DIRECTED, HIGH FREQUENCY, OPEN-AIR COMMUNICATION

GROUP 29:

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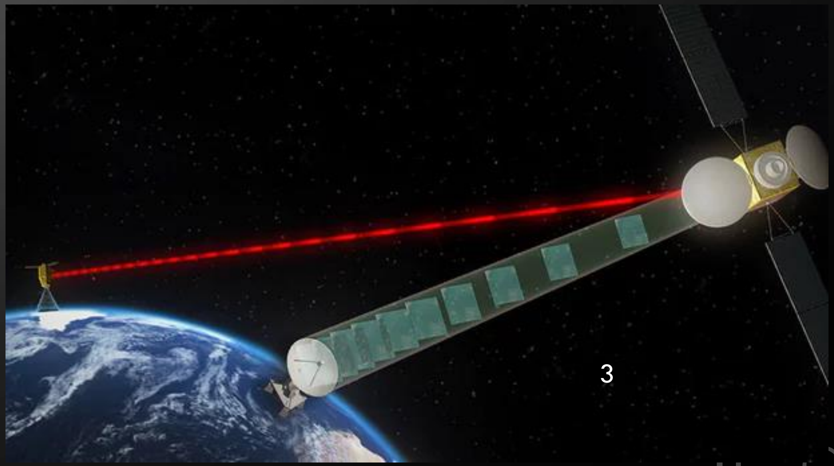
PRESENTATION CONTENTS

- Description, Motivation & Goals
- Specifications
- Component Selection
- Design Approach
- Administrative tasks and budget
- Design challenges & iterations

PROJECT DESCRIPTION

- Sending data from a laser transmitter to a receiver.
- Being able to manually control the direction of the laser.
- Sending an audio signal to an auxiliary input.
- Outputting the data through the receivers speaker.



PROJECT MOTIVATION

- RF communication is the most popular form of data transfer currently for untethered devices. Wi-Fi, Bluetooth, and GSM are all broadcast technologies that allow any slave devices within a spherical range to communicate with the host device.
- This is wasting energy which could be focused on higher-powered and directed data transfer. This project would contain one primary focus and a secondary focus (given enough available resources):

GOAL #1: CREATE OPTICAL TRANSCEIVER PAIR THAT CAN TRANSMIT DATA IN A SERIALIZED FASHION.

SOLUTION: ANALOG AUDIO MODULATED LASER SENDS SIGNAL TO PHOTODIODE RECEIVER AND OUTPUTS AMPLIFIED SIGNAL THROUGH A SPEAKER.

GOAL #2: FIND A WAY TO INTEGRATE OBJECT OR BEAM TRACKING TO LET A STATIC TRANSCEIVER TRACK A MOBILE TRANSCEIVER.

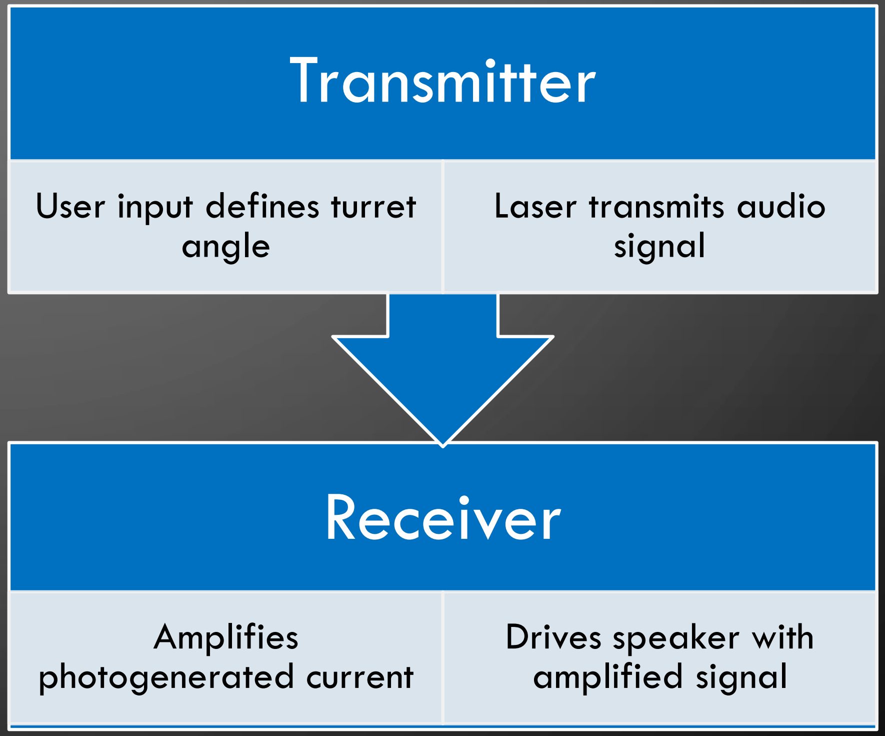
SOLUTION: JOYSTICK AND IR REMOTE INPUT CONTROLS SERVOS

SPECIFICATIONS & PROJECT REQUIREMENTS

- BANDWIDTH ~ 20 kHz
- SIZE < 1 $ft.^3$
- WEIGHT < 1 lb.
- RANGE : [1, 25] ft.

SYSTEM CONCEPT:

- Transmitter takes audio signal to modulate laser.
- User can adjust turret angle.
- Receiver amplifies signal from laser and plays through the speaker.



LASER CONSIDERATIONS

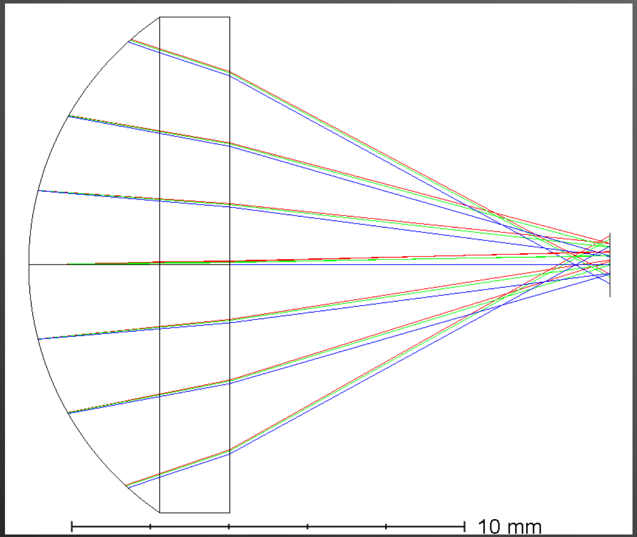
Model	Output power (mW)	Operating current (mA)	Operating voltage (V)	rise/fall time(ns)	Cost (USD)
ML925B11F	6	20	1.2	0.2	$16.83
L1550P5DFB	5	30	1.1	0.1	$81.69
154145-VP	5	40	3.0	-	$3.49

JAMECO VALUEPRO 154145-VP

- Collimation optic simplifies optical design.
- Outputs 5 mW of power at 3 V
- Consumes less than 40 mA of current.
- Peak wavelength of 650 nm

