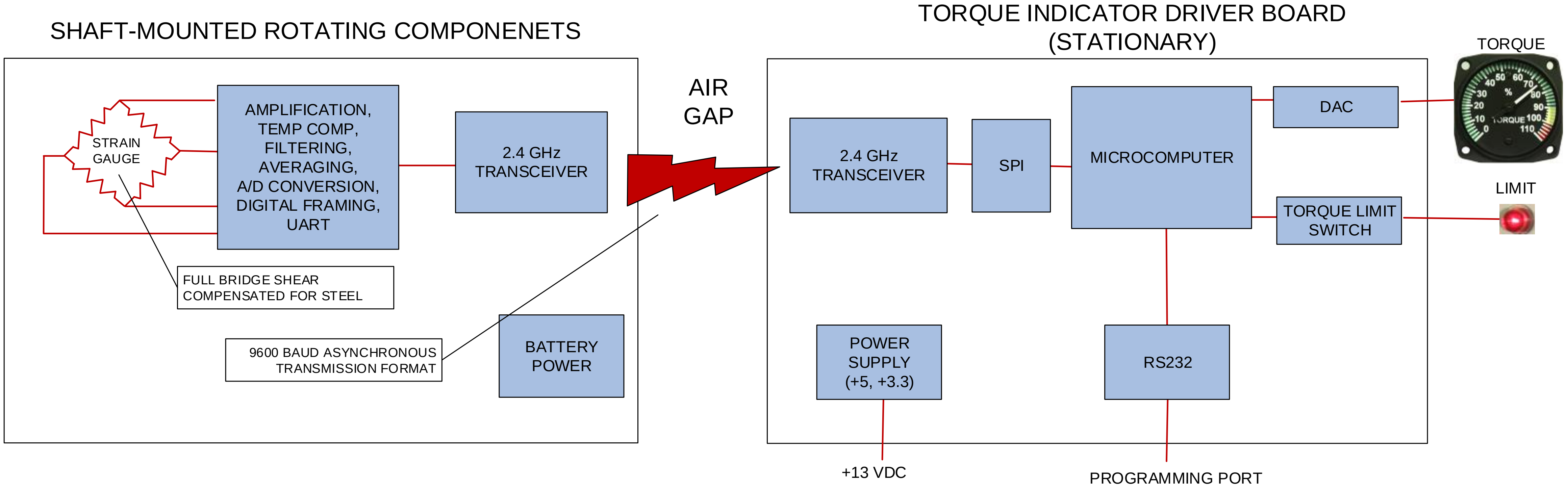
Helicycle Transmission Torque Indicator R&D Project

Juan@WA6HTP.Com

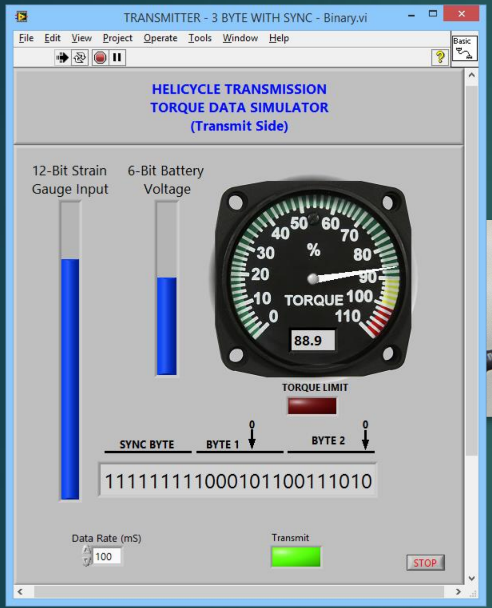
HELICYCLE TORQUE DATA ACQUISITION AND DISPLAY



LabView Modeling

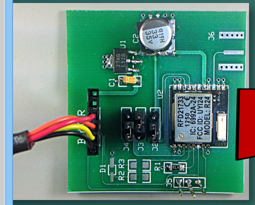
- How often does the indicator need to be refreshed for a smooth response? (Transmitter battery life will be extended as refresh intervals are lengthened.)
- What is the best telemetry format?
- How many data bits are needed for an accurate indication?
- How much latency can be tolerated?
- What if any averaging or smoothing is desirable, and what is the impact on latency? What are the tradeoffs?
- How robust is the RF link? Does it handle errors well?

