Hands-On Flight

Fall Design Review

Outline

- Purpose/ Functionality
- Team
- Block Diagram
- Parts
- Bill of Material
- Power Distribution
- Schematic
- PCB
- Software Development
- Conclusion

Purpose

Purpose

- Design a glove to improve intuitive interactions between humans and machines
  - Integrate smaller circuit design for compact product and ease of use
  - Add additional functionality through haptic feedback
  - Interface new sensors into drone flying experience

Team

Who is the Hands-On Flight Team?

- **Oscar Wang**
  - Project Leader, System Design
- **Juan Reyes**
  - Software Development, Peripheral Integration
- **Eduardo Olmos**
  - Software Development, Android Application
- **Alex Berlanga**
  - Hardware Development, PCB Design
- **Miguel Berlanga**
  - Hardware Development, PCB Design

Functionality

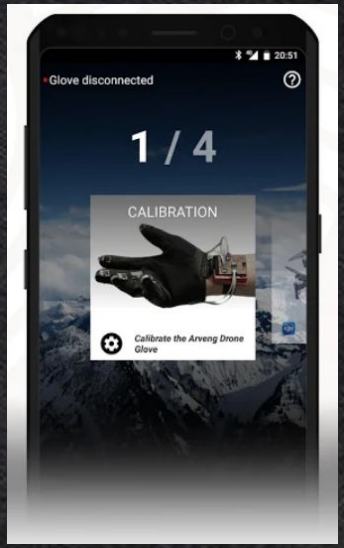
Functionality (sensors/ICs)

- Capture motion of the hand through Inertial Measurement Units and stretch sensors
- Transmit motion data to drone to control drone flight:
  - Throttle
  - Roll
  - Pitch
  - Yaw
- Provide haptic feedback to user for use of throttle and axial movements

Functionality (High Level)

