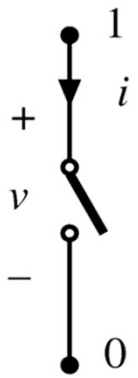
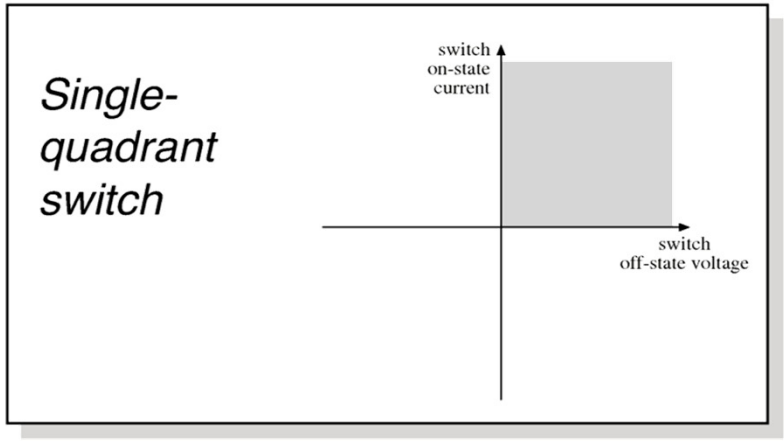
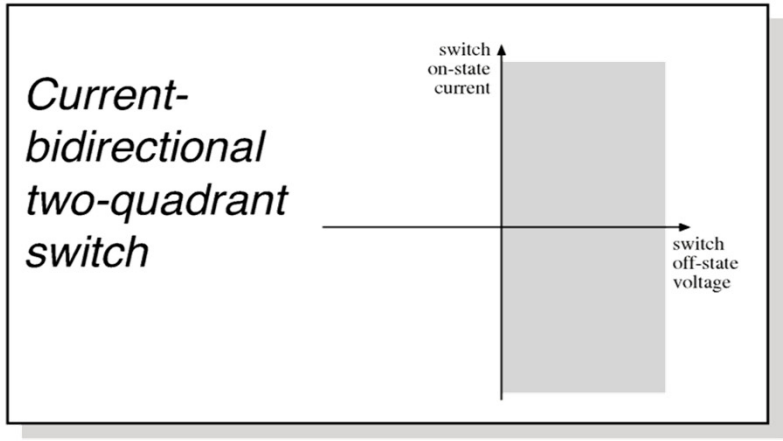
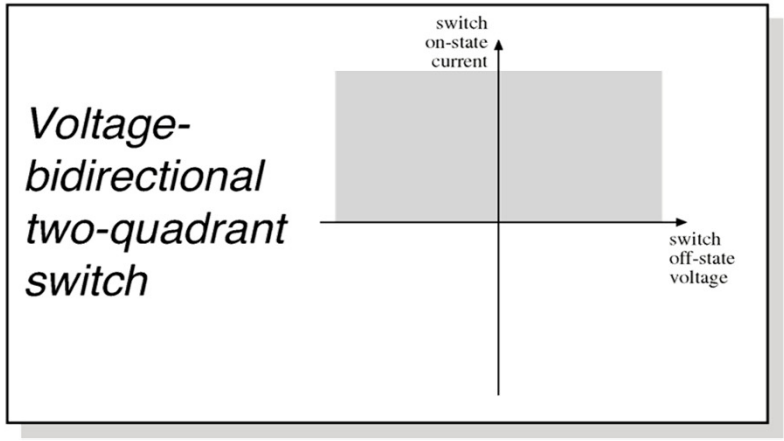
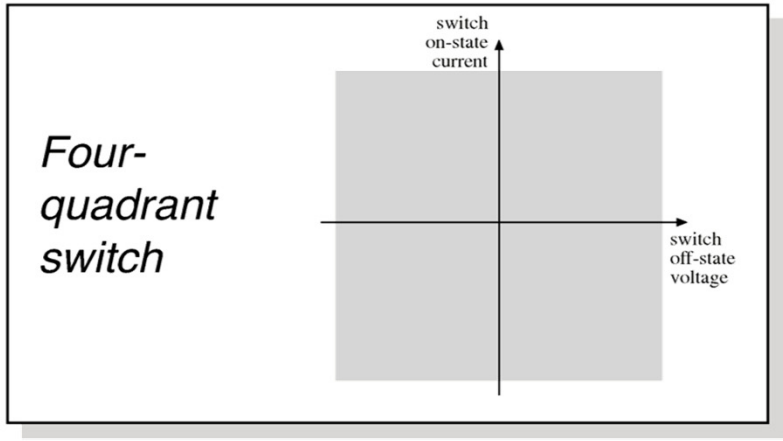
SPST Operating Quadrants



