GAUCHOHAWK CRITICAL DESIGN REVIEW

Vikram Sastry, Yesh Ramesh, Kurt Madland, Jack Zang, Richard Young, and Shawn Zhang

INTRODUCTION

What is the Pixhawk?

Pixhawk is an independent, open-hardware project aiming at providing high-end autopilot hardware and open-source flight control software to the academic, hobby, and industrial communities at low costs and high availability.

Pixhawk Pitfalls

1. No high quality inertial measurement unit (IMU) for precision flight control.
2. No magnetometer for extended periods of inertial guidance and state estimation.
3. No Ethernet interface for high speed connection to Linux Computers or IP data links.
4. No Real Time Kinetic (RTK) capable GPS for accurate reference “truth” measurements.
5. No precise time source for time-stamping sensor data in absence of GPS.

Pixhawk + Improved Hardware + a few Gauchos
(and a little help from Aerovironment)

= GauchoHawk

MEET THE TEAM

Vikram Sastry	Team Lead, System Design
Yesh Ramesh	Software Porting, Digital Design
Kurt Madland	Analog & Digital Design, System Design
Jack Zang	Analog & Digital Design, System Design
Shawn Zhang	Software Porting, Interface Design
Richard Young	Software Porting, Interface Design
Philip Tokumaru	Project Advisor from Aerovironment

PROJECT DESCRIPTION

Shield Hardware Development

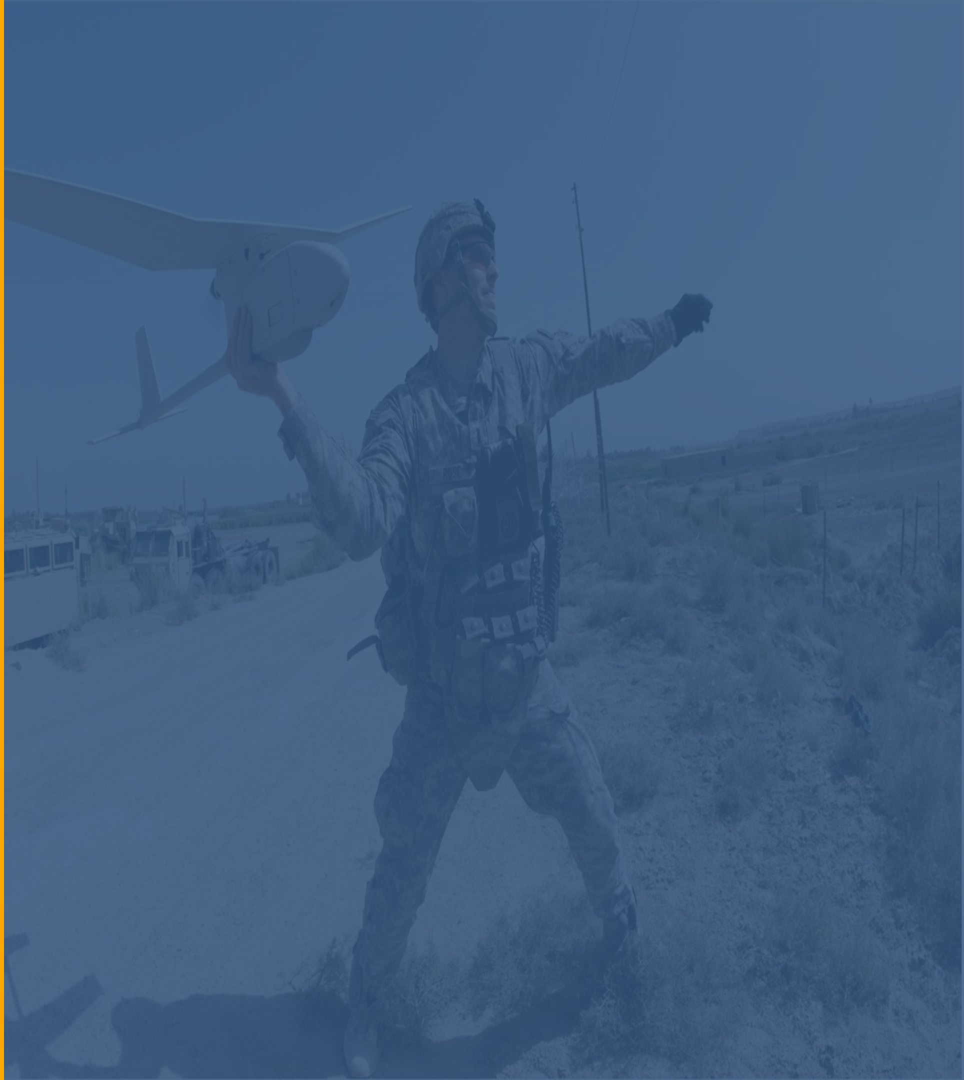
We propose to use the STMicroelectronics Nucleo-STM32F767ZI board in conjunction with a “Shield” daughterboard to introduce a high quality IMU, Barometer/Altimeter, Magnetometer, Airspeed Sensor, RTK GPS, XBEE Radio, SBUS, CAN, Servo/Motor PWM, and Interrupt/GPIO capability.

