a place of mind

# Radio Telescope High Accuracy Tracking Mount

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## Introduction

The purpose of this project is to design a high accuracy tracking mount for a radio telescope. The telescope can be seen in Figure 1. The tracking mount will feature a static structure to support a ten foot mesh radio telescope dish. The dish's movement will be driven by two motors which will both be controlled by a microcontroller. An example of the data that is collected from the radio telescope can be seen in Figure 2.

**Fig. 1**. *A photo of the radio telescope at its current location.*

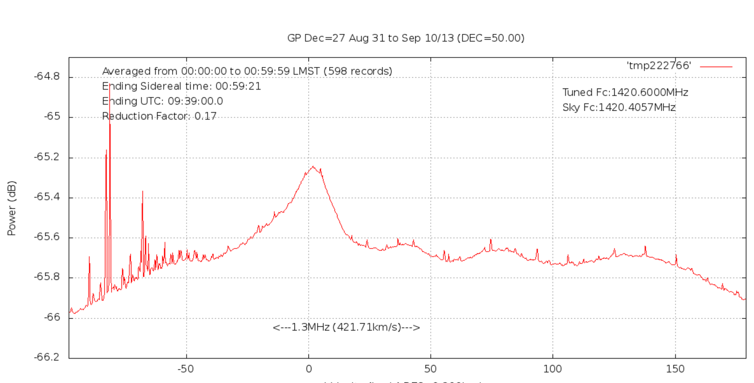

**Fig. 2.** *An example of the data collected by the telescope.*

## Design Constraints and Specifications

**Constraints:**

There are six main constraints that have been stipulated by the industry sponsor for this project. The first is that the dish must clear, when pointing horizontal, a five foot fence. The fence is in place both to protect the dish from the public and to keep the public safe, as there are moving parts on the dish.

The next constraint is that the dish must be able to rotate 360° azimuth and 180° in altitude. This is so the dish can track any point in the sky without impedance.

The tracking dish must also have a high accuracy. In order to track the frequencies, the industry sponsor has set forth that the dish must have an accuracy of 0.2 degrees.

Low cost is another constraint that has been outlined for this project. As the project is funded mostly on donations, there is not a disposable budget available.

It has been requested that the mount uses as few custom parts as possible. This reasoning is so that is simple for the industry sponsor to maintain and build more mounts in the future.

Finally, the design must be robust. The mount has to stand up to the elements, wind, rain, and snow, and continue to maintain the high accuracy that was specified earlier.

**Specifications:**

A list of the specifications can be found below in Table 1.

**Table 1.** *Specifications table.*

| | Specifications |
|---|---|
| Accurate | ±0.1° tracking accuracy |
| Operation | 180° elevation<br>360° azimuth |
| Cost | Under $3000 |

## Structure

The structure of this mount must meet the following objectives:

- Stand at a height of 10m from the ground
- Be equipped to hold two motors , a counterweight, the dish, and the frame that the dish will be mounted on
- Capability to maintain integrity during forceful windstorms
- Durable, convenient, and cost effective

The final is a pyramid shaped structure assembled out of four angled steel supports. Refer to Figure 3 to see a computer aided design. The entire structure will be 10 ft high with a 1ft diameter, steel, circular plate at the top to mount the dish frame. A shaft will extend down from the frame to a second steel plate, where the azimuth motor will be located. This assembly of the dish and motors is what is referred to as the "pivot".

In order to simplify the calculations of the wind and load forces of the dish, it was assumed that only one of the supports would be able to support the entire load. ASTM A36 grade steel has been selected due to its availability and price. The structure must be mounted on a floating concrete pad, which must weight 2200 lbs to accommodate the tension in the supports. Short angled steel components will be sunk into the pad and partially exposed so that the structure may be bolted onto it. Bolts will be used to construct the rest of the structure, allowing it to be easily transported and assembled.

**Fig. 3.** *SolidWorks model of the structural design. Here the structure's pyramid shape and cross bracing can be easily seen.*

## Mechanical

The rotating module is made up of 5 components:

- Two gearboxes
- Two motors
- One base frame which interfaces with the structure
- One top frame which connects the dish and the counterweights to one of the gearboxes
- Counterweights

A computer aided design of the rotating module can be seen in Figure 4.

