

Turn Signal ECU Circuit Experiment Worksheet (**INSTRUCTOR COPY**)

Objective: Explore how an ECU (Electronic Control Unit) Turn Signal circuit functions and understand the relationship between the various components including the battery, fuse, latching switch, ECU, 3-way switch, and LEDs.

Materials Needed:

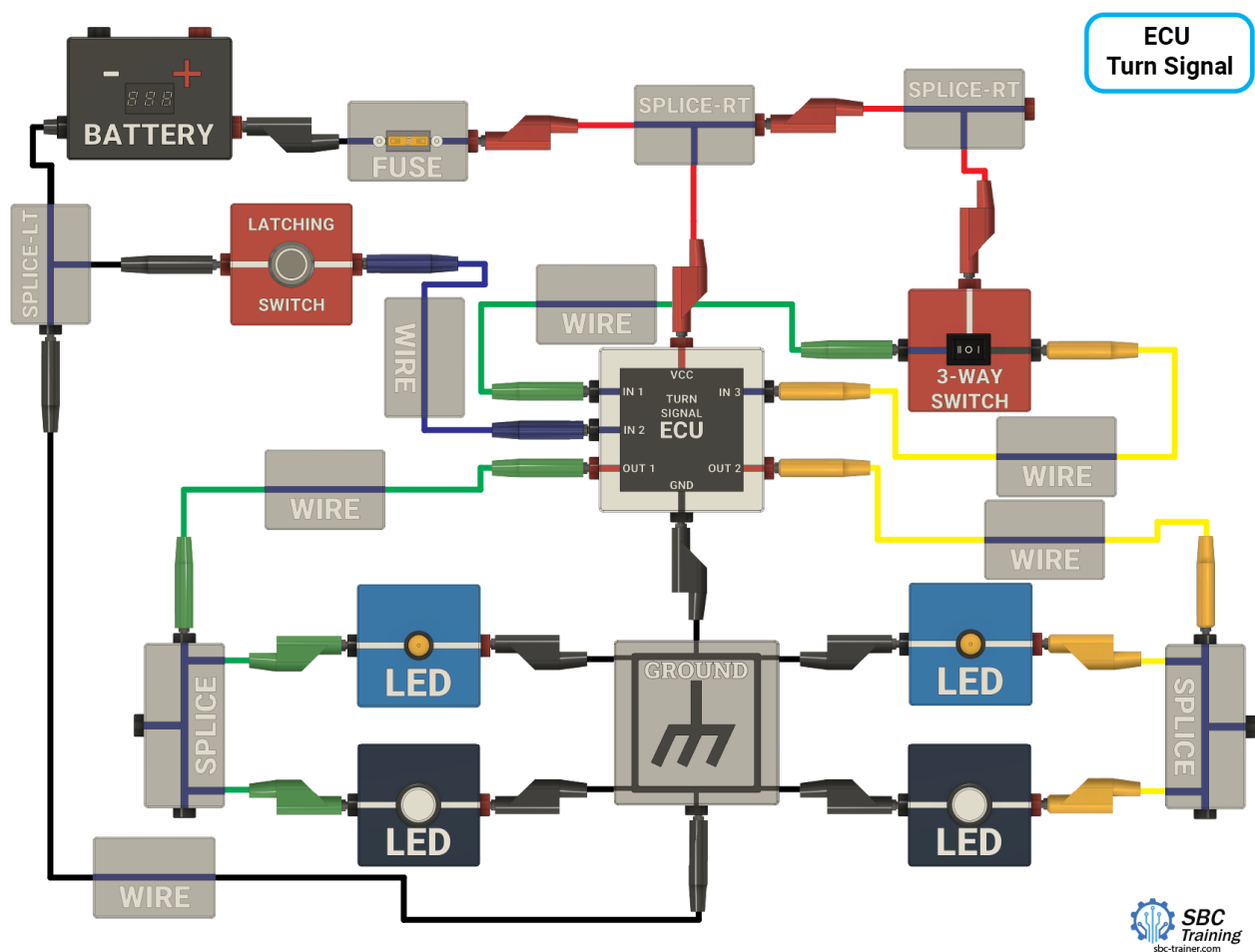
- ECU Turn Signal Kit
- A multimeter (Recommend a Fluke 87)
- Power Supply: Use the one provided in the kit or a bench-top power supply. Ensure the calculations match the voltage being supplied by your power supply.

Safety Precautions:

- Always double-check the circuit connections before powering it on.
- Never handle electrical components with wet hands.
- Be mindful of the power supply voltage to avoid damaging the components or the multimeter. It should be around 12 V

Background on an ECU

An ELECTRONIC CONTROL UNIT (ECU) Turn Signal circuit is designed to control the blinking of turn signal LEDs in vehicles. This setup includes a battery, fuse, latching switch, ECU, 3-way switch, and LEDs. Understanding the roles and interactions of these components is crucial for diagnosing and troubleshooting automotive electrical systems.



Key Components and Behavior:

- **POWER SUPPLY:** Provides the power supply for the circuit
- **BATTERY:** Shows the supplied voltage to the circuit from the Power Supply

- **FUSE:** Protects the circuit from overcurrent by breaking the connection if the current exceeds a certain threshold.
- **LATCHING SWITCH:** Maintains its state (on or off) after being actuated. This acts like a “hazard” switch in a vehicle.
- **ELECTRONIC CONTROL UNIT (ECU):** Manages the signals and controls the operation of the turn signals.
- **3-WAY SWITCH:** Allows for the selection between different circuit paths. This acts like a indicator multi-function switch in a vehicle.
- **LEDs:** Emit light when current flows through them, indicating the turn signal status.

Purpose of an ECU in a Vehicle:

The Electronic Control Unit (ECU) is a critical component in modern vehicles, responsible for managing and controlling various electronic systems. Its primary purpose is to **process inputs** from various sensors and switches, **make decisions** based on programmed algorithms, and **control the outputs** to various actuators and indicators. In the context of a turn signal circuit, the ECU plays a pivotal role in ensuring the turn signals operate correctly and safely.

Inputs to the ECU:

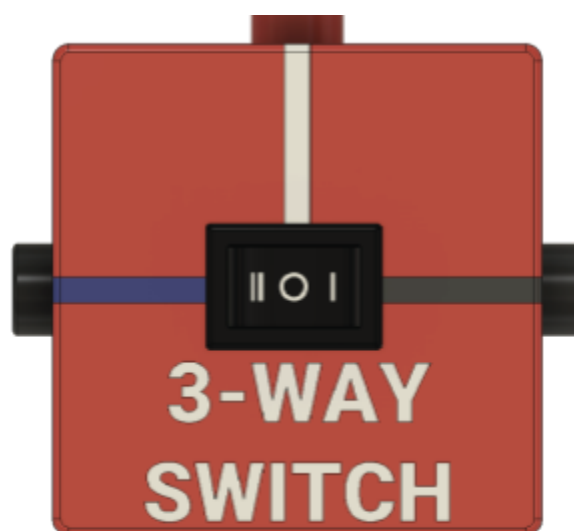
Switch Inputs: These include inputs from the turn signal lever (3-WAY SWITCH) and the hazard switch (LATCHING SWITCH). These switches send signals to the ECU indicating the driver's intention to turn or activate the hazard lights.

Experimental Circuit Inputs:

- LATCHING SWITCH = Hazard Switch
- 3-WAY SWITCH - Turn Signal Lever



HAZARD SWITCH

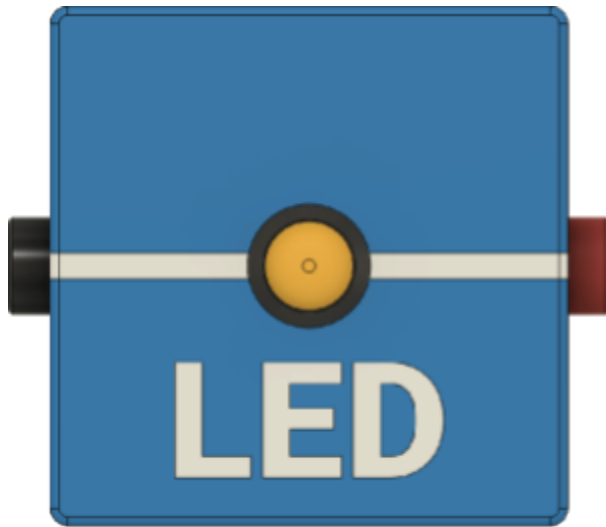


Turn Signal Lever

Outputs from the ECU:

LED Control:

- The ECU controls the blinking pattern of the turn signal LEDs.
- It sends pulses to the LEDs to make them blink at a regular interval, ensuring they are clearly visible to other road users.



