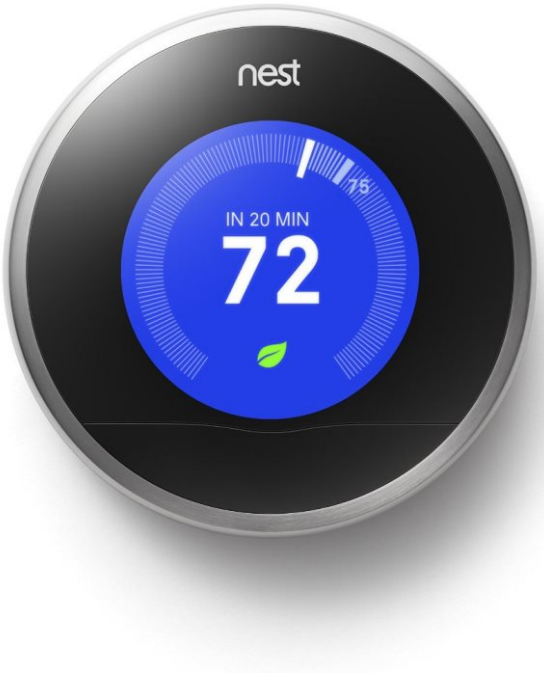
Installation of the Reliant Z-Wave and Nest Thermostats



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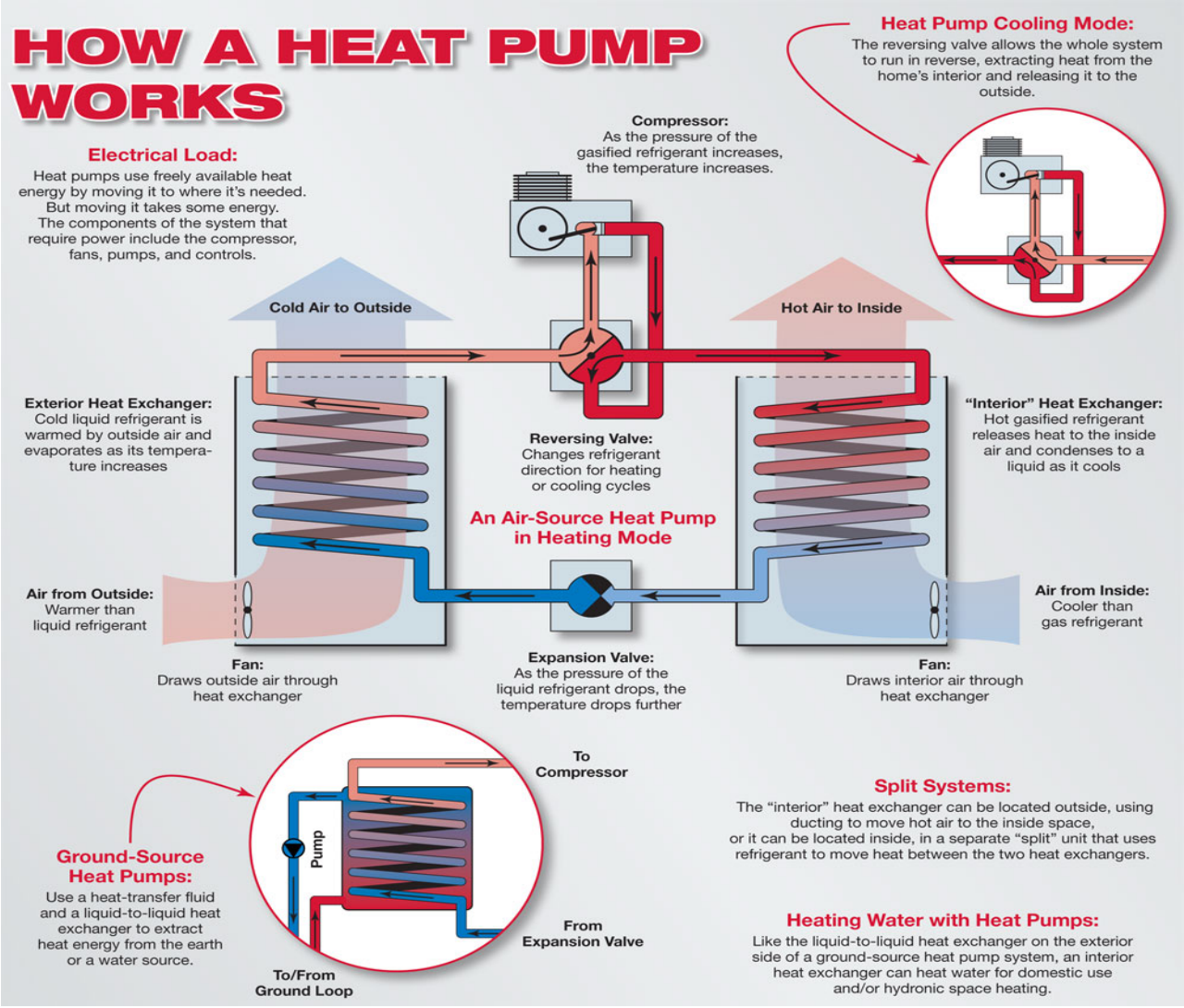
Reliant Z-Wave Thermostat Installation Process Overview

- **Precautions:**
  - Before installing or servicing the thermostat, turn off power to the HVAC system at the circuit breakers.
  - Leave power off until you have finished installing or servicing.
  - Shorting the electrical terminals at the control on the heating or cooling system may damage the thermostat and the HVAC system. *Do not test the HVAC system in this manner.*
  - Follow all local electrical codes and ordinances for wiring the HVAC system.
  - The Reliant thermostat should only be powered by four (4) alkaline AA batteries (or) a listed class 2 power supply at 24V AC (C wire).
  - Amperage higher than one (1) amp to each thermostat relay load may cause damage to the thermostat.
- **Procedures**
  - Site Survey
  - Customer Survey
  - Shut down power
  - Disconnect and remove old thermostat
  - Install Reliant thermostat
  - Restore power
  - Pair Reliant thermostat to the 2GIG panel
  - Complete remaining installation tasks
  - Network Rediscovery
  - Configure Reliant thermostat online
- **Fuses and Transformers**
  - HVAC systems use transformers to step down from the 120V current to 24V control circuitry.
    - We turn off the breakers to protect both the 240V side of the HVAC system- the part that actually supplies power to the compressor, and the 120V side that powers the air handler.
    - We turn off the attic AC switch to protect the 24V side of the HVAC system- the control wiring and activation / actuation components.
    - The transformers often (but not always) have fuses that protect them from short circuits.
    - When an installer crosses two wires (say C and R or RC and RH) while there is voltage present at the end of the HVAC control wires, the fuse blows (or the transformer blows if no fuse is present).
    - This is why we take the precautions with power and bare conductors in HVAC control wiring.
- **C (Common) Wires**
  - The C wire provides power to the thermostat.
    - There is no other function for a C wire.
    - Other wires occasionally power thermostat (see table of Common Thermostat Wiring Terminals).
    - The Reliant thermostat requires an energized C wire only to function as a repeater on the Z-Wave network.

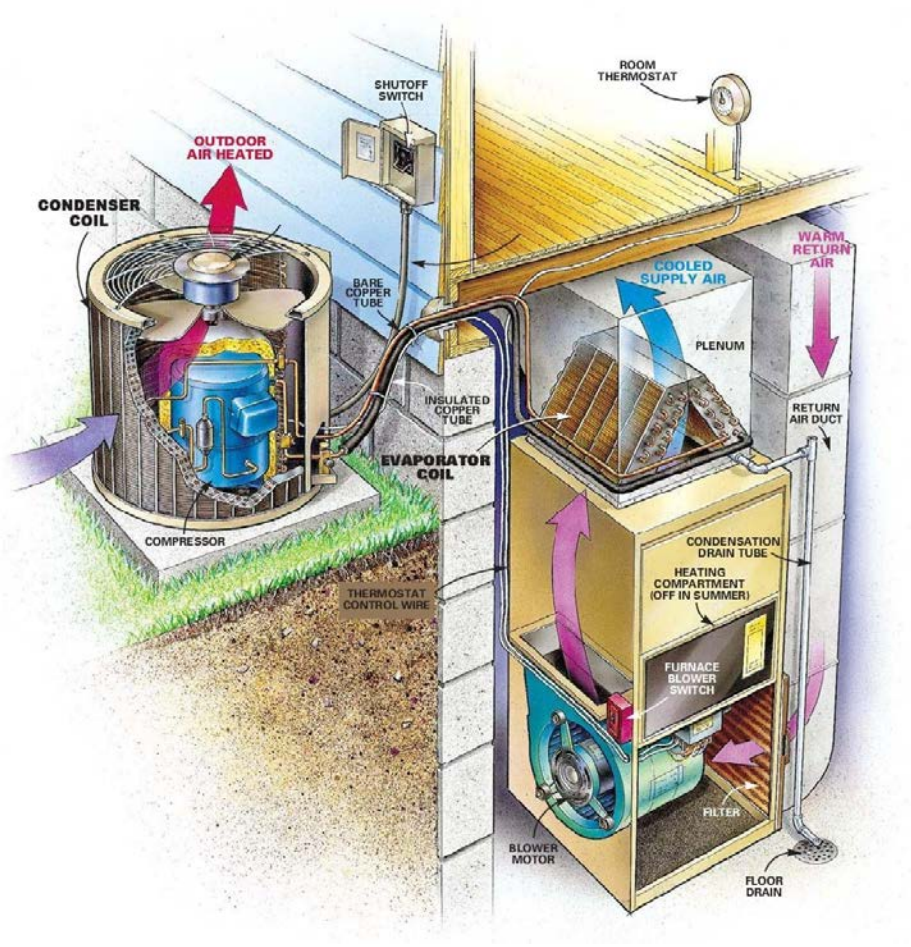
- C wires are sometimes present but not connected.
- If the HVAC installer used “standard” 5 conductor wire but installed a thermostat that didn’t require 24V power, he may have left it disconnected.
- If a fifth wire is wrapped around the control wire bundle but not connected, examine the connections at the air handler to determine if the C wire can be connected.

– **Site Survey**
  – HVAC System Configuration
    - What type of HVAC system is installed in the home?
    - Heat pump?
      – Usually a flatter compressor with some exposed copper tubing.
      – Check the installed thermostat and compressor for indications.



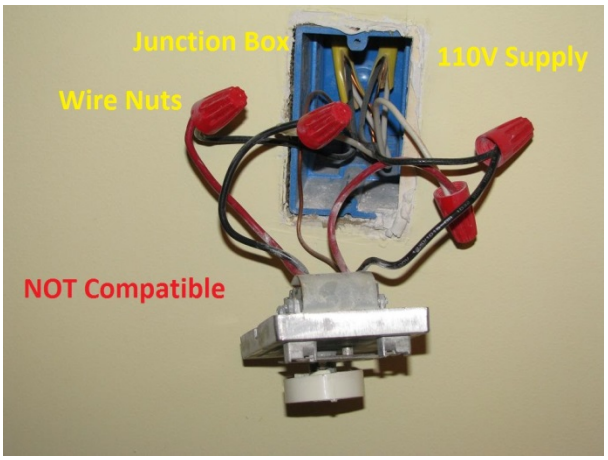
Heat Pump compressors (examples)

- "Standard" heating / cooling?
  - Compressor usually has more exposed cooling area and a boxier or squarer shape.

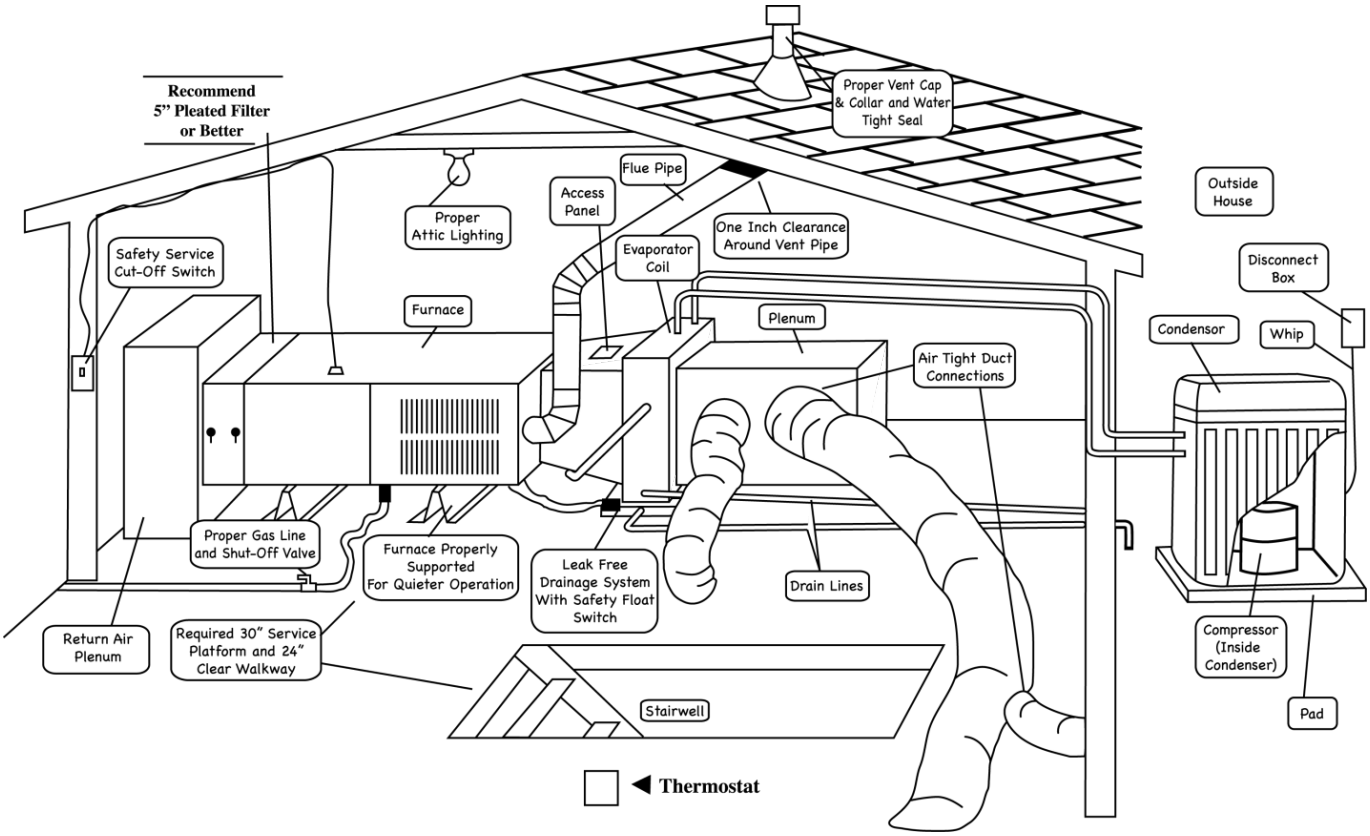


Standard air conditioner compressors (examples)

        - Other heating/cooling system?
            - Solar?
            - Hot Water?
            - Geothermal?
    - HVAC system manufacturer / model?
    - Manufacturer documentation available?
    - Age of HVAC system(s)?
    - Date home was built?
    - Additions / renovations?
        - Homes that have had additions built on or been renovated often have multiple breaker boxes.
    - Last HVAC service performed?
- **<u>Customer Survey</u>**
    - Is the customer familiar with HVAC system configuration?
        - Take a close look at the compressor. There are usually indications of the type of HVAC system on the outside of the "big box outside."
        - Often the thermostat itself indicates the type of HVAC system it controls.
    - Does customer know where breaker box(es) are located?
        - Usually the breaker box will be located in an exterior bedroom, a laundry room, a closet, or in the garage.
        - In newer homes breakers are likely near the electric meter.
        - Additions and renovations often have a separately added breaker box.
    - Has the HVAC system been working normally?
    - Are there any known issues with the HVAC system that would prevent installation of a new thermostat?
    - Where is access to the air handler located?
    - Will the customer be available to answer questions during installation?
- **<u>Thermostat Incompatibility</u>**
    - The Reliant thermostat works with most 24V heating and cooling systems, including gas, electric, oil, solar, hot water, geothermal, forced air, heat pump and radiant heat. However, there are a few systems that are incompatible.
    - <u>Incompatible systems include:</u>
        - HVAC systems with high-voltage controls. If the old thermostat is labeled 120V or 240V, is mounted in a junction box, or is connected to thick wires or wire nuts (picture), the system is high voltage.



- Systems with variable-speed fans. Check any available HVAC documentation to confirm. Often designated X1, T1, 1, 2, or 3.
- At this time, humidifiers and dehumidifiers are not fully supported by the thermostat.
- Proprietary systems such as:
  - Carrier Infinity
  - Bryant Evolution
  - Lennox iComfort
  - Honeywell Redlink



- **Pre-Installation**
  - Installer tools / supplies required:
    - Reliant thermostat with most recent firmware installed and all accessories (control wire labels, batteries, mounting hardware)
    - Reliant range extender (or) smart plug
    - 2GIG Security Panel
    - Screwdrivers (Philips and/or slot)
    - Drill- with 3/16” and 1/8” bits
    - Pliers (needle nose and/or standard)
    - Wire stripper
    - Electrical tape
    - Pencil
    - Access to Alarm.com dealer portal
- **Reliant Thermostat firmware version verification**
  - There are potential known issues with firmware versions prior to 1.10 when used with the 2GIG control panel.
  - Verify that the thermostat to be installed has the latest firmware.
    - With the batteries installed and the thermostat in off mode (no icons lit under temperature display), press and hold the up button on the side of the thermostat.

