University of Central Florida
Department of Electrical Engineering and Computer Science

3D Persistence of Vision Display

Sponsor: KEMCO Industries

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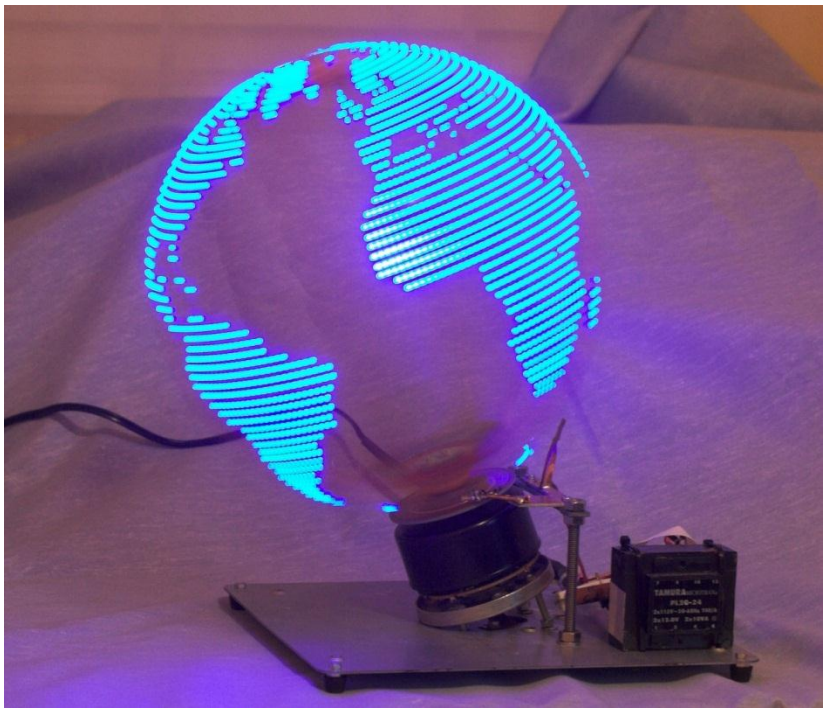
Goals and Objectives

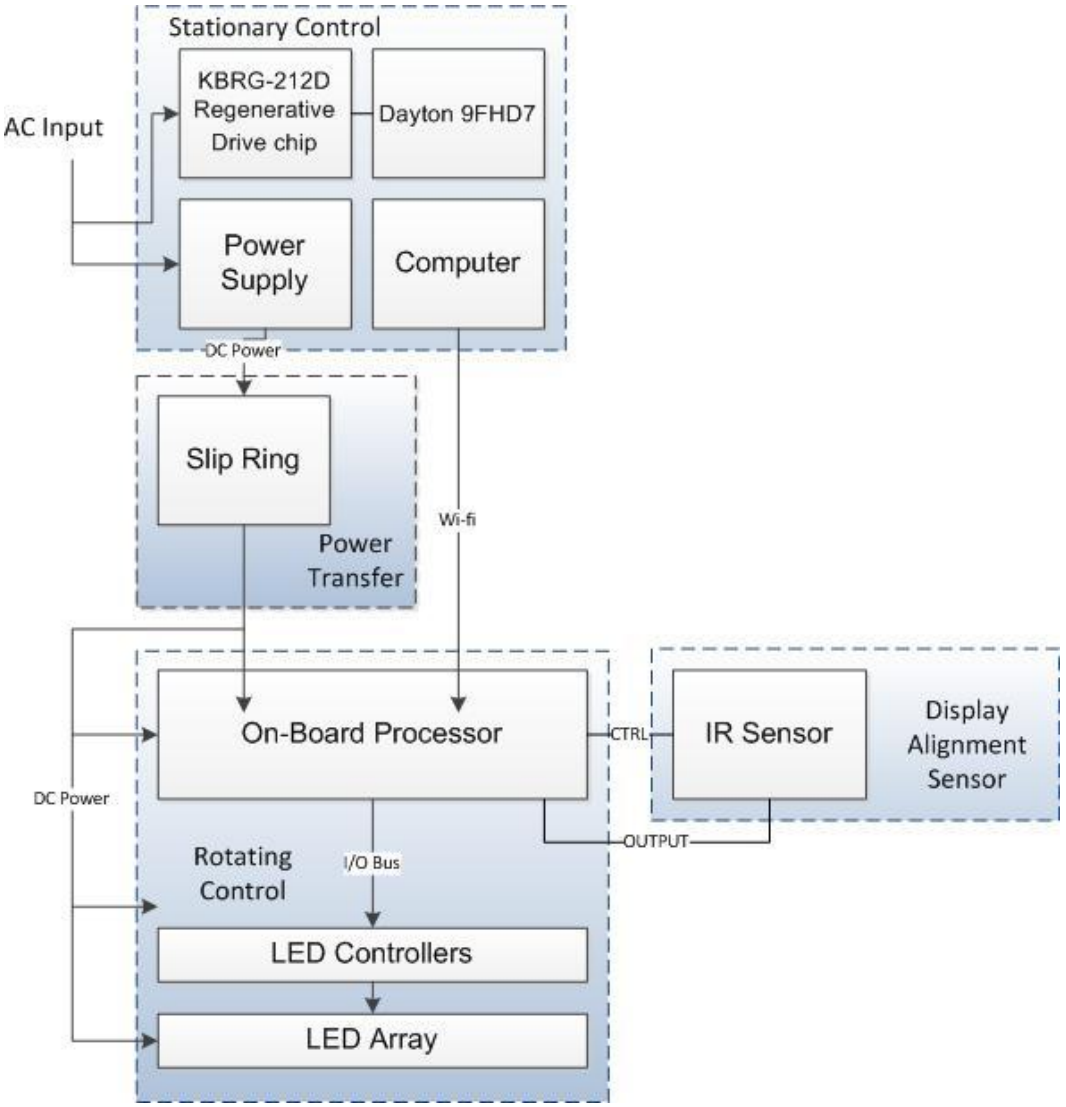
- Computer Interfacing
  - Live program-ability
- High Resolution
  - Capable of displaying complex images and animations.
  - RGB capabilities.
- Portable



Specifications

- 32 RGB LEDs
- 32x384 resolution
- 15-20 fps or 900-1200 rpm
- 18” overall diameter
- 24 in. height
- Less than 100 lbs.
- 120 V AC [Standard US outlet]
- 1-2 Mbits/s wireless data transmission.
- 512 Kb onboard flash memory.

