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Introduction to Powers Process Control Language (PPCL)

Items to be Covered

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1. POINTS
2. PPCL OVERVIEW
3. CONDITIONAL CONTROL
4. POINT CONTROL
5. PROGRAM CONTROL

Basic Points

LDI---Logical Digital Input

LDO---Logical Digital Output

LAI---Logical Analog Input

LAO---Logical Analog Output

Bundled Points

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Bundled points combine two or more digital input and output points to control devices requiring more than one signal.

- L2SL---Logical 2-state Latched
- L2SP---Logical 2-state Pulsed
- LFSSL---Logical Fast-Slow-Stop Latched
- LOOAL---Logical On-Off-Auto Latched
- LOOAP---Logical On-Off-Auto Pulsed

Virtual Points

Virtual points are points defined in the field panel that do not represent a physical device. A room temperature set point is an example of a virtual point.

- LDO---Logical Digital Output
- LAO---Logical Analog Output

Note: Input points can also be commanded, and therefore used as a virtual point, but this is not recommended since LAI points have no initial value.

Point Names

Point names can use up to 30 characters

Can use non-alphanumeric characters such as decimal points, ampersands, and dashes. (.*&%-$ etc…

Can more easily be segmented to show various components of the point name.

Example: Point name with three segments

B304. AHU04.SAT

Programming Objectives

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Definition of PPCL and its function

Steps to create PPCL programs

How to use the PPCL User’s Manual

Rules and Guidelines for PPCL

What is PPCL?

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Advanced Tool:

- PPCL is an advanced tool that works with the features of the Siemens TALON BACnet building automation system

Where is PPCL Used:

- TC Modular Controller
- TC Compact Controllers
- Reduced set in the Programmable TECs (PTEC)

PPCL consists of statements that are used to monitor and control system components.

PPCL Sample Program

The listing below shows part of a PPCL program. This program controls a supply fan, return fan and a virtual point that is used to control the supply air temperature. The PPCL program consists of a series of numbered lines that contain command statements. The common statements act on points to monitor and control the system components.

Line 30 and 100 are examples of a Command statement, which is used to convey instructions for the field panel to execute. Every line of PPCL starts with a line number

```
10 IF (FREEZE.EQ.ALARM) THEN GOTO 100
20 IF(DAY.EQ.OFF) THEN GOTO 100
30 ON(SFAN,RFAN)
40 LOOP(0,DAT,HWV,SET,PG,IG,DG,1,5.5,3.0,8.0,0)
50 GOTO 200
100 OFF(SFAN,RFAN)
110 SET(3.0,HWV)
200 GOTO 10
```

Program Execution

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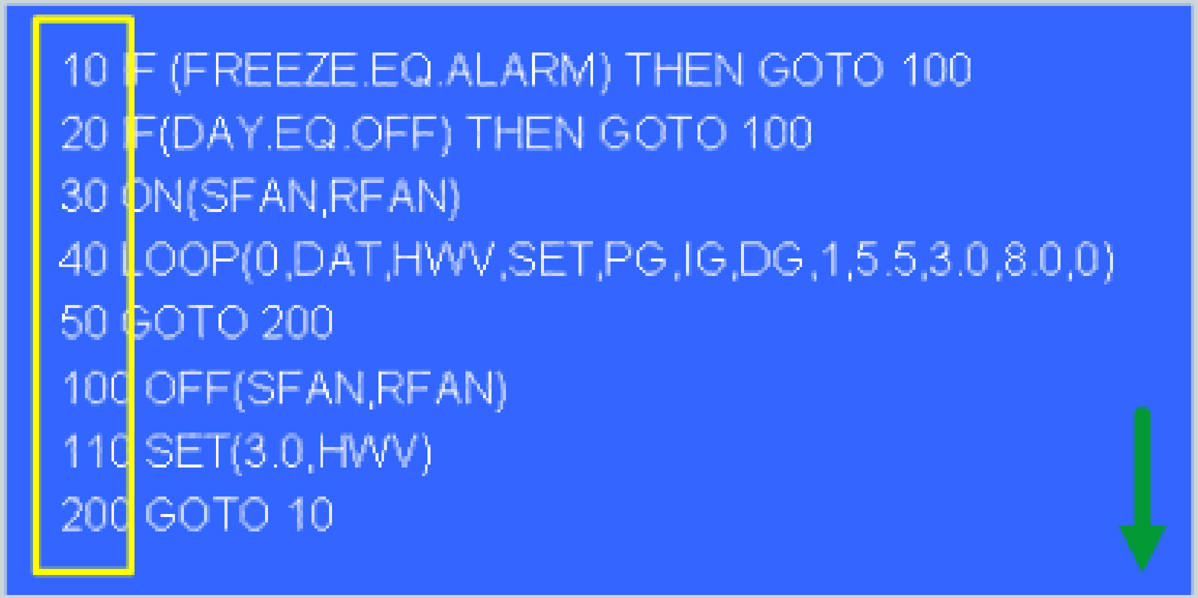
The program executes each line of code in ascending order.

When the program reaches the last line, it automatically returns back to the first line to repeat the process.



Program Execution
Nested Programs

TC's can contain multiple PPCL programs. Because the firmware can only execute one line at a time, each program takes a turn executing a single line, and then passes its turn to the next program. Within each program, lines are still executed in ascending order.

Program 1

```
2700  IF (A01LTD .EQ. ON .OR. A01SSD .EQ. ON .OR. A01RSD .EQ. ON)THEN GOTO 7000
2710  IF (A01MOD.EQ.8.0) THEN GOTO 6400
2720  IF (A01MOD .EQ. 6.0) THEN GOTO 3000
2730  IF (A01MOD .EQ. 7.0) THEN GOTO 4000
...
```

Program 2

```
6000  OFF(A01SAF,A01RAF)
6110  LOOP (128,A01MAT,A01VRT,65.0,A01PGT,A01IGT,0,13,52.0,0.0,100.0,0)
6210  IF (OAA .LT. 45.AND.A01SAF.EQ.OFF) THEN A01HCO = A01VRT
6240  IF (OAA .GT. 48.AND.A01SAF.EQ.OFF) THEN A01HCO = 0.0
...
```

GOTO Statement

The GOTO statement can be used to jump to a particular line of code in the program. In the example below, when line 10 is executed and if FREEZE is in ALARM, the program jumps to line 100, bypassing the lines in-between.

```
10 IF (FREEZE.EQ.ALARM) THEN GOTO 100
20 IF(DAY.EQ.OFF) THEN GOTO 100
30 ON(SFAN,RFAN)
40 LOOP(0,DAT,HWV,SET,PG,IG,DG,1,5.5,3.0,8.0,0)
50 GOTO 200
100 OFF(SFAN,RFAN)
110 SET(3.0,HWV)
200 GOTO 10
```

GOTO Statement

GOTO statements **MUST** always jump to a **HIGHER** line number. **NEVER** use a GOTO statement to jump to a lower number **EXCEPT** for the GOTO statement located on the last line of the program.

Do not use a GOTO to transfer control to the top of a program before the last line is executed – time based commands (LOOP, WAIT, etc.) will not function properly.

```
10 IF (FREEZE.EQ.ALARM) THEN GOTO 100
20 IF(DAY.EQ.OFF) THEN GOTO 100
30 ON(SFAN,RFAN)
40 LOOP(0,DAT,HWV,SET,PG,IG,DG,1,5.5,3.0,8.0,0)
50 GOTO 200
100 OFF(SFAN,RFAN)
110 SET(3.0,HWV)
200 GOTO 10
```

GOTO Statement Example #1

- The GOTO on LINE 10 is executed because the conditional part of the statement is met and then will GOTO Line 100

```
10 IF (FREEZE.EQ.ALARM) THEN GOTO 100
20 IF(DAY.EQ.OFF) THEN GOTO 100
30 ON(SFAN,RFAN)
40 LOOP(0,DAT,HWV,SET,PG,IG,DG,1,5.5,3.0,8.0,0)
50 GOTO 200
100 OFF(SFAN,RFAN)
110 SET(3.0,HWV)
200 GOTO 10
```

GOTO Statement Example #2

- The GOTO on LINE 20 is executed because the conditional part of the statement is met and then it will GOTO Line 100

```
10 IF (FREEZE.EQ.ALARM) THEN GOTO 100
20 IF(DAY.EQ.OFF) THEN GOTO 100
30 ON(SFAN,RFAN)
40 LOOP(0,DAT,HWV,SET,PG,IG,DG,1,5.5,3.0,8.0,0)
50 GOTO 200
100 OFF(SFAN,RFAN)
110 SET(3.0,HWV)
200 GOTO 10
```

GOTO Statement Example #3

- The GOTO on LINE 50 has no conditional part and every time it is executed it will GOTO Line 200

```
10 IF (FREEZE.EQ.ALARM) THEN GOTO 100
20 IF(DAY.EQ.OFF) THEN GOTO 100
30 ON(SFAN,RFAN)
40 LOOP(0,DAT,HWV,SET,PG,IG,DG,1,5.5,3.0,8.0,0)
50 GOTO 200
100 OFF(SFAN,RFAN)
110 SET(3.0,HWV)
200 GOTO 10
```

GOTO Statement Example #3

- The GOTO on LINE 200 has no conditional part and every time it is executed it will GOTO Line 10.
- This is the <u>only time</u> a GOTO Statement should be used to GOTO a lower numbered line.

```
10 IF (FREEZE.EQ.ALARM) THEN GOTO 100
20 IF(DAY.EQ.OFF) THEN GOTO 100
30 ON(SFAN,RFAN)
40 LOOP(0,DAT,HWV,SET,PG,IG,DG,1,5.5,3.0,8.0,0)
50 GOTO 200
100 OFF(SFAN,RFAN)
110 SET(3.0,HWV)
200 GOTO 10
```

The DEFINE statement

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- Creates abbreviated notation for long point names
- When used in a program a percentage (%) must be placed <u>before</u> and <u>after</u> the abbreviation.
- This statement allows a program logic to be easily duplicated from panel to panel provided structured point names.

The DEFINE statement

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Syntax:

- DEFINE(abbrev,string)
  - abbrev is the abbreviations used in other PPCL statements. Represents the string parameter.

  - String is the actual text string that will be substituted where the abbreviation is used. This string text usually contains a significant portion of a long point name.

Example: %X%SAF is the same as “AHU1SAF”

- 10 DEFINE(X,”AHU1”)
- 20 ON(%X%SAF)

- Without the use of the DEFINE statement Line 20 would look like:
- 20 ON(“AHU1SAF”)

Creating PPCL Programs

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There are many ways to create a PPCL program. This section provides an overview of the steps and tools used to create effective PPCL programs.

Programming Steps

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Typically, there are five steps used in the creation of a PPCL program.

1. Clearly understand the problem that is trying to be solved.
2. Plan a solution.
3. Create a solution.
4. Implement the solution.
5. Verify operation and check you work.

PPCL Program Development

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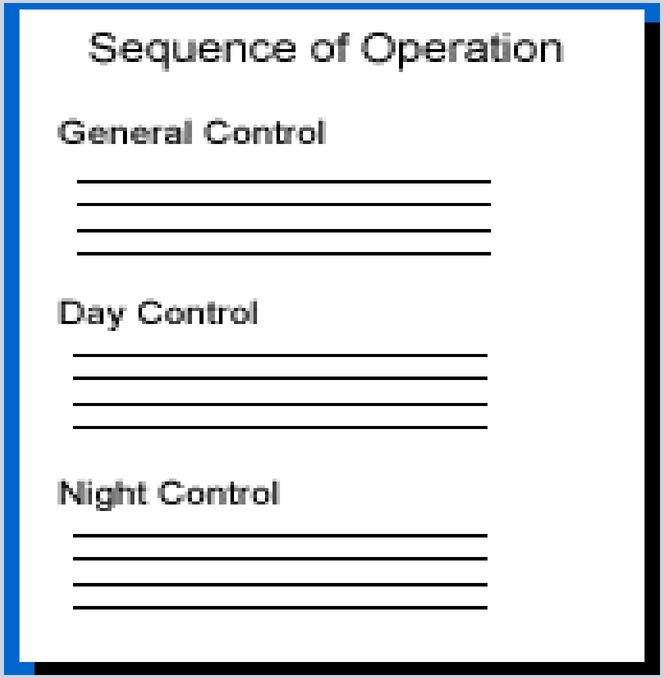
PPCL program development uses several steps to develop and test the program. These are listed below. Each step in the process builds on the result from the previous step.

