IJARST

International Journal of Advanced Research in Science and Technology

https://doi.org/10.62226/ijarst20252562

ISSN 2319 – 1783 (Print)

ISSN 2320 – 1126 (Online)

Proposal for the Fabrication of an Indigenous 1000mm Achromatic Optical Telescope with Automated Drive system for Speed and Position Control

Obi nnamdi J[1], Omeje nnaemeka F[2], Obetta nnamdi T[3], Eze Ifedilichukwu A[4], Okonkwo Okechukwu H[5], Oyibo Muazu O[6].

National space research officer, Center for Basic Space Science and Astronomy (CBSSA) Nsukka Enugu State-National space research and development Agency Nigeria[1,2,3,4,5,6].

ARTICLEINFO

Article history:

Received	17 Jun 2025
Accepted	25 Jun 2025
Available online	02 Jul 2025

Keywords:
Achromatic doublets,
Keplerian arrangement,
servo mechanism,
drive system and control,
Calibration.

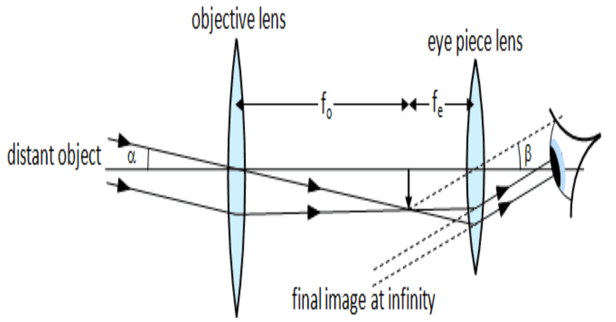
ABSTRACT

The optical telescope is an observational equipment that gathers and focuses light from the visible portion of the electromagnetic spectrum to form a magnified image of a celestial or astronomical object. They are specially used for observing, studying, and analyzing radiations from the visible part of the spectrum by astronomers. The magnified image created can be used for a direct visual inspection either to make a photograph or to collect data via electronic image sensors. Our proposed project entails the Keplerian arrangements in which refracting dioptrics are utilized with recommended specification and arrangement to arrive at a celestial object image formation. The proposed project will come with an orientation and configuration to correct image inversion, aberration of any category and poor image orientation. We can achieve the above by incorporating achromatic doublets and optical relays in our design architecture and specification. The Keplerian design methodology was recommended by our team because refractors produce high quality images and also provides room for aberration correction of any classification. .Refractors known for producing sharp high contrast images with very minimal colour distortion makes them useful for observing planets and other celestial objects .Generally the idea is to come up with a competent refracting telescope with achromatic doublet and an indigenous automated drive system for speed and position control of the observational equipment in order to overcome the difficulties experienced when adjusting the system manually. Any other form of equipment displacement due to natural resources can also be resolved with an indigenous drive system and control mechanism. Active and passive electronic components will be interfaced with the drive system circuitry which will be controlled via a standard programmable micro controller board. In our demonstrative or prototype model the programmable micro controller board is interfaced with the required expansion or daughter board and necessary codes written using the suitable programming language and uploaded to the programmable board, this we intend doing during the process of our real or actual model system development for accurate and precise telescope displacement in azimuth and elevation. An LCD 16 * 2(HITACHI HD 44780 driver compatible) will be used as our display module.

1.1NTRODUCTION

The telescope is more of a discovery of optical craftsman than an invention of a scientist. The lens and the properties of reflecting and refracting light had been known for the since antiquity and theory on how they work was developed by ancient Greek philosophers preserved and later still expanded further in the medieval Islamic world and had reached a significantly advanced state by the time of the telescope invention in early modern Europe.

Telescope can be defined e.g. king, 1955, smith and Thompson as an instrument that increases the angular separation of a range of Plano waves and improves on the limit of the eyes resolution. From our perception, a telescope is an instrument used to view distant objects clearly and usually magnified by collecting electromagnetic radiations.



(Where angle a (alpha (a) represents the angle subtended by the object at the unaided eye, while the angle beta (b) represents the angle subtended by the final image at the eye)

FIG 1 SIMPLIFIED SCHEMATIC DIAGRAM OF A REFRACTING TELESCOPE

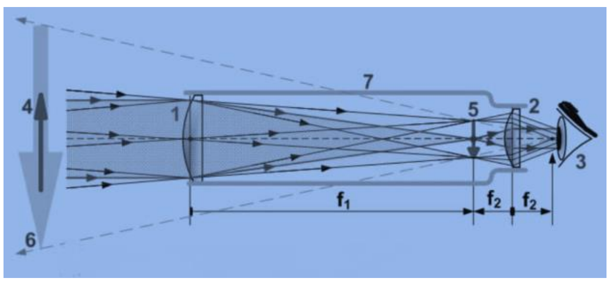


FIG 2 DETAILLED RAY DIAGRAMMATIC REPRESENTATION OF THE KEPLERIAN ARRANGEMENT

(Where F=Focus, F1=Focus 1, F2=Focus 2, 1=Objective lens, 2= eye piece, 3=Observer's Eye, 4= Distant 5=Focus, 6=Magnified virtual image 7=optical telescope tube).

The final image formed is an inverted image and usually corrected by using optical relays placed at the appropriate optical path to correct the image orientation. To further emphasize on the above mentioned points on this proposal, we'll like to present a more elaborate or more detailed schematic illustration of the ray diagram of the refracting (keplerian telescope)

Below is a more elaborate ray diagrammatic representation of the refracting (keplerian) arrangement. It consists of the basic necessary achromatic optics required for an optical telescope fabrication. In the diagram below, the colours represents the field angle and not the spectral hue as indicated in the diagram.

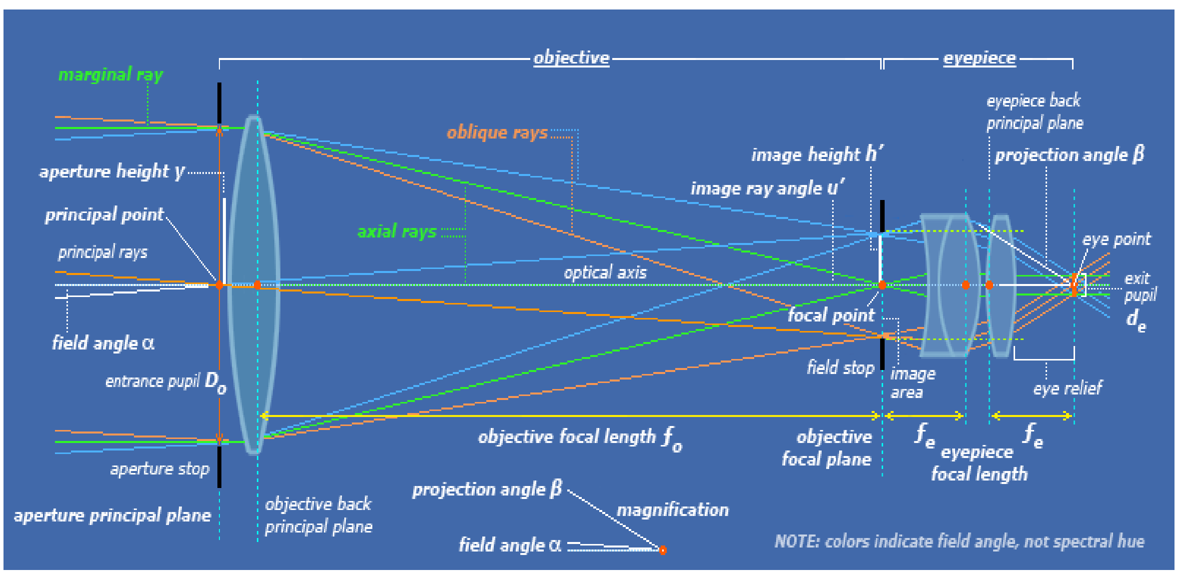


FIG 2B AN INDEPTH RAY SCHEMATIC ILLUSTRATION OF THE KEPLERIAN SET UP.

The 20th century witnessed the technological advancement and expansion of the telescope to view and analyze radiation from the various portion of the electromagnetic spectrum with different wavelength and frequencies like the infrared, radio, ultraviolet, and gamma rays portion of the spectrum.

Galileo telescope utilize convex objective lens and a concave eye lens, a design called the Galileo set up or arrangement. Johannes Kepler proposed an improvement design that used a convex eye piece called the Kepler telescope which was an improvement on the Galileo design.

