LABORATORY WORK BOOK

For Academic Session ______

Semester _____

<u>SATELLITE COMMUNICATION</u>

<u>(TC-493)</u>

For

<u>BE (TC)</u>

Name: ____

Roll Number: ____

Batch: ____

Department: ____

Year: ____

Department of Electronic Engineering
NED University of Engineering & Technology, Karachi

LABORATORY WORK BOOK

For the Course

TC-493 SATELLITE COMMUNICATION

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INTRODUCTION

Satellite Communication provides true global coverage with ignoring the world boundaries. The area where the consumers are sparsely located at a vast area on earth is the one area where Satellite is the only option besides providing broadcasting, monitoring, position location and mobile services to ground, maritime and users in air.

Satellite Communication Practical Workbook covers the lab sessions which are knowledgeable and beneficial in grasping the subject knowledge. These sessions will solidify theoretical concepts discussed in theory classes.

CONTENTS

LAB SESSION 01

OBJECT:-

To study design parameter of a satellite.

THEORY:-

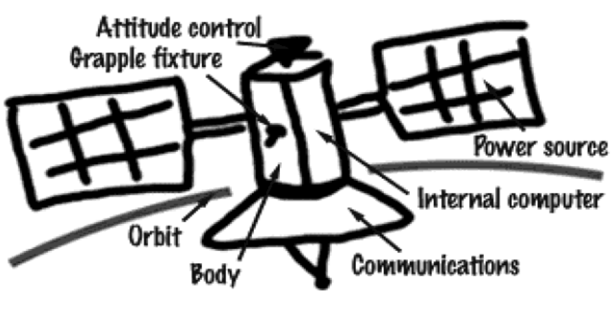
A satellite is basically any object that revolves around a planet in a circular or elliptical path. The moon is Earth's original, natural satellite, and there are many manmade (artificial) satellites, usually closer to Earth.

- The path a satellite follows is an orbit. In the orbit, the farthest point from Earth is the apogee, and the nearest point is the perigee.
- Artificial satellites generally are not mass-produced. Most satellites are custom built to perform their intended functions. Exceptions include the GPS satellites (with over 20 copies in orbit) and the Iridium satellites (with over 60 copies in orbit).
- Approximately 23,000 items of space junk -- objects large enough to track with radar that were inadvertently placed in orbit or have outlived their usefulness -- are floating above Earth. The actual number varies depending on which agency is counting. Payloads that go into the wrong orbit, satellites with run-down batteries, and leftover rocket boosters all contribute to the count.

Launching of a Satellite:-

All satellites today get into orbit by riding on a rocket or by riding in the cargo bay of the Space Shuttle. Several countries and businesses have rocket launch capabilities, and satellites as large as several tons make it safely into orbit on a regular basis.
After a rocket launches straight up, the rocket control mechanism uses the inertial guidance system to calculate necessary adjustments to the rocket's nozzles to tilt the rocket to the course described in the flight plan. In most cases, the flight plan calls for the rocket to head east because Earth rotates to the east, giving the launch vehicle a free boost. The strength of this boost depends on the rotational velocity of Earth at the launch location. The boost is greatest at the equator, where the distance around Earth is greatest and so rotation is fastest.

Diagram of a Satellite



Anatomy of Satellite:-

1. Altitude Control:-

- Satellites must take precise measurements from their place in orbit so they don't wobble, satellites are stabilized
- Stabilizing a satellite is attitude control
- The attitude of a satellite is its position in space - its orientation
- Attitude determines what a satellite looks at - which way its cameras are facing, and the angle the satellite makes with the object it is orbiting
- To stabilize a satellite, the satellite must have a system that keeps it moving evenly through its orbit
- Satellites often use a spinning or gyroscopic motion to keep them stable
- A satellite's measurements and pictures will be inaccurate and fuzzy if it is not stabilized
- A satellite's orbit is more likely to decay - slowly change course either toward the Earth or out into space - if it is not stabilized
- In stabilizing a satellite, the direction that the satellites' instruments and solar panels are facing is also important
- It is easier and cheaper to power a satellite that has solar panels that are constantly exposed to the sunlight; this is necessary for satellites with extraordinarily high energy requirements; however, this is not possible if the satellite is spinning
- There are several ways to stabilize a satellite:
  - spin stabilized
  - spun/despun
  - three-axis stabilized

2. Body:-

The body of a satellite, also known as the bus of a satellite, holds all of the scientific equipment and other necessary components of the satellite. Satellites combine many different materials to make up all of their component parts. Since satellites are essentially pieces of scientific or communications equipment that must go into space, engineers must design a bus that will take the equipment safely into space.

There are several goals that engineers must accomplish when choosing materials for the satellite's bus. Among these are:

- Outer Layer: protecting the satellite from collisions with micrometeorites, or other particles floating in space
- Anti-radiation: protecting the satellite from the radiation of the sun
- Thermal Blanketing: using thermal blanketing to keep the satellite at a comfortable temperature for the instruments to function
- Conduction: conducting heat away from the satellite's vital instruments
- Structural Support
- Connecting Materials

Generally, the smaller the satellite, the better. When choosing the materials for a bus, the following factors are also usually taken into consideration: cost, weight, longevity (how long the material will last), and whether the material has proven to be functional on other satellites before.

3. Communications:-

- All satellites need to have some means of communication with Earth; the satellite may need to receive instructions and transmit the information it collects, or it may relay information sent to it to another site on Earth
- This is generally done using some type of antenna
- Antennas are defined simply as a piece of equipment that allows transmission and reception of radio signals
- Since the information is transmitted using radio waves, which move at the speed of light, this method allows for very fast communications (only a very small time lag)
- Antennas come in many families: simple, dishes, patch arrays, and inflatable

4. Grapple Fixture:-

- The Canadarm can be used for launching or retrieving satellites (satellites can also be launched using rockets)
- So that the Canadarm can grip these satellites, they are built with a part called a grapple fixture, which is attached to the bus of the satellite
- The original grapple fixture consisted of a foot-long metal pin, a baseplate, and a target
- The end of the Canadarm (called its End Effector) has three snare wires which wrap around the grapple fixture using small motors
- The wires are then retracted, and the satellite is pulled snugly against the end of the Canadarm
- Today, grapple fixtures have removable grapple pins so that if the Canadarm fails, an astronaut can manually remove the pin to release the satellite
- Grapple fixtures now have an electrical connector on the end of the pin
- This can join with an electrical adaptor (called a Special Purpose End Effector or SPEE) at the end of the Canadarm
- This allows electrical power and data communications to move from the shuttle to the satellite when it is grappled
- This is used to preserve a satellite's batteries during deploy and retrieval activities
- The Canadarm is unable to grasp older satellites, or satellites not expected to be repaired in orbit, because they were not fitted with grapple fixtures when they were originally launched
- The Canadarm can also only capture satellites which are in the same orbital path as the shuttle (for example, the shuttle never flies in a polar orbit).

5. Internal Computer:-

- All satellites must have a method of storing and analyzing the data collected by the satellite, and a way of controlling its various systems
- This is usually performed by some type of computer
- The satellite subsystem that fulfills this role is called Telemetry Tracking and

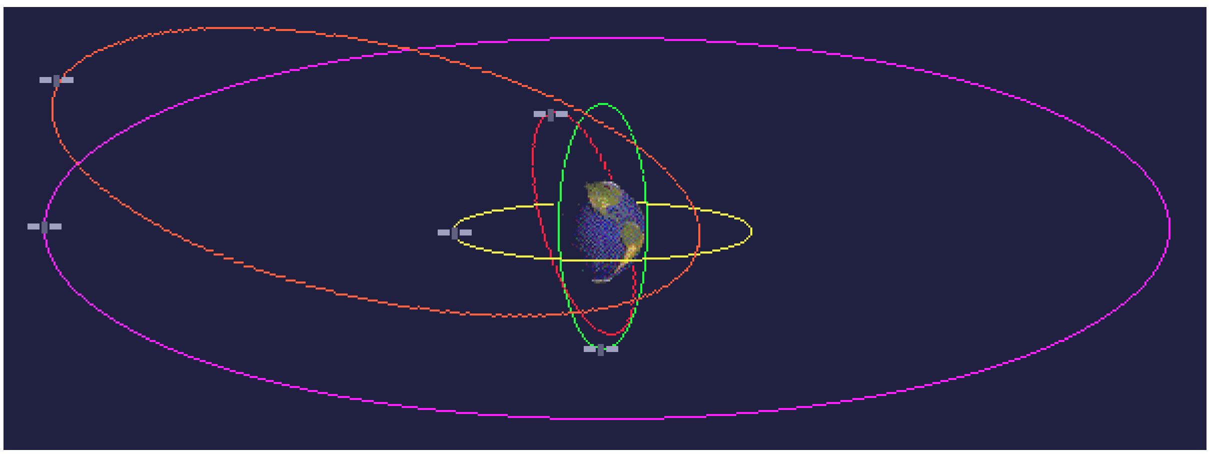
Control (TT&C).

- TT&C is the brain of the satellite and its operating system
- It logs every activity of the satellite, receives information from the ground station, and takes care of any general upkeep, or "housekeeping", the satellite needs to do
- TT&C is made up of three components: Telemetry, Tracking, and Control

6. Power Source:-

- Every satellite needs a source of power
- Factors to consider are cost, durability, and effectiveness (amount of power generated)
- Satellites use up a lot of electricity
- Think! How could a power source be mounted in or on a satellite?
- Some possible power sources for satellites include: Solar panels, Batteries and Nuclear power Heat generators

7. Orbits:-



A satellite's orbit works because of a balance between two forces. The orbit is a combination of the satellite's velocity - the speed it is travelling in a straight line - and the force of the Earth's gravitational pull on the satellite. These forces are similar to the forces that keep all the planets in their places in the solar system. That gravitational pull is the result of the mass or weight of the Earth and the mass of the satellite. Basically, gravity keeps the satellite's velocity from sending the satellite flying out in a straight line away from the Earth, and the satellite's velocity keeps the force of gravity from pulling the satellite back to Earth. To illustrate this concept, think of a yo-yo. There is a long string that holds the weight of the yo-yo ball at the end. The yo-yo ball is the satellite, and your hand holding the end of the string is the Earth (not to scale of course). If you swung that yo-yo in a circle, then the string would act as the gravity. Without the string, the yo- yo ball would fly off into space, but without the weight and forward motion of the yo-yo ball, the string would flop towards the ground.

Since the Earth turns from west to east on its axis, satellites can either seem, from Earth, to be moving very quickly or very slowly. A satellite in orbit travelling towards the east would seem to be moving very slowly to an observer on Earth. On the other hand, a satellite moving toward the west would seem to be moving quickly to someone on Earth. From Earth, there is only one orbit that would seem like it wasn't moving, and that's a geostationary orbit, also known as geosynchronous.

The advantage of having a satellite in one orbit rather than another orbit usually depends on its inclination - the angle at which a satellite's orbit is tilted in relation to the Earth's equator. When engineers are designing a satellite, and designing its function, they must choose an orbit that is appropriate to its function. So, a satellite that is in an orbit very high up will not be able to see objects on Earth in as much detail as orbits that are lower, and closer to the Earth's surface. Similarly, the speed of the satellite moving in the orbit, the angle over the Earth the satellite takes, the areas which the satellite can observe, and the frequency with which the satellite passes over the same portions of the Earth are all important factors to consider when choosing an orbit.