Entire Data Path Modeled in LabView

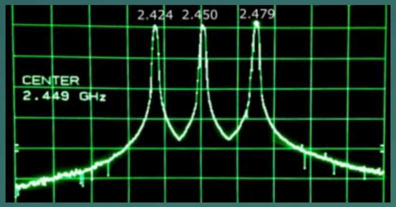


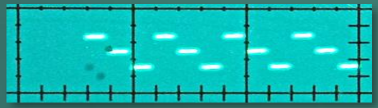
SHAFT ELECTRONICS

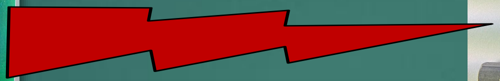
1



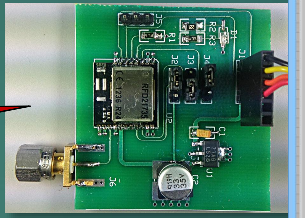
2



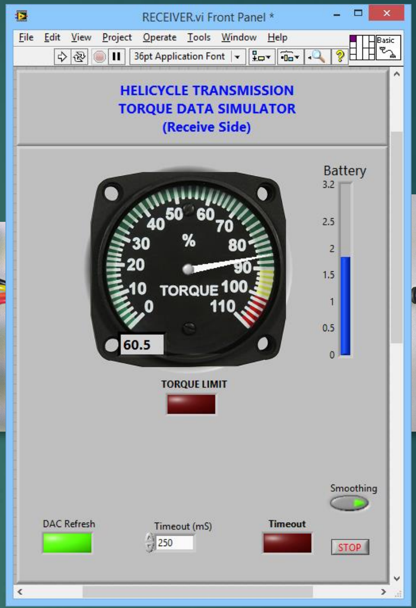




2.4 GHz TELEMETRY LINK

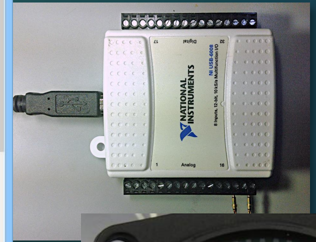


3



RECEIVER/ PROCESSOR

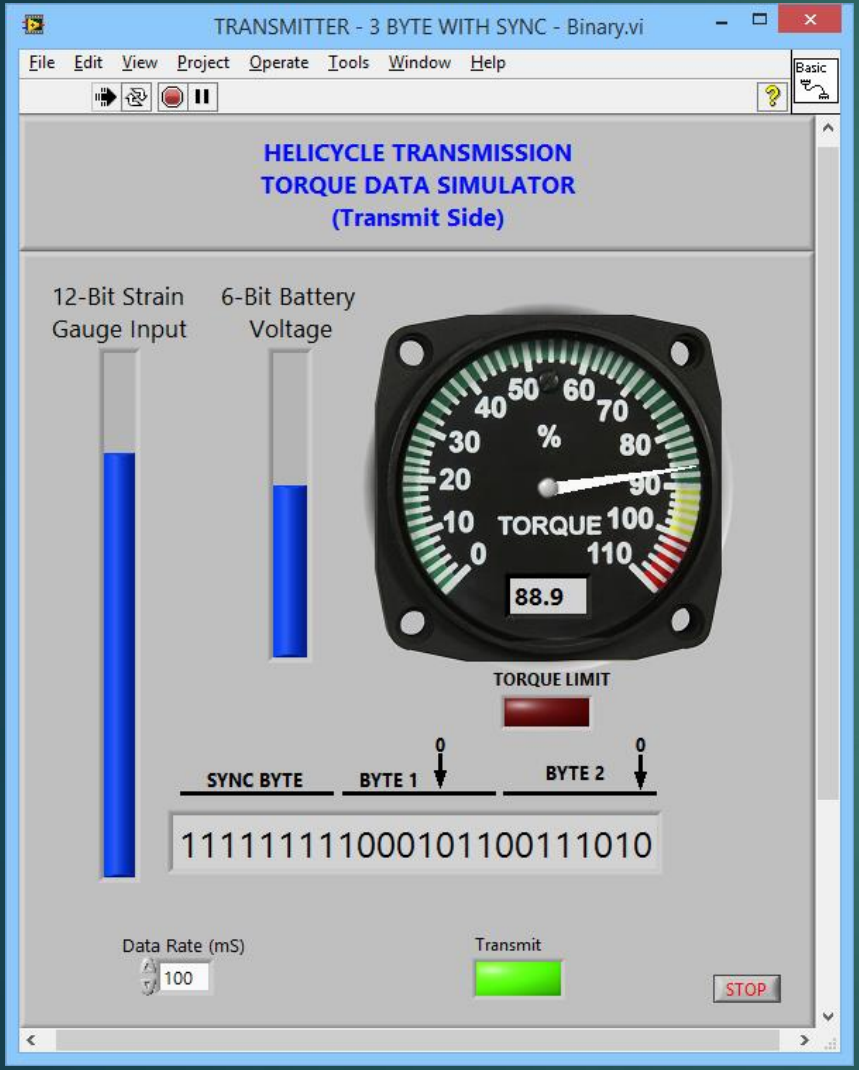
4



5

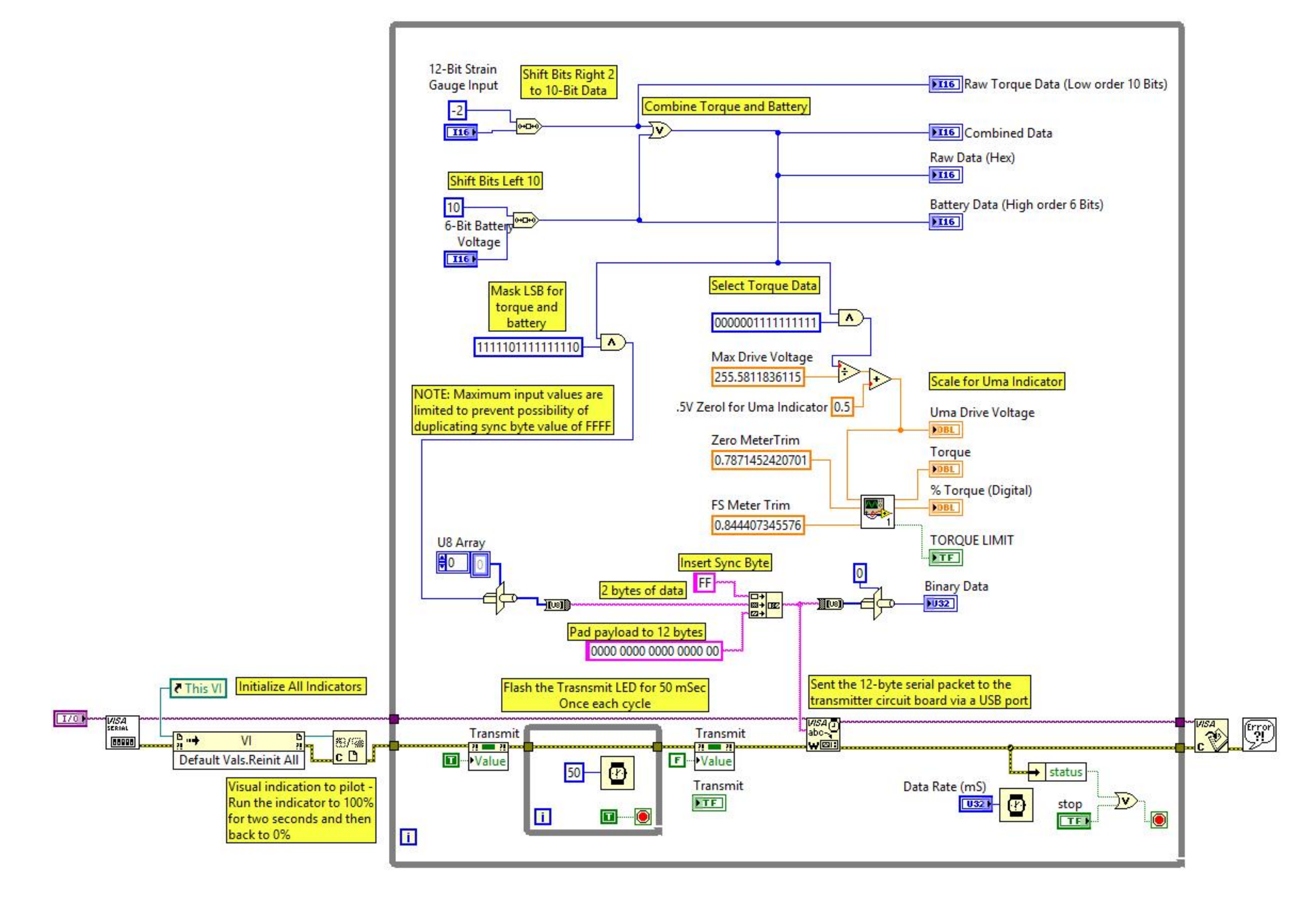
6

1 Rotating Electronic Package

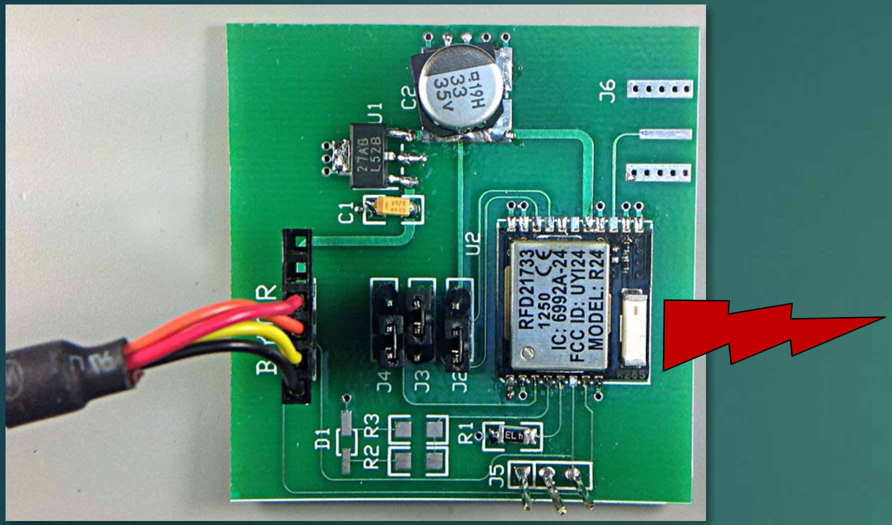


Raw inputs are entered for strain gauge and battery voltage with the blue sliders.
A 2-byte data packet is created from the raw data. A sync byte is inserted ahead of the data and nine bytes of pad are added to bring the total packet size to 12 bytes.
The 12-byte packet is sent to the RF transmitter at intervals set by the 'data rate' window at the bottom.
The green LED lights every time a packet is sent to the transmitter.
This simulator allows the configuration of the data packet and the timing to be modified easily during development.

LabView Block Diagram - Transmit Side



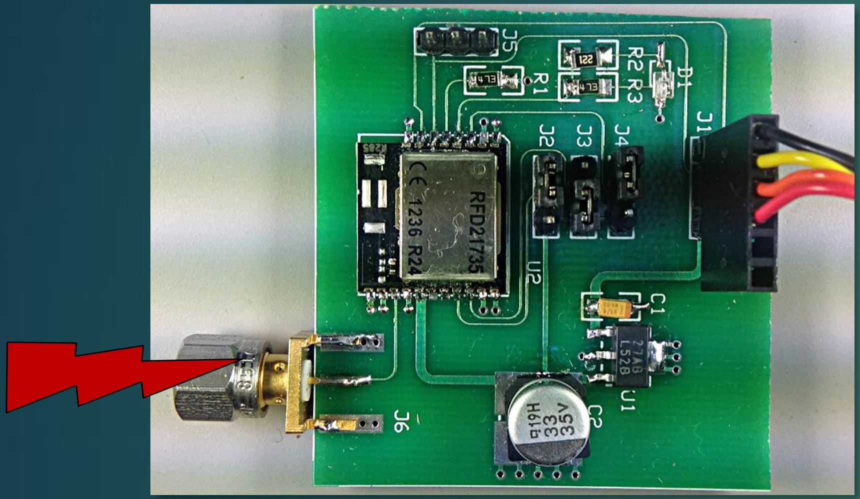
② The RF Telemetry Transmitter



The data packet is sent to the small silver module on this test circuit board where it is processed for transmission by inserting the unit's serial number to the beginning and adding a cyclic redundancy check (CRC) to the end.