FRONT Indicator



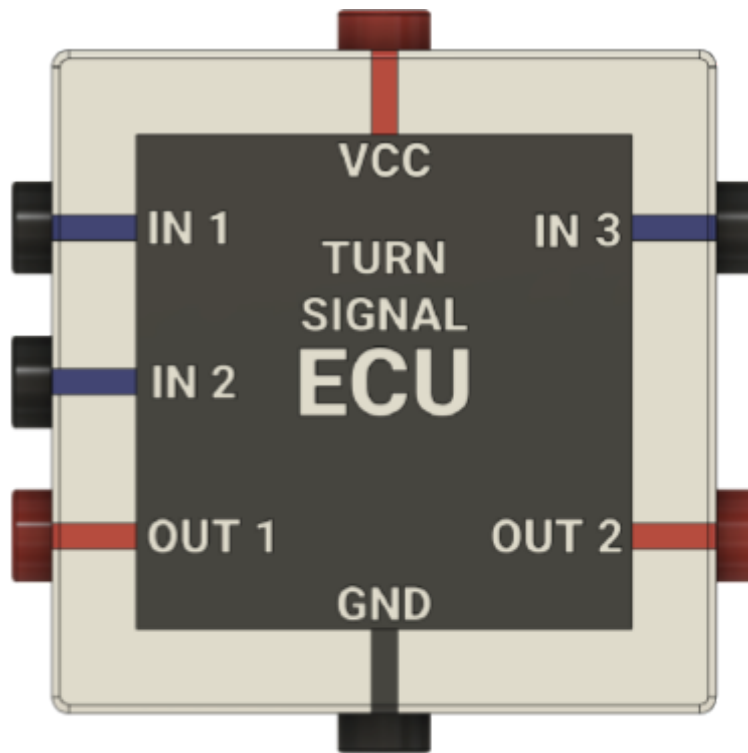
REAR Indicator

Feedback Signals:

- The ECU may also send signals to other vehicle systems or displays on the dashboard, indicating the status of the turn signals or alerting the driver to a malfunction (e.g., a burned-out bulb).

Processing by the ECU:

- **INPUTS:** The ECU **receives input** signals from the switches and sensors, processes these signals according to its internal programming, and generates the appropriate output signals to control the turn signal LEDs.
- **PROCESSING:** The **processing** involves decision-making algorithms that consider the current state of the vehicle (e.g., speed, ambient conditions) and driver inputs to determine the correct operation of the turn signals.
- **OUTPUTS:** Based on its processing, the ECU sends out signals to the turn signal LEDs, making them blink in the desired pattern. It may also send diagnostic or feedback signals to other systems within the vehicle.



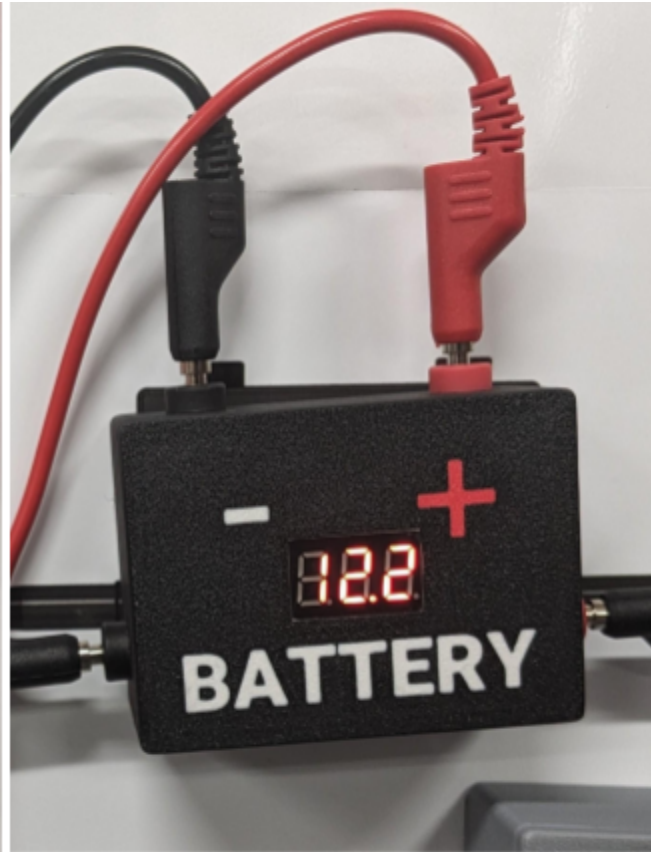
ELECTRONIC CONTROL UNIT

- Receives **INPUTS**
- **PROCESSES** Signal
- Controls **OUTPUTS**

2. Set Up Your Multimeter:
 - a. Before you begin, make sure your multimeter is set to measure DC voltage.
3. Connect the POWER SUPPLY to the battery using the red and black POWER SUPPLY WIRES



POWER SUPPLY Connection



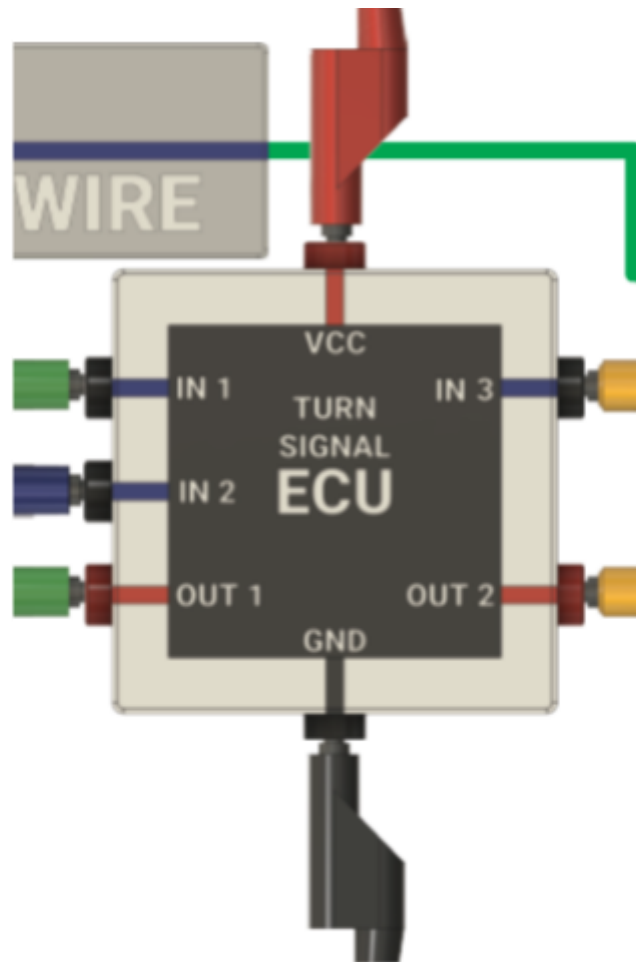
BATTERY Connection

4. Turn on the POWER SUPPLY by pushing up on the switch located at the top left side of the POWER SUPPLY
5. Ensure that the circuit is functioning by verifying that the LEDs are flashing on both the left and right side.
6. Measure Initial Voltage:
 - a. Connect the multimeter probes to the BATTERY to measure the total voltage supplied to the circuit. This is your reference voltage. Compare to your value with that found on the small meter embedded in the BATTERY. They should be similar

ECU INPUTS

Power Supply Input:

- This provides the necessary voltage to the ECU and other components in the circuit. It is typically around 12V, simulating the vehicle's battery.
- Internally, the ECU converts this 12V input to a regulated 5V supply to power its microcontroller and input sensing circuits. This internal 5V regulation is crucial for the stable operation of the ECU's internal electronics. The external outputs controlled by the ECU, such as the signals to the turn signal LEDs, remain at 12V.

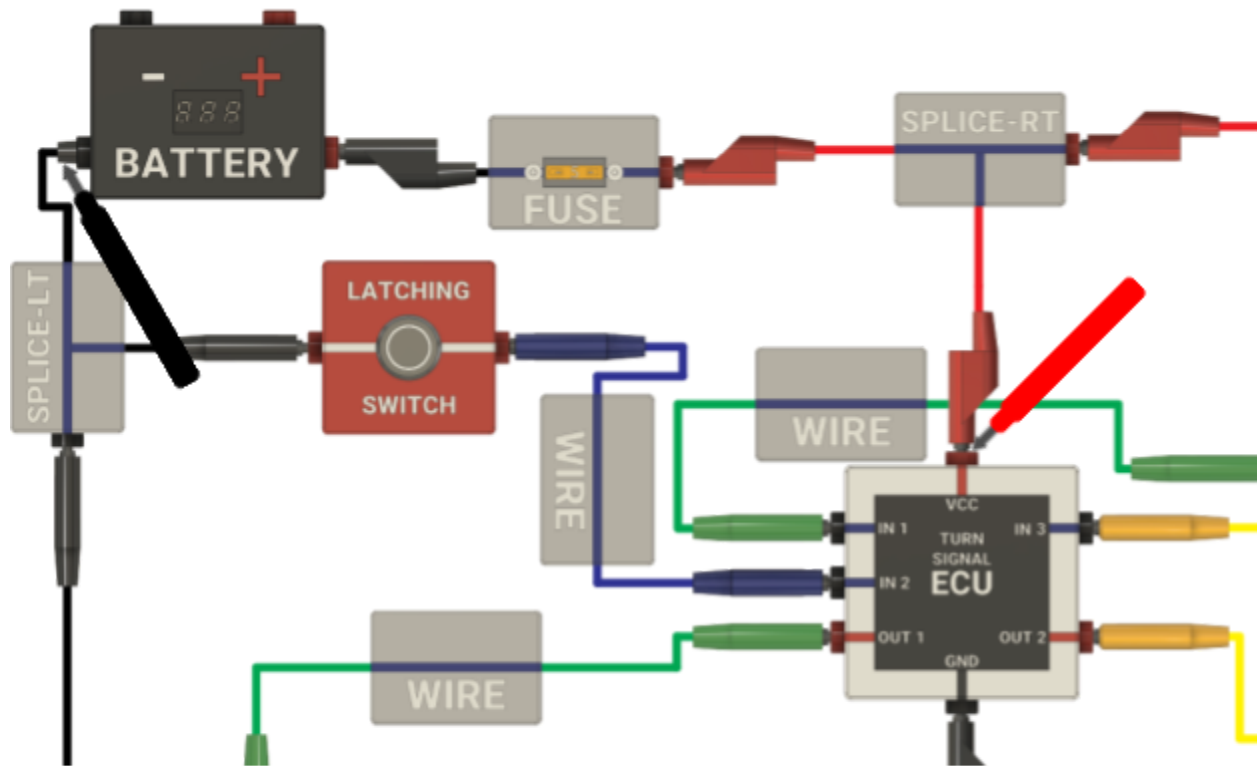


VCC - 12V

GND - Battery Negative

1. Measure and record the voltage at the VCC terminal of the ECU
 - Place the black meter lead on the BATTERY negative
 - Place the red meter lead on the VCC of the ECU

