

1 Features

- 3-axis accelerometer
- User selectable $\pm 2/\pm 6g$ range
- User selectable sample rate of 8, 16, 32, 64, or 128 hertz
- 14-bit resolution
- User selectable deadband setting
- Accurate time stamped data using Real Time Clock (RTC) with power back-up
- Records temperature and battery voltage
- Data recorded to a removable microSD card (1GB included)
- Easily readable comma separated text data files
- Data transfer compatible with Windows or Linux via Universal Serial Bus (USB) interface (no special software)
- System appears as USB Mass Storage Device to Windows and Linux OS's.
- Standard replaceable "AA" type battery
- LED indicator lights for system status

2 Applications

The USB Accelerometer X6-1 is applicable to:

- Continuous time stamped shock and motion monitoring of critical freight.
- Monitoring human motor activity, or actigraphy, such as exercise intensity or sleeping disorders.
- Automotive performance monitoring
- Educational purposes

3 Description

The USB Accelerometer X6-1 uses an 8051 8-bit microcontroller incorporating 14-bit A/D resolution, precise time stamped data logging, microSD memory storage, real-time data access and USB connectivity. Acceleration is collected in X, Y, and Z axes and stored at a user selectable rate of up to 128hz. When connected via the USB to a personal computer, the X6-1 appears as a standard mass storage device containing the comma delimited data files and user setup files. The commercial standard "AA" battery provides extended life operation suitable to long term data acquisition applications.



Figure 1: USB Accelerometer X6-1

3.1 Electrical

3.2 Sensor

Table 1: Accelerometer Sensor Characteristics

Parameter	Condition	Min	Typical	Max	Units
Acceleration range	High Gain	±1.8	±2.0		±g
	Low Gain	±5.4	±6.0		±g
Resolution	High Gain		0.0002		g/count
	Low Gain		0.0007		g/count
Linearity	Best Fit: x, y		±0.3	±1.5	%FS
	Best Fit: z		±0.6	±2.0	%FS
Sensing Element Resonant Frequency	X, Y axis	3.2	4.0	4.8	KHz
	Z axis	1.8	2.5	3.2	KHz
Sensitivity drift vs. temperature	Delta from +25°C		±0.01		%/°C
Zero g level vs. temperature	Delta from +25°C		±1.5		mg/°C

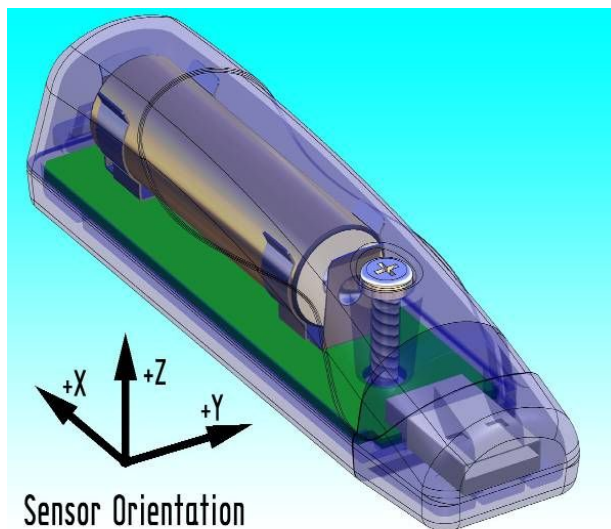


Figure 2: Accelerometer Sensor Orientation

3.2.1 Indicator LEDs

System status is indicated by the two LEDs located near the USB connector. The blue LED indicates system operation. A steady blinking blue LED, approximately once per two seconds, indicates a properly operating system. The blue LED blinks once per second when the USB Accelerometer is connected to a computer via the USB port. A rapid blinking blue LED indicates data recording has stopped due to a low battery condition. The red LED blinks when data is written from the internal cache to the microSD memory card. The period at which the red LED blinks depends on the deadband setting and sample rate. The red LED will also blink with Human Interface Device (HID) communication activity when connected to a PC. The “statusindicators” tag in the system configuration file turns off or changes the brightness of the LED status indicators (see Table 2).

