Interface Definitions

Interface	Properties
outside_to_sytem_acpwr	• Vnominal: 120VAC via a NEMA 5-15R connector • Ipeak: 15A • Inominal: 500mA
fused_acpwr	• Vnominal: 120VAC • Ipeak: 5A • Inominal: 500mA • Disconnects system from input when 5A draw is exceeded
mcu_dcpwr	• Vnominal: 3.3VDC • Vmax: 3.6VDC • Vmin: 2.3 VDC • Inominal: 500mA • Powers ESP32 Microcontroller
node_dcpwr_(n)*	• Vnominal: 4.5VDC • Inominal: 500mA • Powers Relays
sensor_to_mcu_dsig_(n)*	• Vnominal: <1VDC • Reports current on output channels • Inominal: <5A • Utilizes I2C serial protocol • Fmax: 400 kHz
sensor_to_mcu_asig	• VHighMin: 0.75*mcu_dcpwr VDC • VHighMax: VDD + 0.3 VDC • VLowMin: -0.3VDC • VLowMax: 0.25*mcu_dcpwr VDC
mcu_to_node_dsig_(n)*	• Imax: 70mA • Imin: 0A • Disables output after a time of upto 1 hour ± 1 minute when enabled • Operate output channels independently
user_bluetooth_in	• Enable/disable relays • Set a timer up to 60 min. ± 1 min. • Can give commands from over 20 ft • Interface via a mobile phone (Android)
user_bluetooth_out	• Reports on current/voltage draw • Able to report data to phone from over 20 ft away • Confirms length of timers • Disables channels if timer is up

user_wifi_in	• Enable/disable relays • Set a timer up to 60 min. ± 1 min. • Can give commands from over 20 ft • Interface via a mobile phone (Android)
user_wifi_out	• Reports on current/voltage draw • Able to report data to phone from over 20 ft away • Confirms length of timers • Disables channels if timer is up
system_to_outside_usrout	• Display current of outputs - 0-5 A • Able to update output statuses from 20 feet away • Confirms timers if set
outside _to_system_usrin	• User interacts with system via Smartphone App • 9/10 users able to operate switches in <10 seconds without any previous training or knowledge of the interface • Enable/Disable each channel • Set delay on each output • Accepts inputs from 20 feet away • Disables output after a time of upto 1 hour ± 1 minute when enabled
system_to_outside_acpwr_(n)*	• Turn off and on at least 2 independent household lamps with up to 100W incandescent bulbs and report current watts delivered by each channel • Vnominal: 120VAC via a NEMA 5-15R connector • Ipeak: 5A • Inominal: 500mA • Outputs will turn off after times of up to 60 minutes when selected

*note: n represents the nth redundant node

Jorian Bruslind
2/7/19
ECE 342 - Blue 1 | AC Bluetooth Switch
Prof. Shuman

Interface & Property Definition Table for AC Bluetooth Switch Case

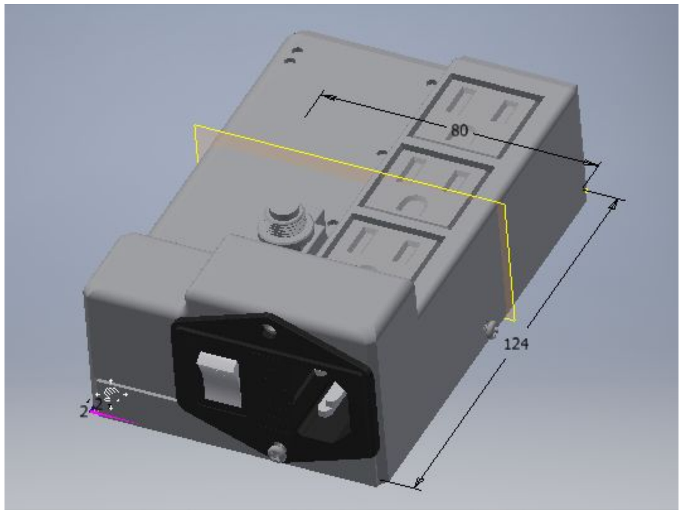

Fig. 1. Render of Case

This is our enclosure for our AC Bluetooth switch. It is fully 3D printed using PLA plastic, which will have a total print time of roughly 12 hours. The goal for this case was to 'ruggedly' enclose the system, which has been specified as not allowing anything bigger than a pencil be able to pass through. Furthermore, all wire connections to the PCB going through the enclosure (entering or leaving) must use connectors.

The case exposes a NEMA-15R compliant input plug to receive power from the wall, a physical on/off switch, and three output channels to plug NEMA-15R components into that you wish to power. Every other component of the project is enclosed by the 124mm x 80mm x 50mm case. The custom PCB is held on four standoffs, while the top of the case is mated to the bottom via four M3 screws.

Table 1. Interface Definitions

outside_to_system_acpwr	NEMA-15R compliant $V_{Nominal}$: 120VAC_{RMS} V_{Min}: 0V Physical cutoff switch
system_to_outside_acpwr	NEMA-15R compliant $V_{Nominal}$: 120VAC_{RMS} * 3 channels V_{Min}: 0V * 3 channels

