Radio Flyers

Low Level Design

**Jay Burns, Julian Corona, Steven Cress,
John Walsh, Karen Yokum**

February 29, 2012

1 Overall Requirements

There are a number of primary system requirements that must be fulfilled to address the problem at hand. In any aerial system, safety must be the first priority. Therefore, one requirement is to have a robust method of allowing the user to control the aircraft if the autopilot system malfunctions. The manual override will be implemented through the control algorithm. A second consideration is the usability of the autopilot. In order to conduct surveillance, the quadrotor will need to provide a stable platform for the camera. To that end, we will need to ensure that the autopilot control software provides stabilization and error corrections to fly the quadrotor, and that the accuracy of the sensors is sufficient to derive accurate position and velocity inputs to the autopilot. This will likely require that the PIC24FJ256GB110 microcontroller perform integral and differential calculus. A variety of sensors will be used to provide position and orientation of the quadrotor. These sensors include an accelerometer, barometer, gyroscope, magnetometer, and ultrasonic range finder. The I^2C and RS232 protocols will be required to interface these sensors with the microcontroller. Another design requirement will be to choose the correct wireless interface for the UAV. The handheld radio controller will use at least 5 channels (4 for primary flight control and a 5th to engage the autopilot). The video transmitter will need to be on a noninterfering wireless band that is powerful enough to send usable data over at least the line-of-sight range of the quadrotor. The system will be powered by two sets of on on-board batteries. The first set will power the microcontroller, camera, and sensors. The second set, providing a higher current, will provide sufficient power to the motors that will be used to propel and maneuver the quadrotor. The user interface will consist of inputting the desired GPS coordinates and taking radio control for takeoff, landing and manual override. The user will input the GPS coordinates via a terminal command prompt.

2 Requirements for Each Subsystem

The autopilot algorithm will start with a user input of GPS coordinates to the microcontroller. This will constitute as the flight plan. The GPS and barometer will provide x, y and z coordinates that will determine where the quadrotor is in space while the gyro will determine the orientation. The autopilot algorithm will track these coordinates, compare them to the GPS and barometer data, and update the flight plan accordingly. The motors will also need to be able to respond to accelerometer/gyroscope readings for orientation in the case of sudden gusts of wind or other acts of God. The camera on board will send real-time visual data back to a user interface. The GPS will interface with the microcontroller using a digital to serial protocol using the transmit (Tx) and receive (Rx) pins. The barometer connects to the microcontroller using I^2C protocol which requires data and clock pins. The accelerometer provides an analog out signal which will connect to the microcontroller via three pins (x, y, z). The camera has a TTL serial to digital output which connects to the microcontroller via Tx and Rx pins. The video transmitter connects to the microcontroller with a serial to digital protocol using Tx and Rx pins. The SD card interfaces using SPI to the microcontroller. A computer will use a USB interface with the microcontroller to program the flight plan. A radio controller will transmit user inputs to the receiver on-board the airplane. The receiver will then pass these inputs to the microcontroller. An autopilot toggle input will determine whether or not to pass the user inputs to the motors or use the output of the autopilot algorithm. This will require 5 digital I/O pins between the receiver and microcontroller. The barometer is an I^2C that will require an I^2C serial bus clock input (SCL), as well as an I^2C serial bus data line (SDA). The barometer has an operating voltage of 3.3 V and consumes 3 μA. The accuracy of the pressure readings is 0.01 hPa. The LSM303DLHC is a combined accelerometer and magnetometer that is also an I^2C device. It has an operating voltage of 3.3 V and has full scale readings of ± 2 g ± 1.3 gauss. The ultrasonic range finder is a serial device that can detect a distance greater than 20 ft. It also has an operating voltage of 3.3 V and consumes 2 mA. The gyroscope includes a sensing element and an I^2C interface. It is a three-axis angular measurement sensor that needs an input of 3.3 V. In total, the microprocessor will require 21 digital I/O pins, 1 analog input pins, a USB interface, an RS232 interface, and an I^2C interface.

3 Detailed Design of Each Subsystem

3.1 Power

Two different battery supplies will be used in the design. A Zippy Flightmax 3S1P battery will provide power to the four motors of the quadrotor. Similarly, a polymer lithium ion battery will provide power to the microcontroller and sensors. The microcontroller will have an LDO (Low-Dropout Regulator) to regulate the 3.7 V input from the polymer lithium ion batteries to a steady 3.3 V output at 150 mA max.

3.2 Transmitter/Receiver

A Futaba 6EXP 6-Channel FM Radio System will be used to manually control the motors when the flight autopilot is not in use. This transmitter will be used in conjunction with the Futaba R156F 6-Channel Receiver. The receiver runs on 72 MHz, and outputs a PWM (Pulse-Width Modulated) signal to the microcontroller. The microcontroller will in turn send these commands to the motors when manual override is activated.

3.3 Interface

A user interface will be required to input the desired GPS coordinates to the microcontroller. A terminal window on a PC will be used to communicate with the microcontroller.

3.4 Sensors

Table 1 depicts the parts used in the sensor subsystem. The cost, manufacturer part number and protocol of each device are listed.

Table 1: Sensors

Sensor	Cost	Manufact. Part #	Protocol
MediaTek MT3329 GPS 10Hz	$29.99	3329	RS232
Barometric Pressure Sensor - BMP085	$3.81	BMP085	I^2C
Ultrasonic Range Finder - Maxbotix LV-EZ1	$25.95	LV-EZ1	ADC
Accelerometer/Magnetometer	$8.43	LSM303DLHCTR	I^2C
Triple Axis Digital Output Gyroscope	$12.95	L3G4200DTR	I^2C

The devices detailed in Table 1 are connected to the microcontroller as shown in Figure 1.

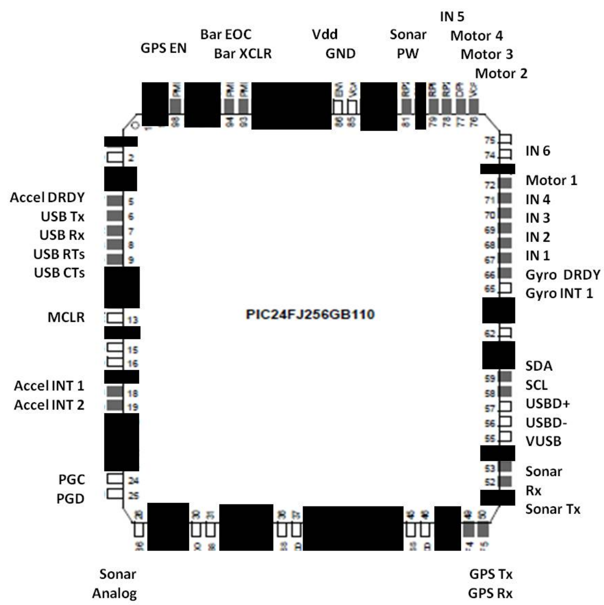

Figure 1: Pin Diagram Connections

As can be seen in Figure 1, the GPS is connected to the serial transmit and receive pins which are pins 49 and 50 respectively. The other devices, namely the accelerometer/magnetometer, barometer, ultrasonic range finder, and gyroscope, are connected to the data and clock lines of the I^2C pins (pins 59 and 58 respectively) of the microcontroller.