A refracting telescope Keplerian arrangement is a type of optical that uses a lens and an objective to form an image, this telescope is also called a dioptrics telescope. A refractors magnification is gotten by dividing the focal length of the objective lens by the focal length of the eye piece.

This work proposal is based on the Keplerian design which provides a magnification with no aberration. The eye piece is an ocular lens which will result to an image with higher magnification

Achromatic doublets which corrected chromatic aberration in the Keplerian design were recommended for this proposal. We will demonstrate what we intend doing using a prototyping model using a low powered electronic peripherals with a micro controller unit.

The voltage/ current and power characteristics of these electronic requirements is carefully taken into consideration in order to balance the power requirement for the proposed observational telescope drive system

1.1 Prototype/demonstrative model description –
This basically involves simulation, calculation and required specification of optical and drive system requirement needed for the proposed observational optical telescope.

Basically, the design set up is the Keplerian arrangement or design and the prototyping or demonstrative drive and control mechanism is the a rotary potentiometer PPS potentiometric position sensor interfaced to a servo motor both operating at a voltage of 5 volts.

FIG 3 A STANDARD 5VOLTS TOWER PRO SERVO MOTOR.

FIG 4 A 10KILOHM 5VOLTS ROTARY POTENTIOMETER.

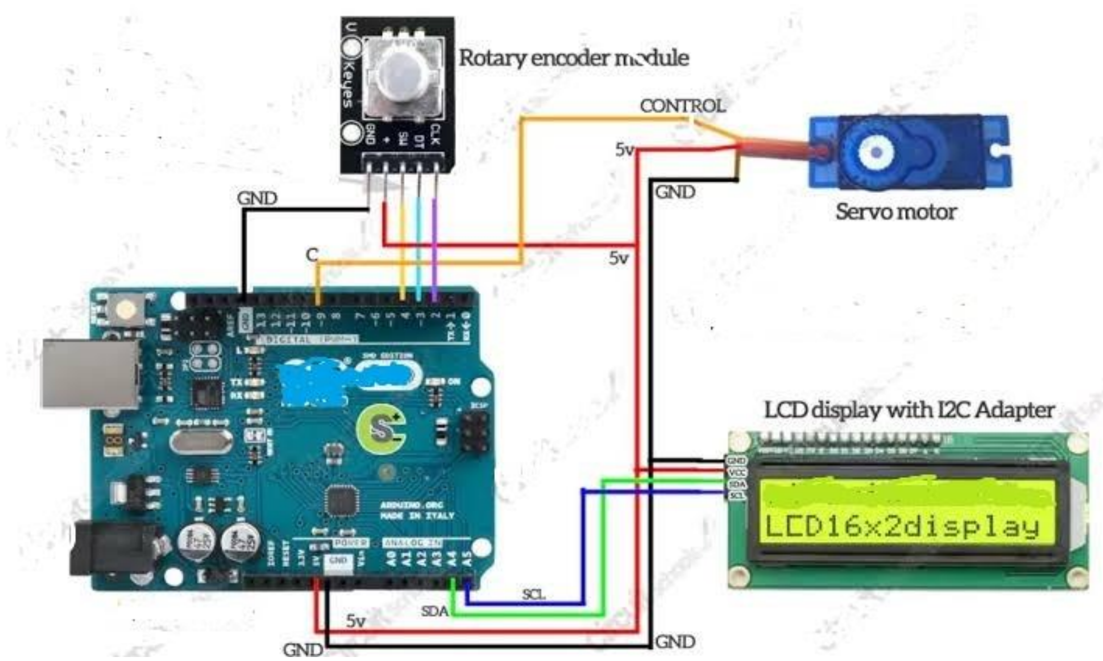


FIG 5 A SIMPLIFIED ILLUSTRATIVE SCHEMATIC DIAGRAM OF THE PROTOTYPE OR DEMONSTRATIVE MODEL.

A 16 * 2 (32 digit 7 segment display) LCD Module is also interfaced in the prototyping model circuitry to display the two servo motor displacement in terms of azimuth and elevation with accuracy and precision. Astronomical telescopes comes in various designs, each design for a specific observational needs or requirement. Our intended Keplerian involves refractors which includes the primary optical component (objective lens) and the eye piece.

Refractors offer significant advantage such as high image quality and little maintenance but may suffer aberration which can be further corrected by utilizing achromatic doublets.

We will be using the 3D optix cloud based simulation software to analyze our intended optical telescope development. Dioptrics and catoptrics telescope designs are able to be built and well analyzed using the convenient 3D Optix tools and templates.

We intend designing and evaluating a unique Kepler telescope (using the 3D Optix tools and templates) we will see how this can be achieved in an explicit manner. Our optical system will illustrate or demonstrate the Keplerian telescope arrangement or design consisting of the following components

1. Light source

-Plano wave

-Circular, 5mm radius

-wavelength, 633mm

-Power-1watt

-unpolarized

2. Thorlabs LA 1301, 1000MM FL Plano convex

3. ThorlabsLA 1131, 20MM FL Plano convex

4. Field stop, 12.7mm

5. Detector; Spot analysis

-spot; Incoherent irradiance

-Analysis rays; 1.2 million

-400 by 400 pixels

The 3D optix simulation software can be downloaded from official websites or from other tools or templates to view additional information about the optical system such as analysis detector and component spacing.

Some attributes of the Kepler telescope

- -longer system due to the two positive lenses
- -more heavier due to the presence of relays prisms and mirrors for inverted image correction
- -good magnification for astronomical viewing.

For positioning the lens and determining system performance, we can use the simple equation below

Lens separation D=F objective + Feye piece (F=Focal length)

System Magnification M=F system /Feye piece (F=Focal length)

From observation and the lens separation equation, we can deduct that the positive lens makes the length of the telescope longer than using a negative lens. Negative lenses are usually found in Galilean telescope but are typically for terrestrial viewing or observation.

Below are a few calculated parameters of the system. As we will proceed in the design more components will be added to complete the design. The system focal length is the path length from objective to the eye or camera. This will be shown further in our analysis.

Lens separation D=1000mm +20mm=1020mm

System magnification M=1000/20= 50

If we have our starting parameters just like we already had, we can proceed and analyze the on –axis collimated light.

We intend adding an extra detector of some mm behind the first detector. This will assist us to determine if the lenses are positioned so the collimation is achieved at the output of the eye piece lens. The lens will be positioned at the nominal placement and the spot size at each detector measured.

The 3D optix analysis platform have an important tool to measure spatial intensity patterns that is quick and easy to use .Depending on the geometry of our source either square or circular can be selected to get a true estimate of the dimension for the beam.

In the course of our demonstrative model we have to include all the component necessary for the Keplerian design we intend developing, We will also need to incorporate the image correcting relay for image inversion, focusing lens and a detector to analyze the system as a whole.

We will simulate a camera with a given focal length and a rectangular focal planetary of some mm to form the image. If we have the full system built with all the necessary components, our next task will be to verify if the image is upright using the mirror detector position.

Conclusively, we are going to modify the light source to output (RGB) red green and blue spectrum to observe the presence of aberration which can be chromatic in this explicit telescope design proposal.

Analysis will be made from the images of the individual wavelength; the spot sizes at the image plane should be of different diameters due to different refractive index for the three wavelengths. For this reason of chromatic aberration it's advisable we use achromatic doublets as our refractors.

When this project must have been completed, we will perform more analytical evaluation and optimization to develop the system further for optimal performance and efficacy.

1.2 Actual model system description

It basically involves the full implementation of the results of our calculation, simulation and specification obtained during our prototyping or demonstrative model design. Actual model description will entail some construction works and final development of our project. The optical telescope architecture and specification intends giving an image of magnification of 50. The basic design of a Keplerian system is considered. The refracting telescope consists of two dioptrics, the objective and the eye piece with each having a distinguishing focusing property

1.2.1 Testing running the lens to determine the focal length

The goal of this exercise is to determine the focusing property of these lenses. The focal length is easily determined by using the sun to establish where the light is brought to focus by the device. The lens is placed in the beam of sunlight and the beam is concentrated by the lens into the most intense point as shown above. Each of the lens is tested this way and the length from the center of the lens to the bright spot measured becomes the focal length of each instrument. This numbers are noted for future reference. Once the focal lengths of the lenses have been determined the device can be assembled for testing.

