Dual-band CPW-fed Antenna for Sub-6 GHz Applications

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Abstract:

A novel mho-shaped dual band microstrip antenna with CPW feed is presented for GSM(DCS) -1.8 GHz, GSM(PCS)-1.9 GHz, CDMA-1.9 GHz, UMTS W-CDMA, IMT-2 GHz, WLAN and 5G Applications. Dual band is obtained from a mho-shaped and modified step-feed radiator in which mho-shaped radiator is accountable for lower frequency band as electric length increases, where operating frequency varies from (1.77 GHz to 2.3 GHz). Modified microstrip line is used to achieve higher frequency band, that varies from 2.85GHz to 4.6 GHz. The realized gain is achieved with low cost FR-4 Material, that varies from 2.06 dB to 4.12 dB where greater than 90% efficiency is obtained in entire dual-band operating frequency.

Key words:

Dual-Band, CPW-fed microstrip antenna, GSM application, 5G Application.

I. Introduction:

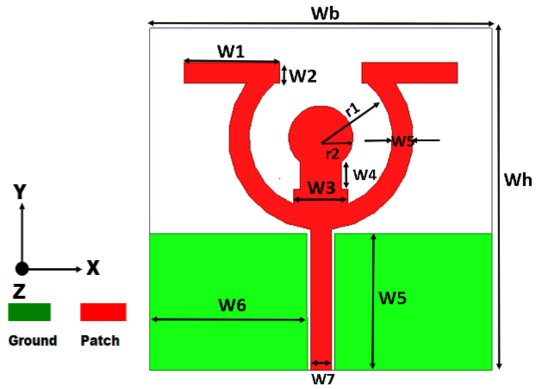
Compact wireless devices such as laptops, mobile phones, smart watches, etc. are designed to operate on more than one frequency band as these devices are capable of communicating for WiFI, WLAN, 5 G cellular (GSM or CDMA) and many more. In portable devices for communication, antenna is considered as a single largest integrated component. Multiple antennas for different frequency consumes more space and are comparatively more expensive where these problems can be overcome with single-element multiband antenna. Dual-band antennas are suitable candidate for wireless communication devices as these antennas are capable to accommodate two bands on a single unit. CPW antennas are fabricated on the same plane, therefore antenna can be integrated on single side of the substrate, this makes the fabrication and incorporation of antenna into devices more economical. CPW antennas are also free from radiation anomalies that occur in the feed when coupled to ground on opposite side of substrate. Several researchers had worked on many unique multi-band antenna designs in wireless communications for GSM (1.71GHz to 1.99 GHz), LTE (2.30 GHz to 2.40 GHz), Wi-Max (3.30 GHz to 3.60 GHz) and 5G (3.3 GHz to 4.2GHz) communication [2- 14]. The size of microstrip antenna for above applications could be high, because when the operating frequency decreases, the electric length and the antenna size increases [1]. In [2], a dual band antenna is presented in the shape of a regular polygon, where, the dual band is achieved by circular slots and vertical slits provide two paths for current. In [3], a triband antenna is structured by densely embroidered metal-coated polymer fibre. Where the antenna is composed of two asymmetric arms along with feeding slot between them and load loop to implement impedance matching. In

