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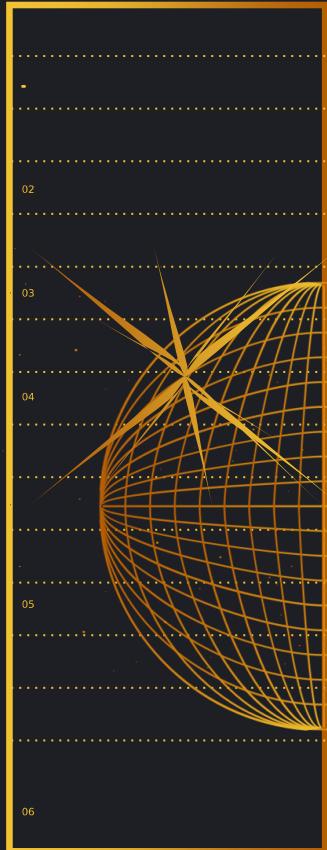
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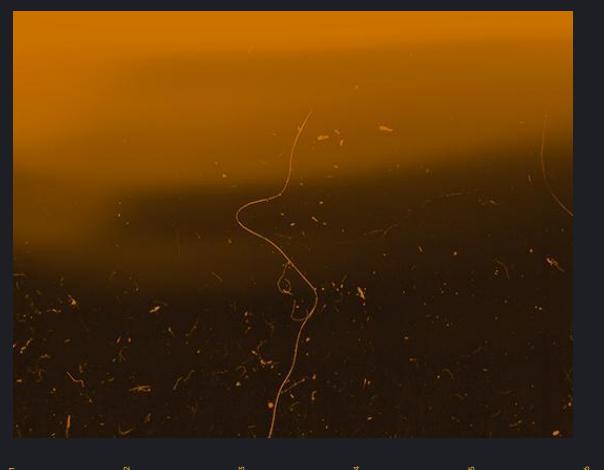
ANTLIA
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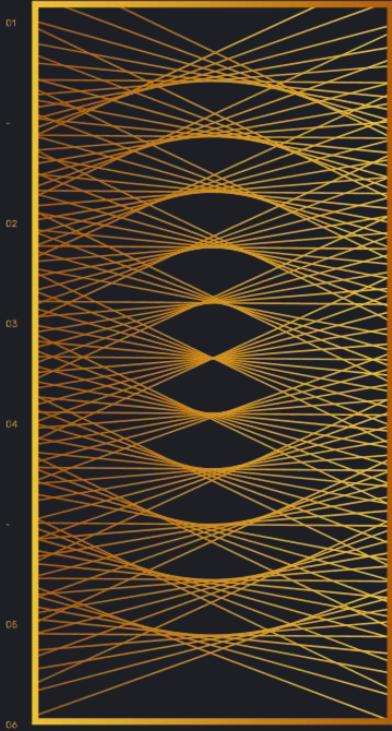
ORION
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TEAM ANANT

ORIENTATION





01.

Intro to Team Anant



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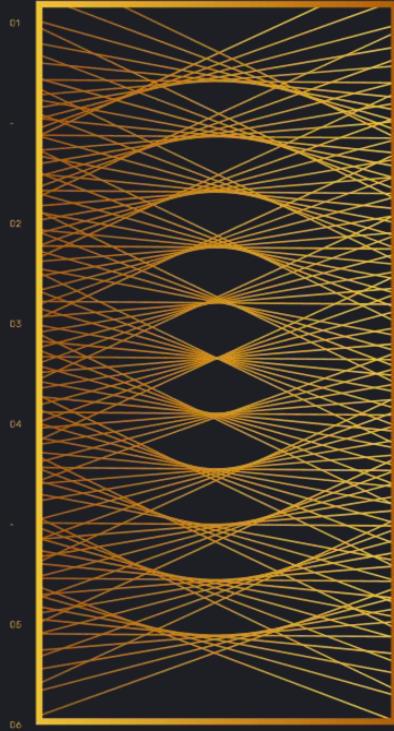
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02.

Systems Overview



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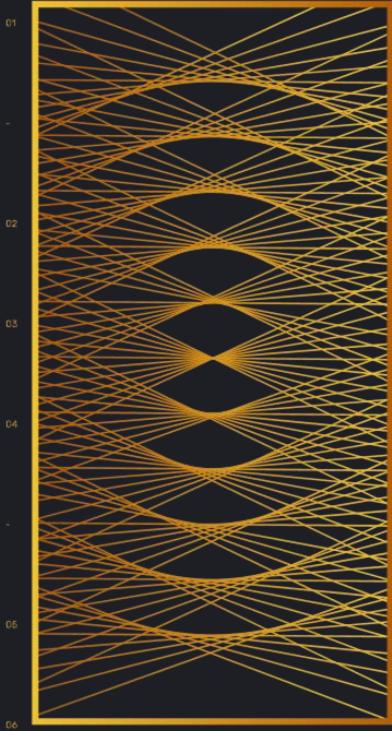
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03.

Attitude Determination and Control Systems



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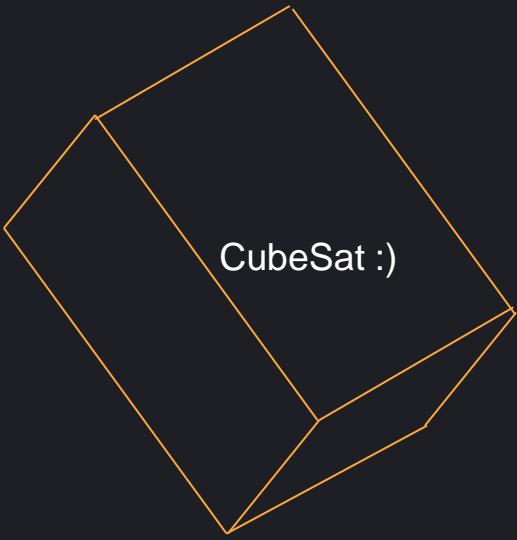
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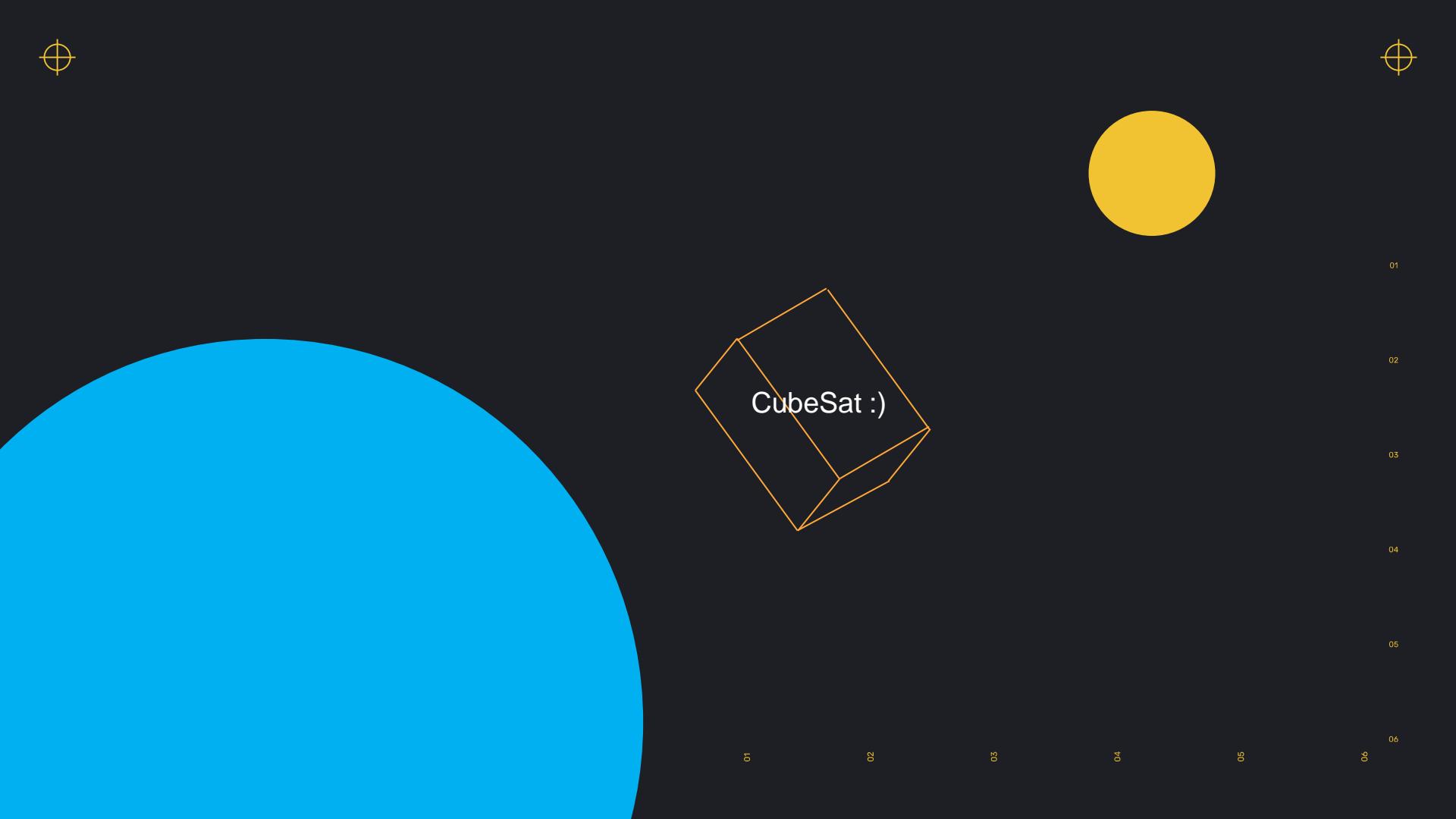
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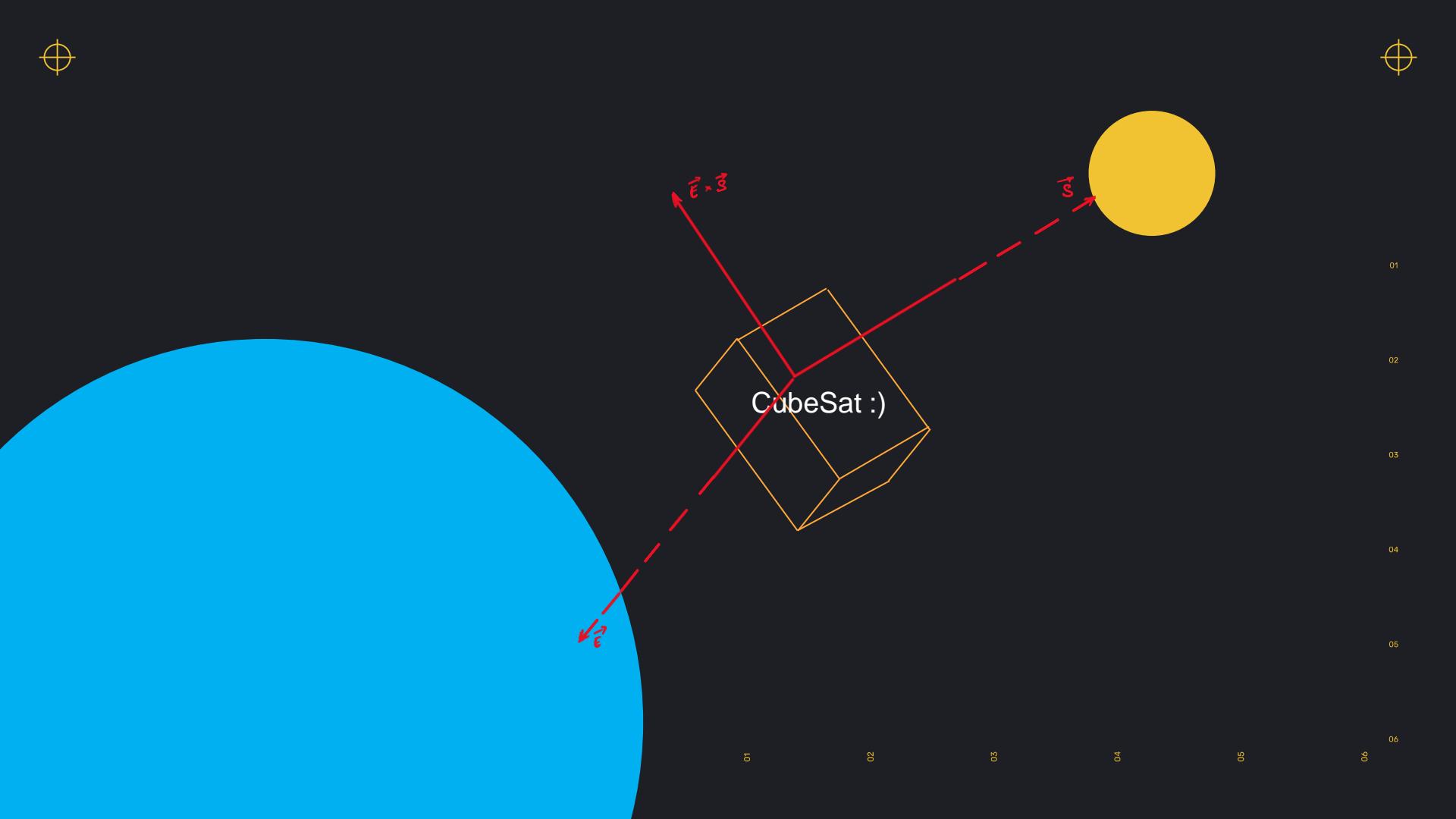
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CubeSat :)





