Products for Indoor Air Quality and Control

Constant Volume Fan Powered Units
AC_H Series

ECM Motor Technical Guide

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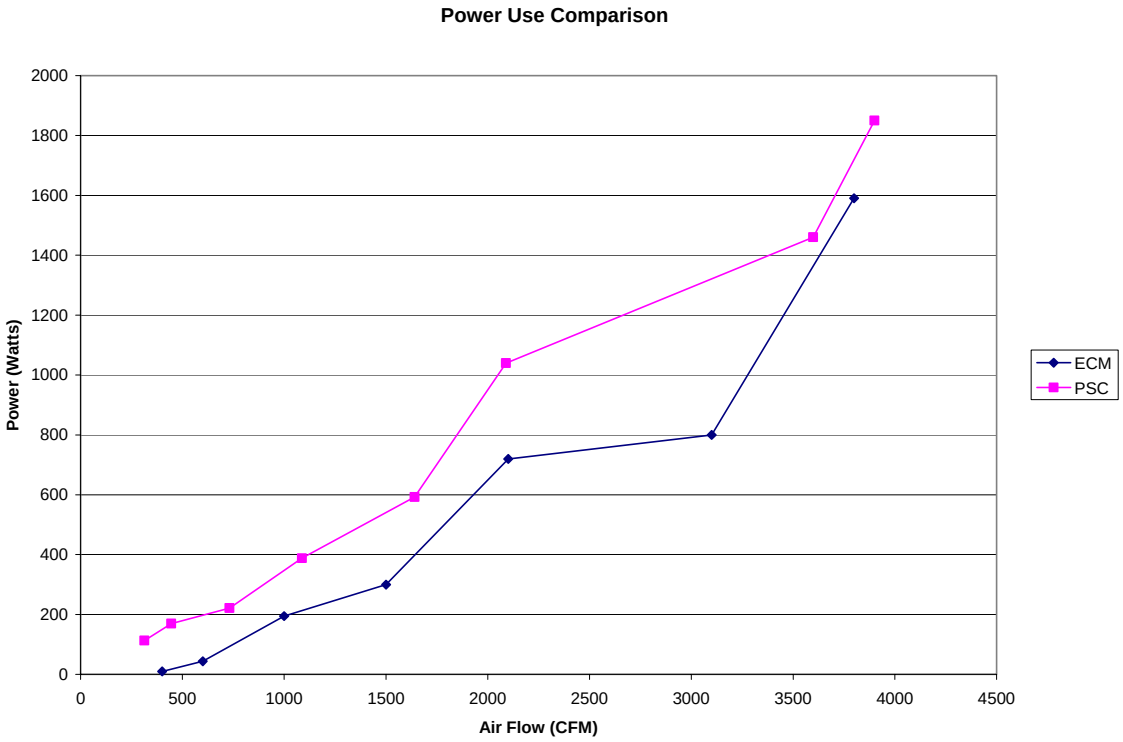
Fan powered constant volume terminal units are designed to deliver a constant volume of air to a given space. Currently a PSC motor with an SCR is used to turn a blower wheel at a constant rate. As primary air from the air handler is increased the amount of air induced from the conditioned space is decreased. Because there are multiple variable air volume units in a system, the duct static pressure may increase or decrease depending on the total load. As the static pressure in the duct system changes the typical PSC motor blower combination cannot adjust itself and therefore the CFM delivered to an area will vary. This makes initial balancing difficult and provides a less than ideal flow of air to the conditioned space

The ideal speed at which an induction motor can turn is fixed by the frequency of the voltage applied and the number of poles it contains. The motor's speed can be reduced by altering the voltage applied across its windings. This can be done with resistors, inductors, transformers or solid-state speed controls. Decreasing the voltage reduces the starting and full- load torque, increases the rotors slip and decreases the motors efficiency. The further the motor operates from its ideal speed, the greater the energy loss and running temperature of the motor. The lack of torque control prevents precise airflow control and the low frequency noise may increase.

In response to the need for a high efficiency motor in which speed can be set and maintained, GE developed an Electronically Commutated Motor or ECM. It is an ultra high efficiency brushless DC motor with a built in inverter. The electronics package, included with the GE ECM motor serves two purposes. One, it switches the DC magnetic fields which allow the motor to operate. Two, it controls torque and speed so that the airflow is maintained despite the pressure seen by the fan. The ECM can be programmed in the factory to set maximum and minimum values, which can then be adjusted in the field to the desired CFM. Once set, the motor will maintain constant airflow within + or – 5%.

