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 human-readable 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 ±300V or 230 VAC rms source and feature input-to-output 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.

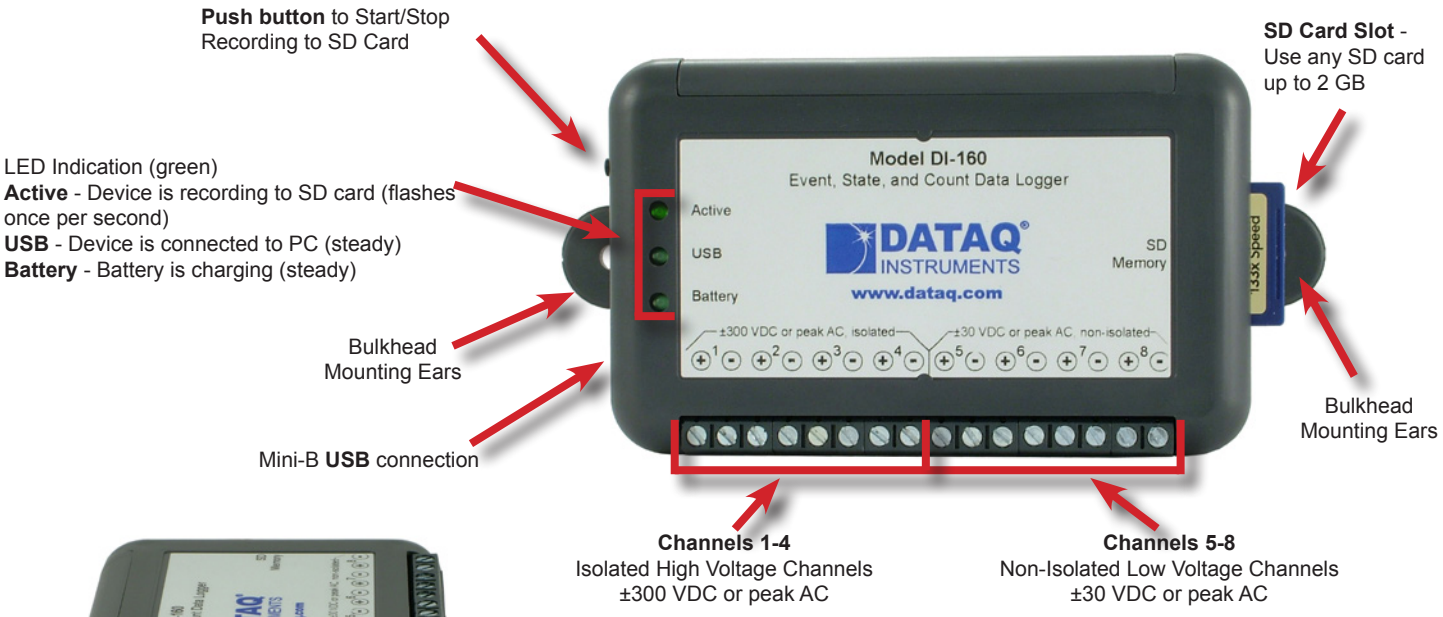
Four measurement modes in one instrument
Allows the DI-160 to be easily reconfigured for a range of different measurements without needing to deploy separate instruments.