ATTITUDE DETERMINATION HARDWARE



MAGNETIC FIELD SENSOR



SUN SENSOR

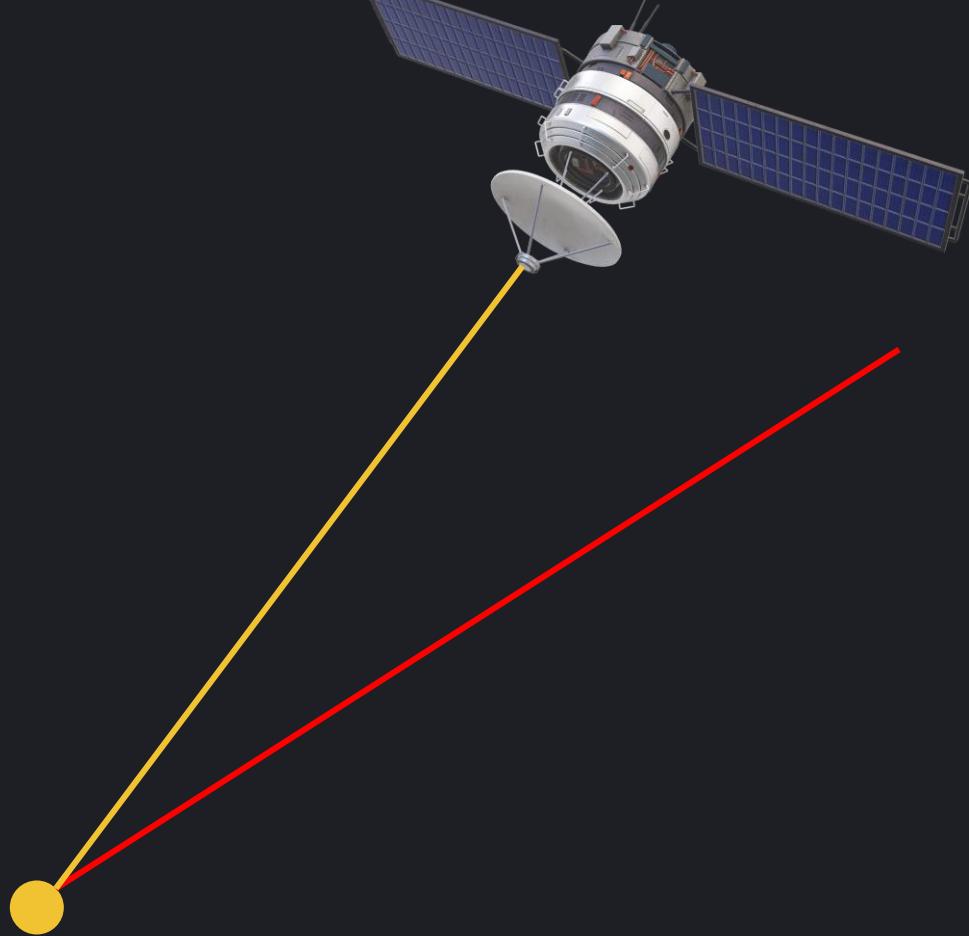


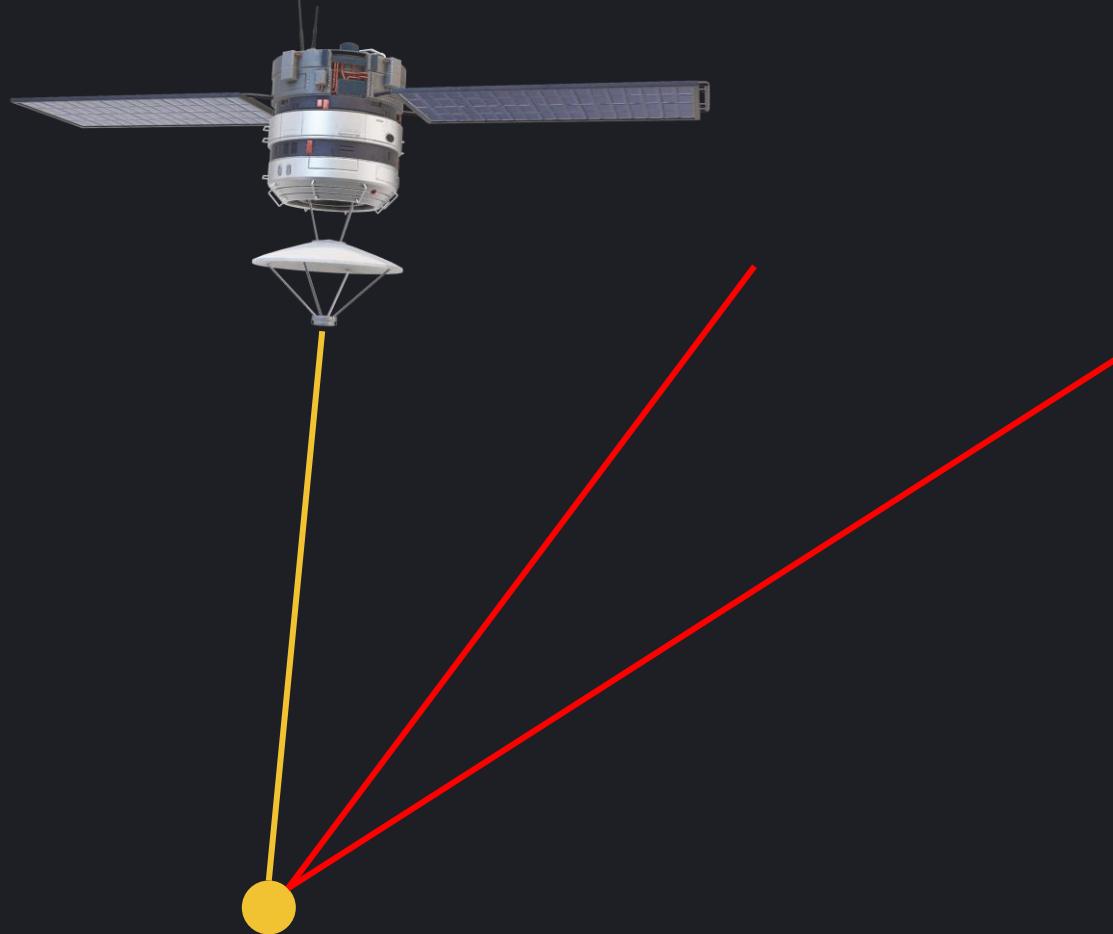
STAR SENSOR

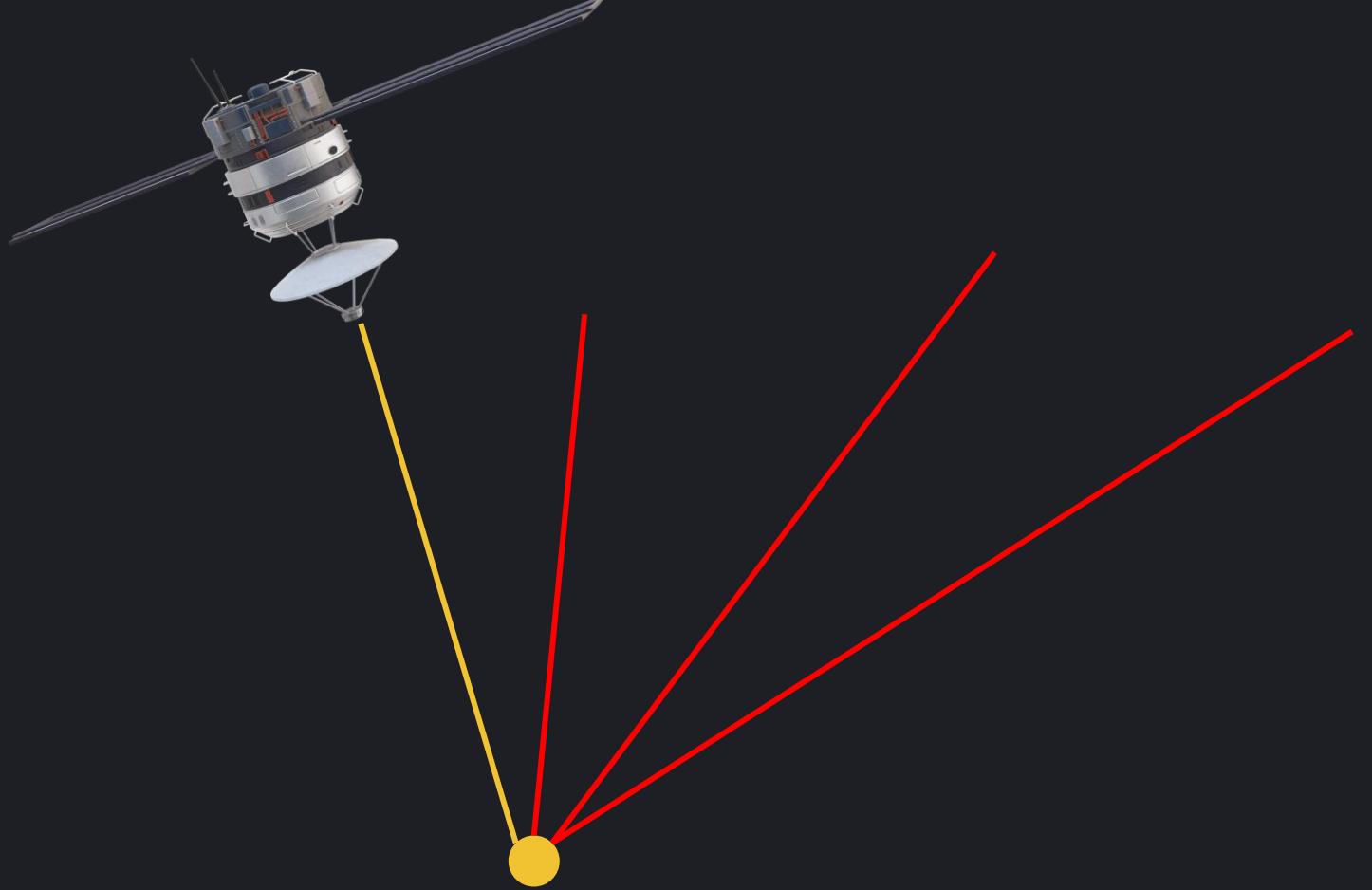


The Need for Estimation













ESTIMATIONS



DATA PREDICTION



DATA FILTERING





Our filter is estimating the error state, and therefore the filter correction equations²⁶,

$$\mathbf{K} = \mathbf{P}\mathbf{H}^\top(\mathbf{H}\mathbf{P}\mathbf{H}^\top + \mathbf{V})^{-1} \quad (273)$$

$$\hat{\delta\mathbf{x}} \leftarrow \mathbf{K}(\mathbf{y} - h(\hat{\mathbf{x}}_t)) \quad (274)$$

$$\mathbf{P} \leftarrow (\mathbf{I} - \mathbf{K}\mathbf{H})\mathbf{P} \quad (275)$$

require the Jacobian matrix \mathbf{H} to be defined with respect to the error state $\delta\mathbf{x}$, and evaluated at the best true-state estimate $\hat{\mathbf{x}}_t = \mathbf{x} \oplus \hat{\delta\mathbf{x}}$. As the error state mean is zero at this stage (we have not observed it yet), we have $\hat{\mathbf{x}}_t = \mathbf{x}$ and we can use the nominal error \mathbf{x} as the evaluation point, leading to



where $h()$ is a general nonlinear function of the system state (the true state), and v is a white Gaussian noise with covariance \mathbf{V} ,

$$v \sim \mathcal{N}\{0, \mathbf{V}\}. \quad (272)$$

Our filter is estimating the error state, and therefore the filter correction equations²⁶,

$$\mathbf{K} = \mathbf{P}\mathbf{H}^T(\mathbf{P}\mathbf{H}^T + \mathbf{V})^{-1} \quad (273)$$

$$\delta\dot{\mathbf{x}} \leftarrow \mathbf{K}(\mathbf{y} - h(\hat{\mathbf{x}}_t)) \quad (274)$$

$$\mathbf{P} \leftarrow (\mathbf{I} - \mathbf{K}\mathbf{H})\mathbf{P} \quad (275)$$

require the Jacobian matrix \mathbf{H} to be defined with respect to the error state $\delta\mathbf{x}$, and evaluated at the best true-state estimate $\hat{\mathbf{x}}_t = \mathbf{x} \oplus \delta\mathbf{x}$. As the error state mean is zero at this stage (we have not observed it yet), we have $\hat{\mathbf{x}}_t = \mathbf{x}$ and we can use the nominal error \mathbf{x} as the evaluation point, leading to

$$\mathbf{H} \equiv \frac{\partial h}{\partial \delta\mathbf{x}} \Big|_{\mathbf{x}}. \quad (276)$$

6.1.1 Jacobian computation for the filter correction

The Jacobian above might be computed in a number of ways. The most illustrative one is by making use of the chain rule,

$$\mathbf{H} \triangleq \frac{\partial h}{\partial \delta\mathbf{x}} \Big|_{\mathbf{x}} = \frac{\partial h}{\partial \mathbf{x}_t} \Big|_{\mathbf{x}} \frac{\partial \mathbf{x}_t}{\partial \delta\mathbf{x}} \Big|_{\mathbf{x}} = \mathbf{H}_{\mathbf{x}} \mathbf{X}_{\delta\mathbf{x}}. \quad (277)$$

Here, $\mathbf{H}_{\mathbf{x}} \triangleq \frac{\partial h}{\partial \mathbf{x}_t} \Big|_{\mathbf{x}}$ is the standard Jacobian of $h()$ with respect to its own argument (*i.e.*, the Jacobian one would use in a regular EKF). This first part of the chain rule depends on the measurement function of the particular sensor used, and is not presented here.

