ECM, PM, or BLDC

Electronically Commutated Motor

Brushless DC motors
Energy savings are estimates only. They are based on an average $0.13/kWh energy cost in PG&E territory.
Efficiency (HVAC Indoor Blower Motors)

PSC = 60% efficient at rated RPM (1075 for 6-pole)
ECM = 80% efficient at all speeds
Six commutation phases "move" the electromagnetic field, which causes the permanent magnets on the rotor to move.

Methods to increase resolution of a Permanent Magnet Stepper:

- Increasing Number of Poles in Rotor
- Increasing Number of Phases
- Increasing Number of Coils per Phase
VFD VS ECM

- Both take AC and convert to DC
- VFD is generally $3\varnothing$
- ECM 1$\varnothing$ in, 3$\varnothing$ out
- VFD & ECM Both have Rectifiers
- VFD & ECM both have transistor outputs
- VFD Out put is to AC motor
- ECM Out put is to DC motor
- VFD motor is induction motor
- ECM motor is a synchronous
- ECM can spin a motor at much higher speeds
- ECM rotor has permanent magnets
- VFD’s induce Lots of noise
- AC motors not as efficient as DC motors
VFD Introduction

- VFDs convert AC to DC...then DC to AC
(at varying frequency and voltage)

- 460 V, 60 Hz
- 640 V, DC
- 307 V, 40 Hz

VFDs allow the motor to operate and consume electricity as if it were the right sized horsepower for the job.
VFD Layout

AC Input Voltage

DC Inductors

Soft Charge Path

VDC = 1.35 X VAC

Inverter Section

Power Card
ECM Controller
ECM wiring

(n+1) switch and diode configuration
What is ECM

• An Electronically commutated Motor
• Three phase wound stator
• Permanent Magnet Rotor
• DC brushless motor
• Synchronous motor
• Incorporated inverter
ECM motor Parts
Motor Speed

- 2 Pole Motor
  POLE DISTANCE = 180
  1 CYCLE = 360° DISTANCE

- 4 Pole Motor
  POLE DISTANCE = 90°
  1 CYCLE = 180° DISTANCE

Synchronous Motor R.P.M. = \( \text{AC Frequency in Hertz} \times 120 \)
Number of Poles in Motor
Types of ECM

- Permanent magnet synchronous
- Switching Reluctance
- Induction (asynchronous)
- Stepper
Variable Speed Ties it all Together

- Fully Modulated ECM provides indoor air with:
  - Quiet Operation
  - Dehumidification
  - Steady Temperatures - No more Hot Flashes
Types of ECM motors

1. On OFF
2. Multiple speed
   1. High
   2. Medium
   3. Low
3. Variable speed
   1. 0-100%
ECM motor characteristics

- Torque linear with speed
- Maximum torque when stationary
- High efficiency
- Permanent magnets on rotor
- Fixed armature
ECM rotor position detection

- **Hall effect sensors**
  A transducer that varies its output voltage in response to a magnetic field

- **Rotary encoder**
  An electro-mechanical device that converts the angular position or motion of a shaft or axle to an analog or digital code
  Can be based on BACK-EMF ♥
ECM construction

• Conventional or Inrunner
  – Permanent magnets are part of the rotor.
  – Three stator windings surround the rotor

• Outrunner or external-rotor
  – Radial relationship between the coils and magnets is reversed
  – The stator coils form the center or core of the motor, the permanent magnets spin within an overhanging rotor which surrounds the core.
ECM Benefits

• Lower Annual operating costs (25%-75%)
  – PSC motors 12-45% Efficiency
  – ECM motors 65-75% Efficiency
• Small as 80 watts
• Reduced Temperature (around ambient)
  – PCM motors 90-150° F.
• Quieter running
• Lower drying effect during heating season
• Reduced motor stress
  – Reduced starts & slewed speed ramps
• More Precise
• Unlimited air flow selection
ECM versions

ECM 3.0

ECM 2.3/2.5

5-pin connection

4-pin connection

16-pin connection

5-pin connection
ECM Module Replacement
ECM Module Replacement

- Tools Required:
  - 5/16” nut driver
  - ¼” wrench
- Time: approx 20 minutes
- Techs Needed: 1

Instructions:
- Remove filter access and blower access panels (indoor side)
  - Furthest left panel is removed first
  - Top does not need to be taken off of unit
- Unplug (2) molex connectors from the ECM module
- Remove (2) ¼” bolts from the top of the ECM module
- Replace
ECM Module Replacement
Remove (2) ¼” bolts from top of ECM module
Disconnect molex plug from Module.
ECM Troubleshooting
Power connections
Models 2.0/ 2.3 / 2.5

