Design of Double Cross Dipole Antenna as NOAA Satellite Signal Receiver for Monitor Cloud Conditions Application

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Abstract. NOAA is a remote sensing satellite that contains informations about the earth, such as mapping land, sea and reporting weather conditions, cloud conditions and hotspots in an area. NOAA satellite works at the downlink frequency of 137-138 MHz. Double Cross Dipole antenna can be used as signal receiver antenna from NOAA satellite. Double cross dipole antenna is designed to operate at frequency range of 137-138 MHz. Simulation result of 137.62 MHz frequency generate return of loss as -20.726 dB, the value of VSWR 1.20 bandwidth of 82.32 MHz, omnidirectional polarization and circular polarization. The result of measurement of double cross dipole antenna it was obtained return loss as -18.911 dB, value of VSWR of 1.255, bandwidth of 32.813 MHz. Double cross dipole antenna can be used to receive NOAA satellite signal in a form of voice. Voice data can be converted into image with the help of WXtoImg software. The result of conversion was in a form of cloud condition in Indonesia area.

1. Introduction

Satellite is space object orbited along with earth. Satellite has function as weather satellite, communication satellite, science and technology satellite and military satellite. Satellite has main advantages which is the speed in obtaining data and its vast coverage. NOAA satellite is a weather satellite which has information data about physical condition of ocean and atmosphere. Information data which can be obtained from NOAA can be applied for analyzing parameters in meteorology, oceanography, and also hydrology. From the result of parameters analysis, information data can also be obtained by observing vegetation, forest fire, albedo data extraction, ocean surface and land temperature data extraction, agriculture, cloud, and snow detection in earth surface. NOAA satellite works at frequency downlink of 137-138 MHz [1-6].

Double cross Dipole antenna is one of antenna types which can be used to capture signal of NOAA satellite. It because the result of polarization double cross dipole antenna is circular. Circular polarization is an suitable kind of polarization from antenna for capturing NOAA signal. It because NOAA transmission uses right hand circular polarization (RHCP). In previous study, conducted by [7], double cross dipole antenna with circulate polarization. The difference from previous study conducted by [8], is in antenna design. Antenna design in this study is the development from cross dipole antenna, in which cross dipole antenna is made into 2 pieces, by then its inner and outer is connected, as shown on figure 1.
2. Methodology
In this study there were several steps to obtain double cross dipole antenna. The first step was calculating antenna element length at working frequency range of 137-138 MHz. After calculating element length, the next step was making antenna simulation using CST software. The second step was making simulation by using double cross dipole antenna design. The process of first and second step is shown on Figure 2.

After obtaining Double Cross Dipole Antenna design, the third steps is designing and fabrication of Double Cross Dipole Antenna. At forth step test in antenna laboratories was conducted, from which the result will be compared with simulation result which has been made previously. The third and the forth step is shown on Figure 2.

Figure 1. Iterelement Coaxial connection for Double Cross Dipole Antenna

Figure 2. Flow diagram of Double Cross Dipole Antenna Design
After obtaining Double Cross Dipole Antenna design, the third step is designing and fabrication of Double Cross Dipole Antenna. At forth step test in antenna laboratories was conducted, from which the result will be compared with simulation result which has been made previously.

Antenna designing is started by determining working frequency of 137.62 MHz with aluminum as the material used. To find out the length of the element used, the value of lambda (λ) was calculated which can be obtained by using following equation\[1\]\[9\]:

\[
\lambda = \frac{c}{f} = \frac{3 \times 10^8}{137.62 \times 10^6} = 2179.91 \text{ mm} \quad (1)
\]

Whence
\[ c = \text{Dielectric constant} \]
\[ f = \text{Working frequency} \]

After obtaining the value of lambda (λ), the element length can be calculated by using following equation:

\[
\frac{1}{2} \lambda \times k = \frac{1}{2} (2179.91) \times 0.95 = 1035 \text{ mm} \quad (2)
\]

\[ \lambda = \text{wave length (mm)} \]
\[ k = \text{velocity factor of aluminum} \]

After calculating, it was obtained a half of lambda (\(\lambda/2\)) as 1035 mm, it means for element length of each element became (\(\lambda/2\)). From the calculation, double cross dipole antenna simulation was made in CST2015 software.

3. Result and Discussion

Although the value of VSWR and return loss had fulfilled the specification expected, still be optimized. The optimization aims to obtain best result for double cross dipole antenna design. After optimization was done for double cross dipole antenna design, VWSR obtained was 1.20 which was shown on figure 3 and return loss as -20.72 dB as shown on figure 4.

