AE8-1328 R1

COPELAND SCROLL™
DIGITAL COMPRESSOR CONTROLLER

October, 2005

Introduction

The Digital Compressor Controller (543-0024-00) is the electronics interface between the Copeland Scroll Digital Compressor and the system controller. The Digital Compressor Controller is designed only for single and three phase Copeland Scroll Digital compressors (reference Copeland AE21-1319 for details on the Digital Compressor). The system controller supplied by the OEM measures temperature, pressure or humidity to calculate the needed compressor capacity and communicates that capacity to the Digital Compressor Controller via an analog signal.

The Digital Compressor Controller provides control, protection and diagnostics for the Digital Compressor system.

• The Digital Compressor Controller "modulates" or cycles the unloader solenoid in an on/off pattern according to the capacity demand signal from the system controller.

• The compressor contactor coil is controlled based on the capacity demand from the system controller and the presence of any compressor trip or lock out conditions.

• The compressor is protected against high discharge temperature by a discharge temperature thermistor. If the maximum temperature limit is exceeded, the Digital Compressor Controller will protect the compressor by turning it off.

• Seven ALERT codes are displayed indicating an abnormal system or compressor condition. Depending on the severity of the code, the Digital Compressor Controller will shut down the compressor or run the compressor in a limited capacity.

• After each compressor shut down event, a two minute anti-short cycle delay timer is active preventing the compressor from restarting.

• For systems that need an accurate suction pressure reading, the Digital Compressor Controller is able to smooth out the pressure swings associated with loading and unloading the compressor. A pressure transducer input is "filtered" by using the unloader control algorithm to output a smooth suction pressure signal.

• For systems that include a compressor vapor injection solenoid valve, the compressor controller energizes this valve whenever the compressor is running.

Specifications

Width: 2.0" (51 mm)

Height: 4.0" (102 mm)
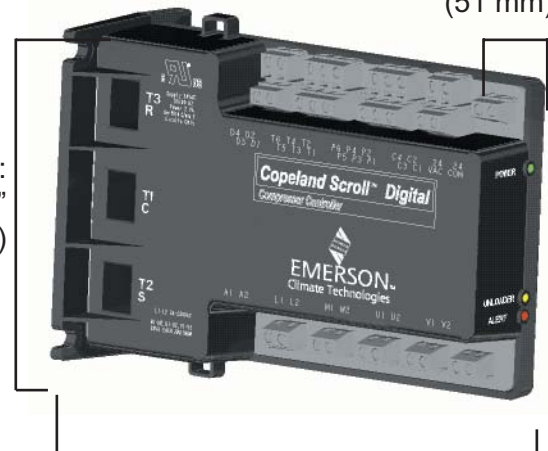
Depth: 6.0" (153 mm)

Operating Temperature: -40°F to 150°F (-40°C to 65°C)

Storage Temperature: -60°F* to 175°F (-49°C* to 80°C)

Supply Voltage: 19-28VAC, 48-62Hz

Supply Power: 2 VA maximum

UL Requirements: For power supply: use only with Class 2 circuits, File #SA8958

Enclosure Protection IP20, NEMA1

*MIL-STD-810F, Method 502.4, 4.5.2

1

Installation

Four #10 self tapping sheet metal screws, at least ½" length, are required for installation. The maximum mounting screw torque is 20 in.lbs. Locate the Digital Compressor Controller inside the electrical enclosure near the compressor contactor (wire routing for compressor power wiring will be easier in this position). The maximum wire terminal screw torque is 7 in. lbs. The Digital Compressor Controller will operate in any mounting orientation where the green POWER LED is at the top. Mount the Digital Compressor Controller so all LEDs are visible from a comfortable viewing position.