    - The thermostat firmware version will appear with heat and cool icons illuminated.

    - While the thermostat firmware version is indicated, tap the down button.
      - The Z-Wave firmware version will appear with the pairing icon illuminated.

- The thermostat will display either firmware version for approximately five (5) seconds.
- If the Reliant thermostat does not indicate firmware version 1.10 or higher, do not install it.

– **Power Precautions- "Defense In Depth"**
  – Never attempt a thermostat swap if/when the HVAC system is running.
    - Wait for HVAC system to shut down before turning off power to the system.
  – Turn off all breakers associated with the HVAC system.
    - There are often two (2) breakers associated with the HVAC system.
      – One (or more) for the air handler (120V).
      – One (or more) for the compressor (240V).
    - Turn off the 120V breaker(s) first, then the 240V breaker(s)
    - Breakers may be labeled HVAC, AC, Furnace, Blower, Heater, Air Handler, etc.
    - Breakers located elsewhere, such as near the compressor or inside the air handler should also be turned off if present.
  – Every HVAC system is behind a breaker somewhere. If not found at the main breaker box, you must locate them and turn them all off.
  – Look for additional breaker boxes.
    - Homes built with additions or renovations often have multiple breaker boxes. Check them for HVAC-related breakers and shut them all off if found.
  – Turn off the attic fan switch.
    - The attic fan switch is often on a separate circuit than the primary HVAC system breaker.
    - Attic fan switch may be labeled AC, Fan, Blower, Air Handler, or (other) and is usually mounted between the attic access point and the air handler.
    - If an attic switch cannot be located, take a second look at the breaker panel(s) to ensure they are ALL off.
  – After shutting off breakers and the attic fan switch, check HVAC system by attempting to turn the system on.
    - If HVAC system energizes, re-check breakers and switches.
    - This method is the only way to ensure no voltage is present at the thermostat prior to its replacement (unless installer has a voltmeter).
    - Turn the HVAC system back off at the thermostat but do not do anything else until the HVAC system shuts off.
  – Ask permission before shutting off the main breaker if it is necessary to do so.

- ***Never*** turn any breakers or switches back on until the entire physical installation is complete.

– **<u>Removal of the old thermostat</u>**
  - Remove the front cover or faceplate from the installed thermostat.
    – The cover or faceplate may be secured by clips, screws, or pressure mounts. Exercise care in removal.
  - Take note of the existing control wire connections.
    – Snap a picture of the existing control wire connections before removing any of them.
      – This aids support agents when troubleshooting. The picture can be emailed to support if issues occur.
      – Be sure the pictures are of acceptable quality- sharp with no blur.
    – Alternatively, write down the connections.
  - Take note of any jumpers or control wire connections that do not correspond to the connectors on the Reliant thermostat.
  - Stick the labels you will need and some pre-cut pieces of electrical tape to the thermostat base plate so you have them nearby.
  - If a C wire is present and connected, disconnect, straighten, label the insulator, and wrap the exposed end of the C wire with electrical tape.
    – Electrical tape protects against stray voltage when the C wire contacts other control wires.
    – Using the electrical tape is best practice.
  - Disconnect, straighten, label the insulator, and wrap the exposed ends of any R wires (R, RH, RC) with electrical tape next.
    – R wires being crossed with any other control wires can potentially short out the transformer fuses.
    – Electrical tape protects against stray voltage when the R wires contact other control wires.
    – Using the electrical tape is best practice.
  - Disconnect, straighten, and label the insulators of the remaining control wires.
    – It is not necessary to wrap the exposed ends of the remaining control wires with electrical tape but it's also not a bad idea.
    – Using the electrical tape is best practice.
  - Ensure the control wires do not fall back into the wall.
    – Spread them out or wrap the G wire around a pencil to keep the wires on the outside of the wall.
  - Remove the old thermostat base plate or body from the wall.
    – Carefully pull the HVAC control wires through the access in the old thermostat to avoid the control wires coming into contact with each other.
    – Save the old thermostat (all parts) until the installation of the Reliant thermostat is complete and verified as functional.

        - The old thermostat should be recycled responsibly by the homeowner- especially if it contains mercury switches. Refer the customer to www.thermostat-recycle.org

- **Installation of the Reliant thermostat**
    - At this point the HVAC control wires are accessible and the same location on the wall should be used for the Reliant thermostat.
        - If any repairs, paint, or other preparation of the mounting area are required this is the time to perform them.
    - Place the Reliant thermostat back plate on the wall to determine mounting location.
        - Snap the provided trim plate (smooth side OUT!) onto the Reliant thermostat back plate if it is needed to cover up any holes or previously used mounting hardware.
    - Once the desired location of the Reliant thermostat has been determined, use the bubble level built into the base plate to ensure it will be mounted level and then mark the mounting hole locations.
        - Ensure that the mounting hole locations are not too close to previous holes in the sheetrock.
    - Drill the mounting holes as required.
        - If there is no mounting board behind the sheetrock a 3/16" drill bit can be used for the provided wall anchors.
        - If there is a mounting board behind the sheetrock a 1/8" drill can be used for the provided screws.
    - Feed the control wires through the hole in the middle of the Reliant thermostat back plate before mounting the back plate to the wall.
    - Mount the thermostat to the wall using the drilled holes.
        - Alternatively the control wires can be connected to the Reliant thermostat back plate prior to the back plate being mounted to the wall.
            - This method alleviates the need for control wires to be "jammed" back into the wall after they are connected.
- **Control Wiring Considerations**
    - There are NO standards for HVAC control wiring.
        - It's all about the connections. It has nothing to do with the control wire COLORS.
        - It is possible that the control wires are connected to the thermostat using the first letter of the wire color (G = Green, etc.) but it's not a given.
        - Each connected control wire is essential to the proper operation of the HVAC system.
        - Each control wire has a specific functionality.
            - C = 24 volt supply to the thermostat to power it.
            - G = Fan / blower control.
            - Y = Cooling control.
            - Y2 = Second stage cooling control.
            - R = Single combined (heating and cooling) transformer power from thermostat.
            - RC = Cooling transformer power from thermostat.
            - RH = Heating transformer power from thermostat.
            - W = Heating control.
            - W2 = Second stage heating control.

- O/B = Reversing valve power for heat pump systems.
- O = Cooling side of heat pump.
- B = Heating side of heat pump.
    - In standard thermostat configurations, pay particular attention to the “C” and “R” terminals; connecting these wires to the wrong terminal may damage the HVAC system. Similarly, in a Heat Pump system, the wire connected to the Reversing Valve (O,B, or another designation) must be connected to the correct terminal.
    - The B terminal will likely be used more than the O terminal because in Texas most heat pumps are also installed with gas furnaces. The B terminal is the normal (unpowered) position for cooling.

- Reliant thermostat HVAC control wire connections:
    - RC = Cooling transformer power.
    - RH = Heating transformer power.
    - Z = Online configurable terminal for W3 (3rd stage), H (humidifier) or D (dehumidifier).
    - W2 = Second stage heating control.
    - W = Heating control.
    - C = 24 volt thermostat power.
    - Y = Cooling control.
    - Y2 = Second stage cooling control.
    - G = Fan / blower control.
    - O/B = Reversing valve power for heat pump systems.

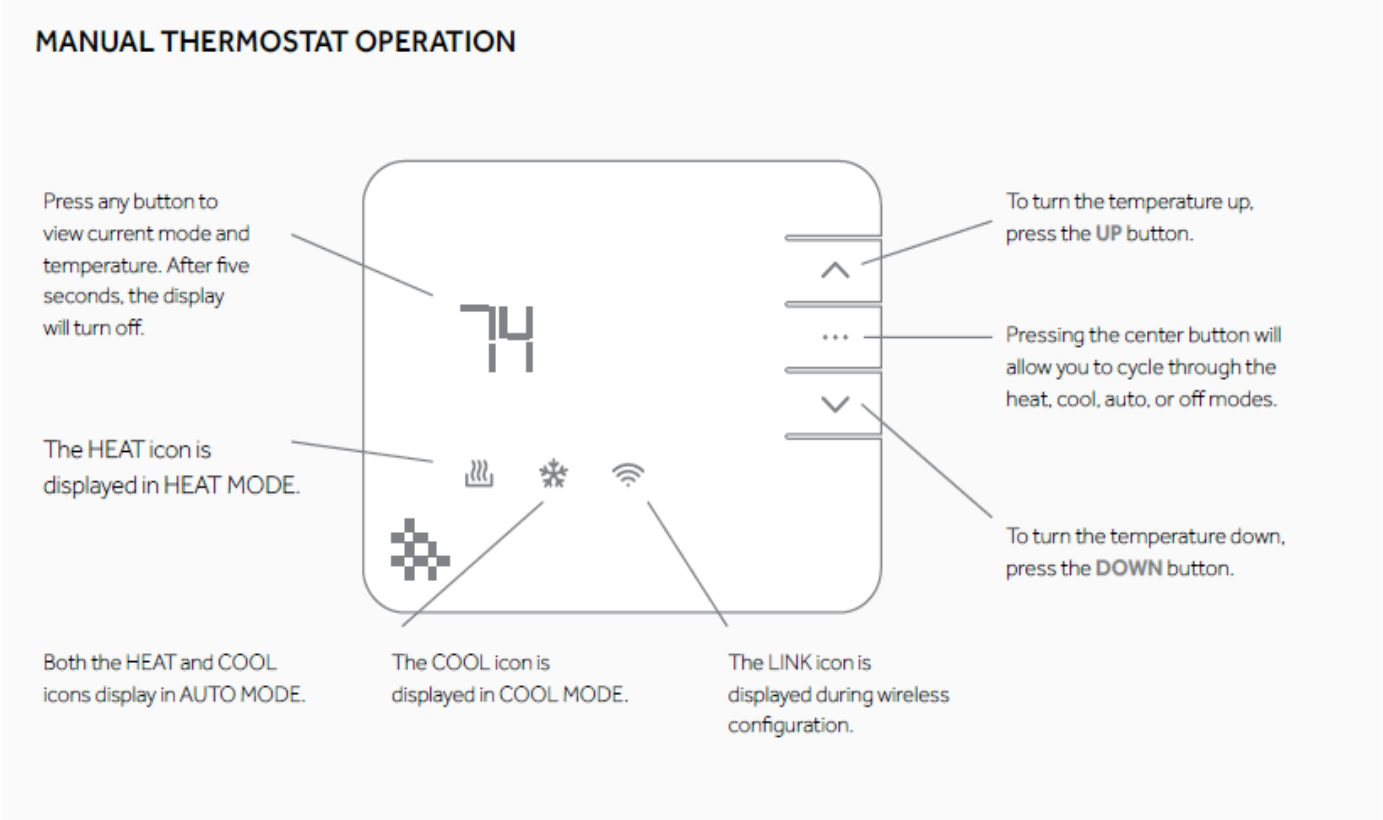
- **<u>Wiring the Reliant thermostat</u>**
  - <u>NOTE: Ensure all HVAC control wire conductors are straight and free of adhesive residue prior to insertion into terminals.</u>
    - If the conductors are not clean any residue can act as a lubricant and allow the HVAC control wires to work free from the terminals.
  - Unwrap the tape from the end of the C wire and insert it straight into the C terminal on the Reliant thermostat back plate first.
    - This keeps the C wire separate from the other control wires.
  - Unwrap the tape from the end of any R wires (R, RH, RC) and insert them straight into the appropriate terminals on the Reliant thermostat back plate next.
    - This keeps the R wires separate from the other control wires and lessens any chance of fuse or transformer problems.
    - If there is only a single R wire then follow these guidelines:
      - If no Y wire was connected to the old thermostat, connect the R wire to RH.
      - If no W wire was connected to the old thermostat, connect the R wire to RC.
      - If a Y wire and a W wire were connected to the old thermostat, connect the R wire to *either* RC or RH.
      - Do NOT remove the jumper from the Reliant thermostat base plate if there is a single R wire.

- Unwrap the tape from the ends of the remaining control wires and insert them straight into the appropriate terminals on the Reliant thermostat back plate.
    - The order of connecting the remaining wires is not important.
- Ensure all connected control wires are securely seated by lightly tugging on each control wire.
    - Reseat any control wires that might not have been connected properly.
- If the old thermostat had separate RC and RH wires connected, remove the jumper from the Reliant thermostat base plate.
    - Failure to remove the jumper in this installation configuration will result in damage to the HVAC system.
- Don't connect any control wires that were not connected to the old thermostat.
- It may be necessary to access the air handler to verify connections between the HVAC system and the thermostat.
    - This is especially true with the C wire. C wires can be present at the thermostat but not connected on the air handler.
    - Not all thermostats require C wires. The Reliant thermostat functions as a Z-Wave repeater when an energized C wire is connected and the thermostat is paired while connected to the energized C wire.

- **Finishing up the physical installation**
    - Push the control wires back into the wall behind the thermostat mounting location.
        - This ensures the thermostat will fit onto the back plate.
    - Install the provided alkaline AA batteries in the Reliant thermostat.
        - Ensure the batteries are installed in the proper polarity.
    - Push the center button on the right side of the Reliant thermostat until no icons are lit under the temperature display.
    - Push the Reliant thermostat straight onto the back plate using steady pressure.
    - The Reliant thermostat will click into place once it is properly mounted.

- If the Reliant thermostat does not provide tactile feedback when mounted, remove the Reliant thermostat by pulling it straight off the back plate and ensure that the control wires are not blocking it.

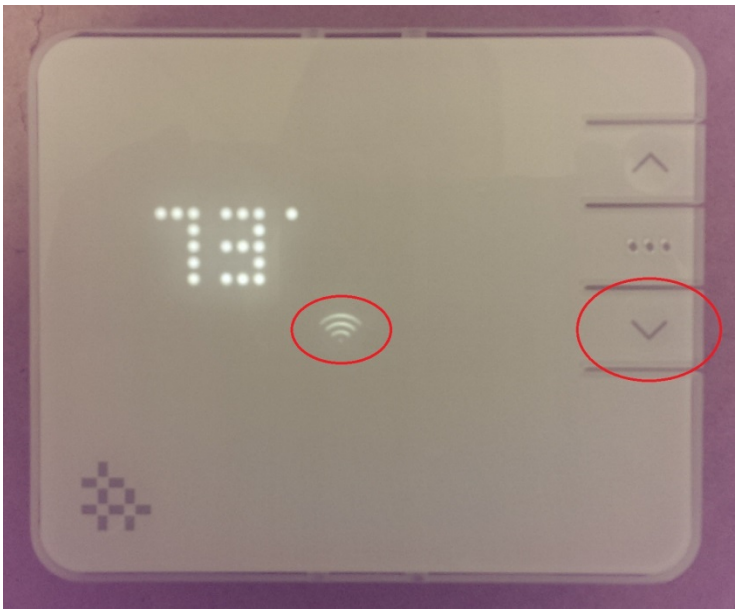
– **Restoring HVAC system power**
  – Ensure the Reliant thermostat is still in off mode (no icons illuminated) before restoring power to any part of the HVAC system.
    - If the thermostat is in off mode, the HVAC system will not activate. But if it in either cool, heat, or auto mode there is a good chance the HVAC system will activate prematurely.
  – Turn the attic fan switch back on first.
  – Turn any breakers previously turned off back on, starting with the 120V breaker(s) and then the 240V breaker(s). If the main breaker was turned off, turn it back on last.
    - Breakers can be tricky. Ensure all breakers are fully engaged when turning them back on.



– **Pairing the Reliant Thermostat to the 2GIG Panel- Panel Preparation**
  – Set the Z-Wave feature before programming Z-Wave devices.
  – (Q79) SELECT Z-WAVE FEATURE (0 to 3).
    - Tap: Go To. Then enter 79 to select a Z-Wave feature.
    - Select: Select Z-Wave Feature (0 to 3) → to select *(0) Disabled and Hidden, (1) Disabled but Visible, (2) Enabled on Panel, Remote Access Disabled*, or *(3) Enabled on Panel; Rules Disabled, Remote Access Enabled*. Then tap ↓.
  – (Q80) SELECT Z-WAVE SWITCHES FEATURE (0 to 1).

- Tap: Go To. Then enter 80 to select a Z-Wave switches feature.
- Select: Select Z-Wave Feature (0 to 1) →to select *(0) Disabled* or *(1) Enabled*. Then tap ↓.
- (Q81) SELECT Z-WAVE THERMOSTATS FEATURE (0 to 1).
- Tap: Go To. Then enter 81 to select a Z-Wave switches feature.
- Select: Select Z-Wave Feature (0 to 1) →to select *(0) Disabled* or *(1) Enabled*. Then tap ↓.

