



Gem Stereo and Gem Multi

Revision A

Bela, a part of Augmented Instruments Ltd

Datasheet Version 1.0 – Revised 2026-08-04

Check <https://bela.io/gem-datasheet> if an updated version of this document exists.

Getting Started: for full assembly and getting started guide please visit: <https://learn.bela.io/gem>

Contents

1	Overview	3
1.1	Datasheet Revision History	3
1.2	Features	3
1.3	Applications	4
2	Electrical specifications	5
2.1	Pinout	6
2.2	DC-Coupled Audio Input on the Gem Multi	8
2.3	Power consumption	9
2.4	Powering from an external Power Source	10
3	Physical Specifications	11
3.1	Technical Drawing and Dimensions	11
3.2	Weight	12
3.3	Assembly Drawings	13
4	Manufacturer Information	14
4.1	Part numbers	14
4.2	Packaging	15
4.3	Address	15
5	Source Files and Licenses	15
5.1	Using our boards in commercial products	15
5.2	Bela Name and Logo	16
6	Warnings and Safety Information	16
6.1	Warnings	16
6.2	Instructions for Safe Use	16
7	Compliance and Conformity	16
8	Disclaimer	16
9	Appendix	17

1 Overview

Gem Stereo and Gem Multi are audio and data acquisition boards designed for the PocketBeagle 2. When used in conjunction with the Bela software, they provide low latency, low jitter audio and sensor processing.

Gem Stereo and Gem Multi are designed, manufactured and supported by Augmented Instruments Ltd; the PocketBeagle 2 is designed, manufactured and supported by the BeagleBoard.org Foundation.

1.1 Datasheet Revision History

This datasheet is version 1.0 of Rev A of Gem Stereo and Gem Multi.

The latest datasheet is available at <https://bela.io/gem-datasheet>

1.2 Features

Table 1: Feature Comparison Table

	Gem Stereo	Gem Multi
Audio Inputs	AC-coupled, line-in	
Channels	2	10
ADC	TLV320AIC3104	TLV320AIC3106 TLV320ADC3140 (2×)
Sample Rate [kHz]	up to 96	
Bit Depth [bit]	up to 24	
Audio Outputs	headphones (min. 1Ω), differential line out	
Channels	2	10 (DC-coupled)
DAC	TLV320AIC3104	TLV320AIC3106, ES9080Q
Sample Rate [kHz]	up to 96	
Bit Depth [bit]	up to 24	
Analog Inputs		
Channels	8	
Codec	ADS8166	
Sample Rate [kHz]	up to 250 across all channels	
Bit Depth [bit]	16	
Digital GPIO	16 (3.3V logic)	
Connectivity		
USB	USB-C device port and USB-A host port ¹	
I ² C	via dedicated pins + Qwiic connector	
Power	5V (can be battery powered)	5V, has LiPo battery connector
Includes	baseplate, spacers, screws	baseplate, spacers, screws 2 extension boards with 3.5mm jacks ²
Compatibility	PocketBeagle 2 and PocketBeagle 2 Industrial	

¹ Supports Wi-Fi, Bluetooth or Ethernet peripherals, MIDI plug-and-play via both USB ports.

² The extension boards have 4 stereo 3.5 mm jacks each, providing a standard interface for all audio channels.

1.3 Applications

The Bela systems are built to enable rapid prototyping and development for a variety of audio, low-latency, low-jitter applications, with connectivity and ease of use in mind. This includes, but is not limited to the following scenarios:

Gem Stereo

Compact, powerful, and easily embedded, Bela Gem Stereo is ideal for engineers, artists, educators, and product designers exploring real-time audio in small, mobile formats.

- Digital musical instruments
- Custom audio effects boxes and wearable devices where low power, small size, and high-quality audio are essential.
- Hearing aids and active noise cancellation applications that depend on real-time responsiveness and robust signal processing.
- Sound art and interactive installations.

Gem Multi

With 10 channels of high-resolution audio I/O, including 10 DC-coupled audio outputs, alongside generous analog and digital I/O, Bela Gem Multi is made for projects that push the boundaries of multichannel sound and control.

