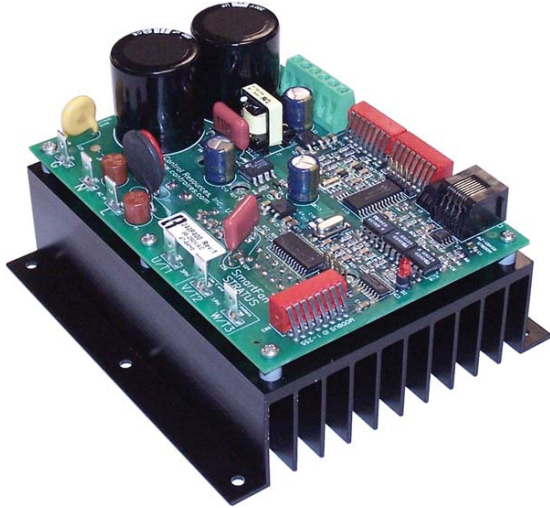# SmartFan® *Stratus*

Variable Frequency Drive

SmartFan Stratus is an economical, yet highly versatile variable frequency drive that provides precise variable speed control of single and three-phase fans, motors and pumps. In general, VFDs are compatible with more motors, can control to lower speeds, have a more linear control curve and are more energy efficient at reduced speeds than a TRIAC (voltage) based control. This microprocessor based VFD is ideal for applications including environmental control (temperature, humidity, pressure, flow), clean room pressurization, equipment cooling, exhaust ventilation and heating/air conditioning systems. On-board programming allows the setting of many parameters providing maximum flexibility.

SPECIFICATIONS

- Input Power: 115 & 230 VAC ±10%
  47-64 Hz
  Single Phase
- Output Power ratings at 40°C:
  — 1 kW load rated for three-phase
  — 800 Watts load rated for single-phase @ 240 VAC
  — 400 Watts load rated for single-phase @ 120 VAC
- Fixed 20 kHz PWM rate
- 0 to 400 Hz output frequency (MODBUS control mode)
- Overload current protection
- Controls fan/motor speed based on:
  — 4-20 mA control signal
  — 1-10 VDC control signal
  — Remote temperature sensor (thermistor)
  — 0-18 VDC transducer (powered from Stratus)
  — Modbus communication link
  — Dual control option (i.e. temperature and humidity)
- Fan Compatibility: For maximum motor life without using a line filter, the use of an inverter grade motor is recommended.

FEATURES

- Selectable voltage-frequency curve, preset linear and fully programmable
- Programmable acceleration and deceleration rates
- On-board Status/Fault LEDs and remote alarm signal indicate loss of control signal, over temperature or over current conditions
- Isolated control inputs
- Programmable temperature control mode options:
  — One or two remote, OR'd temperature sensors
  — Four full speed temperature settings
  — Two control temperature slopes
- Programmable fan/motor turn off at idle
- Agency approvals pending
- Contact CRI customer service for RoHS compliance

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SmartFan® *Stratus*

inch(mm)