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

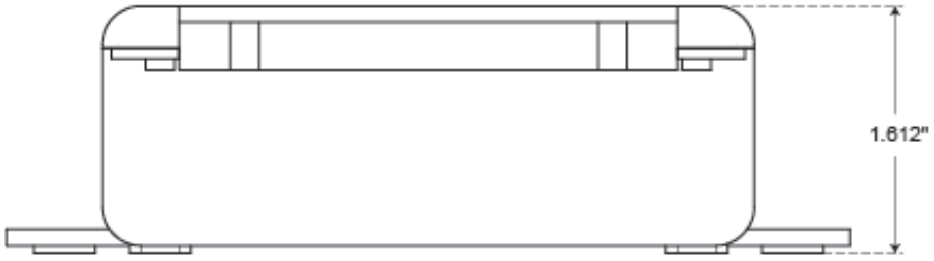


Channels 1-4
Isolated High Voltage Channels
±300 VDC or peak AC

Channels 5-8
Non-Isolated Low Voltage Channels
±30 VDC or peak AC

Screw terminals for signal inputs

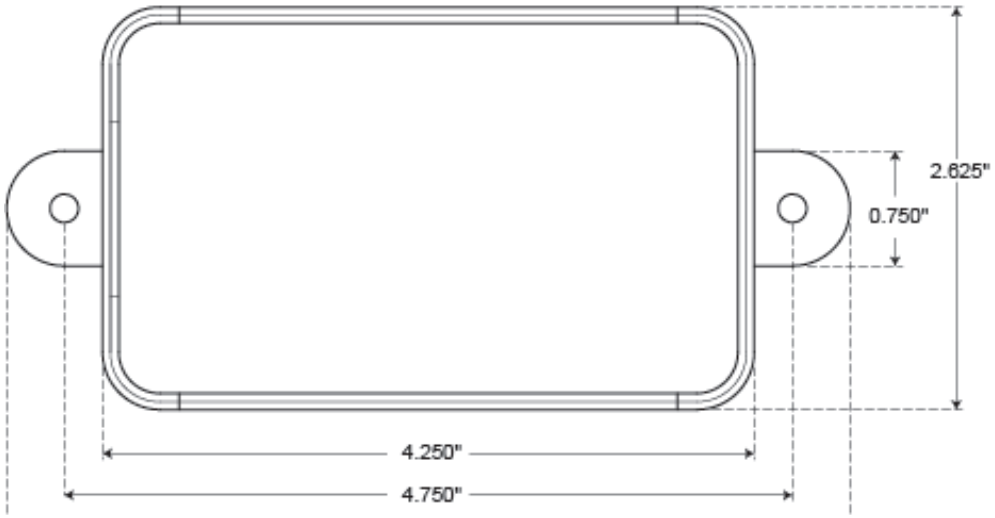
Dimensional Drawing



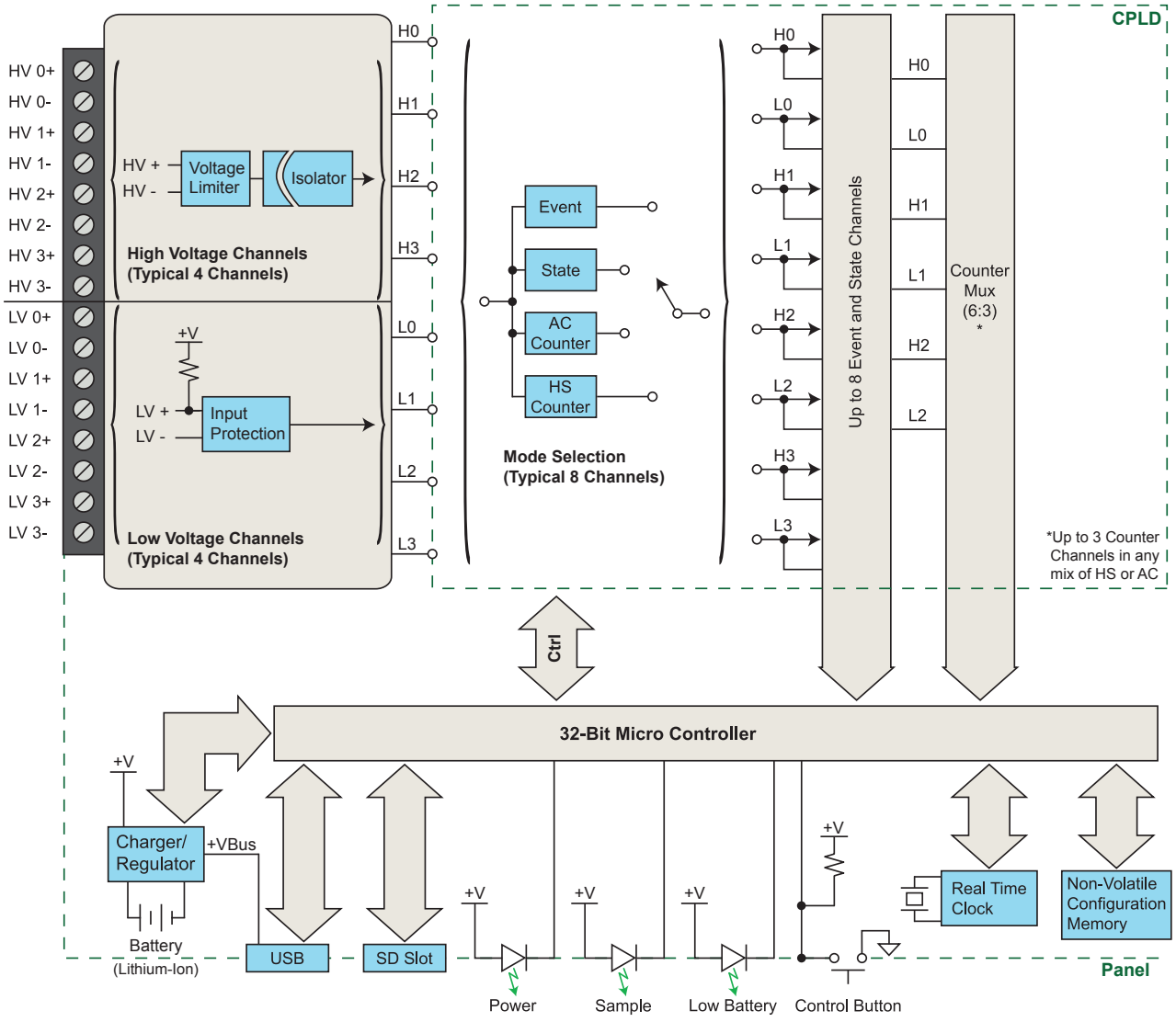
Maximum Record Time vs. Memory Size

SD memory size	Continuous record time (days)*
2 GB	500+
1 GB	250+
512 MB	125+
256 MB	62+
128 MB	31+