- Spatial audio systems, from ambisonic soundfields to custom speaker arrays and dynamic multichannel diffusion.
- Haptic feedback systems with precise, low-latency control over vibrotactile actuators across many channels.
- Microphone arrays for spatial recording, beamforming, or advanced environmental sensing.
- Immersive home entertainment systems or electric vehicle sound designs, where every sound channel needs precise, low-latency control.
- An excellent platform for Eurorack experimentation, combining multiple audio I/O with configurable AC/DC coupling, with rich analog and digital I/O for creating hardware interfaces and working with CV, gates, and triggers.

2 Electrical specifications

The electric specifications of Gem Stereo and Gem Multi are derived from the on-board chips and from the host board, as listed in Table 2. Refer to their respective manufacturer’s documentation for absolute maximum ratings and electrical specifications.

Table 2: Third party components

Bela Gem Stereo	
Host board	BeagleBoard PocketBeagle 2 or PocketBeagle 2 Industrial
On-board chips	Texas Instruments TLV320AIC3104
	Texas Instruments ADS8166
	STMicroelectronics TSV524
	Microchip MIC5317
Bela Gem Multi	
Host board	BeagleBoard PocketBeagle 2 or PocketBeagle 2 Industrial
On-board chips	Texas Instruments TLV320AIC3106
	Texas Instruments TLV320ADC3140
	Texas Instruments ADS8166
	ESS ES9080Q
	STMicroelectronics TSV524
	Microchip MIC5317
	onsemi MC33204
	Texas Instruments LM27761
	Microchip MIC5317

2.1 Pinout

Gem Stereo pinout is shown in Figure 1, Gem Multi pinout is shown in Figure 2. The Gem Multi extension boards for jack outputs are shown in 3. Triangles indicate pin 1 and direction to increment.