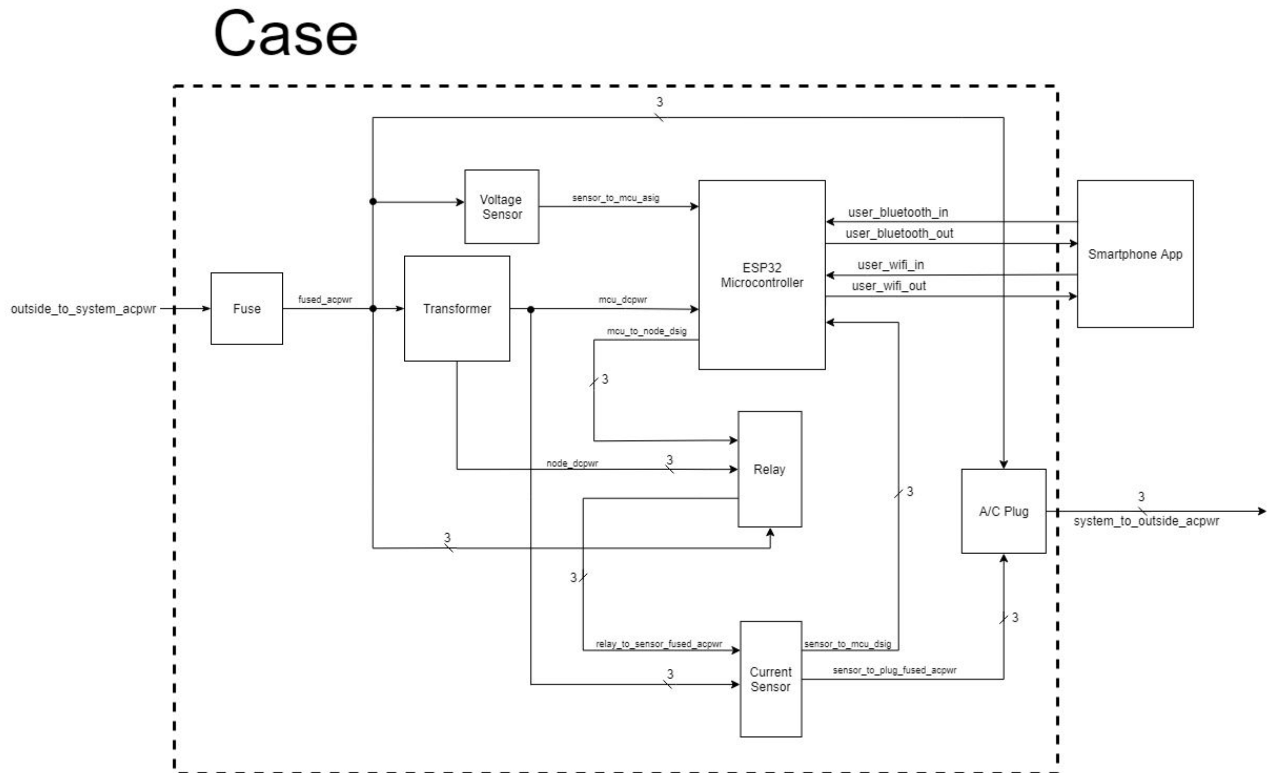

Fig. 2. High Level Block Diagram of System

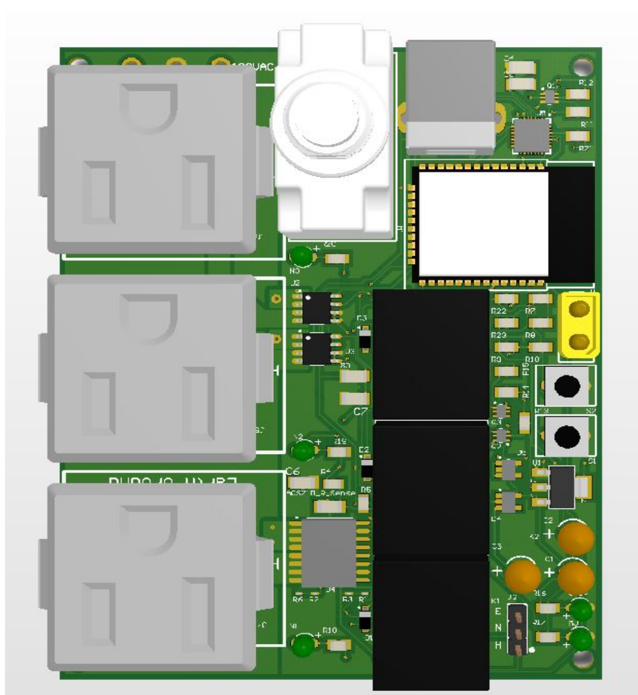

Fig. 3. Render of the PCB to be enclosed

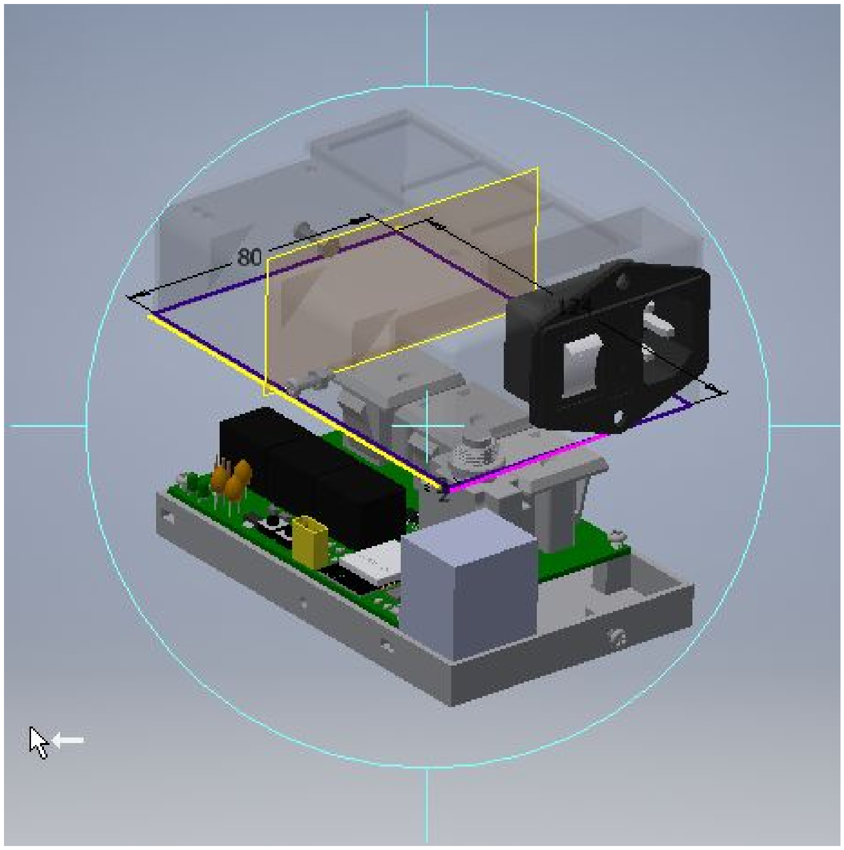

Fig. 4. Isometric Exploded View of the Case

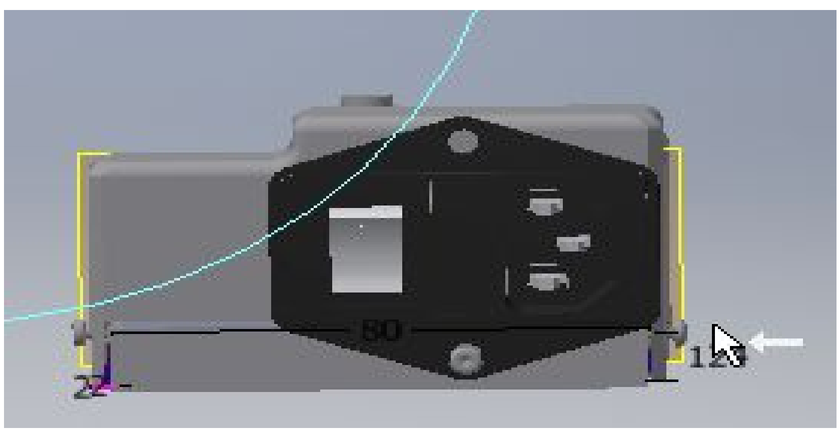

Fig. 5. Side View of the Case

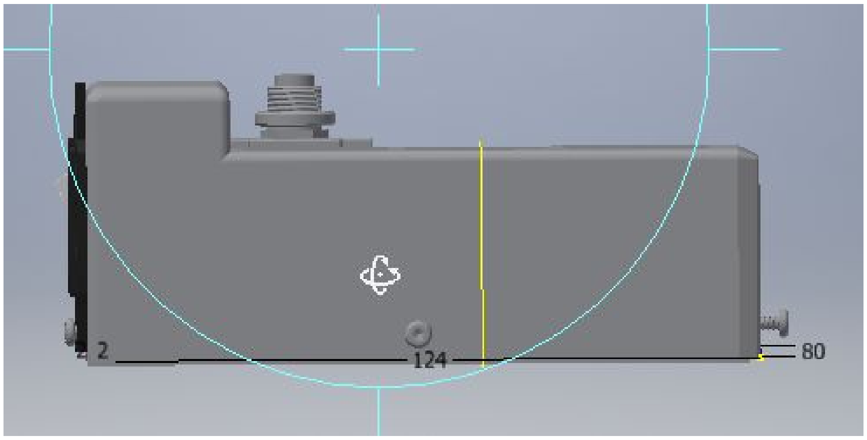

Fig. 6. Rotated Side View of the Case

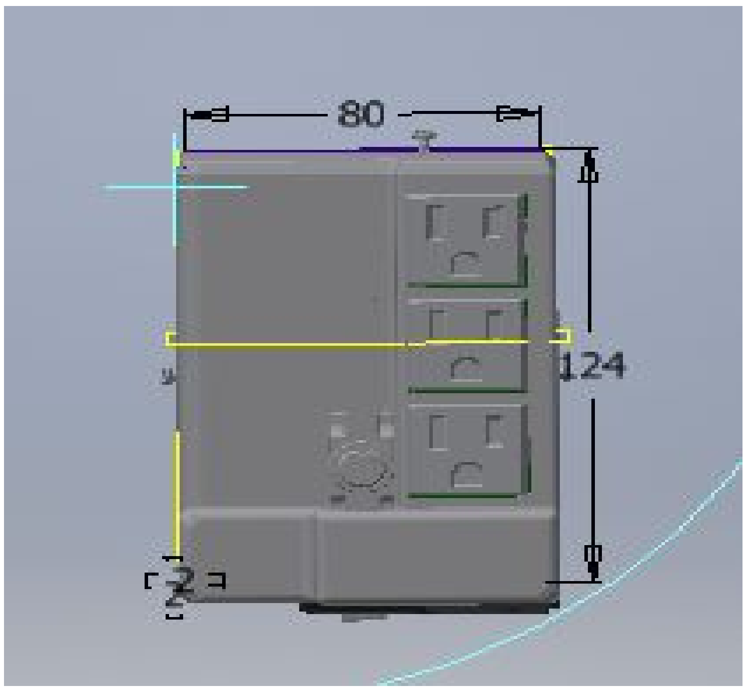

Fig. 7. Top View of the Case

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ECE 342 - Blue 1 | AC Bluetooth Switch
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Interface & Property Definition Table for ACS722LLCTR-40AU-1 Current Sensor