OPEN FRAME

OPTIONAL COVER VIEW
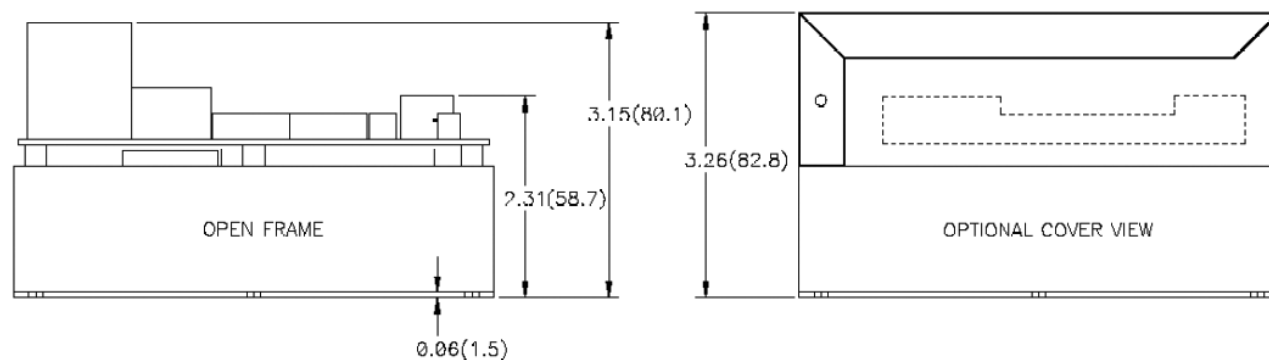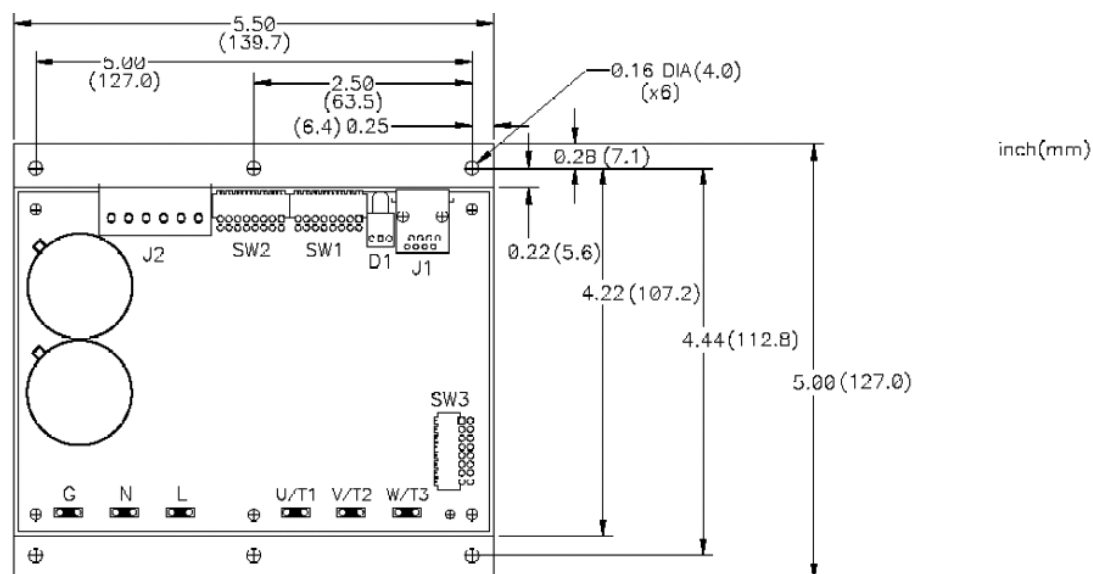
PART NUMBERING

Part No.	Control Inputs	Enclosure
240F400	0-10VDC, 0-20mA, Remote Temp. Sensor, Remote Transducer, ModBus	No
240F402	ModBus only (50 piece minimum order)	No
240F400E	0-10VDC, 0-20mA, Remote Temp. Sensor, Remote Transducer, Modbus	Yes
240F402E	ModBus only (50 piece minimum order)	Yes

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SETTING CONTROL MODES

Unless otherwise specified, Stratus P/Ns 240F400 and 240F400E are factory set to control fans in the Temperature Control mode. To control via voltage, current source or remote transducer make sure SW3 DIP switches 1-8 are set to OFF, set SW2 DIP switches as shown below, then refer to the control mode section you have selected to customize the Stratus for your application.

Table 2: Setting Control Modes via Switch SW2								
	1	2	3	4	5	6	7	8
MODBUS	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
Voltage	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
Current	ON	ON	ON	ON	OFF	ON	OFF	ON
Temp.	ON	ON	OFF	OFF	ON	OFF	ON	OFF
Transducer	Contact CRI Customer Service							

ANALOG CONTROL MODES

USING SINGLE-PHASE OR THREE PHASE MOTORS (switch SW1: #8)

The Stratus can control single or three-phase motors from a single-phase power source. To control a single-phase motor, set SW1, #8 to the OFF position, to control a three-phase motor, set SW1, #8 to the ON position.

USING VOLTAGE OR CURRENT CONTROL MODE

Unless otherwise specified, Stratus P/Ns 240F400 and 240F400E are factory set to control fans in the Temperature Control mode. To switch to controlling fan speed via Voltage or Current signal, switch SW1 #7 ON then refer to table 2 for SW2 switch settings. The Stratus can also be customized to accept other control schemes, contact customer service for details.

