Contents

1 Introduction

Parking lot access control systems are used to allow the authorized vehicles into an area. Although most of these systems only validate the identity of the user, an upgraded version can be achieved by including a check for the availability of empty spaces

These systems have two main parts: a sensory system, and a control unit. Both are located at the parking lot. The systems include light sensors, parking space availability indicators, detectors etc.

The working principle of such a system is as follows: First, the vehicle approaches the access control unit which is proximity-activated, after which it checks the the ID signal transmitted by the vehicle via radio frequency; in addition, it also checks the sensory system to see whether there is available parking space or not. If and only if both these conditions are satisfied, an opening signal is sent to the barrier, which closes after the vehicle has passed; otherwise, the barrier remains closed.

The access control unit is comprised of:

A Proximity Sensor, which senses an approaching vehicle and activates the ID detector and following subblocks

An ID Detector, which checks to see whether the vehicle's ID is authorized or not and informs the decision unit

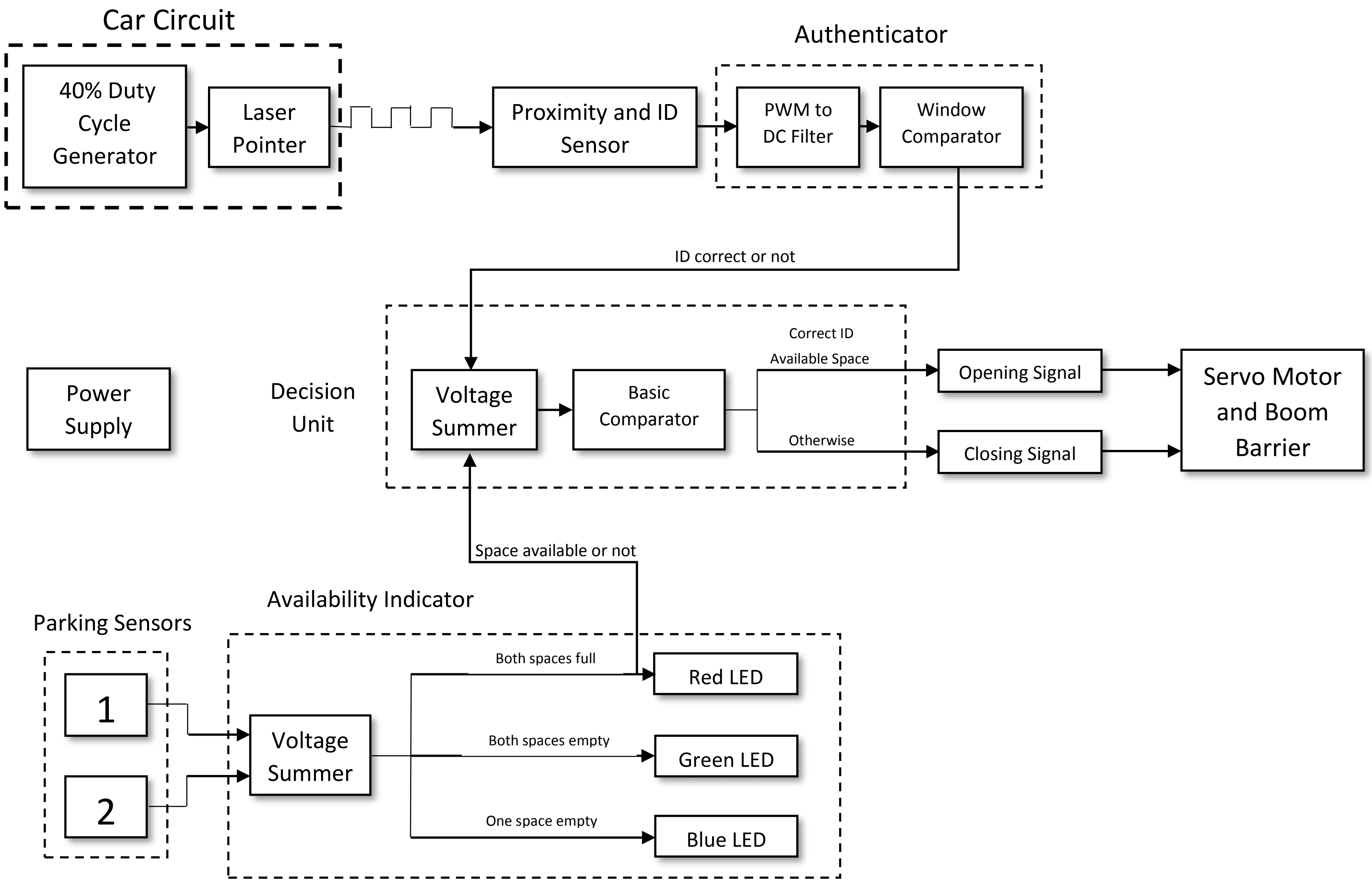
An Availability Indicator, which shows the availability of parking spaces, with coloured LEDs or a segmented display

A Decision Unit, which checks both inputs and decides if the barrier will open or not

An Entrance Barrier, which remains closed or is lifted in according to the output of the decision unit

Our aim as students of Electrical and Electronics Engineering, is to design such an Analog Parking Lot Access Control System in accordance with the specifics stated above, trying to design and assemble an operational circuit, while also trying to achieve minimum power consumption and maximum cost efficiency.

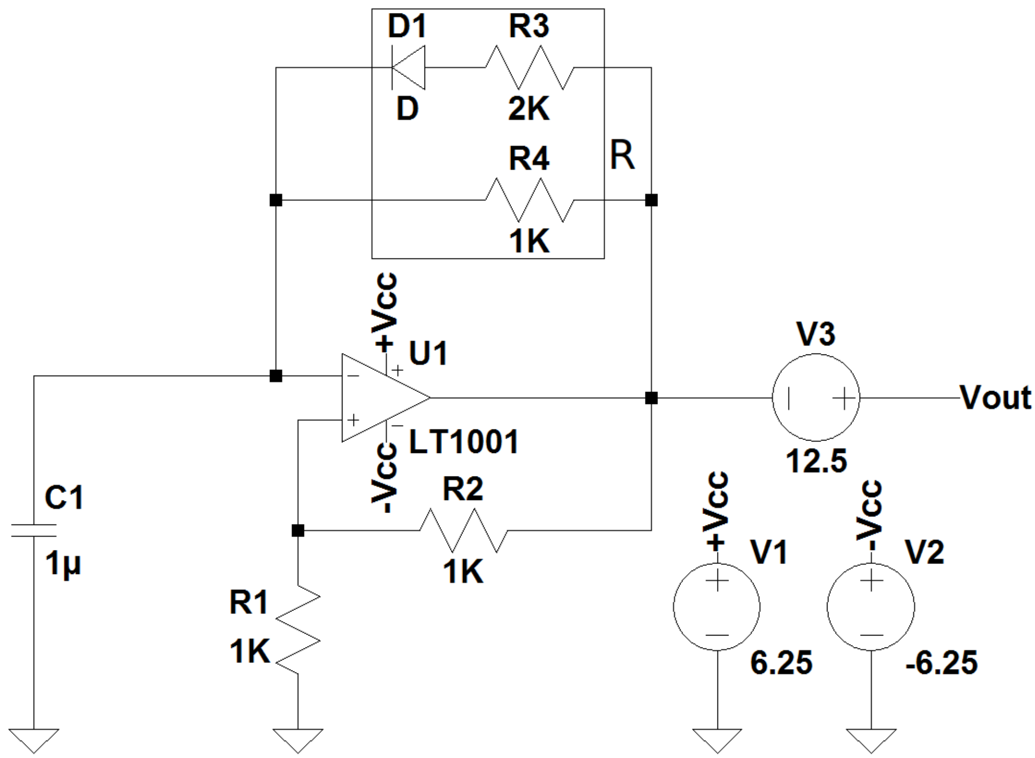
2. Parking Lot Access Control System Design Block Diagram



3 Operation of Subblocks

3.1 Duty Cycle Generator

Figure 1: Duty Cycle Generator



The ID Generator circuit is constructed separately from the rest of the circuit, and its output is fed to a laser pointer modified to take voltages from cables.

First we focused on creating a simple square wave generator; that is, the circuit we obtain when we replace the elements inside the rectangular box with a single resistor of resistance R. Referring to the elements by their names in the picture and setting $V_3 = 0$, by first using voltage division on R_1 and R_2 we get the following:

$$V_+ = V_{out} \cdot \frac{R_1}{R_1 + R_2} \tag{1}$$

Name $\dfrac{R_1}{R_1 + R_2}$ as λ. After that, we find the current i_R going through the resistance R:

$$i_R = \frac{V_{out} - V_-}{R} \tag{2}$$

Doing our analysis with an ideal infinite-gain op-amp model, we can say that $i_+ = i_- = 0$, so the current i_R is also the current that is charging the capacitor C_1, and we can say $i_R = i_c$, also note that $V_- = V_c$. So if we assume $V_{out} = E_s$, the positive saturation voltage for this case, this implies that $V_- < V_+$ which is equivalent to $V_c < \lambda E_s$. This means the capacitor will be charged until $V_- > V_+$, meaning $V_c > \lambda E_s$ at which point V_{out} will instantly flip to $-E_s$, after which it will discharge until $V_c < -\lambda E_s$, and this cycle will go on forever [1]).

