

# BCI2000 g.USBamp Support

Gerwin Schalk

2004-07 Brain-Computer Interface Research and Development Program

Wadsworth Center, New York State Department of Health

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# 1 Introduction

*g.USBamp* is an amplifier/digitizer combination from g.tec medical engineering GmbH / Guger Technologies OEG (<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 than 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. If only one device is connected, this parameter can be set to *auto*.

**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. If only one device is connected, this parameter can be set to *auto*.

**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. Please note that, because the gUSBamp internally has a 5kHz antialiasing filter and always samples with 38.4kHz, you DO NOT need to enable any filter if you do not want. You will never experience aliasing.

**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=BUTTERWORTH

**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 channel per digitized block. Together with the sampling rate, this parameter determines how often per second data are collected, processed, and feedback is updated.

**SamplingRate** The sampling rate of all connected USBamps. 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.)

**SignalType** Defines the data type of the stored signal samples (int16 or float32). If the data type is int16, signal samples (which are produced by the amplifier in units of  $\mu V$ ) are converted back into virtual A/D units (see Data Storage section below). If the data type is float32, the signals are stored in units of  $\mu V$ . In this case, SourceChOffset should be 0, and SourceChGain should be 1 (since the conversion factor from  $\mu V$  into  $\mu V$  is 1).

**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*.

**DigitalInput** Turn on digital input. If turned on, the last sampled channel on each amplifier will contain sampled values of digital input 0 on the DIGITAL I/O input block on the back of the device. For example, if SoftwareCh is 8, then channels 1-7 will represent analog inputs, and channel 8 will represent the digital input. Thus, if DigitalInput is turned on, *SoftwareCh* and *SoftwareChDevices* may be a maximum of 17.

**AcquisitionMode** If set to *analog signal acquisition*, the g.USBamp records analog signal voltages (default). If set to *Calibration*, the signal output is a sine wave test signal generated by the g.USBamp (which can be used to verify correct system calibration). If set to *Impedance*, regular analog signal acquisition is preceded by an impedance test. This impedance test reports input impedances for each channel in kOhms.

**CommonGround** This parameter determines whether the g.USBamp internally connects the GND inputs from all blocks together. If enabled (default), then the signal ground only needs to be connected to one input block, e.g., block 1. Otherwise, all GND inputs need to be externally connected.

**CommonReference** The same as *CommonGround*, except for the signal reference.

**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 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  $\mu V$ . BCI2000 currently supports signed 16 bit integers and floating point numbers for its data storage. If *SignalType* is set to int16, 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:  $sample_{stored}(A/Dunits) = \frac{sample_{acquired}(\mu V)}{SourceChGain}$ . (*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  $\mu V$  by subtracting, from each stored sample, *SourceChOffset* (i.e., zero), and multiplying it with *SourceChGain* for each channel. If *SignalType* is set to float32, data samples are stored in units of  $\mu V$ . In this case *SourceCh* should be a list of 1's (because the conversion factor between data samples into  $\mu V$  is 1.0 for each channel).