Finally, the place from which a satellite is launched is important in determining its orbit. For example, a satellite launched from NASA's Launchpad in Cape Canaveral, Florida has a lesser degree of inclination, so it is not tilted very far off from the line of the equator. A satellite launched from a place with higher latitude, like Canada, would have a higher angle of inclination, so satellites launched into polar orbits might be launched from somewhere as far north as Canada. To put a satellite into equatorial orbit, for example, it would be best to launch it from somewhere close to the equator. Often, NASA launches its rockets carrying satellites into equatorial and geostationary orbit from a Launchpad in French Guyana.

Essentially, there are two major divisions in orbit types; there are circular and there are elliptical orbits. Circular orbits comprise: geostationary, polar, sun-synchronous, and equatorial orbits. Highly elliptical orbits come in all different shapes and sizes. Orbits of different shapes have different eccentricities.

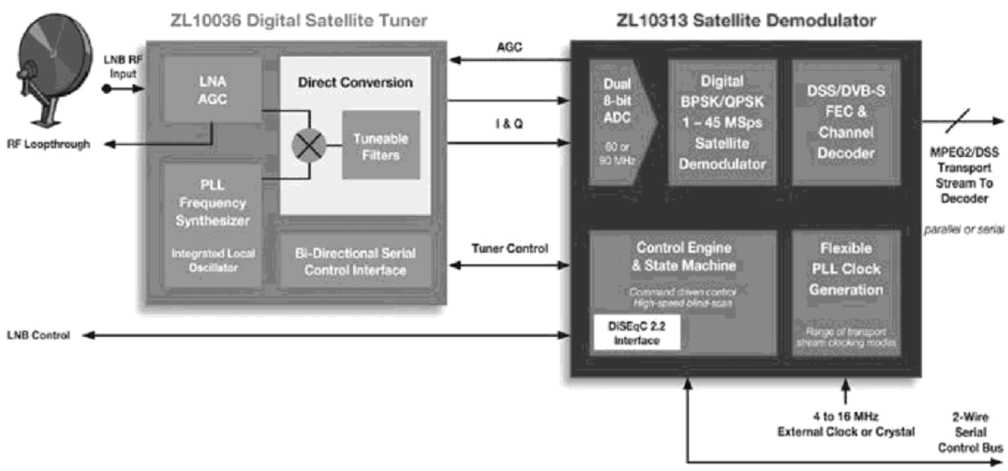
LAB SESSION 02

OBJECT:-

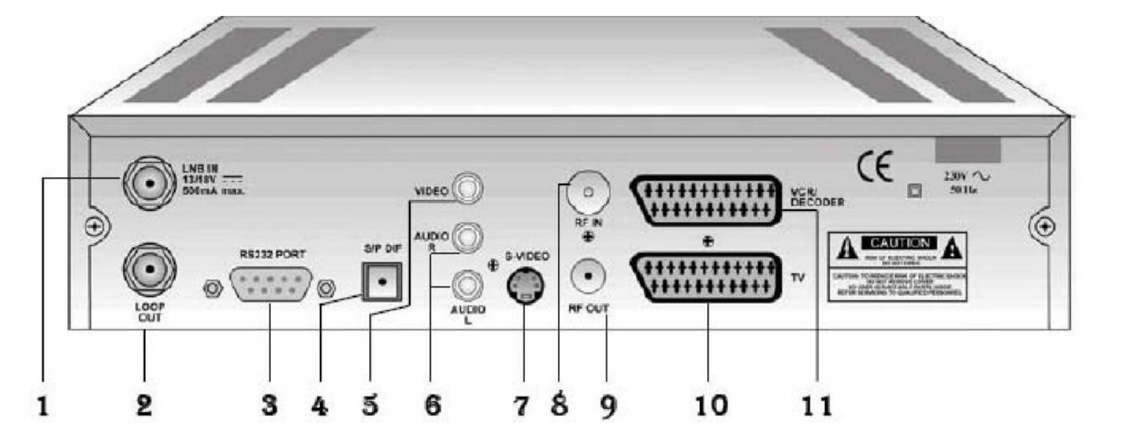
Design of a Digital Satellite Receiver.

THEORY:-

Block diagram of a satellite receiver system.



Functions and controls of a typical receiver set



Connections:-

1. Digital LNB IF input
2. Analog Satellite Receiver LNB output
3. Serial Communication Connection
4. S/P DIF Digital audio output
5. RCA video output
6. RCA audio outputs
7. S-VIDEO (chroma-luma) output
8. External TV antenna input
9. External TV antenna output
10. TV scart output
11. Video Cassette Recorder (VCR) scart output

Connection to TV through RF:-

You may connect your unit to TV through RF. For this purpose, you will need one RF connection cable with one IEC female and one IEC male ends. Connect one end of the cable to the antenna input of TV and other end to the RF OUT of the unit.

Connection to TV through SCART:-

Scart connection allows you to have a better connection in contrast to RF link. For such a connection, you will need a full scart cable with adequate ends in both sides. Connect one end of the scart cable to TV and the other to TV scart output of your unit.

Connection to TV through S-VIDEO (applicable to some models):-

You may make the connection between your TV and unit with a S-Video, which is a connection transferring video signal only. It will need an audio connection at the same time. For this connection, a cable with S-Video ends in both sides is needed. Connect one end of the cable to S-Video input of your TV and other end to S-Video output of your unit.

VCR (Video Cassette Recorder) Connection:-

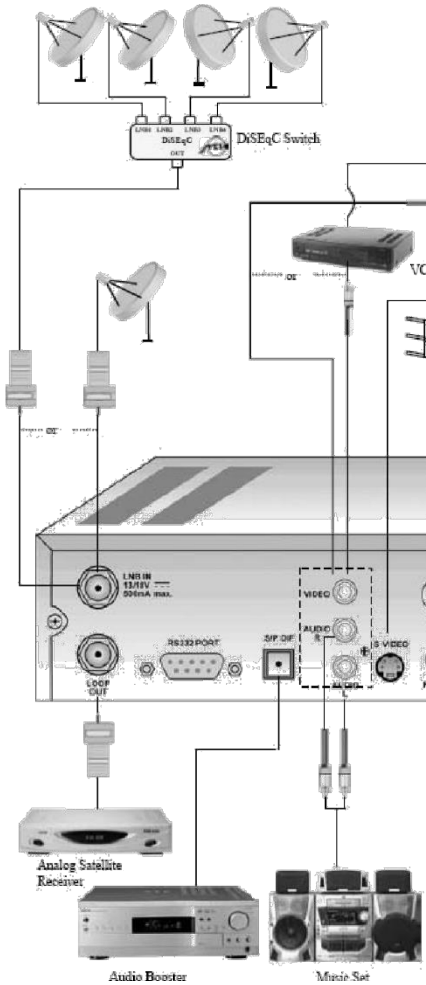
You can make VCR connection through Scart. For such a connection, you will need a full scart cable with adequate ends in both sides. Connect one end of the Scart cable to the VCR unit and the other end to the VCR scart of your unit.

Audio Booster Connection

- Connection through RCA Output
  You may connect your unit to music set through RCA output. For this purpose, use AUDIO-L and AUDIO-R stereo outputs of your unit.
- Connection through S/P DIF Output (applicable to some models)
  You may connect your unit to audio booster through S/P DIF output. For this purpose, use the S/P DIF output of your unit (with optic or toslink type cable)

Using DiSEqC Switch:-

DiSEqC is a switch circuit. You can use 4 dish antennas with one DiSEqC switch.



First installation and TV settings:-

After making all the necessary connections of your satellite receiver, insert the plug into a mains outlet and turn it on by pressing . If your satellite receiver is connected to TV through RF input, you will need to adjust your TV to UHF channel 65. (Factory setting of your satellite receiver is UHF 65.)

- After making all connections, turn on your TV and receiver and then press the keys and MENU in the given order.
- Tune your TV to UHF 65 to see the main menu screen and then store your new TV settings.
- If it is necessary to change the output channel of your receiver, refer to the section ”RF output channel setup”

If your receiver is connected to TV through scart input, you will not need to make any setting on your TV. When you turn on your TV and receiver, the receiver will be automatically displayed on the screen. (Some TVs may not have automatic scart switching feature. In this case, you should tune your TV to AV mode with TV remote control).

Power On/Off:-

Use the key on the remote or on front panel to turn off your satellite receiver. The unit shows the channel number if it is on and shows the preset time if it is off.

Channel Selection:-

The channels in your satellite receiver are ordered from 1 to the number of the last set channel. There are a few ways to go to any desired channel:

- You may select a channel by pressing the keys P+ or P-.
- You may make selection by using the numerical keys on the remote control unit. The numbers you enter shall be displayed on the lower part of the screen. You may make selection in three different ways.
- Enter the channel number in 4 digits. For example, for the channel 1875, enter 1, 8, 7 and 5. For the channel 27, enter 0, 0, 2, 7.
- Enter the channel number and wait for a few seconds. For example, for the channel 168, enter 1, 6 and 8 and then wait. For the channel 56, enter 5 and 6 and wait.
- For quick channel access, hold the last digit of the channel number pressed for a while. For example, for the channel 3 press the key 3 and hold the key pressed. For the channel 14, press 1 and 4 and keep 4 pressed.
- You may make a selection by using the program list. (Refer to “Use the Program List”).

Select Satellite:-

You may select a satellite to watch the channels of that satellite only. Call the satellite list by pressing the SAT key when no menu is open. Satellites which have no preset channels shall not appear on the satellite list. Move to the satellite you prefer using P+, P- keys and confirm it by pressing the OK key.
If a satellite is selected by satellite selection, the unit shall start only in the channels of that satellite (other channels shall not be displayed). If you want to cancel a selected satellite or to reach all channels of all satellites, select the option of All Satellites.

Switch to Radio- Channels:-

Press the TV/RAD key when no menu is open to switch to radio channels. In this way, the unit shall start on radio channels. If there is no preset radio channel in the position you are in, a message “No preset channel” shall appear.
When radio channels are selected, the program list shall be effective only on radio channels (no television channel is displayed). Press the TV/RAD key again to return to television channels.

Freeze the Picture:-

You can freeze the picture on the screen by pressing the PAUSE key. In the models with PIF feature, the live picture shall continue to appear on the right hand side of the screen. Further, you may operate the feature of slow motion by pressing the PAUSE key again and you may move the small picture on the screen by using the keys P+, P-, V+ and V-. It is enough to press any key other than PAUSE, P+, P-, V+ and V- to return to normal program.

Use EPG (ELECTRONIC PROGRAM GUIDE):-

EPG (Electronic Program Guide) is a table sent by the channel, showing the channel flow information. If the channel you watch is sending EPG information (see “Info Bar”), press EPG key to see the information when no menu is open. It is possible to display the information about the programs which were or will be on the air. When the EPG menu is open, you will see the program flow information on the left upper side and selected channels on the lower left side and program flow information of channels on the right side. You can change channels using P+, P- keys and check future programs of that channel on the program flow by using V+, V- keys.
You can see the details of the program selected on the right hand side of the screen. The time and date of the unit must be set correctly so that EPG can show program flow information properly (refer to “Date and Time Setup”).