Setting Idle Speed (switch SW1: #2,3)

The idle speed is the minimum frequency (speed) supplied to the motor. The Stratus can be set for idle speeds of 0, 20, 40 or 60% by setting SW1 DIP switches 2 and 3. The default idle setting is 40%. Other idle speeds can be supplied, contact customer service for details.

Table 3: Idle Speed DIP Switch Settings		
Idle speed	DIP switch SW1	
	2	3
0%	ON	OFF
20%	OFF	ON
40%	OFF	OFF
60%	ON	ON

Motor On / Motor Off Feature (SW1: #1)

To turn motor(s) off below the set idle speed (see figure 2), set DIP SW1, #1 to the ON position. To keep motor(s) running below the set idle speed, set DIP SW1, #1 to the OFF position.

Control Signal Loss Option (SW1: #6)

If the control signal is lost, (less than 4mA in the current mode, less than 1VDC in the voltage mode) when switch 6 is OFF, the motor will automatically switch to full speed. To keep fans idling or off when the control signal is lost (less than 4mA in the current mode, less than 1VDC in the voltage mode) set switch 6 to the ON position.
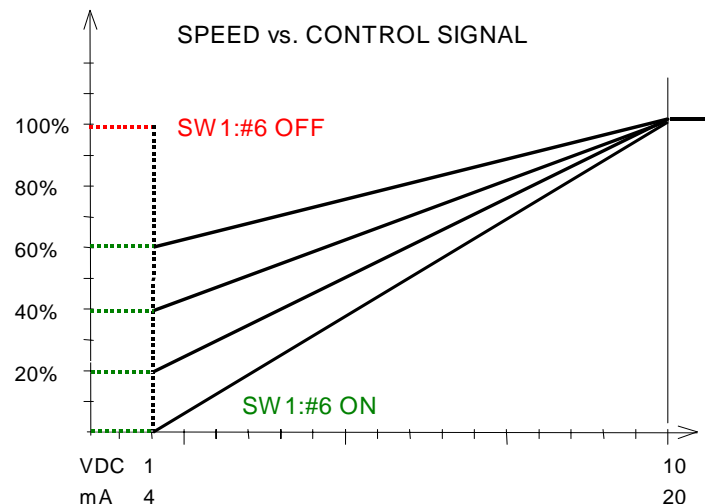

Figure 2

USING TEMPERATURE CONTROL MODE

The Stratus can automatically control temperature (air, liquid or surface) by proportionately increasing or decreasing motor/fan speed as required. One or 2 sensors can be used to sense temperature. When more than one sensor is used, the hottest sensor will control fan speed. To set the Stratus to the temperature control, switch SW1 #7 OFF then refer to table 2 for SW2 switch settings.

Control Temperature (SW1: #4,5)

The control temperature is the point above which fans will run at full speed (T_C). The Stratus is factory set to control fans at 30, 35, 40 or 45°C by setting DIP switch SW1 #4 and #5. The default setting is 35°C. Other temperature setting can be supplied, contact customer service for details.

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Page 3 of 8
2007 (04)

Table 4: Control Temperature DIP Switch Settings			
Control Temperature (T_C)		SW1 DIP switch	
T_C (°C)	T_C (°F)	4	5
30	86	OFF	ON
35	95	OFF	OFF
40	104	ON	OFF
45	113	ON	ON

Setting Idle Speed (SW1: #2,3)

The idle speed is the minimum frequency (speed) supplied to the motor. The Stratus can be set for idle speeds of 0, 20, 40 or 60% by setting SW1 DIP switches 2 and 3. The default idle setting is 40%. Other idle speeds can be supplied, contact customer service for details. See table 3.

Temperature Slope (SW1: #6)

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 SW1 DIP switch #6. The default setting is 4°C. Other slopes can be supplied, contact customer service for details. See figure 3.

Table 5: Temperature Slope DIP Switch Settings		
Temp. Slope (T_S)		SW1 DIP switch
T_S (°C)	T_S (°F)	6
4	7	OFF
10	18	ON

Fan On / Fan Off Feature (SW1: #1)

To turn fans off automatically when temperatures drop below the set idle temperature ($T_C - T_S$), set DIP switch SW1, #1 to the ON position. To keep fans running at idle speed below the set idle temperature, set switch #1 to the OFF position. See figure 3.

