Fully Automated Satellite Tracking System for Directional Antenna

A Thesis

Submitted to the Department of Electrical & Electronics Engineering (EEE), BRAC University

In Partial Fulfilment of the Requirements for the Bachelor of Science Degree in

Electrical & Electronics Engineering

By

Md. Mahbubul Alam	14321036
Md. Monjurul Islam	14321039
Ahmad Tamim Mansoor	14321032

Supervised by

Dr. Md Hasanuzzaman Sagor, PhD
Assistant Professor
Department of Electrical & Electronics Engineering
BRAC University

Co-Supervised by

Md. Mojammel Haque
Satellite Operation Engineer
BRAC Onnesha Ground Station, BRAC University

BRAC UNIVERSITY
Inspiring Excellence

Summer 2018

DECLARATION

This is to declare that this thesis titled ‘‘Satellite tracking System developing, interfacing and controlling (both automatically and manually) for directional antenna’’ is submitted to the department of Electrical and Electronics Engineering of BRAC University for the partial fulfilment of the degree of Bachelor of Science in Electrical and Electronics Engineering. We hereby affirm that the simulation based research and result was conducted solely by us and has not been presented previously elsewhere for assessment. Materials of the study and work found by other researchers have been properly referred and acknowledged.

Submission Date: 1st August, 2018

Signature of Authors

Signature of the Advisor
Dr. Md Hasanuzzaman Sagor, PhD
Assistant Professor
Department of Electrical & Electronics Engineering
BRAC University

Md. Mahbubul Alam
ID: 14321036
Department of Electrical & Electronics Engineering
BRAC University

Signature of the Co-advisor
Md. Mojammel Haque
Satellite Operation Engineer
BRAC Onnesha Ground Station
BRAC University

Md. Monjurul Islam
ID: 14321039
Department of Electrical & Electronics Engineering
BRAC University

Ahmad Tamim Mansoor
ID: 14321032
Department of Electrical & Electronics Engineering
BRAC University

Table of Contents

List of Figures

List of Table

ACKNOWLEDGEMENTS

First, we are thankful to our God for providing us with the patience and strength to go on and complete this thesis.

We are grateful to our supervisor Dr Md Hasannuzzaman Sagor, Assistant Professor of BRAC University and our Co-Supervisor Md.Mojammel Haque, Satellite Operation Engineer, BRAC University for their support as well as critical comments and extensive guidelines. Their invaluable guidance, excellent research attitude and knowledge about the field of study always encouraged us.

ABSTRACT

When a Low Orbiting Cube satellite passes over a location it can receive and transmit HF/UHF frequency in a directional radiation. We get maximum efficiency when the satellite and the GS's antenna stays in straight direction. Here we developed a low cost, dependable and efficient satellite tracking system. This system is able to move GS's directional antenna precisely to maintain a straight-line direction with the targeted satellite throughout the whole pass. The tracking system divided into rotator and control box part. For rotator system we use DC motor for both azimuthal and elevation rotation. The motor have high torque with low RPM to rotate the rotator at precise angle. Controller box is interfaced with CPU such a way that it automatically collect the azimuth and elevation value from CPU and according to the data it will run the gear system. The CPU run algorithm to calculate the present position of the targeted satellite from updated TLE. A feedback system read the position of rotor by using voltage dividing rule and compare the real position with expected position. According the available data, controller box calculate and fix antenna's elevation & azimuth precisely. The control box continue the process again and again throughout the whole pass. That is how satellite and GS's antenna able to maintain a straight direction. The designed system is be able to carry different gain antenna in same antenna tower. Which reduce the space demand for tower installation and increase the efficiency. The designed system is so universal that user can modify the rotator system according to their weight demand. The controller box for the specific rotator is designed by using Atmega 2560, Cytron MD10C, BOURNS 3590 and B10K potentiometer. Through this designed satellite tracking system user will be able to track & operate mission both manually and automatically, when satellite will pass over ground station. This design also increase the chance to install automatic data collection center at remote area and help to gather more field data for further research.

1 Introduction

Nano satellite or cube satellite technology is gradually taking greater importance over the last two decades. Both space emerging countries and non-space countries are now in a race to operate small satellite mission. It is becoming popular among developing countries because of cost effective programme with great capability. Now the share of small satellite in space activity is extending the number of satellite for specific designed mission both for civilian and defence purpose. So, the number of associated lunches, ground station and data collection and distribution system is getting more importance than ever. That's why the demand of LEO satellite tracking system for data collection and distribution is increasing. Here we developed a low cost, dependable and efficient satellite tracking system to make the space research more accessible and practical for developing countries.

In the chapter 1 we discussed about satellite communication and its importance in various field. After that in chapter 2 we point out our contribution in space research accessibility through this project. Then we discussed about scientific terms and the step by step process of tracking system in chapter 3. Then chapter 4, chapter 5 upholds the details about customised mechanical and electrical design of our satellite tracking system. In chapter 6 we finds out our results, measured and analysed it. Than in chapter 7 we include our step by stem result analysis for manual satellite tracking and fully automatic satellite tracking. At last chapter we discussed our future project plan based on this new designed satellite tracking system.

1.1 Literature Review

Satellites are specifically made for telecommunication purpose. They are used for mobile applications such as communication to ships, vehicles, planes, hand-held terminals and for TV and radio broadcasting. They are responsible for providing these services to an assigned region (area) on the earth **[3].** The power and bandwidth of these satellites depend upon the preferred size of the footprint, complexity of the traffic control protocol schemes and the cost of ground stations. A satellite works most efficiently when the transmissions are focused with a desired area. When the area is focused, then the emissions don't go outside that designated area and thus minimizing the interference to the other systems **[7].** This leads more efficient spectrum usage. Satellite's antenna patterns play an important role and must be designed to best cover the designated geographical area (which is generally irregular in shape). Satellites should be designed by keeping in mind its usability for short and long term effects throughout its life time. The earth station should be in a position to control the satellite if it drifts from its orbit it is subjected to any kind of drag from the external forces.

1.1.1 Satellite Communication:

Satellites are functioned to orbit the earth. Based on the application being used, these orbits can be designed to be circular or elliptical. The Gravitational force Fg of the Earth pulling the satellite towards the Earth and the Centrifugal force Fc pulling it away enables the satellites to stay at a constant distance from the Earth **[3].**

$$Fg = m \cdot g\,(R/r2)$$

$$Fc = m \cdot r \cdot 2$$

$$\omega = 2 \cdot \pi \cdot f$$

The variables have the following meaning

m= mass of the satellite;

R= radius of earth with (R = 6,370 km);

r= distance of the satellite to the centre of the earth;

g= acceleration of gravity with g = 9.81 m/s2;

ω= angular velocity;

f= frequency of the rotation.

Both the Gravitational force and the Centrifugal force must equal in order to keep the satellite in a stable circular orbit:

$$Fg = Fc$$

Deriving and solving the equation for the distance r of the satellite to the Centre of the earth results in the following equation:

The distance $r = (g \cdot R2 / (2 \cdot \pi \cdot f)2))\ 1/3$

The above equation shows us that the rotation frequency of a satellite is the main factor for the distance of the satellite to the earth's surface.

1.2 Types of Satellite:

There are a wide range of satellite orbits that can be utilized. Satellite orbits are picked after taking into consideration different factors such as its functions and the area it is to serve. There are cases where the satellite orbit may be at a low altitude of 160km for Low Earth Orbit, LEO, to satellite orbits set to stay at an altitude of over 36,000km for Geostationary Orbits, GEO. The orbits may also be more elliptical than being circular ones. Geostationary Orbits tend to be stationary once it reaches a certain point on the Earth.

Depending on the application that it is to be used for, the satellite orbit is set. For instance, GEOs are used for direct broadcast television as well as for a lot of different communications satellites. On the other hand, applications such as satellite phones and Global Positioning Systems (GPS) use LEOs. Today, there exists various different types of satellites used for different applications depending on which, the orbit is set.

1.2.1 Low Earth Orbits

Low Earth Orbits are typically at a distance of about 160km above the Earth's surface. Satellites in LEO can go around the planet very rapidly, typically taking about 90 minutes to complete a full revolution around the earth. However, when compared to geostationary satellites, these orbits have a very short lifespan. Nevertheless, LEO systems generally offer high quality communication link by ensuring a high elevation for every spot on the planet. LEO satellites are also visible from the earth for only around ten minutes.

Utilizing propelled pressure plans, transmission rates of around 2,400 bits can be sufficient for voice communication. LEOs even give this data transmission to portable terminals with Omnidirectional antennas utilizing low transmit control in the scope of 1W. The delay for bundles conveyed by means of a LEO is generally low (approx. 10 ms). The deferral is practically identical to long-separate wired associations (around 5– 10 ms). Smaller footprint of LEOs take into consideration better frequency reuse, like the ideas for cell systems. LEOs can give a significantly higher rise in Polar Regions thus better worldwide scope. These satellites are for the most part utilized as remote detecting and providing mobile communication (because of lower inertness). **[14-18]**.

LEOs being close to the Earth enables the satellites in this orbit to get a good image of the surface. Hence, Earth observation satellites as well as spy satellites are placed in this orbit. The International Space Station is also in a Low Earth Orbit and is about 330km to 420km above the surface of the Earth. Remote sensing satellites also use LEO to get a more accurate detail due to its distance from the Earth. They can also use sun-synchronous LEO to its advantage at an altitude of about 800km and near polar inclination [18]. An example of this would be the Envisat (2002-2012) which was an Earth observation satellite that used LEO at about 770km.

Disadvantages of LEO:

The most concerning issue of the LEO is the requirement of numerous satellites for worldwide coverage. A few ideas include 50– 200 or much more satellites in orbit. The brief span of visibility with a high elevation requires extra systems for association handover between various satellites. The high number of satellites joined with the quick developments bringing about a high many-sided quality of the entire satellite framework. One common issue of LEOs is the short lifetime of around five to eight years because of environmental drag and radiation from the internal Van Allen belt1. Expecting 48 satellites and a lifetime of eight years, another satellite would be required at regular intervals. The low dormancy by means of a solitary LEO is just 50% of the story **[18]**. Different components are the requirement for directing of information parcels from satellite to if a client needs to impart far and wide. Because of the extensive footprint, a GEO ordinarily does not require this sort of routing, as senders and receivers are most likely to be in the same footprint.

1.2.2 Sun-Synchronous orbits

Sun-synchronous orbits operate according to the position of the sun. They are in a way so that they always face towards the direction of the sun, allowing them to never experience an eclipse. The surface illumination point for these satellites are close to being constant every time. The illumination angle is the angle between the inward surface normal and the direction of light. This implies the illumination angle of a specific purpose of the Earth's surface is zero if the Sun is exactly overhead and that it is 90 degrees at nightfall and at sunrise. Special instances of the sun-synchronous circle are the noon/midnight orbit, where the nearby mean sun based time of section for tropical longitudes is around noon or midnight, and the day break/sunset orbit, where the neighborhood mean sunlight based time of entry for central longitudes is around dawn or dusk, with the goal that the satellite rides the eliminator amongst day and night

An example of a satellite in a sun-synchronous orbit would be Meteorological satellites. These are in polar orbits and are programed so that the satellite follows the Sun’s orientation throughout the year and orbiting the Earth 15 to 16 times a day. This allows access to accurate weather forecasts.

1.2.3 Geosynchronous satellites

Geosynchronous satellites are set into orbits designed to perfectly match the rotation of the Earth. As such, these satellites take 24 hours to complete a full rotation. Countries like Russia and Canada tend to use these satellites in order to get decent communication at high latitudes. The orbits are called Molniya orbits. They're typically placed in highly elliptical orbits allowing them to stay above a certain point on the Earth for most of the day. Throughout its rotation of the Earth, it moves in a figure of eight pattern centered on a fixed latitude and moves according to its usefulness at certain areas: slowly around the pattern where it is most useful and moves rapidly over places of little use. Geosynchronous satellites also do not orbit on the equatorial plane.

1.2.4 Geostationary satellites

Geostationary satellites are placed in orbits directly over the equator and thus follows the paths around the equatorial plane and like geosynchronous satellites, take 24 hours to complete one full rotation. This makes the satellites to be fixed at the point of the equator, orbiting about it, and does not move North or South during the day. These satellites are mostly used for communication purposes. **[16, 17]**. Geostationary satellites last for an average of 15 years. There are three conditions that lead to geostationary satellites:

- The satellite should be placed approximately 36,000 km above the surface of the earth.
- These satellites must travel in the rotational speed of earth, and in the direction of motion of earth, that is eastward.
- The inclination of satellite with respect to earth must be Zero degree.

Geostationary satellite are practically known as geosynchronous as there are a couple of factors which make these satellites shift from the ideal geostationary condition.

i. Gravitational draw of sun and moon makes these satellites go astray from their circle. Over the timeframe, they experience a drag. (Earth's gravitational power has no impact on these satellites because of their separation from the surface of the Earth.)

ii. These satellites experience the centrifugal force due to the rotation of Earth, making them deviate from their orbit.

iii. The non-roundabout state of the earth leads to persistent alteration of speed of satellite from the earth station. These satellites are utilized for TV and radio communication, climate figure and furthermore, these satellites are working as spines for the phone network systems.

Disadvantages of GEO:

GEO satellites also have a few disadvantages. Because of low elevation over a latitude of 60 degrees, the north and south regions of Earth face issues receiving these GEO satellites. Larger antennas are required for this case. Attenuation of the signals is found in urban communities because of high structures and the low elevation causes the quality of transmission to be weak. Because the transmit power required is comparatively high, this causes various issues for battery powered devices and hence, cannot be used for mobile phones **[17]**. Voice and data communication requires a high latency and the issue arises as the signal has to travel at least 72,000km without having any handovers. Either of the frequencies cannot be reused because of the large footprint otherwise the GEO satellites requires special antennas focusing on a smaller footprint. Another problem with GEO satellites is that it can be very costly to transfer it into an orbit.

The Bangabandhu Satellite-1 is the first Bangladeshi geostationary communications and Broadcasting Satellite. It was manufactured by Thales Alenia Space and launched on 11 May 2018.The project is being implemented by Bangladesh Telecommunication Regulatory Commission (BTRC) and was the first payload launched by a Falcon 9 Block 5 rocket of SpaceX.

With the aim to control the Bangabandhu Satellite, the Bangladesh Government formed a Government owned Bangladesh Communication Satellite Company Limited or, BCSCL.

Bangabandhu-1 launched from Kennedy Space Centre on Merritt Island, Florida, USA and utilizes ground control stations built by Thales Alenia Space with its partner Spectra [disambiguation needed] in Betbunia, and Gazipur. The satellite is based on the highly secured and reliable Spacebus-4000B2 platform and currently located at longitude 119.09°E.

1.3 Commercial Satellite Tracking:

Navigation, Fleet following, Aviation technology, and crisis reaction — these depend on GPS to work. The Global Positioning System (GPS) is a "situating, route, and timing (PNT)" benefit in view of 24 operational satellites which are possessed by the U.S. also, oversaw worldwide by control stations. This post audits the historical backdrop of GPS satellites and how they established the framework for business GPS following. Beforehand saved just for military utilize, GPS is presently accessible to everybody. For some, utilizing a GPS gadget in the auto to explore activity or having GPS area in their cell phones is presently simply part of everyday life **[20].**

Altogether, there are 31 operational satellites in the GPS heavenly body, with 3-5 extra satellites for possible later use that can be initiated when required. The satellites circle the Earth two times each day at 20,200 km (12,550 miles) up

1957 — Soviet Union launches Sputnik I satellite.
1960 — U.S. Navy tracks U.S. submarines with satellite navigation.
1978 — Launch of NAVSTAR Block I GPS satellite.
1983 — U.S. announces that it will make GPS available for civilian use after Korean Air Flight 007 shot down.
1989 — Magellan introduces NAV 1000, the first hand-held GPS device. First Block II Satellite is launched.
1993 — Constellation of 24 satellite system becomes operational.
1995 — Full Operational Capability (FOC) declared.
2000 — Selective Availability discontinued by the U.S. Government.
2004 — Qualcomm successfully completes test of live assisted GPS on a mobile phone.
2008 — Block II satellite launched.
2016 — GPS IIF satellite launched.

