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## Integrated Antenna for Multiband Multi-national Wireless Combined with GSM1800/PCS1900/IMT2000 + Extension

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# **Integrated Antenna for Multiband Multi-National Wireless combined with GSM1800 / PCS1900 / IMT2000 + Extension**

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## **Abstract**

A printed triple-band monopole antenna appropriate for use as a terminal antenna in modern wireless multiband systems is proposed. The impedance bandwidth of each band has been optimised using a quasi-Newton technique and the bandwidth includes virtually all wireless bands. Various parameter sweeps are presented which improve the understanding of the antenna, in particular, the effect of groundplane-size and branch-off point on impedance bandwidth and radiation pattern.

## **Introduction**

The proliferation of wireless communications devices has placed many new demands on antenna designers. The requirements of terminal antennas to be small, low-cost, have quasi-isotropic patterns over wide or multiple bandwidths and be integratable into radio circuitry are generally not always simultaneously achievable. Many trade-offs are commonly made, juggling between parameters. Printed monopoles have been recently proposed as suitable contenders with many variations suggested for dualband operation, including a multibranch technique [1, 2] and also the use of F and S shapes [3, 4]. The multibranch technique has already been employed with monopoles, using classical groundplanes [5]. In this paper, a novel simple multibranch monopole printed on low-cost laminate is proposed as a triple-band terminal antenna, contributing many of the requirements for a wireless terminal antenna. These antennas are proposed for the emerging multi-band wireless transceivers, which operate over a wide range of bands as dictated by national authorities.

## Antenna Geometry

The monopole is printed on one side of a low-cost FR4 substrate with a square groundplane located on the back. The substrate properties are ( $t=1.52$  mm,  $35\ \mu\text{m}$ ,  $D_k(2\ \text{GHz}) = 4.3$ ,  $\tan\delta(2\ \text{GHz}) = 0.02$ ). The substrate dimensions are  $l=45$  mm by  $w=80$  mm by  $t=1.52$  mm. For a square groundplane,  $l_g=45$  mm. The microstrip feedline width is  $w_f=2$  mm. The dimensions of the multibranch radiator are  $l_m=28$  mm,  $l_f=15.8$  mm,  $w_f=4$  mm,  $l_r=10.6$  mm and  $w_r=4$  mm. The branch-off point is located  $h_f=2$  mm above the groundplane. These dimensions were obtained using a quasi-Newton optimiser, optimising for the widest bandwidth of the three wireless bands. The antenna geometry is shown in Figure 1.

## Simulation and Measurement

Modelling was performed using CST Microwave Studio, using the finite-integration time-domain technique and a waveguide port for the feed. Measured return loss for the optimised element is shown in Figure 2, which is in good agreement with measured data. The measurements were made using a Rohde & Schwarz ZVB network analyser. The three bands in which the measured return loss is greater than 10 dB are 1.78 GHz to 2.68 GHz, 3.4 GHz to 3.68 GHz and 4.85 GHz to greater than 6 GHz. The lower band includes GSM1800/PCS1900, IMT-2000, the 2.45 GHz ISM band, WLAN, IEEE 802.11b, g and the IMT-2000 Extension band (2.5–2.7 GHz). The middle band includes WiMax and WLL. The upper band covers IEEE 802.11j, a, the US-NII and the 5.8 GHz ISM band. Due to the dispersion in substrate loss, the simulated radiation efficiency drops from 89% at 2 GHz to 69% at 6 GHz.

## Parameter Dependence

The dependence of impedance bandwidth on the height of the tap-off point ( $h_t$ ) was investigated for the three bands. The height  $h_t$  was varied from 0 mm to 4 mm and the return loss was examined. The bandwidth of all three bands is shown in Figure 3. The upper and middle bands show maximum bandwidth for tap-off heights between 1.5 mm and 2.5 mm. The lower band bandwidth increases steadily with tap-off height. The groundplane size was also varied from  $20 \times 20$  mm to  $100 \times 100$  mm square. The bandwidth of all three bands is shown in Figure 4. The upper band shows maximum bandwidth for groundplane sizes above 40 mm. The lower band has its optimum

bandwidth from 40 mm to 50 mm groundplane size. The middle band shows little dependence on groundplane size. It should be noted that the FR4 loss can contribute significantly to antenna bandwidth at the upper band, but its contribution at the lower and middle band is negligible. This is seen in Figure 4, where a plot for a lossless dielectric is shown. The lower edge frequency (LEF) of the low band also is somewhat dependent on groundplane size. It has been shown [6] that the LEF is lowest for GP sizes of 40 to 45 mm.

