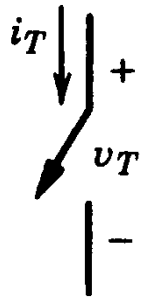
Energoelektronika
2. Półprzewodnikowe elementy mocy

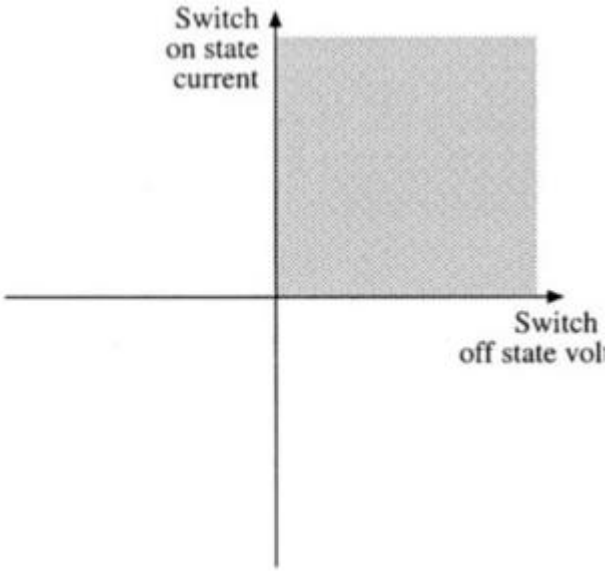
dr inż. Dariusz Janiszewski

Power Electronics Components

- General Switch Symbol
- Single Quadrant Switches
- Double Quadrant Switches
- Four Quadrant Converter
- Real components
  - Diodes
  - MOSFET
  - BJT
  - IGBT
  - Thyristors

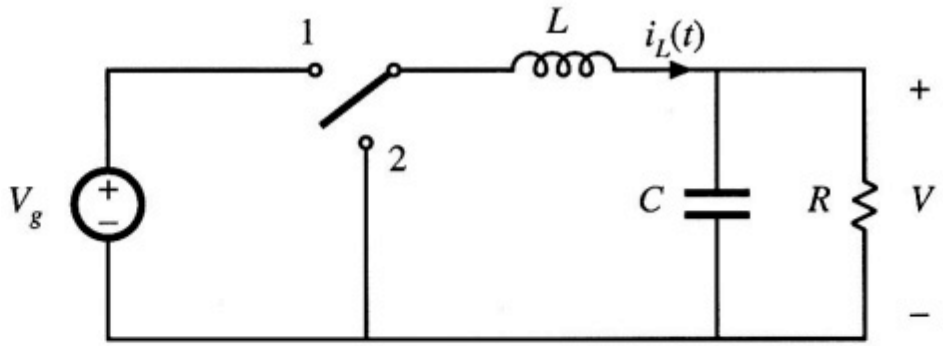
Generic Switch Symbol

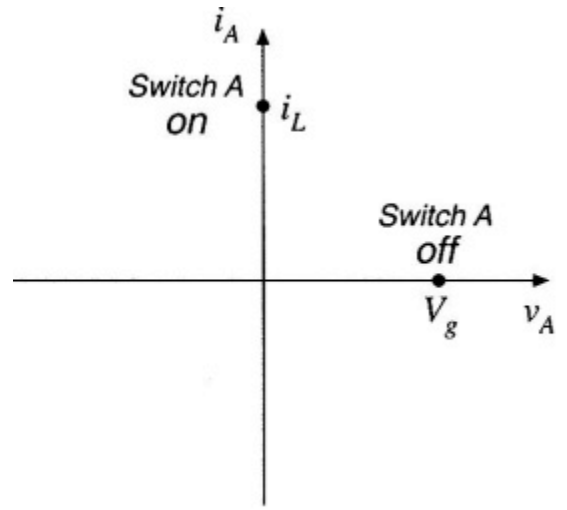


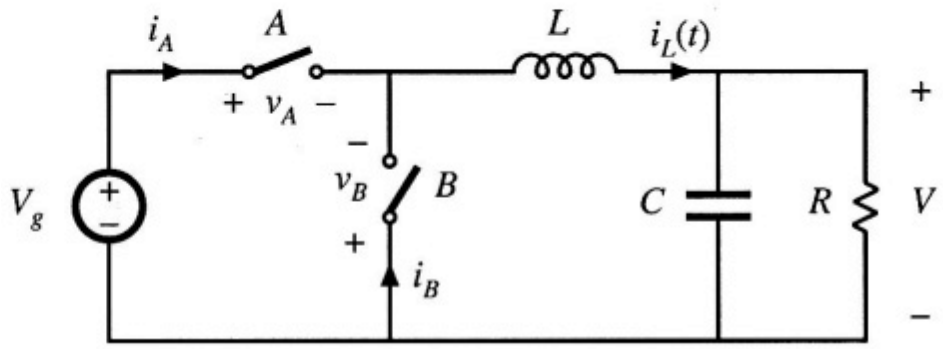


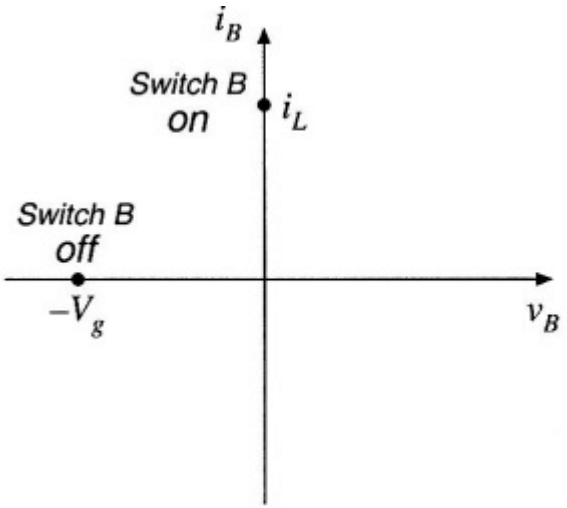
- Idealized switch symbol
- When on, current can flow only in the direction of the arrow
- Instantaneous switching from one state to the other
- Zero voltage drop in on-state
- Infinite voltage and current handling capabilities

