



NSS Enriching Knowledge Series of the Physics Curriculum

# The Design, Development and Future of Electric Vehicle

**Prof. Eric Cheng**

Power Electronic Research Centre  
Department of Electrical Engineering  
The Hong Kong Polytechnic University

<http://perc.polyu.edu.hk>

.....Power the future



## Director of the Power Electronics Research Centre



Prof. Eric Cheng  
郑家伟教授

**The centre:**

- 14 academic staff members
- Formed by Dept. of EE and EIE
- Founded in Nov 2000

**Areas:**

Power conditioning  
Motor and drives  
Energy storage  
power electronics  
High frequency power conversion  
Alternative energy  
Electric vehicle and transportation

<http://perc.polyu.edu.hk>

.....Power the future



# Electric vehicle – Design and working principle of “MyCar”

## Content

- The advantage of electric vehicle
- The concept of electric vehicle
- Hybrid Electric vehicle
- The design of MyCar



# Introduction

## The advantage of electric vehicle



## Present Vehicle

- Emission – unfavourable gases
- Produce emission in city centre
- No power regeneration
- Idle speed
- Consume power when stand still
- Generate unnecessary heat
- Noise pollution



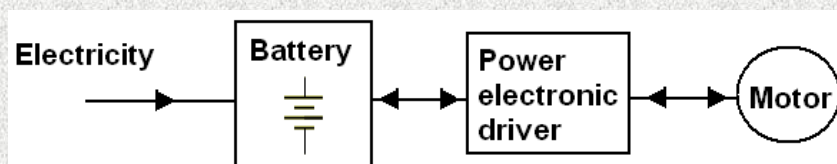
## Present vehicle

- Use mechanical interfacing such as
  - Gear box
  - Transmission
  - Hydraulic
- Reliability
- Life time – mechanical wearing



## Advantage of Electric Vehicle

- Zero emission
- Power Regeneration
- Low noise pollution
- Instant start and direct drive



## Electricity of EV

- Still consume electricity i.e. fuel. Is it environmentally friendly?
- The electricity sources
  - Power station (move power generation to power plant)
  - Alternative energy:
    - Wind
    - Solar
- Provide energy storage



## Early Design: Nissan Activities

New prototype EVs using lithium-ion batteries

**Two-passenger "Hypermini": just over 8 feet (2.5 meters) long; 62 mph, 81-mile range**

- Hypermini already designed to meet European, Japanese and North American safety standards
- Designed Feb 2000