Now we need to find what factors the period of the generated wave, T, depends on. For this, we analyze the time it takes for the capacitor to go from a fully negatively charged state, to the charges state where it flips the output voltage. Calling the charging time t_c, we set our conditions as $V_c(0) = -\lambda E_s$ and $V_c(t_c) = \lambda E_s$. Beginning with 2 and using the capacitor terminal equation:

$$i_R = \frac{V_{out} - V_-}{R} \tag{3}$$

$$i_c = \frac{dV_c}{dt} \tag{4}$$

$$i_c = i_R \tag{5}$$

$$\frac{dV_c}{dt} = \frac{V_{out} - V_-}{R} \tag{6}$$

$$DV_c = \frac{1}{RC}V_{out} - \frac{1}{RC}V_c \tag{7}$$

We get a typical first order circuit differential equation. The solution is omitted to keep the report brief, as well as because we know the quick solution by heart:

$$V_c(t) = V_c(\infty) + (V_c(0) - V_c(\infty))e^{-\frac{t}{RC}} \tag{8}$$

$$= \lambda E_s + (-\lambda E_s - \lambda E_s)e^{-\frac{t}{RC}} \tag{9}$$

$$= \lambda E_s(1 - (1 + \lambda)e^{-\frac{t}{RC}}) \tag{10}$$

From here we can calculate the time it takes for the capacitor to charge to our chosen voltage using again the terminal equation:

$$V_c(t) = V_c(t_0) + \frac{1}{C}\int_{t_0}^{t} i(t')dt' \tag{11}$$

$$V_c(t_c) = V_c(0) + \frac{1}{C}\int_{0}^{t_c} i(t')dt' \tag{12}$$

$$\lambda E_s = -\lambda E_s + \frac{1}{C}\int_{0}^{t_c} \frac{(E_s - V_c(t'))dt'}{R} \tag{13}$$

$$2\lambda C E_s = \int_{0}^{t_c} \frac{E_s(\lambda+1)e^{-\frac{t'}{RC}}dt'}{R} \tag{14}$$

$$2\lambda RCE_s = E_s(\lambda+1)\int_{0}^{t_c} e^{-\frac{t'}{RC}}dt' \tag{15}$$

$$\frac{2\lambda}{\lambda+1}RC = RC(1 - e^{-\frac{t_c}{RC}}) \tag{16}$$

$$1 - \frac{2\lambda}{\lambda+1} = e^{-\frac{t_c}{RC}}) \tag{17}$$

$$t_c = RC\ln\frac{1+\lambda}{1-\lambda} \tag{18}$$

From 18 we can understand that for an invariant λ, the variables that affect our period are R and C, and the simplest way to increase our period is increasing R. It However, the generated duty cycle will always be 50%, as the charge time is the same as the discharching time. An easy way to make the circuit generate a chosen duty cycle is to have a charging resistance, which we will call R_c, different than the discharging resistance R_d by making use of diodes to control the charging and discharging resistances, and the period will be the total of both. In that case we can find:

$$t_c = R_cC\ln\frac{1+\lambda}{1-\lambda} \tag{19}$$

$$t_d = R_dC\ln\frac{1+\lambda}{1-\lambda} \tag{20}$$

$$\frac{t_c}{t_d} = \frac{R_c}{R_d} \tag{21}$$

$$T = t_c + t_d \tag{22}$$

$$\frac{D}{100} = \frac{t_c}{T} = \frac{R_c}{R_c + R_d} \tag{23}$$

This is the principle we applied when creating our circuit, having $\lambda = \dfrac{R_1}{R_1 + R_2} = 0.5$

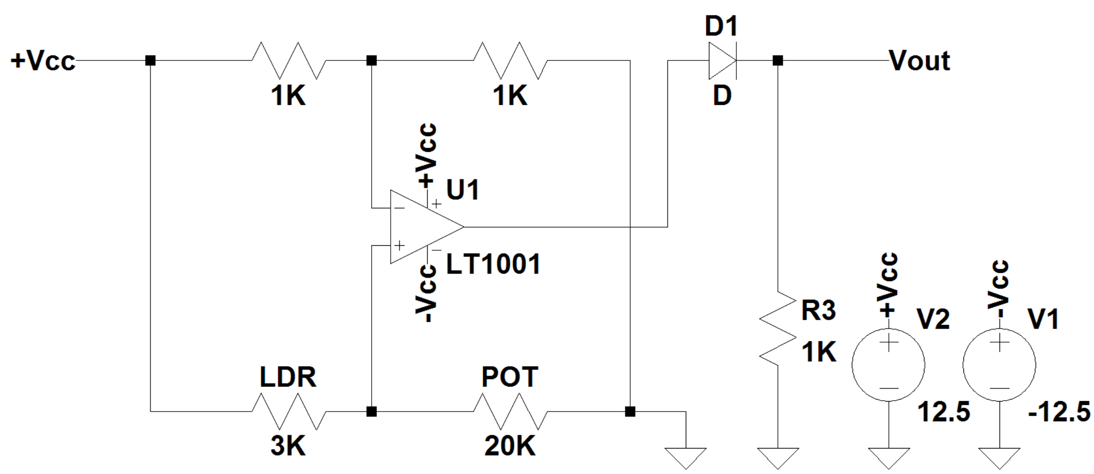
with $R_c = (2\ \text{k}\Omega$ and $R_d = 3\ \text{k}\Omega$, so $D = 100 \cdot \dfrac{R_c}{R_d} = 100 \cdot \dfrac{2}{5} = 40\%$, with our period being:

$$T = t_c + t_d = (R_c + R_d)C \ln \frac{1+\lambda}{1-\lambda} = (5\ \text{k}\Omega \cdot 1\ \mu\text{F}) \ln \frac{1.5}{0.5} = 5.49\ \text{ms} \tag{24}$$

The reason for having put an offset at the end is that we want the voltage fed to the pointer to be always positive so that it emits light constantly, but its intensity changes nonetheless so that the sensor can receive this duty cycle by switching between on and off states.

3.2 Proximity Sensor

Figure 2: Proximity Sensor



The proximity sensor is supposed to sense when a vehicle is closer than a predetermined distance (15 cm for our case). Afterwards, due to the changing laser intensity, it goes between an on and off state and generates the predetermined duty cycle fed to the laser, which then goes to the ID detector.

To sense the approaching vehicle, we use a simple light sensor. Its working principle is quite simple. By voltage division,

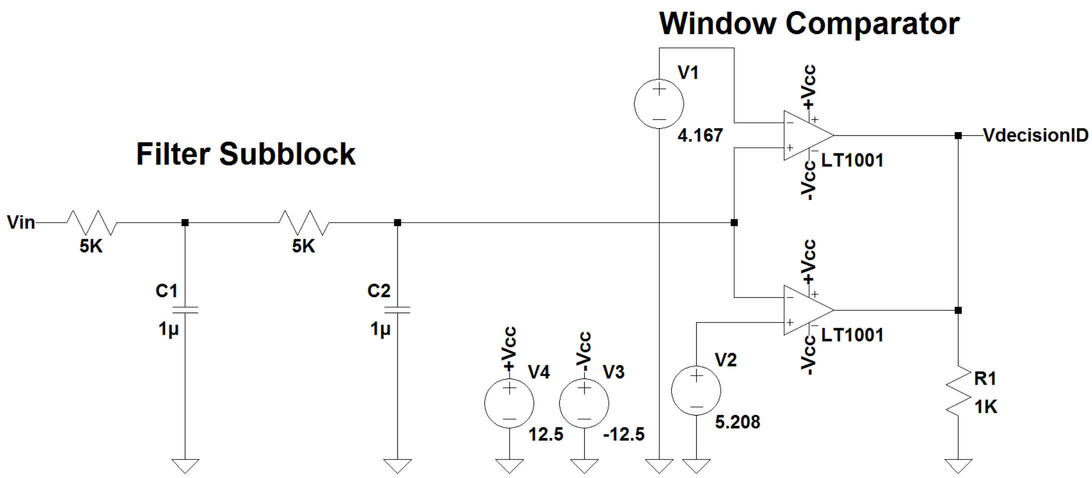
$$V_- = E_s \cdot \frac{1\text{k}\Omega}{1\text{k}\Omega + 1\text{k}\Omega} = \frac{E_s}{2} \tag{25}$$

Looking below, when light falls on the LDR, we want its resistance R to be smaller than the resistance of the potentiometer, and higher when no light falls on it. So we get a voltage $V_+ > \frac{V_{cc}}{2}$ when $R < R_{pot}$, which puts the op-amp in the positive saturation region, which is let through by the diode. When $R > R_{pot}$, we get $V_+ < \frac{V_{cc}}{2}$, so the op-amp goes to the negative saturation region, where no voltage will be let through because of the diode.

So, we have a sensor which provides a signal when there is enough light, and gives no signal when there is not enough light intensity. By varying the intensity of the laser pointer properly, we can generate the same duty cycle provided to the pointer at the output of our proximity sensor, as it will be constantly switching between the on and off state. This output will then be taken by the ID Detector. The reason we chose to use a potentiometer is so we can easily calibrate the sensor to activate at a distance of 15 cm, as many variables we cannot calculate affect the value of this resistance, such as the LDR, the power supply voltage and the op-amps' as well as the laser pointer's specifics.

3.3 Authenticator

Figure 3: Authenticator



The Authenticator receives a PWM signal from the proximity sensor, and is supposed to detect whether the signal has the correct duty cycle or not. The circuit designed for this purpose consists of two sub-blocks:

The first one is the RC filter. This sub-block takes a PWM signal, and feeds it to a simple RC set-up. Using the equation for an RC circuit, we know that:

$$V_c(t) = V_c(\infty) + (V_c(0) - V_c(\infty))e^{-\frac{t}{RC}} \tag{26}$$

The response we get when the square wave is at its maximum value, the top of the duty cycle, $V_in = E_s$ with its initial value at $V_in = 0$ is:

$$V_{C_1}(t) = E_s(1 - e^{-\frac{t}{RC}}) \tag{27}$$

And when the square wave is at its minimum value, the bottom of the duty cycle, $V_in = 0$, with its initial value at $V_in = E_s$, the response is:

$$V_{C_1}(t) = E_s e^{-\frac{t}{RC}} \tag{28}$$

It is easy to see that the voltage will at first rise quickly and fall slowly, but its rise will gradually decrease and fall gradually increase, until they are both equal and the circuit reaches a steady state. The average voltage for this steady state depends on the duty cycle of the given signal, assuming the peak values of the signals are the same. As the increase and decrease are slowed by the time constant, we get a steadier end voltage by increasing R or C, but this also increases the response time of our circuit, which we want to keep as short as viable so that our system doesn't think a wrong ID is a correct one for more than 50 ms.