Example – Buck converter



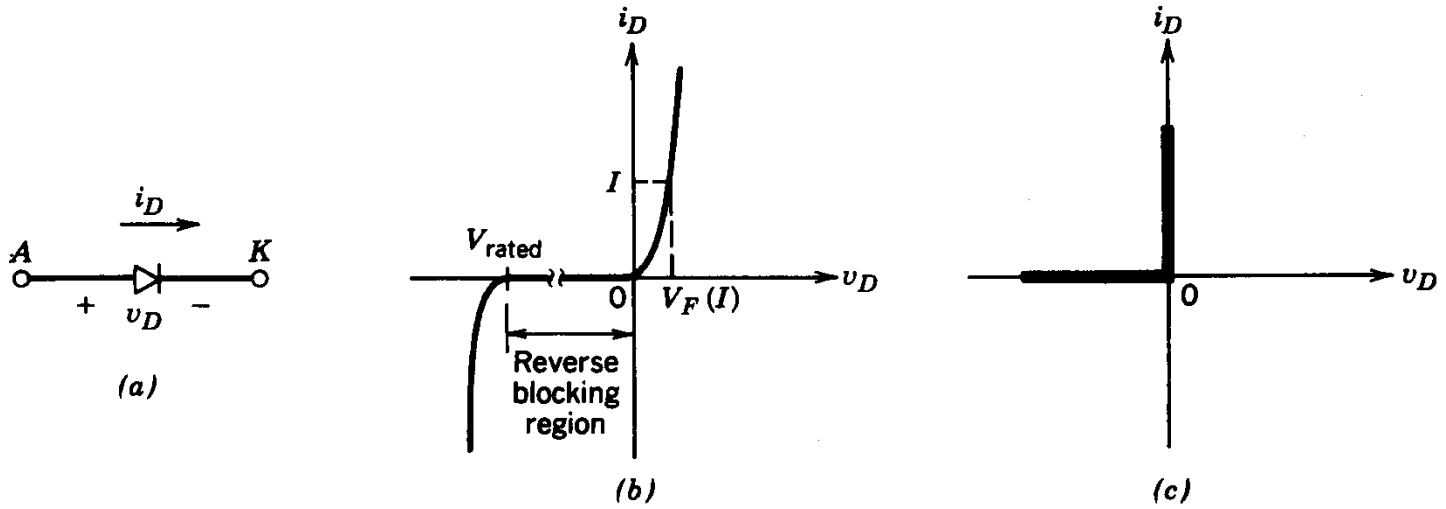




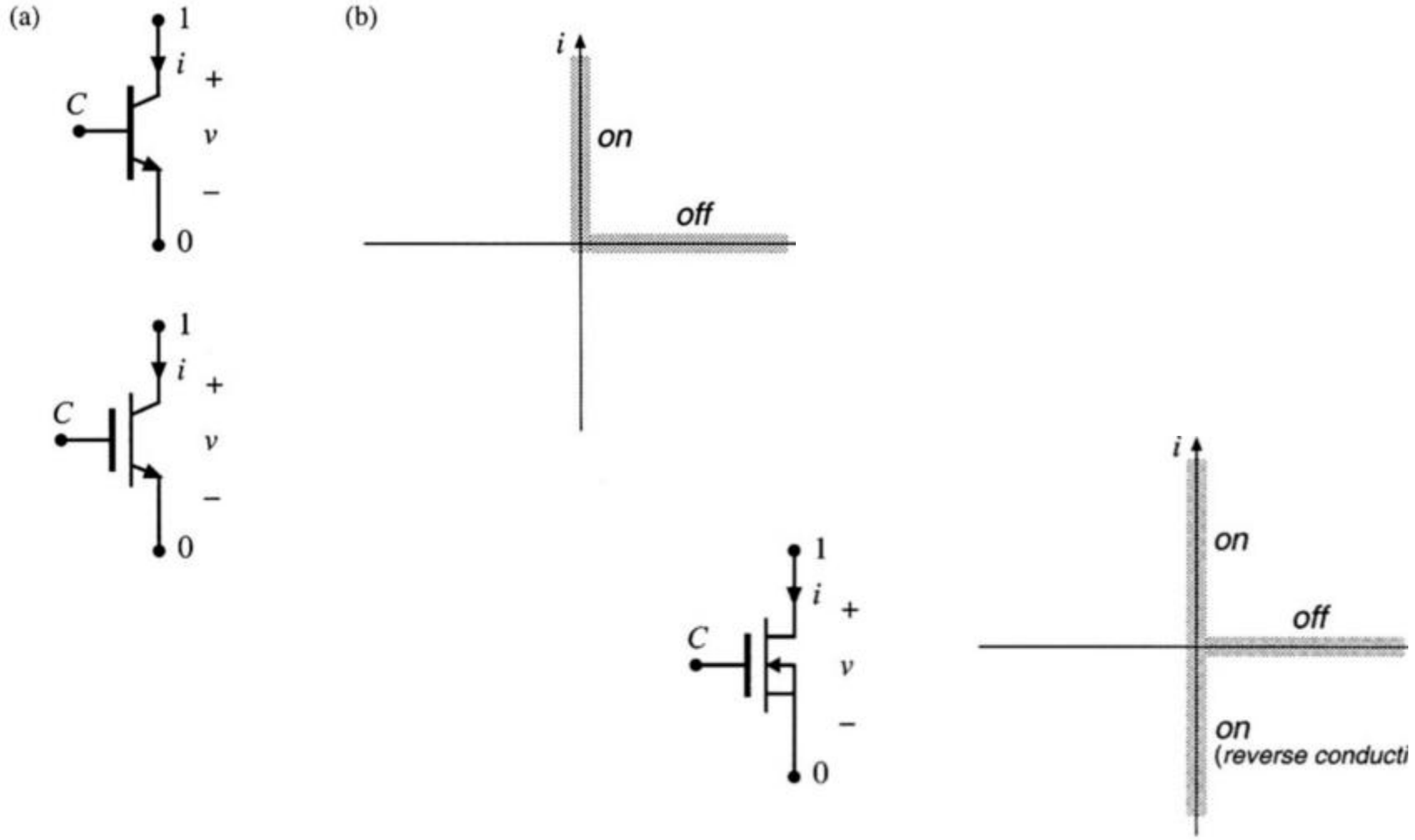


Single Quadrant Switches - Diode

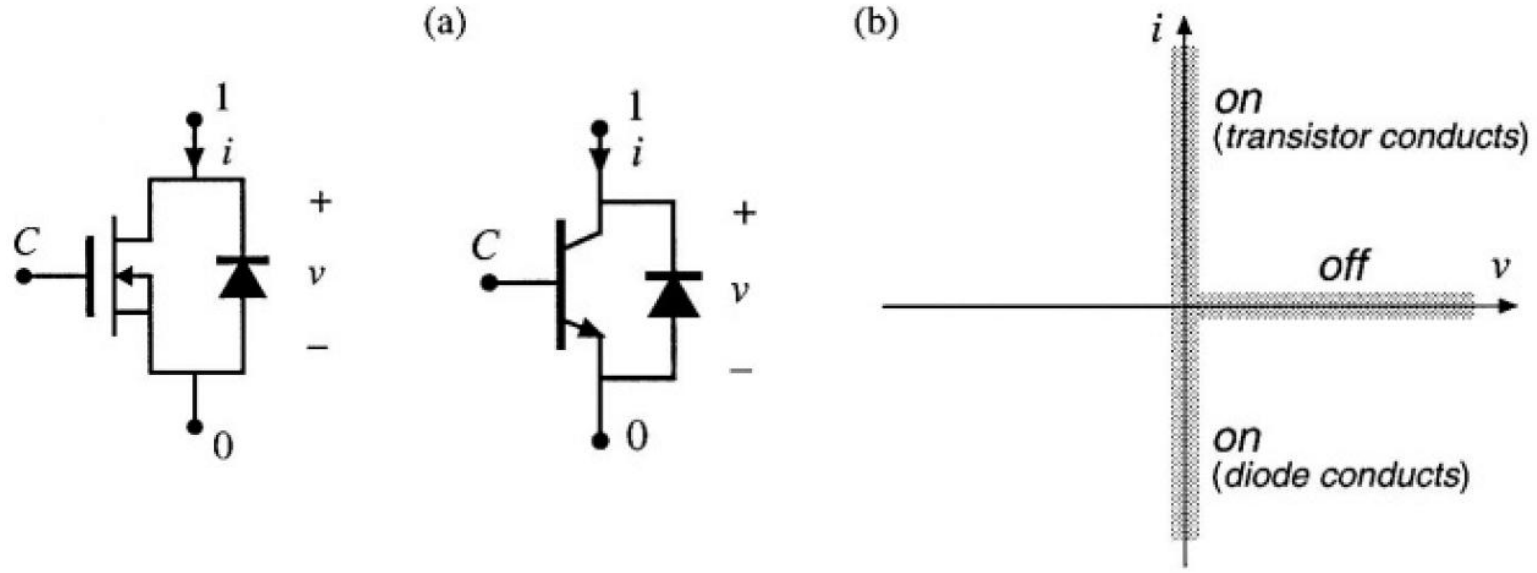
- On and off states controlled by the power circuit



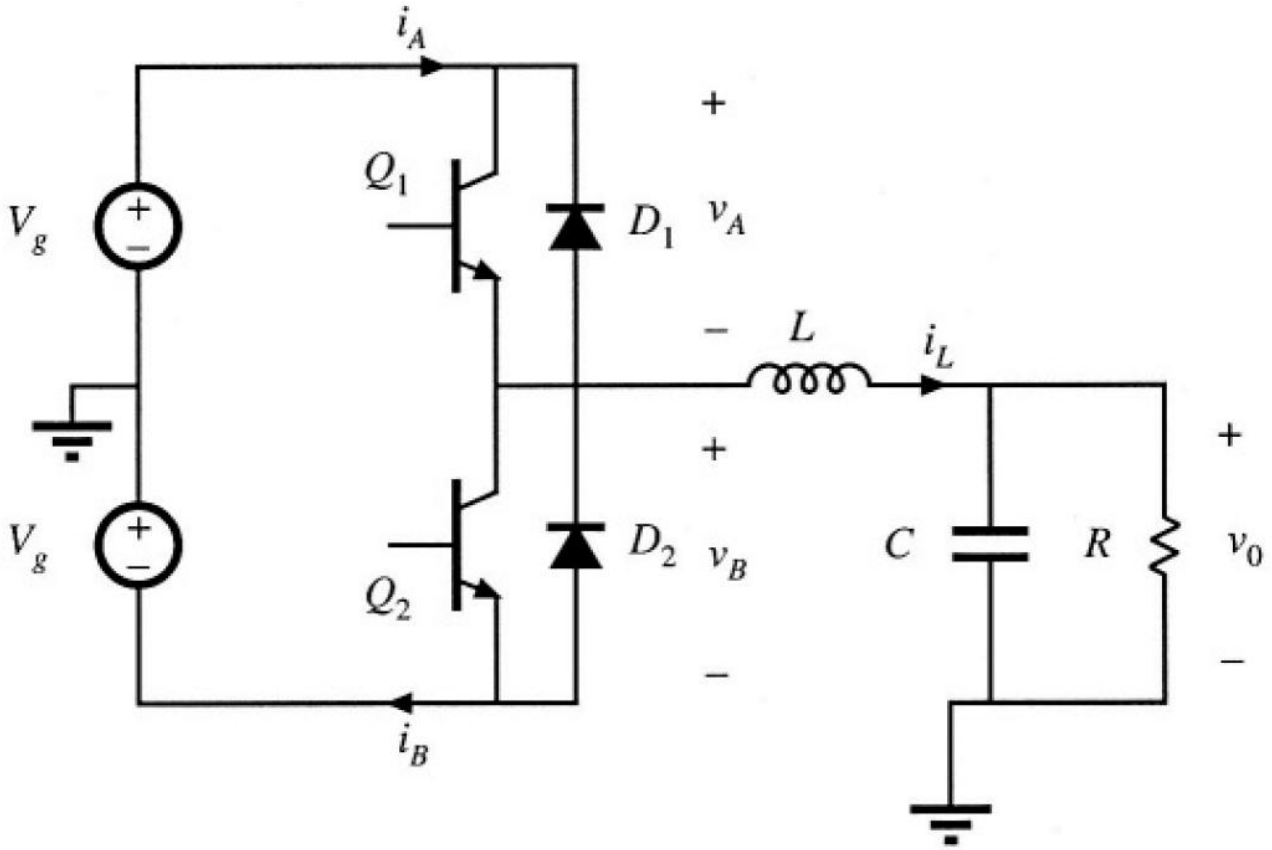
Single Quadrant Switches - BJT, IGBT, MOSFET

