BOS1211 Development Kit

1 Features

- Plug and play development kit to experience piezoelectric actuator button and haptic feedback.
- Low-power BOS1211 integrated circuit, high voltage driver with SPI digital interface.
- Easy generation of high-voltage waveforms up to 120 V
- Enable sensing and emulate button behavior using the actuator
- Interchangeable and stackable (up to 4) BOS1211 driver board
- Compatible with big piezoelectric actuators such as TDK PowerHap™ [1] 120 V models.
- Standard USB audio to prototype haptic effects in MATLAB®, Python®, Audacity® and many other softwares[2].

2 Description

The BOS1211-KIT is a development kit to get familiar with the BOS1211 Piezo Haptic Driver IC.

The BOS1211 driver board can be stacked allowing up to 4 actuators to be driven at the same time. The driver board can also be connected directly to any application system.

This kit connects to associated PC software over USB for easy programming of the BOS1211 and manual generation of waveforms on the connected actuator.

The piezoelectric actuator sensing capability is used to emulate a button behavior. The sensing and feedback parameters can be changed using the software.

An Audio mode makes the kit appears as an USB Audio device to the computer, which allows quick and easy generation of waveforms using existing audio software like Audacity® for haptic prototyping.

The firmware supports autonomous operation for easy integration into development prototypes.

Many GPIOs and hardware features are accessible to ease prototype building.

Table 1: Ordering information

PRODUCT	DESCRIPTION
BOS1211-KIT-A02	Premium Set with two Actuators
BOS1211-KIT-X02	Basic Set with no Actuator
BOS1211-KIT-D02	Driver board only

For details see sections 3 and 13.

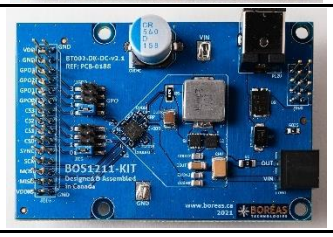
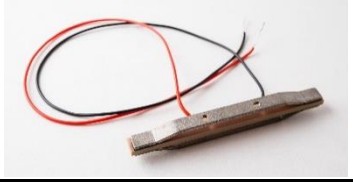
[1] PowerHap™ is a trademark of TDK Corporation.

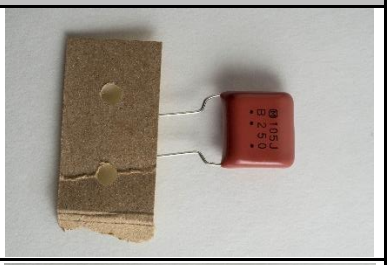
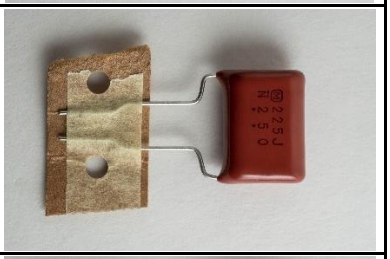
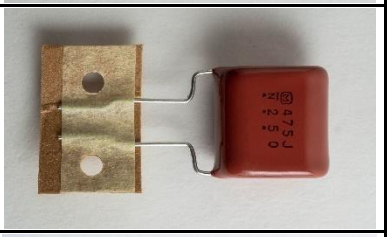
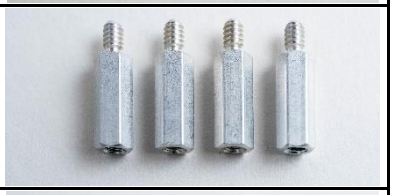
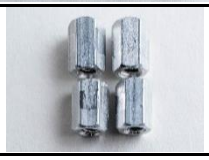
[2] MATLAB® is registered trademark of The MathWorks, Inc.
Python® is a registered trademark of the PSF
Audacity® is a registered trademark of Dominic Mazzoni

3 What's in the Box

The BOS1211-KIT is currently available in many distinct packages: *Basic Set, Premium Set and Driver Board Set*. The *Driver Board Set* requires one of the other sets to operate. The following tables show the content of each set.

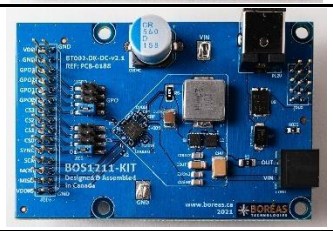
Table 2: ***Premium Set BOS1211-KIT-A02*** *development kit content*

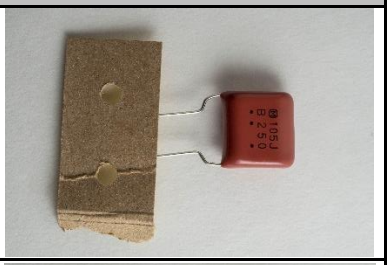
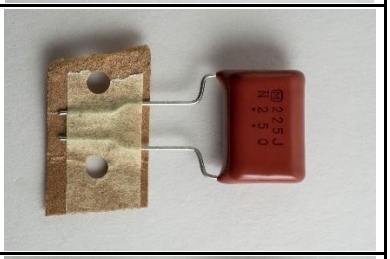
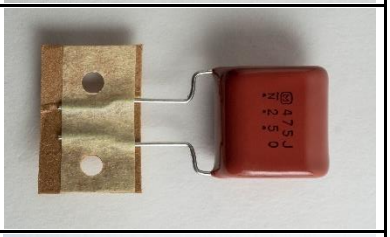
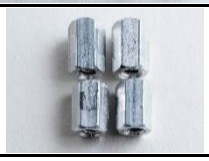
#	ITEM	DESCRIPTION	REFERENCE
1	1 Controller board	BOS1211-KIT controller board	
2	2 driver boards	BOS1211 driver board	
3	USB Cable	Cable to connect the evaluation PCB to a computer Stewart Connector part number SC-2AMK001F	
4	2 terminal block connectors	Male connector used for interfacing the piezoelectric actuator on the driver boards. Molex part number 39510-0002	
5	TDK piezo actuator	TDK PowerHap™ 1313H018V120 Actuator Ordering: Z63000Z2910Z1Z73 Capacitance : 0.9 µF Dim : 12.7 x 12.7 x 1.8 mm	
6	TDK piezo actuator	TDK PowerHap™ 6005H080V120 Actuator Ordering: Z63000Z2910Z1Z49 Capacitance : 3.5 µF Dim : 60 x 5 x 2.1 mm	

#	ITEM	DESCRIPTION	REFERENCE
7	Film capacitor	1 µF capacitor, > 200 V Panasonic Part number ECQ-E2105RJB	
8	Film capacitor	2.2 µF capacitor, > 200 V Panasonic Part number ECQ-E2225RJB	
9	Film capacitor	4.7 µF capacitor, > 200 V Panasonic Part number ECQ-E2475RJB	
10	4 Hex standoffs 1/2 in	Hex standoff #4-40 aluminum 1/2 in RAF Electronic Hardware part number 4505-440-AL-7	
11	4 Hex standoffs 5/8 in	Hex standoff #4-40 aluminum 5/8 in RAF Electronic Hardware part number 4507-440-AL	
12	4 Hex standoffs 1/4 in	Hex standoff #4-40 aluminum 1/4 in RAF Electronic Hardware part number 2053-440-AL	
13	One 6-position thru-hole header connector	2.54 mm pitch header connector for connection to external system (J3 connector on PCB). Würth Electronik part number 61300611021 (6-pin) or equivalent.	

#	ITEM	DESCRIPTION	REFERENCE
14	12 V Power Supply with adapter	Power supply to provide 12 V to the Evaluation PCB. CUI inc. part number SDI90-12-U-P5 with power chord CUI inc. part number AC-C13 NA or equivalent. Adapter Mean Well USA Inc. part number DC PLUG-P1J-P1I initially mounted. It is recommended to always keep the adapter connected to the cable for long term reliability.	
15	Power adapter	European power adapter Ceptics model CT-9 or equivalent	

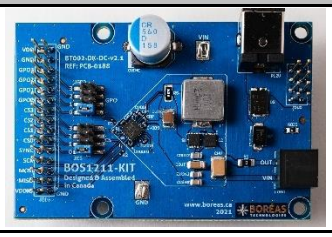
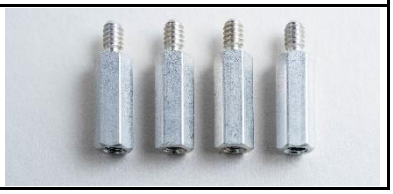
*Table 3: **Basic Set BOS1211-KIT-X02** development kit content*

#	ITEM	DESCRIPTION	REFERENCE
1	1 Controller board	BOS1211-KIT controller board	
2	1 Driver board	BOS1211 driver board	
3	USB Cable	Cable to connect the evaluation PCB to a computer Stewart Connector part number SC-2AMK001F	
4	1 terminal block connector	Male connector used for interfacing the piezoelectric actuator on the driver boards. Molex part number 39510-0002	

#	ITEM	DESCRIPTION	REFERENCE
5	Film capacitor	1 µF capacitor, > 200 V Panasonic Part number ECQ-E2105RJB	
6	Film capacitor	2.2 µF capacitor, > 200 V Panasonic Part number ECQ-E2225RJB	
7	Film capacitor	4.7 µF capacitor, > 200 V Panasonic Part number ECQ-E2475RJB	
8	4 Hex standoffs 5/8 in	Hex standoff #4-40 aluminum 5/8 in RAF Electronic Hardware part number 4507-440-AL	
9	4 Hex standoffs 1/4 in	Hex standoff #4-40 aluminum 1/4 in RAF Electronic Hardware part number 2053-440-AL	
10	One 6-position thru-hole header connector	2.54 mm pitch header connector for connection to external system (J3 connector on PCB). Würth Electronik part number 61300611021 (6-pin) or equivalent.	
11	12 V Power Supply	Power supply to provide 12 V to the Evaluation PCB. CUI inc. part number SDI90-12-U-P5 with power chord CUI inc. part number AC-C13 NA or equivalent. Adapter Mean Well USA Inc. part number DC PLUG-P1J-P1I initially mounted. It is recommended to always keep the adapter connected to the cable for long term reliability.	

#	ITEM	DESCRIPTION	REFERENCE
12	Power adapter	European power adapter Ceptics model CT-9 or equivalent	

*Table 4: **Driver Board Set BOS1211-KIT-D02** development kit content*

#	ITEM	DESCRIPTION	REFERENCE
1	1 Driver board	BOS1211 driver board	
2	1 terminal block connector	Male connector used for interfacing the piezoelectric actuator on the driver boards. Molex part number 39510-0002	
3	4 Hex standoffs 1/2 in	Hex standoff #4-40 aluminum 1/2 in RAF Electronic Hardware part number 4505-440-AL-7	

4 Board Overview

The purpose of this section is to show the location of the components the user can interact with on the BOS1211-KIT boards. The focus is on indicators (LEDs) and controls (buttons), informing on the state of the board and allowing the user to change its operating state.

