DI-160 Event, State and Count Data Logger

Logs when, how long, and how many times events occur

Eight measurement channels

Isolated high voltage inputs

Removable, SD-style memory

Four Measurement Modes

Built-in USB Interface

The DI-160 features programmable capture modes to detect events (when the events happen), states (how long between events) and counts (how many events). An internal real time clock provides time and date stamping for each captured quantity, and storage is accomplished to a removable SD-style memory card.

Data storage format is comma-separated value (CSV) so recorded files are humanreadable and easily imported to other applications like Microsoft Excel.

The DI-160 features eight input channels split between four high voltage and four low voltage types. The high voltage channels may be connected to any ± 300 V or 230 VAC rms source and feature input-tooutput and channel-to-channel isolation of 500 VDC or ± 250 V peak AC. The four low voltage inputs are internally pulled-up and may be used to detect activity from switch closures, TTL-level signals, or DC levels up to 30 Volts.

A USB interface is provided to allow the DI-160 to be configured for measurements. The unit can be powered by an AC adaptor or an internal rechargeable battery. Three status LEDs are provided: USB interface detected, sampling, and battery charging.



Features

Built-in battery with AC power option

Allows the DI-160 to operate independent of AC power, and also to bridge power outages if running on AC power.

Twenty-one programmable sample intervals

Allows the DI-160 to adapt to a wide range of event input intervals from one second to 24 hours.

Isolated high voltage inputs

Connects directly to real world signals like motors, actuators, controllers, etc. and eliminates the need for extraneous external conditioners.

Removable, SD-style memory

Allows the DI-160 to store virtually limitless quantities of data, and facilitates data extraction by simply swapping memory cards (Please Note: Memory cards cannot be swapped during a recording session).

Built-in USB interface

Connects directly to a PC without the need for external adaptors.

Four measurement modes in one instrument

Allows the DI-160 to be easily reconfigured for a range of different measurements without needing to deploy separate instruments.

Eight measurement channels

Provides the flexibility to measure several quantities at once, since each channel can be programmed for either event or state operation, with as many as three pulse counter inputs.

CSV file generation

Creates human-readable ASCII files that are easily imported to a variety of applications and operating systems for detailed analysis and report generation. The most popular application, Microsoft Excel, is directly compatible.

Internal nonvolatile configuration memory

Stores configuration information and allows the instrument to be easily programmed in one location and deployed in another. The configuration stays with the instrument, eliminating the need to track multiple SD memory cards.

DI-160 Close-up



* Assumes the following worst-case configuration: Sample interval of 1 second, all channels and three counters enabled.