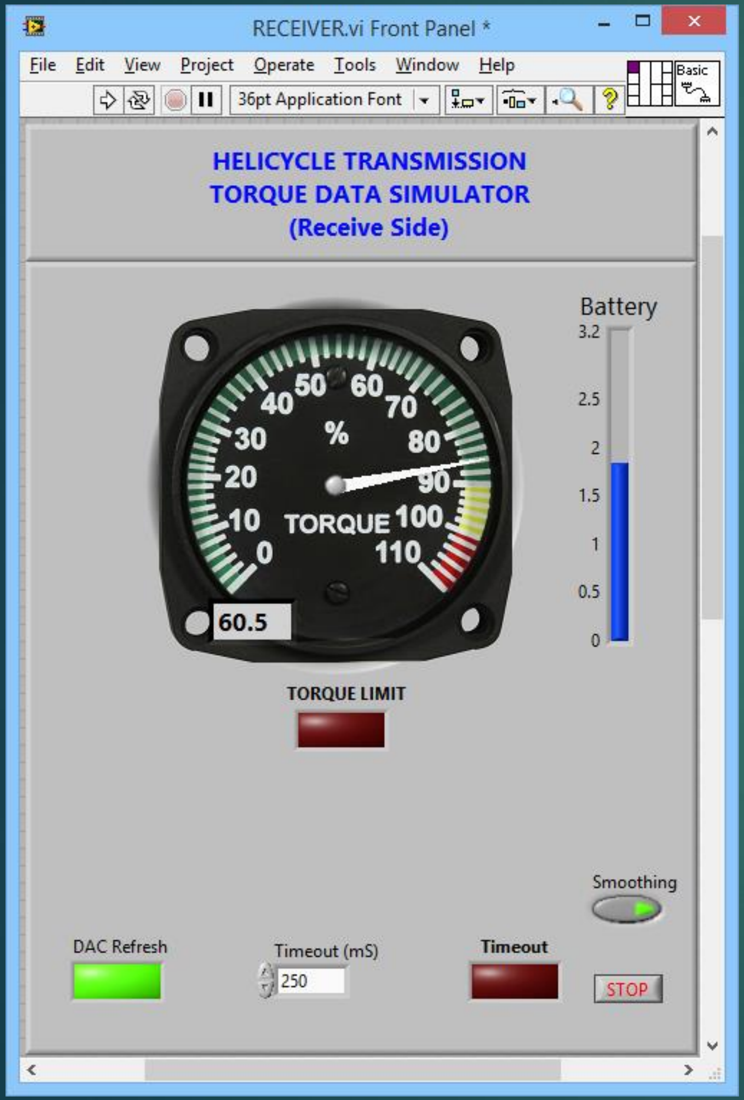
Each new data packet containing the original 12-byte payload is transmitted twelve times on three separate frequencies to insure accurate reception regardless of noise or other interference on the link. This process is repeated five times each second.

3 The RF Telemetry Receiver



The receiver uses a proprietary technique to select the first of the twelve copies of the packet that is error-free. It uses the CRC data to determine accuracy.
Once an error-free copy has been found the serial number and CRC data is stripped off and the original 12 bytes of data are sent to the processor. Both this receiver and the processor will be located in the cabin in a small enclosure.

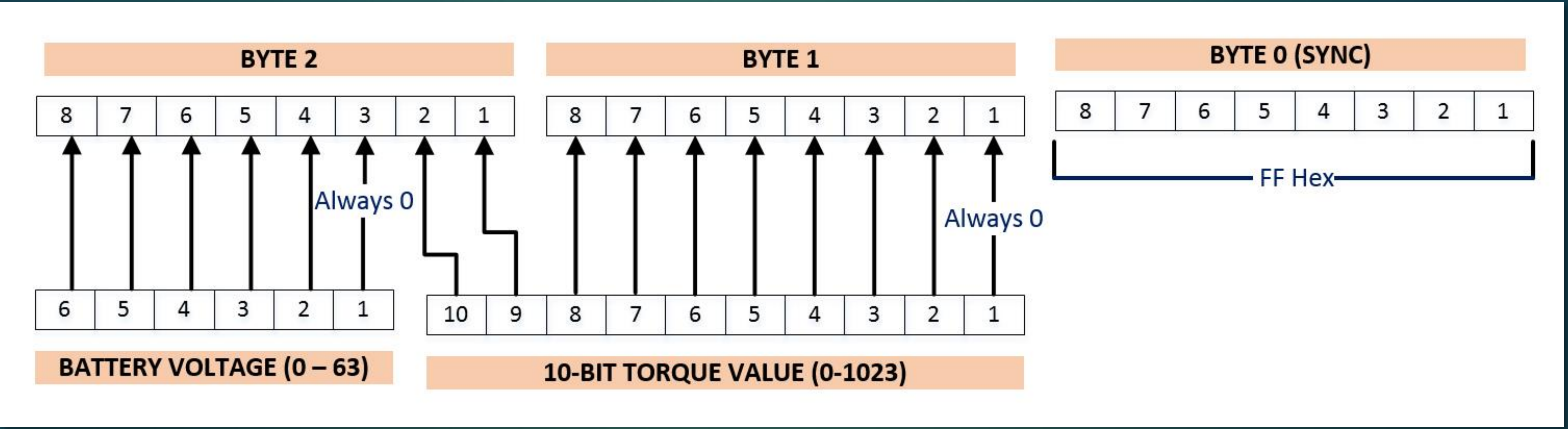
4 The Receiver Processor Unit



The processor receives data from the receiver and looks for an 8-bit byte containing all 1's. This is the sync byte and marks the beginning of data. The sync byte insures that the processor never gets out of step with the transmitted data.

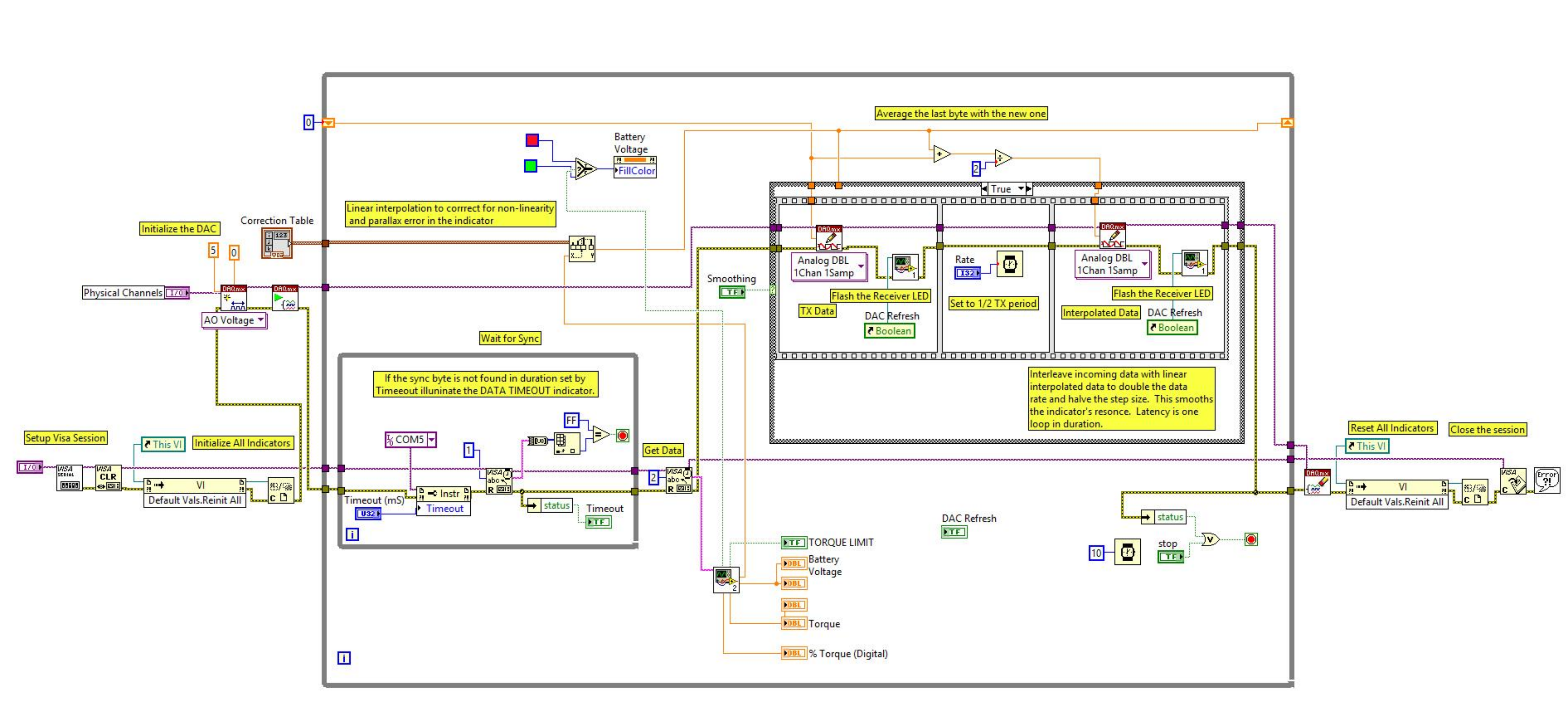
The sync byte is stripped off, along with the padding, and the remaining data is processed and separated into torque and battery voltage values. Different types of data smoothing and averaging can be experimented with here to produce the smoothest indicator response.