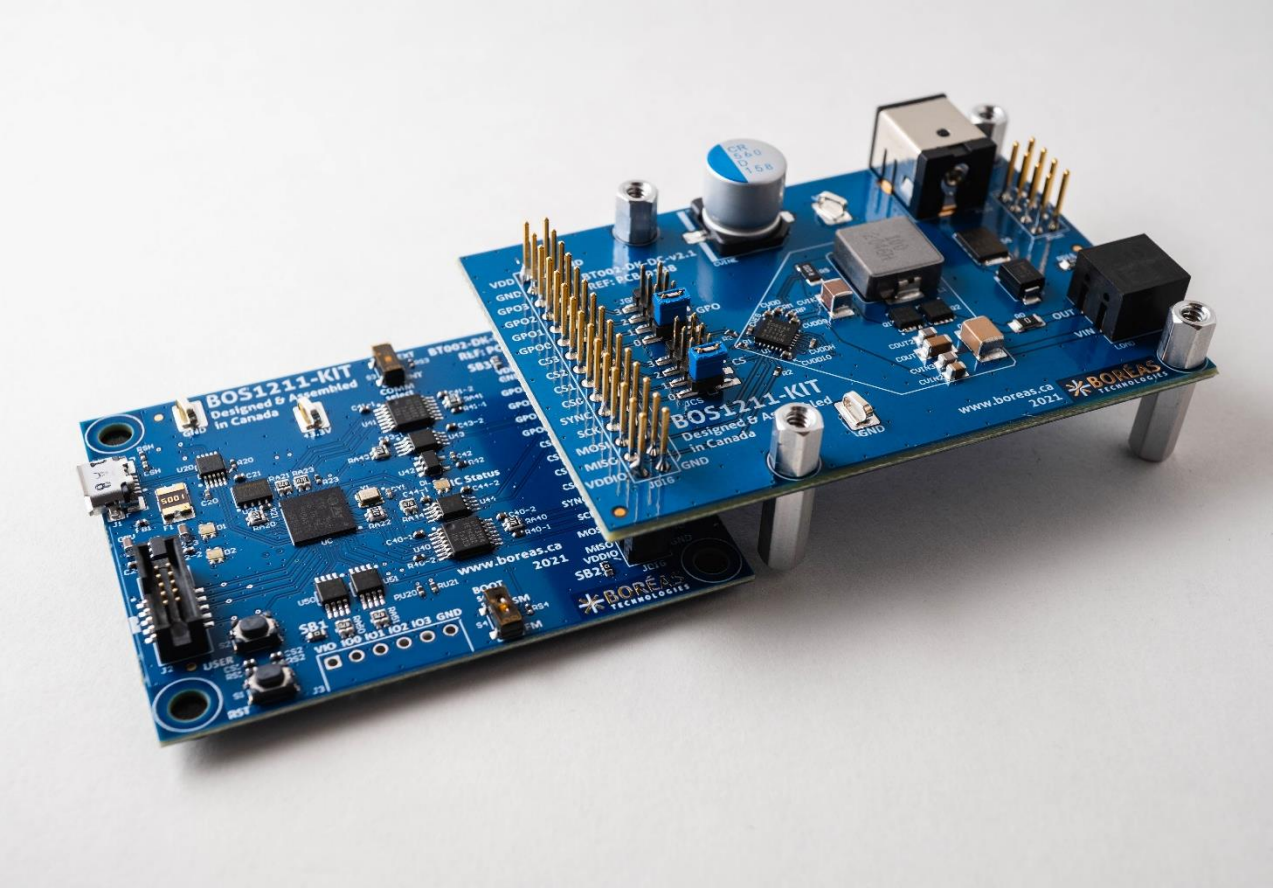


Figure 1: BOS1211-KIT assembled

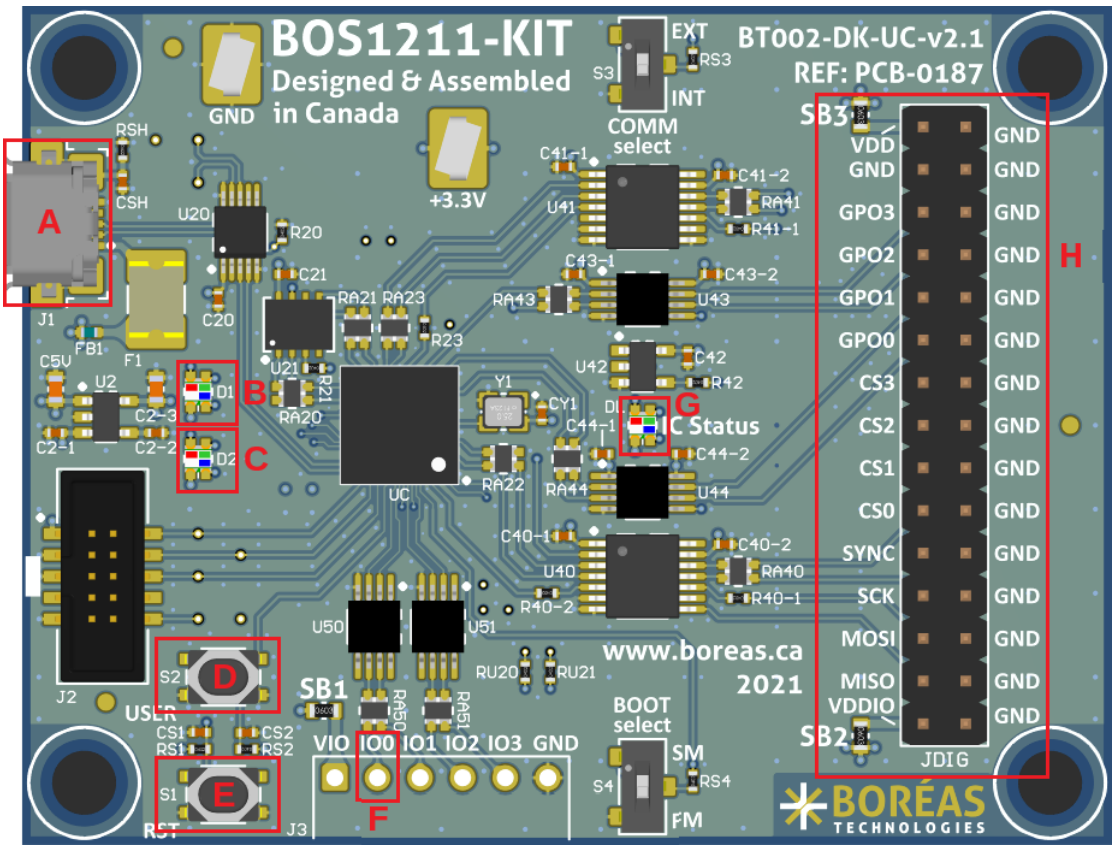


Figure 2: BOS1211-KIT controller board user interface

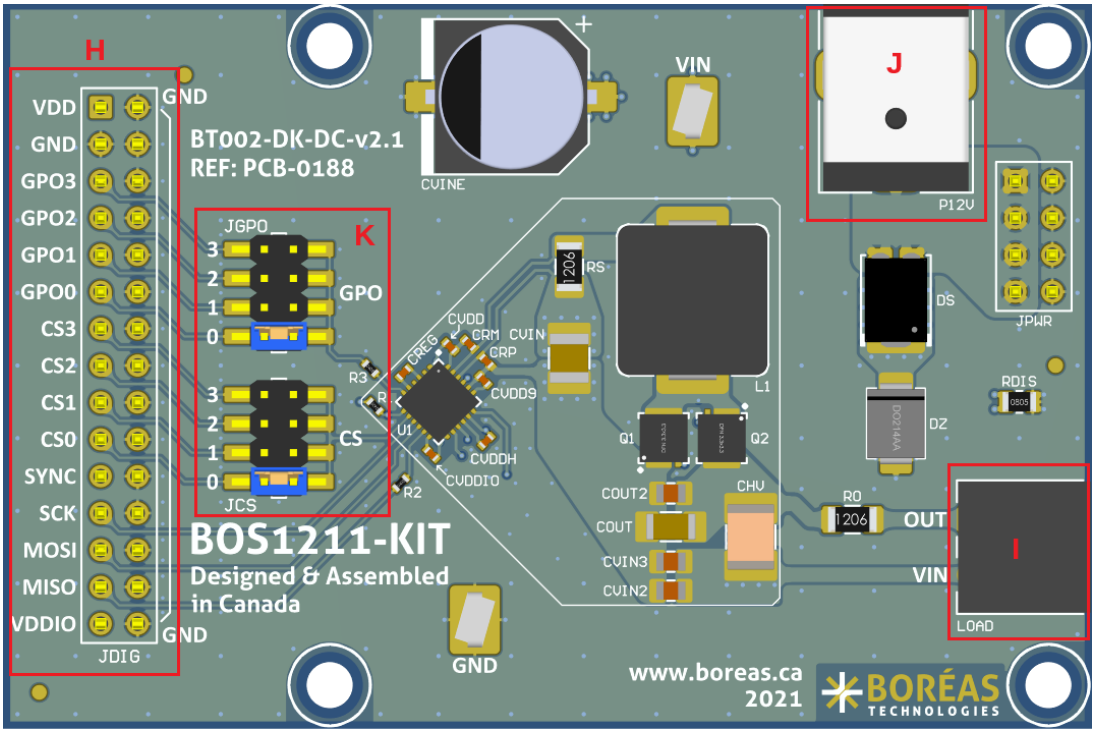


Figure 3: BOS1211-KIT driver board user interface

Table 5: BOS1211-KIT boards user interface

Components	Board	Name	Description
A	Controller	USB connector	Supply power to the controller board and provides connectivity with the GUI.
B	Controller	Operation mode LED	Flashing if alive and color shows the current operation mode.
C	Controller	BOS1211-KIT status LED	Stays red if an error is detected.
D	Controller	Change operation mode button	Change the current operation mode on press.
E	Controller	Reset button	Reset the micro-controller on press.
F	Controller	GPIO to trigger haptic feedback	If configured as a haptic trigger event, a rising edge on that GPIO will trigger a haptic feedback on a piezo actuator.
G	Controller	BOS1211 IC status LED	LEDs displaying the current state of the BOS1211. Stays red if an error is detected on a BOS1211.
H	Controller & Driver	Interface port	Port where both the controller board and driver board connect.
I	Driver	BOS1211 terminal block	Terminals where piezoelectric actuator are connected.
J	Driver	12 V supply connector	12 V supply power to the BOS1211 IC.
K	Driver	CS/GPO Jumpers	Jumpers used to address each of the stacked boards individually.

4.1 Operation Mode LED Details

This section describes the meaning of the different colors and state transitions of the operation mode LED. Any other pattern or color behavior may be caused by unofficial firmware or bug.

Table 6: Operation mode LED detail

Pattern	Color	Description
1 second on, 1 second off	Green	In *Haptic mode* and working normally.
1 second on, 1 second off	Blue	In *Audio mode* and working normally.

4.2 BOS1211-KIT Status LED Details

This section describes the meaning of the different colors and state transitions of the BOS1211-KIT status LED. Any other pattern or color behavior may be caused by unofficial firmware or bug.

Table 7: Operation mode LED detail

Pattern	Color	Description
Always off	None	Working normally.
Always on	Red	An error has been detected.

4.3 BOS1211 IC Status LED Details

This section describes the meaning of the different colors and state transitions of the BOS1211 IC Status LED. The BOS1211 chips of all BOS1211-KIT drivers boards connected are monitored for internal errors. If an error is detected, the IC Status LED is used to indicate the detection of this error. See section 8.5.3, for more information on the procedure to get the details of the error.

Table 8: BOS1211 IC Status LED details

Pattern	Color	Description
Always off	N/A	No error detected on any BOS1211.
Always on	Red	At least one internal error has been detected by a BOS1211.
Always on	Green	Sensing the voltage of the piezo electric actuator. The LED will turn off when the actuator is pressed and return to green when released.
Always on	Blue	Sending haptic feedback data to the BOS1211.

5 Your First Piezoelectric Actuator Button Experience

The BOS1211 and a piezoelectric actuator can be used together to implement the equivalent of a button. Before being shipped, the BOS1211-KIT board is set up in this button mode, so that you can experience it without additional extensive configuration or software installation.

1. Open the box, take the BOS1211-KIT boards, the USB cable, the terminals block plugs, and the TDK 1313 piezo actuator (black round button).
2. Connect the driver board to the controller board.
3. Insert the terminal block plug into the development kit's terminal block socket.
4. Using a small slotted screwdriver, install TDK 1313 piezo electric actuator on terminals block plugs. **Pay attention to connect the red wire on the OUT terminal and the black wire on the VIN terminal**. Refer to Figure 3 to identify location of OUT and VIN on the terminal block.
5. Connect the 12 V power supply into the 12 V supply connector.
6. Connect the development kit board to a USB port using the USB cable.
7. Press the RST button.
8. When the operation mode green LED is flashing and BOS1211 IC status LED is solid green, you are ready to go. Press on the piezo actuation to experience the piezo actuator button.

Important Note:

When powering up the board, always connect the 12 V supply first, then the USB connector.

When powering off the board, always disconnect the 12 V supply first, then the USB connector.

6 Get Started

The purpose of this section is to give instructions on where to get the latest versions of Boréas software and firmware. Keeping the software up to date ensures the latest features available are taken advantage of.

6.1 Creating a Boréas Account

Relevant documentation and software are available in the support section of Boréas website. Here are the instructions for accessing it:

1) Go to https://www.boreas.ca/account.
2) Click on "Create account".
3) Enter the requested information.
4) Click on "Create Account".

6.2 Identifying the BOS1211-KIT Boards and BOM Revision

Each PCB board reference design ("REF:") and revision (BT###-DK-v#.#) numbers are printed on the board silkscreen. A printed label stuck on the back of the PCB provides the board part number (P/N), containing the BOM revision suffix "-Bx"), and the assembly code ("####AA"). The table below indicates compatibility with the firmware and Devkit Controller software.

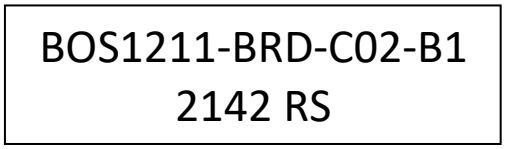


Figure 4: Label example giving board part number with BOM revision suffix, and assembly code

Table 9: BOS1211-KIT boards and software compatibility list

BOARD P/N*	PCB REVISION	COMPATIBLE FIRMWARE	COMPATIBLE PC SOFTWARE
BOS1211-BRD-C02-B1	PCB-0187 BT002-DK-UC-v2.1	BOARD_PCB_187_BOS1211_DEVKIT-{VERSION}.hex Version starting at 1.13.x	Starting at 2.11.x
BOS1211-BRD-L02-B1	PCB-0188 BT002-DK-DC-v2.1	BOARD_PCB_187_BOS1211_DEVKIT-{VERSION}.hex Version starting at 1.13.x	Starting at 2.11.x

** Board P/N include BOM revision suffix*

Any PCB reference design number not listed into Table 9 are considered obsolete. The relevant documentation and software for obsolete products are still available into the archive section of our web site.

6.3 Download Boréas Application

1) Go to the "BOS1211-KIT Technical Documents" webpage.
2) Log in your Boréas account.
3) Scroll down to section BOS1211-Kit Documents.
4) Download the appropriate “BOS1211-KIT installer” version based on your development kit identification.

6.4 Install Boréas Application

Double click on the installer executable you downloaded and follow the instructions.

