EEE3099F

Milestone 1: Report

Group 12

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GitHub Repository

Circuit Diagram:

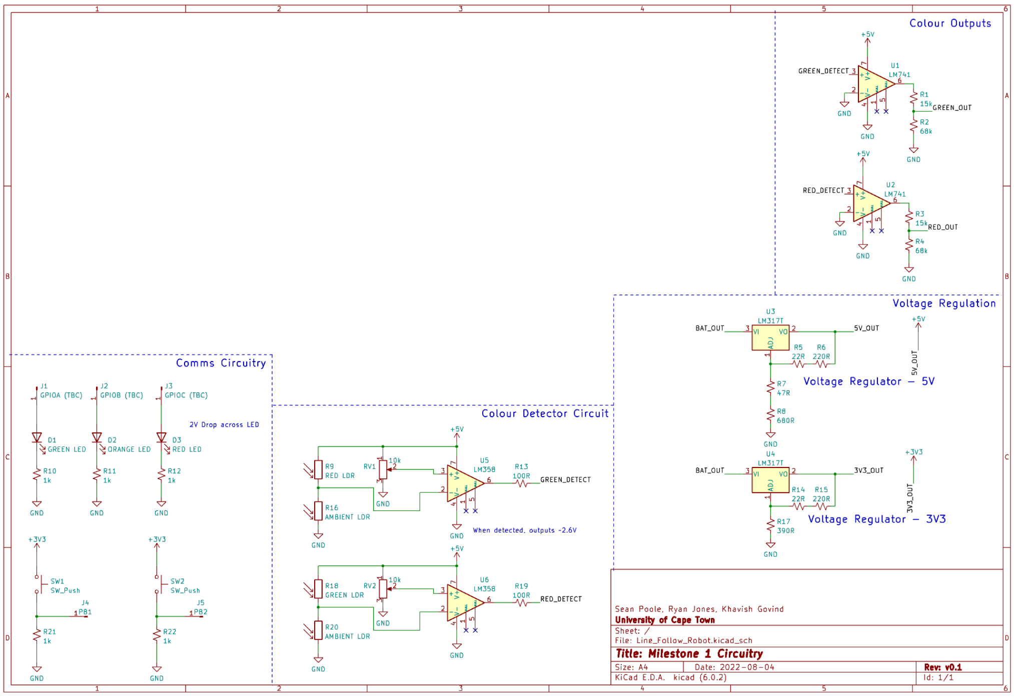


Figure 1: Veroboard Schematic v0.1

Bill of Materials:

Part Name	Part Number	Reference	Quantity	White Lab Ref.	Value
Op-Amp	1	U1, U2	3	LM741	LM741
Op-Amp	2	U3, U4	3	LM317T	LM317T
Op-Amp	3	U5, U6	3	LM358	LM358
Resistior	4	R10, R11, R12, R21, R22	10	1k ohm	1kΩ
Resistor	5	RV1, RV2	4	10k ohm	10KΩ
Resistor	6	R17	2	390 ohm	390R
Resistor	7	R5, R14	4	22 ohm	22R
Resistor	8	R6, R15	4	220 ohm	220R
Resistor	9	R8	2	680 ohm	680R
LDR	10	R9, R16, R18, R20	8	LDR	LDR
Green LED	11	D1	2	Ultra Bright LED(green)	Green
Orange LED	12	D2	2	Ultra Bright LED(orange)	Orange
Red LED	13	D3	2	Ultra Bright LED(red)	Red
Push Button	14	SW1, SW2	4	CD37	Push Button
Potentiometer	15		3	Potentiometer	10k - 20k
VeroBoard	16	N/A	2 (10cm x 5cm)	VeroBoard	VeroBoard
Green Film	17	N/A	1	Green Film	GreenFilm
Red Film	18	N/A	1	Red Film	RedFilm

Figure 2: BOM v0.1

Calculations:

3.3V Output Voltage Divider:

The LM741 Op-Amp outputs 4.02V when a high input is detected on the positive pin. This voltage needs to be reduced to 3.3V, and a simple voltage divider was used to achieve this. To calculate the appropriate resistor values, the following equation was used:

$$V_{out} = V_{in} \cdot \left(\frac{R_2}{R_1+R_2}\right)$$

Where V_{in} is the output of the LM741. Setting $R_1 = 15k\Omega$, allowed R_2 to be determined.

