

The Effect of Complimentary Split Ring Resonator Placement on Antenna Patch and Ground Plane to Microstrip Antenna Reduction Dimension and Bandwidth

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Article Information	ABSTRACT
Article History Received : January 31, 2025 Revised : February 10, 2025 Published : April 02, 2025	This reasearch is aimed to observe the comparison of CSRRs performance on Antenna Patch and Ground Plane so that the Antenna can be implemented in ADS-B frequency. The CSRR outer dimension is 13 mm x 10 mm and the inner dimension is 9 mm x 6 mm, obtained of Return loss and VSWR simulation are respectively -13.7860 dan 1.5141. The iteration is done after the CSRR is added to its Patch and ground plane so that return losses are -10,329 dB and -13,554 dB and the VSWRs obtained were 1.8755 and 1.5317. In addition, the redution of Patch and Ground plane dimensions also is occurred when CSRR is on Patch by 18.5% and 30.2%, reduction Patch and Ground plane dimension occurred when CSRR is on Ground plane by 24.1% and 23.16%. Etched on Patch and Ground plane, CSRRs effect Bandwidth, Bandwidth decreases at 0.015 GHz at CSRRs on patch and increases at 0.040 GHz whereas Bandwidth is 0025 GHz before CSRRs is etched.
Keywords: CSRR; Ground Plane; Patch; Return Loss; VSWR;	

INTRODUCTION

Metamaterial is one of the research field attracting researchers' interest. Metamaterial is a way to make material permeability and permittivity apprently zero or negative (Kumar et al., 2022; Padilla & Averitt, 2022; Shen et al., 2022; Shi et al., 2022). Metamaterial can be used as antenna current that alterate its frequency to be new frequency. At the moment, metamaterial is often implemented to microstrip antena due to microstrip characteristic that reduce microstrip antenna dimension.

The one of metamaterial type implemented to microstrip antenna is Complimentary Split Ring Resonators(CSRRs) (Shahzad et al., 2022). CSSRs are composed by compliment of Split Ring Resonator (SRR) and have several shapes that those shapes are rectangular (Al-Gburi et al., 2023). CSRRs is etched on microstrip ground plane surface however it can be etched on microstrip patch suface. CSRR etching on micostrip ground plane as well as on its patch impact on dimension antenna reduction in order that antenna dimension reduction possesses a diffrent dimension from earlier dimension.

Microstrip antenna is also stated as an ideal antenna regarding from Return loss,VSWR and Bandwidth performance. (Alam et al., 2020; Fadilah & Budayawan, 2022; Prasetyani et al., 2021; Rusdiyanto et al., 2020; Zulfikar et al., 2020). Minimum Return loss for ideal antenna is about < -10 dB, VSWR is about < 2 that antenna frequency is on antenna frequency resonance and hold a wide bandwidth (Rashid et al., 2022). Antenna frequency resonance can be put in various application such as *Automatic Dependent Surveillance-Broadcasts* (ADS-B) device (Hakim et

al., 2020; Rifai et al., 2020). This device occupy a receiver that receiver frequency operate from 1090 MHz-1100 MHz (Adi et al., 2020; Makfirah et al., 2020; Pálenská et al., 2020).

Microstrip Antenna ADS-B 1090 MHz design implementing CSRRs on its Patch and Ground plane is shown in this article. This technic is designed with etching rectangular CSRRs on its Patch and Ground plane and iterate Patch and Groundp plane dimension. Iterating dimension of Patch and Ground plane is acted with reducing and extending Patch and Ground plane dimension to get antenna frequency in 1095 MHz. Measurement and comparation minimum Return loss, VSWR and Antenna Bandwidth are undertaken by simulation.