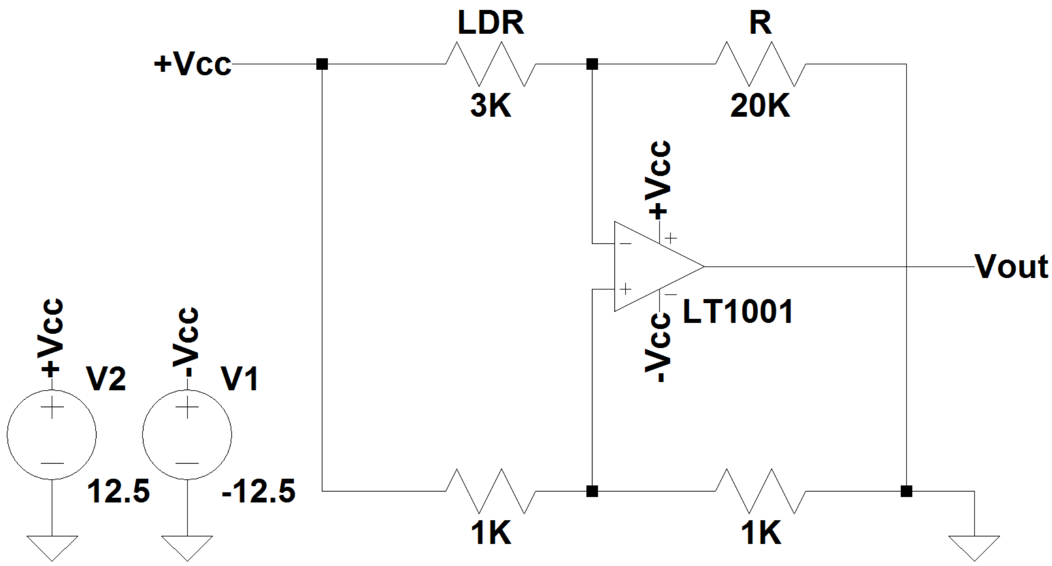
A second filter gives us an even steadier output voltage while not increasing response time dramatically and is used for our circuit, as a better alternative to increasing the time constant of the single RC set-up.

As we get a different voltage for every duty cycle, all we need to do to verify ours is to check if the voltage is between two close boundaries which include our duty cycle but no others. As in the simulation we found the voltage we get for a 40% duty cycle to be 4.5 Volts, we designed a window comparator that uses voltages which we can obtain from a +25V/-25V DC power supply.

In this sub-block, the only way both op-amps will be in the positive saturation region is when the input voltage is between the two comparator voltages, in which case our output is $V_{decisionID} = E_s$, the positive saturation voltage. Otherwise they will be in opposite saturation regions and their voltages will neutralize eachother and our output voltage will be 0 V.

3.4 Parking Sensor

Figure 4: Parking Sensor

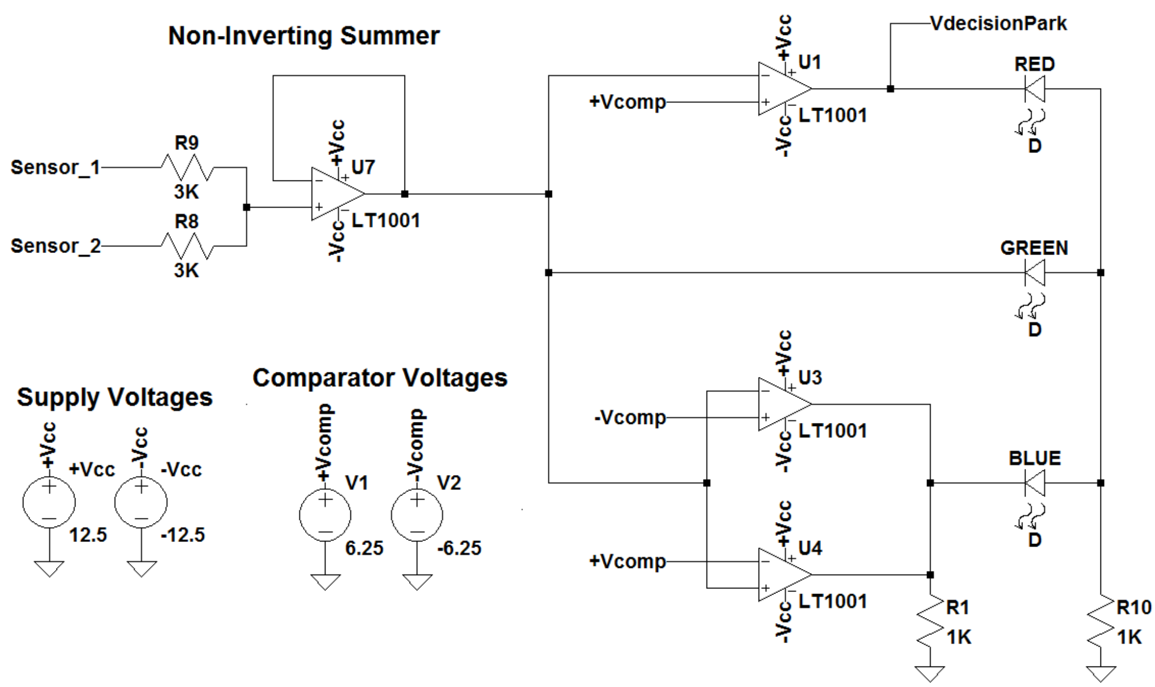


The parking sensor is a simple darkness sensor which is designed to output a positive voltage when a car is on the parking lot -when the ground under it is dark- and a negative voltage when it is empty -when the parking spot is well lit-.

The same principle as the one applied in the light sensor used in the proximity sensor design is applied. By voltage division, $V_+ = E_s V * 0.5 = \frac{E_s}{2}$, so the output is $V_{out} = -E_s$ when $V_- > V_+ = \frac{E_s}{2}$, which requires $R_{LDR} < R$, meaning light shines on the LDR (the parking spot is empty. The inverse holds true when the parking spot is full, as the LDR remains in the dark, $R_{LDR} > R$, causing $V_- < \frac{E_s}{2} = V_+$, which puts in the op-amp in the positive saturated region and causes our output to be $V_{out} = E_s$.

3.5 Availability Indicator

Figure 5: Availability Indicator



The purpose of the availability indicator is to indicate the number of available parking spaces using an RGB LED, and inform the decision unit about the availabilit of parking spaces.

The first sub-block of this circuit is the non-inverting voltage summer. Using the KCL on the node of V_+ we find:

$$\frac{V_+ - V_{Sensor_1}}{3} + \frac{V_+ - V_{Sensor_2}}{3} = 0 \tag{29}$$

$$V_+ = \frac{1}{2}(V_{Sensor_1} + V_{Sensor_2}) \tag{30}$$

And after that what we do with the op-amp is simply using it as a voltage follower, so that the sum remains unaffected by following parts of the circuit. As from our parking sensors' set-up, we have the voltage when the parking spot is full $V_f = E_s$ and the voltage when the parking spot is empty $V_e = -E_s$, we have three possible outputs:

$V_{ff} = E_s,$	the voltage when both spaces are full
$V_{ef} = 0,$	the voltage when one space is empty and the other full
$V_{ee} = -E_s,$	the voltage when both spaces are empty

For the red LED, a basic comparator is used that checks if the voltage is over $\dfrac{E_s}{2}$ or not. If it is, which is only the case for V_{ff}, a negative voltage is applied to the red cathode of the RGB LED which lights the red LED, otherwhise a positive voltage is applied which does not light the LED.

For the green LED, the output of the summer is directly attached to the green cathode of the RGB LED. The only way the green LED would be lit is when the output voltage is negative, which only happens for the V_{ee} case, 0 volts or a positive voltage does not light the LED.

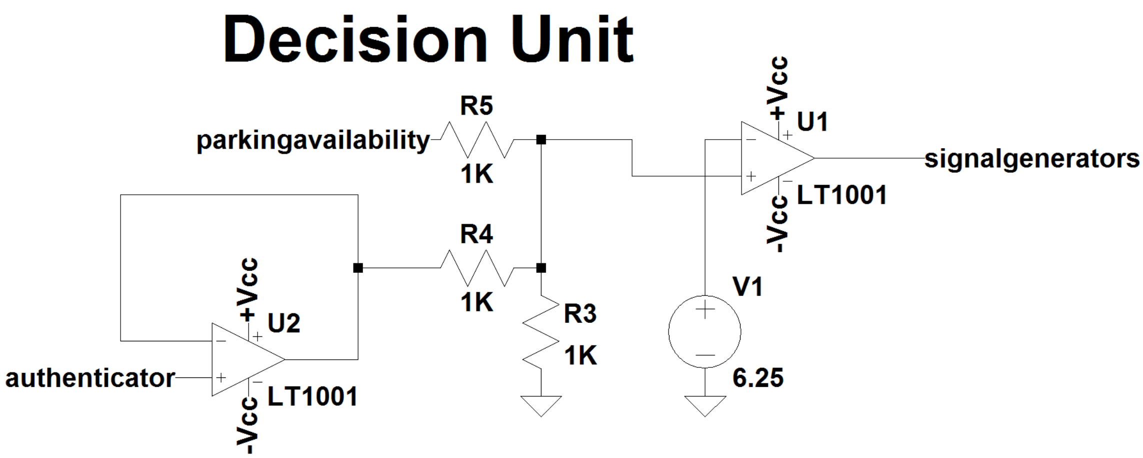
For the blue LED, what we want is for the voltage to be $V_{ef} = 0$. For this, we use a window comparator that checks if the voltage is $\frac{E_s}{2} > V > -\frac{E_s}{2}$, as this is the only case when both op-amps are in the negative saturation region and we get a negative voltage and blue LED lights up, otherwise the op-amps are in opposite saturation regions, and their voltages neutralize eachother and we get 0 volts.

With saturation voltages of about 10 volts as input and a 1kΩ resistor attached to the anode, approximately 10 mA of current flows through the LEDs that are lit, which is a value that causes the LEDs to be lit brightly, while not being too much for them.

In addition, the red cathode input voltage is fed to the decision unit, with $-E_s$ indicating that parking spaces are full, and E_s indicating that there is space.