Voltage at VCC approximately 12 V



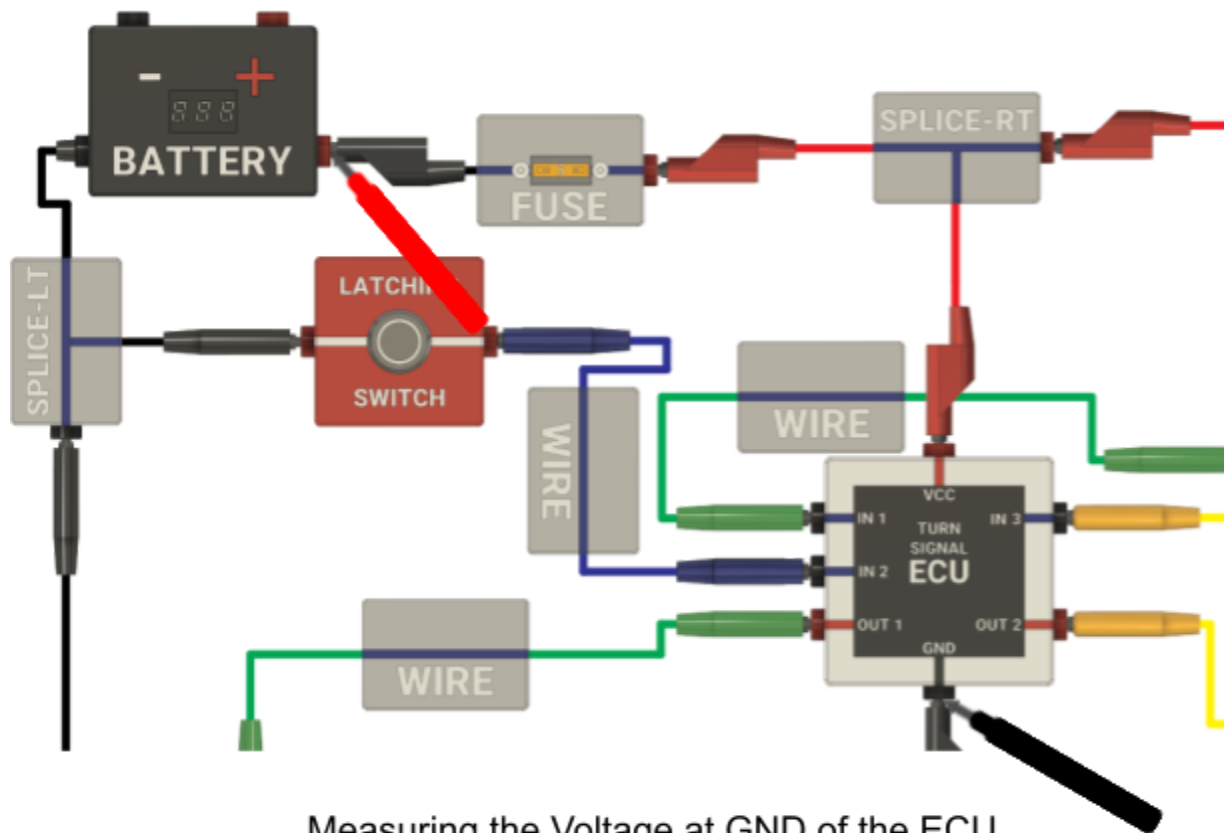
Measuring the Voltage at VCC of the ECU

2. Measure and record the voltage at the GND terminal of the ECU

- Place the black meter lead on GND
- Place the red meter lead on BATTERY +

Voltage at GND approximately 12 V

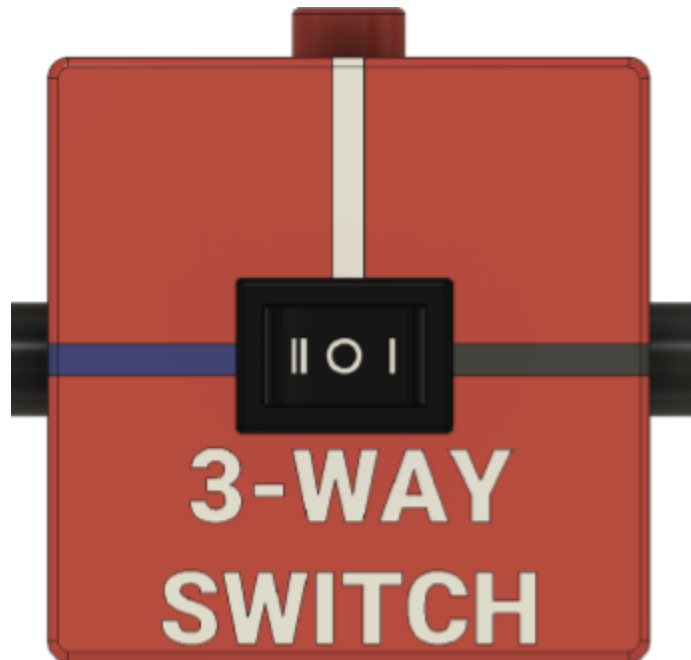
This is one method for validating the ground of the circuit. If a student puts a negative number, it would be good to have a discussion about polarity



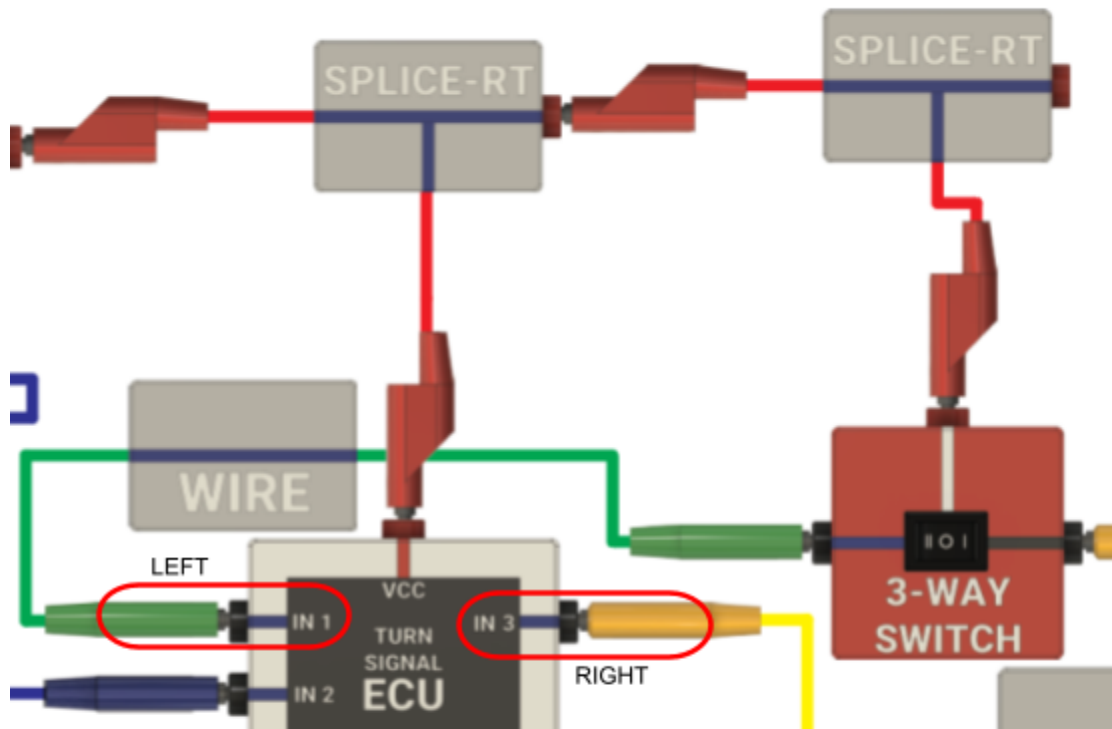
Measuring the Voltage at GND of the ECU

3-Way Switch (Power Side):

- This switch selects between different circuit paths, similar to a turn signal lever in a vehicle.
- This type of switch is known as a rocker switch.
- The switch has 3 positions
 - Left rocker switch position ||
 - Connects the top jack to the left jack
 - Center position O
 - Open switch position
 - Right rocker switch position |
 - Connects the top jack to the right jack
- When the 3-way switch is moved to the left or right, it sends a power signal to the ECU, indicating the driver's intention to turn left or right.



