Size Reduction of Microstrip Antenna with CRLH-TL Metamaterial and Partial Ground Plane Techniques

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1. Introduction

The development of wireless technology today needs components and devices to become smaller and compact. Antenna is one of the important component in wireless communication device, therefore antenna size reduction is also indispensable. There are various techniques to reduce the antenna size. Metamaterial is one technique that can be used for antenna size reduction [1]. The Mushroom Structured Composite Right/Left Handed transmission line (CRLH – TL) metamaterial is chosen. The choice is due to its advantages, which are: antennas size reduction, bandwidth enhancement[2], and gain improvement[3].

The Metamaterial elements is basically an artificial composite material able to change the permittivity and / or permeability to become negative. The Artificial material is not intended to create a particle or a new material but rather to modify existing material, so that it has circuitry structure with negative permittivity and / or negative permeability. This negative values which also called left-handed material gives the backward-wave propagation effects. This is proved by the different signs of the group velocity and the phase.[4]

CRLH transmission line has many unique properties such as supporting the backward wave and zero propagation constant ($\beta = 0$) with zero or non-zero group velocity at a discrete frequency. The backward wave property of the CRLH – TL has been used to realize the characteristics of the half-wavelength resonant antenna. The infinite wavelength property of the CRLH – TL has been used to realize the resonant structure that does not depend on its physical length.[1]

In this paper, the CRLH – TL metamaterial is applied for designing a small antenna with wide bandwidth. The wide bandwidth is obtained by inserting partially ground plane size. A half - wavelength microstrip patch antenna is also used to be compared with the CRLH – TL metamaterial antenna.

2. Antenna design

The proposed antenna designed is shown in Fig. 1 where the antenna is composed with two – unit cell mushrom structure of CRLH – TL. The antenna is fed by a proximity coupling technique. The operating frequency of the antenna is designed to operate at center frequency of 3.3 GHz. The overall size of the CRLH antenna is 20 mm x 35 mm x 1.6 mm. The gap distance between the unit-cell is 0.2 mm and the diameter of via is 1 mm. The antenna is fed by proximity coupling transmission line. The matching condition is realized by varying position of feed line to the antenna. Furthermore, a partial ground plane techniques is iterated to obtain wide bandwidth. The CRLH – TL antenna is then fabricated on Taconic TLY-5 substrate with dielectric substrate permittivity of 2.2, loss tangent of 0.0009 and substrate thickness of 1.6 mm. To compare the performance, a half-wavelength patch antenna working at center frequency 3.3 GHz is also fabricated where the antenna dimension size is 40 mm x 45 mm x 1.6 mm. The half-wavelength antenna is shown in Fig. 2. It is shown that the proposed antenna has 61.11% size reduction.

3. Simulation and measurement results

First a simulation is carried out to obtain the radiation characteristic of the proposed antenna. The optimal antenna design is then simulated to acquire its return loss characteristic. Fig 3 shows the return loss characteristic of the proposed antenna where an operating frequency of 3.3 GHz can be achieved. The resulting frequency range is 3.19 – 3.66 GHz for VSWR $\leq$ 2, which shows the bandwidth of 470 MHz and return loss of 18.54 dB. The return loss characteristic simulation of the half-wavelength patch antenna is shown in Figure. 4. It is shown that the working frequency is 3.33 GHz. The resulting bandwidth for this antenna is 120 MHz for VSWR $\leq$ 2.

Furthermore, Fig. 5 displayed the fabrication of the proposed antena compared to a coin. The return loss comparison between simulation results and measurement result can be seen in Fig. 6. The measurement result show a slight shift, so that the operational frequency which should be 3.3 GHz is shifted to 3.26 GHz. In addition, the measurement of the radiation patterns and antenna gain are carried out. Fig. 7 shows *E – co* and *E – cross* radiation pattern for both simulation and measurement results. The measured antenna gain of 1.97 dB is achieved for the proposed antenna. Meanwhile, based on simulation results the antenna gain is 1.49 dB.

5. Conclusion

A CRLH – TL metamaterial antenna was designed to work at frequency 3.3 GHz. With this techniques the antenna dimensions is reduced 61.11% from the conventional one. In addition, a wideband antenna is obtained by reducing the ground plane of the antenna. The radiation characteristics of antenna showed a good agreement for both simulation and experimental results.

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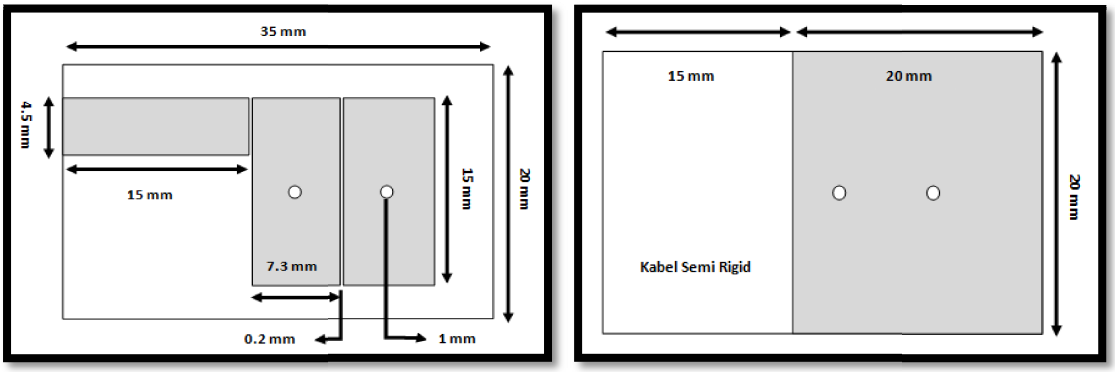


