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Peripheral Slits Microstrip Antenna Using Log Periodic Technique for Digital Television Broadcasting

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Abstract

This paper proposed a new design of log periodic microstrip antenna using peripheral slits for dgital video broadcasting applications in DKI Jakarta. Applying peripheral slits can be reduced the dimension of antenna up to 62.6% with its dimension 400 mm x 150 mm using 4 patches in different frequencies. The patches are one another connected using log periodic technique. The measurement results showed that the antenna was operating at frequency ranges of 450 MHz to800 MHz with impedance bandwidth of 350 MHz, VSWR ≤ 2 and return loss ≤ -10dB. The proposed antenna could receive 11 DVB stations with high definition quality pictureand only channel number 24, such as RCTI, Global TV and MNC TV can not reveive signals as expected.

Keywords*: digital video broadcasting, peripheral slits, log periodic, microstrip antenna*

1. Introduction

Digital television broadcasting is a technology that can not be avoided by any country in the world. The development of digital television broadcasting technology becomes a global demand which nearly each country has and in the process towards the transition from analogue to digital broadcasting systems. The advantages of digital television broadcasting such as high definition picture quality, sound system are of sharper and better efficient allocation of radio frequencies [1].

Digital television broadcasting standard has been also developed from Digital Video Broadcasting-Terrestrial (DVB-T) to Digital Video Broadcasting - Second Generation Terrestrial (DVB-T2). The Indonesian Government has adopted the regulation on standard fixed and not paid Digital Terrestrial Television Broadcasting (free-to-air); known as DVB-T2 digital terrestrial television broadcasting free-to-air standar in Indonesiaas manifestated with the Minister of Communications and Information Technology Regulation No. 05/PER/M.KOMINFO/2/2012 [2]. Beside this regulation, the digital television system in Indonesia also follows the Regulation of Minister of Communication and Information Technology Number 23/PER/M.KOMINFO/11/2011 on the Master Plan of Radio Frequencies for Television Broadcasting in the Digital Terrestrial Radio Frequency Bands between 478 MHz-694 MHz [3].

Several studies related to the producing of digital television receiver antennas with certain expected characteristics were the use of slot technique that produced a dimension of (204.8 x 160.6) mm with omnidirectional radiation pattern and VSWR ≤ 2 [4], research already done by [5] using 5 pieces of element patch log periodic that produced dimension of (169.4 x 113.8) mm, and producing a 2 x 2 array antenna with dimension of (515 x 300) mm [6]. Another research done by [7] proposed a linear array antenna.

In addition to the above as well findings there were some researches conducted using log periodic technique, such as have been done by [8-9] using log periodic dipole array antenna fed by coaxial probe. Another research done by [10] using rectangular patch antenna fed by microstrip line, while [11] was also done using rectangular patch antenna fed by coplanar waveguide. The research done by [12] used elliptical patch antenna fed by microstrip line.

Peripheral slits were able to produce a compact antenna with smaller dimension. This technique could reduce microstrip patch antenna up to 33% of its original size. Therefore

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peripheral slits technique is one method to optimize the microstrip antenna dimension [13]. Peripheral slits is a method of miniaturization techniques microstrip antenna by using some slits on patch antenna.

Based on previous studies results it can be inferred that the peripheral slits method can reduce antenna size. Therefore this paper proposed a new design of peripheral slits microstrip antenna using log periodic technique fed by microstrip line.

2. Antenna Design

The design of the proposed antenna is made based on one layer substrate with relative permitivity (***εr***) of 4.3, substrate thicknes (***h***) of 1.6 mm and loss tangent (***tan δ***) of 0.0265. The dimensions of the rectangular patch antenna are given by the equations as follows.

$$\boldsymbol{W} = \frac{\mathrm{c}}{2fr\sqrt{\frac{(\varepsilon r+1)}{2}}} \quad (1)$$

$$\boldsymbol{\varepsilon e} = \frac{(\varepsilon r+1)}{2} + \frac{(\varepsilon r-1)}{2}\left(\frac{1}{\sqrt{1+12h/_{w}}}\right) \quad (2)$$

$$\boldsymbol{Leff} = \frac{\mathrm{c}}{2fr\sqrt{\varepsilon e}} \quad (3)$$

$$\boldsymbol{\tau} = \frac{f1}{f2} \quad (4)$$

By embedding a stub at the microstrip line, the matching condition can be well achieved and the value of return loss and VSWR can be improved by adjusting the length and width of the stub. Having several iterations related those parameters, afterward peripheral slits was embedded to reduce the dimension of the patch antenna.