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



DI-160 Event Data Logger Block Diagram and Operation Overview



				DI-160 Mode Selections				
Applied Signal				DI-160 Channel Selections		If you want to know…		
Type	Description	Range	Threshold	High Voltage (HV)	Low Voltage (LV)	…when?	…how long?	…how many?
⎓	DC Level Change	0 to ±300V	4V	✓		Event	State	HS Counter
⎍	Pulse (2 KHz max, > 500 µs)	0 to ±300V	4V	✓				
∿	AC Line (50/60 Hz)	230 Vrms max.	4V	✓			Event	AC Counter
⏀	Switch closure (Built-in pull-up)	n/a	n/a		✓		State	HS Counter
TTL	TTL level changes	0-30 V	2.5V		✓			
TTL	TTL Pulse (2 KHz max, > 500 µs)	0-30 V	2.5V		✓			

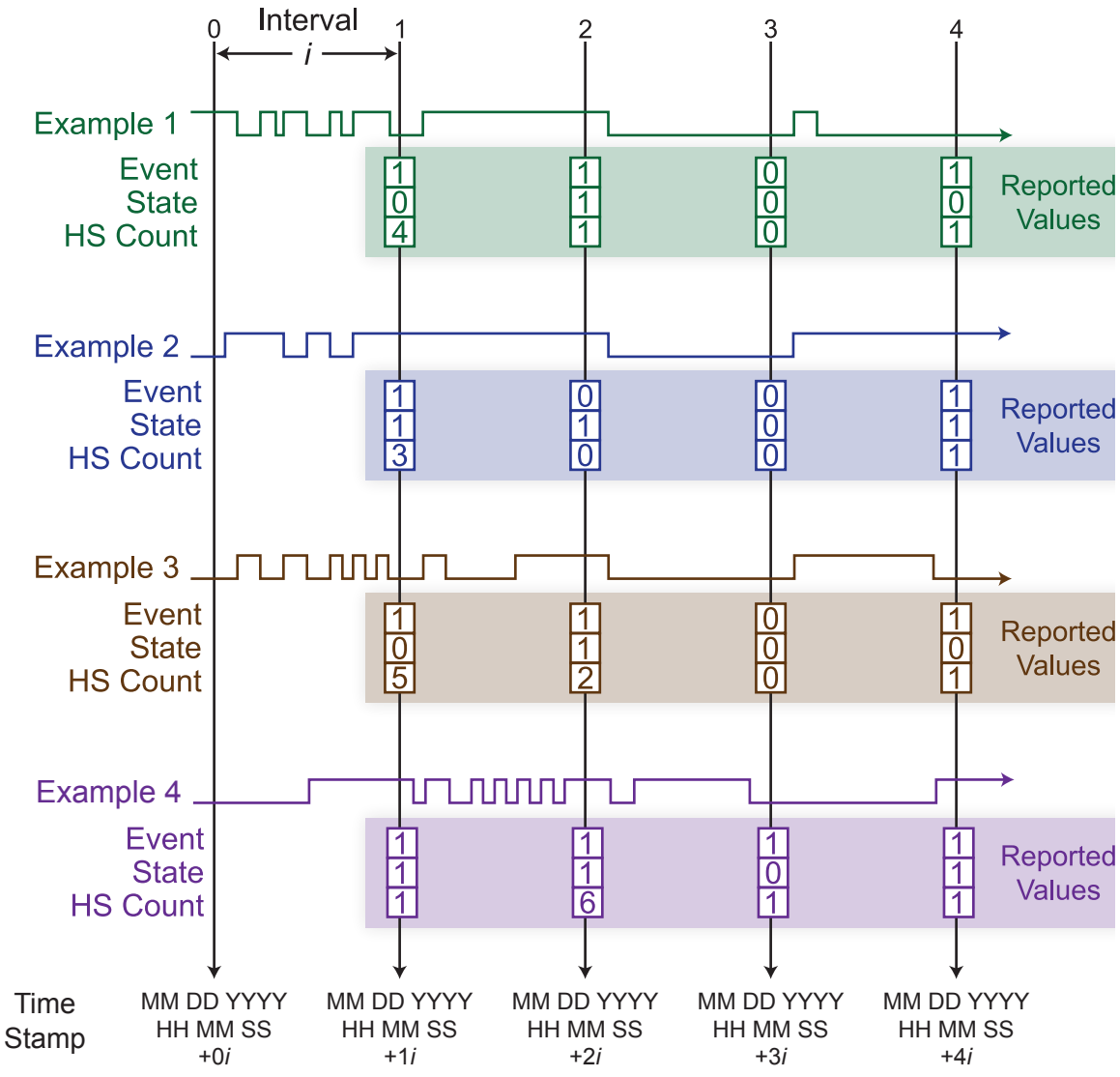
Event, State, and Count Definitions and Examples

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 minimum 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.

