Team 29

Optocan Charger - BorgWarner

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Purdue Mentors / Customers: Professor Blowers & Steve Sonnenberg (BorgWarner)

Customer Background

- EMC validation must use the Optocan device to convert CAN communication to optical
- Reduces EMC radiation from CAN messaging
- Radiation emissions test interference
- The team uses 30 devices
- Devices must be maintained to be ready for testing
- Other BorgWarner validation sites also use the same device

Problem Statement / Scope of Work

The BorgWarner EMC validation team needs an improved method for charging and discharging batteries to optimize the utilization of the Optocan device for EMC testing.

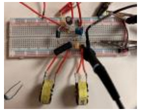
Design a dual charge, single discharge system with status indications and fault protection.

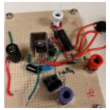
Requirements Matrix

REQ	DESIGN REQUIREMENTS	DESIGN TARGETS	VALIDATION
1	Charge Voltage	Maintain a voltage of 7.5V.	Charge Voltage = 7.5V ±5%
2	Maximum Charge Current	Output 750 mA when the batteries are fully discharged.	Charge Current = 750 mA ±10%
3	Maximum Charge Time	Charge time shall be less than 4 hours.	< 4 hours
4	Input Voltage	Operation with 110V AC voltage sources.	Verify Input Voltage is operational with both 110V AC sources.
5	Discharge Current	Discharge current of 200 mA.	Measure discharge current and verify: Discharge Current = 200 mA ±10%
6	Display Status	Indicate charge/ discharge status	Verify LED is solid when charging/ discharging
7	Simultaneous Charging	Charging two batteries simultaneously.	Confirm both charge circuits function simultaneously. Verify total max current= 1.5A ±10%
8	Enclosure Dimensions	500 'L' x300 'W' x100 'H' mm	Length < 500mm (about 1.64 ft) Width < 300mm (about 11.81 in) Height < 100mm (about 3.94 in)
9	Over Charge Protection	Protect from overcharging the battery.	Verify the charger terminates charge when Charge Voltage < 7.75V
10	Short Circuit Protection	Protect from short circuit on the charger output.	Termination when Voltage < 1.0V

Experimentation / Concepts Exploration

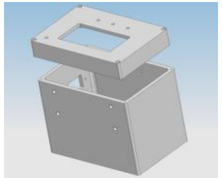
1st Design



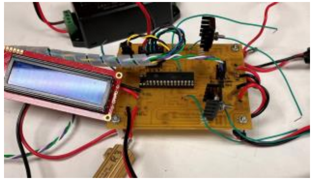


2nd Design

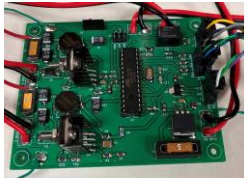
Enclosure #2



3rd Design



Final Design



Failure Mode and Effect Analysis

Issue #	Item Description	Potential Failure Mode	Potential effects of Failure	Severity	Potential causes or mechanisms of failure	Current Prevention Control (PC) of FC	DFMEA Preventive Action	DFMEA Detection Action	Action Taken with Pointer to Evidence	Completion Date	Severity | OI	Remarks
1	LT1513 IC	Device breakdown, Leakage current, short between pins	Damage to IC, Overheating/ Fire, Battery damage	10	Design Specs not followed, Component failure	Follow design requirements, Follow manufacturer specs	Verify functionality of circuit meets requirements listed in datasheet through bench testing.	Identify design requirements for proper IC function, then verify requirements are met.	Heat sink inplace for proper heat dissipation and cool-down the IC, feed-back control to avoid over-current or voltage damage	25-Nov-2022	3	Passed all the functional safety and parametric testing.
2	Inductors	Leakage Current, short circuit, excessive resistance	Damage to surrounding areas, battery damage, Fire	6	Wrong device selection, Design Error	Follow design requirements, Follow manufacturer specs	Confirm inductors used limit leakage current and resistance to a safe level. Inspect inductors for possible short circuit.	Measure inductor leads to confirm resistance is within datasheet requirements. Check circuit for short.	Surface mount very low resistance inductors with short current path to mitigate the potential causes of failure.	25-Nov-2022	2	Passed all the functional safety and parametric testing.
3	Capacitors	Leakage Current, Dielectric breakdown, moisture, over voltage	Parts Damage, battery damage, venting or explosion	7	Wrong device selection, Design Error	Select capacitors based on acceptable values.	Verify capacitor capability through functionality testing. Confirm components meet or exceed expectations.	Derate when calculating capacitor voltage rating. Verify capacitors can handle functional testing.	Capacitors with twice the requirements have been slected to ensure proper functioning during testing and operation.	1-Dec-2022	2	Passed all the functional safety and parametric testing.
4	Power Supply Unit (PSU)	Incorrect voltage supplied/regulated, voltage transients, total failure	Damage to charge control or peripherals, product fails to operate	8	Product failure, lack of transient protection	Compatible power supply with protection	Perform testing on power supply unit to verify proper function. Develop circuits for transient protection.	Perform functional testing to verify product will not fail from power supply issues.	Power supply capable of 3A current selected in line with 5A fuse.	2-Mar-2023	1	Passed all the functional safety and parametric testing.
5	Harness	Damage from enclosure panel mount, short circuit	Damage to battery or charge circuit	7	Rough handling, poor mechanical design	Thermal insulated wire rated to withstand max current	Perform testing on harness design to verify damage won't occur	Construct a push/pull test on harness. After test, measure resistance to check for short.	Harness protected with sleeve and connector placed in-line to avoid breakage/short.	2-Mar-2023	1	Passed all the functional safety and parametric testing.
6	Mechanical Enclosure	Assembly issues, fastener failure, sharp edges, tolerance stack up, short circuit	Failure to assemble properly, potential for user to experience injury	6	Improper mechanical design, fabrication doesn't meet specifications	Smooth edges, high tolerance, plastic.	Verify dimensions meet design drawings, review assembly of enclosure for potential concerns	Visual inspection for assembly issues and sharp edges.	Protection seals placed, spring washers to ensure faster tightness.	5-Apr-2023	1	Passed all the functional safety and parametric testing. Need size and ventilation improvement.

Testing