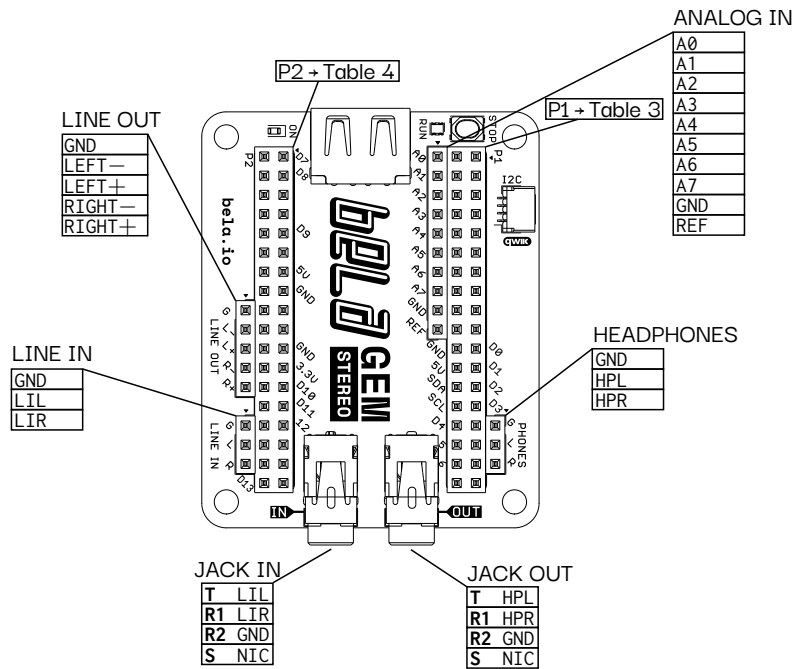


Figure 1: Bela Gem Stereo pinout

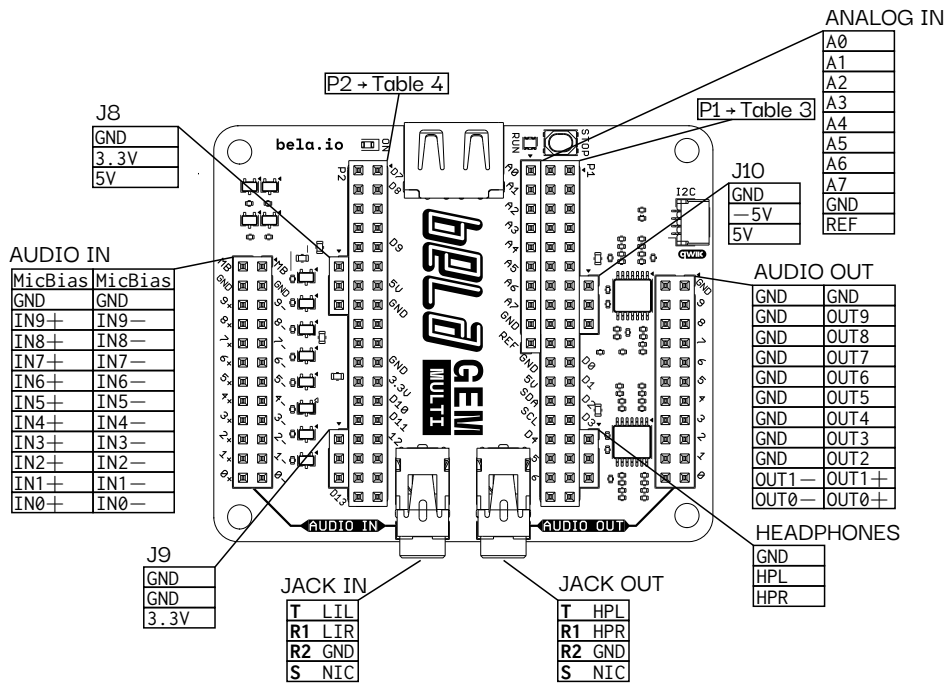


Figure 2: Bela Gem Multi pinout

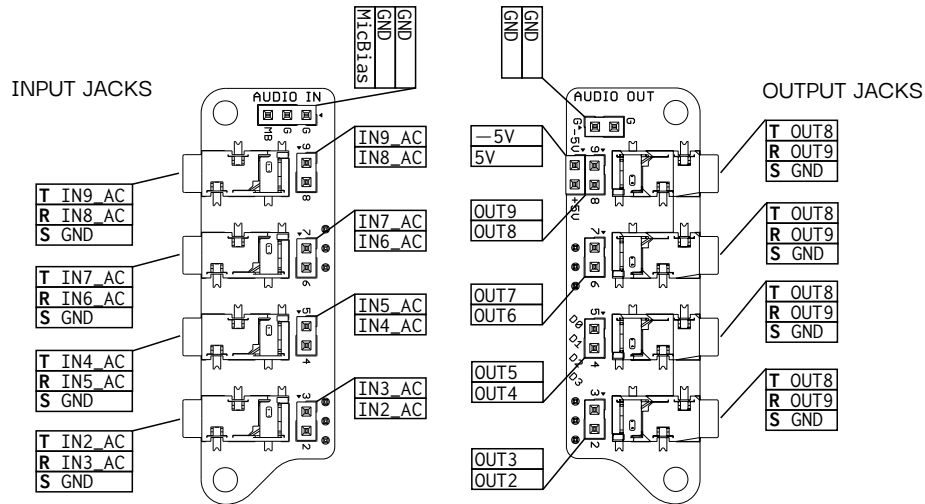


Figure 3: Bela Gem Multi extension boards pinout

Table 3: Sockets P1

P1					
2×18 pin socket header on Gem Stereo and Gem Multi					
Even row			Odd row		
Type	Function	No.	No.	Function	Type
I/O		P1.02	P1.01	VIN	P
I/O		P1.04	P1.03	USB1.DRVVBUS	P
0	SPI ADC CNV	P1.06	P1.05	USB VBUS	P
0	SPI ADC SCK	P1.08	P1.07		
I	SPI ADC MISO	P1.10	P1.09	USB DN	I/O
0	SPI ADC MOSI	P1.12	P1.11	USB DP	I/O
P	3.3 V	P1.14	P1.13	USB1.ID	I/O
P	GND	P1.16	P1.15	USBGND	P
P		P1.18	P1.17		P
I/O		P1.20	P1.19		I
P	GND	P1.22	P1.21	D0	I/O
P	5 V	P1.24	P1.23	D1	I/O
I/O	I ² C SDA	P1.26	P1.25	D2	I/O
0	I ² C SCL	P1.28	P1.27	D3	I/O
I/O	D4	P1.30	P1.29		I/O
I/O	D5	P1.32	P1.31		I/O
I/O	D6	P1.34	P1.33	AUD SDA	I/O
0	AUD SCL	P1.36	P1.35		I/O

