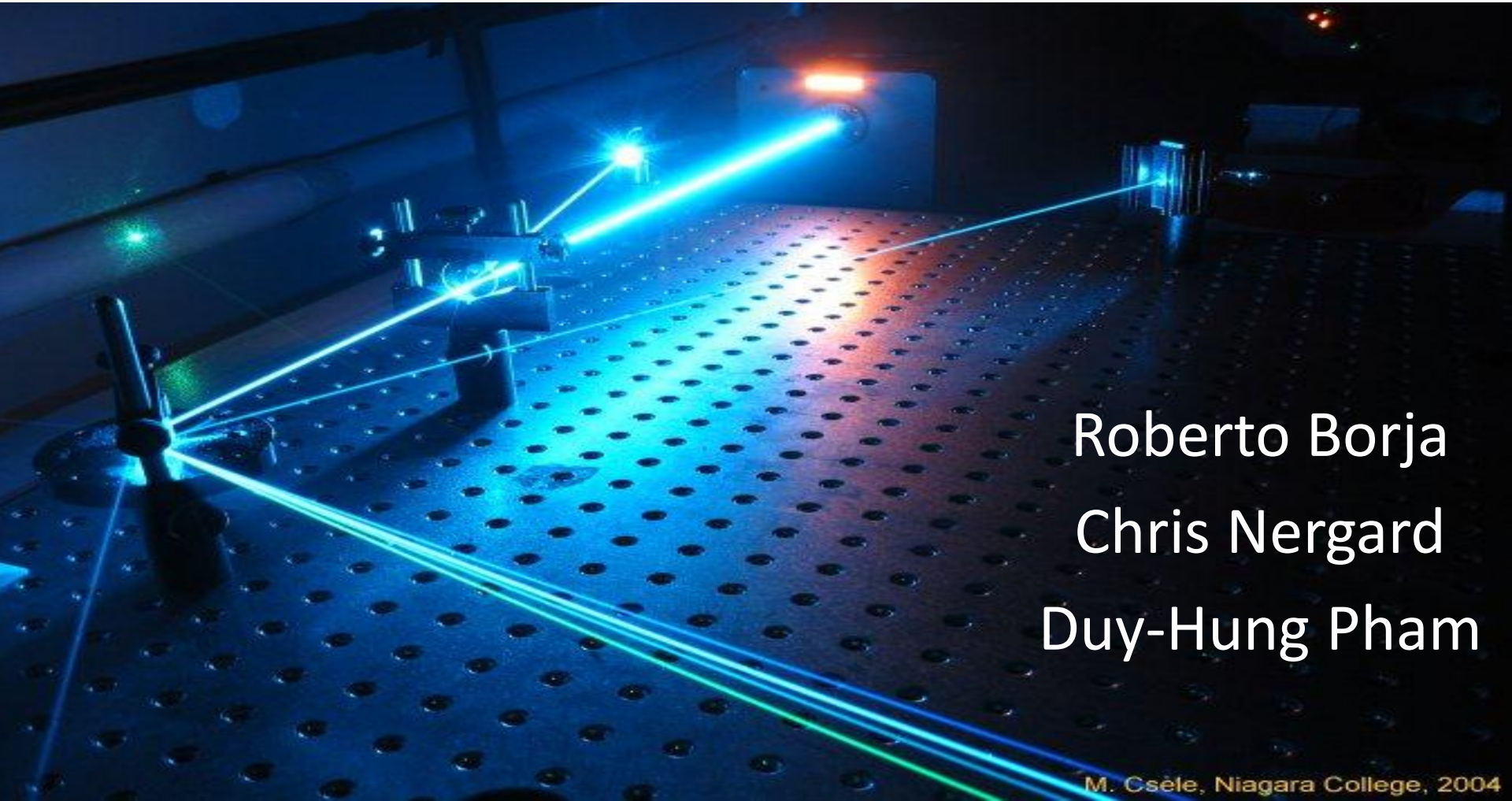
Automated Optical Setup

Group #16



Roberto Borja

Chris Nergard

Duy-Hung Pham

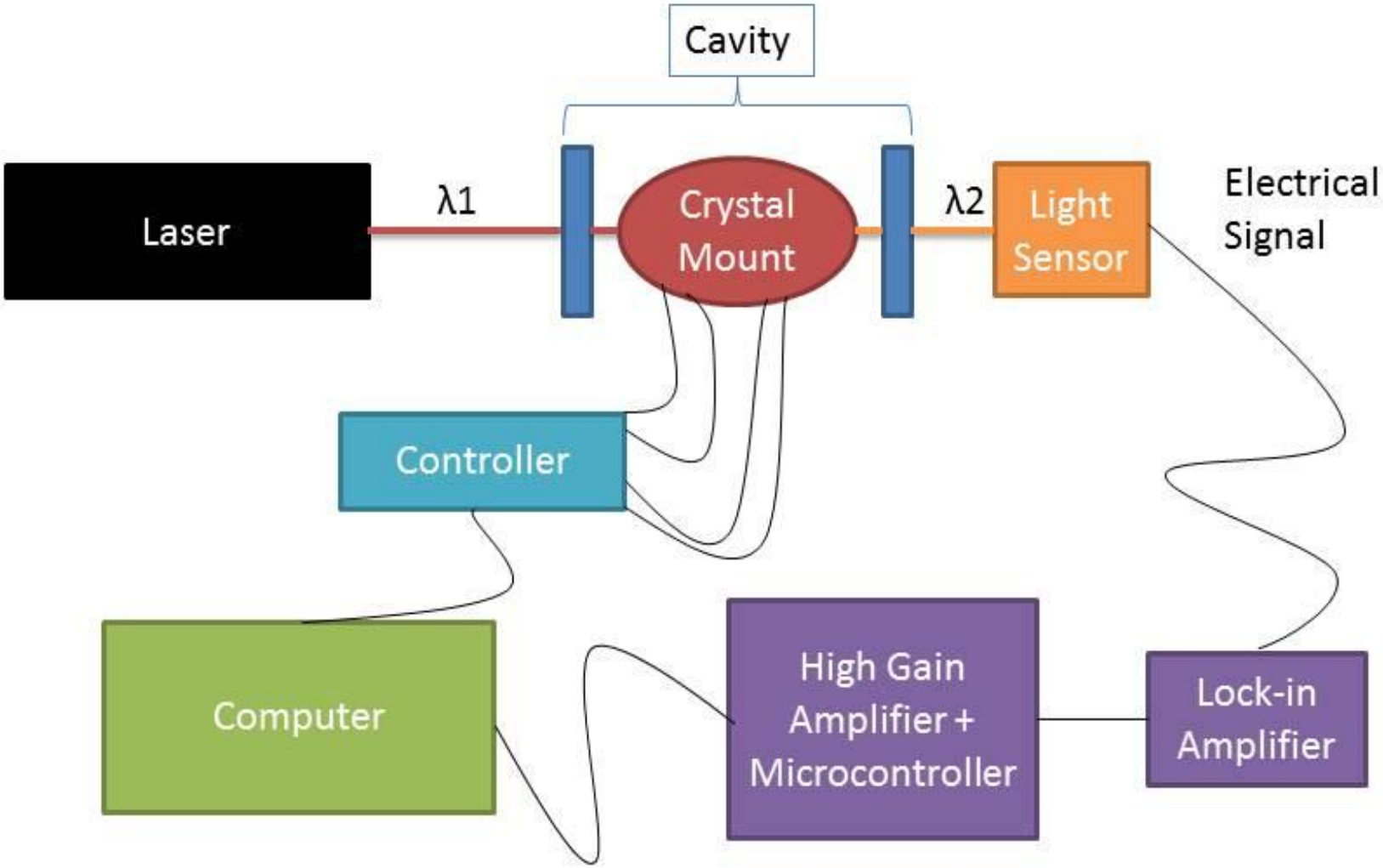
Problem

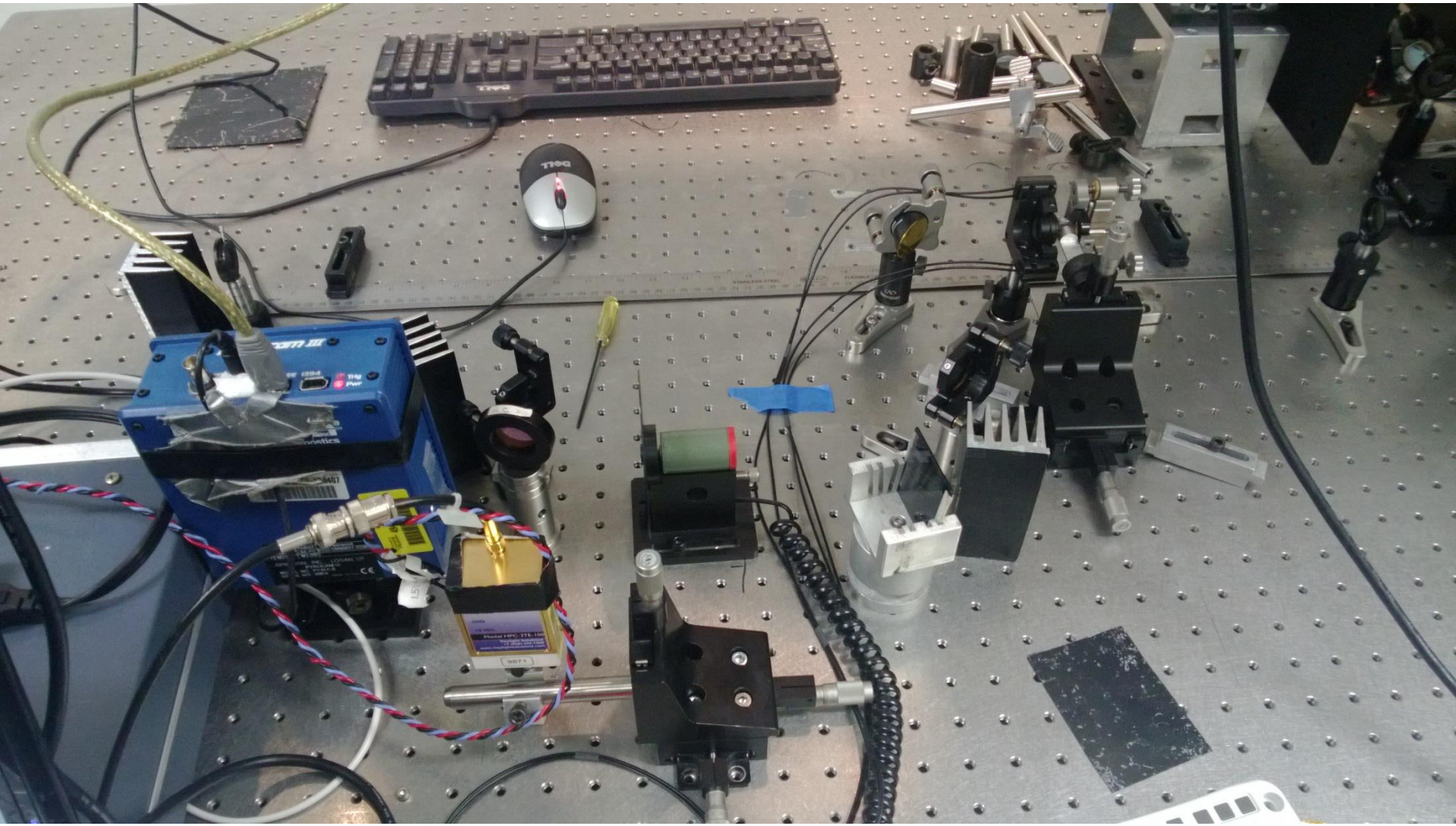
- Optical Parametric Oscillators requires a very precise orientation of a crystal
- Doing this by hand is very tedious
- The crystal degrades the power of the laser beam significantly
- Optical experiments require very sensitive setups

