Design of Wide-Band Slot Antennas for UWB Systems

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1. Introduction

There has been significant interest in developing ultra-wideband (UWB) antennas for short-range high-speed wire-less communications since the Federal Communications Commission (FCC) allocated the frequency band from 3.1 to 10.6 GHz, which represents a bandwidth of 110 % for UWB systems in 2002. In particular, the antenna of ultrawide bandwidth is the key component of the UWB system. Various types of printed slot antennas have been reported for UWB systems because of the feasible features, such as ultrawideband performances of the impedance matching, smaller sizes, light weight, easy of fabrication, low manufacturing cost and integration with RF components [1]– [3].

In this paper, two novel designs of small size printed slot antenna are proposed for UWB wireless systems. One or two slots are fed by dual offset coplanar wave guide (CPW) in order to expand the frequency bandwidth. The simulated and the measured results of the S_{11} characteristics and the measured results of the radiation pattern are presented and discussed.

2. Dual Offset CPW Fed Slot Antenna

Fig. 1 shows the geometry of a dual offset CPW fed slot antenna. The antenna is printed on a PCB with a relative permittivity of $\varepsilon_r = 2.25$, a loss tangent of $\tan\delta = 0.00038$(@10GHz), and a thickness of $t = 1.6$ mm. The antenna consists of a slot and CPW on the top side of the substrate. The length and width of the rectangular slot are S_l and S_w, respectively. The slot is fed by two symmetrically placed 100 Ω CPW which are connected in parallel to the 50 Ω CPW. This feeding technique provides very wideband matching for slot antenna and patch antenna fed by microstrip line [4], [5]. The 50 Ω CPW is fed through an SMA connector. Table 1 shows the optimized antenna dimensions in order to widen the bandwidth.

Fig. 2 illustrates the simulated and the measured frequency characteristics of the return loss of the dual offset CPW fed slot antenna. The return loss is simulated by using FDTD method. The size of Yee cell is $\Delta x = \Delta y = \Delta z = 0.1$ mm. The absorbing boundary condition is the eight layers of Perfectly Matched Layer. Note that the simulated result almost agrees with the measured results. It is shown that the S_{11} characteristics is less than −10 dB in the frequency band of about 3 GHz to 7 GHz. The bandwidth of the simulated and the measured results are about 75 % and 90 %, respectively. Consequently, it is shown that the achieved bandwidth of the dual offset CPW fed slot antenna can not cover the whole FCC defined UWB frequency band.

3. Dual Offset CPW Fed Dual Slot Antenna

The geometry of the dual offset CPW fed dual slot antenna is shown in Fig. 3. The antenna is printed on the PCB of the same type as having described in the previous section. There are two slots which have overlapped partially on the PCB and the slots are fed by the dual offset CPW. The shorter slot is added for cover the high frequency band above 7GHz. The optimized antenna dimensions for widening the bandwidth are shown in Table 2.

Fig. 4 shows the simulated and the measured return loss for the dual offset CPW fed dual slot antenna as a function of frequency. It is seen that the calculated input impedance is well matched as the

−10 dB return loss bandwidth covers the entire UWB band. On the other hand, the measured return loss characteristics is higher than −10 dB on the frequency of about 6 GHz. It appears that the fabrication accuracy of the antenna and the undesired coupling with a cable affect the measured result because of the small dimensions of the antenna. In order to improve the measurement accuracy, we made the triple size antenna which enlarged the dimension of the dielectric substrate and the slot, and the characteristic impedance of CPW transmission lines of the antenna are not changed. The measured return loss characteristic of the triple size antenna is also illustrated in Fig. 4 on the converted frequency. It is observed that the measured result of the triple size antenna rather agrees with the simulated result. The bandwidth for the return loss is less than −10 dB of the measured results of the triple size antenna and the simulated result of a full scale are 112 %.

