

GE ECM by Regal-Beloit

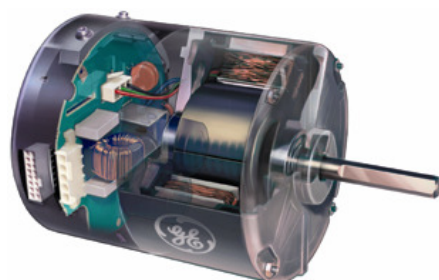


GE ECM

By REGAL-BELOIT

ECM Indoor Blower Motors

Premium Models 2.3/2.5 & Standard Model X13



Technical Manual



www.theDealerToolbox.com

Table of Contents

Premium ECM Indoor Blower Motors	1 - 72
Then and Now – The History of the GE ECM™	1
Residential Blower Motor Applications	2
ECM vs. PSC	3
Constant Airflow	4 - 5
PSC Motor Operation	6
Premium ECM Motor Operation	7 - 9
Comfort	10
Efficiency	11
ECM Myths and the Air Distribution System	12
The ECM Technology (overview)	13 - 14
Premium ECM Motor Construction	15 - 16
Rotor Position Sensing	17
The Line Voltage (high voltage) Power Connection	18 - 19
The Signal Cable (low voltage) Connection	20 - 22
Initial Set-Up Modes of Operation	23 - 38
Thermostat Mode	23 - 33
PWM (Pulse Width Modulation)	34 - 36
DSI (Direct Serial Interface)	37 - 38
Servicing the Premium ECM Motor	39 - 72
Service Basics	40 - 43
If the Motor is Operating	43 - 49
If the Motor is not Operating	50 - 54
Checking the Motor Control and Motor module	55 - 60
Replacing the ECM Modules	61 - 70
Premium ECM Motor Failure Footnotes	71 - 72
Standard ECM Indoor Blower Motor	73 - 91
X13 Standard ECM Features	74
X13 vs. PSC	74 - 75
X13 Connections and Communication	76 - 81
Servicing the X13	82 - 88
Replacing the X13	89 - 91

Premium ECM Indoor Blower Motors

Then and Now – The History of the GE ECM™

1987 ECM 1.0 Hardware Programmable



Once the program was installed in the motor control it could not be changed.

- Basic constant airflow Algorithm
- Often Called the ICM-1 (Integrated Control Module)
- **No Longer in Production**

1992 ECM 2.0 Complete Motor and Control Design



- Torque Calibrated machine
- Refined airflow regulation algorithm
“motor is the airflow sensor”
- Late point product identification – software programmable, program could be changed
- Often called the ICM-2 (Integrated Control Module)

- **No Longer in Production**

1998 ECM 2.3 Response to Reliability Improvement

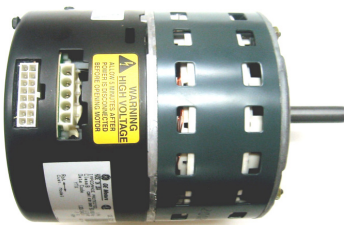
This is the current production blower motor for most OEM's using variable speed.



- Control Electronics and packaging redesign
- Electronics encapsulated for moisture resistance
- New motor controller “ASIC”
- Improved performance and features
- Sometimes called the ICM-2+ (Integrated Control Module)

- **Currently in Production**

2002 ECM 2.5 Digital Serial Communication



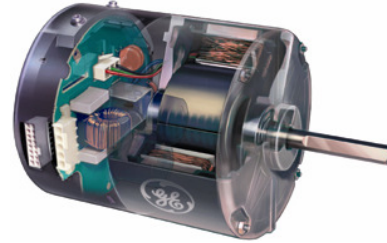
- Enables plug & play HVAC systems
- Fewer replacement part numbers
- More accurate operation and fault reporting

- **Currently in Production**

Residential Blower Motor Applications

Premium ECM Models 2.3/2.5

- 120/240vac & 277vac power input on one motor
- Thermostat, PWM, or DSI control input
- 1/3, 1/2, 3/4, 1 Hp options
- Airflow range 0 – 2400 CFM



Premium ECM indoor blower motors are primarily found in multi-stage premium systems. However they can be and are used in single stage systems as well.

Two-Stage Furnace



Geothermal Heat Pump



Air Handlers/Fan Coils



Package Systems



Proven.

ECM vs. PSC

Why is the Premium ECM motor so much better than a PSC induction motor?



Constant Airflow

Airflow is one of the most important factors in an HVAC system. Proper airflow is required to maintain capacity, efficiency and comfort.

- Decreased airflow leads to decreased heat transfer, which reduces the capacity of the system.
- The system now has to run longer to provide the same amount of heating or cooling to the home. This reduces the efficiency of the system as longer run time uses more energy.

Incorrect airflow can lead to numerous and expensive repairs.

- Tripping limits cause the electronic controls to cycle more reducing longevity.
- Overheated heat exchanges expand and contract more, often putting more stress on today's thinner wall metals.
- Flooding can lead to compressor failure.
- Frozen evaporators can cause water damage to critical electronic controls including the motor when they thaw.

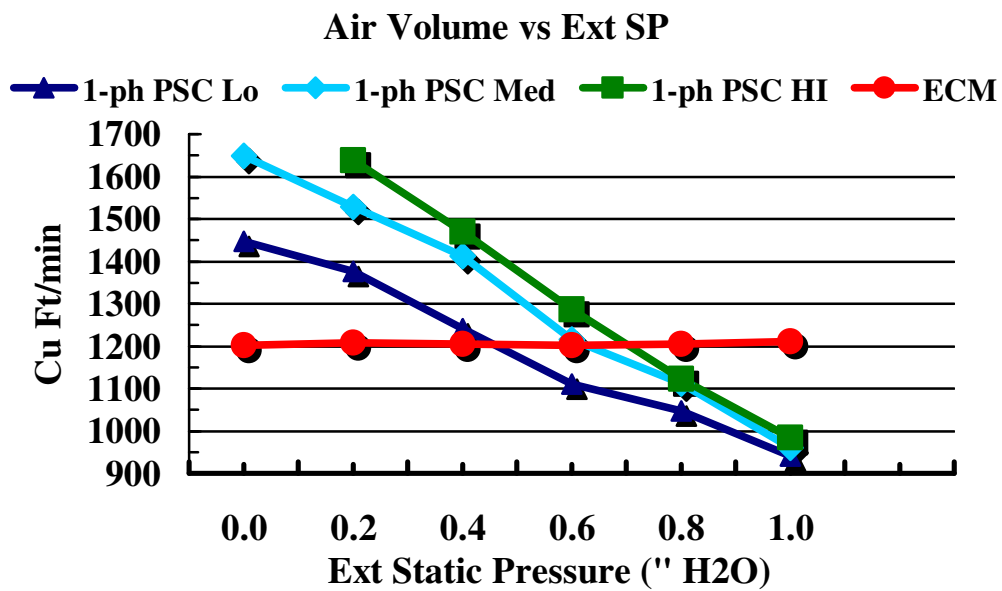
Continuous airflow (constant fan operation) is being utilized more often with the increased focus on Indoor Air Quality (IAQ).

This is where the ECM motor excels. Not only does it maintain constant airflow, but it also uses less energy in doing so. The energy savings is even larger when continuous fan is utilized.

Once the motor is set-up, its programming takes over to maintain constant airflow. Ok, how does it do this you ask, and why can't a PSC motor do the same thing?

Let's look at the following chart and see how the two motors perform when static pressure changes in a system.

- Notice that the PSC motor actually moves less air (CFM) as the external static pressure (from now on we will just call it pressure) increases. By design that's all it can do.
- The ECM motor is designed to maintain constant airflow throughout a wide range of pressures (typically from .1 to .9 in. wc.).



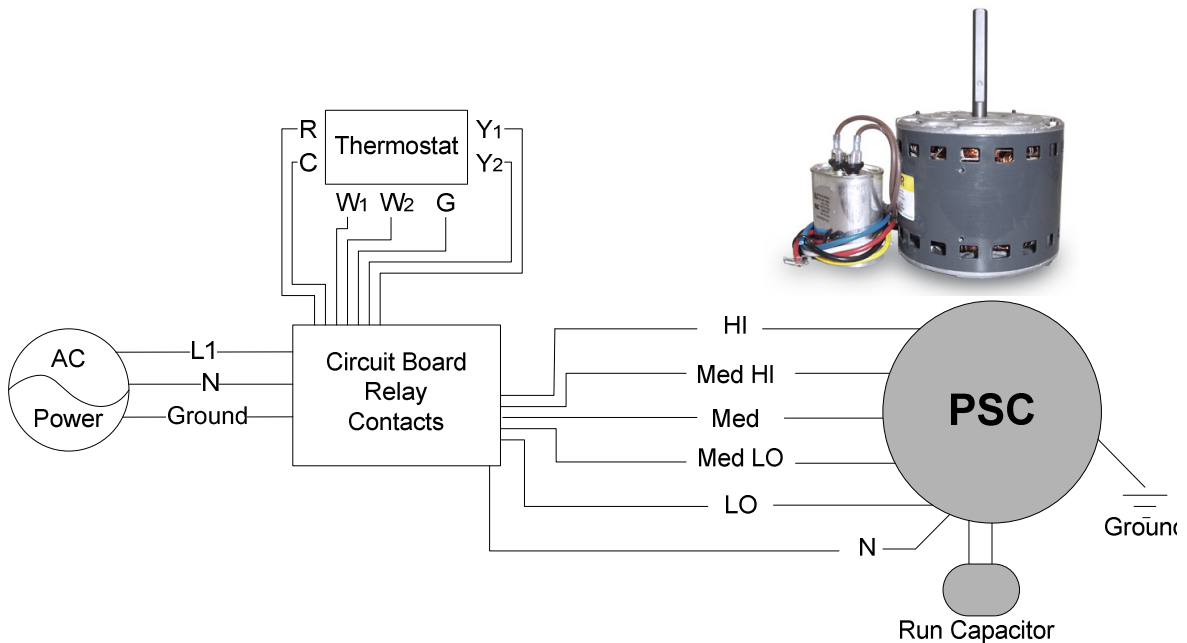
PSC motor charts are typically listed in the OEM installation guide. They provide the same information as the above chart, but look more like this one.

External Static Pressure	Air Volume CFM per blower speed		
	High	Medium	Low
0.2	1625	1520	1375
0.4	1475	1410	1225
0.6	1290	1200	1100
0.8	1120	1110	1040
1	990	950	925

PSC (Permanent Split Capacitive) Motor Operation

The PSC motor is a slave to the frequency of the supplied voltage, the poles of the motor, and the load on the motor.

- A 6 pole motor at 60Hz has a theoretical speed of 1200 rpm, with a typical rated speed of 1050 rpm.
- However it can only run at the rated rpm to make the designed airflow if the static pressure is also at the design rating.
- Without the ability to add power and increase the speed of the motor, it simply moves less air when static pressure increases.



Demands

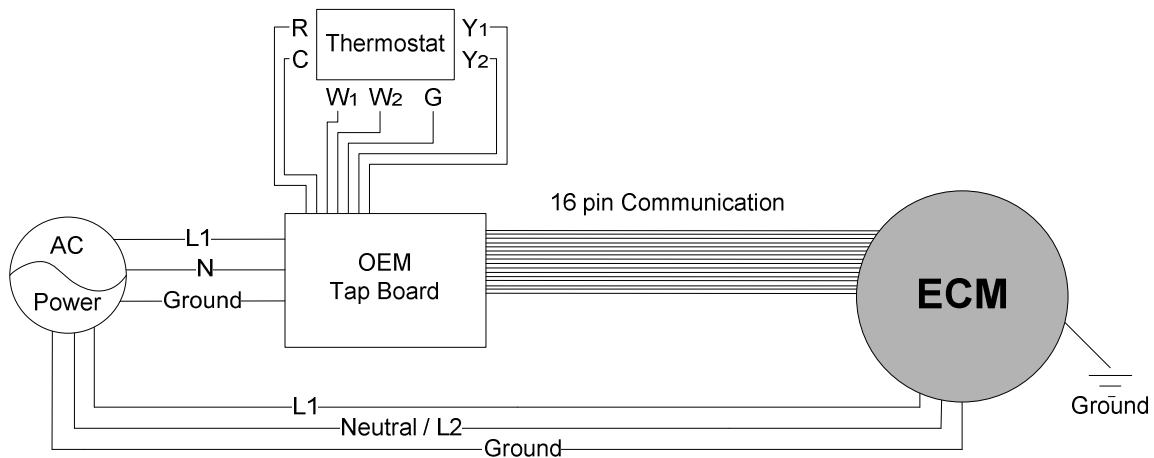
- 1st stage heat
 - 2nd stage heat
 - 1st stage cool
 - 2nd stage cool
 - Continuous fan
 - De-humidification
 - Emergency Heat
- } - Three stage
} - Modulating

Speeds

- Up to 5

The PSC motor suffers from too many demands and not enough options, audible start/stop noise, and low efficiency.

Premium ECM Motor Operation



Specific airflow requirements for all demands are programmed into the motor control and OEM control board. Motor provides airflow matched to the system and maintains airflow within an acceptable external static pressure range.

Let's first look at how the ECM motor is programmed to each OEM's (Original Equipment Manufacturer) specifications.

- In a series of tests by the OEM, (manufacturer of the HVAC system) the motor is "taught" the relationship between speed, torque, airflow and external static pressure.
- In these tests, or airflow characterization process, a development engineer will adjust the ECM torque and chamber static pressure, and measure the resulting ECM speed and airflow.
- These values over a wide range of static pressures and airflows are used in a GE ECM supplied development program to create a set of blower constants that are specific to each air mover (furnace/air handler).
- "Airflow" is programmed by the OEM and is specific and unique to the motor and air mover combination.

No other motor offers so many ways to control comfort and efficiency.

So each motor knows the specific airflow the OEM is looking for over a wide range of external static pressure, specific to each unit, for each demand (heat, cool, continuous fan).

At the time of installation, all that is required of the installer is to set the required CFM (Cubic Feet per Minute) for each demand to the size of the equipment the motor is used in and/or with.

We are no longer setting speeds; we are selecting the exact CFM designed by the OEM for the demand.

Example of airflow tables:

Cooling Airflow Selection								
2nd Stage	Dip Switch Number							
CFM	1	2	3	4	5	6	7	8
A 800	0	0						
B 1000	1	0						
C 1200	0	1						
D 1400	1	1						

Heating Airflow Selection									
Temp Rise Range (30 - 60°F)									
2nd Stage	Dip Switch Number								
CFM	1	2	3	4	5	6	7	8	Rise (°F)
A 550			0	0					51
B 600			1	0					47
C 650			0	1					43
D 700			1	1					40

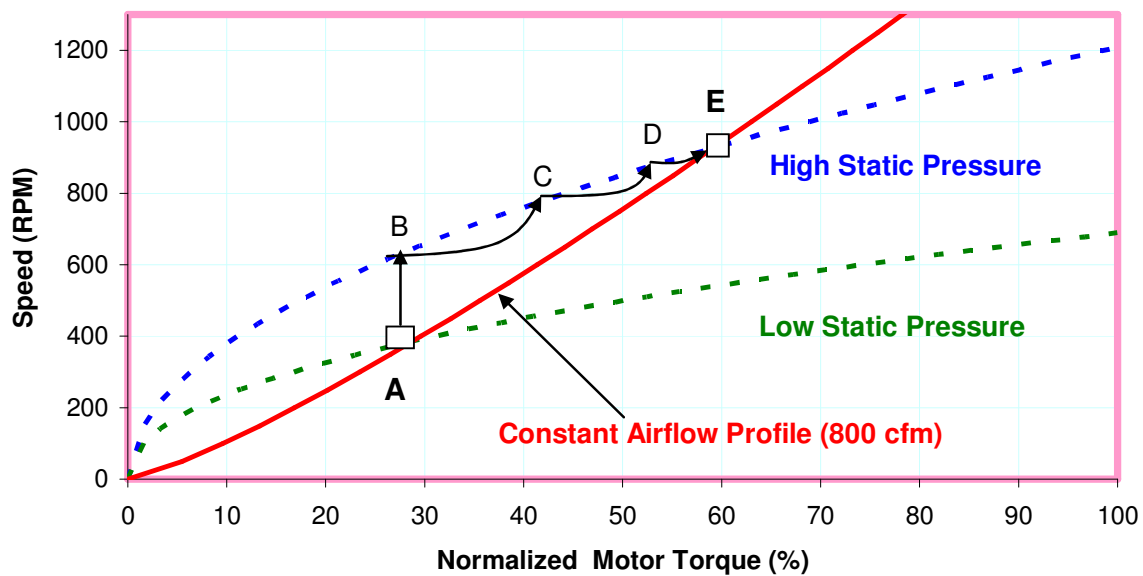
Trim/Adjust Airflow Selection								
	Dip Switch Number							
CFM	1	2	3	4	5	6	7	8
A Norm					0	0		
B +10%					1	0		
C -10%					0	1		
D N/A					1	1		

Climate/Delay Profile Selection								
	Dip Switch Number							
	1	2	3	4	5	6	7	8
A							0	0
B							1	0
C							0	1
D							1	1

Airflow for all demands and comfort options is easily selected and perfectly matched to the system.

Now for you techies out there, the “how”:

- Each motor has a set of constant CFM curves that are programmed into the motor; they are unique for each motor/air handler system determined by the OEM.
- For each CFM value used by the unit there is a constant airflow curve that plots Torque vs. RPM, like the one shown below.
- Essentially the plot says to meet the CFM needs of the unit (800 CFM in this example) the motor must turn at a specific RPM and develop a specific torque.
- The ECM’s ability to adjust speed in increments to find a combination of speed and torque that sits on a specific constant airflow curve allows the same system to maintain airflow even if the pressure changes.



So how does the motor know when the pressure has changed?

This one can get complicated so let’s keep it simple. We will stick with the above chart. Like a PSC motor, when pressure increases, speed (RPM) increases, except in the case of the ECM motor, torque does not change, yet. The motor knows from its program that the new speed and existing torque is off the curve. This is where the cool stuff happens. The motor will gradually increase torque in small increments, checking the speed after each change. Through a series of these iterations, the motor eventually brings the torque and speed back to the airflow curve. And voila, you have constant airflow.

Comfort

Two big comfort issues, noise and stratified air, are both improved with the ECM motor.

Noise can be a big problem, especially in smaller homes, condos, or any design where the furnace or air handler is located near the customer or where the return run is short. There are really two noise issues, start up, and air movement.

- Start up noise is greatly reduced by slowing bringing the motor up to speed. This is also done on the off setting as well. Comfort (delay) profiles reduce noise issues even more.
- Air movement can be very noisy through the supply registers and return grills where the air enters the home. In the continuous fan mode and, 1st stage operations of two stage equipment, this noise is almost unnoticeable in most cases. This will obviously depend on the design of the duct as previously mentioned.

Another comfort improvement is stratified air. When there is no air movement in a room, the hotter air will rise and the cooler air will fall. By running the fan continuously the air is always being circulated not just in one room, but throughout the home. This can even help all of the rooms of the home stay at a more even temperature.

You can see how running the fan continuously would be something most homeowners would want to take advantage of, especially with the energy savings, added comfort, and virtually unnoticeable operation of the ECM motor.

Efficiency

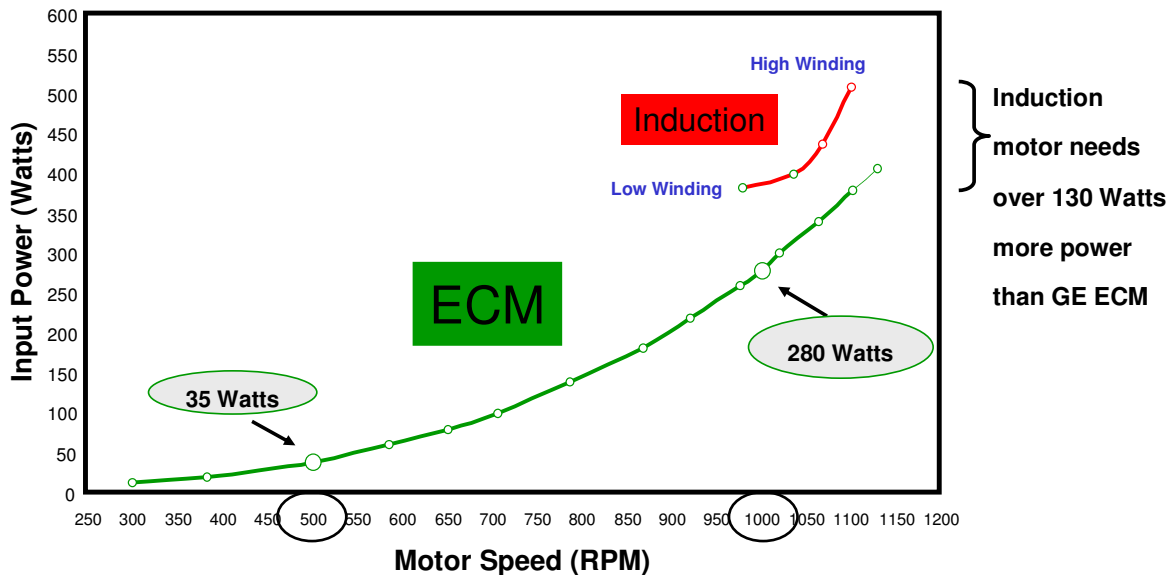
Efficiency in simple terms of dollars and cents is big concern to consumers these days. Products that save money on utility bills are in high demand.

The ECM motor simply costs less to operate than the PSC motor. However, the amount of savings will vary depending on its use. The more the motor is used, the more it saves. So depending on the market it is used in the savings will vary.

Obviously the motor is in use anytime the heating or cooling system is operating. With two stage systems becoming the norm for comfort and efficiency, the savings really grow. Two-stage equipment is going to run longer than single stage equipment, and first stage runs at a lower airflow. That means the motor is going to run more as well.

The big savings comes at the continuous (constant fan) setting. With constant fan being utilized more and more for comfort and indoor air quality, this savings is the big winner. The PSC motor can only run at its lowest speed tap/winding. The ECM motor can be programmed to run much lower. And the power consumption drops off dramatically, as shown here.

Depending on the programming, the continuous fan operation of the ECM motor could actually cost less than a typical household light bulb to operate.



ECM Myths and the Air Distribution System

ECM motors can overcome poor duct construction and sizing. This is true within reason. However, severe duct blockages, improper installation practices and under sizing can cause airflow problems and noise issues.

ECM motors can overcome dirty filters and coils. This is also true within reason. In fact this problem may even be worsened if the filter being used has a high pressure drop.

Here are some air distribution system guidelines:

- Low static, high quality ducted applications will run slowly, quietly and efficiently while delivering the correct airflow.
- High static applications will run fast, be noisy and power hungry. The ECM may still provide the correct airflow, but at a price.

Use good duct design practices and hold static pressure to less than 1", ideally around .5", or the pressure recommended by the manufacturer.

Use deep pleated, low pressure drop, high efficiency filters, sized to the proper CFM.

Because of the ECM motor's reputation for "constant airflow" over a wide range of static pressure too often contractors install ECM's to overcome poor ductwork practices. **ECM's will run quiet and with high efficiency at the manufactures recommended external static pressure.**

Even ECM Motors do have their limits:

If we didn't put limits on the motor, it would just keep increasing power and speed, beyond the reliable design of its components. The motor program has a built in limit, again specific to each OEM. In extreme high static applications the motor may reach that limit and basically "max out". This can lead to oscillation and high power consumption.

- ECM motors are not thermally protected
- Open returns in high ambient areas may cause permanent damage to the motor.
- Zoning and humidifier bypass connections should be as far upstream in the return as possible from the unit.
- ECM motors are designed to handle the maximum (or higher) return air temperature specified by the manufacturer for their unit.

The ECM Technology (overview)

Models 2.3 & 2.5

The ECM motor is a brushless DC, Three-Phase (3Ø) motor with a permanent magnet rotor. Motor phases are sequentially energized by the electronic control, powered from a single-phase power supply. Huh? Lets break that down a little more.

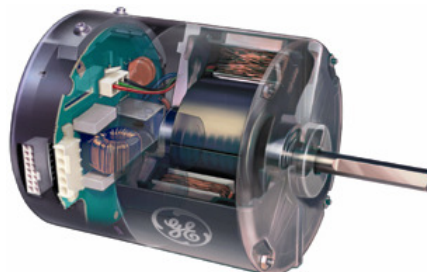
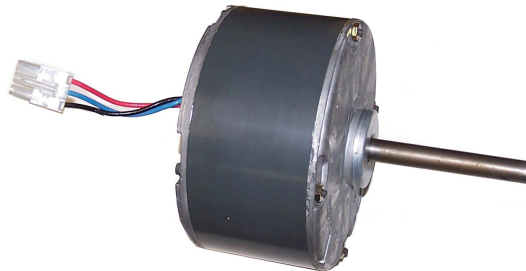
- This motor can operate from an input power supply of 120vac or 240vac on the same motor. **(Caution: with the proper jumper connection).**
- The motor control converts the incoming AC power to DC power.
- The motor control also decides at what speed (RPM) and torque to operate the motor to obtain and maintain the desired airflow. The amount of airflow desired is communicated to the motor from the OEM's external circuit board (tap board).
- To operate at the desired speed, the motor control converts the DC power back to Three-Phase AC power at a specific level of power and frequency.

