



Small Duct Heating, Cooling and  
Indoor Air Quality Systems

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# PWM

(Pulse Width Modulation Zone Controller)

## Design, Installation, and Operation



### **Includes:**

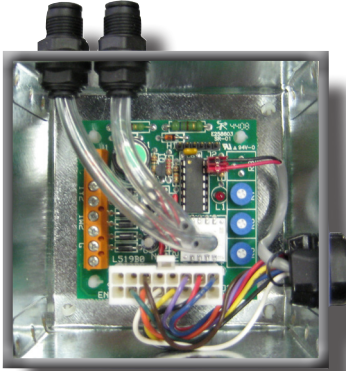
PWM Design  
PWM Installation Manual  
Zone Controller Input Sheets

Manufactured By





## PULSE WIDTH MODULATION (PWM) DESIGN & INSTALLATION GUIDE



The PWM is a pressure reactive Zone Controller that will change the energy input to maintain constant CFM flow of open outlets from 150 cfm to 1250 cfm, eliminating the need for by-pass dampers. The PWM controller has three independent settings for Cooling, Heating and Recirc. Fan, allowing for fine tuning with variable commands. The PWM unit is compatible with most forced air zoning packages and has been successfully integrated with Inverter Drive Heat Pump Condensing Units, providing leading edge technology for unsurpassed comfort and energy efficiency.

### LAYOUT DESIGN

There are three basic layout styles to be used with the PWM controller: the Perimeter Loop/Branch (**Fig. 01**), the Main Plenum Branch (**Fig. 02**), and the Open Duct standard design (**Fig. 03**).

The **Perimeter Loop** layout is as the term implies. A perimeter loop of plenum duct is installed in the structure, from there branch tees are installed for each zone dependant on the zone size, and a zone damper is installed for each take-off/zone.

The **Main Plenum Branch** method is similar to a Perimeter Loop, in that you direct the main plenum to the area loads, with branch tees directing each zone to the outlets, once again installing zone dampers.

The **Open Duct** layout is the same concept that is used in the **Hi-Velocity Design Manual**. This method utilizes the branch split and bullhead tees planning of air flow, with each zone being individually controlled.

Each basic layout has it's typical applications. For example, the Perimeter Loop and Main Branch Layouts are best served doing multi-zones of 4 or more, with the Open Duct best servicing 2 - 4 zones. Perimeter Loop works well in a single level application, while the Main branch is better suited for multi-level applications.

In some installations, it is necessary to reduce the size of the main plenum. Caution must be used when reducing plenum size, since smaller ducts can handle less number of outlets. Also keep in mind that once reduced, the main

plenum cannot be increased again. The Branch Take Offs easily form to ducts in the 6" to 8" range; extra care must be taken with smaller sized ducts to ensure a proper air seal. For tee reductions, keep the tee to the full duct size, reducing only after the tee. Keep the length of the smaller duct sizes to a minimum, since the duct loss is much higher. If a hole saw will be used to drill the branch take-off holes, metal ducts are recommended to be 28 gauge steel.

Whichever method of zoning layout is utilized, it continues to be important for Indoor Air Quality that a certain amount of air is by-passed through each zone. This air recirculation is also important for Energy Efficiency, and even though the zone may not be calling for it, the recirc air will aid in overall living comfort.

### PERIMETER LOOP (**Fig. 01**)

When designing the perimeter loop, first determine the system load and individual zones. Locate the Fan Coil and vent outlets as per the design manual. Design the Perimeter Loop with the proper diameter 8" or 10" duct, as determined by the fan coil unit. Use appropriate plenum duct size around the perimeter of the structure.

When sizing the branch zone plenum off the Perimeter Loop, use the Zoning Duct Reduction Guide (**Table 01**). Total the outlets for each individual zone to determine the zone plenum duct diameter. Locate the tee servicing this zone to minimize the zone plenum duct, and run the plenum where it'll be possible to keep the AFD duct to 10' and 15' lengths. There is no minimum length on the Zone Main Plenum run. For maximum length allowed refer to the Zoning Duct Reduction Guide. (**Table 01**)

### MAIN PLENUM BRANCH (**Fig. 02**)

The Main Plenum also requires that a comprehensive system load is completed, zones determined, fancoil and outlets located as per the design manual. The Plenum duct is then located to direct the air to the loads at each zone, and elbow and tees can be located where required, as per the design manual.

