Experiment 8: Coupling *Balance* with *Speed* Control

Name/NetID:

Teammate/NetID:

Section AB/BB:

0 1 2 3 4 5 6 7

8 9 A B C D E F

(circle one)

Laboratory Outline:

We have built several circuits to do specific tasks. Examples include the oscillator to generate a PWM signal and the MOSFET-based motor-drive circuit. We have also learned that a cascade of circuits, a series of sub-circuits combined to achieve a "larger" goal, might require *buffering* elements to prevent loading effects. For example, in the figure below, suppose circuit C_1 is to be connected to C_3. Often, the two circuits will require some sort of a buffer, C_2, so that C_3 does not affect C_1's desired operation and C_1 does not affect C_3's desired operation. Recall this is why we used an extra inverter after our oscillator to protect the oscillation when connecting it to the voltage divider of the motor-drive circuit (recall Experiment 5, Figure 3).

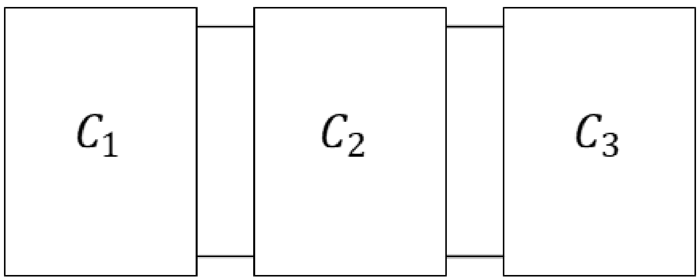
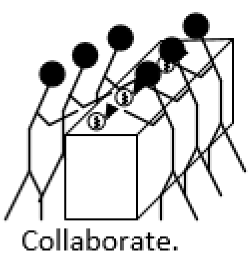


***Figure 1**: Coupling two circuits, C_1 and C_3, often requires the aid of a buffer or other coupling circuit, C_2.*

Today, we will investigate one method of combining two inputs to control a single output. We will be using the logical AND circuit constructed in prelab to combine two signals into a single control signal for each of the two car wheels. The fact that we are dealing with binary (two) voltages only aides us in our task by allowing us to use simpler "logical" circuitry that does not require careful preservation of more-intricate voltage waveforms.

Breakout Session #1



Notes:

Consider the circuit schematic of a single button plus its resistor and the battery designed to produce a “logical”, two-valued, input as shown in the figure below.

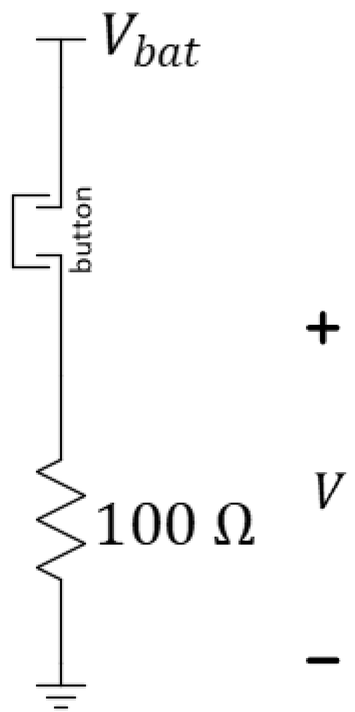


__Figure 2__: An easy circuit to generate a logical input.

Question 1: Explain, *using KVL, KCL, and/or Ohm’s Law circuit theory,* how this button circuit produces a “low” voltage at V when not pressed and a “high” voltage when pressed. Show your circuit solutions.

Replace your red LEDs from the prelab circuit with signal diodes (maintain the proper orientation). Now add the 1 $k\Omega$ plus button combinations to imitate the two inputs. The blue LED should only illuminate when both buttons are pressed.

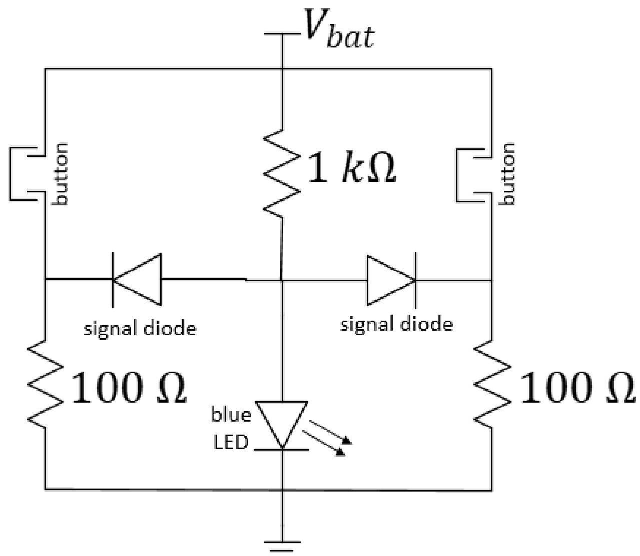
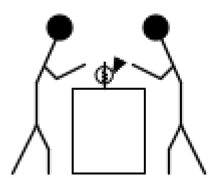