So what does ECM stand for? ECM stands for Electronically Commutated Motor. Ok so what does that mean? In a DC motor, commutation or phase shifting is controlled by the brushes. In this motor the phase shifting is controlled electronically using sensor less position feedback.

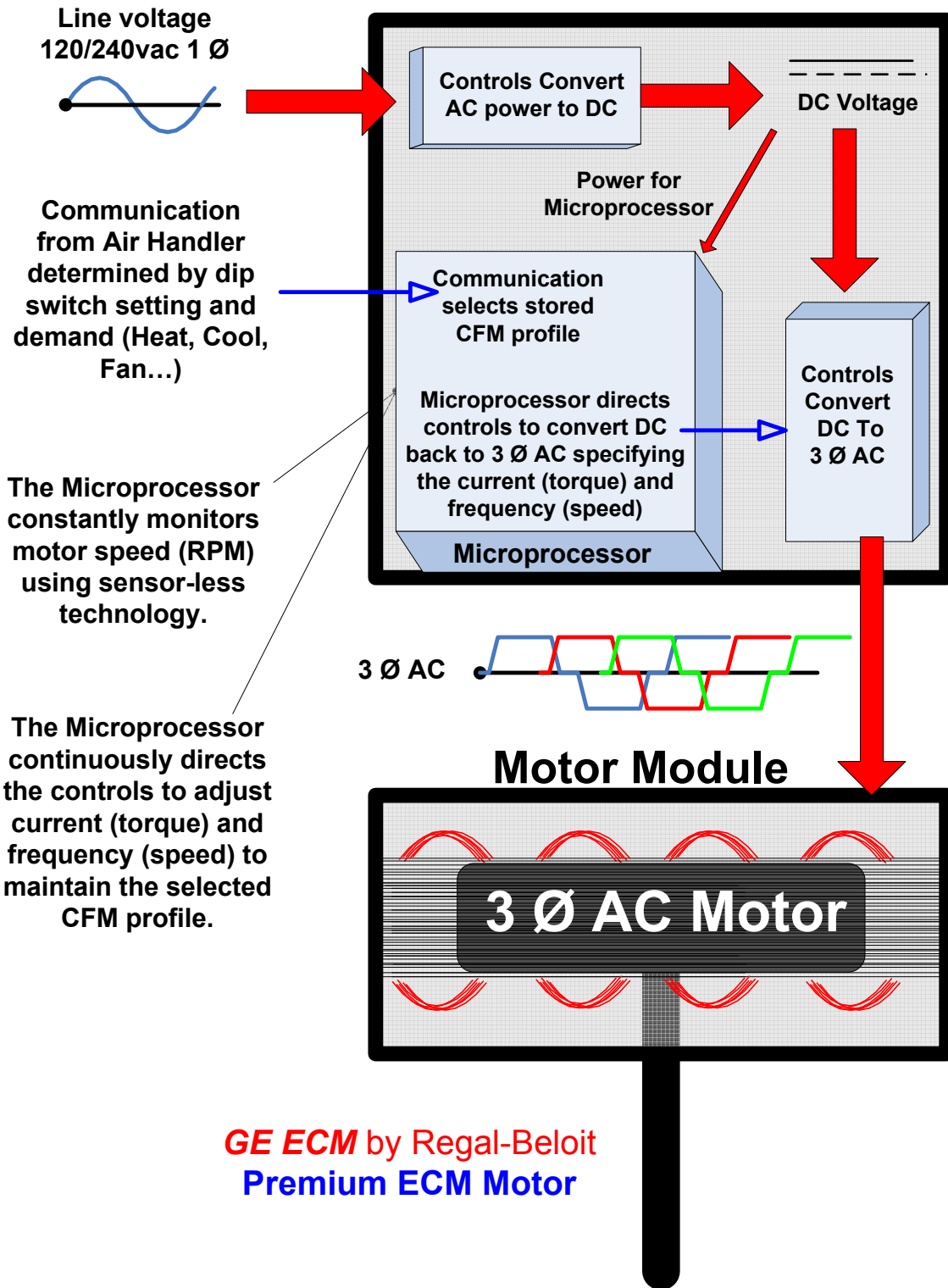
Motor Control



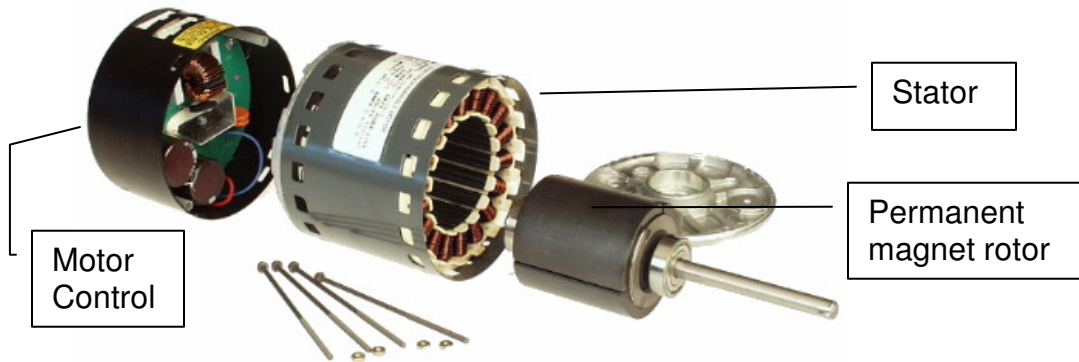
3-Phase AC Motor



Motor Control Module

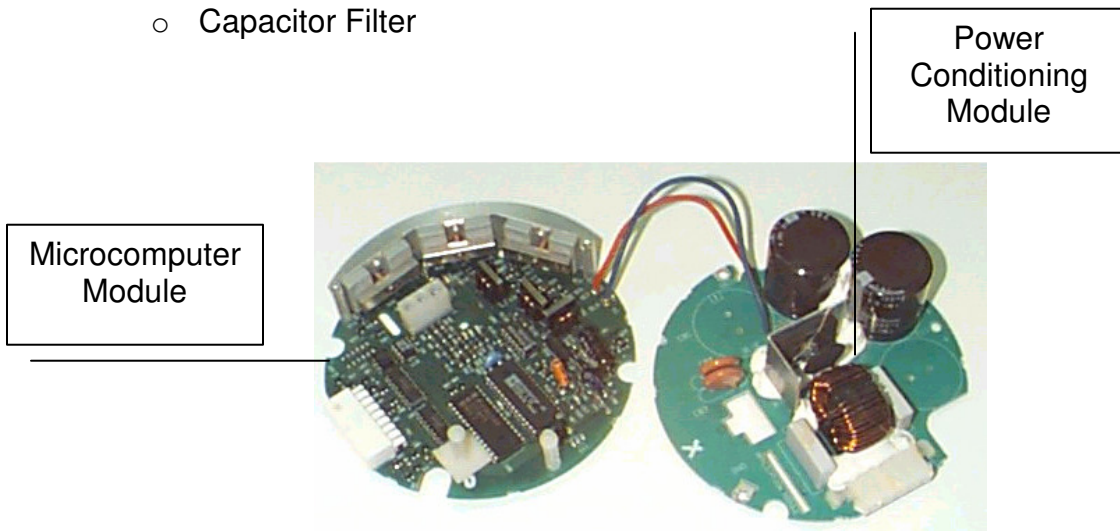


Premium ECM Motor Construction



Motor Control Construction

- Microcomputer module
 - o Microcomputer
 - o Isolated User Interface
 - o EEPROM
 - o ASIC
 - o 3 Ø Inverter
 - o Rotor Position Feedback Control
- The microcomputer module is encapsulated with a polyurethane compound to protect against moisture. This is done to enhance reliability.
- Power conditioning module
 - o EMI (Electro Magnetic Interference) Filter
 - o Rectifiers
 - o Capacitor Filter



Motor Module Construction

Stator Construction

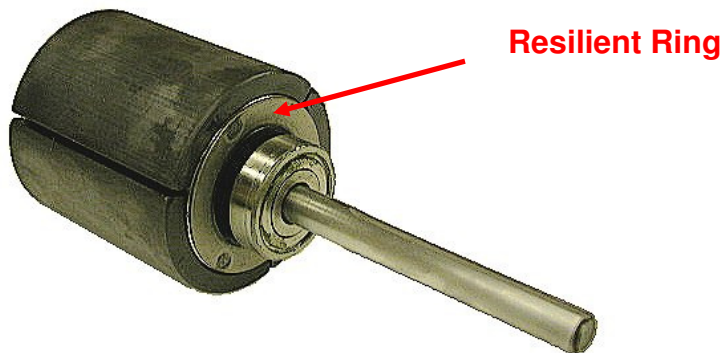
- Laminated, interlocked stator
- Steel shell, aluminum end shield, through-bolt construction
- Inslot Salient wound
 - o Each pole is individually wound
 - o Less wasted copper
- Available in a closed, partial, or fully vented shell



Rotor Construction

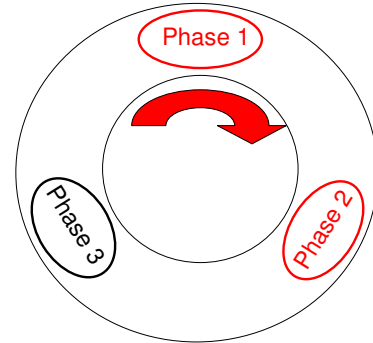
ECM Rotor

- Three Iron Ferrite magnets glued on rotor sleeve
- Magnetized at GE ECM Factory
- Two Resilient Rings isolate the shaft from the rotor
- Ball Bearings (perform better at low RPM)



Rotor Position Sensing

- At any given time while the motor is running, two of the three phases are energized.
- The movement of the magnetized rotor past the third phase induces a voltage, or back EMF (Electromotive Force), in the un-energized phase.
- The voltage in the third phase communicates the rotor's position to the control.
- With this information the motor control knows when to change phases, and what the actual rpm or speed of the motor is at any time. This motor operates at synchronous speed, meaning whatever frequency the phases are shifted at, the motor will operate at that speed.
- Motor Torque is regulated at a given level by an accurate control of the current in the motor phases.
- The microcomputer control keeps torque constant regardless of operating speed.



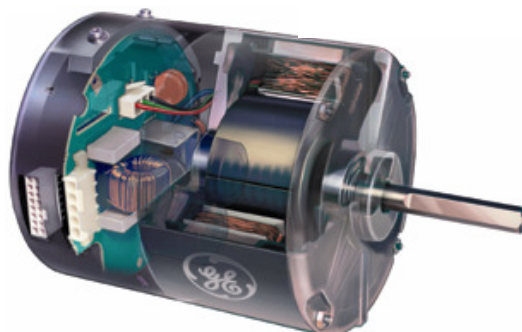
Let's pull it all together again.

The ECM motor is basically a 3-Phase motor operated by a motor control.

Motor Control



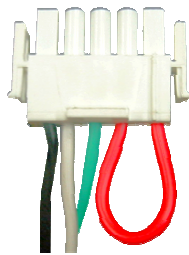
3-Phase AC motor



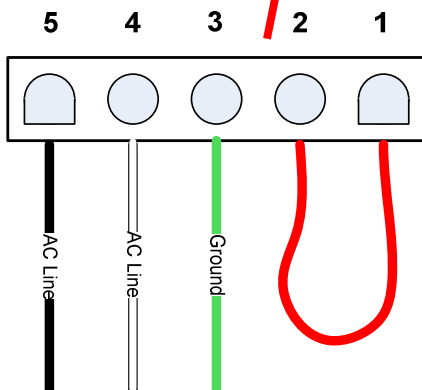
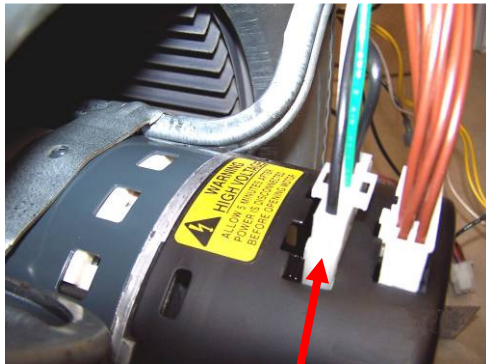
The Line Voltage (high voltage) Power Connection

- Line voltage to this motor can be either 120vac or 240vac through the 5 pin power connector. (Caution: with proper jumper connection)
- The connector is keyed for proper connection.

The 120vac input
uses a jumper
(red wire)



The 240vac input
does not use a
jumper



The motor control is designed to operate from an input voltage of 240volts. However, the input power supply can also be 120volts, due to the built in voltage doubler.

- As shown on the previous page, when 120vac is used for input power, the red jumper is left in place, enabling the integrated voltage doubler circuit in the motor control.
- When 240vac is used for input power, the jumper must be removed.
- The jumper may not be red on all OEM products.

Caution: If the jumper is not removed when 240vac is applied to the motor control, the motor will be permanently damaged.

The motor control will provide constant airflow even if the input voltage is $\pm 15\%$ of nominal. Nominal being 120vac or 240vac.

Nominal Voltage 120v Minimum Voltage 102v Maximum Voltage 138v

Nominal Voltage 240v Minimum Voltage 204v Maximum Voltage 276v

The motor control is connected to line voltage at all times as shown on the previous page. The motor control will draw current from the line to power its control devices as soon as the motor is powered up. This electric energy is consumed whether or not the motor is doing useful work.

The ECM motor was designed for minimum standby power consumption. Standby mode means that the motor is powered with a nominal voltage, but not operating. If the motor remains in an off position for a long time, the small power consumption in the control electronics will keep the motor slightly warm. This does not result in damage of any kind to the motor or electronics.

The standby input power on average for the 120/240vac motor is approximately 2–3 watts.

Important Note: The ECM 2.3/2.5 motor is designed to be powered at all times.

The Signal Cable (low voltage) Connection

The 16 pin signal cable connects between the “OEM tap board” and the motor controller.

The connector is keyed for proper connection.

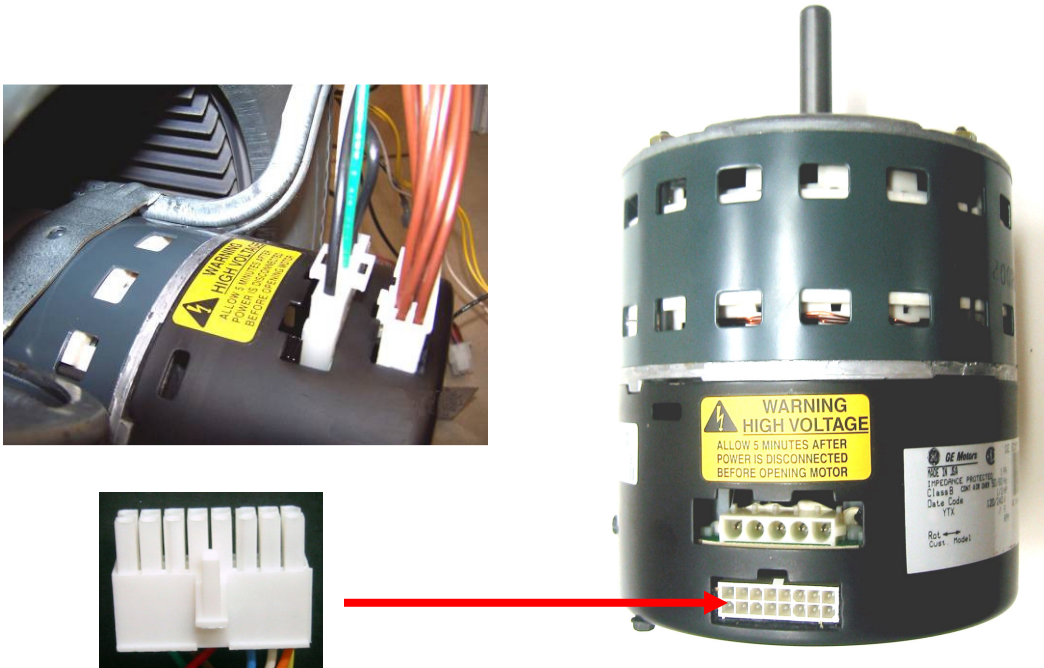
There are three modes of operation control (communication). The OEM decides which type of operation they will use. All three use the same 16 pin plug utilizing all or some of the pins depending on the mode of operation and the systems requirements.

The 2.3 motor communicates in one of two formats.

- Thermostat Mode (also used on model 2.0 motor)
- PWM (Pulse Width Modulation) Mode

The 2.5 motor communicates in one format.

- DSI (Digital Serial Interface) Mode.



Communication to the motor is far more diverse than the simple 24vac heat, cool, and continuous fan demands we are used to. This is necessary to be able to select multiple programmed airflow and comfort settings for each of these demands as well as delays, and other comfort selections.

Understanding the types of communication is not as important as understanding how to set up the system(s) for proper operation and comfort.

The OEM control board and the motor control are already programmed for all of the airflow and comfort settings needed for properly matched systems.

Using the OEM manuals to understand how to select the airflow and comfort settings is the key to proper operation, comfort and efficiency.

- Cooling Airflow
- Heating Airflow
- Trim/Adjust Multipliers
- Climate (delay) Profiles
- Continuous Fan
- Humdistat Option

Set-up at the time of installation is always necessary.

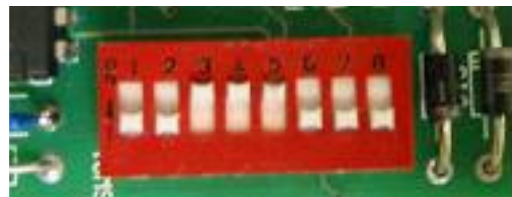
These selections are located on either the interace (tap) board or the main control board in the air handler.

The OEM charts shown previously along with other set-up information found in the manufacturers manuals will show how to set the various types of controls (shown below) for proper airflow, operation, comfort and efficiency.

Jumper Pins



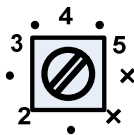
Dip Switches



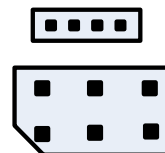
Rotary Switch for Delay Time



Rotary Switch for Cooling Tonnage

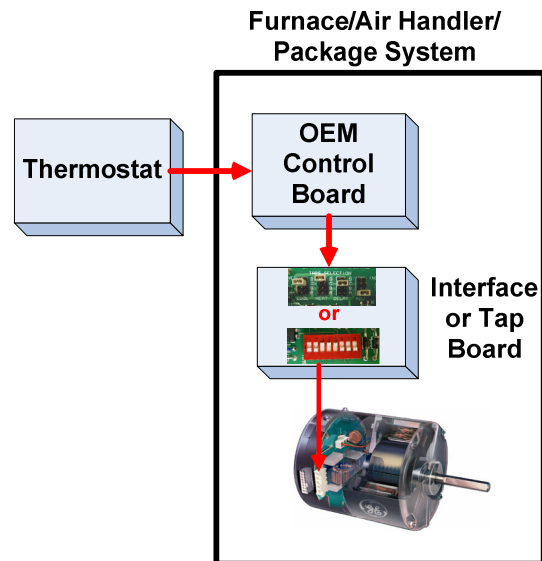


Model Plugs for Heating Selection



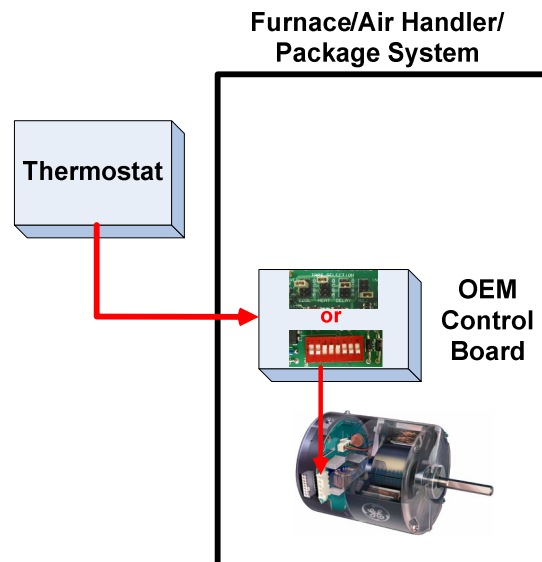
Models 2.0 & 2.3 communication example with the selections on an interface (tap) board that is separate from the main control board.

- The thermostat sends the 24vac demand (heat, cool, continuous fan...) to the OEM control board.
- The OEM control board sends the 24vac demand to the interface (tap) board.
- The interface (tap) board sends the selected airflow communication per demand to the motor.



Models 2.0 & 2.3 communication example with the selections on the main control board.

- The thermostat sends the 24vac demand (heat, cool, continuous fan...) to the OEM control board.
- The OEM control board sends the selected airflow communication per demand to the motor.



Initial Set-Up and Modes of Operation

Thermostat Mode (Premium ECM Models 2.0 & 2.3)

Thermostat mode is the most widely used method of control for residential systems. This mode allows for discreet field selection of airflow settings and comfort options. A 24vac thermostat can communicate directly to the motor or through an interface board (tap board). Most systems use an interface board.

ECM 2.0 & 2.3 Motor Control



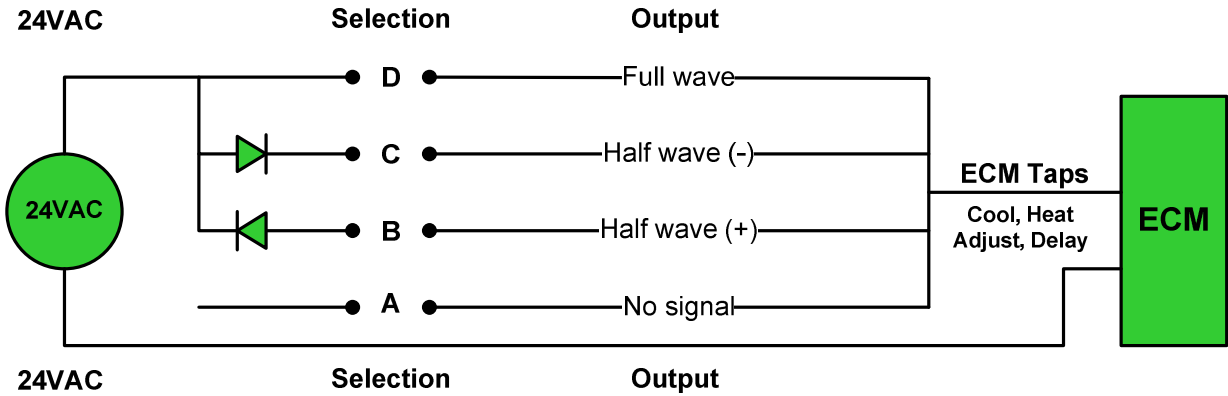
Pin number

1	Common C1
2	W/W1
3	Common C2
4	Delay tap select
5	Cool tap Select
6	Y1
7	Adjust tap select
8	Output -
9	Return valve (heat pump only)
10	Humidistat (BK)
11	Heat tap select
12	24 VAC (R)
13	2 nd stage heat (EM/W2)
14	2 nd stage cool (Y/Y2)
15	Fan (G)
16	Output +

Thermostat mode communication is based on the use of 24vac. However to achieve multiple signals from 24vac on the same line rectifiers are used to change the voltage and polarity. The motor control can read these different signals and match them to a stored airflow or timing programmed into the motor per demand.

- These functions are designed to convert one thermostat input into as many as four discrete field selectable outputs to the motor control.
- The OEM decides which functions to use and how many selectable outputs to provide.
- There are four discrete selectable outputs for:
 - o Cooling Airflow
 - o Heating Airflow
 - o Trim/Adjust Multipliers
 - o Climate (delay) Profiles
- A humidistat function may also be used.

The interface selections choose which circuit to send the signal through to the motor control. Each circuit is set up to send a different signal to the motor control. The motor control is programmed to deliver a different pre-programmed airflow for each signal.



For Example:

A demand for first stage heat sends 24vac from the interface board to terminal 2 (W/W1).

The OEM manual says to select tap (B) for proper airflow in first stage heat.

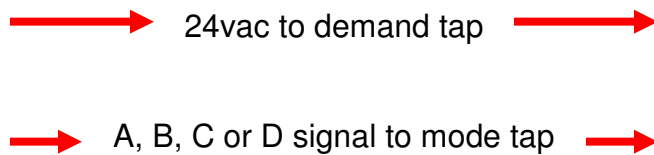
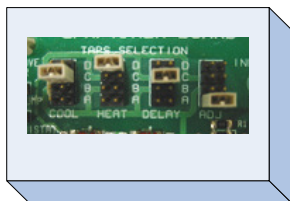
The interface board sends 24vac through the (B) circuit converting it to a 24vdc+ signal that is sent to the motor on terminal 11 (Heat tap select).

