BCI2000 g.USBamp Support

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July 15, 2005

Contents

1 Introduction

g.USBamp is an amplifier/digitizer combination from g.tec Technologies (`http://www.gtec.at`). This document describes support for this device in BCI2000, which consists of two components: A BCI2000-compatible Source Module (`gUSBamp.exe`) and a command-line tool (`USBampgetinfo`).

2 g.USBamp Hardware

The USBamp consists of 16 independent 24-bit A/D converters that can sample at up to 38.4kHz per channel. Because there is one A/D converter for each channel, one particular sample is digitized at the exact same time for each channel. This is unlike with traditional A/D converter boards that only have one A/D converter. BCI2000 has a feature that can align samples in time (parameter *AlignChannels* in Section *Filtering*). Because this feature is not needed in conjunction with the USBamp, it needs to be turned off (i.e., *AlignChannels* needs to be 0).

3 g.USBamp Source Module

The BCI2000-compatible Source Module `gUSBamp.exe` can be used instead of any other source module. In addition to standard parameters (i.e., *SampleBlockSize*, *SamplingRate*, *SoftwareCh*, *TransmitCh*, *TransmitChList*), it also contains the following parameters:

DeviceIDMaster Serial number of the master device. If you only have one device, this parameter has to equal *DeviceIDs*. If you have more then one device, then this parameter represents the serial number of the device whose SYNC goes to the slaves, i.e., the only device that has a cable connected at SYNC OUT, but none connected to SYNC IN.

DeviceIDs List of serial numbers of all devices. If you have more than one device, this list determines the order of the channels in the data file.

FilterEnabled Choose 1 if you want a pass band filter, and 0 if you don't. The gUSBamp is a DC amplifier and thus you most likely will want a pass band filter.

FilterHighPass High pass frequency for pass band. You need to query the amp for possible values. See description of the USBampgetinfo tool for more info.

FilterLowPass High pass frequency for pass band. See description of the USBampgetinfo tool for more info.

FilterModelOrder Model order for passband filter. See description of the USBampgetinfo tool for more info.

FilterType Type of passband filter. 1=CHEBYSHEV, 2=BUTTER-WORTH

NotchEnabled Choose 1 if you want a notch filter, and 0 if you don't.

NotchHighPass Similar to FilterHighPass.

NotchLowPass Similar to FilterLowPass.

NotchModelOrder Similar to FilterModelOrder.

NotchType Similar to FilterType.

SampleBlockSize Samples per digitized block. The block size has to be chosen such that $SoftwareChDevices * SampleBlockSize * 4$ is a multiple of 512. (This is apparently a limitation of the USB driver.)

SamplingRate The sampling rate of all connected USBamps. While there is no hardware constraint on the sampling rate, it has to be chosen so as to satisfy the constraint described for *SampleBlockSize*. Furthermore, if one wants to use a bandpass or a notch filter, there needs to be a filter configuration for that particular sampling rate (see the section on the `USBampgetinfo` tool). (Guger Technologies can provide you with a new driver configuration file if you need a different filter.)

SoftwareCh The total number of channels across all USBamp devices.

SoftwareChDevices The number of channels acquired from each device. If there is only one device, this parameter has to equal *SoftwareCh*. For example, '16 8' will acquire channels from the first device listed under *DeviceIDs*, and 8 channels from the second device listed under *DeviceIDs*. Data acquisition always starts at channel 1. The sum of all channels (e.g., 24 in this example) has to equal the value of *SoftwareCh*.

TransmitCh The number of channels that are transmitted to the BCI2000 Signal Processing module. See the BCI2000 Project Outline for further information.

TransmitChList The list of channels that are transmitted to the BCI2000 Signal Processing module. See the BCI2000 Project Outline for further information.

3.1 Assumptions

The USBamp source module assumes that the amplifier is not turned off during the session. (Since the EEG display would stop, this is a fairly safe assumption.) This assumption is made since it takes about 2.5 seconds to program new filter settings into one USBamp (and correspondingly more time for more amps). Thus, any click on *Set Config* would be followed by a fairly long delay. In consequence, the USBamp source module only programs the filter settings on the first run or if the filter settings have changed.

