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Abstract. In wireless communication technology, antennas of folded dipole have been used very often. In this study, a folded dipole antenna is proposed using the Finite Difference Time Domain (FDTD) method, which can work on the SHF spectrum. So, it can be applied to wireless communication tools. The folded dipole antenna is designed using copper material with a thickness of 0.029 mm. After that, it was coated with FR-4 with a size of $50 \times 30 \times 1.6 \text{ mm}^3$. For the communication device to work in low signal areas, the folded dipole antenna must be reconfigurable. The reconfigurable type used is optically reconfigurable. So, on the right and left sides of the antenna, a red photodiode is installed. Based on the simulation results, it works at a frequency of 9.021 GHz before being irradiated by a red laser at 650 nm 5 mW and 6.660 GHz after being irradiated by a red laser. Furthermore, the change in frequency of the folded dipole antenna becomes wider, so a resonator is added. Based on the simulation results using a resonator, it works at a frequency of 10.781 GHz before being irradiated by a red laser and 2.559 GHz after being irradiated by a red laser.

INTRODUCTION

The use of antennas in communication tools is a significant matter to be discussed. Wireless communication tools have been used widely in the world. Therefore, the antenna becomes an important part of wireless communication tools to absorb and transmit electromagnetic waves [1].

In this study, an antenna of folded dipole with a microstrip structure is proposed. The antenna of folded dipole was chosen because it can produce a very large of energy with a size that is not too small, so it can be used to absorb and emit electromagnetic waves in the microwave region [2]. The antenna of folded dipole is made of copper plate and coated with FR-4. Copper was chosen because it has the highest efficiency compared to other metals [3].

Furthermore, for the antenna to work in the low signal region, the antenna of folded dipole must be reconfigurable [4]. Therefore, it is installed a red photodiode. The red photodiode was chosen because it can absorb red light, which has the largest wavelength in visible light [5]. Then, photodiodes are mounted on the right and left sides of the antenna. After that, the photodiode is irradiated with a red laser. The type of red laser used is 650 nm 5 mW. With the irradiation method, the frequency of the antenna of folded dipole has shifted with a certain value. This method is called optically reconfigurable on folded dipole antennas [6].

Next, the frequency changes can become wider than before a resonator is added to the antenna of folded dipole. A resonator as a tool to keep electromagnetic waves acting on the antenna can be reflected so that the frequency changes that occur in the antenna become wider than before. This method is expected to be applied to wireless communication devices with easy fabrication, low prices, and lightweight to carry everywhere [7].

MATERIAL AND METHODS

In this study, the simulation method uses the Finite Difference Time Domain (FDTD) [7]. Thus, the materials used to design a folded dipole and photodiode antenna are copper plate with a thickness of 0.029 mm, FR-4 with a thickness of 1.6 mm, and silicon as the base material of a photodiode with a thickness of 7 mm [8]. The shape and size of the antenna of folded dipole can be shown in Figure 1.

