Introducing SmartFan® Inversion

"The convenience of AC power, the control and efficiency of a DC fan"

Rev: 0 (904)

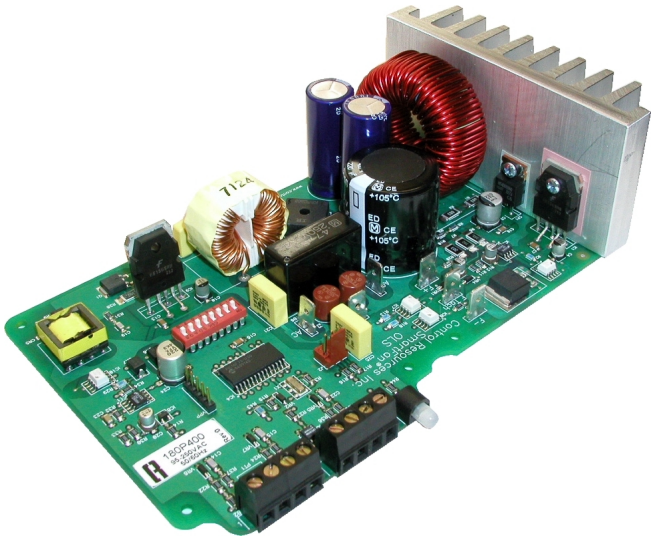

Fig. 1 CRI #180P400 Control Board

Fig. 2 CRI #180P200E, Inversion in ABS enclosure

SmartFan® Inversion combines an AC – DC power supply and a DC fan control to provide the best of both worlds; the convenience of AC power, the control and efficiency of a DC fan. When power conservation or fan controllability is important, nothing beats a DC fan. At reduced voltages, typical DC fans use 40-65% less power than their AC counterparts. The voltage vs. flow curve of a DC fan is also much more linear than a typical AC fan making speed control more accurate. Other advantages of using the SmartFan Inversion are longer fan life and three fan alarm options including: fan speed, over-temperature or loss of signal. Inversion regulates fan speed based on temperature or a control signal (4-20mA, 2-10VDC) input.

SPECIFICATIONS & FEATURES

Specifications

- Power Source: 115 / 208 / 220 / 230VAC ±15%
- Frequency: 50 / 60 Hz ±7%
- Output: 24 or 48VDC (jumper selectable)
- Current Rating: 180P400 (board only) 4.0Amps
  180P200E (enclosure) 2.5Amps
- Controls fan/motor speed based on:
  - ✓ 4-20mA control signal or
  - ✓ 2-10VDC control signal or
  - ✓ Remote temperature sensor (sold separately)
- Enclosure (180P200E only): UL 94-5VA rating
- Storage Temp.: -40°C to 125°C
- Ambient Operating Temp.: -25°C to 40°C

Features

- Compatible with 24 or 48 VDC fans
- PCB mount or ABS plastic enclosure
- One or two remote, OR'd temperature sensors (sold separately).
- Four full speed temperature settings
- Two control temperature slopes
- On board status LED and remote alarm options:
  - ✓ Over temperature
  - ✓ Loss of control signal
  - ✓ Failed fan (low fan speed)
- Three fan alarm trigger speed settings
- Special and custom configurations are available
- CUL recognition and CUL listing pending

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Advantages of Using the SmartFan Inversion Speed Control

DC fans have been widely used in computer, telecommunication and medical applications for many years. HVAC applications have historically used AC fans due to price, availability of larger DC fans and the lack of a DC power source. With recent technical innovations and efficiencies of volume production, the price and availability gap between larger AC and DC fans has been greatly diminished. DC fans offer significant advantages over AC Fans:

- ❖ Linear speed vs. voltage curve
- ❖ Longer life expectancy
- ❖ Low cost fan speed monitoring
- ❖ No motor heating at reduced voltages
- ❖ Linear speed/torque relationship
- ❖ Higher energy efficiency at reduced speeds
- ❖ No speed changes due to line voltage and frequency variation
- ❖ Lower EMI and RFI noise levels

