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Session - 14: ON EVOLVING TRENDS IN UTILITY AUTOMATION

Wireless Charging of an Electric Vehicle

Presented By

Dr. Ritesh Kumar Keshri, Associate Professor, VNIT Nagpur

Battery Charging : Definitions

Process of submission of energy to a battery by forcing current into it is called charging of a battery.

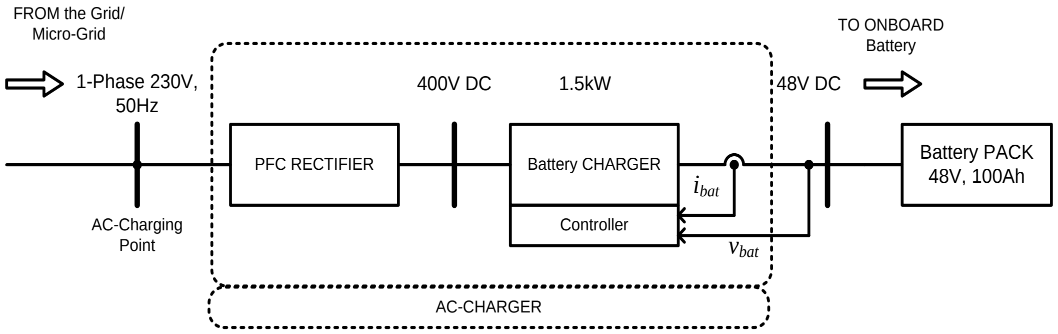
Fast charging:

Injection of the charging current into a battery to be charged at a rate higher than C/10 (normal charging) is termed as fast charging.

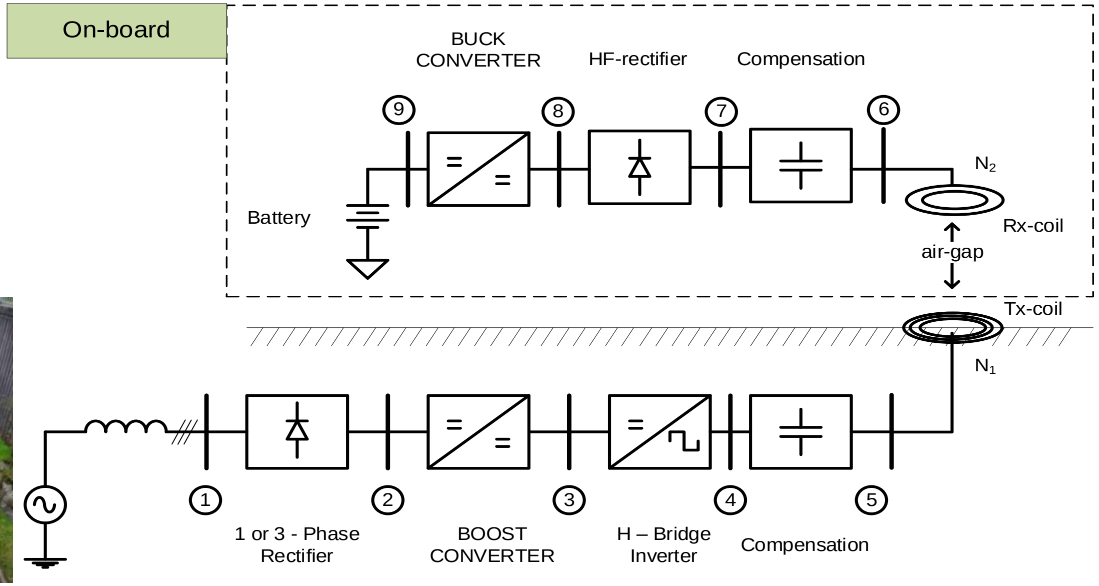
Degree of fastness can be higher or lower and is represented by *k*C/10, i.e. number of times the C/10.

Where C is the capacity of the battery in A·h.

Conductive Charging:



Wireless Charging:



Static Charging **Dynamic Charging**

Technologies of Wireless Power Transfer

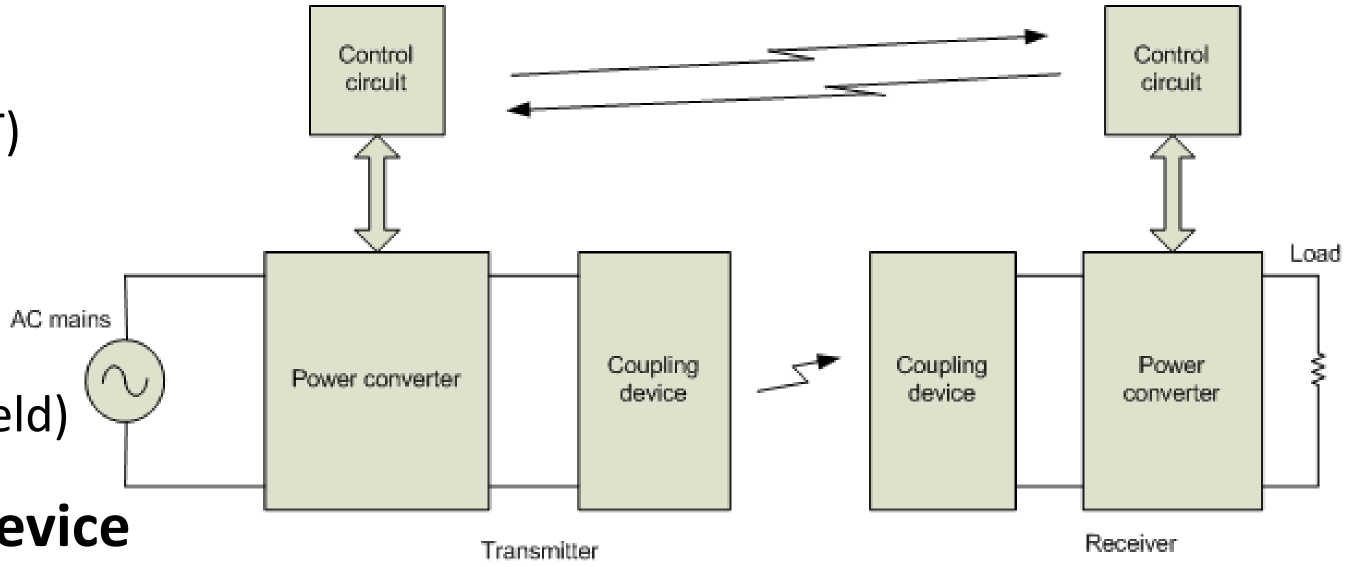
As per field involved in coupling

Near field wireless power transfer (WPT)

- Capacitive WPT (*electric field*)
- Inductive WPT (*magnetic field*)

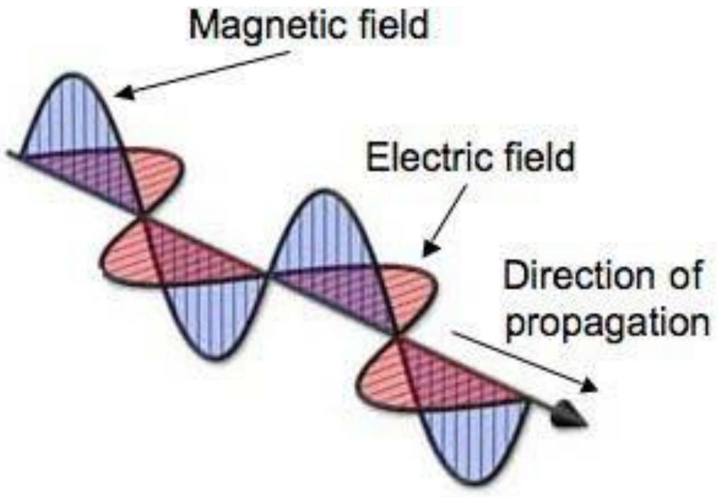
Far field wireless power transfer (WPT)

- Radiant WPT (electromagnetic field)

