

# EE 238

## Power Engineering - II

### Power Electronics



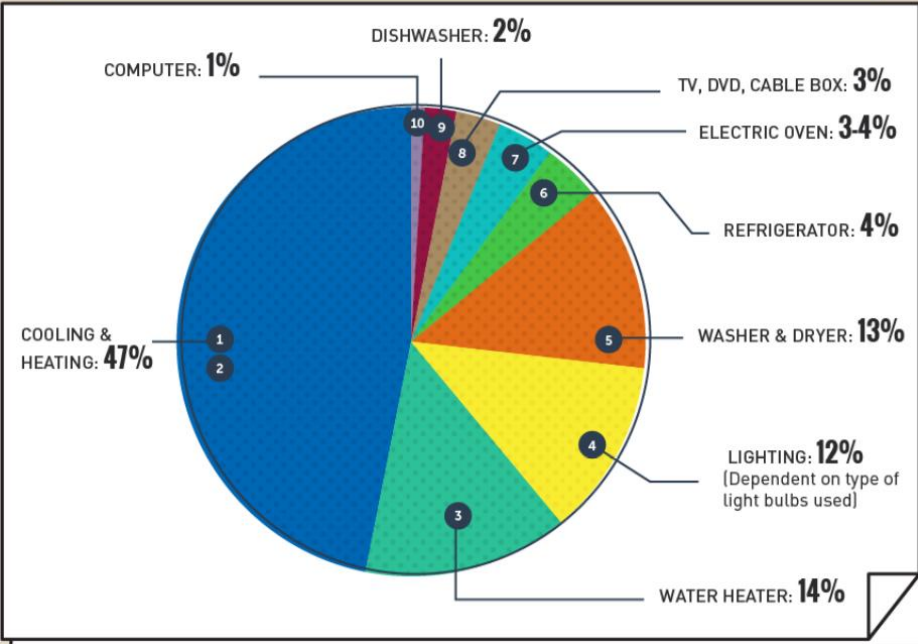
## Lecture 1

Instructor: Prof. Anshuman Shukla

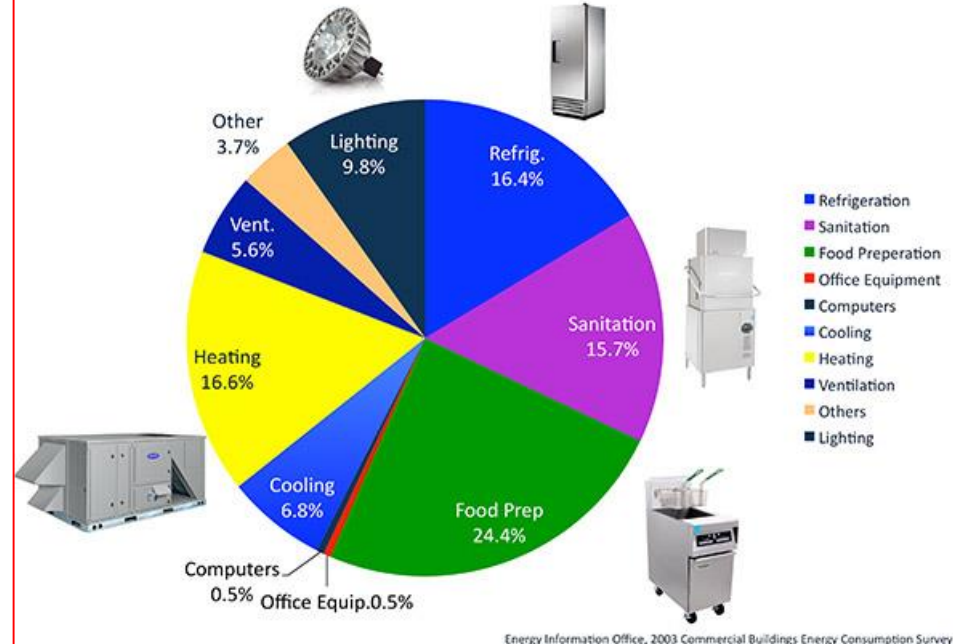
Email: [ashukla@ee.iitb.ac.in](mailto:ashukla@ee.iitb.ac.in)

# Energy Consumption

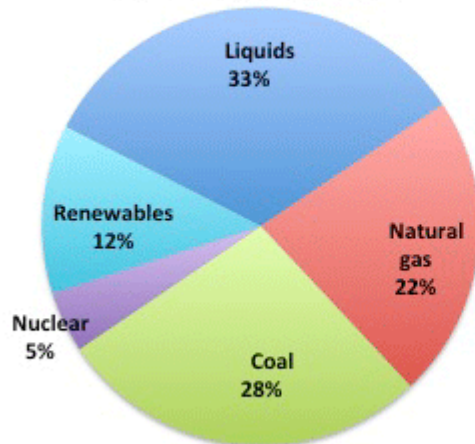
## TOP TEN ENERGY USERS IN YOUR HOME:



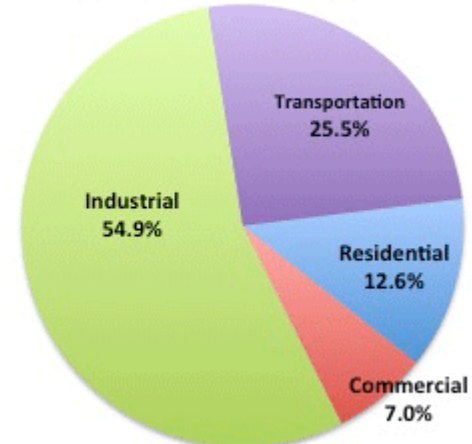
## Restaurant Energy Use



**(A)** Global energy consumption by fuel type  
(576 quadrillion Btu, 2015)



**(B)** Global energy delivered by sector  
(433 quadrillion Btu, 2015)



# Power Electronics: Why?

Our 21<sup>st</sup> century lives rely on electronics



Without it, our day-to-day lives are completely different



Electronics require power to operate



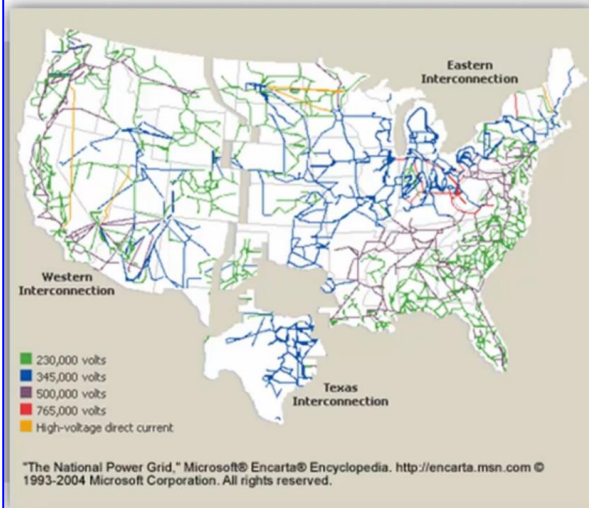
Power is the product of voltage times current and is measured in Watts

