Instruction Manual

TD340 Dual-Probe Two-Stage Heat and Cool Controller For HVAC

Version 1.1 (June, 2023)

1. Overview

TD340 is a dual-probe, two-stage, heat and cool controller for room temperature and ventilation control. The controller comes with two sensors. The primary sensor (Sensor 1) should be placed in the room where the temperature needs to be regulated. The auxiliary sensor (Sensor 2) should be used to monitor the air temperature outside the room.

The controller can automatically switch between the heating mode and the cooling mode as the condition changes. There are two stages in each mode, and each stage have its own setpoint. There are two independent output sockets. The user has the flexibility to configure any stage in either heating or cooling mode to any one of these sockets.

This is a plug-n-play controller. No additional wiring is needed. Both output sockets are on/off control. It is similar to a mechanical thermostat but has much higher precision due to adjustable hysteresis band, high precision sensor, and digital read out. User can also adjust the timer interval between the two stages. Anti-Short (AS) function is available for the cooling channel to protect the compressor from being turned on/off frequently.

Two digital silicon band gap sensors are used. This type of sensor is much more reliable in moist environment comparing to thermistor sensors. It can be immersed in water over an extended period of time. It also has high uniform accuracy over an entire specified temperature range. Two sensors are interchangeable. One of the sensors has a 12-feet (2 m) cable, which makes it easy to reach the external medium.

2. Specifications

Temperature Control Range	-50 ~ 105°C, -58 ~ 221°F
Temperature Resolution	0.1°C (between -9.9 ~ 99°C) 1°C (between -50 ~ 10°C, 100 ~ 120°C) 0.1°F (between -9.9 ~ 99.9°F) 1°F (between -58 ~ 10°F, 100 ~ 248°F)
Temperature Accuracy	0.5°C or 0.9°F
Temperature Control Mode	On/off Control. Heating and Cooling
Temperature Control Output	10 A, 120 V or 240 V AC *
Audio Alarm	High and low limit
Sensor Type	Silicon Band Gap Sensor (digital)
Sensor Size	0.25" O.D. (6.35 mm) x 1" (25 mm) long
Sensor1 Cable Length	6 ft (2 m)
Sensor2 Cable Length	12 ft (4 m)
Operating Temperature	-20°C ~ 50°C (0°F ~ 120°F)
Power Cable Length	3 ft (1 m)
Dimension	3.6'' x 5.5'' x 1.8'' (91 x 140 x 46 mm)
Input Power	85 ~ 240 VAC, 50 Hz / 60 Hz
Warranty	One (1) year.

***Note** * Either the heating or the cooling device is limited to 10 Amps. The output voltage is the same as the input voltage. When the controller is plugged into 120 VAC, the output will be 120 VAC. If the controller is connected to 240 VAC, the output will be 240 VAC also.*

3. Front Panel

Figure 1. The front panel of TD340.

3.1 Descriptions

(a) Display window. Shows temperature readings and parameters.
(b) SET key. Press set key to display parameters and save changed values.
(c) UP arrow key/mute alarm. Increase value; mute the alarm buzzer.
(d) DOWN arrow key. Decrease value.
(e) Relay A socket indicator. Synchronized with the power output socket on the left.
(f) Relay A socket. Supply power to the connected device. The voltage is the same as the input power to the controller.
(g) Relay B socket indicator. Synchronized with the power output socket on the right.
(h) Relay B socket. Supply power to the connected device. The voltage is the same as the input power to the controller.
(i) Sensor 1 socket. For the primary sensor which measures the temperature of the subject to be controlled.
(j) Sensor 2 socket. For the auxiliary sensor which measures the temperature of the external medium that helps to control the temperature.

4. Connecting the Controller

Here are the basic operating procedures to use this controller. To fully understand the functions on this controller, please read the entire manual.
1) Connect the two temperature sensors to the sensor sockets that is located on the bottom of the controller. Please check the alignment of the slot on the plug with the key on the socket.

