MASTER CONTROL FACILITY

DEPARTMENT OF SPACE, MCF – ISRO, Salagame Road, Hassan - 573201

INTERNSHIP REPORT

BACHELOR OF ENGINEERING

in

ELECTRONICS AND COMMUNICATIONS

by

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Under Supervision of

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Preface and acknowledgement

First, I would like to express my gratitude to **Pankaj Damodar Killedar, Director, Master Control Facility (MCF/ISRO)** and **Mr. SK Khuba, Head of PPEG at MCF – ISRO**, for providing me with the opportunity to intern within the organization.

I would like to express my deepest gratitude to the **PPEG and TNH Dept of MCF-ISRO**. Additionally, I am immensely thankful **to Mrs. Anita K.A** for her unwavering support and guidance throughout my journey at MCF – ISRO.

I would like to express my gratitude to all the wonderful people I had the pleasure of working with at **MCF – ISRO**. Their fun-loving spirit and remarkable dedication contributed to creating an enjoyable and productive working environment.

With immense gratitude and great pleasure, I wholeheartedly acknowledge the invaluable assistance of everyone at MCF.

I am highly indebted to Principal **Dr. Meenakshi M,** for the facilities provided to accomplish this internship**.**

I would like to thank my Head of the Department **Dr. Mahalinga V Mandi** for his constructive criticism throughout my internship.

I am extremely great full to my department staff members and friends who helped me in successful completion of this internship.

NITHIN P

ABSTRACT

<u>Organisation Information</u>:

Master Control Facility (MCF) at Hassan in Karnataka and Bhopal in Madhya Pradesh monitors and controls all the **Geostationary / Geosynchronous satellites** of ISRO, namely, **INSAT**, **GSAT**, **EOS**, **CMS** and **IRNSS** series of satellites. MCF provides overall radio visibility **coverage extending from Persian Gulf in the West to Australia in the East, a geo-arc of 150 degrees** which makes it ideal control centre in South Asian Region.

MCF has the expertise in operations of Indian Geosynchronous Space assets for **Communication**, **Navigation** and **Metrological Payloads**. All these geosynchronous satellites are being **monitored**, **operated** and **maintained** in the desired orbit**.**

<u>MCF Mission:</u>

- Effective & efficient **Monitoring** & **Control** of Communication, Navigation and Meteorological Spacecrafts from launch to end of life.
- Bring out continuous improvement and **automation** through developmental activities in Spacecraft and Ground Operations for Enhanced Services, Resource

MCF Capabilities:

- MCF is responsible for spacecraft operations starting from **Launch and Early Orbit Phase (LEOP)** of geosynchronous & IRNSS class of spacecraft, capable of Orbit Raising of spacecraft, that are injected into the **Geosynchronous Transfer Orbit (GTO)** or **sub-GTO** by the launch vehicle, **In-Orbit Testing (IOT)** of communication payloads operating in multiple frequency bands, meteorological, navigational and science payloads and subsequent On-Orbit Operations. MCF has the capability to handle **operations for Dual launches and dual injection** of spacecraft.
- MCF activities include round-the-clock **Tracking, Telemetry & Commanding (TT&C) operations**, and special operations like **Eclipse management, Station-keeping manoeuvres** and **Recovery actions** in case of contingencies. MCF interacts with User Agencies for effective utilization of the satellite payloads and to minimize the service disturbances.
- It also takes care of **decommissioning of spacecraft** to grave yard orbit towards the End -Of -life. To carry out these operations effectively, MCF Hassan is having an Integrated Facility consisting of Spacecraft Control Centres, Launch Control Centre, Mission Computer Network and TTC &R Ground Network of Satellite Control Earth Stations & Antennas.
- **Round-the-clock Operations:** Satellite **health monitoring** and **control**, **Station keeping manoeuvres**, **Eclipse Management**, **Spacecraft Contingency management**,
- **Flight Dynamics Activities**: Initial Phase **Orbit-Raising**, **Orbit maintenance** & **Colocation management**, **Space Situational Awareness** (SSA) activities for avoiding collision with space debris, Orbital Repositioning, Re-orbiting and De-commissioning of satellite at the End-Of-Life (EOL).
- **Telemetry, Tracking, Commanding and Ranging (TTC&R) & User-Services:** In-Orbit Testing (IOT) of payloads, User-services Support, Payload Interference Resolution & Geo-location of Interfering Source

Earth Station -3

- **Satellite Control Centre:** Spacecraft Control Centre (SSC) facilitates monitoring and control for all Spacecraft. The operations carried out from here are, Health Monitoring, Attitude Maintenance, Orbit and co-location Management, Eclipse Management, Contingency Handling, Payload Management, Performance Evaluation, Trend Analysis, **Balance Propellant Estimation**, **Solar Power Degradation Estimation**, Space Weather monitoring and alert etc.
- **Satellite Data Processing - Mission Computer Network:** Computer Systems are heart of MCF where all spacecraft data is collected, processed and distributed to clients at different operations areas spreading across MCF on real time as well as offline basis through a dedicated Mission network.
- Mission computer systems are configured in **server-client architecture over TCP/IP network**. Normally two setups of server configured for collecting same spacecraft data where one setup is called **prime chain** and another setup is called **backup chain**. If anyone chain server is down for any reason still data is available to second chain server and clients.
- Mission network is deployed across MCF in **star topology** through which all the computer systems are interconnected.

Satellite Data Processing - Mission Computer Network of Baseband System (mcf.gov.in)

Mission Analysis Room (MAR): MAR facilitates pre and post analysis of the mission data by dedicated team of subsystem engineers who analyse system performance / health and take necessary actions as per requirement including planned operations and anomalies. Trend analysis is carried out to understand the behaviour of each element of subsystem with statistical methods with comprehensive data of all the present and past missions using state of art analysis tools.

WEEKLY OVERVIEW OF INTERNSHIP ACTIVITIES

	DATE	DAY	NAME OF THE TOPIC/MODULE COMPLETED
1st WEEK	16/08/23	Monday	Facility Visit
	17/08/23	Tuesday	Overall Operation done at MCF
	18/08/23	Wednesday	Overview of Spacecraft Operations
	19/08/23	Thursday	Python and Machine Learning
	20/08/23	Friday	Network Programming and MySQL

	DATE	DAY	NAME OF THE TOPIC/MODULE COMPLETED
2nd WEEK	25/10/23	Wednesday	RF Systems and Sub System Tests
	26/1023	Thursday	Servo Motor and Control Systems
	27/10/23	Friday	Servo Motor, Control Systems and Antenna

	DATE	DAY	NAME OF THE TOPIC/MODULE COMPLETED
3rd WEEK	30/10/23	Monday	Baseband Systems
	31/10/23	Tuesday	In Orbit Testing (IOT)
	1/11/23	Wednesday	Instrumentation Laboratory
	02/11/23	Thursday	On-Board Thermal Systems
	03/11/23	Friday	Software Testing and Image Processing

	DATE	DAY	NAME OF THE TOPIC/MODULE COMPLETED
4th WEEK	06/11/23	Monday	Project
	07/11/23	Tuesday	Project
	08/11/17	Wednesday	Project
	09/11/17	Thursday	Project
	10/11/17	Friday	Project

1. Facility Visit

- I had the opportunity to visit the Master Control Facility (MCF) in Hassan, India. I was accompanied by Sudhakar Sir, who provided detailed explanations of the various facilities and operations at the MCF.
- Our first stop was the Command Station, where we learned about the health monitoring of Earth Station components such as High-Power Amplifiers (HPAs), Down Converters, Upconverters, and Switching Networks. The Command Station plays a crucial role in ensuring the smooth operation of the Geo-Synchronous and Geostationary Satellite by continuously monitoring its critical components.