Table 4: Sockets P2

P2					
2×18 pin socket header on Gem Stereo and Gem Multi					
Even row			Odd row		
Type	Function	No.	No.	Function	Type
I/O	LED A	P2.02	P2.01	D7	I/O
I/O	LED B	P2.04	P2.03	D8	I/O
I/O	BUTTON	P2.06	P2.05	AUD DOUT	O
I/O	POWER LED DISABLE	P2.08	P2.07	AUD IN	I
I/O	AUD WCLK	P2.10	P2.09	D9	I/O
I	PWR BTN	P2.12	P2.11	AUD MCLK	I/O
P	BAT.VIN	P2.14	P2.13	5V	P
I/O	BAT.TEMP	P2.16	P2.15	GND	P
I/O	ADC RST	P2.18	P2.17		I/O
I/O		P2.20	P2.19	AUD BCLK	I/O
I/O		P2.22	P2.21	GND	P
I/O		P2.24	P2.23	3.3V	P
I		P2.26	P2.25	D10	I/O
I/O		P2.28	P2.27	D11	I/O
I/O		P2.30	P2.29	D12	I/O
I/O		P2.32	P2.31		O
I/O		P2.34	P2.33	D14	I/O
I/O	D13	P2.36	P2.35	D15	I/O

2.2 DC-Coupled Audio Input on the Gem Multi

On the Gem Multi systems, audio inputs 2-9 are DC-coupled. Typical signals should be centered around 1.375 V with an amplitude of $\pm 1V$. Input must not exceed the safe range of $-0.3V$ to $3.6V$. Additional AC-coupling circuitry is necessary when connecting them to signals that have a DC component referenced to ground. See Table 5 for a schematic view of the required circuitry of each case.

In order to connect signals to the board's inputs with appropriate AC-coupling, the following is required for a single-ended AC-coupled signal:

- A 1 μF capacitor in series with the signal going into the + pin.
- A 1 μF capacitor to ground from the – pin.

For a differential AC-coupled signal:

- A 1 μF capacitor in series with the signal going into the + pin.
- A 1 μF capacitor in series with the signal going into the – pin.

For a single-ended DC-coupled signal:

- Connect the signal directly to the + pin.
- Connect the – pin to ground.

For a differential DC-coupled signal:

- Connect the + signal directly to the + pin.

- Connect the — signal directly to the — pin.

Table 5: Schematic view of circuits required on input connection for channels 2-9 of the Gem Multi

Signal \ Coupling	AC	DC
	single ended	single ended
single ended		
differential		

The input extension board with stereo phone jacks already provides the single-ended AC-coupling circuitry above for both the jack and pin inputs, and so it can be used to connect such signals without external components.

Caveats

Some sources may appear to have an AC-coupled output because they have a series DC-blocking capacitor. However, if they also have a resistor to ground (or other DC reference) after the capacitor, they will still need the series capacitor prescribed above, otherwise this will result in a DC offset on the ADC's output.

If the ADC's negative input is left floating while a single-ended signal is connected to the positive input, the ADC's output may seem to work, however it will be more noisy and sensitive to external-interference. For this reason, the negative input should always be properly connected as described above.

2.3 Power consumption

See Table 6 for details on power consumption, measured when powering the PocketBeagle 2 and the Gem Stereo or Gem Multi with 5 V via USB-C.

Table 6: Power consumption

	Unit	Value	Condition
PB2 only	W	1.21	idle
PB2 only	W	2.00	4 core load
PB2 + Gem Stereo	W	1.21	idle
PB2 + Gem Stereo	W	1.32	audio + 1 core load
PB2 + Gem Stereo	W	2.15	audio + 4 core load
PB2 + Gem Multi	W	1.32	idle
PB2 + Gem Multi	W	1.95	audio + 1 core load
PB2 + Gem Multi	W	2.78	audio + 4 core load

2.4 Powering from an external Power Source

The PocketBeagle 2 uses three ideal diodes (LM73100) in its power path to automatically select one of three available power sources, as shown in the simplified circuit, Figure 4.