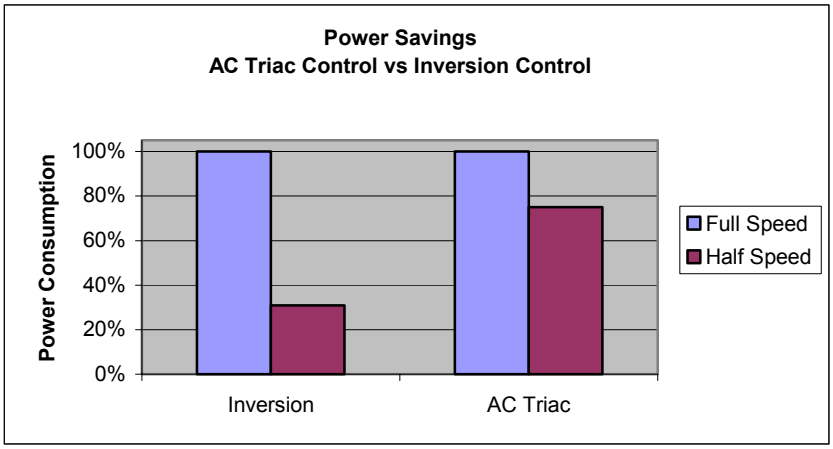
SmartFan Inversion is designed to bring these benefits to HVAC and other applications that only have an AC power source.

Power Saving Comparison of AC vs. DC Fan Speed Control

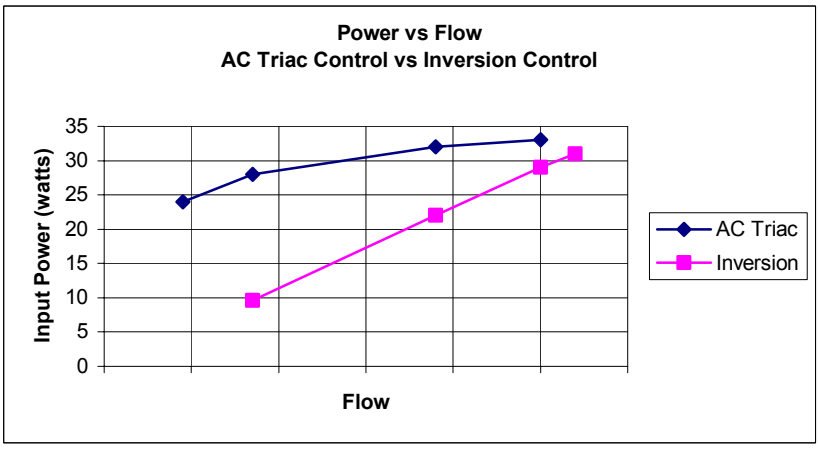
Fans Used			
Make/Model	Volts	Watts	CFM
ebmpapst 6224NH	24 VDC	26	283
ebmpapst W2E143-AB09-01	230 VAC	29	295

The following charts clearly illustrate the energy efficiency advantages of DC fans.

This chart shows the significant savings in power consumption possible by using DC fans in a variable speed control application. The Inversion control uses 70% less power when fans are running at half speed compared to full speed. The AC Triac control only uses 25% less power when fans are running at half speed compared to full speed.



This chart shows how a DC fan (ebmpapst 6224NH) connected to the Inversion provides significant power savings (up to 65% in this example) at reduced speeds when compared to an AC fan (ebmpapst W2E143-AB09-01) connected to a TRIAC control.



