Quest Controls
Smart Control Solutions for Buildings

Model 400
User's Manual

Rev 1.3 2/23/24

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CRITICAL APPLICATIONS DISCLAIMER

QUEST PRODUCTS ARE NOT INTENDED OR AUTHORIZED FOR USE IN ANY APPLICATION THAT REQUIRES FAIL-SAFE OPERATION, OR ANY SYSTEM THAT IS RESPONSIBLE FOR PROVIDING DETECTION, MONITORING OR CONTROL OF CRITICAL SAFETY, LIFESAVING OR LIFE-SUPPORT CONDITIONS, FUNCTIONS OR OPERATIONS (INCLUDING BUT NOT LIMITED TO FIRE DETECTION, ALARMING, OR SUPPRESSION), OR ANY APPLICATION WHEREIN A FAILURE OR MALFUNCTION OF THE PRODUCT MAY LEAD TO SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE, PERSONAL INJURY OR DEATH.

Revision History

Date	Rev #	Modifications	By:
02/23/23	1.3	Correct cool off delta default value	K. Nickel
08/19/22	1.2	Added sensor errors to the trouble shooting section	K. Nickel
12/18/20	1.1	Updated figure – Typical wiring diagram	C. Last K. Nickel
11/12/20	1.0	Initial release of manual	K. Nickel

1 Overview

The Quest Controls Model 400 is designed for unitary equipment with single or multi-stage heating and cooling packages. The controller supports economizer control using Quest's patented Economizer Control Algorithm. The system is an easy-to-use thermostat for small to medium-sized mission-critical facilities such as telecommunications, cable/broadband, and Utility facilities.

The Quest Controls Model 400 provides functionality and configurability to accommodate most conventional & heat pump applications. The application-specific approach ensures that commissioning is straightforward and hassle-free. Each Model 400 contains internal programming logic to operate independently and can be configured to lock out local access to ensure programming integrity and ongoing correct control. The Model 400 remotely communicate through Modbus RTU to the ESB2 or any other Modbus polling agent.

The Model 400 contains an onboard temp sensor making it suitable for zone mounting and a remote input for panel mounting applications or when internal and external zone sensors are desired. The Model 400 includes inputs terminals for supply air, mixed air temperature, 4-20 milliamp for current sensing, and digital inputs for HVAC lockout and fan proof of run.

1.1 Applications

Quest's Model 400 is designed to control most unitary HVAC equipment including:

Rooftop Units Split-systems Wall Packs Heat Pumps

1.2 Features and Benefits

- Stand-alone or network operation to control HVAC systems
- Modbus RTU communications
- Control based on internal, remote zone temperature sensor or both
- Monitor zone temp, discharge air temp mixed air, HVAC current, HVAC lockout, and fan status
- Use industry-standard 10k type 3 thermistor
- 2 stages of cooling + 2 stages of heat + 1 fan
- Analog outputs for damper control and variable speed fans
- Backlight display - 2-line 16-character display for ease of use
- Adjustable Min & Max run time for stages
- 5 button keypad and display for easy programming
- Lockout or limit user access via password
- Temperature displayed in F or C

2 Installation / Wiring

The Model 400 utilizes a simple application-specific configuration for wiring to either a Single or Two-Stage Conventional AC unit or a Heat Pump.

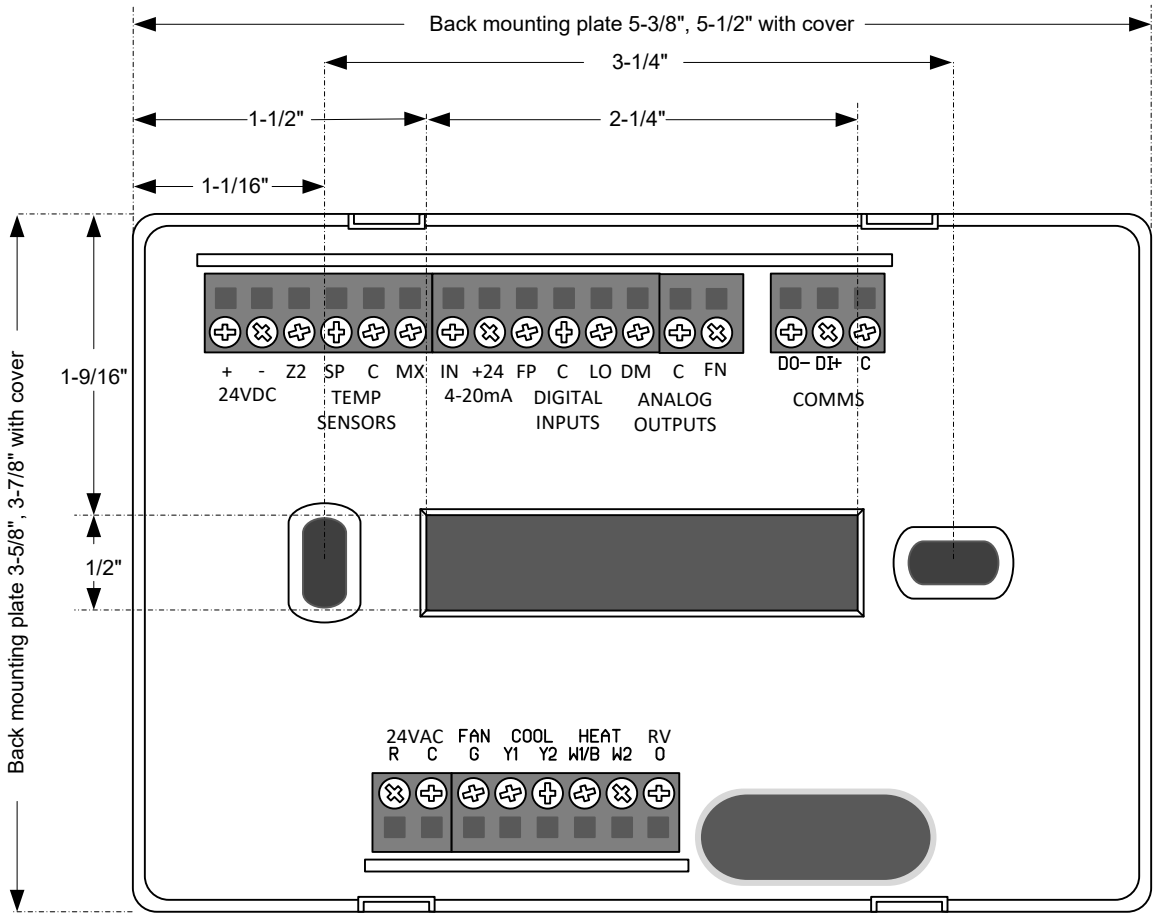


Figure 1 - Back Plate Mounting

2.1 Installing the mounting plate

1. **Plan the Location** – When zone mounting, the Model 400 should be near eye level, on an interior wall, and away from external sources of heat or cold (windows, doors, HVAC supply ducts, Servers, etc.)
2. **Prepare the Area** - The mounting screw holes will line up on a standard duplex outlet box or can be flush mounted to the wall. When flush mounting, ensure clearance for the wires to exit through the center window on the backplate. Install outlet box or screw anchors, run thermostat wires, sensor wire, and bus cable.
3. **Remove the cover** - The cover of the Model 400 is held on by four clips, two on the top and two on the bottom. Remove the cover carefully, as the cover may be snug and depressing the clips through the slot openings may help in getting the cover off.
4. **Mount the Plate** - Dress the wires through the center window on the backplate and install mounting screws. Tighten screws to ensure the plate is mounted securely, but do not over tighten and warp the backplate.