Hardware Flowchart

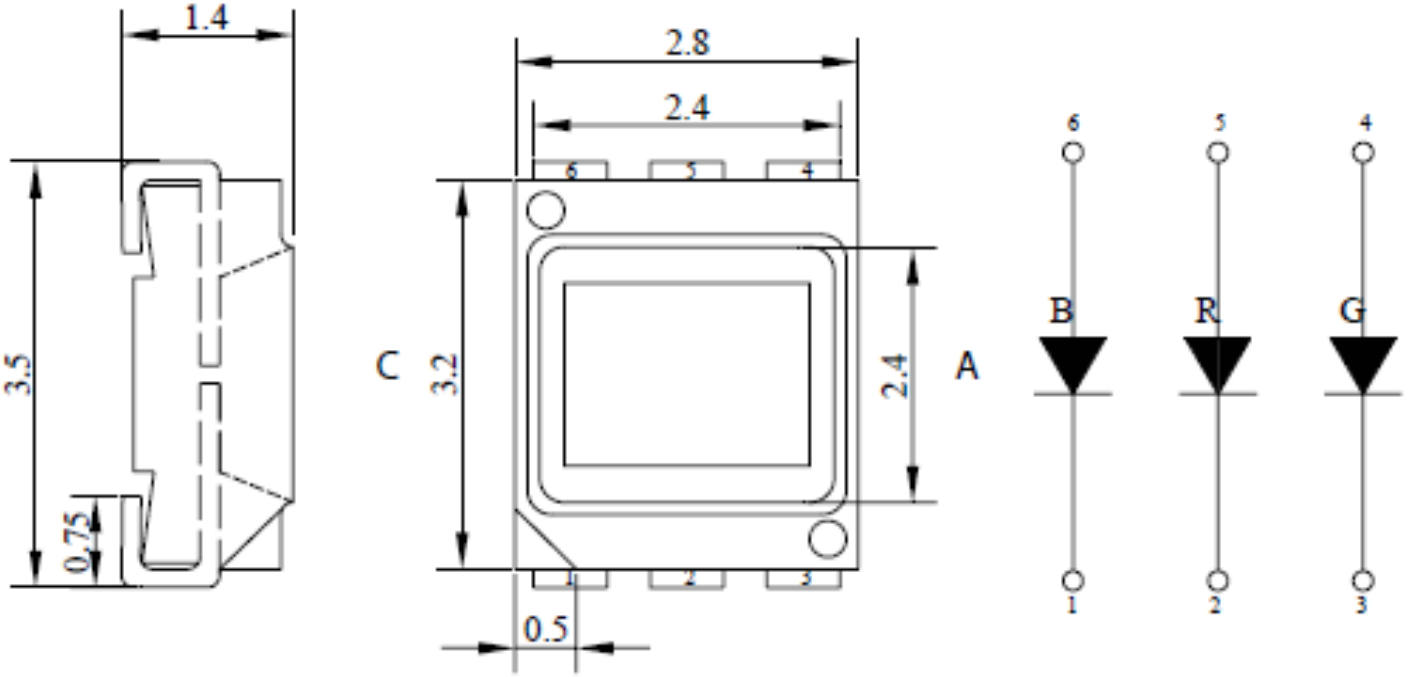


LED Arrays
Main Overview

- Primary LED Array:
  - Used to display the picture
  - Consist of (32) RGB LEDs and (6) LED Controllers
  - Produces an image of (32) pixels x (384) pixels
  - Operates at 3.3 V
- Secondary LED Array:
  - Used to display a text message
  - Text message will appear to “stand off” from the picture being displayed by the Primary LED Array.
  - Consist of (16) Mono-color LEDs and (1) LED Controller
  - Operate at 3.3 V

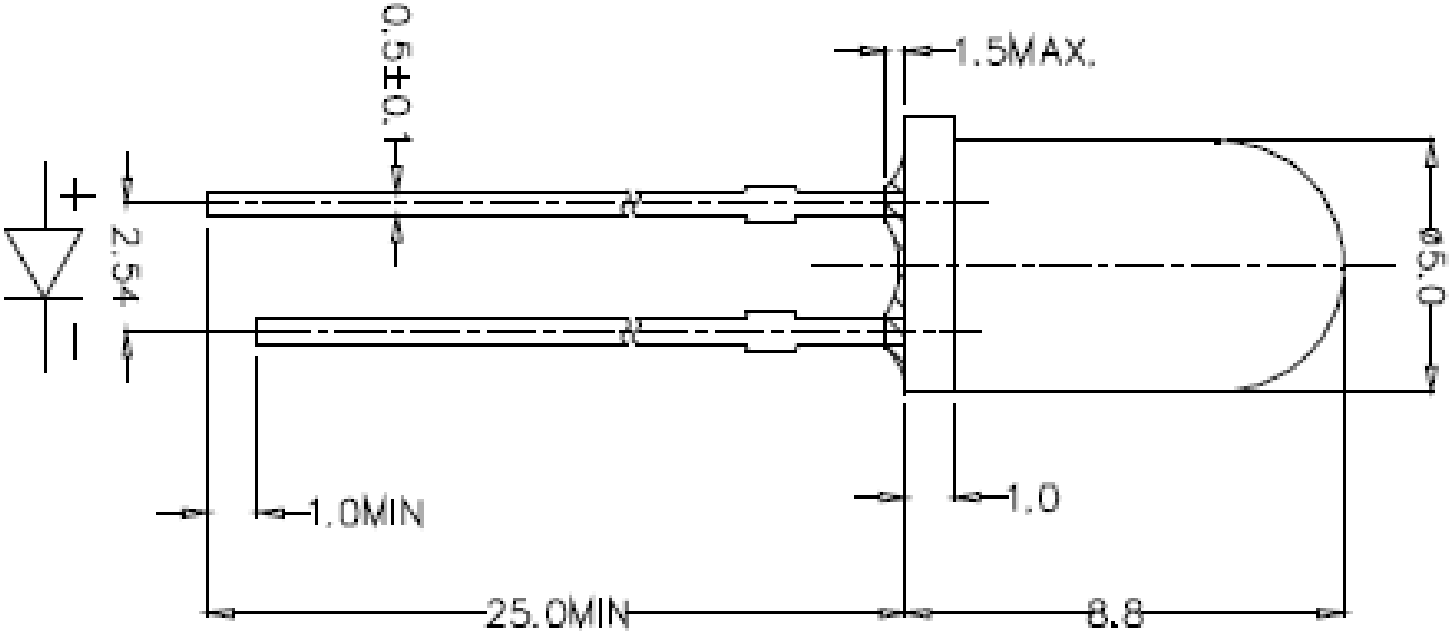
LED Arrays
RGB LED Specifications

- Surface Mount
- Low Profile Package
- Operates at 3.3 V and 30 mA
- Part Number: OVS-3309



LED Arrays
Mono-Color LED Specifications

- Through Hole – T-1 ¾ (5mm) Package
- Green LED
- Operates at 3.3 V and 20 mA
- Part Number: C503B-GAN-CB0F0791

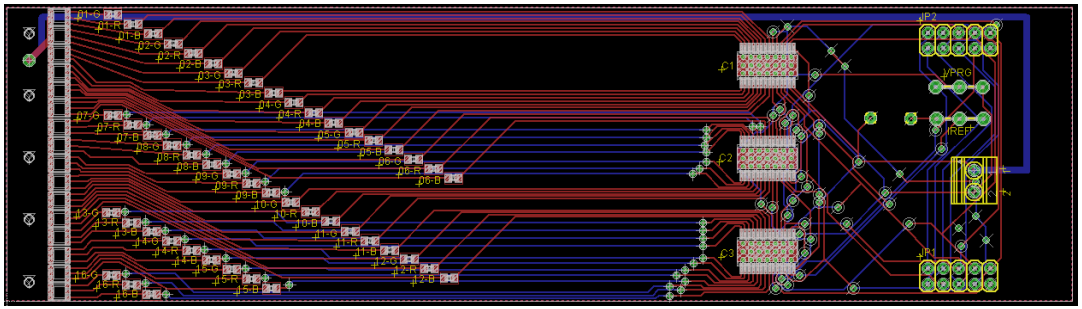


LED Arrays
LED Controllers

- 16 Channel Constant-Current Sink LED Driver
- Each channel has individually adjustable PWM
- PWM has (4096) Steps (12 Bit)
- Drive Capabilities:
  - 0mA to 60mA when Vcc < 3.6 V
- Serial Data Interface
  - Multiple Controllers can be wired in series or cascaded together and use the same output from the microcontroller
- 30MHz Data Transfer Rate
- Part Number: TLC5940PWP (Surface Mount)

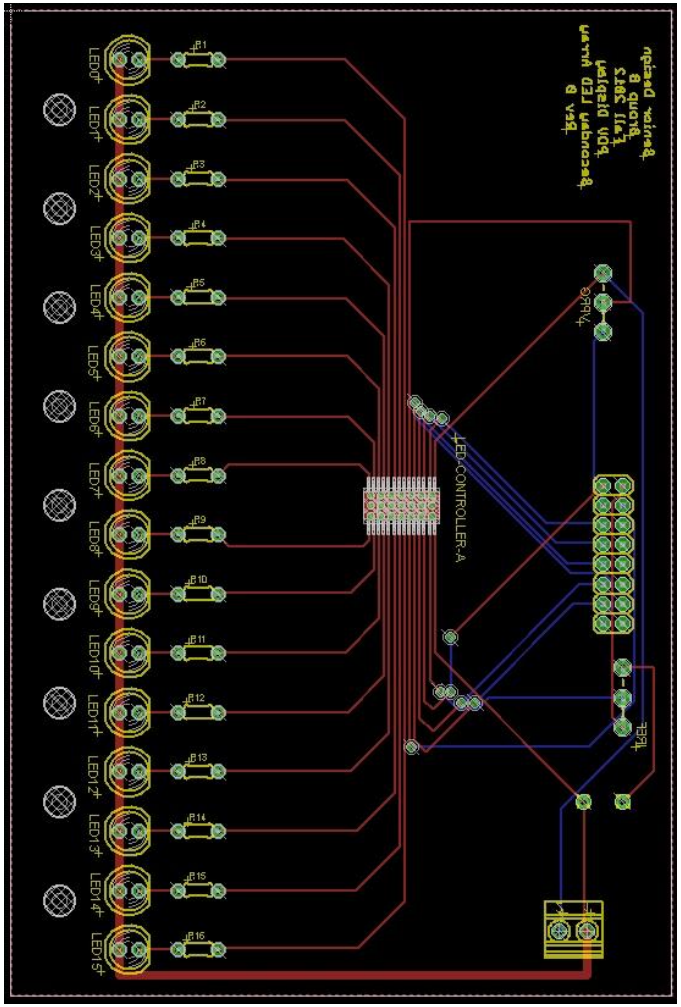
LED Arrays
Primary LED Array Design

- Created module LED arrays that can be pieced together.
- Each module will contain (16) RGB LEDs and (3) LED Controllers
- Each module is identical in design
- Modules have surface mount terminal blocks for jumpering modules together and power supply
- Approximate dimensions of each module will be 1.823” H x 3.00” W