Hand Control

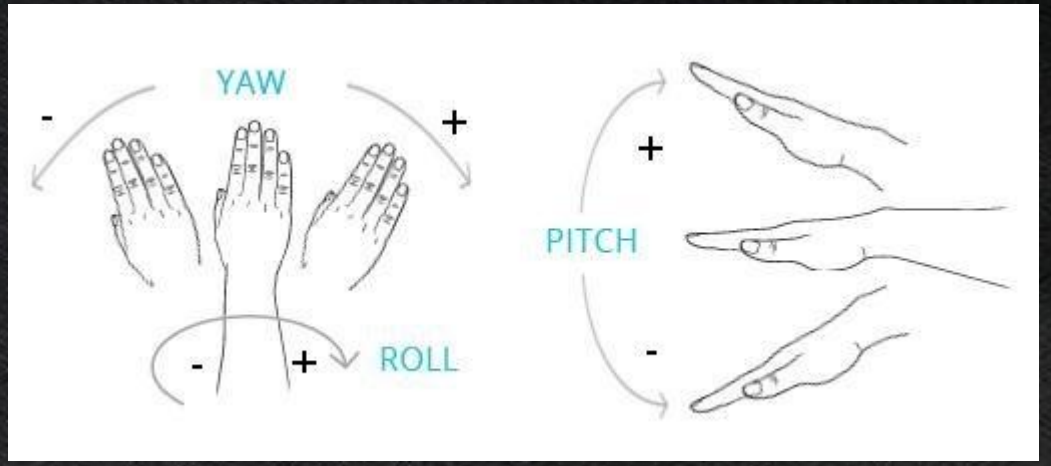
Sends IMU and Stretch Sensor Data

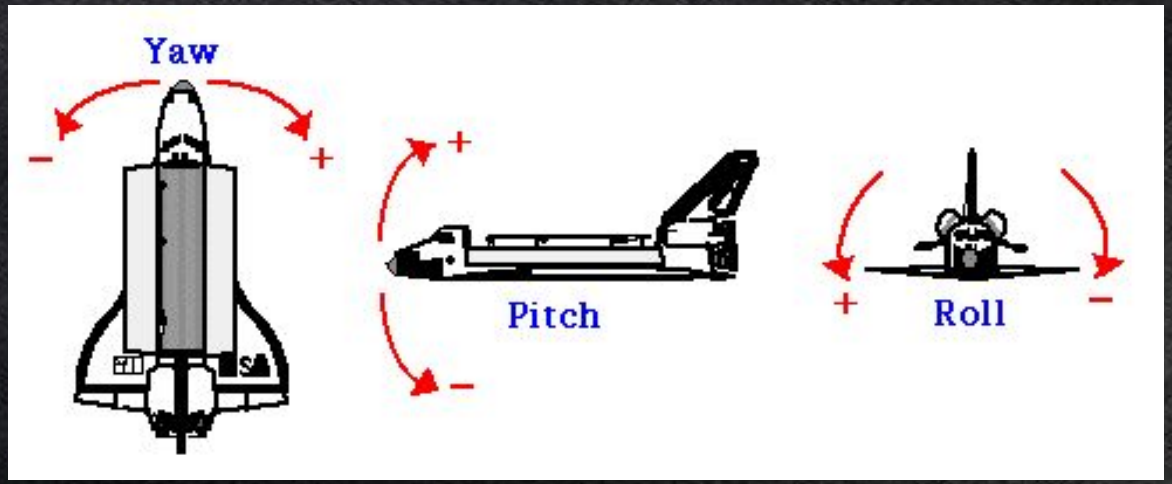


Arveng Control App

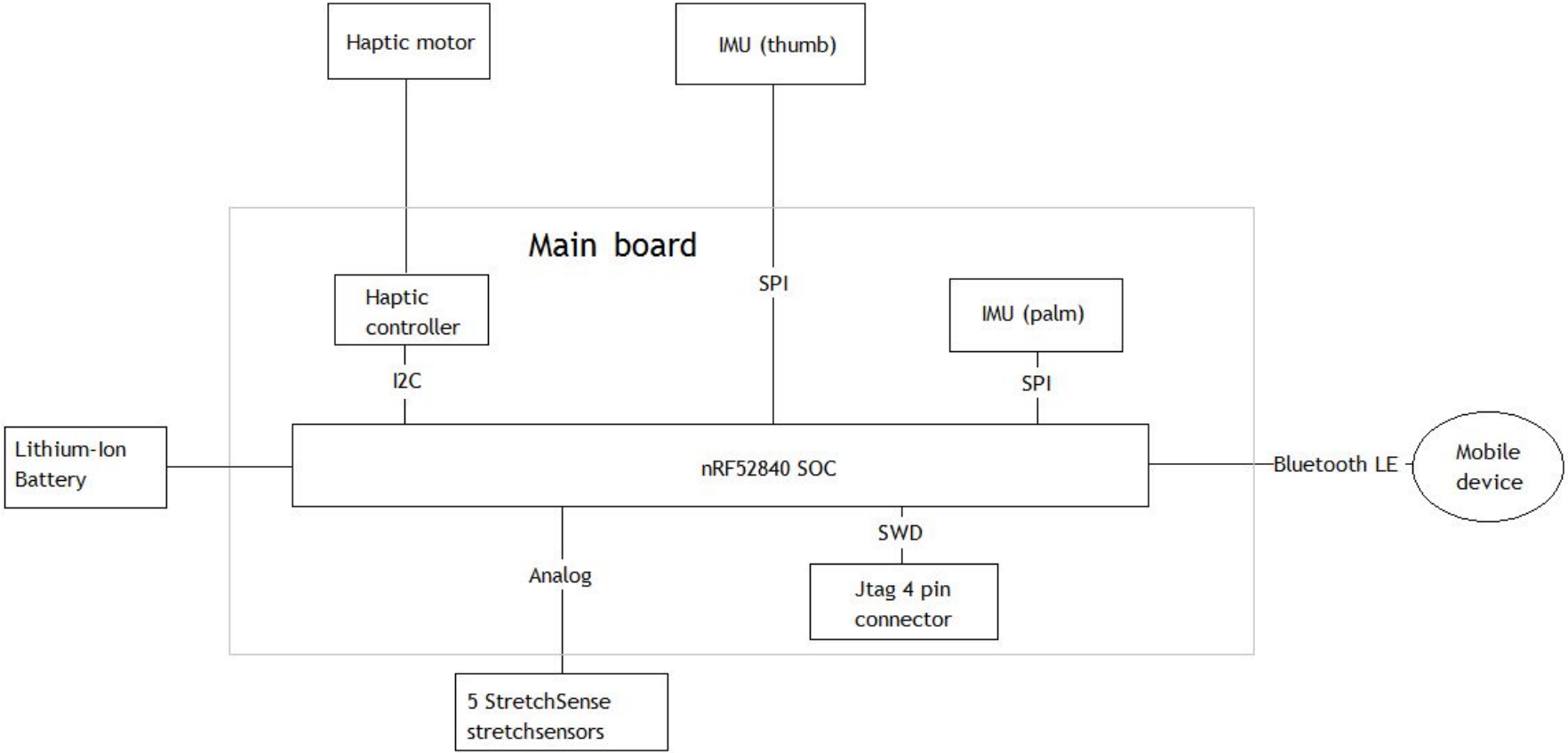
Translates data received into controls for drone