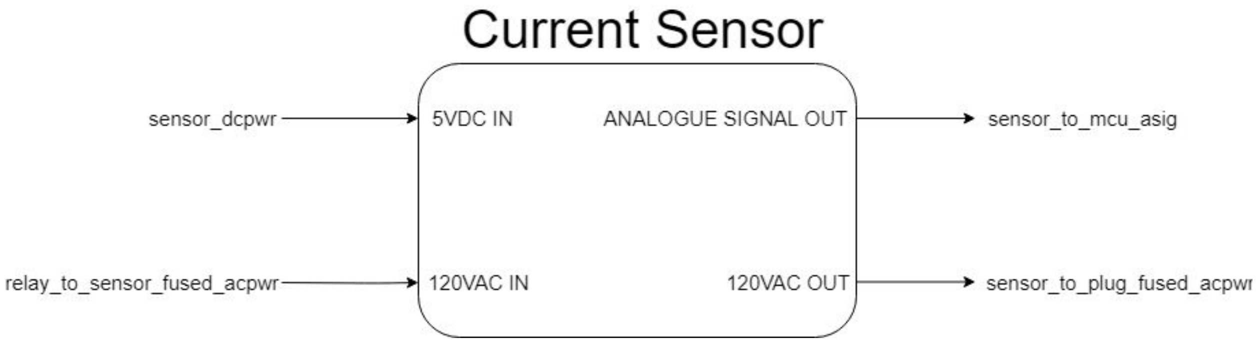

Fig. 1. Black Box Diagram of Current Sensor Block

Table 1. Current Sensor Block Interfaces and Properties

Interface	Properties
sensor_dcpwr	V_{Min}: 3VDC $V_{Nominal}$: 3.3VDC V_{Max}: 3.6VDC $I_{Nominal}$: 9mA I_{Max}: 12mA
sensor_to_mcu_asig	V_{Max}: 6 VDC $V_{NominalLow}$: 0.36 VDC $V_{NominalHigh}$: 5 VDC V_{Min}: -0.5 VDC t_{Rise}: 4μs $t_{Response}$: 5μs t_{Prop}: 1μs
relay_to_sensor_fused_acpwr	$V_{Nominal}$: 120VAC$_{RMS}$ I_{Max}: 5A I_{Min}: -5A $f_{Nominal}$: 60Hz

sensor_to_plug_fused_acpwr	$V_{Nominal}$: 120VAC_{RMS} I_{Min}: -5A I_{Max}: 5A $f_{Nominal}$: 60Hz

