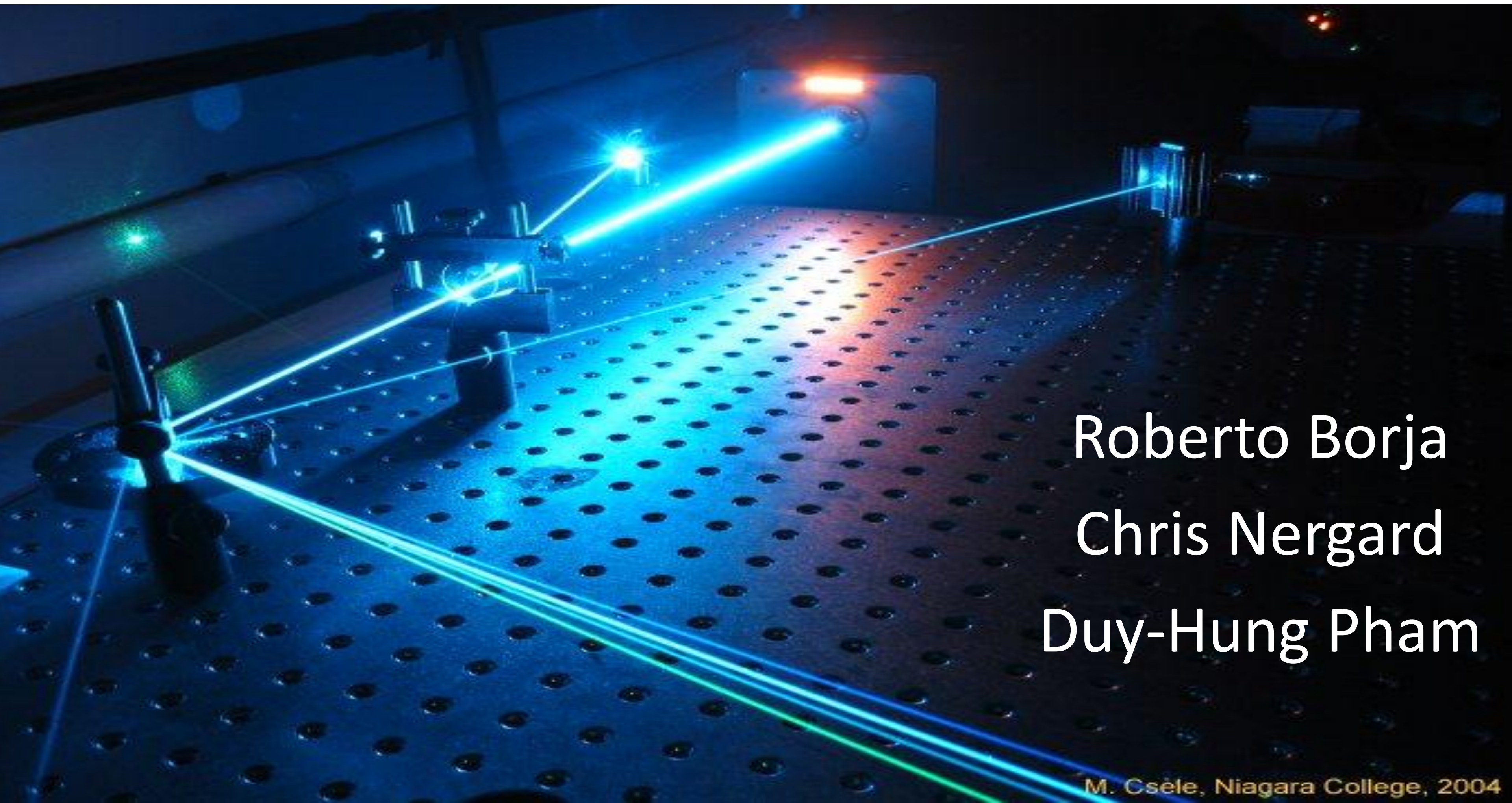
Automated Optical Setup

Group #16



Roberto Borja
Chris Nergard
Duy-Hung Pham

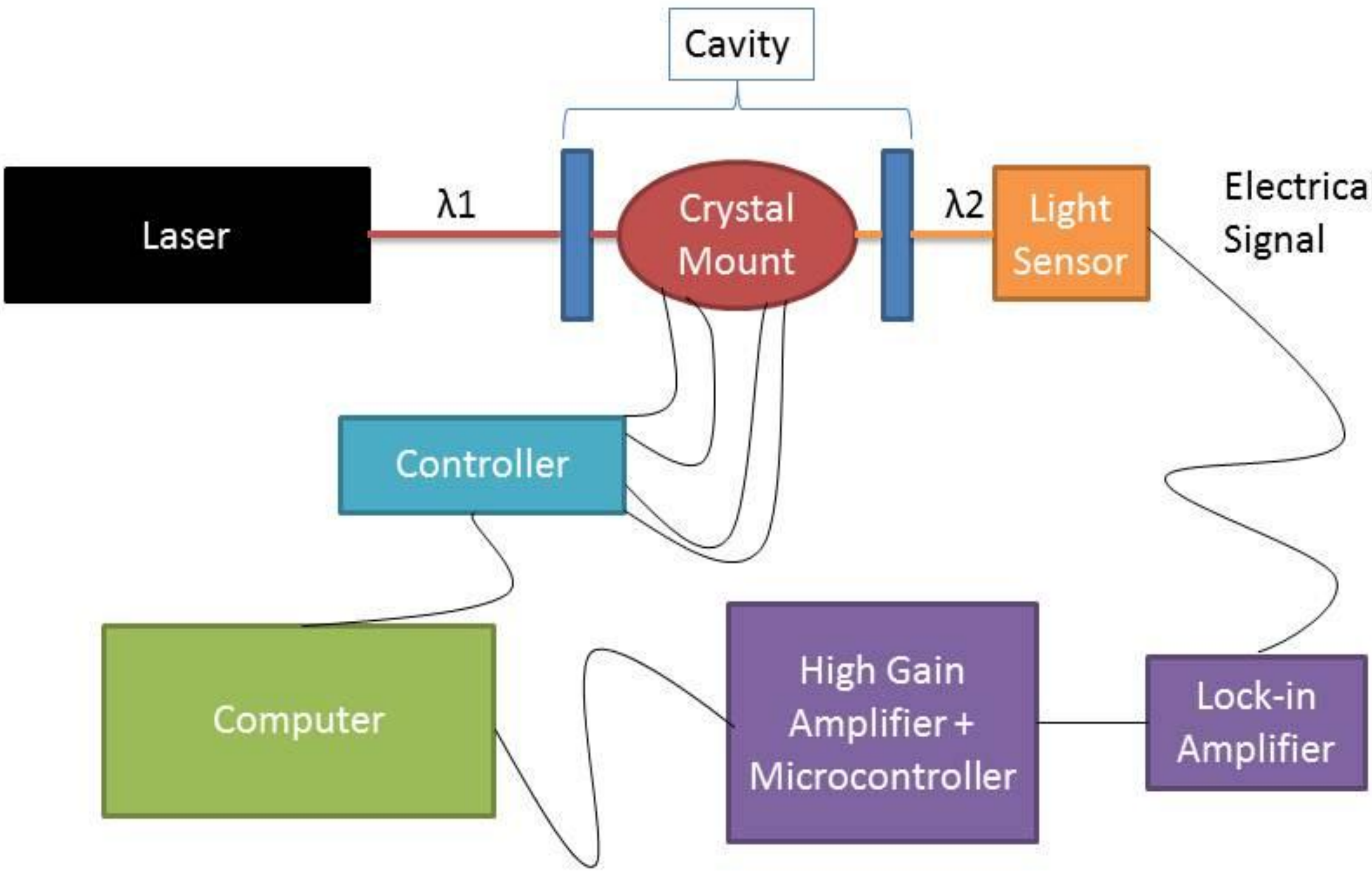
Problem

- Optical Parametric Oscillators requires a very precise orientation of a crystal
- Doing this by hand is very tedious
- Constant adjustment of crystal due to noise
- The crystal degrades the power of the laser beam significantly
- Optical experiments require very sensitive setups

The AOS Project

The project is to create an automated setup that involves rotating an optical element that a laser beam will pass through ending up at a sensor that will measure the intensity of that beam. Automation allows for a convenient, time saving, and accurate experiment.

Optical Parametric Oscillator



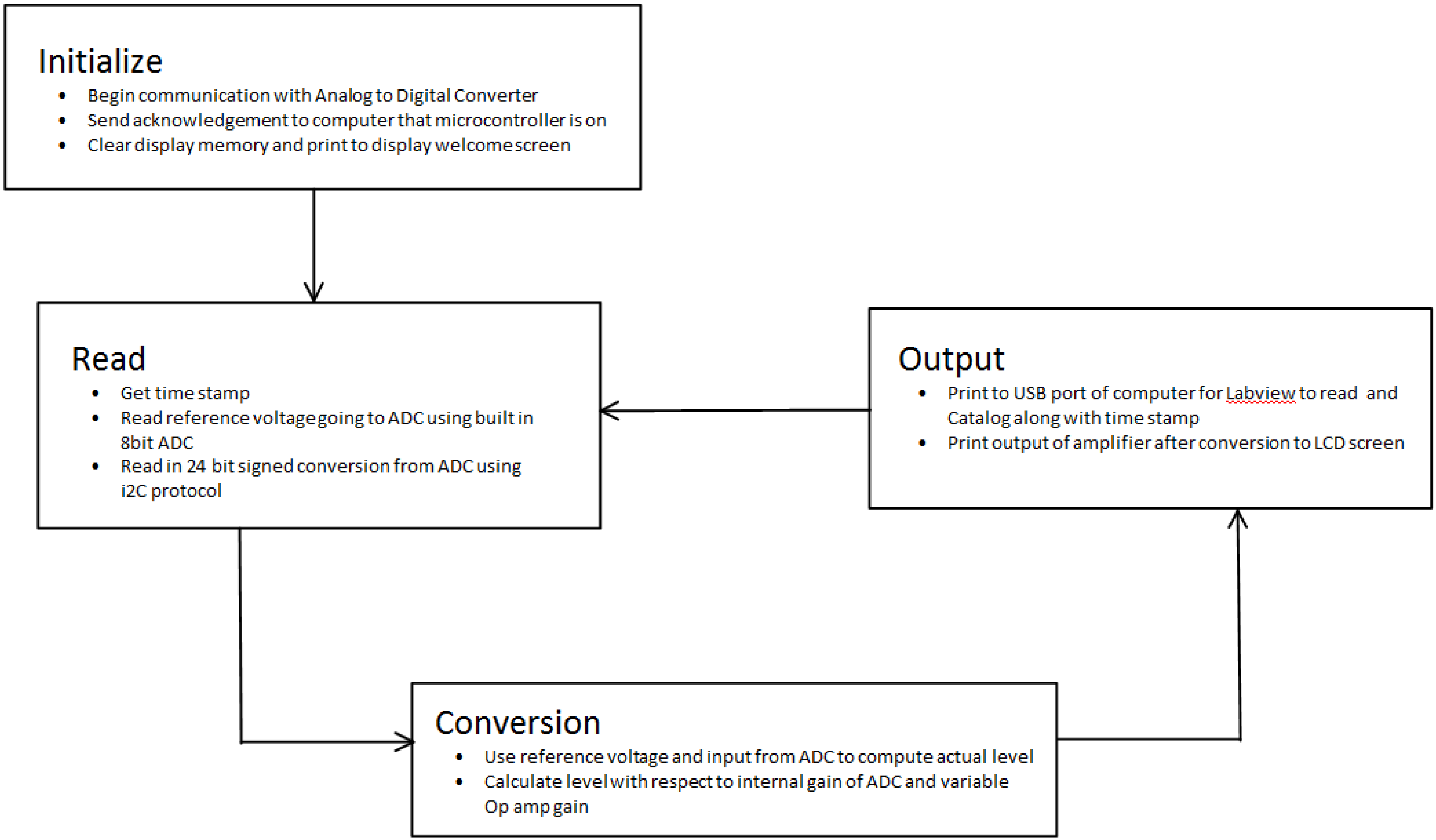
Goals

- High precision
- Absolute position of mount known
- Quick response
- No motor burnout
- Smooth adjustment
- User friendly
- Multifunction
  - Automation
  - Manual

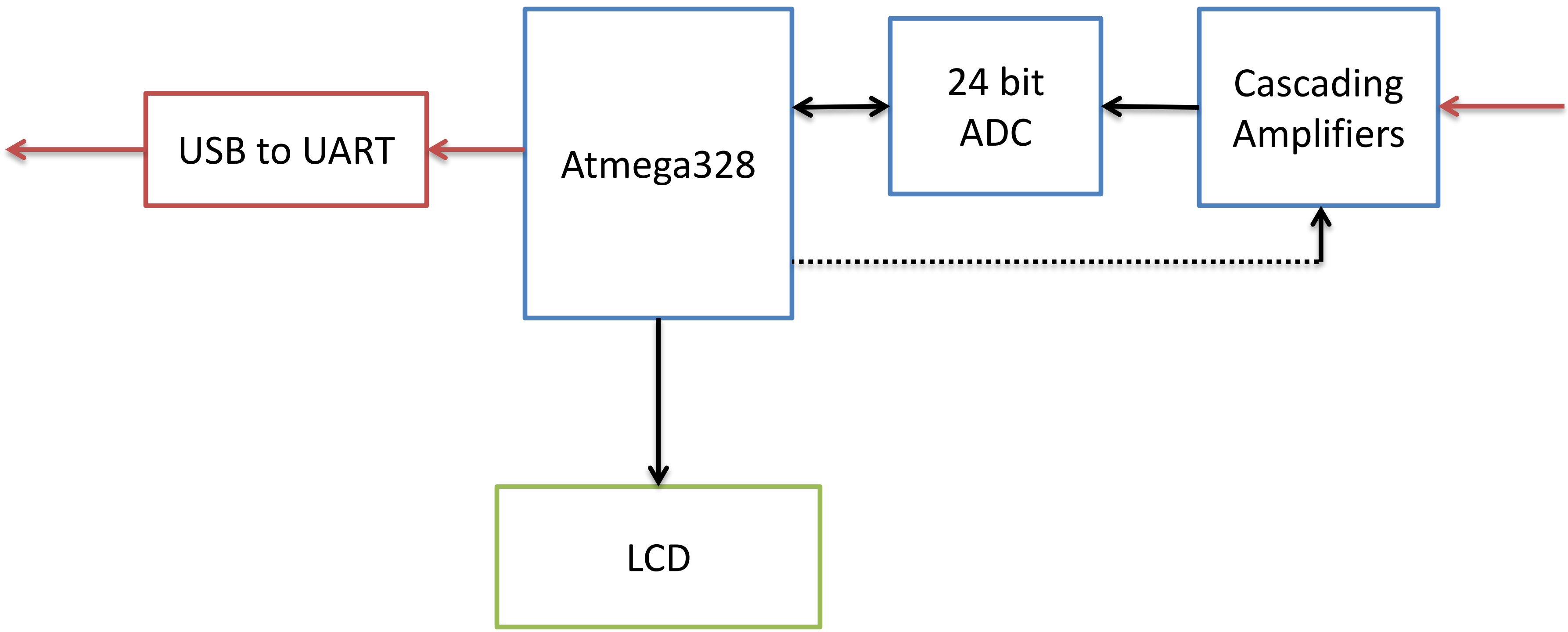
Specification

Component	Parameter	Design Specification
Amplifier	Gain	46656
Amplifier	RF signal	< 15 kHz
Mount	Position accuracy	0.1^o
Mount	Adjustment sensitivity	$2\ \mu rad$
Mount	Speed	$0.5^o/s$
Mount	Angular Range	$\pm 2^o$
Mount	Thickness	< 35mm
Display	Dimensions	< 25mm, 60mm
Display	Number of characters	> 10
GUI	Update time	<2s

