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**DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING**
**ACADEMIC YEAR 2022-23 ODD SEMESTER**

# Internal IEEE Faculty Seminar Report

**Title of the seminar** : Multilevel Inverters for Electric Vehicle Applications

**Date** : 25.11.2022

**Resource Person** : Dr.P.Narasimman, AP/EEE, KCE

**Beneficiaries** : EEE Faculty Members- 6

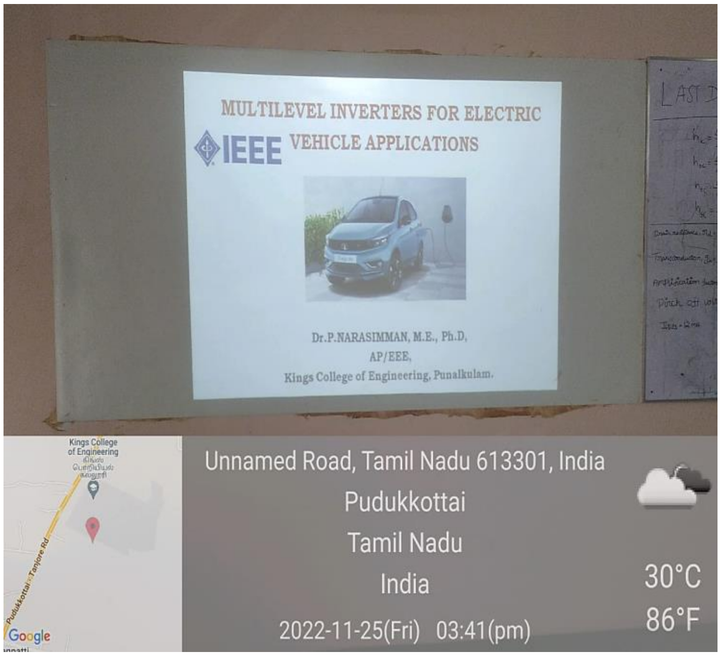
**Venue** **:** EEE – Smart Classroom

On behalf of the Department of EEE and IEEE Branch organized an Internal Seminar on "Multilevel Inverters for Electric Vehicle Applications" for the faculty members of EEE Department on 25.11.2022. The main objective of the internal seminar is to provide an exposure to our faculty members on various research areas in multilevel inverters for electric vehicle applications.

The following points were discussed during the session:

- The development of electric and hybrid-electric vehicles will offer many new opportunities and challenges to the power electronics industry, especially in the development of the main traction motor drive.
- Multilevel inverters are used in electric vehicle (EV) and hybrid-electric vehicle (HEV) motor drives.
- Advantages of Diode-clamped and cascaded H-bridge multilevel inverters are:
  (a) It can generate near-sinusoidal voltages with only fundamental frequency switching.
  (b) They have almost no electromagnetic interference (EMI) and common mode voltage and
  (c) It make an EV more accessible safer and open wiring possible for most of an EV's power system.
- The system configuration of an EV motor drive uses cascade multilevel inverter. In the motoring mode, power flows from the batteries through the cascade inverters to the motor. In the charging mode, the cascade converters act as rectifiers, and power flows from the charger (ac source) to the batteries.

**Photos:**



MULTILEVEL INVERTERS FOR ELECTRIC VEHICLE APPLICATIONS
IEEE
Dr.P.NARASIMMAN, M.E., Ph.D,
AP/EEE,
Kings College of Engineering, Punalkulam.
Unnamed Road, Tamil Nadu 613301, India
Pudukkottai
Tamil Nadu
India
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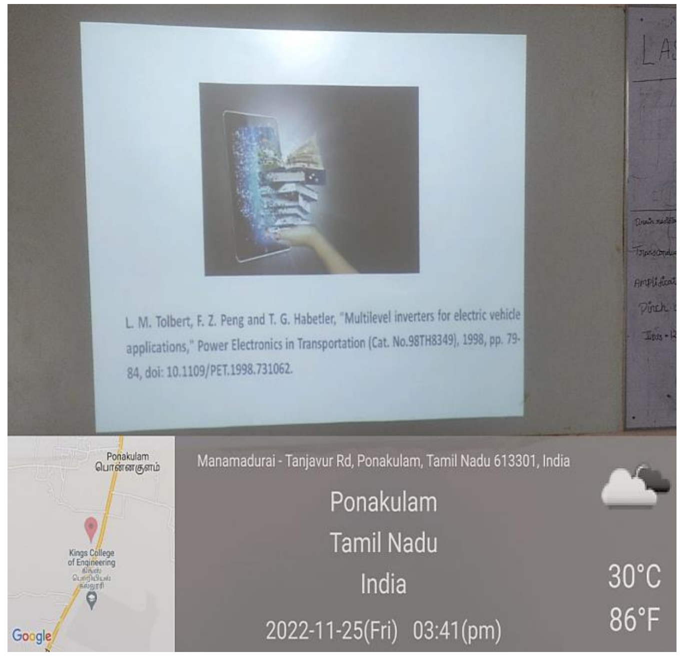

