Design and build a digital TV receiver double biquad antenna for the Greater Malang region and its surroundings

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***Abstract*— Many types of antennas can be used for digital TV receivers; in this article we try to design a double biquad antenna. This is due to a simple form, easy to make, a wide beamwidth. In designing a digital TV receiver for the Malang area, an STB device is needed, so that analog TV can still receive digital TV broadcasts. In this study, the antenna is made of copper wire, each side length: ¼ λ , with a working frequency: 650 MHz. In order to match the impedance of the 75Ω coaxial cable with the antenna, a balun 4:1 is required. The research place is in the Polinema Telecommunications laboratory. The test results show that the lowest return loss (RL) occurs at a frequency of F=605 MHz, namely RL: -17.8 dB, for a frequency of F=650 MHz, the magnitude of RL: -11.3 dB. The large VSWR antenna at the working frequency F: 650 MHz is 1.46. So that it can be said that it has fulfilled the antenna parameters, namely VSWR < 2. It means that there is a power loss of less than 10%. The largest antenna gain occurs at a frequency: 400 MHz namely: 14.85 dB,. While the average gain of the antenna is 2.21 dB. The antenna radiation pattern is omni directional. The double biquad antenna is very good for use as a digital TV receiver for the Greater Malang area, either without using a reflector or with a reflector.**

***Keywords*— Digital TV, double biquad antenna, Return Loss, VSWR, Gain.**

I. INTRODUCTION

Antenna is a tool for transmitting and receiving communication signals in the form of radio waves / electromagnetic waves. Guided waves flowing along a transmission line are radiated as vacuum waves. The transmission area between the guided wave and the vacuum wave can be called the antenna [1]. The biquad antenna is a double-loop square loop dipole antenna with a flat panel reflector with a slightly longer side width than the dipole circuit. thereby acting as if it were an infinite field. The location of the reflector is not far from the dipole which aims to dampen radiation towards the back. With a small distance between the antenna and reflector, this arrangement will result in a greater forward radiation gain. This antenna consists of 2 square loop antennas combined into one, so that the biquad antenna has 2 loops, [2], [3].

Whereas the Double Biquad antenna has previously been implemented as a telemetry system at a frequency of 915 MHz [4], as a ground segment device at a frequency of 433 Mhz [5], and applied at a frequency of 2.4 GHz [6], [7], as well as antenna design. Microstrip for Wlan [8]. Furthermore, this research will try to design a double biquad antenna that is used to get digital TV broadcasts in the Malang area at UHF frequencies. The antenna has a simple shape, the sides are parallelograms, the beamwidth is wide and it is easily made from copper wire.,and the dual biquad antenna has a fairly high gain. So it is good enough to be used as a digital TV receiver for the poor and surrounding communities. Given the Ministry of Communication and Informatics regulations regarding migrating or turning off analog TV broadcasts to digital TV, so that analog TV can still view TV broadcasts, a DVB T2 STB (Set Top Box) device is needed. The research was carried out in the Polinema Telecommunications Laboratory and was used as a practicum learning material on transmission lines for Telecommunications students

II. METHOD

The following antenna planning flow chart is shown in Fig. 1:

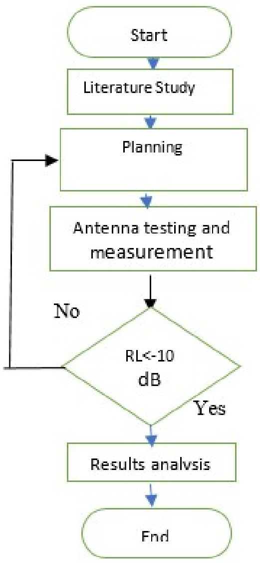

Figure 1. Antenna planning

The dimensions of the Biquad Antenna are a combination of 2 quad antenna elements which are assembled into an antenna element. The length of the biquad antenna driver element is 1λ where the wavelength value λ can be formulated as follows:

$$\lambda = c / f \quad (1)$$

Where : λ= Wavelength (m),
c = Speed of light waves (3 x 10^8 m/s) ,
f = UHF antenna working frequency (Mhz)

For the design of the UHF TV biquad antenna driver element, it is obtained from the wavelength λ which is folded to form a parallelogram, so that the length of each side becomes 1/4λ

For planning the size of the biquad antenna design can be described as Fig. 2, [2], [3] :

