Zoning Design Guide
This manual is intended as a general guide and reference for the correct application of Orion zoning systems. It is not intended to be a substitute for careful HVAC system engineering design and layout. WattMaster assumes no responsibility for incorrect or poor system application or design implemented by any of WattMaster’s representatives or their respective customers.
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Orion Systems

**General**

Even though there are some similarities between zone control systems and Variable Air Volume (VAV) systems, there are some major differences. In many cases systems will be called VAV when in fact they are really a zoning system or are referred to as a zoning system when they are really a VAV system. Always make sure that you do not try to adapt a zoning system to a VAV design system. Understanding the differences will help you to prevent misapplication of the Orion zoning system. In the paragraphs that follow we will try to explain the differences, advantages and disadvantages of each and explain their operation.

**VAV Systems**

These systems consist of an HVAC unit that is generally a *cooling only* unit and VAV terminal units located in the downstream ductwork that are used to control the amount of constant temperature air delivered to the various building zones. Sometimes the HVAC unit may have gas or electric heat, but it is typically sized and applied for morning warm-up purposes. The HVAC unit is designed to vary the volume of air that is supplied to the duct system by using either inlet vanes or an electronic variable frequency drive. These devices modulate to control the air flow through the supply fan in response to the static pressure in the duct system. VAV systems typically use high velocity VAV terminal units to distribute the air to the zones. As the various VAV terminal units in the different zones open and close to supply the constant temperature air to the spaces, the HVAC unit varies the volume of constant temperature air based on the static pressure in the ductwork. The HVAC unit is designed to maintain a constant cold supply air temperature regardless of the air flow volume in the system. The HVAC unit cycles its cooling stages to maintain a constant predetermined supply air temperature. It typically runs continuously based on a schedule.

For perimeter zones requiring heat, reheat coils (electric or hot water) located in the terminal units are used to supply heated air to the space. Many times fan powered terminal boxes are used and most of them incorporate electric or hot water heating coils to provide perimeter zone heating. In summary a true VAV system uses a variable volume fan supplying constant temperature air to the system with variable volume terminal units used to control the volume of constant temperature air delivered to the space. Generally these systems use pressure independent damper control.

**Orion Zoning Systems**

The Orion zoning system is quite different in operation and design from the VAV system previously discussed. Air volume control of the zoning system can either be achieved by utilizing a VFD drive to modulate the unit fan speed or achieved by bypassing air from the HVAC unit supply duct back into the HVAC unit return air duct on the unit inlet. The supply fan VFD or the bypass air damper is controlled and modulated based on the static pressure value sensed by a static pressure sensor located in the supply air duct downstream of the unit supply air discharge. The supply fan VFD modulates the fan speed or the bypass damper modulates open and closed based on the static pressure in the duct. The temperature at the HVAC unit discharge varies in relation to the demand from the zones.

HVAC units used for the zoning system will typically have both heating and cooling capabilities. The unit supplies a variable volume of cold or hot air to the duct system which is fed to the individual zones by modulating zone dampers. Each zone controller relays its heating or cooling demand to the Polling Device installed on its local communications loop. The Polling Device determines the HVAC unit mode of operation (heating, cooling or vent mode) depending on the demand from the zone controllers and relays this to the HVAC unit controller. The Polling Device utilizes a voting system to determine the correct mode of operation. Each zone controller determines (based on its heating and cooling setpoints) whether or not to use the air being supplied by the HVAC unit. For example, one of the zones is calling for cooling when the temperature in the duct is above the zones cooling setpoint. This zone will move to its minimum cooling position to prevent warm air being introduced into the space. With the zoning system the zone dampers are generally pressure dependent. Pressure independent operation is available but is not very common. Reheat and/or fan powered terminal units can be used but aren’t commonly part of the typical zoning system.

**Conclusion**

Typically a VAV, HVAC unit and associated controls is more expensive than a CAV (Constant Volume) unit utilizing zoning system control, especially on smaller HVAC units. Many times the system can be redesigned to a zoning system with a significant cost savings and equal or better performance and comfort than a VAV system would provide. Orion Systems allow you the option of which one is best for your application. Or if desired, VAV and zoned HVAC systems can also be mixed and matched on the same control system.
How Orion Works

As previously discussed, in contrast to the VAV system the zoning system supplies variable temperature air to the supply ductwork. The zone dampers modulate and supply the correct amount of conditioned air to the building zones and the zone dampers. The Polling Device calculates the heating and cooling requirements for each zone based on real time information received from each Zone Controller/Damper. The Polling Device then directs the HVAC unit to provide the appropriate amount of heating, cooling, and ventilation to satisfy each zone’s requirements. A static air pressure sensor is used to allow the controller to modulate a bypass damper or a VFD (variable frequency drive) to maintain constant duct pressure.

The Orion system uses a unique 3 tier approach to controlling the system:

- Voting Zones
- System Demand
- Priority

This 3 tier system works in an integrated fashion to maintain proper control of the equipment and effective control of comfort in the zone.

First the zone must initiate a vote to the HVAC unit. This occurs when a zone becomes more than 1 degree off setpoint. At this time a vote is placed for heating or cooling. Next the Polling Device evaluates the total cooling demand or heating demand of the zones served by the HVAC unit, to determine which requirement is more critical. Finally, the system looks for any priority conditions, which would take precedence over other zones. All three of these elements working together provide accurate and stable control of comfort.

Additional control features are taken into account to provide very effective control of the system. Some of these include priority override, supply air temperature limits, outside air temperature lockouts, and minimum /maximum position control over the zone dampers.

Substantial savings can be realized using the Orion Zoning system instead of having to install multiple rooftop units to accommodate multiple zone requirements. The Orion Zoning system is versatile and can be used with any packaged rooftop unit or split system. It controls a variety of terminal unit functions including single duct pressure dependent, pressure independent, series fan, parallel fan terminals and electric or hot water reheat.
Why Should I Use Orion?

Orion system was designed using proven technology with a long history of successful installations. Our systems have been refined over the years with the help of feedback from people in the field who work and live with these systems on a daily basis. Our success is greatly due to the fact that we have implemented changes and enhancements based on real world experience not from tinkering with equipment in an isolated lab environment. This real world approach provides engineers, contractors, and end users with a control system that is efficient, reliable, and most importantly, keeps the customers comfortable!

What Is Unique About Orion?

**Orion is unique** because it has many features not found on other systems. These features include

**Integration with Existing Equipment**
The Orion HVAC unit controller is usually factory installed by AAON®. However, if you have a job with new AAON equipment being installed and you would like to tie in existing AAON® or other manufacturers HVAC equipment to the system, the Orion controllers are designed to work with any manufacturers HVAC equipment that will accept a standard thermostat connection. Another value added feature is that the Orion controllers include very comprehensive documentation, which was written in a format specifically for a “non-controls technician”. All setup and configuration procedures are simple and easy to implement.

**Pre-Engineered Software**
System design, software, and documentation has already been done for you. This eliminates the costly expense usually associated with conventional DDC systems, making the Orion system more competitive and easier to install and operate.

**One Controller for VAV, Zoned or Single Zone CAV Systems**
The VAV/CAV unit controller can be field configured for VAV, zoning or constant volume applications. Not only does Orion provide a networked zone control system for one or multiple VAV or zoned HVAC units, you can also connect individual CAV (constant volume) single zone units to the system eliminating the need to use programmable thermostats. Add-on devices are available which can control lighting, exhaust fans, boilers and other building equipment on the same controls system.