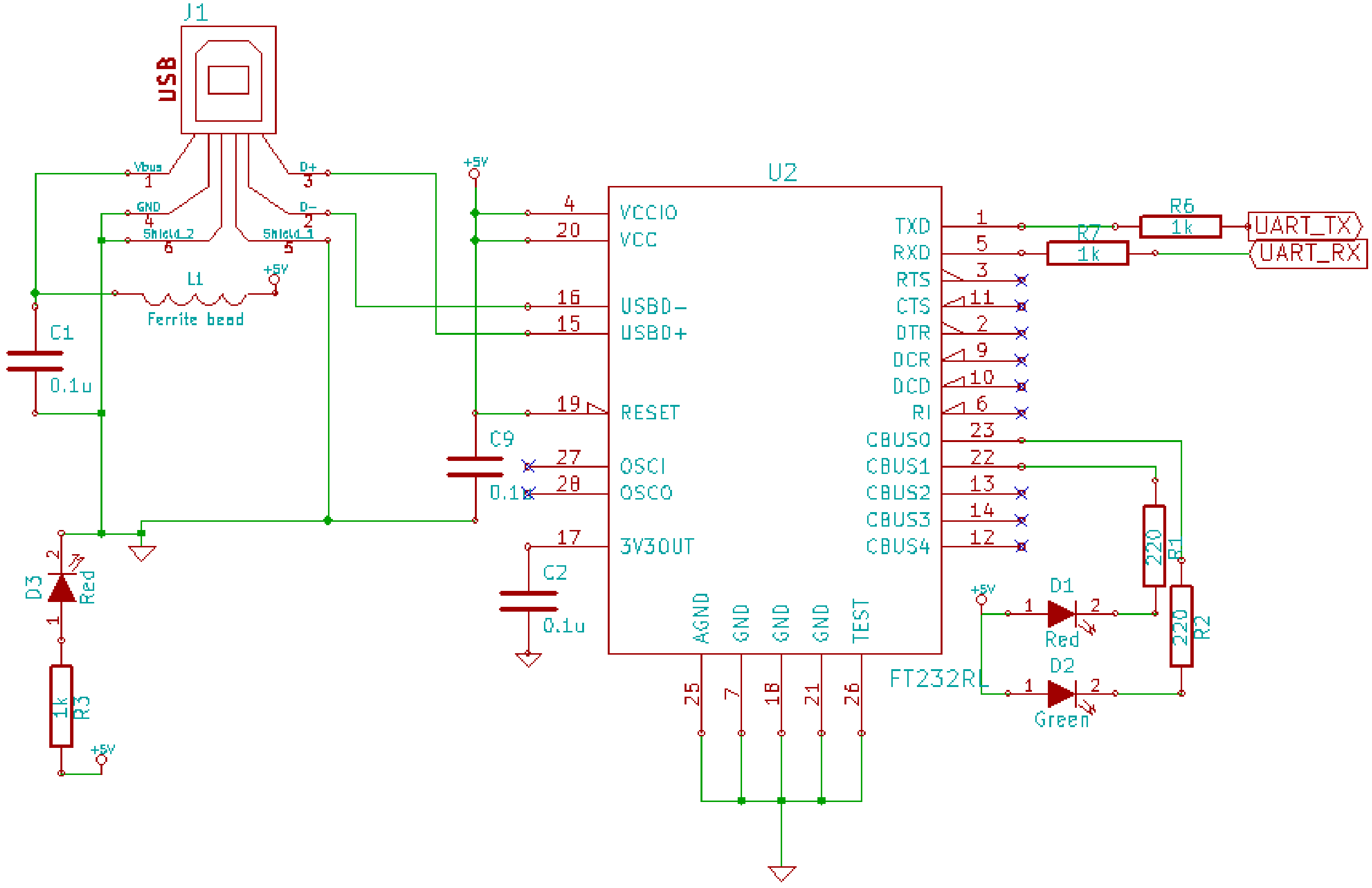
Atmega Block diagram



Hardware diagram

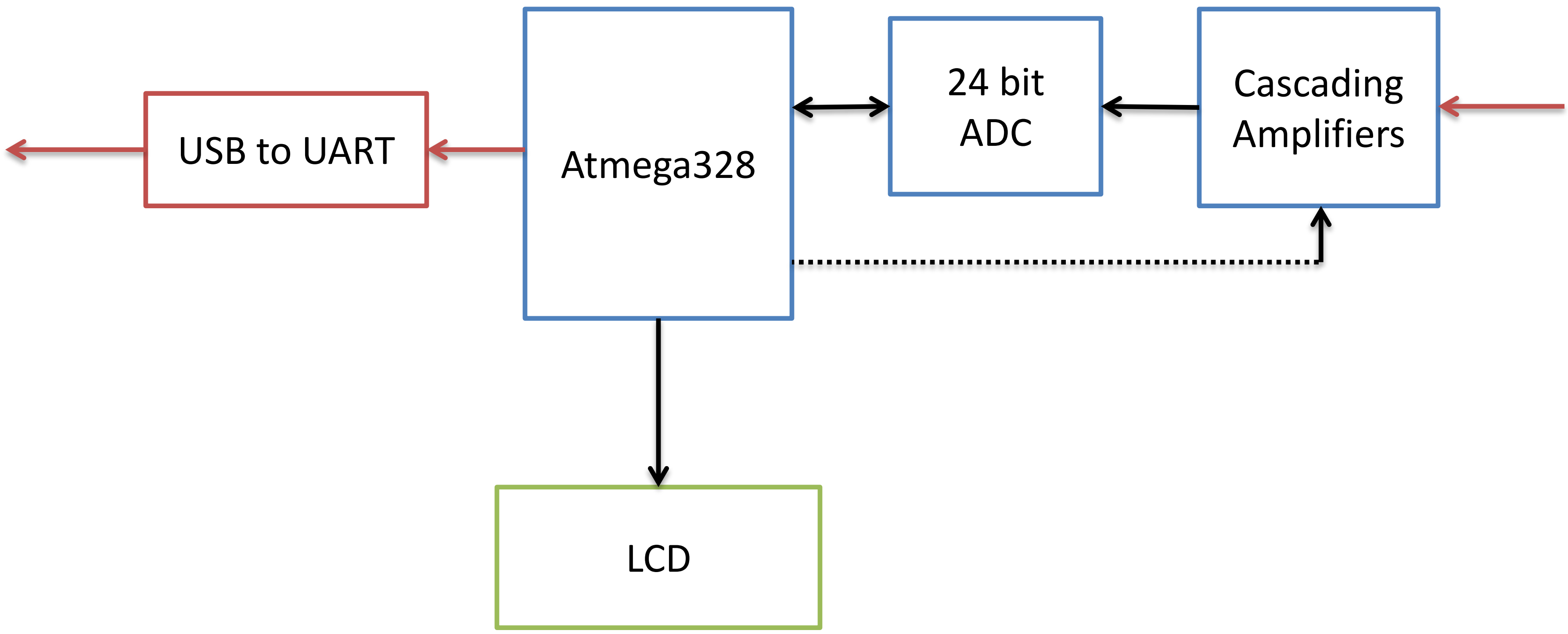


USB to UART

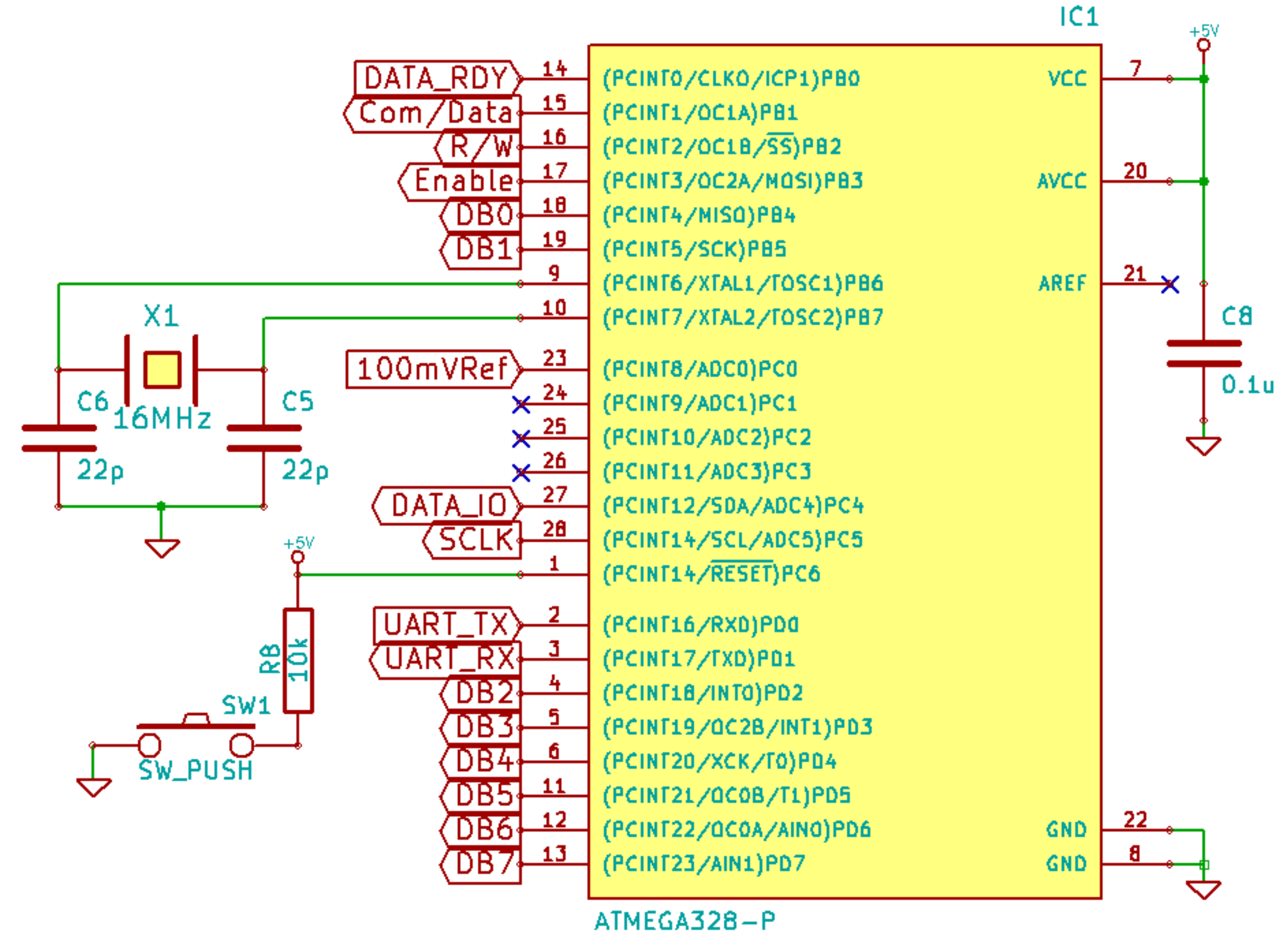


J1
USB
Vbus
GND
D+
D-
Shield_2
Shield_1
L1
Ferrite bead
+5V
C1
0.1u
C9
0.1u
C2
0.1u
D3
Red
R3
1k
U2
VCCIO
VCC
USBD-
USBD+
RESET
OSCI
OSCO
3V3OUT
AGND
GND
GND
GND
TEST
FT232RL
TXD
RXD
RTS
CTS
DTR
DCR
DCD
RI
CBUS0
CBUS1
CBUS2
CBUS3
CBUS4
R6
1k
R7
1k
UART_TX
UART_RX
R1
220
R2
220
D1
Red
D2
Green

