Quarknet Radio Telescope: The mechanization to track celestial objects

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Abstract

The purpose of this experiment is to get high school students around the Fermilab area involved in science. The experiment involves building a radio telescope and measuring at the 21cm hydrogen line. The experiment will then be passed on to high schools around the U.S. once the initial team is done with the building and getting everything ready. This will allow others to set up an interferometry of radio telescopes to better observe the Milky Way.

This paper reports on the project to motorize the dish so we can track celestial objects, and aim at objects in the sky. Using two linear actuators controlled by a relay connected to a raspberry pi, powered by python code.

Introduction

Background

Radio Astronomy is interesting because, it has helped us understand a lot more about our universe than we knew before because, a lot of extraterrestrial objects give off radio frequency radiation. Which is the lowest energy wave on the electromagnetic spectrum. Radio wave wavelengths go from around 1000 meters, longer than our tallest building, all the way down to around a centimeter, about the width of a pencil. We didn't know about radio frequency radiation before 1931, because that is when Karl Jansky, a radio engineer at Bell Telephone Laboratories, was tasked with trying to minimize the radio interference caused by thunderstorms. He realized the thunderstorms did not account for all the interference he was getting, and that it was coming from something extraterrestrial. He published his findings in 1933. The next big step towards modern radio telescopes was made by Grote Reber in Wheaton, Illinois in 1937. His telescope could pick up wavelengths as short as 1.87 meters. Radio Astronomy flourished after WWII because of all the radars used to detect planes. These could also detect radio frequency radiation from the sun. Some recent advances in Radio Astronomy would be the building of Arecibo Observatory in Puerto Rico in 1963, which used to be the largest radio telescope in the world but, China just finished building the Five Hundred Meter Aperture Spherical Telescope, which is about 1.6 times larger than the Arecibo Observatory. All radio telescopes are constructed of similar parts, the only thing that differentiates the ones listed above is that their dishes are huge so they can collect larger amounts of radiation and focus it, into the antenna. The antenna then sends it somewhere to record, or it can send it to a pre amplifier that amplifies the energy of the waves. The waves are at a low frequency, so they have a low energy, and it makes it hard to detect. It could also then be sent to a airspy or equivalent, which translates the data and sends it to a computer, in our case a raspberry pi.

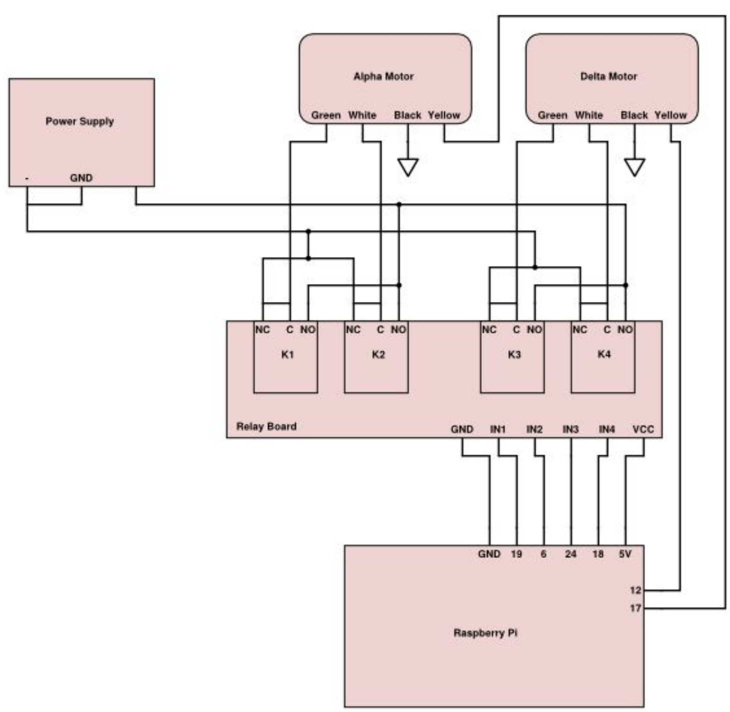
Context of this work

The project that this paper reports on is an inexpensive radio telescope that is meant to get more high school kids involved in science and experiments. There are multiple ways that this telescope will contribute to the future of the society, once everything we want to get done is implemented and fully running, it will be passed to high schools where it can then inspire the next generation of scientists and thinkers. When we have a lot of telescopes we will be able to set up a large interferometry, that will be able to take good data. Things we are trying to accomplish this summer is, make the telescope move according to the Right Ascension, and Declination system. Also, we need to see if we can observe the Sun.