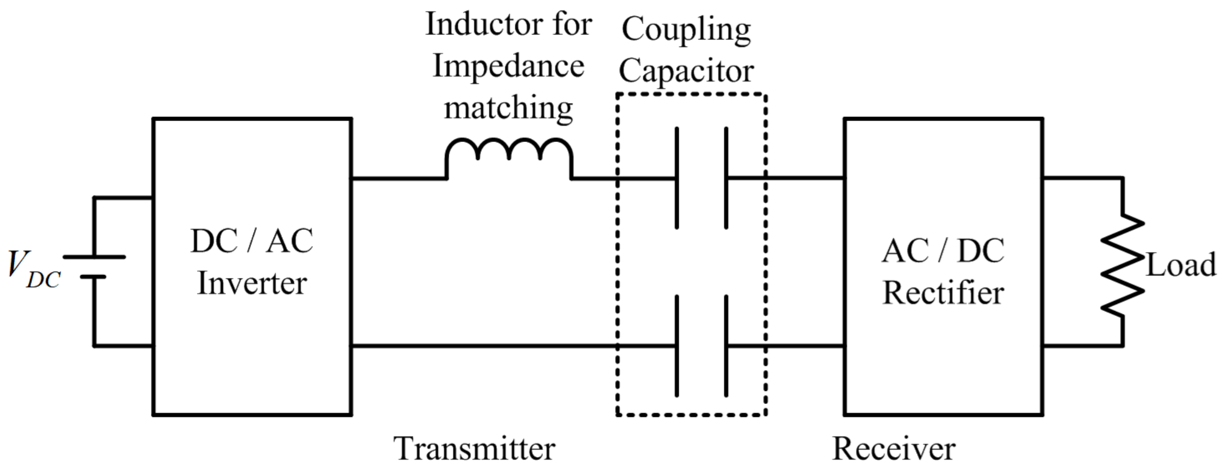


As per state of motion of coupling device

- Static charging
  both of the coupling device remains stationary
- Quasi dynamic charging
  vehicle slowly decelerate/move with ground device
- Dynamic charging
  coupling device with the vehicle moves at rated speed



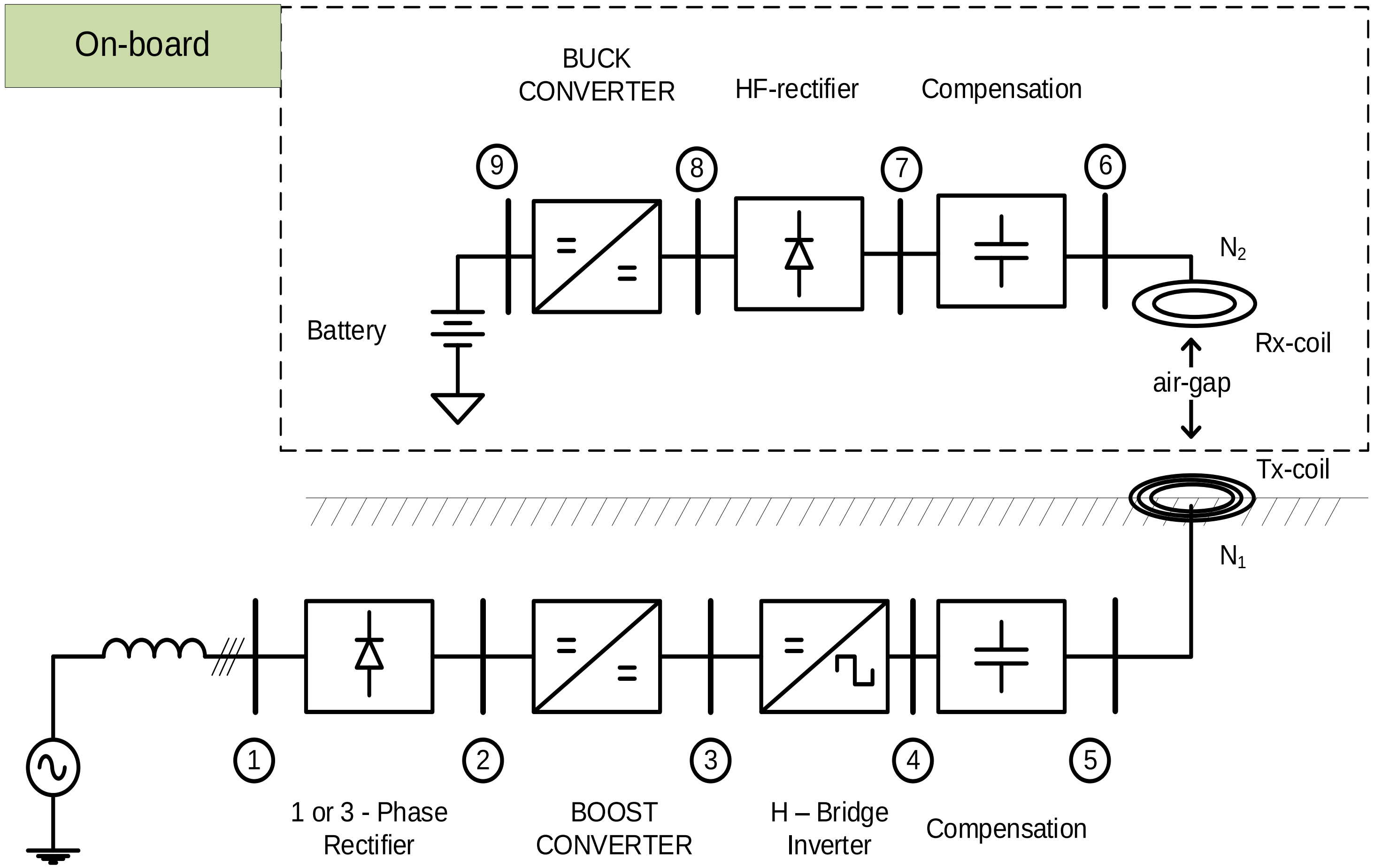
Capacitive wireless charging



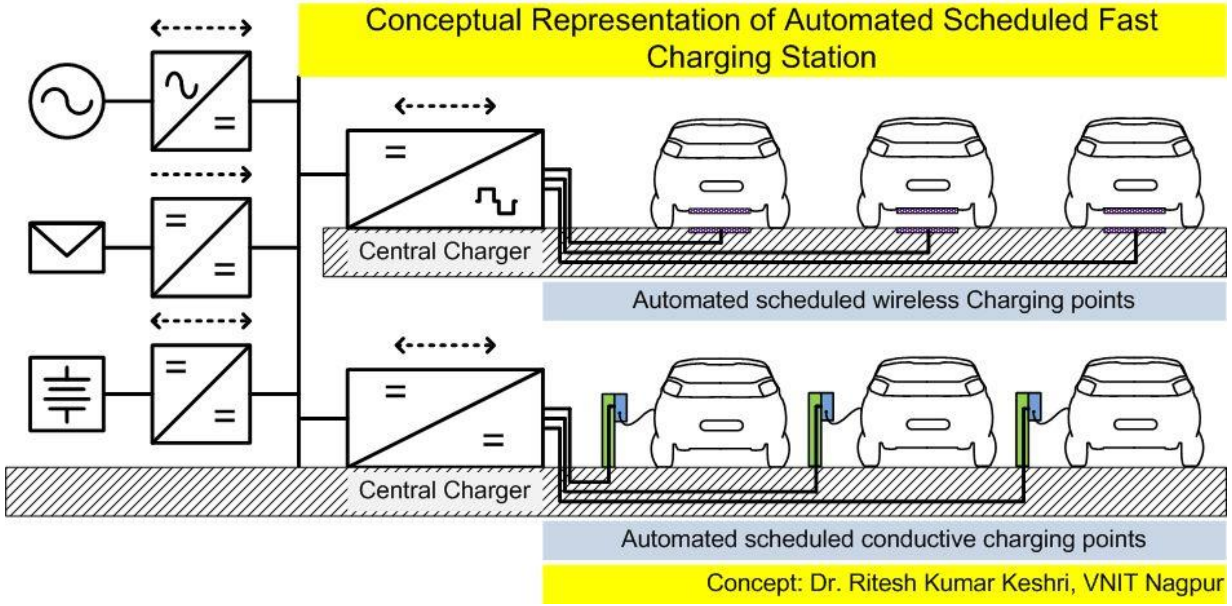
- coupling device of the transmitter and the receiver consists of metal plates coupled through an electric field
- continuity of current is ensured by a displacement current.
- A series inductor is used to match the input impedance so that power can be transferred efficiently with zero phase angle operation.

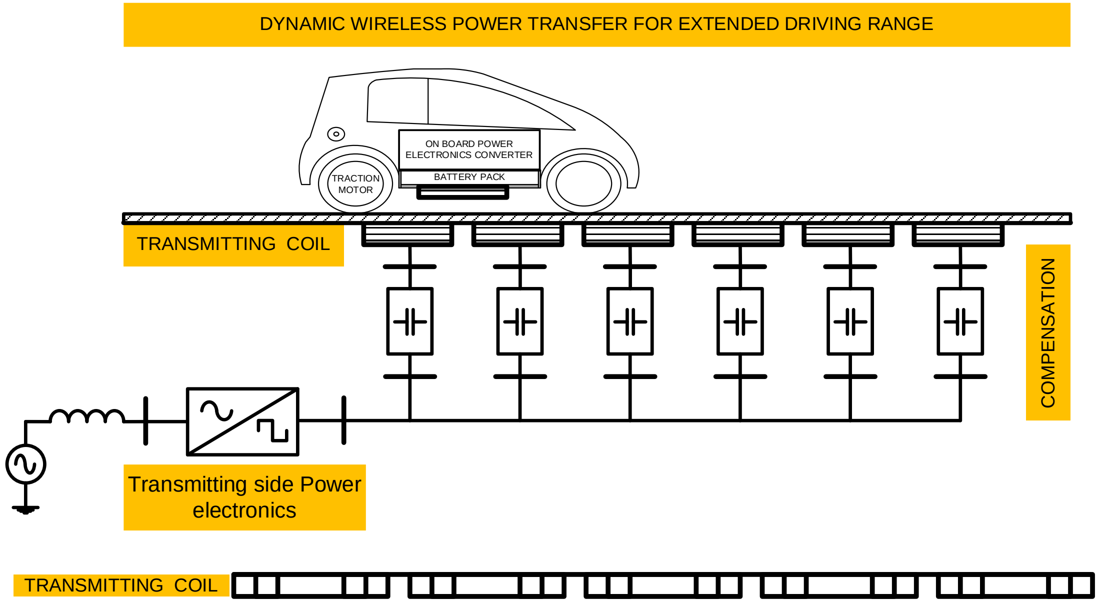
- A series inductor is used to match the input impedance so that power can be transferred efficiently with zero phase angle operation.
- The main advantages are low losses, negligible electromagnetic emissions and the capability of transferring the electromagnetic field through metal shields without inducing eddy currents.
- As the energy density stored in free space between the metal plates is comparatively low, it is limited to low power applications.