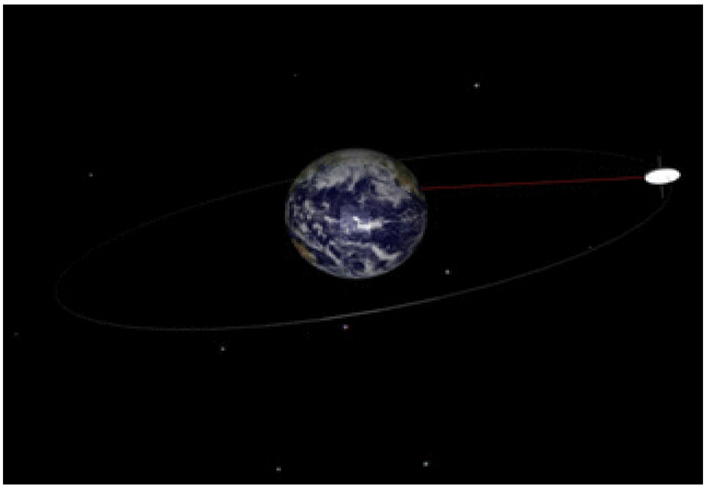
- Next, we visited the Baseband Division, where we gained insights into the signal processing involved in satellite communication. We learned how signals are received, digitally demodulated, bit synchronized, and phase synchronized before being processed further. We also gained an understanding of the uplink chain, where signals are sent to the Command Encoder, modulated, and transmitted to the Earth Station for up conversion.

- Finally, we visited the Earth Station itself, where we delved into the intricacies of antennas and their associated components. We learned about HPAs, Upconverters, waveguides, and other terms involved in antenna systems. The Earth Station is the heart of satellite communication, responsible for sending and receiving signals to and from satellites.

2. Overall Operation done at MCF

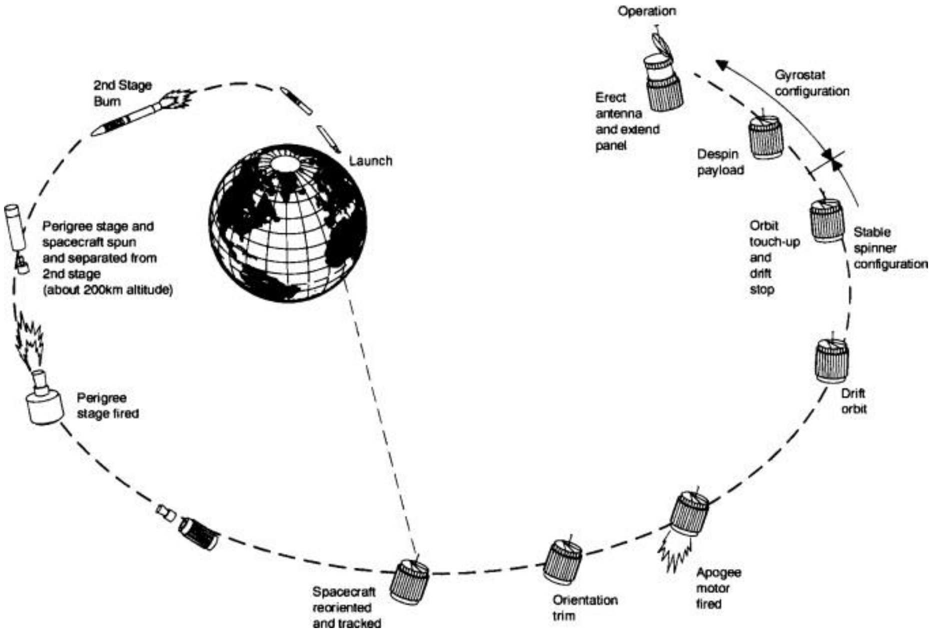
MCF is responsible for spacecraft operations starting from Launch and Early Orbit Phase (LEOP) of geosynchronous & IRNSS class of spacecraft, capable of Orbit Raising of spacecraft, that are injected into the Geosynchronous Transfer Orbit (GTO) or sub-GTO by the launch vehicle, In-Orbit Testing (IOT) of communication payloads operating in multiple frequency bands, meteorological, navigational and science payloads and subsequent On-Orbit Operations. MCF has the capability to handle operations for Dual launches and dual injection of spacecraft.

A geostationary orbit, also referred to as a geosynchronous equatorial orbit (GEO), is a circular geosynchronous orbit 35,786 km (22,236 mi) in altitude above Earth's equator, 42,164 km (26,199 mi) in radius from Earth's center, and following the direction of Earth's rotation.



The life cycle of a Geo-Stationary Satellite consists of three distinct phases:

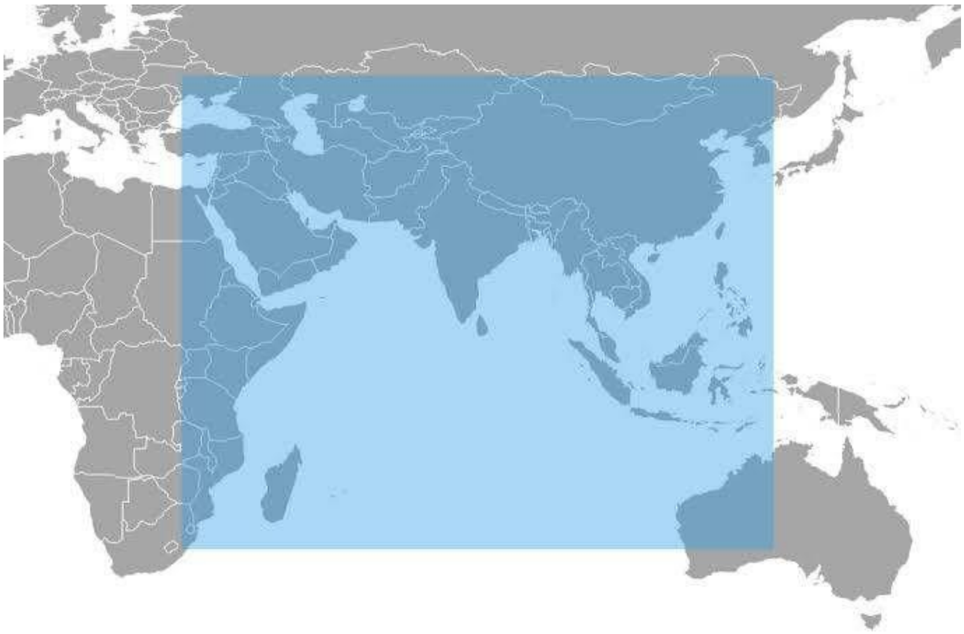
- Initial Phase (LEOP)
- On-orbit Phase (Normal Phase)
- End of Life phase (EOL)



Satellite Control Earth Stations (SCES) operating in C-band, Ku-Band & Ext C-Band, provide TTC&R support for the in-orbit satellites. During the LEOP support, MCF facilitates a global TTC&R network using Earth Stations at Hassan, Bhopal and hired stations at other parts of the globe. Capability to support TTC operations of Co-located Satellites using single antenna terminal has facilitated efficient utilization of ground hardware. Payload Support and In-Orbit Testing (IOT) of payloads in UHF, L, S, C, Ext-C, Ku and Ka bands are facilitated by MCF. High Throughput Satellites like GSAT-19 & GSAT-11 operations are facilitated with required ground-based beacon stations network.