125+

62+

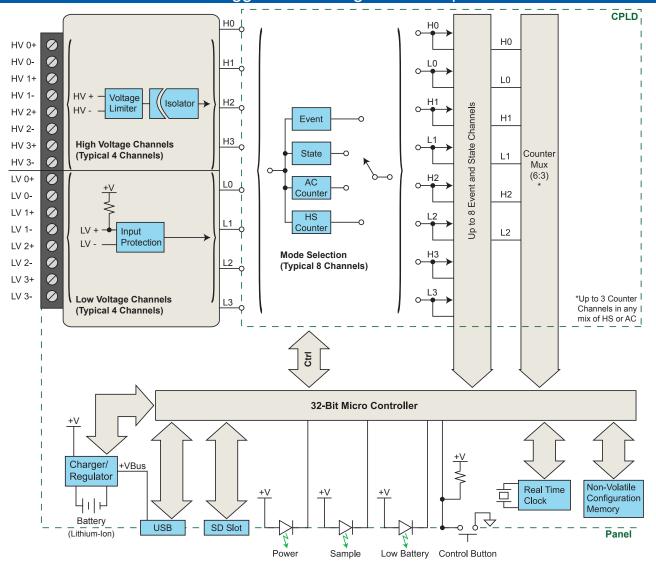
31+

330-668-1444

512 MB 256 MB

128 MB

DI-160 Event Data Logger Block Diagram and Operation Overview



| | | | | | | D | I-160 Mode Sel | ections |
|-----------------------|--------------------------------------|------------------|---------------------------|-------------------|---------------------|-------|----------------|------------|
| Applied Signal | | | DI-160 Channel Selections | | If you want to know | | | |
| Туре | Description | Range | Threshold | High Voltage (HV) | Low Voltage (LV) | when? | how long? | how many? |
| | DC Level Change | 0 to ±300V | 4V | \checkmark | | | | |
| Л | Pulse (2 KHz max, > 500 μs) | 0 to ±300V | 4V | \checkmark | | | State | HS Counter |
| Ð | AC Line (50/60 Hz) | 230 Vrms max. | 4V | \checkmark | | | Event | AC Counter |
| \mathcal{A}_{\circ} | Switch closure (Built-in pull-up) | n/a | n/a | | \checkmark | Event | | |
| <u></u> | TTL level changes | 0-30 V | 2.5V | | \checkmark | | State | HS Counter |
| ודדן | TTL Pulse (2 KHz max, > 500 μs) | 0-30 V | 2.5V | | \checkmark | | | |

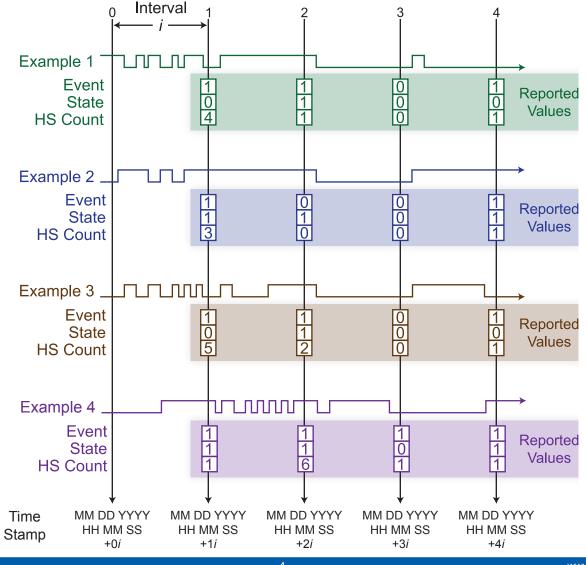
Event, State, and Count Definitions and Examples

The relationship and differences between events, states, high-speed counters, and AC counters can be confusing upon first observation. The following explanations and examples should help resolve any misconceptions and provide a clearer understanding of how the DI-160 may be deployed to solve specific measurement problems:

| Mode | Description | Example | | |
|-----------------------|--|--|--|--|
| Event* | A single occurrence within a sample interval. Even though multiple events may occur within a sample interval, only one will be recorded. | The machine was turned on during the last sample interval. | | |
| State | How long an event lasts. Sampled only at the end of a sample interval. | The machine was powered on at 9:00 AM, and remained on until 12:00PM. It was powered back on at 1:00 PM and remained on until 5:00 PM. | | |
| High-speed Counter | Totalizes the number of events occurring within a programmable time interval. | The machine produced an average of 80 parts per minute over 420 total minutes of operating time (7 hours). The maximum and mini- mum run rates were 120 and 62 parts per minute respectively. | | |
| AC Counter | Designed to count AC power on/off within a sample interval. Optimized for 50/60 Hz. | The 120VAC pump turned on 25 times during the sample interval. | | |

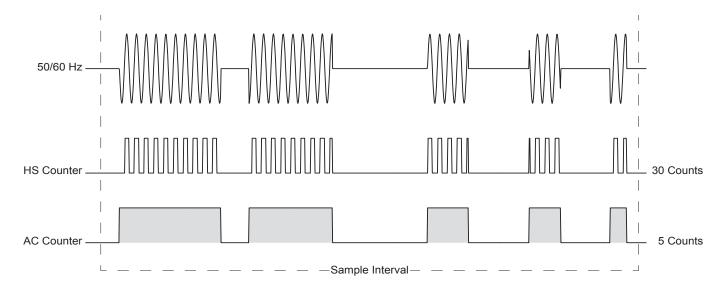
* Only leading edge transitions are captured. Falling edge transitions are ignored.