LED Arrays
Secondary LED Array Design

- Similar in design to the Primary LED Array
- Array contains (16) Mono-color LEDs and (1) LED Controller
- Approximate dimensions of module is 4.0” H x 3.00” W



Microcontroller Requirements

- 32 X 384 pixels with 8 bit color.
- 15-20 FPS refresh rate.
- Gray scale data contains 12 bits per color.
- 32 X 384 X 7 X 20 = 1,720,320 bits of data that must be sent to the LED controllers per second.

Microcontroller Requirements

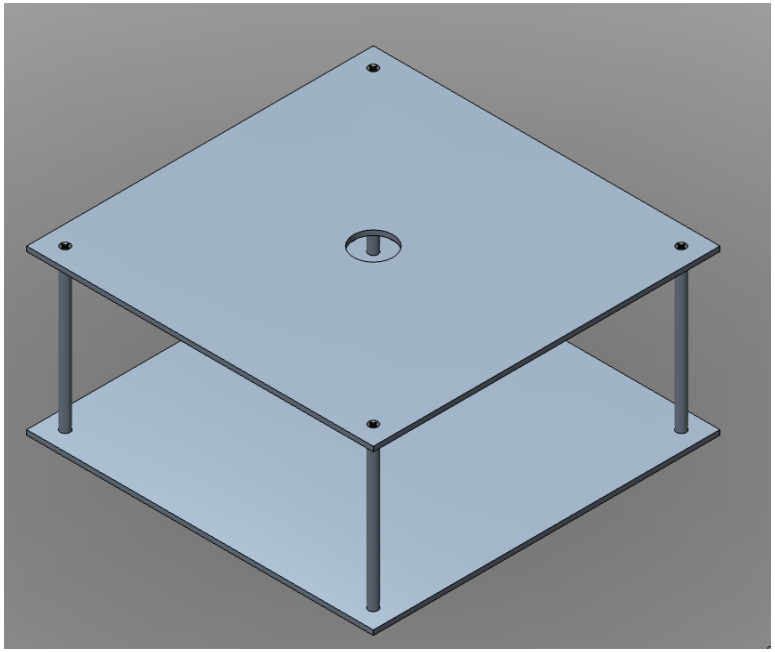
- A single image stored in flash will require 393,216 bits.
- Wi-Fi connectivity to receive a new image.
- An image for the text display requires 1 byte per character.
- Total storage requirement: 399,360 bits

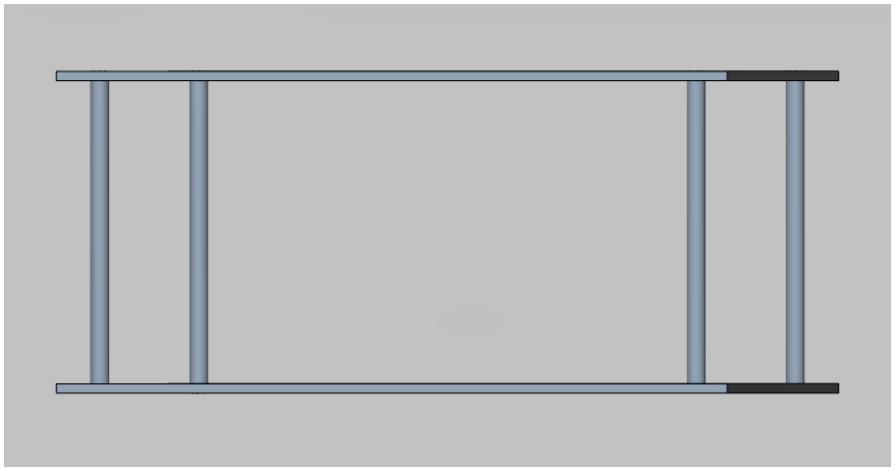
Microcontroller

- chipKIT uc32
- 80 Mhz
- 512K Flash
- 32K SRAM
- 42 available I/O’s

Chassis Design
Chassis Base

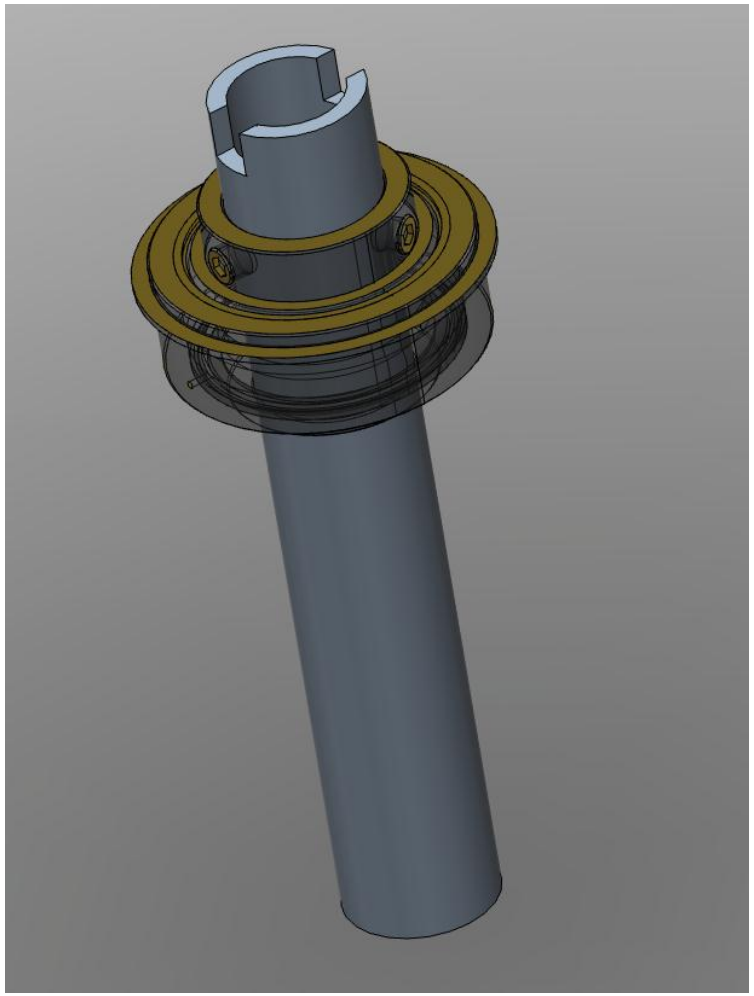
- Constructed from aluminum
- Painted Satin Black
- Open in middle for mounting motor and power supply
- Approximate Dimensions: 18” W x 18” L x 12.5” H





