LONMARK®
Functional Profile:
VAV Controller (VAV)
Overview

This document describes the profile of a VAV controller object which has self-contained hardware inputs and outputs for sensors and actuators such that it can provide standalone control functionality. The object is used to control sensed room temperature (and optionally box flow) by controlling a damper actuator, fan and heating outputs (staged or modulating).

A room temperature sensor input is mandatory and can either reside in the node itself (may be hard-wire connected to the node) or optionally reside on the network in which case the sensor input is provided via network variables. If the flow control option is used (pressure independent box) an integral flow sensor is assumed (hard-wire or network connected).

The VAV Profile is shown below.

![Figure 1 Functional Profile](image)

Example Usage

The VAV object interacts with one or more of the following LONMARK devices:
- room temperature sensor node
- remote wall module (including temperature sensor, setpoint)
- supervisory node (occupancy mode, application mode)
- monitoring node
- commissioning node (manual positioning for balancing)
The VAV object can control damper, reheat and fan outputs directly through hardware outputs. This requires no mandatory controller outputs be available for actuator nodes.

Figure 2 Object Details “VAV”
Mandatory Network Variables

**Space Temperature Input**

```
network input SNVT_temp_p nviSpaceTemp;
```

This input network variable is used to connect an external space temperature sensor to the node. It is mandatory to the profile, but it does not have to be bound to a sensor node. The VAV Device can have a locally wired space temperature sensor. In any case, valid values of nviSpaceTemp have priority over local sensor values.

**Valid Range**
The valid Range is -10°C to 50°C. The value 0x7FFF = +327.67°C will be handled as an invalid value.

**Default Value**
Default Value is 0x7FFF (= +327.67°C). This value will be adopted at power-up and in case of a bound input not receiving an update within the specified receive heartbeat time to allow default behavior.

**Temperature Setpoint Input**

```
network input SNVT_temp_p nviSetPoint;
```

This input network variable is used to allow the temperature setpoint for the occupied and standby mode to be changed via network. The individual heat/cool setpoints for occupied and standby mode then derive from nviSetpoint minus/plus half the occupancy zero-energy-bands calculated from nciSetPnts i.e.

\[
\text{zeb}_\text{occ} = \text{occupied}_\text{cool} - \text{occupied}_\text{heat} \\
\text{zeb}_\text{standby} = \text{standby}_\text{cool} - \text{standby}_\text{heat}
\]

where the zero-energy-band is defined as the range where neither heating nor cooling is active.

Although this network variable input is mandatory to the profile, it does not have to be bound to any setpoint node. If a valid setpoint value is written to nviSetPoint, it will be used as the center setpoint. If an invalid setpoint is in nviSetPoint, either a locally wired setpoint knob or the appropriate setpoint as configured in nciSetPnts will be used.

**Valid Range**
The valid Range is 10°C to 35°C.

**Default Value**
Default Value is 0x7FFF (= +327.67°C). This value will be adopted at power-up and remains until an update receives. In this case, the VAV object will work according to the configuration of nciSetPnts.
Space Temperature Output

This output network variable is used to send the value of the controlled space temperature (either from a locally connected space temperature sensor or from the nviSpaceTemp input) to other nodes. It is mandatory to the profile.

Valid Range
The valid Range is -10°C to 50°C. The value 0x7FFF = +327.67°C will be handled as an invalid value in case of a sensor failure.

When Transmitted
The variable is transmitted immediately when its value has changed significantly or after the send heartbeat time if nonzero and a significant change has not occurred in that time.

Update Rate
There is no maximum update rate.

Default Service Type
The default service type is unacknowledged.

Unit Status Output

This output network variable is available to report the object status. It combines the operating mode, the capacity of heating and cooling used and an indication if any alarms are present in the object.

Valid Range

OpMode: HVAC_HEAT, HVAC_COOL, HVAC_MRNG_WRMUP, HVAC_NIGHT_PURGE, HVAC_OFF - HVAC_AUTO is not used, other enumerations are optional

heat_output: 0-100%, 0xFFFF (INVALID)
heat_output_secondary: 0-100%, 0xFFFF (INVALID)
cool_output: 0-100%, 0xFFFF (INVALID)
econ_output: 0xFFFF (INVALID)
fan_output: 0-100%, 0xFFFF (INVALID)
in_alarm: 0 Means there is no alarm, Not 0 Means there is an alarm.