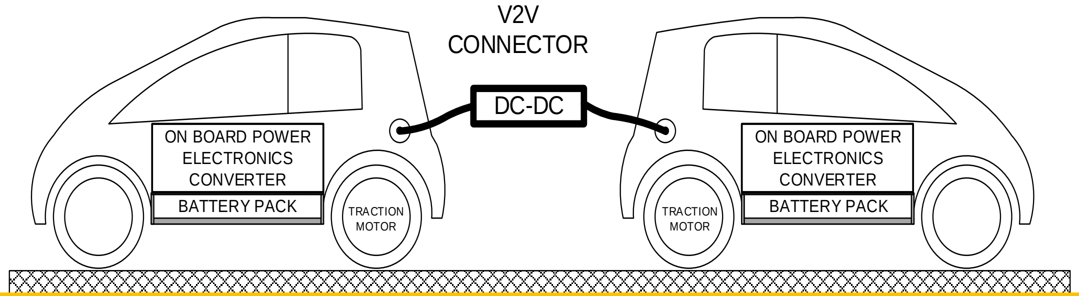
Inductive wireless charging



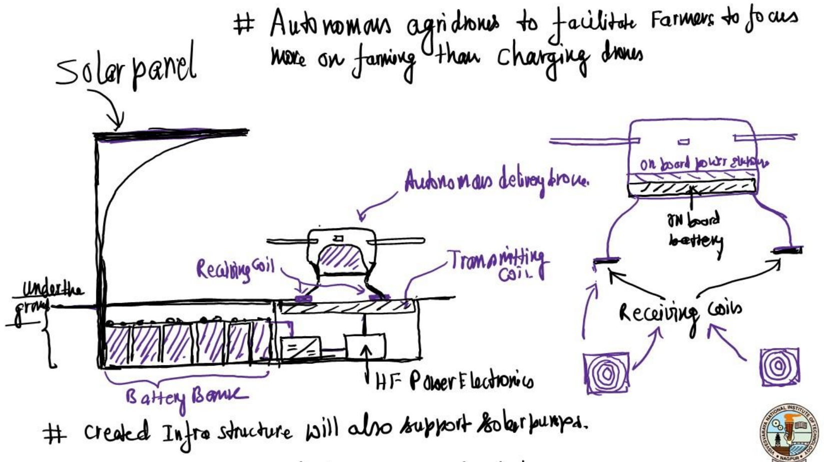
CONTEXT: Focus on Autonomous mobility than charging







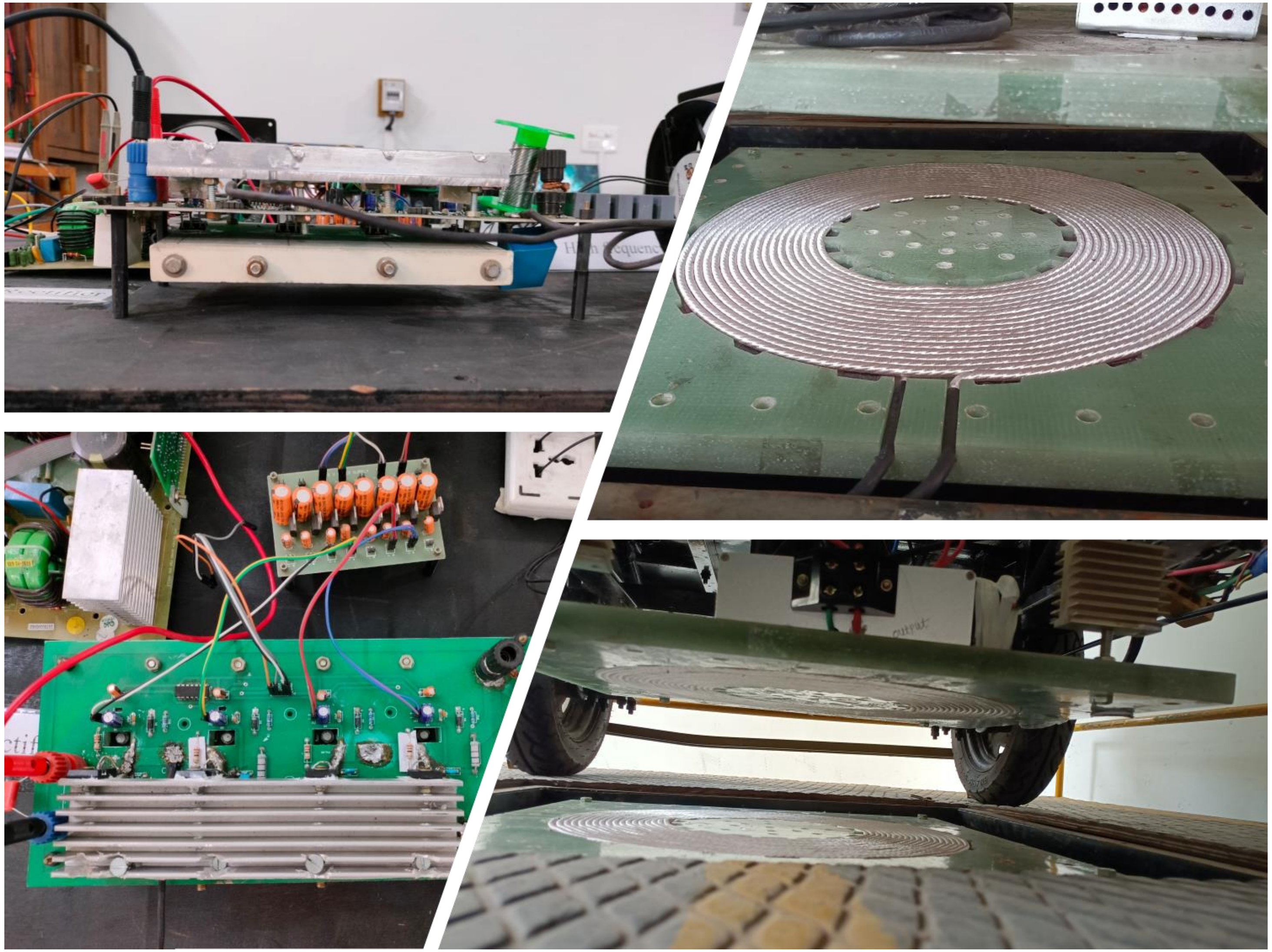
V2V Connector for Energy Exchange between Vehicles

