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ANALYSIS OF GEOMETRY CHANGES TO THE ISOLATION ON THE MICROSTRIP BRANCHLINE COUPLER

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Keywords: Branch line Hybrid Coupler, Isolation, Radar.

ABSTRACT

In this research, Microstrip Branch line Coupler based simulation will be carried out with each input and output impedance of 50Ω. where has a different shape (geometry) but has the same dimensions, one is H shape junction and the other is J shape junction. Coupler is a passive multiport device that each port can be the entry point or exit point of the wave. The material used is Epoxy, and works at a frequency of 3.0 Ghz, and can be applied to the duplexer used in pulse radar antenna systems. First, using the initial parameters from the calculation results there was a shift in the working frequency of the desired VSWR value ≤ 1.5 and the desired coupling factor of -3 dB. For coupler simulation, CST 2019 software is used. The most influential coupler simulation results are the isolation value for H shape junction S_{14} = -44.79 dB and J shape junction -52,296 dB. Other parameters J Junction Return loss -30,725 dB, insertion loss -3.5926 dB, Factor coupling -3.42 dB. While the value of vswr is = 1. 036, for the H junction value can be seen in the table.

Keyword : Branch line HybridCoupler, Isolation, Radar.

I.INTRODUCTION

Branch line hybrid coupler (BLC) is a telecommunications device that plays an important role in various applications in microwave devices such as butler matrix systems, balanced mixers, balanced amplifiers, and power combiners / dividers [1]

Basically, BLC has 3 basic elements, namely patch, dielectric substrate and ground plane. In addition to microstrip antennas with a square patch shape usually consists of several elements, L indicates the length of the patch, W indicates the size of the patch

width, t indicates the size of the thickness of the patch, and h indicates the size of the thickness of the dielectric substrate [2].
Branchline Coupler can divide the power equally and produce a different output phase 90^o without having to phase shift again [1]. To differentiate the two phases of the signal at one of the power distribution ports, a transmission of λ / 4 was added as a phase slider. In fact, this phase slider will reduce the signal so that the output and the two ports will be of different magnitude. [3]. The performance of BLC is determined by 4 parameters namely: Coupling factor, insertion loss, return loss, and isolation

.In [4] a hybrid3-dB circuit or branch line coupler is used as a separator between the transmitter and receiver, the branchline coupler is the main part of the duplexer, while the duplexer is part of the antenna on the pulse radar. because on this type of radar only has one antenna to send and receive signals on the same antenna [4]. The pulse radar operates in the S band frequency. This duplexer has the ability to isolate the signal sent and the signal received. [2] The quality of this duplexer is determined by the isolation value of the BLC, a good isolation value is the one that has the smallest value. Therefore, a duplexer must be designed that can isolate perfectly between Tx and Rx[6]

Conventional BLC has an isolation value <-20 dB [6] with an isolation value of this magnitude at high frequencies that cannot be used because there are many signals from different phase angles. to overcome the above carried out modifications to the shape and size of the conventional branchline [5]

BLC which is designed in microstrip, has the following advantages: low cost, is a complete circuit on a substrate and is suitable for integration of integrated microwave circuits. the design and realization of BLC largely determine its performance [7]. One parameter that can be used as a reference to show a performance [8] is the S-parameter (scattering parameter). In general, the S-parameter is defined by incident waves and reflected waves [9]. The principle uses 2-port circuit analysis with several terms including S_{11} and S_{22} (reflection coefficient), S_{14}(isolation), and S_{21} (insertion loss). The numerical index of the term indicates the numbering of the observed ports where the first numbering is the output port and the second numbering is the input port. So S_{11} shows the comparison between reflected waves at port 1 and incoming waves at port 1, as well as S_{22}, S_{12}, and S_{21}. To obtain a good BLC performance, it is determined how the designing process and the right realization.

