Rooftop Unit Technical Training Guide

Trevor Thomson
Total HVAC Inc.
trevor.thomson@totalhvac.com
613-723-4611
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Objective
To <u>supplement</u> the official maintenance and operation documentation that is contained in the AAON Installation, Operation, and Maintenance manuals for the RN and RQ Rooftop Units. The official manual is downloadable via the AAON.com website, or available through Total HVAC in hard copy. This manual will typically focus on the internal control boards, and operating logic of the AAON Rooftop Units, as opposed to the general maintenance of the various mechanical devices that make up the Rooftop Units, which is in the official installation, operation, and maintenance manual.

Accuracy
This manual will strive for 100% accurate and informational content. If at any time you identify something that you believe is not 100% correct, please contact Total HVAC to report the potential issue. Total HVAC Inc assumes no liability for any errors or omissions in this manual.

Technical assistance phone numbers
Total HVAC   613-723-4611
AAON   918-382-6400
Wattmaster   866-918-1100
Yaskawa   800-927-5292

Phone technical assistance
Whenever possible, please call Total HVAC first for any issue. We would like to assist all technicians with issues, and it also gives us a better indication of potential on-going issues. If we can't solve the problem, we will point you to the company that will be able to assist you in the timeliest way possible.

On-site Assistance
Total HVAC offers on-site assistance upon request. If you have an issue with a Rooftop unit, or whether you are looking to modify it in some way, we can assist you. At Total HVAC's discretion, a factory trained technician may also be sent out to assist you with an issue, or an experienced office employee, typically free of charge. Total HVAC should always be your first call for troubleshooting, or field modifications. On-site training and in-office training are also available on a variety of topics, with proper notice.

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1.0   Controls Section

AAON Rooftop units have a wide variety of controls options. The options range from a unit being able to be controlled with an off the shelf thermostat (no VCC compressor), full DDC control with discrete terminals, standalone controls, and an internal controller with BAS integration.

1.1   Terminal Strip Control (Previous Terminal Strip style of control)
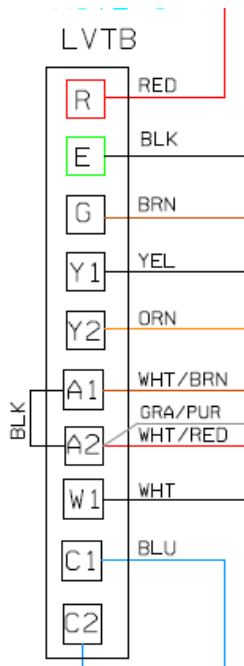
Units with Terminal Strips, that were built Pre-2013 are considered to have AAON's "Terminal Strip for thermostat control" scheme. The main difference between this Terminal Strip version, and what is used today is listed below.

Figure 1 - Basic terminal strip control (T-stat compatible)

- The economizer, power exhaust, and heatwheel were all turned on with a single set of contacts
- Economizer position was a manual adjustment in most cases
- Economizer free-cooling operation was enabled or disabled based on an enthalpy controller resident in the unit. When free-cooling mode was active, a cam on an economizer gear made a contact with an end switch, disabling the heatwheel (if one was included).
- Digital Scroll compressors were not available in this controls option

1.2 Field Installed DDC Controls by Others (current Terminal Strip style of control)
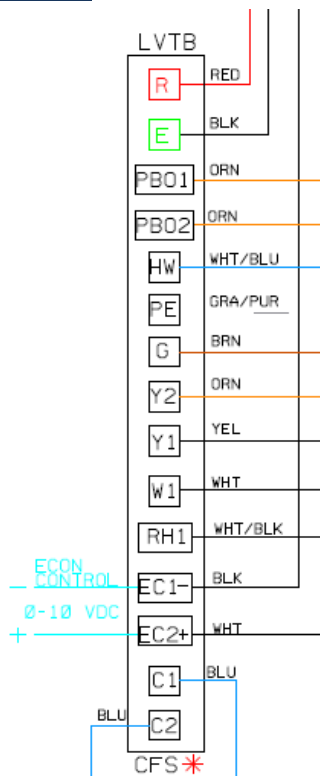
Most units with Terminal Strips, built in 2013 and later, are using AAON's "**Field Installed DDC Controls by Others**" control scheme. The differences between this and the previous scheme is listed below in general points. The main item to note is that all devices inside the AAON unit now have discrete points. This also means that 100% of the logic for running the RTU must reside at the BAS level. This is a powerful control scheme AAON has, as long as there is a robust BAS that can properly control all aspects of the RTU.

Figure 2 - Current typical terminal strip for total unit control

- Every device has its own set of points
- Safety logic is by RTU relay logic or specific control boards, such as:
  - Compressor ambient lockouts
  - Compressor short cycling and safety board
  - High temp shutoff
  - Air proving sensor
  - Pressure switches
- On/Off & Modulation calls are by BAS
- Operational logic for every device in an RTU is by BAS
- Staging of gas heaters is controlled by RTU, as long as a call and modulation signal are present
- VFD's have their own terminals for feedback
  - If the unit has multiple VFD's for a single function (ie. two supply fan VFD's), the BAS would need to wire back to each VFD to get full feedback information, but only a single set of wires for enable and modulation will be required.

Control signal information
- Enabling a device (fan, heat, cool, economizer, heatwheel, dehum...) requires a 24v signal
- Modulating a heating device or fan requires a 0-10vdc signal
- Modulating a digital scroll compressor requires a 0-5vdc signal (1.44v = on, at 10%)
- Modulating an economizer damper requires a 2-10vdc signal

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1.3 Wattmaster Controls/AAON Controls

For jobs that do not require the flexibility and customizability of a full BAS system, AAON has a variety of standalone controllers. The primary brand of product used is <u>Wattmaster Controls which was bought by AAON in 2018</u>, however there are others available to us for select specialty control sequences.

The main benefit of a AAON onboard controller is the low cost of operation of a rooftop unit. AAON units supplied with a standalone controller will normally also be supplied with either a wall mounted interface, or a handheld technician service tool. While all the onboard controllers are fully capable of standalone operation, most also have integration capabilities with BACnet, and a variety of other BAS protocols. The key point to keep in mind with BAS integration is that some points may not be available via protocols, such as VFD and damper feedback.

If a BAS is present, but a protocol is not required, and only hard wires 0-10vdc, and 24v signals available, AAON boards have the ability to accept the below signals.

- Remote Occupied   24v
- Remote Heat   24v
- Remote Cool   24v
- Remote Dehum   24v
- Remote Vent   (No 24v on cooling and heating terminals will enable this mode)
- Supply Air Reset   0-10vdc

The controllers that are utilized in AAON rooftop units have been designed for simple functionality and optimized by AAON. The version and type of controller is based on the options of the rooftop unit. The software updates inside a controller, may require technicians update their handheld service tool from time to time. The new black handheld tools that were sold starting in 2014, store all data on a removable SD memory card. This can be easily updated on laptops. Total HVAC can update your handheld at any time. **If a password is ever required for settings, schedules, and configurations, the default password is 2222 for technicians, and 1111 for users.**

AAON controllers work based on configurations that tell the controller what features the unit has, and setpoints to control the air discharge from the unit. In select instances, there is also a free PC software called Prism, which through a separate device, acts as a fully featured front end similar to what is seen on a BAS screen.

On Wattmaster VCMX, and newer boards, the error codes are shown right on the board's plastic cover, for easy identification of issues. On VCBX units, it has an LCD display, to view status, and to set BACnet MSTP information.

Training on Wattmaster/AAON controls can be received from Total HVAC, provided it is planned.

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1.4   AAON Onboard Controller with BACnet MSTP

When an AAON unit is ordered with an onboard controller, we also try to ensure it has BACnet MSTP functionality. Not all unit configurations allow BACnet controllers, but they are provided whenever possible.

BACnet MSTP functionality with our newer Wattmaster/AAON VCBX & VCCX controllers are very powerful, and easy to interface with BMS systems. There are select monitoring points that are available via the onboard BACnet, as well as full functionality in controlling the unit. When a BAS system is responsible for controlling our RTU, there are several key points they need to control, to ensure the unit runs properly.
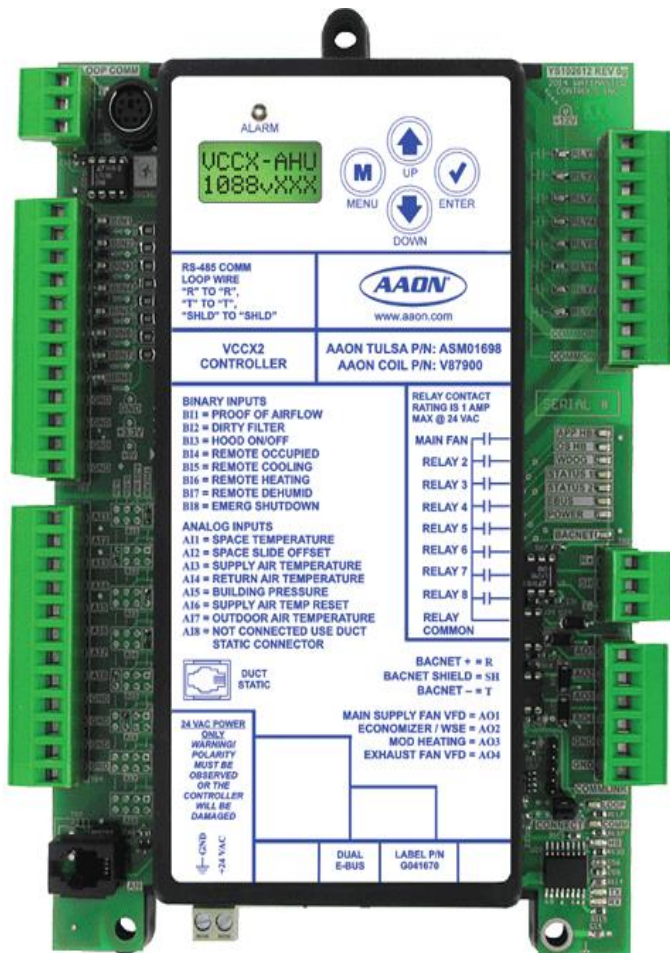
See below for this critical BACnet points. The BAS would write to these points, and the unit would act accordingly. These are the minimum points required. There are many other points for job specific functionality that may be required.

Figure 3 - VCCX Controller (BACnet capable)

1.5   Minimum Required BACnet MSTP Points Required for VCCX

- Unit Status   (Object: AV:62)
    - Occupied   (Value: 1)
    - Unoccupied   (Value: 2)

- Unit Mode   (Object: AV:63)
    - Ventilation Mode (Min damper position, Min supply fan speed, No Heating or Cooling)   (Value: 1)
    - Cooling Mode   (Value: 2)
    - Heating Mode   (Value: 3)
    - Vent Dehum Mode   (Value: 4)
    - Cool Dehum Mode   (Value: 5)
- Setpoints
    - Supply Air Cooling Setpoint   (Object: AV:10)
    - Supply Air Heating Setpoint   (Object: AV:11)
- Minimum Outside Air Damper Position   (Object: AV:44)

1.6   Factory Installed Third Party Controls

There are times when it is beneficial to install BAS controllers in the building and run the wires up to the unit. However, there are other times, when it is preferred to have a BAS controller directly inside the rooftop unit that is being worked on. If a job requires it, AAON will install third party control boards and sensors that are shipped to the factory by the BAS controls company. The third-party controller is factory mounted and wired as if it was a normal AAON standalone controller. The only limitation is space; as long as it can fit in the cabinet, AAON will install it.