1. Sequence of Operation
2. Decision Table
3. Flowchart
4. PPCL Code

Sequence of Operation

The first step in creating a PPCL program is to analyze the problem. During the analysis, a Sequence of Operation is developed and/or reviewed. The Sequence of Operation describes how the system should operate.

Once the PPCL program is created, its operation must be tested and compared to the Sequence of Operation.



Sequence of Operation

Between the scheduled hours of occupancy, the supply and return air fans will constantly run, and the hot water valve will modulate to maintain supply air temperature.

Outside of the scheduled hours of occupancy, the supply and return fans will be off, and the hot water valve will be shut and a low temperature detector will be provided in the supply duct.

If the low temperature detector trips, the supply and return fans will be shut off, and the hot water valve will be closed.

Note: Notice that the modes are separated and the equipment that it controls is defined during those modes.

Decision Table

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The Decision Table is created from the Sequence of Operation. The Decision Table lists all the equipment (or outputs) that the PPCL program needs to control.

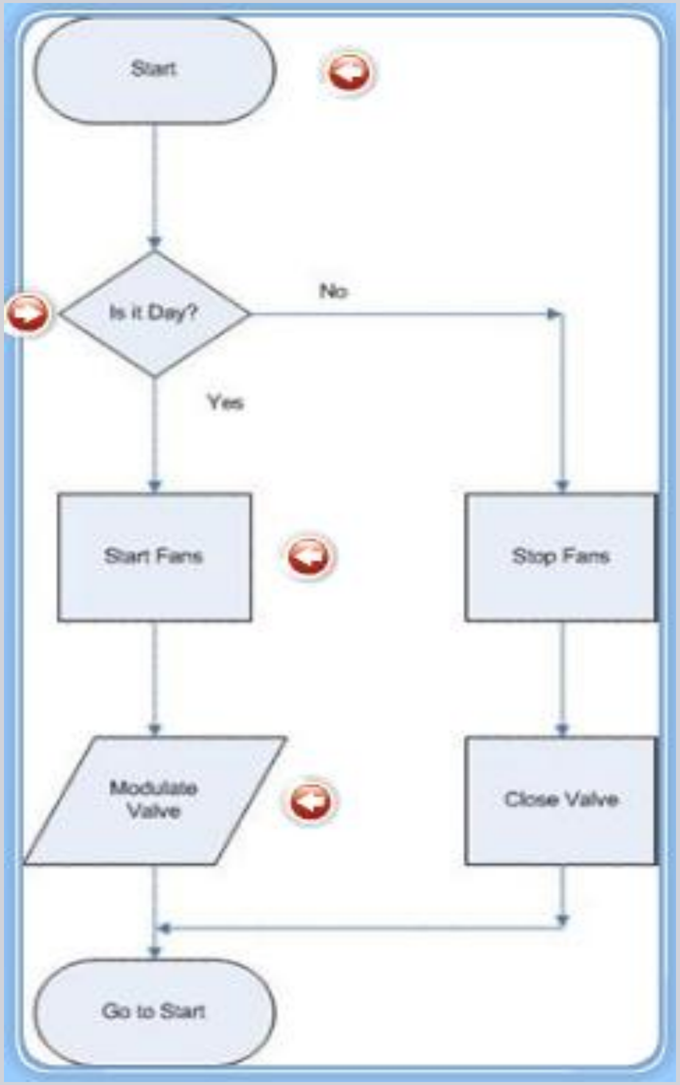
The Decision Table separates the modes of operations (day, night, etc.) and identifies the operating state (ON, OFF, Modulate, etc) of the equipment for a particular mode.

	DAY	NIGHT	FREEZE
SAF	ON	OFF	OFF
RAF	ON	OFF	OFF
HWV	MODULATE	CLOSED	CLOSED

Flowchart

The Flowchart is a visual diagram that shows the logical progression of the control strategy.

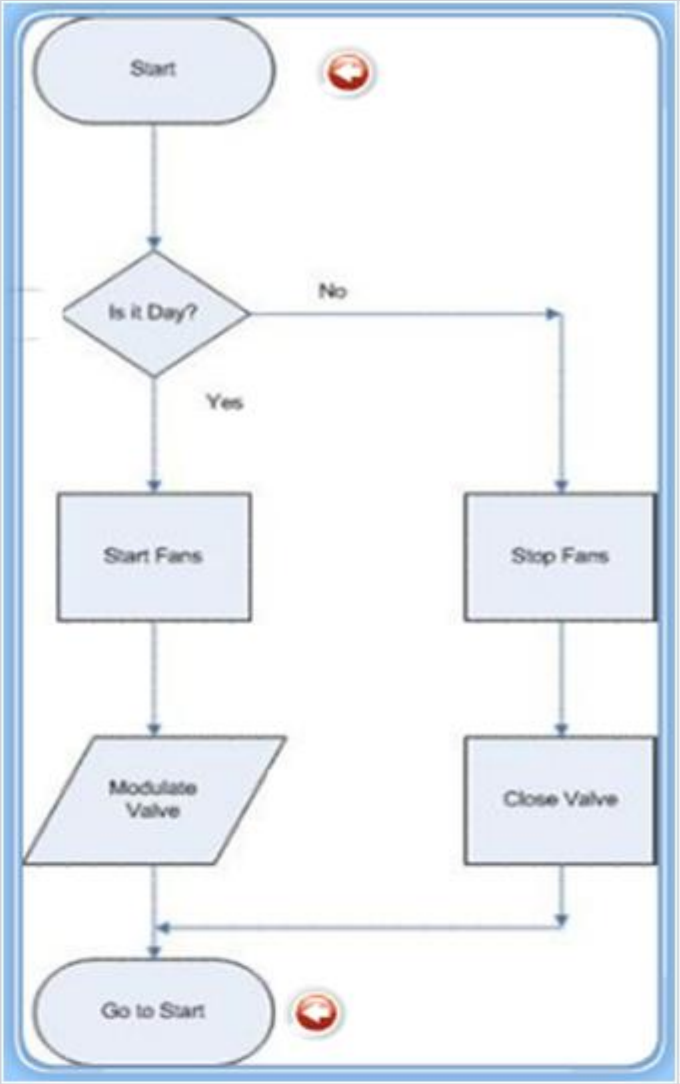
Flowcharts use a set of conventitial symbols to visually show how each action or decision leads to the next.



Flowchart

A Directional Box represents the:

- Flowchart beginning,
- Flowchart end or
- Continuation to another flowchart section.



Flowchart

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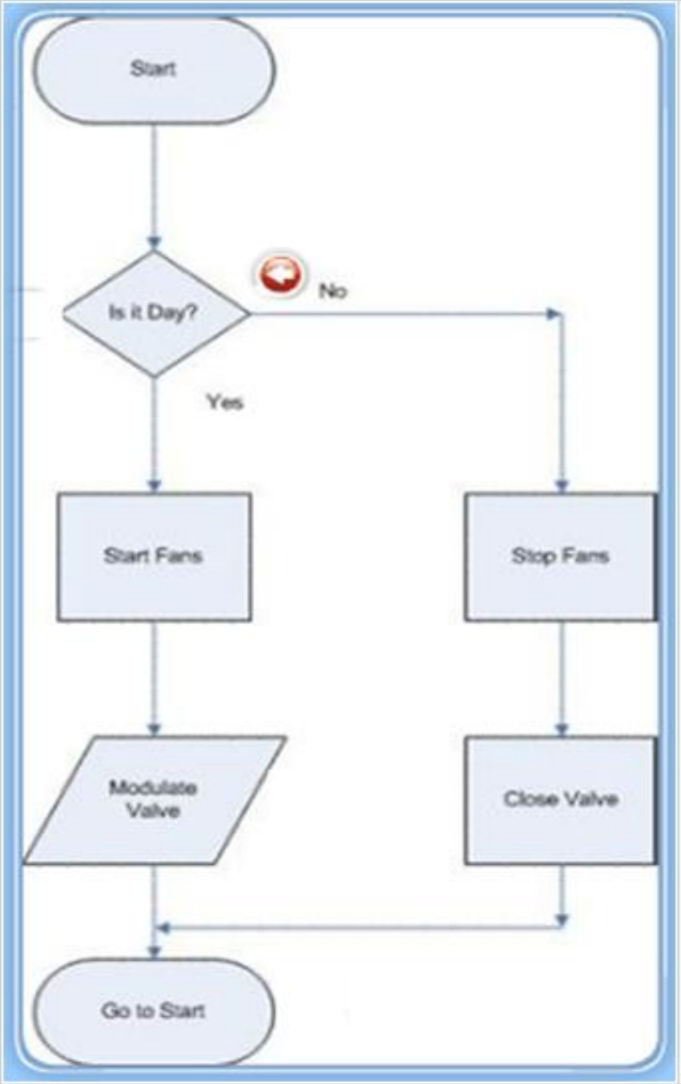
The Decision Box is a diamond-shaped box used to make YES/NO decisions.



Flowchart

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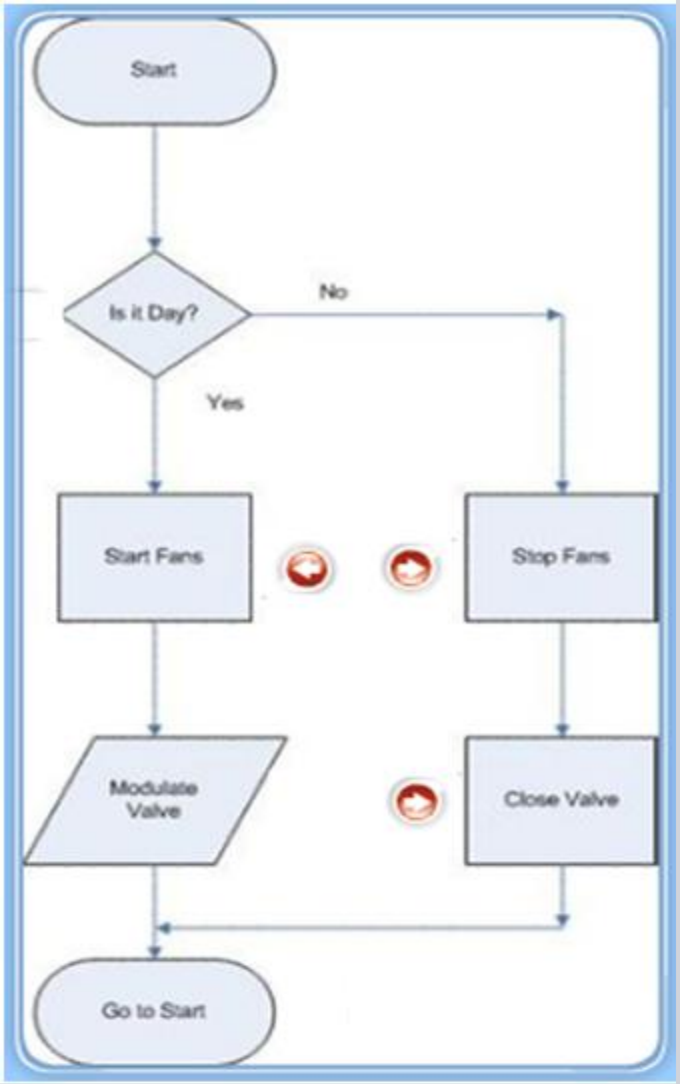
The Procedure Box is used to direct commands such as ON, OFF, and SET.



Flowchart

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The Input / Output Box commands equipment based upon specific calculations.