RESEARCH METHODS

Microstrip antenna implementing CSRRs Technic has 3 stages such as calculation of antenna dimension, etching CSRR on Antenna Patch and Ground plane and Antenna Return loss and VSWR measurement. The earliest step is begun with calculating of conventional microstrip patch width and length and antenna variabels are included calculation components such as resonating antenna frequency at 1.09 GHz, 4.4, 1.6 mm, and 0.02 for substrate dielectric constant, susbrute thickness and susbrute lost tangen respectively. In order to antenna width calculation, dielectric is involved to width equation that is shown:

$$W = \frac{c}{2f\sqrt{\epsilon_r+1}} \quad (1)$$

for W = antenna patch width, f = resonates antenna frequency, ϵ_r = dielectric constant and c is light propagation velocity. Applying ϵ_r and substrate thickness h , Effective dielectric constant ϵ_{eff} is obtained by using equation:

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2} \left(1 + 12 \frac{h}{W}\right)^{-\frac{1}{2}} \quad (2)$$

furthermore, patch extended patch antenna length on its each side is acquired using equation:

$$\Delta L = 0,412h \frac{(\epsilon_{eff}+0,3)(\frac{W}{h}+0,264)}{(\epsilon_{eff}-0,258)(\frac{W}{h}+0,8)} \quad (3)$$

the patch effective length is gained from the actual length L so that the actual length is found using equation:

$$L = \frac{1}{2f\sqrt{\epsilon_{eff}\mu_0\epsilon_0}} - 2\Delta L \quad (4)$$

lastly, the patch effective length is calculated using equation:

$$L_{eff} = L + 2\Delta L \quad (5)$$

CSRRs etched on Conventional Microstrip Antenna that CSRRs is compounded by Rectangular SRR. The etching of Antenna Patch and Ground plane is shown in Figure 1 and Table 1 for SRR dimension detail.

Table 1. SRR Dimension Fiture etching on Patch and Ground plane

Dimension	Size
W_{out}	13 mm
L_{out}	10 mm
W_{in}	6 mm
L_{in}	9 mm
T	1 mm
G	1 mm
S	1 mm

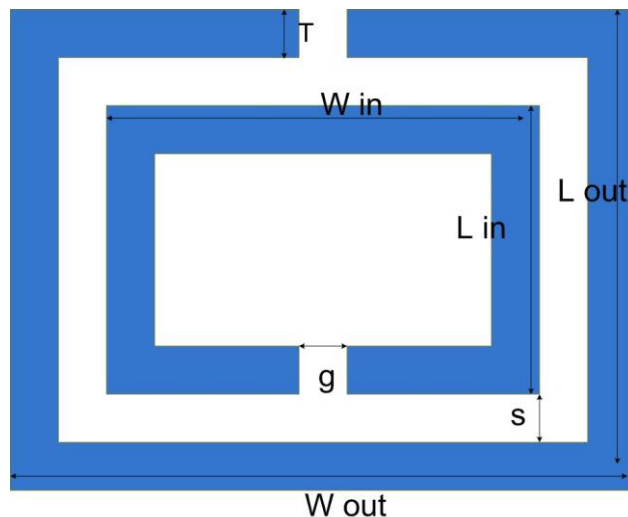
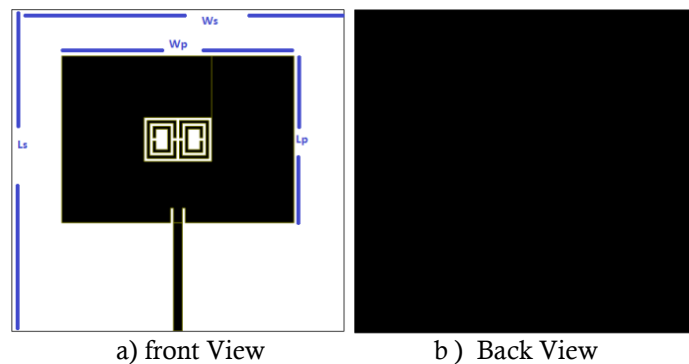