2.2 Wiring

1. **Terminate the Wire Connections** – Cut off excess wire, dress wire flush to the back panel, and strip 1/4" of insulation to expose conductor. Insert and tighten using the Wire Terminations diagram.
2. **Connection Descriptions**:

24VDC + 24VDC -	For an additional 24VDC source to power the Model 400, This will power the unit and operate the analog outputs. 24VAC is required to operate the digital outputs. Note: Both 24VAC & DC must be off to power down the Model 400.
Z2 C	For use with a remote zone temperature sensor
SP C	Supply Duct temperature sensor
MX C	Mixed Air temperature sensor. Required for direct control of the economizer damper.
4-20 mA IN 4-20 mA +24	4-20mA sensor. Can be used to monitor HVAC current
FP C	FAN Proof of Run digital input
LO C	HVAC Lockout alarm contact
DM C	Analog output for direct control of 0-10V dampers for Econ mode
FN C	Analog output 0-10VDC for variable speed fans
D0- D1+ C	Bus Wire from Quest ESB2 (or Modbus RTU polling agent). Daisy chain to additional devices or add EOL resistor on last device.
R C	24VAC power - Red 24VAC common - Black
FAN G	Fan Control – Green
COOL Y1 COOL Y2	Call for Cool, stage 1 - Yellow Call for Cool, stage 2 – Blue/Orange
HEAT W1/B HEAT W2	Call for Heat, stage 1 - White Call for Heat, stage 2 – Varies
RV - 0	Heat Pump Reversing Valve - Orange

Figure 2 - Connection Descriptions

3. Typical Wiring Diagram

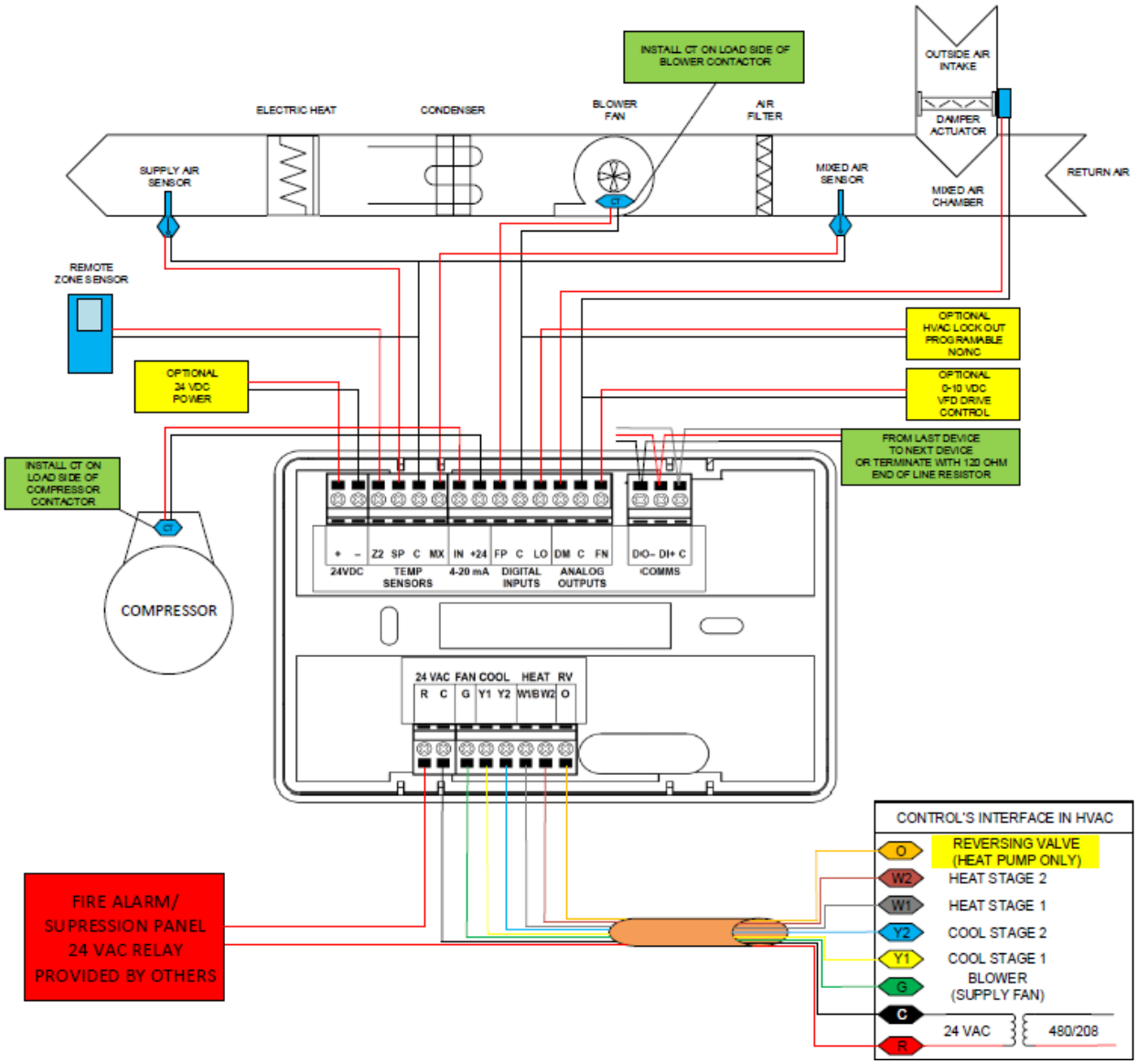


Figure 3 - Typical Wiring Diagram

2.3 RS485 End of Line resistor

RS485 networks require an end of line resistor (EOL) to be present on the end devices of a daisy chain network. For the Model 400 at the end of the network, add the included 120-ohm EOL resistor between D0 - and D1+ terminals.