PPCL Program Development

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The final step is to enter the PPCL code. Since the Decision Table and Flowchart have already been developed, the PPCL code can be written more easily.

Always test your program by comparing its functionality with the Flowchart, Decision Table, and the Sequence of Operation.

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Syntax Section

The Syntax section describes command usage and parameters:

Syntax

ON(*pt1,...,pt16)*

pt1 through *pt16*	Point names that are commanded to ON.

ON(@prior,pt1,...,pt15)

@prior Defines a specific point priority.	
pt1 through *Pt15*	Point names of LDO, L2SL, L2SP, LOOAL, or LOOAP points

Use Section

The Use section describes what function the command performs and provides on-line examples of program code.

Use

Changes the operational status of an ON/OFF/AUTO point to ON.

- A maximum of 16 points can be changed with one ON command.
- A maximum of 15 points can be defined with one ON(*@prior…)* command.

Example

```
100 IF (OATEMP.LT.60.0)THEN ON(@NONE,
    PUMP1,PUMP2)
```

Remarks and See Also Section

Remarks

Give helpful hints regarding the command.

See Also

Refers you to other similar types of commands

See also

AUTO, FAST, OFF, SLOW

Point Control Statements

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Common used point control statements

- The ON statement is a PPCL command used to command a digital point to the ON Condition.

Syntax:

ON(*pt1,...,pt16*)

Each point must be separated by a comma and up to 16 points can be commanded in one statement.

Examples

Single Point

10 ON(SFAN)

Multiple Points

20 ON(SFAN,RFAN)

30 ON(FAN1,FAN2,FAN3,FAN4,FAN5)

Point Control Statements

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Common used point control statements

- The OFF statement is a PPCL command used to command a digital point to the OFF Condition.

Syntax:

OFF(*pt1,...,pt16)*

Each point must be separated by a comma and up to 16 points can be commanded in one statement.

Examples

Single Point

10 OFF(SFAN)

Multiple Points

20 OFF(SFAN,RFAN)

30 OFF(FAN1,FAN2,FAN3,FAN4,FAN5)

Point Control Statements

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Common used point control statements

- The SLOW statement is a PPCL command used to command a bundle point to the SLOW Condition.

NOTE: The SLOW statement is only valid for the following bundled point types:

- Logical Fast-Slow-Stop Latched (LFSSL)
- Logical Fast-Slow-Stop Pulsed (LFSSP)

Syntax:

SLOW(*pt1,...,pt16*)

Each point must be separate by a comma and up to 16 points can be commanded in one statement.

Examples

Single Point

110 SLOW(SFAN)

Multiple Points

120 SLOW(SFAN,RFAN)

Point Control Statements

Common used point control statements

- The FAST statement is a PPCL command used to command a bundled point to the FAST Condition.

NOTE: The FAST statement is only valid for the following bundled point types:

- Logical Fast-Slow-Stop Latched (LFSSL)
- Logical Fast-Slow-Stop Pulsed (LFSSP)

Syntax:

FAST(*pt1,...,pt16)*

Each point must be separate by a comma and up to 16 points can be commanded in one statement.

Examples

Single Point

110 FAST(SFAN)

Multiple Points

120 FAST(SFAN,RFAN)

Point Control Statements

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Common used point control statements

- The SET statement is a PPCL command used to command an assign value to an analog point.

Syntax:

SET(value, *pt1,...,pt16)*

First part of the statement is the value you want each point to be. Each point must be separated by a comma and up to 16 points can be commanded in one statement.

Examples

540 SET(10,ETHR1)

550 SET(3,CNDVLV,HWVLV,DAMPER)

Note:

Also an assignment (=) can be used to set a point to a single value

560 ETHR2 = 5

Conditional Statements

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The IF-THEN statement is used to test for a specific condition

- The condition being tested for is the expression.
- If TRUE, then the command after the THEN is executed.
- If FALSE, the program does not execute and continues to the next line

Expressions are used to compare point values:

- For example compare the value of the Hot Water Pump (HWPMP) to On or compare the Outside Air Temperature (OAT) to 72 degrees.

Expressions are either relational or logical.

Command section is placed after the THEN and is only executed if the expression evaluated is TRUE.

Conditional Statements

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The IF-THEN statement Example

- The expression testing for the point FAN to be ON.
- If the FAN is ON, then the expression is TRUE and the command is executed.
- If the FAN is OFF, then the expression is FALSE and the Command is ignored.
- The statement would be written as:

110 IF(FAN.EQ.ON) THEN ON(PUMP)

Point Status Indicators

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- Part of the conditional statements are the point status indicators
- Point status indicators are used to compare a point to a specific condition

ALARM - Used to determine if an alarmable point is in the ALARM state
AUTO – Used to determine if an LOOAP or LOOAL is in AUTO
DAYMOD – Used to determine if a equipment controller (TEC or PTEC) is in DAY mode
DEAD – Used to determine if the battery in any TALON BACnet field panel is discharged (compared to $BATT.)
FAILED – Used to determine if the operational state of a point or node is FAILED
FAST – Used to determine if an LFSSL or LFSSP point is in the FAST operational mode
HAND – Used to determine if a point is being controlled by the manual override switch
NGTMOD – Used to determine if a equipment controller (TEC or PTEC) is in NIGHT mode
OFF – Used to determine if a logical or bundled point is in the OFF state
OK – Used to determine if the battery in any TALON BACnet field panel is charged (compared to $BATT.)
ON – Used to determine if a logical or bundled point is in the ON state
PRFON – Used to determine if a bundled point proof has been made
SLOW – Used to determine if an LFSSL or LFSSP point is in the SLOW operational mode

Relational Operators

- **Part of the conditional statements is the relational operator**
- **Relational operators establish how factors of the conditional statements are compared**

.EQ. the relational operator Equal to is used to check if the first value is equal to the second value.
Examples:
FAN.EQ.ON (fan equals on)
TEMP.EQ.72.0 (temperature equals 72)

.GT. the relational operator Greater Than is used to check if the first value is greater than the second value.
Examples:
TIME.GT.08:00 (time greater than 8 am)
TEMP.GT.72.0 (temperature greater than 72)

.GE. the relational operator Greater Than or Equal To is used to check if the first value is greater than or equal to the second value.
Example:
TEMP.GE.72.0 (temperature greater than or equal to 72)

Relational Operators

.LT. the relational operator Less Than is used to check if the first value is less than the second value.
Examples:
TIME.LT.17:00 (time less than 5 pm)
TEMP.LT.72.0 (temperature less than 72)

.LE. the relational operator Less Than or Equal To is used to check if the first value is less than or equal to the second value.
Examples:
TEMP.LE.72.0 (temperature less than or equal to 72)

.NE. the relational operator Not Equal To is used to check if the first value is different than second value.
Example:
FAN.NE.ALARM (fan is not in alarm)
PUMP.NE.FAILED (pump has not failed)

Using Relational Operators

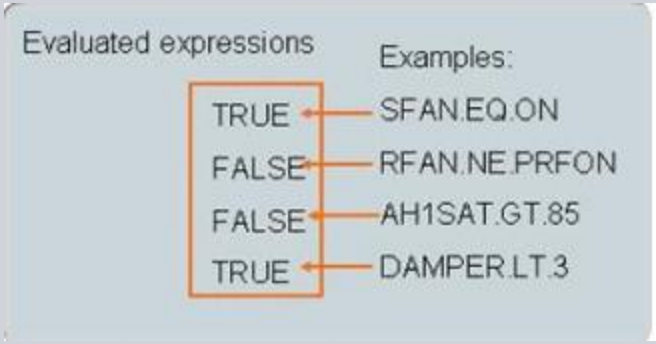
- **Relational operators always compare one value to another**
- **The points name is always placed on the left side of the operator**

Example:

Check the status of the SFAN being ON
SFAN.EQ.ON

Check the status of the proof point of the RFAN to ON
RFAN.NE.ON

Check the status of a point to some value.
AH1SAT.GT.85
DAMPER.LT.3



Evaluation

Relations operators always evaluate to TRUE or FALSE.

Relational Operators

IF-THEN Evaluation 1

The following relational expression is used in an IF-THEN statement.

Example:

IF(SFAN.NE.ON) THEN ON(SFAN)

(If the SFAN is not ON then turn on the SFAN)

The first step to evaluating an IF-THEN statement is examine the expression.

- The expression in the above statement is SFAN.NE.ON if it is TRUE then the command after the THEN is executed. If the expression is FALSE then the command after the THEN is ignored.

Resident Points

These are maintained by the system

- They are pre-defined
- Have reserved names that cannot be used by another point
- Cannot be viewed directly
- Are activated when used
- Do not take any additional memory from the field panel

There are three types of resident Points

- Time Based Resident Points
- Alarm Based resident Points
- Other Resident Points

Resident Points can be used in place of regular points in the IF-THEN statements.

Time Base Resident Points

Time

Use

- This resident point maintains the current time and stores the value in military time. The TIME value can contain a value from 0:00 to 23:59.
- The following examples show how TIME stores values:
  7:15 a.m. = 7:15
  7:30 p.m. = 19:30

Example

```
500 C
501 C THIS CODE DEFINES A TIME PERIOD
502 C FROM 6:45 A.M. TO 5:30 P.M. FOR
503 C SFAN TO OPERATE.
      510 IF(TIME.GE.6:45.AND.TIME.LE.17:30)THEN ON(SFAN) ELSE OFF(SFAN)
```

Notes

The time is updated every second. TIME cannot be used to assign a value to a virtual point since its value is not in a standard decimal form. CRTIME should be used for this purpose. TIME can be used in PPCL for comparison in the IF/THEN/ELSE statement.

Time Based Resident Point

CURRENT TIME (CRTIME)

Use

- This resident point maintains the current time and stores the value in a decimal format. The following examples show how CRTIME stores values:
  - 7:15 a.m. = 7.25
  - 7:30 p.m. = 19.50

The values for this point can range from 0.00 to 23.999721.

Example

```
500 C
501 C THIS CODE DEFINES A TIME PERIOD
502 C FROM 6:45 A.M. TO 5:30 P.M. FOR
503 C SFAN TO OPERATE.
504 C
510 IF (CRTIME.GE.6.75.AND.CRTIME.LE.17.50)
      THEN ON(SFAN)ELSE OFF(SFAN)
```

CRTIME can also be used to assign the current value of time to a virtual LAO type point which allows you to read the current time on a graphic, point log, etc. For example:

```
100 VTIME = CRTIME
```

Notes

CRTIME is updated every second.

Time Based Resident Point

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DAY

Use

This resident point specifies the current day of the week. The values used for the DAY point are as follows:

Number	Day of the Week
1	Monday
2	Tuesday
3	Wednesday
4	Thursday
5	Friday
6	Saturday
7	Sunday

Example

300 IF (DAY.EQ.1) THEN TOTRAN = 0

Notes

These values are not related to the modes used in the TODMOD statement.

Time Base Resident Point

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Day of the month (DAYOFM)

Syntax
DAYOFM

Use

This resident point specifies a particular day of any month. Valid values for DAYOFM are 1 through 31. The value corresponds to the numerical calendar day of a month.

Example

```
160 C THIS SECTION OF CODE DETERMINES IF
162 C IT IS THE FIRST DAY OF THE MONTH.
164 C IF SO, SET TOTMON TO 0.
166 C
180 IF (DAYOFM.EQ.1) THEN TOTMON = 0
```

Notes

This point is helpful when you have to perform certain operations on a specific day (for example, generating a report on the first day in the month).

Time Base Resident Point

MONTH

Use

This resident point specifies the current month. The values used for the MONTH point are as follows:

Number	Month
1	January
2	February
3	March
4	April
5	May
6	June
7	July
8	August
9	September
10	October
11	November
12	December

Example

950 IF (MONTH.GE.4.AND.MONTH.LE.10) THEN SEASON = 1 ELSE SEASON = 0

Time Base Resident Point

Seconds counter (SECNDS)

SECNDS

Use

This resident point counts real time seconds and can be used as a timer. The computer adds one (1) to the SECNDS variable for every one second of real time that passes.

