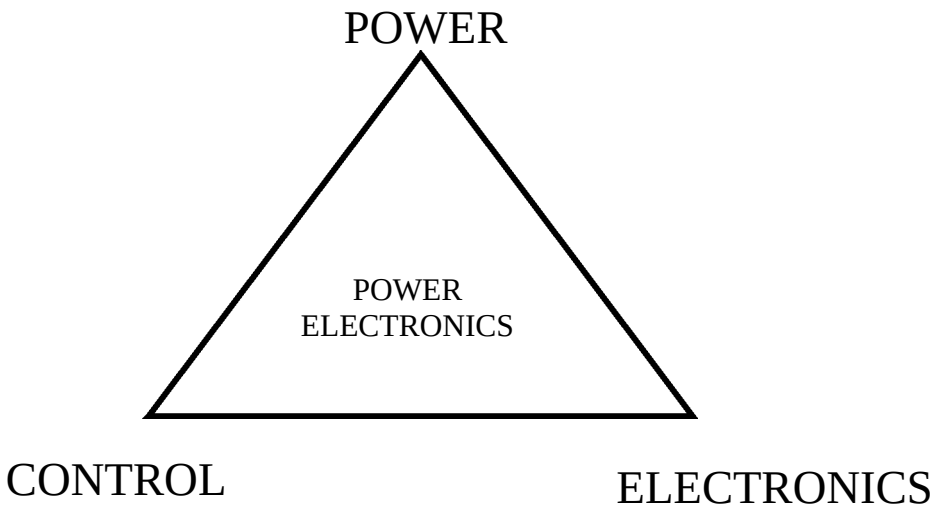
# What is Power Electronics?

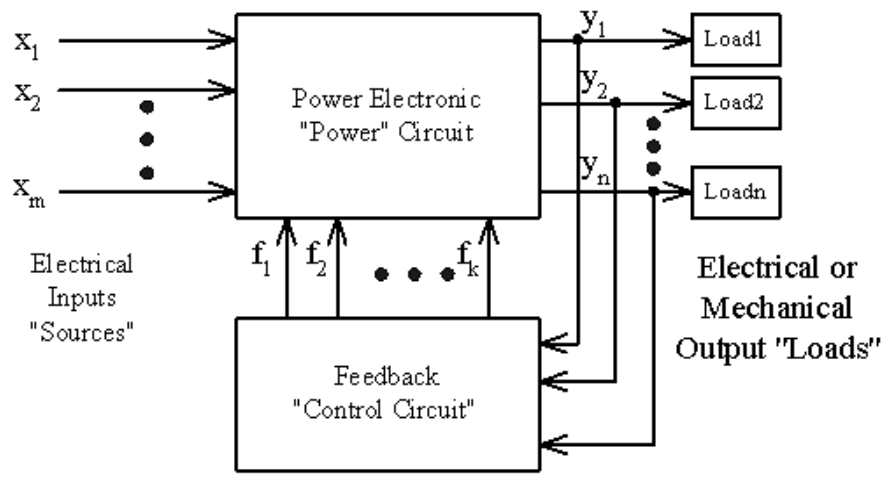
- **Electronics:** Solid State Electronics Devices and their Driving Circuits.
- **Power:** Static and Dynamic Requirements for Generation, Conversion and Transmission of Power.
- **Control:** The Steady State and Dynamic Stability of the Closed Loop system.

**POWER ELECTRONICS may be defined as the application of Solid State Electronics for the Control and conversion of Power.**



**The function of power electronics circuits** is to process and control the flow of electrical power by supplying voltages and currents in a form that is optimally suited for user loads.

Simplified Block Diagram for a Power Electronics System



# Recent Growth in Power Electronics

- The field of power electronics has recently experienced unprecedented growth:
- The revolutionary advances made in the microelectronics field which led to the development of very efficient, and highly integrated circuits(IC's) used for generation of control signals for processing and control purposes

-The ever increasing demand for smaller size and lighter weight power electronic systems.