3-WAY SWITCH is a
power side switch
– || – Left position
– | – Right position
– O – Off position



3-WAY SWITCH is a power side switch
 IN 1 Left Switch
 IN 3 Right Switch

Power Side Input (IN 1, IN 2):

The IN 1 and IN 3 inputs power side inputs, which typically uses a pull-down resistor. This configuration ensures that the input pin reads a low voltage (0V) when the switch is open. When the switch is closed, it connects the input to the power supply, resulting in a high state (12V). This design helps in preventing floating states on the input pin and ensures reliable operation of the ECU.

Power-down Resistor

A pull-down resistor is a resistor used in electronic circuits to ensure that a particular input pin is at a defined logic level when no active signal is present. Specifically, a pull-down resistor connects the input pin to ground (0V), pulling the pin to a low state when the switch or signal source is open or inactive. This prevents the input from floating, which can cause erratic behavior or unintended triggering of the circuit. In the context of a power side input, a pull-down resistor ensures that the input reads as low (0V) when the switch is open, and switches to a high state (e.g., 12V) when the switch is closed and power is applied. Pull-down resistors are essential in maintaining stable and predictable input states in digital circuits.

In our circuit, when the switch is open, the input pin connected to the pull-down resistor will have a voltage close to 0V. This is because the pull-down resistor ensures that the input pin is grounded, preventing it from floating and causing erratic behavior. When you measure the voltage at the input pin with a multimeter, you should see a reading near 0V, confirming that the pull-down resistor is effectively pulling the pin to a low state. This stable low voltage is crucial for the proper functioning of the ECU, ensuring that it correctly interprets the input signal when the switch is not activated.

SWITCH OFF

When you measure the voltage at the input pin with a multimeter, you should see a reading near 0V, confirming that the pull-down resistor is effectively pulling the pin to a low state. This stable low voltage is crucial for the proper functioning of the ECU, ensuring that it correctly interprets the input signal when the switch is not activated.

SWITCH ON

When the switch is closed, the input pin will be connected to the power supply, and the voltage at the input pin will rise to 12V. Measuring the voltage at this point should show 12V, confirming that the input pin is now in a high state. This stable voltage behavior is crucial for the proper functioning of the ECU, ensuring that it correctly interprets the input signal when the switch is either activated or not.

3. Measure and record the voltage at the 3-WAY SWICHT left terminal

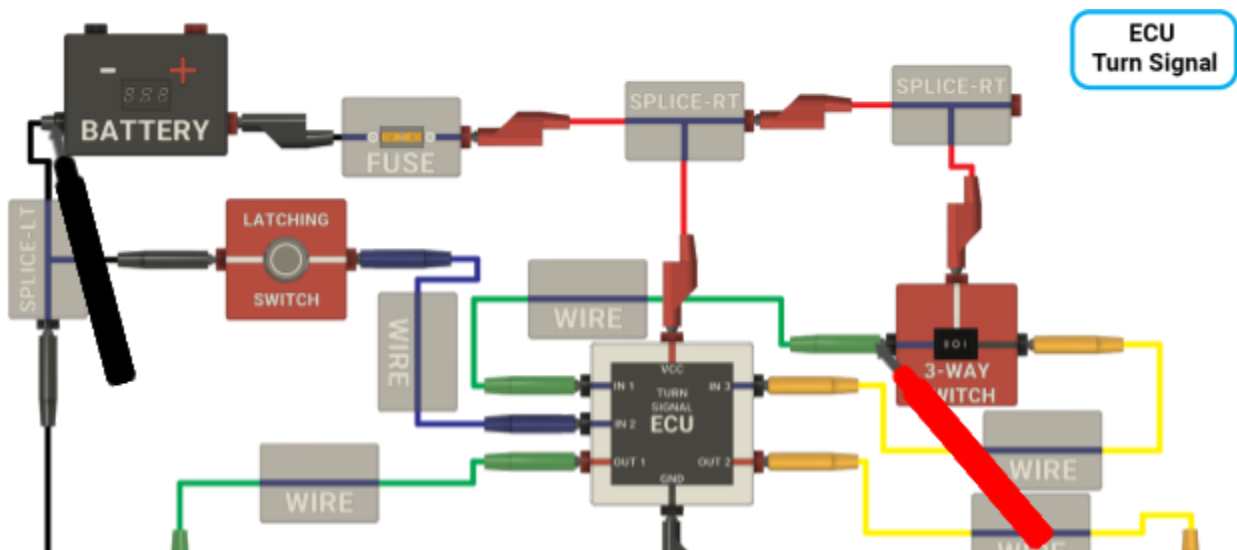
- Place the black meter lead on GND
- Place the red meter lead on Left terminal (green wire)

Voltage at Left (SWITCH OFF -0 -) 0V to 0.5 V

Remind students that the presence of a pull-down resistor is likely why they may observe a small amount of voltage at the input pin when the switch is off. This voltage should be around 0.35V, depending on the voltage available in the circuit. The short answer is that the ECU does have some residual voltage as part of the input.

In an actual vehicle, this residual voltage can serve an important diagnostic function. It might be used by the vehicle's onboard diagnostic system to identify faults and set trouble codes. This helps in detecting issues such as open circuits or failed components, ensuring the system operates correctly and safely.

Voltage at Left (SWITCH Left -|| -) approximately 12 V



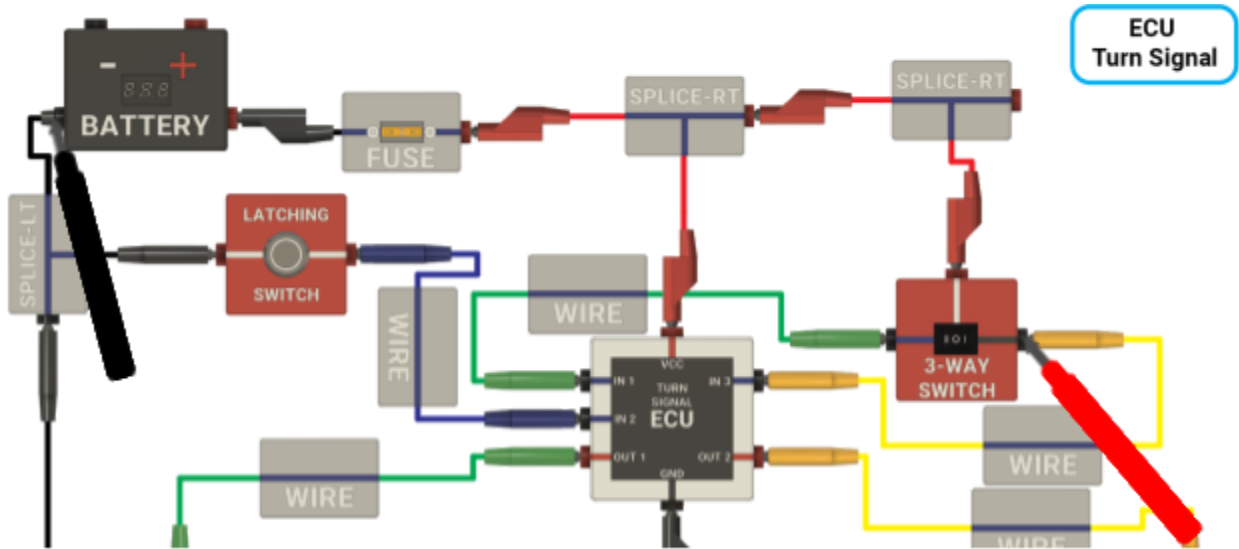
Measuring voltage at Left

5. Measure and record the voltage at the 3-WAY SWICHT right terminal
 - Place the black meter lead on GND
 - Place the red meter lead on right terminal (yellow wire)

Voltage at Right(SWITCH OFF -0 -) 0V to 0.5 V

Same as question 3

Voltage at Right(SWITCH Left -| -) approxiamately 12 V



Measuring voltage at Right

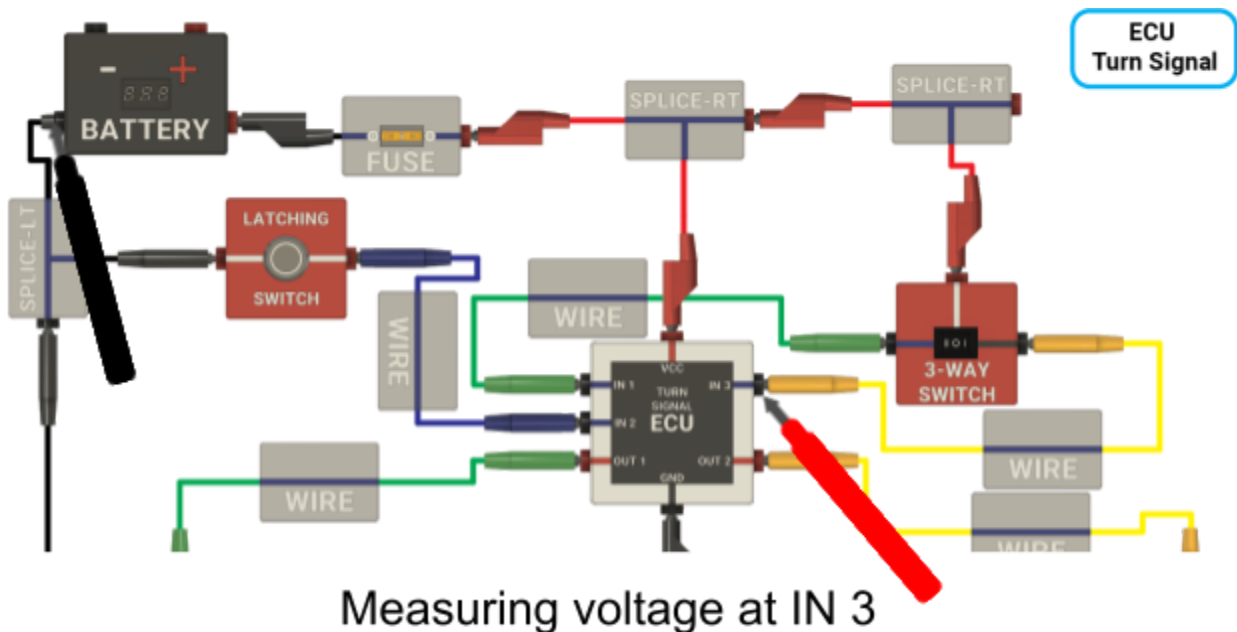
6. Measure and record the voltage at the IN 3 input of the ECU