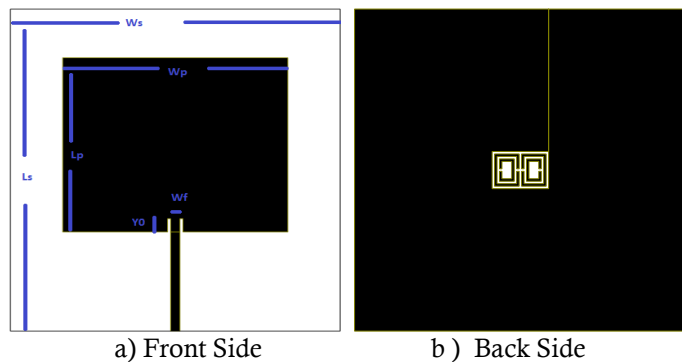
Figure 1. Simulated SRR Dimension

CSRRs is put in Center of Antenna Patch to facilitate antenna dimension iteration and shown in Figure 2. Dimension Iteration is carried out by reducing and extending patch and Ground plane dimension thus antenna frequency resonant in ADS-B frequency range. CSRRs is etched on the middle of Antenna Patch shown in Figure 2.



a) front View b) Back View
Figure 2. CSRRs Etched on Antenna Patch

The etching CSRRs steps are not only etched on its middle of Antenna Patch but also on middle of Antenna Ground Plane shown in Figure 3.



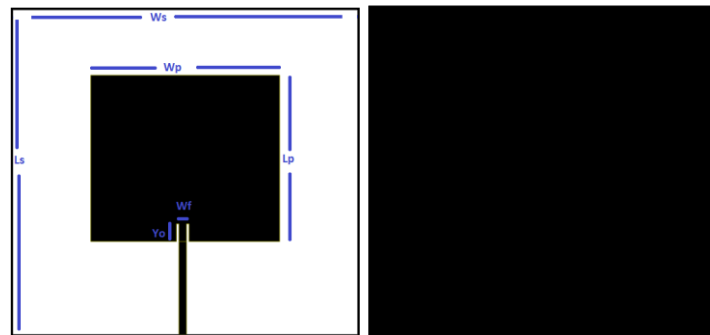
a) Front Side b) Back Side
Figure 3. CSRRs design on Antenna Ground Plane

The Antenna dimension is optimized by antenna dimension iteration that is done with reduced and extended length and width antenna. These steps is implemented on Antenna patch and Ground Plane, otherwise CSRRs dimension is not changed. Optimization result is simulated by complying antenna parameter. VSWR and Return loss are antenna parameters, ideal antenna

parameter for antenna VSWR is < 2 , and Return is > -10 dB at 1.09 GHz (1090 MHz). the antenna that fill antenna parameters measured and result is compared to observe the best antenna performance. Moreover, bandwidth is addition parameter that include to antenna measurement.

RESULTS AND DISCUSSION

The antenna calculation result obtained by using equation (1)-(5) is revealed in Figure 4 and the antenna specification is represented in Table 2.



a) Front View

b) back view

Figure 4. The Earliest Microstrip Antenna Design

Table 2. Conventional Microstrip Antenna Dimension feature

Dimension	Ukuran
Patch Width (W_p)	85 mm
Patch Length (L_p)	65 mm
Feed Line Width (W_f)	1 mm
Inset Feeder (Y_o)	5 mm
Substrate Width (W_s)	137 mm
Substrat Length (L_s)	130 mm

This Return loss Conventional antenna is obtained by simulation result revealed in Figure 5. The simulation result of Return loss antenna is -13.7860 dB and that is a maximum Return loss while the antenna frequency resonates at 1.09 GHz. The VSWR antenna acquired by simulation is shown in Figure 6.

