Thoughts on design

IO BOARD

1. Since sensors are placed far apart top and bottom. Sensors may need amplification if too far apart from processing unit.
2. There is a need of multiple IO boards.
3. Sensors are assumed to be 28 V tolerant.
4. Output of each is assumed to be analog 3.3V max (Strain gauges, LVDTs , pots etc.).
5. Requirements : V reference = 3.3 V, ADC bit of 12 bit or higher required for a LSB of 0.8 mV or less. (0.012 % quantization error)
6. Need of cascaded 28 V -> 19.8 V -> 11.6V -> 3.4 V regulators with high PSRR and current ratings.
7. Assuming supply is either 28 V or 0V (No ramp).
8. 5 inputs each. No diffrential inputs assumed.
9. Bandwidth requirement of the protocol should be higher than 12 * 5 = 60 bits per seconds. (Per frame)
10. Since the design revolves around a single board (the logic controller) the protocol to be chosen is CAN FD (easy to implement, along with redundancy check, robust against EMI/EMFs, simple bus implementation, cost effective, future proof for higher bandwidth etc)
11. Need of small package STM32 with minimal package pins, 5 digital inputs, 1 CAN controller (plus point if five 12 bit ADC channels present).(Approximately 10-20 pins)
12. Need of a can transceiver

Similar to the above we will be designing a MASTER board to connect both the boards and connect to the ECU to send the data via the inbuilt radar of the helicopter.

CAN FD (Flexible Data-rate) allows a larger data field compared to Classical CAN. While Classical CAN supports only up to 8 bytes (64 bits) of data, CAN FD extends this to 64 bytes, or 512 bits. The frame also includes overhead bits for arbitration, control, CRC, and so on, which usually adds about 80 to 100 bits depending on the frame structure.

In our case, each IO board is assumed to collect data from 5 analog sensors. If each sensor reading is 12 bits, then one IO board transmits 12 × 5 = 60 bits of data. Including around 4 bits for spacing or metadata, the total data per frame becomes 64 bits, or 8 bytes, which fits comfortably within the CAN FD payload limit.

Frame Size Estimate

Assuming an 8-byte payload and about 100 bits of overhead, the total frame size comes out to roughly 164 bits per CAN FD frame. This is an approximation, but it’s a reasonable value for estimation purposes.

Bandwidth Calculation

Let’s assume the arbitration phase runs at 1 Mbps, and the data phase runs at 2 Mbps, which is a conservative value. Since arbitration is slower and data is faster, the effective average transmission rate can be estimated at about 1.33 Mbps.

At this rate, the number of such 164-bit frames that can be transmitted per second is approximately:

1.33 million bits per second divided by 164 bits per frame ≈ 8110 frames per second.

Since each IO board provides 12 sensor readings, the total number of analog sensor readings transmitted per second becomes:

8110 × 12 = 97,320 analog sensor readings per second.

Identifier Limit

In Classical CAN, only 11 bits are available for the identifier field, which limits the number of unique node addresses (e.g., IO boards) to 2^{11} = 2048.

In CAN FD with extended frame format, the identifier is 29 bits long. This allows for up to 2^{29} = 536,870,912 unique IDs, which is more than enough for any large system.