CHAPTER FOUR

SYSTEM IMPLEMENTATIONS

4.1 Autopilot System Overview:

This chapter presents the system structure, components, electrical diagrams and software. The UAS system is separated into four sub-systems to simplify and understand the system structure. These subsystems are shown in Figure 4.1 as:

(1) Flight platform.

(2) Avionics.

(3) Payload.

(4) Ground station.

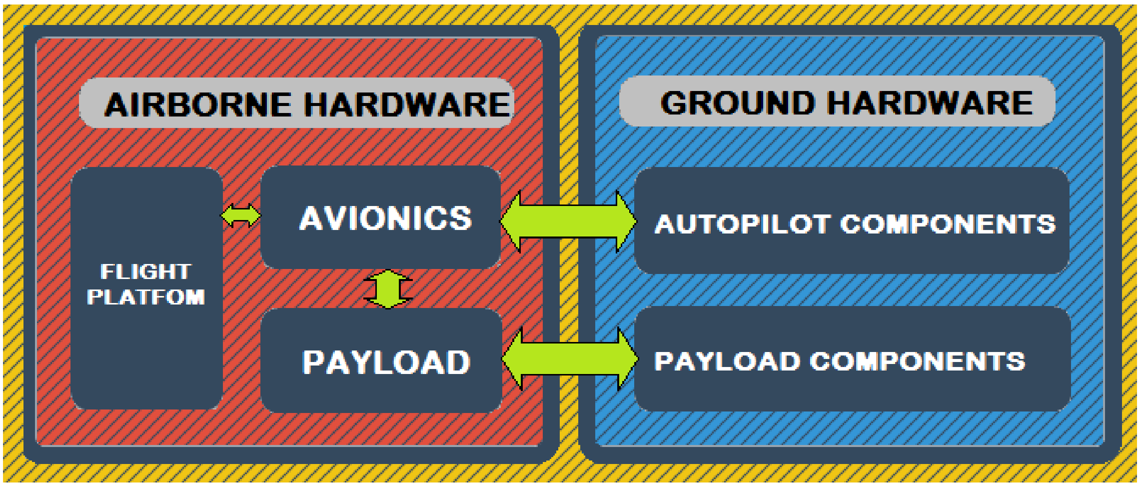


Figure 4.1: Autopilot Subsystems [10].

The purpose of the flight platform is to carry the avionics and the payload. The flight platform consists of the airframe, the actuators that move the control surfaces, the batteries that power the autopilot, and the propulsion system. The avionics consist of the autopilot, GPS receiver, and digital modem. Their purpose is to control the aircraft and communicate with the ground station. The payload subsystem consists of the hardware not related to the flight platform or avionics. The payload is placed on the aircraft to accomplish user objectives. The ground station includes hardware and software needed to support the avionics and payload in flight. The ground station includes a laptop computer and digital modem. A graphical interface was written for the autopilot. The graphical interface runs on the ground station computer.