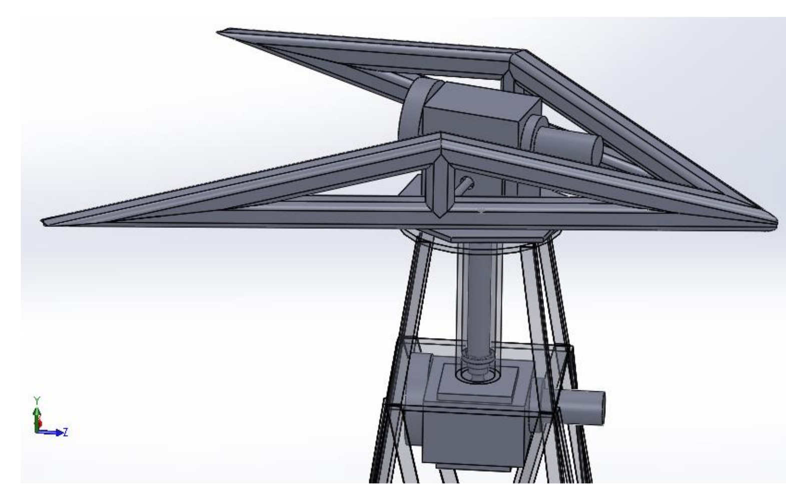

**Fig. 4.** *SolidWorks model of the rotating module.*

The design chosen uses a motor, Figure 5, and gearbox to control each direction separately. The first gearbox, controlling the azimuth direction, is mounted near the top of the structure and is directly connected to a 2 foot shaft. The shaft is welded to a plate that supports the gearbox controlling the elevation, and will support stabiliser bearings, if they prove to be necessary. The 2 foot shaft has two roller bearings, to prevent angular deflection, and a turntable bearing, which supports the vertical force from the weight of the dish and elevation gearbox. The upper gearbox supports the dish frame. Overall the mechanical components have been designed with stability in mind.

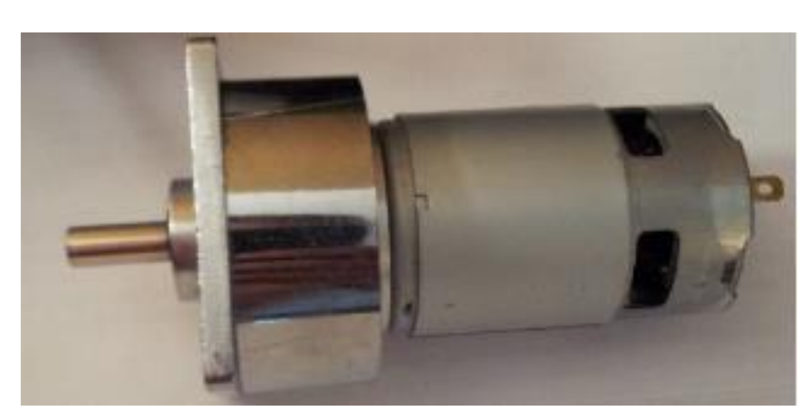

**Fig. 5.** *Motor used to power rotation.*

## Electrical

The electrical system will provide communication and power between the tracking mount and the support building. It will also provide a means of controlling the elevation and azimuth motors.

3 Category 5 cables will be used to power the tracking mount as well as provide an ethernet and serial connection. Signals will be returned to the support building through coaxial cable.

A microcontroller will take positioning data from encoders placed on the elevation and azimuth gears. The selected microcontroller can be seen in Figure 6. The controller will use this data to adjust the positioning of the gears via there respective motors and motor drivers.

**Fig. 6.** *The RCM5700 Microcontroller.*

**Table 2.** *Electronics used.*

| Component | Specifications |
|---|---|
| Digi™ RCM5700 Microcontroller | •Utilises a "Dynamic C" programming environment<br>•Allows for serial communication between components |
| Pololu Dual MC33926 Drivers | • Capable of operating over a very large temperature range<br>• Can fulfill the motor power requirements and uses PWM |
| TSINY™ DC motors | • 60rpm<br>•1.8 nm torque |
| AMT203 12-bit Absolute Encoders | • 4096 positions which equates to 0.09° increments<br>• ±0.2 degree accuracy |
| LMR400 coaxial cable | • Used for VHF/UHF applications |
| Cat5e cable | • Twisted pair cable<br>• Used for ethernet connections |

## Conclusions

In conclusion, this has been a very challenging and rewarding project. A design has been finalized and budgeted completely and the Royal Astronomical Society can begin construction of the mount as soon as they have gained the materials and are prepared. The steel structure have the ability to hold its position against opposing forces, and the pivoting parts have been designed robust enough to be durable and steady for a long duration. It is our hope that the mount will be constructed and can be advanced towards the Astronomical Society's future plans of having three solar powered radio telescopes mounted and continuously gathering astronomical objects and their activities.

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## Acknowledgments

We would like to thank Vlado Neykov for passing this project along to capstone program, giving us the opportunity to come on board, and for providing the details of his previous work on this project. We would also like thank our industry sponsor, Hugh Pett, as he was an integral part of the design process and always available for consultation.

## For further information

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**Capstone Design 2013-2014**