PX4 Software Implementation

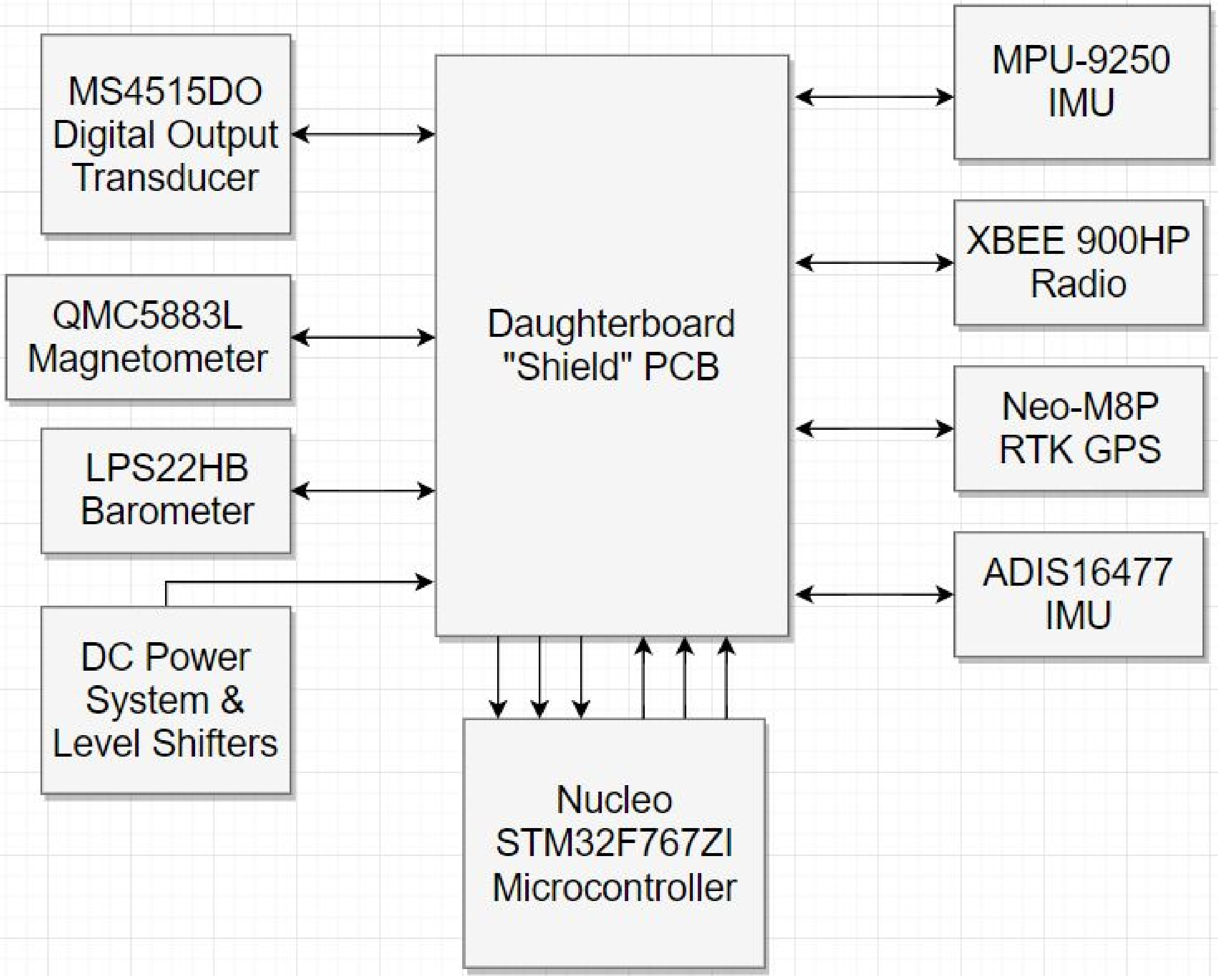
We propose to port the open source PX4 middleware, flight control stack, and NuttX OS to the Nucleo board and develop a new sensor driver suite to support the full expanded functionality of the sensor shield daughterboard.

