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Development of 4-Elements Printed Dipole Array for RF Energy Harvesting Application

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Abstract—posted dipole reception equipment has been implemented for some applications. This paper introduces the improvement of a 4-thing microstrip dipole radio twine, implied for energy reaping software program. The strolling recurrence of the proposed reception system is .1 GHz it truely is the LTE band. Estimation result demonstrates that the recieving cord acquires immoderate growth up to 6.18 dBi and a completely low go once more misfortune, all the manner all of the way all the way down to - 27.685 dB.The were given transmission potential is of round 600 MHz it truly is adequate to get a commonly immoderate reaped electricity.

Keywords—Antenna array; Energy Harvesting; Printed Dipole.

I. INTRODUCTION

Planar dipole-based antenna has been explored for many years, mainly for communication applications. These include the utilization of such antenna for wireless sensor [1], radar [2], RFID [3]-[5], dual-band application [6]-[7], and even has been proposed for 5G application [8]. In [9], planar dipole antenna was investigated and developed in a flexible substrate, which might be suitable for wearable antenna application. Printed dipole has been also developed in array structure, mainly to increase the gain [10], shaping the beam [10]-[11], and to increase the usable bandwidth [12]-[13].

In a RF energy harvesting system, antenna is also one of the most explored sub-system components. Some research on this field includes [14] and [15]. In this particular application, the antenna is expected to inherit high gain that it can collect more RF energy. Hence, increasing the gain of antenna become the strong research objective, as has been explored in [16] and [17].

This paper presents the development of a printed 4-element dipole array meant for RF energy harvesting application.

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II. ANTENNA ARCHITECTURE

The proposed antenna is designed to be printed in FR4 dielectric material. It is comprising four dipole structures' where only one arm from each dipole connected to the microstrip line. The other arms are not electrically connected and hence working like parasitic elements. These dipoles are printed in one side, while on the other side of the antenna consists of a relatively short groundplane. The overall size of the proposed antenna is 178 mm × 85 mm. The dipole arms are 34.48 mm long and 5 mm wide, separated by a 1 mm gap. Overall geometry of the proposed antenna is depicted in Figure 1, while the parameters are listed in Table 1. All of the dimensions are presented in millimeters.

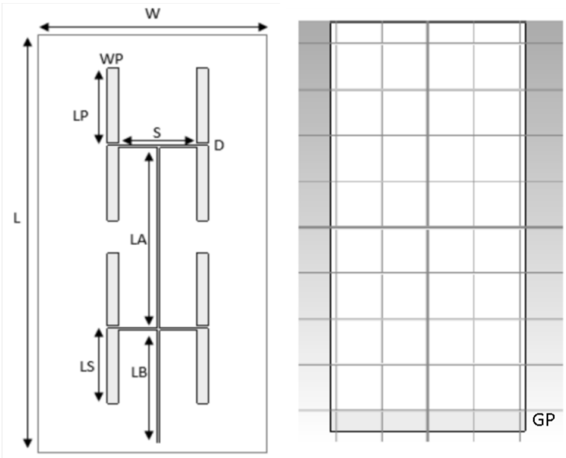

Figure 1: Geometry of the Proposed Antenna
Left: Front view, Right: Back view

Table 1
Parameters of the Antenna Geometry

Parameters	Values (mm)
W	85
L	178
LB	53.48
LA	82.96
S	35
LS	34
LP	34
WP	4
D	1
GP	9

III. RESULTS AND DISCUSSION

The proposed design is obtained from varying the geometry parameters by employing simulation software. Introducing defects on the groundplane structure has been known as the method to obtain some specific characteristic, for example for miniaturization [18] or to achieve low return loss, which is applied in the proposed antenna. Figure 2 shows the variation of return loss following the changes of groundplane height. It can be seen that 9 mm is the optimum height for the groundplane as it provides the lowest return loss (of about -20.289), and also the highest gain (of about 4.732 dBi) as shown in Figure 3.