6.5 Upgrade Development Kit Firmware

The native BOS1211-KIT controller board firmware includes an over-USB firmware upgrade mechanism. The BOS1211-KIT software will upgrade the firmware if needed on next connection with the development kit.

1) Connect the development kit to a PC using the USB cable.
2) Start the BOS1211-KIT software.
3) Select the development kit communication port into the drop-down field:

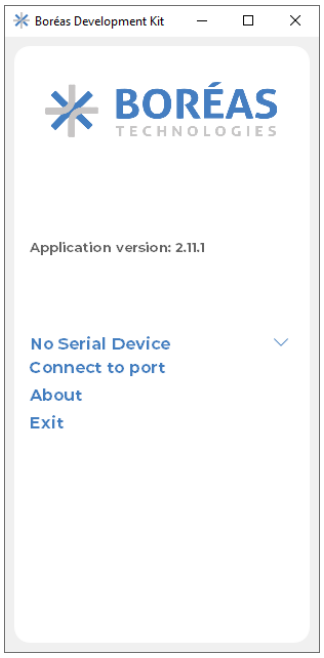


Figure 5: Connection dialog

4) Click on *Connect to port*.
5) If an upgrade is needed the BOS1211-KIT software will pop up a dialog:

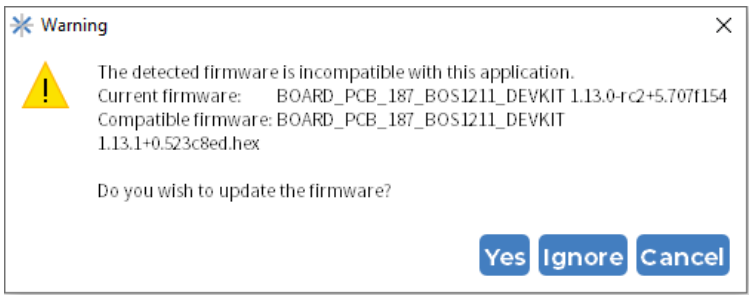


Figure 6: BOS1211-KIT Firmware upgrade dialog

6) Click on *Yes* to proceed and wait for the update process to complete or click on *Ignore* to keep the currently installed firmware and still try to connect.
7) BOS1211-KIT software will automatically start after the upgrade.
8) All is up-to-date and ready to go.

7 Product Overview

The BOS1211-KIT has been designed to meet a multitude of needs. The main objective is to demonstrate the capacity of the BOS1211 but also to help integrators in the development of haptic effects and in its product prototyping.

The BOS1211-KIT is delivered with a graphical user interface (GUI) for ease of use but it is not required to operate. It can save and restore its configuration at start-up. We will refer to operation without the GUI by saying that the development board is used autonomously. It is configured in one of these autonomous mode before shipping (see section 5). We will explain in more detail the so-called autonomous modes in this document.

The BOS1211-KIT supports multiple operation modes:

Table 10: Operation mode list

Mode	Will help the user to
Haptic	• Experience piezo haptic button emulation. • Experiment with simple waveforms on various piezoelectric actuators. • Experiment with piezoelectric device sensing. • Evaluate any piezoelectric actuator for the application. • Evaluate BOS1211 performance (waveform output, power consumption) in the context of the application. • Optimize BOS1211 operation using specific registers value. • Command BOS1211-KIT waveform trigger from the system using an external trigger signal.
Audio	• Easily experiment with various waveform shapes and amplitudes. • Easily produce and compare various waveforms and identify the effects most suited for the application. • Play synchronous waveforms on many channels of BOS1211-KIT.

In *Haptic mode*, the GUI allows the user to fire a given waveform from a variety of trigger mechanisms.

The BOS1211-KIT is used to test the capacity of the BOS1211 with various piezoelectric actuators. The trigger events that can be used are: an action *Play* in the GUI, a rising edge on IO0, an action of pressing and releasing the piezoelectric actuator. When the IO0 or the piezoelectric actuator are used as trigger, the development kit can work without the GUI. The GUI also provides a section to read and write all registers of the IC. For more details about this mode refer to section 8.5.1

In *Audio mode*, the development kit is detected as a standard stereo USB audio device by the PC.

The BOS1211-KIT provides flexibility and control over the waveform used various haptic effects. The audio mode gives the user complete control over the wave transmitted to the BOS1211 via the USB port. The PC finds the BOS1211-KIT as an audio card stereo output. Audio mode settings can be

configured using the graphical user interface, even though this mode is designed to be operated without the GUI. For more details about the audio mode refers to section 8.5.2.

The operation mode can be changed in the GUI or by pressing the *USER* button on the controller board. See section 8.5 for details.

The BOS1211-KIT development kit can be used as a basis for the development of a prototype.

It is possible to connect an external SPI master without separating the driver board from the controller board from the BOS1211-KIT. This operation requires a good knowledge of the electrical design of the BOS1211-KIT. For more details about the hardware refers to section 9.

8 Boréas Development Kit Software v2.11.x

8.1 Overview

Boréas Development Kit software is a desktop application intended to ease evaluation of the BOS1211.

In Haptic mode, the tool can be used to:

- Play a sinusoidal waveform on-demand.
- Configure the BOS1211-KIT to play a sinusoidal waveform when:
  - a signal is received on the pin IO0.
  - press and release events are detected on a piezo actuator (button emulation).
- Get read/write access to the registers of the BOS1211.
- Monitor the BOS1211 status and display any error.
- Reset the BOS1211-KIT to its factory default state.
- Change the operation mode of the BOS1211-KIT.

In Audio mode, the tool can be used to:

- Configure the minimum and maximum voltage of each output channel.
- Reset the BOS1211-KIT to its factory default state.
- Change the operation mode of the BOS1211-KIT.

8.2 PC Requirements

- OS: Windows 10
- Minimum display resolution: 1366 X 768
- Storage: At least 200 MB of available space.

8.3 Software Installation

Refer to the section Get Started.

8.4 Disconnected State

At start-up, the application is in disconnect state. The communication port is not connected with the BOS1211-KIT controller board. A drop-down list allows the user to select the BOS1211-KIT controller board to use. (1 entry per board connected to the PC).

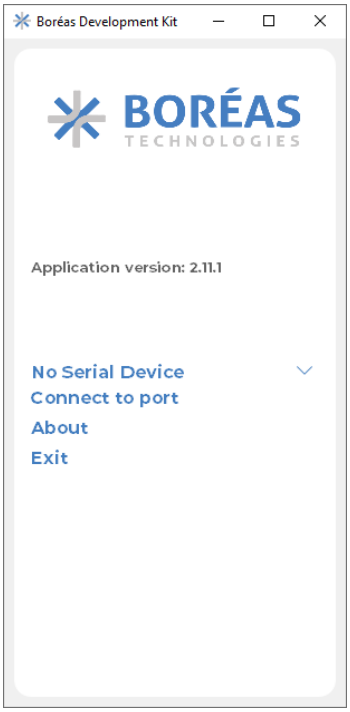


Figure 7 Application window in disconnected state

To transition to the connected state:

1. Select the communication port associated to the BOS1211-KIT controller board.
2. Press the *Connect to port* button to establish the communication.

Upon connection, the compatibility between the application and the board firmware will be validated and a message dialog will appear if the firmware of the kit needs to be updated. (More details are provided in the section Upgrade development kit firmware).

The application will automatically return to the disconnected state if:

- The connection with the BOS1211-KIT controller board is lost.
- The BOS1211-KIT controller board power cycles.
- The BOS1211-KIT controller board is returned to factory default.
- The user presses the mode change button on the BOS1211-KIT application.
- The user presses the mode change button on the BOS1211-KIT controller board.

8.5 Connected State

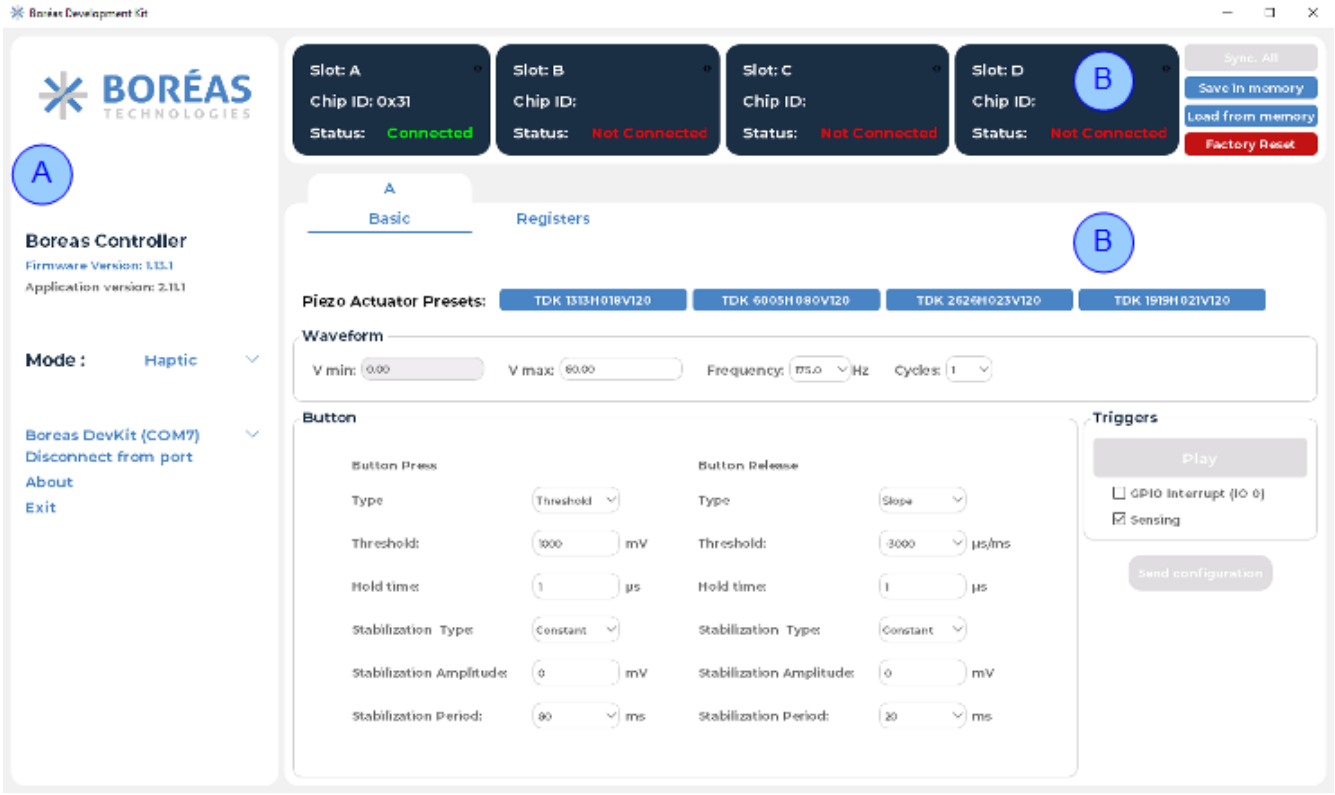


Figure 8 Application window when connected (Haptic mode)

Left Section (A): Menu

The left menu is used to present information about the BOS1211-KIT controller board:

- Firmware and software version
- Operation mode (*Haptic* or *Audio*)
- Communication port of the currently connected BOS1211-KIT controller board
- Status (if errors are detected, they will be displayed in the bottom section of the left panel).

In this menu, buttons are also available to:

- Change the mode of the BOS1211-KIT controller board.
- Close the communication link with the BOS1211-KIT controller board (to return to the disconnected state)
- Show version information of the software.
- Exit from the application.

Right Section (B): Content

The BOS1211-KIT supports 2 modes of operation: *Haptic* mode and *Audio* mode.

The right section of the application main window presents the capabilities and the features offered in each operation modes. Details for each mode are presented in the next sections.

