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Design and Development of Dipole Antenna for NOAA Satellite Image Acquisition System and Processing

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Abstract. The National Oceanic Atmospheric and Administration (NOAA) satellite is the 3rd Series of American meteorological for take information about the physical state of ocean and atmosphere. This research will describes the design of Satellite Image Acquisition System using two kinds of antenna, double cross dipole and Double V Double Dipole antenna as receiver of NOAA satellite and about performance of receiver system. The designed antenna works at frequency 137 Mhz with omnidirectional radiation pattern. The analysis process with analyzing the data receiving process with return loss parameter, signal to noise ratio (SNR), noise floor and image . The process of receiving data is by connecting antenna with RTL-SDR, SDRSharp software, WxtoImg, and Gpredict that has installed on laptop. Both antenna can receive data from NOAA satellite well, the data received are return loss value, noise floor, and image of Indonesian island that can be used for remote sensing. The antenna parameter for Double V Double Dipole are return loss -30.421 dB, VSWR 1.063, input impedance 51.642 Ohm and Gain 5.2 dB. For double cross dipole are return loss -29.315 dB, VSWR 1.071, input impedance 46.946 Ohm and Gain 4.47 dB. Both antenna have omnidirectional radiation pattern.

1. Introduction

National Oceanic and Atmospheric Administration (NOAA) satellites are satellites with LEO (Low Earth Orbit) orbits which are remote sensing satellites that are used for monitoring and research for ocean and weather conditions. NOAA satellite information is sent to earth stations with direct readout service that consisting of images from satellite sensor capture. This direct readout service is operated and developed by the Government of United States. There are two of the most popular services: HRPT (High Resolution Picture Transmission) and APT (Automatic Picture Transmission) data[1]. In general, to receive weather satellite data must have complete device facilities such as those in the Pustekdata LAPAN but once receipt of weather data can be built in a simpler infrastructure using one of the NOAA satellite services on APT services so that weather data from the reception can be used for information, weather data in the form of image images about classification of clouds can be accepted with low operational costs. in order to receive NOAA APT satellite data, the reception subsystem is needed in the form of an antenna that matches the working frequency of the VHF band at a frequency of 137 Mhz.

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2. Literature Review and Hypothesis Development

There have been several NOAA researchers and satellite activists who have made satellite receiver antenna prototypes. The NOAA satellite transmits signals to the earth using circular polarization. This polarization was chosen to avoid depolarization by the earth's atmosphere. To receive signals with polarization like this, it is necessary to have an omnidirectional receiver antenna. In [2] and [3] a quadrifilar helix antenna (QFH) is used. This type of antenna has advantages such as NOAA satellites emit signals with the form of radiation that is polar radiation. This type of quadrifilar antenna is very suitable as the recipient because it is able to accept the type of polar radiation and is able to resist linear polarization originating from the earth and the gain pattern of this antenna is suitable for receiving signal levels from satellites. As a result, this antenna will be able to receive signal quality from the satellite stably.

In its implementation this type of antenna is more difficult to fabricate. One antenna that is easy to fabricate is a dipole antenna. This dipole antenna can also produce or receive helical polarization. Two dipole antennas that are placed perpendicular to each other and the current / voltage that interpolates them at a 90 degree phase will produce helical polarization[4]. With this concept, the use of dipole antennas as NOAA satellite data receivers has been carried out using the cross dipole type [5] and V dipole [6] was developed also using cross dipole helix types [7].

3. Methodology

Through an analysis of previous research, two dipole antennas have been designed namely double V double dipole and double cross dipole with improved antenna dimensions to obtain better antenna performance parameters than previous research. The reason why the type of dipole antenna is chosen is because of its ease in designing and manufacturing. In order to fulfill the desired performance, the antenna design and manufacture refers to the antenna performance parameters as in Table 1 below

Table 1. Standard NOAA receiver antenna parameters

Parameters	Value
Frequency	137.1 MHz
Return Loss	< -10 dB
VSWR	< 2
Gain	> 3 dB
Radiation Pattern	Omnidirectional