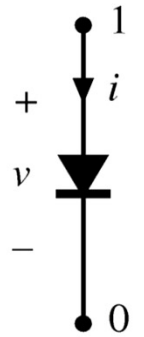




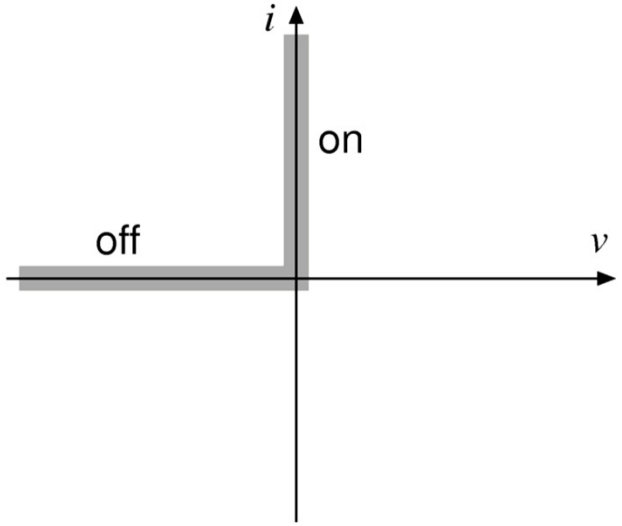




The Diode



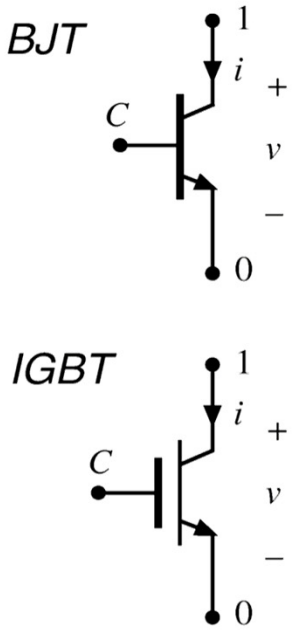
Symbol

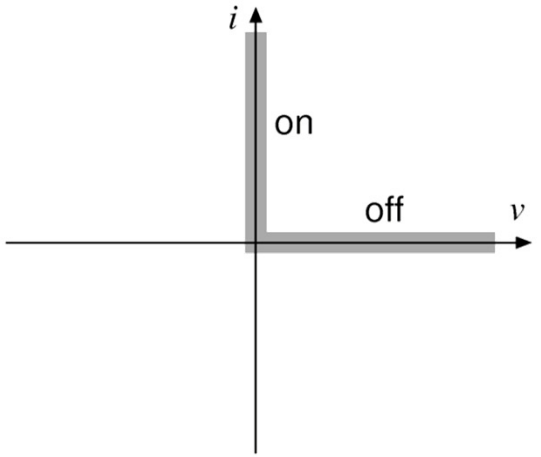


instantaneous i-v characteristic

- *A passive switch*
- *Single-quadrant switch:*
- *can conduct positive on-state current*
- *can block negative off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the diode i-v characteristic, then switch can be realized using a diode*