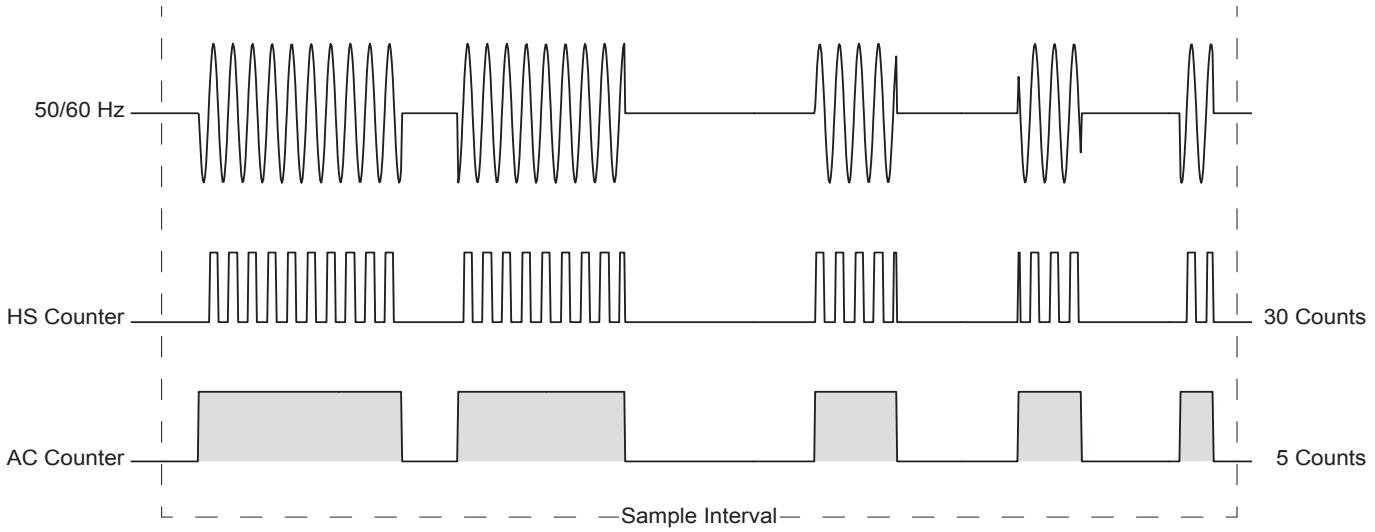
* Only leading edge transitions are captured. Falling edge transitions are ignored.

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



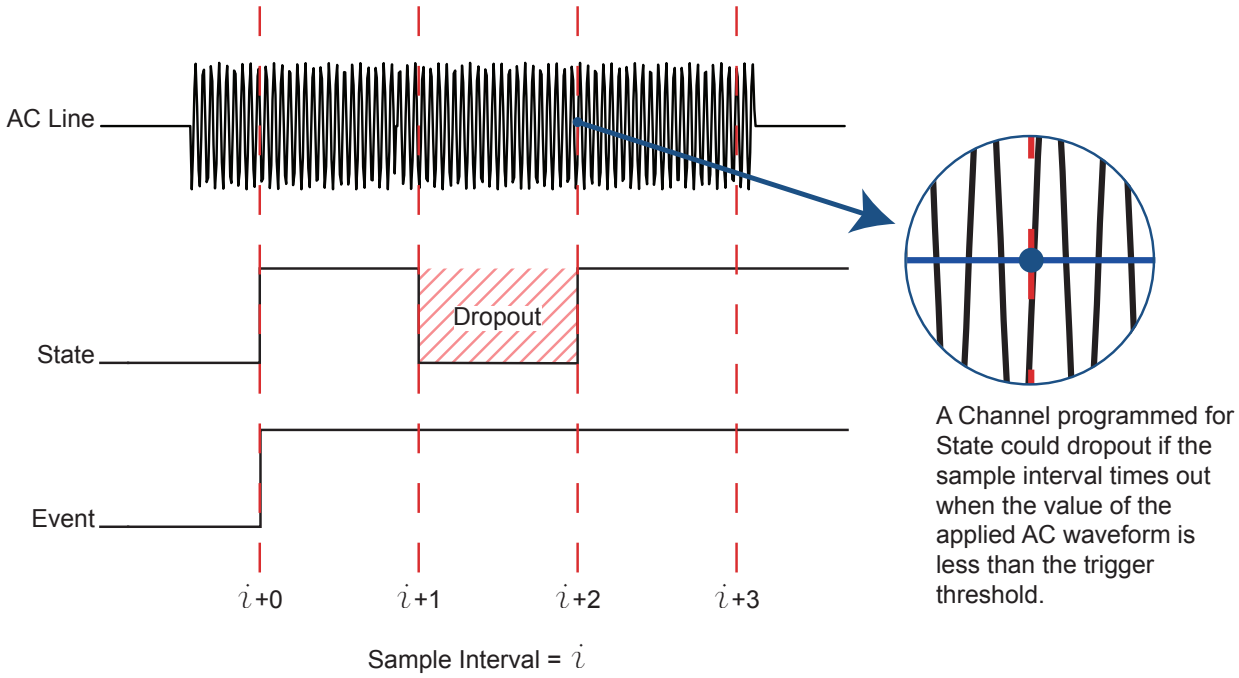
Comparing High-speed and AC Counter Operation