3.2.2 Battery

3.2.2.1 Main Battery

The X6-1 is powered by a single “AA” sized battery (ANSI type 15A or IEC type LR6). Gulf Coast Data Concepts recommends an alkaline battery but NiMH rechargeable batteries are sufficient to operate the X6-1. Typical operation times range from 3 to 5 days depending on system configuration and battery type. The battery is not used when the system is connected to a computer USB port. USB communication activity halts the data recording. Therefore, extended operation is achieved by connecting a 5V supply via the USB connector (such as a personal electronics USB charger).

3.2.2.2 RTC Power Backup

If the system battery is depleted or removed, the real time clock (RTC) maintains the current time using a secondary backup capacitor power system. The backup capacitor will operate the RTC for several hours. The backup capacitor charges using the main battery or the USB power from a personal computer. Therefore, time must be allowed for the capacitor to charge after it has been depleted.

3.2.3 System Configuration Options

The X6-1 is configured using a set of tags and settings stored in a file named “config.txt”, which is located in the root directory of the microSD card. The system reads the configuration file each time a new data file is opened. Table 2 lists the configuration file keywords. Lines starting with a semicolon (“;”) are treated as comments and ignored by the system. Figure 3 illustrates an example configuration file. The system will use the default settings listed in Table 2 if the config.txt file is not found.

Table 2: Configuration File Tags and Descriptions

Tag	Valid Settings	Default	Description
gain	“high” or “low”	High	Sets the sensor to high gain ($\pm 2g$) or low gain ($\pm 6g$)
deadband	An integer between 0 and 1200	0	Sets the deadband in “counts” units. A new sample from the sensor must exceed the last recorded reading by the deadband value. Convert counts to g-force using equations 1 and 2. Note that a new sample is forced every 30 seconds regardless of deadband setting.
samplesperfile	An integer between 100 and 30,000	10,000	The number of lines of data per data file before a new file is created
samplerate	8, 16, 32, 64, or 128	16	Sets the rate at which data is collected and recorded to the microSD card
statusindicators	“Normal”, “High”, “Off”	Normal	LED status indicators can be activated with normal brightness (Normal), activated with high brightness (High), or completely deactivated (Off).

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; config.txt - usb&accelerometer x6-1 settings
; example configuration file
gain = low
deadband = 20
samplesPerFile = 20000
statusIndicators = normal
sampleRate = 128
    
```

Figure 3: Example Configuration File

3.2.4 Data Files

The X6-1 creates a new data file when the system is booted or when the maximum number of data lines is reached in the previous data file. A system boot condition occurs when power is restored to the system or when the X6-1 is removed from a computer USB port. Data files are placed in a folder named “GCDC” and are named data-XXX.csv, where XXX is a sequential number starting with 000. The system will create up to 1000 files. At the beginning of each file, a header is written describing the system configuration and the current time when the file was created. Table 3 lists the valid header tags, although not all tags may occur in the header.

Data is written to the file in comma separated text format starting with the time entry. Each line represents a data event and ends with a newline character. The time entry is in seconds past the start time recorded in the header. The count reading from the X, Y, and Z axes are recorded after the time. Figure 4 represents an example data file. Equations 1-2 convert the raw data into g-force using the nominal characteristics of the sensor system.

Low gain: $g - force = (counts - 8192) * 15 / 16384$ **Equation 1**

High Gain: $g - force = (counts - 8192) * 5 / 16384$ **Equation 2**

