HEV, PHEV and EV architectures

ECEN 2060
Series HEV

- Capable of realizing all HEV efficiency improvements, simplest system control
- Simple single-gear transmission
- ED2 must be sized for maximum traction power
- ICE power processed by all components in series: ED1, ED2, Transmission
• ICE and ED2 mechanically coupled to combine traction power
  \[ n_{\text{ice}} T_{\text{ice}} + n_2 T_2 = nT \]
• Reduced size ED2; in a “micro” hybrid, ED2 is a low-power starter/alternator
• One electric drive: it is not possible to have electric drive traction and battery charging at the same time
• Requires multi-gear transmission
• ICE, ED1 and ED2 mechanically coupled via a planetary gear; ICE and electric drive can combine traction power
• Capable of realizing HEV efficiency improvements
• Simple single-gear transmission
Series/parallel HEV example: Prius

Overall drive train system power rating:
82 kW (110 hp)

57 kW @ 5000 rpm

Energy storage

DC-DC

500 V

3-phase inverter/rectifier 2

50 kW PMSM

ICE

Transmission

208 V 1.3 kWh NiMH

boost

buck

500 V

3-phase inverter/rectifier 1

25 kW PMSM

ED1

ED2

25 kW PMSM

Electric motor/generator 2

112

Electric motor/generator 1

Wheels (radius \( r_v \))

Mechanical coupling (planetary gear)

n = \( n_2 = 1.4n_{ice} - 0.4n_1 \)

nT = \( nT_2 + n_{ice}T_{ice} + n_1T_1 \)

Planetary gear ("power split device (PSD)") animation: http://eahart.com/flash/PSDAnim.swf
Series/parallel HEV example: Prius

Power electronics
(2 inverters and a boost DC-DC)

HEV drive train

Generator 1
Power split device
Motor 2

Engine
Reduction gear
Drive shaft
Plug-in EV’s

Plug-in HEVs and EVs:

- Recharge batteries from the electric power grid: shift some of transportation energy from oil to electricity (however, recall: in the US, 50% of electricity is currently generated by coal powered plants)
- Extended all-electric drive range requires (much) larger batteries
- Vehicle-to-grid (V2G) concept: use plug-in HEVs and EVs as distributed energy storage for the electric utility