The antenna can be applied at various frequencies as presented by Table 1 for Digital Television Broadcasting application in DKI Jakarta Region.

Table 1. DVB Frequencies for DKI Jakarta Region

No	Patch	Channel	Frequency
1	RCTI, Global TV, MNC TV	24	498 MHz
2	Metro TV	32	562 MHz
3	TV One, ANTV and Sport One	34	578 MHz
4	BeritaSatu TV (BSTV)	36	594 MHz
5	Transcorp (Trans TV, Trans 7) and Kompas TV	40	626 MHz
6	SCTV, Indosiar, and O Channel	44	658 MHz
7	RTV	48	690 MHz

All of those frequencies in Table 1 are classified into four groups of patches as shown in Table 2. These all four patches are combined using log periodic technique which is shown in Figure 1. The patches size and dimension, as shown by Figure 1, are differ one to another which are given by Table 3. The length of microstrip line of log periodic antenna is Z_L of 332.6 mm.

Table 2. Frequency of Each Patch Antenna

No	Patch	Frequency
1	Patch 1	580 MHz
2	Patch 2	630 MHz
3	Patch 3	670 MHz
4	Patch 4	720 MHz

Table 3. Dimension and Size of Log Periodic Peripheral Slit Microstrip Antenna

Patch 1	W1 = 77.4 mm	L1 = 89.5 mm	Y1 = 27.8 mm	Ls1 = 24 mm
Patch 2	W2 = 77 mm	L2 = 80 mm	Y2 = 28 mm	Ls2 = 24 mm
Patch 3	W3= 65 mm	L3 = 73 mm	Y3 = 23 mm	Ls3 = 14 mm
Patch 4	W4= 58 mm	L4 = 65 mm	Y4 = 23 mm	Ls4 = 14 mm

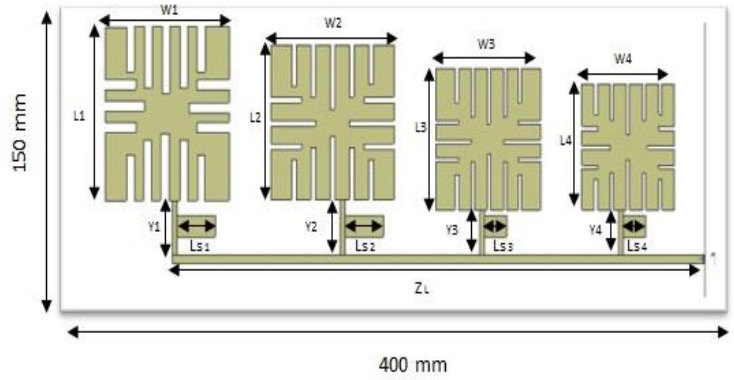
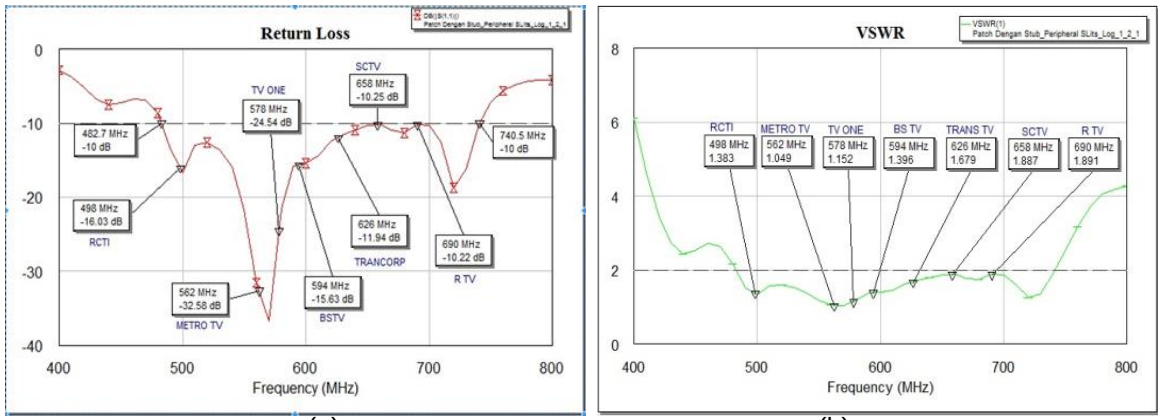