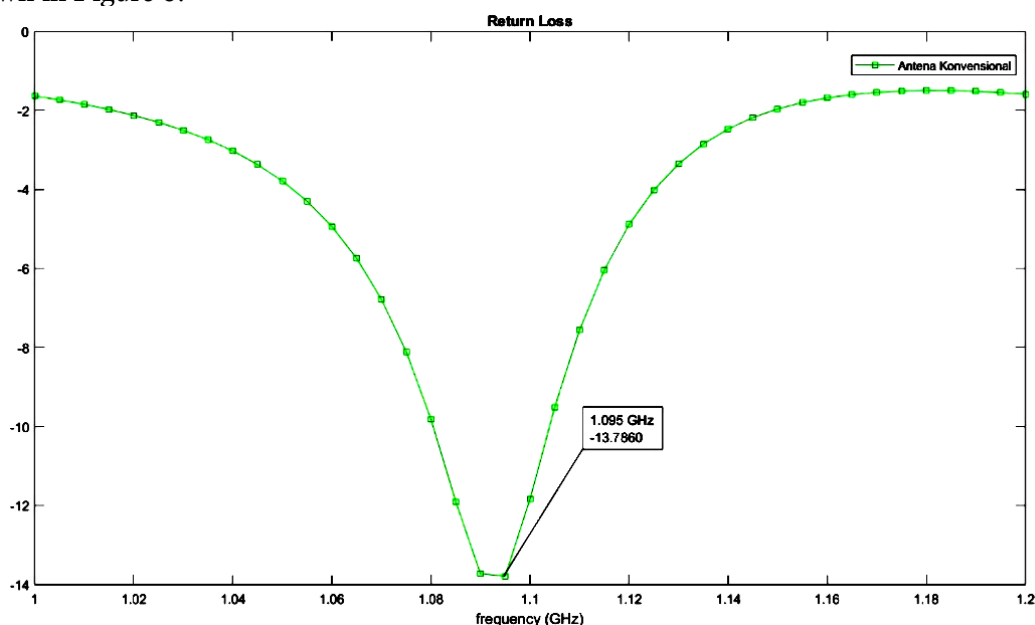


Figure 5. Return Loss Conventional Antenna

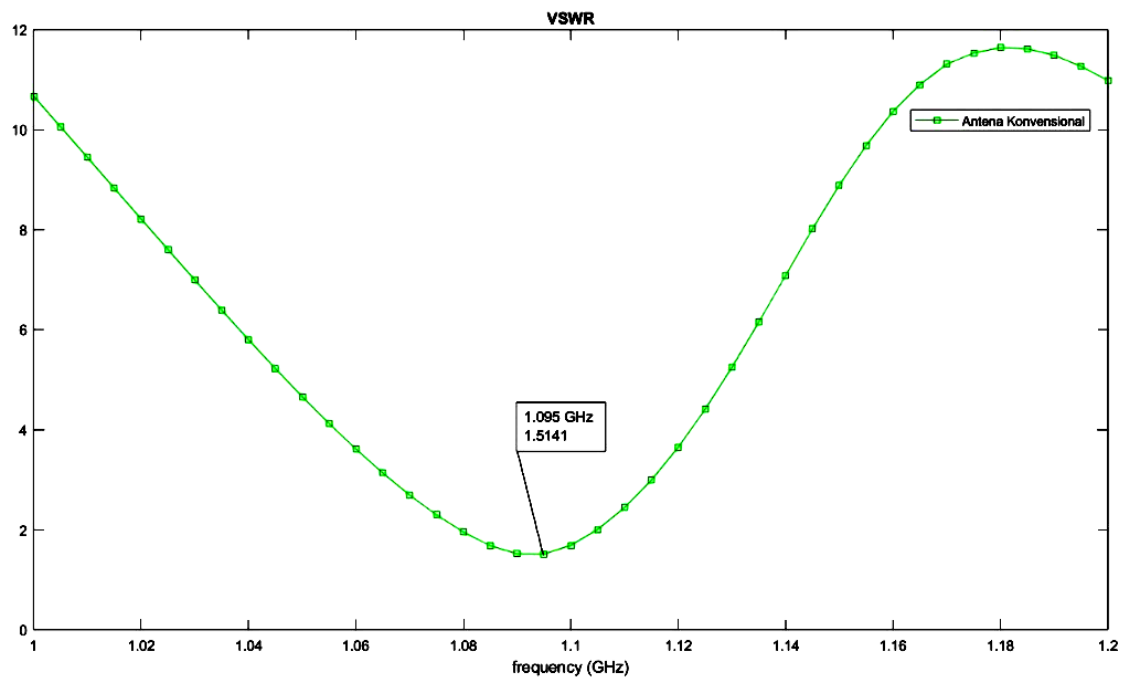


Figure 6. Conventional Antenna VSWR in Simulation

VSWR value is determined since Return loss is acquired by simulation and the VSWR value that antenna frequency resonates at 1.09 GHz is 1.514. The Return loss and VSWR value got by simulation is not over allowed the Return loss and VSWR value. After CSRRs are etched on both Antenna Patch and Ground Plane, affect to Return loss and VSWR value shown in Figure 7 and Figure 8. The increment antenna parameter value is noticed after CSRRs etched on Patch and Ground Plane.