Transponder Settings:-

Transponder settings are used for recording such transponders broadcasting from a satellite. It is possible to use the information to enable the unit to search channels swiftly and correctly. Transponder information is used only at the time of channel search. It is not important while watching channels. Select “Transponder” from “Installation” and press the OK key to see the list of all defined transponders of the satellite selected on the screen. Press the yellow function key for changing the satellite selected and selects a new satellite from the list

Specifications:-

Tuner:-
Frequency range: 950-2150 MHz Input signal level -65 - -25 dBm IF frequency 0 MHz
Input impedance: 75Ω
LNB supply: 13/18 Volt, 22 kHz
DiSEqC: 1.0, 1.2
Channel locking: PLL
Connector: F-female
Output: Loop-out (For analogue receiver)

Demodulator:- Type: QPSK
Symbol Rate: 1-45 Msps
Viterbi 1/2, 2/3, 3/4, 5/6, 7/8
Reed Solomon: 204, 188, 8
System: SCPC, MCPC

Video:-
System: MPEG2 ISO13818 MP@ML
Resolution: 720*576*50
Output: PAL

Audio:-
System: MPEG1 ISO 11172-3
Sampling: 32, 44.1, 48kHz
Audio Mode: Mono, Dual mono, Stereo

Video Output:-
TV Scart: Video (CVBS), Video (RGB), Audio (Stereo)
VCR Scart: Video (CVBS), Audio (Stereo)
RCA: Video (CVBS), Audio (Stereo)
S/P DIF: Digital Audio
S-Video: Luma, Chroma

RF modulator:-
Output channel: 21 – 69 UHF
Standard PAL-BG, PAL-I
Video Level: 70 ± 5 dBµV
Output impedance: 75Ω
Connector: IEC (female and male)

Data:-
Standard: RS232 115200,8,n,1
Connector: 9pin D-type male

Power Source:- Type: SMPS
Power consumption: 30W (max)
Working voltage: 230V AC

Other:-
Temperature in operation: 5-40 ºC

LAB SESSION 03

OBJECT:-

Analysis of a GPS Receiver.

THEORY:-

The GPS system consists of a constellation of 24 satellites. While not officially declared fully operational, for all practical purposes the system is now fully operational. These satellites orbit the earth at an altitude of about 10,900 miles and at an inclination of 55 degrees. As I will demonstrate in my next column, this orbit translates to an orbital period of 12 hours. The orbits are distributed around the earth in such a way that at least 4 satellites are always visible from virtually any point on the surface of the earth. This provides a means of precisely determining the position of the user in longitude, latitude, and altitude. The satellites operate at two frequencies, known as L1 and L2. These two frequencies are 1575.42 MHz and 1227.6 MHz, respectively.

The whole system operates at a system clock frequency of 10.23 MHz, which is an exact submultiple of the L1 and L2 frequencies. The two transmission frequencies are modulated with a pseudo-random signal to produce spread spectrum signals. The L1 channel is modulated with both a 1.023 Mbps pseudo-random code known as the C/A (course/acquisition) code and a 10.23 Mbps PN code known as the P (precision) code. The L2 channel is only modulated with the P code. The two codes are considerably different in characteristics. The L1 code repeats every 1023 bits, or every 1 millisecond. The P code, on the other hand, only repeats itself every 267 days. Furthermore, the P code can be encrypted by the Department of Defense, so as to make it unavailable to civilian (or unauthorized) users. This limits the best accuracy obtainable by unauthorized users to about 30 meters, while allowing authorized users to achieve accuracies of up to 3 meters. Additionally, the DOD, at its discretion, can disseminate slightly inaccurate information pertaining to the location of the satellites, so as to further degrade the accuracy obtainable by unauthorized users to about 100 meters. These accuracy degradation capabilities are important, since hostile nations could use the information against us in times of war.

As time has gone by, however, more potential applications have been developed for GPS and many techniques have been developed to augment the accuracy available to unauthorized users. Techniques like carrier phase tracking and differential GPS can allow users to obtain centimeter level accuracy, especially in cases where measurements are being made at a fixed location. However, it is well established that even aircraft positions can be determined to an accuracy of better than several meters, even in real time.

Other applications include moving map displays in cars and trucks. Attitudes of aircraft and spacecraft can also be determined with GPS. GPS equipment is currently set-up in the San Francisco area to allow researchers to measure the amount of shifting in the earth's surface during the next earthquake. GPS was also recently used to measure the height of Mount Everest and K2. Forest fire fighters use GPS to define the extent of fire and townships are using GPS equipped vans to map roads in a small fraction of the time that would be required for conventional surveying techniques.

GPS Receiver:-

The Global Positioning System (GPS) works on the principle that if you know your distance from several locations, then you can calculate your location. The known locations are the 24 satellites located in six orbital planes at an altitude of 20,200Km. These satellites circle the Earth every 12 hours and broadcast a data stream at the primary frequency L1 of 1.575GHz which carries the coarse -acquisition (C/A) encoded signal to the ground. The GPS receiver measures the time of arrival of the C/A code to a fraction of a millisecond, and thus determines the distance to the satellite.

The Core Subsystems include:

- **Front End**

The GPS L1 signals (Maximum = 24 signals) at 1.575GHz are received at the antenna and amplified by the Low-Noise-Amplifier (LNA). The RF front-end further filters, mixes, and amplifies (AGC) the signal down to the IF frequency where it is digitally sampled by a ADC.

- **Baseband Processor/CPU**

The ADC samples of GPS C/A code signals are correlated by the DSP and then formulated to make range measurements to the GPS satellites. The DSP is interfaced with a general-purpose CPU, which handles tracking channels and controls user interfaces. TI OMAP integrates both DSP and ARM processor on the same chip.

- **Memory**

- The processor runs applications stored in memory. The OS is stored in non- volatile memory such as EE/FLASH/ROM. Applications may be loaded in FLASH or DRAM.

- **User Interface**

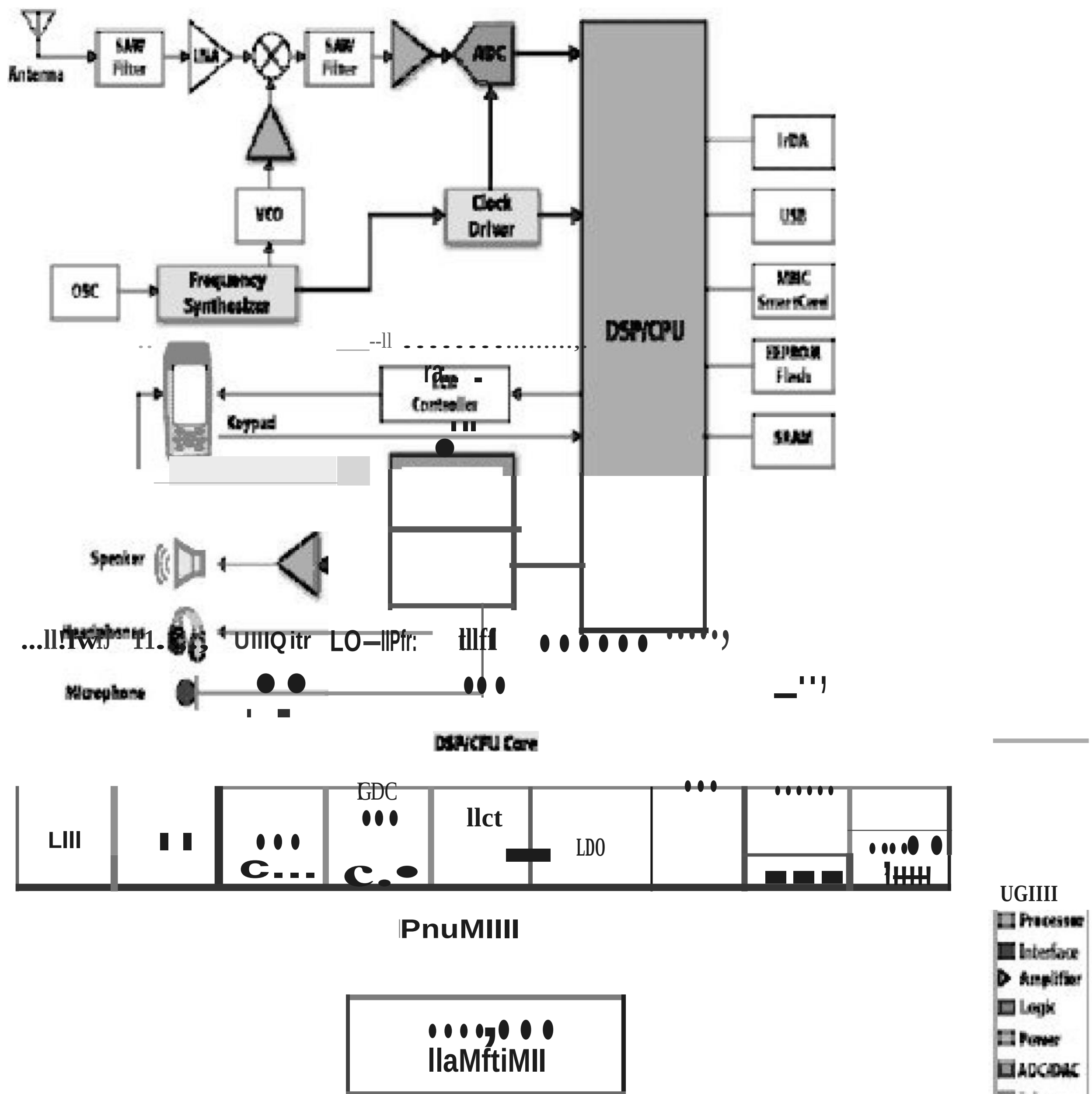
Allows user to input/output data from the receiver using input commands va microphone, touch screen, and output MP3 to the earplug.

- **Connectivity**

Allows the receiver to connect to the USB port.

