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Miniaturization Cross Dipole Antenna based on Helix and Meander Structure for NOAA Receiver Application

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Abstract

The dipole antenna is an antenna made of copper wire to resonate at the expected working frequency. In this research, the design of Dipole antenna was at the frequency of 137 MHz for NOAA Satellite Receiver Application. The dipole antenna has dimensions of L = 468.856 mm with r = 32.22 mm. For miniaturaization the antenna, the Cross Dipole Helix method was done. Therefore the antenna has a smaller size with a fixed working frequency. After miniaturaization, the cross dipole helix antenna has dimensions of L = 270.6 mm with r = 32.22 mm. The simulation results show that this antenna was able to work at the frequency of 137.9 MHz with return value (S_{11}) of -28.29 dB, VSWR of 1.08, bandwidth of 22.17 MHz, and gain of 1.661 dBi. Moreover, a Cross Dipole Meander method also was proposed. After miniaturaization, the cross dipole meander antenna has dimensions of L = 325 mm with r = 32.22 mm. The simulation results show that this antenna was able to work at the frequency of 137.9 MHz with return value (S_{11}) of -12.86 dB, VSWR of 1.58, bandwidth of 11.8 MHz and gain of 2.046 dBi. The design results show that the antenna works well for NOAA Satellite receiver applications.

Keywords: Antenna, Dipole, Helix, Meander, VSWR, Return Loss

INTRODUCTION

A subsystem of wireless transceiver consists of oscillator [1], band-pass filter (BPF) [2][3][4][5], low noise amplifier (LNA) [6], and antena [7]. Antenna is a circuit element that transforms the wave form of the guided wiring on the cable channel (Tx) into the free space wave and captures all electromagnetic waves, and vice versa-Rx [8]. Meanwhile the antenna definition based on IEEE by Stutzman & Thiele is part of the delivery and reception system designed to radiate or capture electromagnetic waves [9].

The transmitting antenna function (transmitter) and the receiving antenna has the same function which is process the signal, but the way it works is different. The transmitting antenna functions as the radiated signal collector. A good transmitter antenna alters the radio frequency energy (RF) produced by the radio transmitter into an electro-magnetic field that will be transmitted into the air. The transmitting antenna converts energy from one form to another. The receiving antenna does the same thing, but with the reverse direction. The receiving antenna converts the electromagnetic field into energy (RF) which is then transmitted to the radio receiver [10].

The function of the antenna is to convert the electrical signal into an electromagnetic signal, then radiate it. In conrast the antenna can also receive electromagnetic signals and convert them into electrical signals. The antenna area is a limitation of the characteristics of electromagnetic waves emitted by the antenna. The division of the surrounding area is made to facilitate the observation of the field structure in each of the antenna areas [8]. The energy antenna area is forwarded freely so that this region is a transition between guided waves with free waves [8]. The dipole antenna is an antenna made of copper wire cut to size to resonate at the expected working frequency.

In this research, the design of Dipole antenna was at he frequency of 137 MHz for NOAA Satellite Receiver Application. The dipole antenna has dimensions of L = 468.856 mm with r = 32.22 mm. For miniaturaization the antenna, the Cross Dipole Helix method was done. Therefore the antenna has a smaller size with a fixed working frequency. After miniaturaization, the cross dipole helix antenna has dimensions of L = 270.6 mm with r = 32.22 mm. Moreover, a Cross Dipole Meander method also was proposed. After miniaturaization, the cross dipole helix antenna has dimensions of L = 325 mm with r = 32.22 mm. The antenna was then simulated using CST software which then to be optimized and analyzed

DESIGN OF HELIX AND MEANDER ANTENNA STRUCTURE

A. Helix Antenna

The helix antenna consists of a single conductor or multi-conductor open helix-shaped. Helix antenna is a three-dimensional antenna. The shape of the helix antenna resembles a spring or spring and the diameter and distance between windings of a certain size [10].