**User Friendly Set Up**
Since the Orion comes with menu driven, fill in the blank programming, system setup is simple. The system manual takes you step by step through the set up process. Default parameter values are programmed into permanent memory so the system can be operational at start-up. Specialized training is not required.
True Network Communications
The Orion uses a three wire, RS-485 loop for communication between all controllers in the system. This provides a very reliable form of communication with flexibility of installation. The loop can be wired in a “daisy chain” or “star” configuration. Many other zoning systems utilize “home run” wiring that requires all communication cables to be brought back to a central point adding additional cost to the project and complicating wiring.

High Integrity Communications
Many communicating control systems are susceptible to electrical interference. One major manufacturer of zoning systems recommends that their communication cable should not be strapped to conduit because of potential interference. The Orion Systems have a communication bus that is almost immune to any noise or electrical interference problems that can be found in many commercial facilities. This feature makes installation problems non-existent and insures the continued reliability of the controls system.

Microprocessor Controllers
All controllers in the Orion System have an on board microprocessor. This is what gives the Orion its powerful features and capabilities not found in other systems.

Stand Alone Systems
All Orion Systems are true stand-alone and do not require a computer to operate. Unit controllers maintain their own 7 day time clock, 365 day holiday scheduling, and setpoints within each controller.

Menu Driven Operators’ Interface
All Orion systems have the ability to be connected to an operators’ keypad and display terminal. This gives you access to system status and parameter values without the need for a computer. The Modular Service tool or the Modular System Manager have 4 line by 20 character displays that are backlit making them easy to read even in low light environments. Function keys and menu driven programming makes the system extremely user friendly. In addition, the interface panel is password protected to keep unauthorized users from accessing the system.

Communications Via Optional Modem
The Remote Link is used for achieving remote communications with the Orion system. It connects to the CommLink II communications interface and a local phone line. With the Remote Link, the Orion system can be programmed and monitored from a remote location, using a computer and the Prism graphical computer front end software package. An internet interface is also available when using the Prism software package.

Modulating, Heavy Duty Actuators with Real Time Feedback
All Orion actuators utilize true modulating control unlike many systems, which are two position. This gives the system-improved control, which translates, to better comfort levels. Our actuators are also rated for 2.5 million cycles, making our actuators some of the most reliable in the industry. One other critical feature is the real time feedback. Many other systems have no feedback at all. They blindly estimate the travel time of their actuator, which, in the real world, is not a very repeatable estimate. To help correct the problems inherent with this approach, they recycle all the actuators in the system once or twice a day. They may save a few dollars by not including feedback but they sacrifice system performance. Not so with Orion.

Commercial Grade – Insulated Round Zone Dampers
Orion Systems utilize commercial grade zone dampers, not cheap, flimsy, “light commercial” or “residential” style dampers like many other manufacturers. Our round damper is ARI certified and comes from the factory fully insulated. Why? When many zone dampers are installed they are improperly insulated or not insulated at all. This can cause problems with the damper “sweating” from condensation. With factory insulated zone dampers, we eliminate a common problem for the contractor while insuring the end user will not have problems with condensation dripping down onto the ceiling.

Rectangular Dampers
Orion uses only top of the line, aluminum air foil rectangular control dampers. No other zone system on the market today utilizes a damper of this quality and performance!
What Is Unique About Orion?

Patented Flush Mount Room Sensors

Our flush mount room sensors are so unique, they are patented (U.S. Patent No. 4,659,236). Even though part of the sensor is recessed into the wall to provide an attractive yet tamper proof flush mounting, internal wall temperatures do not influence the sensor. A special plate on the face of the sensor accurately senses space temperature. Even though the attractive off white plastic housing is a preferred color, the sensor housing can be painted or wallpapered to blend with room decor without affecting sensor performance. The sensors are offered in four different configurations:

- Sensor
- Sensor w/override
- Sensor w/setpoint adjustment
- Sensor w/setpoint adjustment & override

Modular Connections

The VAV/Zone Controllers used with the Orion System are designed with modular connections for easy, error free wiring. A Power/Comm board is used to supply power and communications to the branch circuits. The VAV/Zone Controller boards and the Power/Comm board are provided with Molex® connectors. Prefabricated cables with Molex® connectors are supplied in various lengths for connection between the VAV/Zone Controllers and the Power/Comm Board. In addition to the power and communications wiring between the Power/Comm Board and the VAV/Zone Controllers many Orion auxiliary devices are connected to the controllers via modular plugs like the ones used on telephones. This also simplifies installation and eliminates the possibility of wiring errors. The devices, which utilize this method are the damper actuators for zone control, modular room sensors used with the zone controllers, auxiliary relay boards, and static pressure/air flow sensors. There is one interesting side note about the auxiliary relay board and airflow sensors. These devices are typically used on the zone controllers in the Orion systems. When the system is powered up, it automatically looks to see if these devices are connected to the controller. If they are, the controller automatically reconfigures itself to utilize these devices and activates the appropriate set up screens back at the operators interface. This feature makes setup a breeze!

FREE! Windows™ Graphics Software

Each Orion system can be monitored on site or remotely using a PC and our Windows 98, “Prism” computer front end software. This full-featured package is very user friendly and can be used to monitor one system or hundreds. Prism is not copy protected so it can be installed on multiple PC’s without additional expense. Just some of its many features include but are not limited to:

- Pre-designed status screens for all controllers
- Alarm dial out capability
- Programming of all system parameters
- Trend logging
- Alarm Handling
- Custom graphics capability

Open Protocol System

Orion is an open protocol based system allowing other manufacturers to develop direct interfaces to the communications loop. This gives you the ability to integrate the Orion system into products from other vendors. Our engineering staff will be glad to assist any vendor in this process.
Basics of Designing A Zoning System

This is a summary of the key items you need to consider for the design and layout of a successful zoning system.

It is important that you study the design guide for a more in depth understanding of proper system design.

By following the design guide and these tips you can eliminate many unnecessary headaches that occur when the basic rules of zoning are not followed. Always contact WattMaster Controls if you have any questions.

- Always group zones with similar load profiles on the same HVAC unit.
- Never mix perimeter zones with interior zones on the same HVAC unit.
- Each zoned HVAC unit should have a minimum of 3 to 4 zones. Any less and you should consult the factory.
- Each zoned HVAC unit can support a maximum of 16 voting zones. Any more zones and you should contact the factory.
- When using auxiliary heat for individual zones, perimeter heat such as baseboard is always preferred and more economical to operate than a fan terminal unit with reheat.
- If you have electric reheat coils mounted on terminal units, it is recommended these be fan powered terminals. Consult the factory for further details concerning this application.
- If there is an economizer on the HVAC unit, it is highly recommended, though not required, that the Orion HVAC unit controller controls the economizer.
- Pressure Independent Zones must always use round dampers or VAV boxes, never rectangular - no exceptions!
- Never attempt to use a zone control system on a true VAV application. See “Zoning Systems Versus True VAV Systems” on page 5 of this guide for detailed information.
- Bypass dampers should always be sized for 60%-70% of the HVAC units rated CFM.
- Even though the Orion system has certain features to help protect your equipment, never override or disconnect any safety devices associated with the HVAC unit.
- To prevent low load cycling of the equipment, a hot gas bypass system on the first stage of cooling is highly recommended.
Load Diversity

A zoning system is designed to improve tenant comfort by dynamically rebalancing the air distribution when used with a typical constant volume rooftop heating/cooling unit. If zones with extremely different load conditions are serviced by a single rooftop unit, the result will be poor control and excessive wear due to cycling of the equipment.

