SIEMENS

TEC Custom Solutions Application 2408:

Air Velocity Control with Differential Pressure Sensors

TEC-0635.08

This document contains the following topics:

Overview

Application 2408 maintains the air velocity in two exhaust ducts at the desired air velocity set points. This application does not measure the air velocity in each duct directly. Instead, it measures the differential pressures in both ducts and converts these readings into air velocity values. Refer to Figures 2408-1 through 2408-3.

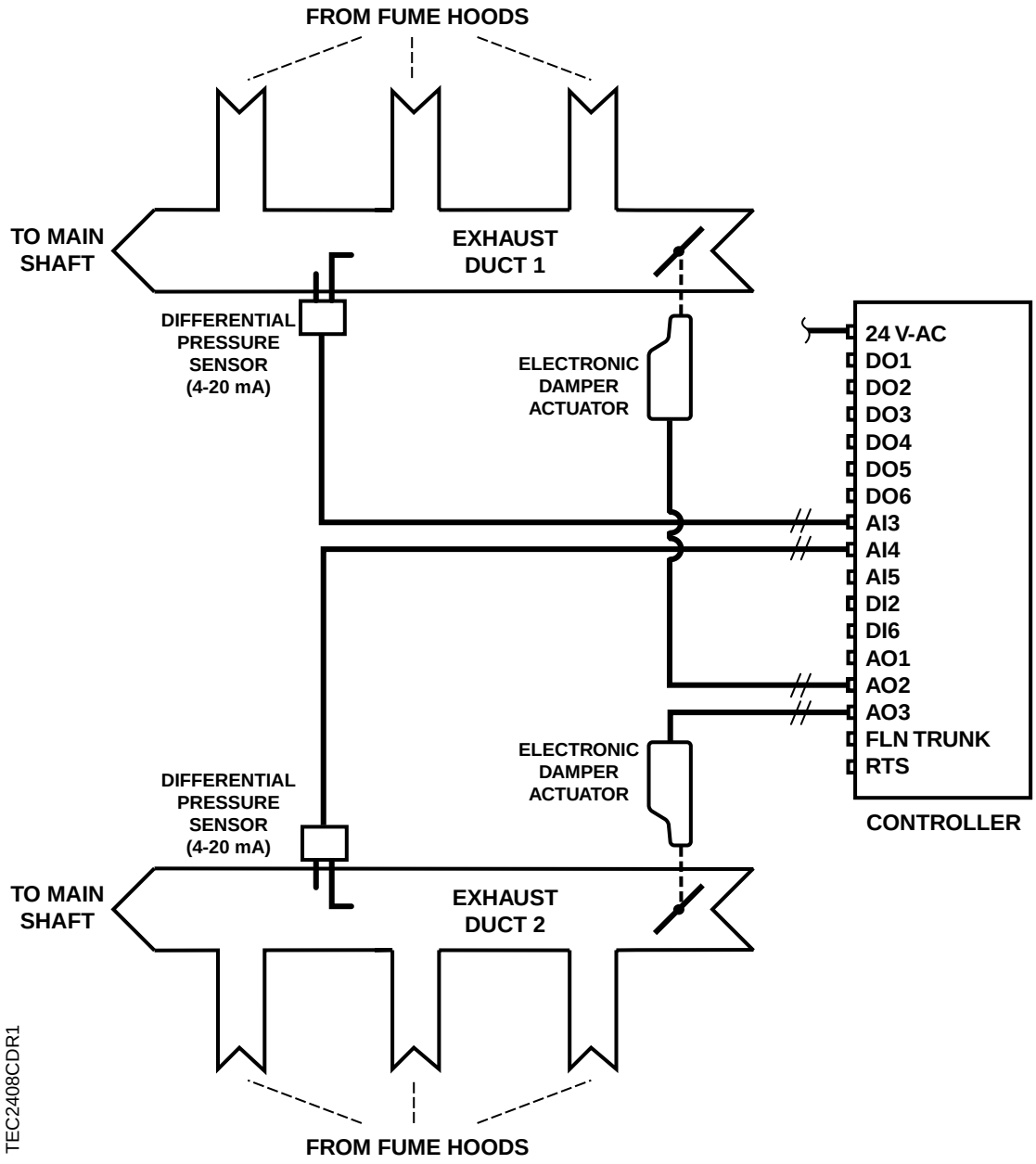
Other features include:

1. A user-adjustable fail-safe value for each exhaust damper. The exhaust damper goes to this value if the differential pressure sensor in its duct fails.

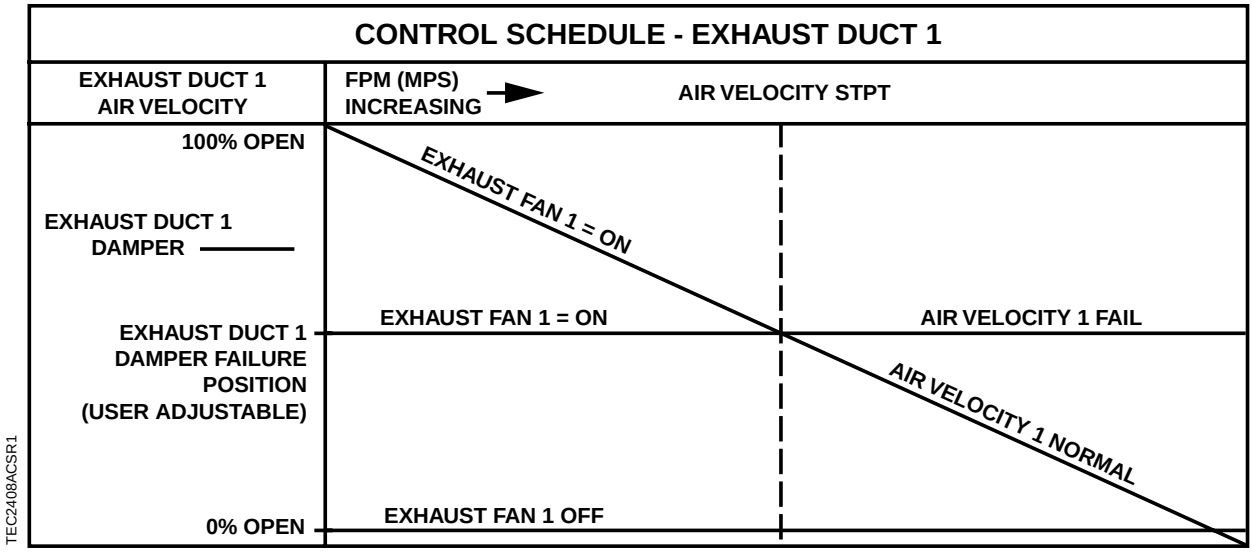
2. Air velocity control is disabled in an exhaust duct when its exhaust fan(s) is (are) off. Air velocity control is enabled in an exhaust duct when its exhaust fan(s) is (are) on.

3. The airflow in CFM is available for each exhaust duct for monitoring and display purposes.

NOTE: Application 2408 is designed to use Siemens Building Technologies 0-10V electronic actuators for damper control. An AO-E (analog out electronic) module comes with each actuator and mounts in the same enclosure.