$$\text{Power} = \text{Voltage} \cdot \text{Current}$$

Energy is the product of power times time and is commonly measured in Watt-Hours (Wh) or Kilo-Watt-Hours (kWh)

$$\text{Energy} = \text{Power} \cdot \text{Time}$$

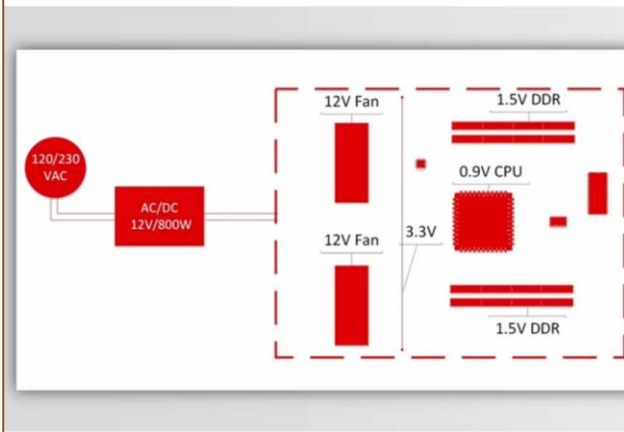
# Power Distribution, Macro-Level



<http://energy.gov/articles/top-9-things-you-didnt-know-about-americas-power-grid>

- Electricity moves across the grid at voltages  $>230,000\text{Vac}$
- Most loads operate at voltages much less than  $230\text{kVac}$ 
  - Voltage must be converted

# Power Distribution, Micro-Level

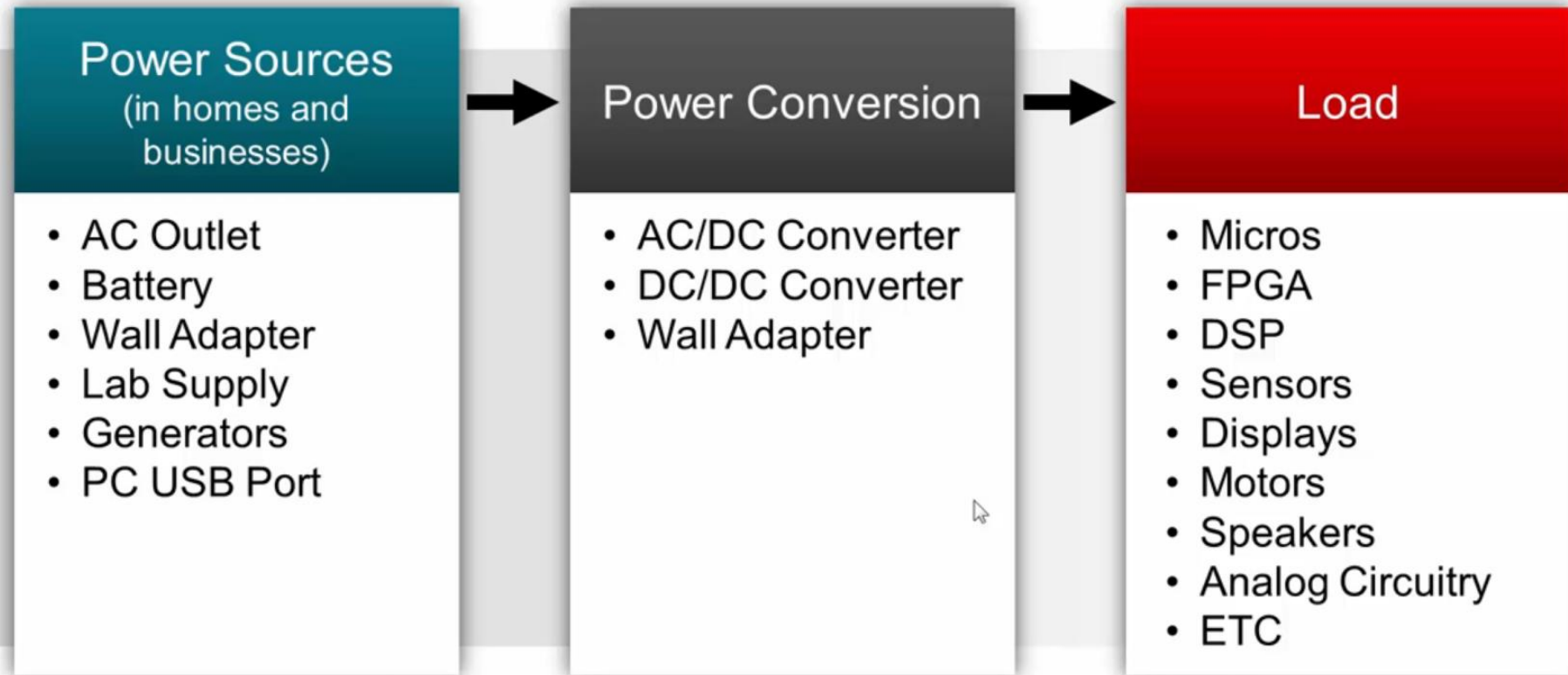


- Due to the high number of unique voltage rails, an intermediate-bus architecture is commonly used – similar to the US Power Grid
  - 12Vdc is distributed throughout a server motherboard
- Voltage is converted from 12Vdc to 1.5Vdc, 0.9Vdc, 3.3Vdc, etc. at the loads
  - Commonly referred to “Point of Load” conversion