SPEED vs. TEMPERATURE
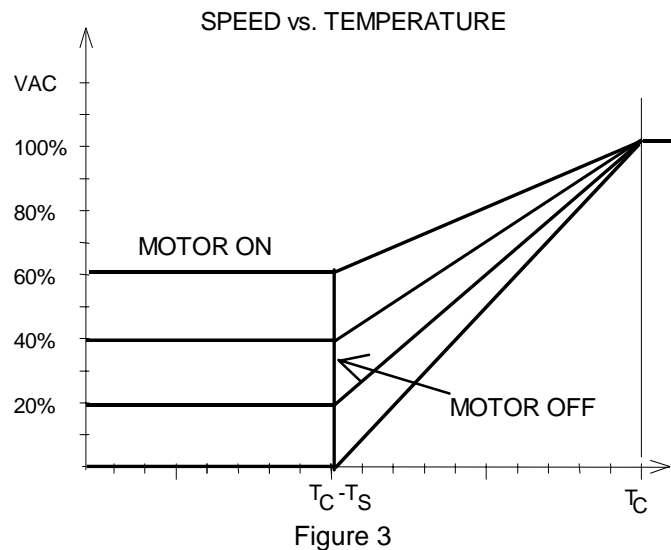
Figure 3

USING REMOTE POWERED TRANSDUCER MODE

The Stratus can be configured to control motor speed based on input from many transducers, i.e.: humidity sensor, pressure sensor, air quality sensor etc. The Stratus can also be supplied with an on board pressure transducer. Contact customer service for details.

MODBUS CONTROL MODE

Unless otherwise specified, Stratus P/Ns 240F402 and 240F402E can only be used in MODBUS control mode. Using a MODBUS communications link, the Stratus can control motor speed, acceleration, deceleration and direction. The protocol required to use MODBUS with the Stratus is listed below:

MODBUS RTU Protocol:

Baud Rate: 9600
Word Length: 8
Parity: None
Stop Bits: 1
MODBUS ID: 1-255

Setup for MODBUS Control

Use switch SW3 to select a unique ID number between 1 and 255 on your MODBUS network. To set an ID number, turn ON any number of switches 1-8 on SW3 and add up their associated "Value" see chart below. Example: turning ON switches 2, 5 and 7 would give a unique ID number of 2+16+64=82.

Table 6: SW3 Switch Settings								
Switch #	1	2	3	4	5	6	7	8
Value	1	2	4	8	16	32	64	128

Connecting to a MODBUS Network

Use an RS-485 2 wire twisted pair cable, connected to the MODBUS network (see figure 5 for proper pinout). Note: when connecting several MODBUS controllable units in a daisy chain fashion, sever pin 7 (18VDC) connection or contact customer service about supplying units with no voltage on pin 7. See figure 5.

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Page 4 of 8

2007 (04)

Controlling via MODBUS

Use table 7 as a quick reference when controlling using MODBUS. Only the shaded registers are required to get a motor turning, for detailed information concerning all registers, see definitions below.

Table 7: Stratus MODBUS Memory Map		
Register	Description	Valid Entry
40001	Motor Direction	0,1,3
40002	Set Speed (% of full)	0-100
40003	Set Frequency (Hz)	0-400
40004	Ramp Up Rate (Hz/sec)	0-60
40005	Ramp Down Rate (Hz/sec)	0-60
40006	Current Trip Limit (Amps)	0-100
40008	Current Output Frequency	Read Only
40009	STATUS Flags	Read Only
40010	Default Startup Speed (% of full)	0-100
40011	Revision (2 bytes)	Read Only
40013	Motor Phase	1 or 3
40014	Bit 0: Default Start/Stop	0,1,3
40016	Max. Motor Frequency (Hz)	0-400
40017	Number of Good Packets	Read Only
40018	Number of Bad Packets	Read Only
40019	DC Bus Voltage	Read Only
40020	Motor Current (100 = 10Amps)	Read Only
40021	IGBT Temp. (raw value)	Read Only

40001 – Motor Direction:
    0=Stop,   1=Forward,   3= Reverse

40002 – Set Speed (% of full): Use this register to set motor speed as a percentage of full speed, 0-100% in 1% increments.

40003 – Set Frequency (Hz): Use this register to set the desired output frequency in 1Hz increments from 0-400Hz, this will also adjust the speed. Use register 40016 to limit the maximum frequency for your motor.