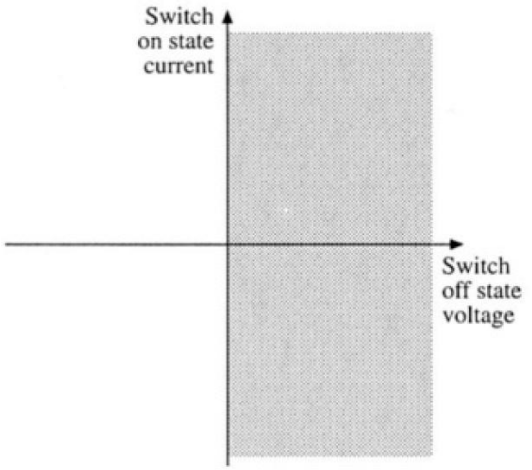


Current Bidirectional Two Quadrant BJT, MOSFET + AntiParallel Diode

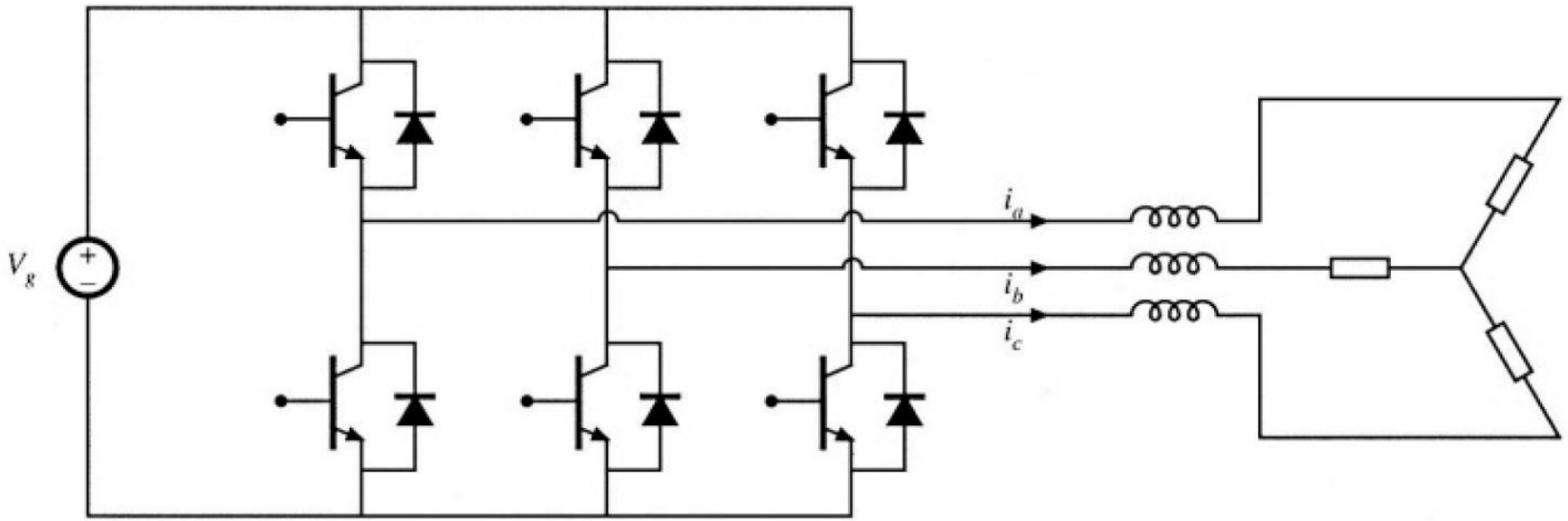


Inverter for two quadrat switches

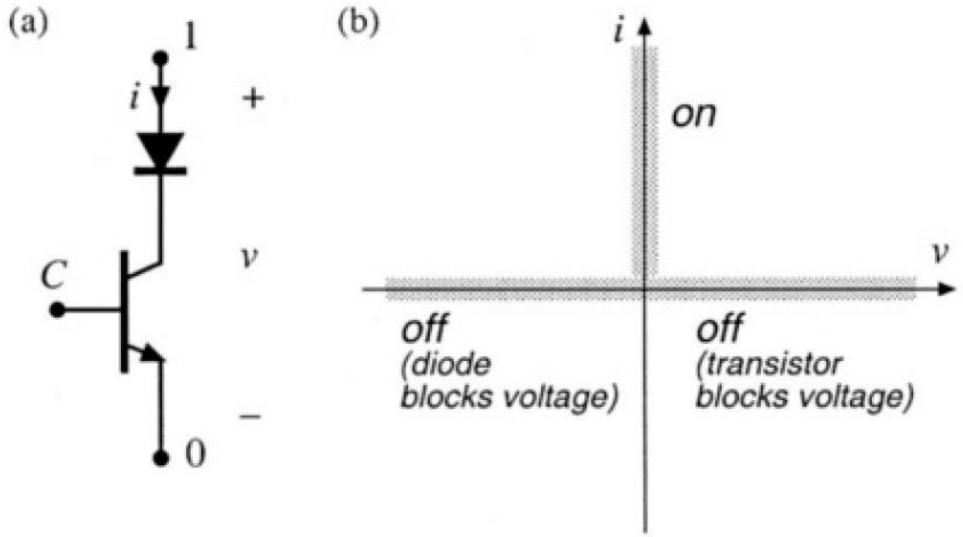




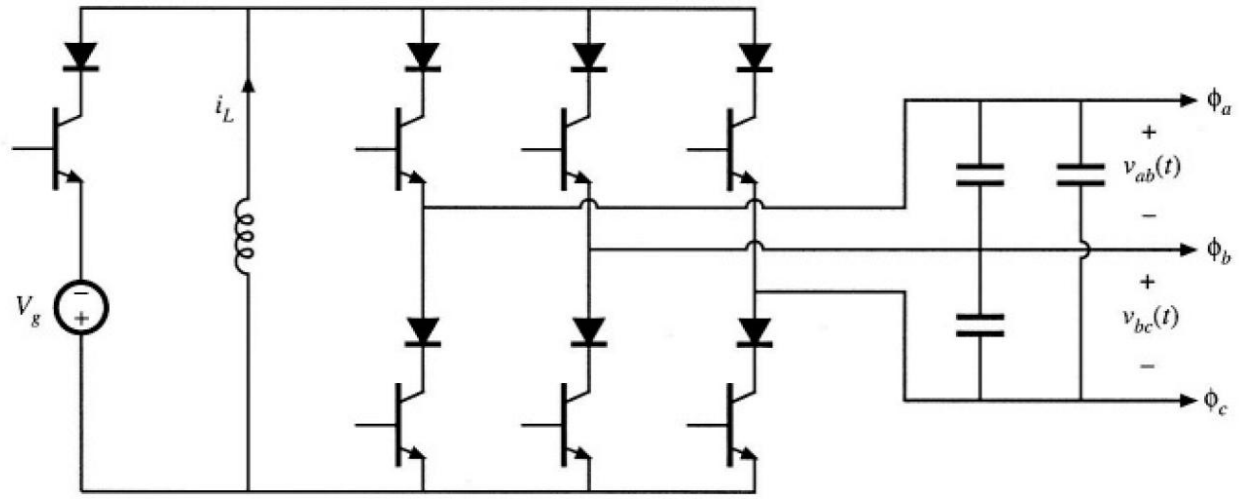
Voltage source inverter



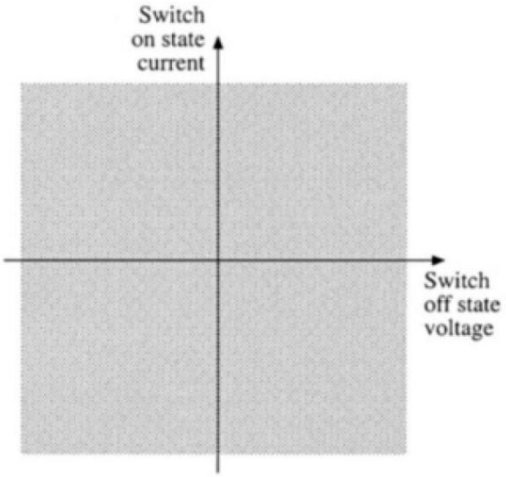
Voltage Bidirectional Two Quadrant BJT, MOSFET + Series Diode

