

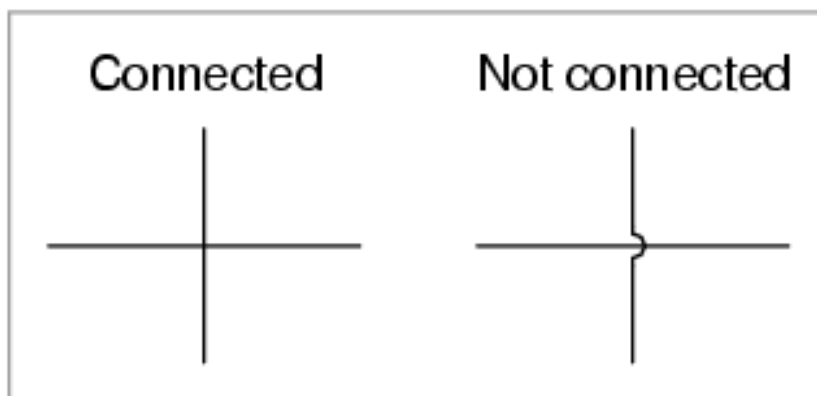
# Chapter 9: Circuit Schematic Symbols

- Wires and connections
- Power sources
- *Resistors*
- *Capacitors*
- *Inductors*
- Mutual inductors
- Switches, hand actuated
- Switches, process actuated
- Switches, electrically actuated (relays)
- *Connectors*
- *Diodes*
- Transistors, bipolar
- Transistors, junction field-effect (JFET)
- Transistors, insulated-gate field-effect (IGFET or MOSFET)
- Transistors, hybrid
- *Thyristors*
- Integrated circuits

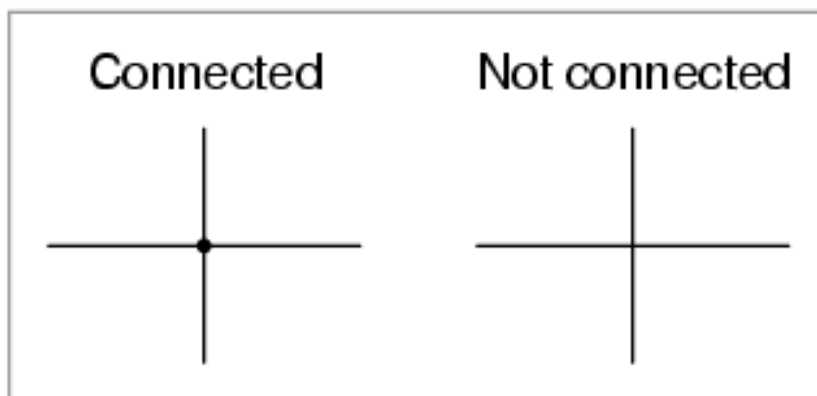
- Electron tubes

## Wires and connections

### Older convention



### Newer convention

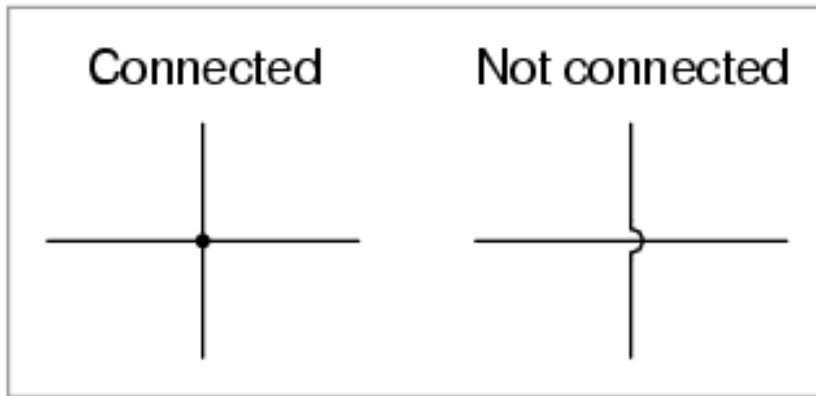


Older electrical schematics showed connecting wires crossing, while non-connecting wires "jumped" over each other with little half-circle marks. Newer electrical schematics show connecting wires joining with a dot, while non-connecting wires cross with no dot. However, some people still use the older convention of connecting wires crossing with no dot, which may create confusion.