It is especially important to avoid mixing interior zones (which require cooling all year) with exterior zones (which may require constant heat during winter months). If you must mix zones under these conditions, consider using either VAV boxes with heat or separate external heat on perimeter zones. Orion Zoning systems offer a variety of methods to control additional zone heat to help you avoid problems.

Group similar loads on an individual unit and use more than one zoned unit if required. Any special loads can be handled by using separate constant volume units.

The Orion Plus system offers the designer considerable flexibility by allowing both multiple-zoned units and single-zone units to be connected within a single simple system.

Cooling - Partial Load Conditions

The engineer must be aware of several potential problems when applying a zoning system for cold weather operation.

1.) Low Ambient Temperature Lockout. During very cold weather it is common for mechanical systems to have “low temperature lockouts” which protect equipment from damage if operated under these conditions. Orion also provides user programmed lockouts for protection purposes, although mechanical safeties should always be used as the final stage of protection.

If the rooftop unit services interior zones with thermal loads, which require cooling when outside temperatures are below the safe operating limits for your equipment, you should seriously consider installing an economizer on your rooftop unit. The Orion control system is designed to take advantage of an economizer if it is installed. The use of an economizer will save money on utilities and provide comfort under conditions when it is not possible to operate the mechanical cooling system.

2.) Low Supply Air Temperatures. Under lightly loaded conditions much of the supply air may be bypassed back into the return air side of the HVAC unit. This bypassing will result in the lowering of the supply air temperature, which may result in the supply air temperature reaching the low temperature safety limit. If the supply air low temperature safety limit is exceeded, the control system will “cut off” the mechanical cooling to protect it from damage. Excessive cycling of the mechanical system will result if this condition persists. Comfort may also suffer if the system cannot run long enough to satisfy cooling demands.

A number of things can be done to reduce this problem. Some of these things depend upon the type of installation.

Avoid oversizing the unit. Do the system load calculations carefully. Since the zoning system directs the heating or cooling to the zones which require it, you may find that you can use a smaller unit in many cases. Oversizing is the number one cause of excessive low supply air temperature cycling.

Always specify that the unit is equipped with hot gas bypass on the first stage of cooling. This will allow the evaporator coil to operate at minimum loads without the system cycling due to low temperature or pressure safety limits and will in turn maintain the supply air discharge temperature within a preferred range.

Use an economizer. Although this is not a cure-all, it greatly improves operation during cool weather when cooling loads are minimal. Using an economizer also improves ventilation and lowers operating costs.

Increase cooling minimum airflow. Increase your cooling minimum airflow or damper position settings to allow more air during cooling operation. Be careful to avoid minimum settings that are so high they may cause over cooling of the spaces.

Bypass the air into the ceiling plenum. If you have a system without ducted return, bypass the air into the
Increase your static pressure setpoint. This will help reduce the amount of air being bypassed. Be aware of increased noise levels and the cost of operation if you use excessive static pressures. This will not work if you are using pressure independent zone controllers, since they will maintain a constant flow of air to the zones regardless of duct static pressure. This technique will likely cause overcooling of the spaces due to increased airflow at minimum positions.

Warning:
If the fan system has the capability of producing static pressures which could damage ductwork you must provide a manual reset, high pressure limit switch (Dwyer 1900-5-MR or equal) to cut off the fan system in the event of high duct static. Do not use your Orion Zoning system as a safety device!

Heating - Partial Load Conditions
Heating difficulties are less common than cooling difficulties. They are similar in nature, however, and the cures are generally the same. Again, a number of things can be done to reduce the effects of this problem.

Increase heating minimum airflow. Increase your heating minimum airflow or damper position settings to allow more air during heating operation. Be careful to avoid minimum settings that are so high they may cause over heating of the spaces.

Increase the static pressure. Set the static pressure setpoint to be as high as practical. Increasing static pressure does not help if you are using pressure independent control operation.

Avoid oversizing the unit. Do your all load calculations carefully. Since the zoning system directs the heating or cooling to the zones which require it, you may find that you can use a smaller unit in many cases.

Bypass the air into the ceiling plenum. If you have a system without ducted return, bypass the air into the ceiling plenum instead of into the return air intake. This method works best with plenum returns. Do not use this method with ducted returns

Use auxiliary heat. Use an auxiliary heat source in either your VAV boxes or use baseboard heaters.

Orion has a number of auxiliary heat control options which provide solutions to most problems. Refer to the Auxiliary Heat Control Options topic near the end of this section.

Override Conditions
After-hours overrides can produce aggravated partial load conditions in both the heating and cooling modes. A single zone being overridden for after-hours use most commonly causes the problem. This causes the rooftop equipment to operate for only one zone. The Orion system offers an improved solution to this common problem by allowing a single override to trigger a group of zones via a “global” override. This allows the system to operate with sufficient load to reduce cycling caused by light load conditions.

Building Pressurization
If you are using an economizer, building pressurization must be addressed. Failure to properly handle building pressurization may result in doors remaining open when the economizer is operating. Pressurization problems can render economizer operation useless. The following suggestions will help to avoid potential problems.

Use powered exhaust. A power exhaust fan(s) must be used when the system utilizes ducted returns. The return duct pressure drop will cause most barometric relief dampers to function poorly or not at all. Orion has the ability to control a powered exhaust whenever the economizer is operating.

Use building pressure control. The Orion VAV/CAV Controller can be configured to control building pressure with the addition of a building pressure sensor. The controller will modulate a VFD equipped exhaust fan or control a modulating exhaust damper to maintain a specific building pressure setting.
Zoning Design Guide

Zoning Design Procedures

General
There are six basic steps to designing an Orion Zoning system:

1.) Determining the number and location of zones
2.) Sizing the central unit
3.) Duct Considerations
4.) Room air motion and diffuser selection
5.) Bypass damper sizing
6.) Sizing the zone dampers

Step #1 - Determining The Number And Location Of Zones
A single HVAC unit should have no more than twenty zones and no fewer than 3 zones. If the number of zones exceeds twenty, then more than one HVAC unit may be required to service the zones. Please consult the factory for situations that are borderline.

The primary precaution to be taken in applying the Orion Zoning System is to select the zoning so that no zone will be at maximum (design) heating (or cooling) load when any other zone requires the opposite temperature air to satisfy its load. For example, depending on the wall, ceiling and floor material and location within the building (e.g. top or middle floor), a typical floor of a building usually has several distinct temperature or control zones that are affected uniquely by the outdoor load. These zones are depicted in Figure 1-2.

Depending on the size of the building and partition layout, some of these zones may overlap or be insignificant from a zoning standpoint. For example, Zone 11 could be multiple conference or computer rooms where additional zoning would be required, or it could be as small as a corridor where no zoning is required. Similarly, zones 7 and 8 could have no external windows and no partitions between them and could be considered a single zone. Some zones could be divided into multiple offices with full partitions between them, thus requiring separate Zone Controllers because of different internal loads, but the same external load.