### **Radiation Patterns**

Measured radiation patterns are presented in Figure 5. The maximum gain was found to be 3.0 dBi at 2 GHz, 2.5 dBi at 3.4 GHz and 3.4 dBi at 5.5 GHz. The patterns exhibit quasi-omnidirectional patterns in the  $x$ - $y$  plane as shown in Figure 5a. The  $x$ - $z$  and  $y$ - $z$  cuts are in Figure 5b and 5c.

### **Conclusion**

A printed tripleband multibranch monopole was presented. The dependence of impedance bandwidth on groundplane size and branch-off point was shown for each band. A wireless-optimised triple-band printed monopole was presented.

### **Acknowledgements**

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## **Figure captions**

Figure 1: Geometry and coordinate system of the printed multibranch monopole

Figure 2: Measured and simulated return loss for optimised geometry

Figure 3: Impedance bandwidth dependence on tap-off point

Figure 4: Impedance bandwidth dependence on groundplane size

Figure 5: Measured radiation patterns

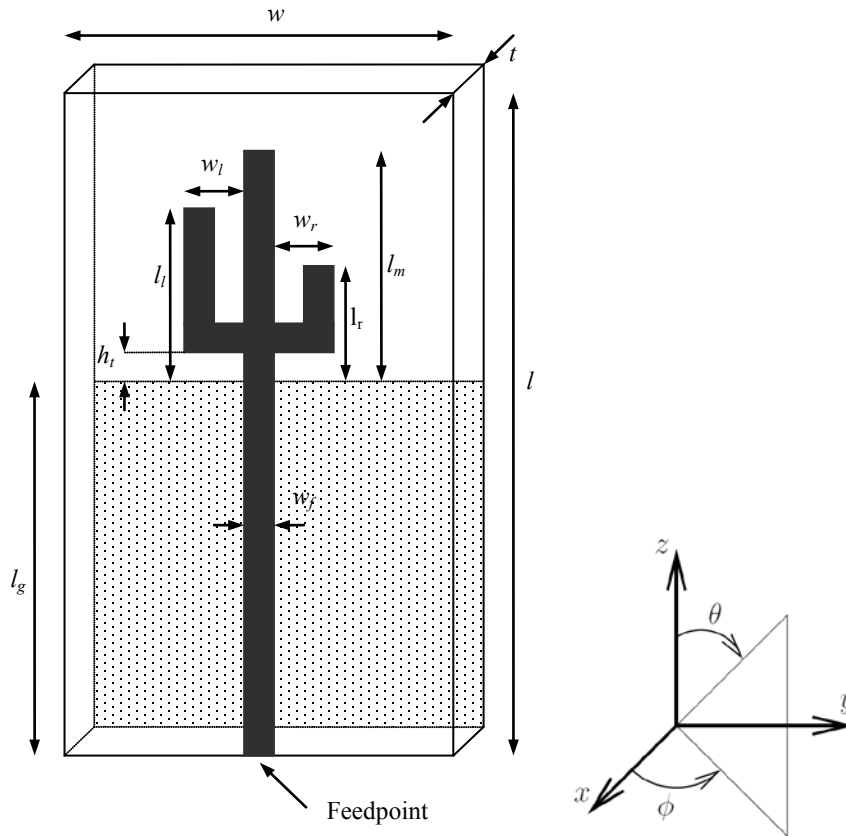


Figure 1: Geometry and coordinate system of the printed multibranch monopole

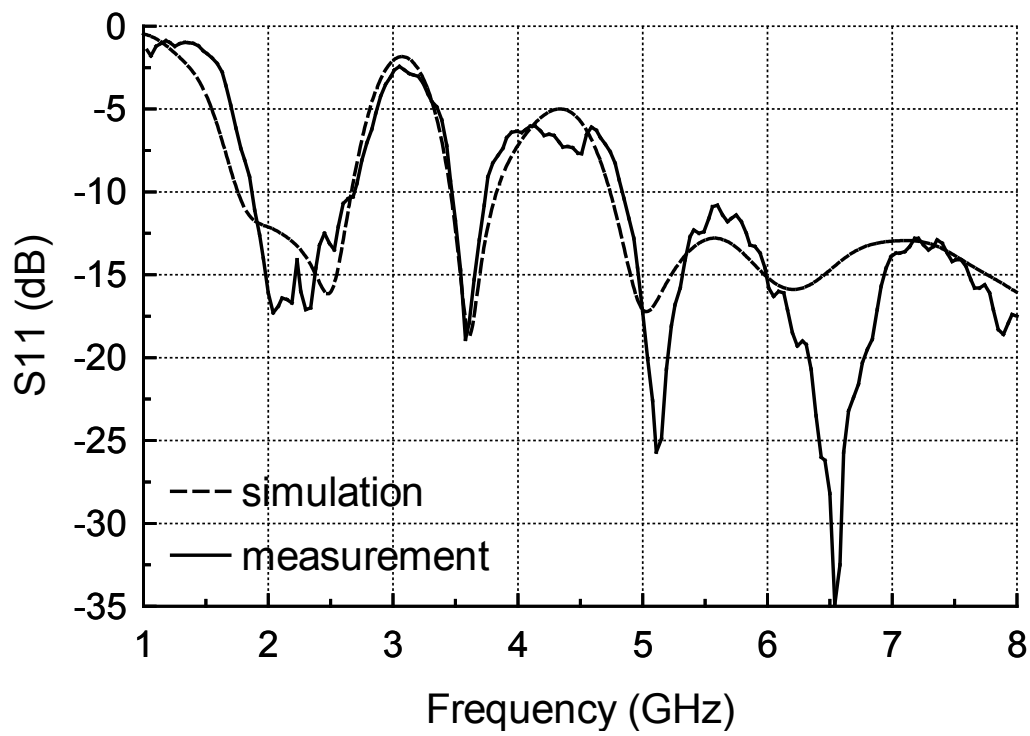


Figure 2: Measured and simulated return loss for optimised geometry