Helix antennas have been widely used. As in the research of [11] implements the use of cloverleaf antennas installed in video transmitters on a quadcopter as well as a helix antenna installed a quadcopter video receiver located on a ground station with a frequency of 5.8 GHz which is used as a tool to maximize shooting video from the air or commonly known in the term of aeromodelling as First Person View (FPV).

Other studies [12] aimed at designing, simulating, and implementing helix antennas used in communications between wireless LAN (wifi) network points that operate at a frequency of 2.4 GHz or can also function as antennas substitute on the client. While in the study [13] is designed helical directional type that can operate on GSM frequencies with variations on the number of turns. Before implementation, to know or estimate the dimensions of the antenna, it would be calculated manually and assisted by using the software. The antenna parameters to be measured are transmitting power and receiving power, working frequency, VSWR and radiation pattern. To find out the antenna helix performance, the antenna was connected to a GSM modem installed on the laptop using a special pigtail. The test was performed on areas with low power level signals and GSM signal receiving power values observed using the software so that it can be known whether the helix antenna can improve the signal or not.

Helix antenna is an antenna consisting of conducting wire wrapped around a helix-shaped buffer. Helix antenna is an antenna that has a three-dimensional shape. The shape of the Helix antenna resembles a spring with a winding diameter as well as the distance between windings of a certain size. The shape of the Helix antenna [8]:

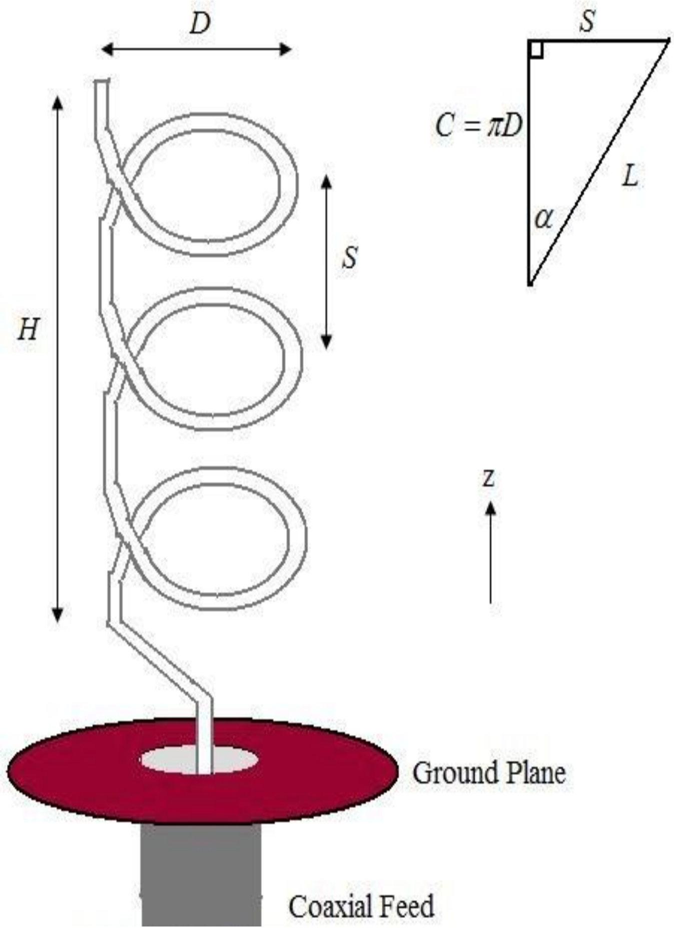

Figure 1: Helix antenna

The Helix antenna uses a copper wire wrapped around a PVC (Polyvinyl Chloride) pipe, zinc plates as a ground plane, Female SMA Connector and a pigtail that connects the antenna to the mobile phone and modem. Helix antenna selection because it has a good ability to strengthen the signal and the process of making can be understood by many people. Helix antennas have 3-dimensional geometry, the following figure is the basic shape of a Helix antenna with its parameters:

D = diameter of Helix, C = circumference of Helix = πD, α = pitch angle = arctan S/πD, S = distance between windings, L = length of 1 winding, n = number of loops, A = axial lenght = nS, d = the diameter of the helix conductor.