- The initial value of the SECNDS point is set by a PPCL command.
- The SECNDS point can be set to a maximum value of 9,999.

Example

890 IF (SFAN.NE.PRFON) THEN SECNDS = 0

Notes

For TALON field panels, each program has a unique SECNDS point. This point can also be viewed in the interface using the program name, system delimiter (:)SECNDS format.

Time Base Resident Point

Seconds counters (SECND1 through SECND7)

Syntax

SECND*n*

n The number that describes which SECNDn point is referenced.

Valid values for SECND*n are* ***1 through 7.***

Use

These seven resident points count real time seconds and can be used as timers. The computer adds one (1) to the SECND*n variable* for every one second of real time that passes.

- The value of a SECND*n point can only be set by a PPCL* command.
- The maximum value a SECND*n point can be set to is 9,999.*

Example

600 IF(SECND1.GT.15) THEN ON(RF) ELSE OFF(RF)

Notes

For TALON field panels, each program has unique SECNS*n points.* These points can also be viewed in the interface using the program name, system delimiter (:)SECND*n format.*

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Other resident Points

- $BATT
- $PDL
- LINK
- NODE0 through NODE99

Other resident Points

$BATT

TALON filed panels have the ability to monitor the strength of their backup battery, the $BATT resident point allows you to access that status. The status of $BATT can be tested for a numeric value. The status can also be tested by using the backup battery status indicators

- $BATT numeric values are 0, 50, or 100
  - A $BATT value of 0 indicates battery has discharged and must be replaced.
  - A $BATT value of 50 indicates battery is about to be discharged and should be replaced to prevent loss of data.
  - A $BATT value of 100 indicates battery does not need to be replaced.

- $BATT status indicators are LOW, DEAD, or OK
  - A $BATT status is LOW or DEAD , then the battery has discharged and must be replaced.
  - A $BATT status of OK indicates battery does not need to be replaced

Example 1:
200 IF($BATT.EQ.0) THEN ALARM(P26BAT)

Example 2:
210 IF($BATT.EQ.DEAD) THEN ALARM(P26BAT)

Other resident Points

$**PDL**

Is a resident point that takes on the current value of the demand prediction for each calculated interval made by the PDLMTR statement. The point can be assigned to a virtual LAO point, displayed, and trended

Example:
350 KWH=$PDL

Other resident Points

LINK

Is a resident point that indicates the condition of communications. Depending on the status of the communications link, a point contains one of the following values:

0 - The node where the LINK point resides in not communicating with the network

1 - The node where the LINK point resides is actively communicating with the network

Example:
300 IF(LINK.EQ.0) THEN ON(ALARM)

Other resident Points

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NODE0 through NODE99

Allows the program to check the status of a node on the network. All field panels on the network occupy a node corresponding to its address. This point is generally used to test for normal operation of nodes for control strategies that depend on network communication

Example:

600 IF(NODE22.EQ.FAILED) THEN ON(ALARM)

Note:

This command is not described in the TALON PPCL manual so there needs to be confirmation on how this works with BACnet.

Logical Expressions

A Logical Expression is two or more relational expressions linked together by logical operators

- .AND.
- .OR.
- .XOR.
- .NAND.

Logical expressions use Truth Tables to determine the TRUE or FALSE value of the expression.

Example:

- For the AND expression to be TRUE, both the first and the second relational expressions must be evaluated TRUE

Logical Expressions

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OR statement checks two sets of conditions and returns a TRUE if either condition is TRUE.

- Below is a basic OR Truth Table

X	Y	OUTPUT
T	T	TRUE
T	F	TRUE
F	T	TRUE
F	F	FALSE

In the second row of the table, X is TRUE (the Lights are ON), and Y is FALSE (the Lights are not on). Since the OR operator only requires one out of the two to be TRUE, the whole experience expression X .OR. Y will be equated to TRUE

Example

200 IF (TIME.LT.5:00.OR.TIME.GT.17:00) THEN ON(LIGHTS)

Logical Expressions

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AND statement checks two sets of conditions and returns a TRUE if both condition are TRUE.

- Below is a basic AND Truth Table

X	Y	OUTPUT
T	T	TRUE
T	F	FALSE
F	T	FALSE
F	F	FALSE

In the second row of the table, X is TRUE (the Lights are ON), and Y is FALSE (the Lights are not on). Since the AND operator requires both to be TRUE, the whole expression X AND Y will be equated to FALSE

Example

200 IF (TIME.LT.19:00.AND.TIME.GT.5:00) THEN ON(LIGHTS)

Logical Expressions

XOR statement checks two sets of conditions and returns a TRUE if either condition is TRUE. However if both conditions are TRUE it will return a FALSE.

- Below is a basic XOR Truth Table

X	Y	OUTPUT
T	T	FALSE
T	F	TRUE
F	T	TRUE
F	F	FALSE

In the first row of the table, X is TRUE (PUMP1 is ON), and Y is TRUE (PUMP2 is ON) as well. Since the exclusive or operator requires only one out of the two to be TRUE, the whole expression X exclusive or Y will be equated to FALSE

Example

200 IF (PMP1.EQ.ON.XOR.PMP2.EQ.ON) THEN NORMAL(PMPALM)

Logical Expressions

NAND statement checks two sets of conditions and returns a FALSE if both conditions are TRUE. Otherwise it will return a TRUE. It is opposite of the AND statement

- Below is a basic NAND Truth Table

X	Y	OUTPUT
T	T	FALSE
T	F	TRUE
F	T	TRUE
F	F	TRUE

In the second row of the table, X is TRUE (the Lights are ON), and Y is FALSE (the Lights are not on). Since the not and operator is only FALSE if both X and Y are FALSE, the whole expression X not and Y will be equated to TRUE

Example

100 IF (LDO1.EQ.ON.AND.LDO2.EQ.ON) THEN OFF(LDO3) ELSE ON(LDO3)

X= “LDO1.EQ.ON”

Y=“LDO22.EQ.ON”

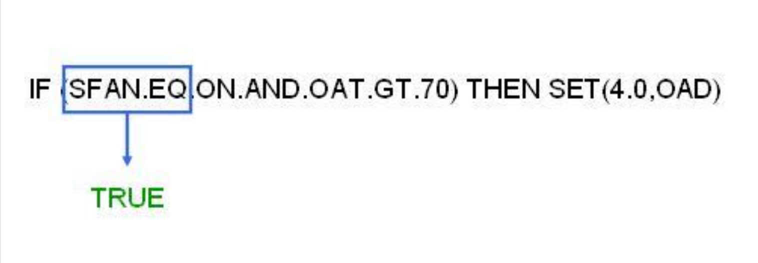
Logical Expression Evaluation Examples

IF (SFAN.EQ.ON.AND.OAT.GT.70) THEN SET (4.0, OAD)

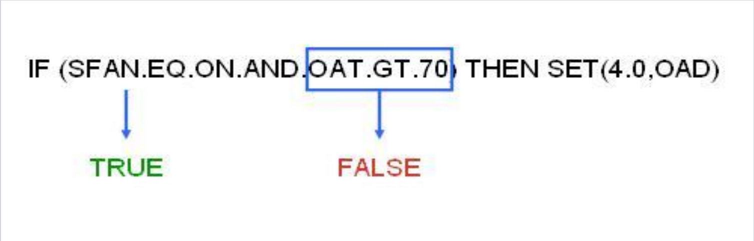
The IF-THEN statement shown above is read as "if the supply fan equals on and the outside air temperature is greater than 70 degrees, then set the outside air damper to 4 percent.

Logical Expression Evaluation Examples

1. The first step in evaluating a logical expression is to always evaluate the left (X) and right (Y) condition. In our example, the SFAN is ON, so the left condition (SFAN.EQ.ON) evaluates to TRUE

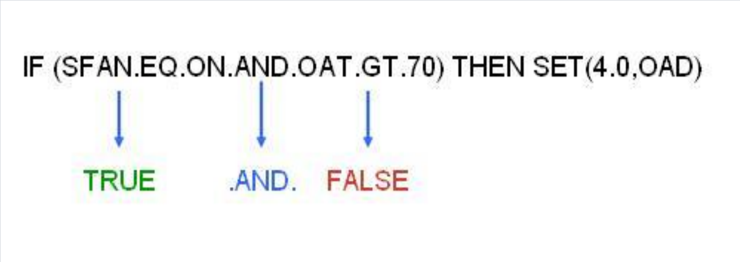


2. Now the right side (Y) of the logical expression is evaluated. In this example, the outside air temperature is 65 degrees. This makes the condition (OAT.GT.70) equate to FALSE since 65 is not greater than 70

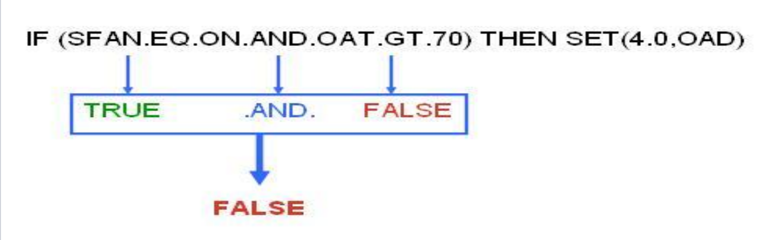


Logical Expression Evaluation Examples

3. Once the left and right hand sides of the logical expression are evaluated, the .AND. is brought down between the results from the left and the right side. Now the expression reads "TRUE and FALSE“

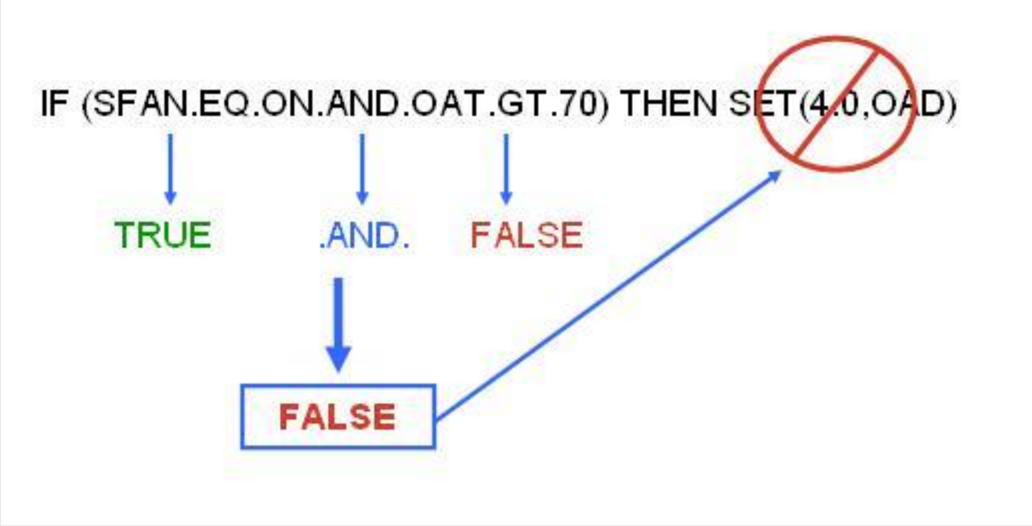


4. Finally, the logical expression can be evaluated for the answer. The .AND. operator requires both the left (X) and right (Y) side conditions to be TRUE to evaluate to TRUE, so our expression evaluates to FALSE



Logical Expression Evaluation Examples

5. Finally, the logical expression can be evaluated for the answer. The .AND. operator requires both the left (X) and right (Y) side conditions to be TRUE to evaluate to TRUE, so our expression evaluates to FALSE



IF-THEN-ELSE

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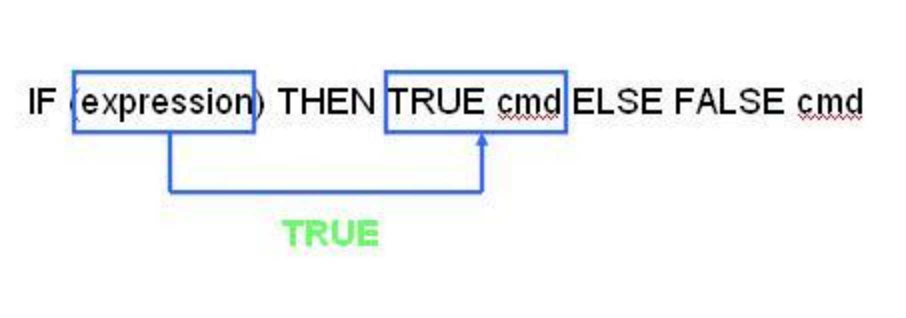
Just Like the IF-THEN statement, when the expression evaluates to TRUE, the command directly following the TRUE command is executed.



