TRANE®

Setup and Operation

Tracer™ AH540/541 Version 2 Air-Handler Controller

CNT-SVX05B-EN

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April 2004

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Printed in the U.S.A.

NOTICE:

Warnings and Cautions appear at appropriate sections throughout this manual. Read these carefully:

⚠WARNING
Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury.

⚠CAUTION
Indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

CAUTION
Indicates a situation that may result in equipment damage or property damage.

The following format and symbol conventions appear at appropriate sections throughout this manual:

IMPORTANT
Alerts installer, servicer, or operator to potential actions that could cause the product or system to operate improperly but will not likely result in potential for damage.

Note:
A note may be used to make the reader aware of useful information, to clarify a point, or to describe options or alternatives.

◆ This symbol precedes a procedure that consists of only a single step.

Contents

Chapter 1

Overview and specifications

The Tracer™ AH540 and the Tracer AH541 air-handler controllers provide digital control for a variety of constant-volume and variable-air-volume (VAV) air-handling units that conform to the LonMark® Space Comfort Controller (SCC) profile or the Discharge Air Controller (DAC) profile. The Tracer AH541 is available in several models for field installation (BAS-PRC013-EN describes them). The Tracer AH540 controller is available installed, pre-wired, and tested with the following Trane air-handling units:

- Packaged Climate Changer™ air-handling unit
- M-Series Climate Changer air-handling unit
- T-Series Climate Changer air-handling unit

The functionality of the factory-installed Tracer AH540 controller is identical to that of the field-installed Tracer AH541 controller. This document refers to both versions of the controller as “the Tracer AH540/541” or “the controller” unless a distinction needs to be made between the two.

Note:
This manual applies to Version 2 of the Tracer AH540/541 controller. Both hardware and functional differences exist between Version 1 and Version 2. Version 2 hardware has four additional binary outputs and a universal analog input. These hardware additions support Version 2 functions, which include all of those inVersion 1 plus DX cooling, electric heat, dehumidification, and two-pipe changeover.

Configuration options

Air-handling unit configurations supported by the Tracer AH540/541 are shown in Table 1 on page 2. Functionality options are shown in Table 2 on page 2.

Table 1. Tracer AH540/541 air-handling unit configuration options[1]

Unit configuration	Options		
	Preheat	Cool	Reheat
Heating only	• Steam coil • Hydronic heats coil • Electric heat • Face-and-bypass hydronic heat-ing		
Cooling only	• Hydronic cooling • DX cooling		
Heating and cooling	• Steam coil • Hydronic heat coil • Electric heat • Face-and-bypass hydronic heat		
Cooling and heating	—	• Hydronic cooling • DX cooling	• Steam coil • Hydronic heat coil • Electric heat
Two-pipe changeover		• Heat/cool changeover	
		• Heat/cool changeover	• Electric heat
	• Electric heat	• Heat/cool changeover	
	• Face-and-bypass heat	• Heat/cool changeover	
	• Face-and-bypass heat	• Heat/cool changeover	• Electric heat

1 Not all configuration options will be available on all air-handling units.

Table 2. Tracer AH540/541 controller functions

Function	Space temperature control	Discharge air temperature control
Fan control	On/Off	Variable or On/Off
Duct static pressure control		X
Hydronic cooling	X	X
Hydronic heating	X	X
Steam heat	X	X
Face bypass heating	X	X
Ventilation control	X	X
Economizer damper	X	X
Warm-up functions	X	X
Mixed-air temperature control	X	X
Exhaust fan (on/off)	X	X
DX cooling	X	X
Electric heat	X	X
Dehumidification	X	
Two-pipe changeover	X	

Communication with other controllers

Tracer AH540/541 controllers operates either in stand-alone mode or as part of a building automation system. In either mode of operation, multiple controllers can be bound (bindings are configured using the Rover service tool) to other LonTalk®-based controllers so they can communicate data to one another. Controllers that are bound as peers can share the following data:

- Setpoint
- Zone temperature
- Zone relative humidity
- Outdoor air temperature
- Occupancy mode
- Heating/cooling mode
- Fan status
- Unit capacity control

Applications having more than one unit serving a single space can benefit by using this feature; it allows multiple units to share a single space temperature sensor and prevents multiple units from simultaneously heating and cooling. For more information, see “AH540/541 network variables” on page 109.

Controller circuit boards

The main controller board is the same for both Tracer AH540 and Tracer AH541 (see Figure 1), but the termination boards are different (see Figure 2 on page 5 for Tracer AH540 and Figure 3 on page 6 for Tracer AH541).

Figure 1. Tracer AH540/541 main controller board

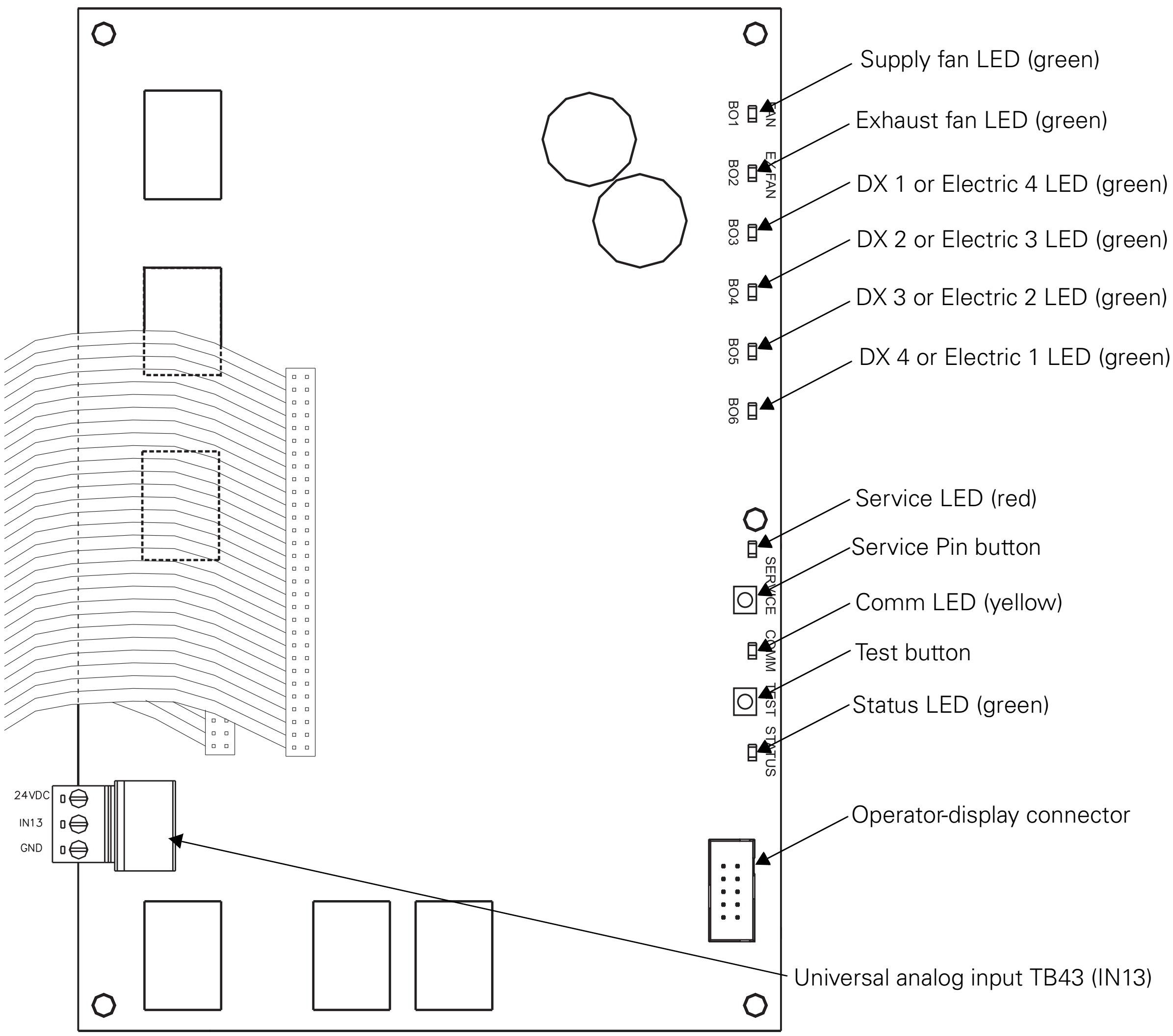


Figure 2. Tracer AH540 termination board

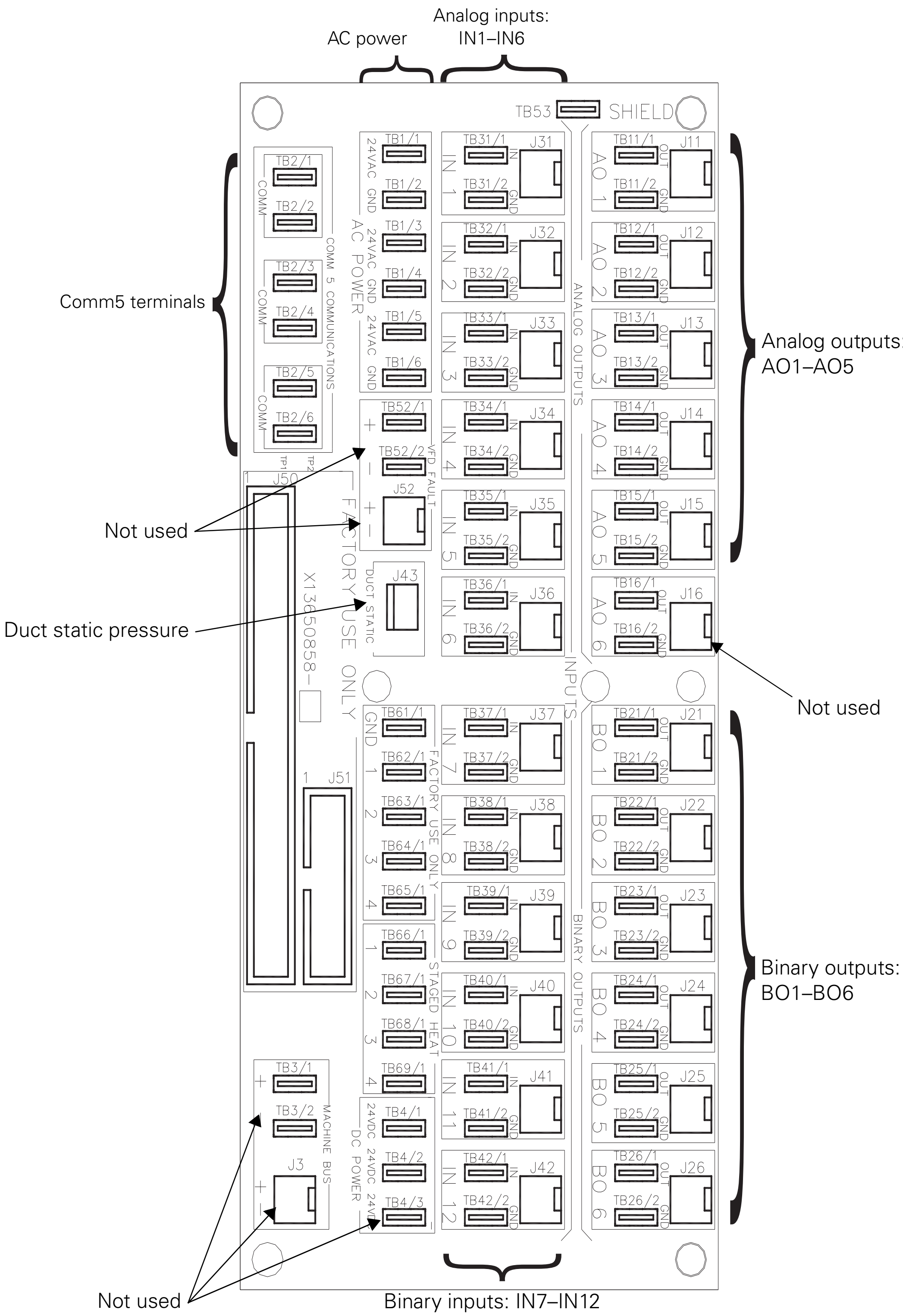
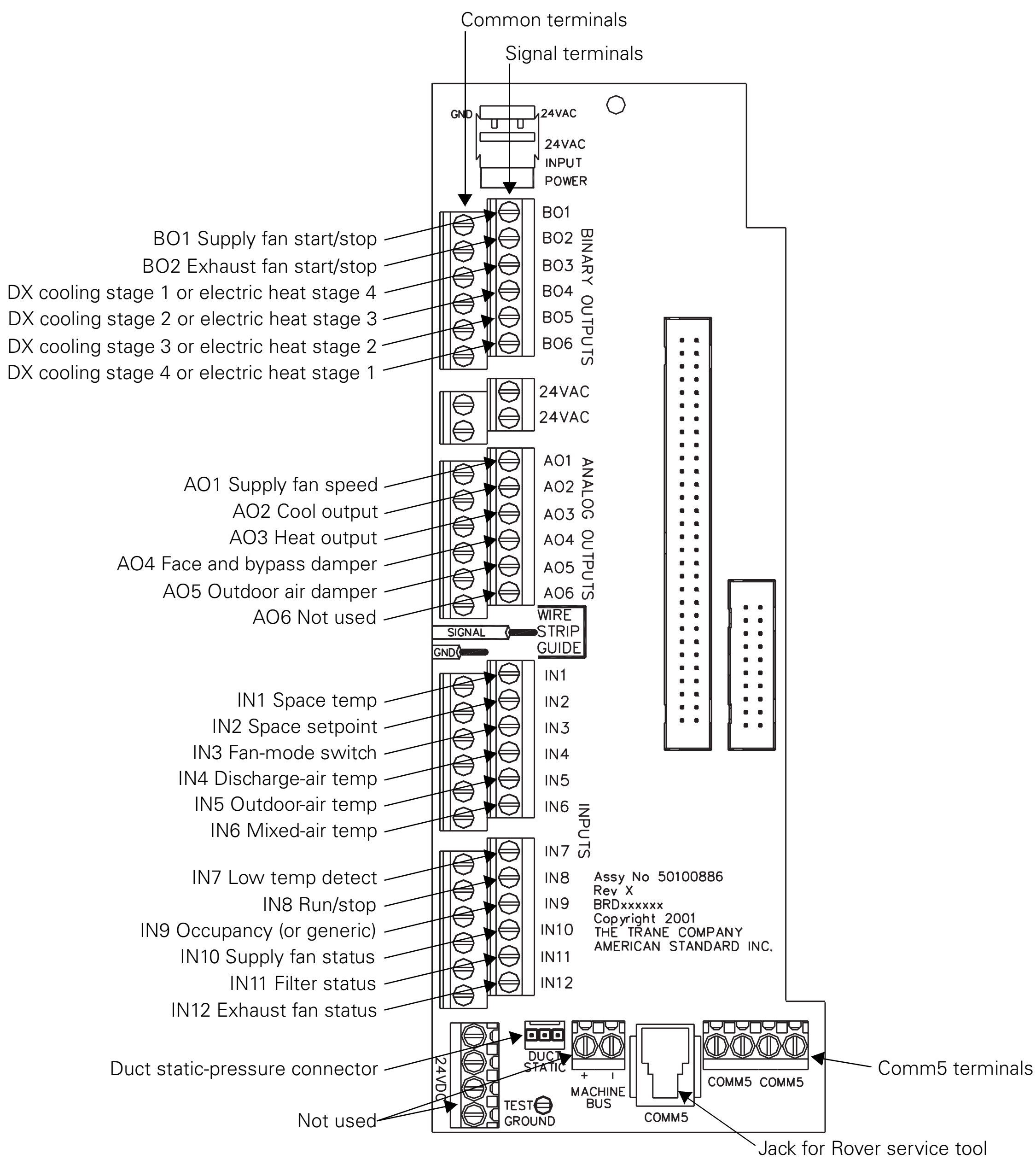


Figure 3. Tracer AH541 termination board



Specifications

Dimensions

Controller board

- Height: 5½ in. × 8 in. × 2 in.
- (140 mm × 203 mm × 51 mm)

Termination boards

- Tracer AH540: 3½ in. × 8 in. × 1 in. (89 mm × 203 × 51 mm)
- Tracer AH541, frame-mounted: 10¼ in. × 8 in. × 3½ in. (260 mm × 203 mm × 89 mm)
- Tracer AH541 NEMA-1 enclosure: 16½ in. × 14¾ in. × 5½ in. (418 mm × 373 mm × 140 m)

Operating environment

- -40° to 70°C (-40° to 158°F)
- 5% to 95% relative humidity non-condensing

Storage environment

- -40° to 85°C (-40° to 185°F)
- 5% to 95% relative humidity non-condensing

Agency conformance

UL

- UL unlisted component
- UL 873 Temperature Indicating and Regulating Equipment
- CUL C22.2 No. 24-93 Temperature Indicating and Regulating Equipment

CE

• Conducted Emissions	EN 55022 Class A EN 55022 Class B EN 61000-3-2 EN 61000-3-3
• Radiated Emissions	EN 55022 Class B
• Immunity	EN 50082-2 Industrial

FCC

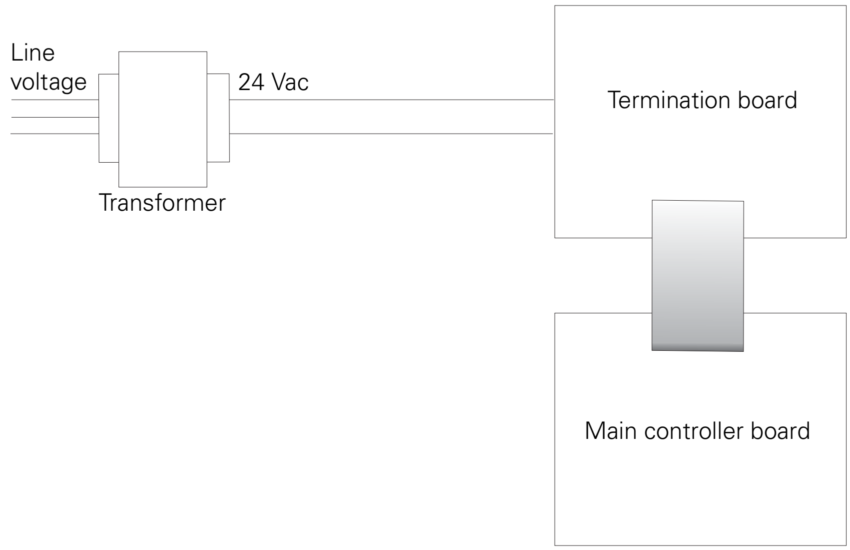
- CFR 47, Part 15, Subpart A, Class A
- CFR 47, Part 15, Subpart A, Class B

Power requirements

(see Figure 8 on page 16)

- Low-voltage, class 2, non-safety device
- 18 to 32 V ac (24 Vac nominal)
- Maximum VA = 21 VA (control board)
- 50 or 60 Hz

Figure 4. Power requirements



Chapter 2

Operator display

This chapter shows how to:

- Install a Tracer AH540/541 stand-alone operator display
- Connect a portable operator display to a Tracer AH540/541 controller
- Set up the operator display

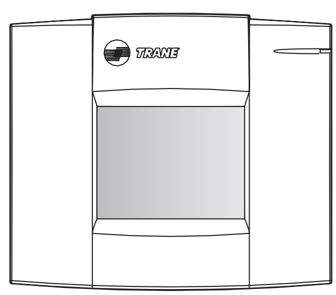
Installing the stand-alone operator display

With the attached cable, the stand-alone operator display (see Figure 5) can be mounted up to 10 ft (3 m) from the Tracer AH541 controller. You can extend this distance up to 150 ft (46 m) using four-conductor wire and the included pig-tail connectors. Alternately, use three twisted-pair wires.

Trane recommends the following four-conductor wires:

- Plenum 18 AWG, Trane part number 400-2059
- Plenum 22 AWG, Trane part number 400-2020
- Non-plenum, Trane part number 400-1005

Figure 5. Tracer AH541 stand-alone operator display



CAUTION

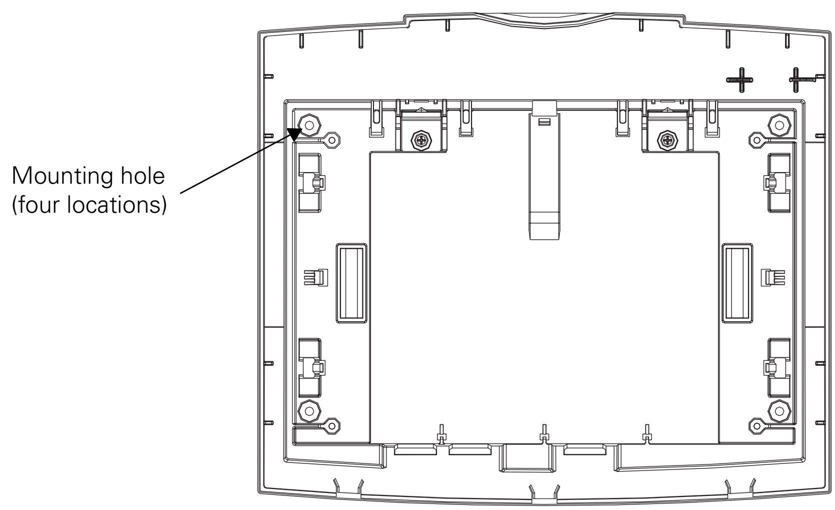
Avoid Equipment Damage!

To clean the operator display, use a cloth dampened with commercial liquid glass cleaner. Spraying water or cleansers directly on the screen may result in equipment damage.

To install the stand-alone operator display:

1. Unsnap the gray plastic backing from the operator display.
2. Carefully disconnect the operator-display cable from the connector inside the operator display.
3. Use the plastic backing as a template to mark the position of the four mounting holes on the mounting surface (see Figure 6 on page 10).

Figure 6. Stand-alone operator-display mounting holes

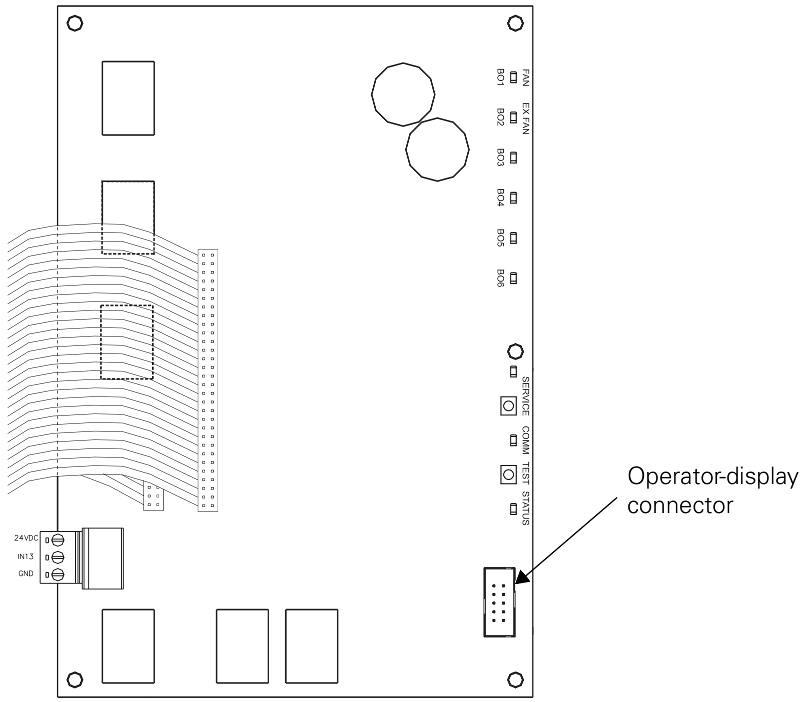


4. Set the plastic backing aside and drill holes for #8 (4 mm) screws or #8 wall anchors.
5. Secure the plastic backing to the wall with #8 (4 mm) mounting screws (not supplied).
6. Connect the operator-display cable to the operator display, then snap the operator display to the plastic backing.

   The operator-display cable is keyed to the connector. If you have difficulty connecting it, make sure the key is lined up with the slot.
7. Run the operator-display cable to the Tracer AH541, affixing it to the wall with wiring staples or wire mold. Do not run operator-display cable in the same wire bundle with high-voltage power wires. Running input/output wires with 24 Vac power wires is acceptable.
8. Feed the cable into the Tracer AH541 enclosure.
9. Attach the operator-display cable to the operator-display connector on the circuit board (see Figure 7 on page 11).

   The operator display receives power from the Tracer AH541 and turns on automatically when it is connected to the controller.

Figure 7. Operator-display connector on the Tracer AH541



Connecting the portable operator display

The portable operator display is designed for temporary connections to Tracer AH541 controllers. It can be hot-swapped.

CAUTION

Avoid Equipment Damage!

To clean the operator display, use a cloth dampened with commercial liquid glass cleaner. Spraying water or cleansers directly on the screen may result in equipment damage.

IMPORTANT

The portable operator display is not used for time clock scheduling. To provide scheduling, you must use a permanently-connected door-mounted operator display, stand-alone operator display, or Tracer Summit system.

To connect the portable operator display:

1. Open the Tracer AH541 enclosure door.
2. Attach the operator-display cable to the operator-display connector on the circuit board (see Figure 7 on page 11).

   The operator display receives power from the Tracer AH541 and turns on automatically when it is connected to the controller. The operator display is hot-swappable, so there is no need to power down the controller.

Setting up the operator display

The home screen is the starting point for navigating through the screens of the operator display. The home screen is displayed when the unit is idle. The screen contains the following information from top to bottom:

- Time and date
- The controller location label: When no location is specified and the controller is a Tracer AH540, “Tracer AH540” is displayed. When no location is specified and the controller is a Tracer AH541, “Warning: Unit Config Required” is displayed.
- Operating parameters of the controller
- Push buttons: Touch one of the five buttons—View, Alarm, Schedule, Override, or Setup—to access the desired set of screens.

Note:
The schedule button does not appear on the Home screen when a portable operator display is connected to the controller because the portable operator display does not have a time clock and therefore cannot be used to set up schedules.

Setting up time and date

To change the time for the operator display:

1. On the home screen, press the Setup button. The Setup menu appears.
2. Press the down arrow button to go to Page 2 of 2.
3. Press the Change Time button to view the next screen.
4. Using the buttons, type the time using the format hh:mm, where *hh* is the hour and *mm* is the minute. Press either the AM or PM button, as appropriate.
5. To correct an error, press clear and start again. To accept the changes, press the OK button.

To change the date for the operator display:

1. On the home screen, press the Setup button. The Setup menu appears.

2. Press the down arrow button to go to page 2 of 2.
3. Press the Change Date button to view the next screen.
4. Press the forward and back arrows to move the cursor from day to month to year. Use the buttons to type the appropriate date.
5. To correct an error, press the reset button. To accept the changes, press the OK button.