DJI Drone


YAW
-
+
ROLL
-
+
PITCH
+
-


Yaw
-
+
Pitch
+
-
Roll
+
-

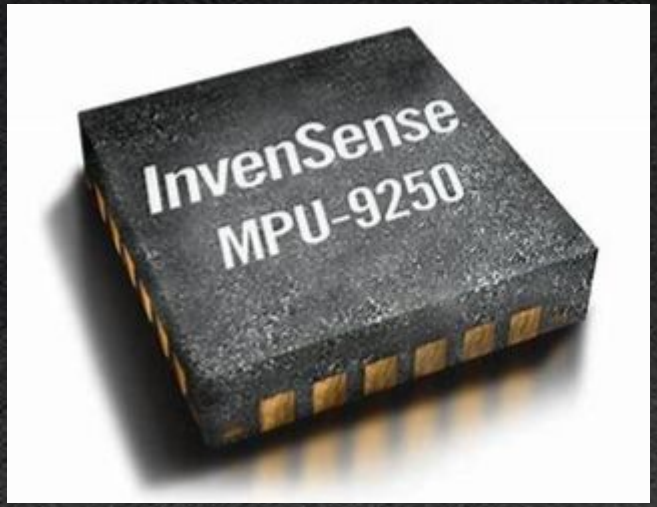
Block Diagram


Haptic motor
IMU (thumb)
Main board
Haptic controller
SPI
IMU (palm)
I2C
SPI
Lithium-Ion Battery
nRF52840 SOC
Bluetooth LE
Mobile device
SWD
Analog
Jtag 4 pin connector
5 StretchSense stretchsensors

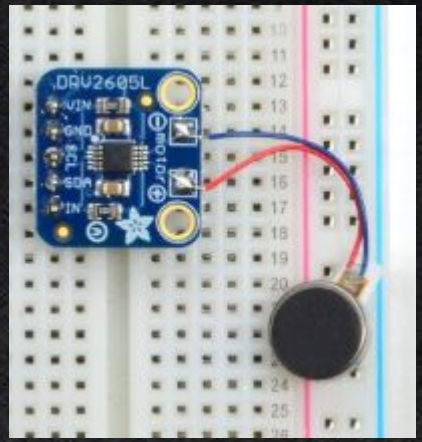
Parts

Parts

- MPU 9250
  - SPI serial communication
  - Orientation calculations



Parts



- Haptic components
  - Vibrating Mini Motor Disc
  - DRV2605L
  - I2C serial communication
  - User feedback for limits of MPU 9250

Parts

- StrechFABRIC
  - Analog communication
  - Used to interact with drone

Parts

- nRF52840
  - Bluetooth 5 Technology
    - Supports long range
  - Supports SPI and I2C