2) Plug the controller's power cord to a wall outlet. When the controller is powered on, it will display temperature reading from Sensor 1. Press and hold the DOWN key to display the temperature reading from Sensor 2. If either one of the sensors is not connected or shorted, the digital display will show error code "Err".

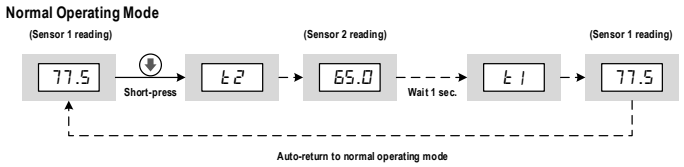


Figure 2. How to check the Sensor 2 reading.

3) Set up the setpoints and system parameters. Please read the rest of this manual for details. See the flow chart in Figure 3 for how to access the set temperatures and the parameters.

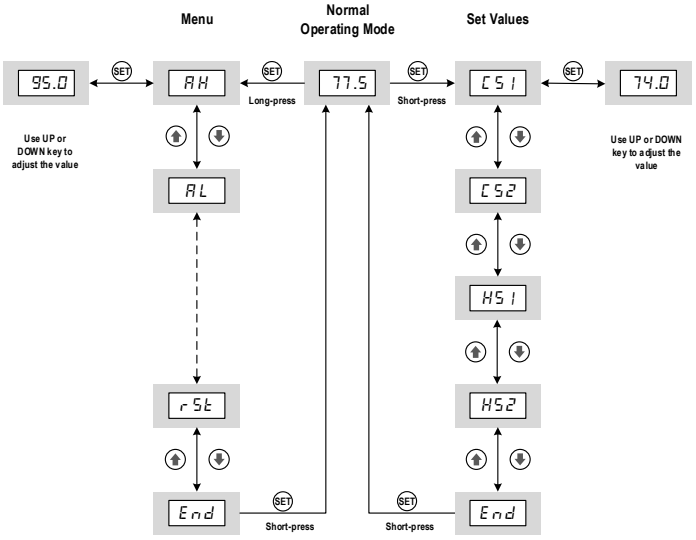


Figure 3. How to access the set values and the parameters in the menu.

4) Plug in the cooling device and/or heating device to the output sockets on this controller. Once powered up, the controller will start running according to the saved settings. When an output socket is energized, its LED indicator will lit.

5. Basic Operations

5.1 Check the Temperature Readings

In normal operating mode, the LED window shows the reading from Sensor 1. To check the Sensor 2 reading, please press and hold the DOWN arrow key. The LED window will show "t2" shortly and then show the Sensor 2 reading. Once the DOWN arrow key is released, display will show "t 1" shortly and display the Sensor 1 reading.

5.2 Access Setpoints

To access the setpoints, press SET key momentarily. The controller will show **CS1** (cooling setpoint, stage 1). To check and change the value, press the SEK key again. To access other setpoints, use UP or DOWN arrow key to go through **CS2** (cooling setpoint, stage 2), **HS1** (heating setpoint, stage 1), and **HS2** (heating setpoint, stage 2). To exit this sub-menu, select END and press SET key.

5.3 Access Parameters

To access the system parameters, press and hold the SET key for 3 seconds, the controller will enter the Parameter Setting Mode. The first parameter "AH" will be shown in the display window. Use UP or DOWN key to go to other parameters in the sub-menu. To check the value of a parameter, press SET key. To change the value of a parameter, use UP or DOWN key, then press SET to confirm the change. The display will return to normal operation mode if no key is pressed for 15 seconds.

5.4 Mute the Alarm Buzzer

Press the UP key to mute the buzzer when it is triggered.

6. Using the Controller

6.1 Control Logic

The primary application of this controller is to use external air to help regulate the room temperature within a specified temperature range, where the upper boundary is set by cooling setpoints **CS1** and **CS2** and the lower boundary is set by heating setpoints **HS1** and **HS2**. The **CS1** and **HS1** are stage 1 cooling and heating setpoints, and the **CS2** and **HS2** are the stage 2 setpoints. The room temperature is monitored by the Primary Sensor (Sensor1), while the temperature of the external air is monitored by the Auxiliary Sensor (Sensor 2).