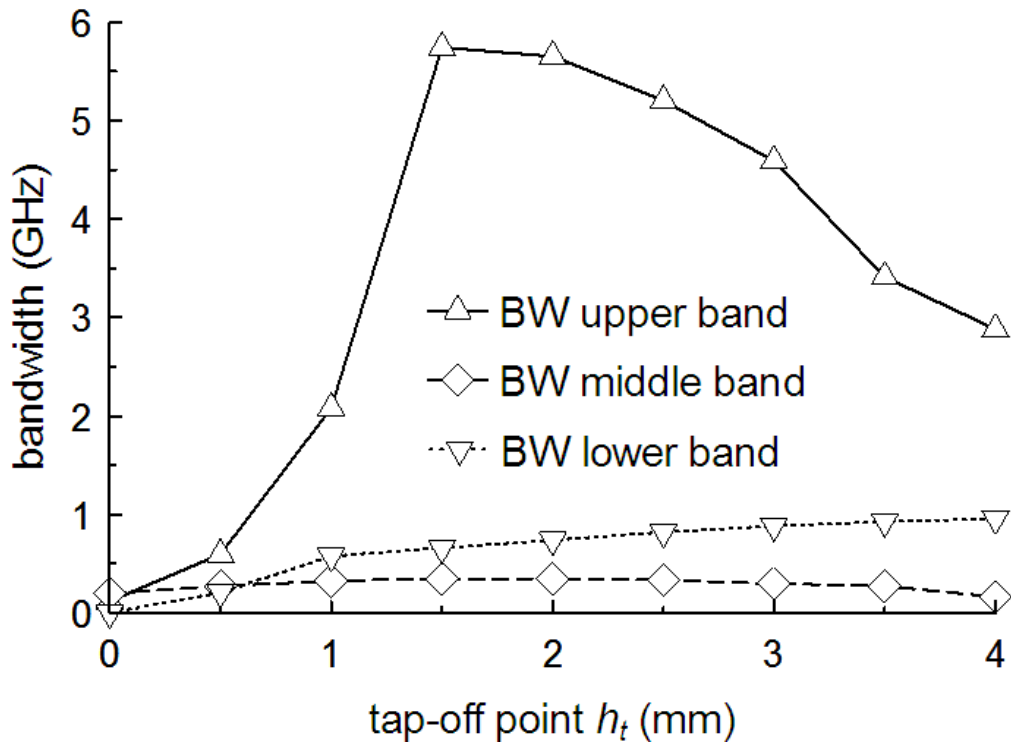


Figure 3: Impedance bandwidth dependence on tap-off point

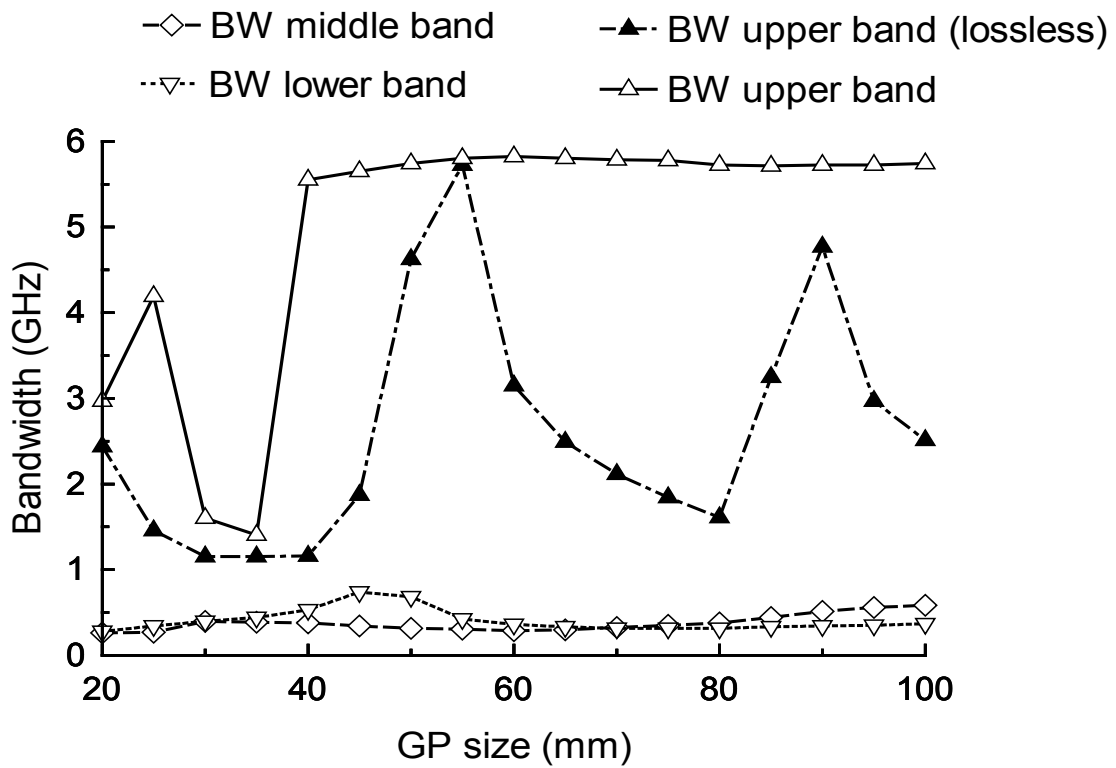


Figure 4: Impedance bandwidth dependence on groundplane size



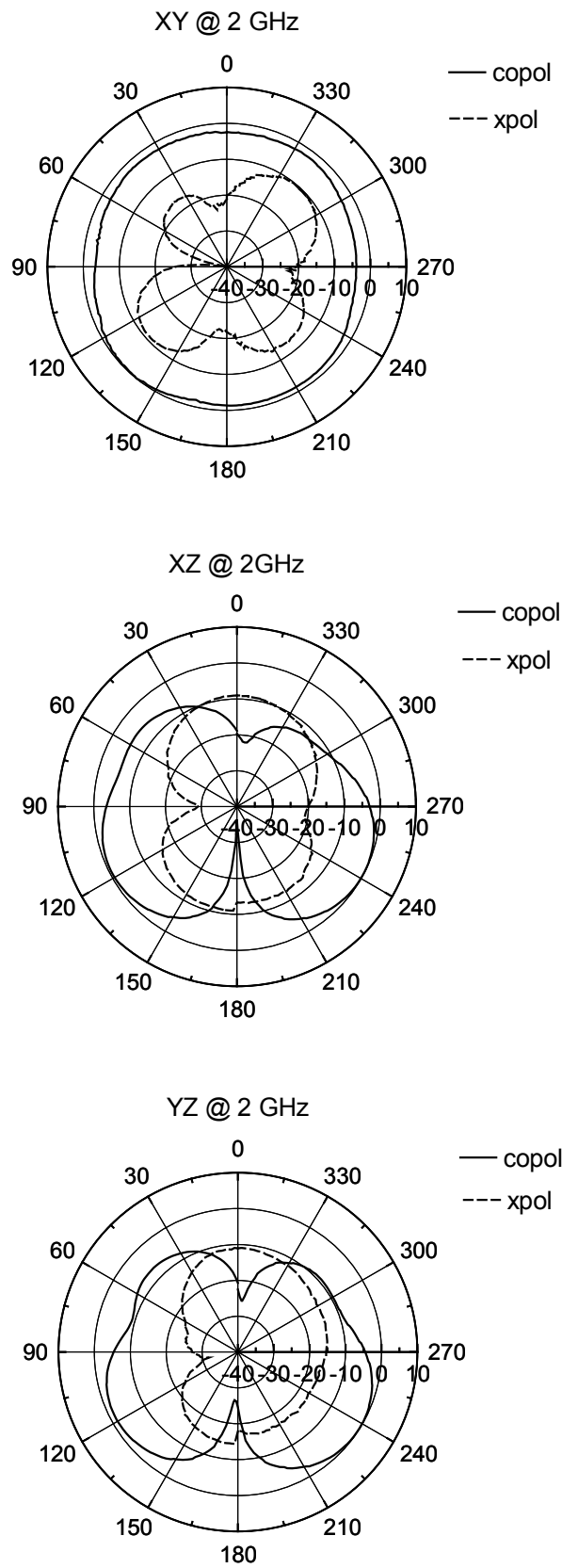


Figure 5(a)

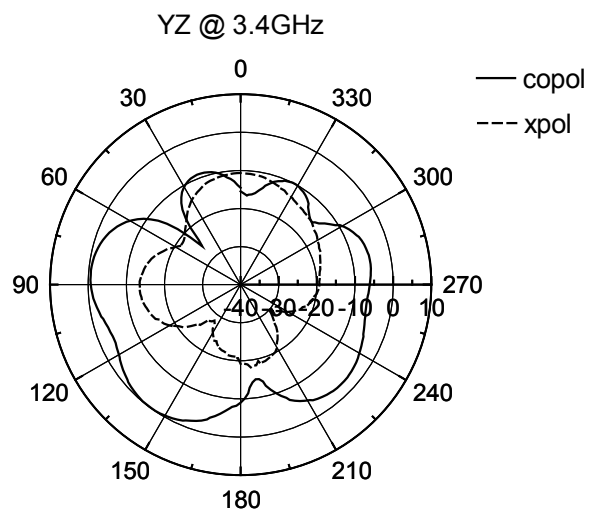
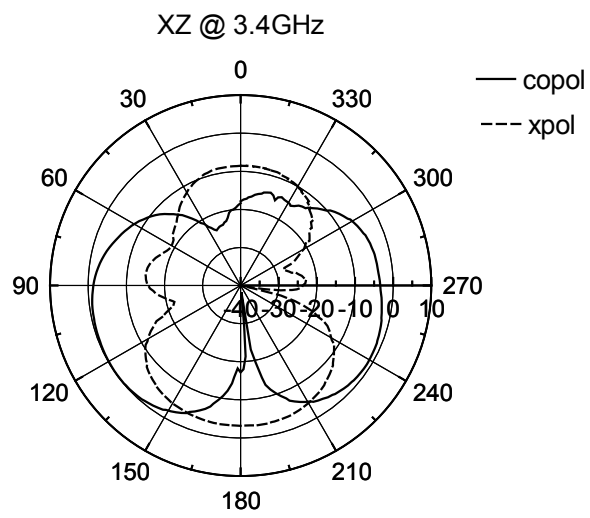
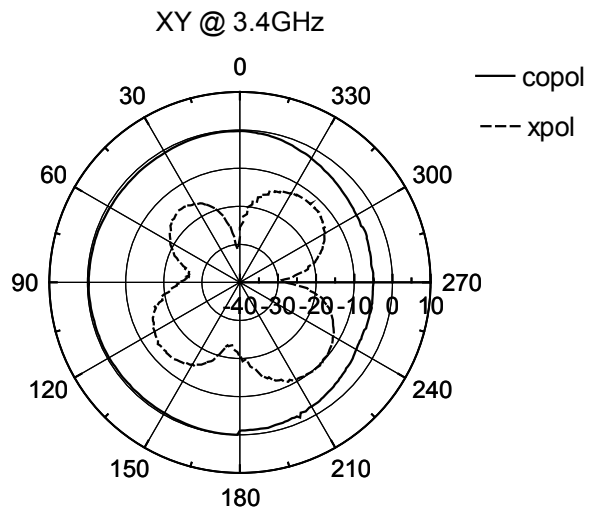