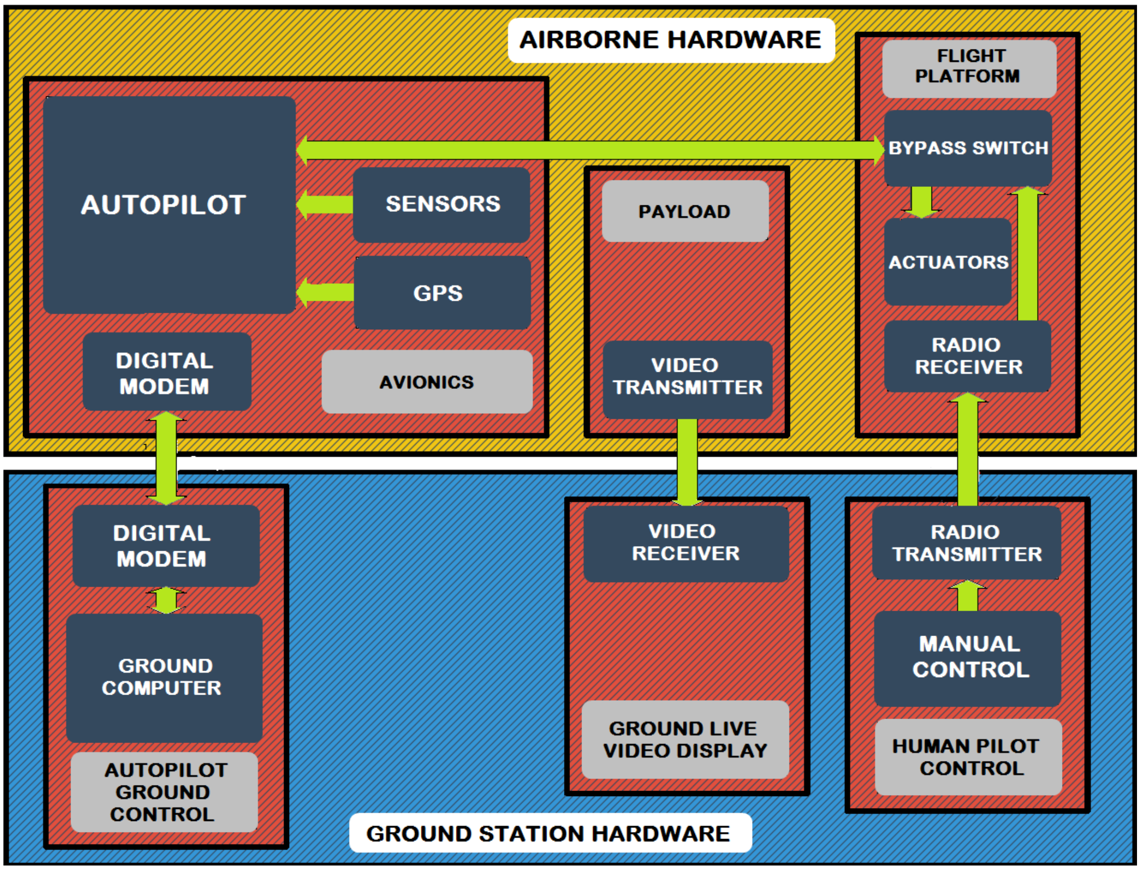


Figure 4.2: Detailed Autopilot system [10].

4.2 System hardware components

The following section provides a review on the hardware components of the model system.

- **Flight platform:**

  The plane shown in Figure 4.3 is made of foam and carbon fiber and it will be used to develop, implement and carry the GNC system.

Figure 4.3: Fixed wing airplane model.

- **Autopilot CPU:**

  The microcontroller board shown in Figure 4.4 is the main brain of the system. It is responsible of sensors processing and data acquisition, calculations and applying control algorithms.

  Arduino is an open-source physical computing platform based on a simple I/O board and a development environment that implements the Processing/Wiring language. Arduino can be used to develop stand-alone interactive objects or can be connected to software on personal computer.

  The Arduino Mega is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Figure 4.4: Arduino Mega Microcontroller Board

- **Digital modem (air and ground modules):**

In order to keep link between the ground station and the aircraft a digital communication module should be used. Radios allow ground station computer to communicate with vehicle wirelessly, providing unparalleled ease of use for viewing in-flight data, changing missions on the fly, and tuning. Figure 4.5 is showing the air and ground digital communication modules used in this system.

Figure 4.5: Air and ground radio modules.

- **GPS sensor:**

This is an updated GPS module that can used with Arduino mega. This GPS module uses the latest technology to give the best possible position information, allowing for better performance with control platform. Figure 4.6 shows the GPS sensor module used.

Figure 4.6: GPS Sensor Module.

- **Servo motors:**

In this system four servo motors are used. Two motors for the Ailerons, one for the Elevators and one for the Rudders. (Figure 4.7 shows a servo motor) Two optional servos may be used to control camera gimbal if needed.

Figure 4.7: Servo motor.

