ANALOG OUTPUT FOR THE TSI® DUSTTRAK™ AEROSOL MONITOR MODEL 8520

APPLICATION NOTE ITI-073

Introduction

Newer models of the DUSTTRAK™ Model 8520 are capable of providing an analog output voltage signal that is proportional to the displayed concentration. They also provide a switch closure that is tied to an alarm value. See Application Note ITI-074 Alarm Output for the DUSTTRAK™ Model 8520 for further details about the alarm feature.

Users can configure the DUSTTRAK™ aerosol monitor to automatically transmit aerosol mass concentration values through the interface cable. This new functionality allows you to monitor aerosol concentrations in real-time from remote locations.

How to tell if your DUSTTRAK™ Aerosol Monitor has Analog/Alarm Output Capability

All DUSTTRAK™ aerosol monitors have the analog output and alarm functions as of **10/18/00** beginning with serial number **22499**. You can visually verify if your DUSTTRAK™ monitor is equipped with these features. Look for the 4-pin, mini-DIN connector labeled “Analog/Alarm Output”. It is located on the backside of the instrument (a picture of this connector and label is shown below). All DUSTTRAK™ monitors with serial numbers from **21960** to **22498** can be upgraded to incorporate these functions for a nominal fee. Older DUSTTRAK™ monitors with serial numbers lower than **21960** **cannot** be upgraded to incorporate this new feature.

***Note*:** *For technical information on using the DUSTTRAK™ monitor’s analog output features see Application Note ITI-074, Analog Output on the TSI Website at www.tsi.com.*

For technical information on communicating with the DUSTTRAK™ monitor via the RS-232 serial port see Application Note ITI-044 Serial Data Acquisition on the TSI Website at www.tsi.com. .

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Applications

The DUSTTRAK™ monitor enables you to monitor aerosol mass concentrations in real-time and transmit data from remote locations via the analog output. This real-time information can be used for applications such as:

- Environmental site perimeter monitoring for fugitive dust emission. If the fugitive dust emissions exceed some action limit, this may trigger additional monitoring and/or dust control.
- Ambient or other remote monitoring applications - where long-term data collection is necessary to provide historical data; to assist in determining what or when engineering controls are necessary and then to measure their effectiveness.
- Process control area monitoring - where continuous monitoring is used to assist in evaluating process area conditions.

Note: *TSI supplies the analog output connector and cable only. It is the user's responsibility to:*

- Provide all engineering services,
- Provide all wiring and other necessary components,
- Make all installations and connections to equipment.

Specifications

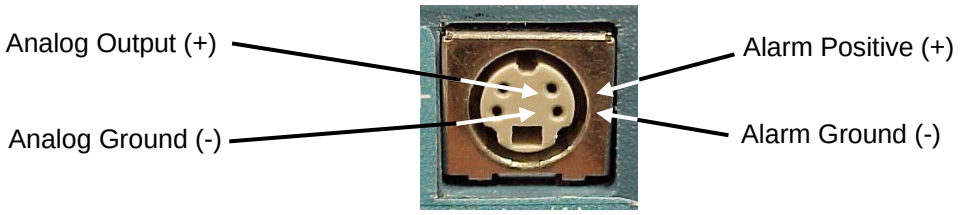
The analog output has an output voltage range of 0 to 5 VDC, with user selectable output scaling ranges of:

0 to 100 mg/m^3
0 to 10.0 mg/m^3
0 to 1.00 mg/m^3
0 to 0.100 mg/m^3

These ranges are set through TRAKPRO™ Data Analysis software. The analog output impedance is 0.01 ohm, with a maximum output current of 15 mA.

Analog/Alarm Output Connector

The Model 8520 DUSTTRAK™ Aerosol Monitor contains a connector that serves both the analog and alarm output functions. The DUSTTRAK™ monitor is supplied with an output cable. The cable contains a 4-pin, mini-DIN connector. The pin-outs for the connector and the wiring for the cable are shown below.



4-pin miniDIN connector

Cable Wiring Diagram	
Brown Wire	Analog Gnd
Orange Wire	Analog Out
Red Wire	Alarm (+)
White Wire	Alarm (-)
Black Wire	Shield

Wiring the Analog Output

The user is responsible for selecting the actual analog receiver to be used with the DUSTTRAK™ monitor and for implementing and integrating the designed system. Please note the following important specifications for that system:

- Output voltage: 0 to 5 VDC.
- Output impedance: 0.01 ohm.
- Maximum output current: 15 mA.
- Correct polarity must be observed (see pin-outs above).

Since applications of this function will vary, TSI supplies only the output cable. The output cable (part no. 801652) is labeled with the pin-out wiring diagram. The user is responsible for all additional equipment needed for making connections to their own equipment.