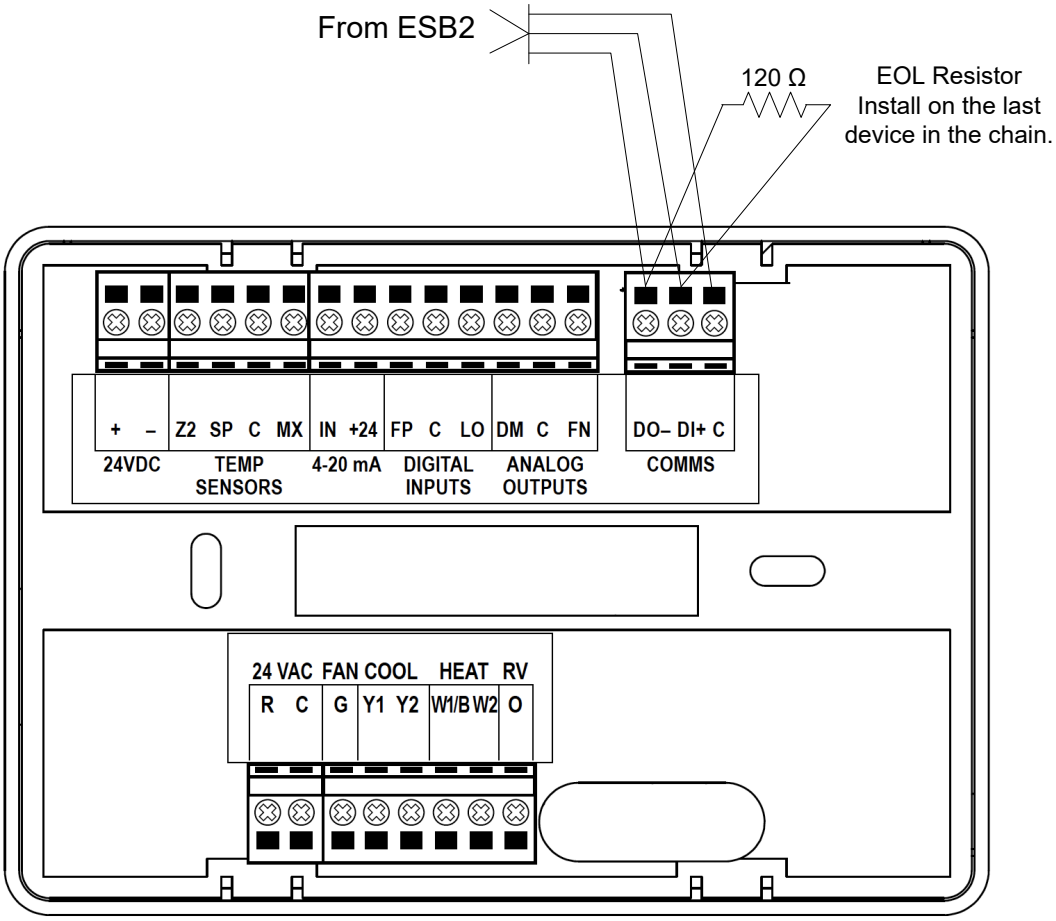


Figure 4 - Setting Communication Jumper

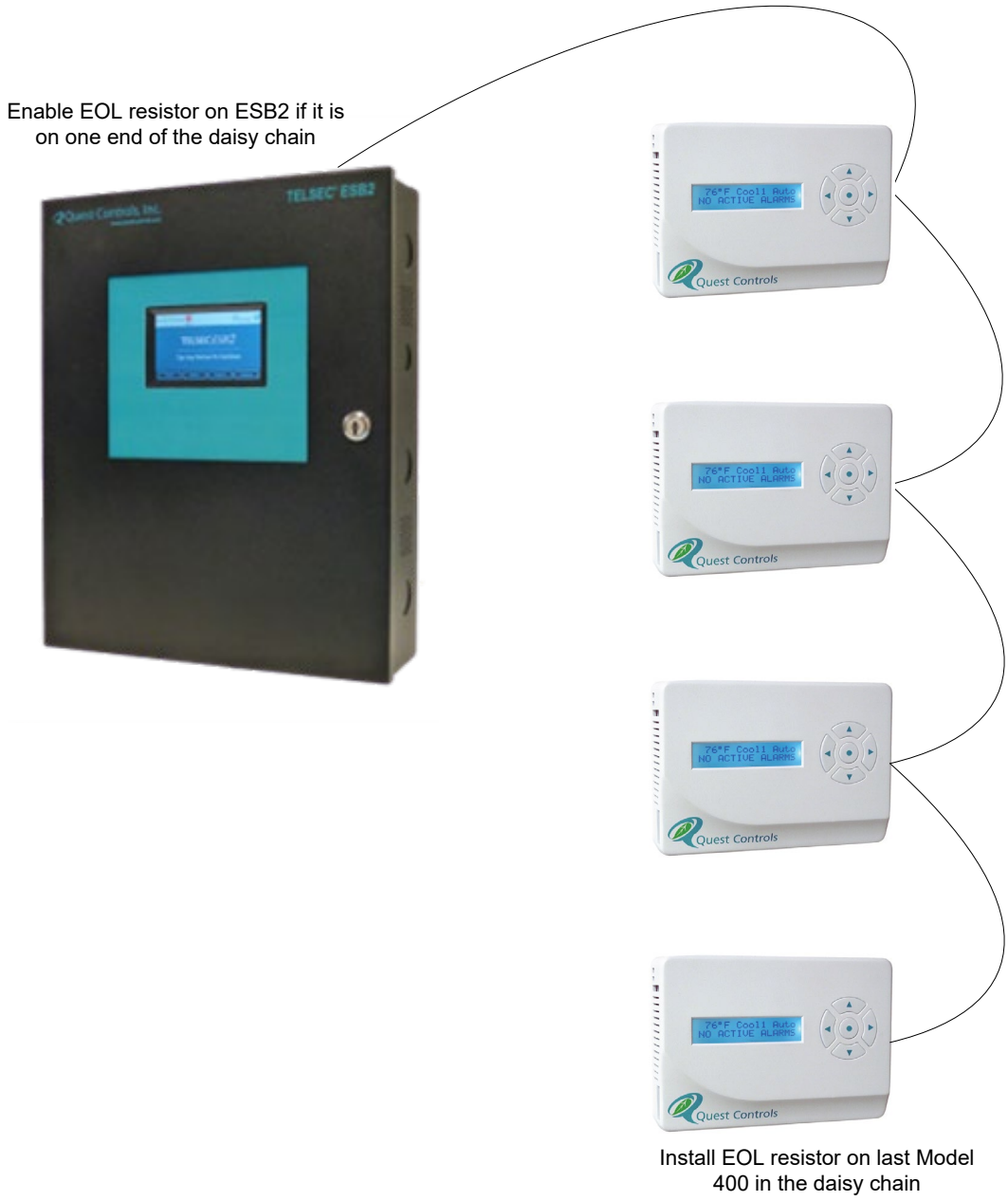


Figure 5 - Networking Model 400 Units to the ESB2

3 Front Panel Display/Keypad Operation

The Quest Model 400 has a 2X16 character backlit LCD and five buttons for status review and programming. The backlight is normally off but will turn on with a press of any key. The backlight will turn off after a few seconds of no keys being pressed. The first press of the keypad will turn on the backlight and tell the Model 400 to be ready for additional key presses. All keypad operation described below is after you press and release any key to enable the backlight.

3.1 Run Mode

The display will show the controlling temperature reading, the HVAC control mode, and the fan control mode on the top line. The second line will show any active alarm condition or the message "NO ACTIVE ALARMS". Press the up and down arrow keys to cycle through the status screens to obtain current readings for all defined sensors.

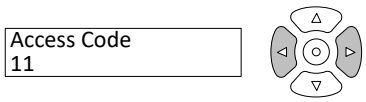
3.1.1 Additional displays:

Press the up and down arrow keys to cycle through the status screens to obtain current readings for all defined sensors. The screens will show in the following order:

Screen	Description
Z1 <reading> Z2 <reading>	Shows the current reading of both sensors. Note Z2 will show OER if no sensor is connected to the input. If there is a sensor connected to Z2 then OER would indicate an open reading. Check for broken wires. A reading of SER indicates a short to ground.
S <reading> Mx <reading>	Value of the supply (S) air and mixed air (Mx)sensors. Mixed air sensor will only be shown when direct economizer mode is selected.
FnFl <ON/OFF> LCK <ON/OFF>	The status of the fan failure input and the HVAC lockout input
Curr sens <value>	The value in amps that the current sensor is reading
SF % DMP %	The Supply Fan (SF) precentage output for variable speed fans. DMP % is shown if the unit is setup for direct control of the damper. This will show the percent open of the damper.

3.2 Programming the Model 400

Press and hold the left and right arrow simultaneously until the display shows the enter password option. The default password is 11. Use the up/down arrow keys to change the password value and press the center button to log in. Passwords can be turned off or changed to any value from 11 to 99 via Modbus and the front panel System menu. From this menu use the up/down arrows to navigate to the available choices: System, Setpoints, Economizer, Alarms & Run. Choosing one of these options will present the available choices. Use the up/down arrows to cycle through the choices for each field and the center button to accept the change and move to the next choice. Once you start in one of the program menus,



you must step through all choices until the end to accept your changes. Press the center button to accept the current program value and go on to the next choice.