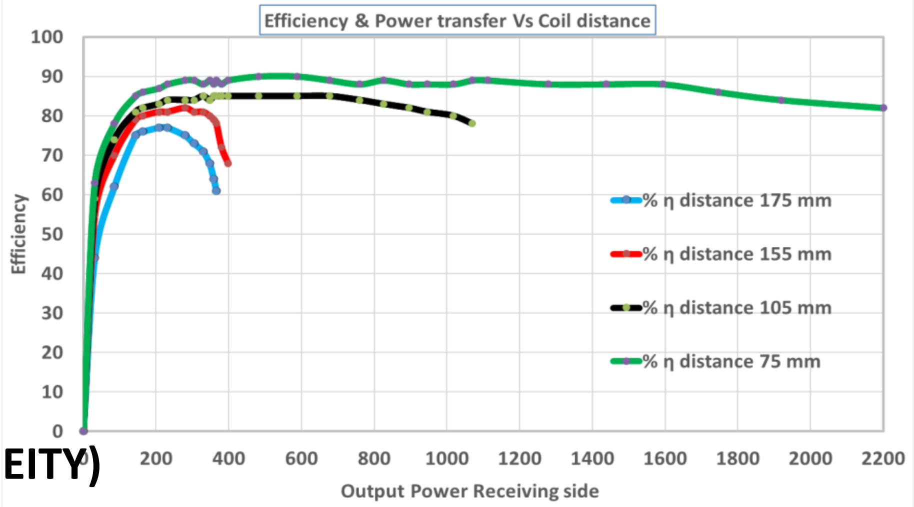


Autonomous Agri drones

RELEVANCE : 1.5kW@48 / 5kW@320V Wireless Charger

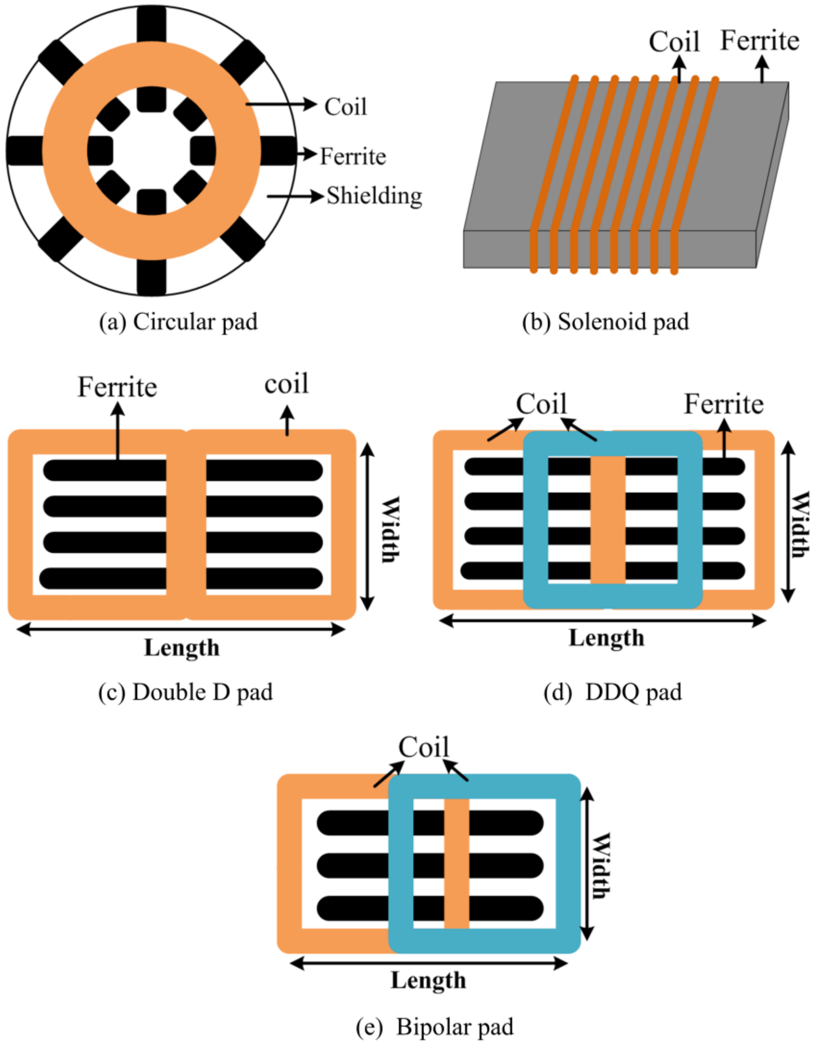
Ministry of Electronics and Information Technology
Government of India





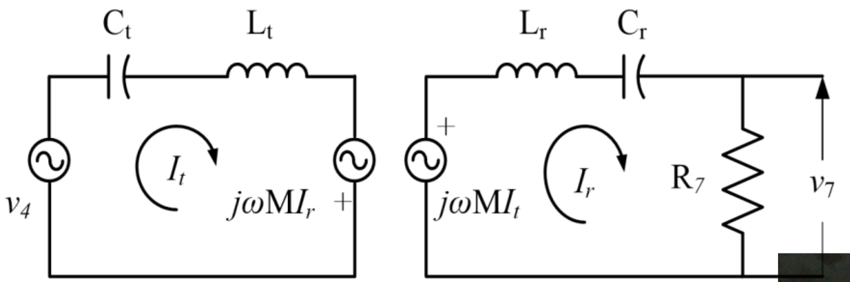
Developed wireless charger 1.5kW@48V/5kW@320V under NaMPET Ph-3 (MEITY)

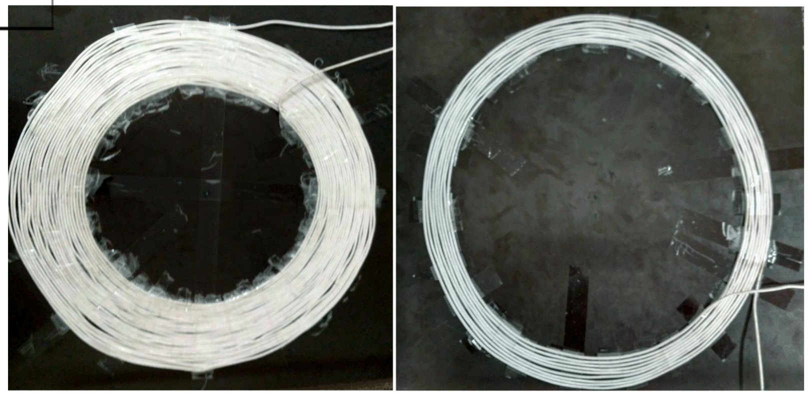
Different types of magnetic coils



- Generally these magnetic pads are named by the structure of the coil and or by the profile of the magnetic field.
- Among these, the prominent are the Circular, Double D, DDQ which is derived by adding quadrature coil to Double D, Solenoid, bipolar and tripolar pads.
- Based on the profile of the magnetic field, these pads are further distinguished as non polarized (Circular) or polarized (Solenoid, DD) and based on the excitation given to different coils in the pad, DDQ, Bipolar, Tripolar can develop either non-polarized or polarized magnetic field.
- A non-polarized pad ideally generates and couples perpendicular component of the flux where as polarized pad generates and couples flux which is parallel to one of the dimensions of the pad.
- In general circular coils are preferred for stationary charging, as they require less cost for fabrication and there is no angular misalignment. So vehicle can approach from any direction.

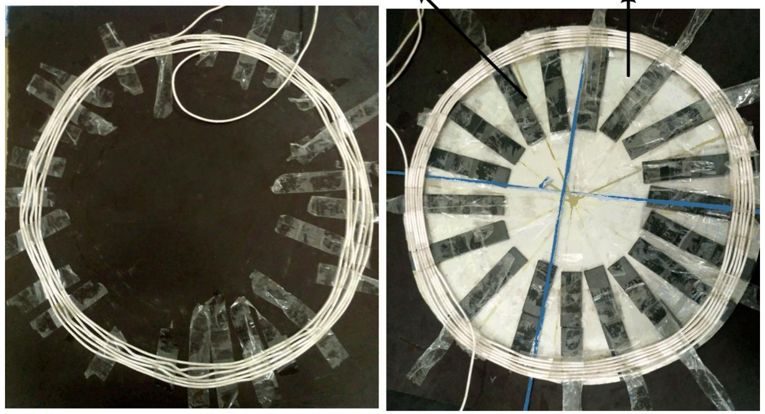
Flux distribution with and without Ferrite core