40004 – Ramp Up Rate (Hz/sec): Use this register to set the desired output ramp up rate in 1Hz/sec. Increments.

40005 – Ramp Down Rate (Hz/sec): Use this register to set the desired output ramp down rate in 1Hz/sec. Increments.

40006 (disabled for Rev:1 assemblies, contact customer service for details) – Programmable Current Trip Limit (Amps): Use this register to set the desired output current trip point in 0.1Amp increments. The unit will fault (output will shut off, LED D11 turns RED) when the entered value is reached.

40008 – Current Output Frequency: This register displays the frequency in (Hz) regulating the motor.

40009 – Status Flags:
Bit 0 Run/Stop
Bit 1 Actual direction
Bit 2 Programmable current trip (also displayed on D11)
Bit 3 Hardware current trip (also displayed on D11)
Bit 4 Over temperature trip (also displayed on D11)
Bit 5 Unused
Bit 6 MODBUS enabled
Bit 7 Timer tick

40010 – Default Startup Speed (% of full): The value in this register is copied to 40002 at power-up.

40011 – Revision (2 bytes): Displays current firmware Revision of IC1 in 2 Bytes.

40013 – Motor Phase:
        1 = 1 Phase,   3 = 3 Phase

40014 – Bit 0 : Default Start/Stop: The value in this register is copied to 40001 at power-up.

40016 – Max. Motor Frequency: Limits the frequency supplied to the motor. Set this value to the maximum frequency of the motor being controlled (from 0-400Hz) before setting 40003 to avoid inadvertent damage to the motor.

40017 – Number of Good Packets: Displays the number of completed MODBUS transmissions.

40018 – Number of Bad Packets: Displays the number of incomplete MODBUS transmissions.

40019 – DC Bus Voltage: Voltage reading displayed in 40019 is a raw value. DC Voltage can be determined using the following formula: CountsValue/2.236 = DC Bus Volts.

40020 – Motor Current (100 = 10A): Displays the current draw of the motor being powered.

40021 (disabled for Rev:1 assemblies, contact customer service for details) – IGBT Temp (raw value): The junction temperature of the Stratus Power Module (IC2) in raw form. To convert the value to C^0 = (Value x (-.137)) + 152. This value should always be less than 379(100C°). The unit will fault (output will shut off, LED D11 turns RED) when 379(100C°) is reached.

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Page 5 of 8
2007 (04)

MOUNTING

The Stratus is supplied with six .16"D mounting holes suitable for #6 screws. Use at least 4 screws to mount the Stratus. See figure 1.

CONNECTIONS

WARNING: Dangerous voltages are present on the circuit board when connected to the power line and for some time after power is removed. Power must be removed for 30 seconds before making any connections or adjustments to avoid electrical shock or damage to the unit.

Power Connections

It is recommended that an adequately sized circuit breaker be connected between the power service and the Stratus to permit fail-safe removal of power before making adjustments or connections. Using .250" Female spade type terminals supplied, connect line power (white) to location N, connect line power (black) to location L, connect Earth ground (green) to location G. See figure 4.

Motor Connections

For motor connections, use .250" Female spade type terminals supplied. For single-phase motors, connect motor to positions marked W/T3 and V/T2. For three-phase motors connect to locations W/T3, V/T2 and U/T1. If three-phase motor runs backwards, disconnect power and switch any 2 of the three wires. Any number of motors may be controlled in parallel from one unit as long as the total current does not exceed the current rating.

To help reduce electrical noise emissions, use shielded cable or place motor wires in a grounded metal conduit. See figure 5.

D11 Output Status / Fault LED

Green	Red	Description
Flashing	OFF	Normal operation
Flashing	ON	Output over current or over temperature fault

During power up it is normal for D11 LED's to display invalid conditions for up to 10 seconds.

If the green LED is not flashing (either on or off), the output drive circuit has failed/latched up and power should be cycled to the Stratus.

Current or Voltage Control Signal Connections

When used in the current or voltage control mode (see table 2), connect a 0-10VDC or 4-20mA control signal to A+ and COM as shown in figure 5.

Temperature Sensor Selection and Connection

The Stratus will accept signals from one or two temperature sensors and control fan speed based on the hottest sensor. When sensing air temperature, use the CRI sensor P10. For sensing temperatures of liquids or surfaces, contact CRI customer service.