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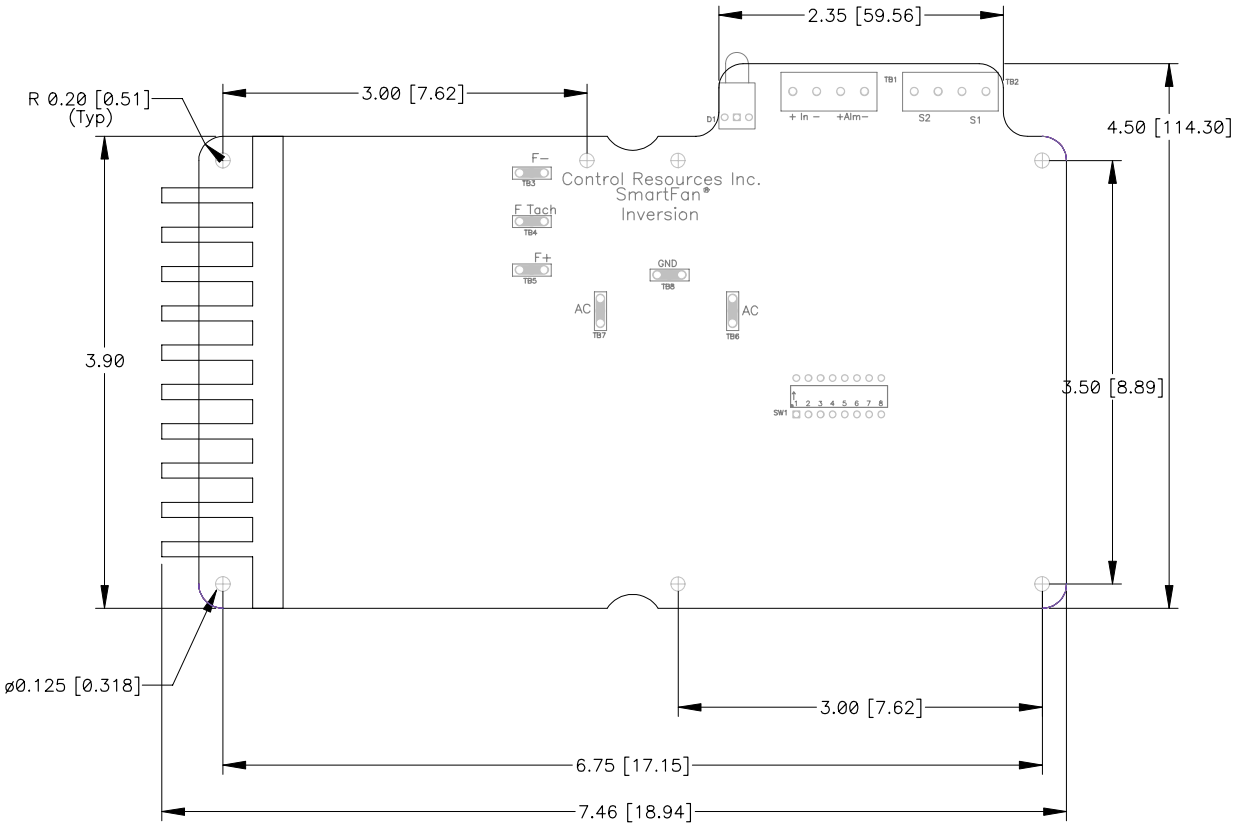

Fig. 3 (180P400) Max Height: 2.00” [50.80mm]

Fig. 4 (180P200E) Max Height: 3.13” [79.5mm]

WARNING: Dangerous voltages are present on the circuit board when connected to the power line. Power must be removed before making any connections or adjustments to avoid electrical shock or damage to the unit. The Inversion will not recognize any changes in switch settings made with power applied.

SETTING FAN VOLTAGE

The Inversion can provide power to 24 VDC or 48 VDC fans as determined by the jumper setting at header J2. Reference Table 5 to set fan voltage. For custom Idle and Max. voltages, contact customer service.

Table 1: Fan Voltage Settings		
J2 jumper setting	**Idle voltage**	**Max. voltage**
24 (factory setting)	13	25
48	26	50

SETTING CONTROL MODES

Unless otherwise specified, the Inversion is factory set to control fans in the Voltage Control mode. To control via temperature or a current source, set switches 1 and 2 as shown below, then refer to the control mode section you have selected to configure the Inversion for your application.

Table 2: Setting Control Modes		
Control Via	DIP switch	
	1	2
Current 4-20mA	ON	OFF
Voltage 2-10V	OFF	OFF
Temperature	OFF	ON

USING CURRENT OR VOLTAGE CONTROL MODES

The off-the-shelf versions of the Inversion will run fans at maximum speed with a 10VDC or 20mA control signal and at idle speed (55% of Max.) with a 4VDC or 8mA control signal. Reference Figure 5.