8.5.1 Haptic Mode

8.5.1.1 Panel Overview

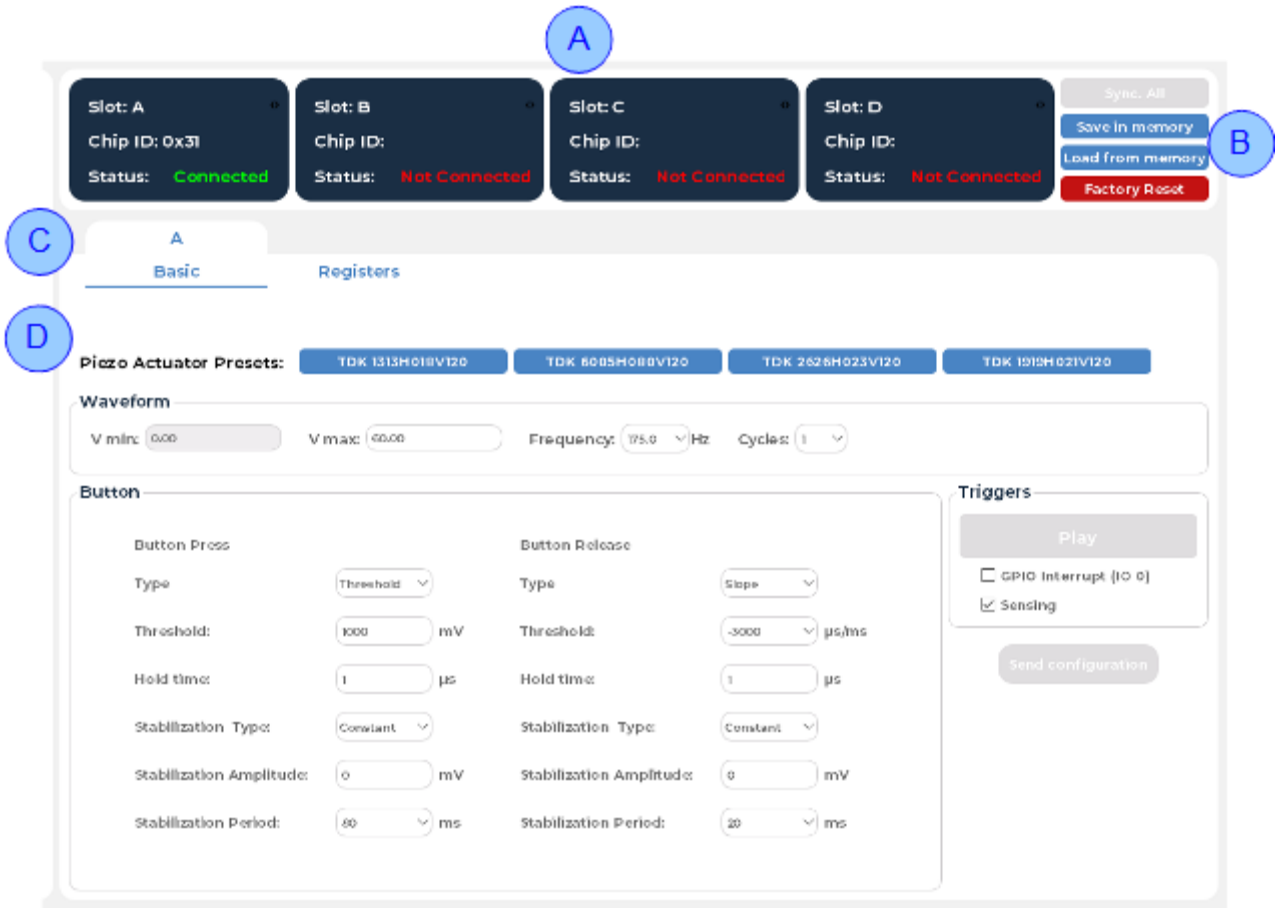


Figure 9:Panel overview – Haptic mode

Section A: Drivers Identification

The top of the right panel provides information about the driver connected to the microcontroller. The associated chip ID will appear, and the driver is marked as "*Connected*".

Section B: Buttons

Sync. All / Desync. All: Enables / disables the synchronized feedback mode. (More details provided in the use cases section)

Save in memory: Saves the current configuration (waveform, sensing parameters and triggers) to the board memory. Those parameters are automatically loaded at the next power up. This allows specific configurations to run in autonomous mode. This mode can also be operated with the BOS1211-KIT controller board powered from a battery bank or USB charger.

***Load from memory*:** Changing parameters with the interface allows experimenting various behaviors. Changing those parameters and sending them to the board does not affect the board memory state which is loaded automatically at power up. Clicking the *Load*

from memory button will return the board to the configuration contained in its memory and load this configuration in the interface window.

***Factory Reset*:** Resets the BOS1211-KIT controller board to its default factory state. This action will also trigger a reset of the BOS1211-KIT controller board and the application will return to its disconnected state.

Section C: Channel Selection Tabs

Select the connected channel to configure (channels *A* to *D*)

Section D: Basic and Registers Tabs

The basic panel provides functionalities to configure the BOS1211-KIT controller board (configure waveform, sensing parameters and triggers).

The register panel provides a read and write access to the registers of the BOS1211. More details about each view will be provided in the use cases sections that follow.

8.5.1.2 Play a Waveform - Manual Trigger

Description

User configures a sinusoidal waveform and plays it on a piezo actuator (channels *A* to *D*) by pressing the *Play* button in the application.

Prerequisites

- Software is connected to the BOS1211-KIT controller board in *Haptic* mode.

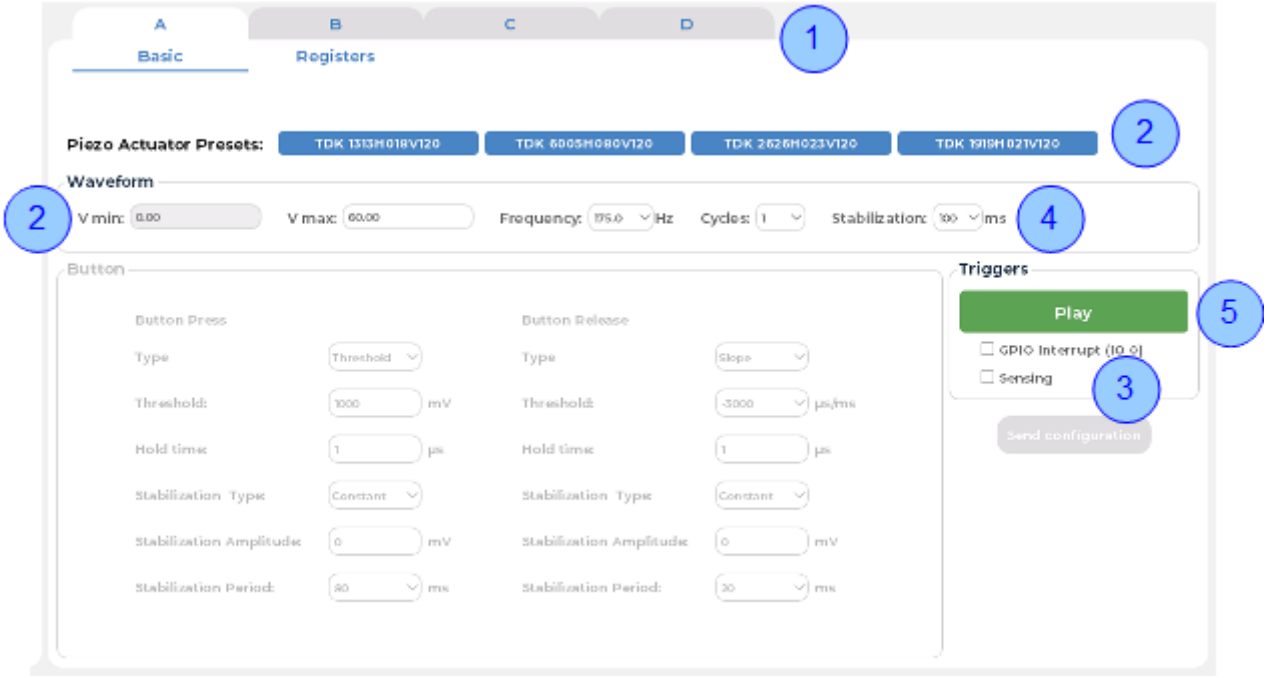


Figure 10:Play waveform – Manual trigger

Steps

1. Select a channel tab (*A* to *D*)
2. If the board is connected to a piezo actuator supplied in the BOS1211-KIT, click on the corresponding piezo electric preset button to set the voltage operating range (*Vmin* and *Vmax*). Otherwise, manually set the *Vmin* and *Vmax* fields in the *Waveform* section.
3. In the *Triggers* section, uncheck *Sensing* checkbox.
4. Configure the waveform:
   - Sinusoidal waveform frequency (between 100.0 and 300.0 Hz)
   - Number of cycles (between 1 and 254)
   - Set the stabilization time (between 0 and 1000 ms)
5. In the *Triggers* section, click on *Play* button to play the wave on the piezoelectric actuator.
6. (Optional): Change the waveform parameters (*Vmin*, *Vmax*, *Frequency*, *Cycles* and *Stabilization*) to see how it change the feedback when the play button is pressed.

8.5.1.3 Play a Waveform - External Trigger (GPIO)

Description

User configures the BOS1211-KIT controller board to play a sinusoidal waveform on the detection of a rising edge on the IO0. The input signal is debounced with 5 ms delay.

Prerequisites

- Software is connected to the BOS1211-KIT controller board in *Haptic* mode.

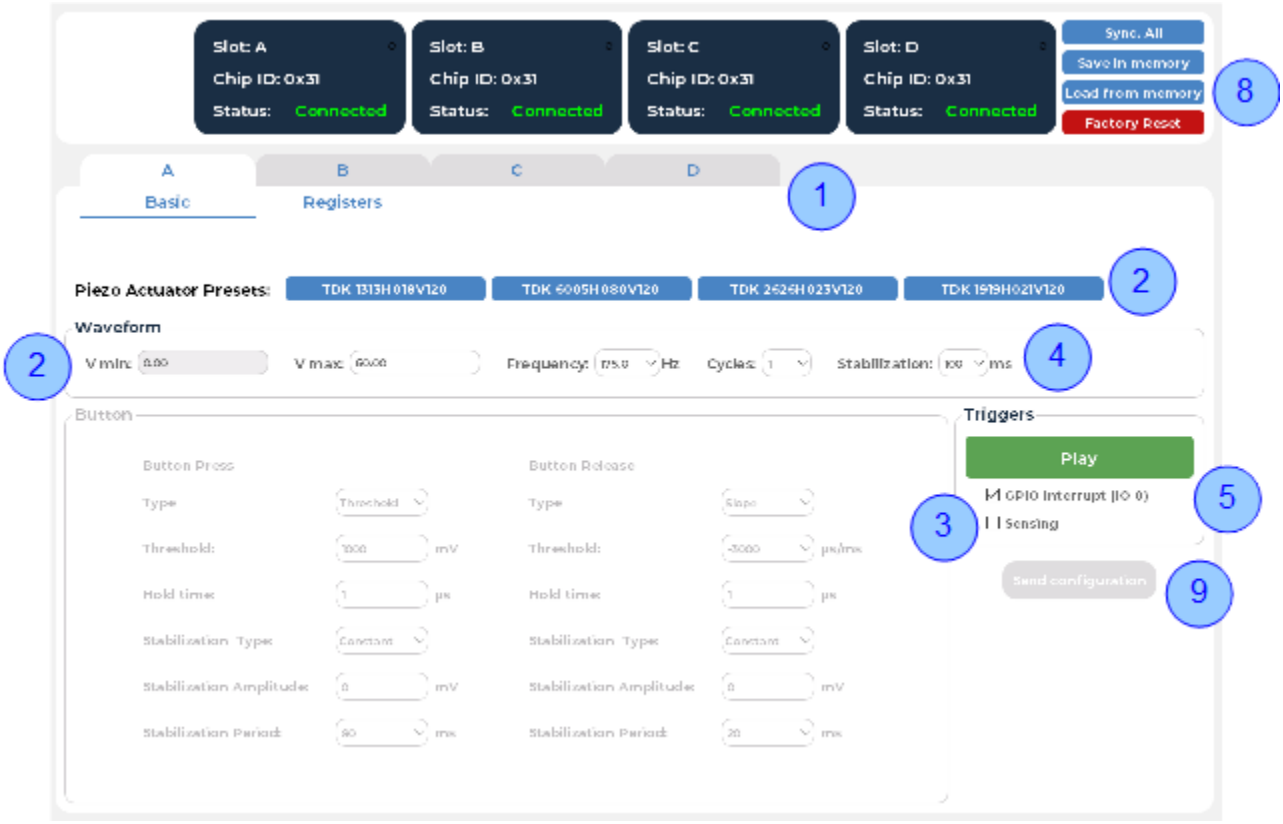


Figure 11:Play waveform – External trigger

Steps

1. Select the channel tab (*A* to *D*)
2. If the board is connected to a piezo actuator supplied in the BOS1211-KIT, click on the corresponding piezo electric preset button to set the voltage operating range (*Vmin* and *Vmax*). Otherwise, manually set the *Vmin* and *Vmax* fields in the *Waveform* section.
3. In the *Triggers* section, uncheck *the Sensing* checkbox.
4. Configure the waveform:
   - Sinusoidal waveform frequency (between 100.0 and 300.0 hertz)
   - Number of cycles (between 1 and 254)
   - Set the stabilization time (between 0 and 1000 ms)
5. In the *Triggers* section, check *the GPIO interrupt* checkbox.

6. Connect the IO0 on the BOS1211-KIT controller board to the external signal used to trigger the waveform feedback.
7. On detection of a rising edge of the signal connected on IO0, the waveform feedback will be played on the selected channel.
8. (Optional): Press the *save in memory* button to persist the configuration of the BOS1211-KIT controller board in memory. This saved configuration will be loaded in autonomous mode.
9. (Optional): If the waveform parameters are changed after the *GPIO interrupt* box is checked, the *Send configuration* button must be pressed again to send the waveform configuration to the BOS1211-KIT controller board.

8.5.1.4 Play a Waveform – Sync Mode

Description

User configures the BOS1211-KIT controller board to play a sinusoidal waveform on all connected channels simultaneously. The trigger to play the waveform can be manual using the *Play* button from the software or an external signal connected on *IO0*.

Prerequisites

- Software is connected to the BOS1211-KIT controller board in *Haptic* mode.

