Multiple Output Contactless Inductive Power Transfer System For Electric Vehicle Battery Charging Station

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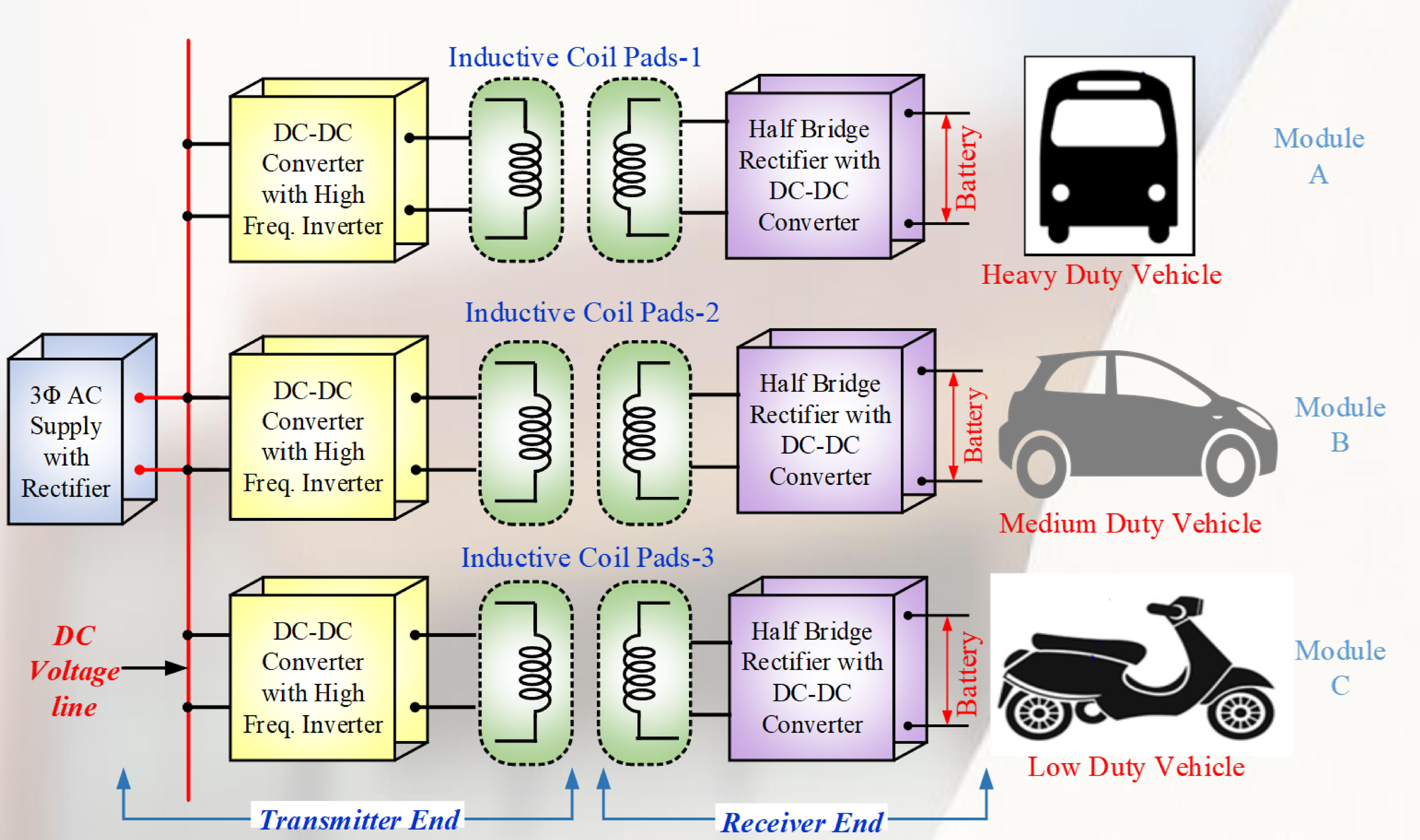
Aim

The major aim of the work is to design and develop a wireless battery charging stations with single input and multiple outputs in order to charge Electric Vehicles of various range and ratings simultaneously in a short period of time. .

