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MODELLING OF THE STABILIZATION AND TRACKING CONTROL SYSTEM FOR ANTENNA

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Abstract: In order to speed up the data rate, the antennas are required to operate at higher radio frequencies. The increased frequency requires more precise antenna pointing system and the need of pointing control is to counter act the effect of external disturbances which includes wind gust, terrain profile etc. All these factors demand an embedded system engineer to design a more accurate antenna control system. This paper describes the control system engineering principles used in designing, testing and implementing, a control and measurement system on an antenna. The control system is modelled to monitor and control the antenna in elevation (Vertical axis) and azimuth (Horizontal axis). The system is also stabilized with the help of level sensor.

Keywords: Antenna, control system, elevation, azimuth

I. INTRODUCTION

The main purpose of an antenna is to collect and convert electromagnetic waves to electronic signals. Transmission lines then guide these to the receiver front end. Increasing antenna gain by 3 dB generally requires increasing the size by a factor of 2-3. The newly designed antennas, radio telescopes, and telescopes have to satisfy control and pointing requirements that challenge existing technology. In order to increase the data rate, the antennas are required to communicate at higher radio frequencies: from S-band (2.3 GHz) to X-band (8.5 GHz) to Ka-band (32 GHz). The increased frequency requires more precise antenna pointing systems and the increased size creates multiple pointing and control challenges.

The objective of this project is modelling the stabilization and control system for azimuth and elevation axis for antenna. Antennas are positioned at different geographical location and different terrains; the wind plays a major role on the system which creates major problems for antenna pointing mechanism. Hence level sensors are used to determine the tilt in X and Y axis.

II. METHODOLOGY

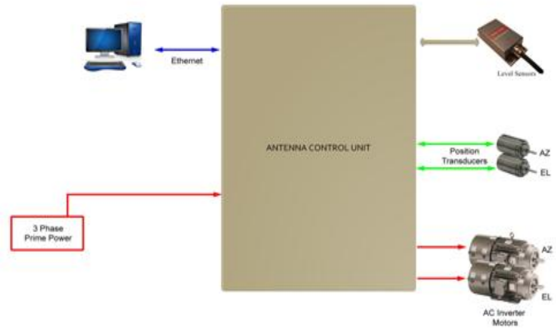

Fig.1 Antenna Control System

1. Controlling Drive Speed:

The drive speed is ultimately controlled by the torque changes induced by varying voltage levels across the motors. In order to control the voltage applied across the motors for both elevation and azimuth, the following options are available:

A. Varying the amplitude: whereby the amplitude of the input voltage is varied to control the torque generated across the motor.

B. Varying the duty cycle: by adjusting the duty cycle, the average output voltage would change, therefore varying torques would be applied across the motor of the antenna subsequently causing the respective axes to move at different speeds.

The chosen method for controlling the voltage across the motors was that of varying the duty cycle with a pulse width modulation (PWM) scheme. A PWM scheme would allow for simple interfacing with the DAC. In PWM, the power supply to the motor is switched on and off rapidly. The DC voltage is converted to a square-wave signal that alternates between 0V and the supply voltage. By adjusting the duty cycle of the signal, the average power can be varied and subsequently, the motor speed. The variable 10 bit DAC output voltage is integrated as an input to the operational amplifier which acts as a comparator circuit. As a result, various DAC outputs would be used to drive the motor at different speeds.

2. Limit Switch:

The limit switches are designed to prevent uncontrolled motion of the motors on the elevation axis. With the help of limit switches, the antenna will be deployed in elevation i.e., between 0 to 90 degree safely. When the antenna reaches its upper limitation, limit switch with the help of relay cuts off the motor's voltage supply. The elevation

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axis will then only move if a reverse polarity voltage is applied across it. The absolute encoders is used to get the exact position of the antenna in both azimuth and elevation axis and brake supply is provided whenever the antenna reaches its upper/lower limits

3. Antenna System Stabilization:

The level sensor is used to get the angles of slope or tilt with respect to gravity. Inclinometers sensors achieve an output resolution to 0.01 degrees. The stabilization motors are controlled based on the feedback information from the sensors.

4. Maintenance and Control:

Ethernet Controller network is used for monitoring and controlling the antenna control system. Any point on the network can monitor and control the various I/O points. The address for the unit is automatically assigned or can be fixed during set-up. VC++ programming language is used to create the simulation software for Ethernet.

III.SOFTWARE REQUIREMENTS

1. Kicad EDA:

KiCad is used to create schematic diagrams and printed circuit board up to 16 layers. KiCad comes with a rich set of libraries with 3D models as well.

2. Freescale Codewarrior:

CodeWarrior Development Studio is a complete Integrated Development Environment (IDE) that provides a highly visual and automated framework to accelerate development of the most complex embedded applications.

3. Microsoft Visual C++:

It is a commercial integrated development environment (IDE) product from Microsoft for the C, C++ and C++/CLI programming languages. It features tools for developing and debugging C++ code, especially code written for the Microsoft Windows API, the DirectX API, and the Microsoft .NET Framework.

IV.RESULTS

The antenna control system is designed and tested successfully. The results obtained such as controlling the speed of the motor through DAC commands is shown in fig 2. The feedback information from encoder which describes the exact position of the antenna is shown in fig 3 and level sensors which indicate the tilt in X and Y axis is shown in fig 4.

1. Controlling Drive Speed

```
Select DATA:
                1.-10 Volts
                2.-7.5 Volts
                3.-5 Volts
                4.-2.5 Volts
                5.0 Volts
                6.+2.5 Volts
                7.+5 Volts
                8.+7.5 Volts
                9.+10 Volts
```

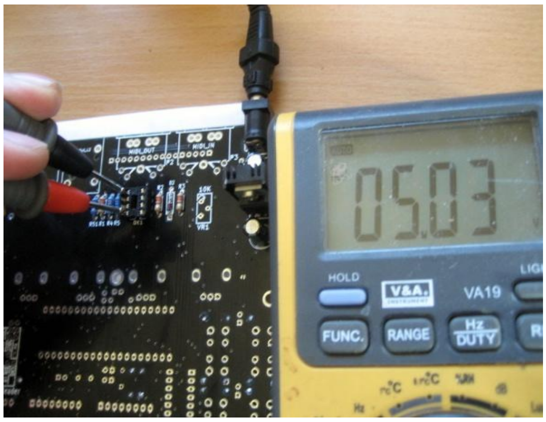

Fig.2 DAC output for controlling drive speed

+5V generated as seen in fig 2 delivers a 50% duty cycle across load.

2. Encoder Data

```
53.470

188.778
188.778
188.778
25.642
188.778
188.778
188.778
183.142
188.778
188.778
188.778
90.154
188.778
188.778
188.778
180.319
188.778
188.778
188.954
5.6804
188.954
188.954
188.954
_
```

Fig.3 Antenna Position Feedback

A 0.005 degree change in antenna position can be seen in fig 3.

3. Level Sensor Data

Fig.4 Level Sensor output which indicate X and Y axis tilt

As it can be seen in fig 4 where X axis indicates the angle it has tilted in Roll axis and Y axis indicates the angle in Pitch axis.

V.CONCLUSION

From the objectives presented, a stabilization and control system for antenna is designed. The system would ultimately control the direction, speed and axis of rotation of the antenna from a variable user input. The motion attributes (angle and velocity) would then be captured and displayed as an output to the user on a computer based interface. There are many approaches to model antenna control systems. Pointing mechanisms, antenna system, its drive, gear boxes, controlling algorithms are having different variants and sub variants. Modelling each of this can be carried out in many ways.

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