The main benefit to factory installed third party controls, is that technicians have access to the controller while at the unit. The other key feature is that the controller and all sensors are now shown in full point to point detail, on the AAON custom color wiring diagram that comes with every unit. Technicians can easily see where each device terminates without tracing wires between a BAS and rooftop wiring diagram.

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2.0   Energy Recovery Section

AAON provides heatwheels in most units as a way to recover the sensible and latent energy from the exhaust air stream. Heatwheels are a very simple device in a rooftop unit, but they can make a significant impact in the comfort and cost effective operation of a rooftop unit.

All heatwheels are driven via belts specifically designed for heatwheels. The belts are designed to last at least five years, and typically only need to be replaced between the eight-to-ten-year mark. It is normal for the belts to stretch over their life.


In the image on the left, you can see the heatwheel, as well as the outside air bypass damper, heatwheel motor, and outside air filters.

During economizer operation, the outside air bypass damper, and the exhaust air bypass damper will open up to allow unrestricted airflow.

It is important to remember to change these filters when changing the other filters in the unit. Total HVAC recommends Camfil 30/30 Merv8 filters. They are very strong, and last longer than other brands.

Figure 4 - Heatwheel media, motor, econ bypass damper, and fresh air filters shown
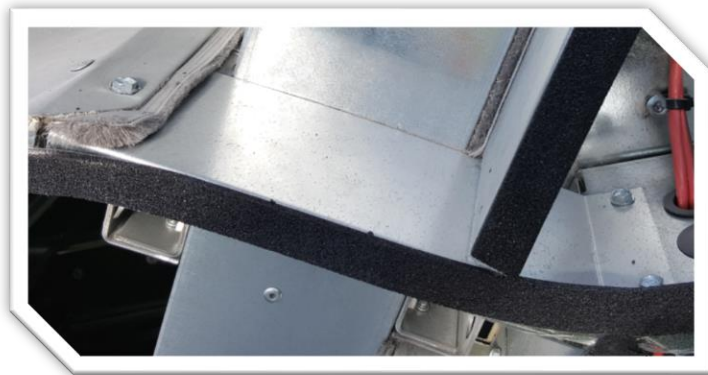
On some units, this baffle bracket is installed to hold the heatwheel in place, and to divide the return air and fresh air. If one of these is installed in the unit being serviced, it will have to be removed before sliding out the heatwheel.

Figure 5 - Heatwheel baffle bracket

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2.1   Operation

When a unit is supplied with a heatwheel, it is very important that it is controlled properly. The key points to remember are listed below.

- When the unit is in heating or mechanical cooling mode, and the fresh air damper is open, the wheel should be on
- When the wheel is on, the power exhaust motor should be running
- When the unit is in free-cooling economizer mode, the heatwheel should be off
- When the unit is running during a mild day, and it is not specifically looking for free cooling, but simply want to maintain a neutral temperature, turning the heatwheel on or off as required may be enough to keep the space perfectly satisfied, without actively heating or cooling the space

2.2   Defrost Control

When using a heatwheel with a terminal strip style of control, a defrost timer is supplied which will turn off the heatwheel for a preset amount of time, at specific intervals. This is not required for standalone controller units.

Figure 6 shows a timer set up to turn the heatwheel off for 10 seconds, every 10 minutes. This timer is triggered when the OSA (Outside Air) temperature sensor which is wired into this timer, measures 32F or below. Please note, the OSA is adjustable, and should be set to 32F. This will allow enough time for the warmer exhaust air, to melt any potential frost that may be forming on the wheel. This is the recommended setting for all defrost timers.

Figure 6 - Heatwheel defrost timer. The setting shown is the recommended setting for all Heatwheels.

2.3   Maintenance

All AAON rooftop units that come with heatwheels, also come with heatwheel filters on the outside air intake. It is very important that these be changed regularly. If they become too clogged, they may fall apart, and be pulled into the heatwheel, causing damage to the media. Heatwheels are inherently a self-cleaning device, with the exhaust air and fresh air in opposite directions. This will lead the wheels to need generally only cleaning every couple of years. A visual inspection should be completed once per year however, to ensure proper operation and cleanliness.
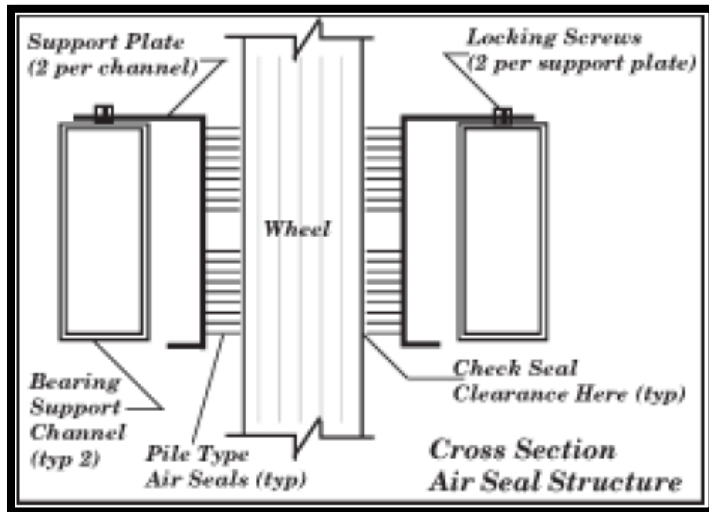
Figure 7 - Side view of a typical Heatwheel and support pieces

Adjustments to air seals

A heatwheel is situated between two pile type air seal gaskets. They are there to ensure a low amount of air leakage. When performing maintenance on a heatwheel, it is good practice to ensure gaskets are almost touching the heatwheel, but not so tight that they are restricting rotation of the heatwheel. Spacing between the gaskets and the heatwheel should be approximately the thickness of two business cards.

If gaskets need to be adjusted (see figure 7), loosen all of the plate retaining screws from the bearing support channels. Place two business cards into the gap between the gaskets and the wheel and move the support channels back into place, one at a time, while keeping the proper distance required.

2.4   Cleaning

All heatwheels are built to slide out of a unit fully, for easy serviceability. It typically takes only a few screws to be removed, and the wheel can be fully slid out on its track. A visual check of the cleanliness of the wheel media should be done once a year. If dust and debris are noticed in the wheel, there are some cleaning methods that should be used, they are listed below.

- Carefully vacuuming a wheel will remove surface dust and large loose particles out
- Do not pressure wash, or use any type of high-pressure device to clean the media
- Do not use any acidic detergents or industrial cleaners
- For a wheel with a large amount of dust, perhaps from poorly maintained filters, washing the media is recommended.
  - Get a plastic tub that is larger than a media section, and at least twice as deep
  - Fill it up with warm water and a small amount of light detergent (such as mild dish soap)
  - Submerge the media sections one at a time, and move it around to dislodge any dirt that was held into the media
  - Once satisfied that the media is clean, rinse it with a low-pressure hose
  - If possible, allow the media sections to dry before re-installing

2.5   Replacement

In most cases, heatwheels can be cleaned if they get dirty. On occasion, the sections themselves could get damaged due to lack of maintenance, or mechanical failure. Media sections can be purchased separately as required, and do not require the purchase or an entire new heatwheel. This is only true for polymer wheels, as aluminum wheels are a full wheel without individual segments. AAON uses both. Replacement should always be a last resort.

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3.0   Cooling Section

AAON Rooftop Units have many ways to cool the air being delivered, but the predominant and the most complex method, is air-cooled DX. The focus in this section is specifically on 3 to 50 Ton configurations.

3.1   Compressors

In the 3 to 50 Ton range, AAON uses either 1, 2, or 4 compressors. On virtually all newer units, Copeland Digital Scroll Compressors (VCC) are used as the first stage of mechanical cooling, and fixed stage compressors are on the second and later stages. Digital Scroll compressors are classified as Variable Capacity compressors, as they always maintain the same rotation speed, but modulate how often they compress and pump the refrigerant. The compressor modulates the cooling performance by raising the upper scrolling head, which stops compression. This allows the VCC to attain a minimum turndown of 10%, while maintaining proper oil return to the compressor.
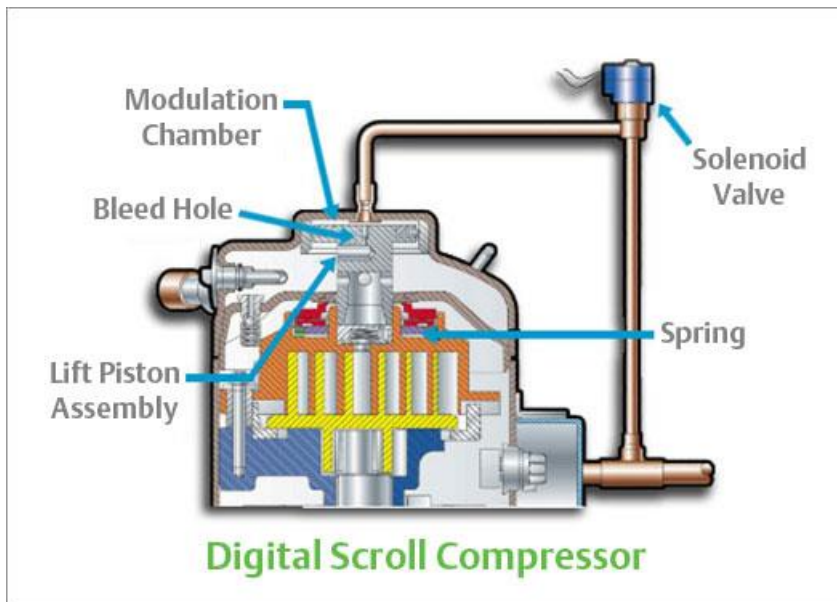

Figure 8 - Copeland Digital Scroll Compressor

When a unit is supplied with a terminal strip control scheme, controlling the VCC and staged compressors is simple to do, see below for control information.