A service panel label (Form 2003CC-80) describing the terminals and ALERT flash codes is included with each Digital Compressor Controller. This label should be in a visible location for the technician when he is troubleshooting the system.
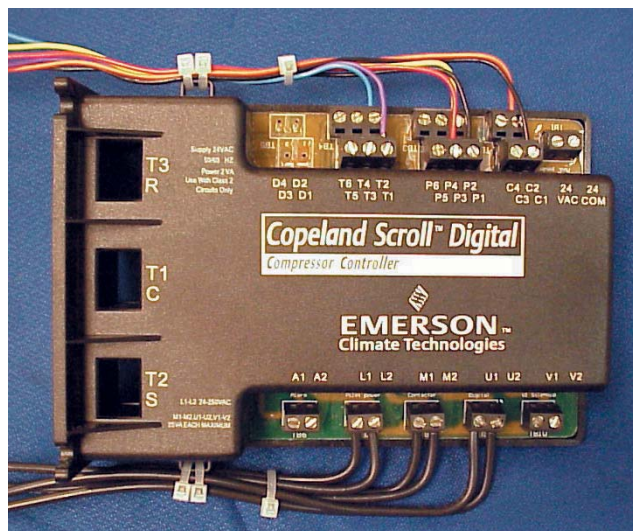
Compressor Wiring

The Digital Compressor Controller senses compressor motor current for diagnostics and protection. The compressor motor leads must be run through the holes in the plastic housing for a current transformer to sense motor current.

Single Phase Compressors: the scroll compressor's run (R), common (C) and start (S) wires must be routed through the holes in the Digital Compressor Controller module marked "R," "C" and "S." The run capacitor may be located on either side of the Digital Compressor Controller module.

Three Phase Compressors: the scroll compressor's T1, T2 and T3 wires must be routed through the holes in the Digital Compressor Controller module marked "T1," "T2" and "T3." The Digital Compressor Controller module is phase insensitive and will not detect reverse phasing of the compressor.

NOTE! Do not bundle low voltage wires with compressor power or high voltage wires.

NOTE! Attach cable ties through loops on side of the housing for wire strain relief.

**Digital Compressor Controller Terminals
See Figure 1 and 2 for wiring diagrams.**

Low Voltage Terminals
24VAC   Module Power
24COM   Module Common
C1   Demand Input –
C2   Demand Input +
P1   Pressure Common
P2   Pressure Input
P3   Pressure Power 5VDC
P4   Pressure Shield
P5   Pressure Output –
P6   Pressure Output +
T1   Discharge Temp Sensor
T2   Discharge Temp Sensor

High Voltage Terminals
A1   Alarm Relay Out
A2   Alarm Relay Out
M1   Contactor
M2   Contactor
L1   Control Voltage L
L2   Control Voltage N
U1   Unloader Solenoid
U2   Unloader Solenoid
V1   Vapor Injection Solenoid
V2   Vapor Injection Solenoid

NOTE! To avoid damaging the Digital Compressor Controller do not connect wires to terminals C3, C4, T3, T4, T5 or T6.

Application Engineering

Copeland®

AE8-1328 R1

BULLETIN

EMERSON
Climate Technologies

(24VAC, 24COM) Digital Compressor Controller Power

The power supply for the Digital Compressor Controller is 19-28VAC, 48-62Hz. The maximum load is 2 VA. The 24VAC phasing for the Digital Compressor Controller must match the system controller to avoid a transformer short circuit condition because the two controllers have their commons connected together.

(C1, C2) System Controller Demand

Controller Demand is an analog input signal from the system controller to the Compressor Controller, proportional to the capacity required from the compressor. Controller Demand is a 1-5VDC input where 1.0VDC is 0% capacity and 5.0VDC is 100% capacity. When the signal falls below 10% capacity (1.44VDC) the Digital Compressor Controller will shut down the compressor. When the signal rises above 10% capacity (1.44VDC) and the anti-short cycle timer has timed out, the Digital Compressor Controller will start the compressor again. See **Figure 3** for a graphical representation. **The maximum input voltage for C1, C2 is 5.3 VDC.**

(P1, P2, P3, P4) System Pressure Input

If a pressure transducer is used with the Compressor Controller, the System Pressure Input is a measurement of the system suction pressure. For pressure transducer signal wiring, short wire runs and shielded wiring are recommended. For best signal resolution, the smallest acceptable pressure transducer range for the refrigerant should be used. The Digital Compressor Controller provides a precision source 5VDC for the pressure transducer to accurately measure the pressure. This 5VDC source is capable of sourcing a maximum of 10mA

