Design and Analysis of Circular Polarized Receiver Antenna as Video Stabilizer in UHF Television

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ABSTRACT
In analog terrestrial television systems received video disturbances often occurs. Polarization parameters and radiation patterns are important things that are rarely considered in television antenna systems. In addition, the *Pulse synchronize* parameter on the CVBS signal can be a reference for the ongoing video stability. Researchers conducted an experiment by designing and analyzing the characteristics of a circular polarized Skew Planar Wheel (SPW) antenna and comparing it with a Dipole antenna which has linear polarization. Both of these antennas have omnidirectional radiation and are implemented parallel as analog terrestrial television receiver antennas at UHF frequencies. The test is performed by rotating the antenna tilt angle at 0º, 45º, 90º horizontally and 45º and 90º vertically to the direction of the transmitter. The lowest VSWR at the center frequency of 642 MHz SPW antenna is obtained 1.5 while for Dipole 1.04. The maximum S-parameter value of SPW is -13.86 dB while the Dipole is -34.03 dB. The maximum Gain of the SPW antenna is 1.38 dB while the Dipole has a greater maximum Gain of 2.21 dB. Based on the test results, it is known that the SPW antenna can help stabilize the amplitude value of the *Pulse synchronize* parameter to remain around -300mV at all test angles, this makes the video displayed on television stable. Whereas for the Dipole antenna there are disturbances at the testing angle 90º horizontally and 45º, 90º vertically. In addition, there is no *ghost image* when using SPW antenna compared to Dipole.

Keywords
Antenna, SPW, Dipole, *Pulse Synchronize*, Polarization.

1. INTRODUCTION
Currently analog terrestrial television communication systems via UHF frequency are still widely used. One of the devices that greatly affects broadcast quality is the antenna. Antennas play an important role in the transmission and reception of electromagnetic waves wirelessly in both analog and digital television transmission systems. Important parameters that are rarely considered in television antenna systems are the polarization and radiation pattern. Polarization is the direction of the electric field vector to the direction of propagation which is mainly divided into two, namely linear and circular [1]. Meanwhile, the radiation pattern is a directional pattern of emission or reception from the antenna itself which is generally divided into directional and omnidirectional [2].

In terms of receiving analog television signal waves, the antenna that is commonly used is the yagi antenna, which is characterized by a directional radiation pattern and linear polarization. However it is not suitable for placement in some situations such as when the polarization and radiation pattern of the receiving antenna is not correct and matches the state of the transmitter [1], such as if the television receiving antenna is at a point where there are various television transmitters around it. In addition, the determination of polarization orientation also considers natural aspects [3]. The use of antennas with circular polarization and directional radiation patterns has been done by [4] which showed that Helical antennas have a long beam distance. However, as it is known that if the antenna direction does not match the position of the beam, various disturbances will arise in the ongoing television display.

Disturbances in analog television broadcasting systems, such as image shaking, scrolling until there is a shadow image effect or what is known as *ghost images* and other problems. These disturbances occur when the polarization and radiation patterns of the receiving antenna do not match the direction of propagation emitted by the transmitting antenna. One of the important parameters in broadcast image stability is viewing the Composite Video Baseband Signal (CVBS) television. The main parameter in CVBS is the *Pulse synchronize* amplitude which must be fixed at -300mV [5]. Research related to the stability of television images was carried out as in studies [6] and [7] which explained the importance of the *pulse synchronize* form in the CVBS signal as the stability and clarity of the display of analog television broadcast images.

Skew Planar Wheel is known as a transmitter and receiver antenna at the frequency of 5.8GHz which is commonly used in FPV video systems in drones (UAV). As in Research [8] which carried out the design and optimization of the Skew Planar Wheel antenna, it was shown that this antenna is known to have the ability to stabilize video images even when the UAV is maneuvering with various directions of polarization angles and radiation patterns. In addition, this antenna is known to have the multipath interference rejection function [9]. There is an antenna that is similar to the Skew Planar Wheel, namely the Cloverleaf antenna, the difference between the two antennas is only the number of leaves from the antenna. The Skew Planar Wheel antenna has 4 leaves and Cloverleaf has 3 leaves. There is research related to the Cloverleaf antenna [10] which states that modifying the angle of the Cloverleaf antenna to 55º has the potential to result in a wider bandwidth and higher gain.