Data Format



The two bytes of data and the sync byte are shown here. The nine bytes of padding are not shown. One bit is permanently set to zero in the two data bytes so that the only byte that will ever be all 1's is the sync byte. This insures that no combination of torque and battery voltage will ever be mistaken for sync.

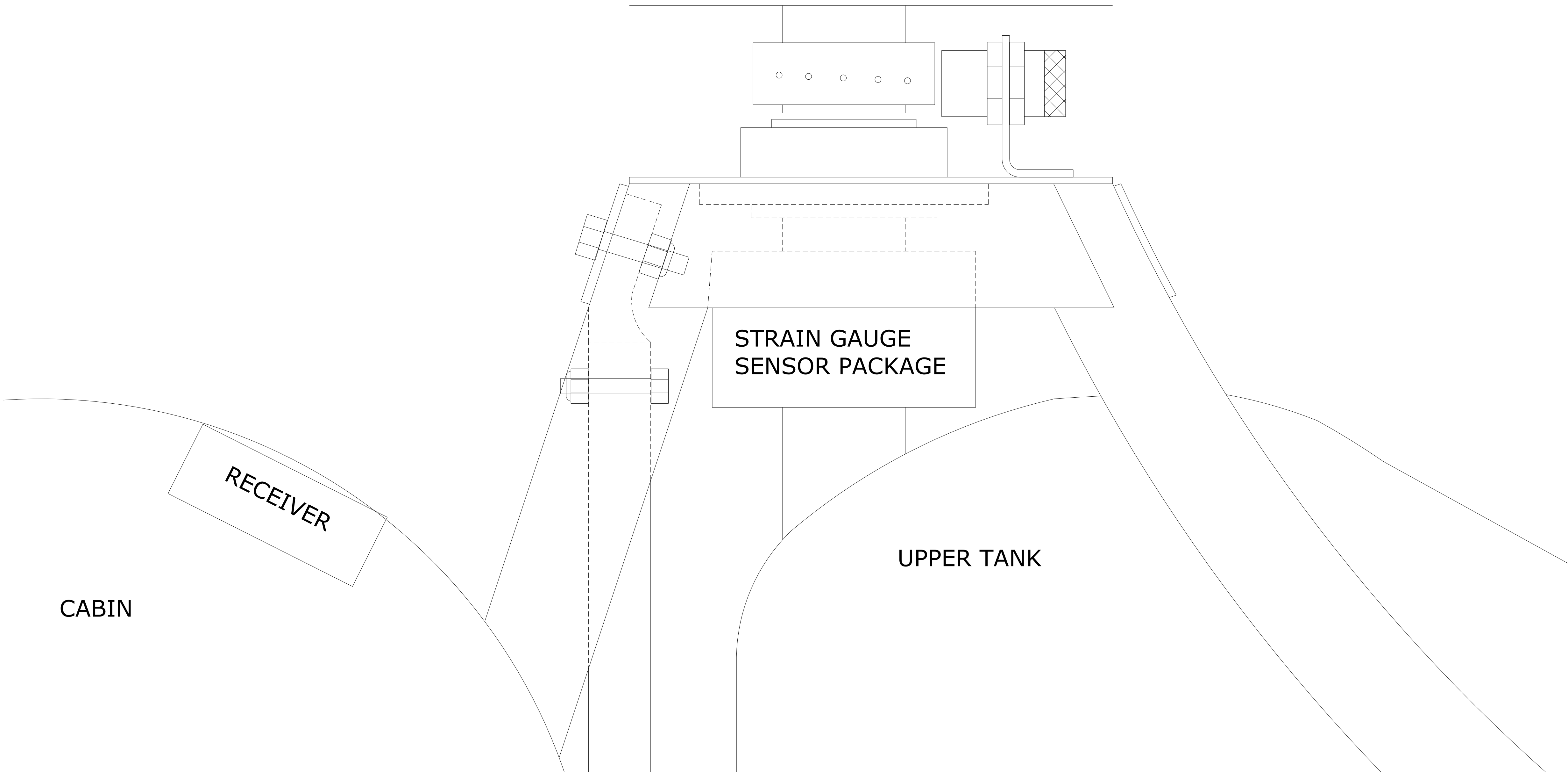
LabView Block Diagram – Receive Side



5 6

The DAC and the Indicator

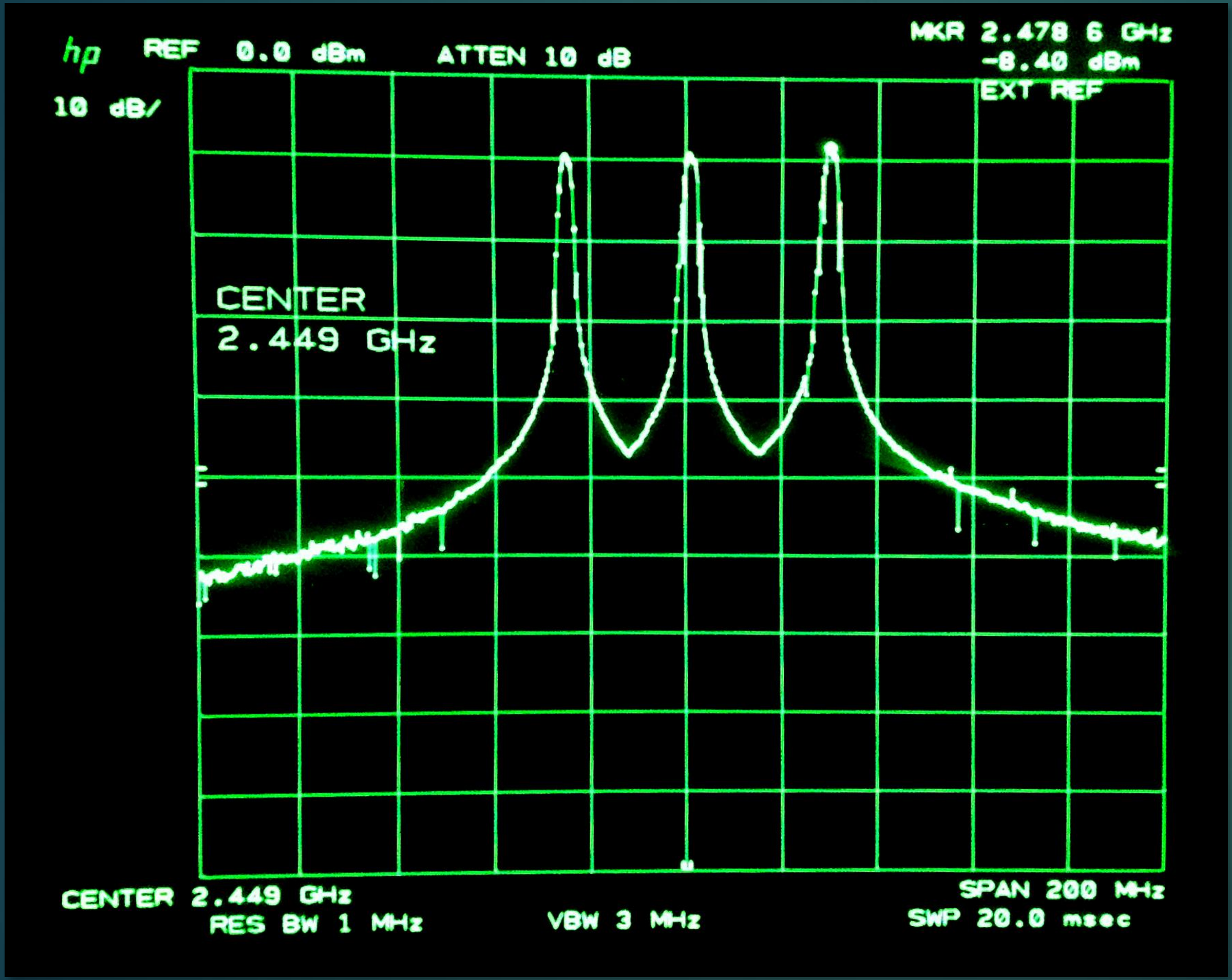
A 12-bit value is sent to this laboratory digital-to-analog (DAC) converter from the processor each time data is received from the rotating electronic package on the shaft. The DAC produces the analog DC voltage that is required to drive the instrument panel torque indicator.
Since the simulation is driving the actual indicator it is easy to see exactly what affect changes to the data format, timing, and averaging have on accuracy, latency and indicator response. In the finished circuit this DAC will be replaced with a single integrated circuit.