3.2.1 Programming flow:

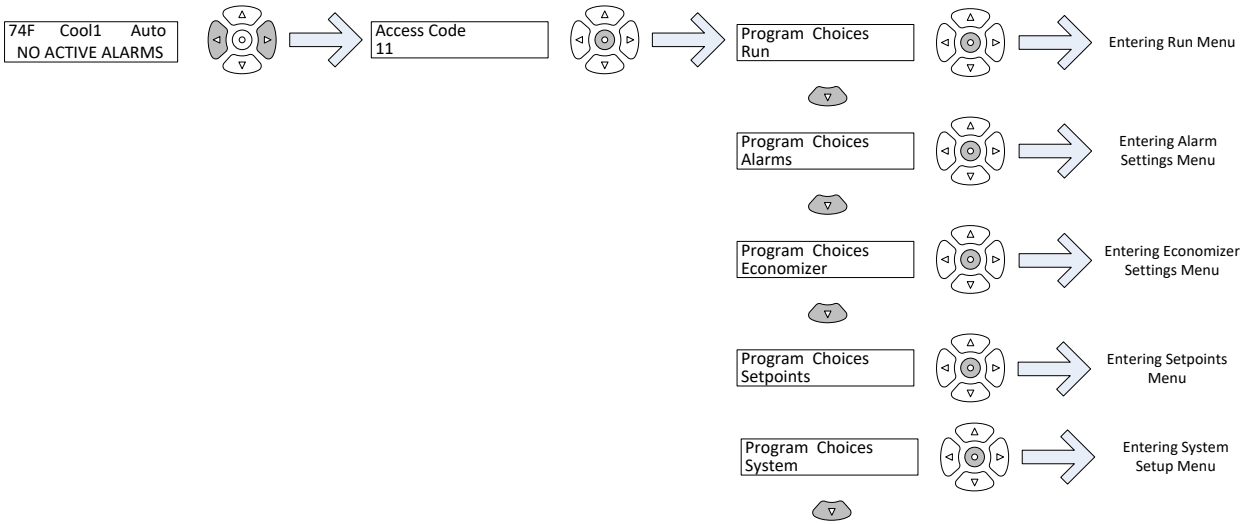


Figure 6 - Programming Flow

3.2.2 Submenus

This section shows the program menus and available options. Items underlined indicate the default setting. All temperature values are shown in Fahrenheit.

System Menu

Temp Units: Fahrenheit, Celsius
Control Sensor: Z1, Z2, High Zone Z1 & Z2, Avg Zone Z1 & Z2
HVAC type: Dual Stage DX, Single Stage DX, Heat Pump
Economizer: None, Integrated, Direct Control
Fan Mode: Auto, On
Residual Fan Delay: 0-180 seconds (30)
Current Sens Max AMP: 0-150 (0)
Restart Delay: 0-900 seconds (0)
Modbus Address: 1-247 (1)
Baud Rate: 9,600, 19200, 38400, 57600, 76800
Access Code: 11-99 (11)
Prog Menu Access: Allow, Don't Allow

Alarm Menu

HighTemp Alarm SPT: 70-140 (80)
LoTemp Alarm SPT: 20-60 (50)
Lockout Alarm: Disabled, Normally Open, Normally Closed
FanFail Alarm: Disabled, Normally Open, Normally Closed

Cooling Fail SPT: 50-75 (65)
Heating Fail SPT: 90-120 (100)

Economizer Menu
OSA L2 Setpoint: 45-90 (65)
OSA L1 Setpoint: 45-90 (62)
OSA Float MaxChg: 0-10 (5)
OSA Dwell Time: 60-900 (60)
Mixed Air SPT: 45-65 (50)
Mixed Air Delta: 0-10 (3)
Damper Min Pos%:0-50 (0)
Damper Pct Chg: 1-10 (5)
Dmpr Dwell Time 10-300 (60)
Supply Fan Min %: 0-100 (50)
Fan Dwell Time: 15-300 (30)

Setpoint Menu
Cool SPT: 70-110 (76)
Cool Off Delta: 1-10 (5)
Heat SPT: 34-65 (55)
Cool Stg 2 Delta: 1-10 (2)
Cool Stg 3 Delta: 1-10 (2)
Heat Stg 2 Delta: 1-10 (2)
Cool Min On Time: 60-600 (120)
Cool Min Off Time: 60-600 (120)
Heat Min On Time: 60-600 (120)
Heat Min Off Time: 60-600 (120)

Run: Puts the Model 400 back in run mode. Note: some changes require a restart. The Display will show “Restarting Soon” to indicate it is storing changes to flash and will reboot with the new configuration.

4 Remote Communications

The Model 400 may be programmed using either the keypad and display or through the ESB2 web interface. The keypad can also be locked out to require remote programming only. Before programming the ESB2, you must set the address and baud rate when using multiple Model 400 units on the same network. The default is Address 1 and baud rate of 19,200 baud. Review the Modbus map (appendix A) for the available registers and functionality.

The Model 400 will accept writes to certain registers from the ESB2. Some of the registers being written to are only used while the unit is communicating. When communications are lost for two minutes, the

Model 400 will revert to local control mode. This section will discuss those registers that can be set remotely but return to local default when the unit is reset or communications are lost. Consult the ESB2 User Manual for additional information on defining Modbus points and writing equations. It is recommended that when using equations to send data to the Model 400 that you put delays in the equations to reduce unnecessary traffic on the data bus. The examples below show equations with "wait" delays in seconds which prevents the ESB2 from writing to the Model 400 registers every cycle.

4.1 Controlling Temperature

The controlling temperature register is holding register 100. This register will show the value of the sensor(s) being used to make control decisions. For example, if the Model 400 has two zone sensors and is configured to average those sensor readings, then the value of register 100 will be the average of those two sensors. This register can also be written to by the ESB2 to change the value of the controlling temperature. An example of this function would be to use a temp sensor in the ESB2 for control and using an equation to make the register equal to the ESB2 sensor.

esb2temp```
MODP.a100 = INP.uin3 wait 60
```

Another example would be if there is multiple Model 400 units being used for lead/lag function then the ESB2 could average all the zone sensors from the units and then write the average to the controlling temperature register.

avgzonetemp "'
VAR.var1 = math.avg(MODP.a001, MODP.b001, MODP.c001)
MODP.a100 = VAR.var1 MODP.b100 = VAR.var1 MODP.c100 = VAR.var1 wait 60
```

4.2 Outside Air Temperature

Modbus holding register 101 is used to tell the model 400 what the outside air temperature is so that the unit can determine if economizer mode can be used. Use an equation to make this register equal the outside air sensor terminated on the ESB2. For example, to share the outside air sensor terminated on input 1 of the ESB2 with three Model 400 units, you can use the following equation:

outsideair```
MODP.a101 =INP.uin1 MODP.b101 =INP.uin1 MODP.c101 =INP.uin1 wait 300
```

## 4.3 Operational Cooling Setpoint

Modbus holding register 102 is used to display the current cooling setpoint. This will either be the locally stored value, or an equation can write a value to this register. Write the desired cooling setpoint to this register when you want to coordinate Lead/Lag operation between multiple units and or change the setting based on time or occupancy. Writing a value of 65535 will cause the Model 400 to use the locally stored value of Modbus register 1100.
```

4.4 Operational Heating Setpoint

Modbus holding register 103 is used to display the current heating setpoint. This will either be the locally stored value, or an equation that can write a value to this register. Write the desired heating setpoint to this register when you want to coordinate Lead/Lag operation between multiple units and or change the setting based on time or occupancy. Writing a value of 65535 will cause the Model 400 to use the locally stored value of Modbus register 1104.