Calibrating the operator display

To calibrate the operator display:

1. On the home screen, press the Setup button. The Setup menu appears.
2. Press the page down button to go to Page 2 of 2.
3. Press the Display Setup button. The Display Setup menu appears.
4. Press the Calibrate Touch Screen button. A screen with a target appears.

CAUTION
Avoid Equipment Damage!

Do not allow the operator display to come in contact with sharp objects.

5. Touch the target using a small, pliable, blunt object, such as a pencil eraser. Hold until the beeping stops. A second calibration screen appears.
6. Again, touch the target with the object. Hold until the beeping stops. The Setup menu appears.
7. Press the Home button. The home screen appears.

Adjusting brightness and contrast

To adjust the brightness and contrast of the operator display:

1. On the home screen, press the Setup button. The Setup menu appears.
2. Press the page down button to go to Page 2 of 2.
3. Press the Display Setup button. The Display Setup menu appears.
4. Press the Adjust Brightness and Contrast button. The Brightness and Contrast screen appears.
5. To increase the brightness, press the buttons along the top row, in sequence, from left to right. To decrease the brightness, press the buttons from right to left.

6. To increase the contrast, press the buttons along the bottom row, in sequence, from left to right. To decrease the contrast, press the buttons from right to left.
7. Press the Home button. The home screen appears.

Setting up, changing, or disabling the security password

To set up or change a security password or to disable its use:

> **Note:**
> If security is enabled, the logon screen will display whenever you try to change a value that is security protected. To log on, type the password using the numeric type pad. You will remain logged on while you continue to work. After 20 minutes, the system will log you off.

1. On the home screen, press the Setup button. The Setup menu appears.
2. Press the page down button to go to page 2 of 2.
3. Press the Display Setup button. The Display Setup menu appears.
4. Press the page down button to go to page 2 of 2.
5. Press the Setup Security Password button. The Setup Security Password screen appears.
6. To set up or change the password, use the number keys to enter 4 to 8 numbers. Press OK. Security is enabled.

> **Note:**
> If a password was previously set up, a Disable Security button appears on the Setup Security Password screen. Press the Disable Security button to disable security.

Chapter 3

Input and Outputs

This chapter provides information about the function of inputs and outputs of the Tracer AH540/541 controller. The Tracer AH540 is configured at the factory per unit configuration and order information. The field-installed Tracer AH541 must be configured using a Rover service tool (refer to the *Rover Operation and Programming* guide, EMTX-SVX01E-EN, for more information).

Binary outputs

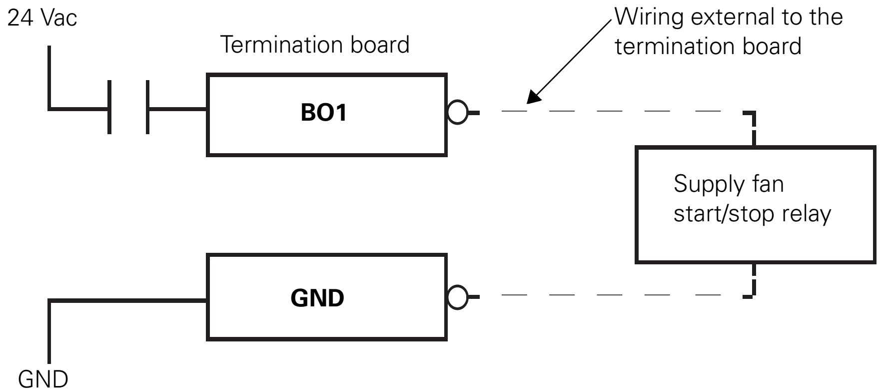
The Tracer AH540/541 controller has six binary outputs that are assigned to the specific functions shown in Table 3.

Table 3. Binary output functions and locations

AH540			AH541	Function	Power function	Maximum output rating
Output label	Terminal label	Factory terminal label	Field terminal label			
BO1	TB21/1 OUT TB21/2 GND	J21	BO1	Supply fan start/stop	24 Vac ground	12 VA
BO2	TB22/1 OUT TB22/2 GND	J22	BO2	Exhaust fan start/stop	24 Vac ground	12 VA
BO3	TB23/1 OUT TB23;2 GND	J23	BO3	DX stage 1 or electric stage 4	24 Vac ground	12 VA
BO4	TB24/1 OUT TB24/2 GND	J24	BO4	DX stage 2 or electric stage 3	24 Vac ground	12 VA
BO5	TB25/1 OUT TB25/2 GND	J25	BO5	DX stage 3 or electric stage 2	24 Vac ground	12 VA
BO6	TB26/1 OUT TB26/2 GND	J26	BO6	DX stage 4 or electric stage 1	24 Vac ground	12 VA

The binary outputs are normally-open, form A relays. The relays act as a switch by either completing or breaking the circuit between the load (the end device) and the 24 Vac power. For example, when binary input BO1 is energized, 24 Vac is supplied to terminal BO1, which in turn energizes the supply fan start/stop relay (see Figure 8 on page 16).

Figure 8. Binary output wiring schematic



Each binary output has a green status LED on the Tracer AH540/541 controller board (see Figure 1 on page 4). The LED is off when the relay contacts are open. The LED is on when the relay contacts are closed.

When the binary output relay is Off (contact is open), a multimeter should measure 0 Vac across the output terminals. When the binary output relay is On (contacts are closed), a multimeter should measure 24 Vac across the output terminals.

Analog outputs

The Tracer AH540/541 controller has five analog outputs that are assigned to the specific functions shown in Table 4

Table 4. Analog output functions and locations

AH540				AH541	Function	Output range default value[1]	Maximum output rating
Output label	Terminal label		Factory terminal label	Field terminal label			
AO1	TB11/1 TB11/2	OUT GND	J11	AO1	Supply fan speed	0 to 10 Vdc ground	20 mA
AO2	TB12/1 TB12/2	OUT GND	J12	AO2	Cool valve output or two-pipe changeover	2 to 10 Vdc ground	20 mA
AO3	TB13/1 TB13/2	OUT GND	J13	AO3	Heat output (water, steam, or electric heat sequencer)	2 to 10 Vdc ground	20 mA
AO4	TB14/1 TB14/2	OUT GND	J14	AO4	Face-and-bypass damper	2 to 10 Vdc ground	20 mA
AO5	TB15/1 TB15/2	OUT GND	J15	AO5	Outdoor air damper	2 to 10 Vdc ground	20 mA
AO6	TB16/1 TB16/2		J16	AO6	Not used	—	—

1 Each analog output can be configured for 0–10 Vdc or 2–10 Vdc operation, and normally open or normally closed.

Analog inputs

The Tracer AH540/541 controller has eight analog inputs. Table 5 describes the function of each of the analog inputs. Each function is described in the following paragraphs. For an explanation of the diagnostics generated by each input, see Chapter 6, “Verifying operation and communication.” For more information about how the controller operates, see Chapter 4, “Sequence of operation.”

Table 5. Analog input functions and locations

AH540			AH541	Function	Sensor type[1]	Valid ranges
Input label	Terminal label	Factory terminal label	Field terminal label			
IN 1	TB31/1 IN TB31/2 GND	J31	IN1	Space temperature	10 kΩ thermistor	5°F to 122°F (-15°C to 50°C)
IN 2	TB32/1 IN TB32/2 GND	J32	IN2	Local setpoint	1 kΩ potentiometer	50°F to 85°F (10°C to 29.4°C)
IN 3	TB33/1 IN TB33/2 GND	J33	IN3	Fan mode switch[2]	Switched resistance	Off (4870 Ω ±5%) Auto (2320 Ω ±5%)
IN 4	TB34/1 IN TB34/2 GND	J34	IN4	Discharge air temperature	10 kΩ thermistor	–40°F to 212°F (-40°C to 100°C)
IN 5	TB35/1 IN TB35/2 GND	J35	IN5	Outdoor air temperature	10 kΩ thermistor	-40°F to 212°F (-40°C to 100°C)
IN 6	TB36/1 IN TB36/2 GND	J36	IN6	Mixed-air temperature	RTD[3]	-40°F to 212°F (-40°C to 100°C)
IN 13[4]	TB43			Space relative humidity	Current: 4–20 mA	0 to 100%
				CO_2 sensor	Current: 4–20 mA	0 to 2000 ppm
				Entering water temperature	10 kΩ thermistor	-40°F to 212°F (-40°C to 100°C)
				Evaporator refrigerant temperature	10 kΩ thermistor	-40°F to 212°F (-40°C to 100°C)
				Generic temperature	10 kΩ thermistor	-40°F to 212°F (-40°C to 100°C)
Duct static		J43	Duct static	Duct static pressure	Duct static-pressure sensor (Trane part number 4020 1159)	0 to 1250 Pa 0 to 5.02 in. water

1 See Appendix for analog input sensor curves (Table 73, Table 74, Table 75, Table 76, and Table 77).
2 Sensor type: Switched resistance fan auto = 2320 Ω, ±5%, fan off = 4870 Ω, ±5%.
3 Sensor type RTD averaging sensor, 1000 Ω at 0°C, platinum 385 curve.
4 This input is located on the main control board.

IN1: Space temperature

Analog input IN1 measures space temperature only. The space temperature is measured with a 10 kΩ thermistor that is included with Trane zone sensors. The Tracer AH540/541 receives the space temperature from either a wired zone sensor or as a communicated value. A communicated value has precedence over a locally wired sensor input. Therefore, the communicated value, when present, is automatically used by the controller.

If a Tracer AH540/541 is operating in constant-volume space temperature control mode and the space temperature fails or does not receive a communicated value, the controller generates a Space Temperature Failure diagnostic.

The space temperature input may also be used to generate timed override On/Cancel requests to the controller. If a momentary short in the space temperature signal occurs, the Tracer AH540/541 interprets the signal as a timed override On request.

The Tracer AH540/541 uses the timed override On request (while the zone is in unoccupied mode) as a request to go to the occupied bypass mode (occupied bypass). The occupied bypass mode lasts for the duration of the occupied bypass time, typically 120 minutes. The occupied bypass time can be changed using the Rover service tool.

Press the Cancel button on the zone sensor to cancel the override request and return the controller to unoccupied mode. This creates a momentary fixed resistance (1.5 kΩ), which sends a Cancel request to the space temperature input.

Calibrating IN1

IN1 can be calibrated with the Rover service tool. Add the calibration value to the measured value to determine the effective value. For more information about calibrating this input, see Table 36 on page 76.

IN2: Local setpoint

Analog input IN2 functions as the local (hard-wired) temperature setpoint for applications using a Trane zone sensor with a temperature setpoint thumbwheel (see “Zone sensors” on page 28). The local setpoint input is configurable (as enabled or disabled) using the Rover service tool. A setpoint value communicated by means of a Comm5 link can also be used for controllers operating on a building automation system. If both hard-wired and communicated setpoint values are present, the controller uses the communicated value. If neither a hard-wired nor a communicated setpoint value is present, the controller uses the stored default setpoints (configurable using the Rover service tool). If a valid hard-wired or communicated setpoint value is established and then is no longer present, the controller generates a Setpoint Failure diagnostic.

Calibrating IN2

IN2 can be calibrated with the Rover service tool. Add the calibration value to the measured value to determine the effective value. For more information about calibrating this input, see Table 36 on page 76.

IN3: Fan mode switch

Analog input IN3 responds to specific resistances corresponding to a fan mode switch provided with certain Trane zone sensors. The fan mode switch on a Trane zone sensor generates the fan mode signal.

The Tracer AH540/541 controller detects the unique resistance corresponding to each position of the fan mode switch. By measuring this resistance, the controller determines the requested fan mode. See Table 6.

If the Tracer AH540/541 controller does not receive a hard-wired or communicated request for fan mode, the unit recognizes the fan input as Auto.

Table 6. Determining fan mode (IN3)

Fan modes	Tracer AH540/541 operation
Off	Fan Off (4870 Ω ±1%)
Auto	In occupied mode, the fan runs. In unoccupied mode, the fan cycles off when no heating or cooling is required (2320 Ω ±5%)

IN4: Discharge air temperature

The Tracer AH540/541 controller cannot operate if the controller does not sense a valid discharge air temperature input. If the sensor returns to a valid input, the controller automatically allows the unit to resume operation.

The Tracer AH540/541 controller uses analog input IN4 as the discharge air temperature input with a 10 kΩ thermistor only. This sensor is hard-wired and located downstream from all unit heating/cooling capacity at the unit discharge area. The discharge air temperature is used as a control input to the controller which is used for control modes of operation: space temperature control and discharge air temperature control.

Any time the discharge air temperature signal is not present, the controller generates a Discharge Air Temp Failure diagnostic and performs a unit shutdown. If the sensor returns to a valid input, the controller automatically clears the diagnostic and allows the unit to resume operation.

IN5: Outdoor air temperature

Analog input IN5 measures the outdoor air temperature. Analog input IN5 measures outdoor air temperature only. The outdoor air temperature is measured with a 10 kΩ thermistor.

The controller uses the IN5 value to determine if economizing (free cooling) is feasible. For economizing to be allowed, economizing must be enabled and the outdoor air temperature must be below the economizer enable point (default 60°F, configurable). If the outdoor air temperature is equal to or above the economizer enable point, or if there is no value is present, economizing is not allowed. If both hard-wired and communicated outdoor air temperature values are present, then the controller uses the communicated value.

If a valid hard-wired or communicated outdoor air temperature value is established and then is no longer present, the controller generates an Outdoor Air Temp Failure diagnostic and economizing is no longer enabled. If the sensor returns to a valid input, the controller automatically clears the diagnostic and allows economizer operation.

IN6: Mixed-air temperature

Analog input IN6 is used for mixed-air temperature, with an averaging 1000 Ω (at 32°F [0°C]) RTD sensor only (see Table 75 on page 107). The input is used for mixed-air tempering and outdoor air economizing operations.

The Tracer AH540/541 controller does not allow economizing if the controller does not sense a valid mixed-air temperature input. If the sensor returns to a valid input, the controller automatically checks to see if economizer operation is possible.

If a valid mixed-air temperature signal has been established by the RTD sensor, but then the value is no longer present, the controller generates a Mixed Air Temperature Failure diagnostic and disallows economizer operation. When the sensor returns to a valid input, the controller automatically clears the diagnostic and checks to see if economizer operation is possible.

IN13: Universal analog input

The universal analog input IN13 (TB43) can be configured for a variety of sensors using the Rover service tool (see “Configuration” on page 73). The input must be configured properly for the sensor wired to the input. The input can be used for only one sensor at a time. The following sensors are supported:

- Space relative humidity (4–20 mA)
- CO2 sensor (4–20 mA)
- Entering water temperature (10 kΩ thermistor)
- Evaporator refrigerant temperature (10 kΩ thermistor)
- Generic temperature (10 kΩ thermistor)

Relative humidity

When using the universal analog input with a relative humidity sensor first configure the controller input using the Rover service tool, and then make the wiring connections. The sensor must provide a 4–20 mA signal where 20 mA is equal to 100% relative humidity (see Table 76 on page 107).

A space relative humidity input is required for space dehumidification control. If valid space relative humidity input does not exist, space dehumidification control will be disabled. The controller will accept a valid hard-wired sensor input or a communicated value for space relative humidity. If both a hard-wired and a communicated value exist, the controller will use the communicated value for control. The communicated value has priority over the hard-wired input.

When a space relative humidity input is established (either hard-wired or communicated), the controller generates a Humidity Input Failure diagnostic if the signal is no longer valid, and disables space dehumidification. If the sensor or communicated value returns to a valid input, the controller automatically clears the diagnostic and allows space dehumidification operation.

CO_2 sensor

When using the universal analog input with a CO_2 sensor first configure the controller input using the Rover service tool for CO_2 and then make the wiring connections. The sensor must provide a 4–20 mA signal, where 20 mA is equal to 2000 ppm (see Table 77 on page 108).

The CO_2 input, reported in parts per million, is not used for any AH540/541 control purposes. Instead the input is reported to the building automation system using Comm5 or other devices as a data point. When a CO_2 sensor input is established, the controller generates a CO_2 Sensor Failure diagnostic if the signal is no longer valid, but the diagnostic has no effect on controller operation. If the sensor returns to a valid input, the controller automatically clears the diagnostic.

Entering water temperature

The universal analog input configured as entering water temperature accepts a 10 kΩ thermistor input (Table 74 on page 106). A valid entering water temperature value (hard-wired or communicated) is required for two-pipe changeover operation for space temperature control air-handling units with one hydronic coil. If both a hard-wired and a communicated value exist, the controller will use the communicated value for two-pipe changeover operation. The communicated value has priority over the hard-wired input.

When valid entering water temperature input is available to the controller it is used to determine if hot or cold water capacity is available for space heating and cooling operation. If the entering water temperature input is not valid, the controller assumes hot water exists and disables hydronic cooling operation.

When an entering water temperature input is established (either hard-wired or communicated), the controller generates an Entering Water Temp Failure diagnostic, if the signal is no longer valid, and assumes a cold entering water temperature. If the sensor or communicated value returns to a valid input, the controller automatically clears the diagnostic and allows two-pipe changeover operation.

Evaporator refrigerant temperature

The universal analog input configured as evaporator refrigerant temperature accepts a 10 kΩ thermistor input (see Table 74 on page 106). A valid evaporator refrigerant temperature is not required for DX cooling operation but does aid in protecting condensing unit compressors.

When a valid evaporator refrigerant temperature input is available to the controller, it is used to determine if the DX cooling capacity should be decreased to prevent low refrigerant temperatures. This function is referred to as defrost operation (see "Defrost operation" on page 65). Low refrigerant temperatures indicate frost conditions on the evaporator and therefore cooling capacity must be reduced to defrost the coil.

When the evaporator refrigerant temperature input is established, the controller generates an Evap Refrigerant Temp Failure diagnostic if the signal is no longer valid, but the diagnostic has no affect on controller operation. If the sensor returns to a valid input, the controller automatically clears the diagnostic.

Generic temperature input

The universal analog input configured as generic temperature accepts a 10 kΩ thermistor input. The input can be used in a variety of applications using Tracer Summit. This input has no effect on the controller operation but will report a Generic Temperature Failure diagnostic message if the input becomes invalid or out or range. The diagnostic automatically reset when the input is valid or in range.

J43: Duct static pressure

The duct static pressure input (terminal J43) interfaces with a specialized pressure transducer only. When a valid duct static pressure value (either hard-wired or communicated) exists and a variable-air-volume supply fan is present, the controller uses this value for duct static pressure control.

When a duct static pressure is established, the controller generates a Duct Static Press Failure diagnostic if the signal is no longer valid, and shuts down the unit. When the sensor returns to a valid input, the controller automatically clears the diagnostic and allows the unit to resume operation.

The Tracer AH540/541 controller, if configured for variable-air-volume control, cannot operate without a valid duct static pressure input. When the sensor returns to a valid input, the controller resumes unit operation. The controller is not required to have a duct static pressure input for constant-volume space temperature or constant-volume discharge air temperature control.

ON/CANCEL buttons on the zone sensor

Momentarily pressing the ON button on the zone sensor during unoccupied mode places the controller in occupied bypass mode for 120 minutes. You can adjust the number of minutes the Tracer AH540/541 is placed in the occupied bypass mode by using the Rover service tool. The controller remains in occupied bypass mode until the override time expires or until you press the CANCEL button on the zone sensor.

If the building automation system sends an unoccupied mode command to the controller and ON button on the zone sensor is pressed, the controller goes to occupied bypass and communicates back to the building automation system that its effective occupancy mode is occupied bypass.

If the controller is in the unoccupied mode, regardless of the source (the building automation system or a hard-wired occupancy binary input), pressing the ON button causes the controller to go into the occupied bypass mode for the duration of the configured occupied bypass time.

Binary inputs

The Tracer AH540/541 controller has six binary inputs. Each binary input associates an input signal of 0 Vdc with closed contacts and 24 Vdc with open contacts. If the wired binary device has closed contacts, a multimeter should measure less than 1.0 Vdc across the binary input terminals. If the binary input has opened, a multimeter should measure greater than 20 Vdc across the binary input terminals.

Table 7 describes the function of each of the binary inputs. For an explanation of the diagnostics generated by each input, see "Diagnostics" on page 89 For more information about how the functions of the controller operate, see Chapter 4, "Sequence of operation."

Table 7. Binary input functions and locations

AH540				AH541	Function	Power function
Input label	Terminal label		Factory terminal label	Field terminal label		
IN 7	TB37-1 TB37-2	IN GND	J37	IN7	Low-temperature detection or coil defrost	24 Vdc ground
IN 8	TB38-1 TB38-2	IN GND	J38	IN8	Run/stop	24 Vdc ground
IN 9	TB39-1 TB39-2	IN GND	J39	IN9	Occupancy or generic[1]	24 Vdc ground
IN 10	TB40-1 TB40-2	IN GND	J40	IN10	Supply fan status	24 Vdc ground
IN 11	TB41-1 TB41-2	IN GND	J41	IN11	Filter status	24 Vdc ground
IN 12	TB42-1 TB42-2	IN GND	J42	IN12	Exhaust fan status or coil defrost	24 Vdc ground

1 When configured as a generic binary input, it has no direct effect on controller operation.

IN7: Low-temperature detection or coil defrost

Binary input IN7 can be configured either as a low-temperature detection input or a coil defrost input.

Low-temperature detection

When configured as a low-temperature detection input, IN7 protects the coils of hydronic units. A low-temperature-detection device (freezestat) connected to the input detects the low temperature. The Tracer AH540/541 controller can protect the coil using one binary input. When the controller detects the low-temperature-detection signal, the controller generates a Low Temp Detect diagnostic, which disables the fan, opens all unit water or steam valves, and closes the outdoor air damper (when present).

The low-temperature detection device can be automatically or manually reset. However, you must manually reset the Low Temperature Detect diagnostic to clear the diagnostic and restart the unit. See "Resetting diagnostics" on page 89 for instructions on clearing controller diagnostics.

Table 8. Low-temperature detection controller operation

Diagnostic	Fan operation	Valve operation	Face-and-bypass damper	Outdoor air damper
Low-temperature detection	Off	Open[1]	Face	Closed

1 When hydronic or steam is the source of heat, the heat output is cycled open and closed when the controller is shut down by a Low Temp Detect diagnostic. See "Freeze avoidance" on page 70 for further details.

Coil defrost

Binary input IN7 can be configured as a coil defrost input in direct expansion (DX) cooling applications when a binary device is used to detect low evaporator refrigerant temperatures. When the DX coil refrigerant temperature drops below the detecting device threshold and the device output changes states, the Tracer AH540/541 controller disables all DX cooling until the frost condition is cleared. DX cooling operation automatically resumes when the binary input is normal.

For more information regarding coil defrost operation, see "Coil defrost binary input" on page 66.

> **Note:**
> Binary input IN12 can also be configured as a coil defrost input.

Table 9. Coil defrost binary input configuration

Configuration	Contact closed	Contact open
Not used	Normal	Normal
Normally closed	Normal	DX cooling disabled
Normally open	DX cooling disabled	Normal

IN8: Run/stop

This hard-wired binary input IN8 can be used for a variety of functions to shut down the unit. The Tracer AH540/541 controller systematically shuts down unit operation and reports a Unit Shutdown diagnostic upon detecting a stop input. For example, a condensate overflow sensor or a smoke detector can be connected to the run/stop input to shut down unit operation.

The run/stop input can be configured as a latching or non-latching Unit Shutdown diagnostic. If the input is configured as non-latching, the unit will be returned to normal operation when the input is in the run state. If the run/stop input is configured as latching, the input must first be returned to the run state, and the diagnostic must be reset in the controller before the unit is allowed to run. See Table 10.

Table 10. Run/stop IN8 binary input configuration

Configuration	Contact closed	Contact open
Not used	Run	Run
Normally closed	Run	Stop
Normally open	Stop	Run

IN9: Occupancy or generic

The Tracer AH540/541 controller uses the occupancy binary input IN9 for two occupancy-related functions or as a generic binary input.

Local occupancy mode request

For controllers not receiving a communicated occupancy mode request, the local occupancy binary input determines the unit occupancy based on the hard-wired signal (see Table 11 on page 25). Normally, the signal is hard-wired to a binary switch or clock.

If the occupancy input is configured as normally open and a hard-wired occupancy signal on binary input IN9 is open, then the unit switches to occupied mode. If the hard-wired occupancy signal is closed, the controller switches to unoccupied mode (only if the occupied bypass timer = 0; see “Occupied bypass mode” on page 43).

For more complete information on occupancy arbitration, see Table 17.

Table 11. Occupancy IN9 binary input configuration

Configuration	Contact closed	Contact open
Normally closed	Occupied	Unoccupied
Normally open	Unoccupied	Occupied

Generic binary input

Binary input IN9 can be configured as a generic binary input for a variety of applications with a Tracer Summit system only. The binary input does not affect controller operation. A generic binary input can be monitored only from Tracer Summit.

IN10: Supply fan status

The fan status binary input IN10 indicates the presence of air flow through the supply fan of an air-handling unit. For Tracer AH540/541 applications, a differential pressure switch detects fan status, with the high side of the differential being supplied at the unit outlet and the low side supplied inside the unit. During fan operation, differential pressure closes the normally open switch and confirms that the fan is operating properly.

A Low Supply Fan Air Flow diagnostic is detected during the following two conditions:

- The controller is commanding the fan On and the fan status switch is not in the closed position.
- The fan status switch does not close the binary input within the configurable fan On delay time limit of the controller commanding the fan On.

Although the fan status switch is normally open, it is configurable (see Table 12).

Table 12. Fan status binary input IN10 configuration

IN10 configuration	Contact closed	Contact open
Not used	Normal	Normal
Normally closed	Latching diagnostic[1]	Normal
Normally open	Normal	Latching diagnostic[1]

1 A latching diagnostic, Low Supply Fan Air Flow, is generated when the controller turns on the supply fan output, but binary input IN10 indicates that the supply fan is not running after the fan delay time (configurable).

IN11: Filter status

The filter status switch connected to binary input IN11 detects a dirty air filter and indicates a need for maintenance. For Tracer AH540/541 applications, a differential pressure switch detects filter status, with the high side of the differential being supplied at the filter inlet and the low side supplied at the filter outlet. During fan operation, filter differential pressure increases as the filter becomes increasingly dirty.

A normally open filter status switch closes when the differential pressure reaches a set threshold. This is a non-latching, informational diagnostic; the controller will continue normal unit operation.

Although the filter status switch is normally open, it is configurable (see Table 13).