```
;Title, http://www.gcdataconcepts.com, usb-accelerometer, x6-1
;Version, 303:377M, Build num, 0x418, Build date, 20090102 14:02:47, SN:CCDC020081127
;Start_time, 2009-01-05, 08:21:14.000
;Temperature, 22.75, deg C
;Battery voltage, 1197,mV
;Gain, low
;SampleRate, 128,Hz
;Deadband, 0
;Headers, time,Ax,Ay,Az
0.007,8448,7819,9129
0.015,8489,7798,9124
0.022,8457,7826,9106
0.030,8451,7873,9154
.
.
.
229.566,8313,7926,9189
229.573,8328,7924,9164
229.581,8334,7914,9145
229.588,8341,7939,9150
```

Figure 4: Example Data File

Table 3: Data File Header Tags

Tag	Description
BATTERYVOLTAGE	Voltage condition of battery when the data file was created
DEADBAND	A new sample from the sensor must exceed the last reading by the deadband value
GAIN	“high” or “low” indicating the system gain setting
HEADERS	The names of each column of data in the file
SAMPLERATE	Rate at which data is recorded to the microSD card
START TIME	The current time when the data file was created
TEMPERATURE	Temperature of sensor in °C when data file was created
TITLE	The name of the USB Accelerometer X6-1 unit
VERSION	The version control information of the USB Accelerometer firmware

3.2.5 Real Time Clock

A real time clock (RTC) is integrated into the X6-1 system and is used to determine time for each line of data recorded. The RTC maintains ± 2 ppm accuracy (0°C to +40°C) and is backed up by a separate power system (see section 3.2.2.2). The RTC also provides the system temperature (°C) recorded to the header of each data file.

The RTC is set using a text file named “time.txt” located in the root directory of the microSD card. The system looks for the time.txt file upon booting. If the file exists, the time stored in the file is loaded to the RTC and the time.txt file is deleted. The time information in the time.txt file must be in the exact “yyyy-MM-dd HH:mm:ss” 24-hour format, occur on the first line, and end with a newline character. The time file method of setting the RTC does not require any special communication drivers to the device so it can be implemented using any text editor. Direct initialization of the RTC is possible but requires specific device drivers from Gulf Coast Data Concepts.