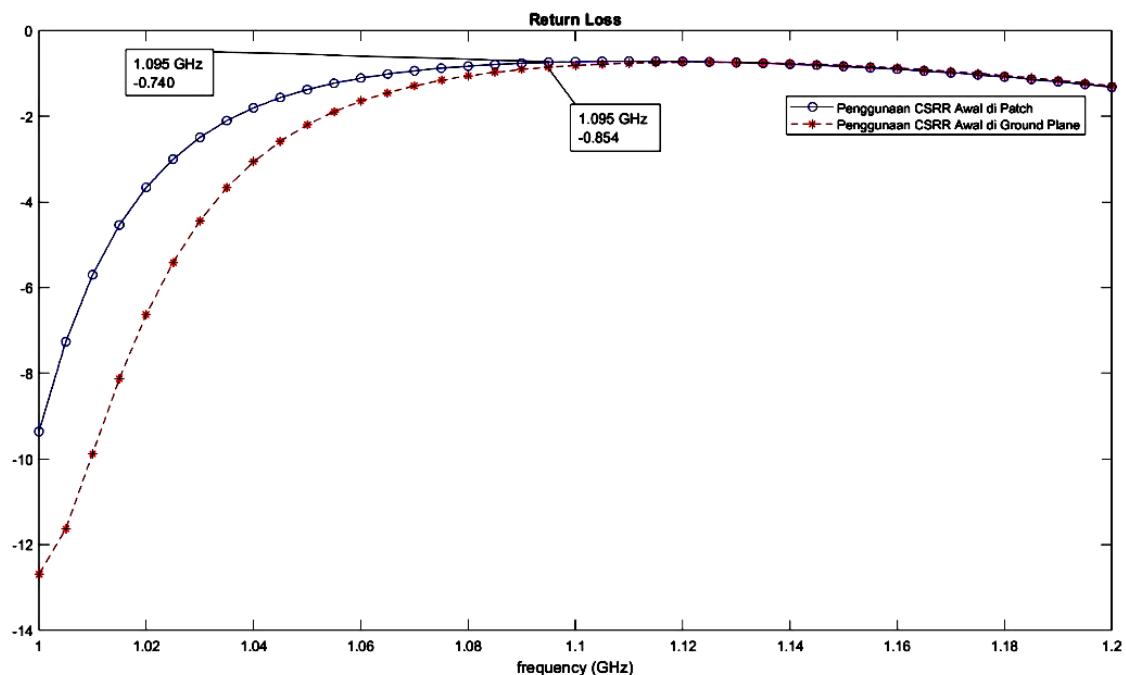


Figure 7. Return Loss Shift after CSRRs Etched on Patch and Ground Plane

The Antenna Return loss grows up to -0.740 dB for etching CSRRs on Patch and -0.854 dB for etching CSRRs on Ground Plane. The increment of that antenna frequency resonates at 1.09 GHz.