Bill of Materials

Bill of Materials

Comment	Description	Designator	Footprint	LibRef	Quantity
NCP5662DS33R4G	ON Semiconductor NCP5662DS33R4G, LDO Voltage Regu	B1	D2PAK_5-LE	NCP566	1
DRV2605LTDGSRQ1	Haptic Driver for ERM and LRA With Built-In Library and S	B2	SOP50P490	DRV260	1
MPU-9250	Accelerometer, Gyroscope, Magnetometer, 3 Axis Sensor	B3	QFN40P300	MPU-92	1
1.0µF	Capacitor, X7R, ±10%	C1	CAPC1608X06L		1
N.C.	Capacitor, NPO, ±2%	C2, C13, C16	CAPC1005X04L		3
12pF	Capacitor, NPO, ±2%	C3, C4, C9, C12	CAPC1005X04L		4
1uF	Capacitor, NPO, ±2%	C5, C11	CAPC1005X04L		2
100nF	Capacitor, NPO, ±2%	C6, C8, C18, C2	CAPC1005X04L		4
1.0uF	Capacitor, X7R, ±10%	C7	CAPC1608X06L		1
100pF	Capacitor, NPO, ±2%	C10	CAPC1005X04L		1
1.0pF	Capacitor, NPO, ±2%	C14, C15	CAPC1005X04L		2
820pF	Capacitor, NPO, ±2%	C17	CAPC1005X04L		1
4.7µF	Capacitor, X7R, ±10%	C19, C20, C21	CAPC1608X06L		3
IST Battery Connector	PH Series 2 Position 2 mm Pitch Surface Mount Side Entry	J1	IST_S2B-PH	S2B-PH	1
Debug JTAG		J2	TE_640456-	640456	1
3.9nH	High frequency chip inductor ±5%	L1	INDC1005X04L		1
External_Header 9X2H	Header, 9-Pin, Dual row, Right Angle	P1	HDR2X9H	Header	1
Resistor	Resistor	R1, R2, R3, R4,	I1-0603	Res3	5
Res3	Resistor	R6	I1-0603	Res3	1
nRF52840-QIAA	Multi-protocol Bluetooth Low Energy, IEEE 802.15.4, ANT a	U1	AQFN50P700X700X		1
32MHz	XTAL SMD 2016, 32MHz, Cl=8pF, Total Tol: ±40ppm	X1	BT-XTAL_2016		1
32.768kHz	XTAL SMD 3215, 32.768kHz, Cl=9pF, Total Tol: ±50ppm	X2	XTAL_3215		1