The motor operates at the stored programmed airflow that matches that signal in the first stage heat mode.

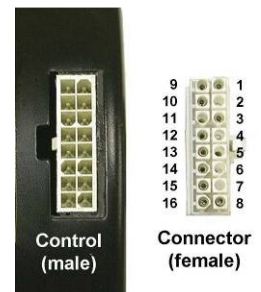
The **demand taps** are W/W1, EM/W2, Y1, Y/Y2, G and Humidistat. The **mode taps** are Heat, Cool, Delay and Adjust (tap select)

- | Pin number | |
|------------|------------------------------------|
| 1 | Common C1 |
| 2 | W/W1 |
| 3 | Common C2 |
| 4 | Delay tap select |
| 5 | Cool tap Select |
| 6 | Y1 |
| 7 | Adjust tap select |
| 8 | Output - |
| 9 | Return valve (heat pump only) |
| 10 | Humidistat (BK) |
| 11 | Heat tap select |
| 12 | 24 VAC (R) |
| 13 | 2 nd stage heat (EM/W2) |
| 14 | 2 nd stage cool (Y/Y2) |
| 15 | Fan (G) |
| 16 | Output + |

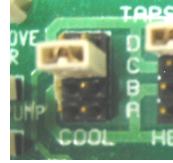
Interface Board



ECM 2.0 & 2.3 Motor Control



Cooling Airflow Selection



Installation

- Typically this setting will come factory set to the highest available cooling airflow
- This setting must be changed at the time of installation to match the cooling tonnage of the installed condensing unit. The tonnage of the condensing unit can be found in the installation manual for each unit and also in the model number of the unit. Tonnage is rated as 12,000 BTU/Ton.
- For instance: ABC-**036**-131
 - o The 036 designates the BTU rating of the unit to be 36,000 BTU. The tonnage is therefore 3 ton (36,000 BTU / 12,000 BTU/Ton = 3 ton).
- CFM is usually set at 400 CFM/Ton. Typically the charts will list the CFM per ton in the following manner:

018 = **1.5 ton** = 600 CFM
 024 = **2 ton** = 800 CFM
 030 = **2.5 ton** = 1000 CFM
 036 = **3 ton** = 1200 CFM
 042 = **3.5 ton** = 1400 CFM
 048 = **4 ton** = 1600 CFM
 054 = **4.5 ton** = 1800 CFM
 060 = **5 ton** = 2000 CFM

Example of Airflow Table

Cooling Airflow Selection								
2nd Stage	Dip Switch Number							
CFM	1	2	3	4	5	6	7	8
A 800	0	0						
B 1000	1	0						
C 1200	0	1						
D 1400	1	1						

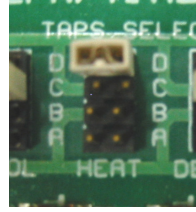
- The manufacturer’s instructions (charts) will show which setting to use from up to four available cooling airflows. There is typically a different chart for each furnace/air handler used by each OEM.
- First stage cooling airflow is typically a preset percentage of the selected cooling airflow setting.

Benefits

- Easily select the exact cooling airflow needed at the time of installation.
- Up to four different cooling airflow settings allow the versatility of installing the same furnace/air handler in various system configurations (i.e. 1200, 1000, 800, 600).

There is only a 1 in 4 chance that the factory “as shipped” cooling airflow is correct for the condenser being used.

Heating Airflow Selection



Installation

- Option 1
 - o Typically the heating airflow is factory set for the furnace the motor is supplied with to operate at the middle of the heat rise range
 - o Field adjustment will modify the heat rise for unique installations.

- Option 2
 - o The heating airflow can be factory set to operate for a unique furnace model (i.e. 60, 80, 100, 120K BTU input)
 - o Each setting is unique to a specific size furnace
 - o CAUTION – Any field adjustment will significantly alter the systems performance.

Example of Airflow Table

Heating Airflow Selection										
Temp Rise Range (30 - 60°F)										
2nd Stage	Dip Switch Number								Rise (°F)	
CFM	1	2	3	4	5	6	7	8		
A	550			0	0					51
B	600			1	0					47
C	650			0	1					43
D	700			1	1					40

- First stage heating airflow is typically a preset percentage of the selected heating airflow setting.

Benefits

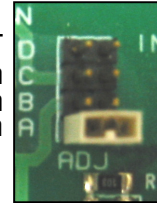
- Option 1
 - o The heat rise can be easily optimized at the time of installation.

- Option 2
 - o One ECM model can be used with up to 4 different size furnaces.

Never assume the factory setting is the correct setting without checking the installation manual first. Always check the temperature rise and confirm that it is within the manufacturers specifications on every job.

Trim/Adjust Multipliers Settings

TEST
+ Trim
- Trim
No Trim



Installation

- This setting is usually factory set at the normal position (no trim).

Example of Airflow Table

Trim/Adjust Airflow Selection		Dip Switch Number							
CFM		1	2	3	4	5	6	7	8
A	Norm					0	0		
B	+10%					1	0		
C	-10%					0	1		
D	N/A					1	1		

- This setting is capable of adjusting the airflow as much as $\pm 15\%$. However smaller changes may be programmed into the motor by the OEM (i.e. 7%, 10%, 12.5%).
- This setting may be factory programmed to adjust either the cooling airflow, heating airflow or both cooling and heating airflows together. Trim can be selected to optimize airflow for each unique installation.
- Changes to the trim are NOT implemented until the motor is cycle off and on.
- **Changes to the trim are typically not needed if the system is matched and set up properly. Adjustments to this setting should only be made following the factory recommendations.**

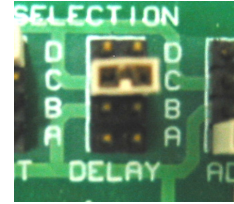
Benefits

- The trim setting is good for tailoring a system for specific comfort and dehumidification needs.
- Per OEM specifications the trim could be adjusted up or down to enhance the temperature rise, provide additional dehumidification (increased latent capacity) or less dehumidification (increased sensible capacity).

Tech Tip

- Before making changes to this setting you must know what affect it will have on these airflow settings.
- If this setting affects both and the change is being made to adjust the cooling airflow, the temperature rise will also be affected. This may require the heating setting to be adjusted for proper temperature rise after this setting has been changed.

Climate (Delay) Profiles



Installation

- This option is only available in the thermostat mode.
- There are up to four unique Climate/Delay Profile options.

- Instead of simple on/off delay settings, profiles provide more control of timing and airflow.

Example of Airflow Table

Climate/Delay Profile Selection								
	Dip Switch Number							
	1	2	3	4	5	6	7	8
A							0	0
B							1	0
C							0	1
D							1	1

- **Profiles are available for the heating or cooling selections but not both.**

- They are typically applied to the cooling selections.

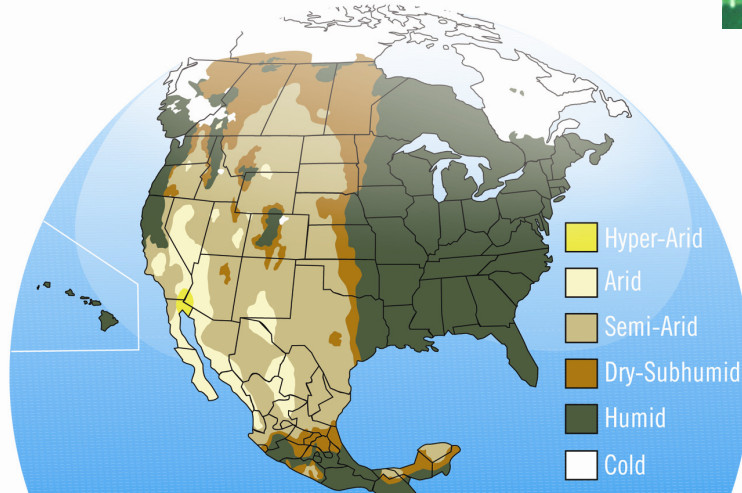
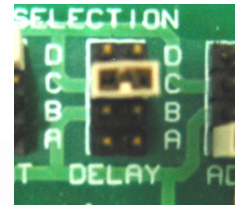
- Heating selections typically use fixed on delays with adjustable off delays.
- Each profile changes both the slew rate and the airflow at each level.
- The Climate/Delay Profiles are specific to each motor program.
- Many manufacturers have optimized dehumidification using the available profiles.

Benefits

- The motor runs at a reduced airflow on initial start-up to allow the system coils to heat up or cool down to eliminate unwanted hot or cold air blasts.
- The profiles help to alleviate temperature extremes and noticeable temperature swings. The desired temperature may be reached before airflow reaches 100%, saving energy/money, while keeping the noise to a minimum.
- The controlled ramping eliminates the loud start-up found in standard systems with induction motors
- Ramping down to zero slowly allows the system to take advantage of already heated or cooled air left over in the ventilation system.

Climate (Delay) Profiles

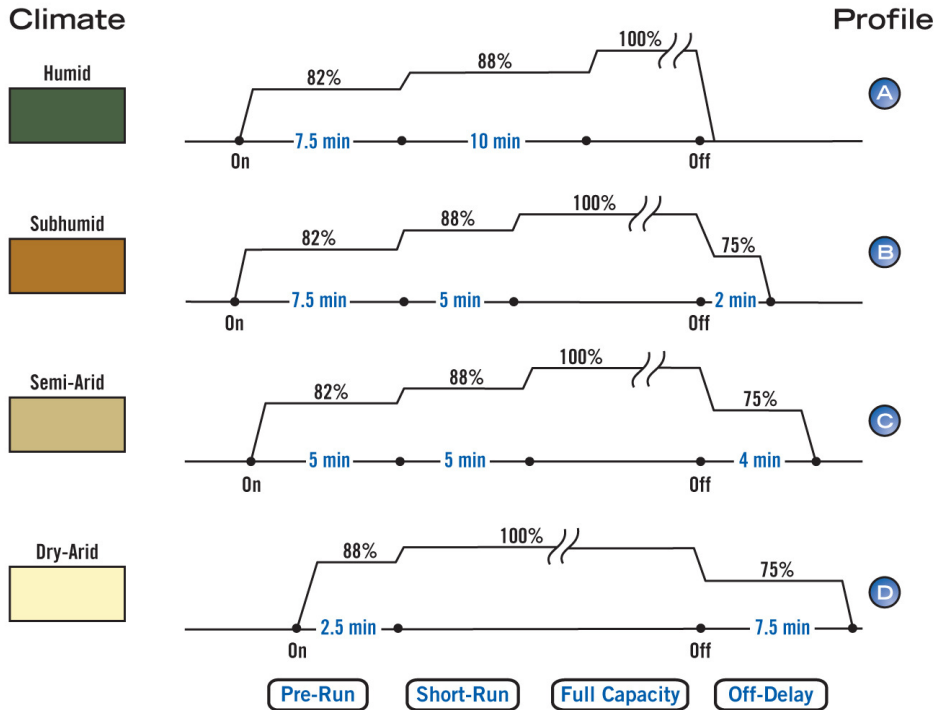
Shown here are the recommendations for cooling profiles in relationship to the humidity index map.



NORTH AMERICAN HUMIDITY INDEX MAP

Based on a ratio of annual precipitation and potential evapotranspiration. The data provided was obtained from the United Nations Environment Program

GE ECM Cooling Airflow Profiles



Climate (Delay) Profiles

The technician should be aware of what delays or ramping profiles are programmed into the motor from the manufacturer's literature. This will save the misunderstanding of what the motor is doing on initial start of a cycle and at the end of the cycle.

- There may be a programmed amount of time before the motor starts, or the motor may start at a low almost un-noticeable airflow depending on the program. The motor must be given time to run through the profile timings and steps before it reaches the 100% airflow for that setting.
- Conversely there may be a programmed amount of time once the cycle ends before the motor will come to a full stop. There may even be step down levels in the off cycle depending on the program.
- Remember that once the cycle ends, and the profile is complete, the motor may continue to run if continuous fan is selected at the thermostat. This motor can run at a very slow almost in-audible speed in continuous fan mode.
- Notice that the "slew rate" also changes with each profile. This is the rate at which the motor transitions between two states.
- **Always follow the manufacturer's literature when setting up delays or profiles.**

There may be situations where a specific profile is not recommended.

For example:

In a hot/humid climate, off cycle delay may not be recommended due to re-humidification.

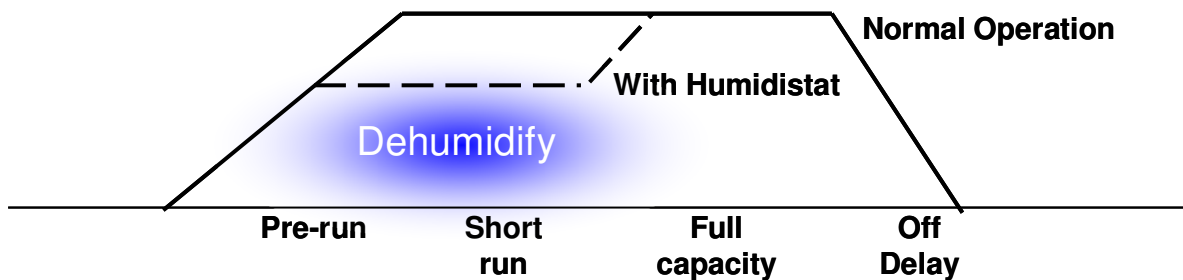
The Humidistat Option

Installation

- Most manufacturers will require the removal of a jumper pin, wire connection or a dip switch setting change on their control board to allow the use of a humidistat. This is OEM specific.
- In this application, a high humidity signal from the humidistat will command the ECM to operate at a lower airflow than the cooling selection (typically a 15% reduction). Airflow will return to normal when the set humidity level is satisfied.

Benefits

- Lower airflow across the cooling coil will remove more moisture by allowing it to condense on the coil and drain.
- Lower humidity allows the cooling set point to be higher and still be comfortable. Setting the thermostat as little as two degrees higher can save money.
- The cooling call will follow whatever profile has been selected; however the airflow will be reduced at each step during the dehumidification mode.

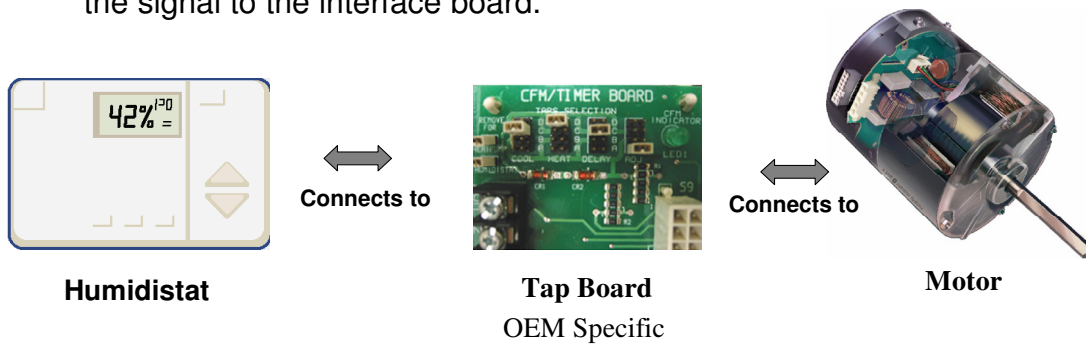


The Humidistat Option

The humidistat wiring may be through the OEM's main control board or the interface board. The connection may be labeled (DeHum) or (DH). In simple terms a humidistat works just like a thermostat. The customer sets the level of humidity desired, and the humidistat opens and closes a set of contacts when the humidity is higher or lower than the set point. The humidistat option is typically utilized in one of two ways.

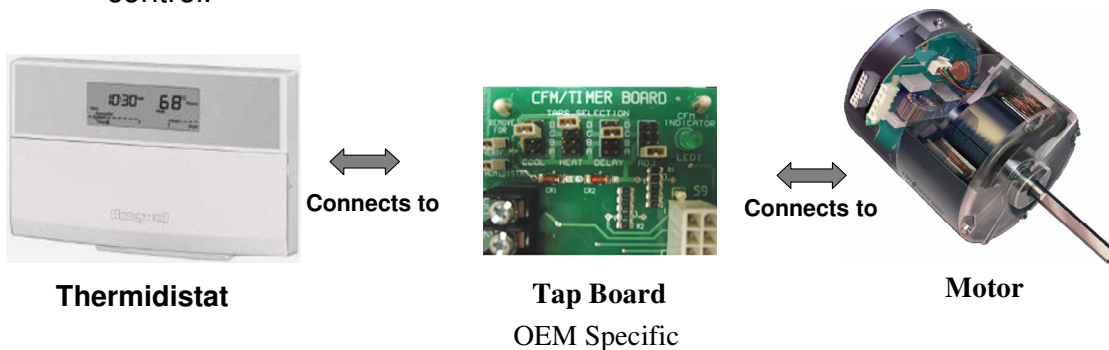
Option 1

- In this application a humidistat is used separate from the thermostat to break the signal to the interface board.



Option 2

- In this application the thermostat and humidistat functions are built into one control.



Keep in mind that each manufacturer may or may not utilize this function and may have other options of control, wiring and set-up.

Constant Fan

Installation

- This option is typically factory programmed to operate at 50% - 60% of the cooling airflow per the manufacturer. Some OEM's provide the ability to adjust this setting for customer preference.
- The operation is selected by the consumer at the thermostat.

Benefits

- Continuous air circulation provides:
 - o Efficient air filtration
 - o Less stratification (the effect of warm air rising and cool air falling).

Remember that in the constant fan mode, this motor is extremely efficient operating at around 60–90 watts. This is less than the typical household light bulb. A standard induction motor in constant fan can operate between 400-700 watts.

In some climates constant fan is not recommended due to re-humidification.

Output Options

We have learned that this motor will maintain constant airflow by responding to changes in duct pressure. Another feature is the use of output information that the OEM can program for different options.

The most commonly used option is the CFM Demand (blink) Mode. An LED on the interface or main control board will blink once per 100 CFM of the selected airflow.

To determine the selected CFM, count the number of flashes between pauses and multiply by 100 (unless programmed otherwise).

- If the system is in the cooling mode, and the indicator flashed 12 times, the selected CFM is 1200.
- If viewing the indicator requires removing the blower access panel, remember that RPM will be lower to maintain the selected CFM. However this will not change the reading on the indicator since it is providing the selected CFM not the actual CFM.



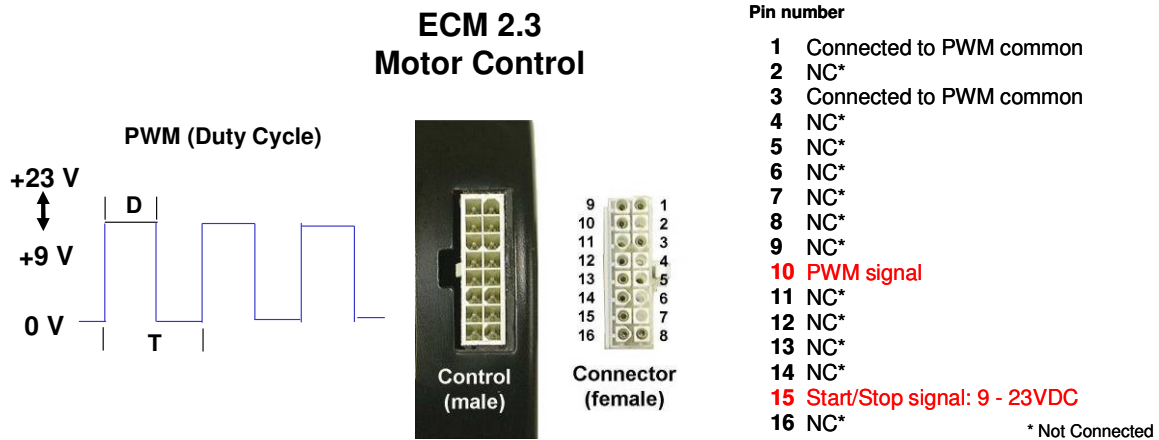
Another option is to use the limit mode. This function allows the OEM to use the output signal as an indicator that motor is over or under speed. This information is typically designed to indicate to the consumer when the filter is blocked by an alert on the thermostat.

PWM (Pulse Width Modulation) Mode (Premium ECM Model 2.3)

This form of communication or signal is best suited for commercial systems although some OEM's have, and are currently using it in residential applications. This is suitable for full variable speed control of the motor by use of an external PWM signal.

PWM simply uses two signals, a start/stop signal and a PWM signal.

- In simple terms the start/stop does exactly what it says, it provides the motor with the information of when to turn on and when to turn off. However, it also gives the value that will be used for the percentage of airflow.
- The PWM signal is the information for the percentage of programmed airflow. Or to say that another way, it represents the desired motor output.



OEM charts are used to select demand airflow, delays, de-humidification option and continuous fan option.

There are no climate profiles in PWM mode. The OEM can provide fixed and adjustable on and off delays

A de-humidification call simply reduces the airflow percentage of demand to the motor.

OEM Zoning systems can control airflow per zone. The manufacturer can set up the motor to provide different levels of airflow depending on the demand and the size of the zone.

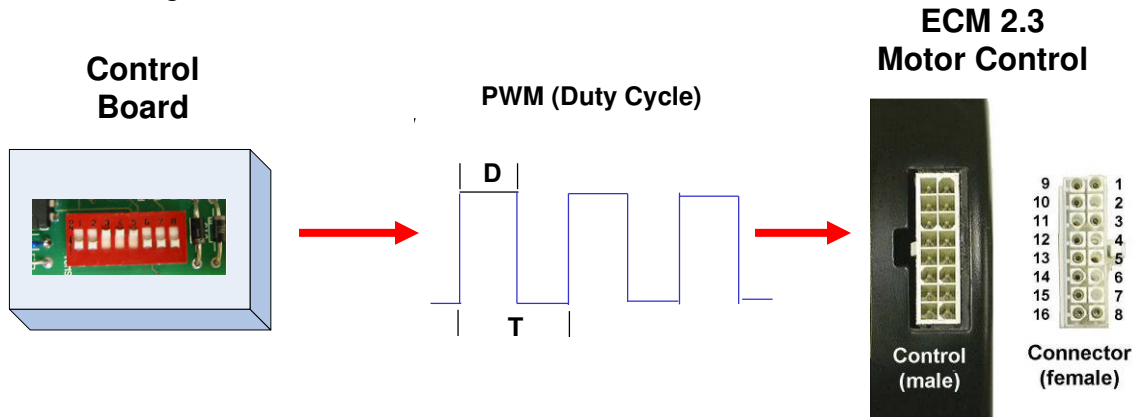
Since this is strictly OEM specific, the manufacturer's literature must be consulted for set-up options and troubleshooting.

This is a more simplified means of communication that provides infinite control of airflow by adjusting the PWM signal.

The airflow characterization is stored in the OEM control board.

The motor is programmed with a minimum and maximum airflow range that is specific to each air moving system.

A PWM signal from the OEM board communicates to the motor what percentage of the airflow range is needed for each demand.



The voltage supplied to Pin #15 is the start/stop signal.

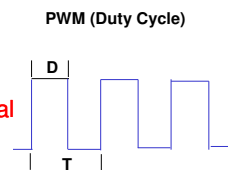
- The voltage range is 9-23vdc

The PWM signal is supplied to Pin #10.

- The PWM signal (duty cycle) itself cannot be easily measured.
- The dc voltage on this line can be measured and used in a formula to determine the demand output percentage.

Pin number

- 1 Connected to PWM common
- 2 NC*
- 3 Connected to PWM common
- 4 NC*
- 5 NC*
- 6 NC*
- 7 NC*
- 8 NC*
- 9 NC*
- 10 **PWM signal**
- 11 NC*
- 12 NC*
- 13 NC*
- 14 NC*
- 15 **Start/Stop signal: 9 - 23VDC**
- 16 NC*



* Not Connected

If the manufacturer provides the information in their troubleshooting guides as to what these dc voltages should be, the communication can be diagnosed with a dc volt meter. Make sure the meter is set to dc volts and the polarity of the connections is correct following the OEM guides.

The information provided below is strictly “nice to know” information. A technician would not make the following checks to diagnose the motors operation or output.

- The motor does not look at the dc voltage on the PWM circuit. It is reading the duty cycle as a representation of the desired motor output.

The following formula can be applied to the dc voltage readings to help understand the % demand of the PWM signal (duty cycle)

For Example:
$$\% \text{ Demand} = \frac{D}{T} \times 100$$

(in torque or airflow)

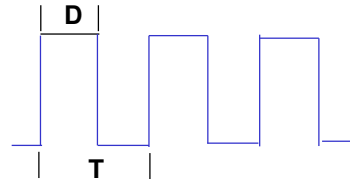
20 vdc is measure between terminals 3 and 15 (value T)
10 vdc is measure between terminals 3 and 10 (value D)

The percentage of demand (motor output or airflow) would be 50%.