(P5, P6) System Pressure Output

If a pressure transducer is connected to the System Pressure Input terminals, the System Pressure Output provides an analog output of the filtered suction pressure. The Digital Compressor Controller "filters" this suction pressure by using the unloader capacity algorithm to smooth the pressure fluctuations measured by the suction pressure transducer. The output of 0.5 – 4.5VDC corresponds to the range of the pressure transducer connected to the System Pressure Input terminals. This output is capable of sourcing a maximum of 10mA.

(T1, T2) Discharge Temperature Input

The Discharge Temperature Input is a thermistor input. There is no polarity requirement for the thermistor. For thermistor signal wiring, short wire runs are recommended. The cut out temperature is 268°F (131°C) and the cut in or reset temperature is 250°F (121°C). See **Table 1** for thermistor temperature/resistance values.

(A1, A2) Alarm Relay

The Alarm Relay output is a normally open, dry contact relay output. The maximum operating voltage for this relay is 250VAC or 30VDC and the maximum load is 3 A. During an alarm condition, the relay contacts close until the alarm condition ceases or power is turned off.

(M1, M2) Compressor Contactor

The compressor contactor output is a triac output. **The maximum continuous contactor coil load is 0.5A and the peak inrush current is 6A.** The maximum coil operating voltage is 250VAC. This output is incompatible with DC coil voltages. The compressor contactor is energized when there are no ALERT conditions and the demand signal is greater than 1.44VDC.

(L1, L2) Control Power
NOTE! Control Power supplied to Digital Compressor Controller must be the same voltage as the compressor contactor coil, unloader solenoid and vapor injection solenoid.

The Control Power requirement is a single phase, 19-250VAC, 48-62Hz source. **The control power must be isolated with a transformer from the mains power supply.** The maximum load on the control power circuit is 1.5A based on a motor contactor, unloader solenoid and vapor injection solenoid connected to the Compressor Controller.

(U1, U2) Unloader Solenoid
The Unloader Solenoid output is a triac output. The maximum continuous solenoid load is 0.5A and the peak inrush current is 6A. The maximum solenoid operating voltage is 250VAC. This output is incompatible with DC solenoid voltages. The unloader solenoid is energized in an on/off pattern to deliver the capacity requested by the demand signal.

(V1, V2) Vapor Injection Solenoid
The Vapor Injection Solenoid output is a triac output. The maximum continuous solenoid load is 0.5A. The maximum solenoid operating voltage is 250VAC and the peak inrush current is 6A. This output is incompatible with DC solenoid voltages. The vapor injection solenoid is energized whenever the compressor contactor is energized.

Compressor Start And Shut Down
The Digital Compressor Controller always unloads the compressor for 0.1 seconds at each startup. After this brief unloading period, the unloader solenoid will be deenergized and the compressor will run loaded according to the level of the Demand input signal. Each time the compressor shuts down, the Digital Compressor Controller will run the compressor unloaded for 0.5 seconds. Energizing the unloader solenoid for this period of time will allow the discharge and suction pressures to equalize, minimizing scroll reverse rotation.

Compressor Running
The loaded/unloaded cycle always equals 20 seconds. The loaded sequence always precedes the unloaded sequence. Capacity modulation is achieved by energizing and de-energizing the solenoid valve. When the solenoid valve is de-energized, the compressor capacity is 100%. When the solenoid valve is energized, the compressor capacity is zero. Therefore, the capacity achieved is the time average capacity, which is a variable from 10 – 100%. Example: If the solenoid is de-energized (loaded) for 16-seconds, then energized (unloaded) for 4-seconds, the resulting capacity will be 80%.