The primary GPS collector for purchasers was produced by Magellan. The NAV 1000 was 1.5 pounds, cost $3,000 and could keep running for two or three hours on end on battery control. The surprising expense of satellite route implied that outside the military, just cargo and conveyance organizations and select others could bear to utilize the framework. As GPS exactness enhanced, a wide range of enterprises could exploit GPS innovation **[20-21]**. GPS following is substantially more reasonable nowadays. GPS trackers are lightweight and can fit in the palm of your hand

1.4 Importance of Satellite Communication

Compared to the standard long distance transmissions, Satellites provide various advantages when it comes to communication. For instance, high frequency radio don't pose any sort of threat of interfering with satellite links. The high attenuation of wire or cable facilities are also a problem which satellite communication doesn't have. Gone are the days when we needed several repeater stations needed for line of sight. Satellite communication provide the reliability and flexibility required by the military for their operations. Satellite communications links add numerous value to the communication system that we have and also provide additional routings for communication traffic.

1.4.1 Weather Forecasting

Satellites play an irreplaceable role when it comes to predicting the weather. They are programmed in a way such that they can monitor the climate condition of the Earth. Images of the Earth from the satellite help with the weather predictions of the region that the satellite is assigned to. The images are obtained at the Earth station once they're transferred over using their assigned radio frequency. Earth station is basically a radio station used mainly for relaying signals from satellites [6,15]. Hurricanes and other natural disasters can now be detected ahead of time with the help of these satellites. Furthermore, they can be used to monitor the changes in Earth's vegetation, sea state, ocean colour as well as ice fields.

1.4.2 Radio and TV Broadcast

The thousands of channels available all over the world are broadcasted using these dedicated satellites. 30-40cm sized dish is the major component of these satellites which allow these channels to be available globally. The news, live matches, etc are all broadcasted using these satellites [11].

1.4.3 Navigation Satellites

Satellites used for navigation purposes allow for a precise localization all around the world. With the use of advanced technology, these precisions have been narrowed down to a range of some meters. GPS systems are used worldwide today for navigation. They're used in road vehicles, ships and even in aircrafts [20]. In other cases, they're used to detect vehicles or even devices when they're lost or stolen, in order to locate their exact position.

1.4.4 Global Telephone

The foundation of international telephone backbones saw the first usage of satellites for communication purposes. At times, it was seen to be faster to launch a satellite rather than using cables **[6]**. Even so, communicating over long distances prefer using fiber optic cables as opposed to using satellites as light is much faster than radio frequency. Thus, it is much faster communicating using fibre optics **[11-12]**. In order to get to a distance of about 10,000km away, the signal has to travel about 72,000km. This includes sending data from the ground to the satellite and then again, from the satellite to another location on earth. This produces a huge amount of delay and poses a problem for users during voice calls.

1.4.5 Connecting Remote Areas

Associating Remote Areas Due to their geographical area numerous spots everywhere throughout the world don't have direct wired links with the phone network or the web (e.g., analysts on Antarctica) or due to the present condition of the infrastructure of a country **[7]**. Here the satellite gives an entire scope and (for the most part) as there is one satellite constantly present over a horizon.

1.4.6 Global Mobile Communication

The essential purpose behind satellites for mobile communication is to broaden the region of coverage. Phone frameworks, for example, AMPS and GSM (and their successors) don't cover all parts of a country. Zones that are not covered typically have low population where it is excessively costly, making it impossible to introduce a base station **[6]**. With the incorporation of satellite correspondence, be that as it may, the cell phone can change to satellites offering overall network to a client. Satellites cover a specific territory on the earth. This region is named as footprint of that satellite. Inside the footprint, communication with that satellite is feasible for clients. These clients communicate utilizing a Mobile-User-Link (MUL). The base-stations speak with satellites utilizing a Gateway-Link (GWL). Some of the time it ends up vital for satellite to make a communication interface between clients having a place with two unique footprints **[21]**. Here the satellites send signs to each other and this is finished utilizing Inter-Satellite-Link (ISL).

2 Improvement and Contribution through this Research:

i. The system design includes the interfaces between personal computer, Atmega 2560 (Arduino Mega), Cytron MD10C, BOURNS 3590 and B10K potentiometer in the antenna rotator system. It is easily synchronizing with the PC providing a better ecosystem for the user.

ii. Our rotator system is much more enhanced than the previous rotator (YEASU G-5500) and is able to carry more weight than the existing model. The rotator system allows antennas of different gain to be placed in vertical parallel position which requires less space and is much more efficient and thus allows the system to be portable. (Fig 1)

iii. Portable system allows much better communication and can be taken at any remote areas where there is less signal interference which will be able to track the satellite more accurately.

iv. The system is very much compatible with our environment mainly because all the raw materials used for hardware and assembly of the system is available in our region, these factors reduces the overall cost of the system compared to existing model.

v. The system also provides tracking system for Amateur radio communication. It is also known as HAM radio communication. It uses radio frequency spectrum for non-commercial exchange of moss code, messages and emergency communication.

vi. The motor system allows to control the speed of the rotator according to user demand, this function is achieved using gear train and DC motor controlling in our system. Speed control allows the user to move to destination tracking angle more conveniently.

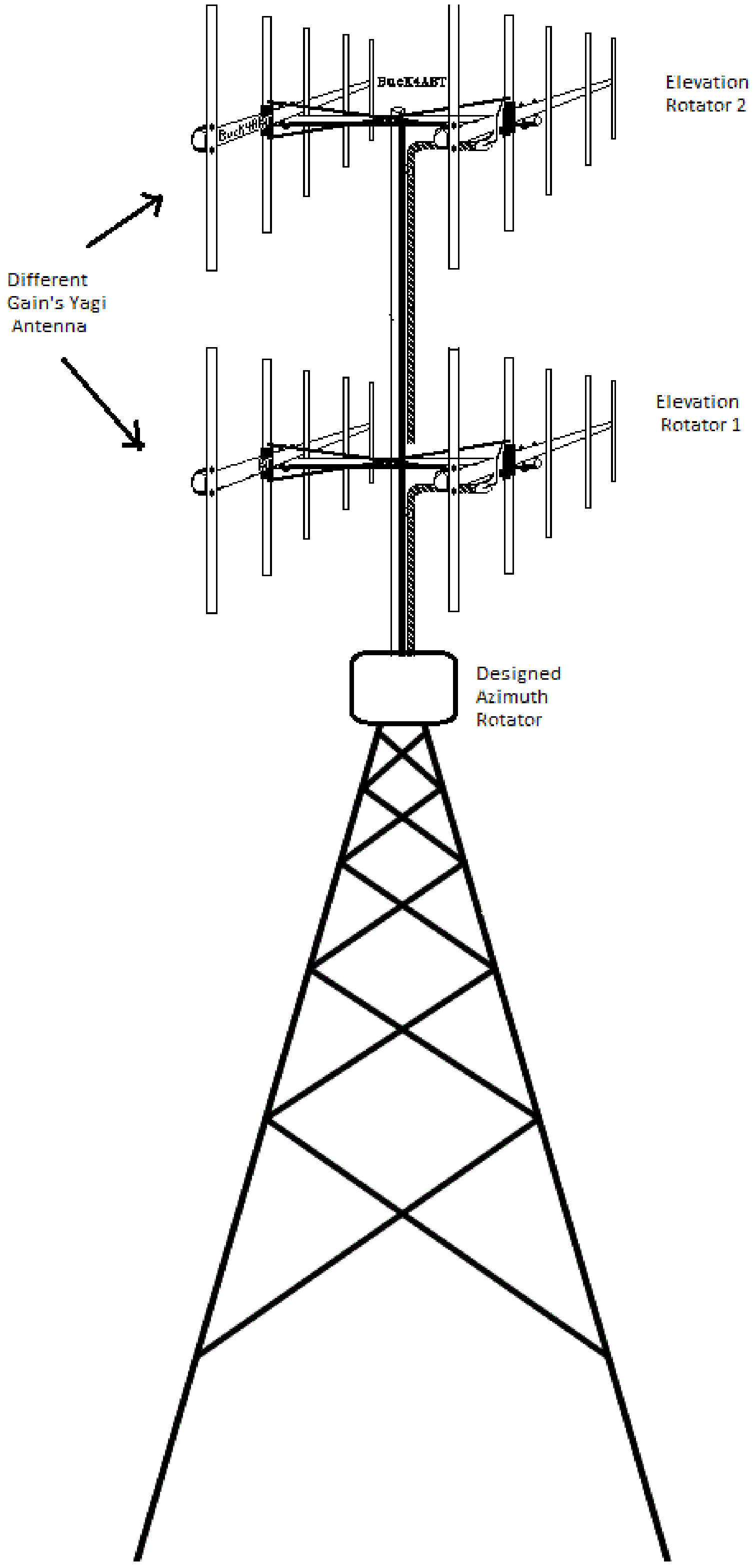


Figure 1: Antennas of different gain placed in vertical parallel position.

3 Satellite Tracking Software

Satellite tracking software is important to tracking the satellite correctly. This software collect the TLE and ground station position and from that position find out the Azimuth and Elevation value.

3.1 TLE:

The two-line element data or TLE represents all kind of data to identify a satellite. Two line Element represents all information in a a specific pattern **[22].** The TLE changes is the path of the satellite changes. So NASA and NORAD mainly provide the updated TLE in their website.

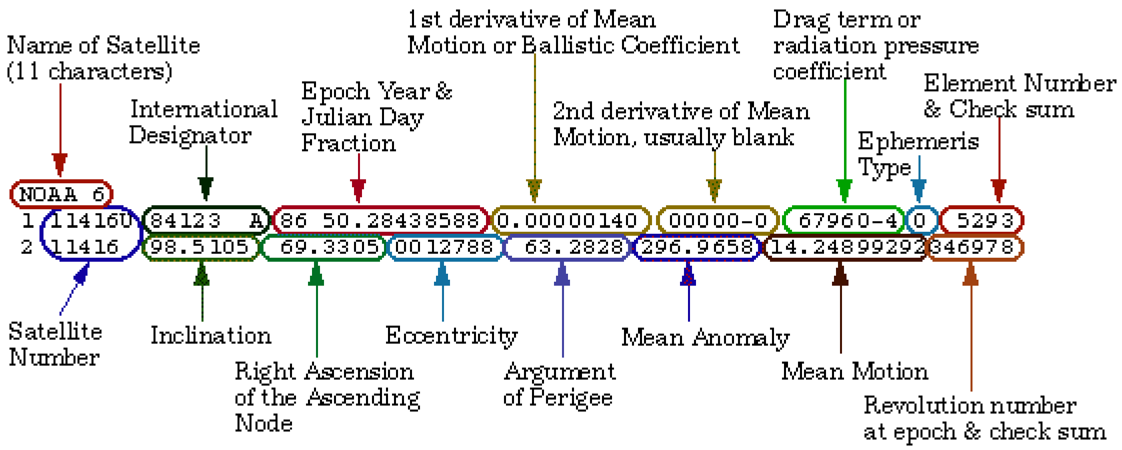


Figure 2 Two Line Element pattern of NOAA 6 **[22]**

3.2 Azimuth & Elevation:

Satellite is orbiting earth keeping its antenna position towards earth to communicate with earth, to receive and transmit data efficiently. When satellite send data, it can be received from a specific are. How much is covered by the satellite is called its footprint. The beam pointing direction of the antenna is always maintaining a straight line with the satellite's antenna's beam direction. The angle between the straight line and the horizontal plane of the antenna tower is called elevation angle. When antenna beam is in horizon the angle is 0 degree and when the beam pointed straight up the elevation is 90 degrees. When the beam direction comes opposite's horizon it is 180 degrees. So elevation is 0 to 180 degree**. [22-27]**

].

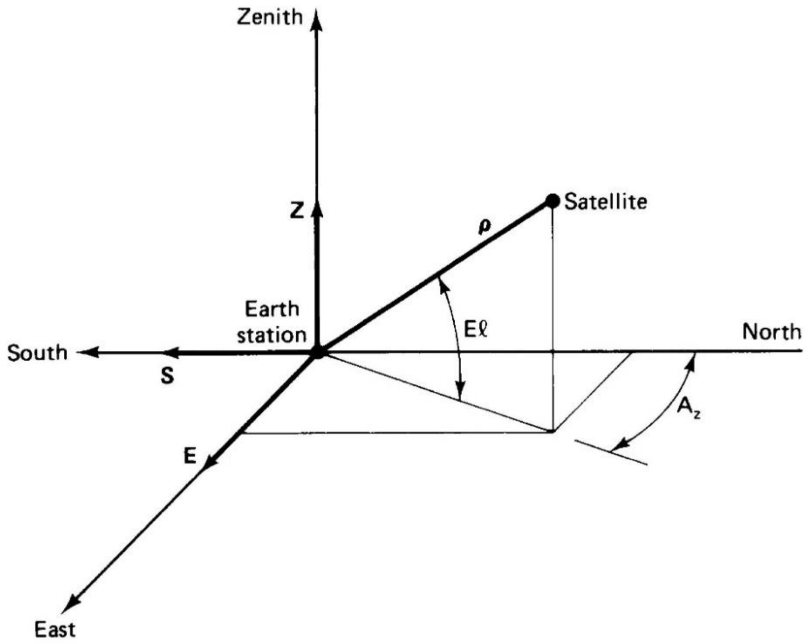


Figure 3: Azimuth (Az) and Elevation (El) Diagram **[20]**

Azimuth angle indicate the angle in vertical axis. It is the 360 degree around us. Typically, the north is 0 degree, if we rotate anti clockwise the east is 90 degrees, the south is 180 degree and west is 270 degrees. Again when north is considered 360 degrees. So it is a loop of 0 to 360 degree **[20-23].**

When the elevation angle is lower than 5 degrees (fir C band) and lower than 10 degrees (for KU band) the straight line between satellite and antenna is longest. The transferred wave has to pass long distance. So, the distraction is high and received signal power is low in that case. The signal is power is high when elevation angle is 90 degrees.