The following examples further demonstrate the relationships between the various operating modes.



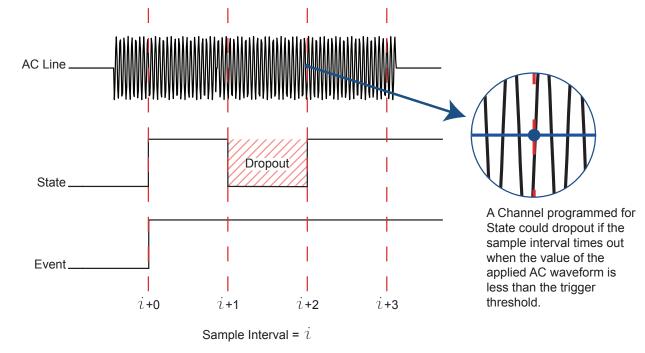
Comparing High-speed and AC Counter Operation

The decision to apply the DI-160's HS (high-speed) or AC (alternating current) counter mode depends upon what information is desired from the measurement. The high-speed counter mode is used when you need to totalize each pulse that occurs within a sample interval. A flow sensor with a pulsed output is a good example, where each pulse represents an incremental flow value and therefore carries information. But what if you're interested only in the number of times a 120V/60Hz fan by was activated within a six-hour sample interval? Use of the HS counter mode in this situation yields the number of 60 Hz pulses that occurred during that time – not exactly what you want. The AC counter mode is optimized to ignore 50/60 Hz power line transitions and to change state only when power is removed or applied. Applying the AC Counter mode to the fan application provides exactly the information you need – the number of times the fan activated within successive six-hour periods.

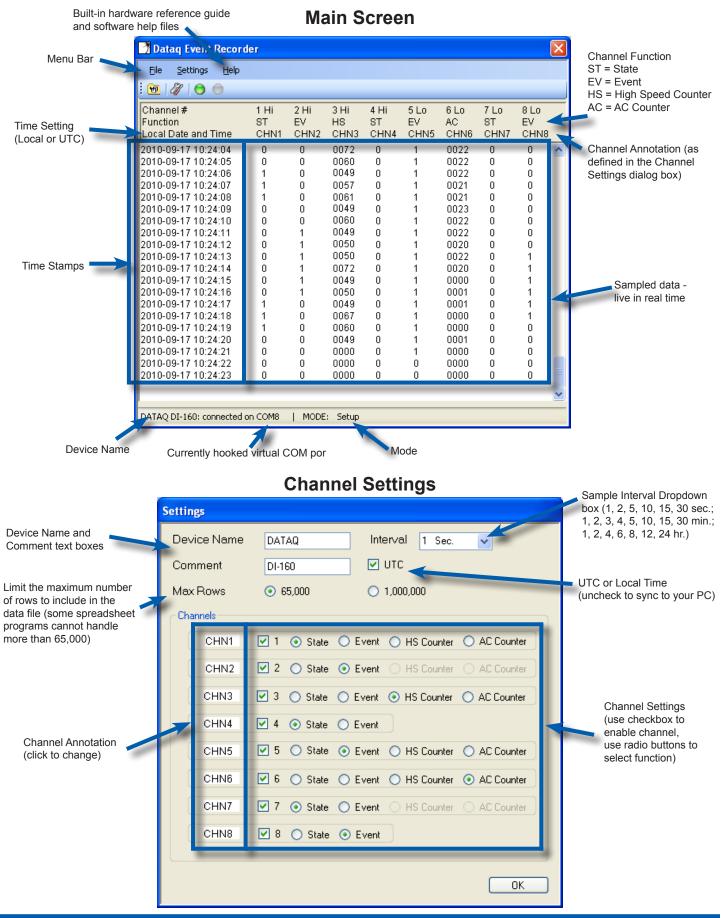


Using the Event Configuration for 50/60 Hz Power Detection

When sampling an AC line waveform, by definition a channel programmed for the State mode is sampled only once at the instant the sample interval times out. Should the value of the applied waveform be lower than the trigger threshold when the sample interval times out, the DI-160 will erroneously indicate that power was removed for the entire sample interval. So, in situations where you need to know how long an AC-powered device was enabled, program the channel for the Event mode.