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





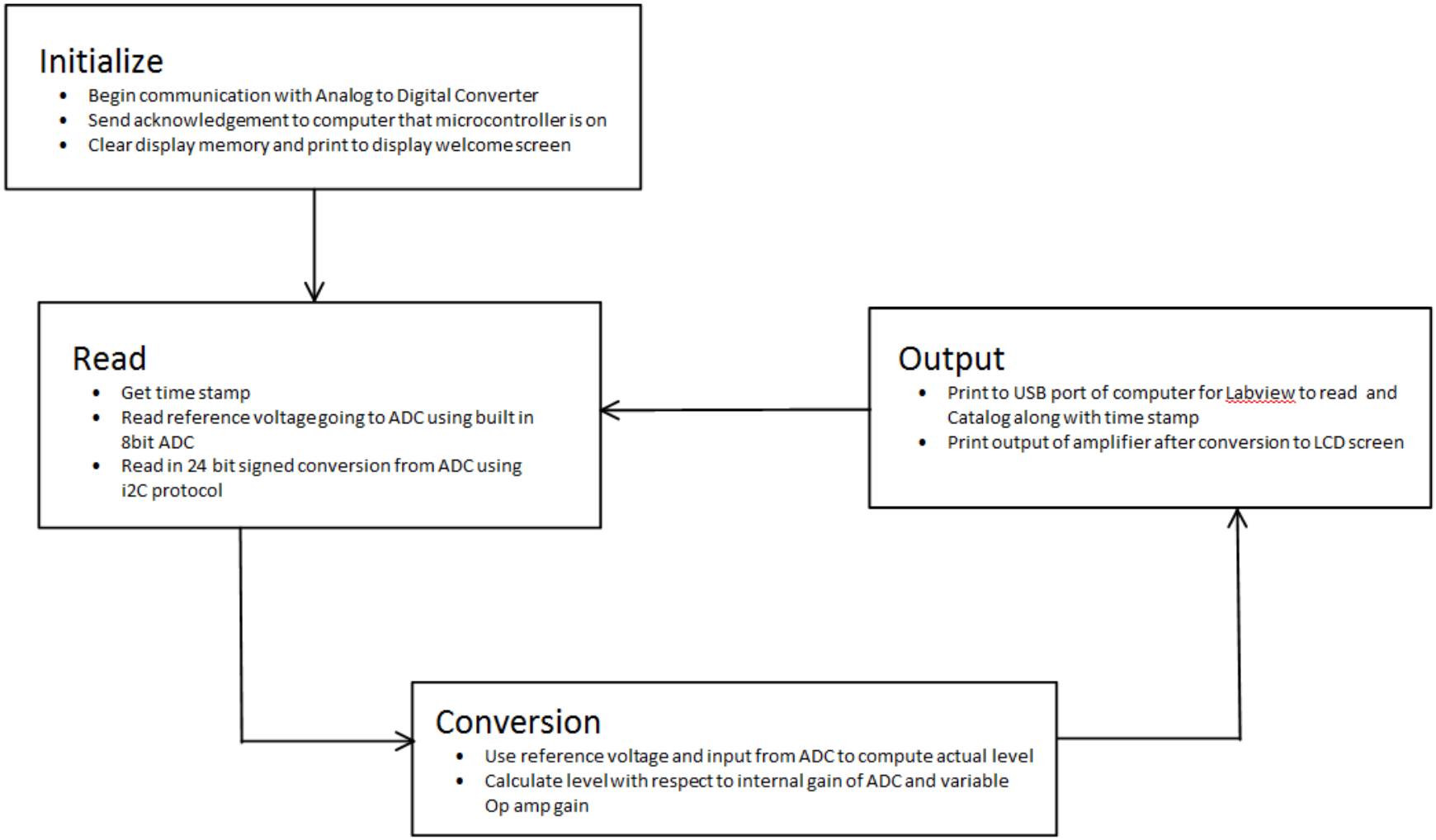
Goals

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

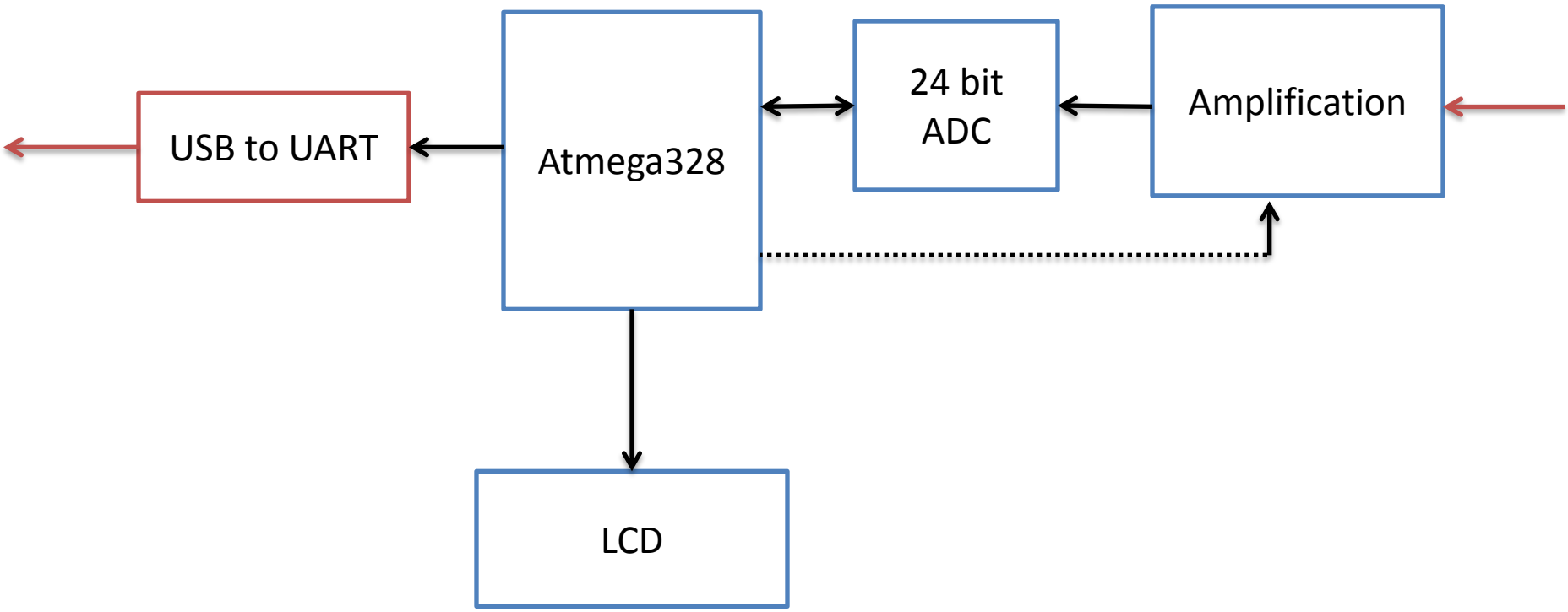
Specification

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

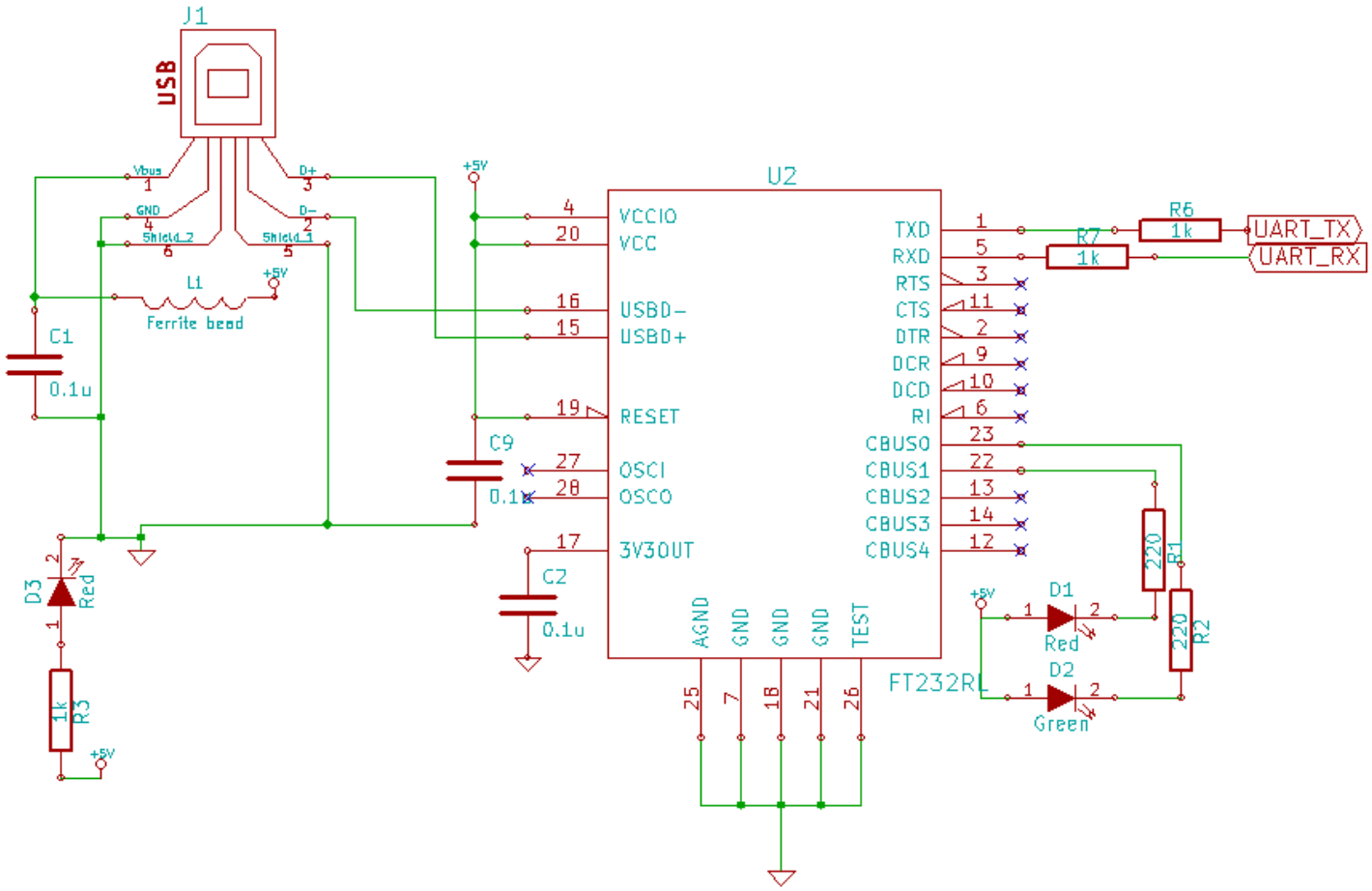
Atmega Code Block diagram



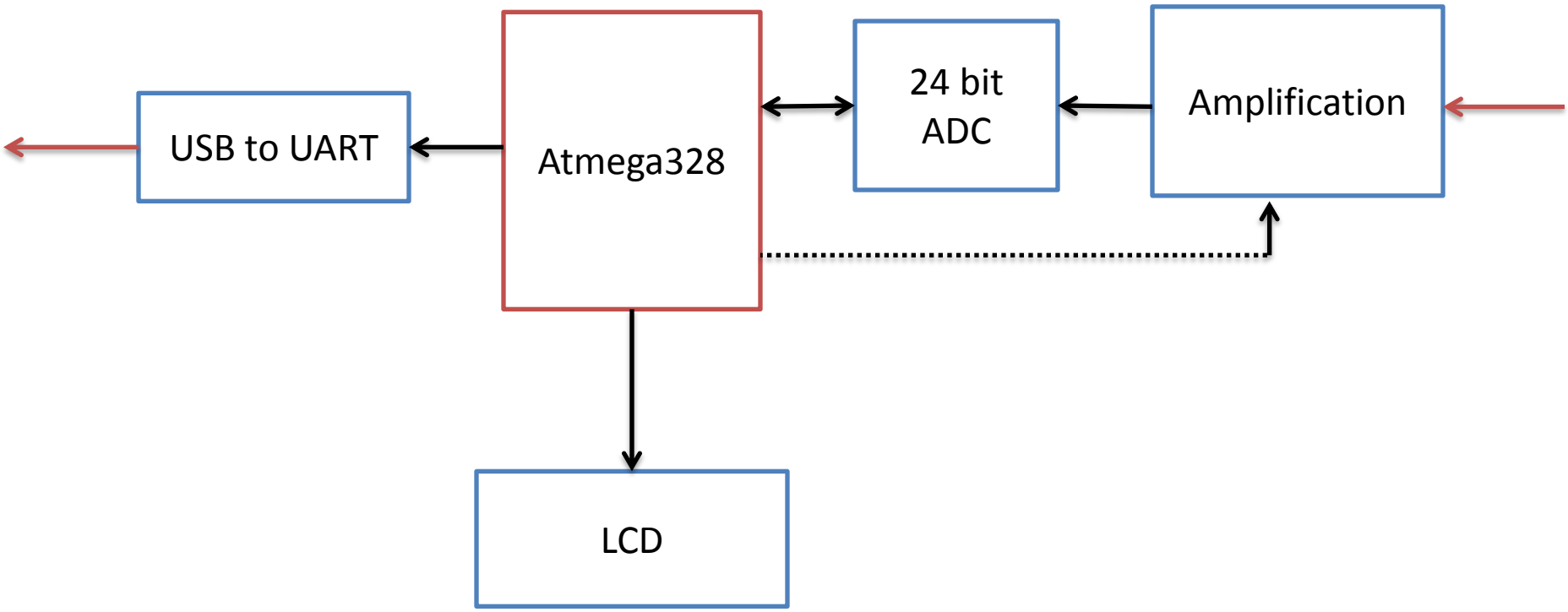
Hardware diagram



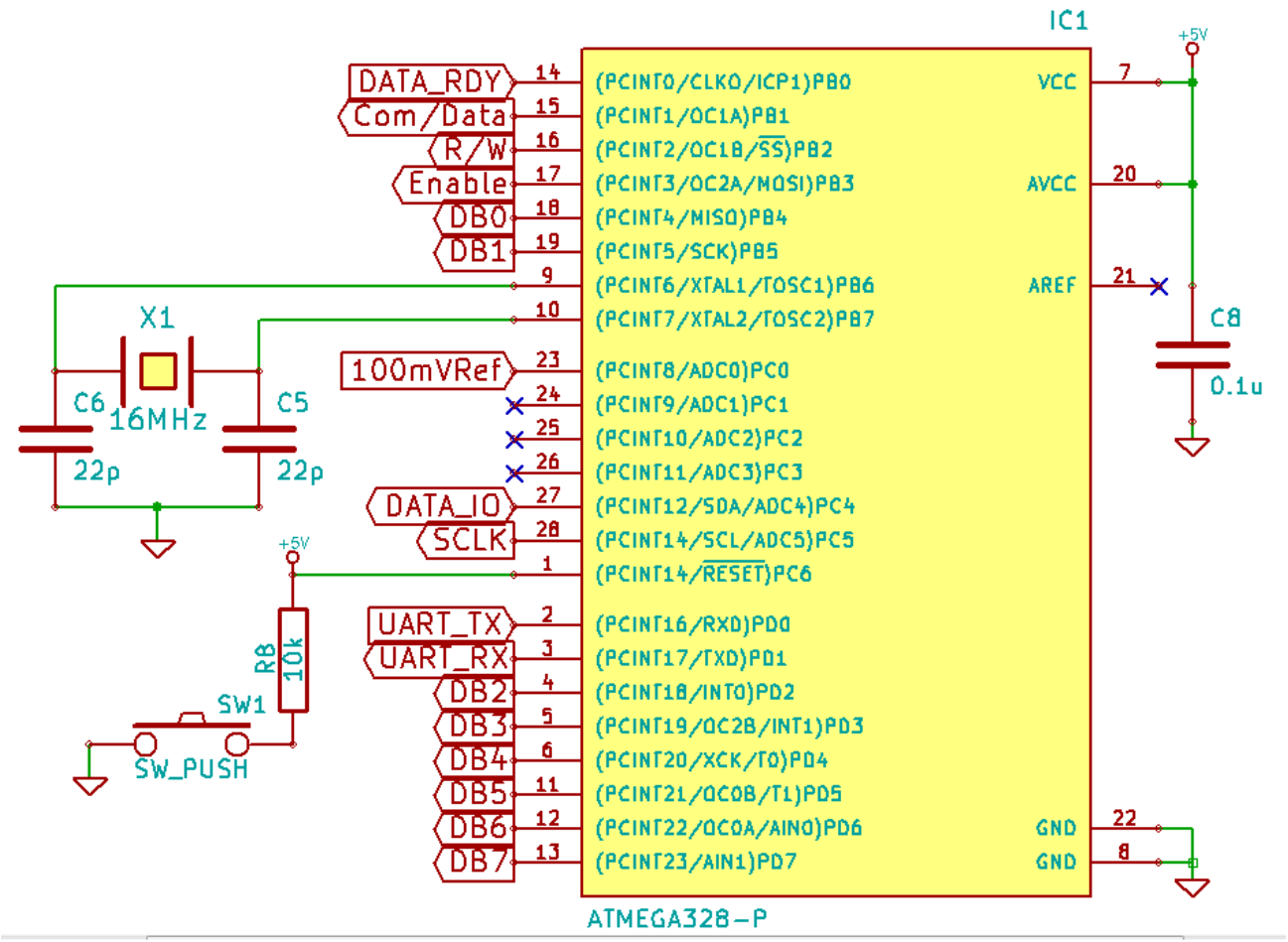
USB to UART


J1
USB
Vbus
1
D+
3
GND
4
D-
2
Shield_2
6
Shield_1
5
L1
Ferrite bead
+5V
C1
0.1u
U2
VCCIO
4
VCC
20
USBD-
16
USBD+
15
RESET
19
OSCI
27
OSCO
28
3V3OUT
17
C9
0.1u
C2
0.1u
AGND
25
GND
7
GND
18
GND
21
TEST
26
FT232RL
TXD
1
RXD
5
RTS
3
CTS