The zone duct diameter is determined from the duct reduction guide (**Table 01**) and an appropriate balanced tee installed. Locate the tee servicing this zone to minimize the zone plenum duct, and run the plenum where it'll be possible to keep the AFD duct to 10' and 15' lengths. There is no minimum length on the Zone Main Plenum run. For maximum length allowed refer to the Zoning Duct Reduction Guide. (**Table 01**)

### OPEN DUCT SYSTEM (**Fig. 03**)

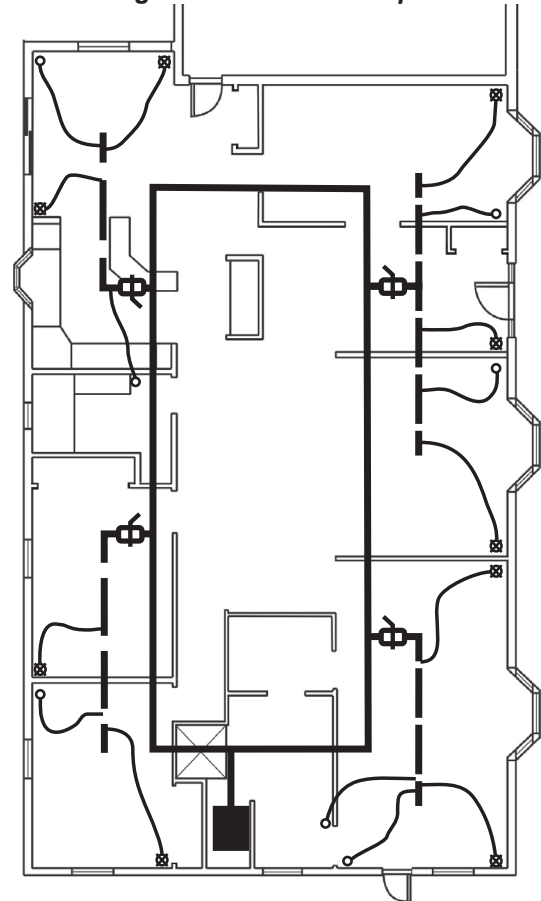
The Open Branch layout utilizes the **Hi-Velocity Design Manual** in its entirety, from Load calculation to duct location. This method is best suited when 2 - 4 zones are utilized, by following the design manual and duct reduction guide if necessary. You will either branch or bullhead the tees to 1 or 2 zones, and continue the plenum to the furthest run, installing zone dampers where required.

## PULSE WIDTH MODULATION (PWM) DESIGN LAYOUTS

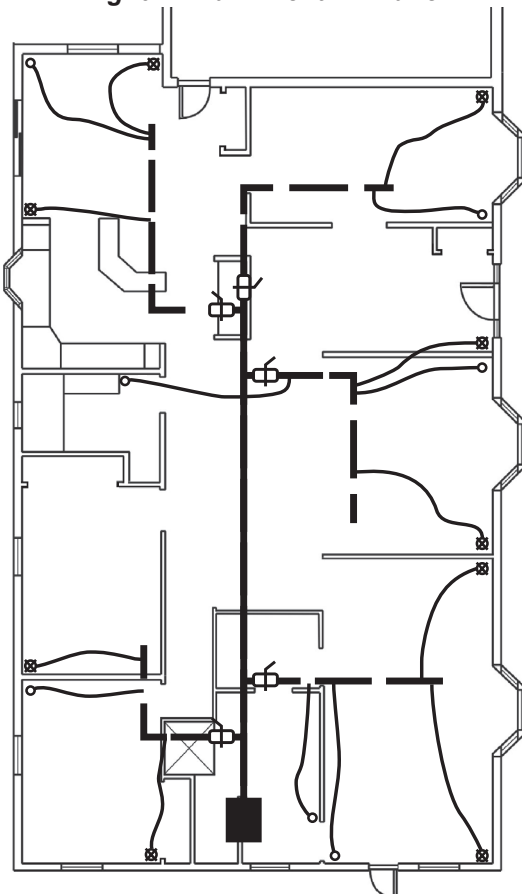
**Fig. 01 - Perimeter Loop**

| Table 01 - Zoning Duct Reduction Guide |                 |                 |                    |
|----------------------------------------|-----------------|-----------------|--------------------|
| Duct Size                              | # of vents (2") | # of vents (HE) | Plenum Max. Length |
| 5"                                     | 6               | 3               | 40'                |
| 6"                                     | 12              | 6               | 50'                |
| 7"                                     | 19              | 9               | 60'                |
| 8"                                     | 29              | 14              | 70'                |
| 10"                                    | 50              | 25              | 100'               |