OPTICS & DIODE POSITIONING

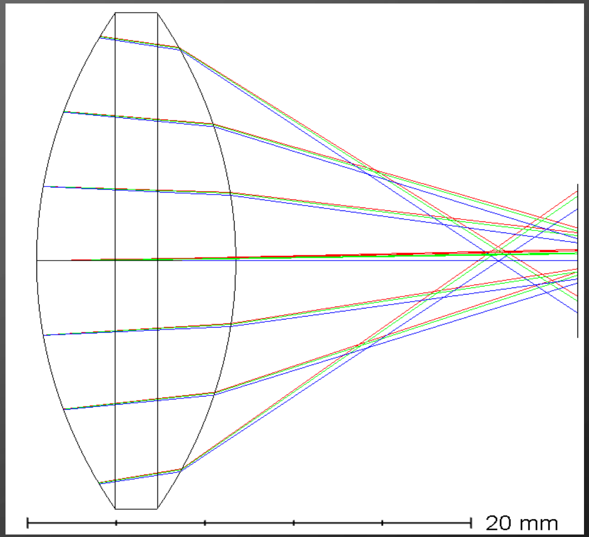
Transmitting plano-convex optic



f = 14.9 mm

Sets beam divergence

Receiving bi-convex optic



f = 25.3 mm

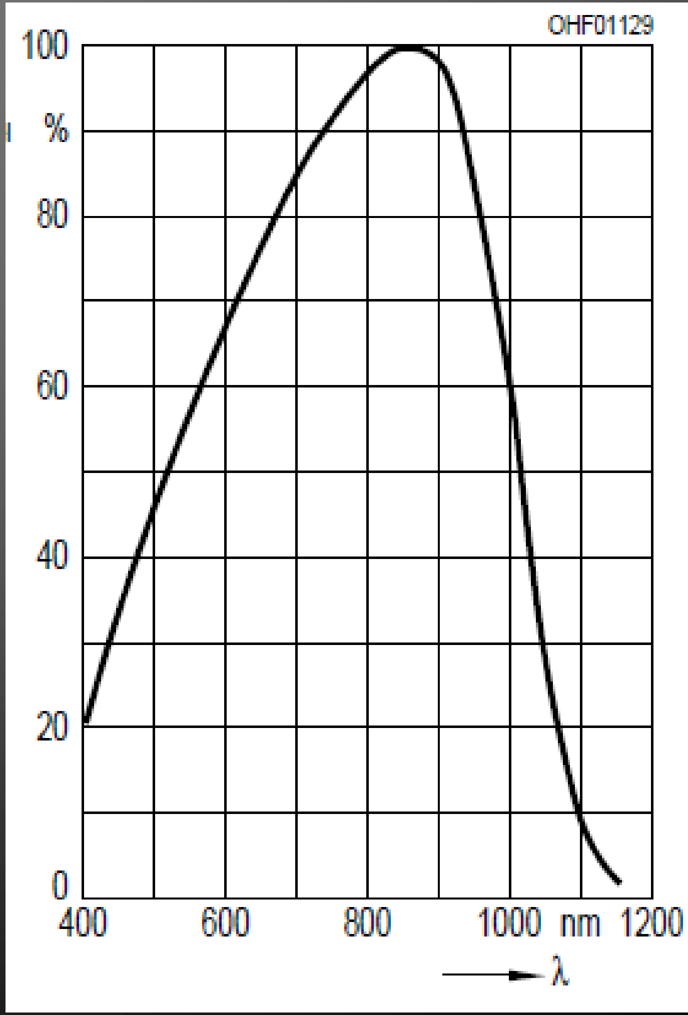
Converges beam onto photodiode

PHOTODIODE CONSIDERATIONS

Model	NEP ($W/Hz^{1/2}$)	Responsivity (A/W)	Rise / fall time (ns)	Active area (mm^2)	Cost (USD)
FGA01	$4.5*10^{-15}$	1.003 (1550 nm)	.3	.12	$60.93
FGA015	$1.3*10^{-14}$	0.95 (1550 nm)	.3	.15	$56.65
SFH 203 P	$.029*10^{-12}$	0.75 (650 nm)	5	1	$1.06

OSRAM SFH 203 P PHOTODIODE

- Responsivity of .75 A/W at 650 nm
- 1 mm^2 active area

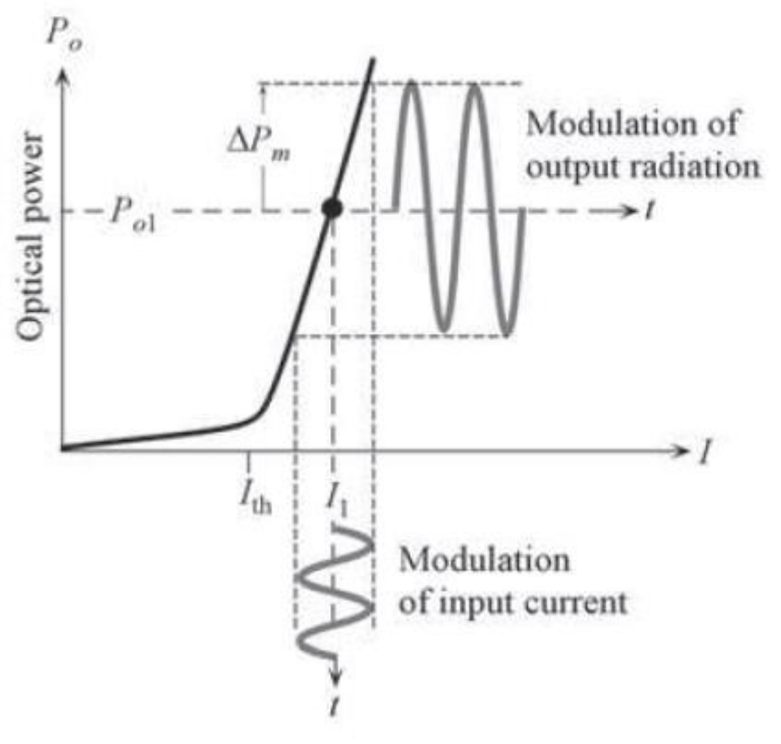


DESIGN APPROACH – AUXILIARY INPUT

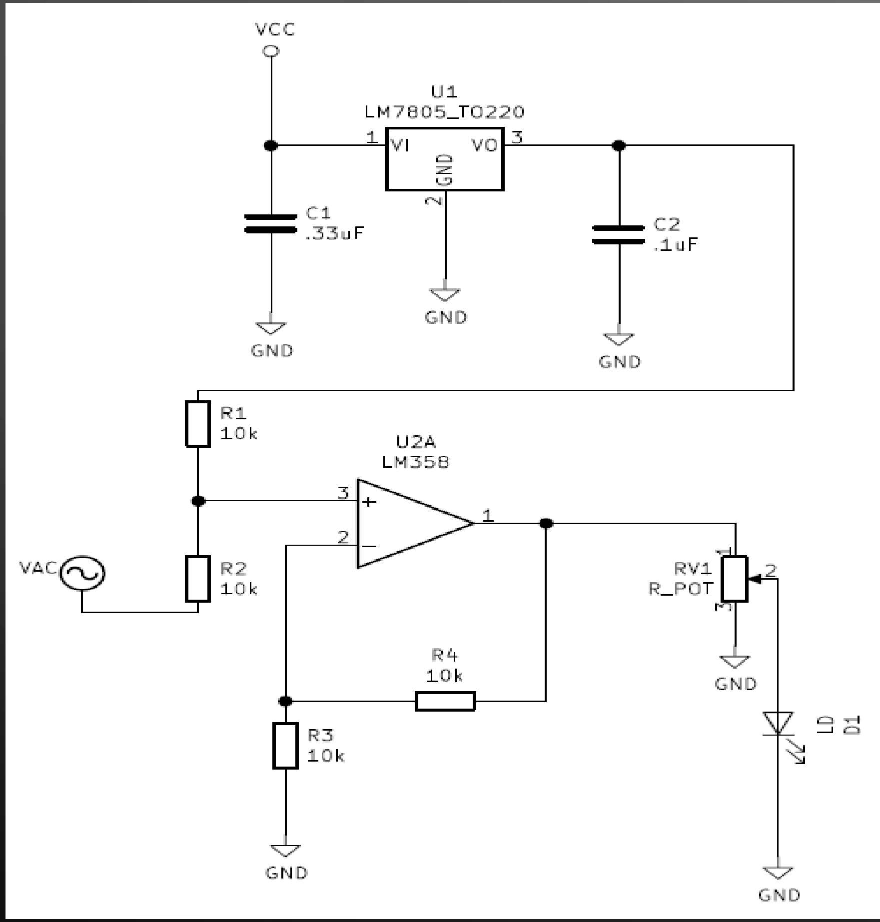
- The audio signal is taken from the left or right audio channel to modulate the laser.

DESIGN APPROACH – LASER TX

- The laser must be biased to avoid saturation and cutoff to ensure linearity in the signal.