IF-THEN-ELSE

The IF-THEN-ELSE statement also provides a command to execute when the expression evaluates to FALSE. The command is placed after the ELSE and denoted a FALSE command.

IF-THEN-ELSE

IF (expression)THEN true cmd ELSE false cmd

Examples:

100 IF (DAY.GE.6) THEN ON(WKEND) ELSE OFF(WKEND)

110 IF (TIME.LT.08:00.OR.THIME.GT.18:00) THEN OFF(DAYMD) ELSE ON(DAYMD)

120 IF (SECNDS.GT.30) THEN SET(8.0.OAD) ELSE SET(3.0.OAD)

Summary So-Far

- How to use point command statements like ON, OFF, FAST, and SET
- How to interpret an IF-THEN statement
- How to use relational operators like .EQ., .GT., and .LE.
- How to use resident points
- How to use logical operators like .AND. and .OR.
- And how to interpret the IF-THEN-ELSE statement

Point Comparison Statements

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There are several statements to used to compare points

These statements include:

- MIN
- MAX

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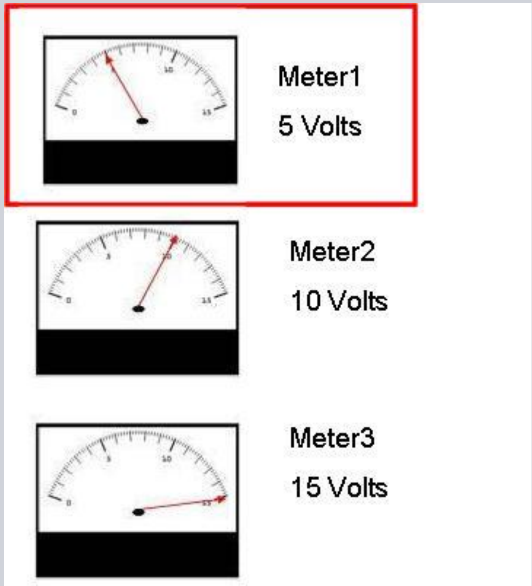
Point Comparison Statements

The MIN statement examines a group of up to 15 points (pt1,....pt15) and selects the point with the lowest value. This value is assigned to the result point.

For the three meters shown below, we could write a MIN statement to determine the lowest value. In this case, the value of meter one will be set equal to the result point.

MIN(LOWVOL, Meter1,Meter2,Meter3)



Point Comparison Statements

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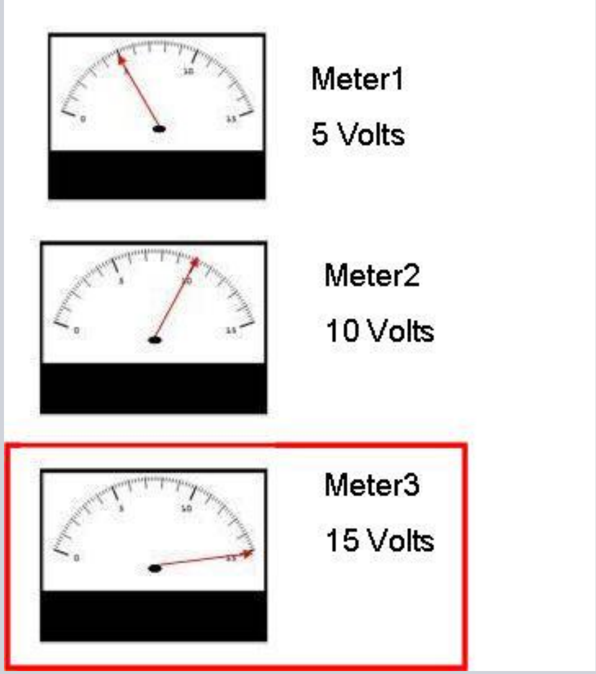
The MAX statement examines a group of up to 15 points (pt1,....pt15) and selects the point with the highest value. This value is assigned to the result point.

For the three meters shown below, we could write a MAX statement to determine the highest value. In this case, the value of meter one will be set equal to the result point.

MAX(MAXVOL, Meter1,Meter2,Meter3)



Time Average Statement

TIMAVG(RESULTS,ST,SAMPLES,INPUT)

- The TIMAVG statement is used to average the INPUT point's values over time.
-
- The SAMPLES entry tells the field panel values to average.
- The sample time (ST) designates how much time between individual samples.
- The average is stored in the RESULT point.

Time Average Example

We will examine the outside air temperature over a five minute period

Time	OAT
12:00	72
12:05	73
12:10	73
12:15	74
12:20	74

$$\text{TIMAVG} = \frac{\text{Sum of Samples}}{\text{Number of Samples}}$$

TIMAVG(AVGTEMP,300,4,OAT)

Time Average Example

First calculation

Since the number of samples is 4, we will look at the first 4 samples (12:00-12:15) of our data. The sample time is 300 seconds, or 5 minutes. For the first calculation, the OAT values are added together and divided by 4 to yield 73 degrees

Time	OAT
12:00	72
12:05	73
12:10	73
12:15	74
12:20	74

SUM=72+73+73+74=292

TIMAVG = 192/4=73

TIMAVG(AVGTEMP,300,4,OAT)

Time Average Example

The next calculation occurs at 12:20

This calculation takes into account the previous 4 times to get a value of 73.5 for the result point AVGTMP

Time	OAT
12:00	72
12:05	73
12:10	73
12:15	74
12:20	74

SUM=72+73+73+74=294

TIMAVG = 192/4=73.5

TIMAVG(AVGTEMP,300,4,OAT)

Delay Methods

WAIT statement.

In many instances, you will want to program delays into your system. For example, when the supply fan starts, wait for 30 seconds, and then start the return fan.

Programming delays are normally done in one of two ways

WAIT statement
SECNDS counter with IF-THEN statement

Delay Methods

Each mode is designated by a two-digit number (0=OFF, 1=ON). The first digit corresponds to the trigger point, and the second digit corresponds to the command point. The chart lists all possible modes

Mode	When Trigger Turns…	The command point turns…
11	ON	ON
10	ON	OFF
01	OFF	ON
00	OFF	OFF

Delay Methods

WAIT(time,trigger pt,command pt, mode)

- The WAIT statement can be used to place delays on digital points
- The WAIT command waits for the trigger point to change its value, and then commands the command point after the time delay
- The mode defines how the WAIT statement operates

Delay Methods

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Use

The **WAIT command turns a point ON or OFF based on the trigger** point switching ON or OFF. Selection of trigger/result action is based on the mode you enter.

Example

WAIT(30,SFAN,RFAN,11)

WAIT(120,PLITE,OLITE,00)

WAIT(45,DAYMD,NITEMD,01)

WAIT(time,trigger pt,command pt, mode)

Delay Methods

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Example

WAIT(30,SFAN,RFAN,11)

Since this has a mode of 11

- SFAN turns ON (1)
- WAIT statement will delay 30seconds
- Then turn ON (1) RFAN

WAIT(time,trigger pt,command pt, mode)

Delay Methods

Example

WAIT(120,PLITE,OLITE,00)

Since this has a mode of 00

- When PLITE turns OFF (0)
- WAIT statement will delay 120 seconds
- Then turn OFF (0) OLITE

WAIT(time,trigger pt,command pt, mode)

Delay Methods

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Example

WAIT(45,DAYMD,NITEMD,01)

Since this has a mode of 01

- When the DAYMD turns OFF (0)
- WAIT statement will delay 45 seconds
- Then turn ON (1) NITEMD

WAIT(time,trigger pt,command pt, mode)

Delay Methods

The position of a WAIT statement within a program will affect its operation. The WAIT statement will only work if it sees a change of value (COV) for the trigger point.

In other words:

- The WAIT statement needs to "see" the trigger point in both the ON and OFF states.
- If the WAIT statement does not see the trigger point change, then the command point will never be commanded.

Correct Method:

```
100 WAIT(30,FAN1,FAN2,11)
110 ON(FAN1)
```

Incorrect Method:

```
100 ON(FAN1)
110 WAIT(30,FAN1,FAN2,11)
```

Delay Methods

Correct:

Correct Method:

```
100 WAIT(30,FAN1,FAN2,11)
110 ON(FAN1)
```

Incorrect Method:

```
100 ON(FAN1)
110 WAIT(30,FAN1,FAN2,11)
```

This is a proper way to employ the WAIT statement. Notice that the WAIT statement is written before FAN1 is commanded ON. This allows the WAIT statement to "see" FAN1 in both the ON and OFF states, so the trigger will operate properly.

In general, WAIT statements are usually placed at the top of a program so that they will be executed every pass.

Delay Methods

Incorrect:

Correct Method:

```
100 WAIT(30,FAN1,FAN2,11)
110 ON(FAN1)
```

Incorrect Method:

```
100 ON(FAN1)
110 WAIT(30,FAN1,FAN2,11)
```

When the WAIT statement is written as it is in this example, it will never see the point FAN1 in the OFF state. This occurs because line 100 will turn FAN1 ON before line 110 is executed.

This, in effect, hides the COV from the WAIT statement. Since the WAIT statement will never see the value change, it will never trigger the delay

Delay Methods

The WAIT statement is an effective and easy way to incorporate equipment delays, but it does have limitations

- **The WAIT statement only makes one attempt at commanding the point.**
- **The WAIT statement only allows one point to be commanded per statement.**
- **The WAIT statement only works with digital points**

Using IF-THEN Statements for Delays

Conditional statements can also be used to delay commands. Conditional statements use timers such as the SECNDS counter to enact command delays.

Line 100 operates the trigger by keeping the SECNDS counter at 0 until we want the delay to begin (in this case, when the SFAN turns ON). Line 100 does this by commanding the SECNDS counter to 0 when the SFAN is OFF. Remember, the SECNDS counter always counts up, unless we change its value.

```
100 IF(SFAN.EQ.OFF) THEN SECNDS = 0
110 IF(SECNDS.GT.30) THEN ON(RFAN) ELSE OFF(RFAN)
```

Line 110 watches the SECNDS counter that is being controlled by line 100. When the SFAN turns ON, line 100 stops commanding the SECNDS counter and it begins to count up.

When the SECNDS counter becomes greater than 30 seconds, the RFAN is commanded ON. Note that this line also commands the RFAN OFF when the SECNDS counter is below 30 seconds.

```
100 IF(SFAN.EQ.OFF) THEN SECNDS = 0
110 IF(SECNDS.GT.30) THEN ON(RFAN) ELSE OFF(RFAN)
```

Dead band Switch

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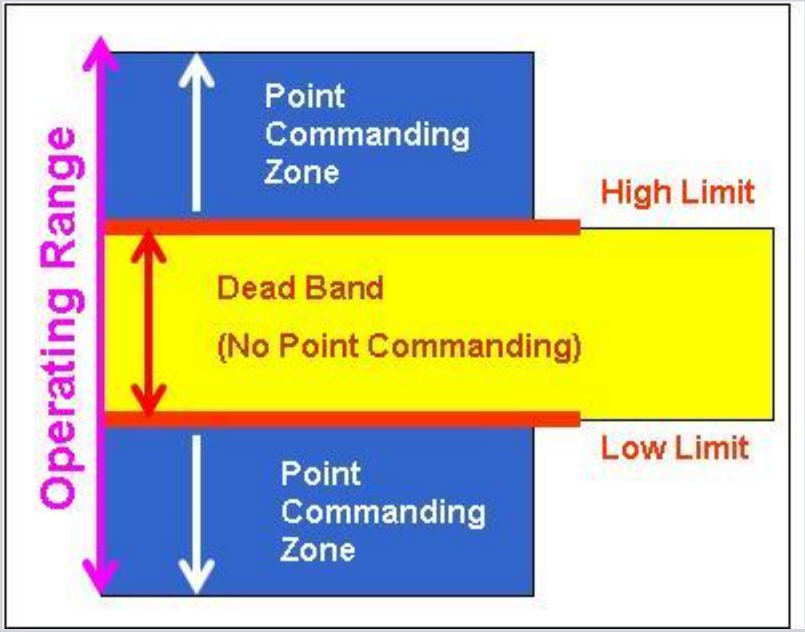
Dead Band control is a method of maintaining system parameters between a high and low limit.