Control signal information
- Enabling Cooling requires a 24v signal per stage (fixed stage, or VCC)
- Modulating a digital scroll compressor requires a 0-5vdc signal (1.44v = on, at 10%)
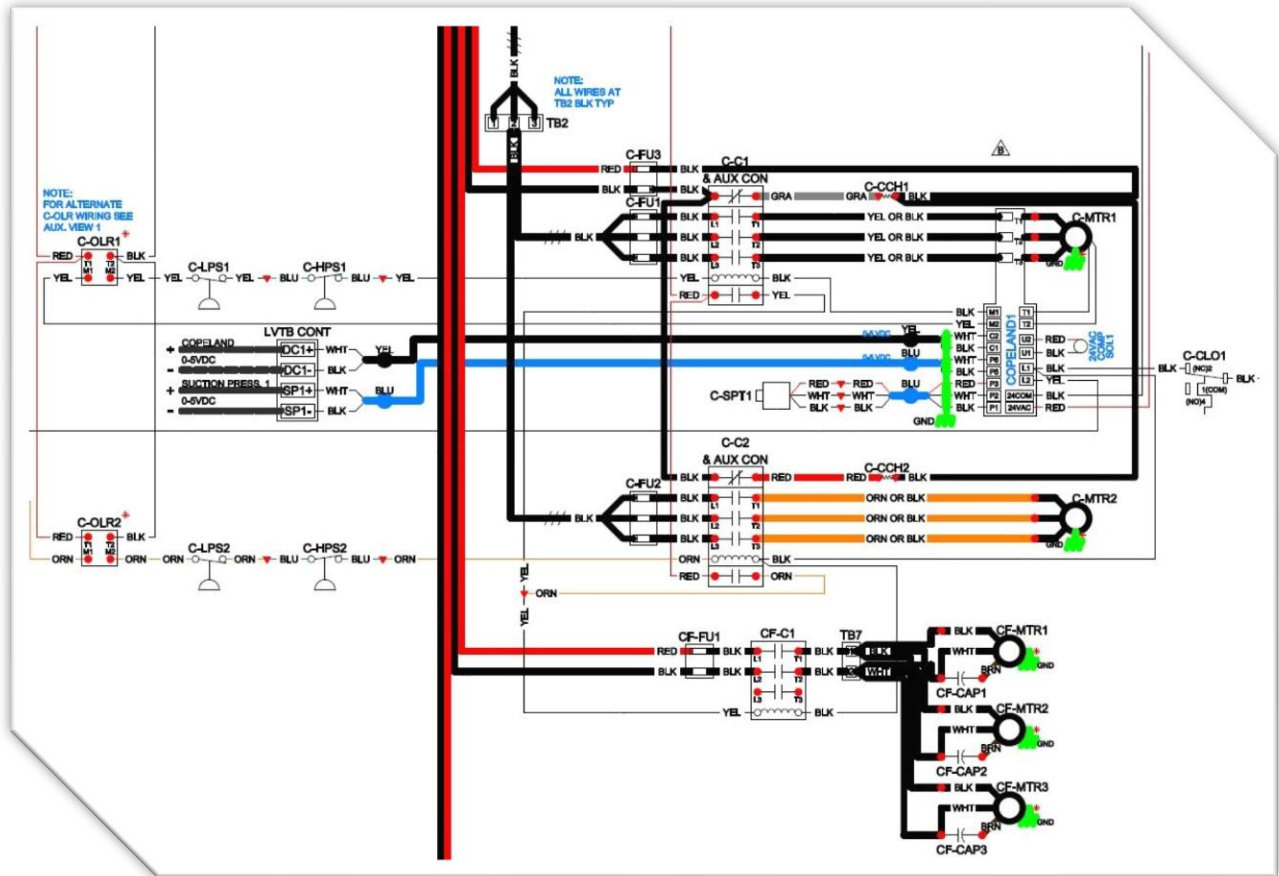
Figure 9 - Example wiring diagram of a single VCC, with single on/off compressor and 3 condenser fan motors

3.2 Sound Profile and Modulation

Digital Scroll Compressors have a unique sound profile. When they are actively compressing gas (in the Loaded state), they make a lower tonal noise. When the compressor is in the Unloaded position, the tone is higher. When the compressor is in the Unloaded position, the Copeland digital scroll compressor module's Unloader LED will be solid yellow. It is important to note that the cycling and tonal changes are by design and is not a sign that the compressor is short cycling. The compressors modulate based on a 15second, or 20second time window (depending on the controller being used).
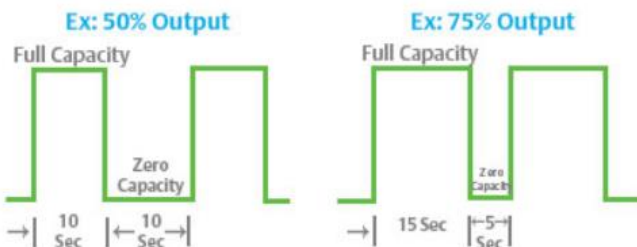

Figure 10 - Digital scroll compressor modulation graph

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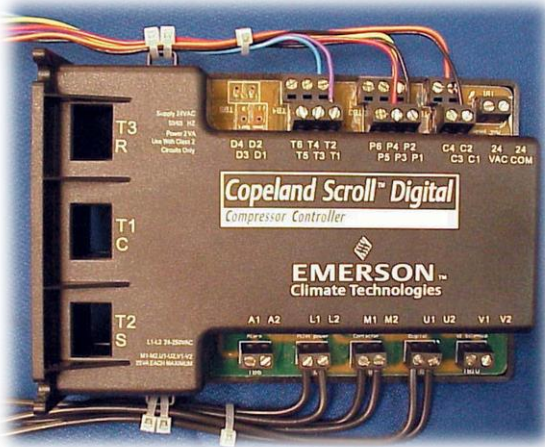### 3.3 Copeland Compressor Controller for Digital Scroll Compressors

Figure 11 - Copeland digital scroll compressor controller

This controller is required for most units that have Digital Scroll compressors. The only units that do not require this controller are units with a Wattmaster VCBX Controller. For all DDC Terminal Strip configurations, this will be a standard component of the unit.

The purpose of this controller is to always ensure safe and reliable operation of the compressor within its operating envelope. It has built-in safeties which prevent short cycling of the compressor and will also shut down the compressor if wired in safeties are tripped.

Please note, only errors that have the proper sensors wired in, will be shown as an alarm.

Figure 12 - Copeland digital scroll compressor controller, side and back view

There are LED's on the end of the controller as shown here, which display the status of the compressor. When the Unloader light is a solid yellow, the compressor is not actively compressing gas and the upper scrolling head is raised.

When the red light is blinking, an issue exists that should be addressed. There is a chart on the back of the controller, that correlate the # of blinks to error codes.

In the Appendices at the end of this manual, there will be a section for this controller. It will go into details on exactly what the error codes mean, and what internal safeties have been triggered. It also describes the terminals available on this controller, and the voltage to performance chart for compressor output.

3.4   Air-Cooled Condenser with VFD and ECM Head Pressure Control

AAON Rooftop units have a variety of ways to control the air-cooled condenser. On/Off and fan cycling switches are common and are well understood. This section will focus on Head Pressure control, which is not as typical, and more complex.

AAON's approach to accurate Head Pressure control is to pair a Wattmaster Head Pressure Control module with either an EC Motor, or a VFD & PSC Motor. The tonnage of the unit dictates which configuration the unit is built with. When using a VFD condenser fan motor, maximum and minimum frequencies can be programmed into the VFD to limit radiated noise by ensuring the motors do not reach maximum nominal RPM. Great care must be taken if this is something that is going to be done, as it may imbalance the DX system if not done properly, and cause trips. EC Motors do not have the ability to modify the max speed.

OPTIONS Dip Switch Settings	Head Pressure Setpoint	
	Air Cooled Condenser	Water Cooled Condenser
Binary Value	R410-A	R410-A
0	340 (DEFAULT)	235 (DEFAULT)
1	260	210
2	270	220
3	280	230
4	290	240
5	300	250
6	310	260
7	320	270
8	330	280
9	340	290
10	350	300
11	360	310
12	370	320
13	380	330
14	390	340
15	400	350

Figure 13 - Head pressure settings for VFD controlled condenser fans

The Wattmaster Head Pressure control module has dip switches, which allow a technician to modify the head pressure setpoint of the condenser fans. The default is 340psi for an air-cooled system without dehumidification. If dehumidification controls are present in the system, the suggested head pressure is 400psi.

These dip switches only work when the board is used standalone, without a main Wattmaster controller. If this board is used in conjunction with a VCMX or VCBX, the head pressure setpoints must be set into the main controller along with all other setpoints.

The range is adjustable from 260psi to 400psi. Unit power must be cycled to the unit after making a dipswitch change. Please see appendix for more information.
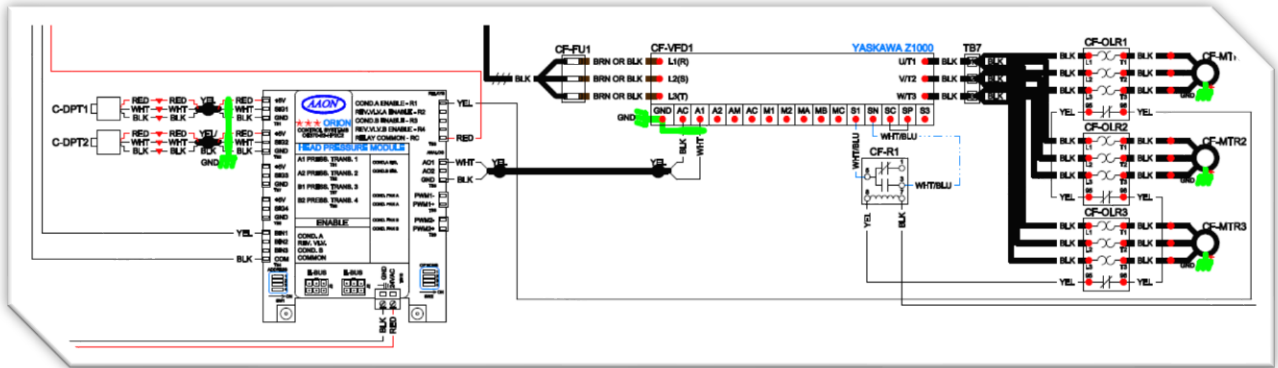
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Figure 14 - Example of a Head Pressure controller with a VFD and Condenser Fan Motors
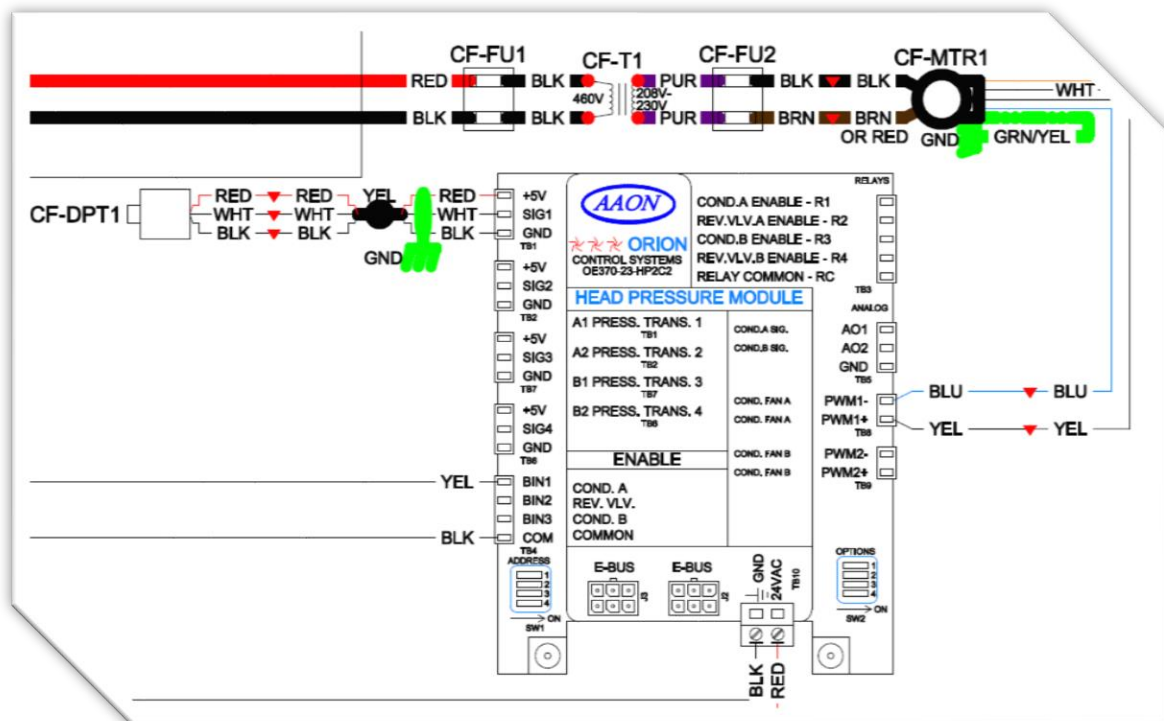

