Fundamentals of DDC

Fan Control

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Block Objective

- The objective of this block is to apply programming tools to the supply air fan and return air fan processes. The control logic will provide for the starting and stopping of the fans and for the variable speed drives associated with the fans when they are used with variable volume systems. Considerations for both time and temperature based control are discussed as are interlocks with the mixed air section, smoke control dampers and the fire control system.
- Sample DDC Software Solutions are shown.

Fan Control

- This presentation will build logic for controlling the supply fan that includes:
  - Time based control with proofing
  - Time and temperature control
  - Mixed Air Low Limit
  - Smoke Damper
  - Pressurization & Evacuation
  - Building Purge Cycle
- Control logic for the variable speed drive process will also be presented.

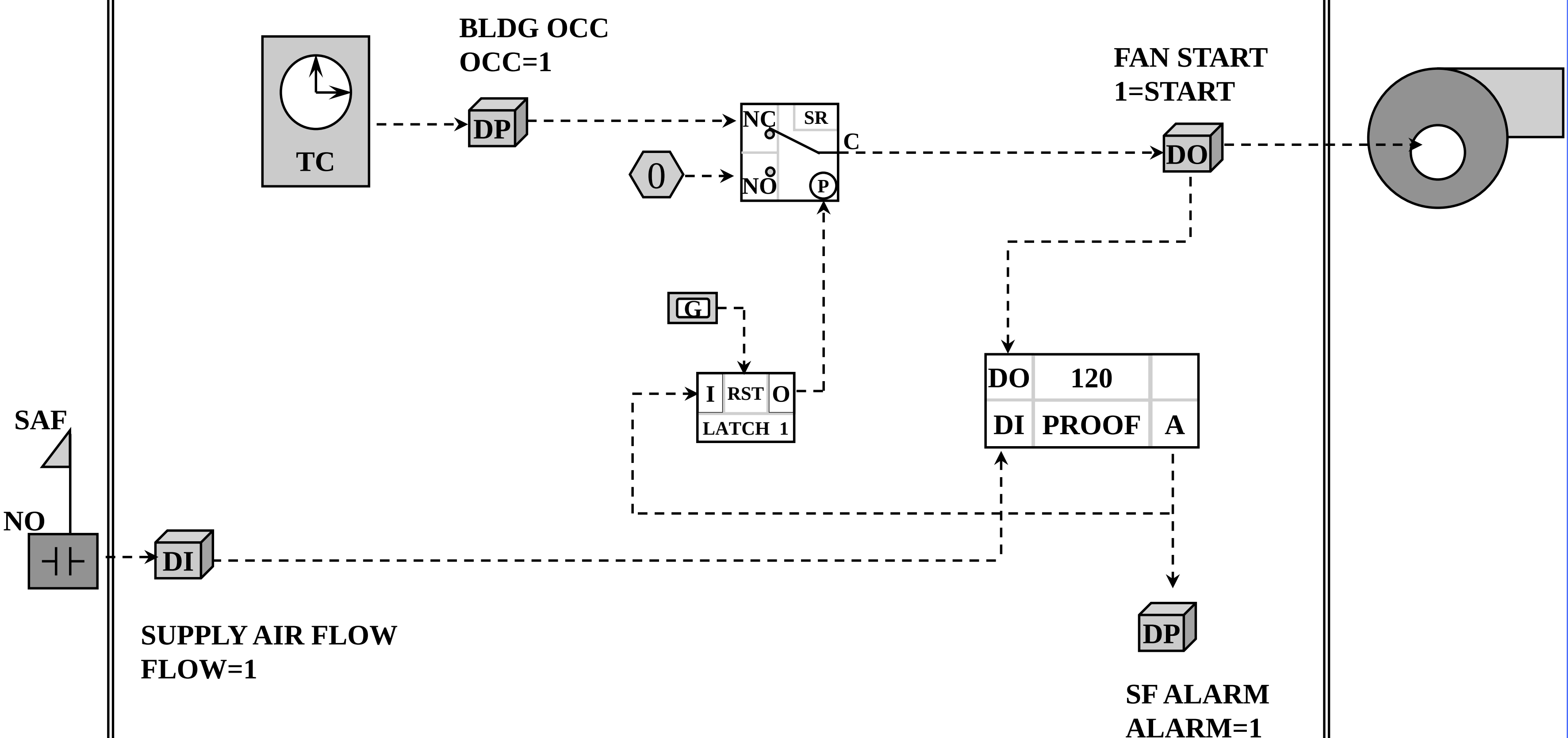
Fan Control

- Control logic for the return fan will be discussed.
  - Coordination with Supply Fan
  - Smoke Damper
  - Pressurization & Evacuation
- Control logic that coordinates the control of the return fan VSD with control of the supply fan VSD will also be presented.

Supply Fan (Time)

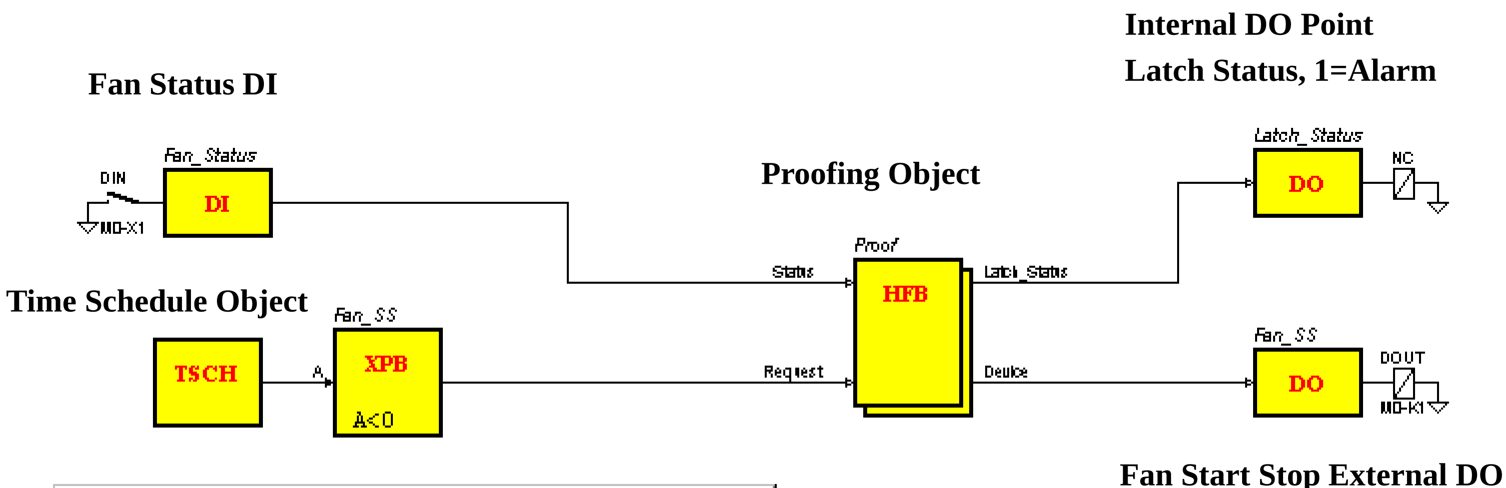
- **Controlled Device: Fan Start/Stop Circuit**
- **Process Variable: Time**
- **Relationship: Two position control**
- **Parameters: Time Schedule**
- **Limits & Conditions**
  - **Proof must be normal**
  - **Latch off if proof is off normal, manual reset from operator station required**
  - **Proofing requires a time to state delay**

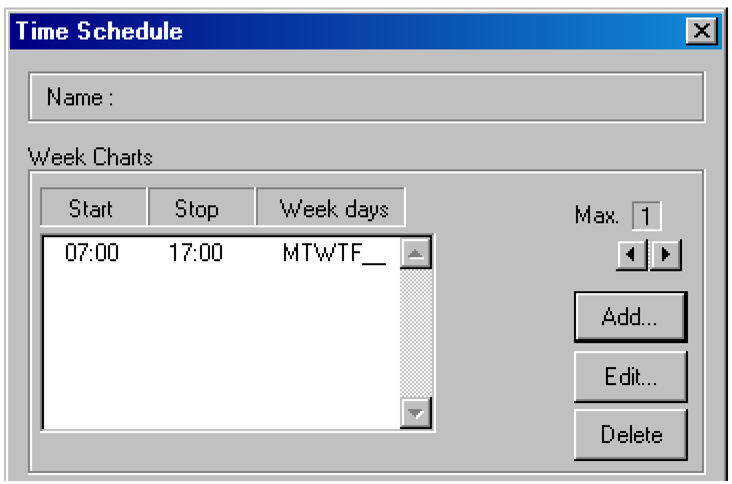
Supply Fan (Time)



DP=Internal Digital Point

DDC Software



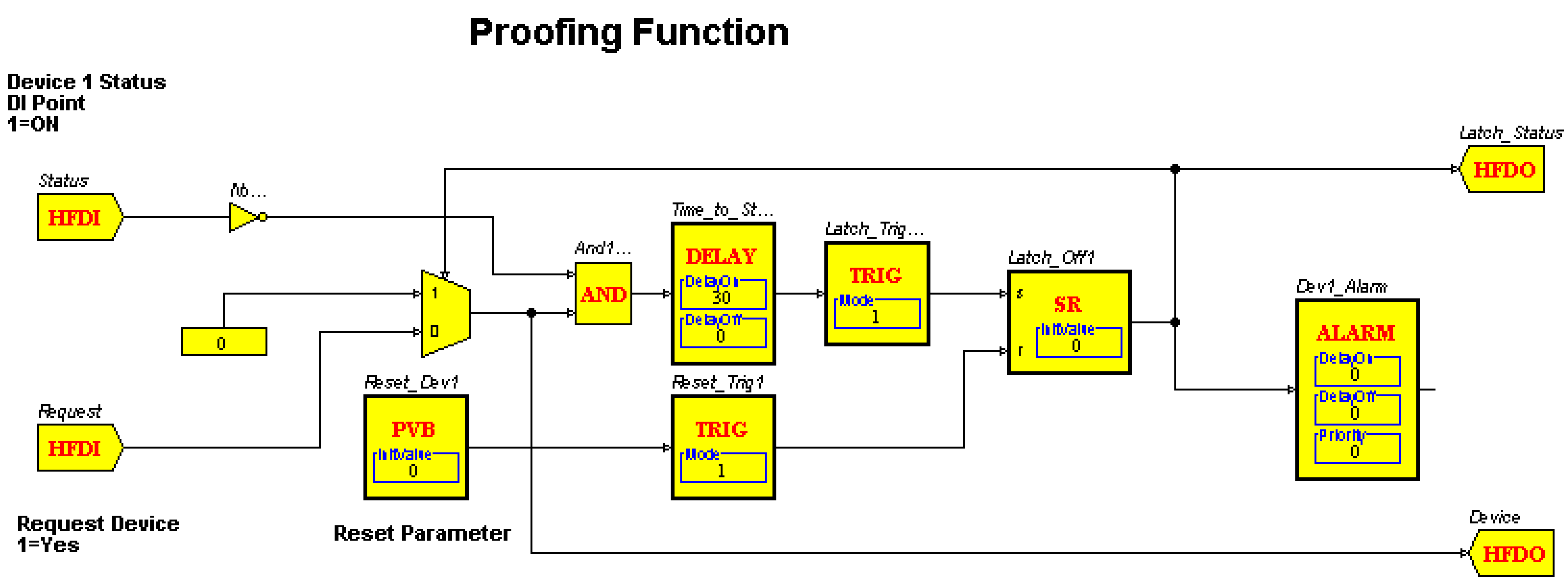


The TSCH (Time Schedule) object is quite unique. Its output is the time in minutes until the next event. If the value is positive then the schedule is awaiting a start command (off mode) and if the value is negative then the schedule is awaiting a stop command (on mode).

The calculation asks, "Are you negative…awaiting a stop command". If this is true (the system is on) the output of the calculation will be a 1 (start).

FanCntrl1

Proofing Object Expanded



Proofing Function: Upon a request for the device to start, the device status will be monitored. If the device status does not indicate a start within a specified period of time, the request for the device shall be interrupted, the request shall be latched off and an alarm shall be generated.
The operator shall have the ability to clear the latch from the HMI through a controllable parameter. Note that this logic does not preclude the use of "Hand Mode Control" that will result in a positive device status without a software request for the device.

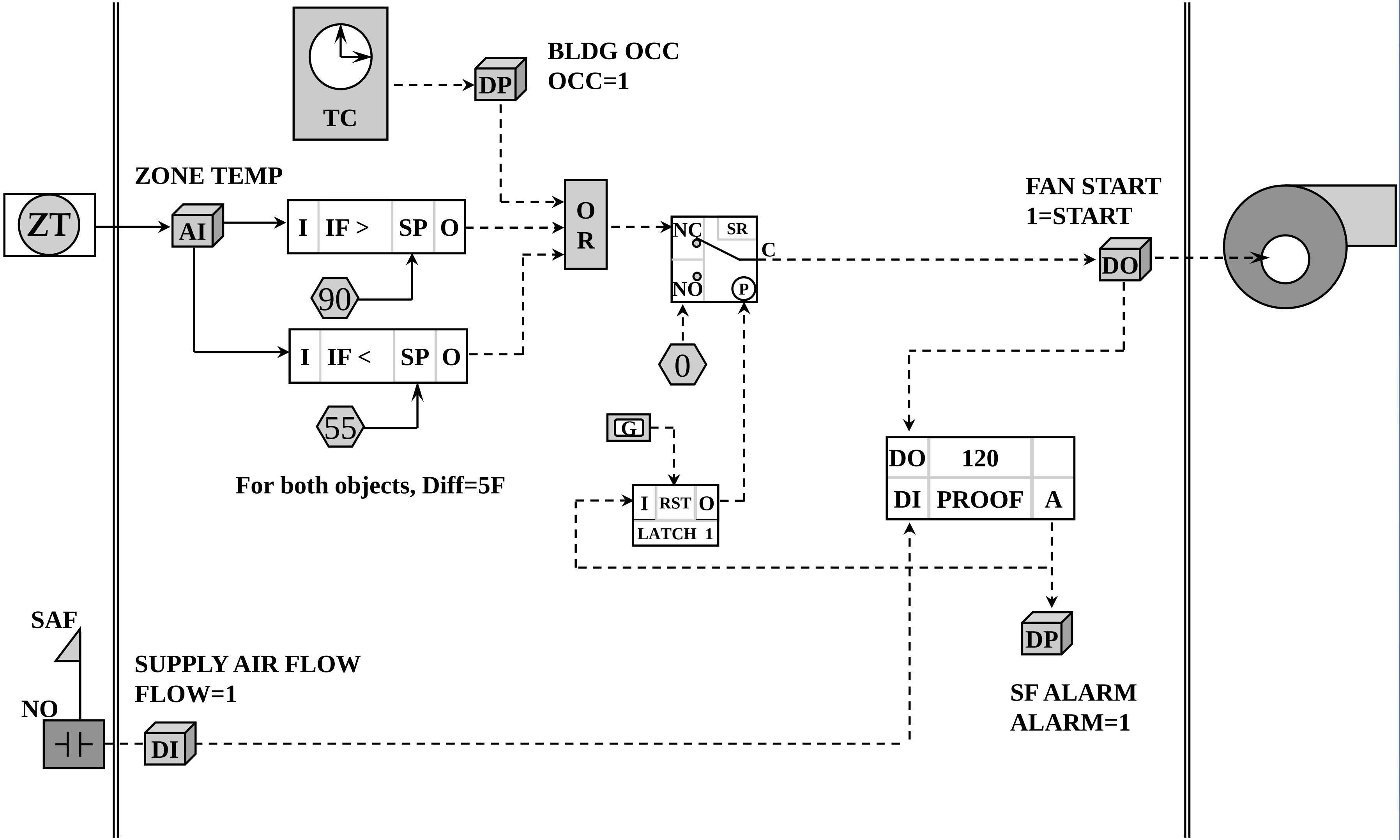
Control Signal to the end device.
(DO Point: 1=Start)