Therefore it is necessary to carry out measurements and research in more depth to produce BLC which has good performance. Various techniques have been proposed to improve the isolation value, one of which is proposed to reduce the odd mode phase velocity of a microstrip coupled-line with a dielectric overlay material. to reduce the difference in phase velocity [10]

In Another approach,In [11] two capacitance diodes are added to the hybrid circuit which are used as tunning to get the working frequency of 866 MHz, In [12], a realization of a 180 ± hybrid that has a cascade structure with two parallel coupled line couplers. With a dielectric constant of 3.5,, and a thickness of 1.5 mm. a loss tangent of 0.003 and known isolation value is -28 dB

Microstrip antennas are widely used in telecommunications systems. Antennas that use microstrip-based materials can be found in radar systems, satellite communications, or even in GPS systems (Global Positioning System). The simplest form of a microstrip antenna consists of a radiating element (patch) on one side, while on the other side there is a groundplane [11]. Between the patch and groundplane there is dielectric material. ordinary microstrip antenna which consists of a pair of parallel conductor layers separated by a dielectric medium or known as a substrate. In this arrangement, the upper conductor layer or "patch" functions as a radiation source where electromagnetic energy travels along the edge of the patch side into the substrate [12]. The lower conductor layer acts as a perfect reflecting ground plane, returning energy back through the substrate to free space [13].

The selection is based on the desired material characteristics for optimal power at a certain frequency range. General specifications include dielectric constant values, dissipation factor (loss tangent), and thickness [8]. Dielectric constant values between $2.2 < \varepsilon r < 12$ are used for operating frequencies from 1 to 100 GHz. Therefore it is possible with proper manipulation of the substrate, such as the use of the EBG (Electromagnetic Band Gap) structure, which will improve the characteristics of the microstrip antenna. Microstrip antennas are widely used in telecommunications system applications. Microstrip antenna has the advantages of small dimensions, low prices and easy [9]. However, this antenna has shortcomings such as narrow bandwidth, small gain, and low efficiency. The radiation properties of microstrip antennas can be improved by providing a partial ground plane

Radar is one of the technologies being developed in Indonesia, because the use of radar is needed in Indonesia which consists of various islands. Antennas that can support technology or radar devices are microstrip antennas. The reason for using microstrip antennas is that they are low profile, easy to operate, are not heavy, and do not require large costs. But the disadvantages of microstrip antennas are the small gain achieved and the small bandwidth [5]. Where the antenna needed for radar applications requires a relatively wide bandwidth, it is necessary to design an antenna that can produce a wide bandwidth for the radar application

Radar consists of an antenna system, a motor stator as part of the antenna drive, a power supply down converter that functions to convert the RF signal to IF [10] The development of radar (Radio Detection and Ranging) is currently growing rapidly. Besides being integrated into the air traffic guidance system, radar is also used to guide marine traffic as a portable coastal radar. Portable coastal. Radar has an advantage in the form of convenience for monitoring coastal areas by moving locations according to the observational data to be obtained

Radar (Radio Detection and Ranging) is an electromagnetic wave system, which is useful for detecting, measuring distances, and making a map of objects such as airplanes, various motor vehicles and weather information [14]. Radio waves or signals emitted from an object can be captured by the radar then analyzed to find out the location and even the type of object. Although the received signal is relatively weak, radar can easily detect and strengthen the signal [7]. Radar generally operates by spreading limited electromagnetic power inside an antenna dish which aims to capture signals from objects passing through the catchment area [10]. When an object enters the antenna catchment area, the captured signal will be forwarded to the center of the radar system and will be processed until the object will later appear on a monitor or display. [11]

Microstrip antenna as one of the microwave antennas which is used as a radiator in a number of modern telecommunications systems because it has a simple, small, lightweight, efficient, economical, and tends to be easier to make [5]

Antenna as part of a radar device that has an important role as a modifier of guided electric waves into free space waves . Antennas that can support technology or radar devices are microstrip antennas which have small dimensions with several other advantages [6]. Consideration of the use of microstrip antenna design is that microstrip antennas are not heavy (light), thereby reducing the cost of making tower antennas [13]. The microstrip antenna is of a low profile so it can make it easier for this antenna to be controlled in all places, but the microstrip antenna also has some disadvantages, namely, the gain achieved is small and the resulting bandwidth is small. The performance of the coupler is largely determined by how the process of designing and realizing is appropriate [14]. Therefore it is necessary to carry out measurements and research in more depth to produce a hybrid ring coupler that has good performance.