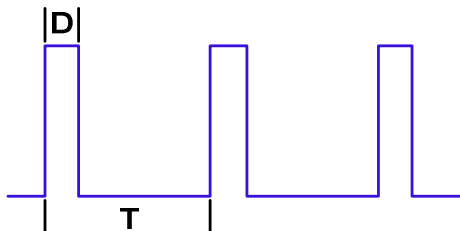
$$\frac{10 (D)}{20 (T)} = .5 \times 100 = 50\%$$

The actual PWM signal would look like the example to the right, where the signal is on for 50% of the cycle and off for 50% of the cycle.

PWM (Duty Cycle)

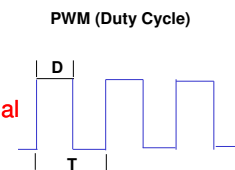


If the demand percentage was 20% the PWM signal would be on for 20% of the cycle and off for 80% of the cycle. This signal would like the example to the below.



Pin number

- 1 Connected to PWM common
- 2 NC*
- 3 Connected to PWM common
- 4 NC*
- 5 NC*
- 6 NC*
- 7 NC*
- 8 NC*
- 9 NC*
- 10 **PWM signal**
- 11 NC*
- 12 NC*
- 13 NC*
- 14 NC*
- 15 **Start/Stop signal: 9 - 23VDC**
- 16 NC*



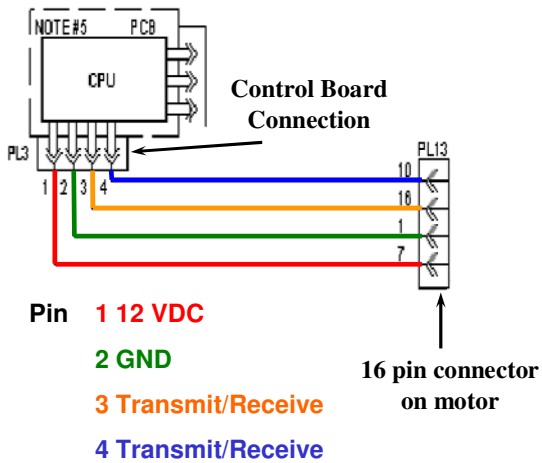
* Not Connected

DSI (Digital Serial Interface) Mode (Premium ECM Model 2.5)

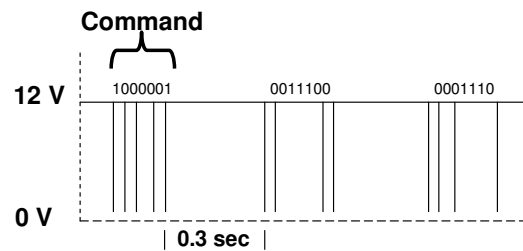
This is the next generation in communicating systems controlled by a Digital Bus System Controller.

The system controller digitally communicates with the motor: Speed, Airflow, Starts, Stop, etc.

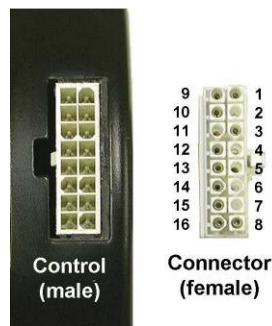
There are 2 leads for power (12VDC) and 2 leads for communication.



Communication Example



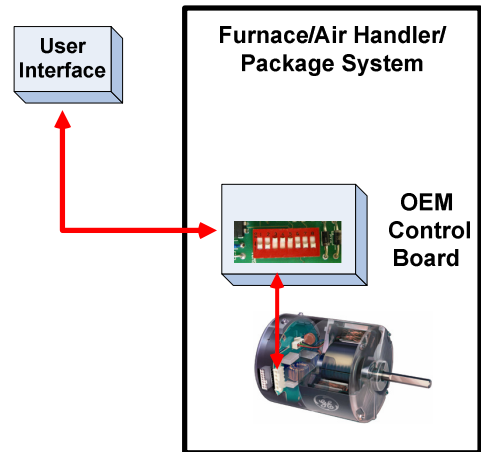
ECM 2.5 Motor Control



- Pin Number
- 1 Optional ground common
 - 2 NC*
 - 3 Optional ground common
 - 4 NC*
 - 5 NC*
 - 6 NC*
 - 7 Voltage pin supplier for data out
 - 8 Ground common
 - 9 NC*
 - 10 Data in
 - 11 NC*
 - 12 NC*
 - 13 NC*
 - 14 NC*
 - 15 NC*
 - 16 Data out
- *Not Connected

Advantages to DSI Communication

The motor program is now stored completely in the OEM control board. The OEM control board can store multiple programs for different model units. This means that one motor (OEM specific) can be used for more than one unit reducing parts. When a new motor is connected to the OEM control board, the program and settings are automatically loaded into the motor. Just like the “Plug and Play” feature of most computer accessories.



The OEM manuals are still used for set-up options and how to use the “User Interface” (the replacement for the thermostat). The user interface is similar to a touch screen communication device that can be used to set-up the systems airflow and comfort settings as well as setting other features. This device is in constant communication with the control boards (microprocessor) in the unit and can actually recognize what it is connected to. In most systems with DSI communication almost all of these set-up selections that were previously made at the control board will be made at the user interface, including diagnostics.

With the high level of communication between components, the user interface may also be able to provide indicators such as when to change or clean the filter and when to service the system and connected IAQ devices.

Airflow for OEM matched zoning systems can not only be tailored to the size of each zone but may be able to set itself up, reducing time.

System to system wiring is typically reduced to four (4) or less wires since an infinite amount of information can be communicated. Pulling extra wires through the wall may not be necessary when converting from single stage systems to multi-stage systems.

OEM classes are highly recommended for the specific technical knowledge of this style equipment and the ability to educate the customer on all of the features and how to use them.

Servicing Premium ECM Motors

The ECM Service Guide

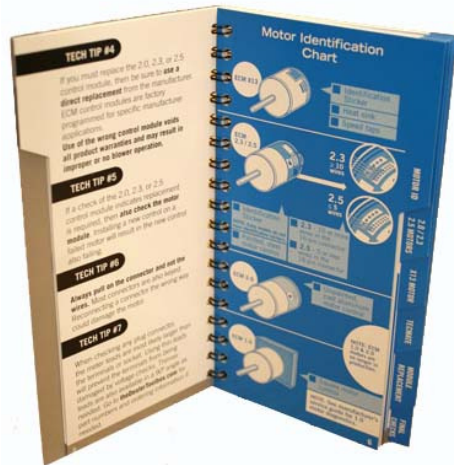
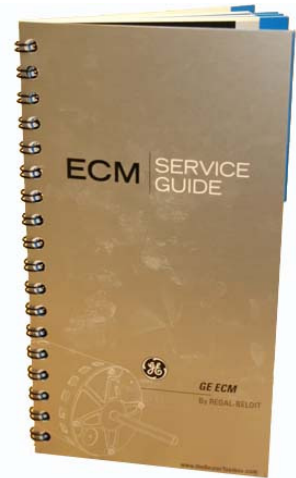
This pocket sized guide covers everything in this manual on troubleshooting and repair of Premium ECM Motors.

Order the rugged hard copy or download and print a free copy from our web site at:

www.thedealertools.com

Included in this guide are the following:

- HVAC System Troubleshooting Basics
- Tech Tips
- Motor Identification Chart
- Premium ECM Motor Diagnostics
- Standard ECM Motor Diagnostics
- TECMate Usage Chart
- Troubleshooting with the TECMate Module and Motor Replacement
- Final Installation Checks



The ECM Service Guide replaced the Home Comfort Guide.



Service Basics

Even before you begin to troubleshoot, one of the most common problems is that the factory settings were not changed (set-up) at the time of installation, or someone without the factory installation guide has changed the settings.

- **The installation guide should be left on site near the furnace or air handler.** This statement is even listed inside the manual. Now more than ever this manual and the factory service manual should be hanging in a convenient location for all service technicians to use. FYI – this is also a good place for company information, the manuals for all of the accessories including the condensing unit, and invoices for reference of the previous work. Customers will appreciate the fact that you're building a reference section for them and everyone will know where to look for that information.
- Some technicians may think that the customer will think less of them for referencing a manual. On the contrary, most customers will see this as professionalism. As a consumer, I would be more leery of the technician that does not read the manual, and just starts poking around in my very sophisticated system. If there is a question about why the manuals are being referenced keep this in mind:

When you call for technical assistance on a computer, the technician on the other end of the phone is using a troubleshooting guide. They could not possibly memorize all of the settings for every computer or program. Today's HVAC systems are very similar in that they have many different settings and troubleshooting procedures that are unique to each manufacturer. It would be impossible to memorize even one manufacturer's information, much less all of them.

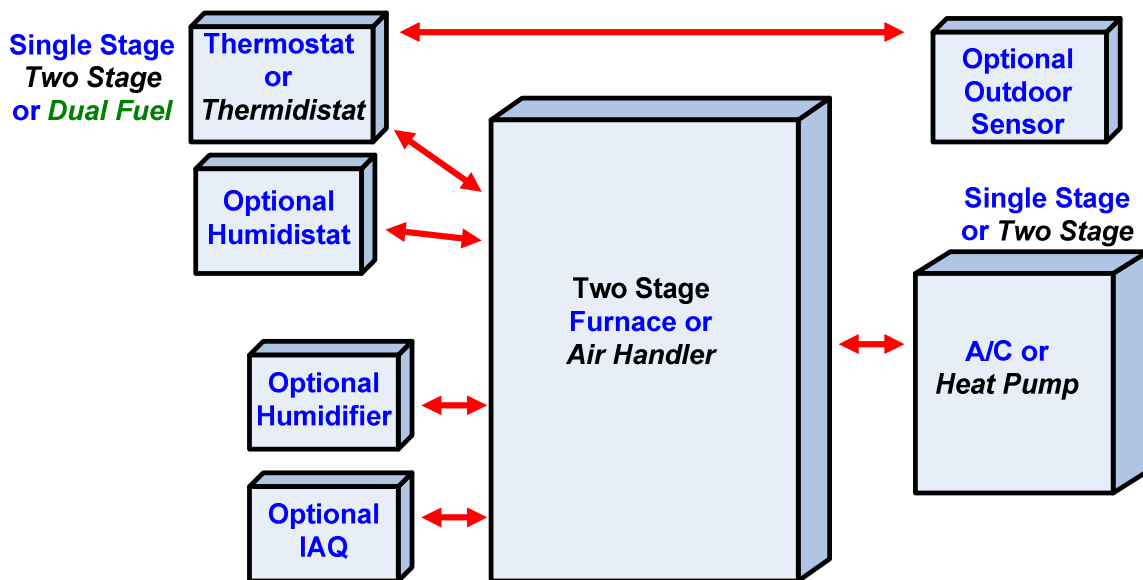
It's a good idea to start the service call by checking the set-up of all of the dip switches or jumper pins, even the ones that don't apply to the ECM motor. The circuit board can only function properly when it is set up properly. The motor must be powered off, and the wheel must come to a complete stop, before tap adjustment changes will take affect. This is not an issue if removing the blower door is required to get at the tap settings and the blower door switch disconnects the main power. However, **it is a good practice to always turn the main power off**, before removing the blower door. Do not count on the blower switch to de-energize the circuit. It is not uncommon for the blower switch, when failed or during servicing to be bypassed. This is not recommended. A defective door switch should always be replaced and a bypassed door switch should always be returned to working order and checked. This is a safety switch.

RTM – Read The Manual

It's also a good idea to check the control wiring in the system as well before beginning the troubleshooting process. Even in matched systems there are many wiring options depending on the type and style of components connected to the air handler.

This step goes hand in hand with the OEM manuals, especially when single stage and multi-stage equipment is combined in one system. There will not only be specific wiring options for these types of systems but there may also be specific settings required on the OEM board.

A quick look at the picture below will remind us of just how many system to system options there are, including IAQ devices.



After the system wiring and set-up are confirmed, we need to determine if this is an operational motor problem or a failed motor problem. Keep in mind that even a system that is not currently running could be an operational system problem.

For Example:

If the system has been tripping on limit due to a plugged filter, the control board may have locked it out. Resetting the system will most likely get it to run again, but not for very long. This is an operational motor problem, where the motor and the system are operating, but there are other factors that caused the service call.

Check the System Demand Inputs to the Circuit Boards.

- Is the correct thermostat input and only the correct input voltage present at the interface or main circuit board? If there is a call for more than one mode at the same time, certain demands take over in the motor programming.
- Are there any limits, rollouts or safeties tripped?
- Loose terminal connections can be a simple problem that is often overlooked.

If the thermostat is calling for continuous fan (G), and a heat or cool demand is initiated, then those demands must show up at the interface board or main circuit board. If not, then the motor is going to continue to run at the continuous fan airflow.

When checking low voltage always use the (C) terminal on the board, never ground. Some manufacturers may use a different letter to represent common other than (C). They may also use different letters than those listed below for the heating and cooling stages.

Call for 1st Stage Heat:

24vac between W1 and C

24vac between R and C

24vac between G and C (If also calling for continuous fan)

Call for 2nd Stage Heat:

24vac between W1 and C

24vac between W2 and C

24vac between R and C

24vac between G and C (If also calling for continuous fan)

Call for 1st Stage Cooling:

24vac between Y1 and C

24vac between R and C

24vac between G and C

Call for 2nd Stage Cooling:

24vac between Y1 and C

24vac between Y2 and C

24vac between R and C

24vac between G and C

Call for Continuous Fan only:

24vac between G and C

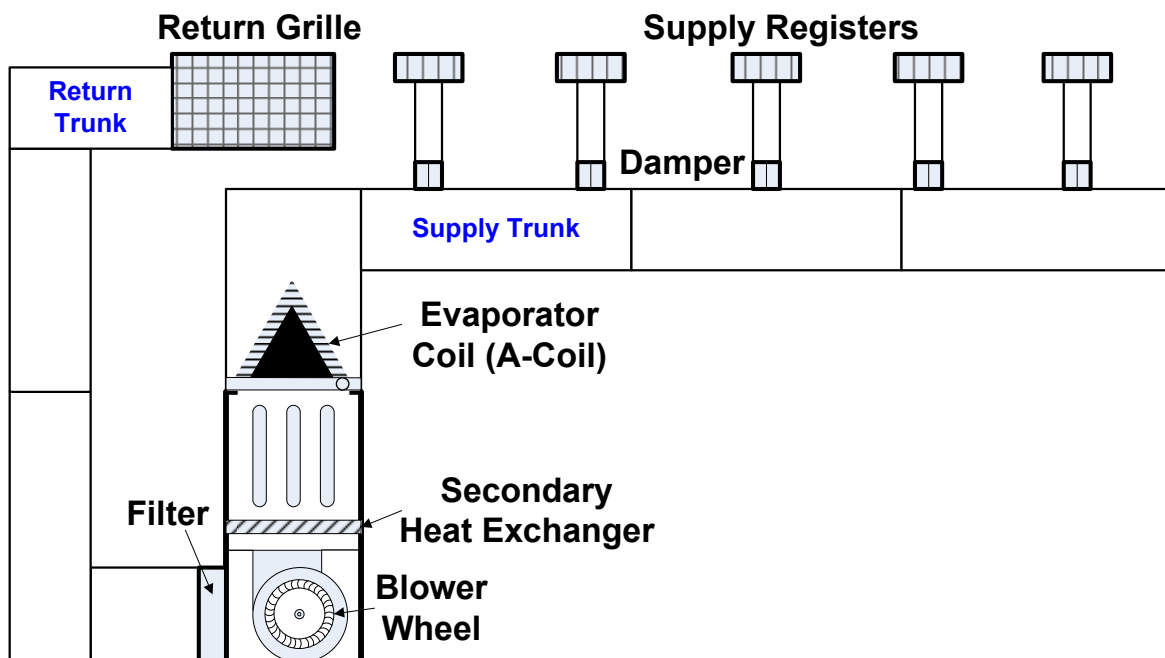
24vac between R and C

Remember that the customer is your best source of information on what the system is doing, was doing, and how it performed when running properly. This can save a lot of diagnostic time, and build your reputation with the customer as someone who not only cares enough to ask their opinion, but is professional enough to not just go for the meter and the tools.

If the motor is operating...

If the motor is running, but is noisy or doesn't appear to be at the proper airflow after any delays or profiles have ended, then the problem may be restrictions in the air side of the HVAC system, not the motor.

- Check and clean or make the necessary adjustments as needed to the following airside components. Keep in mind these things should be checked and maintained regularly.
 - Filter (clean)
 - Registers and grills (clear and open)
 - Dampers (open or at least not closed)
 - Blower wheel (clean)
 - Secondary Heat Exchanger (clean)
 - Evaporator Coil (clean)
 - If the system is zoned, what position are the dampers in and what position should they be in?



Severe airflow restrictions may cause the motor to oscillate, sometimes called huffing or hunting. This is when the motor appears to be speeding up and slowing down over and over. This is due to the motor program hitting the speed limit and backing off the motor torque, and then ramping back up again in an attempt to maintain airflow.

Some manufacturers also have fault codes that indicate when the motor is at the speed limit. The system may still be operating with this fault code or may be shut down depending on how the fault code is applied. This is also typically an indication of an airflow restriction, since we know that the wheel speed increases when pressure increases.

Checking the External Static Pressure (ESP) of the system should be done at the time of installation and is also a valuable troubleshooting tool. If all of the above airside components are clean and there is still a restriction problem external static pressure can help isolate where that problem is.

ESP (often simply called pressure) can be checked with most any analog or digital manometer that can read down to 0.01 inches water column (in. wc.). However a differential gauge is the most effective since it takes both readings at the same time.

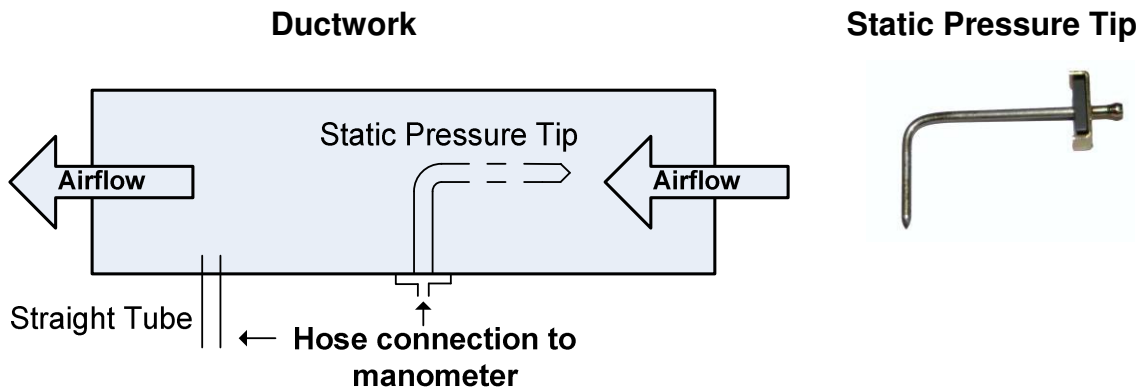


Incline Manometer



Courtesy Dwyer Instruments and Test Products International (TPI)

A static pressure tip can also make the readings more accurate. However since static pressure exerts force in all directions a straight tube can also be used.

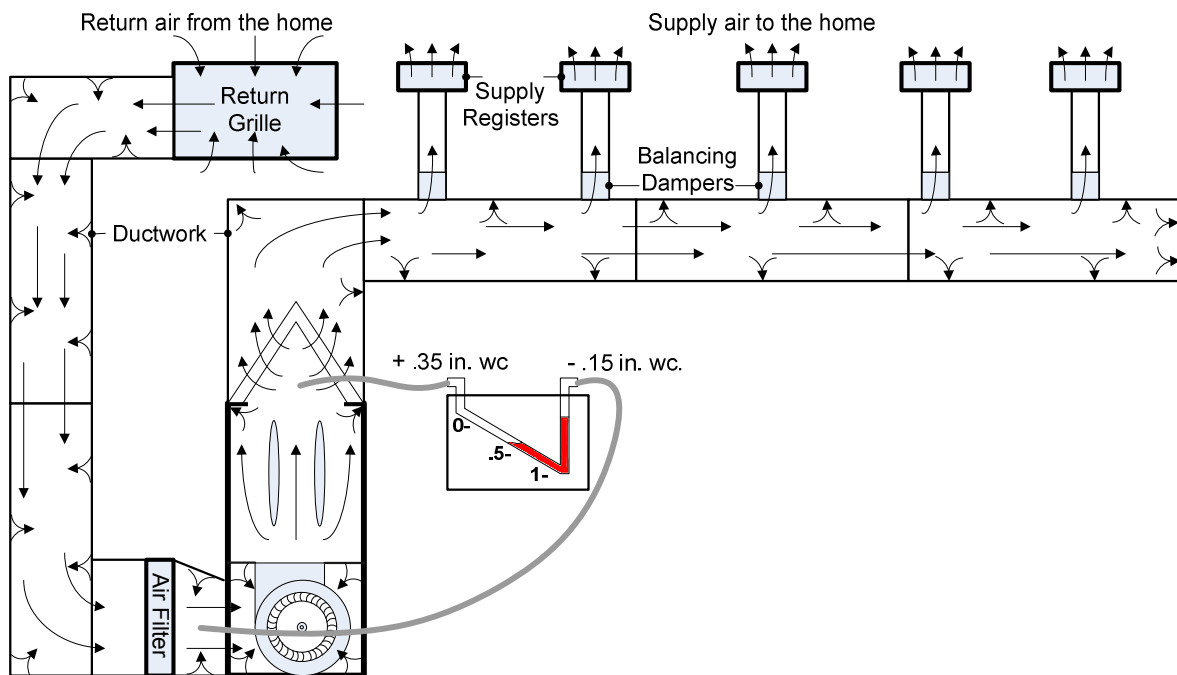


ESP is simply the difference in pressure between the supply side of the system and the return side of the system. Keep in mind that the return side static is negative pressure since the air is being pulled through the duct, and the supply side static is positive pressure since the air is being pushed through the duct. Static pressure is a measurement of how much resistance there is to airflow in the duct system on both sides combined.

Most furnaces recommend a maximum ESP of .5 in. wc. However this recommendation may be different on air handlers and package systems. Always follow the OEM's specification. This information should be listed on the equipment data plate or in the factory manuals.

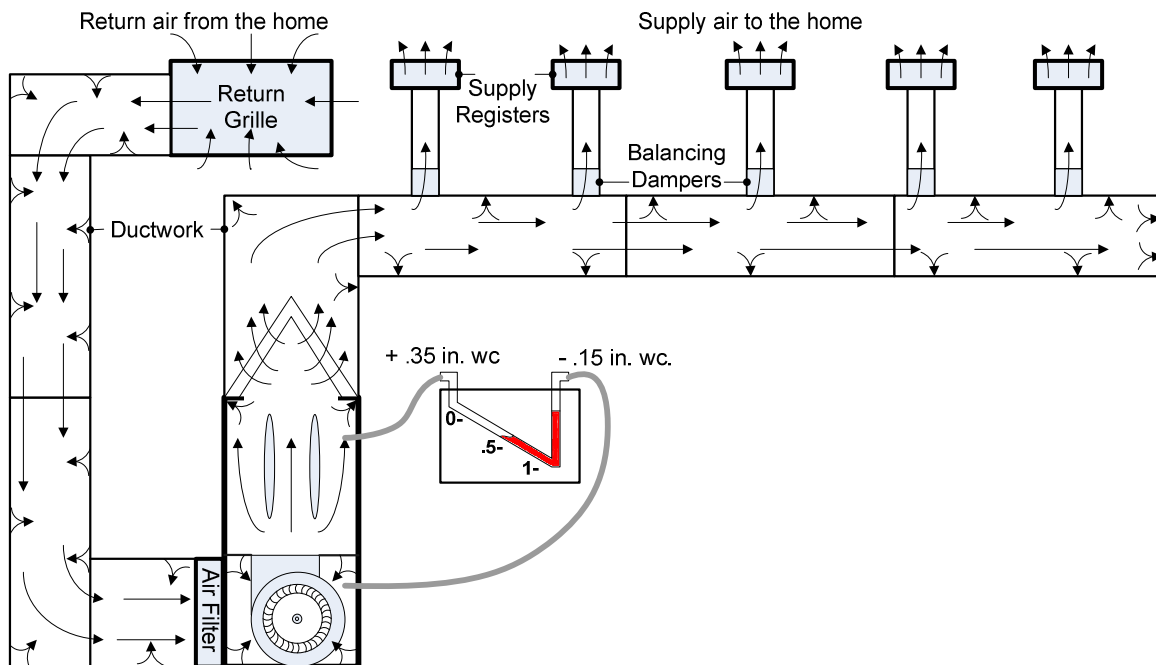
On the diagram below the reading is taken under the evaporator coil for the supply reading and the after the filter for the return reading, in relationship to the direction of the flow of air. Furnaces are typically rated for ESP without the evaporator coil and filter included, which means we have to include them in the external static pressure of the ductwork that the motor must work against to move air.

