Chapter 1 Power Electronic Systems

Power Electronic Systems

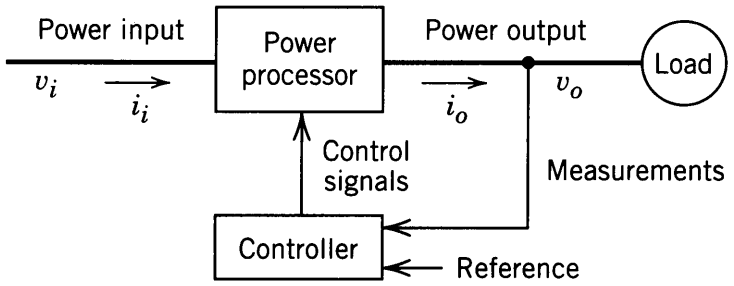
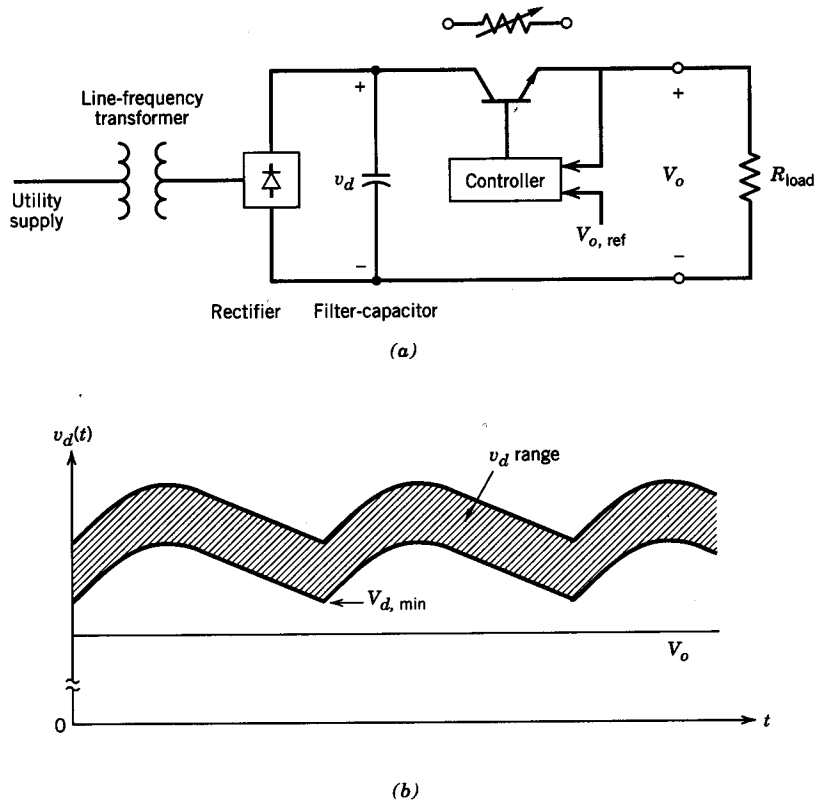


Figure 1-1 Block diagram of a power electronic system.

