SIMULATION AND REALIZATION OF MARKER BEACON ANTENNA ON THE AVIATION INSTRUMENT LANDING SYSTEM (ILS) USING VERY HGH FREQUENCY 75MHZ

Journal

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1. Background

Aircraft is one of the most riskiest transportation that exist, but yet it is the safest transportation, it is called risky because every flying position of the aircraft is critical position and dangerous, and in every critical condition of the aircraft a device that help the pilot to operate the aircraft and minimalize any human errors is needed. One of the example for the critical condition of the aircraft is when approaching the runway (landing), in that position the aircraft must on the appropriate distance and altitude, if the aircraft is still far from the runway but the aircraft is already dive too high it will resulting the aircraft to stall error, and if the altitude is too low to the ground it will be very dangerous for the aircraft itself. The critical condition of the aircraft in every situation making every devices such as navigation system and communication system on the aircraft are always equipped and connected with radio frequency to know the actual condition of the surrounding area and the condition of the aircraft itself, and one of the device that help the aircraft to approach the runway is Instrument Landing System (ILS) which consist of Marker Beacon, Glide Slope, and Localizer[2], those three devices works with different system as one group of ILS. The ILS system is already developed since 1928 by the Federal Aviation Administration (FAA) and the first test of ILS was held in 1929 with the first America's civil airlines[15], although this tool has been around for a very long time and has been developed but its use is still not evenly distributed in every airport around the world, seeing the importance of using this tool to reduce human error and also help the pilot to land the aircraft on the bad weather.

ILS marker beacons are used to facilitate the aircraft when landing. The tool used will simulate a marker beacon working system that resembles what is on an actual plane. By drawing indicators in the form of lights that indicate that the position experienced when the indicator lights up is the distance that is being obtained by the plane towards the runway. The Instrument Landing System (ILS) has an important role in navigating the aircraft, namely to help align the aircraft against the runway and help the aircraft to landing. ILS is divided into several systems such as marker beacons, glide sloop, localizer[2]. This final project will discuss how to work and the system in marker beacons.

Marker beacon consist of receivers and transmitters, receivers are located on air planes while transmitters are located on ground or land which have a working principle of receiving signals from signals emitted from transmitters installed on land and also runways with signal frequencies worth 75 MHz and receiver information output as lights indicators with information frequency such as white 3000 Hz, 1300 Hz amber, and 400 Hz blue[4][5].

The working principle of marker beacon is to emit signals carried out by transmitter antennas placed on land and received by receiver antennas on the aircraft. The antenna that is grounded serves to transmit information in the form of distance from the runway to be addressed in the direction and pattern of the vertical beam and the carrier frequency of 75 MHz. The marker beacon that located on the aircraft work as antenna receivers, data processing, and indicators. The aircraft receives a signal from the transmitter and then processes it by separating the carrier signal from the information signal and the output of the information signal will be displayed on the indicator in the form of lights.

Marker Beacon antennas are using a yagi antenna design and it is a type of a commercial radio or television antenna. This antenna is a directional antenna which is increasing the gain on one side of the antenna, the antenna side behind the reflector has a lower gain. the receiver antenna or transmitter antenna in the marker beacon both use the 75 MHz frequency as a carrier signal and have a data signal with a frequency of 400 Hz to 3000 Hz so as shown in the table 1.1 the frequency band designation for Marker beacon antenna is Very high frequency (VHF) where the frequency is suitable for air navigation and communication process.

2. Marker Beacon Working Principle

The working principle of marker beacon is to emit signals carried out by transmitter antennas placed on land and received by receiver antennas on the aircraft. The antenna that is grounded serves to transmit information in the form of distance from the runway to be addressed in the direction and pattern of the vertical beam and the carrier frequency of 75 MHz. The marker beacon transmitter antenna is divided into 3 antennas and has a different information frequency, namely the outer marker has an information frequency of 400 Hz, the middle marker has an information frequency of 1300 Hz, and the inner marker has an information frequency of 3000 Hz.[4][13]