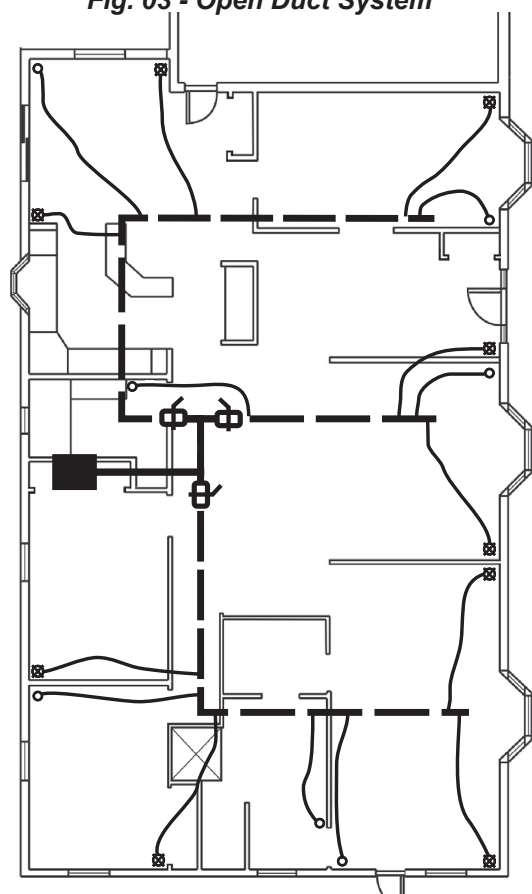
| LEGEND                                                                            |                     |
|-----------------------------------------------------------------------------------|---------------------|
|  | Main Plenum         |
|  | Branch Zone         |
|  | HE Outlet           |
|  | 2" Outlet           |
|  | HE and 2" Flex Duct |
|  | Zone Damper         |



**Fig. 02 - Main Plenum Branch**



**Fig. 03 - Open Duct System**



## INSTALLING THE PWM ZONE CONTROLLER

The PWM Controller is compatible with most Forced Air Zoning Packages. Zoning control panels with a Recirculation Fan Option are strongly recommended, so as to utilize continuous air circulation for optimal Indoor Air Quality (IAQ) and Energy Efficiency. Independent testing has shown that utilizing the recirculation fan with the Hi-Velocity Systems EPC motor reduces total energy usage. This is due to less on/off cycling of AC and Heating equipment by constant de-stratification of the air.

Quick acting, spring shut dampers are not to be used with the PWM control. Instead, it is suggested to use a slow acting electronic damper, which gives the PWM controller adequate time to adjust to variations in duct pressure.

### PWM INSTALLATION

**BE SURE TO READ ALL INSTRUCTIONS PRIOR TO BEGINNING INSTALLATION!**

Begin by removing the entire control assembly, the circuit board, motor control board, mounting system, etc.

Mount the new control assembly (Fig. 01) in the fan coil. The control assembly is held in place by the blower access hatch, so ensure that the screw holes are not covered by the edges of the assembly.

Fig. 01 - PWM Controller Assembly



Reconnect the motor cable, power supply, and thermostat wiring.

Using the 1/4" tubing provided, connect the air lines to their designated ports on the PWM circuit box. The air lines provided are marked with a positive or negative sign. Each line is to be connected to its respective quick connect port on the outside of the PWM circuit box. These ports are marked with a matching positive or negative sign. (Fig. 02)

Fig. 02 - Port Markings

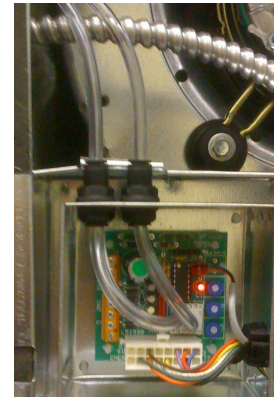


Route both air lines to the exterior of the fan coil through one of the three holes located on the side of the fan coil, inserting the provided plastic grommet into the chosen hole before running air lines. (Fig. 03) Run air lines to the outside of the unit through the provided grommet. The air lines may be secured to the unit by the supplied plastic conduit straps. (Fig. 03) Ensure that there are no kinks in the air lines as this may hinder performance. The positive marked air line is to be connected to the Pressure Tap. The shorter air line, marked with a negative sign, is to be mounted on the exterior of the unit, to sense atmospheric pressure. Ensure that this line is mounted facing downwards to prevent any accumulation of debris. **Do not block or restrict any air lines.** (Fig. 04)

Fig. 03 - Air Lines



Fig. 04 - Air Lines



### PRESSURE TAP LOCATION & INSTALLATION

The location of the Pressure Tap is important for proper operation. Assure that it is located a *minimum* of 18" (457mm) downstream from the fancoil. 36" (914mm) downstream provides the most consistent reading, located before any dampers. If an elbow or tee is installed before the tap, then the tap must be a minimum of 18"(457mm) downstream from that point.