***Figure 2**: Circuit schematic of a two-input logical AND using buttons for inputs.*

Help your peers achieve a working logical-AND circuit as well. Once all of the group's logical-AND circuits are working, show your TA and then you may continue back at your work bench.

At Your Bench



Work together.
One circuit.

Build the motor-control circuit below that includes an adjustable wheel-speed balance potentiometer combined with speed control. You should see the familiar motor-drive circuits as well as two oscillators and two copies of the logical AND.

Notes:

If there is only one pushbutton in your kit, it is okay to work with your lab partner and just produce one of these circuits in the breakout session.

Notes:

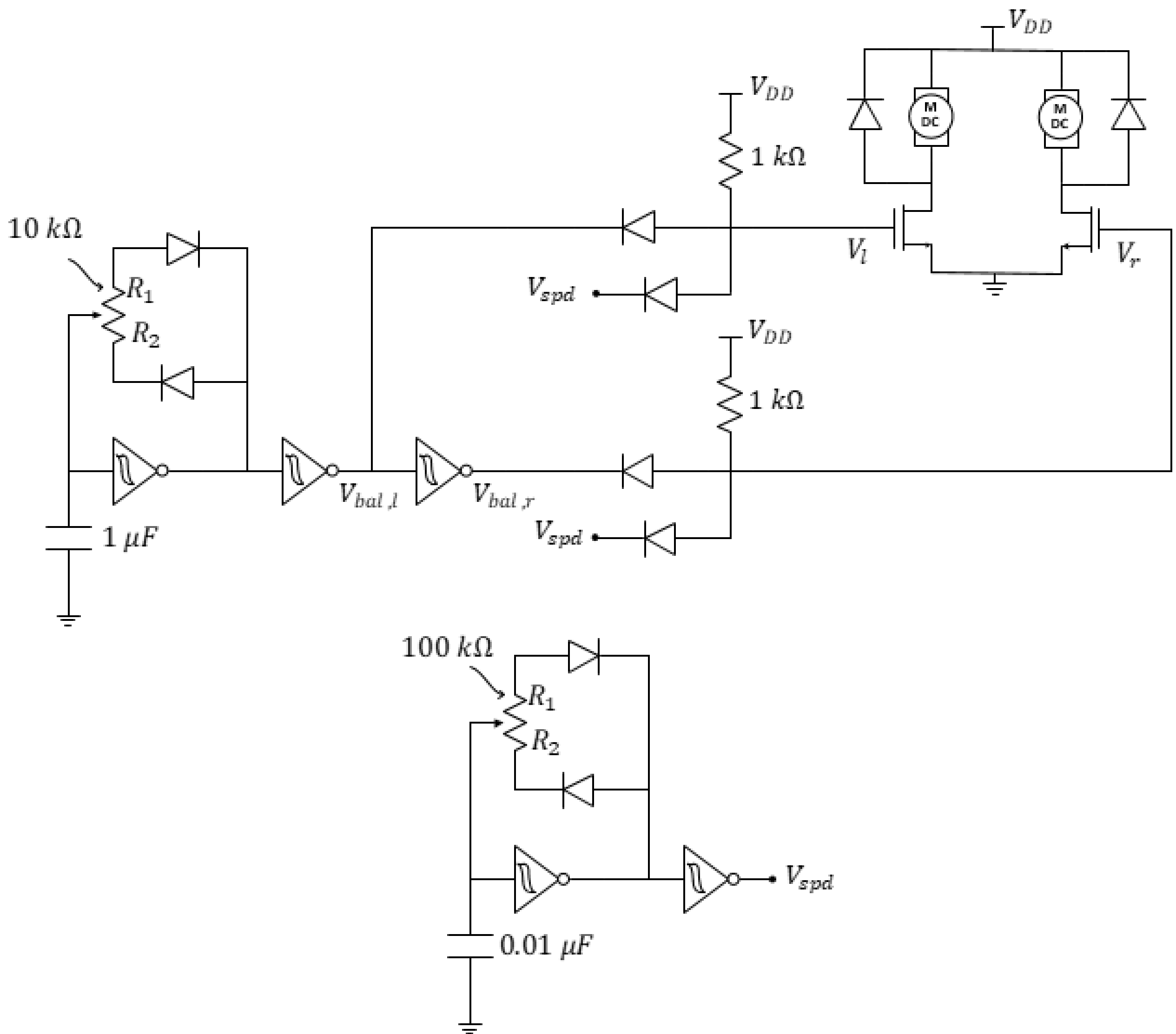


Figure 3: *PWM-based wheel balancer plus speed control. The speed control circuit is drawn separately for clarity, but notice that the nodes labeled* V_{spd} *must all be connected.*

Notes:

> **<u>Oscilloscope Hint</u>**: Please remember to start the oscilloscope from its **default setup** to make it easier to get to the configuration you desire.

Use the oscilloscope to verify proper oscillation. Set both oscillators to a duty cycle of 50%.

Question 2: Use the oscilloscope to measure the frequency of $V_{bal,l}$. Record that frequency here.

Use the oscilloscope to measure the frequency of V_{spd}. The frequency of V_{spd} should be **8-20 times higher** than the frequency of $V_{bal,l}$. If it is not**, replace the $\mathbf{0.01\ \mu F}$ capacitor with something more appropriate from your kit**. When you are satisfied with the frequency of V_{spd}, you may continue.

Question 3: Record the frequency of V_{spd} here.

Explore More! Modules

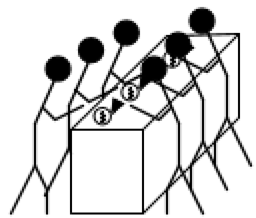