3.2 Data Storage

Unlike other systems, the USBamp is a DC amplifier system that digitizes at 24 bit. Bandpass and notch filtering is performed on the digitized samples, resulting in floating point signal samples in units of μV. Because BCI2000 currently only supports signed 16 bit integers, the floating point values have to be converted back into integers before they can be stored and transmitted to Signal Processing. This is done by the following transformation: $sample_{stored}(A/D units) = \frac{sample_{acquired}(\mu V)}{SourceChGain}$. (*SourceChOffset* is assumed (and required) to be zero for all channels.) BCI2000 Signal Processing or any offline analysis routine can derive, as with any other BCI2000 source module, sample values in μV by subtracting, from each stored sample, *SourceChOffset* (i.e., zero), and multiplying it with *SourceChGain* for each channel.

Once BCI2000 is able to support floating point samples, this conversion can be removed.

4   The `USBampgetinfo` Command Line Tool

This command line tool displays all connected USBamps, including their serial number and the USB port that they connect to. Further, this tool reads, for the first of the connected amplifiers, all supported bandpass and notch filter configurations. Thus, this tool can be used to determine which filters can be used for a particular sampling frequency within BCI2000. The following is an example screen output:

```
*******************************************
BCI2000 Information Tool for g.USBamp
*******************************************
(C)2004 Gerwin Schalk
        Wadsworth Center
        New York State Department of Health
        Albany, NY, USA
*******************************************
Amp found at USB address 2 (S/N: UA-2004.08.03)
Printing info for first amp (USB address 2)

Available bandpass filters
==================================
num| hpfr  | lpfreq |  sfr  | or | type
==================================
000|  0.00 |   15.0 |   32 |  3 | 1
001|  0.01 |   15.0 |   32 |  3 | 1
002|  0.10 |   15.0 |   32 |  3 | 1
003|  0.50 |   15.0 |   32 |  3 | 1
004|  2.00 |   15.0 |   32 |  3 | 1
005|  0.00 |   30.0 |   64 |  3 | 1
006|  0.01 |   30.0 |   64 |  3 | 1
007|  0.10 |   30.0 |   64 |  3 | 1
008|  0.50 |   30.0 |   64 |  3 | 1
009|  2.00 |   30.0 |   64 |  3 | 1
010|  0.00 |   30.0 |  128 |  4 | 1
011|  0.00 |   60.0 |  128 |  4 | 1
012|  0.01 |   30.0 |  128 |  2 | 1
013|  0.01 |   60.0 |  128 |  2 | 1
```

```
014|   0.10  |    30.0  |  128  |  3  |  1
015|   0.10  |    60.0  |  128  |  3  |  1
016|   0.50  |    30.0  |  128  |  3  |  1
017|   0.50  |    60.0  |  128  |  4  |  1
018|   2.00  |    30.0  |  128  |  3  |  1
019|   2.00  |    60.0  |  128  |  4  |  1
020|   0.00  |    30.0  |  256  |  4  |  1
021|   0.00  |    60.0  |  256  |  4  |  1
022|   0.00  |   100.0  |  256  |  4  |  1
023|   0.01  |    30.0  |  256  |  2  |  1
024|   0.01  |    60.0  |  256  |  2  |  1
025|   0.01  |   100.0  |  256  |  2  |  1
026|   0.10  |    30.0  |  256  |  2  |  1
027|   0.10  |    60.0  |  256  |  2  |  1
028|   0.10  |   100.0  |  256  |  2  |  1
029|   0.50  |    30.0  |  256  |  2  |  1