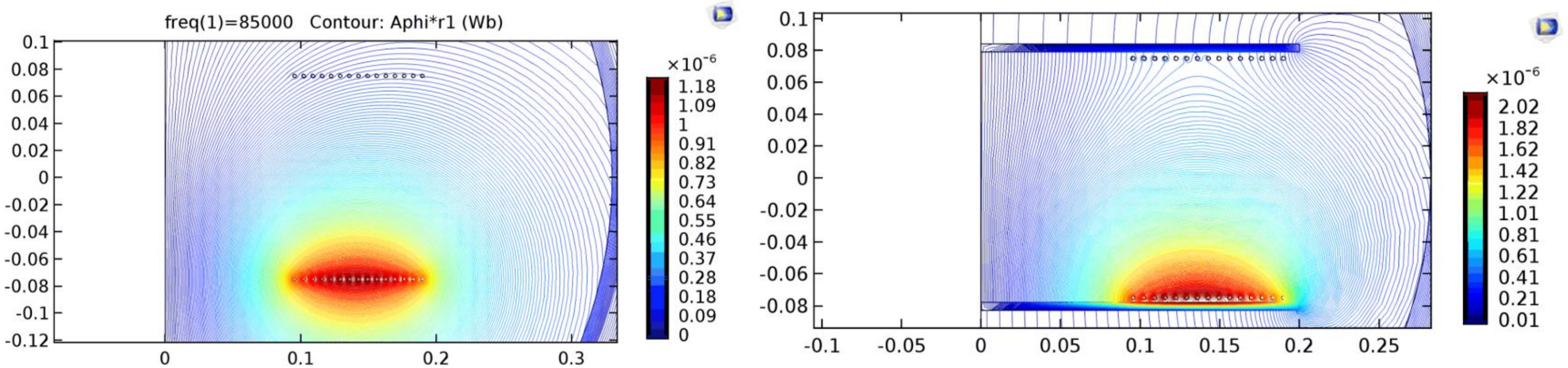
(a) Transmitting coil

(b) Receiving coil



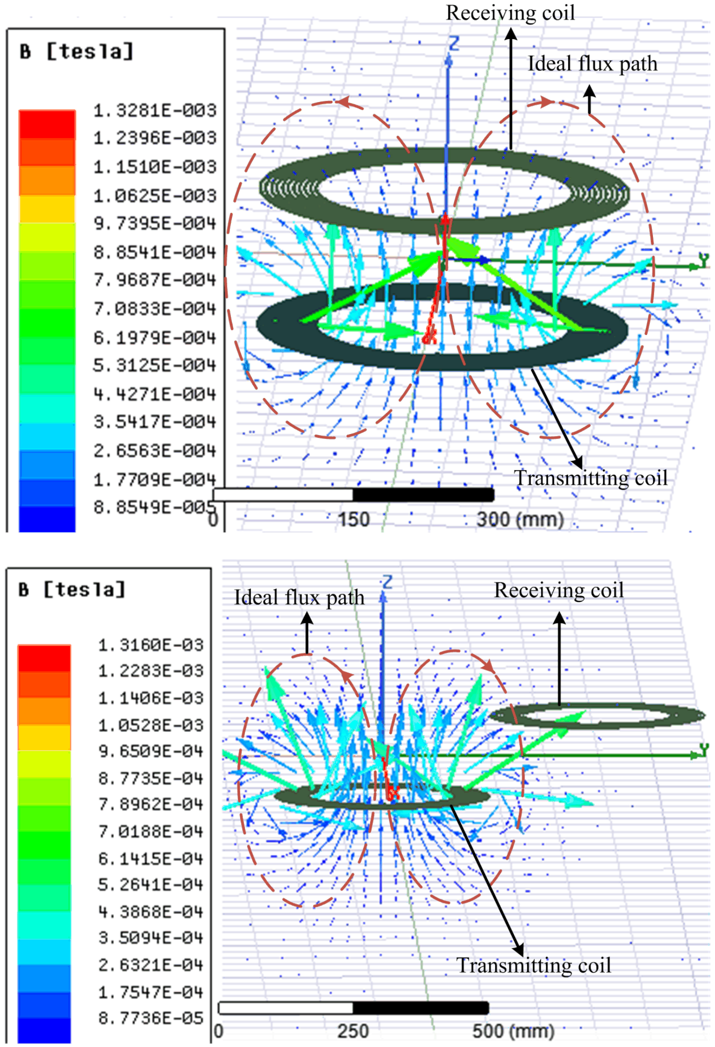
Transmitting coil

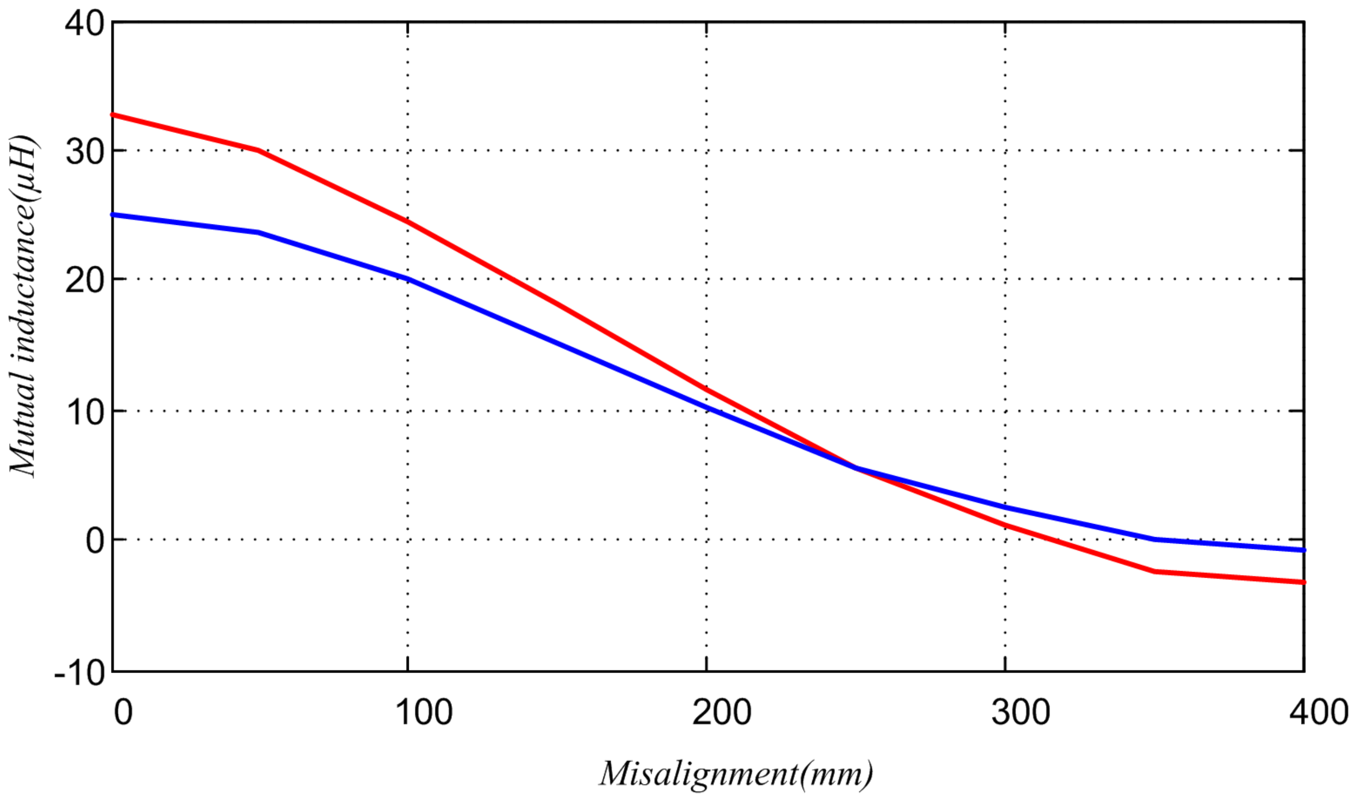
Receiving coil



Flux density distribution

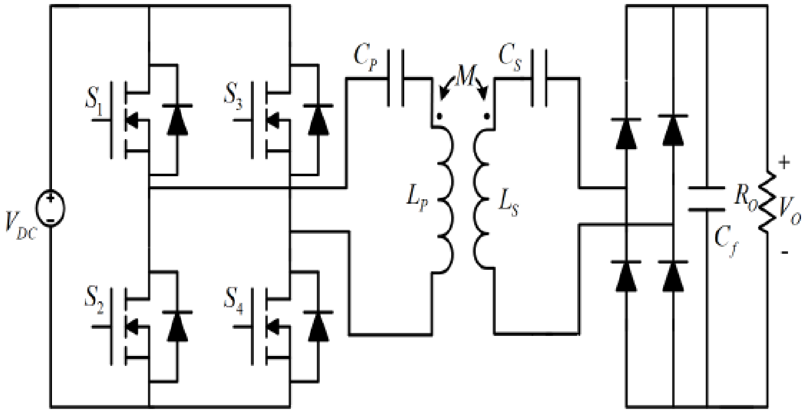
Coil misalignment



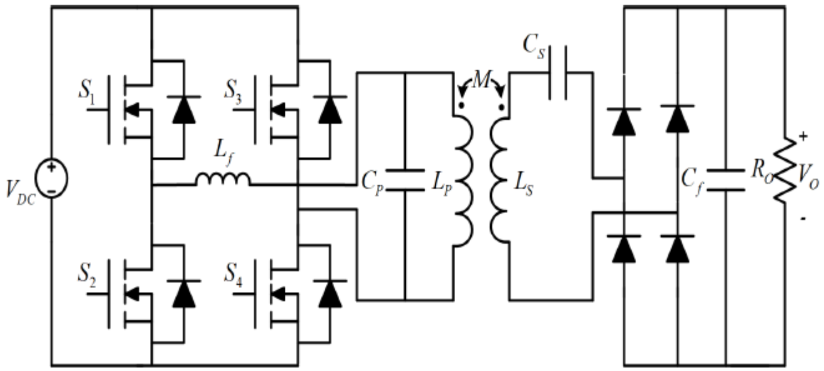


Mutual inductance variation with misalignment

Evaluation of CEES for with S-S and PS compensation strategies



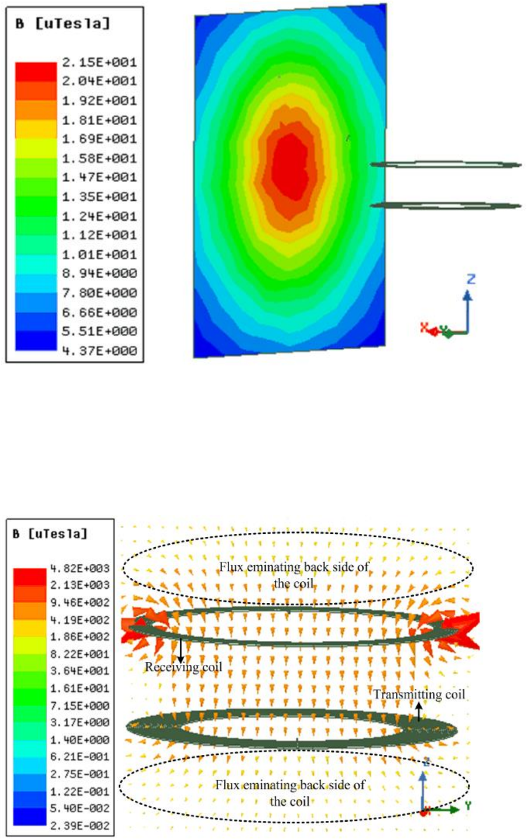
S-S compensation