Hardware diagram

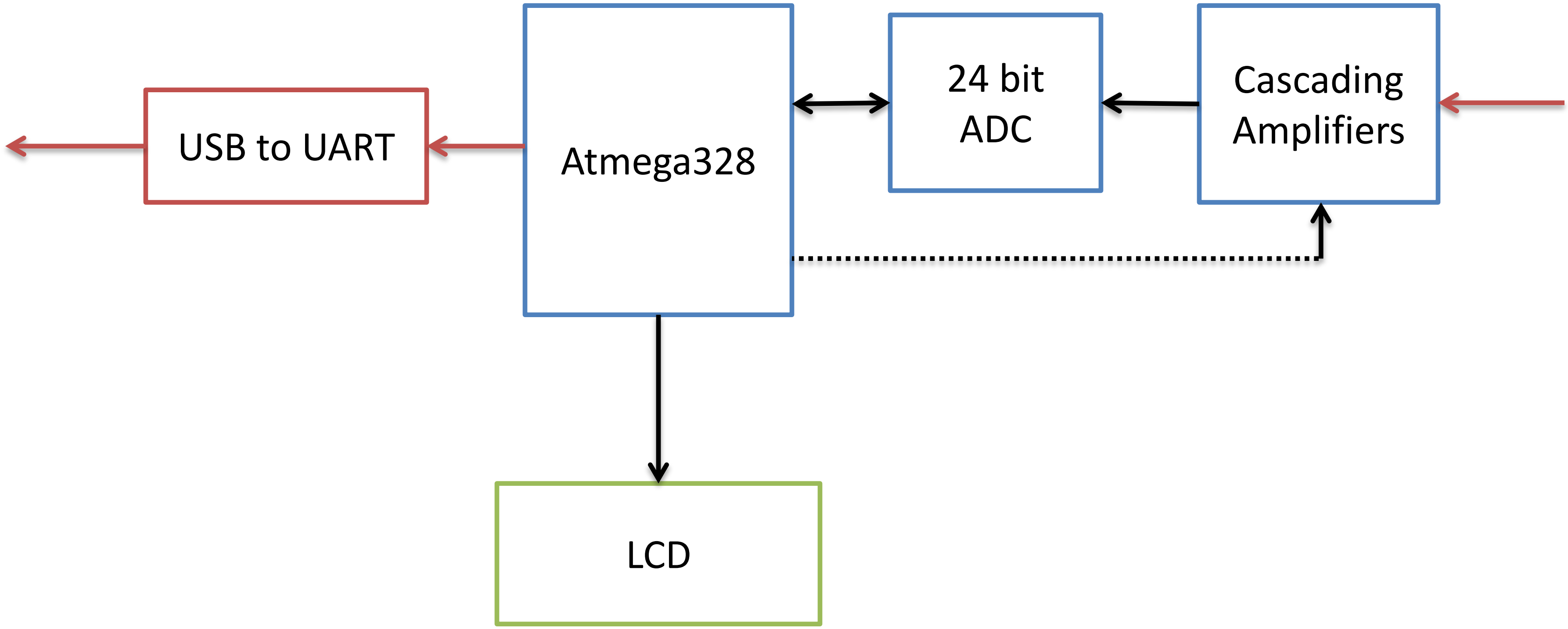


Atmega328

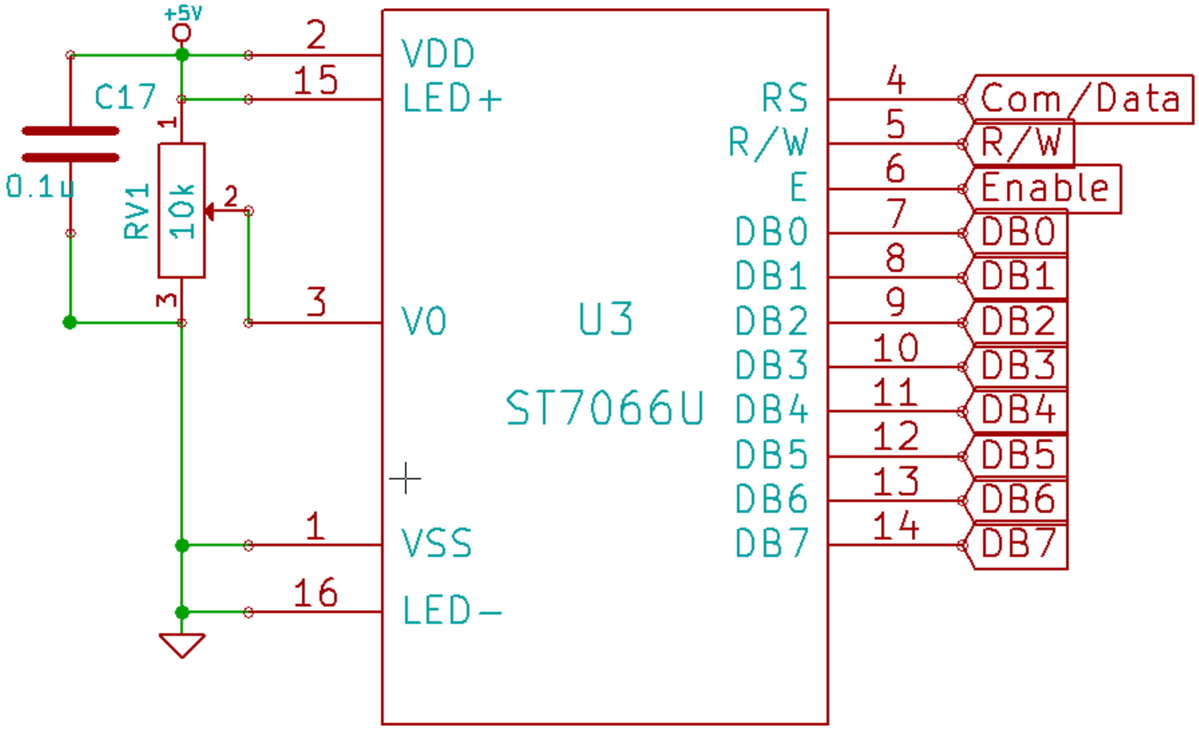


IC1
+5V
DATA_RDY
Com/Data
R/W
Enable
DB0
DB1
14
15
16
17
18
19
9
10
(PCINT0/CLKO/ICP1)PB0
(PCINT1/OC1A)PB1
(PCINT2/OC1B/SS)PB2
(PCINT3/OC2A/MOSI)PB3
(PCINT4/MISO)PB4
(PCINT5/SCK)PB5
(PCINT6/XTAL1/TOSC1)PB6
(PCINT7/XTAL2/TOSC2)PB7
VCC
7
AVCC
20
AREF
21
C8
0.1u
X1
16MHz
C6
22p
C5
22p
100mVRef
23
24
25
26
27
28
1
(PCINT8/ADC0)PC0
(PCINT9/ADC1)PC1
(PCINT10/ADC2)PC2
(PCINT11/ADC3)PC3
(PCINT12/SDA/ADC4)PC4
(PCINT14/SCL/ADC5)PC5
(PCINT14/RESET)PC6
DATA_IO
SCLK
+5V
R8
10k
SW1
SW_PUSH
UART_TX
UART_RX
DB2
DB3
DB4
DB5
DB6
DB7
2
3
4
5
6
11
12
13
(PCINT16/RXD)PD0
(PCINT17/TXD)PD1
(PCINT18/INT0)PD2
(PCINT19/OC2B/INT1)PD3
(PCINT20/XCK/T0)PD4
(PCINT21/OC0B/T1)PD5
(PCINT22/OC0A/AIN0)PD6
(PCINT23/AIN1)PD7
GND
22
GND
8
ATMEGA328-P

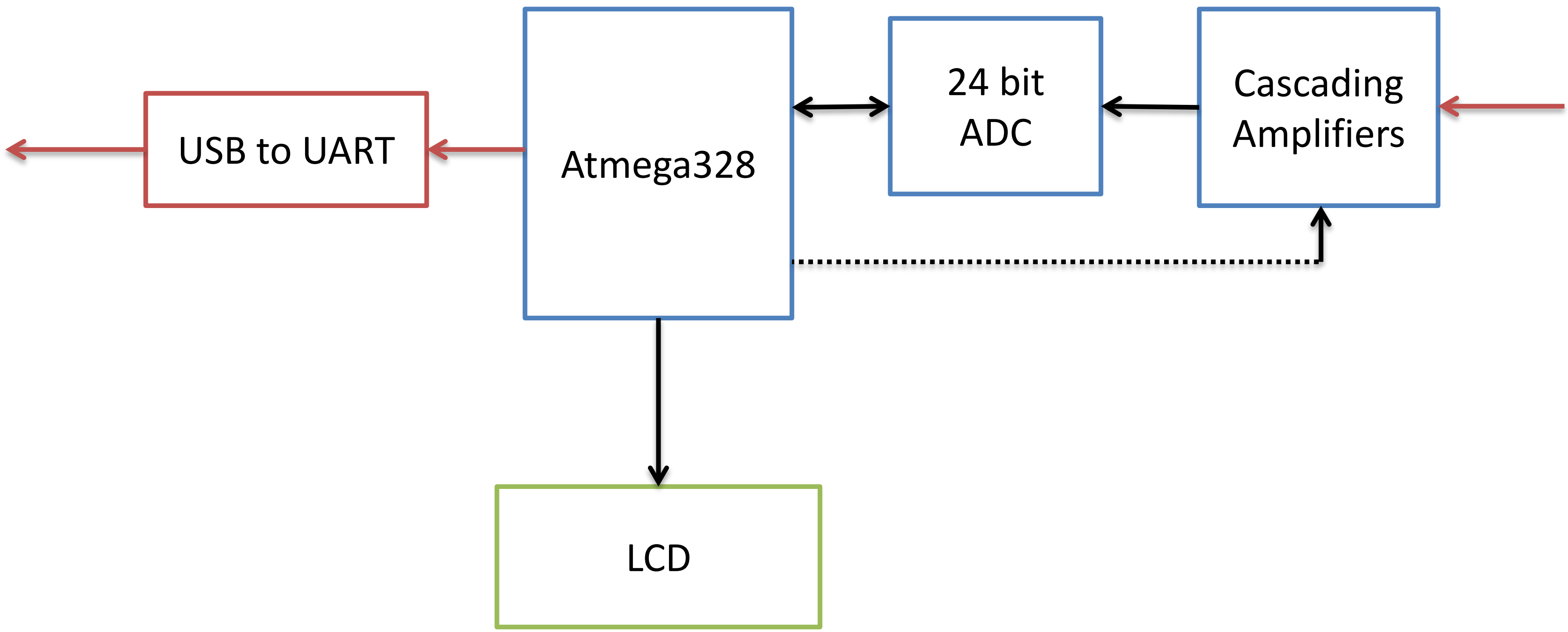
Hardware diagram



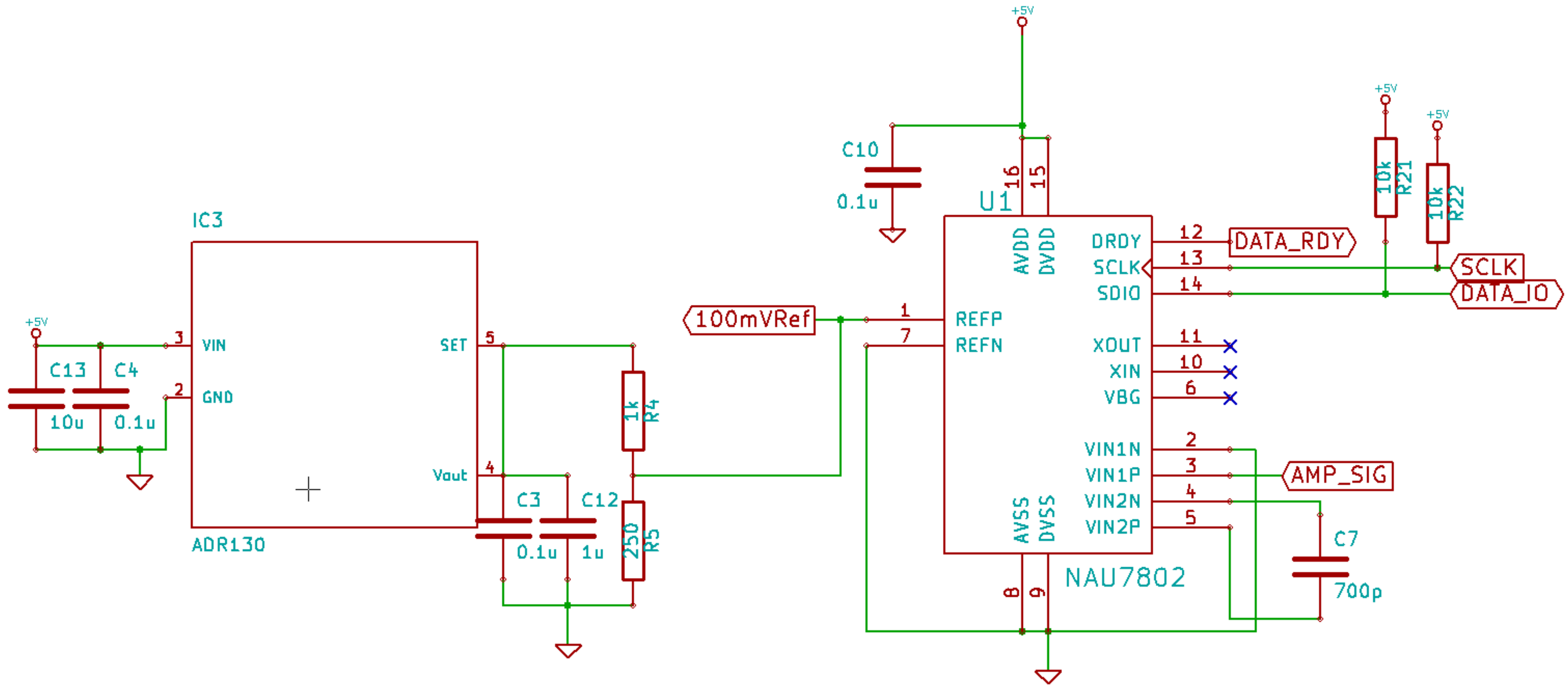
Atmega + Display



Hardware diagram

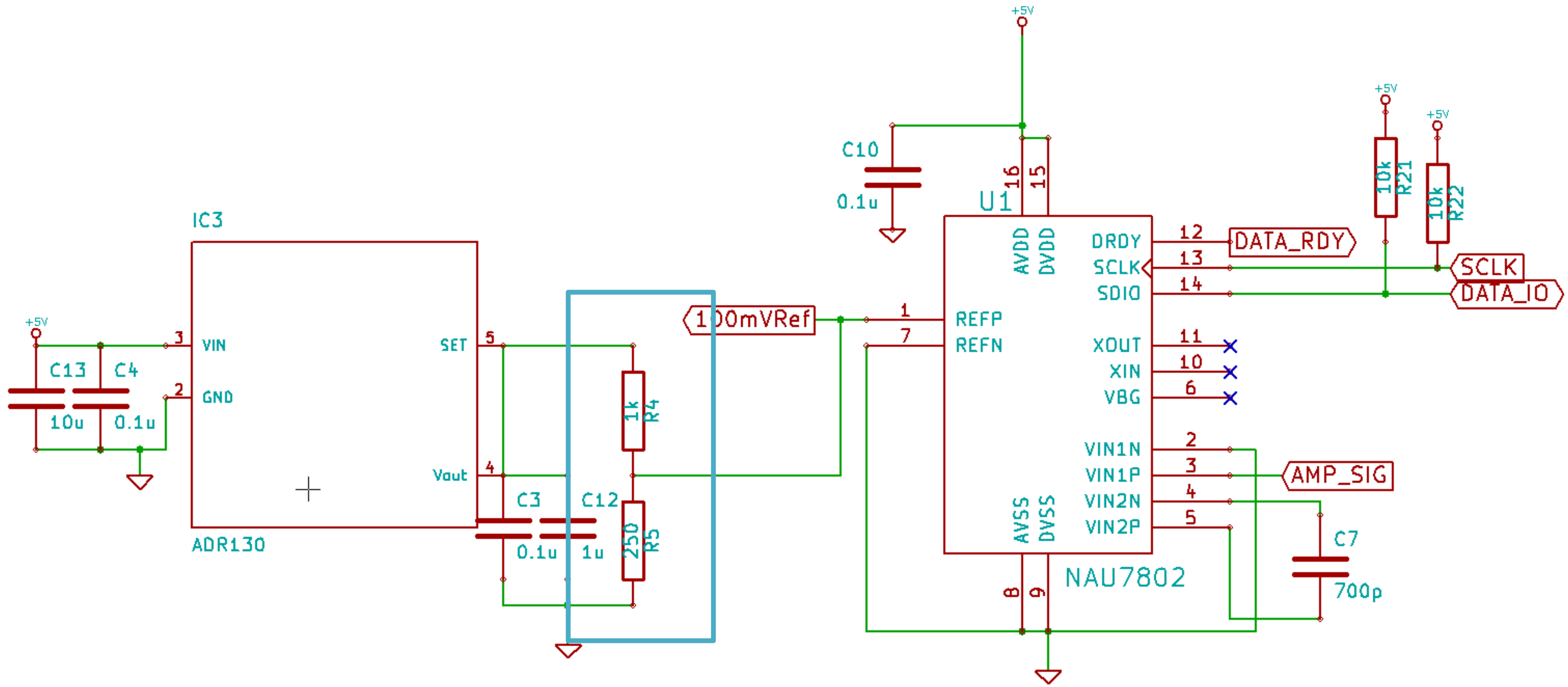


24-bit ADC


+5V
C10
0.1u
16
15
U1
AVDD
DVDD
DRDY
SCLK
SDIO
12
13
14
DATA_RDY
SCLK
DATA_IO
10k
R21
10k
R22
IC3
VIN
GND
SET
Vout
ADR130
C13
C4
10u
0.1u
C3
C12
0.1u
1u
1k
R4
250
R5
100mVRef
REFP
REFN
XOUT
XIN
VBG
VIN1N
VIN1P
VIN2N
VIN2P
AMP_SIG
AVSS
DVSS
NAU7802
C7
700p

