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Design of Survey Tools for Obstacle Height Monitoring on the Line of Sight Communication Path

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Abstract: The quadcopter, which is basically used as the top viewer picture taker, in this research will be used as a device to carry the laser rangefinder to measure the obstacle height on the communication path between the location points of near end to far end. The obstacle height reading results were transmitted using a 5.8 GHz wireless transceiver to the monitoring center in real time. The data received were then processed to be displayed in graphical form, which shows obstacle height as a function of line of sight communication distance. The test results show that this device is very helpful in line of sight survey work, especially for monitoring obstacle height on the communication pathway with an accuracy of more than 90%. This device is very efficient because without using a 3-dimensional map the highest obstacle can be detected so that it can be used as a basis for determining the high position of a microwave communication antenna with clearence status.

Keywords: Line of sight, Laser Rangefinder, Obstacle height, 5.8 GHz wireless transceiver, Near end, Far end

1. INTRODUCTION

Radio communication system requires two antennas installed within communication paths; one antenna is installed in the transmitter to radiate the signal to the air while the other is installed in the receiver to receive the signal in the air. Both of the antennas should be placed above high objects in the line of sight [1][2].

The standard operational procedure of radio transmission survey is carried out manually by determining the location coordinates "near end" and "far end", followed by scanning the path by measuring the height of objects along the paths that are suspected to be the obstacles of communication system. The result of object height scanning is then analysed using pathloss application [6] as the basis for determining the optimum height of communication antenna[5], by ensuring there is no obstacles within the path of line of sight. [7].

The scanning of object height itself, however, cannot be done if the communication path lies on areas that are not accessible by transportation system in general. Therefore, the determination of the height of the antenna can only be based on estimation value of object height suspected as obstacles in the path. The estimation method is quite susceptible to errors thus the equipment installation recommendation can possibly be wrong or inaccurate.

This research aims at designing and creating a supporting equipment for survey line of sight in the micro-wave radio communication system. The equipment will do a monitoring of object height that is suspected to be the obstacles within the path of line of sight by utilizing proximity/ altitude sensor laser rangefinder. Laser rangefinder is used to find out the proximity of a particular object [8][9][10] surface by measuring the round trip travel time of light pulses.

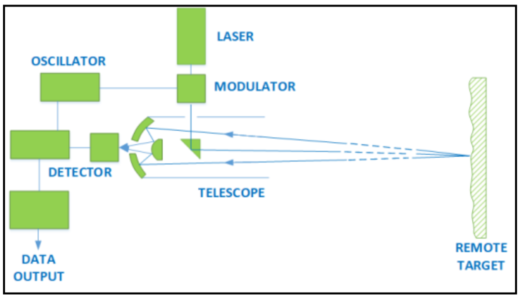

Figure 1. Object Proximity/ Altitude Sensor Using Laser

A light pulse is used to measure the distance from its travel time [11], starting from radiating the pulse until reaching the object, then the bounce of the pulse is received back by a detector. Since light propagation (c) and the travel time from being radiated to received back by the sensor (Δt) have been found out, the proximity/ height (d) can be measured using the equation below:

$$d = 2\ x\ c\ x\ \Delta t \qquad (1\text{-}1)$$

where :

d : distance from the equipment to the object (meter)
c : wave propagation (meter/second)
Δt : travel time (second)

Rangefinder Laser measures only the distance in the direction of view with a high level of accuracy [12][13]. The

Rangefinder laser brought by quadcopter autopilot to move between two point locations of “near end” and “far end”. Quadcopter is equipped by Rangefinder laser as the sensor to determine the height of the object under communication path of line of sight [7]. The result will be transmitted to the monitoring location using wireless transceiver 5.8 GHz. The data received in the location is then processed to obtain the real time display of object height graphics in the communication path. The graphics are useful for easing the analysis to directly determine the position and also height of the objects that possibly become the obstacles in the path.