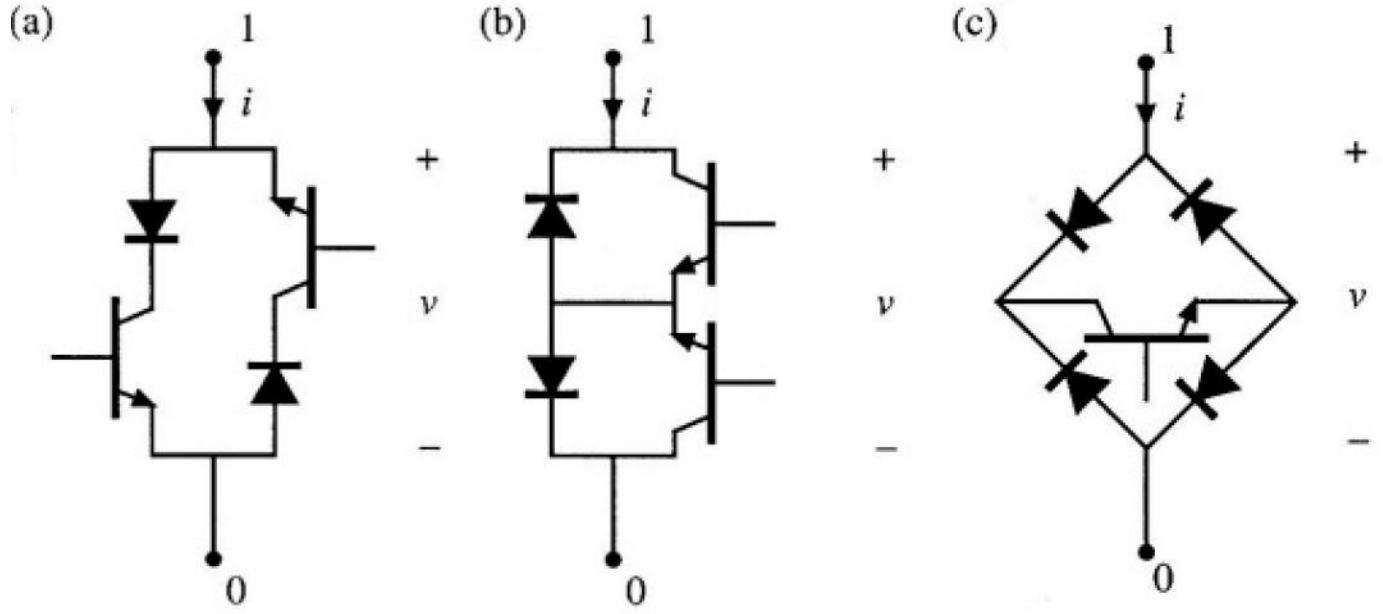


DC-3ph Buck-Boost Inverter

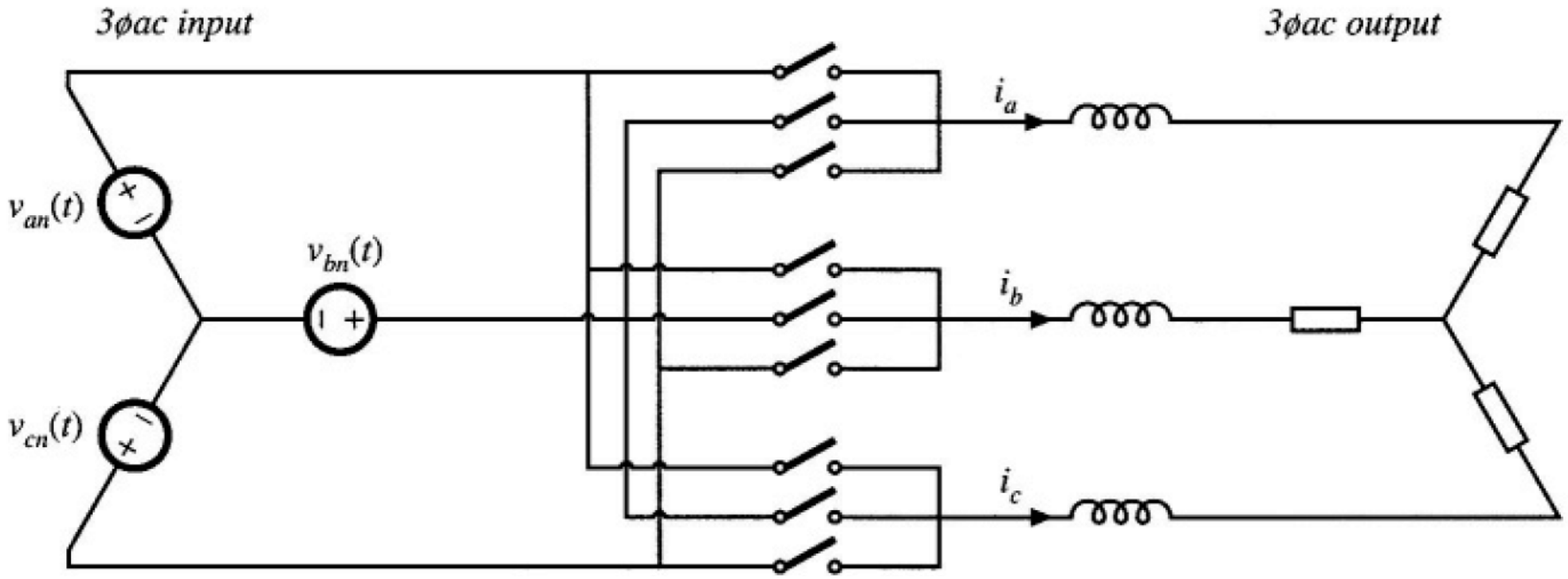


Four Quadrant Switches

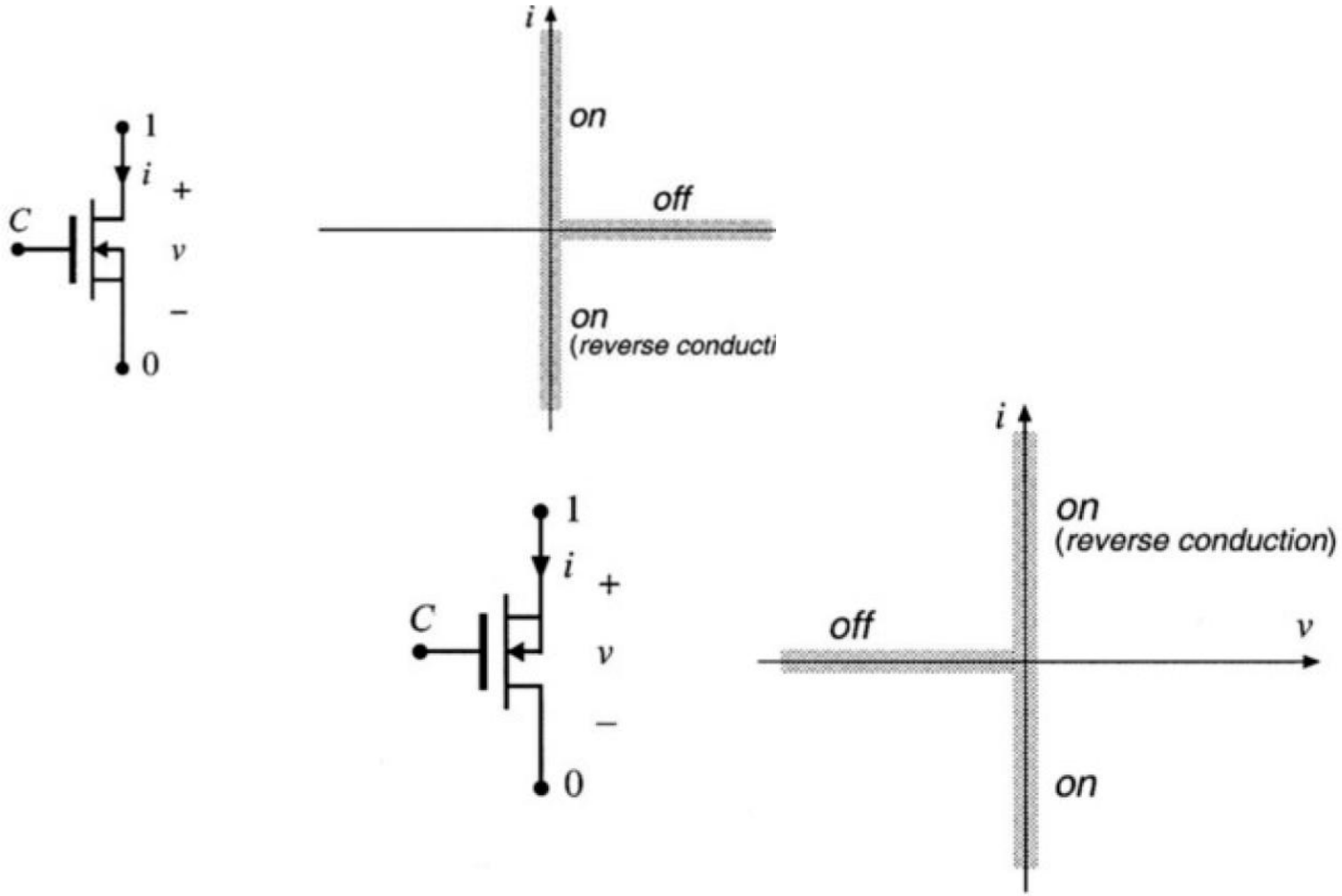




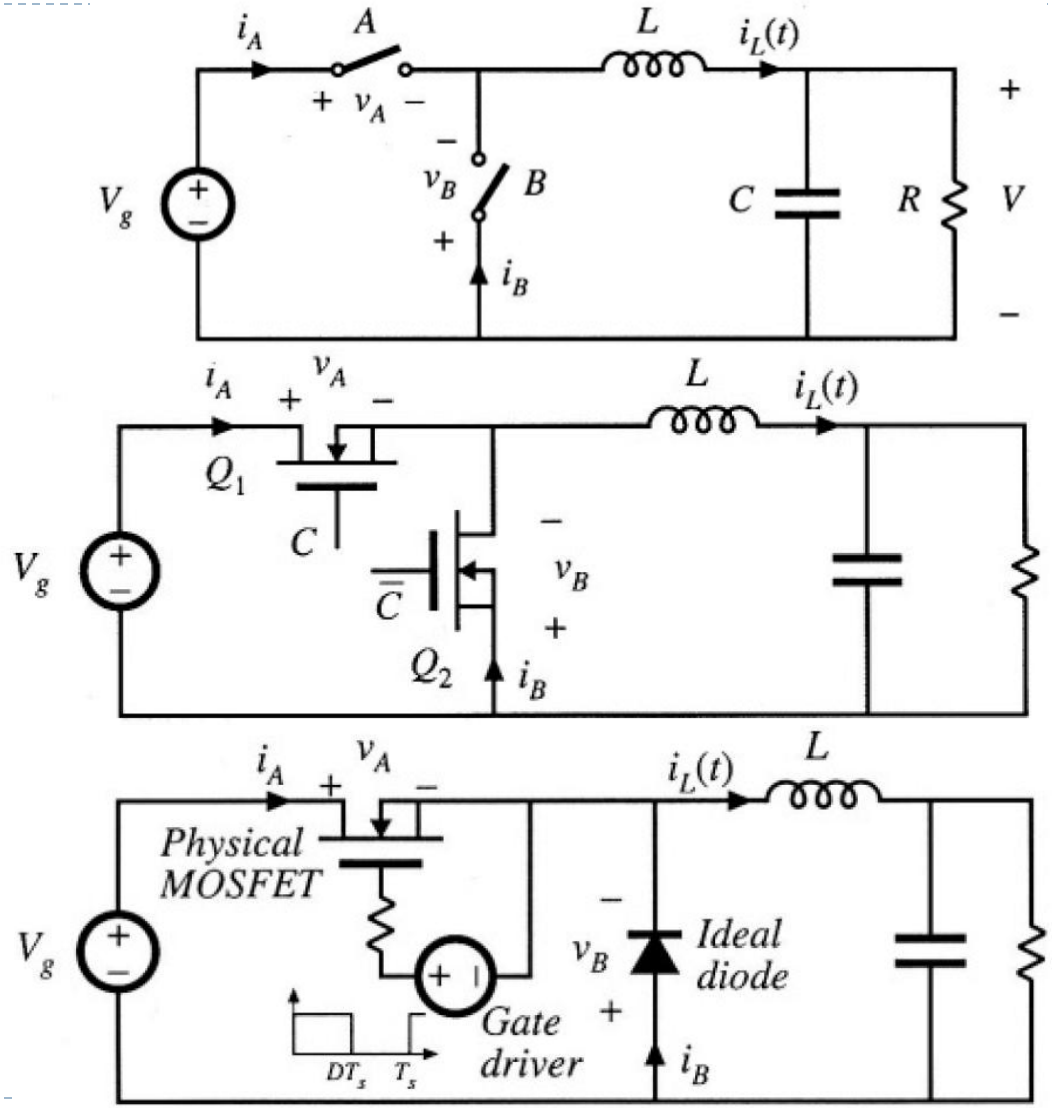
Matrix Converter



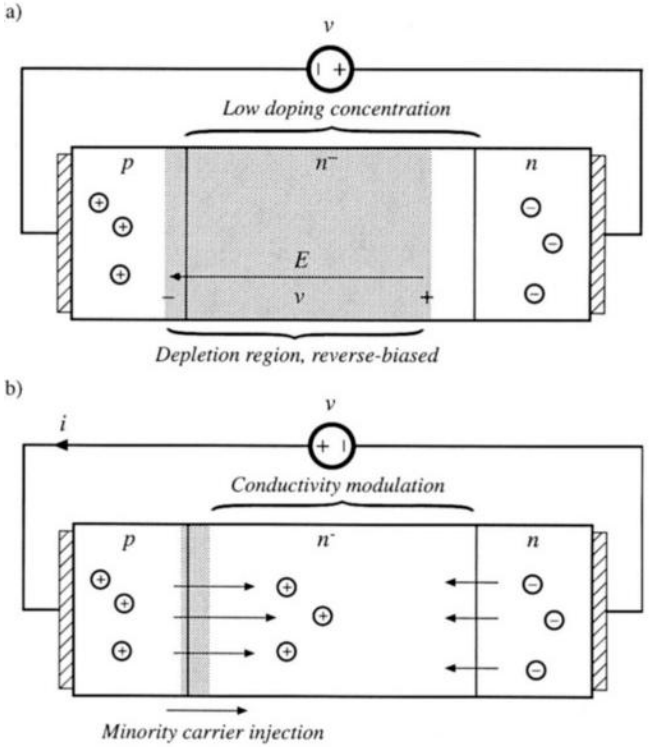
Synchronous Rectifier

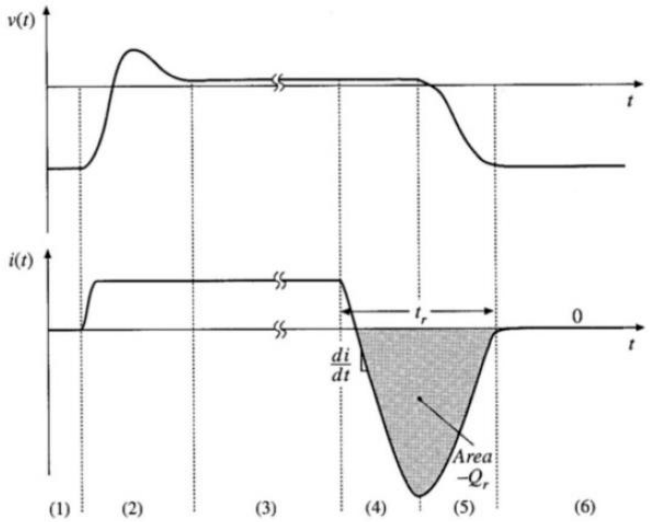


Buck Converter cont.