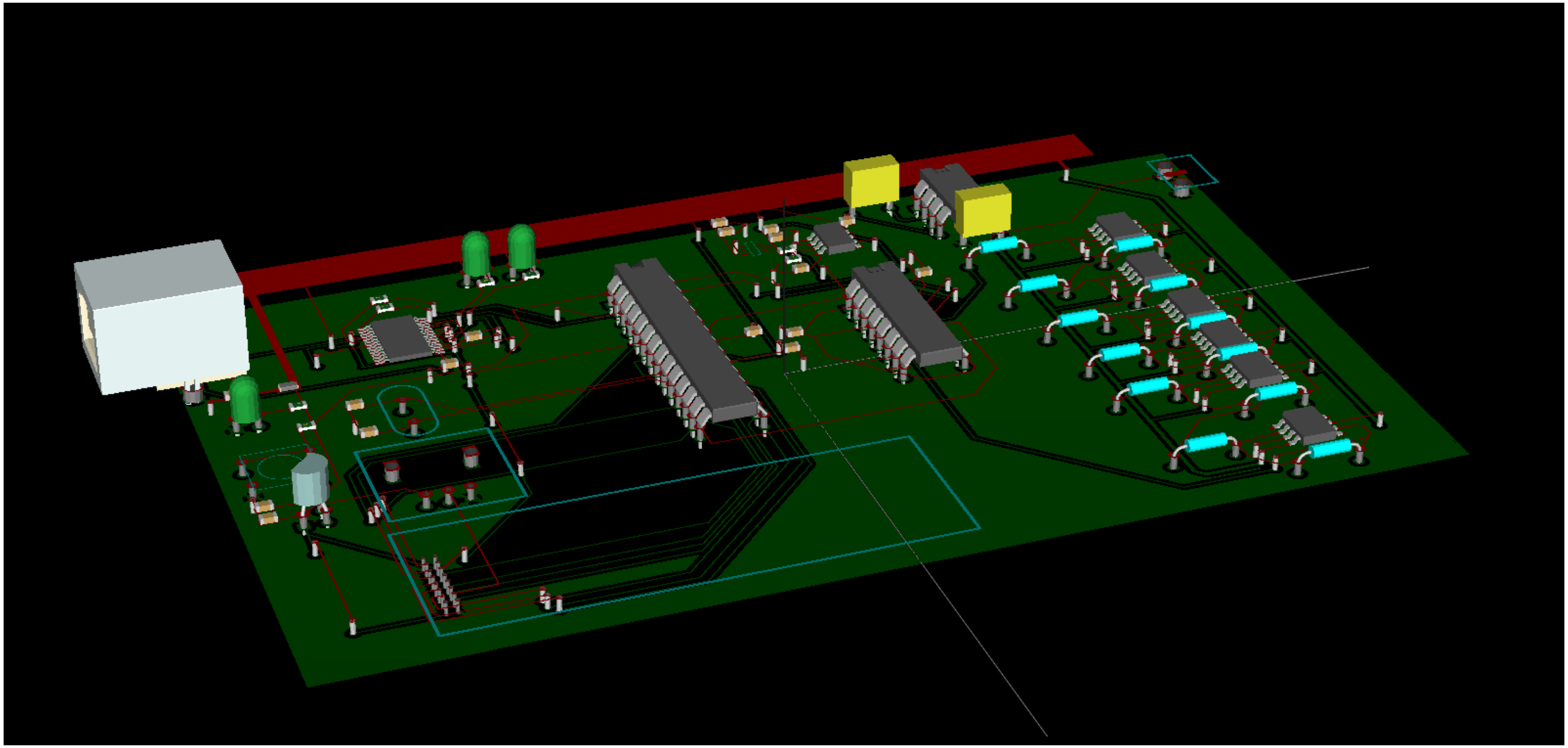

nuvoTon
NAU7802

24-bit ADC


+5V
C10
0.1u
16
15
U1
AVDD
DVDD
DRDY
SCLK
SDIO
12
13
14
DATA_RDY
SCLK
DATA_IO
10k
R21
10k
R22
IC3
VIN
GND
SET
Vout
ADR130
C13
C4
10u
0.1u
C3
C12
0.1u
1u
1k
R4
250
R5
100mVRef
REFP
REFN
XOUT
XIN
VBG
VIN1N
VIN1P
VIN2N
VIN2P
AVSS
DVSS
AMP_SIG
C7
700p
NAU7802


nuvoTon
NAU7802

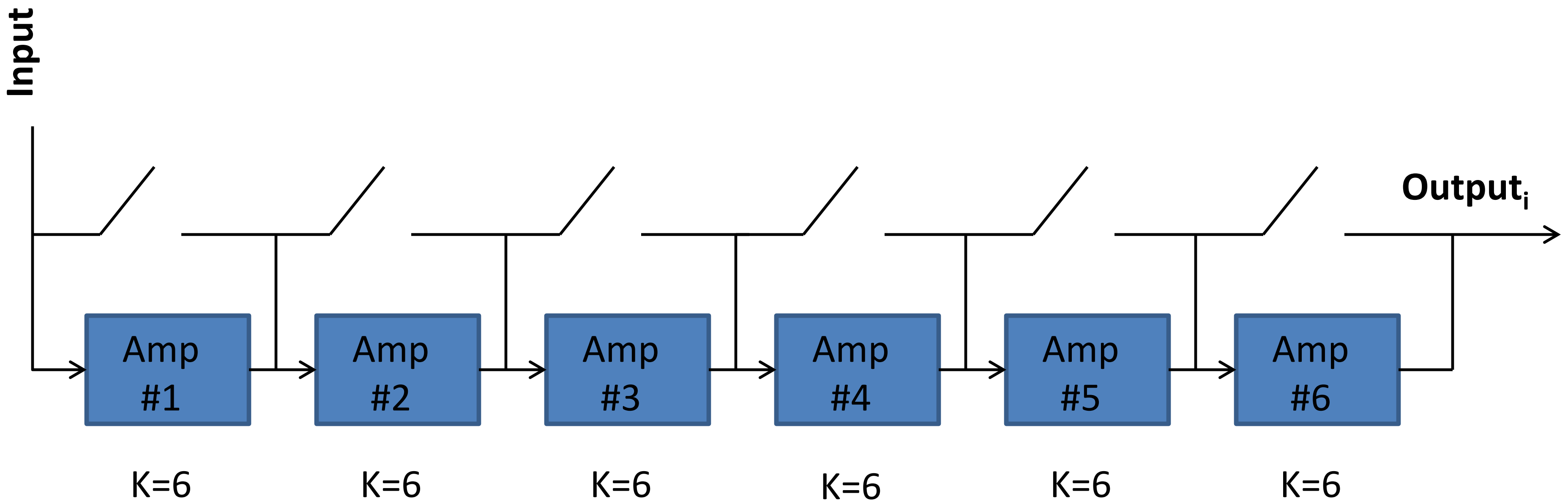
Original PCB layout

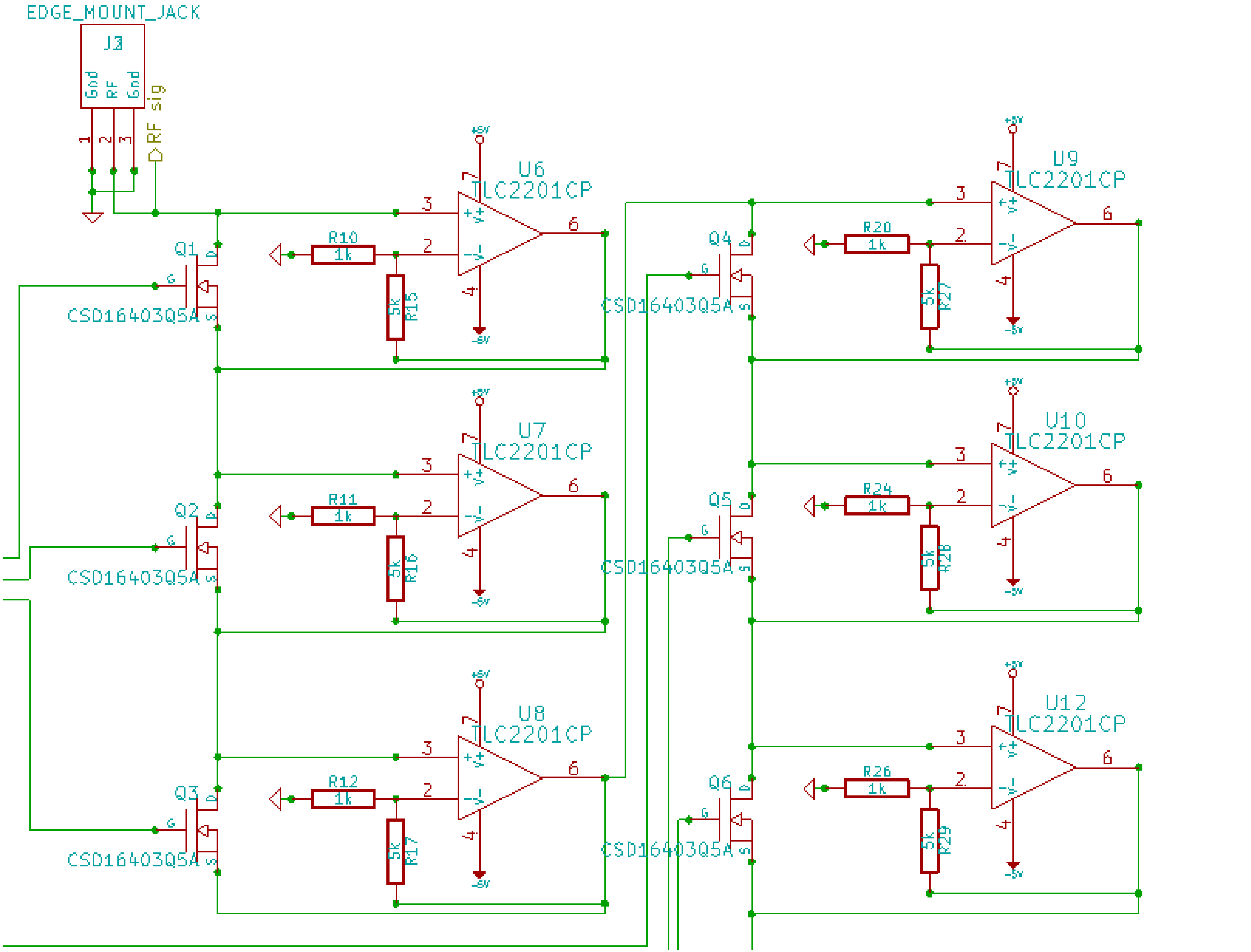


Amplifier Goals

- Signal has the ability to bypass the amplifier.
- The gain can be adjustable.
- Low noise
- Noise filtration

Amplifier Block Diagram



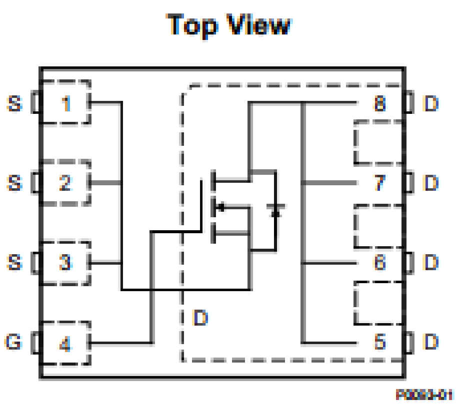

EDGE_MOUNT_JACK
J3
Gnd
RF
Gnd
RF sig
U6
TLC2201CP
U7
TLC2201CP
U8
TLC2201CP
U9
TLC2201CP
U10
TLC2201CP
U12
TLC2201CP
Q1
Q2
Q3
Q4
Q5
Q6
CSD16403Q5A
CSD16403Q5A
CSD16403Q5A
CSD16403Q5A
CSD16403Q5A
CSD16403Q5A
R10
1k
R11
1k
R12
1k
R20
1k
R24
1k
R26
1k
5k
R15
5k
R16
5k
R17
5k
R27
5k
R28
5k
R29
+5V
-5V

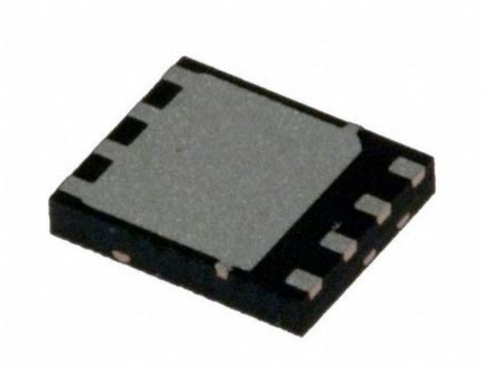
Op Amps Comparison

Model	Gain Bandwidth	Noise	Slew rate
OPA355	200 MHz	5.80 nV/√Hz	360 V/µs
OPA847	3.90 GHz	0.85 nV/√Hz	950 V/µs
TLC2201	1.90 MHz	12.0 nV/√Hz	2.70 V/µs

