Fundamentals of DDC

Programming Tools

Presented by:
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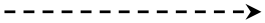
Block Objective

The goal of this section is to introduce the most common logical blocks that are necessary to describe most HVAC control sequences. A standard symbology will be developed for use in the applications portion of the course. In addition, symbols will be introduced for program flow.

Programming Tools

- **Programming Tools are the logical software blocks that perform different functions to create an overall control strategy**
  - **Information Flow/Tags**
  - **Control Models**
    - **Time based control models**
  - **Digital Logic**
  - **Switches**
  - **Math Functions and Models**
  - **Special hardware models**
  - **Programming Issues**

Information Flow/Tags

- Analog data flow shown by solid line 
- Digital (1/0) shown by dashed line 
- Constants shown in hexagon 

- Tags to bring data elsewhere in logic are shown in trapezoids 

- Software/Virtual/Memory Storage points are shown in cubes 
- Alarms are shown as follows 

- Messages are shown as follows 

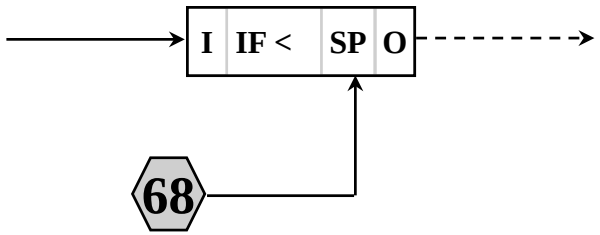
- Graphic/User interface are shown as follows 

Control Models

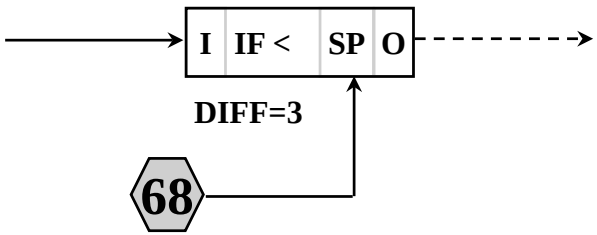
- **Two Position**
  - **Based on Analog Input exceeding SP**
  - **Based on Time meeting a schedule**
- **Floating**
  - **True Floating**
  - **Proportional Control with Two Digital Outputs**
- **Proportional Integral Derivative (PID)**
  - **One Mathematical Model**
  - **Proportional Only (Zero Integral & Derivative Terms)**
  - **Proportional Integral, PI (Zero Derivative Term)**
  - **Proportional Integral Derivative, PID**

Two Position

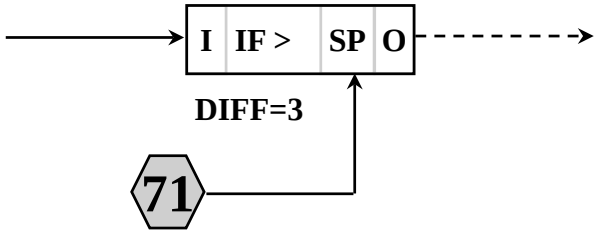
- Functions as an “If the input is greater than or less than a SP” than generate an output of 1
- Output is a zero when the input is below/above the SP plus the differential
- Output stays the same if the input is below/above the SP but not below/above the differential