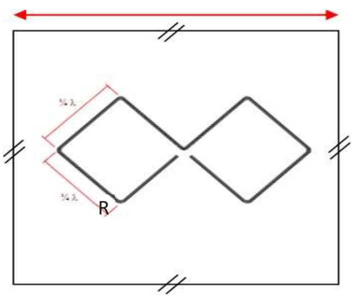

Figure 2 Biquad Antenna Design Size

To plan a biquad antenna assuming the working frequency of the UHF antenna is f = 650 MHz. Then the wavelength can be calculated as follows:

λ =c/f=0.4615 m = 46.15 cm

Then the length of each side of the biquad antenna is ¼ λ = 11.54 cm. As for the calculation of the double biquad antenna, the principle is the same as the biquad antenna. The design of the double biquad antenna can use the calculator software shown in Fig. 3 [10],

Double BiQuad Antenna Calculator

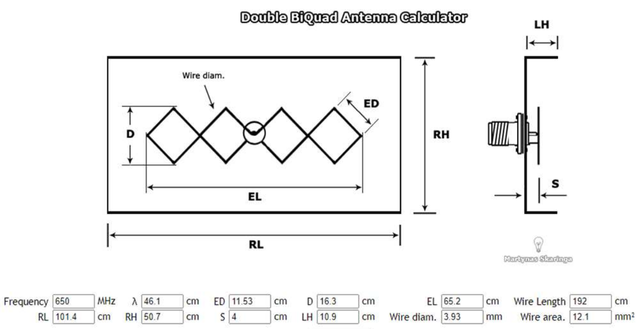

Figure 3. Double biquad antenna design

For the design a double biquad antenna at a frequency of f= 650 MHz. With software calculator [10] as follows:

Wavelength = 46.1 cm
Length of each side ED = 11.53 cm
Antenna width D = 16.3 cm
EL antenna length = 65.2 cm
RH (reflector) width = 50.7 cm
Length of RL (reflector) = 101.4 cm
Wire diameter = 3.93 mm
Wire length = 192 cm
Area of wire = 12.1 cm2
Distance S = 4 cm

The design form of the double biquad antenna can be shown as shown in Figure 4, [10].

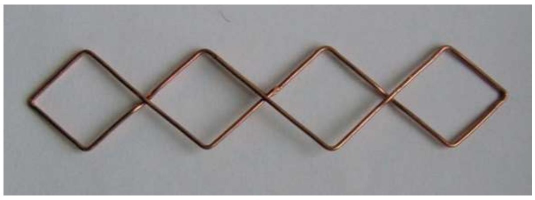

Figure 4. The shape of the double biquad antenna

III. RESULTS AND DISCUSSION

A. Antenna Return Loss and VSWR Measurement

In antenna theory, Return Loss (RL) has a standard value to meet the feasibility of using an antenna, namely -10 dB, or the same as VSWR 2. To find out the Return Loss and VSWR values, you must first know the value of the frequency level. The following is the preparation and testing of the antenna to determine the Return Loss and VSWR values. The Return Loss measurement method is shown in Fig. 5, [11].

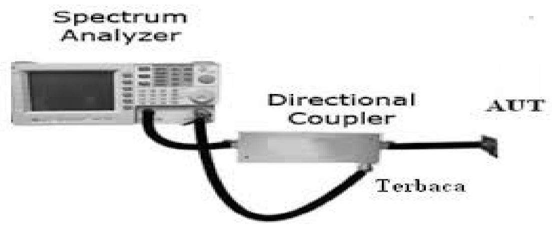

Figure 5. Antenna Return Loss Measurement method

To calculate the RL, value, you can use the following formula [11] : RL = Read level - DC attenuation (-20 dBm) - Ref level. Moderate to calculate VSWR by using the formula [12]:

$$VSWR = \frac{V\max}{V\min} = \frac{1+|\Gamma|}{1-|\Gamma|} \quad (2)$$

The test for the return loss of the double biquad antenna is shown in Fig. 6.