Bill of Materials

Part Label	Description	Manufacturer	Manufacturer Part Number	Vendor	Vendor Part Number	Quantity	Unit Price	Total	Datasheet
SoC	Nordic nRF52840	Nordic Semiconductor	nRF52840-QIAA-R	Mouser Electronics	949-NRF52840-QIAA-R	1	7.08	7.08	http://infocenter.nordicsemi.com/pdf/nRF52840_PS_v1.0.pdf
Stretch Sensors	StretchFABRIC Sensing Element	StretchSense				4		Provided by Sponsor	https://www.stretchsense.com/wp-content/uploads/2018/08/StretchFABRIC-0SEF-Datasheet.pd
IMUs	InvenSense MPU-9250	TDK InvenSense	MPU-9250	Mouser Electronics	410-MPU-9250	2	9.32	18.64	https://www.mouser.com/ProductDetail/TDK-InvenSense/MPU-9250?qs=sGAEpiMZZMve4%2fb
Vibration Motors	Vibrating Mini Motor Disc	Adafruit	1201	Mouser Electronics	485-1201	3	1.95	5.85	https://www.mouser.com/ProductDetail/Adafruit/1201?qs=%2fha2pyFaduik7jI7qeINq9OO55T0
Breakout for Haptic Controller	Adafruit DRV2605L Haptic Motor Controller	Adafruit	2305	Mouser Electronics	485-2305	3	7.95	23.85	https://www.mouser.com/ProductDetail/Adafruit/2305?qs=%2fha2pyFaduhNmwFKKfs2J6cvOI2
Haptic Controller	DRV2605LTDGSRQ1	Texas Instruments	DRV2605LTDGSRQ1	Mouser Electronics	595-DRV2605LTDGSRQ1	1	4.02	4.02	http://www.ti.com/lit/gpn/drv2605l-q1?HQS=TI-null-null-mousermode-df-pf-null-wwe&DCM=ye
JST Connector	CONN HEADER PH SIDE 2POS 2MM SMD	JST Sales America Inc.	S2B-PH-SM4-TB(LF)(SN)	Digi-Key Corporation	455-1749-1-ND	1	0.58	0.58	http://www.jst-mfg.com/product/pdf/eng/ePH.pdf
4 Pin Header Debug	Headers & Wire Housings FRICTION LCK HDR 4P S	TE Connectivity / AMP	640456-4	Mouser Electronics	571-6404564	1	0.24	0.24	https://www.mouser.com/datasheet/2/418/NG_CD_640456_W3-1255682.pdf
Hot Glue Gun	SparkFun IMU Breakout - MPU-9250	Cobiz	CZGLUEGUN001	Amazon.com Services	142-7312568-4758059,1	1	23.99	23.99	https://www.amazon.com/Cobiz-Premium-Sticks-Christmas-Decoration/dp/B0721PTD5B/ref=sr
IMUs Breakout		SparkFun	SEN-13762	Amazon.com Services	142-7312568-4758059,2	1	15.95	15.95	https://cdn.sparkfun.com/assets/learn_tutorials/5/5/0/MPU9250REV1.0.pdf
SoC DK	EVAL BOARD FOR NRF52840	Nordic Semiconductor	NRF52840-DK	Digi-Key Corporation	1490-1072-ND	3	46.25	138.75	http://infocenter.nordicsemi.com/pdf/nRF52840_OPS_v0.5.1.pdf
IMUs Breakout	SparkFun IMU Breakout - MPU-9250	SparkFun	SEN-13762	Digi-Key Corporation	1568-1420-ND	2	14.95	29.90	https://cdn.sparkfun.com/assets/learn_tutorials/5/5/0/MPU9250REV1.0.pdf
Regulator	LDO Voltage Regulators 3.3 V 2A LDO REG	ON Semiconductor	NCP5662DS33R4G	Mouser Electronics	863-NCP5662DS33R4G	1	1.68	1.68	https://www.mouser.com/datasheet/2/308/NCP5662-D-369125.pdf
