Investigative Study On The Development Of A Green UWB Antenna

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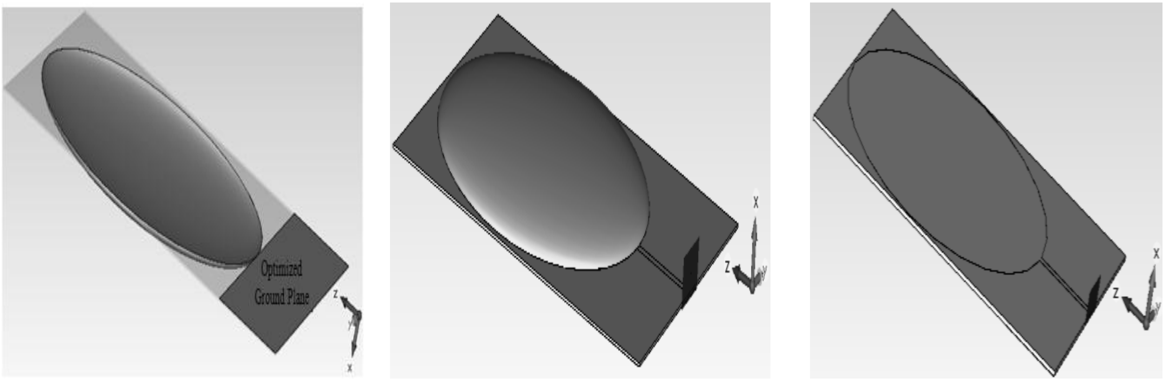
1. Introduction

With the growing popularity of wireless, there is also an increasing need to make and keep it greener through more efficient power usage. A recent green technology approach in the cellular industry is to reduce or virtually eliminate the amount of power absorbed by the mobile handset user and to redirect that power towards an improvement in power transmitted to the base station [1]. However, in UWB wireless applications such an approach would not make significant impact as the user's body is not in direct contact with the devices unless designed as a wearable antenna. For UWB applications, a major hurdle is the inverse relationship of the data rate to range or transmission distance constrained by the FCC's power limitation of -41.3dBm for the frequency band of 3.1GHz to 10.6 GHz. The green technology approach in UWB applications thus would be improving the transmission range, or maintaining the range and improving the data rate for the same power allowed by the commission. The power level in this case not being considered a point for argument as it is deemed to be really low compared to other applications in the wireless applications. However, with recent approvals to go beyond these bands to higher frequency bands in the millimetre wave region of 60Ghz and subsequently, up to 79Ghz, could necessitate the need to consider the power aspect as the maximum power level approved has been increased accordingly [2]. The green aspect could then really come into play if the power usage also can be lowered and still achieve a desired range or data rate or both.

In this paper, an investigate study to design an antenna design that can save the personal area network (PAN), wide personal area network (WPAN) and the wireless industry in general, power usage through improved efficiency and using 25% to 50% less power is explored. The proposed semi-planar UWB microstrip antenna design aims to achieve this by attempting to improve the gain by 3dB or 6dB more than its planar version of the same size in the horizontal plane thus effectively reducing its power requirement by half or by quarter respectively. The antenna design if successful can be used in the 3.1 to 10.6 GHz frequency band in a reciprocate manner by keeping the power level constant and extending the coverage or range of transmission, or maintaining the range and reducing the power required, or a combination of both whereby reducing the power level by 50% instead of by 25% and extending its transmission correspondingly thus achieving an optimum both ways. These can be achieved through controllers in the devices that incorporate this antenna design. The design concept can be extended to narrowband applications thus making the semi-planar microstrip design universal or portable and as a result widening its applications possibly to the cellular industry. In such scenarios, the antenna is expected to demonstrate higher transmission power to a base station compared to the existing antenna of the cellular device. The resultant benefits of the improved output power could be many such as improved battery life, improved range and improved efficiency.

2. Antenna Design

The microstrip antenna design comprises of an optimized ground plane on the backside of the substrate as in Figure 1 (a), and a circular monopole antenna on the front side. The substrate is 0.8mm thick and has a dielectric of 3.5 . The radiating copper surface of the antenna is embossed and circular in shape (Figure 1 (b)). Two embossed antennas were designed. The first design, Semi-Planar 73 (SP73), is 73mm in diameter with an emboss height of 11mm while the other, Semi-Planar 54 (SP54) is 54mm in diameter with an emboss height of 15mm. A planar version of the SP73, P73 as shown in Figure 1 (c)) was also designed as a comparison to verify the effectiveness of the embossed approach in terms of gain enhancement. The narrow feed line is 20mm in length and 1.8mm in width for the three antennas.



(a) (b) (c)

Figure 1: (a) Optimized ground plane (b) Embossed antenna (c) Planar antenna

3. Measurement and Simulation Results

The antennas were designed and simulated on CST Microwave Studio. The performance of the proposed semi-planar concept was verified by fabricating the monopole UWB ground plane antennas as shown in Figure 2 (a) and (b) and also a planar version of the antenna as shown in Figure 2 (c) and measuring the return loss.

