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A 2x1 Coplanar Monopole Antenna Structure for Wireless RF Energy Harvesting

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Abstract. The objective of this paper is to design an efcient wireless energy harvesting (WEH) system to eliminate the problem to continuous charging of a battery operated electronics devices. Most of the devices are battery operated so charging of a battery time to time is serious issue. This WEH system receives the Radio Frequency (RF) and Microwave frequency signals present in the atmosphere and converting it into DC signal so that it can stores in Capacitor or charges a battery for utilize the power. For this RFenergy harvesting purposes 21 antenna array structure of the coplanar monopole antenna is presented. This structure shows the gain of 10.2 dBi and 83% efciency. This structure is designed for resonating on multiple bands (Radio, GSM, ISM, and UWB). It is useful for this application because it covers almost all useful bands in the maximum capturing area. The antenna can be connected directly to an RF-DC converter module and it uses about 60% of the total PCB area. And RF to DC convertor circuit can be implemented in that remaining 40% area on the same substrate so it eliminates the need of port connectors and impedance matching circuit between them. This design is worked in receiving mode only when used for energy harvesting purposes. This may be useful for the biomedical and satellite applications.

Keywords- Energy Harvesting System, Monopole Antenna, RF-DCConverter, Coplaner Antenna, Wilkinson Power Divider

1. INTRODUCTION

In the Field of energy harvesting the RF energy harvesting is the new and interesting era of the researchers because RF spectrum is free to use and easily available everywhere. The basic building blocks for the harvester for RF ranges are composed of three segments 1) RF receiv-ing antenna 2) Rectifying & amp; Booster circuits 3) Impedance matching circuits. Antenna designing is the important part of the harvesting circuit. The antenna may be designed for any band of RF For UWB band designing Coplanar antenna is suitable option. M. Yazdi et al. Presented an UWB planar antenna with band rejection characteristics [2]. For particular band rejection di erent variations in patch dimensions were investigated [3]-[5]. Parasitic patch is also one solution for band rejection [5]-[7].

The authors have already designed a compact coplanar monopole antenna [8] which is capable to resonant on multi bands e.g. Radio , GSM,. ISM and UWB band (900MHz-3.1GHz and 5.6GHz- 9.6GHz) with band rejection for WLAN(3.1GHz - 5.6GHz) bands.

This paper presents the extension of that work by array arrangement of that coplanar monopole antenna structure to improves the gain .

2. ANTENNA DESIGN

Figure 1 illustrates the structural geometry of the proposed 2 1 array of coplanar monopole antenna. The power of these array structures has been combined by using Wilkinson power combiner. The benet of implementing this combiner comparison to others is that impedance matching with the antennas is easy. The matching of impedances at the antenna ports and the power combiner has been optimized.

The impedances at the antenna ports have measured and the two output ports impedances of the combiner have calculated from the formulas.
Antenna and combiner ports a matching by parametric analysis has been implemented at the end of the line feed. The substrate is taken FR4 epoxy here with a relative permittivity of 4.4 and a thickness of 1.6mm. The antenna is designed to cover some usable bands e.g. radio, GSM, ISM and UWB bands (900MHz - 3.1GHZ & amp; 5.6GHz - 9.9GHz).

In between these bands 3.1GHz - 5.6GHz has been rejected because it provides only inter-ference for energy harvesting application. The optimized values of the design parameters are as follows: L_S= 126mm, W_S =40mm. patch length L_p = 20mm and width W_p= 20mm. Designed frequency is 9GHz.

The Array arrangement of the structure by using Wilkinson power combiner is as shown in gure1.

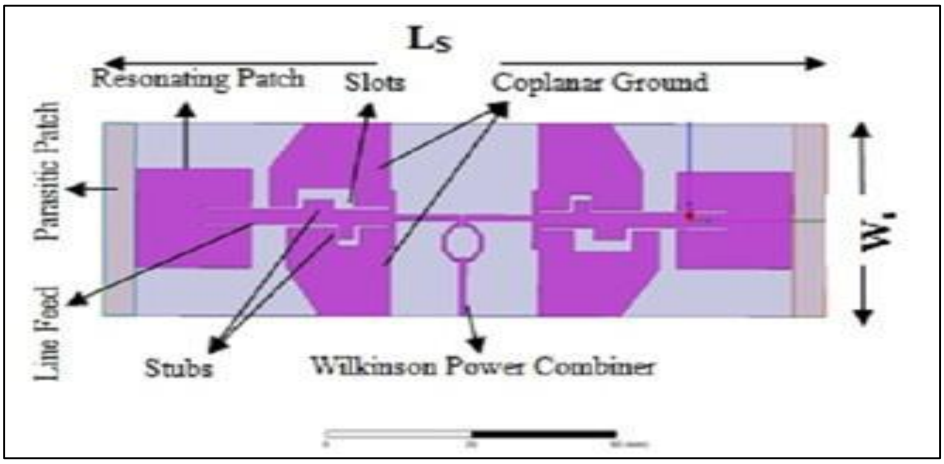

Figure 1. Array arrangement of Monopole antenna.