Two Position Logic Symbols



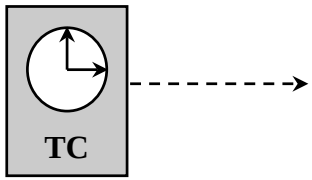
1 = Heat
0 = No Heat



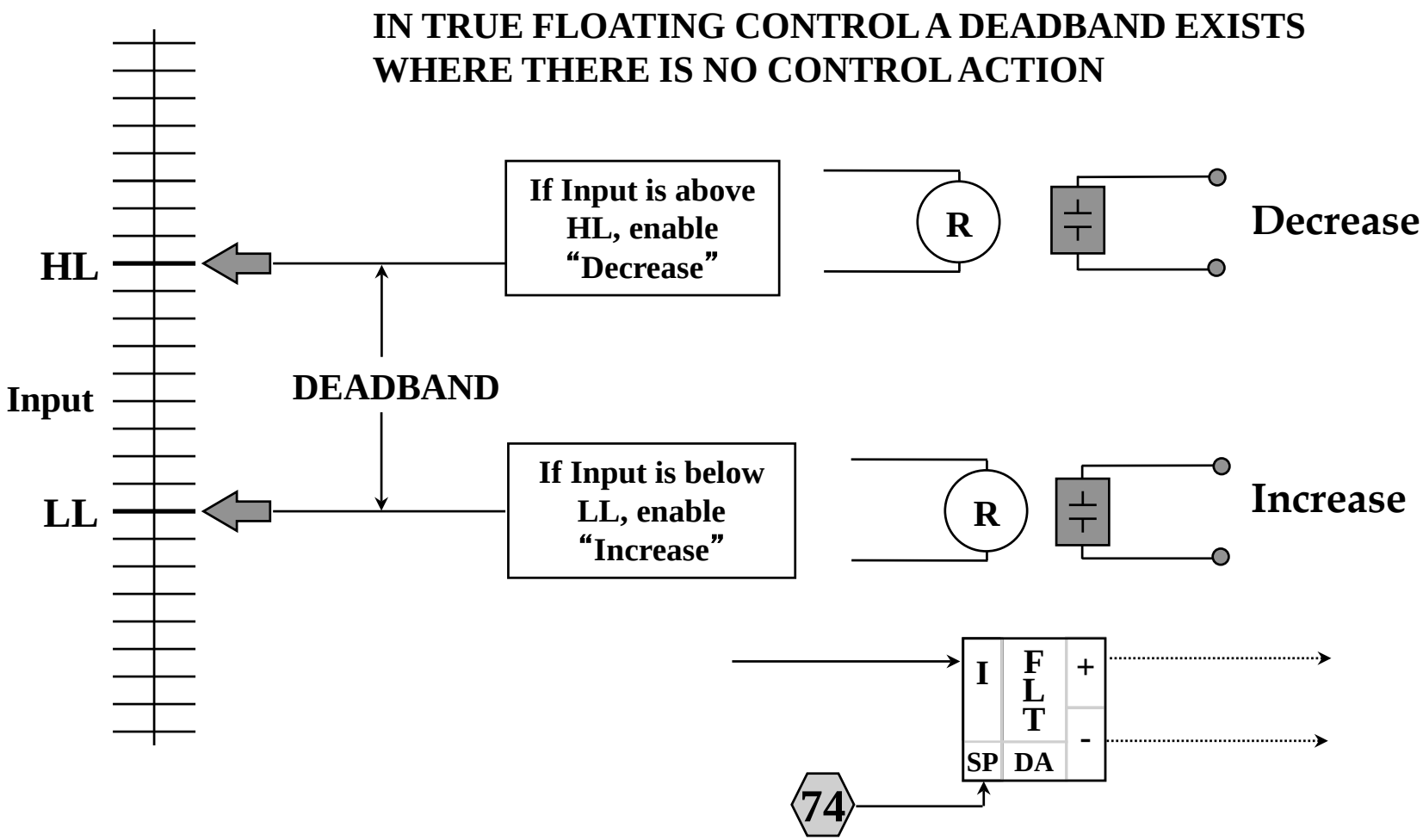
1 = No Heat
0 = Heat

Two Position Time Based Control

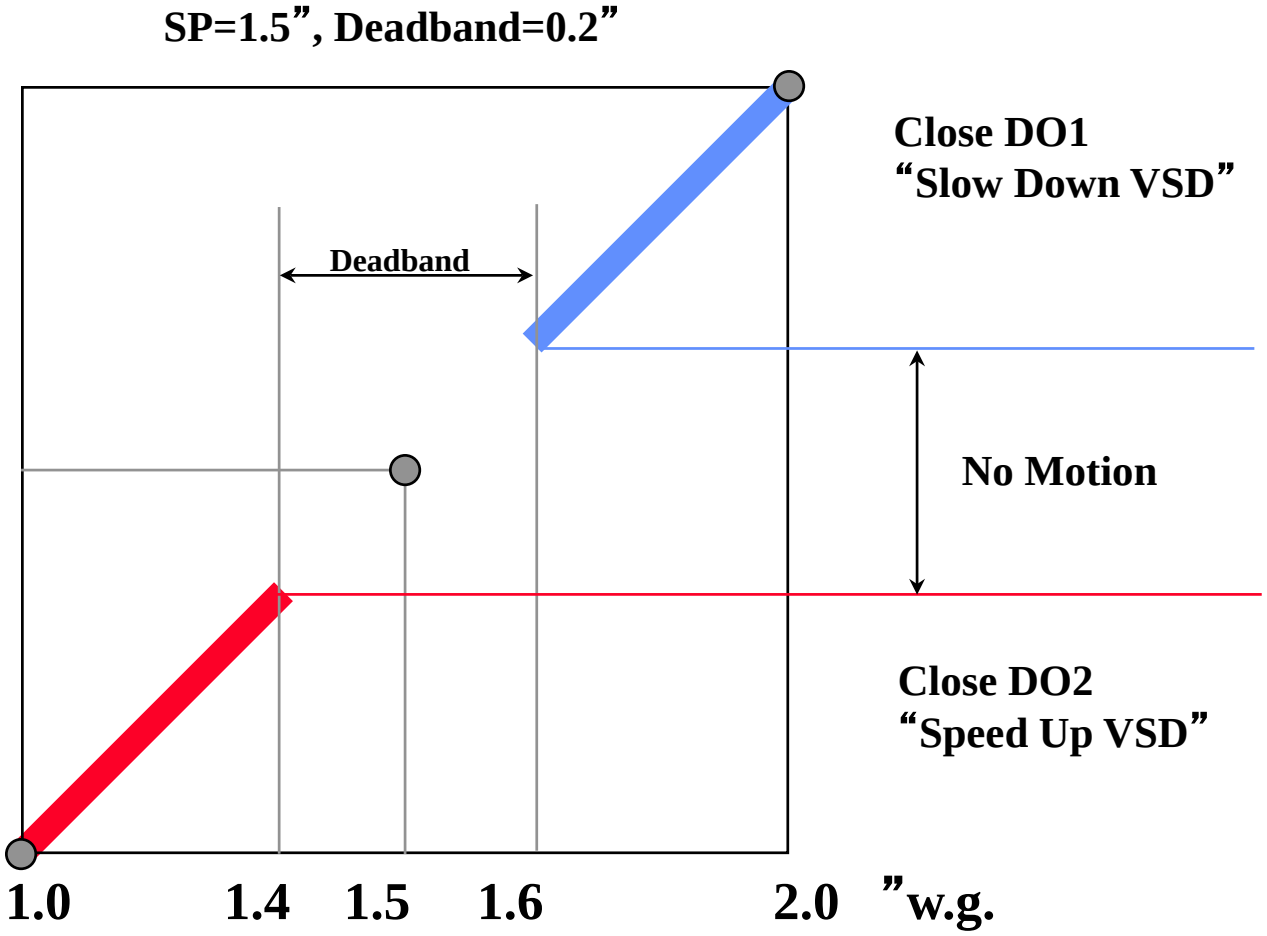
- Simple time schedules
  - Basic
  - Special
  - Temporary
- Priority
  - Temporary is highest (manual override)
  - Special or holiday schedules next, (date specific)
  - Regular schedule is lowest priority