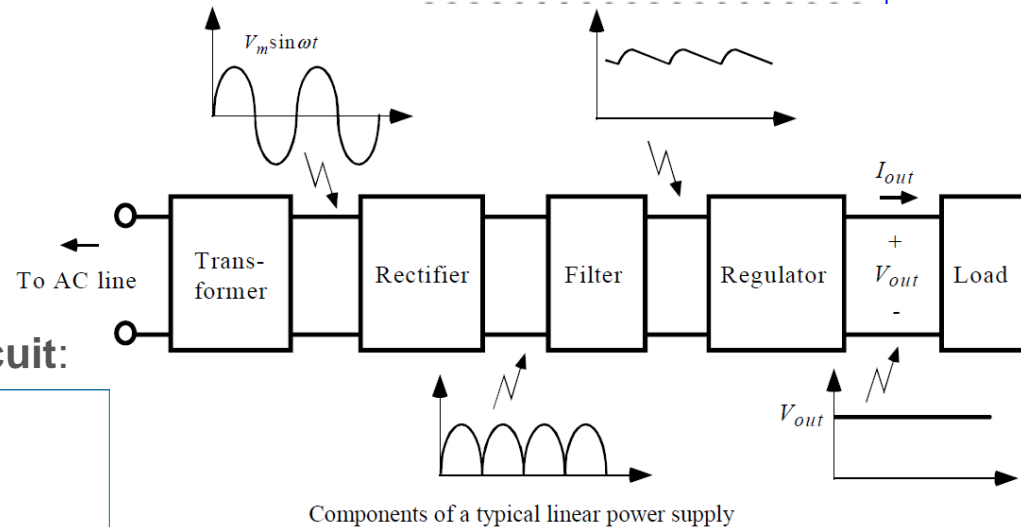
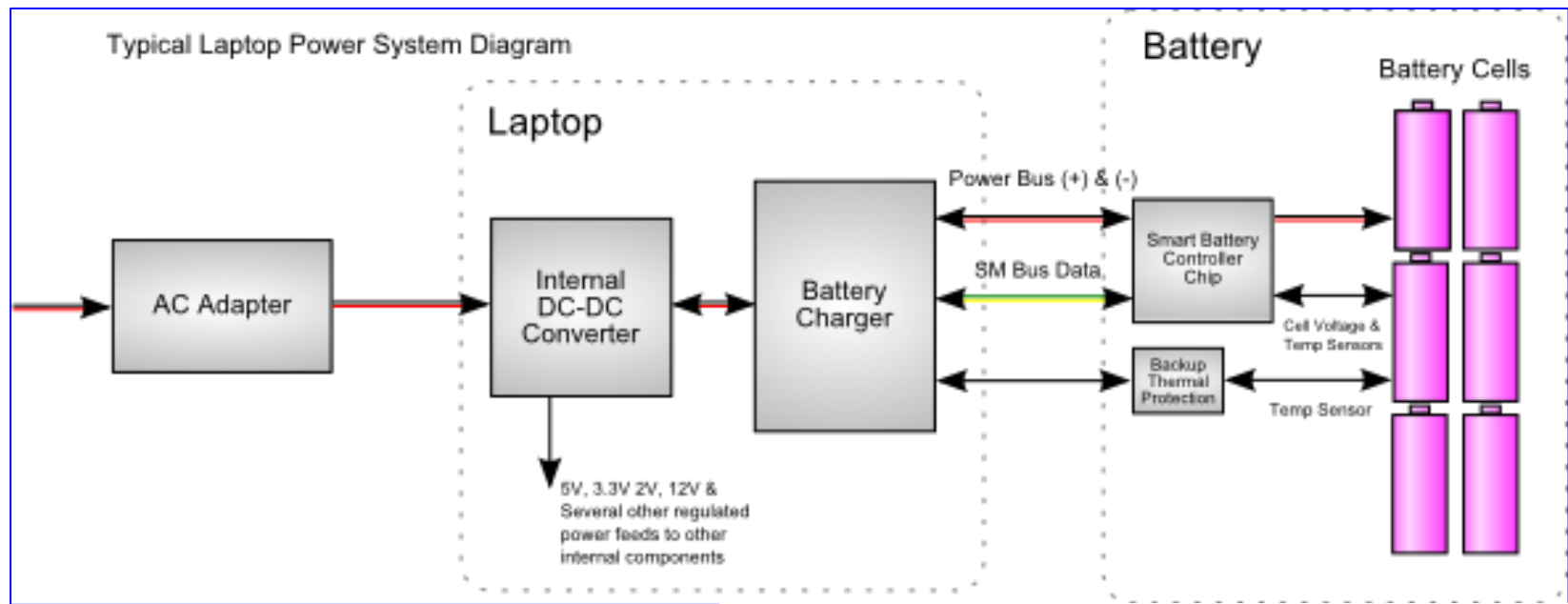
***Power Electronics is the electronics applied to conversion and control of electric power.***

