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Development of Meandered Microstrip Antenna for RFID Application

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A B S T R A C T

Antenna miniaturization has become one important research, especially in mobile communication technology development. This paper presents the development of a miniaturized antenna for RFID application (924 MHz). Meandering technique has been adopted to create a geometrically small antenna relative to its operating frequency. Measurement result shows that the fabricated antenna inherits low return loss, down to -25.915 dB. The geometry of the antenna is 25.54 mm × 16 mm, which is much smaller than its resonance wavelength (0.079λ × 0.049λ). The measured gain is relatively small, of about -12 dBi. Nevertheless, the obtained parameters are acceptable since the antenna is meant for near field communication application.

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1. Introduction

Mobile communication nowadays requires small, light-weight and low-profile antenna as the front-end sub-system component, especially for near field communication (NFC) application. Therefore, miniaturization of the antenna becomes more explored to obtain geometrically small antennas. Research on this particular field includes the utilization of spiral antennas [1]-[8], miniaturization of PIFA antennas [9]-[10], employment of chip antenna [11] and exploration on material for antenna structure for example magnetic composite films [12].

In RFID application, microstrip patch antenna still one of the most explored antennae, as it not only provides all of the requirements for NFC application but also allows planar installation. Among research in microstrip RFID antenna include printed folded dipole [13], circular loop structure [14] as well as single-sided meandered-dual-antenna structure [15].

This paper presents the development of a miniaturized microstrip patch antenna for RFID application, operated at 924 MHz. This frequency is allocated for RFID application in Indonesia [16] with a bandwidth of 2 MHz. The proposed antenna is meandered by adopting a square loop structure. This method has successfully provided the design of a very small antenna with good return loss.

2. Antenna Architectures

The overall size of the proposed antenna geometry is 25.54 mm × 16 mm, which is equal to 0.079λ × 0.049λ. Cooper is utilized as the material for the patch and ground plane, with a thickness of 0.035 mm. These patch and ground plane are printed on a 1.6 mm thick FR4 substrate. The patch is using square loop structure with three turns on its loop, separated of about 0.78 mm between loops. The width of the radiating element is 1 mm. The patch is fed using a microstrip line with a length of 13.94 mm from the terminal point and width of 2.9435 mm. On the back side, the ground plane is only 4 mm long from the terminal point, leaving most of the substrate exposed. The geometry of the proposed antenna is shown in Figure 1 while its parameters are listed in Table 1.

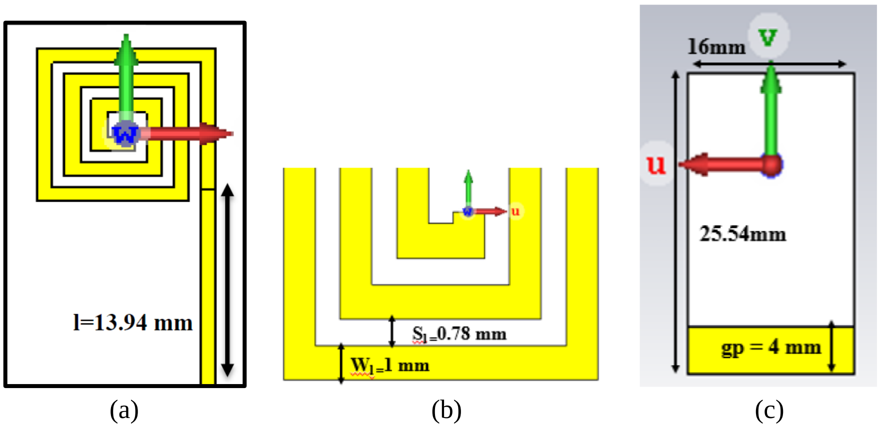


Figure 1 Geometry of the proposed antenna (a); Front-view (b); Detail on the square-loop patch structure (c) back-view

Table 1 Parameter of the proposed antenna geometry

Parameter	Values (mm)
Cooper thickness (patch & ground plane)	0.035
Substrate thickness (FR4)	1.6
Loop separation (S_l)	0.78 (0.0024λ)
Patch width (W_l)	1 (0.0031λ)
Length of the feeder (l)	13.94 (0.0429λ)
Width of the feeder	2.9435 (0.0091λ)
The Height of the ground plane (gp)	4 (0.0123λ)
Overall length (u)	25.54 (0.079λ)
Overall width (v)	16 (0.049λ)

3. Result and Discussion

Optimization of the antenna overall size is listed in Table 2. It can be seen that the geometry of 25.54 mm × 16 mm provides the center operating frequency at 924 MHz. This center frequency is also affected by the length of the feeder and the height of the ground plane, as shown in Table 3 and 4 respectively.