DustTrak Analog Output/Alarm Cable
TSI part no. 801652

Output Ranges and A/D Conversion

The scaling range for the analog output should be chosen depending upon the anticipated range of aerosol concentration. For example, if you anticipate that normal aerosol concentrations during the sampling period will be less than 0.080 mg/m^3, you should select the "0 to 0.100 mg/m^3" range. This range will provide the greatest resolution and the largest analog signal, per unit mass of aerosol.

In most applications, the DUSTTRAK™ analog output will be read by an analog-to-digital (A/D) converter. A/D converters have a specified bit-level resolution. For example, a simple 8-bit A/D converter can resolve only 256 bits of information. By way of contrast, a 12-bit A/D converter can resolve 4096 bits of information. If the DUSTTRAK™ analog output is read by an A/D converter, the user's ability to resolve aerosol concentration information is directly tied to two important parameters: 1) the bit-level resolution of the A/D converter and 2) the scaling range of the DUSTTRAK™ analog output. Several simple formulas demonstrate this relationship.

A/D Bit Resolution

A/D converters have the following bits of resolution.

A/D Converter	Bits of Resolution
8-bit	256
10-bit	1024
12-bit	4096
14-bit	16,384
16-bit	65,536

Formulas and Sample Calculations

There are four scaling ranges to be used with these formulas and calculations. In the following example, we will assume:

DUSTTRAK™ monitor scaling range: 0 to 100 mg/m^3
Analog Output Full Scale: 5 VDC
A/D Converter: 12-bit

Formula 1: Aerosol concentration, per output voltage

$$\frac{\text{DUSTTRAK™ Monitor Scaling Range}}{\text{Full Scale Voltage}} = \frac{100\ \text{mg/m}^3}{5\ \text{volts}} = 20\ \text{mg/m}^3\text{/volt}$$

Formula 2: Output voltage, per A/D bit

$$\frac{\text{Full Scale Voltage}}{\text{Bits of Resolution}} = \frac{5\ \text{VDC}}{4096\ \text{bits}} = 0.00122\ \text{VDC/bit}$$

Formula 3: Aerosol resolution, per A/D bit

$$\frac{\text{DUSTTRAK™ Monitor Scaling Range}}{\text{Bits of Resolution}} = \frac{100\ \text{mg/m}^3}{4096\ \text{bits}} = 0.024\ \text{mg/m3/bit}$$

A/D Resolution and Examples

Example A: Very Dirty Environment

User "A" plans to monitor in a very contaminated environment. Aerosol mass concentrations readings of 15 to 20 mg/m^3 are experienced on a regular basis. Because of these high readings, they set the analog output scaling to the maximum range of "0 to 100 mg/m^3". A very low resolution, 8-bit A/D converter is used in their control/monitoring system.

Using formula #3, calculate the aerosol resolution, per A/D bit.

$$\frac{\text{DUSTTRAK™ Monitor Scaling Range}}{\text{Bits of Resolution}} = \frac{100\ \text{mg/m}^3}{256\ \text{bits}} = 0.391\ \text{mg/m}^3\text{/bit}$$

- This monitoring "system" will only be able to resolve aerosol concentration changes or values of "0.391 mg/m^3" or greater.
- If the DUSTTRAK™ monitor is reading less than this value (for example, 0.100 mg/m^3), their system would interpret this reading as "0.000".
- Since User "A" is only concerned about very large aerosol readings, this low resolution could be acceptable.

Example B: Moderately Dirty Environment

In the previous example, let us assume that User "A" made some improvements in their engineering controls. They now routinely experience aerosol concentrations below 2 mg/m^3. To adapt to these cleaner conditions, they re-program the DUSTTRAK™ Monitor analog output scaling range to "0 to 10 mg/m^3". Using the same 8-bit A/D converter, they now experience the following resolution:

$$\frac{\text{DUSTTRAK™ Monitor Scaling Range}}{\text{Bits of Resolution}} = \frac{10.0 \text{ mg/m}^3}{256 \text{ bits}} = 0.039 \text{ mg/m}^3\text{/bit}$$

- This monitoring "system" will be able to resolve aerosol concentration values of "0.039 mg/m^3" or greater. This is a factor of 10 improvement over Example A.

Example C: Clean Environment

In the previous example, let us assume that User "A" made even more improvements in their control system. They sometimes experience large peaks in aerosol concentration (up to 3 mg/m^3), but typically see concentrations below 0.100 mg/m^3.

User "A" still wants to "see" the large peaks; therefore they want to keep the range at 0 to 10 mg/m^3. However, they also want better resolution in the low end. To obtain better resolution, they upgrade their system to a 12-bit A/D converter. They now experience the following resolution:

$$\frac{\text{DUSTTRAK™ Monitor Scaling Range}}{\text{Bits of Resolution}} = \frac{10.0 \text{ mg/m}^3}{4096 \text{ bits}} = 0.0024 \text{ mg/m}^3\text{/bit}$$

- This monitoring "system" will be able to resolve aerosol concentration changes as small as 0.002 mg/m^3.