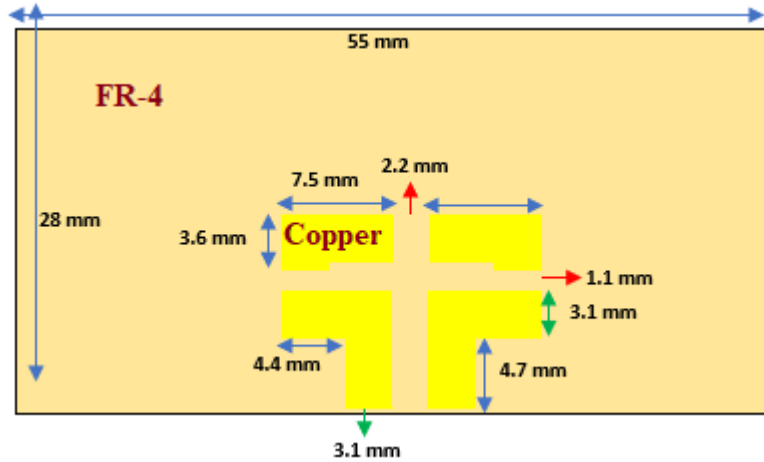


FIGURE 1. The shape and size of the folded dipole antenna

The antenna of folded dipole is designed to work at a frequency of 9 GHz. Thus, it has a certain size as shown in Figure 1. Next, photodiodes are mounted on the right and left sides of the folded dipole antenna. While the connectors are installed on both feedlines of the folded dipole antenna. Photodiode as a tool to receive electromagnetic waves from the laser and a connector as a tool to connect the antenna of folded dipole with power lines [9]. The shape of the photodiode and connector when mounted on an antenna of folded dipole can be shown in Fig. 2.

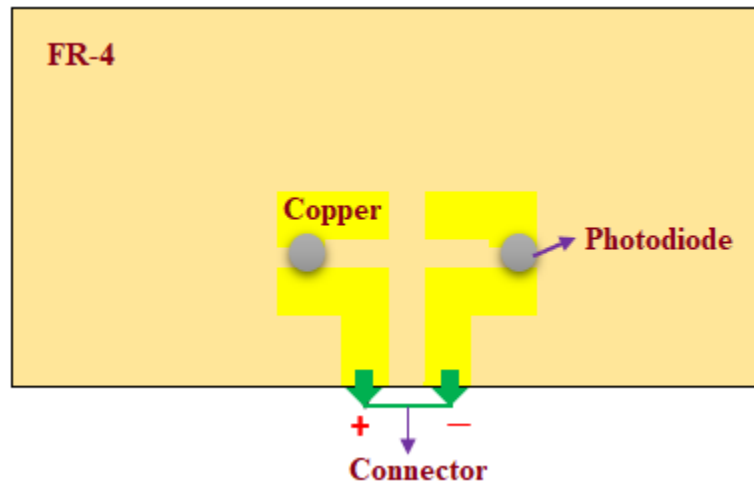


FIGURE 2. The shape of the photodiode and connector when mounted on a folded dipole antenna

Furthermore, the change in frequency of the antenna of folded dipole which functions as an optical reconfigurable becomes wider, so a resonator is added. The resonator is made of copper with a thickness of ± 1.65 mm and a size of $1.25\lambda \times 0.5\lambda \times 0.5\lambda$ [10]. After that, the positive feedline on the antenna of folded dipole is extended to 1λ and inserted into the resonator box. In the resonator box which is 0.25λ from the bottom, a connector is installed. The connector is

attached to the positive feedline of the antenna of folded dipole to allow it to connect to the power line. Next, the negative feedline of the antenna of folded dipole is attached to the outer side of the resonator box. The shape of the antenna of folded dipole that can be attached to the resonator and its resonator box is shown in Fig. 3. The combined shapes of the antenna of folded dipole and resonator are shown in Fig. 4.