Fan On / Fan Off Feature (switch #3)

To turn fan(s) off below the idle speed control signal (reference figure 5), set switch #3 to the ON (down) position. To keep fans running at idle speed below the idle speed control signal, set switch #3 to the OFF position. Reference figure 5.

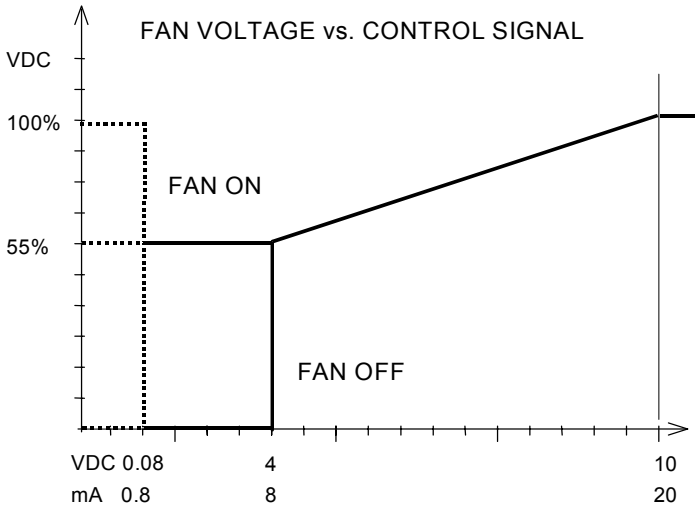

Figure 5

Control Signal Loss Options (switch #4)

If the control signal is lost, (less than 0.8 mA in Current Mode, less than 0.08 VDC in Voltage Mode) when switch 4 is OFF (up) fans will continue to idle or remain off. To send fans to full speed if the control signal is lost (less than 0.8 mA in Current Mode, less than 0.08 VDC in Voltage Mode) set switch 4 to the ON (down) position. Reference figure 5.

Alarms in Current or Voltage Control Mode

When controlling fans from a current or voltage signal, an alarm will be triggered if the control signal drops below 0.8 mA in Current Mode or 0.08 VDC in Voltage Mode. The alarm will also be triggered due to a severed or loose control signal wire. When using a fan with a speed sensing tach output wire, this alarm will also be triggered to indicate a significant reduction in fan speed. To set the fan speed at which the alarm is triggered, reference table 3. Note: the Inversion senses fan speed signals in Pulses Per Minute (PPM). Some fans generate more than one pulse per revolution; consult your fan manufacturer for details.

Table 3: Setting Fan Speed Alarm		
Alarm trigger speed (PPM)	DIP switch	
	7	8
Disabled	OFF	OFF
1000	OFF	ON
2000	ON	ON
4000	ON	OFF

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When an alarm condition is sensed, an on-board LED will turn from GREEN to RED and an alarm signal will be generated at terminal block connection TB1. To connect the alarm signal to a remote LED, contact customer service. Reference the Alarm Connections section for other alarm output connections.

USING TEMPERATURE CONTROL MODE

The Inversion automatically controls temperature (air, liquid or surface) by proportionately increasing or decreasing fan speed as required. One or two sensors (refer to www.controlres.com/sensors.htm for specifications) can be used to sense temperature. When two sensors are used, the hottest sensor will determine fan speed. To set the Inversion to Temperature Control Mode, refer to table 2. Refer to figure 6 when setting up temperature control parameters.