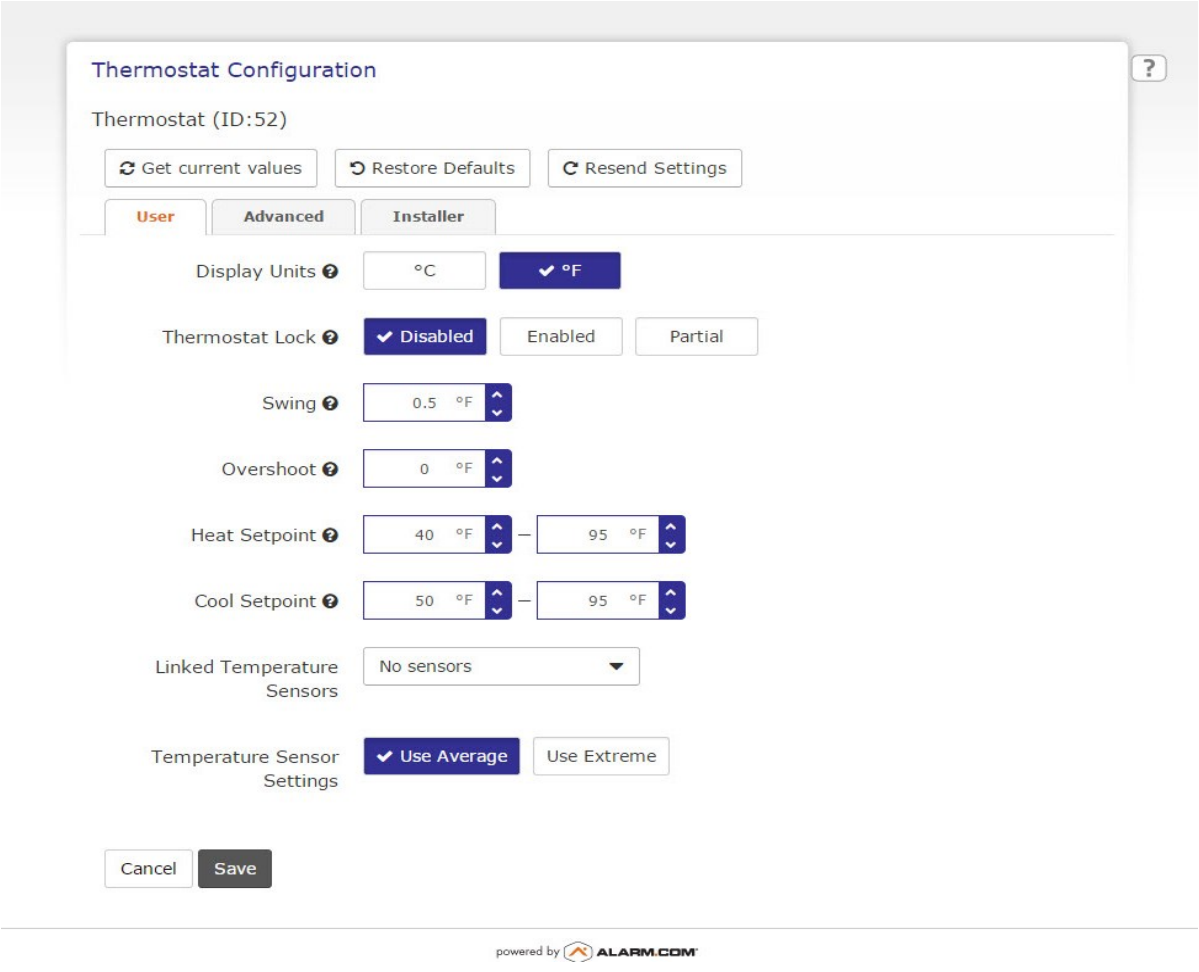
– **<u>Pairing the Reliant thermostat to the 2GIG Panel- thermostat location for pairing.</u>**
  – If the thermostat can be connected to an active C wire, pair the thermostat while it is mounted and connected to the C wire.
    - This will ensure the thermostat functions as a Z-Wave network repeater.
  – If the thermostat cannot be connected to an active C wire (none present), remove the thermostat from the back plate and bring the thermostat body to the panel and pair the thermostat while it is in close proximity to the panel.
    - If no C wire is present then the thermostat will *not* function as a Z-Wave network repeater.
– **<u>Pairing the Reliant Thermostat to the 2GIG Panel- Pairing Procedure</u>**
  – Tap: Home Services.
  – Tap: Toolbox (this is the little wrench icon in the corner of the display).
  – Enter: Master Installer Code.
  – Tap: Add Devices.
  – Press and Hold: The down arrow button on the thermostat until the pairing icon (Link) begins to flash.



    - Once the thermostat is added to the network the flashing white Link icon will remain illuminated.
  – Allow time for the panel to fully query the device information.
  – The control panel displays the following message: A device has been added to the network.
  – Press: Back.
  – Press: Back (again).

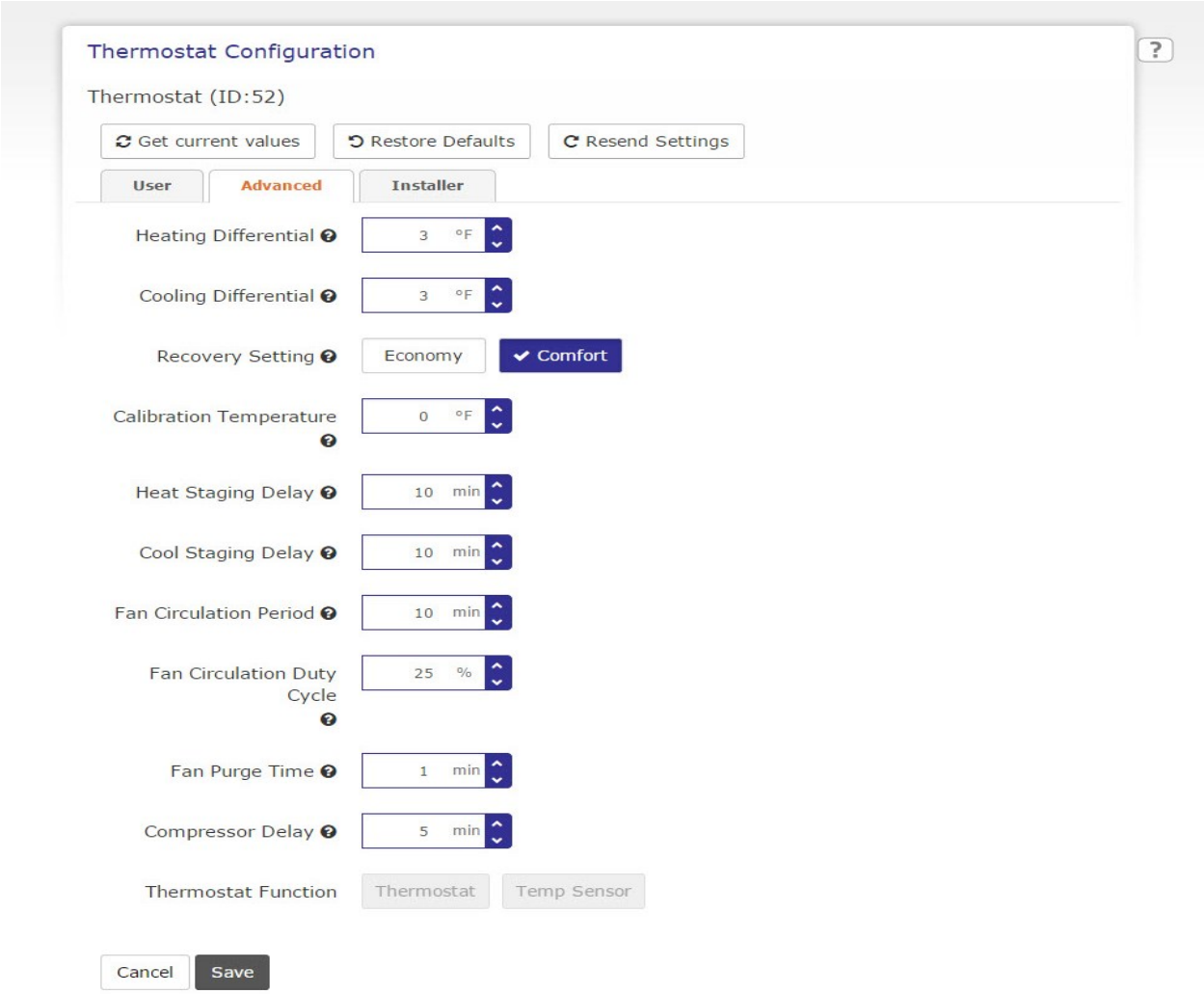
- **Complete remaining installations**
  - Finish all other equipment installations and pairings with the 2GIG Control Panel.
    - Plugs, locks, sensors, etc.
- **Network Rediscovery**
  - Once a Z-Wave network has been set up or a device has been added, a network rediscovery should be initiated.
  - Network rediscovery strengthens the network and promotes communication between the devices as well as between the devices and the control panel.
  - To initiate a network rediscovery:
    - Tap: Home Services.
    - Tap: Toolbox (this is the little wrench in the corner).
    - Tap: Advanced Toolbox.
    - Tap: Select Rediscover Network.

- **Online Configuration of the Reliant thermostat**
  - The **User** tab displays the parameters below:



- User tab definitions:
  - **Display Units** is the parameter for the thermostat display to indicate degrees Celsius or degrees Fahrenheit.
    - Default is Fahrenheit.
  - **Thermostat Lock** is the parameter for the various selectable lock types
    - The default is disabled. Total local control of the thermostat is allowed.
    - Enabled completely locks out local changes to the thermostat settings.
    - Partial locks changes to the mode (heating or cooling) but allows changes to the setpoint via the up and down buttons.
  - **Swing** is the difference between the selected or scheduled temperature setting and the actual temperature at which the HVAC system will **activate** to heat or cool the home.
    - The default Swing setting is 1.5°F.
    - Example when in cool mode: Setpoint 78 degrees with swing set to 1.5 degree = max temp will get up to 79.5 (displayed as 80) before HVAC system activates and cools the home.
    - Example when in heat mode: Setpoint 68 degrees with swing set to 1.5 degree = low temp will get to 66.5 (displayed as 67) before HVAC system activates and heats the home.
    - NOTE: The Reliant thermostat does not display half-degree increments. Therefore the displayed temperature in the example scenarios above can appear to be 1 degree cooler or warmer than expected.
  - **Overshoot** is the difference between the selected or scheduled temperature setting and the actual temperature at which the HVAC system will **shut off** after heating of cooling the home.
    - The default Overshoot setting is 1.5°F.
    - Example when in cool mode: Setpoint 78 degrees with overshoot set to 1.5 degree = HVAC system cools the home down to 76.5 (displayed as 76) before shutting off.
    - Example when in heat mode: Setpoint 68 degrees with overshoot set to 1.5 degree = HVAC system heats the home to 69.5 (displayed as 70) before shutting off.
    - NOTE: The Reliant thermostat does not display half-degree increments. Therefore the displayed temperature in the example scenarios above can appear to be 1 degree cooler or warmer than expected.

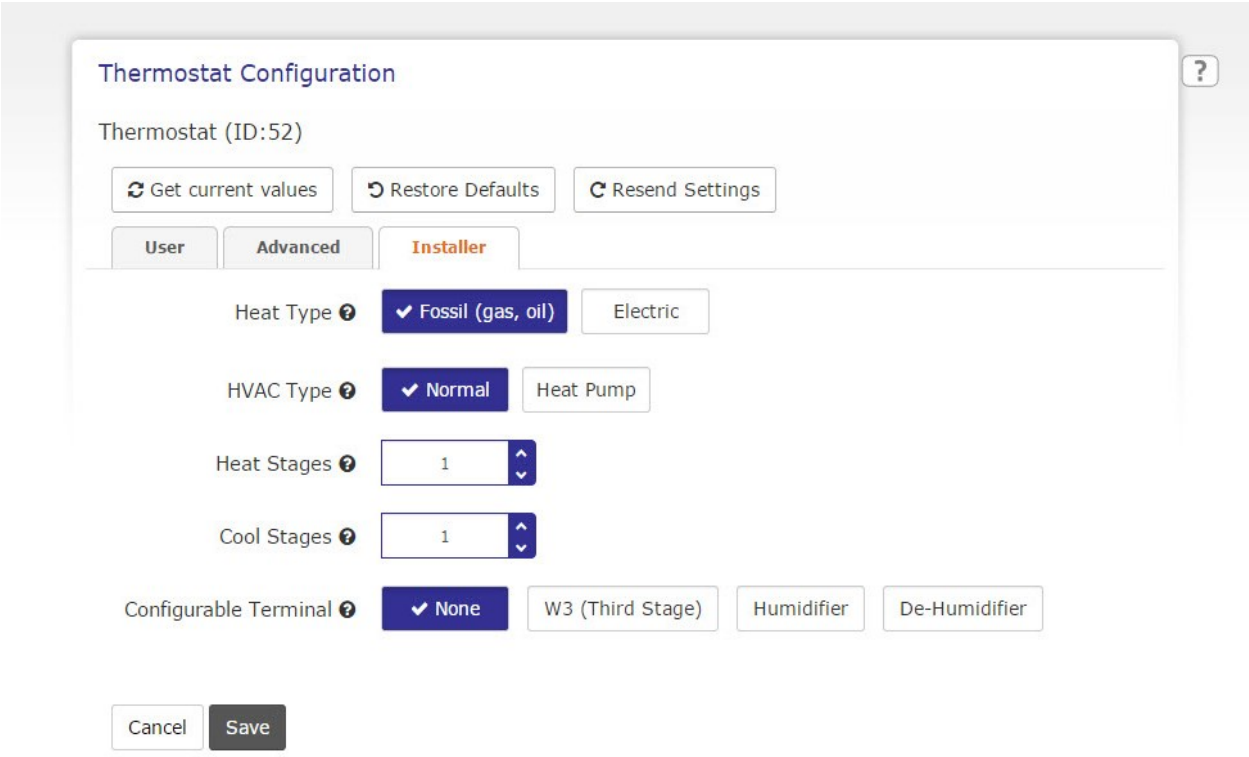
– The **Advanced** tab displays the parameters below:



– Advanced tab definitions:
  - **Heating Differential** is the difference in degrees between the activation of the first stage and activation of the second stage in dual-stage heating systems.
    – Characterized by both W (or W1) and W2 wires connected.
  - **Cooling Differential** is the difference in degrees between the activation of the first stage and activation of the second stage in dual-stage cooling systems.
    – Characterized by both Y (or Y1) and Y2 wires connected.
  - **Recovery Setting** determines the amount of energy used to heat or cool the home when large changes in temperature are necessary.
    – Economy is the preferable selection for this parameter.
  - **Calibration Temperature** determines what temperature the thermostat “thinks” it is reading in the home environment.
    – Generally the calibration temperature is left at 0 degrees.

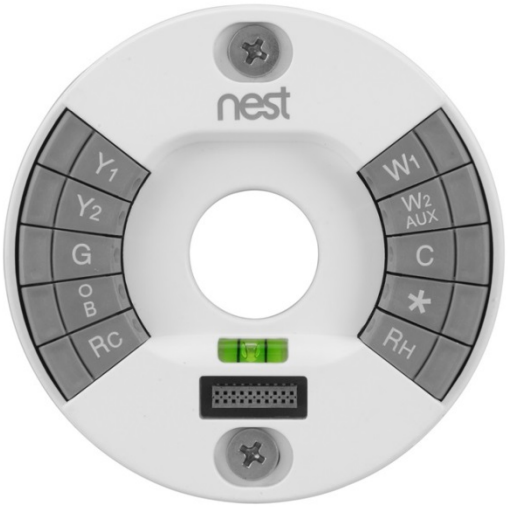
- **Heat Staging Delay** is the amount of time between the activation of the first stage and activation of the second stage in dual-stage heating systems.
  - Characterized by both W (or W1) and W2 wires connected.
- **Cool Staging Delay** is the amount of time between the activation of the first stage and activation of the second stage in dual-stage cooling systems.
  - Characterized by both Y (or Y1) and Y2 wires connected.
- **Fan Circulation Period** is the amount of time the HVAC fan will operate when the fan is operated, independent of heating or cooling, to circulate only the air in the home.
  - Default is 20 minutes.
- **Fan Circulation Duty Cycle** is the percentage of the available fan power used when the HVAC fan is operated, independent of heating or cooling, to circulate only the air in the home.
- **Fan Purge Time** is the amount of time the HVAC fan will run after the compressor shuts down to circulate remaining cool air from the system.
- **Compressor Delay** is the amount of time the compressor will wait to respond to a call for activation from the thermostat.
  - Compressor Delay is used to protect the compressor from damage that can be caused by short-cycling. The compressor builds up pressure that must be equalized between activations.
- **Thermostat Function** is reserved for future use.