A filter alarm will also be indicated using this field.

When Transmitted
The variable is transmitted immediately when its value has changed significantly or after the send heartbeat time if nonzero and a significant change has not occurred in that time.

Update Rate
There is no maximum update rate.
**Default Service Type**
The default service type is unacknowledged.

---

## Optional Network Variables

### Application Mode Input

```plaintext
network input SNVT_hvac_mode nviApplicMode;
```

This network variable input is used to coordinate the VAV object with the air handler control or any other supervisory controller or intelligent human interface device.

#### Valid Range

- **HVAC_AUTO:** The control loop automatically changes between application modes if available (e.g. HEAT and COOL) to provide the control objectives.
- **HVAC_HEAT:** The control loop is in HEAT mode.
- **HVAC_COOL:** The control loop is in COOL mode.
- **HVAC_MRNG_WRMUP:** The morning warm up control strategy is in effect.
- **HVAC_NIGHT_PURGE:** The night purge control strategy is in effect.

The other enumerations provided by `SNVT_hvac_mode` are optional.

#### Default Value

The default value is HVAC_AUTO. This value will be adopted at power-up and in case of a bound input not receiving an update within the specified receive heartbeat time to allow failure reaction.

### VAV Manual Override Input

```plaintext
network input SNVT_hvac_overid nviManOverride;
```

This input network variable is used for commanding the controller into a manual mode (most importantly when balancing the box). It has the fields: state, percent and flow. For details refer to The SNVT Master List and Programmer's Guide.

#### Valid Range

- **state:**
  - **HVO_OFF:** normal control.
  - **HVO_POSITION:** set damper to the value in the percent field.
  - **HVO_FLOW_VALUE:** control flow to value in the flow field.
  - **HVO_FLOW_PERCENT:** control flow to value calculated from the value in percent field and min/max flow limits.
  - **HVO_OPEN:** Fully open the damper.
  - **HVO_CLOSE:** Close the damper.
HVO_MINIMUM: Control flow to the minimum value (nciMinFlow).
HVO_MAXIMUM: Control flow to the maximum value (nciMaxFlow).
HVO_NULL: INVALID (use default).

percent: 0 to 100%
flow: 0 to 65,534 liters/sec

**Default Value**
The default value is HVO_OFF. This value will be adopted at power-up or if an invalid value is received.

---

**Setpoint Offset Input**

network input SNVT_temp_p nviSetpointOffset;
This input network variable is used to shift the temperature setpoint via the network by adding nviSetpointOffset to the current setpoint. It is typically bound to a supervisory node providing outside air temperature compensation or to an external wall module having a relative setpoint knob. This setpoint shifting operates only on occupied and standby setpoints and does not affect the unoccupied setpoint.

**Valid Range**
The valid Range is -10°C to +10°C.

**Default Value**
Default Value is 0°C to disable the setpoint offset. This value will be adopted at power-up and in case of a bound input not receiving an update within the specified receive heartbeat time to allow default behavior.

---

**Occupancy Input**

network input SNVT_occupancy nviOccCmd;
This input network variable is used to command the VAV object into different occupancy modes. It is typically set by a supervisory node.

**Valid Range**
The valid range is described in the table below:

| OC_OCCUPIED: The VAV object should operate in occupied mode as defined by the manufacturer and use the occupied setpoint. |
| OC_UNOCCUPIED: The VAV object should operate in unoccupied mode as defined by the manufacturer and use the unoccupied setpoint. |
| OC_BYPASS: The VAV object should operate in temporary occupied mode. This input can be commanded from the supervisory node. When the configured bypass time elapses, the VAV Device returns to the original occupancy mode. |
OC_STANDBY: The VAV object should operate in standby mode as defined by the manufacturer and use the standby setpoint.

