CHAPTER TWO

LITERATURE REVIEW

2.1 Technical Background:

2.1.1 Overview of Satellites:

Satellites are objects in orbits about the Earth. An orbit is a trajectory able to maintain gravitational equilibrium to circle the Earth without power assist. Physical laws that were conceptualized by Newton and Kepler govern orbital mechanics. Satellites are classified by the distance of their orbits above the Earth as shown in figure (2.1) into:

- Geostationary or geosynchronous earth orbit (GEO).
- Low Earth Orbit (LEO) satellites.
- Medium Earth Orbit (MEO) satellites[2].

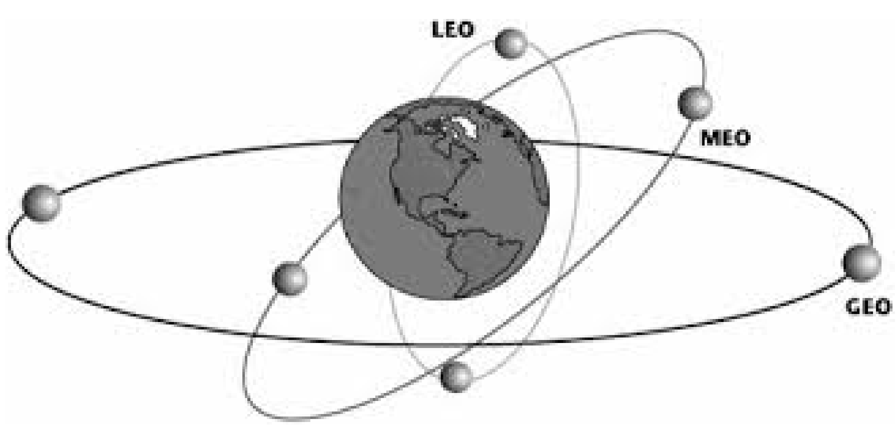

Figure (2.1): LEO, MEO and GEO Satellite orbits.

2.1.1.1 Geostationary or geosynchronous earth orbit (GEO):

GEO satellites are those satellites which they rotate using the same speed of the earth rotation and they need one day to exactly complete one cycle so they appear at a fixed point to the earth. These satellites are placed in the space in such way that only three satellites are sufficient to provide connection throughout the surface of the Earth (that is; their footprint is covering almost 1/3rd of the Earth). The orbit of these satellites is circular. There are three conditions which lead to geostationary satellites.

- The satellite should be placed 37,786 kms (approximated to 36,000 kms) 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 angle of satellite (angle between the satellite position and the equatorial plane) with respect to earth must be 0^0.

Geostationary satellite in practical is termed as geosynchronous because it has the same period as the earth period, there are multiple factors which make these satellites shift from the ideal geostationary condition.

- Gravitational pull of sun and moon makes these satellites deviate from their orbit. Over the period of time, they go through a drag. (Earth's gravitational force has no effect on these satellites due to their distance from the surface of the Earth.)
- The non-circular shape of the earth leads to continuous adjustment of speed of satellite from the earth station.

These satellites are used for TV and radio broadcast, weather forecast and also, these satellites are operating as backbones for the telephone networks.

GEO suffer several drawbacks. First Northern or southern regions of the Earth (poles) have more problems receiving these satellites due to the low elevation above a latitude of 60°, i.e., larger antennas are needed in this case. Second shading of the signals is seen in cities due to high buildings and the low elevation further away from the equator limit transmission quality. Third the transmit power needed is relatively high which causes problems for battery powered devices. Fourth these satellites cannot be used for small mobile phones, the biggest problem for voice and also data communication is the high latency; the signal has to at least travel 72,000 kms. Fifth due to the large footprint, either frequencies cannot be reused or the GEO satellite needs special antennas focusing on a smaller footprint. Sixth transferring a GEO into orbit is very expensive [3].

2.1.1.2 Low Earth Orbit (LEO) satellites:

These satellites are placed in lower altitudes usually in the range 500-1500 kms. As LEOs rotate on lower orbits, hence they have a much shorter period that is 95 to 120 minutes. These satellites are mainly used in remote sensing a providing mobile communication services (due to lower latency). The biggest problem of the LEO concept is the need for many satellites if global coverage is to be reached. Several concepts involve 50–200 or even more satellites in orbit. The short time of visibility requires additional mechanisms for connection handover between different satellites. The high number of satellites combined with the fast movements resulting in a high complexity of the whole satellite system. One general problem of LEOs is the short lifetime of about five to eight years due to atmospheric drag. Assuming 48 satellites and a lifetime of eight years, a new satellite would be needed every two months [4].