CSD16403Q5A

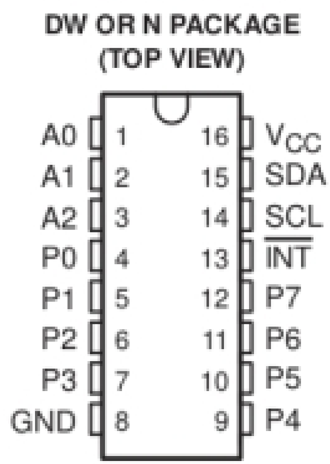
- N channel MOSFET
- Drain to Source Voltage (Vdss): 25V
- Vgs(th) (Max) @ Id : 1.9V @ 250µA
- Rds On (Max) @ Id, Vgs : 2.8 mOhm @ 20A, 10V
- Surface mount

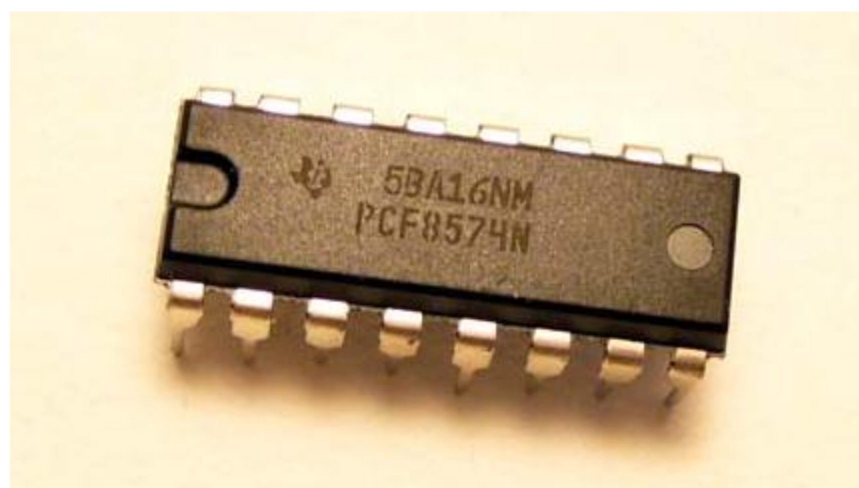


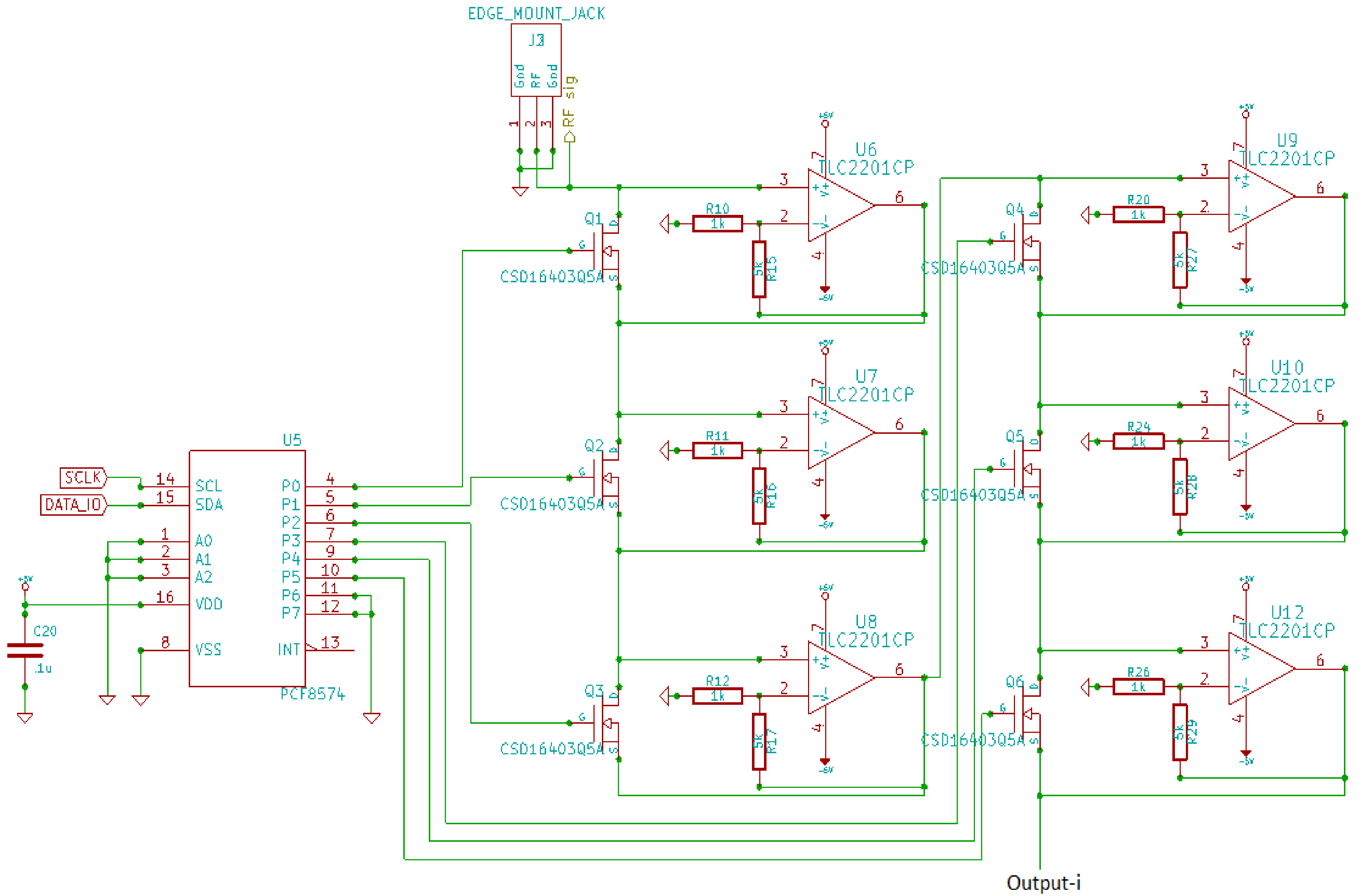


PCF8574

- 8 bits I/O port expander that uses the I2C protocol
- 2 ports of microcontroller to control up to 8 digital I/O ports. (SDA & SCL)

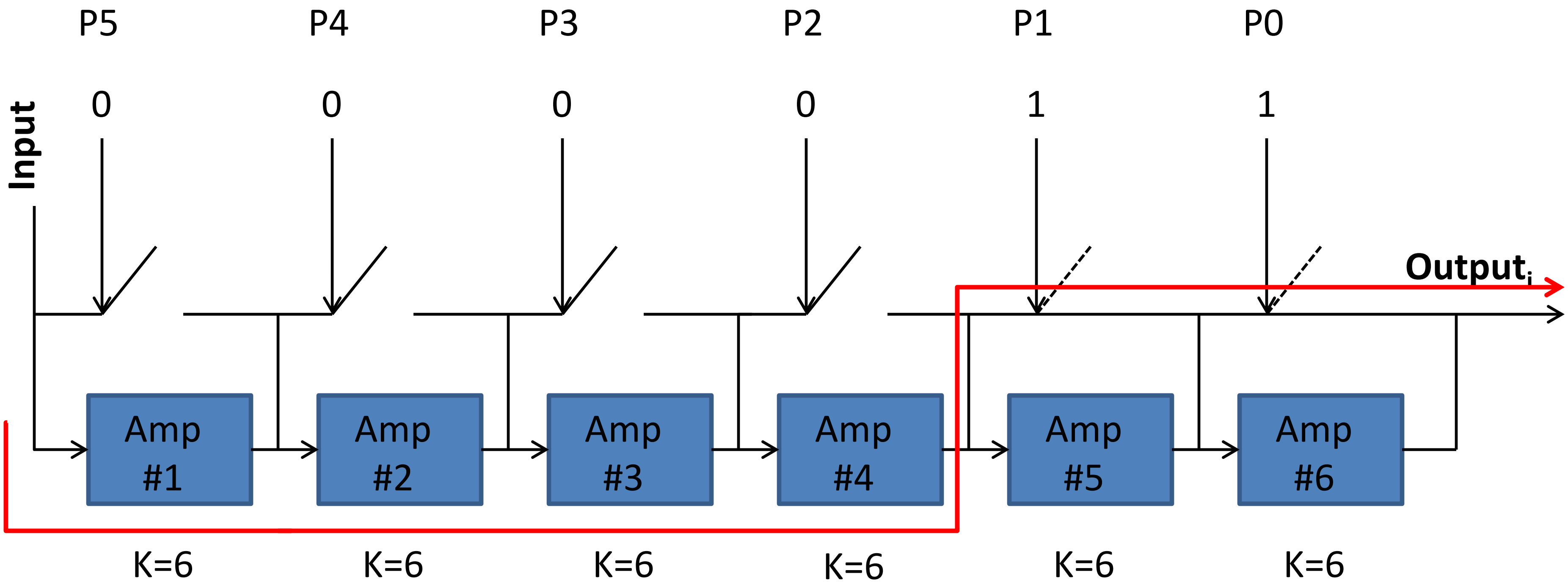






EDGE_MOUNT_JACK
J3
Gnd
RF
Gnd
RF sig
U5
PCF8574
SCLK
DATA_IO
SCL
SDA
A0
A1
A2
VDD
VSS
P0
P1
P2
P3
P4
P5
P6
P7
INT
C20
.1u
Q1
Q2
Q3
Q4
Q5
Q6
CSD16403Q5A
R10
R11
R12
R15
R16
R17
R20
R24
R26
R27
R28
R29
1k
5k
U6
U7
U8
U9
U10
U12
TLC2201CP
Output-i

Example



P5
P4
P3
P2
P1
P0
0
0
0
0
1
1
Input
Output$_i$
Amp #1
Amp #2
Amp #3
Amp #4
Amp #5
Amp #6
K=6
K=6
K=6
K=6
K=6
K=6

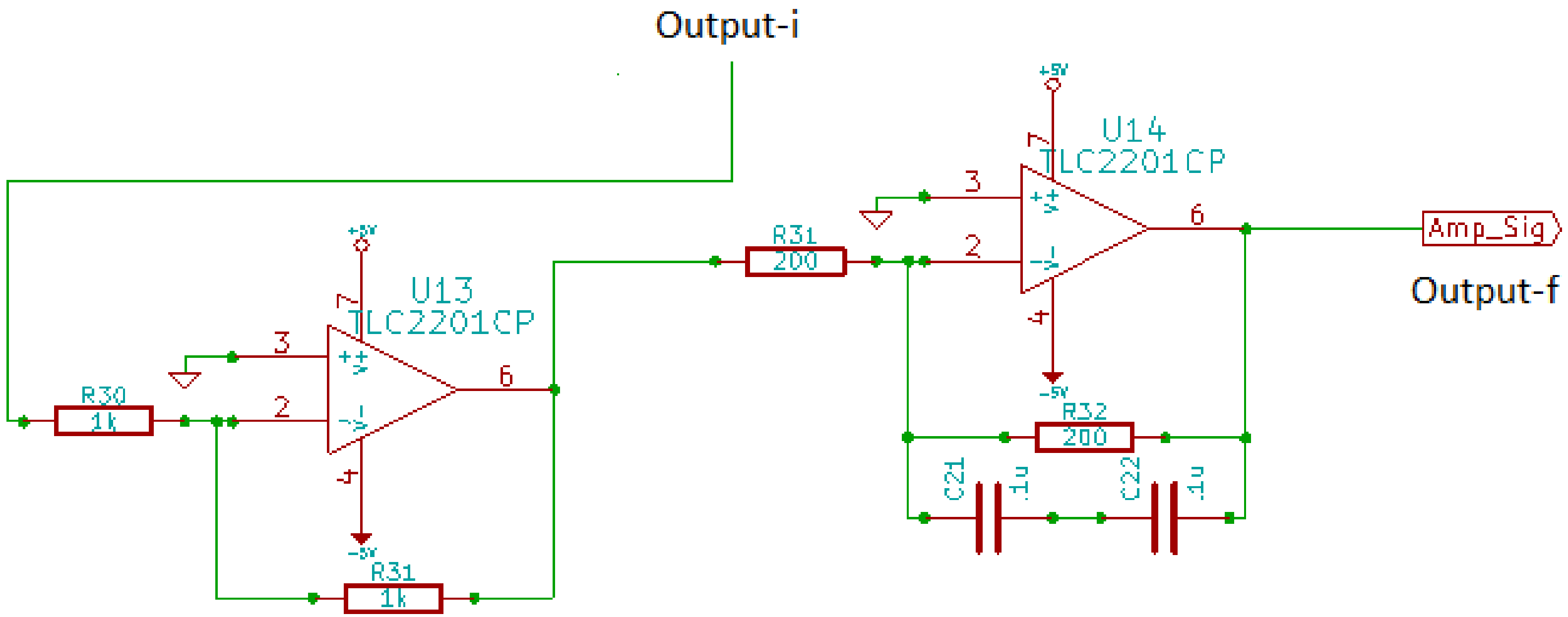
Amplifier Block Diagram

$$f_c = \frac{1}{2*\pi*R*C}$$

$$f_c = \frac{1}{2*\pi*200\Omega*[(.1\mu F*.1\mu F)/(.1\mu F+.1\mu F)]}$$

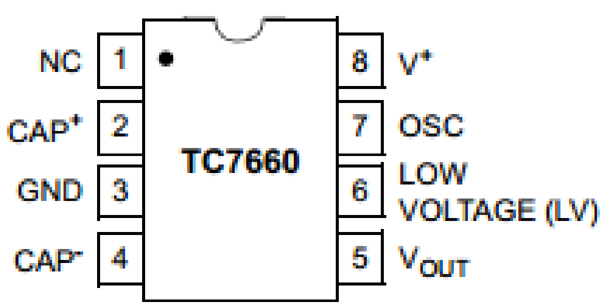
$f_c \approx$ 15.915 kHz

Low Pass Filter Sch.