Whether a heating stage or a cooling stage will be triggered depends on two criteria:
1) Whether the Sensor 1 reading is greater/lower than a setpoint.
2) Whether the temperature difference between Sensor 1 and Sensor 2 is greater than the threshold **dLH** (i.e., Deviation Limit for Heating) or **dLC** (i.e., Deviation Limits for Cooling).

Please see the flow chart in Figure 4 for a simplified illustration of the controller's operating logic. Other parameters such as **C1H**, **C2H**, **H1H**, **H2H**, **tBS**, and **AS** also affects the output status. Please refer to Section 7 in this manual for detailed explanation of each parameter.

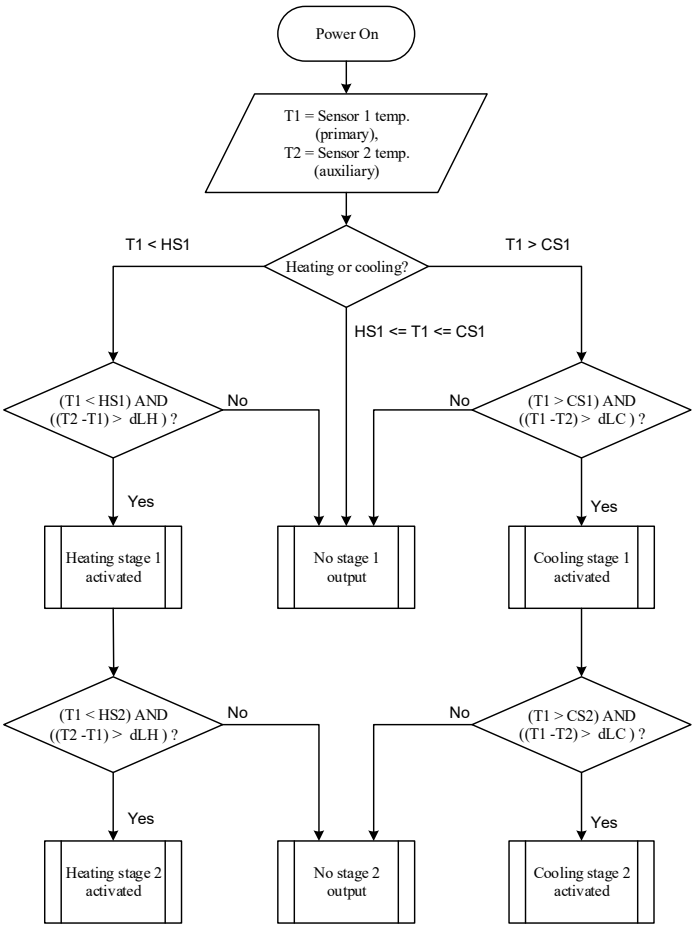


Figure 4. The operating logic of TD340.

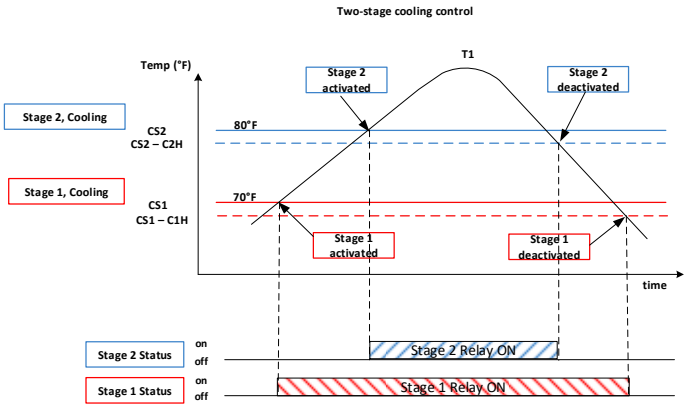


Figure 5(a). Relay output during two-stage cooling control.