3.3 Doppler Effect

When frequency radiating object moves the frequency of the object changes. IT happens when Low earth orbit satellite pass the Ground station. When LEO satellite comes towards ground station the downlink frequency (which might be in UHF or VHF) increases and when LEO satellite moving from the ground station the frequency decreases. The following mathematical formulas which used to calculate the change of Doppler frequency for satellite velocity **[33-36].**

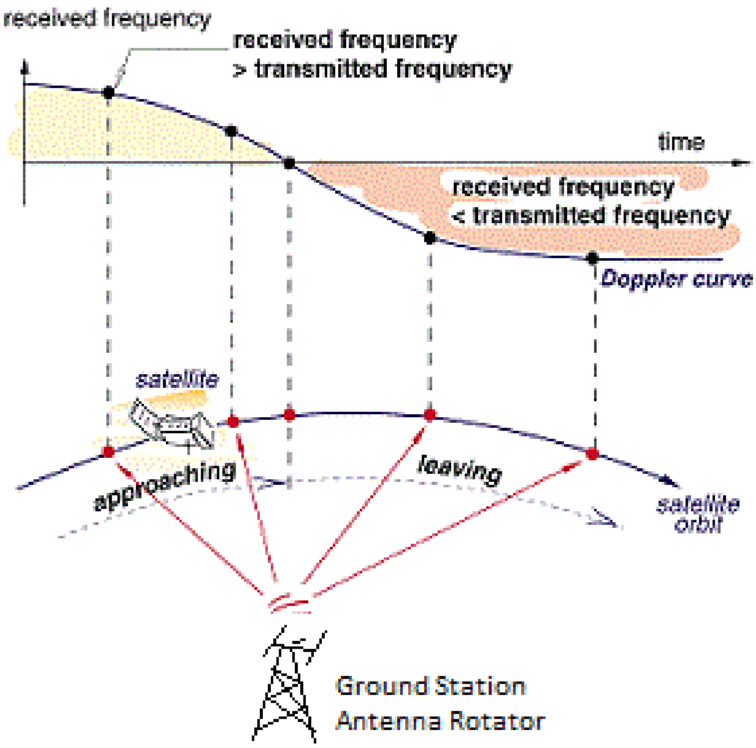


Figure 4: Doppler Effect **[29]**

3.4 Tracking Software:

For satellite tracking the most important part is satellite tracking software. Satellite tracking software gives us the azimuth and elevation angle to rotate our directional antenna. Tracking software use updated TLE and the ground station antenna position to calculate the expected azimuth and elevation value. There are commercial and free satellite tracking software available.

The most common Software is:

1. Ham Radio Delux
2. Orbitron
3. WXtoImg
4. CWget

In our project we considered Orbitron, because is free for research purpose and has unlimited license. We also use Ham Radio Delux Version 5.24.0.38. To perform software efficiently it gets recent updated of TLE. Then it collect the position of Antenna and through a calculation provides AZ-EL angle. It also calculate the Doppler shift of the frequency.

$$\text{Change in frequency: } \Delta f = f\ (V/C)$$

$$\text{Downlink Correction: } fd = f\ (1+v/c)$$

$$\text{Uplink Correction: } fu = f(1-v/c)$$

Where:

fd = Doppler corrected downlink frequency for Listing

fu = Doppler corrected uplink frequency for Transmitting

f = Original frequency which original specification each sat

v = Velocity of the satellite related to ground station in *m/s*.

Here,

(+) when *moving towards*

(-) when *moving away.*

C = Speed of Light in a vacuum space (3x108 m/s).

This calculation is normally done by satellite tracking software. **[26-32]**

3.5 Loss because of Pointing Miss-match

We need to keep the satellite antenna and the ground station antenna in same direction. If we can do it, we will achieve the optimum power for Low Earth orbit satellite satellite communication for.

The optimum power consumption during communication is achieved by maintaining the correct elevation and azimuth angle. The antenna pointing error can be calculated by the equation.

$$LT = 12\ (\theta T\ /\theta 3db)2dB$$

Here,

LT = Loss because of pointing mismatch (dB)

θT = pointing mismatch (o)

$\theta 3db = 70\lambda/D$, where D is the distance and λ is the wavelength **[25-26]**

3.6 AZ-EL Calculating controlling

Azimuth and elevation data calculated by software and the value is implemented by the microcontroller. Here we use Atmega 2560 and Cytron motor driver and close loop feedback system to control the hardware.

3.6.1 AZ-EL Calculating Flow Chart

We can calculate the Azimuth and elevation by python programming. Python have the library to calculate the Azimuth and elevation of a satellite aspect to ground station position and in a specific day and time. The flow chart of the steps is looks like that.

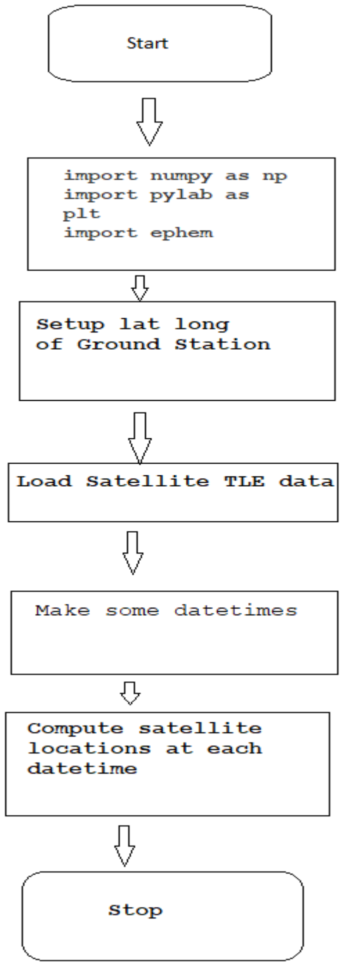


Figure 5: Flow chart AZ-EL calculation by python.

3.6.2 Rotator Control System:

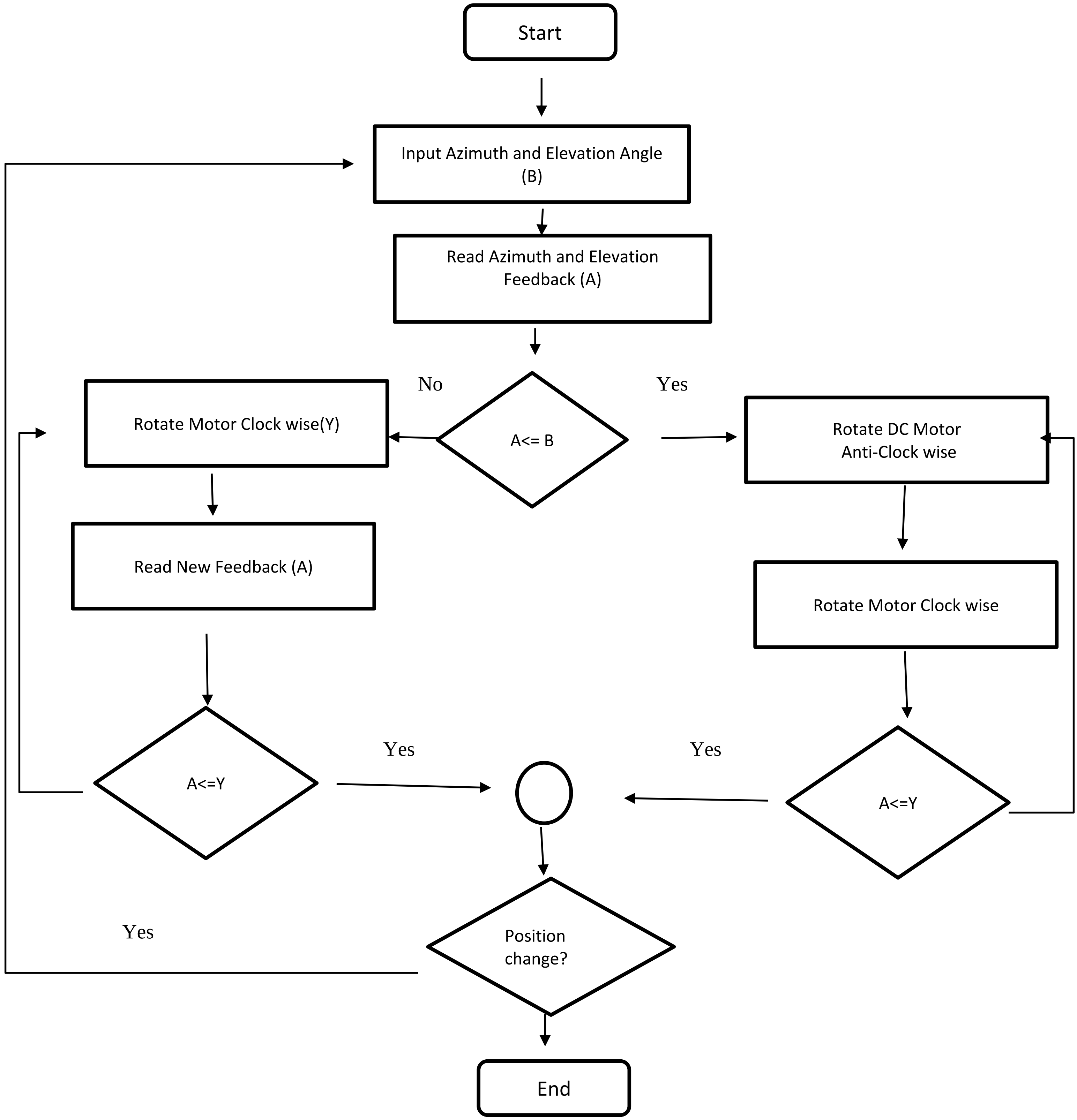


Figure 6: Rotor Controlling Flow chart

4 Azimuth and Elevation Antenna Rotator Design -Mechanical System

4.1 Motor Selection

Selection of motor is one of the major part of the rotator system. For rotating the antenna in proper angle it's important to have a low rpm motor. We used both for azimuth and elevation DC motor. After doing research we got two match having low rpm for our system. For azimuthal rotation we used *kotto-36501* power window motor and for elevation *TSUKASA TG-05* brush gear motor.

Figure 7: KOTTO-36501 and TSUKASA TG-05 DC Motor

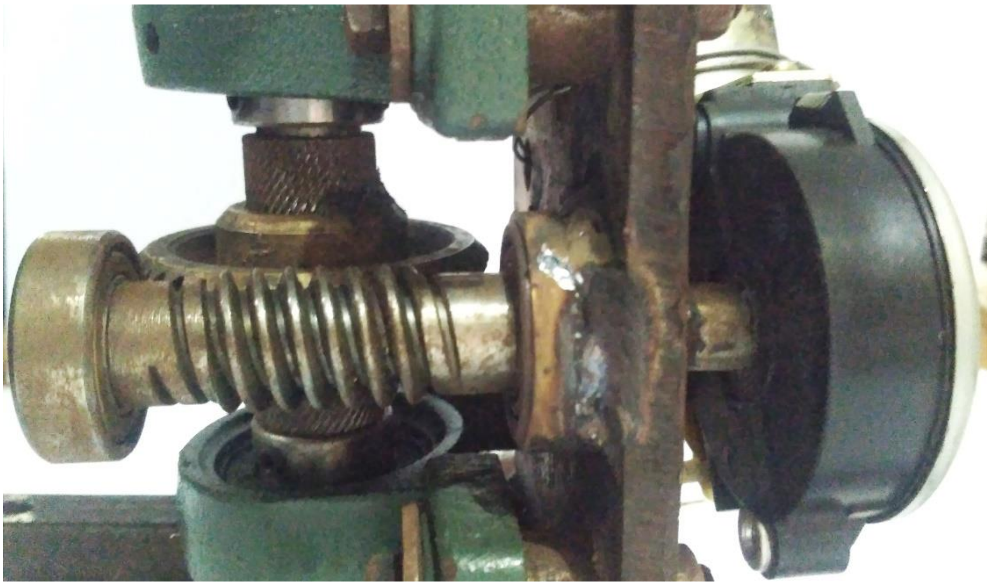


Figure 8: Modified Azimuth Gear and Shaft

4.2 Shaft & Gear Modification

We open up the KOTTO-36501 and remove its last gear. After that we wielding it with 59 mm long and 21.79 mm diameter worm. So we get a whole shaft fixed with *KOTTO-36501* motor. In the Elevation side 60 mm a worm gear is assembled. The gear is 32 mm in diameter and the worm is .15” in diameter. We customized the shaft to maintain the required speed and torque. First we take down the worm and welding it with the shaft of 24v gear motor.

4.3 Feedback Gear

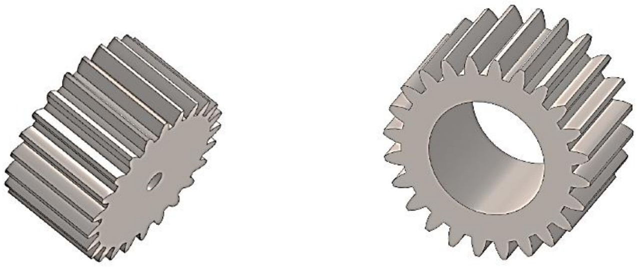


Figure 9: Feedback gear 3D model by AutoCAD, Elevation-shaft feedback gear (Right side), Elevation-potentiometer feedback gear (Left Side).

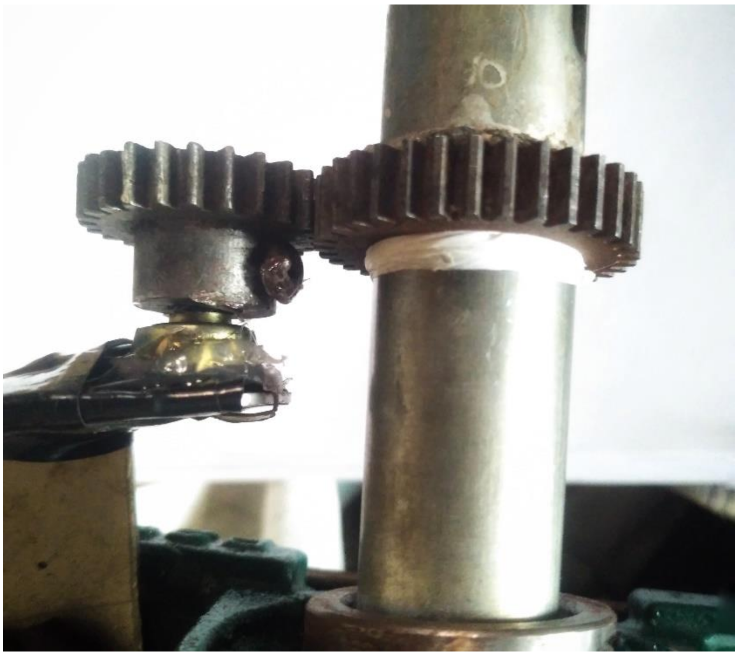


Figure 10: Implemented Feedback gear Elevation-shaft feedback gear (Right side), Elevation-potentiometer feedback gear (Left Side).

A potentiometer is attach inside the Elevation box by gear. The diameter of the input gear which is fixed with the elevation shaft is 35 mm. It is called Elevation-shaft feedback gear (Right side). The output gear which is connected with potentiometer is 36.96 mm in diameter. Which is named Elevation-potentiometer feedback gear (Left Side).

The Elevation-shaft feedback gear (Right side) has a cut of 35 mm diameter to fit with the elevation shaft. The Elevation-potentiometer feedback gear (Left Side) has a cut of 6.48 mm diameter in the middle to fit with potentiometer.

The ration of the feedback gear is 1.3:1. That means if the elevation-shaft gear rotate 10 times the potentiometer rotate 13s times and the voltage value changes. We find out the output position by voltage deviation rule.

4.4 Gear Ratio:

Gear ratio of a gear train is defined as the ratio of the angular velocity of the input gear to the angular velocity of the output gear. It's also known as speed ratio.

$$R = Wa/Wb = Nb/Na$$

The equation of calculating the gear ratio where Na is the number if teeth on the input gear and Nb is the number of teeth of output gear. Here in our system we used worm gear. Worm gear has two part one is called worm screw which is the input gear to the angular velocity and another is worm wheel which is the output gear to the angular velocity.