Because of the principle of this idea, researchers conducted experiments and explorations by comparing an antenna with an omnidirectional radiation pattern with a Skew Planar Wheel antenna that has circular polarization and a linear polarized Dipole comparator antenna in terms of receiving analog terrestrial television broadcasts. This comparator is carried out to determine the effect of polarization of an antenna on the UHF frequency of the analog terrestrial television system regulated by KOMINFO Indonesia.

2. METHODOLOGY

All The general research procedure is as shown in Figure 1.

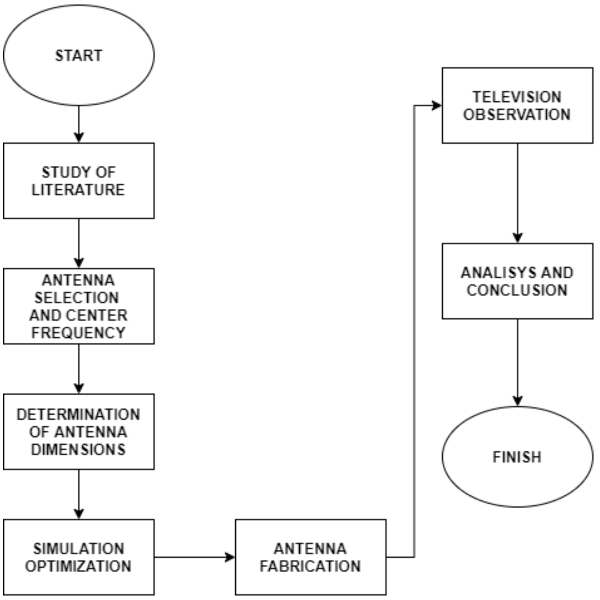


Figure 1. Research Flowchart

2.1 Literature Review

In theory, the formulas for determining the value of antenna parameters such as VSWR, S-Parameters, Radiation Pattern, Gain and Polarization respectively Refer to (1), (2), (3), (4), (5).

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} \quad (1)$$

$$a_r = -20\log|r| = -20\log\left(\frac{V_{refl}}{V_{forw}}\right) \quad (2)$$

$$Do \simeq -172.4 + 191\sqrt{0.818 + \frac{1}{HPBW(degrees)}} \quad (3)$$

$$G = \frac{4\pi\, U(\theta,\phi)}{Pin\ (lossless\ isotropic\ source)} \quad (4)$$

$$|R| = \frac{major\ axis\ length}{minor\ axis\ length} \quad (5)$$

$$R(dB) = 20\log|R| \quad (6)$$

In the VSWR parameter [11] Refer to (1), there is a coefficient Γ, namely the reflection factor. Meanwhile, the variable a_r [12] Refer to (2) is the S-Parameter. The Radiation Pattern formula for an antenna is [2] Refer to (3) which has a variable Half Power Beam Width (HPBW) angle, while the antenna Gain formula is [13] Refer to (4). Omnidirectional Polarization formula without minor lobe [14] Refer to (5) and (6).

The value and form of the *Pulse synchronize* in the CVBS signal at PAL television system are shown in Figure 2.

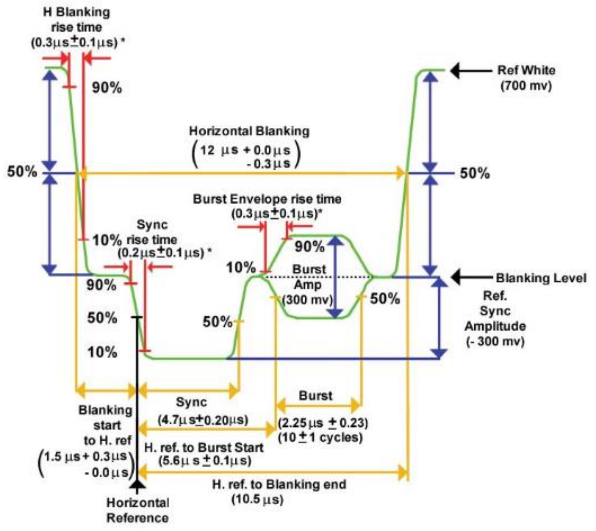


Figure 2. Pulse Synchronize PAL System [5]

Based on Figure 2, it is known that the ideal *Pulse Synchronization* in terrestrial analog television systems is with an amplitude value of -300 mV [5].