Figure 15 - Example of a Head Pressure controller with an EC Motor

3.5 Dehumidification

AAON uses the Wattmaster Modulating Hot Gas Reheat (MHGR) module to accurately control humidity in its Rooftop Units. The MHGR controller controls a condenser valve and reheat valve to redirect waste heat to a reheat coil downstream of the cooling coil. In larger systems, a snap acting secondary stage hot gas reheat valve may be installed into the system. If the first stage (modulating) valves can't meet setpoint, the on/off valve will be energized to handle the additional load, and de-energized when not required.
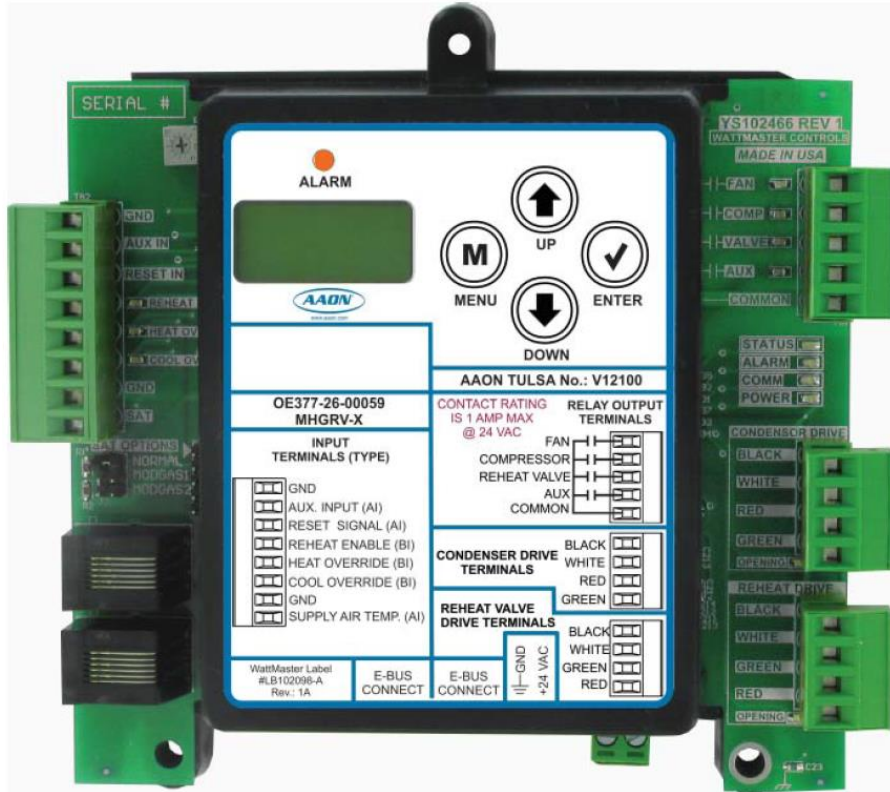
Figure 16 - Wattmaster modulating hot gas reheat dehumidification controller

Control signal information (control scheme 1)
- Enter Setpoint and Reset range into the board
- Enable cooling and dehumidification, requires two 24v signals
- Modulate VCC between 80% and 100% (5vdc) (higher is better)
- Modulating the dehumidification performance requires a 0-10vdc signal (reset upwards from supply air setpoints, 0vdc = lowest temp, 10vdc = highest temp)

Control signal information (control scheme 2)
- Enter a fixed Setpoint into the board
- Enable cooling and dehumidification, requires two 24v signals
- Modulate VCC between 80% and 100% (5vdc) (higher is better)
- Control board will modulate to a programmed supply air temperature

If the unit is not already calling on fan or compressors, the MHGR board will call them on. In the case of a unit using a Variable Capacity compressor, the compressors will still need to be given a 0-5vdc signal, the MHGR board does not do this. It is always best to control the fan and compressors, external to this board. In systems where there is a Variable Capacity compressor, and an on/off compressor, a proper control scheme must be in place, to ensure everything runs properly. Below are some constraints to keep in mind, when diagnosing issues, or designing the dehumidification system sequences.

- Hot Gas Reheat is tied to second stage of mechanical cooling
- First stage of mechanical cooling must not drop below 80% of compressor performance, while in dehumidification mode, otherwise there will not be enough hot gas for proper operation
- In part load conditions, when it would be preferable to have an on/off compressor on, and a VCC below 80%, cooling performance must be sacrificed to ensure proper dehumidification
  - Either shut down the on/off compressor, and run the VCC at 100%, or keep running the on/off compressor, and enable the VCC to 80%
- In systems where the unit has VCC's on all circuits, it is possible to operate at any cooling modulation required, if the first stage VCC is between 80% and 100% (higher is better)
- If using control scheme 1 (listed above), the higher the voltage sent to the MHGR board, the higher the reheated air temperature will be.
- Running the first stage compressor higher than is required for cooling only, is not going to overcool the space in most situations, as the reheat coil will also reheat more
- The higher modulation the compressor is ran at, the more moisture will be removed from the air

3.6   Notes

If the unit is a terminal strip style of unit with no Wattmaster main control board but has a ModgasX board and Modulating Hot Gas Reheat Board (dehum), ensure that the jumper on the left side of the board titled SAT OPTIONS, is set to the middle position. Older boards labeled it "Modgas1", newer boards labeled it "ModgasX". If this jumper isn't set correctly, the supply air temperature sensor connected to both boards will show the incorrect temperature. If using this board with a Wattmaster main controller, disregard this note entirely.

If a unit has Modulating Hot Gas Reheat, it is possible that after a long term of not using the cooling system, that liquid refrigerant might migrate to the MHGR coil. This may cause a nuisance low pressure trip. Cycling the condenser and MHGR coil stepper valves will correct this problem if it occurs.

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4.0   Heating Section

AAON Rooftop Units have many ways to heat the air being delivered, but the predominant one is natural gas modulating heat. This will be the focus in this section, and specifically on 3 to 50 Ton unit configurations.

Control signal information
- Enabling Heating requires a single 24v signal
- Modulating between the setpoint range in the modgas board, requires a 0-10vdc signal
- Always ensure that the setpoint and reset range programming in the BAS, matches the same ranges on the modulating gas board.

4.1   Standard Modulating Gas Heat

Most AAON Rooftop units supplied are with standard modulating gas heat. In this configuration, the below items are present.

- Modulating gas board
- Ignition control module
- Single main gas valve (on/off) (Two valves in 26ton, 31ton and above units)
- Single Modulating gas valve   (Two valves in 26ton, 31ton and above units)
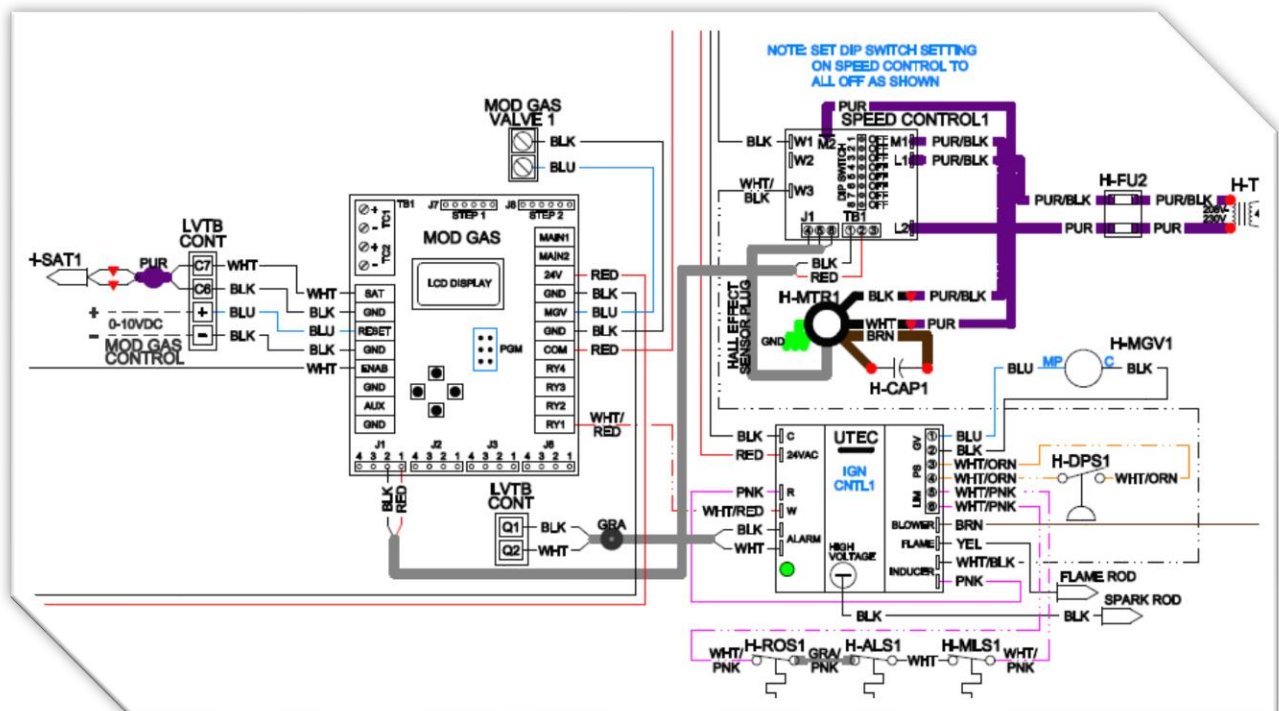- Sparkers
- Sensors
- Safeties

Figure 17 - Example of a typical modulating heat wiring diagram (Note: the new 2015 ignition control module is shown)

4.2   High Turndown Modulating Gas Heat

High turndown gas heat has been an option that is being requested more frequently. In this configuration, the below items are present.

