

Design of Wireless Automatic Microwave Antenna Alignment System

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Abstract – Microwave link alignment is an important operation in communication systems. Misalignment in line of sight link due to rain, wind etc is considered the basic problem faced by the microwave system. This problem caused a direct termination of the microwave link. Automatic antenna alignment will guarantee best communication at the link's ends without any risks of human interface. This paper presents low cost design of an automatic antenna alignment system based on Arduino and using Xbee wireless technology. The design proposed in the paper is by automatically adjusting the horizontal and vertical angles in the transmitter and receiver sides of the microwave link. The controller compares the measured values of these two angles with the reference values. The correction of error in the angles is done by moving the antenna towards the correct position. The design was tested in different angles positions and the results are reported in the paper. The simulation results verify that the system works successfully.

Keywords: Antenna, Design, Xbee, Alignment

Article History

Received 31 August 2019

Received in revised form 22 February 2020

Accepted 11 March 2020

I. Introduction

Microwave link refers to radio beam that is used for communication between transmitter and receiver [1]. Microwave communication uses high frequencies and point to point link [2]. This type of link requires a unique setup of antennas which is done by placing them in high position to avoid any obstacles and direct link between antennas must be available to provide clear radio link [3]. Generally, for line of sight (LOS) link the position of the strongest signals are often been accounted [4]. The mechanism of aligning any two microwave antennas can be done manually or automatically as suggested in this paper. In manual microwave antenna alignment system, the maintenance service is expensive and wasting time.

It is possible to say that in the 21st century the world had become small village because in this age time the communication technologies and services help people from all over the world to meet or chat via different communication technologies such as internet and cell phones. Microwave communications are the backbone that join all these technologies. It has a lot of advantages such as the large bandwidth, small size of antenna and the advantage of environment stability due to not using any ground cable installations. The structure design of the radio wave tower is based on the applications of the microwave communications, for example TV

broadcasting often needs tall towers [5]. Servo motor allows the angular control and it has sensor for position feedback. This type of motor is used widely in many applications such as robotics and a lot of automation process [6]. This paper proposes a design of automatic antenna helps to solve the problem of expensive cost of the manual alignment and the hard works that are required for this operation. The following sections of the paper contains the related works, types of alignments, hardware and software description, before finally demonstrating the obtained results of the system.

II. Related Works

There are lot of papers published in the field of antenna alignment where some of them perform different types of alignment such as the satellite dish alignment while the mechanism for most of them is often based on measuring the received power beam. Unlike the published papers which summarized in Table I, the significant of this paper is shown in the design of control circuit which using the Arduino and the wireless technology used for the mechanism of alignment. Wibisono [7] presented a circuit diagram for satellite dish alignment where the architecture was based on AVR microcontroller. Chang [11] introduced simple design for

detecting any unwanted movement of antenna and correcting the alignment of antenna using pensioner and specific algorithm operated by feeding input parameters. Singh [8] discussed the ability to use hybrid power source in automatic alignment in telecommunication system where the paper focused on the concept of aligning antenna without introducing real design. Adib [10] in his paper presented alignment of interference relative to the required displacement of antenna. Prasanna [9] presented simple design used for aligning TV antenna based on the GPS system. However, it does not use wireless connection monitoring and is not offering alignment of point to point link.

TABLE I
SURVEY OF RELATED WORKS

<i>Author</i>	<i>Year</i>	<i>Description</i>
<i>Wibisono [7]</i>	2016	This paper describes the basic on procedures for the manual alignment of satellite dish, was proposed. The design used AVR microcontroller.
<i>Singh [8]</i>	2016	In this paper an auto alignment of microwave antenna using renewable source to generate power for the antenna alignment is proposed. It also contains battery for storage reason.
<i>Prasanna [9]</i>	2016	Automatic dish antenna alignment based on microcontroller and use stepper motor.
<i>Adib [10]</i>	2013	The contributions of this paper are to demonstrate the feasibility of interference alignment and nulling purely via motion.
<i>Caldeirinha [11]</i>	2011	In this paper the alignment is performed through position and a specifically developed algorithm.
<i>Chang [12]</i>	2004	Design provides an automatic alignment that is used for calibration of hydrometers.