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

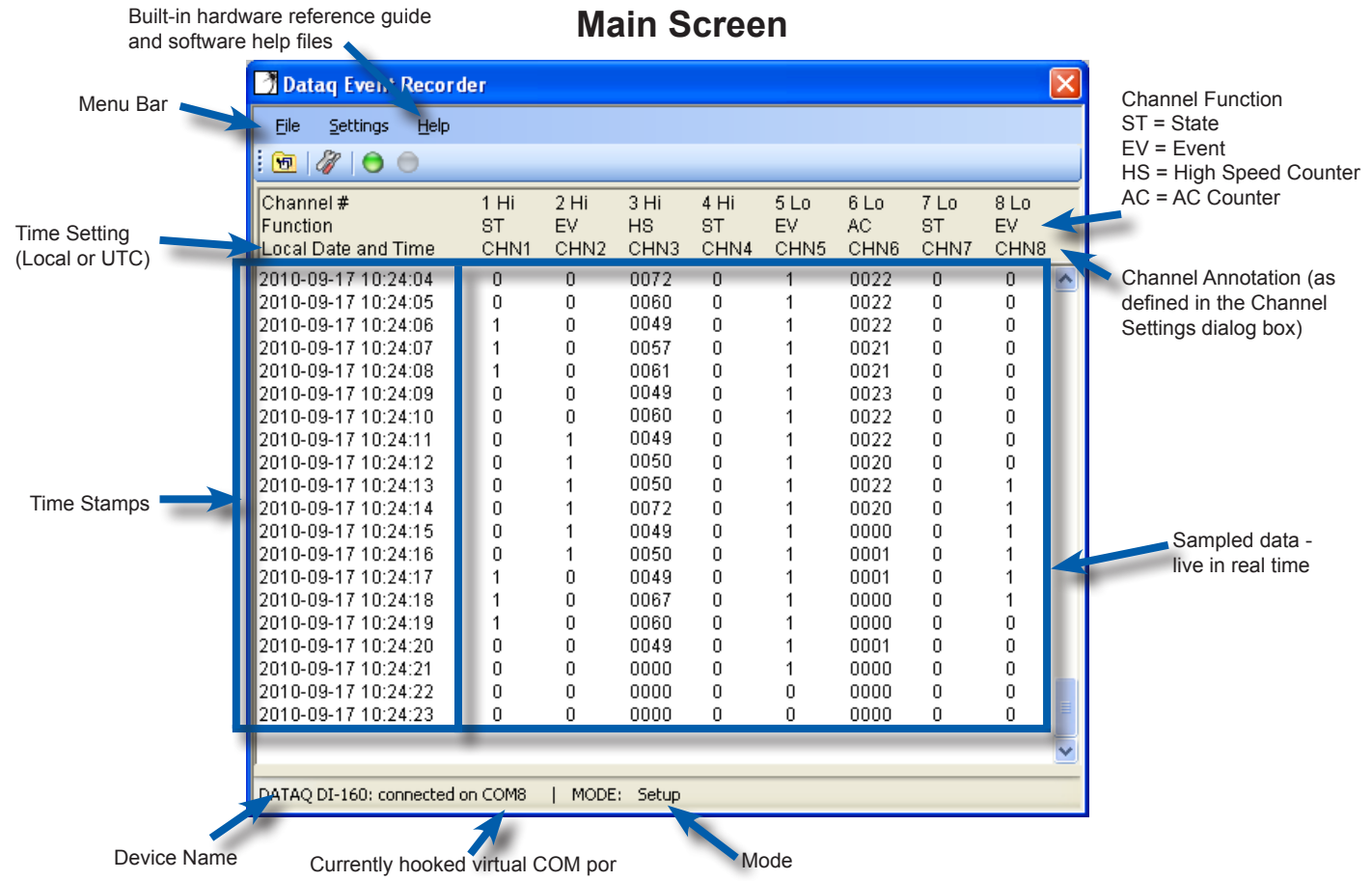
When sampling an AC line waveform, by definition a channel programmed for the State mode is sampled only once at the instant the sample interval times out. Should the value of the applied waveform be lower than the trigger threshold when the sample interval times out, the DI-160 will erroneously indicate 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.