2.2 Antenna Selection and Center Frequency

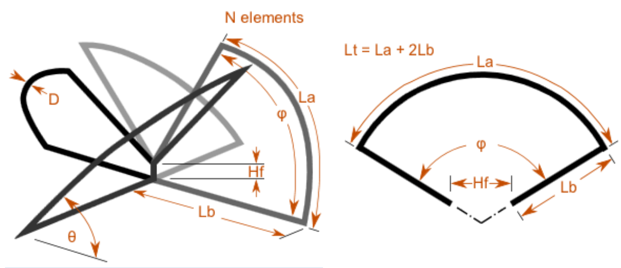
Based The type of antenna studied is Right Hand Circular Polarization (RHCP), which is a circular polarized antenna using a Skew Planar Wheel (SPW) antenna, while a linear polarization antenna is only used as a comparator using a Dipole antenna. Based on the Indonesian KOMINFO regulation [15], the frequency range of terrestrial analog television broadcasts in Indonesia is from 478 MHz to 806 MHz. Equation (7) is used for determining the center frequency of the antenna being designed.

$$Fc = \frac{478 + 806}{2} = 642\ MHz \quad (7)$$

So that the center frequency (Fc) obtained is at a frequency of 642 MHz.

2.3 Determination of Antenna Dimensions

Antena Skew Planar Wheel antenna and Dipole comparator antenna which are designed using copper wire with a diameter of 1 mm, were chosen because it can make easy in the fabrication process. Dimensional parameters of the Skew Planar Wheel antenna and the Dipole antenna are as shown in Figure 3 and Figure 4.



(a) (b)

Figure 3. Skew Planar Wheel (a) Whole Parameters Dimention and (b) One Parameter Dimention

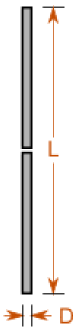


Figure 4. Dipole Antenna Dimension Parameters

The dimensional parameters of the Skew Planar Wheel antenna and the Dipole antenna shown in Figure 2 and Figure 3 refer to the calculation of the formulas described [10], Equation (8), (9), (10) are the calculation of dimensions of Skew Planar Wheel antenna to get (Lt), (La)/2 and (Lb)/4.

$$(Lt)\ \lambda = \frac{c}{f} = \frac{3 \ x\ 10^8\ m/s}{642\ MHz} = 46.728\ cm \qquad (8)$$

$$(La)\ \frac{\lambda}{2} = 0.23364\ m = 23.364\ cm \qquad (9)$$

$$(Lb)\ \frac{\lambda}{4} = 0.11682\ m = 11.682\ cm \qquad (10)$$

Meanwhile, the calculation results of the formula for the Dipole comparator antenna have been described [16]. For length λ/2 Dipole antenna Refer to (11) and Feeding Gap between the two antenna wire Refer to (12).

$$L = \frac{143}{f\ (MHz)} = \frac{143}{642} = 22.274\ cm \qquad (11)$$

$$g = \frac{L}{200} = \frac{0.22274}{200} = 0.111\ cm \qquad (12)$$

The both of antennas will be used as analog television broadcast receivers, therefore use a coaxial cable with a channel impedance Z = 75 Ω.

2.4 Simulation Optimization

The simulation was carried out using the CST Studio Suite 2020 software to be used as a reference in the antenna fabrication process. At this stage, the calculation results of the antenna dimensions that have been obtained in the previous stage will be optimized. The purpose of optimization is to obtain optimal and appropriate yield parameters from the antenna designed and to make easy in the fabrication process. Optimized the dimensions of the Skew Planar Wheel antenna and the Dipole antenna as shown in Figure 5.