For this reason, I opt to use a hybrid convention, with connecting wires unambiguously connected by a dot, and non-connecting wires unambiguously "jumping" over one another with a half-circle mark. While this may be frowned upon by some,

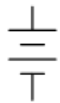
it leaves no room for interpretational error: in each case, the intent is clear and unmistakable:

### Convention used in this book



## Power sources

DC voltage



DC voltage



AC voltage

Variable  
DC voltage

*A diagonal arrow  
represents variability  
for **any** component!*

DC current



Generator



AC current



## Resistors

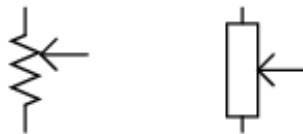
Fixed-value



Rheostat



Potentiometer



Tapped



Thermistor

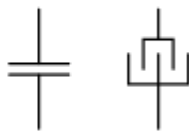


Photoresistor

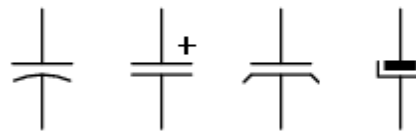


## Capacitors

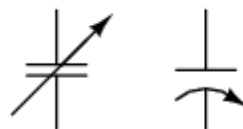
Non-polarized



Polarized (top positive)



Variable



## Inductors

Fixed-value



Iron core



Variable



Variac

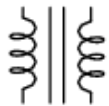


Tapped

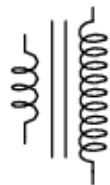


## Mutual inductors

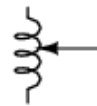
Transformer



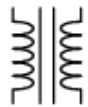
Step-up/step-down transformer



Variac



Transformer



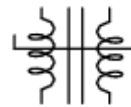
Transformer



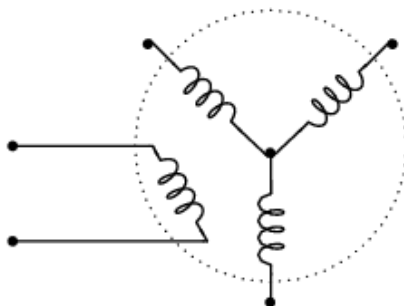
Transformer



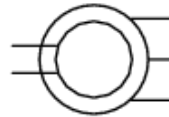
Saturable reactor




Synchro