2.1.1.3 Medium Earth Orbit (MEO) satellites:

MEOs can be positioned somewhere between LEOs and GEOs. Again, due to the larger distance to the earth, delay increases to about 70–80 ms. the satellites need higher transmit power and special antennas for smaller footprints [5].

2.1.2 Types of Motors:

2.1.2.1 Stepper Motor:

A stepper motor is an electro mechanical device, which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates indiscrete step increments when electrical command pulses are applied to it in the proper sequence. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation of input pulses applied. Stepper motor suffer several advantages. First the rotation angle of the motor is proportional to the input pulse. Second the motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control. Third stepper motor provides precise positioning and repeatability of movement. Furth excellent response for starting, stopping and reversing. Fifth It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft. Sixth a wide range of rotational speed is proportional to the frequency of the input pulses. Seventh very reliable motor since there are no contact brushes in the motor. Therefore, the life to the motor is simply dependent on the life of the bearing. On the other hand, stepper motor suffers from Resonance that can occur if not properly controlled and It Not easy to operate stepper motor at extremely high speeds. One of the most significant benefits of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. Your position is known simply by keeping track of the input step pulses. Stepper motor can be used in several applications such as Industrial machines in automotive gauges and machine tooling, Security in new surveillance product for security industry, Medical inside medical scanner, sampler's also digital dental photography and Consumer electronic for automatic electronic digital camera "focus and zoom function" [6].

2.1.2.1.1 Stepper Motor Types:

Based on the construction of the magnetic circuit there are three main types of stepper motors these are Variable reluctance (VR) stepper motors, Permanent magnet (PM) stepper motors and Hybrid stepper motors.

- **Variable reluctance (VR) stepper motors:**

have uniformly distributed teeth, made of iron, on both the stator and the rotor, control windings being mounted on the stator's teeth, while the rotor is passive. By energizing one or more phases, the rotor will turn in such manner that the magnetic field lines should follow a minimum reluctance path, i.e. the rotor's teeth must align themselves either with the teeth on the stator, or with the bisectrix of the stator's electromagnetic poles. This type of construction allows for achieving small to medium step angles and operation at high control frequencies. However, a motor of this type cannot hold its position, i.e. has no holding torque, when no current flows through the stator windings. That the flow of the current through the windings of a VR motor must not be reversed to change the direction of rotation, this is achieved through the impulse sequence. This type of control, where the current flow must not be reversed is called ***unipolar***.

- **Permanent magnet (PM) stepper motors:**

have a different construction, here the teeth on the rotor are made of permanent magnet material with poles set up in a radial fashion, the stator construction being similar. When the stator windings are energized, magnetic fields that are generated interact with the PM's flux, generating torque to move the rotor. Control sequences are similar to VR motors however when for instance the south pole of a PM approaches an electromagnetic south pole on the stator, the current flow through that respective winding must be reversed, in order to generate an electromagnetic north pole for the purpose of maintaining the direction of the forces. So, the phases are energized by alternating polarity impulses, this type of control being called ***bipolar***. This type of motor can provide higher torque and also has the property of holding torque, when the windings are not energized. Steps are large 45 to 120 degrees, because the number of permanent magnets that can be mounted on the rotor is much smaller than the number of teeth found on the stator of a VR motor.

- **Hybrid stepper motors**:

represent a combination of the other two types, and are the most common type of stepper motors employed. In a hybrid stepper, the rotor is made from a permanent magnet, mounted length-wise, with two ferromagnetic toothed crowns, mounted at both ends of the magnet, so that the teeth of one crown are north poles and the ones on the other crown are south poles [7].

2.1.2.1.2 Specific Stepper Motor Parameters:

For proper operation of stepper motor several parameters must be verified. These parameters are First step angle; represents angular displacement of the rotor for one control impulse. Second maximum no load start frequency; represents the maximum control impulse frequency at which the unloaded motor can start, stop or reverse without losing steps. Third limit start frequency; represents the maximum impulse frequency at which the motor can start without losing steps, when a given moment of inertia and torque load are presented at the shaft. Fourth pull-in torque; represents maximum torque load at the shaft, at which the motor can start without losing steps. Fifth maximum frequency; maximum frequency of impulses at which a motor keeps its timing for given torque load and inertia. Sixth pull-out torque; maximum torque that can be maintained by the motor at a certain speed, without losing steps. Finally, angular speed; is calculated as a product between the stepping angle and the control frequency [8].