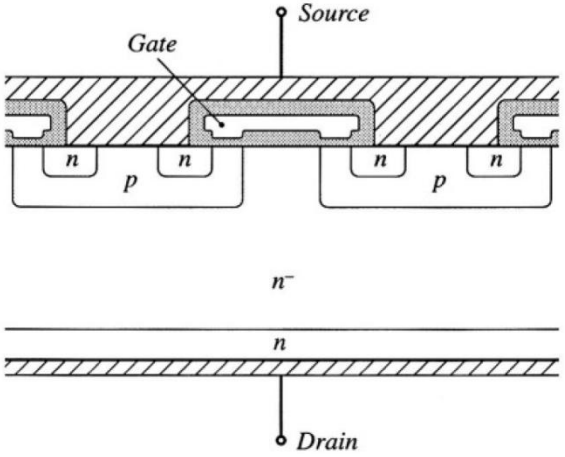


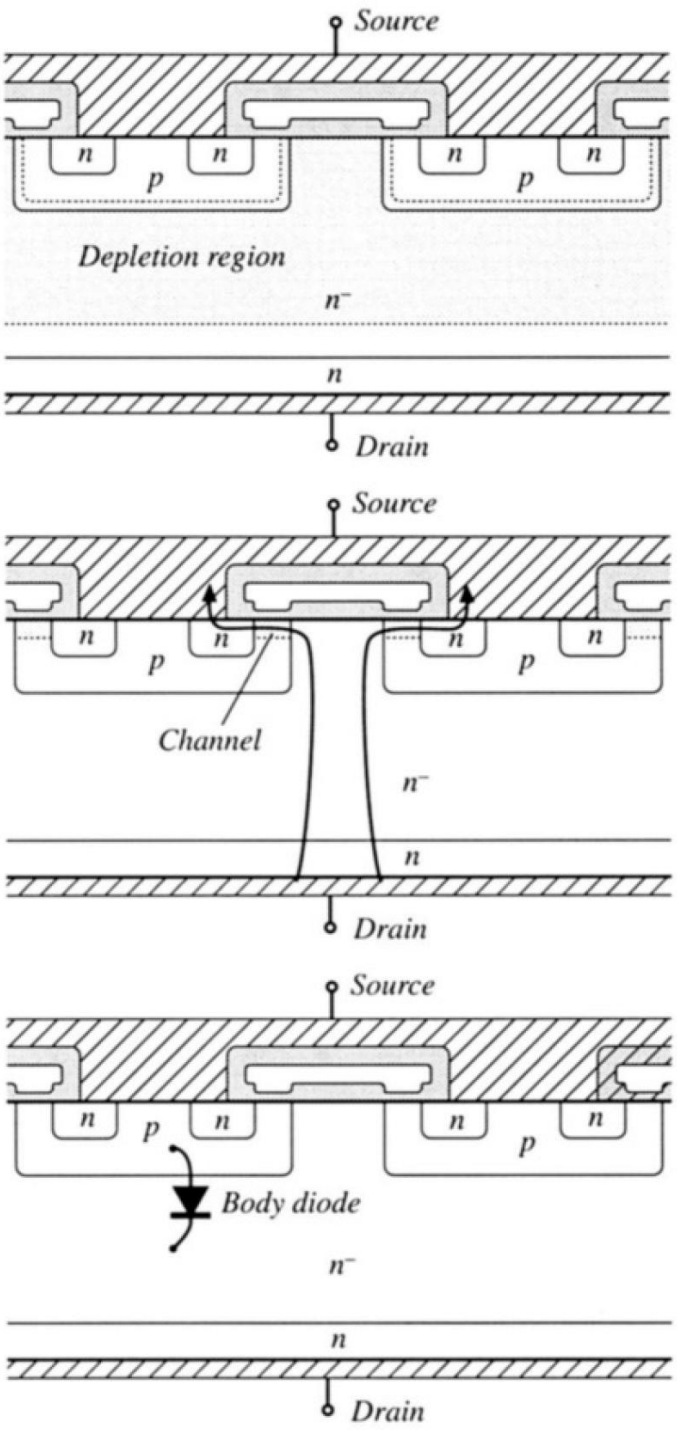
Nonideal diodes

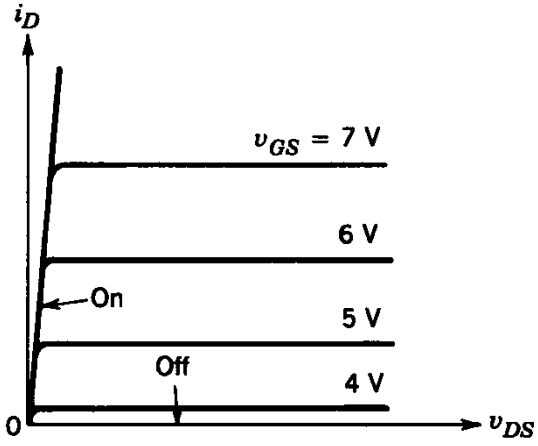


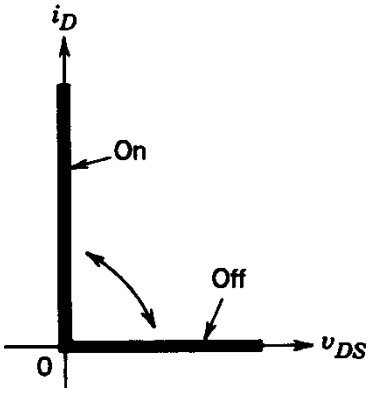


Metal On Silicon Field Effect Transistor

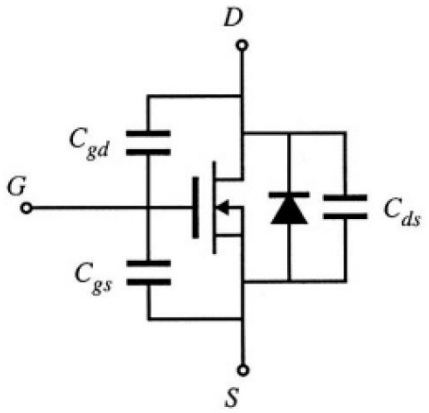


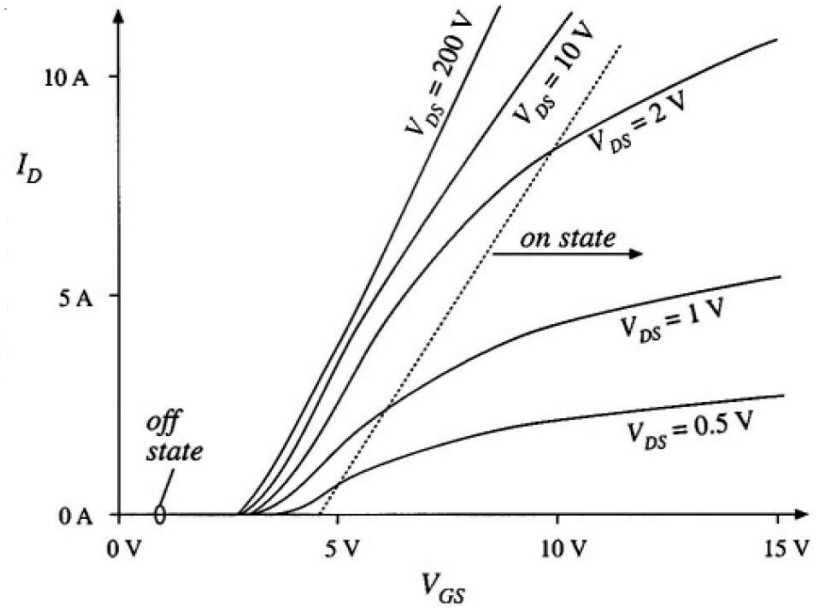






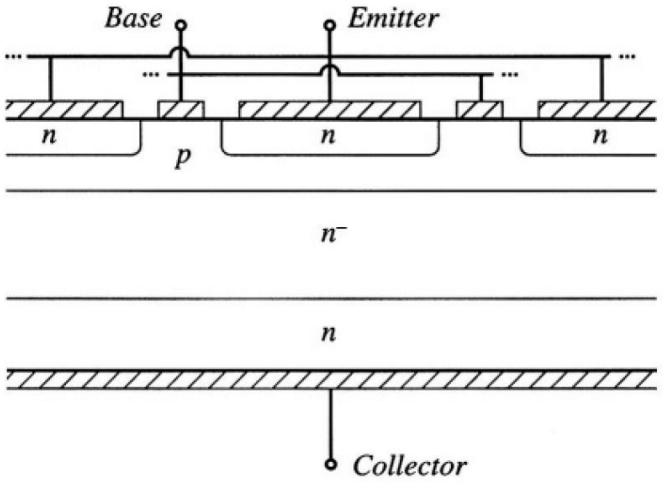
Metal On Silicon Field Effect Transistor

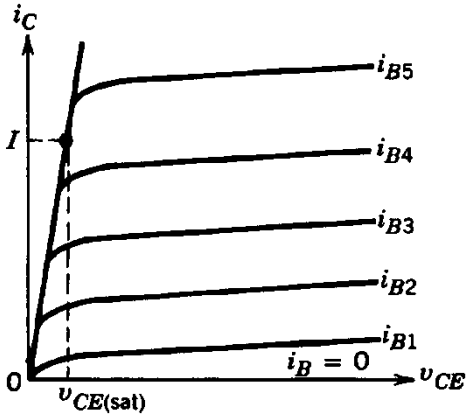


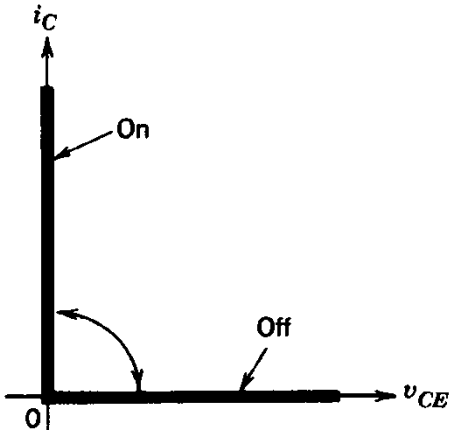


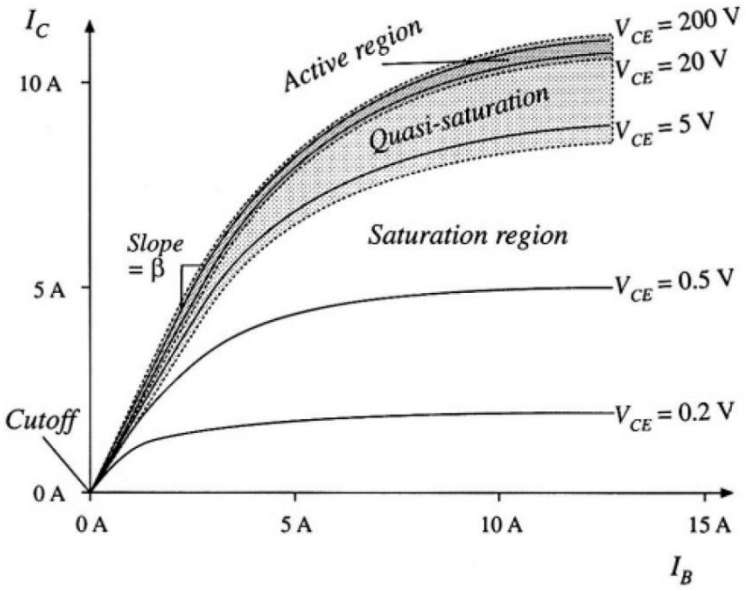
Part number	Rated maximum voltage	Rated average current	R_{on}	Q_g (typical)
IRFZ48	60 V	50 A	0.018 Ω	110 nC
IRF510	100 V	5.6 A	0.54 Ω	8.3 nC
IRF540	100 V	28 A	0.077 Ω	72 nC
APT10M25BNR	100 V	75 A	0.025 Ω	171 nC
IRF740	400 V	10 A	0.55 Ω	63 nC
MTM15N40E	400 V	15 A	0.3 Ω	110 nC
APT5025BN	500 V	23 A	0.25 Ω	83 nC
APT1001RBNR	1000 V	11 A	1.0 Ω	150 nC

