

SIEMENS



TEC Controller

Terminal Box Controller (VAV) - Cooling Only, Application 2020

Application Note

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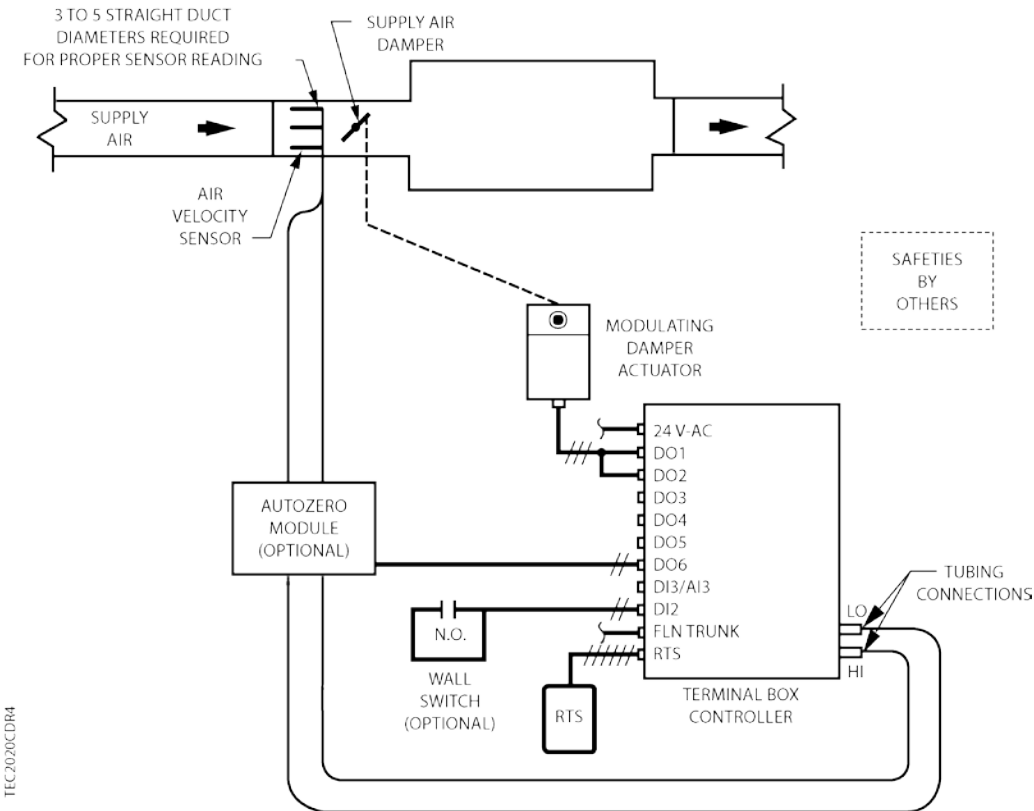
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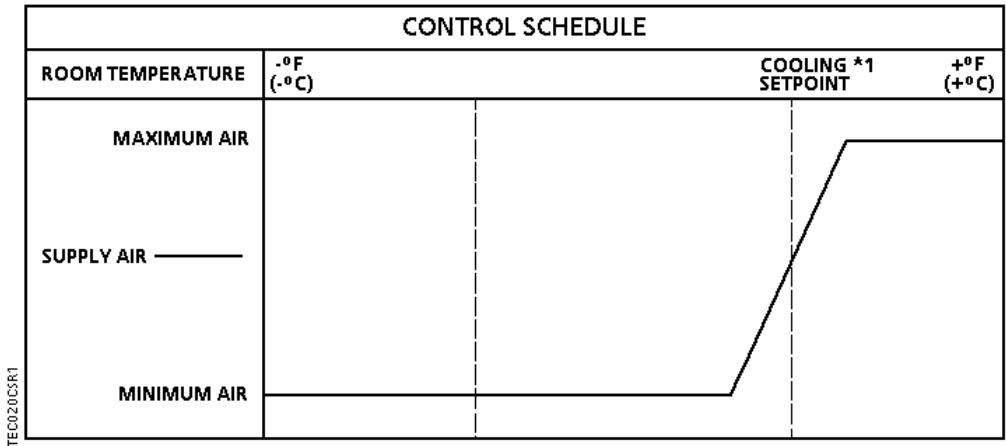
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Overview

In Application 2020, the controller modulates the supply air damper of the terminal box for cooling. In order for it to work properly, the central air-handling unit must provide cool supply air.