Band	Frequency	Wavelength	Typical Application
Ka	27 – 40 GHz	1.1 – 0.8 cm	Rarely used for SAR (airport surveillance)
K	18 – 27 GHz	1.7 – 1.1 cm	rarely used (H_2O absorption)
Ku	12 – 18 GHz	2.4 – 1.7 cm	rarely used for SAR (satellite altimetry)
X	8 – 12 GHz	3.8 – 2.4 cm	High resolution SAR (urban monitoring,; ice and snow, little penetration into vegetation cover; fast coherence decay in vegetated areas)
C	4 – 8 GHz	7.5 – 3.8 cm	SAR Workhorse (global mapping; change detection; monitoring of areas with low to moderate penetration; higher coherence); ice, ocean maritime navigation
S	2 – 4 GHz	15 – 7.5 cm	Little but increasing use for SAR-based Earth observation; agriculture monitoring (NISAR will carry an S-band channel; expends C-band applications to higher vegetation density)
L	1 – 2 GHz	30 – 15 cm	Medium resolution SAR (geophysical monitoring; biomass and vegetation mapping; high penetration, InSAR)
P	0.3 – 1 GHz	100 – 30 cm	Biomass. First p-band spaceborne SAR will be launched ~2020; vegetation mapping and assessment. Experimental SAR.

Indian Regional Navigation Satellite System: The Indian Regional Navigation Satellite System (IRNSS), with an operational name of NavIC is an autonomous regional satellite navigation system that provides accurate real-time positioning and timing services. It covers India and a region extending 1,500 km (930 mi) around it, with plans for further extension. An extended service area lies between the primary service area and a rectangle area enclosed by the 30th parallel south to the 50th parallel north and the 30th meridian east to the 130th meridian east, 1,500–6,000 km (930–3,730 mi) beyond borders where some of the NavIC satellites are visible but the position is not always computable with assured accuracy. The system currently consists of a constellation of eight satellites, with two additional satellites on ground as stand-by.



NavIC coverage area

3. Orbit and Station keeping Operation

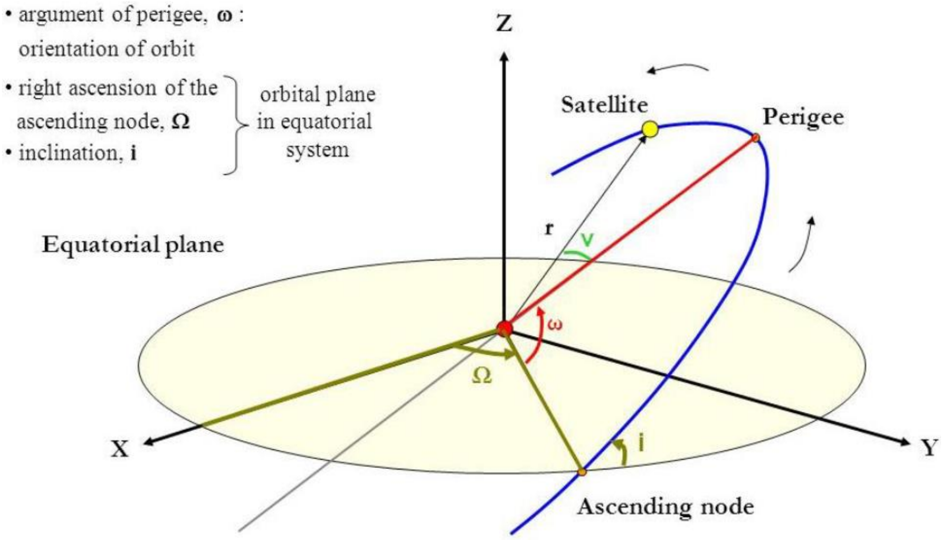
A typical geostationary orbit has the following properties:

Inclination: 0°

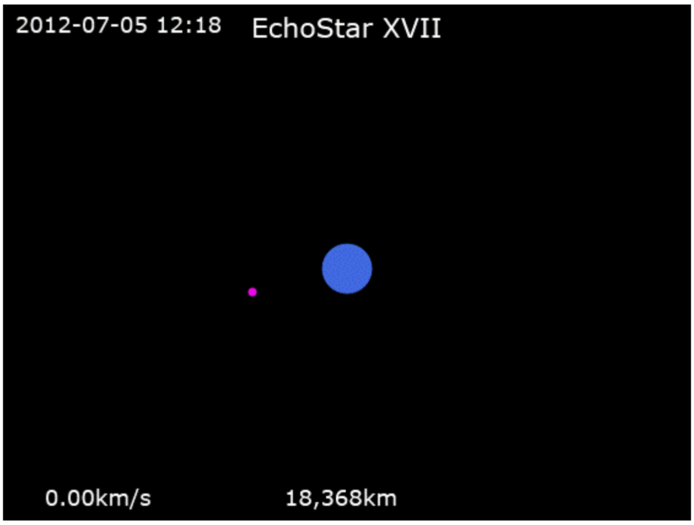
Period: 1436 minutes (one sidereal day)

Eccentricity: 0

Argument of perigee: undefined, **Semi-major axis**: 42,164 km



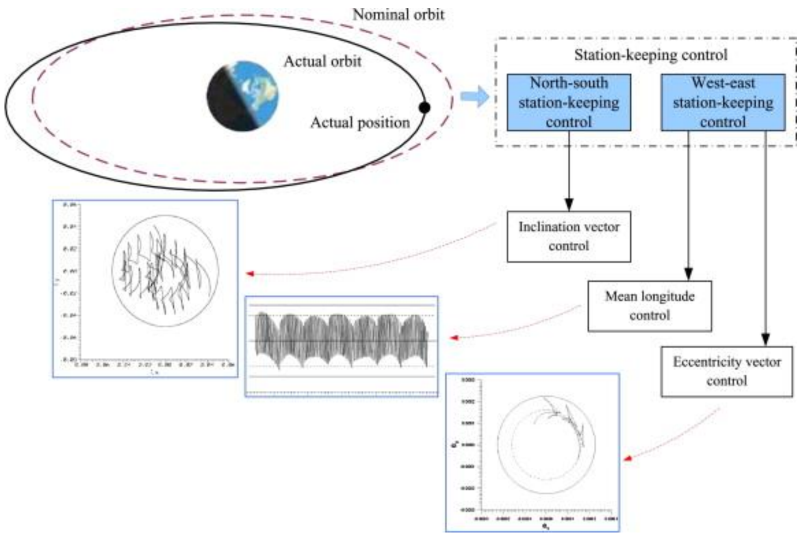
Geostationary satellites are launched to the east into a prograde orbit that matches the rotation rate of the equator. The smallest inclination that a satellite can be launched into is that of the launch site's latitude, so launching the satellite from close to the equator limits the amount of inclination change needed later. Additionally, launching from close to the equator allows the speed of the Earth's rotation to give the satellite a boost. A launch site should have water or deserts to the east, so any failed rockets do not fall on a populated area



An example of a transition from temporary GTO to GSO.

Satellites in geostationary orbit must all occupy a single ring above the equator. The requirement to space these satellites apart, to avoid harmful radio-frequency interference during operations, means that there are a limited number of orbital slots available, and thus only a limited number of satellites can be operated in geostationary orbit.

A combination of lunar gravity, solar gravity, and the flattening of the Earth at its poles causes a precession motion of the orbital plane of any geostationary object, with an orbital period of about 53 years and an initial inclination gradient of about 0.85° per year, achieving a maximal inclination of 15° after 26.5 years. To correct for this perturbation, regular orbital station keeping manoeuvres are necessary, amounting to a delta-v of approximately 50 m/s per year. A second effect to be taken into account is the longitudinal drift, caused by the asymmetry of the Earth – the equator is slightly elliptical. There are two stable equilibrium points (at 75.3°E and 108°W) and two corresponding unstable points (at 165.3°E and 14.7°W). Any geostationary object placed between the equilibrium points would (without any action) be slowly accelerated towards the stable equilibrium position, causing a periodic longitude variation.



4. Python Programming

Python is a general-purpose programming language that is easy to learn and use. It is used for a wide variety of applications, including web development, data science, machine learning, and artificial intelligence.

Python is a dynamically typed language, which means that variables do not need to be declared with a specific type. This makes Python code more concise and readable.