Bipolar Junction Transistor

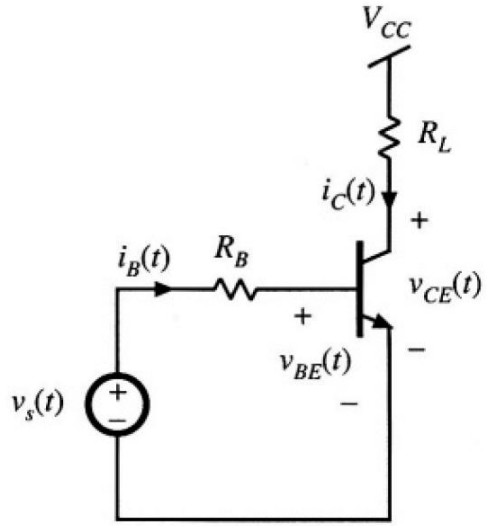


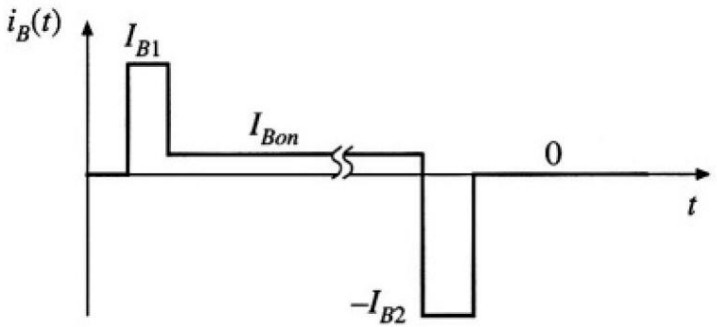


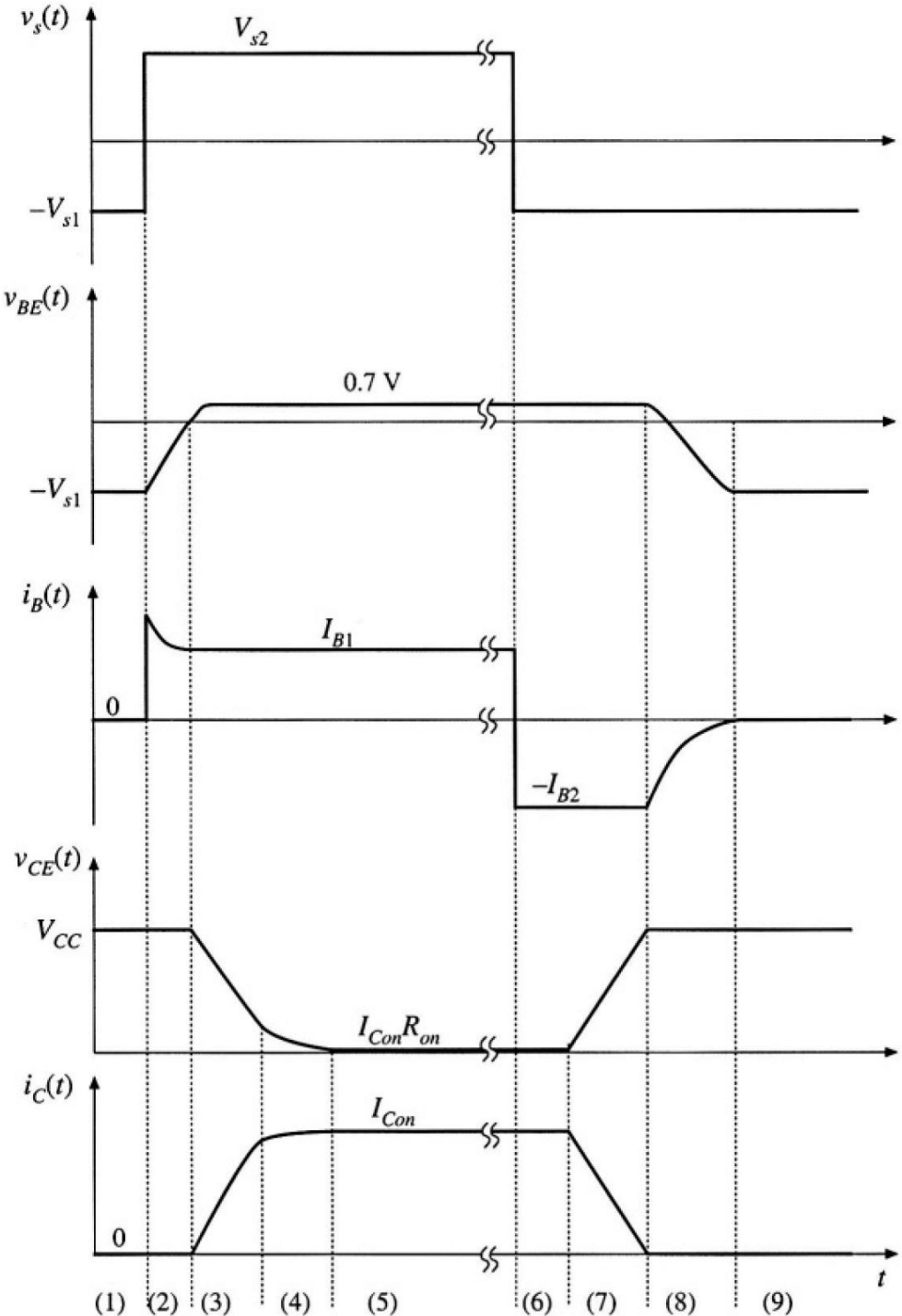




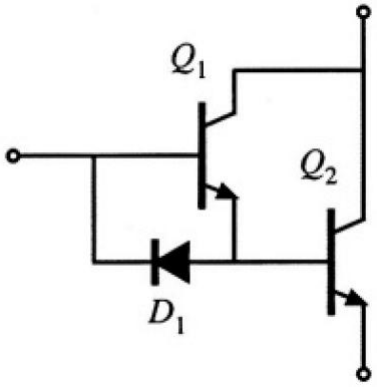
BJT
Timing Properties

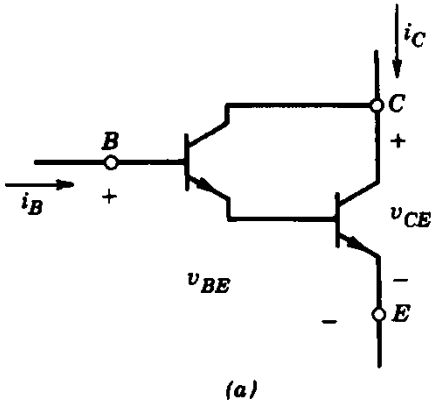




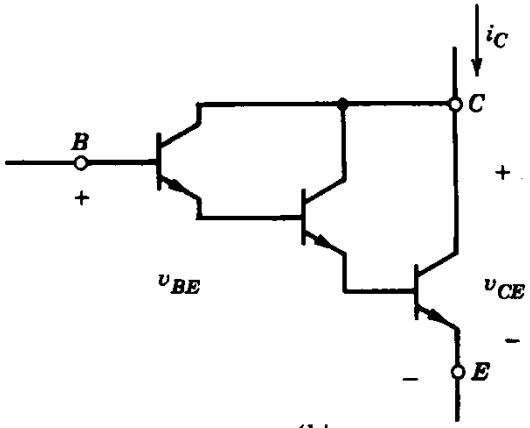


Darlington-Connected BJT



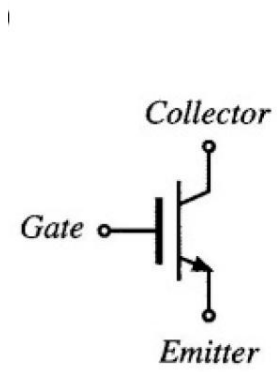


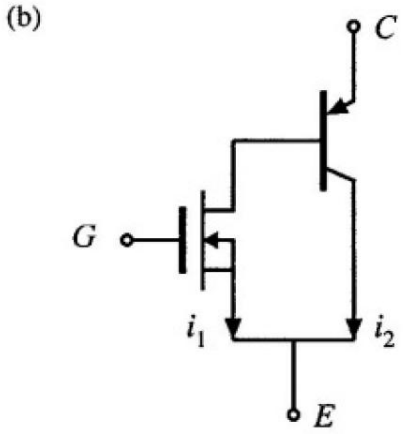
(a)

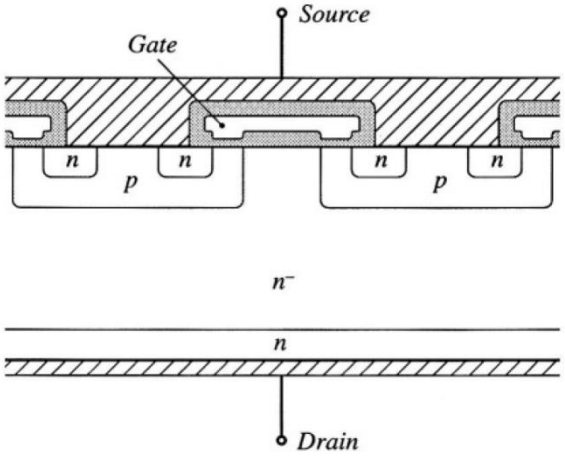


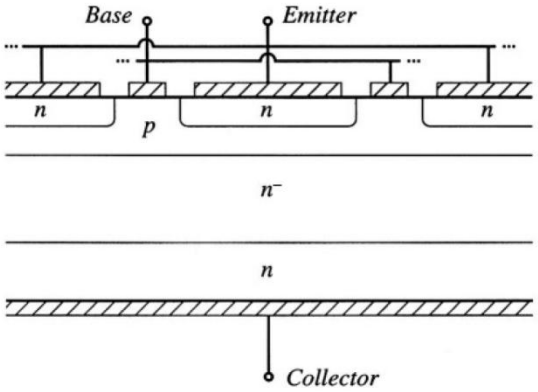
(b)