The incline manometer shows a reading of .5 in. wc. from a combined total of .15 in. wc. return and .35 in. wc. supply.



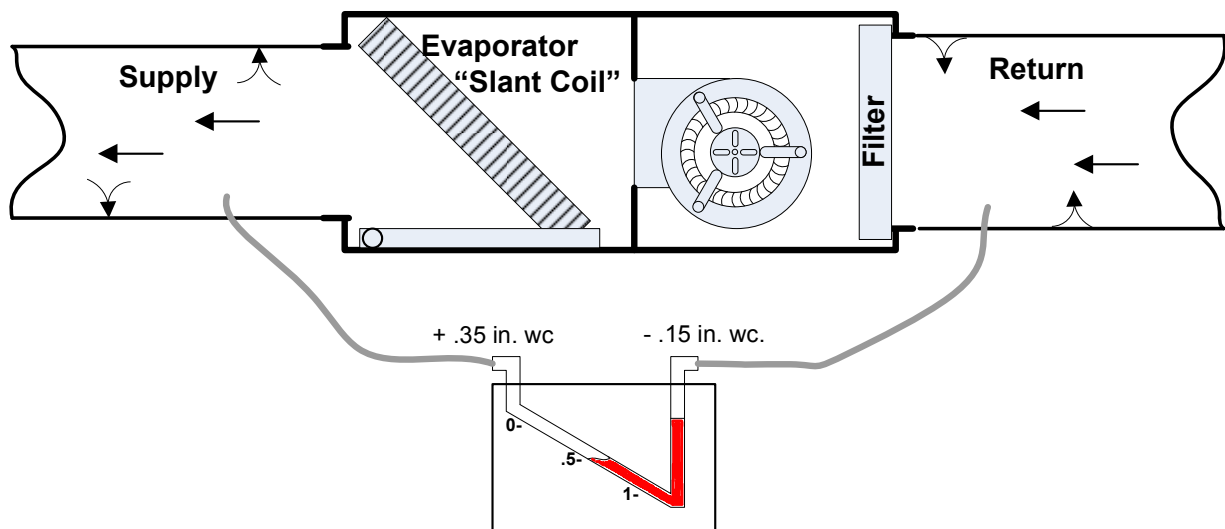
The maximum external static a system can handle should also be listed in the manufactures manuals. In most cases you will find this maximum between 0.8 -1.0 in. wc.

On the diagram below the return reading is taken in the return cabinet and the supply reading is taken in the cabinet after the blower. If the filter is mounted directly on the cabinet and there is no access to the evaporator cabinet, this is the only way to get the ESP on this system. These readings will be just as accurate, however it is **highly recommended that you check with the manufacturer of that system for approval to drill test holes in their cabinet.**



Some furnace manufactures and many air handler manufactures include the filter in the ESP rating. If this is the case the ESP reading in the return would be taken before the filter. However, if the filter used is not the style or size that the manufacturer specified it may be more restrictive than they rated for.

Air handlers and package systems that have the evaporator coil inside their cabinet include them in the ESP rating. If this is the case the ESP reading would be taken at the return and supply connections depending on where the filter is and if it is also included in the rating.

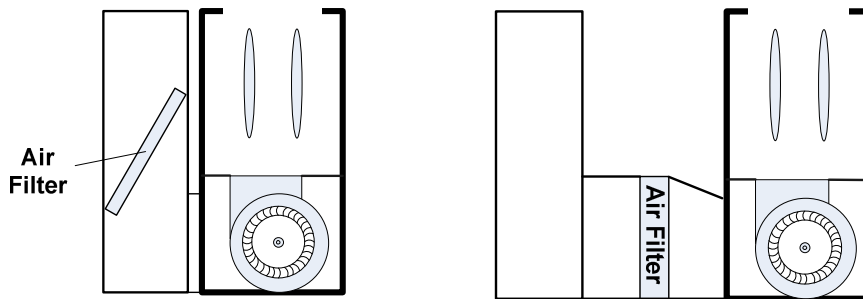


Filters are also a common airflow restriction problem. Most filters supplied and recommended by the manufacturer are not very restrictive. That is to say that they are good at moving air but bad at catching the dust and dirt that we want to keep out of the system and remove from our air. Many times these filters get replaced with higher efficiency filters that are good at catching dust and dirt but will be bad at moving air if they are not sized properly.

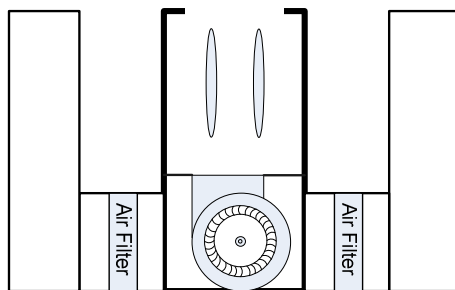
Filter sizing -

Probably the biggest problem or at least the one that will creep up the most is the filter. Make sure that low velocity, high static filters are sized properly and kept clean. Some of these filters may be too restrictive, even when clean, if they are sized incorrectly. Low velocity filters such as deep pleated media and electronic air cleaners typically provide the most benefit for the money with the least amount of added problems.

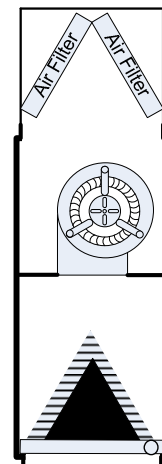
- Filters may need to be re-sized if changed from what the manufacturer supplied and or recommended. Follow the filter manufacturers guidelines and try to keep the filters pressure drop to less than 0.2 in. wc. unless the ductwork resistance is low enough to keep the ESP below the recommended maximum.
- The OEM filter rack may not be large enough for the new filter and a transition may be required to fit the proper size filter into the duct system.



- Over 1600 CFM many manufacturers of equipment and filters recommend two filters for proper airflow.
- Two return entrances could be the sides, one side and a bottom or other depending on the flow of the equipment.



- Always follow the OEM specifications.



MERV ratings are for filter performance but not for filter sizing.

- OEM specs from filter manufacturers are needed for sizing and pressure drop

Duct systems should be routinely inspected during annual maintenance visits.

Poor construction and maintenance can lead to duct restrictions even if the ductwork is properly sized.

- Flexible duct should be stretched out completely with no sharp bend and supported a least every 5' with 1½" straps with a maximum sag of ½".
- Any duct that is crushed dented or otherwise distorted from its original size should be repaired.
- Dirt or debris (mainly in returns) should be removed and cleaned.

If the external static pressure is too high, then the problem must be corrected.

Even though the premium ECM motor will compensate for variations in static pressure, it does have its limits, as previously discussed.

- Clean all airside components
- Duct sizing, design and construction should follow ACCA (Air Conditioning Contractors of America) Manuals J & D and/or SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) standards
- Filters may need to be re-sized if changed from what the manufacturer supplied and/or recommended.

The Cost Factor -

Remember that good duct static will move air quietly and cost less money to operate. The ECM motor will make up for ductwork that has moderately high static, but at a cost. Constant airflow means the system capacity will be maintained, but the motor will be using more energy as well. Compare this to a PSC motor, where high duct static will reduce airflow, lower system capacity, and cost a lot more to operate in long system cycles.

This motor ROCKS!!!

No not that kind of rock. Many technicians will notice that when the ECM motor first starts up; it will rock back and forth. This is normal. The motor is using its electronic position sensing to make sure that it is turning in the proper direction. Remember the back EMF in the unused winding? If the rotor is not turning, then no back EMF is produced. When it first starts, it may rotate correctly or incorrectly. Once the rotor position is sensed, the motor control energizes the phases in the direction of the required rotation.



If the motor is not operating...

Troubleshooting the premium ECM motor can be very simple if you remember that it is not just on or off. There are basically four problems that will not allow the motor to run.

- There is no input power to the motor controller (high voltage inputs).
- There is improper or no communication to the motor controller (low voltage inputs). This problem could be in the interface board or the low voltage connector.
- The motor controller has failed.
- The motor module (3Ø motor) has failed.

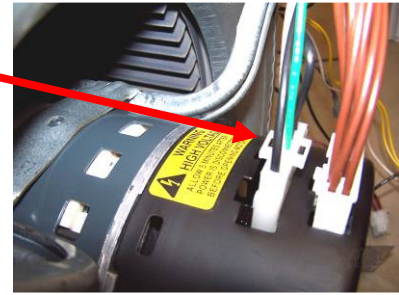
Of these four problems, we can help you with three, leaving only the communication from the OEM's interface board for troubleshooting using the OEM's service guide.

**40% of GE ECM™ field returns are
“No Problem Found”.**

Do not simply assume the motor has failed because it is not running!

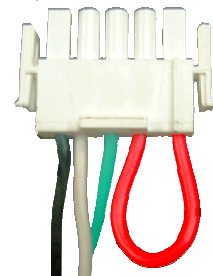
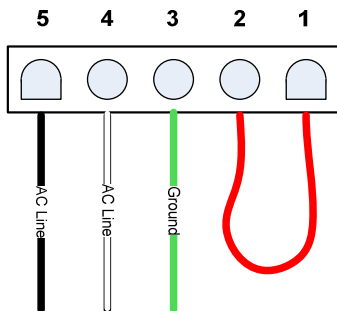
Check the Input power (High Voltage) to the motor controller.

1. Disconnect the power to the system
2. Disconnect the 5-pin (high voltage) connector
3. Restore the power to the system
4. Check for proper input power



Safety Notes:

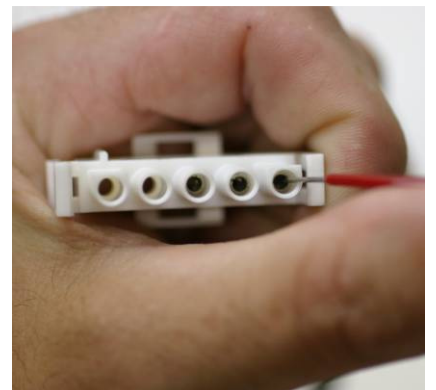
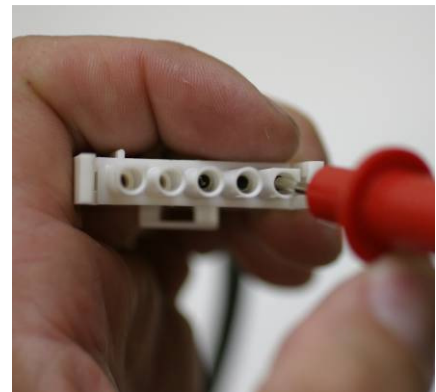
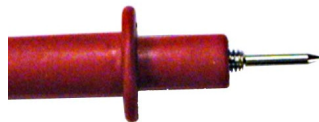
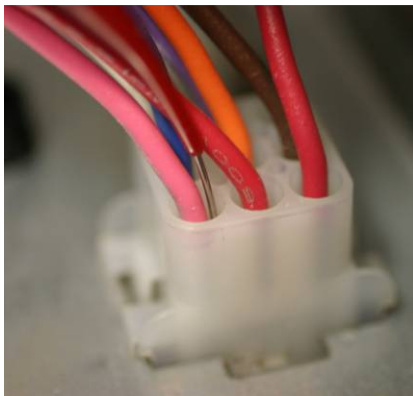
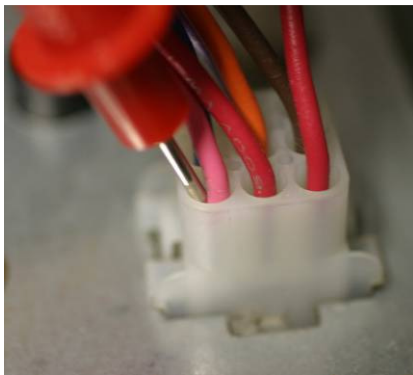
- **Never disconnect the 5-pin high voltage connector from the motor with the power on to prevent arcing.** The ECM motor may draw as much as 150 amps peak when powered up. Remember that the ECM motor uses electrical energy even if the motor is not doing useful work (is at rest).
- Do not trust the blower door switch for power disconnection. To avoid frequent arcing of the door switch contacts use the main disconnect on any system with an ECM motor before removing or replacing the blower door.
- Always pull on the connector and not the wires. The 5-pin connector has latches on each end. To remove the connector, squeeze the two latches together and pull gently. You may want to note the orientation of the plug. Remember it is keyed, often located in the down position on the motor, and sometimes where there is limited working space.



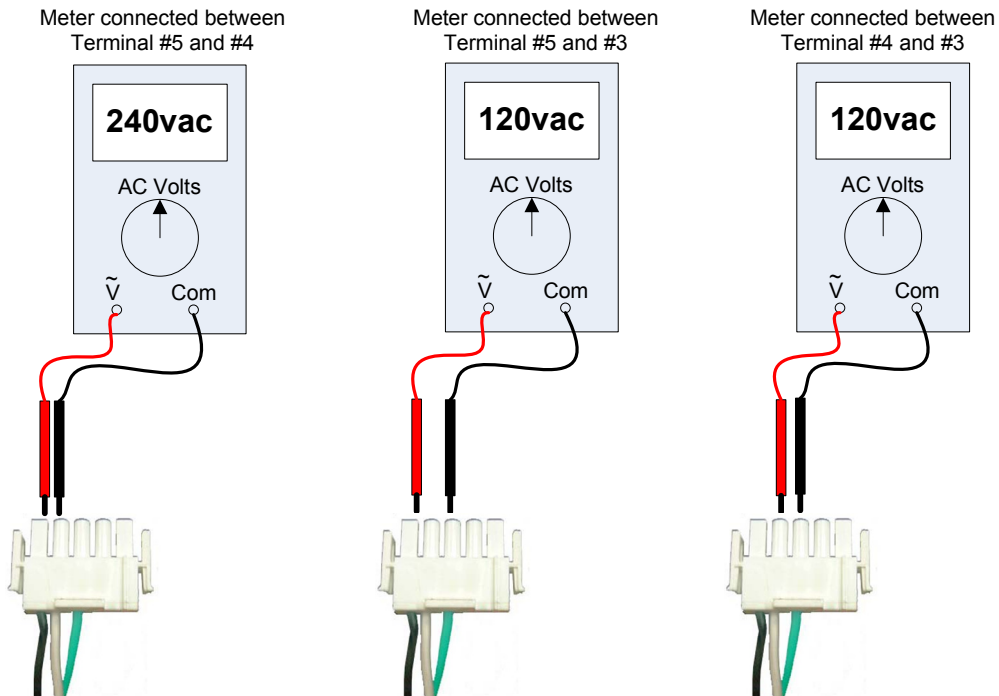
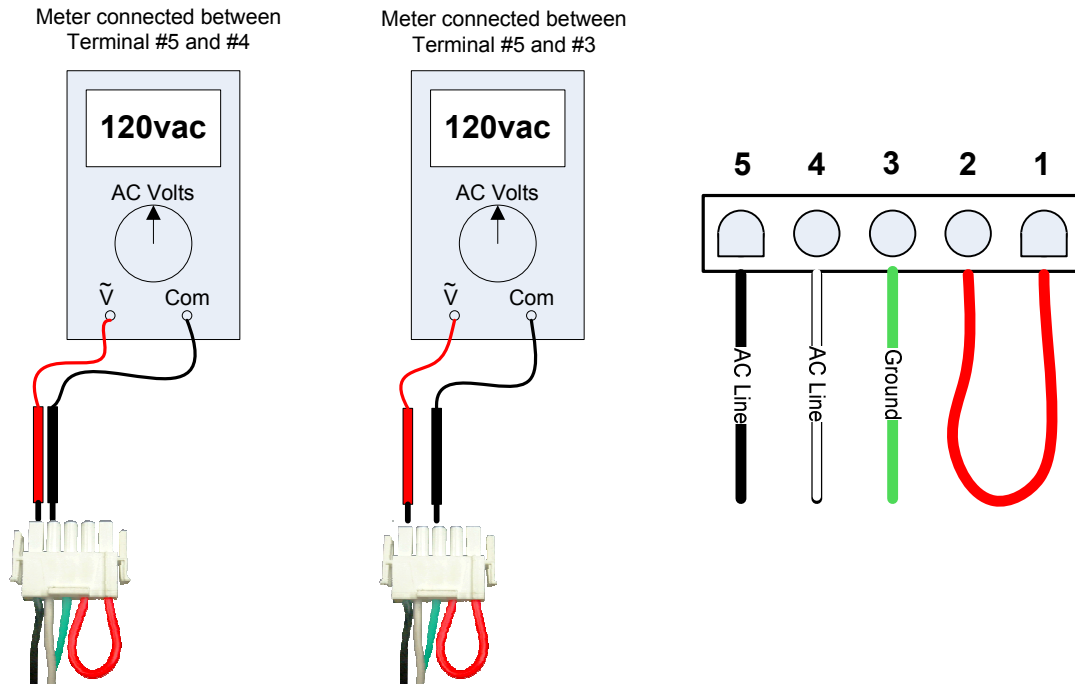
- Always confirm that the system power has been disconnected with a meter. Check line to line and each line to ground.

Tech Tips

- The input power can be within $\pm 15\%$ of the nominal 120vac or 240vac. Any voltage outside of this range should be corrected.
- A True-RMS meter is not needed to check input voltage to this motor. Any standard AC voltmeter analog or digital will work as long as it can read voltage up to at least 500 volts.
- If the polarity is reversed on the 120v connection the motor may still run, but this should be corrected.
- Remember that the 120vac application requires the red jumper and the 240vac application must have this jumper removed. The jumper may not always be red.
- Standard meter leads test pins are typically larger than the terminals or sockets from the plug connections being checked for voltage. Using thinner test pins will prevent terminals from being damaged by voltage checks. Below is an example of a standard meter lead test pin and a thinner one. These test pins are also available in 90° angle for tight areas. These types of leads (as shown below) can be purchased from most meter manufacturers. Our leads were supplied by Test Products International (TPI). For more information on these leads please visit our website at www.theDealerToolbox.com.



With the main power restored, check the power at the 5-pin connector as shown.



Reconnecting the plug

After all of the input high voltage power connections have been confirmed or corrected turn the power off and reconnect the plug to the motor control.

- When reconnecting the plug remember that the connector is keyed. Many times this connector is forced in the wrong way in tight dark areas.
- Make sure that the plug is in all the way to prevent arcing. If it is not fully connected vibration may cause the connection to be broken. When the plug is fully inserted the latches should click on both sides. If the plug is inserted with the correct orientation, it should slide gently all the way in until both clicks are heard.
- Forcing the plug in the wrong way may cause irreversible damage to the motor.
 - On the 120vac application the motor may actually run but future damage and /or operation problems could result.
 - On the 240vac application the motor will be permanently damaged with high voltage on the voltage doubler circuit.

Ground

It is also a good practice to make sure that the ground connection from this connector to the main ground is good.

Where is the ground from the 5 pin plug connected?

Where is the main ground from the line power to the system connected?

If they are not together, you can check the ohms between the two connections. This will ensure that the cabinetry between the two connections has sufficient grounding quality. Turn the power off to the system before checking the ohms.

- The ohms reading should be 0 between the two connections.

The motor will run if not grounded properly but **this is a safety concern that must be corrected.**

There is also an optional ground wire that can be installed from one of the motor bolts to the blower housing. If the OEM specifies this ground wire make sure it is in place.

Checking the motor control and motor module

On motor models 2.0 and 2.3, using Thermostat Mode or PWM, the motor control can be checked with the TECMate Service Tool from GE ECM. This tool makes short work of the big question, is it the motor or the communication?

The TECMate has been built in two versions. The TECMate XL™ is a 4 switch version (**now discontinued but still available through some distributors**). The TECMate PRO™ is a single switch version (**current model**). Both perform the same basic function of sending an artificial communication to the motor controller, telling it to run.

TECMate XL™







TECMate PRO™



TECMate Usage Chart

GE ECM by Regal Beloit

 GE ECM By Regal-Beloit	 4 button TECMate XL*	 1 button TECMate PRO	 4 button w/three position (G) switch** GE ECM Troubleshooter
	Indoor Blower Motors All manufacturers 1.0, 2.5, X13 All manufacturers 2.0 / 2.3***	N/A Y	N/A Y

Y = This tool will accurately diagnose this motor
 N/A = This tool is not applicable to this motor

- * The TECMate XL is no longer available. It has been replaced by the TECMate PRO.
 - ** The GE ECM Troubleshooter contains its own instructions for use and is available only from Carrier/Bryant distributors part number (P/N HK50EA001).
 - *** The TECMate XL may not accurately troubleshoot Carrier/Bryant 2.0/2.3 motors.
- Note - These tools are not for use on GE ECM condensing fan or draft inducer motors.**

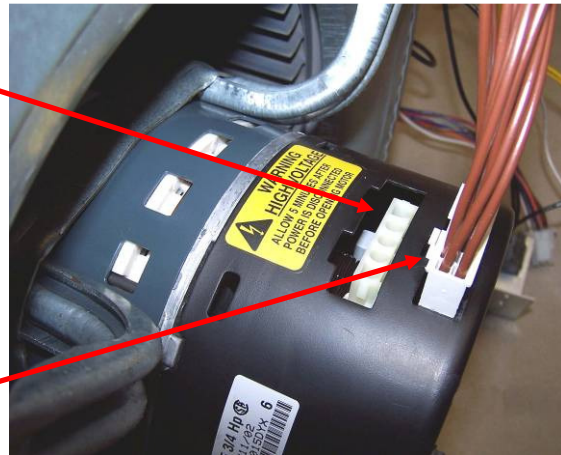
Connecting the TECMate

Both TECMate models are connected in the same manner.

1. Disconnect the AC power from the system and wait for the motor to come to a complete stop.
2. Remove the 16-pin connector from the motor, and connect the 16-pin connector from the TECMate to the motor. Do not disconnect the 5-pin AC power connector from the motor. However, removing the 5-pin connector will make it easier to get at the 16-pin connector latch. Simply reconnect the 5-pin connector once the TECMate is connected.

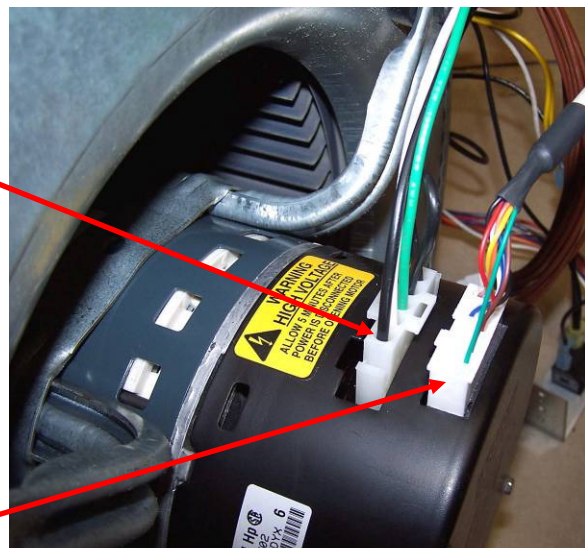
**5-pin
Connector
Removed**

**OEM 16-pin
Connector
Latch**

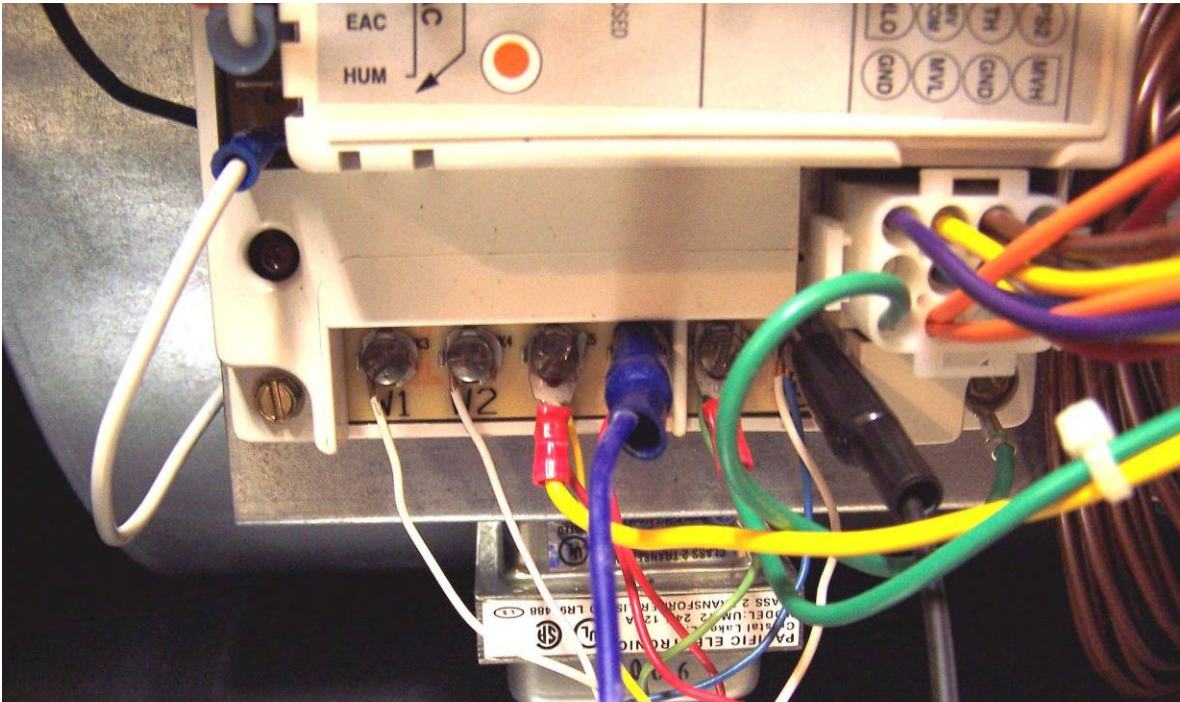


**5-pin
Connector
Re-installed**

**TECMate
16-pin
Connector**



3. Connect the two alligator clips from the TECMate to a 24vac source. (Terminals R and C on most furnaces and air handlers represent 24vac power and 24vac common respectively). These two wires are not polarity sensitive. If these wires are connected to 120vac or 240vac, permanent damage may be done to the motor and the TECMate.