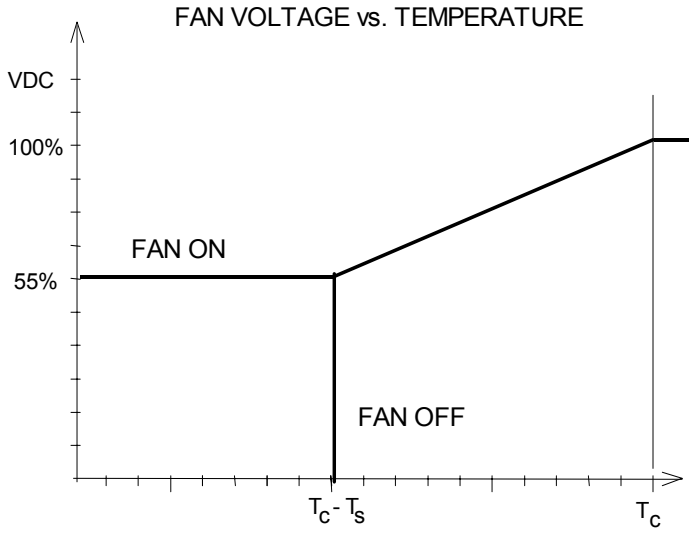

Figure 6

Control Temperature (switch #5,6)

The control temperature (T_C) is the temperature above which fans will run at full speed. The Inversion is factory set to control fans at 30, 35, 40 or 45˚C by setting DIP switches 5 and 6. The default setting is 35˚C. Other temperature setting can be supplied, contact customer service for details. Reference figure 6 and table 4.

Table 4: Control Temperature DIP Switch Settings			
Control Temperature (T_C)		DIP switch	
T_C (˚C)	T_C (˚F)	5	6
30	86	OFF	ON
35	95	OFF	OFF
40	104	ON	OFF
45	113	ON	ON

Temperature Slope (switch #4)

The temperature slope (T_S) is the temperature difference between idle speed and full speed. The slope can be set at 4˚C or 10˚C by using DIP switch #4. The default setting is 4˚C. Other slopes can be supplied, contact customer service for details. Reference figure 6 and table 5.

Table 5: Temperature Slope DIP Switch Settings		
Temp. Slope (T_S)		DIP switch
T_S (˚C)	T_S (˚F)	4
4	7	OFF
10	18	ON

Fan On / Fan Off Feature (switch #3)

To turn fans off automatically when the temperature drops below the set idle temperature ($T_C - T_S$), set switch #3 to the ON (down) position. To keep fans running at idle speed when the temperature drops below the set idle temperature, set switch #3 to the OFF position. Reference figure 6.

Alarms in Temperature Control Mode

When controlling fans from a temperature sensor, an alarm will be triggered to indicate an over temperature condition if the temperature is more than 10°C (18°F) over the control temperature (T_C). The alarm will also be triggered due to a severed or loose sensor wire. When using a fan with a speed sensing tach output wire, this alarm will also be triggered to indicate a significant reduction in fan speed. To set the fan speed at which the alarm is triggered, reference table 3. The Inversion senses fan speed signals in Pulses Per Minute (PPM). Some fans generate more than one pulse per revolution; consult your fan manufacturer for details.

When an alarm condition is sensed, an on board LED will turn from GREEN to RED and an alarm signal will be generated at terminal block connection TB1. To connect the alarm signal to a remote LED, contact customer service. Reference the Alarm Connections section for other alarm output connections.

HARDWARE OPTIONS

For installation convenience, we encourage sample and low volume customers to order the CRI hardware packs listed below. They include hardware for typical mounting and connecting applications.

P/N 180P400	**P/N 180P200E**
Hardware Pack P/N H119	**Hardware Pack P/N H120**
(6) ¼" female spade terminal Keystone P/N 3528	(6) ¼" female spade terminal Keystone P/N 3528
(6) Snap in spacer Richco P/N LCBSM-4-19	(2) Terminal block plug Phoenix Contact P/N 1757035
	(1) Strain relief clamp Thomas & Betts P/N 3303
	(4) 6-32 x 5/8" screws

MOUNTING

Circuit Board Form (P/N 180P400)

When supplied in circuit board form (P/N 180P400), a spacing of ¼" (6.3mm) should be maintained between the circuit board and chassis ground and 5/16" (8mm) to any un-insulated secondary circuits to satisfy safety agency requirements. The board may be mounted using 4-40 or #3 metric screws or plastic circuit board supports such as Richco, Inc. P/N LCBSM-4-19

ABS Plastic Enclosure (P/N 180P200E)

When supplied in an ABS plastic enclosure (P/N 180P200E), attach the enclosure using the 4 external mounting holes. The enclosure can be mounted horizontally or vertically but must always be mounted with the ventilation slots facing up. Allow sufficient air space around the vent slots. Allow sufficient room on the connection side of the enclosure for power, fan, and signal connections.