Explore More! Modules provide students with options to investigate new concepts! As time allows, do one or more of the modules before returning to the laboratory's core procedure.

This week, we highly recommend the following ***Explore More! Modules:***

***Explore More*! 8B The Clipping Circuit**	***Explore More*! 7F: Schmitt Trigger IV**	***Explore More*! 9B: Voltage-Follower Buffer**

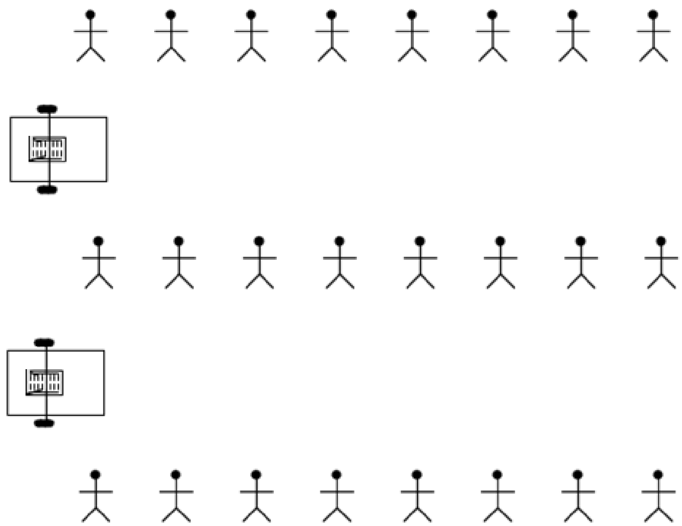
Notes:

Breakout Session #2



Collaborate.

When called back to the breakout, you may race your cars in straight-line paths using the two potentiometers to adjust for both speed and wheel balance.



Learning Objectives

- Deeper skills in building cascaded circuits useful for future design projects.

You are now ready to build a self-navigating vehicle. In the process, you have learned to model devices, predict behavior, build circuits, analyze circuit behavior, measure circuit parameters, and troubleshoot using the oscilloscope as a window into your work.

Lab 8 Summary (To be submitted at the end of the laboratory session)

Question 4: In the procedure prior to Question 3, *if* the frequency of V_{spd} had been too low, should you have tried a $0.1\ \mu F$ capacitor or a $0.001\ \mu F$ capacitor? Explain.

Question 5: Discuss why the frequencies of V_{bal} and V_{spd} need to be different. In doing so, also discuss what could go wrong if the two frequencies were the same. HINT: Sketch time-domain PWM signals with similar frequencies and the logical AND of them below and think about different alignments (remember, they are assumed to be ***incoherent***).

Modules submitted today:

Notes:

Name:

NetID:

Section AB/BB:

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Bench:

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