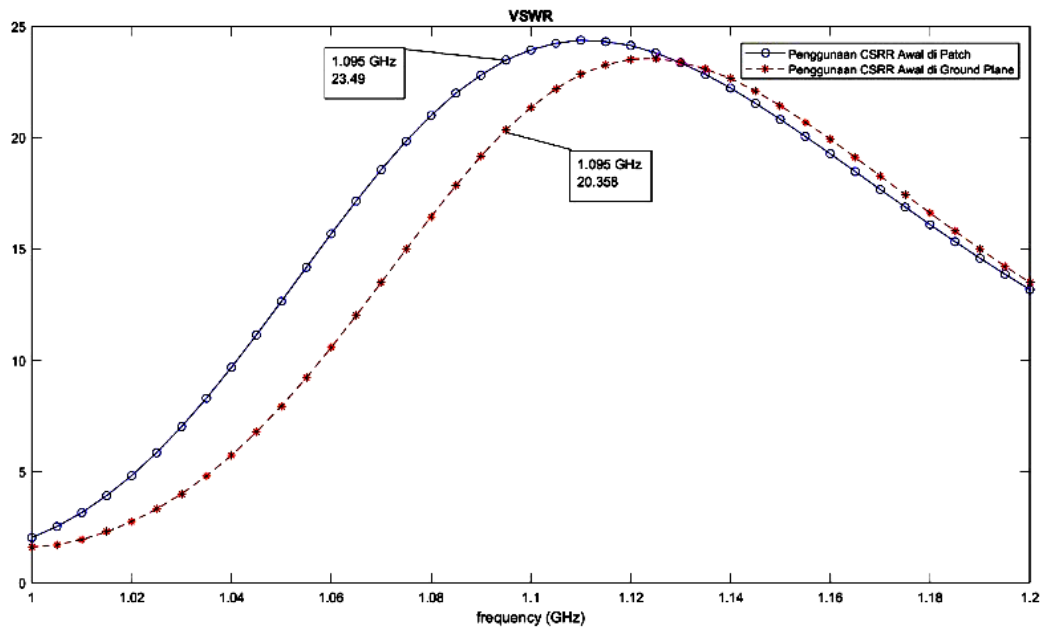


Figure 8. VSWR Shift after CSRRs Etched on Patch and Ground Plane

The Antenna VSWR value is 23.49 for CSRRs on Patch and 20.358 for CSRRs on Ground Plane. VSWR explained in figure is simulated using antenna frequency resonance at 1.09 GHz. Iteration with width and length reduced and extended is generating to new dimension antenna and Return loss and VSWR value at once. The dimension alteration is shown in Table 3 and Return loss result in Figure 9.

Table 3. Iteration Effect to Antenna Dimension and Size

Dimension	CSRRs on Patch Antenna Size	CSRRs on Ground Plane Antenna Size
Patch Width (Wp)	79 mm	71 mm
Patch Length (Lp)	57 mm	59 mm
Feed Line Width (Wf)	1 mm	1 mm
Inset Feeder (Yo)	5 mm	5 mm
Substrate Width (Ws)	113 mm	119 mm
Substrate Length (Ls)	110 mm	115 mm

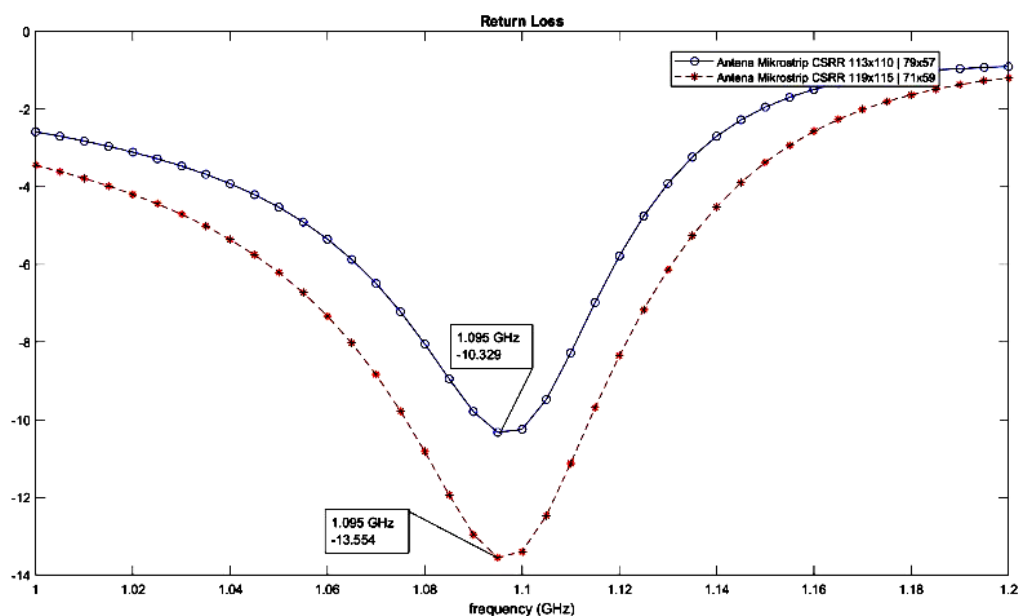


Figure 9. Minimum Return Loss for CSRRs Antenna Optimization

Width and length Patch and Ground Plane Iteration make Return loss being minimum. Return loss value while CSRRs on Ground plane is -13.554 dB and CSRRs on patch is -10.329 dB. Return loss for CSRRs on Ground plane is preferable to CSRRs on Patch. Iteration is influenced antenna VSWR value as well and this effect can be seen in Figure 10.