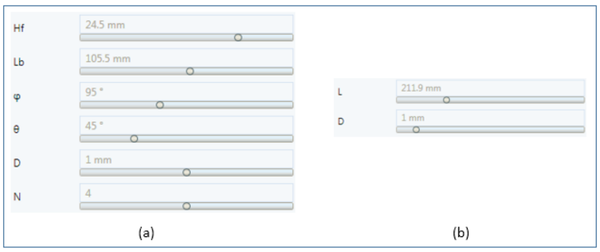
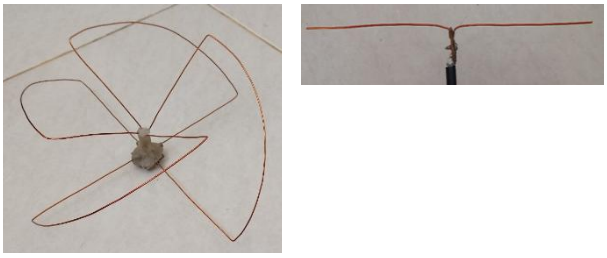


Figure 5. Value of Dimensional Optimization Parameters (a) Skew Planar Wheel and (b) Dipole

2.5 Antenna Fabrication

1 mm copper wire is used in the fabrication process of this antenna. Making the antenna is done by cutting the copper wire and forming the design of the two antennas in accordance with the dimensions of the optimization results in the CST Studio Suite 2020 software. By referring to the dimensions of the optimization results, it is expected that the yield parameters in the field practice of the two antennas are in accordance with what has been simulated. The results of the fabrication of the two antennas can be seen in Figure 6.



(a) (b)

Figure 6. Fabrication Results (a) Skew Planar Wheel and (b) Dipole

The Skew Planar Wheel antenna and the Dipole comparator antenna are placed parallel to and next to each other to make observations about the various angles of the antenna to the direction of propagation of the transmitter.

2.6 Research Observation Techniques

The television observation stage is carried out by utilizing the two types of antennas as an analog terrestrial television broadcast receiver antenna. The observation equipment system is carried out as in Figure 7. Based on Figure 7, the two receiving antennas are connected to the Antenna In port on the RF to AV converter in turn using a 75Ω Coaxial cable. The RF to AV send a Composite Video Baseband Signal (CVBS) via the AV Out port. The CVBS signal that is generated will be continuously connected to the oscilloscope and the TV simultaneously. The goal is that every change in the video image displayed by the television, the CVBS signal can be detected by the oscilloscope used.

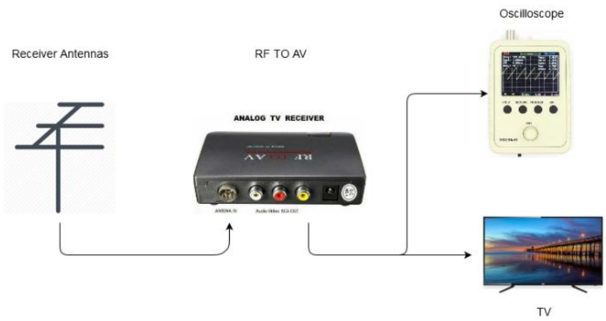


Figure 7. Research Observation System

Observations were made on two main things, namely the composite Television signal parameters obtained from the AV Out port and the image displayed by the television. In general, the description of the observations to be carried out is as shown in Figure 8.

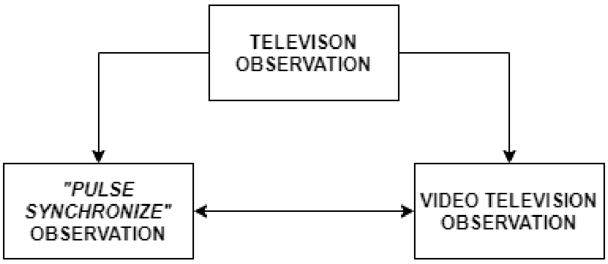


Figure 8. Television Observation

Pulse synchronize can be an important reference for getting a stable image on any video display on any monitor or television. In addition, observations were made of the images displayed on television during broadcasts. Observation of the display image is also carried out to determine the effect of other disturbances displayed on the television monitor such as *ghost images*.

In this block the Skew Planar Wheel and Dipole receiver antennas that are installed are rotated at an angle of 0º, 45º and 90º horizontally and 45º and 90º vertically to the transmitter as shown in Figure 9 and Figure 10. The rotation test of these angles is carried out to test the effect of the polarization and radiation pattern of the antenna designed to the stability of the ongoing broadcast video image.