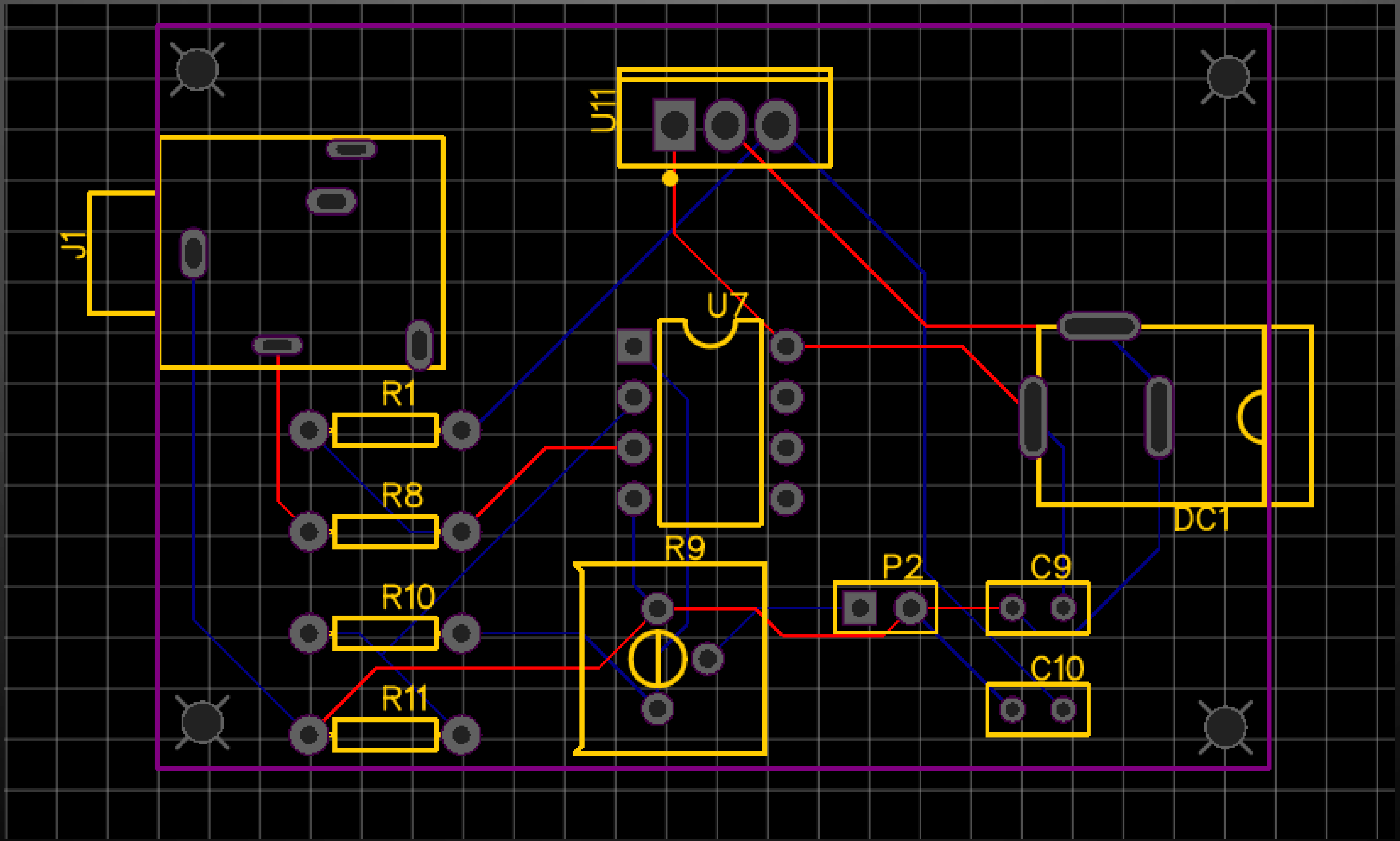


TRANSMITTER CIRCUIT/SCHEMATICS

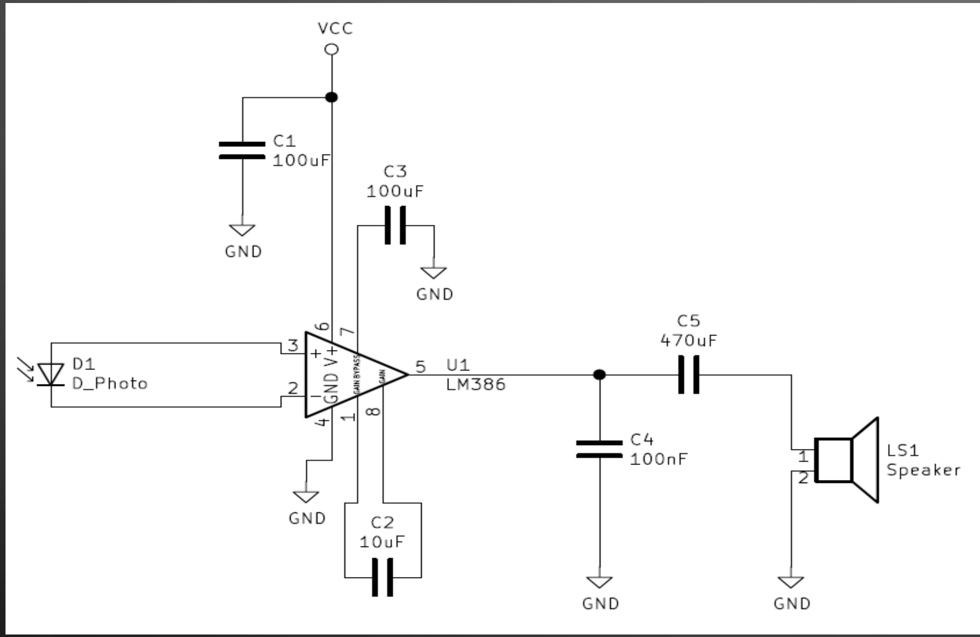


- Voltage regulator sets DC input to op-amp
- Audio signal is superimposed
- Laser diode is biased to 3.3 V DC