Table 13. Filter status input configuration

IN11 configuration	Contact closed	Contact open
Not used	Clean	Clean
Normally closed	Clean	Dirty
Normally open	Dirty	Clean

IN12: Exhaust fan status or coil defrost

Binary input IN12 can be configured either as an exhaust fan status input or a coil defrost input.

Exhaust fan status

When configured as an exhaust fan status binary input, IN12 indicates the presence of air flow through an exhaust fan associated with the controlled air-handling unit. For Tracer AH540/541 applications, a differential pressure switch detects exhaust fan status, with the high side of the differential being supplied at the outlet. During exhaust fan operation, differential pressure closes the normally open switch and confirms that the fan is operating properly.

A Low Exhaust Fan Air Flow diagnostic is detected during the following two conditions:

- The controller is commanding the exhaust fan On and the status switch is not in the closed position.
- The fan status switch does not close the binary input within two minutes of the controller commanding the exhaust fan On.

Although the fan status switch is normally open, it is configurable (see Table 14 on page 27).

Table 14. Exhaust fan status binary input IN12 configuration

IN12 configuration	Contact closed	Contact open
Not used	Normal	Normal
Normally closed	Exhaust fan diagnostic[1]	Normal
Normally open	Normal	Exhaust fan diagnostic[1]

1 A Low Exhaust Fan Air Flow diagnostic is generated when the controller turns on the exhaust fan output, but the exhaust fan status binary input indicates the exhaust fan is not running after a 2 minute time delay. This diagnostic is latching, but it does not affect controller operation of the air-handling unit.

Coil defrost

Binary input IN12 can be configured as a coil defrost input. See “Coil defrost” on page 24.

Zone sensors

The controller accepts the following zone sensor inputs:

- Space temperature measurement (10 kΩ thermistor)
- Zone sensor setpoint thumbwheel (either internal or external on the zone sensor module) (see Table 73 on page 106)
- Fan mode switch
- Timed override On request
- Timed override Cancel request
- Communication jack
- Service pin message request

Space temperature measurement

Trane zone sensors use a 10 kΩ thermistor to measure the space temperature. Typically, zone sensors are wall-mounted in the room and include a space temperature thermistor. A valid space temperature input is required for the controller to operate in space temperature control.

If both a hard-wired and communicated space temperature value exist, the controller ignores the hard-wired space temperature input and uses the communicated value.

Zone sensor setpoint thumbwheel

Zone sensors with an internal or external setpoint thumbwheel (1 kΩ) provide the Tracer AH540/541 controller with a local setpoint (50ºF to 85ºF [10ºC to 29.4ºC]). An internal setpoint thumbwheel is concealed under the front cover of the zone sensor. To access it, remove the zone sensor cover. An external setpoint thumbwheel (when present) is accessible from the front cover of the zone sensor.

See "Zone sensor setpoint thumbwheel" on page 36 for an explanation of how the controller determines the setpoint.

Fan mode switch

The zone sensor fan mode switch provides the controller with a fan request signal (Off, Auto). If the fan control request is communicated to the controller, the controller ignores the hard-wired fan mode switch input and uses the communicated value.

The zone sensor fan mode switch input can be enabled or disabled through configuration using the Rover service tool. If the zone sensor switch is disabled, the controller resorts to the Auto fan mode.

When the fan mode switch is placed in the Off position, the controller does not control any unit capacity. The unit remains powered and all outputs are driven Closed or Off.

Upon a loss of signal on the fan speed input, the controller reports a diagnostic and reverts to using the Auto fan mode of operation.

ON/CANCEL buttons

Some Trane zone sensor modules include timed override ON and CANCEL buttons. Use the timed override ON and CANCEL buttons to place the controller in override (occupied bypass mode) and to cancel the override request.

The controller always recognizes the timed override ON button. If someone presses the zone sensor timed override ON button, the controller initializes the bypass timer to 120 minutes (adjustable).

If the controller is unoccupied when someone presses the ON button for two seconds, the controller immediately changes to occupied bypass mode and remains in the mode until either the timer expires or someone presses the zone sensor's timed override CANCEL button. If the ON button is pressed during occupied bypass mode before the timer expires, the controller re-initializes the bypass timer to 120 minutes.

If the controller is in any mode other than unoccupied when someone presses the ON button, the controller initializes the bypass time to 120 minutes. As time expires, the bypass timer continues to decrement. During this time, if the controller changes from its current mode to unoccupied (perhaps due to a change based on the system time-of-day schedule), the controller switches to occupied bypass mode for the remainder of the bypass time or until someone presses the zone sensor timed override CANCEL button.

Zone sensor communication jack

Use the RJ-11 communication jack (present on some zone sensor modules) as the connection point from the Rover service tool to the communication link when the communication jack is wired to the communication link at the controller. By accessing the communication jack via Rover, you gain communication access to any controller on the link.

Service Pin message request

Pressing the zone sensor ON button for ten seconds and then releasing it causes the controller to transmit a Service Pin message. The Service Pin message can be useful for installing the controller on a communication network. (See the *Rover Operation and Programming* guide, EMTX-SVX01E-EN, for more information).

Zone sensor wiring connections

Typical Trane zone sensor wiring connections *with* a fan mode switch are as follows:

- 1: Space temperature
- 2: Common
- 3: Setpoint
- 4: Fan mode

- 5: Communications
- 6: Communications

Typical Trane zone sensor wiring connections *without* a fan mode switch are as follows:

- 1: Space temperature
- 2: Common
- 3: Setpoint
- 5: Communications
- 6: Communications

Chapter 4

Sequence of operation

The Tracer AH540/541 is a configurable controller. All of the controller sequences of operation are predefined with no need for programming the controller. Configurable parameters are provided to allow the user to adjust the controller operation. For example, the minimum occupied outdoor air damper position can be changed.

All configuration parameters are set to defaults predetermined through extensive air-handling unit testing in several different operating conditions. The factory default settings are also based on the air-handling unit configuration and order information.

Control modes

The Tracer AH540/541 controller is configurable to operate in one of two air-handling temperature control modes:

- Space temperature control
- Discharge air temperature control

When the AH540/541 is configured for space temperature control, it conforms to the LonMark® Space Comfort Controller (SCC) profile. When the AH540/541 is configured for discharge air temperature control, it conforms to the LonMark® Discharge Air Controller (DAC) profile.

Note:
Some sequences in this chapter are specific to the space temperature control mode and some are specific to the discharge air temperature control mode. Some sequences are common to both modes, but operate differently. Where mode-dependent differences exist, they are explained in this chapter.

Space temperature control

The Tracer AH540/541 controller requires both a space temperature and discharge air temperature sensor to be present for space temperature control operation (also called cascade control). In this control mode, the Tracer AH5405/541 uses the space temperature and the measured discharge air temperature to maintain the space temperature at the active space cooling setpoint or the active space heating setpoint. The controller modulates its heating or cooling outputs to control the discharge air temperature to the discharge air temperature setpoint. This calculated discharge air temperature setpoint is the desired discharge air temperature (supply air temperature) that the unit must deliver to maintain space temperature at the space heating or cooling setpoint.

The space temperature can be hard-wired to analog input IN1 on the termination board (10 kΩ thermistor only) or can be communicated to the controller via Comm5. Similarly, a setpoint can be provided with either a hard-wired setpoint thumbwheel to analog input IN2 on the controller, with a communicated value, or by using the stored default setpoints in the controller. The discharge air temperature must be a hard-wired analog input IN4 to the termination board (10 kΩ thermistor only).

The controller heat/cool mode is determined by either a communicated request or by the controller itself, when the heat/cool mode is Auto. When the heat/cool mode is Auto, the controller compares the active space setpoint and the active space temperature and decides if the space needs heating or cooling.

The Tracer AH540/541 controller must have a valid space temperature and discharge air temperature input to operate space temperature control.

When the controller is configured for a supply fan and space temperature control, the controller will not operate the unit if the space temperature or discharge air temperature sensors are missing or have failed.

The space temperature control algorithm uses two control loops: a space temperature loop and a discharge air temperature loop. The space temperature control loop compares the active heat/cool space setpoint and the space temperature and calculates a discharge air temperature setpoint. The calculated discharge air temperature setpoint range is bound by configurable heating (maximum) and cooling (minimum) limits.

The discharge air temperature loop compares the discharge air temperature to the calculated discharge air temperature setpoint (calculated by the space temperature loop), and calculates a heat or cool capacity to respond to the discharge air temperature setpoint.

The capacity calculation, as a result of the discharge air temperature control loop, is used to drive the air-handling unit actuators to maintain space temperature at the space temperature setpoint.

Control gains

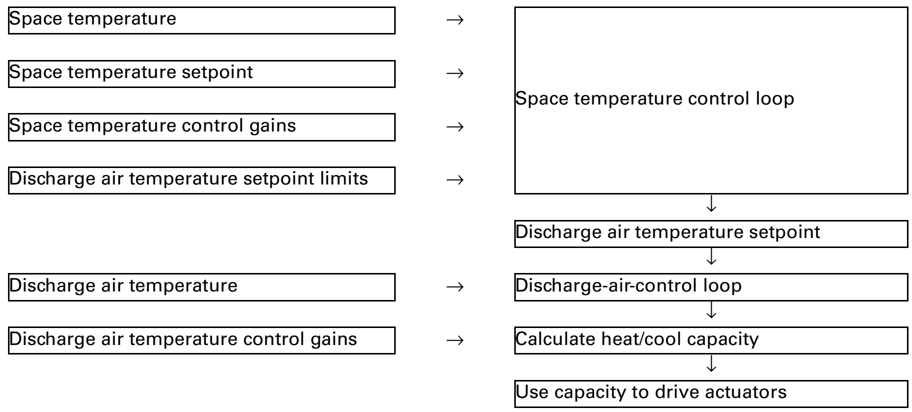
Figure 9 on page 33 illustrates the separate control for the space-temperature control loop and discharge air temperature control loop. The gain parameter values that control the different loops have been determined through extensive testing of different types of heating or cooling capacities and at operating conditions of the air-handling unit.

Heating/cooling mode control

The heating or cooling mode of the controller can be determined two ways:

- Communicated request
- Automatically by the controller

Figure 9. Space temperature control block diagram



Communicated request

A building automation system or peer controller may communicate the heating or cooling mode to the controller via network variables nviHeatCool and/or nviApplicMode. Heating mode commands the controller to heat only. Cooling mode commands the controller to cool only. The Auto mode allows the controller to automatically change from heating to cooling or vice versa. See Table 71 on page 101 for more information.

Table 15 shows space temperature control based on communicated request. Enabled means normal operation; disabled means that the controller cannot use the request.

Table 15. Space temperature control based on communicated request

Request[1]	Supply fan	Mechanical heating	Mechanical cooling	Outdoor air damper	Exhaust fan
Auto	Enabled	Enabled	Enabled	Enabled	Enabled
Heat	Enabled	Enabled	Disabled	Enabled	Enabled
Morning warm-up	Enabled	Enabled	Disabled	Closed	Disabled
Cool	Enabled	Disabled	Enabled	Enabled	Enabled
Night purge	Enabled	Disabled	Disabled	Ventilation disabled Economizer enabled	Enabled
Pre-cool	Enabled	Disabled	Enabled	Ventilation disabled Economizer enabled	Disabled
Off	Disabled	Disabled	Disabled	Disabled	Disabled
Test	Enabled	Enabled	Enabled	Enabled	Enabled
Emergency heat[2]	Enabled	Enabled	Enabled	Enabled	Enabled
Fan only	Enabled	Disabled	Disabled	Disabled	Enabled

1 Enabled means the operation is normal. Disabled means that the controller cannot use the request.
2 The Tracer AH540/541 controller does not support emergency heat. The controller will treat emergency heat as Auto.

Auto mode

A communicated request of Auto or the controller default operation (Auto) can place the unit into heating or cooling mode. When the controller automatically determines the heating or cooling mode while in Auto mode, the unit switches to the desired mode based on the control algorithm.

If the Tracer AH540/541 controller is operating space temperature control, it uses the space temperature and space temperature setpoint to automatically determine heat or cool mode of operation. When the controller first powers up or after a reset, it makes an initial determination if the heat/cool mode should be heat or cool. If the controller is configured as heating and cooling, the controller determines the appropriate mode.

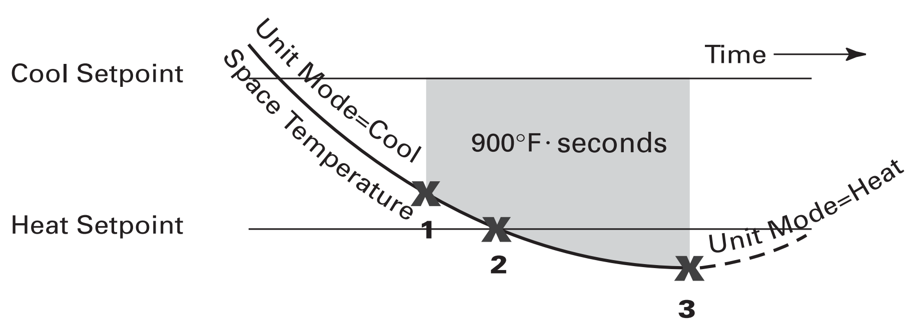
For example, if the initial space temperature is less than the occupied space heat setpoint then the initial heat/cool mode is heating. The heat/cool mode for a cool-only unit is always cool. The heat/cool mode for a heat-only unit is always heat.

When the controller is allowed to automatically determine its space heating and cooling mode, the unit changes from cool to heat or from heat to cool, when the integrated error between the active space setpoint and the active space temperature is 900°F• seconds or greater. The integrated error is calculated once every ten seconds.

See Figure 10 for an example of the controller changing from space cooling (unit mode = cool) to space heating (unit mode = heat). In this example, the initial unit mode is cool because the space temperature is above the cool setpoint, and the cooling capacity is greater than 0%.

Following the curve from left to right, the space temperature falls below the cool setpoint, and the controller reacts by lessening its cooling capacity. When the space temperature reaches 1, the cooling capacity is 0%. The rate at which the controller reaches 0% capacity depends on the space temperature rate of change.

Figure 10. Automatic heat/cool changeover logic example



Point 1 on the curve in Figure 10 indicates the point at which the cooling capacity equals 0%, space temperature is less than 0.5°F below the cooling setpoint, and the error integrator starts to add up. Error integration does not begin until the capacity is 0%. See the “Heat/cool changeover: error integration example” on page 35.

Point 2 on the curve indicates the active heat setpoint. The space temperature must fall below the active heat setpoint before the controller can change to heating. Conversely, the space temperature must rise above the active cooling setpoint before the controller can change to cooling.

Point 3 on the curve indicates the point at which the controller switches to heat (from cool) after the error integrator exceeds 900°F • seconds.

The controller must be able to heat before it will switch to heat. A unit that cannot heat will not switch to heat. A unit that cannot cool will not switch to cool.

Heat/cool changeover: error integration example

If the active space temperature is 66.5°F, the current mode is cooling, the cooling capacity is 0°F, and the space cooling setpoint is 70°F. The error calculation is 70 – 0.5 – 66.5 = 3°F. If the same error exists for 60 seconds, the error integration term is (3°F • 60 seconds = 180°F seconds). Therefore, after five minutes (3°F • 300 seconds = 900°F seconds), the controller will switch from cooling to heating mode if the space temperature is below the occupied heating setpoint.

Cooling operation

The heating and cooling space setpoint high and low limits are always applied to the occupied and occupied standby setpoints. During the cooling mode, the Tracer AH540/541 controller attempts to maintain the active space temperature at the active space cooling setpoint. Based on the controller occupancy mode, the active space cooling setpoint is one of the following:

- Occupied cooling setpoint
- Occupied standby cooling setpoint
- Unoccupied cooling setpoint

The cooling outputs are controlled based on the unit configuration and the required machine cooling capacity. At 0% machine cooling capacity, the cooling valve is closed and the outdoor air damper is at its minimum position. As the required machine cooling capacity increases, the cooling valve and/or the outdoor air damper opens above their minimum positions.

The discharge air temperature control algorithm calculates a desired discharge air temperature to maintain the space cooling setpoint. Cool capacity is controlled to achieve the desired discharge air setpoint. Heat capacity can also be used to temper cold outdoor air conditions to maintain ventilation and the discharge air setpoint.

The outdoor air damper is used for cooling whenever economizing is possible and there is a need for cooling. If economizing is not possible, it will not be used in cooling. If economizing is possible, it is always the first stage of cooling. See “Outdoor air damper operation” on page 56 for more information.

Heating operation

In the heating mode, the Tracer AH540/541 controller attempts to maintain the space temperature at the active heating setpoint. Based on the controller occupancy mode, the active space heating setpoint is one of the following:

- Occupied heating setpoint
- Occupied standby heating setpoint
- Unoccupied heating setpoint

The outputs are controlled based on the unit configuration and the required machine heating capacity. At 0% machine heating capacity, the heating capacity is at its minimum position. As the required machine heating capacity increases, the heating capacity is opened above its minimum position. At 100% machine heating capacity, the heating capacity is open to its maximum position.

The economizer outdoor air damper is never used as a source of heating. The economizer damper is used only for ventilation when the unit is heating. For more information, see “Outdoor air damper operation” on page 56.

Space temperature setpoint arbitration

The space temperature setpoint can be communicated either by a building automation system or peer-to-peer using a binding (see “Communication with other controllers” on page 3). When the Tracer AH540/541 is in occupied mode, occupied standby mode, or occupied bypass mode, a communicated setpoint takes precedence over a local (hard-wired) setpoint. When neither a communicated nor a local (hard-wired) setpoint is present, the controller uses the locally stored default heating and cooling setpoints.

The exception is when the controller is in unoccupied mode. Then the controller always uses locally stored default unoccupied setpoints. These setpoints are configured at the factory prior to shipment. Use the Rover service tool to modify these default unoccupied setpoints.

Zone sensor setpoint thumbwheel

Zone sensors with an internal or external setpoint thumbwheel (1 kΩ) provide the Tracer AH540/541 controller with a local setpoint (50°F to 85°F [10°C to 29.4°C]). An internal setpoint thumbwheel is concealed under the front cover of the zone sensor. To access it, remove the zone sensor cover. An external setpoint thumbwheel (when present) is accessible from the front cover of the zone sensor.

When the local (hard-wired) setpoint thumbwheel is used to determine the setpoints, all unit setpoints are calculated based on the local setpoint value, the configured setpoints, and the active mode of the controller.

For example, assume the controller is configured with the following default setpoints:

- Unoccupied cooling setpoint 85°F (29.4ºC)
- Occupied standby cooling setpoint 76°F (24.4ºC)
- Occupied cooling setpoint 74°F (23.3ºC)
- Occupied heating setpoint 70°F (21.1ºC)
- Occupied standby heating setpoint 66°F (18.9ºC)
- Unoccupied heating setpoint 60°F (15.6ºC)

Absolute Setpoint Offset = Setpoint Input – Mean Setpoint

From the default setpoints in this example, the mean setpoint is the mean of the occupied cooling and heating setpoints, which is 72°F [(74+70) / 2]. The absolute setpoint offset is the difference between the setpoint input and the mean setpoint.

Assume a thumbwheel setpoint input of 73°F, resulting in an absolute setpoint offset of 1°F (73–72=1). The controller adds the absolute setpoint offset (1°F) to occupied and occupied standby default setpoints to derive the effective setpoints, as follows.

- Unoccupied cooling setpoint 85°F (same as default)
- Occupied standby cooling setpoint 77°F (default+1=77)
- Occupied cooling setpoint 75°F (default+1=75)
- Occupied heating setpoint 71°F (default+1=71)
- Occupied standby heating setpoint 67°F (default+1=67)
- Unoccupied heating setpoint 60°F (same as default)

When a building automation system or other controller communicates a setpoint to the controller, the controller ignores the hard-wired setpoint input and uses the communicated value. The exception is the unoccupied mode, when the controller always uses the stored default unoccupied setpoints.

After the controller completes all setpoint calculations based on the requested setpoint, the occupancy mode, the heating and cooling mode, and other factors, the calculated setpoint is validated against the following setpoint limits:

- Heating setpoint high limit
- Heating setpoint low limit
- Cooling setpoint high limit
- Cooling setpoint low limit

These setpoint limits only apply to the occupied and occupied standby heating and cooling setpoints. These setpoint limits do not apply to the unoccupied heating and cooling setpoints stored in the controller configuration.

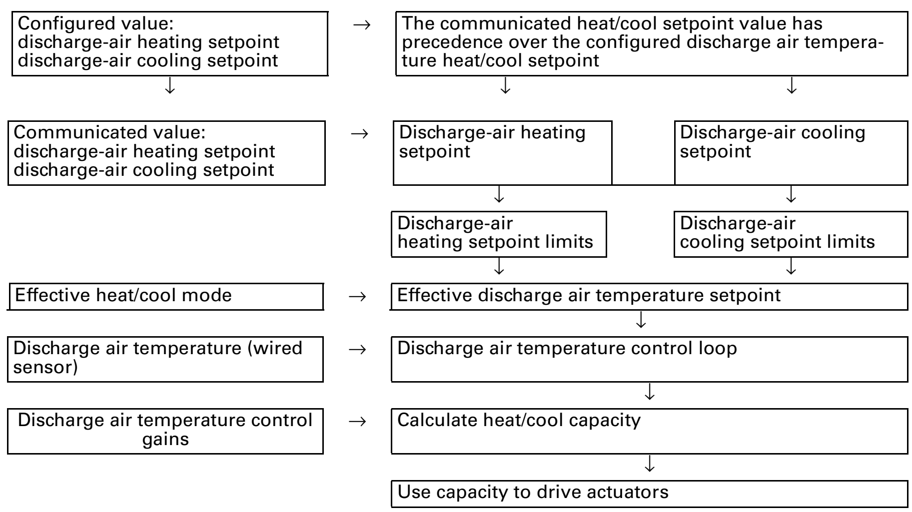
Unit configuration also exists to enable or disable the local (hard-wired) setpoint at the zone sensor module. This parameter provides additional flexibility to allow you to apply communicated, hard-wired, or default setpoints without having to make physical wiring changes to the controller.

Discharge air temperature control

The controller requires a discharge air temperature sensor (10 kΩ thermistor only) to operate in the discharge air temperature control mode. Discharge air temperature control modulates the heating or cooling outputs to maintain discharge air temperature at the discharge air temperature setpoint regardless of the entering air conditions of the air-handling unit.

Figure 11 shows the steps the Tracer AH540/541 controller takes to control discharge air. First the controller determines if a communicated discharge-air heating setpoint and discharge-air cooling setpoint are present. The communicated setpoint has precedence over the configured (default) setpoint. If no communicated value is present, the controller uses the configured discharge air temperature setpoint.

Figure 11. Discharge air temperature control flow diagram



Discharge air temperature setpoint minimum and maximum limits are placed on the discharge air setpoint depending on the effective heat or cool mode. If the effective heat/cool mode is cool, the maximum discharge-air cooling setpoint limit and minimum discharge-air cooling setpoint limit the discharge-air cooling setpoint. See Chapter 5, "Configuration" for more information about discharge-air heating and cooling setpoint limits.

The effective discharge air temperature setpoint is determined from:

- Communicated or configured discharge air temperature setpoint value
- Minimum and maximum heat/cool setpoint limits
- Effective heat/cool mode

See Table 16 and Table 17 for an example of how the controller determines the effective discharge air temperature setpoint.

Table 16. Example of configuration parameters

Discharge-air cooling setpoint	55°F (18.2°C)
Maximum discharge-air cooling setpoint	68°F (20.0°C)
Minimum discharge-air cooling setpoint	50°F (10.0°C)
Discharge-air heating setpoint	100°F (37.8°C)
Maximum discharge-air heating setpoint[1]	104°F (40.0°C)
Minimum discharge-air heating setpoint	86°F (30.0°C)

1 When the controller is applied to an air-handling unit with a draw-through supply fan, the maximum discharge-air heating setpoint should be set to 104°F (default setpoint). This prevents the discharge air temperature from exceeding the high temperature limit of the supply fan motor. Exceeding the motor temperature limit can cause premature failures.

Table 17. Example of communicated values

Discharge-air cooling setpoint input	50°F (10.0°C)
Discharge-air heating setpoint input	None
Effective heat cool mode	Cool

Since the effective heat cool mode is cool and the communicated value has precedence over the local configuration value, the discharge-air cooling setpoint is 50°F. The maximum and minimum discharge-air cooling setpoint limits are then applied to determine an effective discharge-air temperature setpoint of 53 °F, from Table 16.

In this example, if the effective heat cool mode is Heat, the effective discharge air temperature setpoint would be 100°F.

The discharge air temperature control loop uses the effective discharge air temperature setpoint, discharge air temperature (from the wired sensor), and the configured control gains to calculate an output capacity for the end devices.

Heating/cooling mode control

The heating or cooling control mode of the controller can be determined in two ways:

- Communicated request
- Automatically by the controller

Communicated request

A building automation system or peer controller may communicate the heating or cooling mode to the controller using network variable nviApplicMode. Heating mode commands the controller to heat only. Cooling mode commands the controller to cool only. The Auto mode allows the controller to automatically change from heating to cooling or cooling to heating. See Table 72 on page 103.

Auto mode

A communicated request of Auto or the controller default operation (Auto) can place the unit into cooling mode. A zone temperature input is required for discharge air temperature control when auto heat/cool changeover is desired. When the controller automatically determines the heating or cooling mode using auto mode, the unit switches to the desired mode based on the control algorithm and the relationship between zone temperature to the configured daytime warm up start and stop setpoints. See daytime warm up in configuration section of this manual.

When the controller first powers up or after a reset, it makes an initial determination if the discharge air temperature control mode should be heating or cooling. The discharge demand for a cooling-only unit is always cooling. The discharge demand for a heating only unit is always heating. A unit that can heat or cool initially starts in cooling mode.

Power-up sequence

This sequence applies to both space temperature control and discharge air temperature control.

When 24 Vac power is initially applied to the AH540/541 controller, the following sequence occurs:

1. Green Status LED turns On.
2. All binary outputs are controlled to their de-energized state, and analog outputs are set to the normally closed output voltage.
3. The controller reads the inputs to determine initial values.
4. Power-up control wait feature is applied. The controller waits 300 seconds to allow ample time for the communicated control data to arrive. If after 300 seconds, the controller has not received any communicated control data, the unit assumes stand-alone operation.
5. Normal operation begins assuming no diagnostics have been generated.

Manual output test can be initiated at any time in the power-up sequence or during normal operation. Refer to the “Performing a manual output test” on page 84.

Occupancy modes

The occupancy mode can be either communicated to the controller or hard-wired using the occupancy binary input IN9.

The valid occupancy modes for space temperature control are:

- Occupied
- Unoccupied
- Occupied standby
- Occupied bypass

The valid occupancy modes for discharge air temperature control are:

- Occupied
- Unoccupied
- Occupied bypass

Occupied mode

The occupied mode is the normal operating mode for occupied spaces or daytime operation. The Tracer AH540/541 controller operates this sequence according to the configured control mode.