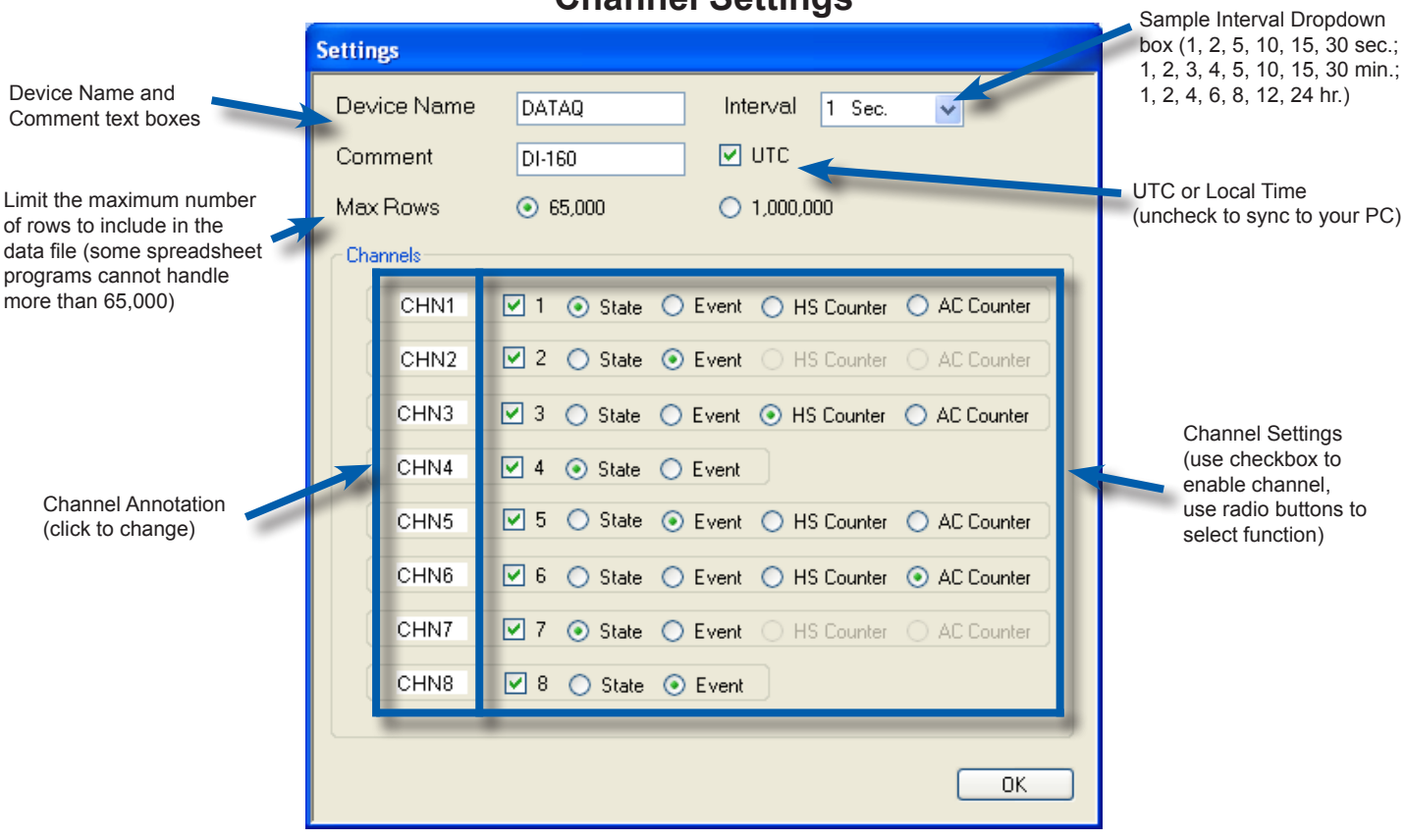
A Channel programmed for State could dropout if the sample interval times out when the value of the applied AC waveform is less than the trigger threshold.