STRAIN GAUGE
SENSOR PACKAGE
RECEIVER
UPPER TANK
CABIN

The Data Link…

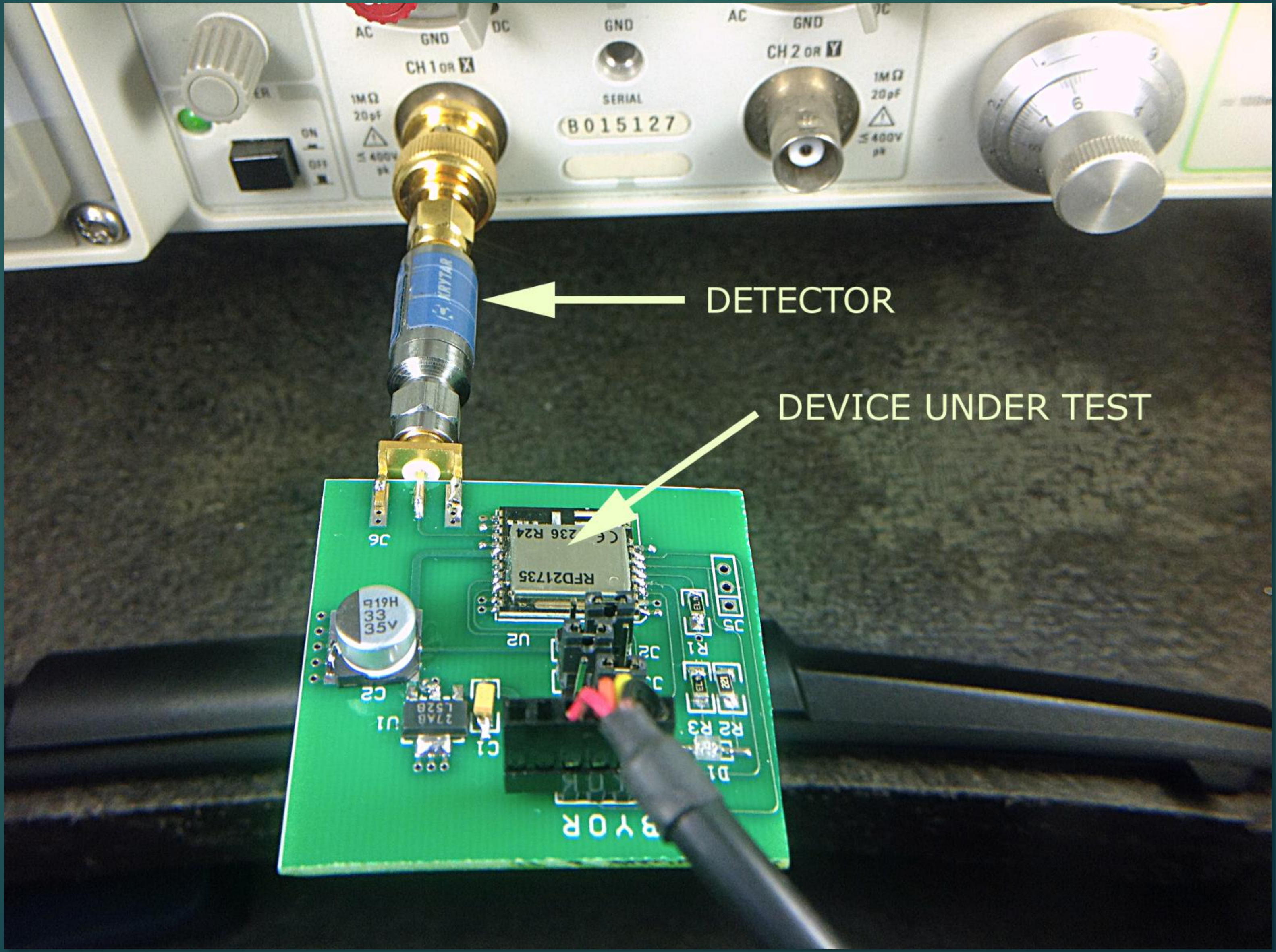
- To guard against corrupt data, the receiver does CRC (Cyclic Redundancy Check) validation on each packet before passing it on to the processor. It has twelve chances to acquire an error-free packet. After extensive testing no data errors have been seen.
- The link is immune to high levels of interference. Transmitting with a 4-watt VHF portable held one foot from the receiver had no affect on reception. A 40-watt UHF TDMA digital transmitter ten feet from the receiver also had no affect.
- The link will update the torque indicator five times a second for smooth response.