- Place the black meter lead on GND
- Place the red meter lead on IN 3 Terminal

Voltage at IN 3 (SWITCH OFF – 0 –) 0V to 0.5 V

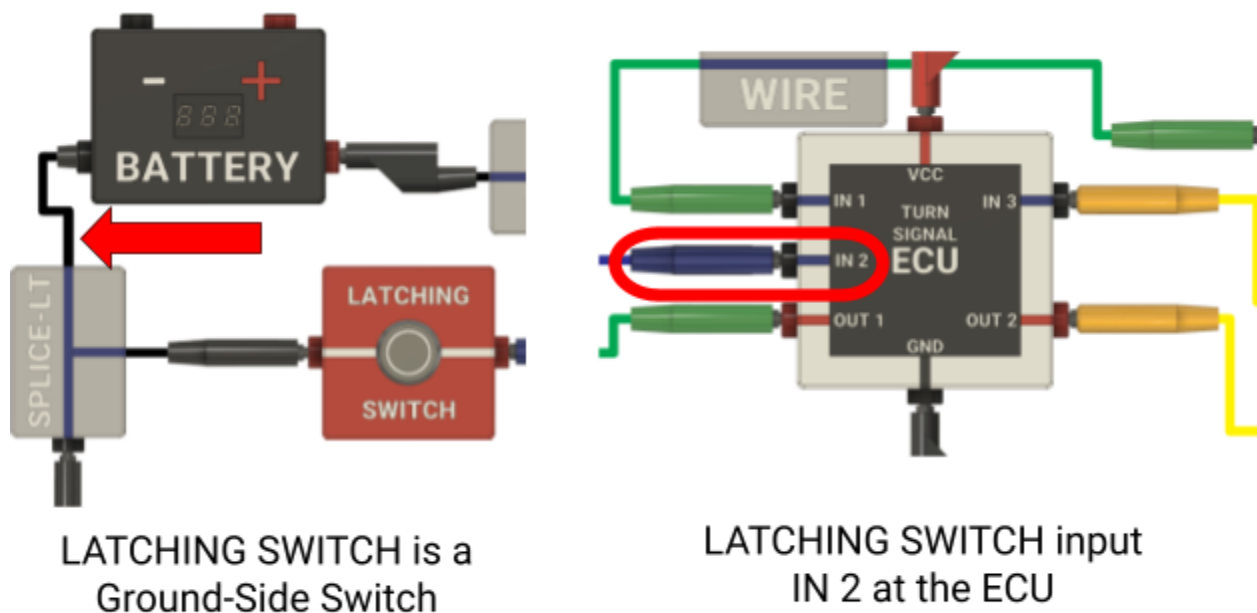
Same as question 3

Voltage at IN 3 (SWITCH Right – 1 –) approximately 12 V



Latching Switch (Ground Side):

- This switch maintains its state after being actuated, similar to a hazard switch in a vehicle. Once pressed, it mechanically locks into position and remains engaged without the need to hold it down.
- When the latching switch is turned on, it provides a ground connection to the ECU, indicating the activation of the hazard lights.
- The input to the ECU from the latching switch is at position IN 2 on the ECU



Ground Side Input (IN 2):

The IN 2 input is a ground side input, which typically uses a pull-up resistor. This configuration ensures that the input pin reads a high voltage (5V) when the switch is open. When the switch is closed, it connects the input to ground, resulting in a low state (0V). This design helps in preventing floating states on the input pin and ensures reliable operation of the ECU.

Pull-up Resistor

A pull-up resistor is a resistor used in electronic circuits to ensure that a particular input pin is at a defined logic level when no active signal is present. Specifically, a pull-up resistor connects the input pin to the positive voltage supply (e.g., 5V), pulling the pin to a high state when the switch or signal source is open or inactive. This prevents the input from floating, which can cause erratic behavior or unintended triggering of the circuit. In the context of a ground side input, a pull-up resistor ensures that the input reads as high (e.g., 5V) when the switch is open, and switches to a low state (0V) when the switch is closed and connected to ground. Pull-up resistors are essential in maintaining stable and predictable input states in digital circuits.

In our circuit, when the switch is open, the input pin connected to the pull-up resistor will have a voltage close to 5V. This is because the pull-up resistor ensures that the input pin is pulled to the positive voltage supply, preventing it from floating and causing erratic behavior.

SWITCH OFF

When you measure the voltage at the input pin with a multimeter, you should see a reading near 5V, confirming that the pull-up resistor is effectively pulling the pin to a high state. This stable high voltage is crucial for the proper functioning of the ECU, ensuring that it correctly interprets the input signal when the switch is not activated.

SWITCH ON

When the switch is closed, the input pin will be connected to ground, and the voltage at the input pin will drop to 0V. Measuring the voltage at this point should show 0V, confirming that the input pin is now in a low state. This stable voltage behavior is crucial for the proper functioning of the ECU, ensuring that it correctly interprets the input signal when the switch is either activated or not.

7. Measure and record the voltage at the LATCHING SWITCH output terminal

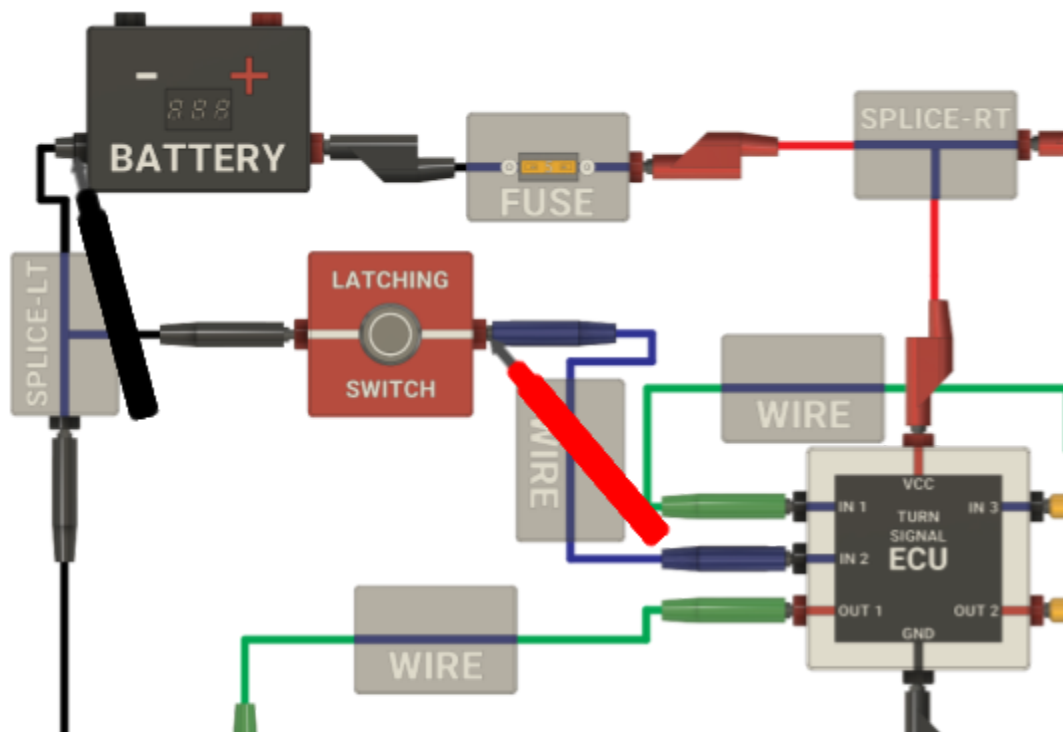
- Place the black meter lead on GND
- Place the red meter lead on output terminal (blue wire)

Voltage at output terminal (SWITCH OFF) approximately 5 V

Remind students that the pull-up resistor is likely why they see a voltage at the input pin when the switch is off. In our circuit, this voltage should be around 5V. This 5V is a regulated voltage provided by the ECU, even though the VCC (power supply) is 12V.