Space temperature control: Occupied mode

If configured for space temperature control, the controller attempts to maintain the space temperature at the active occupied heating or cooling space setpoint, based on the measured space temperature, the discharge air temperature, the active setpoint, and the proportional/integral control algorithm. Additional information related to controller setpoints can be found in “Space temperature setpoint arbitration” on page 36.

Discharge air temperature control: Occupied mode

If configured for discharge air temperature control, the controller maintains the discharge air temperature at the configured discharge air heating or cooling setpoint. The default occupied mode of the controller is cooling. In the occupied mode, the controller communicated application mode input (nviApplicMode) and heat/cool mode input (nviHeatCool) determine the controller heating and cooling setpoint. See Table 72 on page 103 for heating and cooling control modes of operation.

Unoccupied mode

The unoccupied mode is the normal operating mode for unoccupied spaces or nighttime operation. When the controller is in the unoccupied mode, the controller attempts to maintain the space temperature between the configured unoccupied heating and cooling setpoints, based on the measured space temperature. The Tracer AH540/541 controller operates according to the configured control mode.

Space temperature control: Unoccupied mode

In unoccupied mode, if configured for space temperature control, the supply fan is Off whenever the space temperature is between the unoccupied heating and cooling setpoints. If the space temperature rises above the unoccupied cooling setpoint the Tracer AH540/541 turns On the supply fan and provides cooling at the unoccupied cooling setpoint.

If the space temperature drops below the unoccupied heating setpoint the controller turns On the supply fan and provides heating at the unoccupied heating setpoint. See Table 43 on page 78.

Discharge air temperature control: Unoccupied mode

In unoccupied mode, if configured for discharge air temperature control, the controller must have either a hard-wired or communicated space temperature input from the Tracer Summit building automation system.

In unoccupied mode, the supply fan is Off whenever the space temperature is between the unoccupied heating and cooling setpoints. If the space temperature rises above the unoccupied cooling setpoint the Tracer AH540/541 turns On the supply fan and provides cooling at the discharge air cooling setpoint.

If the space temperature drops below the unoccupied heating setpoint the controller turns On the supply fan and provides heating at the discharge air heating setpoint. See Table 44 on page 79.

Note that primary heating or cooling capacity is defined by unit type and whether heating or cooling is enabled or disabled. For example, if the economizer is enabled and possible, it will be the primary cooling capacity. If hydronic heating is possible, it will be the primary heating capacity.

Occupied standby mode

If configured for space temperature control, the controller uses the occupied standby mode to reduce heating and cooling demands during occupied hours when a space is vacant or unoccupied. For example, the controller may use occupied standby mode for a classroom while the students are out of the room.In the occupied standby mode, the controller uses the occupied standby cooling and heating setpoints. Because the occupied standby setpoints typically cover a wider range than the occupied setpoints, the Tracer AH540/541 controller reduces the demand for heating and cooling the space. Also, the outdoor air economizer damper uses the economizer standby minimum position to reduce the heating and cooling demands.

Occupied standby is a mode in which the controller has received an occupied request from Tracer Summit, but has also received a local unoccupied binary input IN9 signal. For example, an unoccupied conference room (as sensed by a local occupancy sensor) in an occupied building (as commanded by a Tracer Summit system) is in occupied standby mode. When the conference room becomes occupied with people, the local occupancy sensor changes the controller mode to occupied.

The controller can be placed into the occupied standby mode when a communicated occupancy request is combined with the local (hard-wired) occupancy binary input signal. When the communicated occupancy request is unoccupied, the occupancy binary input (if present) does not affect the controller occupancy. When the communicated occupancy request is occupied, the controller uses the local occupancy binary input to switch between the occupied and occupied standby modes.

During occupied standby mode, the controller economizer damper position goes to the economizer standby minimum position. The economizer standby minimum position can be changed using the Rover service tool.

When no occupancy request is communicated, the occupancy binary input switches the controller operating mode between occupied and unoccupied. When no communicated occupancy request exists, the unit cannot switch to occupied standby mode.

Occupied bypass mode

If configured for either space temperature control or discharge air temperature control, the controller uses occupied bypass mode for timed override conditions. For example, if the controller is in unoccupied mode and someone presses the ON button on the zone sensor, the controller is placed in occupied bypass mode for 120 minutes (adjustable) or until someone presses the CANCEL button on the zone sensor. The controller can be placed in occupied bypass mode by either communicating an occupancy request of Bypass to the controller or by using the timed override ON button on the Trane zone sensor.

When the controller is in unoccupied mode, you can press the ON button on the zone sensor to place the controller into occupied bypass mode for the duration of the bypass time (typically 120 minutes).

If the controller is in the occupied standby mode, you can press the ON button on the zone sensor to place the controller into occupied bypass mode for the duration of the configured bypass time. Typically, the controller is in occupied standby mode rather than occupied mode because of the local binary occupancy input.

Sources of occupancy mode control

There are four ways to control the occupancy mode (see Table 16 on page 39):

- Communicated request (usually provided by the building automation system or peer device)
- Pressing the zone sensor timed override ON button (or CANCEL button)
- Occupancy binary input (see “Occupancy binary input” for more information)
- Default operation of the controller (occupied mode)

A communicated request from a building automation system or another peer controller can change the controller occupancy. However, if communication is lost, the controller reverts to the default operating mode (occupied) after 15 minutes (configurable, specified by the “receive heartbeat time”), if no local hard-wired occupancy signal exists.

Occupancy binary input

The Tracer AH540/541 controller uses the occupancy binary input IN9 for two occupancy-related functions. For controllers not receiving a communicated occupancy request, the occupancy binary input determines the occupancy of the unit based on the hard-wired signal. Normally, the signal is hard-wired to a binary switch or time clock.

When a hard-wired occupancy signal is open, the unit switches to occupied mode (if the occupancy input is configured as normally open). When a hard-wired occupancy signal is closed, the controller switches to unoccupied mode.

For controllers that receive a communicated occupancy request from a building automation system, the hard-wired occupancy binary input is used with a communicated occupancy request to place the controller in either occupied mode or occupied standby mode.

In occupied mode, the controller operates according to the occupied setpoints. In occupied standby mode, the unit controller operates according to the occupied standby setpoints. When the controller receives a communicated unoccupied request, the controller operates according to the unoccupied setpoints regardless of the hard-wired occupancy input state.

If neither the hard-wired binary input nor a communicated request is used to select the occupancy mode, the controller defaults to occupied mode because the occupancy binary input (if present) typically is configured as normally open and no occupancy device is connected.

Determining the occupancy mode

The occupancy of the controller is determined by evaluating the combination of three potential communicating inputs, as well as the hard-wired occupancy input and the occupied bypass timer (see Table 16 on page 39). Three different communicating inputs affect controller occupancy mode:

- Occupancy—manual command
- Occupancy—schedule
- Occupancy—sensor

These inputs provide maximum flexibility, but the number of inputs you decide to use varies with the application and the features available in your building automation system.

Occupancy—manual command

Some communicating devices may request occupancy based on the information communicated in the network variable (nvoOccManCmd). Trane systems and zone sensors do not communicate this information to the controller, but the Tracer AH540/541 controller accepts this network variable as communicated input (nviOccManCmd).

Occupancy—schedule

Building automation systems normally communicate an occupancy request to the Tracer AH540/541 controller using a network variable input (nviOccSchedule).

Occupancy—sensor

Some occupancy sensors may be equipped with the ability to communicate an occupancy mode to the controller. In such devices, network variable input (nviOccSensor) is used to communicate occupancy to the controller. Trane systems and zone sensors do not currently send this variable. The hard-wired occupancy input of this controller is handled as if it is a communicated occupancy sensor input. When both a hard-wired input and a communicated input exist, the communicated input is used.

Table 18: Effective occupancy arbitration for Tracer AH540/541 with operator display

Manual override[1] (nviOccMan Cmd)	Commun-icated schedule (nviOcc Schedule)	Local schedule	Occupancy sensor (nviOcc Sensor[3])	Local occupancy binary input	Bypass timer[4]	Result (nvoEffect Occup)
Occupied	—	—	—	—	—	Occupied
Unoccupied	—	—	—	—	zero	Unoccupied
					not zero	Bypass
Bypass	Occupied	—	—	—	—	Occupied
	Unoccupied	—	—	—	zero	Unoccupied
					not zero	Bypass
	Standby	—	—	—	zero	Standby
					not zero	Bypass
	Null[2]	Occupied	—	—	—	Occupied
		Unoccupied	—	—	zero	Unoccupied
					not zero	Bypass
		Null	Occupied	—	—	Occupied
			Unoccupied	—	zero	Unoccupied
					not zero	Bypass
			Null	Occupied	—	Occupied
				Unoccupied	zero	Unoccupied
					not zero	Bypass
				Not present	—	Occupied

1 This value is the last enumeration received. It can come from either the nviOccManCmd network variable or the operator display schedule override.
2 Null = any other value.
3 The variable nviOccSensor is used with the SCC profile only. Refer to the Null rows in this column for the DAC profile.
4 This value represents whether or not the bypass timer is at zero or not. When a bypass request is made, the timer is set to the value specified in the Occupied Bypass Timer field, and it begins to count down. While it is counting down, the value is not zero. When the count down is complete, the value is zero.

Table 18: Effective occupancy arbitration for Tracer AH540/541 with operator display (continued)

Manual override[1] (nviOccMan Cmd)	Commun-icated schedule (nviOcc Schedule)	Local schedule	Occupancy sensor (nviOcc Sensor[3])	Local occupancy binary input	Bypass timer[4]	Result (nvoEffect Occup)
Standby	—	—	—	—	zero	Standby
					not zero	Bypass
Null	Occupied	—	Occupied	—	—	Occupied
			Unoccupied	—	zero	Standby
					not zero	Bypass
			Null	Occupied	—	Occupied
				Unoccupied	zero	Standby
					not zero	Bypass
				Not present	—	Occupied
	Unoccupied	—	—	—	zero	Unoccupied
					not zero	Bypass
	Standby	—	—	—	zero	Standby
					not zero	Bypass
	Null	Occupied	Occupied	—	—	Occupied
			Unoccupied	—	zero	Standby
					not zero	Bypass
			Null	Occupied	—	Occupied
				Unoccupied	zero	Standby
					not zero	Bypass
				Not present	—	Occupied
		Unoccupied	—	—	zero	Unoccupied
					not zero	Bypass
		Null	Occupied	—	—	Occupied
			Unoccupied	—	zero	Unoccupied
					not zero	Bypass
			Null	Occupied	—	Occupied
				Unoccupied	zero	Unoccupied
					not zero	Bypass
				Not present	—	Occupied

1 This value is the last enumeration received. It can come from either the nviOccManCmd network variable or the operator display schedule override.
2 Null = any other value.
3 The variable nviOccSensor is used with the SCC profile only. Refer to the Null rows in this column for the DAC profile.
4 This value represents whether or not the bypass timer is at zero or not. When a bypass request is made, the timer is set to the value specified in the Occupied Bypass Timer field, and it begins to count down. While it is counting down, the value is not zero. When the count down is complete, the value is zero.

Timed override control

This sequence applies to both space temperature control and discharge air temperature control, with differences as noted.

If the zone sensor has a timed override option (ON/CANCEL buttons), pushing the ON button initiates a timed override request. A timed override request changes the occupancy mode from unoccupied mode to occupied bypass mode. In occupied bypass mode, the controller controls the zone temperature based on the occupied heating or cooling setpoints. The occupied bypass time, which resides in the Tracer AH540/541 and defines the duration of the override, is configurable from 0 to 240 minutes. The default value is 120 minutes for space temperature control; the default value is 0 minutes (disabled) for discharge air temperature control. When the occupied bypass time expires, the unit transitions from occupied bypass mode to unoccupied mode. Pushing the CANCEL button cancels the timed override request. A timed override cancel request will end the timed override before the occupied bypass time has expired and will transition the unit from occupied bypass mode to unoccupied mode.

If the controller is in any mode other than unoccupied when the ON button is pressed, the controller still starts the occupied bypass timer without changing the mode to occupied bypass. If the controller is placed in unoccupied mode before the occupied bypass timer expires, the controller will be placed in occupied bypass mode and remain in that mode until either the CANCEL button is pressed on the Trane zone sensor or the occupied bypass time expires.

Morning warm-up

The morning warm-up function initiates a special heating sequence to raise space temperature to occupied conditions. This sequence is especially useful for a building occupancy transition from unoccupied to occupied.

The Tracer AH540/541 controller operates this sequence according to the configured control mode.

Space temperature control: Morning warm-up

The controller keeps the outdoor air damper closed (when a mixing box is present) anytime during a occupied, occupied bypass, or occupied standby mode when the space temperature is 3ºF or more below the heating setpoint. The damper remains closed indefinitely (no time limit). As the space temperature increases above this threshold, the outdoor damper progressively opens toward the minimum position setpoint. When the space temperature is within 2ºF of the effective heating setpoint, the outdoor air damper will be at the minimum position setpoint.

The outdoor air damper normally is open to a minimum position during the occupied mode when the controller turns On the supply fan. The damper normally is closed during:

- Warm-up/cool-down mode
- Unoccupied mode
- Certain diagnostic conditions
- Low ambient damper lockout
- Anytime the supply fan is Off

Morning warm-up can also be a communicated request from a Trane Tracer Summit building automation system. When the Tracer AH540/541 controller receives a communicated morning warm-up request, heating mode is enabled and the outdoor air damper closes. The controller remains in morning warm-up until a different request is communicated.

Discharge air temperature control: Morning warm-up

If the controller is configured for discharge air temperature control, the controller requires a space temperature input (hard-wired or communicated) and setpoint input (local, communicated, or default value) to initiate the morning warm-up sequence of operation. The space temperature and setpoint inputs are used by the controller to determine if heating or cooling air should be supplied to the space.

On a transition from unoccupied to occupied, occupied bypass, or occupied standby, the controller compares the space temperature to the heating setpoint. If the space temperature is 1.5°F below the heating setpoint, morning warm-up is initiated. The outdoor air damper closes (or remains closed) and heat/cool mode is heating.

The morning warm-up control sequence has no time limit upon a transition from unoccupied to occupied, when the controller is configured for discharge air temperature control.

Morning warm-up can also be a communicated request from a building automation system. When the Tracer AH540/541 controller receives a communicated morning warm-up request, heating mode is enabled and the outdoor air damper closes. The controller remains in morning warm-up until a different request is communicated.

Daytime warm-up

This sequence applies to controllers configured for discharge air temperature control. The air-handling units must have heating capacity (hydronic or steam) and a communicated or wired space temperature must exist.

Daytime warm-up allows the controller to automatically change to heating if the space temperature is below the effective heating setpoint by a temperature that is more than the configured daytime warm-up enable differential. Daytime warm-up coordinates the controller heat/cool to heating, as well as communicates the controller mode of operation to the duct system for changeover.

The daytime warm-up start setpoint is a configurable temperature below the effective space heating setpoint. When the space temperature drops to below the start setpoint, the daytime warm-up function is initiated by the controller.

The daytime warm-up terminate setpoint is a configurable temperature above the start setpoint. When the space temperature rises above the stop setpoint, the warm-up function is terminated by the controller.

Unlike morning warm-up, the outdoor air damper is at the configured minimum position or at the communicated minimum damper position according to the effective occupancy.

Cool-down

In cool-down operation the controller closes the outdoor air damper eliminating any additional cooling load due to warm outdoor temperatures. Normally the outdoor air damper is closed in this mode of operation and hydronic or mechanical cooling is provided to cool-down the space. However if the outdoor air temperature is suitable economizer cooling is allowed.

The Tracer AH540/541 controller operates this sequence according to the configured control mode.

Space temperature control: Cool-down

If configured for space temperature control, the controller provides an automatic cool-down function on a transition from unoccupied to occupied or occupied standby mode of operation. Cool-down is initiated and the outdoor air damper remains closed if space temperature is greater than 3ºF above the active cooling setpoint. As the space temperature decreases below this threshold, the outdoor damper progressively opens toward the minimum position setpoint. When the space temperature is within 2ºF of the effective cooling setpoint, the outdoor damper will be at the occupied or occupied-standby minimum position setpoint.

Cool-down can also be initiated by a building automation system with a mode command of pre-cool (optimal-start). The controller will stay in the pre-cool until the mode is removed by the system. For more details, see Table 71 on page 101.

A heating-only air-handling-unit configuration, with no cooling capacity, disables the automatic cool-down function. The outdoor air damper (if present) will open to minimum position and provide economizing, if enabled.

Discharge air temperature control: Cool-down

If configured for discharge air temperature control, the controller enters a cool-down mode only when coordinated by a building automation system (optimal-start). In cool-down, the controller’s heat-cool mode is reported as pre-cool. The controller will stay in the pre-cool until the mode is removed by the automation system. For more details, see Table 72 on page 103.

Supply fan operation

The controller determines fan operation based on the selected control mode. If the controller is configured for space temperature control, the supply fan operates in constant-volume. If configured for discharge air temperature control, the supply fan can be configured to operate either with constant-volume or variable-air-volume.

With both constant-volume and variable-air volume supply fan operation, the controller turns the supply fan binary output (BO1) On continuously during occupied, occupied standby, and occupied bypass modes.

During the unoccupied heating and cooling modes of operation, the supply fan will cycle Off when the space temperature is between the heating and cooling setpoints. If electric heat is energized during unoccupied heating periods of operation, the supply fan will run for an additional 120 seconds after electric heat capacity is de-energized.

The supply fan is normally Off during air-handler operation with the following exceptions:

- During unoccupied mode when there is no requirement for heating and cooling
- When entering water temperature sampling is initiated
- As a result of certain diagnostic conditions
- During manual or system overrides

If a supply fan status binary input sensor is wired to the controller (at IN10) it is used to verify fan operation before heating and cooling start. Upon energizing the supply fan output BO1, the Tracer AH540/541 controller waits a configurable time period (fan status delay) to allow the fan time to reach a desired air flow. Then the controller verifies fan operation (fan status).

A Low Supply Fan Air Flow diagnostic is generated if the controller powers the fan On and the fan status switch is not in the fan running position, or if the fan status switch is not set to make the fan run within the configured time limit after the controller commands the fan On. This latching diagnostic discontinues unit operation until the diagnostic is cleared from the controller. Fan operation can also be affected by other diagnostic conditions that cause the controller to shut down the unit. See Table 63 on page 91 for details.

Constant-volume supply fan operation

For constant-volume supply fan operation, the controller must be configured either for space temperature control or for discharge air temperature control with constant-volume.

In constant-volume operation, the fan runs continuously during occupied, occupied standby, and occupied bypass modes of operation, except when the controller is in occupied mode and turns the fan Off during entering water sampling periods. During unoccupied periods, the supply fan binary output BO1 controls the supply fan Off and On depending on heating or cooling requirements. The supply fan is normally Off during unoccupied modes of operation when space temperature is between the unoccupied heating and cooling setpoints.

If the controller is wired to a Trane zone sensor, the user can change the supply fan operation through the fan mode switch (when present). When the fan mode switch is in the Off position, the controller shuts down the unit. If the fan mode switch is moved to the Auto position, the controller operates the fan On and Off according to heat and cool demands and the active occupancy mode.

Variable-air-volume supply fan operation: Duct static pressure

For variable-air-volume supply fan operation, the controller must be configured for both discharge air temperature control and for variable-air-volume fan operation.

When configured for variable-air-volume operation, the controller uses a duct static pressure control routine. Variable-air-volume operation always maintains duct static pressure control in all modes of operating with the supply fan On. The air-handling unit duct static pressure is maintained by a duct static pressure control sequence.

The supply fan variable frequency drive in a variable-air-volume system is controlled to maintain the duct static pressure setpoint. When the fan is On, the controller reads and compares the duct static pressure input to the duct static pressure setpoint and adjusts the supply fan speed analog output signal (AO1) to the variable frequency drive.

The duct static pressure signal can be from a wired sensor or communicated via a network variable. If the controller does not have a valid duct static pressure from a wired sensor or communicated, the controller generates a Duct Static Press Failure diagnostic and shuts down the unit. The controller does not operate duct static pressure control without a valid duct static pressure input.

If the controller has both a hard-wired and communicated duct static pressure input, the communicated value is used for duct static pressure control. The greater of the two values, local (hard-wired) or communicated, is used for duct static pressure high limit shutdown.

The Tracer AH540/541 controller has a configurable duct static pressure high limit setpoint. If the duct static pressure exceeds the duct static pressure high limit setpoint, the controller shuts down the unit and generates a Duct Static Press High Limit diagnostic. This latching diagnostic must be cleared from the controller before the unit is allowed to operate.

Valve operation

This sequence applies to both space temperature control and discharge air temperature control.

The controller uses analog modulating (0–10 Vdc or 2–10 Vdc) valves for heating or cooling operation. The controller supports one or two modulating valves for hydronic heating, steam heat, and hydronic cooling operation. The Tracer AH540/541 controller supports both one- and two-valve unit configurations. See Chapter 5, "Configuration" for more information about heating and cooling configurations.

Heating only, cooling only, and heating and cooling controller configurations will always use the heating analog output for valve heating and cooling analog output for valve cooling. For two-pipe changeover configurations with only one hydronic coil installed, use the cooling analog output for heating/cooling valve operation.

Normally, heating and cooling valves remain closed any time the supply fan is Off. Valves can open when the supply fan is Off during:

- Entering water temperature sampling
- Freeze avoidance
- Certain diagnostic conditions
- Valve override open

The Tracer AH540/541 controller operates with either normally open or normally closed valves. The normal state of the valve is the position of the valve when power is not applied. When power is applied, the controller has full control of the valve. For example, if the fan mode switch on the zone sensor is in the Off position, the controller closes the valve, regardless if it is configured normally open or normally closed.

Freeze-avoidance valve cycling

During low-temperature detect or freeze-avoidance diagnostic conditions that cause the unit to shutdown, the controller opens all heating and cooling valves 100% to prevent the coil from freezing. When hydronic or steam heat is present, the controller cycles the heat valve output On, then Off, over a period of five minutes (configurable) to prevent excessive unit cabinet temperatures. The heat valve output open position is configurable from 0 to 100%.

For example, if valve cycling, duty cycle is configured for 25% (default), the controller opens the valve for 75 seconds (25% of 5 minutes) and closes it for 225 seconds.

Two-pipe changeover

This sequence applies only space temperature control.

The controller provides a two-pipe changeover function when an air-handling unit has one hydronic coil for heating and cooling operation. Two-pipe changeover allows the controller to provide heating or cooling to the space depending on the entering water temperature.

When a two-pipe changeover unit has secondary electric heat the controller uses the electric heat if the entering water temperature is not appropriate for heating. If entering water temperature is appropriate for heating, the controller uses hydronic heating and disables electric heat operation.

Two-pipe changeover units without an auxiliary source of heat, like electric heat, determine their mode based on the following sequence:

1. If the controlled space requires heating or cooling, the controller changes from heating to cooling and cooling to heating based on the space temperature, active setpoint, and integrated error between the two. Once the controller changes modes, it verifies the entering water temperature.
2. If the controller does not have a valid entering water temperature (hard-wired or communicated), the controller assumes hot water is present.
3. When the entering water temperature is not appropriate for the desired capacity (either heating or cooling), the controller remains at 0% hydronic capacity. Economizer cooling would remain available if needed regardless of the entering water conditions.
4. If the entering water temperature is appropriate for heating or cooling, the controller energizes the appropriate output to control the space temperature at the heating setpoint in heating mode or cooling setpoint in cooling mode.

Entering water temperature sampling

This sequence applies to controllers configured for space temperature control.

If configured for space temperature control, the controller can sample the entering water condition for air-handling units with a single hydronic coil. The entering water temperature is important for reliable heating and cooling control. The entering water temperature must be at least 5ºF above the space temperature for hydronic heating and 5ºF below the space temperature for hydronic cooling for satisfactory capacity control.

Three-way valve applications

When using three-way control valves, the central water supply flows continuously to the unit valve and is either directed through the coil or bypassed around the coil. Because the water flow is continuous, the entering water temperature sensor can be installed on the pipe where the flow rate is constant. For both three-way valves and bleed lines, continuous water flow when combined with proper sensor location gives a continuous and reliable measurement of the entering water temperature.

Note:
Entering water sampling (also referred to as purge) is not required for three-way valve applications.

Two-way valve applications

The AH540/541 controller offers a control solution for two-way valve applications. The entering water temperature sampling function (purge) periodically opens the two-way valve to allow temporary water flow, producing a reliable entering water temperature measurement.

When water flows normally and frequently through the coil, the controller does not initiate the entering water temperature sampling function because the water temperature measurement is valid for determining the entering water condition. During unit startup or changeover, the controller determines its ability to deliver heating or cooling. The controller initiates the entering water temperature function to determine if the entering water temperature is adequate for delivering the desired heating or cooling. The measurement must indicate that the water is warm enough to heat the space or cool enough to cool the space.

When the controller initiates the entering water temperature sampling function, the controller turns Off the supply fan and opens the hydronic valve for no more than the maximum sampling time while measuring entering water temperature. An initial stabilization period is allowed to open the valve to a configured position (50% default) and to flush the piping. When this temperature stabilization period has expired, the controller compares the entering water temperature to the effective space temperature (either hard-wired or communicated) to determine if it can be used for the desired mode. The controller continues to compare the entering water temperature to the effective space temperature for the maximum sampling time (see Table 52 on page 80).

Whenever the entering water temperature is warmer than 110°F, the controller assumes the entering water temperature is hot because it is unlikely the coil would drift to a high temperature unless the actual temperature was very high. See Figure 15 on page 105 for a detailed description of the entering water sampling process.

If the entering water temperature is not usable for the required space demand, the controller closes the water valve and starts the supply fan until the next sampling period (configurable). If the controller determines the entering water temperature is adequate for heat or cooling, it resumes normal heating/cooling control and effectively disables entering water sampling until it is required.

Entering water temperature sampling is disabled when:

- Unit configuration is dedicated heating and cooling or two-pipe changeover without purge (three-way valve application).
- Entering water temperature is communicated to the controller.
- For cooling, entering water temperature is less than five degrees colder than the space temperature or greater than 110°F.
- For heating, entering water temperature is greater than 5º warmer than the space temperature.

Face-and-bypass damper operation

This sequence applies to both space temperature control and discharge air temperature control.

The face-and-bypass damper modulates a percentage of air to the face of the heat coil and around the coil (bypass) to maintain the supply air temperature setpoint. The air passing through the hot water coil is mixed with the air bypassing the coil to produce a desired discharge air temperature.