3.6 Decision Unit

Figure 6: Decision Unit



The decision unit is designed to output a positive voltage when the conditions are satisfactory for the door to open, and a negative one when the conditions are unsatisfactory. It determines the condition by using a summing set-up and a basic comparator. The voltage coming from the ID authenticator is buffered to prevent the circuit from affecting that output; the voltage coming from the parking availability indicator does not have to be buffered, as it is already the output of a previous op-amp. Knowing that $i_+ = 0$, we can find a formula for V_+ using Kirschoff's Current Law on its node, calling the availability indicator voltage V_{park} and the authenticator voltage V_{ID}:

$$\frac{V_+ - V_{park}}{1} + \frac{V_+ - V_{ID}}{1} + \frac{V_+}{1} = 0 \tag{31}$$

$$3V_+ = V_{park} + V_{ID} \tag{32}$$

$$V_+ = \frac{1}{3}(V_{park} + V_{ID}) \tag{33}$$

Equation 33 shows us that V_+ is indeed a multiple of the sum of V_{park} and V_{ID}. Now, as we know that the output of the parking availability indicator is E_s and $-E_s$ for available and unavailable cases, repectively; and the output of the authenticator is E_s for a correct ID case and 0 otherwise, let us make a table for the possible values of V_+:

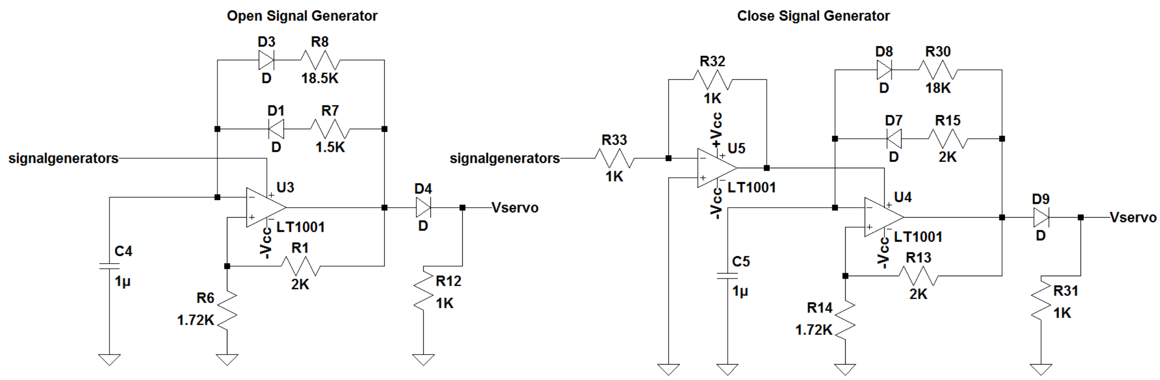
Table 1: Decision Unit Comparator Inputs (V_+)

Parking\Authenticator	Correct (E_s)	Incorrect (0)
Available (E_s)	$\frac{2}{3}E_s$	$\frac{1}{3}E_s$
Unavailable ($-E_s$)	0	$-\frac{1}{3}E_s$

From table 1 we can infer that the only case where we should have a positive output from the decision unit is when $V_+ = \frac{2}{3}E_s$. For a suitable result, we can reach the desired result by setting $V_- = \frac{1}{2}E_s$. The output of this comparator is then fed to the Signal Generators.

3.7 Servo Control Signal Generator

Figure 7: Servo Control Signal Generators



The idea figure 7 represents is having two different signal generators for the opening and closing signal, and controlling them with the output of the decision unit.

First let us talk about the way the servo motor is controlled. A PWM servo motor expects a pulse every 20 ms, and the width of that pulse determines the position command; 1.5 ms is the center position, 2.0 ms is the right position, and 1.0 ms is the left position, in general. We want to generate a 1.5 ms signal for the gate to be closed, and a 2.0 ms signal for the gate to be open. To generate this signal, we need to precisely calculate the period and on-time of the signal. For this we refer to 18 from the duty cycle generator section:

$$t_c = RC \ln \frac{1+\lambda}{1-\lambda} \tag{34}$$

We will from now on refer to this equation as 34. To be able to easily choose resistance values, we want $ln\dfrac{1+\lambda}{1-\lambda} = 1$. The value that makes this equation hold is $\lambda = \dfrac{e-1}{e+1}$, so from 7 we set $R_6, R_{14} = e - 1 = 1.72$ kΩ and $R_1, R_13 = 2$ kΩ so that our charge time simply becomes $t_c = RC$. So for a 1.5 ms on time 20 ms signal, we set $R_c = 1.5$ kΩ and $R_d = 18.5$ kΩ, and similarly $R_c = 2$ kΩ, $R_d = 18$ kΩ for the other signal.

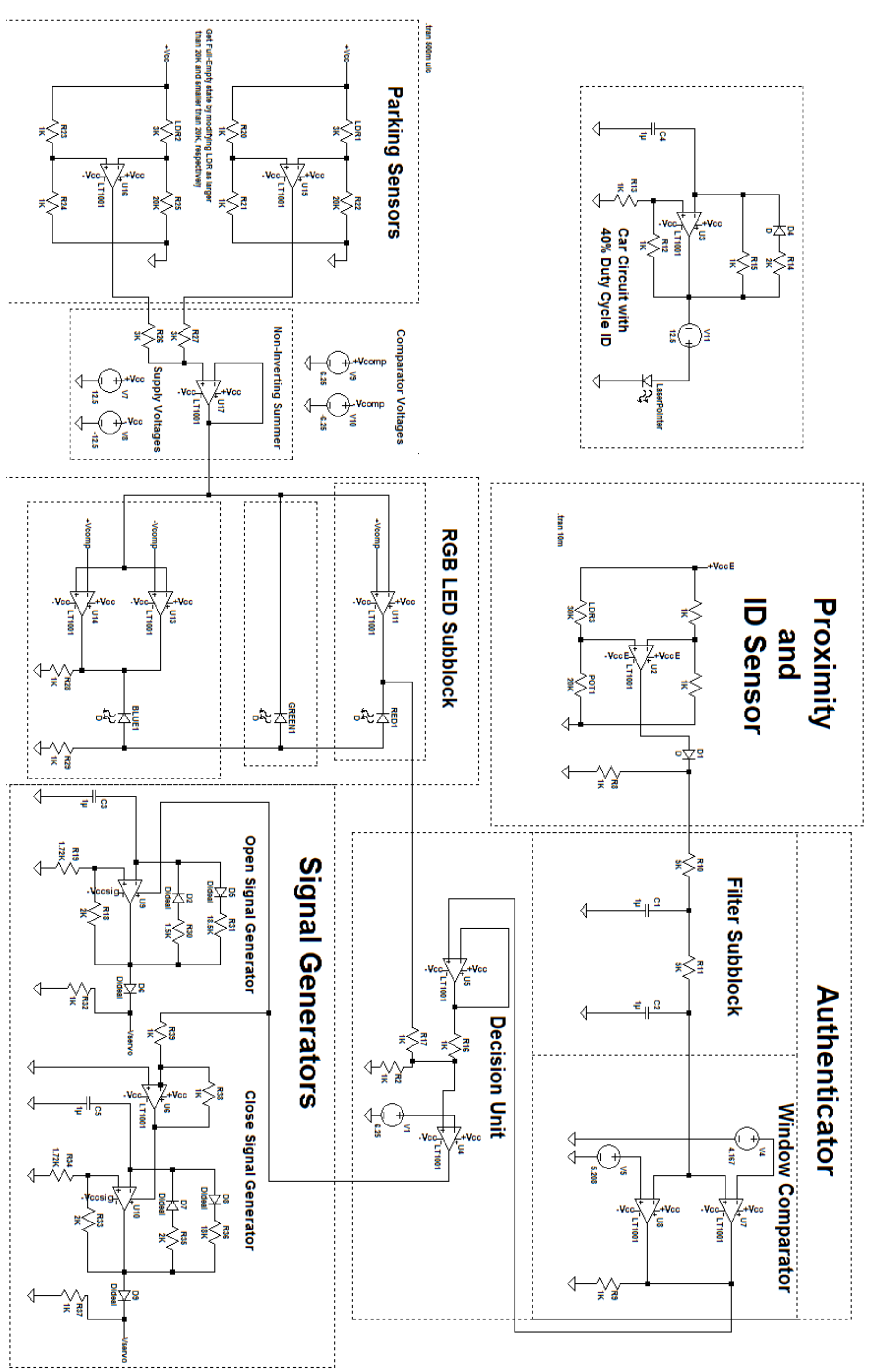
The way we decide which signal is sent at what time is by manipulating the power supply of the op-amps. For the gate opening pulse generator, the output of decision unit which can have the values of E_s or $-E_s$ is fed to opamp's positive input, $+V_{cc}$. Diode is connected in such a direction that it lets the current pass on it only if the output of opamp is positive, that is in our case E_s. With this construction, only a positive valued signal can activate the pulse generator. The positive value corresponds that both the vehicle is authorized and there is an available space in parking area. The gate-close pulse generator operates in a similar way. It receives the same input as gate opening pulse generator but with an inverting amplifier, it first inverts this input and afterwards feeds the inverted one to the positive input of the second opamp. Similarly, diode is connected to operate when a positive voltage appears between its terminals. With this construction, the generator operates only when a positive voltage appears in the second opamp's $+V_{cc}$, which implies that only a negative valued input to the first opamp can activate the generator. This corresponds to $-E_s$ and an unauthorized ID or not available space.

In the movement of the barrier, proportional control is used. That is, the motor's speed is proportional to the difference in the actual and desired position. This means the motor slows down as it gets near the desired position.

Note that in this case the opening and closing signal is sent constantly to keep the servo in position, otherwise the barrier would fall to the ground when the motor is deactivated. A way to prevent this would be to make a physical block at the closed level of the barrier, so that the servo can be safely turned off.