The second part, $\mathbf{X}_{\delta\mathbf{x}} \triangleq \frac{\partial \mathbf{x}_t}{\partial \delta\mathbf{x}} \Big|_{\mathbf{x}}$, is the Jacobian of the true state with respect to the error state. This part can be derived here as it only depends on the ESKF composition of states. We have the derivatives,

$$\mathbf{X}_{\delta\mathbf{x}} = \begin{bmatrix} \frac{\partial(\mathbf{p}+\delta\mathbf{p})}{\partial \delta\mathbf{p}} & \frac{\partial(\mathbf{v}+\delta\mathbf{v})}{\partial \delta\mathbf{v}} & 0 \\ \frac{\partial(\mathbf{q}\otimes\delta\mathbf{q})}{\partial \delta\theta} & \frac{\partial(\mathbf{a}_b+\delta\mathbf{a}_b)}{\partial \delta\mathbf{a}_b} & \frac{\partial(\omega_b+\delta\omega_b)}{\partial \delta\omega_b} \\ 0 & \frac{\partial(\mathbf{g}+\delta\mathbf{g})}{\partial \delta\mathbf{g}} & \end{bmatrix} \quad (278)$$

²⁶We give the simplest form of the covariance update, $\mathbf{P} \leftarrow (\mathbf{I} - \mathbf{K}\mathbf{H})\mathbf{P}$. This form is known to have poor numerical stability, as its outcome is not guaranteed to be symmetric nor positive definite. The reader is free to use more stable forms such as 1) the symmetric form $\mathbf{P} \leftarrow \mathbf{P} - \mathbf{K}(\mathbf{P}\mathbf{H}^T + \mathbf{V})\mathbf{K}^T$ and 2) the symmetric and positive *Joseph* form $\mathbf{P} \leftarrow (\mathbf{I} - \mathbf{K}\mathbf{H})\mathbf{P}(\mathbf{I} - \mathbf{K}\mathbf{H})^T + \mathbf{K}\mathbf{V}\mathbf{K}^T$.

- The perturbations \mathbf{w} are never sampled.

As a consequence, the integration over Δt of these two stochastic processes differs. Let us examine it.

The continuous-time error-state dynamics (424) can be linearized to

$$\dot{\delta\mathbf{x}} = \mathbf{A}\delta\mathbf{x} + \mathbf{B}\tilde{\mathbf{u}} + \mathbf{C}\mathbf{w}, \quad (427)$$

with

$$\mathbf{A} \triangleq \frac{\partial f}{\partial \delta\mathbf{x}} \Big|_{\mathbf{x}, \mathbf{u}_m}, \quad \mathbf{B} \triangleq \frac{\partial f}{\partial \tilde{\mathbf{u}}} \Big|_{\mathbf{x}, \mathbf{u}_m}, \quad \mathbf{C} \triangleq \frac{\partial f}{\partial \mathbf{w}} \Big|_{\mathbf{x}, \mathbf{u}_m}, \quad (428)$$

and integrated over the sampling period Δt , giving,

$$\delta\mathbf{x}_{n+1} = \delta\mathbf{x}_n + \int_{n\Delta t}^{(n+1)\Delta t} (\mathbf{A}\delta\mathbf{x}(\tau) + \mathbf{B}\tilde{\mathbf{u}}(\tau) + \mathbf{C}\mathbf{w}^c(\tau)) d\tau \quad (429)$$

$$= \delta\mathbf{x}_n + \int_{n\Delta t}^{(n+1)\Delta t} \mathbf{A}\delta\mathbf{x}(\tau) d\tau + \int_{n\Delta t}^{(n+1)\Delta t} \mathbf{B}\tilde{\mathbf{u}}(\tau) d\tau + \int_{n\Delta t}^{(n+1)\Delta t} \mathbf{C}\mathbf{w}^c(\tau) d\tau \quad (430)$$

which has three terms of very different nature. They can be integrated as follows:

1. From App. B we know that the dynamic part is integrated giving the transition matrix,

$$\delta\mathbf{x}_n + \int_{n\Delta t}^{(n+1)\Delta t} \mathbf{A}\delta\mathbf{x}(\tau) d\tau = \Phi \cdot \delta\mathbf{x}_n \quad (431)$$

where $\Phi = e^{\mathbf{A}\Delta t}$ can be computed in closed-form or approximated at different levels of accuracy.

2. From (426) we have

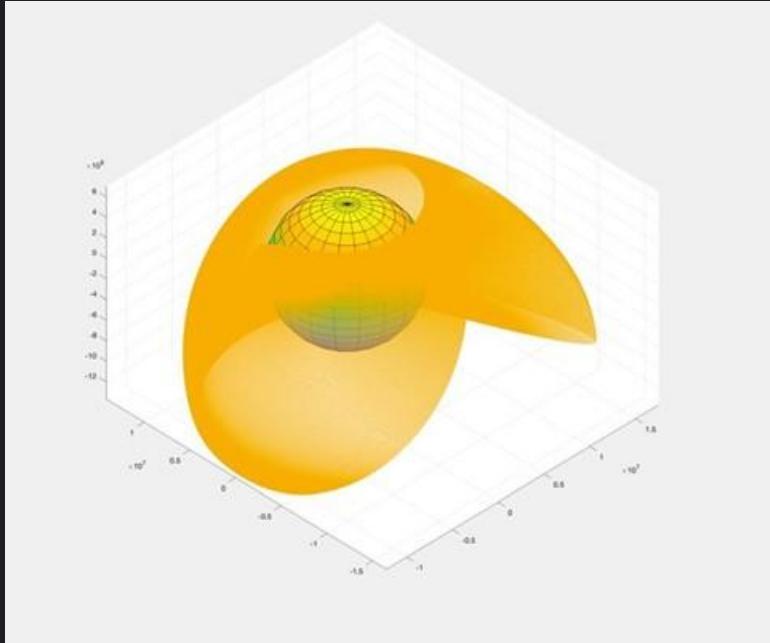
$$\int_{n\Delta t}^{(n+1)\Delta t} \mathbf{B}\tilde{\mathbf{u}}(\tau) d\tau = \mathbf{B}\Delta t\tilde{\mathbf{u}}_n \quad (432)$$

which means that the measurement noise, once sampled, is integrated in a deterministic manner because its behavior inside the integration interval is known.

3. From Probability Theory we know that the integration of continuous white Gaussian noise over a period Δt produces a discrete white Gaussian impulse \mathbf{w}_n described by

$$\mathbf{w}_n \triangleq \int_{n\Delta t}^{(n+1)\Delta t} \mathbf{w}(\tau) d\tau, \quad \mathbf{w}_n \sim \mathcal{N}\{0, \mathbf{W}\}, \quad \text{with } \mathbf{W} = \mathbf{W}^c \Delta t \quad (433)$$

We observe that, contrary to the measurement noise just above, the perturbation does not have a deterministic behavior inside the integration interval, and hence it must be integrated stochastically.

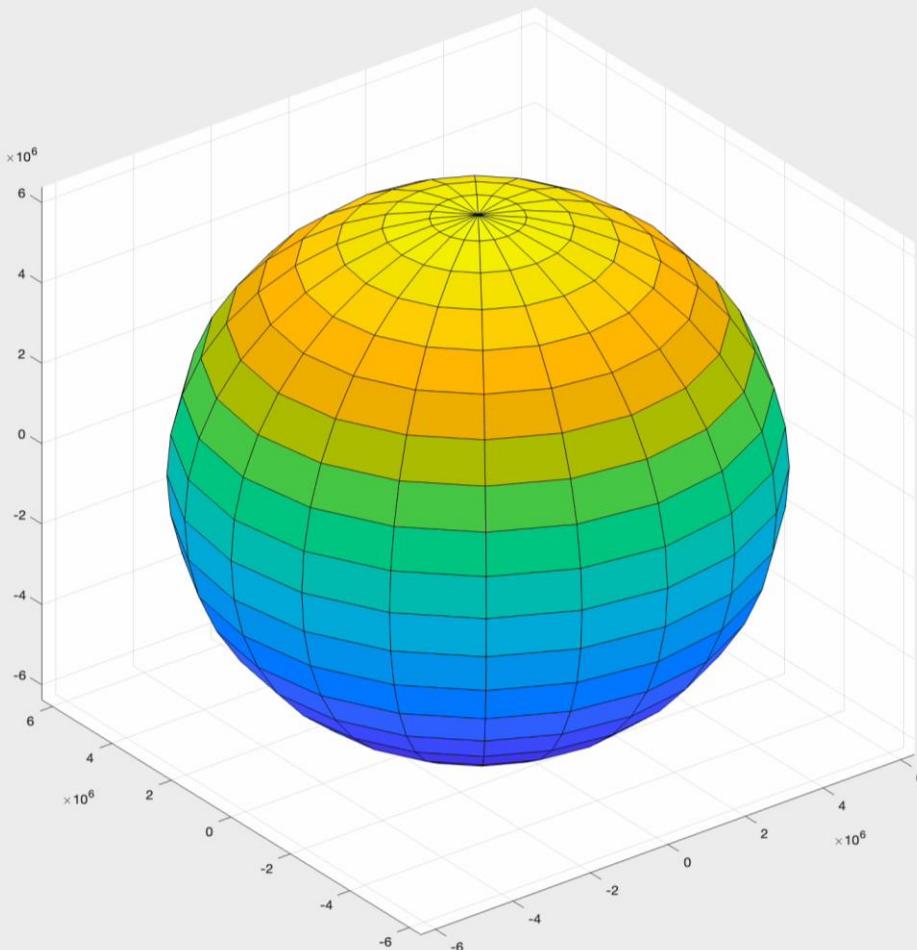


NAVIGATION

- ORBIT PROPAGATION
- ORBITAL MODES

Code_Final.m

```
42
43     arr1_v_mag = [];
44     arr2_ke = [];
45     arr3_g = [];
46
47     dt = 100;
48     total_time = 5e4;
49
50
51     overall = [];
52
53     for j = 1:dt:total_time
54         [a_g, a_J2] = acc(r(1),r(2),r(3),constants);
55         a_drag = drag(rho(norm(r), data_table), getNormals(), v, constants) / mass;
56         F_SRP = solarPressure(r(1), r(2), r(3), getTime(getJulian(j)), getNormals(), constants);
57         a_SRP = F_SRP / mass;
58         a = a_g + a_J2 + 0*a_drag + 0*a_SRP;
59         v = v + a*dt;
60
61         arr1_v_mag = [arr1_v_mag norm(v)];
62         arr2_ke = [arr2_ke mass*norm(v)^2/norm(r)];
63         arr3_g = [arr3_g a_g*mass];
64
65         r = r + v*dt;
66         pos = [pos r];
67
68         rho(norm(r), data_table);
69     end
70
71     [X,Y,Z] = sphere;
```