“True Floating” Control

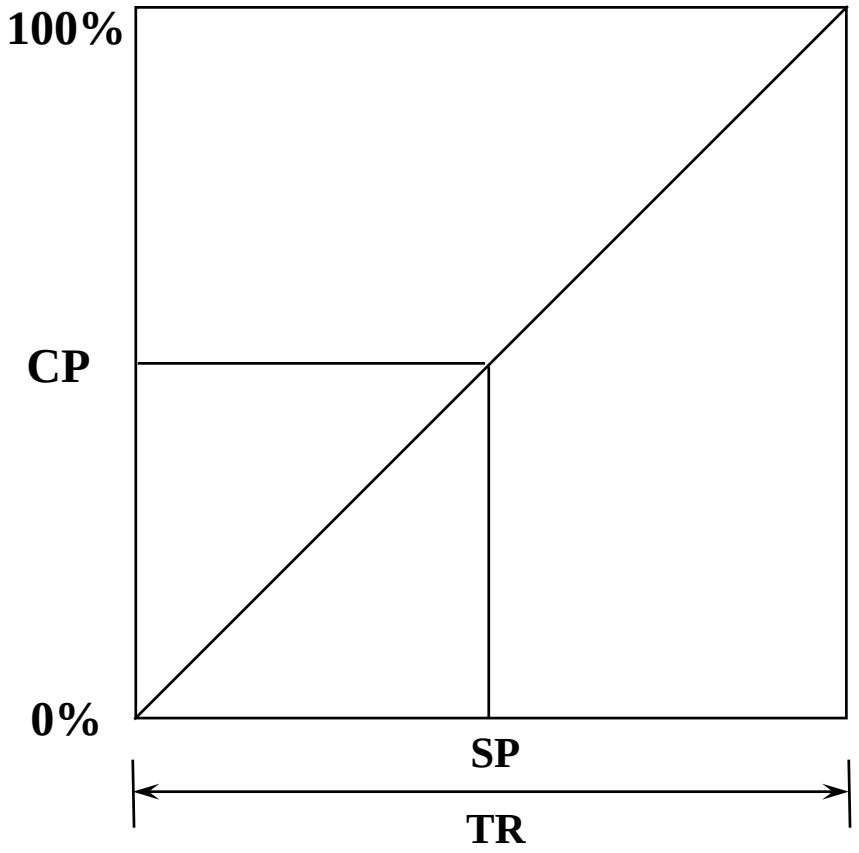


“True Floating” Control



PID Control Model

- **Proportional Control**
  - **Setpoint**
  - **Calibration Point**
  - **Throttling Range**
  - **Action**



PID Control Model

- **Proportional Only**

$$\%\text{Travel} = \underbrace{CP + [PG \times E]}_{\text{P Term}} + \underbrace{\left[IG \int_0 Edt\right]}_{\text{I Term}} + \underbrace{DG \times \frac{dE}{dt}}_{\text{D Term}}$$