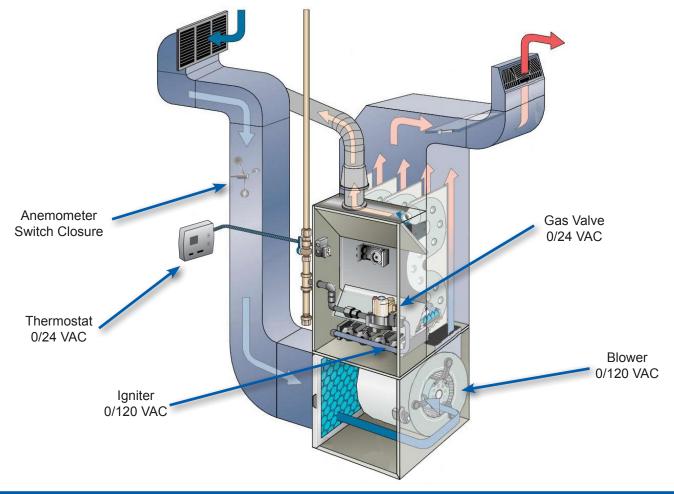
Setup Software Close-up



Typical Application

The DI-160 is applied to measure the timing of various events that occur during the heating cycle of a gas furnace, in addition to measuring duct airflow while the furnace blower is enabled. Measurements accumulate over a 7-day period, and are then compiled into an Excel spreadsheet for a final report. The typical sequence of events and measurement modes are:

| Sequence | Event | Characteristics | Input Channel Type | Mode |
|----------|----------------------------------|---------------------------------|--------------------|--------------------|
| 1 | Thermostat demands heat | $0 \rightarrow 24 \text{ VAC}$ | High Voltage (HV) | Event |
| 2 | Delay | | | |
| 3 | Igniter Activates | $0 \rightarrow 120 \text{ VAC}$ | High Voltage (HV) | Event |
| 4 | Delay | | | |
| 5 | Gas valve opens | $0 \rightarrow 24 \text{ VAC}$ | High Voltage (HV) | Event |
| 6 | Igniter deactivates | $120 \rightarrow 0 \text{ VAC}$ | | |
| 7 | Delay | | | |
| 8 | Blower starts | $0 \rightarrow 120 \text{ VAC}$ | High Voltage (HV) | Event |
| 9 | Duct airflow begins (anemometer) | Multiple switch closures begin | Low Voltage (LV) | High Speed Counter |
| 10 | Delay | | | |
| 11 | Thermostat cancels heat | $24 \rightarrow 0 \text{ VAC}$ | | |
| 12 | Gas value closes | $24 \rightarrow 0 \text{ VAC}$ | | |
| 13 | Delay | | | |
| 14 | Blower stops | $120 \rightarrow 0 \text{ VAC}$ | | |
| 15 | Duct airflow (anemometer) | Switch closures stop | | |
| 16 | Wait for temperature to fall | | | |
| 17 | Repeat | | | |



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Gas Furnace State Analysis using Microsoft Excel

The DI-160 Event Data Logger stores data to its SD memory card using a comma-separated value (CSV) format that is simple for human review in any text editor, and perfect for importing into Microsoft Excel for detailed analysis. CSV is also operating system-independent, allowing data to be reviewed and analyzed on literally any computer. In the furnace application example, data was continuously recorded for over 7 days from a home in Northeast Ohio during the month of March. Average low and high temperatures in that area range from 28 to 46°F (-2 to 8°C), so much furnace activity was expected. A total of 128,802 samples (rows) were recorded and ultimately imported into Excel 2007. Note that unlike previous versions, Excel 2007 places no restriction on the maximum number of rows that a spreadsheet may contain. This feature allowed us to maximize time resolution (5 seconds) and create a large file with full confidence that it could be imported and analyzed in its entirety.