Generally, the greater the number of individual Zone Controllers, the greater the comfort. The designer will have to look at the specific building, balancing the costs of multiple zones with the added comfort possible with multiple zones, to match the owner’s requirements.

It is important to recognize that there are purely internal zones, such as Zone 11 in Figure 1-2, which may contain separate offices/conference/computer rooms. These internal zones could easily have high cooling requirements while external zones (1,2,3, etc.) could be at or near design heating load. This is a misapplication of the Orion, zoning (or any heating/cooling change-over) system. The interior zones with cooling only loads should be served by a separate single zone rooftop HVAC unit (that could be zoned between multiple rooms with a similar load profile). Supplemental heat could be added to the perimeter zones and controlled with the auxiliary heat control board from the Zone Controller. System performance will generally be compromised and frequent change-over from the heating to the cooling mode will occur during the heating season if purely internal zones are combined on the same air-conditioning unit serving perimeter zones. The exposure to the sun has a large affect on the loading of the building. With the building zoned as shown below, for the best control, zones 6, 7, 8, 9 and 10 should be put on one HVAC unit, and zones 1, 2, 3, 4 and 5 on another HVAC unit. Zone 11 should be on a separate single zone con-
Here is another example of the building’s exposure affecting the zoning. **Figure 1-3** below shows a building layout with 7 zones, it has 3 zones with an eastern exposure, 4 zones with a western exposure and two each north and south exposures. This building can be controlled from a single, constant volume air handler. All of the zones have exterior surfaces and there are no totally internal zones, so they should have similar load requirements.

**Figure 1-3: Zone Layout With External Zones Only.**

**Figure 1-4** shows a building with 7 zones, 4 of the zones have a north exposure and the other 3 have a south exposure. Since there is a big difference in the affect on the building between north and south exposures, this situation should use two zoned HVAC units.

**Figure 1-5** shows a combination manufacturing facility and office area. The space temperature in the individual zones numbered 1 through 6, would all be controlled by a single HVAC unit. A single constant volume HVAC unit would be used for each of the zones 7 through 12.

**Figure 1-4: Zones With North And South Exposures.**

**Figure 1-5: Zoning And Constant Volume Units**
Step #2 - Sizing the Central Unit

Because the zones are controlled with variable air volume, it is unlikely that all zones will be at design load at the same time. The zoning allows for the diversity of loads to be taken into account and will often provide better comfort with a smaller HVAC unit.

In sizing the system, the individual zone loads should be calculated using any dependable load estimating method. Because of diversity, the central unit should be selected for the instantaneous peak load, not the sum of the peak loads, as would be done with a constant volume single zone system. Consider the following when sizing the central unit.

- Size the peak cooling load based on the month day hour of the greatest total building system load

- Heating should be sized for the lowest design temperature with an additional margin for morning “pickup”. This margin is generally recommended to be 20 to 25 percent of base design.

Step #3 - Duct Design Considerations

The Orion system uses a typical low pressure duct design. To reduce noise problems duct pressures should not exceed 1 inch W.C.

Primary trunk ducts should not be “undersized.” This is especially true for “pressure dependent” systems. Pressure dependent refers to the typical Orion Zone Controller without the airflow sensor. With larger trunk ducts, it is easier to assure relatively constant pressure to each zone. Runs should be as short as possible, and the trunk duct system kept as symmetrical as possible to facilitate system balancing. Wherever possible, run the trunk ducts above corridors and locate the zone dampers above corridors to reduce the noise in the space and facilitate service of the units. Trunk ducts should be sized for no more than 0.1 inch W.C. drop per 100 feet, and a maximum duct velocity of 2000 FPM.

Note

For pressure independent terminal units with velocity sensors and conventional “VAV” boxes properly selected for “quiet” operation, this 2000 FPM rule can be exceeded by up to 50 percent. The designer, however, should be very experienced in VAV system design before considering modification of this general rule.

Typical VAV systems with pressure independent terminals use the static regain method for sizing ducts. The typical Orion Zoning system is a low-pressure, pressure dependent system that utilizes conventional unitary air-conditioning units. These systems should use the equal-friction method of sizing the ducts, and use the maximum loss of 0.1 inch per 100 feet as described above.

Step #4 - Air Motion/Diffuser Selection

Air motion is a consideration for occupant comfort. The selection of diffusers for an Orion Zoning system requires more care than a constant volume system due to varying flow of air into the zones. Slot diffusers are recommended due to their superior performance at low airflows. Because the zone airflow is variable volume, lower cost round or rectangular diffusers that were satisfactory for constant volume may prove unsatisfactory with an Orion Zoning system. These diffusers may result in “dumping” of the cold air at low flows in the cooling mode, and insufficient room air motion at low airflows in the heating mode. Although high air motion in the heating mode can be undesirable, a slot diffuser with a high induction ratio generally helps to reduce room air “stratification” when the heating comes from a ceiling diffuser. Linear slot diffusers should be properly selected for the airflow and “throw” suited to the specific installation or zone.

Additional factors to consider in diffuser selection is sound level and throw at design flow. Generally, multiple diffusers will result in lower sound levels in the space, but this must be balanced with the additional hardware and installation costs. It is commonly recom-
mended that slot diffusers be located near the perimeter or outside wall with the airflow directed into the room. Consult your diffuser supplier or catalog for proper diffuser sizing and location.

Series fan boxes may be used instead of zone dampers where higher induction rates are desirable. If the heat loss on perimeter walls is high, such as large areas of glass, the use of Series Fan Boxes may be indicated to maintain higher induction rates to offset “downdrafts.” If the heat loss is greater than 275 BTUH/linear foot, you should use high quality slot diffusers next to the outer wall with the airflow directed inward to counteract downdrafts during heating. Serious downdraft problems occur when heat losses exceed 400 BTUH/linear foot and both high induction diffusers and series fan boxes are recommended.

**Step #5 - Bypass Damper Sizing**

The function of the bypass damper is to allow a constant volume air handling unit to be used with variable volume zone dampers. The bypass damper modulates on a signal from a duct static pressure sensor to “bypass” air from the supply duct back into the return air duct. If the duct static pressure exceeds the adjustable setpoint, then the damper opens to bypass more air, and if the static pressure drops below the setpoint, it closes to bypass less air.

Using a load calculation program, the bypass damper should be sized to give you the maximum CFM of air to be bypassed, typically 60 to 70 percent of the HVAC units rated capacity.

To size the damper, select a damper from the table based on calculated bypass CFM and a maximum velocity between 1750-2250 FPM. When determining the bypass duct size, be sure to take into account any transition fittings and associated pressure drops. (See Tables 1-1 & 1-2: Damper Sizing Charts)

Whenever possible, use a single bypass damper and round duct for the bypass. If space limitations or total airflow requires it, multiple bypass dampers can be controlled in parallel or a rectangular damper may be used.

For proper control of the Bypass Damper, the static pressure sensor location is very important. Refer to Figures 1-8 Thru 1-10 for proper sensor installation location information and guidelines.
Step #6 - Sizing Zone Dampers

Use a load program to determine the peak load for each zone. These calculations will be used in selecting the appropriate zone damper sizes.