The diameter and circumference are used as parameters in determining the working frequency of Helix. Axial Length and pitch angle determine the gain of Helix. To find the Helix antenna diameter it can be used the following equation [14]

$$D = \lambda/\pi \quad (1)$$

While to calculate the circumference can use the following equation [9]:

$$C = \pi x D \quad (2)$$

Circumference of the Helix antenna is worth approximately one wavelength at its working frequency ($0.75\lambda < C < 1,3\lambda$) or the optimum value is 1. Meanwhile the pitch angle, the optimal α is between $120 \leq \alpha \leq 140$. The distance between coils are calculated by using the formula [14] :

$$S = 0.25\ C \quad (3)$$

To find the length of the Helix antenna, the following equation can be used [3] :

$$A = n\ x\ S \quad (4)$$

The longer the axial length the greater the gain of the Helix antenna would be. Helix antennas are usually instaled on a groundplane as shown in Figure 1. Ground plane can be anything but usually rectangular or circular with a diameter of at least 3/4. The use of the ground plane is intended to allow the back lobe of the Helix antenna to be minimized

B. Meander Antenna

In a meander antenna (also called rampart line antenna), the radiating element consists of a meandering line formed by a series of sets of right angled compensated bends, as shown in Figure 2. The fundamental element in this case is formed by four right angled bends and the radiation mainly occurs from the discontinuities (bend) of the structure. [14] The right angle bends are chamfered or compensated to reduce the right angled discontinuity susceptance for impedance matching.

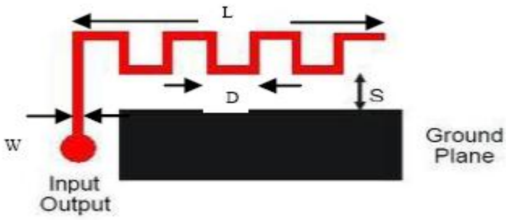

Figure 2: Meander Antenna

The meander-line antenna can be in a dipole or ground plane format. The idea is to fold the conductors back and forth to make the overall antenna shorter, which is shown in Figure 2.

DESIGN AND RESULT CROSS DIPOLE HELIX AND MEANDER ANTENNA STRUCTURE

A. Cross Dipole Antenna

The dipole antenna is designed to work at a frequency of 137.9 MHz. The first dimension is shown in Figure 3 below. The antenna has a length of L = 452,215 mm and with of d = 50 mm

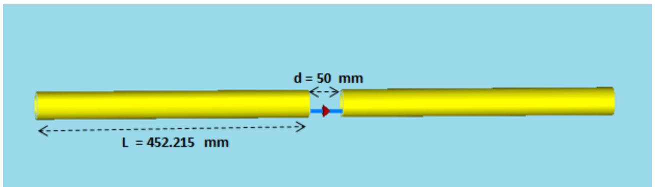

Figure 3: Dimensions of 137.9 MHz dipole antenna

After optimization, figure 4 shows the single cross dipole antenna design. This antenna has dimension of L= 468.856 mm

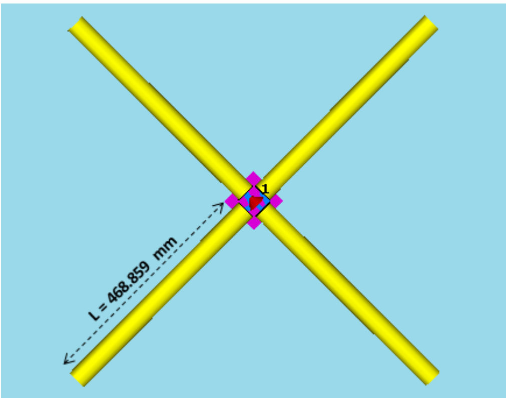

Figure 4: Dimensions of 137.9 MHz cross dipole antenna

B. Helix Cross Dipole Antenna

For miniaturaization the antenna, the Cross Dipole Helix method was done. Therefore the antenna has a smaller size with a fixed working frequency. The last step is to design the dipole antenna. The design is shown in Figure 5. Here are the dimension of L = 270.6 mm with r = 28 mm and d = 28 mm.