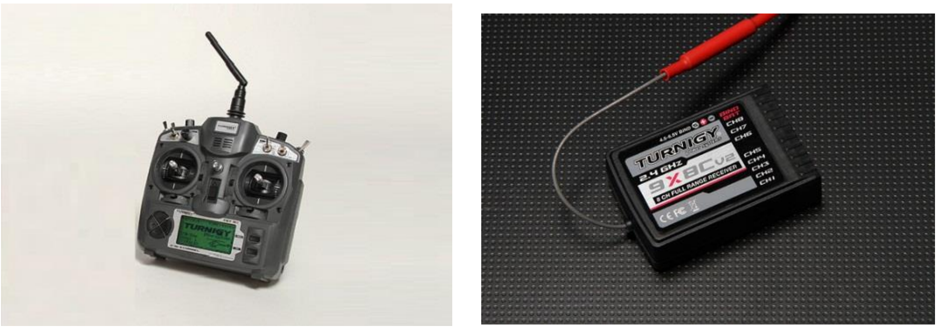
- **Brushless DC motor:**

The thrust needed for plane is provided by a brushless dc motor with an appropriate propeller (Figure 4.8). The motor used is 1800 rpm/v and maximum power is 700w.

Figure 4.8: Brushless dc motor.

- **Backup transmitter/receiver remote control:**

During testing and normal operation a backup transmitter and receiver are needed to take over control (manual control) of the plane in case of any failure happened to the autopilot system. Figure 4.9-a shows a transmitter and manual remote control devices used for flight control and Figure 4.9-b shows its receiver.



a) Transmitter. b) Receiver

Figure 4.9: Remote control devices

- **Power source:**

  A lithium-polymer battery will be used as main power supply for airplane electronics and actuators.

- **Inertial Measurement Unit:**

The IMU unit is composed of gyro, accelerometer, magnetometer and temperature sensors. The combination of those sensors will provide the system with inertial measures to estimate the body attitude. Figure 4.10 shows the IMU unit board. Data sheets are provided in appendixes.

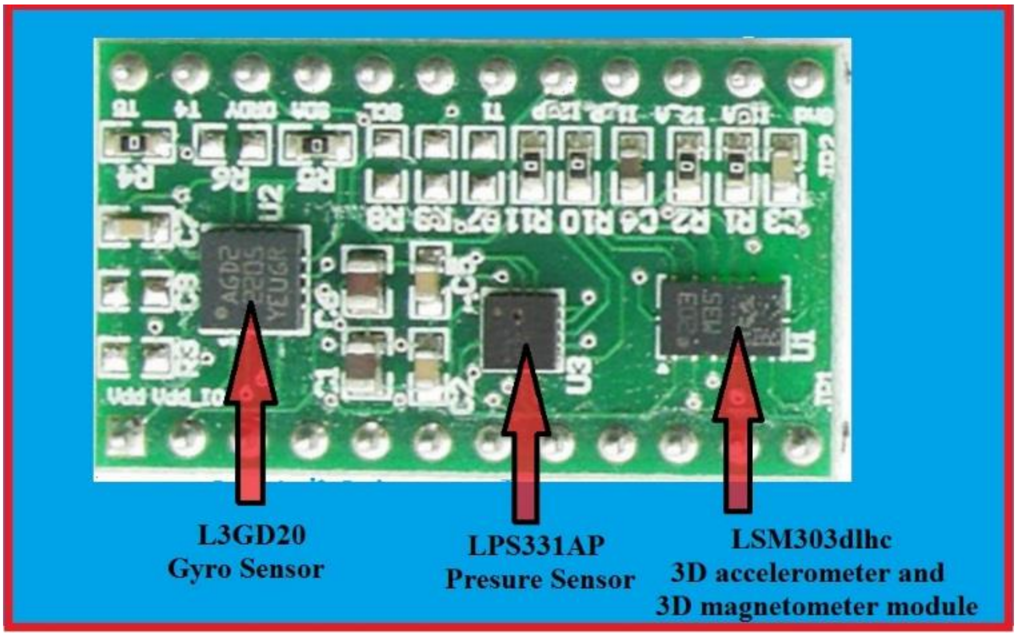


Figure 4.10: Inertial Measurement Unit

4.3 Electrical Diagram

Figure 4.11 provides an overview on the electrical diagram of the flight platform. A lithium-polymer battery (LIPO) is powering the system. A brushless DC motor is used as thrust actuator; the speed of this motor is controlled from the autopilot through a brushless dc motor electronic speed controller (ESC).