Using the maximum acceptable velocity for a branch duct (typically 1000-1500 FPM for minimal noise), find the smallest damper that will deliver the required CFM as determined by the load program.

Locate the branch velocity used in the duct design program on the left hand column of either the round or rectangular damper sizing chart (Table 1-1 or Table 1-2). Move across the chart and find the damper which will provide the acceptable CFM to meet your specific zone requirements.

Note  Compare the damper size selected against the duct size to determine if the next size up or down will provide acceptable performance without requiring a transition fitting.

The master zone damper can have up to 2 additional dampers slaved together with it for large zones. This should be reserved for situations when it is not practical to use a single large damper. Each zone damper must be sized for an equal portion of the total CFM required for the zone. The slaved zone(s) track the master zones modulation, therefore only pressure dependent control is allowed when zone dampers are slaved.
Pressure Dependent Dampers
With pressure dependent (PD) dampers, the minimum and maximum airflow is set based on damper position. During the final commissioning of the system, each zone is typically balanced with a flow hood and the min/max position is fixed either mechanically or the preferred method, in the controller software. Since this min/max setting is based only on position, as the static pressure fluctuates it will cause the actual airflow at the zone damper to increase or decrease. Therefore the name, pressure dependent since the airflow is dependent on the static pressure. Pressure dependent dampers are available in round or rectangular configurations. See Figure 1-11 for a diagram of a typical pressure dependent zone damper.

Figure 1-11: Pressure Dependent Damper

Pressure Independent Dampers
When using pressure independent (PI) dampers this minimum and maximum is set based on actual CFM of airflow through the damper. Airflow is measured using a pickup tube mounted in the zone damper and an electronic air flow sensor. Using this method you always know the actual airflow through each zone damper instead of just the damper percentage open. The minimum and maximum settings are based on this actual airflow reading. As the static pressure fluctuates, the flow sensor reads the variation and automatically repositions the damper to maintain the minimum or maximum flow setpoints. Since the minimum or maximum airflow is maintained independently of the static pressure available in the duct it is called pressure independent operation. Pressure independent operation is available for round zone dampers only. Pressure independent rectangular dampers are not available. See Figure 1-12 for a diagram of a typical pressure independent zone damper.

When pressure independent dampers are used they must be field calibrated so the CFM of airflow for the minimum and maximum airflow setpoints will be correct. This should be done by the field technician during the commissioning portion of the system installation. The K-factor is the amount of airflow in CFM that the specific damper will produce with 1” W.C. velocity pressure on the damper flow sensor. This K-factor is used by the controller software to maintain the correct minimum or maximum airflow setpoint regardless of the static pressure in the duct. The K-factor and the minimum and maximum damper CFM can be entered by using the System Manager, or Modular Service Tool. K-factors can also be entered using a personal computer with the Prism computer front end software installed. The K-factors for each damper size are listed in Table 1-1: Round Air Damper Selection. Once the correct K-factors and minimum and maximum damper CFM setpoints are entered, the damper will modulate to try to maintain these CFM airflows during damper operation. If zone dampers or fan terminal units manufactured by others are used, the correct K-factors must be obtained from the equipment manufacturer.

Figure 1-12: Pressure Independent Damper
**Zoning Design Procedures**

**Table 1-1: Round Damper Selection Data**

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<th>Damper Round Duct Size (Area Ft²)</th>
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<th>10”</th>
<th>12”</th>
<th>14”</th>
<th>16”</th>
</tr>
</thead>
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<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
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<td>36</td>
<td>42</td>
<td>48</td>
</tr>
<tr>
<td>12”</td>
<td>24</td>
<td>32</td>
<td>38</td>
<td>44</td>
<td>50</td>
<td>56</td>
</tr>
<tr>
<td>14”</td>
<td>30</td>
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<td>16”</td>
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<td>48</td>
<td>54</td>
<td>60</td>
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**CFM @ 1” Velocity Pressure**

Air Flow Probe “K” Factor - For Pressure Independent Applications Only

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<th>950</th>
<th>1417</th>
<th>2120</th>
<th>2908</th>
<th>3700</th>
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<td>141</td>
<td>188</td>
<td>235</td>
<td>282</td>
<td>329</td>
<td>376</td>
</tr>
<tr>
<td>1000</td>
<td>254</td>
<td>338</td>
<td>423</td>
<td>507</td>
<td>592</td>
<td>676</td>
</tr>
<tr>
<td>1250</td>
<td>399</td>
<td>532</td>
<td>665</td>
<td>798</td>
<td>931</td>
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**Velocity Through Zone Damper FPM**

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<th>399 (0.01)</th>
<th>577 (0.02)</th>
<th>788 (0.01)</th>
<th>1031 (0.01)</th>
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<tr>
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<td>188 (0.05)</td>
<td>338 (0.03)</td>
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<td>769 (0.03)</td>
<td>1050 (0.02)</td>
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<tr>
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<td>235 (0.07)</td>
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<tr>
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<td>1154 (0.05)</td>
<td>1575 (0.04)</td>
<td>2062 (0.03)</td>
</tr>
<tr>
<td>1750</td>
<td>329 (0.12)</td>
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<td>931 (0.06)</td>
<td>1346 (0.06)</td>
<td>1838 (0.05)</td>
<td>2405 (0.04)</td>
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<td>2000</td>
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<td>2100 (0.07)</td>
<td>2749 (0.05)</td>
</tr>
<tr>
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<td>1197 (0.09)</td>
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<td>2363 (0.08)</td>
<td>3094 (0.06)</td>
</tr>
</tbody>
</table>

**Airflow Through Zone Damper - CFM (ΔP₃ inches W.C. With Air Damper Full Open)**

WattMaster reserves the right to change specifications without notice.
Rectangular Dampers

The Orion Rectangular Damper is used in applications where rectangular duct is specified or required because of space limitations or job requirements. Rectangular Dampers are only available for pressure dependent applications. A Rectangular Damper Kit is used in conjunction with the Rectangular Damper to provide control of the damper. Rectangular Damper Kits are available for Bypass, Pressure Dependent Zone and Slaved Zone configurations. Rectangular Damper Kits are not available for pressure independent applications.

The Rectangular Damper utilizes opposed blades of airfoil design for improved air flow control. The Rectangular Damper frame is made of .080 thick extruded aluminum. The blades are also made of extruded aluminum. Blade pins are 7/16” hexagon shaped aluminum fixed to a Celcon inner bearing rotating within a polycarbonate outer bearing inserted in the damper frame. The Damper linkage is mechanically assembled and located in the damper frame. The linkage components are constructed of aluminum, zinc and nickel plated steel. Blade gaskets are made of extruded EPDM material and are secured within an integral slot on the blade. Jamb seals are of extruded TPE material for low leakage through the damper when closed. The control shaft is 1/2” diameter hexagon shaped rod and can be extended 9” past the damper frame for connection to the damper actuator. The damper shaft is shipped retracted into the frame area and must be adjusted to the required length in the field.

Mounting

The Rectangular Damper should be mounted in the ductwork according to standard duct installation practices. The rectangular damper should be selected for the nominal inside duct size. All Rectangular Dampers are supplied with 1” flanges all around the damper frame, making the overall damper width and height 2” larger than the nominal inside duct size thus providing for external flange mounting to ductwork. See Figure 1-13.