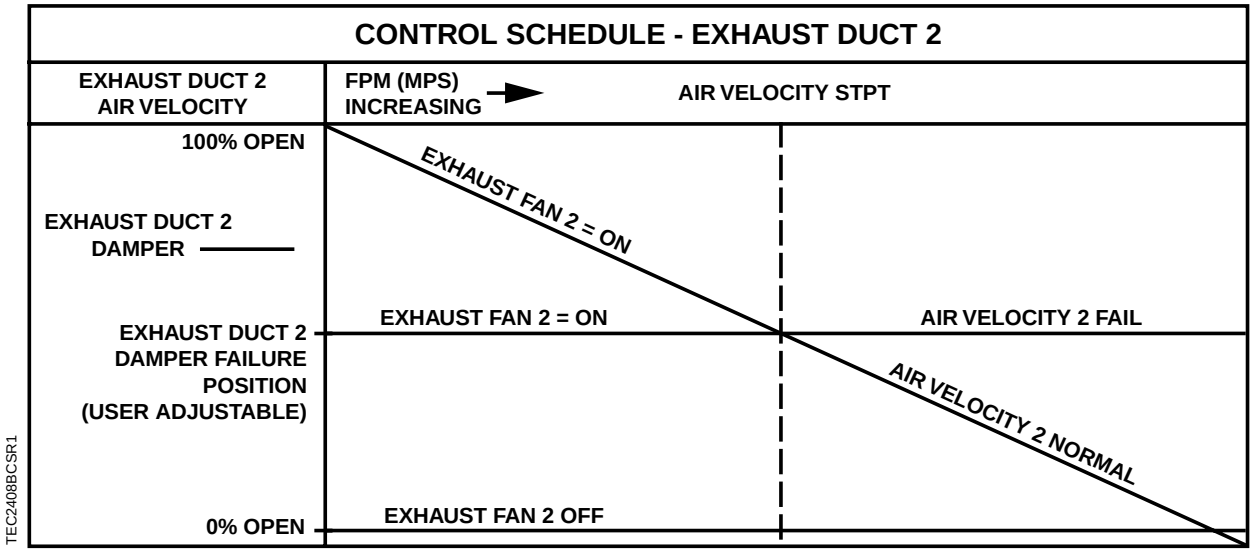


Figures 2408-1. Application 2408 Control Drawing.



NOTE: Except for duct and fan number, this control schedule is identical with the one that follows.

Figure 2408-2. Application 2408 Control Schedule for Exhaust Duct 1.



NOTE: Except for duct and fan number, this control schedule is identical with the previous one.

Figure 2408-3. Application 2408 Control Schedule for Exhaust Duct 2.

Hardware Inputs

Analog

- 4-20 mA Differential Pressure Sensors (two required).

Hardware Outputs

Analog

- Damper for Exhaust Duct 1.
- Damper for Exhaust Duct 2.

Ordering Notes

You can either order the Air Velocity Controller with Differential Pressure Sensors as part number 540-864A, or, you can order it as Custom Solution 256.

Sequence of Operation

The following paragraphs present the sequence of operation for TEC Custom Solutions Application 2408: Air Velocity Control with Differential Pressure Sensors.

Air Velocity and Air Flow Readings

Application 2408 uses a TABLE Statement (just like a regular PPCL TABLE Statement) to convert the 4-20 mA readings of AI 3 (Point 15) and AI 4 (Point 68) into differential pressure values that are stored, respectively, in EX1 DIF PRES (Point 14) and EX2 DIF PRES (Point 67). These differential pressure values represent velocity pressures of the airflows in the exhaust ducts. For example, when AI 3 equals 4mA, EX1 DIF PRES equals EX1DP LO RNG (Point 07). When AI 3 equals 20mA, EX1 DIF PRES equals EX1 HI RNG (Point 08). When AI 3 is between 4mA and 20mA, the TABLE Statement uses linear interpolation to set EX1 DIF PRES to a value between EX1DP LO RNG and EX1 DP HI RNG.

Note that the example(s) just given can also be made by substituting AI 4 for AI 3 and EX2 for EX1. Here, for convenience, are the respective point names and numbers associated with exhaust duct 2:

- EX2DP LO RNG (Point 60)
- EX2 HI RNG (Point 61)

Determining EX1 VEL (Point 09) and EX1 VOL (Point 10):
Once EX1 DIF PRES is determined, EX1 VEL is determined by the following equation:

EX1 VEL = 4005 * EX1 FLO COEF (Point 11) * SQRT(EX1 DIF PRES)

Once EX1 VEL is determined, the air velocity feedback loop in exhaust duct 1 is used to maintain EX1 VEL at its desired value.