- Block diagram
- Role of Power Electronics
- Reasons for growth

Linear Power Supply



- Series transistor as an adjustable resistor
- Low Efficiency
- Heavy and bulky

Switch-Mode Power Supply

- Transistor as a switch
- High Efficiency
- High-Frequency Transformer

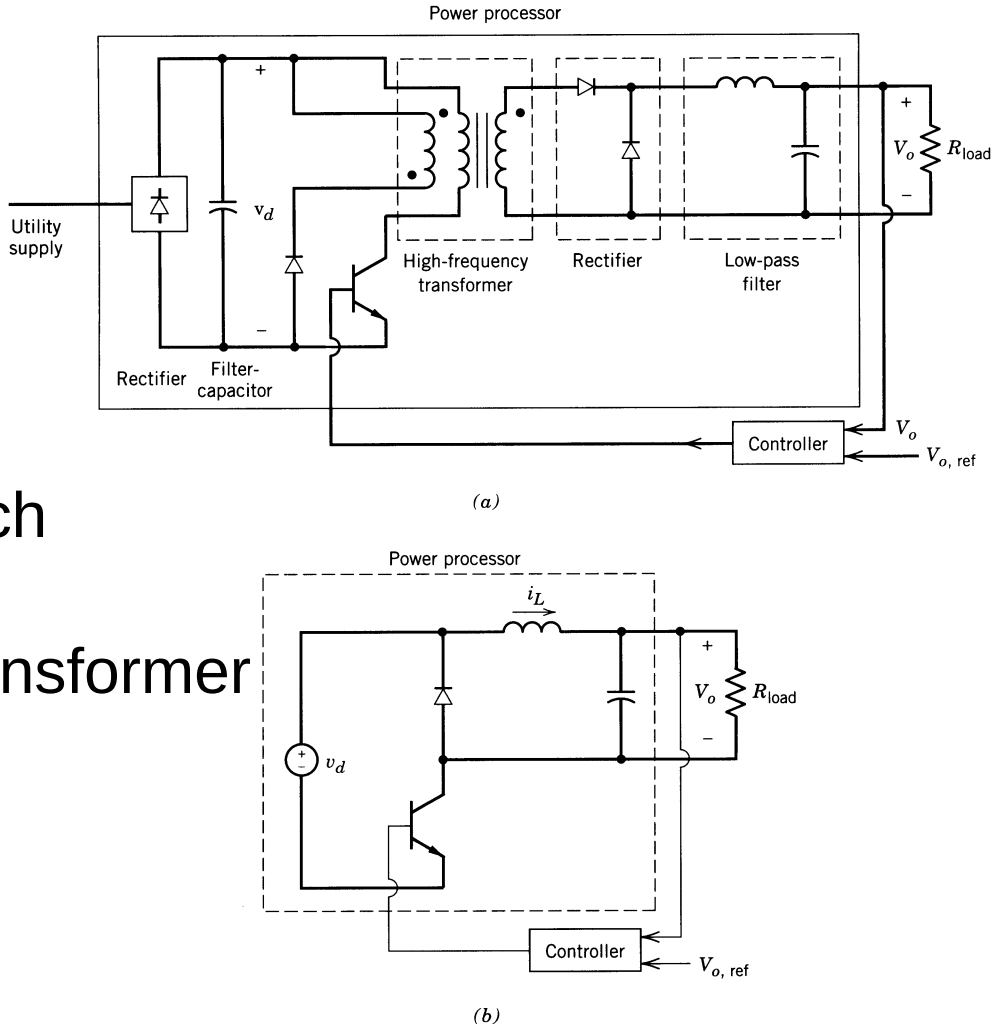


Figure 1-3 Switch-mode dc power supply.

Basic Principle of Switch-Mode Synthesis

- Constant switching frequency
- pulse width controls the average
- L-C filters the ripple