<http://perc.polyu.edu.hk>

.....Power the future

Hypermini EV



## Electric Vehicles on the Road

GM EV1

GM EV1

Ford Ranger EV

Chrysler EPIC

Toyota RAV4 EV

Honda EV+

Nissan Altra

Nissan FEVII

PIVCO City Bee

Mercedez Benz  
Samrt

<http://perc.polyu.edu.hk>

.....Power the future



## Other EVs

- Electric bicycle
- Light rail
- Cable car
- Train
- Electric moped

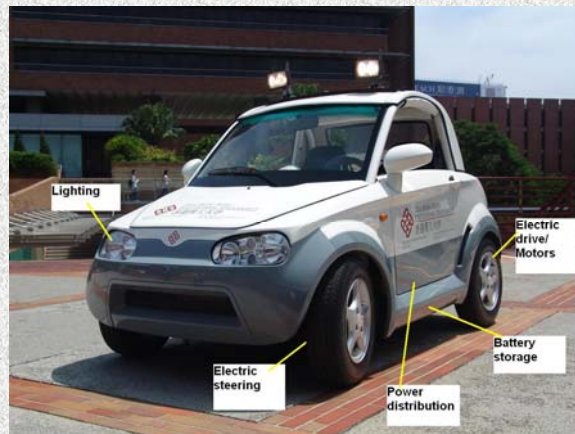


<http://perc.polyu.edu.hk>

.....Power the future



## Principle and components of EV

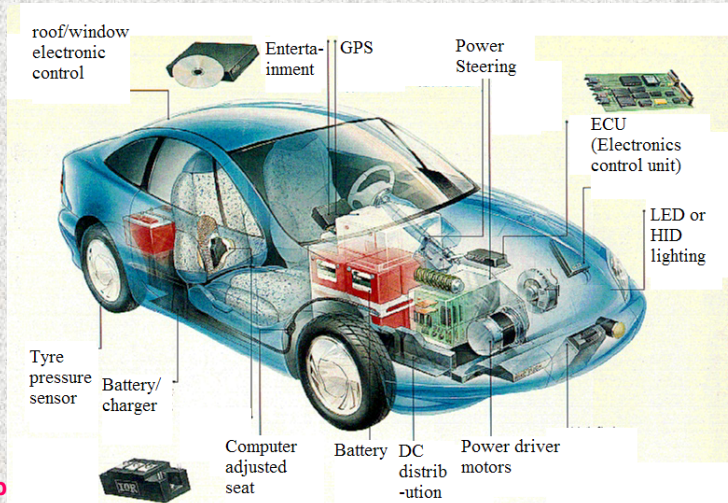


<http://perc.polyu.edu.hk>

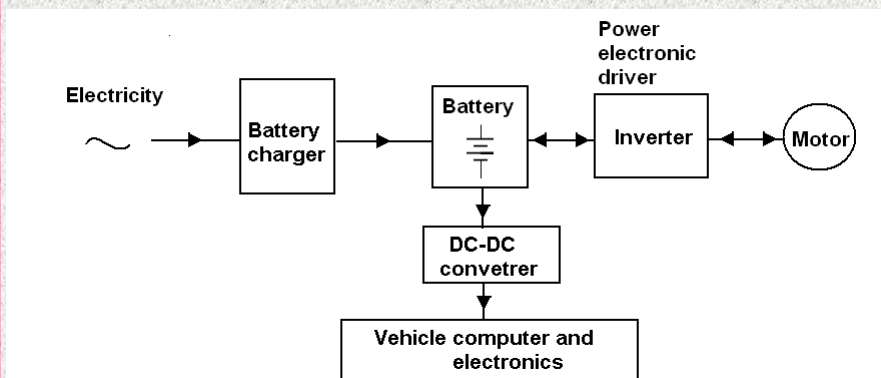
.....Power the future



# Electronic control



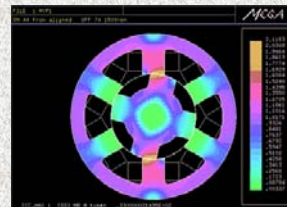
# The components





# Motors

- DC motors
- Induction motor
- DC brushless motor
- Permanent magnetic synchronous motors
- Switched reluctance motor



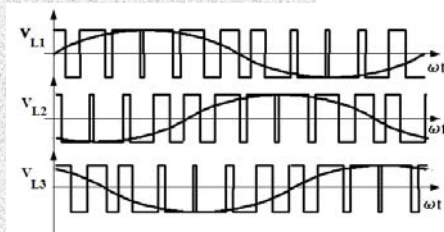
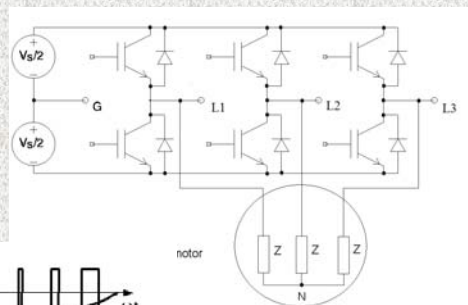
<http://perc.polyu.edu.hk>

.....Power the future



# Motor driver

- Use Inverter to drive the motor
- Use IGBT or Mosfet
- Provide PWM for driving



<http://perc.polyu.edu.hk>

.....Power the future





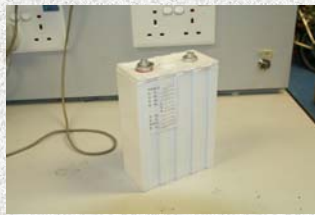
## Battery



Lead-Acid



NiMH



Li-ion



Li-ion

<http://perc.polyu.edu.hk>

Power the future



## Comments on EV

- Battery Electric Vehicle offer quiet, pollution-free operation
- Far cleaner than gasoline-powered vehicle
- However, EV is not pollution-free, it produces indirect environmental impact. The electricity generation is from power generation.
- However, it can be produced from alternative energy source.
- Require an infrastructure of battery management
- Range limited – improvement in battery, electric motor and power conversion

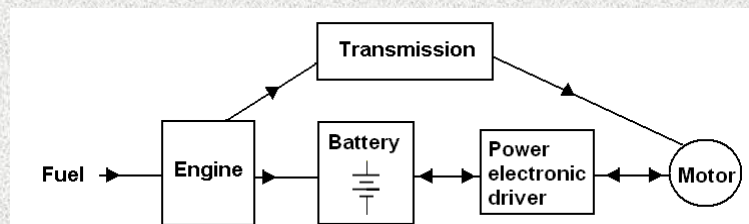
<http://perc.polyu.edu.hk>

.....Power the future



## What is Hybrid electric vehicle

- Hybrid electric vehicles (HEVs) combine the internal combustion engine (ICE) of a conventional vehicle with the battery and electric motor of an electric vehicle.