PROJECT APPLICATIONS

1. Agriculture
   - Identifying irrigation deficiencies, inspect crops for stress, etc.
2. Military
   - Training, tactical UAV missions, missile guidance, etc.
3. Online Retail
   - Reduce delivery overhead, etc.
4. Many more...



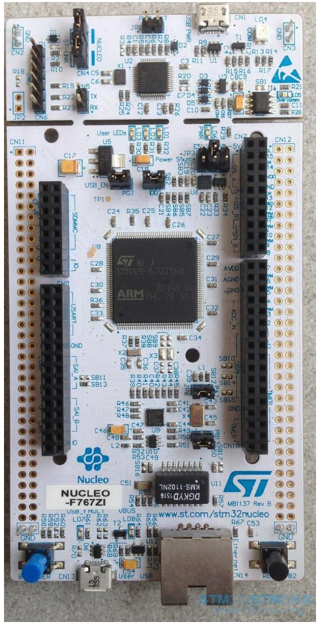
SYSTEM DESIGN OVERVIEW



Components

- Features that we concern about:
  - I2C or SPI interface
  - Power Efficiency
- List of Components
  - Microcontroller Unit – STM32F767ZI
  - Wireless Network – XBEE 900HP
  - Pressure – LPS22HB
  - Pressure & Temperature – MS4515DO
  - Navigation – Neo-M8P
  - Magnetometer – QMC5883L
  - Motion Tracking – MPU-9250 IMU

STM32F767ZI



Microcontroller Unit

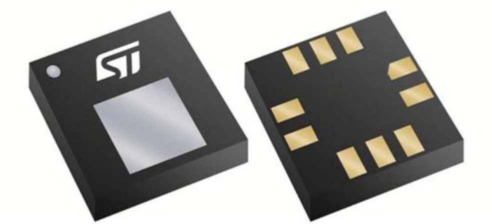
- Arm® 32-bit Cortex®-M7 CPU
- Up to 216 MHz CPU frequency
- Up to 2 Mbytes of Flash memory
- SRAM: 512 Kbytes
- Up to 4 I2C interfaces
- Up to 6 SPIs

XBEE 900HP

Radio Frequency Module

- Provide wireless connectivity to end-point devices in mesh networks
- ADF7023 transceiver, Cortex-M3 EFM32G230 @ 28 MHz
- RF data rate at 200 kbps and 10 kbps
- 10 Kbps: up to 2000 ft (610 m)
- 200 Kbps: up to 1000 ft (305 m)
- 128-bit AES encryption