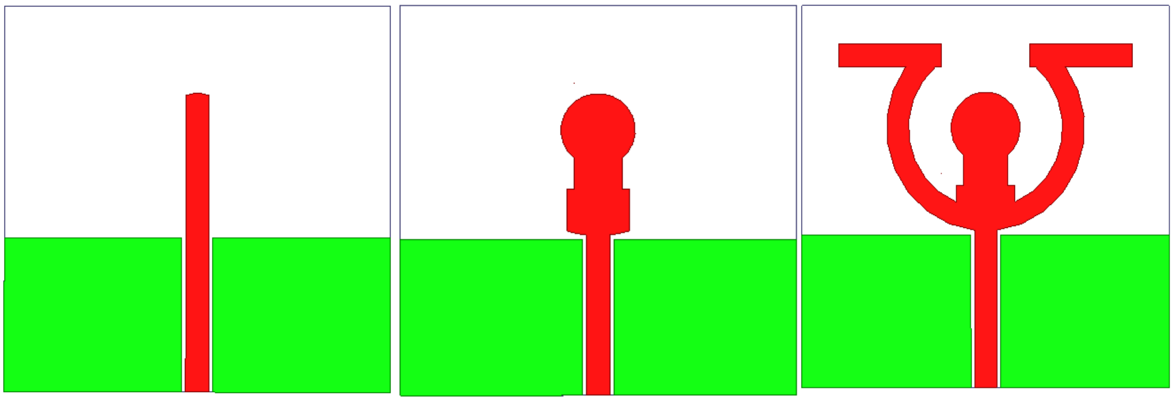
[4], an EBG based fractal antenna is presented for two bands. In [5], a metamaterial pattern reconfigurable antenna, is presented for 2.4 GHz. In [6], A quad-band based on circular radiator with extended inverted V-shaped slot is used for multiple resonant frequency. In [7], CPW-fed multi-band antenna is presented, where an isosceles triangular patch with slanted slots are responsible for triple-band where the ground structure is extended for improving impedance bandwidth. In [8], FSS based antenna with SRR and DGS is presented for 5G, where E-shaped radiator with defected ground structure is used for millimeter wave communication. In [9], an antenna structure with EBG is accomplished at 2.4 GHz to improve front-to-back ratio. In [10], a CPW-fed antenna is presented with flower shaped design where five radiating strips is used to achieve quad-band. In [11], a CPW-fed antenna with a rectangular patch is designed where magneto-dielectric material is used as a substrate. In[12] a CP-CPW antenna is designed, where a semi-circular shaped structure is utilized to mitigate current which results in CP. In [13] an SRR with a cross shaped structure is integrated on a hexagonal structure to generate metamaterial characteristics. In [14], a flower shaped antenna is designed for UWB applications with a CSRR and EBG to achieve notch at two frequency bands. In [15], a PIN diode is utilized to connect the parasitic radiator to obtain two switchable frequencies. In this article, CPW-fed microstrip antenna is designed for dual-band applications. The |S11| of the antenna depends upon the mho-shaped and a microstrip line to achieve the dual-band. The mho-shaped radiator is responsible for lower band frequency, which varies from 1.77 GHz to 2.37GHz. The modified microstrip line is used to achieve frequency band of (2.85 GHz to 4.6 GHz) for WiMax and 5G communication, where poor impedance matching at the feed eliminates a band from 2.4 GHz to 2.8 GHz to reduce interference from DTH applications.

II. Antenna Design:

An optimized and compact geometry of the antenna, designed on FR4 glass epoxy (Relative Permittivity $(\varepsilon_r) = 4.4, \text{thickness}(t) = 1.6\ \text{mm}$) as illustrated in Fig. 1(a). The prototype area of dual-band antenna is 50(Wb) x 50(Wh) x 1.6(t) mm^3. Antenna dimensions (in mm) are as follows: W1 = 14, W5 = 20, W2 = 3, W4 = 3.9, W3 = 8, W6 = 23, W7 = 3, r1 = 10.5 and r2 = 4.65.

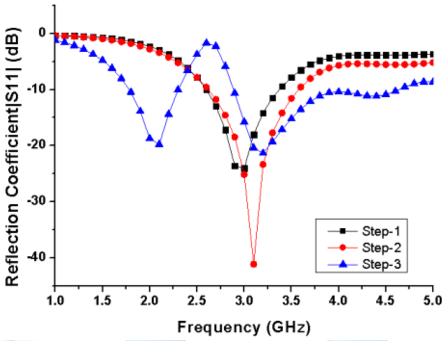
(a)





Step-1 Step-2 Step-3

(b)



(c)

Fig. 1(a) Proposed double band CPW-fed antenna, (b) Steps of evolution (c) |S11| parameters (steps)