(a) (b) (c)

Figure 9. Horizontal Rotation Angle (a) 0º, (b) 45º, (c) 90º

(a) (b)

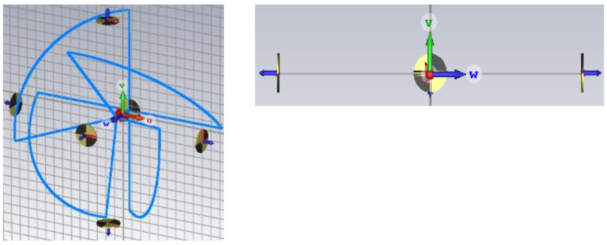
Figure 10. Vertical Rotation Angle (a) 45º dan (b) 90º

3. RESULTS AND DISCUSSION

Observation of this antenna is generally carried out in 2 stages, namely the parameter analysis stage of the results of the characteristics of the Skew Planar Wheel and Dipole antenna itself and the next stage of observation of the television. The parameter analysis stage of the Simulation Results of Skew Planar Wheel and Dipole antennas is carried out by analyzing the VSWR, S-Parameters, Radiation Pattern, Gain and Polarization parameters while the Television Observation Stage is carried out by applying the antenna as an analog television broadcast receiver with various test angles. In detail the observations made are as follows.

3.1 Simulation Results Parameters of Skew Planar Wheel and Dipole Antenna

The sketch form of the Skew Planar Wheel antenna and the Dipole comparator antenna are designed as shown in Figure 11.



(a) (b)

Figure 11. Antenna Sketch (a) Skew Planar Wheel Wheel and (b) Dipole

As shown in Figure 11 part (a) the shape of the Skew Planar Wheel antenna which is designed to have 4 leaves and each leaf has an angle of 45º this is done to get the desired circular polarization. Whereas in Figure 11 part (b) of the Dipole antenna is only a straight shape where the supply is in the middle of the antenna. Based on the parameters of the simulation results carried out, the VSWR of the Skew Planar Wheel and Dipole antennas can be seen in Figure 12 and Figure 13.

In Figure 12, the VSWR value obtained by the Skew Planar *Wheel antenna at the center frequency of 642 MHz is 1.509.* This VSWR value is obtained for the coaxial cable supply impedance, which is 75Ω. The VSWR value obtained is quite good considering that this antenna is used as a receiver and not as a transmitter which is very sensitive to the VSWR value which must be closer to the value 1. Whereas in Figure 13 the VSWR value of the Dipole antenna at the center frequency of 642 MHz is 1.04.

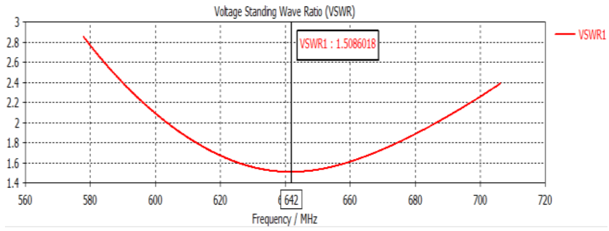


Figure 12. VSWR of Skew Planar Wheel

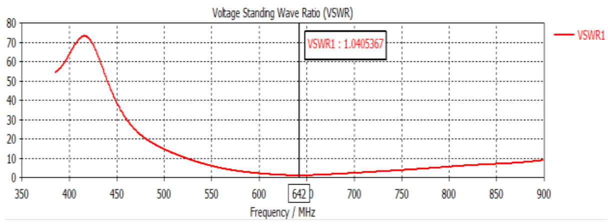


Figure 13. VSWR of Dipole

The S-parameter values obtained from these two antennas can be seen as in Figure 14 and Figure 15.

