CPW-Fed Semicircular Slot Antenna for UWB PCB Applications

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Introduction

Earlier efforts in ultra wide-band (UWB) systems mainly concentrated on RADAR applications. The allocation of the 3.1 to 10.6 GHz band by the US Federal communication commission (FCC) for wireless communication renewed the interest in printed UWB antennas of small electric size at low cost. Printed monopoles antennas (PMAs), with many regular geometric shapes such as circular, elliptical, rectangular and square [1], provide attractive features for UWB. These shapes were optimized and investigated in straight (printed) and dual (slot) configurations. Many Bowtie slot antennas (BTSAs) have been investigated for broadband operation [2-4]. A broadband BTSA fed by CPW, investigated [2], did not however support UWB band because of the non supporting feed that caused high input impedance at the vertex. This mismatch problem was overcome with use of taper metal stubs [3] and inductive coupling [4]. A simple and innovative impedance transition in CPW feed for BTSA was investigated [reference?]. While providing impedance match for the complete UWB spectrum, a study of vertex angle is given which shows variation in bandwidth for different vertex angles [5].

We propose a CPW-fed semicircular slot antenna (SSA) based on a previously investigated transition [5]. In conventional cases of circular or elliptical configurations, matching is achieved easily [6-7] but in this case of semicircular design the feed is at the edge, which leads to further increase in the vertex angle resulting in higher input impedance and hence impediment in matching. In the proposed configuration a step transformer is incorporated to achieve matching for semicircular configuration. Overall size of the SSA structure (including feed and semicircular aperture) is half wavelength at lower cutoff frequency (3 GHz). Theoretical impedance bandwidth of 8.61 GHz (2.99 to 11.6 GHz) is achieved with omni-directional radiation patterns over the band, which has been experimentally verified.

Antenna Design

Proposed configuration of the CPW fed SSA is shown in fig. 1. The antenna is compact and fabricated on low cost FR4 substrate (εr=4.4) that has a thickness of 0.787 mm and area of 60x30 mm. Impedance match over the complete band is achieved with the use of taper transformation L1 (implemented in [5]) and Step impedance transformer formed by L2, L3, L4, L5 L6 and final match is provided

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by the feed gap G. Complete length of antenna is λ/2 (L1+L2+L3+L4+G+R) at the lower cutoff frequency.

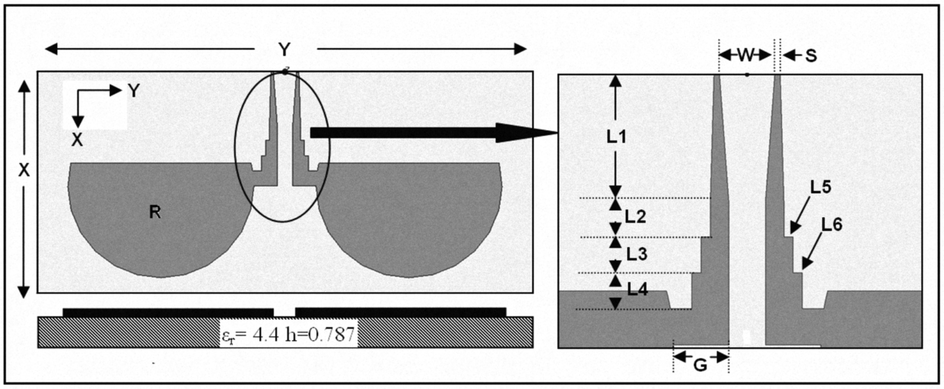

Fig.1 CPW fed semicircular slot antenna X=30, Y=60, L1=7, L2=L3=L4=2, L5=L6=0.5, W=3, S=0.3, G=2.5, R=12. (All dimensions are in mm)

In the design process, a CPW fed SSA with no transition (no taper and no step transition) was designed first. With an intention of covering lower end of UWB band as well, a radius of 10 mm [6] was chosen and G was fixed at 1.5mm. Then the taper [5] and subsequently a step transformer along the taper were implemented to achieve the desired impedance bandwidth.

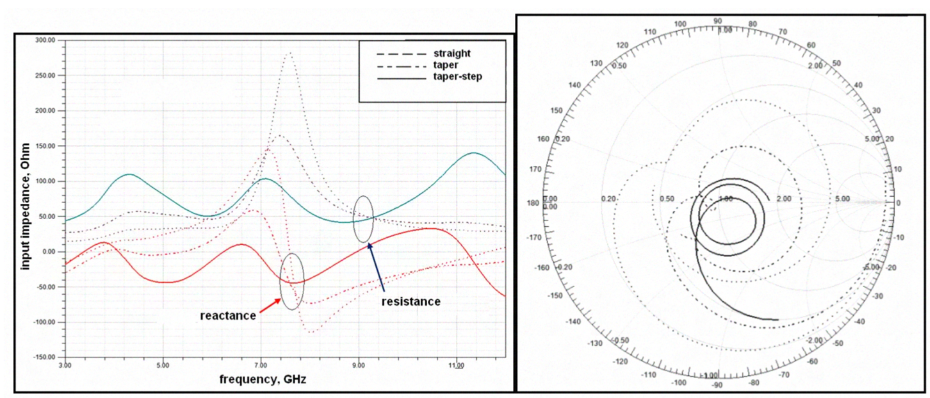

Fig.2 (a) Input impedance for various feeding schemes for SSA (b) Optimization of feeding arrangement (i) Linear Feed ········· (ii) Taper Feed– · – ·
(iii) Taper and Step feed ———

Input impedance plots are shown in Fig.2 (a). For straight feed it shows a high resonance impedance peak. For taper feed we observe a flattening in input impedance curve. Finally with the taper step combination the input impedance curve improves further with further flattening across the band. Resistance values vary around 75 ohm which is corroborated by the impedance variation of step from 78 to 105 ohm. Fig. 2 (b) shows for the improvement of matching with step transformation on a Smith chart. Step feed impedance provides a wide impedance matching from 3.5 GHz to 12 GHz to obtain a VSWR <2. In order to improve the lower cut-off, the radius is increased further to 12 mm. For each radius, the feed gap G has to be optimized for maximum bandwidth.