Digital Compressor Controller LEDs
POWER LED (green) – indicates voltage is present at the 24VAC power terminals. When the anti-short cycle timer is active, the green LED will flash.
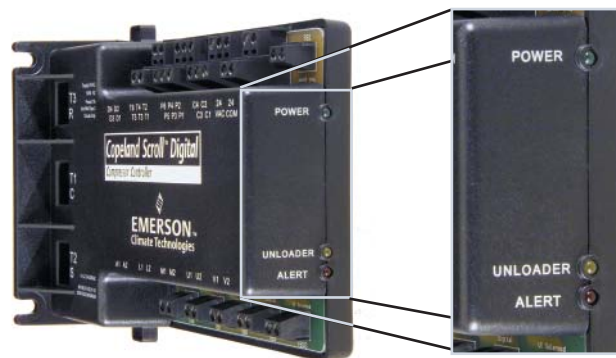
UNLOADER LED (yellow) – indicates the unloader solenoid status. This LED is on when the unloader solenoid is energized.

ALERT LED (red) – communicates an abnormal system condition through a unique flash code. *The ALERT LED will flash a number of times consecutively, pause and then repeat the process. The number of consecutive flashes, defined as the Flash Code, correlates to a particular abnormal condition.*

Flash Code Troubleshooting
While each ALERT code is active, the alarm relay contacts (A1 and A2) are closed. The ALERT code will remain active and the alarm relay contacts closed until the reset conditions have been met or 24VAC power has been cycled off and on. All Flash Codes except Code 6 and 8 result in the compressor contactor, unloader solenoid and vapor injection solenoid being deenergized.

All LEDs flashing at the same rate indicates 24VAC supply is too low for operation. All LEDs on solid at the same time indicates Digital Compressor Controller failure.

Whenever power is cycled off and on, the current Flash Code and all internal counters are reset.

Flash Code 1 - Reserved for future use

Flash Code 2 - High Discharge Temperature
The discharge temperature thermistor has measured a temperature above 268°F (130°C) or the thermistor is short circuited (jumpered out).

The Digital Compressor Controller will deenergize the compressor contactor, unloader solenoid and vapor injection solenoid. The alarm relay contacts will close.

The compressor will be allowed to restart after a 30 minute delay and after the thermistor temperature is below 250°F (120°C). The flash code and alarm relay contacts will be reset after the compressor has run for 60 uninterrupted minutes without any other ALERTs.

If five high discharge temperature ALERTs have occurred within four hours, the Digital Compressor Controller will lock out the compressor. The lockout can only be reset by cycling the 24VAC power off and on.

Flash Code 3 - Compressor Protector Trip
The demand signal from the system controller is greater than 1.44VDC and there is no compressor current detected. This could be due to the compressor's internal overload protector being open, fuse or breaker open, power disconnected to compressor contactor, compressor power wiring not run through Digital Compressor Controller current transformer port or a compressor contactor failure.

The Digital Compressor Controller will deenergize the compressor contactor, unloader solenoid and vapor injection solenoid. The alarm relay contacts will close.

The Digital Compressor Controller will wait for the two minute anti-short cycle timer to time out and if the system controller demand signal is still greater than 1.44VDC, energize the compressor contactor again. If compressor current is detected on the restart, the ALERT code and alarm relay

output will reset. The Digital Compressor Controller will attempt to restart compressor as long as the system controller demand is above 1.44VDC. There is no lockout feature for this ALERT.

Flash Code 4 - Locked Rotor
A locked rotor condition in the compressor is sensed by the Digital Compressor Controller on four consecutive start ups.

The Digital Compressor Controller will deenergize the compressor contactor, unloader solenoid and vapor injection solenoid. The alarm relay contacts will close.

This code results in a lockout and can only be reset by cycling the 24VAC power off and on.

Flash Code 5 - Demand Signal Loss
The demand signal input has dropped below 0.5VDC. The demand input signal wire may be disconnected or the system controller providing the signal may not be powered.

The Digital Compressor Controller will deenergize the compressor contactor, unloader solenoid and vapor injection solenoid. The alarm relay contacts will close.

Once the system controller demand signal input has risen above 0.5VDC, the ALERT code and alarm relay output will reset. If the demand signal is above 1.44VDC and the anti-short cycle timer has timed out, the compressor will restart.