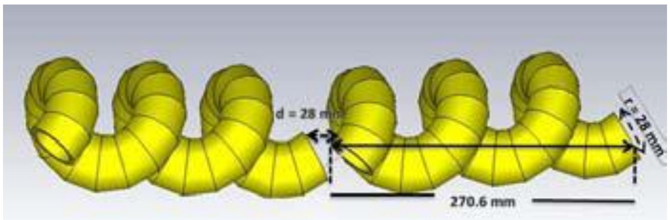

Figure 5: Helix Antena Design

Figure 6 shows the optimization of helix antenna design. The design of the antenna was simulated at the frequency of 100 MHz up to 200 MHz. This antenna has a varied response. The iteration of the return loss value was done by changing the r value from 28 mm up to 35 mm. The best r value was obtained at r = 32.22 mm.

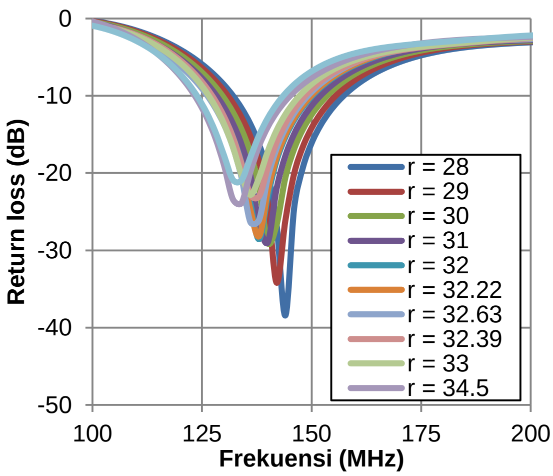

Figure 6: Optimization Helix Antena Design

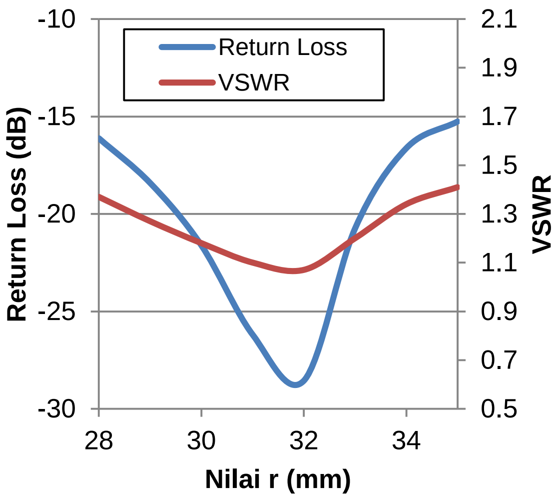

Figure 7: The r value iteration as well as its effect on return loss and VSWR.

Figure 8 shows the r value iteration as well as its effect on return loss and VSWR. The retrun loss value is proportional to the VSWR value. The best value of terun loss was obtained at r = 32.22 with VSWR of 1.08. So the optimal dimension was obtained when the value of r = 32.22 mm