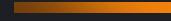
CONTROL SYSTEMS



REACTION WHEELS



MAGNETOTORQUERS



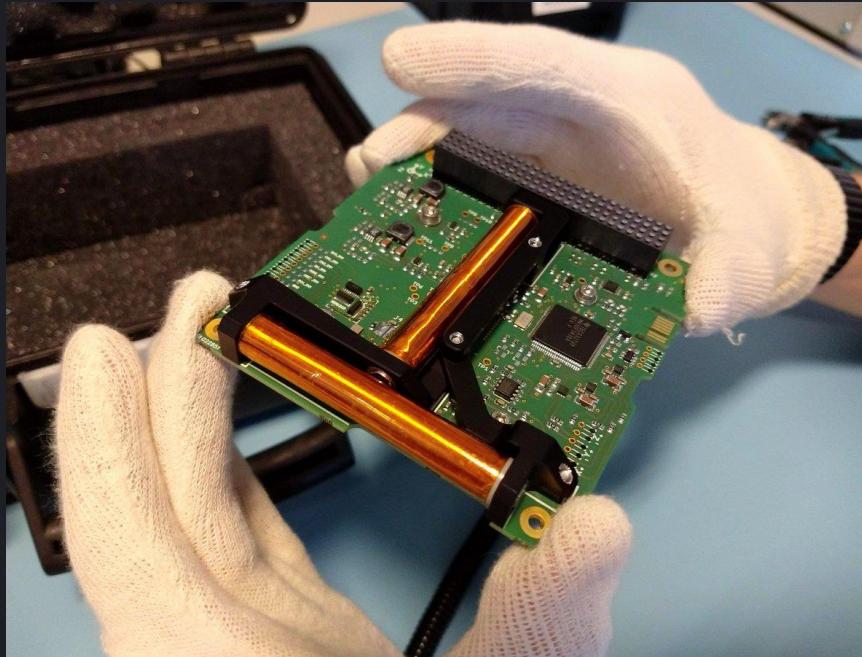
003-1040559

1250 003-77156.8

1760 0009-14563.7

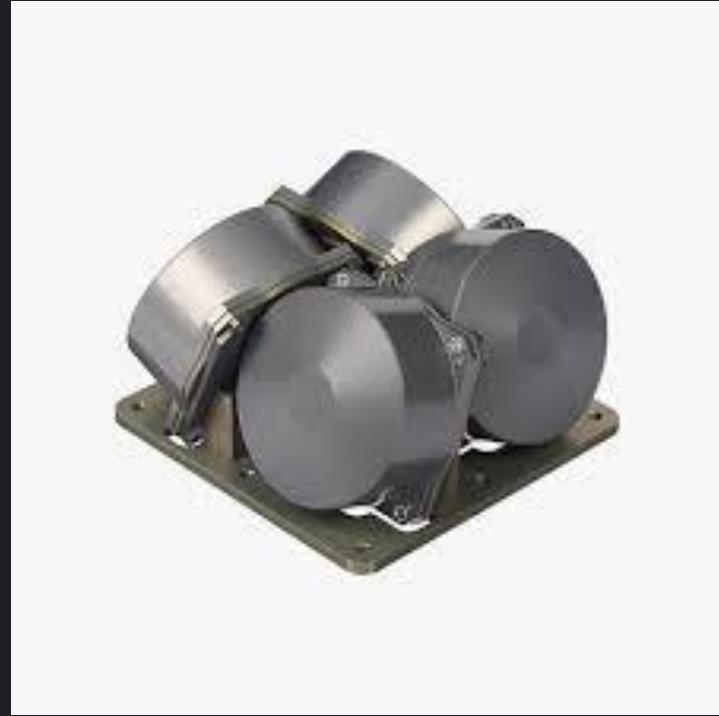
73273

MAGNETORQUERS



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REACTION WHEELS



003-1040559 1250 003-77156.8 1760 0009-14563.7 73273

REACTION WHEELS



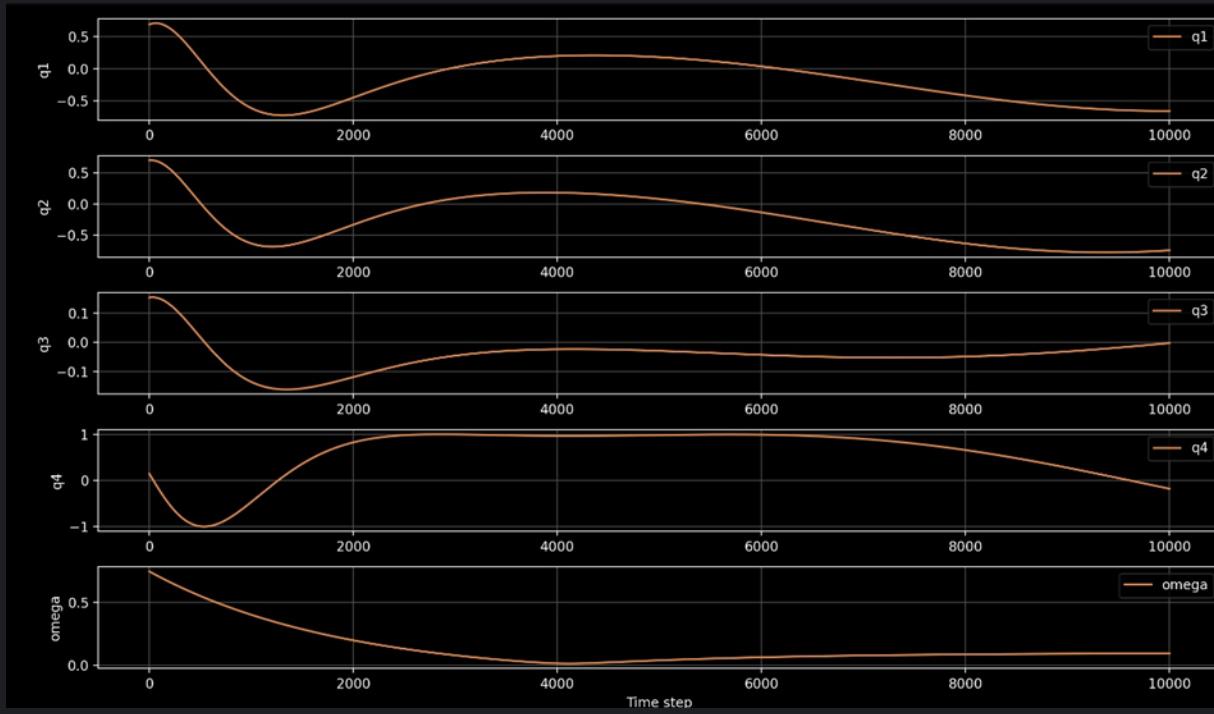
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1250 003-77156.8

1760 0009-14563.7

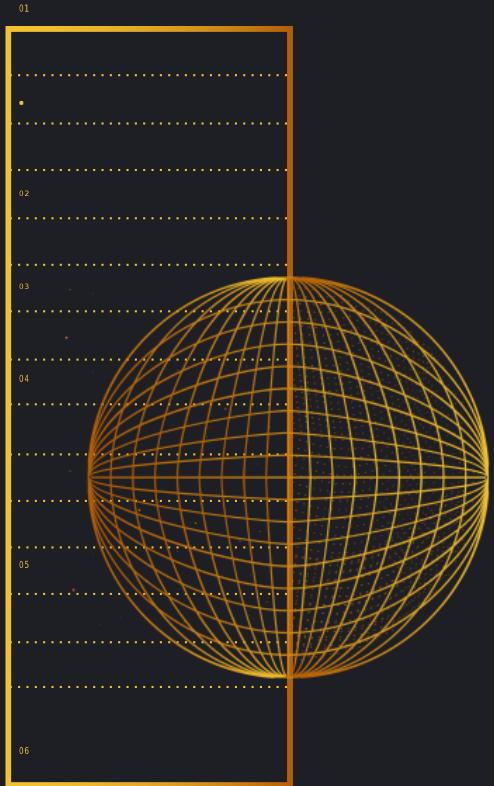
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CONTROL





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04.

TELEMETRY, TRACKING AND COMMAND



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Telemetry Tracking & Command: WWWHAAATT??!!!



Telemetry: Downlinking of Data from the satellite to the ground station.



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Telemetry Tracking & Command: WWWHAAATT??!!!



Tracking: Locating the position of the satellite in the orbit to ensure that the ground station antennas stay pointed towards the satellite.





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Telemetry Tracking & Command: WWWHAAATT??!!!



Command: Uplink data/instructions from the ground station to the satellite.



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Forms of Data that we deal with:



Primary Data: The image. This is downlinked from the satellite to the ground station.





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Beacon: This signal is tracked, to locate the satellite in orbit and to ensure that the satellite is alive. Also provides basic housekeeping data about the satellite.





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Forms of Data that we deal with:



Commands: These instructions are uplinked from the ground station to the satellite.





Software Defined Radios

Communication system that uses software for digital signal processing.





Communication system that uses software for digital signal processing.



003-1040559

1250 003-77156.8

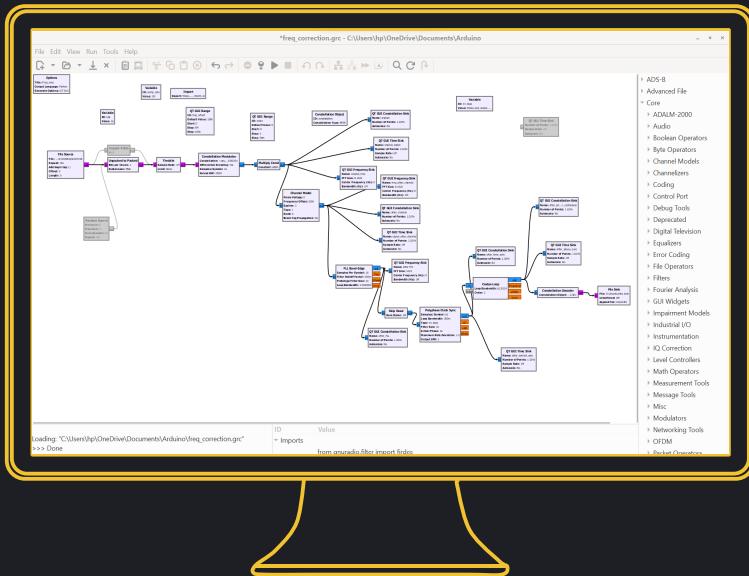
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OK, but how do I use the SDR?

GNU Radio Companion is a visual tool for designing and simulating software-defined radios and signal processing systems using flowgraphs.



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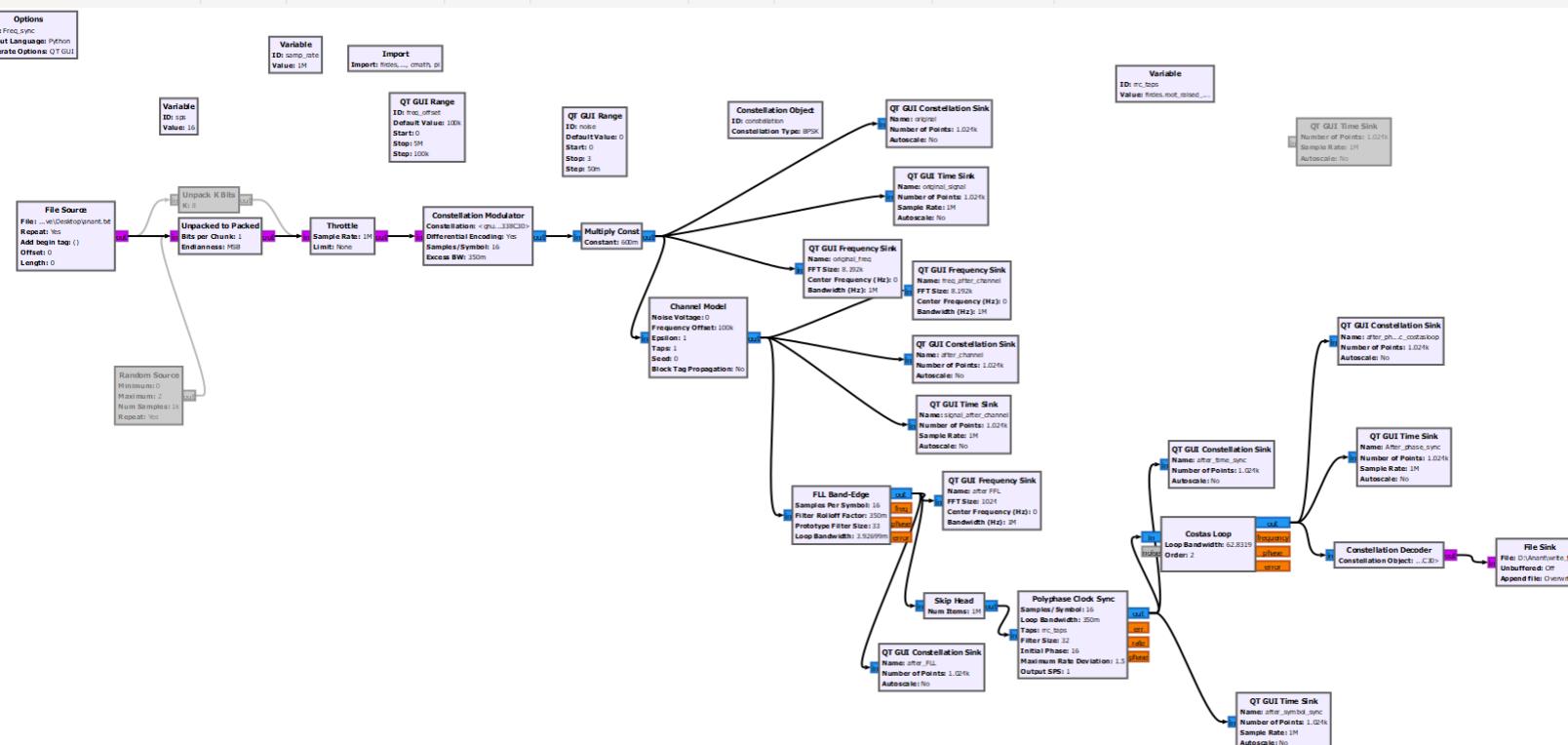
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ADS-B

Advanced File

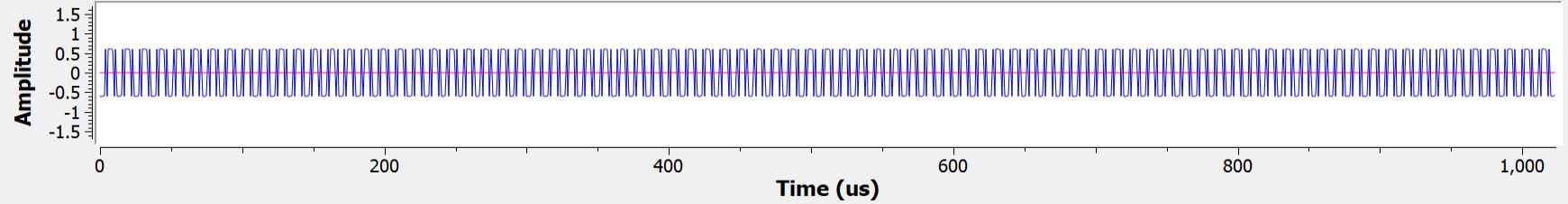
Core

- ▶ ADALM-2000
- ▶ Audio
- ▶ Boolean Operators
- ▶ Byte Operators
- ▶ Channel Models
- ▶ Channelizers
- ▶ Coding
- ▶ Control Port
- ▶ Debug Tools
- ▶ Deprecated
- ▶ Digital Television
- ▶ Equalizers
- ▶ Error Coding
- ▶ File Operators
- ▶ Filters
- ▶ Fourier Analysis
- ▶ GUI Widgets
- ▶ Impairment Models
- ▶ Industrial I/O
- ▶ Instrumentation
- ▶ IQ Correction
- ▶ Level Controllers
- ▶ Math Operators
- ▶ Measurement Tools
- ▶ Message Tools
- ▶ Misc
- ▶ Modulators
- ▶ Networking Tools
- ▶ OFDM
- ▶ Packet Operators

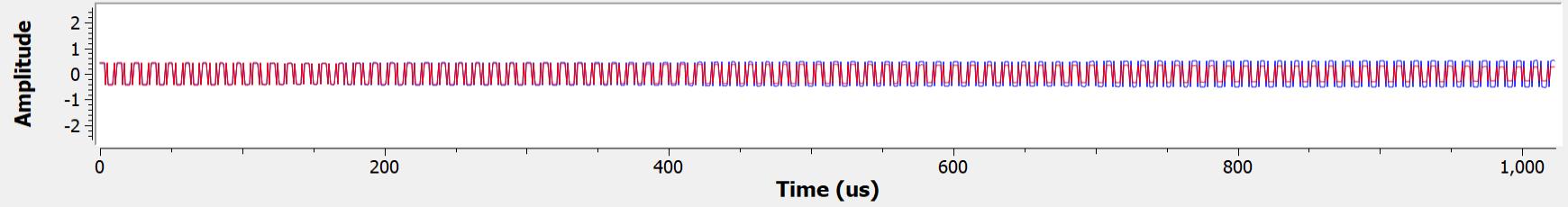
Freq_sync



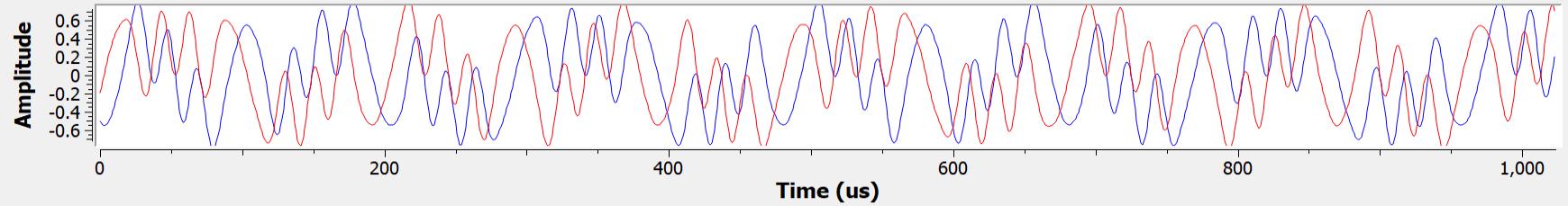
After_phase_sync



after_symbol_sync



signal_after_channel



original_signal





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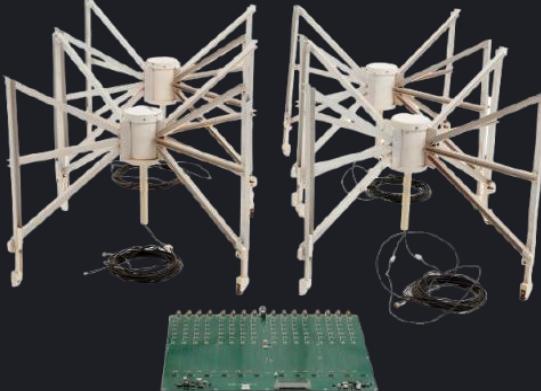
0E