**Range of power scale : milliwatts(mW) → megawatts(MW) → gigawatts(GW)**

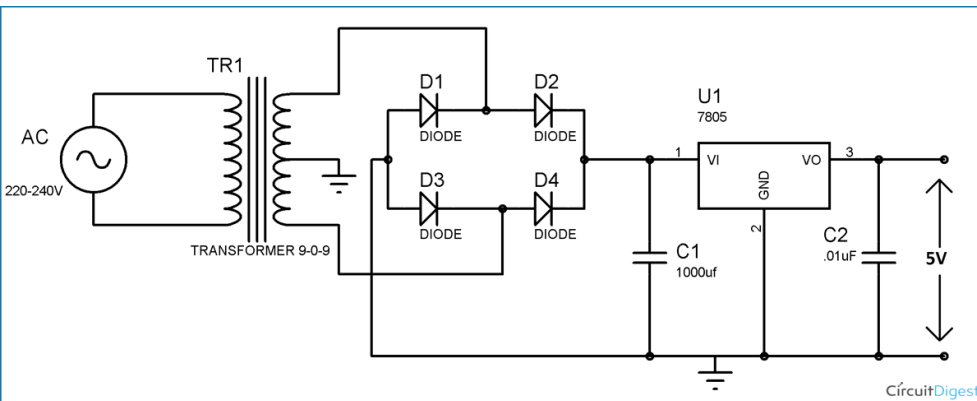
# Power Overview

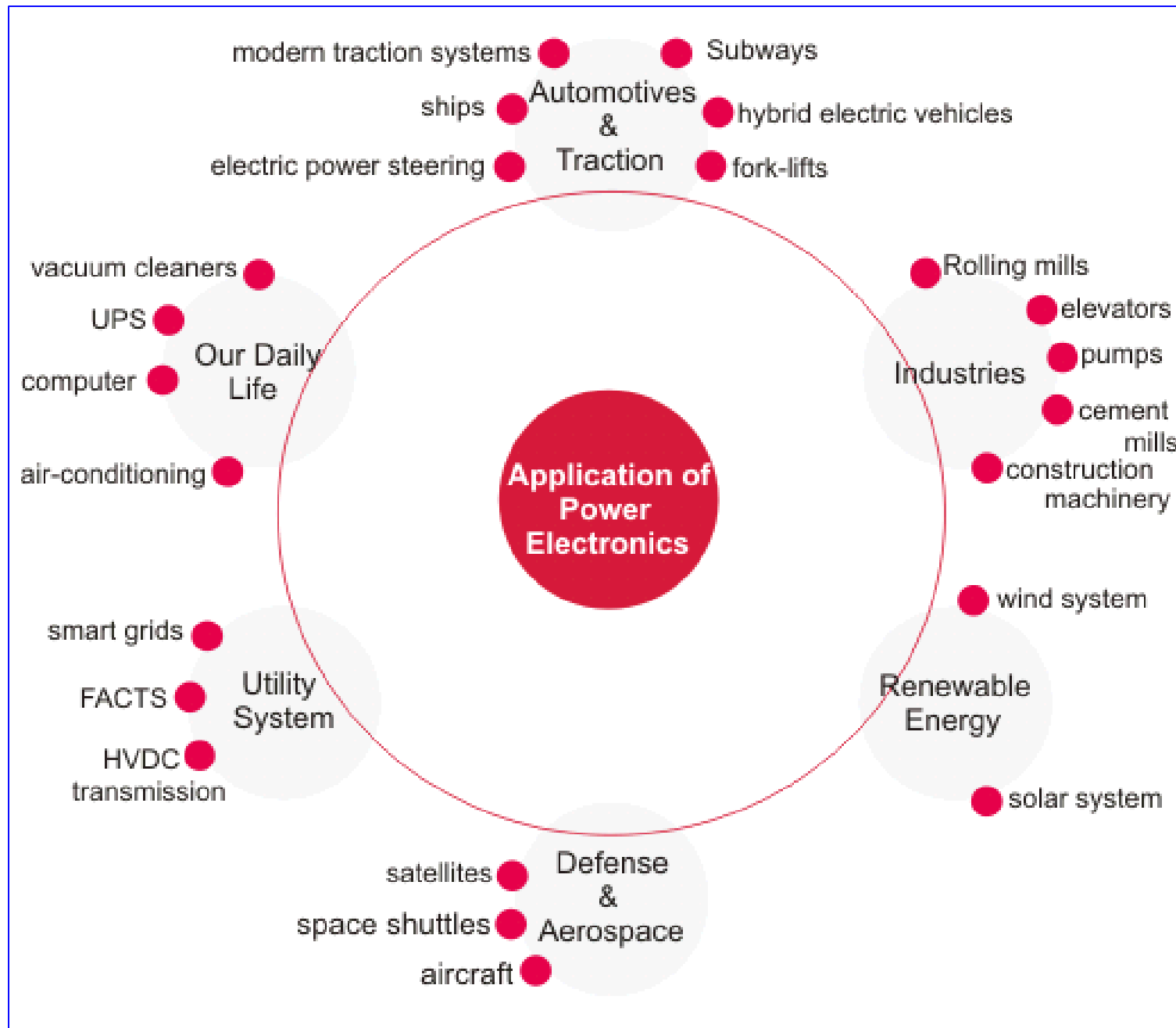






**Circuit diagram for cell phone charger circuit:**

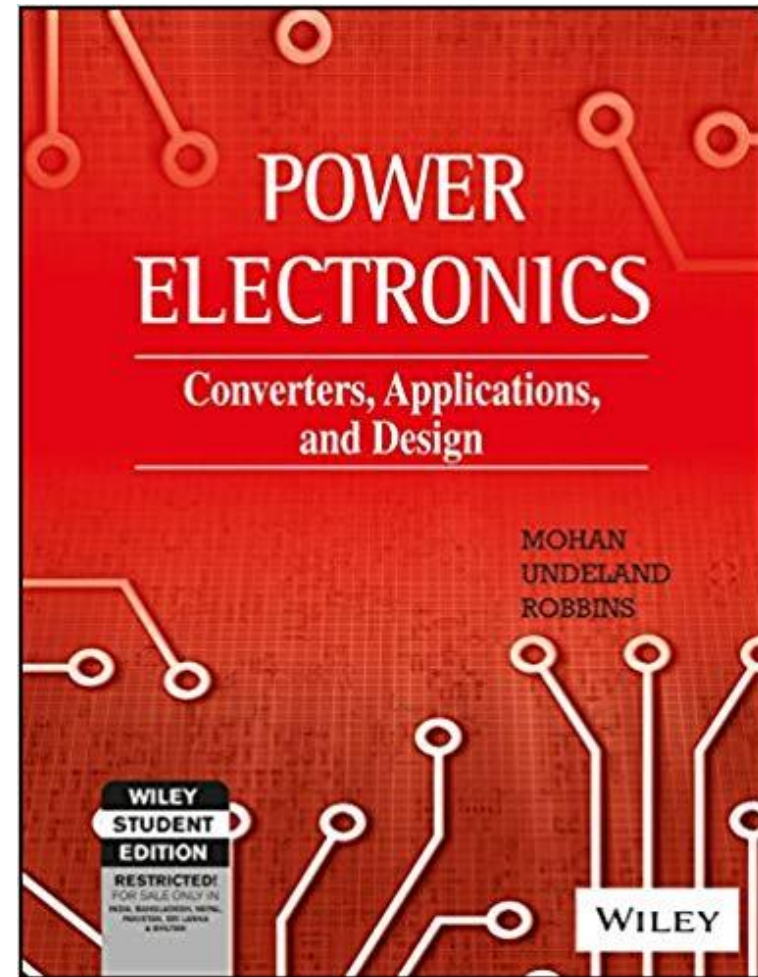




# Books for Reference

*The required textbook is*

[1] N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design, 3rd ed. Hoboken, NJ: John Wiley & Sons, 2003, 824 pp.



*The following are useful references for power electronics.*

[2] M. H. Rashid, Ed., Power Electronics Handbook: Devices, Circuits, and Applications, 3rd ed. Burlington, MA: Elsevier, 2011, 1417 pp.

[3] R. W. Erickson and D. Maksimović, Fundamentals of Power Electronics, 2nd ed. New York, NY: Springer, 2001, 912 pp.