4.5 Operation Fan Mode

Modbus holding register 108 is used to remotely set the fan operation to Auto or ON. Writing a 1 to this register will put the fan in always-on mode. Writing a 0 will put the fan in auto mode and writing 65535 will tell the Model 400 to use the predefined mode for the fan (Modbus register 1004). This will allow you to change the fan operation when coordinating lead/lag control of multiple Model 400 units.

4.6 Front Panel Request

Modbus holding register 107 is used to indicate a user has pushed the local request on the display. This occurs when the user touches a key to enable the backlight and then presses and holds the enter button until the display says User Request ON. Equations can be written to do an action when the button is pressed such as change setpoints, clear alarm conditions, etc. The register will stay as a value of 1 until either the user presses and holds the enter button again or you change the value to 0 with an equation.

4.7 HVAC Shutdown

Holding register 106 is used to force the HVAC to off mode. When this value of this register is greater than 0 then the HVAC will be forced off and the damper (if controlled) will be set to full close instead of minimum position. Write a 0 to this register to resume normal operation.

4.8 Econ Disable

Holding register 105 is used to disable the economizer mode on a Model 400. Writing a value greater than 0 will disable economizer operation. For example, there is a humidity sensor connected to the ESB2 monitoring the zone and if the humidity is too high, you want to prevent the economizer from operating. Writing a 0 to the register will allow the Model 400 to continue economizer operation as needed.

4.9 Econ Damper Output

Holding register 0 is used to report the current damper position from 0% = closed to 100% being fully opened. Writing to this register can override the calculated position and force the damper to the desired value. Write the value 65535 to put the damper back in automatic mode.

4.10 Supply Fan Speed

Holding register 1 is used to report the current supply fan speed from 0% = off to 100% being full speed. Writing to this register can override the calculated position and force the fan to the desired value. Write the value 65535 to put the fan back in automatic mode.

4.11 HVAC Mode

Holding register 104 is used to enumerate the current control mode of the HVAC system. For example, a value of 4 equals econ mode operation. Writing to this register will override the current control mode and force the HVAC unit to a specific control mode. Writing to this register requires two pieces of information. The high byte is the number of minutes for the bypass and the low byte is the desired mode. For example, if you want to bypass the HVAC unit to cool 2 mode for 60 minutes you would write the value 15366, which is calculated as follows:

High byte Hex value of minutes + low byte Hex value of mode = The register value in Hex. Then convert the value to decimal.
60 minutes = 3c hex + 06 for Cool 2 mode = 3c06 hex which equals decimal 15366.

Tip: you can use the built-in Windows calculator in programmer mode to do the calculations.

The Model 400 will countdown and return to automatic mode at the end of the bypass time. Alternatively, you can write a 0 to the register to clear the bypass.

4.12 Alarm Monitoring

The Model 400 has built-in alarm monitoring functions to determine when an alarm condition is present and will display the alarm on the front panel as well as making the corresponding register have a value of 1. Registers 200-205 contain the available alarm status points. Writing any value to the register will clear the alarm condition which will change the register value to 0 and clear the message from the display. The alarm will not occur again until the problem clears and occurs again.

5 Sequence of operations

This section will focus on the local control functions for the controller. Please see section 4 - Remote Communications for control functions when the unit exists in a network.

5.1 Controlling temperature

The system will make all control for the HVAC system based upon the “controlling temperature”. The controlling temperature is defined in the system setup to be either zone sensor 1, zone sensor 2, the average of both sensors, or the highest reading of the two sensors. If one of either the zone 1 or 2 sensor is selected, the system will use that sensor provided there is a valid reading (between -25-150°F). If there is no valid reading then the system will report a sensor error on the display, turn the supply fan on and turn off heating and cooling.

When using the average or high of the two sensors, the system will use that function provided both sensors have valid readings. If one sensor is in error, then the Model 400 Controller will only use the sensor with valid readings. If there is no valid reading from either sensor then the system will report a sensor error on the display, turn the supply fan on and turn off heating and cooling.

The controlling temperature point will have write capability to allow the ESB2 (remote controller) to write a value to the point. The Model 400 Controller will use the written value for control unless a

communications fault is detected. When a communications fault occurs, the controller will default back to the defined controlling temperature sensor mode.

5.2 Fan control

5.2.1 Fan Digital output

The fan control output will be programmable from the display for continuous run or automatic mode. Automatic operation means the fan output is turned on when there is a call for heating or cooling. For automatic mode, the fan will stay on until a user-definable delay after heating or cooling is turned off. The Residual Fan Delay will be a default 30 seconds but will be user selectable from 0-180 seconds.

5.2.2 Fan Analog Output

The analog output (AOP) for variable speed fan control will operate regardless if there is a variable speed fan connected to the output. This way no user configuration is required to enable the variable speed function. The analog output for the fan will be at 0% output when the fan is commanded to be off. When in mechanical cooling or heating mode the analog output will be at 100% output.

When the temperature is above the cooling setpoint and economizer mode is active or if the fan is in continuous run mode then the fan speed will be 100%. When the controlling temperature is between the cooling setpoint and the cooling off temperature (cooling spt – cooling off diff) and in Econ mode then the speed of the fan will be a proportional output between the minimum fan output percentage and the max output.

If the fan is defined as auto and the zone temperature falls below the cooling off temperature for the residual fan delay, then fan output will be 0%. Note there is also a supply fan dwell time that is used to regulate the time between supply fan adjustments.

5.3 Economizer Control

The Model 400 Controller will use Quest's economizer control algorithm to automatically adjust the OSA setpoint for when economization can be used instead of mechanical cooling. Since the Model 400 Controller does not have an outside air sensor, the economizer function will only operate when this value is remotely communicated to the controller. Once the controller receives the OSA temp, it will make economizer decisions based on the setpoints configured in the unit. OSA temperature greater than L2 setting for the dwell delay will disable economization. OSA temperature below L2 for the dwell delay will allow the economizer to be used when there is a call for cooling. If the OSA temperature is bouncing between above and below L2 before satisfying the dwell delay, the last known economizer setting will be used.

The method of controlling the economizer will be based upon the setup configuration.

5.3.1 Direct Econ control

Direct control of the economizer means the Model 400 Controller will use the mixed air sensor to make decisions to modulate the OSA damper using the damper analog output. The mixed air sensor must be connected to the controller and operational for the control to function properly. If the mixed air sensor is in error, the controller can open the damper to 100% provided the outside air sensor reading is

greater than the mixed air setpoint minus the mixed air dead band. The Model 400 Controller will disable econ control If the mixed air sensor is in error (or not present) and the outside air sensor reading is less than the mixed air setpoint – the mixed air dead band.

5.3.1.1 Damper control algorithm

Damper position will not be calculated when the mixed air temperature is within the window of the mixed air setpoint plus and minus the mixed air delta. A new damper output percentage will be calculated when the mixed air temperature is outside this window. This new position will be calculated after waiting for the damper dwell time delay.

5.3.2 Integrated Econ Control

Integrated economizer control means the economizer is being controlled by the HVAC system. In this case, the Model 400 Controller will decide to use the economizer and turn on stage 1 of cooling. The HVAC system will then decide to use economization or mechanical cooling. The mixed air sensor is not required for this mode to operate. If temperature continues to rise, the Model 400 Controller will turn on Cool stage 2. This will cause the HVAC system to switch to mechanical cooling.

5.3.3 Adjusting OSA Setpoints

The Model 400 Controller will float/adjust the economizer OSA setpoint by using the Quest patented algorithm. Successfully cooling with OSA will move the setpoint up. Failure to cool the zone with OSA only will cause the setpoints to adjust down.