4. Make sure the switch(s) on the TECMate are in the off position.
5. Reconnect the AC power to the system.

The ECM motor can be operationally checked while the blower housing is in or out of the furnace or air handler, however it is preferred to be in. The motor should never be operationally checked without the blower wheel attached. Such operation will cause the motor to oscillate up and down.

TECMate XL™

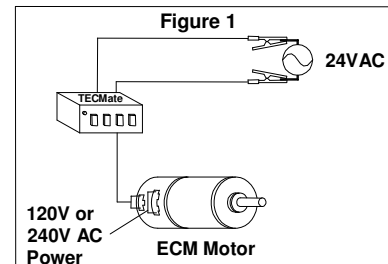
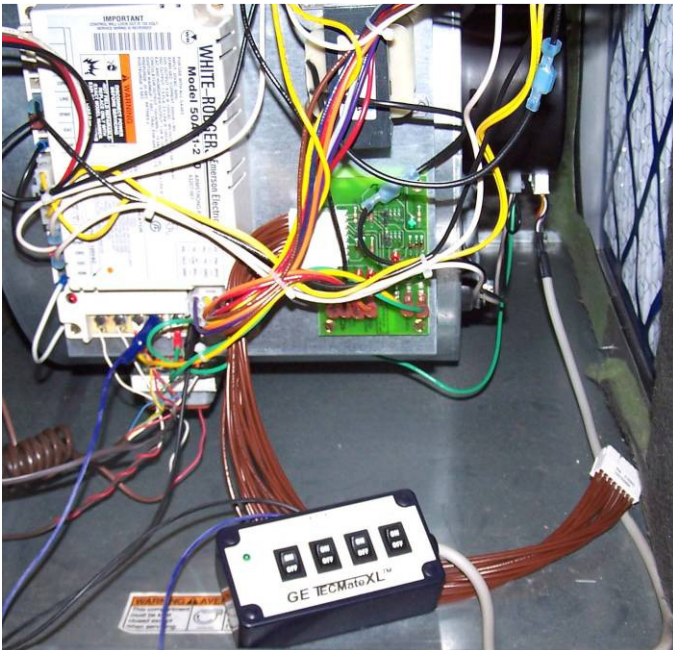
When the power is turned on to the system, the TECMate XL™ power LED light should illuminate.

- Place the correct switches in the ON position and observe the motor for 15 seconds. (Refer to the table on the back of the TECMate XL for switch selections of the various test mode settings.)

Table as shown on the back of the TECMate XL™

Test Mode	Switch Selections				Expected Result of Typical System
	Continuous Fan [G]	Heat [W / W1]	Cool [Y]	[BK / PWM]	
Fan-only	ON	OFF	OFF	OFF	Motor runs at fan airflow
Heating	ON	ON	OFF	OFF	Motor runs at Heating airflow (higher than Fan only)
Cooling	ON	OFF	ON	ON	Motor runs at Cooling airflow (higher than fan only)
Dehumidification	ON	OFF	ON	OFF	Motor runs at Dehumidification airflow (lower than cooling airflow)
Variable Speed	ON	OFF	OFF	ON	Motor runs

Table 1: Settings for Thermostat mode and Variable Speed Mode



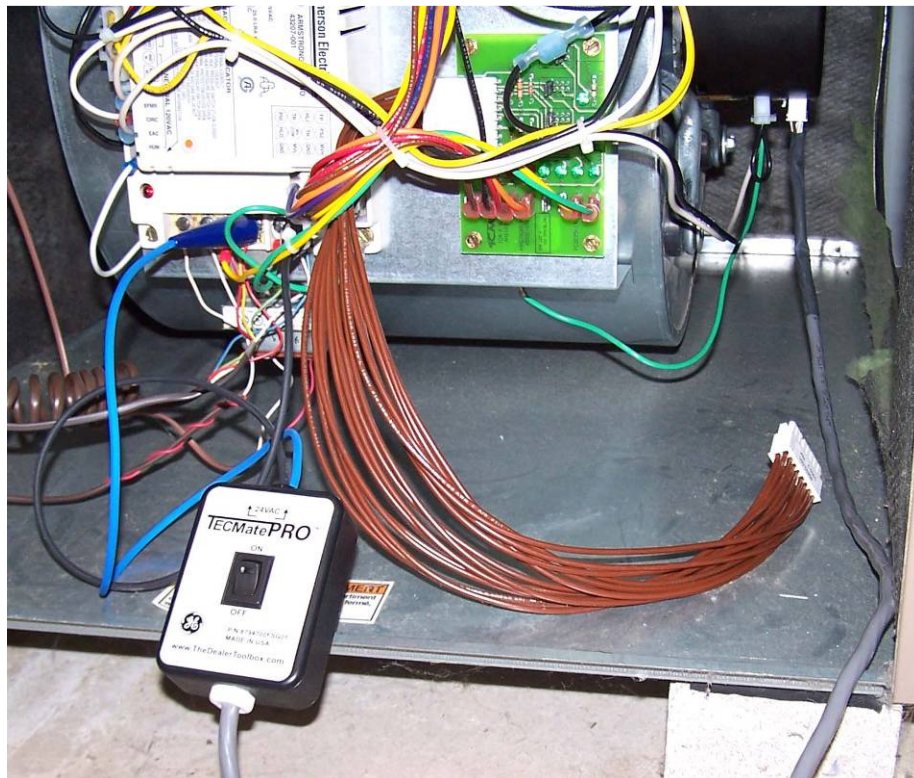
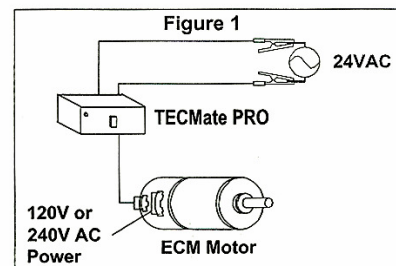
TECMate PRO™

6. Place the switch in the ON position and the LED light on the switch should illuminate when connected properly to 24vac. Observe the motor for 15 seconds. (Refer to the Table on the back of the TECMate PRO™ for operation guidelines.)

Table as shown on the back of the TECMate PRO™

1. Make sure the TECMatePRO™ and HVAC units are OFF.
2. Unplug 16 pin Connector from ECM Motor.
3. Plug in 16 pin connector from TECMatePRO™ to ECM motor.
4. Attach blue and black clips to 24VAC source and power ON HVAC unit.
5. Turn TECMatePRO™ ON.
6. Motor should start within 15 seconds.
7. Turn power OFF to TECMatePRO™ and HVAC unit.

P/N 8794700FSG01



If the motor starts with the TECMate:

The system malfunction is not caused by an ECM control or motor problem.

- When finished testing with either TECMate, place the switch(s) in the OFF position on the TECMate and wait for the motor to completely stop. (Based on the OEM program, sometimes the motor will not shut off immediately after a test; this is normal.)
- Once the motor comes to a complete stop, turn off the system power before removing the TECMate. Reconnect the 16-pin connector from the system and proceed with diagnosis. Remember that this connector is also keyed, and has one clip that should click, when the connector is inserted properly and completely.

The next logical step is to check the low voltage communication on the 16-pin connector. Whether the OEM is using Thermostat Mode or PWM, this troubleshooting is going to require their flowcharts. **At this point the most likely problem is the communication from the OEM board or the communication through the 16-pin connector.**

Do not assume the connector is good. Check the connections at both ends for damage from improper connection and the wires to the connector. Make sure none of the sockets are distorted, bent or pushed out of the connector.

If the motor does not start with the TECMate:

The electronic control (motor control) should be replaced. Before replacing the electronic control module, you must test the motor module to ensure it is not also damaged. Procedures for testing the motor module are included in “Replacing the ECM Module” on the next page.

Motor Control



3-Phase AC motor

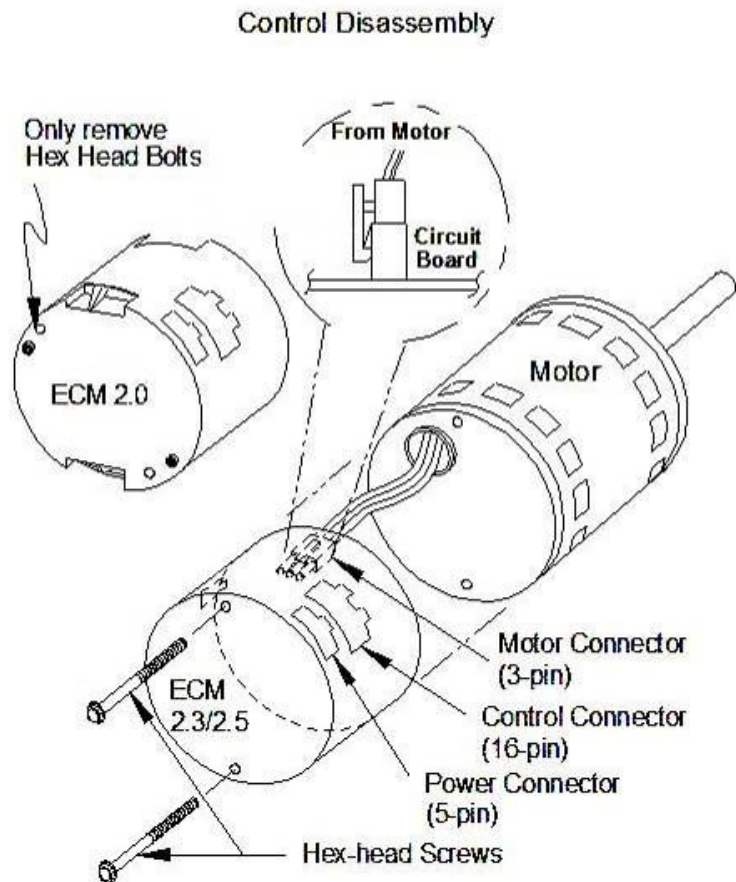


Replacing the Premium ECM Control Module

Warning – You must have the correct replacement module. USING THE WRONG MODULE VOIDS ALL PRODUCT WARRANTIES AND MAY PRODUCE UNEXPECTED RESULTS.

Warning – Disconnect AC power from the HVAC system and wait 5 minutes before opening the motor to avoid electrical shock from the motor's capacitors.

1. Unplug the 5-pin connector and the 16-pin connector from the motor control.
2. Remove the blower assembly from the HVAC system.
3. Remove the two (2) hex-head screws from the back of the control.
4. Unplug the 3-pin connector from inside the control by squeezing the latch and gently pulling on the connector.
5. Ensure the motor module is not damaged by performing the two simple tests listed on page 65.



Premium Motor Control Disassembly Review

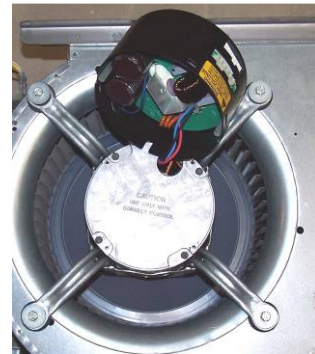
Step 1 – Unplug the 16-pin connector and the 5-pin connector from the motor control.



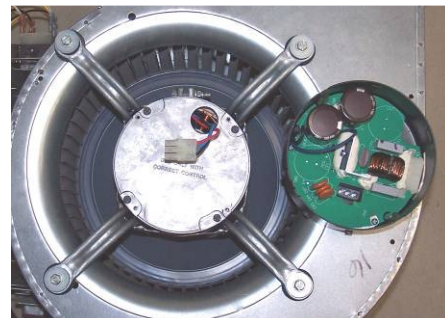
Step 2 – Remove the blower assembly from the HVAC system.



Step 3 – Remove the two (2) hex-head screws from the back of the control.



Step 4 - Unplug the 3-pin connector from inside the control by squeezing the latch and gently pulling on the connector.



Motor Module Tests

These tests are no different than ohming out a 3-phase compressor motor. We want to confirm that the windings are not shorted to ground and still have equal resistance phase to phase.

Test A – measure the resistance between each of the 3 motor leads to the unpainted part of the end shield (Winding to Ground Resistance). Typically a good motor would read infinite ohms to ground on all leads and a bad motor would read 0 (zero) ohms to ground on any one or all of the leads. However for the purpose of this test, we will use 100,000 (100K) ohms as the bar, and set the meter to the highest ohms scale unless it's auto-ranging. **Meg-ohm meters should not be used for this test.**

If the motor fails (the resistance is less than 100k ohms on any one or more leads) **then replace the motor module with the equivalent.**

If the motor module passes (the resistance is greater than 100k ohms) **then perform Test B.**

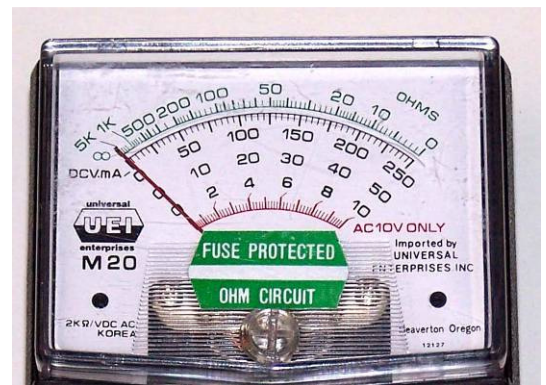


Tech Tip

Analog or digital ohm meters will work for this test. Keep in mind that “infinite” ohms on digital meters may show up in many different ways as such as (**.OL**), (**I[∞]**), or even (**Open**).

Just as a reminder or a way to check a new meter to confirm its readings, when the leads are not touching, this is infinite ohms. When the leads are touching, this should be 0 (zero) ohms.

Infinite ohms on an analog meter is basically no needle movement. If you look closely you can see the infinity symbol (∞). When an analog meter reads 0 (zero) ohms, the needle typically moves to the opposite end of the scale. Zero can also be calibrated on most analog meters. On this meter it's the screw in the middle under the words “OHM CIRCUIT”. To calibrate the meter to 0 (zero) you would touch the two leads together, and adjust the screw until the needle is over the 0 (zero).



Motor module **Test A** (winding to ground) exercise. Circle the “Pass” or “Fail” next to each meter and under the motor number.

<p>Motor # 1</p> <p>Pass or Fail</p>	<p>Lead 1 to Ground</p> <p>Pass or Fail</p>	
	<p>Lead 2 to Ground</p> <p>Pass or Fail</p>	
	<p>Lead 3 to Ground</p> <p>Pass or Fail</p>	
<p>Motor # 2</p> <p>Pass or Fail</p>	<p>Lead 1 to Ground</p> <p>Pass or Fail</p>	
	<p>Lead 2 to Ground</p> <p>Pass or Fail</p>	
	<p>Lead 3 to Ground</p> <p>Pass or Fail</p>	

Test B – measure the motor phase-to-phase resistance by checking these combinations of the 3-pin motor connector with an ohmmeter. For the purpose of this test, start at either end of the connector as Lead 1.

- Lead 1 to Lead 2
- Lead 1 to Lead 3
- Lead 2 to Lead 3



The resistance values from each lead to lead check should be in the ranges indicated below with the meter set to the highest ohms scale unless it's auto-ranging.

The lead to lead resistance across any two leads should be less than 20 ohms.

Each lead to lead resistance should be the same within $\pm 10\%$.

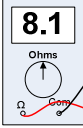

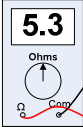

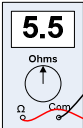

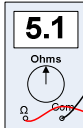

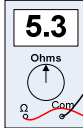



If the measured resistance is outside either of these ranges, then the motor module needs to be replaced with an equivalent.

The motor must pass both tests to be good. If the motor passes both tests, replace the motor control (control module) only as long as your local distributor can supply it that way. If it is under warranty always replace whatever the OEM specifies. If the motor fails either test, it must be replaced.

Motor module **Test B** (phase to phase) exercise. Circle the "Pass" or "Fail" next to each meter and under the motor number.

<p>Motor # 1</p>	<p>Lead 1 to Lead 2</p> <p>Pass or Fail</p>	
<p>Pass or Fail</p>	<p>Lead 1 to Lead 3</p> <p>Pass or Fail</p>	
	<p>Lead 2 to Lead 3</p> <p>Pass or Fail</p>	

Motor module **Test B** (phase to phase) exercise. Circle the “Pass” or “Fail” next to each meter and under the motor number.

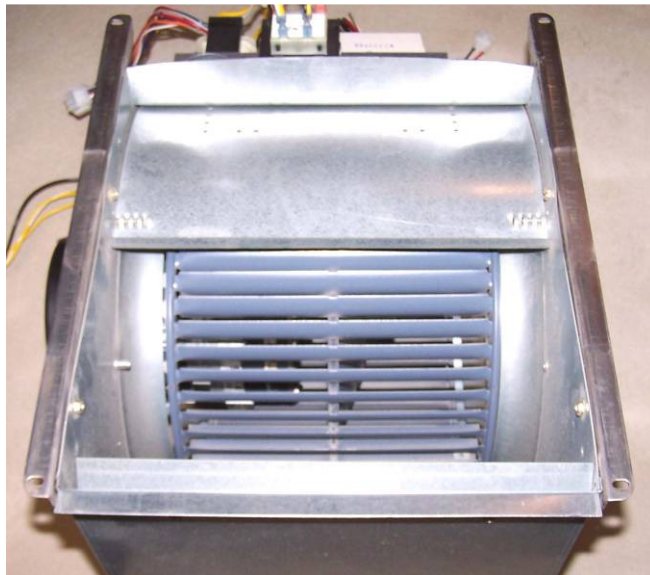
	Lead 1 to Lead 2		
	Pass or Fail		
Motor # 2			
Pass or Fail	Lead 1 to Lead 3		
	Pass or Fail		
	Lead 2 to Lead 3		
	Pass or Fail		
	Lead 1 to Lead 2		
	Pass or Fail		
Motor # 3			
Pass or Fail	Lead 1 to Lead 3		
	Pass or Fail		
	Lead 2 to Lead 3		
	Pass or Fail		

If the motor module needs to be replaced, make sure the belly band is not covering any vents, and is not installed on the motor control. The motor module does not have a specified orientation, however, the motor control does. Make sure the three wire plug will reach the motor control when it is oriented properly before tightening down the belly band. The control module orientation is covered on the next page.

Always make sure to tighten the wheel key on the flat side of the motor shaft with blower wheel centered in the housing.



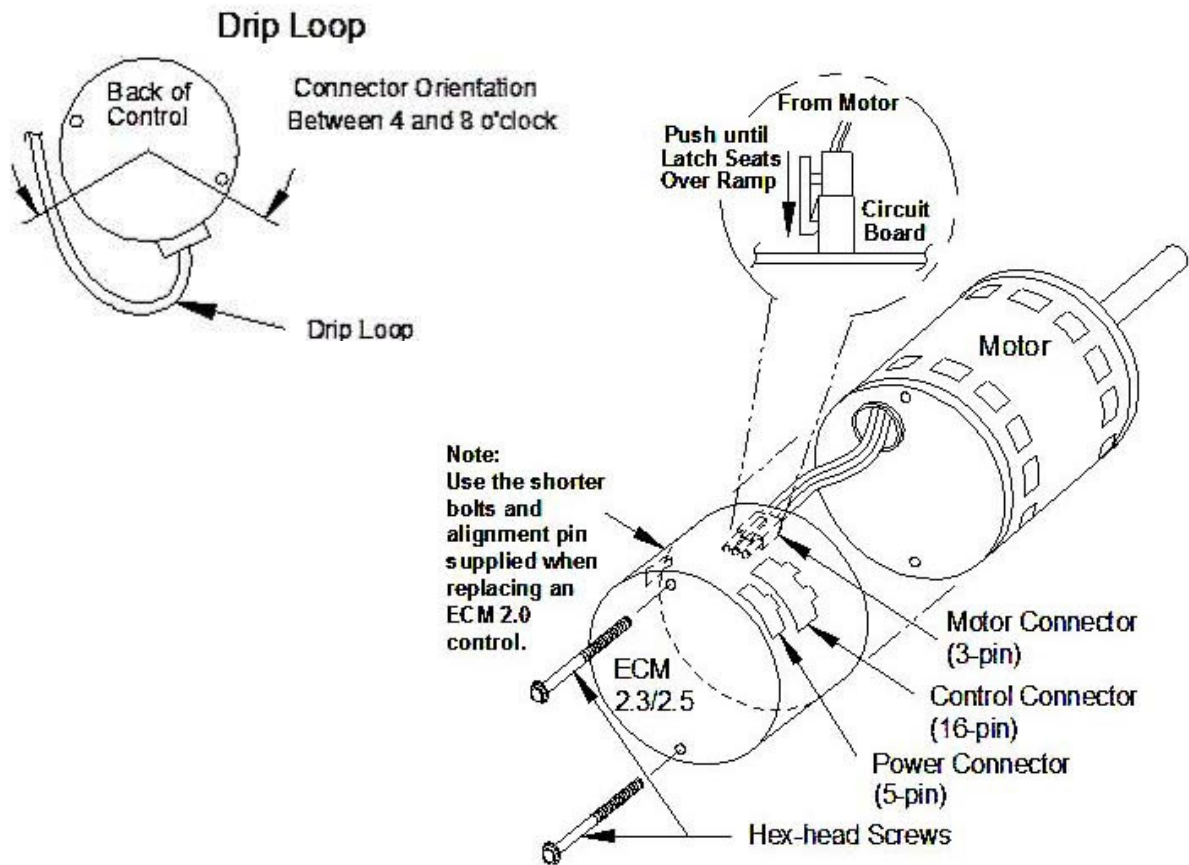
If the wheel sits too close to the motor when centered or cannot be centered because it hits the motor, the motor must be adjusted in the belly band.



Attaching the new control module

Insert the 3-pin connector back into the new control module. A slight click will be heard when inserted properly.

If replacing an ECM 2.0 control with an ECM 2.3 control, insert the plastic tab into the perimeter of the replacement control and align the tab with the mating hole in the end shield. Use the new shorter bolts provided to ensure a secure attachment. Orient the control connectors to the end shield between 4 & 8 o'clock insert the bolts and tighten.



If replacing an ECM 2.3 with and ECM 2.3 control, orient the new control to the motor's end shield with the connectors facing down, insert the bolts and tighten.

Re-install the blower/motor assembly into the HVAC system by following the manufacturer's guidelines.

Plug the 16-pin connector and the 5-pin connector back into the motor. Make sure the keyed connectors are inserted properly and securely until they click.

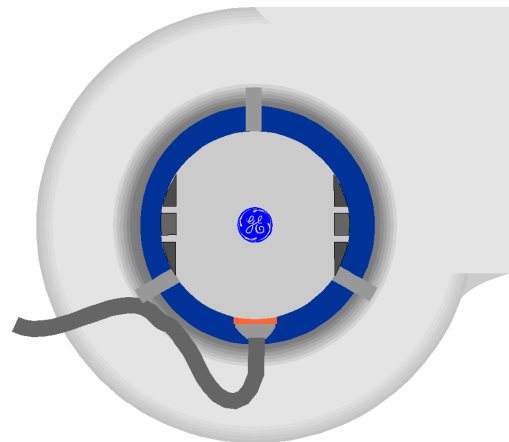
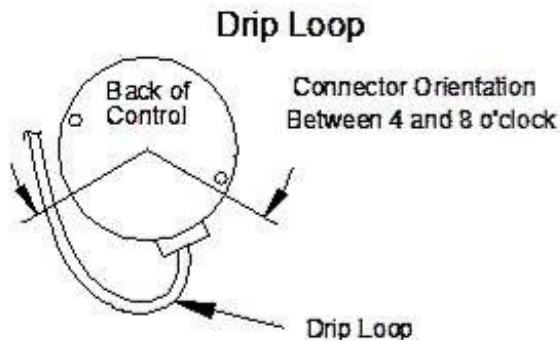
Re-install the blower/motor assembly into the HVAC system by following the manufactures' guidelines.



