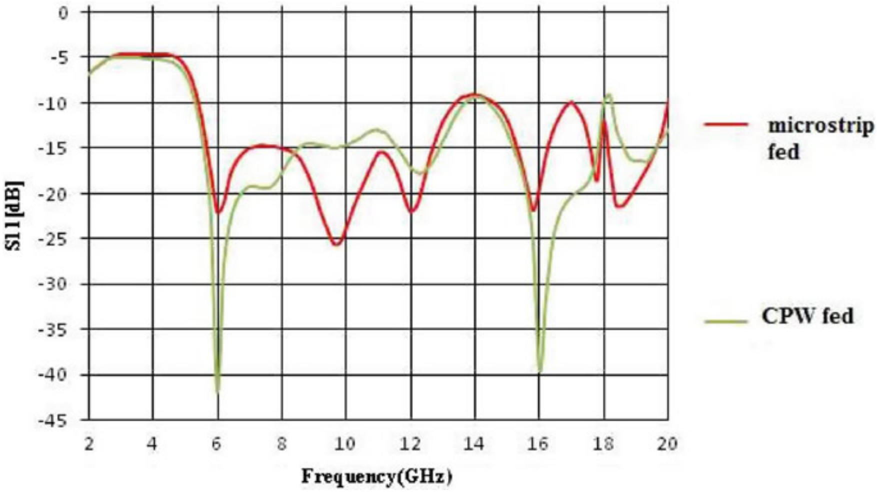


Fig. 3 Return loss versus frequency (GHz)

Table 3 Return loss for various ground dimensions for microstrip-fed antenna

Ground plane dimension	Operating centre frequency (GH)	$\lvert S_{11} \rvert$dB	−10 dB Bandwidth (GHz)	Fractional bandwidth (GHz)
$L_{ge} = 15.9$ mm $W_{ge} = 13.4$ mm	$f_{cn1} = 7.4$ $f_{cn2} = 15.4$	−23.30 −15.97	(4.9–12.1) (13.2–19)	79.6 28.9
$L_{ge} = 15.9$ mm $W_{ge} = 12.4$ mm	$f_{cn1} = 6$ $f_{cn2} = 16$	−25.69 −31.9	(5.2–12.8) (12.0–18.0)	70.4 25
$L_{ge} = 15.9$ mm $W_{ge} = 11.4$ mm	$f_{cn1} = 6$ $f_{cn2} = 16$	−39.5 −37.91	(5.13–13.6) (14.1–18.2)	80 25
$L_{ge} = 15.9$ mm $W_{ge} = 10.4$ mm	$f_{cn1} = 6$ $f_{cn2} = 17.4$	−39.58 −24.68	(5.3–13.5) (14.4–19.7)	78 29.5
$L_{ge} = 15.9$ mm $W_{ge} = 9.4$ mm	$f_{cn1} = 6$ $f_{cn2} = 15.8$	−19.97 −19.97	(3.59–13.4) (14.6–15.10)	77 15

fed not in the case of microstrip fed, and this indicates that CPW has a better radiation pattern than microstrip fed.

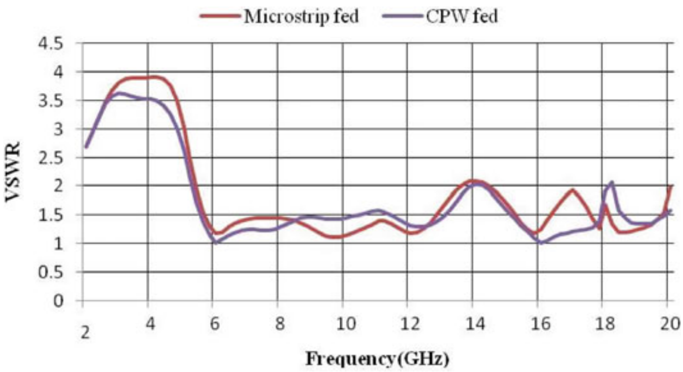


Fig. 4 VSWR versus frequency (GHz)

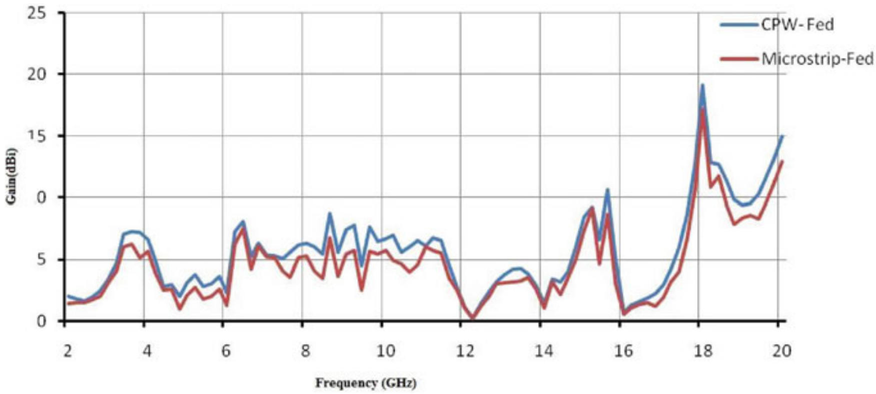
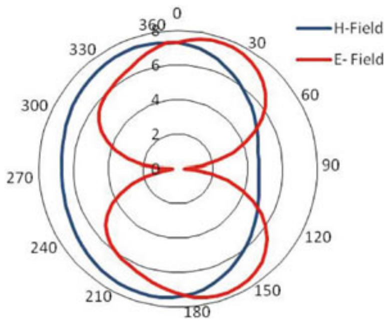


Fig. 5 Gain (dBi) versus frequency (GHz)

Fig. 6 Radiation pattern microstrip fed



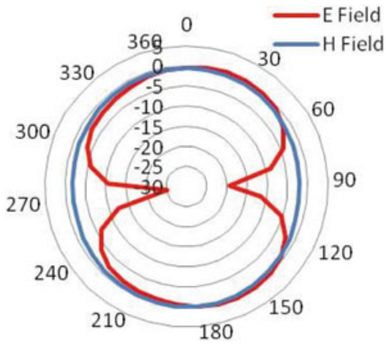


Fig. 7 Radiation pattern CPW fed

4 Conclusion

The CPW-fed antenna gives a better impedance bandwidth when compared to microstrip fed. Not only bandwidth in terms of return loss absolute value of −41 dB can be achieved in case of CPW fed. Regarding gain CPW can be reached a gain of 8.77 dBi which is a good value of gain and a fair uniform radiation pattern can be achieved. In both cases, reduction in ground plane helps in improving the antenna performance. When ground plane's size is further decreased again after reaching a critical level, the bandwidth naturally initiates to decline.

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