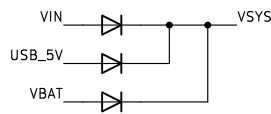


Figure 4: PocketBeagle 2 power path

The voltage inputs are:

- USB_5V is available on P1.07 and is also connected to the USB-C port's 5 V pin. Valid voltages are between 3.8 V and 5.5 V.
- VIN_5V is available on P1.01. Valid voltages are between 3.8 V and 5.5 V.
- VBAT is available on P2.14. Valid voltages are between 3.2 V and 4.6 V. It is turned off if any of the others are present.

VSYS is a voltage output available on all pins labelled 5V on the Gem boards. An external power source should not be connected to it directly. External power sources can be added to the on-board pool of available, mutually exclusively, power sources if connected to VSYS via a diode.

In general, the ideal diode network into VSYS selects the power source with the highest voltage and connects it to VSYS. Each ideal diode has voltage thresholds with hysteresis. A battery charger (BQ21040) is connected to VBAT and can recharge a single-cell Li-Ion or Li-Polymer battery at up to 540 mA when USB_5V is available.¹ A JST PH series-compatible connector with GND and VBAT is present on the Bela Gem Multi board.

To power the board when a USB-C power source is not available, VBAT should be used for LiPo cells and VIN_5V should be used for any other power source, except as noted below.

REV A4 and below

On Bela Gem Stereo and Multi boards version A4 and below, the USB-A host port is powered directly from USB_5V. If the USB host port needs to be functional when USB-C power is not available, then an external 5 V power source should use USB_5V via a diode. The diode ensures that if USB-C and the external power source are both active at the same time they are not short-circuited. The diode should have a small enough forward voltage to ensure that the voltage at USB_5V remains above 4.45 V as per the USB specs. If USB-C power and the external power supply will never be present at the same time, the diode can be bypassed.

REV A5 and above

On Bela Gem Stereo and Multi boards version A5 and above, the USB-A host port is powered from VSYS. As such, any voltage in the valid range applied via the USB-C cable, USB_5V or VIN_5V will automatically power the USB-A port.

¹See <https://docs.beagle.cc/boards/pocketbeagle-2/03-design-and-specifications.html> and the PocketBeagle 2 schematic for full details.