Figure 3 shows result of VSWR simulation from double cross dipole antenna design after being optimized. From the graph as shown on figure 3 from x axis shows frequency and y axis shows VSWR value, with detected frequency range was 100-300 MHz. It was known that the lowest VSWR was ±1.2 at the frequency of 137.62 MHz and the highest was ±9 located at frequency of 100MHz. From the graph it shows that the frequency which has VSWR value of <2 was at frequency of 120 MHz up to 210 MHz. VSWR value from simulation was 1.20. This result met the expected specification which is <2.
Figure 4 shows the result of return loss from double cross dipole antenna design after being optimization. From the graph as shown on figure 4, the x axis shows frequency and y axis shows return loss, with detected frequency range was 100-300 MHz. It was known that the lowest VSWR was -20 dB at the frequency of 137.62 MHz and the highest was 2dB located at frequency of 100MHz. The graph also shows that the frequency which give return loss of <-10 dB was in the frequency of 120 MHz up to 210 MHz. The return loss was 20dB. Those result has met the expected specification which was <-10dB. In addition to VSWR and return loss, other parameters are radiation pattern, gain, and polarization. For radiation pattern obtained is omnidirectional, which is shown in Figure 5.

Gain which obtained from the simulation results was 3,814 dB as shown in Figure 5. From the simulation results after optimization, the best element length was 495 mm for the double cross dipole antenna. Furthermore, fabrication of the double cross dipole antenna design was conducted. In antenna simulation, antenna design was conducted on 5 lower frequencies and 5 upper frequencies at 137.62 MHz middle frequency. It aims to compare the results of the design of the double cross antenna dipole for several frequencies. Figure 6 the shows results of return loss comparisons of 11 antenna frequencies.
Figure 7 shows the comparison of VSWR from 11 frequencies. The chart shows that the VSWR values is good. At the working frequency, the VSWR value has lower than 2. This result indicate that the antenna is working properly.

![Figure 7. Comparison of VSWR from 11 frequencies](image)

After the design and fabrication stage, the next step is measuring antenna parameters. Measurements were conducted in the antenna laboratory test lab. The parameters measured are VSWR, return loss, polaradiation and gain. For the VSWR measurement results obtained 1.255 and return loss of -18.911 dB. From the results of VSWR and return loss measurements, the results of the parameters were in accordance with the antenna requirements. VSWR ≤ 2 and return loss ≤ -10 dB. For the results of the gain measurement, the gain is 5.17 dB. And the results of omnidirectional polaradiation measurements, as in Figure 8.

![Figure 8. Polaradiation measurement result](image)

Furthermore, the application testsis to determine the performance of the double cross dipole antenna that has been made and tested. In generally NOAA satellites recorded an area by receiving Advanced Very High Resolution (AVHRR) data from satellites in the form of regular raw data 2-4 times a day. In this study, where the double cross dipole antenna receiver NOAA satellite data. Data Collection is done by following the NOAA satellite schedule that passes in the Indonesia region [9]. The NOAA satellites currently active are NOAA 15, NOAA 18 and NOAA 19 [11]. The test is done by connecting the double cross antenna dipole with the RTL-SDR dongle, which is used to receive signals sent by NOAA satellites [12-15].

The result of NOAA signal is captured in the form of voice is obtained with the help of SDRSharp software to read the signal level that been received at different times and days. The signal strength that was received using the simple Omni directional antenna available with RTL SDR was as weak as -3dBm due to the right hand polarized nature of the received satellite beam [2][14][15].
In this study, are using two datatset in the form of data voice and as can be seen in Figures 9 and 11, the data is containing a cloud images in Figures 10 and 12 on different times and days.

Figure 9. Display data power level 1 in SDRSharp in the form of Voice

Figure 9 is the data test of signal level reception on NOAA 18 satellite using a double cross dipole antenna. Tests carried out at 03:10 on August 8, 2017 at MEL 88 E and the results are, antenna receive the data in form of data voice with a level of 35 dB, taken using SDRDsharp software.

Figure 10. Convert Results data voice1 on WXtolmg in the form of a cloud image

The data voice in Figure 9 can be converted into image, that produces cloud images with the help of WXtolmg software [11] [12] to produces cloud images as shown in Figure 10.

Figure 11. Display the data power level 2 in SDRSharp in form of Voice
Figure 11 is the data test of signal level reception on NOAA 15 satellite using a double cross dipole antenna. The test was carried at 19:26 on September 8, 2017 at MEL 65 W, and antenna receive in the form of data voice with a level of 20 dB which took by using SDRDharp software.

![Figure 11](image.png)

**Figure 11.** The data test of signal level reception on NOAA 15 satellite using a double cross dipole antenna.

Data Voice in Figure 11 can be converted into image that produce cloud images with the help of WXtoImg software as seen in Figure 12. From the results of application testing on data1 and 2, it’s can be seen that the double cross dipole antenna is capable to be used to received signal from NOAA satellites, resulting cloud images using SDRSharp software and WXtoImg software. The cloud image from data 1 is better than the cloud image data 2. The cause is the data damage that receive due to the factor of frequency allocation in Indonesia which has not been fully adhered by the community of radio communication. Besides of that there is noise and attenuation during the acquisition process on poor antenna placement, which can be greatly affected the satellite data that will be obtain.

