Sequential Process Control

A process in which one event follows another until a job is completed

For a process with N steps

Event 1 → Event 2 → ........ → Event N

**Characteristics**

1.) Discrete loads
2.) Product output is in units (cans boxes)
3.) Different equipment modifies the product at each step
4.) Steps are staged (do step 1 before 2)
Applications

Assembly Line process
Conveyor systems
Industrial Robots
Power protection systems
Motor starting and control
Sequential Vs Process Control

Feedback is continuous. Controller could be implemented with analog or digital control (DSP) methods.

Sequential Control: Status I/O typically bi-level (on-off) in nature.
Devices Used in Sequential Control

**Inputs:** Manually Operated Switches

- **toggle switches** - multiple poles multiple positions (on/off)
- **selector switches** - sets different operating modes (on/off/auto)

**Schematic symbols**

- Single pole single throw (SPST)
- Single pole double throw (SPDT)
- 3-pole double throw

**Drawing standard - switches shown in the un-operated or open position**

On B

On A

On B

On A

DPDT
dashed line
indicates mechanical links
Inputs-Manually Operated Switches

**Push Buttons** - momentary contact switches

Push buttons can be either normally open (NO) or normally (NC). Some types can be stacked to have multiple sets of NO and NC contacts.

**Schematic symbols**

- Actuated
- Normally closed ganged with normally open
- Normally open NO
- Normally closed NC

Depressing the button causes all associated contacts to change state. Drawn in un-actuated position.

Push buttons usually used to start and stop pieces of equipment in industrial operation.
Mechanically Operated Switches

Switches used to sense the operation of devices

**Limit switches** - switches that change contact state when there is movement. Detect if part of machine has reached a specific location. Usually physically linked to machine.

**Types**
- **Contact type** - roller arm, wand type
- **Proximity type** - detect ferrous and non-ferrous metals
Mechanically Operated Switches

Limit Switches

Schematic symbols

- NC limit switch
- NO limit switch
- NO held closed limit switch

Limit switches can have multiple contacts of both NO and NC type that change state when actuated.

Drawing standard - switch drawn in the un-operated position.
Mechanically Operated Switches

Used as sensors to detect conditions of operation

**Temperature switches** (similar to thermostat)

- NO
- NC

**Pressure switches**

- NC
- NO

**Level or float switches**

- NC
- NO

**Flow Switch**

(NO)

changes state when flow reaches preset value (can produce pulses proportional to flow)
Control Devices

**Control Relays** - implement Boolean logic using electromechanical relays and contacts.

Schematic symbols

Drawing convention: control relay contacts shown with coil de-energized. Contacts associate with coil have similar identification.

Coils and contacts need not be located together physically **on schematic**

**Control Relay Characteristics**
Coil voltage, current type (ac, dc), power consumption, pull-in power, I/V ratings of contacts, coil time constant
Control Relay Characteristics

**Coil voltage** - operating range (+110% -80%)
  typical values - 24, 48, 125 250 Vdc
  48 120, 480 Vac

Low supply voltage causes relays to "drop out"

**Coil Power** - given in VA. Determine power capacity of supply.
  typical 50 - 100 VA per coil

**Pull-in Power** - power necessary to move relay armature and close contacts.
Pull-in Power and In-Rush Current

When energized, coil requires 7-10 times rated (Reluctance high due to air gap)
Electromechanical Timers/Counters

Schematic symbols: note either coil type is used

On-delay action - TR **energized**, contacts change state after set time interval

Off-delay action - TR **de-energized**, contacts change state after set time interval

On-delay timer
Off-delay timer

Contact symbols determine the type of timer action
Electromechanical Counters

Typically have three connections on schematic symbol for coil. Takes pulse input (contact closures) from other devices.

Schematic symbols

Contacts CTR change state after the preset number of counts are accumulated by CTR coil symbol

CTR device may also take a reset input that clears counter.
Final Control Devices

**Solenoid** - electromechanical device which uses a movable iron core to actuate another device

typical applications - valve control (liquid, pneumatic hydraulic)

Schematic Symbol
Final Control Devices

Motor Controllers - integrate switching with thermal overload protection

Schematic symbol

3-phase motor

control coil

thermal overloads
Basic Motor Control

Thermal overloads result from:

1.) Attempting to drive mechanical load greater than motor rating
2.) High inertia loads with long acceleration times
3.) Motor mechanically unable to turn
4.) Low motor terminal voltage
5.) Excessive starting and stopping (jogging) (heat build-up due to high I)
6.) Loss of one of the three phases (single phasing)
Miscellaneous Devices

Panel Lights - Incandescent or LED

- fuse
- white
- green
- red
- Size in amps indicated near symbol
- used to prevent moisture buildup and component icing in outdoor equipment

heater

Resistor
Ladder Diagrams

Circles on each side of contact indicate that it is physically separate from the other devices in the schematic.