Fig. 5 shows measured normalized radiation patterns of the dual offset CPW fed dual slot antenna in the *xy* plane, *xz* plane and *yz* plane at 3.0 GHz, 6.9 GHz and 11.1 GHz, respectively. The patterns were measured with the triple size antenna at converted frequency using a network analyzer in an anechoic chamber. Note that the copolarized patterns are reasonably omnidirectional in the *xy* plane and bidirectional in the *yz* plane and *xz* plane at 3.0 GHz. It can be seen that the influence of the radiation pattern in the *xz* plane by frequency is relatively small. Except for the pattern in the xy plane at 11.1 GHz, the cross-polarization levels are lower than the copolarization by more than approximately 10dB.

4. Conclusion

In this paper, two novel designs of small size printed slot antenna have been proposed for UWB wireless systems, which have one or two radiating slots fed by the dual offset CPW. The dual offset CPW fed slot antenna shows that the simulated and measured bandwidth for the return loss is less than −10 dB are 75 % and 90 %, respectively. Additionally, we propose the dual offset CPW fed dual slot antenna in order to achieve the broadband characteristic of the impedance matching. There are two slots overlapping partially each other fed by the dual offset CPW. It is shown that the bandwidth of the measured results of the triple size antenna and the simulated result of the full scale antenna are 112 %. It is observed that the measured radiation patterns are nearly omnidirectional in *xy* plane and bidirectional in *yz* plane and *xz* plane. These features are attractive for UWB applications.

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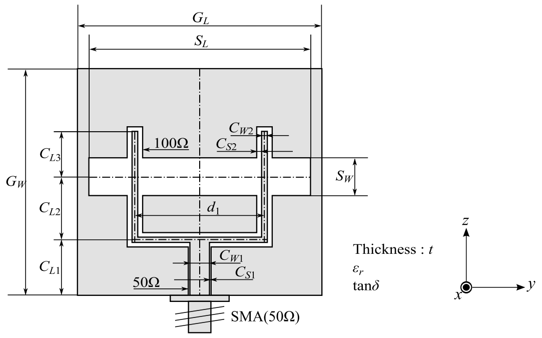


Figure 1: Structure of the dual offset CPW fed slot antenna.

Table 1: Structural parameters of the dual offset CPW fed slot antenna (unit:mm).

G_W	G_L	S_L	S_W	d_1	C_{L1}	C_{L2}
30.0	30.0	27.2	5.0	15.9	7.35	8.35
C_{L3}	C_{W1}	C_{S1}	C_{W2}	C_{S2}	t	ε_r
6.0	2.4	0.2	0.7	0.6	1.6	2.25

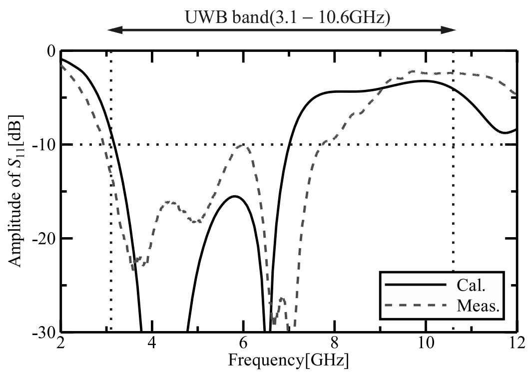


Figure 2: Measured and calculated S_{11} characteristics of the dual offset CPW fed slot antenna.

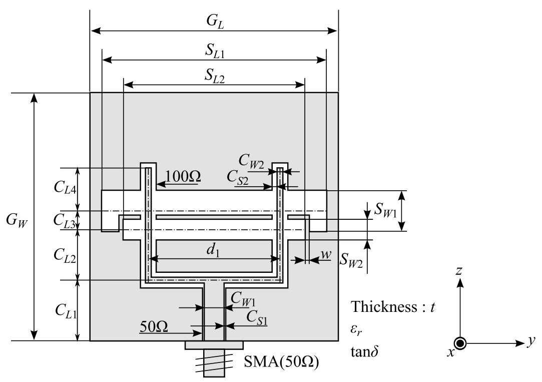


Figure 3: Structure of the dual offset CPW fed dual slot antenna.

Table 2: Structural parameters of the dual offset CPW fed dual slot antenna (unit:mm).