Connect sensor to terminal block J2, A+ and COM or/and B+ and COM. In "Temperature mode", if no sensors are connected or all sensors read below -20°C, fans will run at full speed and the temperature alarm will activate. The Stratus can also be supplied with a board mount sensor, contact customer service for details. See wiring diagram, figure 4.

Remote Powered Transducer Connections

When used in the remote transducer mode, the Stratus can power and control from any 0-5VDC transducer (humidity, pressure, flow etc.) with a maximum supply current of 5mA. Connect the + lead to B+, connect – to COM, connect Vout to +18V.
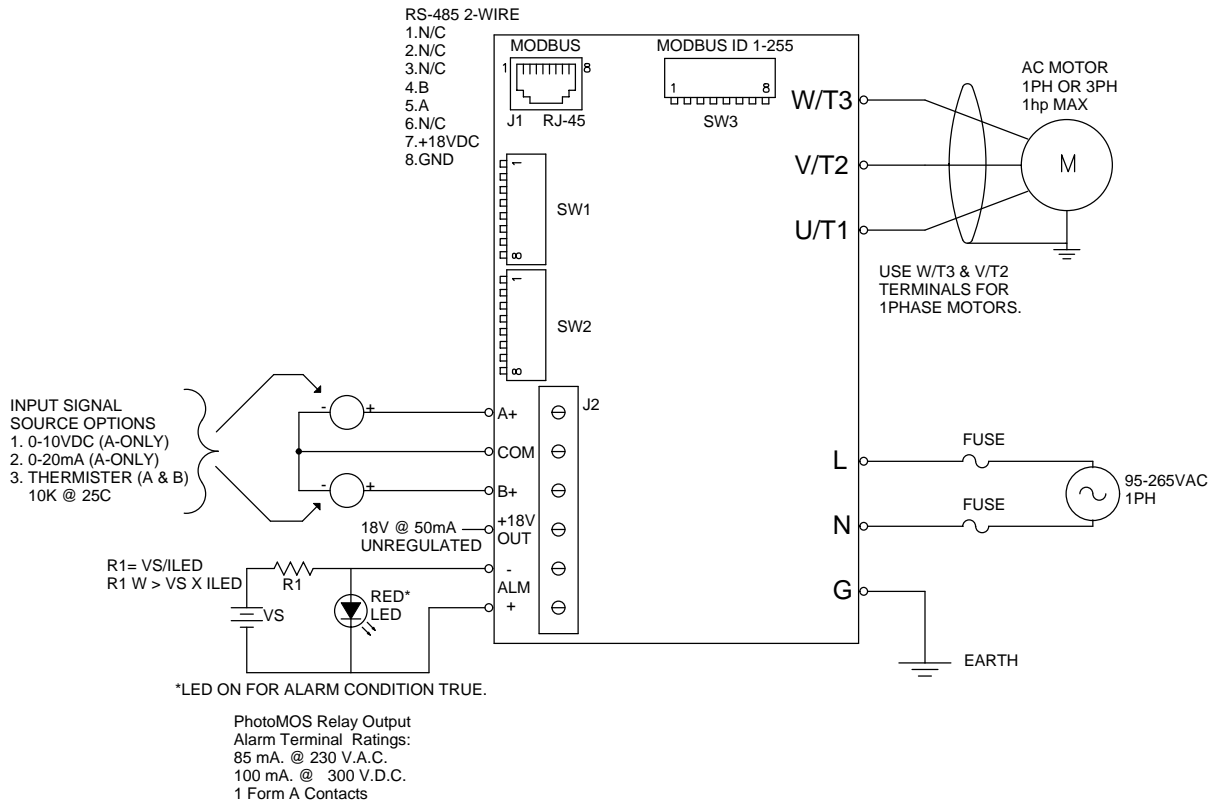
Refer to "USING REMOTE POWERED TRANSDUCER MODE" section to set control parameters for your transducer.

Over Temperature and Loss of Signal Alarm Connection

When used in the temperature control mode, (see table 2) an over-temperature alarm is triggered when the temperature goes 10˚C (18˚F) above the control temperature (T_C) or below -20°C. When used in the Voltage or Current signal mode a "loss of signal" alarm is triggered when SW1 DIP switch #6 is in the ON position. To signal an alarm condition, a bicolored LED (D1) changes from green to red. An alarm signal is also passed through connections –ALM+ at J2.