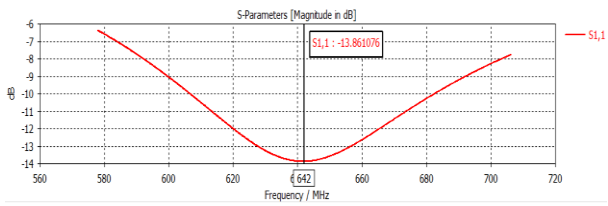


Figure 14. S-Parameter of Skew Planar Wheel

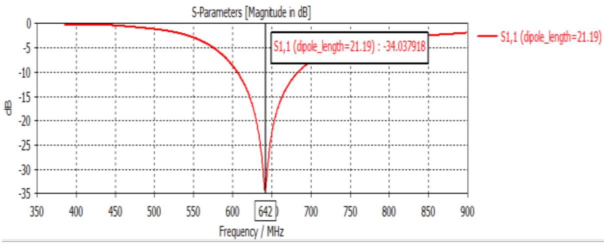


Figure 15. S-Parameter of Dipole

Based on Figure 14, it is known that the S-Parameter value of the Skew Planar Wheel antenna at the center frequency of 642 MHz is obtained -13.86 dB. Whereas for the Dipole comparator antenna as shown in Figure 15 the value is -34.037dB. The S-Parameter and VSWR values have a correlation with the channel input impedance, namely coaxial 75Ω. Radiation pattern and gain value and from these two antennas can be seen as in Figure 16 and Figure 17. Based on Figure 16, the Skew Planar Wheel antenna and the Dipole comparator antenna are designed to have an omnidirectional radiation pattern, which means they have a radiation pattern in all directions evenly. The maximum gain of the Skew Planar Wheel Antenna is 1.38 dBi while for the Dipole comparator Antenna in Figure 17 it is greater, namely 2.21 dBi.

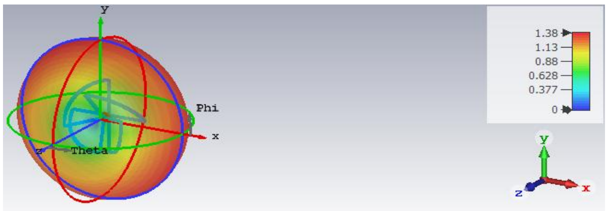


Figure 16. Radiation Patterns and Gain Skew Planar Wheel

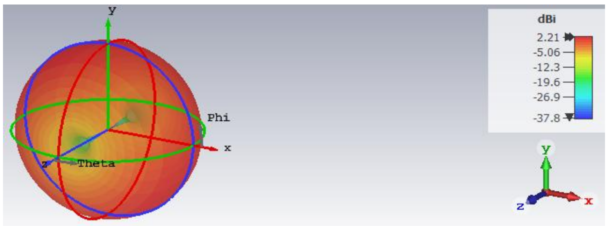


Figure 17. Radiation Patterns and Gain Dipole

Determining the type of polarization is by knowing the Axial Ratio value of each antenna. Based on [14] it is known that if the antenna's Axial Ratio value is <3 dB, it can be said that the antenna has circular polarization and vice versa. The Axial Ratio graph of the two antennas can be seen in Figure 18 and Figure 19.

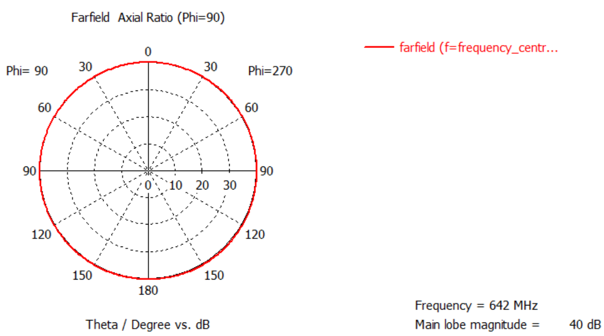


Figure 18. Axial Ratio of Skew Planar Wheel

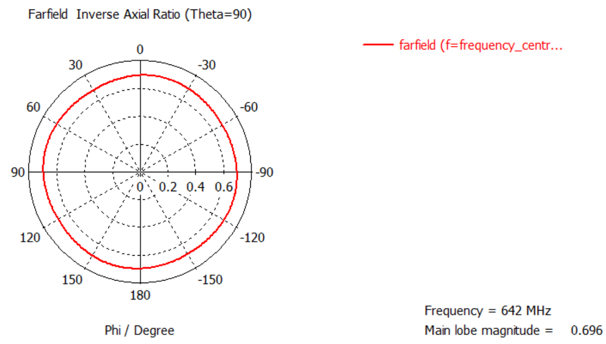


Figure 19. Axial Ratio of Dipole

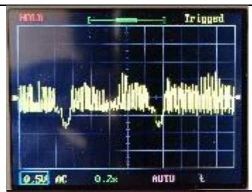
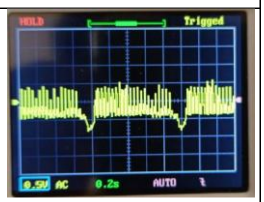
Figure 18 shows that the designed Skew Planar Wheel antenna has a maximum Axial Ratio value of 0.696 dB which means it has circular polarization. Whereas Figure 19 shows the Axial Ratio value on the Dipole antenna which has a maximum value of 40 dB which means it has linear polarization.