OC_NUL: This is the initial value after power-up and it remains until another value is received. It is used to operate according manufacturer-specific defaults.

**Default Value**
The default value is $\text{OC\_NUL} = \text{0xFF}$.

---

**Emergency Command Input**

```c
network input SNVT_hvac_emerg nviEmergCmd;
```

This input network variable is used to command the VAV object into different emergency modes. It is typically set by a supervisory node.

**Valid Range**
The valid range is described in the table below:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMERG_NORMAL</td>
<td>Normal Condition</td>
</tr>
<tr>
<td>EMERG_PRESSURIZE</td>
<td>Start the EMERG_PRESSURIZE operation</td>
</tr>
<tr>
<td>EMERG_DEPRESSURIZE</td>
<td>Start the EMERG_DEPRESSURIZE operation</td>
</tr>
<tr>
<td>EMERG_PURGE</td>
<td>Start smoke Purge operation.</td>
</tr>
<tr>
<td>EMERG_SHUTDOWN</td>
<td>Start SHUTDOWN operations.</td>
</tr>
<tr>
<td>EMERG_NUL</td>
<td>Invalid mode.</td>
</tr>
</tbody>
</table>

**Default Value**
The default value is EMERG_NORMAL.

---

**Box Flow Input**

```c
network input SNVT_flow nviBoxFlow
```

This variable represents the input to a VAV controller object from a flow sensor on the network. Valid values of nviBoxFlow have priority over local sensor values.

**Valid Range**
The valid Range is 0 to 65,535 liters/sec. The value 0xFFFF = 65,535 liters/sec will be handled as an invalid value.

**Default Value**
Default Value is 0xFFFF (65,535 liters/sec). This value will be adopted at power-up and in case of a bound input not receiving an update within the specified receive heartbeat time to allow default behavior.
Fan Speed Command

network input SNVT_switch nviFanSpeedCmd;

This input network variable is used to connect an external fan speed switch to the node or to allow any supervisory device to override the fan speed controlled by the node’s control algorithm. nviFanSpeedCmd can be used to support multi-state: OFF / SPEED#1 / SPEED#2 / SPEED#3 / ... / SPEED#h / AUTO SPEED#1 / SPEED#2 / SPEED#3 / ... / SPEED#h / AUTO.

Valid Range

The valid range is the range provided by SNVT_switch as described below:

<table>
<thead>
<tr>
<th>state</th>
<th>value</th>
<th>fan speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (OFF)</td>
<td>na</td>
<td>OFF</td>
</tr>
<tr>
<td>1 (ON)</td>
<td>0%</td>
<td>OFF</td>
</tr>
<tr>
<td>1 (ON)</td>
<td>0.5</td>
<td>(1/n) 100%</td>
</tr>
<tr>
<td>1 (ON)</td>
<td>0.5+(1/n)</td>
<td>(2/n) 100%</td>
</tr>
<tr>
<td>1 (ON)</td>
<td>0.5+(1/(m-1)/n)</td>
<td>(m/n) 100%</td>
</tr>
<tr>
<td>1 (ON)</td>
<td>0.5+(n-1)/n</td>
<td>100%</td>
</tr>
<tr>
<td>0xFF</td>
<td>na</td>
<td>fan AUTO</td>
</tr>
</tbody>
</table>

NOTE: Truncation should be used when computing the above values.

OFF: The fan should be switched OFF.
fan speed #1: The fan should always run at the lowest speed (fan speed #1).
fan speed #2: The fan should always run at the second fan speed stage (fan speed #2)
...
fan speed #m: The fan should always run at the fan speed stage #m.
fan speed #n: The fan should always run at the highest fan speed stage (fan speed #n).
fan AUTO: The fan is not controlled by the switch.

Default Value

Default value is “fan AUTO”, which means there is no external fan speed switch assigned nor any supervisory device overrides the locally wired fan speed switch.