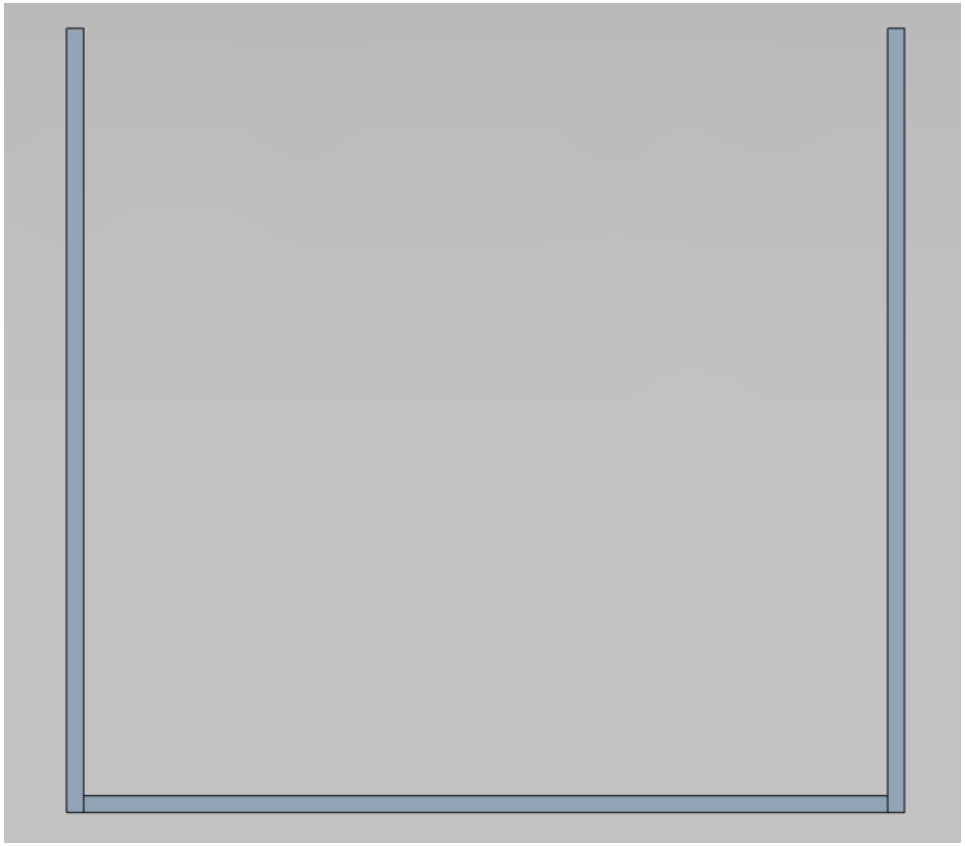
Chassis Design
Rotary Interface

- Extended-Ring Bearing with set screws to secure a pipe to the inner ring of the bearing.
- Bearing to be welded to the top of the chassis base
- Pipe will be notched on top to secure the LED Support Frame



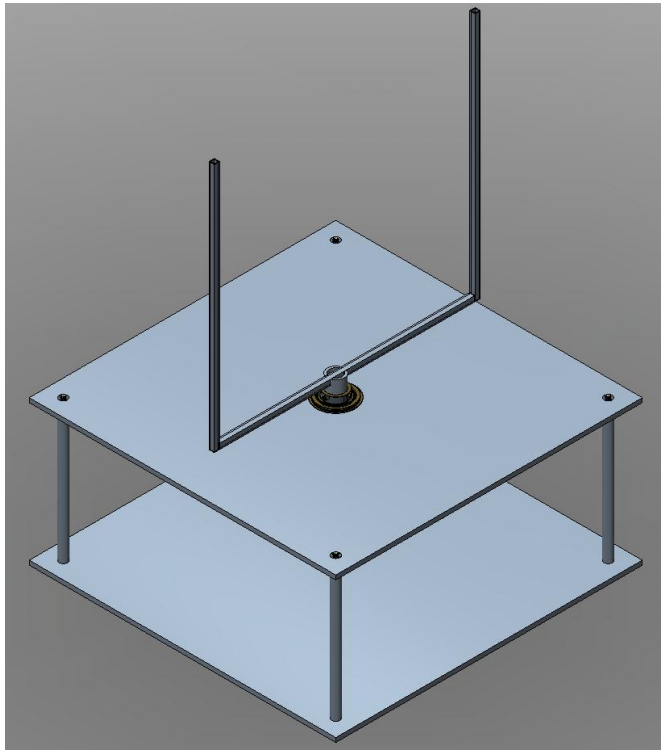
Chassis Design
LED Array Support Structure

- Aluminum flat bar (1/4” x 1/2”)
- Two holes drilled in center to mount frame to pipe.
- Horizontal support frame is longer on one side for the Secondary Text LED Array
- Approximate Dimensions: 12.5” H x 16” W



Chassis Design
Motor Interface

- Mounted the motor directly under the pipe at the center of rotation
- Used set screw to secure pipe to motor shaft.
- Allows for the motor to directly drive the LED array.



Chassis Design
Torque Requirements

Simplified LED Support Structure

$$M1\ (mass\ of\ primary\ LED\ array) = 0.15\ kg$$
$$M2\ (mass\ of\ secondary\ LED\ array) = 0.15\ kg$$
$$R1 = 0.35448\ m\ and\ \ 0.0875\ kg$$
$$R2 = 0.40752\ m\ and\ 0.1125\ kg$$

$$I_{M1} = M1\ x\ R1^2 = (0.15\ kg)x(0.35448)^2 = 0.0188\ kg \cdot m^2$$
$$I_{M2} = M2\ x\ R2^2 = (0.15\ kg)x(0.40752)^2 = 0.0249\ kg \cdot m^2$$
$$I_{R1} = {}^1/_3\ x\ MR1\ x\ R1^2 = (0.333)x(0.0875kg)x(0.35448)^2 = 0.00366\ kg \cdot m^2$$
$$I_{R2} = {}^1/_3\ x\ MR2\ x\ R2^2 = (0.333)x(0.1125kg)x(0.40752)^2 = 0.00622\ kg \cdot m^2$$

$$\sum I = I_{M1} + I_{M2} + I_{R1} + I_{R2} = 0.05358\ kg \cdot m^2$$

Chassis Design
Torque Requirements

Simplified LED Support Structure

$$\sum I = 0.05358\ kg\ \cdot\ m^2$$

$$\alpha = \frac{[(15)x(2\pi)^2]}{[(2)x(1)x(2\pi)^2]} = 7.5$$

$$T = \sum I\ x\ \alpha = 0.402\ N \cdot m$$

Motor Requirements

- The motor needs to be light weight.
- Capable of maintaining 15-20 fps
  - 900 to 1200 rpm
- Low Noise.
- Capable of handling 0.4 N·m of Torque.
- Large motor shaft
  - For mounting LED array directly or in the case of using a pulley system to rotate array.

Motor

- Dayton 9FHD7 DC motor
  - Runs on 90 V, 1.5 A.
  - 1800 rated rpm.
  - 0.49 N·m of torque.
  - Light weight.
  - 0.5 in. shaft diameter.
  - 1.38 in. shaft length.

Motor Control

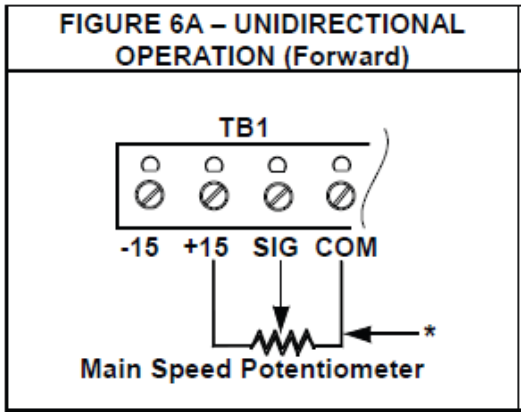
- Limited Functionality minimum
  - Turn on
  - Turn off
  - Maintain
- Duals as a power supply for the motor
- Expandable functionality desired

KBRG-212D Regenerative Drive Chip

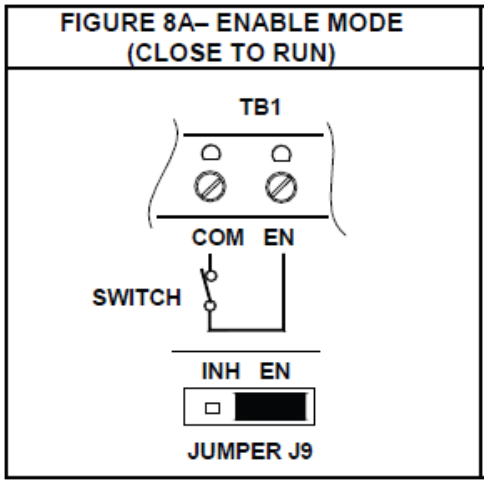
- 115 or 230 VAC
- Multiple driving modes
  - Forward
  - Reverse
  - Bidirectional
- Enable/Inhibit terminal
- Speed or Torque mode
- Both powers and controls