In 1974 the first fan powered variable air volume boxes were introduced to the market. They provided significant energy savings compared to standard system at that time because of their ability to recapture plenum heat. With increasing energy costs, the demand for higher efficiency motors has increased. Through testing, the Carnes Company has shown that the ECM has proven true to its reputation for using less energy. The following chart shows the wattage used at various airflows over the range of units provided by Carnes.

Energy Savings



The energy savings for the ECM motor can be quite significant. Depending on energy cost for a given area, the payback for the ECM motor can be seen in as little as two years.

One of the unique features of the ECM motor is that it can be controlled by a 0-10V dc signal from the building automation system. The fan speed can now be increased in cooling mode and decreased for heating mode. This allows the design engineer to further optimize performance.

ECM Motor Control

ECM Motor Taps

The ECM motor was originally designed for the residential HVAC market. Because of the need to provide a different airflow rate for heating versus cooling, two different tap positions were provided. In addition two more tap wires are provided. One is to adjust the flow rate, for example in an application where humidity control was a concern. The other provided a way to delay the start of the fan according to a desired delay profile. The ECM motor tap connections are provided via the ECM control connection pictured below. Additional taps are provided as a way for the thermostat to send a control signal to the ECM motor. All of these tap positions are available when the ECM motor is programmed for the TSTAT mode. (See figure 1, table 1)

Variable Speed Control
When applying the ECM to use with a Variable air volume box it is more desirable to be able to provide a variable speed control. This allows the ECM to operate over a range of CFM values. The maximum and minimum airflow rates are programmed into the motor at the factory. The speed of the motor is then set by Pulse width modulated (PWM) signal sent to the ECM motor via a special controller provided by Carnes. The ECM tap positions are all given below. The positions used by Carnes for the Variable air volume application are out lined in blue.

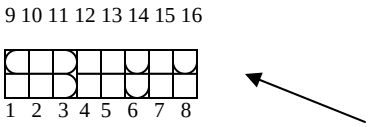


Figure 1

PIN	DESCRIPTION
1	C1
2	W/W1
3	C2 (GREEN WIRE) COMMON
4	DELAY
5	COOL
6	Y1
7	ADJUST
8	OUT – (GREEN WIRE)
9	O
10	PK/PWM (RED) CONTROLS SPEED OF MOTOR
11	HEAT
12	R
13	EM/W2
14	Y/Y2
15	G (WHITE WIRE) MOTOR ON/OFF – GROUND
16	OUT+(BLACK) - TACHOMETER

Table 1

The GE ECM motor is unique in that it is turned off and on via a 24 V control signal. Power should not be disrupted to the motor as a means to control the motor. In fact doing so will reduce the life span of the motor.

Carnes Control Options
Carnes is working together with Evolution Controls to provide three control options with the ECM motor. The standard electronic control is the VCU. It has a digital number readout, which allows the user to see the RPM output of the motor as well as the flow

index. The flow index is a range of flow from 0-100. A flow index of zero marks the minimum flow of the VAV box. A flow index of 100 is the maximum airflow of the VAV box. Refer to table 2, which is a listing of the expected CFM (within + or – 10%) for the various size units. Once a flow rate is set on the VAV unit, the ECM will maintain the airflow with in + or – 5% of the set value.