RF Module Spectrum

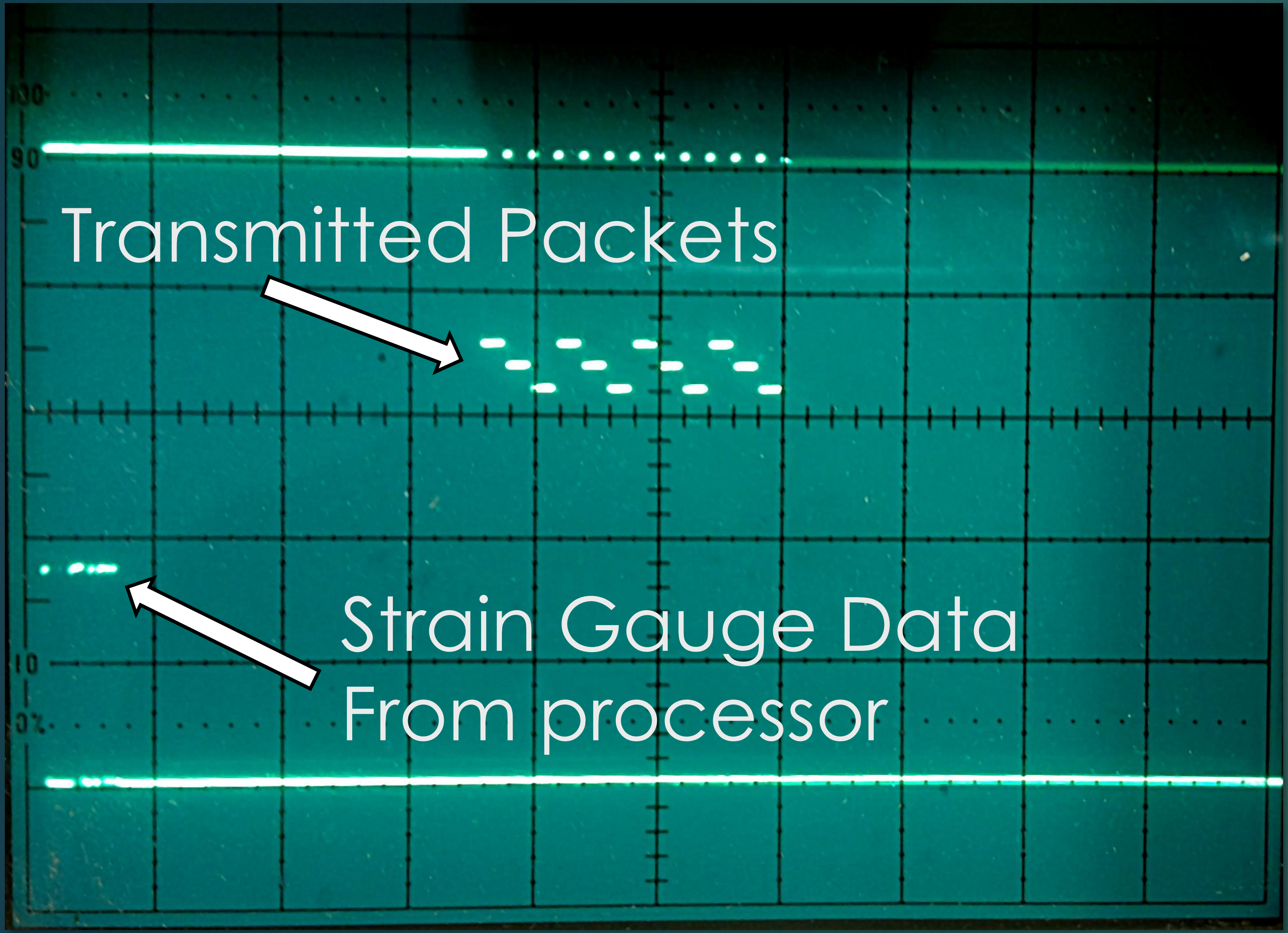


- Unit transmits on three separate frequencies to avoid interference

RF Test PCB #2

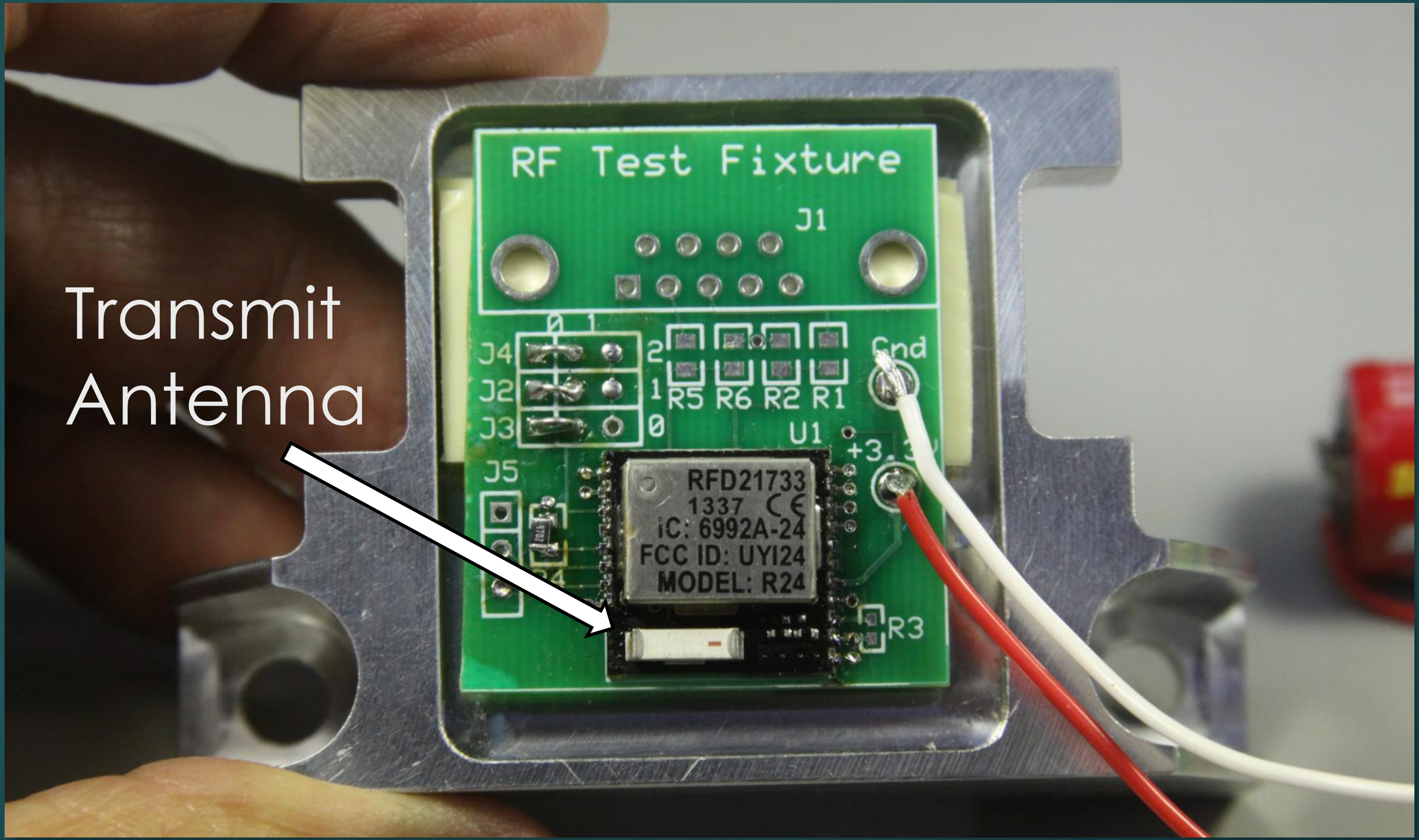


Robust Format



- Each packet is sent four times on three separate frequencies to overcome interference and noise (Repeats 5 times a second for smooth indicator response)