(a) **(b)**

Fig 1.. CRLH antenna (a) top view (b) bottom view

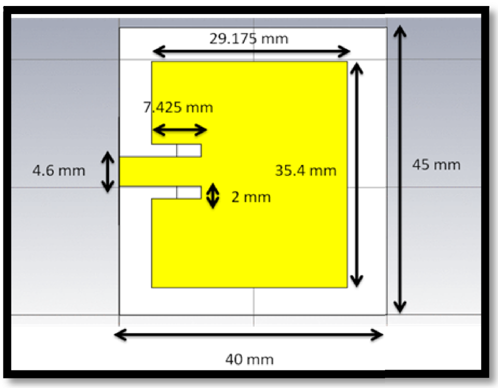


Fig 2. A half-wavelength patch antenna

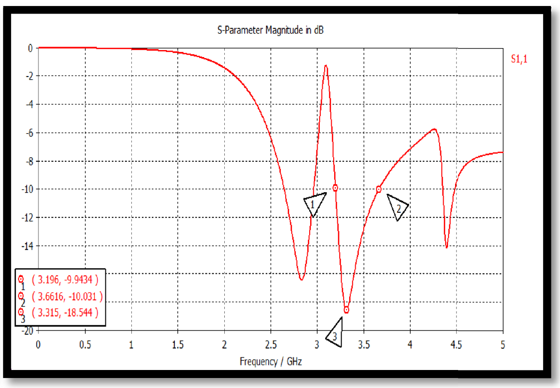
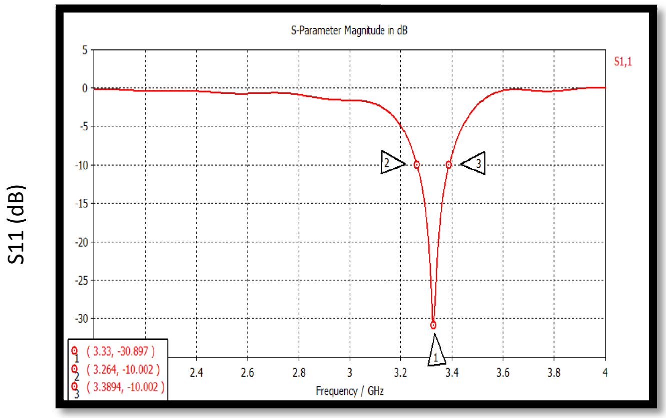


Fig. 3. Return loss characteristic of the CRLH – TL antenna



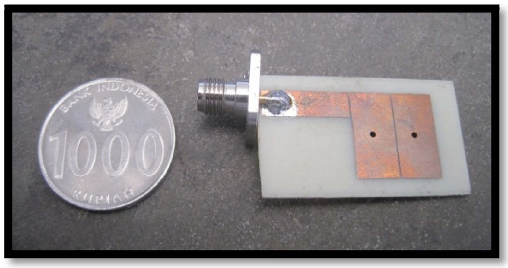


Fig. 4. Return loss characteristic of a half-wavelength antenna. **Fig 5.** Fabrication result for a CRLH antenna

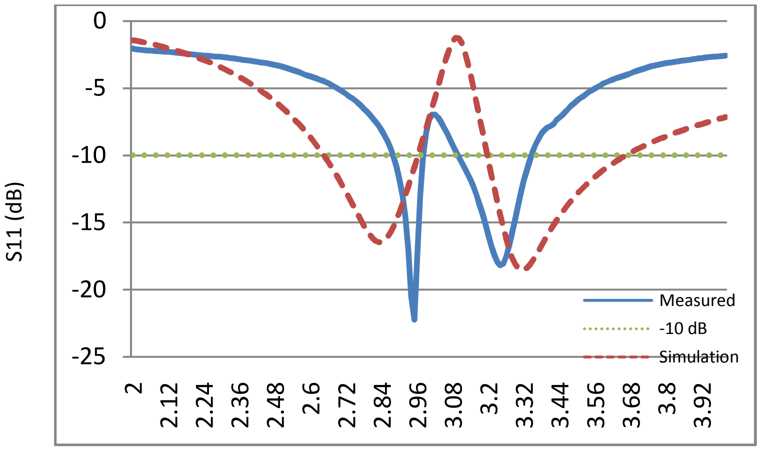


Fig 6. Return loss characteristic comparison

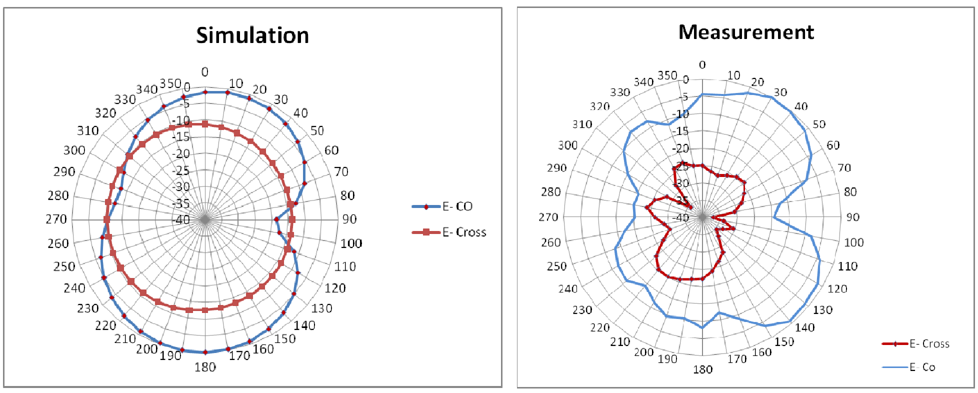


Fig 7. Radiation pattern of *E-co* and *E-cross* for both simulation and measurement results.