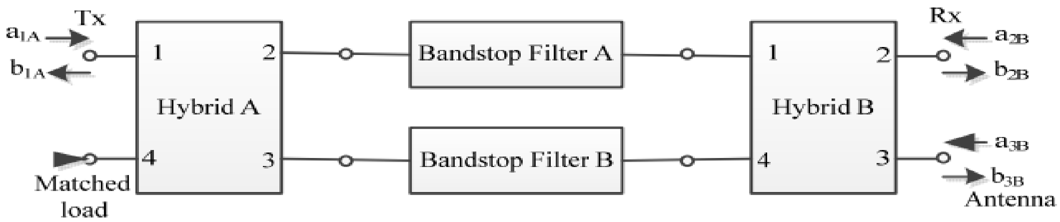

Fig 1. Duplexer

From Figure 1 it can be seen that the branch line coupler has four symmetrical ports. The first port is called the input port, the second and third ports are output ports and the fourth port is an isolated port. The second port is also called the direct or through port and the third port is also called the coupled port [12]. It can be seen that there are two impedance transmissions used in designing microstrip branch line couplers namely Z_o and Z_A where the magnitude of $Z_A = Z_o / \sqrt{2}$.

Furthermore, this impedance transmission is converted into units of length and width for its application to the microstrip.

II.DESIGN

BLC is designed at a frequency using FR-4 substrate (Efoxy) with a relative permittivity value of 4.6 and thickness (h) of 1.6 mm, copper thickness of 0.035 mm. The geometrical shape of the branch line coupler that will be designed in this paper is shown in Figures 2 and 4. The branch line coupler consists of two series transmission lines connected by two branch lines. The simulation here aims to determine the antenna's performance before it is realized.

$$\boldsymbol{\lambda}g = \frac{c}{f \times \sqrt{\varepsilon r}} \qquad (3.1)$$

$$\boldsymbol{\lambda}g = \frac{3 \times 10^8}{(3 \times 10^9) \times \sqrt{4{,}6}} = 0{,}04612 \text{ m} = 46{,}63\text{mm}$$

Quarter wavelengthwasobtained

$L = \frac{\lambda g,}{4} = \frac{46{,}63}{4} = 11{,}66\ mm$, then the long AP=BP=CP =11,66 mm

Quarter wavelengths indicate the length of the impedance transmissions for 50 Ω and 35 Ω (L50Ω and L35Ω) or L50Ω = L35Ω = L.

The magnitude of the ratio w / d

To determine the width can be calculated [5] :

$$\frac{W}{d} = \frac{8_{e^a}}{e^{2a} - 2} \qquad (3.2)$$

where Zo = 50 Ω :

$$a = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right) \qquad (3.3)$$

then :

$$a = \frac{50}{60}\sqrt{\frac{4{,}6 \ +1}{2}} + \frac{4{,}6 \ -1}{4{,}6 \ +1}\left(0.23 + \frac{0.11}{4{,}6}\right)$$

$$a = 1{,}56$$

$$\frac{W}{d} = \frac{8_{e^a}}{e^{2a} - 2}$$

$$\frac{W}{d} = \frac{8_{e^{1{,}61}}}{e^{2.1{,}61} - 2}$$

$\frac{W}{d} = 1{,}845$, d=1,30 mm,

$w = 1{,}845 x$ 1,6 = 2,952 mm

$AL = BL = 2,952\ mm$

If zo = 35,35 Ω

$$a = \frac{35{,}35}{60}\sqrt{\frac{4{,}6 \ +1}{2}} + \frac{4{,}6 \ -1}{4{,}6 \ +1}\left(0.23 + \frac{0.11}{4{,}6}\right) = 1{,}149$$

$$\frac{W}{d} = \frac{8_{e^{1{,}149}}}{e^{2.1{,}149} - 2} = 3{,}173$$

$$w = 3{,}173\ x\ 1{,}6 = 5{,}078\ mm$$

the value of transmission line AP = BP =CP = 11,66 mm,
AL = BL = 2,952 mm dan CL = 5.078 mm