The Tracer AH540/541 controller supports face-and-bypass operation for low outdoor temperature heating modes of operation only. During low outdoor temperatures, when the outdoor air temperature is lower than the face-and-bypass heat modulation setpoint, the heating valve is fully opened and the face-and-bypass damper is used for heating to prevent the coil from freezing. During economizer cooling operation, when outdoor temperature is less than the face and bypass heat modulation setpoint, the face-and-bypass damper is full bypass.

The face-and-bypass heat modulation setpoint is the outdoor air temperature (40°F default, configurable) at which the controller changes over to face and bypass heating operation. The face-and-bypass heat modulation setpoint can be changed using the Rover service tool.

When the outdoor air temperature is greater than 3°F above the face-and-bypass heating modulation setpoint, the hydronic heating valve is modulated to maintain discharge air temperature. The face-and-bypass damper is positioned for full face air flow. When the outdoor air temperature is less than the face and bypass heating modulation setpoint, the controller fully opens the heating valve and uses the heat face-and-bypass damper to modulate heating capacity to maintain the desired discharge air temperature.

During diagnostic and fan Off conditions, when the controller shuts down unit operation, the face-and-bypass damper is in the full bypass position. During freeze avoidance operation or a Low Temp Detect diagnostic, the face-and-bypass damper is driven to full face.

Table 19. Face-and-bypass damper operation based upon outdoor air temperature

Outdoor air temperature	Hydronic heating valve	Face-and-bypass damper
Outdoor air temperature is greater than face-and-bypass heat modulation setpoint[1]	Modulated to maintain desired setpoint	Full coil face (operation disabled)
Outdoor air temperature is less than-face and-bypass heat modulation setpoint	100% open	Modulated to maintain desired setpoint (operation enabled)

1 The outdoor air temperature must rise 3°F above the face and bypass heating enable point before face-and bypass-heating operation is disabled.

Outdoor air damper operation

This sequence applies to both space temperature control and discharge air temperature control.

The controller operates the modulating outdoor air damper according to effective occupancy, outdoor air temperature (communicated or hard-wired sensor), space temperature, effective space temperature setpoint, discharge air temperature, and discharge air temperature setpoint. Default minimum damper positions are provided and can be changed using the Rover service tool for occupied and occupied standby ventilation.

The controller can also receive a communicated outdoor air damper minimum position setpoint. A communicated minimum position setpoint has priority over all configured minimum position setpoints. When a communicated minimum position setpoint is not present, the controller uses the configured minimum setpoints (see Table 20 on page 56).

Table 20. Determining the outdoor air damper minimum position setpoint

Occupancy	nviOAMinPos communicated value	Active outdoor air damper minimum position setpoint
Unoccupied	Present or not present	Zero
Occupied	Present	Communicated value
	Not present	Occupied minimum
Occupied bypass	Present	Communicated value
	Not present	Occupied minimum
Occupied standby	Present	Communicated value
	Not present	Occupied standby minimum

During occupied modes, the damper remains at a minimum damper position, whether it is configured or communicated.

Mixed-air temperature control

The Tracer AH540/541 controller provides minimum ventilation requirements according to the effective occupancy mode. Ventilation requirements are maintained by mixed-air temperature control depending on available heating and cooling sources, unit configuration, and mixed-air temperature control type (configurable). Low mixed-air temperatures can be a concern for units with hydronic heating and cooling.

Mixed-air temperature control is used to maintain the mixed-air temperature above the mixed-air low-limit setpoint (configurable). See Table 21 on page 57. If the air-handling unit does not have a mixing box section, then mixed-air temperature control is not required.

Table 21. Mixed-air temperature control

Air-handling unit configuration	Mixed-air temperature control type (configurable)	Controller action
No mixing box present	None	None
Heat only unit Cool only unit Cool reheat unit Preheat cool unit	Mixed-air temperature control	Reduce ventilation. Mixed-air temperature is maintained above the mixed-air low-limit setpoint (48°F default, configurable) by reducing the outdoor air ventilation below minimum position. The lower percent of outdoor air raises the mixed-air temperature.
Preheat cool unit	Mixed-air preheat control	Preheat before reducing ventilation. Preheat capacity is used to maintain the mixed-air temperature above the mixed-air low-limit setpoint (48°F default, configurable). If 100% preheat capacity does not maintain the mixed-air temperature above the mixed-air low-limit setpoint, outdoor air ventilation is reduced below minimum position.

Heat only, cool only, preheat cool, or cool reheat air-handling configurations with a mixing box can be configured for mixed-air temperature control. If cold outdoor air conditions exist, depending on ventilation requirements, the mixed-air temperature can create freezing conditions. Mixed-air temperature control reduces the outdoor air damper below the minimum position to maintain mixed-air temperature above the mixed-air low-limit setpoint.

Air-handling units with preheat can use mixed-air preheat control to maintain mixed-air temperature before reducing ventilation. Cold entering air conditions from the mixing box can be heated with the preheat capacity to maintain the mixed-air temperature above the mixed-air low-limit setpoint. Mixed-air preheat control attempts to use preheat until it has reached 100% capacity. At 100% preheat capacity, if mixed-air temperature is below the low-limit temperature, the mixed-air preheat control then lowers the outdoor air damper below the minimum position to maintain mixed air above the mixed-air low-limit setpoint.

If ventilation is not a concern, the Tracer AH540/541 controller can be configured for mixed-air temperature control when preheat capacity is available. Mixed-air preheat control is the best choice for preheat air-handling units with ventilation requirements.

Mixed-air temperature sensor location

It is important to mount the mixed-air temperature sensor in the proper location according to the mixed-air temperature control configuration (see Table 22).

Table 22. Mixed-air temperature sensor location

Mixed-air temperature control configuration selected	Mixed-air temperature sensor location
Mixed-air temperature control	Entering air side of the first coil
Mixed-air preheat control	Leaving air side of the first coil

Economizing

This sequence applies to both space temperature control and discharge air temperature control.

Economizing is a mode in which outdoor air is used as a source of cooling capacity before hydronic cooling. With a valid outdoor air temperature (either hard-wired or communicated) or a communicated Enable command from the Tracer Summit system, the Tracer AH540/541 controller uses the modulating economizer damper as the highest priority source of free cooling.

Economizing is possible during the occupied, occupied standby, unoccupied, and occupied bypass modes. It requires a mixed-air temperature sensor and an air-handling unit equipped with a mixing box. The mixed-air temperature sensor is used as a low-temperature limit, to keep mixed-air temperatures above freezing. It also requires an outdoor air temperature value to be present. If an outdoor temperature is not available, a communicated request can enable economizing.

The controller initiates the economizer function if the outdoor air temperature is cold enough to be used as free cooling capacity. If the outdoor air temperature is less than the economizer enable setpoint (absolute dry bulb), the controller modulates the outdoor air damper (between the active minimum damper position and 100%) to control the amount of outdoor air cooling capacity. When the outdoor air temperature rises 5°F above the economizer enable point, the controller disables economizing and moves the outdoor air damper back to its predetermined minimum position based on the current occupancy mode or communicated minimum damper position (see Table 23 on page 59).

Table 23. Relationship between outdoor temperature sensors and damper position

	Outdoor air damper		
Outdoor air temperature	**Occupied or Occupied bypass**	**Occupied standby**	**Unoccupied**
No or invalid outdoor air temperature	Open to occupied minimum position	Open to occupied standby minimum position	Closed
Failed outdoor air sensor	Open to occupied minimum position	Open to occupied standby minimum position	Closed
Outdoor air temperature less than the low ambient damper lockout setpoint[1]	Closed	Closed	Closed
Outdoor air temperature present and economizing feasible	Economizing, damper controlled between occupied minimum position and 100%	Economizing, damper controlled between occupied standby minimum position and 100%	Open and economizing during unit operation, otherwise closed
Outdoor air temperature present and economizing not feasible[2]	Open to occupied minimum position	Open to occupied standby minimum position	Closed

1 The low ambient damper lockout setpoint is a configurable temperature setpoint used to close the outdoor air damper, regardless of occupancy, when extreme outdoor air temperatures are present.
2 The Tracer AH540/541 controller disables economizing if the mixed-air temperature sensor is not present or is not valid.

Low ambient damper lockout

The controller closes the outdoor air damper during any heating, cooling, or economizer mode of operation or occupancy when extreme outdoor air temperatures exist. This condition disables outdoor air damper ventilation and economizing functions, but low ambient damper lockout does not affect other unit operations.

The outdoor air temperature must rise 9°F (5°C) above the low ambient damper lockout setpoint before economizing and ventilation become possible again.

Exhaust fan operation

This sequence applies to both space temperature control and discharge air temperature control.

The exhaust fan/damper is coordinated with the unit supply fan and outdoor damper operation. The exhaust output is energized only when the unit supply fan is operating and the outdoor damper position is greater than or equal to the configurable exhaust fan start setpoint. The exhaust fan output is disabled when the outdoor air damper position drops 10% (configurable) below the exhaust fan start setpoint. If the enable point is less than 10% (configurable), the unit turns On at the start setpoint and Off at zero.

The controller logic commands the exhaust fan to be energized/de-energized based on the target position of the economizing damper. Because of device stroke time, the state of the exhaust fan may change before the economizing damper reaches its target position.

If the exhaust fan start setpoint is set at or lower than the outdoor air damper minimum position, the exhaust fan will be On continuously when the outdoor air damper is at minimum position.

If the exhaust fan start setpoint is set higher than the outdoor air damper minimum position (minimum ventilation) the exhaust fan will be Off during periods of minimum ventilation. During economizer cooling operation the exhaust fan start setpoint can be selected to compensate for the increased outdoor ventilation.

The exhaust fan status binary input is present to detect operation of a belt-driven exhaust fan. An Exhaust Fan Air Flow diagnostic is detected when the control starts the exhaust fan and the exhaust fan status binary input does not indicate operation after two minutes. This is an exhaust fan latching diagnostic and discontinues exhaust operation until the diagnostic is reset. All other control functions continue to operate normally.

Electric heat operation

This sequence applies to both space temperature control and discharge air temperature control, with differences as noted.

The Tracer AH540/541 supports two methods of controlling staged electric heat:

- Staged electric heat using binary outputs.
- Staged electric heat using a sequencer

For details, see “Staged electric heat” on page 61.

Electric heat operation can produce high discharge air temperatures if the unit air flow rate is low or the entering air temperature is high. The controller provides an electric heat discharge high limit control in addition to functional and safety limits of the product. In draw-through unit configurations in which the electric heat source is positioned before the supply fan in the air stream, the discharge air temperature is limited to 115°F (default). Blow-through electric heat unit configurations allow a discharge-air-control high limit of 135°F (see Table 44 on page 79).

The Tracer AH540/541 controller supports only unit configurations with one source of heating capacity, with the exception of a two-pipe changeover unit with electric heat, if the controller is configured for space temperature control (see “Two-pipe changeover” on page 53). When hydronic-heating capacity is available, electric heat operation is disabled. If hydronic-heating capacity is not available, electric heat is enabled.

Electric heat is normally disabled during:

- Hydronic heating (two-pipe changeover unit)
- Building automation system mechanical heating lockout is active

- Cooling modes of operation (except dehumidification)
- Anytime the supply fan is Off

Electric heat operation is restricted to heating modes of operation. When staged electric heat is mounted in preheat position (before cooling capacity), the controller will not allow the use of electric heat for mixed-air preheat control. If mixed-air temperature control is desired because of installed hydronic capacity, mixed-air temperature control should be used rather than mixed-air preheat control.

Space temperature control: Electric heat

For space temperature control applications, the Tracer AH540/541 performs cascade space temperature control and stages electric heat capacity up and down based on the discharge air temperature and discharge air temperature setpoint.

Discharge air temperature control: Electric heat

For discharge air temperature control with variable-air-volume fan operation, the Tracer AH540/541 provides electric heat operation only with the following sequences:

- Morning warm-up
- Daytime warm-up
- Unoccupied mode

If one of these sequences is initiated, the VAV boxes are controlled to their fully open position or to the maximum air flow setpoint. The controller responds by modulating the supply fan speed to maintain the duct static pressure at the duct static pressure setpoint (see “Variable-air-volume supply fan operation: Duct static pressure” on page 51).

The controller will delay electric heat operation for the maximum heat delay time (4 minutes default, configurable). Because duct static pressure control is always maintained, maximum heat delay allows time for the VAV boxes to fully open and allows the air handler to establish full airflow before electric heat operation begins.

Staged electric heat

The controller stages the heaters On sequentially, adding 1 stage every 2 minutes. In the unoccupied heating mode, the supply fan will delay turning Off for 120 seconds after electric heat capacity stages Off to remove residual heat.

The controller supports two methods of controlling staged electric heat:

- Staged electric heat using binary outputs
- Staged electric heat using a sequencer

Staged electric heat using binary outputs

One to four electric heat stages can be directly controlled from binary outputs. Since the controller binary outputs can also be configured for stages of DX cooling the binary outputs are assigned as follows where the number of electric heat stages plus the number of DX cooling stages cannot exceed four outputs.

- BO3: DX cooling stage 1 or Electric heat stage 4
- BO4: DX cooling stage 2 or Electric heat stage 3
- BO5: DX cooling stage 3 or Electric heat stage 2
- BO6: DX cooling stage 4 or Electric heat stage 1

Staged electric heat using a sequencer

Analog output AO3 can be configured to control an electric heat sequencer. This option fixes the AO3 output configuration at 0–10 Vdc, normally closed. The sequencer discrete binary outputs control the electric heat stages. The AO3 signal will step according to the configured sequencer control thresholds, the number of stages installed, and to the number of stages to be energized. See Table 30 on page 74.

For example, if the controller is configured for electric heat sequencer and six heat stages, connect the step controller to analog output AO3 according to device-specific wiring instructions.

For this example, configure the Tracer AH540/541 controller as follows:

- AO3: Electric Heat (Sequencer)
- Number of electric heat stages: 6
- Electric heat sequencer control: default values (see Table 30 on page 74)

Care should be taken to match the sequencer characteristics to the Tracer AH540/541 configuration. The controller will step AO3 according to the defined configuration. Figure 12 illustrates the default operation for a six-stage electric heat sequencer configuration. Table 24 on page 63 shows staging characteristics for a common, off-the-shelf, sequencer with one to six stages. According to the table, the sequencer requires a minimum input of 5.21 Vdc to turn On the third stage. Analog output AO3 will output 6 Vdc to energize the third stage of the sequencer, default configuration.

Figure 12. Tracer AH540/541 default operation for a six-stage electric heat sequencer configuration

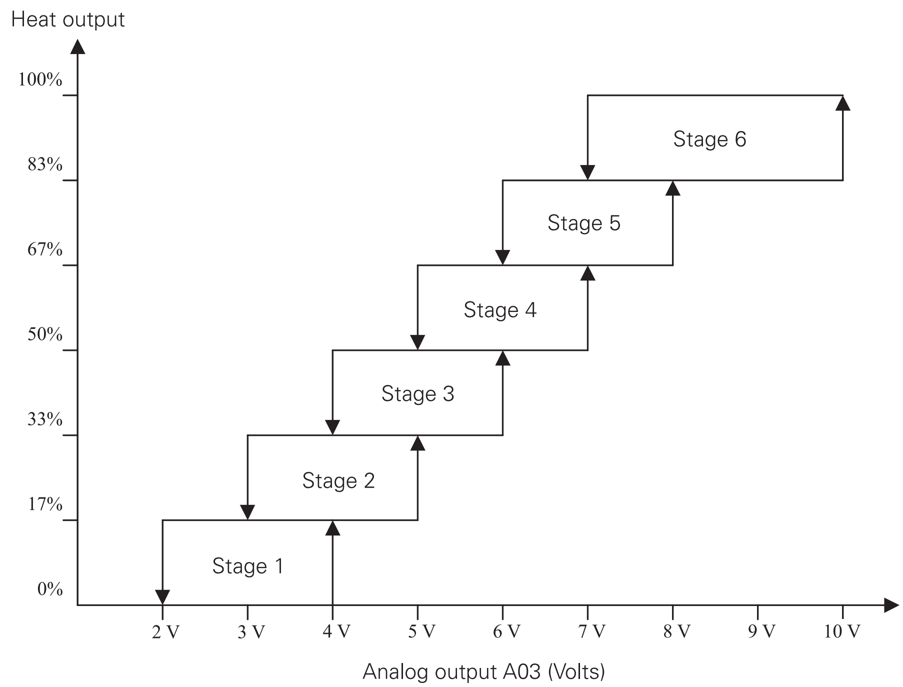


Table 24. Typical staging of a step controller, output stage verses input voltage

Stage	Sequencer											
	1 stage		2 stage		3 stage		4 stage		5 stage		6 stage	
	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
1	5.75 V	2.00 V	4.50 V	2.00 V	3.88 V	2.00 V	3.50 V	2.00 V	3.25 V	2.00 V	3.07 V	2.00 V
2			7.00 V	4.50 V	5.75 V	3.88 V	5.00 V	3.50 V	4.50 V	3.25 V	4.14 V	3.07 V
3					7.63 V	5.75 V	6.50 V	5.00 V	5.75 V	4.50 V	5.21 V	4.14 V
4							8.00 V	6.50 V	7.00 V	5.75 V	6.29 V	5.21 V
5									8.25 V	7.00 V	7.36 V	6.29 V
6											8.43 V	7.36 V

DX cooling operation

This sequence applies to both space temperature control and discharge air temperature control.

The Tracer AH540/541 controller provides four DX cooling binary outputs to control up to four stages of cooling. A cascade control algorithm is used for space temperature control. Valid discharge air temperature sensor and space temperature sensor inputs are required for operation. As space temperature rises above the cooling setpoint, it creates a demand for more discharge-air cooling capacity. Discharge air temperature control directly controls DX cooling to provide discharge air temperature at the desired discharge-air cooling setpoint.

Anytime the discharge air temperature drops below the discharge-air low-limit setpoint (45°F, configurable) DX cooling capacity is reduced to prevent low discharge air temperatures.

DX cooling operation will be suspended if the outdoor air temperature falls below the compressor lockout temperature setpoint (50°F default, configurable). DX cooling will automatically resume when the outdoor air temperature is greater than the compressor lockout temperature plus 5°F. DX cooling can also be suspended by communicated mechanical cooling lockout command from a building automation system. DX cooling will remain disabled until the mechanical cooling lockout is released.

DX cooling can be coordinated with economizer operation by adjusting the Economizer Enable Temperature (60°F, default). Given the default setpoints for DX cooling and economizer operation based on outdoor air temperature, DX and economizer operation will be initiated when outdoor air temperature falls below 60°F. DX cooling will be disabled below 50°F outdoor air temperature and economizing will be disabled above 65°F outdoor air temperature.

When outdoor air temperature is less than 50°F DX cooling operation will be disabled. When outdoor air temperature rises above 65°F, economizer operation is disabled.

DX cooling is normally disabled if:

- System mechanical cooling lockout is active
- Outside air temperature is less than compressor cooling lockout setpoint
- Defrost condition exists
- Supply fan is Off

Staged DX cooling

One to four DX cooling stages can be directly controlled from binary outputs. Since the controller binary outputs can also be configured for stages of electric heat the binary outputs are assigned as follows where the number of DX cooling stages plus the number of electric heat stages cannot exceed four outputs.

- BO3: DX cooling stage 1 or Electric heat stage 4
- BO4: DX cooling stage 2 or Electric heat stage 3
- BO5: DX cooling stage 3 or Electric heat stage 2
- BO6: DX cooling stage 4 or Electric heat stage 1

The controller will enforce a minimum On time and minimum Off time for each compressor stage. A compressor will not be allowed to stage On until the compressor minimum Off time has expired and a compressor will not be allowed to stage Of until the compressor minimum On time has expired. See Table 39 on page 77.

Inter-stage delays are also enforced. A minimum of 3 minutes will be enforced between additional cooling stages. A minimum of 2 minutes will be enforced between subtracting cooling stages.

Defrost operation

Low evaporator refrigerant temperatures can cause the coil to frost. The Tracer AH540/541 controller provides two methods of detecting low evaporator refrigerant temperatures:

- One uses the evaporator refrigerant temperature (analog input IN13) to measure suction temperature
- The other uses a binary thermostat device (binary input IN7 or IN12) applied to the evaporator suction line

Two-circuit split-system DX cooling applications should provide an evaporator refrigerant sensor or binary thermostat device on the first circuit or the circuit with the first cooling stage. As an option, both an evaporator refrigerant sensor and binary thermostat can be used on a unit with one device installed on each circuit. The controller will respond according to either frost input.

Two binary thermostat devices can also be used with one device installed on each circuit. The devices are separately hard-wired to coil defrost inputs IN7 and IN12, or the thermostat devices are wired in series to coil defrost input IN7 or IN12.

Evaporator refrigerant temperature

A 10 kΩ thermistor can be hard-wired to the universal analog input IN13. The controller has the ability to directly measure the evaporator refrigerant temperature. If evaporator refrigerant temperature drops below the defrost setpoint (30°F, default) the controller will unload one compressor stage every 120 seconds. If the refrigerant temperature rises above the defrost setpoint, DX cooling will stop unloading and each stage that frosted will be enabled after a minimum of 10 minutes. If the refrigerant temperature increases above the defrost setpoint + 10°F, an integrating function is initiated. When the evaporator refrigerant time-temperature satisfied, defrost operation is terminated. When defrost is terminated, DX cooling capacity is allowed to once again stage On (see Table 25).

Table 25. Evaporator refrigerant temperature effect on DX cooling

Evaporator refrigerant temperature	DX cooling operation
Less than defrost setpoint.	• DX cooling outputs will turn Off in sequence according to a time-temperature function until the refrigerant temperature rises above the defrost setpoint.
Between defrost setpoint and defrost setpoint +10°F.	• DX cooling outputs stop unloading. • Frosted DX cooling outputs will be re-enabled following a minimum 10 minute defrost time interval.
Greater than defrost setpoint +10°F.	• A time-temperature function will enable all compressor stages.

Coil defrost binary input

The controller provides two binary inputs that can optionally be configured for coil defrost, IN7 and IN12. These inputs should be used if the universal analog input is not available or cannot be configured for evaporator refrigerant temperature.

When the coil defrost binary input is active, the controller de-energizes the last active DX cooling stage. All subsequent binary outputs will de-energize; one stage every 120 seconds or until the coil defrost binary input resets to a normal state.

DX split-system cooling

The Tracer AH540/541 controller provides air-handling-unit, direct-expansion-cooling sequence of operation for split-system air-handling units. In order for the control system to operate, the controller must be properly wired and configured to the condensing unit.

The controller does not provide any lead-lag, condensing unit protection, condenser fan control, or periodic pump-out control. Pump-out and condenser fan control must be coordinated with condensing unit operation using electromechanical devices.

Compressor stages and circuits

The Tracer AH540/541 controller provides four 24 Vac binary outputs (BO3 to BO6) for staged DX cooling. Each output is energized sequentially BO3, BO4, BO5, BO6 as cooling capacity demand increases in a last-On, first-Off method. To optimize the controller ability to manage coil frost conditions, adhere to the following staging and circuit information when making wiring connection between the controller and the condensing unit.

For four-stage, two-circuit condensing units connect BO3 to the first stage of circuit 1, BO4 to the first stage of circuit 2, BO5 to the second stage of circuit 1, and, finally, BO6 to the second stage of circuit 2 (see Table 26 on page 67).

Table 26. DX cooling compressor circuit wiring

Tracer AH540/541 controller		Condensing unit	
DX cooling stages	Binary output	Single circuit	Two circuit
1	BO3	1st stage	N/A
2	BO3	1st stage	1st stage of circuit 1
	BO4	2nd stage	1st stage of circuit 2
4	BO3	1st stage	1st stage of circuit 1
	BO4	2nd stage	1st stage of circuit 2
	BO5	3rd stage	2nd stage of circuit 1
	BO6	4th stage	2nd stage of circuit 2

Frost protection

The controller provides three options for coil frost protection. Use the Rover service tool to properly configure the controller for the following options.

- Analog thermistor input (evaporator refrigerant temperature sensor) wired to the universal analog input (IN13).
- Binary thermostat device wired to binary input IN7, coil defrost input.
- Binary thermostat device wired to binary input IN12, coil defrost input.

Two-circuit split-system DX cooling applications should apply an evaporator refrigerant sensor or binary thermostat device on the first circuit or the circuit of the first cooling stage.

For protection on each circuit both an evaporator refrigerant sensor and binary thermostat sensor or two binary thermostat sensors can be used at the same time. Apply a sensor to each circuit. The controller will respond according to the active input.

Also two binary thermostat devices can be applied to each circuit and wired in series to binary input IN7 or IN12. If either device detects a low refrigerant temperature condition, the controller will enter a defrost mode of operation.

Minimum On and Off timers

Remove (if installed), or disable, all electromechanical compressor minimum On and Off timers from the condensing unit. The controller will enforce a minimum On time and minimum Off time for each compressor stage. A compressor will not be allowed to stage On until the compressor minimum Off time has expired, and a compressor will not be allowed to stage Off until the compressor minimum On time has expired (see Table 39 on page 77).

Neglecting to remove or disable the electromechanical timers will cause the compressor operation to lose coordination with the controller compressor staging control, and will result in poor control performance.

Dehumidification

This sequence applies only to space temperature control.

The Tracer AH540/541 controller provides both occupied and unoccupied dehumidification control when cooling and reheat capacity is available. The dehumidification control sequence is allowed on unit configurations with hydronic or DX cooling and hydronic or electric reheat.

Both occupied and unoccupied space humidity setpoints are provided as well as setpoint offset values (10% default) to terminate dehumidification mode. To disable occupied space dehumidification, set the Occupied Space RH setpoint to 0%. Likewise, to disable unoccupied space dehumidification, set the Unoccupied Space RH setpoint to 0%. Use the Rover service tool to edit these setpoints.

Space dehumidification requires a space relative humidity sensor input hard-wired to the universal analog input IN13 or a communicated RH value. If both a hard-wired relative humidity sensor and a communicated RH value is present, the communicated value will be used for dehumidification control.

Occupied and unoccupied mode dehumidification

When the space relative humidity is greater than the Occupied Space RH Setpoint, dehumidification control is initiated. The dehumidification control mode will remain active until space relative humidity is less than the Occupied Space RH Setpoint minus Occupied Space RH Offset value. The controller will automatically revert back to occupied or occupied standby space temperature control.

When in unoccupied mode and the space relative humidity is greater than the Unoccupied Space RH Setpoint, dehumidification is initiated until space relative humidity is less then the Unoccupied Space RH Setpoint minus Unoccupied Space RH Offset value. The controller will automatically revert back to unoccupied space temperature control.

Space temperature and relative humidity are both controlled when dehumidification is active. Cooling capacity is modulated or staged to reduce space humidity, while heating capacity is modulated or staged to control space temperature. Hydronic cooling capacity is modulated (increased and decreased) to offset the relative humidity load in the space. DX cooling capacity operates as a limit control and is only allowed to stage up (increase) to maintain or decrease the relative humidity in the space.