- **Power Conversion**

Receiver Diagram:-



LAB SESSION 04

OBJECT:-

Analysis of Data services in INMARSAT communication system

THEORY:-

Data technologies in Inmarsat communications system:

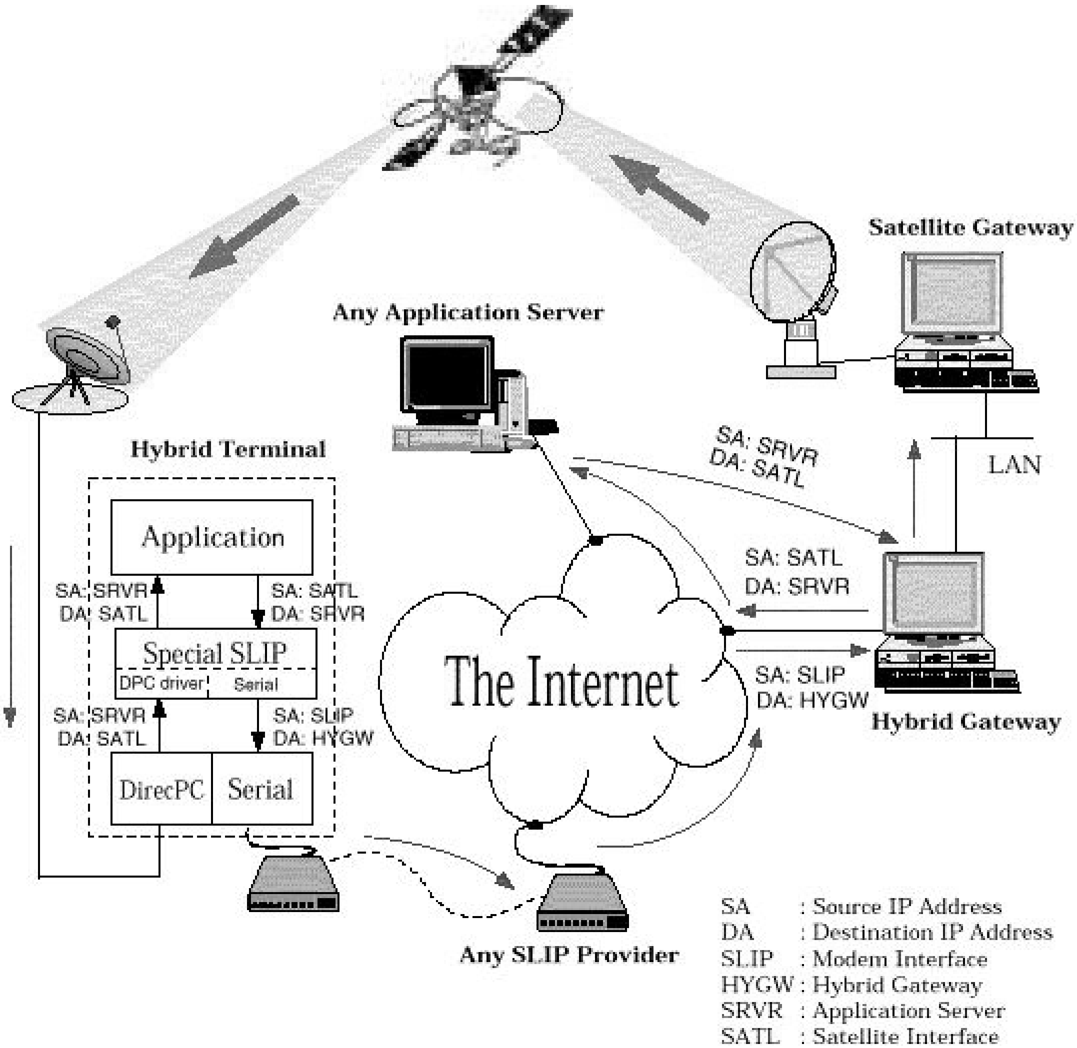
There is a wide range of data technologies available in the different lnmarsat communication subsystems. The low speed 600 bps store and forward messaging data services are provided in Inmarsat-C. In all the real time subsystems - both in Inmarsat-A and in the new digital Inmarsat-M/B/fvlini-M the full duplex medium speed single channel per carrier (SCPC) data services are available. From the user's point of view and the terrestrial network protocols used the medium data services can be considered as asynchronous ones. On the satellite part of the link the speeds of services depend on the protocols used by the particular subsystem and on the terrestrial part of the link they depend on the particular implementations at Land Earth Stations (LESes) - gateways between lnmarsat system and terrestrial networks. In Inmarsat-B the medium data services are available at 9600 Kbps with the fallback to 4800 and 2400 Kbps.ln Inmarsat-M/Mini-M the upper limit for the speed on the satellite part is 2400 Kbps. In Inmarsat-B the so called High Speed Data (HSD) or Premium full duplex synchronous service is available with speeds 64 or 56 Kbps.

Specific features of the Inmarsat data services:

There are quite a number of specific features of the data services available in Inmarsat subsystems which are very similar to other mobile wireless systems - cellular,trunk etc. The specific features are related both to the nature of the wireless networks and to the particular applications. In the digital subsystems - Inmarsat- B/M/Mini-M the communications link consists of the three main parts (Fig.1) - "computer-satellite user terminal" one, satellite part (MES-LES) and terrestrial part. On the computer-satellite terminal. The computer- telephone modem or computer-high speed data port)) protocols are used. On the satellite part of the link the synchronous protocols developed to allow for the specific features of propagation of the signals in the space are implemented. On the terrestrial part the protocols of the terrestrial telephone or ' ISDN/56 Kbps networks are effective. The propagation delay only because of the signal path length (70-80 thousand km) amounts up to 250 ms. The loss of connection can be experienced due to the obstruction of the signal line, or bad weather conditions leading to the fading of the signals or some other reasons. The actual delays vary depending on the network loading, on the queues in the networks especially in the peak time and on the particular application techno1ogies.h some of the applications round trip delays can be as big as 1000 ms because of the additional processing requirements like when transport layer protocols are used. The cost of traffic is rather high compared to the terrestrial networks that require the development of technologies ensuring reliable and quality connections. If to compare with the voice and facsimile services where the end user equipment is a standard and relatively simple mass product manufactured in general in accordance with the widely accepted international standards, the data technologies are very different. They serve as a basis for implementation of different application technologies requiring the special end user equipment connected both to a satellite terminal and to the terrestrial network termination points. As a rule they are computers with the special boards and software. In digital systems for connection of the end user equipment to the satellite terminals the V.24p.28 interface is used without any modem as on the logical level all digital satellite terminals have internal modem interface unit which accepts the basic and extended sets of AT commands. The basic set of AT commands includes the most frequently used commands to control the modems and the extended set provides the options to configure the satellite link, computer-terminal link and a number of parameters of the terrestrial networks connection. These commands allows to choose the speed of transmission on the satellite part of the link, on the terrestrial part, on the link computer-satellite terminal)), the error correction procedures - ARQ on the satellite part and/or V.42 on the terrestrial part, and to configure quite a number of other parameters. For digital systems the link budget in 99% of cases provides the channels with 1 error bit for every 100000 bits. The forward error correction (FEC) is always used on the satellite link with the rate 1/2 in Inmarsat-B and Mini-M and 3/4 in Inmarsat-M. In addition to the FEC in medium speed data services the ARQ mode on the satellite part and V.42 mode on the terrestrial part of the link can be used. The ARQ protocols used on the satellite part conform to the IS0 HDLC procedure as defined in the recommendations ISO/IEC 3309, ISO/IEC 4335 +AMD4, ISO/IEC7809+AMD7. The synchronous two way simultaneous duplex nonswitched version is used with extended sequence numbering modulo 128 (the maximum implemented size of window in terminals is equal to 63 frames). ARQ mode allows using the variable size of window, the transmission and receiving buffers of variable size. A user can make a choice which part of the link to protect or not to protect additionally - satellite part with ARQ procedure and terrestrial part with V.42 procedures and any combinations are allowed that is a user can protect both the satellite and terrestrial parts, only satellite part or only terrestrial part of the link, or not to use ARQp.42 procedures. On the Land Earth Stations (LESes) the processing of data and conversion it to the terrestrial networks real time protocols is affected. In spite that at both ends of the link the standard interfaces are used the transmitted data undergoes two stage transformations - in accordance with lnmarsat protocols for transmission over the satellite part of the link and in accordance with the telephone networks protocols or ISDN/data networks for transmission over the terrestrial part. This can require the adjustments of parameters of the links to obtain the better performance of the whole application technology. Both the medium and high speed data services use synchronous full duplex transmission over the satellite part of the link with assignment of forward and return channels. In Inmarsat-B V.32 protocol is used and in Inmarsat-M/Mini-M - V.22bis. The integrity of data in HSD mode is provided by forward error correction and application technologies. The data transmission is effected in synchronous mode at 64/56 Kbit/s with the support of lSDN/56 kbps networks protocols on the terrestrial part. Depending on the model of a satellite terminal different end user interfaces are used - usually RS232 or V.35 or RS442/RS449. There are models available in which the required interface can be chosen when purchasing - from RS232 up to SO3.

Application technologies:

Applicability of the particular application technology is determined by both the users requirements and economical calculations. Thus, when the amounts of data to be sent are very small (less than 1 Kbyte of data) using Inmarsat-C can be more cost effective. With files of bigger sizes Inmarsat-M/Mini-M or Inmarsat- B can be the right solution. When it is necessary to send big amounts of data (files of greater than 150-200 Kbytes size) or to use broadband technologies like video conferencing or high quality audio HSD mode can be applicable. So, when making a choice which technology to use it is reasonable to include. Assessment of the cost of transmission of data in addition to the other components of the analyses. It is worth to note that modern lnmarsat terminals are very compact and not heavy. There are models of the



Inmarsat-B transportable terminals which have the size of a medium suitcase and weigh only 16 kg, and note-book sized Mini-M terminals.

Medium speed data technologies can be used in the same way as when working in the terrestrial networks

- for point to point file transfer, e-mail and real time interactive access. It is necessary to stress that to obtain effective results in many cases it is reasonable to use special solutions with proprietary protocols developed to allow for specific features of the lnmarsat networks. The general recommendation can be to use the z-modem type protocols allowing for the big time delays. High Speed Data applications are considered to be of very great importance because of the rapid development of the digital terrestrial networks (ISDN and etc.). HSD applications include:

- dedicated file transfer systems with information speed of 60-64 Kbit/s;
- LAN/WAN routing and remote access
- Video conferencing;
- Store and forward video;
- Multiplexing (Fig.3);
- Audio broadcast

Dedicated file transfer systems were very first HSD applications They are designed specifically for lnmarsat channels, use very efficient protocols and are delivered as a complete set of hardware and software. They provide 60-64 Kbps speed of transmission that allows to send, for example, a book of 500 pages in electronic form during 2.5-3 minutes.

File transfer can be affected in the point to point mode not only to the addressee connected to ISDN or 56 Kbps network but in the terminal to terminal mode as well. There are several packages available on the market.

Video conferencing is another widely used technology, when live video and audio are transmitted over lnmarsat channels with access to ISDN networks or in terminal to terminal mode.

In Inmarsat-B the ITU-T G.728 for audio and H.261 (p*64) CIF and QClF for video are supported. It can be used both as a video conferencing for media or Telemedicine or other applications and as a surveying system for one of the very important applications is Store & Forward video which can help a lot to nl reporters and news gathering teams. The recording of the video image is effected directly from the camera to the special device named videocodec, which converts the image into a data file and the data file is transmitted over the lnmarsat channels. For transmission of one minute of low speed motion picture recorded at 384 Kbps 6 minutes of lnmarsat air time will be required. Transmission of a one minute high quality video film recorded at 1152 Kbps will require 18 minutes of lnmarsat air time. The transmission can be effected both in ((terminal to ISDN. and ((terminal to terminal. modes. In conclusion it is necessary to mention the lnmarsat initiative in support of the most promising Wireless Messaging Technology. The main idea is to develop a network independent solution, which can provide reliable communication links on the particular network using the client-server architecture. On the server side Windows NT is used and on the client side - Windows-95(or later versions) with the Microsoft Exchange as the user interface. There are several products built in accordance with this architecture currently available on the market.