Below is a screen shot displaying only a very small portion of the furnace data imported to Excel. The green-colored section is the raw data acquired by the DI-160. It consists of date and time information as well as five recorded channels. Four were event channels: TMST (thermostat); IGTR (igniter); GVLV (gas valve); BLWR (blower). These channels assume states of either "0" (inactive), or "1" (active) for each of the 128,802 samples. The fifth channel ASPD (air speed) was configured as a counter and connected to an anemometer located inside the cold air return that generated one switch closure per revolution. The number of switch closures occurring within each 5-second sample interval is counted, recorded, and then reset. Using Excel this count is converted to duct air speed in units of feet per second using the anemometer's transfer function.

The yellow section of the spreadsheet represents calculated data, all of which is derived from raw DI-160 event and count data in the green section. A description of each calculated quantity is also provided.

| | □ 17 - (21) - | | rnace.xlsx - | | | | 14 | | 2 |
|--------|----------------------------------|------------|--------------|--------|-------------------|---|-----------|---|---|
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| | A | B | С | D | E | F | G | Н | t |
| 1 | Channel # | 1Hi | 2Hi | 3Hi | 4Hi | 5Lo | U | | T |
| 2 | Function | EV | EV | EV | EV | HS | | | |
| - | Tunction | | | | | 115 | Air Speed | Furnace | |
| 3 | Local Date and Time | TMST | IGTR | GVLV | BLWR | ASPD | (Ft/Sec) | Cycle | |
| 28775 | 3/16/10 11:33:03 | 1 | 0 | 1 | 1 | 8 | 5.87 | | Ţ |
| 28776 | 3/16/10 11:33:08 | 1 | 0 | 1 | 1 | 6 | 4.40 | | |
| 28777 | 3/16/10 11:33:13 | 1 | 0 | 1 | 1 | 7 | 5.13 | | |
| 28778 | 3/16/10 11:33:18 | 1 | 0 | 1 | 1 | 7 | 5.13 | | |
| 28779 | 3/16/10 11:33:23 | 1 | 0 | 1 | 1 | 7 | 5.13 | | |
| 28780 | 3/16/10 11:33:28 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 128781 | 3/16/10 11:33:33 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 128782 | 3/16/10 11:33:38 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 28783 | 3/16/10 11:33:43 | 0 | 0 | 0 | 1 | 7 | 5.13 | | |
| 128784 | 3/16/10 11:33:48 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 128785 | 3/16/10 11:33:53 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 128786 | 3/16/10 11:33:58 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 128787 | 3/16/10 11:34:03 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 128788 | 3/16/10 11:34:08 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 128789 | 3/16/10 11:34:13 | 0 | 0 | 0 | 1 | 8 | 5.87 | | |
| 128790 | 3/16/10 11:34:18 | 0 | 0 | 0 | 1 | 7 | 5.13 | | |
| 128791 | 3/16/10 11:34:23 | 0 | 0 | 0 | 1 | 7 | 5.13 | | |
| 128792 | 3/16/10 11:34:28 | 0 | 0 | 0 | 1 | 7 | 5.13 | | |
| 128793 | 3/16/10 11:34:33 | ō | ō | 0 | 1 | 6 | 4.40 | | |
| 128794 | 3/16/10 11:34:38 | 0 0 | ō | ō | 1 | 7 | 5.13 | | |
| 128795 | 3/16/10 11:34:43 | ő | o | ō | 1 | 8 | 5.87 | | |
| 128796 | 3/16/10 11:34:48 | 0 | 0 | 0 | 1 | 8 | 5.87 | | |
| 128797 | 3/16/10 11:34:53 | ő | o | ō | 1 | 6 | 4.40 | | |
| 128798 | 3/16/10 11:34:58 | 0 | 0 | 0 | 1 | 6 | 4.40 | | |
| 128799 | 3/16/10 11:35:03 | 0 | 0 | 0 | 0 | 1 | 0.73 | | |
| 128800 | 3/16/10 11:35:08 | 0 | 0 | 0 | 0 | 0 | 0.75 | | |
| 128800 | 3/16/10 11:35:13 | 0 | 0 | 0 | 0 | 0 | | | |
| 128801 | 3/16/10 11:35:18 | 0 | 0 | 0 | 0 | 0 | | | |
| 128802 | | 0 | 0 | 0 | 0 | 0 | | | |
| 128803 | 3/16/10 11:35:23 | 0 | 0 | 0 | 0 | 0 | | | |
| | 3/16/10 11:35:28 | 0 | 0 | 0 | 0 | 0 | | | |
| 128805 | 3/16/10 11:35:33 | - | - | - | - | 1////////////////////////////////////// | | ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | 7 |
| 128806 | ON time (hours) | 16.22 | 1.23 | 14.10 | 14.64 | | | | |
| 128807 | OFF time (hours) | 162.67 | 177.66 | 164.79 | 164.25 | | | | |
| | Total time | | 07 10: | 53:25 | | | | | |
| 128808 | (dd hh:mm:ss) | | | | | | | | |
| 128809 | % ON time | 9.07% | 0.69% | 7.88% | 8.18% | | | | |
| 128810 | Maximum air speed (FPS) | | | | | | 6.60 | | |
| 128811 | Average air speed (FPS) | | | | | | 4.79 | <i></i> | 1 |
| 28812 | Total furnace cycles | | | | | | | 105 | |
| - | M dataq001 🖓 | | | | | | | | |