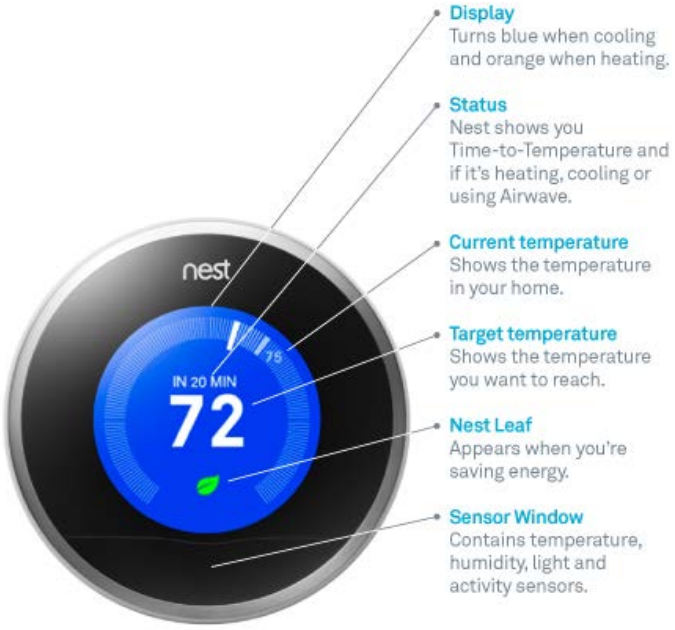
– The **Installer** tab displays the parameters below



- Installer tab definitions
    - **Heat Type** is the selector for electric heat or fossil fuel (gas/oil) heat
        - Few homes in the area have electric heat, but the default setting is electric because electric heat does not have a delay between the furnace and the blower turning on the way that gas and oil-fired furnaces do.
    - **HVAC Type** is the selector for heat pump or normal
        - Default is normal. If a heat pump is installed at the dwelling you **must** configure it properly. Refer back to the HVAC control wiring configuration and site survey to ensure that the thermostat configuration matches the HVAC system to which it is connected.
    - **Heat Stages** is the parameter for the number of stages in the heating part of the HVAC system.
        - Check for W2 wire.
    - **Cool Stages** is the parameter for the number of stages in the cooling part of the HVAC system.
        - Check for Y2 wire.
    - **Configurable Terminal** (terminal Z) is the parameter for controlling a connected third stage (usually heating), a humidifer, or a de-humidifer.
        - As of this training the humidifier and de-humidifier functionality is not implemented.
- Verify that all parameters chosen are correct and complete.
- Online configuration- Final steps
    - After clicking Save a Warning dialog box appears asking if installer wants to proceed.
        - Click Proceed.
    - Configuration is complete.

Nest Thermostat Installation Process Overview

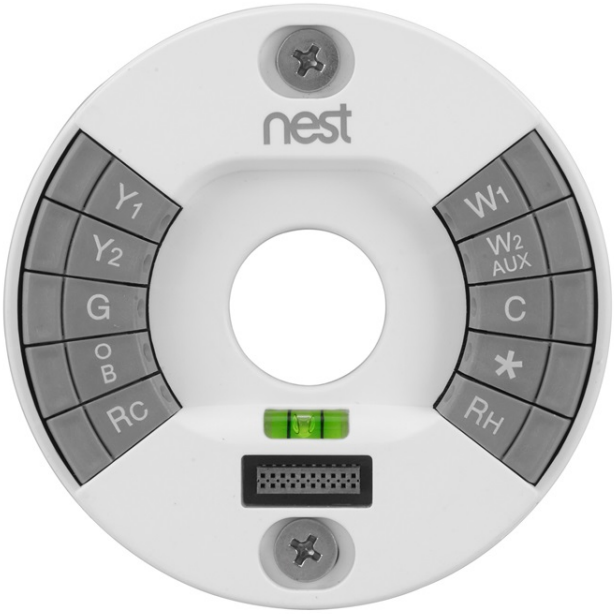


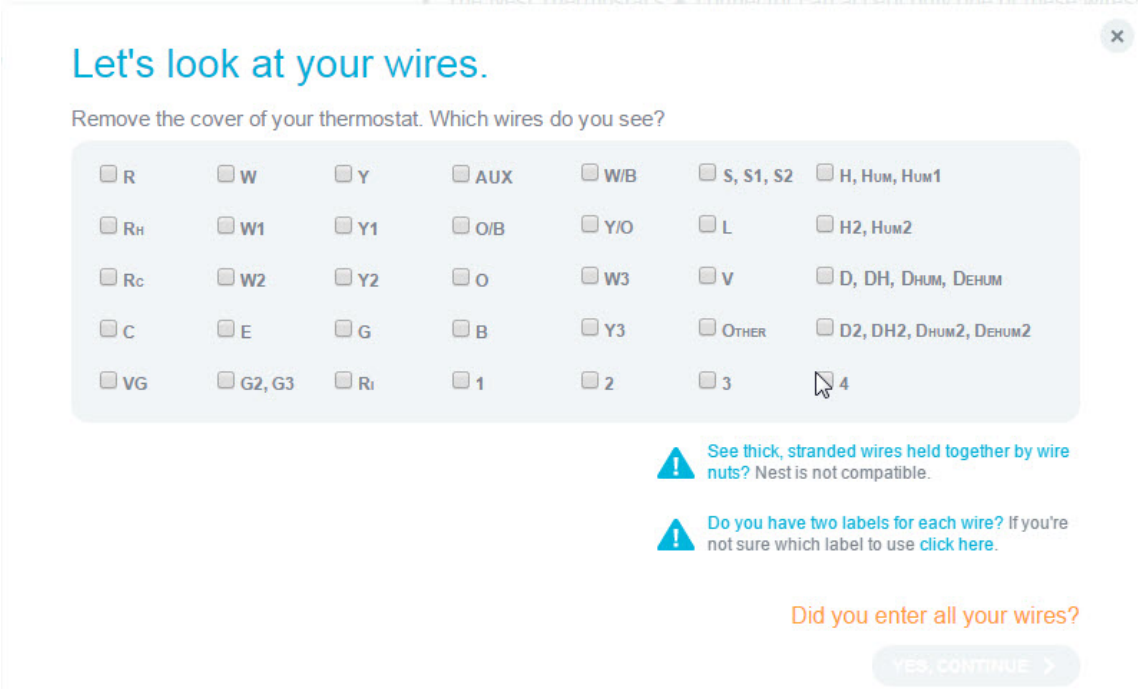


Reliant Thermostat	**Attribute**	Nest Thermostat
Full control only available via online portal and app. Limited functionality via physical interaction.	**Physical Interface**	Nearly full functionality on device.
Yes	**DIY**	Yes
ADC website	**Programming**	All interaction via app. Limited controllability via ADC website
ADC app and ADC website	**Remote Access**	Nest app, ADC app, and ADC website
Geo-Fencing enabled	**Auto-Away**	Internal motion sensors in the thermostat face.
Supports advanced rules across all devices in the home	**User-Defined Rules**	No integrated home rules supported.
Z-Wave	**Radio(s)**	Wireless (802.11b/g/n) and Nest Weave (802.15.4)
Z-Wave hub (gateway) or 2GIG Security Control Panel	**Communication via**	Broadband wireless router (802.11b/g/n) or to other Nest products (802.15.4)
Push-in spring-loaded (no tools required)	**Terminal Type**	Push-in spring-loaded (no tools required)
RC, RH, Z (configurable), W2, W, C, Y, Y2, G, O/B	**Available Terminals**	Y1, Y2, G, O/B, RC, RH, *(configurable), C, W1, W2/Aux
24V heating and cooling- gas, electric, oil, solar, hot water, geothermal, forced air, heat pumps, radiant heaters.	**Compatibility**	Same, plus humidifiers and de-humidifiers
Present; Must be configured correctly	**Jumper for RC to RH**	Not present; Nest claims R wire configurations are automatically configured
Energized C wire required for Z-Wave network repeater functionality only.	**C Wire**	Not required but without an energized C wire the Nest can malfunction
4X alkaline AA batteries	**Batteries**	Integrated rechargeable
Over-The-Air only	**Firmware Updates**	Over-The-Air or via micro-USB connector
Any other paired Z-Wave devices on the network	**Connectivity Aids**	802.11b/g/n network extender only
Trim plate, AA batteries, mounting hardware, control wire labels	**Supplied Accessories**	Trim plate, mounting hardware, control wire labels, wicked cool screwdriver
Push three Buttons on one side of the device	**Control Interface**	Spin body to view options, push down to select
Display not active unless a button is pushed	**Display Behavior**	Senses presence and activates display
Controls the HVAC system	**Functionality**	Controls the HVAC system

Installing the Nest Thermostat

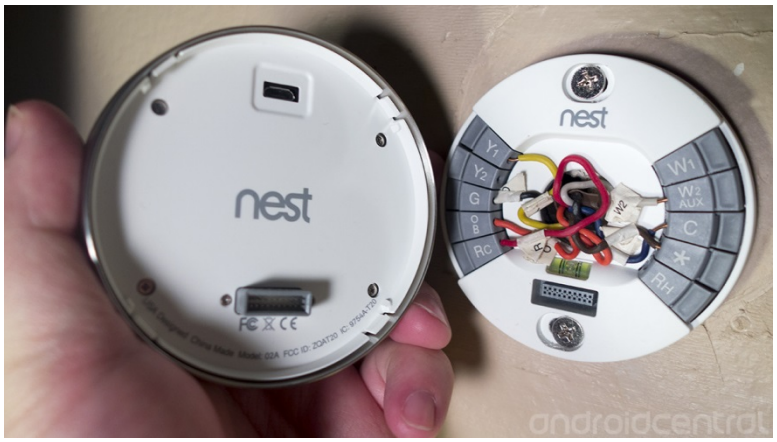
- **All procedures prior to the actual physical install are identical**
  - Site Survey
  - Customer Survey
  - Shut down power
  - Disconnect and remove old thermostat
- Nest thermostat connections
  - The Nest thermostat works with over 95% of 24V heating and cooling systems, including gas, electric, oil, solar, hot water, geothermal, forced air, heat pump and radiant.
  - The Nest thermostat can control the following types of HVAC systems:
    - Heating: one, two and three stages (W_1, W_2, W_3)
    - Cooling: one and two stages (Y_1, Y_2)
    - Heat pump: with auxiliary and emergency heat (O/B, AUX, E)
    - Fan (G)
    - Power (C, Rh, Rc)
    - Humidifier or dehumidifier (HUM, DEHUM)
  - The Nest thermostat's * connector can accept only one of these wires:
    - W_3, E,HUM or DEHUM.
  - The Nest thermostat is designed to work even if your home doesn't have a common "C" wire, but installing a new C wire may be required in rare cases.
  - Important Note: Professional installation is recommended for:
    - Dual fuel systems (heat pump with furnace)
    - Whole-home humidifiers and dehumidifiers

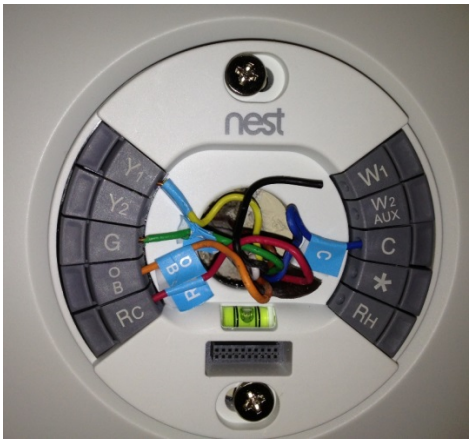


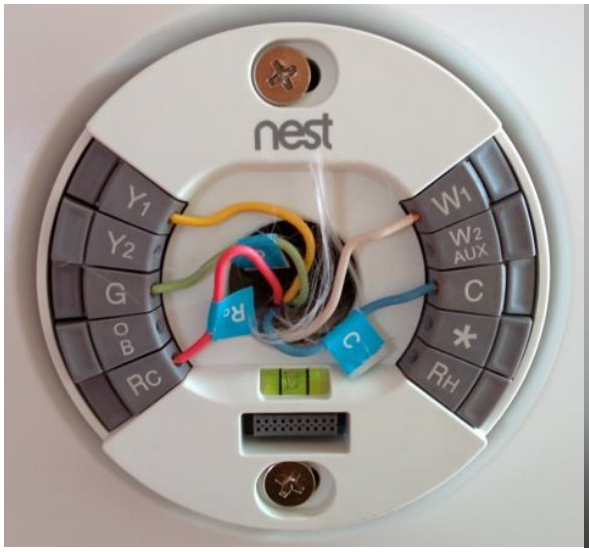


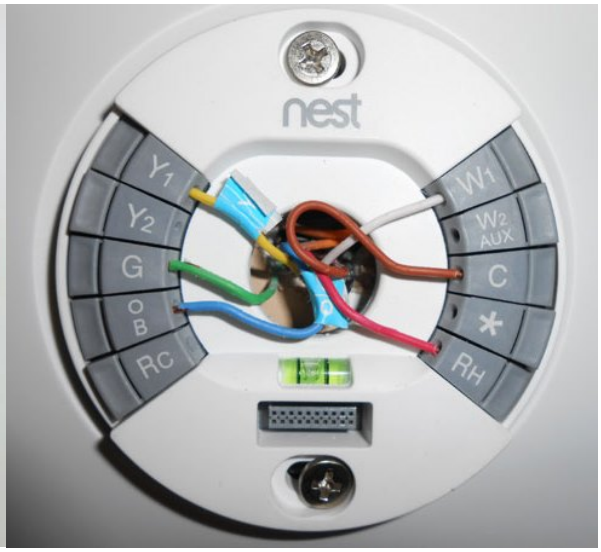
- **<u>Wiring Considerations</u>**
  - Nest thermostat HVAC control wire connections:
    - RC = Cooling transformer power
    - RH = Heating transformer power
    - * = Online configurable terminal for W3 (3rd stage), H (humidifier) or D (dehumidifier)
    - W2/Aux = Second stage heating control
    - W1 = Heating control
    - C = 24 volt thermostat power
    - Y1 = Cooling control
    - Y2 = Second stage cooling control
    - G = Fan / blower control
    - OB = Reversing valve power for heat pump systems
- **<u>Wiring the Nest thermostat.</u>**
  - Unwrap the tape from the end of the C wire and insert it straight into the C terminal on the Nest thermostat back plate first.
    - This keeps the C wire separate from the other control wires.
  - Unwrap the tape from the end of any R wires (R, RH, RC) and insert them straight into the appropriate terminals on the Nest thermostat back plate next.
    - This keeps the R wires separate from the other control wires and lessens any chance of fuse or transformer problems.
    - When there is only a single R wire connected, use the following guidelines:
      - If no Y wire was connected to the old thermostat connect the R wire to RH.

        - If no W wire was connected to the old thermostat connect the R wire to RC.
        - If a Y wire and a W wire were both connected to the old thermostat connect the R wire to either RC or RH.
    - Unwrap the tape from the ends of the remaining control wires and insert them straight into the appropriate terminals on the Nest thermostat back plate.
        - The order of connecting the remaining wires is not important.
- Ensure all connected control wires are securely seated by lightly tugging on each control wire.
    - Reseat any control wires that might not have been connected properly.
- Don't connect any control wires that were not connected to the old thermostat.
    - It may be necessary to access the air handler to verify connections between the HVAC system and the thermostat.
        - This is especially true with the C wire. C wires can be present at the thermostat but not connected on the air handler.
        - Not all thermostats require C wires. The manufacturer of the Nest thermostat claims it can charge its internal battery from any energized wire. However, the C wire is the most reliable way to keep a charge on the Nest battery.









- **Finishing up the physical installation.**
  - Push the control wires back into the wall behind the thermostat mounting location.
    - This ensures the thermostat will fit onto the back plate.
  - Push the Nest thermostat straight onto the back plate using steady pressure.
    - The Nest thermostat will click into place once it is properly mounted.
    - If the Nest thermostat does not provide tactile feedback when mounted, remove the Nest thermostat by pulling it straight off the back plate and ensure that the control wires are not blocking it.
  - Turn the attic fan switch back on first.
  - Turn any breakers previously turned off back on, starting with the 120V breaker(s) and then the 240V breaker(s). If the main breaker was turned off, turn it back on last.
    - Breakers can be tricky. Ensure all breakers are fully engaged when turning them back on.
- **Configuring the Nest Thermostat**
  - After the Nest thermostat is installed for the first time and the power is turned on, the Nest thermostat will begin setup.
    - Language selection
    - Internet Connection
      - **Network ID and password required**
  - Heating and Cooling
    - Fuel Source
    - Heat Pump
    - Dual Fuel
  - Location / Time Zone
  - Temperature Preferences
    - Heating and cooling set points
- **Pro Setup**
  - Pro Setup is required to set up dual fuel systems (e.g. heat pump with furnace) as well as humidifiers and dehumidifiers. It is available to installation professionals during and after installation and allows them to set which wire has power and what kind of equipment it controls, including fuel type for each stage of a dual fuel system.
  - When you setup your Nest Learning Thermostat for the first time, you will be asked if you are a homeowner or a professional. if you answer Professional, then you will be presented with Pro Setup.
  - To enter Pro Setup on your Nest Learning Thermostat after the main setup, follow these steps:
    - Go to SETTINGS > EQUIPMENT > CONTINUE > CONTINUE > PRO SETUP
    - Read the disclaimer, and if you are an installation professional, continue.
    - From there, you can turn the ring to select each of the wires connected to your Nest Thermostat. Click to select one. You can set and change the source type (e.g. Gas, Electric, Oil) and the delivery type (e.g. forced air, in-floor radiant). Once you validate your changes, this wire will be highlighted in green while the wires you haven't set yet remain in yellow.

– Once you are done with the advanced configuration, click DONE > CONTINUE > DONE.