G_W	G_L	S_{L1}	S_{W1}	S_{L2}	S_{W2}	d_1	C_{L1}	C_{L2}
30.0	30.0	27.2	5.0	22.0	2.5	15.9	7.35	6.1
C_{L3}	C_{L4}	C_{W1}	C_{S1}	C_{W2}	C_{S2}	t	w	ε_r
2.25	5.2	2.4	0.2	0.7	0.6	1.6	0.5	2.25

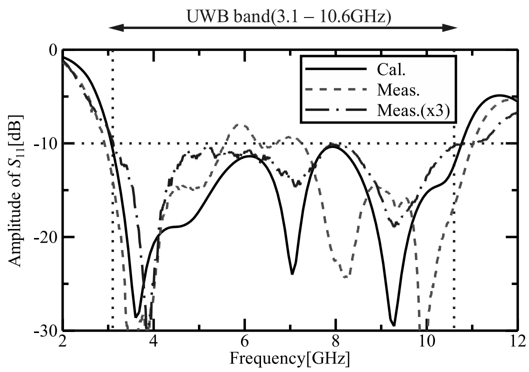
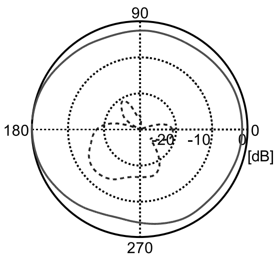
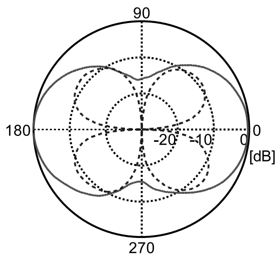


Figure 4: Measured and calculated S_{11} characteristics of the dual offset CPW fed dual slot antenna.

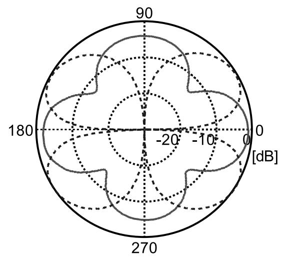
Co-pol., Cross-pol.



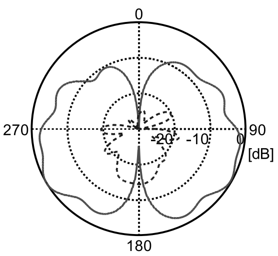
(a) *xy* plane at 3.0GHz



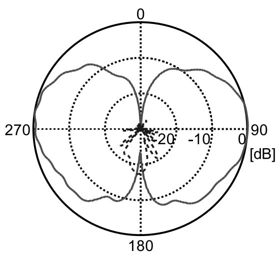
(b) *xy* plane at 6.9GHz



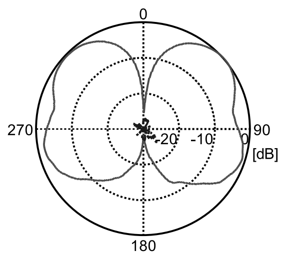
(c) *xy* plane at 11.1GHz



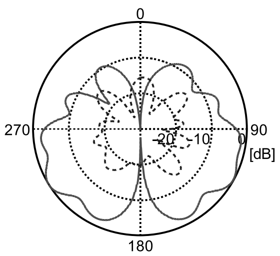
(d) *xz* plane at 3.0GHz



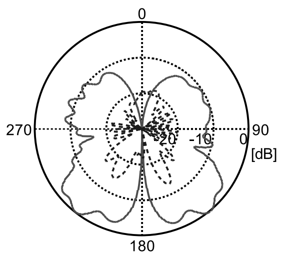
(e) *xz* plane at 6.9GHz



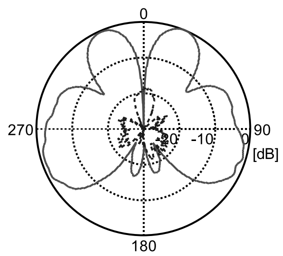
(f) *xz* plane at 11.1GHz



(g) *yz* plane at 3.0GHz



(h) *yz* plane at 6.9GHz



(i) *yz* plane at 11.1GHz

Figure 5: Measured radiation patterns for triple size antenna at converted frequency.