III. Antenna Alignment

Microwave alignment can be done automatically using smart control device often works by selecting the strongest incoming signals. The microwave antenna alignment can also be done manually. There are lot of

risks and efforts in the manual method. The operation of manual alignment basically performed in the following three steps [13]:

- Step 1: Preparation: this step done by mounting the antenna using installation instruction
- Step 2: Coarse Alignment: in this operation step the engineered works to find a visually align between antenna and the far end antenna.
- Step 3: Final Alignment: conducting fine alignment.

Any successful alignment operation of microwave antennas must ensure the following:

- The outdoor unit should be powered up at both sides.
- Use the correct frequency instruction at both sides.
- Use the correct transmitted power.

There are some consequences in the application if the alignment procedure did not ensure using the correct setup of frequency or power such as, interference. There are two features available to assist antenna alignment depending on the measurement of the received signal the received signal Strength Indicator and the receive signal level.

IV. Methodology and Results

The main concept of this paper is to design control system that can be used to align any point to point microwave antenna automatically by storing the correct horizontal and vertical angles within the memory of the controller as reference angles. It then sends the measured angles of the antenna every time through Xbee module to control the circuit which is used to repair the misalignment if it exists. Both antenna at the ends of the microwave point to point link require a transmitter and receiver with an alignment circuit as shown in Fig.1. Both sites are connected to the monitoring circuit on the ground using the Xbee module. Potentiometer is used to simulate the unwanted movement of the antenna.

The major components that are used in the hardware part are the Arduino, the Xbee module and two servo motors which are used to adjust both angles of each antenna to the reference angle stored in the system. Fig. 2 shows the monitoring circuit which continuously received the current status of alignment for the two microwave antennas up the tower.

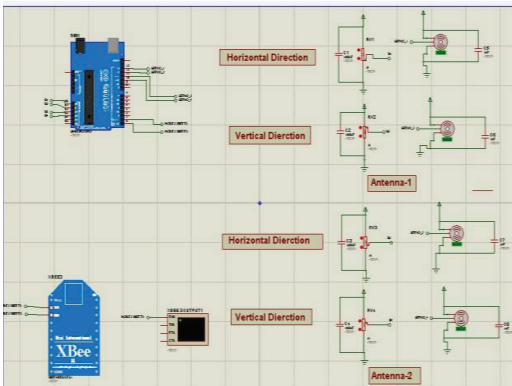


Fig.1. Microwave Alignment Circuit

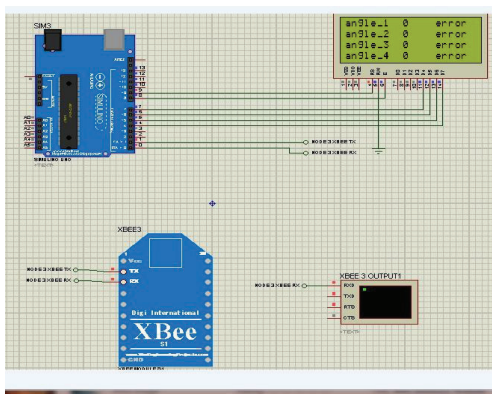


Fig.2. Monitoring Circuit

The antenna alignment system is basically a closed loop system that deals with a continuously varying values from the measured angles positions of each antenna. It is then fed to decision making device to decide any mismatch and depending on the mismatch information, the control circuit the controls the operation of the two servo motors. The operation algorithm as shown in Fig.3 is carried out in the following steps:

- Step 1: measuring the angles of the microwave antenna to detect any unmatched value.
- Step 2: sending the obtained value to the controller circuit to decide if was matched with the reference value saved in the system
- Step 3: adjusting the alignment of angles to the correct value as saved in the system.

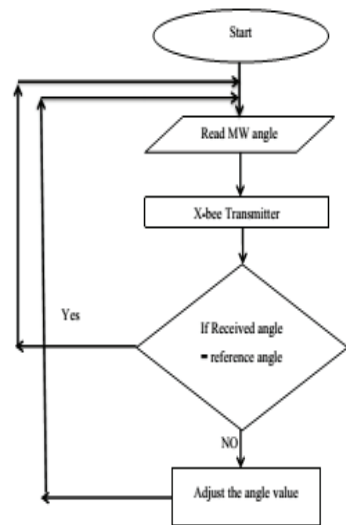


Fig.3. Algorithm of the system operation

The control circuit compares the measured values of the angles with the existing reference values in the system. If the controller finds any change as a result of external factors such as strong wind, the decision control circuit will send order to correct the direction of the motors to adjust antenna toward the right position.