The magnification of the telescope can be determined by sighting through it at an object and estimating the gain in size when the object is viewed with the telescope and when it is viewed with naked eye. The estimate can be confirmed mathematically by taking the focal length of the eye piece and that of the objective. We divide the focal length of the objective to that of the eye piece to get our magnification.

Magnification = FL eyepiece/FL objective ***(FL=Focal length)***

1.2.2 Telescope drive system and control interface

The drive system and control that will result in rotational movement and linear movement of the proposed telescope will consist of two motors, one for azimuth and one for elevation motion. We will match the weight and size of the observational telescope to the current /voltage characteristics of the specific servo motor required to provide angular displacement to the equipment.

Depending on our design architecture the length of the optical telescope should be adjustable 1020mm.A plastic tube of this size is required and the weight of the entire observational telescope taken into consideration.

A Low powered motor that matches the drive requirement in Kilovolts Ampere or Volts Ampere (KVA/VA) or Watts/Kilowatts (W/KW) is also considered. The project will incorporate a potentiometric position sensor (PPS) or (RVDT) rotary variable differential transformer) which can be selected or custom made as per the telescope degree of rotation. The whole system will be calibrated with great precision as per the equipment movement or displacement in azimuth (left and right) and elevation (up and down) movement.

2. Literature review

C.I Onah, C.M Ogudo, design and construction of a refracting telescope. International journal of astrophysics and space science vol 2 no4;2014 pp.56-65.The above work was on the design and development of an Keplerian arrangement with design specification but there was no drive system to automatically control the movement or positioning of the observational equipment to any direction. The optical telescope was mechanically controlled.

Human or environmental factors can alter or vary the position of observational equipment resulting in altercation or adjustment of the observational equipment position. We will interface or incorporate an indigenous automated drive system for speed and position control.

Amrutha May A.S, Divyassue mv, jesnepreem, kayasree SM; Keesthana Vasu proposed a system microcontroller based wireless 3D Position position control for Antenna.

This system is based on android application, desired angles are keyed in and the antenna rotates to the specified direction. In our proposal we will utilize the rotary variable differential transformer (RVDT) mechanism which uses the potentiometric position sensing mechanism to operate. In this mechanism a potentiometer will be interfaced to a step servo motor of specific electrical rating that matches that of the potentiometer rating. The rotary potentiometer system will be used to drive our step servo motor via a programmable micro controller board. The angular displacement or position of our motor will displayed on a 16 *2 LCD 7 segment display module.

3 Proposed design methodology

The design methodology to be utilized in this project will be divided into 3 phases-the optical dioptrics requirement, the hardware requirement and the drive system and control requirement. The dioptrics to be used is the achromatic dioptrics for the eye piece and objective which have been already mentioned. The hardware requirement involves a light plastic tube, lens adapters, and prototyping facilities. The drive system and control requirements the software IDE, servo motors, Cables and rotary potentiometer.

3.1Definition of optical terminologies

3.1.1 Field of view (FOV)-The field of view is the portion of the sky visible to the eye piece. We measure (field of view) FOV in degrees or fractions of a degree. Basically astronomers or observers refer to the actual field visible in the eyepiece as the true field of view (TFOV).Knowing the true of view of our eyepiece is very important since we can then compare what we visualize in the eye piece to printed star charts which assists us in identifying what we are observing. Some objects require a wider field of view to show the entire object so we need to choose the eye piece that will let the observer take everything in. Extended objects like star clusters and some nearby galaxies are only visible in their entirety with a wider field of view. The field of view is analogous to the screen of a phone, laptop or a television. Calculation as regards field of view is done using a scope calculator when relevant information is provided or keyed in.

- **Eye piece field of view (EFOV)**-An eye piece of view is just the angular diameter expressed in degrees of the circle of light that can be seen by the eyes.
- **Apparent field of view (AFOV)**-Apparent field of view is usually obtainable from the manufacturers of the eye piece. Most eye piece has apparent field of view of 50degrees.The AFOV is calculated by multiplying the true field of view and the magnification.

The field of view is analogous or comparable to the phones television or laptop screen, when we change our eye piece we witness different magnification leading to a variation of total amount of sky we can see.

3.1.2 Focal length-The focal length is the distance between the optical center of the lens and the focal point of the lens. The focal length of an optical system is a measure of how strongly the system converges or diverges light. It is the inverse of the systems optical power.A system with a shorter focal length bends the ray more sharply bringing them to a focus in a shorter distance or in diverging them more quickly. In our proposed fabrication we will utilize a refracting lens with specific dimensions and arrangement to arrive at a magnified image based on our design specification

3.1.3 Magnification-It is simply referred to as enlarging the apparent size of an object. The Ratio of the focal length of the objective lens to that of the eye piece gives us the magnification of an optical telescope.

The magnification formula is given below;

M=Hi/Ho=Di//Do (where Hi and Di are image height and image distance and Di and Do are image and object distances.)

3.1.4 F-number (Focal number)-It is a measure of the light gathering ability of the optical system. It is calculated by dividing the system focal length by the diameter of the lens or aperture. It can also be referred to as the focal ratio or focal stop. The focal ratio or focal focal no is dimensionless and represented using a lower case f with a format F/N where where N is the F number This is referred to as the inverse of the lens diameter or aperture.

3.1.5 Resolving power/Resolution power (RP)-This is the ability of an optical system to form distinguishable images of objects separated by small angular distances. The smaller the angle between two double stars or details in a planet ,the greater the aperture needed to achieve higher resolution and be able to separate the objects. The separate resolution of two objects is often called minimum separate acuity. The formula for resolving power of an optical telescope is given by;

Resolving power= D/d = 122 / /((where ***/(=wavelength of the light radiation, D and d = diameter of the aperture or the distance between objects respectively. 122=k (it represents a constant, specifically the wavelength in nanometers (nm) of a particular spectral line in the hydrogen spectrum, the number122 is a coefficient that usually reflects the fundamental limits of resolution imposed by the wave nature of light and the diffraction of light passing through the aperture.).*** Basically there are two yardsticks for the evaluation of resolving power or capacity or resolution, they are;

- **The Rayleigh criterion**; This is derived from diffraction theory, Two objects can be observed as separate when the diffraction minimum of one object coincides with the diffraction minimum of the second object. We can also deduct that from the diffraction theory for Wavelength of 550 nanometers (that is maximum of human sensitivity).

  Resolving power in arc seconds =138/aperture in mm.(***where the number 138=k (specifically it is a constant used in spatial resolution and in Rayleigh criterion to calculate the minimum angular separation of two objects that can be distinguished, It is a numerical constant that arises due to aperture of the objective and the wavelength of light and aperture is the diameter of the objective)***
- **The Dawas criterion**; This is an experimental formula based on observation. Based on this Criteria you can also identify a star as a double star if it looks oval, the size of any disc affects the telescope resolving power. The higher the telescope resolution the smaller the airy disc appears in the telescope.

Resolving power doesn't have any S.I unit, this is because the resolving power is the ratio of a mean wavelength of a pair of spectral lines and the difference of wavelength between them, since the two quantities have the same unit, the resolving power has no unit.

Technically the resolving power or capacity is determined by the telescope, s aperture. at the larger the aperture the more resolution of closely separated objects.

The resolving capacity also called the minimum separable ability indicates how small the angular distance between 2 objects may be whilst still being recognizable as 2 objects. The angular distance is measured in arc seconds.

1arc second =1/3600 degrees

From experience, the result of resolving capacity is as follows; Resolving capacity in arc seconds =117/d (***Where d=diameter of the lens or mirror that collects rays of light.117=it is a constant and an empirical formula used in the Dawes criterion to estimate the resolving power of optical telescope) .***It is so important to note that this value is considered an estimate and subject to slight variation. The formula is an approximation and the value of the constant can vary depending on some specific condition and object being observed. Practically air turbulence is the most significant factor which usually limits the resolving power or Capacity to one arc second. Also the thermal behavior of the optical telescope is also a significant factor that continues to affect the resolving (resolution) capacity or power.

3.1.6 Aperture

An optical telescope aperture refers to the diameter of the lens or catoptrics. The optical telescope can collect light in a much bigger or wider dimension if its aperture or diameter is large or wider enough. The larger the light the telescope gather the finer the details of the image formed.