3 Physical Specifications

3.1 Technical Drawing and Dimensions

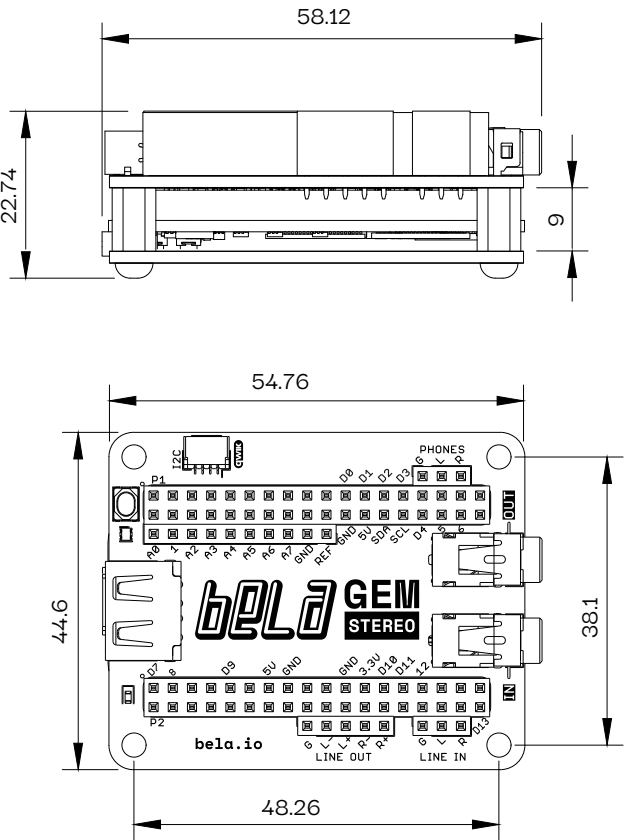


Figure 5: Bela Gem Stereo dimensions

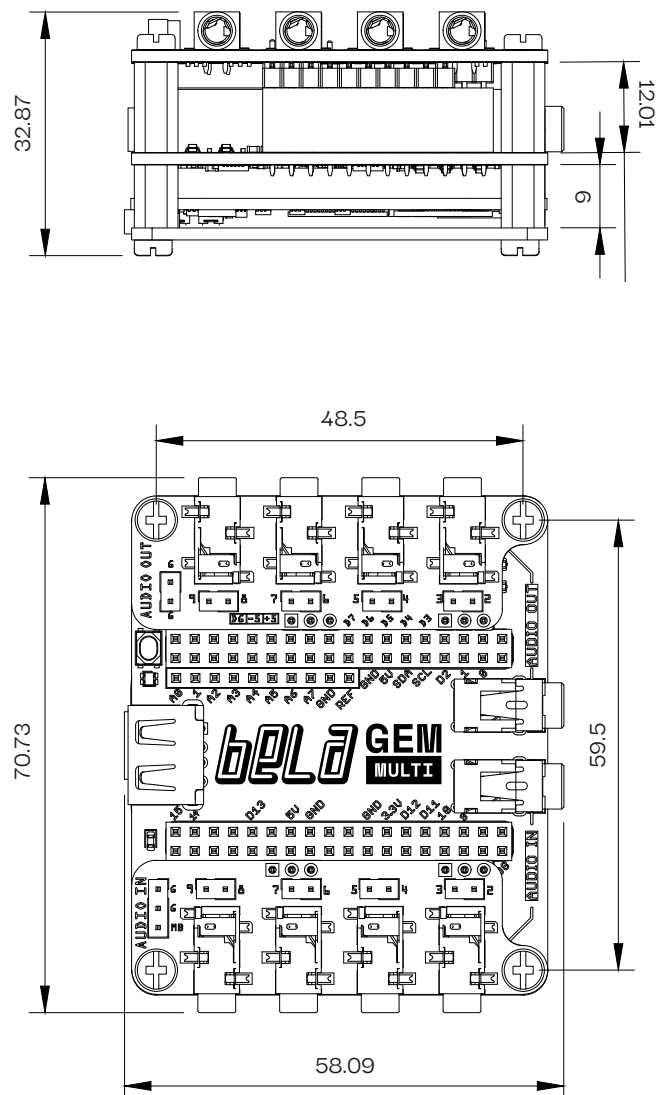


Figure 6: Bela Gem Multi dimensions (with audio extension boards installed)

3.2 Weight

Gem Stereo: 35 g

Gem Multi: 50 g

3.3 Assembly Drawings

Insert the PocketBeagle 2 securely, then assemble your system using a Philips screwdriver. For the Gem Stereo assembly see Figure 7 and the parts list in Table 7.

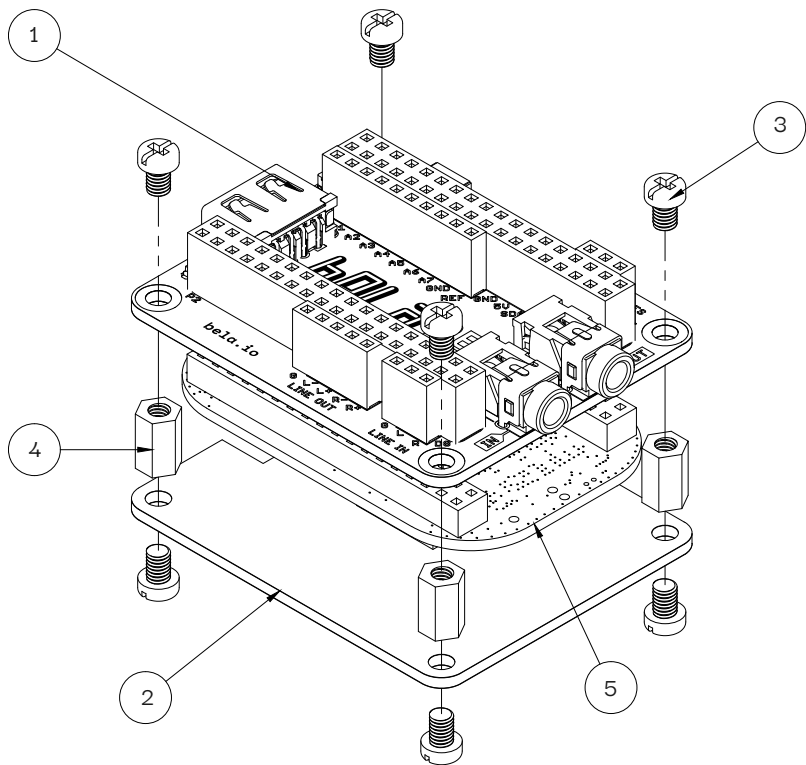


Figure 7: Bela Gem Stereo Assembly

Table 7: Gem Stereo parts list

Item	Quantity	Description
1	1	main PCB
2	1	baseplate
3	8	M3 4mm screw
4	4	M3 9mm spacer
5	1	PocketBeagle 2 (not included)

For the Gem Multi assembly see Figure 8 and the parts list in Table 8.