Technical Objectives

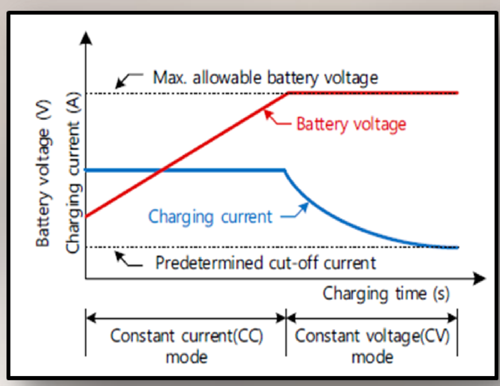
1. *The full order modeling of the multi-output battery charger with grid side power quality control.*
2. *Design optimization of the inductive power transfer coils based on analytical model equations and finite element analysis.*
3. *The design of the charge controllers for both charging and discharging modes of operation based on input-output feedback linearization, the determination of the minimum number of states to be measured in order to estimate the unmeasured states.*
4. *The study and control of the converters for the power transfer to the grid including development of a battery SOC based decision tree to determine how much power and when power can be transferred to the grid and the use of the grid side rectifier to improve grid power factor at the point of common cou-*

Proposed Wireless Charging Architecture

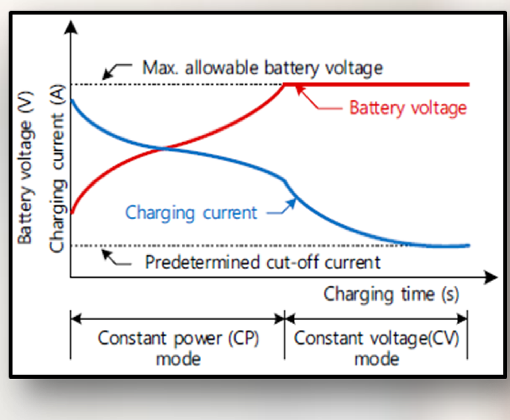


EV Charging Schemes

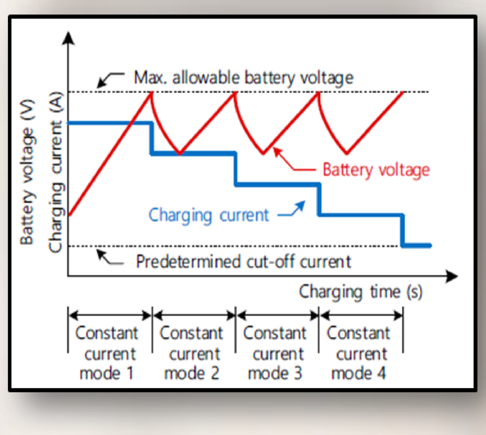
Constant Current & Voltage Method
- Widely Acceptable
- Simple in control
- Battery voltage is controlled at cut off voltage
- Suitable for Li-i



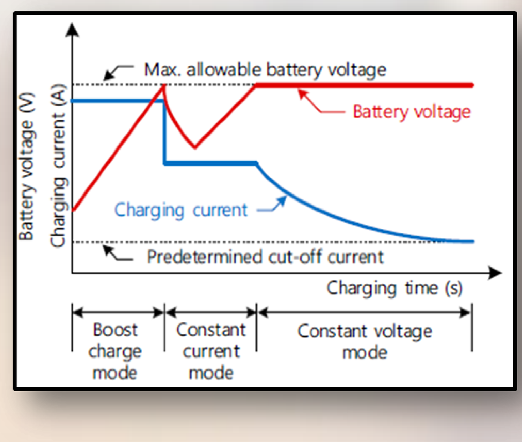
Constant Power Charging Method
- Complex Control
- Less requirement of thermal management
- Suitable for Li-i



Multistage Constant Current Method
- Complex Control
- V_{bat} is controlled to minimize the battery temp.
- Multiple current modes only
- Suitable for Li-io



Boost Charging Method
- Similar to MCCM
- CC and CV mode observed.



Low Duty EV
- <25 kwh battery
- 250 km / battery charge
- 150-400 V
- 30-150 A
- Harley Davidson Livewire

Medium Duty EV
- 120 > X > 25 kwh battery
- 365 km / battery charge
- 350-450 V
- 250 A
- Tesla

Heavy Duty EV
- >160 kwh battery
- 136 km / battery charge
- 600-900 V
- 750 A
- Xcelsior Charge 60

Types of EV Charging

Level-1: Home Charg.
Voltage: 120 V AC
Time: 8-12 hrs
Range: 3-8 km/hr
Eg. Orion, Duosi

Level-2: Office Charg.
Voltage: 240 V AC
Time: 3-4 hrs
Range: 60 km/hr
Eg. Siemens