Python is also a highly interpreted language, which means that Python code is executed line by line. This makes Python code easy to debug and test.

We tried our hands with Python Programming and also built satellite Azimuth, Elevation entry Graphic User Interface.

Tkinter: Tkinter is the standard GUI toolkit that comes bundled with Python. It is a mature and stable toolkit, but it can be difficult to learn and use.

This code creates a simple GUI with a label, an entry field, and a button. When the button is clicked, the greet() function is called, which displays a personalized greeting based on the user's input in the entry field.

```
import tkinter as tk

# Create the main window

window = tk.Tk()

window.title("Simple GUI")

# Create a label and entry field

label = tk.Label(window, text="Enter your name:")

label.pack()

entry = tk.Entry(window)

entry.pack()

# Create a button and bind it to an event handler

def greet():

  name = entry.get()

  greeting_label = tk.Label(window, text="Hello, " + name + "!")

  greeting_label.pack()

button = tk.Button(window, text="Greet", command=greet)

button.pack()

# Start the main event loop

window.mainloop()
```

5.Machine Learning

Machine learning is a field of computer science that gives computers the ability to learn without being explicitly programmed. Machine learning algorithms are used to train computers to make predictions or decisions based on data.

There are three main types of machine learning algorithms: supervised learning, unsupervised learning, and reinforcement learning.

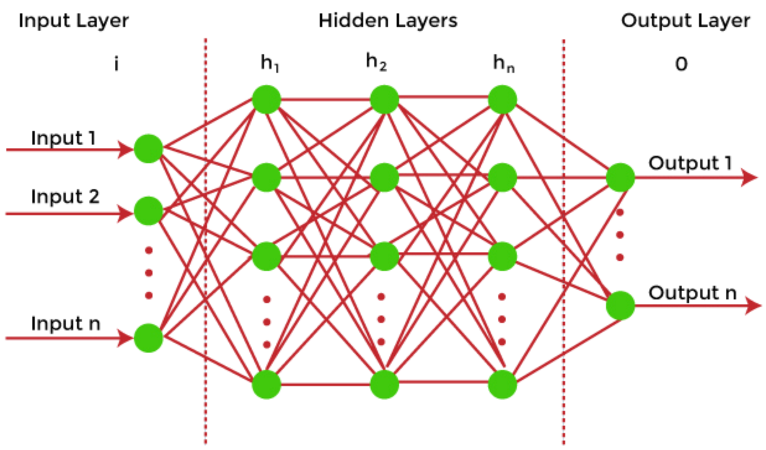
- Supervised learning algorithms are trained on data that has been labelled with the correct output. The algorithm learns to predict the output for new data based on the patterns it has learned from the training data.
- Unsupervised learning algorithms are trained on data that has not been labelled. The algorithm learns to find patterns in the data without any prior knowledge of the data.
- Reinforcement learning algorithms are trained by interacting with their environment. The algorithm learns to take actions that maximize its reward and minimize its punishment.

Neural Networks

Neural networks are a type of machine learning algorithm that is inspired by the structure and function of the human brain. Neural networks are made up of interconnected nodes, each of which performs a simple mathematical operation.

Neural networks can be trained to learn complex patterns in data. For example, neural networks can be used to recognize images, translate languages, and generate text.

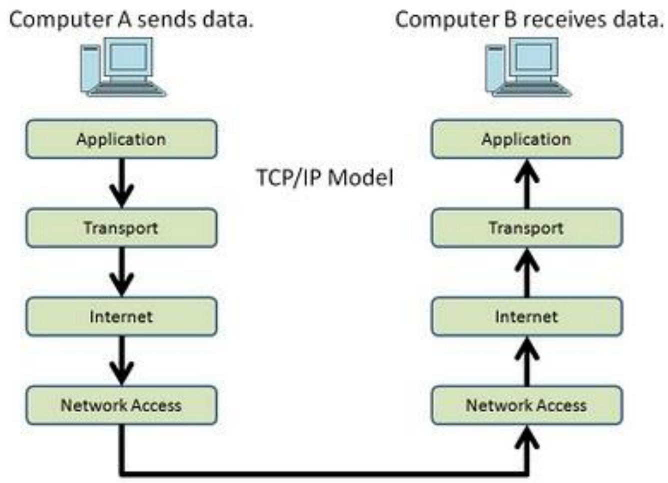
We learnt about various Mathematical models used in Machine Learning.



Neural Network

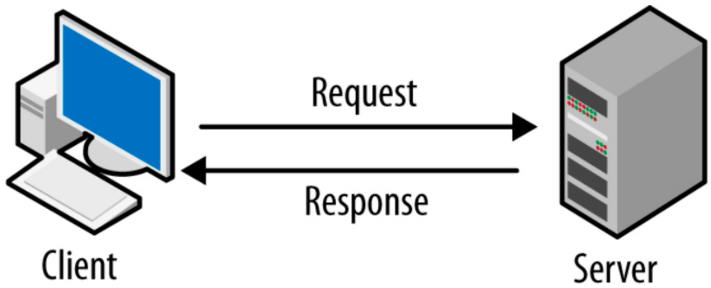
6.Networking with Java

Network computing using Java is a powerful tool that allows developers to create applications that can communicate over a network. Java provides a variety of classes and interfaces that make it easy to write network-based applications.

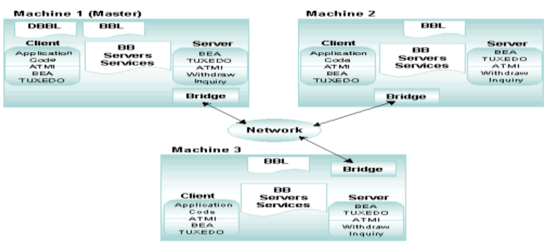


Java network programming can be used for a variety of tasks, including:

- Client-server applications: Client-server applications are applications in which a client computer connects to a server computer to request or receive data. Java is an ideal language for writing client-server applications because it is platform-independent and can be used to write applications that run on a variety of operating systems.



- Distributed applications: Distributed applications are applications that are spread out over multiple computers. Java is a good choice for writing distributed applications because it provides a number of features that make it easy to write applications that can communicate over a network, such as the Remote Method Invocation (RMI) API.



7.Web Applications Using HTML and CSS

HTML and CSS are the two cornerstones of web development. HTML (Hypertext Markup Language) is responsible for the structure and content of a web page, while

CSS (Cascading Style Sheets) is responsible for the presentation and style of a web page.
Together, HTML and CSS can create visually appealing and interactive web pages that can be accessed by users all over the world.

HTML:

HTML is a markup language that uses a set of tags to define the structure and content of a web page.

```html
<h1>Welcome to my website</h1>
<p>This is a paragraph of text.</p>
```

HTML also includes attributes that can be used to provide additional information about a tag. For example, the <img> tag can be used to insert an image into a web page. The following code inserts an image of a cat into a web page:

```html
<img src="cat.jpg" alt="Cat image">
```

CSS:

CSS is a style sheet language that is used to style the presentation of a web page. CSS rules are applied to HTML elements using selectors. Selectors can be based on the element's name, ID, class, or attribute.

```css
p {
  font-size: 16px;
}
```

CSS rules can also be used to change the color of an element, the background color of an element, and the margins and padding of an element.

Combining HTML and CSS:

```html
<!DOCTYPE html>
<html lang="en">
<head>
  <title>My Web Page</title>
  <link rel="stylesheet" href="style.css">
</head>
<body>
  <h1>Welcome to my website</h1>
  <p>This is a paragraph of text.</p>
</body>
```

```
</html>
```

CSS file:

```css
p {
  font-size: 16px;
}

h1 {
  color: red;
}
```

This code will create a web page with a red heading and a paragraph of text.
HTML and CSS are powerful tools that can be used to create visually appealing and interactive web pages. With a little practice, anyone can learn to use HTML and CSS to create their own websites.