Application 2408 also calculates EX1 VOL using the following equation:

EX1 VOL = EX1 VEL * EX1DUCT AREA (Point 97)

EX1 VOL is not used by this application for control purposes. It is created for monitoring and display purposes.

Determining EX2 VEL (Point 62) and EX2 VOL (Point 63):
Once EX2 DIF PRES is determined, EX2 VEL is determined by the following equation:

EX2 VEL = 4005 * EX2 FLO COEF (Point 64) * SQRT(EX2 DIF PRES)

Once EX2 VEL is determined, the air velocity feedback loop in exhaust duct 2 is used to maintain EX2 VEL at its desired value.

Application 2408 also calculates EX2 VOL using the following equation:

EX2 VOL = EX2 VEL * EX2DUCT AREA (Point 96).

EX2 VOL is not used by this application for control purposes. It is created for monitoring and display purposes.

Air Velocity Control

When EX1 FAN (Point 17) is ON and EX1 DIF PRES (Point 14) is NORMAL, the air velocity feedback loop in exhaust duct 1 is active. When active, this loop modulates EX1 DMP AO2 (Point 57) in order to maintain EX1 VEL (Point 09) at EX1 VEL STPT (Point 13).

This loop can be tuned by adjusting the value of EX1 PGAIN (Point 16). The sample time for this loop is 0.2 seconds.

NOTE: EX1 DMP AO2 can be set up for normally open or normally closed operation. If EX1 CLOSED (Point 23) is greater than EX1 OPEN (Point 22), then the damper in exhaust duct 1 is normally open. If EX1 OPEN is greater than EX1 CLOSED, then the damper is normally closed.

When EX1 FAN is OFF, the air velocity loop in exhaust duct 1 is inactive and EX1 DMP AO2 is closed. (This happens regardless of whether the status of EX1 DIF PRES is NORMAL or FAIL.)

Following here is a repeat of the above, but with points relating to air velocity control in exhaust duct 2 instead of exhaust duct 1:

When EX2 FAN (Point 70) is ON and EX2 DIF PRES (Point 67) is NORMAL, the air velocity feedback loop in exhaust duct 2 is active. When active, this loop modulates EX2 DMP AO3 (Point 58) in order to maintain EX2 VEL (Point 62) at EX2 VEL STPT (Point 66).

This loop can be tuned by adjusting the value of EX2 PGAIN (Point 69). The sample time for this loop is 0.2 seconds.

NOTE: EX2 DMP AO3 can be set up for normally open or normally closed operation. If EX2 CLOSED (Point 73) is greater than EX2 OPEN (Point 72), then the damper in exhaust duct 2 is normally open. If EX2 OPEN is greater than EX2 CLOSED, then the damper is normally closed.

When EX2 FAN is OFF, the air velocity loop in exhaust duct 2 is inactive and EX2 DMP AO3 is closed. (This happens regardless of whether the status of EX2 DIF PRES is NORMAL or FAIL.)

Fail-Safe Operation

Exhaust duct 1 damper fail-safe position
If EX1 DIF PRES (Point 14) fails when EX1 FAN (Point 17) is ON, then EX1 DMP AO2 (Point 57) goes to the percent open position that is stored in EX1 FAIL POS (Point 18).

Example: Assume EX1 FAIL POS = 60% OPEN, EX1 OPEN = 10 VOLTS, and EX1 CLOSED = 2 VOLTS. If EX1 DIF PRES fails, then EX1 DMP AO2 is sent to 6.8 VOLTS, because:

10V – 2V = 8V
8V × 0.6 = 4.8V
4.8V + 2V = **6.8V**

See Figure 2408-4 for a graphical illustration of this example.

When EX1 FAN is OFF, EX1 DMP AO2 is sent to its closed position regardless of the NORMAL or FAIL status of EX1 DIF PRES.