5.4 Cooling Mode

The Model 400 Controller has two setpoints for cooling mode. If econ mode is disabled, then mechanical cooling stage 1 will be enabled when the controlling temperature exceeds the cooling setpoint. If the temperature continues to rise past the cool 2 mode (cooling spt + cool 2 delta), then cooling 2 stage 2 will be enabled. When economizer mode is enabled, the mechanical cooling will not be enabled until the controlling temperature exceeds the cool mode 2 threshold. Mechanical cooling stage 2 will be enabled when the temperature is greater than stage 3 mode (cooling spt + cool 2 delta + cool 3 delta).

Once a stage of cooling is turned on, it must remain on until the controlling temperature is below the cooling off setpoint (cool spt – cool off delta).

There are minimum on and minimum off time delays for each stage of cooling. These timers must elapse before there can be a change of state on the output relays. For example, if mechanical cool stage 1 is off, it must be off for the minimum delay time before it is turned on. Once it is running, the cooling must continue to run for at least the minimum on time.

Also, note that the unit won't ever "jump" a cooling stage based on controlling temperature. As in, if the unit is off and calculations would like the unit to be in cool2, the unit will first try cool1 (or even econ if calculations allow) for the normal on times before moving to cool2.

5.5 Heating Mode

The Model 400 Controller has two setpoints for heating mode. Heating stage 1 will be enabled when the controlling temperature is below the heating setpoint. If the temperature continues to lower to where the controlling temperature is below the heat 2 threshold (heating spt – heat 2 delta) then heat stage 2 will be enabled. Once a stage of heating is active, it must stay on until the controlling temperature is greater than the heating setpoint + five degrees.

There are minimum on and minimum off time delays for each stage of heating. These timers must elapse before there can be a change of state on the output relays. For example, if heating stage 1 is off, it must be off for the minimum delay time before it is turned on. Once it is turned on, it must continue to stay in the on state for at least the minimum on time.

Also, note that the unit won't ever "jump" a heating stage based on controlling temperature. As in, if the unit is off and calculations would like the unit to be in heat2, the unit will first try heat1 for the normal on times before moving to heat2.

6 Alarm Sequence of Operation

All alarm conditions in this section will cause a message about the alarm to be displayed on line 2 of the local display. The message will alternate with the current operating condition of the HVAC. The display will rotate through all alarm messages if there is more than one active alarm condition.

6.1 High Temperature

The Model 400 Controller will compare the controlling temperature to the high temperature alarm setpoint and alarm if the controlling temperature is greater than the setpoint for one minute. The alarm will clear when the controlling temperature is below the high temp setpoint minus 2 degrees for 1 minute.

6.2 Low Temperature

The Model 400 Controller will compare the controlling temperature to the low temperature alarm setpoint and alarm if the controlling temperature is less than the setpoint for one minute. The alarm will clear when the controlling temperature is above the low temp setpoint plus 2 degrees for 1 minute.

6.3 HVAC Lockout

The Model 400 Controller will monitor the lockout alarm input based on the system configuration. The system will enter the HVAC lockout alarm mode when the input is active for 15 seconds. When this input is active, the controller will turn off the mechanical cooling. The controller can use econ mode for cooling if the conditions for economizer control are met. The economizer will stay active even if the controlling temperature exceeds the mechanical cooling setpoint.

6.4 HVAC Fan Failure

The fan failure alarm will occur if the Model 400 Controller is configured for fan failure. When the controller calls for the fan to run and the fan feedback input is not active after 5 minutes then the

system will go into fan failure alarm. The system will leave the fan output on but will turn off all heating and cooling. Once the controller is calling for the fan to run and the feedback input is active then the controller can clear the fan failure alarm.

6.5 Cooling Failure

When the Model 400 Controller is calling for mechanical cooling for the failure delay time and the supply temperature is greater than the cooling failure setpoint then the system will generate a cooling failure alarm. The control sequence for cooling will not be interrupted. Once the controller is calling for cooling and the supply temperature is below the cooling alarm setpoint for 1 minute, the cooling fail alarm will clear.

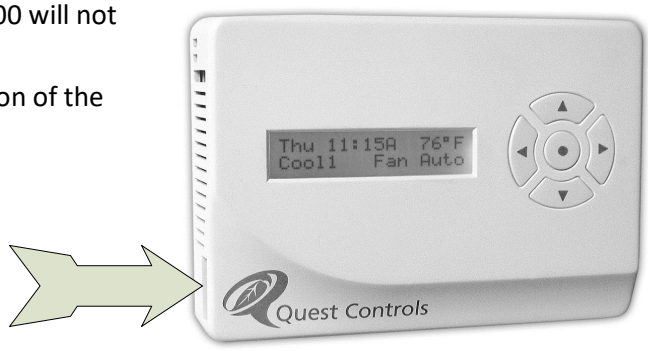
6.6 Heating Failure

When the Model 400 Controller is calling for heating for the failure delay time and the supply temperature is less than the heating failure setpoint then the system will generate a heating failure alarm. The control sequence for heating will not be interrupted. Once the controller is calling for heating and the supply temperature is above the heating alarm setpoint for 1 minute, the heating fail alarm will clear.

7 Care and Cleaning

The Model 400 should provide years of uninterrupted service. Minimal preventive maintenance is required. However, it is important to make sure that the Model 400 is kept free of dust. A dusty Model 400 will not allow air to circulate properly around the built-in temperature sensor affecting the proper operation of the unit.

Ensure temperature probe in this air tunnel is free of dirt and dust.



8 Troubleshooting

LCD Screen is dark and no characters are displayed	Remove cover and verify the presence of power on the “R” terminal, check the connection of the common on the “C” terminal. Check for the presence of 24VAC between R and C.
Controlling Sensor reads OER or SER	The zone sensor(s) used for controlling the HVAC unit are either shorted to ground (SER) or are open (OER). Check the

	wiring and terminations for possible shorts or broken connections. Note if no sensor is terminated to Zone 2 (the remote sensor) then it is normal for the reading to be OER for the input. If the controlling sensor reads OER then make sure Z2 is not chosen as the sensor for control when it is not physically present.
Model 400 mode says Cool1, but the compressor does not engage	Verify the connection to HVAC unit. Ensure the short-cycle timer is not inhibiting unit.
Model 400 won't communicate to the ESB2	Verify the wiring and polarity. Verify the Modbus address and baud rate. Verify that all Model 400s on the network have a unique address.
Buttons do not respond	Press buttons slowly, some functions may take pressing the button twice.
Display is corrupted	First, cycle power to the unit. If this does not correct the problem, reset the system by removing the Model 400 body from the mounting plate. Then return the body to the mounting plate while depressing the down arrow at the same time. The display will respond with "Cold Sense", the down button must be held for a minimum 5 seconds. This will begin a system restart and the display will respond with "Cold Start". Release the buttons at this time. This action will reset the Model 400 and return all settings to their factory defaults. The Model 400 will then need to be reconfigured with the desired settings. 

9 Model 400 Specifications

Specifications	
Part Number	150966-5
Mounting	Wall mount directly or standard single gang electrical box
Enclosure	Color: Quest white Material: Two-piece thermal molded plastic enclosure. All wiring is done on the mounting base and the controller is pull-off.
Inputs	Digital Inputs:(2) dry contact closures Analog inputs: Temperature sensors (4) Thermistors sensor ± 1°F (0.5°C) 4-20mA input (1) – HVAC Current Monitoring
Outputs	Digital Outputs: (6) 30V AC max, 1 A continuous, 3A in-rush Analog Outputs: (2) 0-10VDC
Power	24VAC and 24VDC simultaneously
LCD	Type: Backlit LCD Display Area: 2 rows of 16 characters each
Keypad	Five-button directional arrows plus enter button
Communication	RS485, Modbus RTU
Environmental	Operating Temperature: 0°C to 50°C; 32°F to 122°F Storage Temperature: -30°C to 50°C; -22°F to 122°F Relative Humidity: 0 to 95% non-condensing
Dimensions	5.32”W x 3.5”H x 1.5”D (135 x 89 x 38 mm)
Weight	0.5 lb (227 g)
Warranty	1 year

Specifications are subject to change without notice.