See it for yourself!

Download this data file and examine it on your own: furnace.csv.zip (raw data file 346 KB) furnace.xlsx.zip (Excel data file 3017 KB)

| Air SpeedDuct air speed calculated from ASPD as follows:ASPD \times 2.5 × 5280 |
|---|
| <u>5</u> × <u>3600</u> |
| A blank line is displayed whenever ASPD=0. |
| Furnace Cycle How many times the furnace engaged. =IF(AND(B3=1,B2=0),1,"") If TMST in the previous row is "0" and "1" on the current row, then cell="1" else the cell is blank |
| ON time (hours) For each event channel, counts the number of times the channel was active (1), then converts to hours. For the TMST channel: =COUNTIF(B2:B128803,"=1")*5/3600 |
| OFF time (hours) For each event channel, counts the number of times the channel was inactive (0), then converts to hours. For the TMST channel: =COUNTIF(B2:B128803,"=0")*5/3600 |
| Total timeCalculates total record time as the differencebetween the last and first recorded time stamp.Displayed as days, hours, minutes, seconds, this isthe same for all channels and is calculated directlyfrom the Date & Time column:=A128803-A2 |
| % ON time Calculated for each state channel as follows: ON time ON time + OFF time × 100 |
| Maximum air speed Seeks and displays the largest value of all the calculated air speeds: =MAX(G2:G128803) |
| Average air speed Calculates the average of all air speeds, excluding rows when the blower was off. =SUM(G2:G128803)/COUNTIF(G2:G128803,">0") |
| Total furnace cycles Total number of times the furnace engaged over the recording period. =COUNT(H2:H128803) |
| |

