UNIVERSITY OF MICHIGAN-DEARBORN

Detailed Test Plan
Team PowerPack

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Test 1: Physical Properties

- Traces to 1.1 & 1.2 requirements
- The total weight of the PowerPack should not exceed 37 pounds for safety
  - Will be weighed on a calibrated scale
- The size of the backpack must not be too large for comfort (12inx8inx18in)
  - Will be measured with a tailor ruler for best accuracy

Test 1: Physical Properties

- Data Analysis and Failure Mode
  - This test is deemed a failure if the backpack weight is over the desired amount or is too large

- Weight:
  - Excellent if under 30 pounds
  - Passes if under 37 pounds
  - Fails if over 37 pounds

- Size:
  - Passes if under 12x8x18 dimensions
  - Fails if larger than 12x8x18

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
Backpack is too heavy	Backpack would be a safety concern to wear on users back	A major requirement of the system would not be met	Purchase a heavy backpack or components weighed more than expected.
Backpack is too large	Backpack would be a nuisance to wear	A minor system requirement. The system will still fully function.	Unable to find a bag that size to fit the budget.

Test 2: Output Sine Waveform

- Traces to 2.1 2.2 & 7.1 requirements
- Desired output waveform: **120V 60Hz sine wave**
- We will use a voltage divider to get our waveform to a lower voltage
- An oscilloscope will be used to measure voltage value and frequency

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Test 2: Output Sine Waveform

- Data Analysis and Failure Mode
  - This test is deemed a failure if our signal is not close enough to the 120V/60Hz requirement

- Voltage:
  - Passing if voltage is within 10% tolerance
  - Excellent if voltage is within 5% tolerance
  - Fails if voltage is outside 10% tolerance

- Frequency:
  - Passes if frequency is within 2% tolerance
  - Fails if outside 2% tolerance

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
Voltage is outside the tolerance	Output waveform is inaccurate, could harm equipment	Could be major or minor, if equipment could still run then minor, if nothing can run then major.	Circuit consumes more power than expected
Frequency is outside tolerance	Output waveform is inaccurate, could harm equipment	A minor system requirement. Powerpack would still function as intended	Interrupt timer to control H-Bridge is inaccurate

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Test 3: Run Time

- Traces to 3.1 requirement
- The PowerPack must be able to run a 300 watt tool for 30 mins
  - 150 watt/hr
- In a lab setting, run a tool of distinct power and record time until battery dies
- Complete calculations to verify watt/hr requirement is met

Test 3: Run Time

- Data Analysis and Failure Mode
  - This test is deemed a failure we do not reach our watt/hr requirement
  - Run time:
    - Excellent if watt/hr is above 150 watt/hr
    - Passes if in range 100-150 watt/hr
    - Fails if below 100 watt/hr

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
Run time is poor	Not worth using product if it can not run tools for a decent time frame	Minor system requirement. Product still functions, but not well	Low efficient circuit, batteries hold less charge than we thought

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Test 4: Display Accuracy

- Traces to 4.1 & 4.2 requirements
- Display must show accurate information
- We will use an oscilloscope to compare our display values to the oscilloscope values in the lab
  - Verify that values are equal

Test 4: Display Accuracy

- Data Analysis and Failure Mode
  - This test is deemed a failure if the display value is not within 5% of the actual value
  - Accuracy:
    - Excellent if accuracy is below 2%
    - Passes if accuracy is below 5%
    - Fails if accuracy is above 5%

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
The display is inaccurate	Display is showing inaccurate information	Minor system requirement. Product will function the same with or without the display.	Using ADC or sensor wrong, coding issue with sending value to display