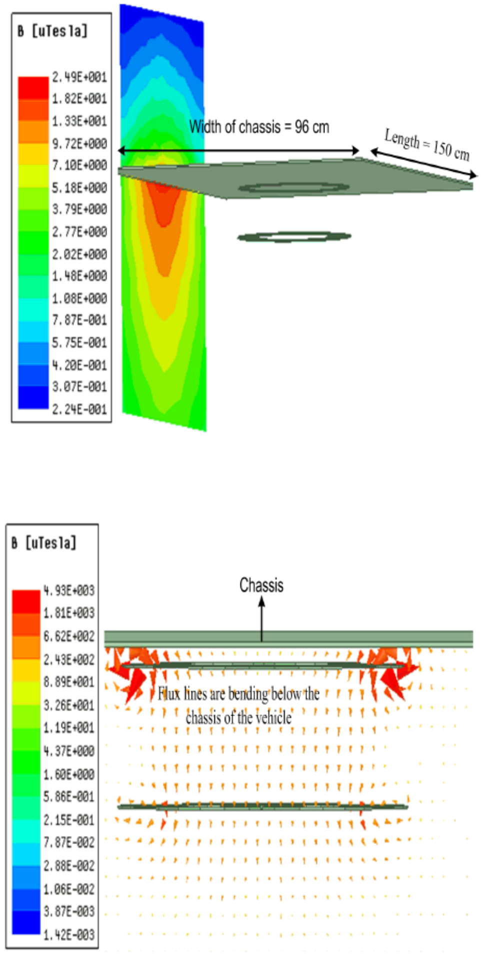
PS compensation

	S-S Compensation	P-S Compensation
Voltage stress on Transmitting side capacitor	high	Within limit
Voltage stress on transmitting coil	high	Within limit
Current stress on Transmitting side Capacitor	Within limit	high
Voltage stress on inverter switches	Within limit	Within limit
Protection of Source unprotected protected Weight of coil	unprotected	Less protected

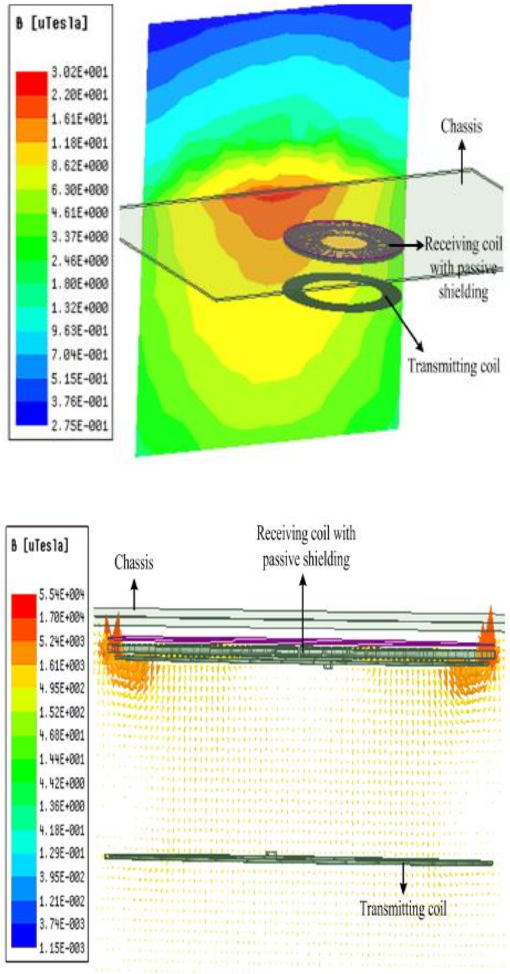
Evaluation and selection of shielding methods