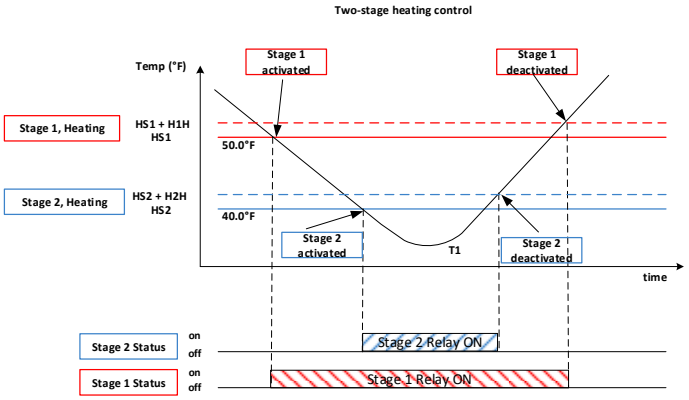


Figure 5(b). Relay output during two-stage heating control.

6.2 Two-Stage Control

Here are a few notes on the 2-stage heating or cooling:

1) Stage 1 must turn on first. Stage 2 can only be turned on after stage 1 has been activated for a period of time decide by **tBS** parameter.
2) Stage 2 must turn off first. Stage 1 can only be turned off after stage 2 has been deactivated for a period of time decided by **tBS** parameter.

The two diagrams in Figure 5 are examples to illustrate how the two-stage control are used in cooling (Figure 5(a)) and in heating (Figure 5(b) situations.

For example, in a two-stage cooling application, we want to open a shutter to allow natural ventilation if the room temperature is higher than 70°F; and want to turn on a ventilation fan if the room temperature is above 80°F. The diagram in Figure 5(a) shows when the Stage 1 cooling will begin and when the Stage 2 cooling will begin.

Similarly, in a two-stage heating application, we may want to turn on a small circulation pump if an object is colder than 50°F; and want to turn on a small heater to heat the circulation water if the object is colder than 40°F. The diagram in Figure 5(b) shows when the Stage 1 and Stage 2 heating will begin.

6.3 Configure the Output Relays

The TD340 gives the user to configure each of the output socket with a great flexibility. A relay output socket can be used for Stage 1 heating, Stage 2 heating, Stage 1 cooling, Stage 2 cooling, Stage 1 heating & cooling, Stage 2 heating & cooling, or nothing at all. This configuration is done by setting the parameter **rLA** and **rLB**. Please see Section "7. Parameter Settings" and Note 10 for details.

7. Parameters Settings

Please see a list of a system parameters in Table 1. See the notes below for detailed explanations.

Table 1. Parameters.

Code		Description	Range	Initial Value	Note
Short-press the SET key					
CS1	CS1	Cooling setpoint, stage 1	-58°F ~ 248°F, -50°C ~ 125°C	74.0	1, 5
CS2	CS2	Cooling setpoint, stage 2	CS1 ~ 248°F, CS1 ~ 125°C	76.0	1, 5