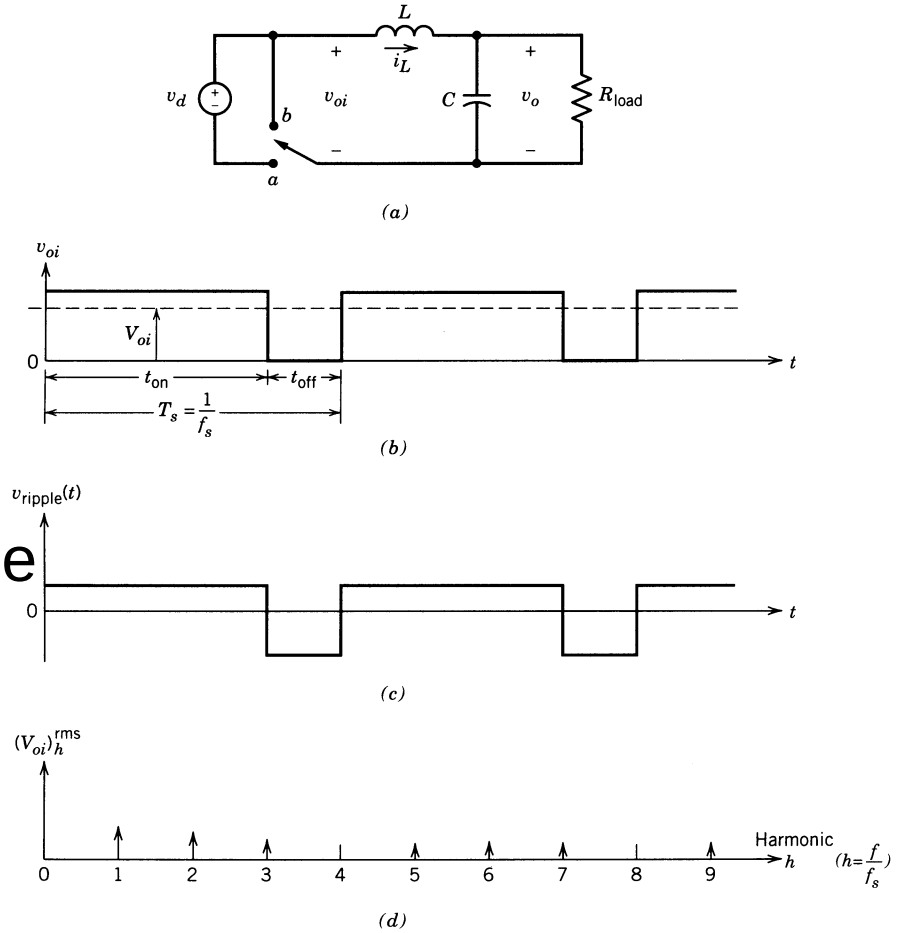


Figure 1-4 Equivalent circuit, waveforms, and frequency spectrum of the supply in Fig. 1-3.

Application in Adjustable Speed Drives

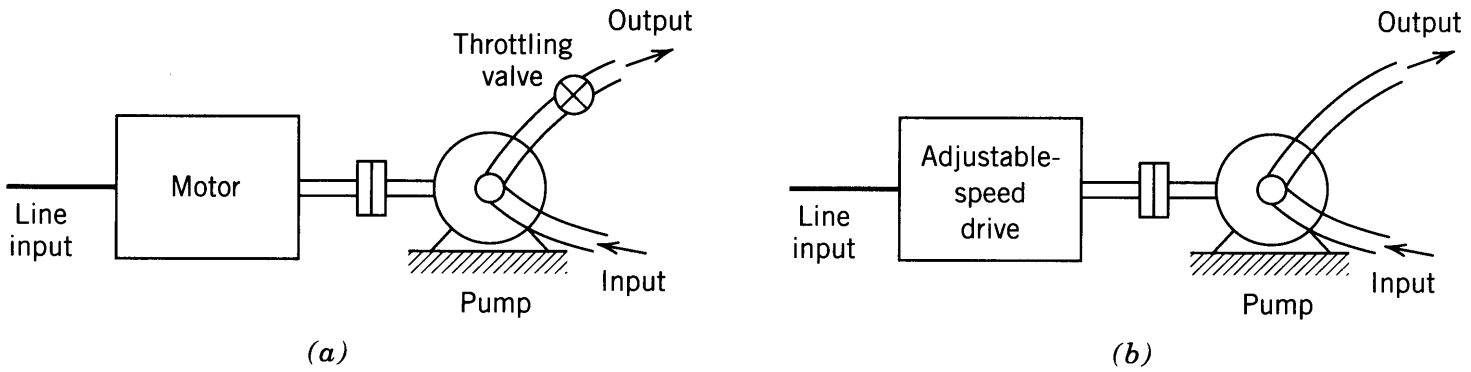


Figure 1-5 Energy conservation: (*a*) conventional drive, (*b*) adjustable-speed drive.

- Conventional drive wastes energy across the throttling valve to adjust flow rate
- Using power electronics, motor-pump speed is adjusted efficiently to deliver the required flow rate

Scope and Applications

TABLE 1-1 Power Electronic Applications

(a) *Residential*	(d) *Transportation*
Refrigeration and freezers	Traction control of electric vehicles
Space heating	Battery chargers for electric vehicles
Air conditioning	Electric locomotives
Cooking	Street cars, trolley buses
Lighting	Subways
Electronics (personal computers, other entertainment equipment)	Automotive electronics including engine controls
(b) *Commercial*	(e) *Utility systems*
Heating, ventilating, and air conditioning	High-voltage dc transmission (HVDC)
Central refrigeration	Static var compensation (SVC)
Lighting	Supplemental energy sources (wind, photovoltaic), fuel cells
Computers and office equipment	Energy storage systems
Uninterruptible power supplies (UPSs)	Induced-draft fans and boiler feedwater pumps
Elevators	(f) *Aerospace*
(c) *Industrial*	Space shuttle power supply systems
Pumps	Satellite power systems
Compressors	Aircraft power systems
Blowers and fans	(g) *Telecommunications*
Machine tools (robots)	Battery chargers
Arc furnaces, induction furnaces	Power supplies (dc and UPS)
Lighting	
Industrial lasers	
Induction heating	
Welding	