Flash Code 6 - Discharge Thermistor Fault
The Digital Compressor Controller is not receiving a signal from the discharge temperature thermistor. The thermistor may be missing, disconnected or a wire is broken.

The alarm relay contacts will close and the Digital Compressor Controller will not increase the capacity of the compressor beyond 50% loading.

This ALERT code and alarm relay output are reset by reconnecting the thermistor.

Flash Code 7 - Unloader Solenoid Fault
Reserved for future use

Flash Code 8 - Compressor Contactor Fault
Compressor current is detected when the system controller demand signal is below 1.44VDC. The compressor contactor may have welded contacts or the contacts may be mechanically jammed. The compressor will continue to run in this condition since the Digital Compressor Controller cannot open the compressor contactor.

The Digital Compressor Controller will energize the compressor contactor and vapor injection solenoid. The alarm relay contacts will close. The unloader solenoid will remain energized causing the compressor to run unloaded as long as the system controller demand signal is less than 1.44VDC. If the system controller demand is greater than 1.44VDC, the unloader solenoid will deenergize causing the compressor to run loaded.

The ALERT code and alarm relay output are reset when current is no longer detected while system controller demand signal is below 1.44VDC.

Flash Code 9 - Low 24VAC Supply
Supply voltage to the Digital Compressor Controller has dropped below 18.5VAC.

The Digital Compressor Controller will deenergize the compressor contactor, unloader solenoid and vapor injection solenoid. The alarm relay contacts may close if the voltage is high enough for the alarm relay to pull in.

The ALERT code and alarm relay output are reset when the supply voltage to the Digital Compressor Controller rises above 19.5VAC.

OEM Testing
The Digital Compressor Controller can remain in circuit during factory hi-pot testing. The maximum hi-pot test voltage that should be applied between ground and the 24VAC Low Voltage Inputs and Outputs is 600VAC. The maximum hi-pot test voltage that should be

applied between the High Voltage Control and High Voltage Outputs is 2500VAC. The normal leakage current should be less than 200 microamps.

Testing The Installed Digital Compressor Controller
Once installed, the Digital Compressor Controller can be tested to verify it is working properly. In each test, 24VAC must be supplied to 24VAC and 24COM. For the output test, 24-250VAC must be supplied to L1 and L2.

Input Tests
Thermistor Input – disconnect the discharge temperature sensor wires from terminals T1 and T2. If functioning normally, the Digital Compressor Controller should display a Code 6 unless a previous ALERT code was present.

Demand Input – disconnect the System Controller Demand signal wires from C1 and C2. If functioning normally, the Digital Compressor Controller should display a Code 5 unless a previous ALERT code was present.

Output Tests
Contactor Output – while the Digital Compressor Controller is powered off (no supply voltage to 24VAC and 24COM), disconnect the System Controller Demand signal wire from C1 and C2. Add a jumper wire from P3 to C2 and a second jumper wire from P1 to C1. Reapply power to 24VAC and 24COM. If functioning normally, a voltmeter should read the same voltage across M1 and M2 as is measured across L1 and L2, unless an ALERT code is present.

Unloader Output – while Digital Compressor Controller is modulating the unloader solenoid, a voltmeter should read the same voltage across U1 and U2 as is measured across L1 and L2 whenever the yellow "Unloader "LED is lit.