CP = Calibration Point

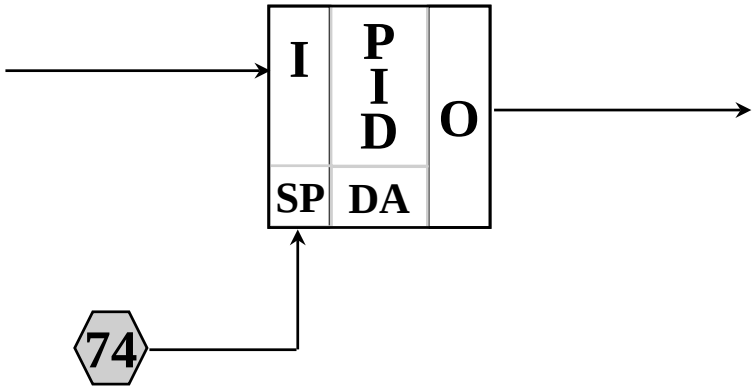
PG = Proportional Gain

E = Error

IG = Integral Gain

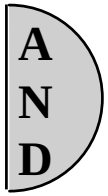
DG = Derivative Gain

$$\%\text{Travel} = P + I + D$$



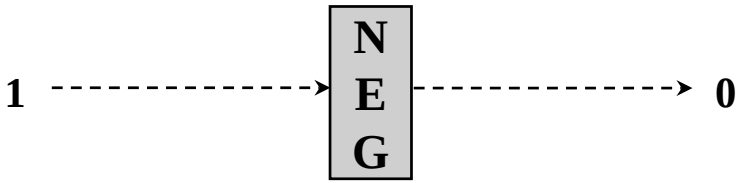
Digital Logic

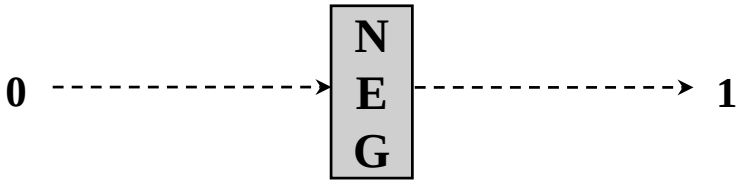
- Logical AND



- Logical OR

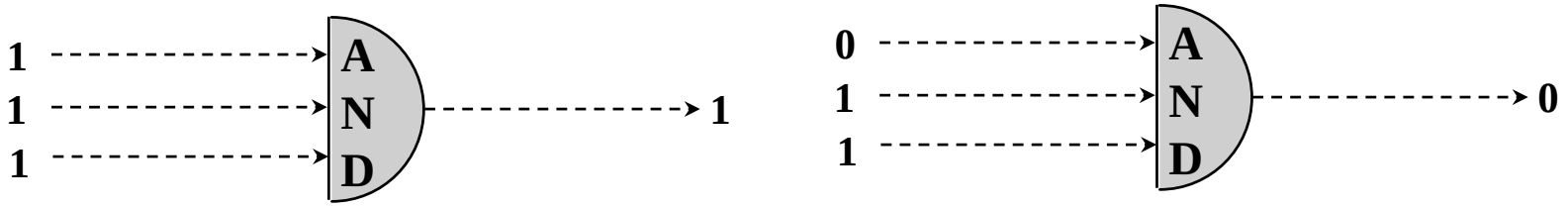
- Logical NOT



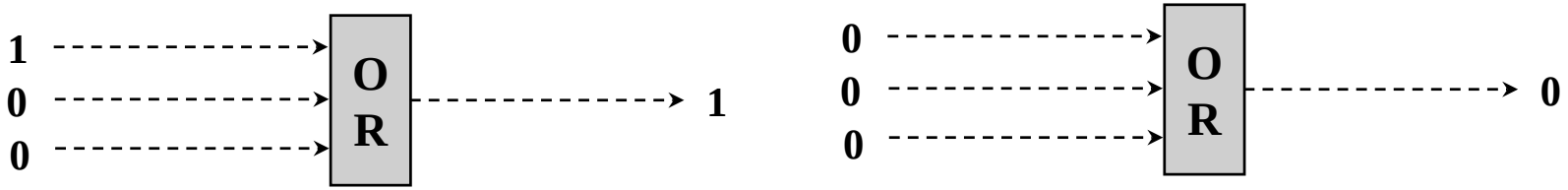


Logical AND & OR

- Output is 1 if all inputs are 1
- Output is 0 if any input is 0



- Output is 1 if any input is 1
- Output is 0 if all inputs are 0

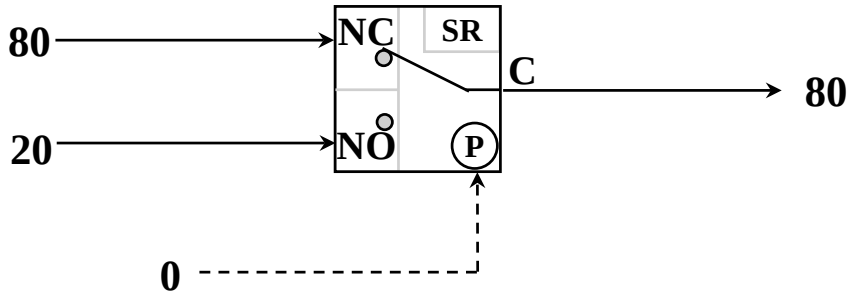


Switching Hardware Models

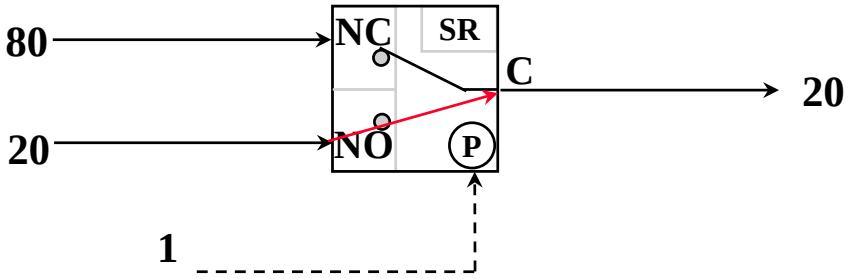
- Single pole double throw switching relay (SR) with discrete activation
  - Standard Switch based on Digital Pilot Signal
  - Standard Switch based on Analog Pilot Signal exceeding SP
  - Interval timer

Standard Switching Model

- Two Analog inputs and Digital Pilot Signal
- One Analog output
- Output is “NC” connection when Pilot Signal is 0

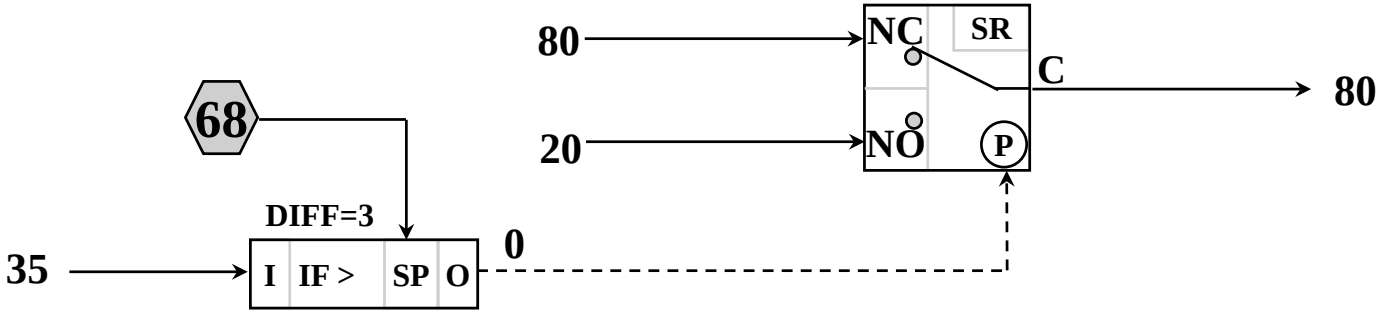


- Output is “NO” connection when Pilot Signal is 1

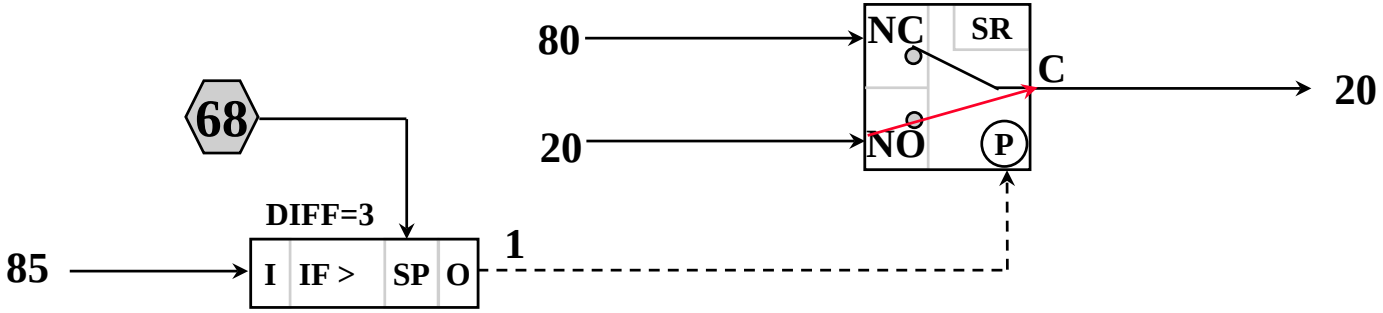


Analog Pilot Switch

- Combine Two Position Model & Standard Switch
- Output is “NC” connection when Pilot Signal is 0, Analog Pilot less than SP of Two Position Model