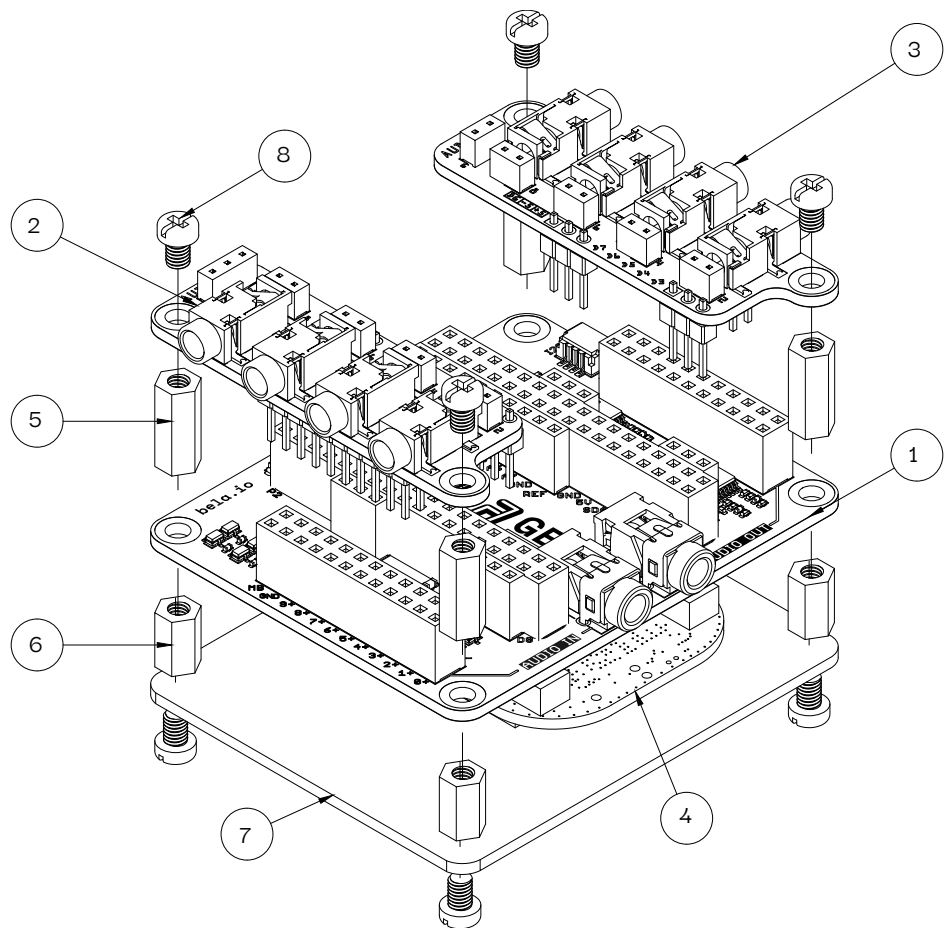


Figure 8: Bela Gem Multi assembly

Table 8: Gem Multi parts list

Item	Quantity	Description
1	1	main PCB
2	1	audio input extension board with TRS ¹ jacks
3	1	audio output extension board with TRS ¹ jacks
4	1	PocketBeagle 2 (not included)
5	4	M3 12mm spacer
6	4	M3 9mm spacer
7	1	baseplate
8	8	M3 4mm screw

¹ Tip, Ring, Sleeve – a jack with three electrical contacts.

4 Manufacturer Information

4.1 Part numbers

Table 9 lists the manufacturer number and the Global Trade Item Number (formerly known as European Article Number) for both Gem variants.