Synchro




## Switches, hand actuated




SPST toggle  
*normally open*




DPST toggle



Pushbutton  
*normally open*



SPST toggle  
*normally closed*



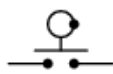
DPDT toggle




Pushbutton  
*normally closed*



SPDT toggle



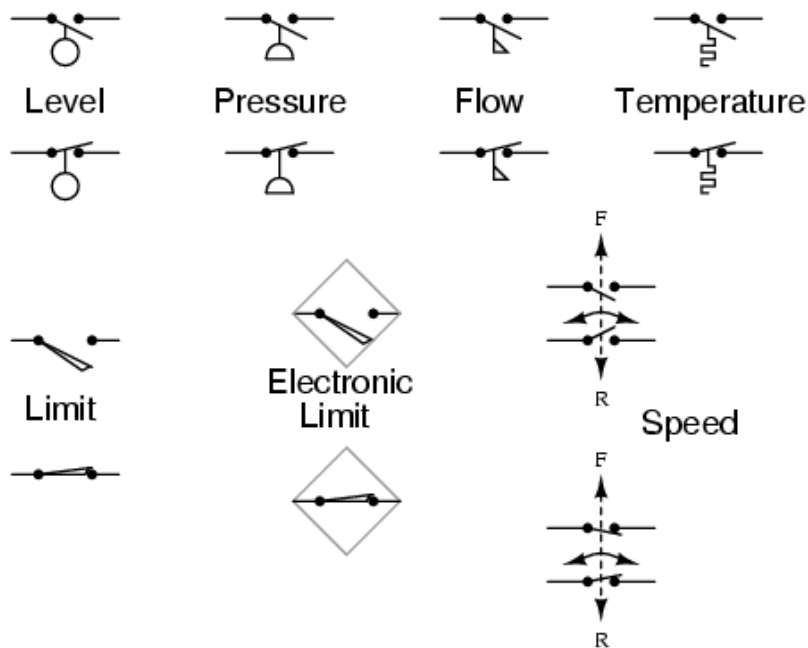
SPST joystick  
*position of dot  
on circle indicates  
joystick direction*



4PDT toggle

## Switches, process actuated

*Normally open shown on top; normally closed on bottom*



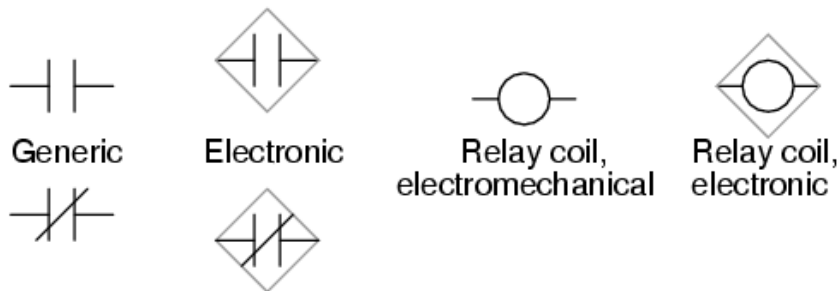
It is very important to keep in mind that the "normal" contact status of a process-actuated switch refers to its status when the process is absent and/or inactive, *not* "normal" in the sense of process conditions as expected during routine operation. For instance, a *normally-closed* low-flow detection switch installed on a coolant pipe will be maintained in the actuated state (open) when there is regular coolant flow through the pipe. If the coolant flow stops, the flow switch will go to its "normal" (unactuated) status of closed.

A *limit* switch is one actuated by contact with a moving machine part. An *electronic limit* switch senses mechanical motion, but does so using light, magnetic fields, or other non-contact means.



## Switches, electrically actuated (relays)

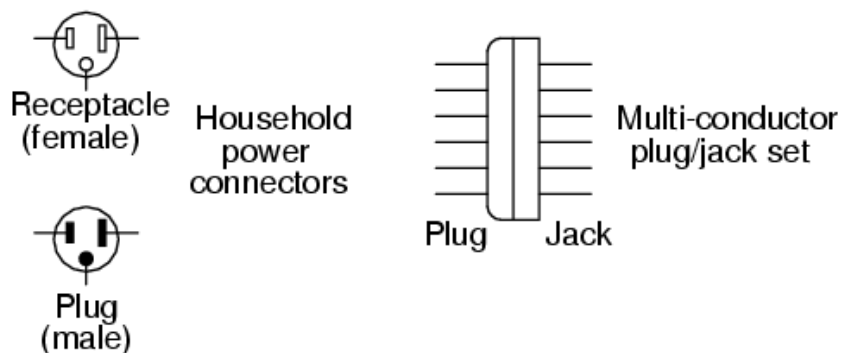
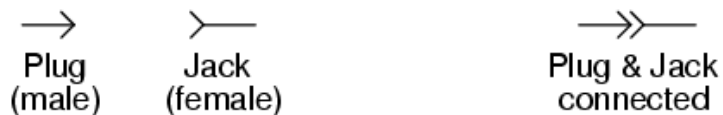
*Relay components, "ladder logic" notation style*