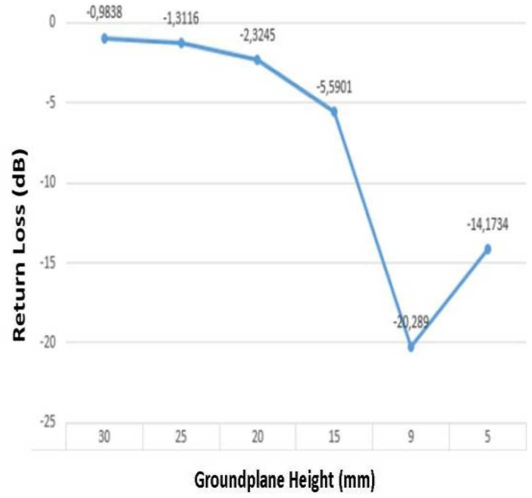

Figure 2: Variation of Return Loss on the Groundplane Height

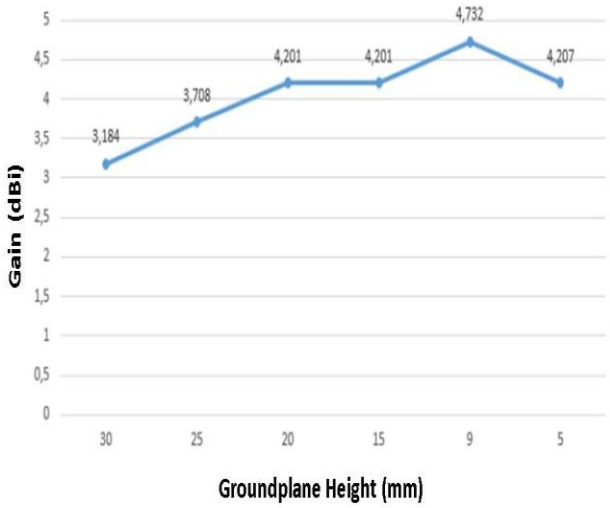

Figure 3: Variation of Gain on the Groundplane Height

Other parameters that affect the return loss of the proposed antenna are including the width and length of the dipole arm, which is a similar characteristic to a conventional (wire) dipole. Effect of the dipole arm width and length toward the return loss are shown in Figure 4 and 5 respectively. The variation was first applied to the width, from which give 4 mm for the lowest simulated return loss. This value was then used to vary the length. The lowest return loss, of about -20.3466 dB was then achieved when the length is 34 mm. This length is also providing the highest gain, of about 4.732 dBi, as depicted in Figure 6.