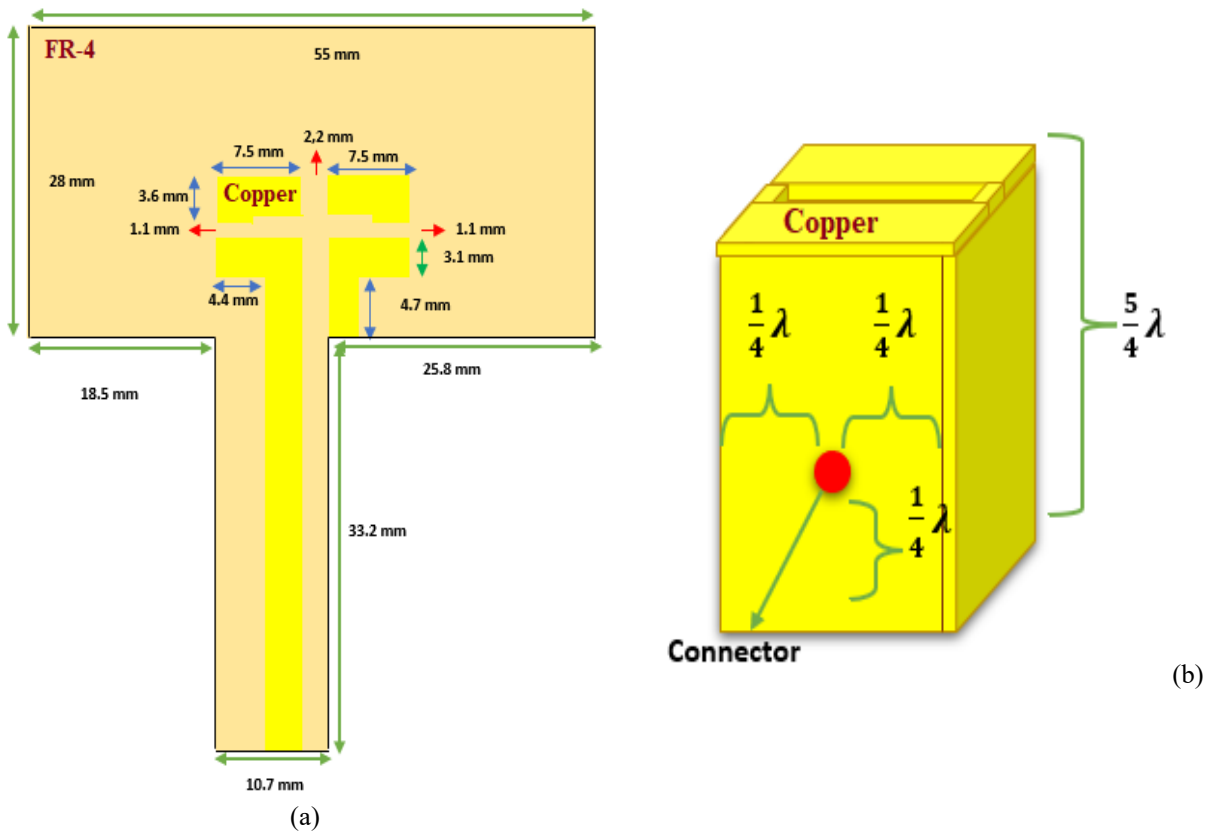


FIGURE 3. The shape of the antenna of folded dipole that can be attached to the resonator and its resonator box: (a) the folded dipole antenna, (b) resonator box

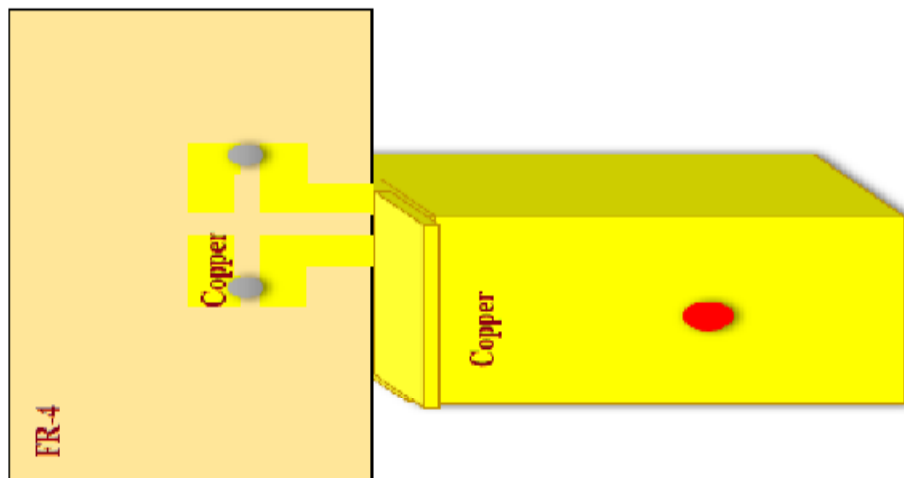


FIGURE 4. The combined shapes of the antenna of folded dipole and resonator

RESULTS AND DISCUSSION

Based on the simulation results using the FDTD method, a graph of the relationship between frequency and return loss is obtained. For the first type of antenna, when the antenna of folded dipole before installed a resonator, the graph between frequency and return loss is shown in Fig. 5.