Exhaust duct 2 damper fail-safe position
If EX2 DIF PRES (Point 67) fails when EX2 FAN (Point 70) is ON, then EX2 DMP AO3 (Point 58) goes to the percent open position that is stored in EX2 FAIL POS (Point 71).

Example: Assume EX2 FAIL POS = 80% OPEN, EX2 CLOSED = 9 VOLTS, and EX2 OPEN = 1 VOLT. If EX2 DIF PRES fails, then EX2 DMP AO3 is sent to 2.6 VOLTS, because:

$$9V - 1V = 8V$$
$$8V \times 0.8 = 6.4V$$
$$9V - 6.4V = \mathbf{2.6V}$$

See Figure 2408-4 for a graphical illustration of this example.

When EX2 FAN is OFF, EX2 DMP AO3 is sent to its closed position regardless of the NORMAL or FAIL status of EX2 DIF PRES.

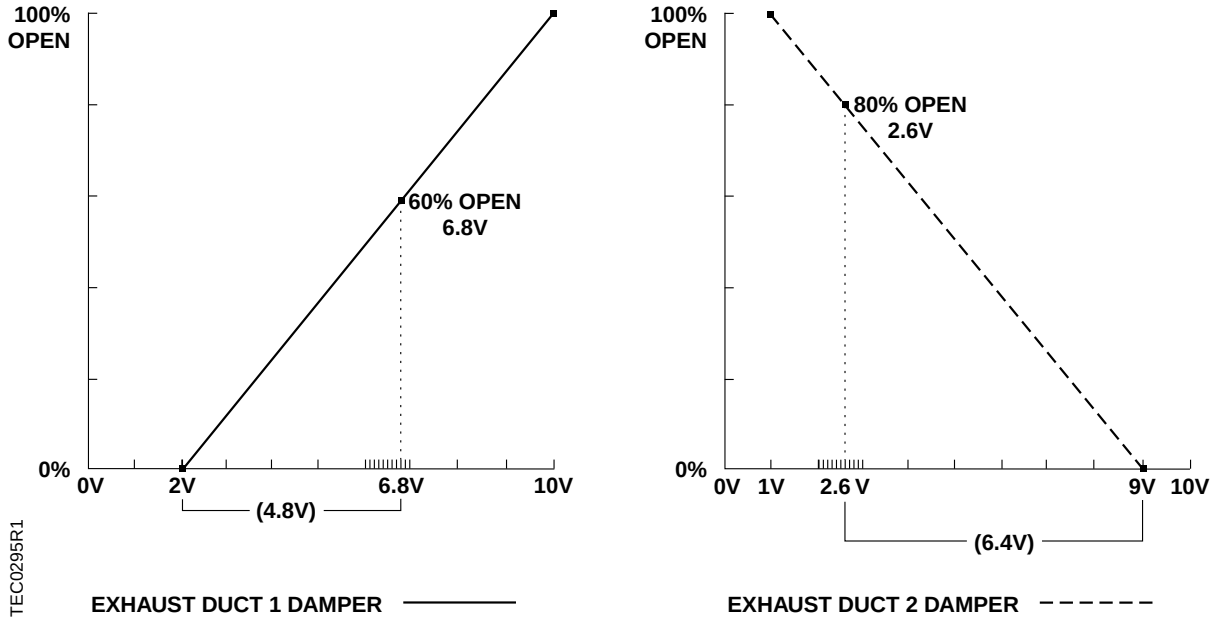


Figure 2408-4. Hypothetical Damper-Actuation and Fail-Safe Voltages.