8.SQL Database Basics

SQL (Structured Query Language) is a programming language that is used to interact with relational databases. SQL is used to perform operations on data in a database, such as inserting, updating, and deleting data.

SQL is a relatively easy language to learn, and there are many resources available online to help you learn SQL.

The SELECT clause specifies which columns to retrieve from the database. For example, the following query selects the name and email address columns from the customer's table:

```sql
SELECT name, email
FROM customers;
```

The FROM clause specifies the table from which to retrieve the data. In the previous example, the FROM clause specifies the customer's table.
Other clauses can be added to an SQL query to filter the results, sort the results, or group the results. For example, the following query selects all customers from the customers table who are from California:

```sql
SELECT name, email
FROM customers
WHERE state = 'CA';
```

The WHERE clause filters the results to only include customers who have a state of 'CA'.

Here are some examples of other simple SQL queries:

- Select all customers from the customers table:

```sql
SELECT * FROM customers;
```

- Select the first 10 customers from the customers table:

```sql
SELECT * FROM customers LIMIT 10;
```

- Select the name and email address columns from the customers table, sorted by name:

```sql
SELECT name, email
FROM customers
ORDER BY name;
```

- Select the average order amount for each customer:

```sql
SELECT customer_id, AVG(order_amount) AS average_order_amount
FROM orders
GROUP BY customer_id;
```

9.RF Systems and Sub System Tests:

General Uplink Chain:

***Command in hex code*:** The command to be sent to the satellite is encoded in hex code.

***Command encoder*:** The command encoder converts the hex code command into a digital signal which is then converted to Analog using PSK.

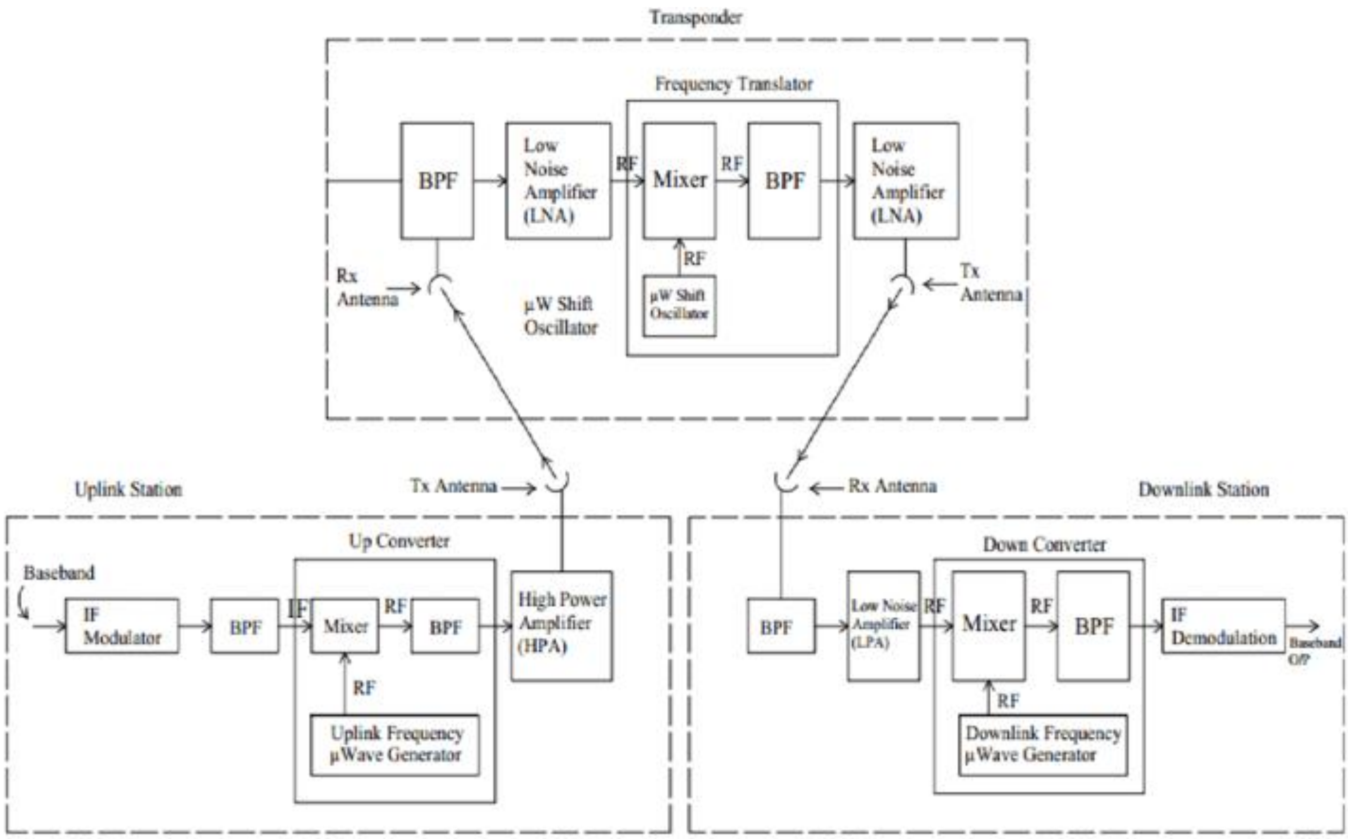
***FM modulation*:** The Analog signal is frequency modulated (FM) onto a carrier wave.

***Upconverter*:** The FM modulated signal is upconverted to the frequency of the satellite's uplink band.

High power amplifier (HPA): The HPA amplifies the upconverted signal to a high power level.

Switching matrix: The switching matrix selects the correct antenna for the uplink signal.

Antenna: The antenna transmits the uplink signal to the satellite.



General Downlink at MCF:

Antenna: The antenna receives the downlink signal from the satellite.

Low noise amplifier (LNA): The LNA amplifies the downlink signal to a higher power level without introducing much noise to the received telemetry.

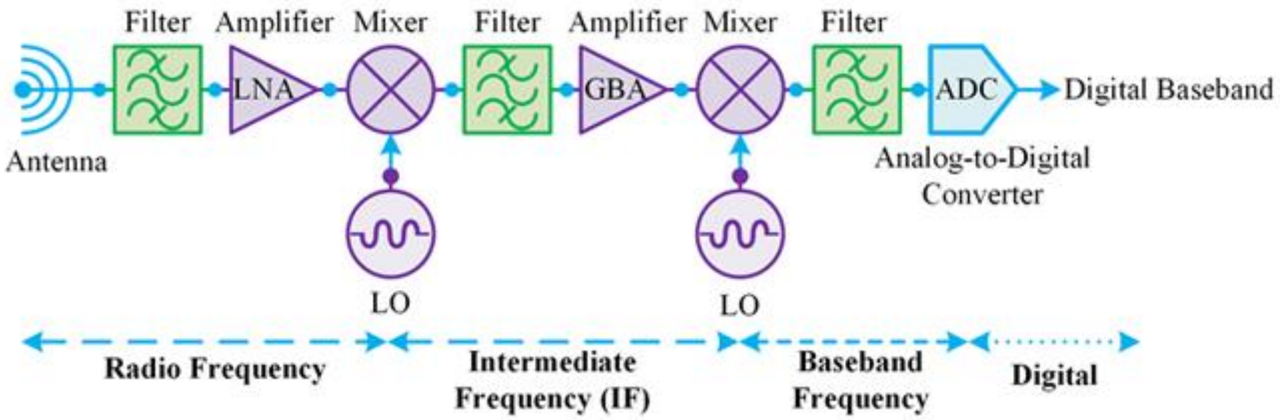
Downconverter: The downconverter down converts the downlink signal to the frequency of the MCF's downlink band.

Switching matrix: The switching matrix selects the correct antenna for the downlink signal.

