Identification of Cumulonimbus Cloud using Sensor Data of NOAA Satellite Captured by Low Cost Flower Cross Dipole

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Abstract: The implementation of a flower cross dipole could be a promising candidate to receive any information from NOAA satellite in certain frequency. Flower cross dipole was designed to work in 137 MHz frequency. This work urgently discusses about identification of cumulonimbus cloud based on NOAA satellite sensor data which was received by flower cross dipole. The detection system has been developed by real-time monitoring based on NOAA satellite sensor data, then convert to cloud image. The further study would be focus on cumulonimbus cloud which causes bad weather in a region. The identification result was validated by Meteorological, Climatological, and Physical Agency of Indonesia and analyzed by kernel-erison method. The overall results indicate the flower cross dipole has 1.58 VSWR value with -12.85 dB return loss. In other hand, the flower cross dipole produced omnidirectional radiation pattern with 11.8 MHz bandwidth and 2.307 dB gain. The low-cost flower cross dipole only has 52.59 cm length with unique and simple design to be produced.

1 INTRODUCTION

Weather conditions are meteorological elements that have a high variation in scale of space and time, so it is difficult to predict. However, weather information is very important and needed by almost all fields such as agriculture, transportation, plantations, to early warning of natural disasters, floods, landslides, and drought (Sun, 2016). Information on weather conditions is still limited, one of which is due to difficult data access. Therefore, we need a technology system that can determine the exact state of the national weather. Satellite technology is a necessity that cannot be avoided anymore at this time because satellite data is able to quickly display data with wide coverage.

The National Oceanic and Atmospheric Administration (NOAA) is a USA scientific agency that has 19 satellites. The main activity of these satellites is to observe the ocean and atmosphere on a global scale (Bosquez, 2016). Hence, it is able to monitor the territorial waters of Indonesia with a broad scope for the benefit of weather monitoring. NOAA satellites are at an orbit altitude of 833-870 km with inclination around 98.7 ° - 98.9 °. NOAA took aerial photography at around 16:00 to 17:00 WIB. From the images taken by NOAA satellites, it can be processed so that cloud types and weather predictions are classified (Rafsyam, 2017) (Rafsyam, 2017). Cumulonimbus clouds are a type of condensation cloud formed from water vapor and carried by the wind. The danger of these clouds is it can produce thunder and bad weather which is usually found in the tropics area (Sun, 2016) (Dian, 2014) (Rafsyam, 2017) (Rafsyam, 2071). In addition to bad weather and lightning, these clouds are also accompanied by ice and have very cold temperatures. To detect and predict cumulonimbus clouds, sensor data is needed from NOAA satellites that cross Indonesia 2-4 times in 1 day. Hence, NOAA satellite sensor data can observe the detection of cumulonimbus clouds in real time (Rafsyam, 2017) (Rafsyam, 2017).

Earth stations, the satellite signal receiver system from NOAA satellites with a specified frequency, have been developed in this work. The earth station system consists of an omnidirectional antenna to capture NOAA signals that are connected to a processing system software. Cross Dipole Antenna is an omnidirectional system that produces singular radiation patterns that can receive signals from all directions. On the other hand, transmissions from

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NOAA satellites using right hand circular polarization (RHCP) (Geeta, 2015). Cross dipole antenna has high gain with circular polarization. Therefore, antenna design must have a working frequency of 136 - 138 MHz, impedance of 50 ohms, and a minimum gain of 12 dBi (Dian, 2014) (Shi, 2016) (Rafsyam, 2017). Sensor data captured by the dipole antenna should be delivered to a single rectifier (Vignesh, 2016). The signal is processed by the software and analyzed using the kernel erison method to show the comparison of cloud validation from BMKG with the cloud image analysis results from the receiver.

2 SYSTEM DESIGN

The system design of the earth station is shown in Figure 1, consisting of a satellite signal receiver and processing of the 137.9 MHz NOAA satellite signal which is real-time and can be accessed anytime and anywhere. In other hands, the flower cross dipole is designed in several stages before it can be used as a NOAA satellite signal receiver. In overall, the calculation of the length of the antenna element that can work at frequencies 137-138 MHz and simulates the antenna design based on the calculation results. Finally, if it matches the simulation results, the antenna design is fabricated to be tested and validated.