LAB SESSION 05

IONOSPHERE

Objective:

- To study Ionosphere
- How to Launch and analyze NASA 4D Ionosphere

Tools:

Google Earth

Theory:

Sky Wave Propagation:

Electromagnetic waves that are directed above the horizon level are called sky waves. Typically, sky waves are radiated in a direction that produces relatively large angle with reference to Earth. Sky waves are radiated towards the sky, where they are either reflected or refracted back to earth by ionosphere. Because of this, sky wave propagation is sometimes called Ionospheric propagation.

Ionosphere:

It is the region of space located approximately 50km to 400km above Earth's surface. The Ionosphere is the upper portion of Earth's atmosphere. Therefore it absorbs large quantity of earth's radiant energy, which ionizes the earth the air molecules and creates free electrons.

When a radio wave passes through the ionosphere, electric field of the wave exerts force on free electrons, causing them to vibrate. The vibrating electrons decrease current, which is equivalent to reducing dielectric constant. Reducing the dielectric constant increase the velocity of propagation and causes electromagnetic wave to bend away from the regions of high electron density towards region of low electron density region (i.e. increasing refraction). As the wave moves farther from the earth; ionization increases; however there only few air molecules to ionize.

Therefore, the Upper Atmosphere has high percentage of ionized molecules than the lower atmosphere, higher the ionization density higher the refraction. Also, because of ionosphere's nonuniform composition and its temperature and density variations, it is stratified. Essentially, three layers make up the ionosphere (D, E and F) see figure 1 and figure 2.

It can be seen that all three layers of ionosphere vary in location and in ionization density with the time of the day. Ionosphere is denser during times of maximum sunlight.

D layer:

- Lowest layer of Ionosphere.
- Located approximately between 50km to 100km above earth's surface.

- Being farthest from the sun it has little ionization; therefore, it has little effect on propagation of radio waves.
- The amount of ionization density in D layer depends on altitude of sun above the horizon. Therefore it disappears at night.
- It reflects VLF and LF
- It absorbs MF and HF

E layer:

- It is located between 100km to 140km approximately above earth's surface
- E layer has maximum density at noon
- As with D layer it totally disappears at night
- E layer aids MF Surface wave propagation and reflects HF waves during day time
- When there is an increase in ionization density there is an improvement in Radio wave propagation

F layer:

- F layer is made up of two layers F_1 and F_2
- During day time F_1 is located between 140km to 250km approximately above earth's surface; the F_2 layer is located between 250km to 300km approximately above earth's surface during winter and approximately between 200km to 250km above earth's surface in summer. During the night F_1 layer combines with F_2 layer to form single layer
- F_1 layer absorbs and attenuates HF waves, whereas F_2 refract waves back to eart

PRE-LAB:

How Ionosphere helps Radio Wave Propagation?

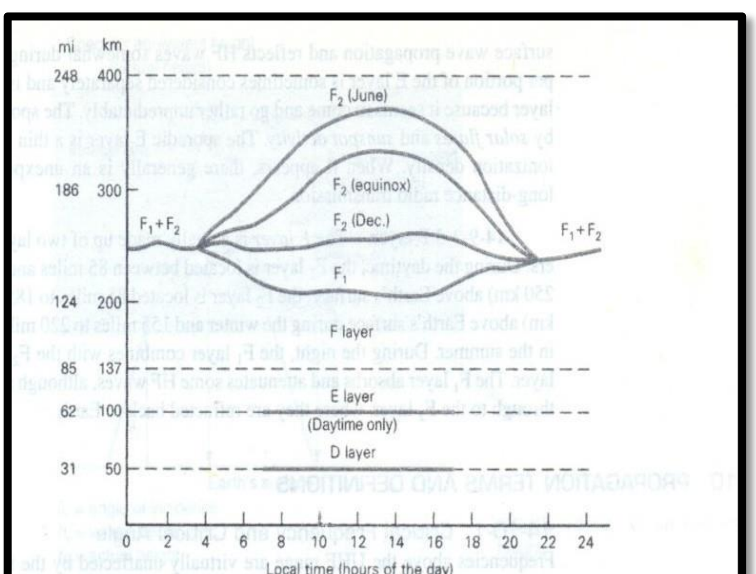


Figure 1

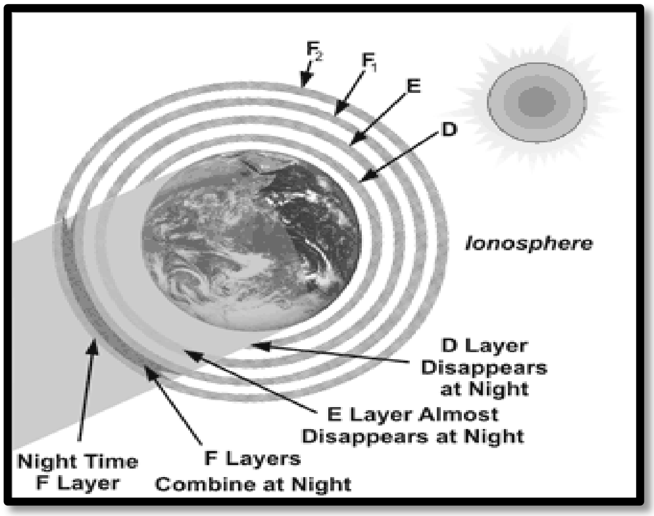


Figure 2

TASK:

1. Watch, "**Explore the Earth's Ionosphere with NASA and Google**" on you tube to gain the better understanding of the task to performed.
2. Download and Install Google Earth from http://www.google.com/earth/index.html.
3. Visit the site http://sol.spacenvironment.net/~ionops/.
4. Click the link, Earth Space 4-D global 4-D ionosphere.
5. Now Download ES4D KML files to your computer.
   - Recent total electron content
   - Earlier 24 Hours TEC Movie
6. Double-click or drag-drop the files selected above onto the Google Earth application icon.
7. In Google Earth, select **Karachi** on the globe for Earlier 24 Hours TEC Movie.
8. Under the **View** option in Google Earth, Select **Sun** and **Atmosphere** options.
9. Activate the time line by clicking on the Arrow on the slide bar.

Observation and Inference:

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Deliverables:

Screen shot of the Earlier 24 Hours TEC on Google Earth.

LAB SESSION 06

OBJECT:-

Analysis of Modulation Techniques for LEO Satellite Downlink Communications.

EQUIPMENT REQUIRED:

1) Personal Computer equipped with Pentium -4 or above processor.
2) Simulation software (MATLAB, C, C++).

THEORY:-

The discussion explains the methodology and the simulation results of the performances of modulation techniques under the implications of highly dynamic LEO satellite downlink. Modulation schemes that can possibly serve the objectives are the phase shift keying type modulations. Hence, the performance of binary phase shift keying (BPSK), quadripbase shift keying (QPSK), offset QPSK (OQPSK) have been investigated through simulations considering the LEO satellite communication downlink channel properties. The modulators and demodulators are synthesized using computer programs. The simulations demonstrated the necessity of applying non-coherent demodulators in order to fight with the multipath fading present in the downlink channel. When LEO communication is considered, reliability and robustness of the link should have the highest priority. Therefore, achieving high data rates has to be accompanied by a robust and reliable system. In order to study the performance of various modulation schemes, it is essential to understand clearly the constraints applied by tbe.LE0 communication link. Hence, the characteristic properties of downlink have to be examined carefully, which was one of the necessary parts of the research.
Modulation schemes that can possibly serve the objectives are the phase shift keying type modulations. Hence, the performance of binary phase shift keying (BPSK), quadri-phase shift keying (QPSK), offset QPSK (OQPSK) have been Therefore synthesized demodulators need to cover these two crucial circuits. Final objective was to compare the performances of the mentioned modulation schemes under LEO satellite communication environment and, if it is possible, to demonstrate better one or ones that might be used in future mission.

Simulated Circuits & Results

BPSK

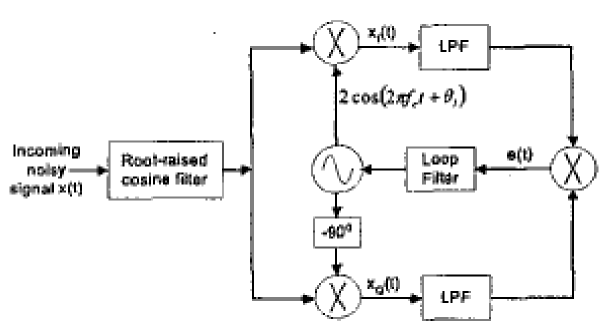
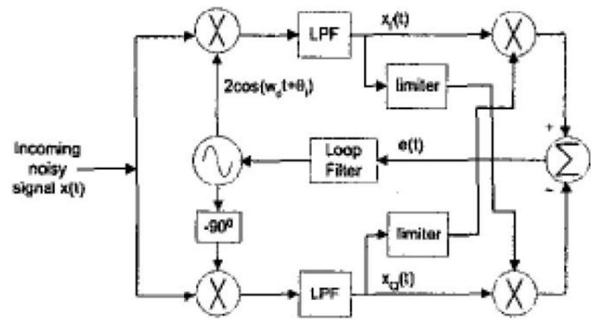


Fig 1 BPSK Costas loop demodulator

QPSK



FJg J QPSK hllfd limited Coslas loop

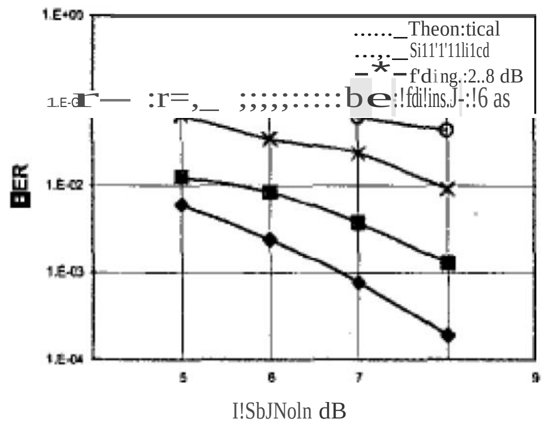
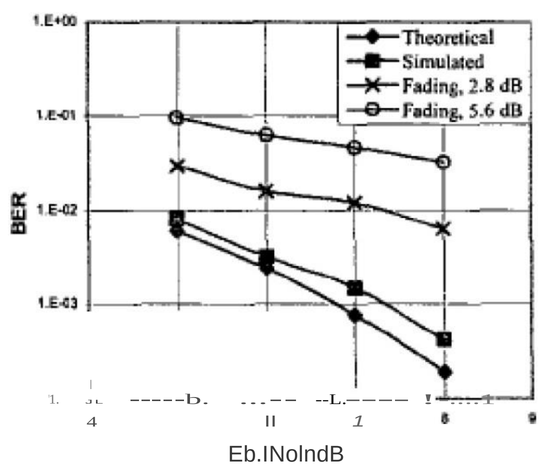


Fig 8 Performance curves of BPSK



Flg *9* Perfo.nncutce Clli'Ves of QPSK

LAB SESSION 07

EFFECTS AND IMPACTS OF RAIN ATTENUATION

OBJECT:-

Determine the value of Percentage time with respect to Attenuation, Elevation angle with respect to Attenuation and Height above mean sea level with respect to Attenuation with user defined values of height above sea level, the rain height, the elevation angle and rain rate.