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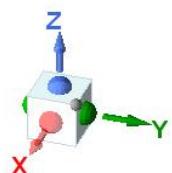
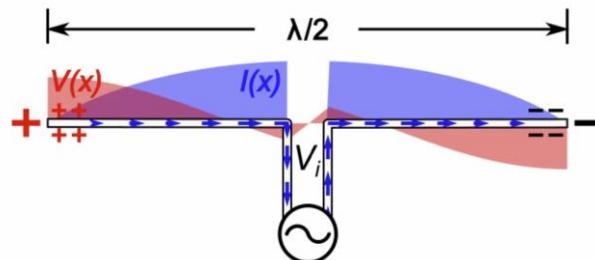
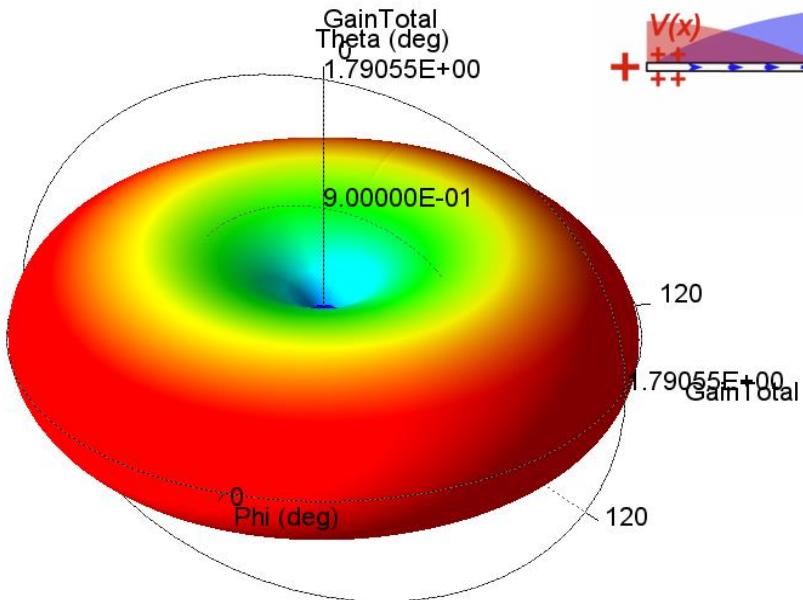
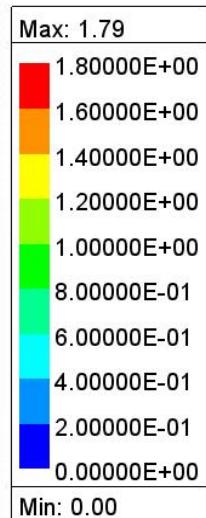
0G

Antennas?!

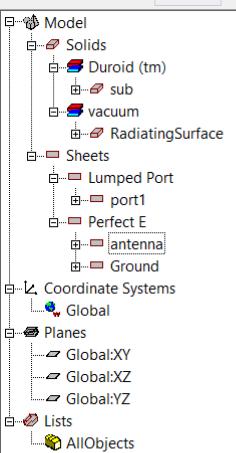
A little (sometimes large) metal thingy
that sends EM waves to a far away place.



Gain Plot 1



SIMULATED GAIN PLOT FOR A DIPOLE ANTENNA OPERATING AT 2.4 GHz

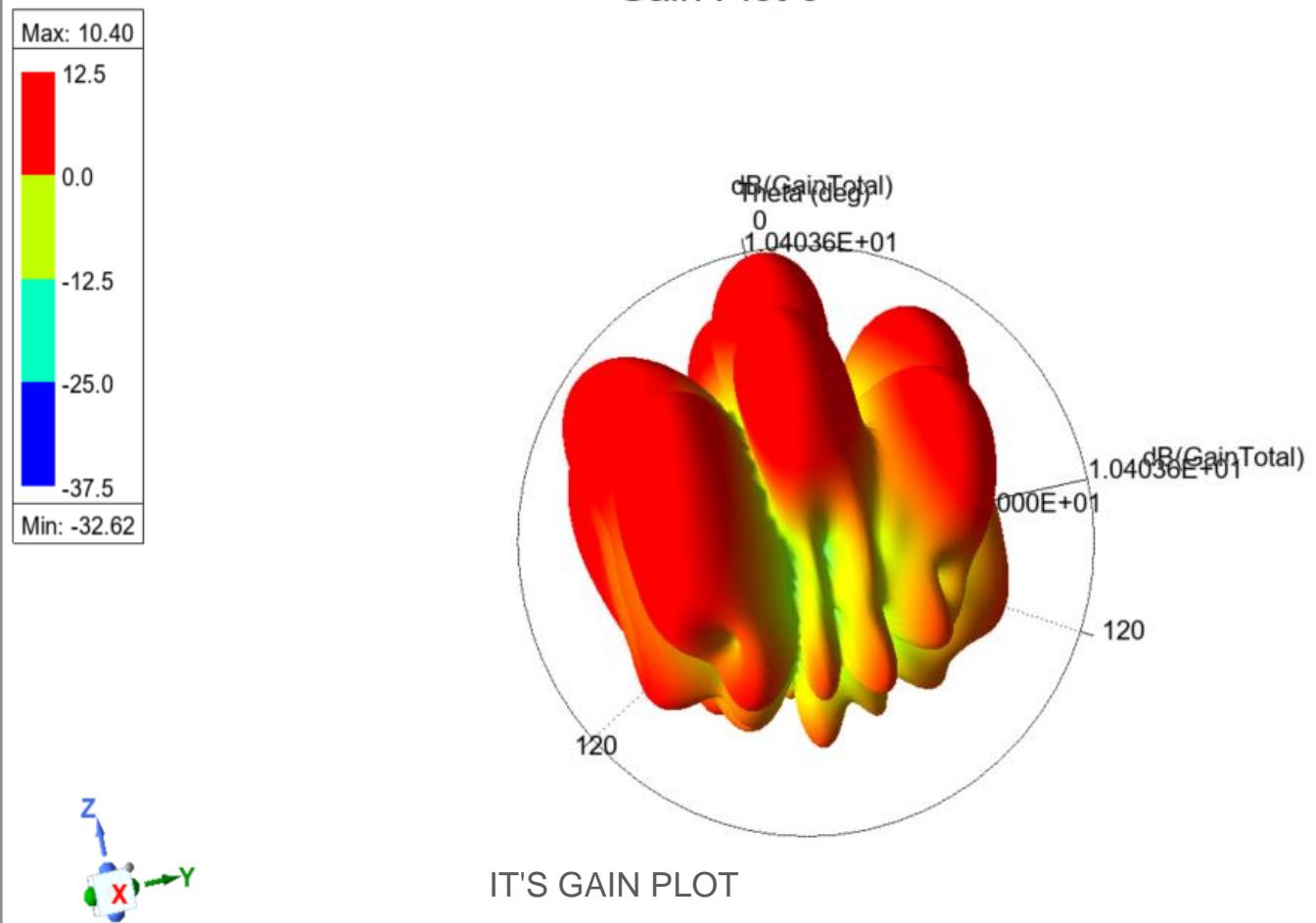


Ansys
2024 R2
STUDENT

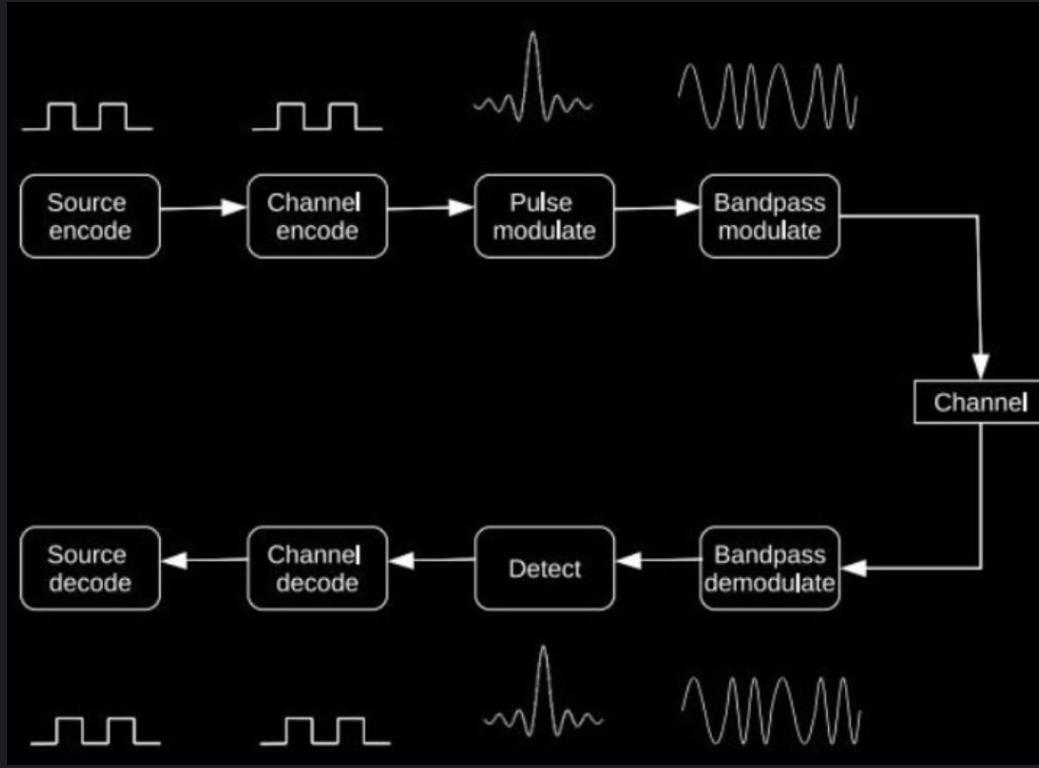
0 3.5 7 (cm)

Show 1 Messages Show Progress

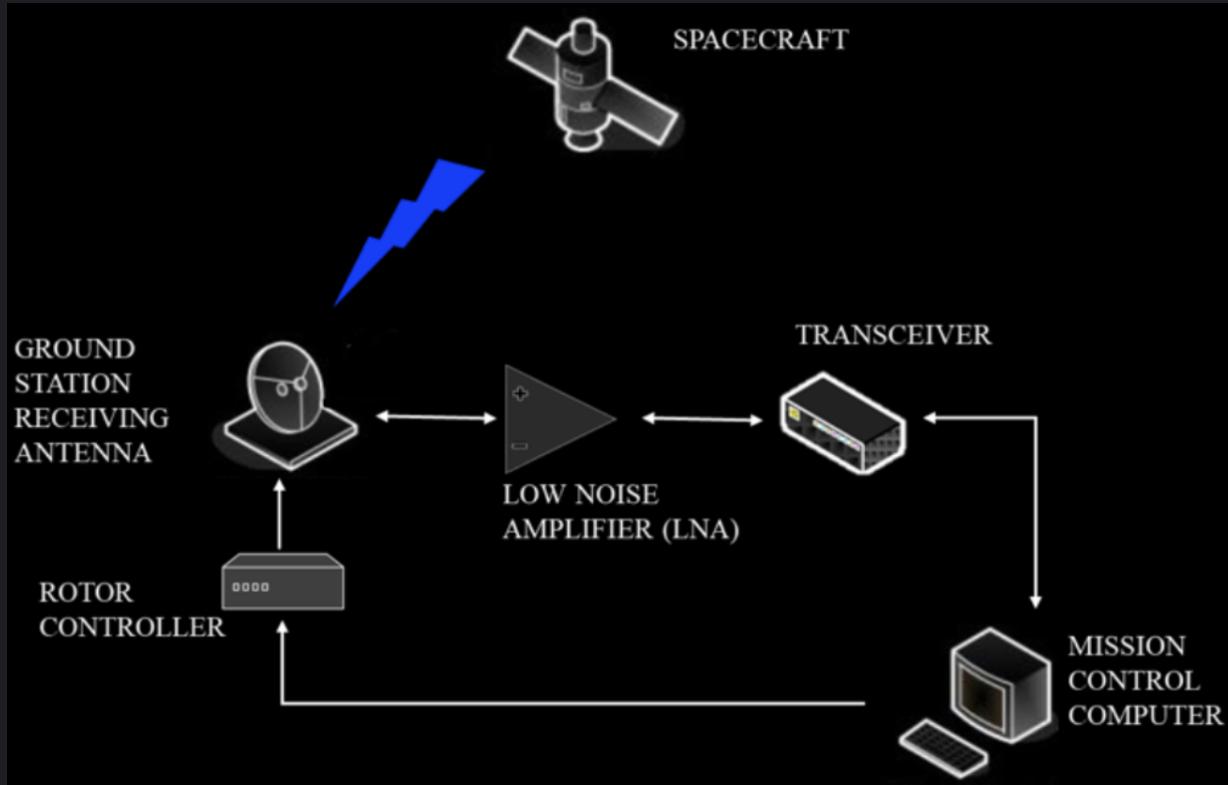
Gain Plot 6

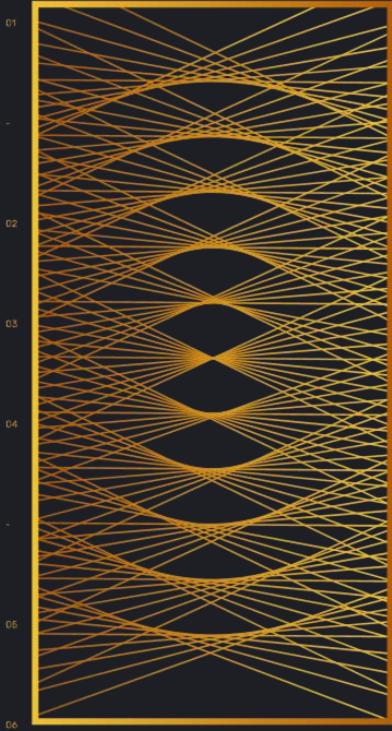


Telemetry Tracking & Command: Digital Communication



Telemetry Tracking & Command: Ground Station





05.

