A New Bidirectional Integrated Onboard Charger (IOBC) Designed For Electric Scooters

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Introduction

A trend towards electric scooters and other light electric vehicles (LEVs) reflect a need for advancements in LEV technology to address the limitations of traditional EV charging methods.

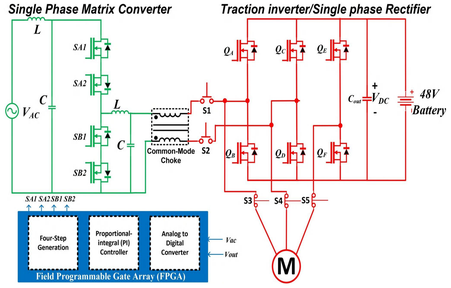
The development of a new Integrated Onboard Battery Charger (IOBC) offers a more convenient, cost-effective, and efficient charging solution to help support the transition to greener transportation by eliminating the need for external charging modules.

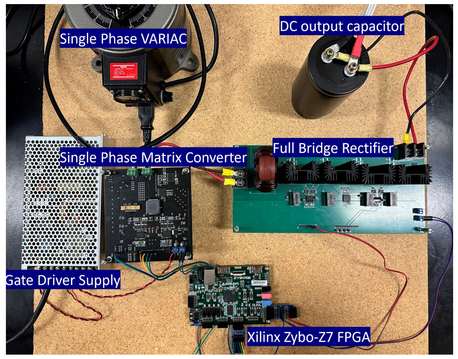
Research Question: how do we overcome the current limitations of current IOBC technology?

- Main concerns due to the limited dimensions of the EV: cost, size, and weight
- The IOBC comprises three main components:
  - AC-AC stepdown converter
  - FPGA microcontroller
  - Full Bridge Rectifier

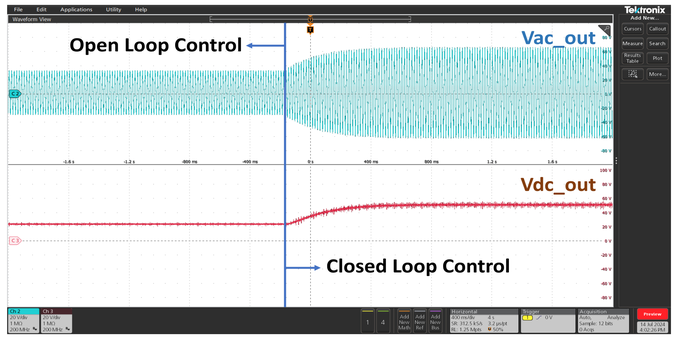
Methodology

- PLECS environment for simulating circuit designs
- Altium used for PCB design and searching for proper components
- Ordered custom PCBs and soldered most components
- Validated the reliability of the switching mechanism in the proposed matrix converter system (MOSFETs and Gate Drivers).
- Tested FPGA for sensor/gate driver control
- Single Phase VARIAC used for “real-world” testing
- Compared performance of IOBC to external scooter chargers available to the public with comparable power ratings

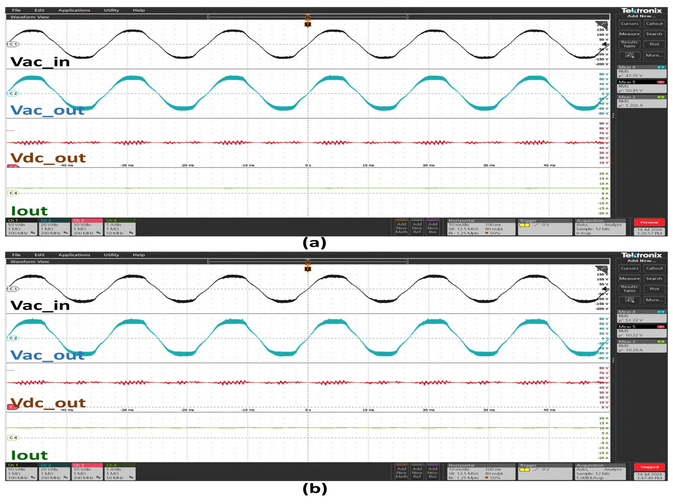




Onboard Battery Charger for LEVs Featuring FPGA-Enhanced Precision Delay Time Control for Four-Step Switching AC-AC Converter (Topology and Setup)



Experimental AC and DC outputs under open-loop and closed loop PI control.



Experimental results of proposed IOBC operating at (a) 50% and (b)100% rated power

Experimental Results

The results show that the AC-AC step down converter

- steps down the input voltage to $50V_{rms}$
- converts the power input to $50V_{dc}$.

Both results demonstrate an output of 50V ± 10% with the corresponding output current.

Discussion

The IOBC yields promising results. According to the experimental data, the IOBC's performance, optimized for size and efficiency, is comparable to the larger and heavier external scooter charging modules available to the public.

Future research could further optimize this design by minimizing the amount or power variation produced by the inductors used in this project.

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- Sandoval, J. J., Essakiappan, S., & Enjeti, P. (2015, March). A bidirectional series resonant matrix converter topology for electric vehicle DC fast charging. In *2015 IEEE Applied Power Electronics Conference and Exposition (APEC)* (pp. 3109-3116). IEEE.