# Definition of Power Electronics

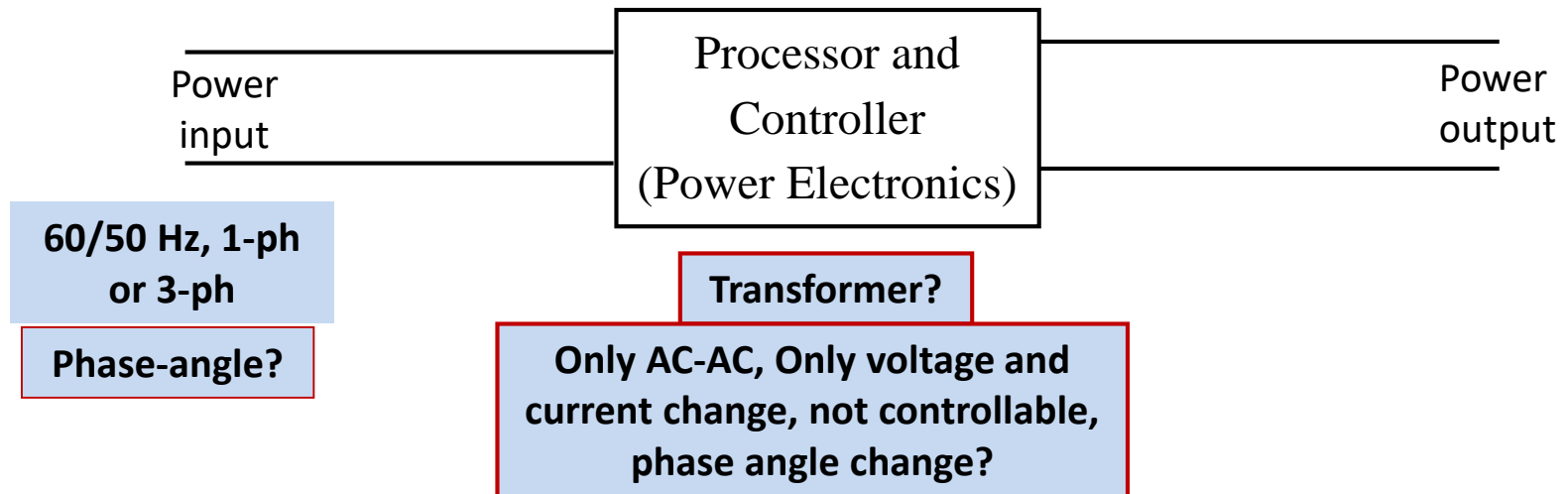
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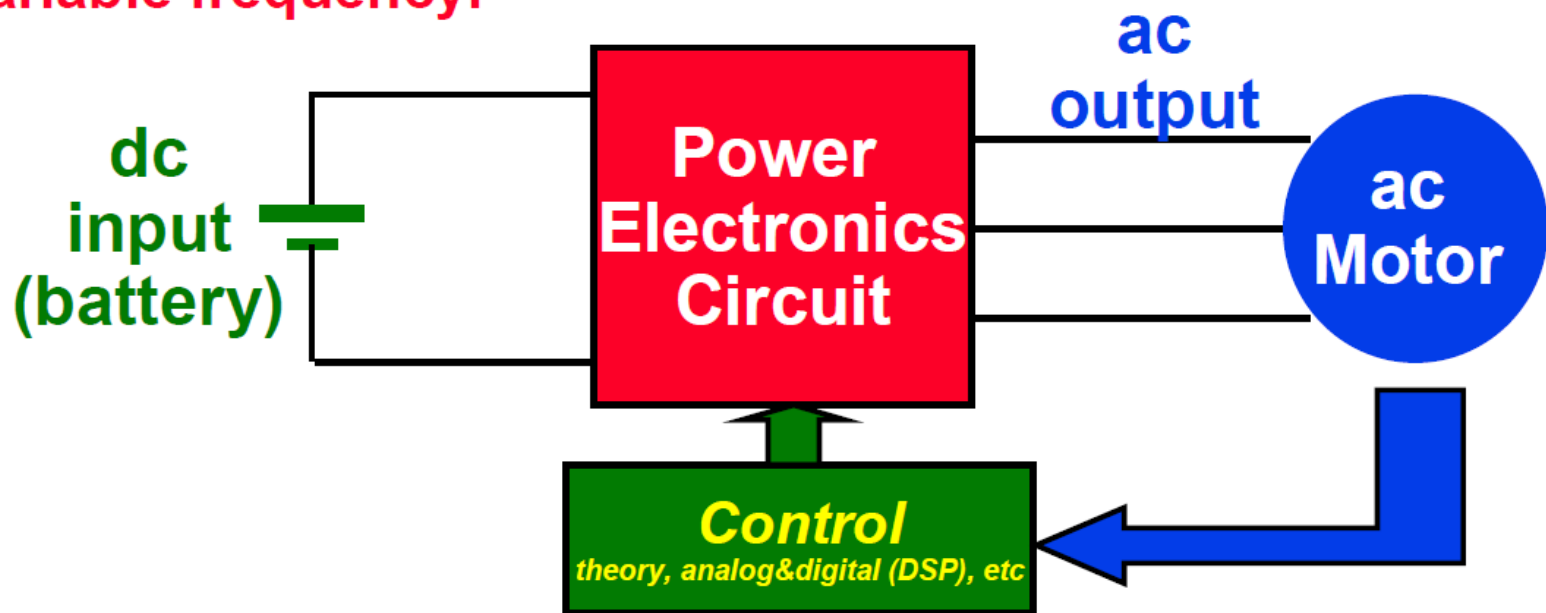
A more exact explanation:

To convert, i.e. to *process* and *control* the flow of electric power by supplying voltages and currents in a form that is optimally suited for *user loads*.