- Modulating gas board
- Single or multiple ignition control modules
- Single or multiple main gas valve (on/off)
- Single or multiple modulating gas valves (stepper motor or standard valves)
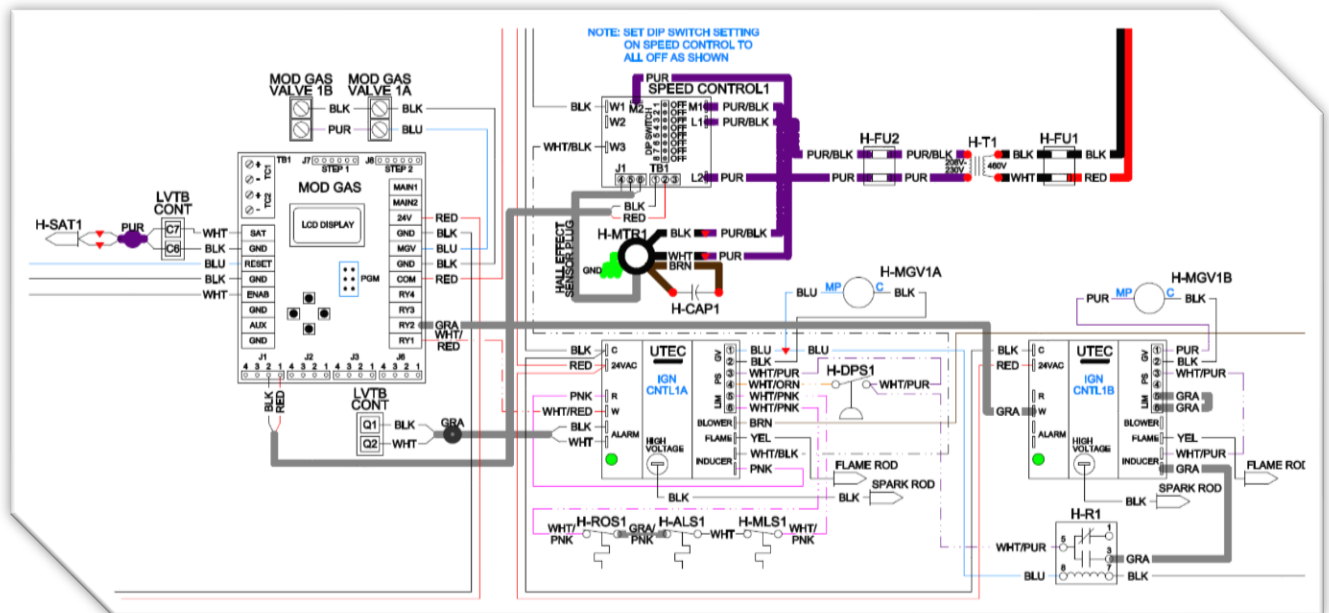- Sparkers
- Sensors
- Safeties

Figure 18 - Image depicts a high turndown unit with multiple ignition control modules, and new wiring for safeties
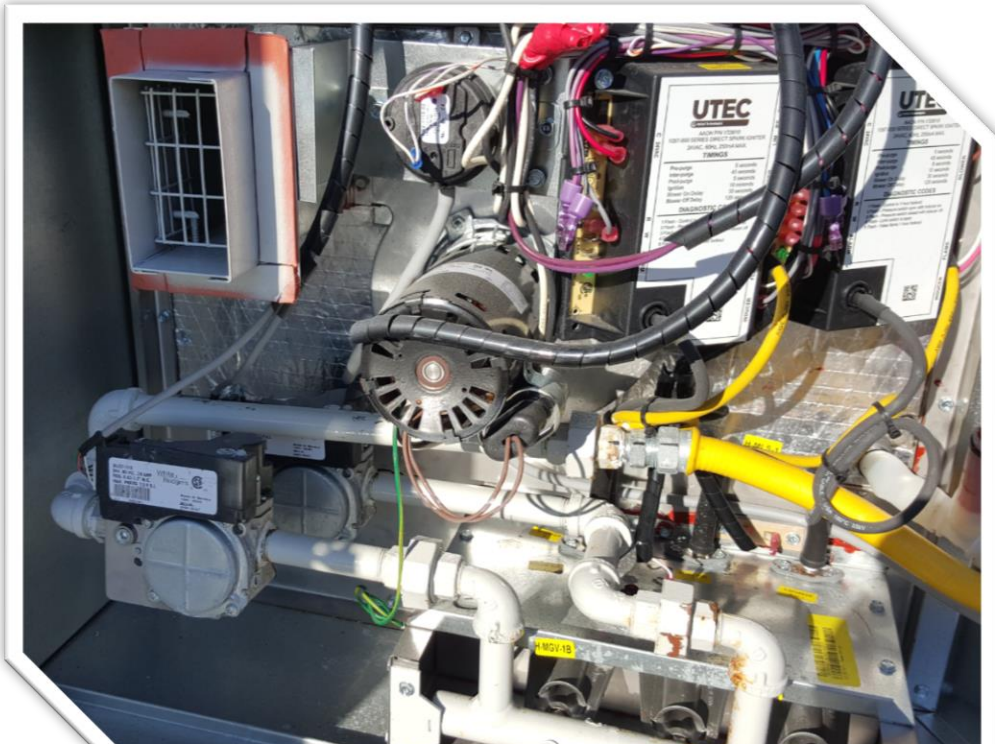
Figure 19 - This unit a high turndown gas train with split manifolds, two stepper gas valves, and two ignition control modules

Combustion Blower Motor Speed Board

Figure 20 - Combustion blower motor speed board (460v motor version)

The primary combustion blower motors that are present in AAON rooftop units, are modulating motors, that are ran at two speeds. The low speed is set on the speed control board, via dip switches. The proper dip switch settings are all switches on, except for #8 which should be off. This will set the low speed for the combustion blower motor to 2560RPM. The high speed is based on the nominal RPM of the motor. Most combustion blower motors are rated for 3400RPM. Remember to cycle power if changing this dipswitch setting.

It is important to ensure you are using the correct speed board for the unit. The yellow sticker in the middle of the board has the model number of the board, and its rated voltage. Always match the top end of the voltage, to the motor. The 460v board is as shown, and the 230v board does not have the upper section of circuitry, hence they look physically different.

The current versions of the speed boards are listed below. If a combustion blower motor on a unit has been replaced with regularity, and an older generation speed board is being used, it is suggested to upgrade to a newer speed board.

The EAC6 version of the board runs both legs of power through the board, and power flows through the board to the motor on a call for heat. With the EAC2 version of the board, one of the legs of power always ran to the motor, and the other leg ran through the board.

Current Generation Boards
EAC6-00   230v motor compatible
EAC6-10   460v motor compatible

Previous Generation Boards   (Replace with EAC6 if having issues)
EAC2-00   230v motor compatible
EAC2-10   460v motor compatible

4.4   Supply Air Temperature Sensor Resistance Chart

Temperature Sensor Resistance/Voltage Chart

Temp °F	Resistance* Ohms	Voltage @ Input*	Temp °F	Resistance* Ohms	Voltage @ Input*	Temp °F	Resistance* Ohms	Voltage @ Input*	Temp °F	Resistance* Ohms	Voltage @ Input*
-10	93333	4.620	45	21094	3.470	69	11906	2.780	84	8514	2.352
-5	80531	4.550	50	18655	3.330	70	11652	2.752	86	8153	2.297
0	69822	4.474	52	17799	3.275	71	11379	2.722	88	7805	2.242
5	60552	4.390	54	16956	3.217	72	11136	2.695	90	7472	2.187
10	52500	4.297	56	16164	3.160	73	10878	2.665	95	6716	2.055
15	45902	4.200	58	15385	3.100	74	10625	2.635	100	6047	1.927
20	40147	4.095	60	14681	3.042	75	10398	2.607	105	5453	1.805
25	35165	3.982	62	14014	2.985	76	10158	2.570	110	4923	1.687
30	30805	3.862	64	13382	2.927	78	9711	2.520	115	4449	1.575
35	27140	3.737	66	12758	2.867	80	9302	2.465	120	4030	1.469
40	23874	3.605	68	12191	2.810	82	8893	2.407	125	3656	1.369

*Chart Notes:
1. Use the resistance column to check the thermistor sensor while disconnected from the controllers (not powered).

2. Use the voltage column to check sensors while connected to powered controllers. Read voltage with meter set on DC volts. Place the "-"(minus) lead on GND terminal and the "+"(plus) lead on the sensor input terminal being investigated. If the voltage is above 5.08 VDC, the sensor or wiring is "open." If the voltage is less than 0.05 VDC, the sensor or wiring is shorted.

4.5   Wattmaster ModgasX (and ModgasX-WR) Modulating Gas Boards
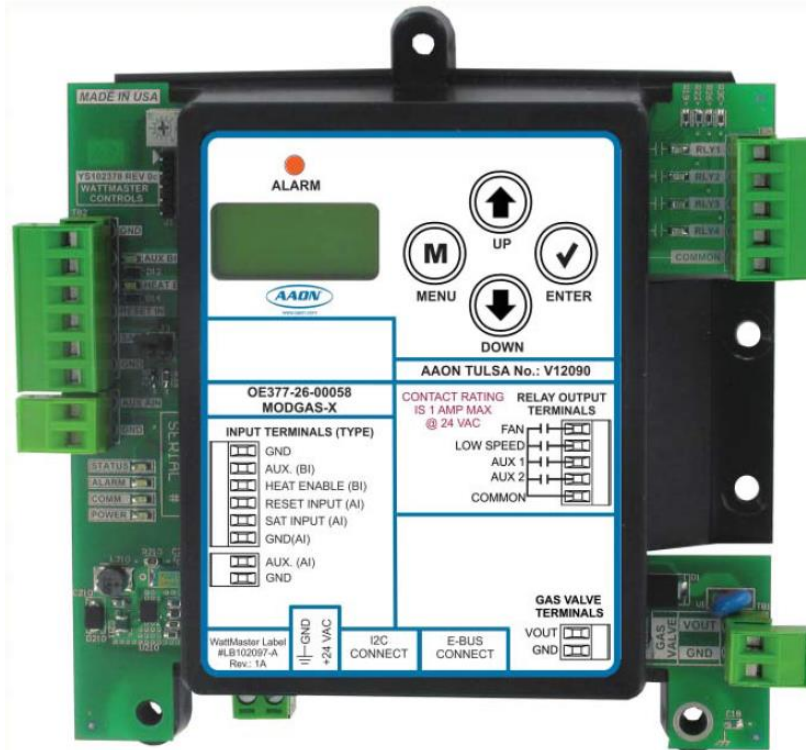
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Figure 21 - Wattmaster ModgasX modulating gas board

The Wattmaster ModgasX (and ModgasX-WR) boards are the standard modulating gas board AAON offers. It allows technicians to program the setpoint and reset, via the LCD display and menu buttons in a terminal strip control scheme. If these boards are used in conjunction with a Wattmaster main control board, program the setpoints via the main control board.

The board will light up its alarm LED if there is an issue. Errors can be found via the onboard menu. For testing purposes, heating can manually engage to any modulation rate via the onboard menu. The ModgasX board is used in standard turndown configurations, and the ModgasX-WR board is used for high turndown configurations.

4.6   Notes
When connecting this Modgas board to a Wattmaster VCMX, add a heat stage relay to the unit in the configuration section, and it will automatically connect to these boards. Do not configure the VCMX board heating type as "Modulating Heat".

When connecting these boards to a Wattmaster VCBX, configure the VCBX board heating type as "Modgas Heat", in the configuration menu. It will then know to use a ModgasX board for any heating action.

