Universal Ground Station Receiver

For Hubsan X4 – CDR

Embedded Systems Laboratory EN.525.743.91

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# System Description

The Universal Ground Station Receiver is a headless embedded system which will bind with compatible Bluetooth devices, listen to incoming Bluetooth control packets, and re-broadcast control packets in a format that the Hubsan X4 (H107L) Quadcopter can understand. The ultimate goal is for the system to be able to accept virtually any Bluetooth slave device as a transmitter, enabling a broad range of standard compliant devices to potentially become a quadcopter controller with minimal software setup time. Examples of devices which could communicate with the ground station include (but are not limited to):

* A Bluetooth enabled personal computer
* A smartphone
* A Bluetooth handheld classic controller (Corrie’s project)
* A glove controller with Bluetooth adapter (Corrie’s project)

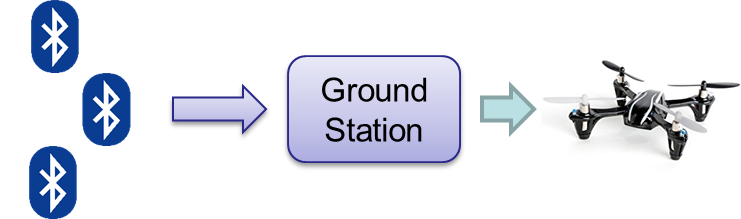


Figure 1: Top level control flow of system (Hubsan X4 pictured on right)

## Capabilities

The Ground Station Receiver will support the following capabilities:

* Perform command translation and relay communication for Quadcopter controls
* Any Bluetooth enabled device may pair
* Support a Quadcopter over Bluetooth Universal Protocol (QoBUP) communication scheme.
  + QoBUP has an accompanying developer ICD which has been developed as a part of this project
* Support a “training mode” for new user to become accustom to new interfaces

## Limitations

In order to constrain the scope of the project, the Ground Station Receiver have the following limitations:

* Only Bluetooth protocol will be support between transmitter and receivers
* Single Quadcopter brand supported (Hubsan X4 H107L)
* Only one quadcopter may be commanded by one transmitter
* Only A7105 RF chip will be supported for the Quadcopter RF communication

# Functional Description

## Overall System

This project is only one half of the entire functional system. In order to fully realize the capability of the Universal Ground Station Receiver two different types of controllers will be implemented by another member of the class, Corrie Russell. She is a project partner and her half of the system is required for the full system implementation. See the CDR documents pertaining to Corrie’s controllers for specific implementation details on the transmitter side. Each controller designed will adhere to the QoBUP standard. Each transmitter will leverage the QoBUP to send controls to the ground station.