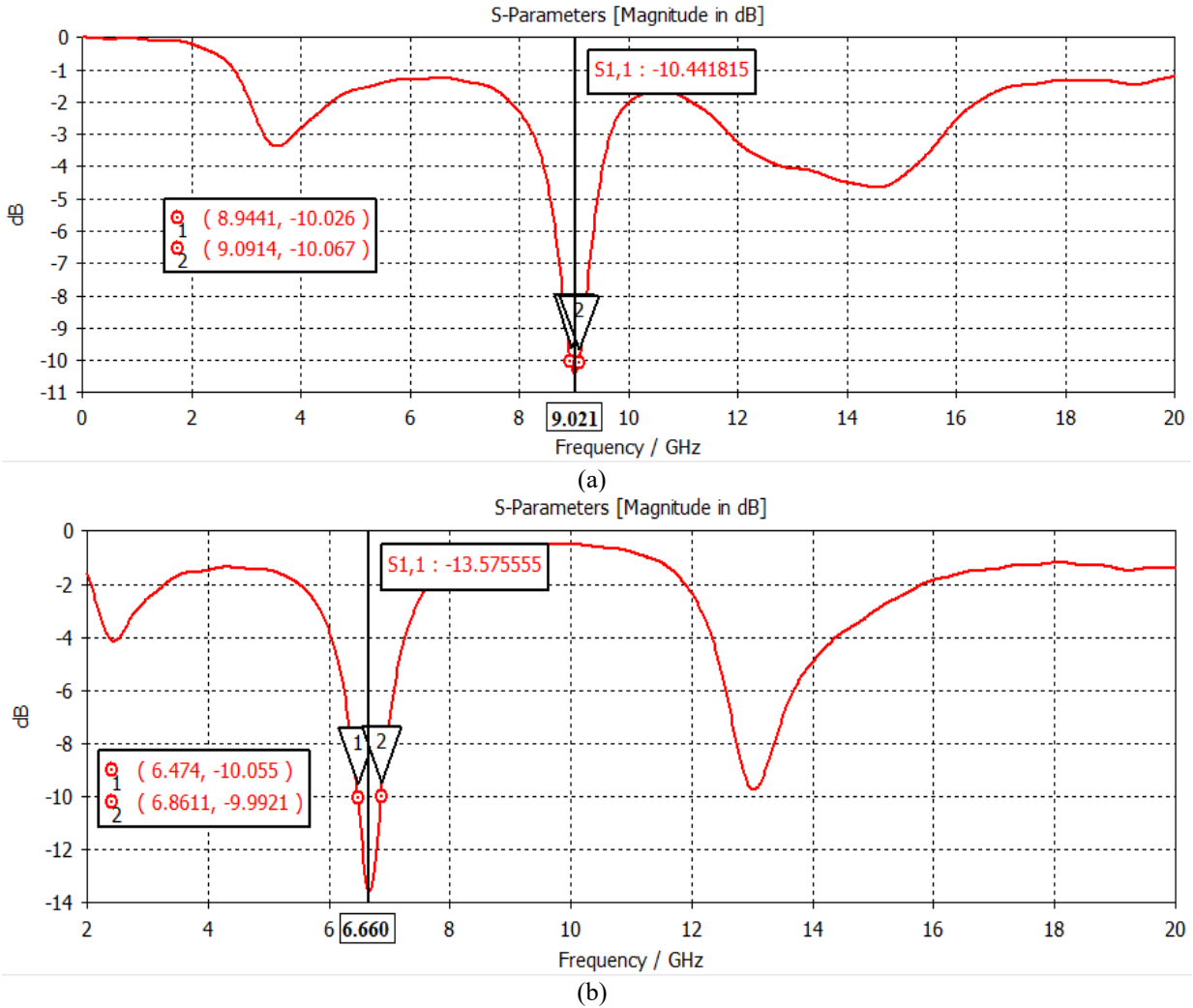


FIGURE 5. The graph between frequency and return loss when the antenna of folded dipole before installed a resonator: (a) with red laser off, (b) with red laser on.