The results of this paper are based on simulation that were carried out using proteus design software. For simulation purpose the paper assumed a tower with two microwave antennas, where the system stores a reference values of horizontal and vertical angles of antenna A1 as (91°, 30°) and A2 as (80°, 45°) respectively. The horizontal and vertical angles for A1 are referred in the display unit as angle_1 and angle_2, while angle_3 and angle_4 are used for A2. The results of misalignment case are shown in Fig. 4 where in this case an unwanted movement of antenna (A1) occurred in both angles at several times such as (26°, 95°) for horizontal and vertical angles respectively.

The same operation behaviour occurred for the case where an alignment error occurred in A2. As shown in Fig. 4, both alignment angles experienced an unmatched values given by (46°, 76°). The misalignment cases were recorded as “error” in the display screen if there were unmatched values for both angles of any antenna. The matched values are shown in the display unit as “right”.

The two servo motors rotate the antenna to the normal direction of the antenna. Therefore, the system automatically corrects any unwanted movement of the antennas by moving the antennas to the correct position regarded to the reference angles which saved in the system as shown in Fig. 5.

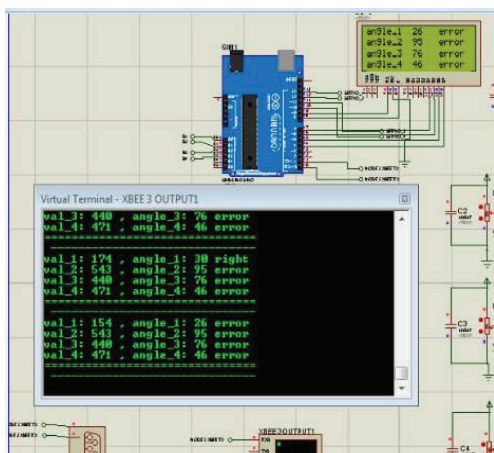


Fig. 4. Results on simulation for misalignment case

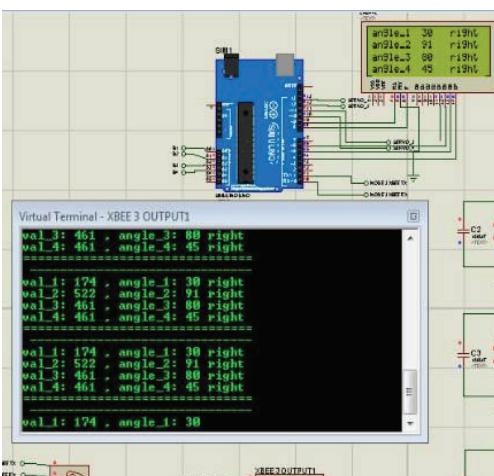


Fig. 5. Results on display on the correction of angles

The place where the design circuit is installed is shown Fig. 6. Each end of the alignment link requires a module circuit. Therefore, each side of the alignment link has the reference angles saved in the controller.

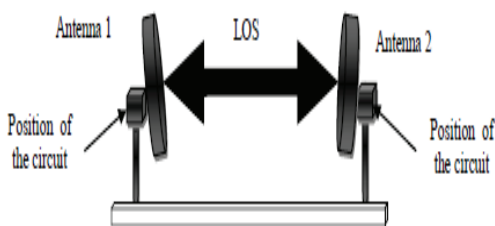


Fig.6. Basic construction of the circuit installation

In addition, the risks in the manual microwave alignment is considered a very expensive operation. Table II gives an approximate amount for the manual alignment cost at around \$30,000.00/year, while the total costing of the proposed design is approximately around \$300.00.

TABLE II
COST OF MANUAL ALIGNMENT (IN MONTH)

Item	Cost/month (US Dollar)
Car rent	300.00
Car maintenance	500.00
Fuels	150.00
Spending	40.00
Salary's	1500.00
Tools	20.00
Total	2510.00

V. Conclusion

This paper presents an advanced design of antenna alignment system. The system uses the Xbee technologies to send accurate angles to adjust the servo motor in the correct position. The system is useful in reducing the down time of the microwave link and the risks of manual aligning. The proposed design has simple structure and low in cost in compared with the costing of manual alignment. The system was simulated and tested with different alignments cases. The obtained results show that the system results were accurate and reliable where the system can be used successfully.

Acknowledgements

This work was supervised at the Engineering Department of AL-Gezira Technology College, Sudan.

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