Application 2020 – VAV Cooling Only Control Diagram.



Application 2020 Control Schedule.



Hardware Inputs

Analog

- Air velocity sensor
- Room temperature sensor
- *(Optional)* Room temperature setpoint dial
- *(Optional)* Auxiliary temperature sensor (100K Ω thermistor)

Digital

- *(Optional)* Night/Unoccupied mode override
- *(Optional)* Wall switch

Hardware Outputs

Analog

- None

Digital

- Damper actuator (DO 1/DO 2)
- *(Optional)* Autozero Module
- *(Optional)* Spare DOs

Ordering Notes

540-100N TEC Terminal Box Controller

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2020, VAV - Cooling Only.

Control Temperature Setpoints

This application has a number of different room temperature setpoints (NGT CLG STPT, RM STPT DIAL, and so on.). The application actually controls using the CTL STPT. CTL STPT is set to different values depending on its override status, the time of day, whether or not a temperature deadband (zero energy band) has been configured, and the type of RTS used.

CTL STPT is Overridden

If CTL STPT is overridden, that value is used regardless of any other settings.

CTL STPT in Night Mode

The controller is in Night mode if DAY.NGT = NGT and NGT OVRD = NGT.

When the controller is in Night mode, CTL STPT holds the value of NGT CLG STPT. When the controller is in Night mode, the value of RM STPT DIAL is ignored.

CTL STPT in Day Mode

The controller is in Day mode if DAY.NGT = DAY or NGT OVRD = DAY.

Without setpoint dial:

When the controller is in Day mode and STPT DIAL = NO, CTL STPT holds the value of DAY CLG STPT.

With setpoint dial:

When the controller is in Day mode and STPT DIAL = YES, CTL STPT is set based on the value of the setpoint dial, and is limited between RM STPT MIN and RM STPT MAX.

Room Temperature and CTL TEMP

ROOM TEMP is the temperature that is being sensed by the room temperature sensor (RTS).

CTL TEMP is the room temperature that is used for control purposes. In other words, what the application is trying to do is to maintain CTL TEMP at the control setpoint.

When CTL TEMP is not overridden, CTL TEMP and ROOM TEMP are related by the following equation:

If CTL TEMP is not overridden then,

- The current value of ROOM TEMP (normal or overridden) will be used to determine the value of CTL TEMP.
- If ROOM TEMP has a status of Failed the last known good value of ROOM TEMP will be used to determine the value of CTL TEMP.

If CTL TEMP is overridden then,

- CTL TEMP equals its overridden value and ROOM TEMP has no effect on the value of CTL TEMP.

Day and Night Modes

The day/night status of the space is determined by the status of DAY.NGT. The control of this point differs depending on whether the controller is monitoring the status of a wall switch or if the controller is connected to a field panel.

When a wall switch is physically connected to the termination strip on the controller at DI 2 (see the *Control Diagram* in the Overview section), and WALL SWITCH = YES, the controller monitors the status of DI 2. When the status of DI 2 is ON (the switch is closed), then DAY.NGT is set to DAY indicating that the controller is in day mode. When the status is OFF (the switch is open), then DAY.NGT is set to NIGHT indicating that the controller is in night mode.

When WALL SWITCH = NO, the controller does not monitor the status of the wall switch, even if one is connected to it. In this case, if the controller is operating stand-alone, then the controller stays in day mode all the time. If the controller is operating with centralized control (that is, it is connected to a field panel), then the field panel can send an operator or PPCL command to override the status of DAY.NGT.