11
DTR
2
DCR
9
DCD
10
RI
6
CBUS0
23
CBUS1
22
CBUS2
13
CBUS3
14
CBUS4
12
R6
1k
R7
1k
UART_TX
UART_RX
D1
Red
D2
Green
R1
220
R2
220
D3
Red
R3
1k

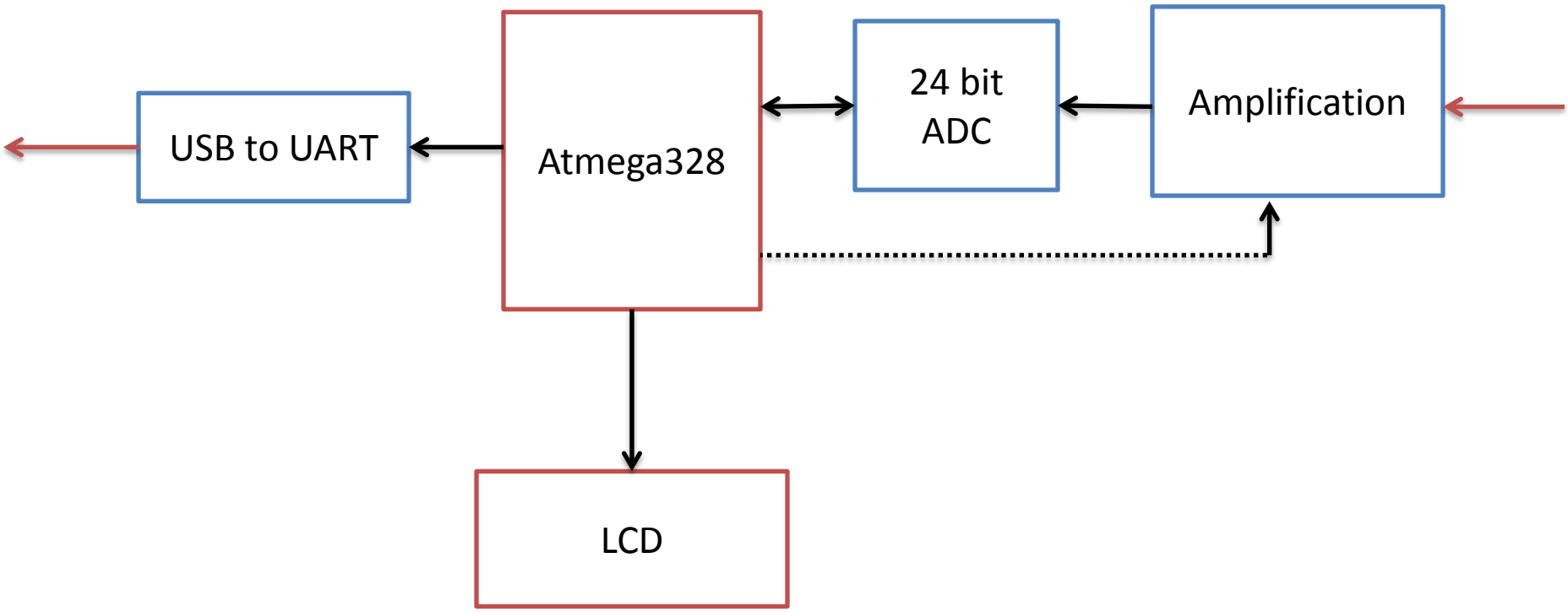
Hardware diagram



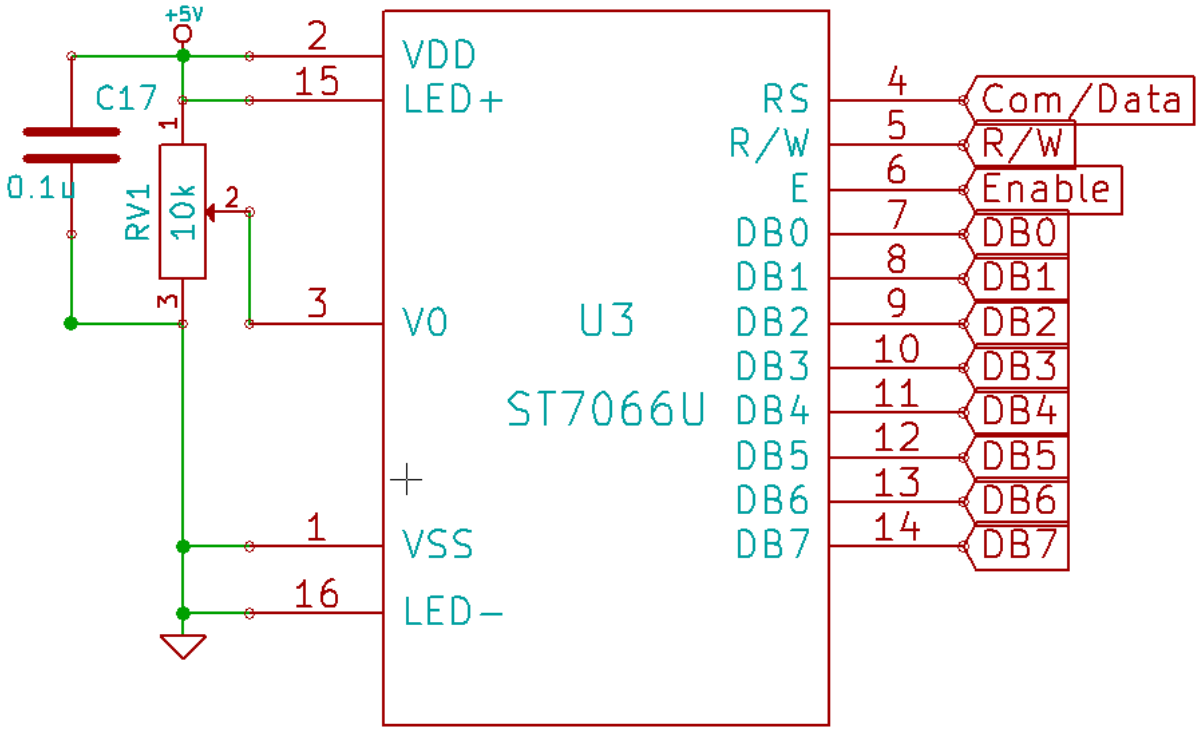
Atmega328


IC1
DATA_RDY
Com/Data
R/W
Enable
DB0
DB1
100mVRef
DATA_IO
SCLK
UART_TX
UART_RX
DB2
DB3
DB4
DB5
DB6
DB7
(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
(PCINT8/ADC0)PC0
(PCINT9/ADC1)PC1
(PCINT10/ADC2)PC2
(PCINT11/ADC3)PC3
(PCINT12/SDA/ADC4)PC4
(PCINT14/SCL/ADC5)PC5
(PCINT14/RESET)PC6
(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
VCC
AVCC
AREF
GND
GND
ATMEGA328-P
+5V
C8
0.1u
X1
16MHz
C6
22p
C5
22p
R8
10k
SW1
SW_PUSH