### MOUNTING THE PRESSURE TAP

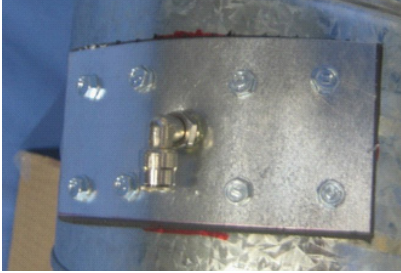
Begin by drilling a 3/4" (127mm) hole in the plenum at the desired point. (Fig. 05)

Fig. 05 - Drill 3/4" (13mm) hole



Assuring that the pressure tap is over the hole, Attach pressure tap with (8) 5/16" self tapping screws provided. (Fig. 06)

**Fig. 06 - Attach pressure tap**



Connect the positive air line to the quick connect fitting on the pressure tap. This line is to be connected at the opposite end to the PWM Controller through the positive fitting. (Fig 07)

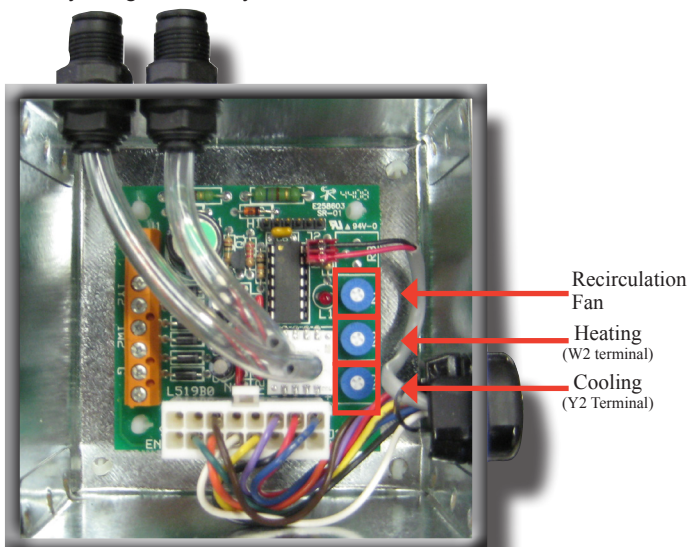
**Fig. 07 - Quick Connect**



## SETTING THE PWM DEVICE

To set the PWM Controller, the required airflow capacity must be determined for each operating mode. The required CFM/Ton (l/s per kW) is 250 (34), 200 (27), and 125(17) for Cooling, Heating and Recirculation Fan respectively. Divide the total CFM required for each fan speed by the total number of outlets. Keep in mind that each HE outlet represents 2 standard outlets. This will provide the average CFM per outlet.

With the PWM module hooked into the circuit board, control board and the duct work, you can go about adjusting the trimpots to your desired performance. Make sure everything internally to the unit is reconnected.



## BASIC PROGRAMMING

- Ensure air lines are correctly mounted and secured
- Power Unit
- Ensure all zones and outlets are open
- Energize the thermostat setting to be adjusted. (Cooling, Heating, or Recirculation Fan)
- Using a controls screwdriver, adjust the appropriate trim pot. (Cooling, Heating, or Recirculation Fan) A clockwise turn will increase the airflow output, while a counter-clockwise turn will decrease the airflow. Be sure to take note of the red LED light present on the PWM controller.
- When the PWM controller has reached the set point and is operating within an acceptable range, the red LED light on the PWM controller will flicker sporadically on and off to show that it is properly sensing pressure in the system.
- Be sure to wait 45 seconds between adjustments to allow the PWM controller to reach and maintain the set point.
- If the light on the PWM controller remains either off or on after 45 seconds, the current set point is outside the normal operating range and must be adjusted accordingly:
  - \* No light indicates that the trim pot is *above* normal operating range and should be decreased (counter-clockwise).
  - \* A solid light indicates that the trimpot is *below* normal operating range and should be increased (clockwise).
- When all trim pots have been adjusted to normal operating conditions, fine tuning of the PWM controller may commence.

## FINE TUNING THE PWM CONTROLLER

With the basic programming set, you are now ready to fine tune the PWM Controller. With the power on, all zone dampers opened, and the cooling energized, allow the fan 2 minutes to fully ramp up. Once the fan is fully ramped up, read and record airflow readings from all of the outlets. Total the cfm output of all outlets, and divide that number by the total number of outlets, to find the mean average. Keep in mind that each HE outlet represents 2 standard outlets. Select one outlet that is representative of this average, and use that outlet as a base reference for further adjustment. Increase or decrease the trim pot to obtain the ideal average cfm, using the average outlet as a tuning guide. Finally, once again read and record total airflow for cooling mode, to assure proper total cfm.