Figure 1. Peripheral Slits Microstrip Antenna Using Log Periodic Technique

3. Results and Analysis

Return loss and VSWR value can be obtanined after having several iterations by adjusting the width and length of the patch antenna and also the dimension of the slits. To produce the best value of return loss and VSWR can be achieved by controlling the length of the microstrip line and the stub length, and the outcome of return loss and VSWR can be seen in Figure 2.



(a) (b)

Figure 2. Results from (a) Return Loss Value and (b) VSWR Value

The overall iteration are summarized in Table 3 for the parameters of the proposed antenna and in Table 4 for the return loss value. Its can be seen the return loss results of ≤ -10 dB in the range of 482.7 MHz to 740.5 MHz can be achieved at the third iteration by varying the parameters of the width of the second patch (W2), the length of the first patch (L1) and the length of the second patch (L2).

Table 3. Iterations of the parameters antenna

Iterations	Parameters (mm)							
	W1	W2	W3	W4	L1	L2	L3	L4
1	77.4	70	65	58	83.5	80	73	65
2	77.4	73	65	58	83.5	73	73	65
3	**77.4**	**77**	**65**	**58**	**89.5**	**80**	**73**	**65**

Table 4. Return Loss Results

Iteration	Return Loss (dB)						
	C.24	C.32	C.34	C.36	C.40	C.44	C.48
1	-11.6	-25.9	-17.8	-28.5	-11.7	-9.3	-13.1
2	-6.3	-15.7	-14.6	-14.3	-21.7	-12.7	-12.7
3	**-16.0**	**-32.6**	**-24.6**	**-15.6**	**-11.9**	**-10.3**	**-10.2**

The fabrication of the proposed microstrip antenna design was done after the simulation of the third iteration process. FR4 Epoxy substrate and SMA connector which have 50 Ohm impedance value are used in this fabrication and the fabrication result can be seen in Figure 5.

Figure 5. Fabrication of microstrip antenna design

After the fabrication, the measurements of return loss and VSWR have been done in the laboratory as seen in Figure 6 and Figure 7. From Figure 6 it can be sen that the proposed antenna can work at the range frequency between 498 MHz to 690 MHz for Digital Television Broadcast application in DKI Jakarta Region.The impedance bandwidth of the measurement result is 350 MHz (450 MHz–800 MHz) compared to 257.8 MHz (482.7 MHz 740.5 MHz) from the simulation process. It can be seen that the impedance bandwidth from the proposed antenna is increased up to 35.76%.

From Figure 7, VSWR ≤ 2 from the proposed antenna can be achieved in the frequency range 470 MHz to 740 MHz.