Night Mode Override Switch

If an override switch is present on the room temperature sensor and a value (in hours) other than zero has been entered into OVRD TIME, pressing the override switch resets the controller to DAY operational mode for the time period that is set in OVRD TIME.

The status of NGT OVRD changes to DAY. After the override time elapses, the controller returns to night mode and the status of NGT OVRD changes back to NIGHT.

The override switch on the room sensor only affects the controller when it is in Night mode.

Control Loops

The terminal box is controlled by two Proportional, Integral, and Derivative (PID) control loops; a temperature loop and a flow loop.

The temperature loop is a cooling loop. The active temperature loop maintains room temperature at the value in CTL STPT. See *Control Temperature Setpoints*.

Temperature Loop – A cooling loop that maintains room temperature at the value in CTL STPT. See *Control Temperature Setpoints*.

The temperature loop generates cooling loopout which is then used to generate FLOW STPT. FLOW STPT is the result of scaling the cooling loopout to the appropriate range of values determined by CLG FLOW MIN and CLG FLOW MAX. In order to scale it, the loopout is multiplied by the range (MAX – MIN) and then added to the minimum setpoint.

When $\text{CLG FLOW MIN} > 0 \text{ CFM}$, $\text{FLOW STPT} \geq \text{CLG LOOPOUT}$, the minimum flow setpoint is $(\text{CLG FLOW MIN} / \text{CLG FLOW MAX}) \times 100\% \text{ flow}$. And, FLOW STPT is $[\text{CLG LOOPOUT} \times (100\% - \text{minimum setpoint})] + \text{minimum setpoint}$.

Example

If CTL FLOW MIN = 200 cfm, and CLG FLOW MAX = 1000 cfm, the minimum flow setpoint is $(200 \text{ cfm}/1000 \text{ cfm}) \times 100\% \text{ flow} = 20\%$.

When CLG LOOPOUT is 0%, FLOW STPT = 20% flow.

$[0\% \times (100\% - 20\%)] + 20\% = 20\%$

This ensures that the airflow out of the terminal box is no less than CTL FLOW MIN.

When CLG LOOPOUT is 50%, FLOW STPT = 60% flow.

$[50\% \times (100\% - 20\%)] + 20\% = 60\%$

When CLG LOOPOUT is 100%, FLOW STPT = 100% flow.

$[100\% \times (100\% - 20\%)] + 20\% = 100\%$

Advanced PID algorithm for the temperature control loops is employed to provide stability and to reduce unnecessary changes in the Flow setpoint when the room temperature is at or near the room temperature setpoint.

Flow Loop – The flow loop maintains FLOW STPT by modulating the supply air damper, DMPR COMD. The flow loop maintains the airflow between CTL FLOW MIN and CTL FLOW MAX.

To enhance stable flow control, an advanced algorithm is used to calculate a controllable setpoint as the value approaches zero cfm (lps).

You can set CLG FLOW MIN equal to, but not greater than, CLG FLOW MAX. If the minimum and maximum values are set equal, the flow loop becomes a constant volume loop and loses its ability to control temperature.

FLOW is the input value for the flow loop. It is calculated as a percentage based on where AIR VOLUME is between 0 cfm and CTL FLOW MAX. This percentage is referred to as % flow.

- If AIR VOLUME = 0 cfm, FLOW is 0% flow.
- If AIR VOLUME = CTL FLOW MAX, FLOW is 100% flow.

The low limit of FLOW STPT is the percentage that corresponds to the volume given in CTL FLOW MIN. This percentage can be calculated as:

$$(\text{CTL FLOW MIN}/\text{CTL FLOW MAX}) \times 100\% \text{ flow}$$

The flow loop ensures that the supply air will not be less than CTL FLOW MIN.

Example

If CTL FLOW MIN = 250 cfm, and CTL FLOW MAX = 1000 cfm,

the low limit of FLOW STPT = $(250 \text{ cfm}/1000 \text{ cfm}) \times 100\% \text{ flow}$

= $0.25 \times 100\% \text{ flow}$

= 25% flow.