The customized Elevation gear ratio of the worm is 25:1. If the worm rotates 25 times then the gear rotates 1 times. The customized Azimuth gear ratio of this worm gear is 10:1. If the worm rotates 10 times the gear disk rotates 1 times.

Figure 11: Worm Gear

4.5 Mechanical Model:

The mechanical Part of your system is divided into two part.

1) Azimuth rotator Box
2) Elevation rotator Box

4.5.1 Azimuth rotator part:

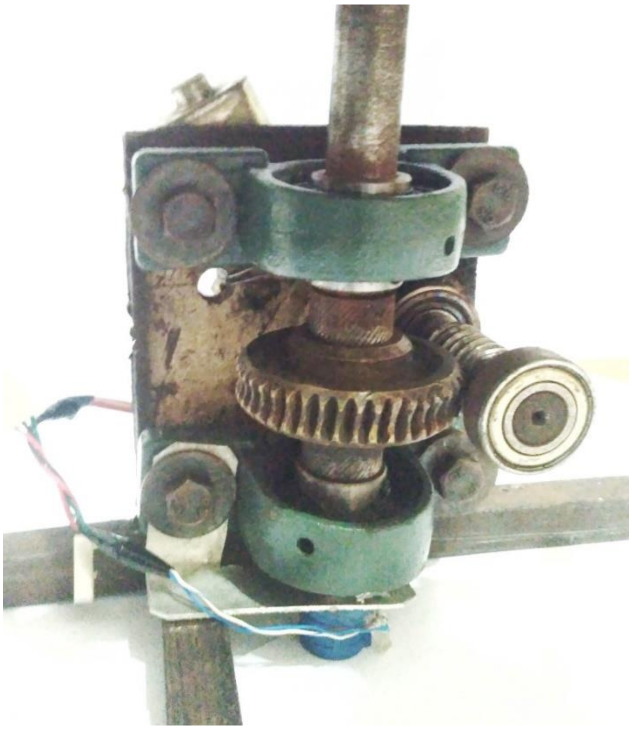


Figure 12: Designed Azimuth rotator part

The azimuth part of rotating system is responsible to rotate in X axis. The limit of the rotation is o degree to 360 degree. The rotation part is constructed such a way that it can move freely up-to 2 round. So it can rotate 360*2=720 degree. The rotating shaft is 20 mm in diameter and positioned vertically. From the bottom at 20 mm SKF Pillow Block Ball Bearing is connected. The shaft is fixed by two bolts with the bearing. The bearing is connected is cast iron body. The cast iron body is connected with the main iron frame by two bolts.

Figure 13: SKF Pillow Block Ball Bearing

After that at 2.5mm internal diameter gear is connected. The external diameter of the gear is 65.95 mm. Then a 127.5 mm worm is designed to maintain high torque and low speed and keep fixed with iron body by bearing to ensure the smooth movement with gear.

The ratio of this worm gear is 10:1. If the worm rotate 10 times the gear disk rotate 1 times. The gear box is the main part where the speed of the dc motor will be decreased and the torque of the system is increased.

Then in the end side a .20 mm SKF Pillow Block Ball Bearing is connected to ensure the smooth circulation. The bearing is fixed with the iron body. The iron cast frame is screwed with the main frame; makes the design non bendable. And the weight remains centralized. Under the shaft a plate is set for the feedback potentiometer.

4.5.2 Elevation rotator Box

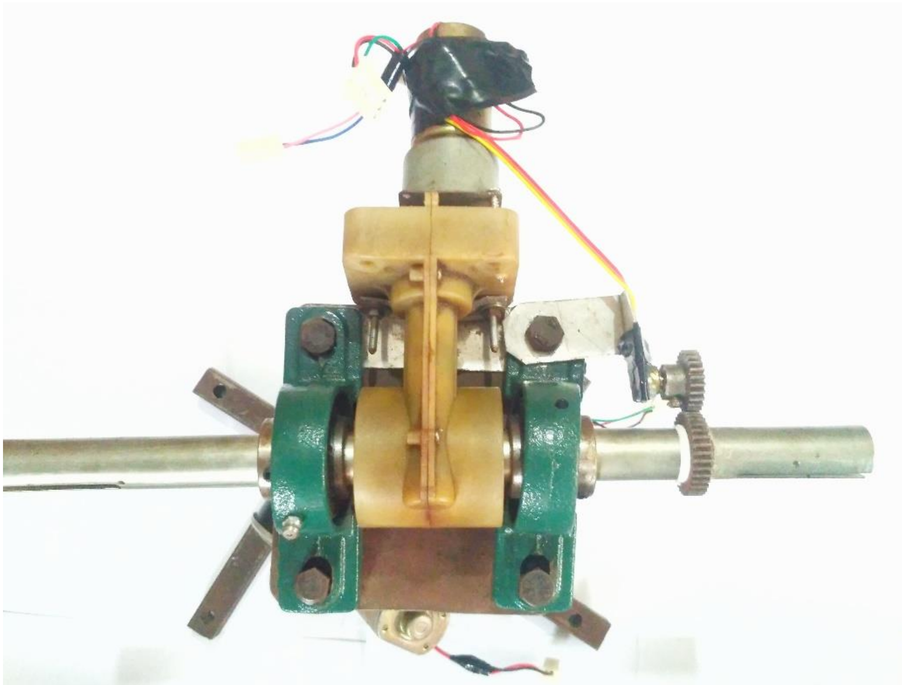


Figure 14: Elevation part of the rotator

The elevation part of the mechanical part is responsible to move the antenna in Y axis. The shaft can move from 0 degree to 360 degrees but use 0 to 180-degree limit. The main rotating shaft is 12” in length and 32 mm in diameter. The whole 12” shaft is like a pipe. In The both side of the shaft the antenna remains attached.In the middle of the main shaft 60 mm a worm gear is assembled. The gear is 32 mm in diameter and the worm is .15” in diameter. We customized the shaft to maintain the required speed and torque. First we take down the worm and welding it with the shaft of 24v gear motor.

The ratio of the worm is 25:1. If the worm rotates 25 times then the gear rotates 1 times. The gear box is attached with 24V 3-amp DC motor.

The both side of the shaft two 32mm diameter SKF Pillow Block Ball Bearing is being attached. The Iron Cast Body is screwed with the ironed frame. The distance between two SKF Pillow Block Ball Bearing is 120mm.

The main shaft is located near the Azimuthal Rotator Box and the DC motor is over the main shaft. The weight of the dc motor is perpendicular with the Azimuthal rotating box. So, the mass point of the whole system remains in one straight line.

5 Electrical Circuit

We designed an electrical control box to control the hardware efficiently. The designed control box is also used to interface with software.

5.1 Circuit interfacing Block Diagram

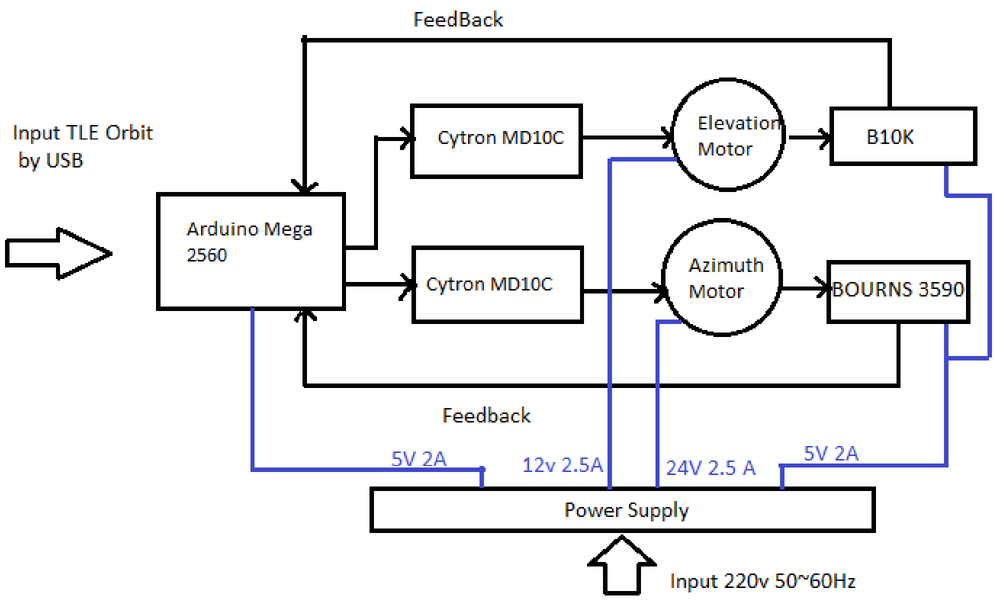
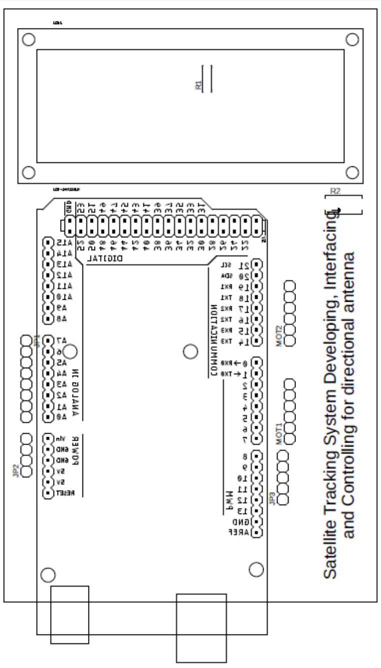


Figure 15: Block diagram of full electrical system

5.2 Circuit simulation connection



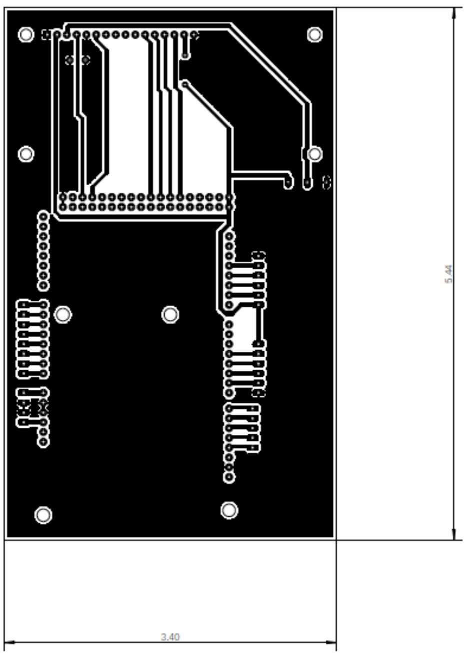


Figure16: Stack and display unit (Front View)   Figure17: Stack and display unit (PCB View)

In the circuit Arduino mega 2560 is used as central processing unit. Arduino is connected with USB port of PC through USB cable. In the PC satellite tracking software is installed. Arduino Mega collect the expected azimuth and elevation angle according to that is runs the DC motor. To run the DC motor we used Cytron MD10C motor driver. We used two motor driver two run two DC motor. For the Azimuth Motor control the positive and negative wire of dc motor is connected with the A and B pin of Cytron MD10C. The power input is 12 V and 2A. The DIR pin of Cytron MD10C is connected with number 2 pin of the arduino. The PWM pin is connected with the number 3 pin.To measure the position we connect BOURNS 3590 precision Potentiometer as feedback. There are three pin in the BOURNS 3590. The number 1 pin is connected with 5V DC. And number 2 pin is ground. The number 3s pin is connected with the analogue pin A1 of Arduino Mega 2560.

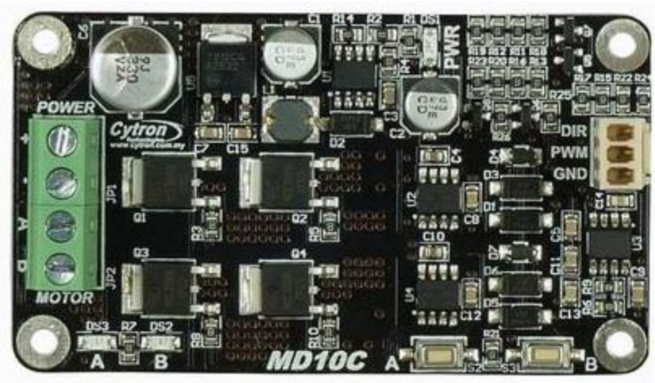


Figure 18: Cytron MD10C Motor Driver

For the Elevation DC motor controlling we used same motor driver. The power input for the elevation DC motor is 24 V DC and 2.5 amp. The PWM pin of Cytron MD10C is connected with number 6 pin, the DIR pin is connected with number 5 pin. The feedback pin of BOURNS 3590 precision Potentiometer for Elevation DC motor is connected with analogue pin A2 of Arduino Mega 2560. Then we Power the Arduino by 5V 2A adapter.

5.3 Feedback Sensor Circuit:

The BOURNS 3590 is high precision potentiometer. Standard Resistance Range is 200 to 100 K ohms. The Power Rating is 2 watt. Rotational Life is 1,000,000 shaft revolutions and load life is 1000 hours in 2watt. Independent Linearity of this potentiometer is 3600 ° +10 °, -0 °. Operating temperature range -40 °C to +125 °C and IP rating is ip64. Full body seal. So, it can operate in harsh environment.

Figure 19: BOURNS 3590 precision Potentiometer and B10K Knurled Shaft Linear Rotary Taper Potentiometer

We use 10k B10K Knurled Shaft Linear Rotary Taper potentiometer for elevation feedback. The Power Rating is 0.3W Maximum voltage input 200 VDC. Rotational Life is 2,000,000 cycles shaft revolutions. Independent Linearity of this potentiometer is 0 to 280°. Operating temperature range -10°C to +85°C. So, it can operate in harsh environment.

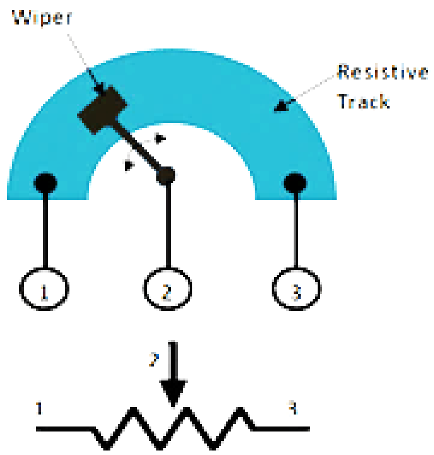


Figure 20: Pin Configuration of B10K Knurled Shaft Linear Rotary Taper Potentiometer

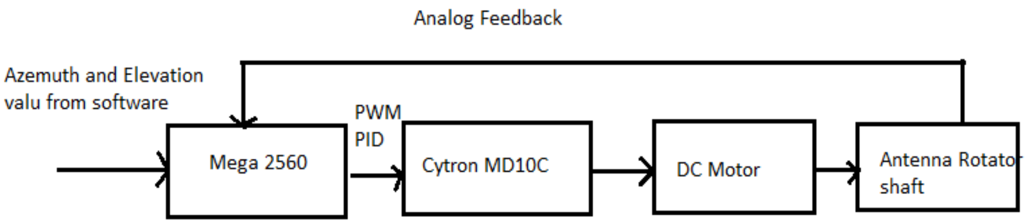


Figure 21: Block Diagram of Feedback system

5.4 Circuit connection summary

Table 1: Summary of Circuit connection

	Motor Driver			Power	Feedback		
Azimuth	**PWM**	**DIR**	**+ Pin**	**A & B Pin**	**GND**	**Data pin**	**Power**
	3	**2**	**12 V**	**KOTTO-36501**	**GND**	**A1**	**5V**
Elevation	**6**	**5**	**24V**	**TSUKASA TG-05**	**GND**	**A2**	**5V**

6. Measurement and Analysis

In this part the output from the total system is discovered, measured and analysed. To maintain the global standard the received data is also compared with standard data.