Based on Figure 5, the operating frequency of the antenna of folded dipole changes from 9.021 GHz when the red laser is off to 6.660 GHz when the red laser is on. Reconfigurable optics on folded dipole antennas can cause frequency changes to 2.361 GHz. This frequency change is very large, almost the same as the frequency on mobile phones with 4G technology. In addition, the return loss on the antenna of folded dipole becomes smaller and the bandwidth becomes wider than when the red laser is off. This is because more electromagnetic waves are absorbed by the antenna higher than reflected [11].

Next, For the second type of antenna, when the antenna of folded dipole is after installed a resonator, the graph between frequency and return loss is shown in Fig. 6.

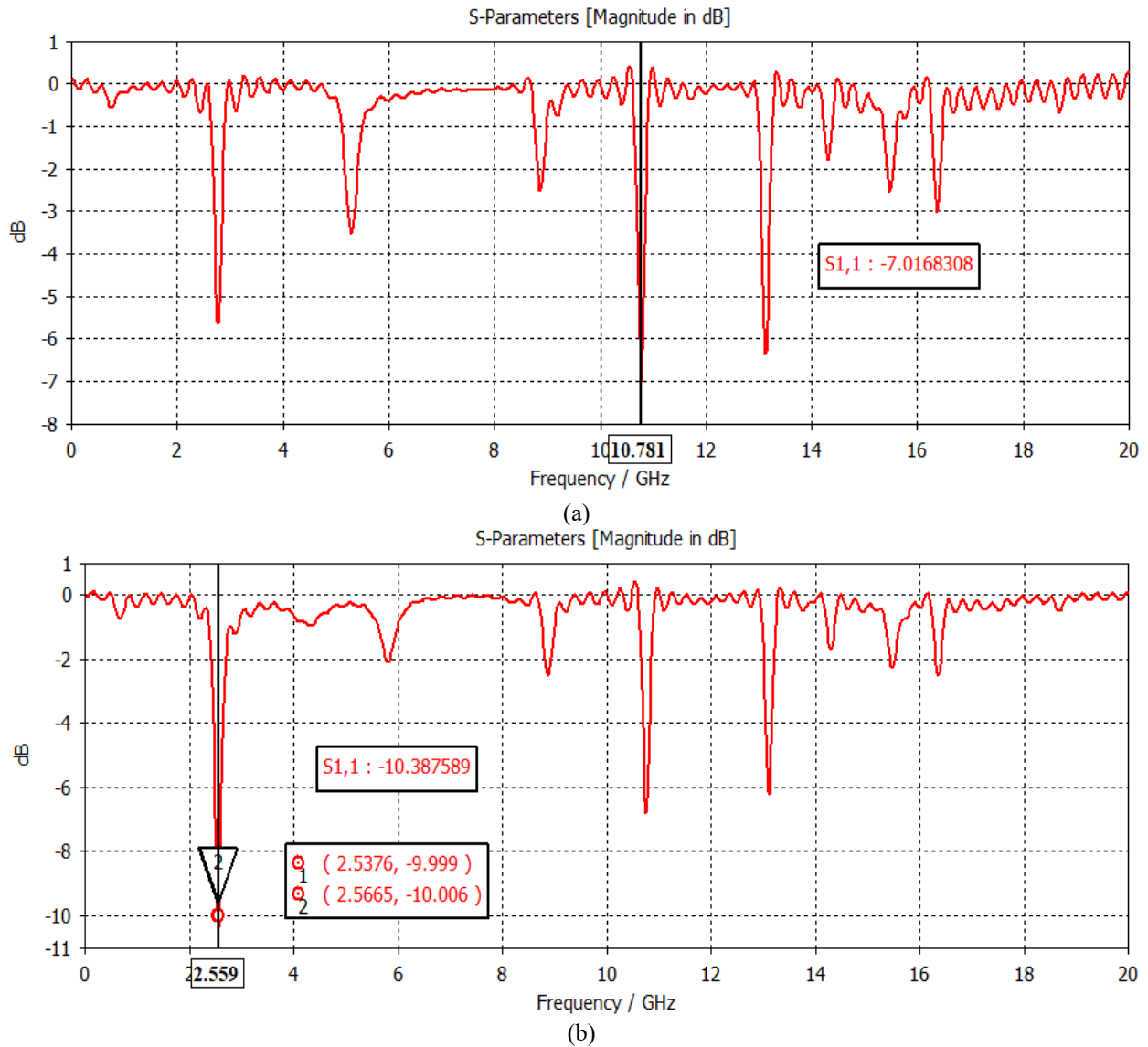


FIGURE 6. The graph between frequency and return loss when the antenna of folded dipole after installed a resonator: (a) with red laser off, (b) with red laser on.

Based on Figure 6, the operating frequency of the antenna of folded dipole changes from 10.781 GHz when the red laser is off to 2.559 GHz when the red laser is on. Reconfigurable optics on folded dipole antennas can cause frequency changes to 8.222 GHz. Adding a resonator to a antenna of folded dipole can increase its frequency change to 3.5 times that before adding a resonator. In addition, the return loss on the antenna of folded dipole becomes smaller and the bandwidth becomes wider than when the red laser is off. However, the return loss on the antenna of folded dipole becomes larger and the bandwidth becomes narrower than when before adding the resonator. This can result in the reflected electromagnetic wave being higher than before the resonator was added. Therefore, the power of the laser needs to be increased again. Thus, the electromagnetic waves absorbed by the antenna of folded dipole can be increased.

Next, several comparisons of each character on the antenna of folded dipole both before and after adding the resonator are shown in Table 1.