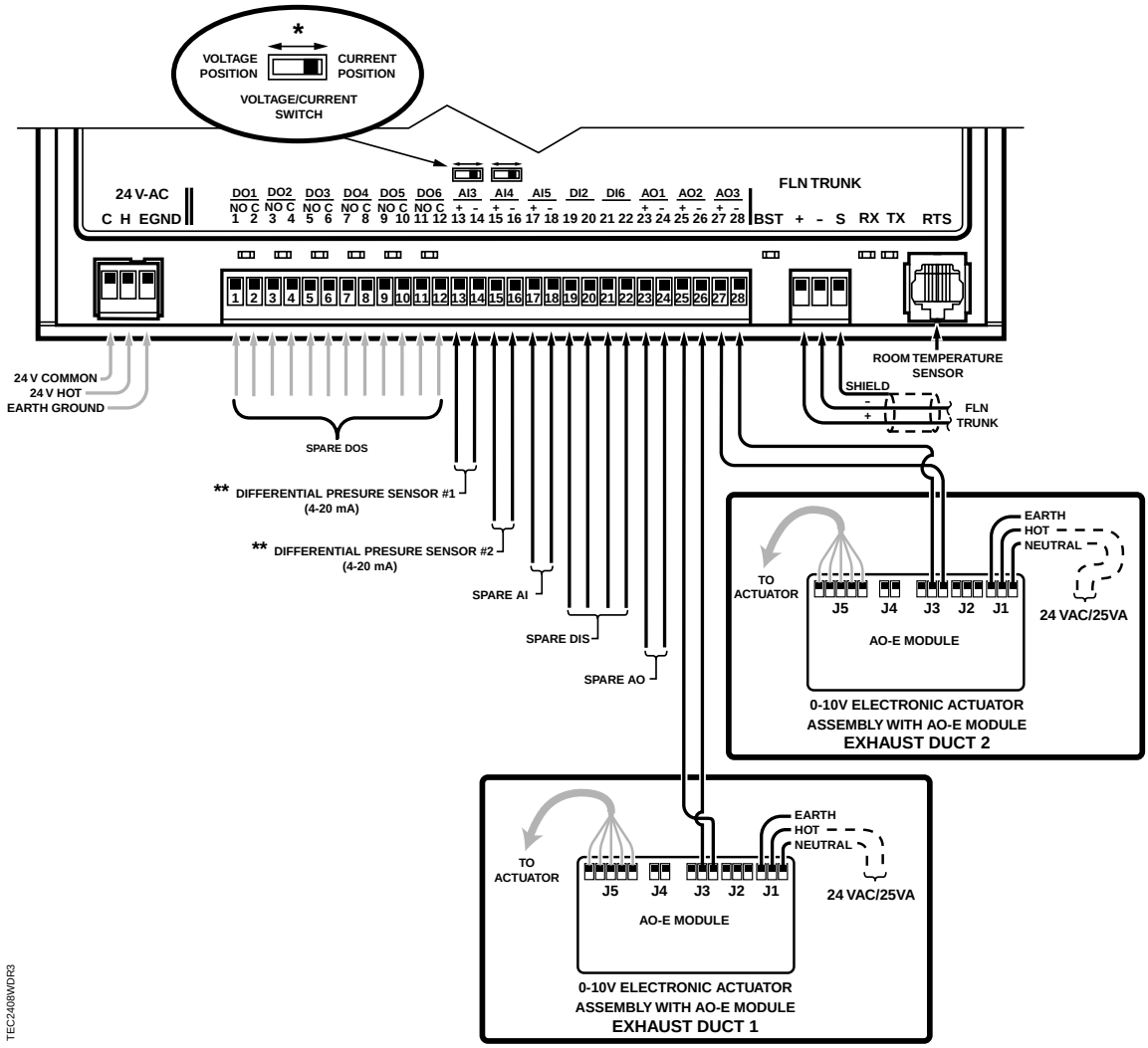
Wiring Diagram

CAUTION:

The controller's digital outputs (DOs) control 24 Vac loads only. The maximum rating is 12 VA for each DO. Use an interposing 220V 4-relay module for any of the following:

- VA requirements higher than the maximum
- 110 or 220 Vac
- DC power
- Separate transformers used to power the load