Power Processor as a Combination of Converters

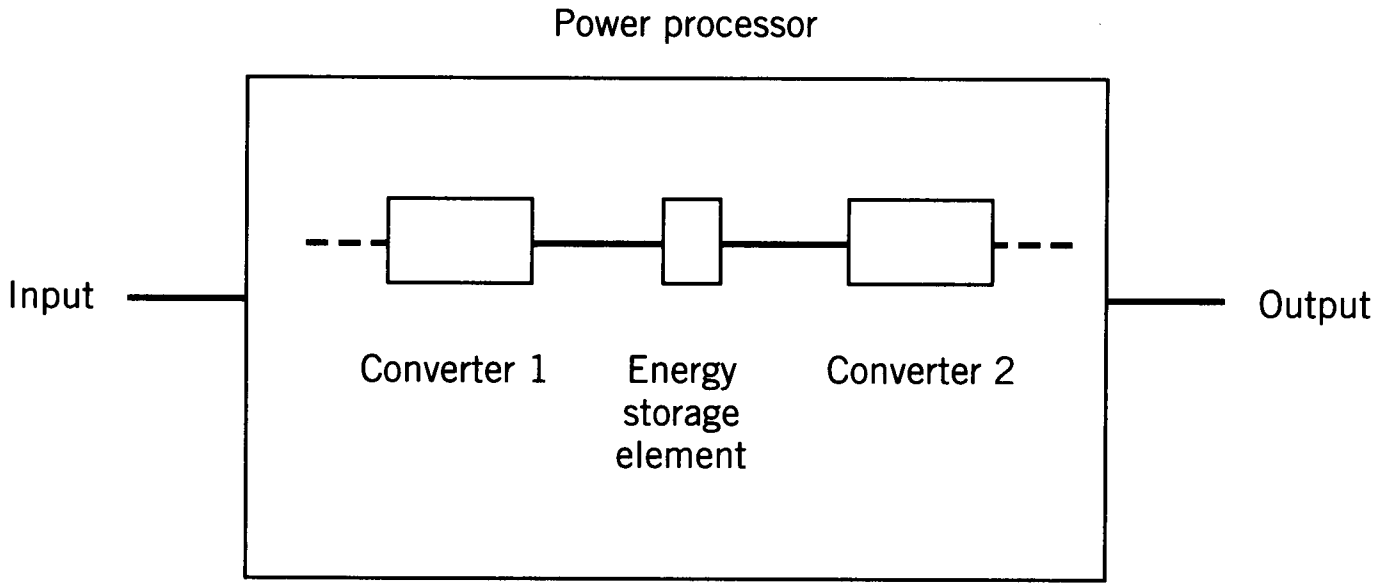


Figure 1-6 Power processor block diagram.

- Most practical topologies require an energy storage element, which also decouples the input and the output side converters

Power Flow through Converters

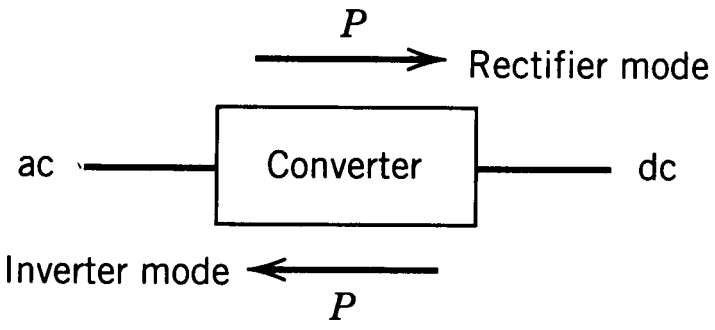


Figure 1-7 ac-to-dc converters.

- Converter is a general term
- An ac/dc converter is shown here
- Rectifier Mode of operation when power from ac to dc
- Inverter Mode of operation when power from ac to dc