III.STRUCTURE

The basic design of the normal hybrid coupler is shown in Figure 2. The input transmissions on the hybrid coupler are divided into series and shunt arms. The distance between arms is ¼ λ where the input transmision has a characteristic impedance of Z_0, while the impedance of the series arm is 2 Z_0 / ohm and the impedance of the shunt arm is Z0 ohm

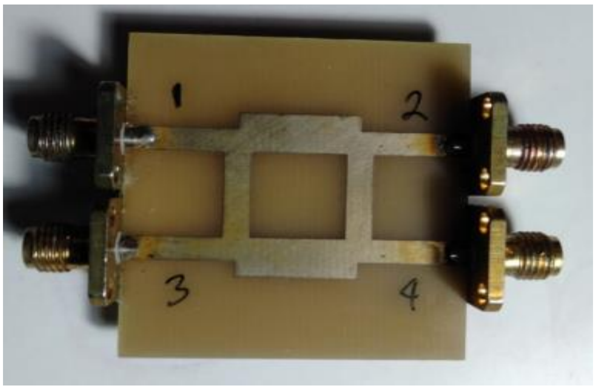

Fig 2.Branchline Coupler H Shape junction

Based on Figure 2 and the formula (1) then the transmission widtheach arm on a normal hybrid coupler can be calculated. In the shunt arm which has an impedance value of Z_o = 50 Ω, the transmission width is 3 mm and the series arm has an impedance value of $Z_o / \sqrt{2}$ = 35 Ω

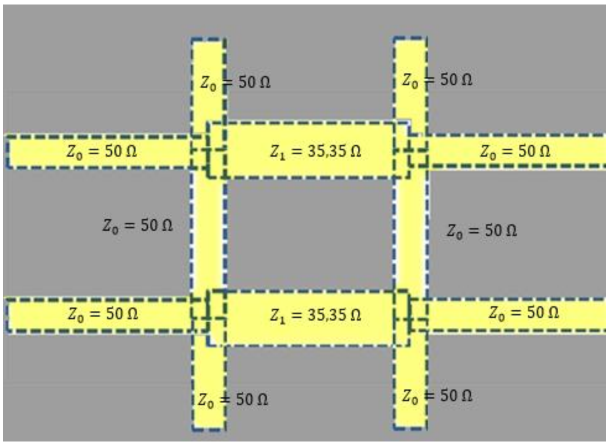

Fig 3. H shape Junction with Impedansi

With these results it means that the width of the transmission in the series arm is equal to the distance between the series arms, where the distance ¼ λ to 2.55 GHz is 29.5 mm

The working principle of the Quadrature Hybrid coupler, namely output [S21] and coupling [S31] has divided power. The phase difference of 90 o depends on the length λ / 4, when [S21] the length is λ / 4 and when at [S31] the length is 2λ / 4 so the difference between [S21] and [S31] is λ / 4 which is equal to 90o

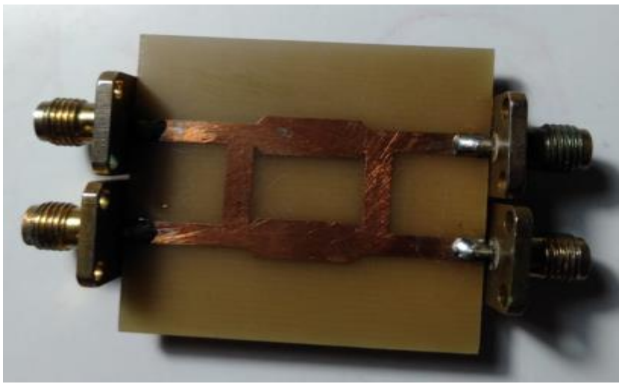

Fig 4. Branchline Coupler J Shape Junction

For isolation in the circuit above has a phase difference of 180o ie when [S41] is length λ / 4 and when from port 1, to port 2, and to port 3 and finally to port 4 has a length of 3λ / 4 so it has a difference of 2λ / 4 or 180o so that they eliminate each other, so ideally isolation is 0