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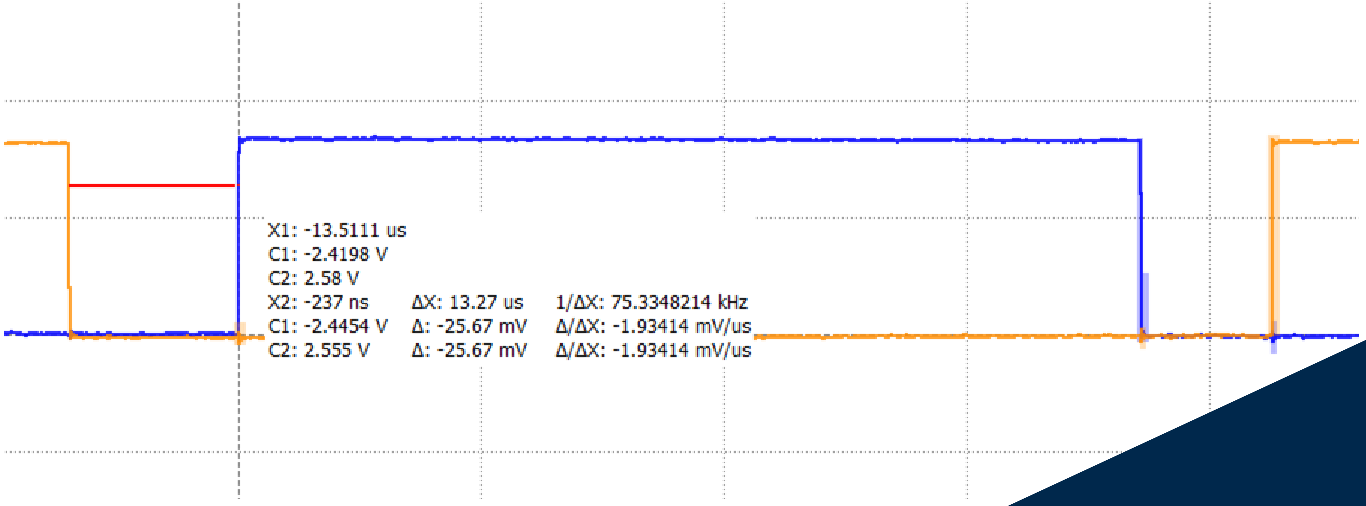
Test 5: Safety Delay

- Traces to 5.1 requirement
- An added safety delay between switching is necessary to prevent circuit shorting
- We will use an oscilloscope in the lab to measure the duration of the safety delay
- We want a safety delay present, but not too large to effect operation of product



Test 5: Safety Delay

- Data Analysis and Failure Mode
  - This test is deemed a failure if we do not have a delay or if its too large
  - Accuracy:
    - Excellent if delay is under 10 us
    - Passes if delay is under 15 us
    - Fails if no delay or over 15 us

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
No safety delay	We ground 168 volts and break our circuit	Major system requirement. Entire system would break.	Poorly written safety code that does not work.

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Test 6: Efficiency of Circuit

- Traces to 6.1 requirement
- Test to make sure our inverter is meeting efficiency requirements while converting DC power into AC
- Po / Pin * 100
  - Put a load onto circuit and obtain needed measurements to obtain efficiency
  - Measure the input voltage, input current, output voltage, and output current
    - Verify that calculated values satisfy requirement

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Test 6: Efficiency of Circuit

- Data Analysis and Failure Mode
  - This test is deemed a failure if the circuit is not efficient enough
  - Accuracy:
    - Excellent if efficiency is 90% or higher
    - Passes if efficiency is 80% or higher
    - Fails if efficiency is below 80%

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
Efficiency is too low	Wasted power that turns into heat.	Minor system requirement. System will still run just not as well as we wanted	Varying PWM waves look more rectangular than sinusoidal.