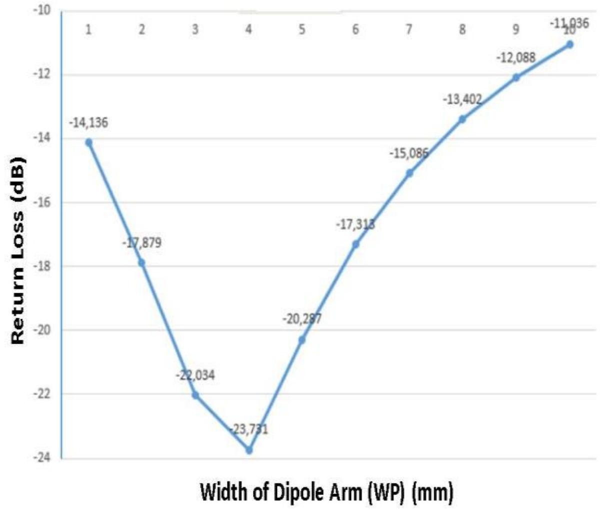

Figure 4: Variation of Return loss on the Dipole Arm Width

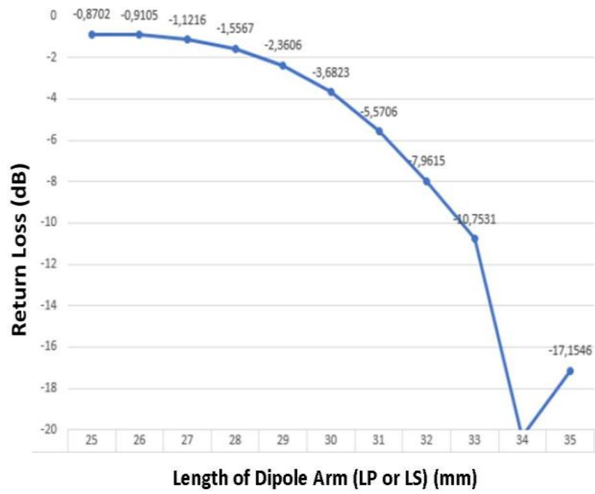

Figure 5: Variation of Return loss on the Dipole Arm Length

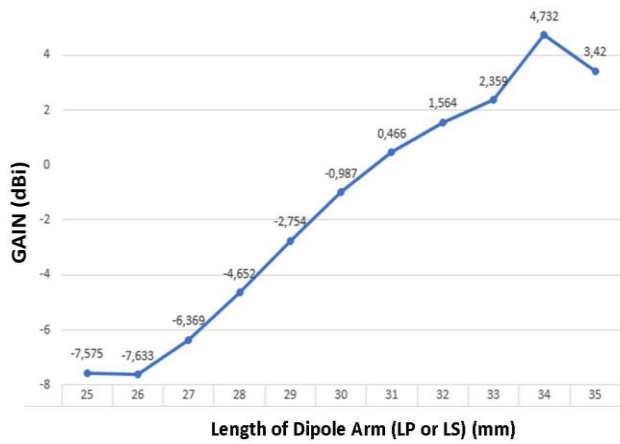

Figure 6: Variation of Gain on the Dipole Arm Length

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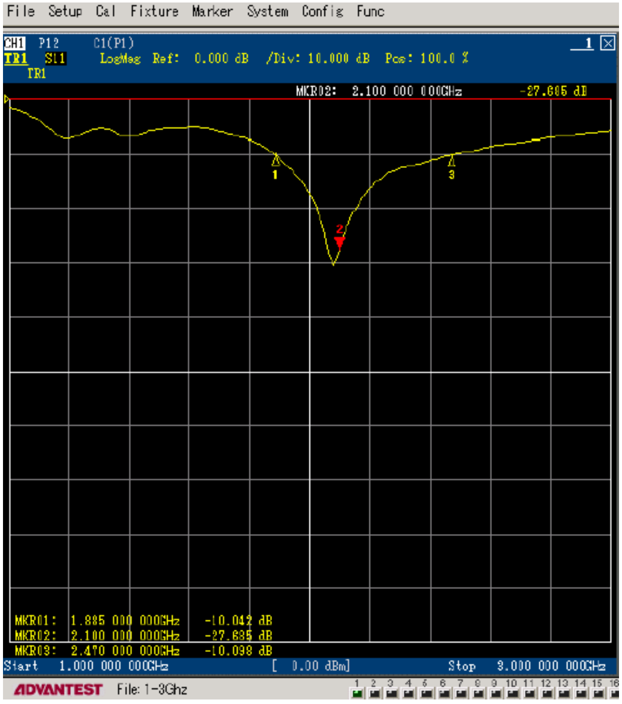

Figure 7: Measured Return Loss of the Proposed Antenna

The proposed antenna has been fabricated as shown in Figure 7. It was then measured to verify the simulated characteristic. Figure 8 shows the snapshot of return loss measurement, obtained from Vector Network Analyzer. It can be seen that the achieved return loss is actually lower than the simulation result. It was measured down to -27.685 dB. However, since the measurement was conducted inside an anechoic chamber, this result might be affected be the environment where the measurement took place.

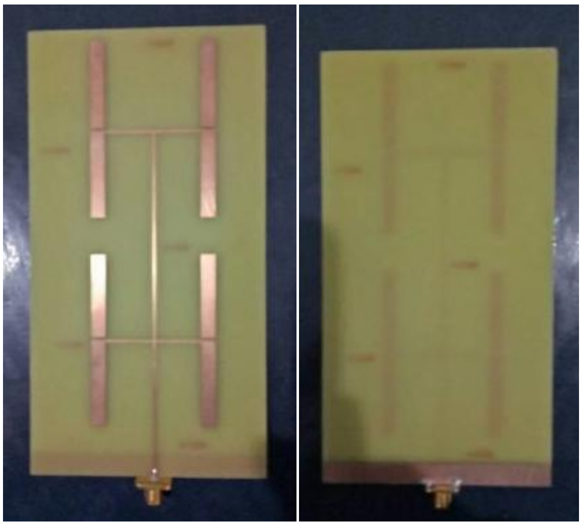

Figure 8: The Fabricated Antenna Left: Front View, Right: Back View

Figure 9 and 10 depicts the measured radiation pattern of the proposed antenna on Azimuth and Elevation axis respectively. Since the measurement was also not conducted inside an anechoic chamber, there possibility that the result has been affected by unwanted signal in the ambient. Regardless, the result shows a good agreement with simulation result, that the proposed antenna inherits bi-directional pattern. This is also agreeing with some result from other research (i.e. [19]) that a microstrip antenna with defected ground structure tend to have bi-directional radiation pattern. Maximum gain of the proposed antenna was also measured, of about 6.18 dBi. But again, it might have been affected by the environment.