3.2.6 Memory Card

The X6-1 stores data to a removable microSD flash memory card. The memory card must be formatted to FAT16 for proper operation of the X6-1. Under Windows XP, the card must be formatted using the “FAT” file system and the default allocation size. Do not select “Quick Format” or “FAT32”. The X6-1 will create a folder called “GCDC”, if not already present, to place the data files (see section 3.2.4). The “config.txt” and “time.txt” files must occur in the root directory (see section 3.2.3 and section 3.2.5). The X6-1 functions as a Mass Storage Device to computer operating systems when transferring data to and from the microSD memory card.

3.3 Mechanical

The X6-1 electronics are enclosed in a three-part plastic enclosure. The semi-transparent blue colored ABS plastic allows attenuated sight of the two indicator LEDs. The top and bottom enclosure components and the printed circuit board are secured together with a 0.75" long #6-32 screw and nut. Longer screw lengths can facilitate attachment of the X6-1 to other structures. A slip-on cap protects the USB connector.

3.3.1 Dimensions

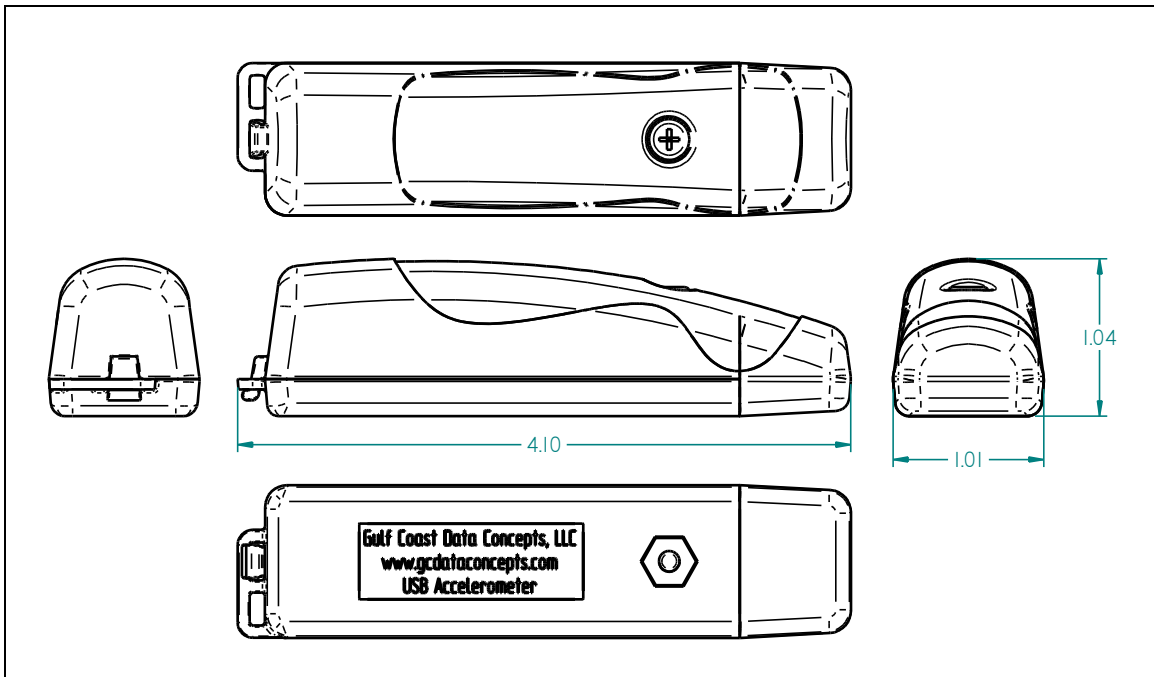


Figure 5: Enclosure Dimensions

3.3.2 Assembly

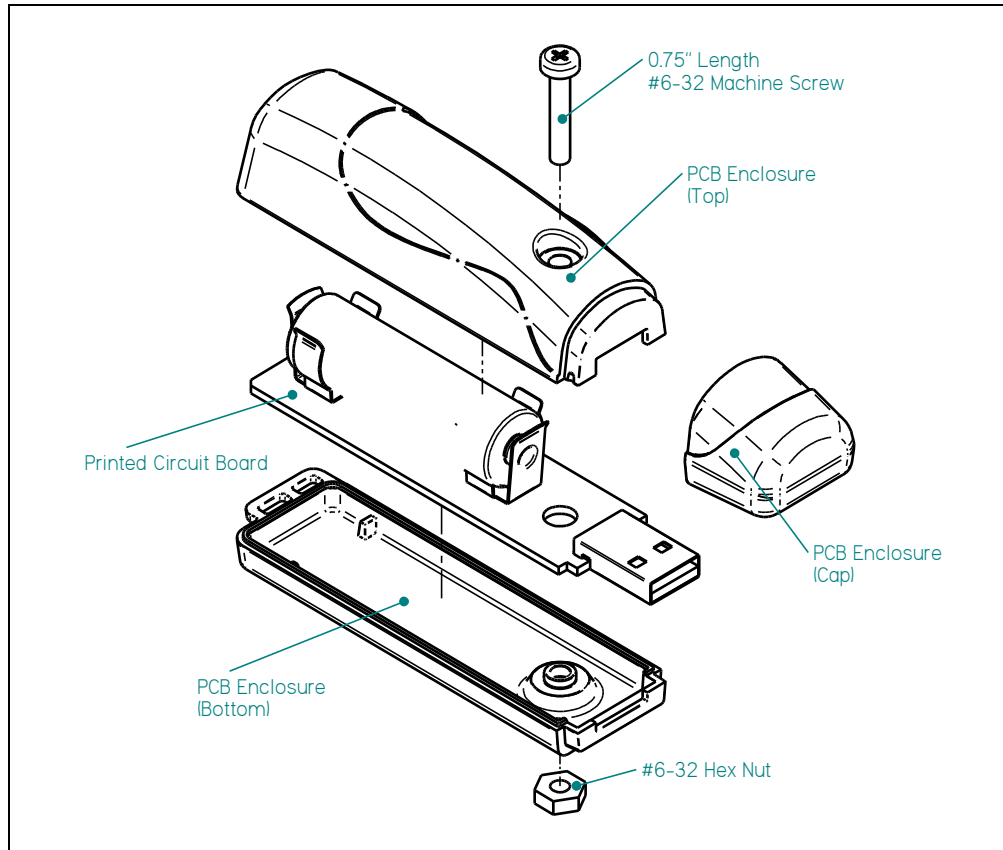


Figure 6: Exploded View of USB Accelerometer X6-1

4 Software

The X6-1 records data to comma delimited text files and uses text based files for configuration settings. Therefore, no special software is required to utilize the X6-1. However, Gulf Coast Data Concepts provides the Java based software program *XLR8R* that allows easy visual presentation of the data, copy-paste export of data segments, as well as configuration file and time file creation utilities. *XLR8R* is included on the microSD card of each X6-1 unit or can be downloaded from the website at www.gcdadataconcepts.com. For data analysis, Gulf Coast Data Concepts recommends using a commercial or open source mathematics package, such as MathCAD, Microsoft Excel, OpenOffice Calc, Octave, R, or similar applications.