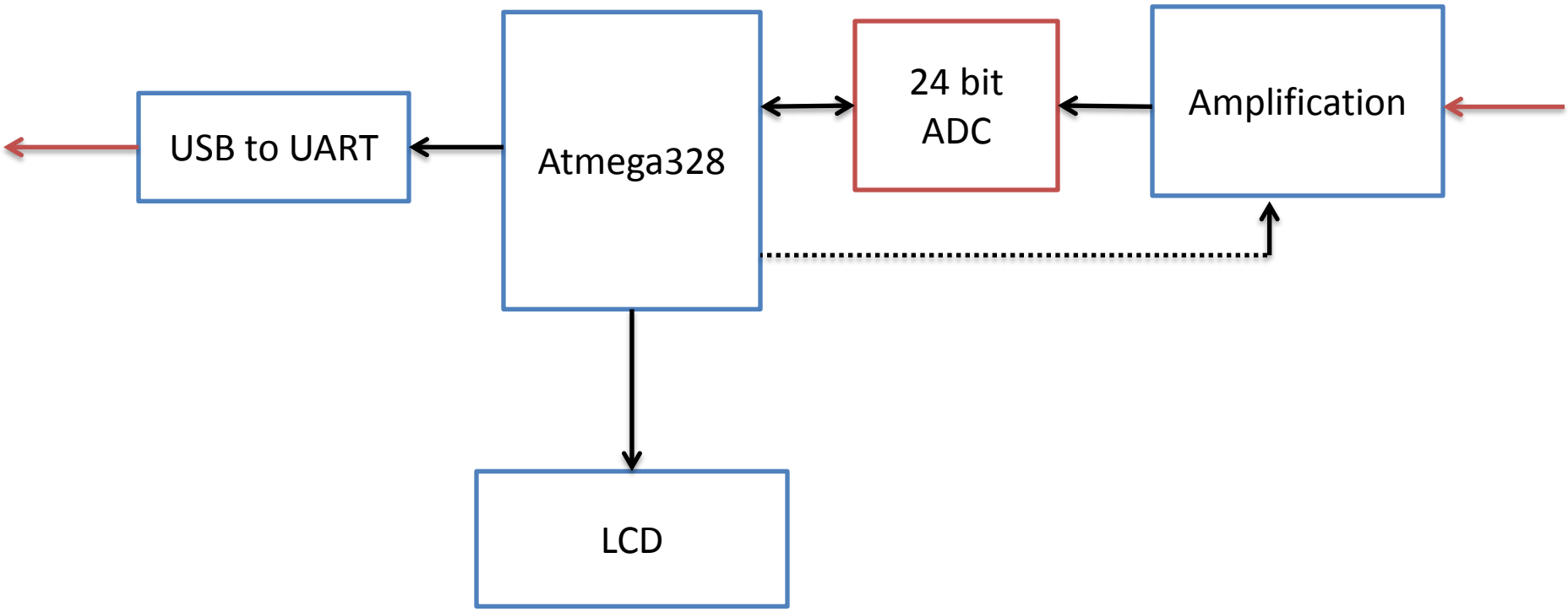
Hardware diagram



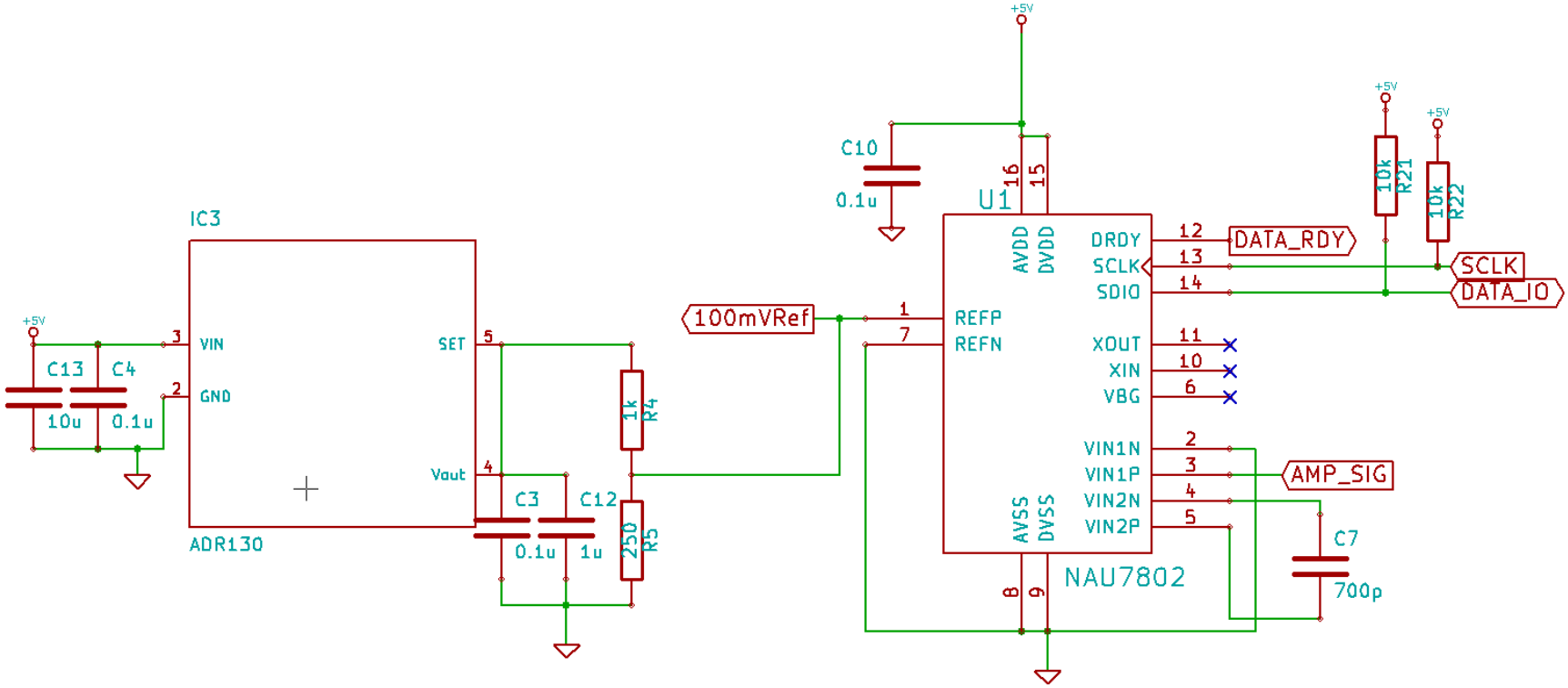
Atmega + Display



Hardware diagram

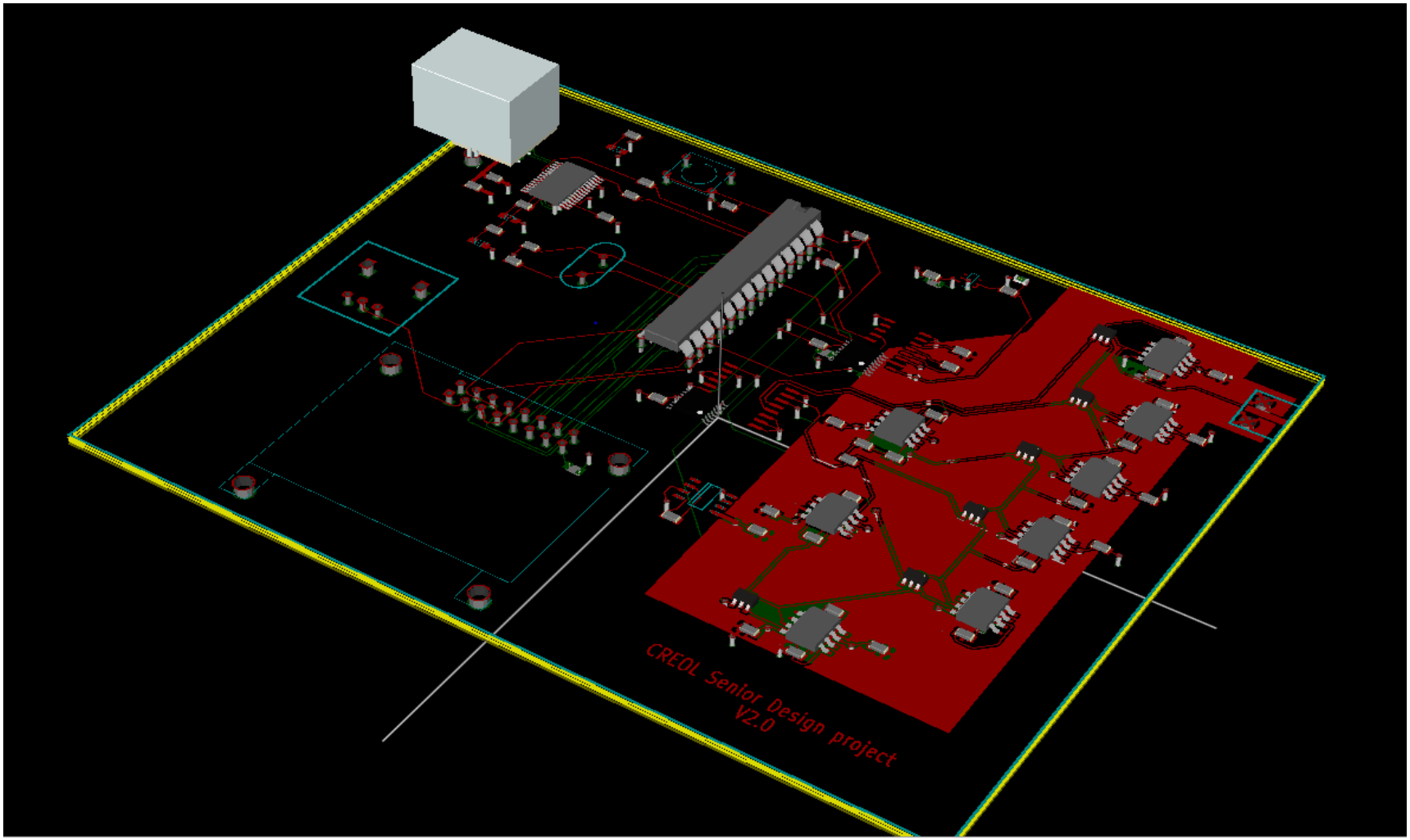


24-bit ADC


+5V
C10
0.1u
U1
16
15
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
1
7
REFP
REFN
XOUT
XIN
VBG
11
10
6
VIN1N
VIN1P
VIN2N
VIN2P
2
3
4
5
AMP_SIG
AVSS
DVSS
8
9
NAU7802
C7
700p