(a) (b) (c)

Figure 2: (a) Semi-planar antenna with Ø = 73mm b) Semi-planar antenna with Ø = 54mm (c) Planar antenna with Ø = 73mm

The measured return losses for both the semi-planar antennas versus a comparative planar antenna of diameter 73mm are as shown in Figure 3.

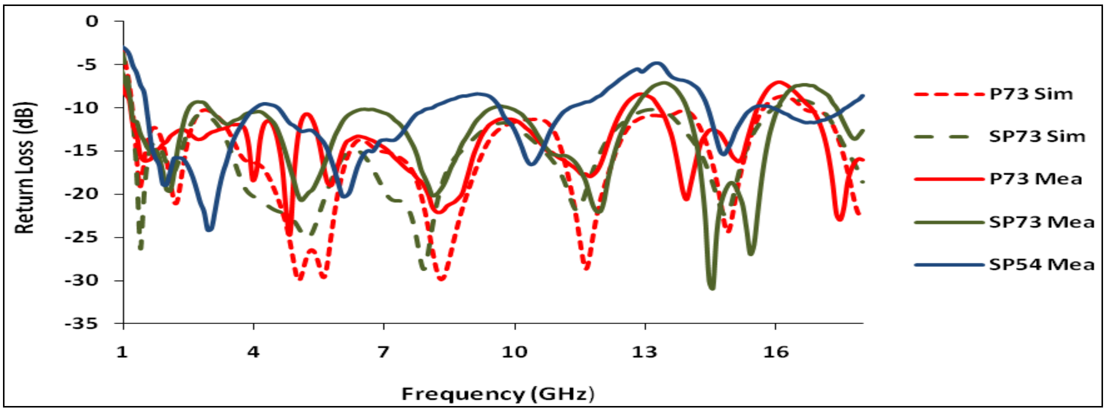
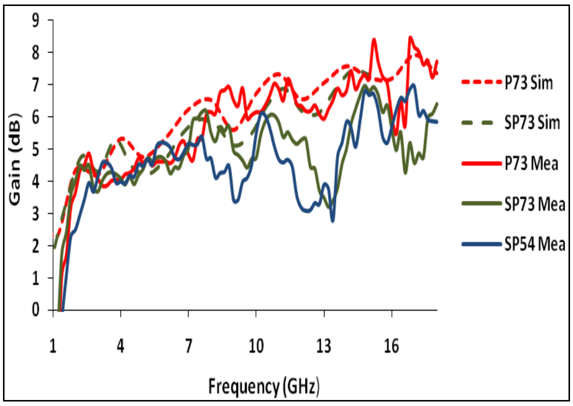


Figure 3: Measured return losses of the semi-planar and planar antennas

The measured return losses are almost similar and show that even with a reduction in size like from a diameter of 73 mm to 54mm does not affect the performance of the antenna much. The slight variations could be attributed to fabrication accuracy and soldering proficiency and the difference in emboss height. This indicates that scaling the antenna to fit within the small antenna definition may be possible.

Similarly, the corresponding simulated and measured gain and efficiency measurements of the three antennas are shown in Figure 4. The gain deteriorates above 7GHz. This may be probably because the current distribution is being concentrated over a smaller area at the raised emboss portion resulting in a wider beam and hence a lower gain. Alternatively, it can be argued that the gain deterioration is because the higher frequency electrical paths lengths are along the radial circumferences of the raised portion of the emboss. As these portions are not in contact with the substrate, they are less influenced by the substrate dielectric thus possibly causing the gain to deteriorate. However, these provides an opportunity to introduce higher dielectric materials either as a lining on the under-surface of the copper emboss or as a fill in the hollow of the emboss to see how this will improve the gain of the semi-planar antenna above that of the planar antenna. The possibility of such an antenna yielding high gain is further strengthened by the improved gain seen in simulation when a dielectric material of 2.08 was introduced into the hollow portion of the copper emboss with further optimization of the ground plane as shown in Figure 5. Measured return loss of the SP73 as shown in Figure 6, showed improved bandwidth when the hollow was lined with a thick 3 mm vinyl lining (VL) which is known to have a dielectric between 2.8 and 4.5. Experimental studies to verify both the above arguments are currently underway.