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Test 7: Transient Response

- Traces to 8.1 requirement
- Testing to see how our circuit responds to a load
- Circuit to return to steady state within 100ms, as desired
- Attach a load to the circuit
- Use an oscilloscope to measure the time to takes for the circuit to reach steady state

Test 7: Transient Response

- Data Analysis and Failure Mode
  - This test is deemed a failure if the circuit takes too long to reach steady state
  - Accuracy:
    - Excellent if transient response is under 100 ms
    - Passes if transient response is under 150 ms
    - Fails if transient response is over 150 ms

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
Large transient response	Will be able to see tools bog down on start up	Minor system requirement. System will still run just not as well as we wanted	Circuit not rated to handle the type of load we wish to use it for

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Test 8: Temperature Sensor

- Traces to added safety feature requirement
- Testing our safety temperature sensor
- If the temperature reaches over 100C, the sensor will turn off the PWM signals
- Add heat to a material and monitor the sensor to verify it reads and turns off at the desired point
  - Use thermometer to collect temperature value of heated material

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Test 8: Temperature Sensor

- Data Analysis and Failure Mode
  - This test is deemed a failure if the sensor can not read the temperature correctly
  - Accuracy:
    - Passes if sensor tells system to shut off
    - Fails if sensor does not tell system to shut off

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
High unmonitored temperature	Circuit can overheat and break	Major system requirement. MOSFETs start to function worse pass 100C. If circuit gets too hot it will spot working	Code does not collect data and apply it correctly. Sensor is unable to measure temperature accurately.

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Test 9: Testing Breaker

- Traces to added safety feature requirement
- A test to make sure our 15A breaker will protect the system
  - All components are rated for at least 20A, we want to avoid current hitting that level
- We will use a combination of high power resistors on the batteries to adjust the current across the breaker until it breaks the circuit.
  - The breaker will be tested at ~11.2 amps and ~22.4 amps.

Test 9: Testing Breaker

- Data Analysis and Failure Mode
  - This test is deemed a failure if the current to pop the breaker is too large or too small
  - Accuracy:
    - Passes if breaker pops with 22.4 A test and not during 11.2 A test
    - Fails if breaker pops with 11.2 A test or not during 22.4 A test

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
High current flow in the circuit	If current value is over 20A components in the circuit will break	Major system requirement. This will cause for the entire system to fail.	Our breaker does not function as we expect a 15A breaker to work.

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Test 10: Emergency Shut off

- Traces to added safety feature requirement
- An emergency switch near the batteries included in design
  - Turns off the entire system in the event of an emergency
- We will test to verify that when the switch is turned, there is no voltage going through the system

Test 10: Emergency Shut off

- Data Analysis and Failure Mode
  - This test is deemed a failure there is still voltage in the system once it is turned off
  - Accuracy:
    - Passes if no voltage is found
    - Fails if voltage is still flowing in system

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
Unable to control the voltage in circuit.	Someone could get injured if the system fails and the circuit is still live.	Major system requirement. Could be a serious injury.	The emergency switch is not in a location to cut off power supply.

Test 11: Batteries

- Traces to requirements 2.1 (output voltage) and 3.1 (energy capacity)
- The batteries power the entire system, so they are critical to the design. Batteries contain an internal BMS and already have chargers.
- We will test that the EGO batteries are capable of producing the correct voltage and power output.

Test 11: Batteries

- Data Analysis and Failure Mode
  - Batteries fail testing if they produce more or less voltage than the requirements allow when fully charged, and do not supply enough power for a given time
  - Standard tolerance for AC voltage is 10% of nominal (120V RMS). Charged batteries must output within 10% of 170VAC (Peak)
  - System should produce

Failure Modes	Potential Effects	Degree of Severity	Potential Causes
Battery voltage too high/low	Poor performance of connected devices.	Moderate. Connected devices should function, just not optimally.	Improper charging, battery cell failure, BMS failure.
Batteries do not produce enough power	Shorter runtime of connected devices	Minor. Can be rectified with larger capacity batteries.	

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Advisor Approval

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Michael Putty

to Joan, George, Noriko, me

Hello All,

We met to discuss your test plan on Monday Feb 19. You use this email for my approval of your test plan.

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Q&A