Figure 6 Testing the return loss of a double biquad antenna

To measure the reference level value, it is used in calculating the Return Loss and VSWR values. The frequency of 605 MHz is the resonant frequency obtained when testing the antenna with a measured reference level of -22.3 dBm, for a frequency of 650 MHz with a reference level of -22.8 dBm and for a frequency of 750 MHz with a reference level of -23.5 dBm. While the results of measuring the return loss of the double biquad antenna are shown in Fig. 7

Figure 7. Results of measuring the return loss of a double biquad antenna

From the results of the RL measurement, it can be explained as follows:

1) Marker 4 is the lowest resonant frequency, which is 605 MHz, with a value of test level : -60.2 dBm

2) Marker 6 is the upper resonant frequency at a frequency of 750.6 MHz with test level value : -60.6 dBm

3) Mark 5 is the working frequency of the double biquad antenna, namely f = 650 MHz with test level value : -54.1 dBm

From the measurement results of the return loss as shown in Figure 7, it can be seen that the lowest return loss values are indicated by marks 4 , and 6, namely frequency f= 605 MHz and f=750.6 MHz. So the large return loss of the antenna is as follows:

For f = 605 MHz,

RL = reading point (test level) – Ref – Att.directioner couple

RL = - 60.2 dBm – (- 22.3 dBm) – (-20 dB)

RL = - 17.8 dB.

While the frequency is 750.6 MHz, the antenna's return loss is:

RL = reading point (test level) – Ref – Att.DC

RL = - 60.6 dBm – (- 23.5 dBm) – (-20 dB)

RL = - 17.1 dB

And for the antenna working frequency f = 650 MHz is

RL = -54.1 dBm –(-22.8 dBm) – (-20 dB)

RL = - 11.3 dB

Meanwhile, the return loss price at f=650 MHz, f=605 MHz and f=750 MHz is still smaller than – 10 dB, so it can be said that the antenna has suitable for use as a TV receiver.

After the Return Loss is known, it can be calculated the value of the reflection coefficient used for the calculation of the VSWR. To calculate the magnitude of the reflection coefficient Γ using the following formula , [10], [11] :

RL = 20 log Γ ,

Γ = anti-log RL/20

For f=605 MHz , the value of the reflection coefficient Γ is

Γ = anti log (-17.8/20) = anti log (- 0.89)

Γ= 0.128

From the results of the calculation of the reflection coefficient Γ, so the VSWR value is:

VSWR = (1+0.272)/(1-0.272) = 1.272/0.872 =1.46

And for f=750.6 MHz, the value of the reflection coefficient is Γ= anti log (-17.1/20) = anti log (- 0.855) = 0.139

From the results of the calculation of the reflection coefficient, the VSWR value is:

VSWR = (1+0.139)/(1-0.139) = 1.139/0.861 = 1.32

From the VSWR calculation, it shows that the VSWR value is < 2, meaning that the double biquad antenna can be declared or has met the criteria for being eligible as an antenna receiver. Because VSWR < 2 , it means that the reflected power back to the source is quite small, less than 10%. so that it can be said that the antenna has met the criteria of a digital TV receiving antenna.

B. *Antenna Gain Measurement*

The purpose of this test is to determine the magnitude gain of the double biquad antenna.

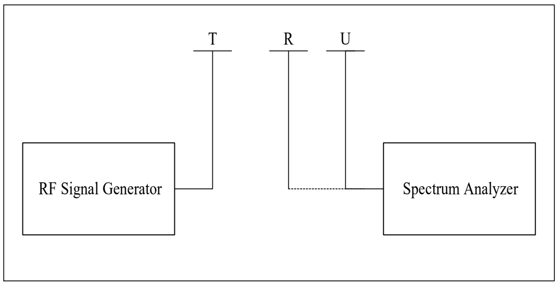

Figure 8. Block Diagram of Antenna Gain Measurement

Antenna gain can be determined by comparing the reception level of the antenna being tested by AUT (Antenna Under Test) with the level of the reference antenna [15]. The reference antenna used as a comparison is an antenna that has the intensity of a standard antenna, namely an $\lambda/2$ dipole antenna. The calculation of the gain with the following formula [11], [12] : $Gain = LevelAUT - Levelref + 2{,}15\ dB$

Antenna Gain Measurement block diagram is shown in Fig. 8. while the antenna gain measurement results are shown in Table 1.