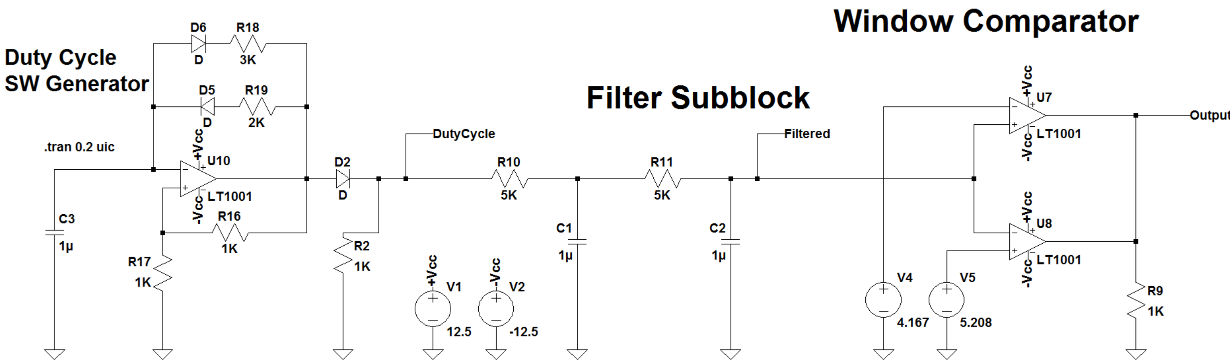
4 Simulation Results

4.1 Overall Schematic



4.2 Duty Cycle Generation and Detection

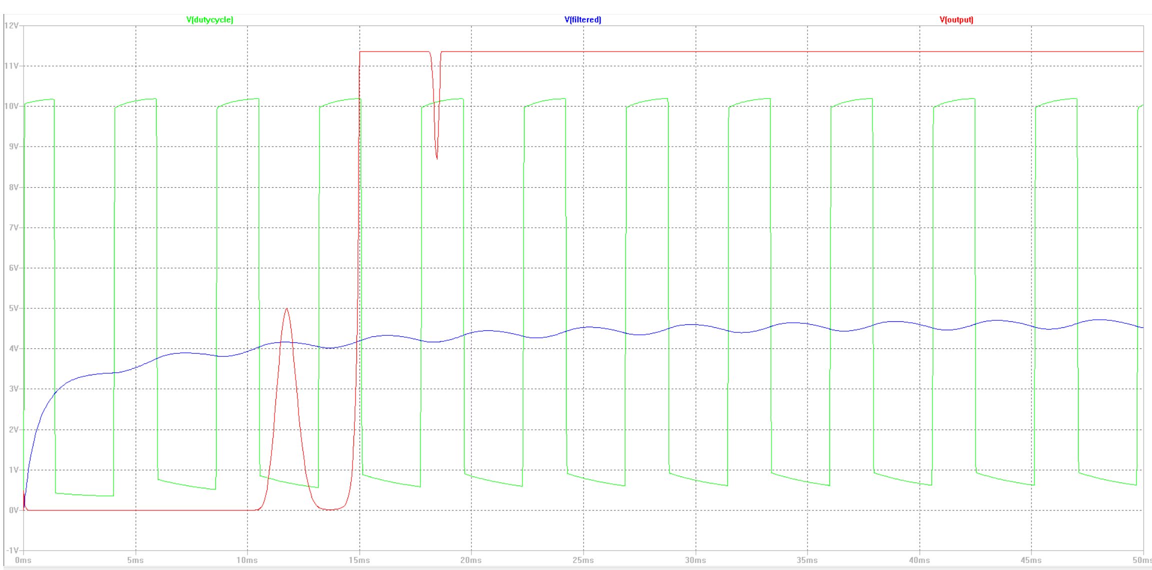
Figure 8: Duty Cycle Control Block



The above schematic represents the duty cycle generation and the detection of the generated duty cycle with the duty cycle generator directly connected to the authenticator to represent the laser pointer-LDR mechanism. The three following graphs illustrate the duty cycle (V(dutycycle)) with a period of 5.49 ms, the voltage after the filtration of the duty cycle, (V(filtered)) and the output of the authenticator (V(output)) for three different cases using a simulation time of 50 ms:

4.2.1 Expected Duty Cycle

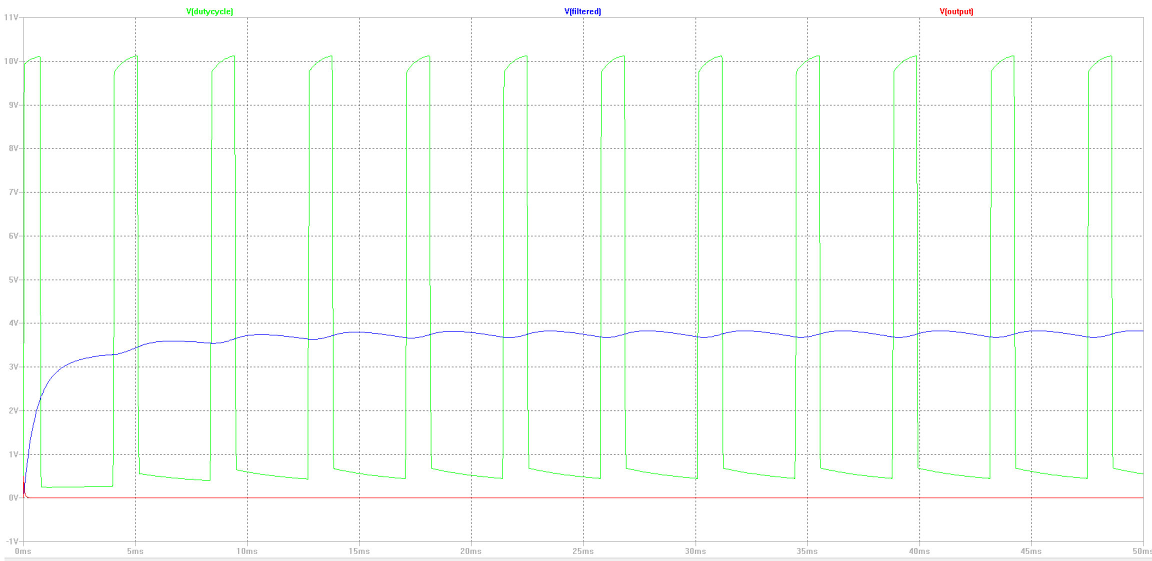
Figure 9: Correct Duty Cycle Response



In this graph the generated duty cycle is at 40%, which is the correct duty cycle for our specifications. The filter takes about 20 ms to respond, which is quite fast, and since the steady state voltage is between 4.167 and 5.208 volts we get $V_{output} = E_s$, which shows a successful authentication.

4.2.2 Lower Duty Cycle

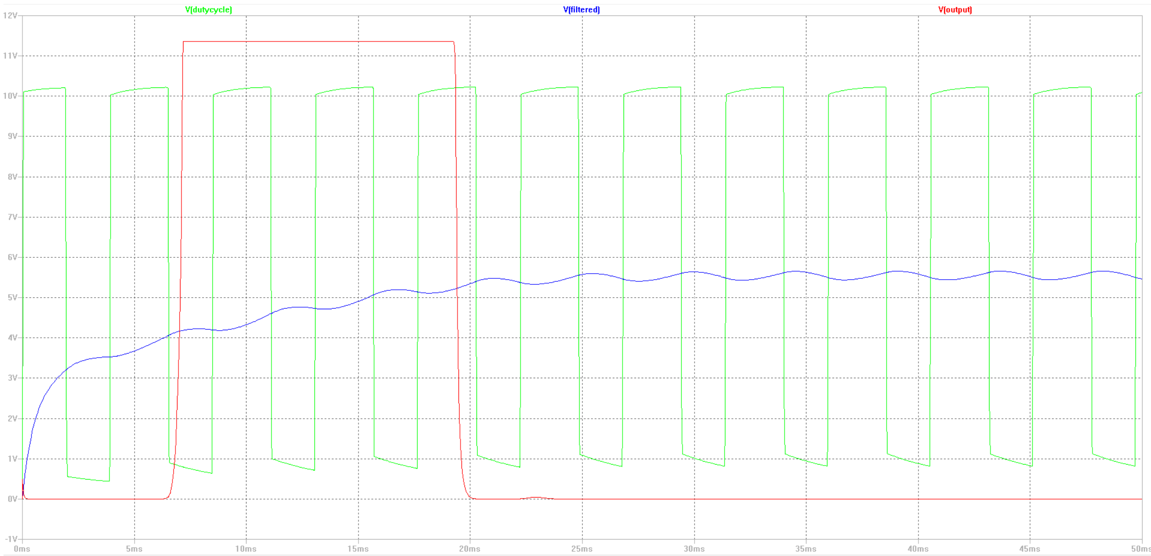
Figure 10: Low Duty Cycle Response



In this graph the generated duty cycle is at 20%, which is lower than our expected value. Here the steady-state voltage the filter reaches is between 3 and 4 volts, which is outside the range of our window comparator, and therefore the output we get is always $V_{output} = 0$ volts.

4.2.3 Higher Duty Cycle

Figure 11: High Duty Cycle Response

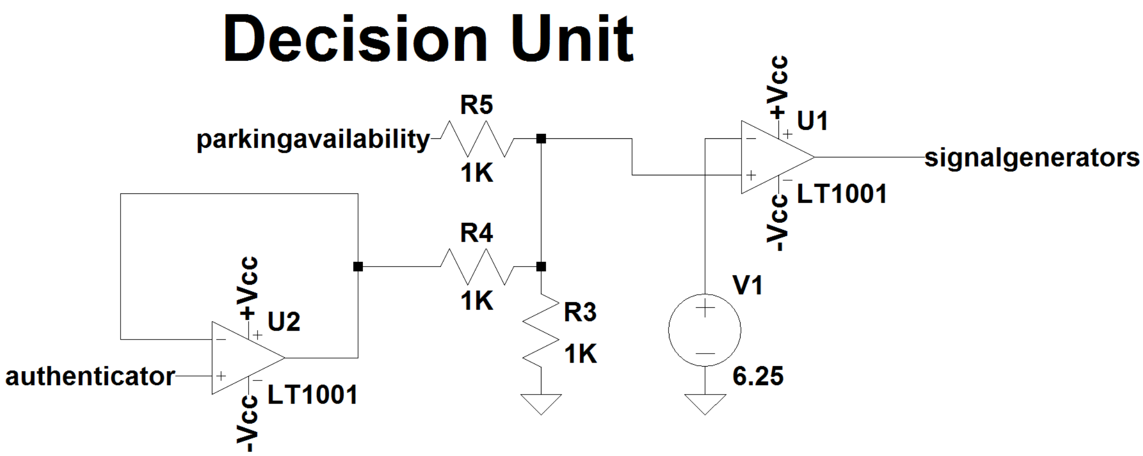


In this graph the generated duty cycle is at 60%, which is higher than our expected value. Here the response time of the filter is around 25 ms, after which it reaches a steady state voltage around 5.5 volts. Since this voltage is outside the range of our window comparator, the final output voltage we get is $V_{output} = 0$. We may notice that the output is correct for the time where the voltage is rising between the boundaries of our window comparator, however the time for which this state is active is less than 15 ms, which is obviously not enough for the system to activate and the barrier to rise, so it is a minor concern. What matters is that the steady-state output which is quickly reached is outside the comparator's bounds.