TABLE 1. The simulation results on antenna of folded dipole before and after the resonator is added.

Parameter	Without resonator		With resonator	
	without red light laser	with red light laser	without red light laser	with red light laser
Frequency on antenna (GHz)	9.021	6.660	10.781	2.559
Wavelength on antenna (mm)	19.300	26.143	16.149	68.038
VSWR	1.859	1.530	2.609	1.920
Reflection Coefficient	0.300	0.209	0.446	0.315
Return Loss (dB)	-10.442	-13.575	-7.017	-10.387
Bandwidth (dB)	0.1473	0.3871	0	0.0289
Phase	14.89°	-156.79°	10.58°	-176.65°
Characteristic impedance (Ω)	89.287+i15.156	33.453-i5.778	124.219+i25.662	26.796-i1.042
Gain (dBi)	3.026	-3.001	-2.201	-3.246
Directivity (dBi)	4.667	3.729	4.684	4.723

In table 1, it can be seen that the gain becomes smaller when the red laser is turned on. In addition, adding a resonator to the antenna of folded dipole can cause the gain to be smaller than before. However, the change in a gain reduction in folded dipole antennas after adding a resonator is smaller than without a resonator. This is caused by the electromagnetic waves on the antenna of folded dipole being reflected by the resonator. In addition, the directivity both before and after the addition of the resonator is almost the same.

Furthermore, the reconfigurable optical on the dipole antenna using red laser 650 nm 1 mW performed by [12] can experience a frequency change of 1.92 GHz. Besides that, research conducted by [13] using a red laser 655 nm 100 mW can produce a change of 0.05 GHz. In this study, the reconfigurable optical on the antenna of folded dipole with red laser 650 nm 5 mW before the resonator was installed could change the frequency of 2.361 GHz and 8.222 GHz after the resonator was installed.

CONCLUSION

The addition of a resonator to the antenna of folded dipole can increase the frequency change to be wider than before when irradiated with a red laser. However, adding a resonator can also cause the return loss to increase so that the antenna bandwidth becomes narrower than before. In addition, it can also reduce the antenna gain.

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