Occupied and unoccupied mode dehumidificiation: Cooling only

In occupied or unoccupied mode, when dehumidification mode is active and space temperature is greater than the space occupied cooling setpoint minus 1.5°F (0.83ºC), dehumidification is controlled with only cooling capacity. Cooling capacity is increased to further dry the supply air to the space (see A in Figure 13).

Occupied and unoccupied mode dehumidificiation: Cooling and reheat

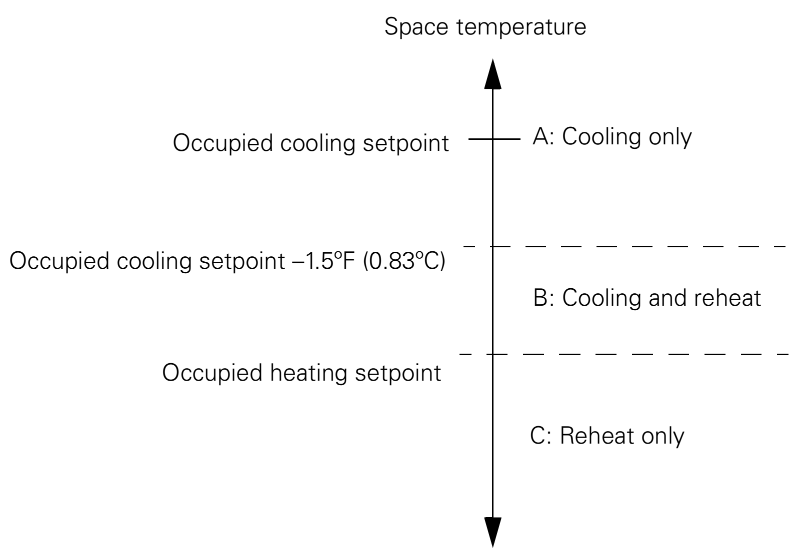
If the space temperature drops 1.5°F (0.83ºC) below the occupied cooling setpoint, reheat capacity is invoked and modulated to maintain space temperature control. Cooling capacity continues to modulate or stage to reduce space humidity (see B in Figure 13).

Occupied and unoccupied mode dehumidificiation: Reheat only

Anytime the space temperature drops below the occupied heating setpoint (occupied, occupied standby, or unoccupied), cooling capacity is disabled and reheat only is provided until the space temperature raises to 3°F (1.67ºC) below the occupied cooling setpoint.

At the time dehumidification is initiated, if space temperature is greater than 3ºF (1.67ºC) below the occupied cooling setpoint, reheat only is provided until space temperature rises to within 3ºF (1.67ºC) of the occupied cooling setpoint (see C in Figure 13).

Figure 13. Space dehumidification heating and cooling control



Unit protection strategies

The following strategies are initiated, for both space temperature control and discharge air temperature control, when specific conditions exists in order to protect the unit or building from damage:

- Run/stop binary input (see “IN8: Run/stop” on page 25)
- Supply fan status (“IN10: Supply fan status” on page 26)
- Condensing unit protection
  - Coil defrost (see “Defrost operation” on page 65)
  - Compressor minimum On/Off timers (see “DX cooling operation” on page 64)
- Duct static pressure high limit (see “Variable-air-volume supply fan operation: Duct static pressure” on page 51)
- Coil freeze protection
  - Face-and-bypass heating (“Face-and-bypass damper operation” on page 55)
  - Freeze avoidance (see “Freeze-avoidance valve cycling” on page 52)
  - Mixed-air temperature control (see “Mixed-air temperature control” on page 57)
  - Low-temperature detection (see “IN7: Low-temperature detection or coil defrost” on page 24)
- Supply fan motor thermal protection (see “Electric heat operation” on page 60)
- Filter status (see “Filter status” on page 70)
- Freeze avoidance (see “Freeze avoidance” on page 70)

Filter status

The controller filter status is based on the supply fan cumulative run hours. The controller compares the fan run time against an adjustable fan run hours limit (maintenance required setpoint time, stored in the controller) and recommends unit maintenance as required. The Maintenance Required diagnostic is informational only. Its state does not affect unit operation.

Use the Rover service tool to edit the Maintenance Required setpoint time. When the setpoint limit is exceeded, the controller generates a Maintenance Required diagnostic. To disable the diagnostic feature, set the maintenance required setpoint time to zero.

You can use Rover service tool or Tracer Summit to clear the Maintenance Required diagnostic. When the diagnostic is cleared, the controller resets the fan run time to zero and resumes accumulating fan run hours.

Freeze avoidance

Freeze avoidance is used as low ambient temperature protection and is only initiated anytime the supply fan is Off. The controller enters the freeze avoidance mode when the outdoor air temperature is below the freeze avoidance setpoint (configurable). The controller disables freeze avoidance when the outdoor air temperature rises 3°F (1.67ºC) above the freeze avoidance setpoint. When the controller is in freeze avoidance mode:

- All water valves are driven open to allow water to flow through the coil
- Steam and hydronic heat valves are cycled open and closed to prevent excessive cabinet temperatures
- Supply fan is Off
- Face-and-bypass damper (when present) is at full bypass

Freeze avoidance protects the air-handling unit hydronic heating and cooling coils from freezing when cold outdoor air temperatures are present and the supply fan is Off. For example, the Tracer AH540/541 is not able to run the air-handling unit because the run/stop input is set to stop (supply fan is Off). If the outdoor air temperature is below the freeze avoidance setpoint, the Tracer AH540/541 opens all water valves.

Overrides

The controller has the capability, whether using space temperature control or discharge air temperature control, to override both analog and binary output (typically for testing and commissioning) through the Tracer Summit building automation system or from the Rover service tool. For more information about the output overrides, refer to literature for those products.

In addition, AH540/541 override capability include:

- Manual output test
- Emergency override
- Water valve override

Manual output test

The controller includes a manual output test function, which allows the user to manually exercise the outputs in a predefined sequence using the Test push button (see “Performing a manual output test” on page 84). You can also perform the manual output test remotely using the Rover service tool. The Rover service tool communications through the Comm5 link to place the controller in service override mode. From the Rover computer screen you can step the controller through the manual output test.

Emergency override

The Tracer AH540/541 controller can be placed into emergency override by using the communication variable (nviEmergOverride). Emergency override allows a building automation system such as Trane Tracer Summit to pressurize, depressurize, or purge the air from a building space. It can also be used to shut down the controller operation of the unit.

The emergency override command influences the controller's supply fan, outdoor air damper, and exhaust fan to create the desired condition, as shown in Table 27.

Table 27. Emergency override commands

Command	Supply fan	Outdoor air damper	Exhaust fan
Pressurize	On	Open	Off
Depressurize	Off	Close	On
Purge	On	Open	On
Shutdown	Off	Close	Off

Duct static pressure (when present) is always controlled when the supply fan is running. Freeze avoidance in emergency override can force the heating and cooling valves open.

Water valve override

To support water balancing, the controller includes a communication variable (nviValveOverride) that allows a user to specify the desired state of all water valves. The states supported are:

- Open all valves
- Close all valves

Unless the communicated variable is refreshed within 10 hours, the override ends and the valve operation reverts to normal heating/cooling operation.

Use the Rover service tool to access this feature.

Chapter 5
Configuration

The Tracer AH540/541 controller is factory configured and commissioned with fixed sequences of operation. All of the controller configuration parameters are predefined and loaded based upon the air-handling unit configuration. The Rover service tool provides access to these parameters to make adjustments to the controller operation. (Refer to the *Rover Operation and Programming* guide, EMTX-SVX01E-EN, for more information.)

Use the Rover service tool to configure the Tracer AH540/541 controller. You can configure each of the inputs as normally open or normally closed. Configure inputs or outputs that are not in use (one to which no device is physically connected) as Not Used. This will disable the generation of diagnostics for this function.

The Tracer AH540/541 contains configuration parameters for selecting the control mode of the air-handling unit, heating and cooling source, face-and-bypass damper, and outdoor air damper. The desired air-handler operation determines the valid temperature control options: space temperature control or discharge air temperature control. See Table 28 through Table 48.

Table 28. Control mode configuration

Air-handler operation	Temperature control options
Constant-volume	• Discharge air temperature control • Space temperature control
Variable-air-volume	• Discharge air temperature control

Table 29. Unit type configuration

Unit type	Entering water sampling (purge)	Secondary heat
Heating only	N/A	N/A
Cooling only	N/A	N/A
Heating and cooling	N/A	N/A
Heating and cooling (two-pipe changeover)	• None • Entering water sampling	• None • Electric heat staged • Electric heat sequencer

Table 30. Controller location label configuration

Location label	Maximum length
Name the controller to identify its physical location.	30 characters

Table 31. Heating configuration

Heating type	Heating source	Electric heat stages	Face-and-bypass damper
• Preheat • Reheat	Hydronic	N/A	• None • Face-and-bypass damper
	Steam	N/A	N/A
	Staged electric heat[1]	1, 2, 3, or 4	N/A
	Electric heat sequencer[2]	1, 2, 3, 4, 5, or 6	N/A

1 When heating source is staged electric heat, the controller binary outputs BO6, BO5, BO4, and BO3, are used to control discrete electric heat stages 1, 2, 3, or 4, respectively.
2 When heating source is electric heat sequencer the heat analog output AO3 is used to control a step controller/sequencer, up to six stages.

Table 32. Supply fan heat source configuration

Heating source
Draw-through
Blow-through

Note: Configure the supply fan to indicate the relationship of the supply fan to the heating source. For example, if the heating source is located after the supply fan in the air stream, blow-through should be selected. If the unit is heating and cooling (two-pipe changeover), indicate the relationship of the supply fan to the secondary heat source, if installed.

Table 33. Cooling source configuration

Cooling source	DX cooling stages	Outdoor air damper
Hydronic[1]	N/A	• None • Outdoor air damper
DX cooling[2]	1, 2, 3, or 4	

1 When cooling source is hydronic, the cool analog output AO2 is used to control a modulating valve.
2 When cooling source is DX cooling, controller binary outputs BO3, BO4, BO5, and BO6 are used to control discrete compressor stages.

Table 34. Binary output configuration

Terminal label	Function[1]
BO1	Supply fan
BO2	Exhaust fan
BO3	• None • DX cooling stage 1 • Electric heat stage 4
BO4	• None • DX cooling stage 2 • Electric heat stage 3
BO5	• None • DX cooling stage 3 • Electric heat stage 2
BO6	• None • DX cooling stage 4 • Electric heat stage 1

1 Factory-installed Tracer AH540 controllers are configured according to model number specification.

Table 35. Analog output configuration

Analog output[1]	Function	Output voltage range	Valid range[2]	Default value
AO1	Supply fan speed	• 0–10 Vdc • 2–10 Vdc	• Normally slow • Normally fast	• 0–10 Vdc • Normally open
AO2	Cool output	• 0–10 Vdc • 2–10 Vdc	• Normally open • Normally closed	• 2–10 Vdc • Normally closed
AO3	Heat output	• 0–10 Vdc • 2–10 Vdc	• Normally open • Normally closed	• 2–10 Vdc • Normally open
AO4	Face-and-bypass damper	• 0–10 Vdc • 2–10 Vdc	• Normally face • Normally bypass[3]	• 2–10 Vdc • Normally face
AO5	Outdoor air damper	• 0–10 Vdc • 2–10 Vdc	• Normally open • Normally closed	• 2–10 Vdc • Normally closed

1 The Rover service tool uses the unit type to determine and download the proper default analog output configuration. For example, if you configure the controller as a space temperature controller, Rover will not allow AO1 to be configured for a supply fan speed output. Analog output AO1 is only used when the controller is configured as a variable-air-volume controller.
2 The normally open/closed configuration item refers to the inactive state of the end device, such as a cooling valve. If the device is a normally open valve, the configuration for analog output AO2 must be normally open.
3 A normally face damper is positioned full coil face, and a normally bypass damper is positioned full coil bypass when the analog output is at 0 Vdc.

Table 36. Analog input configuration

Analog input[1]	Function	Calibration range	Default value
IN1	Space temperature	±10.0°F (±5.7°C) (0.1°F resolution)	0°F
IN2	Setpoint	±10.0°F (±5.7°C) (0.1°F resolution)	0°F
IN3	Fan switch	N/A	N/A
IN4	Discharge air temperature	N/A	N/A
IN5	Outdoor air temperature	N/A	N/A
IN6	Mixed-air temperature	N/A	N/A
Duct static	Duct static pressure	N/A	N/A
IN13	• Space relative humidity • CO2 sensor • Entering water temperature • Evaporator refrigerant temperature • Generic temperature	N/A	Space relative humidity

1 The Rover service tool uses the unit type to determine and download the proper default analog input configuration.

Table 37. Binary input configuration

Binary input[1]	Function	Valid range	Default Configuration
IN7	• Low temp detect • Coil defrost • Not used	• Normally open • Normally closed	Dependent on air-handling unit type
IN8	• Run/stop • Not used	• Normally open • Normally closed • Latching or nonlatching	• Run/stop • Normally open • Latching diagnostic[2]
IN9	• Occupancy • generic • Not used	• Normally open • Normally closed	• Occupancy • Normally open
IN10	• Supply fan status • Not used	• Normally open[3] • Normally closed[3]	Sales order dependent
IN11	• Filter status • Not used	• Normally open[4] • Normally closed[4]	Sales order dependent
IN12	• Exhaust fan status • Coil defrost • Not used	• Normally open • Normally closed	Sales order dependent

1 The Rover service tool uses the unit type to determine and download the proper default binary input configuration.
2 The run/stop binary input can be configured as a latching or nonlatching diagnostic.
3 When the supply fan is Off, the state of the fan status device is its normal state. For example, if the fan status switch (end device) is normally open when the fan is Off, the controller should be configured for a normally open fan status input.
4 When the supply fan is Off, the state of the filter status device is its normal state. For example, if the filter status switch (end device) is normally closed when the fan is Off, the controller should be configured for a normally closed filter status input.

Table 38. Outdoor air damper configuration

Parameter	Valid range	Default value
Economizer control	Enable or disable	Enable or disable
Economizer temperature (dry bulb)	32°F to 122°F (0°C to 50°C)	50°F (10°C)
Occupied minimum position	0 to 100%	15%
Occupied standby minimum position[1]	0 to 100%	10%
Low ambient lockout setpoint[2]	-40°F to 32°F (-40°C to 0°C)	-20°F (-28.9°C)
Ramp time[3]	0–30 minutes	5 minutes

1 Occupied standby minimum damper position only applies to space temperature control operation.
2 This is the outdoor air temperature below which the outdoor air damper will always be closed.
3 Adjustable open time for the outdoor air damper to open from 0% to minimum position.

Table 39. DX cooling configuration

Parameter	Valid range	Default value
Ambient lockout setpoint[1]	-40 to 122°F (-40 to 50°C)	50°F (10°C)
Discharge low limit setpoint[2]	32 to 122°F (0 to 15°C)	45°F (7.22°C)
Coil defrost setpoint[3]	20 to 40°F (-6.67 to 4.44°C)	30°F (-1.11°C)
Compressor minimum On timer	3 to 20 minutes	3 minutes
Compressor minimum Off timer	3 to 20 minutes	3 minutes

1 If outdoor air temperature is less than the compressor lockout temperature DX cooling is disabled.
2 If discharge air temperature is less than this setpoint the controller will start reducing DX cooling capacity.
3 When the universal analog input is configured for evaporator refrigerant temperature, and applied to the suction line of a split DX system; if the evaporator refrigerant temperature is below the defrost setpoint the controller will reduce DX cooling capacity.

Table 40. Dehumidification control configuration

Parameter	Valid range	Default value
Occupied space RH setpoint[1]	0–100%	60%
Occupied space RH offset[2]	0–100%	10%
Unoccupied space RH setpoint[1]	0–100%	60%
Unoccupied space RH offset[2]	0–100%	10%
Reheat stages allowed[3]	0–6 stages	6 (all stages available)

1 Setting the occupied space RH setpoint to 0% disables occupied dehumidification control; likewise, setting the unoccupied space RH setpoint to 0% disables unoccupied dehumidification control.
2 The space RH offset value is subtracted from the space RH setpoint to determine the dehumidification control termination setpoint.
3 Number of electric heat stages allowed for dehumidification control.

Table 41. Local zone sensor fan switch configuration

Parameter	Valid range	Default
Zone sensor fan switch	Enabled or disabled	Enabled

Table 42. Space temperature setpoint and limit configuration

Default setpoint	Valid range	Default value
Occupied heating setpoint	40 to 115°F (4.44 to 46.1°C)	71°F (21.7°C)
Occupied cooling setpoint	40 to 115°F (4.44 to 46.1°C)	74°F (23.3°C)
Occupied standby heating setpoint	40 to 115°F (4.44 to 46.1°C)	67°F (19.4°C)
Occupied standby cooling setpoint	40 to 115°F (4.44 to 46.1°C)	78°F (25.6°C)
Unoccupied heating setpoint	40 to 115°F (4.44 to 46.1°C)	60°F (15.6°C)
Unoccupied cooling setpoint	40 to 115°F (4.44 to 46.1°C)	85°F (29.4°C)
Heating setpoint low limit[1]	40 to 115°F (4.44 to 46.1°C)	40°F (4.4°C)
Cooling setpoint low limit[1]	40 to 115°F (4.44 to 46.1°C)	40°F (4.4°C)
Heating setpoint high limit[1]	40 to 115°F (4.44 to 46.1°C)	104°F (40°C)
Cooling setpoint high limit[1]	40 to 115°F (4.44 to 46.1°C)	104°F (40°C)
Thumbwheel setpoint	Disable or enable	Enable

1 The heating and cooling setpoint high and low limits only apply to the occupied and occupied standby setpoints and are never applied to the unoccupied setpoints.

Table 43. Space temperature control discharge air temperature setpoint and limit configuration

Setpoints and limits	Valid range	Default value
Unoccupied heating discharge air temperature setpoint	38 to 150°F (3.3 to 65.6°C)	100°F (37.8°C)
Unoccupied cooling discharge air temperature setpoint	35 to 150°F (1.7 to 65.6°C)	55°F (12.8°C)
Electric heat discharge air temperature high limit[1]	70 to 200°F (21.1 to 93.3°C)	115°F (46.1°C) draw-through 135°F (57.2°C) blow-through

1 Electric heat capacity is reduced if the discharge air temperature exceeds this limit.

Table 44. Discharge air temperature control setpoint configuration

Setpoints and limits	Valid range	Default value
Discharge air temperature cooling setpoint	32°F to 86°F (0°C to 30°C)	55°F (12.8°C)
Discharge air temperature heating setpoint	50°F to 158°F (10°C to 70°C)	100°F (37.8°C)
Discharge air temperature cooling setpoint high limit	32°F to 86°F (0°C to 30°C)	68°F (20°C)
Discharge air temperature cooling setpoint low limit	32°F to 86°F (0°C to 30°C)	44.6°F (7°C)
Discharge air temperature heating setpoint high limit	32°F to 158°F (0°C to 70°C)	104°F (40°C)
Discharge air temperature heating setpoint low limit	32°F to 158°F (0°C to 70°C)	86°F (30°C)

Table 45. Daytime warm-up setpoint configuration

Parameter	Valid range	Default value
Daytime warm-up start setpoint[1]	40 to 87.0°F (4.4 to 30.6°C)	62°F (16.7°C)
Daytime warm-up termination setpoint[2]	43 to 90°F (6.1 to 32.2°C)	71°F (21.7°C)

1 When the space temperature is below the daytime warm-up start setpoint, the daytime warm-up sequence is initiated.
2 When the space temperature is above the daytime warm-up stop setpoint, the daytime warm-up sequence is terminated.

Table 46. Duct static pressure setpoint and limit configuration

Parameter	Valid range	Default value
Duct static pressure high limit[1]	0 to 5 inH_2O (0 to 1250 Pa)	4 inH_2O (1000 Pa)
Duct static pressure setpoint	0 to 5 inH_2O (0 to 1250 Pa)	1.5 inH_2O (375 Pa)
Duct static pressure setpoint high limit	0 to 5 inH_2O (0 to 1250 Pa)	3 in H_2O (750 Pa)
Duct static pressure setpoint low limit	0 to 5 inH_2O (0 to 1250 Pa)	0.5 inH_2O (125 Pa)

1 This is the pressure at which the controller shuts down the unit to prevent duct damage.

Table 47. Mixed-air temperature control configuration

Parameter	Valid range	Default value
Mixed-air low limit setpoint[1]	-4°F to 104°F (-20°C to 40°C)	48°F (8.9°C)
Mixed-air control sequence[2]	• None • Mixed-air control • Mixed-air preheat control	Dependent on air-handler type
Pre-ventilation setpoint[3]	32°F to 86°F (0°C to 30°C)	48°F (8.9°C)

1 If the mixed-air temperature reaches this low limit setpoint, the controller uses the configured mixed-air control sequence to maintain mixed-air temperature above the configured mixed-air low limit setpoint.
2 The Tracer AH540/541 controller can be configured three different ways to control mixed-air temperature above the mixed-air low-limit temperature. If *none* is selected, the controller does not attempt to prevent low mixed-air temperature conditions. Low temperature detect provides unit freeze protection from freezestat binary input IN7. *Mixed-air* control reduces the outdoor air damper minimum position to maintain mixed-air temperature. The *mixed-air preheat* control sequence first attempts to use preheat (if available) to maintain mixed-air temperature above the low limit temperature. If preheat capacity cannot maintain the air-handling unit's mixed-air temperature above the configured mixed-air low limit temperature, the controller lowers the outdoor air damper below its minimum ventilation position.
3 If discharge air temperature or mixed-air temperature is less than the pre-ventilation setpoint, heating capacity is energized early in the unit start-up process.

Table 48. Supply fan status ignore time configuration

Parameter	Valid range	Default value
Fan status ignore time[1]	0.0 to 6,553 seconds	45 seconds

1 This configuration property defines the maximum period of time the supply fan status binary input is ignored after the control has started the supply fan.

Table 49. Face-and-bypass damper heat modulation setpoint configuration

Parameter	Valid range	Default value
Heat modulation setpoint	14 to 122°F (-10 to 50°C)	40°F (4.4°C)

Note: This parameter is only used when a face-and-bypass damper is present. When the outdoor air temperature is below this outdoor-air-temperature setpoint, the face-and-bypass damper is used to modulate the hydronic heat capacity. When the outdoor air temperature rises to 3°F (1.67°C) above this setpoint, the heat valve is used to modulate the hydronic heat capacity.

Table 50. Freeze avoidance setpoint configuration

Parameter	Valid range[1]	Default value
Freeze avoidance setpoint[2]	32 to 122°F (0 to 50°C)	35°F (1.67°C)

1 A freeze avoidance setpoint value outside the valid range disables the freeze avoidance function.
2 This setpoint defines the outdoor air temperature with which the controller initiates the freeze avoidance function.

Table 51. Freeze avoidance valve configuration

Parameter	Valid range	Default value
Time period	0 to 120 minutes	20 minutes
Duty cycle[1]	0 to 100%	50%
Valve open position[2]	0 to 100%	50%

1 Duty cycle is the percentage of the time period the steam valve is open.
2 The steam valve open position can be set to a partially open position to prevent excessive steam coil temperatures.

Table 52. Entering water temperature sampling configuration

Parameter	Valid range	Default value
Time period between sampling cycles	60 to 1440 minutes	120 minutes
Maximum sampling time[1]	90 to 3600 seconds	180 seconds
Ignore time[2]	0 to 30 seconds	60 seconds
Valve position during sampling	0 to 100%	50%

1 The controller will sample the entering water temperature for this amount of time, after the ignore time.
2 The entering water will not be sampled until ignore time has expired, allowing the water valve time to open and establish flow.

Table 53. Timer configuration

Parameter	Valid range	Default value
Power-up control wait	0 to 1000 seconds	300 seconds
Maintenance required time setpoint (based on fan run hours)	0 to 10,000 hours	600 hours
Occupancy bypass timer [1] Space temperature control	0 to 240 minutes (1-minute resolution)	120 minutes
Occupancy bypass timer [1] Discharge air control	0 to 100% (1-minute resolution)	50%
Maximum heat delay [2]	0 to 60 seconds	240 seconds (4 minutes)

1 The occupied bypass time is used for timed override applications when a building automation system is not present or when the building automation system does not send the occupied (override) request. The timed override timer is maintained in the unit controller. When the timed override is applicable, the controller reports Occupied Bypass as its effective occupancy mode.
2 Amount of time a variable-air-volume unit will delay electric heat operation on a transition from occupied to daytime warm-up operation.

Table 54. Diagnostic alarm level configuration

Parameter	Valid range	Default value
Diagnostic alarm level[1]	• Service required • Critical alarm	Service required
Diagnostic language[2]	• English • Spanish • French	English

1 Duct Static Pressure Failure, Duct Static Pressure High Limit, Space Temperature Failure, Discharge Air Temperature Failure, Unit Shutdown, Low Temperature Detect, and Low Supply Fan Air Flow diagnostics can be configured as a group to be either service required or critical alarm diagnostics; the diagnostics cannot be individually configured.
2 Alarm message text that will be communicated to the building automation system.

Table 55. Analog electric heat sequencer control configuration

Parameter[1]	Range	Default value	Default value					
			1 stage	2 stage	3 stage	4 stage	5 stage	6 stage
Stage 1 On	0 to 10 V	4.2 V	10.0	6.6	5.6	4.9	4.5	4.2
Stage 1 Off	0 to 10 V	0 V	0.0	0.0	0.0	0.0	0.0	0.0
Stage 2 On	0 to 10 V	5.2 V	10.0	10.0	7.4	6.4	5.7	5.2
Stage 2 Off	0 to 10 V	3.6 V	10.0	5.4	4.7	4.2	3.8	3.6
Stage 3 On	0 to 10 V	6.3 V	10.0	10.0	10.0	7.8	7.0	6.3
Stage 3 Off	0 to 10 V	4.7 V	10.0	10.0	6.4	5.6	5.1	4.7
Stage 4 On	0 to 10 V	7.4 V	10.0	10.0	10.0	10.0	8.2	7.4
Stage 4 Off	0 to 10 V	5.7 V	10.0	10.0	10.0	7.1	6.3	5.7
Stage 5 On	0 to 10 V	8.4 V	10.0	10.0	10.0	10.0	10.0	8.4
Stage 5 Off	0 to 10 V	6.8 V	10.0	10.0	10.0	10.0	7.5	6.8
Stage 6 On	0 to 10 V	10.0 V	10.0	10.0	10.0	10.0	10.0	10.0
Stage 6 Off	0 to 10 V	7.8 V	10.0	10.0	10.0	10.0	10.0	7.8

1 These set-up parameters are required for Tracer AH540/541 to properly stage electric heat when a step controller is connected to analog output AO3. The controller assumes each stage On and Off voltage threshold matches the step controller setup.