6.1 Power Supply Test

The power supply is divided in two part. Microcontroller power supply and motor driver power supply.

The input Voltage: 220 Volt AC, 50~60 Hz

Microcontroller power supply: 5 volt DC, 2 A

Azimuth motor driver power supply: 12 volt, 2.5 A

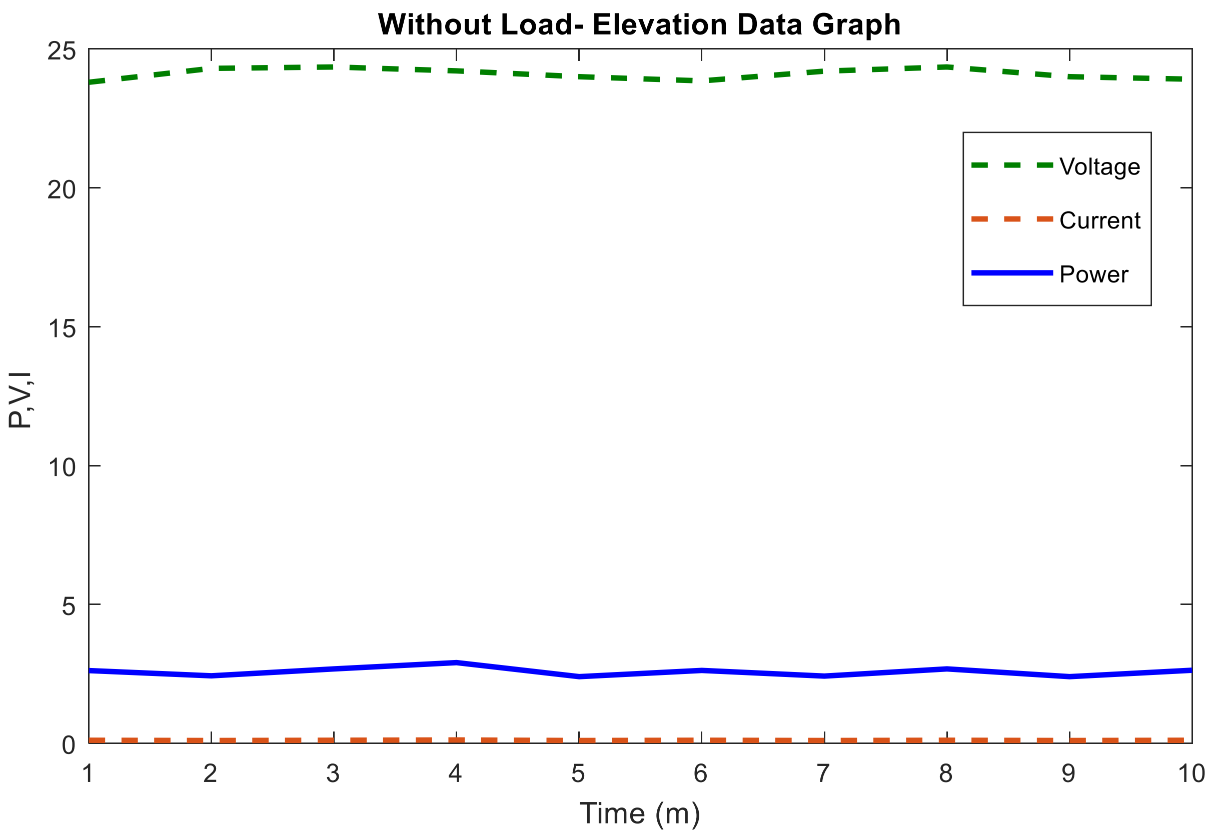
Elevation motor driver power supply: 24 volt, 2.5 A

6.2 Motor Load Current Test:

A specific power supply is created for this rotator system. The Azimuth and Elevation motor needs more power to perform accurately when load is increased. As we know,

Power (P) =Voltage (V)* Current (I)

The supply of current increased with the increasing of load/weight. This current is called load current.



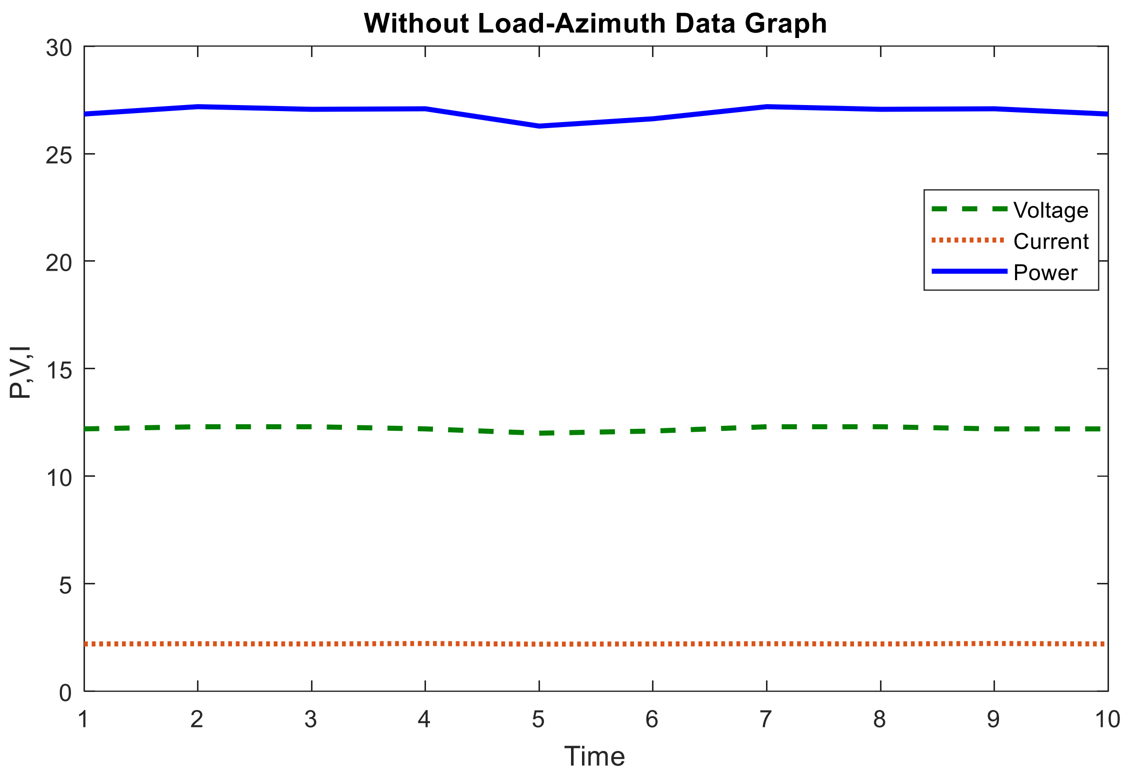
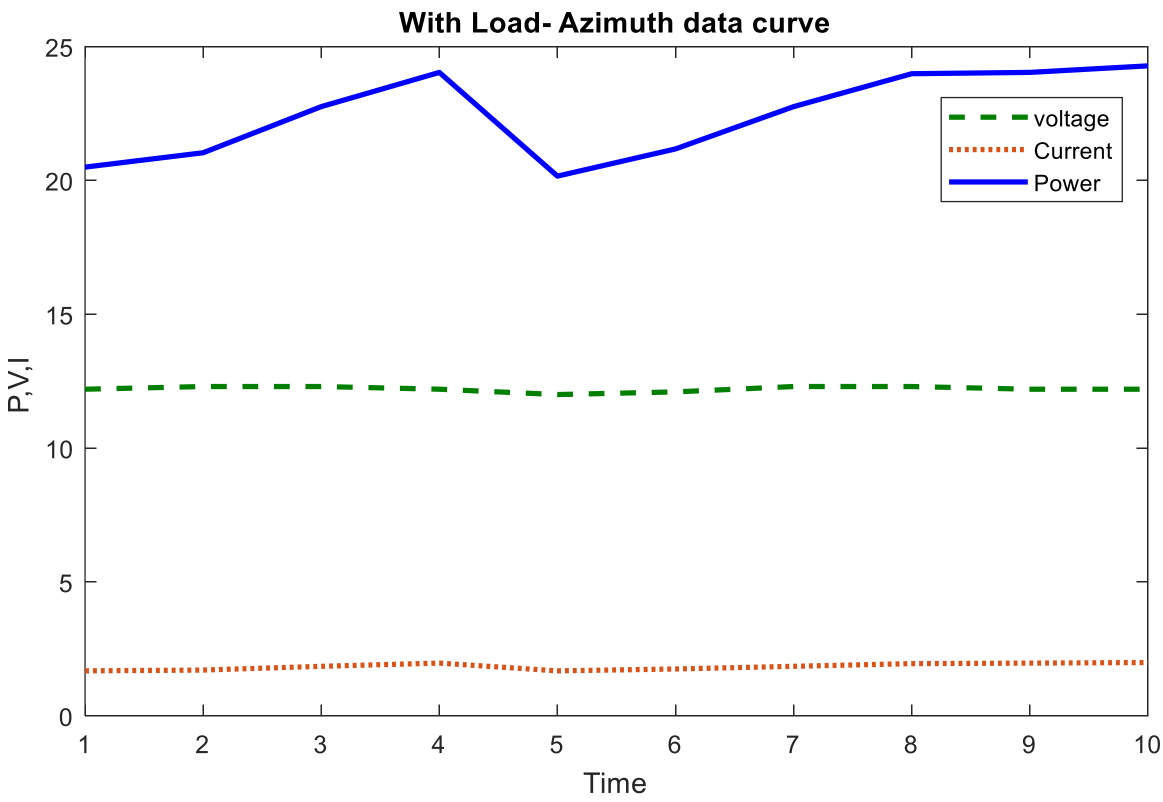


Figure 22: Azimuth power and elevation power (without load)



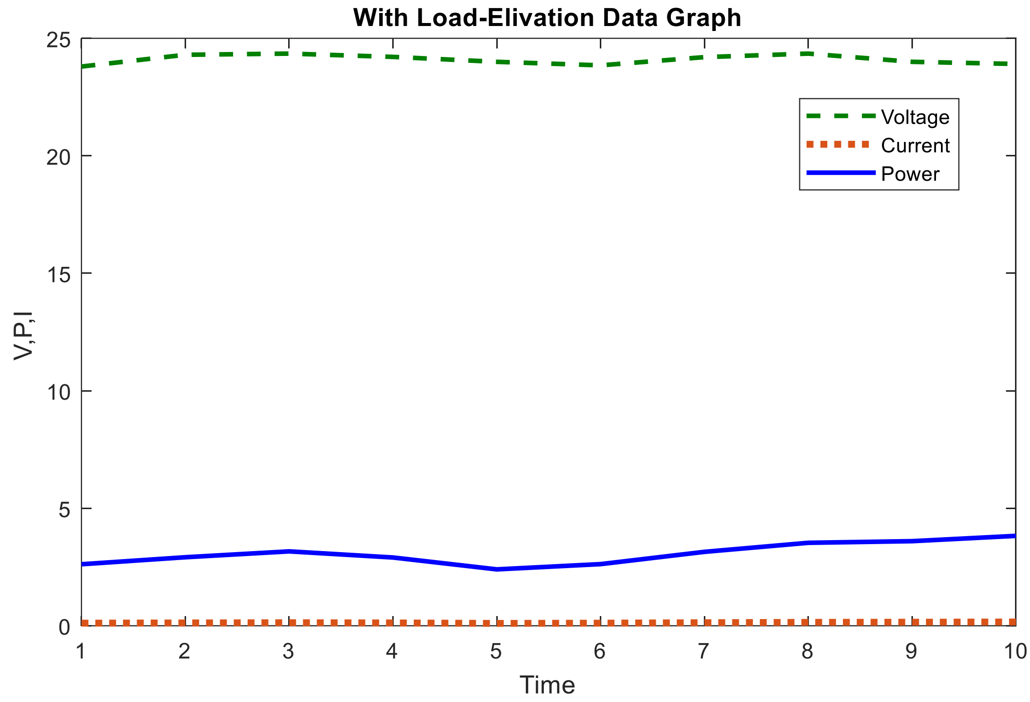
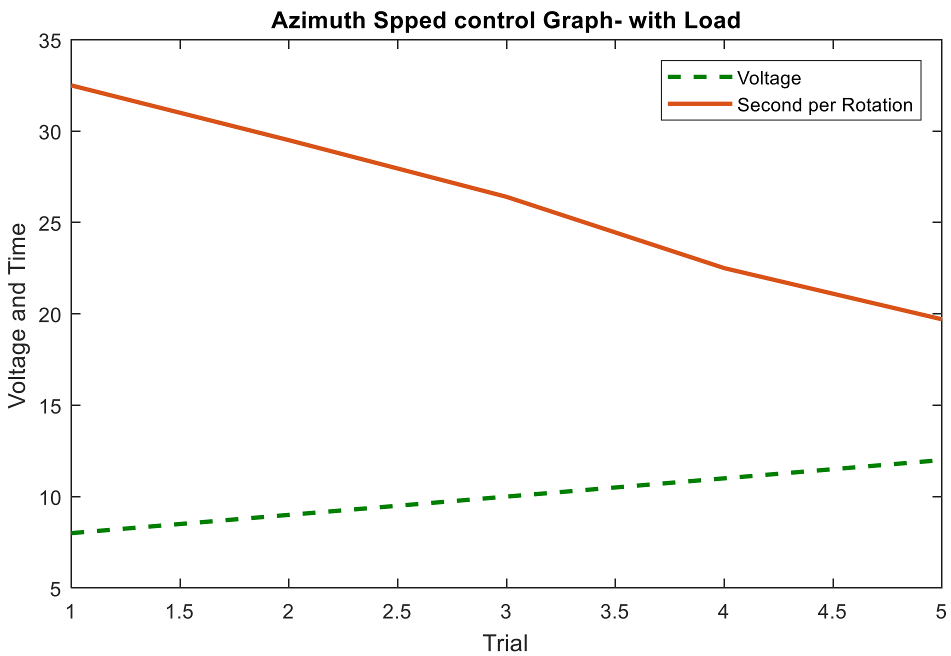


Figure 23: Azimuth power and elevation power (with load)

6.3 Mechanical Rotation Speed Test

The rotator system have two mechanical gear. The design have flexibility to change the speed according to user demand. The horizontal rotation speed for azimuth shaft is 3*360= 1080 degree per minute. The vertical rotation speed for elevation shaft is 2*360= 420 degree per minute. SO, this design is able to track satellite over the antenna.