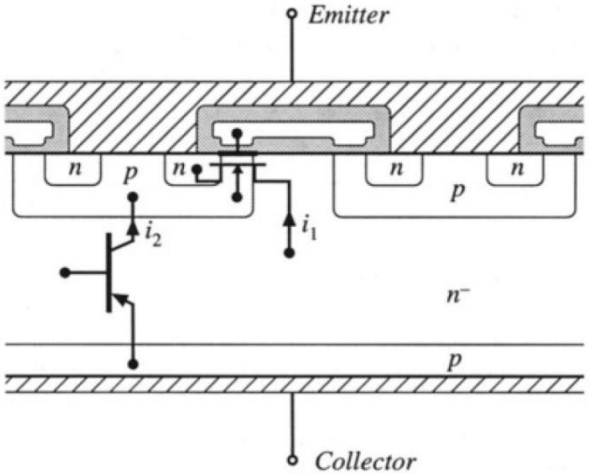
Insulated Gate Bipolar Transistor IGBT



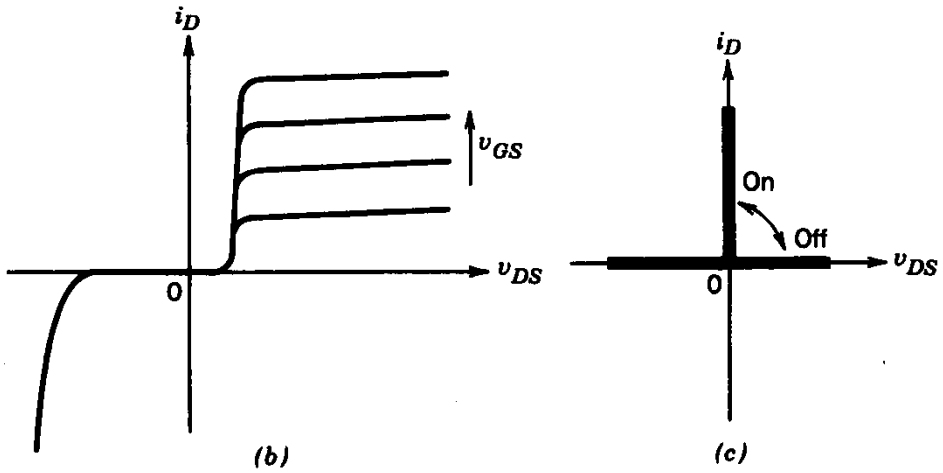






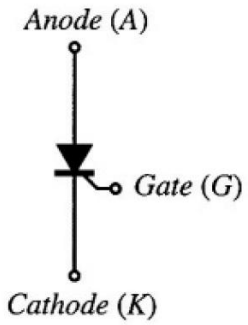


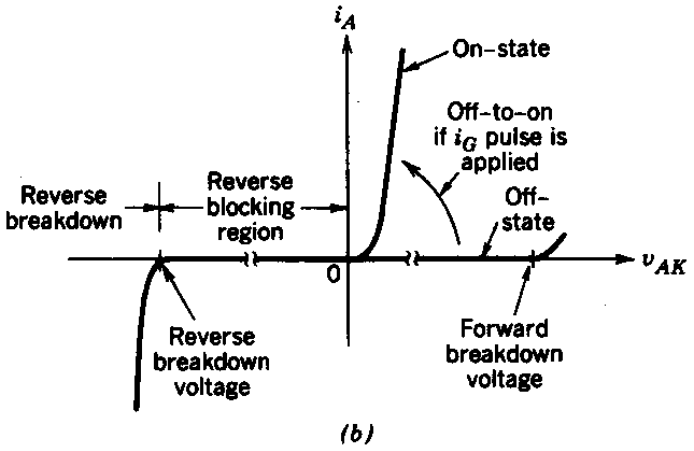
Insulated Gate Bipolar Transistor IGBT

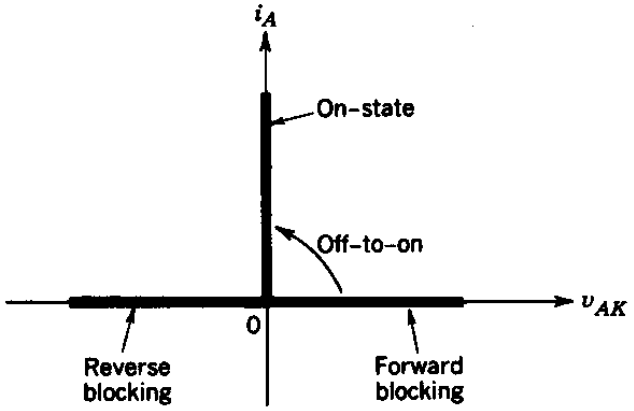


Part number	Rated maximum voltage	Rated average current	V_F (typical)	t_f (typical)
Single-chip devices				
HGTP12N60A4	600 V	23 A	2.0 V	70 ns
HGTG32N60E2	600 V	32 A	2.4 V	0.62 μs
HGTG30N120D2	1200 V	30 A	3.2 V	0.58 μs
Multiple-chip modules				
CM400HA-12E	600 V	400 A	2.7 V	0.3 μs
CM300HA-24E	1200 V	300 A	2.7 V	0.3 μs
CM800HA-34H	1700 V	800 A	3.3 V	0.6 μs
High voltage modules				
CM 800HB-50H	2500 V	800 A	3.15 V	1.0 μs
CM 600HB-90H	4500 V	900 A	3.3 V	1.2 μs

Thyristors

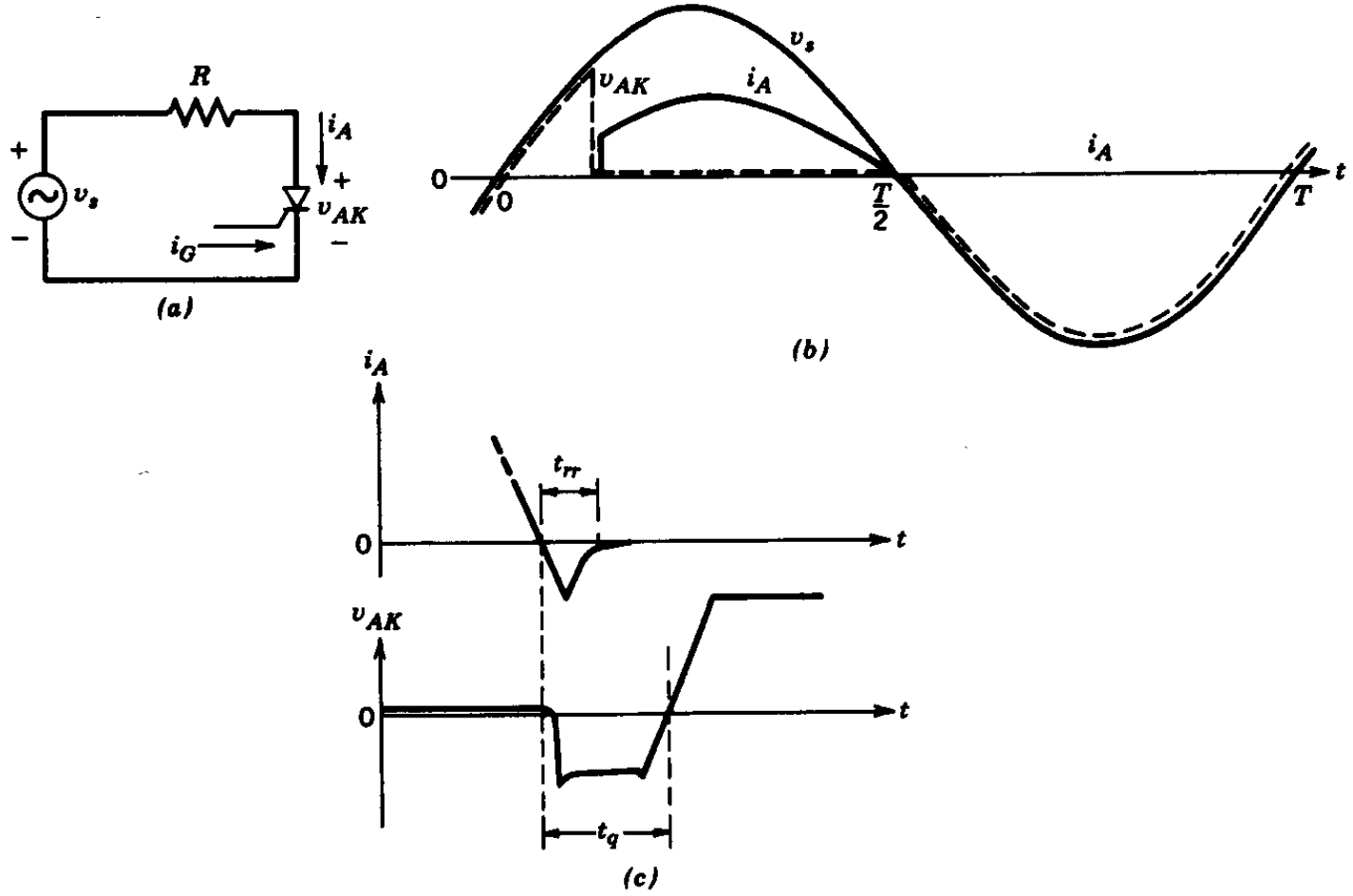




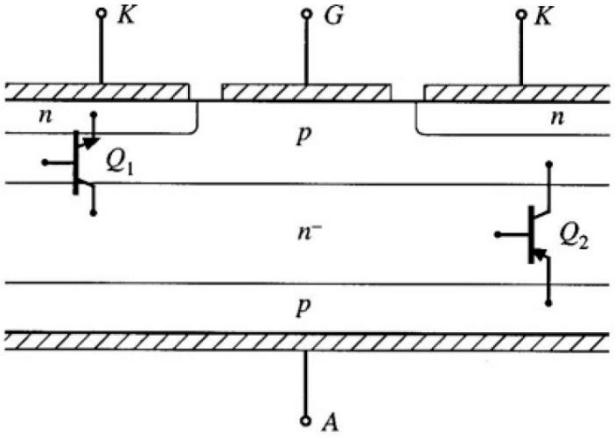


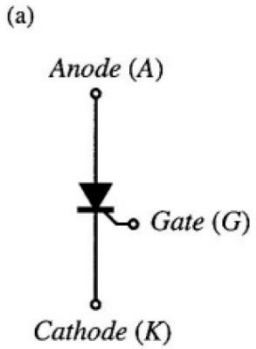
- Silicon Controlled Rectifier
- Gate Turn Off *Thyristor*
- MOSFET Controlled *Thyristor*