TRANSMITTER PCB DESIGN

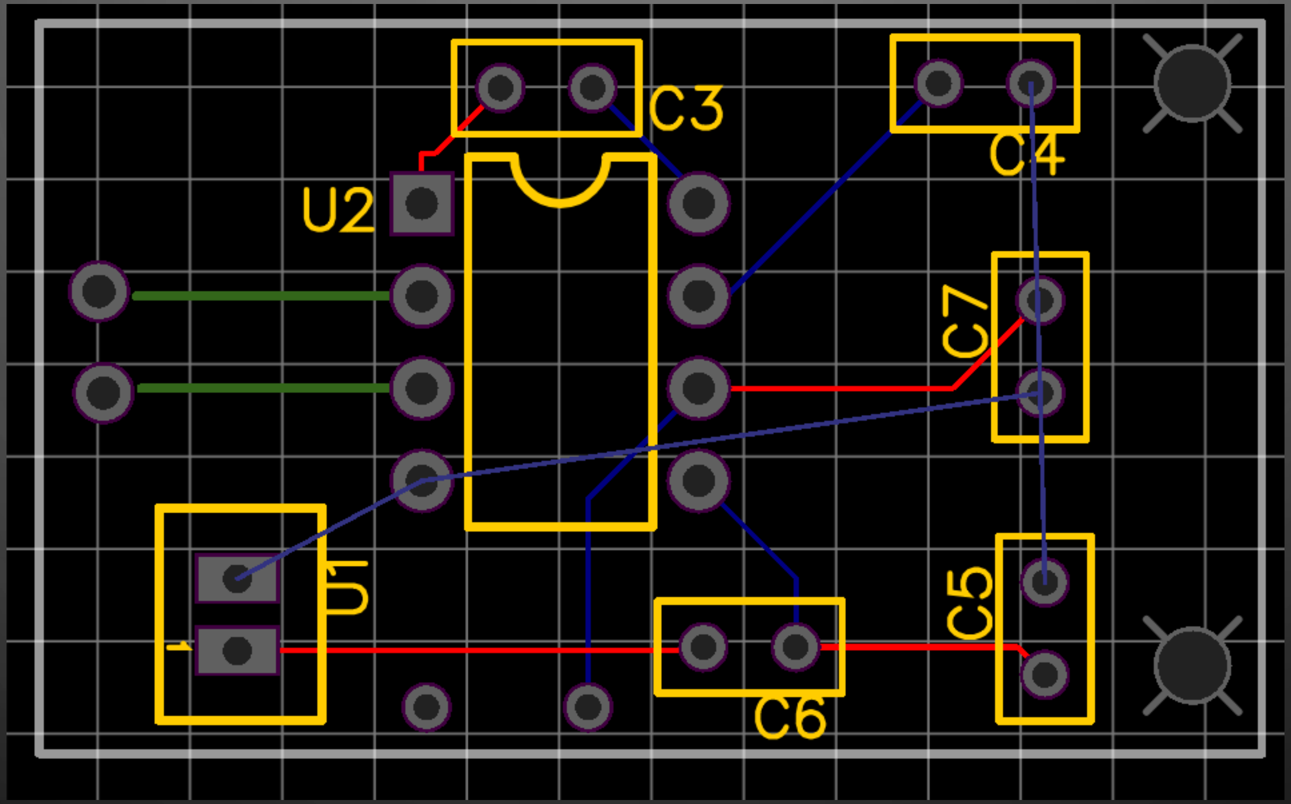


RECEIVER CIRCUIT/SCHEMATICS



- 10 uF capacitor sets gain to 200
- LM 386 drives an 8 ohm 2" speaker

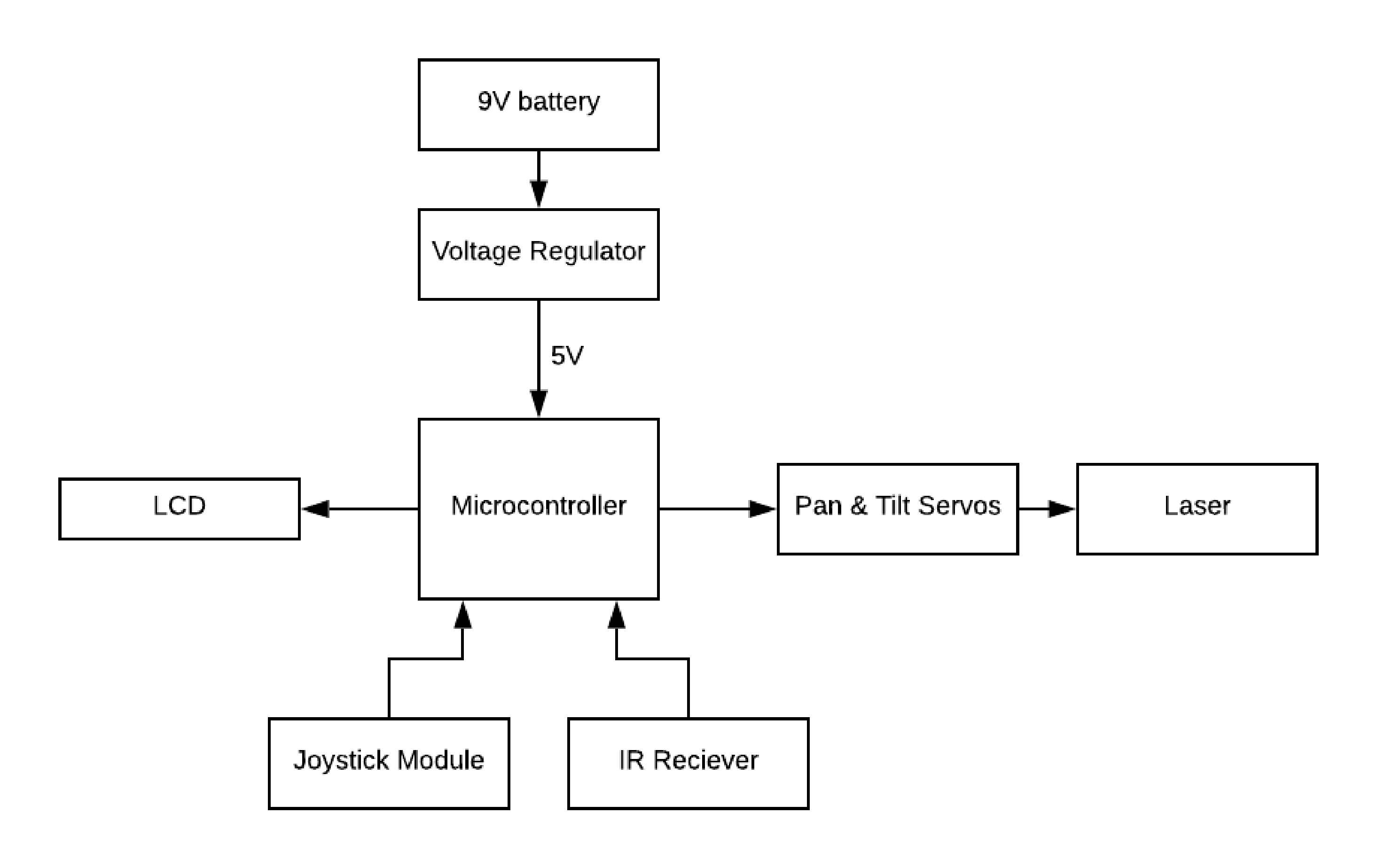
RECEIVER PCB DESIGN



WORKING SOLUTION: MANUAL BEAM TRACKING

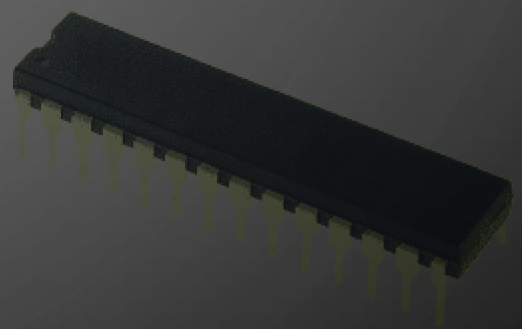
- All servo adjustments are manually controlled by the user
  - No need for accelerometers or sensors
- Manual controls are all done by the sender MCU
  - No wireless modules needed. No receiver MCU needed
- Joystick can be used to quickly adjust servos
- For precise adjustments, a IR remote can be used in two modes
  - “D-Pad” mode: use 4 buttons to control the pan and tilt servos
  - Manual entry: select a servo to control and enter desired angle
- LCD used to display the angles of the servos, which one is being edited, and the desired angle

MANUAL BEAM TRACKING BLOCK DIAGRAM



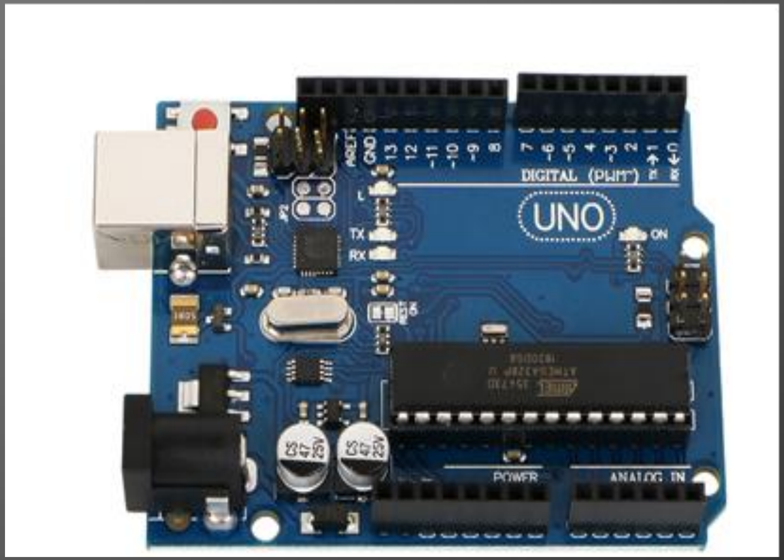
MCU: ATMEGA328P-PU

- Pros:
  - Clock Speed: 20 MHz
  - Through hole mounting
  - Software familiarity (C and Arduino)
  - Resources and troubleshooting
- Cons:
  - 32 kB Program size



HARDWARE SELECTION

SAME70-XPLD
Atmel (Microchip)
ATSAME70Q21 microcontroller



Arduino UNO
Atmel (Microchip)
ATMega328p microcontroller

Initial processor selection was SAME70-XPLD based on performance
After software requirements were firmed up, Arduino UNO was chosen

OPTICAL & AUDIO COMPONENT SELECTION SUMMARY

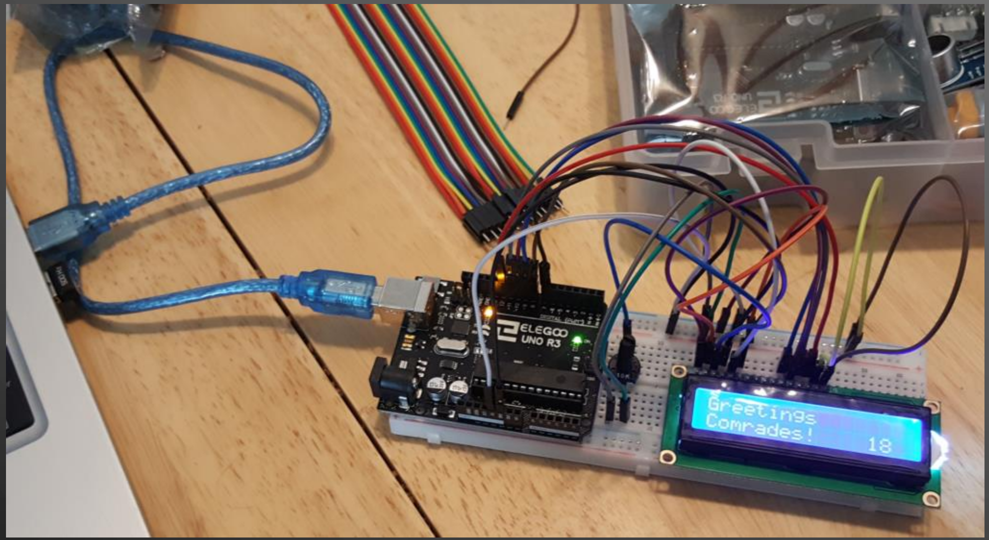
- Laser – Jameco Valuepro 154145-VP
- Photodiode – Osram SFH 203 P
- Voltage regulator – LM7805CT
- Op-amps – LM 386, LM 358N

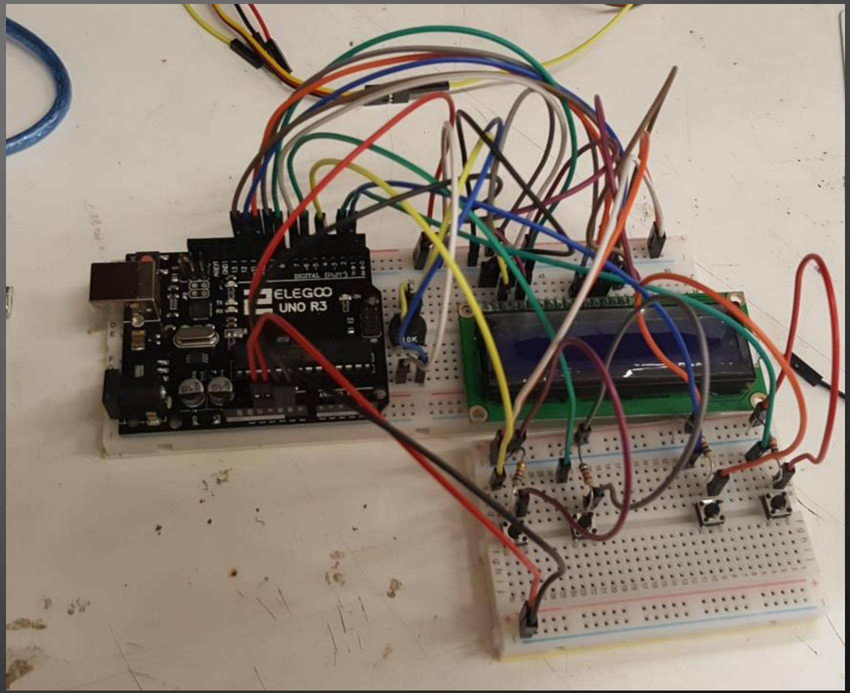
SERVO CONTROL COMPONENT SELECTION SUMMARY

- MCU: ATMEGA 328P-U
- LCD: 16x2 LCD
- VOLTAGE REGULATOR: 7805 (5V)
  - All hardware requires 4.8V-6V
  - Familiarity from labs
- Standard IR Reciever
- Standard Joystick

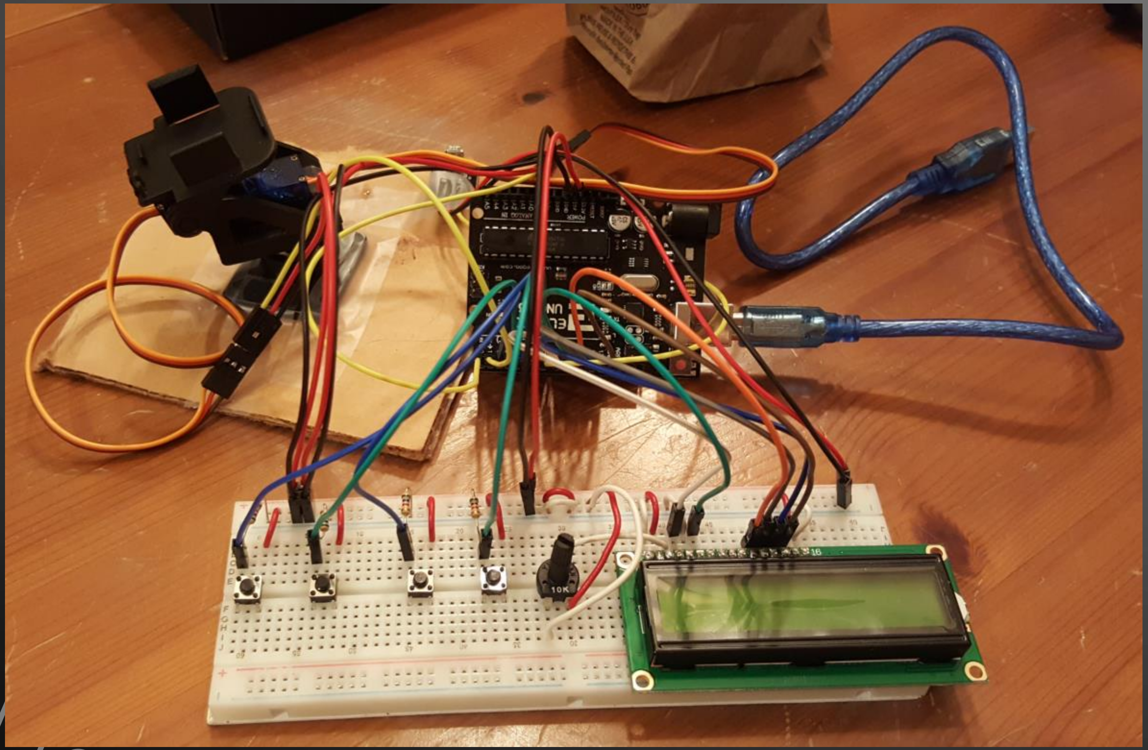
- Servos: Micro size
  - Just holding a laser emitter (no heavy lifting required)