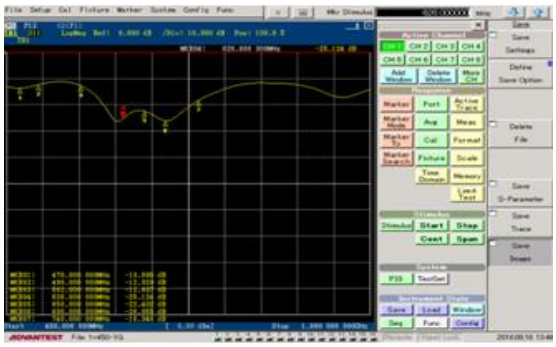


Figure 6. Measurement of Return Loss

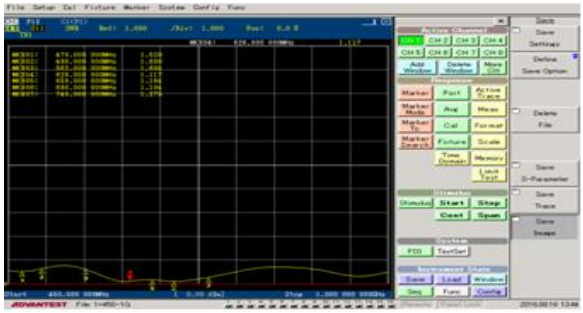


Figure 7. Measurement of VSWR

The results of return loss and VSWR of the simulation and measurement are tabulated in Table 5 and the graphic of the comparison are seen in Figure 8 and Figure 9 below. From Table 5 it can be seen that all of the return loss value is ≤ -10 dB and also the VSWR value is ≤ 2. With this results indicated that all of the channel of DVB stations can receive the signal.

Table 5. Comparison Simulation and Measurement of Return Loss and VSWR

Channel	Working Frequency	Return Loss Simulation Results (dB)	Return Loss Measurement Results (dB)	VSWR Simulation Results	VSWR Measurement Results
24	498 MHz	-16.0	-12.3	1.38	1.64
32	562 MHz	-32.6	-12.7	1.05	1.59
34	578 MHz	-24.6	-15.0	1.15	1.43
36	594 MHz	-15.6	-18.9	1.40	1.24
40	626 MHz	-11.9	-25.1	1.68	1.12
44	658 MHz	-10.3	-22.4	1.89	1.14
48	690 MHz	-10.2	-26.0	1.89	1.1

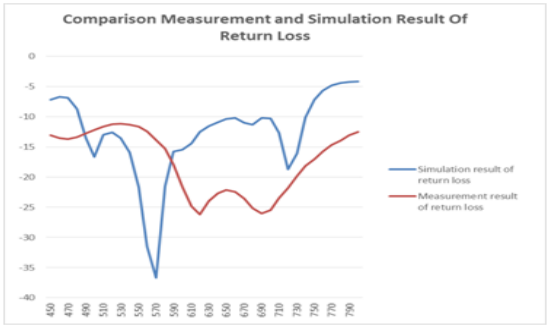


Figure 8. Comparison Measurement and Simulation Results of Return Loss

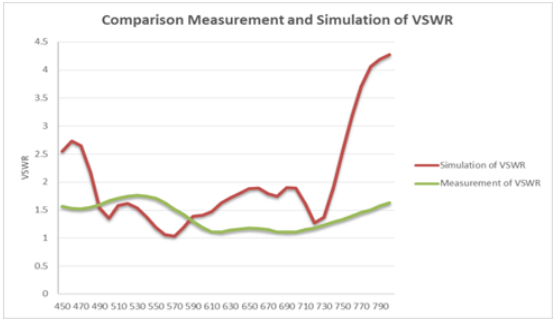


Figure 9. Comparison Measurement and Simulation Results of VSWR

Figure 10 shown the radiation pattern from the proposed antenna design with Half Power Beamwidth (HPBW) of 120^0 and its indicated that the radiation pattern is broadside.