FanCntrl1

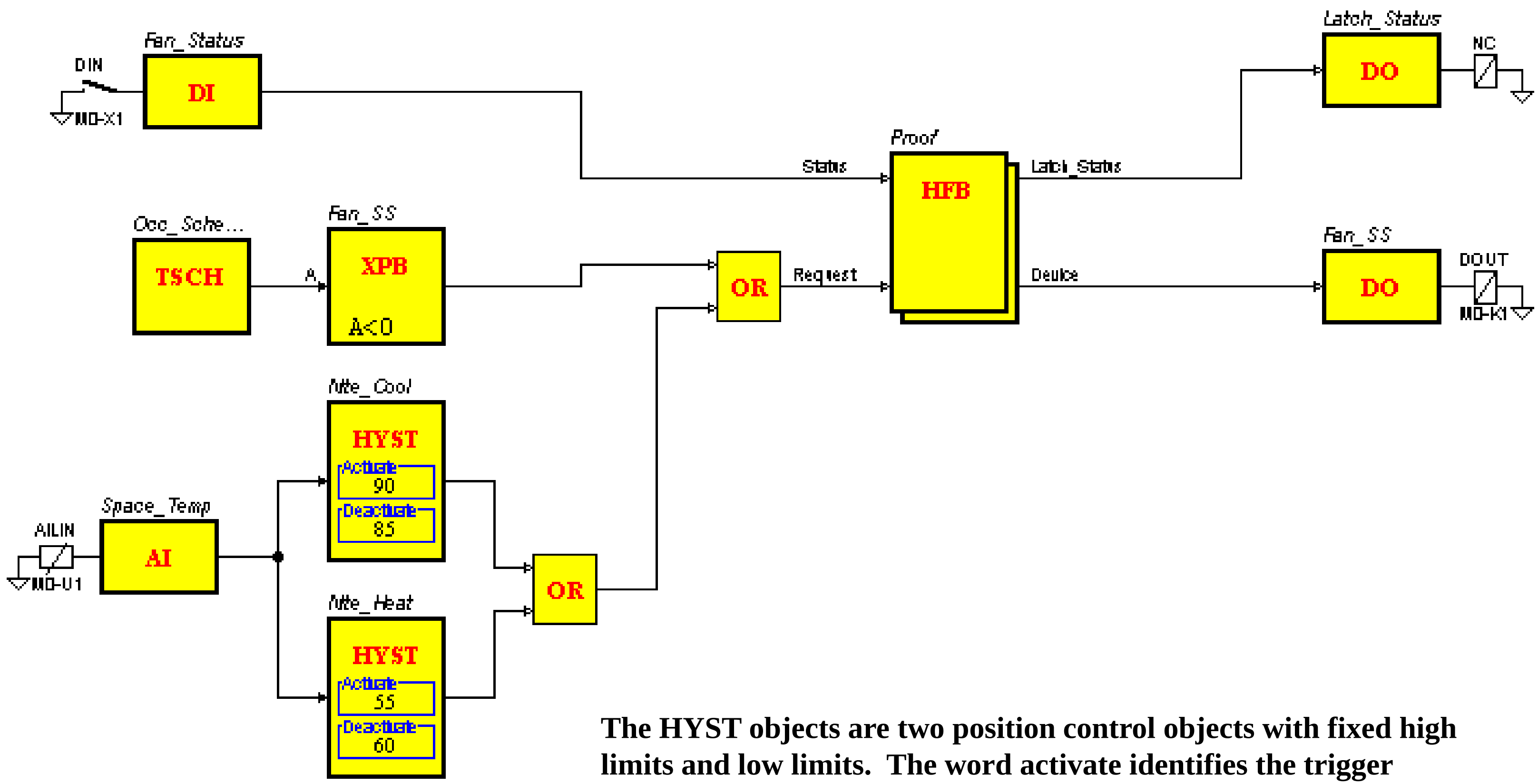
Supply Fan (Time & Temp)

- Controlled Device: Fan Start Stop Circuit
- Process Variable: Time
- Relationship: Two Position
- Parameters: Time Schedule
- Limits & Conditions
  - Proof must be normal
  - Latch off if proof is off normal, manual reset from operator station required
  - Time to State delay on the proof required
  - When system is unoccupied, a space temperature greater than 90F or less than 55F shall cause a temporary start to change the space temperature by 5F.

Supply Fan (Temperature)



Adding Temperature Control



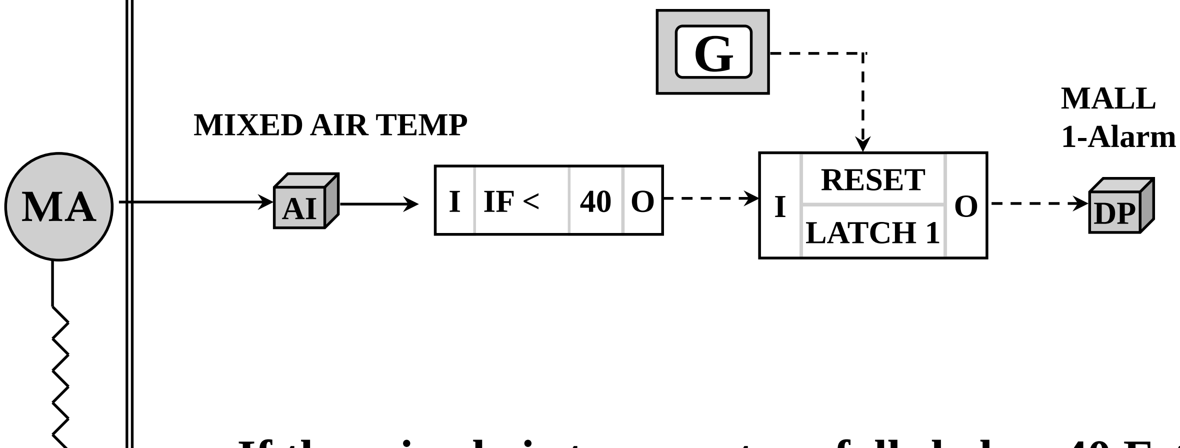
The HYST objects are two position control objects with fixed high limits and low limits. The word activate identifies the trigger point that creates an output of 1. The word deactivate identifies the trigger point that creates an output of 0.

FanCntrl2

Add Another Limit

- **Should the mixed air temperature fall below 40F, the fan shall be stopped and the control logic shall be latched to an off mode.**

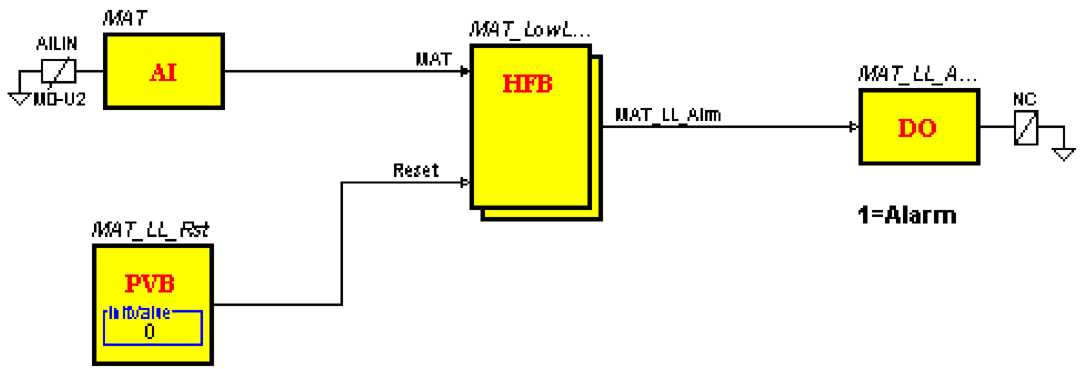
Mixed Air Low Limit



If the mixed air temperature falls below 40 F, this loop will produce a value of one for MALL (Mixed Air Low Limit) that is latched.
Operator reset is required to remove the latch.

We refer to this as secondary logic (logic to define a limit, condition or parameter).

Mixed Air Low Limit



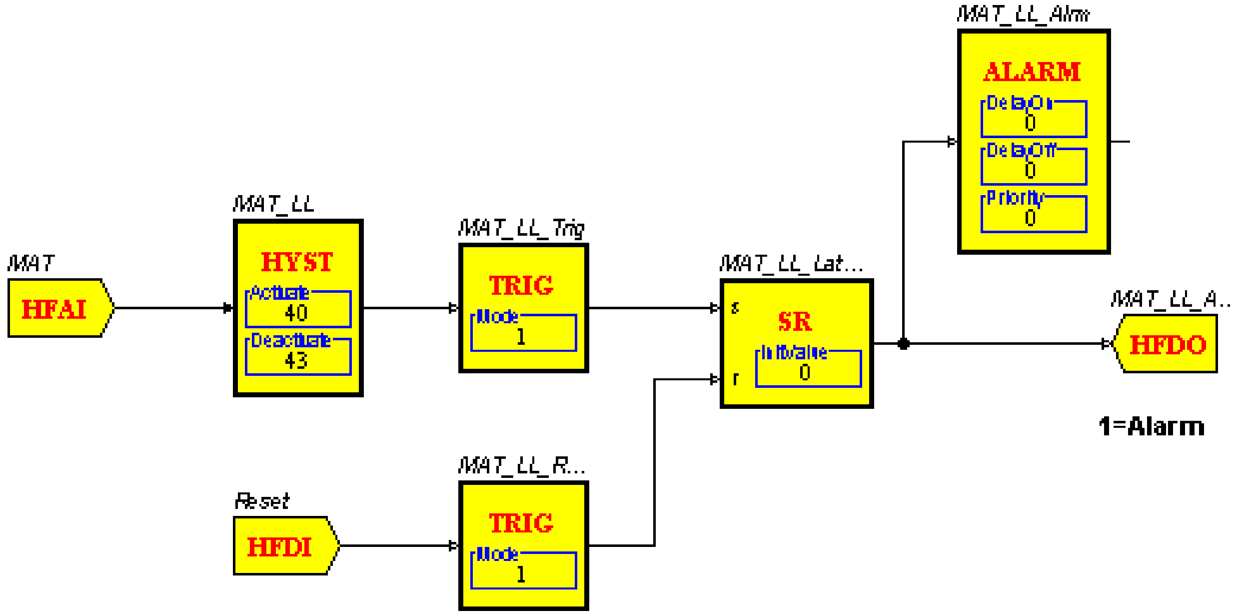
Low Limit Latching Object

FanCntrl4

Low Limit Latching Object

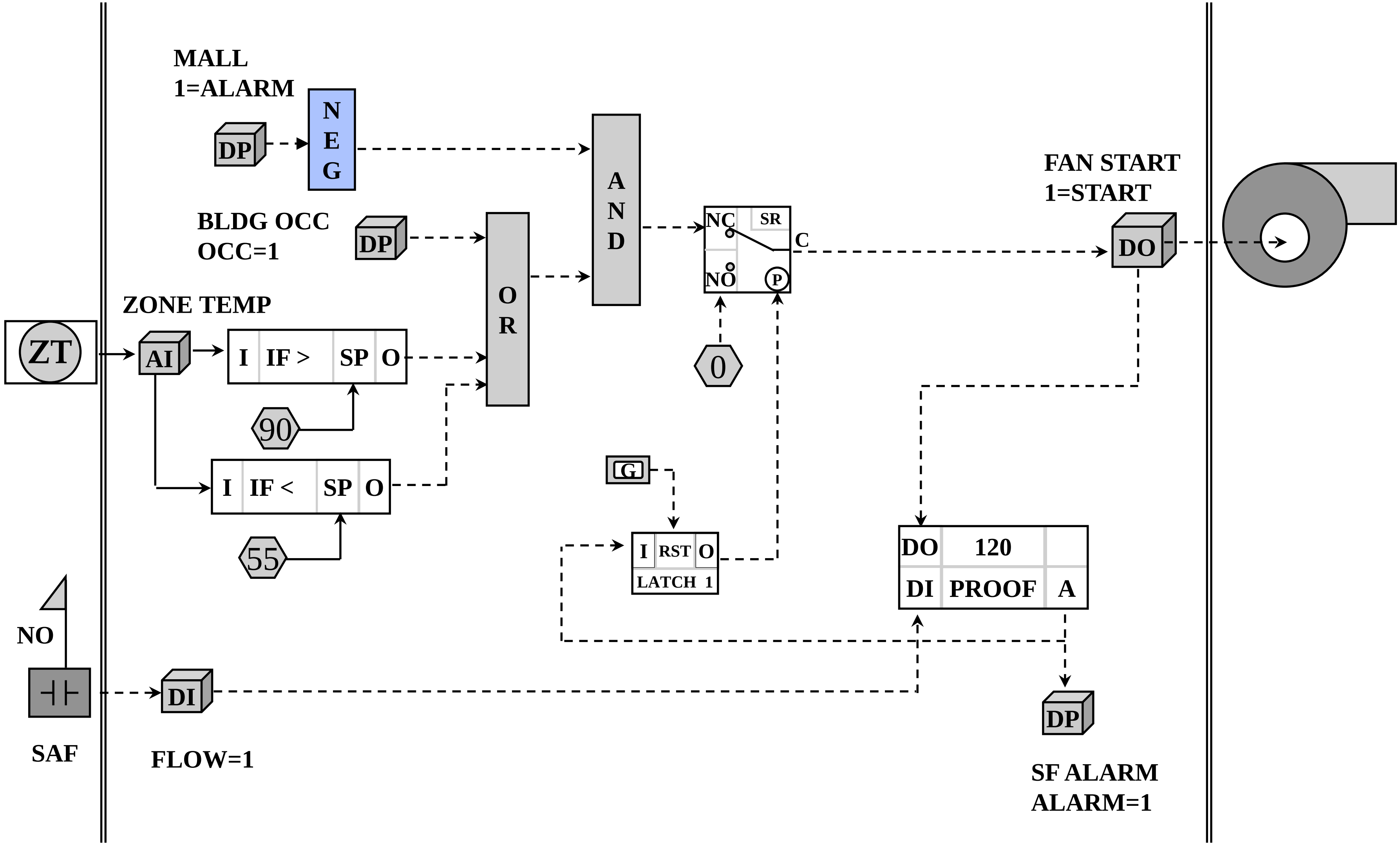
Note the Activate at 40F and Deactivate at 43F.

The SR object and the two trigger objects create the generic Latch 1 object described in the programming tools presentation.