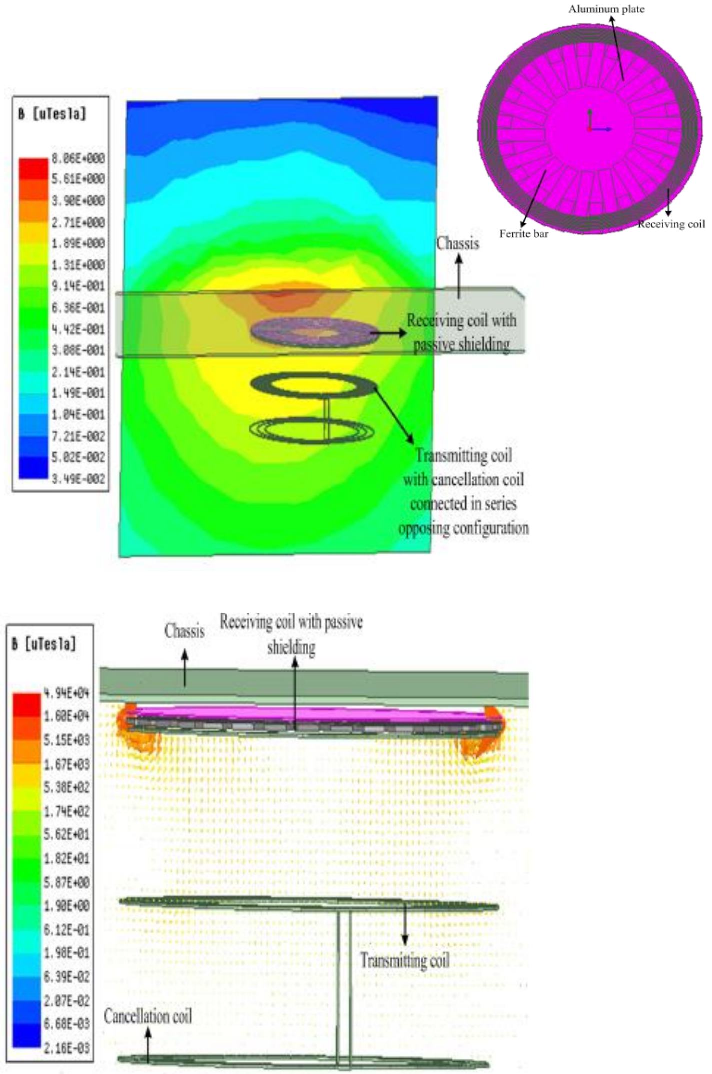
Without chassis



With chassis

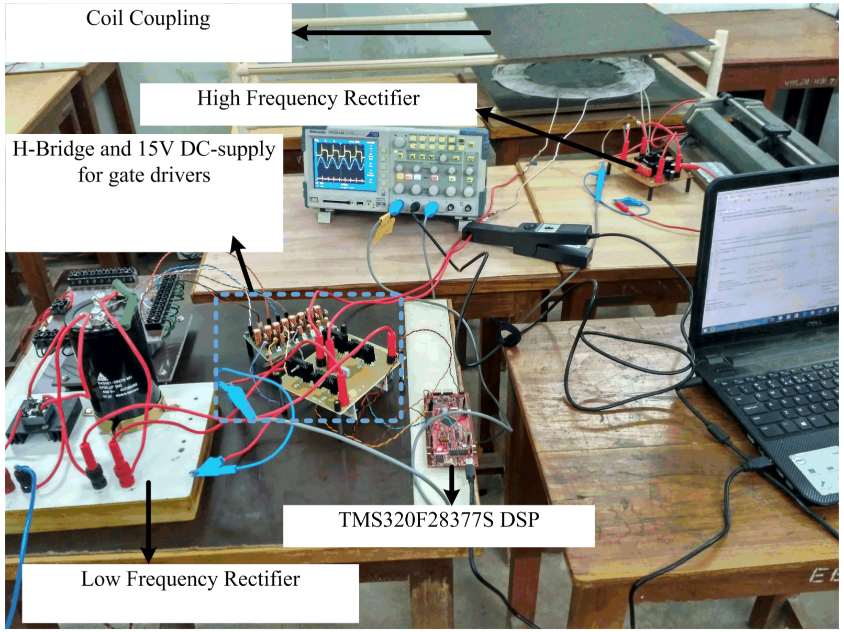


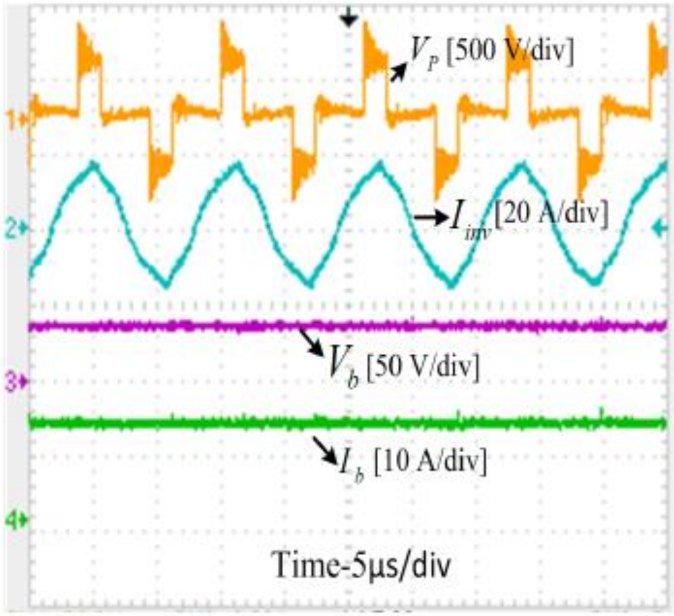
Passive Shielding



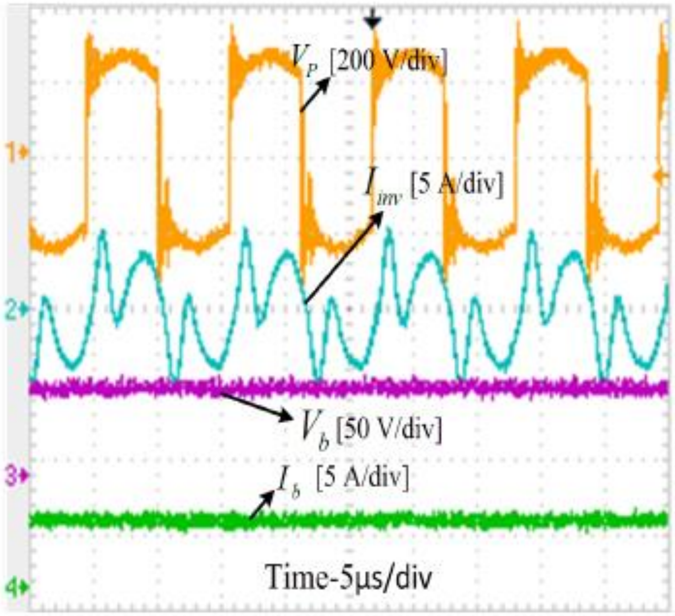
Active and Passive Shielding

First Experimental Prototype 576W@48V

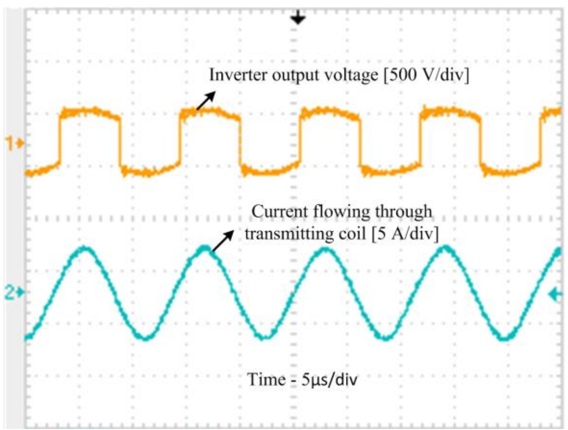




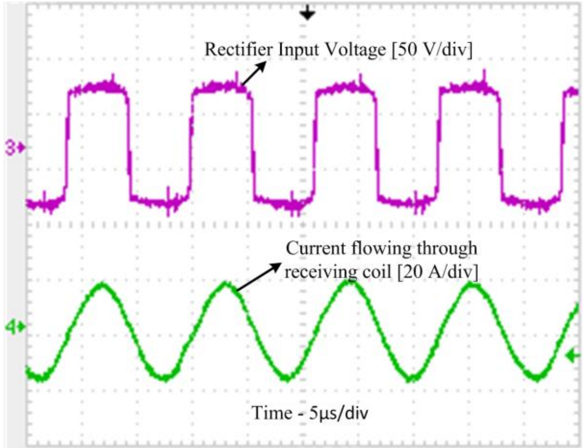
CC Charging



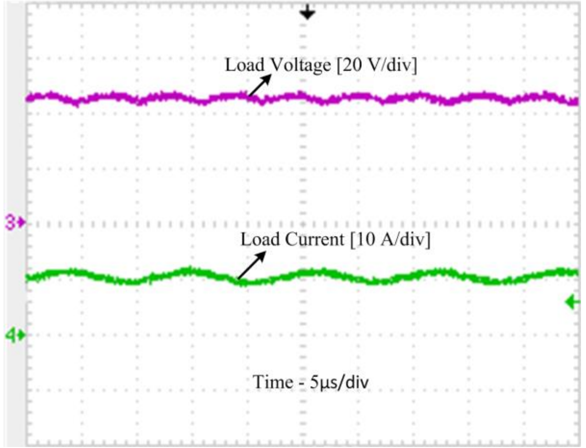
CV Charging



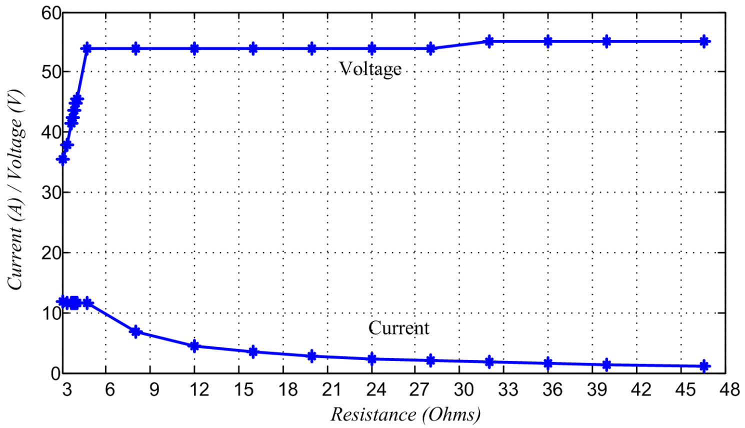
Transmitting side



Receiving side



Battery input



CC/CV Charging

Wireless charger for Light vehicle

1.5kW Charger

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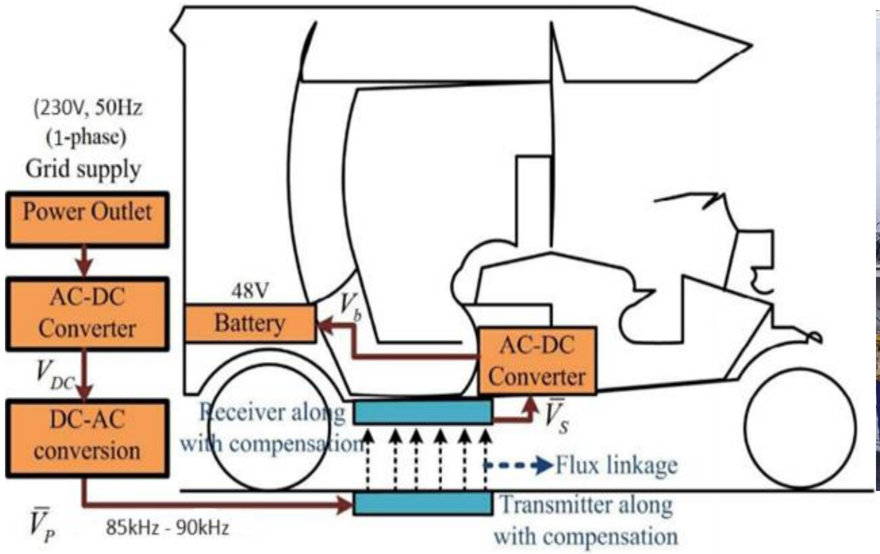


