Precision DAQ Package for Aerospace Applications

Problem Statement

- FusionFlight has developed a set of aerospace electronics to improve the current sensing solutions for advanced unmanned aerial mobility operations.
- Prioritizes real-time data acquisition, onboard storage, and wireless streaming, focusing on IMU and GPS data collection.
- A variety of sensors are employed to fuse positional data into a single source.
- The hardware draws less than 25W, with a BOM cost less than $1000.

System Features and Requirements

- Current solutions sample GPS at 1 Hz and IMU data at 10 Hz, significantly limiting the processing potential. FusionFlight hardware can sample GPS at 10 Hz, and distributed sensing systems and inertial modules at 100 Hz.

GPS

- GPS Interface Card acts as a RDC (remote data collection) to collect, process, store, and transmit data.
- Collects 550 parameters in one second (1).
- Receives 5 signals from GPS satellites and decodes raw data to calculate 550 parameters per second.
- Processed data is externally stored to log data on the microSD card.
- Encapsulates collected data string and communicates over custom protocol compatible with industry standard Serial Peripheral Interface (SPI) (4).

Data Acquisition Motherboard

- The motherboard serves as the central hub, it distributes operating system allowing for CPU processing potential.
- Daughter cards were tested on breadboards with Raspberry Pi 5 for further analysis by FusionFlight.
- Powered by a 3S drone battery through XT60, the motherboard efficiently distributes 5V/3A (15W) to daughter cards using automotive rated buck converters (5).

R-Sensors

- Distributed inertial and environmental sensing network.
- One “pod” measures magnetic field and acceleration (position).
- 5 pods work in tandem to collect, store, and visualize data in real-time 3D.

IMU - Inertial Measurement Unit

- Custom ESP32 carrier board with multiple sensors: accelerometers, magnetometers, gyroscopes, pressure and temperature sensors.
- FreeRTOS based operating system allowing for deterministic and high frequency communication (2) (Up to 100 Hz sample rate on select sensors) (3).
- Adjustable full-scale measurement range, allowing for tunable accuracy across varied physical environments.
- Automotive rated parts used wherever possible to ensure robust and reliable operation.

Testing and Results

- Daughter cards were tested on breadboards with off the shelf development boards to begin firmware.
- GPS functionality tested and verified under varied natural environments (inclement weather, clouds, etc.).
- Static acceleration rig to calibrate accelerometers at a standard 1 m/s² acceleration.
- R-Sensors experimentation was done on separate rig to independently verify its measurements for each pod.
- All daughter cards can successfully communicate and are powered by the motherboard.

Future Work and References

- Perform rigorous flight testing and collect datasets from differing flight conditions.
- Fuse all sensor data together with FusionFlight ML algorithm for real time positioning.
- Use NEO-8M8N GPS Modules as a cheaper, lower power consumption, and higher precision alternative for commercial use.
- Refine 3D data plotting by using MATLAB or optimizing Python; develop R-sensor daughter card.