In the next section by using licensed software $HFSS_{TM}$ 16,the antenna performance has been simulated and analyzed.

3. RESULTS AND DISCUSSION

3.1. Parametric Study

Two patches of 20x20 mm^2 dimensions have been simulated on the substrate 126 x40 x1.6 mm^3 for the designed frequency 9 GHz. The application of this antenna is basically for RF energy harvesting. So for designing multiband (Radio, GSM, ISM, and UWB) antenna optimization of

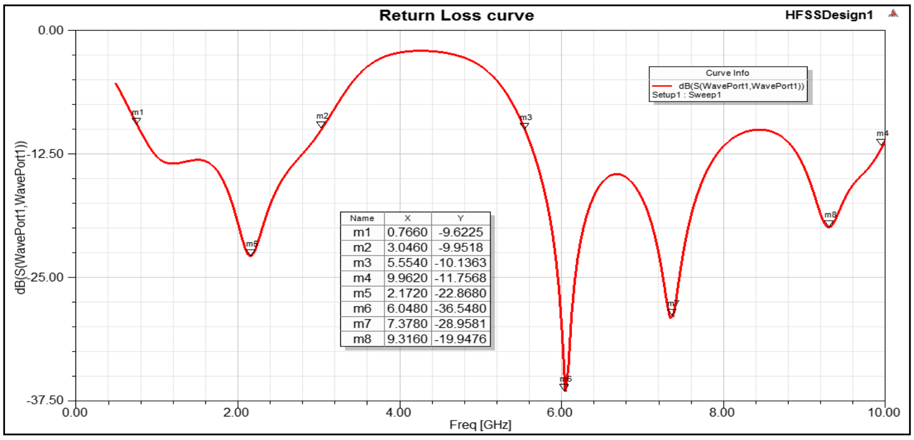

Figure 2. Return Loss vs. Frequency curve of UWB Antenna.

different parameters by parametric has been applied. In this structure parametric analysis has been applied on the following structures:

(a) The gap between the coplanar ground and resonating patch has been optimized for reso-nant the antenna on multi band e.g. Radio, GSM and ISM (900MHz - 2.4GHz).

(b) The coplanar structure has optimized for UWB range. The Corner edges cutting dimen-sions of the coplanar ground have been optimized for bandwidth enhancement of this UWB range.

(c) The location and dimensions of the slots in coplanar grounds and the stub of feed line have been optimized for impedance matching.

(d) The dimensions of the parasite patch above the resonating patch has been optimized for WLAN band (3.1-5.6 GHz) rejection for avoiding the interference of this band particularly for energy harvesting applications.
In Figure 2 the structure has shown resonance from 900 MHz - 3GHz and From 5.5GHz - 10GHz and also the band rejection from 3GHz - 5.5GHz.

3.2. Current Distribution
The current distribution in figure 3 shows that the current is maximum at the corner edges.

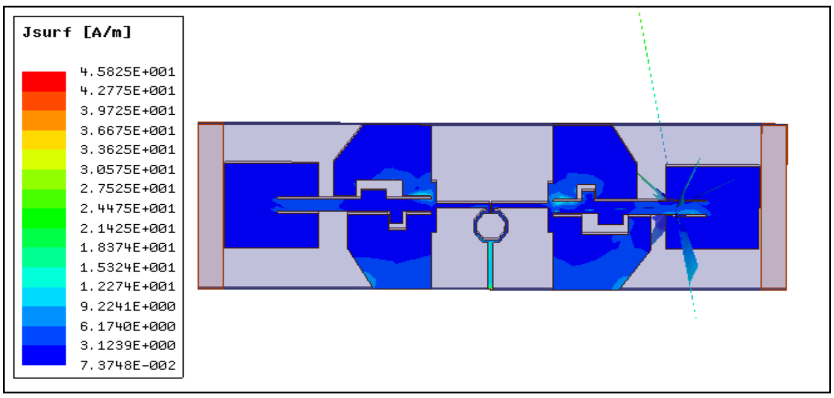

Figure 3. Current Distribution of Array of Monopole antenna

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3.3. Radiation Pattern

The H- field patterns for the frequency 2.4 GHz and the values of θ= 90º, 60º and 180º has shown in figure 3. The E-field pattern for the same frequency 2.4 GHz and θ = 0º, 90º and 30º has been shown in figure 4. The H- field and E- field patterns shows the omni directional behavior of the structure.