L. M. Tolbert, F. Z. Peng and T. G. Habetler, "Multilevel inverters for electric vehicle applications," Power Electronics in Transportation (Cat. No.98TH8349), 1998, pp. 79-84, doi: 10.1109/PET.1998.731062.
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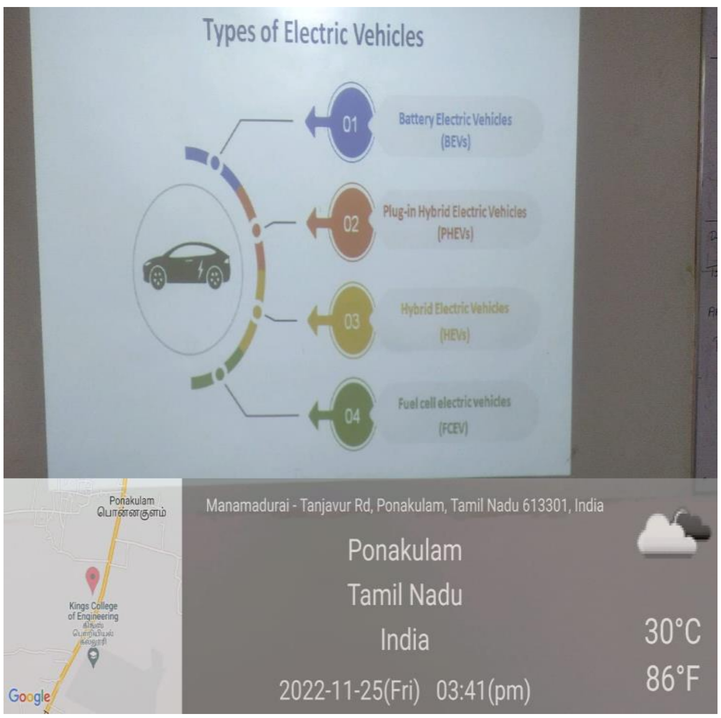

Types of Electric Vehicles
01 Battery Electric Vehicles (BEVs)
02 Plug-in Hybrid Electric Vehicles (PHEVs)
03 Hybrid Electric Vehicles (HEVs)
04 Fuel cell electric vehicles (FCEV)
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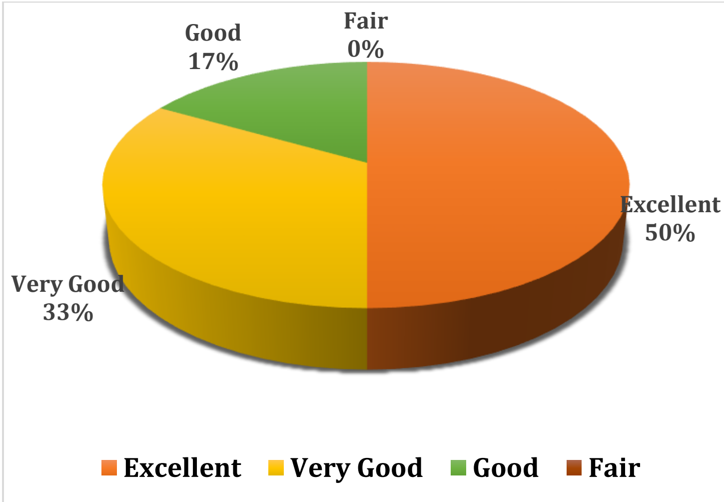
**Feedback Analysis:**