Appendix A – Modbus Register Map

Function Code	Register	Description	Read/ Write	Type	Default	Notes	Non-volatile
Analog Inputs							
Input Register (FC4)	0	Zone Thermistor Temp	RO	sword	N/A	Integer value 327 to -327	N
	1	Remote Zone Thermistor Temp	RO	sword	N/A	Integer value 327 to -327	N
	2	Supply Air Thermistor Temp	RO	sword	N/A	Integer value 327 to -327	N
	3	Mixed Air Thermistor Temp	RO	sword	N/A	Integer value 327 to -327	N
	4	Current sensor (scaled value)	RO	word	N/A	Integer value 0-user defined max	N
	100	Zone Thermistor Temp (hundredths)	RO	sword	N/A	Integer value 32727 to -32727	N
	101	Remote Zone Thermistor Temp (hundredths)	RO	sword	N/A	Integer value 32727 to -32727	N
	102	Supply Air Thermistor Temp (hundredths)	RO	sword	N/A	Integer value 32727 to -32727	N
	103	Mixed Air Thermistor Temp (hundredths)	RO	sword	N/A	Integer value 32727 to -32727	N
	104	Current sensor (scaled value) (hundredths)	RO	word	N/A	Integer value 0-user defined max * 100	N
	200	Zone Thermistor Temp	RO	float	N/A	IEEE754 Floating point (32 bits)	N
	202	Remote Zone Thermistor Temp	RO	float	N/A	IEEE754 Floating point (32 bits)	N
	204	Supply Air Thermistor Temp	RO	float	N/A	IEEE754 Floating point (32 bits)	N
	206	Mixed Air Thermistor Temp	RO	float	N/A	IEEE754 Floating point (32 bits)	N
	208	Current sensor (scaled value)	RO	float	N/A	IEEE754 Floating point (32 bits)	N
Digital Inputs							
Discrete Input (FC2)	0	Fan Proof of Run	RO	byte	N/A	0 = off and 1 = on based on Reg 1203	N
	1	HVAC Lockout	RO	byte	N/A	0 = off and 1 =on based on Reg 1202	N

Function Code	Register	Description	Read/ Write	Type	Default	Notes	Non-volatile
Digital Outputs							
Read coil/output (FC1)	0	Fan Output	RO	byte	N/A	0 off, 1 on	N
	1	Cool 1 Output	RO	byte	N/A	0 off, 1 on	N
	2	Cool 2 Output	RO	byte	N/A	0 off, 1 on	N
	3	Heat 1 Output	RO	byte	N/A	0 off, 1 on	N
	4	Heat 2 Output	RO	byte	N/A	0 off, 1 on	N
	5	O Output	RO	byte	N/A	0 off, 1 on	N
Analog Outputs							
Holding Register (FC3)	0	Damper Output Pct (0-100)	RW	word	N/A	Write will override internally calculated value. Write of 65535 will resume local operation.	N
	1	Supply Fan Output Pct (0-100)	RW	word	N/A	Write will override internally calculated value. Write of 65535 will resume local operation.	N
Operation/Status							
Holding Register (FC3/6/16)	100	Controlling Temperature	RW	word		Write will override internally calculated value based on Reg 1001. Write of 65535 will resume local operation.	N
	101	Outside Air Temperature	RW	word	0	degrees	N
	102	Operational Cooling Setpoint	RW	word	Reg 1100	Write will override internally calculated value. Write of 65535 will resume local operation.	N

Function Code	Register	Description	Read/ Write	Type	Default	Notes	Non-volatile
	103	Operational Heating Setpoint	RW	word	Reg 1104	Write will override internally calculated value. Write of 65535 will resume local operation.	N
	104	HVAC Mode	RW	word	N/A	Enumerated low byte: 1 = Off, 2 = Heat 1, 3 = Heat 2, 4 = Econ, 5 = Cool 1, 6 = Cool 2. High byte is the number of minutes for bypass or 0 for return to local operation.	N
	105	Econ Disable	RW	word	0	not 0 = Disable economizer, 0 = resume local operation	N
	106	HVAC Shutdown	RW	word	0	0 = Remove remote shutdown, not 0 = Enable remote shutdown	N
	107	Front panel request	RW	word	0	1 if a user pressed the special front panel sequence, 0 if not. Any write clears it to 0.	N
	108	Operational Fan Mode	RW	word		0 = fan mode auto, 1 = fan mode on, write 65535 to resume local operation	N
	109	Adjusted Outside Air L2 Setpoint	RO	word	Reg 1111	Current L2 setpoint with adjustments	N
	110	Adjusted Outside Air L1 Setpoint	RO	word	Reg 1112	Current L1 setpoint with adjustments	N
	200	High temperature alarm status	RW	word	0	0 = inactive, 1 = active, any write clears active alarm	N
	201	Low temperature alarm status	RW	word	0	0 = inactive, 1 = active, any write clears active alarm	N
	202	HVAC Lockout alarm status	RW	word	0	0 = inactive, 1 = active, any write clears active alarm	N

Function Code	Register	Description	Read/ Write	Type	Default	Notes	Non-volatile
	203	HVAC Fan Failure alarm status	RW	word	0	0 = inactive, 1 = active, any write clears active alarm	N
	204	Cooling failure alarm status	RW	word	0	0 = inactive, 1 = active, any write clears active alarm	N
	205	Heating failure alarm status	RW	word	0	0 = inactive, 1 = active, any write clears active alarm	N
Configuration							
Holding Register (FC3/6/16)	1000	Temperature Units	RW	word	0	0 = F, 1 = C	Y
	1001	Control Sensor Scheme	RW	word	0	Enumerated: 0 = use onboard zone sensor, 1 = use remote zone sensor, 2 = use average of both sensors, 3 = use high of both sensors	Y
	1002	HVAC Type	RW	word	0	0 = dx1, 1 = dx2, 2 = hp	Y
	1003	Economizer Type	RW	word	0	0 = none, 1 = direct, 2 = integrated	Y
	1004	Fan Mode	RW	word	0	0 = auto, 1 = always on	Y
	1005	Residual Fan Delay	RW	word	30	0-180 seconds	Y
	1006	Current Sensor Max Amps	RW	word	0	0-150 amps	Y
	1007	Restart Delay	RW	word	0	0-900 seconds	Y
	1008	Modbus Address	RW	word	1	1-247	Y
	1009	Baud Rate	RW	word	1	Enumerated: 0 – 9600, 1 – 19200, 2 – 38400, 3 – 57600, 4 – 76800	Y
	1010	Front Panel Access Code	RW	word	11	0 = disable, 11-99 to enable	Y
	1011	Front Panel Program Menu Lockout	RW	word	0	0 = allow, 1 = don't allow	Y