The damper shaft is shipped retracted into the damper frame. Loosen the two nuts on the U-bolt that secures the damper shaft to the damper blade and adjust to length. It is recommended that the shaft length be adjusted so approximately 4” of shaft extends beyond the inside of the damper frame. Retighten the two nuts on the U-bolt that secures the damper shaft to the blade. After installation of the Rectangular Damper to the ductwork, it is recommended that insulation be applied around any non-insulated surface on the ductwork where the Rectangular Damper was installed.

Rectangular Damper Kit Installation

The Rectangular Damper Kit is simply slid over the damper shaft, the actuator shaft collar setscrews tightened and the supplied self tapping screws are used to mount the enclosure to the ductwork. Detailed mounting and installation instructions are provided with each kit. A knockout is provided in the front access cover, which can be punched out to allow for damper shaft lengths, which extend past the enclosure depth. When mounting the Rectangular Damper Kit, be sure to allow clearance for removal of the access cover. Conduit knockouts are provided in the top and bottom of the enclosure for simplified wiring installation.

Figure 1-13: Rectangular Damper & Damper Kit
**Zoning Design Procedures**

Rectangular Damper Selection Procedure

Locate the required CFM on the Rectangular Damper Selection Data table below. This table is based on an airflow velocity of 1000 FPM across the damper. This is the recommended velocity for quiet operation and normal pressure drop through the damper. When space considerations or design criteria dictate, dampers may be selected for other face velocities by using the multipliers listed in the notes associated with the table. Move across the table and find the damper selection, which will provide the required CFM and fit within the ceiling area where the damper will be located. Pressure drop across the damper is shown in parenthesis below the CFM.

### Table 1-2: Rectangular Damper Selection Data

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<thead>
<tr>
<th>Damper Height &quot;B&quot;</th>
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<th>10&quot;</th>
<th>12&quot;</th>
<th>14&quot;</th>
<th>16&quot;</th>
<th>18&quot;</th>
<th>20&quot;</th>
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<th>24&quot;</th>
<th>26&quot;</th>
<th>28&quot;</th>
<th>30&quot;</th>
<th>32&quot;</th>
<th>34&quot;</th>
<th>36&quot;</th>
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<tbody>
<tr>
<td><strong>Airflow Data with Full Open Damper – CFM @ 1000 FPM Velocity</strong> (ΔP = inches W.C. @ 1000 FPM Velocity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For airflow CFM at other velocities use these multipliers: 750 FPM = 0.75, 1250 FPM = 1.25, 1500 FPM = 1.5, 2000 = 2.0, 2250 = 2.25</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<table>
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<th>1810</th>
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*WattMaster reserves the right to change specifications without notice*
Auxiliary Heat Control Options

The Orion Zoning system offers the user a variety of methods to deal with zone heating requirements. In order to control zone heat, an optional Relay Expansion Board is required. When deciding how to handle zone heating requirements the user should consider the following:

- Does the rooftop unit have heat?
- Are you using fan-powered boxes with reheat?
- Is auxiliary heat, such as baseboard or radiant ceiling panels being used?

If the zone has some type of heat, the user must consider how the heat is to be used. The following are things that should be considered when configuring the auxiliary heat.

Using the zone heat as a first stage where it will become active before a heating demand is created at the rooftop unit. This mode is useful if you expect to have both heating and cooling demands at the same time. The zone will use its own heat and allow the rooftop unit to continue to provide cooling for other zones. This mode is also useful if the roof top unit does not have any heating capabilities.

Using the zone heat only as a second stage, where it will be activated only if the roof top unit cannot maintain the space temperature, such as during very cold weather? In this mode of operation the rooftop will examine the heating and cooling demands at the same time. The zone will use its own heat and allow the rooftop unit to continue to provide cooling for other zones. This mode is also useful if the roof top unit does not have any heating capabilities.

The zone heat is locked out if the rooftop unit is supplying hot air. Many times it is desirable to use the rooftop heating whenever possible and only use zone heat when the rooftop unit is in cooling. This mode of operation will lockout zone heat if the rooftop is delivering heated air that is $10^\circ$ above the heating setpoint.

Zone Controller Expansion Boards

The following describes the operation of each of the relays on the optional OE 321 Relay Output Expansion Board and the optional OE322 Analog/Relay Output Expansion Board. Both boards have 3 usable relay outputs. The OE322 Analog/Relay Output Board in addition, has a 0-10VDC analog output for control of a modulating hot water valve.

Output #1 - Relay Output - Series or Parallel Fan

If the VAV/Zone controller is configured for Series Fan terminal, this output will be energized anytime the main HVAC unit is on. If the controller has been configured for Parallel Fan operation, this output will energize when the zone temperature drops below the heating setpoint. It deactivates when the temperature rises $0.5^\circ$ above the heating setpoint. This output can also be configured to activate when the damper closes to a minimum position or a minimum CFM for pressure independent zones.

Output #2 - Relay Output - Heat

This heat output can activate anytime the zone temperature drops below the heating setpoint. It deactivates when the temperature rises $0.5^\circ$F above the heating setpoint. In the unoccupied mode, the unoccupied heating setpoint, with adjustable deadband values, is used. This allows the zone to maintain a lower heating setpoint at night than it does during the daytime. This heat output is not allowed to activate if the air being supplied by the air handling unit is $10^\circ$ or more above the heating setpoint. This output is intended to allow zone reheat while the Polling Device is satisfying cooling demands in other zones. This output is also intended to allow zone heating to augment the normal heating mode and to allow a zone an attempt to satisfy its own heating needs before creating a heating demand at the Polling Device.

Output #3 - Relay Output - Heat

In the occupied mode, this heat output will activate anytime the zone temperature is $1.0^\circ$F below the heating setpoint. It deactivates when the temperature rises to $0.5^\circ$F below the heating setpoint. In the unoccupied mode, the unoccupied heating setpoint, with the same deadband values mentioned above, is used. This allows the zone to maintain a lower heating setpoint at night than it does during the daytime.

Output #4 - OE321 Relay Output Board (Not Used)

Output #4 - OE322 Analog/Relay Output Board (Modulating Hot Water Heat)

This relay output is not used on the OE 321 Relay Output Expansion Board. On the OE 322 Analog/Relay Output Board, it supplies a 0-10VDC or 2-10VDC signal to control a modulating hot water valve. The output voltage starts to increase from minimum as the space temperature drops to $0.5^\circ$F above the heating setpoint and will be at the full 10 volts when the space temperature is $1.5^\circ$F below the heating setpoint.
System Installation

Mounting Of Controllers
All Orion Round Dampers or Rectangular Damper Kits have the required controllers, actuators etc. factory mounted in an indoor rated control enclosure. If you wish to use another manufacturer's dampers for zoning control you must purchase Zone or Bypass Packages from WattMaster. These are furnished without a mounting enclosure. Most local codes require these components be mounted in an enclosure. If yours does not require this it is still strongly recommended that you do mount them in an enclosure. Components that are not in an enclosure are in danger of being damaged, and are susceptible to dirt and moisture contamination. You may furnish your own enclosure or one is available from WattMaster. The part number for the WattMaster enclosure is EE000075-01. This is an indoor rated enclosure. If the zone mounting location is susceptible to water damage, watertight enclosures can be purchased at any local electrical supply. Mounting location for the controllers should not violate any local, state or national codes.