*Relays, electronic schematic notation style*



## Connectors



## Diodes

Generic



Schottky



Shockley



Constant current



Zener



Light-emitting



Photo-



Step recovery



Tunnel



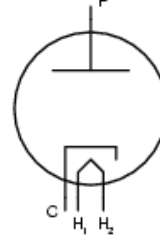
Varactor



PIN



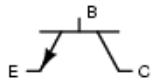
Vacuum tube



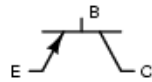
A = Anode  
K = Cathode

## Transistors, bipolar

Bipolar NPN



Bipolar PNP



... with case

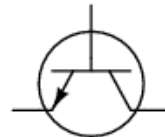
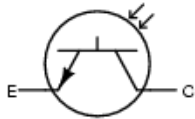
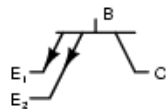


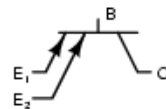
Photo-



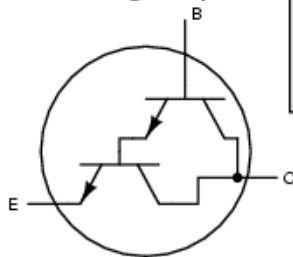
Dual-emitter NPN



Dual-emitter PNP

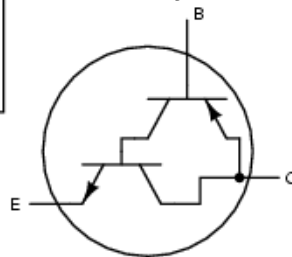


Darlington pair



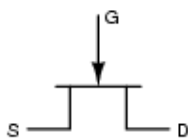
E = Emitter  
B = Base  
C = Collector

Sziklai pair

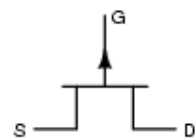


## Transistors, junction field-effect (JFET)

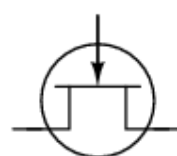
N-channel



P-channel

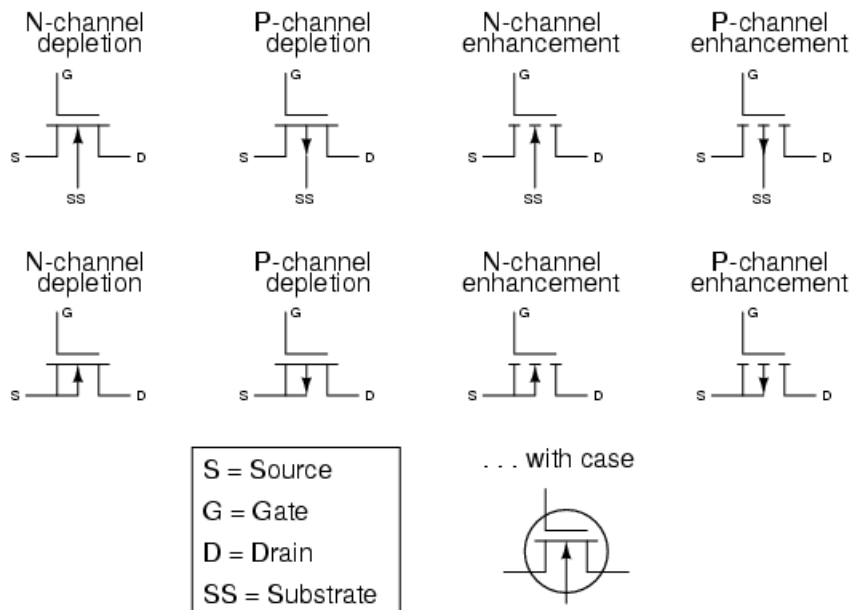


... with case



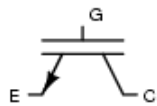
S = Source  
G = Gate  
D = Drain

## Transistors, insulated-gate field-effect (IGFET or MOSFET)

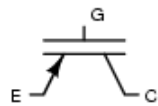


## Transistors, hybrid

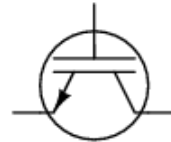
IGBT (NPN)



