Power Flow
Unidirectional: input-to-output
Power Flow – Bi-directional

Power Processing circuit (Ploss)
Power Conversion Dictates
Change in Current and/or Voltage:

• Voltage/Current form AC or DC
• Voltage/Current level (magnitude)
• Voltage frequency (line or otherwise)
• Voltage/Current waveshape (sinusoidal or nonsinusoidal such as square, triangle, sawtooth, etc.)
• Voltage phase (single- or three-phase).
Conversion Type Description

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

  a) DC-to-DC Conversion
  b) Rectification (AC-to-DC)
  c) Inversion (DC-to-AC)
  d) Cycloconversion
     (AC-to-AC different frequencies) or
     (AC-to-AC same frequency)
Types of Power Conversion
Figures of Merit
for Power Electronic Converters

• What is the objective?
  – Overall goal: To produce a converter that performs well in these areas:
    • Efficiency
    • Transient Response
    • Load and Line Regulation
    • Power Density
    • Input/Output Distortion (Input Power Factor)
    • Reliability (MTBF – Mean Time Between Failure)
    • Cost
  – In the final analysis, the job is to process and control the flow of electric energy by supplying currents/voltages in a form most suited to both the load and energy source
Non-isolated DC-DC Converters: Buck
Non-isolated DC-DC Converters: Buck, Boost, and Buck-Boost
Non-isolated DC-DC Converters: Cuk
Isolated DC-DC Converters: Flyback

Buck-boost converter

Replacing inductor by transformer

Flyback converter
Isolated DC-DC Converters: Forward

Forward converter

Forward converter with tertiary winding
A single-phase inverter

“H-bridge”
Modulate switch duty cycles to obtain sinusoidal low-frequency component
Three-phase Pulse-width Modulation (PWM) Rectifier
Active Filter
Typical PC Power Supply

![Diagram of a typical PC power supply with a rectifier, DC link, and DC to DC converter with two loads.](image)
Motor Drive

3-phase AC line

Rectifier

DC link

Inverter

variable frequency variable ac voltage

load
A laptop computer power supply system

Diagram:
- Charger
- PWM Rectifier
- Inverter
- Display backlighting
- Buck converter
- Microprocessor
  - Power management
- Boost converter
- Disk drive
- Lithium battery
- AC line input 85-265 Vrms
Power system of an earth-orbiting spacecraft
An electric vehicle power and drive system
AC-AC Cycloconverter: Single Phase
AC-AC Cycloconverter:
Three Phase to Single Phase
Frequency Link Systems
AC-AC Cycloconverter:
Three Phase to Three Phase
Inverter Followed by A Forced Cycloconverter
UIC’s Inverter for 2005 IEEE International Fuel Cell Energy Challenge: Ranked First in USA and 3rd in the World
Simplified Block Diagram of a Power Electronics System

- **Power Electronic "Power" Circuit**
  - Electrical Inputs "Sources" $x_1$, $x_2$, ..., $x_m$
  - Feedback "Control Circuit" $f_1$, $f_2$, ..., $f_k$

- **Electrical or Mechanical Output "Loads"** $y_1$, $y_2$, ..., $y_n$
  - Loads 1, 2, ..., n
Detailed Block Diagram of Power Electronics System

Pre-stage

Filter & Rectify

Power proc. stage

PE Circuit

Post stage

Filter & Rectify

Could generate undesirable waveforms

Control Circuit

Switch Drives

Process feedback signals and decide on control

Interface between control and power circuits

Input

Form of electrical energy

Mostly ac line voltage (single or three phase)

Mostly unregulated dc voltage

Load

Electrical

Mechanical

Output

Form of elec. or mechan. energy

Electrical Variable Feedback

Mechanical Variable Feedback

Could generate undesirable waveforms

Mostly ac line voltage (single or three phase)