System Wiring
Wiring requirements for Orion systems can be broken down into four main categories:

1.) Power Wiring
2.) Communications Wiring
3.) Controller Wiring
4.) Sensor Wiring

The Orion System utilizes two different methods of connecting the above categories of wiring between the components on the Orion system. Some devices utilize standard terminal to terminal wiring while other devices utilize modular wiring connections with prefabricated cables being used to connect the devices to each other. VAV/Zone Controllers, the Modular System Manager and the Modular Polling Device power and communications wiring is achieved by using a Power/Comm distribution board and prefabricated modular cables. These cables distribute the power and communications signals to each modular device connected to the Power/Comm board(s). These devices also use modular connections for all sensor wiring.

All HVAC Unit Controllers such as the VAV/CAV Controller, MUA Controller and the HCCO Controller use terminal to terminal wiring for power, communications, sensor and controller wiring. The GPC Controller, GPC-17 Controller, Lighting Panel Controller and the Optimal Start Scheduler also utilize this wiring method.

Standard Terminal to Terminal Power Wiring
All Orion Unit Controllers and Add-On Devices are powered by 24 VAC. It is possible to power these by using one or more common transformers or individual transformers for each device. Possible problems you may encounter using common transformers to power multiple devices are:

- **Polarity Must Be Maintained Between Devices Connected To A Common Transformer.**
  
  If polarity is not maintained, shorting of the transformer will occur resulting in damage to the system electronics.

- It is important when powering multiple devices from one transformer that total VA load and wiring voltage drops be taken into account. For proper sizing of the transformer and wire see **Figure 1-16.**

It is therefore recommended that in most installations individual transformers be installed for each device. This will greatly reduce the possibility of errors and possible damage to the system.

Power wiring should always be done in accordance with any local, state, or national codes.
Modular Power/Communication Wiring
As previously described, VAV/Zone Controllers, the Modular System Manager and the Modular Polling Device, power and communications wiring is achieved by using a Power/Comm distribution board and prefabricated modular cables. The items below must be considered when sizing and wiring the modular devices:

- Size the transformer for the correct VA load based on the type and number of devices to be connected to each Power/Comm Board. The largest transformer that may be used to power the Power/Comm Board is 100VA. For transformer sizing of devices with modular connectors, see Figure 1-17.

- **Do Not Ground The Power/Comm Board Transformer!**
  *If the Power/Comm Board transformer is connected to earth or chassis ground, the Power/Comm Board and all devices connected to it will be damaged.*

- Each Power/Comm Board has 4 individual branch circuit connectors. No more than 6 devices may be connected to an individual branch circuit. If more connections are needed, add another Power/Comm Board.

- The maximum total length of cables allowed on a single branch circuit is 240 feet. If distances to the devices would be greater than this, add another Power/Comm Board at a location that is closer to the farthest controller(s).

The modular wiring and prefabricated cables virtually eliminate power and communications wiring errors. Simply plug in the cables between modular connectors.

Prefabricated Power/Comm Cables are available in 25, 40, 80 and 120 feet lengths. Power/Comm Extension Cables are available in 10 and 20 feet lengths. With these cable assemblies and extensions, almost any communications cable length desired can be achieved with the least number of connections. Always use the shortest Power/Comm Cable Assembly between devices so as not to exceed the maximum branch circuit cable length requirement of 240 feet.

Communication Loops
The Orion system utilizes two different communications loops. These are the network loop and the local loop. Communication between devices on each local loop are via a 9600 Baud communication rate. Communications between devices on the network loop utilize a 19200 Baud communications rate. All modular controllers (as previously discussed under the modular power wiring) are connected by modular cable and will not be discussed. All other controllers use terminal to terminal wiring for communications. Please refer to the following information for proper communications wiring of the Orion system.

WattMaster requires that all communication wire be 18 gauge minimum, two wire shielded cable, Belden #82760 or equivalent. WattMaster offers communications cable for this purpose. The 18 gauge color coded and labeled wire is available for the local loop and the network loop communications wiring. The local loop wire is supplied in 1000 ft. spools and is labeled “Local Loop” with a green candy stripe. The network loop wire is supplied in 500 ft. spools and is labeled “Network Loop” with a red candy stripe.

The loop is best connected in a daisy chain configuration, meaning the loop is connected from one controller to another. It is not necessary to sequentially address the zone controllers in relation to their location on the loop.
Even though the daisy chain configuration is preferred, the star configuration can also be used. If required, a combination of the two can also be used. Remember, the best communications loop wiring is the one which utilizes the minimum number of ends while using the shortest wiring path.

Communication Wiring terminals on most Orion controllers are marked “T”, “R” and “SHLD” (Note: instead of SHLD the CommLink is marked “G”). All wiring should be connected T to T, R to R and SHLD to SHLD throughout the entire loop system. Communication wire should be color coded to facilitate error free wiring. The communication loops will not work if any of the wires are reversed or otherwise landed incorrectly. Communications loops can be run up to a maximum of approximately 4000 ft. in total length. If your system exceeds this length, please consult the WattMaster factory for more information regarding extended communication loop lengths and solutions.

**Caution:** Make sure when you are inserting wires into the terminal blocks that strands of wire do not stick out and touch the adjacent terminals. If adjacent wires touch each other or another terminal, shorting and subsequent damage to the circuit board could result.

**Controller Wiring**

All controller wiring should be in accordance with all local, state, and national codes. It is recommended that all wire be a minimum of 18 AWG unless otherwise specified in the charts below. Controller connections and wire sizing is as follows:

**VAV/CAV Controller**

- 24 VAC Supply Voltage (8 VA)
  (2) Conductors - Determine minimum wire size from Figure 1-16 on page 26.
- Communications Loop
  (2) Conductors 18 gauge minimum twisted pair with shield
  (WattMaster communication wire, Belden #82760 or equal)
- Supply Air Temperature Sensor
  (2) Conductors 24 gauge minimum
- Return Air Temperature Sensor
  (2) Conductors 24 gauge minimum
- Outside Air Sensor
  (2) Conductors 24 gauge minimum
- Supply Static Pressure Sensor
  (2) Conductors 24 gauge minimum
- Bypass Damper
  (3) Conductors 24 gauge minimum
- HVAC Unit Control Wiring
  (6) Conductors 24 gauge minimum
  R (Common), G (Fan), Y1 (Cool 1), Y2 (Cool 2), W1 (Heat 1), W2 (Heat 2)
  For VAV/CAV Controller With Optional Staging Expansion Board up to an additional (8) conductors Y3 through Y6, W3 Through W6
System Manager

- 24 VAC Supply Voltage (6 VA) and Communications Loop
  *Use Prefabricated Modular Cable*

VAV/Zone Controller

- 24 VAC Supply Voltage (6 VA) and Communications Loop
  *Use Prefabricated Modular Cable*

- Modular Room Sensor
  *Use Prefabricated Modular Cable*

Sensor Wiring

Orion temperature sensors utilize a type III thermistor element that is one of the most commonly used sensors in the building controls industry. The sensor wire should be a minimum of 24 gauge however larger wire such as 18 gauge is commonly used. The exception to this is the VAV/Zone Controller utilizes a Modular Room Sensor which is connected with a prefabricated modular cable.