Plug the 16-pin connector and the 5-pin connector back into the motor. Make sure the keyed connectors are inserted properly and securely until they click.



Be certain to form a drip-loop so that water cannot enter the motor by draining down the cables. Condensate or droplets can accumulate in the harness and may find their way into the motor.



Final installation checks

- Check all wiring and connections, especially those removed while servicing.

Ensure the system is setup as follows:

- Verify the condensate drain is not plugged or clogged.
- Reconnect the AC power to the HVAC system and verify that the new motor control module is working properly.
- Check and plug leaks in return ducts and equipment cabinet.
- Verify that the system is running quietly and smoothly, in all modes (heating, cooling, and continuous fan) and all stages (if applicable).
- Return all thermostat settings to the customer's preference.

Note: If this is a repeat failure, then it is important that you check the following:

- Any evidence of moisture requires correcting the issue.
- If this area is subject to high amounts of lightning strikes, the use of additional transient protection may be helpful.

Good Practices

- Finish all service calls by checking all safeties, and perform a visual inspection of the overall job to prevent call-backs.
- Check the level of Carbon Monoxide (CO) in the vent(s) and living spaces of all homes with fossil-fuel appliances.
- Recommend annual maintenance

Premium ECM Motor Failure Footnotes

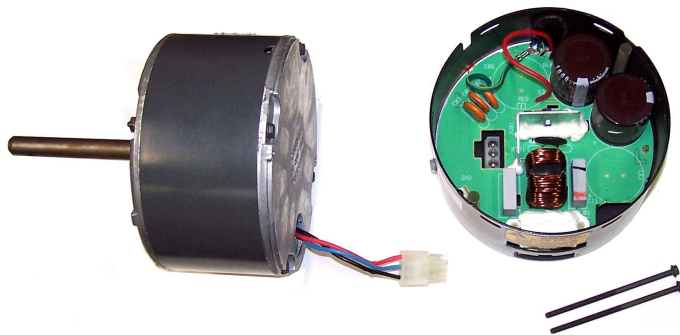
First and most important, **all repair parts for ECM motors must be obtained from the OEM as a specific match to the existing motor or control.** Even if the new part looks like a direct replacement, **read all literature that comes with the new part.** There may be a very small but very important change in mounting, programming, wiring etc... that could make the difference between a long term repair and a short term call back.

Model 1.0 - If this motor is suspect, the TECMate will not help. Use the manufacturer's literature only for troubleshooting. **The 1.0 motor is no longer in production.** If the motor has failed in any way, the entire motor and control assembly will typically be replaced as one piece by the OEM with a 2.0 or 2.3 motor. There may also be a need for an updated "tap board" kit depending on the OEM. These kits may no longer be available. Check with your distributor before quoting the repair. With the age of this system, it may not be a bad idea to recommend replacement of the entire system, especially if the motor and board update is out of warranty.

Models 2.0/2.3 - If these motors are suspect follow the instructions on the TECMate and in the ECM Service Guide to determine if the motor, motor control or both have failed and replace as needed. **The 2.0 motor control is no longer in production.** The replacement motor control will be the 2.3. There should not be any wiring modifications needed. The motor modules are the same.

Model 2.5 – If this motor is suspect, the OEM literature will be needed for troubleshooting and replacement. Currently the TECMate is not set up to test this motor.

Most manufacturers will offer the motor control separate from the motor module on models 2.3 and 2.5. Check with your local distributor to see if they offer control only parts. Sometimes under warranty they may simply provide you with an entirely new motor assembly.



Motor Identification Chart

GE ECM by Regal Beloit model designations

ECM 2.3/2.5



ECM 2.0



Two changes to the 2.3/2.5 model motors

1. Model ID on the nameplate
2. Gray paint

Current Models



Early models



Model 1.0 motors were not labeled as such. They are the only motor with a square motor control.

Model 2.0 motors were not labeled as such. They are the only motor with a round un-painted motor control with 5-pin and 16-pin connections.

Model 1.0 and 2.0 motors are no longer in production.

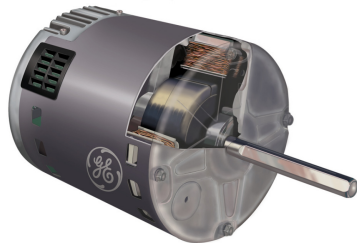
Early model 2.3/2.5 motors were not labeled as such. These motors can be identified as follows:

- 2.3 motors will have 10 or more wires in the 16-pin connector
- 2.5 motors will have 5 or less wires in the 16-pin connector

All current model 2.3/2.5 motors are labeled as such.



Standard ECM Indoor Blower Motor



Proven.

THINK of it
as a TANK that gets 200 MPG.

Introducing the X13 – our new blower motor combines the simplicity of PSC speed taps with the efficiency of our field-proven permanent-magnet technology. The result is a rugged standard-ECM machine that's easy to set up in the field and up to 200% more efficient than a PSC motor. The X13 is now available in new equipment from every major manufacturer. See your distributor for details.

2006
DEALER DESIGN
AWARDS
NEWS | GOLD

X13 Standard ECM Motor Features:

- Available in typical horse power (Hp) ranges of 1/3, 1/2, 3/4, and 1 Hp
- Approximately 2 inches longer than a typical induction motor



- One piece motor design
- All of the electronics are housed safely inside the motor shell
- Fully encapsulated electronics to prevent water damage
- Ball Bearings to support the speed range
- EMI Filter for surge protection and line transient issues



X13 Motor

- Easy Set-up
- Easy Troubleshooting
- One Piece Replacement
- 5 Outputs
- Demand Specific Torque Programming
- Programmable Fixed Off Delays Only
- High Efficiency



PSC Motor

- Easy Set-up
- Easy Troubleshooting
- One Piece Replacement
- 5 Outputs

vs.

As of July 2006, the **current applications of the X13 include** single stage:

Air Handlers/Fan Coils

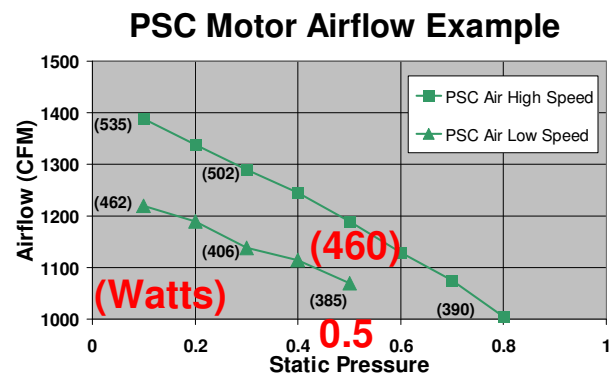
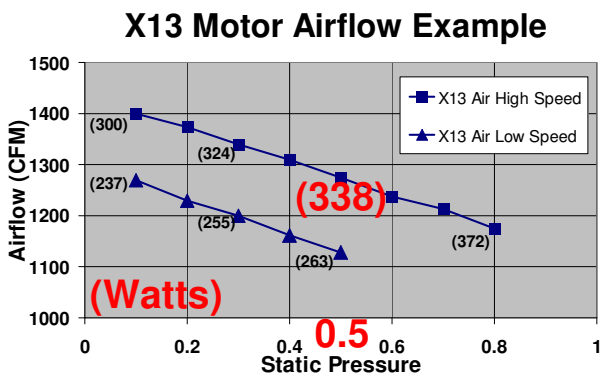


Package Systems



The efficiency of the X13 helped some manufacturers get their product up to 13 SEER.

The X13 standard ECM motor uses less energy (watts) than the PSC motor both at rated speed and constant fan mode. The charts below show Airflow (CFM) on the left and Static Pressure (ESP) along the bottom. Notice at 0.5 in. wc. the X13 is using less energy and making more airflow.

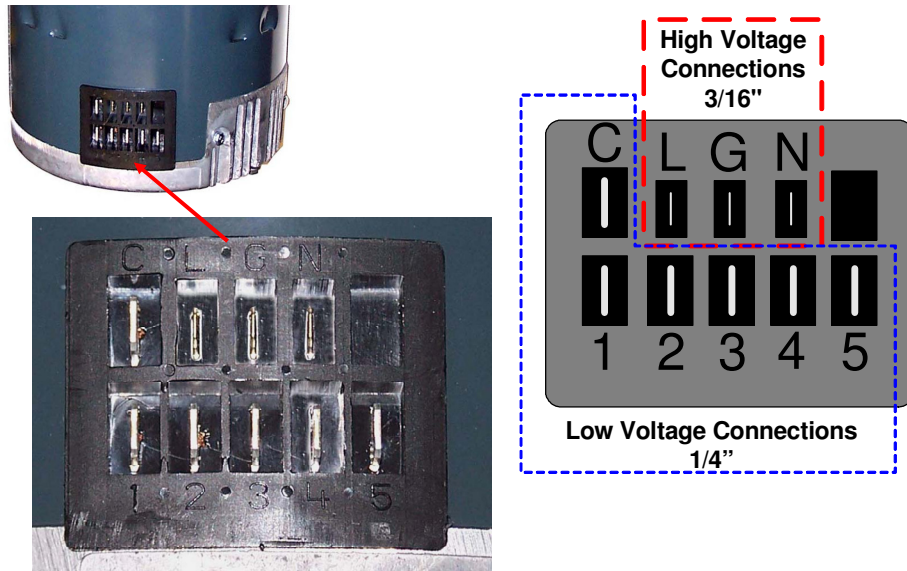


The X13 motor is programmed to provide constant torque. Or simply put, if static pressure changes, the motor program will only maintain the amount of programmed torque. This should not be confused with constant airflow. Even though the X13 can maintain torque, if static pressure increases, airflow will decrease, similar to the PSC motor curve shown above. However, airflow will not decrease as poorly as a PSC motor, since torque is being maintained.

If the static pressure on these systems went up to 0.8 in. wc., the X13 motor would be making almost 1200 CFM, whereas the PSC motor would only be at 1000 CFM. This is because the PSC motor cannot maintain torque if pressure increases.

So even though the X13 operates by constant torque, it still provides airflow on a curve just like the PSC motor in response to changes in static pressure. Only it holds that curve up a little better than the PSC motor does.

X13 Connections and Communications



There is one connection block on the X13 motor with two rows of terminals and two different size terminals used.

The Power Inputs (High Voltage) to the motor connect through the 3/16" terminals on the following terminals:

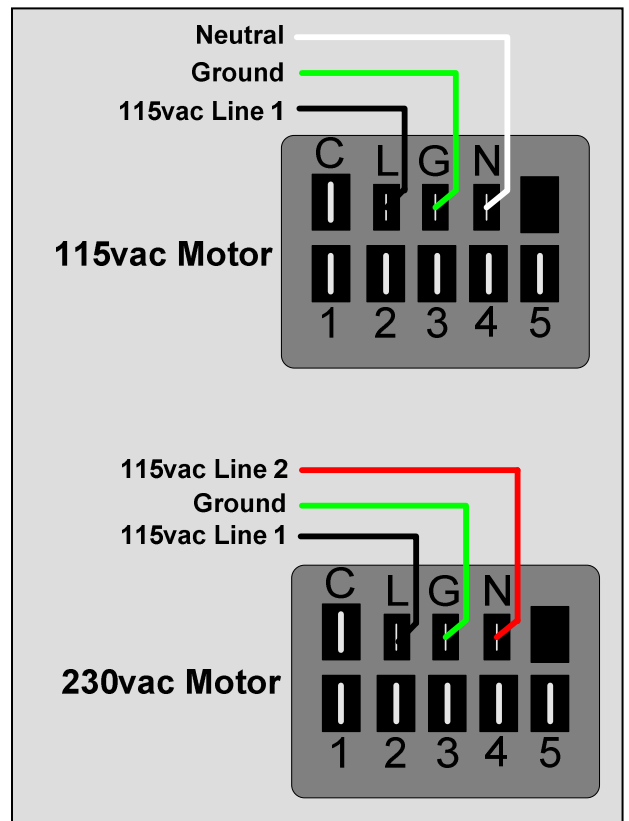
- (L) – Line 1
- (G) - Ground
- (N) - Neutral or Line 2

The power connected to these terminals is live whenever they system is powered regardless of a demand call to power the internal electronics.

There are two discrete models per voltage, one for 115vac applications and one for 230vac applications.

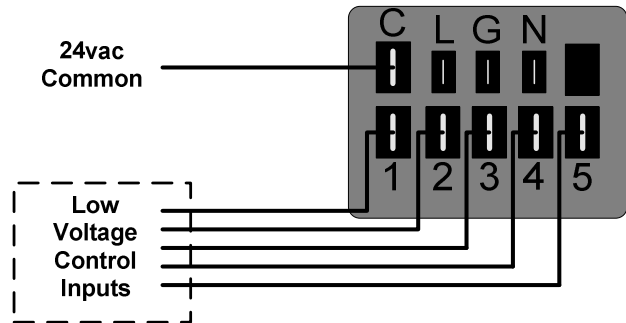
The allowable voltage range on these motors is:

- 98-132vac on the 115vac model
- 196-264vac on the 230vac model



The Control Inputs (Low Voltage) to the motor connect through the 1/4" terminals. Terminal (C) is used for common and terminals 1-5 are used to select airflow settings programmed into the motor.

Communication to the X13 motor is the low voltage 24vac that is provided to taps 1-5. It is important to understand this voltage is used to communicate to the motor only, not to operate it. In simple terms, the 24vac provided to each tap is only a communication signal used to select up to five different torque values. The motor's control board uses this signal to determine which torque value it should deliver, and then uses the line voltage (high voltage that is continuously connected) to operate the motor, according to that program.



The X13 can also accept 9-23vdc as a communication signal. However currently all manufacturers are using 24vac.

The X13 motor is programmed to provide airflow according to the manufacturers specifications of the torque required to create the airflow needed for each tap selection from lab testing.

Example 1 – If tap 1 is to provide airflow for the furnace and the torque needed to provide the airflow for a proper temperature rise in that furnace is 76% of the maximum torque ability of the motor that will be the value programmed into the tap.

Example 2 – If tap 2 is to provide the airflow for a connected air conditioner and the torque needed to provide the airflow for a specified tonnage of cooling is 88% of the maximum torque ability of the motor that will be the value programmed into the tap.

The manufacturer can specify either the % of maximum torque or the actual torque value in the motor program.

These values are of no consequence to the field technician other than to understand what its capabilities are. The manufacturer will simply provide a table or diagram showing which tap is to be used for heating, cooling and continuous fan selections depending on the equipment it is used in, i.e. a furnace, air handler or package system.

The information most important to the field technician is understanding how the X13 motor operates compared to a PSC motor or the Premium ECM 2.3 motor for proper set-up and troubleshooting.

Even though changing tap connections does change the speed of the motor, it is important, in theory at least, to understand that these are programmed levels of torque. Referring to the taps as “speeds” or “speed taps” is only a problem if the you do not understand three important points:

1. Manufacturers could program the taps in any order they choose. For example they could put the higher cooling airflow selection on Tap 1 and the lower heating airflow selection on Tap 2. Most manufacturers are programming the motor starting at Tap 1 and building in torque values respectively.
2. Each tap can have a unique amount of torque programmed for a specific purpose. For example switching from Tap 1 to Tap 2 may very well increase the airflow but not necessarily at a specific interval like changing from low speed to medium low speed on a PSC motor would. Even more important, each motor has a unique program. Changing taps on one motor will most likely have different results than any other.
3. It is not necessary to program all of the taps. If the manufacturer only needs two functions, they may only program two taps, and so on up to five. All X13 motors will physically have 5 taps.

As long as the manufacturer’s charts are always referenced for selecting the tap required per demand, this will not be an issue. Never simply increase or decrease tap settings to adjust airflow without checking these charts.

Important Note: The X13 motor is programmed, by the manufacturer, with the levels of torque required for each specific unit it is used in. Replacement motors must be a direct replacement from the manufacturer for the exact model and size unit. The X13 motor cannot be used as a universal replacement motor for PSC motors or other X13 motors.

On the next page are examples of how different programs could be utilized for different applications by the manufacturers.

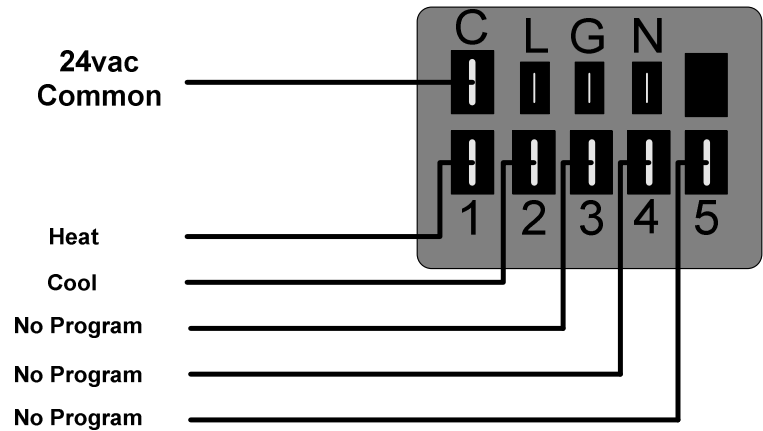
Each of our examples shows an un-programmed tap. However, that does not mean that a manufacturer could not and will not program all taps if needed for a particular application.

Our examples also do not show a tap specifically programmed for a continuous fan selection. This is also up to the manufacturer to decide. Depending on the application, the heating or cooling selection may be used for continuous fan as was done with many induction motor controls. This information is manufacturer specific, listed in the installation instructions for each unit.

Program Examples –

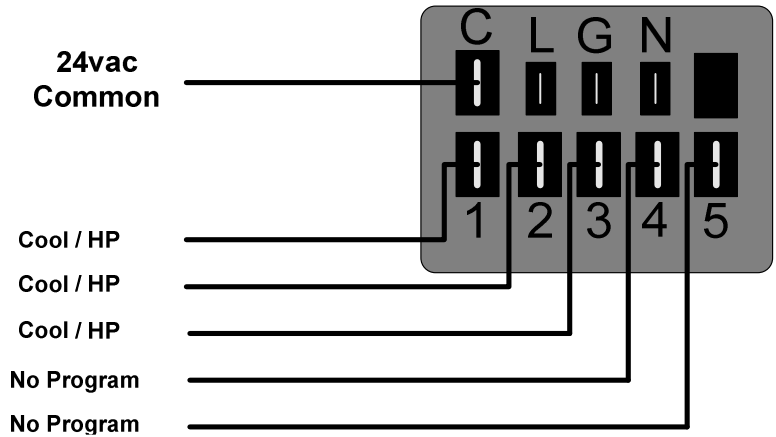
Example 1.

Heat/cool package system.



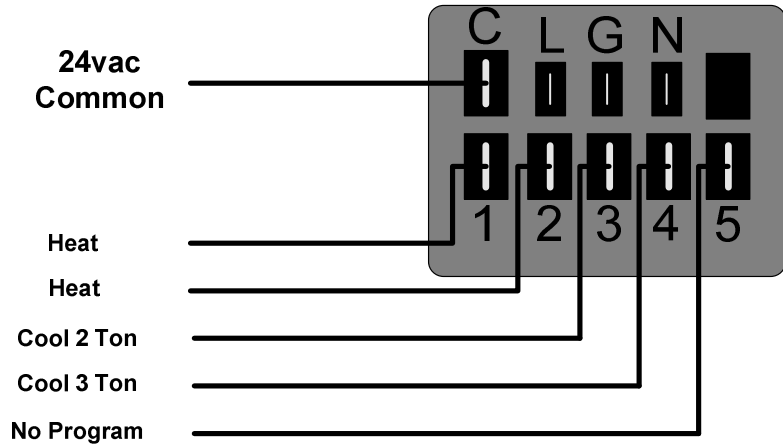
Example 2.

Air handler used with a heat pump.



Example 3.

Gas heat furnace with the ability to operate with two different tonnage A/C units.



X13 Connections

The wiring connections to the X13 can be made with connectors or individual wires.

Connectors –

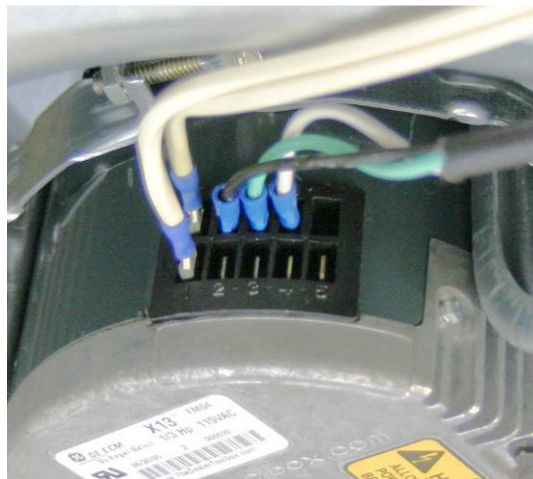
The high voltage connection plug contains the three 3/16” terminals for (L), (G), and (N), and one 1/4” terminal for (C).



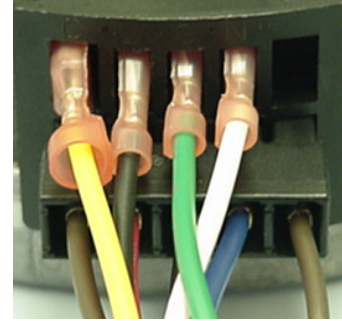
The low voltage connection plug contains the five (1-5) 1/4” terminals.



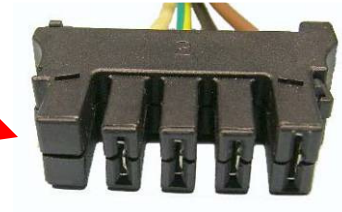
Each of these terminals could also be individually wired as shown here.



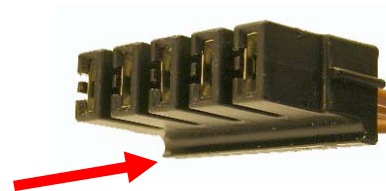
It is the manufacturer's option to use one or both of the plugs, all terminals wired individually, or a combination of the two. Keep in mind that if the high voltage plug is used, it would also need to be used to check the low voltage to the motor, since the 24vac common terminal is in this plug.



The plugs are designed to prevent improper connection. The high voltage plug has a full blank tab on the opposite end from the (C) terminal. This prevents it from being installed on the low voltage (1-5) terminals.



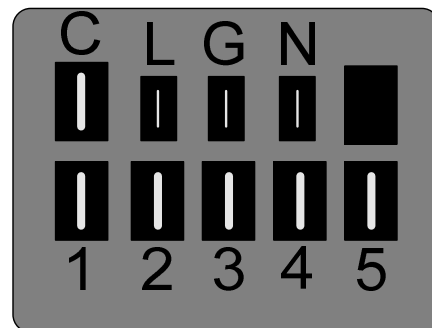
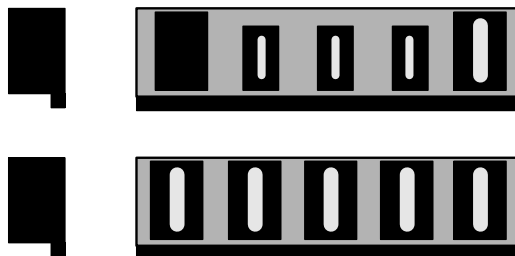
Both the high and low voltage plugs have tabs on the bottom of them. When the high voltage plug is installed properly, the low voltage plug can only be installed with its tab down, or opposite from the high voltage plug. This will properly orient the low voltage terminals 1-5.



Below is a schematic view of these plugs and the specific designs explained here.

Side View

Front View



Servicing the X13 Motor

The ECM Service Guide

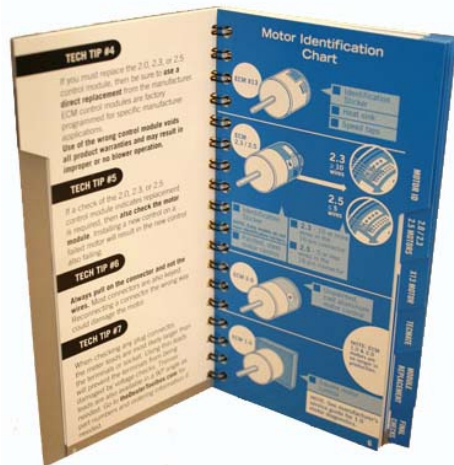
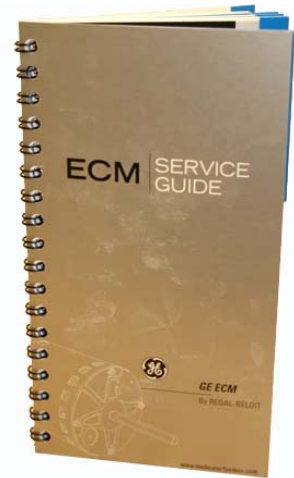
This pocket sized guide covers everything in this manual on troubleshooting and repair of Standard ECM Motors.