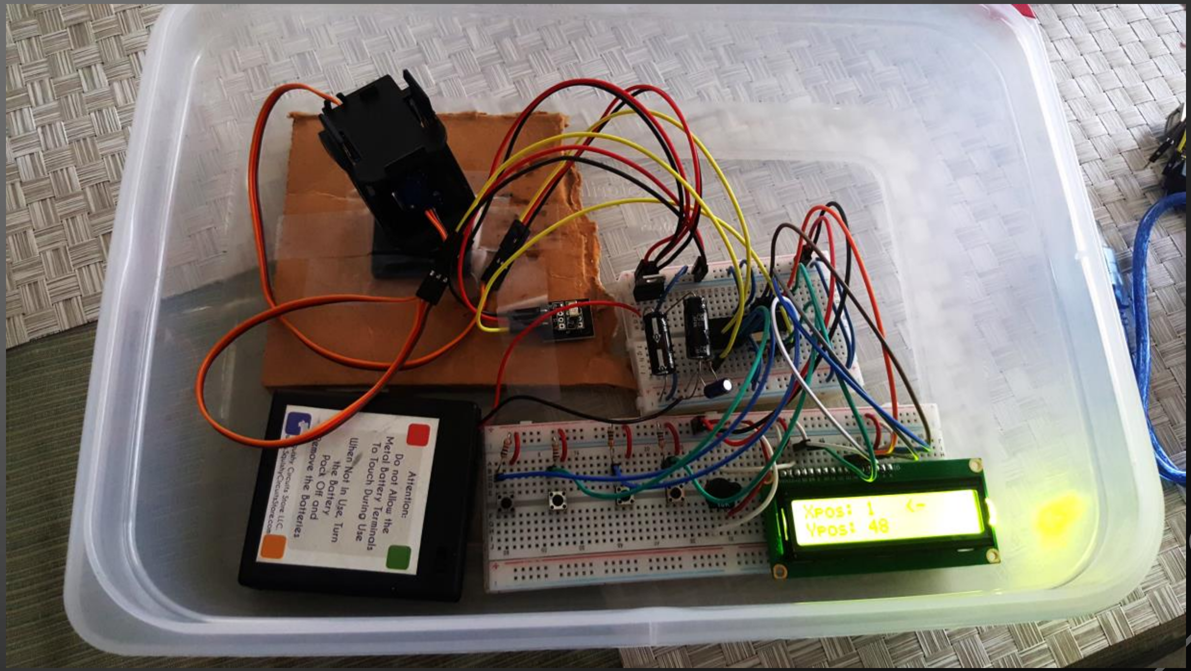
SERVO CONTROL PROTOTYPES



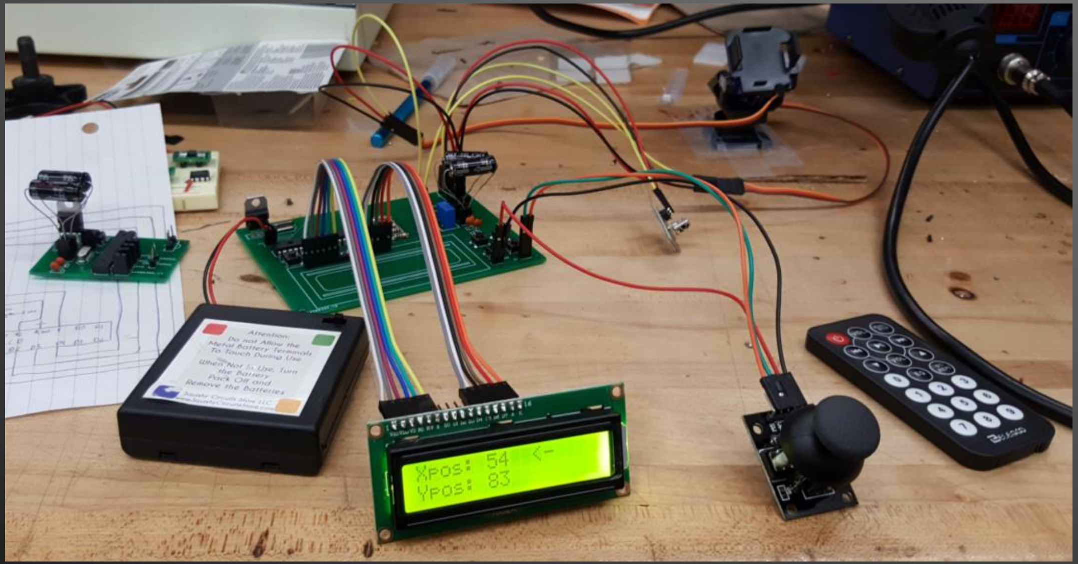


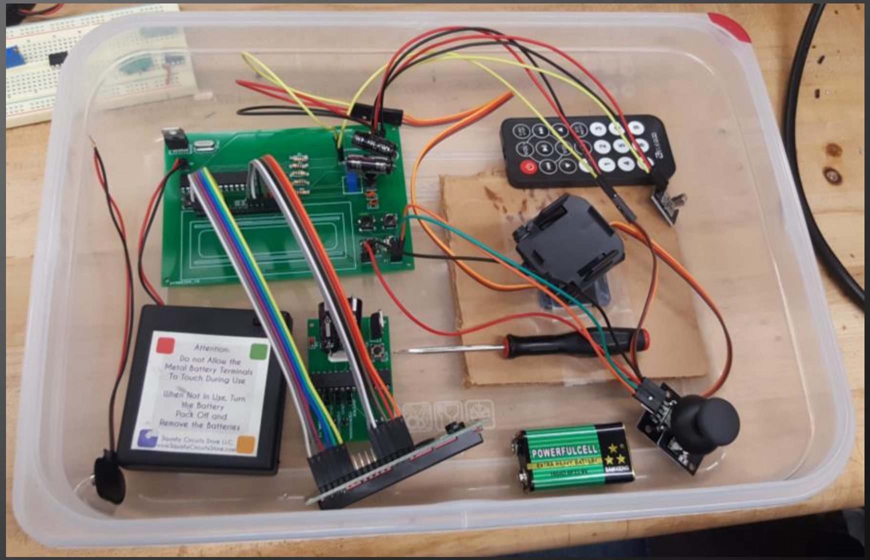
SERVO CONTROL PROTOTYPES



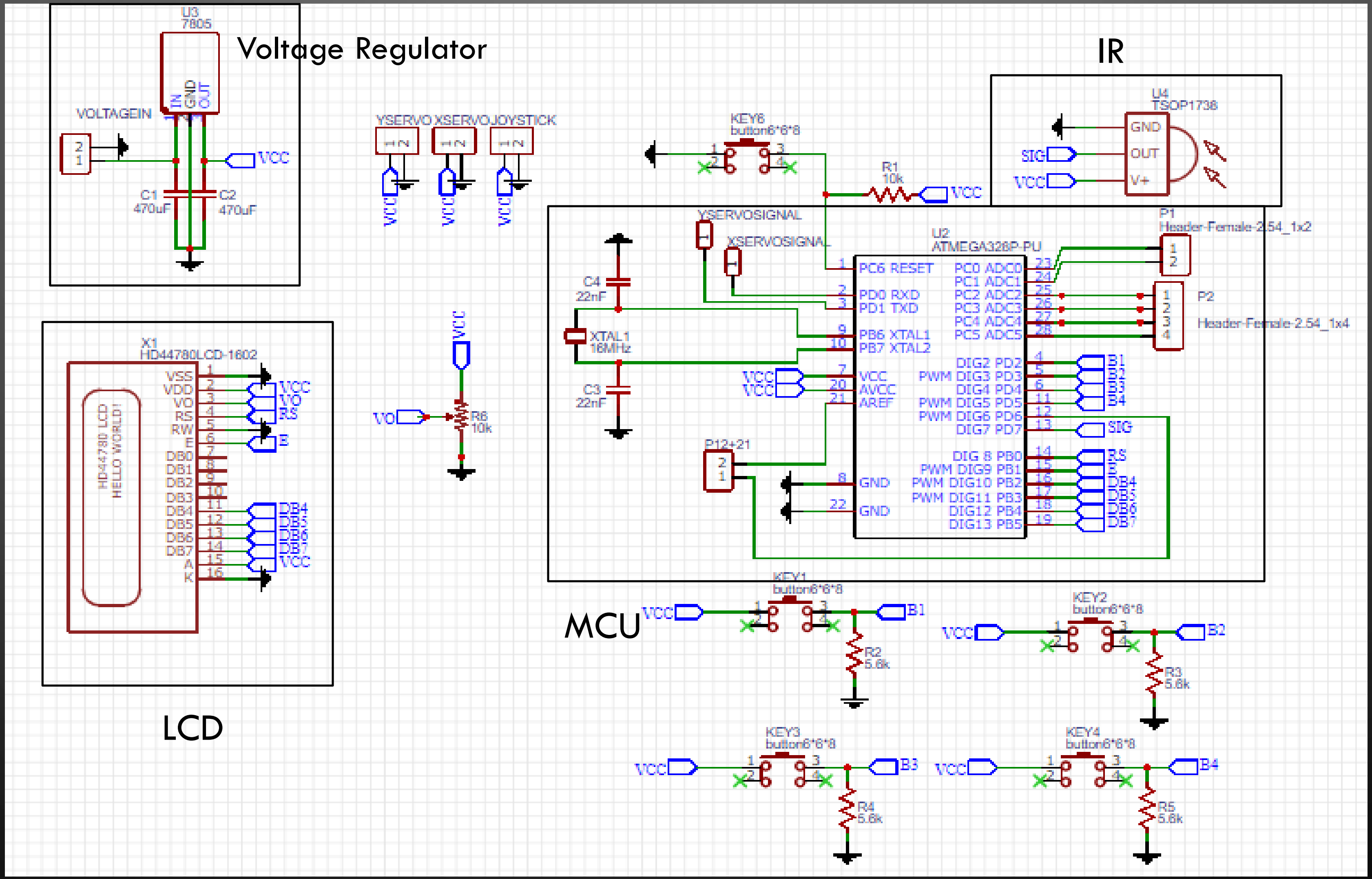


SERVO CONTROL PROTOTYPES

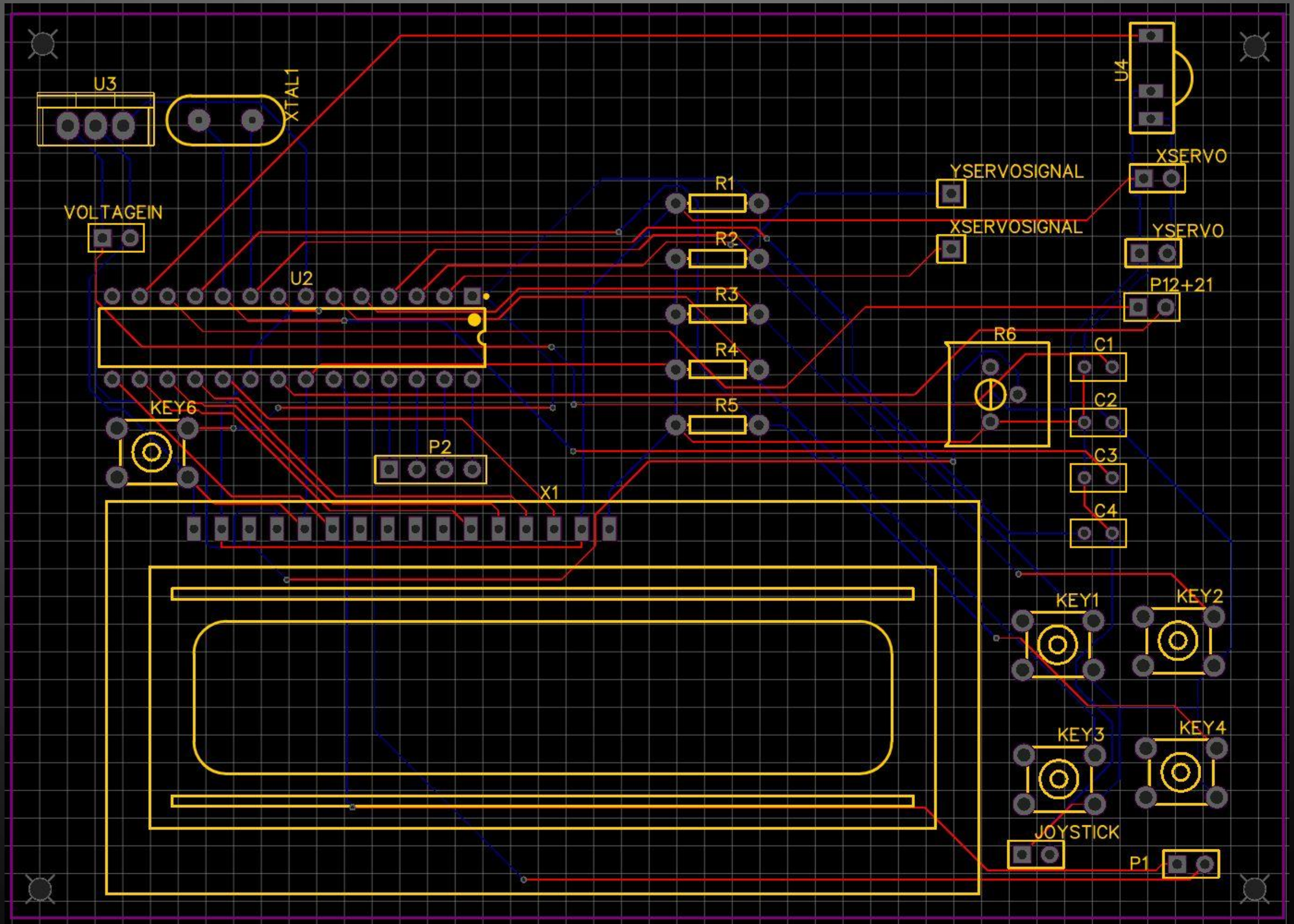




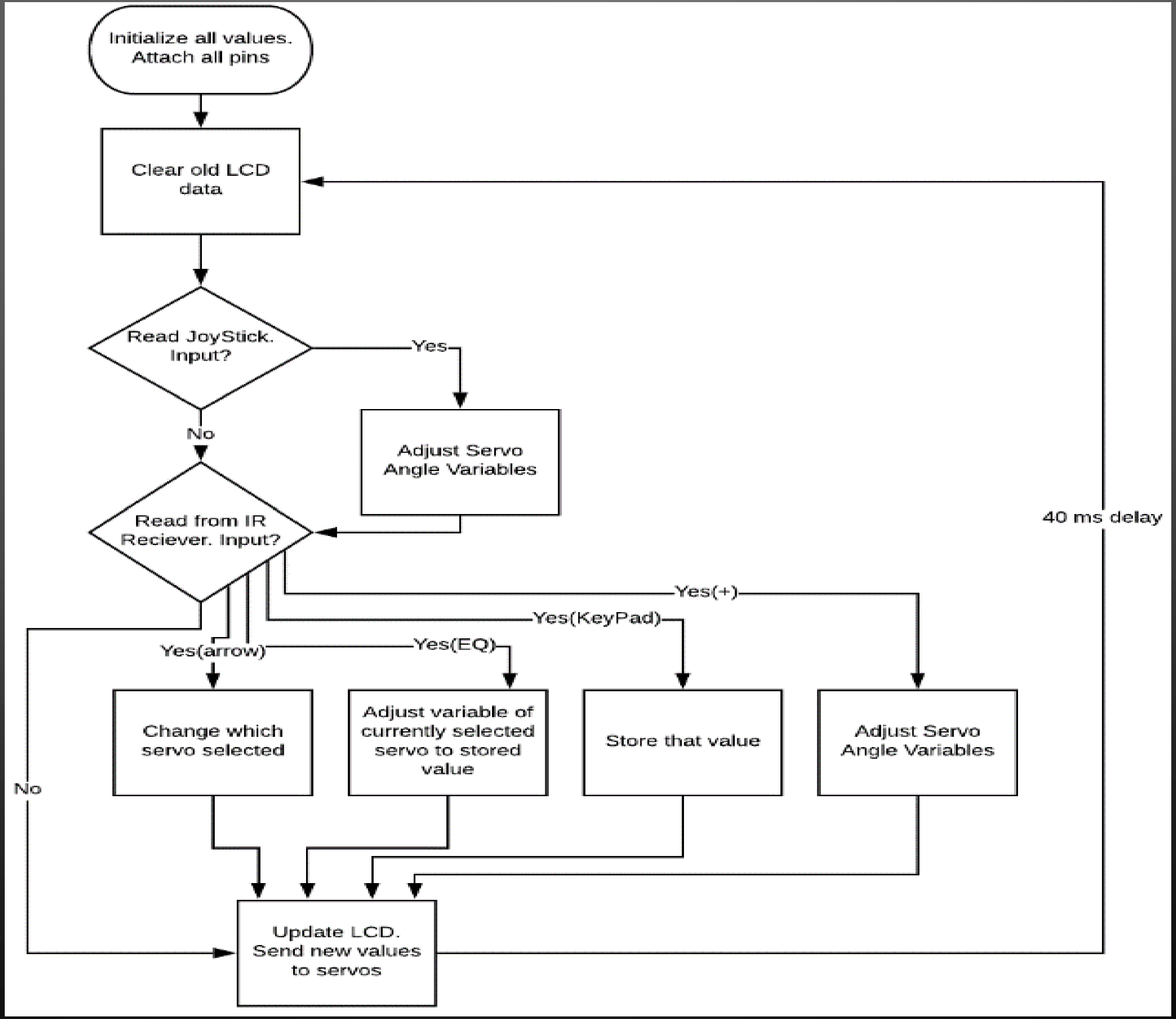
SERVO MICROCONTROLLER SCHEMATIC



SERVO MICROCONTROLLER PCB DESIGN