	AC_H06B	AC_H07C	AC_H08D	AC_H10E	AC_H12F	AC_H14G	AC_H16H
Max CFM	400	600	1000	1500	2100	3100	3800
Min CFM	150	350	550	900	1400	2000	2700
Flow Index	Fan CFM						
0	150	350	550	900	1400	2000	2700
1	153	353	555	906	1407	2011	2711
2	155	355	559	912	1414	2022	2722
3	158	358	564	918	1421	2033	2733
4	160	360	568	924	1428	2044	2744
5	163	363	573	930	1435	2055	2755
6	165	365	577	936	1442	2066	2766
7	168	368	582	942	1449	2077	2777
8	170	370	586	948	1456	2088	2788
9	173	373	591	954	1463	2099	2799
10	175	375	595	960	1470	2110	2810
11	178	378	600	966	1477	2121	2821
12	180	380	604	972	1484	2132	2832
13	183	383	609	978	1491	2143	2843
14	185	385	613	984	1498	2154	2854
15	188	388	618	990	1505	2165	2865
16	190	390	622	996	1512	2176	2876
17	193	393	627	1002	1519	2187	2887
18	195	395	631	1008	1526	2198	2898
19	198	398	636	1014	1533	2209	2909
20	200	400	640	1020	1540	2220	2920
21	203	403	645	1026	1547	2231	2931
22	205	405	649	1032	1554	2242	2942
23	208	408	654	1038	1561	2253	2953
24	210	410	658	1044	1568	2264	2964
25	213	413	663	1050	1575	2275	2975
26	215	415	667	1056	1582	2286	2986
27	218	418	672	1062	1589	2297	2997
28	220	420	676	1068	1596	2308	3008
29	223	423	681	1074	1603	2319	3019
30	225	425	685	1080	1610	2330	3030
31	228	428	690	1086	1617	2341	3041
32	230	430	694	1092	1624	2352	3052
33	233	433	699	1098	1631	2363	3063
34	235	435	703	1104	1638	2374	3074
35	238	438	708	1110	1645	2385	3085
36	240	440	712	1116	1652	2396	3096
37	243	443	717	1122	1659	2407	3107
38	245	445	721	1128	1666	2418	3118
39	248	448	726	1134	1673	2429	3129
40	250	450	730	1140	1680	2440	3140
41	253	453	735	1146	1687	2451	3151
42	255	455	739	1152	1694	2462	3162
43	258	458	744	1158	1701	2473	3173
44	260	460	748	1164	1708	2484	3184
45	263	463	753	1170	1715	2495	3195
46	265	465	757	1176	1722	2506	3206
47	268	468	762	1182	1729	2517	3217
48	270	470	766	1188	1736	2528	3228
49	273	473	771	1194	1743	2539	3239

50	275	475	775	1200	1750	2550	3250
51	278	478	780	1206	1757	2561	3261
52	280	480	784	1212	1764	2572	3272
53	283	483	789	1218	1771	2583	3283
54	285	485	793	1224	1778	2594	3294
55	288	488	798	1230	1785	2605	3305
56	290	490	802	1236	1792	2616	3316
57	293	493	807	1242	1799	2627	3327
58	295	495	811	1248	1806	2638	3338
59	298	498	816	1254	1813	2649	3349
60	300	500	820	1260	1820	2660	3360
61	303	503	825	1266	1827	2671	3371
62	305	505	829	1272	1834	2682	3382
63	308	508	834	1278	1841	2693	3393
64	310	510	838	1284	1848	2704	3404
65	313	513	843	1290	1855	2715	3415
66	315	515	847	1296	1862	2726	3426
67	318	518	852	1302	1869	2737	3437
68	320	520	856	1308	1876	2748	3448
69	323	523	861	1314	1883	2759	3459
70	325	525	865	1320	1890	2770	3470
71	328	528	870	1326	1897	2781	3481
72	330	530	874	1332	1904	2792	3492
73	333	533	879	1338	1911	2803	3503
74	335	535	883	1344	1918	2814	3514
75	338	538	888	1350	1925	2825	3525
76	340	540	892	1356	1932	2836	3536
77	343	543	897	1362	1939	2847	3547
78	345	545	901	1368	1946	2858	3558
79	348	548	906	1374	1953	2869	3569
80	350	550	910	1380	1960	2880	3580
81	353	553	915	1386	1967	2891	3591
82	355	555	919	1392	1974	2902	3602
83	358	558	924	1398	1981	2913	3613
84	360	560	928	1404	1988	2924	3624
85	363	563	933	1410	1995	2935	3635
86	365	565	937	1416	2002	2946	3646
87	368	568	942	1422	2009	2957	3657
88	370	570	946	1428	2016	2968	3668
89	373	573	951	1434	2023	2979	3679
90	375	575	955	1440	2030	2990	3690
91	378	578	960	1446	2037	3001	3701
92	380	580	964	1452	2044	3012	3712
93	383	583	969	1458	2051	3023	3723
94	385	585	973	1464	2058	3034	3734
95	388	588	978	1470	2065	3045	3745
96	390	590	982	1476	2072	3056	3756
97	393	593	987	1482	2079	3067	3767
98	395	595	991	1488	2086	3078	3778
99	398	598	996	1494	2093	3089	3789
100	400	600	1000	1500	2100	3100	3800

Table 2

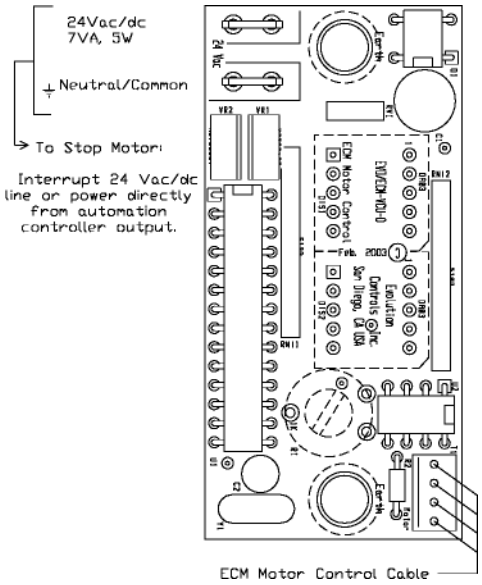
Visual Control Unit (VCU)

