Lab 10
Experiment 21

Design a Traffic Arrow
Just so it is clear

• This is it.
  – Last official experiment for the semester.
    • It is your option as to whether or not you do a make-up experiment.
  – This is the last lab lecture for the semester

There is NO final in this course!
Design a Traffic Arrow

You should place the LEDs on your ANDY board in a similar configuration.
Sequence

1. All LEDs are off
2. 20-40 ms later, Section 1 LEDs turn on
3. 20-40 ms later, Section 2 LEDs turn on
   - Section 1 LEDs remain on
4. 20-40 ms later, Section 3 LEDs turn on
   - Section 1 and 2 LEDs remain on
3. 20-40 ms later, Section 4 LEDs turn on
   - Section 1-3 LEDs remain on
All LEDs are off
Section 1 LEDs are on
Section 2 LEDs are on
Section 3 LEDs are on
All LEDs are on
All LEDs are off
To obtain desired clock frequency

- Use digital clock (CLCK) on the ANDY board be used.
  - The minimum clock frequency is ~ 70 Hz—a frequency well above the maximum suggested in lab manual.
- To slow down the clock, connect two 100 μF electrolytic capacitors (in series) to the EXT CAP socket header on the ANDY board.

Note: it is critical to wire electrolytic capacitors with the correct polarity as discussed in Section 3.1 of this text.

Failure to wire the capacitors correctly could result in an explosion of the devices.
Electrolytic Capacitors

The positive lead of capacitor C1 should be plugged into either the top-left or bottom-left pin of the EXT CAP socket header (J17). The negative lead of capacitor C2 must be connected to ground.

There is a negative sign on this side of the capacitor. Also, the negative lead is shorter than the positive lead.
Block Diagram of Circuit

- Charging of $C_3$ is determined by $R_4C_3$ time constant.
• Discharging of $C_3$ is accomplished using LED 6 when the clock pulse from the ANDY board is at 0V.
Diodes (even LEDs) act like switches

• When the voltage on the positive side of the diode is greater than the voltage on the negative side plus the turn-on voltage (~2V), the diode conducts current.

• When the voltage on the positive side is less than the voltage on the negative side plus the turn-on voltage (~2V), the diode acts like an open circuit.
Operation of LED 6

\[ V_{\text{LED6}} < 2V \]
\[ 5 - V_{C3} > -2V \]

\[ V_{\text{LED6}} > 2V \]
\[ (0V - V_{C3}) < -2V \]

LED6 will be inserted into the circuit ‘backwards’ compared to the other LEDs.
Series of Voltage Comparators

- Voltage dividers are used to determine the reference voltage at which the op amp output voltage changes from (roughly) V- to V+.
  - You need to calculate based upon an exponential shape to the voltage across the capacitor, what the reference voltages should be to obtain the correct timing of the lights. [Review Lab 5]
Resistor Values

• $R_0$, $R_1$, $R_2$, and $R_3$ are used to limit the current that flows through the LEDs.
  – This should be $\sim 10\text{mA}$.

• $R_4$ in combination with $C_3$ determines the rate at which the voltage increases on the input of the voltage comparators.
  – Note that $C_3$ will not fully discharge through LED6.
Oscilloscope Measurements

• You can measure about 4-6 seconds worth of data using the Velleman oscilloscope.
  – It must be set to DC coupled as the rate of change of the voltage across $C_3$ is slow. AC coupling will filter out what appears to be a dc voltage across $C_3$.
  – You can use the ANDY Clock signal to trigger the measurement of the other voltages.
    • You can use the oscilloscope to debug your circuit.
Pre-Lab

• PSpice schematic of your full circuit with all resistor and capacitor values included.
• PSpice simulation of the voltage across $C_3$ as a function of time and the voltage of the pulse generator voltage for the subcircuit shown below.
Circuit Validation

• Demonstrate that the LEDs light in the prescribed sequence and at the prescribed time (approximately one-half to one second apart).
Post-Validation Report

• The design report, which may be written in a format of your choosing, should be self-contained. At a minimum, the report must include the following:

1. A statement of the objectives of the project
2. A description of the design principles used and the feature set included
3. A schematic diagram of the circuit
4. A PSpice analysis showing the bias voltages and the locations of any PSpice voltage and/or current probes. A screen snapshot of the PSpice waveforms showing the pulse generator voltage versus the voltage at the junction of R4 and C3 should be included. The waveforms must also show the output voltages from the op amps. Be sure to answer the question in Procedure Part A, step 6.
5. Test results that demonstrate the performance of the design.