DI-160 Specifications

| Signal Inputs | | Internal Date/Time | Clock |
|--|--|----------------------------|--|
| High Voltage Channels | | Accuracy: | 20 ppm |
| Number of Channels: | 4 | Sync Method: | via connected PC during setup |
| Working Range: | ±300 VDC, 230 Vrms | System Configura | |
| Trigger Threshold: | 4 Volts | | Via PC-based program; Uploaded via USB por |
| Channel-to-channel Isolation: | 500 V DC, ±250 V peak AC | | Enabled/disabled channels; Sample interval; |
| Input-to-output Isolation: | 500 V DC, ±250 V peak AC | | Function (AC counter, HS counter, Event, |
| Max Input without Damage: | ±360 V DC or peak AC | | Pulse); User annotation per channel; Device |
| Low Voltage and Switch Closu | re Inputs | | name |
| Number: | 4 | Data Memory | |
| Configuration: | Internally pulled up | Туре: | Removable SD-stye |
| Working Range: | TTL | Maximum memory size: | 2 GB |
| Trigger Threshold: | 2.5 V DC | Storage format: | ASCII comma separated value (.csv) |
| Isolation: | None | Controls. Indicato | rs, and Connections |
| Max Input without Damage: | ±30 V DC or peak AC | | USB 2.0 (mini-B style connector) |
| Operation | | | Removable SD-style memory |
| Programmable functions: | Event, State, Count (alternating current | | Stop/Start recording to SD memory |
| r rogrammable functions. | (AC) counter or high-speed (HS) counter; | | Active, USB, Battery |
| | HV channels 1-3 and LV channels 5-7 may | Input Connections: | One 16-position terminal strip divided into two |
| | function as counters, but no more than three | 1 | sections (High Holtage and Switch Closure/ |
| | counters can be enabled at any time.) | | TTL) |
| Counter Operation | | Power | |
| Reset condition: | Programmable interval timeout | Internal Battery Type: | Rechargeable lithium-ion |
| Maximum count: | 1 sec interval, 8,192 | Internal Battery Run time: | Minimum of 40 hours |
| | >1 sec interval, 9,999 | Current drain: | 450 mA max @ 5VDC |
| Maximum frequency: | | AC adaptor: | 100-240 VAC, 50-60 Hz |
| Minimum pulse width: | | External Power: | via USB port or provided AC adaptor |
| HS Counter Operation: | Used whenever the need exists to account for | Environmental | |
| | and totalize each pulse that occurs within a sample interval | | 0°C to 35°C (32°F to 95°F) |
| AC Counter Operation: | Optimized for 50/60 Hz power line | | 0 to 90% non-condensing |
| AC Counter Operation. | frequencies. Designed to ignore power line | | -20°C to 45°C (-4°F to 113°F) |
| | transitions and to change state only when | | 0 to 90% non-condensing |
| | power is removed or applied. | Physical Characte | - |
| | Maximum line frequency: 120 Hz | | Hardened Plastic |
| | Maximum count frequency: 20 Hz | | Desktop; bulkhead |
| State Operation | Determines the DURATION of an event. Records the state that exists upon termination | - | $2.625D \times 5.5W \times 1.53H$ in. |
| | of a sample interval. | Dimensions. | $(6.67D \times 13.97W \times 3.89H \text{ cm.})$ |
| Event Operation | Determines WHEN an event occurred, but | Weight: | · · · · · · · · · · · · · · · · · · · |
| r i i r | does not yield the duration of the event. | OS Compatibility | |
| | Records a single time-stamped data point | | Windows XP (32-bit), Windows Vista and |
| | when one or more events occur within a | Setup software. | Windows 7 (32- and 64-bit versions) |
| | definable interval. | SD-based CSV files: | × / |
| · · | > 500 μs | | |
| Programmable intervals: (applies to all channels) | 1,2,5,10,15,30 seconds 1,2,3,4,5,10,15,30 minutes | | |
| (applies to an enamels) | 1,2,3,4,5,10,15,50 minutes 1,2,4,6,8,12,24 hours | | |
| | | g Guide | |

| Description | Order No. | Description | Order No. |
|---|-----------|---|------------|
| DI-160 Event Recorder Event Recorder with USB cable, rechargeable battery | DI 160 | SD Card Standard 2 GB SD card | 101014-2GS |
| (pre-installed), AC power adaptor, and software on CD. | DI-160 | SD Card Reader Standard USB SD Card Reader. | 101014-CR |

Product Links

(click on text to jump to web page) Data Acquisition | Data Logger | Chart Recorder Contraction of the second state of the second

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