Methods

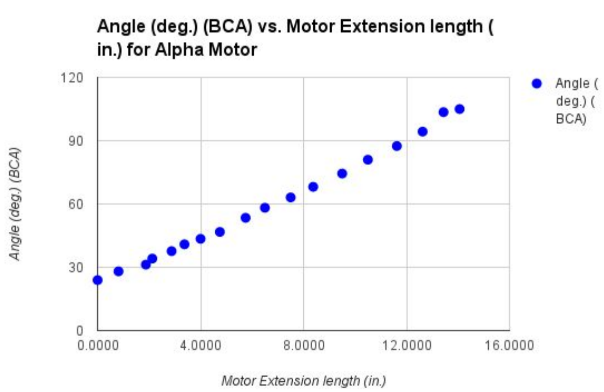
Equipment

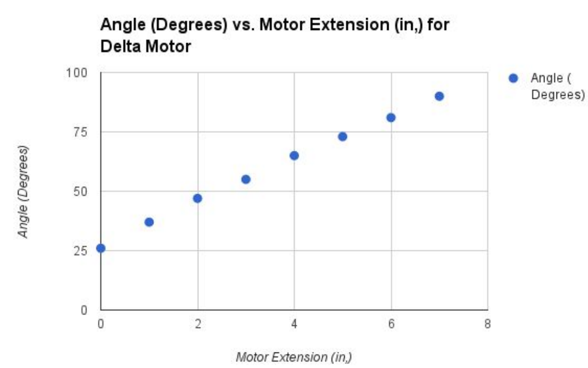
The equipment that was used to do the tracking is as follows: two 24” linear actuators, one potentiometer, a four channel relay module, a pi cobbler plus cable, perf board, wires, satellite dish, 36 volt power supply, and a raspberry pi. In order to control the motors we used a circuit, that is shown below. Which starts at a raspberry pi, then it is connected to a perfboard using a pi cobbler and cable. There are then wires running from the perfboard to the relays, and also the motors. The wires that run to the motors, give us information that we can use to see how far we have extended the motors. The way it gives us the information is, it checks how many times the electromagnetic field in the motor has changed. The sensor to detect that is a reed switch in the motor which opens or closes the circuit depending on whether the magnetic field is applied or not. The wires that run to the relays, are the ones that control the relays, which in turn control the direction of the motors by switching between high and low voltage states. Right now the connections to the motor, from the relay are being powered by a 36 volt power supply, but we hope to change that in the future.



Data and Analysis

The data that was needed to move the motors was angle to arm distance, then arm distance to counts. For the data that we needed to know counts, which is number of switches in the reed switch, we just extended the motor to full length and had a program running that counted the switches. We then measured the length of the arm when fully extended and took that number and divided the number of switches by the length of the arm in inches, to get the amount of switches per inch. We then needed to get the length of the arm compared to the angle on the dish, so we took measurements and did some trigonometry to get the angles. Then we had to get our Polar Angles to Altitude and Altitude angles, so we could get the Right Ascension and Declination. That coordinate system is constant no matter where you are on Earth, because it is fixed to the sky. So, in order to go from the Polar to Altitude and Altitude angles we had to first convert the Polar Angles to Cartesian Coordinates(x,y,z). We did that using some more trigonometry. We went from Cartesian to Altitude and Azimuth, finally we went from Altitude and Azimuth to Right Ascension and Declination, using more trigonometry. Also when doing Right Ascension and Declination you need to use your Latitude and Longitude, along with the days since January 1st, 2000, also know as Julian 2000, and Universal Time.





Results

What we were looking for this summer was to make the dish be able to be moved using motors, which we did. Then after that, it was to make the motors be able to move to a Right Ascension and Declination position, which is being debugged right now but almost done. Then finally, it was to make so people will be able to follow what we have done, which has not happened yet but, it is something that we need to do in the future.

Because, of the work described in the paper, the group that is working on the project will now be able to point at certain celestial objects, to a greater degree of accuracy, and take more data on them.

There are still things that need to be done on the project. The telescope and electronics need to be weather-proofed, and it needs to be able to be powered off of a solar panel. The project also needs to be better documented in order to pass this on to other high school students.

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