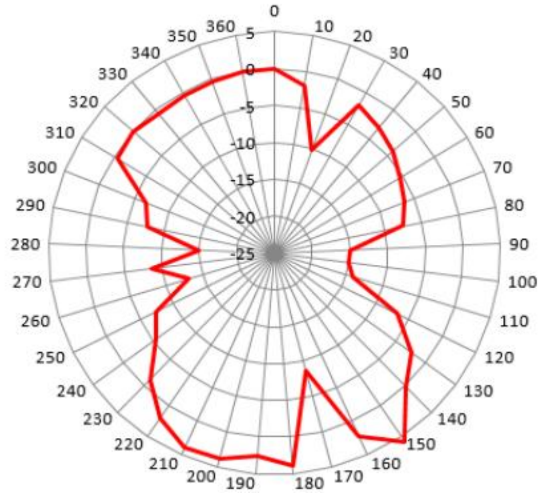

Figure 9: Azimuthal Radiation Pattern of the Proposed Antenna

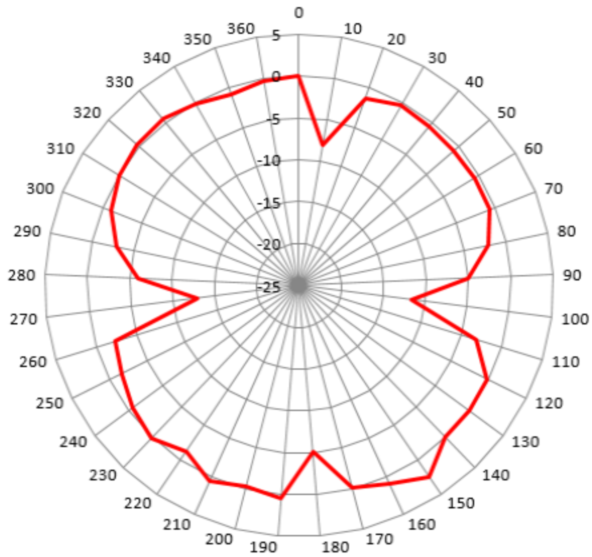

Figure 10: Elevation Pattern of the Proposed Antenna

After the characteristic has been verified, the proposed antenna was tested to harvest RF energy. The tests were conducted indoor and outdoor, by utilizing two rectifiers comprises a 3-stage and a 7-stage rectifiers. These rectifiers were also used to test the antenna in [17]. The measurements were conducted inside and outside Wi-Com Lab at School of Applied Science Telkom University building, nearby a mobile communication tower. The outputs were measured using voltmeter.

Indoor test showed that with 3-stage rectifier, the proposed antenna was able to draw voltage of about 2.7 millivolt and of about 25.2 mV with 7-stage rectifier, as shown in Figure 11. Figure 12 shows the outdoor test result.

The harvested signals were measured of about 43 mV and 288.9 mV with 3-stage and 7-stage rectifiers respectively. It showed that the proposed antenna can work properly as the front end module in an RF energy harvesting system.

Figure 11: Indoor RF Energy Harvesting Test Left: with 3-stage rectifier, Right: with 7-stage rectifier

Figure 12: Outdoor RF Energy Harvesting Test Left: with 3-stage rectifier, Right: with 7-stage rectifier

IV. CONCLUSION

This paper has affords the improvement of a 4-issue published dipole recieving wire. The proposed shape has been manufactured, anticipated and professional starting test to fill in as electricity collector front cease sub-framework phase. immoderate increase and low flow lower again misfortune have been gotten via estimation. The functionality to entice RF power moreover has been mounted from starting indoor and outdoor trying out with rectifier circuits, recommending that the proposed radio wire is suitable for strength gathering software.

affirmation

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