STRUCTURAL AND THERMAL SUBSYSTEM



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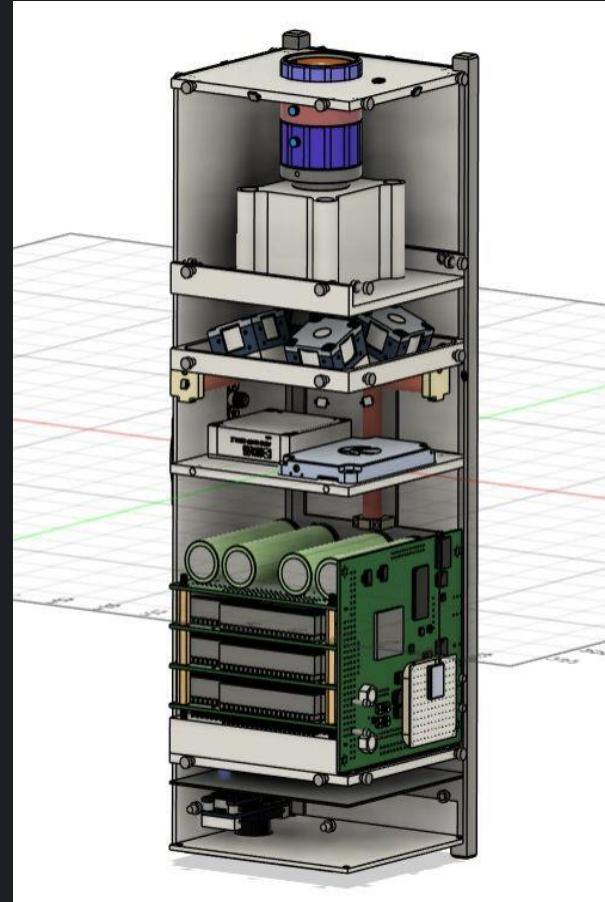
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STRUCTURE

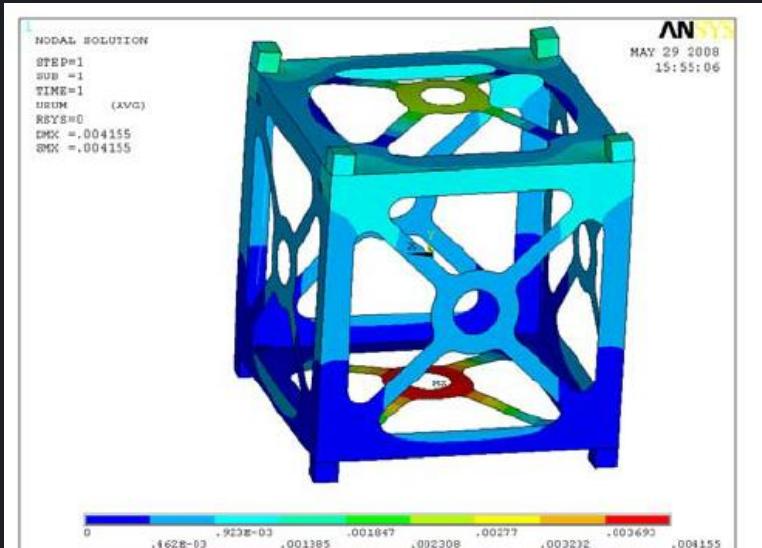
As part of the structure we need to design something that will survive launch loads, while providing an easily accessible data and power bus for debugging and assembly of components.





STRUCTURAL ANALYSIS

Static Loads



Quasi Static Loads

Random Vibrations

Sinusoidal Vibrations

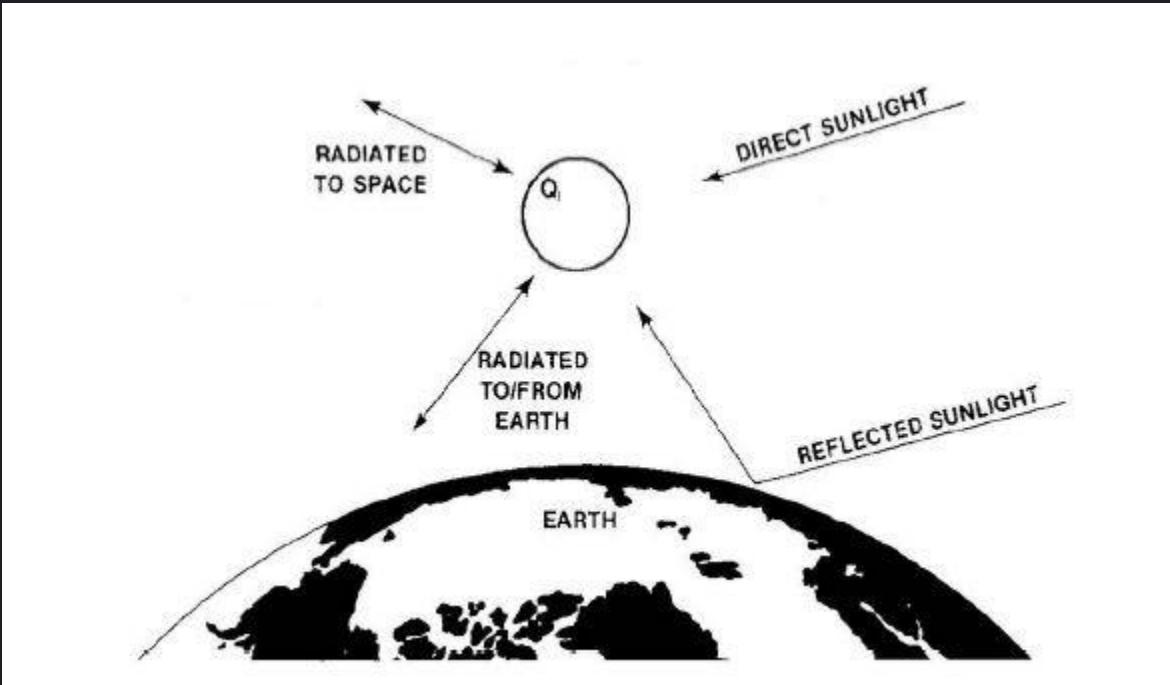


IMPORTANCE OF THERMAL ANALYSIS





IMPORTANCE OF THERMAL ANALYSIS



SIGNIFICANCE OF THERMAL ANALYSIS

- Maintaining the temperatures for each component of the satellite is important for the safety of the components.
- Orbital parameters like different angle values, vectors and values like Lтан (local time at ascending node), influence the thermal loads that the CubeSAT experiences.

Component	Operating Temperature (degrees Celsius)
Batteries	10 to 45
Solar Panels	-25 to 50
Geomagnetic Sensors	-40 to 85
PCBs	-40 to 85





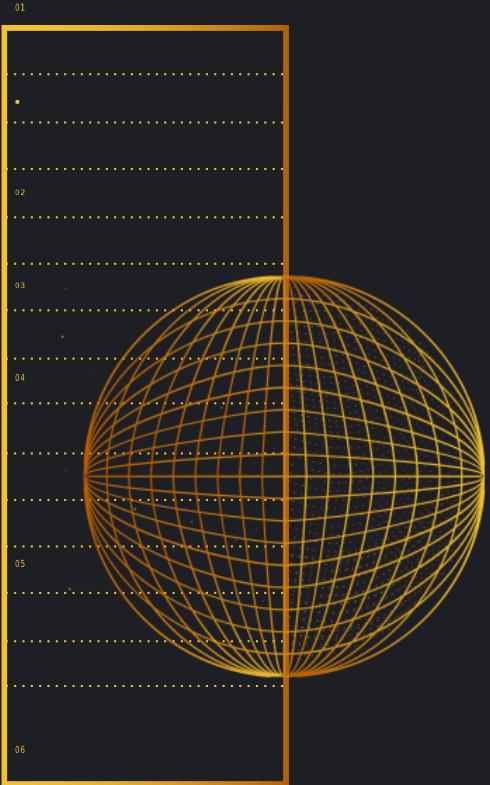
MANUFACTURING

In STS Manufacturing is the ultimate constraint to a design.

You can have the most magnificent design but if it can't be made it isn't as useful as it can be.

We use both additive manufacturing as well as classical methods of manufacturing to make our prototypes for subsystems to use.





06.

PAYLOAD



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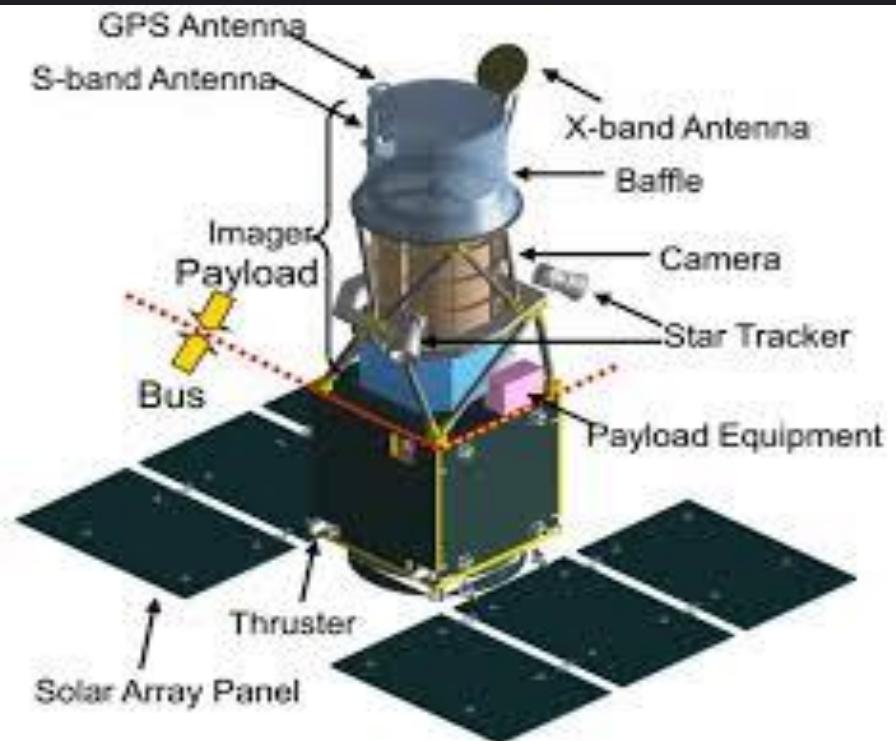
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PAYLOAD



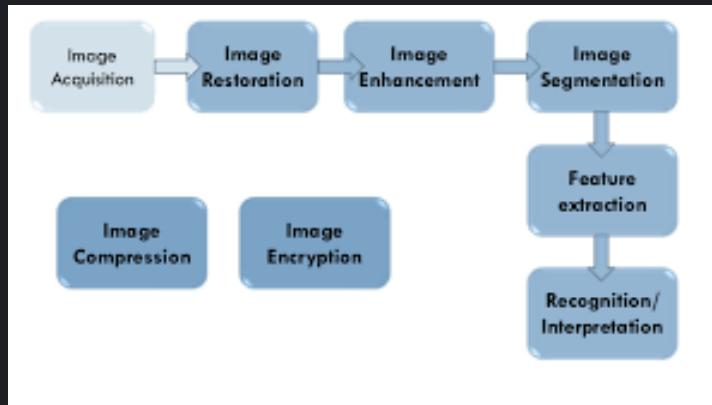
A scientific or technological instrument on a satellite that's designed to achieve the satellite's mission

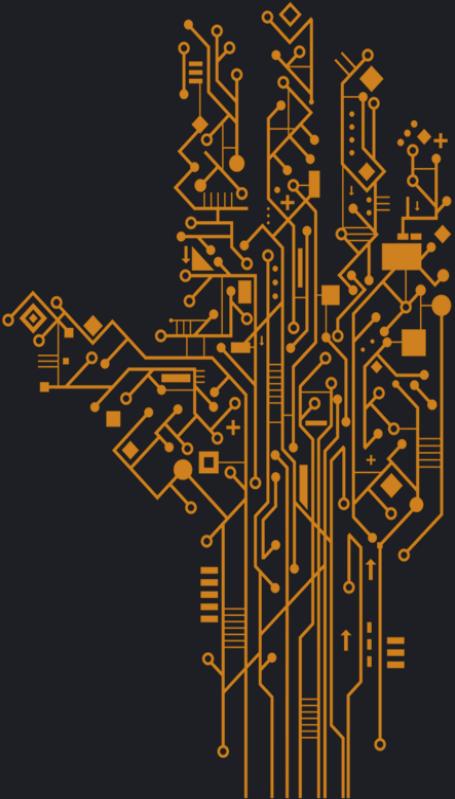
SKILLS REQUIRED

MACHINE LEARNING & DEEP LEARNING

IMAGE PROCESSING

WILL TO LEARN!!!





07.

ELECTRICAL POWER SYSTEM





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ABOUT EPS



The Electrical & Power Subsystem (EPS) is one of the essential subsystems for the CubeSat since it handles power generation, energy storage, and power distribution to all other subsystems.



Therefore, the design of EPS becomes crucial for successful CubeSat mission, wherein the first step is the selection of EPS architecture.