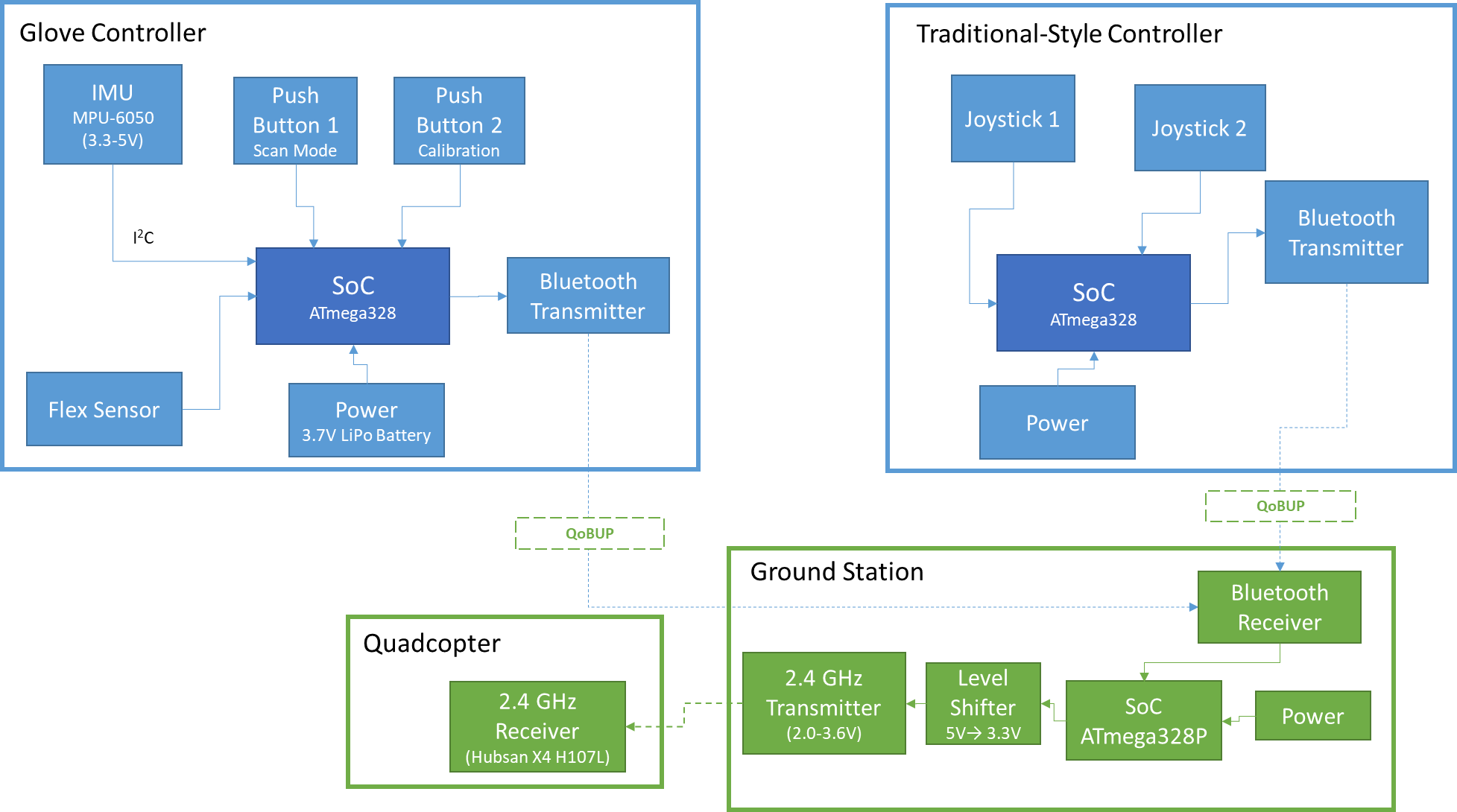


Figure 2: Overall system block diagram.

## Ground Station System

Upon reception of controls from the Bluetooth enabled transmitter the Microcontroller Unit (MCU) will read the contents of the incoming message over a standard UART interface which connects to the Bluetooth module receiver.

### MCU Software Operation

The MCU will read in the control message through the Bluetooth UART Interface into a buffer where it will get picked up by the Protocol Parsing Interface. At this stage, validation is done on the message to ensure the message adheres to the QoBUP ICD. Once validation is complete once all sub-blocks are parsed out into common software structures and command processing is initiated via the Translation Layer. During this stage of software processing, the allocated structures are picked up by a translation stack which is written specifically for the target quadcopter, in this case, the Hubsan X4. The structures are then translated into a set of primitive register read/write commands which are then queued up into the A7105 SPI Interface. Controls are then dispatched to the A7105 over the SPI bus at a controlled rate dictated by the Hubsan X4 communication spec. The flight control packet update rate for the Hubsan X4 is 10ms (Hung, 2015). Finally, the SPI bus will need to be level shifted in order to accommodate the A7105 transmitter’s 2V-3.6V tolerance. The overall ground station hardware/software block diagram can be seen in Figure 3.