Function Code	Register	Description	Read/ Write	Type	Default	Notes	Non-volatile
	1100	Cooling Setpoint	RW	word	76	70-110 degrees	Y
	1101	Cool stage 2 delta	RW	word	2	1-10 degrees	Y
	1102	Cool stage 3 delta	RW	word	2	1-10 degrees	Y
	1103	Cooling off delta	RW	word	5	1-20 degrees	Y
	1104	Heating Setpoint	RW	word	55	34-65 degrees	Y
	1105	Heat stage 2 delta	RW	word	2	1-10 degrees	Y
	1106	Cool/Heat minimum differential	RW	word	4	2-9 degrees	Y
	1107	Cooling minimum on time	RW	word	120	60-600 seconds	Y
	1108	Cooling minimum off time	RW	word	120	60-600 seconds	Y
	1109	Heating minimum on time	RW	word	120	60-600 seconds	Y
	1110	Heating minimum off time	RW	word	120	60-600 seconds	Y
	1111	Outside Air L2 Setpoint	RW	word	65	45-90 degrees	Y
	1112	Outside Air L1 Setpoint	RW	word	62	45-90 degrees	Y
	1113	L1/L2 maximum change	RW	word	5	0-10 degrees	Y
	1114	Outside Air Dwell time	RW	word	300	60-900 seconds	Y
	1115	Mixed Air setpoint	RW	word	50	45-65 degrees	Y
	1116	Mixed Air delta	RW	word	3	0-10 degrees	Y
	1117	Damper Dwell time	RW	word	60	10-300 seconds	Y
	1118	Damper Percentage Change	RW	word	5	1-10%	Y
	1119	Damper minimum percentage	RW	word	0	0-50%	Y
	1120	Supply Fan Dwell time	RW	word	30	15-300 seconds	Y
	1121	Supply Fan minimum percentage	RW	word	50	0-100%	Y
	1200	High temperature level	RW	word	80	70-140 = degrees	Y
	1201	Low temperature level	RW	word	50	20-60 = degrees	Y
	1202	HVAC Lockout	RW	word	0	Enumerated:	Y

Function Code	Register	Description	Read/ Write	Type	Default	Notes	Non-volatile
						0 = disable, 1 = normally open (closure alarms), 2 = normally closed (open alarms)	
	1203	HVAC Supply Fan Failure	RW	word	0	Enumerated: 0 = disable, 1 = normally open (closure alarms), 2 = normally closed (open alarms)	Y
	1204	Cooling Failure Temp	RW	word	65	50-75 = degrees	Y
	1205	Cooling Failure delay	RW	word	900	300-3600 seconds	Y
	1206	Heating Failure Temp	RW	word	110	90-120 = degrees	Y
	1207	Heating Failure delay	RW	word	900	300-3600 seconds	Y
	1300	Product ID	RO	word	400	400	N
	1301	Firmware Revision	RO	word		A.B.C.D in 4-bit numbers	N
	1302	Reset	WO	word		Must write 57005 to data register for reset	N

Appendix B – Control Mode Matrix

The table below will show which outputs are on with the various control modes based on configuration. Note if the HVAC unit doesn't have an economizer then the modes will be the same as if the Econ Mode was disabled.

Single and Two stage DX with Damper Control	Control Mode	Fan Display	Y1	Y2	W1	W2	RV (O)	Fan Speed	Damper
control temp > Cool3 + econ mode enabled	COOL2	ON	ON	ON	OFF	OFF	OFF	Max	min pos.
control temp > Cool2 + econ mode enabled	COOL1	ON	ON	OFF	OFF	OFF	OFF	Max	min pos.
control temp > Cool1 + econ mode enabled	ECON	ON	OFF	OFF	OFF	OFF	OFF	calc speed	Calc pos.
control temp > Cool2 + econ mode disabled	COOL2	ON	ON	ON	OFF	OFF	OFF	Max	min pos.
control temp > Cool1 + econ mode disabled	COOL1	ON	ON	OFF	OFF	OFF	OFF	Max	min pos.
control temp rises above cool off spt.	<fan mode>	ON/Auto	OFF	OFF	OFF	OFF	OFF	calc speed	min pos.
control temp < Cool off	OFF	ON/Auto	OFF	OFF	OFF	OFF	OFF	calc speed	min pos.
control temp < heat1	HEAT1	ON	OFF	OFF	ON	OFF	OFF	Max	min pos.
control temp < heat2	HEAT2	ON	OFF	OFF	ON	ON	OFF	Max	min pos.

Single and Two stage DX with integrated econ	Control Mode	Fan Display	Y1	Y2	W1	W2	O	Fan Speed	Damper
control temp > Cool3 + econ mode enabled	COOL2	ON	ON	ON	OFF	OFF	OFF	Max	N/A
control temp > Cool2 + econ mode enabled	COOL1	ON	ON	ON	OFF	OFF	OFF	Max	N/A
control temp > Cool1 + econ mode enabled	ECON	ON	ON	OFF	OFF	OFF	OFF	calc speed	N/A
control temp > Cool2 + econ mode disabled	COOL2	ON	ON	ON	OFF	OFF	OFF	Max	N/A
control temp > Cool1 + econ mode disabled	COOL1	ON	ON	OFF	OFF	OFF	OFF	Max	N/A
control temp rises above cool off spt.	<fan mode>	ON/Auto	OFF	OFF	OFF	OFF	OFF	calc speed	min pos.
control temp < Cool off	<fan mode>	ON/Auto	OFF	OFF	OFF	OFF	OFF	calc speed	N/A
control temp < heat1	HEAT1	ON	OFF	OFF	ON	OFF	OFF	Max	N/A
control temp < heat2	HEAT2	ON	OFF	OFF	ON	ON	OFF	Max	N/A

Heat pump with Damper Control	Control Mode	Fan Display	Y1	Y2	W1	W2	O	Fan Speed	Damper
control temp > Cool3 + econ mode enabled	COOL2	ON	ON	ON	OFF	OFF	ON	Max	min pos.
control temp > Cool2 + econ mode enabled	COOL1	ON	ON	OFF	OFF	OFF	ON	Max	min pos.
control temp > Cool1 + econ mode enabled	ECON	ON	OFF	OFF	OFF	OFF	ON	calc speed	Calc pos.
control temp > Cool2 + econ mode disabled	COOL2	ON	ON	ON	OFF	OFF	ON	Max	min pos.
control temp > Cool1 + econ mode disabled	COOL1	ON	ON	OFF	OFF	OFF	ON	Max	min pos.
control temp rises above cool off spt.	<fan mode>	ON/Auto	OFF	OFF	OFF	OFF	OFF	calc speed	min pos.
control temp < Cool off	<fan mode>	ON/Auto	OFF	OFF	OFF	OFF	OFF	calc speed	min pos.
control temp < heat1	HEAT1	ON	ON	OFF	ON	OFF	OFF	Max	min pos.
control temp < heat2	HEAT2	ON	ON	OFF	ON	ON	OFF	Max	min pos.

Heat pump with integrated econ	Control Mode	Fan Display	Y1	Y2	W1	W2	O	Fan Speed	Damper
control temp > Cool3 + econ mode enabled	COOL2	ON	ON	ON	OFF	OFF	ON	Max	N/A
control temp > Cool2 + econ mode enabled	COOL1	ON	ON	ON	OFF	OFF	ON	Max	N/A
control temp > Cool1 + econ mode enabled	ECON	ON	ON	OFF	OFF	OFF	ON	calc speed	N/A
control temp > Cool2 + econ mode disabled	COOL2	ON	ON	ON	OFF	OFF	ON	Max	N/A
control temp > Cool1 + econ mode disabled	COOL1	ON	ON	OFF	OFF	OFF	ON	Max	N/A
control temp rises above cool off spt.	<fan mode>	ON/Auto	OFF	OFF	OFF	OFF	OFF	calc speed	min pos.
control temp < Cool off	<fan mode>	ON/Auto	OFF	OFF	OFF	OFF	OFF	calc speed	N/A
control temp < heat1	HEAT1	ON	ON	OFF	ON	OFF	OFF	Max	N/A
control temp < heat2	HEAT2	ON	ON	OFF	ON	ON	OFF	Max	N/A

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