IF Receiver: Receives the down converted signal in the intermediate frequency range for further processing.

PM demodulation: The PM demodulator demodulates the downlink signal to recover the digital signal.

Telemetry Unit: Receives the digital signal and display and stores data of satellite health and other parameters.



10.Baseband Systems

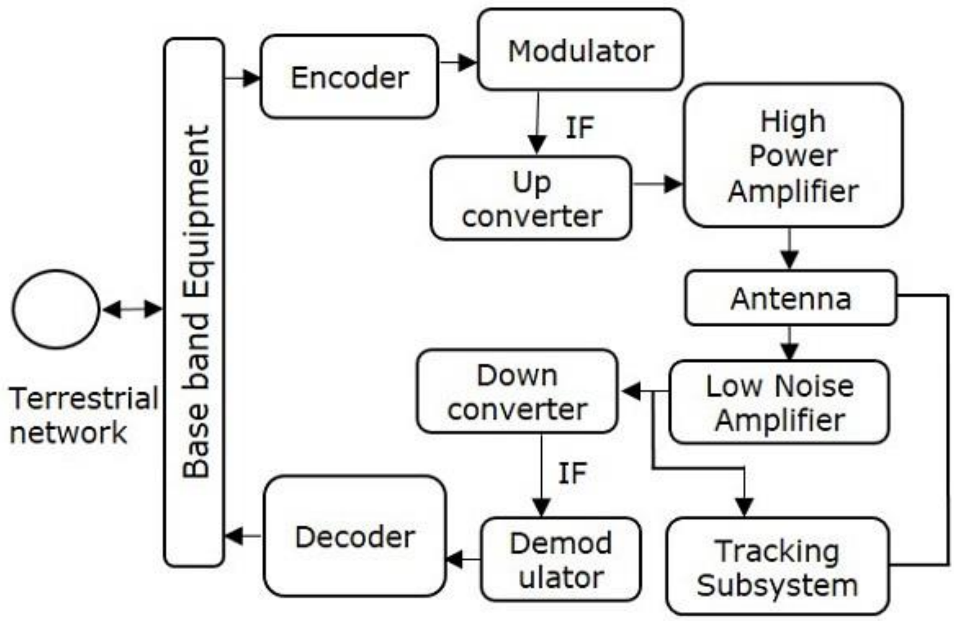
In satellite communication, baseband systems play a crucial role in processing and transmitting signals between satellites and ground stations. These systems handle the digital modulation and demodulation of signals, ensuring the efficient transfer of information.

Baseband processing involves several stages:

1. **Channel Coding**: The input data is encoded using error-correcting codes to protect it from transmission errors caused by noise and interference.
2. **Interleaving**: The coded data is interleaved, spreading it across multiple frequencies to mitigate the impact of burst errors.
3. **Modulation**: The interleaved data is modulated onto a carrier wave, converting the digital signal into a continuous analog waveform suitable for transmission over the satellite channel.

Types of Modulation
Common modulation techniques used in satellite communication include:

1. **QPSK (Quadrature Phase Shift Keying):** QPSK conveys data by shifting the phase of the carrier wave between four distinct states.
2. **8PSK (8-Phase Shift Keying):** 8PSK employs eight different phase shifts to represent more data per symbol.
3. **BPSK (Binary Phase Shift Keying):** BPSK is a simpler modulation scheme that uses two phase shifts to represent binary data.



Baseband Processing at the Receiver

At the receiver, the received signal undergoes demodulation and decoding to recover the original data.

1. **Demodulation:** The modulated signal is demodulated, extracting the original digital data from the carrier wave.
2. **Deinterleaving:** The demodulated data is deinterleaved, reassembling the original data sequence.
3. **Channel Decoding:** The deinterleaved data is decoded using the same error-correcting codes applied at the transmitter, correcting any errors introduced during transmission.

Baseband System Components

Baseband systems consist of various components:

1. **Digital Signal Processors (DSPs):** DSPs handle the complex signal processing tasks, including modulation, demodulation, coding, and decoding.

2. **Analog-to-Digital Converters (ADCs):** ADCs convert Analog signals from the satellite receiver into digital representations for processing.
3. **Digital-to-Analog Converters (DACs):** DACs convert processed digital signals back into Analog waveforms for transmission over the satellite channel.
4. **Channel Filters:** Filters are employed to remove unwanted noise and interference from the received signal.
5. **Synchronization Circuits:** Synchronization circuits ensure accurate alignment between the transmitter and receiver clocks, preventing data corruption.

11.Control Systems Used for Telecommand and Tracking (TTC) in Antennas

Antenna Features

The following are some of the key features of an antenna:

- **Radome**: A radome is a protective cover that is placed over the antenna to protect it from the elements, such as rain, snow, and wind.
- Feed horn: A feed horn is a device that is used to direct radio waves into the antenna.

- **Subreflector**: A subreflector is a smaller reflector that is placed in front of the main reflector of an antenna. The subreflector helps to focus the radio waves onto the main reflector.

Antenna Drive Unit (ADU)

The ADU is a device that is used to control the movement of the antenna. The ADU consists of a motor control card and drivers. The motor control card drives the driver, which in turn controls the induction motors. The induction motors are used to change the elevation and azimuth of the antenna.

The ADU also includes an angle acquisition card, which receives feedback from angle encoders on the antenna and uses the data to accurately move the antenna to the look angle.

Antenna Drive Unit (ADU)

FMA (Full Motion Antenna) Modes

The following are some of the different modes of an FMA:

- Standby mode: In standby mode, the antenna is not moving.

- Command position: In command position mode, the antenna is moved to a specific position based on a command from the user.
- Preset position: In preset position mode, the antenna is moved to a preset position that has been stored in the ADU.
- Program track: In program track mode, the antenna tracks a target satellite based on a pre-programmed schedule.
- Step track: In step track mode, the antenna tracks a target satellite by moving in small steps.
- Auto track/monopulse mode: In auto track/monopulse mode, the antenna tracks a target satellite using a monopulse tracking system.
- Scan mode: In scan mode, the antenna scans a specific area of the sky for a target satellite.

Full Motion Antenna (FMA)

12.In-Orbit Testing

In-orbit testing is the process of testing a satellite after it has been launched into orbit. In-orbit testing is performed to verify that the satellite is functioning properly and to calibrate its instruments.

- The following are some of the tests that are typically performed during in-orbit testing:

- Gain transfer curve: The gain transfer curve measures the gain of the satellite's transponders at different frequencies.
- Antenna patterns: The antenna patterns measure the directivity of the satellite's antennas.
- Gain to noise temperature: The gain to noise temperature measures the ratio of the satellite's gain to its noise temperature.
- Cross pole distortion: Cross pole distortion is a measure of how much the satellite's signal is distorted when it is transmitted over a long distance.
- Noise floor plots: Noise floor plots measure the noise level of the satellite's transponders.
- Back off attenuation calibration: Back off attenuation calibration is the process of measuring the amount of attenuation that the satellite's transponders introduce into the signal.
- Frequency response: The frequency response measures how the satellite's transponders respond to signals at different frequencies.
- Frequency translation: The frequency translation measures the accuracy of the satellite's transponders in translating signals from one frequency to another.
- Group delay response: The group delay response measures the time it takes for a signal to travel through the satellite's transponders.
- Inter modulation products: Inter modulation products are interference signals that are generated when two or more signals are mixed together. The inter modulation products test measures the level of inter modulation products in the satellite's signal.
- Spurious measurements: Spurious measurements measure the level of unwanted signals in the satellite's signal.

13.Instrumentation

The Master Control Facility (MCF) at ISRO is equipped with a variety of instrumentation to support the testing and operation of satellites. Some of the most important instrumentation used at MCF for RF signals include:

- Spectrum analyzer: A spectrum analyzer is used to measure the amplitude and frequency of a signal. Spectrum analyzers are used at MCF to verify the performance of satellite transponders and to troubleshoot problems with RF signals.