TABLE I
ANTENNA GAIN MEASUREMENT

No	Freq (MHz)	P-ref. (dBm)	P-test (dBm)	Gain (dB)
1	400	-58.3	-45.6	14.85
2	425	-44.1	-47.4	-1.15
3	450	-45.4	-48,8	-1.25
4	475	-52.8	-47.4	7.55
5	500	-55.2	-48.7	8.65
6	525	-44.6	-47.1	-0.35
7	550	-47.5	-50.7	-1.05
8	575	-46.2	-48.1	0.25
9	600	-48.8	-47.2	3.75
10	625	-49.2	-48.5	2.85
11	650	-48.9	-48.1	2.55
12	675	-42.3	-41.7	2.75
13	700	-38.3	-40.6	-0.15
14	725	-41.5	-44.2	-0.55
15	750	-47.3	-44.1	5.35
16	775	-40.6	-44.6	-1.85
17	800	-41.3	-44.7	-1.25
18	825	-47.3	-49.7	-0.25
19	850	-46.6	-46.5	2.25
20	875	-43.2	-44.3	1.05
21	900	-44.8	-44.5	2.45
		Big Gain average :		2.21 dB

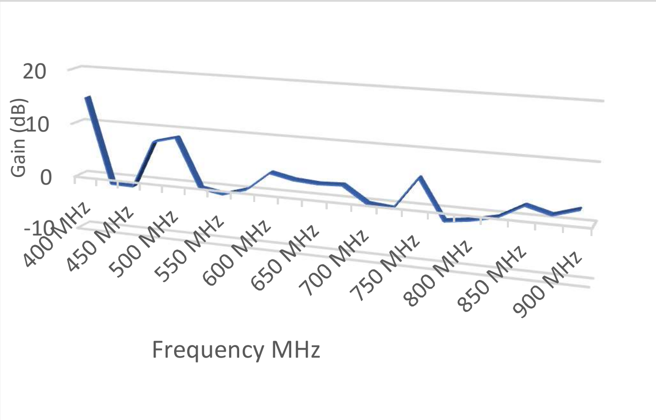

Figure 9. Gain graph of double biquad antenna

From Table 1, the antenna gain measurement shows that the highest gain occurs at a frequency of f= 400 MHz, namely: 14.85 dB. The second largest gain is at a frequency of f= 500 MHz, which is 8.65 dB. The third largest gain occurs at a frequency of f=475 MHz, namely: 7.75 dB and the fourth largest gain occurs at a frequency of f= 750 MHz, which is 5.35 dB. While the average gain of the antenna from a frequency of 400 Mhz to 900 Mhz is 2.21 dB.

C. Antenna Radiation Pattern Measurement

The radiation pattern test aims to determine the shape of the radiation pattern of the double biquad antenna. The radiation pattern test is carried out using two antennas, namely the first antenna as a Tx transmitter which is connected to the Signal Generator. Furthermore, the Rx receiving antenna to be tested (AUT) has been connected to the Spectrum Analyzer. Then by rotating the tested antenna Rx every 10° from 0° to 360° using a rotator. The results of the measurement of the radiation pattern for the horizontal can be shown in Table 2. Then from these measurements normalization is carried out and then the results of the antenna radiation pattern are shown in Fig. 10.

TABLE II
MEASUREMENT OF RADIATION PATTERN

Angle (°)	Measurement at f=750 MHz	
	Level power (dBm)	Normalized (dB)
0	-44.1	-7.5
10	-44.8	-3.5
20	-45.9	-2.9
30	-45.7	-5.3
40	-47.5	-3.7
50	-47.8	-1.9
60	-48.2	-3.1
70	-45.7	-0.6
80	-44.6	-3.3
90	-43.5	-1.6
100	-45.1	-1.9
110	-45.6	-0.8
120	-46.8	-0.8
130	-47.5	-0.4
140	-45	-2
150	-42.1	-0.9
160	-40.6	-0.4
170	-39.7	-2.3
180	-42.7	-2.6
190	-44.8	-0.2
200	-43.1	-4
210	-41.9	-8.8
220	-42.1	-0.2
230	-42.8	-0.1
240	-43.9	-1.6
250	-45.4	-4.9
260	-46.4	-4.8
270	-55	-2.5
280	-51.7	-1.1
290	-52.6	-3.9
300	-56	-5.6
310	-48.5	-1.6
320	-44.8	-2.2
330	-45.3	-1.5
340	-46.3	-1.6
350	-48.2	-7.6
360	-45.3	-0.5