-The expand market demand for new power electronic applications that require the use variable-speed motor drives, regulated power supplies, robotics, uninterruptible power supplies, and

-A result of this increasing reliance on power electronic systems made it mandatory that all such systems have radiated and conducted electromagnetic interference (EMI) be limited within regulated ranges.

# Classification of Power Converter Circuits

Four possible *conversion circuits:*

a) *ac*-to-*ac*

b) *ac*-to-*dc*

c) *dc*-to-*ac*

d) *dc*-to-*dc*

## FUNCTIONAL DESCRIPTION

- Power Electronic systems perform one or more of the following conversion functions:

**a)Rectification (*ac*-to-*dc*)**

**b) Inversion (*dc*-to-*ac*)**

**c) Cycloconversion**

**(*ac*-to-*ac* different frequencies) or**

***ac*-controllers(*ac*-to-*ac*same frequency)**

**d) Conversion (*dc*-to-*dc*)**

# Power semiconductor devices (Power switches)

- Power switches are the work-horses of PE systems.

- PE switches works in two states only:
  - Fully on (conducting);
  - Fully off (blocking)

- Can be categorised into three group
  - Diode : on and off states controlled by power circuit only (Uncontrolled switch).

  - Thyristor (SCR) : Latched on by low-power control signal but must be turned off by power circuit. Cannot be turned off by control signal.

  - Controllable switches: Can be turned on and off by low-power control signals (e.g. BJT, MOSFET, IGBT, GTO)

# Types of Power Diodes

- Line frequency (general purpose):
  - on state voltage very low (below 1V)
  - large $t_{rr}$ (about 25us)
  - very high current (up to 5kA) and voltage (5kV) ratings
  - Used in line-frequency (50/60Hz) applications such as rectifiers

- Fast recovery
  - very low $t_{rr}$ (<1us).
  - Power levels at several hundred volts and several hundred amps
  - Normally used in high frequency circuits

- Schottky
  - very low forward voltage drop (typical 0.3V)
  - limited blocking voltage (50-100V)
  - Used in low voltage, high current application such as switched mode power supplies.

# Types of thyristors

- Phase controlled
  - rectifying line frequency voltage and current for ac and dc motor drives
  - large voltage (up to 7kV) and current (up to 4kA) capability
  - low on-state voltage drop (1.5 to 3V)

- Inverter grade
  - used in inverter and chopper
  - Quite fast. Can be turned-on using “force-commutation” method.

- Light activated (LASCR)
  - Similar to phase controlled, but triggered by pulse of light.
  - Normally very high power ratings

# Ideal vs. Practical power switch

| Ideal switch | Practical switch |
|---|---|
| Block arbitrarily large forward and reverse voltage with zero current flow when off | Finite blocking voltage with small current flow during turn-off |
| Conduct arbitrarily large currents with zero voltage drop when on | Finite current flow and appreciable voltage drop during turn-on (e.g. 2-3V for IGBT) |
| Switch from on to off or vice versa instantaneously when triggered | Requires finite time to reach maximum voltage and current. Requires time to turn on and off. |
| Very small power required from control source to trigger the switch | In general voltage driven devices (IGBT, MOSFET) requires small power for triggering. GTO requires substantial amount of current to turn off. |

# Switches comparisons (2000)

| | Thy | BJT | FET | GTO | IGBT |
|---|---|---|---|---|---|
| Avail-abilty | Early 60s | Late 70s | Early 80s | Mid 80s | Late 80s |
| State of Tech. | Mature | Mature | Mature/ improve | Mature | Rapid improve |
| Voltage ratings | 5kV | 1kV | 500V | 5kV | 3.3kV |
| Current ratings | 4kA | 400A | 200A | 5kA | 1.2kA |
| Switch Freq. | na | 5kHz | 1MHz | 2kHz | 100kHz |
| On-state Voltage | 2V | 1-2V | I* Rds (on) | 2-3V | 2-3V |
| Drive Circuit | Simple | Difficult | Very simple | Very difficult | Very simple |
| Comm-ents | Cannot turn off using gate signals | Phasing out in new product | Good perform ance in high freq. | King in very high power | Best overall perform ance. |