TOAD Radio Ranging Specifications

Ground Side Hardware

Major Components:

- Major components including 2x Si4463’s, ublox GPS, STM32, uSD Card & USB
- Integrated LiPo & charging/power management circuitry with external power switch
- 2x omni-directional antennas, one 434MHz and one 868 /915MHz
- Connectors for rocket rx antenna, and local tx antenna (both panel mount SMA) and also a USB port. (GPS antenna Internal)
- Rugged casing with IP67/68 connectors to withstand environment
- Initialization/status conveyed using visible PCB mount LEDs

Connectors & Casing Suggestions:

- SMA Connector - Farnell 2096227 (x2)
- USB Dust Cap - RS 252-163 (x1)
- USB Cable - RS 252-056 (x1)
- USB Connector - RS 252-438 (x1)
- Pelicase - CPC SG32733 (x1)
- Battery - Farnell 2401856 (x1)
- Power Switch - RS 123-6106 (x1)

Physical Layout:

- 2x SMA bulkhead connectors down the right hand side of the pelicase, with cable plugging into edge mounted sma connectors on right hand side of PCB.
- 3D printed base fits in reverse profile of the pelicase with stand offs and a battery holder
- Power switch panel mounted on left hand side of case with a JST connector plugging into the PCB
- Indicator LED’s sit centeral below the transparent lid surrounded by clear silk screen labels
- USB Mini B comes with cable which goes to a 5 position 0.1” header on left of PCB
- Battery plugs into PCB through a 3-way JST-PA connector
- GPS antenna soldered direct to pcb, inside cutout if required, with clear view of the sky

Timing Strategy:

The GPS module produces a clock signal at it's TIMEPULSE pin which is referenced against UTC to produce a very accurate frequency of 4MHz. This signal however suffers from high jitter due to it's very nature as the frequency is corrected by constantly shifting the period of individual cycles to ensure that the time averaged frequency is exact. To correct for this we use a low jitter timing reference consisting of a TCXO that produces a signal of very constant period of which the exact frequency whilst nominally 26MHz is unknown. These two signals are combined using black magic by a CS2100-CP which produces a very accurate low jitter clock at a frequency of our choosing. In this case we desire a 26MHz clock. This clock is then buffered using a SL18860 and feed to both Si4460's and the STM32.

With the system clock now very well defined and in phase with both radios and the GPS timepulse we are in a position to measure time accurately. The GPS PPS pin produces a pulse with a configurable rising/falling edge at exactly the top of the second. By connecting this pin to a 32-bit timer on the STM32 e.g tim2 or tim5 we can reference the system clock against UTC to within one clock cycle. The GPIO of the RX radio is connected to another 32-bit timer on the STM32, and is set to trigger on reception of the sync word, the first byte of the radio packet. By recording the value of the internal timer when the sync word is received, and having also recorded the value of the timer on the top of the second, we can accurately determine the time of flight of each message given we know the exact frequency at which the timer was ticked (due to our accurate HSE).

In order to get a more accurate estimate of position, we can also have each ground station send a ping to the rocket at a predetermined time and carry out the reverse of the above process. Transmitting at an exact time requires us to pre-load the radio with our message and command it to send on the rising edge of the CS pin in the mode where flushing the transmit buffer takes a constant time. There is less internal delay in the system if this trigger is in the form of the GPS PPS signal, gated to the CS line of the radio. Thus we have to set the PPS signal to the falling pulse mode, with a pulse length of say 0.85s if we want to transmit every time UTC is xx.85s. The pin on the STM32 that is the CS for the radio will feed into an OR gate before reaching the radio. The other input to the OR gate will be the output of an AND gate. The two inputs to the AND gate are the GPS PPS signal and a GPIO from the STM32 which will control when the PPS signal gets passed to the radio CS.

These units will not relay any dart telemetry to the ground station, or uplink commands from the ground station to the rocket. They will however log the dart radio packets to an SD card, along with all of the ranging data, for redundancy. They will also extract and broadcast the radio ranging data from the return trip (ground to dart) from the dart telemetry packet.

Using the secondary 434MHz radios each unit will broadcast its position and the measured time of flight. One unit will be plugged into a laptop which will solely be running the 'ranging software' reading in received data from all stations and computing the darts altitude and velocity.