Aperture diameter D can be measured in inches, millimeter, centimeters or sometime in meters. The larger the aperture, the more light the system gathers and the final details it can see.

3.2 Design Architecture and Specification

Details of the requirement, design and specification for the proposed 1000mm optical is listed below;

- Objective lens –Achromatic dioptrics (doublets)
- Arrangement-Keplerian
- Closest Focus distant-250mm
- Objective lens focal length-1000mm
- Focal Ratio/Focal No-F/10
- Aperture gain-204
- Objective –eye piece distance-1020 mm
- Magnification power-50 times
- Eye piece field of view (EFOV) =60 degrees
- Apparent field of view (AFOV) =50 degrees
- True field of view (TFOV) =1degree
- Erecting system angle of inclination=45 degrees

Eye piece specification

- Lens-Achromatic doublet
- Focal length=20mm
- Maximum eye piece Focal length=70mm
- Closest Focus distance=250mm

3.3 Hardware requirement

These are the various accessories and peripherals needed to design and develop the proposed 1000mm observational telescope .Listed below are some of these accessories and peripherals.

3.3.1 3D printer

The 3D Printer technology is one of the paramount prototyping facility needed, it utilizes state of the art technology to support design and fabrication of research projects.

3.3.2 CNC MACHINE

These machines are capable of cutting and shaping metals, plastics and other materials. These machines are capable of completing complex machining jobs at very high speed and accuracy.

3.3.3 Plastic filament (polyethylene terephethalate glycol modified) PETG 3D Printer filament-It is a popular choice known for its durability strength and ease of use. It combine the advantage of both *(Polyactic acid)* ***PLS*** *and (Acrylon nitrile butadiene styrene)* ***ABS*** making it suitable for a wide range of 3D Printing applications.

Basic Features

- Filament Diameter- *1.75mm*
- Weight- *1kg*
- Material type -*polyethylene terephethalate glycol modified* ***(PETG)***
- Printing temperature -*(230-250) degree centigrade*
- Print speed - *Moderate print speed*
- Compatibility - *Compatible with most (Fused Deposit Modeling)* ***FDM****/(Fused Filament Fabrication)* ***FFF*** *3D Printers that supports (polyethylene terephethalate glycol modified)* ***PETG*** *Filament*

Technical specification

- Density-*1.27g/cm3*
- Tensile strength-*high tensile strength can withstand mechanical stress*
- Storage-*Store in a cool dry place away from sunlight*
- Flexural storage-*good resistance to bending and deformation*

Applications

- Engineering-*Application in engineering and manufacturing where strength and durability is required*
- Prototyping-*Suitable for producing durable prototypes and parts*
- Mechanical parts-*used for mechanical components like gears and brackets*
- House hold items-*used to print house hold items and containers due to its food safe property.*

3.3.4 Eye piece adapter-

This adapter enables hold a lens in position. It provides the needed reinforcement for an eye piece lens or the objective. We will devise the eye piece projection camera adapter which is a two port adapter. This adapter can also be used in conjunction with a small CCD camera when attached to the camera ST thread.

The eye piece projection unit should be about 1,25inches housing height of 2.25 inch and 1. 5 inches maximum outer diameter.

3.3.5 Cylindrical plastic tube

Plastic tubes which are polyvinyl chloride **(PVC)** are required to house the achromatic doublet, the image inverter lens and the lens adapter.

A 1025 mm plastic tube is needed. This can be constructed to and adjustable which will use the rack and pinion system. (A mechanical system).This is used to adjust the 2 lenses for a sharp image formation.

3.3.6 Focusing system

Basically we have two major types of focusers. The cry ford focuser and the rack and pinion focuser. The optical telescope tube should be adjustable to achieve a focus. The optical telescope tube should be adjustable to achieve a focus. The rack and pinion focusing is considered and recommended because the indigenous nature of our optical telescope fabrication. Our focuser (the movable tube) should be able to support or accept an eye piece or star diagonal.

The rack and pinion mechanism is a kind of linear actuator that comprises the gear (pinion) engaging the gear (rack).These mechanism actually involves two types of movement or motion, the rotational and the linear motion. A rack and pinion system can use helical gears or straight gears mechanism.

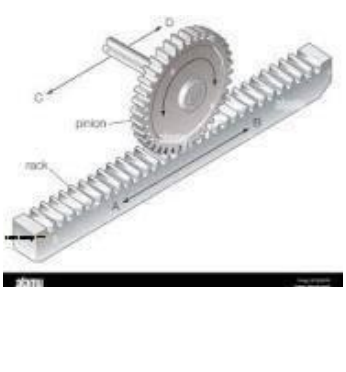


FIG 6 THE RACK AND PINION MECHANISM

We intend involving a dual speed focuser because it is preferable for looking at the moon and making astronomical and planetary observations where magnification and fine adjustment of focus is required.

Helical racks are less expensive but introduce much rotational torque, to avoid these challenge we will utilize the straight rack because it requires low driving force. The maximum force propagated on this mechanism depends on the twisting force on the pinion and its size and vice versa. The rotating force and size of the rack and pinion is taken into consideration after we must have taken records of the optical telescope specification in terms of size, length, weight and other dimensions and specifications.

From our detailed labeled diagram of our proposed observational telescope, we can the view the location of our rack and pinion focusing mechanism used to adjust the telescope tubes to align together when a sharp image is formed

3.3.7 Telescope mount system

The mount is what the observational telescope sits on. The mount allows us to rotate the telescope in azimuth and elevation in order to direct it to the object of observation. A good mount system is also very paramount when considering interfacing equipment for astro photography with the observational equipment. To achieve quality and sharp shots, an efficient motor driven mount is very much required. We have basically three different types of mount system, the altitude/azimuth mount system, the equatorial mount system and the dobosomian mount (comes with the telescope. The altitude /azimuth mount system rotates in the vertical and horizontal direction. This mount system is recommended for this proposal as it is very suitable for aspiring star observers and amateur astronomers. It is as well very easy to operate. The equatorial mount systems have more complex mechanical structure.

FIG 7 THE ENDORSED TELESCOPE MOUNT SYSTEM (THE ALTITUDE/AZIMUTH MOUNT)

The dibsomanian mount is usually for large telescopes and are special type of altitude/azimuth mount. Step servo motors will be incorporated to these mount system in order to rotate our proposed optical telescope to desired position. The drive and control system is designed in such a way that a potentiomeric position sensor(PPS) or a rotary potentiomer interfaced to a step servo motor determines the speed and displacement of the motor shafts. We will employ indigenous technology and improvise using the above rotary variable differential transformer (RVDT) technique because of availability and cost.

The equatorial mounting system is advantageous in the sense that it permits tracking of celestial objects by simple rotation about the polar axis which is fixed to a giving angle corresponding to the latitude at which the telescope is located.

Limit sensors and switches will also be interfaced in our design to limit the rotation of our motors, in that way our observational equipment will be controlled in azimuth and elevation to a chosen point.

3.3.8 Star diagonals-

Sometimes an astronomer finds it very difficult or uncomfortable to make observations using optical telescope. The viewing position sometimes creates problem at the lower or upper part of the neckaxis.The Star diagonal helps to resolve this issue. The diagonal can be a diagonal mirror or diagonal prism. The star diagonal (Catatoptrics) deflects the the light coming from the telescope in a perpendicular direction therefore allowing the viewer to observe and view celestial objects in a more comfortable manner without any stress.

3.3.9 Matt black paint

The above is used to limit internal reflection. The interior of the optical telescope is painted with matt black paint. Meanwhile they are inside surfaces of the draw tube and lens cell that require extra treatment because the matt black paint is reflective when the surface is viewed at a glancing angle. A commendable idea is to machine a thread on such interior surface then paint them black. The thread usually gives the surface a zig zag nature which is almost non reflective completely.

3.4 Software requirement and operating condition

The software required for our micro controller board is the Arduino Integrated development environment (IDE).A programme for Arduino software can be written in any programmable language with compilers that compilees and produce binary Machine code for the biggest processors.

The Arduino integrated development environment (IDE) includes a code editor with feature such as cutting and pasting, searching and replacing of text, syntax highlighting and automatic indenting. There is also the presence of one click mechanism to compile and upload programme to the micro controller board.

The Arduino Integrated development environment (IDE) includes a software library for the hardware wiring interface which provides some input and output procedures. In the course of our demonstrative prototype model, the servo motor, the LCD, and potentiometer library was interfaced in our programmable code in order to drive the above mentioned peripherals/accessories with degree of accuracy and precision. The codes were carefully and meticulously written to drive the telescope to any desired position with great accuracy and precision.