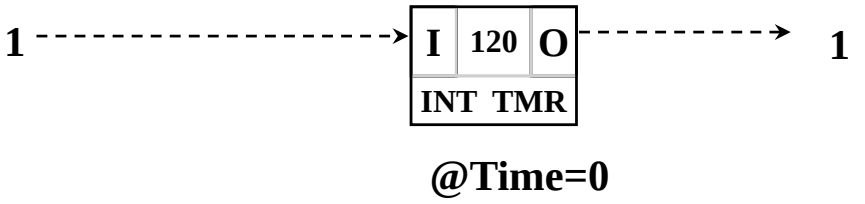


- Output is “NO” connection when Pilot Signal is 1

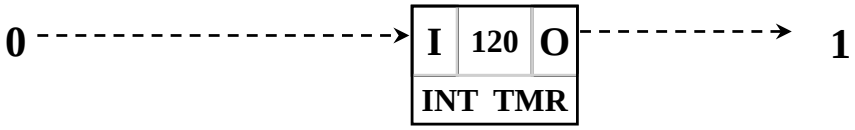


Interval Timer

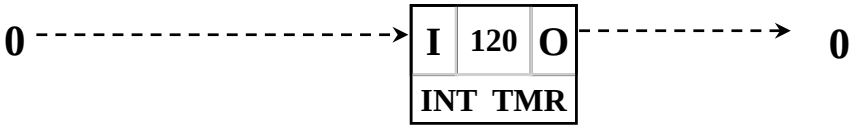
- When Input changes from a 0 to 1, Output is 1 for a minimum specific period of time



@Time=0



@Time=60



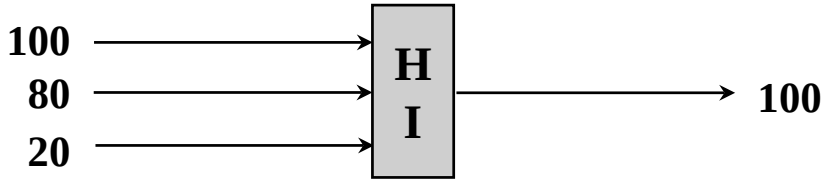
@Time=150

Math Functions and Models

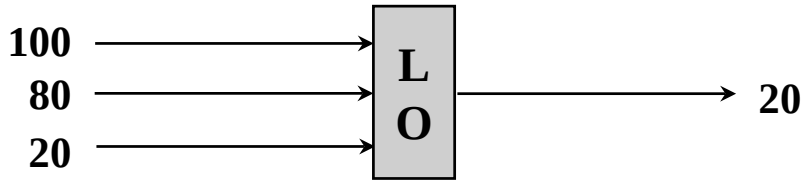
- High
- Low
- Reset/Ratio
- Calculation
- Special
  - Psychrometric

High/Low

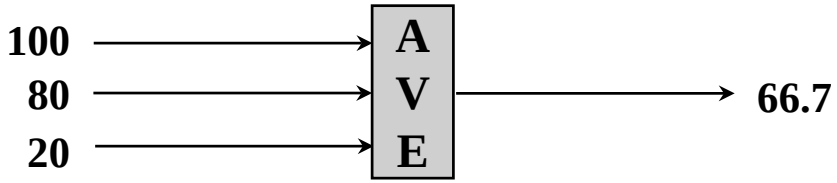
- Analog Inputs, Outputs the highest signal



- Analog Inputs, Outputs the lowest signal

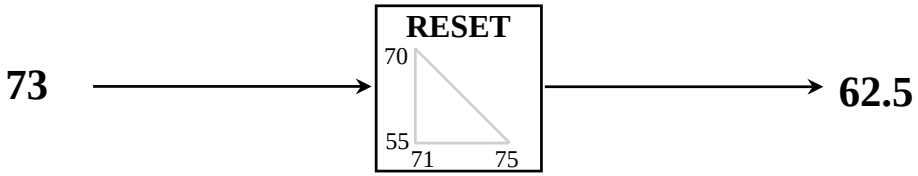


- Analog Inputs, Output is the average of the inputs

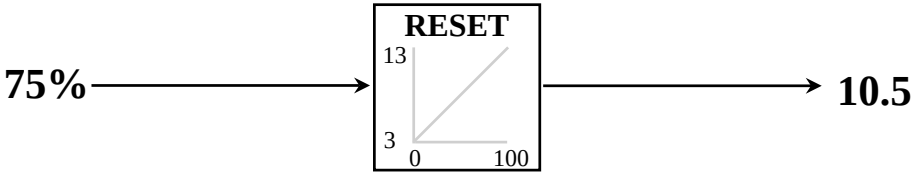


Reset/Ratio Model

- Model that produces the equation of a straight line, y=mx+b.
  - Programmed with two points (x, y for each)
  - Input is new "x" value
  - Output is new "y" value
- Typically used to calculate SP's which are reset