Table 2 Optimization on the overall size of the proposed antenna

Length (mm)	Width (mm)	Frequency (MHz)
24	15	917
24	16	912
24	17	903
25	15	940
25	16	932
25	17	918
26	15	931
26	16	919
26	17	910
25.54	16	924

Table 3 Optimization on the length of antenna feeder

Feeder Length (mm)	Peak Frequency (MHz)	Peak Return Loss (dB)
6.2	865	-6,931
7.4	898	-9,998
11.24	919	-15,98
12.44	922	-19,71
13.94	924	-23,96

Table 4 Optimization on the height of antenna groundplane

Groundplane Height (mm)	Peak Frequency (MHz)	Peak Return Loss (dB)
10	892	-6,46
8	910	-10,196
7	915	-12,118
5	922	-18,424
4	924	-23,968

The return loss of the proposed antenna is also affected by the separation of the loop (S_l) and width of the microstrip patch (W_l). From Figure 2 and 3, it can be seen that separation of 0.78 mm and patch width of 1 mm provide the lowest return loss.

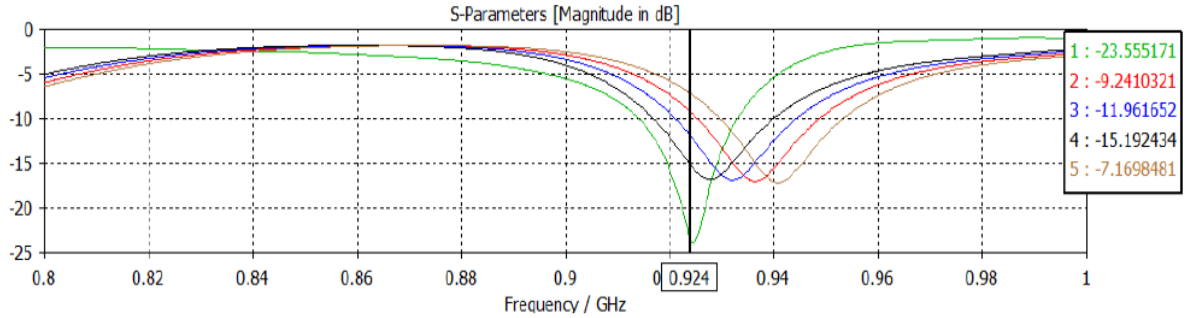


Figure 2 Variation of loop separation on the return loss
1: 0.78 mm. 2: 0.77 mm. 3: 0.76 mm. 4: 0.75 mm. 5: 0.74 mm.

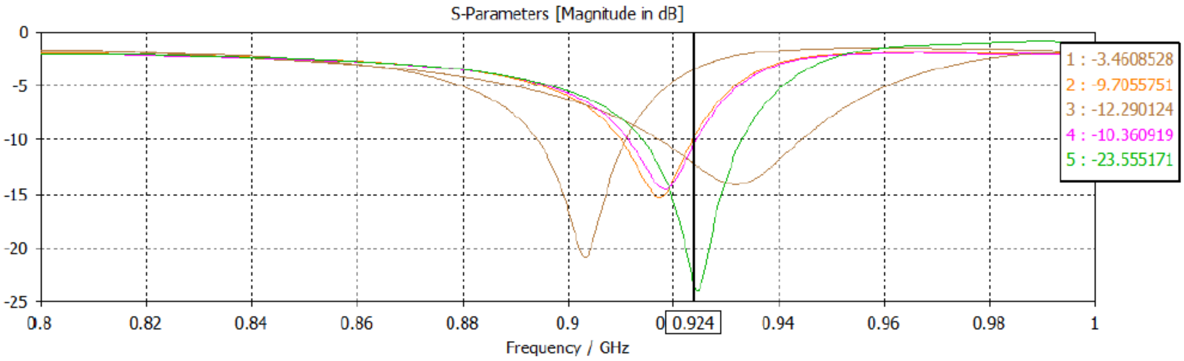
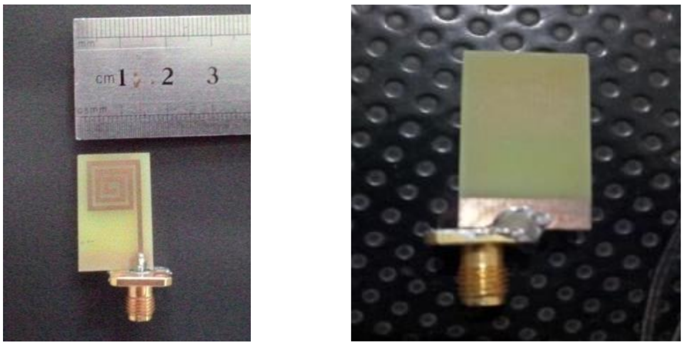


Figure 3 Variation of microstrip patch width on the return loss
1: 0.6 mm. 2: 0.77 mm. 3: 0.8 mm. 4: 0.82 mm. 5: 1 mm.

The proposed antenna has been fabricated and measured. Figure 4 shows the fabricated antenna. It can be seen that the proposed antenna is very small considering its operating frequency.



(a) (b)

Figure 4 The fabricated antenna; Top view (a); Back view (b)

Figure 5 depicts the snapshot of return loss measurement. The low return loss of about -25.915 dB has been obtained and it is lower than the simulated result (-23.96 dB). The obtained bandwidth is of about 24.6 MHz (2.66%) which as much wider than the requirement for RFID antenna specification.