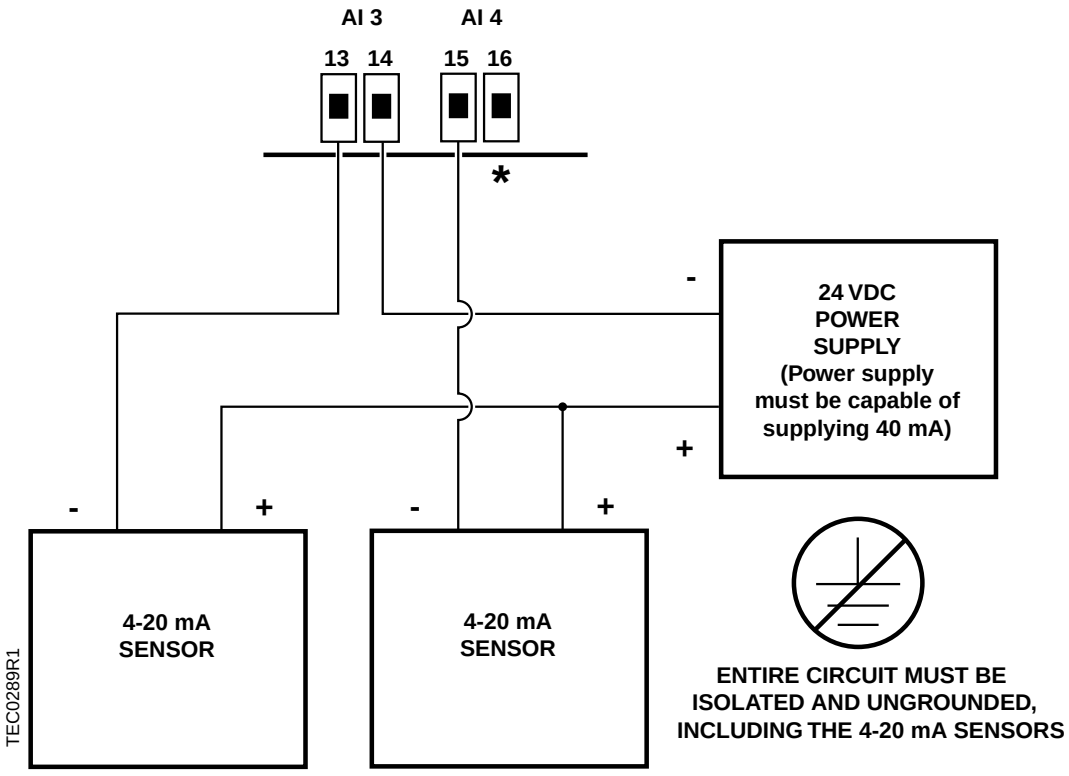
NOTE: Refer to the unit wiring diagrams or consult with the local representative if terminations are missing or different.



***** Dipswitches for AI 3 and AI 4 must be in *current* position. They are located under the controller's cover on the circuit board, behind AI 3 and AI 4.

****** Differential pressure sensors require separate transformer(s). See Figure 2408-6 for special wiring instructions.

Figure 2408-5. Wiring Diagram for Application 2408.



*** AI 4 is connected internally to AI 3 via terminations 14 and 16, therefore wiring both terminal 14 and terminal 16 to the (-) port of the power supply is not necessary.**

Figure 2408-6. Special Wiring Requirements for the 4-20 mA Differential Pressure Sensors in Exhaust Ducts 1 and 2.

CAUTION:

You can NOT use the same transformer to power the TEC and the 4-20 mA sensor(s). A **SEPARATE** power supply is required for the 4-20 mA sensor(s).