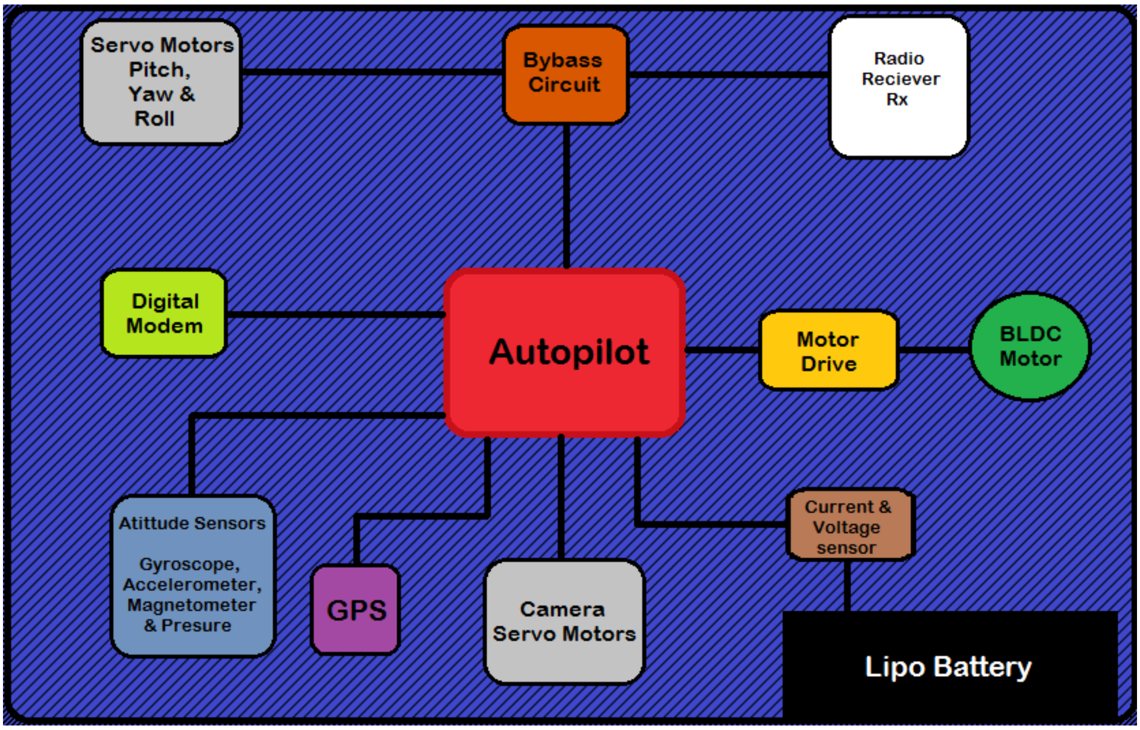


Figure 4.11: Electrical Block Diagram

The autopilot will control the servo motors according to autonomous control or manual control from ground control. It receives the signals from ground station through a receiver (Rx). A payload can be used. In this project a camera is used together with an image processor (OSD) to integrate the video from camera (FPV) with flight data from autopilot and to be sent to the ground station display through a video transmitter (FPV Tx).

4.4 Ground station program

A ground control station (GCS) is a control center that provides the facilities for the control of UAS's. A GCS could be used to control UAV's or Missiles (Rockets).

The ground station used in this project will be composed of a laptop, display screen and ground station software. The software used for real time flight is shown in Figure 4.12.a and Figure 4.12.b and the integrated video with flight data coming from the flight camera is shown in Figure 4.13.

Figure 4.12.a: Ground Station Program

Figure 4.12.b: Ground Station Program

Figure 4.13: UAV Camera Feedback.

4.5 Autopilot program:

This section presents the autopilot program and software used in the system. Figure 4.15 show the flow chart of the software of the autopilot.