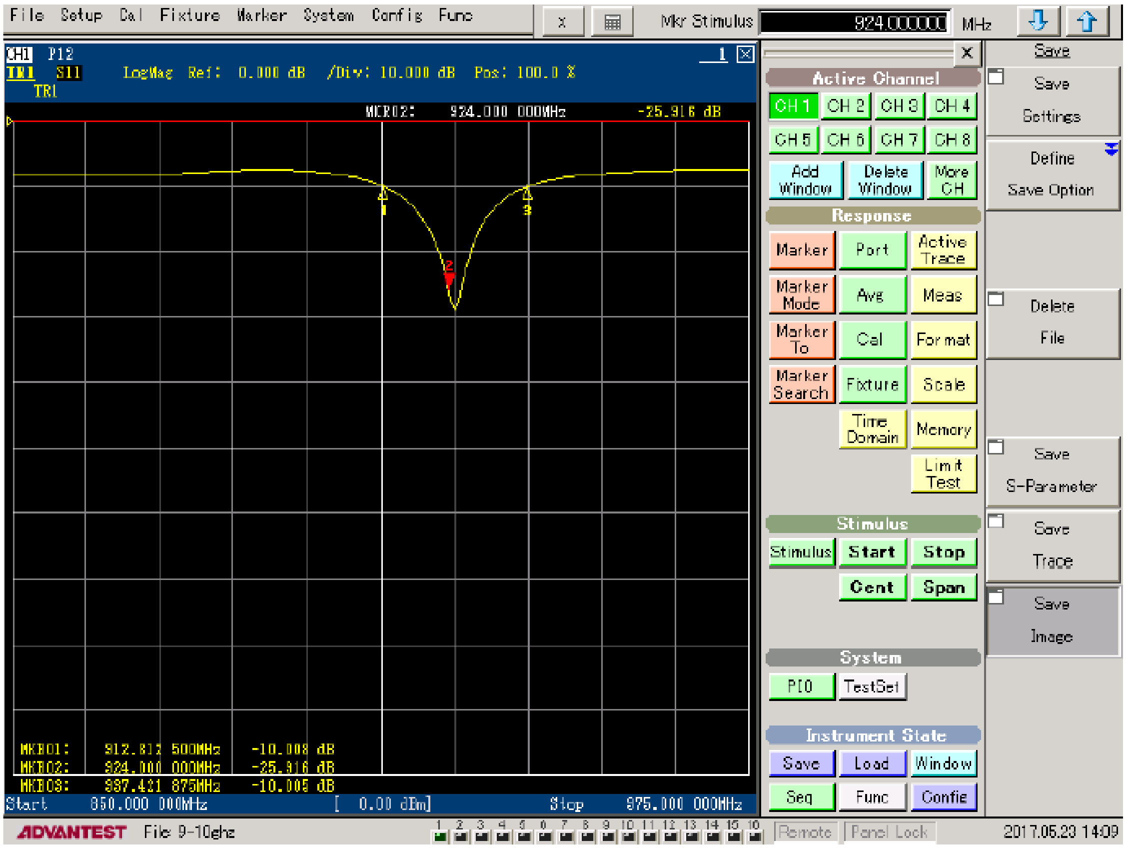
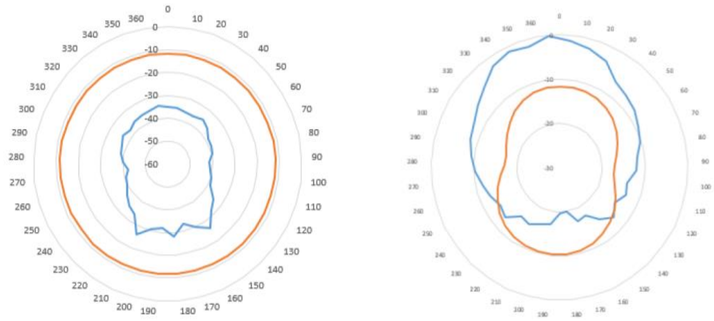


Figure 5 Measurement of the proposed antenna return loss.

Far-field parameters of the proposed antenna have also been measured. The radiation pattern of the proposed antenna is shown in Figure 6. It can be seen that the measured patterns in azimuth and elevation direction are about the same with the simulated curves, despite the difference in magnitude level. These differences occurred probably due to un-ideal measurement environment, as the antenna was measured not inside an anechoic chamber. The measured gain is about -12 dBi, which is lower than the simulated result, about -10 dB. The polarization has also been measured. The obtained axial ratio is about 5.7263, which is corresponding to elliptical polarization.



(a) (b)

Figure 6 Radiation pattern of the proposed antenna (a) Azimuth (b) Elevation

Simulated ——— Measured ———

4. Conclusion

Design of a miniaturized RFID antenna has been presented in this paper. The miniaturization was conducted by adopting meandering technique with square loop structure for the antenna basic geometry. A very small antenna with maximum geometry of 0.079λ × 0.049λ has been achieved. The obtained antenna inherits low return loss, of about -25.915 dB, with measured bandwidth of about 24.6 MHz. The achieved gain is relatively low, of about -12 dB. Nevertheless, this shortcoming is acceptable considering the application of the proposed antenna, which is meant for near field communication.

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