**References:**


1. P. Omer, J. Kumar, and B. S. Surjan, ``A review on reduced switch count multilevel inverter topologies,'' IEEE Access, vol. 8, pp. 22281_22302, 2020.
2. C. Dhanamjayulu, S. R. Khasim, S. Padmanaban, G. Arunkumar, J. B. Holm-Nielsen, and F. Blaabjerg, ``Design and implementation of multilevel inverters for fuel cell energy conversion system,'' IEEE Access, vol. 8, pp. 183690_183707, 2020, doi: 10.1109/ACCESS.2020.3029153.
3. C. Dhanamjayulu and S. Meikandasivam, ``Implementation and comparison of symmetric and asymmetric multilevel inverters for dynamic loads,''IEEE Access, vol. 6, pp. 738_746, 2018.
4. C. Dhanamjayulu and S. Meikandasivam, ``Performance verification of symmetric hybridized cascaded multilevel inverter with reduced number of switches,'' in Proc. Innov. Power Adv. Comput. Technol. (i-PACT), Vellore, India, Apr. 2017, pp. 1_5.
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8. A. P. Patel, V. J. Rupapara, and A. R. Gauswami, ``Design and simulation of 9-level hybrid cascaded H-bridge multilevel inverter with reduced components,'' in Proc. Int. Conf. Current Trends Towards Converging Technol.(ICCTCT), Coimbatore, India, Mar. 2018, pp. 1_7.


**Faculty In-Charge** **HOD/EEE** **Principal**

## Slides

**MULTILEVEL INVERTERS FOR ELECTRIC VEHICLE APPLICATIONS**


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**AP/EEE,**
**Kings College of Engineering, Punalkulam.**



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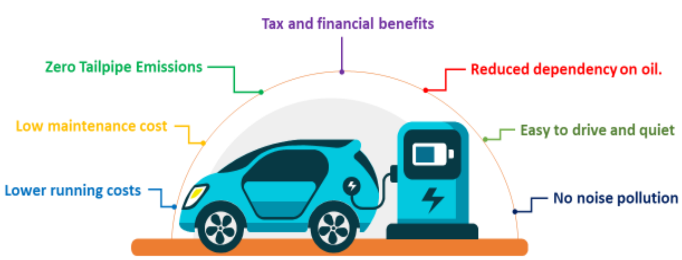
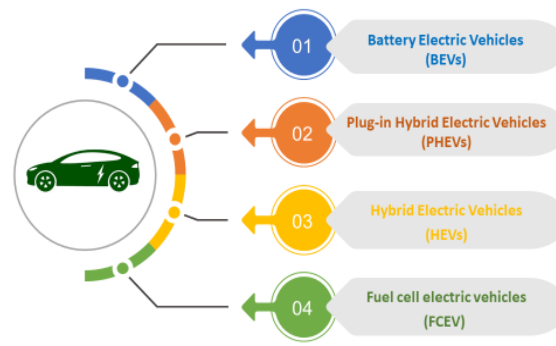
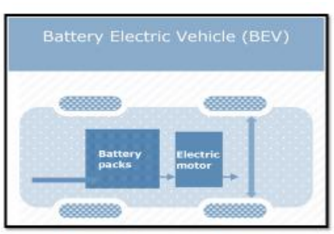
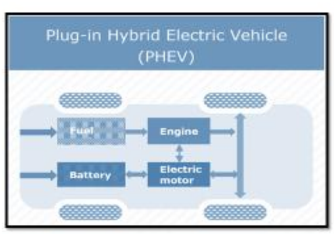
### Why we need electric vehicles?