Conventional thermostat cable is acceptable in most commercial and institutional installations. In some installations which have the potential for high electrical noise, such as broadcast facilities (radio, TV, etc.), heavy industrial (machinery, welding equipment, etc.), and medical (x-ray, scanning, etc.), it is advisable to use shielded cable on sensors which are located in or close to these environments. The same cable used for the communication bus can be used in these situations.

Sensor requirements are:

- Supply Air Sensor
  - (2) Conductors 24 gauge minimum

- Return Sensor
  - (2) Conductors 24 gauge minimum

- Outside Air Sensor
  - (2) Conductors 24 gauge minimum

- Standard Room Sensor (HVAC Unit Controllers Only)
  - (2) Conductors 24 gauge minimum
  - (3) Conductors if using optional slide adjust

- Modular Room Sensor (used with VAV/Zone Controllers Only)
  *Use Prefabricated Modular Cable*
System Installation

Figure 1-15: Networked System Communication Loop Wiring
Application Notes:

Zoning Large Units

Zoning systems work very well for HVAC units up to 40 tons. It is recommended that HVAC units larger than 40 tons should be designed as true VAV systems due to the large number of zones involved. When using HVAC units that are 25 to 40 tons, for zoning applications, several rules must be considered to prohibit potential problems. If

Because of the larger air flow capacities of these units, great care must be taken in sizing zone and bypass dampers.

Use these guidelines to help keep you out of trouble.

- Always specify that the unit is equipped with hot gas bypass on the first stage of cooling.
- Always use a VFD instead of using a bypass damper for controlling duct pressure
- The unit should be equipped with the maximum number of heating and cooling stages available.
- Avoid large zones served by a single damper. Try to break the larger zones up into multiple zones.
- Large units should always have a minimum of 6 zones due to the high air flow capacities. On larger tonnage units, the more zones the better
- To prevent excessive noise in the system, zone damper total minimum airflow settings should be equal to or preferably greater than 30% of the units rated CFM.

As an added precaution, we recommend a high duct static safety switch be installed (Dwyer Model 1900-5-MR or equal) to prevent over pressurization of the ductwork.
24VAC Power - Transformer & Wire Sizing Considerations for Devices Without Modular Connectors

Some installers like to use one large 24VAC transformer to power several devices. This is allowable as long as polarity is maintained to each device on the transformer circuit. **Warning:** If polarity is not maintained, severe damage to the devices may result. WattMaster Controls recommends using a separate transformer for each device in order to eliminate the potential for damaging controllers due to incorrect polarity. Using separate transformers also allows redundancy in case of a transformer failure. Instead of having 8 controllers inoperative because of a malfunctioning transformer you have only 1 controller off line. If the installer does decide to use a large transformer to supply power to several devices, the following transformer and wire sizing information is presented to help the installer correctly supply 24VAC power to the devices.

Following is a typical example to help the installer to correctly evaluate transformer and wiring designs.

Each -GPC Controller requires 8 VA @ 24VAC power. In the examples below we have a total of 8 GPC Controllers.

8 Zone Controllers @ 8VA each........... 8 x 8VA = 64VA.

The above calculation determines that our transformer will need to be sized for a minimum of 64VA if we are to use one transformer to power all the controllers.

Next we must determine the maximum length of run allowable for the wire gauge we wish to use in the installation. Each wire gauge below has a voltage drop per foot value we use to calculate total voltage drop.

18ga wire.................................0.00054 = voltage drop per 1' length of wire
16ga wire.................................0.00034 = voltage drop per 1' length of wire
14ga wire.................................0.00021 = voltage drop per 1' length of wire

For our example we will use 18 gauge wire. WattMaster recommends 18 gauge as a minimum wire size for all power wiring.

Next use the voltage drop per foot value for 18 gauge wire from the list above and multiply by the total VA load of the 8 controllers to be installed.

\[
0.00054 \text{ (Voltage drop per foot for 18 gauge wire)} \times 64\text{VA controller load} = 0.0346 \text{ Volts/Ft.}
\]

WattMaster controllers will operate efficiently with a voltage drop no greater than 2 Volts. Divide the total allowable voltage drop of 2 Volts by the number you arrived at above and you have the maximum number of feet you can run the 18 gauge wire with an 75 VA transformer with no more than a 2 Volt drop at the farthest controller from the transformer.

\[
\frac{2 \text{ (Volts total allowable voltage drop)}}{0.0346 \text{ (Voltage drop per 1 ft. @ 64VA load)}} = 57.80 \text{ feet}
\]

Parallel circuiting of the wiring instead of wiring all 8 controllers in series allows for longer wire runs to be used with the same size wire (as shown in our examples below). It is often necessary for the installer to calculate and weigh the cost and installation advantages and disadvantages of wire size, transformer size, multiple transformers, circuiting, etc., when laying out an installation. No matter what layout scheme is decided upon, it is mandatory that the farthest controller on the circuit is supplied with a minimum of 22 Volts.
## 24VAC Power - Transformer & Wire Sizing Considerations for Devices With Modular Connectors

Modular devices include the VAV/Zone Controller, Modular System Manager & Modular Polling Device. When sizing transformers for the devices it is important to design your layout so that the fewest number of Power/Comm distribution boards and the least number of transformers can be used. The polarity problem discussed in regards to other devices that do not have modular connections is not an issue with the modular devices as they cannot be connected with reversed polarity because of the modular board connectors and cable. Also the prefabricated cable is always 16 gauge. Wire size selection is therefore not an issue with the modular devices. However, the same minimum voltage rules apply to modular devices as with other non-modular devices. In order to simplify wiring design and layout with modular devices the following rules apply:

Power/Comm Board maximum transformer size = 100VA. This is due to the board circuitry and fusing. Each modular device is to be calculated at 6VA. This allows for a maximum of 16 devices per Power/Comm board. If more than 16 devices are required, multiple Power/Comm boards must be used.

No more than 6 modular devices allowed per branch circuit. (The Power/Comm board has a total of 4 branch circuits)

The longest total run per branch circuit is 240 Ft. This is due to voltage drop on the prefabricated cable.

Below are some examples of transformer sizing and branch circuit design.

### Transformer Sizing and Branch Circuit Design Examples

<table>
<thead>
<tr>
<th>Transformer Size</th>
<th>Power/Comm Board</th>
<th>Total Length of Modular Cables</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 VA</td>
<td>120 / 24VAC</td>
<td>12 Devices At 6 VA = 72 VA</td>
</tr>
<tr>
<td></td>
<td>Transformer</td>
<td>Use 75 VA Transformer</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>See Warning Note Below</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 Devices At 6 VA = 78 VA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use 40 VA Transformer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 VA</td>
<td>120 / 24VAC</td>
<td>16 Devices At 6 VA = 96 VA</td>
</tr>
<tr>
<td></td>
<td>Transformer</td>
<td>Use 100 VA Transformer</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>See Warning Note Below</td>
<td></td>
</tr>
</tbody>
</table>
| 12 Devices At 6 VA = 72 VA | Use 75 VA Transformer | Total length of all modular cables used on each branch (A to B) cannot exceed 240 Ft.

### Warning!

**DO NOT GROUND THE 24V TRANSFORMER THAT IS TO BE USED WITH THE POWER/COMM BOARDS.** Grounding Of The Transformer Will Damage The Power/Comm Board And All Boards Connected To It.