HS1	HS1	Heating setpoint, stage 1	-58°F ~ 248°F, -50°C ~ 125°C	65.0	2, 5
HS2	HS2	Heating setpoint, stage 2	-58°F ~ HS1, -50°C ~ HS1	63.0	2, 5
Long-press the SET key					
AH	AH	High temperature alarm	-58°F ~ 248°F, -50°C ~ 125°C	95.0	3
AL	AL	Low temperature alarm	-58°F ~ AH, -50°C ~ AH	45.0	3
AHy	AHY	Alarm hysteresis band	0.0°F ~ 90.0°F, 0.0°C ~ 50.0°C	1.0	3
dLC	dLC	Deviation limit for cooling	0.0°F ~ 180°F, 0.0°C ~ 99.9°C	3.0	4
dLH	dLH	Deviation limit for heating	0.0°F ~ 180°F, 0.0°C ~ 99.9°C	3.0	4
C1H	C1H	Hysteresis for stage 1 cooling	0.0°F ~ 90.0°F, 0.0°C ~ 50.0°C	1.0	5,1
C2H	C2H	Hysteresis for stage 2 cooling	0.0°F ~ 90.0°F, 0.0°C ~ 50.0°C	1.0	5,1
H1H	H1H	Hysteresis for stage 1 heating	0.0°F ~ 90.0°F, 0.0°C ~ 50.0°C	1.0	5, 2
H2H	H2H	Hysteresis for stage 2 heating	0.0°F ~ 90.0°F, 0.0°C ~ 50.0°C	1.0	5, 2
tBS	tbS	Time between stages	0 ~ 60 min	1 min	6
AS	AS	Anti-short for cooling	0 ~ 12 min	3 min	7
SFA	SFA	Sensor failure mode	0-0, 0-1, 1-0	0-0	8
PB1	Pb1	Sensor 1 offset	-90°F ~ +90.0°F, -50°C ~ +50.0°C	0.0	9
PB2	Pb2	Sensor 2 offset	-90°F ~ +90.0°F, -50°C ~ +50.0°C	0.0	9
rLA	rLA	Relay A (left) configuration	C1, C2, H1, H2, A1, A2, OFF	A1	10
rLB	rLb	Relay B (right) configuration	C1, C2, H1, H2, A1, A2, OFF	A2	10
C-F	C-F	C or F	C, F	F	11
RST	rSt	Factory reset	N, Y	N	12

Note 1. CS1 is the setpoint for Stage 1 cooling; **CS2** is the setpoint for Stage 2 cooling. **CS2** must always be higher than **CS1**.

The Stage 1 cooling process starts when T1 (the Sensor 1 temperature) is higher than (**CS1** + **C1H**), where **C1H** is the hysteresis band for stage 1 cooling, and it ends when T1 is lower than the **CS1**. Similarly, the stage 2 cooling process starts when T1 (the Sensor 1 temperature) is higher than (**CS2** + **C2H**), where **C2H** is the hysteresis band for stage 2 cooling, and it ends when T1 is lower than the **CS2**.

The stage 2 cooling can only start after the stage 1 cooling has been activated for a time duration defined by parameter **tBS**. The stage 1 cooling can only end when the stage 2 cooling has been ended for a time duration defined by parameter **tBS**.

Note 2. HS1 is the setpoint for Stage 1 heating; **HS2** is the setpoint for Stage 2 heating. **HS2** must always be lower than **CS1**.

The Stage 1 heating process starts when T1 (the Sensor 1 temperature) is lower than (**HS1** - **H1H**), where **H1H** is the hysteresis band for stage 1 heating, and it ends when T1 is higher than the **HS1**. Similarly, the Stage 2 heating process starts when T1 (the Sensor 1 temperature) is lower than (**HS2** - **H2H**), where **H2H** is the hysteresis band for Stage 1 heating, and it ends when T1 is higher than the **HS2**.

Heating setpoints (**HS1** and **HS2**) do not necessarily need to be lower than cooling setpoints (**CS1** and **CS2**) because the parameters **dLC** and **dLH** implement additional logic condition for heating or cooling.

Note 3. AH is the high temperature alarm, **AL** is the low temperature alarm, and **AHY** is the alarm hysteresis. When the Sensor 1 temperature (T1) is higher than **AH**, the alarm is activated and internal buzzer will go off; and when the temperature drops below (**AH** – **AHY**) the alarm will be turned off. Similarly, when T1 is lower than **AL**, the alarm will be activated and the buzzer will go off; when T1 rise above (**AL** + **AHY**), the alarm will be deactivated and the buzzer will stop. Sensor 2 temperature (T2) will NOT trigger the alarm.

When the alarm is triggered, the display window will flash between the measured temperature and the alarm type (**AH** or **AL**). To mute the buzzer, press the UP key momentarily. If the T1 re-enters the alarm zone, the alarm buzzer will go off again. The alarm can be disabled by setting **AH** = **AL**.