CONNECTIONS

WARNING: Dangerous voltages are present on the circuit board when connected to the power line. Power must be removed before making any connections or adjustments to avoid electrical shock or damage to the unit.

Fan Connections

Fan connections are made through ¼" x .032" spade lugs (TB3, TB4, TB5) located on the circuit board. Any number of fans may be connected in parallel as long as the total current does not exceed the Inversion current rating (P/N 180P400 - 4 Amps, P/N 180P200E – 2.5 Amps). For fans with an optional speed sensing tach output wire, attach wire to "F Tach" to monitor fan speed for alarm purposes. Note: For a reliable alarm signal, only one fan may be connected to "F Tach".

The fan connections are not isolated from AC power, use double insulated wires for fans as well as power connections. When installing Inversion P/N 180P200E with the enclosure, connect fan and power wires through the 0.813" D hole in the side of the enclosure and secure with a strain relief. See Figure 7 for fan connections.

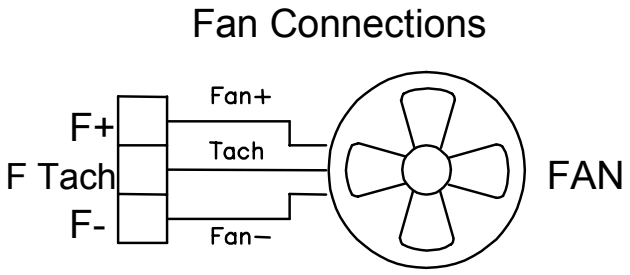

Figure 7

Power Connections

It is recommended that an adequately sized circuit breaker be connected between the power service and the Inversion to permit fail-safe removal of power before making adjustments or connections. For installation in a dwelling, install in accordance to local electrical codes.

Power connections are made through ¼" x .032" spade lugs (TB6, TB7, TB8) located on the circuit board. When installing model number 180P200E with the enclosure, connect fan and power wires through the 0.813" D hole in the side of enclosure and secure with a strain relief. See Figure 8 for line power and ground connections.

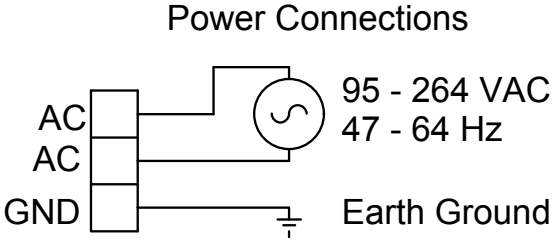

Figure 8

Temperature Sensor Selection and Connection

The Inversion will accept signals from one or two temperature sensors and control fan speed based on the hottest sensor. Choose an air, surface or liquid temperature sensor from the CRI catalog or website at www.controlres.com. When one sensor is used, the sensor may be connected to S1 or S2. There is no polarity consideration when connecting the sensor(s).

For P/N 180P400, sensor connections are made at terminal block TB2. For P/N 180P200E, sensor connections are made on the side of the enclosure at positions labeled S1 and S2 through a removable terminal block plug; Phoenix Contact P/N 1757035.

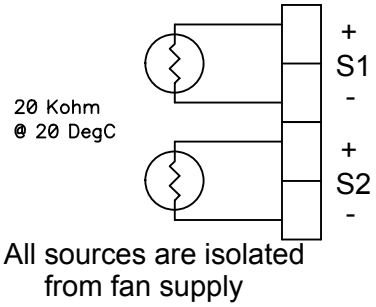

Figure 9

Current or Voltage Control Signal Connections

When used in the current or voltage control mode (see table 2), connect a 0-10VDC or 0-20mA control signal to TB1, + In -. For P/N 180P400, connections are made through a terminal block accepting 12-30awg wire. For P/N 180P200E, sensor connections are made on the side of the enclosure at positions labeled –In+ through a removable terminal block plug; Phoenix Contact P/N 1757035.

