Lesson 14: Introduction To Sequential Control

ET 438B  Sequential Control and Data Acquisition
Department of Technology

Learning Objectives

After this presentation you will be able to:

➢ Explain how sequential control differs from feedback control
➢ List applications of sequential
➢ Identify schematic symbols commonly found on sequential control diagrams
➢ List types of input and output devices used in sequential control systems
➢ Read and interpret ladder diagrams.
**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
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.
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 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
Limit switches can have multiple contacts of both the NO and NC type that change state when actuated.

Drawing standard - switch drawn in the un-operated position.

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Control Devices

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

Schematic symbols

- NO contact
- NC contact

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.

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**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.
When energized, coil requires 7-10 times rated (Reluctance high due to air gap)

- **Pull-in Power and In-Rush Current**

- **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.

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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

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Basic Motor Control

Starter matched to motor by NEMA (National Electrical Manufacturers Association) size

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
- Heater
- Used to prevent moisture buildup and component icing in outdoor equipment

**Ladder Diagrams**

- Rung Number
- Inputs
- Outputs
- Description
- DC Motor
- Control
- 115 Vac

Circles on each side of contact indicate that it is physically separate from the other devices in the schematic.
End Lesson 14: Introduction To Sequential Control

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