THEORY:

Radio propagation is the behavior of radio waves when they are transmitted, or propagated from one point on the Earth to another, or into various parts of the atmosphere. As a form of electromagnetic radiation, like light waves, radio waves are affected by the phenomena of reflection, refraction, diffraction, absorption, polarization and scattering.

Radio propagation is affected by the daily changes of water vapor in the troposphere and ionization in the upper atmosphere, due to the Sun. Understanding the effects of varying conditions on radio propagation has many practical applications; Rain Attenuation is one of them.

RAIN ATTENUATION:

Rain rate and rain attenuation predictions are one of the vital steps to be considered when analyzing a microwave satellite communication links at the Ku and Ka bands. Atmospheric effects play a major role in the design of satellite-to-earth links operating at frequencies above 10 GHz. Raindrops absorb and scatter radio waves, leading to signal attenuation and reduction of the system availability and reliability. The severity of rain impairment increases with frequency and varies with regional locations.

The rate at which the rain water would get accumulated in a rain gauge in the area of interest is called rain rate. Rain attenuation is a function of rain rate. It is calculated in percentage time. A percentage time is generally of a year.

Specific attenuation
Specific attenuation α is given by:

$$\alpha = a\ Rp\ b \text{ dB/km}$$

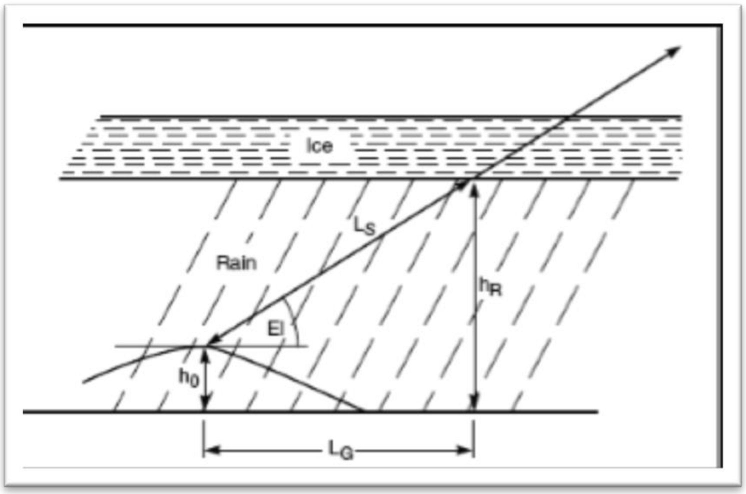
where ‘a’ and ‘b’ depend upon frequency and polarization.

Total attenuation

Total attenuation, denoted by A is given by:

$$\mathbf{A = \alpha\, L\ dB}$$

where L is the effective path length of the signal through rain.



$$\mathbf{Ap = a\ Rp\ b\ Ls\ rp\ dB}$$

Here,

Ls= Slant Height and it depends upon the antenna angle of elevation θ and rain height.

hr = Rain Height at which freezing occurs

L_G = Horizontal projection of Ls

The effective path length L is given by:

$$\mathbf{L = Ls\ rp}$$

where rp is the reduction factor of percentage time p and LG.

$$\mathbf{LG = Ls\cos El}$$

Therefore **rain attenuation** is;

$$\mathbf{Ap = a\ Rp\ b\ Ls\ rp\ dB}$$

RESULT:-

LAB SESSION 08

OBJECT:-

- Evaluation of SNR in Satellite Links.
- To calculate the Carrier to noise ratio for uplink and downlink and also the overall carrier to noise ratio.

EQUIPMENT REQUIRED:

1) Personal Computer equipped with Pentium -4 or above processor.
2) Simulation software (MATLAB, C, C++).

THEORY:-

The important parameter for a communication system is the signal to noise ratio. It is often stated that the carrier to noise ratio is C/N. C is just the available signal power at the receiving antenna terminals and N the available noise power at the same point.

The carrier power and for the noise power we get:

$$\frac{C}{N} = \frac{P_t G_t G_r}{L_s k T_s B_n} \qquad (1)$$

This equation is often expressed in logarithmic terms and forms the basis for the link budget. Often two or more terms in (1) are combined. G_r/T_s is one example.

Eq 1 is sometimes expressed as C/N_o. In this case the noise bandwidth in the denominator on the right side is excluded. (1) in logarithmic terms:

$$\frac{C}{N}\,[\mathrm{dB}] = P_t\,[\mathrm{dBW}] + G_t\,[\mathrm{dBi}] + G_r\,[\mathrm{dBi}] - L_s\,[\mathrm{dB}] - K\,[\mathrm{dB}] - T_s\,[\mathrm{dBK}] - B_n\,[\mathrm{dBHz}] \qquad (2)$$

Ls could include Polarization Loss, Pointing Loss, Atmospheric Attenuation and so on. What you need to take into account depend upon the frequency.

Ls = FSL + AML + RFL + PL + AA

FSL = Freespace loss, AML = Antenna Misalignment loss, RFL=Receiver Feeder loss, PL=Polarization Loss, AA = Atmospheric Absorption**.**

Carrier to Noise Ratio – Uplink

CNRu=EIRPu+GTRu-Lossu+228.6

Carrier to Noise Ratio – Downlink

CNRd=EIRPd+GTRd-Lossd+228.6

Overall Carrier to Noise Ratio

CNRoverall=CNRu *CNRd / (CNRu+CNRd)

RESULT:

LAB SESSION 09

OBJECT:-

Analysis of Link Budget Equation.

EQUIPMENT REQUIRED:-

1) Personal Computer equipped with Pentium -4 or above processor.
2) Simulation software (MATLAB, C, C++).

THEORY:-

A link budget is an accounting of all the gains and losses in a transmission system. The link budget looks at the elements that will determine the signal strength arriving at the receiver. The link budget may include the following items:

• Transmitter power.
• Antenna gains (receiver and transmitter).
• Antenna feeder losses (receiver and transmitter).
• Path losses.
• Receiver sensitivity (although this is not part of the actual link budget, it is necessary to know this to enable any pass fail criteria to be applied.

Where the losses may vary with time, e.g. fading, and allowance must be made within the link budget for this - often the worst case may be taken, or alternatively an acceptance of periods of increased bit error rate (for digital signals) or degraded signal to noise ratio for analogue systems.

Received power (dBm) = Transmitted power (dBm) + gains (db) - losses (dB)

The starting point is, that the satellite transmits P_t [W] to the environment. The power is transmitted in all directions, thus spreading out on an imaginary sphere of radius R. Then the power flux density [W/m^2] must be:

$$S = \frac{P_t}{4\pi R^2} \quad \frac{W}{m^2} \qquad (1)$$

The power received by an antenna with an effective area A_{eff} is:

$$P_{avr} = S \cdot A_{eff} = \frac{P_t}{4\pi R^2} \cdot A_{eff} \quad W \qquad (2)$$

P_{avr} is the available power from the receiver antenna, A_{eff} is equal to the actual physical area of the parabola times the efficiency of the antenna (η):

$$A_{eff} = A \cdot \eta = \pi \frac{D^2}{4} \eta \quad m^2 \tag{3}$$

D is the diameter of the parabolic dish.

The area of an antenna is very easy to understand when we talk about a parabola, as in this case - but it is possible to find a general relationship between the gain of an antenna and the effective area. This is:

$$G_i = \frac{4\pi\, A_{eff}}{\lambda^2} \Rightarrow A_{eff} = G_i \frac{\lambda^2}{4\pi} \quad m^2 \tag{4}$$

G_i is the gain relative to an isotropic antenna (an antenna transmitting equally in all directions). The gain of the antenna is just a measure of how good it is to concentrate the radiated power in a certain direction. The efficiency is included in G_i. λ is the wavelength.

Combining (2) and (4):

$$P_{avr} = \frac{P_t}{4\pi\, R^2} G_{ir} \frac{\lambda^2}{4\pi} = \frac{P_t\, G_{ir}}{\left(\frac{4\pi R}{\lambda}\right)^2} \tag{5}$$

G_{ir} is the gain of the receiver antenna. P_t was the power radiated by the satellite antenna in all directions. Usually we use a directional antenna, which concentrates the power in one direction. In that case we talk about the Effective Isotropic Radiated Power (EIRP). Clearly this is a much better idea. This means that the EIRP is substituted for P_t. The EIRP is given by:

$$EIRP = P_a \cdot G_{is} \quad W \tag{6}$$

Where P_a is the power supplied to the transmitter antenna terminals and G_{is} is the gain of the transmitter antenna.

Combining (5) and (6):

$$P_{avr} = \frac{P_a\, G_{is}\, G_{ir}}{\left(\frac{4\pi R}{\lambda}\right)^2} \quad W \tag{7}$$

The denominator is usually called the free space loss but it is really a result of the spreading of the transmitted power. We will use the term L_s:

W

$$P_{avr} = \frac{P_a\, G_{is}\, G_{ir}}{L_s} \quad W \tag{8}$$

Where,

$$L_s = \left(\frac{4\pi R}{\lambda}\right)^2 \tag{9}$$

When we look at actual links we will encounter other losses. They are taken into account by adding several other L's. This could be the attenuation in the atmosphere (L_a), polarization loss (L_p) and others.

What we have found now is the available signal power at the antenna terminals. Unfortunately there is noise as well.

RESULT:-

LAB SESSION 10

RELATIONSHIP BETWEEN ALTITUDE AND SATELLITE ANTENNA DIAMETER FOR LINK BUDGETING

OBJECT:

"To obtain a plot of the relationship between the Height of the satellite i.e. Orbital Altitude and the Satellite Antenna Diameter for the parameters achieved during Link budget Analysis"

THEORY:

SATELLITE ALTITUDE:

Different satellites have different orbits depending upon their advantages and disadvantages. These types of orbits help in classifying the use of satellite for different communication purposes. Following are some of the types mentioned according to their characteristics:

Low Earth Orbits (LEO)
They rotate 200 to 1200 Km above the Earth with a single orbit taking approximately 1.5 hour to complete. These satellites have "Simple launch vehicles" which can be used to place large masses' satellites into orbit. Other advantages include low packet delay and less transmission power. The disadvantage of LEO Satellites include very Short period of life as compared to Geo Synchronous and Geo Stationary satellites. Moreover, special handover mechanisms are required and thus more satellites to cover the Earth.