030|   0.50  |    60.0  |  256  |  3  |  1
031|   0.50  |   100.0  |  256  |  3  |  1
032|   2.00  |    30.0  |  256  |  2  |  1
033|   2.00  |    60.0  |  256  |  3  |  1
034|   2.00  |   100.0  |  256  |  4  |  1
035|   5.00  |    30.0  |  256  |  2  |  1
036|   5.00  |    60.0  |  256  |  3  |  1
037|   5.00  |   100.0  |  256  |  4  |  1
038|   0.00  |    30.0  |  512  |  4  |  1
039|   0.00  |    60.0  |  512  |  4  |  1
040|   0.00  |   100.0  |  512  |  4  |  1
041|   0.00  |   200.0  |  512  |  4  |  1
042|   0.01  |    30.0  |  512  |  1  |  1
043|   0.01  |    60.0  |  512  |  1  |  1
044|   0.01  |   100.0  |  512  |  2  |  1
045|   0.01  |   200.0  |  512  |  2  |  1
046|   0.10  |    30.0  |  512  |  1  |  1
047|   0.10  |    60.0  |  512  |  1  |  1
048|   0.10  |   100.0  |  512  |  2  |  1
049|   0.10  |   200.0  |  512  |  2  |  1
050|   0.50  |    30.0  |  512  |  1  |  1
051|   0.50  |    60.0  |  512  |  1  |  1
```

```
052|   0.50  |   100.0  |   512  |   2  |  1
053|   0.50  |   200.0  |   512  |   2  |  1
054|   2.00  |    30.0  |   512  |   2  |  1
055|   2.00  |    60.0  |   512  |   2  |  1
056|   2.00  |   100.0  |   512  |   4  |  1
057|   2.00  |   200.0  |   512  |   4  |  1
058|   5.00  |    30.0  |   512  |   2  |  1
059|   5.00  |    60.0  |   512  |   2  |  1
060|   5.00  |   100.0  |   512  |   3  |  1
061|   5.00  |   200.0  |   512  |   3  |  1
062|   0.00  |    30.0  |   600  |   4  |  1
063|   0.00  |    60.0  |   600  |   4  |  1
064|   0.00  |   100.0  |   600  |   4  |  1
065|   0.00  |   200.0  |   600  |   4  |  1
066|   0.00  |   250.0  |   600  |   4  |  1
067|   0.01  |    60.0  |   600  |   1  |  1
068|   0.01  |   100.0  |   600  |   2  |  1
069|   0.01  |   200.0  |   600  |   2  |  1
070|   0.01  |   250.0  |   600  |   2  |  1
071|   0.10  |    60.0  |   600  |   2  |  1
072|   0.10  |   100.0  |   600  |   3  |  1
073|   0.10  |   200.0  |   600  |   3  |  1
074|   0.10  |   250.0  |   600  |   3  |  1
075|   0.50  |    30.0  |   600  |   2  |  1
076|   0.50  |    60.0  |   600  |   2  |  1
077|   0.50  |   100.0  |   600  |   3  |  1
078|   0.50  |   200.0  |   600  |   3  |  1
079|   0.50  |   250.0  |   600  |   3  |  1
080|   2.00  |    30.0  |   600  |   2  |  1
081|   2.00  |    60.0  |   600  |   2  |  1
082|   2.00  |   100.0  |   600  |   3  |  1
083|   2.00  |   200.0  |   600  |   3  |  1
084|   2.00  |   250.0  |   600  |   4  |  1
085|   5.00  |    30.0  |   600  |   2  |  1
086|   5.00  |    60.0  |   600  |   2  |  1
087|   5.00  |   100.0  |   600  |   3  |  1
088|   5.00  |   200.0  |   600  |   3  |  1
089|   5.00  |   250.0  |   600  |   4  |  1
```

```
090|  0.00 |    30.0 | 1200 |  4 | 1
091|  0.00 |    60.0 | 1200 |  4 | 1
092|  0.00 |   100.0 | 1200 |  4 | 1
093|  0.00 |   200.0 | 1200 |  4 | 1
094|  0.00 |   250.0 | 1200 |  4 | 1
095|  0.00 |   500.0 | 1200 |  4 | 1
096|  0.01 |   100.0 | 1200 |  1 | 1
097|  0.01 |   200.0 | 1200 |  2 | 1
098|  0.01 |   250.0 | 1200 |  2 | 1
099|  0.01 |   500.0 | 1200 |  2 | 1
100|  0.10 |   100.0 | 1200 |  1 | 1
101|  0.10 |   200.0 | 1200 |  2 | 1
102|  0.10 |   250.0 | 1200 |  2 | 1
103|  0.10 |   500.0 | 1200 |  2 | 1