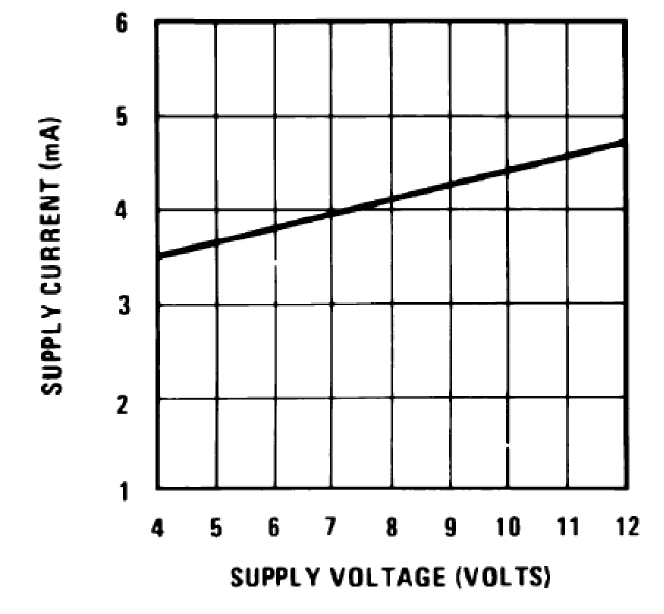


SOFTWARE BLOCK DIAGRAM



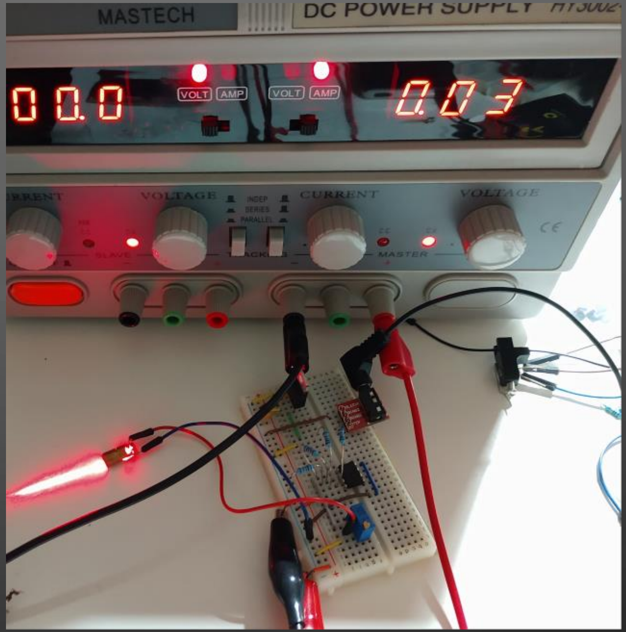
DEVICE POWER

- Receiver amp



.378 W consumed

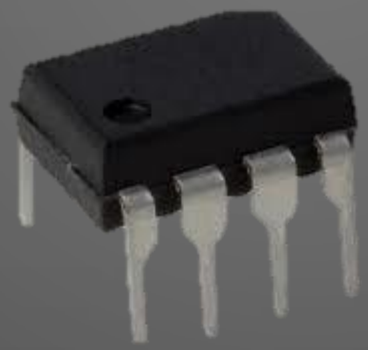
Transmitting circuit pulls .03 A from the source at 9 V



.18 W consumed

OP AMPS

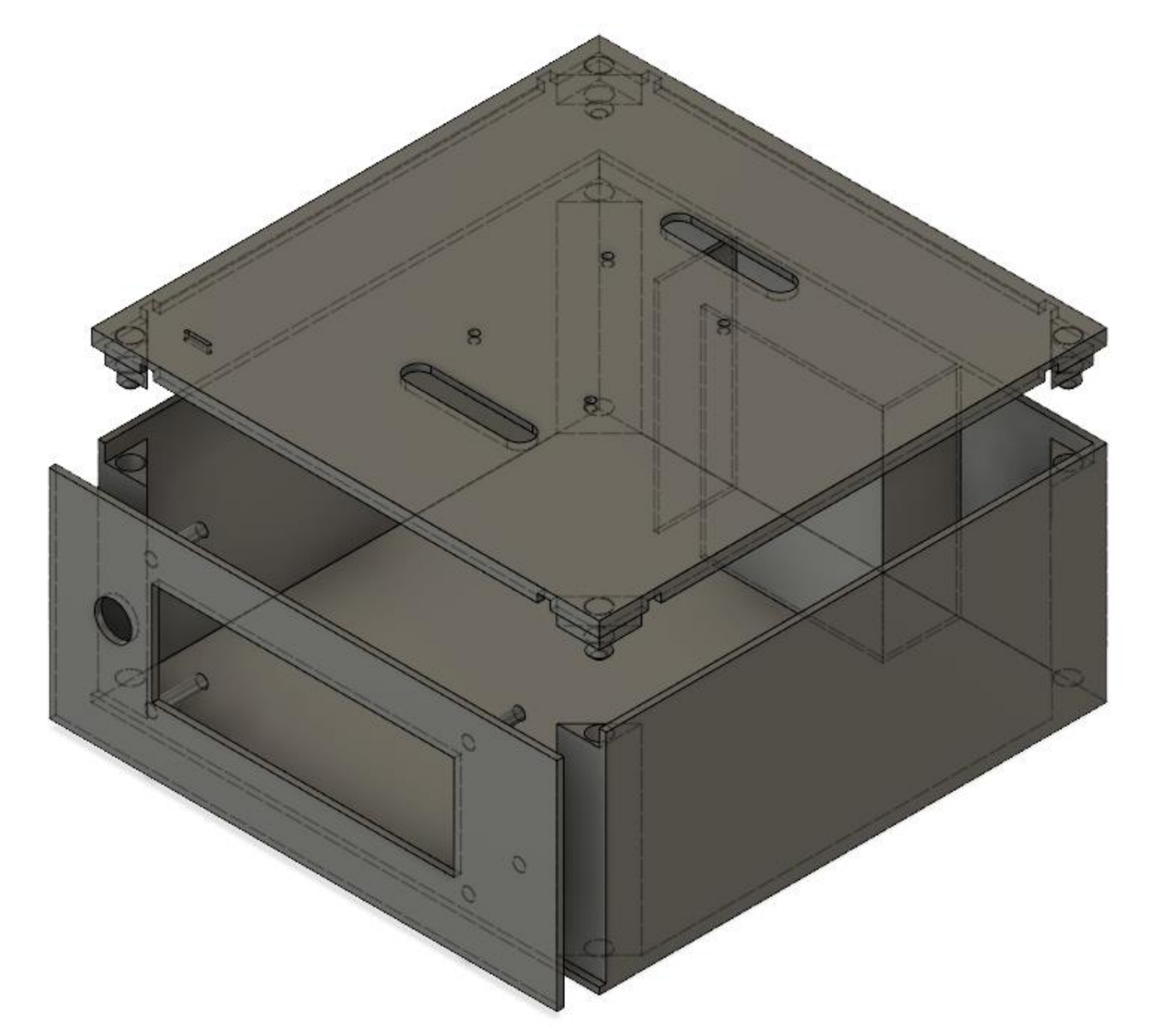
- LM358
  - Advantage
    - Low power
    - Multi-usage
    - Dual Op Amps
  - Usage
    - Amplified signal