(Insulated Gate) Bipolar Junction Transistor

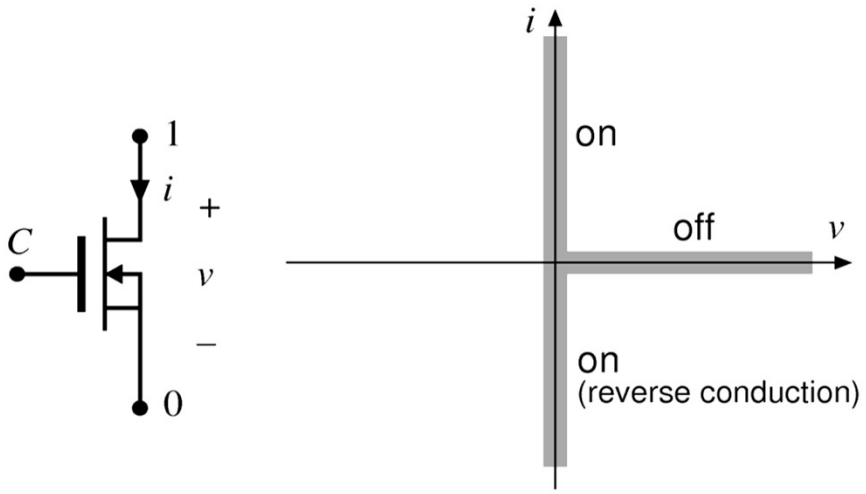




instantaneous i-v characteristic

- *An active switch, controlled by terminal C*
- *Single-quadrant switch:*
- *can conduct positive on-state current*
- *can block positive off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the transistor i-v characteristic, then switch can be realized using a BJT or IGBT*

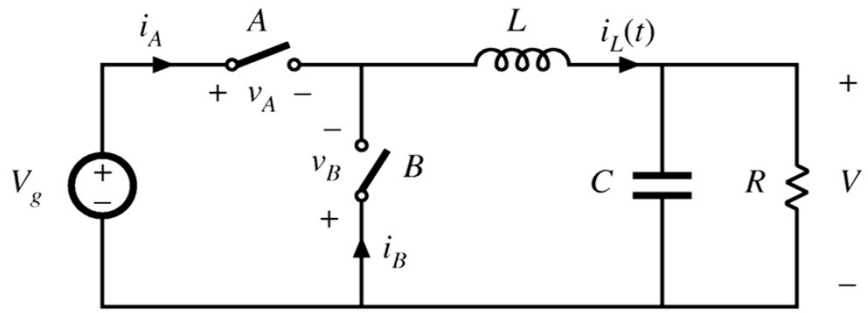
MOSFET



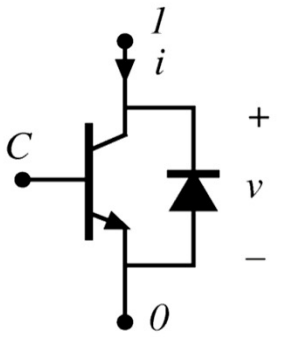
Symbol *instantaneous i-v characteristic*

- *An active switch, controlled by terminal C*
- *Normally operated as single-quadrant switch:*
- *can conduct positive on-state current (can also conduct negative current in some circumstances)*
- *can block positive off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the MOSFET i-v characteristic, then switch can be realized using a MOSFET*

