CanSat

Introduction:

This CanSat is a miniature satellite prototype designed to demonstrate real-world space mission subsystems, including **data acquisition, telemetry, navigation, atmospheric sensing, and payload deployment (parachute)**.

The system is based on an **ESP32-S3 microcontroller**, which manages multiple sensors and handles dual-core processing — one core dedicated to sensor acquisition & telemetry and pyrotechnic deployment logic, the second core dedicated to data logging.

Subsystems

1. **Atmospheric & Environmental Sensing**
   - **SHT31-DIS (Temperature & Humidity Sensor)**
     - Measures air temperature and relative humidity using capacitive sensing.
     - Provides insights into environmental conditions during flight.
   - **BMP390 (Pressure & Altitude Sensor)**
     - High-precision barometric pressure sensor.
     - Calculates altitude using the barometric formula.
     - Essential for detecting **apogee (highest point)** to trigger parachute deployment.

- **VEML6075 (UV Sensor)**
  - Detects UVA and UVB radiation using photodiodes.
  - Converts light intensity into a UV Index (UVI).
  - Helps in atmospheric UV monitoring.

2. **Navigation & Orientation**
   - **LIS2MDL (Magnetometer / Compass)**
     - Measures Earth’s magnetic field.
     - Provides heading (compass direction), useful for attitude/orientation tracking.
   - **BMA400 (Accelerometer)**
     - Measures linear acceleration in 3 axes.
     - Detects motion, vibrations, and impacts.
     - Useful for **flight dynamics** and detecting landing.
   - **MAX-M10S (GPS Module)**
     - Provides latitude, longitude, altitude, and velocity.
     - Uses trilateration from satellites.
     - Key for tracking the CanSat’s location in real time.

3. **Radiation Detection**
   - **Geiger Counter Module**
     - Detects ionizing radiation (gamma, beta).

        - Outputs **pulses** proportional to radiation intensity.
        - Converts **Counts Per Minute (CPM)** into **μSv/h (dose rate)**.
        - Expands mission to **space environment simulation**.

4. **Pyrotechnics & Parachute Deployment**
    - Two **pyro channels** controlled via MOSFETs.
    - **Pyro 1** → Primary parachute deployment (at apogee).
    - **Pyro 2** → Backup parachute deployment (if Pyro 1 fails).
    - Controlled by ESP32-S3 with **arming/disarming logic** for safety.

5. **Data Handling**
    - **ESP32-S3 (Dual-Core MCU)**
        - **Core 1** → Sensor data acquisition & telemetry + Pyro control.
        - **Core 2** → Data logging (SD card / flash)
    - Real-time telemetry sent to **ground station** via RF module (LoRa/E32).
    - Logged data includes environmental readings, GPS location, radiation levels, and events (ignition, parachute deployment).

Mission Profile

1. **Launch Phase**
    - All sensors initialize.
    - GPS acquires satellite lock.
    - Radiation and environmental data recording starts.
2. **Ascent Phase**
    - Pressure decreases, altitude increases.
    - Sensors continuously log environmental data.
3. **Apogee Detection**
    - BMP390 detects peak altitude (altitude starts decreasing).
    - ESP32-S3 triggers **Pyro 1** to deploy the parachute.
4. **Descent Phase**
    - Telemetry continues.
    - If **Pyro 1 fails**, backup **Pyro 2** fires after a delay.
    - GPS provides real-time tracking for recovery.
5. **Landing & Recovery**
    - Accelerometer detects impact/landing.
    - Final location transmitted to ground station.
    - Data retrieved from SD card for analysis.

Key Features

- Multi-sensor data acquisition (atmosphere, radiation, navigation).
- Redundant parachute deployment system.
- Real-time telemetry & onboard logging.
- Dual-core processing for parallel task management.
- Designed for **educational and experimental space missions**.