The AL value must be less and equal to AH. The **AH** value can be set to any value between -58 ºF ~ 248ºF (-50ºC ~ 125ºC). If AH is set to a value lower than the current AL value, controller will automatically set **AL** = **AH**. For example, on a controller, **AH** = 95.0ºF, **AL** = 32.0ºF. Now user can only change **AL** to a value between -58 and 95.0. But for **AH**, user can set it to any value between -58 and 248. If user sets it to 25.0, **AL** will be changed to 25.0 automatically.

Note 4. When external air or water is employed as a means to cool or heat the target, user can use the temperature difference between Sensor1 and Sensor2 as an additional condition for cooling or heating. Two parameters, the Deviation Limit for Cooling (**dLC**) and the Deviation Limit for Heating (**dLH**) are made available for this purpose. For example, when the user wants to blow cool air from outside to an attic to control the attic, but don't want to waste electricity if the outside temperature (T2, read by Sensor2) is not lower than the inside temperature (T1, read by Sensor1) by 3 degrees, the user can set **dLC** = 3.

The **dLC** is defined as (T1 -T2), where T1 is the temperature of Sensor1, T2 is the temperature of Sensor2. It only applies to cooling mode, and it is valid only when **dLC** value is greater than or equal to zero. Unless the T2 is lower than T1 and the difference is greater than **dLC**, the controller won't supply power to the socket that is assigned for cooling.

The **dLH** is defined as (T2 - T1). It only applies to heating mode, and it is valid only when **dLH** value is greater than or equal to zero. Unless the T2 is higher than T1 and the difference is greater than **dLH**, the controller won't supply power to the socket that is assigned for heating. For example, set **dLH** = 5 means that the minimum temperature difference for heating output to be turned on is T2 (Sensor2) is 5 degrees higher than T1 (Sensor1).

Both **dLC** and **dLH** are non-negative numbers in the range between 0.0 and 90.0°F (50.0°C). Default values of **dLC** and **dLH** are 3.0.

Note 5. **C1H**, **C2H**, **H1H**, and **H2H** are the hysteresis bands for different cooling and heating stages. Small hysteresis band gives tight temperature control. Large hysteresis band reduces the frequency of a device being cycled

on and off, which will extend the life of the mechanical relay and/or the compressor if the cooling device was a refrigerator.

Note 6. tBS is Time Between Stages, which set up a minimum time interval between activating or deactivating stage 1 and stage 2. Once the stage 1 is activated, the controller will wait for a time period set by **tBS** before stage 2 can be activated even if the stage 2 condition is met. When the stage 2 is deactivated, the controller will wait for a time period set by **tBS** before stage 1 can be deactivated even if the condition is met. By default, the **tBS** is set to 2 min.

Note 7. The Cooling Anti-Short, **AS**, is the delay time (the unit is minute) to activate a cooling stage again. When the controller is used to control a compressor, it should not switch the compressor on/off too frequently. Activating the compressor when it is still at high pressure (just after it was turned off) may shorten the life of a compressor. The Anti-Short cycle delay function should be used to prevent the rapid cycling of the compressor. It imposes a minimum time interval during which the Normally Open (N.O.) contacts which controls the cooling channel should remain open. The delay overrides any load demand on the cooling channel. It does not allow the N.O. contacts to close until the delay time has elapsed. This delay allows the pressure inside the compressor to release through its evaporator. The Cooling Anti-Short (**AS**) is typically set to 4 ~ 6 minutes. By default, **AS** is set to 3 minutes. This **AS** parameter only applies to the cooling mode, and it doesn't regulate the timer interval between stage 1 and stage 2.

Note 8. The **SFA** defines whether the controller should be sending power to its loads when any of the temperature sensor fails. It can be set to 0-0, 0-1, 1-0, 1-1. Please refer to Table 2 for details.