DEVELOPMENT of advanced electronics have enabled building of CubeSats with powerful capabilities that were previously dominated by larger satellites.





CORE FUNCTIONS OF EPS

Generate

Store

Distribute

Regulate



POWER SOURCE

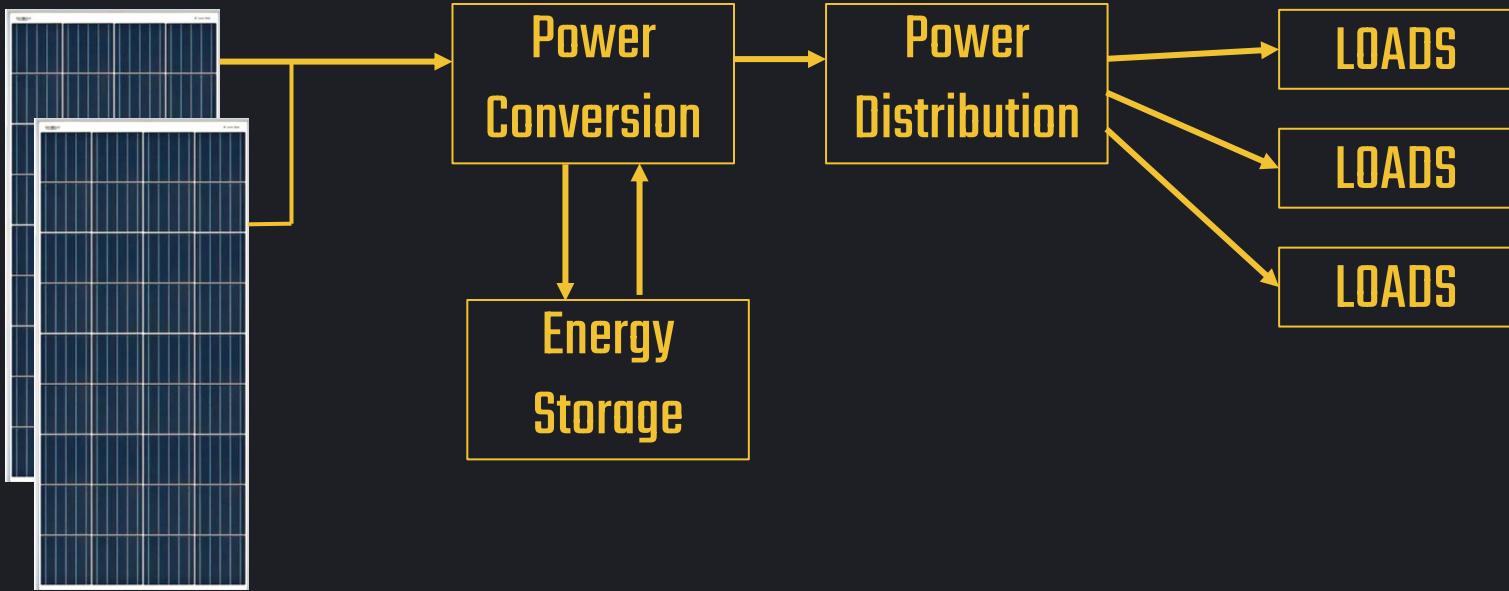
ENERGY STORAGE

**POWER
DISTRIBUTION**

**POWER
REGULATION AND
CONTROL**



Basic Components of CubeSAT EPS





POWER STORAGE

Why do we need Power Storage ?

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As the CubeSat revolves in an orbit, it experiences both sunlit and eclipse periods.

In **Sunlit Period**, the CubeSat is illuminated by sunlight and the angle of incidence of sunlight on the photovoltaic (PV) arrays varies from 66.55 to 90 degrees.

During **Eclipse Period**, the Earth blocks the sunlight from illuminating the CubeSat once in every orbit in all seasons and the temperature drops sharply. The eclipse period is dependent on the orbit altitude, inclination, and the sunlight incidence angle on the orbit plane.





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The storage system is required during **eclipse** period and peak load conditions.



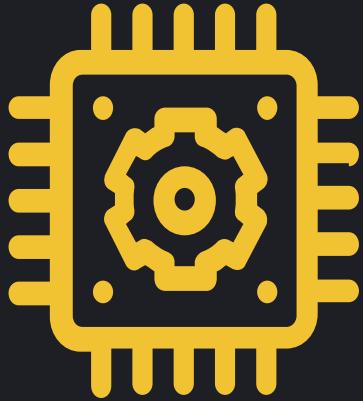
The energy storage system consists of lithium-ion (Li-ion) cells due to higher energy density, higher number of charge/discharge cycles, and lower self-discharge rate.



On the other hand, the **Li-ion batteries** have following disadvantages:

- (1) the life-cycle of Li-ion battery degrades due to higher charge/discharge rates [23]
- (2) Li-ion battery has limited energy density at lower temperatures (<-20°C)
- (3) Charge rate of Li-ion battery is very low at lower temperatures with the possibility of life reduction.





Printed Circuit Boards

Power Distribution

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Traces

PCB



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A Printed circuit board (PCB) is an electronic assembly that uses copper conductors to create electrical connections between components.

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Printed circuit boards provide mechanical support for electronic components so that a device can be mounted in an enclosure. A printed circuit board design must include a specific set of steps that aligns with the manufacturing process, integrated circuit packaging, and the structure of the bare circuit board.

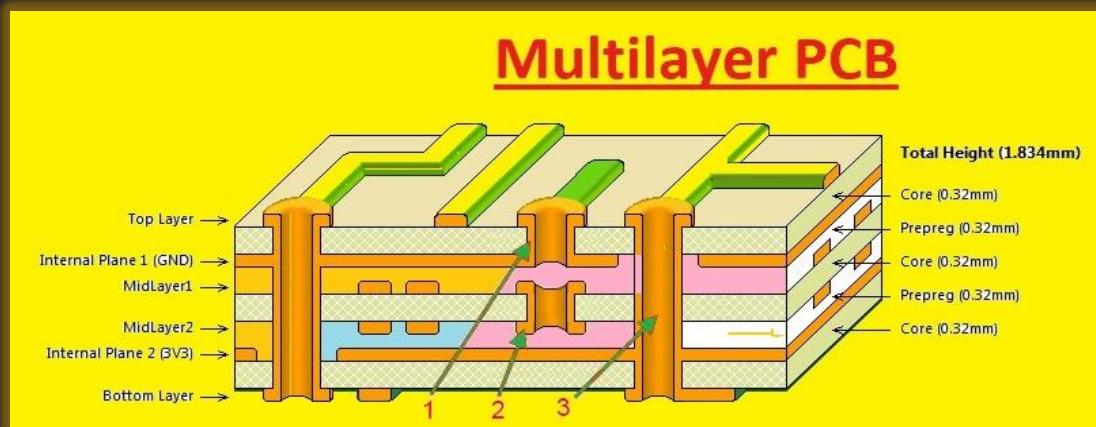
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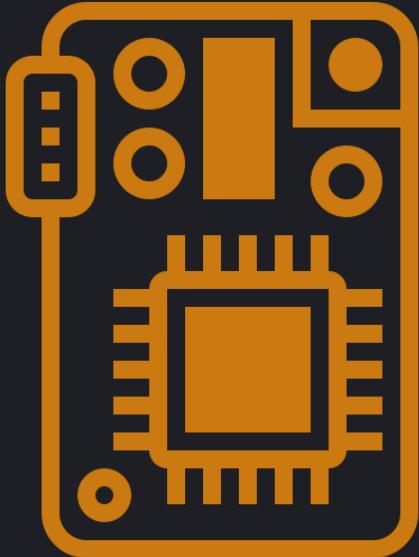
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EPS Microcontroller

MSP430F5529

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MSP430F5529

The MSP has a storage capacity of only 128 kilobytes and consists all of the **software** of the EPS subsystem.

The software used in the satellite is variation of the commonly used language ‘C’ and it’s called ‘embedded C’.



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```
# This function adds two numbers
def add(x, y):
    return x + y

# This function subtracts two numbers
def subtract(x, y):
    return x - y

# This function multiplies two numbers
def multiply(x, y):
    return x * y

# This function divides two numbers
def divide(x, y):
    return x / y

print("Select operation.")
print("1.Add")
print("2.Subtract")
print("3.Multiply")
print("4.Divide")

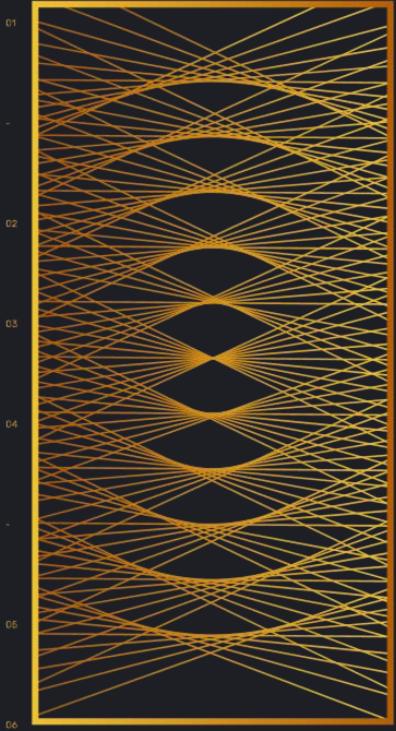
while True:
    # take input from the user
    choice = input('Enter choice(1/2/3/4): ')

    # check if choice is one of the four options
    if choice in ('1', '2', '3', '4'):
        try:
            num1 = float(input("Enter first number: "))
            num2 = float(input("Enter second number: "))
        except ValueError:
            print("Invalid input. Please enter a number.")
            continue