Since 25% of 1000 cfm = 250 cfm, the minimum airflow out of the terminal box will be 250 cfm.

Flow Control in Night Mode

When the controller is in the Night Mode, CTL FLOW MIN is determined differently. If the cooling demand is greater than zero, CTL FLOW MIN = CLG FLOW MIN. When cooling demand is zero (the temperature is less than NGT CLG STPT), airflow is not required and CTL FLOW MIN is set to 0.

Calibration

Calibration of the controller's internal air velocity sensor(s) is periodically required to maintain accurate air velocity readings. CAL SETUP is set with the desired calibration option during controller startup.

Depending on the value of CAL SETUP, calibration may be set to take place automatically or manually. If CAL AIR = YES, calibration is in progress.

- For a controller used without an Autozero Module (CAL MODULE = NO), the damper is commanded closed to get a zero airflow reading during calibration.
- For a controller used with an Autozero Module (CAL MODULE = YES), calibration occurs without closing the damper.

At the end of a calibration sequence, CAL AIR automatically returns to NO. A status of NO indicates that the controller is not in a calibration sequence.

Floating Control Actuation Auto-correct

In addition to the existing options for floating control actuator full stroke actions, all floating control actuators are provided with additional logic to fully drive open or closed when commanded to 100% or 0%.

Fail Mode Operation

If the air velocity sensor fails, the controller uses pressure dependent control. The temperature loop controls the operation of the damper.

If the room temperature sensor fails, the controller operates using the last known temperature value.

Application Notes

- If temperature swings in the room are excessive or there is trouble maintaining the setpoint, the cooling loop must be tuned. If FLOW is oscillating while FLOW STPT is constant, the flow loop requires tuning.
- The controller, as shipped from the factory, keeps all associated equipment OFF.
- Spare DOs can be used as auxiliary points that are controlled by the field panel after being defined in the field panel's database. DO 3 and DO 4 or DO 5 and DO 6 may be used as auxiliary motor points. If using a pair of spare DOs to control a motor, you must unbundle the corresponding motor command point.

For more information, contact your local Siemens Industry representative.

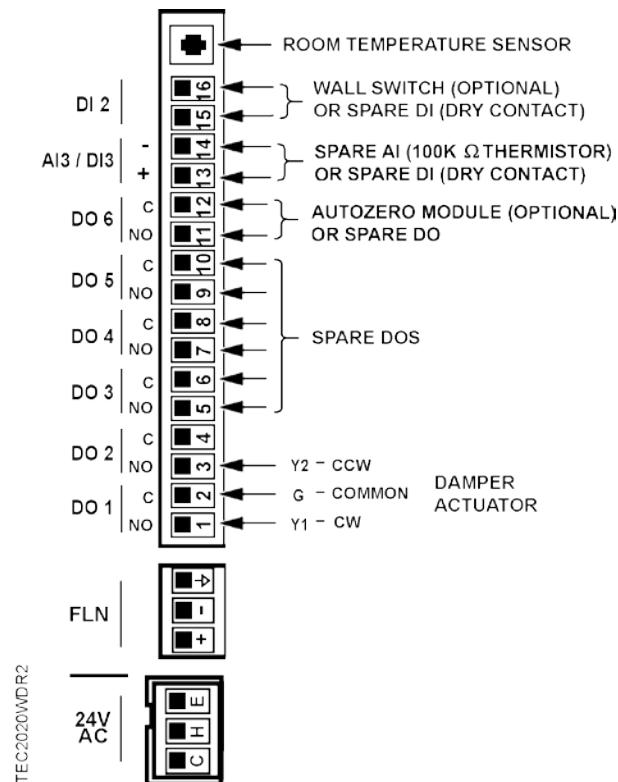
Wiring Diagram



NOTE:

The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. An external interposing relay is required for any of the following:

- VA requirements higher than the maximum
- 110 or 220 Vac requirements
- DC power requirements
- Separate transformers used to power the load
(for example, part number 540-147, Terminal Equipment Controller Relay Module)



Application 2020 – Variable Air Volume Cooling Only.