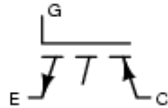
IGBT (PNP)



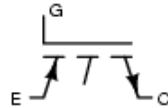
... with case



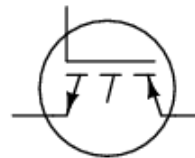
IGBT (N-channel)



IGBT (P-channel)



... with case



<p>E = Emitter</p> <p>G = Gate</p> <p>C = Collector</p>
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## Thyristors

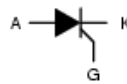
Shockley



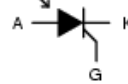
DIAC



SCR



LASCR



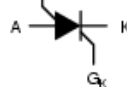
TRIAC



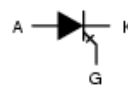
Opto-TRIAC



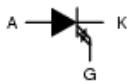
SCS



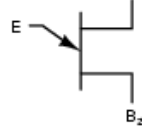
GCS



GTO



UJT



A = Anode

K = Cathode

G = Gate

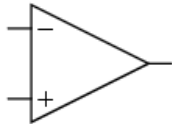
MT = Main Terminal

E = Emitter

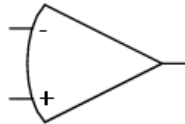
B = Base

## Integrated circuits

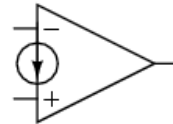
Operational amplifier



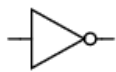
(alternative)