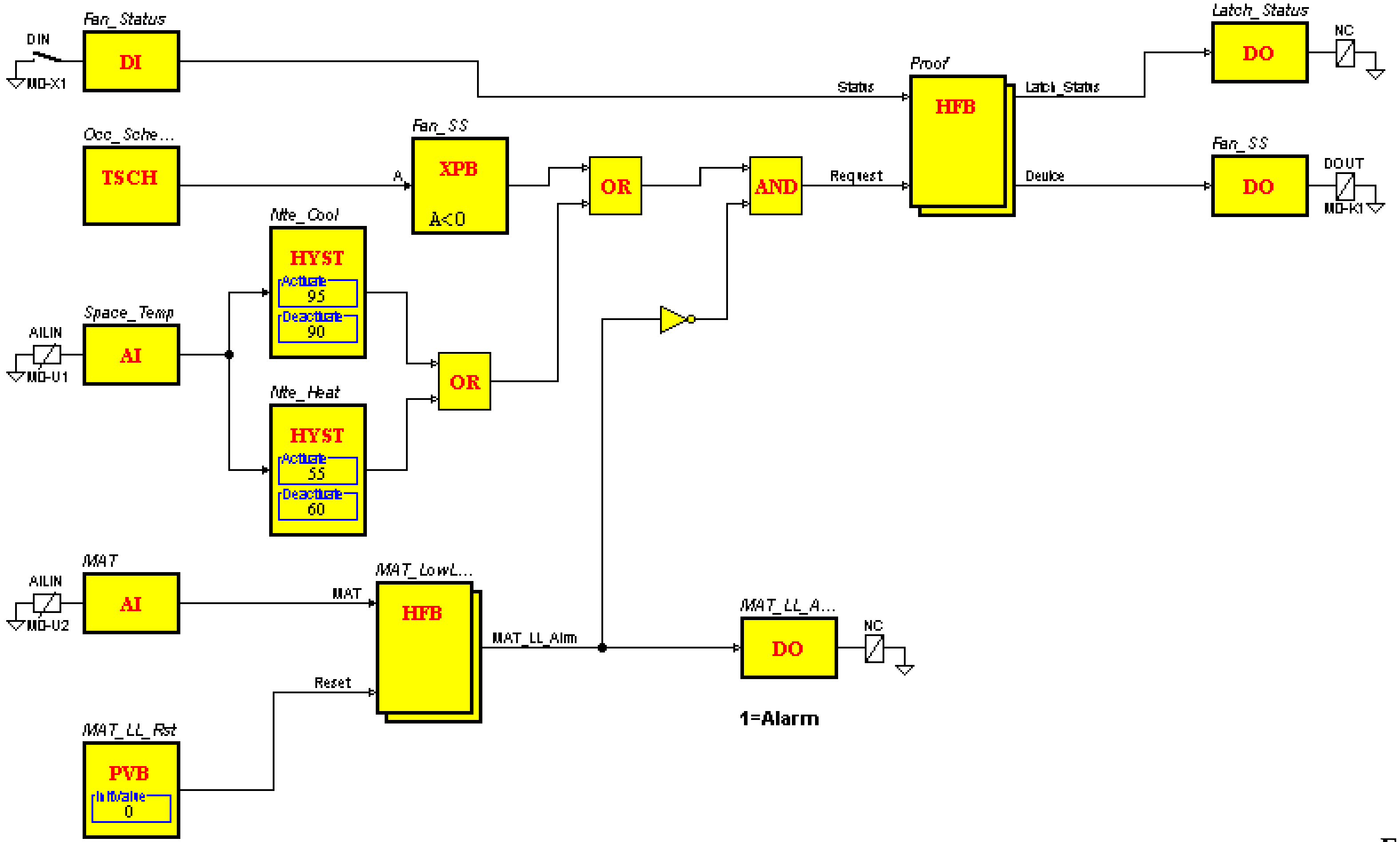


FanCntrl3

Mixed Air Low Limit



Put the Libraries Together



FanCntrl5

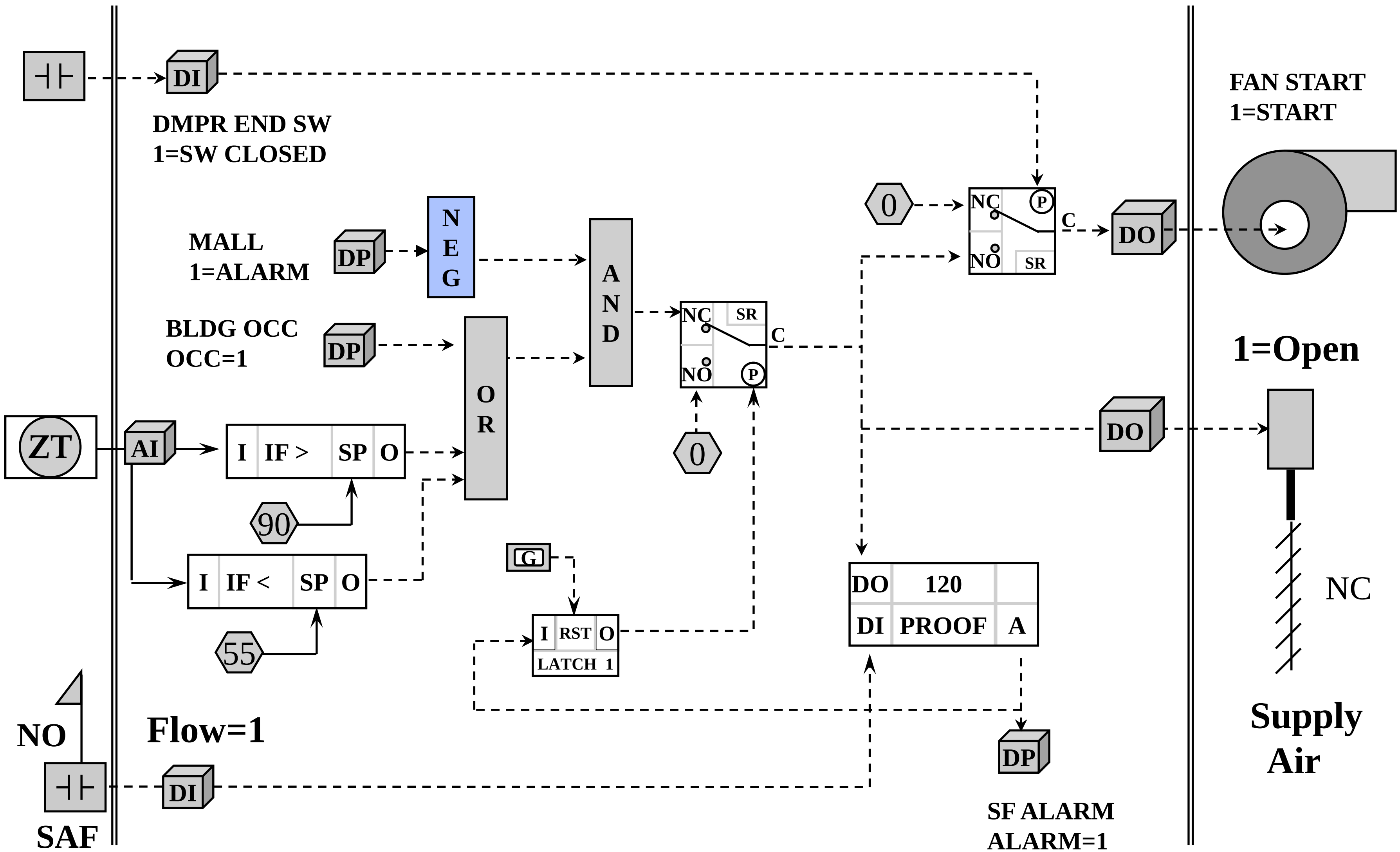
Smoke Control Damper

- Controlled Device: Supply Damper Smoke Damper
- Process Variable: Time
- Relationship: Two Position
- Parameters: Time Schedule
- Limits & Conditions
  - Fan Proof must be normal
  - When system is unoccupied, a space temperature greater than 90F or less than 55F shall cause a temporary request to open the damper until the space temperature rises by 5F.
  - Mixed air temperature low limit must be normal

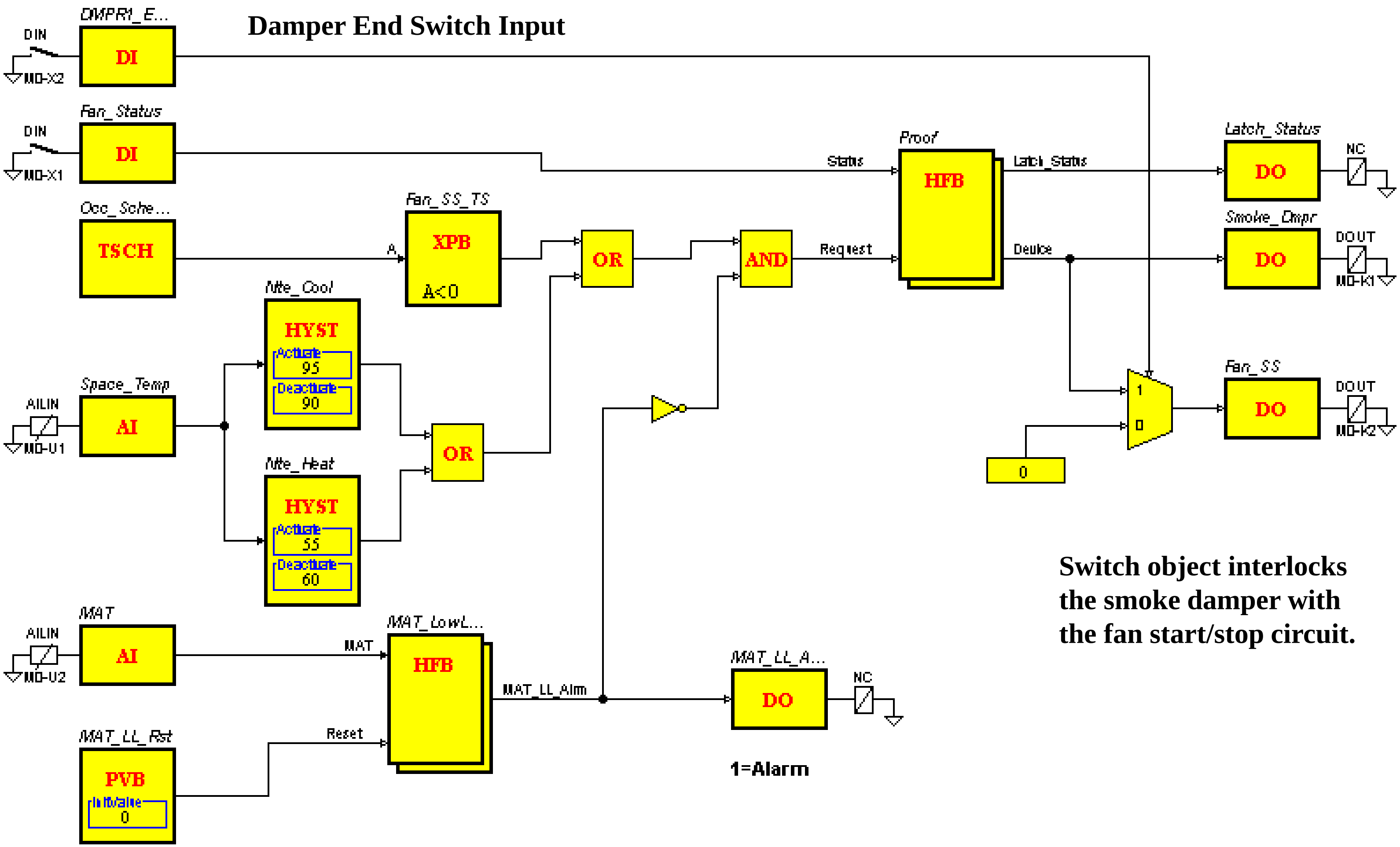
Fan Start Stop

- **Controlled Device: Fan Start Stop Circuit**
- **Process Variable: Time**
- **Relationship: Two Position**
- **Parameters: Time Schedule**
- **Limits & Conditions:**
  - **Fan proof normal**
  - **Time to state delay in the proofing logic**
  - **When system is unoccupied, a space temperature greater than 90F or less than 55F shall cause a temporary request to open the damper until the space temperature rises by 5F**
  - **Supply air smoke damper must be open**
  - **Mixed air temperature low limit must be normal**

Smoke Damper Interlock



Modify The Previous S/W



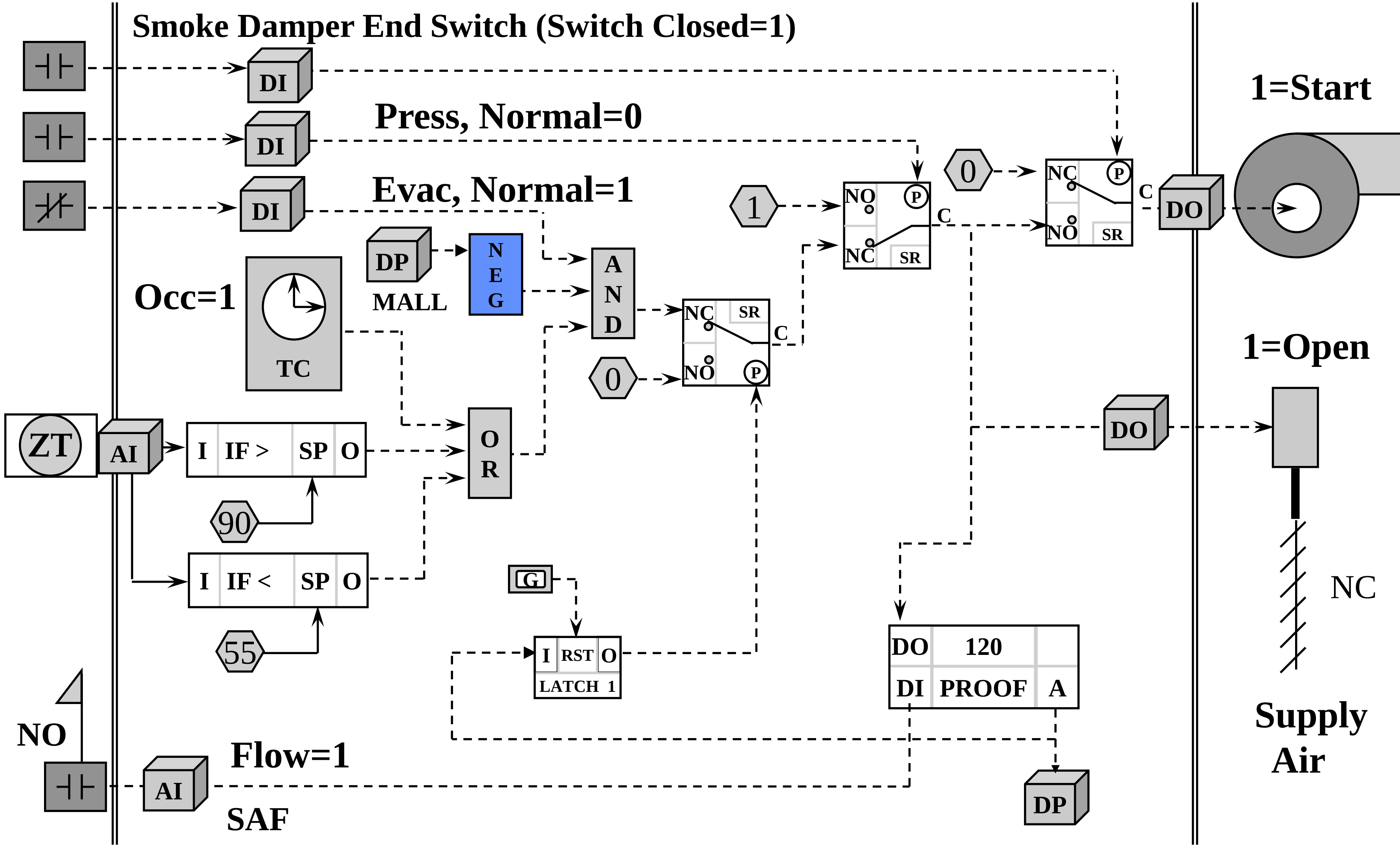
Switch object interlocks the smoke damper with the fan start/stop circuit.

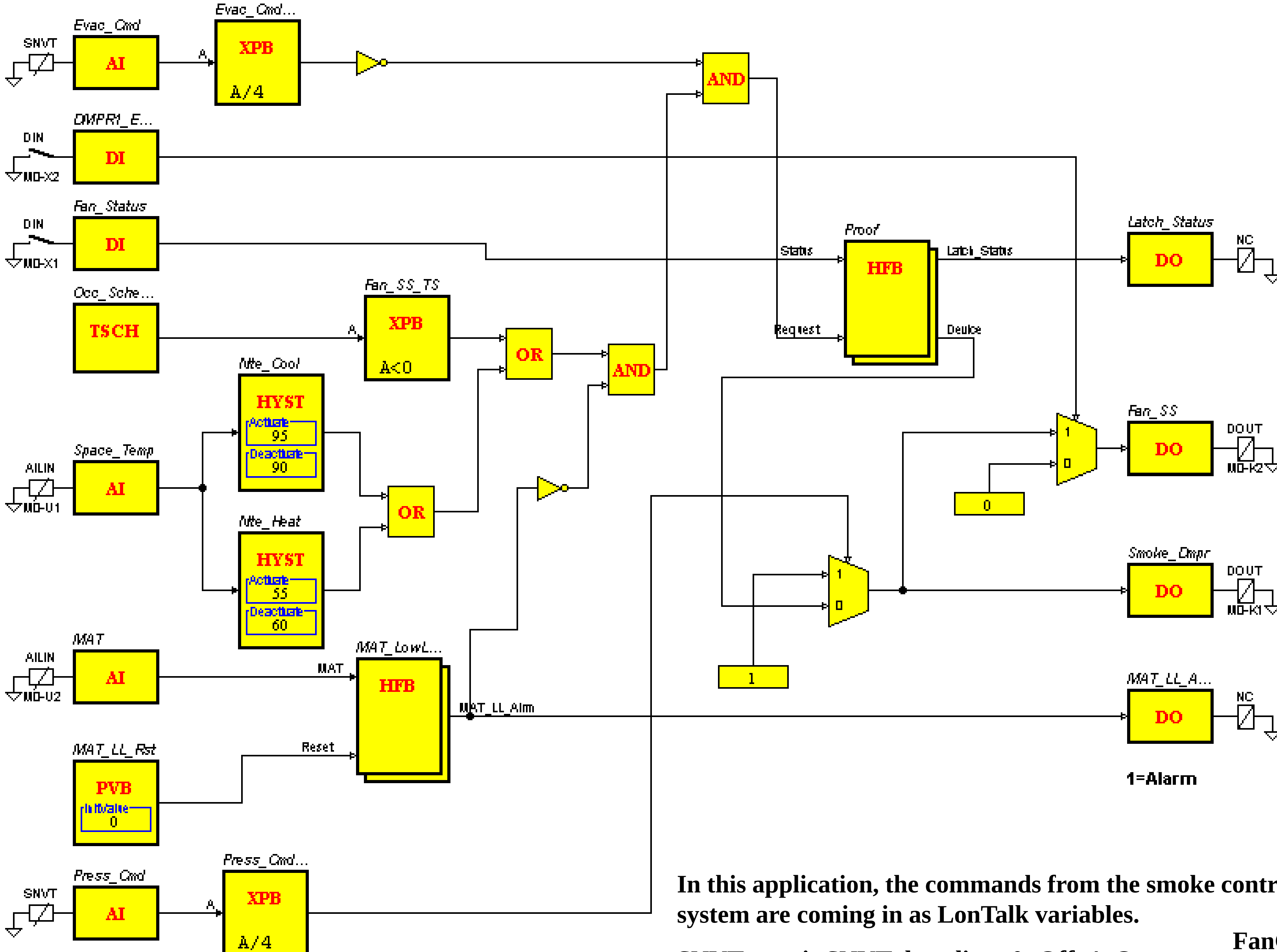
FanCntrl6

Pressurization & Evacuation

- Additional Conditions for the Smoke Damper and the Supply Fan
  - For zone pressurization override the control logic, open the smoke damper and turn on the fan.
  - The start command should be downstream of all possible "human errors" such as a failure to clear a latch after a previous problem.
  - For zone evacuation override the control logic, close the smoke damper and turn off the fan.