Figure 1, the design of a receiver system which is a system flow diagram for receiving data signal information received from satellites. Data acquisition systems can automatically detect and receive information signals from satellites when passing through the system. The information signal is captured by the flower cross dipole and then separated from the carrier by the receiving radio.

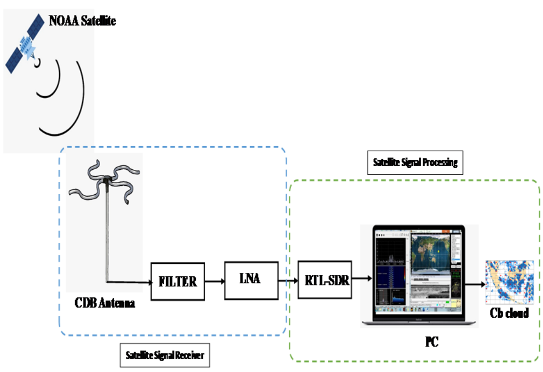

Figure 1: System design of Flower Cross Dipole as sensor data receiver from NOAA satellite

After the information signal is obtained, the sound card will work to convert analog data into digital data. Then the digital signal is processed and recorded in the form of wav files. This file will then be used at a later stage, namely image processing. The signal that is obtained is the sound signal and then converted to an image.

Then this image can be reprocessed so that it can detect cumulonimbus clouds (clouds that have the potential to rain). In satellite signal processing, WxtoImg, python programming and library opencCV software is used. The data that is already in the form of a WAV file is processed further using WxtoImg to produce an image that has information on the state of the cloud which will later be reprocessed by openCV python so it can automatically detect that area has a cumulonimbus cloud.

3 RESULT AND DISCUSSION

The flower cross dipole as shown in Figure 2, is an omnidirectional and right circular polarized antenna that can be proven in the analysis of the antenna test results shown on the Figure 3. This exactly matches the antenna pattern from the satellite. The radiation of cross dipole antenna basically generated from two orthogonal half-wavelength dipoles fed by two sources with magnitude 90º phase difference (Xu, 2016) (Bhaskar 2018). The basic cross dipole is modified in each side of the cross dipole. In figure 3, shows the radiation pattern with the parameters of power received by the flower cross dipole and plotted from an angle of 10º to 360º. If observed in the horizontal plane and vertical plane, the flower cross dipole can receive energy distributions that tend to be the same from all angles. So, the antenna radiation diagram pattern can be illustrated like a spherical. This indicates that for the capture of signals from satellites, the signal's incoming direction can be received by the flower cross dipole from all directions.

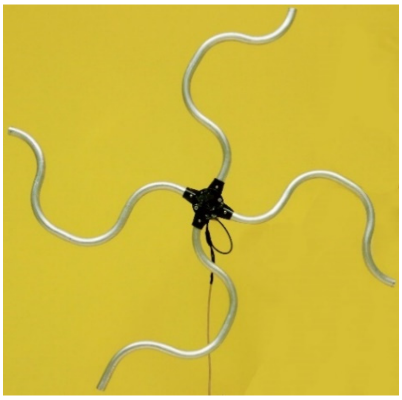

Figure 2. Flower Cross Dipole from above.

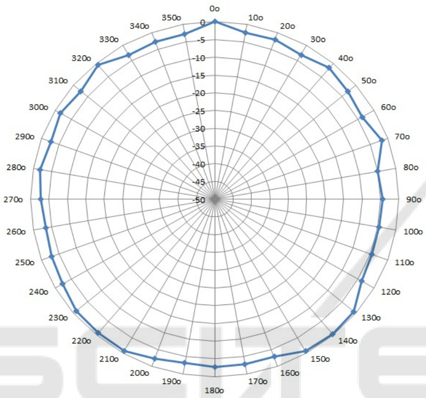

Figure 3. Test result of radiation pattern

In antenna testing, the measured parameter is the amount of energy reflected to the antenna by measuring the value of S11 or return loss and VSWR flower cross dipole at a frequency of 137 MHz to 138 MHz. By knowing the amount of return loss, the amount of energy that can be received by the antenna can be determined. Antenna test results for the return loss parameter is shown in Figure 4, resulting in a return loss value of -12.85 dB. From Figure 4, the x axis shows frequency and y axis shows return loss, with detected frequency range 100-300 MHz. Return loss is known as the ratio of reflected power from a load to the power on that load and expresses in dB (Cui, 2014). Return loss provides is helpful, as it provides a real valued measure of load match. Another parameter of the load match traditional real valued measure is voltage standing wave ratio (VSWR).