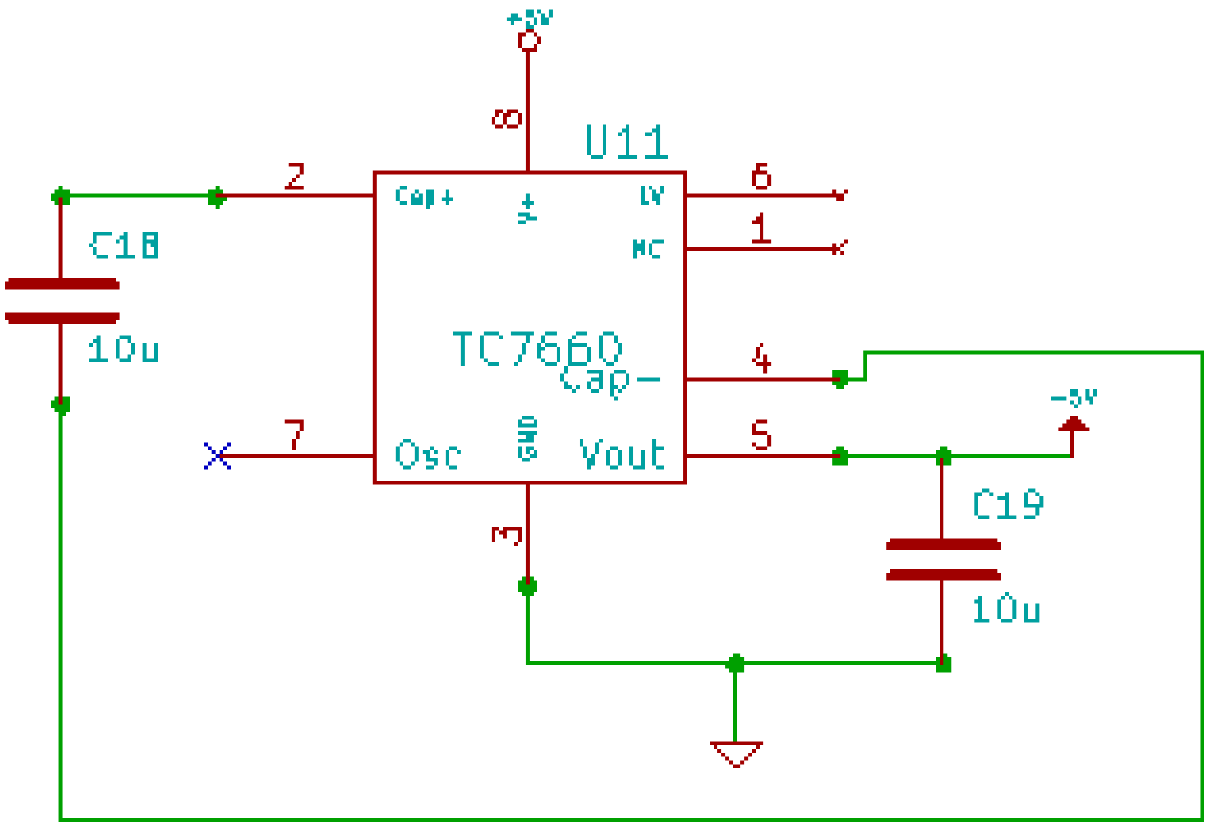


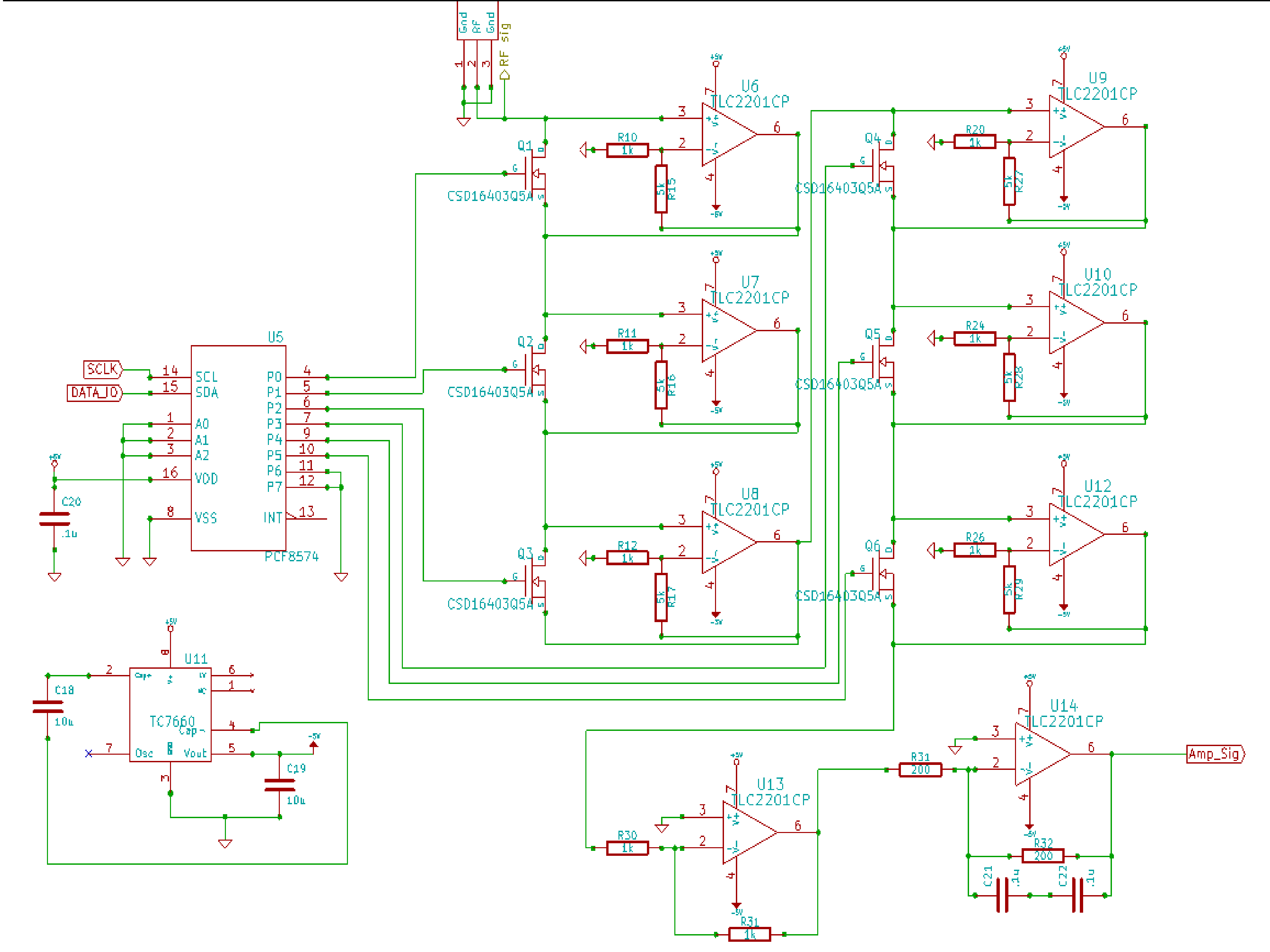
TC7660

- Converts +5V Supply to ±5V System
- Efficient Voltage Conversion: 99.9%
- Excellent Power Efficiency: 98%
- Low Cost and Easy to Use



TC7660 Con. Schematic

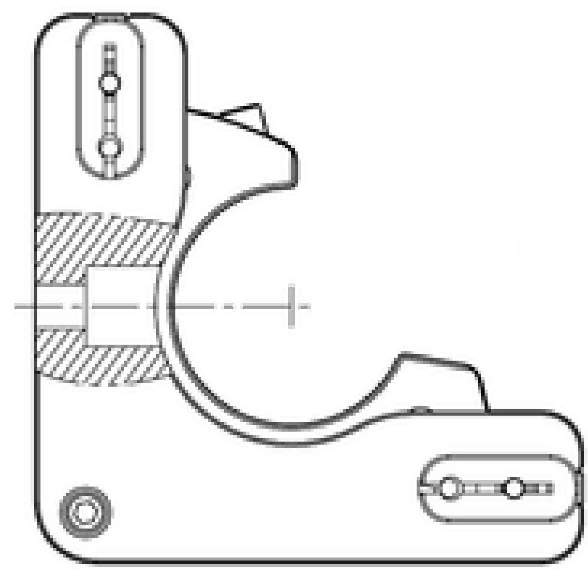




Gnd RF Gnd
RF sig
U6 TLC2201CP
U7 TLC2201CP
U8 TLC2201CP
U9 TLC2201CP
U10 TLC2201CP
U12 TLC2201CP
U13 TLC2201CP
U14 TLC2201CP
Q1 Q2 Q3 Q4 Q5 Q6
CSD16403Q5A
R10 1k
R11 1k
R12 1k
R15 5k
R16 5k
R17 5k
R20 1k
R24 1k
R26 1k
R27 5k
R28 5k
R29 5k
R30 1k
R31 1k
R31 200
R32 200
C21 .1u
C22 .1u
U5
PCF8574
SCLK
DATA_IO
SCL SDA A0 A1 A2 VDD VSS
P0 P1 P2 P3 P4 P5 P6 P7 INT
C20 .1u
U11
TC7660
Cap+ Cap- Osc Vout
C18 10u
C19 10u
Amp_Sig

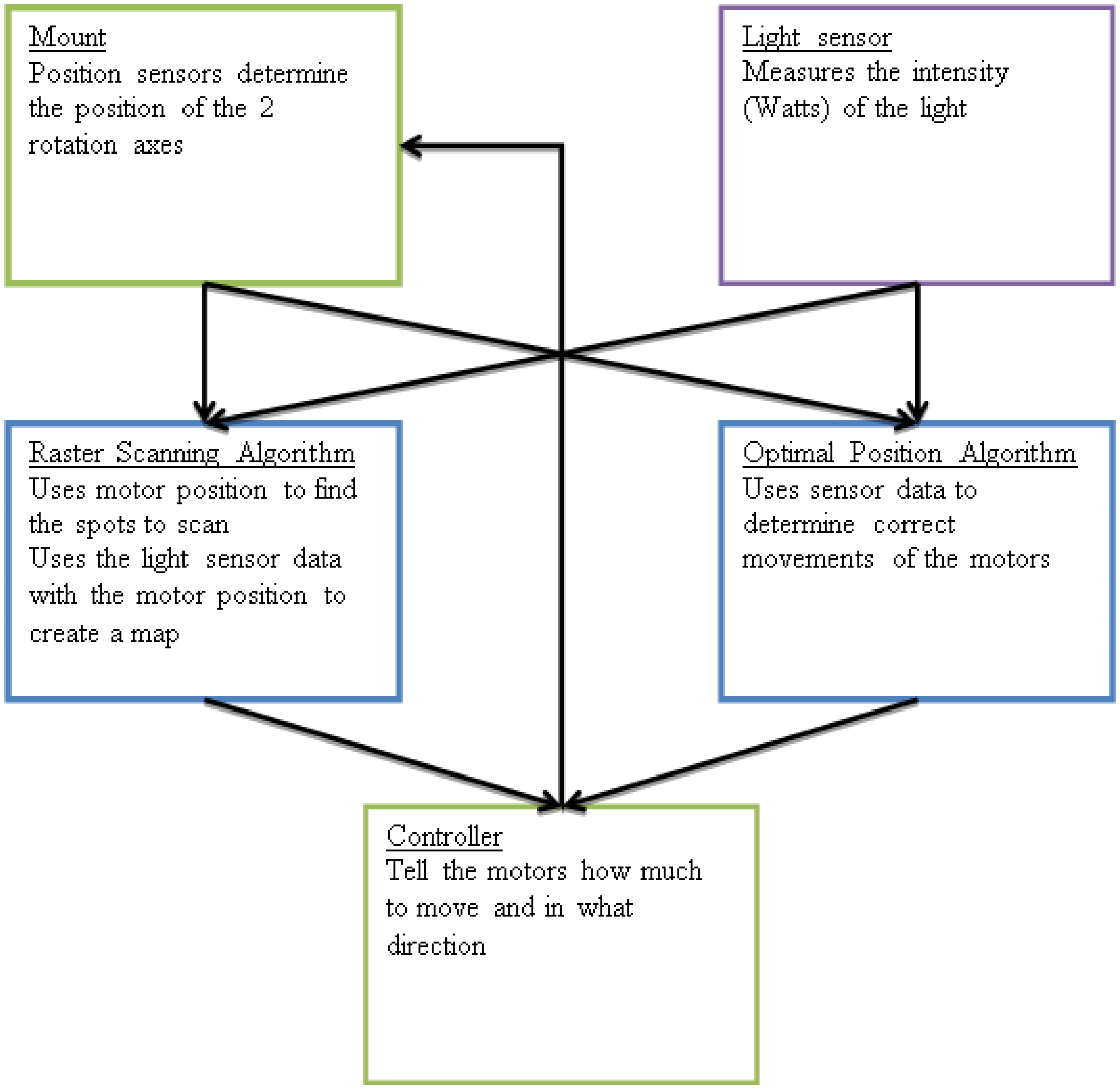
Piezo Motor

Newport AG-M100L	
Optical Diameter	1in (25.4mm)
Angular Range	±2°
Adjustment Sensitivity	1µrad
Absolute Positioning Accuracy	0.05°
Max. Speed	0.75°/s
Thermal Tilt	4µrad/°C