2.1.2.2 DC motor:

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types relay on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line. D.C motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A D.C motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. The concept of the operation of D.C motor states if a conductor, or wire, carrying current is placed in a magnetic field, a force will act upon it. The magnitude of this force is a function of strength of the magnetic field, the amount of current passing through the conductor and the orientation of the magnet and conductor. The direction in which this force will act is dependent on the direction of current and direction of the magnetic field. Electric motor design is based on the placement of conductors (wires) in a magnetic field. A winding has many conductors, or turns of wire, and the contribution of each individual turn adds to the intensity of the interaction. The force developed from a winding is dependent on the current passing through the winding and the magnetic field strength. If more current is passed through the winding, then more force (torque) is obtained. In effect, two magnetic fields interacting cause movement: the magnetic field from the rotor and the magnetic field from the stators attract each other. Figure (2.2) illustrate the operation of D.C motor. D.C motor offer many advantages such as Speed control over a wide range above and below the rated speed, quick starting, stopping, reversing and acceleration, Easy to understand design and Simple, cheap drive design. But It has high maintenance (care required to maintain the mechanical interface used to get current to the rotating field). The D.C are used in elevators, electric trains and toys [9].

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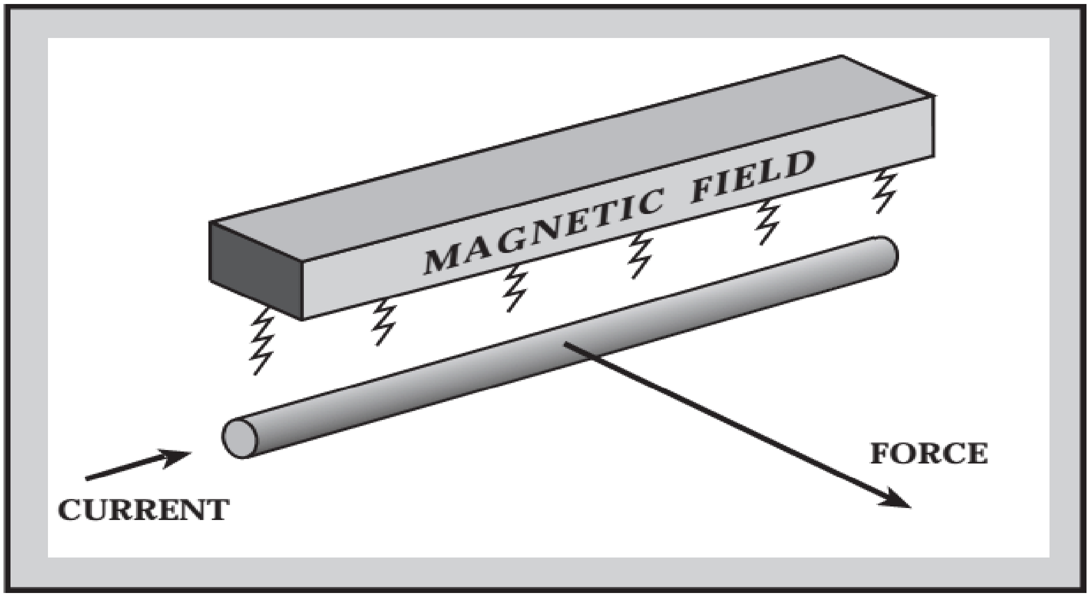

Figure (2.2): D.C motor operation

2.1.2.3 Servomotor:

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. As the name suggests, a servomotor is a servomechanism. More specifically, it is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is some signal, either analogue or digital, representing the position commanded for the output shaft. Servomotor offer many advantages such as high performance, higher speeds and accurate positioning (because of feedback). But It has higher cost and Requires setup/tuning. The Servomotor is a perfect choice for Robotics and CNC machinery or automated manufacturing[10].

2.1.3 Global Positioning System (GPS):

The Global Positioning System (GPS) is a satellite-based system that can be used to locate positions anywhere on the earth. Operated by the U.S. Department of Defense (DoD), NAVSTAR (NAVigation Satellite Timing and Ranging) GPS provides continuous (24 hours/day), real-time, 3-dimensional positioning, navigation and timing worldwide. Any person with a GPS receiver can access the system, and it can be used for any application that requires location coordinates. The GPS system consists of three segments:

- The space segment: the GPS satellites themselves.
- The control system, operated by the U.S. military.
- The user segment, which includes both military and civilian users and their GPS.