Point Database

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
01	CTLR ADDRESS	99	--	1	0	--	--
02	APPLICATION	2491	--	1	0	--	--
07	EX1DP LO RNG	0.0 (0.0)	IN H2O (K PA)	0.0004 (0.0001)	0.0	--	--
08	EX1DP HI RNG	0.1 (0.025)	IN H2O (K PA)	0.0004 (0.0001)	0.0	--	--
{09}	EX1 VEL	0 (0.0)	FPM (MPS)	1 (0.00508)	0	--	--
{10}	EX1 VOL	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
11	EX1 FLO COEF	1.0	--	0.01	0.0	--	--
{12}	EX1 DMPR CMD	-100	--	1	-100	--	--
13	EX1 VEL STPT	0 (0.0)	FPM (MPS)	1 (0.00508)	0	--	--
{14}	EX1 DIF PRES	0.0 (0.0)	IN H2O (K PA)	0.0004 (0.0001)	0.0	--	--
{15}	AI 3	4.0	MA	0.064	4.0	--	--
16	EX1 PGAIN	0.0	--	0.001	0.0	--	--
{17}	EX1 FAN	OFF	--	--	--	ON	OFF
18	EX1 FAIL POS	50	PCT	1	0	--	--
22	EX1 OPEN	1.0	VOLTS	0.01	0.0	--	--
23	EX1 CLOSED	10.0	VOLTS	0.01	0.0	--	--
40	DO DIR.REV	0	--	1	0	--	--
{41}	DO 1	OFF	--	--	--	ON	OFF
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	DO 3	OFF	--	--	--	ON	OFF
{44}	DO 4	OFF	--	--	--	ON	OFF
{45}	DO 5	OFF	--	--	--	ON	OFF
{46}	DO 6	OFF	--	--	--	ON	OFF
{47}	DI 2	OFF	--	--	--	ON	OFF
{50}	DI 5	OFF	--	--	--	ON	OFF
{51}	DI 6	OFF	--	--	--	ON	OFF
{54}	AI 5	74.0 (23.496)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
{56}	AOV 1	0.0	VOLTS	0.01	0.0	--	--

1. Points not listed are not used in this application.
2. A single value in a column means that the value is the same in English units and in SI units.
3. Point numbers that appear in brackets { } may be unbundled at the field panel.

continued on the next page…

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{57}	EX1 DMP AO2	0.0	VOLTS	0.01	0.0	--	--
{58}	EX2 DMP AO3	0.0	VOLTS	0.01	0.0	--	--
60	EX2DP LO RNG	0.0 (0.0)	IN H2O (K PA)	0.0004 (0.0001)	0.0	--	--
61	EX2DP HI RNG	0.1 (0.025)	IN H2O (K PA)	0.0004 (0.0001)	0.0	--	--
{62}	EX2 VEL	0 (0.0)	FPM (MPS)	1 (0.00508)	0	--	--
{63}	EX2 VOL	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
64	EX2 FLO COEF	1.0	--	0.01	0.0	--	--
{65}	EX2 DMPR CMD	-100	--	1	-100	--	--
66	EX2 VEL STPT	0 (0.0)	FPM (MPS)	1 (0.00508)	0	--	--
{67}	EX2 DIF PRES	0.0 (0.0)	IN H2O (K PA)	0.0004 (0.0001)	0.0	--	--
{68}	AI 4	4.0	MA	0.064	4.0	--	--
69	EX2 PGAIN	0.0	--	0.001	0.0	--	--
{70}	EX2 FAN	OFF	--	--	--	ON	OFF
71	EX2 FAIL POS	50	PCT	1	0	--	--
72	EX2 OPEN	1.0	VOLTS	0.01	0.0	--	--
73	EX2 CLOSED	10.0	VOLTS	0.01	0.0	--	--
96	EX2DUCT AREA	1.0 (0.092)	--	0.025 (0.0023)	0.0	--	--
97	EX1DUCT AREA	1.0 (0.092)	--	0.025 (0.0023)	0.0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--

1. Points not listed are not used in this application.
2. A single value in a column means that the value is the same in English units and in SI units.
3. Point numbers that appear in brackets { } may be unbundled at the field panel.