Energy Hold Off Input

network input SNVT_switch nviEnergyHoldOff;

This input is from a device such as a window contact sensor. Moreover it is used if two or more controllers that share one physical window contact or another device (EnergyHoldOff device) that forces all of them to go to a lower energy consuming operation. If for instance two controllers share one window contact, or a dew point sensor, the controller to which the sensor is physically connected provides the sensor’s state on its output, hence the other may obtain the value and switch to EnergyHoldOff (equals to ‘stop heating/cooling while still providing frost protection’) when necessary. If a physical sensor is connected and the network variable is bound, the network variable overrides the physical value, i.e. the network value has precedence over the physical value. See nvoEnergyHoldOff for the corresponding output network variable.
Valid Range
The valid range is the range provided by \texttt{SNVT\_switch}:
EnergyHoldOff (stop heating/cooling) is activated for \texttt{state=1 and value 0\%}. ‘State=0’ or ‘state=1 and value=0\%’ leads to the normal heat/cool control.

Default Value
Default Value is state = FALSE (no Energy Hold Off requested). This value will be adopted at power-up and in case of not receiving an update afterwards.

\textbf{CO2 Sensor Input}
\begin{verbatim}
network input SNVT\_ppm nviCO2;
This input network variable measures the CO2 levels in PPM. The VAV object can have a locally wired CO2 sensor. In any case, valid values of \texttt{nviCO2} have priority over local sensor values.
\end{verbatim}

Valid Range
The valid Range is 0 to 5000 PPM.

Default Value
Default Value is 0x7FFF. This value will be adopted at power-up and in case of a bound input not receiving an update within the specified receive heartbeat time to allow default behavior.

\textbf{Heater Override Input}
\begin{verbatim}
network input SNVT\_switch nviHeaterOverid;
This input disables to be turned on by the VAV controller.
\end{verbatim}

Valid Range
\((\texttt{state = 0)} \text{ or } (\texttt{state =1 \& value = 0}) \text{ or } (\texttt{state =0xFF}))\) means HeaterOverride function is OFF.
\((\texttt{state =1 and value >0})\) means HeaterOverride function is ON and the heater is disabled.

Default Value
Default value is state = 0xFF (invalid). This value will be adopted at power-up.

\textbf{Duct Inlet Temperature Input}
\begin{verbatim}
network input SNVT\_temp\_p nviDuctInTemp;
\end{verbatim}
If the duct inlet air temperature sensor is a LONMARK device, the VAV controller object obtains its value through this network variable. The network value has got precedence over the physical value if both are available.

**Valid Range**
The valid range is -10°C to 50°C. The value 0x7FFF =+327.67°C will be handled as an invalid value.

**Default Value**
Default Value is 0x7FFF = +327.67°C. This value will be adopted at power-up and in case of not receiving an update afterwards.

---

**Effective Setpoint Output**

network output SNVT_temp_p nvoEffectSetPt

The output network variable is used to inform the effective setpoint temperature when the setpoint is changed by local means.

**Valid Range**
The valid Range is 10°C to 35°C. The value 0x7FFF =+327.67°C will be handled as an invalid value in case of a sensor failure.

**When Transmitted**
The variable is transmitted immediately when its value has changed significantly or after the send heartbeat time if nonzero and a significant change has not occurred in that time.

**Update Rate**
There is no maximum update rate.

**Default Service Type**
The default service type is unacknowledged.

---

**Effective Flow Control Point Output**

network output SNVT_flow nvoFlowControlPt

The output network variable is used to inform the effective control point used by the flow control loop.

**Valid Range**
The valid Range is 0 to 65,535 liters/sec. The value 0xFFFF =65,535 will be handled as an invalid value.

**Default Value**
The default value is 0%. This value will be adopted at power-up.

**When Transmitted**
The variable is transmitted immediately when its value has changed significantly.

**Update Rate**
There is no maximum update rate.
Default Service Type
The default service type is unacknowledged.

Box Flow Output

network output SNVT_flow nvoBoxFlow
The output network variable is used to provide the flow in the box.

Valid Range
The valid Range is 0 to 65,535 liters/sec. The value 0xFFFF=65,535 will be handled as an invalid value.

Default Value
The default value is 0%. This value will be adopted at power-up.