The micro controller boards are commercially available from the official website via various authorized distributors or channels.

3.5 Dioptrics requirement

These are the lens and its specification needed for the design of the refracting telescope. The design arrangement is the Keplerian as already mentioned and the lens required is the achromatic doublet in order to correct aberration

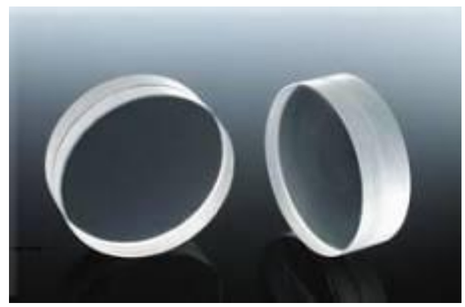


FIG 8 ACHROMATIC DOUBLET

3.5.1 Achromatic doublets- objective lens

The most common type of the achromat is the achromatic doublet which composes of two individual lenses fabricated from glasses with different amount of dispersion. Basically one element is a negative (concave) element made of flint glasses which has a higher dispersion and the other is a positive (convex) element made of crown glass which has a lower dispersion.

3.5.2 Achromatic doublet- eye piece

The only difference is the doublet used for the eye piece is the dimension and specification. We will require a dioptrics of different focal lengrth, aperture and other specification for the eye piece.

Below is the required eye piece specification

Eye piece specification

- Dioptrics-Achromatic doublet
- Focal length-20mm
- Maximum eye piece focal length-70mm
- Closest focus distance-25mm

3.5.3 Optical relays for upright image formation-There are many common ways to correct inverted image inversion in a refracted telescope. They include utilizing erecting prism which can be inserted in the optical path of the telescope to correct image orientation. We can also utilize the software correction method if we are dealing on digital computerized telescopes. We consider using a diagonal mirror prism or even dioptrics to alter our image orientation.

The diagonal mirror is a mirror that reflects light at 90degrees.By placing these dioptrics or catoptrics in the optical path of the telescope, the image is usually reflected and corrected so that it appears upright when viewed through the eye piece.

Some telescopes usually come with eye piece that have in-built correctors to ensure the final image is not inverted but comes upright. These correctors can be in form of lenses, mirrors or prism that are integrated into the eye piece design for image orientation or adjustment.

In our proposed Keplerian arrangement we shall mechanically insert our inverting or erecting catoptrics at the approroraiate optical path of the proposed telescope to finally arrive at an upright image.

4. Drive system requirement, operation mechanism and calibration

Before we elaborate on our intended drive system for the project, we will specifically highlight on the term Servo mechanism.

In control engineering, the term servo mechanism refers to an automatic device that uses error sensing negative feedback to correct actions of a mechanism. They usually include, built –in encoders, position sensors) or position feedback mechanism to ensure the output is achieving the desired effect. Apart from servos, we have other position feedback mechanism. Position control servos can be pneumatic, electric or hydraulic. In this work we will utilize the electric position control servos for the speed and position control of our proposed telescope.

A servo motor is a rotary or linear actuator that allows for precise control of angular or linear positioning, veleocity and acceleration. Servo motors are closed loop servo mechanism that uses position feed back to control its motion and final position.

The specification for our real model drive system design was achieved via simulation .and calculations after obtaining the weight of our load which is the observational equipment (optical telescope).

Drive system are electrical system that creates or causes displacement in actuators or motors. Our system will consist of two actuators or motors for azimuth and elevation speed and directional control. The whole set up will consist of step servo motors, potentiomeric position sensor (PPS)/Rotary potentiometer, a programmable micro controller board and a display module **(Hitachi HD 44780**) compatible.

The micro controller are pre programmed with a boot loader that simplifies the loading of a programme to the on –chip flash memory. A quality and well engineered drive system and control mechanism can as well be used for accurate tracking of celestial objects. We will be using very precise step servo motors and a micro controller for speed and direction control.

Below is a detailed drive system mode of operation and mechanism of control. The hardware requirements and accessories needed for the execution of this very project are highlighted and discussed below.

4.1 Standard programmable micro –controller board - The micro controller are pre programmed with a boot loader that simplifies the loading of a programme to the on –chip flash memory. Our system can be programmed and instructed with languages and interfaced with control mechanism that can be utilized for accurate tracking of astronomical objects. We will use precise step servo motors and a micro controller for speed and direction control.

FIG 9 A MICRO CONTROLLER UNIT (ATMEGA 328p) DUAL IN-LINE PACKAGE (DIL) VERSION WITH 28 PINS

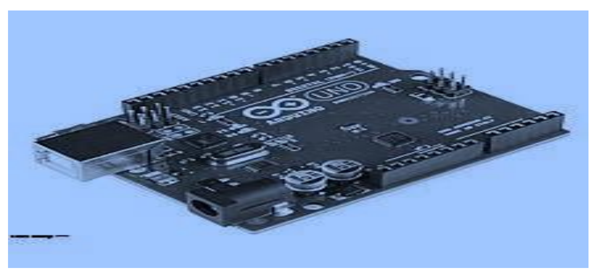


FIG 10 A STANDARD MICRO CONTROLLER (PROGRAMMABLE) BOARD

Most Arduino compatibles and Arduino derived boards also exists. Some are functionally equivalent to an Arduino and can be used interchangeably. The Arduino software codes are used to write programmers to the micro controller unit. The drive system drives and controls the speed of the observational equipment. The dish positioning is controlled by the drive system mechanism.The system will consists of two actuators or servo motors, poetiometric position sensor (PPS) or rotary variable deferential transformer (RVDT), the micro controller and the display module.

The microcontroller board to be incorporated is the well known and powerful Arduino micro controller. The version of the Arduino to be utilized is the Arduino uno micro controller board. During the course of our prototyping or demonstrative model, we used the Arduino micro controller board to demonstrate what we intend doing when we design and develop the real or actual model. Arduino micro controller board design uses a variety of micro processors and controllers. The board are equipped with sets of digital and analog I/O(Input and output pins) pins that can be interfaced to various daughter or expansion boards.

The micro controller unit is the atmega 328p.It shares the same data sheet with micro controller board been used. The board has various features and is 12C Compatible. Some of the electrical features of the micro controller board are listed below.

- Operating voltage-5 -12 volts
- Maximum no of pins-28pins
- Pulse width modulation pins-(PWM)-6
- Type-dual in line package (DIL) VERSION

Programmable memory-328 kb

4.2 A 16 * 2(Hitachi compatible) 7 segment display LCD Module. This is a display unit that comes in various versions. We will utilize the above version for the project. The above is a display unit and should be compatible with the hibachi HD 44780 LCD controller. The Hitachi **HD 44780** LCD Controller is limited to monochrome text display and some of these LCD Modules comes with a backlight which can be LED or fluorescent.

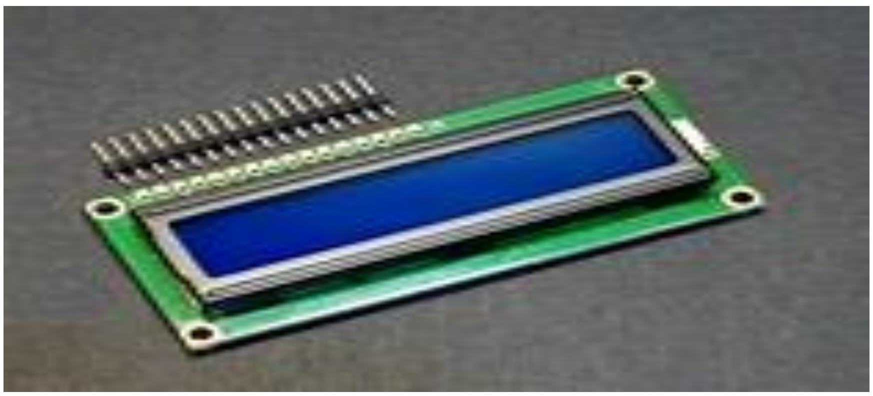


FIG 11 16* 2 LCD 7 Segment DisplayMODULE (HITACHI HD 44780 Compatible) WITH 16 INTERFACE PINS

The Hitachi **HD 44780** micro controller is an alphanumeric dot matrix LCD Controller or driver that comes in several standard configurations like the 16 * 2, 20*2, 20* 4 formats. We will be using the 16 by 2 LCD dip lay module. The 16 by 2 (32 digit 7 segment) interface pins are as follows;

- VSS-(Power pin ground)
- VCC-(Power pin, 5volts)
- Vee-(contrast adjustment)
- Rs-(Register select)
- R/W-(Read /write)
- E-(Clock enable)
- Dbo-data bit pin 1
- Db1-data bit pin 2
- Db2-data bit pin 3
- Db3-data bit pin 4
- Db4-data bit pin 5
- Db5-data pin 6
- Db6-data bit pin 7
- Db7-data bit pin 8
- LED+-backlight LED (positive)
- LED-back light LED (negative)

4.3 50 watts (10kilohm) rotary potentiometer at 12 volts

Rotary potentiometers or (pots) as commonly called by engineers and technicians are essential resistors that incorporate a mechanical adjustment mechanism enabling their resistance to change manually. Basic ally they resistance variation can be used to alter or vary volume or voltage levels in appliances.