Application 2020 Point Database

Point Number	Descriptor	Factory Default (SI Units) ²	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
1	CTLR ADDRESS	99	--	1	0	--	--
2	APPLICATION	2091	--	1	0	--	--
{04}	ROOM TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
6	DAY CLG STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
8	NGT CLG STPT	82.0 (27.92888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
11	RM STPT MIN	55.0 (12.80888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
12	RM STPT MAX	90.0 (32.40888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
{13}	RM STPT DIAL	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
14	STPT DIAL	NO	--	--	--	YES	NO
{15}	AUX TEMP	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5 (3.055556)	--	--
18	WALL SWITCH	NO	--	--	--	YES	NO
{19}	DI OVRD SW	OFF	--	--	--	ON	OFF
20	OVRD TIME	0	HRS	1	0	--	--
{21}	NGT OVRD	NIGHT	--	--	--	NIGHT	DAY
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
{29}	DAY.NGT	DAY	--	--	--	NIGHT	DAY
31	CLG FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
32	CLG FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{35}	AIR VOLUME	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
36	FLOW COEFF	1	--	0.01	0	--	--
{37}	MTR3 COMD	0	PCT	0.4	0	--	--
{38}	MTR3 POS	0	PCT	0.4	0	--	--
39	MTR3 TIMING	130	SEC	1	0	--	--
{41}	DO 1	OFF	--	--	--	ON	OFF
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	DO 3	OFF	--	--	--	ON	OFF
{44}	DO 4	OFF	--	--	--	ON	OFF

Point Number	Descriptor	Factory Default (SI Units) ²	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{45}	DO 5	OFF	--	--	--	ON	OFF
{46}	DO 6	OFF	--	--	--	ON	OFF
{48}	DMPR COMD	0	PCT	0.4	0	--	--
{49}	DMPR POS	0	PCT	0.4	0	--	--
51	MTR1 TIMING	95	SEC	1	0	--	--
{52}	MTR2 COMD	0	PCT	0.4	0	--	--
{53}	MTR2 POS	0	PCT	0.4	0	--	--
55	MTR2 TIMING	130	SEC	1	0	--	--
56	DMPR ROT ANG	90	--	1	0	--	--
58	MTR SETUP	0	--	1	0	--	--
59	DO DIR. REV	0	--	1	0	--	--
63	CLG P GAIN	20.0 (36.0)	--	0.25 (0.45)	0	--	--
64	CLG I GAIN	0.01 (0.018)	--	0.001 (0.0018)	0	--	--
65	CLG D GAIN	0 (0.0)	--	2 (3.6)	0	--	--
66	CLG BIAS	0	PCT	0.4	0	--	--
71	FLOW P GAIN	0	--	0.05	0	--	--
72	FLOW I GAIN	0.01	--	0.001	0	--	--
73	FLOW D GAIN	0	--	2	0	--	--
74	FLOW BIAS	50	PCT	0.4	0	--	--
{75}	FLOW	0	PCT	0.25	0	--	--
{76}	CTL FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
{77}	CTL FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{78}	CTL TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
{79}	CLG LOOPOUT	0	PCT	0.4	0	--	--
{84}	DMPR STATUS	CAL	--	--	--	RECAL	CAL
87	CAL MODULE	NO	--	--	--	YES	NO
{91}	TOTAL VOLUME	0 (0)	CF (L)	4 (113)	0	--	--
{92}	CTL STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
{93}	FLOW STPT	0	PCT	0.25	0	--	--
{94}	CAL AIR	NO	--	--	--	YES	NO
95	CAL SETUP	4	--	1	0	--	--
96	CAL TIMER	12	HRS	1	0	--	--
97	DUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0.025 (0.002323)	0	--	--

Point Number	Descriptor	Factory Default (SI Units) ²	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
98	LOOP TIME	5	SEC	1	0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--

- 1) Points not listed are not used in this application.
- 2) A single value in a column means that the value is the same in English units and in SI units.
- 3) Point numbers that appear in brackets { } may be unbundled at the field panel.

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