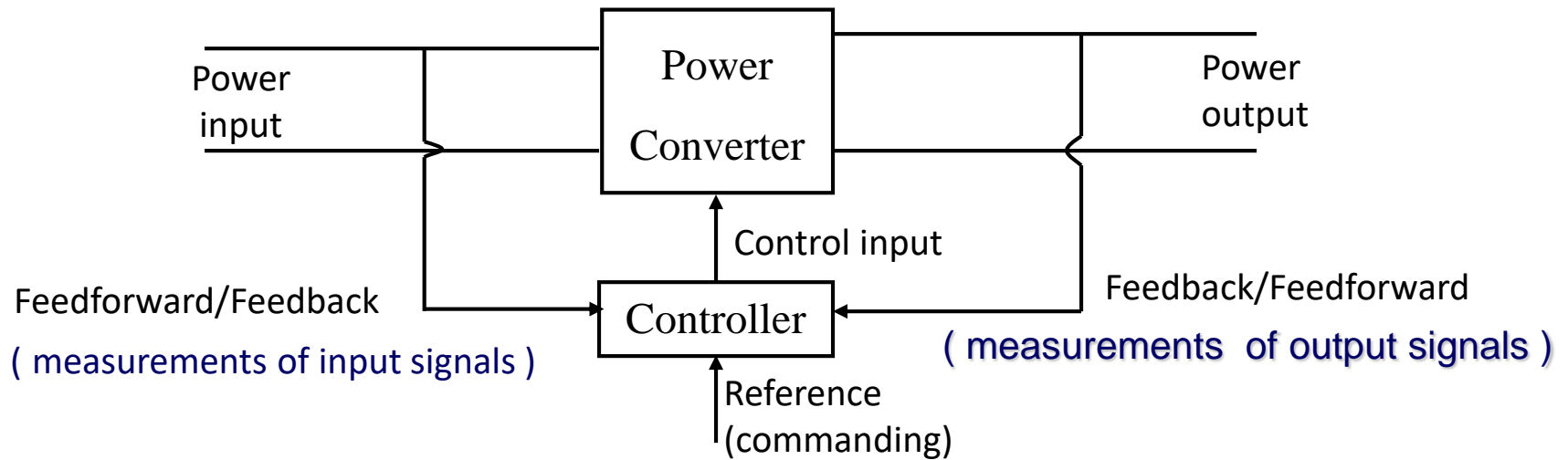
## Definition of Power Electronics

Power Electronics is power conversion and control from one form of power (energy) source to a desired form by using electronic means. **Example: An electric vehicle drive must convert dc input to ac output that has variable voltage and variable frequency.**



➤ Power electronics is power processing circuits and control

# Generic structure of a power electronic system

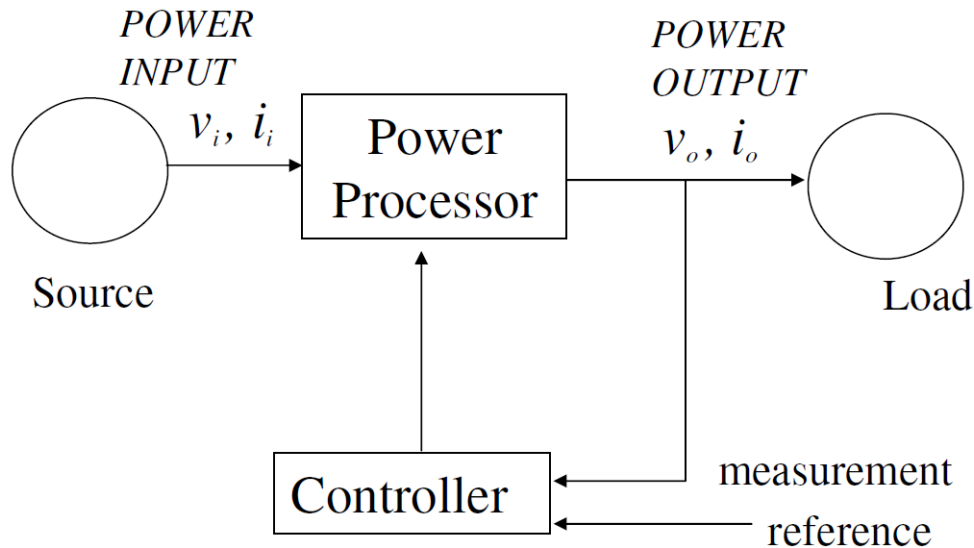


- **Building Blocks:**
  - Input Power, Output Power
  - Power Processor
  - Controller

**The processed output (voltage, current, frequency and the number of phases) is as desired by the load.**

**The power flow may be reversible, thus the input and output may be interchangeable.**

# Power Electronics

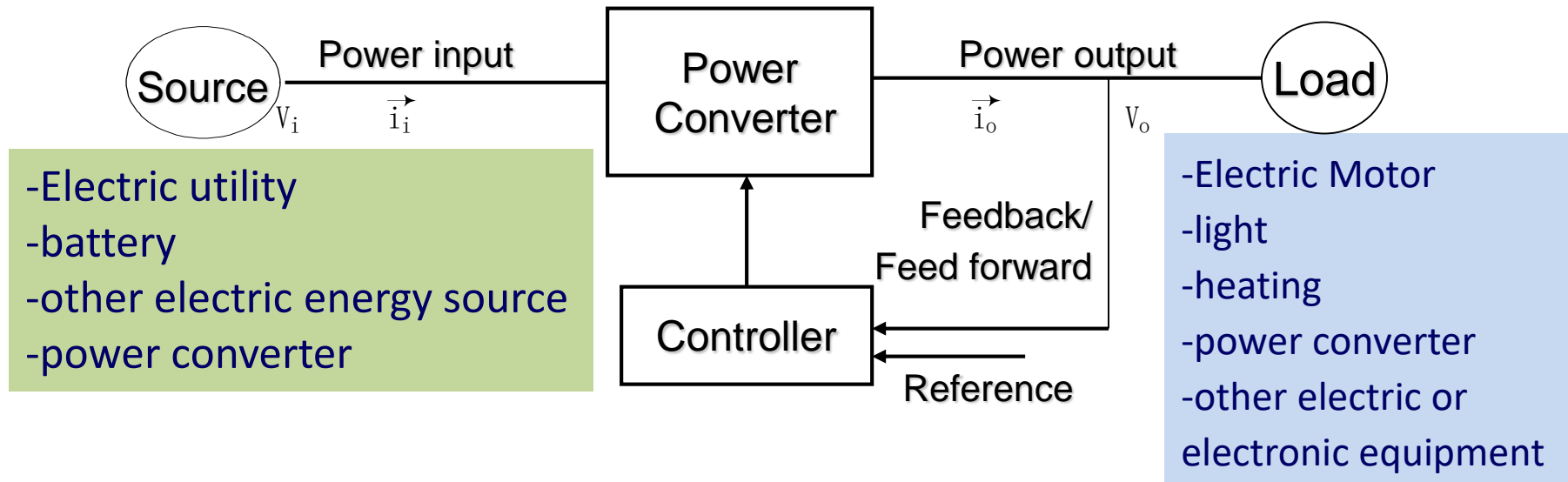


**The controller consists of linear integrated circuits and/or digital signal processors.**



**Lately, there have been significant improvement in the voltage and current handling capabilities and the switching speeds of power semiconductor devices, which make up the power processor unit.**