Back view of AG-M100L

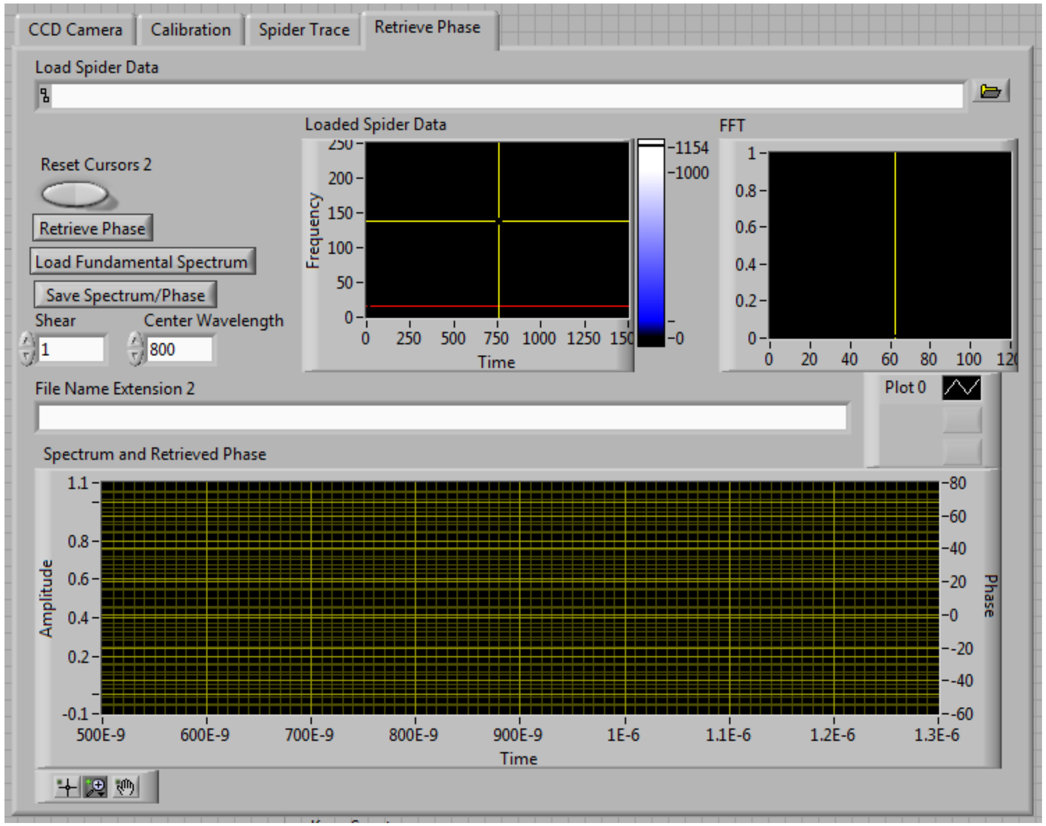
Software/Hardware Interaction

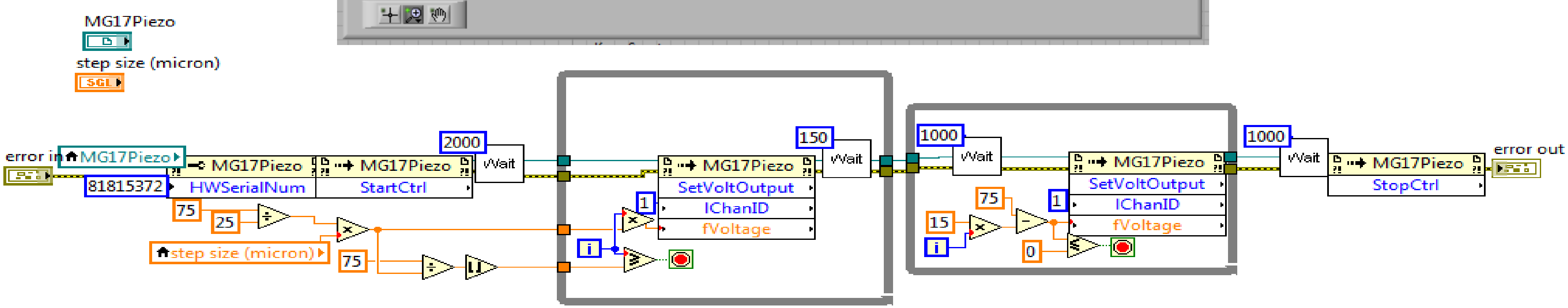


Software Benefits

- Automatically and manually rotate the crystal
- Increase position accuracy
- Decrease setup time
- Remove the inaccuracy of human movement

Software Environment

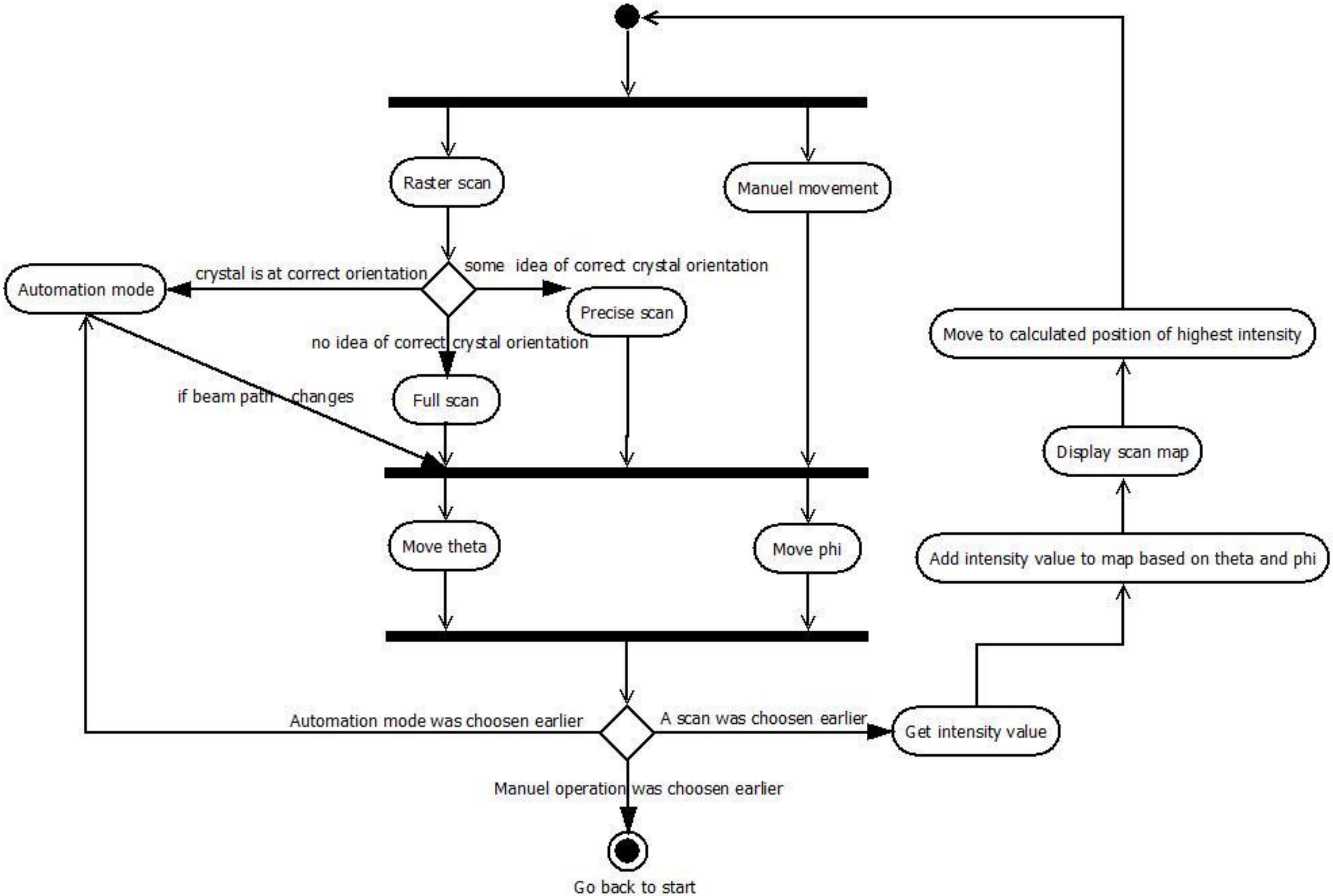




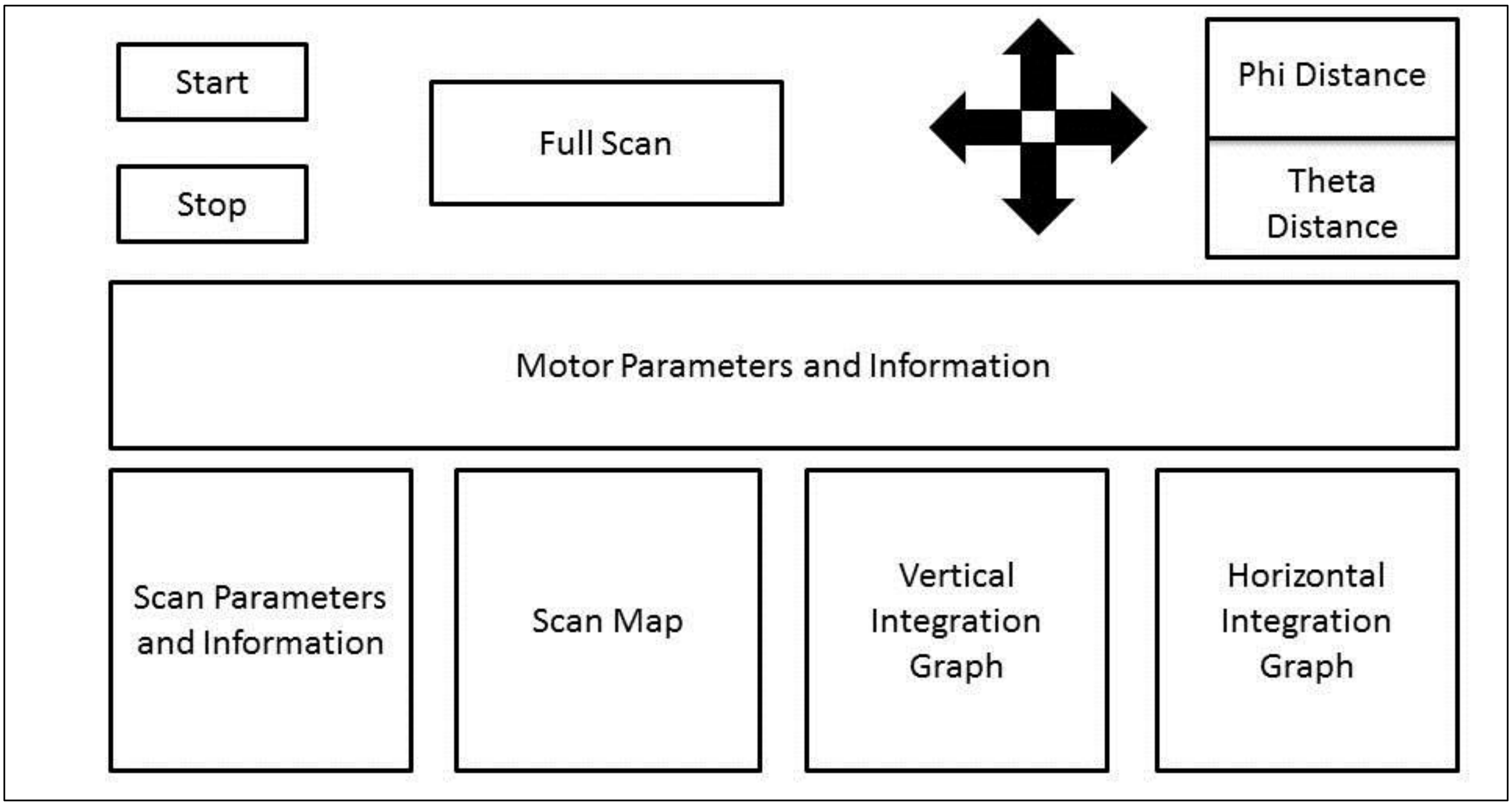
LabVIEW Benefits

- Graphical programing language
  - More difficult to make errors
  - Can quickly see how a program works
- Accepts MATLAB code and a “C like” script
- Parallel execution for multiple threads
- Execution highlighting (debug feature)
- Broken arrow start button lets you know there are errors