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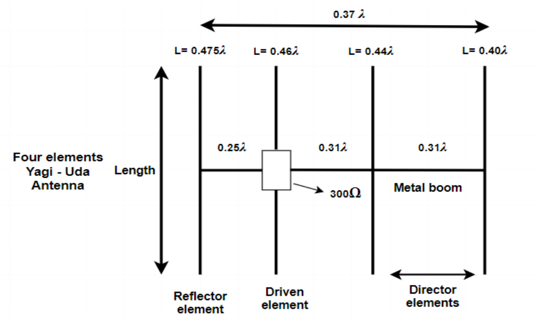
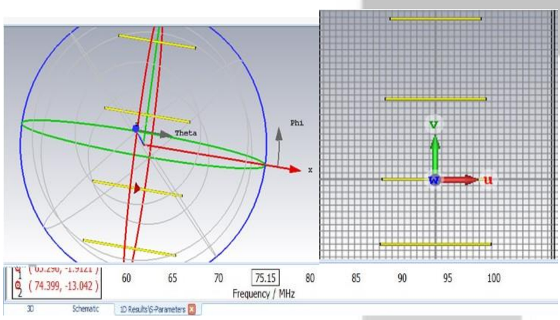
3. Marker Beacon Antenna Parameter

Marker beacon antennas are very important for receiving precise marker signals, and most marker beacon antennas require adjustment after they are installed. Marker beacon using yagi antenna, the antenna that widely used and is an antenna whose design is considered successful for RF directive applications. Now we convert Marker Beacon Antenna from directional antenna shark fin intoYagi antenna. Yagi antenna is used to receive or transmit radio signals. The yagi antenna is a directional antenna, meaning that it can only take or receive signals in one direction, yagi antenna usually has a gain of around 3-20 dB.



4. Marker Beacon Antenna Design Simulation

Before making the antenna design, the first step that must be done is to do the calculation to determine the antenna's



dimension, therefore the wavelength of the antenna should be known so that the antenna dimension can be determined. The formula to determining the wavelength already mentioned before $\lambda = {}^{c}\!/_{f}$ .where λ stands for the wavelength, *c* stands for the speed of light propagation (3×10^8), and *f* stands for the frequency of the antenna, since the frequency of the marker beacon antenna is 75 MHz so here is the calculation:

$$\lambda = \frac{3\times10^8}{75\times10^6} = 4\ m = 400\ cm$$

After the result of the wavelength are known,then the length of each element and the distance between each element can be determined. The simulated Yagi antenna for Marker Beacon consists of a Reflector, Driven, and two directors. The length of each element and the distance between each elements now can be calculated as below:

1. Reflector length = 0.475×400 (*wavelength*) = 190 *cm*
2. Driven length = 0.46×400 = 184 *cm*
3. Director 1 length = 0.44×400 = 176 *cm*
4. Director 2 length = 0.40×400 = 160 *cm*
5. Distance R to D = 0.25×400 = 100 *cm*
6. Distance D to Dr1 = 0.31×400 = 124 *cm*
7. Distance Dr1 to Dr2 = 0.31×400 = 124 *cm*

After all the result are known, so now the antenna design simulation for the Marker Beacon can be run. The antenna design simulation is using software application called CST STUDIO SUITE, so here is the simulation result:

Seen in the figure 3.5 that the length of each element it is not accordance with the calculation above, it is because of the calculation is less inaccurate. The results that obtained according to the calculation only give the frequency on 75,15 MHz which the result is more requency as much 0,15Mhz with the actual antenna, so the length reduction of each element is necessary.

To determine the result of the bandwidth is by calculating the highest curve signal result minus the lowest curve, so the obtained result is:

$$\frac{74.399}{65.296} = 9.103\ \text{Db}$$

5. Antenna Design Realization

The conductor material that being used to make the antenna is an Aluminium referred to the simulation above. Aluminium that being used are having two kind of shape which are Hollow used as a boom of the antenna and Pipe used as the element of the antenna.

The volume of the hollow shaped aluminium is 1.5 inch with 350 cm long and the pipe shaped aluminium volume is 0.875

inch and it is divided into four lengths which are 179 cm long as the reflector element, 173 cm long as the driven element, 165 cm and 149 cm long as the directors. Afterwards, drilling the hollow shaped aluminium is carried out in accordance with the pipe shaped aluminium so it can fit inside the hollow aluminium so it can works well as an elements. The distance between every elements is referred to the simulation above which are 100 cm for every elements.