Generally pots are usually used to alter values like brightness, contrasts, volumes and light levels in systems and devices. The ability of trim or rotary potentiometers to function as a sensor can make it possible to be used as a rotary encoder.

The above potentiometer at 12 voltage is required to drive our 2 servo motors to a desired position (left ,right) and(up ,down).The rotary potentiometer will serve as our potentiometric position sensor or rotary variable differential transformer(RVDT) which can be used for position control of our servo motors as mentioned earlier.

The entire system works on servo mechanism. (an automatic device that uses error sensing negative feedback to correct action of a mechanisms).

The micro controller will read the voltage on the middle pin of the potentiometer and adjust the servo motor position. We will use the (12V, 10Kilohm) rotary potentiometer to drive the 50 watts servo motor at 12volts.The rotary potentiometer drive system is recommended because of availability and affordability. The above-mentioned potentiometer is readily cheap and available and uses the resistive effect as its sensing principle. In the course of our real model design and development, we match our motor power (voltage current and resistance) characteristics with that of our load. However rotary encoders which are basically digital devices are more expensive and rarely available The basic reason for proposing the rotary potentiometer mechanism is to promote indigenous technology and research.

FIG 12 A 50W ROTARY POTENTIOMETER

4.3.1 General internal working of a rotary potentiometer

Rotary potentiometer uses angular movement from a rotary knob and shaft connected to a wiper element which slides across the resistive element. turning the shaft via the knob varies the resistance and the output of the whole mechanism. The rotary potentiometer servo mechanism involves interfacing a rotary potentiometer appropriately to a servo motor of compatible ratings while ensuring that current and voltage characteristics of the servo and potentiometer matches. The potentiometer can sense the position of the motor shaft by measuring the pulse that is applied to turn the motor until the potentiometer indicates that the position corresponds to the incoming pulse. This mechanism is applicable where precise movement and speed control is required.

Both potentiometer and rotary encoder sense the rotation of a shaft but they operate using difference principles and require different set up. However rotary encoders which are basically digital devices are more expensive and rarely available. One of the basic reasons for proposing the rotary potentiometer mechanism is to promote indigenous technology and research.

4.4 Standard step servo motor (50 w, 12V)

FIG 13 A 50W STEP SERVO MOTOR

A servo motor is a special type of motor that is integrates with a rotary encoder or a potentiometer to form a servo mechanism. A potentiometer can provide can provide a simple analog to indicate position .Our equipment movement control system will be based on the above technique or mechanism.

We will utilize a step servo motor as our actuator in this project to drive our equipment (observational telescope) to any position in terms of azimuth and elevation. The servo motor is often preferable because of the presence or integration of a balancing or negative feedback system or encoder which allows for a more precise control of positioning. Other forms of motors lack feedback mechanism example is the steppers and other forms of motors which can be AC or DC powered single or three phase, synchronous or asynchronous series or parallel wound and which can be universally powered with both AC and DC current. We also considered the bandwidth (ability of the servo to respond quickly to input commands) before recommending a step servo motor for the project.

Basically during prototyping, our 5volts tower pro servo motor was interfaced to a 5 volts 10kilohm rotary potentiometer with appropriate wiring or connection. Programmable codes were written based on our calibration and astronomical instrumentation and uploaded to a mico controller board. The whole set up were integrated together and results were achieved. The motors responding to our command inputs and positioned its shaft at a defined speed to the position or angle imputed.

The angular displacement or positions of our motors were displayed on a 16*2 LCD module.

4.4.1Ports introduction

PEND AND ALARM PORTS		
PORT	**SYMBOL**	**NAME**

1	PEND+	IN –POSITION SIGNAL OUTPUT+
2	PEND-	IN- POSITION SIGNAL OUTPUT -
3	ALM+	ALARM OUTPUT+
4	ALM-	ALARM OUTOPUT-
CONTROL SIGNAL INPUT PORTS		
PORT	**SYMBOL**	**NAME**
1	PLS+	PULSE SIGNAL +
2	PLS -	PULSE SIGNAL -
3	DIR+	DIRECTION SIGNAL +
4	DIR-	DIRECTION SIGNAL -
5	ENA+	ENABLE SIGNAL +
6	ENA-	ENABLE SIGNAL -
ENCODER PORTS		
PORTS	**SYMBOL**	**NAME**
1	EB+	ENCODER PHASE B+
2	EB-	ENCODER PHASE B-
3	EA+	ENCODER PHASE A+
4	EA-	ENCODER PHASE A-
5	VCC	INPUT POWER +
6	GND	INPUT POWER(GROUND)
POWER INTERFACE PORTS		
PORTS	**SYMBOL**	**NAME**
1	A+	PHASE A+(GREEN)
2	A-	PHASE A-(BLACK)
3	B+	PHASE B+(RED)
4	B-	PHASE B-(BLUE)
5	VCC	INPUT POWER+(AC 24V-70V),(DC 30V-100V)
6	GND	INPUT POWER-

FIG 14 PORTS INTRODUCTION

We can always consult the data sheet of the bholonath step servo motor for detailed information on specifications and connections of the terminals and ports.

4.4.2 Features

This hybrid stepper servo system integrates the servo mechanism technology into the digital stepper drive and also adopts an optical encoder with speed position feedback. It shares the advantage of both stepper and servo drive system or mechanism, the feature are highlighted below

- -High accuracy
- -Adjustable current control technology
- -High current efficiency
- -Little vibration (lesser vibration noise0
- -Improvement in smoothness
- -Over current over voltage and over position error protection
- -compatible with 1000- and 2500-lines encoder

4.4.3 Technical data /index

- Input voltage-24-70VAC/30-100VDC
- Output-6A20KHZ PWM
- Pulse frequency maximum-200khz
- Communication rate-56.7kbps
- Overall dimension (mm)-150*97.5*53
- Weight=580 gramme
- Operating temperature-70*(centigrade
- Storage temperature -–20*centigrade-centigrade-+65*centigrade
- Humidity—40 -90%RH
- Cooling method-Natural or forced air cooling
- Power input-BH-48vdc
- Encoder option-1000PPR/2500 PPR
- Cable length-3/5 meters
- Motor-Bipolar hybrid stepper motor
- Step angle-1.8 degrees
- Torque-2.1NM -1.6NM
- Operating temperature-(-10 degree centigrade-+70 degree centigrade)
- Weight-1.45 kg
- Insulation class-H
- RPM-0-2000
- Current per phase-2.8 Ampere
- Stock temperature-(-10degree centigrade -+40 degree centigrade)
- Shaft radial play-0.02 Maximum play (450G load)
- Shaft axial play-0.08 maximum play (450G load)
- Maximum axial forcr-15N (20mm from front flange)
- Maximum radial force-75N(20mm from front flange)

4.4.4 Torque VS Speed of rotation (RPM) Correlation with Servo motor

The step servo motor we are recommending is the bholonath step servo motor and they are closed loop stepping system high speed (7200 RPM) Stepper motors with encoders and drivers. Bholonath step servo motors are good substitutes to servo motors. They can range from (25 -1500 watts) and offers high speed performance with accurate feedback and stepping accuracy. Bholanath step servo motor gives better holding torque. The graph below is a torque/ RPM graph of bholonath step servo motor (400) watts and that of servo motor 400 watts