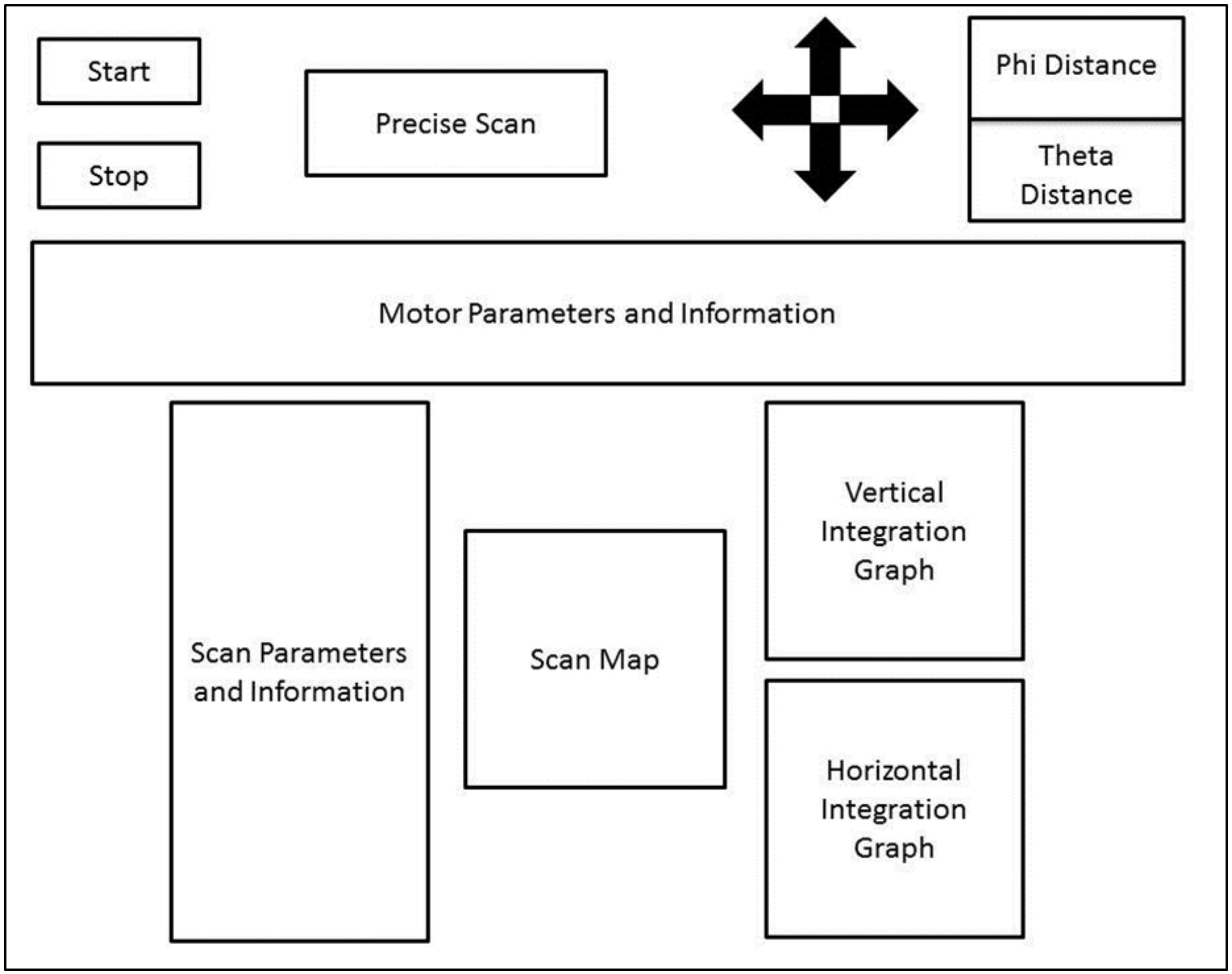
Activity Diagram



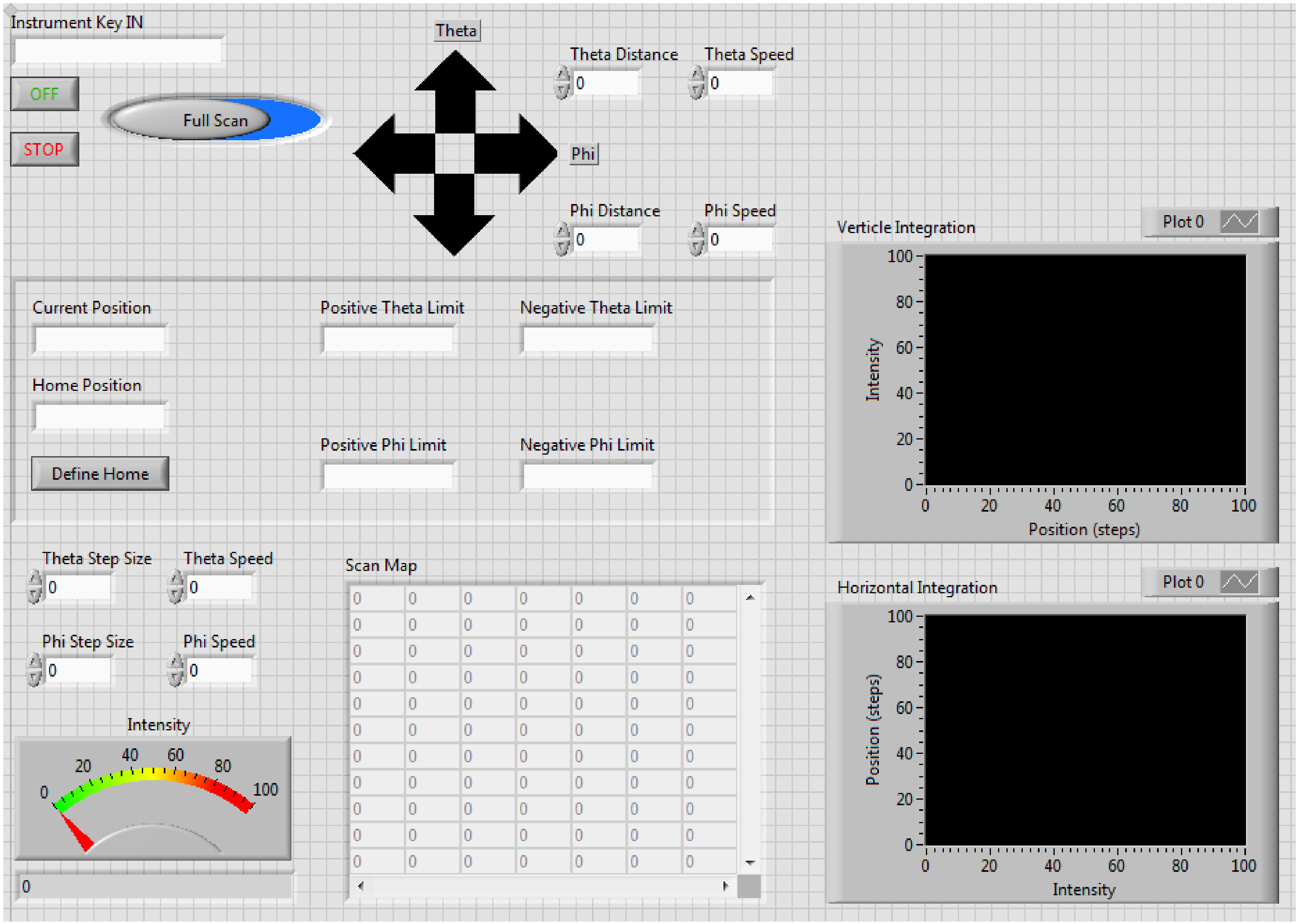
GUI


Start
Stop
Full Scan
Phi Distance
Theta Distance
Motor Parameters and Information
Scan Parameters and Information
Scan Map
Vertical Integration Graph
Horizontal Integration Graph

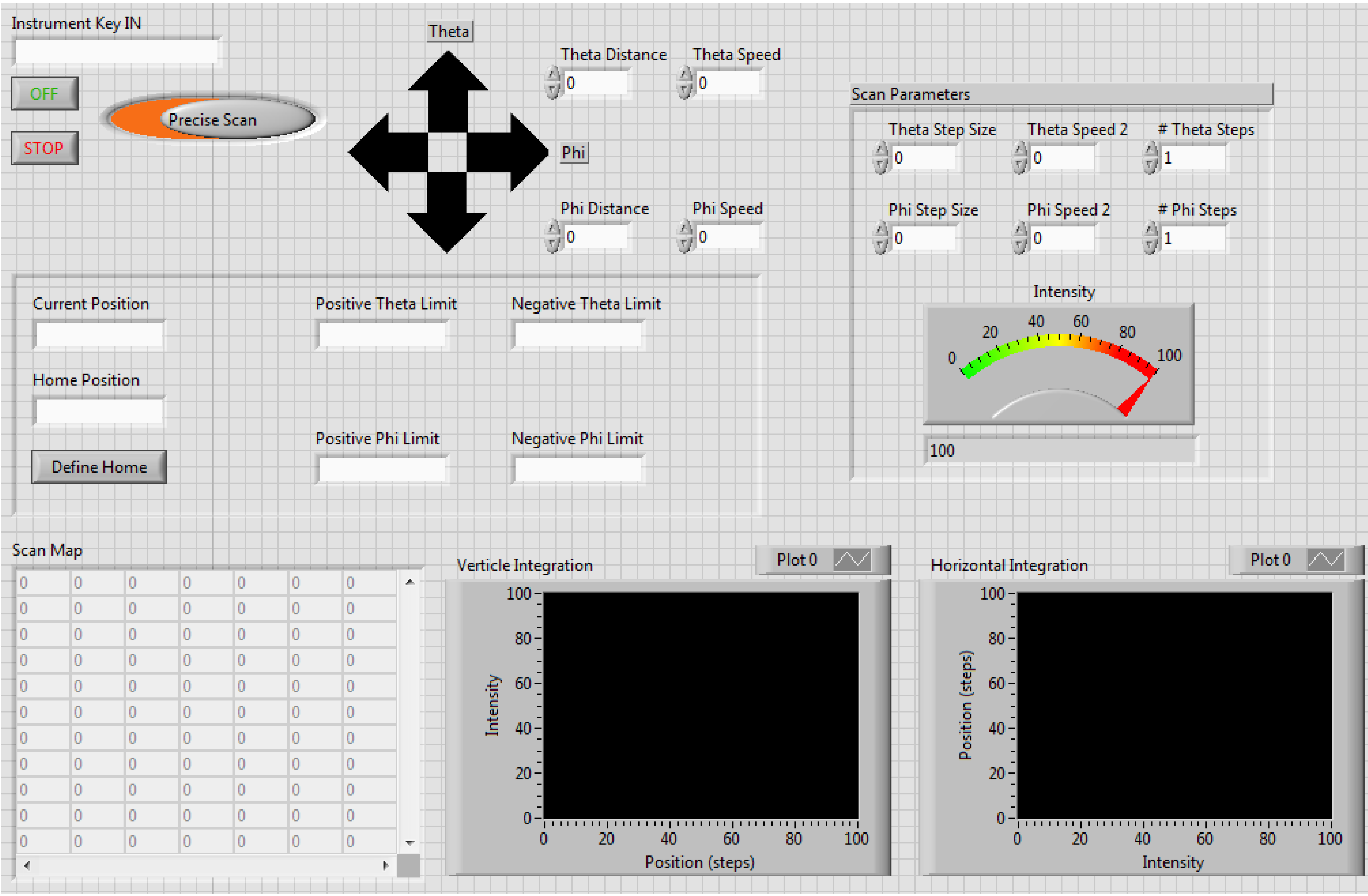
GUI


Start
Stop
Precise Scan
Phi Distance
Theta Distance
Motor Parameters and Information
Scan Parameters and Information
Scan Map
Vertical Integration Graph
Horizontal Integration Graph

Current GUI


Instrument Key IN
OFF
STOP
Full Scan
Theta
Phi
Theta Distance
Theta Speed
Phi Distance
Phi Speed
Current Position
Home Position
Define Home
Positive Theta Limit
Negative Theta Limit
Positive Phi Limit
Negative Phi Limit
Theta Step Size
Theta Speed
Phi Step Size
Phi Speed
Intensity
Scan Map
Verticle Integration
Plot 0
Intensity
Position (steps)
Horizontal Integration
Plot 0
Position (steps)
Intensity

Current GUI



Instrument Key IN
OFF
STOP
Precise Scan
Theta
Phi
Theta Distance
Theta Speed
Phi Distance
Phi Speed
0
Scan Parameters
Theta Step Size
Theta Speed 2
Theta Steps
Phi Step Size
Phi Speed 2
Phi Steps
1
Intensity
0
20
40
60
80
100
Current Position
Home Position
Define Home
Positive Theta Limit
Negative Theta Limit
Positive Phi Limit
Negative Phi Limit
Scan Map
Verticle Integration
Plot 0
Intensity
Position (steps)
Horizontal Integration
Position (steps)
Intensity

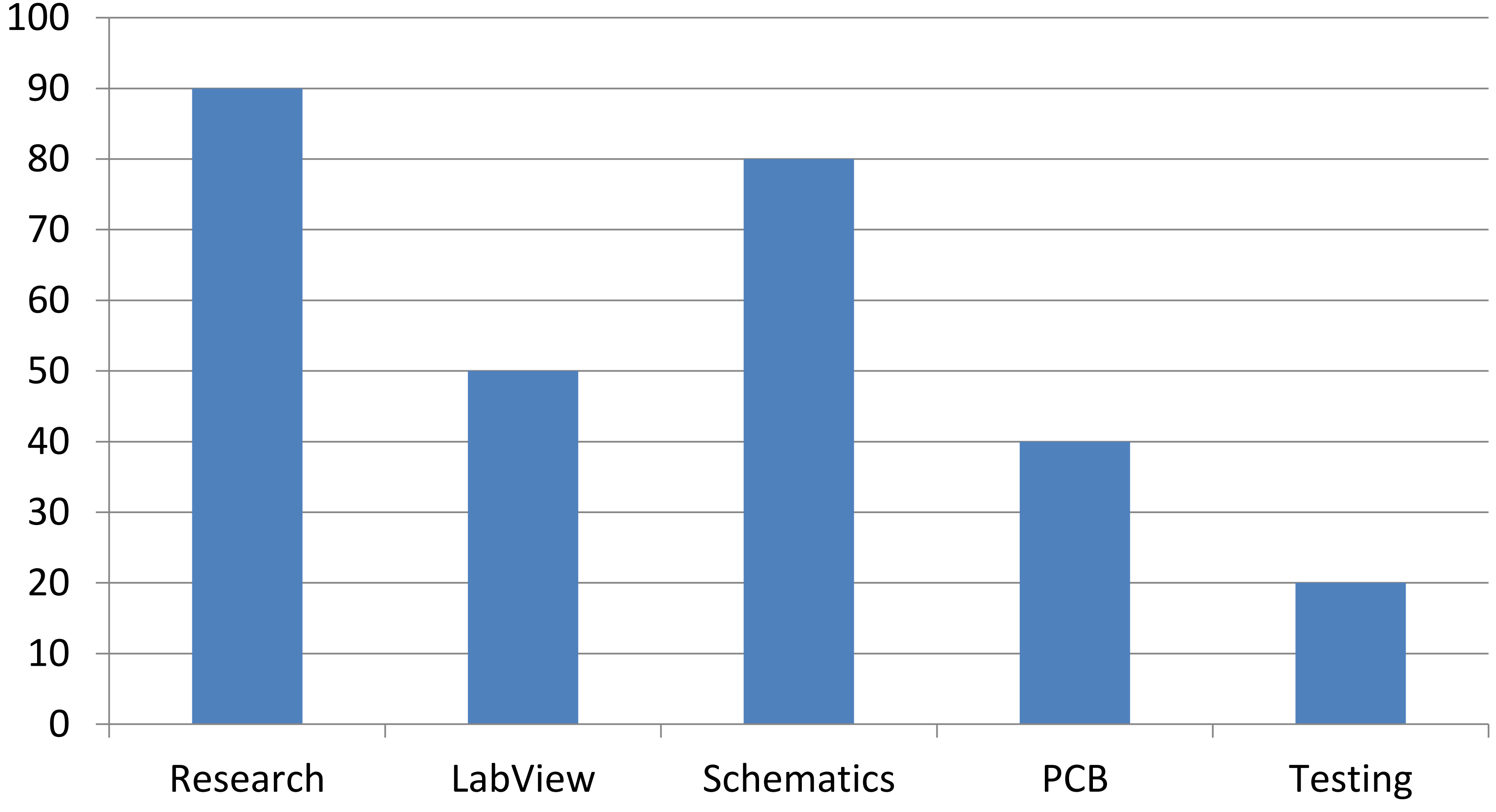
Component name	Subtotal	Our Cost
Resistors/Caps	29.93	0
24 bit ADC	2.47	0
3.3V regulator	0.54	0
Atmega328	3.93	0
ADR130	3.91	0
LEDs	1.11	0
Crystal 16Mhz	0.56	0
Ferrite bead	0.64	0
FT232R- USB to Serial IC	4.5	0
L78L33C	9.5	0
LCD Module	9.5	0
NAU7802	1.71	0
N-MOSFET	3.42	0
PCF8574	1.91	0
Precision 0.5v reference	3.07	0
Resistor 1k - 0.05% (Reference V divider)	4.36	0

Component name	Subtotal	Our Cost
Resistor 250 - 0.05% (Reference V divider)	5.33	0
Switch Button	0.1	0
SMA Female Edge Connector	4.86	0
TC7660	0.95	0
TLC2201CP Op Amp	16.5	0
USB A to B cable 3'	2.02	0
USB B Connector Female	0.54	0
X7R	0.11	0
Voltage inverter -5V	0.95	0
LCD Module	9.5	0
Mirror Mount	732	0
Motor Controller	419	0
PCB	66	0
Total	1338.92	0

Project Delegation

	Roberto	Chris	Hung
Full Scan Process	15%	80%	5%
Precise Scan Process	15%	80%	5%
Hardware/Software Integration	20%	60%	20%
Data Acquisition	70%	30%	0%
Microcontroller	90%	10%	0%
Display	100%	0%	0%
Amplifier	10%	0%	90%
PCB	40%	0%	60%

Progress


100
90
80
70
60
50
40
30
20
10
0
Research
LabView
Schematics
PCB
Testing

Current Problems

- Getting the maximum number of useful bits from conversion
- Reducing noise on the PCB traces
- Noise introduced during the amplification process
- Create a grayscale of the scan map with optimal position highlighted

Questions?