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- Signal generators: Signal generators are used to generate signals at specific frequencies and power levels. Signal generators are used at MCF to test the performance of satellite transponders and to simulate satellite signals in a laboratory environment.
- Power meters and sensors: Power meters and sensors are used to measure the power level of RF signals. Power meters and sensors are used at MCF to verify that satellite transponders are transmitting and receiving signals at the correct power level.
- Network analyzer: A network analyzer is used to measure the magnitude and phase response of a network. Network analyzers are used at MCF to test the performance of satellite antennas and filters.

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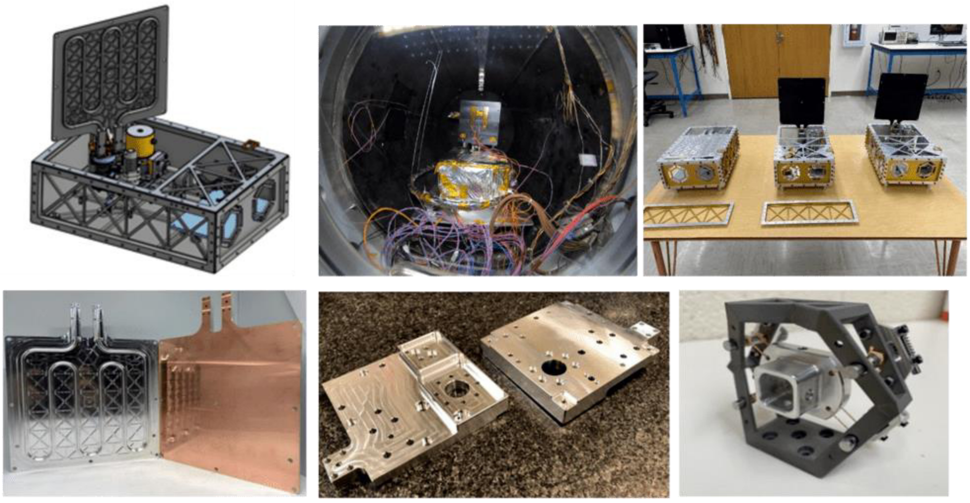
- Frequency counter: A frequency counter is used to measure the frequency of a signal. Frequency counters are used at MCF to verify that satellite transponders are operating at the correct frequency.
- Oscilloscopes: Oscilloscopes are used to visualize the waveform of a signal. Oscilloscopes are used at MCF to troubleshoot problems with RF signals.
- Multi meters: Multi meters are used to measure a variety of electrical parameters, including voltage, current, and resistance. Multi meters are used at MCF to troubleshoot problems with satellite transponders and other electronic equipment.

14.Spacecraft Thermal Systems

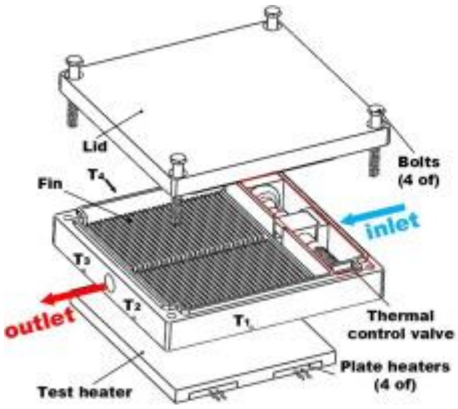
Thermal systems are crucial components of satellites, ensuring that satellite components operate within their specified temperature ranges. Satellites experience extreme temperature variations due to their exposure to the harsh environment of space. On the sun-facing side, temperatures can reach up to 150°C, while on the shaded side, temperatures can plummet to as low as -150°C. These extreme temperature fluctuations can damage sensitive electronic components and compromise the overall performance of the satellite.

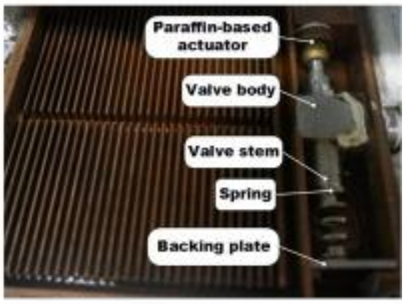
To maintain the thermal stability of satellites, thermal systems employ various techniques to control heat gain, heat rejection, and heat distribution. These techniques include:

1. Passive Thermal Control: Passive methods utilize coatings, insulation, and surface orientation to reflect or absorb solar radiation, minimizing heat gain or loss.
2. Active Thermal Control: Active methods utilize mechanical components such as heat pipes, louvers, and heaters to actively transfer heat within the satellite structure, maintaining desired temperature ranges.
3. Thermal Analysis: Thermal analysis involves modeling and simulating the satellite's thermal behavior to predict temperature distributions and identify potential thermal issues. This analysis helps in designing the thermal system and optimizing its performance.



4. Solar array for power: Solar arrays are used to generate electricity to power the spacecraft's thermal systems.
5. Heaters: Heaters are used to keep the spacecraft's temperature above a certain level. Heaters can be tape and foil heaters or IR detectors.
6. Coolers: Coolers are used to keep the spacecraft's temperature below a certain level. Coolers can be heat pipe coolers, pulse tube cryo coolers, or PCM (phase change material) coupled heatpipe coolers.

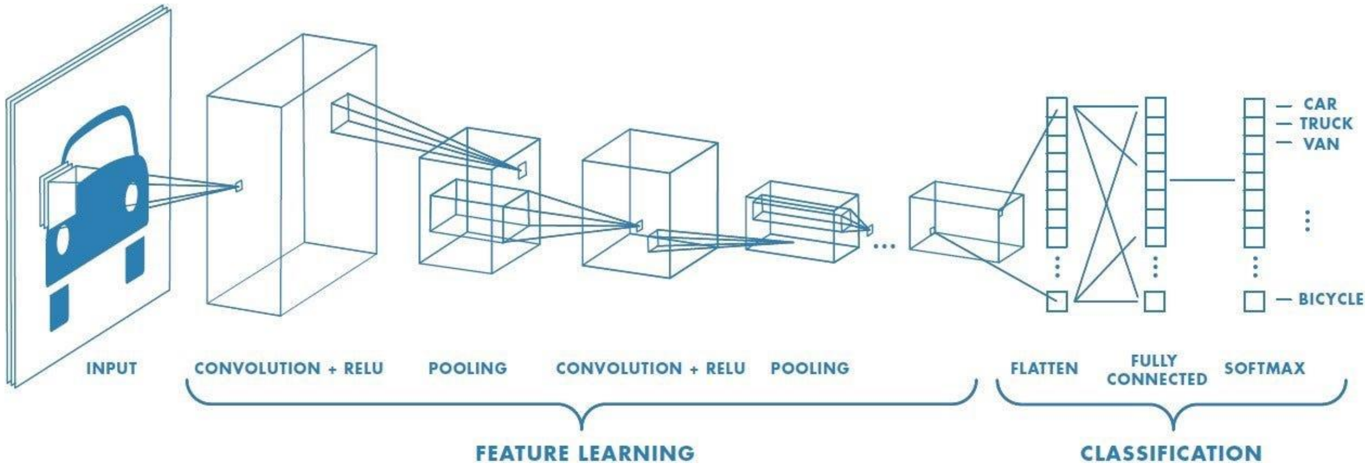




7. PRT and thermistor to measure temperature: PRTs (platinum resistance thermometers) and thermistors are used to measure the temperature of the spacecraft.