The applications of the Global Positioning System fall into five categories: location, navigation, timing, mapping, and tracking. Each category contains uses for the military, industry, transportation, recreation and science. Location is for position determination and is the most obvious use of the Global Positioning System. GPS is the first system that can give accurate and precise measurements anytime, anywhere and under any weather conditions. Some examples of applications within this category are Measuring the movement of volcanoes and glaciers, Measuring the growth of mountains, Measuring the location of icebergs - this is very valuable to ship captains helping them to avoid possible disasters and Storing the location of where you were - most GPS receivers on the market will allow you to record a certain location. This allows you to find it again with minimal effort and would prove useful in a hard to navigate place such as a dense forest. Navigation is the process of getting from one location to another. This was the what the Global Positioning System was designed for. The GPS system allows us to navigate on water, air, or land. It allows planes to land in the middle of mountains and helps medical evacuation helicopters save precious time by taking the best route. Timing that is provided by GPS is precise timing. Each satellite is equipped with an extremely precise atomic clock. This is why we can all synchronize our watches so well and make sure international events are actually happening at the same time. Mapping is used for creating maps by recording a series of locations. The best example is surveying where the DGPS technique is applied but with a twist. Instead of making error corrections in real time, both the stationary and moving receivers calculate their positions using the satellite signals. When the roving receiver is through making measurements, it then takes them back to the ground station which has already calculated the errors for each moment in time. At this time, the accurate measurements are obtained. Tracking applications are ways of monitoring people and things such as packages. This has been used along with wireless communications to keep track of some criminals. The suspect agrees to keep a GPS receiver and transmitting device with him at all times. If he goes where he's not allowed to, the authorities will be notified. This can also be used to track animals [11].

2.2 Related Works:

There are a number of studies for improving the control circuit for positioning satellite dish.

In 4, Jan 2000, Chuong, B. and C. Barry present the design of Positioning mechanism informs an installer of the quality of the signal received by the receiver coupled to the antenna while the installer is positioning the antenna. The system is consisted from a signal generator and a display. A signal generator determining the strength of signals received from the antenna provides a strength signal to a display at a positional antenna, where the display assists an installer for accurate pointing of the antenna toward a satellite [12].

The drawbacks of this Positioning mechanism is that in spite of the signal strength measuring system the dish aligning still too difficult because the physical movement of the motors is performed manually by the installer.

Me Me Kyaw, Chaw Myat Nwe and Hla Myo Tun from Department of Electronics Engineering, Mandalay Technological University present the design of the control unit for aligning a satellite dish consists of the hardware and software. This unit was consisted of hardware components which remote controller, PIC, microcontroller, relay driver and DC motor based servo mechanism. And the software will determine a desired position of the dish and send the command to the motor through the microcontroller.

The control unit works when the remote send the command to microcontroller to calculate the resolution and save degree and pluses in the EEPROM when remote send the degree to the microcontroller the motor will be driven the motor stopped if the count is equal the desired degree. The control unit uses the IR module to receive the pulses form remote to the microcontroller[13] .

The advantage of the control unit can be used remote to control of the Dc motor and microcontroller for calculation. The limitations of the control unit described above are First IR sensor’s accuracy depend on the environment temperature which mean that the system will have a random levels of accuracy. Second IR sensor must have a line of sight communication. Third radiation form the sun causes interferences in the IR sensor readings especially at mid-day. Lastly but not last IR sensor quality depend on company.

Rafael, M.C., J.B. Gonçalves, and P.P.L. developed the positioning circuit consisted from satellite receiver, GPS module, computer, dish and motors. GPS determine the longitude and latitude of the dish it connected to the computer using serial bus. Satellite receiver is responsible for measuring the signal strength received from the satellite periodically and it sends these measurements to the computer via serial bus. Computer responsible for controlling the whole system it receives the dish position from the GPS module and the signal strength from the receiver then it calculates the azimuth and elevation angles. The program moves the motors according to the azimuth and elevation angles. Since the dish is assumed to be in the correct position the signal strength may be weak and for insuring that the dish in the correct position with good signal strength the satellite receiver sends a periodic report about the signal strength to the computer then the computer uses these reports to align the dish so it receives good signal strength from the satellite [14].

The benefits of this poisoning circuit it uses GPS module for determining the longitude and latitude and it uses computer program for calculating the azimuth and elevation angles. The drawbacks of this poisoning circuit it’s wired. Wires restrict the user to stay within a small geographic area.

In January, 2007 Muhibul Haque Bhuyan from Department of Electronics and Telecommunication Engineering, Daffodil International University present the design and implementation of wireless position control system using a computer for calculating azimuth and elevation angles after requesting for both of the satellite location and the antenna location. the program has a function to find out the time needed for each DC motor to be powered on to adjust its corresponding angle. the powering time for each motor is sent to IR sensor by using parallel port then the DC motors are positioned to the specified angles [15].

The limitations of this positioning control system are. First since DC motors are controlled by timing information's any small increasing or decreasing in these information's the system will not be aligned to the correct position. Second IR communication is susceptible to sun interference making them preferred only in night. Third the software used for calculating elevation and azimuth is too difficult for ordinary people that they have to enter the angle of the satellite they wish to receive it's channels they have to enter their position longitude and latitude so users must use another software to locate themselves.