4.3 Decision Unit Outputs

4.3.1 Expected Results

Figure 12: Decision Unit



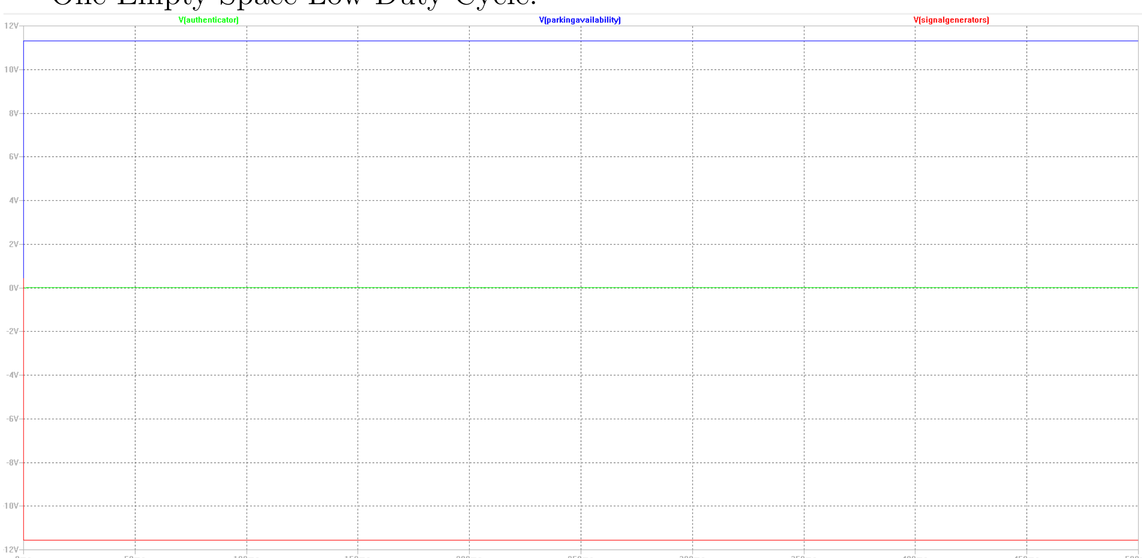
The small circuit piece above is the decision unit, which is designed to output a positive voltage when the ID is correct and there is available parking space; and a negative voltage when this is not the case. It takes two voltages, one comes from the parking availability indicator and the other comes from the authenticator. These values are then summed using the given resistor set-up and the comparator input is $V_+ = \frac{1}{3}(V_{parkingavailability} + V_{authenticator})$. As the parking availability indicator supplies the positive saturation voltage when there is space and the negative saturation voltage when there is not, and the authenticator supplies the positive saturation voltage when the ID is correct and 0 volts when it's incorrect, the only time when the "open barrier" signal must be given is when $V_+ = \frac{1}{3}(E_s + E_s) = \frac{2}{3}E_s > \frac{1}{2}E_s$, we can compare the input to see if it's larger than $\frac{1}{2}E_s$ and output the positive saturation voltage if that is the case, and negative saturation voltage if it is not. Note that the authenticator voltage is buffered to prevent the output from being changed by the summing set-up.

The following graphs show the inputs and output for all 9 possible cases, having a higher(60%), lower(20%), correct(40%) duty cycle and no empty space, one empty space and two empty spaces.

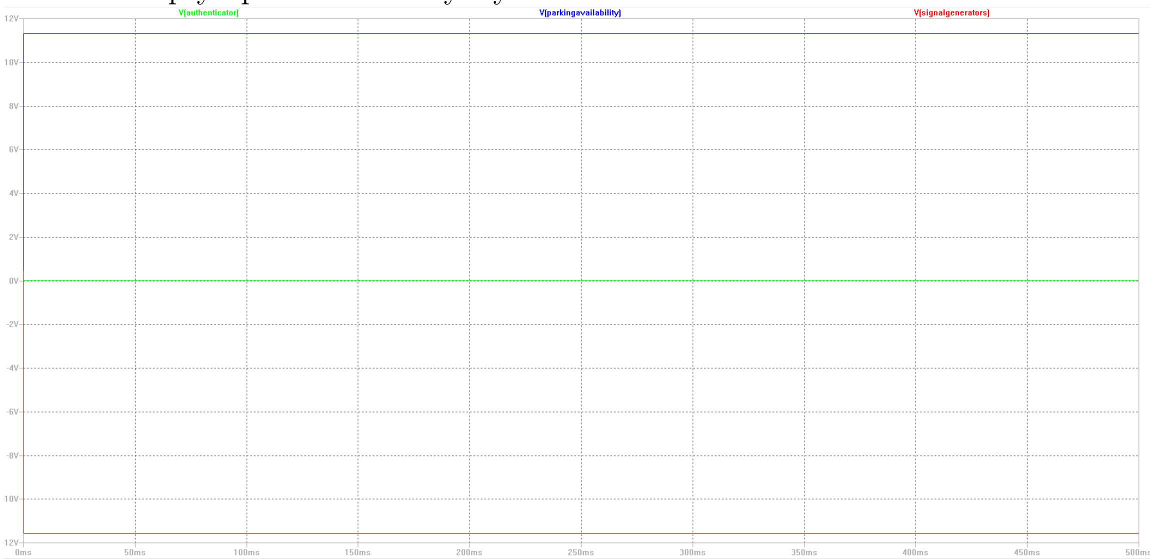
4.3.2 Graphs

No Empty Space-Low Duty Cycle:

One Empty Space-Low Duty Cycle:

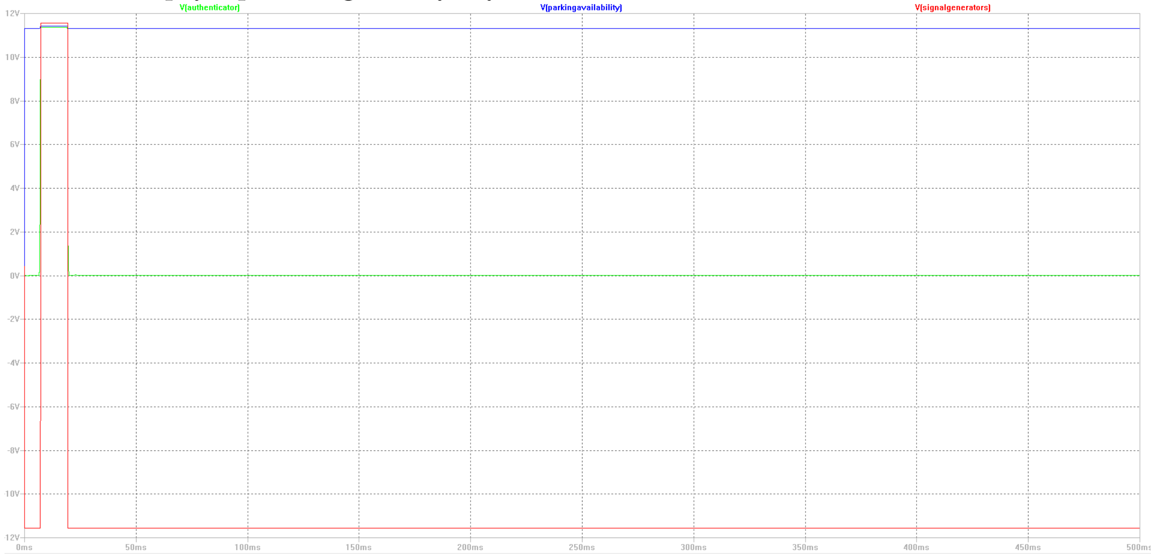


Two Empty Spaces-Low Duty Cycle:



No Empty Space-High Duty Cycle:

One Empty Space-High Duty Cycle:

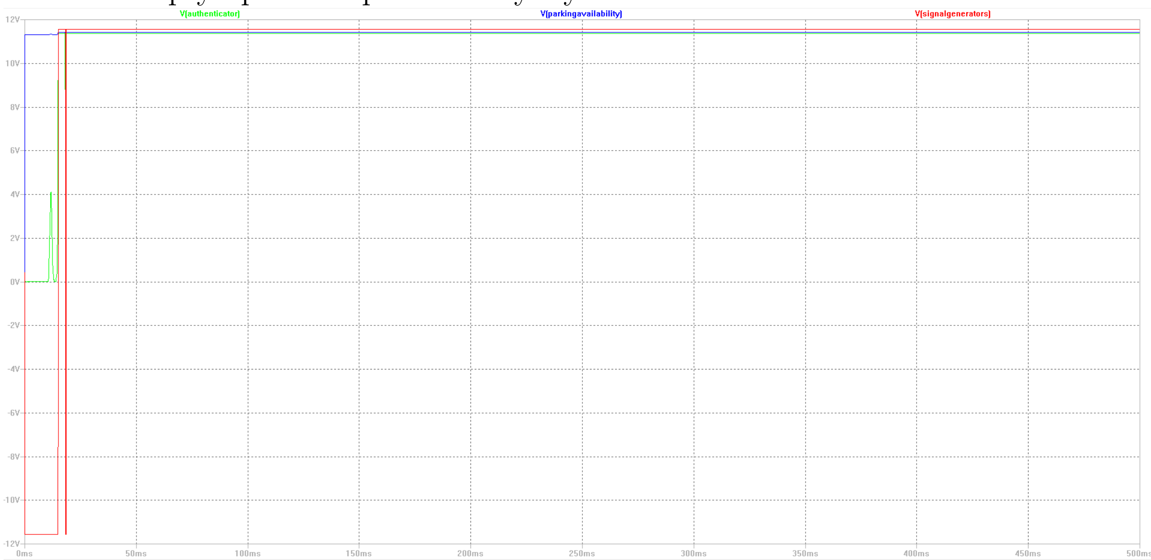


Two Empty Spaces-High Duty Cycle:

No Empty Space-Expected Duty Cycle:

One Empty Space-Expected Duty Cycle:

Two Empty Spaces-Expected Duty Cycle:



To sum the results up in a table:

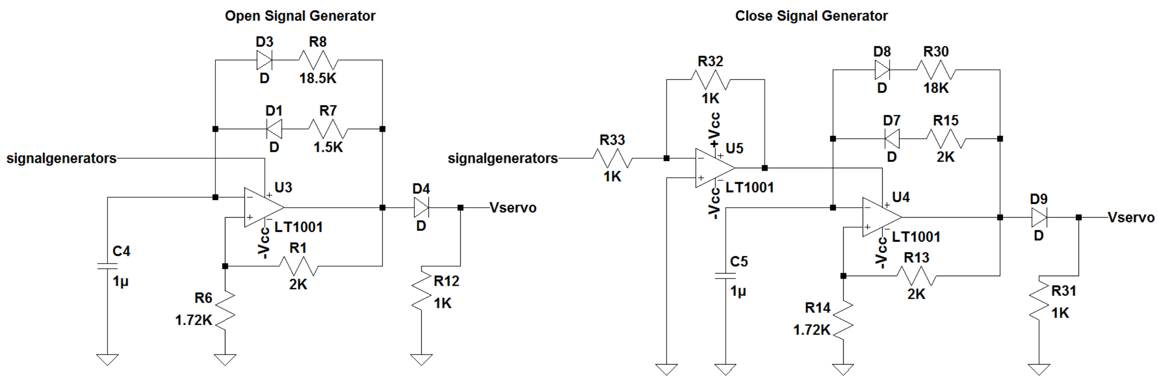
Table 2: Decision Unit Outputs

Duty Cycle\Parking Space	No Empty Space	One Empty Space	Two Empty Spaces
Low Duty Cycle	Negative	Negative	Negative
High Duty Cycle	Negative	Negative	Negative
Expected Duty Cycle	Negative	Positive	Positive

We can clearly see from 2 the only cases where the output is positive (an opening signal will be sent to the door) is when the duty cycle is correct and there is at least one empty space.