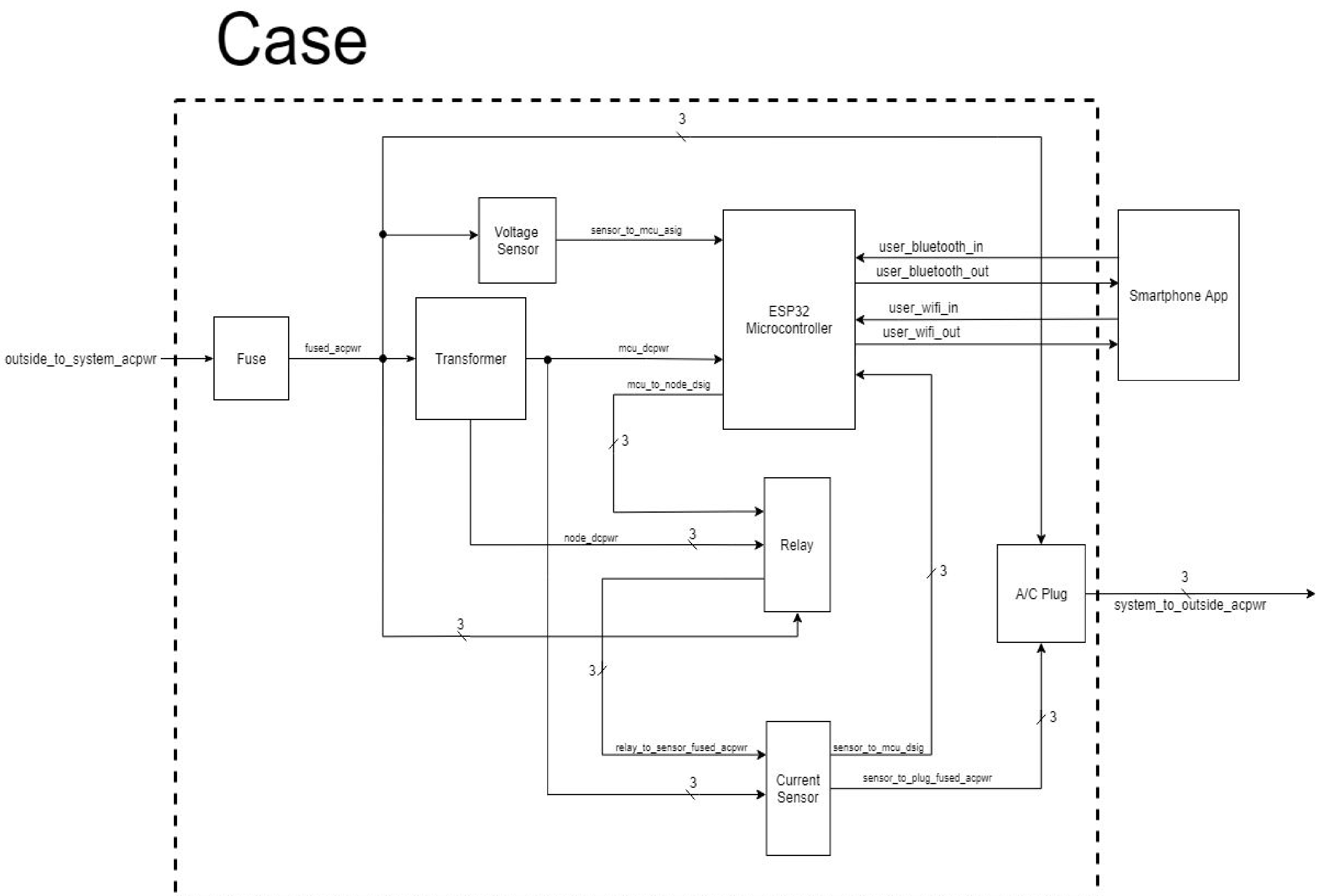

Fig. 2. High Level Block Diagram of AC Bluetooth Switch

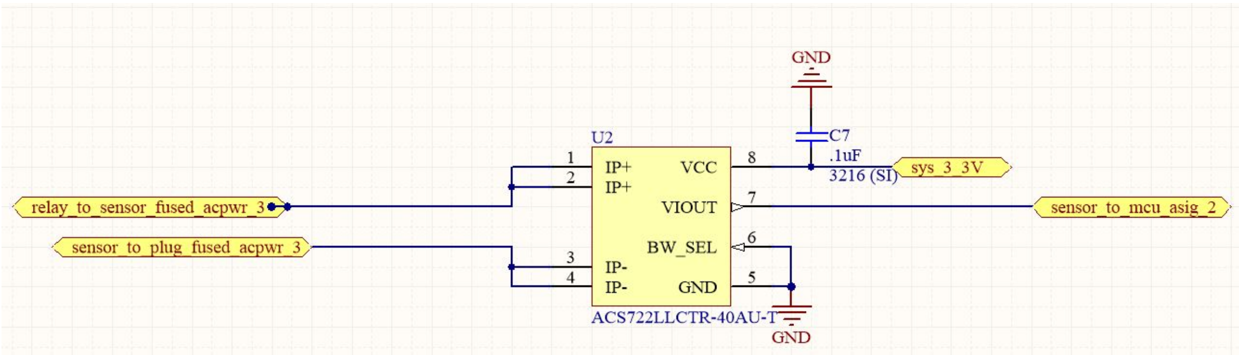

Fig. 3. Schematic for Current Sensor Connections

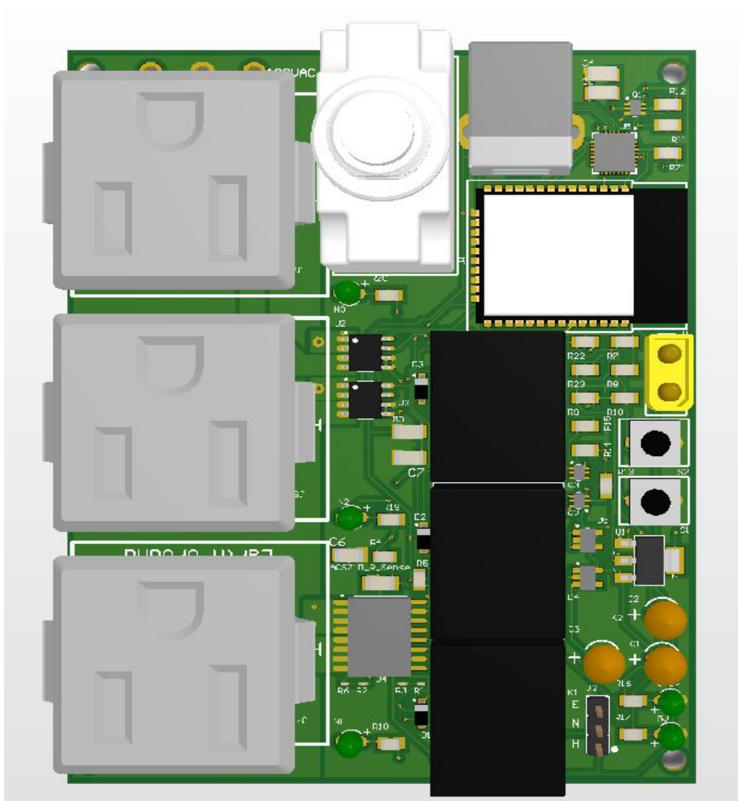

Fig. 4. A Render of the PCB

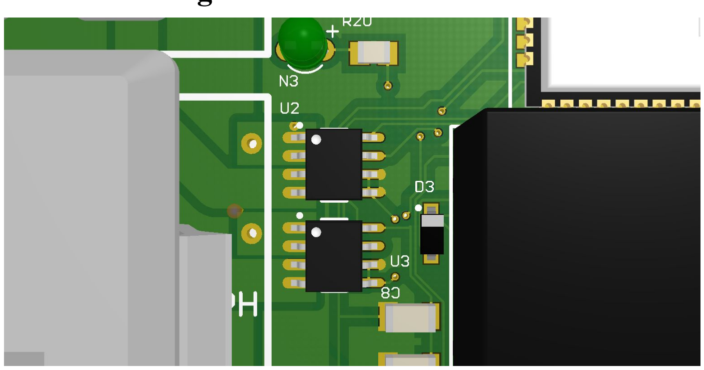

Fig. 5. Closeup of Current Sensor on PCB

Test Cases:

Nominal Current:

1. Connect the GND pin and the bit select pin to ground.
2. Apply 3.3 VDC to the VCC pin.
3. Connect the VIOUT pin to an ADC pin of a microcontoller. Take note of the reading it reports when there is no load attached. This is the zero-load bias we need to account for when taking later measurements.
4. Apply a load of 5A to the IP+ and IP- pins of the IC.
5. Subtract the zero-load bias we found earlier from the reported value. Afterwards, scale the result by the amount specified in the datasheet.

PASS: 5A +- 2% is being reported.

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Interface & Property Definition Table

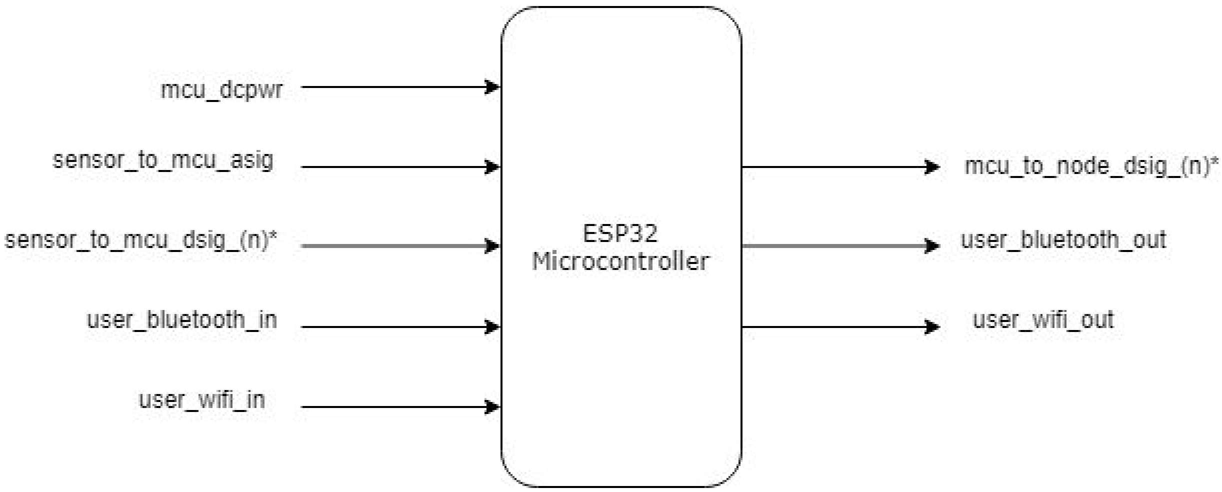

Fig. 1. Black Box Diagram of ESP32 Microcontroller Block

Table 1. ESP32 Microcontroller Block Interfaces and Properties

Interface	Properties
mcu_dcpwr	$V_{Nominal}$: 3.3VDC V_{Max}: 3.6VDC V_{Min}: 2.3VDC I_{Min}: 500 mA
sensor_to_mcu_asig	V_{Max}: 6 VDC $V_{NominalLow}$: 0.36 VDC $V_{NominalHigh}$: 5 VDC V_{Min}: -0.5 VDC
sensor_to_mcu_dsig_(n)*	$V_{HighMin}$: 0.75*mcu_dcpwr VDC $V_{HighMax}$: VDD + 0.3 VDC V_{LowMin}: -0.3 VDC V_{LowMax}: 0.25*mcu_dcpwr VDC
user_bluetooth_in	Must be able to enable/disable relays Must be able to set a time up to 60 min. Must be able to give commands from over 20 ft Interface must be via a mobile phone (Android)