- The range between the high and low limit is known as the Dead Band.
- When the system is above the high limit, or below the low limit, it responds by performing an action that attempts to bring the system back to the Dead Band. These areas are denoted as Point Commanding Zones in the diagram.
- When the system is in the Dead Band area, no action is taken.



Dead Band Switch

Dead Band operate in two different modes or types.

- Cooling Mode (Type 0)
- Heating Mode (Type1)

Type 0 is known as the Cooling Type.

In this type of Dead Band:

- the points are commanded ON above the upper limit
- The points are commanded OFF below the lower limit.
- The points are not commanded within the Dead Band.

Type 1 is known as the Heating Type.

In this type of Dead Band:

- the points are commanded OFF above the upper limit
- The points are commanded ON below the lower limit.
- The points are not commanded within the Dead Band.

Dead Band Switch

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- **DBSWIT(type,input,low,high,pt1,...,pt12)**

The DBSWIT statement (Dead Band Switch) is used to cycle up to twelve (12) digital points ON and OFF through a dead band

type The type of dead band switch action.

- 0 = All output points (pt1,...,pt12) are commanded ON when the input point value rises above the high limit, and are commanded OFF when the input point value falls below the Low limit.
- 1 = All output points (pt1,...,pt12) are commanded ON when the input point value falls below the low limit, and are commanded OFF when the input point value rises above the high limit.

Dead Band Switch

- **DBSWIT(type,input,low,high,pt1,...,pt12)**

The **input** is:

- a point that triggers the commanding within the **DBSWIT**.
- When the **input** rises above the **high** limit, or drops below the **low** limit, the digital points will be commanded ON or OFF based upon the type of Dead Band

low and **high** represent the lower and upper values of the Dead Band area. When the input is between these limits, no action is taken

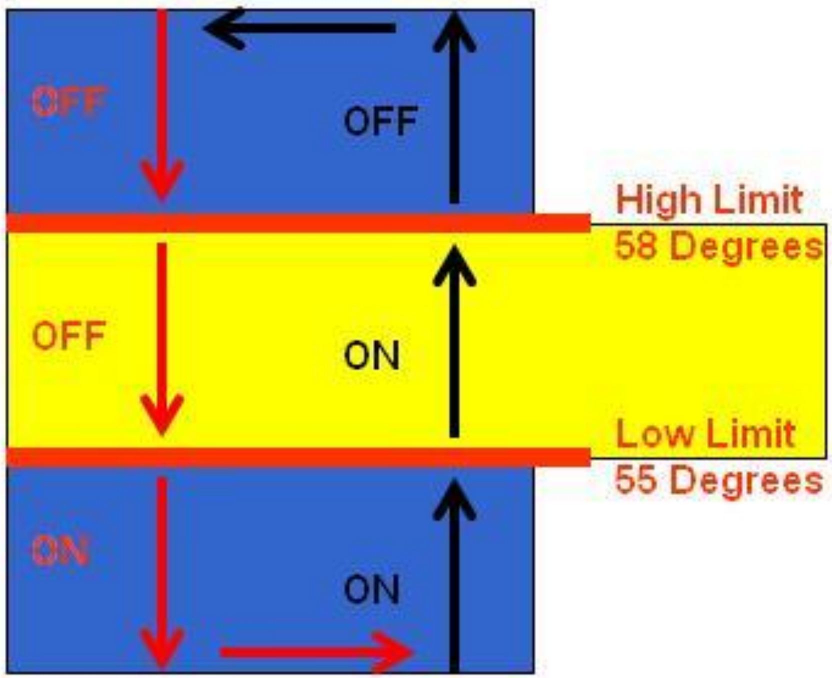
Pt1,….Pt12

This is a list of up to 12 digital points that:

- are commanded when the **Input** rises above the **High** limit
- or drops below the **Low** limit.
- When the input is between those limits, it does not command these points

Dead Band Switch

Example:



Type 1 (Heating)

DBSWIT(1,RMT,55,58,SFAN)

Dead Band Switch

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Example: **DBSWIT(1,RMT,55,58,SFAN)**

Point 1 starts with the SFAN being commanded OFF by the DBSWIT

The OFF command occurs since we are using a Type 1 (Heating) Dead Band and the input room tempature (**RMT**) is above the high limit (58 degrees)

As the room temperature is starts to cool and has entered the Dead Band area

Within the Dead Band, the DBSWIT does not command the SFAN, so it will remain in the OFF position

As the room temperature drops below the low limit of 55 degrees. This triggers the DBSWIT to command the SFAN ON, to bring warm air into the room

The room temperature will not start to rise.

The room temperature (RMT) is now starting to rise and has re-entered the Dead Band area.

Within the Dead Band, the DBSWIT does not command the SFAN, so it will remain in the ON position

The SFAN has now blown enough warm air into the room to raise its temperature above the high limit of 58 degrees

The DBSWIT now turns the SFAN OFF, since the room does not need to be further heated

LOOP Control

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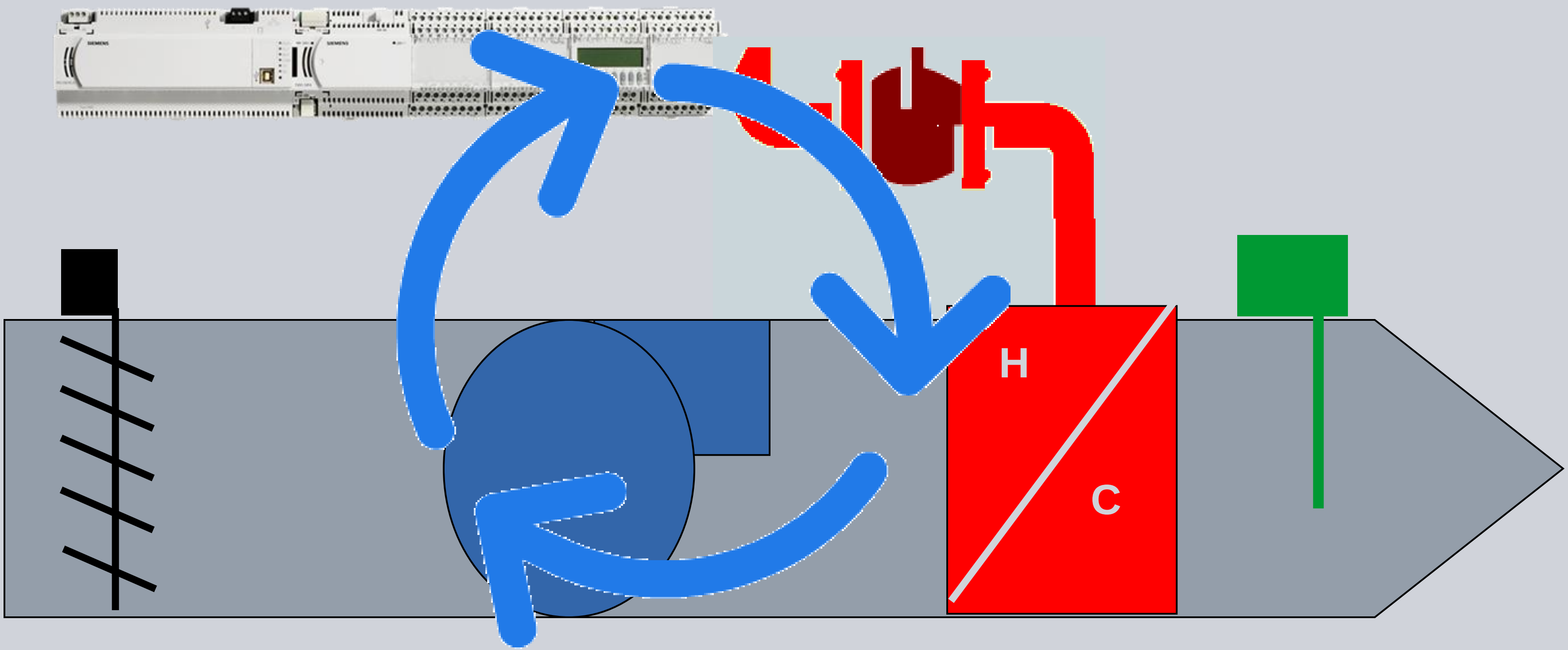
LOOP control compares an input to a set point, and then calculates an output



Loop Control

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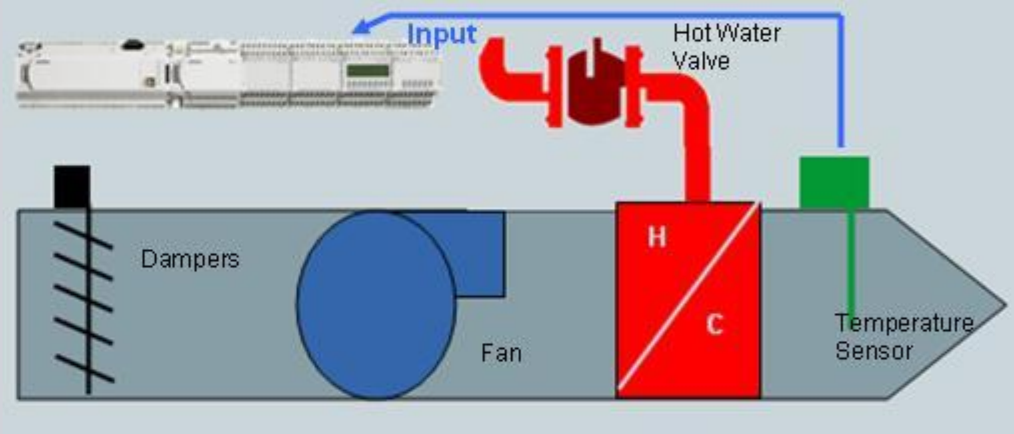

Step #1 The controller reads the input point value. The input is the point that the LOOP is trying to control