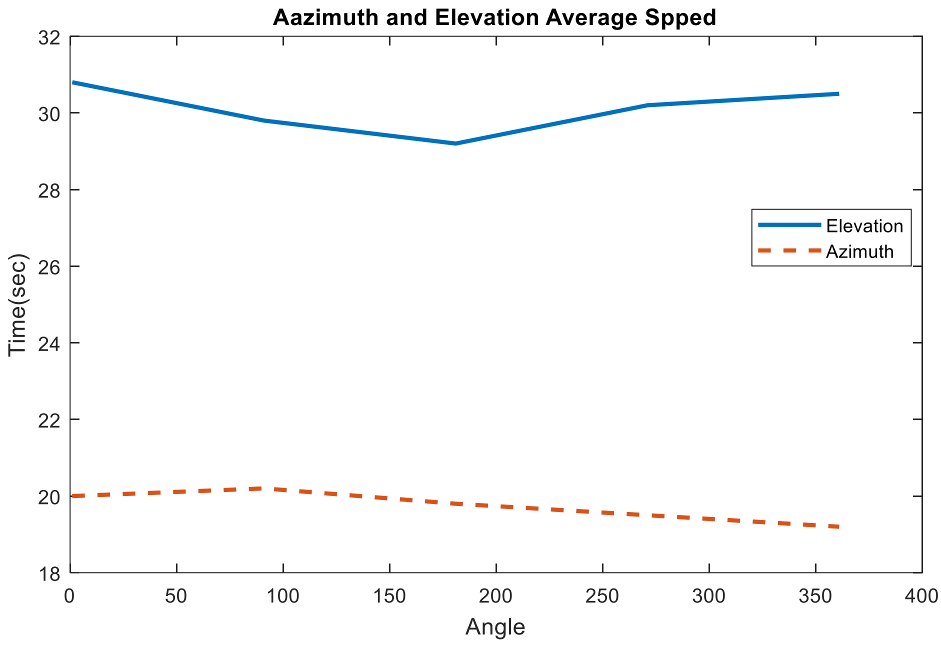


Figure 24: Azimuth and elevation Rotation Speed

6.4 Feedback Testing (AZ and EL)

BOURNS 3590 potentiometer is worked as feedback sensor. It provides analog data. The input voltage of the potentiometer is 5 volt. In every rotation the output voltage changes. In every 360dgree we get a change in the BOURNS 3590 potentiometer is 0.250 Ohm. The B10K Knurled Shaft Linear Rotary Taper Potentiometer provide 10K value. The changes in Actual Electrical Travel, Nominal is 280 degree. The changes in per degree is 35.5 Ohm.

6.5 Angle estimation, comparison and angle accuracy test:

We track the ISS International Space Station through our designed Rotator. The predicted angle by Orbitron and the resulted angle by designed rotor is near same. The error in azimuth angle is +-3% and the error in elevation is +-2.5%.

Table 2: Angle estimation, comparison and angle accuracy test.

	Prediction Azimuth	Result Azimuth	Prediction Elevation	Result Elevation
Trial-1	156.7	152	10.0	11
	124.4	126	13.6	14
	92.4	92	10.0	12
Trial-2	255.5	257	10.1	10
	314.9	314	25.7	27
	13.7	11	10.1	8
Trial 3	332.5	330	10.0	8
	47.6	46	45.9	43
	123.0	124	10.1	10
Trial 4	228.0	227	10.1	8
	312.0	311	65.4	66
	34.2	35	10.0	10
	Azimuth Error	**+-3%**	**Elevation Error**	**+-2%**

6.6 Place Pointing and SSTV Data Transfer Test

In this experiment we poi not a receiving point in difference distance and transfer picture. We connected the Yagi Uda antenna with KENWOOD TH-F6 Tribander Handheld radio and transfer a picture. The Signal is transmitted by "SSTV Encoder" an android app. This app convert images to SSTV signals which we used as sources of our transmitting signal through our handheld radio. In the receiving end we use Robot36 decoder to decode the received data.

By comparing the received picture in different receiving point we ensure that new designed rotator is providing expected angle of the receiving point.

Antenna: Yagi-Uda [40]

Table 3: Place pointing and data transfer test

Distance	**Transmit Power**	**Trial**	**Sending Point**		**Receiving Point**		**Result**
			Longitude	latitude	Longitude	latitude	
>800m	EL	Trial 1	90.4070	23.7820	90.411767	23.771370	Average
	L	Trial2	90.4070	23.7820	90.411767	23.771370	Good
	H	Trial3	90.4070	23.7820	90.411767	23.771370	Good
7KM	EL	Trial 1	90.4070	23.7820	90.369539	23.836468	Average
	L	Trial2	90.4070	23.7820	90.369539	23.836468	Good
	H	Trial3	90.4070.	23.7820	90.369539	23.836468	Best

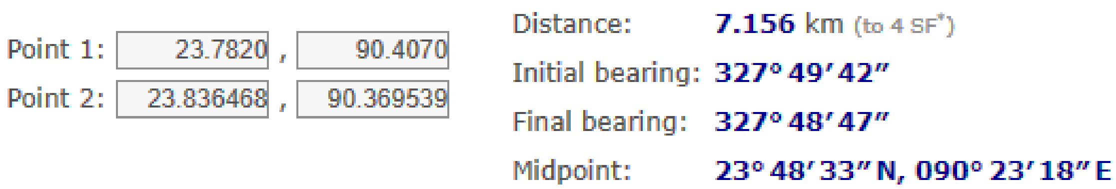


Figure 25: Distance calculation between two points [38]

6.7 SSTV Received Data

Figure 26: Distance >800m, Longitude 90.411767, latitude 23.77137, Power EL

Figure 27: Distance >800m, Longitude 90.411767, latitude 23.77137, Power L

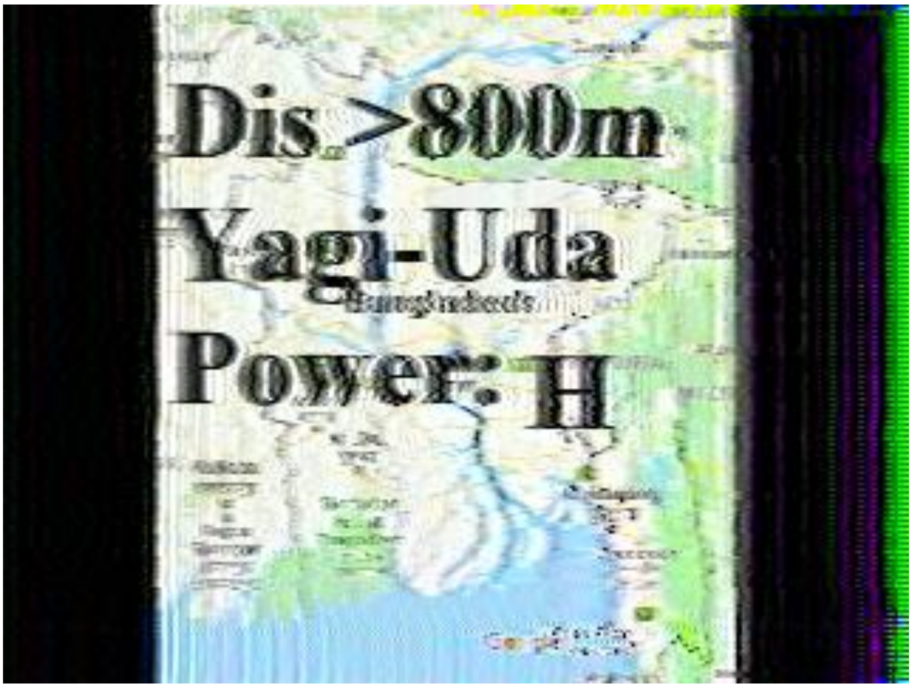


Figure 28: Distance >800m, Longitude 90.411767, latitude 23.77137, Power: H

Figure 29: Distance >7KM, Longitude 90.36953, and latitude 23.836468, Power: EL

Figure 30: Distance >7KM, Longitude 90.36953, and latitude 23.836468, Power: L

Figure 31: Distance >7KM, Longitude 90.36953, and latitude 23.836468, Power: H

7 Satellite Tracking and Operation

7.1 Manual Operation with Button press

7.1.1 Power connection:

First step of the satellite communication operation is turn on the power supply of the rotator. There are three power connection of the system. We have three power output in different devices. 24v 2.5A, 12V 2.5A and 5V 2A. The input voltage is 250V 50~50Hz

7.1.2 Turn on hardware

The second step of the operation is Hardware turn on. The sequence is turn on the Radio then turn on the control box.

7.1.3 Command by control box button:

In Ham communication manual control is very important. Manual control ensure the freedom of the user to command the rotator according to user demand. There is two button for each angle command. Two is for Azimuth and another two is for elevation.

By pressing the AZ-CW button of the controller the azimuth part rotate in clockwise direction. By pressing the AZ-CCW button, the azimuth part of the rotator rotate counter clock wise.

Again, by pressing the EL-UP button of the controller the Elevation part rotate in up direction and by pressing the AZ-Down button, the azimuth part of the rotator rotate in down direction.

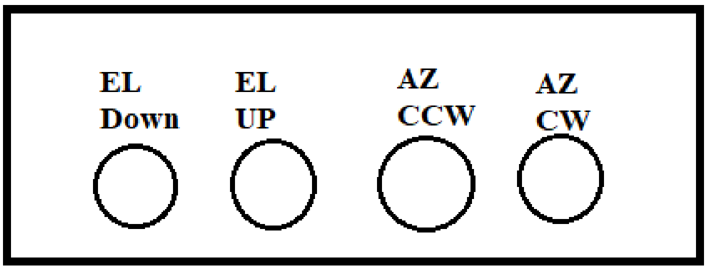


Figure 32: Manual Control button in control box

7.2 Manual Operation by Software Command (SSTV Data Transfer):

After completing 7.1.1 and 7.1.2 we have to continue the next step for Manual Operation by Software Command. We can control the Azimuth angle from the HRD software. The HRD software do not have the elevation controlling option so we do not show the elevation part. For Manual control by software we use HRD Rotator Software. First we select Easy Comm 1 for Arduno dependent control box connection. Then select the port COM 3. Finally connect the HRD rotator with control box.

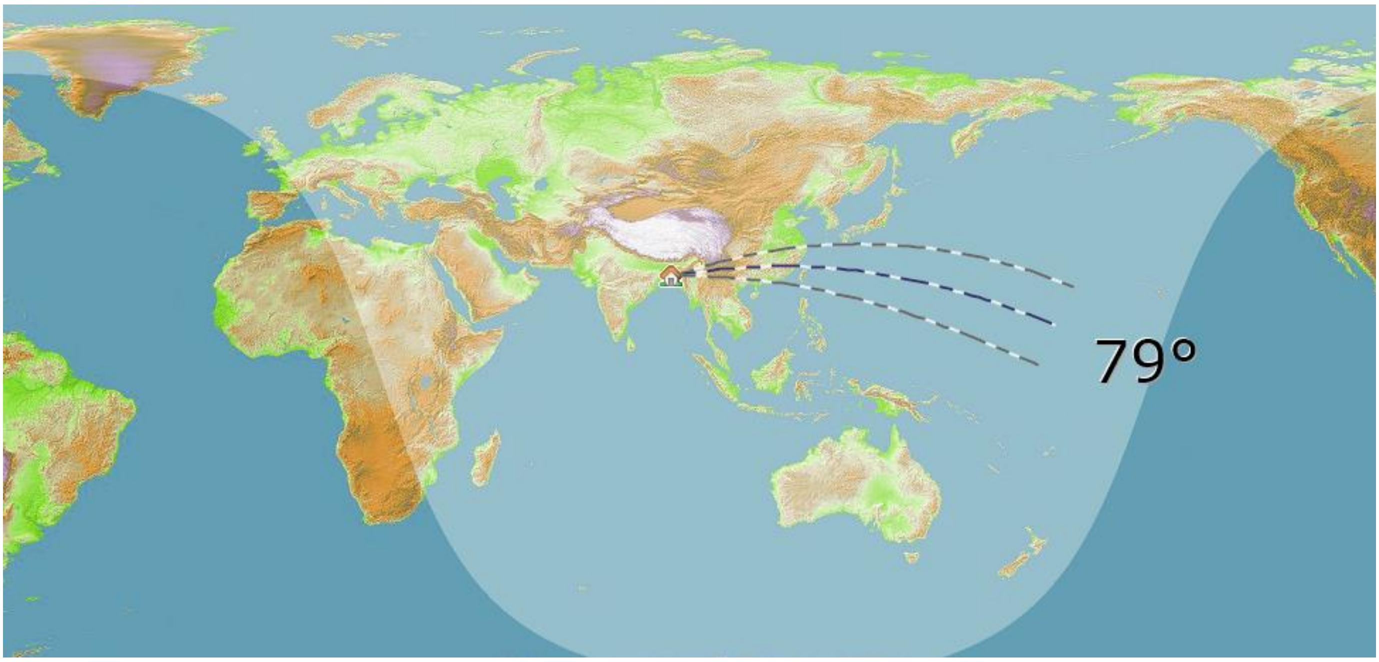


Figure 33: Manual Operation by Software Command (SSTV Data Transfer)

7.3 Automatic satellite Tracking Test (BangabandhuSat-1):

7.3.1 Open Software:

The next part is open the satellite tracking software. Here we use Orbitron and HRD for our operation.

7.3.2 Position Setting:

First we have to set the antennas Longitude and latitude. The Longitude and latitude of UB4 is 90.4070 and 23.7820. To communicate we use the S21BU licence for research purpose provided by BTRC.

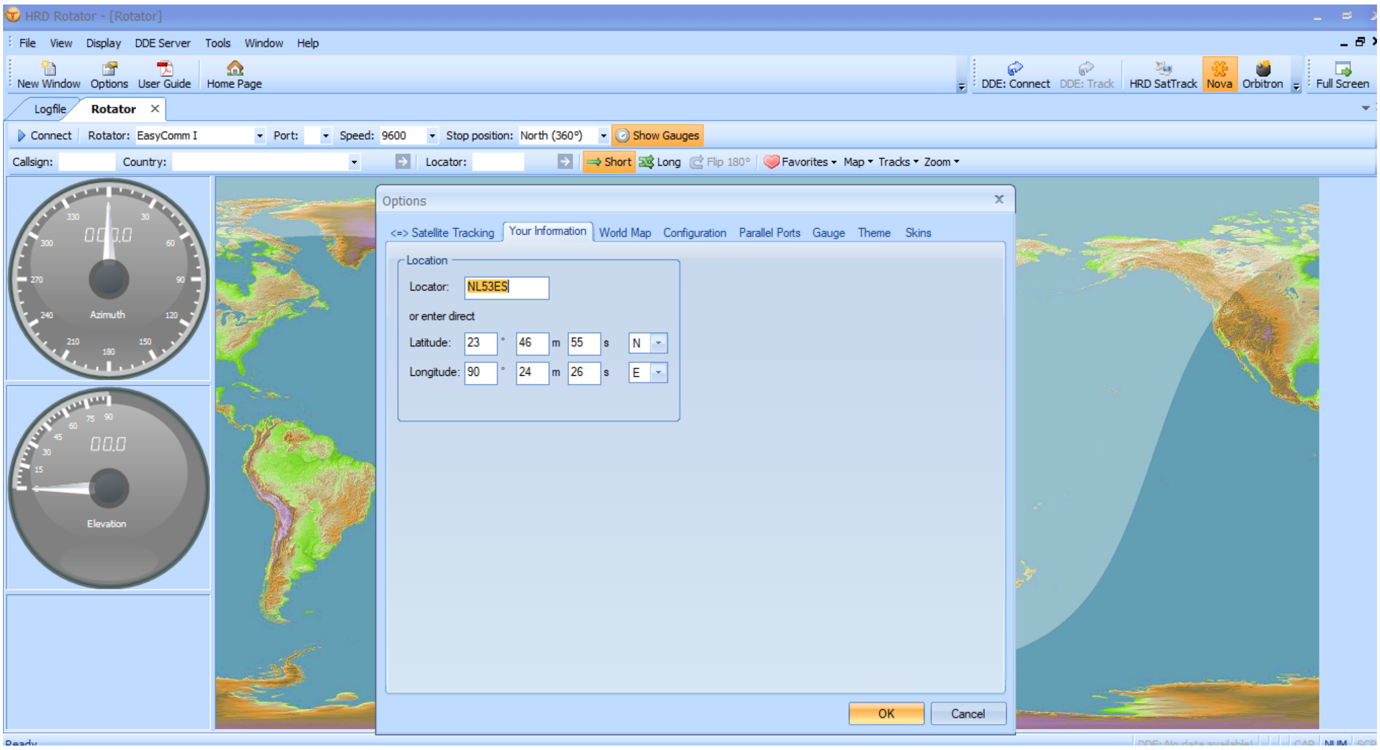


Figure 34: Ground Station (S21BU) Position Setting -HRD Rotator Software

7.3.3 TLE Update

Secondly, we updated the TLE. For this we click on Kepler data. Then, the type of satellite we want to track we can add the URL. We get the updated value from www.celestrak.com. The updated TLE is looks like that.