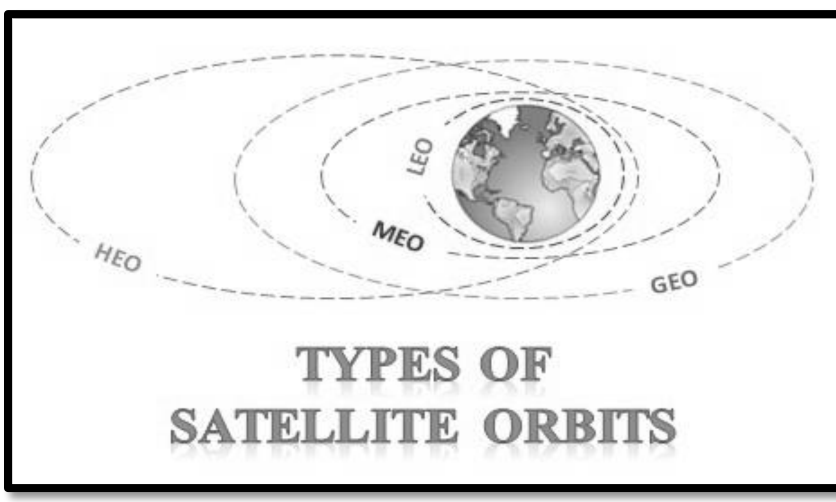


Figure 1: Satellite Orbits

Geo Synchronous Orbits: (Highly Elliptical Orbit)
Their period of rotation is exactly similar to the period of rotation of the Earth i.e. 35286 km. This clearly shows that such satellites would need 24 hours to complete a single rotation. The rotation is around equator near latitudes and the orbit is not the equatorial plane. Geo Synchronous Satellites, due to their position, observe the full hemisphere of the Earth. Satellites in these orbits have a

relatively poor resolution and activities around the poles are difficult to monitor. These satellites are useful for Hurricanes, Cyclones monitoring and Weather forecasting

Geo Stationary Orbits:
They are positioned over the Earth's equator so they don't move North or South during the day and the rotation above the Earth's surface is similar to that of the geosynchronous satellites. It is possible to cover almost all parts of the earth with just 3 geo satellites. They need space shuttle or Arianne Rocket to launch and the power requirements are greater as compared to LEO satellites and large antennas are required.

Medium Earth Obits (MEO):
The MEO satellite operates at about 5000 to 12000 km away from the earth's surface. These satellites provide fewer handovers as compared to LEO and less complex design. But higher power requirements and special antennas make it difficult to be used in communication purpose

SATELLITE ANTENNA DIAMETER AND FREQUENCY RANGE:

Foot print of a satellite:

The process starts at an earth station where an installation is designed to transmit and receive signals from a satellite in orbit around the earth where it sends information in the form of very high power signal having high frequency which is in GHz range to satellites.

The area which receives a signal of useful strength from the satellite is known as the satellite's footprint.

The transmission system from the earth station to the satellite is called the **uplink**, and the system from the satellite to the earth station is called the **downlink**.

Frequency range and antenna diameter:

There is an inverse relationship between frequency and wavelength from the light equation. So, when frequency increases, wavelength decreases. As wavelength increases, we require larger antennas to gather the signal.

C-band satellite transmissions occupy the 4 to 6 GHz frequency range. The minimum size of an average C-band antenna is approximately 2-3 meters in diameter.

Ku-band satellite transmissions occupy the 12 to 14 GHz frequency range. A smaller antenna can be used to receive the minimum signal strength. Ku-band antennas can be as small as 18 inches in diameter.

Ka-band satellite transmissions occupy the 20 to 30 GHz frequency range. These very high frequency transmissions mean very small wavelengths and very small diameter receiving antennas.

A. Equation of Interest:
The relationship of the Antenna Diameter and Orbital Height can be given using the Equation:

$$\textbf{Antenna diameter} = \textbf{Altitude x } [(C/No*32/\eta*k*Ts/EIRP)]^{1/2}$$

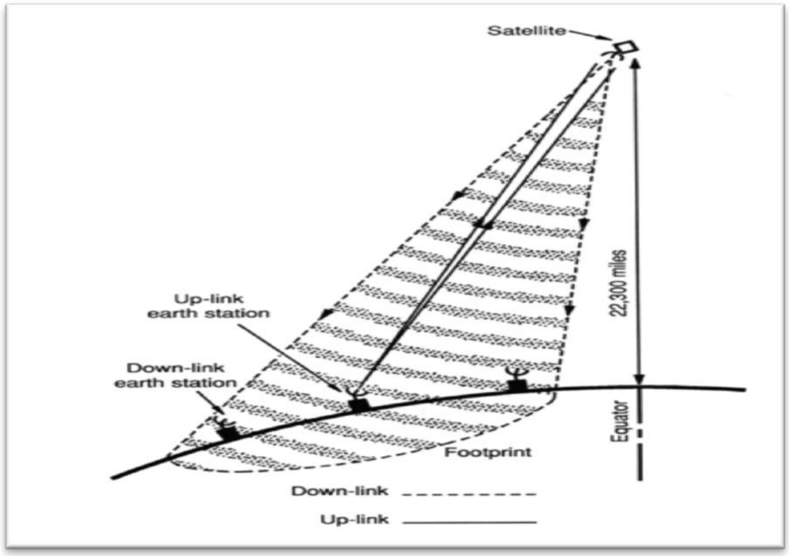


Figure 2: Satellite Footprint with respect to Height

RESULT:

The Lab is an extension of the Link Budgeting analysis studied in Lab session 8 and 9. It is evident that the Diameter increases as the satellite moves at the higher orbital Position which means that in order to maintain the foot print for different altitudes, the Diamter of the satellite antenna must be increased.

FURTHER TASK:

Plot the Orbital Height for the Paraboloid Reflector using Horn Feed antennas. Same task can be done for different types of antennas used in Satellite Communication Systems forthe desired Link Budgeting analysis

LAB SESSION 11

OBJECT:-

Analysis of a Direct Sequence Spread Spectrum (DSSS) Technique.

EQUIPMENT REQUIRED:

1) Personal Computer equipped with Pentium -4 or above processor.
2) Simulation software (MATLAB, C, C++).

THEORY:-

In satellite communications, spread-spectrum techniques offer several advantages because they have the inherent capability of reducing multipath fading and intra-system as well as inter-system interference. Spread-spectrum techniques also permit easy multiple access in the form of CDMA.

An approach to spread spectrum is the Direct Sequence Spread Spectrum Technique. DSSS involves multiplying the baseband data signal by a wider bandwidth signal, which takes the form of a pseudorandom binary code. The advantage if it is resistance to signal jamming.

Direct sequence contrasts with the other spread spectrum process, known as frequency hopping spread spectrum, or frequency hopping code division multiple access (FH-CDMA), in which a broad slice of the bandwidth spectrum is divided into many possible broadcast frequencies. In general, frequency -hopping devices use less power and are cheaper, but the performance of DS-CDMA systems is usually better and more reliable.

Direct sequence spread spectrum, also known as direct sequence code division multiple access (DS-CDMA), is one of two approaches to spread spectrum modulation for digital signal transmission over the airwaves. In direct sequence spread spectrum, the stream of information to be transmitted is divided into small pieces, each of which is allocated across to a frequency channel across the spectrum. A data signal at the point of transmission is combined with a higher data-rate bit sequence (also known as a chipping code) that divides the data according to a spreading ratio. The redundant chipping code helps the signal resist interference and also enables the original data to be recovered if data bits are damaged during transmission.

SYSTEM MODEL:-

Consider the system below (Fig-1) where b[n] is the message signal, s[n] is the spreading function (or pseudorandom code), q[n] is the transmitted bits, r[n] are the received bits.

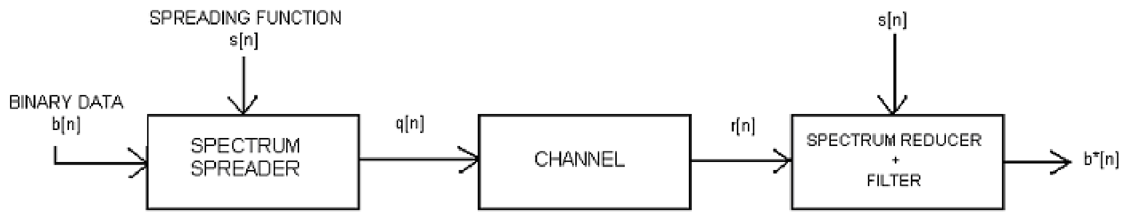
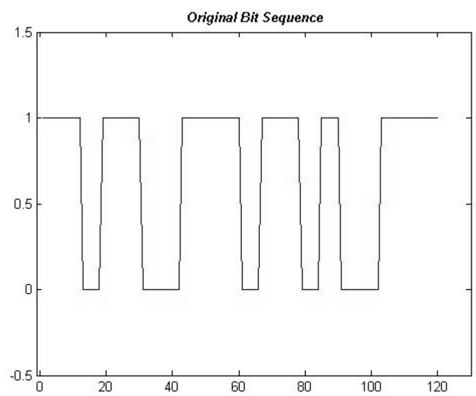
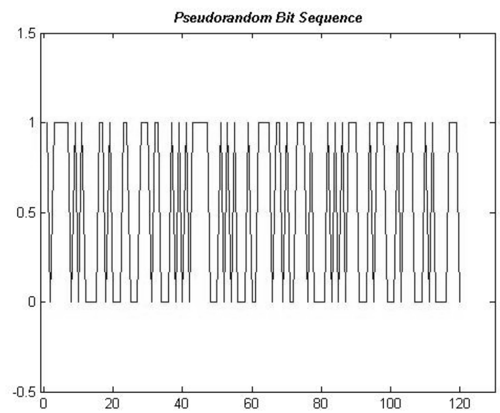


Fig-1: System Model

RESULT:-





LAB SESSION 12

OBJECT:-

Analysis of a Frequency Hopping Spread Spectrum (FHSS) Technique.

EQUIPMENT REQUIRED:-

1) Personal Computer equipped with Pentium -4 or above processor.
2) Simulation software (MATLAB, C, C++).

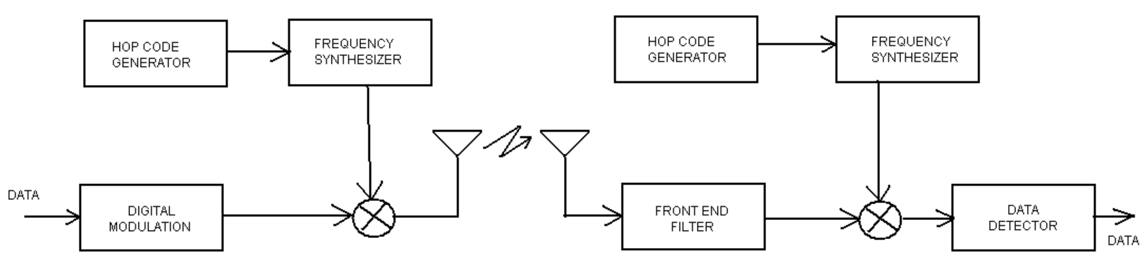
THEORY:-

In satellite communications, spread-spectrum techniques offer several advantages because they have the inherent capability of reducing multipath fading and intra- system as well as inter- system interference. Spread-spectrum techniques also permit easy multiple access in the form of CDMA.

Another approach to spread spectrum is the Frequency Hopping (FH). In FHSS the spreading code is used to control a frequency agile local oscillator, the output of which is used to up- convert the modulated IF carrier to a higher frequency band. The resulting RF output is referred to as a hopping sequence. A replica of the spreading code is applied at the receiver to recover the wanted information.