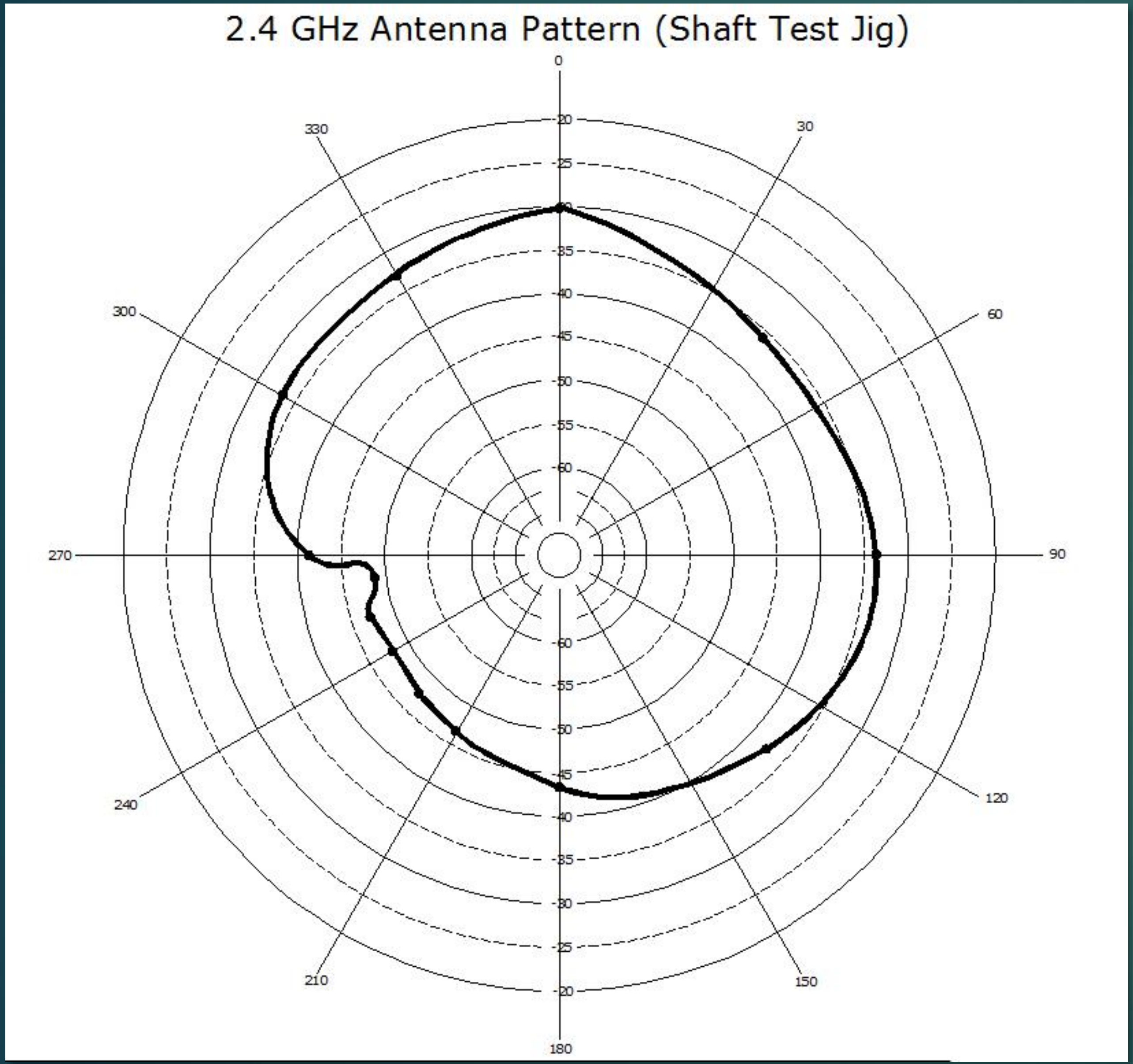
Prototype Housing with Test PCB



Antenna Pattern Baseline Test Setup

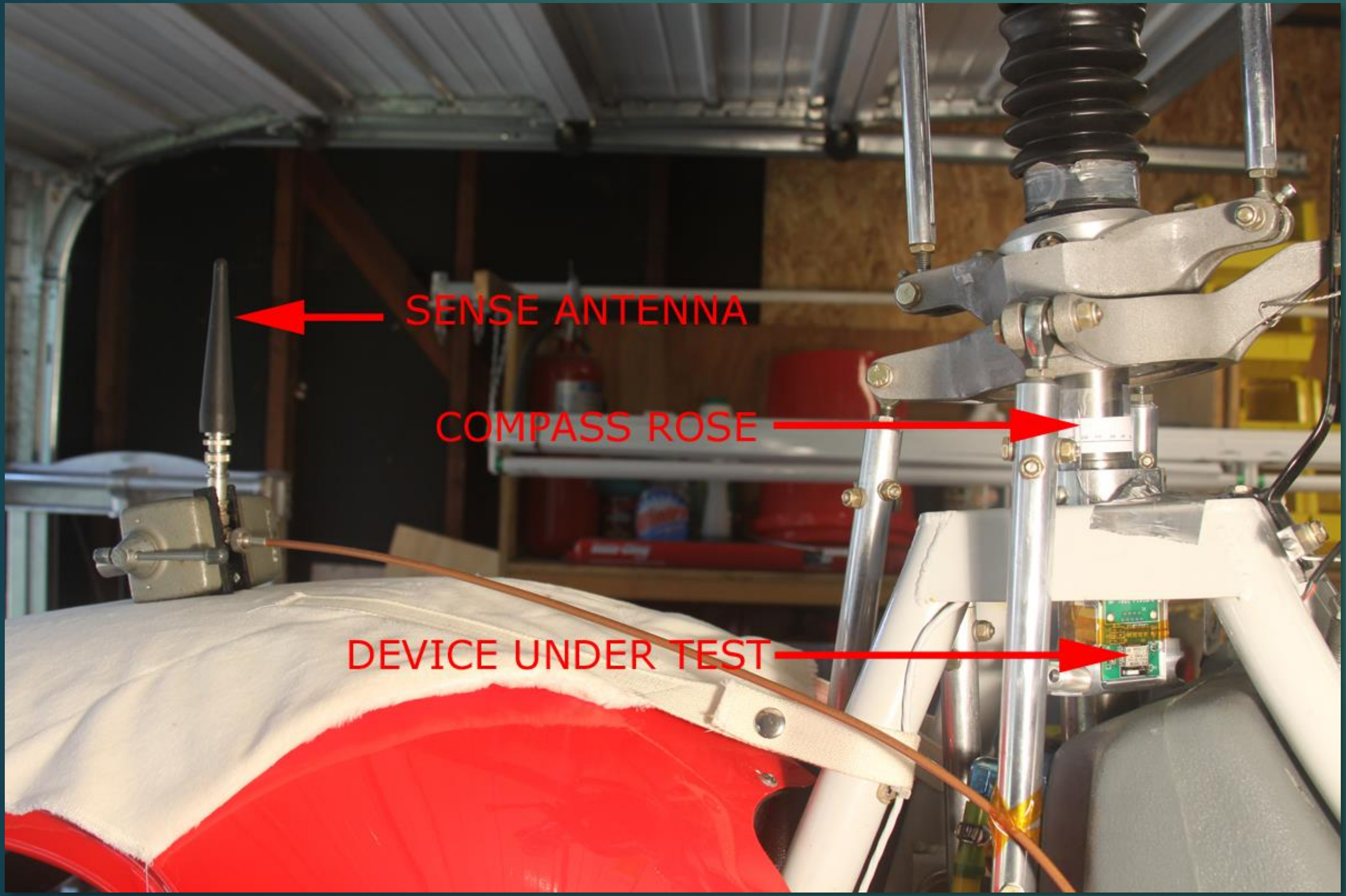
- Test fixture at back
- Sense Antenna in foreground

Baseline Test Results



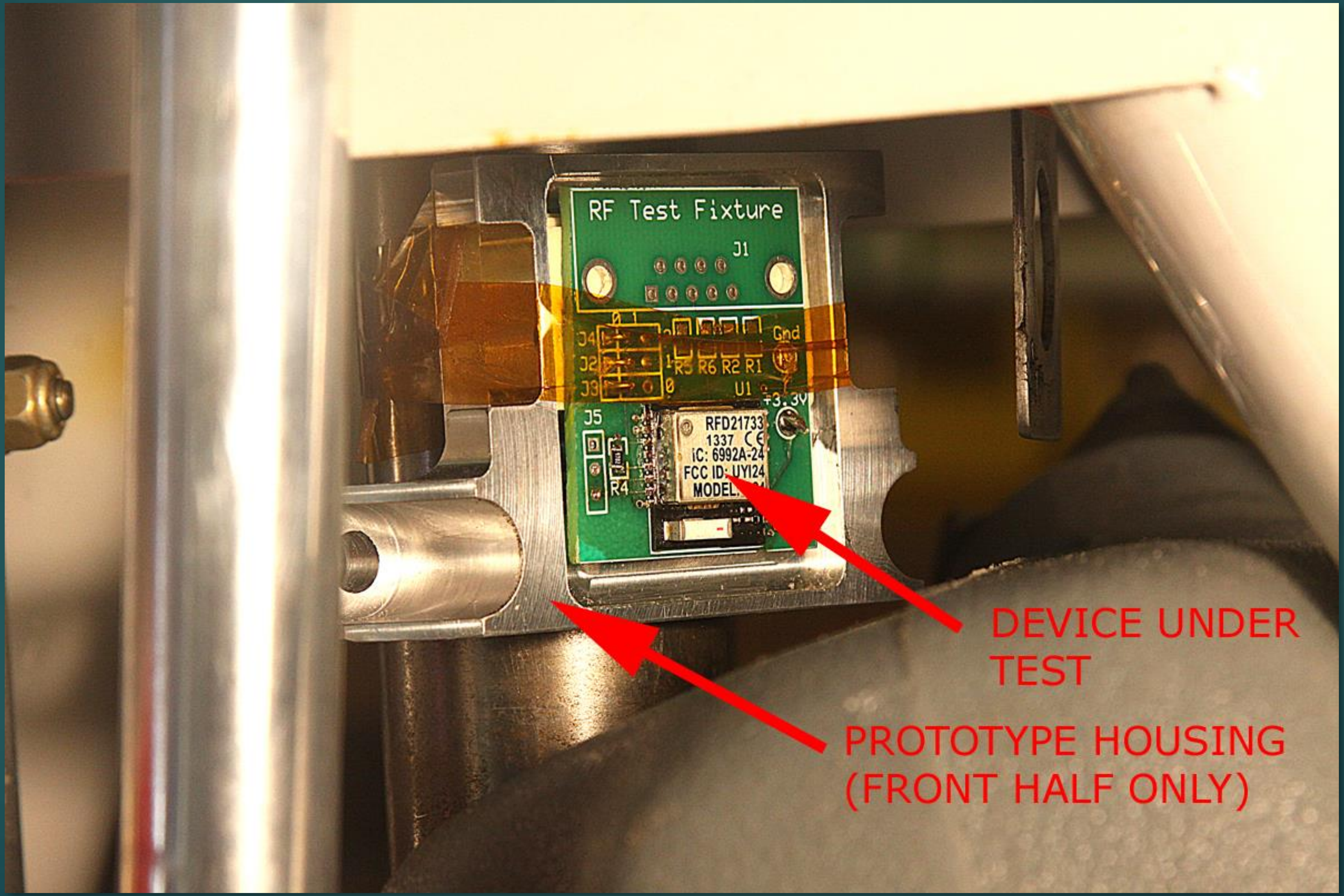
- Best transmission off the front and sides
- Worst off the back (as expected)