Setup Software Close-up

Main Screen



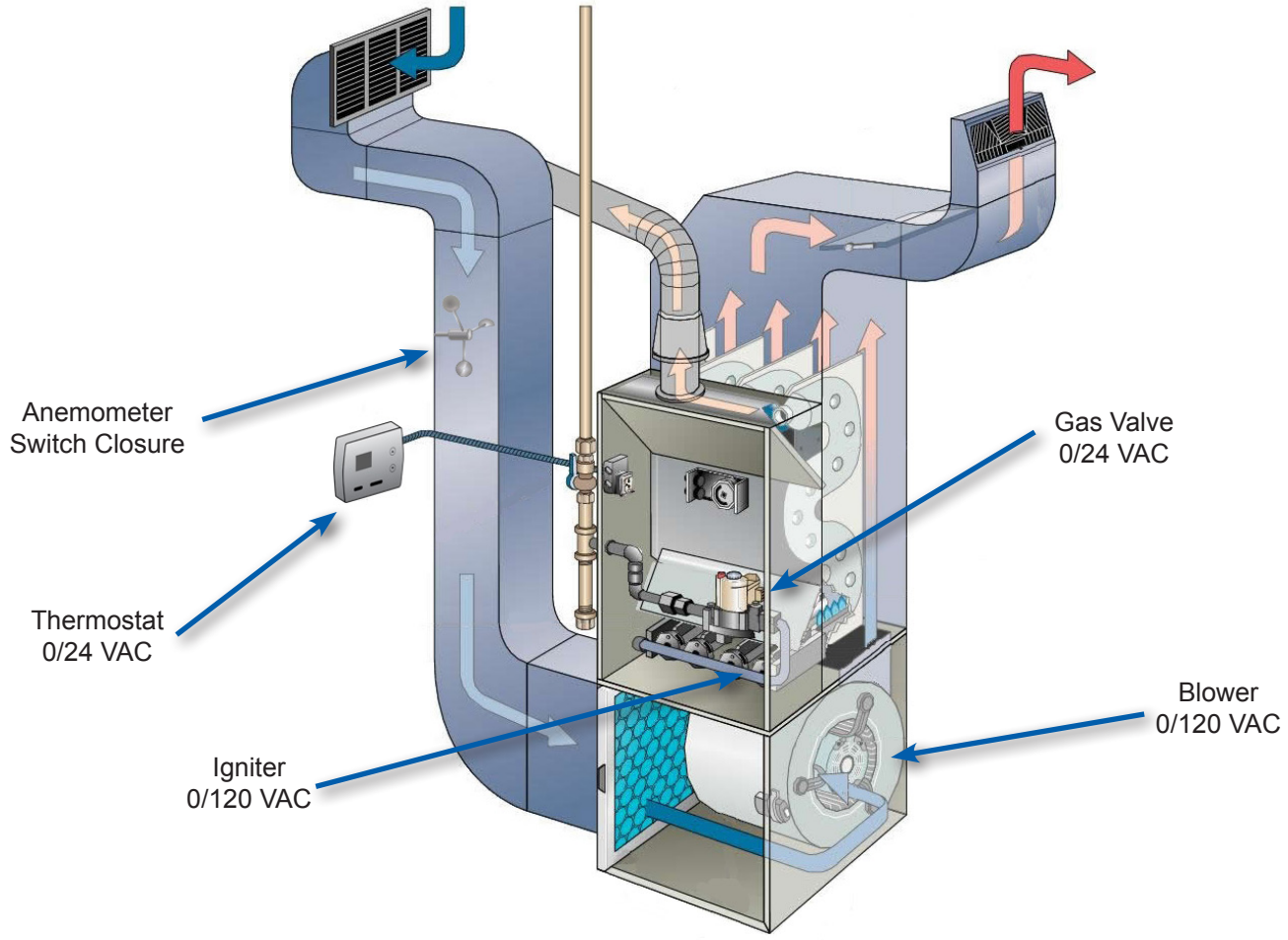
Channel Settings



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 → 24 VAC	High Voltage (HV)	Event
2	Delay			
3	Igniter Activates	0 → 120 VAC	High Voltage (HV)	Event
4	Delay			
5	Gas valve opens	0 → 24 VAC	High Voltage (HV)	Event
6	Igniter deactivates	120 → 0 VAC		
7	Delay			
8	Blower starts	0 → 120 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 → 0 VAC		
12	Gas value closes	24 → 0 VAC		
13	Delay			
14	Blower stops	120 → 0 VAC		
15	Duct airflow (anemometer)	Switch closures stop		
16	Wait for temperature to fall			
17	Repeat			

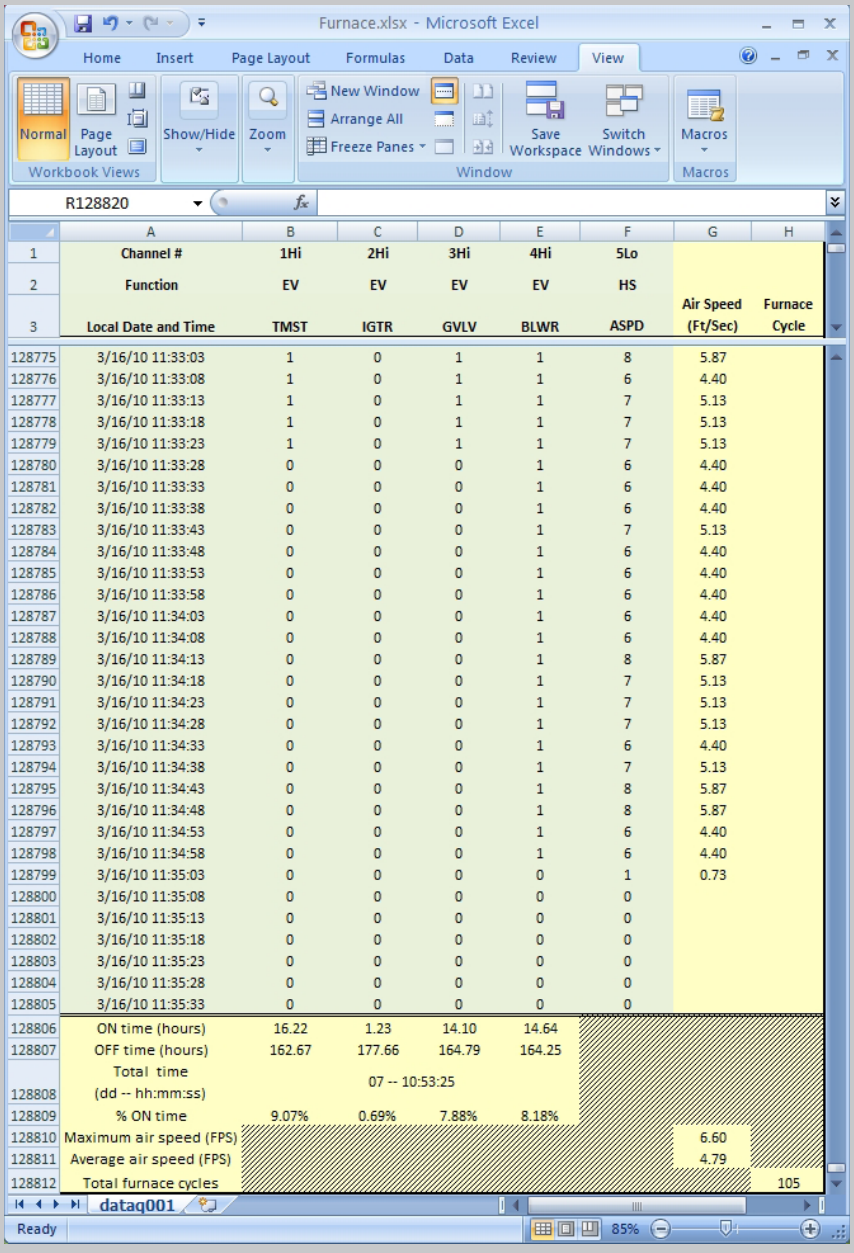


Gas Furnace State Analysis using Microsoft Excel

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 46ºF (-2 to 8ºC), 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.