$$3.3V = 4.02V \cdot \left(\frac{R_2}{15k+R_2}\right)$$

$$\frac{55}{67}(15k + R_2) = R_2$$

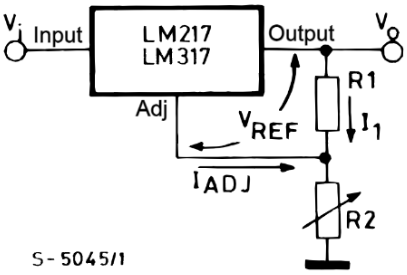
$$\therefore R_2 = \frac{\frac{55}{67} \cdot 15k}{1 - \frac{55}{67}} = 68.75k\Omega$$

LM317T Resistor Values:

The **LM317T** is an adjustable voltage regulator that has an input voltage range of 3-40V. The voltage regulator can be adjusted using resistor values to output a voltage between 1.2V and 37V. The resistor values for the desired output voltage are calculated using the following formula:

$$V_{out} = 1.25 \cdot (1 + \frac{R_2}{R_1})$$

Where R_1 and R_2 are the corresponding resistor values in the example circuit, shown below in **Figure 3**, from the **datasheet**.



[1]

Figure 3: Adjustable voltage regulator circuit

The recommended value for R_1 from the datasheet is 240Ω, however, this value can be adjusted up to $1k\Omega$. This formula and configuration was used for both the 3.3V and 5V regulator to determine the correct resistor values for R_2 for the desired voltage output.

3.3V Regulator	5V Regulator
$V_{out} = 1.25 \cdot (1 + \frac{R_2}{R_1})$ $3.3V = 1.25 \cdot (1 + \frac{R_2}{242})$ $\therefore R_2 = 396.88\Omega$	$V_{out} = 1.25 \cdot (1 + \frac{R_2}{R_1})$ $5V = 1.25 \cdot (1 + \frac{R_2}{242})$ $\therefore R_2 = 726\Omega$

Component Selection:

For the voltage regulators, the calculated resistor values do not match physically realisable resistor values available in White Lab. Therefore, the following values were chosen for R_2:

- 3.3V Regulator R_2 value: 390Ω

[1] *1.2V to 37V adjustable voltage regulators*, LM317, Rev. 22, STMicroelectronics, 2021. [Online]. Available: https://www.st.com/resource/en/datasheet/lm217.pdf

- 5V Regulator R_2 value: 727Ω, made using 680Ω & 47Ω resistors in series

For the Colour Output circuit, two Op-Amps in a basic comparator setup were used to output HIGH or LOW depending on the detected colour. These Op-Amps were chosen as the LM741 as they operated correctly when testing and designing the circuitry in White Lab. As these Op-Amps operate on a 5V supply, a 5V voltage regulator was required.

Through testing the circuit, the output of the LM741 was seen to be ~4.02V when a high input was detected on the positive pin of the Op-Amp. Therefore, a voltage divider was added to the output to regulate this voltage down to the desired 3.3V output. These resistor values are calculated in the **Calculations sub-section**.

Again, due to the calculated resistor values not matching physically realisable resistor values available in White Lab, a resistor value of $68k\Omega$ was chosen for R_2 in the voltage divider for the Colour Outputs circuit.

For the colour detector potentiometer, the range of this was determined experimentally in White Lab by testing the circuit. The best value was determined to be a potentiometer with a range of $10k\Omega - 20k\Omega$.

The BOM states that the LEDs are meant to be bright LEDs. However, White Lab did not have them, and replaced them with normal LEDs.

For the push button circuits and the LED circuits, the values of the resistors were chosen such that the current through them would be low, thus using less power. Since these resistors do not play a large role in the working of the circuit, the value of the resistors is not required to be a certain value.

Working Circuit:

Unfortunately, the Voltage regulator was shorting during the demo, so the overall circuit was not outputting the correct HIGH values, but the sensor was detecting light changes correclty, but it outputted a lower voltage than the 3.3V.

The push buttons were orientated incorrectly, and as such, they didn't work during the demo. The LEDs worked whilst connected to a 3V3 line from a multimeter, and the figure below shows an LED on whilst being provided with 3V3 from a bench power supply.

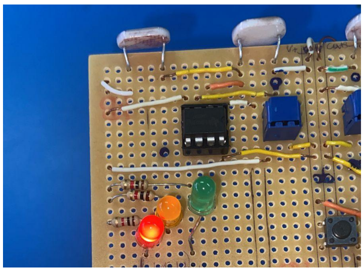


Figure 4: Working LEDs

Contribution:

Note: All team members contributed where they could to try and get an equal amount of contribution from everyone.

Contribution:	**Member:**
Sensor Circuit Design	All 3 members contributed, but Ryan Jones and Khavish Govind contributed more.
Communication Circuit Design	Sean Poole
Soldering	Khavish Govind
BOM	Sean Poole
Circuit Diagram	Ryan Jones
Report Writing	Sean Poole and Ryan Jones