# Typical power sources and loads for a power electronic system



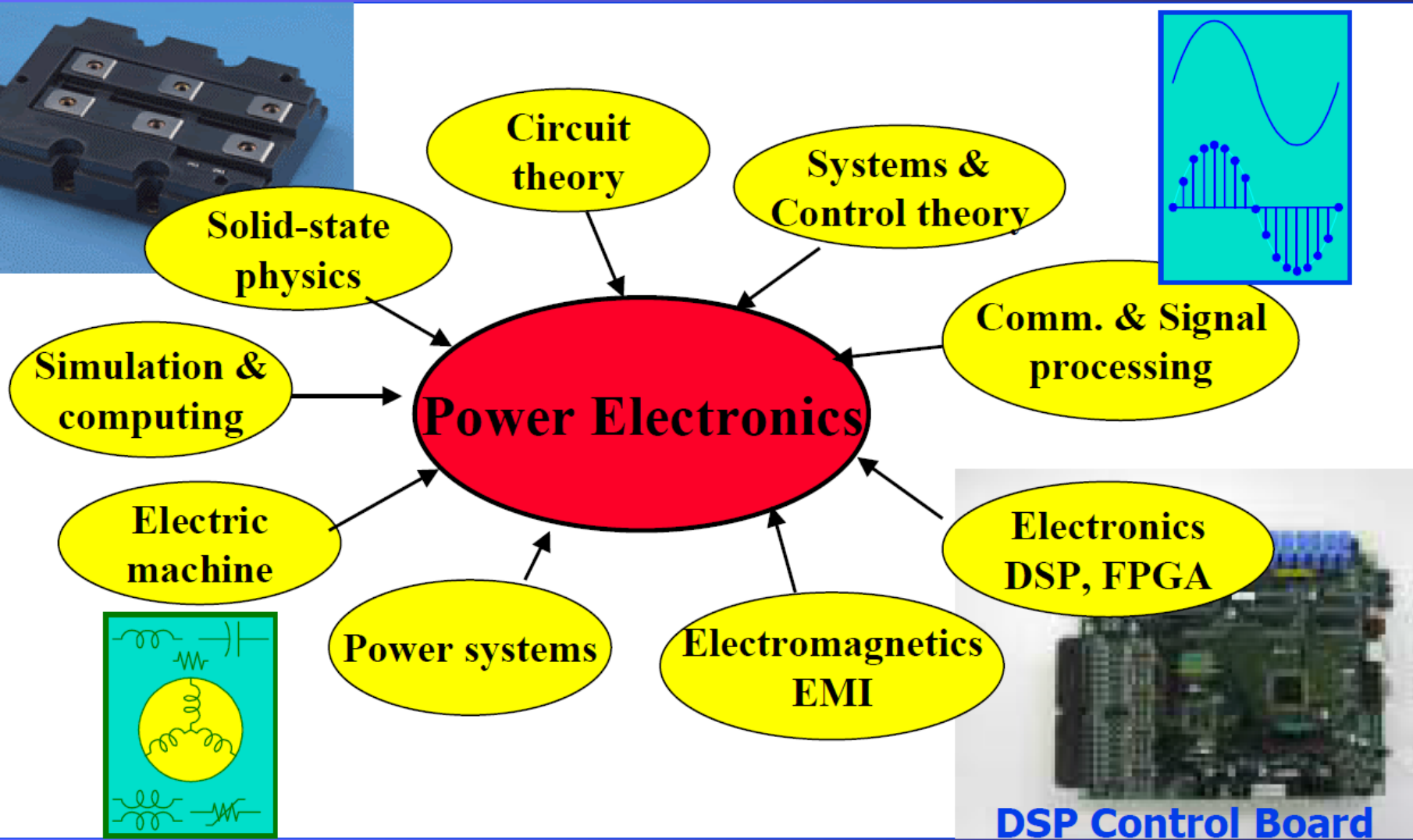
The task of power electronics has been recently extended to also ensuring the currents and power consumed by power converters and loads to meet the requirement of electric energy sources.

The main aims in modern PE systems are to convert electrical energy from one form to another, i.e. from the source to load with:

- highest efficiency,
- highest availability
- highest reliability
- lowest cost,
- smallest size
- least weight.



# Multi-disciplinary Nature of Power Electronics



Power electronics is currently the most active discipline in electric power engineering worldwide.

- **Static applications**

- involves non-rotating or moving mechanical components.

- Examples:

- DC Power supply, Un-interruptible power supply, Power generation and transmission (HVDC), Electroplating, Welding, Heating, Cooling, Electronic ballast

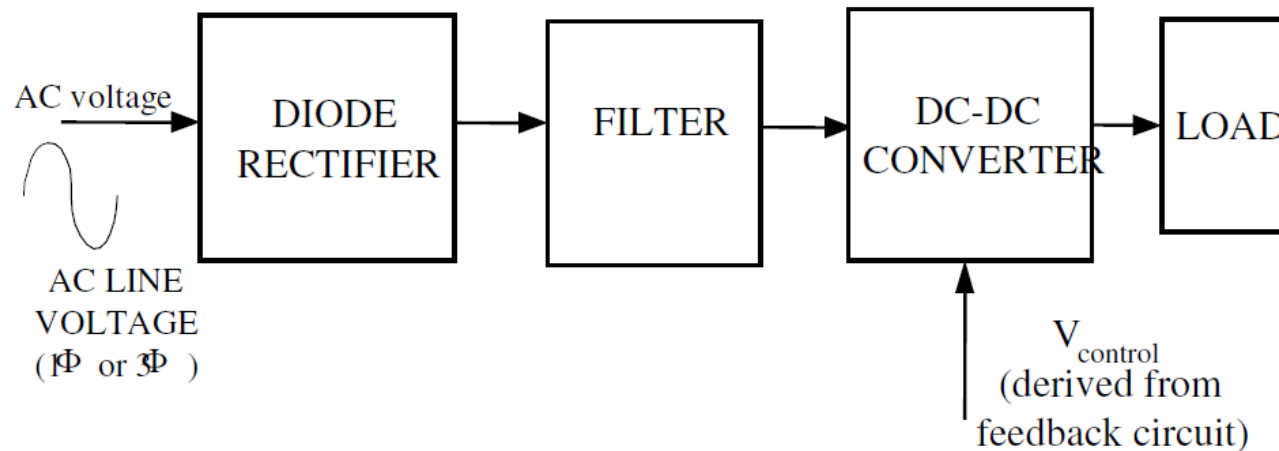
- **Drive applications**

- contains moving or rotating components such as motors.