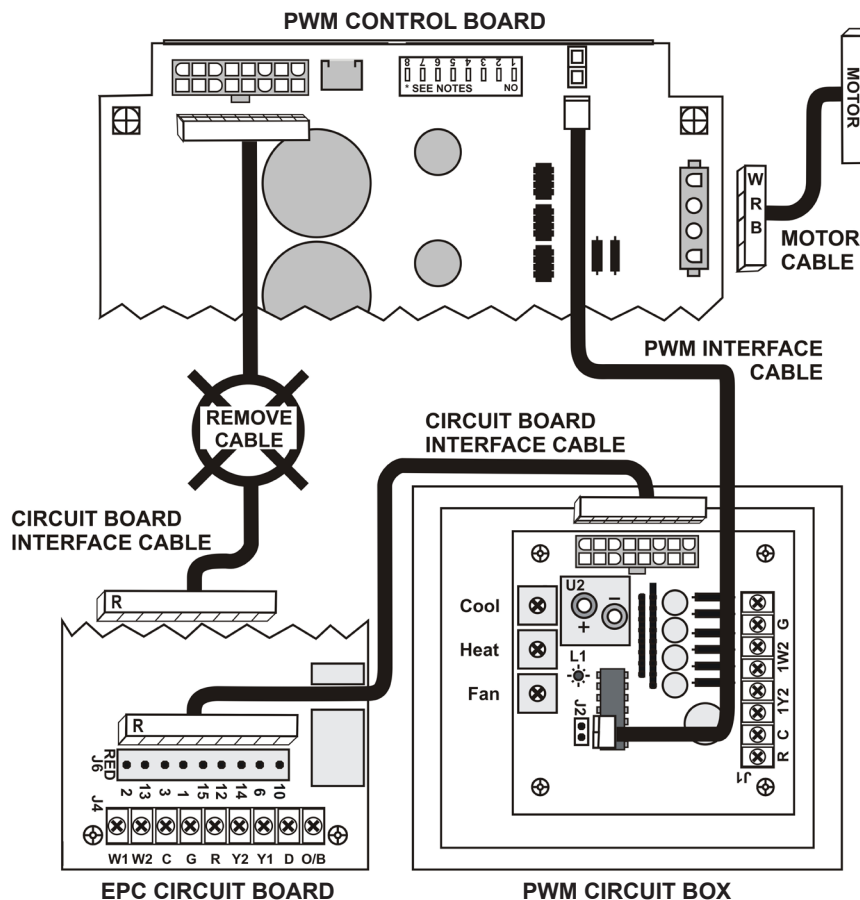
For full and proper tuning of the PWM controller, repeat the above process for heating and recirculation fan.

When tuning is complete, cycle all zone dampers to verify total system operation.

## IMPORTANT NOTES

- Initial programming of the PWM Controller for cooling, heating and recirculation fan must be done with all dampers in the open position, to verify maximum load capacities.
- To find outlet CFM:**  
Multiply **Knots** by 2.2 for **2"**, and by 4.2 for **HE**  
Multiply **FPM** by 0.022 for **2"** and by 0.042 for **HE**
- As the PWM controller takes up to 45 seconds to adjust to changes in duct pressure, the use of slow acting electronic dampers is suggested for proper operation of the PWM controller. Fast acting spring return dampers are not to be used.
- To find outlet L/s:**  
Multiply **Knots** by 1.4 for **2"**, and by 1.98 for **HE**  
Multiply **m/s** by 2.02 for **2"** and by 3.85 for **HE**