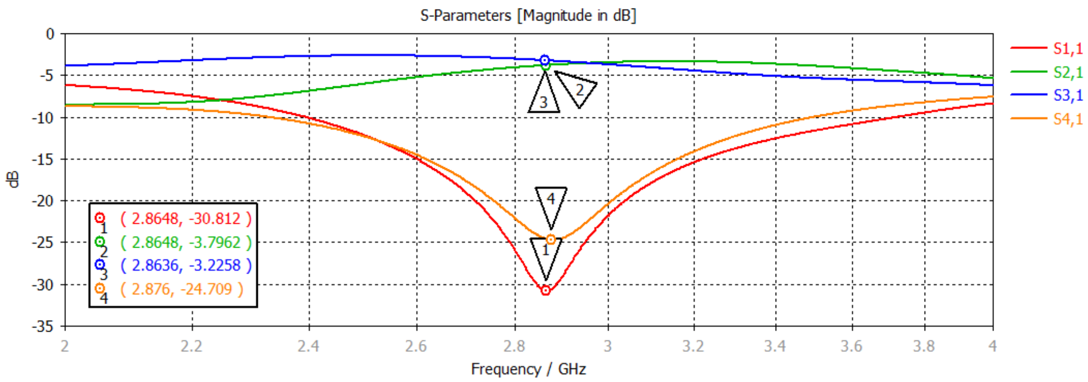

Fig 5. SimulaionResul From Calculation H Junction

It can be seen in the picture above the shifting working frequency which should be 3 GHz shifted to 2.86-2.87 GHz

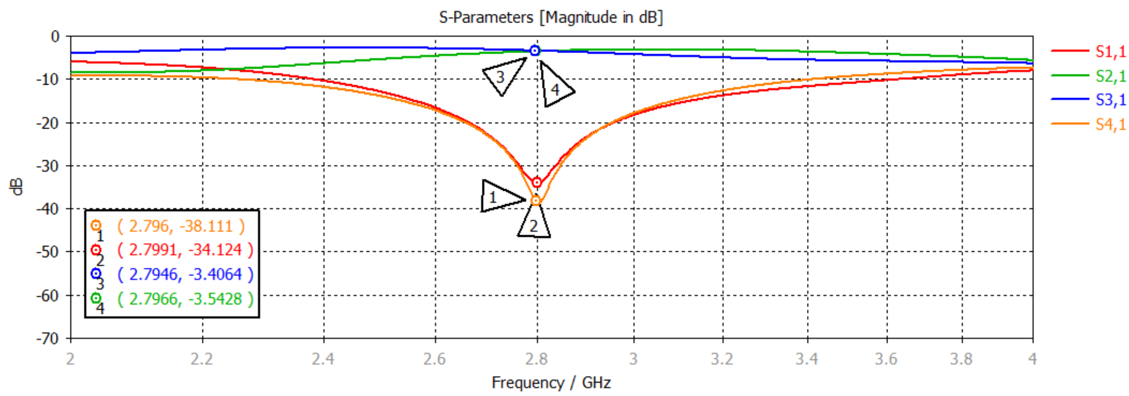

Fig 6. SimulaionResul From Calculation J Junction

Seen in the picture above the shifting working frequency which should be 3 GHz shifts to 2,796-2.99 GHz. This is caused due to the accuracy of rounding the calculation of the numbers when making calculations. How to get the ideal isolation by arrangement impedance length and λ/4 because each transmission has a different length