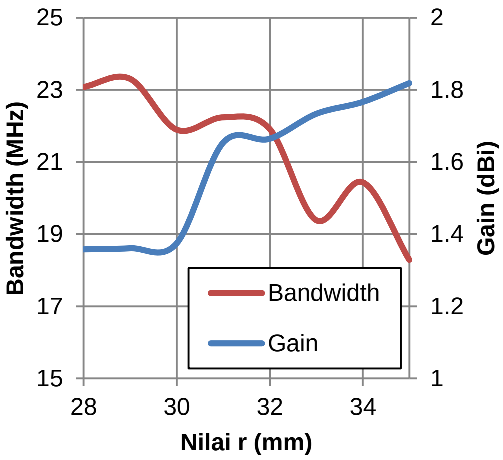

Figure 8: Simulation of bandwidth and gain helix antenna

In Figure 9 shows the antenna bandwidth simulation results (MHz) and antenna Gain (dBi). The simulation results show that the antenna has a Bandwidth between 23 MHz and 18 MHz. The greatest bandwidth value is at r value of 28 mm while the smallest bandwidth value is at r value of 35mm.

In addition to the bandwith value, the antenna Gain value is 1.3 dBi when r is 28 mm. Meanwhile the largest gain was increased at r at 35 mm.

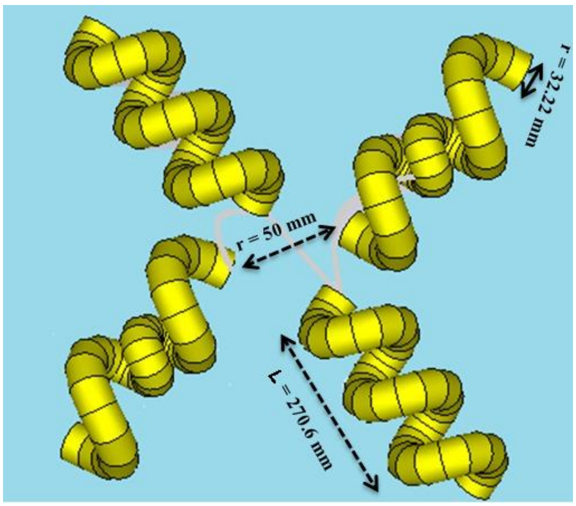

Figure 9: Helix Cross dipole antenna

In this study it was successfully designed dipole-helix antenna which has dimensions of L = 270.6 mm with r = 32.22 mm. The simulation results show that this antenna was able to work at the frequency of 137.9 MHz with return value (S11) of -28.29 dB, VSWR of 1.08, 22.17 MHz bandwidth and 1.661 dBi gain. The design results show that the antenna worked well for NOAA Satellite receiver applications.

C. Meander Cross Dipole Antenna

Cross Dipole Meander method also was proposed. After miniaturaization, the cross dipole helix antenna has dimensions of L = 325 mm with r = 32.22 mm. The simulation results show that this antenna was able to work at the frequency of 137.9 MHz with return value (S_{11}) of -12.86 dB, VSWR of 1.58, bandwidth of 11.8 MHz and gain of 2.046 dBi. The design results show that the antenna works well for NOAA Satellite receiver applications.

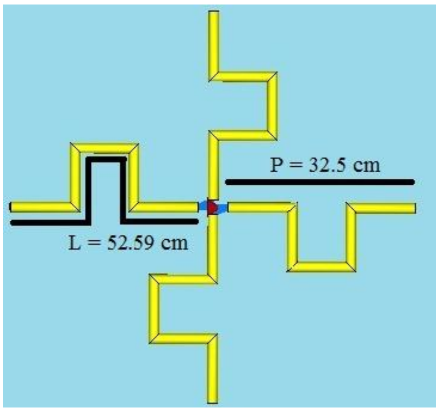

Figure 10: Meander Cross dipole antenna

Figure 11 shows the optimization of menader antenna design. The design of the antenna was simulated at the frequency of 100 MHz up to 200 MHz. This antenna has a varied response. The iteration of the return loss value was done by changing the L value from 46.27 mm up to 54.69 mm. The best r value was obtained at L = 52.59 mm.