## WIRING THE PWM CONTROLLER



# HE FAN COIL - PWM WIRING DIAGRAM

## USE W2 & Y2 FOR HEATING AND COOLING TERMINALS

**Hi-Velocity**  
Systems

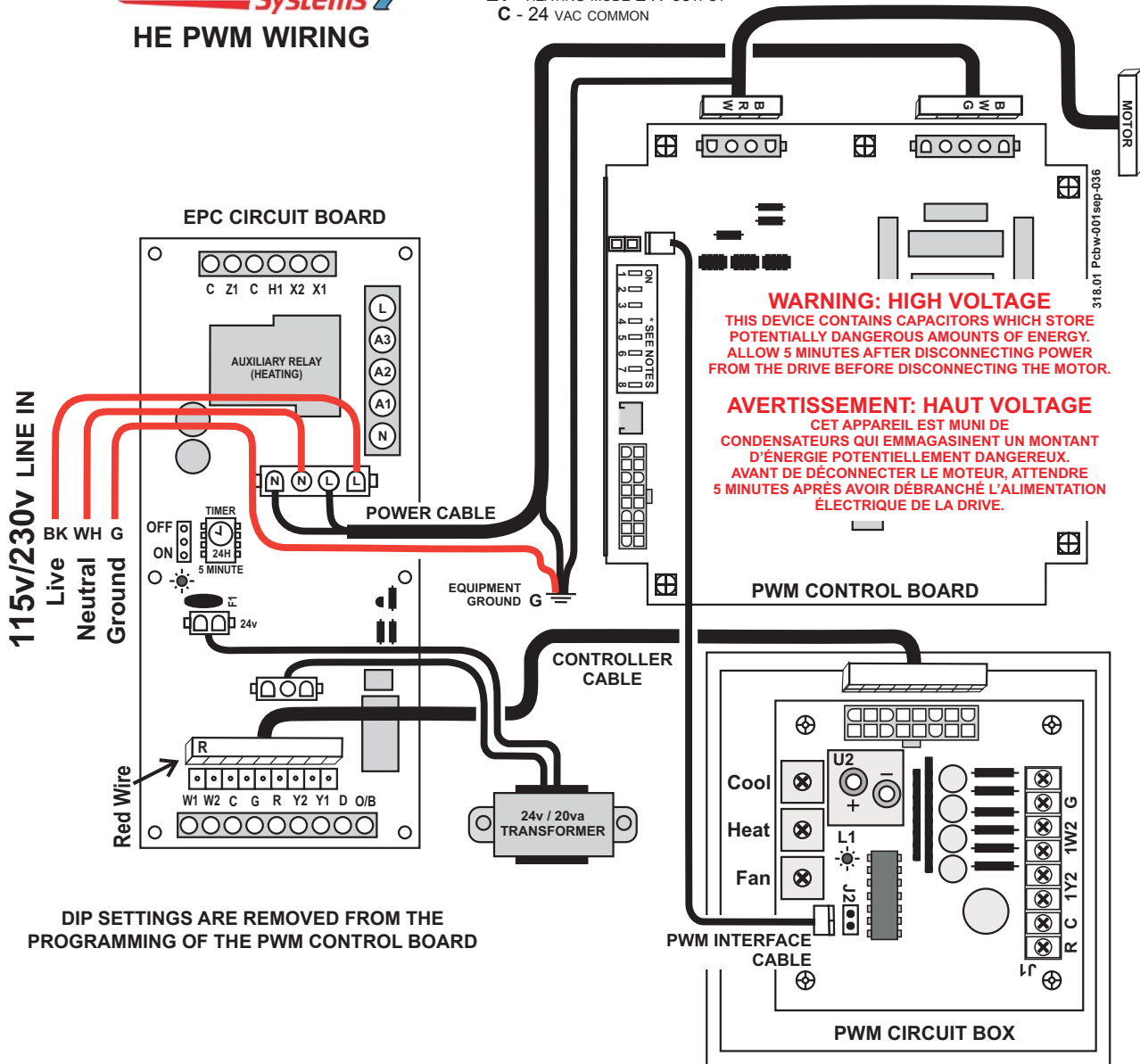
HE PWM WIRING

N - NEUTRAL  
L - LINE VOLTAGE  
A1 - AUXILIARY NORMALLY OPEN  
A2 - AUXILIARY NORMALLY CLOSED  
A3 - AUXILIARY COMMON  
  
X1 - FREEZE STAT TERMINAL  
X2 - FREEZE STAT TERMINAL  
H1 - CONDENSING UNIT 24V OUTPUT  
C - CONDENSING UNIT 24 VAC COMMON  
Z1 - HEATING MODE 24V OUTPUT  
C - 24 VAC COMMON

**CAUTION**  
DISCONNECT THE ELECTRIC  
POWER BEFORE SERVICING

**ATTENTION**  
DECONNECTER DU CIRCUIT  
D'ALIMENTATION ELECTRIQUE  
AVANT L'ENTRE-TIEN

MOTOR CABLE



### NOTES:

MAR.16

- 1) USE THERMOSTAT FAN SWITCH TO DISABLE/ENABLE CONTINUOUS FAN.
- 2) 'C' TERMINAL ON THERMOSTAT (COMMON) IS NOT NEEDED FOR SOME THERMOSTATS. CONSULT THERMOSTAT INSTRUCTIONS FOR DETAILS.
- 3) A3 (AUXILIARY RELAY COMMON) CAN BE USED WITH A1 AND/OR A2 AS DRY CONTACTS, ARMED 24v FROM THE 'R' TERMINAL, OR ARMED FROM THE 'L' TERMINAL.

- 4) AUXILIARY RELAY TIMER ACTIVATES CIRCUIT FOR 5 MINUTES EVERY 24 HOURS STARTING WHEN POWER IS APPLIED TO THE UNIT. RED LIGHT IS ON WHEN AUXILIARY RELAY IS ACTIVATED.
- 5) SEE INSTALLATION MANUAL FOR MORE DETAILED WIRING DIAGRAMS AND DIP SWITCH SETTINGS.
- 6) FAILURE TO READ AND FOLLOW ALL INSTRUCTIONS CAREFULLY BEFORE INSTALLATION COULD CAUSE PERSONAL INJURY AND/OR PROPERTY DAMAGE.