104|  0.50 |   100.0 | 1200 |  1 | 1
105|  0.50 |   200.0 | 1200 |  2 | 1
106|  0.50 |   250.0 | 1200 |  3 | 1
107|  0.50 |   500.0 | 1200 |  4 | 1
108|  2.00 |   100.0 | 1200 |  1 | 1
109|  2.00 |   200.0 | 1200 |  2 | 1
110|  2.00 |   250.0 | 1200 |  3 | 1
111|  2.00 |   500.0 | 1200 |  4 | 1
112|  5.00 |   100.0 | 1200 |  1 | 1
113|  5.00 |   200.0 | 1200 |  2 | 1
114|  5.00 |   250.0 | 1200 |  3 | 1
115|  5.00 |   500.0 | 1200 |  4 | 1
116|  0.00 |    30.0 | 2400 |  4 | 1
117|  0.00 |    60.0 | 2400 |  4 | 1
118|  0.00 |   100.0 | 2400 |  4 | 1
119|  0.00 |   200.0 | 2400 |  4 | 1
120|  0.00 |   250.0 | 2400 |  4 | 1
121|  0.00 |   500.0 | 2400 |  4 | 1
122|  0.00 |  1000.0 | 2400 |  4 | 1
123|  0.01 |   200.0 | 2400 |  1 | 1
124|  0.01 |   250.0 | 2400 |  1 | 1
125|  0.01 |   500.0 | 2400 |  3 | 1
126|  0.01 |  1000.0 | 2400 |  3 | 1
127|  0.10 |   200.0 | 2400 |  2 | 1
```

```
128|  0.10  |  250.0  |  2400  |  2  |  1
129|  0.10  |  500.0  |  2400  |  3  |  1
130|  0.10  | 1000.0  |  2400  |  3  |  1
131|  0.50  |  200.0  |  2400  |  2  |  1
132|  0.50  |  250.0  |  2400  |  2  |  1
133|  0.50  |  500.0  |  2400  |  3  |  1
134|  0.50  | 1000.0  |  2400  |  3  |  1
135|  2.00  |  200.0  |  2400  |  2  |  1
136|  2.00  |  250.0  |  2400  |  2  |  1
137|  2.00  |  500.0  |  2400  |  3  |  1
138|  2.00  | 1000.0  |  2400  |  3  |  1
139|  5.00  |  200.0  |  2400  |  2  |  1
140|  5.00  |  250.0  |  2400  |  2  |  1
141|  5.00  |  500.0  |  2400  |  3  |  1
142|  5.00  | 1000.0  |  2400  |  3  |  1
143|  0.00  |   30.0  |  4800  |  4  |  1
144|  0.00  |   60.0  |  4800  |  4  |  1
145|  0.00  |  100.0  |  4800  |  4  |  1
146|  0.00  |  200.0  |  4800  |  4  |  1
147|  0.00  |  250.0  |  4800  |  4  |  1
148|  0.00  |  500.0  |  4800  |  4  |  1
149|  0.00  | 1000.0  |  4800  |  4  |  1
150|  0.00  | 2000.0  |  4800  |  4  |  1
151|  0.01  |  500.0  |  4800  |  2  |  1
152|  0.01  | 1000.0  |  4800  |  2  |  1
153|  0.01  | 2000.0  |  4800  |  2  |  1
154|  0.10  |  500.0  |  4800  |  2  |  1
155|  0.10  | 1000.0  |  4800  |  2  |  1
156|  0.10  | 2000.0  |  4800  |  2  |  1
157|  0.50  |  500.0  |  4800  |  2  |  1
158|  0.50  | 1000.0  |  4800  |  2  |  1
159|  0.50  | 2000.0  |  4800  |  2  |  1
160|  2.00  |  500.0  |  4800  |  2  |  1
161|  2.00  | 1000.0  |  4800  |  2  |  1
162|  2.00  | 2000.0  |  4800  |  2  |  1
163|  5.00  |  500.0  |  4800  |  2  |  1
164|  5.00  | 1000.0  |  4800  |  2  |  1
165|  5.00  | 2000.0  |  4800  |  2  |  1
```

```
Available notch filters
==================================
num| hpfr  | lpfreq |  sfr  | or | type
==================================
000| 40.00 |   60.0 |  128 |  2 | 1
001| 50.00 |   63.0 |  128 |  2 | 1
002| 40.00 |   60.0 |  256 |  2 | 1
003| 50.00 |   70.0 |  256 |  2 | 1
004| 40.00 |   60.0 |  512 |  2 | 1
005| 50.00 |   70.0 |  512 |  2 | 1
006| 40.00 |   60.0 |  600 |  2 | 1
007| 50.00 |   70.0 |  600 |  2 | 1
008| 40.00 |   60.0 | 1200 |  2 | 1
009| 50.00 |   70.0 | 1200 |  2 | 1
010| 40.00 |   60.0 | 2400 |  2 | 1
011| 50.00 |   70.0 | 2400 |  2 | 1
012| 40.00 |   60.0 | 4800 |  2 | 1
013| 50.00 |   70.0 | 4800 |  2 | 1
```