120VAC SYSTEM

240VAC SYSTEM

Jumper 1 and 2 for 120 VAC
no jumper for 240 VAC
ECM Connections Diagram

Control Connector ***

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### Power Connector *

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<td></td>
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<td>AC Line</td>
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<td>5</td>
<td>AC Line</td>
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PWB Header | AMP 1-350949-0
Model X13 Connections

115VAC MOTOR

1 2 3 4 5

115VAC LINE 1

NEUTRAL

GROUND

230VAC MOTOR

1 2 3 4 5

115VAC LINE 2

GROUND
Modle X13 Speed inputs 1-5
ECM motor

3 PH DC Motor

Aprx. >12 Ω Winding to Winding
One way to test motor & drive

Some Furnaces Units Req. Jumper

Power (4 & 5) & ground (3)
One more way to test motor & drive
Runs to 50%

Some Furnaces Units Req. Jumper

9 VDC
Common

Power (4 & 5) & ground (3)
Motor Running with system faults

- Test controller
- Check Wiring
- Check inputs
- Check power
- Check airflow settings
- Check air distribution system for dirt, closed dampers, registers and grills.
- Measure external static pressure (across fan or system) if above design fix system problem.
Motor not running

- Check high voltage inputs
  - Voltage within 15% of ratings
- Check speed reference inputs
- Check motor windings
- Check controller
- Run function tests.
Symptom analysis

• Motor rocks on starting  (Normal)
• Motor won’t start ( check pwr, connectins, check motor shaft movement, test motor)
• Motor rocks but won’t start (check connections, check wheel tightness, check controller)
• Motor oscillates up and down  ( Normal with no load apply load and retest)
Symptom analysis

• Motor starts however, runs erratically. (Check power sag, check connections, check control output, check system static, check restrictions) Keep static pressure to a minimum

• Evidence of moisture (Fix source of moisture)
Motor test

- Motor windings $R < 20 \, \Omega$
- Each winding within 10% of each other
- $R > 100K\Omega$ to ground
ECM Operation

ECM = Electrically Commutated Motor
ECM - Sequence of Operation

• 1st stage Cooling call
  – Ramps to 25% CFM for 1 minute.
  – Ramps up to 40% CFM for 7.5 minutes.
  – Ramps to 50-65% CFM for remainder of 1st stage cooling call.

• 2nd stage call during 1st stage operation
  – Ramps to 80% CFM for 7.5 minutes.
  – Ramps to 100% for remainder of 2nd stage cooling call.
• 2nd stage Cooling call (from “off” position)
  – Ramps to 50% CFM for 1 minute.
  – Ramps up to 80% CFM for 7.5 minutes.
  – Ramps to 100% CFM for remainder of 2nd stage cooling call.
EBM plenum  Fan

Take top of to get to motor
Typical Illustration. Unit may not appear exactly as shown.
Fan Speed Control
**Speed Setup**

![Diagram with speed setup instructions and tables]

### IDM RPM Indication

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ECM Engine Controller
Adapter Board

Note: Customer Low-Voltage Interface for Fan Speeds, Variable Fan Speed, and 24 Vac Supply
Customer Supplied Terminal Interface

Customer Low-Voltage Interface for Valves, Electric Heat, Dampers, Fan Speeds, Variable Fan Speed, and 24 Vac Supply

Valve(s), Electric Heat, and Changeover Configuration Switches (Factory-Set)
Options Module
EBM plenum Motor Wiring

With PWR to motor place 10 volts to 8 and 7 and fan will run

57
EBM Plenum Motor
EBM motor
## Tabular Performance Data

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<thead>
<tr>
<th>Std. Air Flow (CFM)</th>
<th>Outlet Velocity (ft/min)</th>
<th>0.5 RPM</th>
<th>0.5 BHP</th>
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Airflow form DP

![Graph showing airflow and pressure head relationship with arrows indicating increasing and decreasing impedance.](image)
HP VS BHP

1. HP is the output horsepower rating of an engine, while BHP is the input brake horsepower of an engine.
2. BHP is the measurement of an engine’s power without any power losses, while HP is BHP less the power losses.
3. HP is measured by hooking up the engine to a dynamometer, while BHP is measured in a controlled environment without anything attached to the engine.

1 bhp equals to: 745.5 watts
1.01389 ps
33,000 ft lbf/min
42.2 BTU/min
Supply Duct Static Pressure

1000 rpm, IGV 100% Open

System Resistance At Design

Fan Modulation Curve

Static Pressure (in. wg)

Airflow (1000 cfm)

1000 rpm, IGV 100% Open

1000 rpm, 12 bhp

Fan Modulation

System Resistance At Part Load

12 bhp

Airflow (1000 cfm)

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