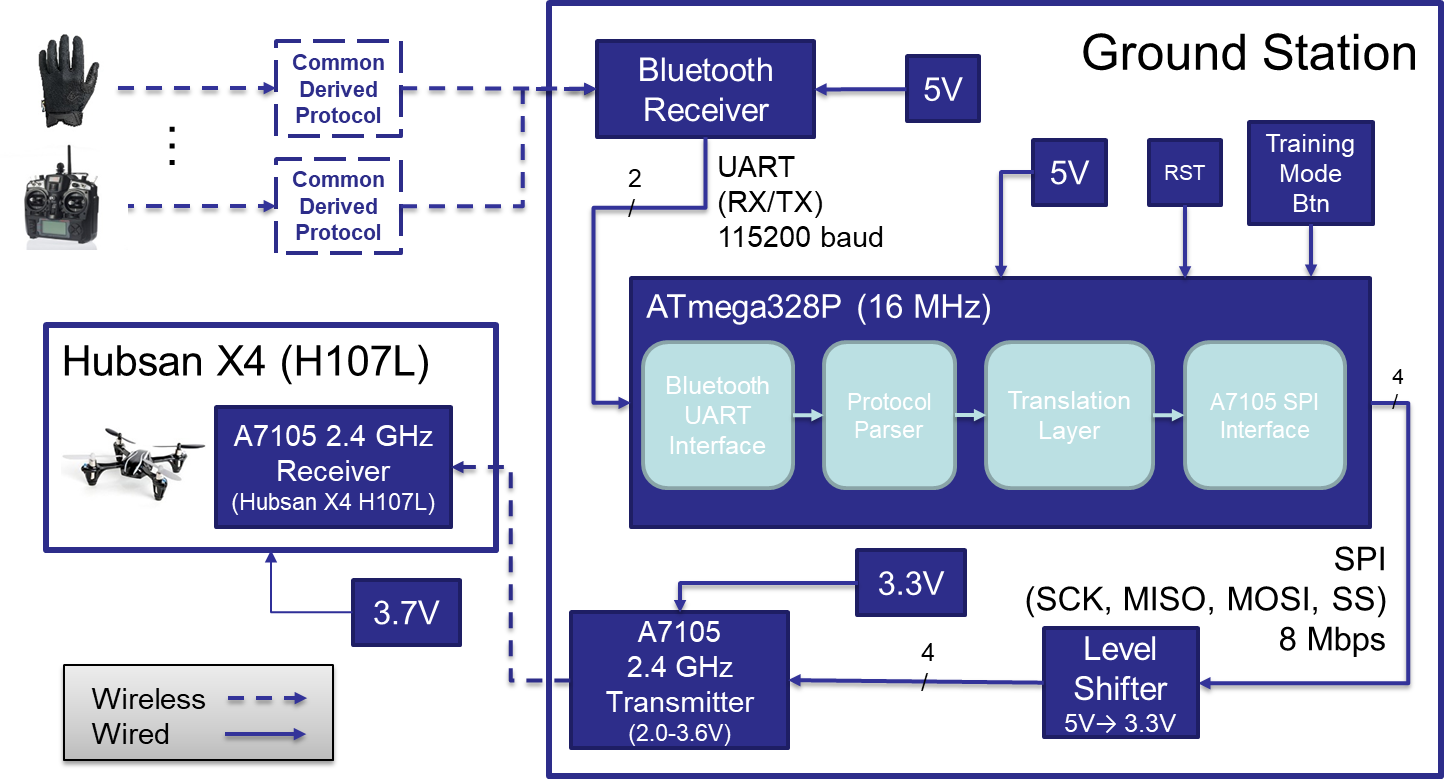


Figure 3: Overall ground station hardware/software block diagram.

### MCU Software Startup

During system initialization, the ground station will attempt to automatically bind to the Hubsan X4. The handshaking involved to complete the binding process is quite involved; however, the entire procedure has been decoded into a step-by-step process outlined on the internet (Hung, Reverse Engineering a Hubsan X4 Quadcopter, 2015).

An additional aspect of system startup will be for configuration of initialization of the Bluetooth transceiver module. The Bluetooth module connected to the ground station will act as the master whereas all transmitters that wish to pair will act as the slave device. All communication (both configuration and controls) to and from the Bluetooth module will occur over UART connection set to a 115200 baud rate.

# Materials & Resources

## Parts List

### Hardware

The list of necessary hardware for the completed ground station is scoped out as follows:

* ATmega328P AVR MCU
* COTS Hubsan X4 (H107L) Quadcopter
* 9V LiPo batteries
* 5V regulator
* Capacitors/Resistors
* LEDs
* Prototyping board
* Insulated prototyping wires
* A7105 Wireless RF 2.4GHz Transceiver Module
* Bluesmirf Bluetooth modem (RN-42)
* 5V to 3.3V level shifter
* 2mm to 2.54mm pitch header adapter

The ground station will operate standalone with a 9V battery powering the entire system, including the MCU and peripherals.

### Software

The following list of development and operational software will be leveraged for the project:

* Linux (development environment)
* Arduino CLI toolchain
  + AVR compiler
  + SPI
  + UART
* Collaboration tools (to work with lab partner)
  + Git
  + Google cloud

All software, with the exception of the AVR support libraries, will be developed as a part of this project. Configuration management will be aided by the use of git as a means for collaboration between the ground station development and the transmitters being developed which is required for the overall system.

### Test Equipment

The following list of test equipment will be used for the project:

* Arduino Mega
* Volt meter
* Oscilloscope
* Breadboard
* Prototyping wires
* LiPo battery charger

## Vendors

The major vendors used for obtaining the above listed parts comprehensively include Amazon and E-Bay. All parts with the exception of the A7105 RF module are available on Amazon at their 2-day prime shipping rate. The A7105 RF module has already been obtained, but had a lead time of approximately 15 days. Redundant parts (double) were ordered for the entire parts list to ensure zero downtime for loss of hardware due to part failure. In the event additional parts must be ordered (so long as it’s not the A7105 part) the lead time will be, in theory, only two days.

## Group Project Logistics

TODOs

* Add feedback LEDs to diagram
* Add in additional test steps to schedule