nuvoTon
NAU7802

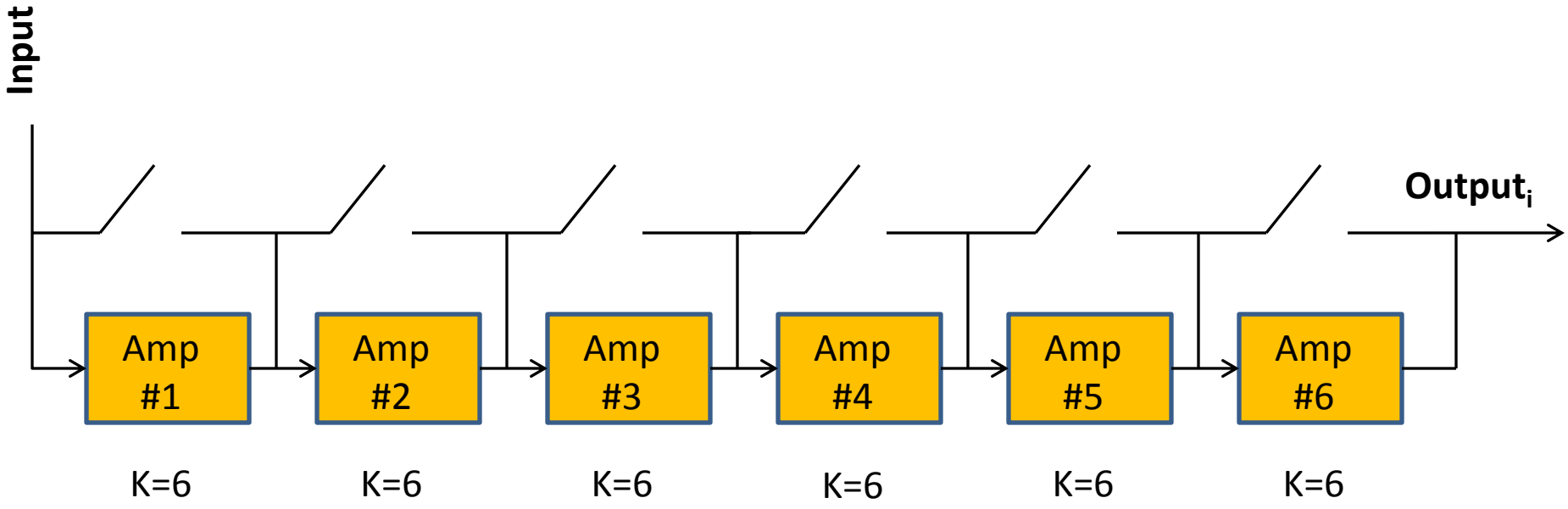
Final PCB layout

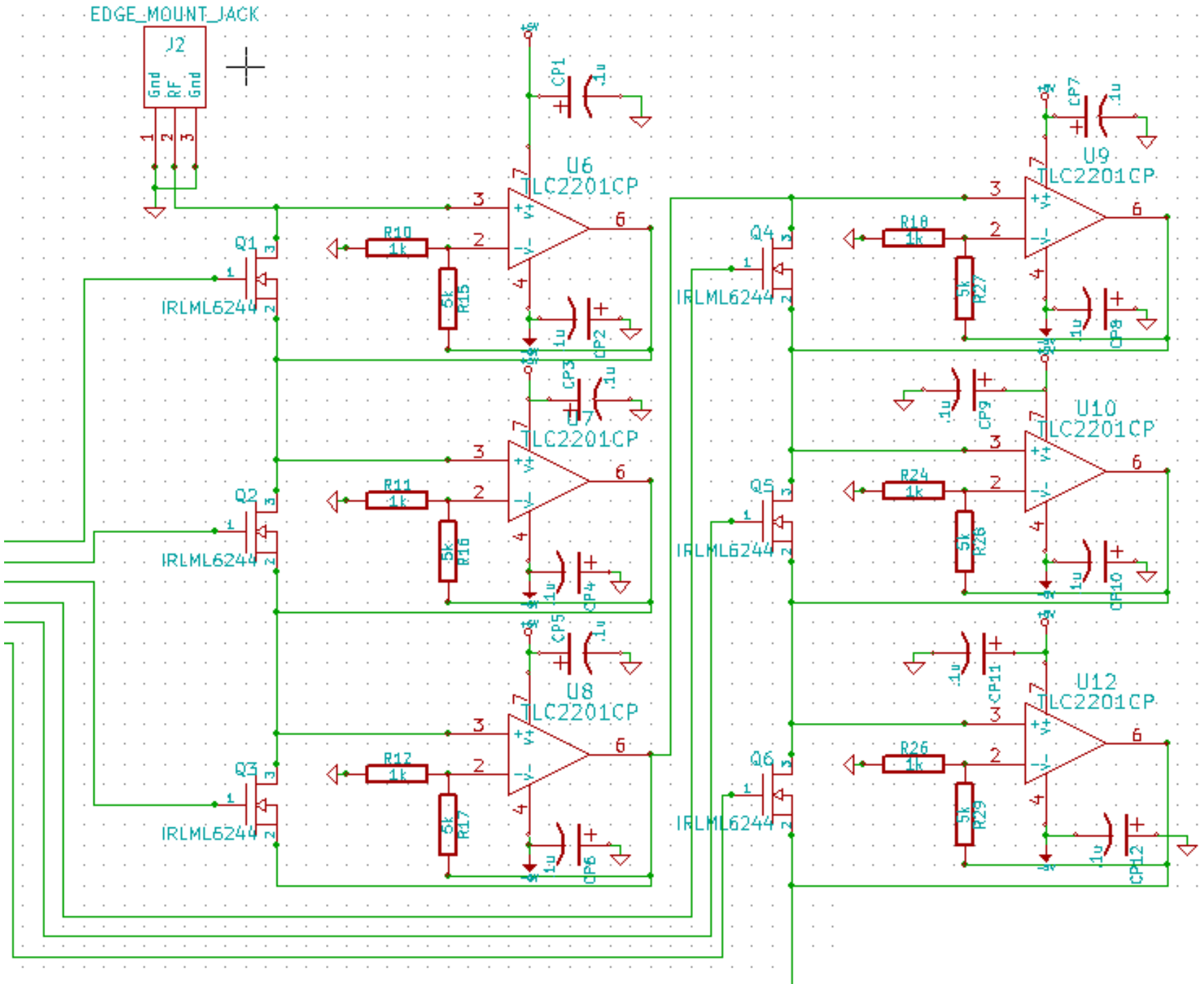


Amplifier Goals

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

Amplifier Block Diagram



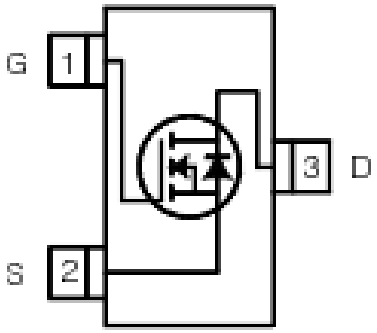

EDGE_MOUNT_JACK
J2
Gnd
RF
Gnd
1
2
3
U6
TLC2201CP
U8
TLC2201CP
U9
TLC2201CP
U10
TLC2201CP
U12
TLC2201CP
Q1
Q2
Q3
Q4
Q5
Q6
IRLML6244
R10
R11
R12
R15
R16
R17
R18
R24
R26
R27
R28
R29
1k
5k
CP1
CP2
CP3
CP4
CP5
CP6
CP7
CP8
CP9
CP10
CP11
CP12
.1u
1u

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

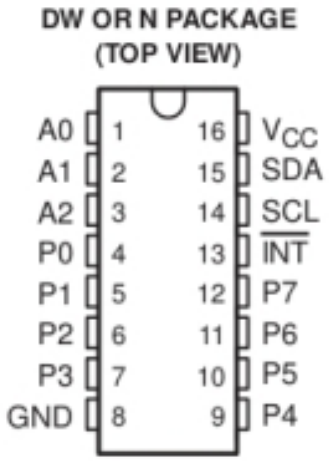
IRLML6244

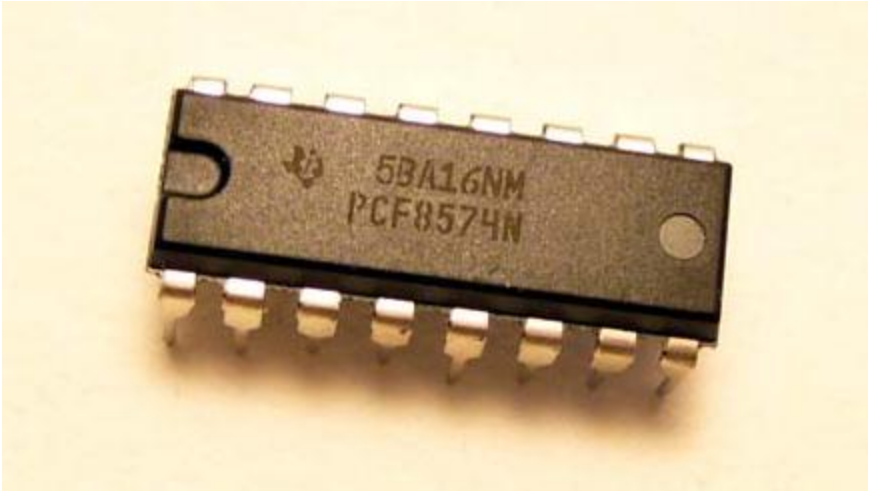
- N channel MOSFET
- Drain to Source Voltage (Vdss): 20V
- Vgs(th) (Max) @ Id : 1.1V @ 10µA
- Rds On (Max) @ Id, Vgs : 21 mOhm @ 6.3A, 4.5V
- Surface mount

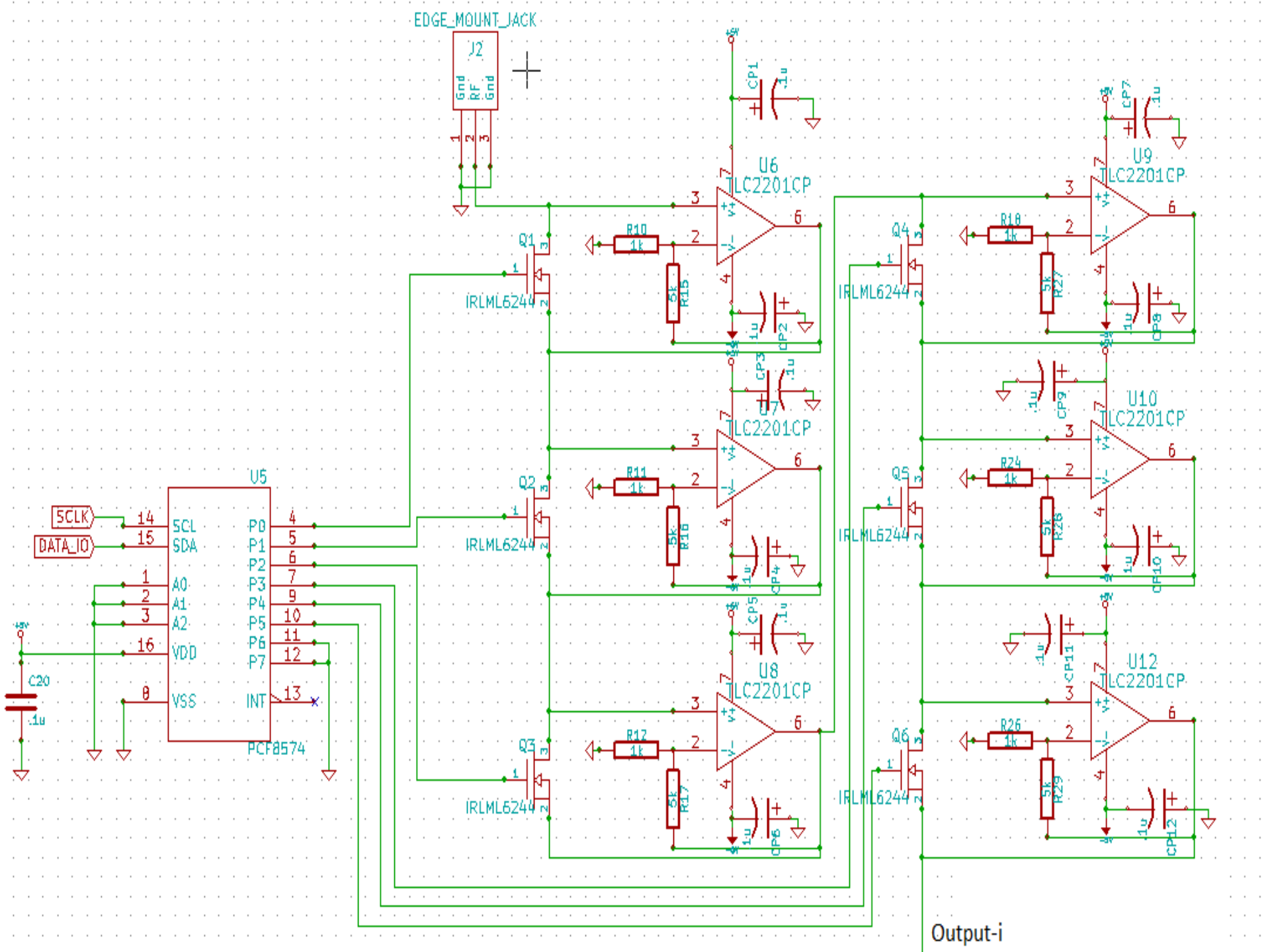


PCF8574

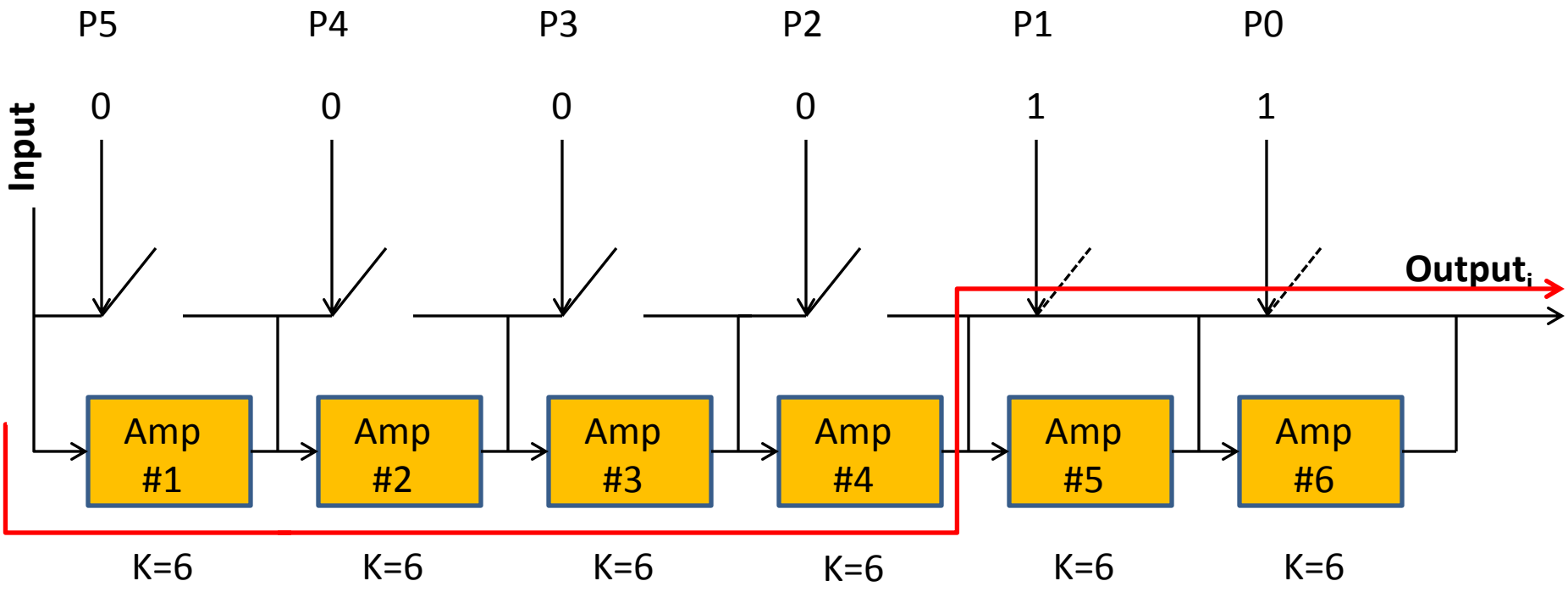
- 8 bits I/O port expander that uses the I2C protocol
- 2 ports of microcontroller to control up to 8 digital I/O ports. (SDA & SCL)