Table 2. Output of the controller when sensor fails.

SFA	Controller output when sensor fails
0-0	Left socket off, right socket off
1-0	Left socket on, right socket off
0-1	Left socket off, right socket on
1-1	Left socket on, right socket on

Note 9. PB1 and **PB2** are sensor input offset for Sensor1 and Sensor2 respectively. These parameters are used to set an input offset on sensor readings to compensate the deviation of readings from true temperatures. For example, if the Sensor1 reads 37ºF when the actual temperature is 36ºF, the user can set the parameter **PB1** = -1 to correct the displayed temperature reading to 36ºF.

Note 10. rLA and **rLB** are the relay configurations of Relay A and Relay B respectively. Relay A is the relay on the left side of the controller, originally labelled as Cooling output, and Relay B is the relay on the right side of the controller, originally labelled as Heating output.

The user can use these two parameters to configure on what mode or what stage should the relays energize. Please see Table 3 below for available settings.

Table 3. Relay configuration setting.

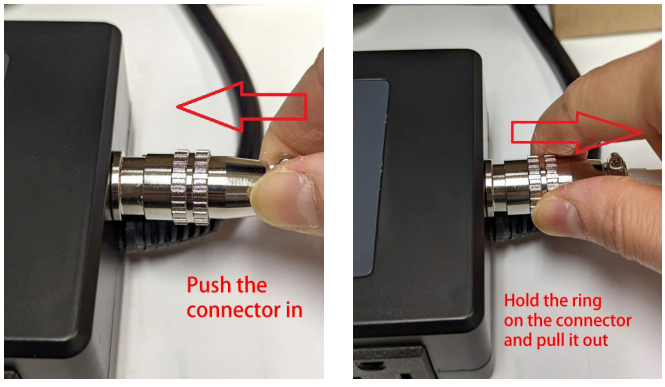
rLA or rLB Value	Symbol	Description
C1	C 1	Cooling, stage 1
C2	C 2	Cooling, stage 2
H1	H 1	Heating, stage 1
H2	H2	Heating, stage 2
A1	A 1	All stage 1 (heating and cooling)
A2	A2	All stage 2 (heating and cooling)
Off	oFF	Disabled, no output

8. Connect a Sensor to the Controller

A pair of sensor connectors has a key on the male connector and the notch on the female connector to help align the connectors. The female connector also has a spring lock mechanism that helps to prevent accidental disconnections.

(a) (b)

Figure 6. (a) The key on the male connector on the controller. (b)The notch on the female connector on the sensor cable.



(a) (b)

Figure 7. (a) To plug in the sensor connector, push from the connector behind the ring. (b) To unplug a sensor connector, hold the ring on the connector and pull it out.

To install the sensor to the controller: 1) identify the key on the male connector (Figure 6(a)) and the notch on the female connector (Figure 6(b)); 2) hold the tail of the female connector, align the notch and the key, and push the female

connector forward (Figure 7(a)). To remove the connector, hold the spring-loaded collar on the female connector and pull it back. Please see Figure 7(b).

9. Application Example

9.1 Use TD340 for room ventilation and temperature control.
A room may get hotter than the rest of the rooms in a home at certain time point during a day while the outside air temperature is relatively cool. In this situation, we want to use the cool air outside to help ventilate the air and regulate the room temperature. We want to open up the window to let the cool air in when the room temperature is higher than 74°F. And if the room temperature gets higher then 76°F, we want to be more aggressive and blow the cool air from outside to the room. However, if there outside air temperature is not cooler by 3°F, there won't be much cooling effect.

So, here is the set up:
Place the Sensor 1 in the room, and place the Sensor 2 outside.

Here are the related parameter settings:
CS1 = 74°F, the stage 1 cooling setpoint.
CS2 = 76°F, the stage 2 cooling setpoint.
dLC = 3°F. This means both the stage 1 and stage 2 cooling can be activated only when the Sensor 2 reading is 3°F lower than the Sensor 1 reading.

(END)

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