Level-3: DC Fast Charg.
Voltage:400 V DC
Time: 30 min
Range: 160 km/charge
Eg. CHAdeMO

Level-4: Super Fast Charg.
Voltage:400 V DC
Time: 10-20 min
Range: 15 km/min
Eg. Tesla V3 Station

Wireless Battery Charging Methods

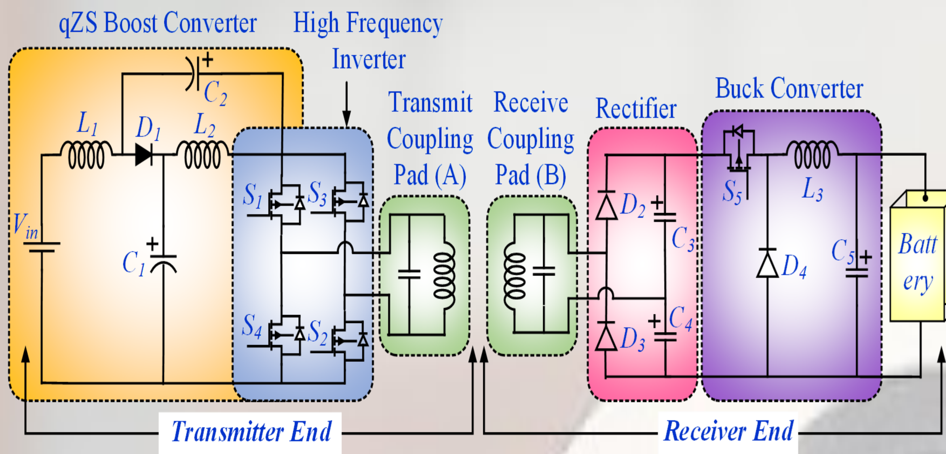
1 Inductive Wireless Power Transfer
- ✓ Minimizing the sensitivity of on-board EV components to flux density and freq.
- ✓ Non-linear flux distribution over the magnetic core that affect eddy current losses and electromagnetic interference

2 Capacitive Wireless Power Transfer
- ✓ More efficient than Inductive WPT.
- ✓ Only Suitable for Low Power Application

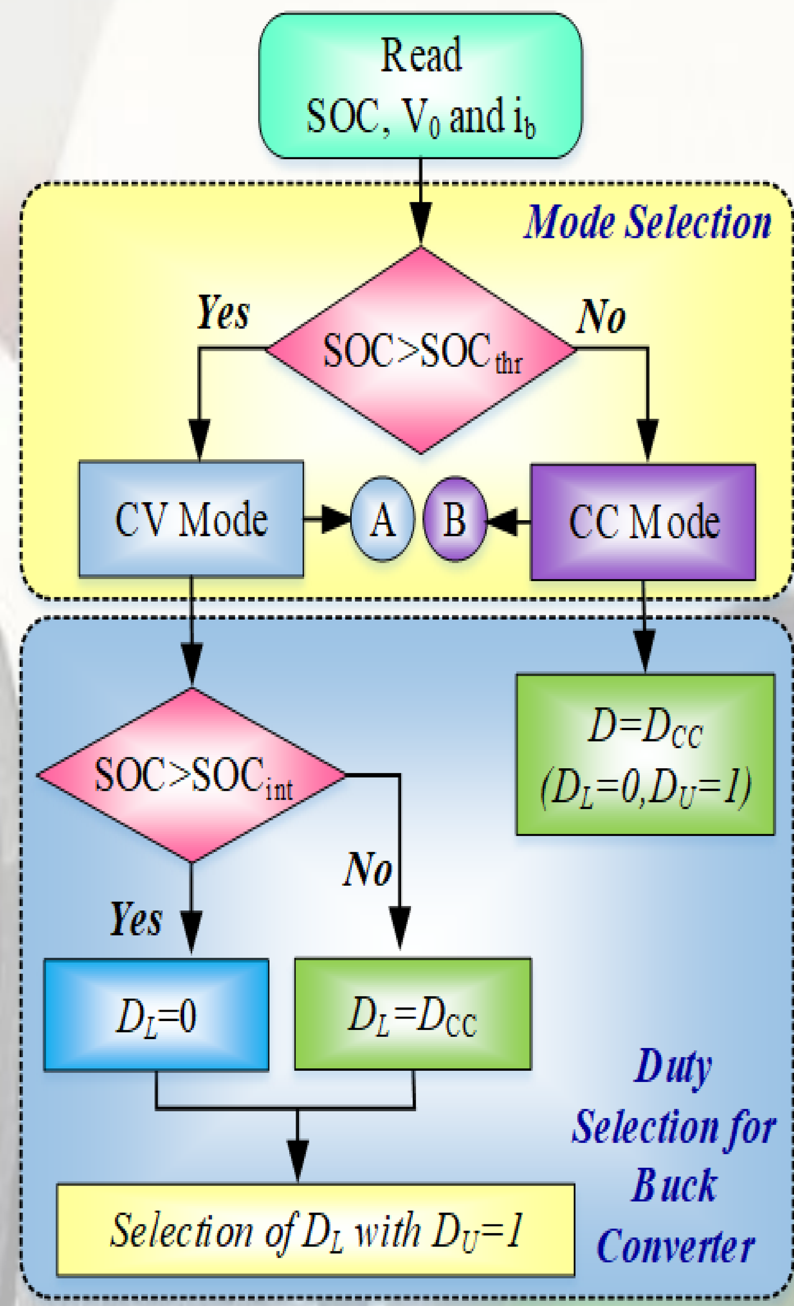
3 Low freq. perm. Magnet Coupling Power Transfer
- ✓ Consisting two magnetically coupled rotor.
- ✓ Applicable for short air gap.
- ✓ Low efficiency

