Sensitivity and Sensitivity Units of the 333D01 ICPD Accelerometer

Revision 11-Aug-14 – Suggested Nominal sensitivity for channel be changed to 33000 and 65000. This is a nominal 100mV/g sensitivity

Introduction

This paper details the sensitivity specification of the 333D01. Because it is a digital accelerometer, traditional analog sensitivity units such as mV/g are not the most accurate. We have determined that units of Digital Counts per m/s^2 would be the most universally accepted and accurate.

Background

Typical analog accelerometers output a voltage proportional to the acceleration they undergo. Conventional systems use some variety of separate analog to digital conversion hardware to read the analog sensor. With the 333D01, the conversion to digital occurs within the sensor itself so the only outputs are digital samples. Because of this, a voltage / acceleration sensitivity value is not the most accurate.

The most accurate units are Digital Counts / (m/s^2). This provides calibration of the analog to digital conversion as well as the acceleration sensing element. Table 1 defines conversions to common engineering units.

The Digital Counts is based on a 24 bit resolution sample. It can be scaled to 16 bit samples by dividing by 256 (bit shifting right by 8).

Source of Sensitivity Values

A calibration sheet is included with each 333D01 sensor that includes the sensitivity value for each channel.

The sensitivity is encoded in text as part of the USB serial number and model number descriptors configured in each sensor. This provides a TEDS-like capability using the standard USB interface.

The model number field is visible in the Windows 7 recorder interface and details page. An Excel example will be provided to parse the calibration example.

Fully featured analyzer software may access these fields for automatic sensitivity usage or a USB descriptor program can be used. A free USB descriptor program is Thesycon USB Descripter Dumper available at http://www.thesycon.de/eng/usb_descriptordumper.shtml.

Embedded Calibration

Prototype 333D01 units did not have the calibration feature implemented. A nominal calibration value of 33000 should be used for channel A (or 1) and 65000 for channel B (or 2) if the calibration data is not present.

Version 0 Format

This format was used in a limited number of beta units and these will be upgraded to version 1. This data was only encoded in the serial number descriptor. We recommend applications that have already implemented this version maintain it for backward compatibility and use the version character to determine the version.

The version 0 format of the information is a follows:

NNNNNNssss0sAAAAAAsBBBBBB

Where

NNNNNN is 6 digit serial number.
s is space.
0 is single character format definition. This indicates format 0 being used.
AAAAAA is 6 digit sensitivity value.
BBBBBB is 6 digit sensitivity value.

Version 1 Format

For general ease of use on Windows 7, we are providing the calibration data in both the model field and the serial number field. We have added the date of calibration as well. The serial number string up to the version identifier has remained the same so applications can accommodate both versions.

The version 1 format serial number field:

NNNNNNssss1NNNNNNAAAAABBBBBYYMMDD

The version 1 format model number field:

333D01s1NNNNNNAAAAABBBBBYYMMDD

Where

NNNNNN is 6 digit serial number.
s is space.
1 is single character format definition. This indicates format 1 being used.
AAAAA is 5 digit sensitivity value.
BBBBB is 5 digit sensitivity value.
YY is the last two digits of the year (00-99).
MM is the month number (1-12).
DD is the day (1-31).

WAV File Calibration Chunk

The WAV file format supports the addition of arbitrary “chunks” of custom defined data. We have defined the following chunk to retain the calibration information with data recorded from a 333D01 sensor. Recorder applications should define this chunk. Analysis applications should interpret this chunk and scale data correctly for analysis.

For general WAV file information, search Google for WAV file formats or take a look at this link: https://ccrma.stanford.edu/courses/422/projects/WaveFormat/ Applications that do not recognize a specific chunk ID should just skip that chunk.

The chunk will have the following format:

CAL1LLLLMMMMMMss<Serial Number Descriptor String><padding spaces>

Where:

CAL1 is the chunk identifier per the WAV specification. It is a 4 byte item

LLLL is the chunk length per the WAV specification. It is a 4 byte integer and defines the length of the rest of the chunk.

MMMMMM is the model number. It will be set to 333D01 for this sensor. A decoding application should confirm the model number data is ‘333D01’ because the chunk identifiers are uncontrolled. As far as we are aware, ‘CAL1’ is unused but this is an important cross check to avoid invalid data.

s Spaces to pad the model number to an even multiple of 4 bytes.

<The Serial Number Descriptor String> formatted as defined above. Note: This format can also be created from the Model number information with some slight rearranging of the data if that is the most convenient to implement.

<padding spaces> Add the necessary spaces so the chunk is a multiple of 4 bytes in length.

Table 1 - Conversion to other units

From	Factor	Decimal	To
Digital Sample -2^{23} to $(2^{23}-1)$	$\frac{1}{sensitivity\left(\frac{counts}{\frac{m}{s^2}}\right) * 9.80665\left(\frac{\frac{m}{s^2}}{g}\right)}$	$\frac{0.10197}{sensitivity}$	g
Digital Sample -2^{23} to $(2^{23}-1)$	$\frac{1}{sensitivity\left(\frac{counts}{\frac{m}{s^2}}\right)}$	$\frac{1}{sensitivity}$	m/s^2
Normalized -1.0 to 1.0 Matlab, M+P Smart Office	$\frac{2^{23}\left(\frac{counts}{signed\ full\ scale}\right)}{sensitivity\left(\frac{counts}{\frac{m}{s^2}}\right) * 9.80665\left(\frac{\frac{m}{s^2}}{g}\right)}$	$\frac{855400}{sensitivity}$	g
Normalized -1.0 to 1.0 Matlab, M+P Smart Office	$\frac{2^{23}\left(\frac{counts}{signed\ full\ scale}\right)}{sensitivity\left(\frac{counts}{\frac{m}{s^2}}\right)}$	$\frac{8388608}{sensitivity}$	m/s^2
%FSV -100% to 100%	$\frac{2^{23}\left(\frac{counts}{signed\ full\ scale}\right)}{100\left(\frac{\%}{full\ scale}\right) * sensitivity\left(\frac{counts}{\frac{m}{s^2}}\right) * 9.80665\left(\frac{\frac{m}{s^2}}{g}\right)}$	$\frac{8553.99958}{sensitivity}$	g
%FSV -100% to 100%	$\frac{2^{23}\left(\frac{counts}{signed\ full\ scale}\right)}{100\left(\frac{\%}{full\ scale}\right) * sensitivity\left(\frac{counts}{\frac{m}{s^2}}\right)}$	$\frac{83886.08000}{sensitivity}$	m/s^2