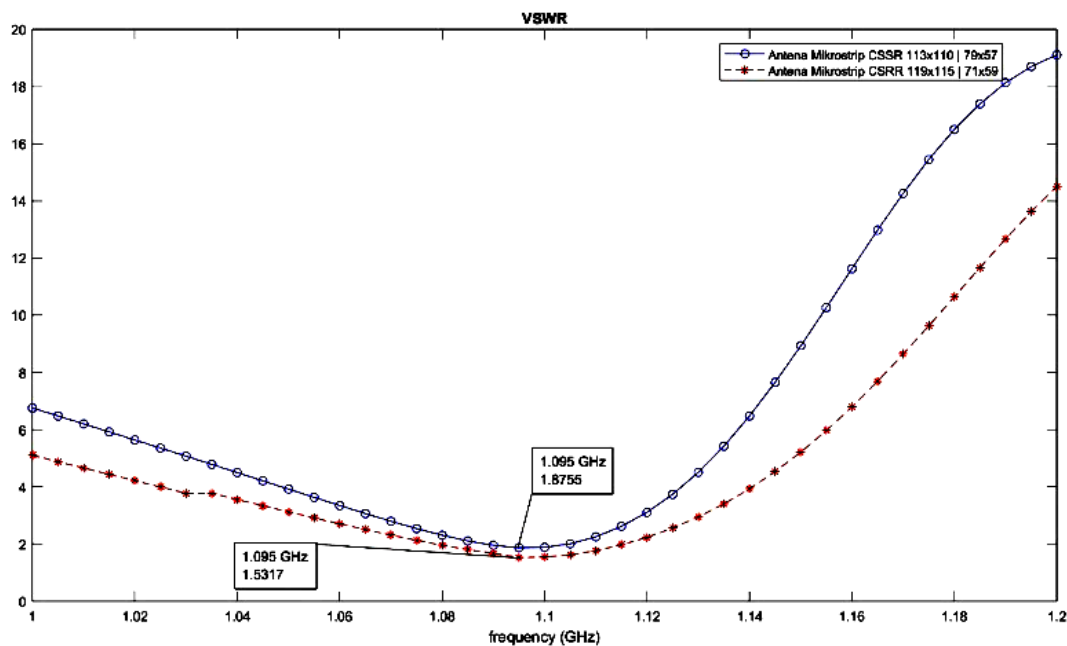


Figure 10. Minimum VSWR for CSRRs Antenna Optimization

CSRRs on Patch and Ground plane make VSWR value shifting to minimum value. The minimum VSWR when CSRRs is etched on its Patch is 1.8755 and its Ground plane is 1.5317. CSRRs on Ground plane has more minimum value than CSRRs on Patch. In addition, Antenna bandwidths received from optimal condition have 0.015 GHz (CSRRs on Patch) and 0.040 GHz (CSRRs on Ground plane).

CONCLUSION

In this article, CSRRs is etched on Microstrip Antenna Patch and Ground plane so that Microstrip Antenna Patch and Ground plane dimension is changed to be a smaller. It can be seen when its Patch width and length are 85x65 mm, Ground plane width and length are 137x130 mm. After CSRRs is etched on Patch, its Patch dimension reduce about 79x57 mm or reduce to 18.5 % and Ground plane reduce about 113x110 mm or 30.2%. Furthermore, Microstrip Antenna that is added of CSRRs on its Ground plane making its Patch lessen about 71x59 mm or 24.1% and 23.16% for its Ground plane. Moreover, antenna bandwidth for Conventional Microstrip antenna is 0.025 GHz, increasing to 0.040 GHz when CSRRs is etched on Ground plane but decreasing to 0.015 GHz when CSRRs is on its Patch.

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