Capacitor	Multilayer Ceramic Capacitors MLCC - SMD/SMT 1	KEMET	C0805T105K4RACTU	Mouser Electronics	80-C0805T105K4RACTU	9	2.06	18.54	https://www.mouser.com/datasheet/2/212/KEM_C1027_X7R_COTS_SMD-1099449.pdf
Capacitor	Multilayer Ceramic Capacitors MLCC - SMD/SMT 5	AVX	04025A120GAT2A	Mouser Electronics	581-04025A120GAT2A	13	0.57	7.41	https://www.mouser.com/datasheet/2/40/C0GNP0-Dielectric-951274.pdf
Capacitor	Multilayer Ceramic Capacitors MLCC - SMD/SMT 1	KEMET	C1210C105M1RAC	Mouser Electronics	80-C1210C105M1RAC	9	1.37	12.33	https://www.mouser.com/datasheet/2/212/C1210C105M1RAC_7bbulk_7d-1384907.pdf
Capacitor	Multilayer Ceramic Capacitors MLCC - SMD/SMT 1	KEMET	C1210C104M4HACTU	Mouser Electronics	80-C1210C104M4HACTU	13	0.62	8.06	https://www.mouser.com/datasheet/2/212/KEM_C1007_X8R_ULTRA_150C_SMD-1102703.pdf
Capacitor	Multilayer Ceramic Capacitors MLCC - SMD/SMT 2	KEMET	C0402C101GAGACAUTO	Mouser Electronics	80-C0402C101GAGAUTO	7	0.48	3.36	https://www.mouser.com/datasheet/2/212/KEM_C1022_C0G_AUTO_SMD-1093282.pdf
Capacitor	Multilayer Ceramic Capacitors MLCC - SMD/SMT C	TDK	C0603C0G1E010C030BA	Mouser Electronics	810-C0603C0G1E010C	9	0.2	1.8	https://www.mouser.com/datasheet/2/400/Icc_commercial_general_en-837201.pdf
Capacitor	Multilayer Ceramic Capacitors MLCC - SMD/SMT 6	KEMET	C1210C821MBRACTU	Mouser Electronics	80-C1210C821MBR	7	1.02	7.14	https://www.mouser.com/datasheet/2/212/KEM_C1010_X7R_HV_SMD-1102742.pdf
Capacitor	Multilayer Ceramic Capacitors MLCC - SMD/SMT C	TDK	C1005X5R0J475K050BE	Mouser Electronics	810-C1005X5R0J475KE	11	0.53	5.83	https://www.mouser.com/datasheet/2/400/Icc_commercial_soft_en-520032.pdf
Inductor	Fixed Inductors 0603 3.9nH 5% 700mA 0.08ohms	Murata Electronics	LQW18AS3N9J0ZD	Mouser Electronics	81-LQW18AS3N9J0ZD	7	0.25	1.75	https://www.mouser.com/datasheet/2/281/c51e-794816.pdf
External Header	Headers & Wire Housings 5+5 DIL PIN HDR GOLD	Harwin	M22-2040505	Mouser Electronics	855-M22-2040505	1	0.74	0.74	https://www.mouser.com/datasheet/2/181/M22-204-1134905.pdf
Clock Oscillator	Standard Clock Oscillators Config. #1 CMOS MEMS	ABRACON	ASEMCC1-ZR	Mouser Electronics	815-ASEMCC1-ZR	2	7.46	14.92	https://www.mouser.com/datasheet/2/3/ASEMCC-16237.pdf
Battery Charger	MCP73831 Battery Charger Power Management E	SparkFun Electronics	PRT-10217	Digi-Key Corporation	1568-1179-ND	1	8.95	8.95	https://media.digikey.com/pdf/Data%20Sheets/Sparkfun%20PDFs/PRT-10217_Web.pdf
Battery	3.7V Lithium-Ion Battery Rechargeable (Secondary	SparkFun Electronics	PRT-13853	Digi-Key Corporation	1568-1491-ND	1	4.95	4.95	https://cdn.sparkfun.com/datasheets/Prototyping/spe-00-DTP401525-110mah-en-1.0ver.pdf
							Total Cost:	366.31	