The DUSTTRAK™ instrument is able to measure changes as small as 0.001 mg/m^3.

Therefore, this new monitoring system (a combination of the DUSTTRAK™ monitor range and the A/D converter resolution) provides resolution that is very close to the DUSTTRAK™ monitor maximum resolution.

Voltage to Amperage Conversion

The DUSTTRAK™ monitor contains only one option for analog output: 0 to 5 VDC. Some users may desire a 4 to 20 mA output instead of the 0 to 5 VDC output. This conversion may be done using standard input/output (I/O) signal converters. TSI only supplies the standard 4-pin, mini-DIN connector. All other wiring, components, and installation are the responsibility of the user.

Troubleshooting

The table below lists the symptoms, possible causes, and recommended corrective actions for common problems encountered with the DUSTTRAK™ monitor analog output.

Symptom	Possible Cause	Corrective Action
Analog output does not work	Cable/connector not correctly installed. Output wired with reverse polarity.	Make sure cable connector is fully seated. Make sure analog output (+) and analog ground (-) are wired correctly to receiver.
Analog output is not in proportion to display	Analog output range in DUSTTRAK™ monitor may be set incorrectly. Data logger scaling factor may be set incorrectly.	Program analog output to desired range through TRAKPRO™ software: • 0 to 0.100 mg/m^3 • 0 to 1.00 mg/m^3 • 0 to 10.0 mg/m^3 • 0 to 100 mg/m^3 Scaling factor must be consistent with DUSTTRAK monitor.

Voltage and Signal Loss

Care must be taken to minimize the voltage drop from the cable between the DUSTTRAK™ monitor and the receiver. If signal transmission is required over a long distance (>100 feet) and high precision is necessary, then a 0 to 5 VDC to 4 to 20 mA signal converter should be considered.

Programming the Analog Output Function using TRAKPRO™ Software

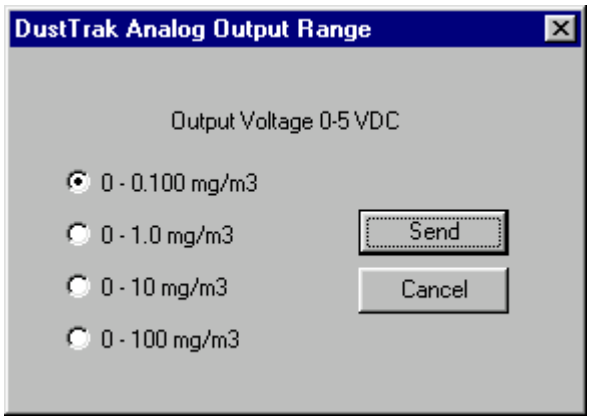
Analog Output

Because the DUSTTRAK™ monitor measures aerosol concentration over such a wide dynamic range, it is necessary to select the appropriate scaling range before using the analog output feature. The instrument may be programmed to one of four options using TRAKPRO™ software. When shipped from the factory, the instrument is programmed to the lowest scaling range (0 to 0.100 mg/m^3).

To program the analog output scaling range, do the following:

1. Connect the DUSTTRAK™ monitor to the computer with the RS-232 serial cable. Install the RJ-45 connector into the DUSTTRAK™ monitor connector port and the serial cable into the serial port on your computer.
2. Turn on the DUSTTRAK™ monitor and start the TRAKPRO™ software (version 3.10 or higher).

3. Select **Parameters**, **Analog Output**, from the **Instrument Setup** menu. The following dialog is displayed:



4. Select one of the four scaling ranges, and press **Send**.

Please note the following considerations when using the analog output feature.

- The analog output function is always “On”. You do not need to activate this function.
- The interpretation of the analog output voltage is directly tied to the chosen scaling range. For example, at the lowest range, each 0.001 mg/m^3 of aerosol is equivalent to 0.050 VDC. If the instrument display shows 0.018 mg/m^3, the analog output voltage would be 18 x 0.050 VDC or 0.9 VDC.
- Select the lowest scaling range consistent with your desired application. For example, if you typically measure aerosol mass concentrations around 0.025 mg/m^3, you should use the first range. This will provide you with the best resolution (strongest signal) corresponding to the mass concentration.
- If your application involves high-mass concentrations (wood dust, etc.) you may want to choose the second or third range.
- If the DUSTTRAK™ monitor measures mass concentrations that are greater than the selected range, the analog voltage will be at a maximum of 5.0 volts (maximum output; with no change in signal beyond that point).
- All of the scaling ranges are referenced back to “zero” mg/m^3.

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