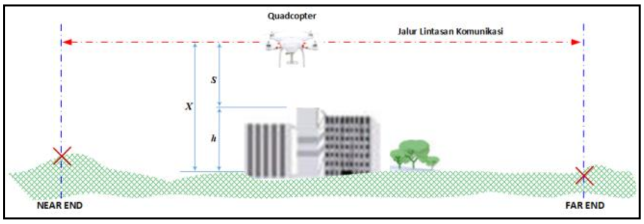

Figure 2. Robot Monitoring of Obstacle Height

Quadcopter with rangefinder laser constantly moves above the highest object along the communication path. Rangefinder detects the height of straight objects beneath, *h* meter (AGL), which is measured using the equation:

$$h = X - S \qquad (1\text{-}2)$$

X is the height of quadcopter and S is the distance of upper tip of the object towards the quadcopter position. By adjusting horizontal quadcopter speed and the setting of measurement periods of object distance using rangefinder, the object height graphics of the intended measurement will be as Figure 3. The graphics directly show the height and position of the highest object suspected as the obstacles, which in this case, the highest objects are d1 and d2 respectively towards “near end” and “far end”, with the height of h meter (AGL).

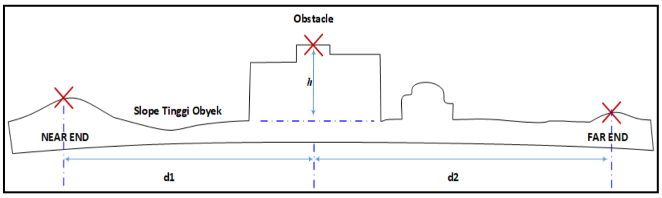

Figure 3. The Graphics of Object Height on the Signal Communication Lane

The last step of the survey is setting the optimum height of antenna position based on the highest object in the communication path, thus the line of sight communication is free from obstacles. It is continued by planning and selecting the equipment to install based on the calculation of link budget so the signal power value received can be as expected. These two steps are completed by using Pathloss application software.

2. METHOD OF RESEARCH

This research aims to design a survey tool for micro-wave radio communication system related to object height monitoring that is suspected to be obstacles on line of sight communication path using a quadcopter. The result of this research is expected to help people finding out the position and highest height of object quickly and easily that can be used as the basis to determine the optimum height position of an antenna so the communication path is clearance. [14][19][20].

Figure 4 shows the block diagram of survey equipment to monitor the height of object.

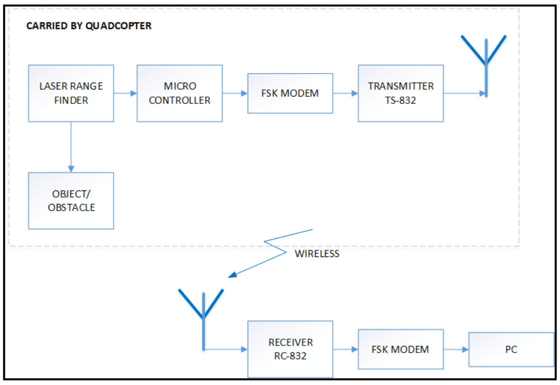

Figure 4. Tools Survey for Object Height Monitoring

2.1 Equipment Specifications

The survey equipment to measure the height of the obstacles in the communication path of line of sight consists of quadcopter to bring rangefinder laser as an altitude sensor, microcontroller, FSK modem, wireless transceiver 5,8 GHz to transmit the result of object height detection in the communication path of line of sight to the center of monitoring location. The data of object height received in the center of monitoring location will be processed to get the graphics, as a function of communication path distance between ”near end” and ”far end”.

The components of the equipment have the specifications as follows:

1) Quadcopter: The quadcopter must be able to move horizontaly straight from the location of near end to far end with constant height as planned that is above the highest object under the communication path of line of sight. It also must be controlable to move automatically and have adequate coverage to accomodate the distance of surveyed communication link. The specifications of the quadcopter are [21]:

TABEL 2.1. SPESIFIKASI QUADCOPTER

No.	Description	Specification
1.	Max. Ascent Speed	5 mps
2.	Max. Descent Speed	3 mps
3.	Max. Speed	16 mps (no wind)
4.	Max. Altitude above sea level	6000 m
5.	Wifi frequency	2.400 GHz – 2.483 GHz
6.	Max. Transmission Distance	FCC 1000 m, CE 500 m
7.	Transmitter Power (EIRP)	FCC 27 dBm, CE 20 dBm