LPS22HB



HLGA-10L
(2.0 x 2.0 x 0.76 mm)

Barometer

- Full-mold, holed LGA package (HLGA)
- 260 to 1260 hPa absolute pressure range
- Need to be separated from heat source

MS4515DO

Pressure & Temperature Transducer

- Pressure Ranges from 2 to 30 inches H2O
- Differential & Gage Temperature Compensated
- Total error band (TEB) of less than 1.0% over the compensated range
- Standby mode (1 uA)

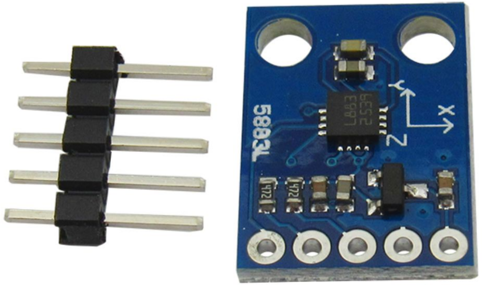
Neo-M8P

NEO-M8P
12.2 x 16.0 x 2.4 mm

High Precision GNSS Modules

- GNSS = Global Navigation Satellite System
- Integrated Real Time Kinematics (RTK)
- Moving Baseline support
- Centimeter-level accurate position measurement between base and rover
- Convergence time 2 RTK < 60 sec

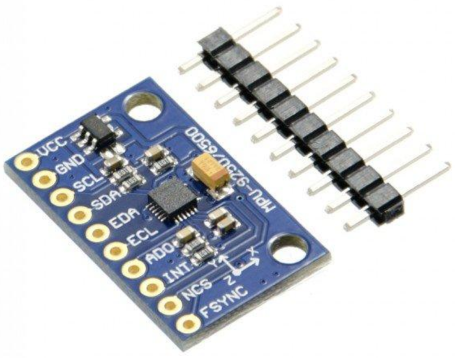
QMC5883L



3-Axis Magnetic Sensor

- 1° to 2° compass heading accuracy
- Designed for battery powered applications
- Offering two modes:
  - Continuous measuring mode
  - Standby mode

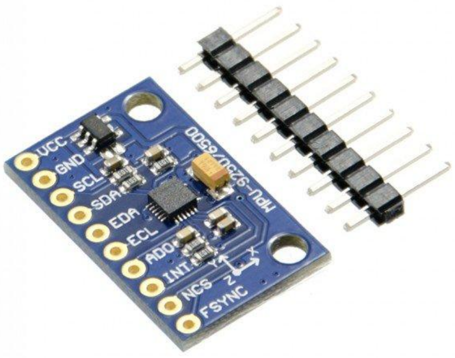
MPU-9250 IMU



9-Axis Motion Tracking device

- IMU = Inertial Measurement Unit
- 3-Axis gyroscope
- 3-Axis accelerometer
- 3-axis magnetometer
- Digital Motion Processor
- Low power consumption
  - Normal Mode - 9.3 µA
  - Low Power Mode - 6.4 µA