Figure 1
Compressor Controller Wiring Diagram
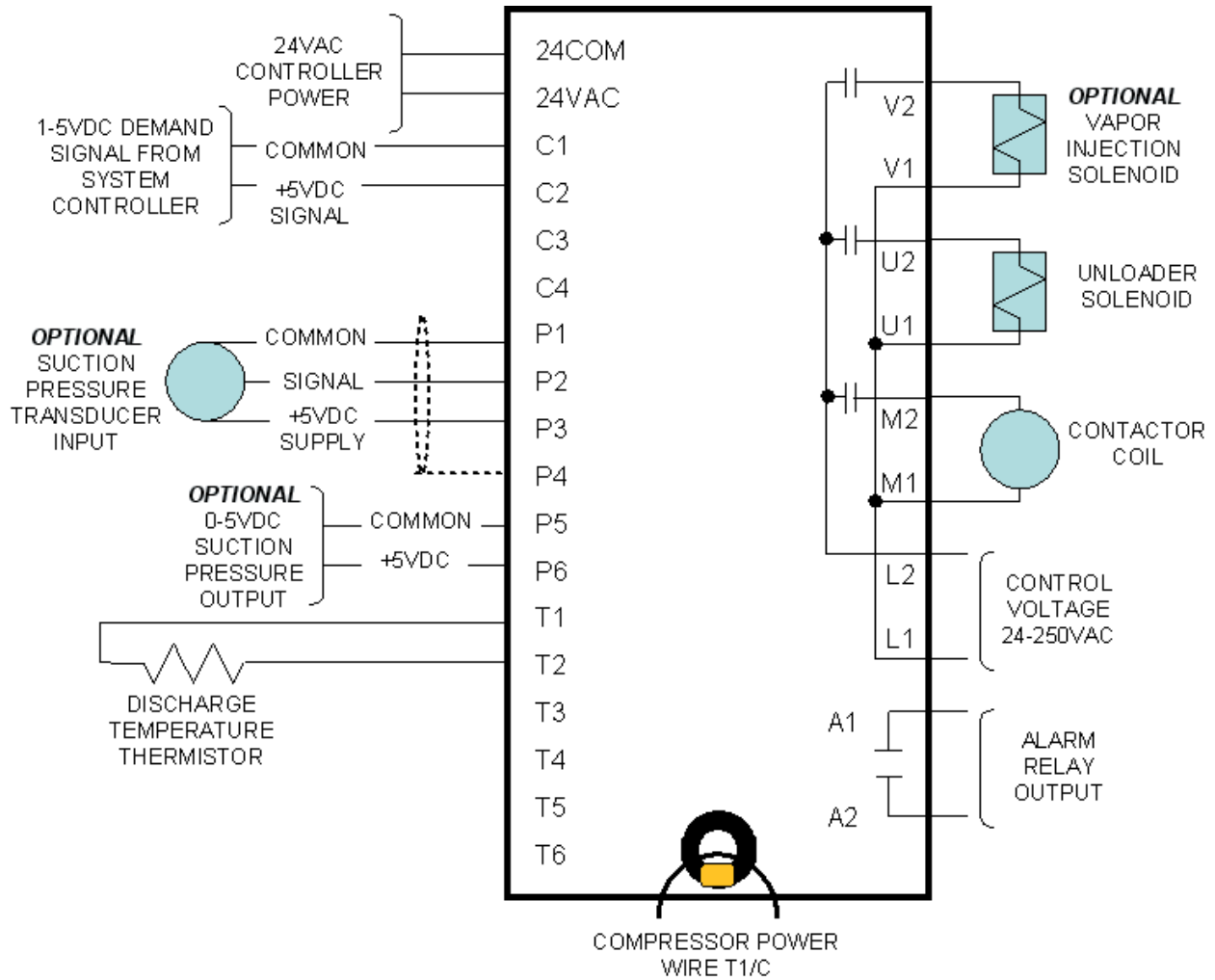
Figure 2
Alternate Compressor Controller Wiring Diagram
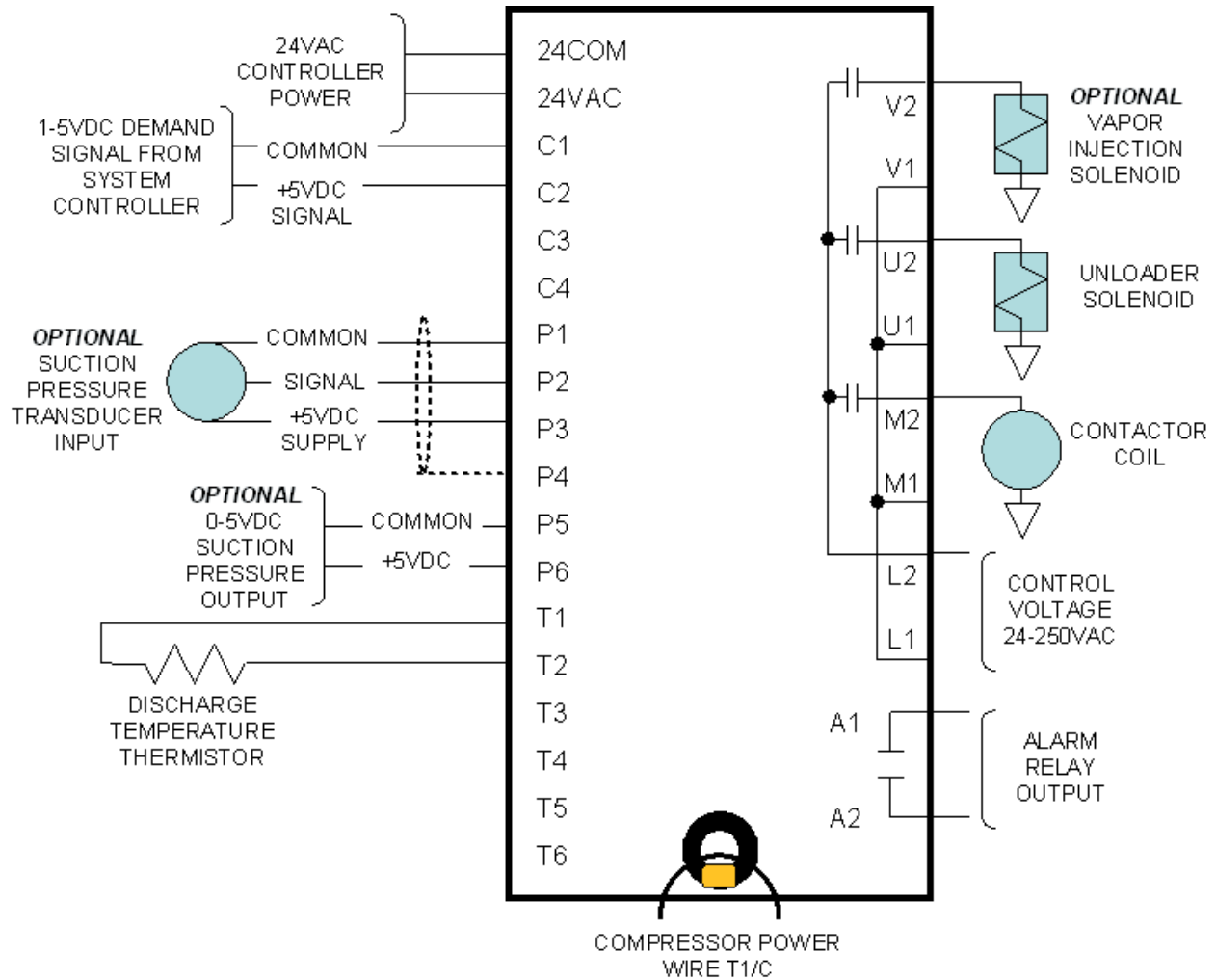
Figure 3
Demand Signal Vs. Modulation Graph
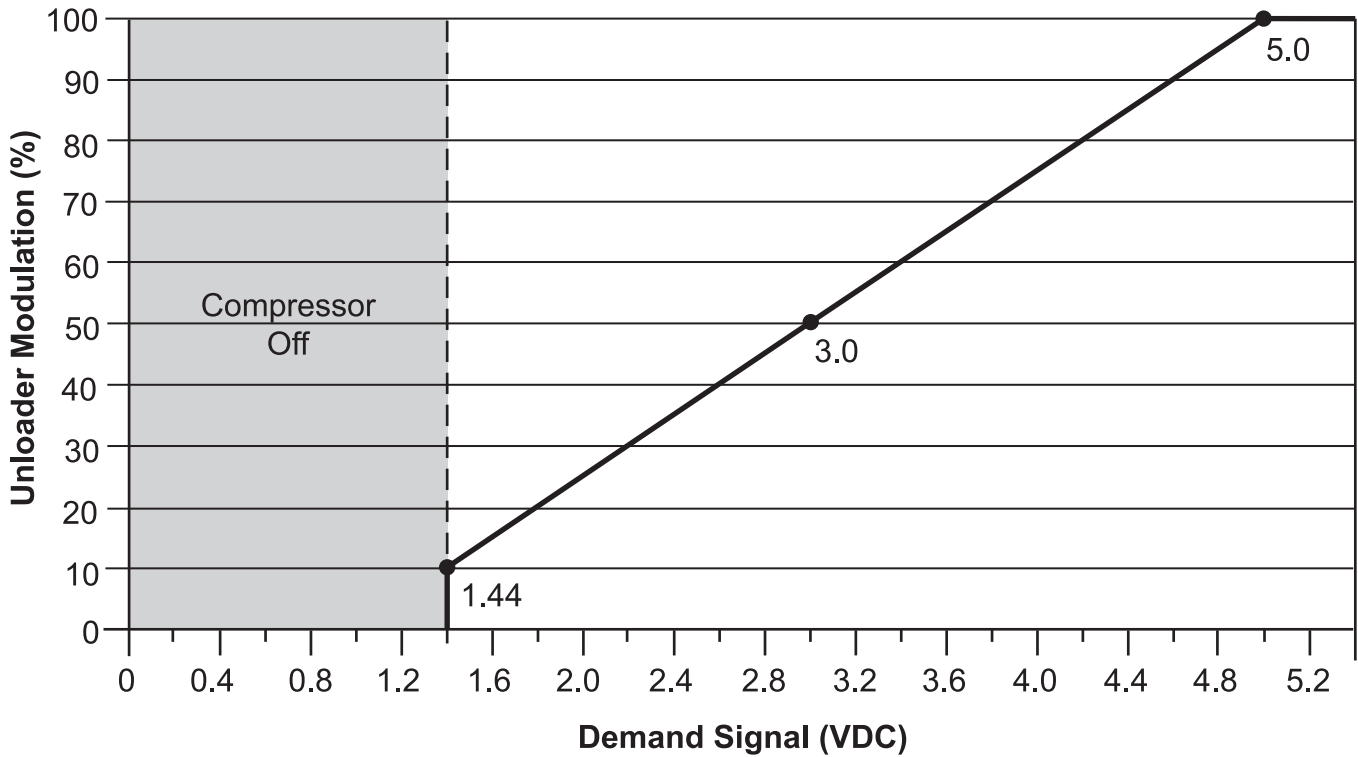
Demand Signal (VDC)	Loaded %	Unloaded %	Time Loaded	Time Unloaded
1.00	Off	Off	Off	Off
1.44	10%	90%	2 seconds	18 seconds
3.00	50%	50%	10 seconds	10 seconds
4.20	80%	20%	16 seconds	4 seconds
5.00	100%	0%	20 seconds	0 seconds

Table 1
Thermistor Temperature/Resistance Values

Deg C	Deg F	Resistance (kOhms)
-40	-40	2889.60
-35	-31	2087.22
-30	-22	1522.20
-25	-13	1121.44
-20	-4	834.72
-15	5	627.28
-10	14	475.74
-5	23	363.99
0	32	280.82
5	41	218.41
10	50	171.17
15	59	135.14
20	68	107.44
25	77	86.00
30	86	69.28
35	95	56.16
40	104	45.81
45	113	37.58
50	122	30.99
55	131	25.68
60	140	21.40
65	149	17.91

Deg C	Deg F	Resistance (kOhms)
70	158	15.07
75	167	12.73
80	176	10.79
85	185	9.20
90	194	7.87
95	203	6.77
100	212	5.85
105	221	5.09
110	230	4.45
115	239	3.87
120	248	3.35
125	257	2.92
130	266	2.58
135	275	2.28
140	284	2.02
145	293	1.80
150	302	1.59
155	311	1.39
160	320	1.25
165	329	1.12
170	338	1.01
175	347	0.92
180	356	0.83