4 Resonant Inductive Power Transfer
- ✓ Uses at least two tuned resonant tanks which resonate at the same frequency.
- ✓ The primary functions of the resonant circuits include:
  - Maximizing the transferred power, Optimizing the transmission efficiency,
  - Controlling the transmitted power by frequency variation,
  - Matching the transmitter coil impedance to the generator
- ✓ The advantages of RIPT over IPT:
  - Increased range up to 40 cm,
  - Reduced EMI, higher frequency operation & Higher efficiency.

Proposed Fast Charging System

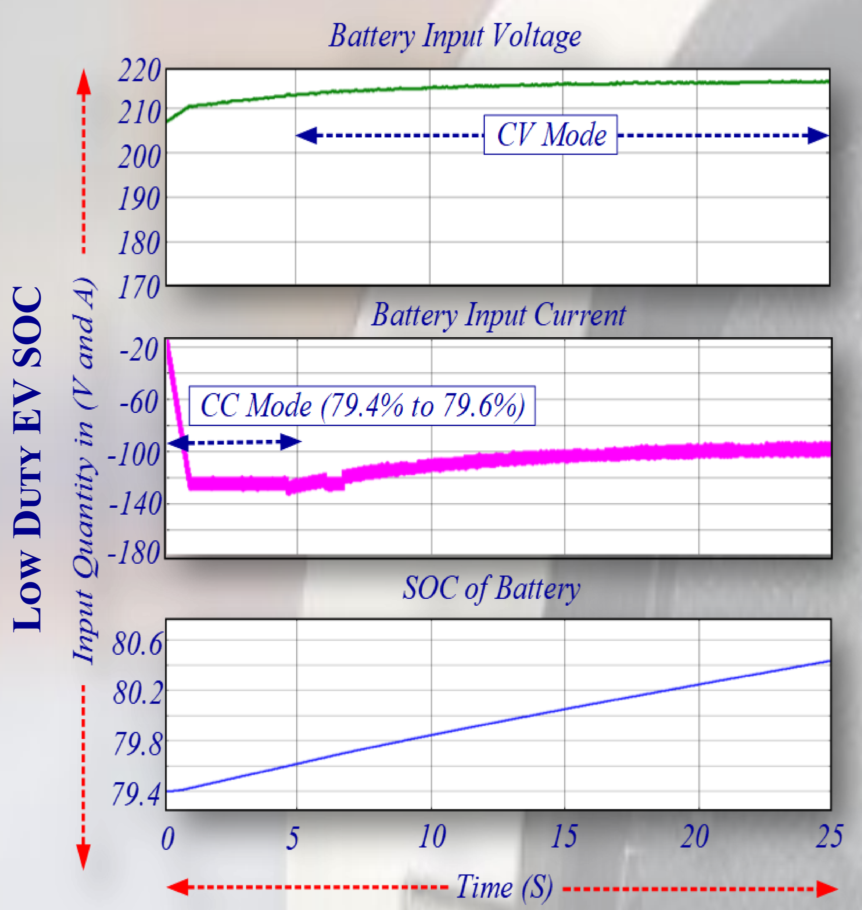


CC & CV Mode Control