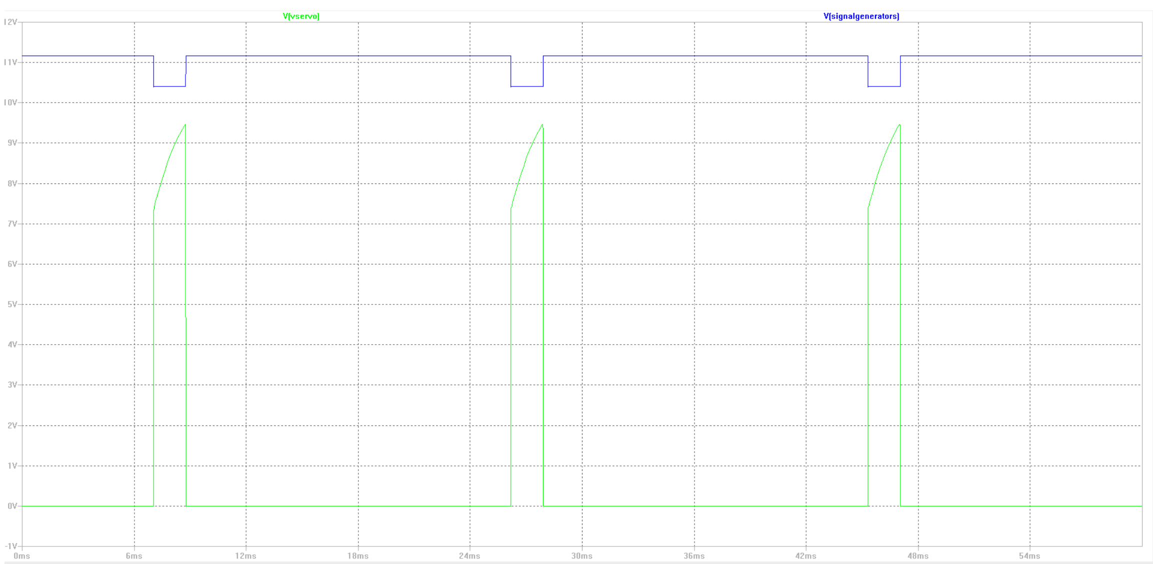
4.4 Servo Motor Control

Figure 13: Servo Control Signal Generators



With our previously explained circuit, the opening signal we get is, where the green signal is the servo control signal and the blue one is the decision unit signal to show that it is indeed positive:

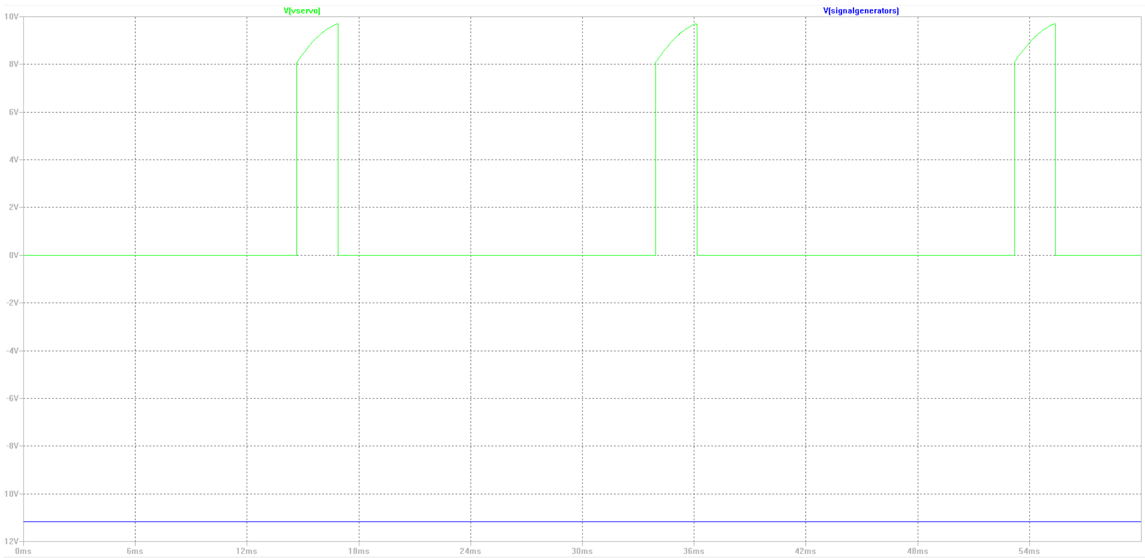
Figure 14: Servo Open Signal



The period here is 20 ms and the pulse-width approximately 1.5 ms, as expected.

The closing signal, with a similar graph to the first one is:

Figure 15: Servo Close Signal



The period stays the same as the total resistance is the same, and the pulse-width is approximately 2.0 ms (it can be observed that it is slightly larger).

What we need to note here is that this simulation is done with ideal op-amp and diode models. In realy life, it is probably very hard to predetermine the pulse width of the signal as it will be affected by many factors such as the small amount of asymmetry between power supplies, the slew-rate of the op-amp, and the non-ideality of the diodes. In this case the best way to generate the proper signal would be using a potentiometer to calibrate the circuit while watching the response with and oscilloscope. Then the proper resistance values for the resistors can be written down and the resistors procured.

5 Power Analysis

Power Analysis for the implemented circuit can be calculated from the voltage and consumed current values we read from the DC Voltage Supplier during lab sessions.

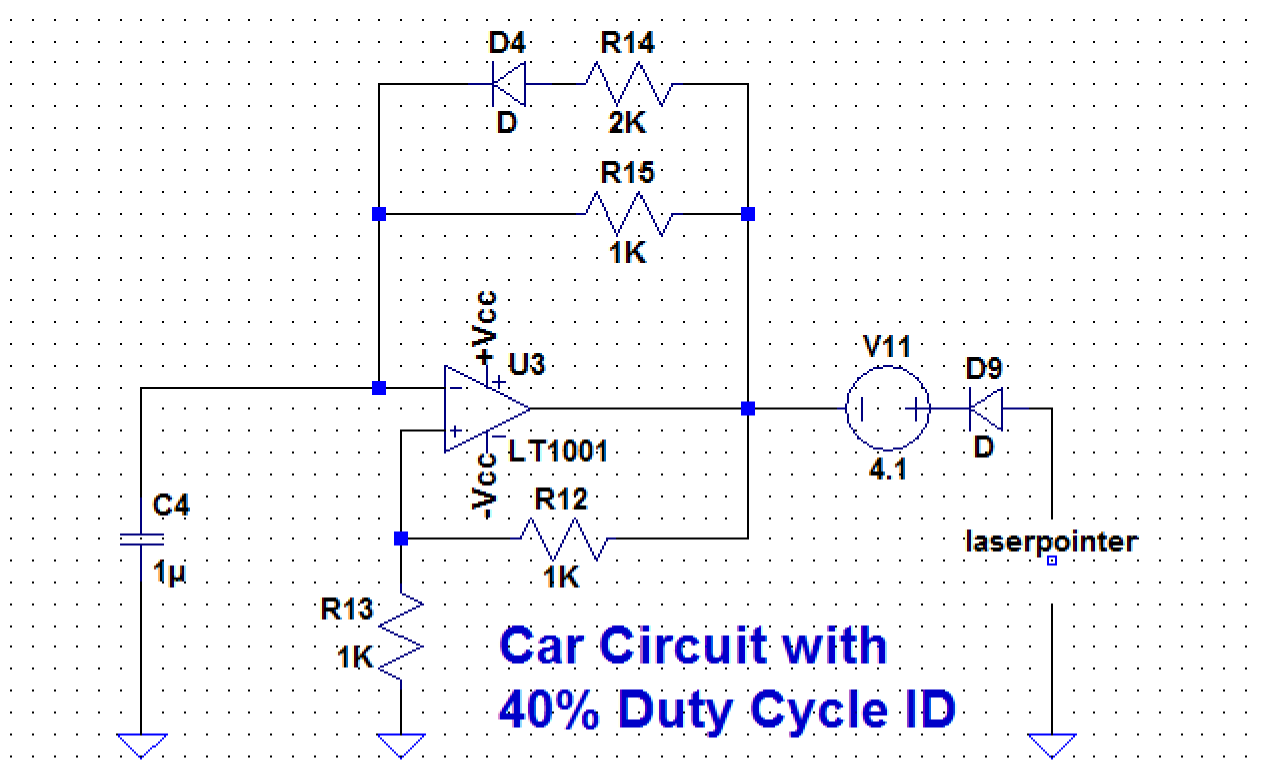
Power Analysis is done for each operating subblock seperately. $V \cdot I = P$ power relationship is used for instantenous power consumption considering time varying elements as well as resistors. The values for V is taken as maximum voltage, taken from DC Voltage Supplier and if necessary the divided values of it and likely for resistor values, $k\Omega$ is clearly indicated with powers of 10. If necessary, one calculation is multiplied where there are similar elements with similar values.

For nonlinear elements, LTSpice is used to observe the waves of power with applying basic operations for instantenous power calculations. However, the graphs here are not showed explicitly but the results are told.

For diodes and cables the power consumption is regarded as 0 as applied current was not very high.