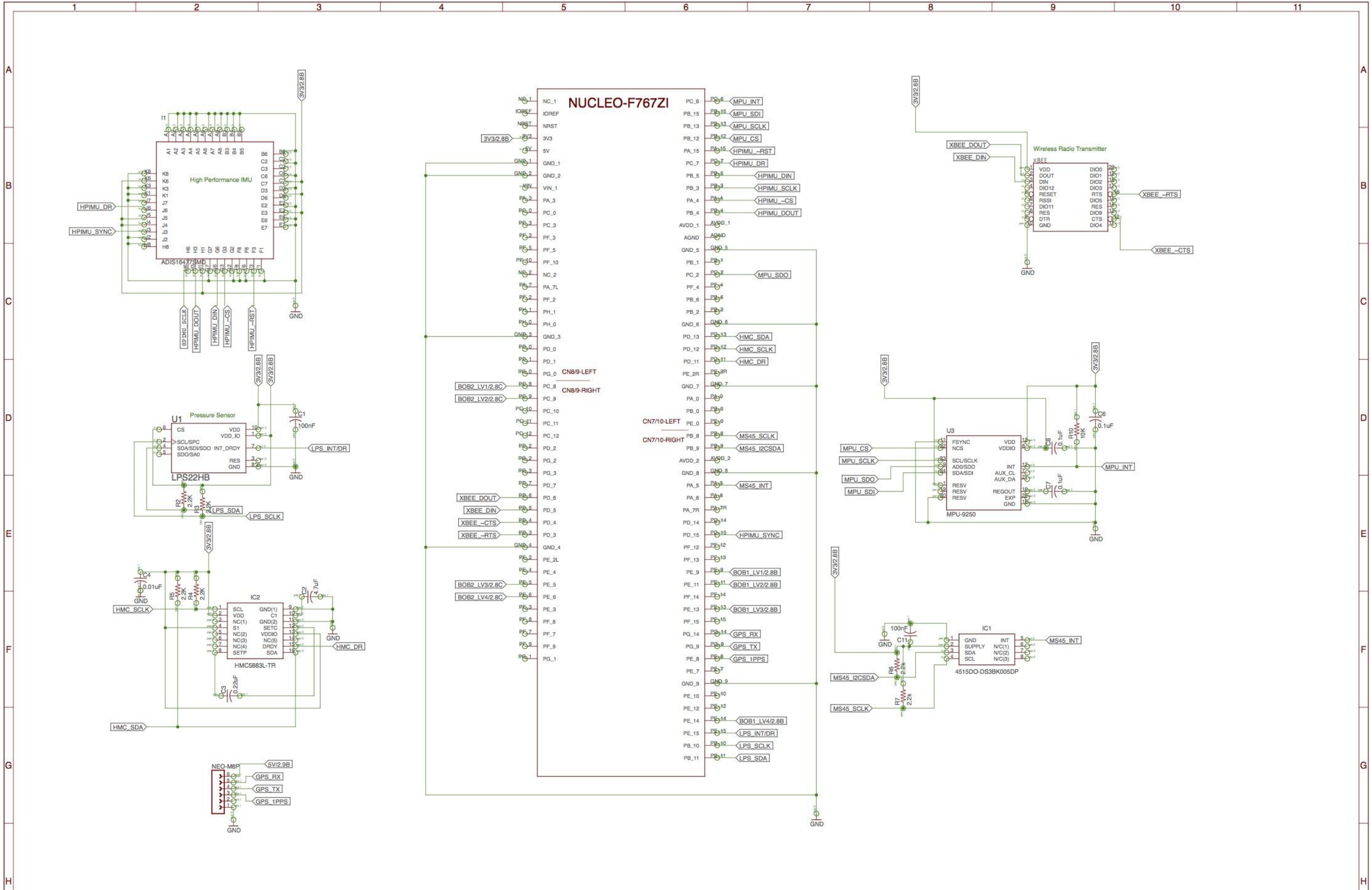
ADIS16477 HP IMU



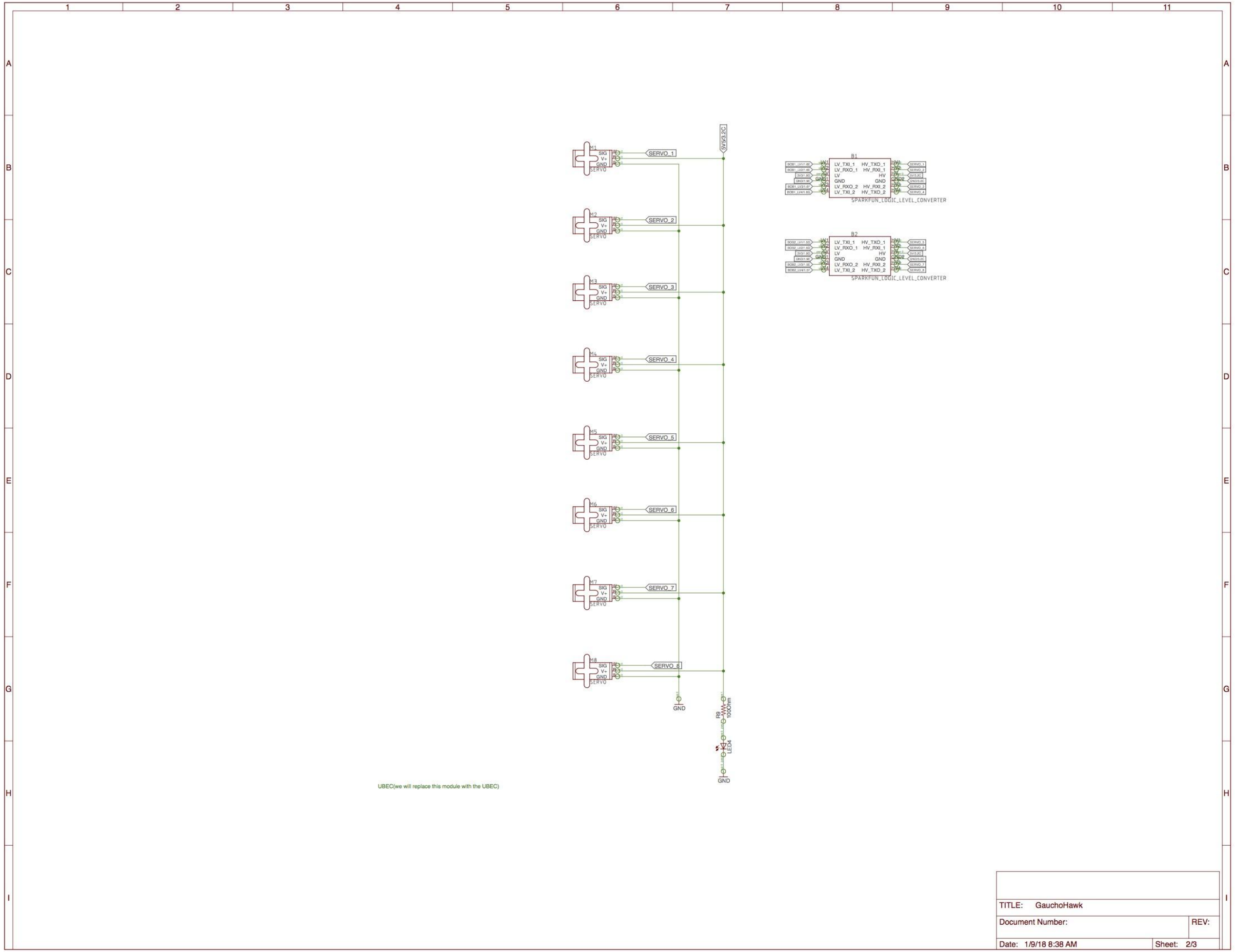
High Performance IMU

- IMU = Inertial Measurement Unit
- Triaxial digital gyroscope
- Triaxial digital accelerometer
- Triaxial digital magnetometer
- Digital Motion Processor
- Low power consumption
  - Normal Mode – 9.3 µA
  - Low Power Mode – 6.4 µA