Pressurization & Evacuation





In this application, the commands from the smoke control system are coming in as LonTalk variables.

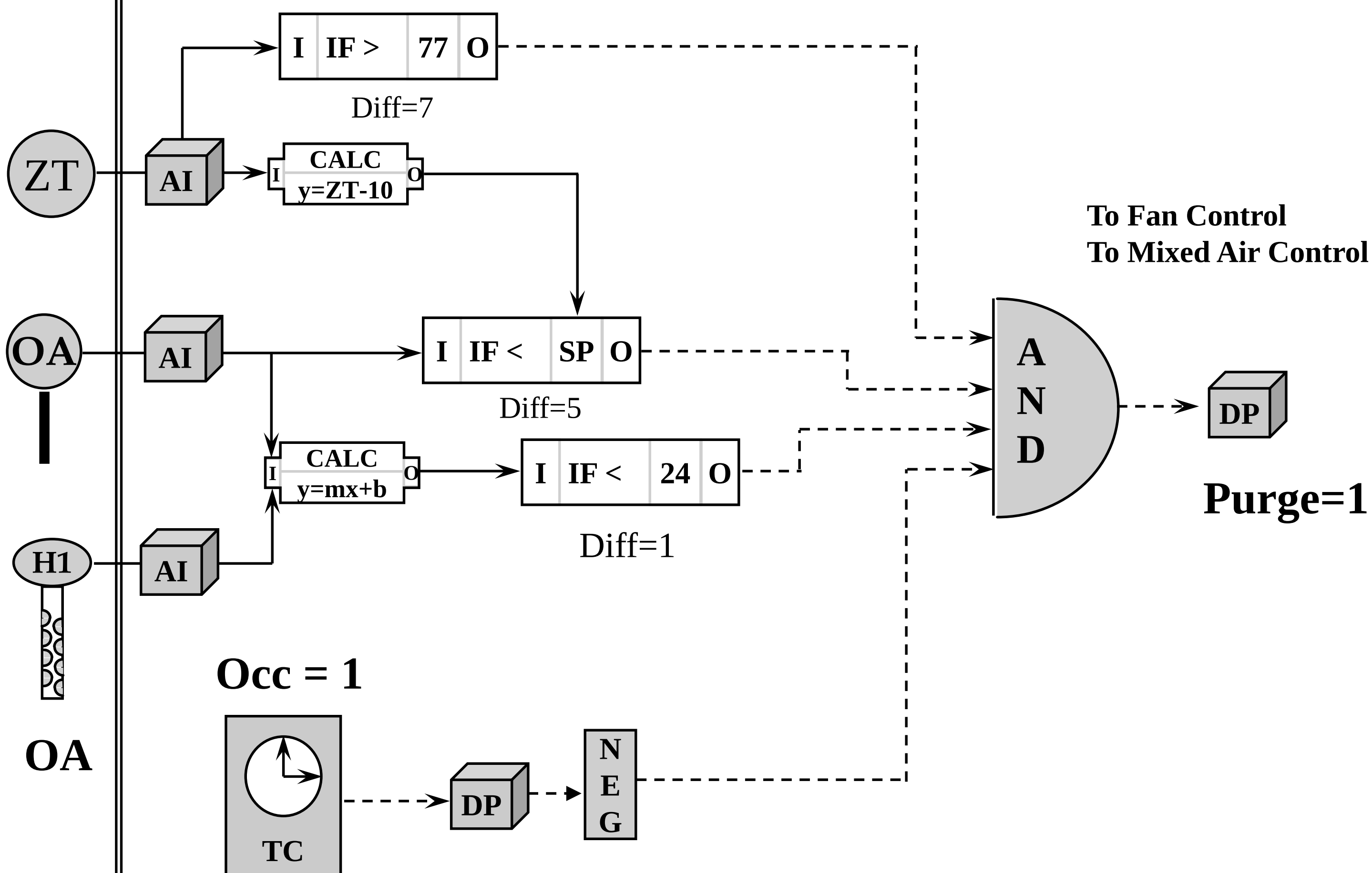
SNVT type is SNVT_lev_disc: 0=Off, 4=On

FanCntrl7

New Limit: Night Purge

- **Turn the Fan on when:**
  - **Outside air temperature is more than 10 degrees below the zone temperature (single zone example) and,**
  - **Zone temperature is greater than 77 F and,**
  - **Outside air enthalpy is less than 24 BTU per pound and**
  - **The mode is unoccupied.**
- **Turn the Fan off when:**
  - **Zone temperature drops to within 5 degrees of the outside air temperature or,**
  - **Zone temperature is less than 70 F or,**
  - **Outside air enthalpy rises above 25 BTU per pound.**

Night Purge

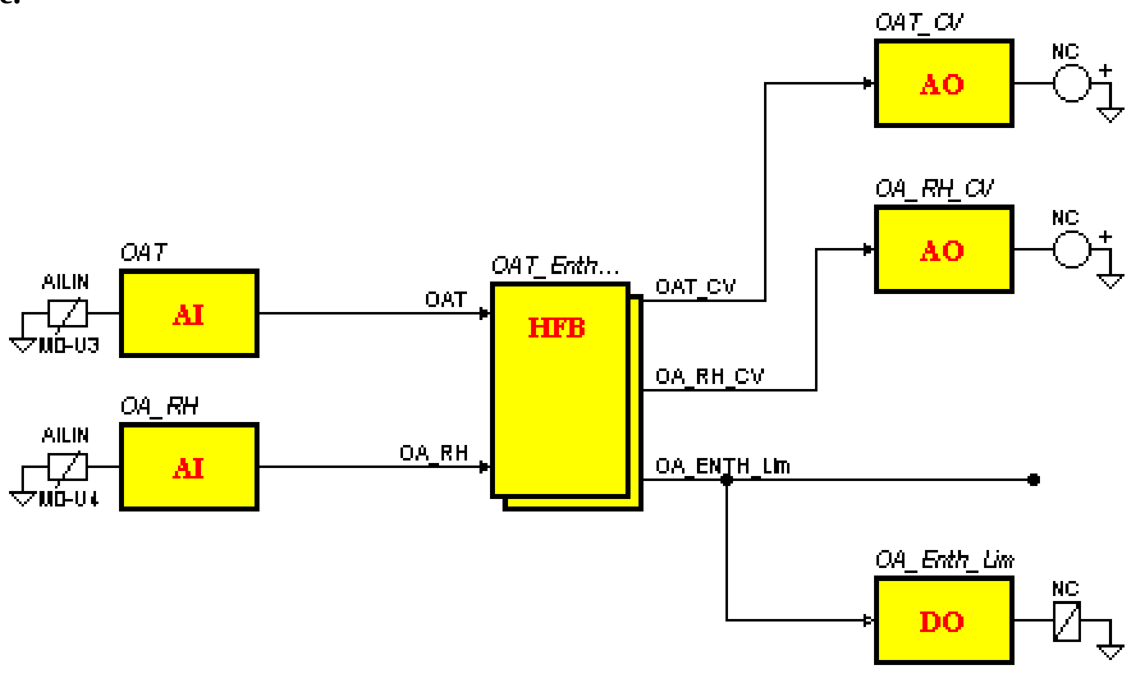


I
IF >
77
O
Diff=7
ZT
AI
CALC
y=ZT-10
I
O
To Fan Control
To Mixed Air Control
OA
AI
I
IF <
SP
O
Diff=5
A
N
D
DP
CALC
y=mx+b
I
O
I
IF <
24
O
Diff=1
Purge=1
H1
AI
Occ = 1
OA
TC
DP
N
E
G

Enthalpy Analysis

This first subset of the logic determines if the outside air enthalpy is less than the set point for purge control.

A composite object is used to keep the presentation simple.



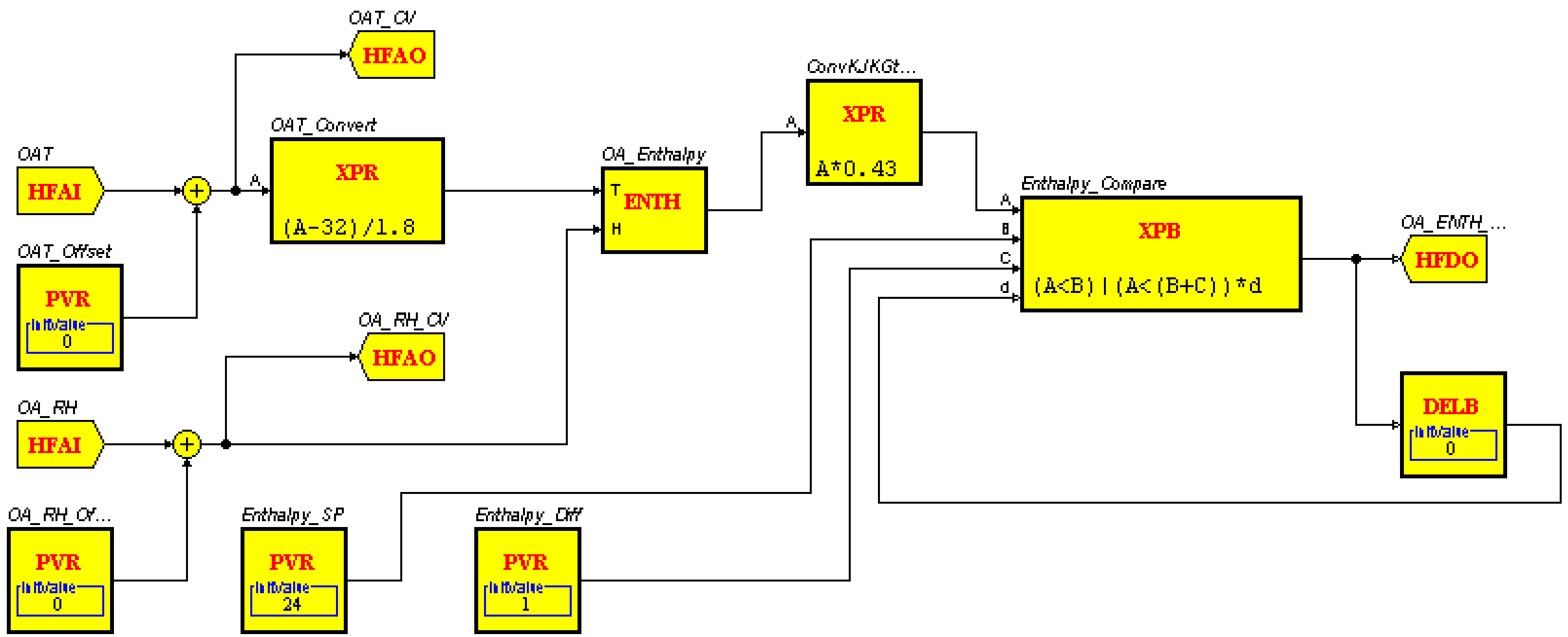
FanCntrl9

The Enthalpy Object

The calculation block converts degrees F to degrees C.

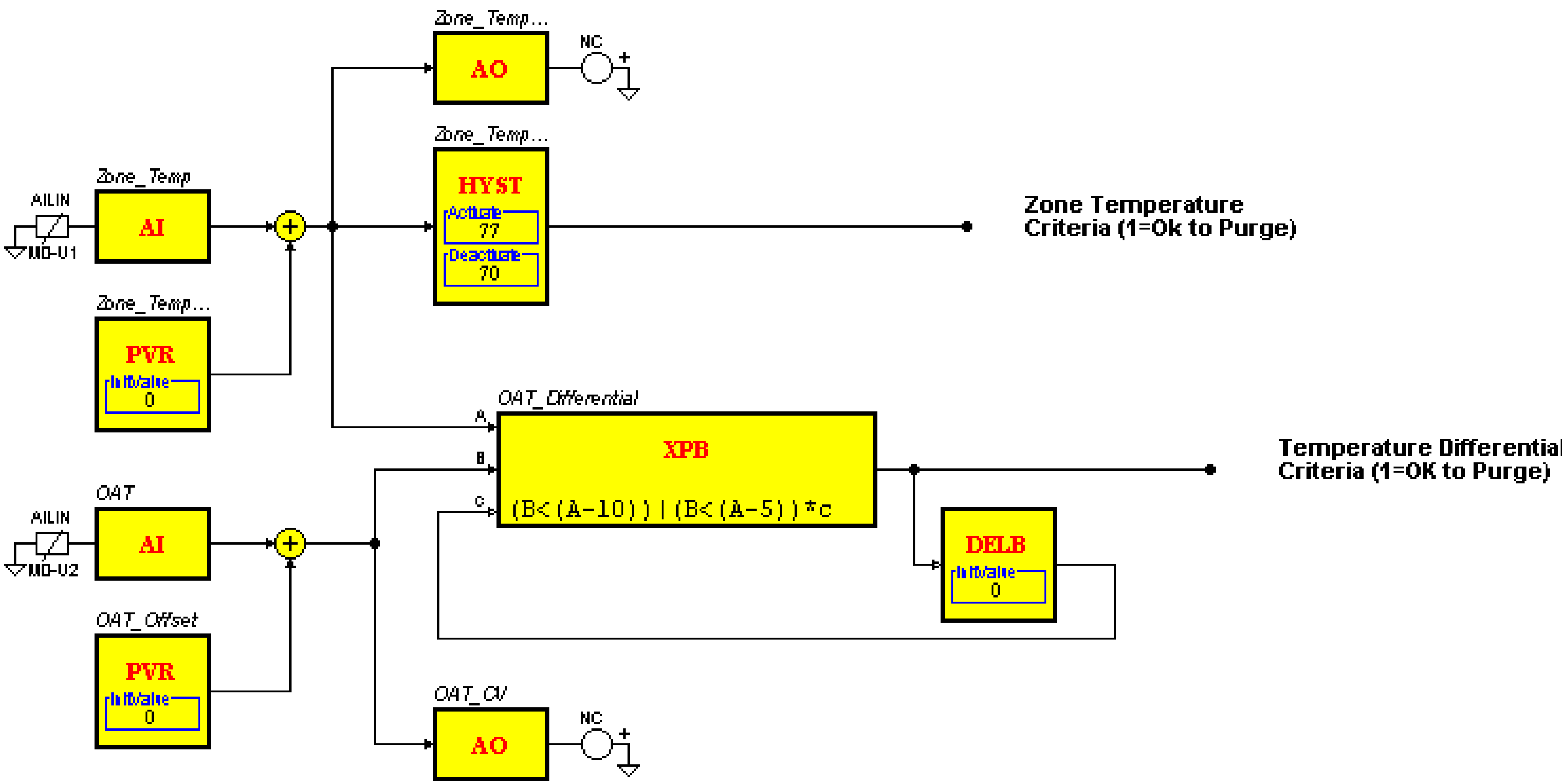
The Enthalpy Object requires degrees C and %RH as inputs. It outputs KJ/KG.

The calculation block converts the KJ/KG to Btu/Lb.