2) Rangefinder laser: Rangefinder laser is used as a sensor to measure the height of the object. The measurement is controlled by a microcontroller that works as measurement control. The specifications of the rangefinder laser are: [22]:

TABEL 2.2. SPESIFIKASI LASER RANGEFINDER

No.	Description	Data
1.	Distance	5 - 600 meters
2.	Wavelength	905 nm
3.	Accuracy	+/-0.5 m
4.	Operating Voltage	5V to 6 V

3) Wireless Transmitter 5,8 GHz: the wireless transmitter works to transmit the rangefinder laser sensor readings in real time to the central location of monitoring. This research utilizes transmitter type AV (audio video) TS-832 that works in the frequency of 5,8 GHz. The detailed specifications of this AV wireless transmitter [23] is seen in the table below:

TABEL 2.3. TRANSMITTER SPECIFICATION TS-832

No.	Description	Data
1.	Item Name	TS-832 Transmitter
2.	Antenna gain	2 dBi
3.	Frequency	5.8 GHz
4.	Transmitting Power	600 mW
5.	Power Input	7.4 – 16V
6.	Video Format	NTSC/PAL Auto
7	Audio Bandwidth	6.5 MHz
8	Video Bandwidth	8 Mhz
9	Connector	RP-SMA jack

4) Wireless Receiver 5,8 GHz: the wireless receiver works to receive transmission data performed by the transmitter module. The technical specifications of the wireless receiver 5,8 GHz type AV RC-832 is seen in the table IV below:

TABEL 2.4. RECEIVER SPECIFICATION RC-832

No.	Description	Data
1.	Number of channels	32 CH
2.	Antenna gain	2 dBi
3.	Frequency	5.8 GHz
4.	Rx Sensitivity	- 90 dBm
5.	Video Output Level	75 Ohm
6.	Video Output Level	10 Kohm
7.	Video Format	NTSC/PAL Auto
8.	Video Bandwidth	8 Mhz
9.	Connector	RP-SMA jack

5) User interface: A user interface is created to connect the systems with users through a particular application program which can process the data from altitude sensor received in the central location of monitoring to be displayed in the form of object height graphics as a distance path function. It is also beneficial to set the storing process of object height logger data.

2.2 System Design

The system design to monitor the height of an object in a communication path of line of sight is performed based on block diagram in Figure 3. The detailed design of each part, especially for transmitting and receiving process, is as follows:

1) Obstacle Altitude Sensor Control*:* The laser rangefinder altitude sensor was controlled by a microcontroller (Arduino Uno R3) [24], then the generated height data were fed to the FSK modem to be transmitted to the monitoring location.

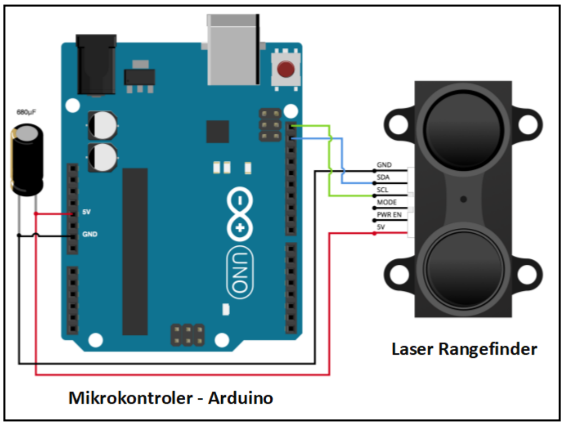

Figure 5. Obstacle Altitude Sensor Control Circuit

2) Obstacle Height Transmission Data: Obstacle height data from rangefinder laser sensor is transmitted to the central monitoring location using AV module (audio video) wireless transmitter TS-832. The obstacle height data is in the form of digital data so conversion to the analog one using modem is needed so that it can be transmitted using wireless transmitter TS-832. The modem used in this research is FSK type IC TCM-3105.