The alarm output at –ALM+ 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 4 alarm configurations.

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Page 6 of 8
2007 (04)

RS-485 2-WIRE
1.N/C
2.N/C
3.N/C
4.B
5.A
6.N/C
7.+18VDC
8.GND

MODBUS

MODBUS ID 1-255

J1   RJ-45

SW3

W/T3

V/T2

U/T1

AC MOTOR
1PH OR 3PH
1hp MAX

M

USE W/T3 & V/T2
TERMINALS FOR
1PHASE MOTORS.

SW1

SW2

INPUT SIGNAL
SOURCE OPTIONS
1. 0-10VDC (A-ONLY)
2. 0-20mA (A-ONLY)
3. THERMISTER (A & B)
   10K @ 25C

A+

COM

B+

+18V
OUT

-
ALM
+

J2

18V @ 50mA
UNREGULATED

R1= VS/ILED
R1 W > VS X ILED

R1

RED*
LED

VS

L

FUSE

N

FUSE

95-265VAC
1PH

G

EARTH

*LED ON FOR ALARM CONDITION TRUE.

PhotoMOS Relay Output
Alarm Terminal Ratings:
85 mA. @ 230 V.A.C.
100 mA. @ 300 V.D.C.
1 Form A Contacts

OTHER ALARM CIRCUIT CONFIGURATIONS.

GRN LED

ALM
-

VS
+
-

R1

+

LED "ON" FOR NO ALARM
CONDITION PRESENT.

LP1 GRN
85 mA. MAX.

ALM
-

+

230 V.A.C. MAX.

A.C. LAMP "OFF" FOR ALARM
CONDITION PRESENT.

68 K
2 Watt

GRN

ALM
-

12V
1N5242B

+

265 V.A.C. MAX.

DRIVING LED WITH A.C. "OFF" FOR
ALARM CONDITION PRESENT.

Figure 4

STRATUS
ID1

STRATUS
ID2

STRATUS
ID3

STRATUS
ID"n"

RS-485   2 WIRE

MODBUS MASTER
-SCADA
-HMI
-PLC

FAN   MIXER

A

120ohm

ID1

ID2

ID"n"

MODBUS
MASTER

5

5

5

B

4

4

4

SHIELD

120ohm

Where Applicable:
Placement of termination resistors should be
considered during installation of Modbus network.
120ohm Termination Resistors are to be placed across
the twisted pair RS485 at network physical endpoints.

Figure 5

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Page 7 of 8
2007 (04)
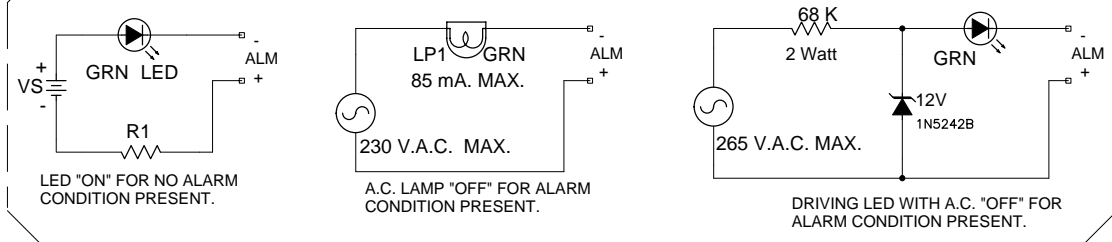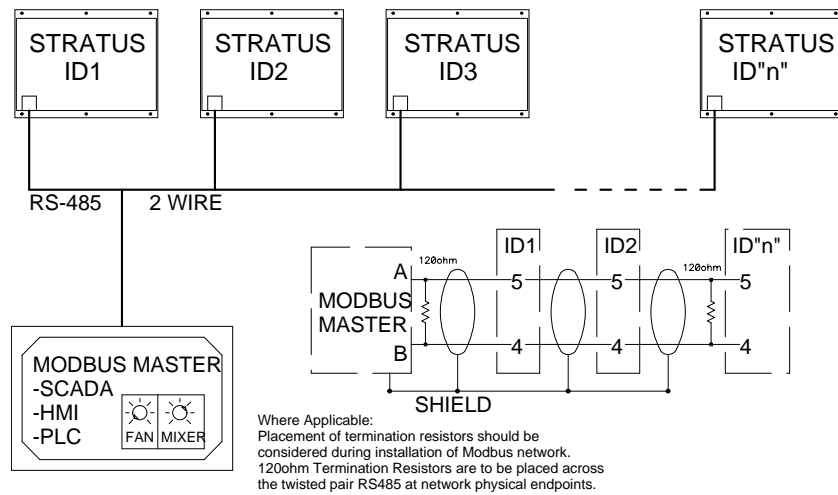
TESTING, TROUBLESHOOTING & TECHNICAL DATA