    - High pass filters
    - Low pass filter
    - Analog addresses



- LM386
  - Advantage
    - Low power
    - Audio transmitting devices
  - usege
    - Battery power devices
    - Guitar amplifier

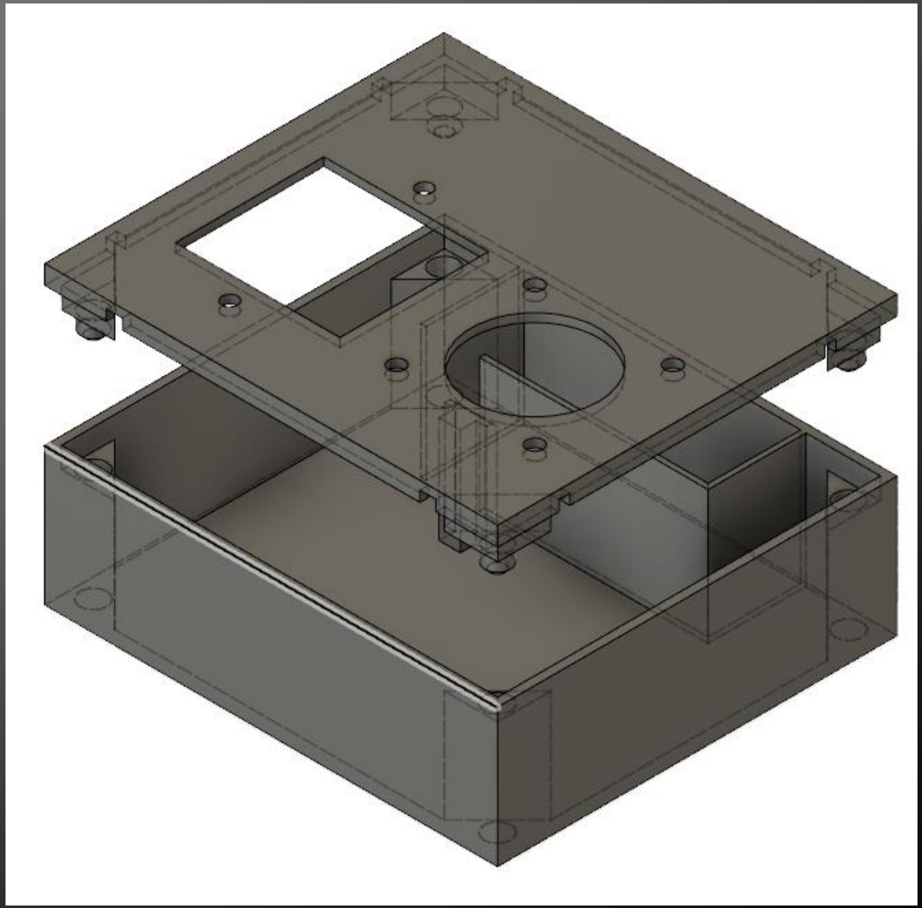
TRANSMITTER HOUSING

- Holes for LCD, audio cable and turret.
- Locations set for microcontroller and transmitter circuit.
- Compartment for 9 V batteries
- Slots for cable routing.