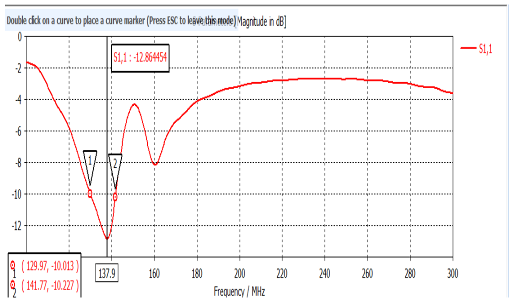

Figure 4: Simulation test result of Flower Cross Dipole in return loss

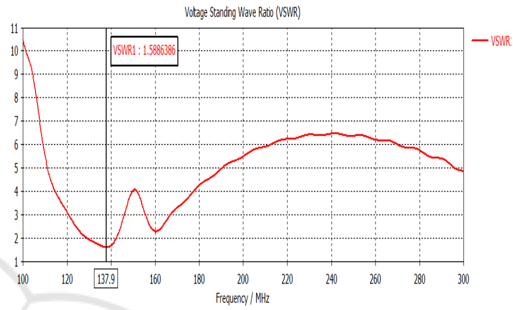

Figure 5: Simulation test result of Flower Cross Dipole VSWR parameters

Figure 5 shows the antenna test results for the VSWR parameter which produces a value of 1.58. The VSWR value is a conversion of the S11 value which shows the ratio of the maximum stationery wave voltage to the maximum travelling wave voltage that occurs on the flower cross dipole when capturing satellite signals. With a VSWR value of around 1.5, the antenna is good enough to be used as a cross dipole antenna. The antenna test results for the S11 and VSWR parameters are validated and shown in Figure 6 which shows the flower cross dipole can capture satellite signals at 137.9 MHz with the same value of S11 and VSWR as the test results in Figure 4. Gain which obtained from the simulation results was 2.307 dB with frequency 137.9 as shown in Figure 5.

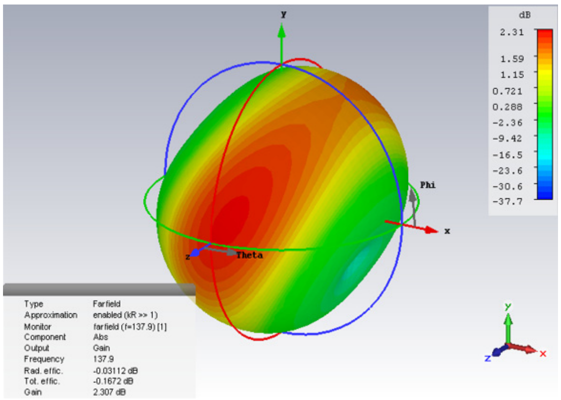

Figure 6: Radiation pattern of Flower Cross Dipole as receiver

Basically, NOAA satellites record an area by receiving Advanced Very High Resolution (AVHRR) data from satellites in the form of 2-4 raw data in one day. In this study, the flower cross dipole received NOAA satellite sensor data and was carried out by following the NOAA satellite schedule that passed in the territory of Indonesia (Rafsyam, 2017)[2]. NOAA satellites that are currently active are NOAA 15, NOAA 18 and NOAA 19 (Uengtrakul, 2014). Test that have been carried out by connecting the flower cross dipole with the RTL-SDR dongle is used to receive signals sent by NOAA satellites (Uengtrakul, 2014).

Figure 7 show us the validation of result of the flower cross dipole after fabricated. The result of the parameters are -17, 692 dB of return loss and 1,357 of VSWR. This result performs better than simulation value which the return loss is below -10 dB while the VSWR is below 1.92 (Kaur, 2016). The reference values realize polarization conversion of the reflected wave, the reflected and directed wave emitted from flower cross dipole will generate polarization wave, like circular polarization (Chen, 2015).