Motor Control Configuration

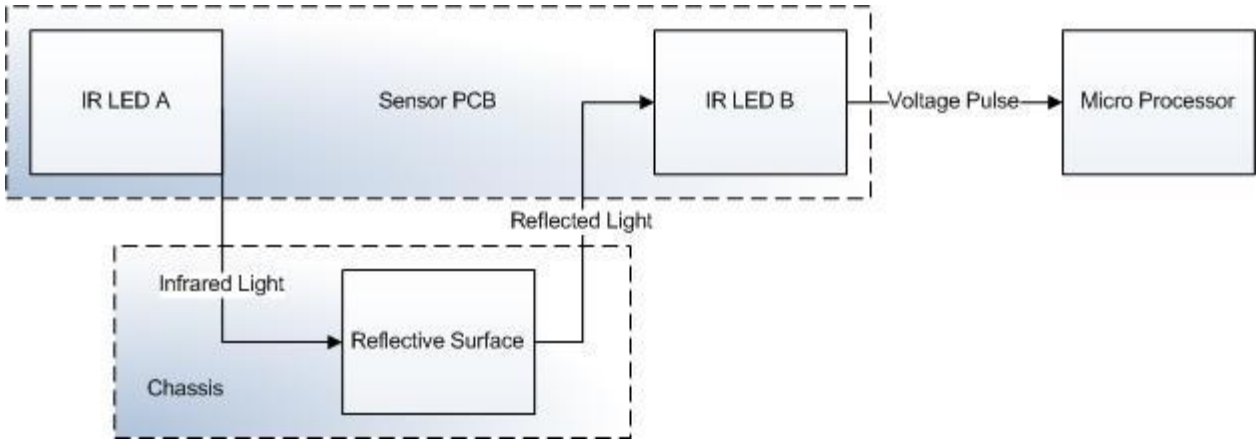
- Forward Unidirectional operation



- Enable Mode Switch

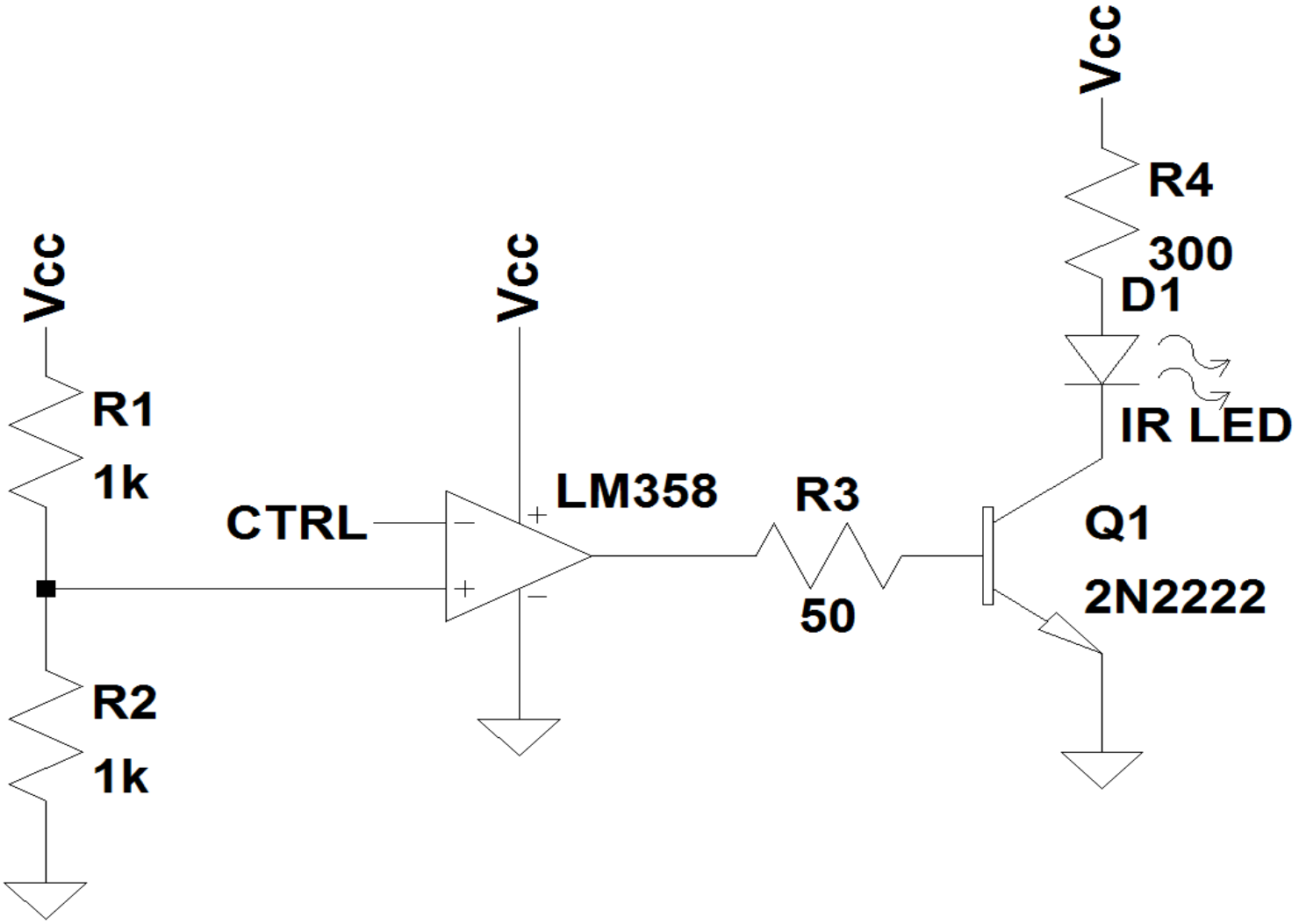


Display Alignment Sensor

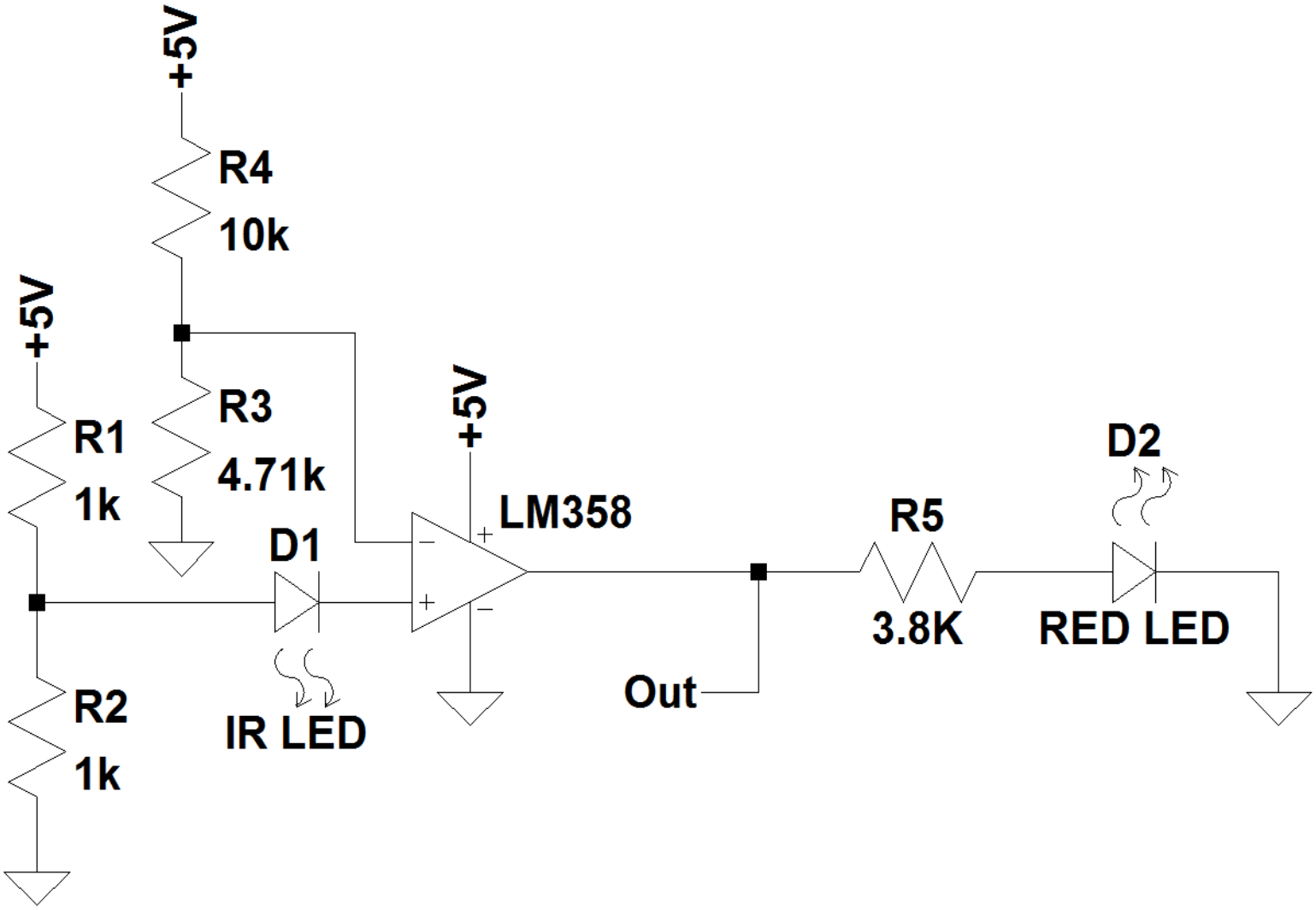


- Works off two IR LEDs and a LM358 Op-amp.
  - Designed around a common principle where LEDs show a voltage drop when light shines on them.
  - Creates a voltage pulse of 3.69 V on the output when the sending LED's light is reflected onto the receiving LED.
  - Both LEDs will be shielded with a black hollow cylinder to help prevent ambient light-noise.