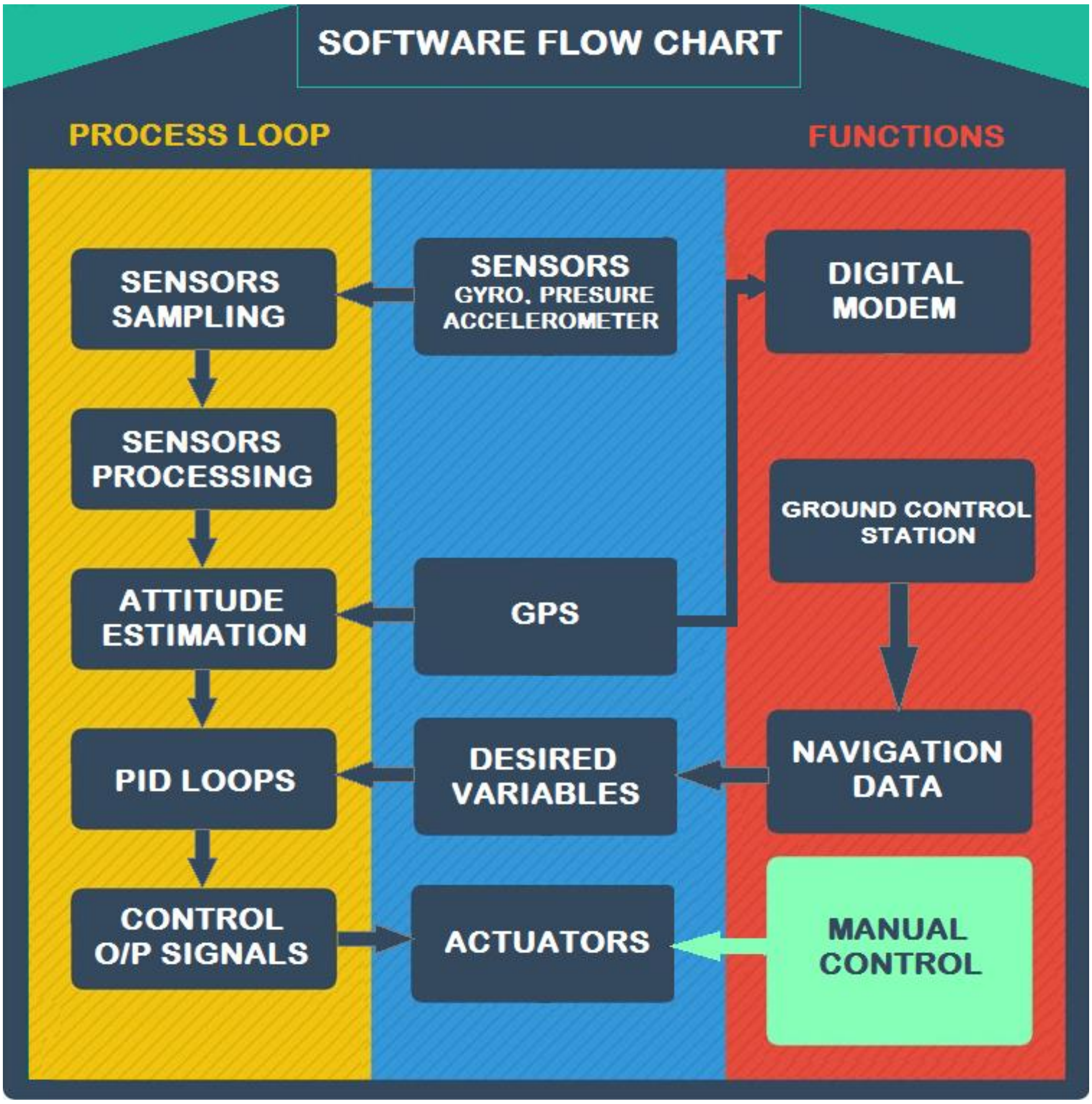


Figure 4.14: Autopilot Software Flow Chart.