If replacing this board with an obsolete Wattmaster Modgas II board, please refer to the Appendix of this binder, for manual for the ModgasX board. On the last page, it will have instructions on the wiring changes. Be sure that if not in a standalone configuration (no main Wattmaster board), that you transfer over the dipswitch settings from the Modgas II board for setpoint and reset temperatures, to the new ModgasX board via the onboard menu.
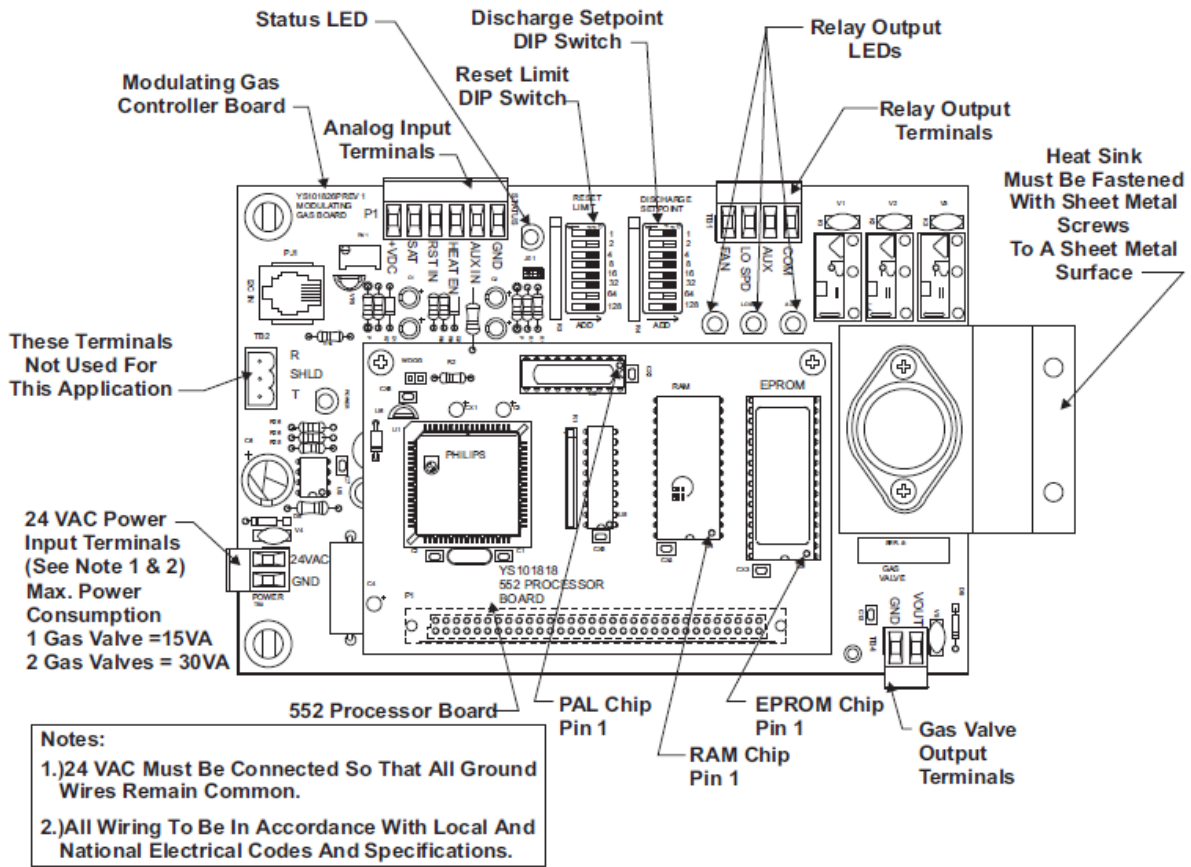## 4.7   Wattmaster Modgas II Modulating Gas Board (Previous generation)

Figure 22 - Wattmaster Modgas II Modulating Gas Board

The Wattmaster Modgas II board is the predecessor to the current ModgasX board. If one of these boards fail, a technician will need to replace it with a Modgas X board. Ensure you transfer over the setpoint and dipswitch settings, if required. Please see the notes in the above ModgasX section for more information.
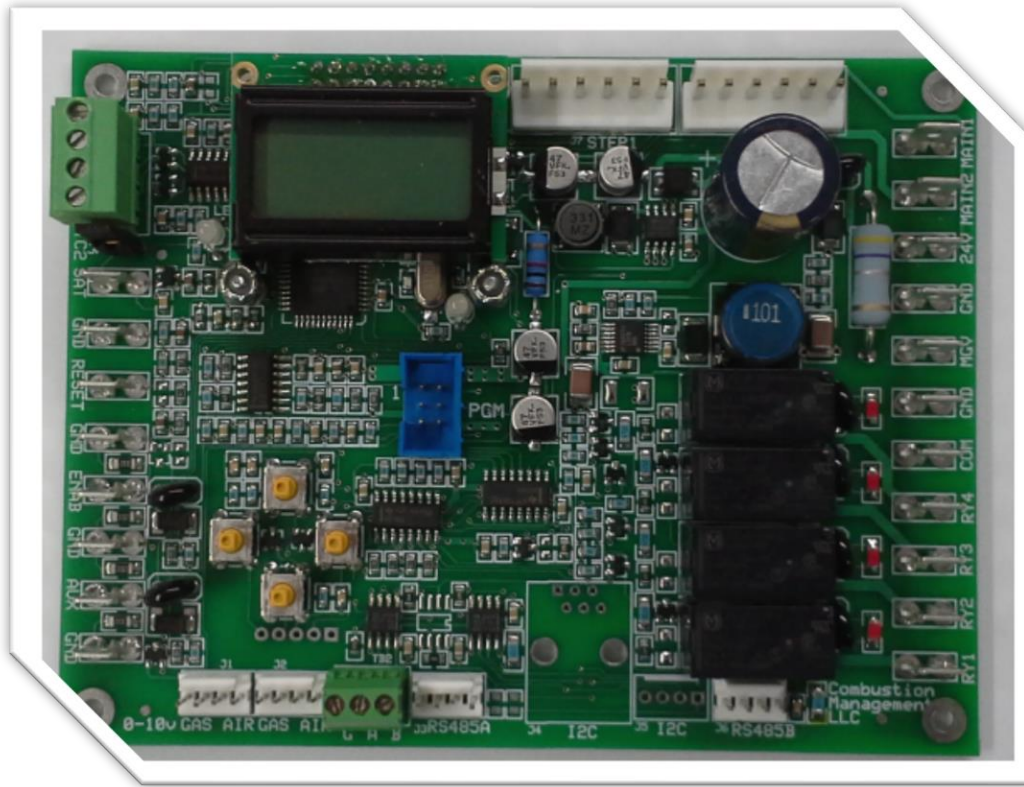
4.8   Exactair Modulating Gas Board

Figure 23 - Exactair Modulating Gas Board

The Exactair modulating gas board was used between approximately 2013, to 2015 by AAON, and only on units without a main Wattmaster controller. It has similar functionality to the Wattmaster ModgasX board, but it is wired up slightly differently, and its interface is much different.

To modify the settings of this board, it will ask for a password. Use the yellow arrows to scroll through the numbers as required, to spell out the password, which is **2425**. There is no enter button, so once you type in the numbers, wait 5 to 10 seconds, and it will allow access to the settings. The main reason for modifying the settings, would be to change the setpoint and reset settings. Always make sure that these match what the BAS has programmed.

As of late 2015, AAON is only using these boards with their new Touch Screen Mini Controller. All other unit control types, such as terminal strip, or Onboard controls, will be exclusively using the Wattmaster ModgasX or ModgasX-WR boards.

4.9   Black Ignition Control Module (previous generation)

Figure 24 - Typical Ignition Control Module

The black ignition control module shown on the left, has been around since well before 2010. On a call for heating, its only task is to spark and light the burner, and sense that the flame is lit when required.

If at any point, this module sensed a flame when there should not have been one, or a flame was not produced when it should have been, it would go into internal alarm. It would lock out for 45seconds, and then try up to 3 times, to achieve normal operation. If it fails in some fashion, it will lock out the heating functions indefinitely. To remove the lockout, either remove the call for heat (W) for more than 5 seconds, or remove the 24v power for more than 5 seconds.

All external safeties were wired in series to the main gas valve, and even if this board sent the signal to open the valve, the safeties would prevent it from doing so, if there was an issue. These safeties are typically the main limit switch, auxiliary limit switch, pressure switch, and/or roll out switch.

4.10   Black/white Ignition Control Module with LED (current)

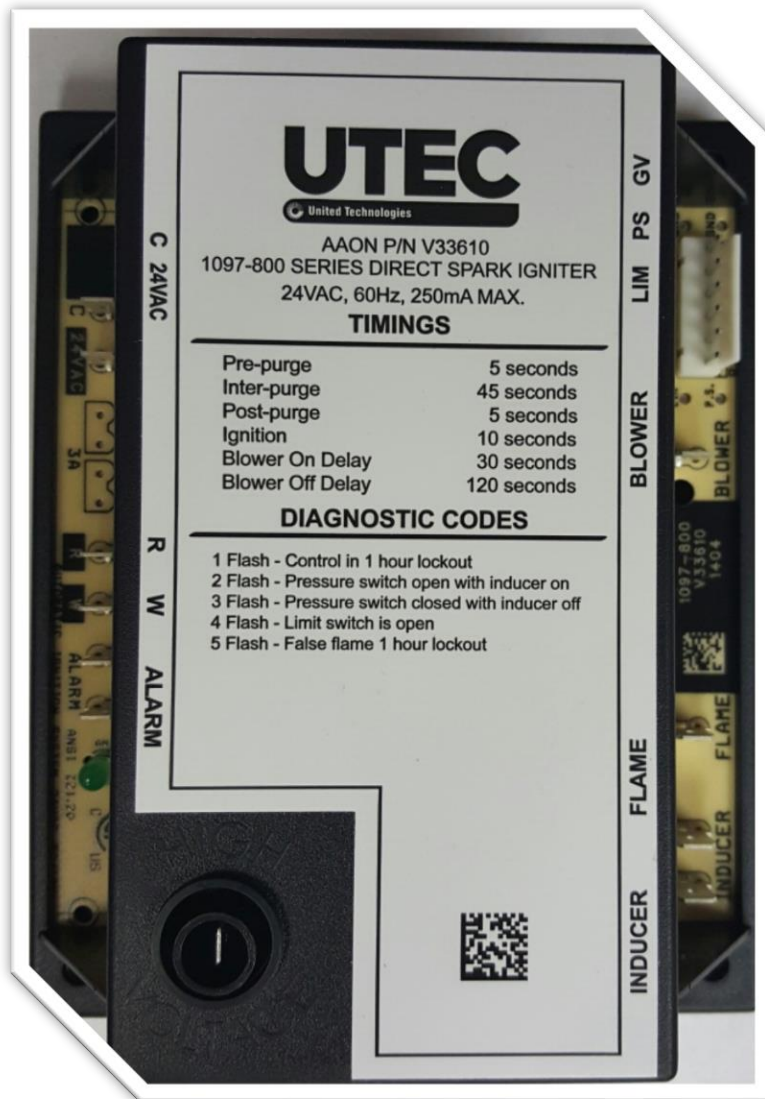**Figure 25 - New ignition control module with built-in safeties and diagnostic LED**

Figure 25 shows the new ignition control module that AAON started using during the spring of 2015. It is from the same company as the previous model, but this version has many enhancements, and useful troubleshooting features.

The biggest difference between this board and the previous board, is that all the safeties get proved by this board, before the main gas valve opens. AAON is no longer using safeties in series, but rather this board has terminals for the safety inputs and outputs.

Another change is that the combustion blower motor gets enabled by this board, and not simply enabled in series with the heat (W) call.