## PWM CONTROLLER INPUT SHEETS (HEATING)

MODEL: \_\_\_\_\_

IDEAL CFM TOTAL: \_\_\_\_\_

# OF OUTLETS: \_\_\_\_\_

PROGRAMMED CFM TOTAL: \_\_\_\_\_

| #                                                     | Location | Ideal<br>CFM | Initial<br>FPM/CFM | Prgm'd<br>FPM/CFM | #  | Location | Ideal<br>CFM | Initial<br>FPM/CFM | Prgm'd<br>FPM/CFM |
|-------------------------------------------------------|----------|--------------|--------------------|-------------------|----|----------|--------------|--------------------|-------------------|
| 1                                                     |          |              |                    |                   | 26 |          |              |                    |                   |
| 2                                                     |          |              |                    |                   | 27 |          |              |                    |                   |
| 3                                                     |          |              |                    |                   | 28 |          |              |                    |                   |
| 4                                                     |          |              |                    |                   | 29 |          |              |                    |                   |
| 5                                                     |          |              |                    |                   | 30 |          |              |                    |                   |
| 6                                                     |          |              |                    |                   | 31 |          |              |                    |                   |
| 7                                                     |          |              |                    |                   | 32 |          |              |                    |                   |
| 8                                                     |          |              |                    |                   | 33 |          |              |                    |                   |
| 9                                                     |          |              |                    |                   | 34 |          |              |                    |                   |
| 10                                                    |          |              |                    |                   | 35 |          |              |                    |                   |
| 11                                                    |          |              |                    |                   | 36 |          |              |                    |                   |
| 12                                                    |          |              |                    |                   | 37 |          |              |                    |                   |
| 13                                                    |          |              |                    |                   | 38 |          |              |                    |                   |
| 14                                                    |          |              |                    |                   | 39 |          |              |                    |                   |
| 15                                                    |          |              |                    |                   | 40 |          |              |                    |                   |
| 16                                                    |          |              |                    |                   | 41 |          |              |                    |                   |
| 17                                                    |          |              |                    |                   | 42 |          |              |                    |                   |
| 18                                                    |          |              |                    |                   | 43 |          |              |                    |                   |
| 19                                                    |          |              |                    |                   | 44 |          |              |                    |                   |
| 20                                                    |          |              |                    |                   | 45 |          |              |                    |                   |
| 21                                                    |          |              |                    |                   | 46 |          |              |                    |                   |
| 22                                                    |          |              |                    |                   | 47 |          |              |                    |                   |
| 23                                                    |          |              |                    |                   | 48 |          |              |                    |                   |
| 24                                                    |          |              |                    |                   | 49 |          |              |                    |                   |
| 25                                                    |          |              |                    |                   | 50 |          |              |                    |                   |
| TOTALS:                                               |          |              |                    |                   |    |          |              |                    |                   |
| AVERAGE: (TOTAL # OF VENTS DIVIDED BY # OF LOCATIONS) |          |              |                    |                   |    |          |              |                    |                   |

## PWM CONTROLLER INPUT SHEETS (COOLING)

MODEL: \_\_\_\_\_

IDEAL CFM TOTAL: \_\_\_\_\_

# OF OUTLETS: \_\_\_\_\_

PROGRAMMED CFM TOTAL: \_\_\_\_\_

| #                                                     | Location | Ideal<br>CFM | Initial<br>FPM/CFM | Prgm'd<br>FPM/CFM | #  | Location | Ideal<br>CFM | Initial<br>FPM/CFM | Prgm'd<br>FPM/CFM |
|-------------------------------------------------------|----------|--------------|--------------------|-------------------|----|----------|--------------|--------------------|-------------------|
| 1                                                     |          |              |                    |                   | 26 |          |              |                    |                   |
| 2                                                     |          |              |                    |                   | 27 |          |              |                    |                   |
| 3                                                     |          |              |                    |                   | 28 |          |              |                    |                   |
| 4                                                     |          |              |                    |                   | 29 |          |              |                    |                   |
| 5                                                     |          |              |                    |                   | 30 |          |              |                    |                   |
| 6                                                     |          |              |                    |                   | 31 |          |              |                    |                   |
| 7                                                     |          |              |                    |                   | 32 |          |              |                    |                   |
| 8                                                     |          |              |                    |                   | 33 |          |              |                    |                   |
| 9                                                     |          |              |                    |                   | 34 |          |              |                    |                   |
| 10                                                    |          |              |                    |                   | 35 |          |              |                    |                   |
| 11                                                    |          |              |                    |                   | 36 |          |              |                    |                   |
| 12                                                    |          |              |                    |                   | 37 |          |              |                    |                   |
| 13                                                    |          |              |                    |                   | 38 |          |              |                    |                   |
| 14                                                    |          |              |                    |                   | 39 |          |              |                    |                   |
| 15                                                    |          |              |                    |                   | 40 |          |              |                    |                   |
| 16                                                    |          |              |                    |                   | 41 |          |              |                    |                   |
| 17                                                    |          |              |                    |                   | 42 |          |              |                    |                   |
| 18                                                    |          |              |                    |                   | 43 |          |              |                    |                   |
| 19                                                    |          |              |                    |                   | 44 |          |              |                    |                   |
| 20                                                    |          |              |                    |                   | 45 |          |              |                    |                   |
| 21                                                    |          |              |                    |                   | 46 |          |              |                    |                   |
| 22                                                    |          |              |                    |                   | 47 |          |              |                    |                   |
| 23                                                    |          |              |                    |                   | 48 |          |              |                    |                   |
| 24                                                    |          |              |                    |                   | 49 |          |              |                    |                   |
| 25                                                    |          |              |                    |                   | 50 |          |              |                    |                   |
| TOTALS:                                               |          |              |                    |                   |    |          |              |                    |                   |
| AVERAGE: (TOTAL # OF VENTS DIVIDED BY # OF LOCATIONS) |          |              |                    |                   |    |          |              |                    |                   |