6. Result Experiment Systematic

For the testing process of the Marker Beacon antenna as a receiver, a transmitter antenna is needed as a referenced antenna, the reference antenna that being used for the experiment is the antenna from selex.inc model 2130 which is provided by Radio Communication Aviation Engineering laboratory of Nurtanio University. The use of the antenna project that is made is capable of being used for both transmitter and receiver separately adjusting to the circuit it carries. And the focus of the Marker Beacon antenna project is used as the receiver antenna that was previously equipped with 75MHz receiver circuit. The test of the receiver antenna is held in the separately in a wide room with the transmitter antenna considering the availability of the room with a few obstacles, in this case relating to the building as an obstacle to frequency propagtion.

7. Simulation

Prepare the receiver circuit for the antenna and don’t forget to kae sure the circuit is not short, cuted down, or failed to connect when it is connected to avo meter. After everything are all prepared, the next step of the process is distributing the power source to the circuit, and then pair it with the signal generator on the antenna and don’t foget to test the shape of the signal from the antenna and also the receiver circuit of the antenna using the oscilloscope.

On the signal generator device at the frquency generator output section is connected to the antenna, and then turn on the power button switch, then adjust the signal size that needed through the frequency selector which are seprated by letters according to the frequency scale. The signal 75MHz placed in mode “e” and then set it up the frequency scale to 75MHz accurately using the frequency control, and then adjust teh frequency reading to the indicator.

The readings of the signal generator measurment or frequency generator is also adjusting to the selector mode (A) at the mode with letter “e”. After the frequency generator is prepared then connect it to the oscilloscope to get the result from the antenna measurement test, these are the steps for the measurement test:

1. The testing process begins with the receiver circuit connected with power to 12VDC of power
2. Connect the coaxial cable form thr antenna to the signal generator with frquency 75MHz.
3. Connect the oscilloscope input cable to the receiver circuit.
4. Push the auto set butten at the osciloscope and adjust the knob volt/div vertical dand horizontal to see the good shape of the frequency signal.
5. Read the measurement device

8. Simulation analysist

The parameters that be reference for transmitter and receiver are from signal processing stages, as for modulating that use for transmitter and receiver need to know how the signal pole radiate, voltage standing wave ratio (VSWR),antenna gain, periode, wave length,and frequency. and this part will explain the laboratory result test that carried out by using oscilloscope. Based on the testing process that is done from sub section 4.2 the measurement result will explain as bellow.

Tabel 4.1 Measurement Analysist with osciloscope

MEASUREMENT ANALYSIST (with osciloscope)	
Vpp	276mV
Vrms	91.3mV
Frequency	75.37 MHz
Offset frequency between antenna reference	More than 0.23Mhz (standard conventional system ±1500Hz)
Periode	12.92ns
Signal Information	No

The main parameter to get the graphic of the signal radiation pattern is the result from the oscilloscope measurement. During the test of the frequency radio wave on both transmitter and receiver, the graphic of the signal pattern is sinusoidal pattern and the frequency that transmitted and received are same which is 75MHz . The following is the graphic of the signal pattern from the oscilloscope.

Table 4.2 Result in Formula

length Antenna for 1 lamda	4 meter
Length antenna for ½ lamda	2 meter
Wave length	2 meter = 78.72 in = 6.56 ft
VSWR	1.654

Tabel 4.3 Result In Design

Name	Value
Driven	173
Reflector	179
D1	165
D2	149
C	3”10’8
F	7,5’10’5
Lambda	c/f
Jrd	100
Jdd1	100
Jd1d2	100

The result from the experimented antenna if it is compared with the conventional existing antenna when it is being tested are.

1. The experimental antenna only demonstrate the frequency result and not expalining the output result of information signal that proved with the lights.
2. The frequency result after it is measured and tested with the oscilloscope give a result 75.33MHz while the tolerance or maximum limit that allowed from ILS Marker Beacon factory-made is ±2250Hz of Standard and offset frequency is ±1250Hz.

9. Conclusion

1. The experimental antenna is worked and can do both transmit and receive the signal 75MHz.
2. The signal intended in the testin the form of AM (Amplitude Modulation)
3. The experiment need a receiver circuit to get the physical result.
4. The experiment is only dicussing and explaining that the antenna is capable to transmit and receive the signal with frequency 75MHz adjusting with the available receiver, and not giving the information about matching with the transmitter antenna.

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