The EVO/ECM-VCU control allows accurate manual adjustment and monitor of fans using General Electric's ECM Motor. (See Figure 2)

The EVO/ECM-VCU features a 4 digit LED numerical display to allow easy reading in dark spaces. Watch the display and set the flow index with a screwdriver adjust. Twenty seconds later, the display shows the motor RPM. Then, the display periodically alternates between the flow index and motor RPM.

The EVO/ECM-VCU may also be used where automation systems only turn the fan on or off.

Front of VCU



Back of VCU control unit.

Figure 2

Specifications

Power	NEC Class II Only 24 Vac ± 20% 50/60 Hz 4 W, 6 VA
Flow Index Adjustment	270° rotation F Off-0-100
RPM	0-2000 RPM ± 2%
Outputs	
Go & Vspd	24 Vdc @ 20 mA
ECM 2.3	Set for Vspd Operation Set Status Flag (7) to RPM Thermal
Stability	>0.01 %/°F
Operating	0°F to 130°F (-18°C to 55°C) Environment 10-80% Rh
Connections	1/4 Tabs

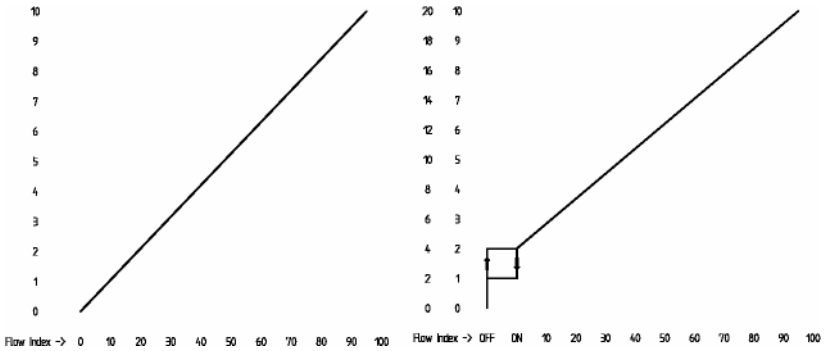
Automatic Control Unit (ACU+)

If digital controls are being used on the project it is possible to control the speed of the ECM motor with a 0-10V control signal using the EVO ACU+ unit. (See figure 3) The on/off signal is provided at a 24V input. Another option is to turn the motor on/off with a 0-1V signal and to use the 2-10V for speed control

The EVO/ECM-ACU+ allows remote adjustment of the output from 0% to 100% of the programmed control range. A LED on the control continuously flashes out the flow index (percent of the programmed control range), so instruments are not required to read the value.

The "P" version provides ON/OFF control by switching the motors "GO" control when the input signal drops below the 2 volt (4 mA) operating point.

The green LED continuously indicates the flow index. After a pause, the LED flashes out the tens digit, then the units digit of a number (percent) between 1 and 99. Two extra long flashes indicate a flow index of 0%. Long flashes represent the tens digit, and short flashes represent the units digit. A flow index of 23%, flashes two longs and three shorts.



Control Test Procedure

Warning: These tests are to be performed by qualified personnel who are familiar with the CARNES VAV box, where the EVO/ECM, series control and connected motor is installed. All mechanical, electrical and other applicable safety practices must be observed when performing these tests. While the EVO/ECM series controls are low voltage devices, they are often installed

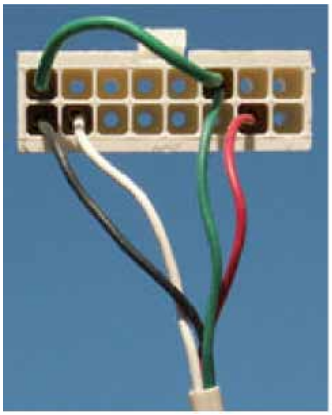
in or near high voltage cabinets and wiring. And they are connected to electrically isolated connections on the ECM motor. Wiring and device faults can occur. Always test for high voltage before starting these tests!

High Voltage Fault Test- Perform this test in addition to all tests and practices prescribed by the equipment manufacturer and your professional training.