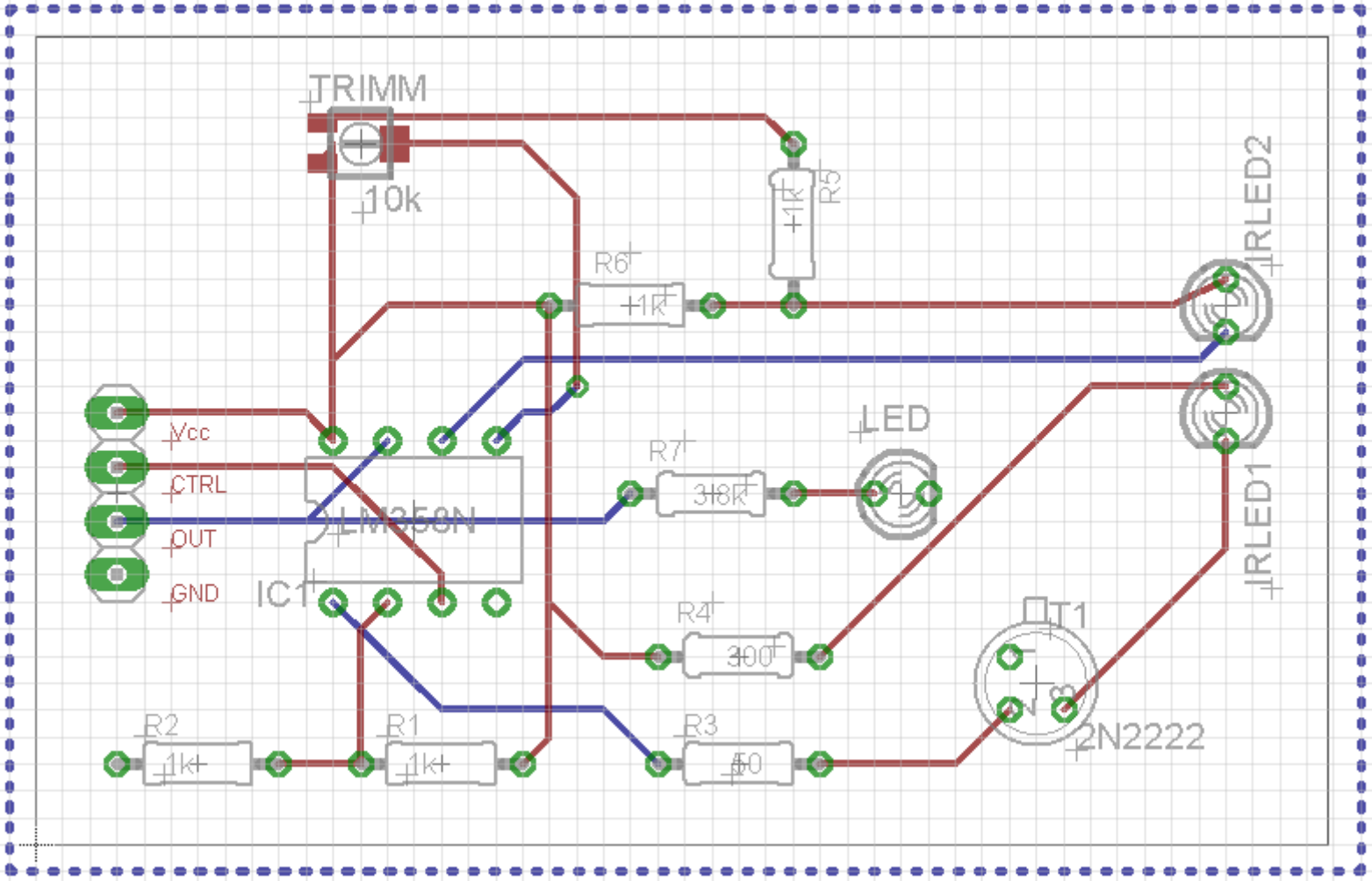
Sender Circuit



Receiver Circuit



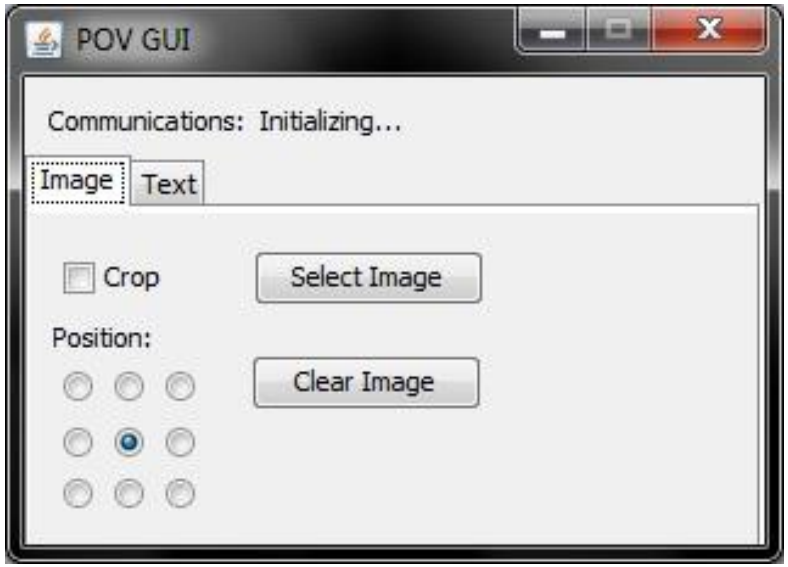
Sensor Board Layout

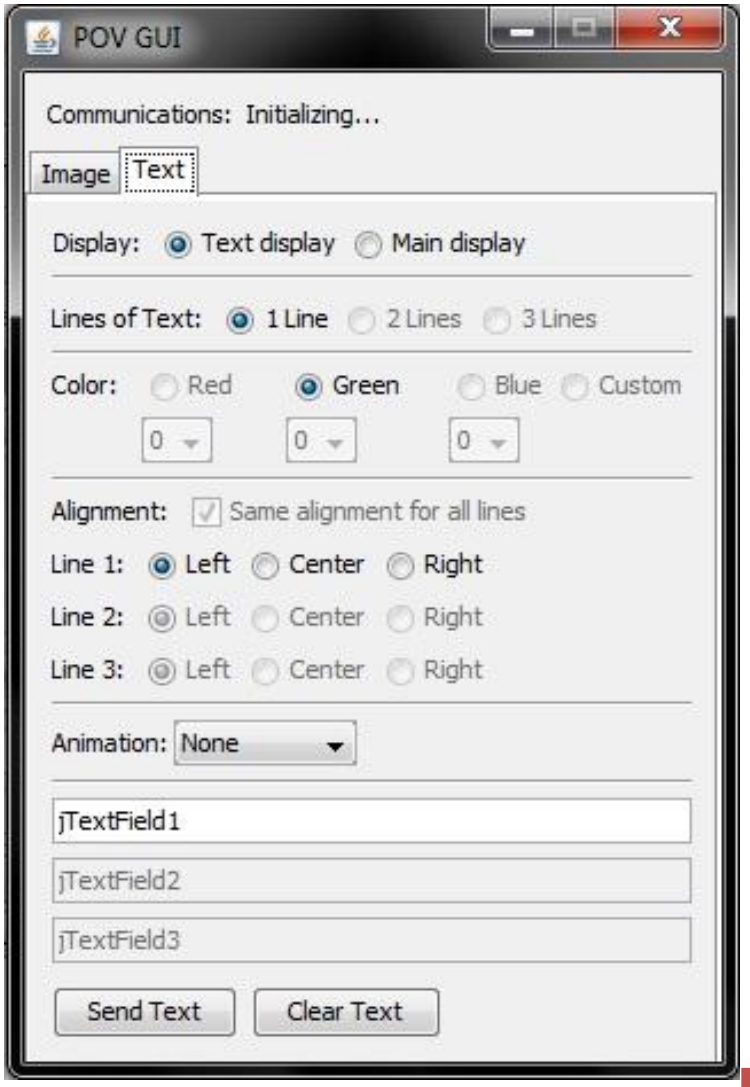


GUI

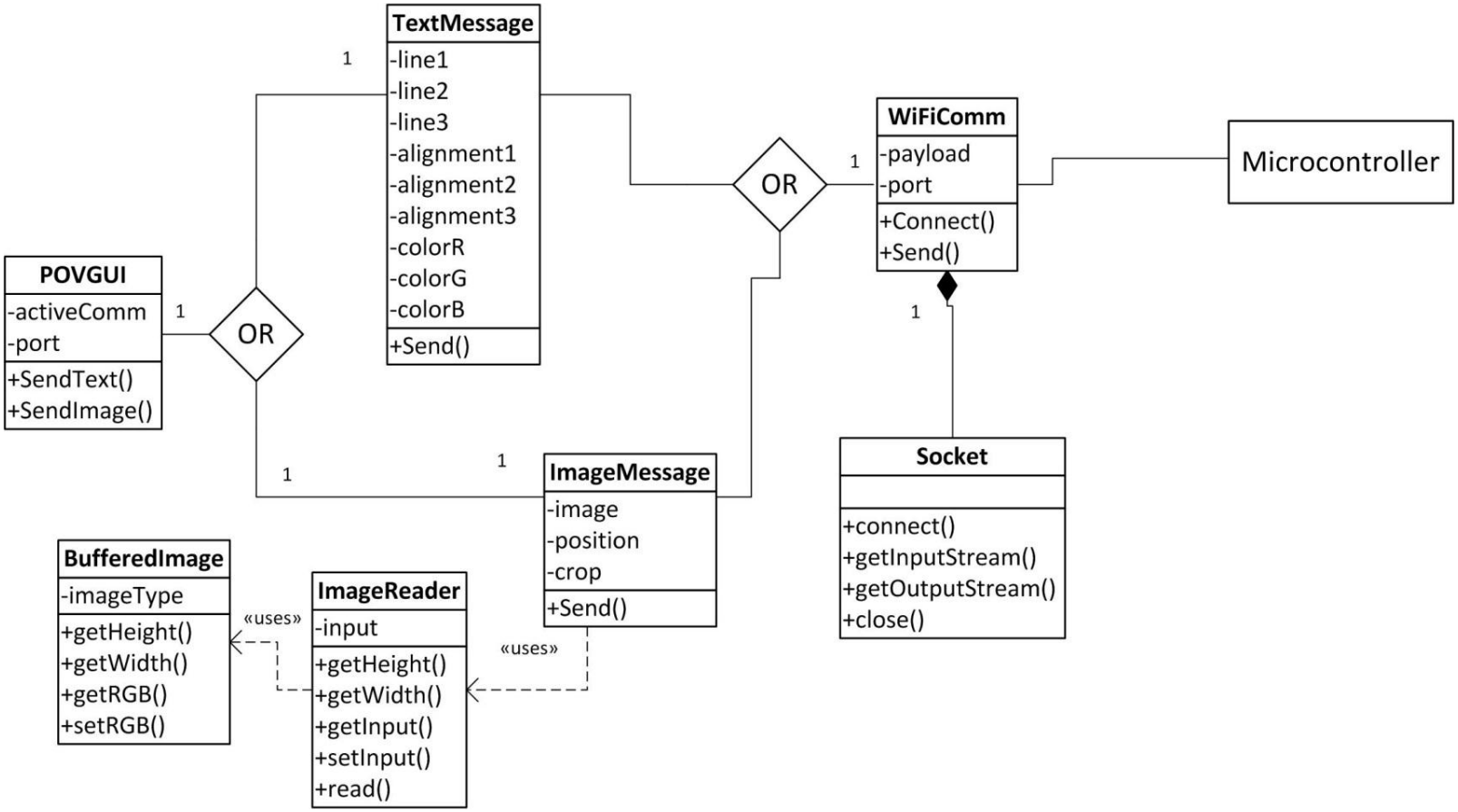
- Easy to use interface
- Allows user to enter a text message or image
- Text: color, animation, and alignment options
- Images: crop, position, and clear options

GUI


POV GUI
Communications: Initializing...
Image
Text
Crop
Select Image
Position:
Clear Image

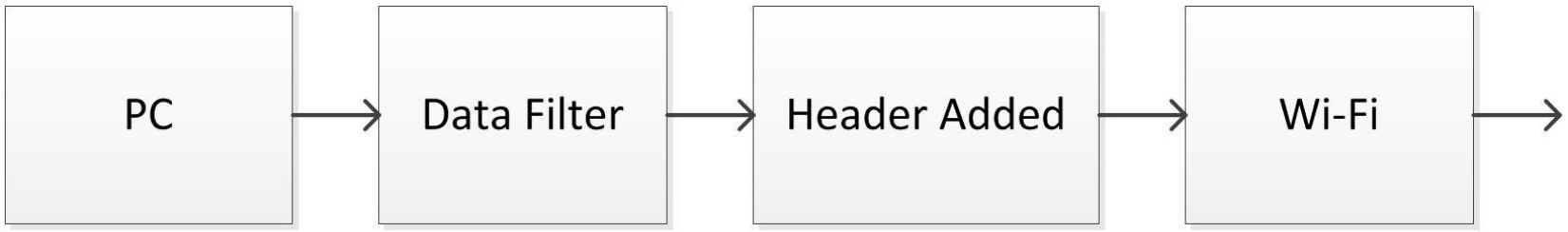

POV GUI
Communications: Initializing...
Image
Text
Display: Text display Main display
Lines of Text: 1 Line 2 Lines 3 Lines
Color: Red Green Blue Custom
0
0
0
Alignment: Same alignment for all lines
Line 1: Left Center Right
Line 2: Left Center Right
Line 3: Left Center Right
Animation: None
jTextField1
jTextField2
jTextField3
Send Text
Clear Text

GUI


TextMessage
-line1
-line2
-line3
-alignment1
-alignment2
-alignment3
-colorR
-colorG
-colorB
+Send()
1
OR
1
WiFiComm
-payload
-port
+Connect()
+Send()
Microcontroller
POVGUI
-activeComm
-port
+SendText()
+SendImage()
1
OR
1
1
1
ImageMessage
-image
-position
-crop
+Send()
Socket
+connect()
+getInputStream()
+getOutputStream()
+close()
BufferedImage
-imageType
+getHeight()
+getWidth()
+getRGB()
+setRGB()
«uses»
ImageReader
-input
+getHeight()
+getWidth()
+getInput()
+setInput()
+read()
«uses»