Norton op-amp



Inverter



AND gate



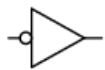
OR gate



XOR gate



Inverter



NAND gate



NOR gate



XNOR gate



Buffer



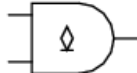
Negative-AND gate



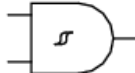
Negative-OR gate

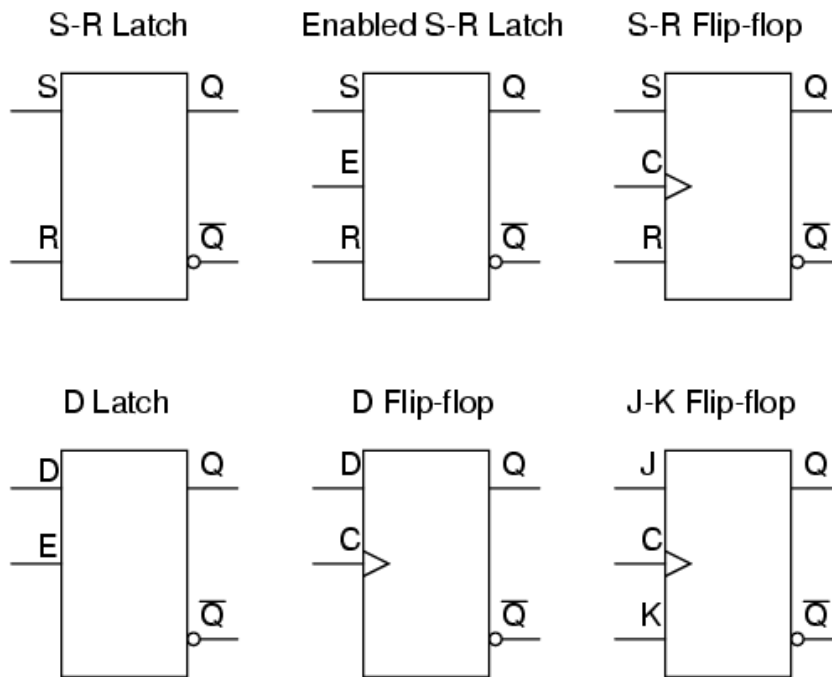


Gate with open-collector output



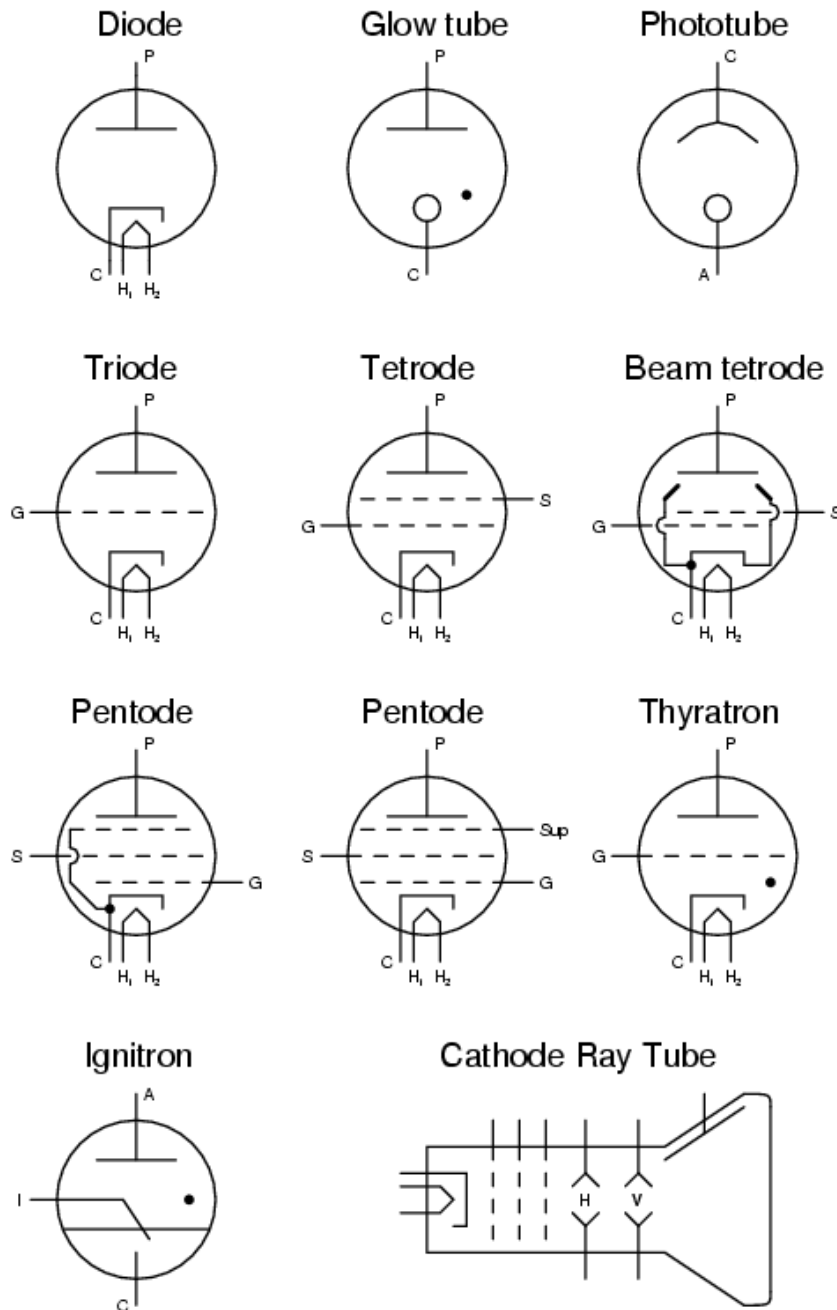
Gate with Schmitt trigger input







## Electron tubes



P = Plate	S = Screen
G = Grid	A = Anode
C = Cathode	H = Heater
I = Ignitor	Sup = Suppressor