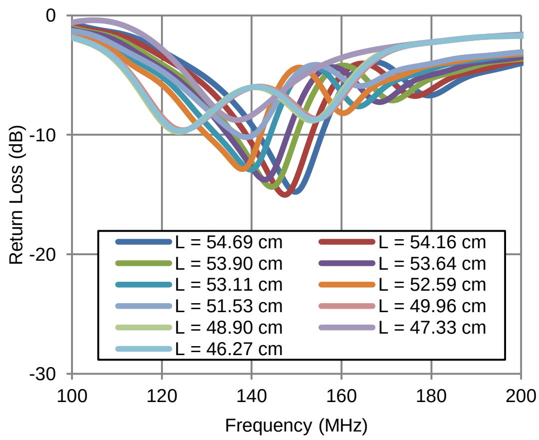

Figure 11: Optimization Meander Antena Design

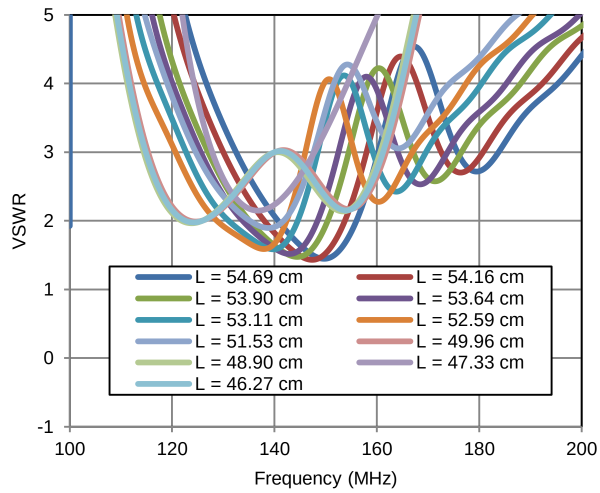

Figure 12: VSWR Meander Antena

Figure 12 shows the optimization of menader antenna design. This antenna has a varied response. The iteration of the VSWR value was done by changing the L value from 46.27 mm up to 54.69 mm. The best r value was obtained at L = 52.59 mm.

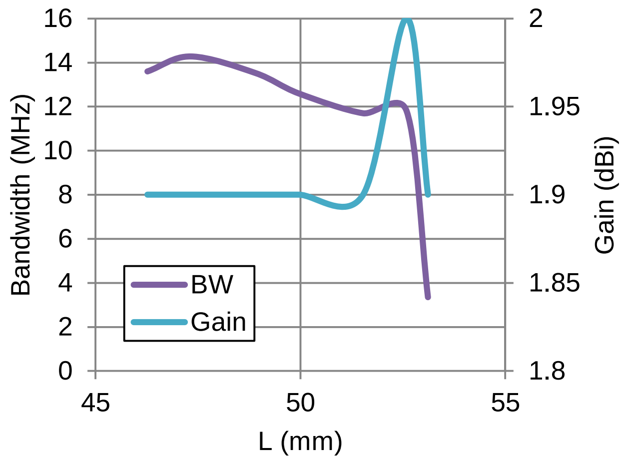

Figure 13: Simulation of bandwidth and gain menader antenna

In Figure 13 shows the antenna bandwidth simulation results (MHz) and antenna Gain (dBi). The simulation results show that the antenna has a Bandwidth between 3 MHz and 16 MHz. The greatest bandwidth value is at L value of 52.9 mm.

In addition to the bandwith value, the antenna Gain value is 2.046 dBi.

Table 1: Comparison of antenna

Parameter	Cross Dipole Helix	Cross Dipole Meander
Frequency Center	137.9 MHz	137.9 MHz
Return Loss	-28.29 dB	-12.86 dB
VSWR	1.08	1.58
Bandwidth	22.1 MHz	11.8 MHz
Gain	1.661 dBi	2.046 dBi
L (mm)	270.6 mm	325 mm