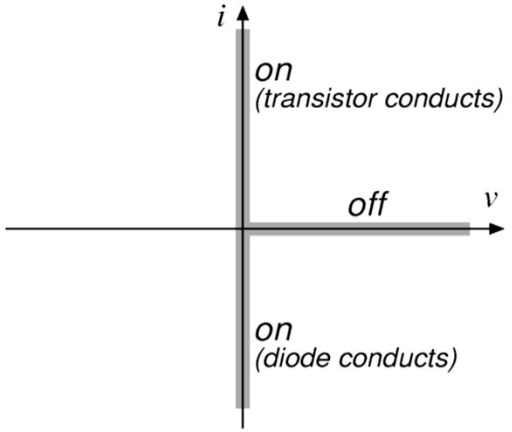
Buck Converter: Switch Realization



Current Bidirectional Two-Quadrant



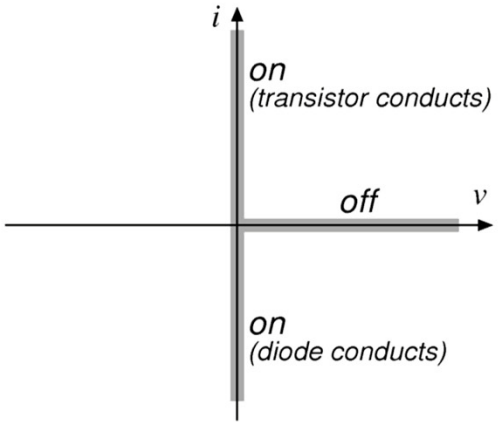
BJT / anti-parallel diode realization



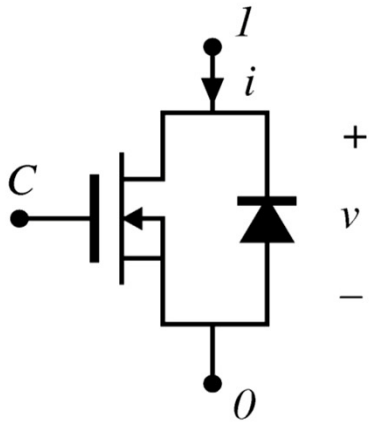
instantaneous i-v characteristic

- *Usually an active switch, controlled by terminal C*
- *Normally operated as two-quadrant switch:*
- *can conduct positive or negative on-state current*
- *can block positive off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the composite i-v characteristic, then switch can be realized as shown*