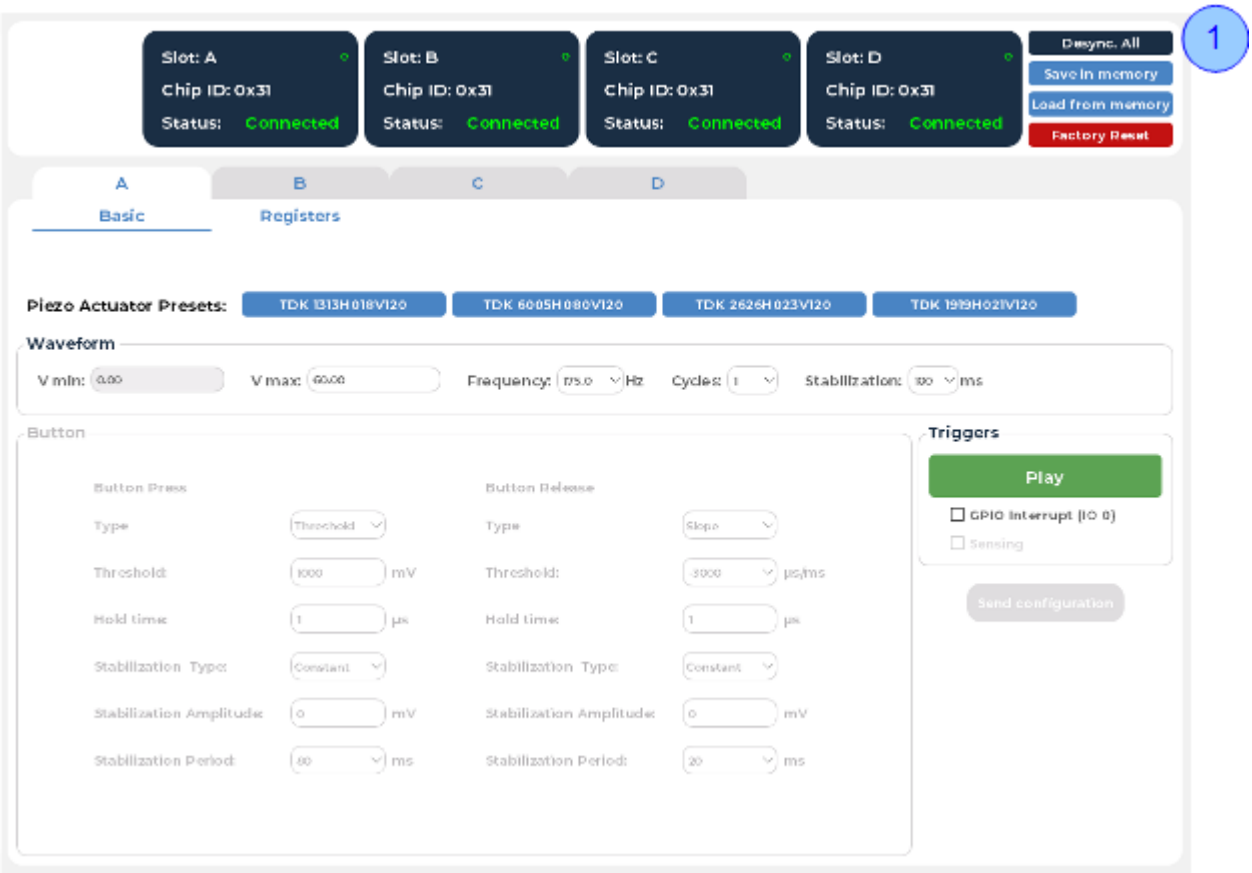


Figure 12:Play waveform – Sync mode

Steps

1. Press the *Sync. All* button of the top panel to enable the synchronized feedback mode. A little green icon in the chip status panel will be displayed to indicate that the mode is enabled. Also, the text of the *Sync. All* button will be changed to *Desync. All* (Use this new button to disable the sync mode).
2. To play feedback using a manual trigger, follow the procedure Play a Waveform - Manual Trigger. To play feedback using an external trigger, follow the procedure Play a Waveform - External Trigger (GPIO).

Note: When the sync mode is enabled, one channel becomes the master (the one in which the sync mode has been enabled). The configuration of the waveform and the trigger can only be done from the master channel.

8.5.1.5 Button Emulation Mode

Description

User configures the parameters of a sinusoidal waveform and the parameters of a sensing algorithm that can detect a button press and button release on the piezo actuator. When these events are detected by the sensing algorithm, the feedback is played on the piezo actuator.

Prerequisites

- Software is connected to the BOS1211-KIT controller board in *Haptic* mode.

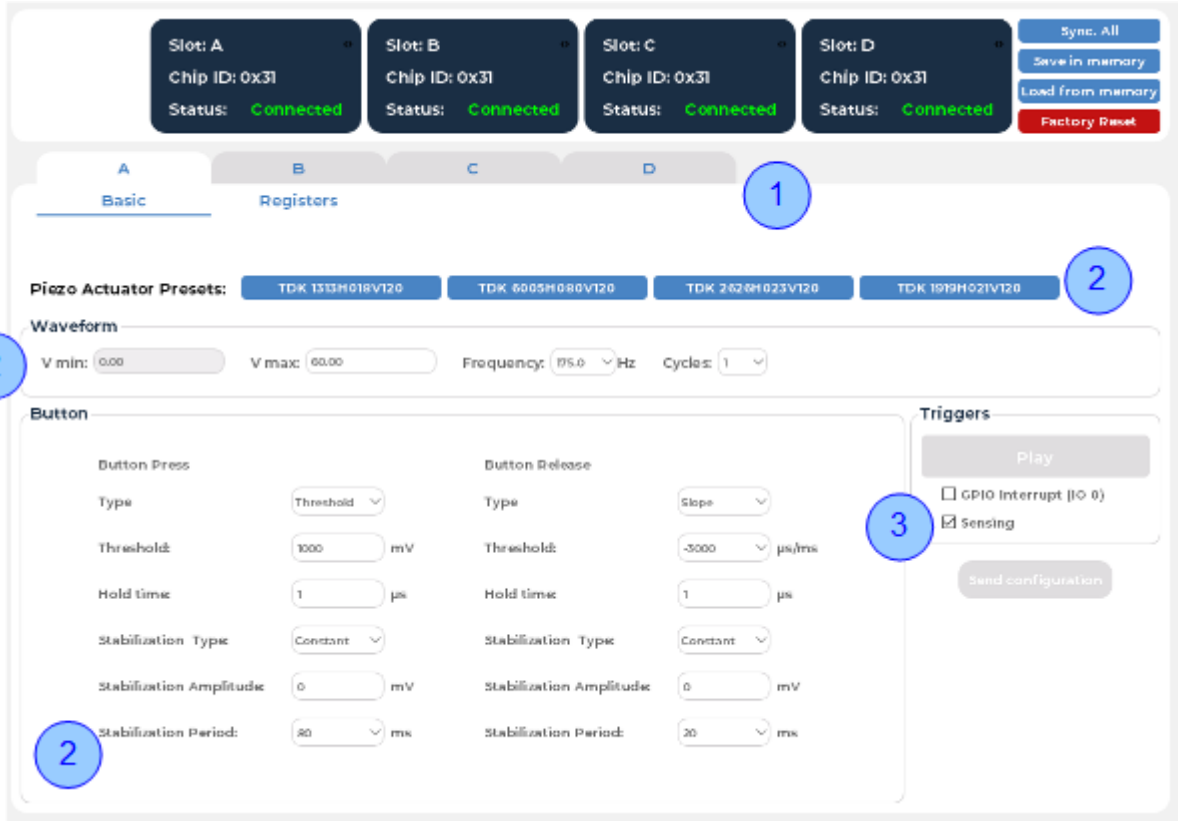


Figure 13:Button emulation

Steps

1. Select the channel tab (*A* to *D*).
2. In the *Triggers* section, check the *Sensing* checkbox to enable the sensing algorithm on the BOS1211-KIT controller board and the BOS1211 IC status LED of the channel will turn solid green.
3. If the board is connected to a piezo actuator supplied in the BOS1211-KIT, click on the corresponding piezo electric preset button to set the voltage operating range (*Vmin* and *Vmax*) and the *Sensing* parameters.

Otherwise, manually set the *Vmin* and *Vmax* fields in the *Waveform* section. The *Sensing* parameters values will also have to be calibrated for a good detection of the press and release events. More details regarding the sensing algorithm are given in Appendix A**.**

4. Gently press the piezo actuator until the press event is detected (user should feel the feedback on his finger). Release the force on the piezo actuator to let the sensing algorithm detect the release event.
   Note: After the detection of a press, the sensing algorithm waits a maximum of 3 seconds before it returns to the state where it is waiting for the detection of the press event.

8.5.1.6 Registers Access

Description

User read and optionally write registers of the connected BOS1211.

Prerequisites

- Software is connected to the BOS1211-KIT controller board in *Haptic* mode.

Figure 14: Register access panel

Steps

1. Select the channel tab (*A* to *D*).
2. Select the *Registers* Tab.
3. Use the *Load All* button to read all registers values from the BOS1211.

4. (Optional): To change the value of a writable register, edit the parameter and press the *Send* button to write the modified register in the BOS1211.

Note: The registers are displayed, one per line. The register label is given on the left, then the register address, then the parameters for this register are given (MSB on the left, LSB on the right)

When selecting a parameter box, the information for that parameter is given on the right side of the screen. Information includes parameter name, its current value, the number of bits of that parameter (Length), the minimum and maximum possible values, and a short description.

8.5.2 Audio Mode

In *Audio* mode, the BOS1211-KIT is seen by the computer as a USB speaker to allow the user to play waveforms directly to the piezo actuator. This section explains the configuration features of this mode. See appendix C for instructions on using Audacity® software to create and play waveforms in *Audio* mode.

8.5.2.1 Panel Overview

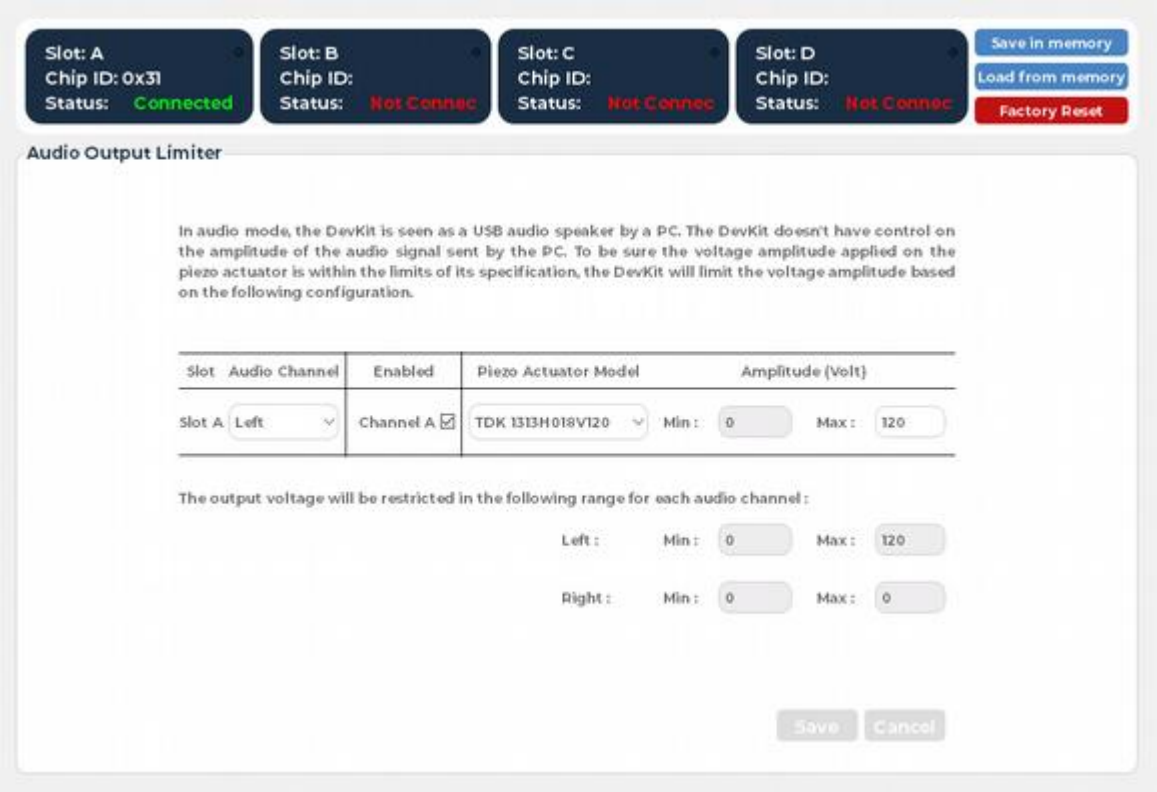


Figure 15:Panel overview - Audio mode (1 channel connected)

