

Introduction to Power Electronics

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Key concepts, components, and applications – concise, easy-to-read notes

1. What Is Power Electronics?

Aspect	Description
Definition	The branch of electrical engineering that deals with the conversion, control, and conditioning of electric power using solid-state electronic devices.
Goal	Transform electrical energy from one form to another (voltage, current, frequency, or AC/DC) with high efficiency, reliability, and compact size.
Typical Power Levels	From a few watts (portable electronics) to several megawatts (industrial drives, grid-level converters).

2. Basic Power Conversion Functions

Conversion	Input	Output	Typical Use
AC/DC (Rectifier)	AC (mains, variable frequency)	DC	Power supplies, battery chargers, EV chargers
DC/AC (Inverter)	DC (battery, PV, fuel cell)	AC	Solar inverters, UPS, motor drives
DC/DC (Converter)	DC (one voltage)	DC (different voltage)	Buck (step-down), boost (step-up), buck-boost, isolated converters
AC/AC (Cycloconverter, Matrix Converter)	AC (one frequency)	AC (different frequency/voltage)	Variable-frequency drives (VFDs), soft starters

3. Core Power Semiconductor Devices

Device	Symbolic Operation	Typical Voltage/Current Rating	Key Features
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Diode	Unidirectional conduction	0.6–1?kV (silicon), >3?kV (SiC)	Fast recovery, low forward drop
Thyristor (SCR)	Latching turn?on, requires gate pulse	1–10?kV, up to 1?kA	Handles high current, used in high?power rectifiers
GTO / IGCT	Gate?turn?off capability	1–6?kV, several kA	Turn?off without commutation circuit
MOSFET	Voltage?controlled, fast switching	30–900?V, up to 200?A	Low on?resistance, high switching speed (?100?ns)
IGBT	Combines MOSFET gate with bipolar conduction	600–4?800?V, up to 1?kA	Moderate switching speed, low conduction loss at high voltage
SiC & GaN Devices	Wide?bandgap semiconductors	600?V–3?kV (SiC), 600?V (GaN)	Higher switching frequency, lower losses, higher temperature tolerance

4. Fundamental Converter Topologies

4.1. Rectifiers

Topology	Diodes / Thyristors	Output	Typical Application
Single?phase half?wave	1 diode	Pulsating DC	Low?power supplies
Single?phase full?wave bridge	4 diodes	Full?wave DC	General?purpose AC?DC supplies
Three?phase bridge	6 diodes / 6 SCRs	Smooth DC	Industrial motor drives, HVDC

4.2. Inverters

Topology	Switches	Modulation	Output
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**Voltage?source inverter (VSI)