PCB SCHEMATIC



NUCLEO-F767ZI
High Performance IMU
ADIS16477SMD
Pressure Sensor
LPS22HB
HMC5883L-TR
NEO-M8P
Wireless Radio Transmitter
XBEE
MPU-9250
4515DO-DS3BK005DP
CN8/9-LEFT
CN8/9-RIGHT
CN7/10-LEFT
CN7/10-RIGHT
3V3/2.8B
5V/2.9B
GND
HPIMU_DR
HPIMU_SYNC
HPIMU_DIN
HPIMU_DOUT
HPIMU_~CS
HPIMU_~RST
HPIMU_SCLK
MPU_INT
MPU_SDI
MPU_SCLK
MPU_CS
MPU_SDO
HMC_SDA
HMC_SCLK
HMC_DR
MS45_SCLK
MS45_I2CSDA
MS45_INT
LPS_INT/DR
LPS_SCLK
LPS_SDA
XBEE_DOUT
XBEE_DIN
XBEE_~CTS
XBEE_~RTS
GPS_RX
GPS_TX
GPS_1PPS
BOB2_LV1/2.8C
BOB2_LV2/2.8C
BOB2_LV3/2.8C
BOB2_LV4/2.8C
BOB1_LV1/2.8B
BOB1_LV2/2.8B
BOB1_LV3/2.8B
BOB1_LV4/2.8B
C1 100nF
C2 4.7uF
C3 0.22uF
C4 0.01uF
C6 0.1uF
C7 0.1uF
C8 0.1uF
C11 100nF
R2 2.2K
R3 2.2K
R4 2.2K
R5 2.2K
R6 2.2k
R7 2.2k
R10 10K
U1
U3
IC1
IC2


SERVO_1
SERVO_2
SERVO_3
SERVO_4
SERVO_5
SERVO_6
SERVO_7
SERVO_8
SIG
V+
GND
SERVO
GND
SPARKFUN_LOGIC_LEVEL_CONVERTER
LV_TXI_1 HV_TXO_1
LV_RXO_1 HV_RXI_1
LV HV
GND GND
LV_RXO_2 HV_RXI_2
LV_TXI_2 HV_TXO_2
UBEC(we will replace this module with the UBEC)
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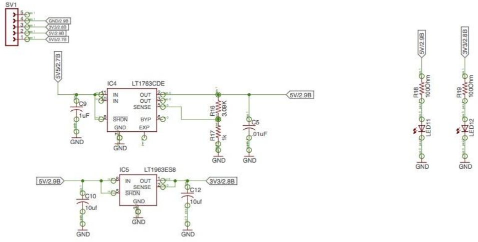
Power System



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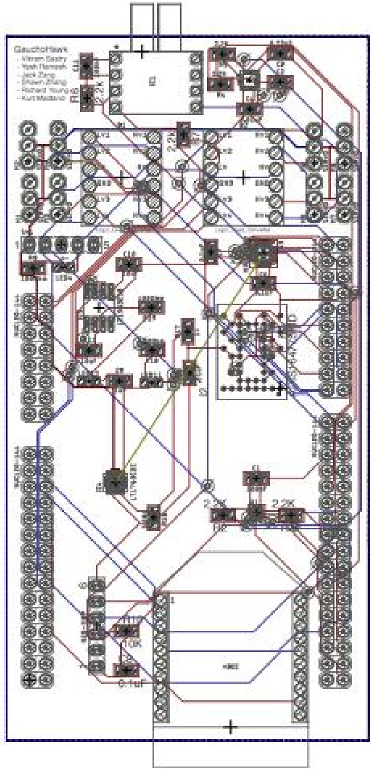
PCB LAYOUT



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BILL OF MATERIALS

Attached to this project

POWER DISTRIBUTION

Power Distribution

Supplying 24V to our PCB

- 5.5 V analog (servos), 5V digital, and 3.3V digital
- Servos require 5.5V to VDD

Component	Supply Voltage
Servos (8)	5.5V
Peripherals (7)	3.3V
Servos Signal (8)	5V

CRITICAL ELEMENTS (potential failure points)

Critical Elements

- IMU sensors are noisy
  - High performance IMU is sensitive to noise

- PX4 software is not portable as is
  - PX4 Opensource Autopilot for F7 may need modifications to be compatible with the board.
  - Autopilot drivers may not work with custom peripherals

- Traces to Servos are too thin
  - Servos draw a lot of current
  - Traces are 12 mil

Moving Forward

- Winter Quarter
  - Port PX4 onto STM32F7
  - Have a working board with all peripherals communicating

- Spring Quarter
  - Depends on how far we get in winter

Thanks!

Any questions?