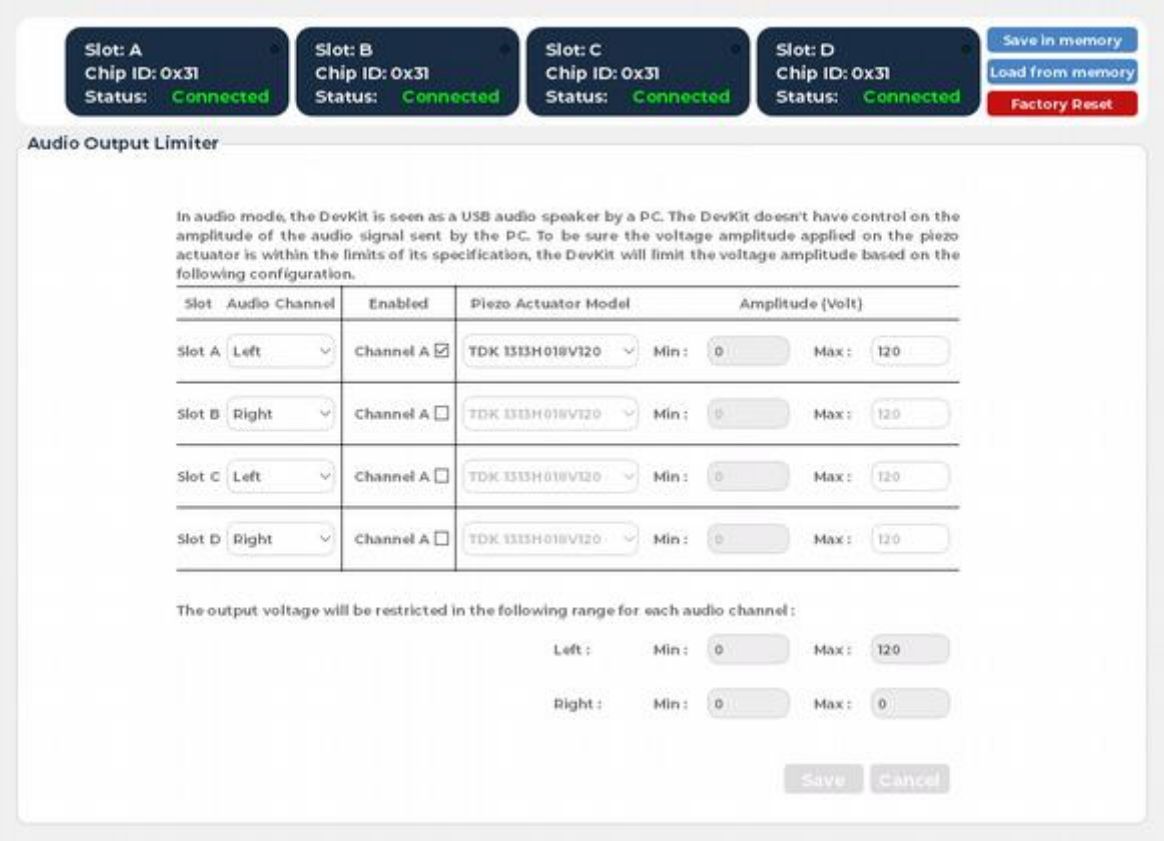


Figure 16:Panel overview - Audio mode (4 channels connected)

When the BOS1211-KIT controller board is in *Audio* mode, it is detected by Windows as a speaker device. When this device is selected, all audio output from the PC will be sent to the board. Make sure to deselect the Boreas DevKit to avoid the PC from playing system sounds on the actuator.

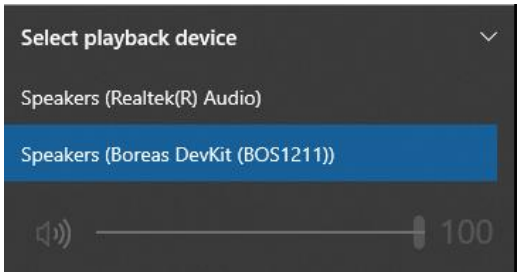


Figure 17:Boreas DevKit speaker

User should use a software that can specifically select an individual USB device as audio output. For example, Audacity® allows to easily create and play waveforms on the piezo actuators attached to the board. See appendix for more details.

8.5.2.2 Channel Configuration

Each channel (*A* to *D*) may be configured independently. They may be enabled/disabled using the checkbox and they may be associated with either the Left or Right audio track.

8.5.2.3 Audio Limiting

Because some piezo actuators have voltage operating ranges that are smaller than the capacity of the BOS1211, the BOS1211-KIT controller board has the capacity to limit the voltage range of the audio signal in order to protect the actuator.

Using the factory default values, the BOS1211-KIT controller **board will limit the output voltage between 0 V and 120 V.** This range is within tolerances of all piezo actuators model supplied in the BOS1211-KIT.

To change the audio limiting configuration, open the BOS1211-KIT software while the board is in audio mode and select the appropriate piezo actuator model. The *Min* and *Max* values of the *Amplitude* field may be changed as desired. Press the *Save* button to send the new values to the BOS1211-KIT. When using different actuators on each channel, the most restrictive range will be used and shown by the greyed *Min* and *Max* values at the bottom of the window.

8.5.2.4 Audio Limiting Illustrated

Original signal without audio limiting:

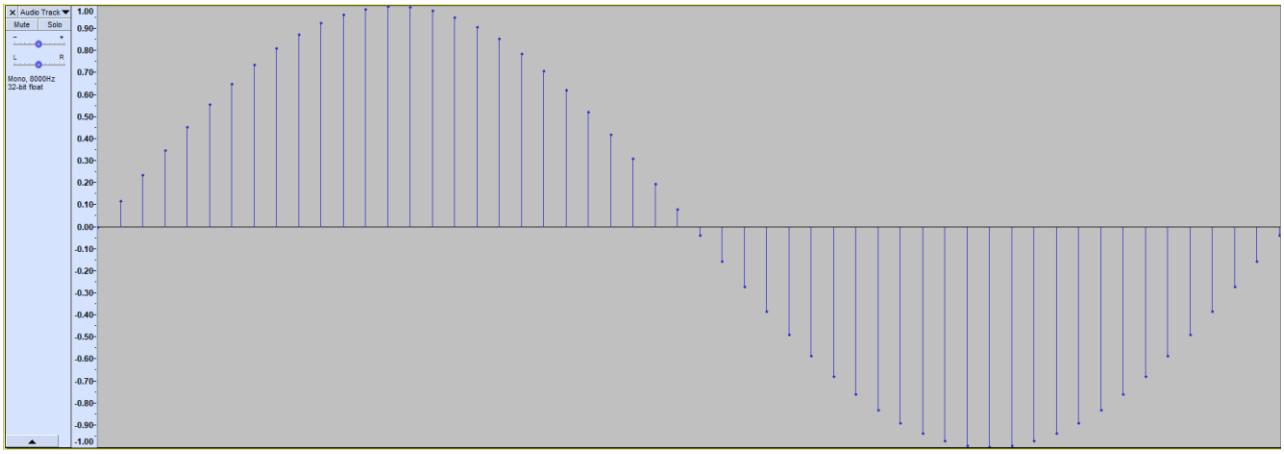


Figure 18:Original audio signal

Same signal with audio limiting set between 0 V to 60 V:

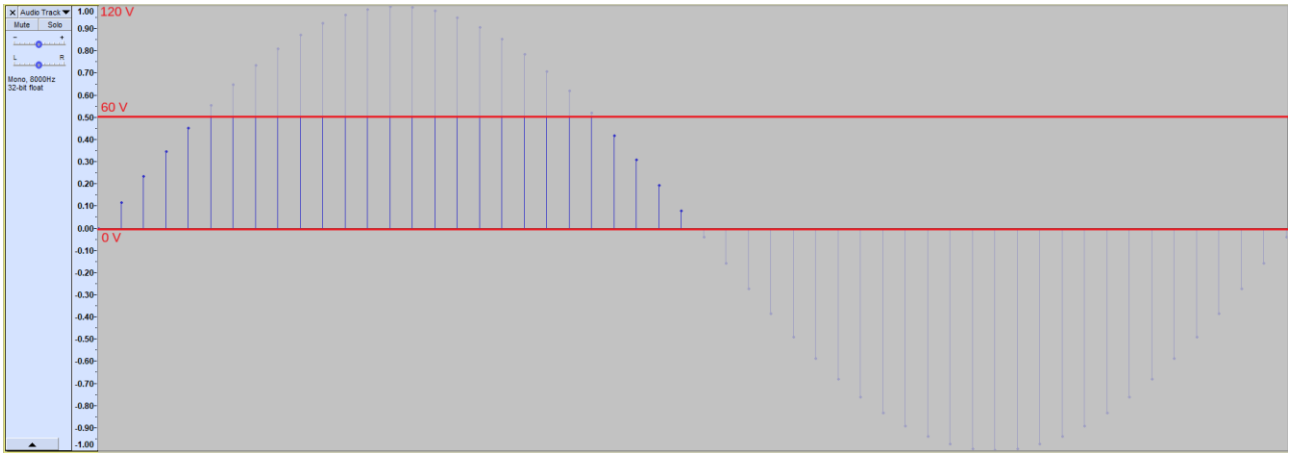


Figure 19:Audio signal with audio limiting

8.5.3 IC Status Monitoring

As displayed above, when the application is connected to the BOS1211-KIT controller board it shows all detected BOS1211 errors in the bottom section of the left panel.

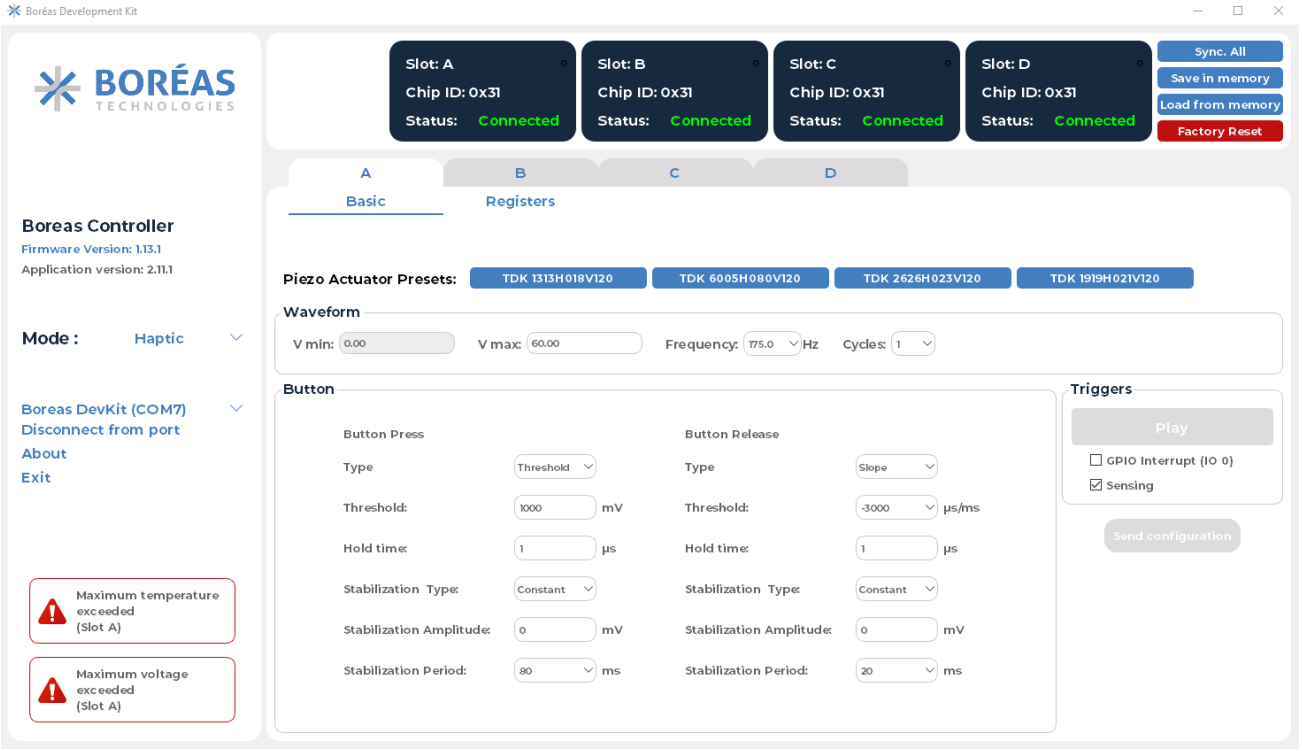


Figure 20 Errors shown in the left panel

Table 11: BOS1211 errors

Reported Error Message	Meaning
IC Controller error	There is a problem with the communication between the IC and the microcontroller.
Short circuit detected between VOUT and VIN	IC has detected a short-circuit condition on its output.
VDD is too low	VDD input supply is below operation range.
VIN is too low	Main power supply voltage is below operation range.
Problem with current detection	There is a problem with current flow in the inductor. This error seldom occurs and is indicative of a hardware issue.
Maximum power, distortion likely	IC has reached maximum power transfer condition. Check the output waveform for possible distortion.
Maximum temperature exceeded	Over temperature detected on the IC. Operation will resume when temperature drops. This error seldom occurs and is indicative of a hardware issue.
Maximum voltage exceeded	Output voltage exceeded the maximum voltage allowed on the IC.
VIN voltage exceeded	Main power supply voltage is above operation range.

9 Hardware

The purpose of this section is to provide information on the hardware design of the BOS1211-KIT PCBs to help the integrator evaluate BOS1211 and to use it in a prototype.