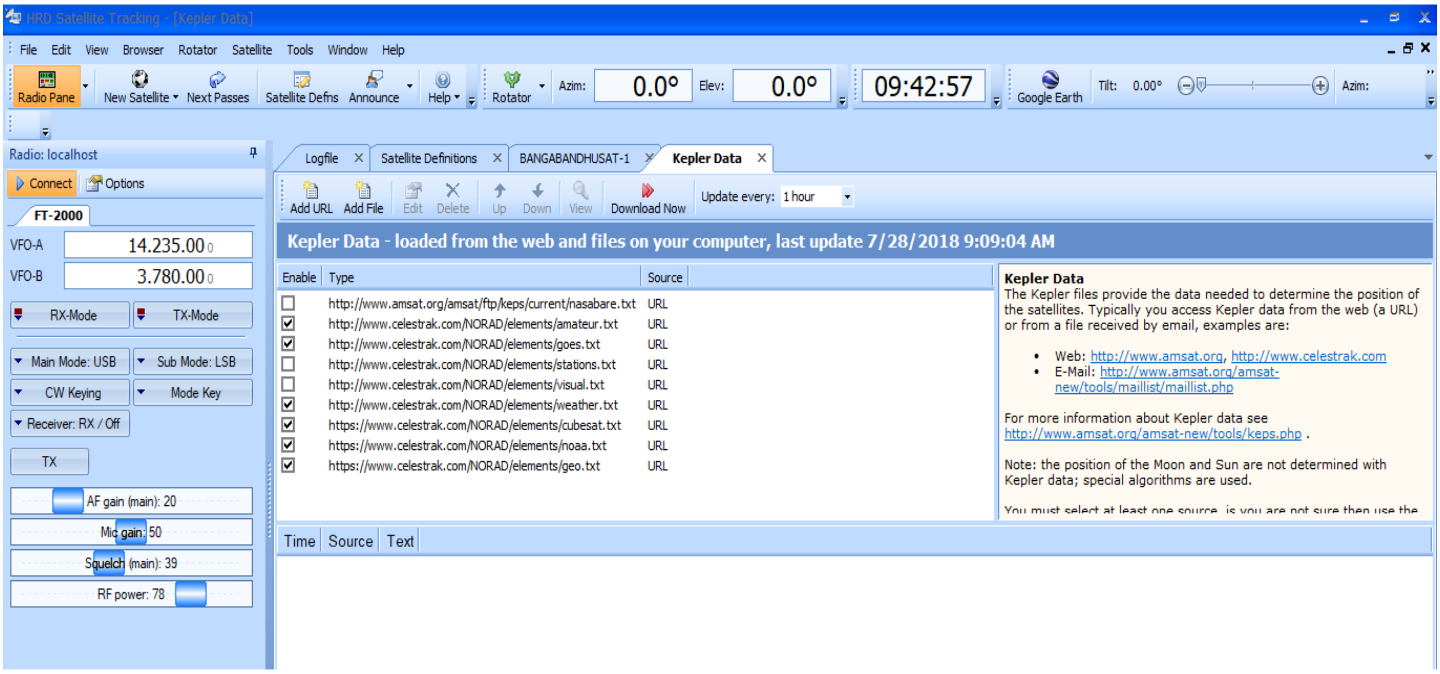


Figure 35: TLE Update (ISS) -HRD Satellite Tracking Software [37]

7.3.4 AZ, El Calculation and Time Prediction

After that we selected the satellite we want to track. In our research we select ISS-international Space Station. Then predict the azimuth, elevation, time date and range. The satellite tracking software calculated it preciously.

Satellite passes / Orbitron 3.71 / www.stoff.pl
Location : Dhaka (90.4070° E, 23.7820° N)
Time zone : UTC +6:00
Search period: 07-21-2018 09:27:22 - 5 days
07-26-2018 09:27:22
Conditions : Maximum sun elevation = None
Minimum sat elevation = 10 deg

Illumination NOT required

```
Time              Satellite              Azm   Elv  Mag Range S.Azm S.Elv
-------------------------------------------------------------------------
07-21-2018 18:10:01 ISS                156.7 10.0  1.3  1443 289.3   7.1
07-21-2018 18:11:44 ISS                124.4 13.6  0.9  1247 289.4   6.7
07-21-2018 18:13:27 ISS                 92.4 10.0  1.2  1449 289.6   6.4

07-21-2018 19:45:09 ISS                255.5 10.1  1.2  1445 299.4 -12.9
07-21-2018 19:47:56 ISS                314.9 25.7  0.0   834 299.8 -13.4
07-21-2018 19:50:43 ISS                 13.7 10.1  1.1  1452 300.2 -14.0

07-22-2018 03:55:37 ISS                332.5 10.0  1.0  1461  56.7 -18.6
07-22-2018 03:58:47 ISS                 47.6 45.9 -1.0   550  57.2 -18.0
07-22-2018 04:01:56 ISS                123.0 10.1  1.1  1452  57.6 -17.4

07-22-2018 18:51:47 ISS                228.0 10.1  1.4  1442 293.2  -2.0
07-22-2018 18:55:00 ISS                312.0 65.4 -1.3   440 293.5  -2.7
07-22-2018 18:58:14 ISS                 34.2 10.0  1.2  1455 293.8  -3.4

07-23-2018 03:03:19 ISS                354.1 10.1  ecl  1458  48.4 -28.2
07-23-2018 03:05:49 ISS                 44.1 20.0  0.2*  999  48.9 -27.8
07-23-2018 03:08:19 ISS                 94.2 10.1  1.0  1456  49.3 -27.4

07-23-2018 04:39:45 ISS                280.9 10.1  1.0  1457  62.7 -10.0
07-23-2018 04:42:06 ISS                234.7 18.4  0.3  1051  62.9  -9.5
07-23-2018 04:44:28 ISS                188.1 10.0  1.1  1455  63.2  -9.0

07-23-2018 17:59:03 ISS                201.1 10.0  1.5  1443 287.9   9.3
07-23-2018 18:02:09 ISS                127.6 43.1 -0.6   570 288.2   8.6
07-23-2018 18:05:15 ISS                 54.9 10.1  1.3  1449 288.5   8.0

07-24-2018 03:46:10 ISS                306.5 10.1  ecl  1457  55.7 -20.6
07-24-2018 03:49:19 ISS                232.0 46.2  ecl   546  56.1 -20.0
07-24-2018 03:52:28 ISS                157.1 10.0  ecl  1454  56.6 -19.4

07-24-2018 17:07:08 ISS                169.0 10.1  1.6  1442 283.3  20.6
```

07-24-2018 17:09:22 ISS	125.1	17.3	0.9	1085	283.5	20.1
07-24-2018 17:11:36 ISS	81.4	10.0	1.5	1449	283.7	19.6
07-24-2018 18:43:05 ISS	264.0	10.0	1.5	1449	291.9	0.2
07-24-2018 18:45:38 ISS	315.8	20.7	0.6	967	292.2	-0.9
07-24-2018 18:48:10 ISS	7.2	10.1	1.3	1450	292.4	-1.4
07-25-2018 02:53:13 ISS	327.0	10.1	ecl	1458	46.9	-30.2
07-25-2018 02:56:27 ISS	48.1	61.3	ecl	458	47.5	-29.7
07-25-2018 02:59:41 ISS	130.4	10.0	ecl	1454	48.1	-29.1
07-25-2018 17:49:30 ISS	235.4	10.0	1.7	1446	286.7	11.2
07-25-2018 17:52:39 ISS	311.6	48.7	-0.6	523	286.9	10.5
07-25-2018 17:55:49 ISS	28.6	10.1	1.5	1450	287.2	9.9
07-26-2018 02:00:44 ISS	347.5	10.0	ecl	1461	35.6	-38.3
07-26-2018 02:03:30 ISS	45.2	24.6	ecl	866	36.2	-37.9
07-26-2018 02:06:15 ISS	102.8	10.1	ecl	1454	36.9	-37.6
07-26-2018 03:37:49 ISS	271.0	10.0	ecl	1459	54.8	-22.4
07-26-2018 03:39:43 ISS	235.3	14.5	ecl	1211	55.1	-22.1
07-26-2018 03:41:36 ISS	199.8	10.1	ecl	1452	55.4	-21.7

Table 4: AZ, El Calculation and time prediction (ISS)- Orbitron Satellite Tracking Software

7.3.5 Rotor Connection and Tracking (BangabandhuSat-1):

After that we connect the rotor. If we track the satellite in automatic mood then the azimuth, Elevation of the rotor, uplink, downlink and downlink mood is filled up automatically. The software calculate the uplink and downlink with Doppler Effect. So we do not need to change the frequency. Here we track down the BANGABANDHUSAT-1 , Bangladesh first communication satellite.

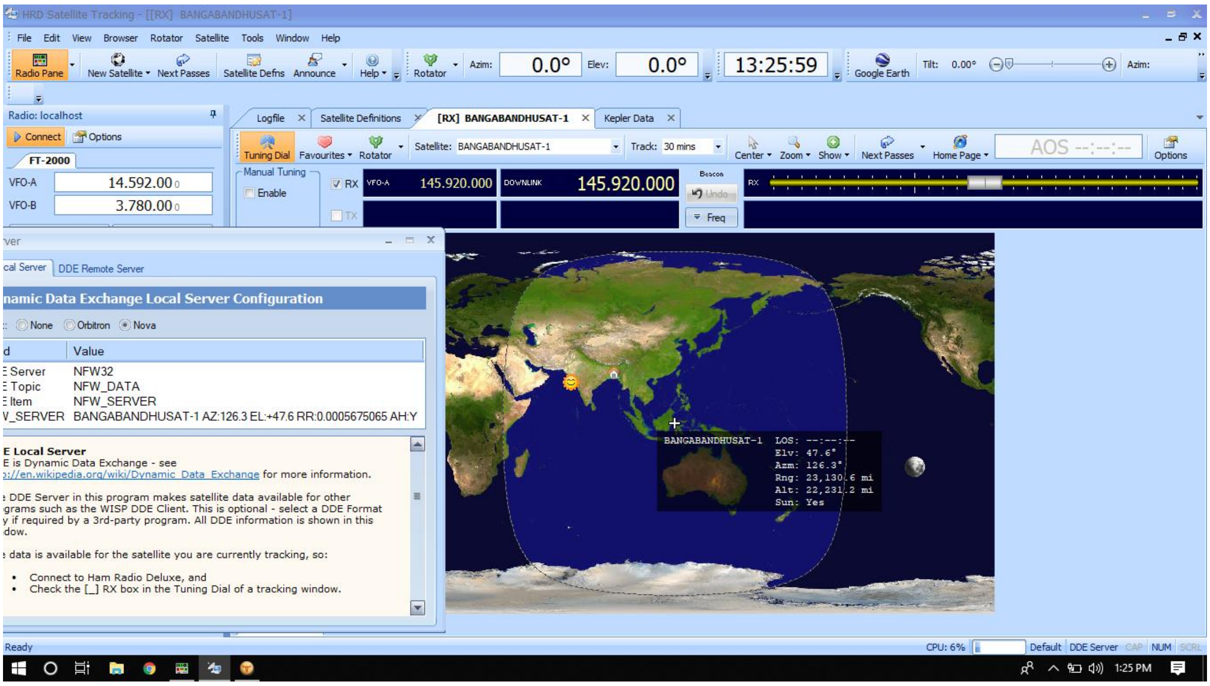


Figure 36: BangabandhuSat-1 tracking- HRD Satellite Tracking Software

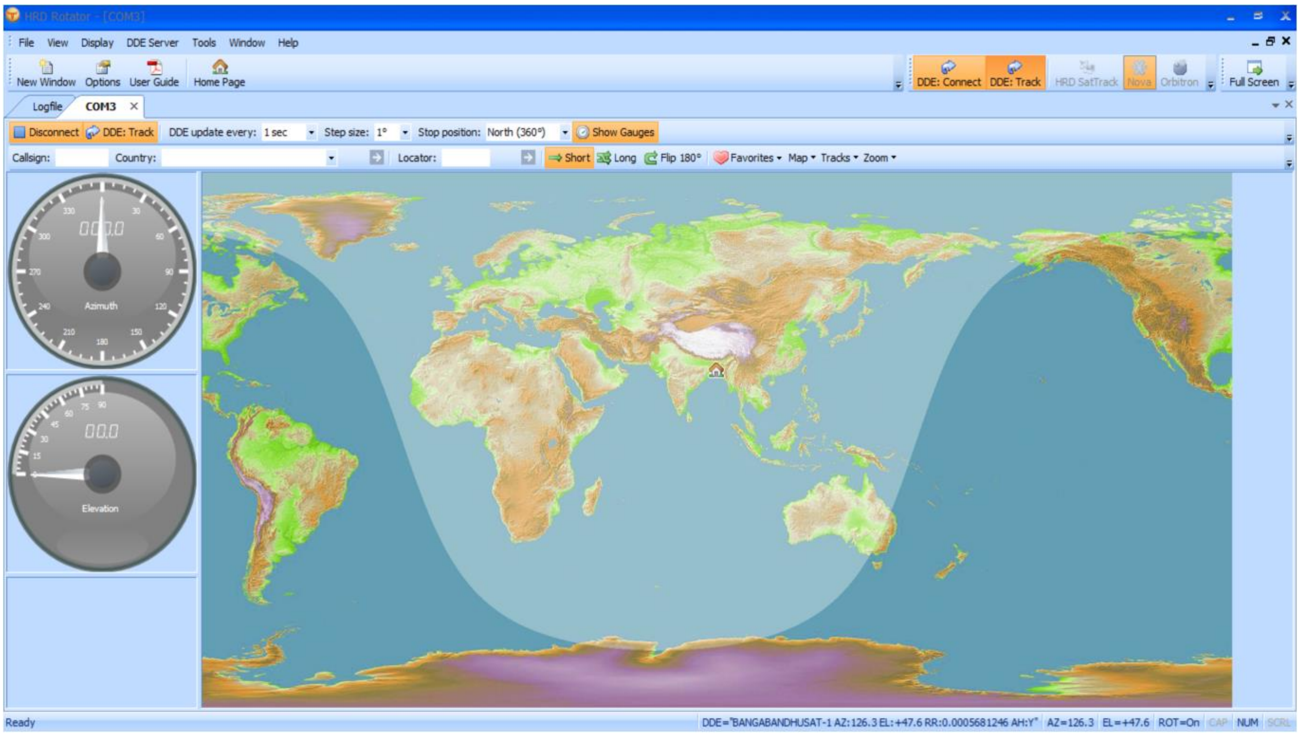


Figure 37: Rotor connection, BangabandhuSat-1 tracking- HRD Rotator Software

7.4 Data Receiving and Transmitting:

7.4.1 Antenna:

After getting our accurate Azimuth and Elevation position we can download and transmit data by connecting proper antenna. The characteristic of an antenna is specific for a satellite.