Helicycle Antenna Pattern Test Setup

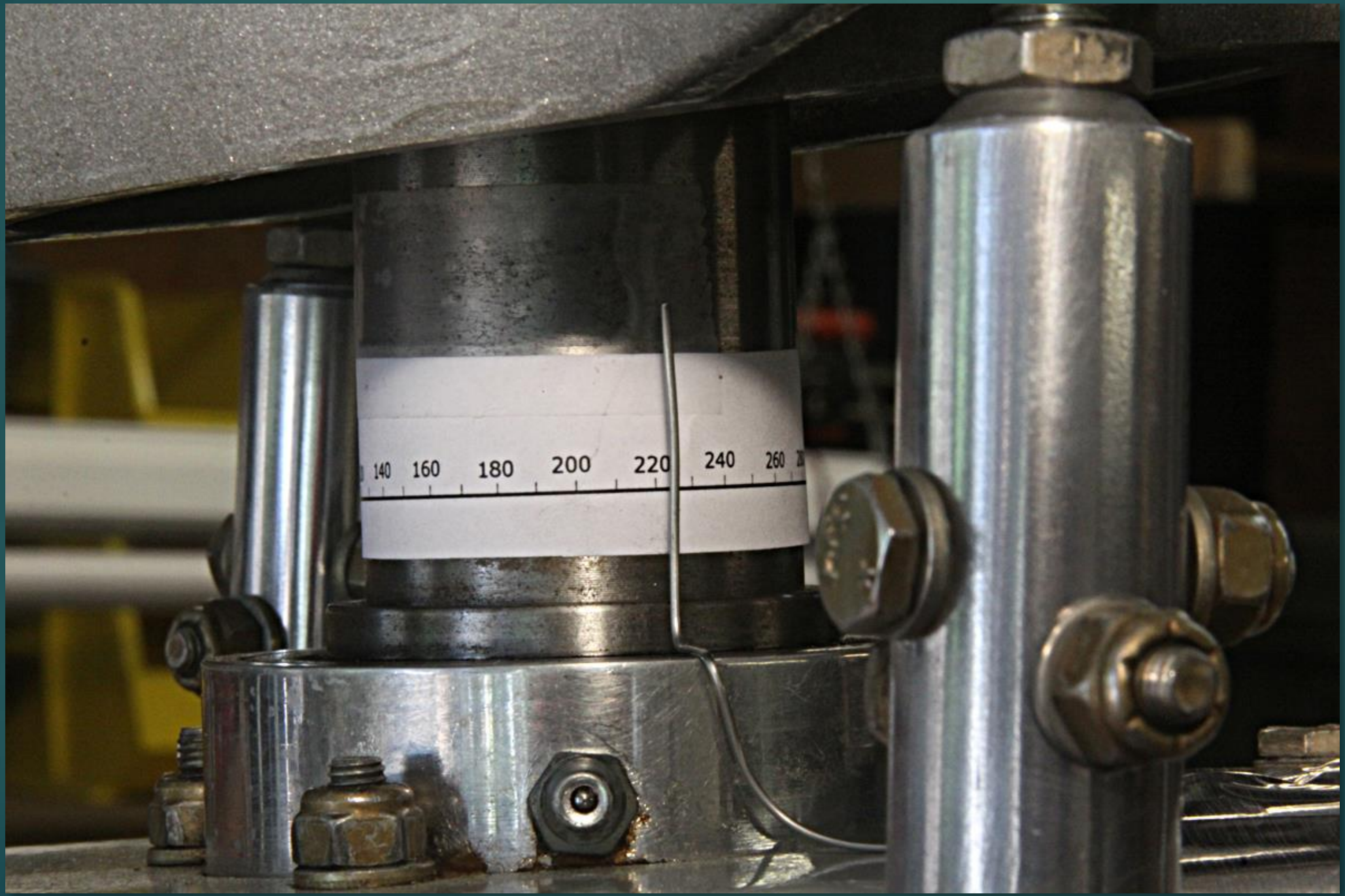


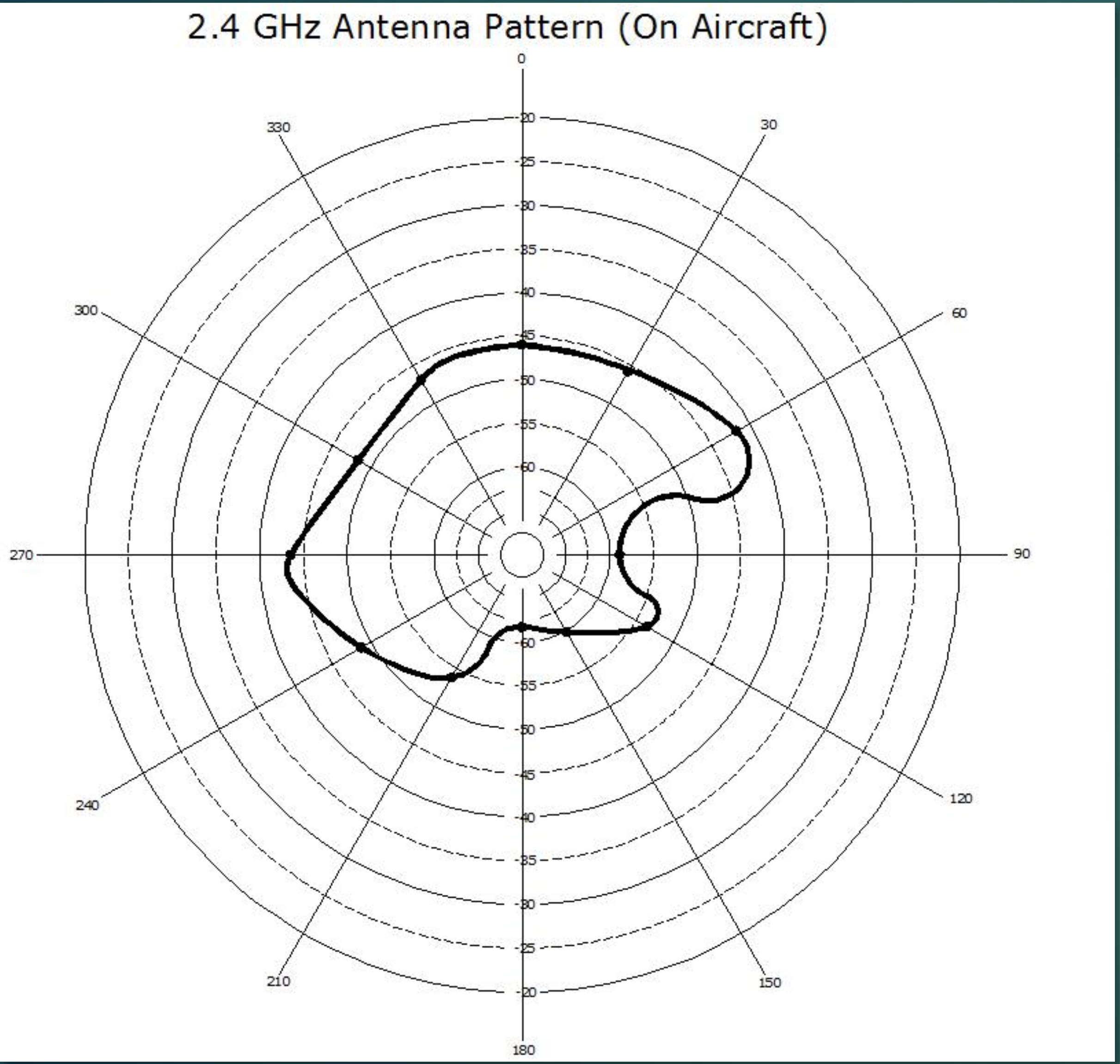
- How reliable will this link be? This link must be rock solid and error-free!

Test Fixture on Rotor Shaft



Compass Rose





Helicycle Test Results

- Multipath degrades path due to many metallic reflective elements
- ~20 dB attenuation off the back side
- Plenty of signal!

Conclusions to date

- The 2.4 GHz modules will work well in this application. Data integrity is insured by the frequency and time diversity transmission scheme and CRC validation.
- No additional error correction is required.
- The RF link will be very solid between the shaft electronics and the receiver/processor in the cabin.
- A 200 mSec refresh rate is sufficient to produce a smooth indicator response.
- 9 bit resolution is sufficient for an accurate indication.

Work Left to Do

- Complete design of both housing halves
- Start looking at the Strain Gauge and the processor
- Install a strain gauge on transmission shaft (removed from Helicycle)
- Calibrate strain gauge 160 ft/lb 100% torque point
- Create a prototype strain gauge processor circuit board
- Program the processor
- Create a prototype transmitter circuit board
- Interface the two boards and mount assembly on shaft
- Mount strain gauge on Helicycle transmission shaft
- Create a receiver/processor circuit board
- Program the processor
- Install torque indicator in Helicycle
- Install temporary wiring harness
- Begin flight testing

I eventually abandoned this project. At the time, there was no good way to provide electrical power to the strain gauge electronics package on the rotating shaft. (There is now)

The project was complicated, and the strain gauge would have been difficult to install on a completed Helicycle.

There was limited interest among other builders.