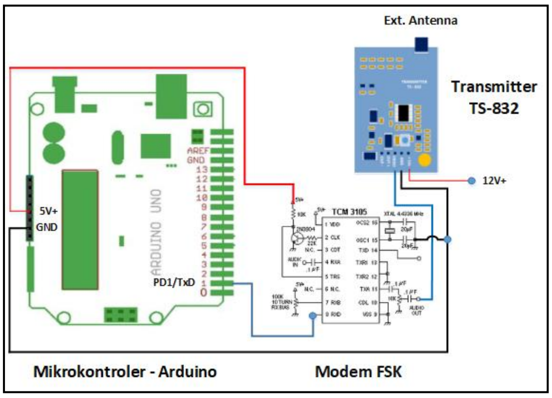

Figure 6. Obstacle Height Data Transmitting Circuit

3) Obstacle Height Data Receiver System: In the location of monitoring center, the obstacle height data is received by wireless receiver AV type RC-832. Since the data is analog, it needs to be converted first just like in the transmitter, that is turned into digital data using FSK modem type IC TCM 3105 [25].

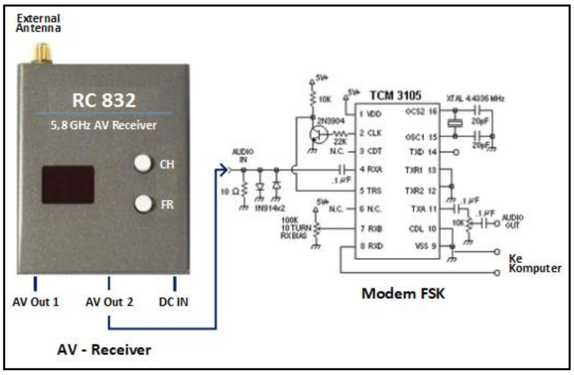

Figure 7. Obstacle Height Data Receiver System

The converted data from FSK modem is then processed by computer so that it can be displayed in graphics. In this way, the final result of obstacle height monitoring process is also in graphics of obstacle height above communication path of line of sight.

3. RESULTS AND DISCUSSION

The result of this research is an artificial model of obstacle height monitoring system device in the micro-wave *line of sight* communication link that consists of two parts:

1) The transmitter: the device is brought by a quadcopter to move above the communication path of line of sight which has been planned, to determine the height of object suspected to be the communication barrier.

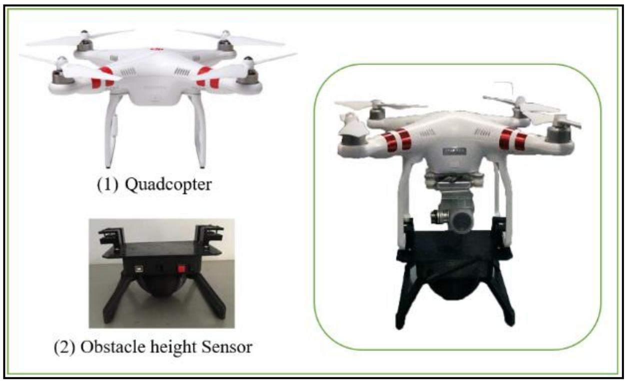

Figure 8. The Transmitter of Obstacle Height Monitoring System

2) The receiver: this device is placed in monitoring location, working to receive the signal of obstacle high sensor transmission data in the transmitter. This part plays the role to interpret the data based on the computer input using USB.

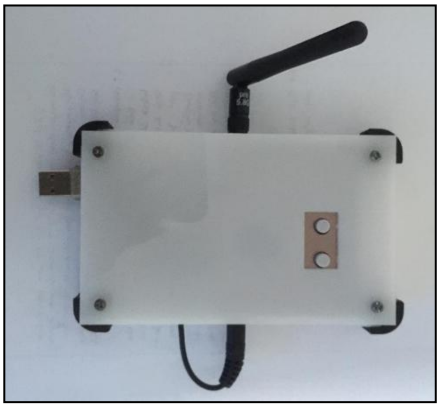

Figure 9. The Receiver of Obstacle Height Monitoring System

The measurement of the height of obstacle was performed using rangefinder laser, while the quadcopter was functioned as rangefinder laser sensor carrier that moves straight horizontal from the point of *near end* to the point of *far end*, following the communication path of line of sight which has been set previously with the height more than the highest obstacle in the path.

The data of rangefinder laser sensor interpretation was sent real time to the location of monitoring centre of obstacle height through wireless receiver 5.8 GHz. After that, the received data was processed to get the graphics version of it thus the users can easily determine the highest object within the communication path of line of sight suspected as the obstacle.