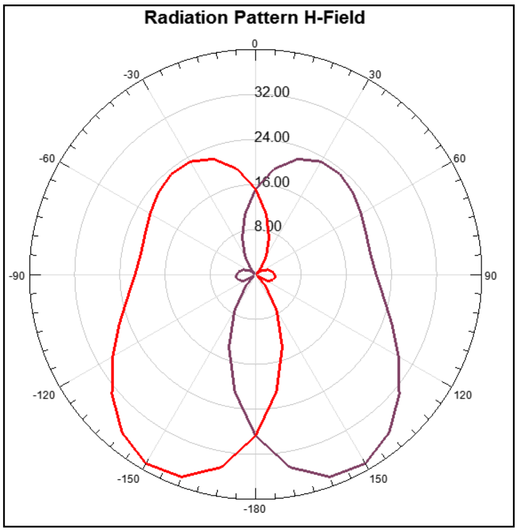

Figure 4. H- Field Pattern.

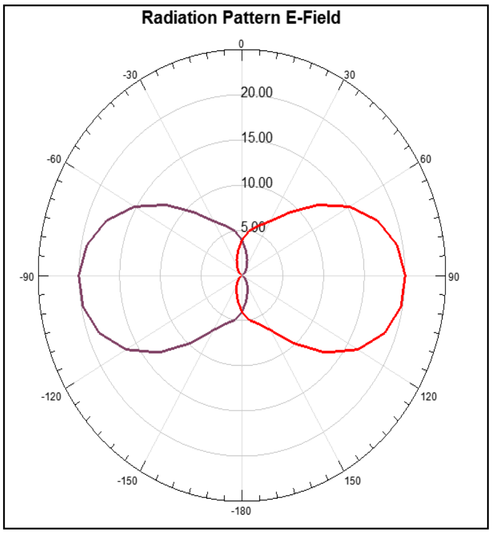

Figure 5. E- Field Pattern.

Gain and Efficiency

The main motive of this array arrangement is to increase the gain. The authors noticed the 7 dBi peak gain of single structure of the coplanar monopole antenna. This 2x1 array arrangement shows the peak gain of 9.2 dBi gain by Figure 6. The effciency of presented array arrangement is 83% as shown in Figure 7.

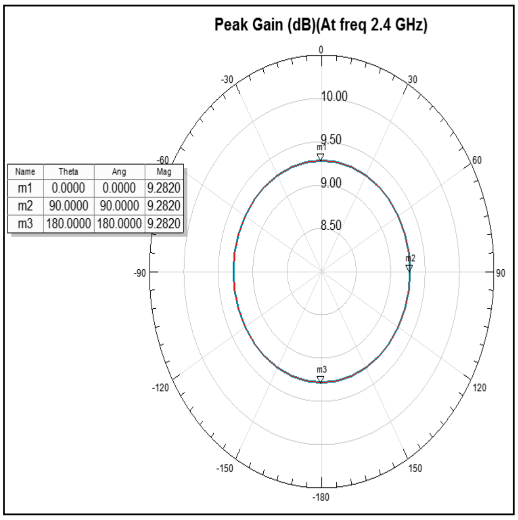

Figure 6. Peak Gain of Designed Structure.

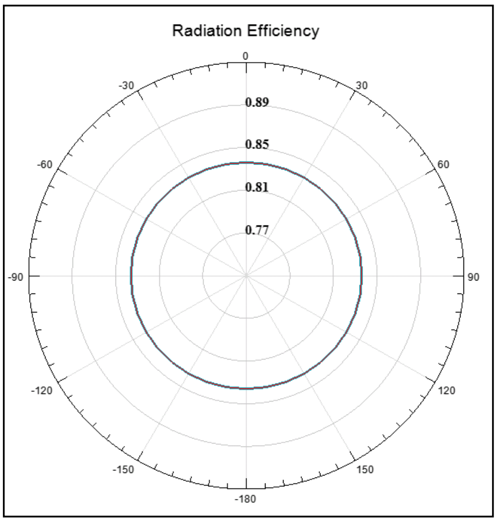

Figure 7. Radiation Efficiency Curve.

4. CONCLUSION

The paper presents an arrangement of array of coplanar monopole antenna for the RF energy harvesting applications. The uniqueness of this arrangement is that a Wilkinson power combiner is added to combine the power of two antennas. So it eliminates the need of impedance matching circuit between the antenna and rectiers circuits. The rectier circuit part of any RF harvester circuit may be directly connected to this antenna. The proposed design of array provides the gain of 9.2 dBi and the efficiency is 83%. The design is ready to fabricate and the measurement may be done and results will be soon compared and presented.

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