	A	B	C	D	E	F	G	H
1	Channel #	1Hi	2Hi	3Hi	4Hi	5Lo		
2	Function	EV	EV	EV	EV	HS		
3	Local Date and Time	TMST	IGTR	GVLV	BLWR	ASPD	Air Speed (Ft/Sec)	Furnace Cycle
128775	3/16/10 11:33:03	1	0	1	1	8	5.87	
128776	3/16/10 11:33:08	1	0	1	1	6	4.40	
128777	3/16/10 11:33:13	1	0	1	1	7	5.13	
128778	3/16/10 11:33:18	1	0	1	1	7	5.13	
128779	3/16/10 11:33:23	1	0	1	1	7	5.13	
128780	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	
128783	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	0	0	0	1	6	4.40	
128794	3/16/10 11:34:38	0	0	0	1	7	5.13	
128795	3/16/10 11:34:43	0	0	0	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	0	0	0	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		
128801	3/16/10 11:35:13	0	0	0	0	0		
128802	3/16/10 11:35:18	0	0	0	0	0		
128803	3/16/10 11:35:23	0	0	0	0	0		
128804	3/16/10 11:35:28	0	0	0	0	0		
128805	3/16/10 11:35:33	0	0	0	0	0		
128806	ON time (hours)	16.22	1.23	14.10	14.64			
128807	OFF time (hours)	162.67	177.66	164.79	164.25			
128808	Total time (dd -- hh:mm:ss)		07 -- 10:53:25					
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	
128812	Total furnace cycles							105

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 Speed
Duct air speed calculated from ASPD as follows:

$$\frac{ASPD}{5} \times \frac{2.5 \times 5280}{3600}$$

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 time
Calculates total record time as the difference between the last and first recorded time stamp. Displayed as days, hours, minutes, seconds, this is the same for all channels and is calculated directly from the **Date & Time** column:
=A128803-A2

% ON time
Calculated for each state channel as follows:

$$\frac{ON\ time}{ON\ time + OFF\ time} \times 100$$

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

High Voltage Channels

Number of Channels:	4
Working Range:	±300 VDC, 230 Vrms
Trigger Threshold:	4 Volts
Channel-to-channel Isolation:	500 V DC, ±250 V peak AC
Input-to-output Isolation:	500 V DC, ±250 V peak AC
Max Input without Damage:	±360 V DC or peak AC

Low Voltage and Switch Closure Inputs

Number:	4
Configuration:	Internally pulled up
Working Range:	TTL
Trigger Threshold:	2.5 V DC
Isolation:	None
Max Input without Damage:	±30 V DC or peak AC

Operation

Programmable functions: Event, State, Count (alternating current (AC) counter or high-speed (HS) counter; HV channels 1-3 and LV channels 5-7 may function as counters, but no more than three counters can be enabled at any time.)

Counter Operation

Reset condition:	Programmable interval timeout
Maximum count:	1 sec interval, 8,192 >1 sec interval, 9,999
Maximum frequency:	2 kHz
Minimum pulse width:	> 500 µs
HS Counter Operation:	Used whenever the need exists to account for and totalize each pulse that occurs within a sample interval
AC Counter Operation:	Optimized for 50/60 Hz power line frequencies. Designed to ignore power line transitions and to change state only when power is removed or applied. Maximum line frequency: 120 Hz Maximum count frequency: 20 Hz
State Operation	Determines the DURATION of an event. Records the state that exists upon termination of a sample interval.
Event Operation	Determines WHEN an event occurred, but does not yield the duration of the event. Records a single time-stamped data point when one or more events occur within a definable interval.
Min capture event pulse width:	> 500 µs
Programmable intervals: (applies to all channels)	1,2,5,10,15,30 seconds 1,2,3,4,5,10,15,30 minutes 1,2,4,6,8,12,24 hours

Internal Date/Time Clock

Accuracy:	20 ppm
Sync Method:	via connected PC during setup

System Configuration

Method:	Via PC-based program; Uploaded via USB port
Parameters:	Enabled/disabled channels; Sample interval; Function (AC counter, HS counter, Event, Pulse); User annotation per channel; Device name

Data Memory

Type:	Removable SD-stye
Maximum memory size:	2 GB
Storage format:	ASCII comma separated value (.csv)

Controls, Indicators, and Connections

Interface:	USB 2.0 (mini-B style connector)
Storage:	Removable SD-style memory
Push button control:	Stop/Start recording to SD memory
Indicators (LED):	Active, USB, Battery
Input Connections:	One 16-position terminal strip divided into two sections (High Holtage and Switch Closure/ TTL)

Power

Internal Battery Type:	Rechargeable lithium-ion
Internal Battery Run time:	24 hours
Current drain:	450 mA max @ 5VDC
AC adaptor:	100-240 VAC, 50-60 Hz
External Power:	via USB port or provided AC adaptor

Environmental

Operating Temperature:	0°C to 35°C (32°F to 95°F)
Operating Humidity:	0 to 90% non-condensing
Storage Temperature:	-20°C to 45°C (-4°F to 113°F)
Storage Humidity:	0 to 90% non-condensing

Physical Characteristics

Enclosure:	Hardened Plastic
Mounting:	Desktop; bulkhead
Dimensions:	2.625D × 5.5W × 1.53H in. (6.67D × 13.97W × 3.89H cm.)
Weight:	4.5 oz.

OS Compatibility

Setup software:	Windows XP (32-bit), Windows Vista and Windows 7 (32- and 64-bit versions)
SD-based CSV files:	OS-independent

Ordering Guide

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

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