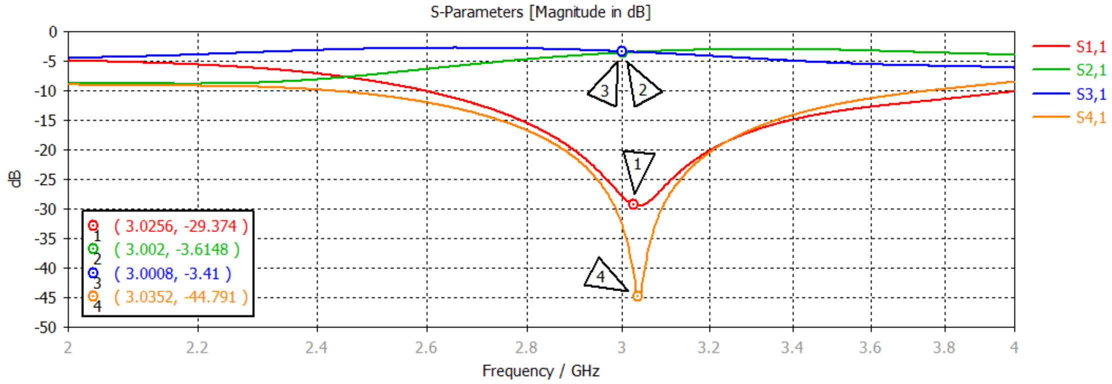

Fig 7. Simulation Result Branch Line Coupler H Shape Junction

From above figure It can be seen S.11 = -29.374 dB,S12= -3.6148, S13=-3.41 dB, S14= -44.791 dB

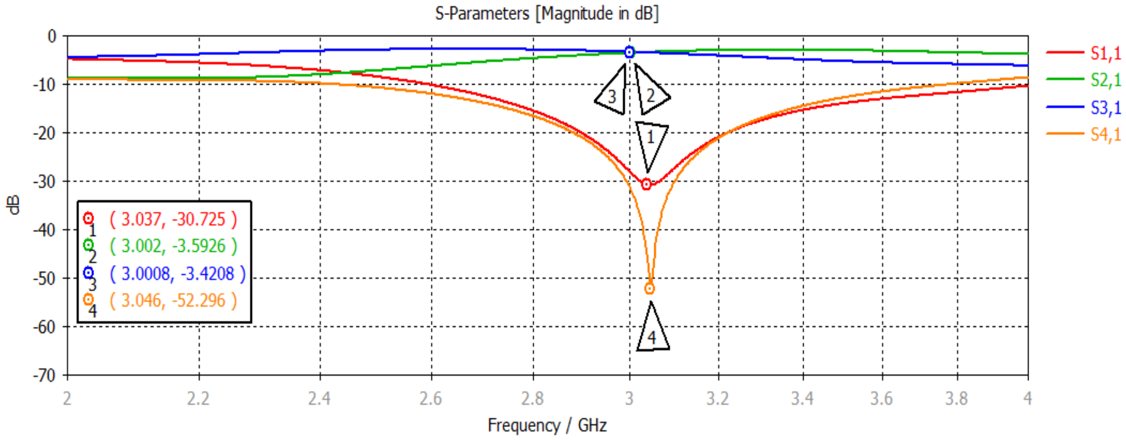

Fig 8. Simulation Result Branch Line Coupler J Shape Junction

From figure 8, It can be seen S.11 = -30.725 dB, S12= -3.5926 dB, S13=-3.4208 dB and S14= -52.296 dB

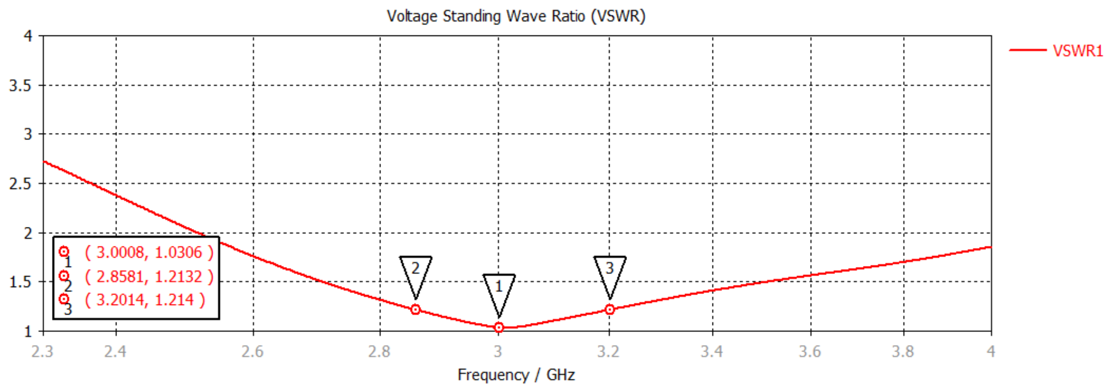

Fig 9. Simulation Result of Vswr H Shape Junction

From above at figure 9 the value of vswr 1,0306 .and bandwidth 3.2014 -2.858 = 0.3434 GHz = 343,4 MHz, The value of vswr is 1.0367 while the bandwidht value = 3.2006 -2.8437=0.3569 GHz = 356.9 MHz , parameter S11, which represents the ratio of the power sent to the load to the power reflected back. The value of VSWR is 1 to ∞. The higher the VSWR value, the higher the mismatch and the lower the VSWR value, the more matching between the transmission and the load.