Double V Double Dipole

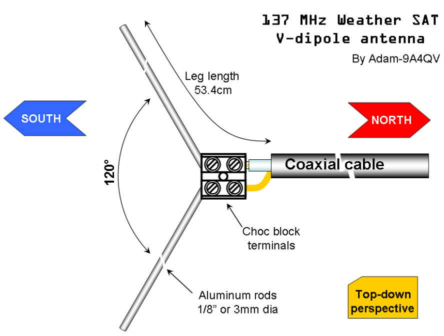
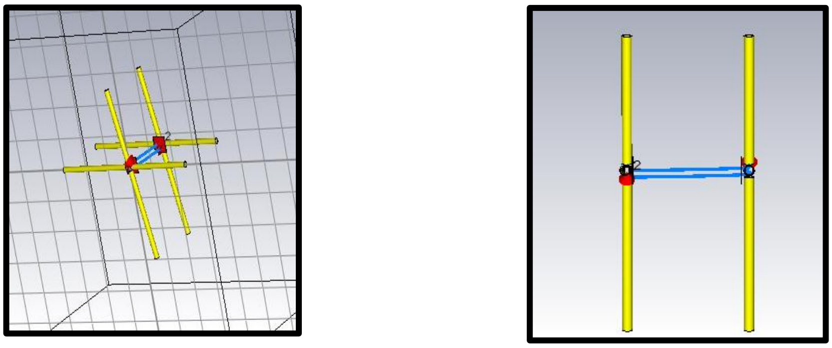


Figure 1. V-Dipole for 137 MHz Weather Satellites[8]

The design and manufacture of these antennas is based on what was previously made. With the V dipole antenna in the horizontal direction, the radiation pattern will be directed to the sky with a pattern of zeros (0). This form is very optimal for receiving satellite signals that are in the direction of the front, side and top of the antenna. Because the direction of the NOAA satellite orbit from north to south or vice versa, the antenna is sufficiently directed towards the south or north. With the V dipole antenna in the horizontal direction, the radiation pattern will be directed to the sky with a pattern of zeros (0). This form is very optimal for receiving satellite signals that are in the direction of the front, side and top of the antenna. Because the direction of the NOAA satellite orbit from north to south or vice versa, the antenna is sufficiently directed towards the south or north. Horizontally polarized antennas will have the advantage that all signals originating from terrestrial with vertical polarization will be reduced to 20 dB thereby reducing interference from terrestrial and overloading on RTL-SDR devices. For QFH type antennas, terestial signals that are reduced are only 3 dB[8]. This type of antenna is also used in WLAN applications, indicating that applications that use these antennas are very diverse and also very reliable[9].



(a) Front View (b) Side View

Figure 2. Double V Double Dipole Antena Design

To obtain better performance, the V antenna type dipole was designed with the addition of the V shape to double V double dipole. The shape of the antenna design is shown in Figure 2. Figure 1 is a reference for making an antenna at a frequency of 137.1 Mhz with a V dipole shape which has an angle of 120°. From the simulation and manufacturing results, the antenna parameter values in Table 2.

Table 2. Double V Double Dipole Antenna Performance Parameters from manufacturing results

Parameter	Value
Frequency	137.1 MHz
Return Loss	-30.421 dB
VSWR	1.063
Input Impedance	51,642 Ω
Gain	5.2 dB
Radiation Pattern	Omnidirectional

For the radiation pattern shown in figure 3. From Figure 3 shows that the antenna radiation pattern is omnidirectional.

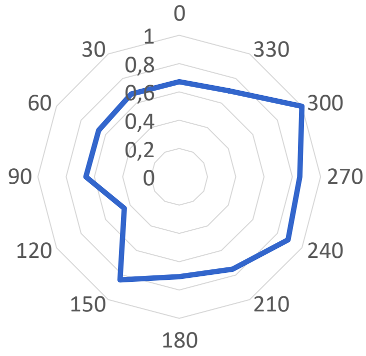


Figure 3. Radiation Pattern for Double V Double Dipole Antenna

Double Cross Double Dipole Antenna

In the design and manufacture of double cross double dipole antennas are also based on previous studies [5] [7] with modifications to the length dimensions of the antenna. In the antenna that has been made, the length of the dipole is made asymmetrical in the hope of getting a better antenna performance value. The results of the design of this antenna are shown in Figure 4.