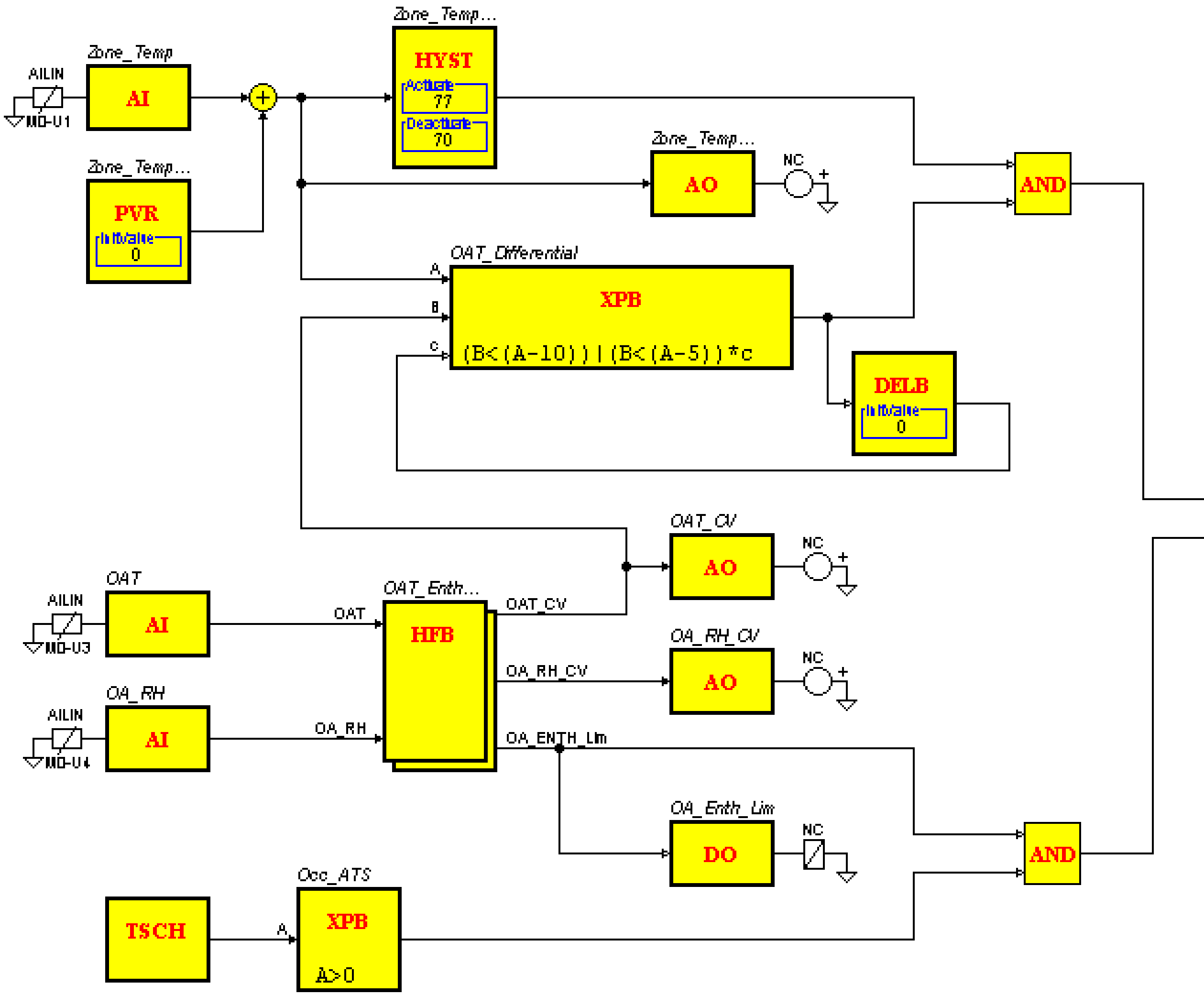


FanCntrl9

The OAT and OAT Differential



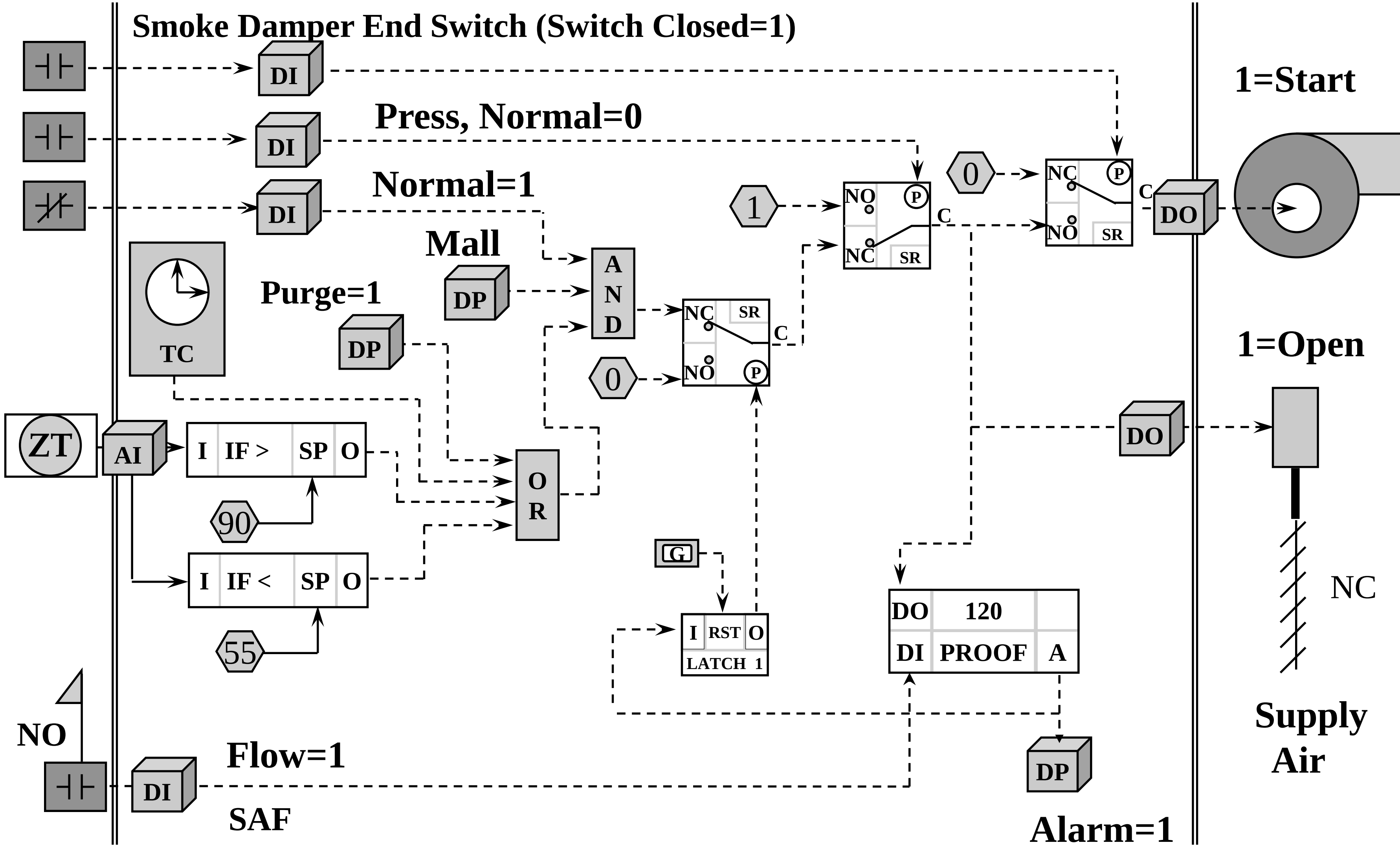
Put the Criteria Together



Internal Point to report purge status, 1=Yes

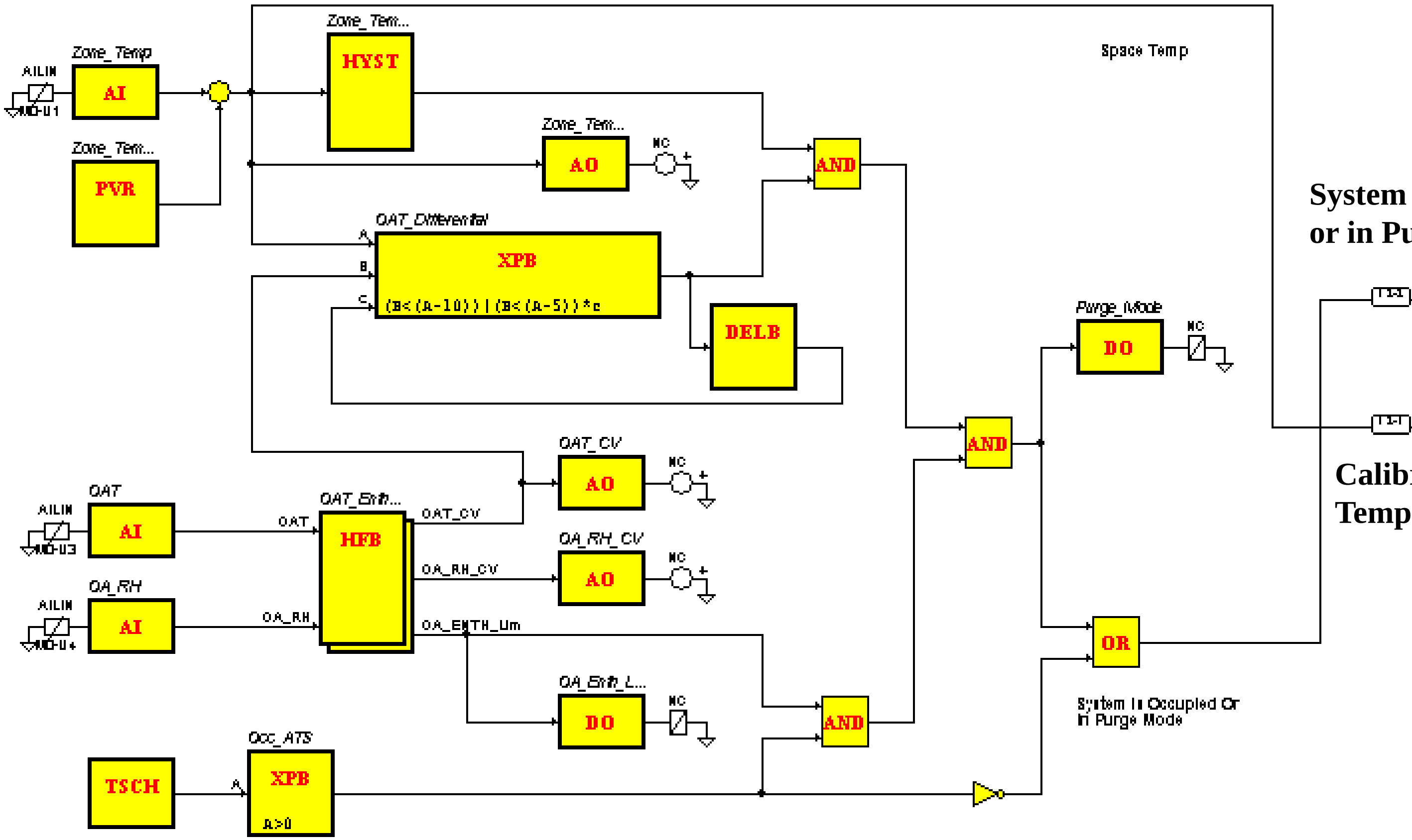
To Other Control Logic

Night Purge



Smoke Damper End Switch (Switch Closed=1)
DI
DI
Press, Normal=0
DI
Normal=1
1=Start
0
1
NC
P
NO
SR
C
NO
P
NC
SR
C
DO
Mall
A
N
D
DP
TC
Purge=1
DP
NC
SR
C
0
NO
P
1=Open
ZT
AI
I
IF >
SP
O
O
R
DO
90
I
IF <
SP
O
G
55
NC
I
RST
O
LATCH 1
DO
120
DI
PROOF
A
NO
Supply
Air
Flow=1
DI
DP
SAF
Alarm=1

DDC Software, Page 1



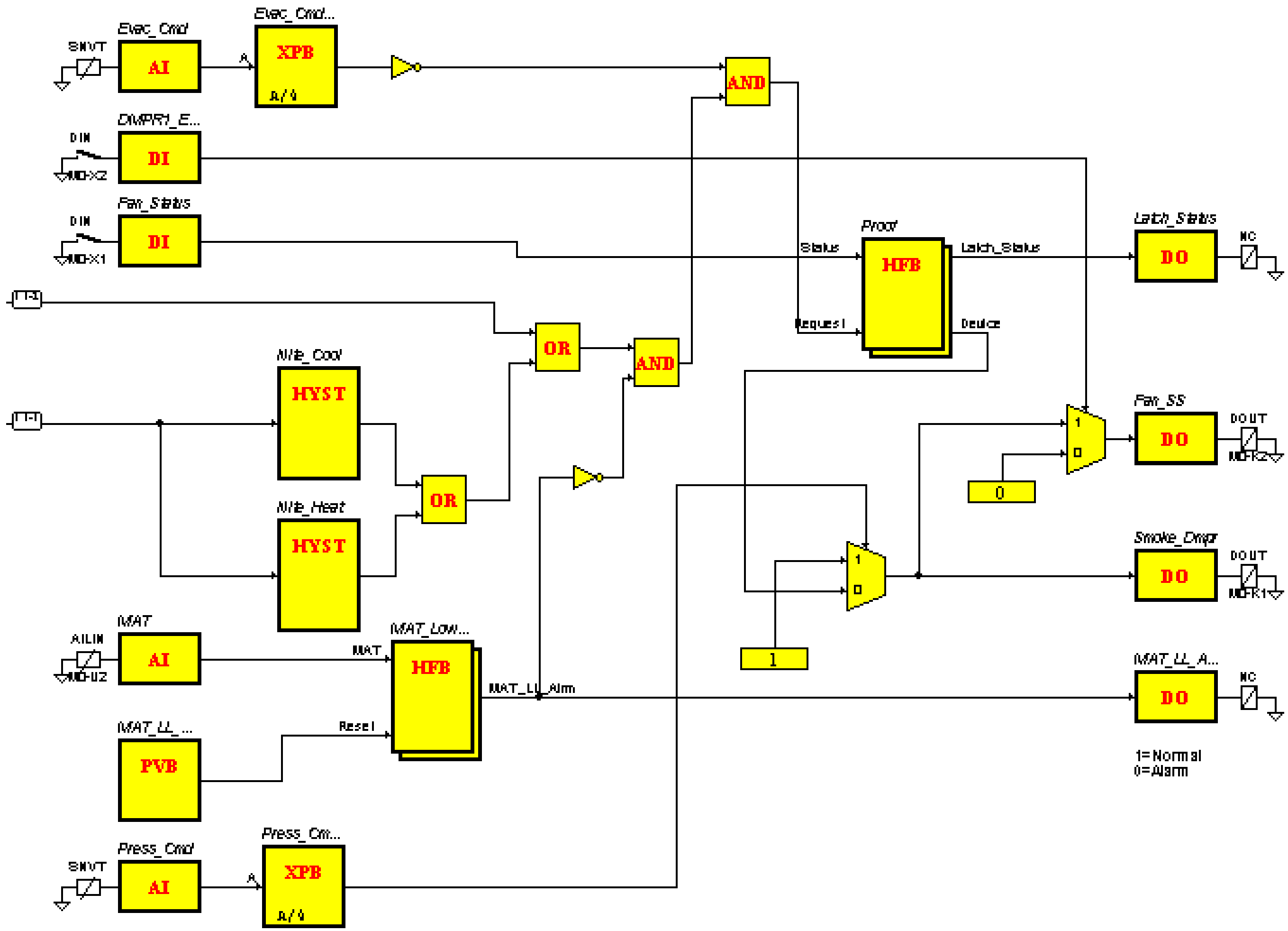
System is Occupied or in Purge Mode.

Calibrated Space Temperature

DDC Software, Page 2

System is Occupied or in Purge Mode.