Because this board has the safeties running through it, onboard diagnostic codes can be shown via Flash codes on the onboard LED. The flash error codes are noted on the faceplate.

Lastly, this module also has a set of alarm terminals. They will not typically be used by AAON, but a BAS system could connect to these if required, and an error indicator could be shown at the BAS front end if there is an issue.

4.11 Heat Tracing on Condensate Line

Starting in 2015, all new AAON Rooftop Units will come with submersible heat tracing on the heat exchanger condensate lines. This is being done to prevent any chance of freeze up, which would cause a no-heat situation.

Figure 26 - Example of a heat tracing line in the condensate drain line

4.12 Combustion blower motor pressure tubing - diameter increase kit

Starting in 2015, all new AAON Rooftop Units will have a larger diameter combustion blower motor pressure tube. This will prevent a few drops of water from beading up, freezing, and tripping off the pressure sensor.

If this issue is identified in older units, this kit is available free of charge.

Figure 27 - Pressure tubing diameter increase kit

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5.0   Yaskawa Variable Frequency Drives

The most complicated device inside of any AAON Rooftop Unit is the Yaskawa VFD. This section will be a brief overview of the typical parameters needed to setup a Yaskawa A1000, or Z1000 VFD for Constant Volume airflow, and Variable Volume airflow. There are many other parameters than what will be listed, but these are the basic ones which will get the unit up and running.

If you ever need your VFD to do something it is not currently doing, or if you think it is not setup properly, call Total HVAC's office. We can give you support and suggestions. If no one in our office is available, Yaskawa's phone support is very good, and you will get excellent assistance from them.

5.1   Yaskawa A1000 & Z1000 Keypad
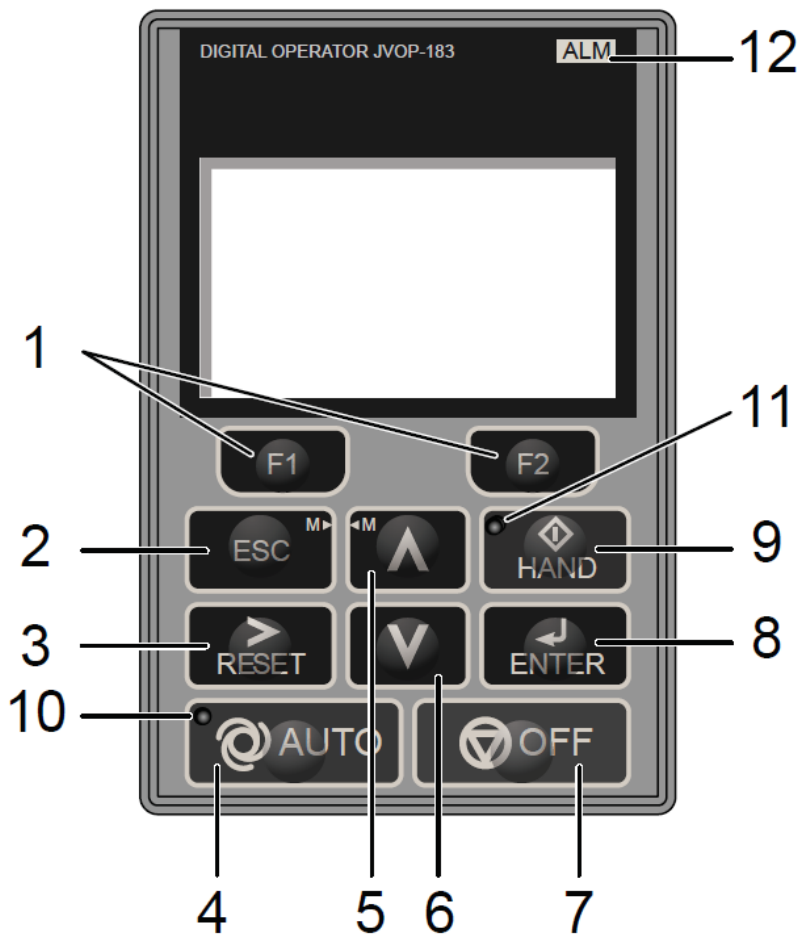
5.2   Yaskawa A1000 & Z1000 Keypad Keys and Functions

■ Keys and Functions

No.	Display	Name	Function
1	F1 F2	Function Key (F1, F2)	The functions assigned to F1 and F2 vary depending on the currently displayed menu. The name of each function appears in the lower half of the display window.
2	ESC	ESC Key	• Returns to the previous display. • Moves the cursor one space to the left. • Pressing and holding this button will return to the Frequency Reference display.
3	RESET	RESET Key	• Moves the cursor to the right. • Resets the drive to clear a fault situation.
4	AUTO	AUTO Key	Selects the source of Run command and frequency reference. • Set the drive to AUTO mode. • Run command input source depends on b1-02. • Frequency reference input source depends on b1-01.
5	∧	Up Arrow Key	Scrolls up to display the next item, selects parameter numbers, and increments setting values.
6	∨	Down Arrow Key	Scrolls down to display the previous item, selects parameter numbers, and decrements setting values.
7	OFF	OFF Key	Follows the stopping method set in b1-03 to stop drive operation. Note: The keypad OFF key is not functional when the drive is in Emergency Override.
8	ENTER	ENTER Key	• Enters parameter values and settings. • Selects a menu item to move between displays.
9	HAND	HAND Key	The drive runs at a selectable frequency reference source by b1-12. • Set the drive to HAND mode. • When b1-13 is set to 1, HAND and AUTO mode can be switched while the drive is running.
10	AUTO	AUTO Light	Lit while the drive is in AUTO mode.
11	HAND	HAND Light	Lit while the drive is in HAND mode.
12	ALM	ALM LED Light	Lit when the drive detects an alarm or error.

5.3   Constant Volume Application Key Parameters

Parameter Number	Parameter Name	Parameter Function	Value
B1-01	Frequency Reference Selection	Change to CAV or VAV mode	0 = CAV 1 = VAV
C1-01	Motor Acceleration Time	Change the speed that the motor ramps up from 0hz to max hz	Time in seconds (45sec typical)
C1-02	Motor Deceleration Time	Change the speed that the motor ramps down from max hz to 0hz	Time in seconds (45sec typical)
D1-01	Frequency Reference	Frequency the motor will run at in CAV mode	Hz
E1-04	Maximum Output Frequency	This may be required, set to D1-01 value	Hz
E1-06	Base Frequency	This may be required, set to D1-01 value	Hz
E2-01	Motor Rated Current	Enter the FLA of the motor. The VFD will monitor and slow down in order to avoid an overamp.	FLA amp

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5.4   Variable Volume Application Key Parameters

Parameter Number	Parameter Name	Parameter Function	Value
B1-01	Frequency Reference Selection	Change to CAV or VAV mode	0 = CAV 1 = VAV
C1-01	Motor Acceleration Time	Change the speed that the motor ramps up from 0hz to max hz	Time in seconds (45sec typical)
C1-02	Motor Deceleration Time	Change the speed that the motor ramps down from max hz to 0hz	Time in seconds (45sec typical)
D2-01	Frequency Reference Upper Limit	Upper % limit based on E1-04 & E1-06	Typically 100%
D2-02	Frequency Reference Lower Limit	Lower % limit based on maximum frequency in E1-04 and E1-06	Typically 34%
E1-04	Maximum Output Frequency	Maximum Hz	Hz
E1-06	Base Frequency	Maximum Hz	Hz
E2-01	Motor Rated Current	Enter the FLA of the motor. The VFD will monitor and slow down in order to avoid an overamp.	FLA amp

5.5   Common Error Codes

Error Code	Cause	Possible Solutions
BB (Base Block)	24v enable is not being received	1) Verify control transformer operation 2) Verify 24v input signal from terminal block
Motor Overload oL1 - Or - Drive Overload oL2	1) Load is too heavy 2) Cycle times for accel and decel are too short	1) Check filter loading 2) Check for blockages 3) Verify accel and decel timings

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6.0 Wattmaster VCMX, VCBX & VCCX Configurations

Wattmaster controllers which AAON uses are powerful standalone controllers, which can be connected to a BAS via protocol, or modulating and dry contact terminals. This section will give a brief overview of basic CAV, VAV, and SZVAV configuration options.

There will be many setpoints and configurations you will be able to change when you are connected to the unit, but the ones listed below are the necessary and common ones. Most others are for applications which are rarely used in our area.

Most configuration items that are not specifically mentioned below should stay at defaults, but that doesn't mean all settings and configurations should not be reviewed in case of relevance. Ensure each option is correct before leaving the unit. Always ensure that the schedule is setup properly, and it is not left in "Forced Occupied" mode. If this happens, fresh air will be delivered to the space 24/7. There will be configuration options asking if an expansion board or sensor is installed. Select the correct choice based on the wiring diagram and control boards in the unit.

6.1   Configuring a Wattmaster VCMX Main Board

Configuration Parameter and Options	Setting and Notes
Duct Static Pressure Control	No (VAV Mode Only)
HVAC Mode Enable Sensor • Supply Air (VAV Mode) • Outdoor Air (100% MUA Mode) • Space Temperature (CAV & SZVAV) • Return Air (CAV, MUA) • SA Tempering (VAV with Trim Heat)	Application Specific
HVAC Reset Source • No Reset • Space Sensor • Return Air Sensor • Remote Reset Signal	Application Specific
Dehumidification Control • Yes • No	Applicable with Hot Gas Reheat option installed
Outdoor Humidity Sensor • Yes • No	Almost always Yes
Indoor Humidity Sensor • Yes • No	Applicable with Hot Gas Reheat option installed
Economizer Control • Yes • No	Almost always Yes, only No in a 100% MUA application

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Proof of Flow Sensor • Yes • No	Almost always Yes
Mod Cooling • Yes • No	Mod Cooling is typically yes (with a VCC Compressor)
Mod Heating *This means hot water, not gas* • Yes • No	Mod Heating is always no. Modgas boards are automatically detected.
Digital Compressor Signal (1volt to 5volt)	Yes if a VCC is installed
CO2 Sensor Output signal • 0 = None • 1 = mA • 2 = VDC	If CO2 sensor is installed, then use 2 (VDC). Otherwise, 0 (None)
CO2 Sensor Maximum Scale - 2000ppm	This is just the scale, not the setpoint
Building Pressure Modulating Control • Yes • No	Use yes if using a building static pressure sensor with pressure tubing

Relay Configuration Options (partial list shown)
• Not Used
  o Default
• Heating Stage
• Cooling Stage
• HGR
• Exhaust Fan
  o If a heatwheel is installed, do not use this for the Ex fan, use the Occupied setting.
  o It will ensure that there is always air being pulled through the heatwheel, recovering energy.
• Alarm
• Occupied
  o This should be used for all Ex fan relays when using a heatwheel.
  o The other use for this, is turning on another unit, or piece of equipment.
• OA Damper (or Economizer)
• Heat Wheel	