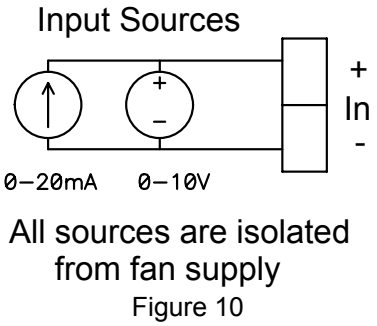

Figure 10

Alarm Connections

Alarm connections are made at –ALM+. For P/N 180P400, connections are made through terminal block TB1 accepting 12-30awg wire. For P/N 180P200E, sensor connections are made on the side of the enclosure at positions labeled –In+ through a removable terminal block plug; Phoenix Contact P/N 1757035.

The alarm output is a normally open, optically isolated MOS Relay. When no alarm condition is present, the relay is closed and can conduct up to 100 mA (AC or DC), of load current. When the alarm is triggered, the relay opens, and can support up to 300 Volts (AC or DC) across its terminals. Other alarm trigger points can be supplied, contact customer service for details. See figure 11 and figure 12 for typical alarm connections.

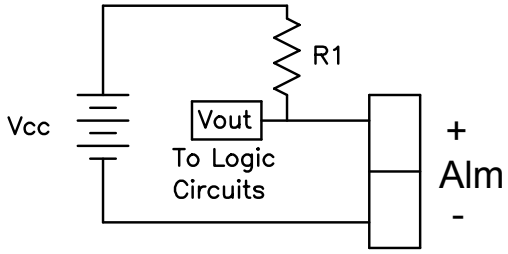

Figure 11 – Logic circuit connection

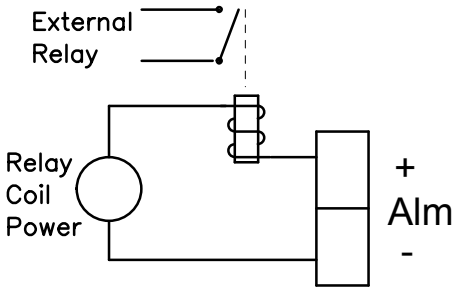

Figure 12 – Relay circuit connection

SPECIALIZED CONFIGURATIONS OF THE INVERSION

Many parameters of the Inversion can be specialized including the following:

- Fan idle voltage
- Control modes
- Control temperature
- Temperature slope
- Fan speed control based on differential temperature
- Alarm outputs
- Remote LED connection
- Monitoring tach pulses from more than one fan
- Fan speed alarm trigger speed
- Optional I2C interface

Contact customer service for assistance with your special requirements.

CONTROL ACCURACY AND HYSTERESIS:

Temperature Mode:
High Temperature Alarm = X2 +10°C
Low Temperature Alarm = -20°C
Temperature Alarm Hysteresis = ±1°C
Temperature Accuracy = ±1°C 0-50°C
= ±2.5°C -20-80°C
Voltage/Current/Transducer Mode:
Signal Loss Alarm Hysteresis = ±1%
Idle Off Hysteresis = ±2%
Input Accuracy = ±5%
Tachometer:
Hysteresis = ±3%
Accuracy = ±1%

CURRENT DERATING:

The Inversion may be run above 40˚C. However, the maximum current ratings will decline according the chart below.

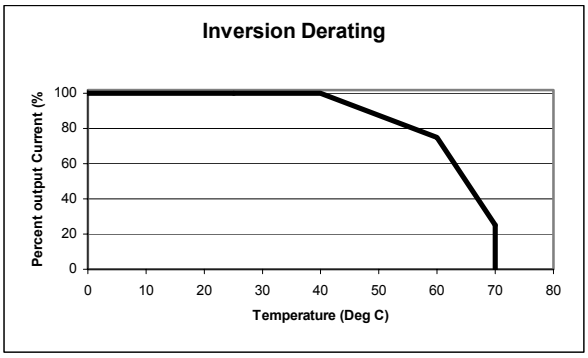

Figure 13