## PWM CONTROLLER INPUT SHEETS (CONSTANT FAN)

MODEL: \_\_\_\_\_

IDEAL CFM TOTAL: \_\_\_\_\_

# OF OUTLETS: \_\_\_\_\_

PROGRAMMED CFM TOTAL: \_\_\_\_\_

| #                                                     | Location | Ideal<br>CFM | Initial<br>FPM/CFM | Prgm'd<br>FPM/CFM | #  | Location | Ideal<br>CFM | Initial<br>FPM/CFM | Prgm'd<br>FPM/CFM |
|-------------------------------------------------------|----------|--------------|--------------------|-------------------|----|----------|--------------|--------------------|-------------------|
| 1                                                     |          |              |                    |                   | 26 |          |              |                    |                   |
| 2                                                     |          |              |                    |                   | 27 |          |              |                    |                   |
| 3                                                     |          |              |                    |                   | 28 |          |              |                    |                   |
| 4                                                     |          |              |                    |                   | 29 |          |              |                    |                   |
| 5                                                     |          |              |                    |                   | 30 |          |              |                    |                   |
| 6                                                     |          |              |                    |                   | 31 |          |              |                    |                   |
| 7                                                     |          |              |                    |                   | 32 |          |              |                    |                   |
| 8                                                     |          |              |                    |                   | 33 |          |              |                    |                   |
| 9                                                     |          |              |                    |                   | 34 |          |              |                    |                   |
| 10                                                    |          |              |                    |                   | 35 |          |              |                    |                   |
| 11                                                    |          |              |                    |                   | 36 |          |              |                    |                   |
| 12                                                    |          |              |                    |                   | 37 |          |              |                    |                   |
| 13                                                    |          |              |                    |                   | 38 |          |              |                    |                   |
| 14                                                    |          |              |                    |                   | 39 |          |              |                    |                   |
| 15                                                    |          |              |                    |                   | 40 |          |              |                    |                   |
| 16                                                    |          |              |                    |                   | 41 |          |              |                    |                   |
| 17                                                    |          |              |                    |                   | 42 |          |              |                    |                   |
| 18                                                    |          |              |                    |                   | 43 |          |              |                    |                   |
| 19                                                    |          |              |                    |                   | 44 |          |              |                    |                   |
| 20                                                    |          |              |                    |                   | 45 |          |              |                    |                   |
| 21                                                    |          |              |                    |                   | 46 |          |              |                    |                   |
| 22                                                    |          |              |                    |                   | 47 |          |              |                    |                   |
| 23                                                    |          |              |                    |                   | 48 |          |              |                    |                   |
| 24                                                    |          |              |                    |                   | 49 |          |              |                    |                   |
| 25                                                    |          |              |                    |                   | 50 |          |              |                    |                   |
| TOTALS:                                               |          |              |                    |                   |    |          |              |                    |                   |
| AVERAGE: (TOTAL # OF VENTS DIVIDED BY # OF LOCATIONS) |          |              |                    |                   |    |          |              |                    |                   |

Energy Saving Products Ltd., established in 1983, manufactures the Hi-Velocity Systems™ product line for residential, commercial and multi-family markets. Our facilities house Administration, Sales, Design, Manufacturing, as well as Research & Development complete with an in-house test lab. Energy Saving Products prides itself on Customer Service and provides design services and contractor support.

For all of your Heating, Cooling and Indoor Air Quality needs, the Hi-Velocity System is the right choice for you!



Small Duct Heating, Cooling and IAQ Systems

## Build Smart, Breathe *Easy*

Hi-Velocity HE Fan Coils, **Green** Technology



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