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Setpoints and Suggested Values	Notes
HVAC Mode Enable Setpoints • Cooling - 74f • Heating - 72f • MUA Setpoints are typically not as tight as those above, it's all based on site requirements	** Must be 1 & 1 if using remote forced heating and cooling terminals **
HVAC Mode Enable Deadband - 1f	This will modify the enable temperature for cooling, raising it by 1f, and it will lower the enable temperature for heating, lowering it by 1f
Unoccupied Setbacks • Cooling - 8f • Heating - 5f	Using a setback of 30f, will tell the unit not to ever heat or cool during unoccupied mode, regardless of enable temperatures
SAT Cooling Setpoints • Cooling - 55f • Reset - 60f	Resets are a good way to automatically adjust the discharge temperature, but they add complexity to the control logic
Cooling Reset Source Setpoints • Space High Temp - 75f @ 55f discharge temp • Space Low Temp - 73f @ 60f discharge temp	This tells the controller what temperatures to modulate your reset range
SAT Heating Setpoints • Heating - 90f • Reset - 100f	It is suggested not to discharge higher than 100f, as it will the warm air to not mix with the cooler air in the space
Heating Reset Source Setpoints • Space High Temp - 70f @ 100f discharge temp • Space Low Temp - 72f @ 90f discharge temp	This tells the controller what temperatures to modulate your reset range
Outdoor Air Lockouts • Cooling - 50f • Heating - 70f	Do not mechanically cool below 50f, and do not heat above 70f, based on outdoor air temperatures

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Dehumidification Setpoint • Indoor RH - 50% • O/A Dewpoint - 55f	Only applicable in a dehumidification unit
Dehumidification Coil Temperature • Setpoint - 45f	This setpoint will allow you to adjust how much dehumidification your coil will perform
Economizer Setpoints • O/A Temperature / Wetbulb - 55f	When the outdoor air is below this setting, economizer will enable as first stage of cooling
Economizer Setpoints • Minimum Position - XX% (Job Specific) • Control Rate - 90s	The minimum position is how much the damper will open when the unit is in Occupied mode. The Control Rate is how fast it will open from 0 to 100%
Maximum Economizer Position on High CO2 Condition • Generally 100% is selected, but lower can be used	Max damper position at 100% CO2 demand
CO2 Limits • Max Level - 1000ppm (typical) • Reset Range - 500ppm	Damper will start to open at Max Level, and will proportionally open as the ppm reaches the Reset Range
Duct Static Pressure Setpoint (VAV Only) • Static Setpoint - XX" • Deadband - 0.10" • Control Rate - 30s	Upon setting this up, and adjusting your VFD, your unit will ramp the fan speed up and down to maintain duct static pressure
Building Static Pressure Setpoint • Setpoint - 0.10" • Deadband - 0.02"	Adjust this setpoint to make the space slightly positive or negative
Fan Starting Delay • Setpoint - 60s	Default is 255s, but this can be set lower, to have the fan enable quicker, upon a power loss or unit startup

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6.2   Configuring a Wattmaster VCBX & VCCX Control Boards

There are some very minor differences between the configurations of the VCBX and VCCX control boards, but I have chosen to show one set of tables for both boards. Ensure all relevant configurations and setpoints are set, based on the unit design.
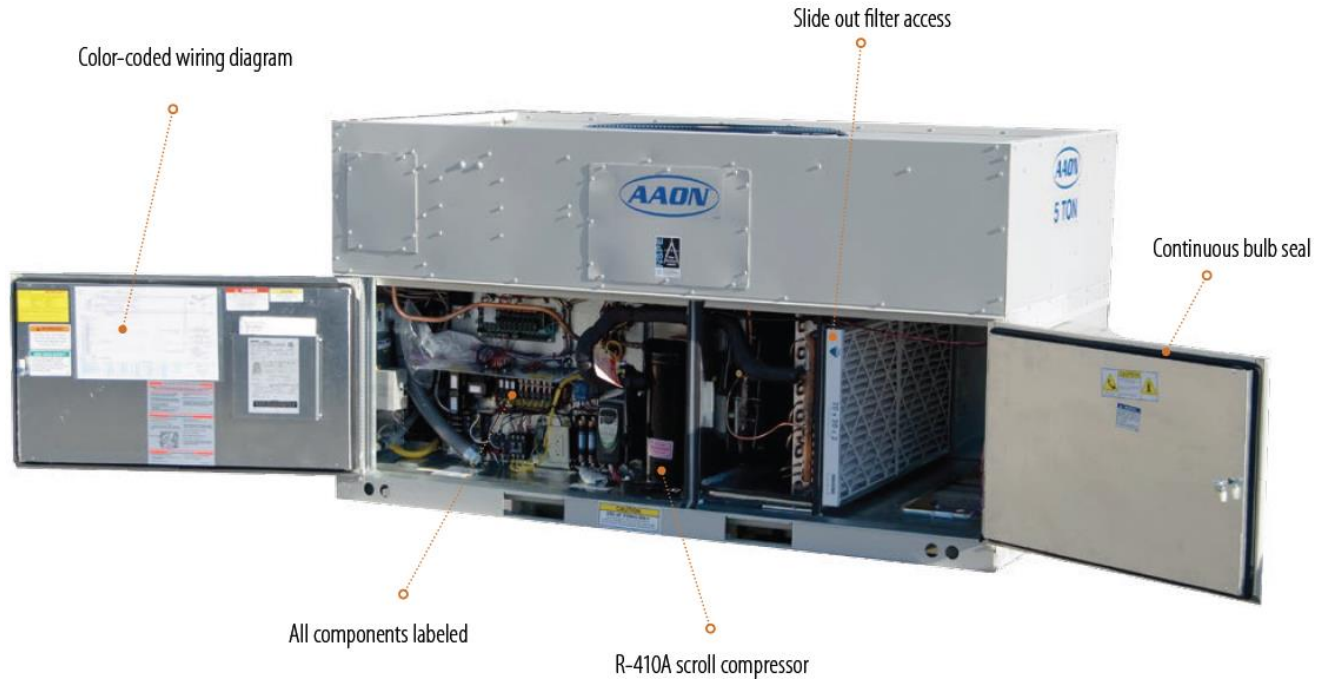
Configuration Parameter and Options	Setting and Notes
MHGRV Installed - Yes if you have modulating reheat Modgas Installed - Yes if you have modulating gas	Application Specific
HVAC Mode Enable Sensor • Supply Air (VAV Mode) • Outdoor Air (100% MUA Mode) • Space Temperature (CAV) • Return Air (CAV, MUA) • Single Zone VAV	Application Specific
HVAC Mode Set by Remote Contact • Yes • No	Ensure this is No, unless you are using the 24v terminals for Forced inputs. Otherwise, the unit will always be in Vent Mode.
HVAC Reset Source • No Reset • Space Sensor • Return Air Sensor • Remote Reset Signal	Application Specific
Static Pressure Control • None • Fan VFD	Enable this if you are using VAV mode, or SZVAV
Fan Proving • Yes • No	Almost always Yes
Heat Type • No Heat • Staged Only • Mod Gas Heat Only • Mod Gas Heat then Staged	Typical units would use "Mod Gas Heat Only". Refer to unit design for correct option.
Cool Type • No Cooling • Staged Only • Mod Only • Mod then Staged	Typical units would use "Mod Only, or Mod then Staged". Refer to unit design for correct option.

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Digital Comp for Mod Cooling • Yes • No	Yes, if a VCC is installed
Economizer Control Type • No Economizer • Standard Economizer • IAQ Economizer (Economizer with CO2 Override)	Typical selection would be standard, unless a CO2 sensor is installed, then it is IAQ Economizer
Economizer Control in Unoccupied Mode • Yes • No	Yes, this will allow free-cooling when outdoor air temperatures allow, in cooling mode only
Building Pressure Modulating Control • None • On/Off Relay • Modulating Exhaust • Supply Fan	Typically the option would be "Modulating Exhaust", if using a building static pressure sensor with pressure tubing
Dehumidification Control • Only Occupied Vent • Only Vent Anytime • All Modes Occupied • All Modes Anytime	Applicable with Hot Gas Reheat option installed. Typical selection would be all Modes Occupied.
Reheat Control • None • Modulating HGR	There are other options, but rarely ordered in our territory

Relay Configuration Options (partial list shown)
• Not Used
  o Default
• Heating Stage
• Cooling Stage
• HGR
• Exhaust Fan
  o If a heatwheel is installed, do not use this for the Ex fan, use the Occupied setting.
  o It will ensure that there is always air being pulled through the heatwheel, recovering energy.
• Alarm
• Occupied	

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o This should be used for all Ex fan relays when using a heatwheel. o The other use for this, is turning on another unit, or piece of equipment. • OA Damper (or Economizer) • Heat Wheel	

Setpoints and Suggested Values	Notes
HVAC Mode Enable Setpoints • Cooling - 74f • Heating - 72f • MUA Setpoints are typically not as tight as those above, it's all based on site requirements	** Must be 1 & 1 if using remote forced heating and cooling terminals **
Unoccupied Setbacks • Cooling - 8f • Heating - 5f	Using a setback of 30f, will tell the unit not to ever heat or cool during unoccupied mode, regardless of enable temperatures
HVAC Mode Enable Deadband - 1f	This will modify the enable temperature for cooling, raising it by 1f, and it will lower the enable temperature for heating, lowering it by 1f
Indoor Reheat Setpoint • Low RH - 50% • High RH - 60%	Only applicable in a dehumidification unit
Dehumidification Coil Temperature Setpoint • High RH Temp - 45f • Low RH Temp - 40f	This setpoint will allow you to adjust how much dehumidification your coil will perform
Duct Static Pressure Setpoint (VAV Only) • Static Setpoint - XX" • Deadband - 0.10"	Upon setting this up, and adjusting your VFD, your unit will ramp the fan speed

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	up and down to maintain duct static pressure
SAT Cooling Setpoints • Cooling - 55f • Reset - 60f	Resets are a good way to automatically adjust the discharge temperature, but they add complexity to the control logic
Cooling Reset Source Setpoints • Space High Temp - 75f @ 55f discharge temp • Space Low Temp - 73f @ 60f discharge temp	This tells the controller what temperatures to modulate your reset range
SAT Heating Setpoints • Heating - 90f • Reset - 100f	It is suggested not to discharge higher than 100f, as it will the warm air to not mix with the cooler air in the space
Heating Reset Source Setpoints • Space High Temp - 70f @ 100f discharge temp • Space Low Temp - 72f @ 90f discharge temp	This tells the controller what temperatures to modulate your reset range
Economizer Setpoints • O/A Setpoint - 55f	When the outdoor air is below this setting, economizer will enable as first stage of cooling
Economizer Setpoints • Minimum Position - XX% (Job Specific)	The minimum position is how much the damper will open when the unit is in Occupied mode.
Maximum Economizer Position on High CO2 Condition • Generally 100% is selected, but lower can be used	Max damper position at 100% CO2 demand
CO2 Limits • Min CO2 Level - 1000ppm • Max CO2 Level - 1500ppm	Damper will start to open at Min Level, and will proportionally open as the ppm reaches the Max Level
Building Static Pressure Setpoint • Setpoint - 0.10" • Deadband - 0.02"	Adjust this setpoint to make the space slightly positive or negative
Outdoor Air Compressor Lockouts • Compressor Cooling - 50f • Compressor Heatpump Heating - 35f	Do not mechanically cool below 50f, and do not mechanically heat below 35f, based on outdoor air temperatures

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Outdoor Air Heating Lockouts	Do not heat when outdoor
• Heating - 70f	air temperature is above 70f

7.0   Notes

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Color-coded wiring diagram

Slide out filter access

Continuous bulb seal

All components labeled

R-410A scroll compressor

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