Power Distribution

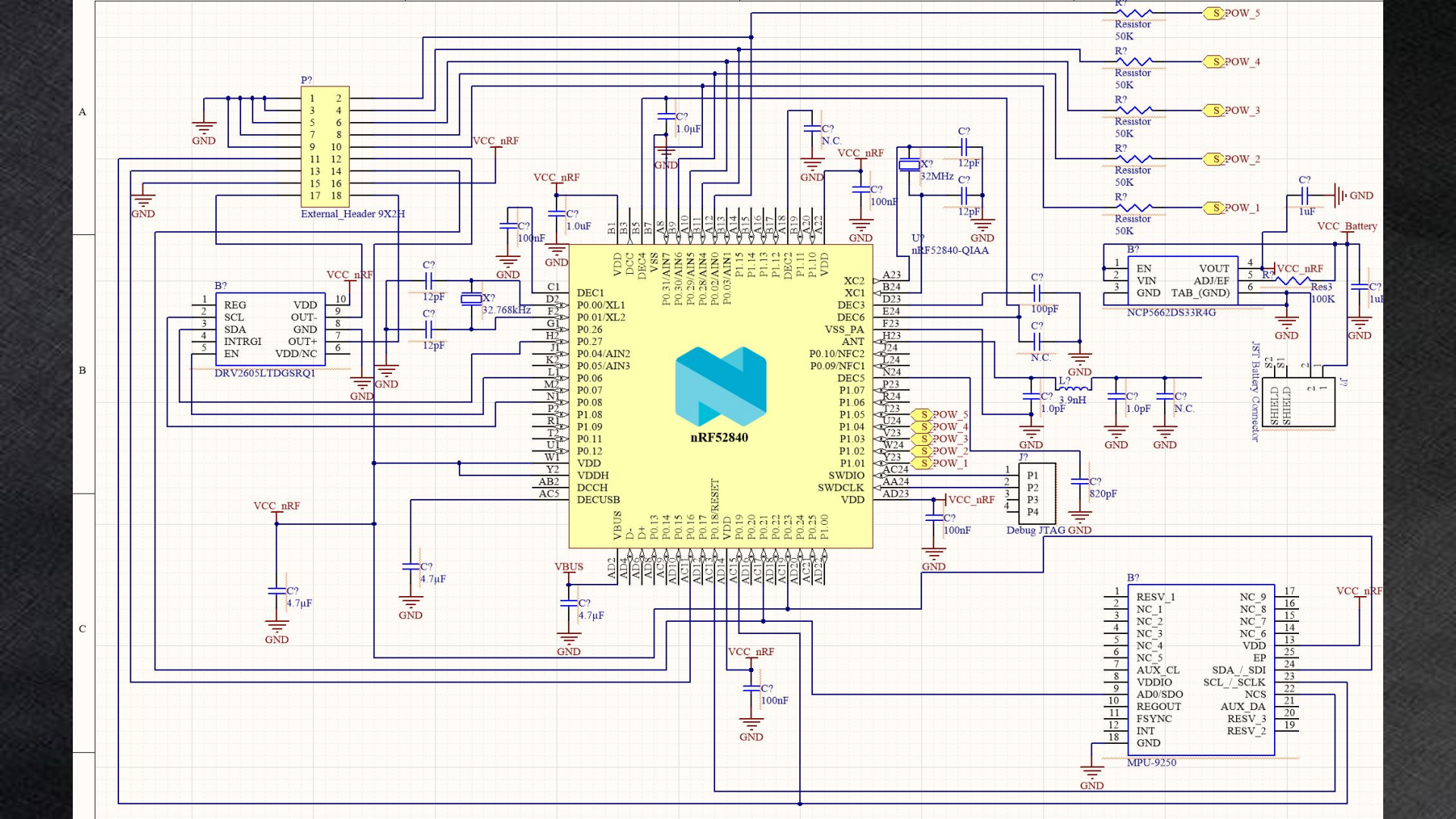
Power Distribution

- MPU 9250
  - VDD supply voltage range 2.4 - 3.6 V
  - Gyroscope operating current: 3.2 mA
  - Accelerometer operating current: 450 uA
  - Magnetometer operating current: 280 uA
- Haptic components
  - Vibrating Mini Motor Disc
    - 3 V, 60 mA
  - DRV2605L
    - 3V, 500 uA

Power Distribution

- StretchFABRIC
  - uA per StretchFABRIC
- nRF52840
  - 12.9mA
- LDO Voltage Regulator 3.3V 2A
- 3.7 Lithium-Ion Battery Rechargeable 110 mAh