- **<u>Online Verification</u>**
  - Verify that on the Dealer Portal the customer has Nest Integration checked off under their Service Plan.
  - When the user logs into their account, in the Empower tab there should be a link titled Log in with NEST.
    - User clicks the link to launch the UI.
  - Click Continue to launch the How To Setup a Works With Nest Connection screen.
  - Enter the customer's account information on the Nest Login screen.
    - The UI will indicate that it is retrieving an updated equipment list.
  - The Thermostats tab launches and indicates the customer's Nest thermostat information and controls.
  - Click Devices under the Empower tab to launch the Empower Devices UI.
    - The Nest thermostat should be listed as a Cloud Thermostat.
    - The name of the device can be changed in the box under Device Name on the left side of the UI. Click Save to send the changes to the network.

Troubleshooting

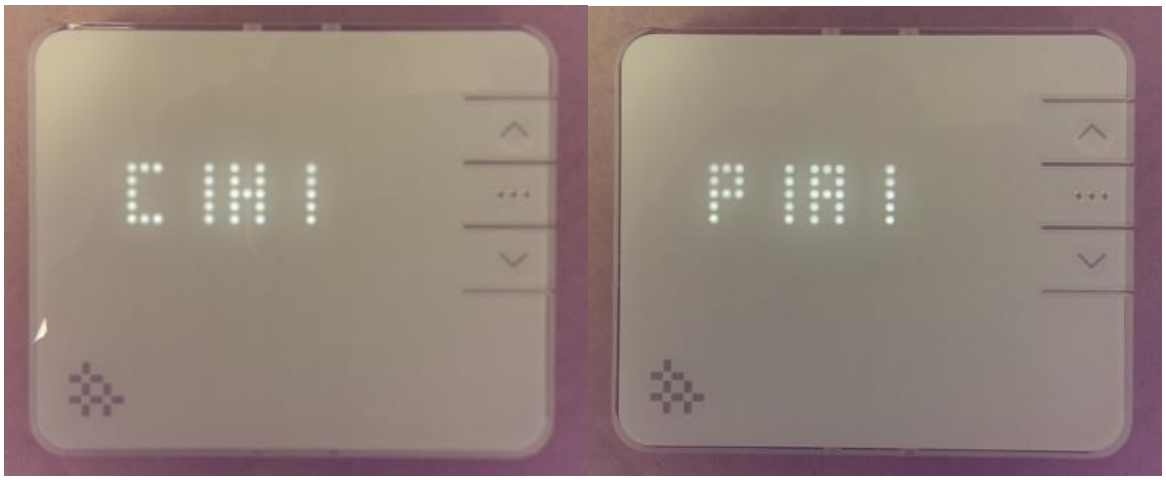
- **How do I remove the Reliant thermostat for troubleshooting after it's been installed?**
  - Follow this procedure to safely remove the thermostat for troubleshooting:
    - Ensure the HVAC system is not running.
    - Push the center button on the thermostat until no icons are displayed under the temperature display (off mode).
    - Pull the thermostat body straight off the back plate to remove it from the back plate.
    - *NOTE: The HVAC system will not activate while the thermostat is disconnected.*
  - Follow this procedure to re-install the thermostat after troubleshooting:
    - Ensure the batteries are still fully seated in the battery mounts.
    - Push the center button on the thermostat until no icons are displayed under the temperature display (off mode).
    - Push the thermostat body straight down onto the mounting lugs on the back plate to mount the thermostat.
    - *NOTE: The HVAC system can and might immediately activate if the thermostat is connected to the back plate while it is in COOL, HEAT, or AUTO mode. The thermostat **must** be in OFF mode.*
- **HVAC system is unresponsive when I try to heat or cool the dwelling**
  - Assuming the HVAC system was working properly before installation and all safeguards were followed to guard against short circuits during installation, then are the following true?
    - Were all breakers turned back on?
    - Were all breakers fully engaged when turned back on?
    - Was the attic fan switch turned back on?
    - Was the air handler door left unsecured (door sensor)?
    - Are there any loose or unseated HVAC control wires?
    - Was the HVAC system properly configured online?
  - Heat works but not cooling.
    - W (heat control) wire(s).
    - RH or R fuse / transformer.
  - Cool works but not heat.
    - Y (cool control) wire(s).
    - RC or R fuse / transformer.
  - Compressor runs but fan not blowing.
    - G wire.
    - Attic fan switch.
    - Air handler breaker.
  - Heat pump not cooling / heating.
    - O / B wire configuration.

- **Why can't the old thermostat just be switched off and pulled off the wall?**
  - The thermostat does not usually have high-voltage wires running to it, but the AC compressor and fan motor are two of the highest electrical load items in the home. Should either one be energized while there is no thermostat connected, serious damage to the HVAC system could result.
- **Why is it so important to label the wires on the old thermostat?**
  - There are multiple possible wiring configurations for HVAC controls depending on your home construction and type of heating/air conditioning. If the HVAC control wires are not connected correctly to the Reliant thermostat, damage to the thermostat and the HVAC system can occur. Therefore, we recommend labeling the control wires as they are individually disconnected from the old thermostat, taking a picture of the HVAC control wiring before disconnection and/or writing down the color/ connector combinations as added documentation of the installation.
- **Why does the Reliant thermostat need batteries?**
  - The batteries in the Reliant thermostat are there to maintain the connection with the network. The batteries also keep settings saved when the thermostat is not connected to a C (common) wire that provides power to the thermostat itself.
- **Can lithium AA batteries be used in the Reliant thermostat?**
  - Alkaline batteries are recommended to ensure consistent performance of the thermostat.
  - Alkaline batteries decay at a predictable rate. Lithium batteries do not.
- **Can the Reliant thermostat be mounted in a different location than the old thermostat?**
  - Usually, when replacing an old thermostat, the new thermostat will be mounted in the same place as the old one. If a new location is desired it will be necessary to move the HVAC control wiring. New installations and relocation should follow the guidelines below to ensure the most accurate temperature reading and ease of use.
    - Mount the thermostat on an inside wall, approximately 5 ft. (1.5m) above the floor in a frequently used room.
    - Do not install in locations near appliances or devices that affect the local temperature such as televisions, lamps, or dryers.
    - Avoid areas that are exposed to large temperature variances, such as direct sunlight, near an A/C unit, above or below auxiliary heat and air vents, and drafts from windows.
    - Do not install on walls shared with or adjacent to unheated rooms or stoves, or walls housing hot water pipes.
    - Damp areas will not only affect the humidity reading of your thermostat, but could lead to corrosion shortening the life of your thermostat.
    - Avoid areas with poor air circulation, such as corners and behind open doors.
    - Wait until construction and painting are finished before installing.
- **What do the R, RC, and RH wires actually do?**
  - The **R wire** connects the HVAC transformer to the thermostat and provides power to the heating system, cooling system, and/or fan when the heating, cooling, or fan circuits are switched on. Most HVAC systems are powered by a single 24 Volt A/C transformer. Systems that have separate heating and cooling transformers will have separate wires controlling each transformer (RH and RC) rather than a single R wire. In the Reliant thermostat, the RC and RH terminals are connected with a jumper and customers that only have a single R or RH (but no RC wire) wire should connect that R or

RH wire to the RH terminal on the NRG base plate. Customers with separate RC and RH wires must remove the jumper before connecting their RC and RH wires.

- The **RC wire** connects the cooling system transformer to the thermostat. The RC terminal provides power to the cooling circuit when the air conditioning is switched on. If both RC and RH terminals are connected, the HVAC system has separate transformers for air conditioning and heating.
- The **RH wire** connects your heating system transformer to the thermostat. The RH terminal provides power to the heating circuit when the heating system is switched on. If both RC and RH terminals are connected, the HVAC system has separate transformers for air conditioning and heating.

- **How do I remove a paired Reliant thermostat from the panel?**
  - To remove a Reliant thermostat from the panel:
    - **Tap: Home Services.**
    - **Tap: Toolbox** (this is the little wrench in the corner of the display).
    - **Enter:** Master Installer Code.
    - **Tap: Remove Devices.**
    - **Press and hold** the down arrow button on the thermostat until the orange pairing icon (Link) begins to blink.
      - Once the thermostat is removed from the network the flashing orange Link icon will remain illuminated.
    - The control panel displays the following message: ”A device has been removed from the/another network.”
    - For more details, refer to the Z-Wave device instructions.
- **How do I manually configure the Reliant thermostat?**
  - NOTE: This method of configuring the Reliant thermostat should only be used when the O terminal (energized cooling cycle) is used.
  - NOTE: If the number of stages displayed does not match the HVAC system configuration, you must use the dealer or user portal to properly configure the number of heating and cooling stages (in the Installer tab UI).
    - There is no way to change the number of stages on the Reliant thermostat.
  - To manually configure the Reliant thermostat:
    - With the thermostat in off mode (no icons indicated under the temperature display), press and hold the up button for ten (10) seconds.
      - At five (5) seconds the firmware version will be displayed.
      - At ten (10) seconds the configuration information will be displayed.



- Press the up or down buttons to select either normal HVAC configuration (C1H1 or C2H2) of heat pump configuration (P1A1 or P2A2).
- Once the configuration has illuminated, allow the display to return to off mode.

Common Thermostat Wiring Terminals		
Terminal	**Alternate**	**What does it do?**
C	**COM** (for common), **B**, **X**	"Common" wire terminal. It provides 24V power to the electronic components in the thermostat. Battery powered thermostats may not require a common wire. The Reliant thermostat can be powered by battery or by the common wire; when a common wire is present, the thermostat batteries are used for back-up power.
R	**V**, **VR** sometimes used in Lennox, Trane, and York systems	Connects the HVAC transformer to the thermostat and provides power to the heating system, cooling system, and/or fan when the heating, cooling, or fan circuits are switched on. Most HVAC systems are powered by a single 24 Volt AC transformer; systems that have separate heating and cooling transformers will have separate wires controlling each transformer (RH and RC) rather than a single R wire. In the Reliant thermostat, the RC and RH terminals are connected with a jumper and customers that only have a single R wire can connect the R wire to either the RC or RH terminals. **Customers with separate RC and RH wires must remove the jumper before connecting their RC and RH wires.**
RC		Connects the cooling system transformer to the thermostat; the RC terminal provides power to the cooling circuit when the air conditioning is switched on. If both an RC and RH terminals are present, the HVAC system has separate transformers for air conditioning and heating.
RH	4	Connects the heating system transformer to the thermostat; the RH terminal provides power to the heating circuit when the heating system is switched on. If both an RC and RH terminals are present, the HVAC system has separate transformers for air conditioning and heating.
G	**F**	Controls the indoor blower or fan. When the fan is on, the power source provided by the R terminal is connecting a circuit to power the fan.
W	**W1**	In most thermostats, the W terminal controls the heat source; the presence of a W (or W1) wire AND a W2 wire TYPICALLY indicates that the heating system has two stages. W, W1, and W2 are occasionally also used to control a heat pump. **If the customer may have a heat pump, check the HVAC system to confirm which terminal the W wire(s) control.** In heat pump systems W may be used to energize the reversing valve in the heating cycle. W may also be jumpered to Y in a heat pump when used to power the reversing valve.
W2		The W2 terminal is typically used to control second stage heating (where present). In a heat pump system, the W2 terminal may be used to control first stage Auxiliary heating.
Y	**Y1**	In most thermostats, the Y terminal is used to control the cool source; the presence of a Y (or Y1) wire AND a Y2 wire TYPICALLY indicates that the cooling system has two stages.
Y2		The Y2 terminal is typically used to control the second stage of cooling (where present).
O/B		The O and B terminals are typically used to power the reversing valve in a heat pump. In the Reliant thermostat, the reversing valve is controlled

		through a single O/B terminal where the direction of the flow is configured online
O		O is typically used when the cooling cycle of a heat pump system is energized. A wire connected to a stand-alone O terminal is usually a sign that the customer has a heat-pump.
B		B is typically used when the heating cycle of a heat pump system is energized. **Please note that York and Trane sometimes use the B terminal as a Common (C). If there is a B wire, confirm that the wire controls a reversing valve before installation.**
E	**AUX**	XXXXXX Emergency or Auxiliary heating typically used to amplify heat pump heating output.
Other (less common designations)		
X2		Equates to the C connection in Trane / American Standard systems
4		Equates to the RH connection in some systems
VR		Equates to the R connection in some systems
Y/O		Controls the cooling contractor. When the thermostat calls for cooling, power is fed to pull in the cooling contractor and the fan relay. This powers up the condenser and the blower fan, cooling the home.
W/B		Controls the heat relay or valve. When the thermostat calls for heat, power is fed to pull in the heat relay or valve and the fan relay. This powers up the furnace and the blower fan or the boiler, heating the home.
H		External Humidifier. Connects to Z on the Reliant thermostat and requires configuration on webpage.
DH		External Dehumidifier. Connects to Z on the Reliant thermostat and requires configuration on webpage.
L		System Monitor is some systems
T		Outdoor Sensor in some systems
M		Lennox heat pump cool control
X1, T1, 1, 2, 3		Proprietary systems and variable-speed compressor / fan systems

HVAC Control Wire Connection Tips:

In standard thermostat configurations, pay particular attention to the “C” and “R” terminals; connecting these wires to the wrong terminal may damage the HVAC system. Similarly, in a Heat Pump system, the wire connected to the Reversing Valve (O, B, or another designation) must be connected to the correct terminal.

Installation and Customer Service Axioms

- **ALWAYS know what kind of HVAC system you're working with BEFORE you begin work.**
- **ALWAYS start with simple and progress toward more difficult. It doesn't always have to be complicated.**
- **ALWAYS use the pictures if dealing with thermostat issues. You know…a thousand words.**
- **ALWAYS check your resources for answers. They're out there- you just have to find them. Study them.**
- **ALWAYS absorb and learn from your experiences and the experiences of other installers. Other installers are the second-best resource available to you.**
- **NEVER assume that anything a customer says is irrelevant. Listen. To. Every. Word.**
- **NEVER jump to conclusions about root cause of issues. Some solutions are easy. Some are not.**
- **NEVER assume that the easy answer isn't the correct answer. Some solutions are difficult. Many are not.**
- **NEVER fail to work the problem. It's what we're all about.**
- **NEVER be afraid to ask a customer a question, but do your best to avoid asking the same questions repeatedly. That's the fastest way to alienate a customer.**

HEAT PUMP TERMINAL CROSS REFERENCE CHART
TABLEAU DE RÉFÉRENCE CROISÉE DE BORNE DE POMPE À CHALEUR
TABLA DE REFERENCIA PARA LA TERMINAL DE LA BOMBA DE CALEFACCIÓN

HEAT PUMP BRAND MARQUE DE POMPES À CHALEUR MARCA DE LA BOMBA DE CALEFACCIÓN	CORRESPONDING TERMINALS BORNES CORRESPONDANTES TERMINALES CORRESPONDIENTES								TAPE OFF (NOT USED) RUBAN RETIRÉ (NON UTILISÉ) DESPRENDIMIENTO (NO UTILIZADO)	
	E	G	Y	R	O	W2	B	C	L	
ARCO / Friedrich	X2	G	Y	RC		W2	B	C	L	
ARCO / Snyder General	E	G	Y	R	O	W1		C	X	
BARD	E	G	Y1	R		W2	B	X	L	
BARD, HP, WH, MHP, HPQ	E	G	Y	R		W2	W1	X	L	
BDP / BRYANT	E	G	Y	R	O	W1		C	F	
CARRIER	E	G	Y	R	O	Y1		C	L	
CARRIER 5Q	to W2	G	Y, W1	R	O	W2		C	L	
CARRIER 50Q, QT382	E	G	Y	R	O	W2		C	L	
COLEMAN		G	Y	RED	V	W2		BLACK		
GE BAY	X2	G	Y	R	O	W		B		T
HEIL-QUAKER / Whirlpool		G	Y	R	O	W		B		
JANITROL / Goodman	E	G	Y	R	O	W2		C		
LENOX TYPICAL HP6		F	M	V/VR	R	Y		X		
LENOX HP8	E	F	M	V/VR	R	Y		X		
LENOX HP9, 10	E	F	M	V/VR	R	Y		X	L	
LENOX HP16, 18, 19	E	F	M	V/VR	R	Y		X	L	
MAGIC CHEF PE	E	G	Y	R	O	W		C		
RHEEM / RUUD	E	G	Y	R		W2	B	X	L	
SNYDER GENERAL H-R811		G	Y	R	O	W1		C		
TRANE	X2	G	Y	R	O	W		B	F	T
WEATHERKING		G	W1	R	Y1	E		C		
WESCO	E	G	W1	R	Y1	W2		C		
WESCO / ADDISON	E	G	W1	R	O			X		
WESTINGHOUSE H50	E	G	Y	R	O	W		X	L1	
WESTINGHOUSE HE		F	C	V/VR		H2	Z	X		
WHITE RODGERS	E	G	Y	R	O	W2		C/X1	L	
YORK		G	Y	R	O	W		B	X	

Thermostatic Wiring Principles

by Bob Scaringe Ph.D., P.E.

Basic Thermostat Types

Many technicians have great difficulty understanding how to properly wire a thermostat or how to replace a thermostat with a different thermostat. In fact, the wiring of a thermostat is quite simple circuitry, the confusion arises principally because of the various different ways different equipment manufactures handle the heating mode of the systems and the different ways a cooling system can be interfaced with the assorted types of heating systems, ranging from furnaces, heat pumps, and electric heat or combinations of many of these heating systems operating in sequence.