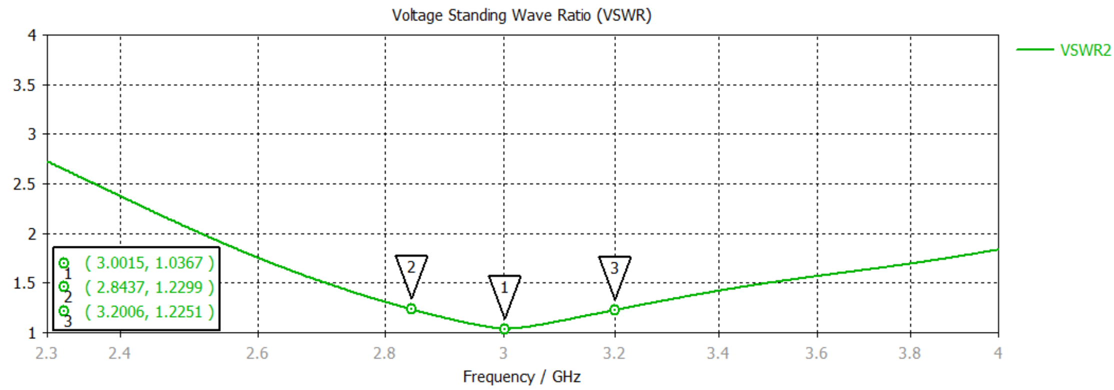

Fig 10. Simulation Result Branch Line Coupler J Shape Junction

From above at figure 10 the value of vswr is 1,0306 .and bandwidth 3.2006 -2.8437 = 0.3569 GHz = 356,9 MHz

Conditions that do not match between the antenna and the transmission line can affect the reflection coefficient and SWR, where the more does not match between the antenna and the transmission line, the greater the reflection coefficient value, causing the SWR value to increase as well.

Measurement of return loss aims to find out the value of return loss at each frequency and find out how much power Many factors cause the shift in the working frequency of this antenna. Among other things coaxial losses, connectors and in terms of soldering, or the effect of differences in the value of εr at the time of simulation and that is used during fabrication. When simulating the substrate antenna using FR4 epoxy with a relative permittivity of 4.3 (the default that exists in the CST software) while the FR4 epoxy fabrication used has a relative permittivity of 4.65 lost on the load. Meanwhile, antenna impedance measurement done to find out the antenna impedance.

Tabel1. The size of the transmission line from the calculation results

Parameter	From calculation (mm)	From Simulation
AP	11.66	10.37
BP	11.66	10.30
CP	11.66	10.25

AL	2.952	2.80
BL	2.952	2.80
CL	5.078	5.070

table 1. length of transmission line from calculation A (AP) = BP= CP= 11.66 mm, width of transmission line A (AL) = BL= 2,952 mm, and width of transmission line C (CL) =5.078 mm .Length of transmission line from simulation A (AP) = 10.37 mm, BP=10.30 mm, CP= 11.25 mm, width of transmission line A (AL) = BL= 2,80 mm, and width of transmission line C (CL) = 5,070 mm

Tabel 2

Parameter	H shape Junction	J shape Junction
Return Loss (S11)	-29.374	-30.725
Insertion Loss (S12)	-3.6148	-3.5926
Coupling(S13)	-3.41	-3.4208
Isolation (S14)	-44.791	- 52.296
Vswr	1.0306	1.0367
Bandwidth (MHz)	343.4	356.9

Where are the abbreviations as follows:
AP, BP, CP=length of the transmission line A, B and C (mm)
AL, BL, CL= width of the transmission line A, B and C (mm)