Chapter 6

Verifying operation and communication

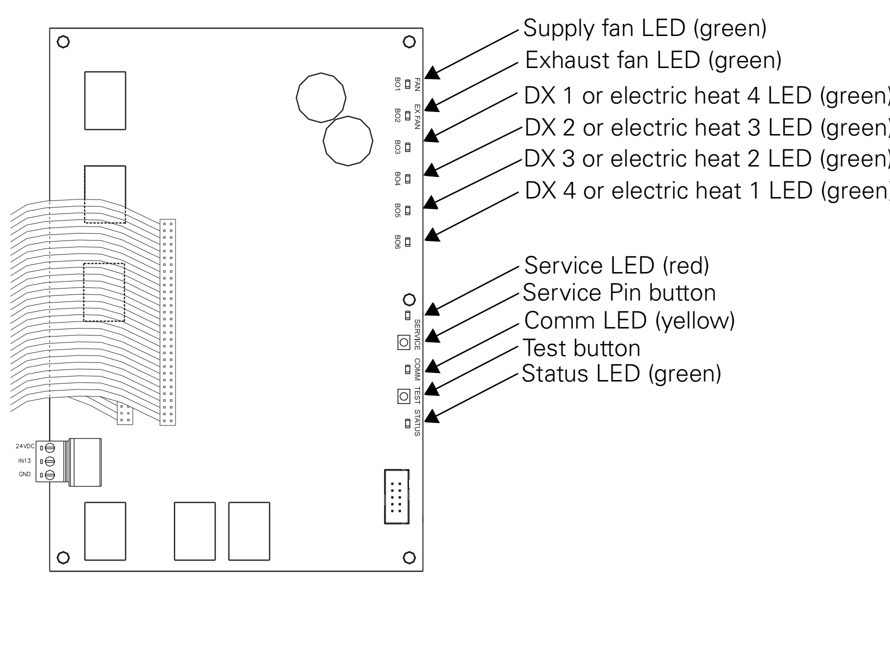
This chapter describes:

- Test button
- How to perform a manual output test
- Service Pin button
- Light-emitting diodes (LEDs)
- Diagnostic conditions

Test button

The Test button is located on the main controller board, as identified in Figure 14. You can use it to perform the manual output test, which verifies that the controller is operating properly. The manual output test is described in the next section.

Figure 14. Locations of Test button, Service Pin button, and LEDs



Performing a manual output test

The manual output test sequentially controls all outputs to verify their wiring and operation. Normal operation of the controller is suspended while the manual output test is being performed.

You can use the manual output test to clear the controller of diagnostics. If any diagnostics are present when a manual test is initiated, the Status LED blinks twice. During the second step of the test, the controller attempts to clear the diagnostics. If the controller cannot clear a diagnostic, the controller exits the manual output test.

You can also use the manual output test for air and water balancing. Step four of the test provides cooling capacity. Step five provides heating capacity. Step four also opens the outdoor air damper to the minimum occupied position and controls the duct static-pressure to the duct static-pressure setpoint.

You can perform the manual output test in three ways:

- Press the Test button to proceed through the test sequence
- Use the Rover service tool
- Use the operator display

To perform a manual output test using the Test button:

1. Press and hold the Test button for 3 to 4 seconds, then release the button to start the test mode. The green Status LED light turns Off when the Test button is pressed, and then it blinks (as described in Table 59 on page 87) when the button is released to indicate the controller is in manual test mode.

2. Press the Test button (no more than once per second) to advance through the test sequence. Table 56 on page 85 shows the resulting activities of the outputs.

3. Finish the test by advancing through the complete test sequence. The test will end automatically if the unit remains in a single step for ten hours.

Table 56. Manual output test sequence

Step[1] (number of times Test button is pressed in sequence)	Supply fan	Cool output(s)	Heat output(s)	Face and bypass damper	Outdoor air damper	Exhaust fan
Step 1[2]	Off, 0%	Closed	Closed	Bypass	Closed	Off
Step 2[3]	On, 0%	Closed	Closed	Face	Closed	Off
Step 3	On, DSP[4]	Closed	Closed	Face	Closed	Off
Step 4	On, DSP	Open or On[5, 6]	Closed	Face	Occupied minimum position	Off
Step 5	On, DSP	Closed	Open or On[7]	Face	Occupied minimum position	Off
Step 6	On, DSP	Closed	Closed	Bypass	Open	On[8]
Step 7	Return to normal operation[9]					

1 The following diagnostics cause the Tracer AH540/541 to exit the manual output test:
- Duct Static-pressure High Limit
- Low Supply Fan Air Flow
- Low Temp Detect
- Unit Shutdown

2 When the manual output test starts, all outputs are turned Off or closed. The status LED blinks once if there are no diagnostics and blinks twice if any diagnostics are present.
3 At the beginning of step 2, the controller attempts to clear any existing diagnostics. If the controller is unsuccessful clearing a diagnostic, the controller exits the manual output test.
4 If the controller is configured for variable-air-volume (VAV) control, the controller tests duct static-pressure (DSP) control during steps 3 through 6.
5 If the Tracer AH540/541 cooling type is hydronic or two-pipe changeover, the valve will open 100% in step 4. If the cooling type is DX the first stage of cooling will be energized in step 4, and each additional DX output will energize sequentially with each Test button press (maximum of 4-stages).
6 DX cooling stages will not energize if defrost operation is active. See "Defrost operation" on page 65 for more information.
7 If the Tracer AH540/541 heating type is hydronic or steam, the valve will open 100% in step 5. If the heat type is staged electric or analog electric the first stage of heating will be energized in step 5, and each additional electric heat output will energize sequentially with each Test button press. Staged electric can have a maximum of 4-stages. Analog electric can have a maximum of 6 stages.
8 If an exhaust-fan status diagnostic occurs, the controller turns Off the exhaust fan during step 6.
9 The controller exits the test by initiating a reset and returning the controller to normal operation.

Service Pin button

The Service Pin button is located on the main circuit board as shown in Figure 14 on page 83. You can use the Service Pin button to:

- Identify a device
- Add a device to the active group in Rover
- Verify communication with Rover

Note:
As an alternative to pressing the Service Pin button, you can hold down the zone sensor ON button for 10 seconds to verify communication with Rover by sending a Service Pin message request (see “Service Pin message request” on page 29).

- Make the green Status LED “wink” to verify that the controller is communicating on the link

Refer to the *Rover Operation and Programming* guide, EMTX-SVX01E-EN, for information on how to use the Service Pin button.

Interpreting LEDs

The information in this section will help you interpret LED activity. The location of each LED is shown in Figure 14 on page 83.

Binary output LEDs (green)

The FAN (BO1) LED indicates the status of the first binary output, which controls the supply fan. The EX FAN (BO2) LED indicates the status of the second binary output, which controls the exhaust fan. Binary outputs BO3, BO4, BO5, BO6 indicate the status of stages of DX cooling and electric heat. Table 57 describes the LED activity for these binary outputs.

Note:
Each binary output LED reflects the status of the output relay on the circuit board. It may or may not reflect the status of the equipment the binary output is controlling. Field wiring determines whether or not the state of the binary output LED also applies to status of the end device. Table 57 describes the LED states.

Table 57. Binary output LEDs (green)

LED activity	Explanation
LED is On continuously	The relay output is energized.
LED is Off continuously	The relay output is de-energized or there is no power to the board.

Service LED (red)

The Service LED indicates whether the controller is operating normally. Table 58 describes Service LED activity.

Table 58. Service LED (red)

LED activity	Explanation
LED is Off continuously when power is applied to the controller	The controller is operating normally.
LED is On continuously when power is applied to the controller	The controller is not working properly, or someone is pressing the Service Pin button.
LED blinks once every second	The controller is not executing the application software because the network connections and addressing have been removed.[1]

1 Restore the controller to normal operation using the Rover service tool.

Status LED (green)

The green Status LED indicates whether the controller is receiving power and if the controller is in manual test mode. Table 59 describes Status LED activity.

Table 59. Status LED (green)

LED activity	Explanation
LED is On continuously	Power is on (normal operation).
LED blinks once	The controller is in manual output test mode. No diagnostics are present.
LED blinks twice	The controller is in manual output test mode. One or more diagnostic is present.
LED blinks (¼ second On, ¼ second Off for 10 seconds)	The auto-wink option is activated, and the controller is communicating.[1]
LED blinks rapidly	Flash download is being received.
LED is Off continuously	Either the power is Off or the controller has malfunctioned.

1 By sending a request from the Rover service tool, you can request the controller’s green LED to blink (“wink”), a notification that the controller received the signal and is communicating.

Comm LED (yellow)

The yellow Comm LED indicates the communication status of the controller. Table 60 describes Comm LED activity.

Table 60. Comm LED (yellow)

LED activity	Explanation
LED is Off continuously	The controller is not detecting any communication (normal for stand-alone applications).
LED blinks	The controller detects communication (normal for communicating applications, including data sharing).
LED is On continuously	An abnormal condition that may occur during discovery. The LED may flash fast enough to look as if it is on continuously. If this LED activity occurs at any other time, the site may have excessive radio frequency interference (RFI).

Required inputs for unit operation

The following locally wired sensor or communicated inputs are required for each control function listed in Table 61. If any one of the sensors does not exist, the controller operates the control function.

Table 61. Required inputs

Control function	Input required to be present (locally wired sensor or communicated value)	Controller operation if input is not present
Variable-air-volume control	Duct static pressure	Diagnostic shutdown
Discharge air temperature control	Discharge air temperature	Diagnostic shutdown
Space temperature control	Space temperature Discharge air temperature	Diagnostic shutdown Diagnostic shutdown
Economizer operation	Outdoor air temperature Mixed-air temperature	Economizer disabled
Space dehumidification	Space relative humidity	Dehumidification disabled
Two-pipe changeover	Entering water temperature	Hydronic capacity assumed to be appropriate for cooling

Diagnostics

Table 63 on page 91 describes the diagnostics that can be generated by the Tracer AH540/541 controller. There are three types of diagnostics:

- Critical—The controller shuts down the unit to prevent possible damage. The controller cannot operate until the diagnostic condition is corrected.
- Service required—The controller disables certain sequences of operation while attempting to maintain unit operation. For example, if the mixed-air temperature sensor fails or is not wired, the controller disables economizer operation.
- Informational—The controller operates normally.

Resetting diagnostics

Diagnostics that cause the unit to shutdown or disable certain operations are either latching or non-latching. Latching diagnostics require manual resetting. Non-latching diagnostics automatically clear when the condition that caused the diagnostic is solved.

Resetting is similar to cycling power to the unit. Resetting clears any latching diagnostics and allows the controller to restart the air-handling unit, if it is running normally. If the condition that caused the latching diagnostic is still present, however, the controller immediately shuts down the unit.

You can reset diagnostics in a variety of ways:

- Manual output test
- Cycling power to the controller
- Building automation system
- Rover service tool
- Any communicating device able to access the diagnostic reset input of the controller
- Zone sensor fan mode switch
- Operator display

Manual output test

Use the Test button on the controller during installation to verify proper end-device operation or during troubleshooting. When you press the Test button, the controller exercises all outputs in a predefined sequence. The first and last outputs of the sequence reset the controller diagnostics. See “Performing a manual output test” on page 84.

Cycling power

When the 24 Vac power to the controller is turned Off and then On, the unit cycles through a power-up sequence (see “Power-up sequence” on page 40). By default, the controller attempts to reset all diagnostics during this sequence.

Building automation system

Some building automation systems can reset controller diagnostics. For more complete information, refer to the product literature for the building automation system.

Rover service tool

You can reset controller diagnostics with the Rover service tool (see the *Rover Operation and Programming* guide, EMTX-SVX01E-EN).

Diagnostic reset input

Any device that can communicate the network variable *nviRequest* (enumeration “clear_alarm”) can reset controller diagnostics.

Zone sensor fan mode switch

When the zone sensor fan mode switch is changed from Off to Auto, the controller attempts to reset all diagnostics. If the zone sensor fan mode switch has been disabled by configuration, then the switch is ignored and cannot be used to reset diagnostics.

Operator display

You can view and reset active diagnostics from the operator display. Active diagnostics are indicated by a flashing status light on the display.

Interpreting multiple diagnostics

Two or more diagnostics can be present at the same time. Diagnostics are reported in the order in which they occur, but each diagnostic has a different priority. For example, if a freezestat condition occurs, the controller communicates a Low Temp Detect diagnostic message at priority one, shuts down the air-handler, and opens all valves. If a stop input condition then occurs, the controller communicates a Unit Shutdown diagnostic message at priority two. However, because the Low Temp Detect diagnostic has a higher priority, the controller does not close the valves.

Table 62 lists the Tracer AH540/541 diagnostics in order of priority, with 1 being the highest and 22 being the lowest.

Table 62. Diagnostics in order of priority

1	Emergency Override	12	Local Fan Switch Failure
2	Manual Output Test	13	Outdoor Air Temp Failure
3	Low Temp Detect	14	Mixed Air Temp Failure
4	Unit Shutdown	15	Humidity Input Failure
5	Low Supply Fan Air Flow	16	Entering Water Temp Failure
6	Low Exhaust Fan Air Flow	17	CO_2 Sensor Failure
7	Space Temperature Failure	18	Evap Refrigerant Temp Failure
8	Duct Static Press Failure	19	Generic Temperature Failure
9	Duct Static Press High Limit	20	Dirty Filter
10	Discharge Air Temp Failure	21	Maintenance Required
11	Local Space Setpoint Failure	22	Invalid Unit Configuration

Table 63 interprets each diagnostic according to what effect it has on the controller outputs.

Table 63. Tracer AH540/541 diagnostics

<table>
<tr><th>Diagnostic</th><th>Configuration</th><th>Outputs</th></tr>
<tr><td>Emergency Override
(informational; nonlatching)</td><td>Space temperature control
Discharge air temperature control</td><td>See “Emergency override” on page 71.</td></tr>
<tr><td>Manual Output Test
(informational; nonlatching)</td><td>Space temperature control
Discharge air temperature control</td><td>See “Performing a manual output test” on page 84.</td></tr>
<tr><td>Low Temp Detect[1,2]
(critical or service required; latching)</td><td>Space temperature control
Discharge air temperature control</td><td>Supply fan: Off
Valves (cooling): Open
Valves (heating): Open/closed
DX cooling/Electric heat: Disabled
Outdoor air damper: Closed
Face and bypass damper: Face
Exhaust fan: Off</td></tr>
<tr><td>Duct Static Press High Limit[2]
(critical or service required; latching)</td><td rowspan="2">Discharge air temperature control</td><td rowspan="7">Supply fan: Off
Valves: Closed
DX cooling /Electric heat: Disabled
Outdoor air damper: Closed
Face and bypass damper: Bypass
Exhaust fan: Off</td></tr>
<tr><td>Duct Static Press Failure
(critical; nonlatching)</td></tr>
<tr><td>Unit Shutdown[2]
(critical or service required; latching)</td><td rowspan="4">Space temperature control
Discharge air temperature control</td></tr>
<tr><td>Low Supply Fan Air Flow[2]
(critical or service required; latching)</td></tr>
<tr><td>Discharge Air Temp Failure[2,3]
(critical or service required; nonlatching)</td></tr>
<tr><td>Invalid Unit Configuration[2]
(service required; latching)</td></tr>
<tr><td>Space Temperature Failure[2,3]
(critical or service required; nonlatching)</td><td>Space temperature control</td></tr>
<tr><td>Low Exhaust Fan Air Flow
(service required; latching)</td><td>Space temperature control
Discharge air temperature control</td><td>Supply fan: Normal operation
Valves: Normal operation
DX cooling /Electric heat: Normal operation
Outdoor air damper: Normal operation
Face and bypass damper: Normal operation
Exhaust fan: Off</td></tr>
<tr><td>Outdoor Air Temp Failure[3]
(service required; nonlatching)</td><td rowspan="2">Space temperature control
Discharge air temperature control</td><td rowspan="2">Supply fan: Normal operation
Valves: Normal operation
DX cooling /Electric heat: Normal operation
Outdoor air damper: Minimum position[5]
Face and bypass damper: Normal operation
Exhaust fan: Normal operation</td></tr>
<tr><td>Mixed Air Temp Failure
(service required; nonlatching)</td></tr>
</table>

Table 63. Tracer AH540/541 diagnostics (continued)

Diagnostic	Configuration	Outputs
Space Temperature Failure (service required; nonlatching)	Discharge air temperature control	Supply fan: Normal operation Valves: Normal operation DX cooling/Electric heat: Normal operation Outdoor air damper: Normal operation Face and bypass damper: Normal operation Exhaust fan: Normal operation
Humidity Input Failure (service required; nonlatching)		
Duct Static Press Failure (informational; nonlatching)	Discharge air temperature control	
Humidity Input Failure[2] (critical or service required; nonlatching)	Space temperature control	
Entering Water Temp Failure[2, 6] (critical or service required; nonlatching)		
Local Space Setpoint Failure (service required; nonlatching)	Space temperature control Discharge air temperature control	
Dirty Filter (informational; nonlatching)		
Maintenance Required (informational; latching)		
Local Fan Switch Failure (informational; latching)		
CO_2 Sensor Failure (informational; nonlatching)		
Generic Temperature Failure (informational; nonlatching)		
Evaporator Refrigerant Temp Failure (informational; nonlatching)		
Normal (informational)		

1 If the freezestat device sending the Low Temp Detect diagnostic requires a manual reset, first reset the freezestat device and then reset the controller.
2 This diagnostic can be configured as a service required alarm or a critical alarm.
3 When a local temperature, setpoint, or pressure sensor has failed after being valid, the controller generates a diagnostic to indicate the sensor loss condition. Because this is a latching diagnostic, the controller automatically clears the diagnostic once a valid sensor value is present.
4 A Space Temperature Failure diagnostic disables morning and daytime warm-up sequence of operation when the controller is configured for constant volume discharge air control or variable-air-volume control.
5 If the outdoor air temperature sensor or the mixed-air sensor fails or is not present, economizer operation is disabled and the outdoor air damper is opened to its minimum position.
6 If the entering water temperature sensor fails, Tracer AH540/541 operation will default to heating mode.

Chapter 7

Troubleshooting

Use Table 64 through Table 70 to assist you in diagnosing any of the following operational problems that you might encounter with the Tracer AH540/541 controller:

- Fans do not energize
- Valves stay closed
- Outdoor air damper stays open
- Outdoor air damper stays closed
- DX cooling binary outputs do not energize
- Electric heat binary outputs do not energize

Table 64. Fan outputs do not energize

Probable cause	Explanation
Power-up control wait	When power-up control wait is enabled (non-zero time), the controller remains Off until one of two conditions occurs: The controller exits power-up control wait when it receives communicated information. The controller exits power-up control wait when the power-up control wait time expires.
Unoccupied operation	When the controller is in the unoccupied mode, the fan is cycled between high speed and Off with capacity to maintain zone temperature control.
Fan mode Off	When a local fan mode switch (provided on the Trane zone sensor) determines the fan operation, the Off position controls the unit Off.
Requested mode Off	You can communicate a desired operating mode (such as Off, Heat, and Cool) to the controller. When Off is communicated to the controller, the unit controls the fan Off. There is no heating or cooling.
Diagnostic present	Specific diagnostics affect fan operation. For more information, see Table 63 on page 91.
No power to the controller	If the controller does not have power, the unit fan does not operate. For the controller to operate normally, it must have an input voltage of 24 Vac. When the green LED is Off continuously, the controller does not have sufficient power or has failed.
Unit configuration	The controller must be properly configured based on the actual installed end devices and application. When the unit configuration does not match the actual end devices, the fan may not work correctly.
Manual output test	The controller includes a manual output test sequence you can use to verify output operation and associated output wiring. However, based on the current step in the test sequence, the unit fan may not be on. Refer to “Performing a manual output test” on page 84.
Unit wiring	The wiring between the controller outputs and the fan relays and contacts must be present and correct for normal fan operation.

Table 65. Valves stay open

Probable cause	Explanation
Normal operation	The controller opens and closes the valves to meet the unit capacity requirements.
Manual output test	The controller includes a manual output test sequence you can use to verify output operation and associated output wiring. However, based on the current step in the test sequence, the valve(s) may be open. Refer to "Performing a manual output test" on page 84.
Freeze avoidance	When the controller is in the unoccupied mode with no demand for capacity (0%) and the outdoor air temperature is below the freeze avoidance setpoint, the controller opens the water valves (100%) and the face and bypass damper to prevent coil freezing.
Diagnostic present	Specific diagnostics affect valve operation. For more information, see Table 63 on page 91.
No power to the controller	If the controller does not have power, a normally open valve remains open. For the controller or valve to operate normally, it must have an input voltage of 24 Vac. When the green LED is Off continuously, the controller does not have sufficient power or has failed.
No power to the valves	If the valve does not have power, a normally open valve remains open. The valves are powered separately from the controller's output signal. If the valves do not have 24 Vac, the controller cannot operate the valves.
Unit configuration	The controller must be properly configured based on the actual installed end devices and application. When the unit configuration does not match the actual end devices, the valves may not work correctly.
Unit wiring	The wiring between the controller outputs and the valve(s) must be present and correct for normal valve operation.

Table 66. Valves stay closed

Probable cause	Explanation
Requested mode Off	You can communicate a desired operating mode (such as Off, Heat, and Cool) to the controller. When Off is communicated to the controller, the unit controls the fan Off. There is no heating or cooling (valves are closed).
Power-up control wait	When power-up control wait is enabled (non-zero time), the controller remains Off until one of two conditions occurs: The controller exits power-up control wait when it receives communicated information. The controller exits power-up control wait when the power-up control wait time expires.
Manual output test	The controller includes a manual output test sequence you can use to verify output operation and associated output wiring. However, based on the current step in the test sequence, the valve(s) may not be open. Refer to "Performing a manual output test" on page 84.
Fan mode Off	When a local fan mode switch (provided on the Trane zone sensor) determines the fan operation, the Off position controls the unit Off and closes the valves.
Diagnostic present	Specific diagnostics affect valve operation. For more information, see Table 63 on page 91.
No power to the controller	If the controller does not have power, a normally open valve remains closed. For the controller or valve to operate normally, it must have an input voltage of 24 Vac. When the green LED is Off continuously, the controller does not have sufficient power or has failed.
No power to the valves	If the valve does not have power, a normally open valve remains closed. The valves are powered separately from the controller's output signal. If the valves do not have 24 Vac, the controller cannot operate the valves.
Unit configuration	The controller must be properly configured based on the actual installed end devices and application. When the unit configuration does not match the actual end devices, the valves may not work correctly.
Unit wiring	The wiring between the controller outputs and the valve(s) must be present and correct for normal valve operation.

Table 67. Outdoor air damper stays open

Probable Cause	Explanation
Normal operation	The controller opens and closes the outdoor air damper based on the controller's occupancy mode and fan operation. Normally, the outdoor air damper is open during occupied, occupied standby, and occupied bypass mode when the fan is running and closed during unoccupied mode unless the controller is economizing. Refer to "Outdoor air damper operation" on page 56 for more information.
Manual output test	The controller includes a manual output test sequence you can use to verify output operation and associated output wiring. However, based on the current step in the test sequence, the outdoor air damper may be open. Refer to "Performing a manual output test" on page 84.
Unit configuration	The controller must be properly configured based on the actual installed end devices and application. When the unit configuration does not match the actual end devices, the outdoor air damper may not work correctly.
Unit wiring	The wiring between the controller outputs and the outdoor air damper must be present and correct for normal outdoor air damper operation.

Table 68. Outdoor air damper stays closed

Probable cause	Explanation
Normal operation	The controller opens and closes the outdoor air damper based on the controller's occupancy mode and fan operation. Normally, the outdoor air damper is open during occupied, occupied standby, and occupied bypass mode when the fan is running and closed during unoccupied mode unless the controller is economizing. Refer to "Outdoor air damper operation" on page 56 for more information.
Warm-up and cool down	The controller includes both a morning warm-up and cool down sequence to keep the outdoor air damper closed during the transition from unoccupied to occupied. This sequence is an attempt to bring the space under control as quickly as possible.
Unoccupied mode	When the controller is in the unoccupied mode, the outdoor air damper remains closed unless economizing is enabled.
Low ambient damper lock out	When the outdoor air temperature is less than the low ambient damper lockout setpoint (which can be changed with the Rover service tool), the outdoor air damper is closed.
Requested mode Off	You can communicate a desired operating mode (such as Off, Heat, and Cool) to the controller. When Off is communicated to the controller, the unit controls the fan Off. There is no heating or cooling (valves are closed). The outdoor air damper is closed.
Power-up control wait	When power-up control wait is enabled (non-zero time), the controller remains Off until one of two conditions occurs: The controller exits power-up control wait when it receives communicated information. The controller exits power-up control wait when the power-up control wait time expires.
Manual output test	The controller includes a manual output test sequence you can use to verify output operation and associated output wiring. However, based on the current step in the test sequence, the outdoor air damper may not be open. Refer to "Performing a manual output test" on page 84.
Fan mode Off	When a zone sensor fan mode switch determines the fan operation, the Off position controls the unit Off and closes the outdoor air damper.
No power to the controller	If the controller does not have power, the unit fan does not operate. For the controller to operate normally, it must have an input voltage of 24 Vac. When the green status LED is Off continuously, the controller does not have sufficient power or has failed.
Diagnostic present	Specific diagnostics affect outdoor air operation. For more information, see Table 64 on page 93.
No power to the damper actuator	If the outdoor air damper actuator does not have power, a normally open damper remains closed. The damper actuator is powered separately from the controller's output signal. If the damper actuator does not have 24 Vac, the controller cannot operate the outdoor air damper.
Unit configuration	The controller must be properly configured based on the actual installed end devices and application. When the unit configuration does not match the actual end devices, the outdoor air damper may not work correctly.
Unit wiring	The wiring between the controller outputs and the outdoor air damper must be present and correct for normal damper operation.