Order the rugged hard copy or download and print a free copy from our web site at:

www.thedealertools.com

Included in this guide are the following:

- HVAC System Troubleshooting Basics
- Tech Tips
- Motor Identification Chart
- Premium ECM Motor Diagnostics
- Standard ECM Motor Diagnostics
- TECMate Usage Chart
- Troubleshooting with the TECMate
- Module and Motor Replacement
- Final Installation Checks



The ECM Service Guide replaced the Home Comfort Guide.

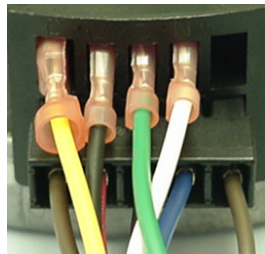


Service Basics

- The X13 motor can be operated by 115vac or 230vac. However these are two different motor models. Unlike the Premium ECM 2.3 motor, the X13 is not a dual voltage motor. Applying incorrect high voltage to the X13 motor may cause the motor to not operate, or even damage the motor.
- The manufacturers' manuals, diagrams and schematics must be consulted for proper set-up, wiring, operation, and all troubleshooting. Remember to check all system limits, rollouts and safeties before troubleshooting the motor.
- The X13 motor has the capability of accepting a communication signal of 9-23vdc as well as 24vac. Currently most manufacturers are using 24vac to our knowledge.

Safety Notes:

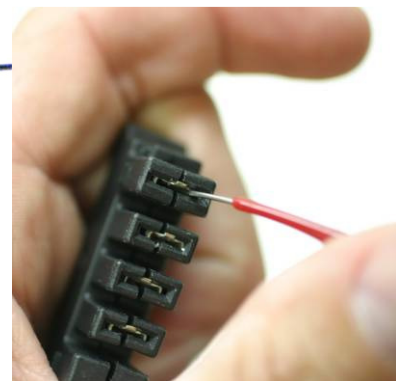
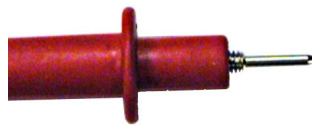
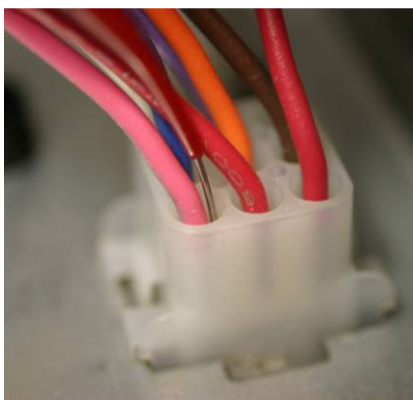
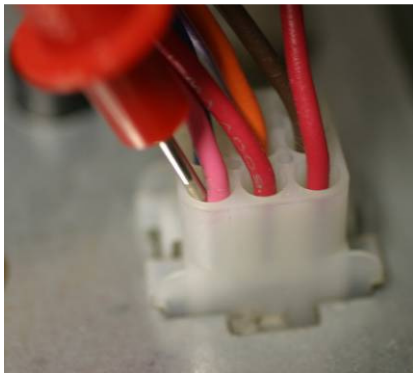
- **Never disconnect or re-connect the high voltage plug or terminals from the motor with the power on to prevent arcing.** The ECM motor may draw as much as 150 amps peak when powered up. Remember that the ECM motor uses electrical energy even if the motor is not doing useful work (is at rest). This is a good practice to follow on the low voltage connections as well.
- Do not trust the blower door switch for power disconnection. To avoid frequent arcing of the door switch contacts use the main disconnect on any system with an ECM motor before removing or replacing the blower door.
- Always pull on the plug or terminals and not the wires. You may want to note the orientation of the plug or terminals. Remember they are often located in the down position on the motor, and sometimes where there is limited working space.



- Always confirm that the system power has been disconnected with a meter. Check line to line and each line to ground.
- It is also a good practice to make sure that the ground connection from the (G) terminal to the main ground is good. For more information on checking the ground see page 55 of this manual.

Tech Tips

- A True-RMS meter is not needed to check input voltage to this motor. Any standard AC voltmeter analog or digital will work as long as it can read voltage up to at least 500 volts.
- If the polarity is reversed on the 115v model the motor may still run, but this should be corrected.
- Always check high voltage between terminals (L) and (N), never ground, to check for proper high voltage power.
- Always check low (control) voltage between terminals 1-5 and (C), never ground.
- Standard meter leads test pins are typically larger than the terminals from the plug connections or wires being checked for voltage. Using thinner test pins will prevent terminals from being damaged by voltage checks. Below is an example of a standard meter lead test pin and a thinner one. These test pins are also available in 90° angle for tight areas. These types of leads (as shown below) can be purchased from most meter manufacturers. Our leads were supplied by Test Products International (TPI). For more information on these leads please visit our website at www.theDealerToolbox.com.

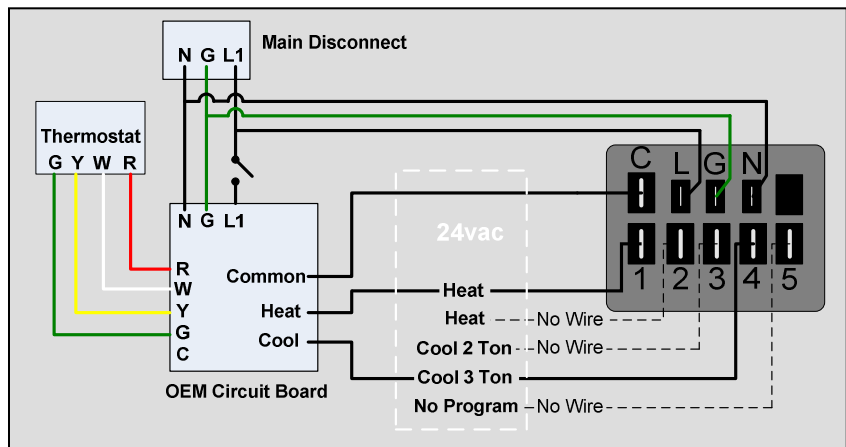


From what we have learned so far, we see that troubleshooting this motor will be fairly simple as long as the following information is known from the manufacturer's manuals:

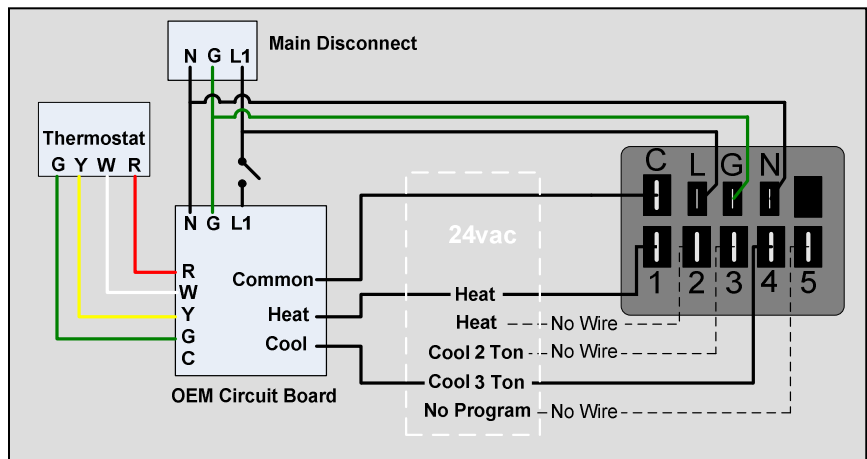
- Which tap(s) have programs and what are their purposes (heating airflow, cooling airflow, continuous fan airflow).
- Where on the manufacturer's controls or circuit board the line voltage and control voltage come from.
- The sequence of operation of the manufacturer's controls or circuit board (when the control voltage is sent to the motor from each thermostat demand and if there are any delays).

Here are some examples of schematics showing the X13 motor and potential manufacturer's connections on a gas furnace.

Some manufacturers may choose to have wires connected to all of the programmed taps with the unused wires loose or connected to un-powered terminals on the circuit board sometimes called "unused", "dummy", or "park". This makes it easier for the technician to make airflow changes at the circuit board.



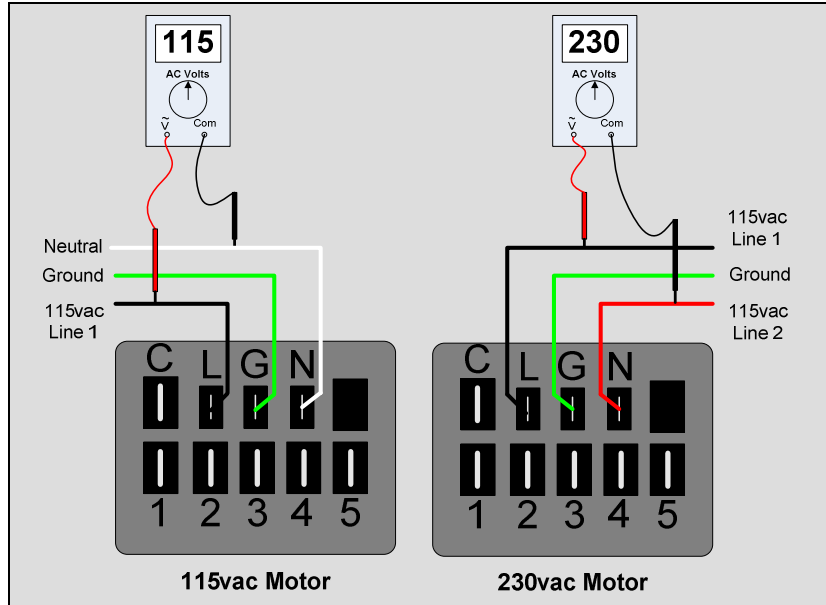
Others may choose to only connect the wires that are powered. Changing the airflow is then done at the motor taps.



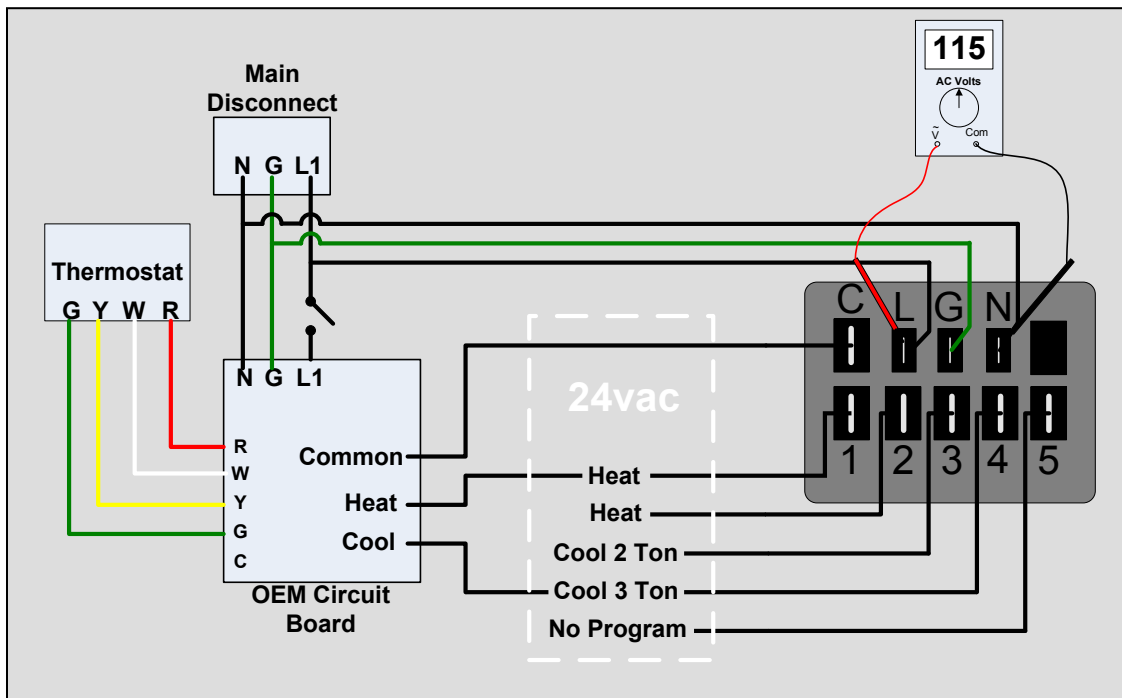
Troubleshooting the voltage at the X13 motor comes down to two simple measurements:

1. Line voltage

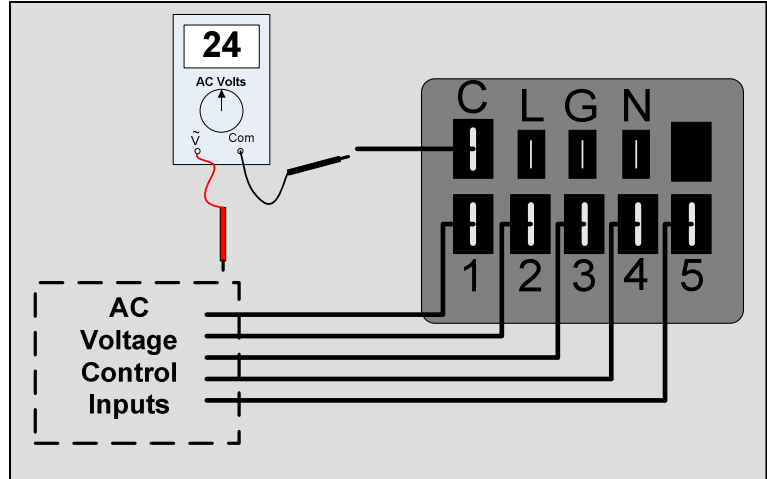
(115vac or 230vac) which should be present at all times with or without a demand for heating, cooling or continuous fan. Make sure voltage is present between the (L) and (N) terminals as shown.



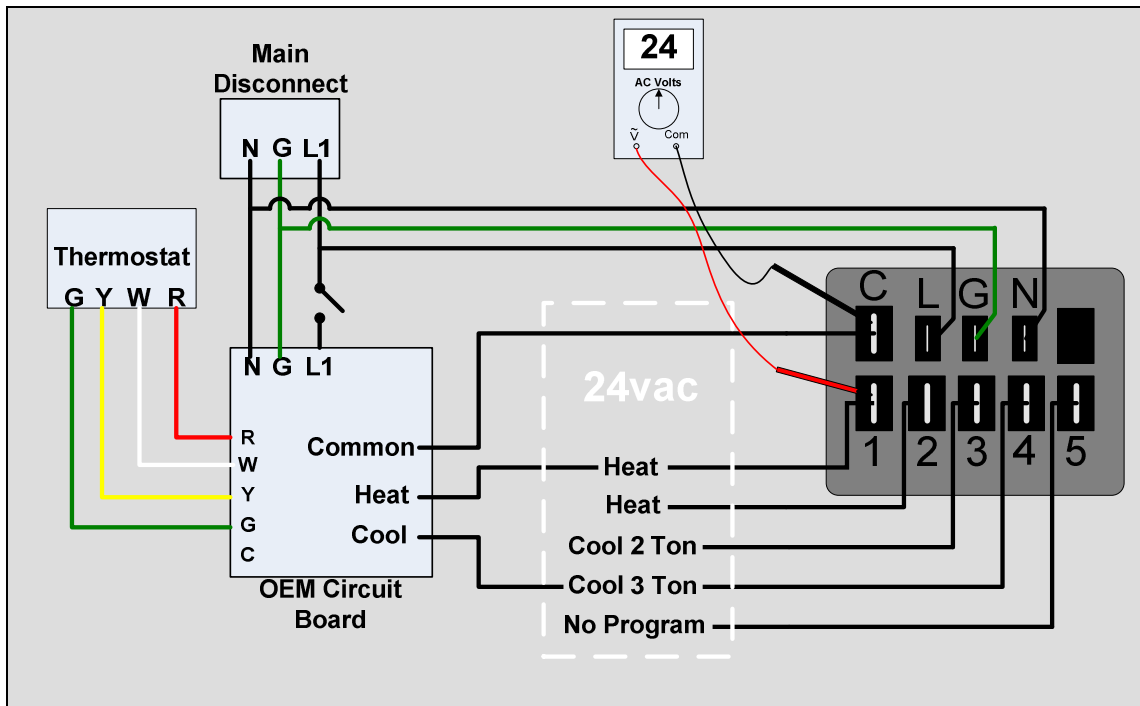
- **If** there is no high voltage present at the motor
- **Then** the voltage loss must be tracked down back towards the manufacturers wiring and controls.
 - o Remember this voltage should be present at the motor with or without a demand from the thermostat.
 - o The allowable voltage variance can be as much as $\pm 10\%$ of the nominal 115vac or 230vac required per motor.



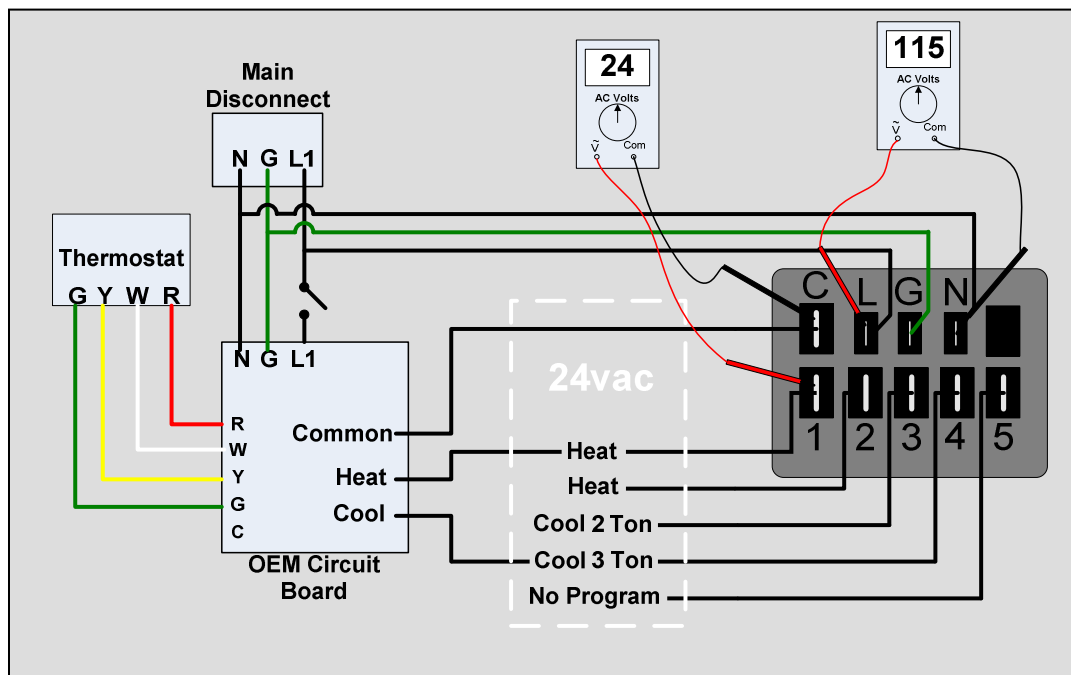
2. **24vac low (control) voltage** at the appropriate tap, with the appropriate thermostat demand call. Make sure voltage is present between terminals 1-5 and the (C) terminal as shown.



- **If** there is no low (control) voltage present at the motor
- **Then** the voltage loss must be tracked down back towards the manufacturers wiring and controls. Remember to confirm that there is a proper demand from the thermostat.
 - o The allowable voltage variance can be as much as $\pm 10\%$ of the nominal 24vac.
 - o If this voltage is present but below this range, confirm that this voltage is present at the unit transformer, and the at the thermostat low voltage connections on the unit control board.



- **If** high voltage is present at the motor, and the low (control) voltage is present on a programmed tap, and the motor is operating
- **Then** any airflow issues such as high or low temperature rise, tripping main limit, freezing coils or compressor overload tripping should be addressed as an airflow issue first. For more information on airflow restrictions see pages 43-49 in this manual. Remember the X13 is not a constant CFM motor. Airflow will decrease if static pressure gets to high in the system.
 - Using the manufacturers installation instructions confirm that the low (control) voltage is applied to the proper tap per the thermostat demand.
 - Correct all obvious airflow restrictions such as closed or blocked registers, grilles or dampers or dirty filter, blower wheel, secondary heat exchanger and evaporator coil.
 - Check the external static pressure (ESP) and correct airflow restrictions if the ESP is above 0.8 inches water column. These issues could be dirty, blocked, crushed or dented ductwork or simply undersized ductwork.
 - Check filter sizing and follow manufacturer's recommendations for proper filter applications.



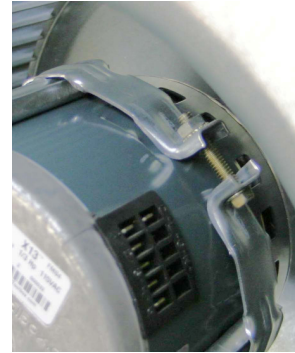
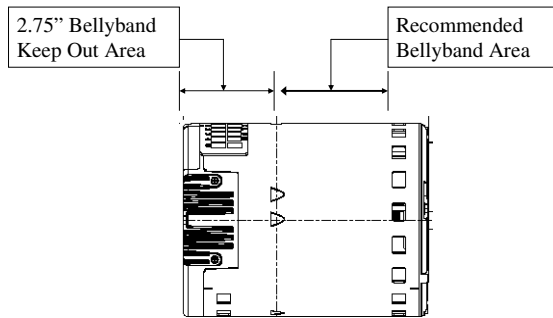
- **If** high voltage is present at the motor, and low (control) voltage is present on a programmed tap, and the motor is not operating
- **Then** the motor must be replaced. A direct replacement motor from the manufacturer for the same model and size unit is required.

Replacing the X13 Motor

When replacing the X13 motor keep in mind that this is a one piece motor that is replaced as a whole and is not field repairable.

This motor must be a direct replacement from the OEM for the specific model, voltage and size unit it came from. There are no generic replacement motors.

When using a bellyband for mounting, the band should not be located in the area identified in the drawing as the “Keep Out Area”.



Always make sure to tighten the wheel key on the flat side of the motor shaft with blower wheel centered in the housing.



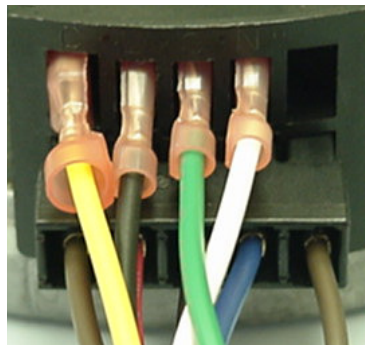
If the wheel sits too close to the motor when centered or cannot be centered because it hits the motor, the motor must be adjusted in the belly band.



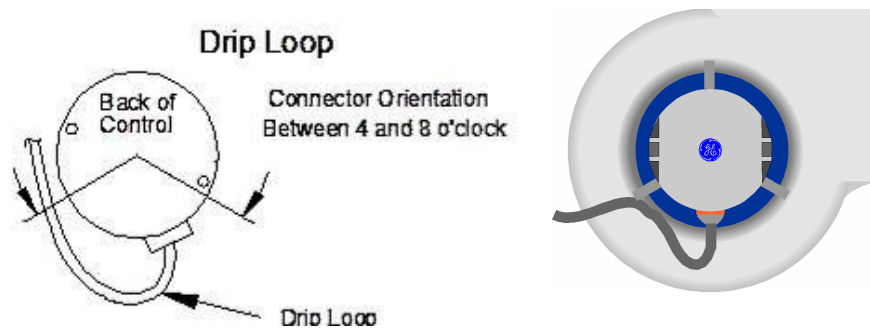
Re-install the blower/motor assembly into the HVAC system by following the manufactures' guidelines.



Reconnect all wires/plugs to the motor confirming connection to proper terminals per demand by the manufacturers' manuals.



Be certain to form a drip-loop so that water cannot enter the motor by draining down the cables. Condensate or droplets can accumulate in the harness and may find their way into the motor.



Final installation checks

- Check all wiring and connections, especially those removed while servicing.

Ensure the system is setup as follows:

- Verify the condensate drain is not plugged or clogged.
- Reconnect the AC power to the HVAC system and verify that the new motor control module is working properly.
- Check and plug leaks in return ducts and equipment cabinet.
- Verify that the system is running quietly and smoothly, in all modes (heating, cooling, and continuous fan) and all stages (if applicable).
- Return all thermostat settings to the customer's preference.

Note: If this is a repeat failure, then it is important that you check the following:

- Any evidence of moisture requires correcting the issue.
- If this area is subject to high amounts of lightning strikes, the use of additional transient protection may be helpful.

Good Practices

- Finish all service calls by checking all safeties, and perform a visual inspection of the overall job to prevent call-backs.
- Check the level of Carbon Monoxide (CO) in the vent(s) and living spaces of all homes with fossil-fuel appliances.
- Recommend annual maintenance