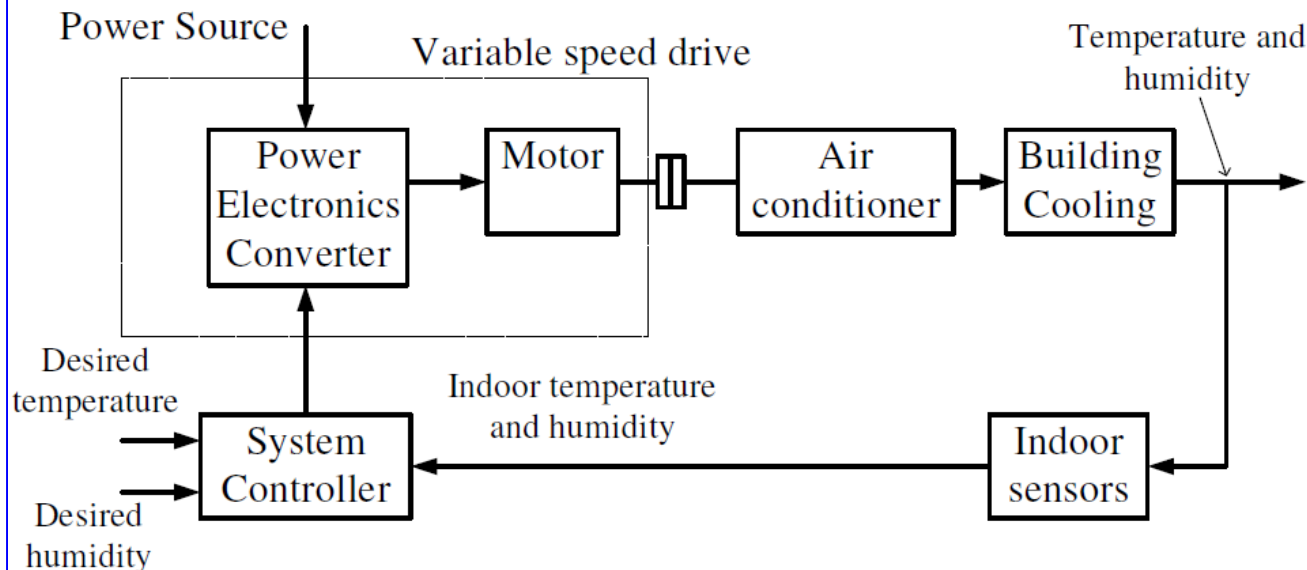
- Examples:

- Electric trains, Electric vehicles, Airconditioning System, Pumps, Compressor, Conveyer Belt (Factory automation).

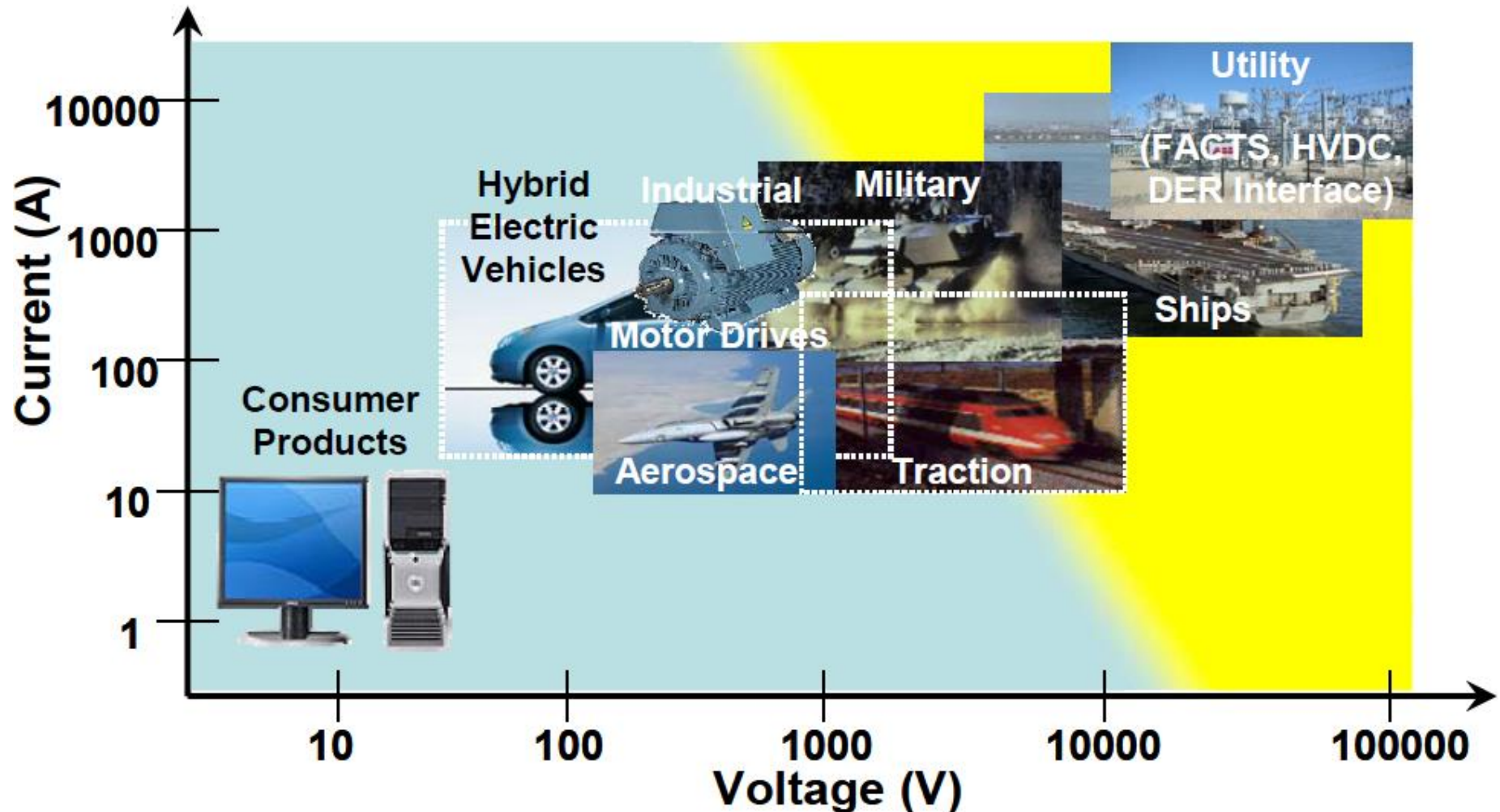
## Static Application: DC Power Supply



## Drive Application: Air-Conditioning System



# Voltage and current rating for different power electronics application areas



The yellow shading indicates that the combined voltage and current ratings exceed those of today's power electronics technology and that several devices must be combined in series or parallel in order to achieve the required application rating for many high-power utility applications.