III. Evolution steps of proposed of Antenna design

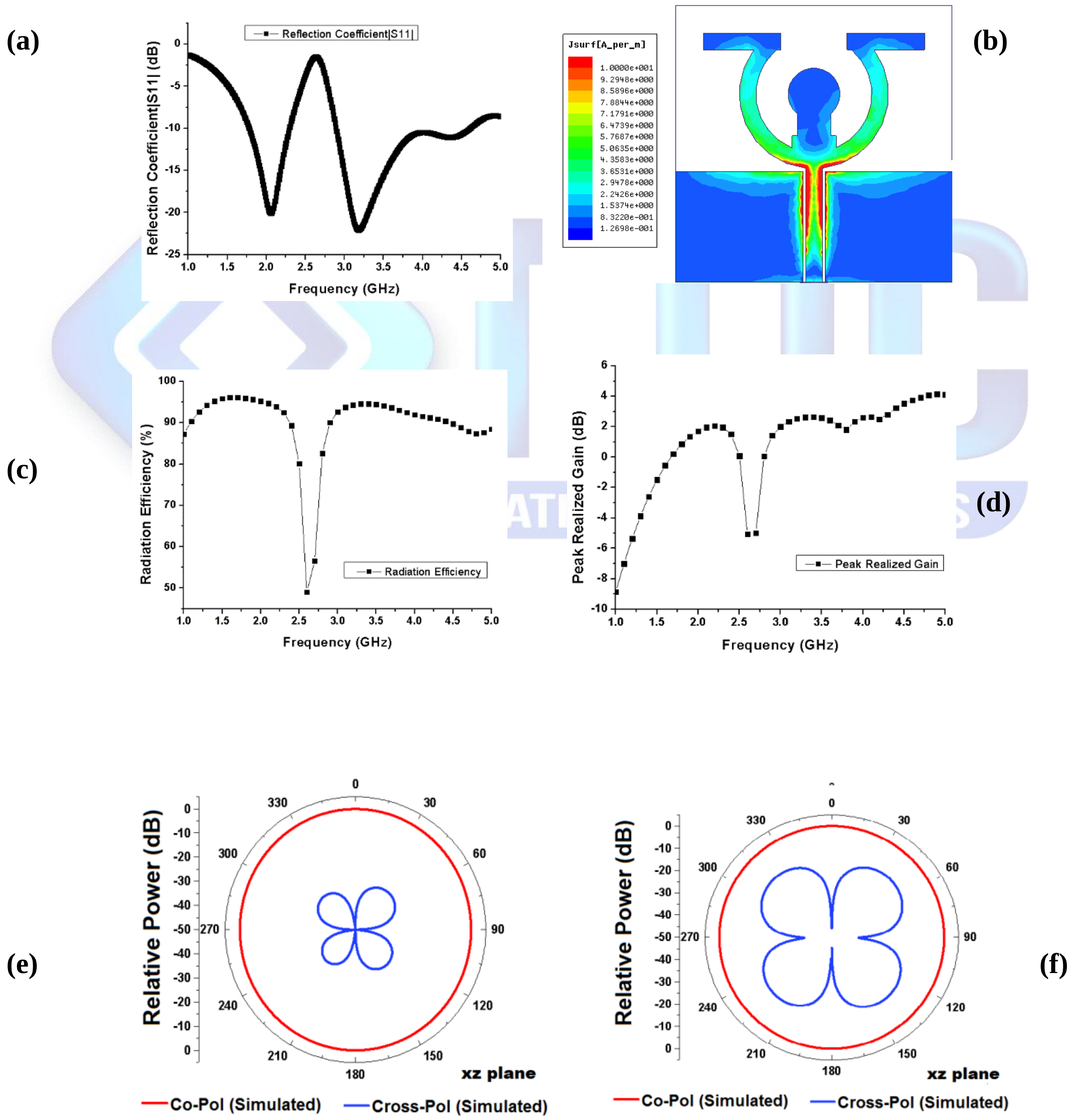
The proposed dual-band CPW-fed antenna is designed in three steps. In step-1, a microstrip line feed of width 3 mm is used to achieve 50-ohm impedance as depicted in figure 1(b), which is responsible for 10dB impedance that radiates from 2.60 GHz to 3.35 GHz as depicted in figure 1(c). In step-2, microstrip line feed is optimized as a bulb shaped radiator is used to improve the current variation and impedance matching which enhances the impedance bandwidth as shown in figure 1(c). The bandwidth in step-2 extends from 2.60 GHz to 3.55 GHz as illustrated in figure 1(c). In the final step, a mho-shaped radiator is accomplished with the bulb shaped microstrip line feed as illustrated in figure 1(b), where mho-shaped radiator increases the electric length and is responsible for lower operating band. The 10dB impedance bandwidth(IBW) varies from 1.77 GHz to 2.3 GHz for DCS 1800 MHz as well as PCS 1900 MHz Applications and from 2.85 GHz to 4.6 GHz for WiMax and 5G Applications.