SYSTEM MODEL:-

Consider the system below:-



The Hop Code generator generates the hopping pattern of the FHSS system. A similar hopping pattern is at the receiver.

RESULT:-

LAB SESSION 13

OBJECT:

To study Julian dates, generate a MATLAB code for its calculation and familiarize with the built-in Julian date functions in MATLAB.

DELIVERABLES:

1. Generate MATLAB code for finding Julian day.
2. Use MATLAB functions for Julian dates.

TOOLS:

MATLAB

- Matlab has built in functions for julian dates where normal dates can easily be converted into julian dates.These functions are:
- jd = juliandate(y,mo,d)
- jd = juliandate(y,mo,d,h,mi,s) %when hours,mins & seconds are specified

THEORY:

Universal Time Coordinated:

Coordinated Universal Time (UTC) is the basis for civil time in many places worldwide. Many devices for measuring and showing time use this 24-hour time scale, which is determined using highly precise atomic clocks. Time zones around the world are expressed as positive or negative offsets from UTC. The hours, minutes, and seconds that UTC expresses is kept close to the mean solar time at the Earth's prime meridian (zero degrees longitude) located near Greenwich, England. UTC is often casually interchanged with Greenwich Mean Time (GMT) when referred to without counting precise accuracies. However, it is important to know that there are differences between these terms, particularly when considering fractions of a second.

UTC divides time into days, hours, minutes and seconds. It is converted into fractional days as:

$$UT_{day} = \frac{1}{24}\left(hours + \frac{minutes}{60} + \frac{seconds}{3600}\right)$$

It is converted into degrees as:

$$U\text{��}^{\circ} = 360^{\circ} \times$$

$$UT_{day}$$

Julian Date:

The Julian Date (JD) of any instant is the Julian day number for the preceding noon plus the fraction of the day since that instant. Julian Dates are expressed as a Julian day number with a decimal fraction added. This system was proposed by J. J. Scaliger in 1583, so the name for this system derived from Julius Scaliger, not Julius Caesar.

Historical Julian dates were recorded relative to GMT or Ephemeris Time, but the International Astronomical Union now recommends that Julian Dates be specified in Terrestrial Time, and that when necessary to specify Julian Dates using a different time scale, that the time scale used be indicated when required, such as JD. The fraction of the day is found by converting the number of hours, minutes, and seconds after noon into the equivalent decimal fraction. Time intervals calculated from differences of Julian Dates specified in non-uniform time scales, such as Coordinated Universal Time (UTC), may need to be corrected for changes in time scales (e.g. leap seconds).

PRE-LAB TASK:

Write a brief note on the evolution of the modern calendar and define the following:

- Universal time coordinated
- Civil year
- Tropical year
- Mean sun
- Mean solar day

RESULTS:

LAB SESSION 14

OBJECT:

To simulate model and analyze antenna look angles of geostationary communications satellite.

TOOLS:

MATLAB

THEORY:

The co-ordinates to which an earth station antenna must be pointed in order to communicate with a satellite are called the antenna look angles. In order to optimize the performance of a satellite communications system, the direction of maximum gain of an earth station antenna (referred to as boresight) must be pointed directly at the satellite. The azimuth angle and the elevation angle are determined so as to ensure that an earth station antenna is aligned. Azimuth angle and elevation angle are jointly referred to as the antenna look angles.

Elevation angle is the vertical angle formed between the direction of travel of an electromagnetic wave radiated from an earth station antenna pointing directly toward a satellite and the horizontal plane. The smaller the angle of elevation, the greater the distance a propagated wave must pass through Earth’s atmosphere. As with any wave propagated through Earth’s atmosphere, it suffers absorption and may severely contaminated by noise. Consequently, if the angle of elevation is too small the wave may deteriorate to the extent that it no longer provides acceptable transmission quality. Generally, 5^0 is considered as the minimum acceptable angle of elevation.

Azimuth is the horizontal angular distance from a reference direction, either the southern or northern most point of the horizon. It is the horizontal pointing angle of an earth station antenna [3]. For navigation purposes, azimuth angle is usually measured in a clockwise direction in degrees from true north. However for satellite earth stations in the Northern Hemisphere and satellite vehicles in geosynchronous orbits, azimuth angle is generally referenced to true south (i.e. 180^0). Angle of elevation and azimuth angle both depend on the latitude of the earth station and the longitude of both the earth station and the orbiting satellite.

With geosynchronous satellites, the look angles of earth station antenna only need to be adjusted once as the satellite will remain in a given position permanently, except of occasional minor variations. Low earth orbit (LEO) satellites “rise” and “set” again and again relative to a single location on the ground, as result of this there is need for continuous tracking of a LEO satellite. In most cases, it is impractical to install an antenna that tracks the movements of these spacecraft, so omnidirectional antennas are normally used.

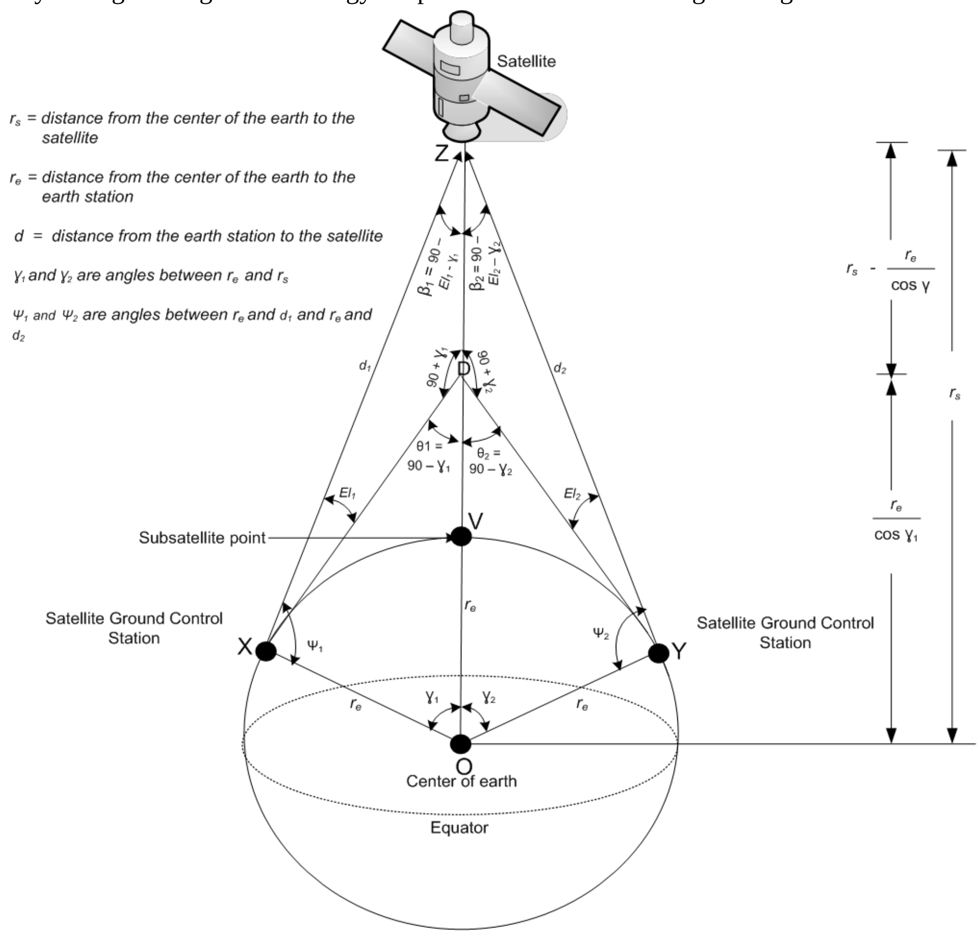


Figure 1 Geometry of look angle determination

(a) Simulation of Range of Communication Satellite

In carrying out the simulation of the range of the satellite the equations [6] below are used:

$$d_1 = r_s\left[1+\left(\frac{r_e}{r_s}\right)^2 - 2\left(\frac{r_e}{r_s}\right)\cos\gamma_1\right]^{1/2} \quad (1)$$

$$d_2 = r_s\left[1+\left(\frac{r_e}{r_s}\right)^2 - 2\left(\frac{r_e}{r_s}\right)\cos\gamma_2\right]^{1/2} \quad (2)$$

Where d_1 is the distance from the Satellite Ground Control Station X to the Satellite and d_2 is the distance from the Satellite Ground Control Station Y to the Satellite.

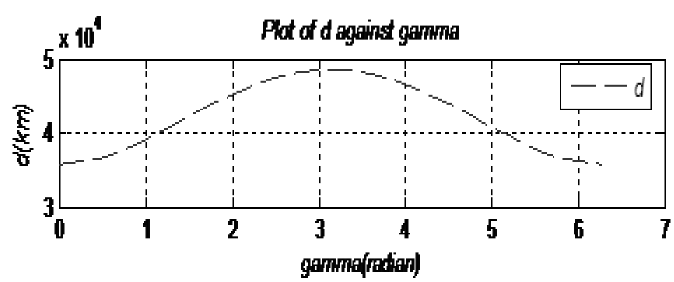


Figure 2 Plot of Range determination

(b) Simulation of the Elevation Angle of the Satellite

The equations [6] below are used for the simulation of elevation angle and they are stated below.

$$El_1 = \sin^{-1}\left[\frac{\left(r_s - \frac{r_e}{cos(\gamma_1)}\right)\sin(90+\gamma_1)}{d_1}\right] = \sin^{-1}\left[\frac{(r_s cos(\gamma_1) - r_e)}{d_1}\right] \quad (3)$$

$$El_2 = \sin^{-1}\left[\frac{\left(r_s - \frac{r_e}{cos\gamma_2}\right)\sin(90+\gamma_2)}{d_2}\right] = \sin^{-1}\left[\frac{(r_s cos(\gamma_2) - r_e)}{d_2}\right] \quad (4)$$

In Figure 3, $gamma$ is the angle between orbital radius r_s and Earth's radius r_e, θ is the angle between local horizon and orbital radius, El is the elevation angle, $beta$ is the angle between d (distance from the earth station to the satellite) and orbital radius.

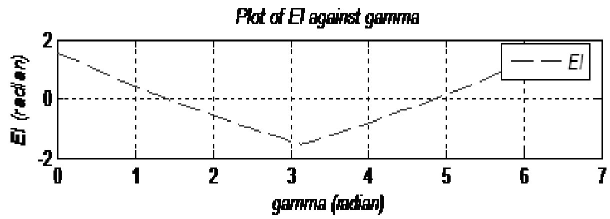


Figure 3 Plots of Elevation Angle

(c) Simulation of the Azimuth Angle of the Satellite

Simulation of the azimuth angle of the satellite is carried out using the equation below.

$$\tan A = \frac{\tan|l_s - l_e|}{\sin(L_e)}, \text{then } A = tan^{-1}\left[\frac{\tan|l_s - l_e|}{\sin(L_e)}\right] \quad (5)$$

RESULTS & ANALYSIS:

Acknowledgement:
"Simulation modelling and analysis of antenna look angles of geostationary communications satellite"
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