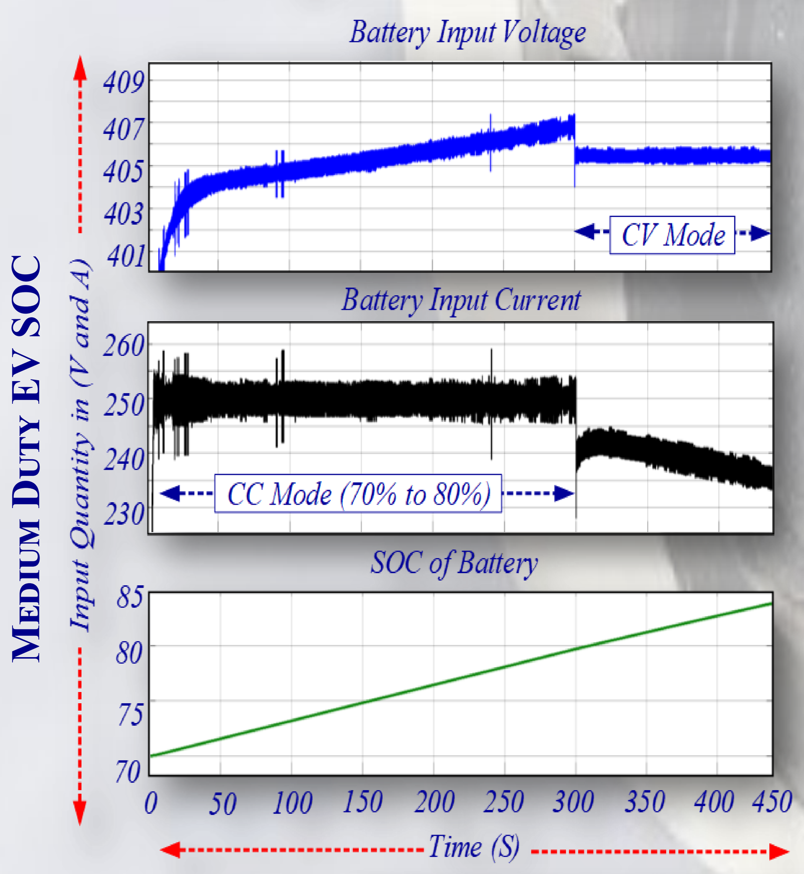


D_L=lower, D_U=upper limit of duty saturation

Low Duty EV SOC

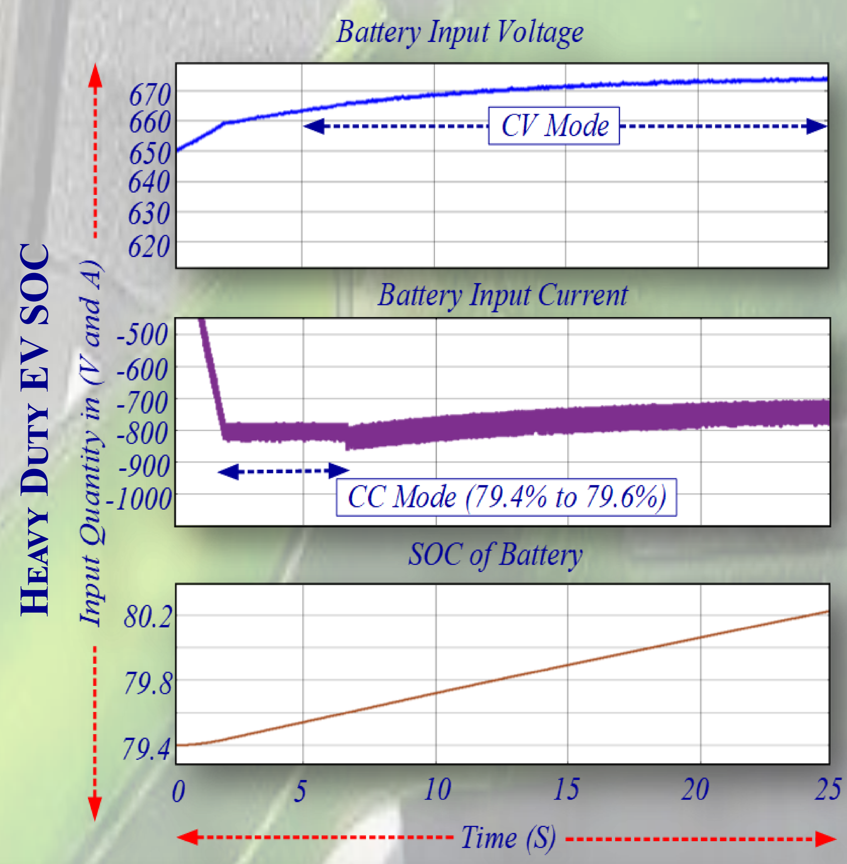


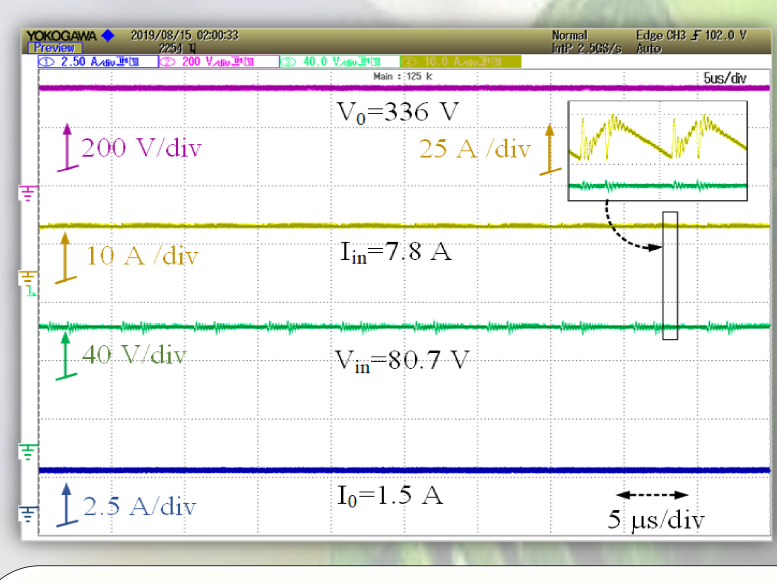
Medium Duty EV SOC

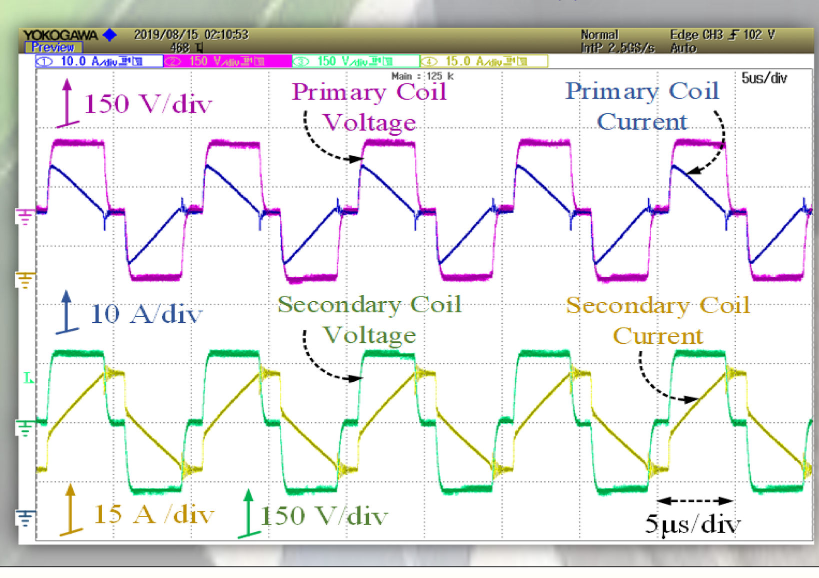


The proposed system is experimented at 630W power

Heavy Duty EV SOC







Conclusion

- ***N-level L-LMBC** requires: 1 switch, 2 inductors, 2N capacitors and 2N+1 diodes.*
- ***L-LMBC** topology gives a higher negative voltage gain compared to existing LY converter and L-YVD converter topology of the XY Family.*
- *The noticeable features of proposed **L-LMBC** topology are:*
  - ***i) Only one power control switch;***
  - ***ii) High inverting output voltage from single input source;***
  - ***iii) Without the use of any transformer;***
  - ***iv) The number of CW (Cockcroft Walton) multiplier levels can be added to achieve high voltage** without changing the connection of main circuits.*
- *The simulation results are provided for verifying the functionality of the L-LMCB.*
- *The simulation results are validated through experimental prototype. The experimental results obtained concur the simulation result well.*

Acknowledgement

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