IV. Results and Discussion:

The presented double band antenna designed on low cost material is simulated on Ansys HFSS-13 software. Figure 2(a) depicts the |S11| in dB of the presented double band antenna, where it reveals that the antenna is resonating at two bands, which varies from 1.77 GHz to 2.30 GHz, and from 2.85 GHz to 4.60 GHz. By analysing the surface current distribution as revealed in figure 2(b), it is observed that from 2.40 GHz to 2.80 GHz, poor impedance matching between transmission line and the radiator is achieved which is due to surface current disturbance, thereby gain and efficiency decreases and it acts as similar to notch performance. However, more than 90 % radiation efficiency is achieved in dual operating band as illustrated in figure 2(c).

The realized antenna gain(dB) is 2.06 in lower operating band, the antenna exhibits a gain of 2 dB to 4.12 dB in the upper operating band as illustrated in figure 2(d).

The proposed CPW fed antenna demonstrates stable radiation patterns in both the operating bands from 1.77 GHz to 2.3 GHz as well as 2.85GHz to 4.60 GHz. The normalized radiation patterns are shown in xz and yz plane, where co and cross polarization difference are more than 20dB and indicate omni-direction radiation pattern at 2.10 GHz and 3.20 GHz frequency, depicted in figure 2(e-h).



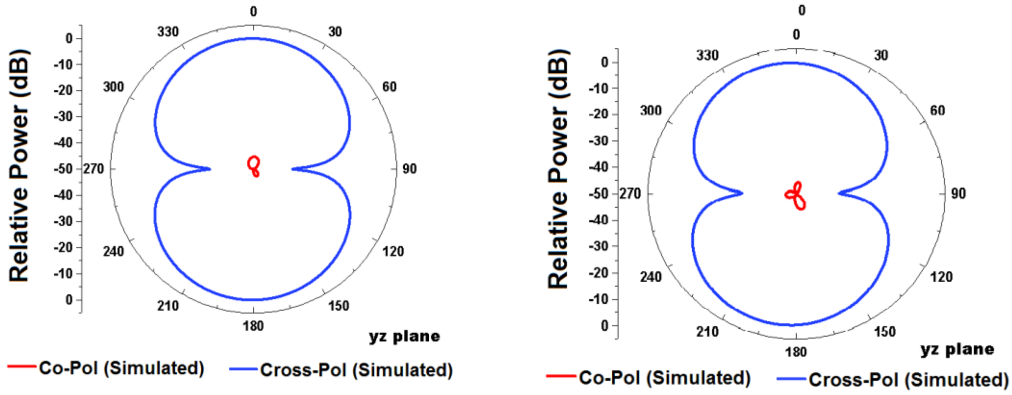
(g)  (h)

Fig. 2(a) Reflection Coefficient, (b) Surface current Analysis at 2.6GHz, (c) Efficiency, (e)Normalized radiation pattern(xz plane-2.1GHz), (f) Normalized radiation pattern(xz plane-3.2GHz), (g) Normalized Radiation pattern(yz plane-2.1GHz), (h) Normalized Radiation pattern(yz plane-3.2 GHz).

V. Conclusion:

A CPW-fed dual-band antenna is presented in the paper for GSM (DCS, PCS) CDMA, UMTS W-CDMA, IMT (2 GHz), applications at operating band of 1.77 GHz to 2.3 GHz as well as Wi-MAX, Wi-Fi/WLAN and 5G (3.30 GHz to 4.20 GHz) applications with higher band from 2.85 GHz to 4.60 GHz for WiMax and 5G Applications. This antenna is based on double radiating strips responsible for double operating band. The antenna exhibits realized gain that extends from 2.05 dB to 4.12 dB, more than 90 % radiation efficiency with stable and omni-directional radiation patterns shows a good characteristic, therefore this antenna can be applicable for wireless communication.

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