In an actual vehicle, this regulated voltage helps in maintaining consistent performance across various operating conditions. The regulated 5V or 8V in some vehicles ensures that the input pin can be accurately read by the ECU, allowing it to correctly interpret the signal when the switch is activated or not. This stable voltage is crucial for the proper functioning of the ECU, contributing to the system's overall reliability and diagnostic capabilities.

Voltage at output terminal (SWITCH ON) approximately 0 V



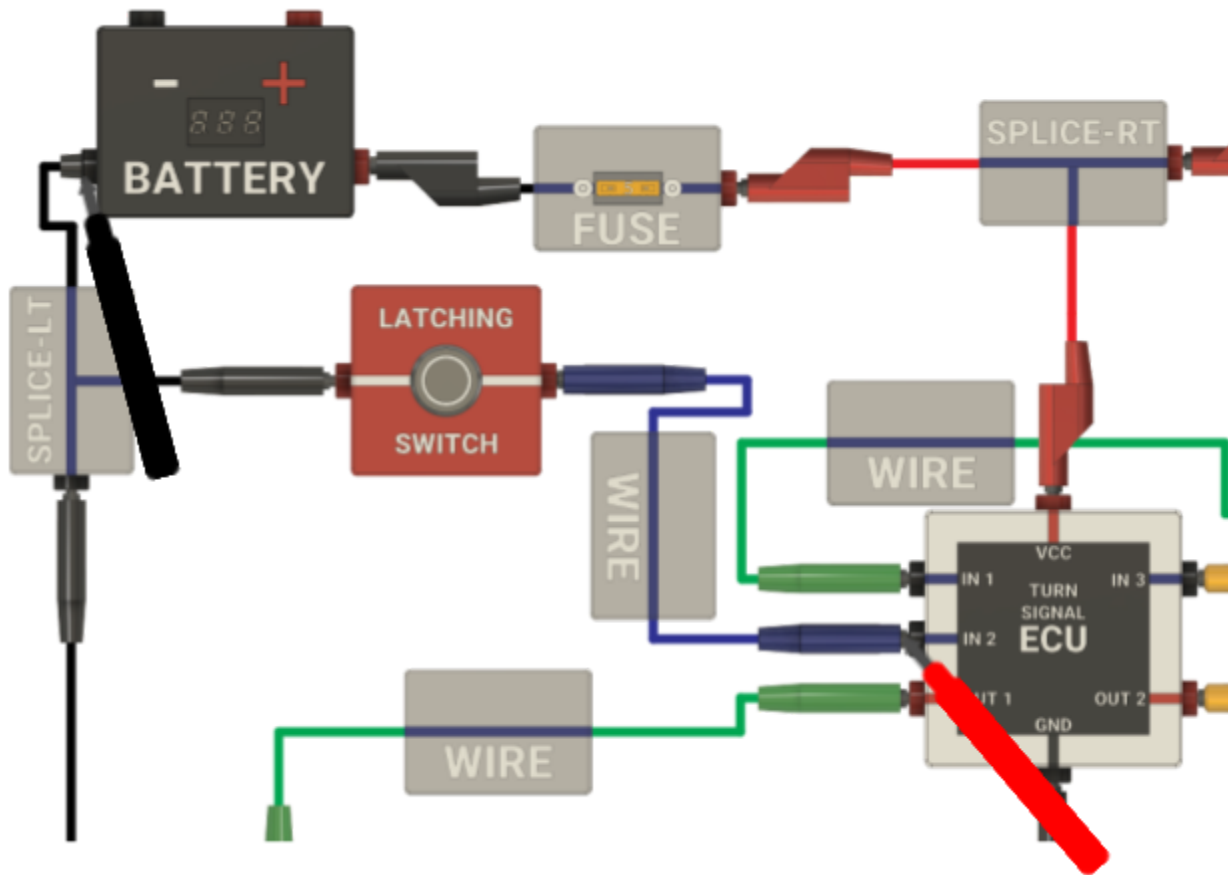
Measuring voltage output terminal of LATCHING SWITCH

8. Measure and record the voltage at the IN 2 input of the ECU

- Place the black meter lead on GND
- Place the red meter lead on IN 2 Terminal

Voltage at IN 2 (SWITCH OFF) approximately 5 V

Voltage at IN 2 (SWITCH ON) approximately 0 V



Measuring voltage at IN 2 of ECU

ECU Outputs

Outputs from the ECU:

The ECU in this circuit controls two outputs, OUT 1 and OUT 2, which are both 12V high side drivers. These outputs are responsible for blinking the turn signal LEDs. Understanding the behavior of these outputs is essential for diagnosing and troubleshooting the turn signal circuit.

OUT 1 (High Side Driver):

Description:

- OUT 1 is a high side driver output, meaning it supplies 12V to the connected load when activated by the ECU. When the ECU sends a signal to OUT 1, it connects the output to the 12V power supply, allowing current to flow to the connected component.

Behavior:

- This output is used to control the left turn signal LEDs. When the turn signal lever (3-WAY SWITCH) is moved to the left, the ECU processes this input and activates OUT 1, causing the left turn signal LEDs to blink.
- When the hazard switch (LATCHING SWITCH) is activated it will also cause the left turn signal LEDs to blink.

OUT 2 (High Side Driver):

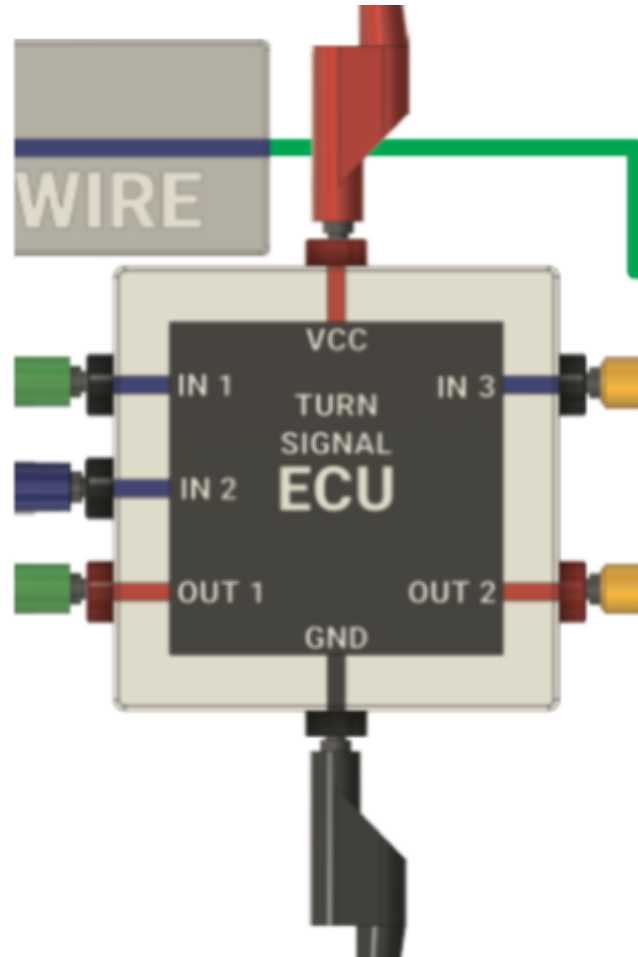
Description:

- OUT 2 is a high side driver output, meaning it supplies 12V to the connected load when activated by the ECU. When the ECU sends a signal to OUT 2, it connects the output to the 12V power supply, allowing current to flow to the connected component.

Behavior:

- This output is used to control the right turn signal LEDs. When the turn signal lever (3-WAY SWITCH) is moved to the right, the ECU processes this input and activates OUT 2, causing the right turn signal LEDs to blink.
- When the hazard switch (LATCHING SWITCH) is activated it will also cause the right turn signal LEDs to blink.

OUT 2 (High Side Driver):



OUT 1 - Left Indicators
OUT 2 - Right Indicators

Using the Min/Max Function on Your Multimeter:

When measuring the outputs from the ECU, which control the blinking of the turn signal LEDs, a traditional multimeter might not show a steady 12V due to the blinking nature of the signal. The blinking causes the multimeter to average the signal, leading to inaccurate readings. To capture the true output voltage, use the min/max function of your multimeter.

Why Use the Min/Max Function:

Blinking Signals:

- The turn signal LEDs blink on and off, causing the output voltage to fluctuate between 0V and 12V. A standard voltage reading will either change numbers rapidly or average these fluctuations, making it difficult to determine the actual peak voltage. Using the min/max function helps capture the true voltage peaks accurately.

Accurate Measurement:

- The min/max function allows the multimeter to record the minimum and maximum voltage values over a period of time. This helps in capturing the peak voltage when the signal is at its highest (12V) and the lowest (0V) accurately.

How to Use the Min/Max Function:

1. Set Up Your Multimeter:

- Set your multimeter to measure voltage (DC).
- Enable the min/max function on your multimeter. This function may be labeled as "Min/Max," "Peak Hold," or something similar, depending on your multimeter model.

2. Connect the Multimeter:

- Connect the multimeter's negative lead to the BATTERY negative terminal.
- Connect the multimeter's positive lead to the output pin of the ECU.