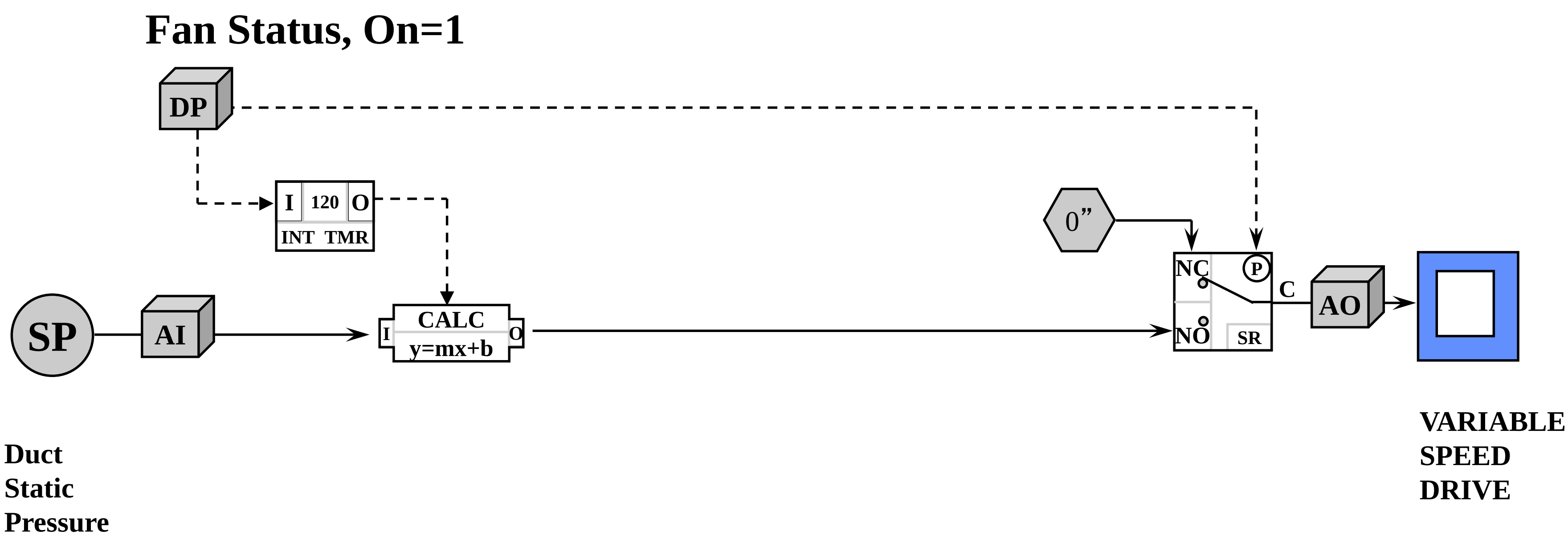
Calibrated Space Temperature



Variable Speed Drive

- Controlled Device: Fan VSD
- Process Variable: Supply Duct Static Pressure
- Relationship: Floating Control
- Parameters
  - Set Point of 1.5 inches
  - 2% bump per sample
  - 4 second sample rate
- Limits and Conditions
  - Fan must be on
  - Hold a position of 50% for the first 5 minutes after a fan start

Variable Speed Drive

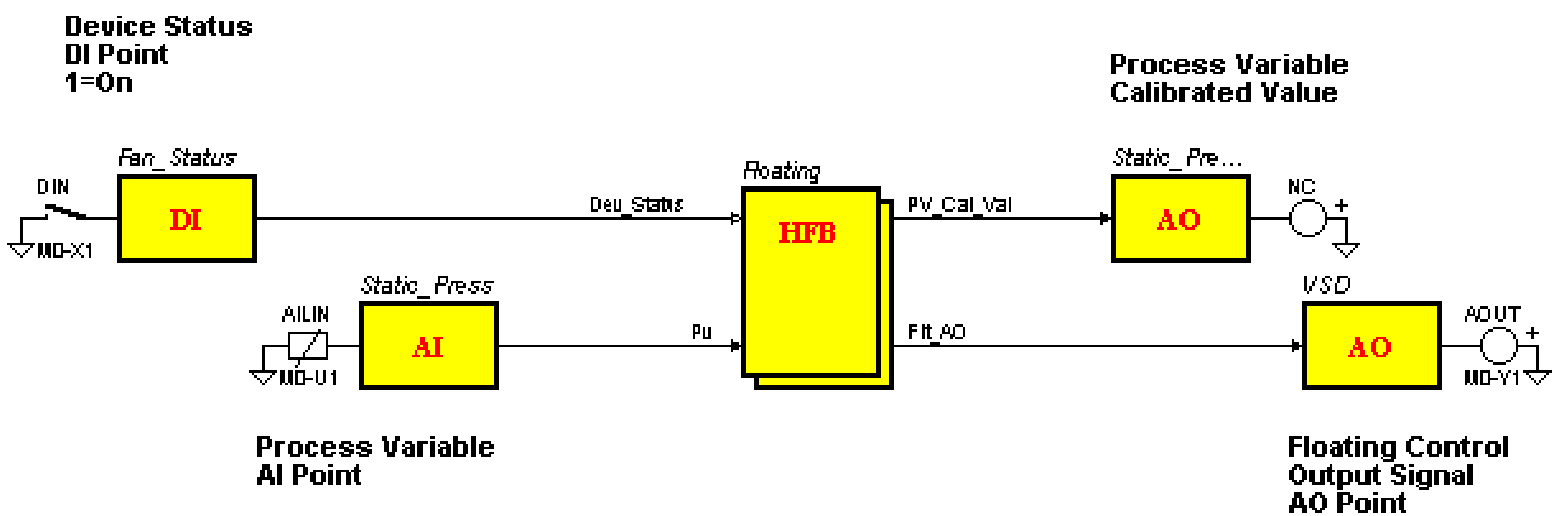


0%=Min RPM
100%=Max RPM

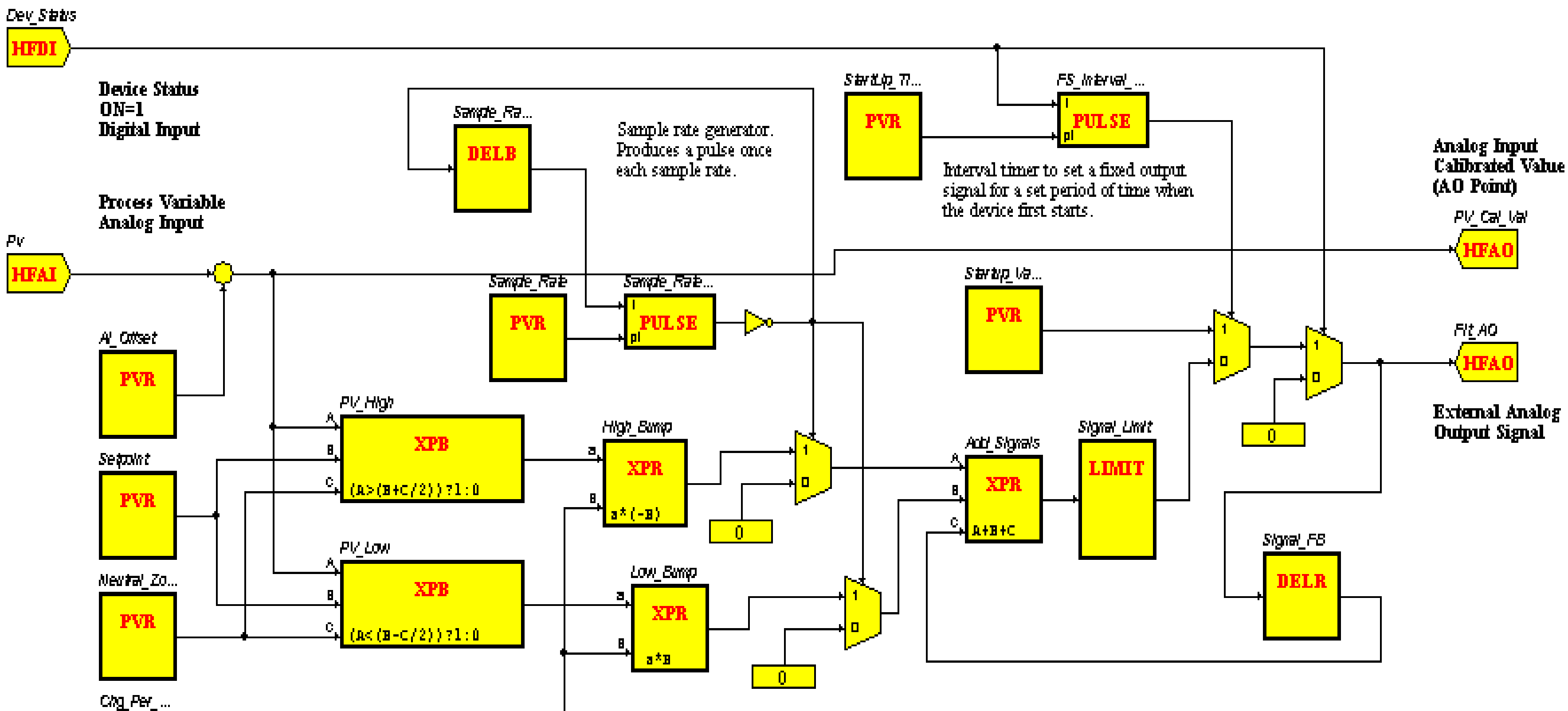
The calculation provides a floating control loop response with an initial start up limit for a defined period of time.

With DDC Software

Floating Control HFB



Floating Control Object

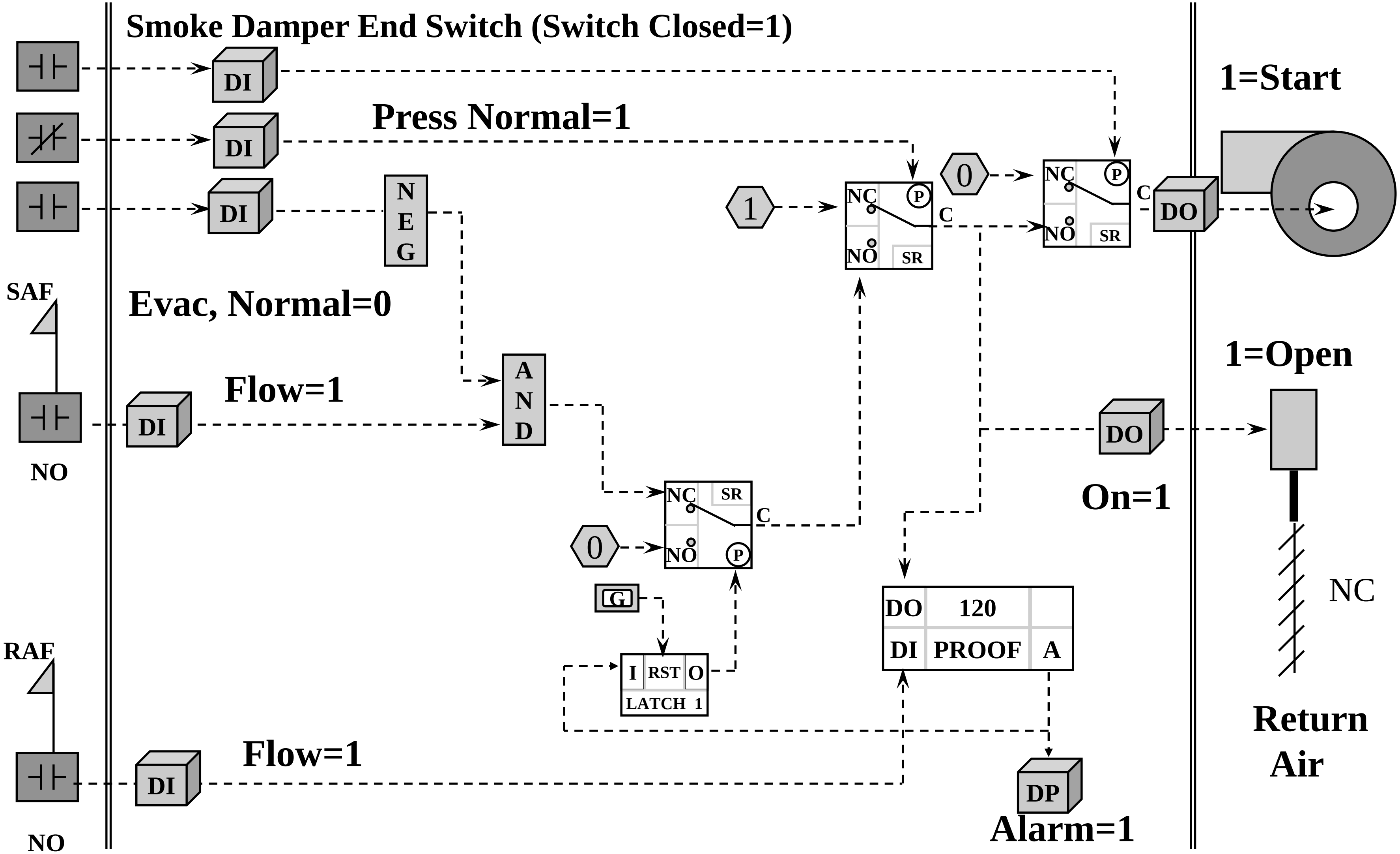


When the process variable is above the set point plus half the deadband the signal to the output device shall be reduced by a set percent once each sample rate. When the process variable is below the set point less half the deadband the signal to the output device shall be increased by the set percent once each sample rate. When the process variable is in the deadband the signal to the output device shall not be changed. During a defined startup time period the signal to the output device shall be controlled to a set value. When the device is off the signal to the output device shall be set at zero.

Return Fan

- Controlled Device: Return Fan Start Stop Circuit
- Process Variable: Supply Fan Status
- Relationship: Digital Tracking
- Parameters: On to On, Off to Off
- Limits & Conditions
  - Return fan proof must be normal
  - Latch off if proof fails, manual reset from operator station is required
  - Fan off on pressurization
  - Fan on during evacuation

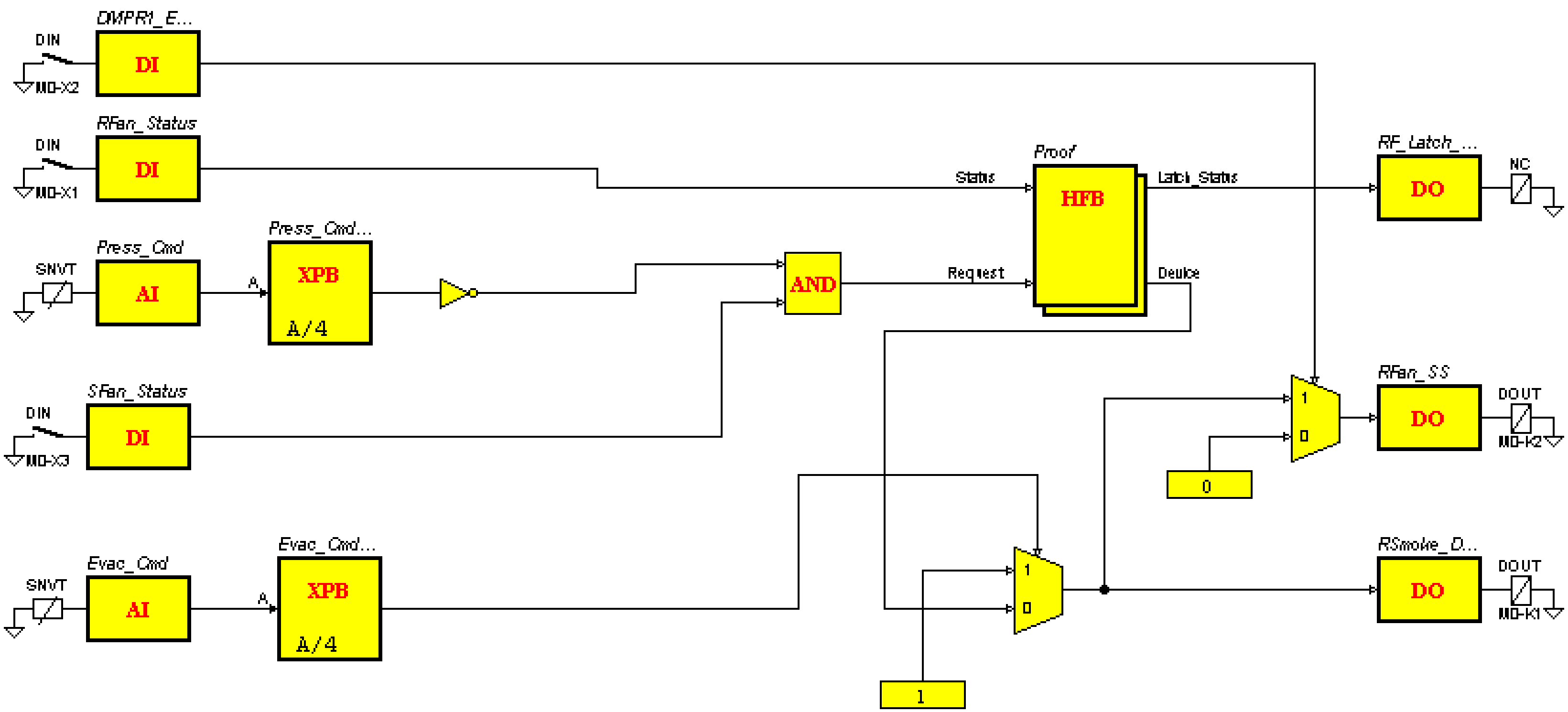
Return Fan



Smoke Damper End Switch (Switch Closed=1)
DI
DI
DI
Press Normal=1
N E G
1
0
NC
P
C
NO
SR
1=Start
DO
SAF
Evac, Normal=0
A N D
1=Open
Flow=1
DI
DO
NO
On=1
SR
0
G
I
RST
O
LATCH 1
DO
120
DI
PROOF
A
NC
RAF
Return Air
Flow=1
DP
NO
Alarm=1

DDC Software-Return Fan

If the Supply Fan status is on and the Pressurization command is off, the return fan will be requested. If the Evacuation command is on, the return fan will be requested. A fan request opens the return duct smoke damper. When the damper end switch makes, the return fan shall be started. Proofing with latch off is provided upstream of the evacuation command.