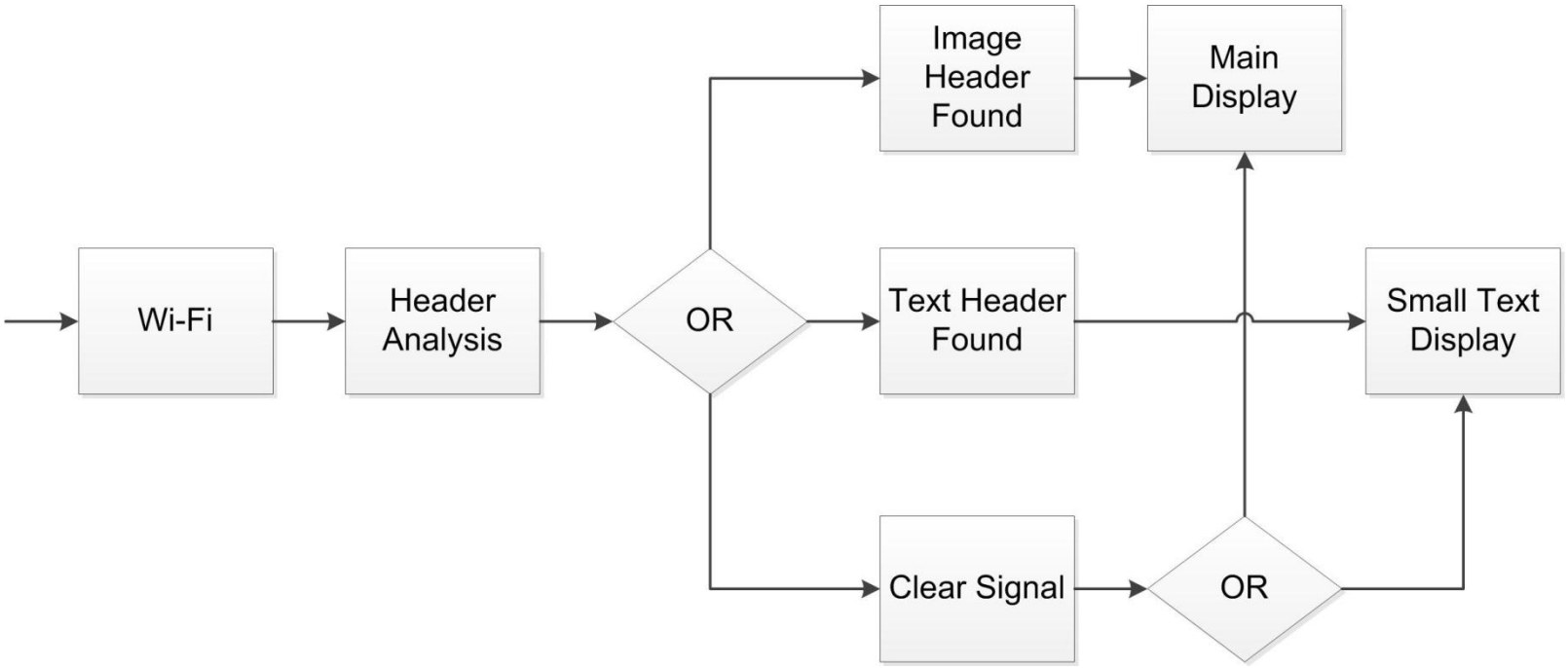
Wi-Fi Client

- PC will connect in ad-hoc mode
- 1-2 Mbps
- TCP protocol
- PC will send formatted data with header



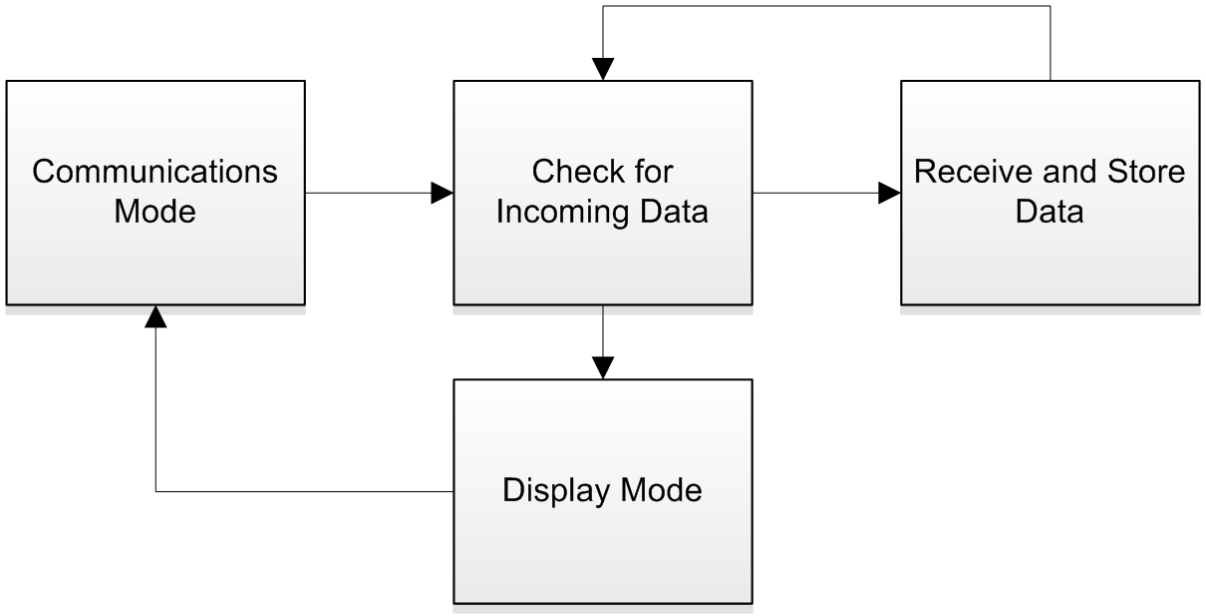
Wi-Fi Server

- chipKIT Wi-Fi shield



Microcontroller Functions

- Communications Mode:
  - Occasional check for incoming data.
  - Receive data and store in memory.
  - Return to Display Mode operations.



Display Mode

- Pin 3 – Grayscale Clock
- Pin 5 – Blank pulse: SPI chip select
- Pin 9 – Latch Pulse
- Pin 11 – Data Line: SPI data
- Pin 13 – SCLK: SPI Clock
- Timer 1 operating at 5 MHz OC for GS
- Timer 2 operating at 1220 Hz OC for BLNK/XLAT

Control Loop using Sensor Input

- The sensor triggers an interrupt in the microcontroller on Pin 7
- Parse character array, obtain column of data from font table
- Edit the data output buffer, and call update which will allow the XLAT and BLANK signals to pulse.

Power Requirements

- Main LED array Power Draw:
  - 90 mA * 3.3 V * 32 LEDs = 9.5 W
- Secondary LED array Power Draw:
  - 20 mA * 3.2 V * 16 LEDs = 1.024 W
- On board Micro-controller Power Draw:
  - 75 mA * 3.3 V = 0.2475 W
- Total Power Draw: 10.77 W

Power Supply

- Powered using standard AC outlet (120 V, 60 Hz)
- Motor controller receives AC at 120 V
- Primary LED Array receives 3.3 V DC through slip ring from separate power supply.

Slip Ring

- The slip ring will consist of two separate copper washers attached to the shaft of the LED apparatus.
  - Insulating material will separate the shaft and the washer from direct contact.
  - One washer will act as the positive feed while the other washer will act as the negative feed.
- A mounted copper wire with a frayed end will create the contact to the outer wall of the washer.
- A hole will be bore through at a point on the inner wall of the copper washer
  - A wire will be connected here and threaded up through the LED apparatus' shaft to the micro-controller and LEDs.

Project Cost

Description	Quantity	Cost (per unit)	Price
Primary LEDs	32	$1.51	$48.32
Green LEDs	16	$0.27	$4.32
LED Controllers	7	$2.52	$17.64
KBRG 212D	1	$106	$106
Motor	1	$35.00	$35.00
Chassis	1	-	Donated
On-board Controller	1	$34.99	$34.99
Wireless Chip	1	$49.99	$49.99
PCB	-	-	$300.00
Misc. Equipment	-	-	$150.00
Prototyping	-	-	$200
		Total:	$946.26

Questions?