AC Motor Drive

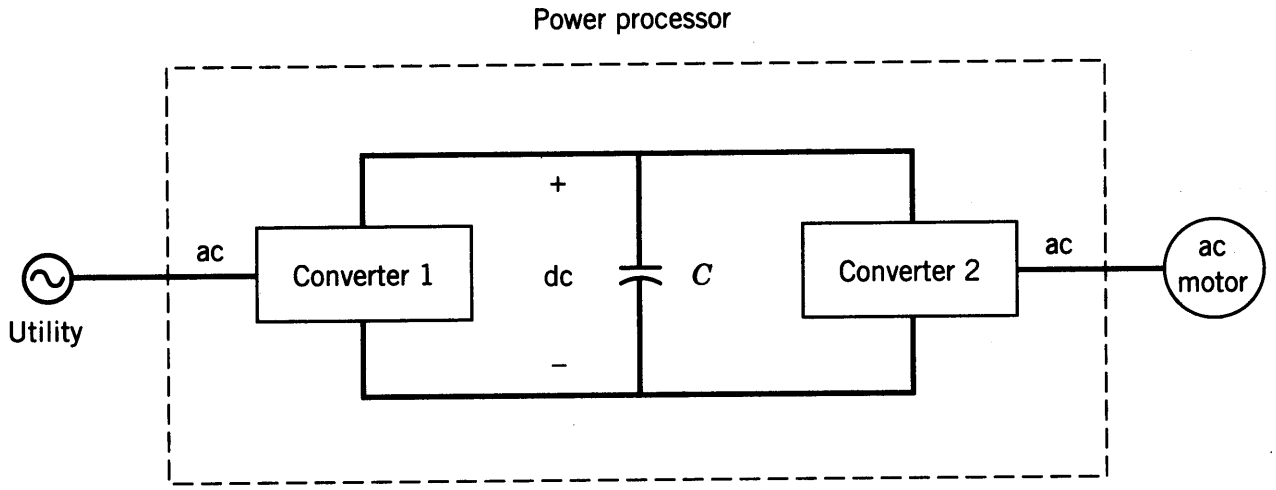


Figure 1-8 Block diagram of an ac motor drive.

- Converter 1 rectifies line-frequency ac into dc
- Capacitor acts as a filter; stores energy; decouples
- Converter 2 synthesizes low-frequency ac to motor
- Polarity of dc-bus voltage remains unchanged
  - ideally suited for transistors of converter 2