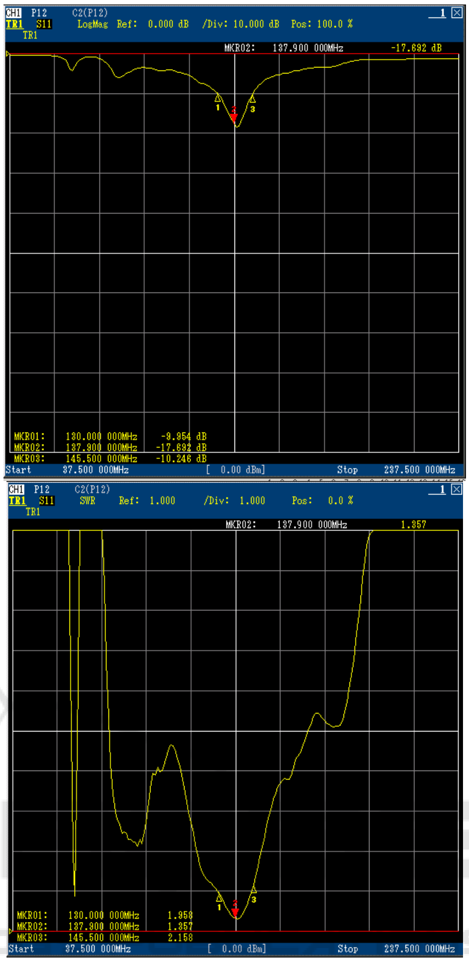

Figure 7: Validation result of Flower Cross Dipole

The cumulonimbus cloud detection test aims to detect cloud from the cloud color gradation parameters formed. The cumulonimbus clouds with a wide range of dense clouds with white light color indicates bad weather conditions in an area. Results from Signal catched from NOAA satellites 18 in the form of sound are recorded with the help of SDR Sharp software (Bosquez, 2016). The software reads the signal level received at different times and days. After that the recorded sound signal is converted into image form with WXtoImg (Mahmood, 2016). The results of this image will be analyzed and validated with BMKG data. Image analysis is shown in Figure 8 using the OpenCV Python kernel 2x2. Cumulonimbus clouds detection can be determined from the color and gradient of clouds formed in Figure 8 and most colors of cumulonimbus clouds are white light. Based on the validation with BMKG data in Figure 7, the results of the detection of cumulonimbus clouds by using a flower cross dipole as a NOAA satellite signal receiver have 9% error of Figure 9.

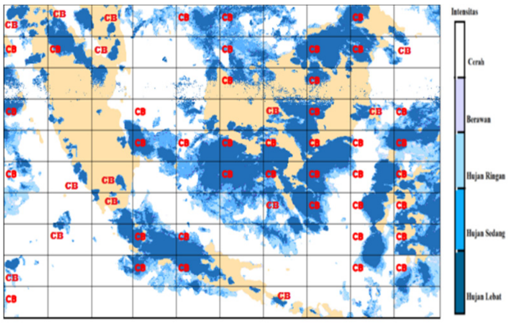

Figure 8: Meteorological, Climatological, and Physical Agency of Indonesia validation

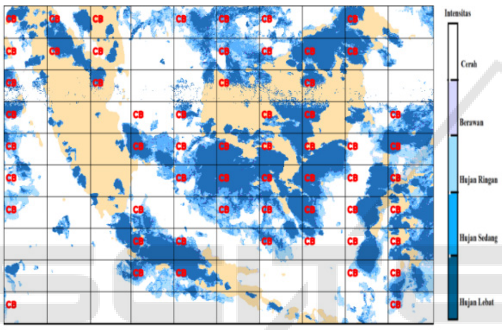

Figure 9: Image processing result using openCV Python kernel (2x2)

4 CONCLUSION

In this study, fabrication of flower cross dipole with a working frequency of 137.9 MHz was successfully tested and validated with several parameters such as VSWR, S11, and gain. The radiation pattern formed is omnidirectional, so that it can receive signals and waves from all directions. Signal processing that has been received by the antenna is validated with the BMKG image results and the percentage of error resulting from image processing is 9%. Hence, the flower cross dipole can be used as a candidate for satellite receiver signals at a working frequency of 137.9 to detect bad weather due to the presence of cumulonimbus clouds in an area. Moreover, the flower cross dipole is a low-cost antenna with aesthetically unique design and shape.

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