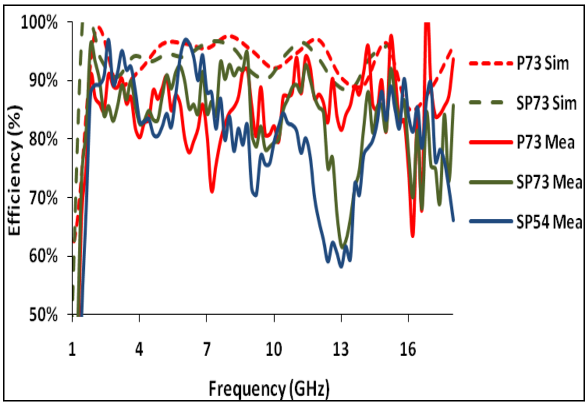
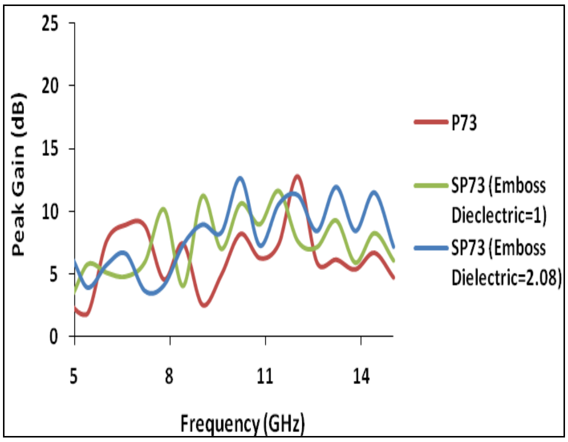


Figure 4: Simulated and measured gain and efficiency of the semi-planar and planar antennas



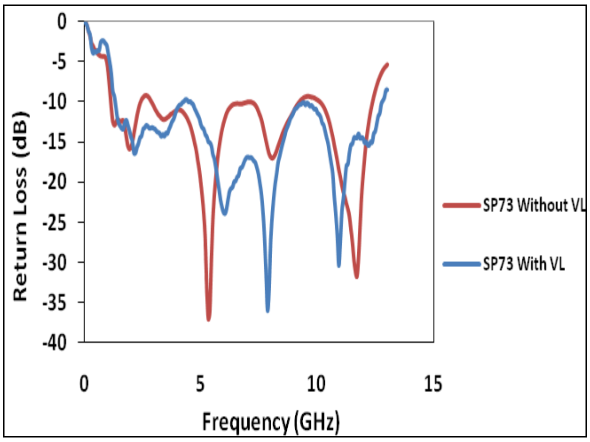


Figure 5: Simulated gain of SP73 antenna with different dielectrics in emboss vs P73.

Figure 6. Measured return loss of the SP73 with and without vinyl lining.

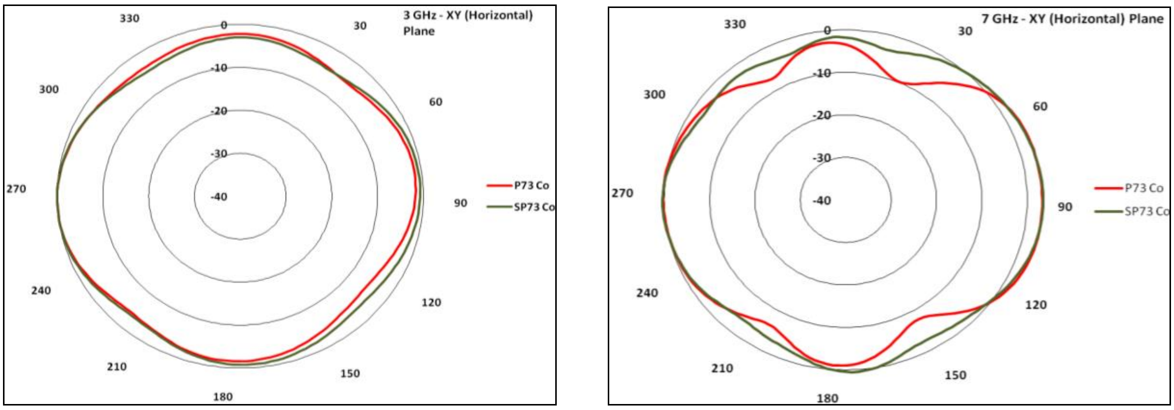


Figure 7: Measured radiation pattern in the X-Y (horizontal) plane at 3GHz and 7GHz.

The measured radiation patterns in the horizontal plane as shown in Figure 7 demonstrate a slightly better gain at the 3GHz and 7GHz frequency band. As mentioned earlier, work on improving the gains at these frequencies and above 7GHz by introducing a higher dielectric material in the hollow underneath the emboss is still being investigated. More information on these will be provided at the conference and future publications.

4. Conclusions

An investigative study to design a novel green UWB antenna design is proposed in this paper. Initial simulated and measured results of the proposed design indicate high possibility of the antenna yielding a high gain if materials of high dielectric are introduced into the hollow of the emboss or used to line the inner surface of the copper emboss. Such a high gain antenna could save UWB wireless applications as well as narrow band applications, power usage with great potentials to be used as green antennas with wide benefits. As the research is still ongoing, more conclusive results will be presented at the conference.

References

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