9.1 Design Overview

The development kit is composed of two distinct boards: a controller board containing the microcontroller and application features, and a driver board containing a BOS1211 chip with associated components. Additional driver boards can be stacked on top of each other to drive multiple actuators from the same controller board. When multiple driver boards are used, jumpers on each board must be set for each IC to be accessed individually by the microcontroller.

The hardware design allows for partial or complete electrical isolation of the microcontroller section from the driver section. This is made possible by the presence of level-shifter circuits on the SPI and GPO, and a series of solder bridges that can be populated or unpopulated with resistance to do the configuration.

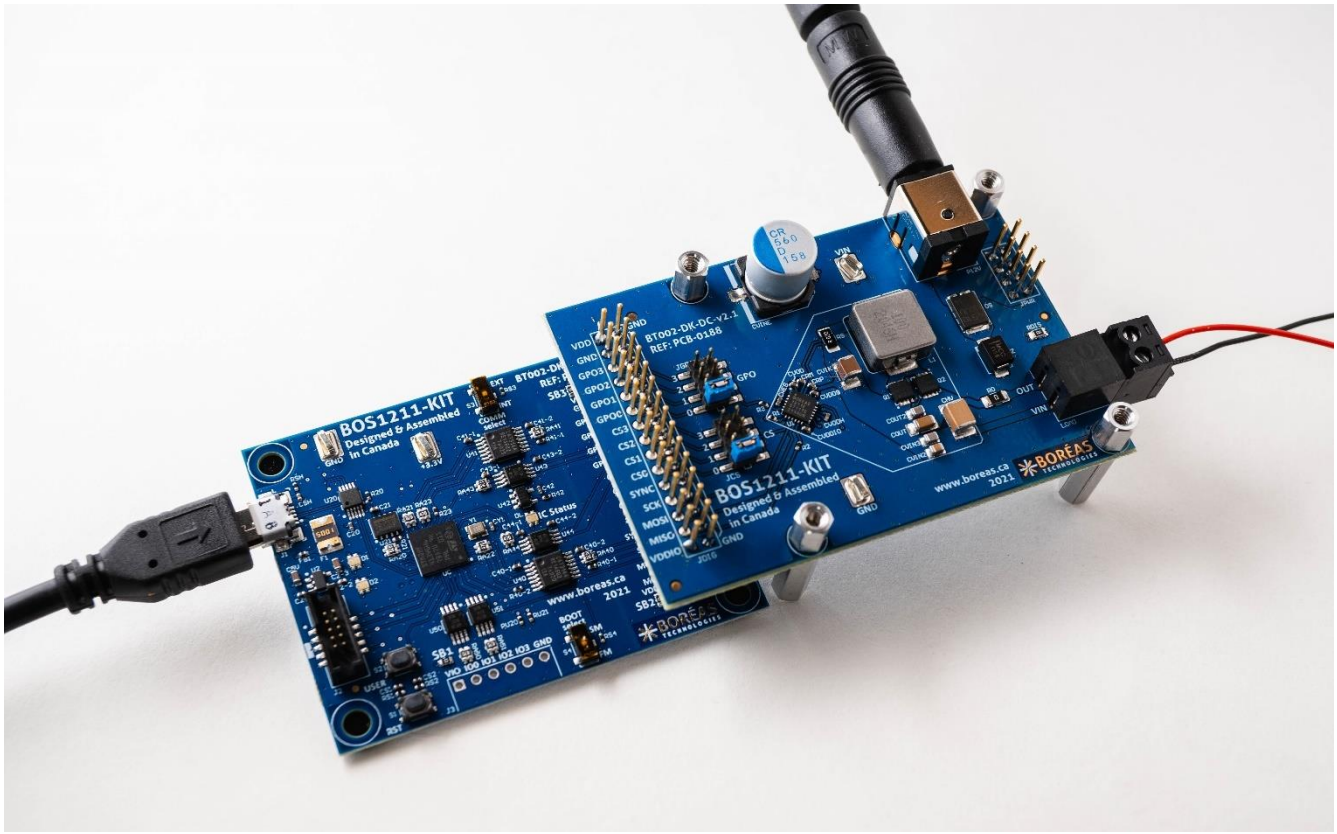


Figure 21: BOS1211-KIT assembled PCBs

9.2 Hardware Features

In this section, we will discuss the various hardware configurations. Except for section 9.2.1, it is assumed that the controller board and driver board are assembled.

Some functionality in this section requires modifications to the PCB and requires a soldering iron. Disconnect the supply before making any changes to the board.

Important Note:

When powering up the board, always connect the 12 V supply first, then the USB connector.

When powering off the board, always disconnect the 12 V supply first, then the USB connector.

9.2.1 Boards Assembly – Single Driver Board

If not already done, assemble both the controller and driver boards using the JDIG connector on each board. Use 5/8-inch standoffs underneath the driver board. Use 1/4-inch standoffs on top on the driver board. Screw the actuator in the insertable terminal block and insert this terminal block in the terminal block socket (LOAD). Verify both jumpers are set to 0. Connect the 12 V power supply first and then the USB cable.

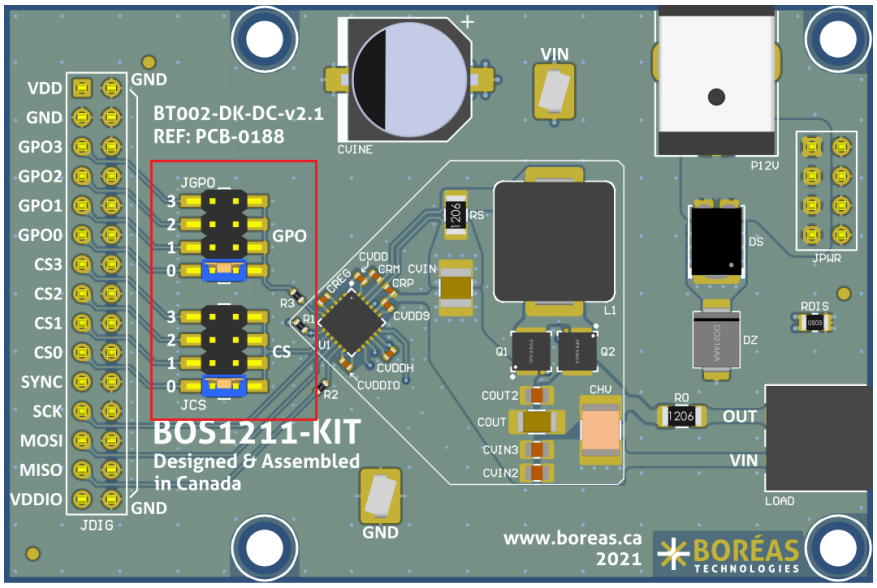


Figure 22: Driver board jumpers

9.2.2 Boards Assembly – Multiple Driver Boards

If stacking multiple driver boards, use 5/8-inch standoffs underneath the bottom board, use 1/2-inch standoffs between boards and 1/4-inch on the topmost driver board. Up to four driver boards can be stacked. Before stacking the boards, set GPO and CS jumpers on each card to a different position for the firmware to individually address each board and avoid conflicts. Make sure the boards are labelled in ascending order (jumpers index 0 to 3) to ease identification in the software (slots A to D respectively). When stacking the boards, align JDIG and JPWR connectors.

Once all board are stacked, connect the bottommost board to the controller board using the JDIG connector on each board. Screw each actuator in an insertable terminal block and insert each terminal block in the associated terminal block socket (LOAD) on each board. Connect the 12 V power supply on any driver board (JPWR connectors distribute the 12V to all boards). Then connect the USB cable.

Important Note:

When powering up the board, always connect the 12 V supply first, then the USB connector.

When powering off the board, always disconnect the 12 V supply first, then the USB connector.

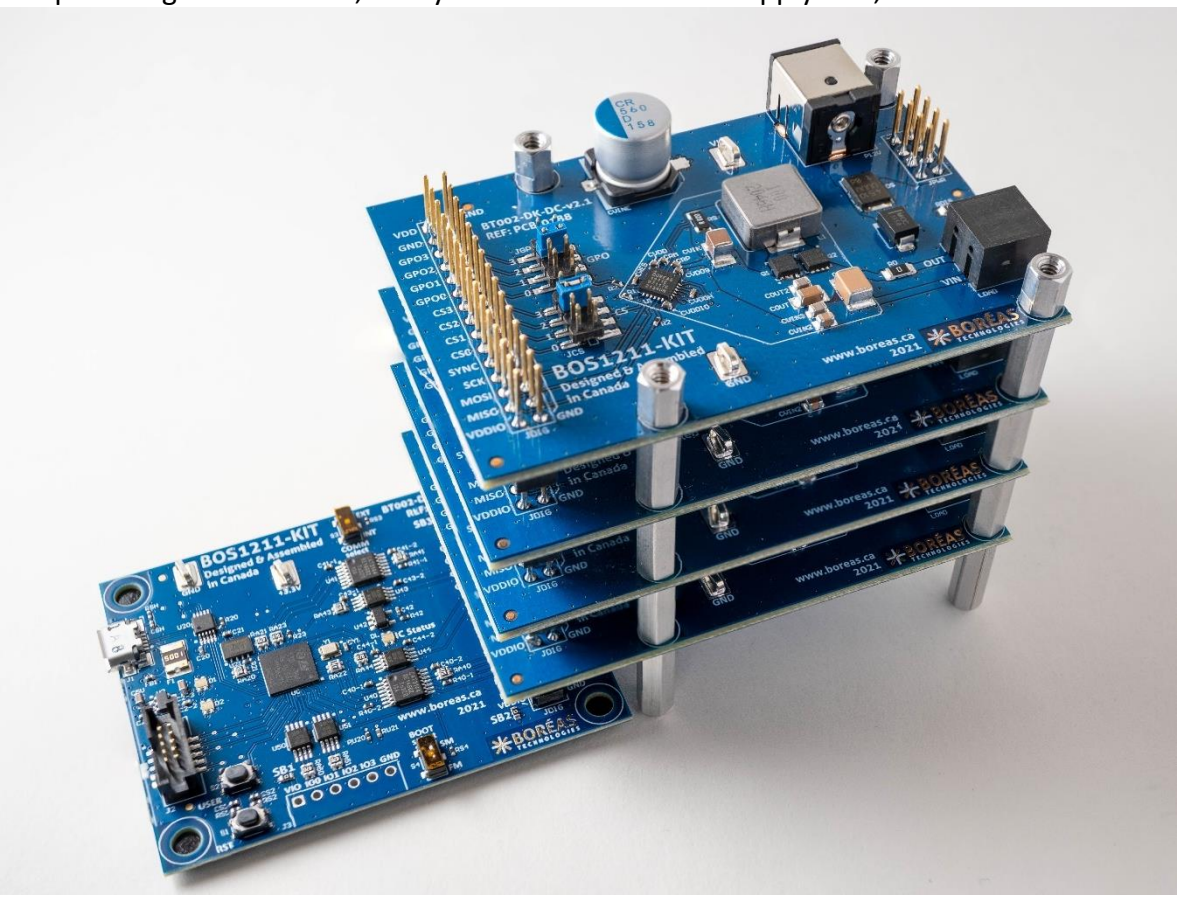


Figure 23: BOS1211-KIT with four driver boards stacked

9.2.3 Driver Board Separated Use

The use of the driver board separated from the controller board, with custom-made firmware is done at the user's own risk of causing damage beyond repair to the BOS1211 circuit. Boréas Technologies will not be held responsible.

One way to integrate a BOS1211 is to use the driver board directly (separated from the controller board) and connect it to another development platform.

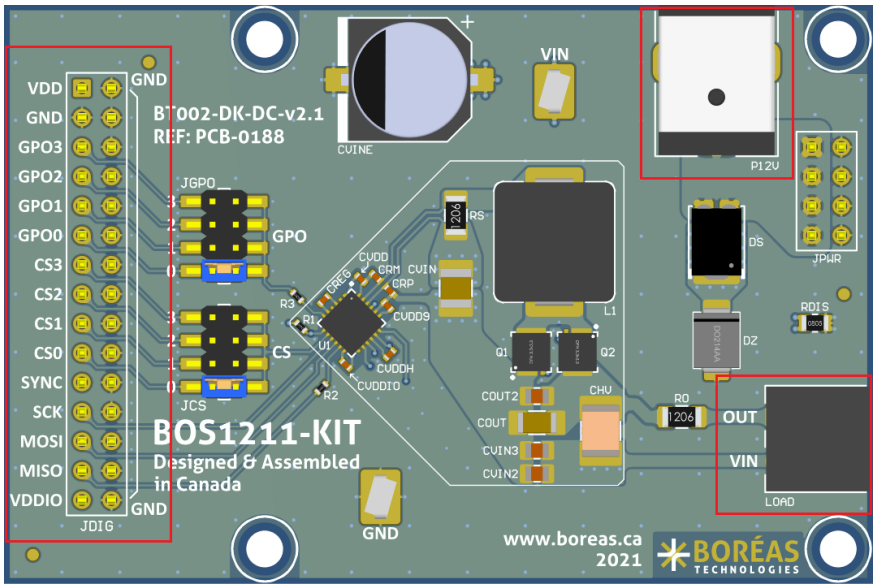


Figure 24: Driver board PCB

The driver board contains a BOS1211 that can be used alone with a user-preferred development platform. Relevant signals on the JDIG connector need to be connected to the development platform.