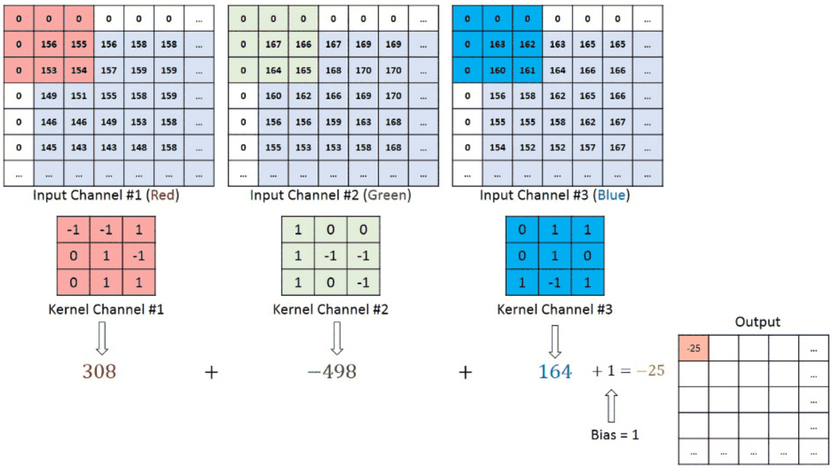
15.Image Processing using Convolutional Neural Networks (CNNs)

Convolutional neural networks (CNNs) have revolutionized the field of image processing, achieving state-of-the-art performance in various tasks such as image classification, object detection, and image segmentation. CNNs are particularly well-suited for image processing due to their ability to extract and learn local patterns from images.



A CNN is a type of artificial neural network (ANN) that is specifically designed for processing grid-like data, such as images. CNNs consist of layers of neurons, each of which applies a convolution operation to its inputs. The convolution operation extracts local patterns from the input image and produces a feature map. The feature map is then passed through an activation function, which introduces non-linearity into the network. This process is repeated multiple times, with each layer extracting more complex and abstract features from the input image.
CNNs have been successfully applied to a wide range of image processing tasks, including:

- **Image classification**: CNNs can be trained to classify images into different categories, such as cats, dogs, or cars. This is achieved by training the CNN on a large dataset of labeled images, allowing it to learn the distinctive features of each category.
- **Object detection**: CNNs can be used to detect objects in images, such as people, faces, or traffic signs. This is done by training the CNN to identify the bounding boxes of objects in a dataset of images.
- **Image segmentation:** CNNs can be used to segment images, which involves dividing an image into different regions or clusters. This is useful for tasks such as identifying different tissues in medical images or segmenting foreground objects from backgrounds.



CNNs have become an essential tool for image processing, enabling researchers and developers to tackle a wide range of challenging tasks. Their ability to learn complex patterns from images and their ability to generalize to new data have made them the preferred method for many image processing applications.

16.Software Testing

Software testing is an integral part of the software development lifecycle (SDLC) that helps ensure the quality, reliability, and usability of software applications. It involves a systematic process of identifying and correcting defects in software to ensure it meets the specified requirements and performs as expected.
Software testing encompasses various techniques and approaches, each designed to uncover different types of defects and assess the overall quality of the software. Some common testing methods include:

1. **Unit testing**: Unit testing focuses on individual units of code, such as functions or modules, ensuring they perform their intended functionality correctly.
2. **Integration testing:** Integration testing verifies the interactions between different units of code, ensuring they work together seamlessly to achieve the desired outcomes.
3. **System testing**: System testing evaluates the entire software system against its requirements and specifications, ensuring it meets the overall objectives and functions as expected in its intended environment.
4. **User acceptance testing (UAT):** UAT involves real users testing the software to ensure it meets their needs and expectations.
5. **Performance testing**: Performance testing assesses the software's performance under various workloads and conditions, ensuring it can handle the expected usage and maintain responsiveness.
6. **Security testing**: Security testing identifies and mitigates vulnerabilities that could compromise the software's security and allow unauthorized access or data breaches.

Software testing is an iterative process that involves continuous testing and refinement throughout the development cycle. This helps identify and address defects early on, reducing the cost of fixing them later in the development process.

17.Project

1. Hands-On Experience with Spectrum and Network Analyzers:

- Participants had the opportunity to work directly with state-of-the-art Spectrum Analyzers and Network Analyzers. This practical experience allowed for a deeper understanding of how these instruments are utilized in analyzing and manipulating signals.

2. Exploration of Advanced Modulation Techniques:

- The project delved into the intricacies of various modulation techniques, including Amplitude Modulation (AM), Frequency Modulation (FM), and Phase Modulation (PM). This provided valuable insights into how different modulation schemes impact signal transmission and reception.

3. Python-Based GUI Development:

- A significant aspect of the project was the creation of a custom Graphical User Interface (GUI) using the Python programming language. This GUI was designed to facilitate the input of azimuth and elevation parameters for antenna orientation, simplifying the configuration process.

4. Testing on Fixed Cassegrain Antenna (FCA):

- The developed GUI was rigorously tested on a Fixed Cassegrain Antenna (FCA), a critical component of satellite communication systems. The successful implementation of the GUI demonstrated its effectiveness in real-world scenarios.

5. In-Depth Knowledge of Satcom Equipment:

- Participants gained in-depth knowledge about a wide range of specialized equipment used in satellite communication, including transmitters, receivers, amplifiers, and frequency converters. This exposure provided a comprehensive understanding of the technology ecosystem that supports satellite communication.

6. Interdisciplinary Collaboration:

- The project required collaboration between individuals with diverse skill sets, including engineers, programmers, and technicians. This interdisciplinary approach fostered a dynamic learning environment and encouraged the exchange of knowledge and ideas.

Overall, the project at the Master Control Facility offered a holistic learning experience, combining theoretical knowledge with hands-on experimentation. It not only expanded participants' technical proficiency but also instilled a deep appreciation for the intricacies of satellite communication systems.

Conclusion

The Indian Space Research Organization (ISRO) is one of the leading space agencies in the world. ISRO's Master Control Facility (MCF) is responsible for the tracking, control, and operation of India's satellites.

MCF uses a variety of technologies to perform its mission. These technologies include:

Orbits: MCF uses a variety of orbits to support India's satellites. These orbits include geostationary orbit (GEO), medium Earth orbit (MEO), and low Earth orbit (LEO).

Station keeping: Station keeping is the process of maintaining a satellite in its desired orbit. MCF uses a variety of techniques to perform station keeping, including onboard thrusters and solar radiation pressure.

Batteries: Batteries are used to provide power to satellites. MCF uses a variety of batteries, including nickel-hydrogen (NiH) batteries, nickel-cadmium (NiCd) batteries, and lithium-ion (Li-ion) batteries.

Propellant: Propellant is used to power satellite thrusters. MCF uses a variety of propellants, including monomethylhydrazine (MMH) and nitrogen tetroxide (N_2O_4).

Antennas: Antennas are used to transmit and receive signals to and from satellites. MCF uses a variety of antennas, including full motion antennas (FMAs), limited motion antennas (LMAs), and full coverage antennas (FCAs).

Control system: The control system is responsible for pointing and tracking satellites. MCF uses a variety of control systems, including analog and digital control systems.

Payloads: Payloads are the components of a satellite that are responsible for performing its mission. MCF supports a variety of payloads, including meteorological payloads, navigational payloads, and communication payloads.

In-orbit testing: In-orbit testing is the process of testing a satellite after it has been launched into orbit. MCF uses a variety of techniques to perform in-orbit testing, including measuring the gain, antenna patterns, and frequency response of the satellite's transponders.

Instrumentation: MCF uses a variety of instrumentation to test and operate satellites. This instrumentation includes spectrum analyzers, signal generators, power meters and sensors, network analyzers, frequency counters, oscilloscopes, and multi meters.

Thermal system: The thermal system is responsible for maintaining the temperature of a satellite within an acceptable range. MCF uses a variety of thermal systems, including solar arrays, heaters, and coolers.

You can check out more about my internship in details in blogs linked below->

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THANK YOU!!!