3.1 The Result of Obstacle Height Measurement

The device prototype of obstacle height monitoring system that did the measurement of object height suspected as obstacle in the communication path of line of sight has the distance of 170 meters with the path as seen in the Figure 9.

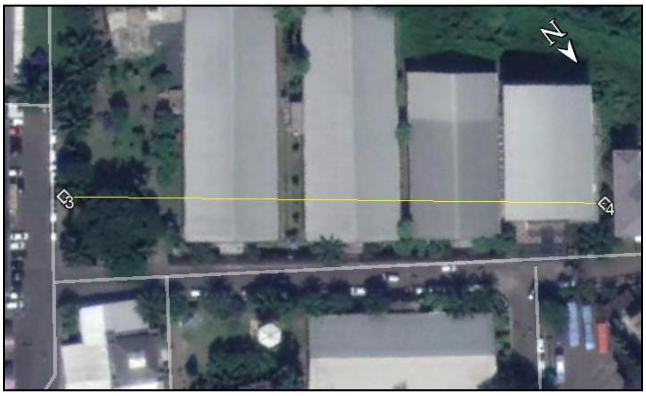

Figure 10. The Testing Path of The Rangefinder

The results of the obstacle height monitoring system are displayed in Figure 10.

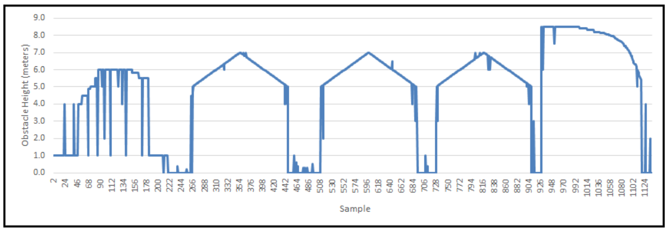

Figure 11. Communication link of the rangefinder testing path

When the laser rangefinder sensor hit leaves or a tree, the measurement results were not stable because some laser beams hit the object underneath or through the leaves. The highest obstacle between communication links was 8.5 meters which was close to the far end location. The Application of Obstacle Height Data is used as the basis to determine the height of the antenna. The obstacle height data which are generated by the monitoring system tool can be used as inputs of pathloss software, which is used to estimate the line of sight radio communication antenna's height [4].

Assuming the communication link had a WiFi frequency of 5.6 GHz, Fresnel of 100%, and the value of K = 1.33, then a communication link that was free of obstacle required the minimum antenna height at the near-end and far-end of 10 m (AGL) and 12 m (AGL), respectively. The results can be shown as in Figure 10 [4].

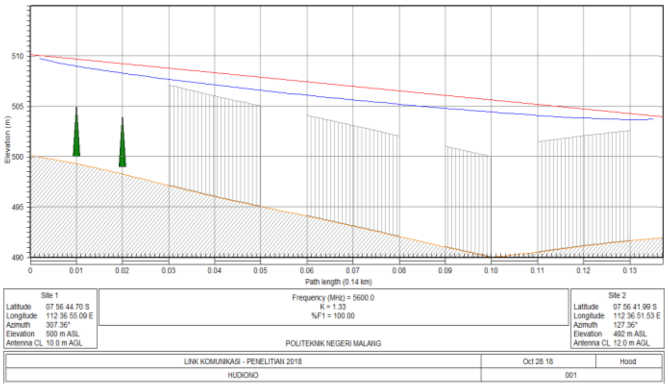

Figure 12. Determining The Antenna Height Using Pathloss-4 Software

4. CONCLUSION

The conclusions of this research are:

1. The laser rangefinder sensor has a maximum measurement specification of 600 meters and it can detect most types of objects, except for transparent objects or the materials that cannot reflect the laser beam.
2. The output of the height monitoring system is displayed in graphs; thus, it is easy to read without having to analyze it first.

3. Quadcopter that carried the monitoring system moved on the line of communication links as planned from the near-end location with coordinates of 07 56 44.70 South and 112 36 55.09 East to the far-end location with coordinates of 07 56 41.99 South and 112 36 51.53 East. The distance was 137 meters and the quadcopter flew above the height of the obstacle, which was 8.5 meters (AGL).

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