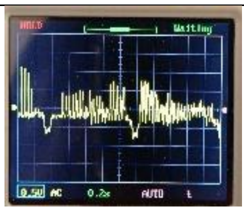
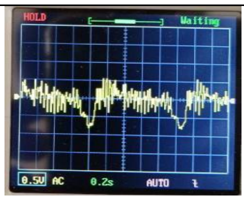
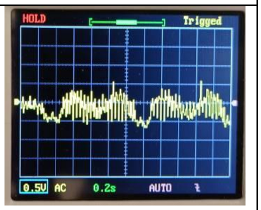
3.2 Simulation Television Observation Results

Television observations made can be seen as in Table 1 and Table 2. Table 1 is a table of observations made by rotating the angles of the both antenna horizontally to the transmitter. As can be seen from the test angles 0º, 45º and 90º in general, the Skew Planar Wheel antenna can help stabilize the broadcast video received by the television, this is also indicated by the shape and amplitude value of the *pulse synchronize* which is still stable according to the recommendations given by the value amplitude is around -300 mV.

The results of the Dipole comparator antenna at an angle of 0º and 45º horizontally to the transmitter still have an amplitude value is around -300 mV and stable video image, but at a tilt angle of 90º the waveform displayed by the oscilloscope does not appear to have a good *pulse synchronize* form so the video results received broadcasts have disturbances such as inappropriate image coloring and *ghost images*.

Table 1. Horizontal to TX Measurement

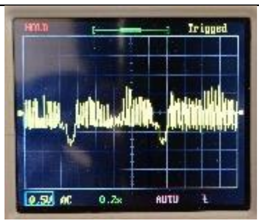
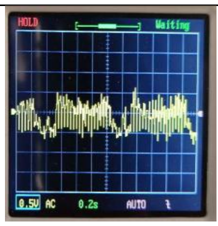
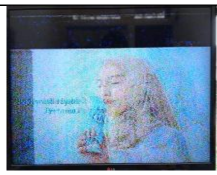
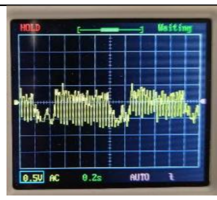
Angel°	SPW	Dipole
0	 	 

45	 	 
90	 	 

While the vertical to TX observation results can be seen as in Table 2. Table 2 is an observation made by rotating the angles of the both antenna vertically to the transmitter by testing at an angle of 45º and 90º. The results obtained with the Skew Planar Wheel antenna at an angle of 45º and 90º obtained the form and value of *pulse synchronize* which are generally stable and remain at an amplitude of -300 mV, these results can also be proven from the results of broadcast video received by television stably.

Meanwhile, for the comparator antenna Dipole at an angle of 45º and 90º, the shape and value of the *pulse synchronize* are not in accordance with the recommendations. As in the table, the *pulse synchronize* form appears to be up and parallel to the video level data (*Luminance* and *Chrominance*). This causes the stability of the broadcast video image that is received by the television, such as dropping images and bad coloration and the effect of *ghost images*.

Table 2. Vertical to TX Measurement

Angelº	SPW	Dipole
45	 	 
90	 	 

Although the results of the *pulse synchronize* obtained by these two antennas are not perfect according to the recommendations used as a reference, in general the use of the Skew Planar Wheel antenna with circular polarization can help stabilize the shape and amplitude value of the *pulse synchronize* on the CVBS analog terrestrial television transmission system at various angles of the test direction compared to a Dipole comparator antenna which is linear polarization.

4. CONCLUSION

The conclusion of this research is that the Skew Planar Wheel antenna and the Dipole antenna have been designed and implemented with a center frequency of 642MHz for analog terrestrial television system receivers. Although the maximum Gain value of the Dipole antenna is greater than the Skew Planar Wheel, the circular polarization of Skew Planar Wheel antenna can help stabilize video by maintaining the *pulse synchronize* amplitude value of the television around -300mV at the angles tested compared to the Dipole comparator antenna which is linearly polarized. In addition, the Skew Planar Wheel antenna used has no *ghost images* on the television video screen compared to the Dipole antenna which has *ghost images*.

5. ACKNOWLEDGMENT

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