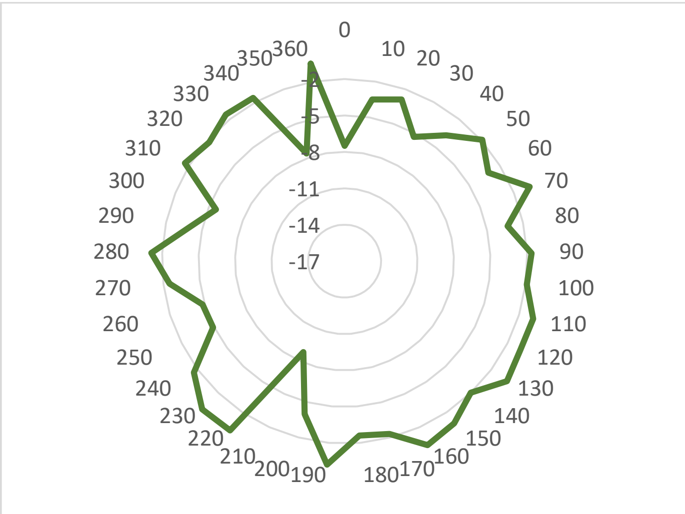

Figure 10. Polar Diagram of the double Biquad Antenna radiation pattern

From the results of Fig. 10 it can be stated that the radiation pattern of the double biquad antenna is close to omni directional. This means that almost all directions can catch TV broadcasts well.

D. Digital TV Receiver Results in Malang area

For TV receivers that are still analog, in order to receive digital TV. Then you have to use the STB-T2 tool. The results of digital TV receivers for Malang and surrounding areas are shown in Fig. 11 to 16. The tests were carried out at the Polinema Telecommunications laboratory. First, assume a digital TV receiver (indoor) with an antenna both without and with reflector.

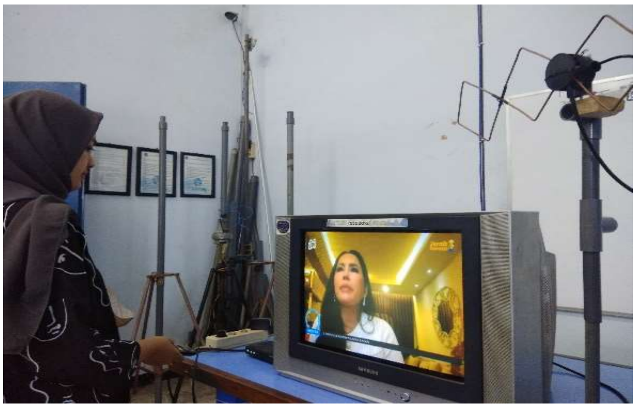

Figure 11. Image Result for JTV SBY Digital TV station

Figure 12. Image Result for Trans-7 Digital TV station

Figure 13. Strong results and signal quality of Kompas digital TV

Figure 14. Image Result for TVRI Channel-3 Digital TV station

Figure 15. Image Result for Gajayana Digital TV station

Figure 16. Strong results and signal quality of Gajayana's digital TV

IV. CONCLUSION

The lowest return loss (RL) of the double biquad antenna occurs at a frequency of f:605 MHz, namely RL: -17, 8 dB and f:750 MHz, namely RL:-17.1 dB. While the working frequency of the antenna is 650 MHz, namely RL: -11 dB. So it can be said that the double biquad antenna has met the standard of a antenna parameter, namely RL < -10 dB. The VSWR value at the antenna working frequency f:650 MHz is 1.56 (VSWR < 2). So that there is a match between the impedance of the coaxial cable and the antenna. Then a balun 4:1 is used which is in the form of a toroid with an air core. For the measurement of the highest gain occurs at a frequency: 400 MHz namely: 14.85 dB, the second largest gain is at a frequency: 500 MHz which is 8.65 dB, the third largest gain occurs at a frequency: 475 namely: 7.75 dB and the fourth largest gain occurs at the frequency: 750 MHz which is 5.35 dB. The average gain of the antenna is 2.21 dB with 21 measurement samples at a frequency of f= 400 MHz to 900 MHz with a ½ λ dipole antenna as a reference antenna.. So that All digital TV transmitting stations can be received well by analog TV receivers using STB-T2 devices, in the Greater Malang area including stations: JTV Surabaya, TV Gajayana Malang, RCTI, TV Indosiar, TV Kompas, TVRI National TV, TV SCTV, TV Magna Channel, Metro TV and so on, both without using a reflector or with a reflector, all can be received clearly of with a strong signal above 80% and a digital TV transmitter signal quality is almost 100%. for further development biquad antenna arranged in an array.

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