user_wifi_in	Must be able to enable/disable relays Must be able to set a time up to 60 min. Must be able to give commands from over 20 ft Interface must be via a mobile phone (Android)
mcu_to_node_dsig_(n)*	Disables output after 1 hr. if timer enabled Operates output channels independently I_{Max}: 1.2A $I_{Min:}$ 0A
user_bluetooth_out	Must be able to report on current/voltage draw Must be able to report data to phone 20 ft away Must be able to confirm length of timers Must be able to disable channels if timer is up
user_wifi_out	Must be able to report on current/voltage draw Must be able to report data to phone 20 ft away Must be able to confirm length of timers Must be able to disable channels if timer is up

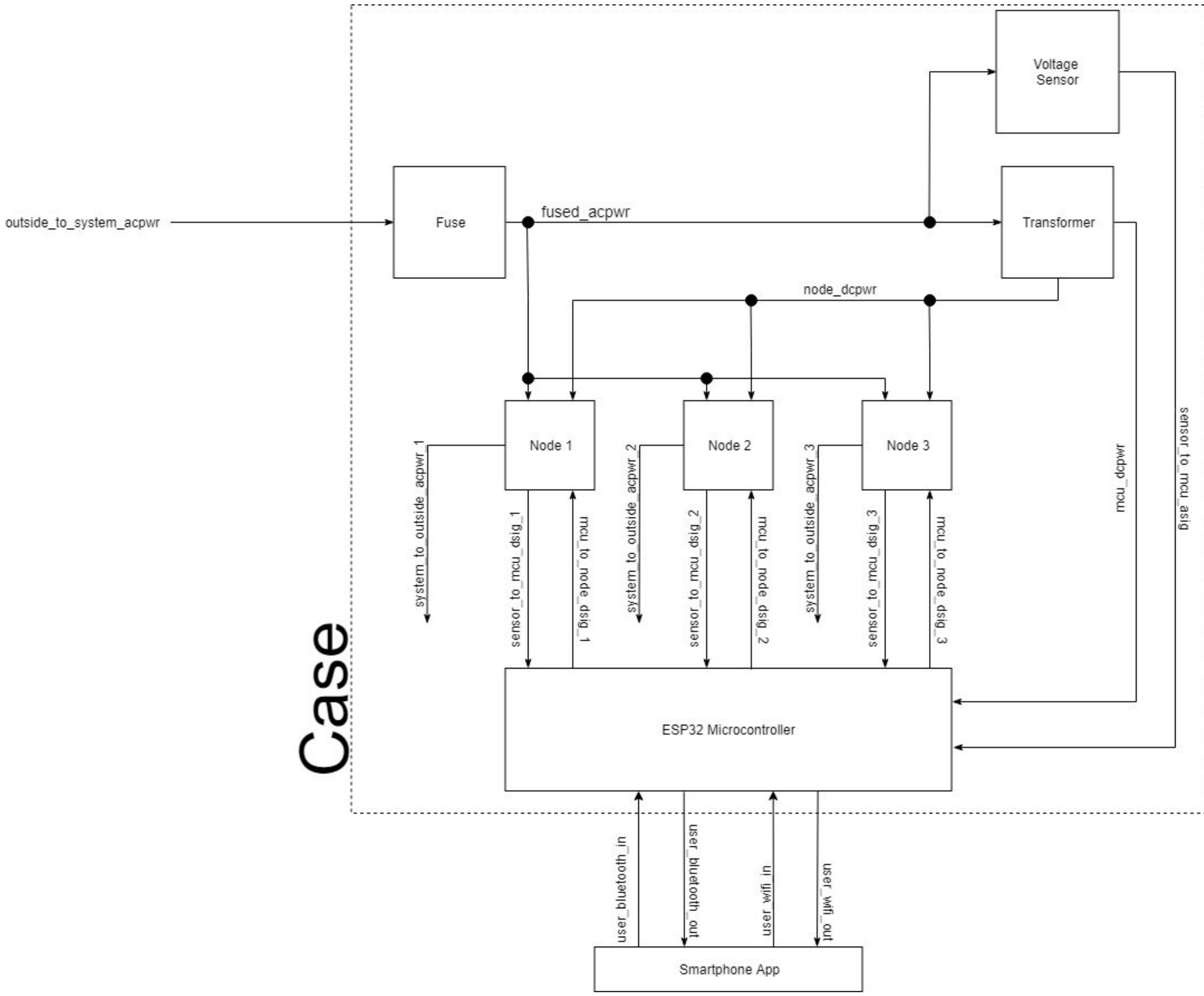

Fig. 2. High Level Box Diagram of AC Bluetooth Switch

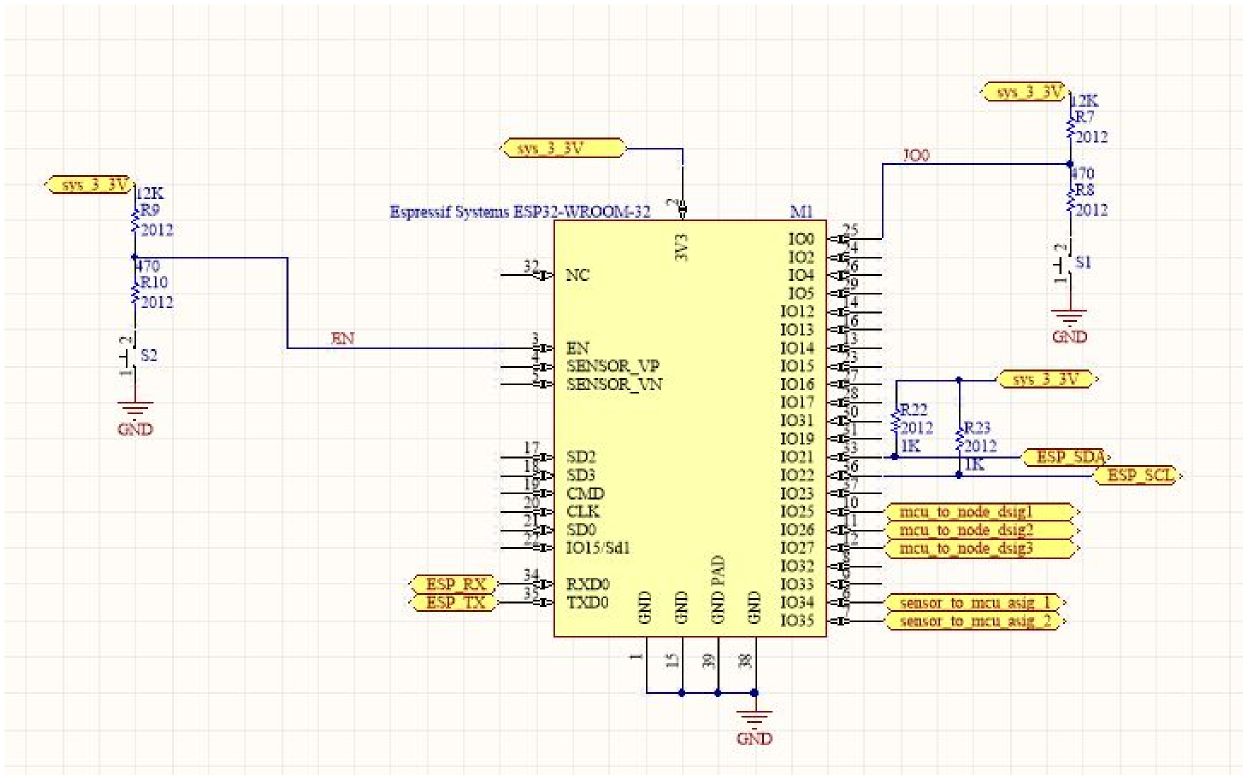

Fig. 3. Schematic of ESP32 Microcontroller Block in Custom PCB

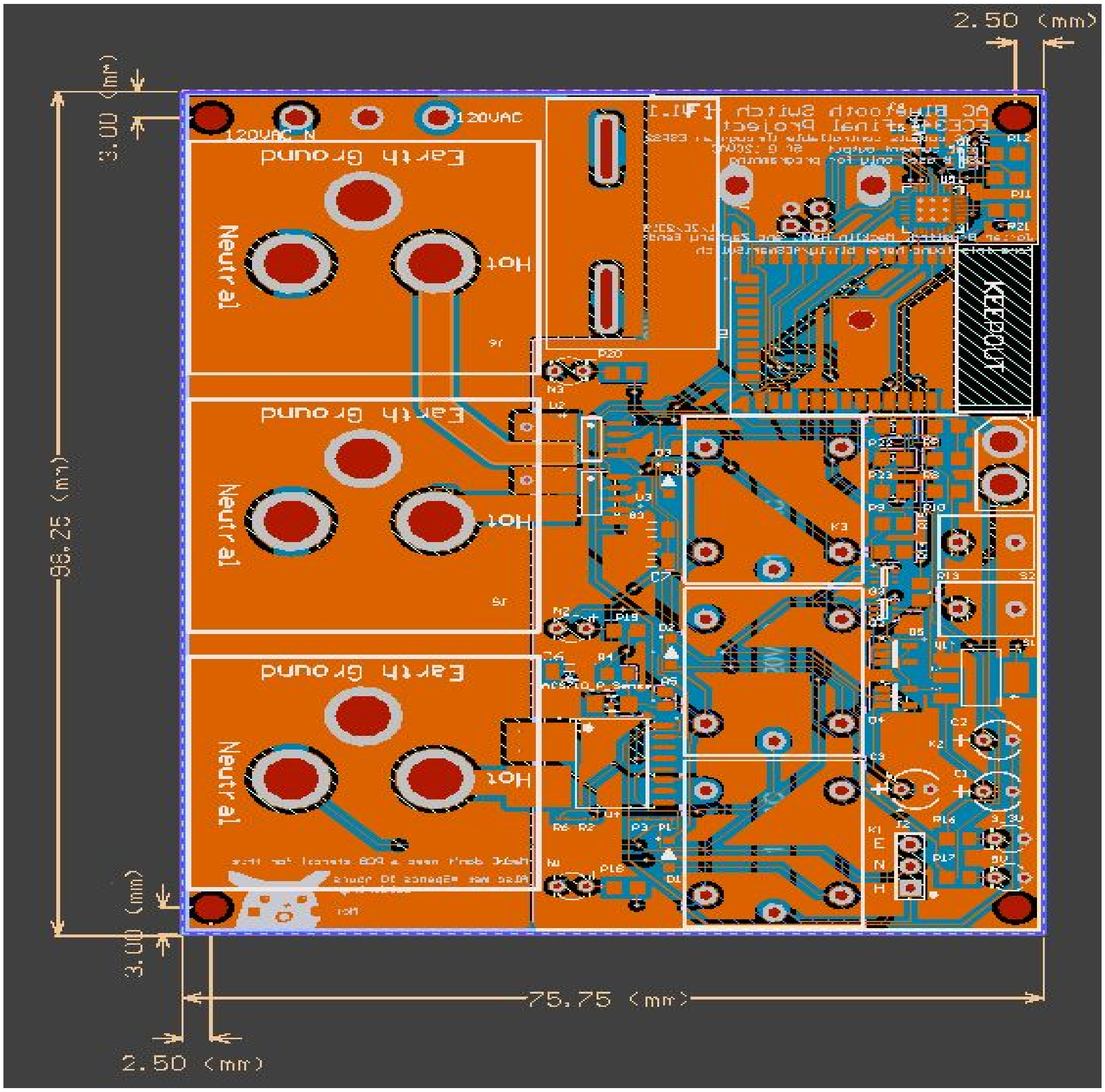

Fig. 4. Schematic of Custom PCB

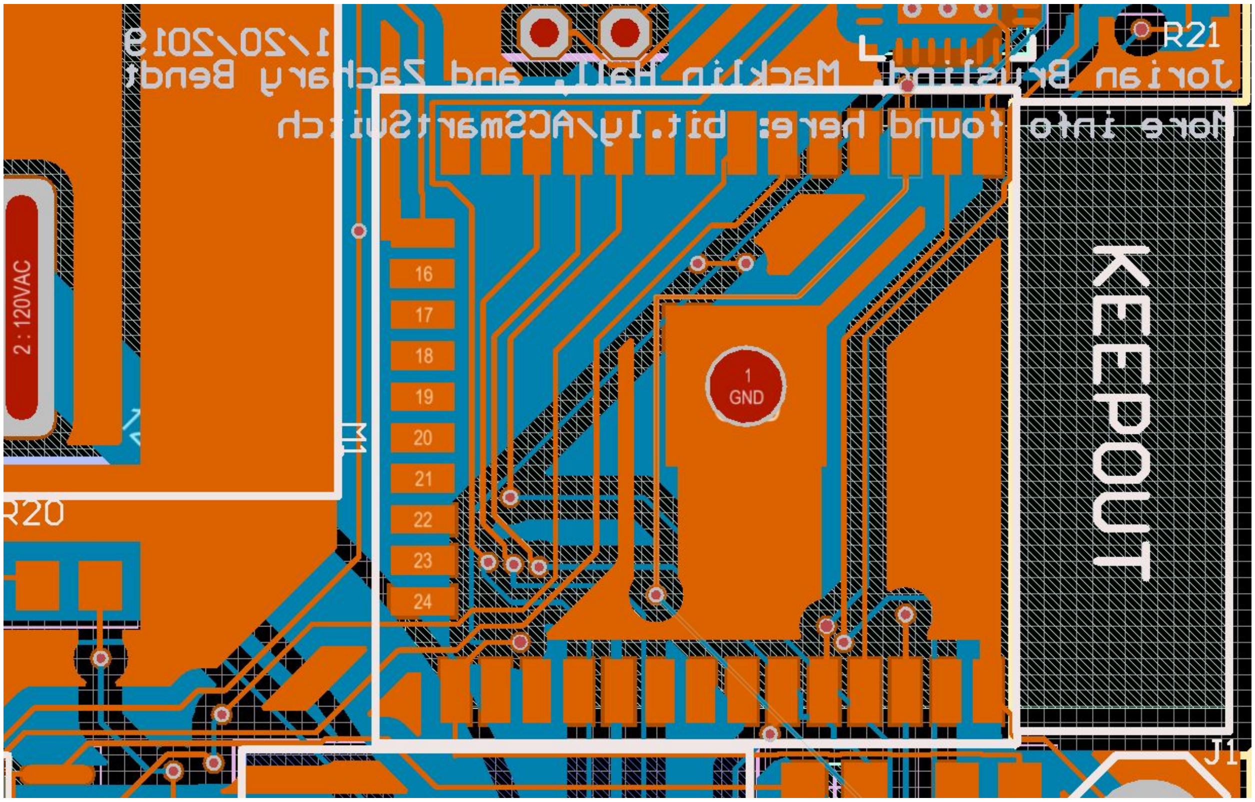

Fig. 5. Closeup of Schematic of ESP32 Microcontroller Slot on Custom PCB
NOTE: The KEEPOUT section has no traces running through it, as to avoid interference with the bluetooth and WiFi signals the microcontroller is sending and receiving.