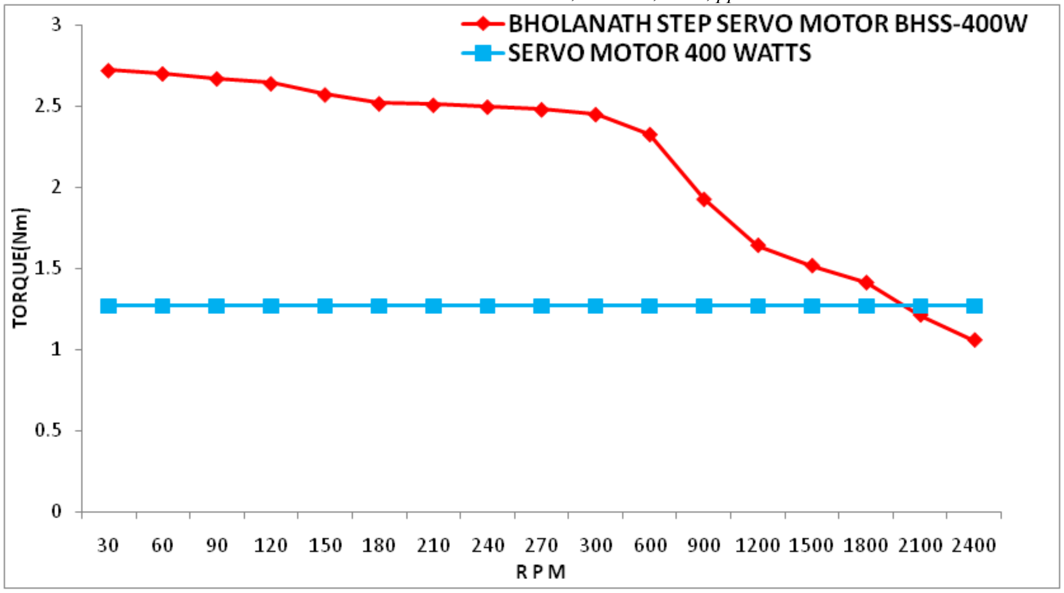


FIG 15 GRAPHICAL ILLUSTRATION OF TORQUE VS SPEED CHARACTERISTICS OF THE ENDORSED STEP SERVO MOTOR IN CORELATION WITH SERVO MOTOR OF 50 WATT AND 400WATT POWER RATINGS.

As we can see from the graph, the bholonath step servo motor torque equals to servo motor torque at 2000 RPM, so for application up to 2000 RPM bholonath step servo motor can easily be used.

At lesser RPM, like 1000 RPM, the bholonath step servo motor gives 50% more torque than servo offering much better performance and efficiency.

The step servo motors have an unpparrraled feature of current adjustment in terms of load adjustment which reduces heat generation thereby increasing efficiency. We can compare the 50 watts BHSS step servo motor to 50 watts servo motor output 2000 RPM .We consider using 50 watt step servo motor to drive our observational telescope because it is more efficient and accurate than other 50 watt servo motors.

The step servo motor BHSS 50 watts gives more torque at lower RPM therefore offering much better optimal performance than 50 watts servo motor s shown in the graph below

4.5 Calculations, Conversion and Calibration

Before we proceed to our calibration technique, we will be converting volts to mill volts because this shall be the basis of our instrumentation and calibration

(1 volt =1000 mill volts)

A rotary potentiometer of specific voltage and current characteristics will be matched with a motor of corresponding specific voltage and current characteristics.

Accessory requirements, voltage rating and angular displacement consideration for instrumentation and calibration.

- ***Prototyping (demonstrative) requirement and voltage rating (For instrumentation and calibration)***
  - 5 volts servo motor
  - 10kilohm 5v rotary potentiometer
  - Highest Angular displacement-90 degrees
  - Lowest Angular displacement-1 degree
  - Voltage range(0-5v)

- ***Actual (Real) model requirement and voltage rating (For instrumentation and calibration)***
  - 12v servo motor
  - 12v 50 watts rotary potentiometer
  - Highest Angular displacement-90 degrees
  - Lowest Angular displacement-1 degree
  - Voltage range(0-12v)

4.5.1 Prototype model calibration

In the course of our prototyping model, we utilized the 5v tower pro Servo motor and the 5v (10kilohm) Rotary potentiometer. The voltage rating of the servo the servo should correspond to the voltage rating of our rotary potentiometer or potentiometric position sensor (PPS), which will serve as our rotary variable differential transformer (RVDT). The rotation of the rotary rotary potentiometer of 5voltage corresponds to (0-5v) rating of the servo motor. Specifically for every each positive increment in angular displacement of servo shaft or for every 1 degree change in servo shaft displacement in the positive direction an output voltage ***of (5/90) volts or***

+0.055 volts or+ (55Millivolts) is sensed by the potentiometer.

Also this applies for every negative decrement in angular displacement of the servo, for every 1 degree change in servo shaft displacement in the negative direction an output voltage ***of – (5/90) or -0.055 volts or (-55 Millivolts)*** is sensed by the potentiometer.

4.5.2 Real model calibration

In our real or actual model calibration ,we will use a BHSS 12V step servo motor at 50 watts and a rotary potentiometer(potentiometric position sensor) PPS of rating 50 watts to create an angular displacement at the servos shaft .The displacement position and speed with accuracy and precision will depend on our programmable codes written on our micro controller unit which sends electronic signals to our potentiometer and motors for mechanical displacement or motion with a defined speed and positioning.

In our demonstrative or prototyping model for each change in angle of rotation, the output voltage changes by+ (5/90) or+ 0.05(mV) Millivolts or -5/90 or(-55Millivolts) .Also in the process of developing our real model, we will use a 12 volts servo so for each change in angle or degree of rotation in the positive direction, the output voltage will change by, or correspond to+ ***(12/90)/+ 0.133 (V) or+ 133 mill volts*** and the same applies to any degree servo shaft displacement in the negative or reverse direction, the voltage sensed by the potentiometer will correspond to ***-12/90 volts/-0.133 volts or -133 millivolts***.For 90 degrees change in angle of rotaton, the voltage variation is 12volts.

On a general note our programmable codes should be written, debugged, verified and uploaded in such a way that precision and accuracy is maintained for an accurate reading of the servo motor shaft displacement for each angular (degree) variation in shaft movement. In the course of the real system design methodology ***0.133 volts*** or ***133 MIllivolts*** should be considered the smallest voltage value for our calibration in terms of sensed output voltage. We can invariably alter the position of the motor rotor or shaft by rotating the knob of the rotary potentiometer at a defined position at variable speed, depending on our programmed codes written to the micro controller unit or board.

5. Detailed labeled diagrammatic presentation of the proposed observational 1000mm achromatic optical telescope

5.1Brief introduction

Below is the detailed labeled diagram of the proposed 1000mm achromatic optical telescope. It shows the in depth analysis of the design architecture and specification. The catoptrics, the dioptrics and the correction or inversion relays (for reinversion of the final inverted real image).The focusing system mechanism, the position of the lens adapter and other specific accessories or peripherals is clearly indicated with the intended location clearly identified. The diagrammatic illustration presents a clearer picture of what we intend fabricating indigeneously.It shows an explicit picture of our design procedure and methodology.

5.2 Labelled diagrammatic illustration of the proposed observational optical telescope

The diagram below illustrates in details the design architecture and requirements of the proposed observational optical telescope.

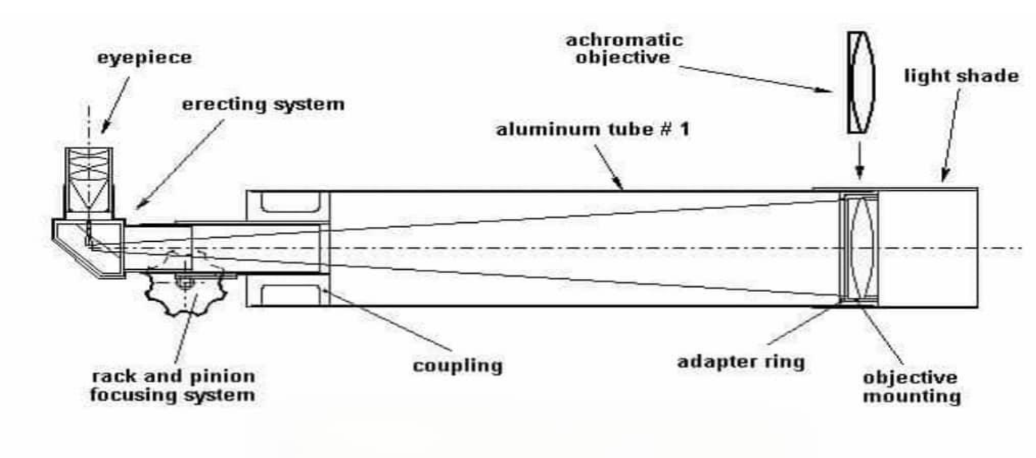


FIG 16 LABELLED DIAGRAMMATIC REPRESENTATION OF THE PROPOSED OPTICAL TELESCOPE

6. Limitation of the Keplerian arrangement and correction

Detailed below are some of the limitation of the Keplerian arrangement and how they are corrected. This limitation led to advancement in optics to correct these limitations.