1. Remove the VAV box control cover to gain access to the component side of the EVO/ECM series control. Leave everything connected.
2. If you removed power to gain access, re-power the equipment as necessary to troubleshoot the equipment.
3. Set the multi-meter to measure AC Volts.
4. Connect the BLACK lead to electrical earth.
5. Touch the RED lead to the EVO/ECM series connection marked 24VAC. The meter should read about 30 volts AC. If the meter reads a voltage above 48 volts AC immediately disconnect the VAV box. There is a high voltage fault somewhere in the system.
6. Touch the RED lead to the other connectors on the board. If the meter reads a voltage above 48 Volts AC, immediately disconnect the VAV box. There is a high voltage fault somewhere in the system.
7. Touch the RED lead to the metal wire grippers (top of connectors) for each of the 4 motor wires. (See Figure 2) If the meter reads a voltage above 48 Volts AC, immediately disconnect the machine. There is a high voltage fault somewhere in the system.

Motor Connection

Figure 2



White – Motor On/Off 0-24V
Black – Tachometer
Green – Common
Red – Speed 0 – min speed, 22 VDC max. Speed

Figure 3

A quick test:

If the motor is not running and you want to determine if the EVO/ECM series control is calling for the motor to run, just measure the DC voltage between the Green and White wires on the motor control cable. If this voltage is greater than 10VDC, the motor should be running.

If you have an instance where the motor stops intermittently, and it restarts when power is removed then restored, perform this test before removing power. It will tell you if the intermittent part is the EVO/ECM series control.

Trouble Shooting Guide

Problem: The ECM motor will not run

1. Check to make sure the power and control cables are securely fastened to both the ECM motor. Check the control connection to make sure it is secure.
2. Verify there is power to the unit.
3. Set the multimeter to read 24VDC
4. Touch the black lead to the motor 0n/Off (White) wire on the 4 pin motor connector.
5. Touch the red lead to the Motor On/Off (white) wire on the 4 pin motor connector.
6. If the DC voltage is 22VDC, the motor should run.
7. If the motor does not run, the cable may be defective
8. Go to the control connector on the motor.
9. Insert the black meter lead into the connector shell hole containing the single green wire (See Figure 3)
10. Insert the red meter lead into the connector shell hole containing the white wire. The DC voltage should be 22VDC. If it is not, the cable is defective. If the voltage is greater than 10VDC and motor does not run, contact CARNES Co. for further instructions.

Problem: The motor runs but the speed does not change

1. Start the motor running
2. Set the multimeter to read 24 VDC
3. Touch the black lead to the common (Green) wire on the 4 pin motor connector.
4. Touch the red lead to the speed (RED) wire on the 4 pin motor connector.
5. Set the EVO/ECM series controller to full speed.
6. The DC voltage should be equal to the voltage on the white wire (24VDC). The motor should run at full speed.
7. If the motor does not run at full speed, the cable may be defective.
8. Go to the control connector on the motor.
9. Insert the black meter lead into the connector shell hole containing the single green wire.
10. Insert the red meter lead into the connector shell hole containing the RED wire. The DC voltage should equal the voltage on the white wire (22VDC). If it is not the control cable is defective. If the voltage is 22VDC and the motor does not run at full speed, contact CARNES CO.

Problem: The VAV box does not run with in the expected speed range.

1. Verify the variable speed control is working correctly.
2. Verify the correct unit is installed in the space
3. Contact CARNES CO.

Problem: The Automation System cannot turn the motor off

1. Turn the ECM motor off using the Automation System.
2. Touch the black lead to the common (Green) wire on the 4 pin motor connector.
3. Touch the red lead to the Tachometer (Black) wire on the 4 pin motor connector.
4. The Dc voltage should be less than 3Vdc
5. If the voltage is too high, the Automation Control is leaking current through its On/Off switching device.

Problem: The speed control does not provide the RPM

Set the multi-meter to read 5Vdc.

1. Touch the black lead to the common (Green) wire on the 4 pin motor connector.
2. Touch the red lead to the Tachometer (Black) wire on the 4 pin motor connector.
3. You should read about 5Vdc.
4. Go to the control connector on the motor.
5. Insert the black meter lead into the connector shell hole containing the single green wire.
6. Insert the red meter lead into the connector shell hole containing the Black wire. The DC voltage should about 5Vdc. If it is not, the control cable is defective. Swap the EVO/ECM series control with a known good control to determine if the problem is with the EVO/ECM series control. If the problem persists, contact Carnes Co. for further details.