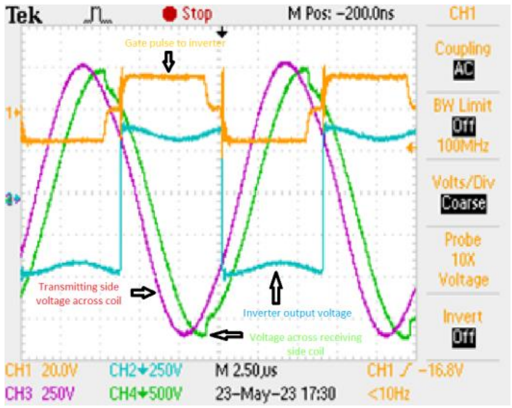
Technology Demonstrator

Wireless charging station and Wireless charger enabled Light vehicle

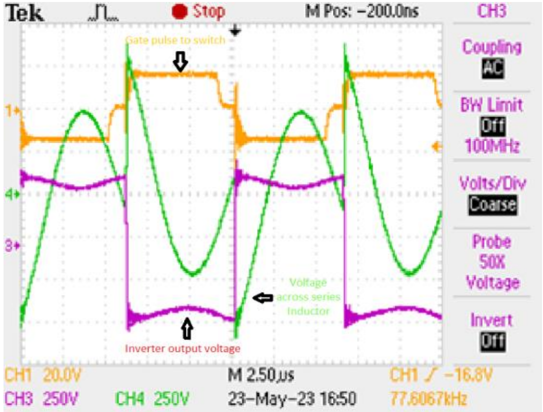
Table –1 Specifications of the identified Buses and the considered efficiency of the power conversion stages and calculated power

Bus no.	Specification	Power Conversion stage	Considered Efficiency	Experimental Efficiency	Bus Power	
1	230 V, 10.2 A	1-3	90%	94%	P1	2.19 kW
3	400 V DC bus, 5.3 A	3-4	97%	98%	P3	1.97 kW
4	400V (rms), 5.2 A (rms)	4-7	85%	95%	P4	1.91 kW
7	220 V(rms), 0 A (rms) (on no load) 125 V(rms), 14 A (rms) (on full load)	7-8	95%	97%	P7	1.63 kW
8	220 V, DC, 0 A ,DC (on no load) 125 V, DC, 12.5 A , DC(rms) (on full load)	8-9	97%	96%	P8	1.55 kW
9	48 V, 30A, 1.5 kW DC				P9	1.5 kW
	Overall frequency	**1-9**	**68%**	**81%**		

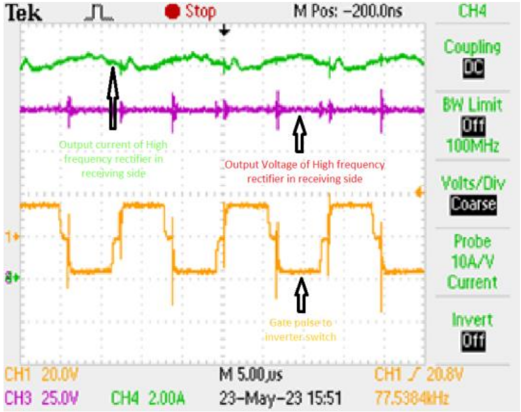
Considered & Experimental efficiency and calculated Bus specifications



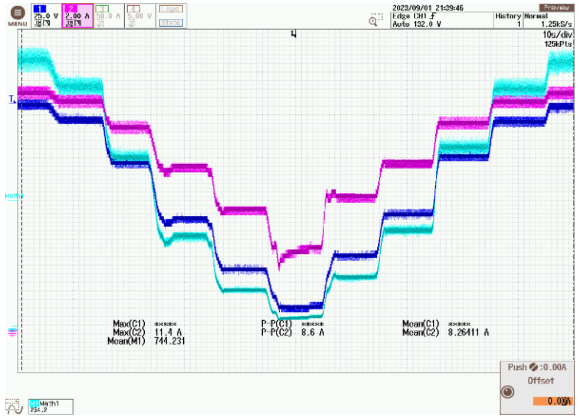
Transmitting side input to coil



Receiving side output of the coil

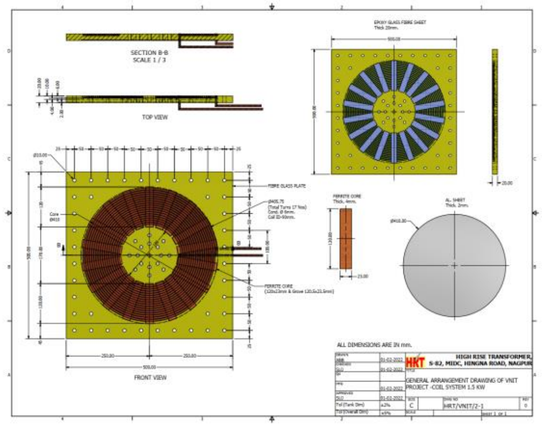


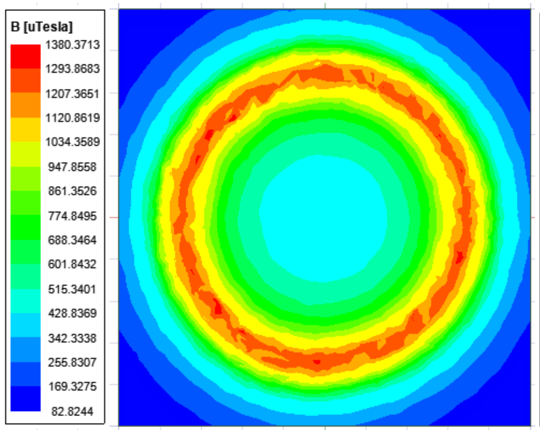
High frequency rectifier output

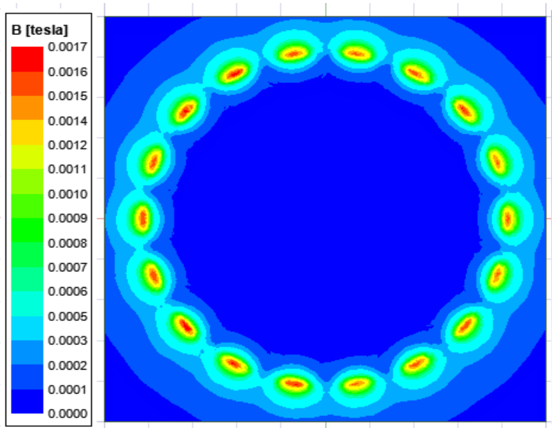


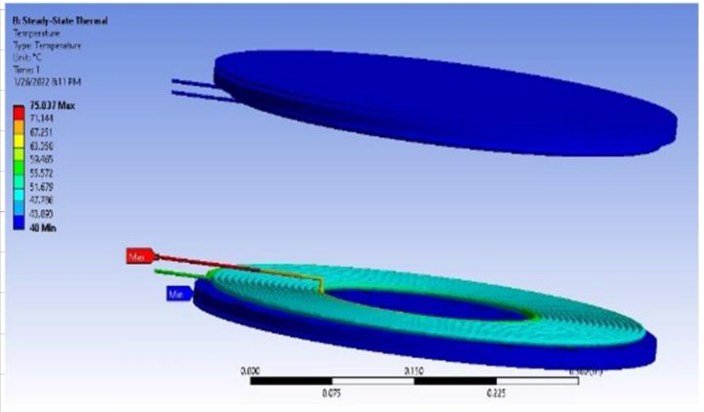
Transferred power, voltage and current under misalignment

Coil fabrication and evaluation

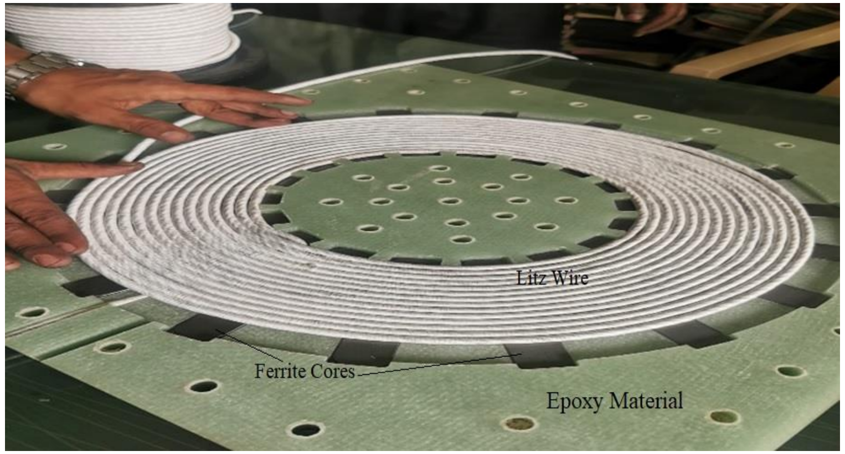


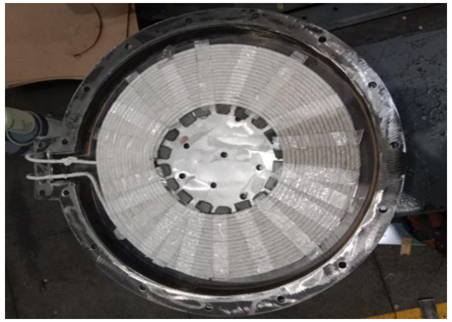






Layout | Thermal evaluation





Fabrication

THANK YOU

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Links/References (If any)