## 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
*****
```

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Wadsworth Center  
New York State Department of Health  
Albany, NY, USA

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Amp found at USB address 1 (S/N: UA-200X.XX.XX)

Printing info for first amp (USB address 1)

Available bandpass filters

=====

num	hpfr		lpfreq		sfr		or		type
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=====

000	0.10		0.0		32		8		1
001	1.00		0.0		32		8		1
002	2.00		0.0		32		8		1
003	5.00		0.0		32		8		1
004	0.00		15.0		32		8		1
005	0.01		15.0		32		8		1
006	0.10		15.0		32		8		1
007	0.50		15.0		32		8		1
008	2.00		15.0		32		8		1
009	0.10		0.0		64		8		1
010	1.00		0.0		64		8		1
011	2.00		0.0		64		8		1
012	5.00		0.0		64		8		1
013	0.00		30.0		64		8		1
014	0.01		30.0		64		8		1
015	0.10		30.0		64		8		1
016	0.50		30.0		64		8		1
017	2.00		30.0		64		8		1
018	0.10		0.0		128		8		1
019	1.00		0.0		128		8		1
020	2.00		0.0		128		8		1
021	5.00		0.0		128		8		1
022	0.00		30.0		128		8		1
023	0.00		60.0		128		8		1
024	0.01		30.0		128		8		1
025	0.01		60.0		128		8		1

026	0.10	30.0	128	8	1
027	0.10	60.0	128	8	1
028	0.50	30.0	128	8	1
029	0.50	60.0	128	8	1
030	2.00	30.0	128	8	1
031	2.00	60.0	128	8	1
032	0.10	0.0	256	8	1
033	1.00	0.0	256	8	1
034	2.00	0.0	256	8	1
035	5.00	0.0	256	8	1
036	0.00	30.0	256	8	1
037	0.00	60.0	256	8	1
038	0.00	100.0	256	8	1
039	0.01	30.0	256	6	1
040	0.01	60.0	256	8	1
041	0.01	100.0	256	8	1
042	0.10	30.0	256	8	1
043	0.10	60.0	256	8	1
044	0.10	100.0	256	8	1
045	0.50	30.0	256	8	1
046	0.50	60.0	256	8	1
047	0.50	100.0	256	8	1
048	2.00	30.0	256	8	1
049	2.00	60.0	256	8	1
050	2.00	100.0	256	8	1
051	5.00	30.0	256	8	1
052	5.00	60.0	256	8	1
053	5.00	100.0	256	8	1
054	0.10	0.0	512	8	1
055	1.00	0.0	512	8	1
056	2.00	0.0	512	8	1
057	5.00	0.0	512	8	1
058	0.00	30.0	512	8	1
059	0.00	60.0	512	8	1
060	0.00	100.0	512	8	1
061	0.00	200.0	512	8	1
062	0.01	30.0	512	6	1
063	0.01	60.0	512	6	1

064	0.01	100.0	512	6	1
065	0.01	200.0	512	8	1
066	0.10	30.0	512	8	1
067	0.10	60.0	512	8	1
068	0.10	100.0	512	8	1
069	0.10	200.0	512	8	1
070	0.50	30.0	512	8	1
071	0.50	60.0	512	8	1
072	0.50	100.0	512	8	1
073	0.50	200.0	512	8	1
074	2.00	30.0	512	8	1
075	2.00	60.0	512	8	1
076	2.00	100.0	512	8	1
077	2.00	200.0	512	8	1
078	5.00	30.0	512	8	1
079	5.00	60.0	512	8	1
080	5.00	100.0	512	8	1
081	5.00	200.0	512	8	1
082	0.10	0.0	600	8	1
083	1.00	0.0	600	8	1
084	2.00	0.0	600	8	1
085	5.00	0.0	600	8	1
086	0.00	30.0	600	8	1
087	0.00	60.0	600	8	1
088	0.00	100.0	600	8	1
089	0.00	200.0	600	8	1
090	0.00	250.0	600	8	1
091	0.01	60.0	600	6	1
092	0.01	100.0	600	6	1
093	0.01	200.0	600	6	1
094	0.01	250.0	600	8	1
095	0.10	60.0	600	8	1
096	0.10	100.0	600	8	1
097	0.10	200.0	600	8	1
098	0.10	250.0	600	8	1
099	0.50	30.0	600	8	1
100	0.50	60.0	600	8	1
101	0.50	100.0	600	8	1



102	0.50		200.0		600		8		1
103	0.50		250.0		600		8		1
104	2.00		30.0		600		8		1
105	2.00		60.0		600		8		1
106	2.00		100.0		600		8		1
107	2.00		200.0		600		8		1
108	2.00		250.0		600		8		1
109	5.00		30.0		600		8		1