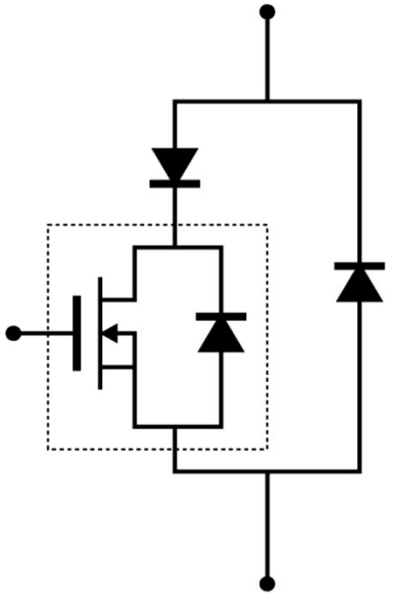
MOSFET Body Diode



Power MOSFET characteristics

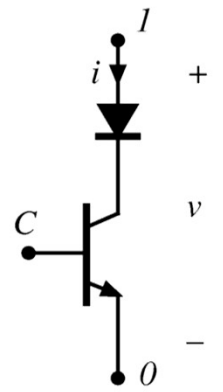


Power MOSFET, and its integral body diode

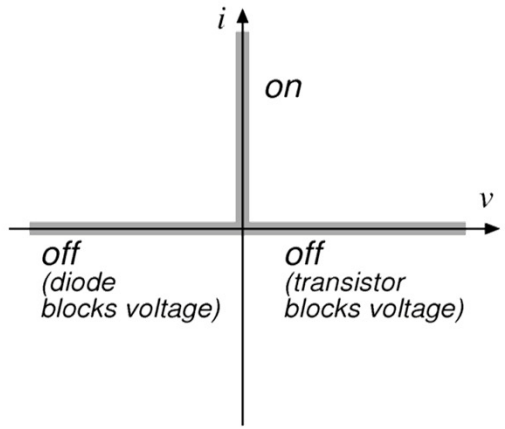


Use of external diodes to prevent conduction of body diode

Voltage-bidirectional Two-Quadrant



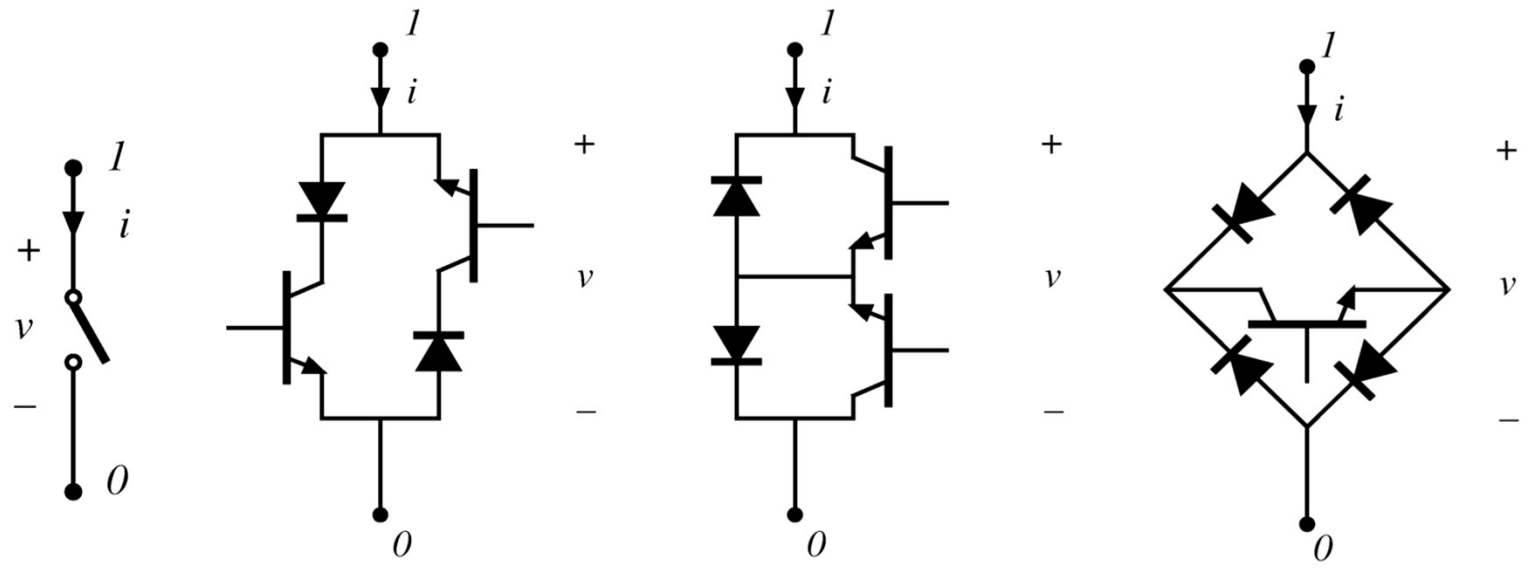
BJT / series diode realization



instantaneous i-v characteristic

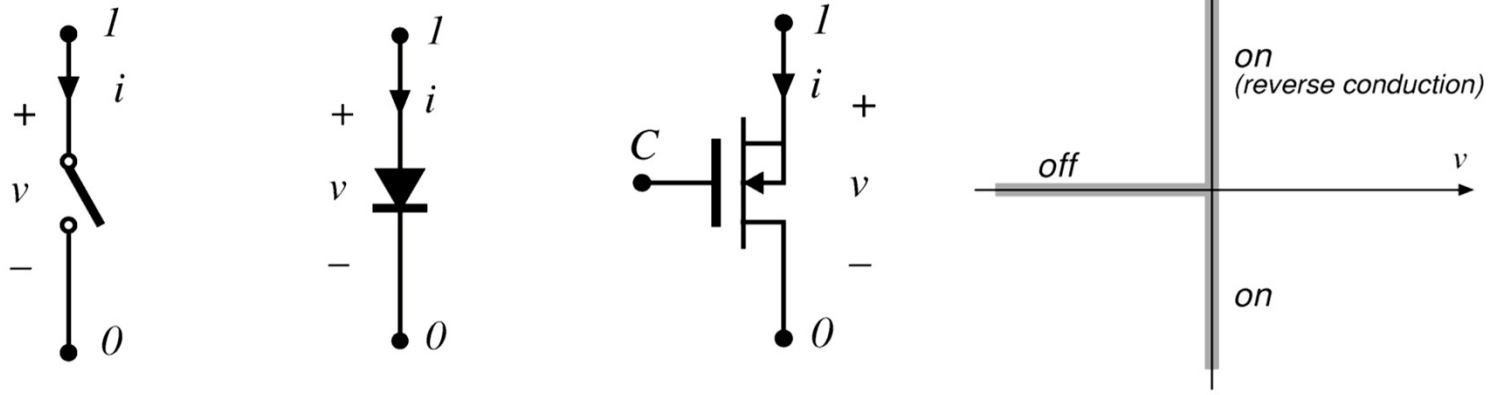
- *Usually an active switch, controlled by terminal C*
- *Normally operated as two-quadrant switch:*
- *can conduct positive on-state current*
- *can block positive or negative off-state voltage*
- *provided that the intended on-state and off-state operating points lie on the composite i-v characteristic, then switch can be realized as shown*
- *The SCR is such a device, without controlled turn-off*

Four-Quadrant Switches



Synchronous Rectifiers

Replacement of diode with a backwards-connected MOSFET,
to obtain reduced conduction loss



ideal switch

conventional diode rectifier

MOSFET as synchronous rectifier

instantaneous i-v characteristic