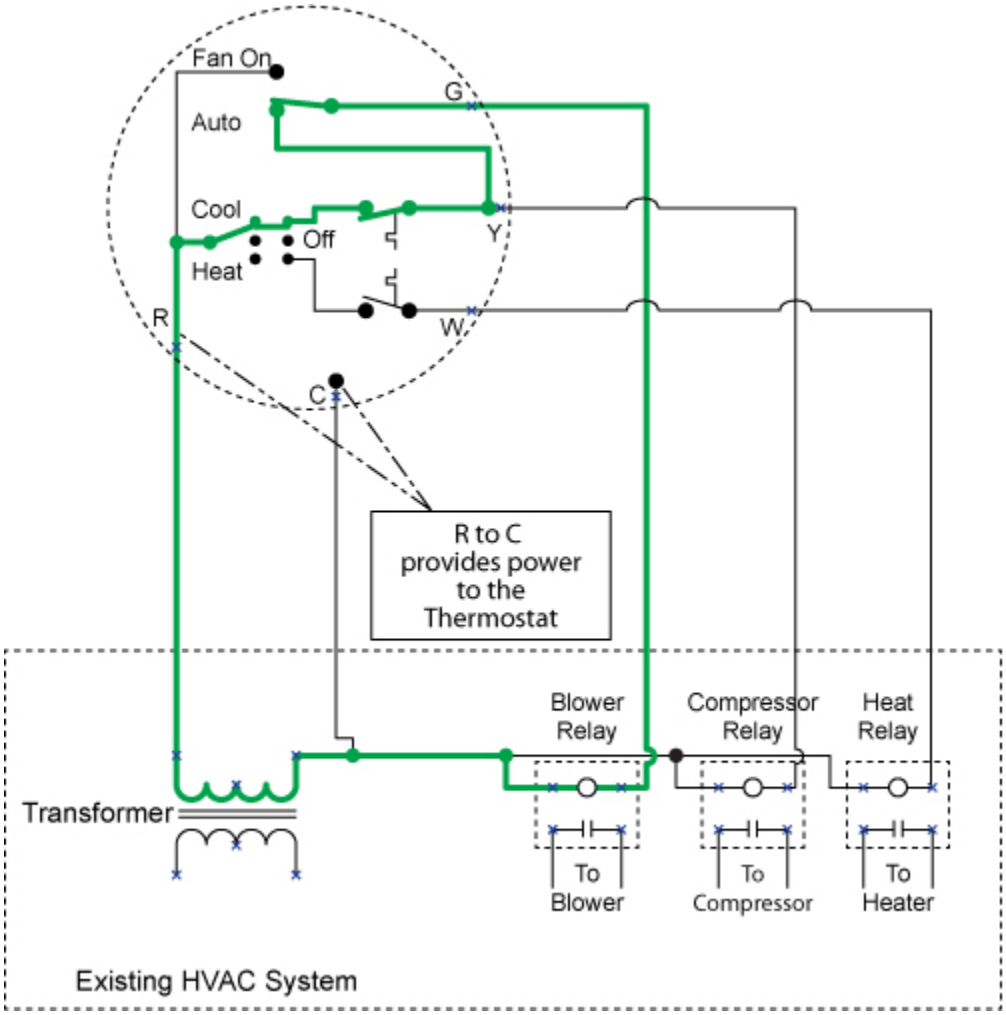
As a start, I think the first step is to understand the basic wiring for a simple cooling circuit of an air conditioner. Then we can add in the various methods of activating the different heating systems.

First, the technician must understand, that just like a light switch circuit, to activate a relay, power is supplied from a power source to a load. In the case of HVAC/R systems, the power source is a low-voltage transformer (usually a 24 VAC transformer) and the two wires supplying the power are labeled C (common) and R.

The common or C wire need not be run out to the thermostat, however if the thermostat requires power, the C wire should be routed to the thermostat. Even if the current thermostat being used does not require external power it is an excellent idea to bring the C wire out to the thermostat in anticipation of a future installation of a thermostat that requires power. For systems that do not have access to the C wire, a battery in the thermostat compartment must be used. This is a poor substitute for a line source of power, since the thermostat will cease to function when the battery dies.

Now for the HVAC/R labeling conventions of other thermostat wires:

The G wire completes the circuit from the R-leg of the power supply, back to the blower contactor coil. The coil then gets the 24 VAC from the common and G wires.



Individual circuit for blower relay coil – Auto

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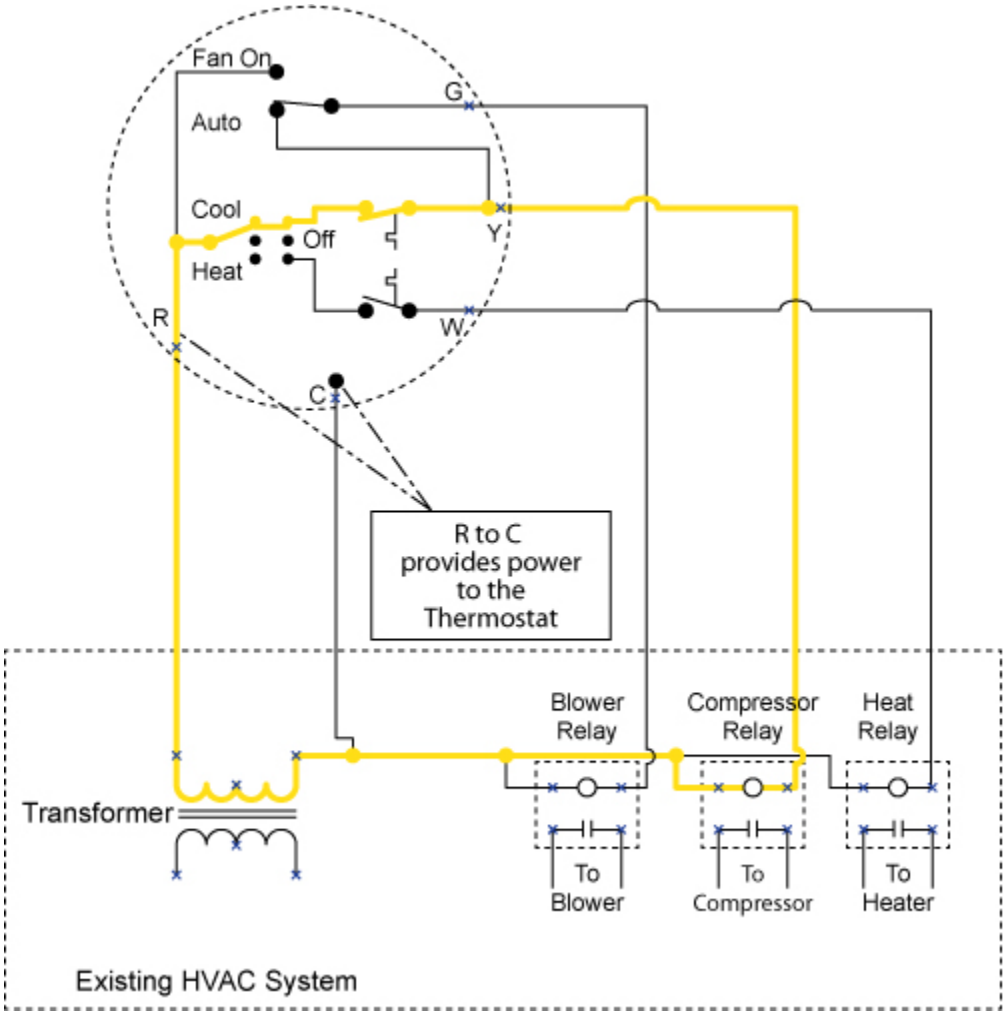
The Y wire completes the circuit from the R-leg of the power supply back to the Compressor/Condenser fan contactor coil.



Individual circuit for compressor relay coil

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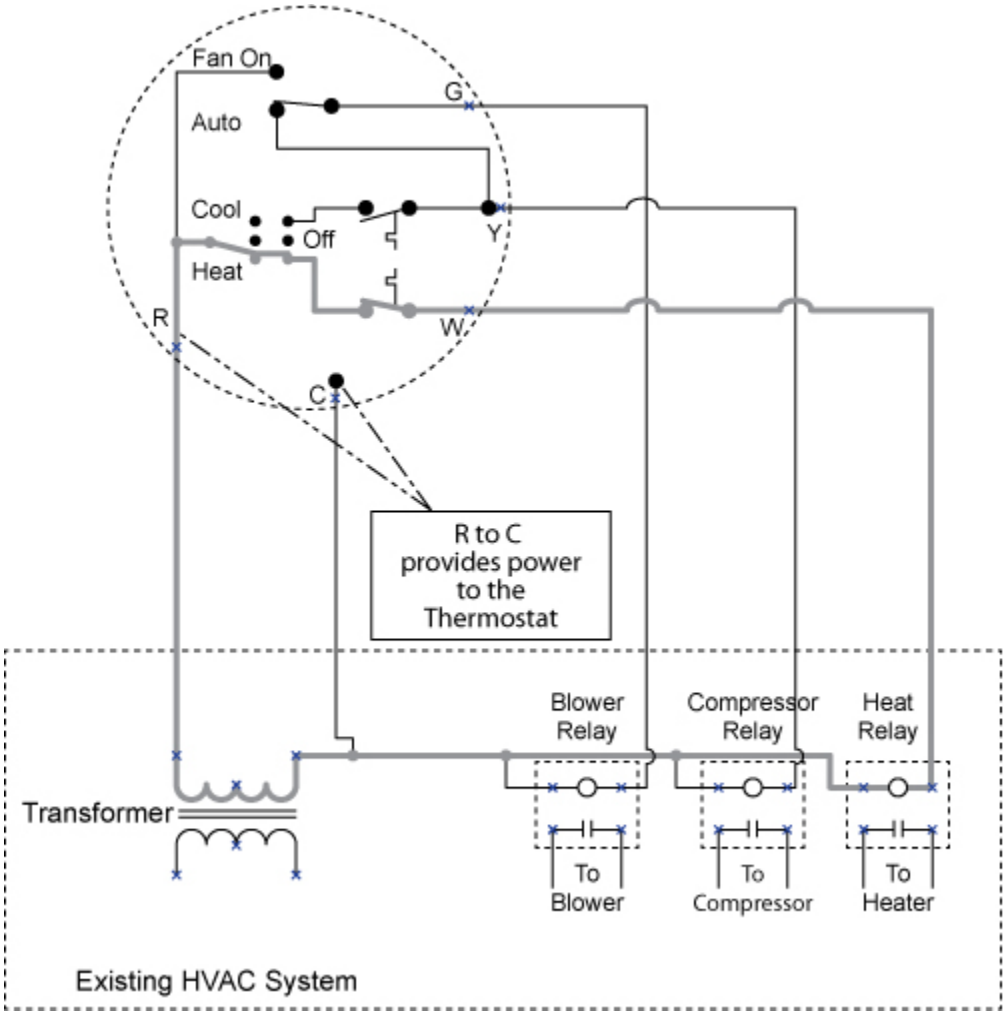
The W wire, if used, completes the circuit from the R-leg of the power supply back to the heater contactor coil. Sometimes there is a W1, W2, etcetera, for several stages of heating.



Individual circuit for heat relay coil

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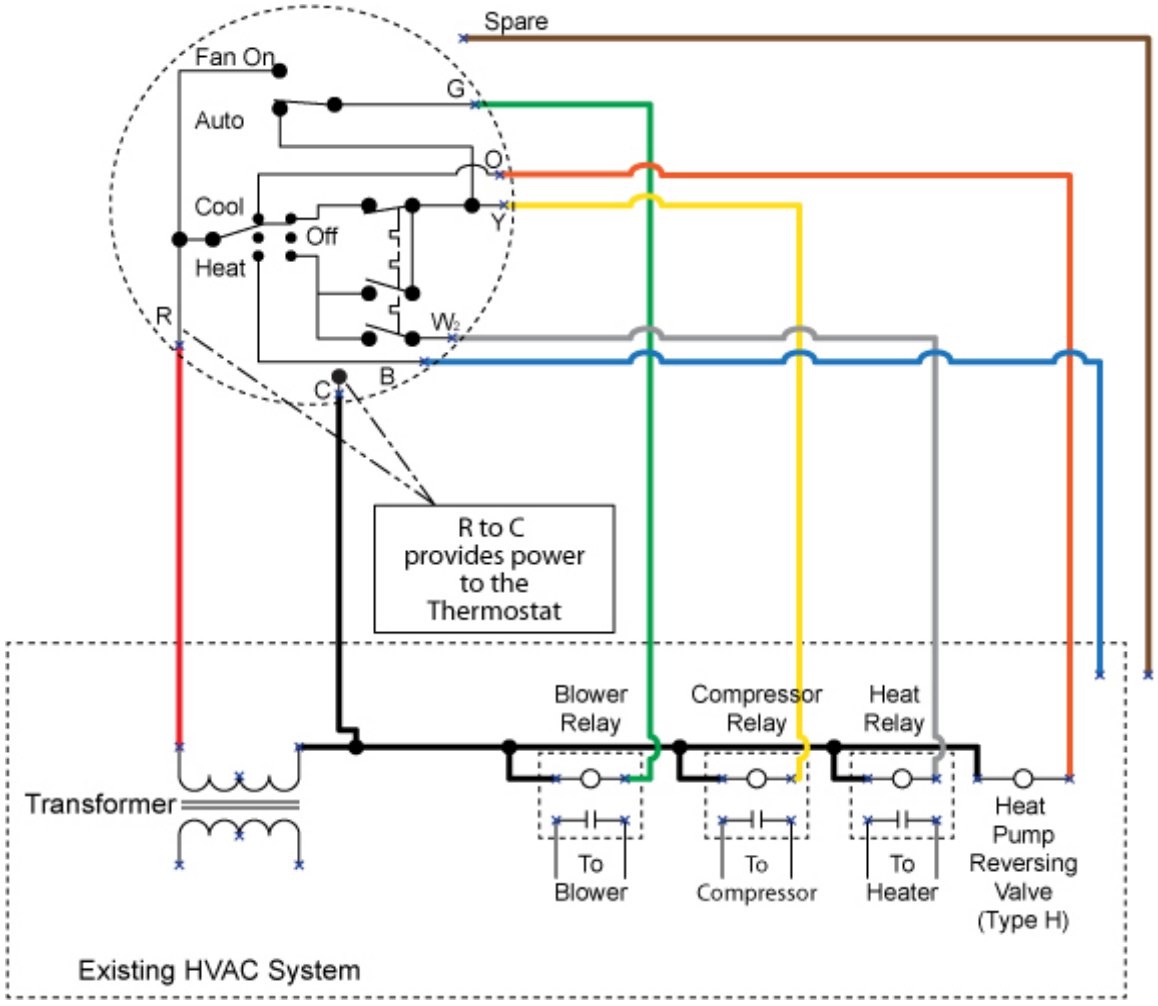
The O terminal, if used, and when the heat pump thermostat mode selector switch is set to cool, completes the circuit from the R-leg of the power supply back to the O wire. It is typically used to bring power to the reversing valve and is used for a heat pump with a reversing valve where the normal (un-powered) position is for heating. If you're using the O terminal you will NOT use the B terminal.



Type H reversing valve (notice O is a circuit while B is not wired)

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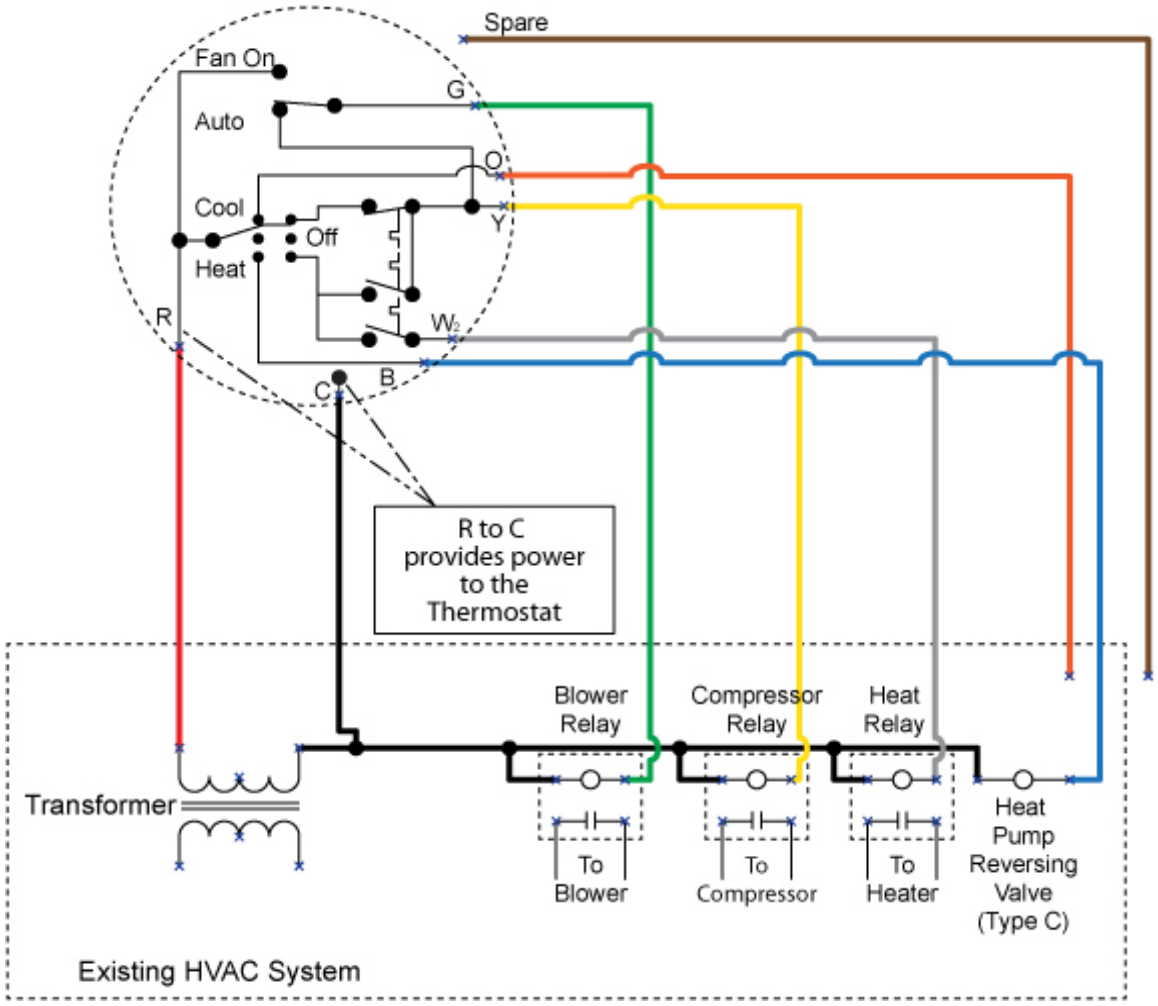
The B wire, if used, is closed when the heat pump thermostat mode selector switch is set to heat. It is typically used to bring power back to the reversing valve and is used for a heat pump with a reversing valve where the normal (un-powered) position is for cooling. If you're using the B terminal you will NOT use the O terminal.