IV.CONCLUSION

This research was conducted to find out how the geometry or shape changes in the two forms of Branch Line Coupler in the form of H Junction and J Junction on performance such as Return Loss, Insertion Loss, Factor Coupling, isolation values, vswr and Bandwidth. Changes in geometry greatly affect the value of insulation where the J shape junction is much better insulation value of -52 dB. Overall J Junction form is better performance where the return loss value $S_{.11}$ = -30,725 while the H shape $S_{.11}$ = -29,374 there is a difference of 1,424 dB

REFERENCES

[1] Pozar , D. M., Microwave Engineering, 2nd edition, Wily, New York, 1998

[2] Mukesh KUMAR, SK. Nurul ISLAM, “Design of Miniaturized10 dB Wideband Branch Line CouplerUsing Dual Feed and T-Shape Transmission Lines “ Dept. of Electronics & Telecommunication Engineering, Indian Inst. of Engineering Science & Technology, Shibpur-711103, Radio Engineering, VOL. 27, NO. 1, APRIL 2018

[3] Nadera N a j ib Al-Areqi, and Kok Yeow You, “Miniaturization of Three- Section Branch - Line Coupler UsingDiamond - Series Stubs Microstrip LineIsolation-Improved Coupler Based On Feed-forward Technique” , Progress I n El ec tro

m a g n eti c s Res ea rch C, Vo l . 8 2 , 1 9 9 – 2 0 7 , 2 0 1 8

[4] Muhammad Yaser dan Untung Priyanto, "Antena Medical Implantable Communication System Menggunakan HFSS 13.0" Jurnal Ilmiah Teknik Elektro, Vol. 1 7, No. 1 , Agustus 201 9, Hlm. 1 5 – 29

[5] Yudi Barnadi, Yanyan Agustian, Fuad Hasan," Improvement Branch Line Coupler Isolation in S Band Frequency" Improving isolation of slot-coupled directional couplers,"Widyatama University, Electrical Engineering Department, Indonesia

[6] AParul Dawar, "Analysis of Microstrip Branchline Coupler using Sonnetlite , Dept. of ECE, GGSIPU University, Guru Tegh Bahadur Institute of Technology, New Delhi, India IJECT Vol. 3, IssuE 1, Jan. - MarCh 2012

[7] Yudi Barnadi, M. Rozahi Istambul, Ajeng Mayang K S, Savitri galih, "Isolation Optimization Method on the Coupler,"Universal Journal of Electrical and Electronic Engineering 6(2A): 46-52, 2019

[8] Shailendra Singh1, Ashok Kumar 2, Kapil Kumar3, Raghbendra Singh Tomar4,, "Extended Port Dual Band Planar Branch Line Coupler , International Journal of Emerging Technology and Advanced Engineering", Volume 4, Special Issue 1, February 2014

[9] Mashury Wahab, Yussi Perdana Saputera, and Yuyu Wahyu, "Research and Development of Transportable Coastal Radar at S-band Frequency with FM-CW Technology for Supporting C4ISR Research Centre for Electronics and Telecommunications of The Indonesian Institute of Sciences (RCET-LIPI) , 3rdInternational Conference on Electric and Electronics (EEIC 2013)

[10] M. Moradian, " Improving isolation of slot-coupled directional couplers,"Electronic Letters 11th, vol.51 No.12,pp 914-915, June 2015

[11] Sebastin. Fajardo, Arturo. Paez, "Characterization of the Branchline and RatRace ideal hybrids through their meritparameters,"Rodríguez, CarlosDepartment of Electronics Pontificia Universidad Javeriana (PUJ) Bogotá,Colombia

[12] Lukas W. Mayer, Arpad L. Scholtz. "CircularlyPolarized Patch Antenna with High Tx/Rx-Separation." Vienna University of Techonology IEEE.2009.

[13] Park, M. J. and L. Byungje, "Coupled line 180 hybrid coupler," Microw. Opt. Technol. Lett.,Vol. 45, No. 2, 173{176, Apr. 2005

[14] N. Zheng1, L. Zhou1, and W.-Y. Yin2 "A Novel dual Band shaped Branch Line Coupler with stepped impedance stubs, Progress In Electromagnetics Research Letters, Vol. 25, 11-20, 2011