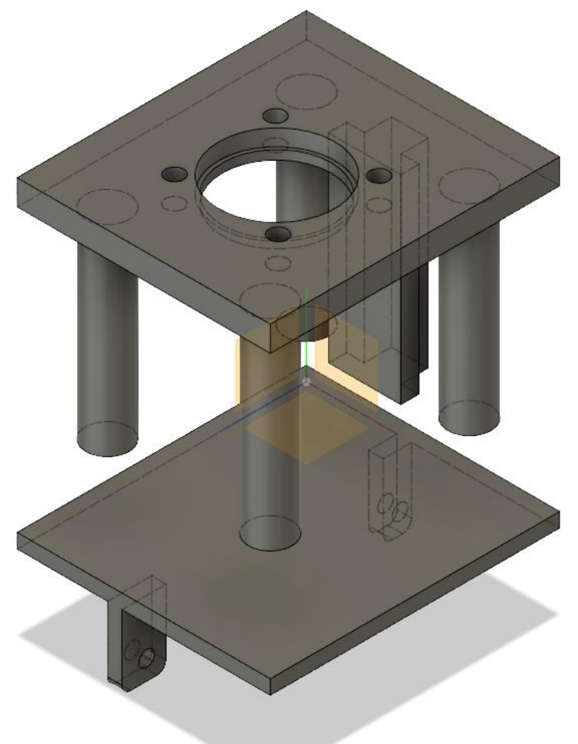


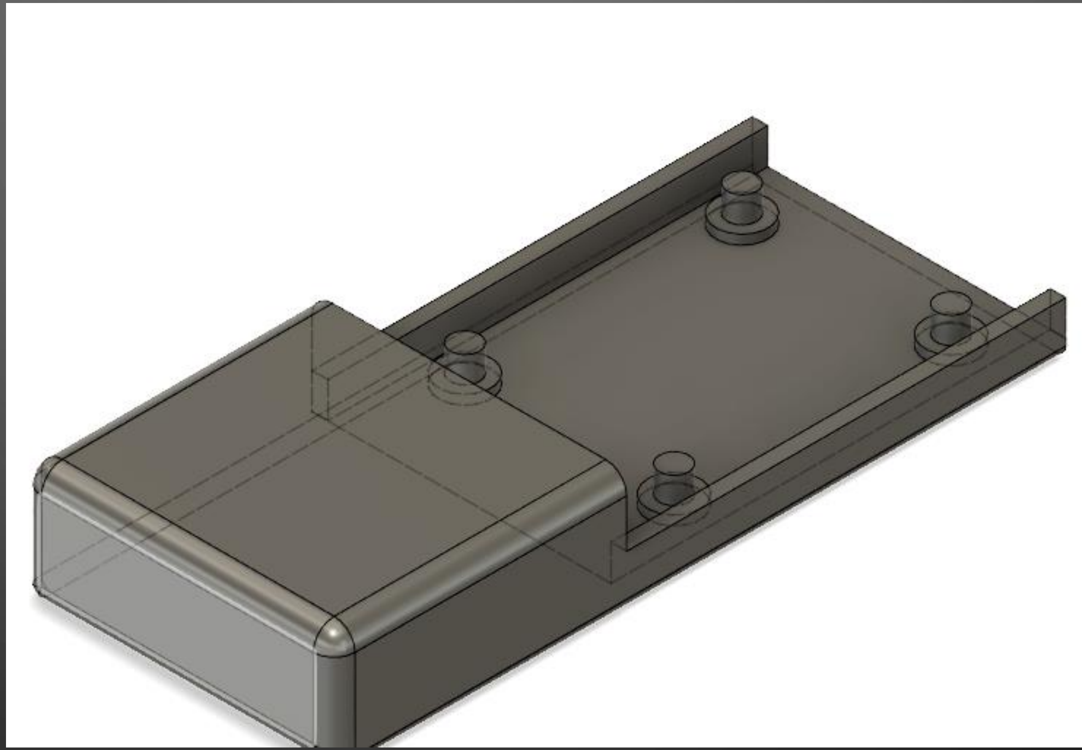
RECEIVER HOUSING

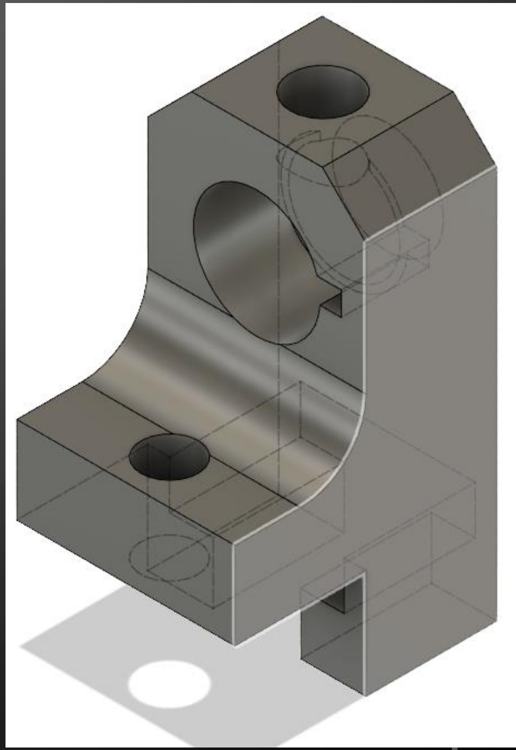
- Contains 9 V battery and soldered perfboard mounted on standoff.
- Cutouts for onboard speaker and receiving optic.



TURRET PLATFORM, JOYSTICK GRIP, DIODE MOUNTS







ADMINISTRATIVE TASK LAYOUT

Team Members	PCB Schematics	Embedded Systems	Software Design	Components Selection	Optics	Housing
Brian	Primary			Secondary	Secondary	
Ryan		Primary	Primary	Secondary		
Sandy	Secondary			Primary	Primary	Primary
Shane		Primary	Primary	Secondary		

PROJECT EXPENSES

Part	Quantity	Cost ($ USD)
Microcontroller	1	$5.95
Laser	1	$.60
Amplifier	1	$.33
Pan and Tilt Servos	1	$19.42
Photodiode	1	$1.13
LCD	1	$5.99
PCB	3	$31.88

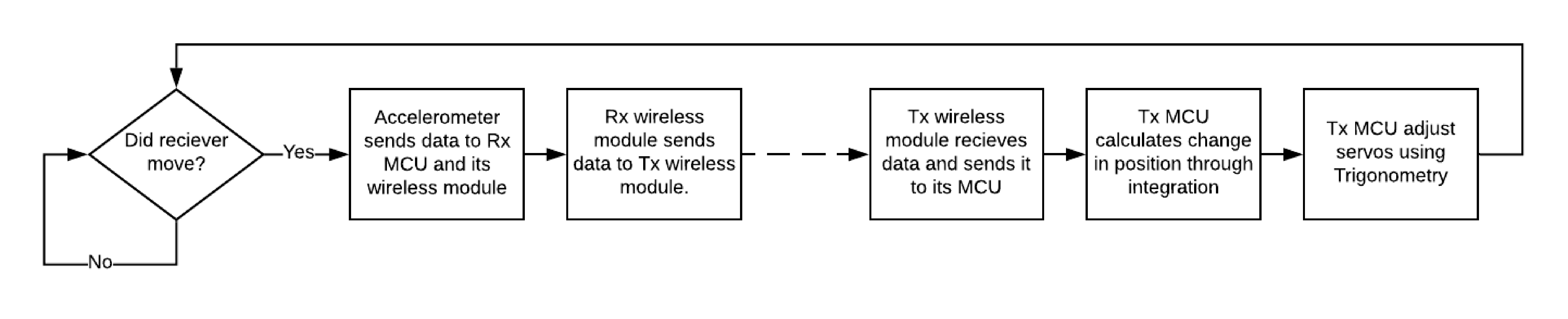
PROJECT DIFFICULTIES & CHALLENGES

- A change in understanding and part availability changes the implementation of design.
- The core function of data transmission and electrical work must precede the work of opto-mechanical design and beam alignment automation.

ORIGINAL GOAL: DIGITAL TRANSMISSION

- Behind schedule on necessary components
- Required more involved signal processing analysis
- Pushed optics & housing work too far behind

ATTEMPTED SOLUTION: ACCELERATION BASED TRACKING



Problems?

- Double integration for acceleration isn't accurate. The error also compounds.
- Objects moving at different constant speeds have the same acceleration but different final positions
- What's the difference between accelerating one way and decelerating while moving the other?
- Now limited by the error rates of the wireless modules.

ORIGINAL MCU: ATSAME70J19A

- Pros:
  - Clock Speed: 300 MHz
  - Connectivity: Ethernet, USB, UART, SPI, I2C
  - Program Memory Size: 512 KB
- Cons:
  - Difficult to program
  - Only SMD (difficult to solder and work with)

EARLY PROTOTYPE – DIGITAL AUDIO TX/RX

- 8KHz 8-bit WAV file
- Read by microcontroller from SD card
- Transmitted as serial bits via laser (76680 baud rate)
- Received by laser receiver
- Output to amplifier and 8 Ohm speaker

QUESTIONS?