Type C reversing valve (notice B is a circuit while O is not wired)

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The low-voltage 24 VAC transformer is typically located on the air condition system air handler. This transformer might also be located in the condensing unit, or anywhere else for that matter. Locating that transformer and identifying the C (common) and R wires is likely the first thing you need to do before you begin wiring your thermostat. Sometimes there are two low voltage transformers, one for the heating system and one for the cooling systems and the outputs of each transformer should not be connected. Having two transformers is very common if the heating system is a furnace while the cooling system is an A/C. When there is a transformer in the cooling system and a second transformer on the heating system then the R wires from each transformer must be kept separated and so they are labeled as Rc (for the R wire from cooling transformer) and Rh (for the R wire from heating transformer). As we mentioned above, whenever there is an R wire there will be a C wire. So if you have two R wires you will also have two C wires. Once again, even if the thermostat you're working with runs on a battery, it's still wise to have the C wire run out to the thermostat in case the equipment owner changes the thermostat out, however only a single common or C wire needs to be run to the thermostat, and it is usually the Cc wire, that is the common wire from the cooling transformer.

The Rh and Ch should only be used to power relays or other components of the heating system, and the thermostat will typically only connect Rh to W (when the thermostat is calling for heating). Likewise, Rc is connected to G, Y, O, B when appropriate.

This next part may be confusing at first but is If there is only one transformer, then wires labeled Rh and Rc are the same and are typically connected or jumpered together in the thermostat. Other times there is another transformer at a heating source so Rh and Rc will be different. One should be connected to the heating unit's transformer (Rh) and the other should be connected to the cooling unit's transformer (Rc). A visual representation of a two transformer circuit is located on the next page.

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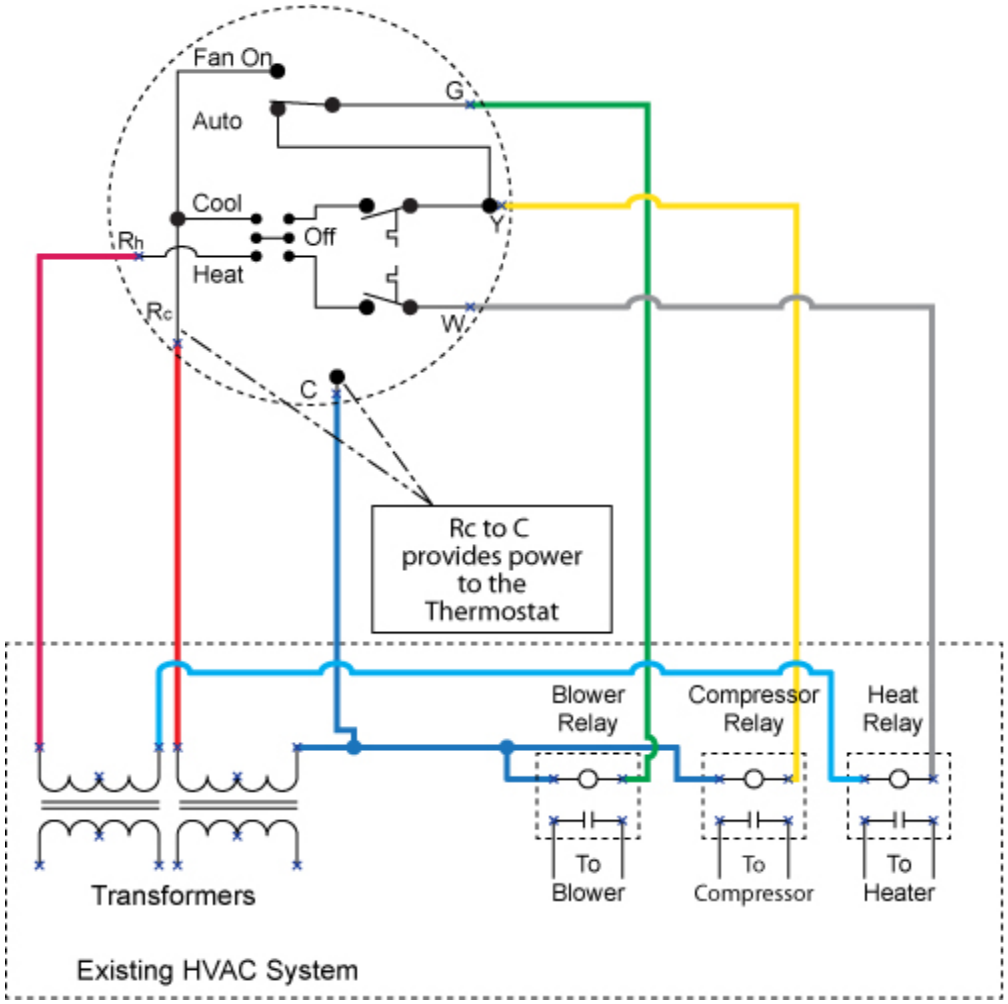

Two transformer basic thermostat circuit

Some thermostats come pre-wired with Rh and Rc jumpered together and this jumper must be cut to create a individual Rh and Rc circuits for a two transformer thermostat circuit.

Basic Wiring

In the most basic form of control, the C or common terminal of the low voltage transformer is connected in parallel to all of the control relays.. The R terminal of the low-voltage transformer is connected through the thermostat to each control relay. The thermostat controls the operation of the heater, compressor and blower as shown in Figure 1. Figure 1 is a circuit diagram showing the simplest possible known thermostat control system for heating and cooling operation of an A/C and Furnace or A/C and electric heat system.. For this system, you will notice that G (air handler blower) and Y (compressor/condenser fan) are connected. Therefore, the compressor/condenser fan and the air handler blower should always turn on at the

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same time. The W (heat) wire is "on its own," so the air handler blower will NOT turn on when the heat is activated. In this case, a heater relay or some other control, such as a plenum temperature sensor, must activate the blower in heating mode. This separate control is not a part of the thermostat. The W heat wire control could also activate electric baseboard heat, where the blower is, of course, not operated.

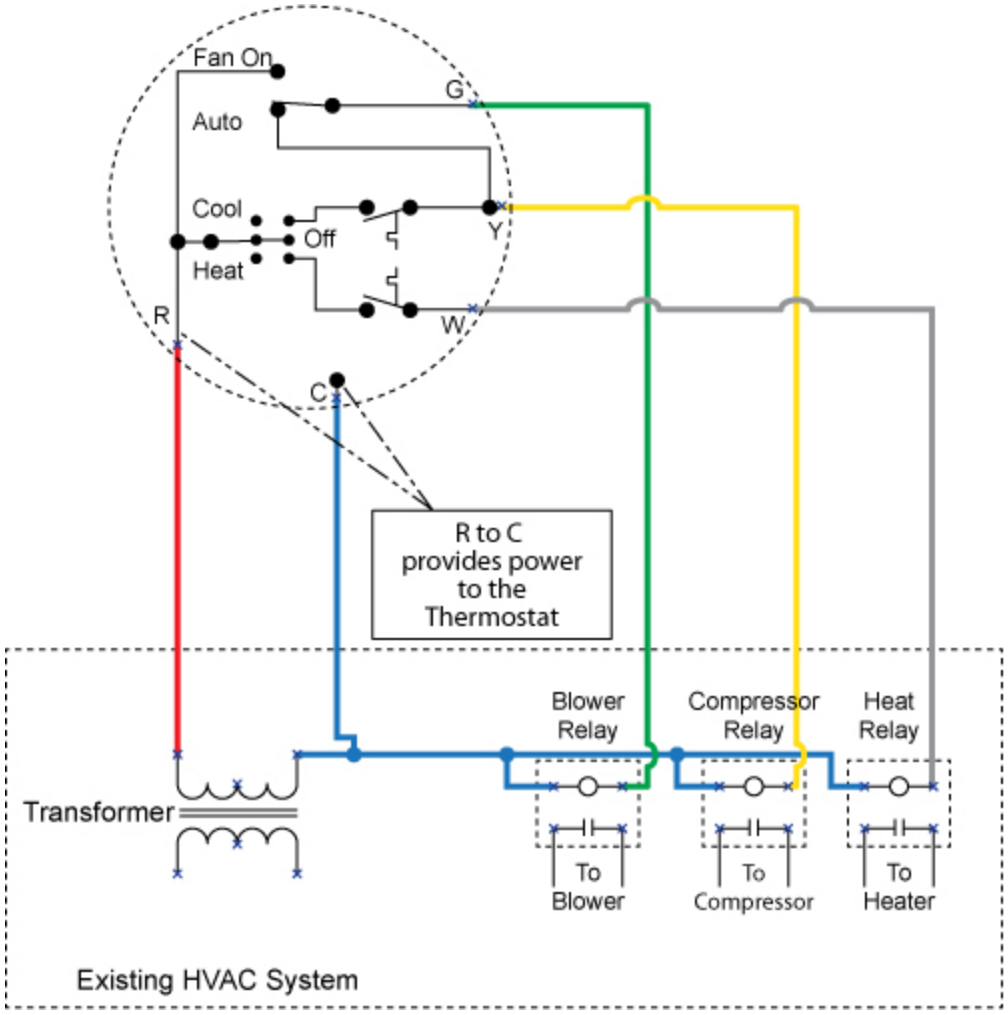

Figure 1. Basic Thermostat Circuit

The following is an explanation of how Figure 1's thermostat actually works. You don't need to know the following to make the thermostat work but if you learn the theory behind why the thermostat above is able to function then it will help you when you come across other more complicated thermostats. If you are new to thermostats or wiring diagrams you may need to read the following section carefully several times. Refer back to the diagram often and don't get ahead of yourself. If possible, share the section below with someone more experienced that can help explain how the thermostat above is capable of working.

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Referring to Figure 1, the wire designated R continues the circuit from the transformer to the thermostat. The wire designated G, when connected to R by the thermostat (look in the area where it says “cool”, “heat”, and “off”), continues the circuit from the R terminal of the transformer to the blower relay, completing the circuit and activating the blower relay and thereby operating the blower. That is when the thermostat connects R-G then the 24 volts from the transformer flows to the contactor coil via the 24 volts AC supplied to C and G.

Likewise, the wire designated Y, when connected to R by the thermostat (see right next to where is says “close on rise,” the Y wire is connected to the G wire), continues the circuit from the R terminal of the transformer to the compressor relay, completing the circuit and activating the compressor relay and usually also the condenser (outdoor) fan. This is because the outdoor fan will always operate when the compressor is operating, therefore only a single contact is necessary.

Refer to Figure 1, whenever the thermostat is set to cool the G and Y wires are both simultaneously connected to the R wire which completes all of their circuits. So when the system is set to cool the compressor/condenser fan (Y) and air handler blower (G) are both activated.

The wire designated Wx, (where x can be 1 or 2, it would be 1 in the above figure) when connected to R by the thermostat, continues the circuit from the R terminal of the transformer to the electric heat heater relay, completing the circuit and activating the heater. In the case of heating, there can be several heating control circuits, sometimes designated W1, W2, etc., where the thermostat may activate one or more heaters depending on the difference between the desired temperature and the actual temperature (when in the heating mode). There are many known variations of the heating configuration where one heating circuit may activate a heat pump, a second may activate a furnace and a third activates an electric heating circuit. Note that in the simple thermostat of Figure 1, when the thermostat (set to the heating position) calls for heat, the W1 circuit is activated, but the blower is not activated because the G wire is not attached to the W wire like it is to the Y wire. In "Heating" mode, when a furnace is used for heating, the blower is not typically activated by the thermostat, but rather may be controlled by a plenum temperature sensor in the vicinity of the heat source. If electric baseboard heating is used, the blower need not be activated.

Many newer replacement thermostats, allow a configuration set up where, if necessary, the G (blower) circuit can be activated when the system is calling for heat. This type of thermostat is commonly used for A/C systems with duct-mounted electric heat and the thermostat, typically has a jumper or software setting that will allow making of both the R-W circuit to activate the heat strip and the R-G circuit to activate the blower during heating operations.

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For most heat pump and A/C systems with electric heat, typically only one transformer is used. However, as stated earlier, many furnace heating systems have a separate transformer to power the furnace heating circuit, so that a separate R circuit exists for the R to W switch, (where the Rc refers to the contact that closes Rc to G and Rc to Y during cooling, while the Rh to W1 contact is closed during heating). Once again, to provide the greatest flexibility, most thermostats have a separate circuit for Rc to G and Y and Rh to W, with a provision to jumper Rc and Rh together, to form the thermostat setup of Figure 1, namely a single R that can be connected to G, Y and W. If you have one transformer Rc and Rh will be jumped together, if the cooling and heat each have separate transformers Rc and Rh need to be separate circuits.

Figure 2 and 3 display a thermostat that is similar in operation to the thermostat of Figure 1, but also has a provision (R to B or R to O, only one is typically used), to activate a reversing valve, for example, in the case of a heat pump. In Figure 2, power to O when cooling is selected is used to activate the reversing valve (use when normal unpowered state of the heat pump is heating) whereas in Figure 3 power to B when heating is selected is used to activate the reversing valve (use when normal unpowered state of the heat pump is cooling).