3. Activate the Circuit:

- Move the 3-way switch to the left or right position to activate the corresponding turn signal.
- Allow the multimeter to record the voltage for a few cycles of the blinking signal. Your meter may make a beeping noise when it records a min or max voltage

4. Observe the Reading:

- Observe and record the maximum voltage reading displayed by the multimeter. This value should be approximately 12V when the turn signal is activated. Pressing the Min/Max button on most meters will toggle the reading between Min and Max values

9. Measure and record the voltage at the OUT 1 terminal using the MIN/MAX feature
 - Place the black meter lead on GND
 - Place the red meter lead on output terminal (green wire)

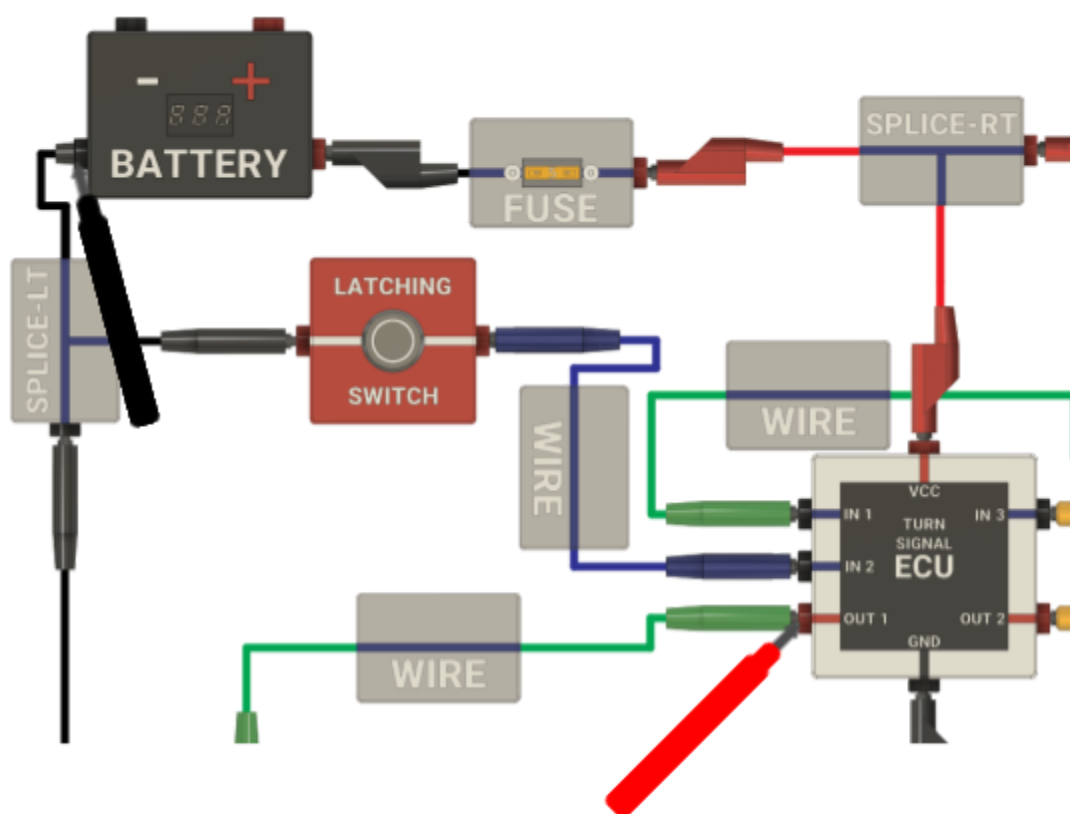
MAX Voltage at OUT1 (LATCHING SWITCH OFF) approximately 0 V

MAX Voltage at OUT1 (LATCHING SWITCH ON) approximately 12 V

If your multimeter shows "OL" (Over Limit) as the MAX reading, try using the peak min/max function by pressing the sound button (used for continuity) on the Fluke 87. Additionally, you can use the average function on the min/max setting, which should give you a reading around 6V. This average value helps you understand the effective voltage in a blinking circuit where the signal alternates between 0V and 12V.

MAX Voltage at OUT1 (3-WAY SWITCH left OFF) approximately 0 V

MAX Voltage at OUT1 (3-WAY SWITCH left ON) approximately 12 V



Measuring voltage output terminal OUT 1

Measure and record the voltage at the OUT 2 terminal using the MIN/MAX feature

- Place the black meter lead on GND
- Place the red meter lead on output terminal (yellow wire)

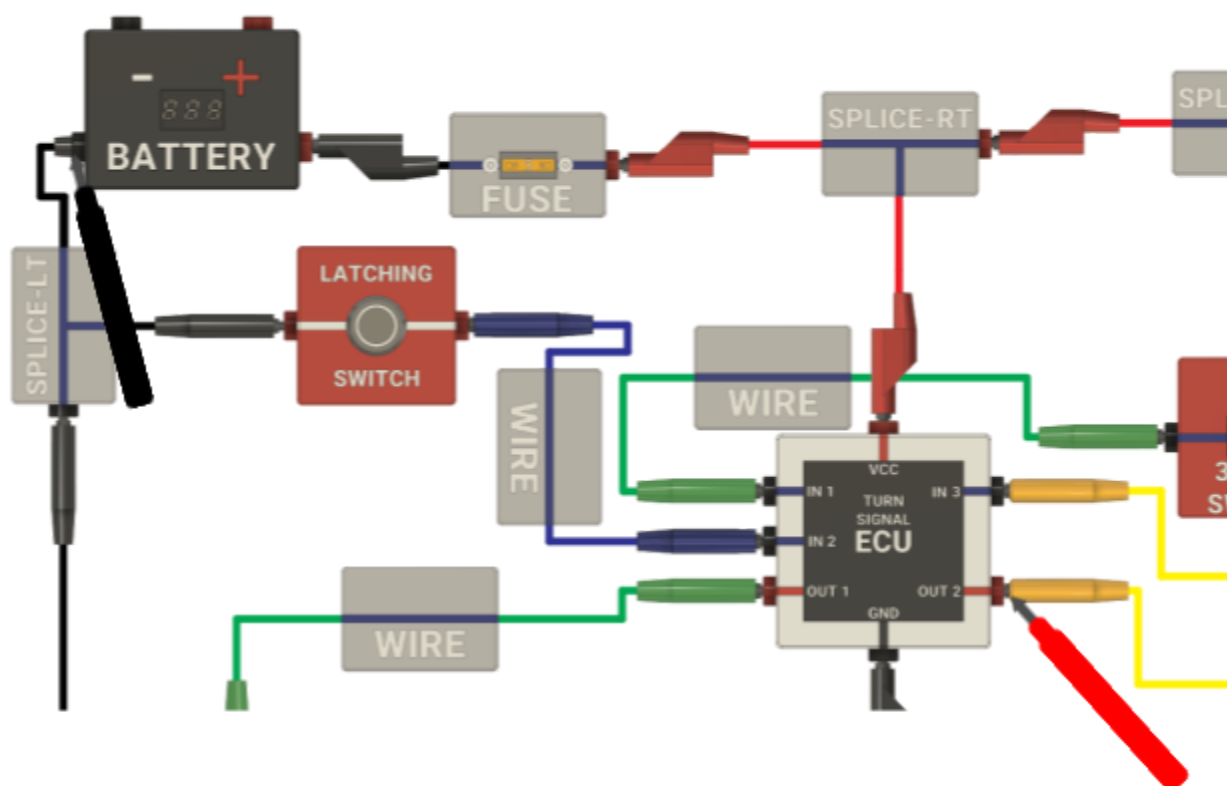
MAX Voltage at OUT2 (LATCHING SWITCH OFF) approximately 0 V

MAX Voltage at OUT2 (LATCHING SWITCH ON) approximately 12 V

MAX Voltage at OUT2 (3-WAY SWITCH right OFF) approximately 0 V

MAX Voltage at OUT2 (3-WAY SWITCH right ON) approximately 12 V

Remind students that the output of the ECU is separate from the input. This is why you get the same voltage measurements regardless of whether the latching switch or the 3-way switch is used to turn the circuit on. The ECU processes the input signals and controls the outputs independently, ensuring consistent operation of the turn signal LEDs regardless of which switch is activated.