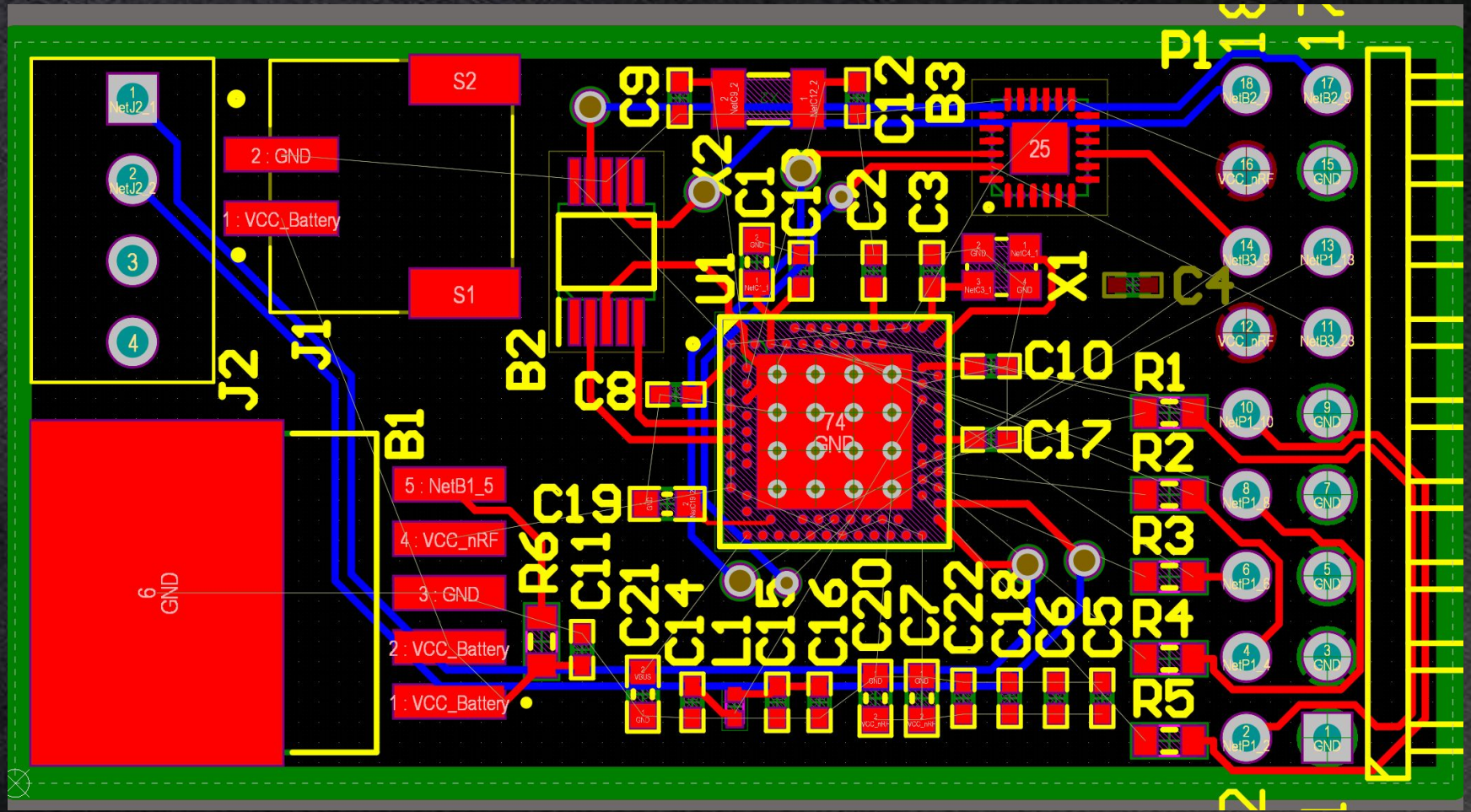
Schematic


nRF52840
U?
nRF52840-QIAA
External_Header 9X2H
DRV2605LTDGSRQ1
NCP5662DS33R4G
Debug JTAG
MPU-9250
JST Battery Connector
Resistor
50K
32MHz
32.768kHz
3.9nH
Res3
100K
VCC_nRF
VCC_Battery
GND
VBUS
POW_5
POW_4
POW_3
POW_2
POW_1
1.0µF
100nF
12pF
100pF
1.0pF
820pF
4.7µF
N.C.

PCB

PCB

- 4-Layer Board
- Dimensions for casing: 2’’ x 1’’ x 0.5’’
- One Power Place (3.3v)
- One Ground Plane
- 2 Planes for traces


S2
2 : GND
1 : VCC_Battery
S1
J2
J1
B1
B2
B3
P1
X1
X2
U1
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C17
C18
C19
C20
C21
C22
L1
R1
R2
R3
R4
R5
R6
74
GND
25
5 : NetB1_5
4 : VCC_nRF
3 : GND
2 : VCC_Battery
1 : VCC_Battery
6
GND

Software Development

Software Development

- IMUs
  - Read quaternion values through SPI
  - Convert quaternions to yaw, pitch, and roll
- Stretch sensors
  - Measuring capacitance through analog
  - A pin and resistor will charge and discharge it
- Haptic motor
  - Read through I2C
  - Use haptic controller to create ramp and other types of vibrations

Software Development

- Data transmitted to phone app via BLE
- Telemetry is processed -> feature extrapolation
  - Control signals generation
  - Debouncing

- Integration with DJI Mobile SDK
  - Rich sensor data available up to 10Hz
  - Transmission to Drone via WiFi Direct

Conclusion

Conclusion

- What we've done:
  - Schematic is completed
  - Finalized BOM
  - Peripherals functionality is tested
- Plans for the future:
  - Finishing up the layout for PCB
  - Integration of MPU 9250 with nRF52840
  - Integration of DRV2605L with nRF52840
  - Developing a wireframe for software applications

Conclusion

Task/Details	Start Week	End Week	Week Duration	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Priority
				10/01-10/07	10/08-10/14	10/15-10/21	10/22-10/28	10/29-11/04	11/05-11/11	11/12-11/18	11/19-11/25	11/26-12/02	12/03-12/09	High
StretchFABRIC														Medium
-Build resistor network	6	9	3											Low
-Pins for StretchFABRIC on SoC	5	8	3											
-Pull accurate data from StretchFABRIC	5	10	5											
				Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	
MPU-9250														
-Integrate MPU-9250 via SPI w/ SoC	8	10	2											
-Pins for MPU-9250 on SoC	5	8	3											
-Pull accurate data from MPU-9250	7	10	3											
				Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	
Haptic Motor Driver														
-Integrate haptic motor driver via I2C w/ SoC	7	10	3											
-Pins for haptic motor driver on SoC	5	8	3											
-Pull accurate data from haptic motor driver	7	10	3											

Conclusion

				Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Haptic Motor Vibrating Disc													
-Hot glue gun haptic motor vibrating disc w/ driver	7	8	1										
-Play with 3 V - 5 V for vibration preference	8	10	2										
-Pull accurate data from haptic driver/disc mechanism	8	10	2										
				Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
nRF52840													
-Choose configuration 1-6	7	8	1										
-Power configuration	7	8	1										
-Integrate IMU with SoC	7	10	3										
-Integrate haptic driver/disc mechanism with SoC	7	10	3										
-Integrate StretchFABRIC with SoC	7	10	3										
				Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Casing													
-Measure the size of the case	7	8	1										
-Schematic for PCB	7	8	1										
-Layout for PCB	7	10	3										

A special thanks to:

- Yogananda Isukapalli, for keeping us on track and heading Capstone Program
- Brandon Pon, for TA Mentorship
- Carrie Segal, for TA Mentorship
- Aveng Technologies, for sponsoring and mentorship

Questions?