Figure 5(b)

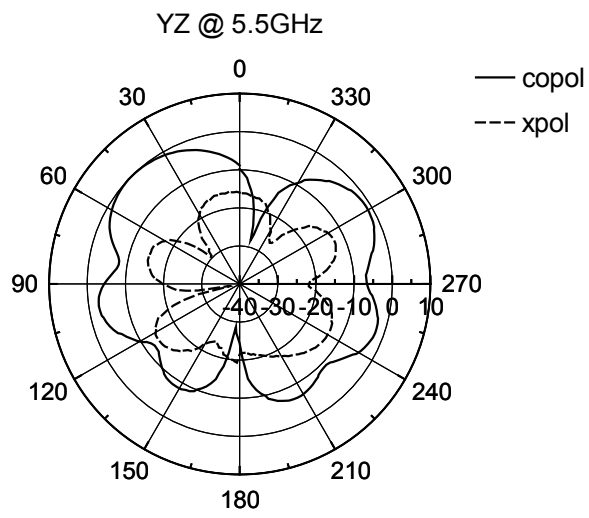
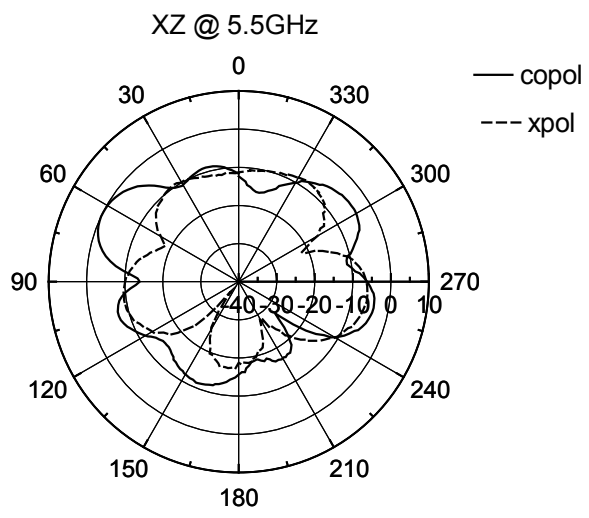
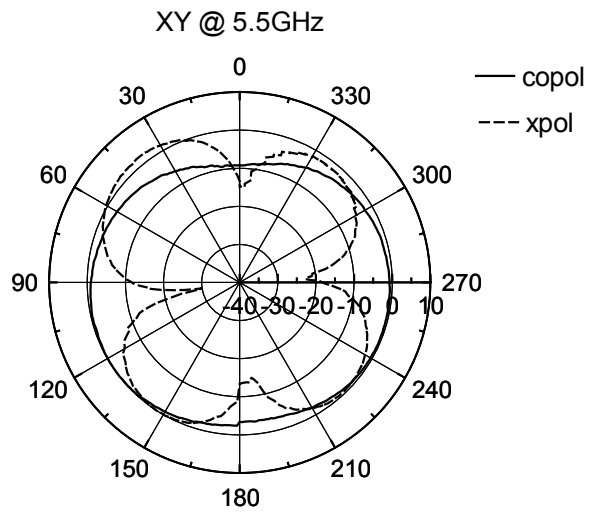


Figure 5(c)  
Figure 5: Measured radiation patterns