Pressurization & Evacuation Commands: Off=0, ON=4

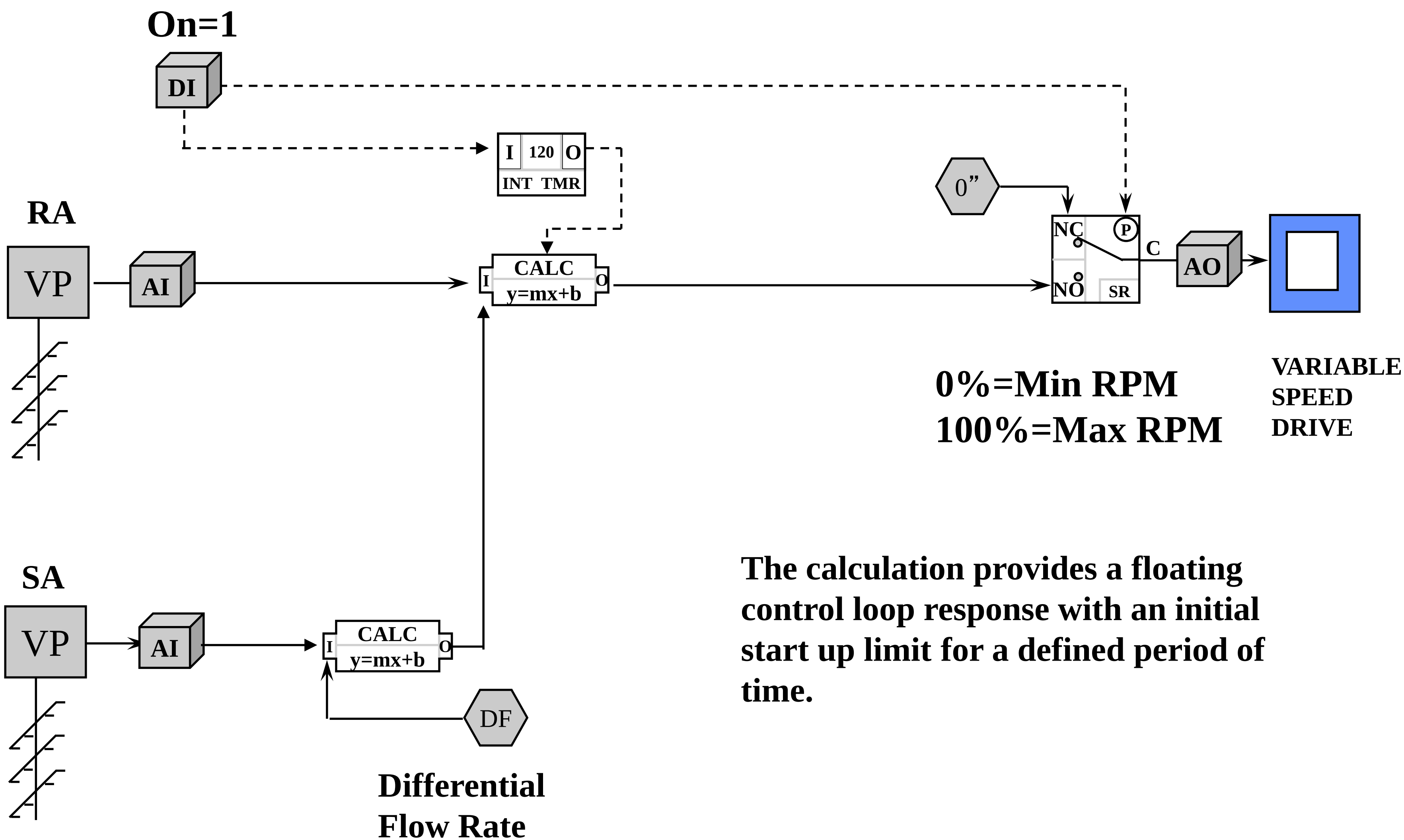
Variable Speed Drive

- Return fan controlled by supply duct static pressure.
- Return fan controlled by return air flow rate.
  - Set point equal to supply air flow rate minus differential
  - "Fan Tracking"
- Return fan controlled by static pressure in return air side of mixing box.

Variable Speed Drive

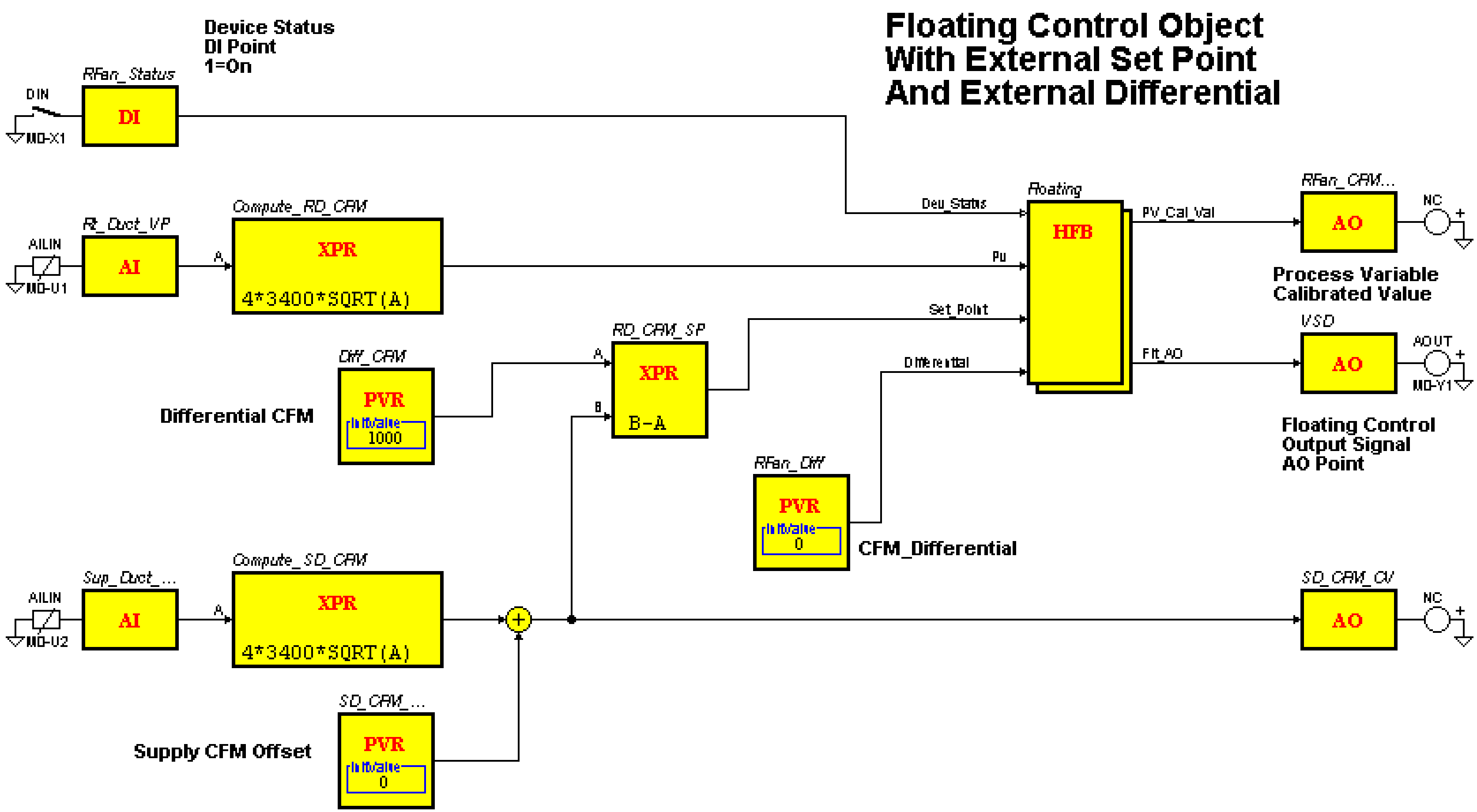
- Controlled Device: VSD (AO Point)
- Process Variable: Return Duct CFM
- Relationship: Floating Control
- Parameters
  - SP equals Supply Duct CFM less 1000 CFM
  - Sample Rate=4 seconds
  - Bump rate=2%
- Limits and Conditions
  - Fan must be on
  - Hold a position of 50% for the first 5 minutes after a fan start

Variable Speed Drive

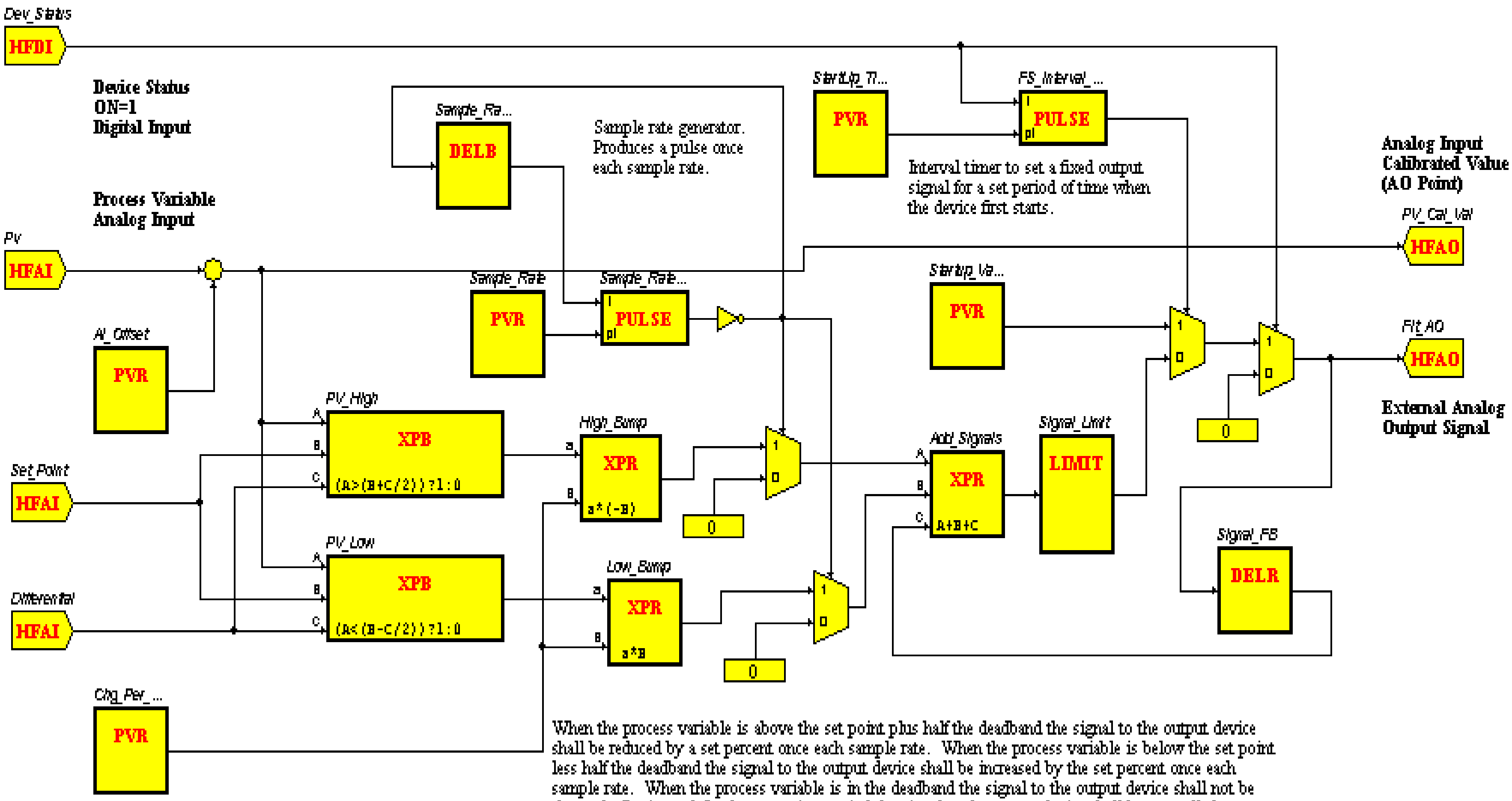


The calculation provides a floating control loop response with an initial start up limit for a defined period of time.

DDC Software-VSD



The Floating Control Object



When the process variable is above the set point plus half the deadband the signal to the output device shall be reduced by a set percent once each sample rate. When the process variable is below the set point less half the deadband the signal to the output device shall be increased by the set percent once each sample rate. When the process variable is in the deadband the signal to the output device shall not be changed. During a defined startup time period the signal to the output device shall be controlled to a set value. When the device is off the signal to the output device shall be set at zero.

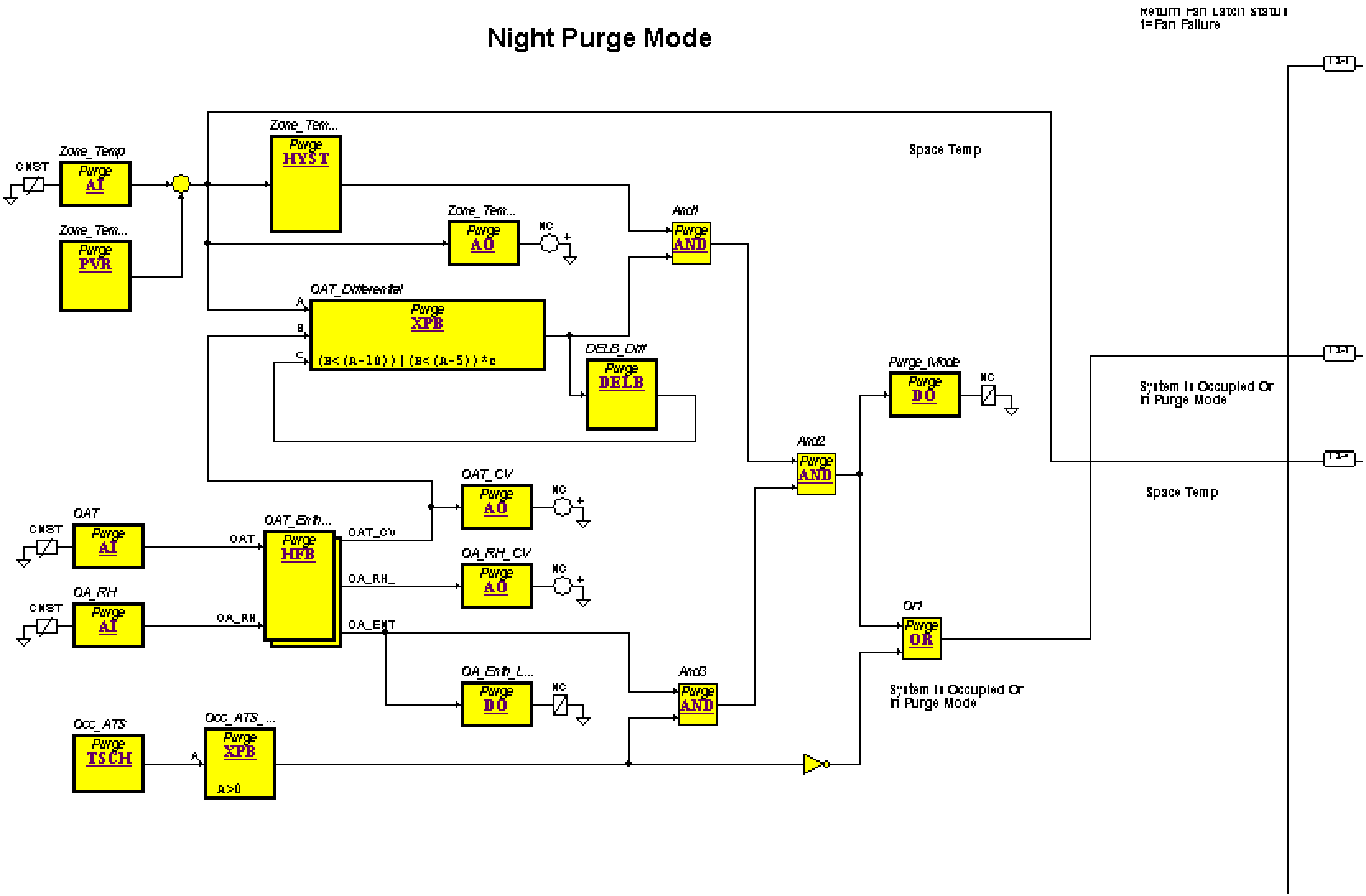
Final Check

- **We have now created a very sophisticated control strategy for the supply and return fans.**
- **Our final question is "Did we miss anything?"**
- **What do you think?**