Table 9: Manufacturer Numbers

Name	Manufacturer Number	GTIN
Bela Gem Stereo	160801-GEM-STEREO	5060821690281
Bela Gem Multi	160802-GEM-MULTI	5060821690298

4.2 Packaging

Gem Stereo and Gem Multi come in plastic-free retail packaging made from cardboard. Package dimensions are listed in Table 10. For OEM orders and other packaging requirements contact the manufacturer.

Table 10: Packaging Dimensions [mm]

Product	Width	Height	Depth
Bela Gem Stereo	110	30	80
Bela Gem Multi	120	40	90

4.3 Address

Augmented Instruments Ltd (trading as Bela)
327 Mile End Road CS300
London E1 4NS
United Kingdom
info@bela.io

5 Source Files and Licenses

Source files can be found here: <https://github.com/BelaPlatform/bela-hardware/tree/master>

The Gem Stereo and Gem Multi hardware designs are licensed under a Creative Commons Attribution Sharealike 4.0 license (or CC-BY-SA), meaning that you can freely use these for your own projects provided you supply attribution and a link to the source files, and release your own design files under the same license.²

The Bela “core code” is distributed under LGPL, the GNU Lesser General Public License (LGPL 3.0), available here: <https://www.gnu.org/licenses/lgpl-3.0.txt>.

The Bela IDE is licensed under GPL, the GNU General Public License, available here: <https://www.gnu.org/licenses/gpl-3.0.en.html>

This datasheet and accompanying documentation is available under a Creative Commons Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) License, meaning it can be freely reused and remixed with attribution, provided modifications remain open source.

5.1 Using our boards in commercial products

Any boards bought from us or one of our official resellers can be resold inside a commercial product and treated like any other off-the-shelf electronic component. We offer discounts for bulk orders of our boards for commercial use; please email info@bela.io to discuss your needs.

There are license restrictions on the use and modification of our hardware and software. Your own custom application code running inside the Bela environment should be dynamically linked to the Bela core code in order to

²Read more about CC-BY-SA on the Creative Commons site <https://creativecommons.org/licenses/by-sa/4.0/>.

respect the LGPL license. If you make any modifications to the core Bela Gem Stereo and Gem Multi hardware or software, those changes need to be released under the same open source terms once your product is released.

If you would like to keep changes made to the core code or hardware closed source, please email info@bela.io to discuss a commercial license.

There are some restrictions on using the trademarked Bela name and logo in your product, which means that your customers can not be given access to the Bela branded IDE through your product without our prior agreement.

5.2 Bela Name and Logo

Bela names and logos are copyright Augmented Instruments Ltd. Any designs that you release or produce should **not** use the Bela name and logo, whether modified or exact copies, without permission.

6 Warnings and Safety Information

6.1 Warnings

- **Compatibility:** these products are designed exclusively for use with the PocketBeagle 2 and PocketBeagle 2 Industrial single-board computers by the BeagleBoard.org Foundation.
- **Power:** use only a regulated 5 V DC supply via USB-C or through the socket headers as specified in this datasheet.
- **Operation:** use only on a dry, non-conductive surface. Avoid contact with conductive materials, liquids, or extreme temperatures while powered. Observe the absolute maximum ratings in Table 2.
- **Handling:** it is recommended to disconnect all power before connecting or removing cables, sensors, or accessories. Do not solder, assemble, or modify the board while it is powered.
- **Assembly:** when stacking boards or mounting in an enclosure, use the provided spacers and screws to prevent mechanical stress or short circuits.
- **Responsibility:** users are responsible for ensuring that connected circuits and accessories remain within the safe voltage and current ratings specified in this datasheet.

6.2 Instructions for Safe Use

- Handle the board by the edges; avoid touching connectors or ICs when powered.
- Keep away from moisture, dust, and strong vibrations.
- Do not operate in exposed or damp conditions.

7 Compliance and Conformity

Gem Stereo and Gem Multi are compliant to RoHS and REACH directives and conform to CE and UKCA regulations. Declaration of conformity are linked on product pages.

8 Disclaimer

All trademarks, logos, and brand names including, but not limited to BeagleBone, BeagleBoard, PocketBeagle, KiCad, and Texas Instruments are the property of their respective owners. All company, product and service names used in this datasheet are for identification purposes only. The use of these names, trademarks, and brands does not imply affiliation or endorsement. All information in this datasheet is subject to change without notice.

9 Appendix

Complete schematic sheets for Gem Stereo and Gem Multi.