When Transmitted
The variable is transmitted immediately when its value has changed significantly or after the send heartbeat time if nonzero and a significant change has not occurred in that time.

Update Rate
There is no maximum update rate.

Default Service Type
The default service type is unacknowledged.

Terminal Load Output

network output SNVT_lev_percent nvoTerminalLoad
The output network variable is used to provide the demand for supply energy. Positive numbers are cooling demand and negative numbers are heating demand. This will be used for coordination within the HVAC subsystem and energy management decisions by the supply equipment.

Valid Range
The valid Range is -163.84% to 163.84%. The value 0x7FFF=+163.84% will be handled as an invalid value.

Default Value
The default value is 0%. This value will be adopted at power-up or an invalid value is received.

When Transmitted
The variable is transmitted immediately when its value has changed significantly or after the send heartbeat time if nonzero and a significant change has not occurred in that time.
**Update Rate**
There is no maximum update rate.

---

**Energy Hold Off Output**

```network output SNVT_switch nvoEnergyHoldOff;```

This output is used to convey to other devices the state of an EnergyHoldOff device that is hardwired to the controller. Refer to EnergyHoldOff Input.

**Valid Range**
The valid range is the range provided by SNVT_switch as described below:

<table>
<thead>
<tr>
<th>state</th>
<th>value</th>
<th>Energy Hold Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (OFF)</td>
<td>0 %</td>
<td>no Energy Hold Off</td>
</tr>
<tr>
<td>1 (ON)</td>
<td>100 %</td>
<td>Energy Hold Off</td>
</tr>
</tbody>
</table>

**Default Value**
Default Value is ‘state=FALSE and value=0% (no Energy Hold Off requested). This value will be adopted at power-up and in case of not receiving an update afterwards.

**When Transmitted**
The variable is transmitted immediately when its value has changed significantly or after the send heartbeat time if nonzero and a significant change has not occurred in that time.

**Update Rate**
There is no maximum update rate.

**Default Service Type**
The default service type is unacknowledged.

---

**Configuration Properties**

**Send Heartbeat (mandatory)**

```network input config SNVT_time_sec nciSndHrtBt;```

This configuration network variable defines the maximum period of time that expires before the following network variable outputs will automatically be updated:

- nvoSpaceTemp,
- nvoUnitStatus,
- nvoBoxFlow,
- nvoTerminalLoad
- nvoEffectSetPt
- nvoEnergyHoldOff
Valid Range
The valid range is any value between 0.0 sec and 6,553.4 sec. Setting nciSndHrtBt = 0 disables the automatic update mechanism.

Default Value
0 (no automatic update)

SCPT Reference
SCPTmaxSendTime(49)

Occupancy Temperature Setpoints (mandatory)

This configuration property defines the occupancy temperature setpoints for heat and cool mode. The setpoint will have an assigned upper and lower limit for each state defined below within the min. and max. range.

Valid Range and Default Value

<table>
<thead>
<tr>
<th>State</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>occupied_cool</td>
<td>10 °C</td>
<td>35 °C</td>
<td>23 °C</td>
</tr>
<tr>
<td>standby_cool</td>
<td>10 °C</td>
<td>35 °C</td>
<td>25 °C</td>
</tr>
<tr>
<td>unoccupied_cool</td>
<td>10 °C</td>
<td>35 °C</td>
<td>28 °C</td>
</tr>
<tr>
<td>occupied_heat</td>
<td>10 °C</td>
<td>35 °C</td>
<td>21 °C</td>
</tr>
<tr>
<td>standby_heat</td>
<td>10 °C</td>
<td>35 °C</td>
<td>19 °C</td>
</tr>
<tr>
<td>unoccupied_heat</td>
<td>10 °C</td>
<td>35 °C</td>
<td>16 °C</td>
</tr>
</tbody>
</table>

SCPT Reference
SCPTsetPtns(60)

Receive Heartbeat (optional)

This configuration property is used to control the maximum time that elapses after the last update to a bound network input before the VAV object adopts a default value for the following:
- nviSpaceTemp,
- nviSetpointOffset,
- nviApplicMode,
- nviBoxFlow
- nviEnergyHoldOff
- nviCO2
- nviDuctTempIn
**Valid Range**
The valid range is any value between 0.0 sec and 6,553.4 sec. Setting `nciRcvHrtBt = 0` disables this network variable receive failure detect mechanism.