From the data testing 1 and 2 it can be stated that the higher of Maximum Elavation (MEL) can affect the strength of the signal to be captured by the antenna. MEL shows how many degrees of angle are formed from the horizontal direction with the attached antenna and directed to the satellite position.

4. **Conclusion**

The results of Double Crossed Antenna design in the frequency range of 137-138 MHz produce VSWR of 1.20, return loss of -20.72 dB, gain of 3.814 dB, with circular polarization and omnidirectional polaradiation. The results of Double Cross Dipole Antenna measurements at frequencies of 137-138 MHz produce VSWR of 1.255, return loss of -18.911, gain of 5.17 dB and omnidirectional polaradiation. Differences from measurement results with simulations are caused by several factors. Factors that cause differences include poor quality of connectors, the unstable room condition at the time of making measurements, or technical errors at the time of doing antenna fabrication. The higher the Maximum Elavation (MEL), the stronger the signal captured by the antenna. Data damage Cloud imagery can be caused by several factors; interference from amateur radio communication, noise, antenna, antenna placement and the position between the ground station antenna and the satellite is not aligned so that the gain received by the ground station is not optimal. Double Cross Dipole Antenna can receive NOAA satellite signal in the form of voice. Voice data can be converted into images with the help of WXtoImg.

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References

[1] Rafsyam, Yenniwarti. Wafi Akhlaqil K, Indra Z, Eri EK, Jonifan, Topik TE, 2017. “Design of Double Cross Dipole Antenna Frequency 137 MHz For NOAA Satellite Receiver”. Proceeding ASAIS. P3M Politeknik Negeri Jakarta.

[2] Carlos Bosquez, Adrian Ramos, Linda Noboa, 2016, “System for Receiving NOAA Meteorological Satellite Images using Software Defined Radio”, Engineering Faculty, GISTEL Research Group Telecommunication Systems, Universidad Politécnica Salesiana Guayaquil, Ecuador, 978-1-5090-2532-9/16/IEEE.

[3] David Aguierre S., P. Raúl Yanyachi, 2017, “Design of a Parabolic Patch Antenna in band L, with Double Layer and Air Substrate, for Weather Satellite Reception”. National University of San Agustin – UNSA (IAAPP) Arequipa, Perú. 978-1-5090-6745-9/17/IEEE.

[4] D.C. , et alt. “Radiation patterns of a large UHF phased-array antenna: a comparison of measurements using satellite repeaters and patterns derived from measurements of antenna current distributions”. IEEE Antennas and Propagation Magazine. Vol. 39 (5). Pp. 88 – 93, 1997.

[5] Jose Alfredo Tirado-Mendez , et al “Inductively-Loaded Yagi-Uda Antenna With Cylindrical Cover for Size Reduction at VHF-UHF Bands”. IEEE Transactions on Antennas and Propagation. Vol. 59 (2). 2011.

[6] Luciano Fonseca., “Experiments for Multibeam Backscatter Adjustments on the NOAA Ship Fairweather”. IEEE Conf. OCEANS, pp. 1-4, 2006.

[7] Rafsyam, Yenniwarti et al. “Miniaturization Cross Dipole Antenna based on Helix and Meander Structure for NOAA Receiver Application”, 2017. International Journal of Applied Engineering Research (IJAER). Vol. 12. pp. 7927-7932. 2017.

[8] Carlos Bosquez ; Adrian Ramos ; Linda Noboa., “System for receiving NOAA meteorological satellite images using software defined radio”. IEEE Conferences .ANDESCON. Pp 1-4. 2016.

[9] C. A. Balanis, 2015. “Antenna Theory: Analysis and Design”, 3rd Edition, WILEY.

[10] Muaffiq, Priest 2015. "Designing And Realization Of Uhf Cross Dipole Antenna With Horizontal Planar Reflector For Dvb T2 Digital Tv Receiver", Contents: Telkom University Journal

[11] Andika, Gilang. 2008. "Cloud Cover Classification Using Noaa / Avhrr Apt Satellite Sensor Data". Jakarta: Thesis University of Indonesia.

[12] Torasa, Chonmapat. 2015. "Low Cost Noaa Satellite Receiving System For Rainfall Prediction". Bangkok: Industrial Electrical Technology Department

[13] Anonim.2012, October 3. "Input Impedance And Ultra Wide Band (Uwb) Uhf Polaradiation Antenna". Electronics Theory. http://elektronika-dasar.web.id/impedansi-input-dan-pola-radiasi-antena-ultra-wide-band-uwband/. [July 12, 2017]

[14] D. B. Boonyarit Uengtrakul, 2014, "A Cost Efficient Software Defined Radio Receiver for Demonstrating Concepts in Communication and Signal Processing using Python and RTL-SDR," in IEEE Fourth International Conference on Digital Information and Communication Technology and its Applications (DICTAP).

[15] Salman Mahmood, Muhammad Tahir Mushtag,Ghulam Jaffer, 2016, "Cost Efficient Design Approach for Receiving the NOAA Weather Satellites Data", 978-1-4673-7676-1/16/IEEE.