Motor Compatibility: For maximum motor life without using a line filter, the use of <u>an inverter duty motor is recommended.</u>

Changing Control Settings: The Stratus will not recognize any changes in switch settings made with power applied. <u>To avoid electrical shock</u>, it is recommended that power be turned off for 30 seconds before changing any switch settings.

Electrical Noise Emissions and filtering: Electrical noise emissions (EMI) are highly dependent on load and environment. For many applications no additional filtering is required to meet EN55011/FCC class A emissions standards. For applications requiring additional filtering CRI recommends the following filters or equivalents:

EN55011/FCC class A: 150KHz – 30mHz	EN55011/FCC class B: 10KHz-30mHz
Filter Concepts: LE series www.filterconcepts.com	Filter Concepts: LX series www.filterconcepts.com
Corcom S series, www.cor.com	Corcom Q series, www.cor.com

Controlling multiple motors: Multiple motors wired in parallel can be controlled from one Stratus VFD as long as maximum peak (startup) currents do not exceed 10 Amps.

Control Accuracy and Hysteresis: Control signal accuracy is as follows:

Voltage ± 0.38VDC
Current ± 0.4mA
Temperature ± 1.5C°

In alarm conditions, loss of signal and ON/OFF feature, hysteresis is added to eliminate cycling. Hysteresis is as follows:

Voltage ± 2%
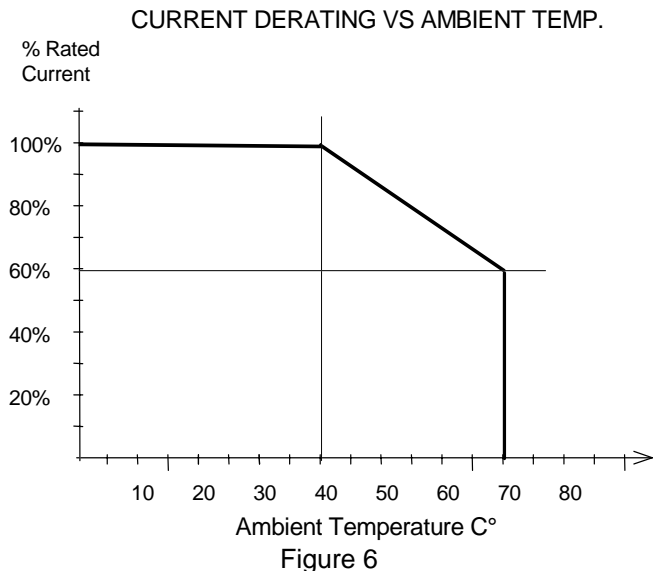Current ± 1.5%
Temperature 1-2C°

RoHS compliance: Contact customer service for the latest compliance information.

Maximum fan currents: Some motors draw higher current at less than maximum voltage. Contact motor manufacturer for details.

HiPot Testing: The Stratus is designed to withstand HiPot testing to 1500Vrms, line input to analog input, motor output to analog input.

Current Derating:

Figure 6

Specifications:

- **Power Source: 95 – 250 VAC**
- **Frequency: 47-64Hz**
- **Output Power at 40°C:**
  - **1 kW load rated for three-phase**
  - **800 Watts load rated for single-phase @ 240VAC**
  - **400 Watts load rated for single-phase @ 120VAC**
- **Maximum peak (startup) current: 10 Amps**
- **Storage Temperature: -40˚C to 125˚C**
- **Operating Temperature: -20˚C to 70˚C**
- **Thermal shutdown at 100°C**
- **Relative Humidity: 95% non-condensing**
- **Weight (no cover): 1.31 lb (594 grams)**
- **Weight (with cover): 1.98 lb (898 grams)**

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Page 8 of 8
2007 (04)