Loop Control

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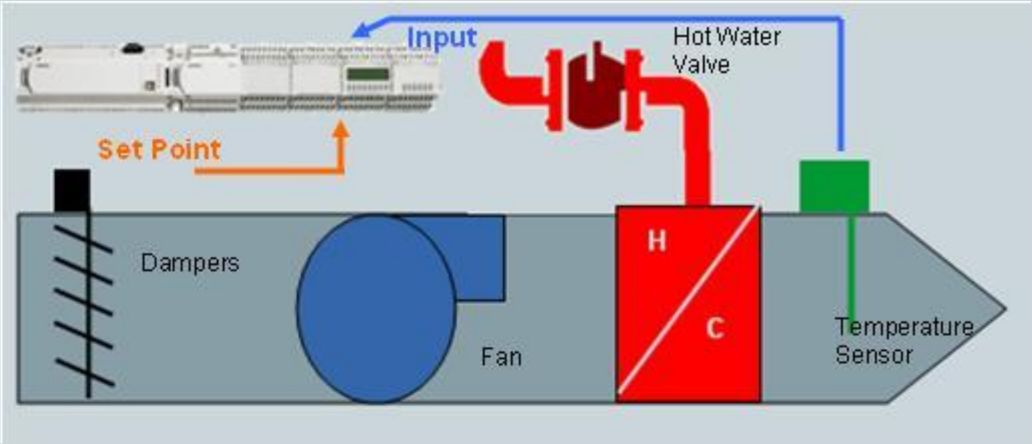
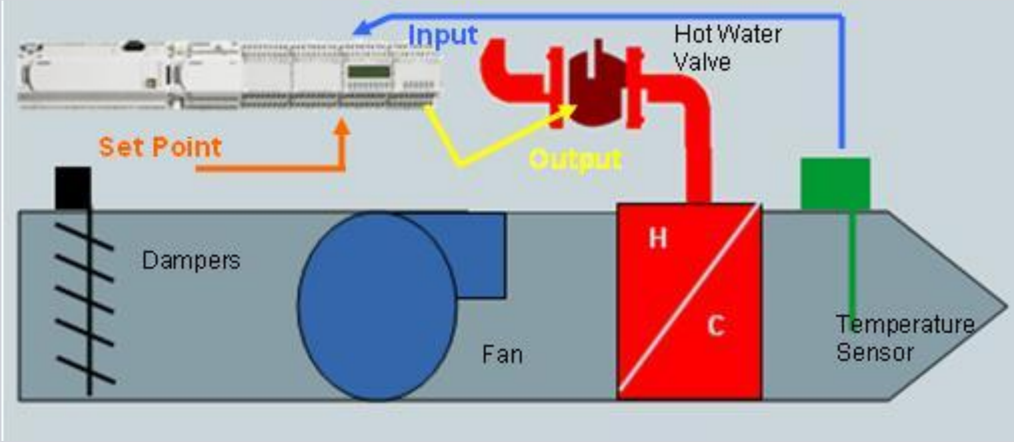


Step # 2 The value of the input is now compared to the set point, and then the controller calculates an output

Loop Control



Step # 3 The calculated output is then sent to the controlled device (e.g. a hot water valve). The output adjusts the conditions in the system to bring the input closer to the set point

Loop Control

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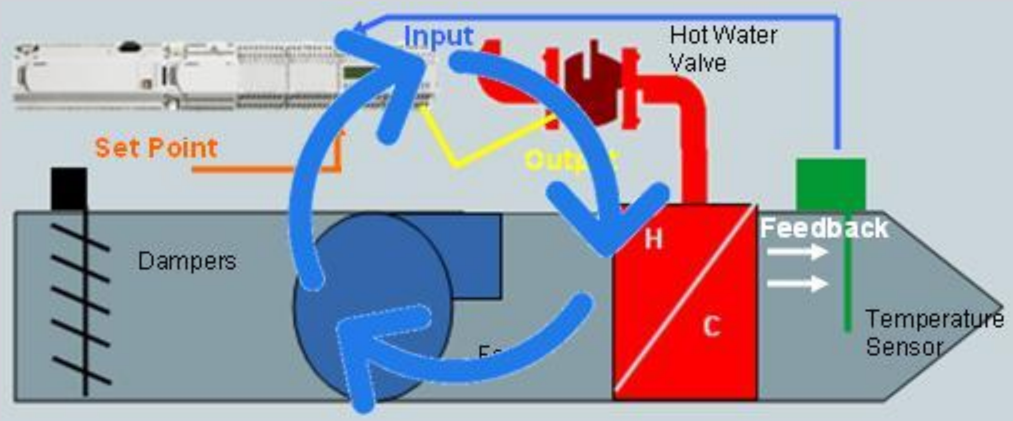
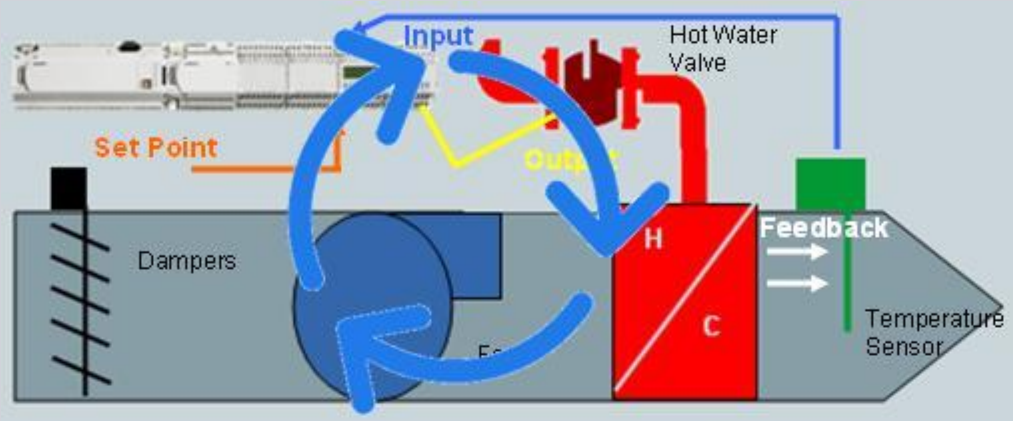


Step #4 Finally, the command given by the output changes the temperature of the air, which is seen by the temperature sensor. This action provides feedback to the LOOP

Loop Control



The whole process continuously repeats itself making minor adjustments as operating conditions change.

LOOP Statement

LOOP(type,pv,cv,sp,pg,ig,dg,st,bias,lo,hi,0)

The LOOP statement provides PID (proportional-integral-derivative) control for your system, and is one of the most powerful statements in PPCL

LOOP Statement

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LOOP(type,pv,cv,sp,pg,ig,dg,st,bias,lo,hi,0)

LOOP control takes into account different types of output adjustments gains:

- Proportional Gain (PG)
- Integral Gain (IG)
- Derivative Gain (DG)

When LOOP control calculates the output signal, it uses PG, IG, and DG to determine how much to adjust the output

Each type of gain reacts to system Error in a different manner. A system's error is simply the difference between the input and the set point

LOOP Statement

LOOP(type,pv,cv,sp,pg,ig,dg,st,bias,lo,hi,0)

The **Type** tells the LOOP statement whether the system is direct-acting or reverse-acting. Type is assigned a value of 0 for direct-acting, and 128 for reverse-acting

The **PV** stands for Process Variable. It is the input for the LOOP. The LOOP commands the output (CV) to move the input (PV) closer to the set point

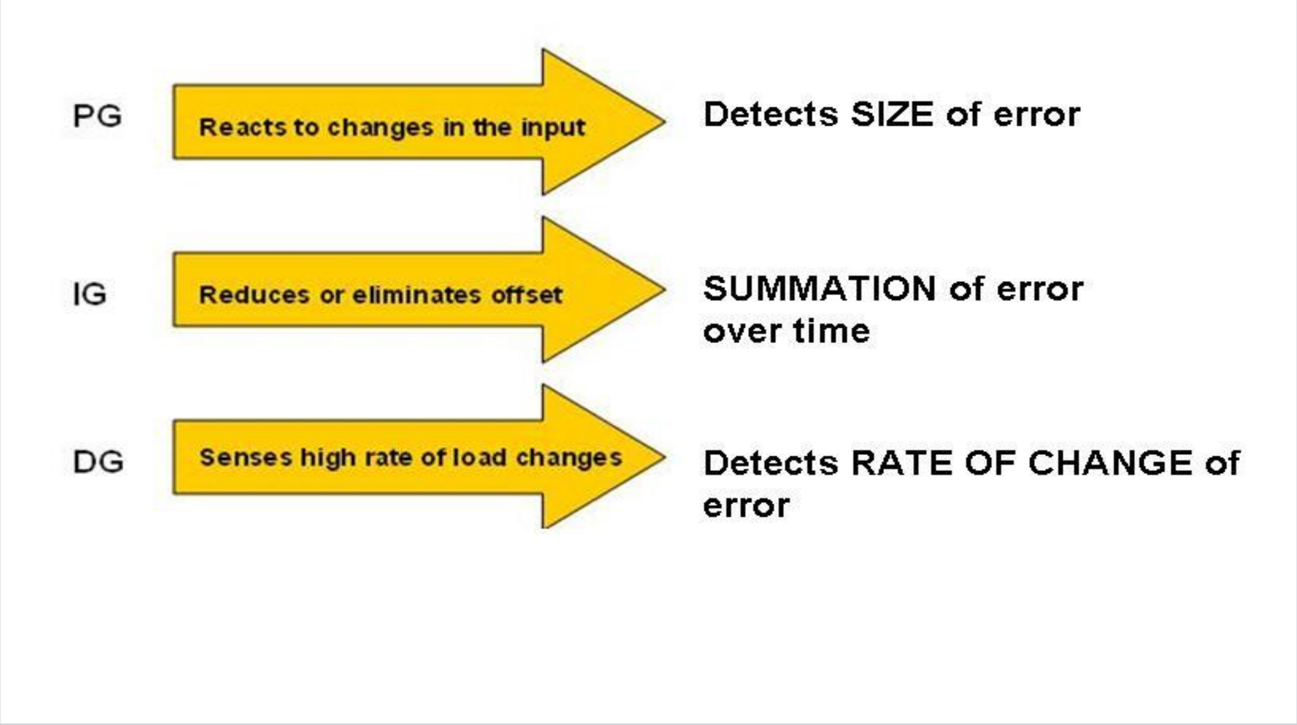
The **CV** stands for Controlled Variable. It is the output for the LOOP. The LOOP controls this output in an attempt to move the input closer to the set point

The **SP** is the Set Point for the input (PV). The LOOP statement adjusts the output (CV) to move the input closer to the set point (SV)

LOOP Statement

LOOP(type,pv,cv,sp,pg,ig,dg,st,bias,lo,hi,0)

PG, **IG**, and **DG** stand for Proportional, Integral, and Derivative Gain. These values are used to calculate the LOOP output

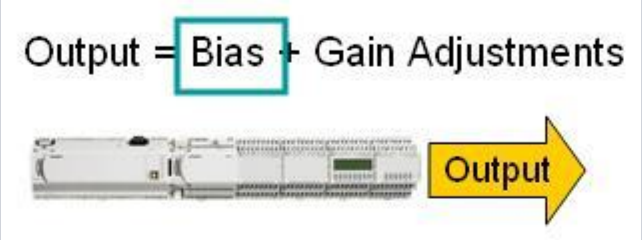


LOOP Statement

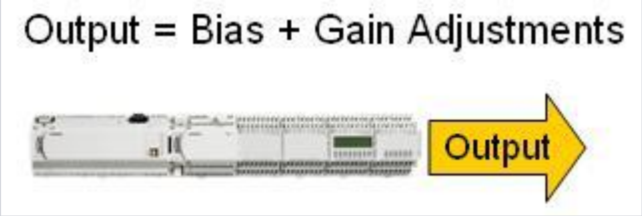
LOOP(type,pv,cv,sp,pg,ig,dg,st,bias,lo,hi,0)

ST is the sample time of the LOOP. Sample time designates how often the LOOP output (CV) is recalculated

Bias is the mid-point of the output command range. For example, if the output is 0-10 V, then the bias is 5V.



LOOP control calculates its output based upon the Bias and Gain Adjustments

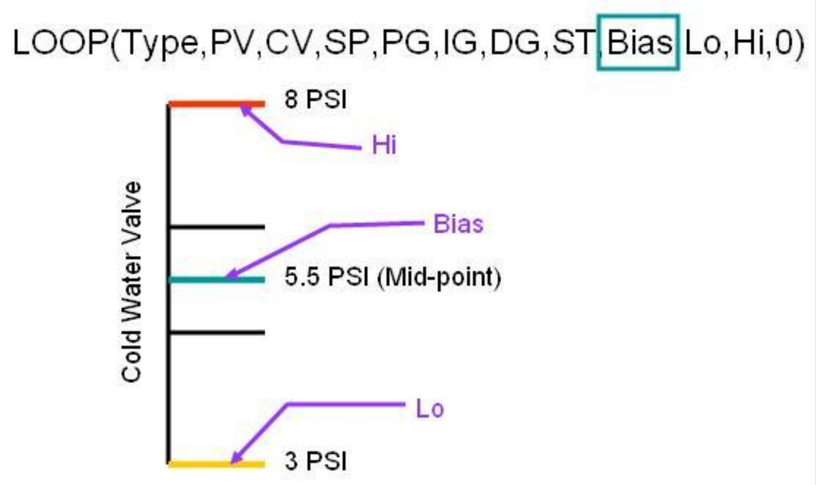


LOOP Statement

LOOP(type,pv,cv,sp,pg,ig,dg,st,bias,lo,hi,0)

The Gain Adjustments portion of the output calculation accounts for the proportional, integral, and derivative gains

Bias is the mid-point of the output command range. For example, if the output is 0-10 V, then the bias is 5V. Lo has a value of 0 and Hi has a value of 10.