        if choice == '1':
            print(num1, "+", num2, "=", add(num1, num2))
```

A Simple Python Calculator is 3 KB





08.

ON BOARD COMPUTING



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FILM NEGATIVE FILM NEGATIVE FILM NEGATIVE

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X
Z

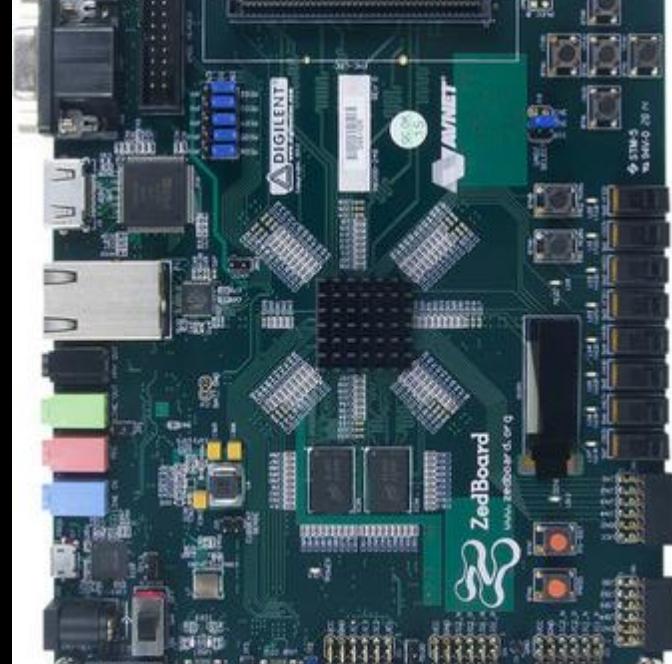


→ 13 → 13 A → 14 → 14 A

MOTHERBOARD OF LAPTOP



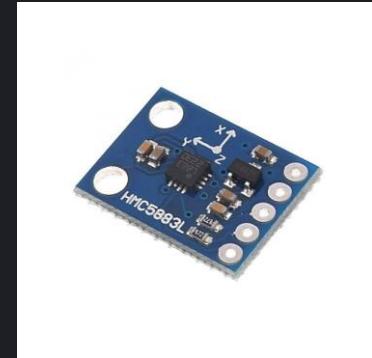
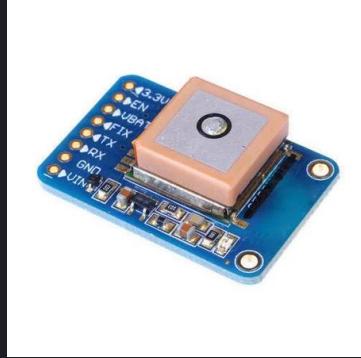
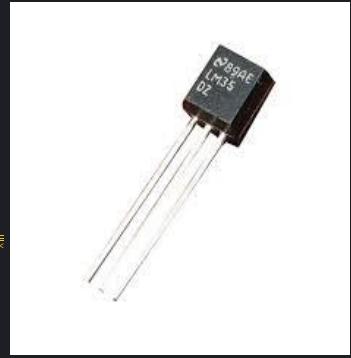
FILM NEGATIVE FILM NEGATIVE FILM NEGATIVE



→ 13 → 13 A → 14 → 14 A

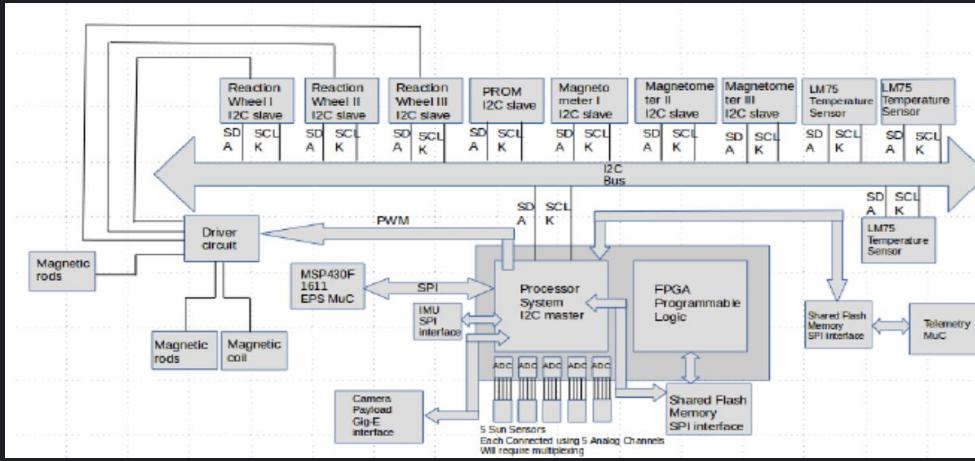
MOTHERBOARD OF CUBESAT





SENSOR INTERFACING

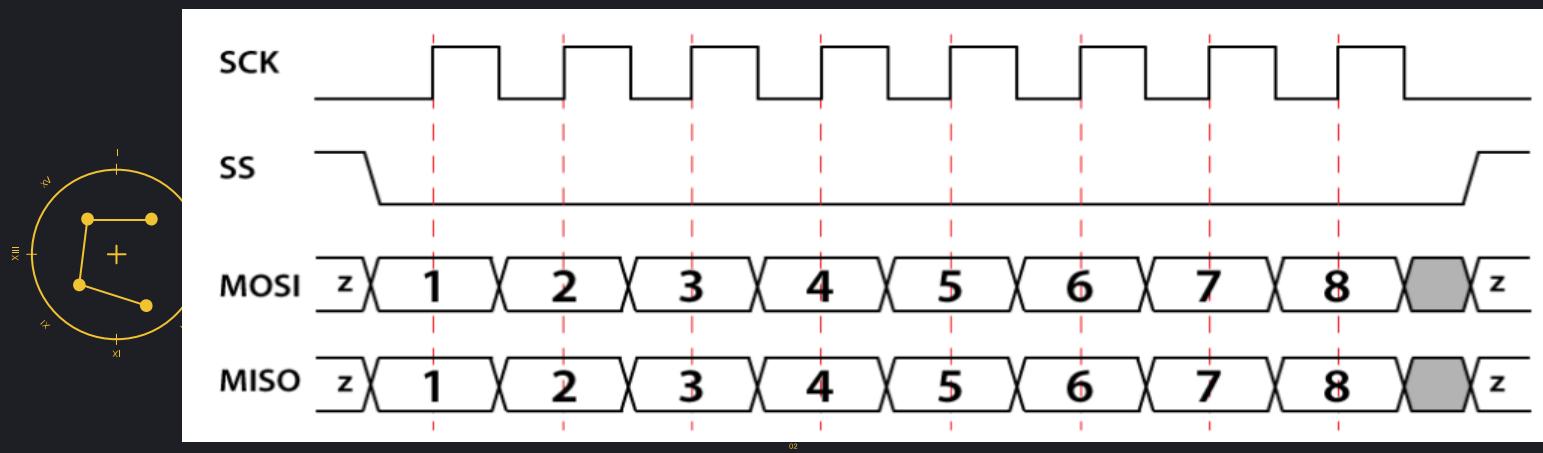
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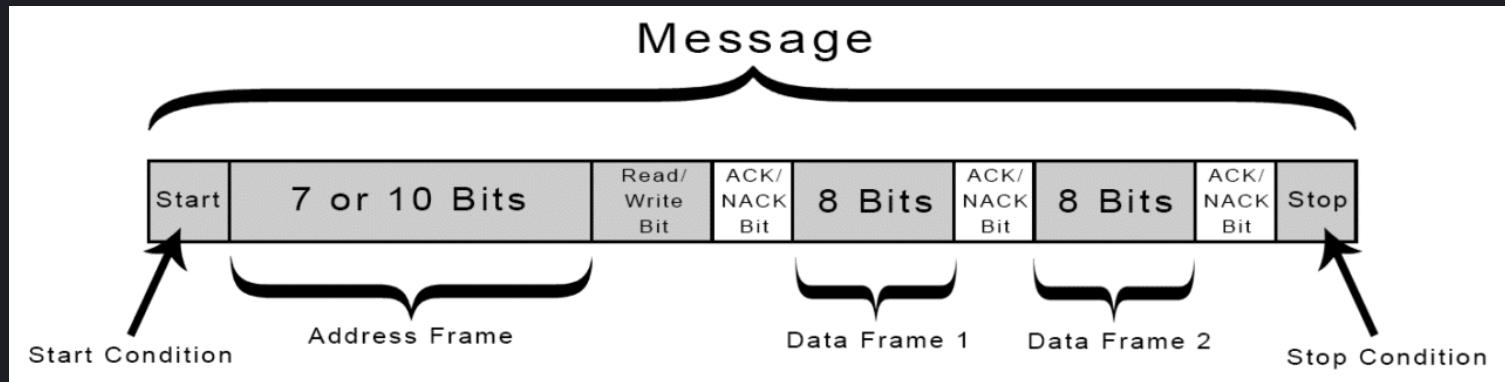
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COMMUNICATION PROTOCOLS

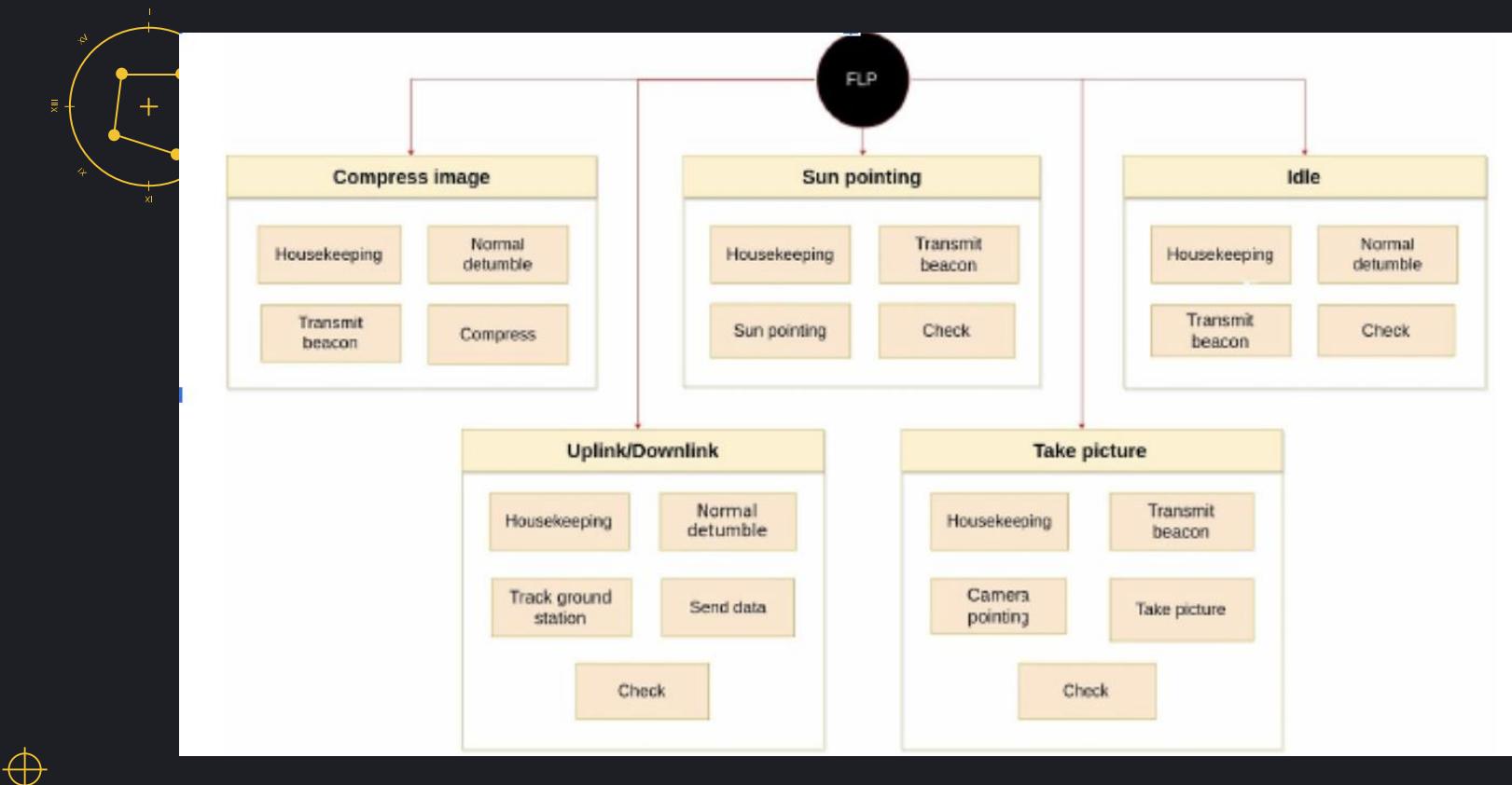




OPERATING SYSTEM - LINUX



FLIGHT PLAN





SO BASICALLY, WE



INTERFACE SENSORS



CODE FLIGHT PLAN



BUILD OS

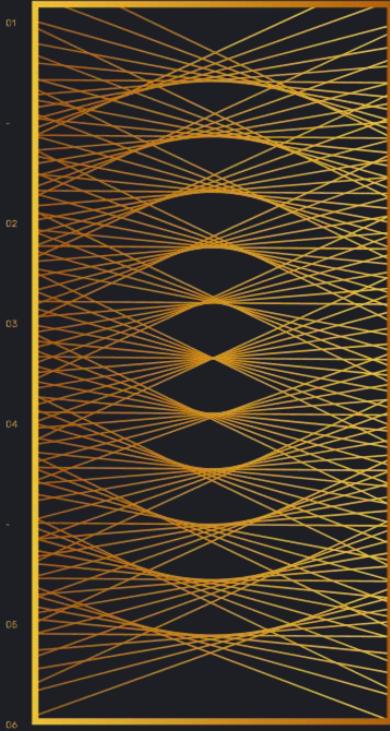


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09.

PUBLICITY SPONSORSHIP AND DESIGN





VERTICALS

WEB DEVELOPMENT

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UI/UX & GRAPHIC DESIGNING

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UI/UX & GRAPHIC DESIGNING

The UI/UX & Graphic Designing Vertical of Team Anant is dedicated to creating visually stunning and user-centric experiences. We are a team of creative minds who blend art and technology to design intuitive interfaces and captivating visuals.

We work on maintaining Team Anant's online presence by creating engaging posts as you all might have seen through our official handles on LinkedIn and Instagram. We also design Team Anant's merch.

Joining the team will equip you with skills like Figma and Adobe Photoshop. Have a happy learning experience!



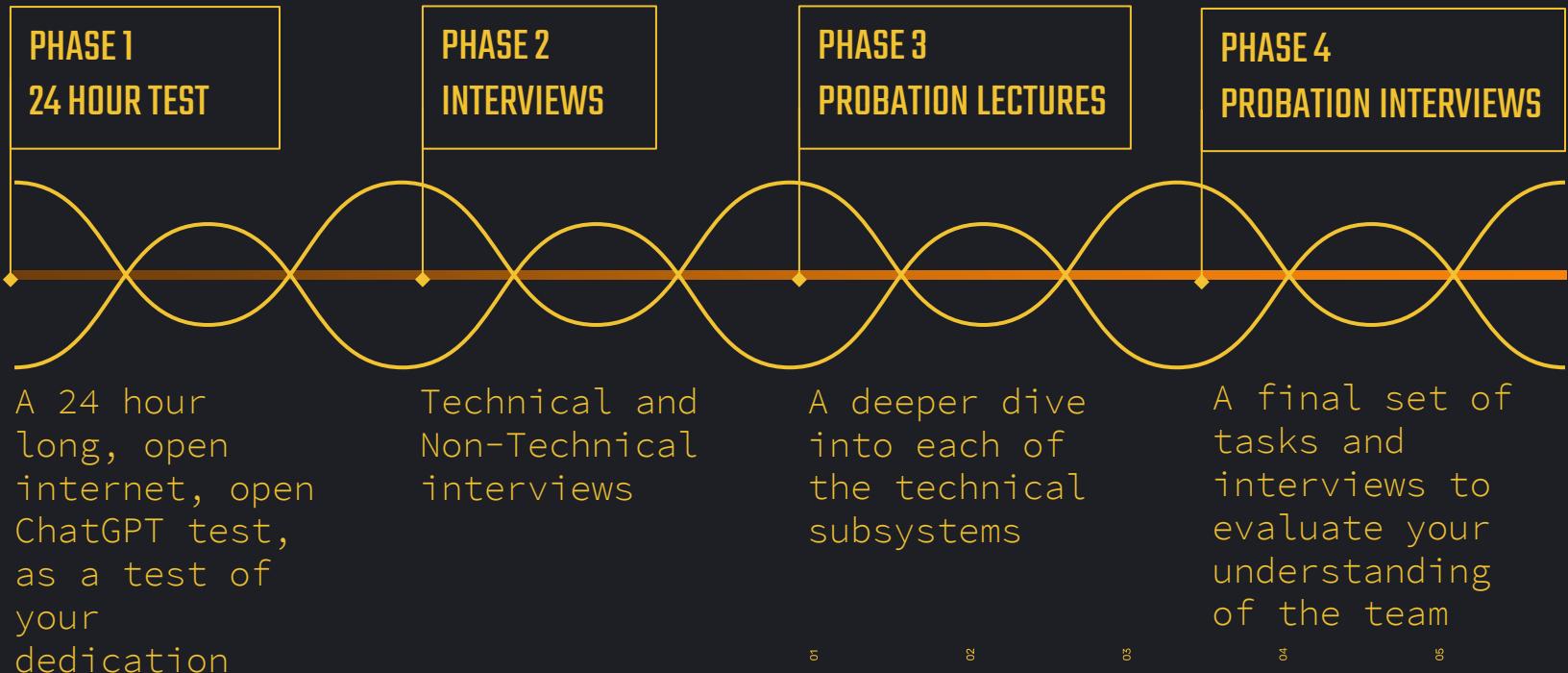
WEB-DEVELOPMENT

The Web Development Vertical of Team Anant is at the forefront of crafting the online presence of the team. We are a passionate group of developers who translate creative ideas into stunning, user-friendly websites. We are responsible for the development, and ongoing maintenance of the Team Anant's online platform. We're currently working on revamping the website. This will provide you with a great opportunity to learn frameworks such as React as well as HTML, CSS and JavaScript.





RECRUITMENT PROCESS





SIGN UP!



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FOR FURTHER DETAILS



Join our WhatsApp Group to stay updated



Check out our website

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