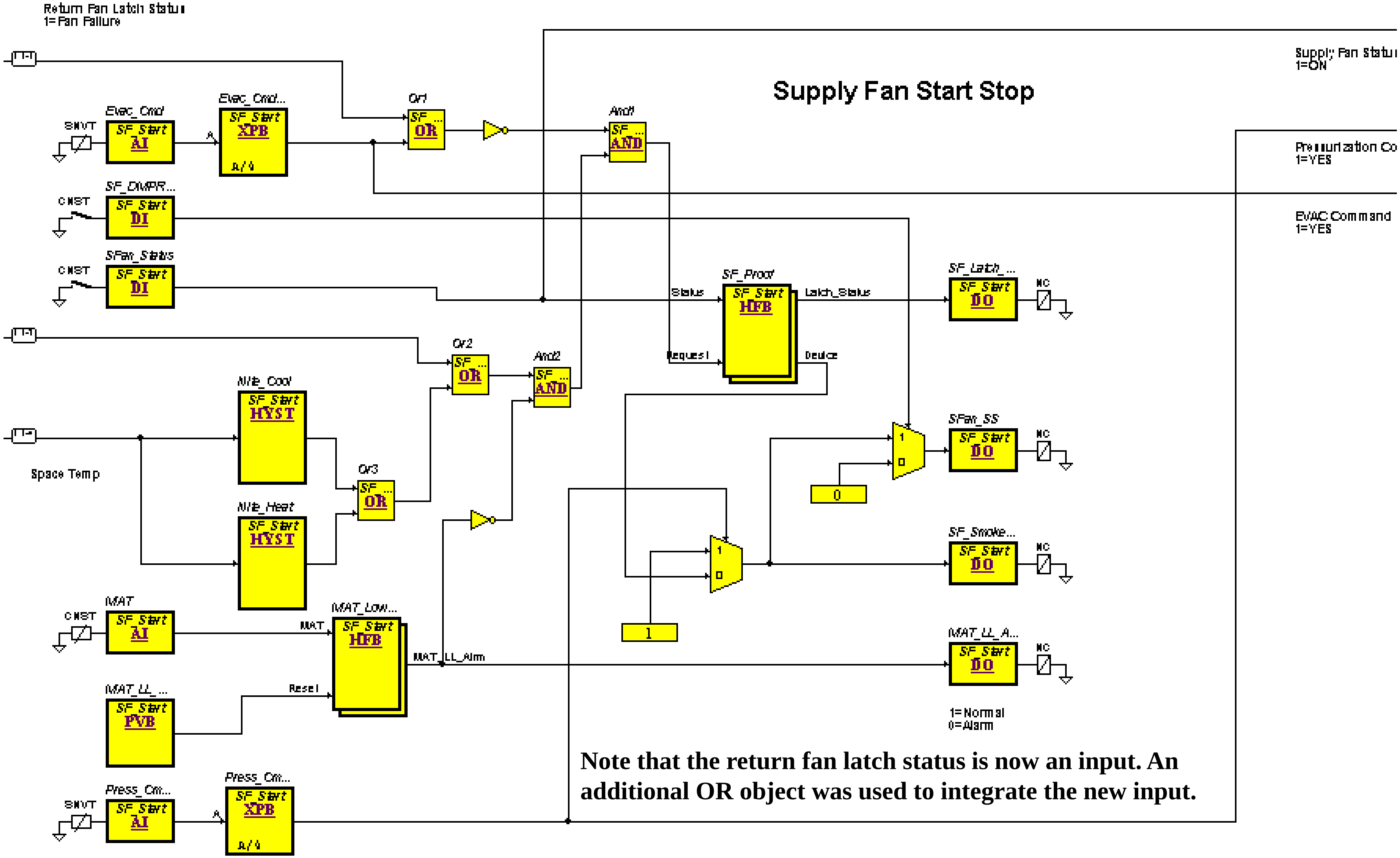
Final Check

- **A full simulation of the final design would show that is does not pass one test.**
  - **When the return fan fails, does the supply fan shut down.**
- **The "Return Fan Latch Status" from the return fan control logic must become an input to the supply fan control logic.**
  - **On failure of the return fan, the latch status goes to 1.**
- **The following slides show the corrected DDC software (several pages).**

Modified Supply Fan Logic, Pg1

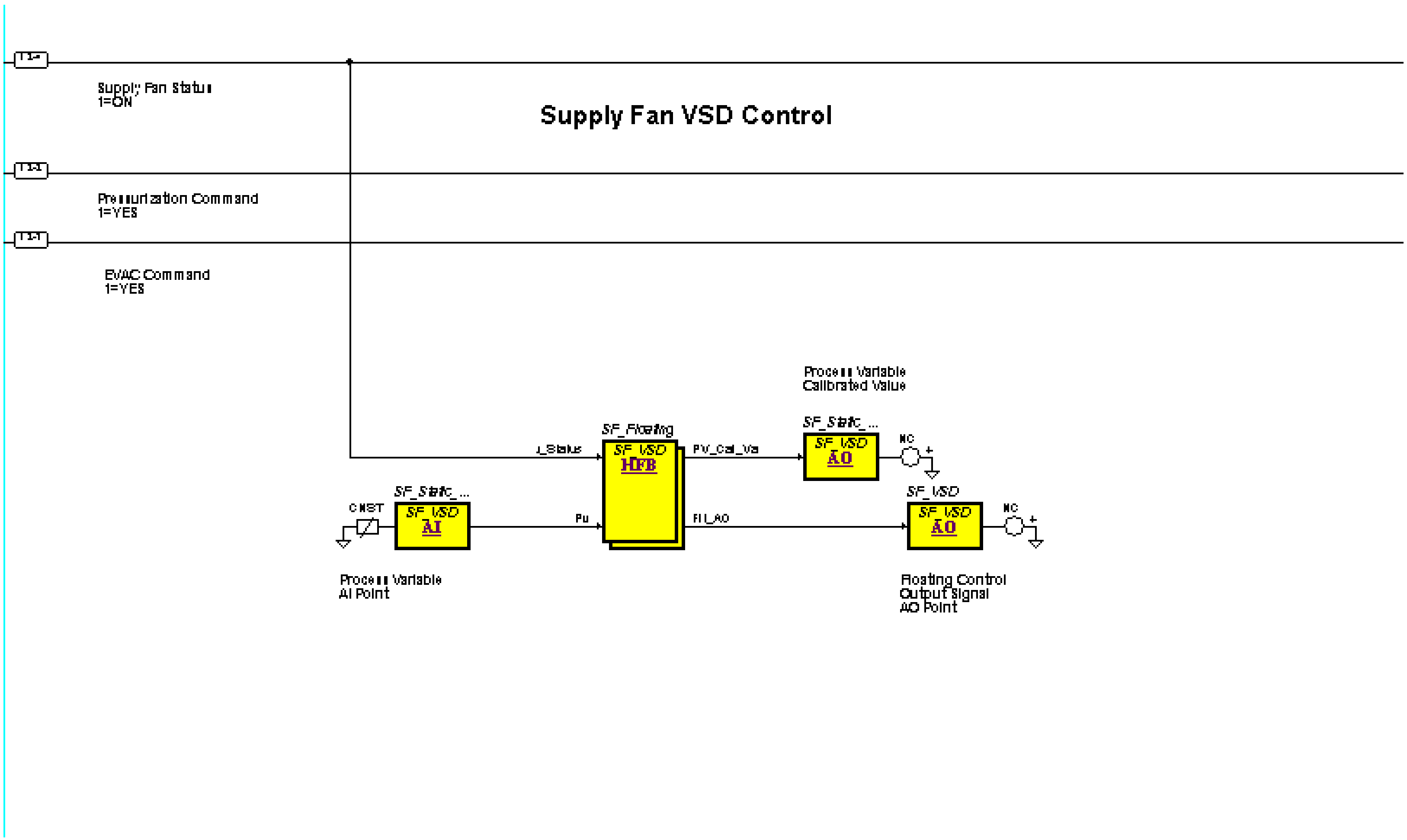


Page 2

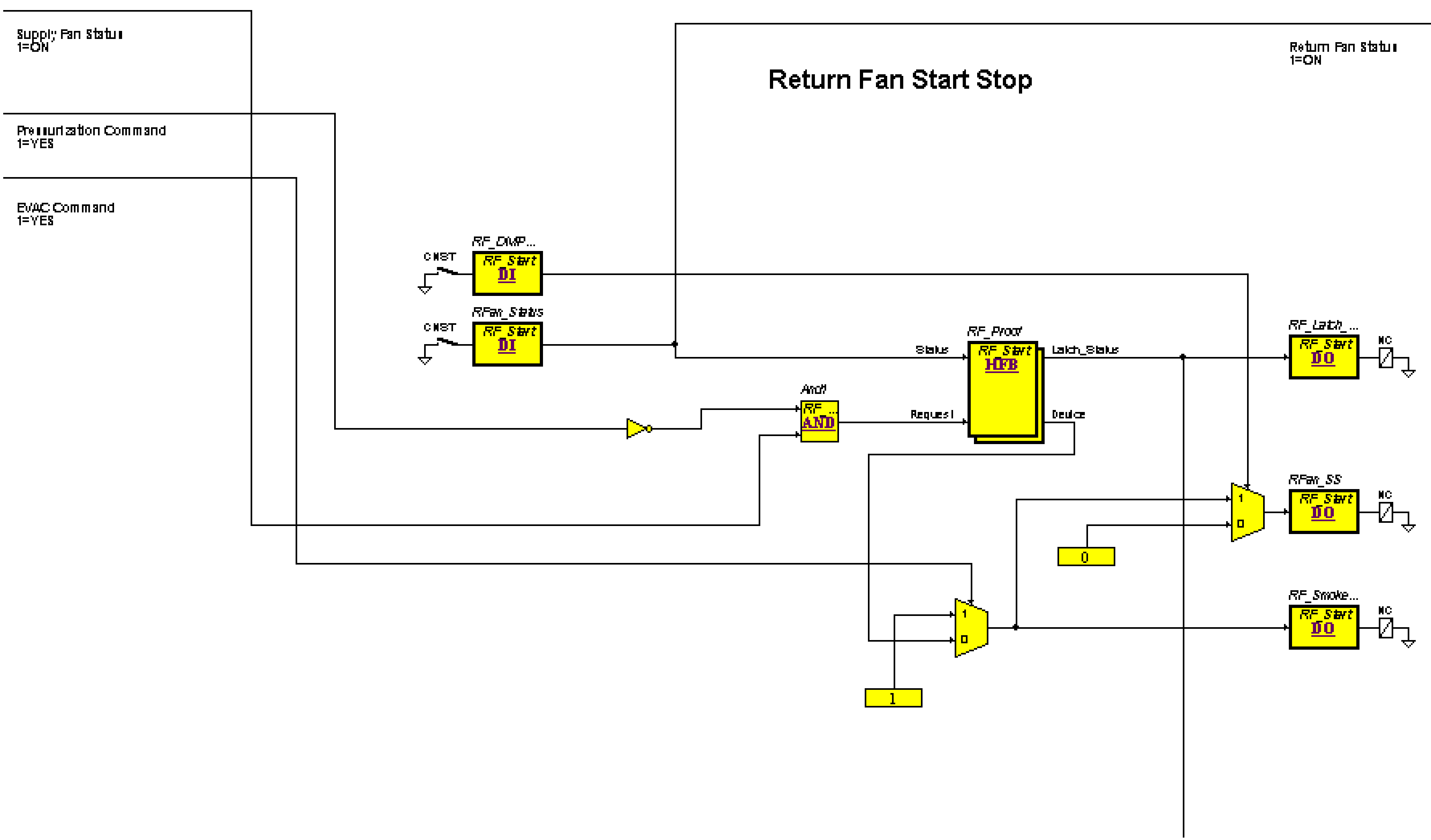


Note that the return fan latch status is now an input. An additional OR object was used to integrate the new input.

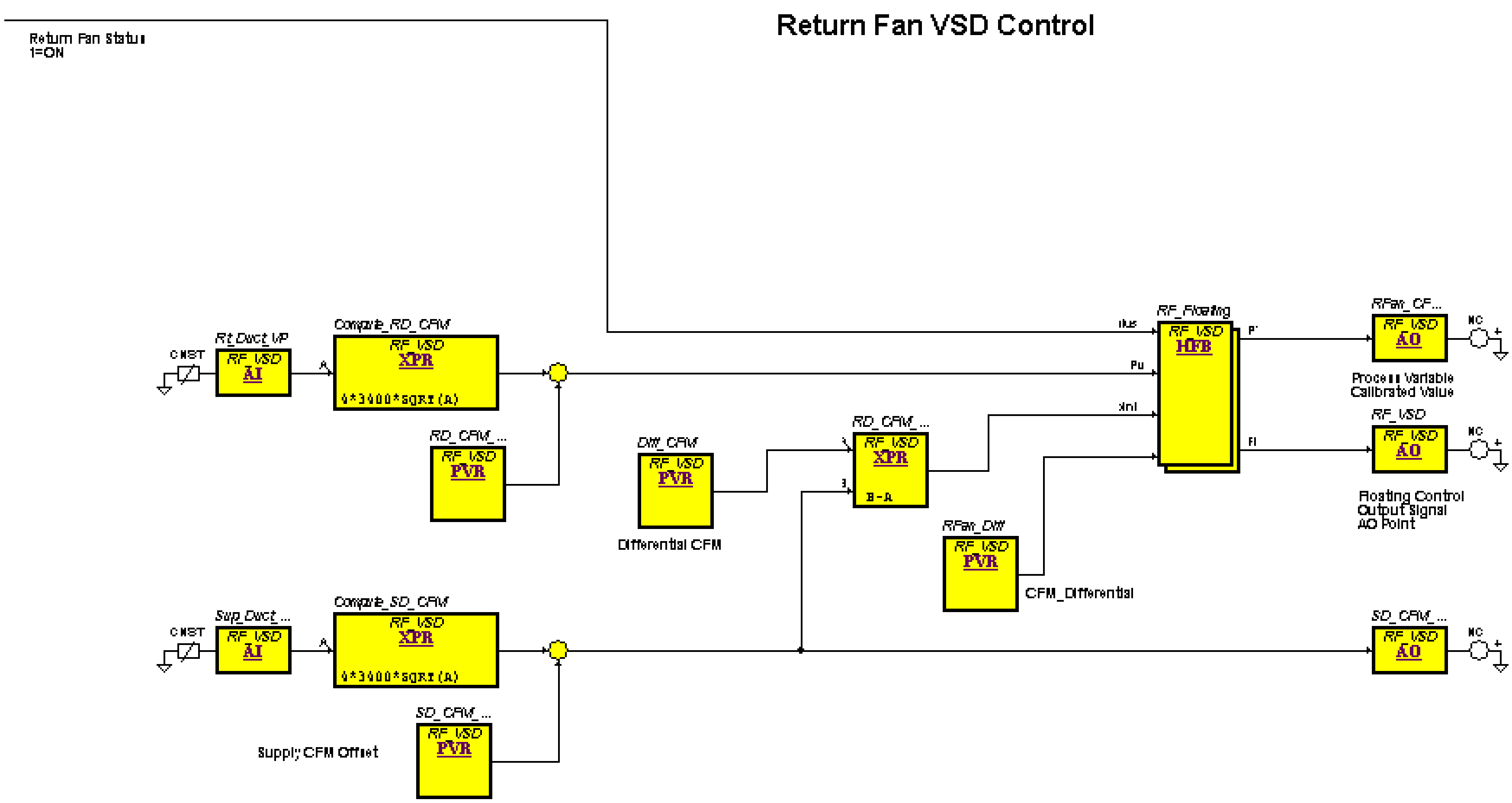
Page 3


Supply Fan Status
1=ON
Supply Fan VSD Control
Pressurization Command
1=YES
EVAC Command
1=YES
Process Variable
Calibrated Value
SF_Floating
SF_VSD
HFB
_Status
Pu
PV_Cal_Va
FI_AO
SF_Static_...
SF_VSD
AO
NC
+
SF_Static_...
SF_VSD
AI
CNST
SF_VSD
SF_VSD
AO
NC
+
Process Variable
AI Point
Floating Control
Output Signal
AO Point

Page 4


Supply Fan Status
1=ON
Pressurization Command
1=YES
EVAC Command
1=YES
Return Fan Start Stop
Return Fan Status
1=ON
RF_DMP...
CNST
RF_Start
DI
RFan_Status
CNST
RF_Start
DI
RF_Proof
Status
RF_Start
HFB
Latch_Status
Request
Device
AndI
RF_...
AND
RF_Latch_...
RF_Start
DO
NC
RFan_SS
RF_Start
DO
NC
RF_Smoke...
RF_Start
DO
NC
0
1

Page 5



Return Fan VSD Control
Return Fan Status
1=ON
CNST
Rt Duct VP
RF_VSD
AI
Compute_RD_CFM
RF_VSD
XPR
RD_CFM_...
RF_VSD
PVR
Diff_CFM
RF_VSD
PVR
Differential CFM
RD_CFM_...
RF_VSD
XPR
B-A
RFan_Diff
RF_VSD
PVR
CFM_Differential
RF_Floating
RF_VSD
HFB
RFan_CF...
RF_VSD
AO
Process Variable
Calibrated Value
RF_VSD
RF_VSD
AO
Floating Control
Output Signal
AO Point
CNST
Sup_Duct_...
RF_VSD
AI
Compute_SD_CFM
RF_VSD
XPR
SD_CFM_...
RF_VSD
PVR
Supply CFM Offset
SD_CFM_...
RF_VSD
AO

Conclusion

- At first glance the control of the fans would appear to be one of the more simple programming tasks, however, considerations for time, temperature, smoke dampers, night purge, and interfacing with the smoke control system quickly complicate the logic.
- With variable volume systems the fan system consists of two processes; the start/stop and the variable speed drive.
- The VSD process has several limits and conditions that are important to remember.

Conclusion

- This presentation included a presentation of actual DDC software programming for the various applications.
- The objective is showing these slides is to convince you that the conversion from our generic control diagrams to a real object oriented programming system is not a difficult step.