Matrix Converter

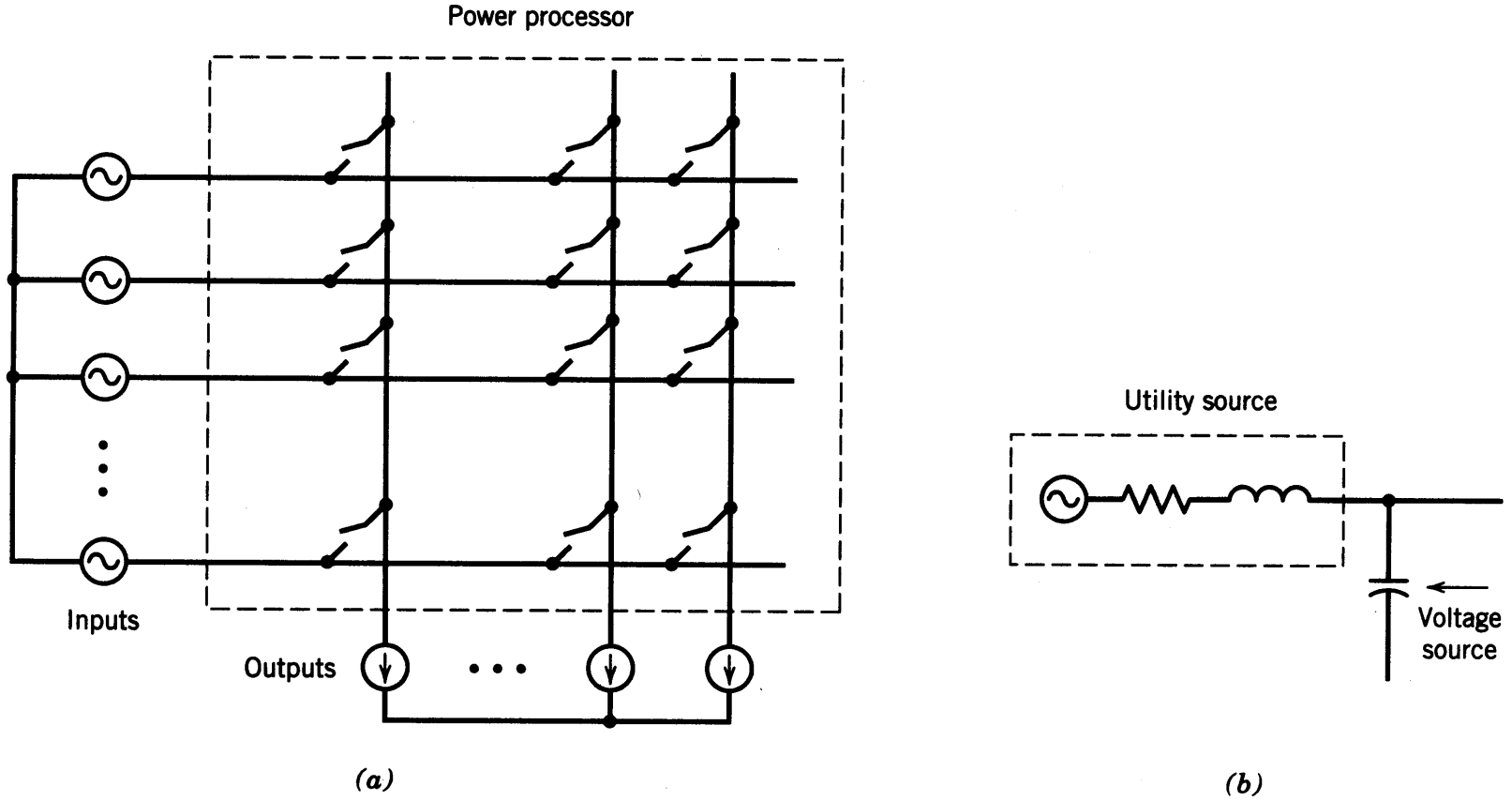


Figure 1-9 (*a*) Matrix converter. (*b*) Voltage source.

- Very general structure
- Would benefit from bi-directional and bi-polarity switches
- Being considered for use in specific applications

Interdisciplinary Nature of Power Electronics

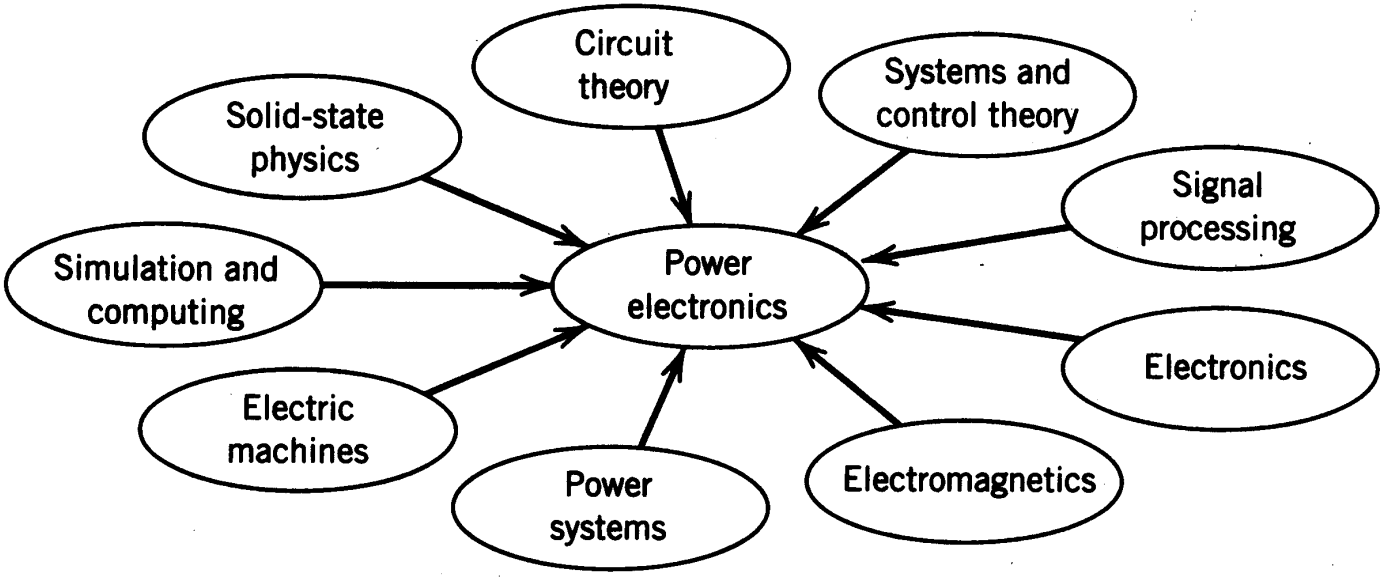


Figure 1-10 Interdisciplinary nature of power electronics.