CONCLUSIONS

In this research, proposed a miniaturaization of cross dipole antenna by using helix and meander method. The Cross Dipole Helix method was done. Therefore the antenna has a smaller size with a fixed working frequency. After miniaturaization, the cross dipole helix antenna has dimensions of L = 270.6 mm with r = 32.22 mm. The simulation results show that this antenna was able to work at the frequency of 137.9 MHz with return value (S_{11}) of -28.29 dB, VSWR of 1.08, bandwidth of 22.17 MHz, and gain of 1.661 dBi. Moreover, a Cross Dipole Meander method also was proposed. After miniaturaization, the cross dipole meander antenna has dimensions of L = 325 mm with r = 32.22 mm. The simulation results show that this antenna was able to work at the frequency of 137.9 MHz with return value (S_{11}) of -12.86 dB, VSWR of 1.58, bandwidth of 11.8 MHz and gain of 2.046 dBi.

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REFERENCES

[1] G. Wibisono and T. Firmansyah., "*Design of dielectric resonators oscillator for mobile WiMAX at 2,3 GHz with additional coupling λ/4,"* TENCON 2011 - 2011 IEEE Region 10 Conference, Bali, 2011, pp. 489-493.

[2] Wibisono, Gunawan et al., *"Multiband Bandpass Filter (BPF) based on Folded Dual Crossed Open Stubs".* International Journal of Technology, v. 5, n. 1, p. 32-39, jan. 2014. ISSN 2087-2100.

[3] G. Wibisono, T. Firmansyah, T. Syafraditya., *"Design of Triple-Band Bandpass Filter Using Cascade Tri-Section Stepped Impedance Resonators".* J. ICT Res. Appl., Vol. 10, No. 1, 2016, 43-56 43

[4] Firmansyah T, Praptodinoyo S, Wiryadinata R, et al. (2017). Dual-wideband band pass filter using folded cross-stub stepped impedance resonator. *Microw Opt Technol Lett*. 59(29), 29–2934. doi: 10.1002/mop.30848

[5] Firmansyah, T., Praptodiyono, S., Pramudyo, A.S. C. Chairunissa, M. Alaydrus. (2017). Hepta-band bandpass filter based on folded cross-loaded stepped impedance resonator. Electronics Letters, 53 (16), 1119–1121. doi: 10.1049/el.2017.1121

[6] Teguh F., Supriyanto S., Herudin H., Gunawan W., Mudrik. "Multiband RF low noise amplifier (LNA) base on multi section impedance transformer for multi frequency application". *International Journal of Applied Engineering Research.* Vol. 11., No. 5. Pp.3478-3483. 2016.

[7] Waterhouse, Rod, "Printed Antennas for Wireless Communications", Sussex, England: John Wiley and Sons Ltd, 2007.pp. 183-184, 258

[8] Ramiati. "*Performance Analysis of Copper, Iron and Aluminum Material For Antenna Applications At Frequencies 630-700 Mhz".* Poly Engineering Vol.8 ISSN: 1858-3709.

[9] Kraus, J.D, 1988, Antennas, Mc grawhill.

[10] Irianto Antonius, 2008. *Design of Helix Antenna For Frequency 2.4 GHz.* Proceedings, National Scientific Seminar on Computers and Systems Intelligence (KOMMIT 2008).

[11] Setiawan Agil, Heroe Wijanto, and Yuyu Revelation. Design and Realization of Cloverleaf Antenna and Helix Antenna As Antenna Fpv (First Person View) On Quadcopter. openlibrary.Telkom-university.ac.id.

[12] Salsabil, syailendra. Year 2006. "2.4 GHz omnidirectional antenna manufacture for wireless-LAN network, PEN-ITS.

[13] D. Fabianu., Etal. Helix Antenna Design To Increase Gsm 900 Signal Receiver Ability That Has Low Power Level. Transient, Vol.3, No. 4, December 2014, ISSN: 2302-9927, 537.

[14] Ristua P. Simangunsong, Orlando, Design of Simulated Antenna HELIX For Bluetooth Applications, TugasAkhir S-1, Universitas Sumatera Utara, Medan, 2010.