- Or, ratio an output

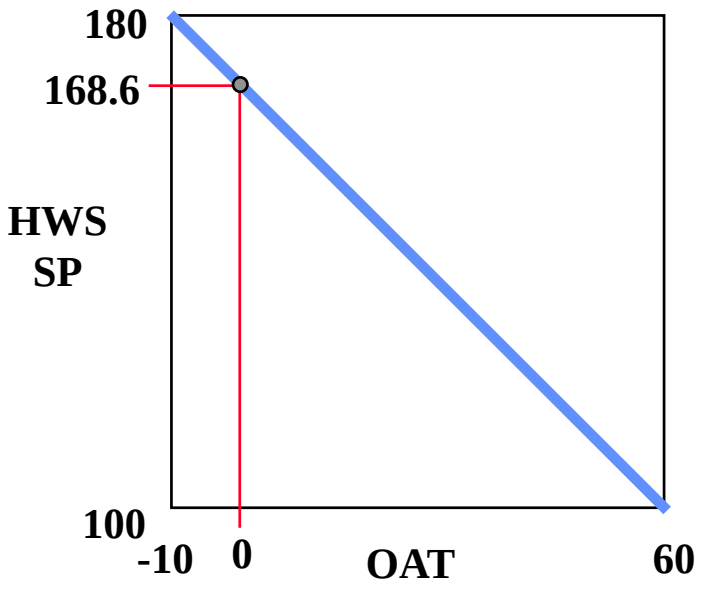


Example - OA Reset of HW

- **Reset Schedule**

OA	HWS SP
-10 ºF	180 ºF
60 ºF	100 ºF

- **Reset Graph**

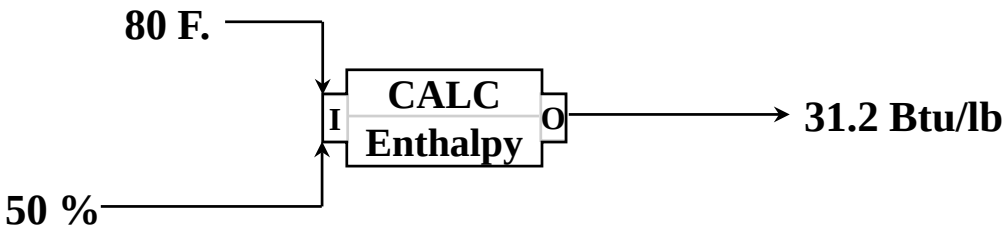


- **Math**

$$y = mx + b = -\left(\frac{80}{70}\right)x + 168.6 = -1.14(OAT) + 168.6$$

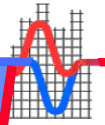
Calculation

- Collection of math functions
- May have multiple analog inputs
- Single analog output



- Example - Enthalpy Calculation
  - Temperature In = 80 F.
  - RH In = 50%
  - Enthalpy Out = 31.2 Btu/lb.

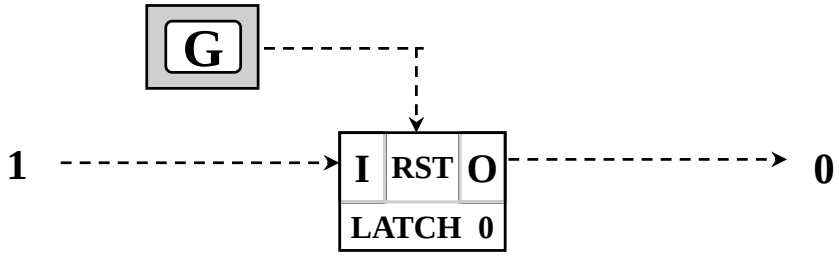
Special Models



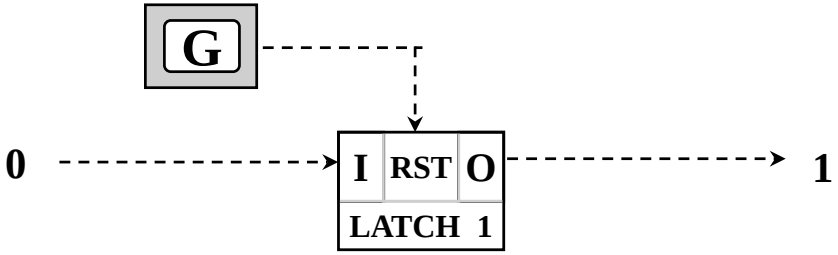
- Latch
- Ramp
- Proof
- Minimum/Maximum
- Runtime Accumulator

Latch

- **Latch Off - once input changes to 0, output stays 0 until reset input changes from 0 to 1**

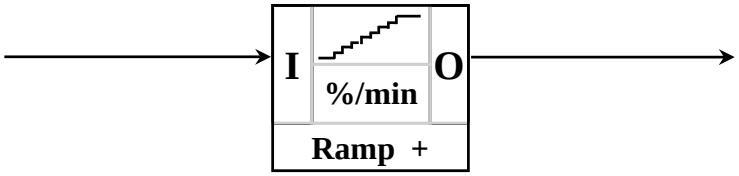


- **Latch On - once input changes to 1, output stays 1 until reset input changes from 0 to 1**

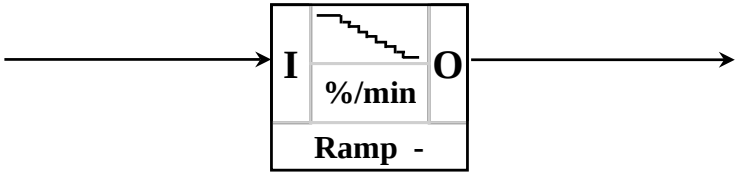


Ramp

- **Ramp Up - Limits the output to x% per minute rise, regardless of input change**

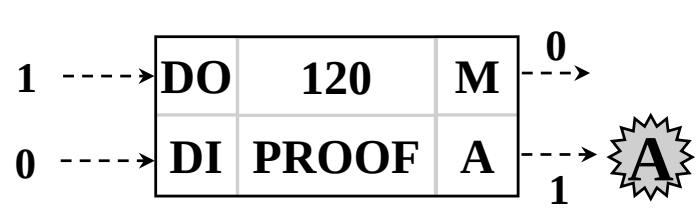


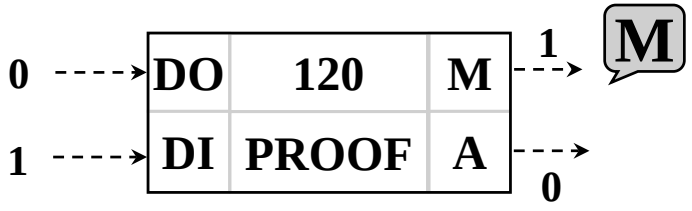
- **Ramp Down - Limits the output to x% per minute fall, regardless of input change**



Proof

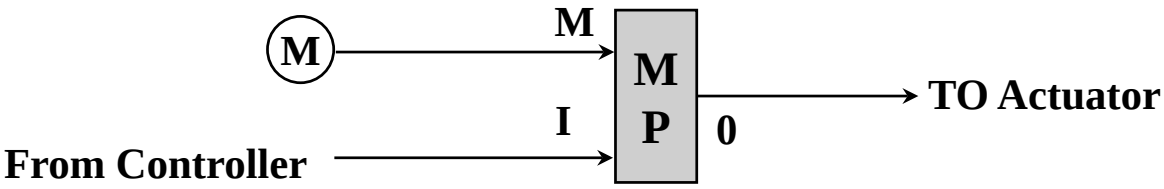
- Compares a Command Digital Point (DO) to a Monitored Digital Point (DI)
  - Incorporates a Time Delay
  - When DO is 1, and DI is 0, generates an Alarm Output
  - When DO is 0, and DI is 1, generates a Message Output