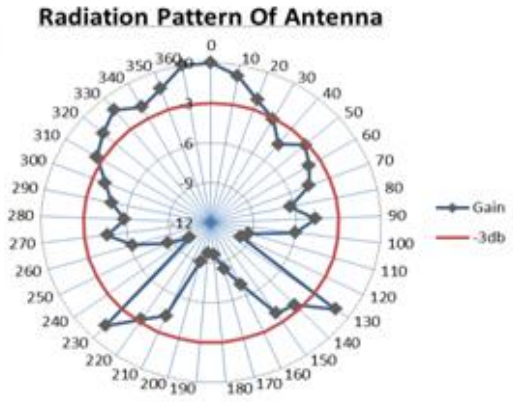


Figure 10. Radiation pattern with HPBW 120^o

After the measuring process is finished, the antenna was applied for DVB application for DKI Jakarta and Figure 11 showed the diagram block for the inspection process of the antenna design. Yaggi antenna as seen in Figure 12 is used as comparison to analyze the perfomance of the proposed antenna design.

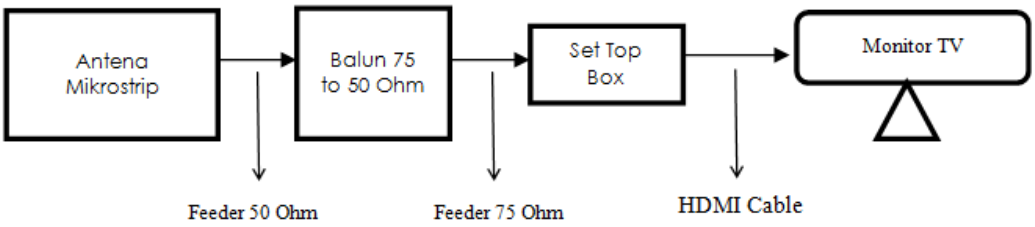


Figure 11. Diagram block of the inspection process

It can be inferred from Figure 11, that matching impedance efforts are advisable to be done between 50 Ohm antenna impedance and the 75 Ohm digital television receiver through its set top box adapter. It is in order to get good quality of related signal receiving sub system by minimizing its reflected signals.

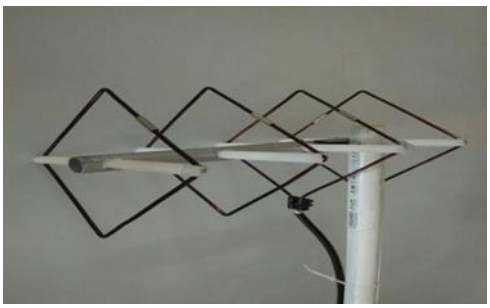


Figure 12. Antenna Yaggi model

The results which is presented by Table 6 below showed that the proposed antenna design can receive 11 DVB application stations with high definition quality picture as seen in Figure 13, as compared to Yaggi antenna that can receive 15 stations.The proposed antenna design could not received the signal only for channel 24, such as RCTI, Global TV, and MNC TV, because gain of the antenna design is 11.62 dB compare with gain of the Yaggi antenna of 13 dB.

Table 6. The Received Frequency Between Yaggi Antena and Microstrip Antenna

No	TV Station	Yaggi Antenna	Microstrip Antenna
1.	RCTI, Global TV, MNC TV	Received	Not Received
2.	Metro TV	Received	Received
3.	TV One, ANTV and Sport One	Received	Received
4.	BeritaSatu TV (BSTV)	Received	Received
5.	Transcorp (Trans TV, Trans 7) danKompas TV	Received	Received
6.	SCTV, Indosiar, and O-Channel	Received	Received
7.	RTV, Jakarta Globe	Received	Received

Figure 13. Quality of picture received from the proposed microstrip antenna

4. Conclusion

The proposed of peripheral slit microstrip antenna using log periodic technique with return loss value of ≤ -10 dB and VSWR value ≤ 2 can be achieved by adjusting the dimension of the patch antenna and the slits and also the length of the feed line and the stub length. Using peripheral slits technique the dimension of the patch antenna can be reduced up to 62.6% and can produce a compact antenna with smaller dimension. Using log periodic technique can increase the bandwidth of the antenna and the impedance bandwidth from the measurement is 350 MHz compared to 257.8 MHz from the simulation process. The proposed antenna could receive 11 DVB stations with high definition quality picture and only channel 24, such as RCTI, Global TV, and MNC TV can not reveived the signal.

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