Fig. 6. Custom Code written to the ESP32 Microcontroller

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January 17, 2019
Remote A/C Switch
Team Blue(1)

Fuse Block Artifacts

Interface	Properties
outside_to_sytem_acpwr	• $V_{nominal}$: 120VAC via a NEMA 5-15R connector • I_{peak}: 15A • $I_{nominal}$: 500mA
fused_acpwr	• $V_{nominal}$: 120VAC via a NEMA 5-15R connector • I_{peak}: 4.5A • $I_{nominal}$: 500mA • Disconnects system from input when 5A draw is exceeded

Testing

It is assumed that peak current, nominal voltage and current are within requirements as they are supplied by wall outlet.

Steps

A. Disconnects system from input when 3A draw is exceeded

The block should disconnect from the system when the 4.5A limit is reached in order to protect the system from overcurrent. This will test if the fuse is functioning property.

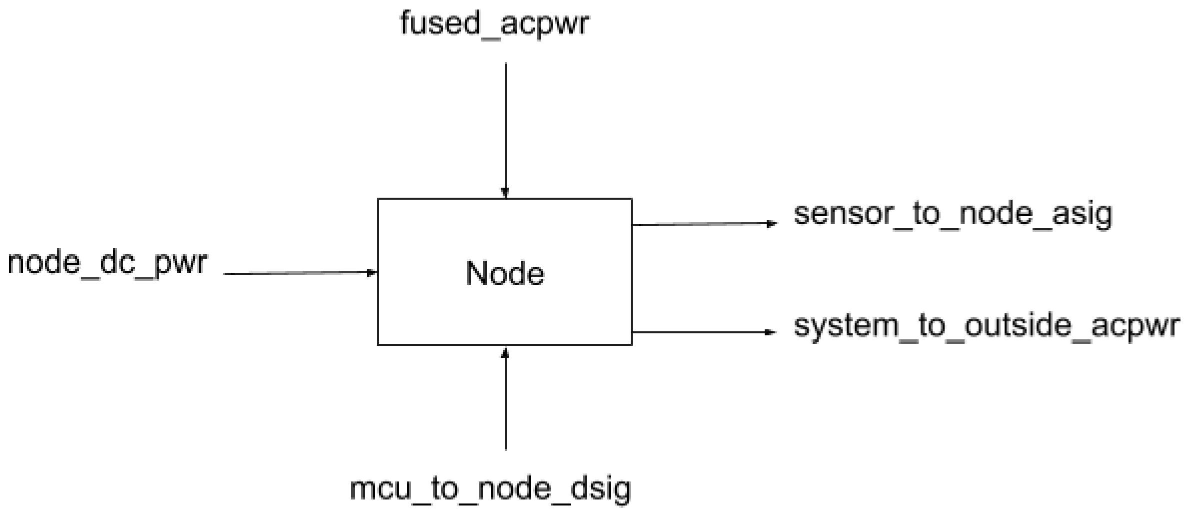
1. Connect the Fuse to a power supply via the **outside_to_sytem_acpwr** interface at 5V.

2. Connect the Fuse to the DC load at the **fused_acpwr** interface.

3. Starting with a 100 mA load, slowly increase the load until the 4.5A limit is exceeded.

PASS: Disconnects system from input when 4.5A draw is exceeded.

If the block passes all of the listed tests, all interface properties have been verified and the block is ready for inclusion into the system.



Interface	Properties
node_dc_pwr	$I_{Nominal}$: 261mA I_{max} : 296mA V_{max} : 5.5V V_{min} : 4.5V
fused_acpwr	$I_{Nominal}$: 0 - 3A (depends on what's plugged in) I_{max} : 5A V_{max} : 125VAC V_{min} : 115VAC
sensor_to_node_asig	$I_{Nominal}$: <1mA I_{max} : <1mA V_{max} : 3.3V V_{min} : 0V
system_to_outside_acpwr	$I_{Nominal}$: 0 - 3A (depends on what's plugged in) I_{max} : 5A V_{max} : 125VAC V_{min} : 115VAC
mcu_to_node_dsig	$I_{Nominal}$: 9mA I_{max} : 10mA V_{max} : 3.3V V_{min} : 0V

Testing Plan

This block has the relay and current sensor functions built into one. It must be able to switch 120VAC (**fused_acpwr** to **system_to_outside_acpwr**) over 0 - 5A using a standard 3.3V (**mcu_to_node_dsig**) signal from the ESP32. This block will also send information about the magnitude of current being passed to the **system_to_outside_acpwr** net through a standard 3.3V signal line (**sensor_to_node_asig**).

Relay Functionality

1. Start with everything powered off/de-energized.
2. Apply 5V to the **node_dc_pwr** line
3. Apply 3.3V to the **mcu_to_node_dsig** line
4. Visually confirm the status LED is active
5. Audibly confirm the relay is active (listen for the switch)
6. Using a multimeter in continuity mode, check that the relay terminals from NO to COM are connected.
7. Using a multimeter in ammeter mode, check the current flowing from **mcu_to_node_dsig** is less than 10mA
8. Repeat steps 3 - 7 for all other relays (if more than 1)

AC Power Functionality

1. Apply Relay Functionality steps 1 - 3
2. Using 120VAC standard household power lines, apply to **fused_acpwr**
3. While relay is active, measure voltage on COM (**fused_acpwr**) and NO (**system_to_outside_acpwr)** relay pins to confirm 120VAC (and that the relay is active)
4. De-energize AC circuit and place a multimeter in ammeter mode in series with the Hot line of the AC power
5. Energize the circuit with AC power
6. Slowly apply a load to the AC power lines until 5A is being drawn
7. Confirm relay is still active after 5A of current

Sensor Functionality

1. Apply Relay Functionality steps 1 - 3
2. Apply AC power steps 5 - 7
3. While ramping up current draw, measure voltage on **sensor_to_node_asig** and confirm up to 3.3V max (and linear scaling)
4. De-energize circuit and put ammeter in series with **sensor_to_node_asig**
5. Apply steps 1 - 2 and confirm current draw does not exceed 1mA on **sensor_to_node_asig**

Node Power functionality

1. Put ammeter in series with **node_dc_pwr**
2. Apply Relay functionality steps 1 - 3
3. Measure current draw and confirm it is not over 296mA

Block 2 Checkoff
Transformer

Introduction

The transformer block includes the transformer which steps down the 120VAC to 5VDC as well as the voltage regulator that converts the 5V to 3.3V. The transformer was salvaged from a Vogek ST270 USB Wall Charger, shown in Figure 1. We removed the USB connectors and connected the transformer to our PCB using an XT30 connector, shown in Figure 4.