<http://perc.polyu.edu.hk>

.....Power the future



## Hybrid Vehicle Component Efficiencies

- Powered by fuel
- Fuel change to electricity and then to motor power
- Perfect condition: 424 mpg
- For high efficiency: 140mpg
- Efficiency without regenerative braking : 70mpg

<http://perc.polyu.edu.hk>

.....Power the future



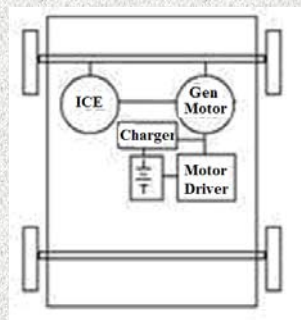
## Hybrid Electric vehicle

- Has series and parallel topologies
- A high portion of commercial vehicles use parallel
- Fuel can be fossil fuel
- Can design can use alternative energy such as solar or wind.



## Parallel Configuration

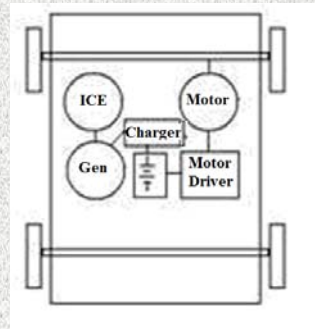
- Has a direct mechanical connection between the PU and the wheels, also has an electric motor that drives the wheels
- The vehicle has more power because both the engine and the motor supply power simultaneously.
- Most parallel vehicles do not need a separate generator because the motor regenerates the batteries.
- Because the power is directly coupled to the road, it can be more efficient.





## Series Configuration

- Power is transferred from chemical energy to mechanical energy, to electrical energy, and back to mechanical energy
- The engine never idles, which reduces vehicle emissions.
- The engine drives a generator to run at optimum performance.
- The design allows for a variety of options when mounting the engine and vehicle components.
- Some series hybrids do not need a transmission



<http://perc.polyu.edu.hk>

.....Power the future



## Sustainable Hybrid Vehicles: Here and Now?

**Toyota**

*Prius*

**HONDA**

*Insight*

*Ford  
Prodigy*

**General  
Motors  
Precept**

<http://perc.polyu.edu.hk>

.....Power the future



## Advantage of Hybrid Elect. Car

- Regenerative braking capability helps minimize energy loss and
- Engines can be sized to accommodate average load, not peak load, which reduces the engine's weight.
- Fuel efficiency is greatly increased. Emissions are greatly decreased.
- HEVs can reduce dependency on fossil fuels because they can run on alternative fuels.
- Special lightweight materials are used to reduce the overall vehicle weight of HEVs.

<http://perc.polyu.edu.hk>

.....Power the future



## Toyota Prius Hybrid

- Now selling in Japan from \$220,000
- Production 280,000 in 2008;
- Target 1 million/year by 2020

*Prius Hybrid electric*

<http://perc.polyu.edu.hk>

.....Power the future



## Power Specification Prius

|         |  |
|---------|--|
| Motor   | Permanent magnet AC synchronous motor<br>(50 kW @ 1200-1540 rpm<br>400 N·m @ 0-1200 rpm) ) |
| Battery | Sealed Nickel-Metal Hydride (Ni-MH)<br>274V, 25kW  |
| ICE     | 1.497 litres<br>70-hp at 4500rpm, Peak torque 110Nm<br>at 4200rpm                          |
| Weight  | 1300kg   |



## Toyota Selling Hybrid Buses

- Toyota has started selling hybrid Coaster bus in Japan
- 21 and 24 passenger versions
- 1500 cc gasoline engine generates power for electric drive





# APS Systems

## Hybrid Transit Bus

- Propane/electric hybrid system
- 40-foot, low-floor transit design
- 210 mile range in hybrid mode
- 40 kW rotary engine/generator, Ni-Cd batteries
- Oxnard CA

<http://perc.polyu.edu.hk>

.....Power the future



# MyCar™



<http://perc.polyu.edu.hk>

.....Power the future



## The design

- Original diesel
- Convert into electric drive
- Includes all electronics system:
  - HID/LED Lighting
  - Electric motor
  - Electric inverter/drives
  - Battery management
  - Battery charger
  - DC distribution



## Three units of MyCar developed for commercial market

- Three units of All electric vehicles developed for commercial market
- Used in MTR
- All electric including window, wiper, motor drive, auto lock, lighting, etc





## Specification

- 3.5kW motor
- Weight 500kg
- 2 seats
- Battery 48V, 200Ahr
- Range: 100km / charger



## Conclusion

- Electric vehicle – zero emission
- Use electricity from many different sources including alternative energy
- More electric vehicle can be realized
- More high performance control can be developed and integrated.



## Conclusion

- EV range per charge still limited by the battery
- Usually 100km is common. Higher range needs more intelligent and material.
- This includes: higher energy density, higher current (fast speed) battery, lighter material, higher efficiency of machines, driver and power converter



Thank you