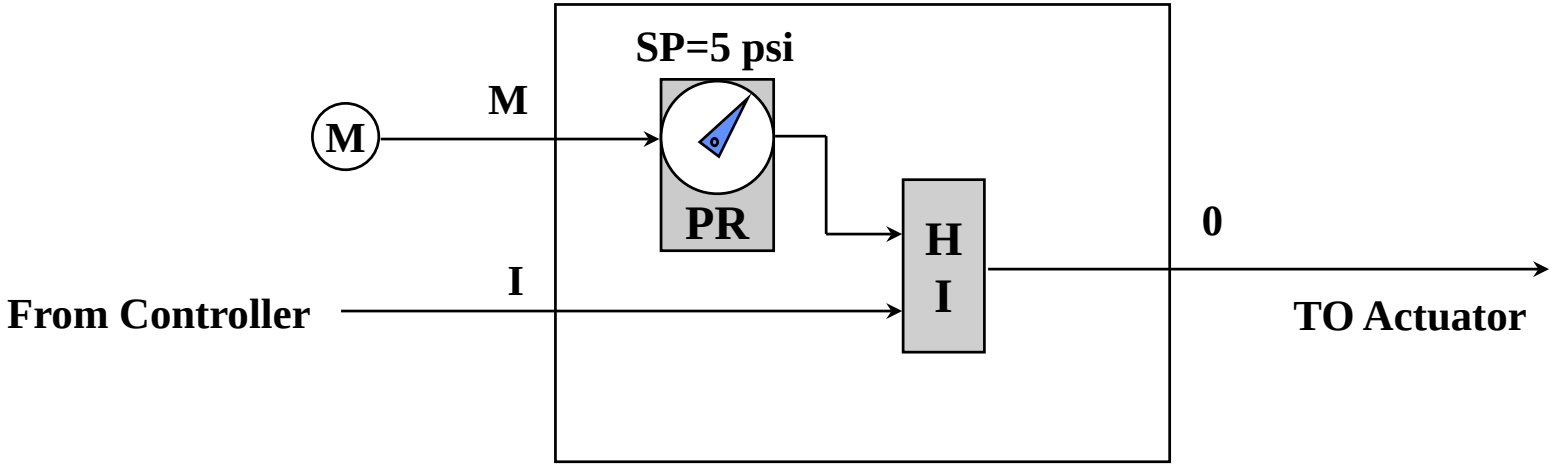


Minimum/Maximum Model

- **Pneumatics - Minimum Positioner**

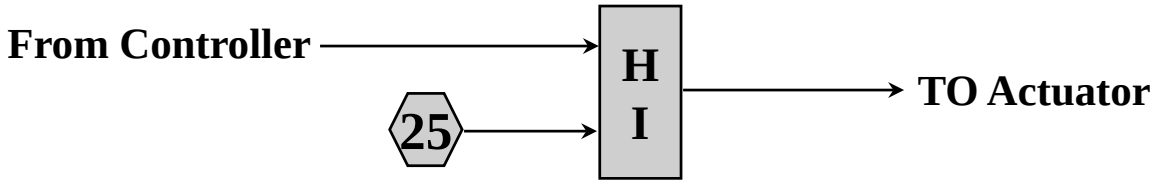


- **Actually Two components**

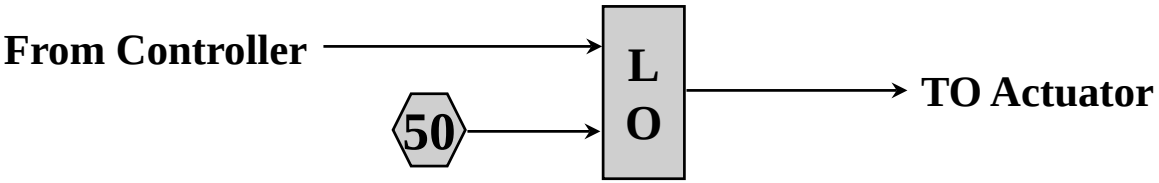


DDC Minimum/Maximum Logic

- **Minimum - Constant and a HI Model**

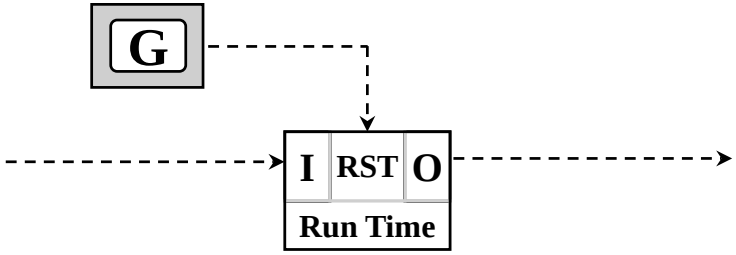


- **Maximum - Constant and a LO Model**



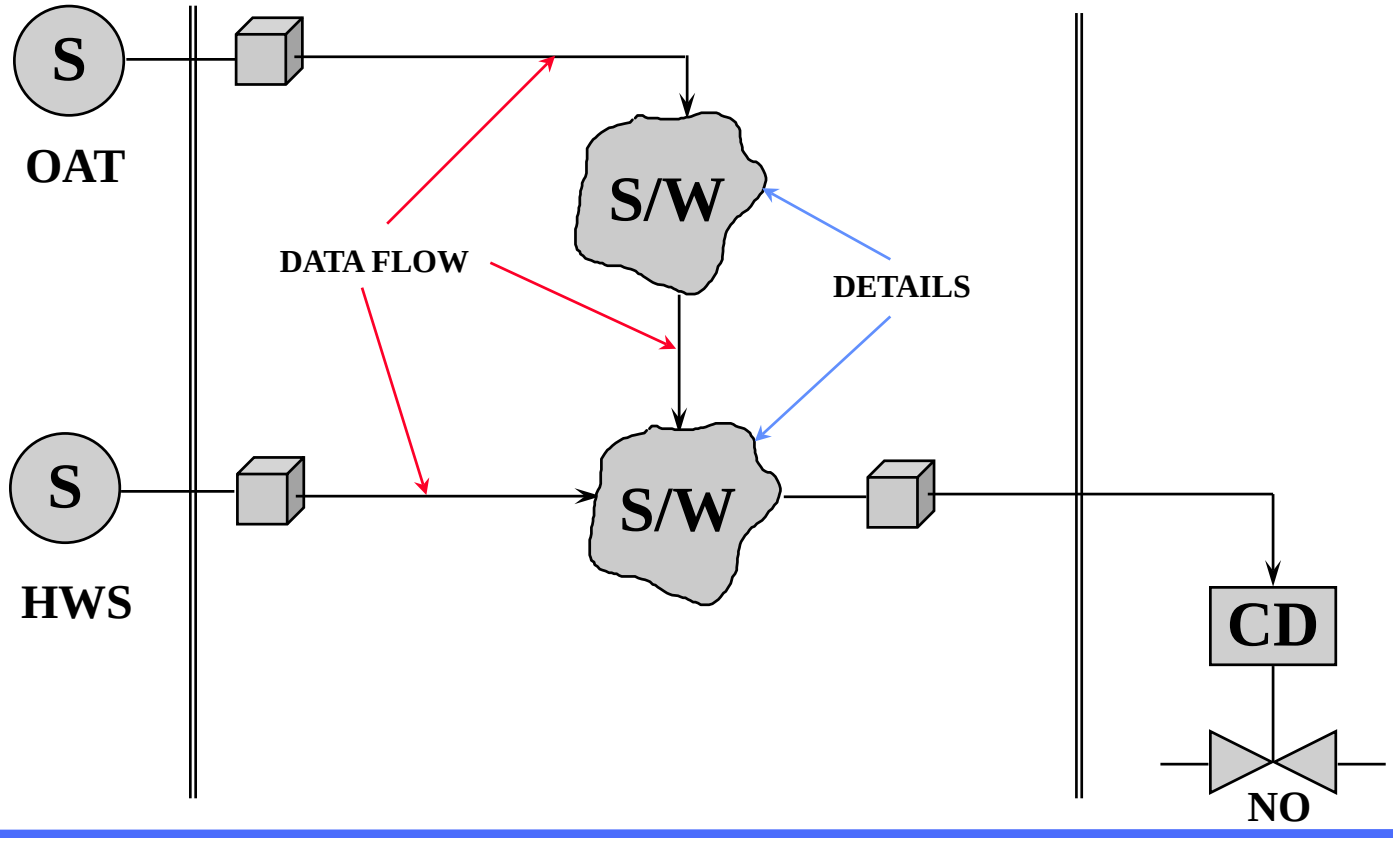
Runtime Accumulator

- This object tracks the time that a input has a value of 1. Its value will increase until the maximum allowable value is reached or the reset input is toggled from a 0 to a 1 which resets the value to zero.



Programming Issues

- Details of programming instructions
- Data Flow (How are the blocks connected)



Programming Templates

- Programming templates have been referred to by many different names within the DDC industry.
  - Menus
  - Parameter Pages
  - Focus Sheets
  - Editors
  - Modules
  - Pop-ups
- In essence, they are the input data sheet for a prepared sub-routine or logic block.

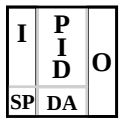
Program Data Flow

- Line Programming
  - Order
  - Go To ###
  - If <Logical Expression> is true, go to ###
- Database Programming
  - Input/Output locations set in modules or templates
  - Data stored in “Lines” or “Software Point”
- Graphical Programming
  - Data “flow” through drawing lines
  - Updates programming modules

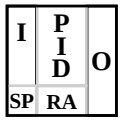