Figure 1. Vogek ST270 USB Charger

Block Diagram

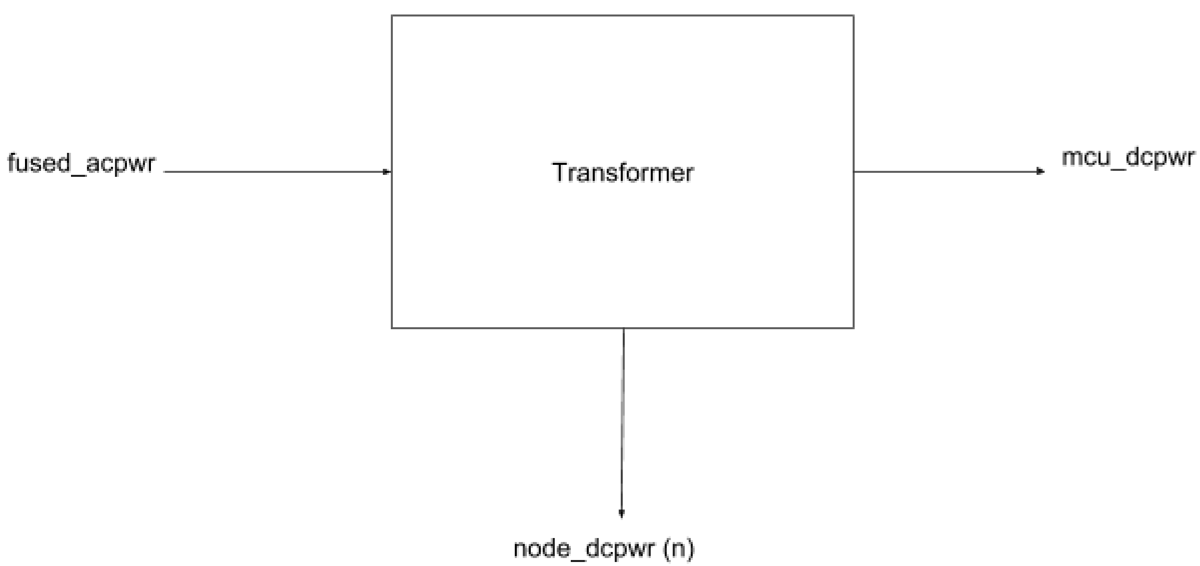


Figure 2. Block diagram for Transformer Block

Interface Definitions

Interface	Properties
fused_acpwr	$I_{Nominal}$: 0 - 3A (depends on what's plugged in) I_{max} : 5A V_{max} : 125VAC V_{min} : 115VAC
mcu_dcpwr	$I_{Nominal}$: 100mA I_{max} : 125mA V_{max} : 3.3V V_{min} : 3V
node_dcpwr	$I_{Nominal}$: 261mA I_{max} : 296mA V_{max} : 5.5V V_{min} : 4.0V

Schematics

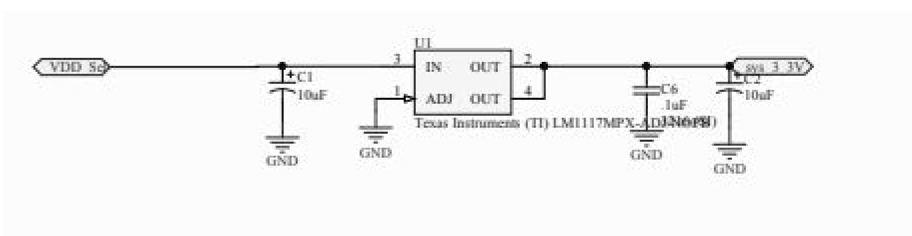


Figure 3. 5V to 3.3V Regulator

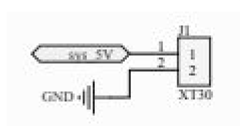


Figure 4. XT30 Connection from transformer to PCB

Testing Plan

This block is fairly simple in operation and has the benefit of being a pre-built solution. It must be able to receive 120VAC power (**fused_acpwr**) and transform that down to 5V nominal @ up to 1.5A (**mcu_dcpwr** and **node_dcpwr**).

Power Functionality

1. Begin with everything de-engerized/powered
2. Connect leads to the **node_dcpwr** and **mcu_dcpwr** lines and plug them into a programmable dc load
3. Provide 120VAC power to **fused_acpwr**
4. Measure the voltage output on the DC load side (either with a DMM or the load itself)
5. Ensure the voltage does not go above/below the nominal voltage
6. Activate the load at 0A and slowly increase current draw until 1.5A is being drawn
7. During this time, ensure voltage does not go above/below nominal
8. Leave load at 1.5A for ~10-15min and watch for any voltage discrepancies

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Draft Interface & Property Definition Table and Tests

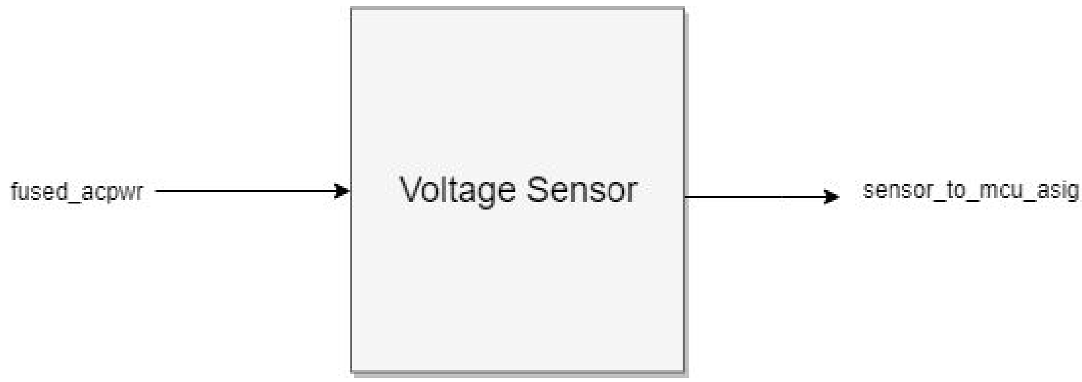

Fig. 1. Black Box Diagram of Voltage Sensor Block

Table 1. Voltage Sensor Block Interfaces and Properties

Interface	Properties
fused_acpwr	$V_{Nominal}$: 120 VACrms V_{Max}: 120 VACrms $I_{Nominal}$: 500mA I_{Max}: 5A $f_{Nominal}$: 60 Hz
sensor_to_mcu_asig	V_{Max}: 6 VDC $V_{NominalLow}$: 0.36 VDC $V_{NominalHigh}$: 5 VDC V_{Min}: -0.5 VDC

Testing Steps

A. **Nominal Voltage Testing**

This block must be capable of measuring the voltage being supplied through the switch to the outlets.

1. Connect the voltage sensor block to the microcontroller block. Ensure that the microcontroller is able to produce an output that is readable by the tester.
2. Connect the voltage sensor block to the fuse block.
3. Connect the fuse block to **outside_to_system_acpwr**.
4. Probe input for a voltage reading.

5. Record readings from microcontroller.
6. Disconnect fuse block from **outside_to_system_acpwr**.
7. Repeat steps 1-2.
8. Generate an AC voltage source of 5 VACrms and 30Hz.
9. Connect to voltage sensor block.
10. Repeat steps 4-5.

PASS: This block passes if the microcontroller produces voltage readings between 117.6-122.4 VACrms for the 1st test (wall source) and voltage readings between 4.9-5.1 VACrms for the 2nd test (lab generated signal). The output has a maximum acceptable error of 2% for expected operating temperatures of the block.