Like For BRAC Onnesh Cube Sat we connect VHF antenna which used VHF band (30 to 300 MHz).

1. Gain 14.39 dB
2. Beam width 38°
3. Folded Dipole Feed
4. Cross polarization

One other side of the rotator used M2 436-CP42UG Antenna for downlink. Which is

1. 18.9 dB Gain
2. 21° circular beam width
3. Folded Dipole Feed
4. Cross polarization

7.4.2 Radio Device:

The transceiver is a radio device can receive radio frequency. Like IC-9100 Transceiver, Which can communicate in HF, VHF, UHF frequency. Again KENWOOD TH-F6 Tri-bender Handheld radio is FM, AM, SSB, CW received capable.

8 Summary

8.1 Conclusion

Satellite tracking systems are used for various purposes from public uses to scientific research. In Today's World, Global positioning system may make work easier and much more convenient. Technology relating to satellites has come on very high position over the past few years and it really is incredible what it is possible to do these days. The designed customized rotator system in order to support the antenna pointing process satisfies the requirements. The average azimuth speed is 7.3 degree per second. The average elevation speed has 7.7 degree per second. The system also has been tested with some loaded-unloaded schemes to clarify the ability of rotator system. The load-tests show that on the average load for azimuth movement needs 58.8 Watts supply; and load for the elevation movement needs 198 Watts supply. We tracked BangabandhuSat-1 and the International Space Station through our designed Rotator. The predicted angle by satellite tracking software and the resulted angle by designed rotor is nearly same. The error in azimuth angle is +-3% and the error in elevation is +-2.5%. Furthermore, the availability of the Nano satellite or cube satellite technology is gradually taking greater importance in developing country like Bangladesh, Srilanka, Bhutan etc SARC oriented country. As designed is focused on low cost both space emerging countries and non-space countries can install numerous number of data sending and distribution centre which will ensure the sufficient number of field data and decrease the error.

8.2 Future work

8.2.1 Weather Proof

The future work for this project is making weather proof. Need to design a cover to protect the whole rotator system from rough weather. It need to be water proof and temperature

8.2.2 Automatic Data Collection from Remote Area

The ground water resource monitoring sensors will measure water quality data. Water quality monitoring sensor will be low cost and weather proof. The sensor will send the data like water level, acidity, clarity, temperature and oxygen etc, through automated station which will send the data through satellite. The satellite can be low cost LEO satellite or the geostationary satellite. To send the data through different satellite from one station we need to track the satellite. The designed low cost tracking system can be used to track and send the data through satellite. Then the satellite will store & forward the data to the ground station. By using the designed tracking system, lots of data sending station can be implemented in remote area. It will increase the mass data and increase the accuracy. [39]

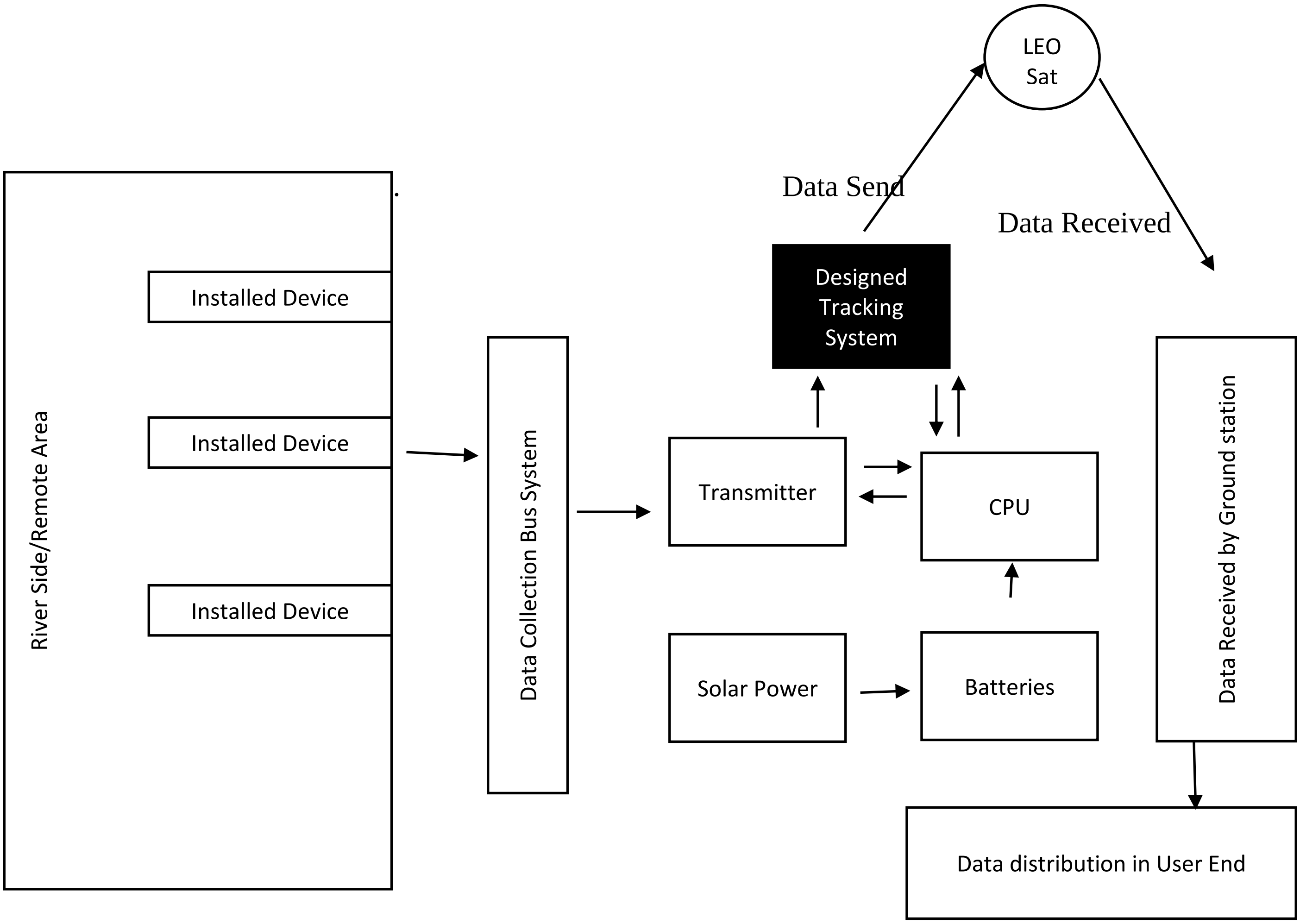


Figure 38: Concept block diagram of using designed tracking system in automatic data collection project from remote area **[39]**

8.2.3 Amateur radio emergency radio communication after disaster:

Amateur Radio is popularly known as "Ham Radio". Amateur radio operators use two way radio stations and communicate with others similarly authorized user. There are various modes of communication like voice, Morse code etc. After disaster when all communication is become off amateur radio communication is the only way to communicate with others and seeking help. This rotator system can be used to track down a specific point and communicate for Aid. By this designed system the overall cost will decrease. So, more deserter-centre will be able to use the facility.

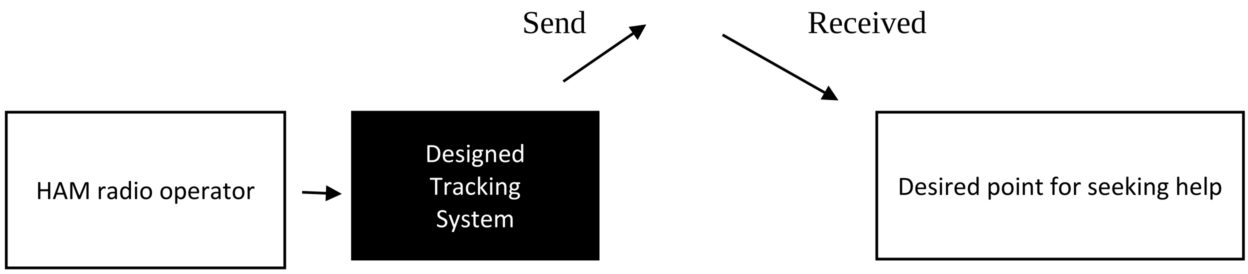


Figure 39: Amateur radio emergency radio communication after disaster

9 References

[1] Pelton J. N. Satellite Communications. New York, Ny: Springer, (2012).

[2] A Close Up Of Doppler Shift Webpage, Available Online Http://Www.Qsl.Net/Vk3jed/Doppler.Html. (June 2012).

[3] Dr. G. C. Weffenbach. Satellite-Tracking and Earth Station. (1974, July 1). Progress Report No.31.Washington, National Aeronautics and Space Administration.

[4] Sebastian Stoff, "Orbitron - Satellite Tracking System", Http://Www.Stoff.Pl/

[5] Retrieved July 15, 2017, From Http://Www.Rtl-Sdr.Com/Simple-Noaameteor-Weather-Satellite-Antenna-137-Mhz-V-Dipole/ (2017).

[6] M. Richharia, Mobile Satellite Communication: Principles and Trends, Pearson Education.

[7] Satellite Communications Dennis Roddy 3rd Edition, Mc-Graw Hill Publication.

[8] Jansson, Dick. "Spacecraft Technology Trends in the Amateur Satellite Service." (1987).

[9] Oscar (Orbiting Satellite Carrying Amateur Radio) From Wikipedia, Item 2.2 Doppler Shift Formula Available Online: Https://En.Wikipedia.Org/Wiki/Oscar

[10] Pra'tt, T.: 'High Efficiency Feeds With Tracking Capability'. IEEE Conference on Earth Station Technology, 1970, Pp. 250- 256.

[11] Chivers, M., and Brain, J.R.: 'A Simple Multimode Tracking System for Microwave Aerials'. Iee Conference Publication on Satellite Communication System Technology, 1975, Pp. 116-121.

[12] Inoue, T., and Kaitsuka, T.: 'K-Band Tracking System for Domestic Satellite Communication System', IEEE Trans., 1981, Ab17, Pp. 561-570.

[13] Raghavan, S.V., and Satyanarayana, T, 'Microprocessor-Based Digital Controller for Antenna Pointing Systems', IRTE (India), 1983, 29, Pp.-57-61.

[14] Dang, R., Watson, B.K., Davis, I., and Edwards, D.J.:'Electronic Tracking Systems for Satellite Ground Stations'. 15th European Microwave Conference, Paris, France, September 1985.

[15] Huele, H.T.: 'An Earth Station for Weather Satellites', Philips Telecom. Rev. September 1981, 39, Pp. 118-129.

[16] Richharia, M.: 'An Optimal Strategy for Tracking of Geostationary Satellites', Jiete (India), 1984, 30, Pp. 103-108.

[17] Ohashi, H., Iguchi, And Hashimoto, Y.: 'A Geostationary Satellite Tracking System for Small-Sized Earth Stations', Reo. Radiores. Lab. (Japan), December 1983, 29, (153), Pp. 527-538.

[18] 'Performance Evaluation of Leo Satellite Constellations with Inter-Satellite Links Under Self- Similar and Poisson Traffic' E. Papapetrou I. Gragopoulos F.-N. Pavlidou.

[19] Johnson, N. L. "History and Consequences of On-Orbit Break-Ups." Advances In Space Research 5.2 (1985): 11-19.

[20] Harries, G., And Heaviside, J.W.: 'Naval Satellite Communication Terminals'. IEEE Conference Proceedings on Satellite Systems for Mobile Communications and Surveillance, 1973, Pp. 48-51

[21] Skolnik, M.I.: 'Introduction to Radar Systems' (Mcgraw-Hill)

[22] E.E. Altshuler and D.S. Linden. "Design of a Loaded Monopole Having Hemispherica Coverage Using a Genetic Algorithm." Ieee Trans. On Antennas and Propagation, Vol. 45, No. 1, (January 1997).

[23] SpaceStack, Available on: Space.Stackexchange.com

[24] T. Pratt, C. Bostian, And J. Allnutt, "Satellite Communications 2nd Edition," Wiley Publications, (2003).

[25] Johnson, N. L. "History and Consequences of On-Orbit Breakups. "Advances in Space Research 5.2 (1985): 11-19.

[26] Jansson, Dick. "Spacecraft Technology Trends in the Amateur Satellite Service." (1987).

[27] Sarkissian, John M. "The Search for the Apollo 11 SSTV Tapes." (2006).

[28] Levit, Creon, and William Marshall. "Improved Orbit Predictions Using Two-Line Elements." Advances in Space Research 47, No. 7 (2011): 1107-1115.

[29] Sebastian Stoff, "Orbitron - Satellite Tracking System", Http://Www.Stoff.Pl/

[30] Dr. T.S. Kelso, "Norad Two-Line Element Sets Current Data", http://www.Celestrak.Com/Norad/Elements/

[31] Richard G. Desaulniers, Ve2dx, "Dual Azimuth Control Protocol", (June 18th 2011).

[32] Oscar (Orbiting Satellite Carrying Amateur Radio) From Wikipedia, the Free Encyclopaedia Item 2.2 Doppler Shift Formula Available Online: https://En.Wikipedia.Org/Wiki/Oscar/

[32] A Close Up Of Doppler Shift Webpage. Available Online Http://Www.Qsl.Net/Vk3jed/Doppler.Html, (June 2012)

[33] Recuenco, Alberto Martín. "Sseti Groundstation." Phd Diss., Master's Thesis, Supervised by M. Fischer and Al Scholtz, Tu Wien, Institut Für Nachrichtentechnik Und Hochfrequenztechnik, (2008):15-18.

[34] Rego, Pablo Vieira. "Integrating 8-Bit Avr Micro-Controllers in Ada." Ada User 33.4 (2012)Pp: 68-73.

[35] Kargov, A., Pylatiuk, C., Klosek, H., Oberle, R., Schulz, S., & Bretthauer, G. (2006, September).

[36] Rama Setya. Hero. Agus D. Prasetyo, Budi Syihabuddin . "Automated Ground Station with Customized Rotator for Antenna Pointing Using Compass Sensor". (2014). IEEE International Conference on Electrical Engineering And Computer Science.

[37] Celestrak, available online https://www.celestrak.com/Norad/Elements/Noaa.txt

[38] Movable-type, Available online https://www.movableType.Co.Uk/Scripts/Latlong.html

[39] Ayumu Tokaji, Ashraf Nabil Rashwan, Innovative Ideas for Micro/Nano –Satellites, "Utilizing Nano Satellite for water monitoring for Nile River" (2013)

[40] Arafat H. and Jamil A., "Establishment of 'BRAC onnesha' nano sattelite ground station and comparitive analysis of different types of antenna as a portable low earth orbit satellite ground station receiving antenna" Supervised by Dr. Md Khalilur R. and Co-Supervised by Dr. Md. Hasanuzzaman S., BRAC University, 2017.

10 Additional images

Picture1: Designed Satellite Tracking System

Picture 2: Azimuth and Elevation Rotator

Picture 3: New designed satellite tracking system (Right) and BRAC Onnesha Ground Station Satellite Tracking system (Left)

Picture 4: Team Member-(from left) Md. Monjurul Islam, Md. Mojammel Haque, Dr. Md Hasanuzzaman Sagor PhD, Md. Mahbubul Alam and Ahmad Tamim Mansoor