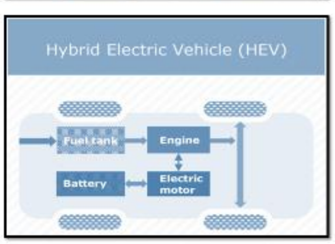


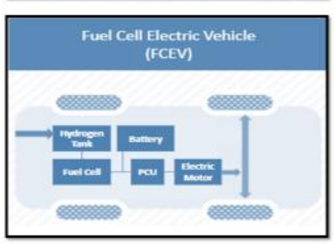

### Types of Electric Vehicles



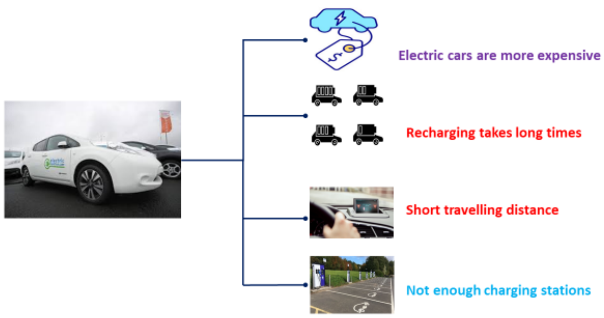



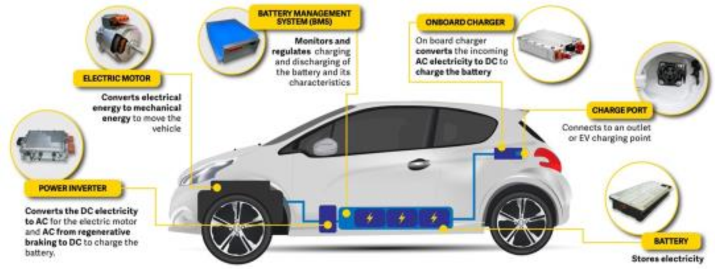

### Comparison of BEV, HEV, and FCEV

| Types of EVs | BEV | HEV | FCEV |
|---|---|---|---|
| Propulsion | • Electric motor drives | • Electric motor drives<br>• ICE | • Electric motor drives |
| Energy System | • Battery<br>• Ultracapacitor | • Battery<br>• Ultracapacitor<br>• ICE generating unit | • Fuel cells |
| Energy Source and Infrastructure | • Electric grid charging facilities | • Gasoline stations<br>• Electric grid charging facilities (optional for plug-in hybrid) | • Hydrogen<br>• Methanol or gasoline<br>• ethanol |
| Characteristics | • Zero emission<br>• Independence on fossil oil<br>• Commercially available | • Low emission<br>• Higher fuel economy<br>• Commercially available | • Zero emission Independence on fossil oil<br>• High energy efficiency<br>• Under development (future trend) |
| Major Issues | • Limitation of battery<br>• Short range(100-200km)<br>• Charging facilities | • Dependence on fossil fuel<br>• complex | • High fuel cell cost<br>• Lack of infrastructure |

## Disadvantages of Electric Vehicle




## Major Components of Electric Vehicle

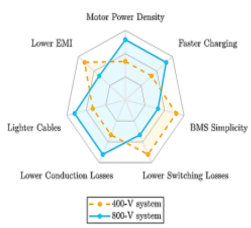



## Higher DC-Link Voltage

### Battery Voltage of some EVs on the market

| Vehicle | First Production Year | Battery Voltage (V) |
|---|---|---|
| Nissan Leaf | 2010 | 350 |
| Tesla Model S | 2012 | 350 |
| Chevrolet Spark EV | 2013 | 400 |
| Audi e-tron | 2018 | 400 |
| Porsche Taycan | 2019 | 800 |
| Lucid Air | 2020 | 900 |

### Advantages and drawbacks of increasing DC-link voltage

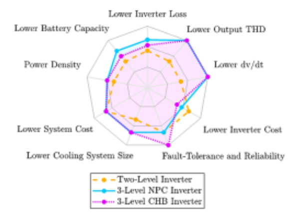



## Multilevel Inverter

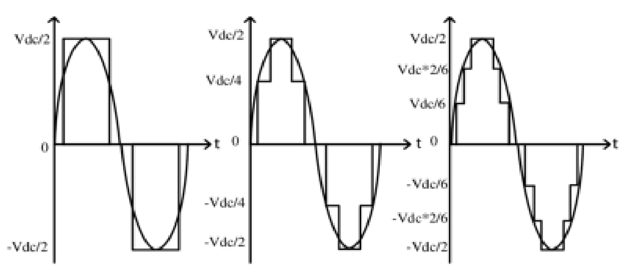
### Traction Inverter's Structure on the Market

| Application | DC Voltage (V) | Structure | Switching Devices |
|---|---|---|---|
| Electric Ships | 1.5kV to 15kV | Two-level or Multilevel | GTO ,Thyristor or IGBT |
| Trains and Tramways | Up to 3kV | Two-level or Three -level | GTO ,Thyristor or IGBT |
| Buses, Trucks | Up to 900V | Two-level | IGBT , MOSFET |
| Passenger EVs | Up to 900V | Two-level | IGBT , MOSFET |

### Comparison of different criteria in conventional two-level, three-level NPC and three-level CHB inverters




## Comparison of Output Voltage Waveform




## Comparison of various MLI topologies