EDGE_MOUNT_JACK
J2
Gnd
RF
Gnd
U5
PCF8574
SCLK
DATA_IO
SCL
SDA
A0
A1
A2
VDD
VSS
P0
P1
P2
P3
P4
P5
P6
P7
INT
C20
.1u
U6
U7
U8
U9
U10
U12
TLC2201CP
Q1
Q2
Q3
Q4
Q5
Q6
IRLML6244
R10
R11
R12
R15
R16
R17
R18
R24
R26
R27
R28
R29
1k
5k
CP1
CP2
CP3
CP4
CP5
CP6
CP7
CP8
CP9
CP10
CP11
CP12
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

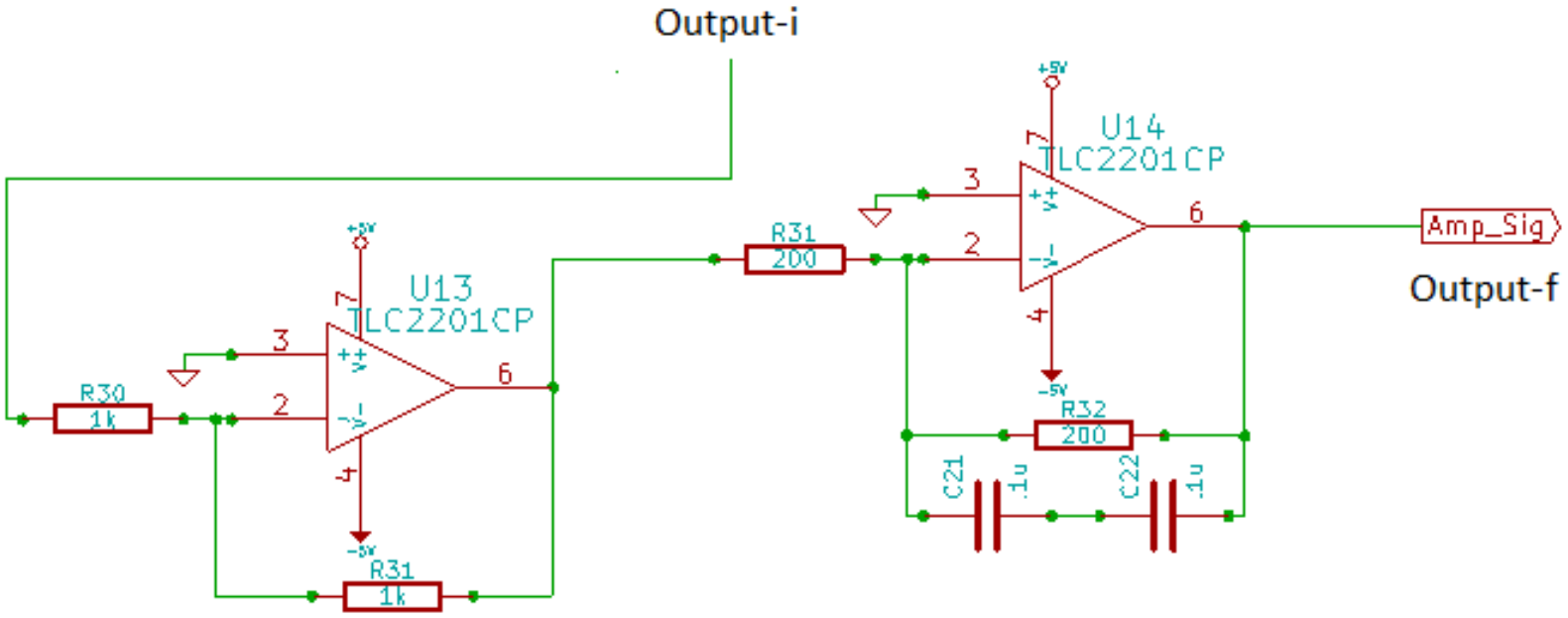
Amplifier Block Diagram

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

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

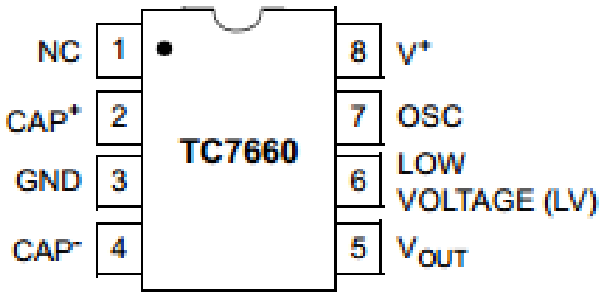
$$f_c \approx 15.915 \text{ kHz}$$

Low Pass Filter Sch.

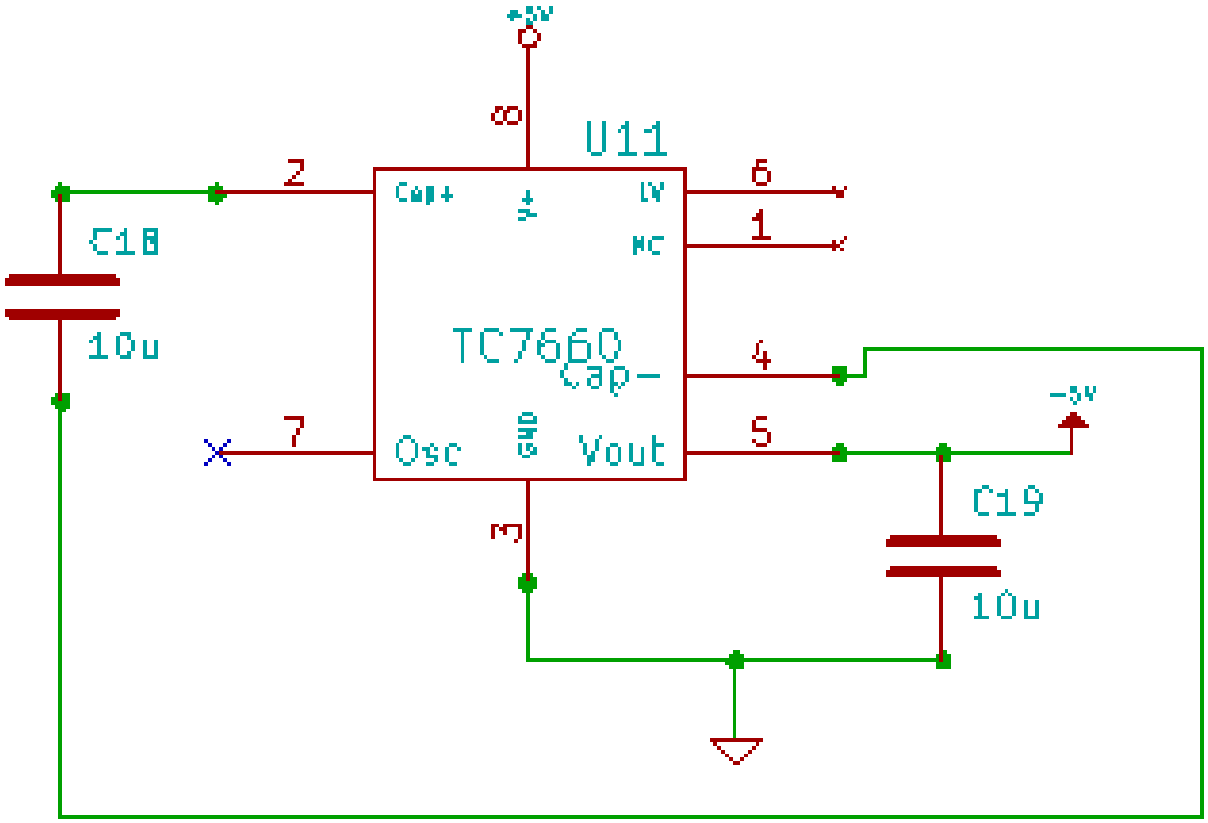


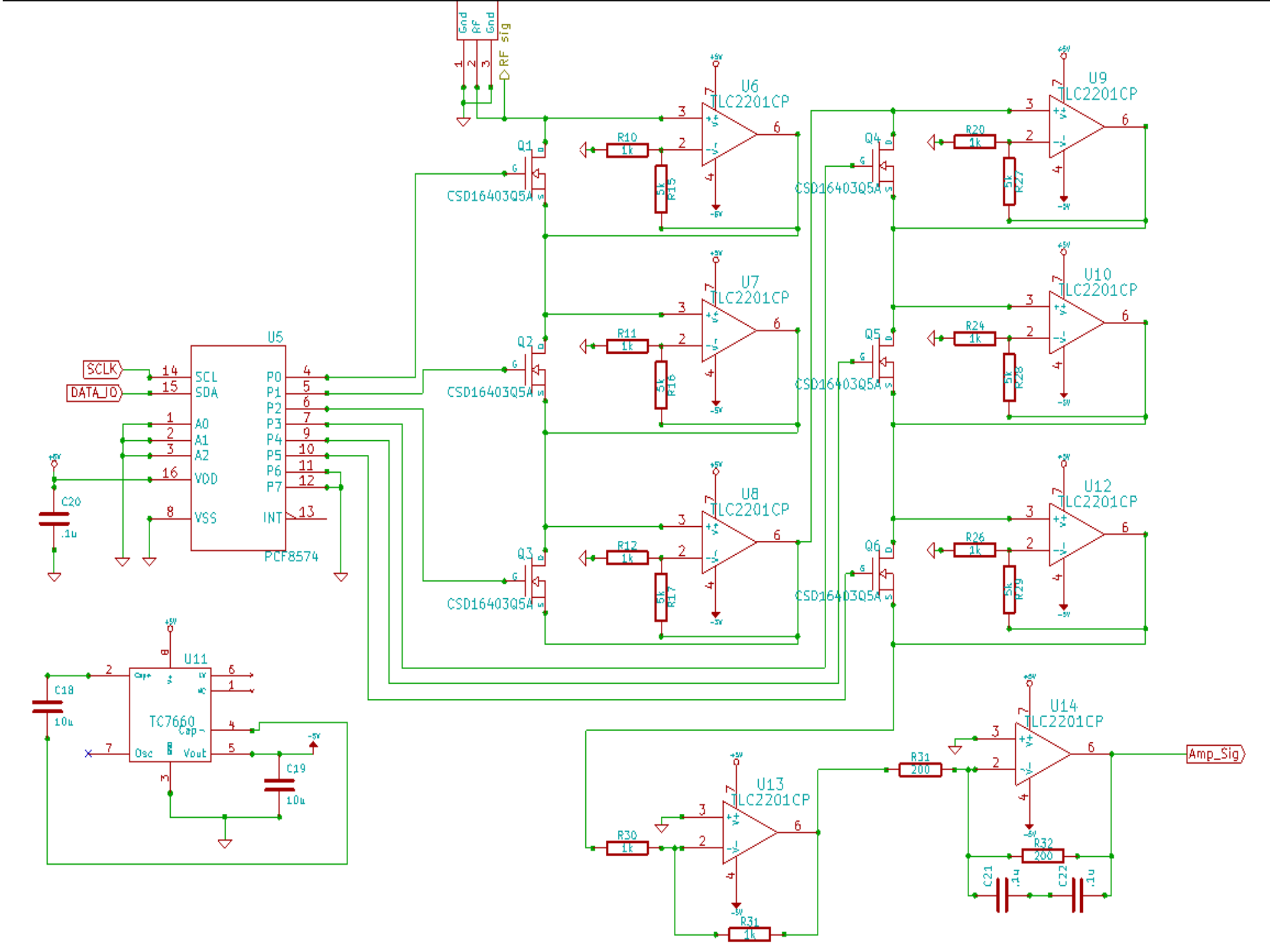
TC7660

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



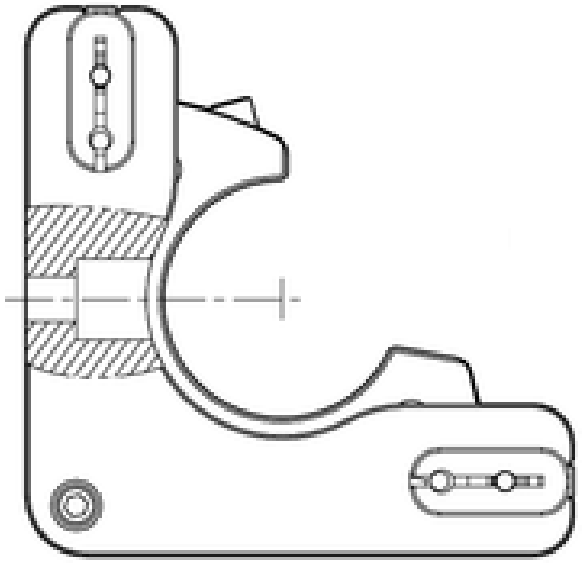
TC7660 Con. Schematic




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
U5
PCF8574
SCL
SDA
A0
A1
A2
VDD
VSS
P0
P1
P2
P3
P4
P5
P6
P7
INT
SCLK
DATA_IO
C20
.1u
U11
TC7660
C18
10u
C19
10u
C21
.1u
C22
.1u
Amp_Sig
+5V
-5V