LOOP Statement

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LOOP(type,pv,cv,sp,pg,ig,dg,st,bias,lo,hi,0)

The last value is always zero (0), and is reserved for future use

Examples:

LOOP(0,RM12,HWV,HWSP,1000,10,0,1,5.5,3.0.8.0,0)

LOOP(128,RM12,EHT,RMSP,750,14,0,1,5.0,0.0,10.0,0)

LOOP(0,SAP,FNVN,SPSP,1200,22,8,1,10.5,8.0,13.0,0)

Creating a Program

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- List the steps for creating a PPCL Program
- Given a Sequence of Operation, create a Decision Table and Flow Chart.
- Identify PPCL statements that can control program flow.
- Describe how point priorities can affect commanding points in PPCL.

Building a Program

1. Read and understand the Sequence of Operation
2. Create a Decision Table
3. Create a Flowchart
4. Write a program
5. Check your work

Sequence of Operation

General Operation

- The zone shall be occupied from 8:00 am to 6:00 pm. The room temperature (Z01RMT) will be averaged (Z01RAV) using 4 samples over a 10 minute period.

Sequence of Operation

Day Mode

- During the day, the air handler shall run continuously. When the air handler is started, the mixed air damper (A01MAD) shall be opened and the supply air fan (A01SAF) shall start. The return fan (A01RAF) shall start 30 seconds after the supply fan starts. The hot water valve (A01HWV) shall be modulated to maintain the supply air temperature (A01SAT) at set point (A01SAS)

- The supply air set point (A01SAS) will be reset based on the following schedule:

Avg. Room Temp. (Z01RAV)	Set Point (A01SAS)
65	100
75	70

Sequence of Operation

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Night Mode

- During the unoccupied period, the mixed air damper (A01MAD) will be closed and the supply fan (A01SAF) and the return fan (A01SAF) are turned off.

Safety Mode

- If the Low Temperature Detector (A01LTD) or the smoke alarm point (A01SMK) go into alarm. Then the system shall shut the mixed air dampers (A01MAD) and turn off the supply fan (A01SAF) and the return fan (A01RAF).

Sequence of Operation

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Point List

A01MAD	Mixed Air Damper (LDO)
A01SAF	Supply Fan (LDO)
A01RAF	Return Fan (LDO)
Z01RMT	Zone 1 Room Temp. (LAI)
Z01RAV	Avg. Room Temp (virtual LAO)
A01SAT	Sup. Air Temp. (LAI)
A01SAS	Sup. Air Set Point (virtual LAO)
A01HWV	Heating Valve (LAO)
A01 LTD	Low Temp. Detector (LDI)
A01SMK	Smoke Alarm (LDI)

Decision Table

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Decision Tables are used to identify the various modes and points that will commanded in the program. It lists all of the points to be commanded and each point's value for the various modes of the program.

Outputs	Day Mode	Night Mode	Safety
A01SAF	ON	OFF	OFF
A01RAF	ON	OFF	OFF
A01MAD	ON	OFF	OFF

Program Flowchart

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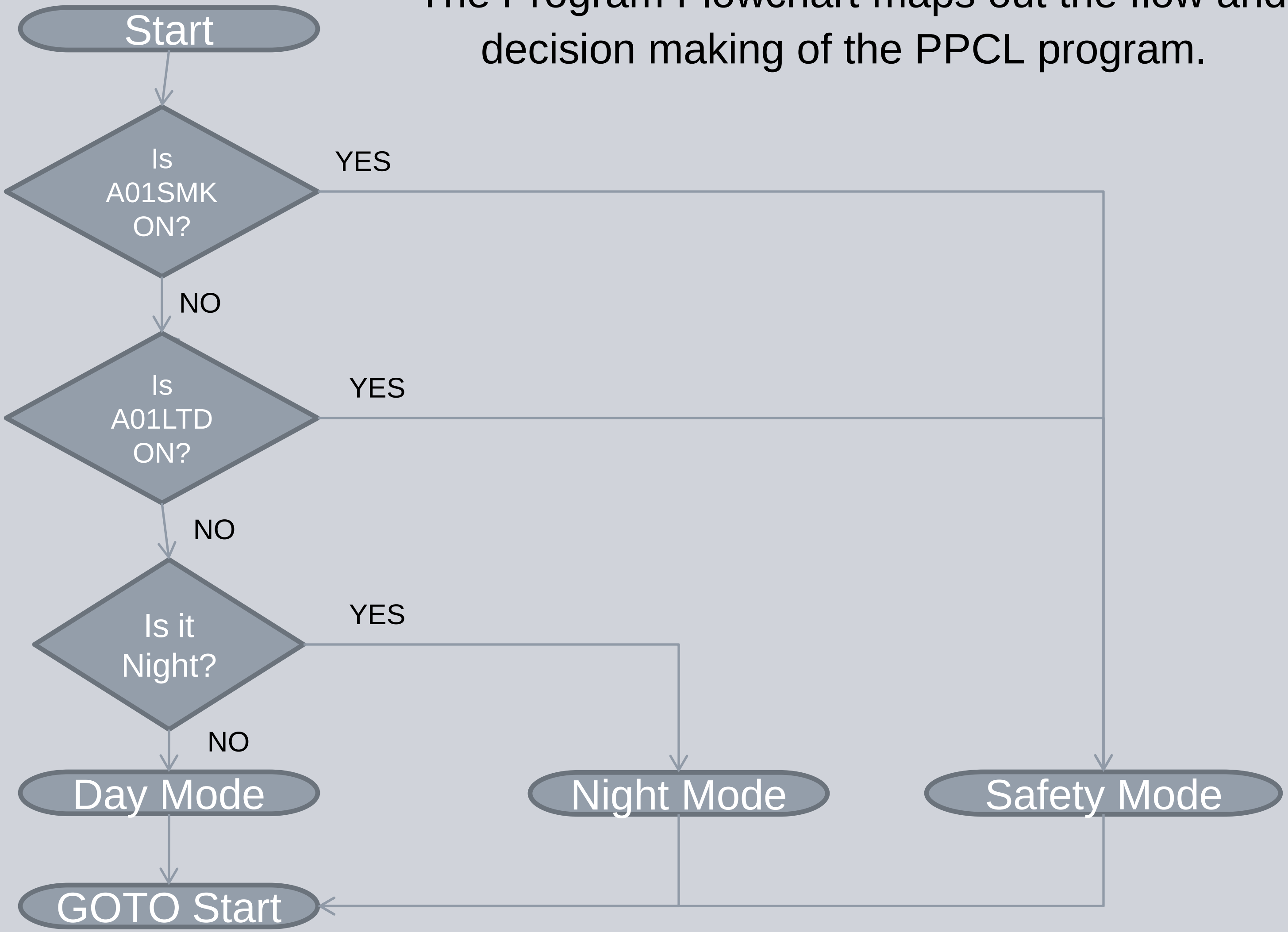
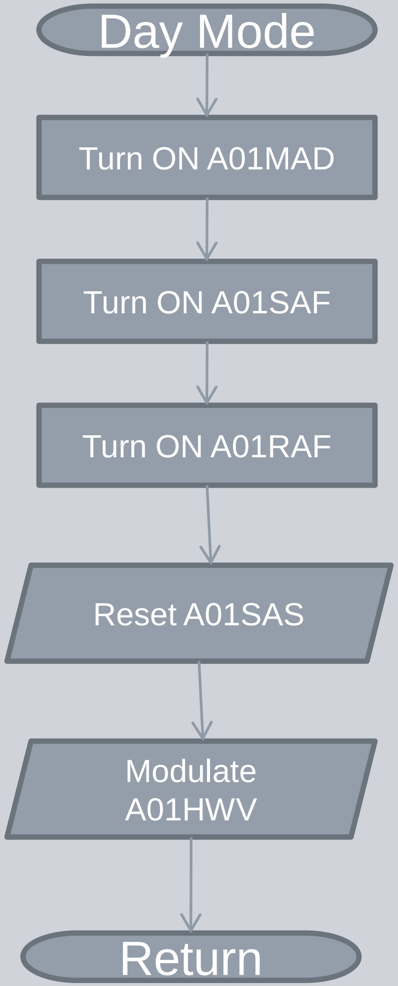
The Program Flowchart maps out the flow and decision making of the PPCL program.



Program Flowchart



Day Mode

Program Flowchart

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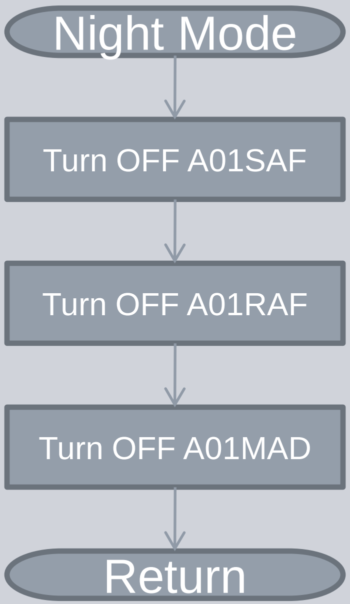

Night Mode

Program Flowchart

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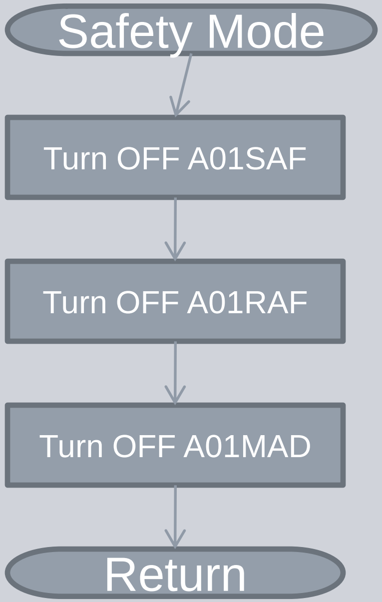

Safety Mode

PPCL Program

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```
 999 C ***COMMON***
1000 TIMAVG("Z01.RAV",600,4"Z01RMT")
1999 C ***PROGRAM DECISION***
2000 IF ("A01.SMK".EQ.ALARM) THEN GOTO 7000
2010 IF ("A01.LTD".EQ.ON) THEN GOTO 7000
2020 IF (TIME.LT.08:00.OR.TIME.GT.18:00)THEN GOTO 6000
2030 GOTO 5000
4999 C ***OCCUPIED***
5000 ON("A01MAD","A01SAF")
5010 IF("A01.SAF.EQ.OFF)THEN SECNDS = 0
5020 IF (SECNDS.GT.30) THEN ON("A01.RAF")
5030 TABLE ("Z01.RAT","A01.SAS",65,100,75,75)
5040 LOOP(0,"A01SAT","A01.HCV","A01SAS",900,25,0,1,5,5,3.0,8.0,0)
5050 GOTO 8000
5999 C***UNOCCUPIED***
6000 OFF("A01.MAD"."A01.SAF","A01.RAF")
6010 GOTO 8000
6999 C***SAFETY***
7000 OFF("A01.MAD"."A01.SAF","A01.RAF")
7010 SET(3.0,"A01.HWV")
7020 GOTO 8000
8000 GOTO 1000
```

Questions?