Conclusion

- This discussion has introduced the most common programming tools.
  - Information Flow/Tags
  - Control Models
    - Time based control models
  - Digital Logic
  - Switches
  - Math Functions and Models
  - Special hardware models
  - Programming Issues
- Different vendors will use adaptations of these tools to accomplish the same performance.

Logic Symbol Library

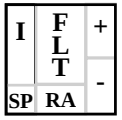


Direct Acting PID Loop

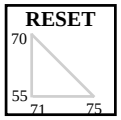


Reverse Acting PID Loop

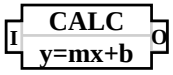
Direct Acting Floating Loop



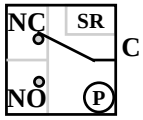
Reverse Acting Floating Loop



Reset Module

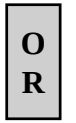


Calculation



Switching Relay
P=0, NC to C
P=1, NO to C

AND

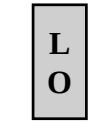


OR

Exclusive OR

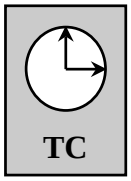
Negate

High

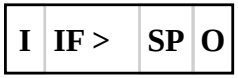


Low

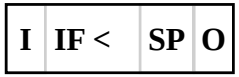
Average



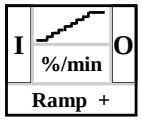
Time Schedule



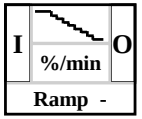
2Pos If >



2Pos If <

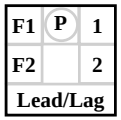


Ramp Up



Ramp Down

Proof Module

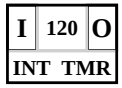


Lead/Lag

Flip/Flop

On Delay

Off Delay



Interval Timer

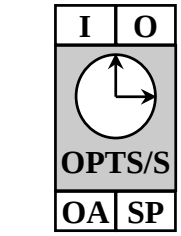
Latch On

Latch Off

To/From Graphic

Data Flag

Alarm



Optimum Start/Stop

Constant

Message