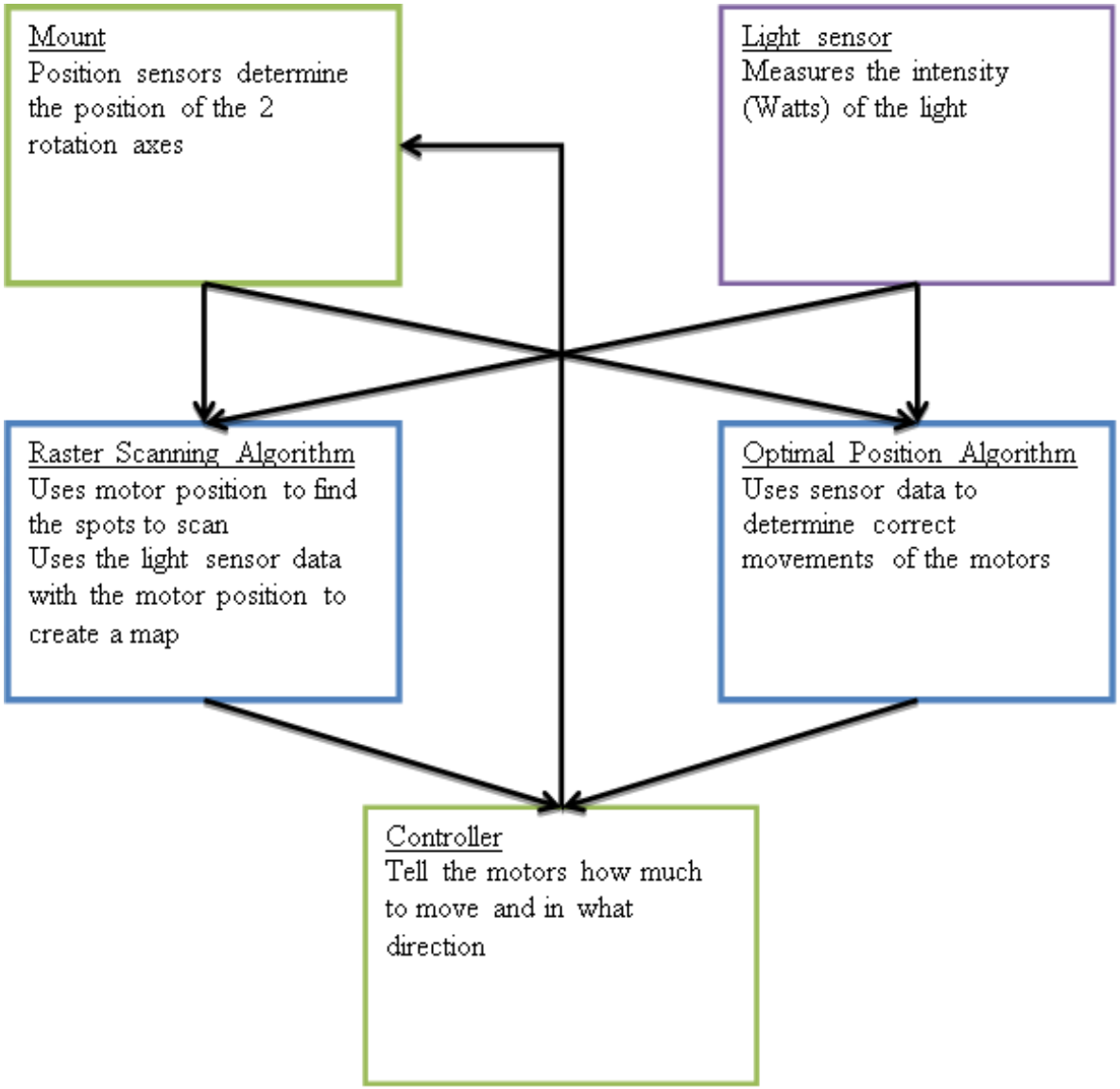
Piezo Motor

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

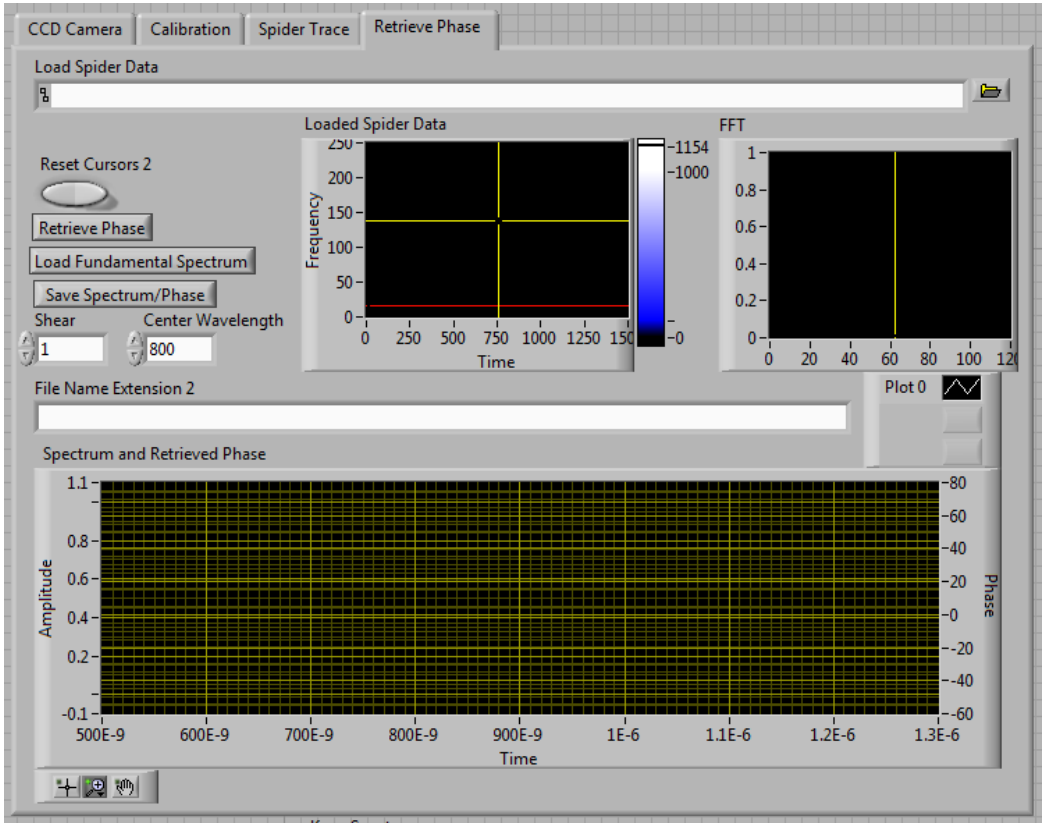
Software/Hardware Interaction

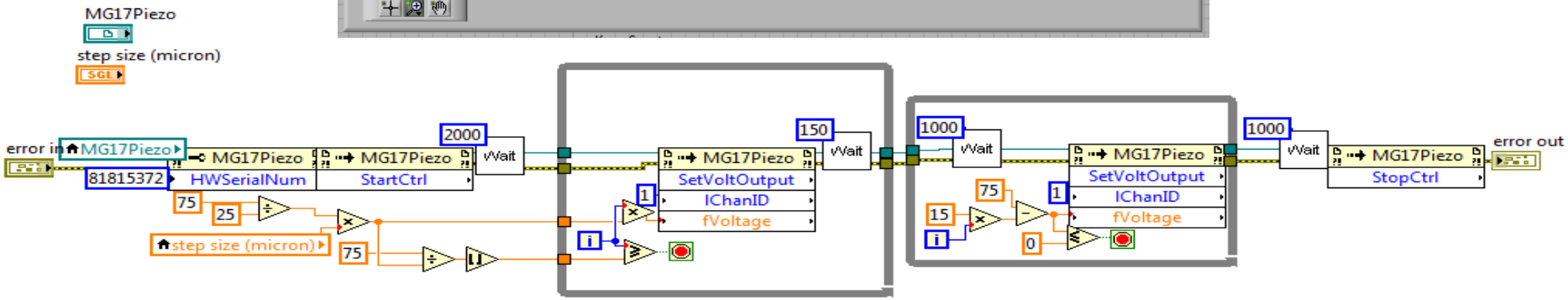


Software Benefits

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

Software Environment

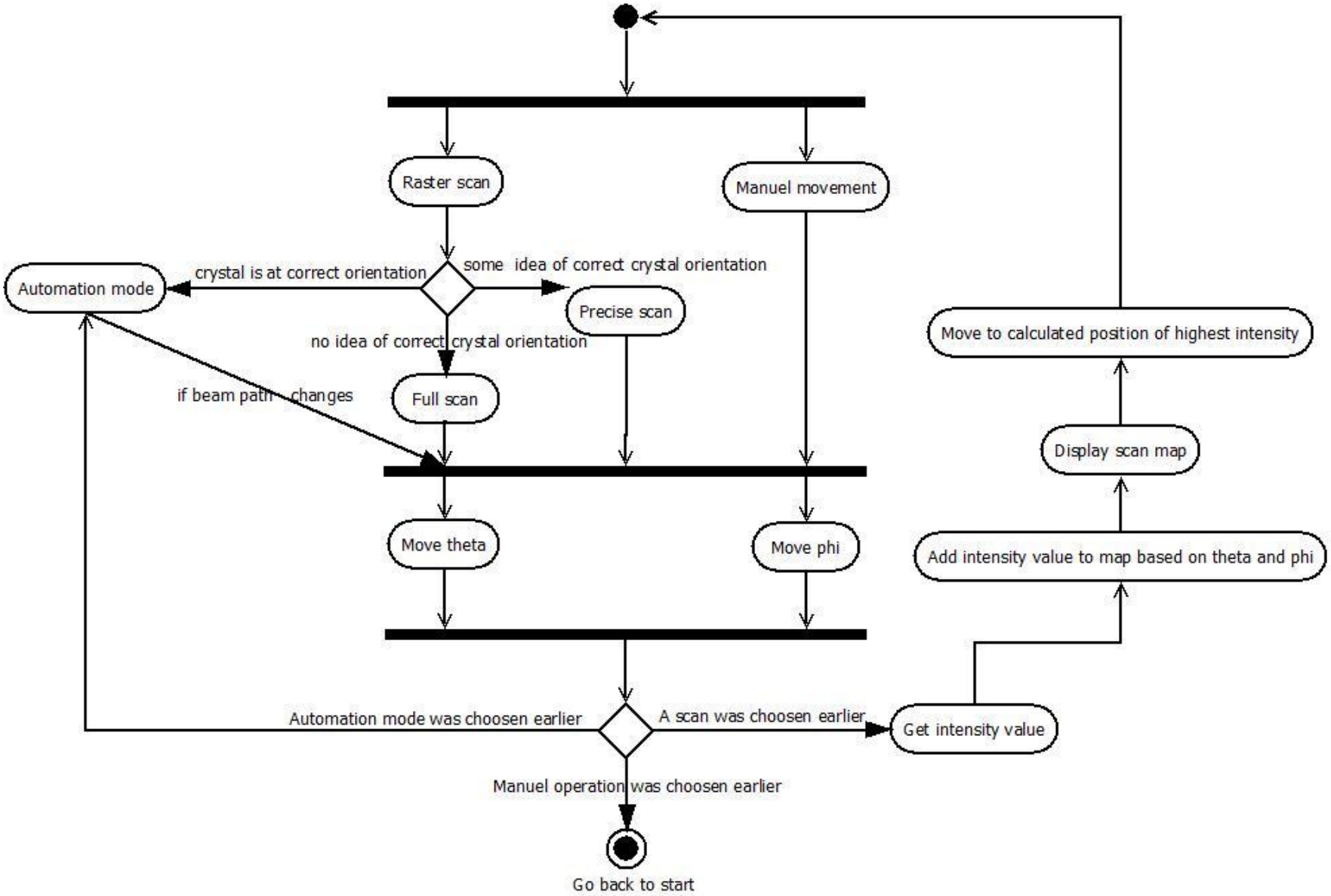




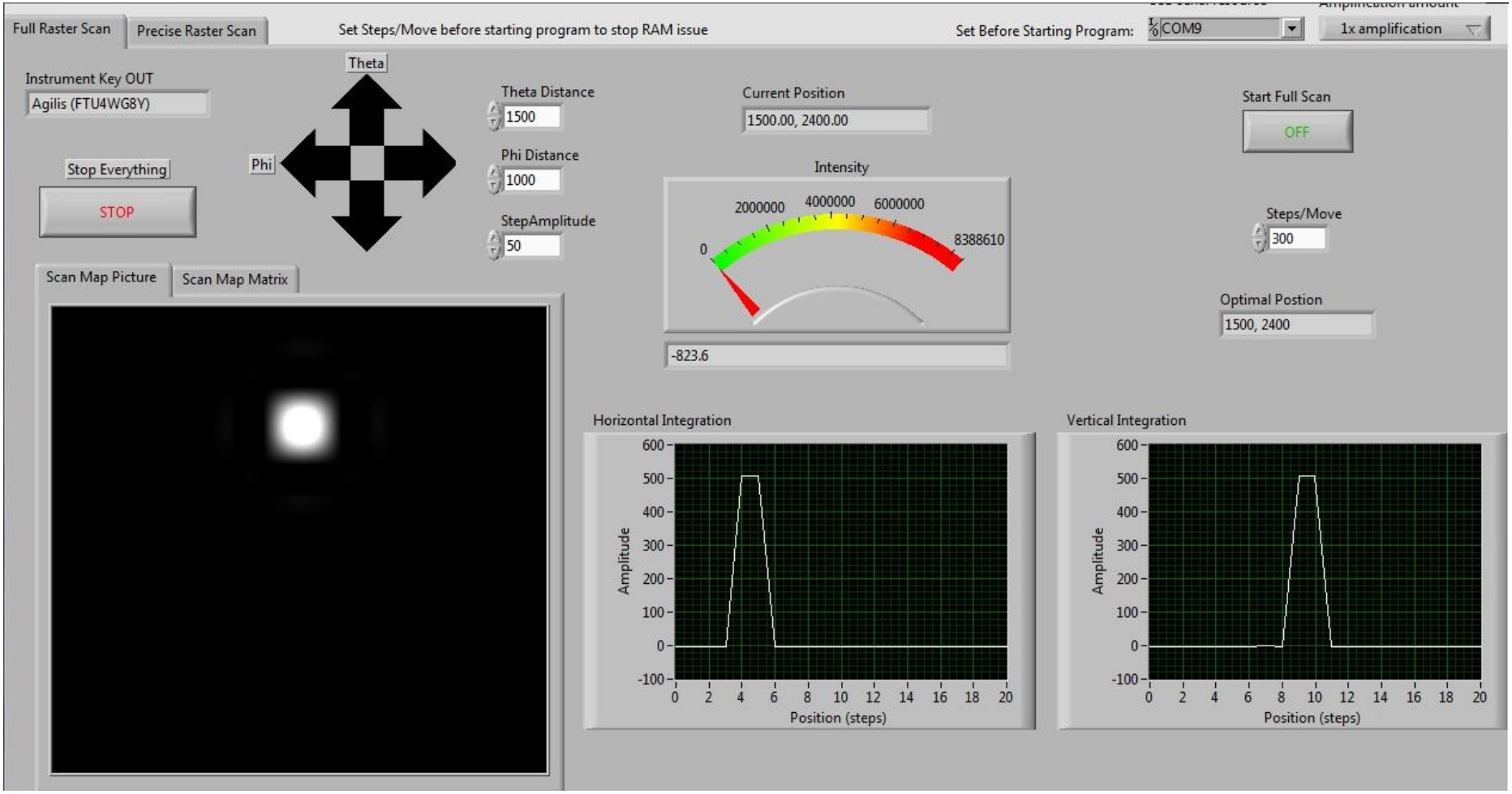
LabVIEW Benefits

- 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

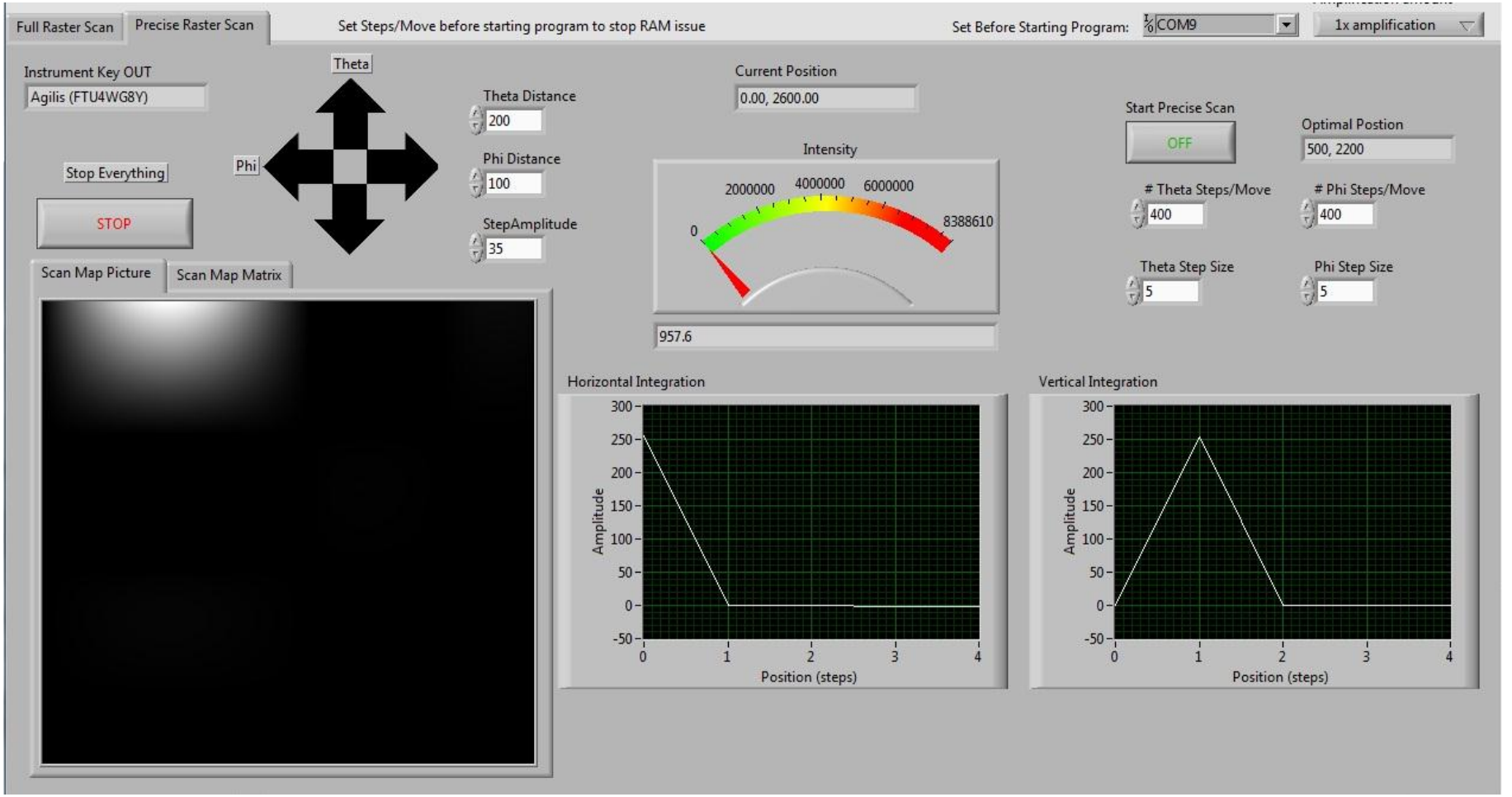
Activity Diagram