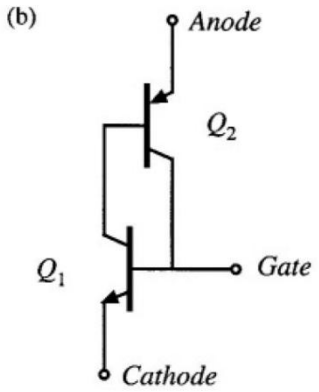
Thyristors



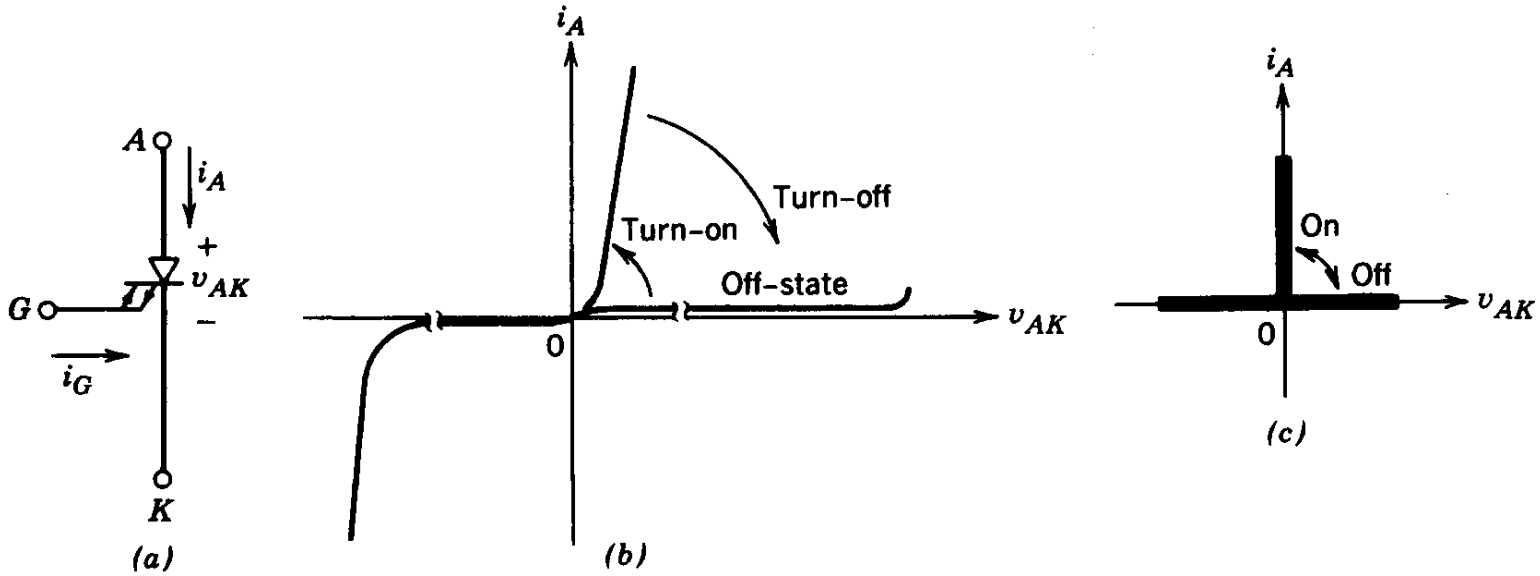
Silicon Controlled Rectifier



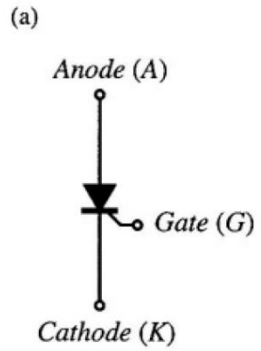


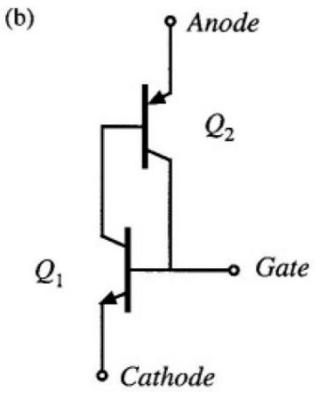


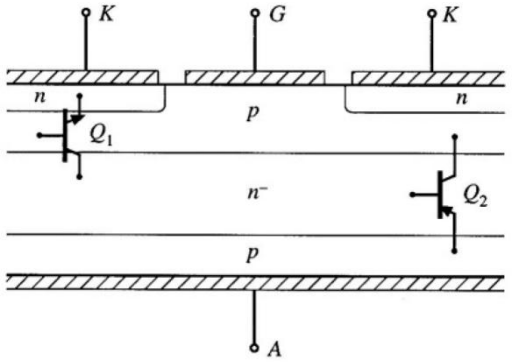
Gate Turn Off *Thyristor*

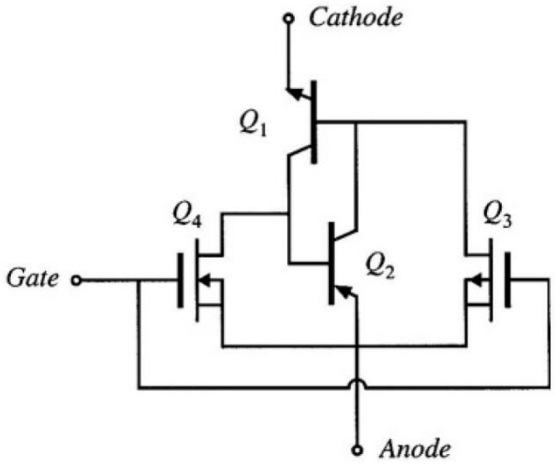


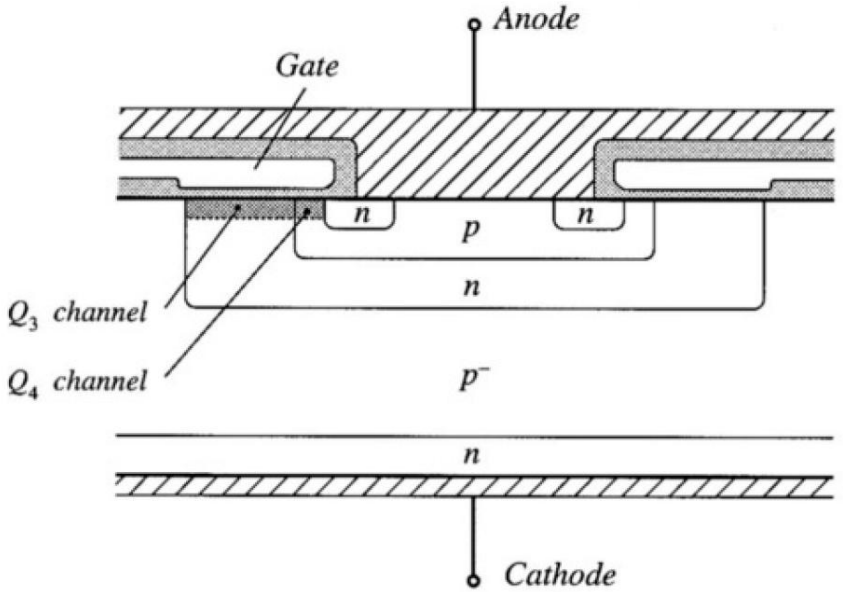
MOSFET Controlled *Thyristor*





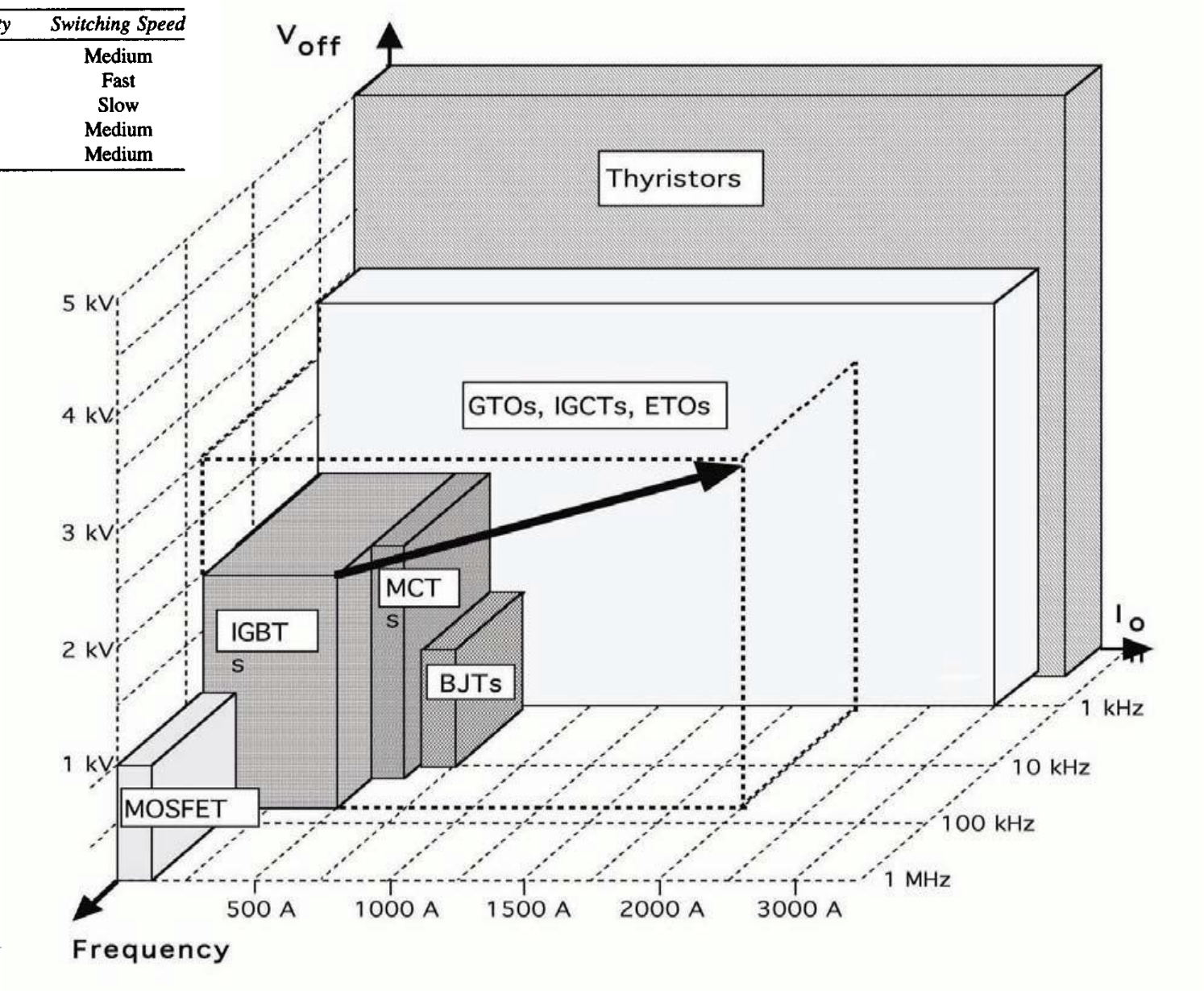






Summary of Device Capabilities

Device	*Power Capability*	*Switching Speed*
BJT/MD	Medium	Medium
MOSFET	Low	Fast
GTO	High	Slow
IGBT	Medium	Medium
MCT	Medium	Medium



Zadanie domowe

- Zaproponować rozwiązania dla układów