**Default Value**
0 (no failure detect)

**SCPT Reference**
SCPTmaxRcvTime(48)

---

**Minimum Send Time (optional)**

```c
network input config SNVT_time_sec nciMinOutTm;
```

This configuration property defines the minimum period of time between output network variable transitions.

**Valid Range**
The valid range is any value between 0.0 sec and 6,553.4 sec.

**Default Value**
0

**SCPT Reference**
SCPTminSendTime(52)

---

**Location Label (optional)**

```c
network input config SNVT_str_asc nciLocation;
```

This configuration property can optionally be used to provide more descriptive physical location information than can be provided by the Neuron Chip’s 6 byte location string. The location relates to the object and not to the node.

**Valid Range**
Any NULL terminated ASCII string of 31 bytes total length.

**Default Value**
The default value is an ASCII string containing all zeros ("\0").

**SCPT Reference**
SCPT_location (17)

---

**Duct Area (optional)**

```c
network input config SNVT_area nciDuctArea;
```

This configuration property can be used to determine the duct area and compute the flow.
**Valid Range**  
0 to 13.1068 m²

**Default Value**  
The default value is 0.

**SCPT Reference**  
SCPTductArea(46)

---

**Minimum Flow (mandatory)**  
network input config SNVT_flow nciMinFlow;  
This configuration property defines the minimum flow through the VAV box

**Valid Range**  
0 to 65,535 liters/sec.

**Default Value**  
The default value is 0.

**SCPT Reference**  
SCPTminFlow(54)

---

**Maximum Flow (mandatory)**  
network input config SNVT_flow nciMaxFlow;  
This configuration property defines the maximum flow through the VAV box

**Valid Range**  
0 to 65,535 liters/sec.

**Default Value**  
The default value is 65,535 liters/sec.

**SCPT Reference**  
SCPTmaxFlow(51)

---

**Minimum Flow For Heat (optional)**  
network input config SNVT_flow nciMinFlowHeat;  
This configuration property defines the minimum flow the VAV controller will control to when reheat mode is utilized.

**Valid Range**  
0 to 65,535 liters/sec.
Default Value
The default value is 0.

SCPT Reference
SCPTminFlowHeat(55)

Minimum Flow Standby (optional)
network input config SNVT_flow nciMinFlowStand;
This configuration property defines the minimum flow through the VAV box in the standby mode.

Valid Range
0 to 65,535 liters/sec.

Default Value
The default value is 0.

SCPT Reference
SCPTminFlowStby(56)

Nominal Flow (optional)
network input config SNVT_flow nciNomFlow;
This configuration property defines the nominal flow through the VAV box.

Valid Range
0 to 65,535 liters/sec.

Default Value
The default value is 0.

SCPT Reference
SCPTnomAirFlow(57)

VAV gain (optional)
network input config SNVT_multiplier nciVAVgain;
This configuration property defines the gain of the VAV controller objec.

Valid Range
0 to 32.7675.

Default Value
The default value is 1.

SCPT Reference
SCPTgainVAV(66)

Data Transfer

None specified

Power-up State

The input variables are set to their default values. The output network variables will be set to their initial value as follows:

- `nvoSpaceTemp`: INVALID
- `nvCO2`: INVALID
- `nvoBoxFlow`: INVALID
- `nvoEffectSetPt`: 0
- `nvoFlowControlPt`: 0
- `nvoTerminalLoad`: 0
- `nvoEnergyHoldOff`: state = 0, value = 0%
- The fields in `nvoUnitStatus` will be set to the initial values:
  - `mode`: HVAC_OFF
  - `heat_output_primary`: 0
  - `heat_output_secondary`: 0
  - `econ_output`: INVALID
  - `fan_output`: 0
  - `in_alarm`: 0

Boundary and Error Conditions

None specified.

Additional Considerations

None specified.