Results & Discussion

Theoretical and measured return losses for designed SSA are shown in Fig. 3. The optimized structure has a measured impedance bandwidth from 3.1GHz to 13.8GHz which is in fact better than the predicted bandwidth from 2.99 to 11.6 GHz. Fig.4 shows theoretical radiation patterns at 3, 6 and 10 GHz. Azimuth plane has an omni-directional pattern in the band; elevation plane pattern has the figure of eight shape. Theoretical gain for the whole impedance bandwidth is shown in Fig.5; a gain of 3 dBi ±0.5 dB is noted till 10 GHz.

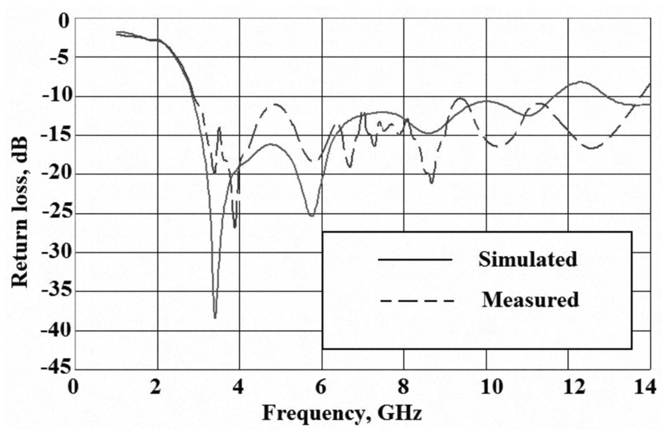

Fig.3 Theoretical and measured return losses of the SSA

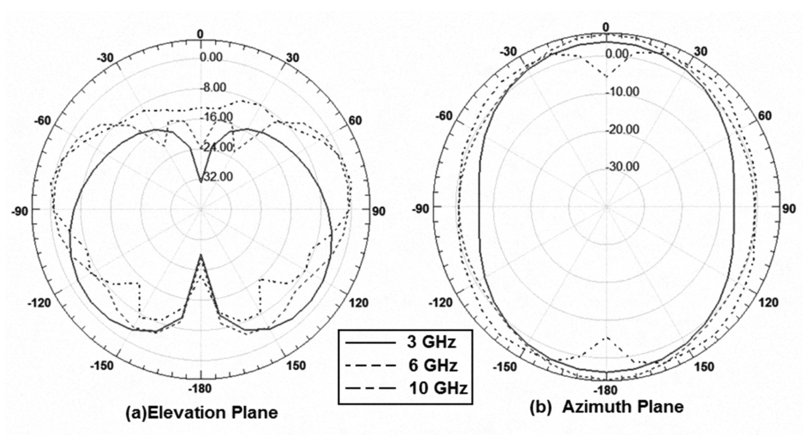

Fig.4 Theoretical E and H Plane radiation patterns at 3, 6 and 10 GHz

Conclusion

A coplanar wave guide (CPW) fed semicircular slot antenna (SSA) with step impedance transformer is presented. Omni-directional radiation pattern in whole band with theoretical gain of 3 dBi with variation of ±0.5 dB is achieved. It has shown that this design of SSA gives experimental bandwidth of 10.7 GHz for VSWR <2. Present results show suitability of structure for UWB communication.

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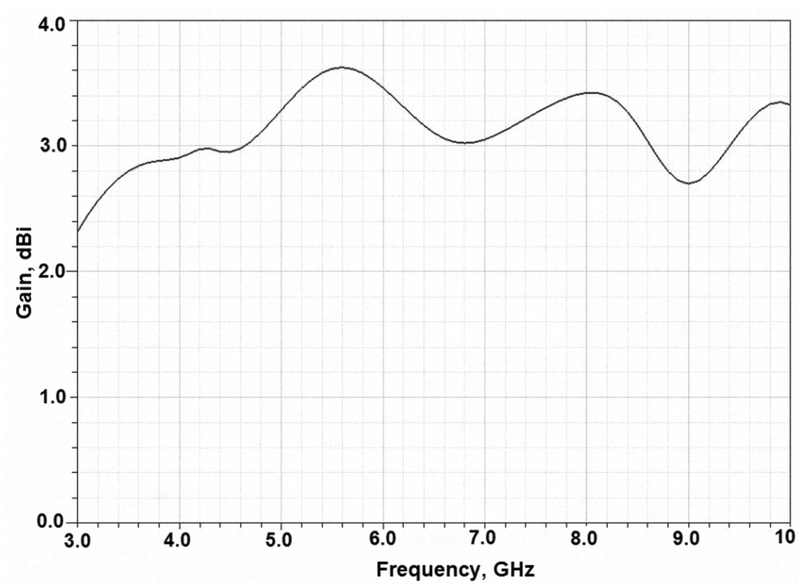

Fig.5 Theoretical peak gain of the SSA