110	5.00		60.0		600		8		1
111	5.00		100.0		600		8		1
112	5.00		200.0		600		8		1
113	5.00		250.0		600		8		1
114	0.10		0.0		1200		8		1
115	1.00		0.0		1200		8		1
116	2.00		0.0		1200		8		1
117	5.00		0.0		1200		8		1
118	0.00		30.0		1200		8		1
119	0.00		60.0		1200		8		1
120	0.00		100.0		1200		8		1
121	0.00		200.0		1200		8		1
122	0.00		250.0		1200		8		1
123	0.00		500.0		1200		8		1
124	0.01		100.0		1200		6		1
125	0.01		200.0		1200		6		1
126	0.01		250.0		1200		6		1
127	0.01		500.0		1200		6		1
128	0.10		100.0		1200		6		1
129	0.10		200.0		1200		8		1
130	0.10		250.0		1200		8		1
131	0.10		500.0		1200		8		1
132	0.50		100.0		1200		8		1
133	0.50		200.0		1200		8		1
134	0.50		250.0		1200		8		1
135	0.50		500.0		1200		8		1
136	2.00		100.0		1200		8		1
137	2.00		200.0		1200		8		1
138	2.00		250.0		1200		8		1
139	2.00		500.0		1200		8		1

140	5.00		100.0		1200		8		1
141	5.00		200.0		1200		8		1
142	5.00		250.0		1200		8		1
143	5.00		500.0		1200		8		1
144	0.10		0.0		2400		8		1
145	1.00		0.0		2400		8		1
146	2.00		0.0		2400		8		1
147	5.00		0.0		2400		8		1
148	0.00		30.0		2400		8		1
149	0.00		60.0		2400		8		1
150	0.00		100.0		2400		8		1
151	0.00		200.0		2400		8		1
152	0.00		250.0		2400		8		1
153	0.00		500.0		2400		8		1
154	0.00		1000.0		2400		8		1
155	0.01		200.0		2400		4		1
156	0.01		250.0		2400		6		1
157	0.01		500.0		2400		6		1
158	0.01		1000.0		2400		6		1
159	0.10		200.0		2400		6		1
160	0.10		250.0		2400		6		1
161	0.10		500.0		2400		8		1
162	0.10		1000.0		2400		8		1
163	0.50		200.0		2400		8		1
164	0.50		250.0		2400		8		1
165	0.50		500.0		2400		8		1
166	0.50		1000.0		2400		8		1
167	2.00		200.0		2400		8		1
168	2.00		250.0		2400		8		1
169	2.00		500.0		2400		8		1
170	2.00		1000.0		2400		8		1
171	5.00		200.0		2400		8		1
172	5.00		250.0		2400		8		1
173	5.00		500.0		2400		8		1
174	5.00		1000.0		2400		8		1
175	0.10		0.0		4800		6		1
176	1.00		0.0		4800		8		1
177	2.00		0.0		4800		8		1

178	5.00		0.0		4800		8		1
179	0.00		30.0		4800		8		1
180	0.00		60.0		4800		8		1
181	0.00		100.0		4800		8		1
182	0.00		200.0		4800		8		1
183	0.00		250.0		4800		8		1
184	0.00		500.0		4800		8		1
185	0.00		1000.0		4800		8		1
186	0.00		2000.0		4800		8		1
187	0.01		500.0		4800		6		1
188	0.01		1000.0		4800		6		1
189	0.01		2000.0		4800		6		1
190	0.10		500.0		4800		6		1
191	0.10		1000.0		4800		6		1
192	0.10		2000.0		4800		8		1
193	0.50		500.0		4800		8		1
194	0.50		1000.0		4800		8		1
195	0.50		2000.0		4800		8		1
196	2.00		500.0		4800		8		1
197	2.00		1000.0		4800		8		1
198	2.00		2000.0		4800		8		1
199	5.00		500.0		4800		8		1
200	5.00		1000.0		4800		8		1
201	5.00		2000.0		4800		8		1

#### Available notch filters

num	hpfr		lpfreq		sfr		or		type
000	48.00		52.0		128		4		1
001	58.00		62.0		128		4		1
002	48.00		52.0		256		4		1
003	58.00		62.0		256		4		1
004	48.00		52.0		512		4		1
005	58.00		62.0		512		4		1
006	48.00		52.0		600		4		1
007	58.00		62.0		600		4		1
008	48.00		52.0		1200		4		1

009	58.00		62.0		1200		4		1
010	48.00		52.0		2400		4		1
011	58.00		62.0		2400		4		1
012	48.00		52.0		4800		4		1
013	58.00		62.0		4800		4		1