Table 69. DX cooling binary outputs do not energize

Probable cause	Explanation
Normal operation	The controller energizes the DX cooling binary output during cooling modes of operation. If low evaporator refrigerant temperature or coil defrost status binary input can disable DX compressor operation until the condition is removed. DX cooling is also suspended if the outdoor air temperature is less than the compressor lockout setpoint. Mechanical cooling lockout can also be enforced through the building automation system.
Manual output test	The controller includes a manual output test sequence you can use to verify output operation and associated output wiring. However, based on the current step in the test sequence, the DX cooling outputs could be Off. See the “Performing a manual output test” on page 84 for more information.
Fan mode Off	When a local fan mode switch (provided on the Trane zone sensor) determines the fan operation, the Off position controls the unit Off and turns Off all outputs.
Diagnostic present	Specific diagnostics affect DX cooling operation. For more information, see Table 63 on page 91.
No power to the controller	If the controller does not have power, a binary output remains de-energized. For the controller or outputs to operate normally, it must have an input voltage of 24 Vac. When the green Status LED is Off continuously, the controller does not have sufficient power or has failed.
Unit configuration	The controller must be properly configured based on the actual installed end devices and application. When the unit configuration does not match the actual end devices, DX cooling outputs may not work correctly. See Table 34 on page 75 and Table 39 on page 77 for more information.
Unit wiring	The wiring between the controller outputs and the compressor contactors must be present and correct for normal DX cooling operation.

Table 70. Electric heat binary outputs do not energize

Probable cause	Explanation
Normal operation	The controller energizes the electric heat binary outputs during heating and dehumidification modes of operation. Two pipe changeover unit configurations with hydronic heating available will disable electric heat operation. Mechanical heating lockout can also be enforced through the building automation system.
Manual output test	The controller includes a manual output test sequence you can use to verify output operation and associated output wiring. However, based on the current step in the test sequence, the electric heat outputs could be Off. See the “Performing a manual output test” on page 84 for more information.
Fan mode Off	When a local fan mode switch (provided on the Trane zone sensor) determines the fan operation, the Off position controls the unit Off and turns Off all outputs.
Diagnostic present	Specific diagnostics affect electric heat operation. For more information, see Table 63 on page 91.
No power to the controller	If the controller does not have power, a binary output remains de-energized. For the controller or outputs to operate normally, it must have an input voltage of 24 Vac. When the green Status LED is Off continuously, the controller does not have sufficient power or has failed.
Unit configuration	The controller must be properly configured based on the actual installed end devices and application. When the unit configuration does not match the actual end devices, electric heat outputs may not work correctly. See Table 34 on page 75 and Table 40 on page 77 for more information.
Unit wiring	The wiring between the controller outputs and the compressor contactors must be present and correct for normal electric heat operation.

Appendix

Unit operation based on heat/cool mode

Table 71. Space temperature control operation based on effective heat/cool output

Application mode input (nviApplicMode)	Heat/cool mode input (nviHeatCool)	Effective heat cool mode output (nvoHeatCool)	Unit operation
Auto	Auto	Determined by controller	Fan enabled Heating enabled Cooling enabled Damper enabled
Auto	Heat	Heat	Fan enabled Heating enabled Cooling disabled Damper ventilation enabled Economizer disabled
Auto	Morning warm-up	Morning warm-up	Fan enabled Heating enabled Cooling disabled Damper closed
Auto	Cool	Cool or humidifying	Fan enabled Heating disabled[1] Cooling enabled Damper enabled
Auto	Night purge	Night purge	Fan enabled Heating disabled Cooling disabled Damper ventilation disabled Economizer enabled
Auto	Pre-cool	Pre-cool	Fan enabled Heating disabled Cooling enabled Damper ventilation disabled Economizer enabled
Auto	Off	Off	Fan disabled Heating disabled Cooling disabled Damper disabled
Auto	Test	Determined by controller	Fan enabled Heating enabled Cooling enabled Damper enabled

Table 71. Space temperature control operation based on effective heat/cool output (continued)

Application mode input (nviApplicMode)	Heat/cool mode input (nviHeatCool)	Effective heat cool mode output (nvoHeatCool)	Unit operation
Auto	Emergency heat	Determined by controller	Fan enabled Heating enabled Cooling disabled Damper enabled
Auto	Fan only	Fan only	Fan enabled Heating disabled Cooling disabled Damper disabled
Auto	Not present	Determined by controller	Fan enabled Heating enabled Cooling enabled Damper enabled
Heat	Any state	Heat	Fan enabled Heating enabled[1] Cooling disabled Damper ventilation enabled Economizer disabled
Morning warm-up	Any state	Morning warm-up	Fan enabled Heating enabled Cooling disabled Damper closed
Cool	Any state	Cool or dehumidifying	Fan enabled Heating disabled[1] Cooling enabled Damper enabled
Night purge	Any state	Night purge	Fan enabled Heating disabled Cooling disabled Damper ventilation disabled Economizer enabled
Pre-cool	Any state	Pre-cool	Fan enabled Heating disabled Cooling enabled Damper ventilation disabled Economizer enabled

Table 71. Space temperature control operation based on effective heat/cool output (continued)

Application mode input (nviApplicMode)	Heat/cool mode input (nviHeatCool)	Effective heat cool mode output (nvoHeatCool)	Unit operation
Off	Any state	Off	Fan disabled Heating disabled Cooling disabled Damper disabled
Test	Any state	Determined by controller	Fan enabled Heating enabled Cooling enabled Damper enabled
Emergency heat	Any state	Determined by controller	Fan enabled Heating enabled Cooling enabled Damper enabled
Fan only	Any state	Fan only	Fan enabled Heating disabled Cooling disabled Damper disabled

1 Heating capacity can be used to control the discharge air temperature to the discharge air temperature setpoint.

Table 72. Discharge air temperature control operation based on effective heat/cool output

Application mode input (nviApplicMode)	Effective heat cool mode output (nvoHeatCool)	Application mode output (nvoApplicMode)	Unit operation
Auto	Determined by controller	Determined by controller	Fan enabled Heating enabled Cooling enabled Damper enabled
Heat	Heat	Heat	Fan enabled Heating enabled Cooling disabled Damper ventilation enabled Economizer disabled
Morning warm-up	Morning warm-up	Heat	Fan enabled Heating enabled Cooling disabled Damper disabled
Cool	Cool	Cool	Fan enabled Heating disabled[1] Cooling enabled Damper enabled
Night purge	Night purge	Cool	Fan enabled Heating disabled Cooling disabled Damper ventilation disabled Economizer enabled

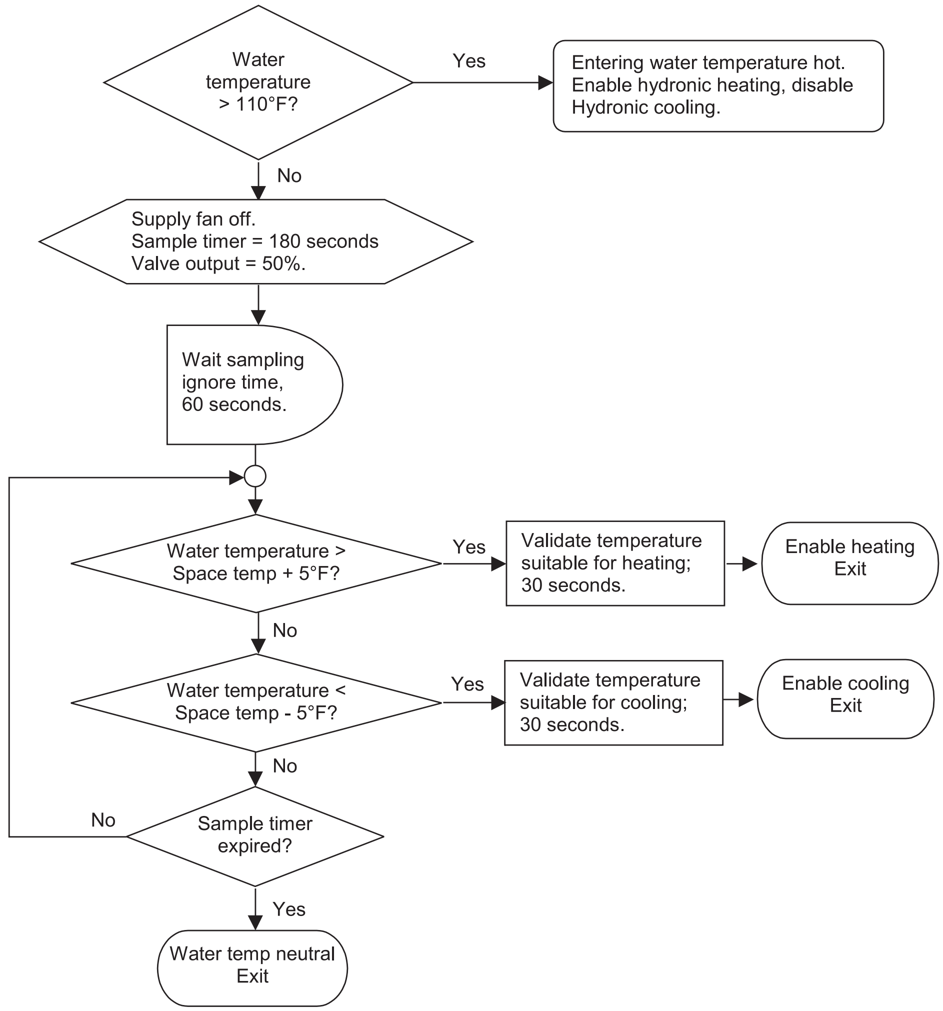
Table 72. Discharge air temperature control operation based on effective heat/cool output (continued)

Pre-cool	Pre-cool	Cool	Fan enabled Heating disabled Cooling enabled Damper ventilation disabled Economizer enabled
Off	Off	Auto	Fan disabled Heating disabled Cooling disabled Damper disabled
Test	Determined by controller	Determined by controller	Fan enabled Heating enabled Cooling enabled Damper enabled
Fan only	Fan only	Auto	Fan enabled Heating disabled Cooling disabled Damper disabled
Maximum flow heating	Maximum flow heating	Maximum flow heating	Fan enabled Heating enabled Cooling disabled Damper enabled

1 Heating capacity can be used to control the discharge air temperature to the discharge air cooling setpoint.

Entering water temperature sampling

Figure 15. Flowchart



Input sensor tables

Table 73. Trane zone sensor hard-wired setpoint thumbwheel

Setpoint	Resistance
50°F (10.0°C)	889.4 Ω
58°F (14.4°C)	733.6 Ω
66°F (18.9°C)	577.9 Ω
70°F (21.1°C)	500.0 Ω
74°F (23.3°C)	422.1 Ω
78°F (25.6°C)	344.2 Ω
82°F (27.8°C)	266.4 Ω
86°F (30.0°C)	188.5 Ω
90°F (32.2°C)	110.6 Ω

Table 74. Hard-wired 10 kΩ thermistor values

Temperature	Resistance (kΩ)	Temperature (continued)	Resistance (kΩ) (continued)
0°F (17.8°C)	87.5	77°F (25.0°C)	10.0
5°F (-15.0°C)	74.6	80°F (26.7°C)	9.3
10°F (-12.2°C)	63.8	85°F (29.4°C)	8.2
15°F (9.4°C)	54.6	90°F (32.2°C)	7.3
20°F (6.7°C)	46.9	95°F (35.0°C)	6.5
25°F (3.9°C)	40.4	100°F (37.8°C)	5.8
30°F (-1.1°C)	34.8	105°F (40.6°C)	5.2
35°F (1.7°C)	30.2	110°F (43.3°C)	4.7
40°F (4.4°C)	26.2	115°F (46.1°C)	4.2
45°F (7.2°C)	22.8	120°F (48.9°C)	3.8
50°F (10.0°C)	20.0	125°F (51.7°C)	3.4
55°F (12.8°C)	17.5	130°F (54.4°C)	3.1
60°F (15.6°C)	15.3	135°F (57.2°C)	2.8
65°F (18.3°C)	13.5	140°F (60.0°C)	2.5
70°F (21.1°C)	11.9	145°F (62.8°C)	2.3
75°F (23.9°C)	10.5	150°F (65.6°C)	2.1

Table 75. Hard-wired 1 kΩ mixed-air sensor RTD values

Temperature	Resistance (kΩ)	Temperature (continued)	Resistance (kΩ) (continued)
0°F (-17.8°C)	930.3	77°F (25.0°C)	1097.3
5°F (-15.0°C)	941.2	80°F (26.7°C)	1103.8
10°F (-12.2°C)	952.1	85°F (29.4°C)	1114.6
15°F (-9.4°C)	963.0	90°F (32.2°C)	1125.3
20°F (-6.7°C)	973.9	95°F (35.0°C)	1136.1
25°F (-3.9°C)	984.8	100°F (37.8°C)	1146.8
30°F (-1.1°C)	995.7	105°F (40.6°C)	1157.5
32°F (0.0°C)	1000.0	110°F (43.3°C)	1168.3
35°F (1.7°C)	1006.5	115°F (46.1°C)	1179.0
40°F (4.4°C)	1017.4	120°F (48.9°C)	1189.7
45°F (7.2°C)	1028.2	125°F (51.7°C)	1200.4
50°F (10.0°C)	1039.0	130°F (54.4°C)	1211.0
55°F (12.8°C)	1049.8	135°F (57.2°C)	1221.7
60°F (15.6°C)	1060.7	140°F (60.0°C)	1232.4
65°F (18.3°C)	1071.5	145°F (62.8°C)	1243.0
70°F (21.1°C)	1082.2	150°F (65.6°C)	1253.7
75°F (23.9°C)	1093.0		

Table 76. Hard-wired relative humidity sensor values

Current (mA)	Relative humidity (%)	Relative humidity (%)	Current (mA)
4	0	0	4
5	6.3	10	5.6
6	12.5	20	7.2
7	18.8	30	8.8
8	25	40	10.4
9	31.3	50	12
10	37.5	60	13.6
11	43.8	70	15.2
12	50	80	16.8
13	56.3	90	18.4
14	62.5	100	20
15	68.8		
16	75		
17	81.3		
18	87.5		
19	93.8		
20	100		

Table 77. Hard-wired CO_2 sensor values

Current (mA)	CO_2 (ppm)	Current (mA)	CO_2 (ppm)
4	0	4	0
5	125	5.6	200
6	250	7.2	400
7	375	8.8	600
8	500	10.4	800
9	625	12	1000
10	750	13.6	1200
11	875	15.2	1400
12	1000	16.8	1600
13	1125	18.4	1800
14	1250	20	2000
15	1375		
16	1500		
17	1625		
18	1750		
19	1875		
20	2000		

AH540/541 network variables

A network variable input (nvi) *receives* data from other devices on the Comm5 network. Network variable inputs (including their SNVTs) that are commonly used are shown in Table 78 on this page and Table 79 on page 110.

A network variable output (nvo) *sends* data to other devices on the Comm5 network. Network variable outputs (including their SNVTs) that are commonly used are shown in Table 80 on page 111 and Table 81 on page 112.

Table 78. Tracer AH540/541 SCC profile network variable inputs

Variable name	SNVT	Data type	Description
nviAuxHeatEnable	SNVT_switch	Analog	Bind to this network variable input to communicate a mechanical heating limit to the device. The valid range is 0% to 100% with a resolution of 0.005%.
nviComprEnable	SNVT_switch	Analog	Bind to this network variable input to communicate a mechanical cooling limit to the device. The valid range is 0% to 100% with a resolution of 0.005%.
nviEconEnable	SNVT_switch	Binary	Bind to this network variable input to communicate economizer operation enable or disable to the device.
nviEmergOverride	SNVT_hvac_emerg	Enumerated	Bind to this network variable input to communicate emergency overrides to the device.
nviHeatCool	SNVT_hvac_mode	Enumerated	Bind to this network variable input to communicate the application mode to the device.
nviOAMinPos	SNVT_lev_percent	Analog	Bind to this network variable input to communicate an outdoor air damper minimum position to the device. The valid range is from 0% to 100% with a resolution of 0.005%.
nviOccManCmd	SNVT_occupancy	Enumerated	Bind to this network variable input to communicate occupancy overrides to the device.
nviOccSchedule	SNVT_tod_event	Enumerated	Bind to this network variable input to communicate scheduled occupancy to the device.
nviOccSensor	SNVT_occupancy	Enumerated	Bind to this network variable input to a local occu-pancy sensor status to the device.
nviOutdoorTemp	SNVT_temp_p	Analog	Bind to this network variable input to communicate the outdoor air temperature in degrees Celsius to the device. The valid range is from -40°C to 100°C with a resolution of 0.01°C.
nviSetpoint	SNVT_temp_p	Analog	Bind to this network variable input to communicate the space temperature setpoint in degrees Celsius to the device. The valid range is from 10°C to 29.44°C with a resolution of 0.01°C.
nviSetptOffset	SNVT_temp_diff_p	Analog	Bind to this network variable input to communicate a space temperature setpoint offset in degrees Celsius to the device. The valid range is from -10°C to 10°C with a resolution of 0.01°C.

Table 78. Tracer AH540/541 SCC profile network variable inputs (continued)

Variable name	SNVT	Data type	Description
nviSetptShift	SNVT_temp_setpt differential	Structure	Bind to this network variable input to communicate heating occupied, occupied-standby, and unoccupied setpoint shifts; and cooling occupied, occupied-standby, and unoccupied setpoint shifts in degrees Celsius to the device. The valid range is from -10°C
nviSourceTemp	SNVT_temp_p	Analog	Bind to this network variable input to communicate the water-loop temperature in degrees Celsius to the device. The valid range is from 0°C to 100°C with a resolution of 0.01°C.
nviSpaceRH	SNVT_lev_percent	Analog	Bind to this network variable input to communicates the space relative humidity in degrees percent to other devices. The valid range is from 0% to 100% with a resolution of 0.005%.
nviSpaceTemp	SNVT_temp_p	Analog	Bind to this network variable input to communicate the space temperature in degrees Celsius to the device. The valid range is from -15°C to 50°C with a resolution of 0.01°C.
nviValveOverride	SNVT_hvac_overid	(Structure)	Bind to this network variable input to communicate water valve overrides to the device.

Table 79. Tracer AH540/541 SCC profile network variable outputs

Variable name	SNVT	Data type	Description
nvoAlarmMessage	SNVT_str_asc	Analog	This network variable output communicates alarm message information to other devices.
nvoDischAirTemp	SNVT_temp_p	Analog	This network variable output communicates the discharge air temperature in degrees Celsius to other devices. The valid range is from -40°C to 100°C with a resolution of 0.01°C.
nvoEffectOccup	SNVT_occupancy	Enumerated	The network variable output communicates the effective occupancy mode of the device.
nvoEffectSetpt	SNVT_temp_p	Analog	This network variable output communicates the effective space temperature setpoint in degrees Celsius to other devices. The valid range is from -5.6°C to 56.1°C with a resolution of 0.01°C.
nvoEnterWaterTmp	SNVT_temp_p	Analog	This network variable output communicates the effective entering water temperature in degrees Celsius to other devices. The valid range is from --40°C to 100°C with a resolution of 0.01°C.
nvoFBDamper	SNVT_lev_percent	Analog	The network variable output communicates face and bypass damper status (0 to 100% open) of the device.
nvoHeatCool	SNVT_hvac_mode	Enumerated	This network variable output communicates unit status information to other devices.
nvoMixedAirTemp	SNVT_temp_p	Analog	This network variable output communicates the mixed-air temperature in degrees percent to other devices. The valid range is from 0% to 100% with a resolution of 0.005%.

Table 79. Tracer AH540/541 SCC profile network variable outputs (continued)

Variable name	SNVT	Data type	Description
nvoOADamper	SNVT_lev_percent	Analog	The network variable output communicates outdoor air damper status (0 to 100% open) of the device.
nvoOutdoorTemp	SNVT_temp_p	Analog	This network variable output communicates the outdoor air temperature in degrees Celsius to other devices. The valid range is from -40°C to 100°C with a resolution of 0.01°C.
nvoSpaceCO2	SNVT_ppm	Analog	This network variable output communicates the space CO2 concentrations in parts-per-million to other devices. The valid range is from 0–2000 ppm with a resolution of 1 ppm.
nvoSpaceRH	SNVT_lev_percent	Analog	This network variable output communicates the space temperature in degrees percent to other devices. The valid range is from 0% to 100% with a resolution of 0.005%.
nvoSpaceTemp	SNVT_temp_p	Analog	This network variable output communicates the space relative humidity in degrees Celsius to other devices. The valid range is from -15°C to 50°C with a resolution of 0.01°C.
nvoUnitStatus	SNVT_hvac_status	(Structure)	This network variable communicates unit status information to other devices.

Table 80. Tracer AH540/541 DAC profile network variable inputs

Variable name	SNVT	Data type	Description
nviDACISP	SNVT_temp_p	Binary	Bind to this network variable input to communicate the discharge air cooling setpoint in degrees Celsius to the device. The valid range is from 0°C to 30°C with a resolution of 0.01°C.
nviDAHtSP	SNVT_temp_p	Analog	Bind to this network variable input to communicate the discharge air heating setpoint in degrees Celsius to the device. The valid range is from 10°C to 70°C with a resolution of 0.01°C.
nviDuctStaticSP	SNVT_press_p	Analog	Bind to this network variable input to communicate the duct static pressure in Pascals to the device. The valid range is from 0 Pa to 1250 Pa with a resolution of 1 Pa.
nviDuctStatPress	SNVT_press_p	Analog	Bind to this network variable input to communicate the duct static pressure in Pascals to the device. The valid range is from 0 Pa to 1250 Pa with a resolution of 1 Pa.
nviEconEnable	SNVT_switch	Binary	Bind to this network variable input to communicate economizer operation enable or disable to the device.
nviEmergOverride	SNVT_hvac_emerg	Enumerated	Bind to this network variable input to communicate emergency overrides to the device.
nviApplicMode	SNVT_hvac_mode	Enumerated	Bind to this network variable input to communicate the application mode to the device.

Table 80. Tracer AH540/541 DAC profile network variable inputs

Variable name	SNVT	Data type	Description
nviOAMinPos	SNVT_lev_percent	Analog	Bind to this network variable input to communicate an outdoor air damper minimum position to the device. The valid range is from 0% to 100% with a resolution of 0.005%.
nviOccManCmd	SNVT_occupancy	Enumerated	Bind to this network variable input to communicate occupancy overrides to the device.
nviOccSchedule	SNVT_tod_event	Enumerated	Bind to this network variable input to communicate scheduled occupancy to the device.
nviOutdoorTemp	SNVT_temp_p	Analog	Bind to this network variable input to communicate the outdoor air temperature in degrees Celsius to the device. The valid range is from -40°C to 100°C with a resolution of 0.01°C.
nviPriCoolEnable	SNVT_switch	Analog	Bind to this network variable input to communicate a mechanical cooling limit to the device. The valid range is 0% to 100% with a resolution of 0.005%.
nviPriHeatEnable	SNVT_switch	Analog	Bind to this network variable input to communicate a mechanical heating limit to the device. The valid range is 0% to 100% with a resolution of 0.5%.
nviSpaceTemp	SNVT_temp_p	Analog	Bind to this network variable input to communicate the space temperature in degrees Celsius to the device. The valid range is from -15°C to 50°C with a resolution of 0.01°C.
nviValveOverride	SNVT_hvac_overide	(Structure)	Bind to this network variable input to communicate water valve overrides to the device.

Table 81: Tracer AH540/541 DAC profile network variable outputs

Variable name	SNVT	Data type	Description
nvoAlarmMessage	SNVT_str_asc	Analog	The network variable output communicates the exhaust fan status of the device.
nvoApplicMode	SNVT_hvac_mode	Enumerated	This network variable output communicates unit heating and cooling status information.
nvoDischAirTemp	SNVT_temp_p	Analog	This network variable output communicates the discharge air temperature in degrees Celsius to other devices. The valid range is from -40°C to 100°C with a resolution of 0.01°C.
nvoDuctStatPress	SNVT_press_p	Analog	This network variable output communicates the effective duct static pressure in Pascals to other devices. The valid range is from 0 Pa to 1250 Pa with a resolution of 1 Pa.
nvoEconEnabled	SNVT_switch	Binary	This network variable output communicates the status of economizer cooling (enabled/disabled). The valid range is from -40°C to 100°C with a resolution of 0.01°C.

Table 81: Tracer AH540/541 DAC profile network variable outputs (continued)

Variable name	SNVT	Data type	Description
nvoEffDATempSP	SNVT_temp_p	Analog	This network variable output communicates the effective discharge air temperature setpoint in degrees Celsius to other devices. The valid range is from 0°C to 70°C with a resolution of 0.01°C.
nvoEffDuctStatSP	SNVT_press_p	Analog	This network variable output communicates the effective duct static pressure setpoint in Pascals to other devices. The valid range is from 0 Pa to 1250 Pa with a resolution of 1 Pa.
nvoEffectOccup	SNVT_occupancy	Enumerated	The network variable output communicates the effective occupancy mode of the device.
nvoExhFanOnOff	SNVT_switch	Binary	This network variable output communicates alarm message information to other devices.
nvoExhFanStatus	SNVT_switch	Binary	The network variable output communicates the exhaust fan command (On/Off) of the device.
nvoFBDamper	SNVT_lev_percent	Analog	The network variable output communicates face and bypass damper status (0 to 100% open) of the device.
nvoHeatCool	SNVT_hvac_mode	Enumerated	This network variable output communicates unit status information to other devices.
nvoMATemp	SNVT_temp_p	Analog	This network variable output communicates the mixed-air temperature in degrees percent to other devices. The valid range is from 0% to 100% with a resolution of 0.005%.
nvoOADamper	SNVT_lev_percent	Analog	The network variable output communicates outdoor air damper status (0 to 100% open) of the device.
nvoOutdoorTemp	SNVT_temp_p	Analog	This network variable output communicates the outdoor air temperature in degrees Celsius to other devices. The valid range is from -40°C to 100°C with a resolution of 0.01°C.
nvoSpaceCO2	SNVT_ppm	Analog	This network variable output communicates the space CO2 concentrations in parts-per-million to other devices. The valid range is from 0 ppm to 2000 ppm with a resolution of 1 ppm.
nvoSpaceRH	SNVT_lev_percent	Analog	This network variable output communicates the space temperature in percent to the device. The valid range is from 0% to 100% with a resolution of 0.005%.
nvoSpaceTemp	SNVT_temp_p	Analog	This network variable output communicates the space relative humidity in degrees Celsius to other devices. The valid range is from -15°C to 50°C with a resolution of 0.01°C.
nvoUnitStatus	SNVT_hvac_status	(Structure)	This network variable communicates unit status information to other devices.

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D

Reader Response Form

Our goal is to provide accurate and efficient information to our customers. Please use this form to help us improve the quality and usability of this guide. Make copies of this form if needed.

1. In a word, how would you describe this guide?

   ____

2. Using the following scale, rate the overall quality of this guide: (Use the following scale.)

1	2	3	4	5
Dreadful				Terrific

3. How do you use this guide? (Choose one.)
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1	2	3	4	5
Not easy at all —very difficult		Moderately easy		Very easy

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I can't follow the instructions at all.		Occasionally the content is confusing		With great ease

6. How well did you understand the product *before* reading this guide?

1	2	3	4	5
Not at all		Somewhat		Thoroughly

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1	2	3	4	5
Not at all		Somewhat		Thoroughly

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