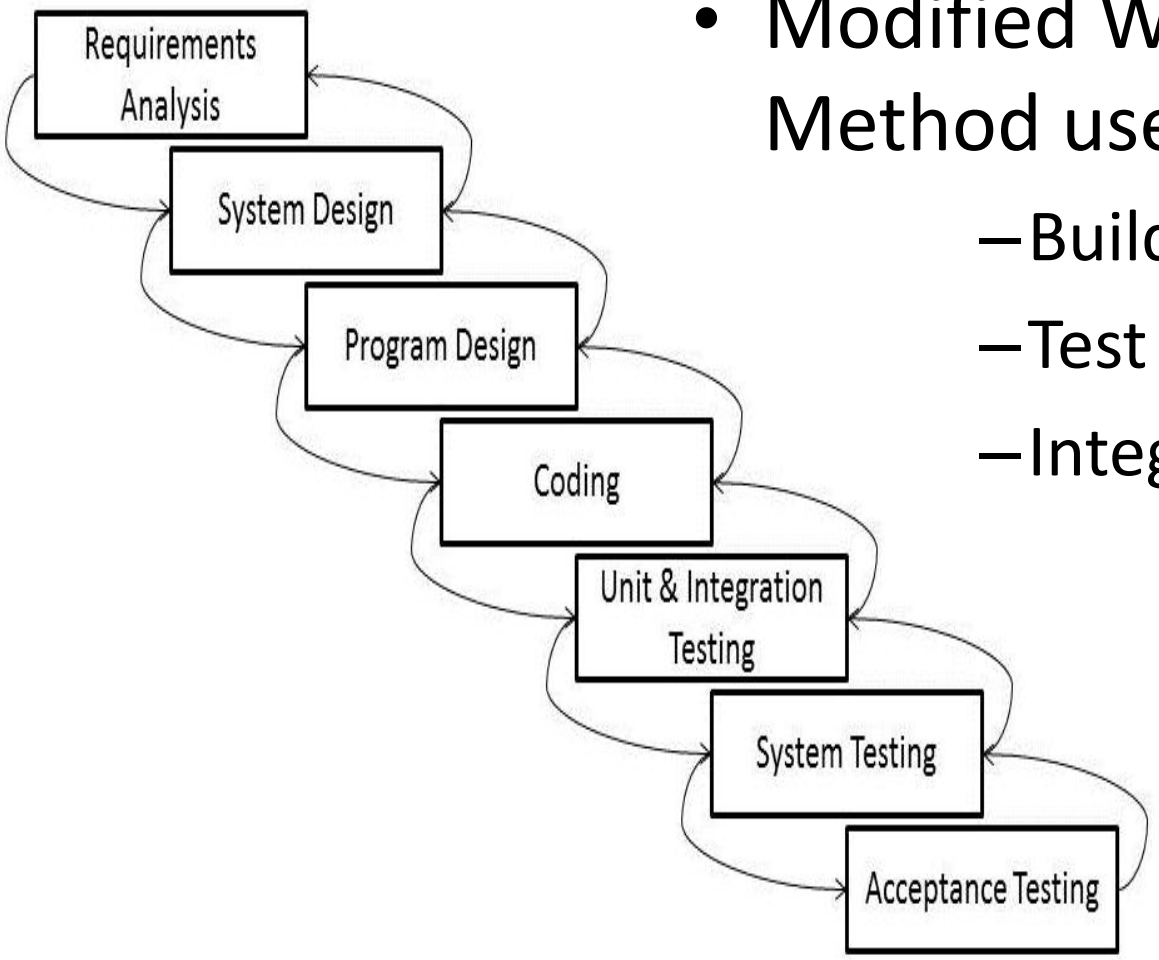
Full Scan GUI



Precise Scan GUI



Software Testing



- Modified Waterfall Testing Method used
  - Build basic functionality
  - Test it
  - Integrate it

Component name	Subtotal	Our Cost
Resistors/Caps	30.04	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
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%

Acknowledgement

- Dr. Martin Richardson, at CREOL for sponsoring this project.

- Dr. Larry Shah for managing the project

- Pankaj Kadwani, CheonHa Jeon, Andreas Vaupel, and Benjamin Webb.

Questions?