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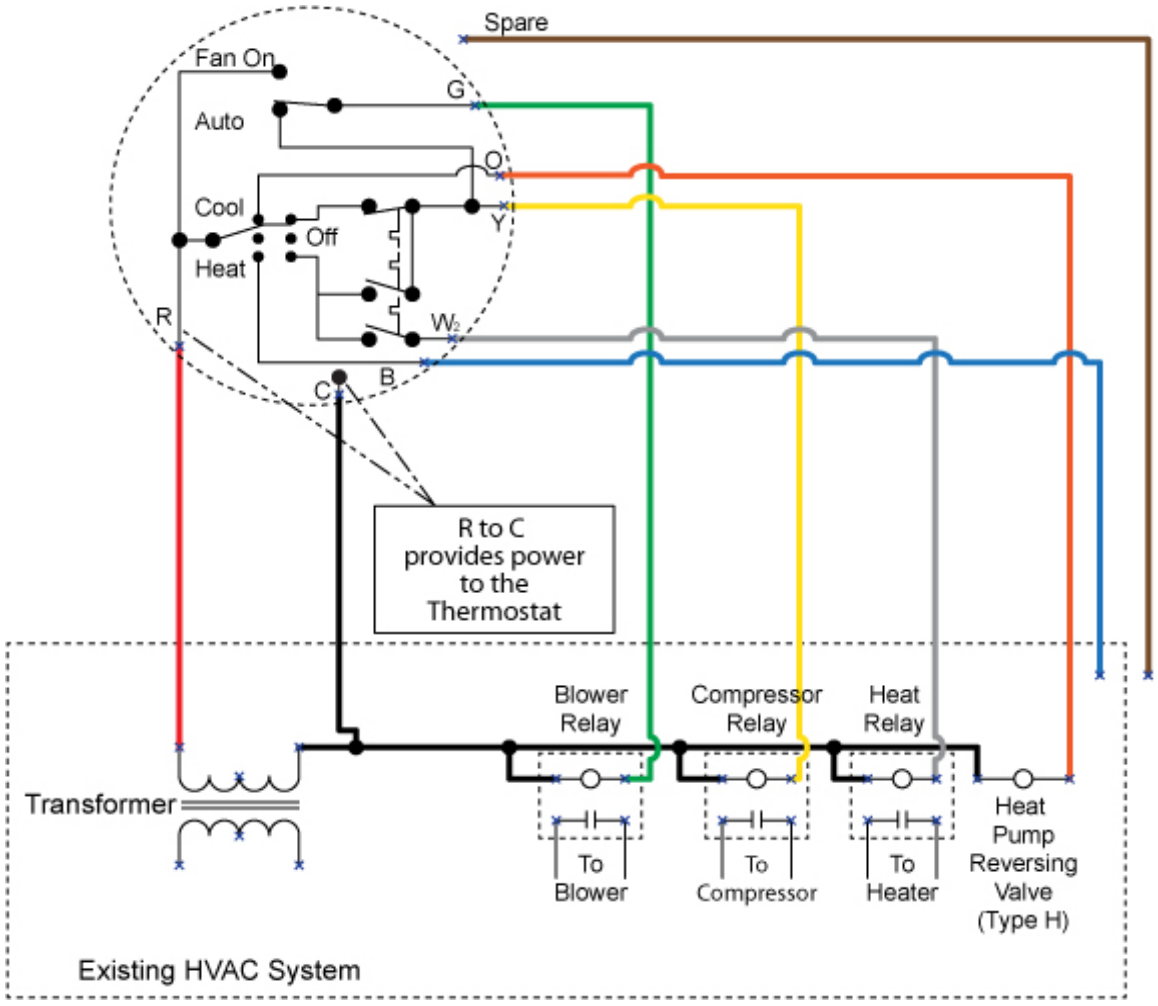

Figure 2. Thermostat wired to activate a reversing valve to activate cooling mode

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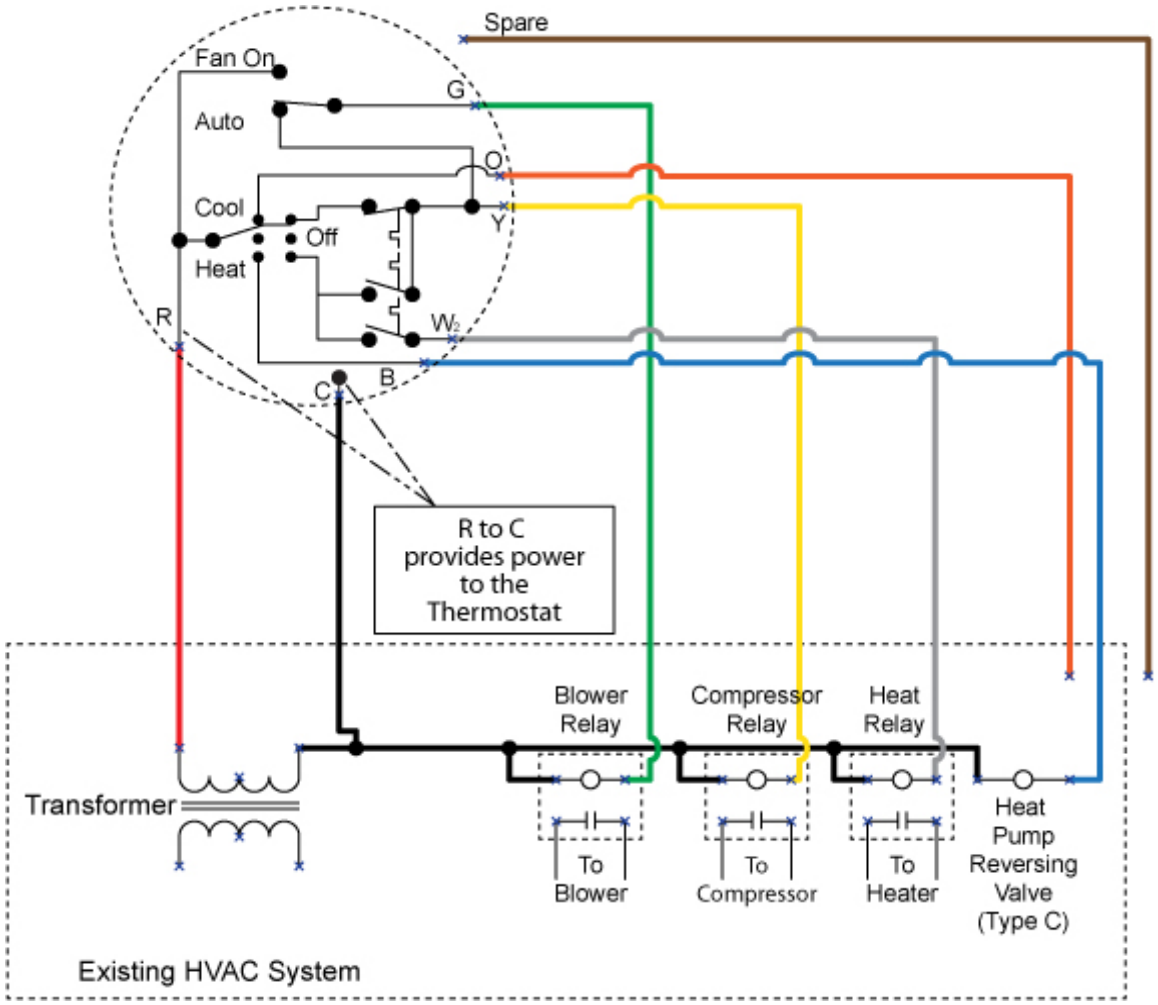

Figure 3. Thermostat wired to activate reversing valve to activate heating mode

Figure 2 and 3 display circuit diagrams of a common modern heat pump thermostat which do not use the W circuit to apply normal heat, instead both Y and G circuits are energized when either cooling or heating is needed, In Figure 2, the R-O circuit is used to energize the reversing valve when set to "COOL." In Figure 3 the same thermostat uses the R-B circuit to energize the reversing valve when set to "HEAT." While heat pumps use a reverse cycle to produce heating, they are almost always equipped with electric heat as a back-up emergency heat source. The R-W2 circuit in this thermostat is used to activate this emergency heating.

Finally, on most thermostats, when the fan switch is placed in the ON position it will complete the R-G circuit without regard to the position of the System Selector Switch, which can be set to "COOL," "OFF," or "HEAT".

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Wiring Routing

The normal wiring of an air conditioning and heating thermostat uses a multi-conductor thermostat wire. As a minimum R, G, Y and W are needed, since Connecting R to G activates the blower, R to Y activates the Compressor, and R to W activates the heat as we have seen, there are lots of variation on how the heat is activated. In addition, if a common C is supplied then 24 VAC is available at the thermostat (across R and C) to power the thermostat. If the thermostat requires power and a C wire is not available, then a battery in the thermostat must be provided to provide the power. Since batteries die at the worst times, and typically the thermostat open-circuits, which turns the system off, when the battery dies, this is a bad procedure. If the home is unoccupied for long periods, such as summer or winter homes, mold or freezing problems can develop, all caused by a dead battery in the thermostat. As a minimum, it is recommended to run at least 6 conductors (C, R, G, Y, W, and B or O) even in an AC installation, since a retrofit to a future heat pump system is still possible. Additional wires prove to be extremely useful when an installed wire fails and it is nearly impossible to run a new set of wires.

Summary

A typically thermostat will have a C terminal which along with the R wire provides 24 VAC to the thermostat for clock and other setback purposes. The G terminal is connected to the blower contactor coil, the Y to the compressor contactor coil, and the W terminal is used for heater activation. When W is used for emergency back up heat, it is typically labeled W2. Either the B terminal or O terminals are used for the heat pump reversing valve, while they can be used for any heating or cooling specific function.. A thermostat will make a R-B connection when it the System Selector is set to "HEAT" (as shown in Figure 3) and it will make the R-O terminal when the system is set to "COOL" as shown in Figure 2). Which circuit to use, namely the R-B or R-O depends on the heat pump reversing valve. If the reversing valve is normally closed in the cooling position, then it has to be powered to switch to heating mode, so the R-B circuit is used and the reversing solenoid is connected to C and B so that when the thermostat is calling for heat and completes the R-B circuit, then 24 VAC is supplied across C-B and the reversing valve is activated into heating mode. Likewise, if the reversing valve is normally closed in the heating position, then it has to be powered to switch to cooling mode, so the R-O circuit is used and the reversing solenoid is connected to C and O so that when the thermostat is calling for cooling and completes the R-O circuit, then 24 VAC is supplied across C-O and the reversing valve is activated into cooling mode.

The B and O terminals can also be used to energize dampers in heating or cooling modes or control any other device that is heating or cooling mode specific, however in

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actual practice these circuits are rarely used on thermostats that are not controlling a heat pump.

With the rising popularity of heat pumps, as well as multiple heating sources, thermostats have been designed with greater flexibility when controlling the assorted heating methods. These newer thermostats are different from standard heating-cooling thermostats in that on heating the thermostat can be configured to make R-W and R-G, compared to a standard thermostat that makes only R-W when heating is being called.

On most thermostats, there is also typically a jumper, or shut that can be cut, when the Rh-W circuit is powered by a heating transformer and the Rc-G is powered from a different transformer. With Rc coming from the cooling system transformer and Rh coming from the heating system transformer. Of course heat pumps only have one transformer.

If these heat pump thermostats have a R-W circuit, it is typically labeled R-W2 (since the first stage of heat is obtained by the reversing valve position and operating the compressor(R-Y) and blower (R-G) and the back-up heat is obtained by activating R-W2. Typically, there is no W1 terminal on this type of heat pump thermostat.

Typically a thermostat for an AC system with electric heat coils in the air handler is configured to make both the R-G circuit at the same time it makes the R-W circuit, instead of relying on an extra set of contacts on the heating relay to activate the blower.

As shown in Figure 1, for a standard heating-cooling thermostat there is no power to the Y circuit when the thermostat is set to either "OFF" or "HEAT." Similarly, if the fan switch is set to "AUTO" there is also no power to the G circuit when the thermostat is set to either "OFF" or "HEAT." There is, however, power to the G circuit if the fan switch is set to "ON," regardless of whether the thermostat is set to "COOL", "OFF" or "ON." See the images below for a visual representation of the various completed G circuits in a basic thermostat.

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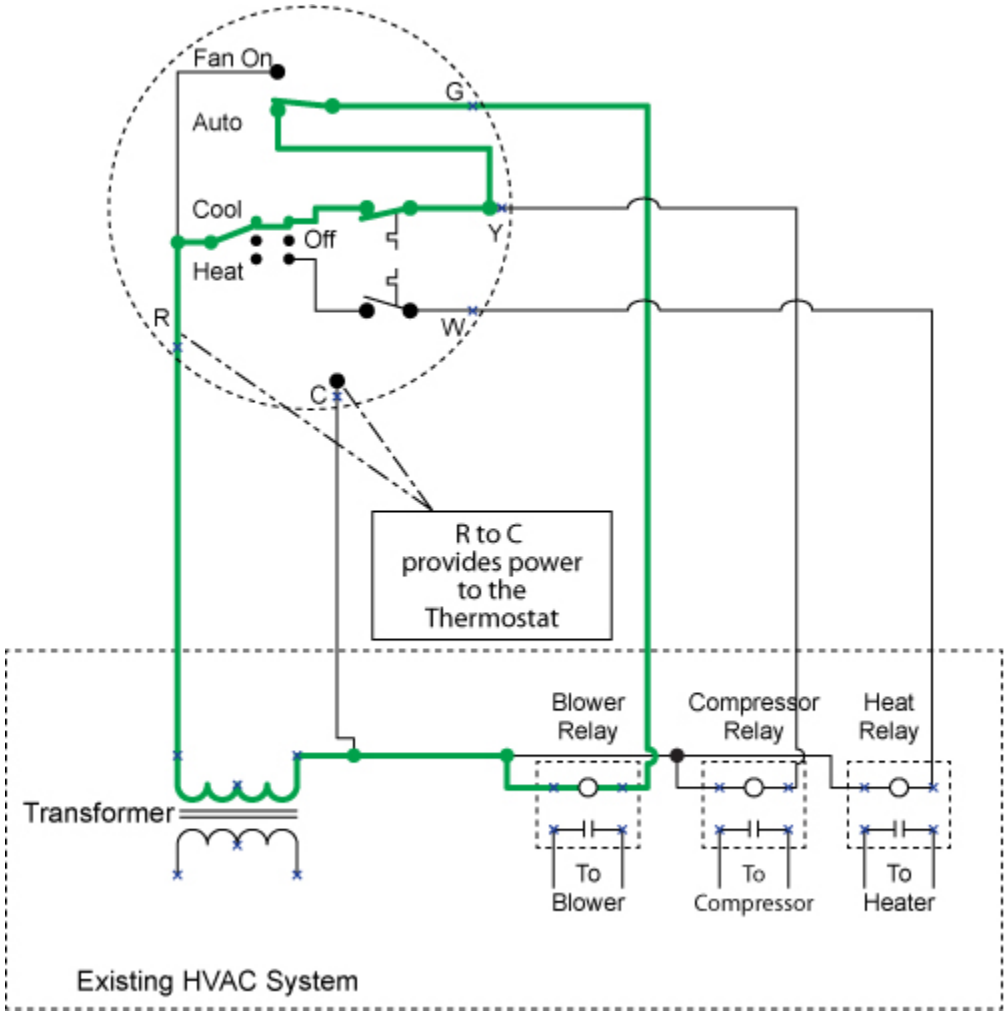

Individual circuit for blower relay coil – Auto

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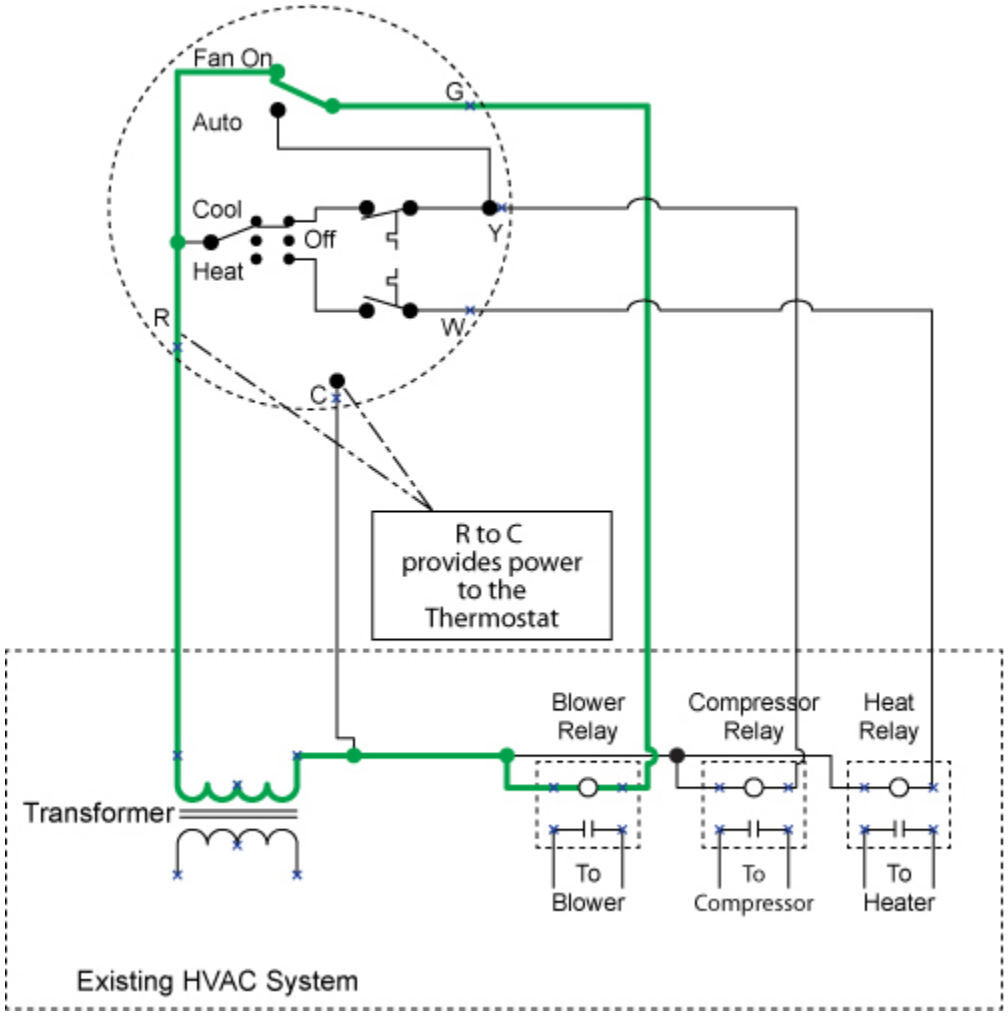

Individual circuit for blower relay coil – On

For a typical thermostat, as shown in Figure 1, when the thermostat is set to "COOL" and the fan set to "AUTO" both the blower (G) circuit and the compressor (Y) circuit are activated simultaneously when the thermostat calls for cooling. When the thermostat is set for "HEAT" (and the fan set to "AUTO"), neither the blower (G) circuit nor the compressor (Y) circuit are activated, regardless of the thermostat setting. Alternatively for a heat pump thermostat, both the R-Y circuit and the R-G circuit are activated on a call for either cooling or heating as shown in Figures 2 or 3.

This guide is by no means completely exhaustive of all thermostat configurations available to control an HVAC/R system. However, I hope that it serves as an in depth introduction to thermostat wiring and principles that a beginner can grow upon.

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