5.1 Duty Cycle Generator

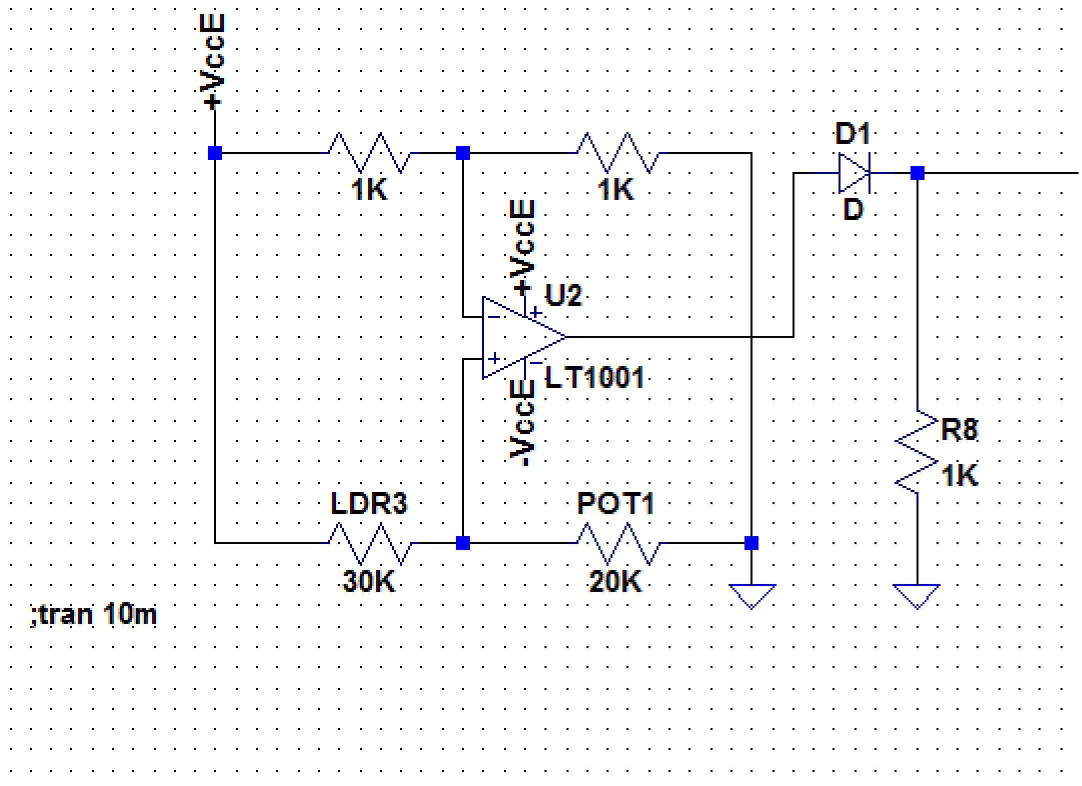
Figure 16: Duty Cycle Generator



The duty cycle generator has a very low power consumption calculated as 2.4 mW.

5.2 Proximity Sensor

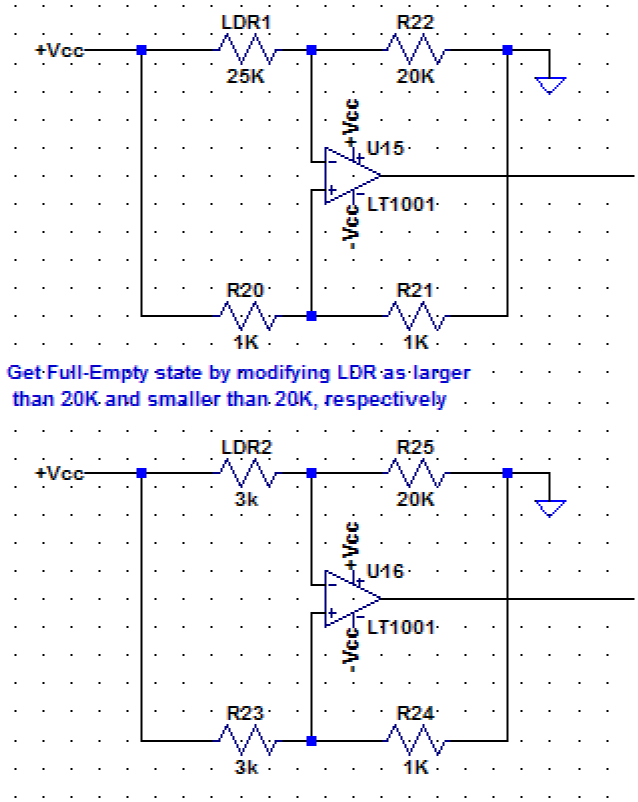
Figure 17: Proximity Sensor



Power Consumption of this unit is calculated as 0.09 mW.

5.3 Parking Sensors

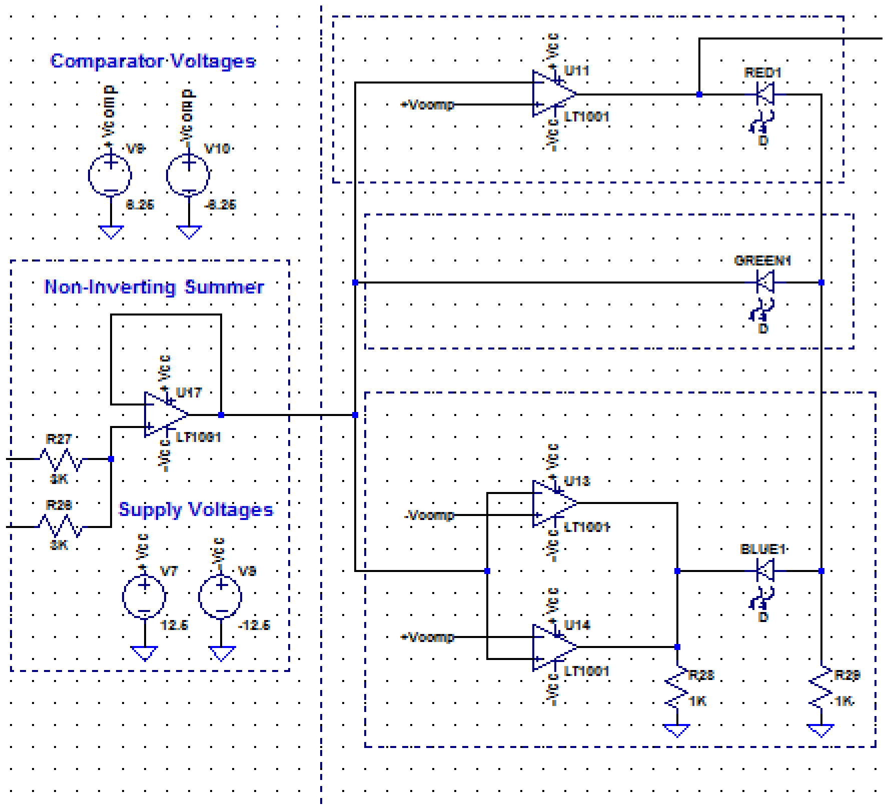
Figure 18: Parking Sensors



The power consumption for this unit is calculated as 0.46 mW.

5.4 Parking Availability Block

Figure 19: Parking Availability Block



The power consumption for this unit is calculated as 90.74 mW.

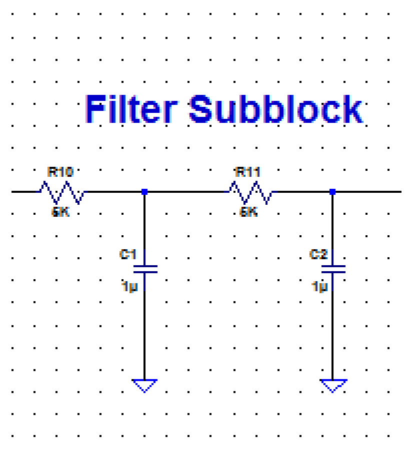
5.5 Voltage Division

For many parts of the circuit one single voltage division was used in the main block. 4 pieces of 1 kΩ resistors were used in total, 2 for each voltage suppliers (+/-). 78 mW power is dissipated for each voltage division.

5.6 ID Detector

5.6.1 Filter Subblock

Figure 20: Filter Subblock



The power consumption for this unit is 0.99 mW.

5.6.2 Window Comparator

(From this point on, our construction failed to operate. Therefore the calculations are merely theoretical not very well tested when they were integrated with other elements of the circuit although some worked separately.) The power consumption was found to be 0. Power consumptions for the rest of the circuit is as follows:
Decision Unit=111mW
Servo Control Unit=0 W
Also showing that the system failed to operate.

6 Cost Analysis

5x1 microFarad capacitors = 0.25X5 =1.25 TYR
11 LM358 opamps = 0.72X11 = 7.92 TRY
10 diodes = 0.64 TRY
2 POTs = 0.85x2 = 1.7 TRY
46 resistors = 0.40 TRY
1 laser pointer = 35 TRY
1 servomotor = 15 TRY
2+1 breadboards = 45 TRY
3 LDRs = 1.5 TRY
1 RGB = 1 TRY
Cables =0
TOTAL=109.41 TRY

7 Conclusion

In this project, we were given a task to perform using our gained knowledge during laboratory sessions throughout the semester and also making some researches. First, we needed to analyze the given problem and understand what was required. Afterwards, we created theories upon the solutions, examining them using a simulation program. We continued to brainstorm and come up with ideas with combining different techniques. Problems during simulation process were encountered due to combination of blocks. We also needed to pay attention to the cost and possible power consumption of the circuit which we were building.

After the preparation process, we were required to obtain our materials with the utmost care of their cost. We faced price problems for some materials like a pricey laser pointer in the circuit.

Most significantly, we faced serious problems in the construction of the real circuit as the combination of subblocks was problematic. It was hard to detect the problem in a complicated circuit with a very limited time and also come up with a reasonable solution in that period. We observed that in reality the circuit was not working as properly as it used to in the theory. We spent a lot of time trying to reconstruct and test it. We managed to make only some parts of the circuit work in the given time. We observed that the behaviours of the circuit were very sensitive to little changes in the environment like small displacements and small contacts. We learned that we needed to give great attention to each maneuver we do.

In brief, we learned in the process of this project that in real life, creating a solution to a problem needs some successive steps which require past theoretical knowledge, experience, new research, great care, a large amount of time and patience. In reality, there are so many things which are not being included in theoretical calculations and even a small change creates a problem in the solution process due to the successive steps we follow.

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