6.1.1 Chromatic aberration

This is also called or referred to as chromatic distortion or color aberration. It is the failure of the lens to focus all colors at the same point. This occurs when the refractive index of the lens element varies with the wavelength of light. The refractive index of most transparent materials decrease with increasing wavelength. Since the focal length of a dioptrics depends on the refractive index any variation in refractive index affects focusing. Chromatic aberration is viewed as fringes of colors along boundaries that separates dark and bright parts of the image.

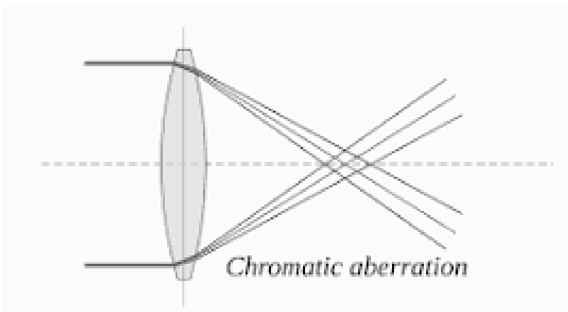


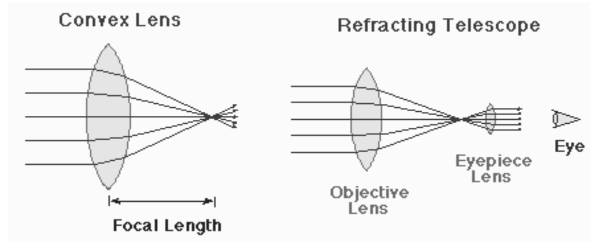
FIG 17 SIMPLIFIED ILLUSTRATATIVE DIAGRAM OF CHROMATIC ABERRATION

Basically we experience two types of chromatic, the longitudinal and lateral chromatic aberration.

- ***The longitudinal chromatic aberration*** -It occurs when different wavelengths of light are focused at different distances from the lens. A t this time the objective lens cannot focus different wavelength at the same focus, this results to colored areas in the resulting image
- ***Lateral chromatic aberration*** –It occurs when the focal length of the eye piece varies with the the wavelength and image of the image is inversely proportional to the eye piece focal length, the magnification of the image will be different at different at different wavelength. This results to lateral chromatic aberration. This results to fringes around objects of higher contrast.

6.2 Aberration correction

A significant step was taken in the evolution of refracting telescope, this was the invention of the achromatic lens.Thesse dioptrics have multiple elements that have solved problems with chromatic aberration which could be longitudinal or lateral. The lens design overcame the need for very long focal length resulting in very long tubes used during optical telescope construction.



Chromatic aberration Correction.

FIG 18 ABERRATION CORRECTIONS (AN ACHROMAIC DOUBLET IS USED TO ACHIEVE A COMMON FOCUS)

6. 2.1 The achromatic doublet

The achromatic doublet consists of two pieces of glass with different dispersion to reduce chromatic and spherical aberration. Each side of each glass is grounded and polished and then assembled together. They are designed to bring two wavelengths especially (red and blue) not focus on the same plane

6.2.2 Apochromatic Refractors

These special refractors or dioptrics are built and fabricated with a very low dispersion material. They are designed to bring three wavelengths (usually red blue and green) wavelength into focus on the same plane. Due to material cost and advanced technology required for the manufacturing of these special optics, most optical telescopes utilizes the achromatic refractors with comparable aperture in their design architecture and specification. Very sharp and resolute image virtually free from all forms of aberration is produced.

7 Results and discussions

In 1609 the Italian scientist Galileo Galilee built its own telescope and was the same person to make astronomical observation with them. These early telescopes consists of 2 glasses lenses set within a hollow lead tube and were rather small.Gallilleo longest tube was about 120cm long and 5cm in diameter. Astronomers such as Johannes Kepler improved on galilee.s earlier telescope with more larger and powerful telescope. Earlier telescopes were affected by aberration and research on lenses made it known that aberration can be eliminated by replacing the lens with two properly shaped made from two different glasses. Research on optics has lead to the advancement in modern day optical telescope development for observing, studying and analyzing astronomical objects. The Keplerian arrangement was chosen because of its huge advantage over the Galilean design.

The Keplerian telescope is an improvement on the Galilean telescope that uses the convex s the eye piece instead of a concave been devised in the Galilean arrangement. The advantage of this arrangement is that the rays of light radiating from the eye piece are converging, this permits a wider field of view but an inverted image is formed

In our prototype or demonstration model, calculations specifications and stimulations were achieved via in depth research on optical astronomy and rotary system transmission mechanism. With the proper arrangement of specification of dioptrics required for the proposed optical telescope, a magnification of 50(times) of the image will be achieved. The optical telescope architecture to be utilized was achieved via optical astronomy research, design and development.

The Keplerian arrangement was chosen because of its huge advantage over the Galilean design. The Keplerian telescope is an improvement on the Galilean telescope that uses the convex s the eye piece instead of a concave been devised in the Galilean arrangement. The advantage of this arrangement is that the rays of light radiating from the eye piece are converging, this permits a wider field of view but an inverted image is formed.

An image erector lens will be interfaced in the arrangement for the inversion of the inverted image to an reinverted upright image. The design will also allow for a micro meter at the focal plane which can be used to determine the angular size and the distance between objects observed.

The inclusion of achromatic doublets in the design specification will help solve the problem of chromatic aberration. Research on optics had led to advancement on modern day optical telescope development for observing, studying and analysis of astronomical objects.

8. Conclusion

The paramount reason for us to come up with this distinctive project is to fabricate the optical telescope in a way that a layman or an amateur astronomer will always have the zeal or enthusiasm to observe celestial objects and make analysis of astronomical observation. In this way we can have a better comprehension of the universe around us and bring the astronomical world to our door step.

Equipment procurement, financial constraint, and pain staking troubleshooting techniques experienced when dealing with non-indigenous observational equipment has prompted the need for indigenous research and development of space observational equipment for frontline space research.

Indigenous research and development backed with a robust and competent technological advancement will deepen collaboration and comprehension among relevant research agencies and aligned institutes.

Coming to our telescope's drive and control system, in our prototype or real model design we will employ a cheap indigenous technology that utilizes a step servo motor and a potentiomeric position sensor or a rotary variable differential transformer (RVDT) mechanism that will be used to drive our observational equipment to desired position for observation and research. The dish will be calibrated and astronomical instrumentation technology will be utilized for efficacy and optimal performance. Corresponding analog voltage varies with the variation of dish position. Like we mentioned earlier the entire system will be precisely calibrated for the rotary variable differential transformer (RVDT) or the potentiometric position sensor (PPS) mechanism as per telescopes position in both dimension. Indigeneous technology will make it easier for us to troubleshoot when a problem is encountered.

To improve on this work, we will recommend the utilization of apochromatic doublets and refractors of larger aperture and shorter focal length, rather than the one been recommended for this proposal. We will also make an in depth research to improve on the already proposed project by introduction of astrophotography technology developed by professionals astronomers over the years to make astronomical observations. This technology will allow multiple images to be stacked while eliminating the noise component of the observation and producing image of faint astronomical objects.

9 Acknowledgements

We are very much grateful and indebted to officers of instrumentation division–Center for basic space science and Astronomy (CBSSA) Nsukka for their motivation, inspiration and overwhelming support that culminated to the initiation of this unique project.

We are also very much indebted to our Able Head of department, Engineer lanre Daniyan and our honorable Director Dr B.I Okere for their massive support and unparalleled encouragement

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