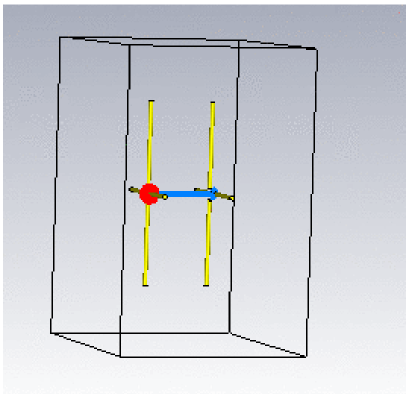


Figure 4. Double Cross Double Dipole Antena Design

Generally for cross dipole antennas the same length / symmetrical pole is used [5] [7]. In the design of this antenna, the dimensions used are not symmetrical. The dimensions of the antenna are 77 cm and 44 cm, and two cross dipoles are made so that they are called double cross double dipoles. From the results of the optimization of the antenna simulation and manufacture, the values for the performance parameters are obtained in Table 3.

Table 3. Double Cross Double Dipole Antenna Performance Parameters from manufacturing results

Parameters	Value
Frequency	137.1 MHz
Return Loss	-29.315 dB
VSWR	1.071
Imput Impedance	46.946 Ohm
Gain	4.47 dB
Radiation Pattern	Omnidirectional

4. Result and Discussion

From the results of the design and fabrication of the two antennas and when compared to the standard for NOAA, the antenna performance parameter values that have been made show very good results. This is shown in Table 4.

Table 4. Comparison of Antenna

Parameters	NOAA Standard	Double V Double Dipole	Double Cross Double Dipole
Frequency	137.1 MHz	137.1 MHz	137.1 MHz
Return Loss	< -10 dB	-30.421 dB	-29.315 dB
VSWR	< 2	-30.421 dB	1.071
Gain	> 3 dB	5.2 dB	4.47 dB
Radiation Pattern	Omnidiretional	Omnidiretional	Omnidiretional

To be more assured of its performance, the antenna that has been made is applied to the NOAA satellite data acquisition system, the block diagram is shown in Figure 5.

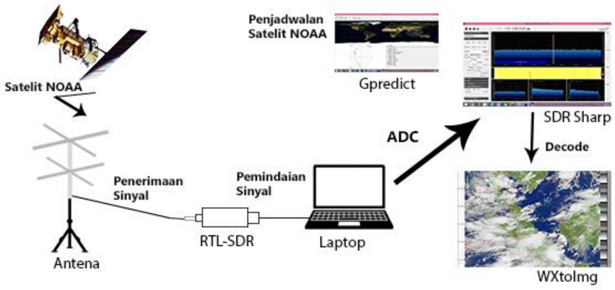
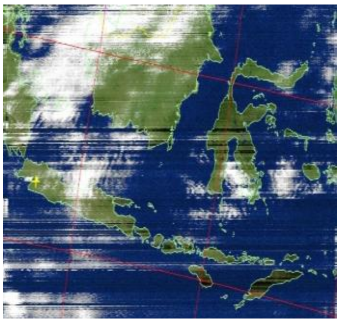
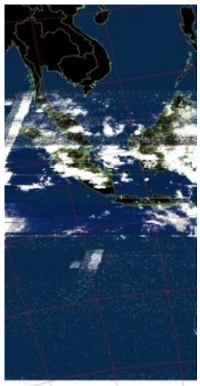


Figure 5. NOAA Satellite Image Acquisition System And Processing Block Diagram

With good antenna performance, the satellite data acquisition process is also easier. The following picture is an example of the system data acquisition results.



(a)



(b)

Figure 6. Acquisition Results Image
(a). Double V Double Dipole Antenna
(b) Double Cross Double Dipole Antena

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5. Conclusion

The results of antenna design and fabrication produce a Double V Double Dipole and double cross dipole antenna that works at a frequency of 137.1 MHz for NOAA satellite receivers 19. Based on the test results, the antenna can also work at Frequency 137.62 and 137,912 for receipt of NOAA 15 and 18. Double cross the dipole design results at 137.1 Mhz return -31.785, VSWR 1.052, frequency 137.9125 Mhz return loss value -26.01, VSWR 1.1054, and frequency 137.62 Mhz return loss value -28.028, VSWR 1.0827. Double V double dipole antenna obtained return loss value of -30.421 dB, VSWR 1,063, impedance 51,642 Ω, and gain 5.2 dB for frequency 137.1 MHz. For frequencies of 137.62 MHz and 137,912 MHz the size is not much different.

Acknowledgment

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