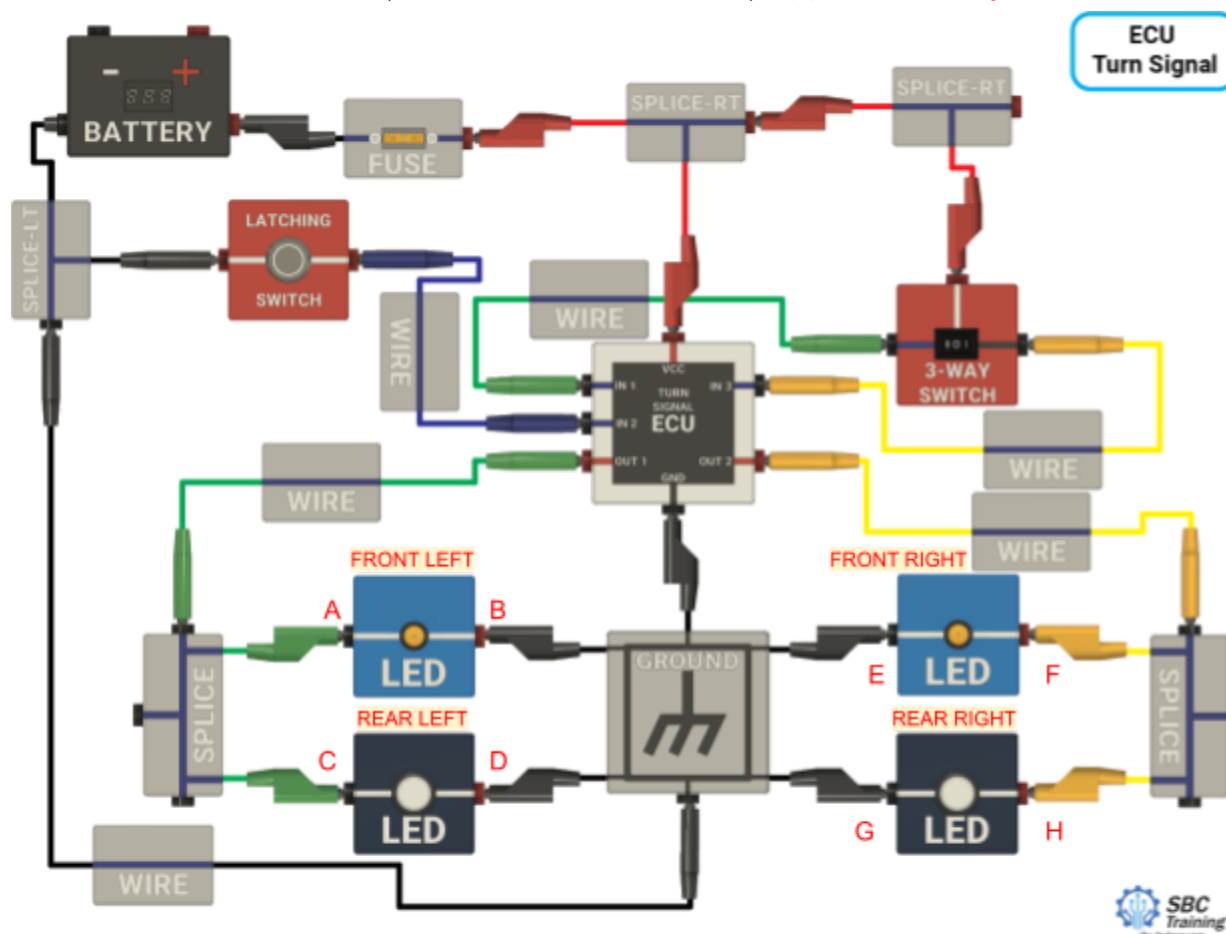


Measuring voltage output terminal OUT 2

10. Measure and record the voltage at each of the following points identified in the image below

- Place the black meter lead on GND
- Place the red meter lead at each of the letters

Voltage at A (LATCHING SWITCH OFF) approximately 0 V
 MAX Voltage at A (LATCHING SWITCH ON) approximately 12 V
 Voltage at B (LATCHING SWITCH OFF) approximately 0 V
 MAX Voltage at B (LATCHING SWITCH ON) approximately 12 V
 Voltage at F (LATCHING SWITCH OFF) approximately 0 V
 MAX Voltage at F (LATCHING SWITCH ON) approximately 12 V
 Voltage at E (LATCHING SWITCH OFF) approximately 0 V
 MAX Voltage at E (LATCHING SWITCH ON) approximately 12 V

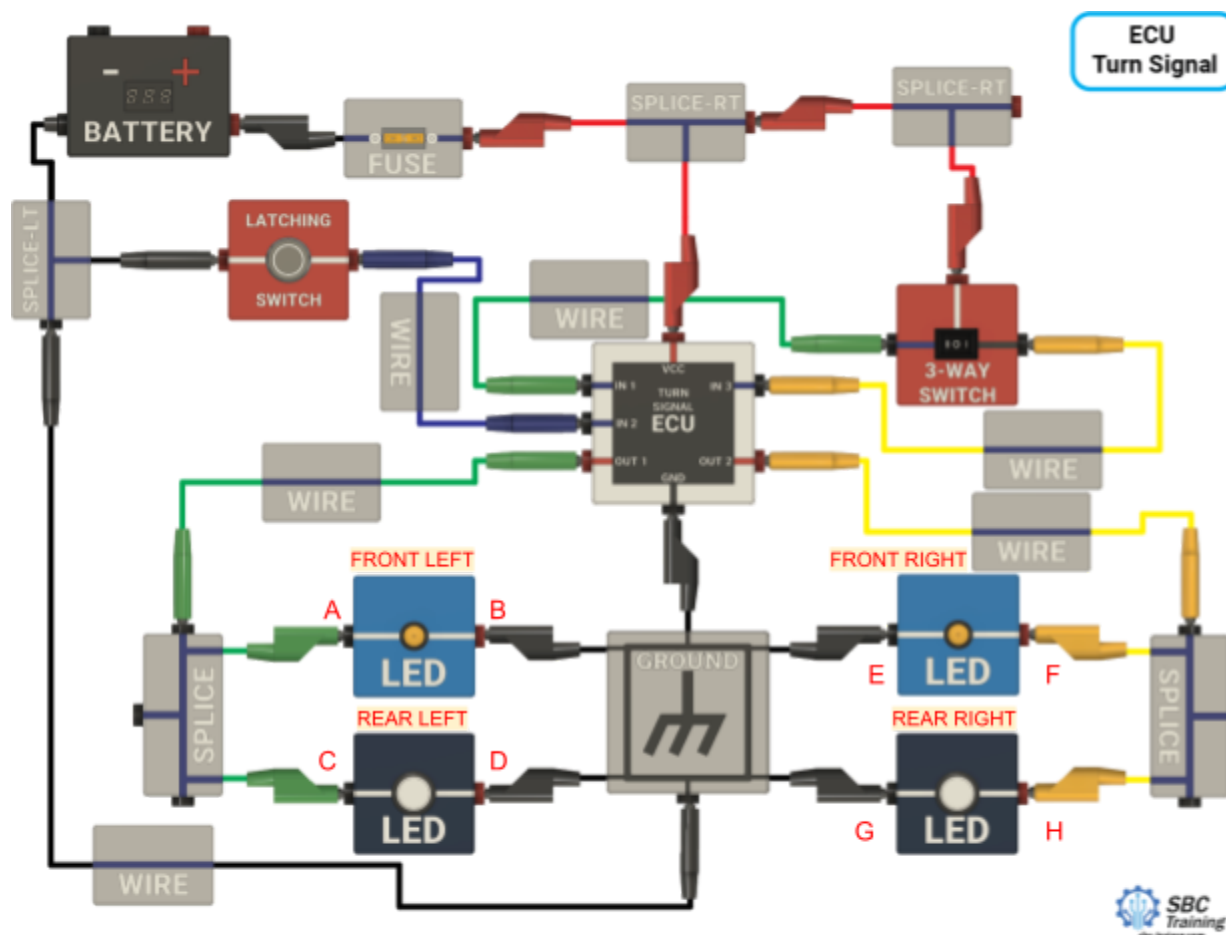


Measuring voltage at each of these positions

11. Measure and record the voltage drop at each of the following points identified in the image below

- Place the black meter lead on GND
- Place the red meter lead at each of the letters

Voltage drop at A to B (LATCHING SWITCH OFF) approximately 0 V
 MAX Voltage drop at A to B (LATCHING SWITCH ON) approximately 12 V
 Voltage drop at C to D (LATCHING SWITCH OFF) approximately 0 V
 MAX Voltage drop at C to D (LATCHING SWITCH ON) approximately 12 V
 Voltage drop at E to F (LATCHING SWITCH OFF) approximately 0 V
 MAX Voltage drop at E to F (LATCHING SWITCH ON) approximately 12 V
 Voltage drop at G to H (LATCHING SWITCH OFF) approximately 0 V
 MAX Voltage drop at G to H (LATCHING SWITCH ON) approximately 12 V



Measuring voltage drop at each of these positions

1. Describe the difference between a power side input and a ground side input.
 - A. A power side input connects to the ground when activated; a ground side input connects to the power supply when activated.
 - B. A power side input uses a pull-up resistor; a ground side input uses a pull-down resistor.
 - C. A power side input connects to the power supply when activated; a ground side input connects to the ground when activated.
 - D. A power side input uses a pull-down resistor; a ground side input uses a pull-up resistor.
2. Why is it necessary to use the min/max function of a multimeter when measuring the outputs from the Turn Signal ECU?
 - A. To capture the average voltage accurately.
 - B. To measure the current flow precisely.
 - C. To capture the true voltage peaks and fluctuations accurately.
 - D. To measure the resistance of the circuit.
3. How can you check the ground connection of the ECU using a multimeter?
 - A. Set the multimeter to measure resistance, connect one lead to VCC and the other to ground.
 - B. Set the multimeter to measure voltage (DC), connect the red lead to the battery positive terminal, and the black lead to the ground pin of the ECU.
 - C. Set the multimeter to measure current, connect leads in parallel to the ground pin.
 - D. Set the multimeter to measure capacitance, connect leads to the battery and ground pin.
4. Which type of input configuration typically uses a pull-up resistor?
 - A. Power side input
 - B. Ground side input
 - C. Both power and ground side inputs
 - D. Neither power nor ground side inputs
5. What is a high side driver output in the context of the ECU turn signal circuit?
 - A. An output that connects to ground when activated
 - B. An output that supplies 12V to the connected load when activated
 - C. An output that regulates the input voltage to 5V
 - D. An output that measures the resistance of the circuit