Table 12: Driver board interface signals

Signal	Description	Constraint
GND	0 V reference	
VDD	5 V main controller supply	
GPO0-3	Configurable digital output	Connect the pin selected by the associated jumper.
CS0-3	SPI Chip Select signal	Connect the pin selected by the associated jumper.
SYNC	Multi-chip synchronizing pin	Tie together SYNC pin on all BOS1211 that need synchronizing.
SCK	SPI Clock signal	
MOSI	SPI Master Out/Slave In signal	
MISO	SPI Master In/Slave Out signal	
VDDIO	Digital IO power supply	Digital signals voltage domain. Must be between 1.62 V and 5.5 V.

Refer to BOS1211 datasheet for a complete description on how to use and program the circuit.

The 12 V supply and actuator must also be connected using the P12V and LOAD connectors. If stacking multiple boards, only one 12 V power supply is needed since the JPWR connectors distribute the supply to all boards.

9.2.4 Probe Hooks

Probe hooks are available around the boards to ease connection of instruments for measurement when debugging.

On the driver board, JDIG header pins connector can be used to probe VDD and VDDIO supplies and digital signal levels. The 12 V supply can be probed on the VIN hook next to the P12V connector on the card. Note each driver board VIN supply is isolated from the other ones – it must be probed on the same card the waveform is played on.

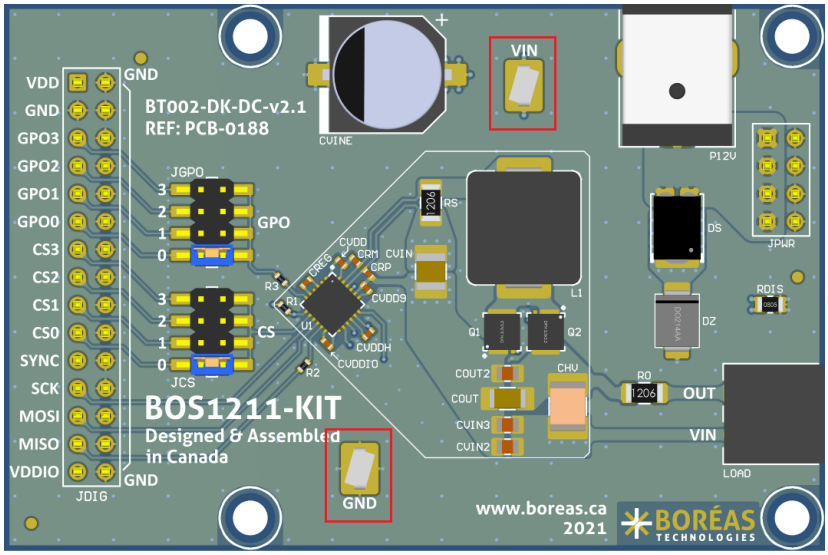


Figure 25: Probe hook locations on driver board

On the controller board, the +3.3V hook allows monitoring of the digital supply level.

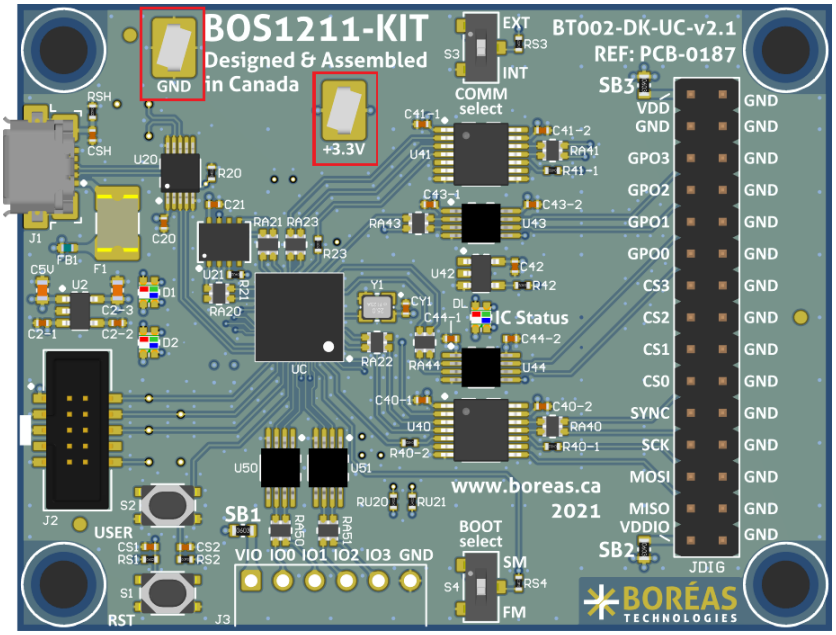


Figure 26: Probe hook locations on controller board

9.2.5 Digital GPIOs

General-purpose inputs and outputs (GPIOs) are provided to ease integration of the development kit in a prototype. For example, digital inputs may be used as trigger inputs to fire the waveforms or to send information from the system to the development kit. Four pins can be configured as input or output.

Using these GPIOs implies to modify the firmware to support them. However, they are already physically implemented and routed to the MCU. They need to be activated in the firmware software code project.

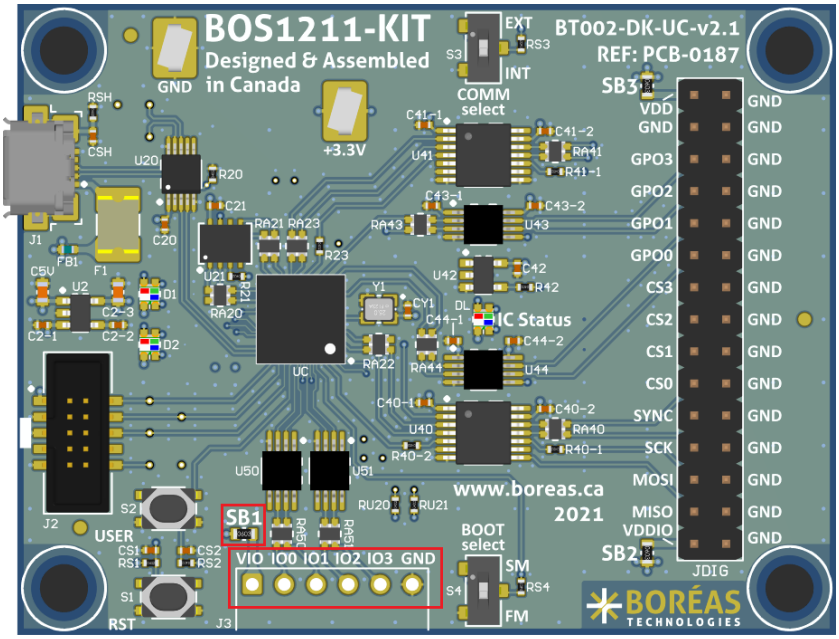


Figure 27: GPIOs and GPIOs supply voltage configuration solder bridge location

By default, the GPIOs are in the microcontroller 3.3 V supply domain. To use these GPIOs with a system operating in another voltage domain requires modification of the BOS1211-KIT controller board configuration.

Table 13: GPIOs supply voltage solder bridge configuration

GPIOs Supply Source	SB1 State
+3.3V (MCU supply)	Populated
VIO (1.2 V to 5.5 V)	Unpopulated

When SB1 is unpopulated, GPIOs supply voltage is provided by VIO and GND of the J3 connector. This J3 header connector is provided in the box but is not initially populated. Refer to the board schematics in section 10.1 for MCU pins numbers corresponding to IO0, IO1, IO2 and IO3.

9.2.6 External SPI

The BOS1211 features an SPI communication interface. By default, each BOS1211 are connected to the MCU SPI master. It is possible to bypass the MCU and use an external SPI master without disassembling the boards. This can be useful when trying to connect a BOS1211 directly to an external system.

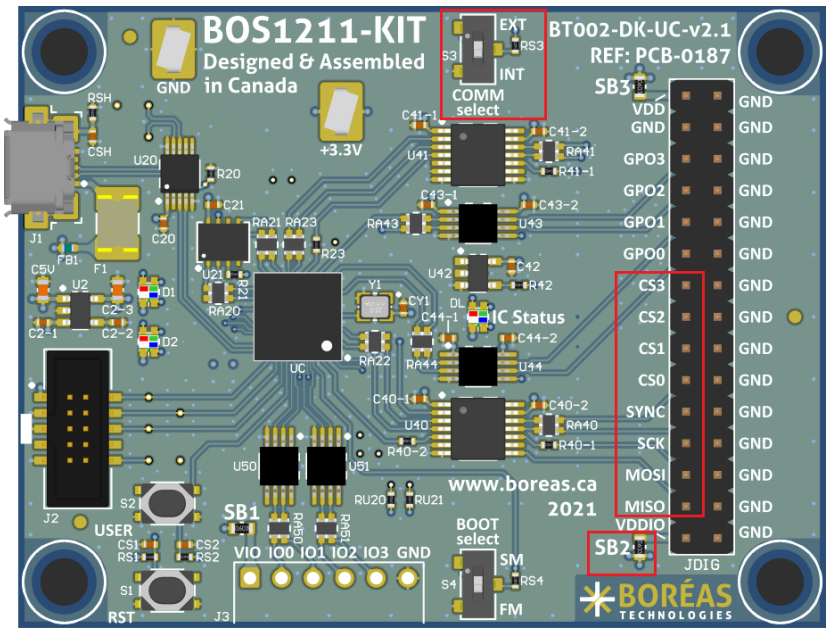


Figure 28: Comm selection switch and SPI header location

To use an external SPI, it is mandatory to enable it using the COMM Select switch (S3) on the board by setting it to EXT position. USB port must still be connected since it supplies the digital switches.

By default, the SPI signals are in the microcontroller 3.3 V supply domain. To use these SPI signals with a system operating in another voltage domain requires modification of the BOS1211-KIT controller board configuration.

Table 14: SPIs supply voltage solder bridge configuration

SPI Supply Source	SB2 State
+3.3V (MCU supply)	Populated
VDDIO (1.62 V to 5.5 V)	Unpopulated

When SB2 is unpopulated, SPI supply voltage is provided by VDDIO and GND of the external SPI header connectors (JDIG). The external SPI signals can be connected directly on JDIG on either the controller board or the driver board.

9.2.7 External VDD Supply

By default, each BOS1211 VDD supply are connected to the controller board USB supply (5 V). It is possible to bypass this supply and use an external supply without disassembling the boards. This can be useful when trying to assess application power consumption.

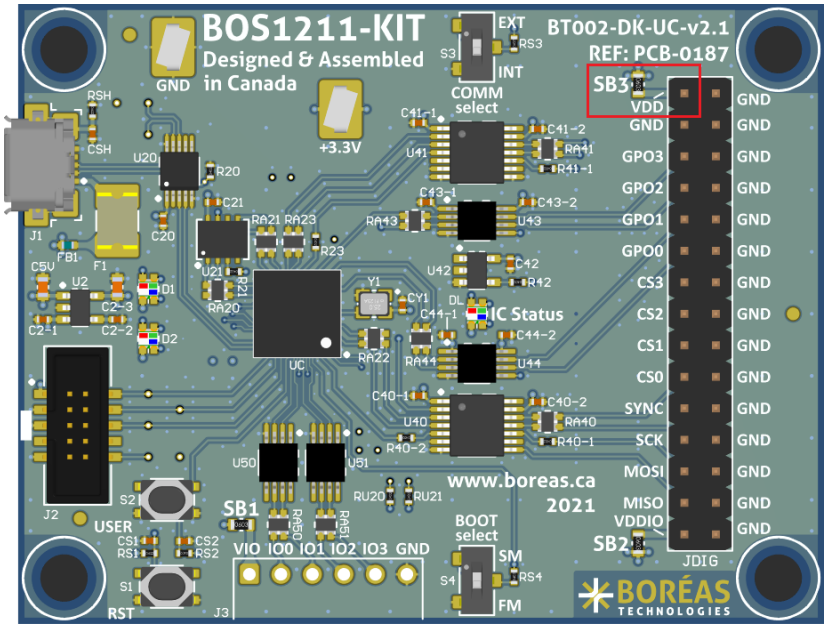


Figure 29: Comm selection switch and SPI header location

Using an external VDD supply requires modification of the BOS1211-KIT controller board configuration.

Table 15: VDD supply voltage solder bridge configuration

VDD Supply Source	SB3 State
+5V (USB supply)	Populated
VDD (4.5 V to 5.5 V)	Unpopulated

When SB3 is unpopulated, VDD supply voltage is provided externally directly on JDIG VDD pin either by the controller board or the driver board.

9.2.8 Piezo Actuator Low-Pass Filter

On the driver board, a 1206 resistor R0 is in series with BOS1211 output OUT. It can be used to create a low-pass filter with the actuator and filter out audible noise if needed. Resistor values to use are determined by the desired cut-off frequency and the actuator capacitance. A bode plot is useful to assess the amplitude attenuation at the waveform frequency to compensate it in the programmed voltage waveform. Initially, the populated value is 0 ohm.

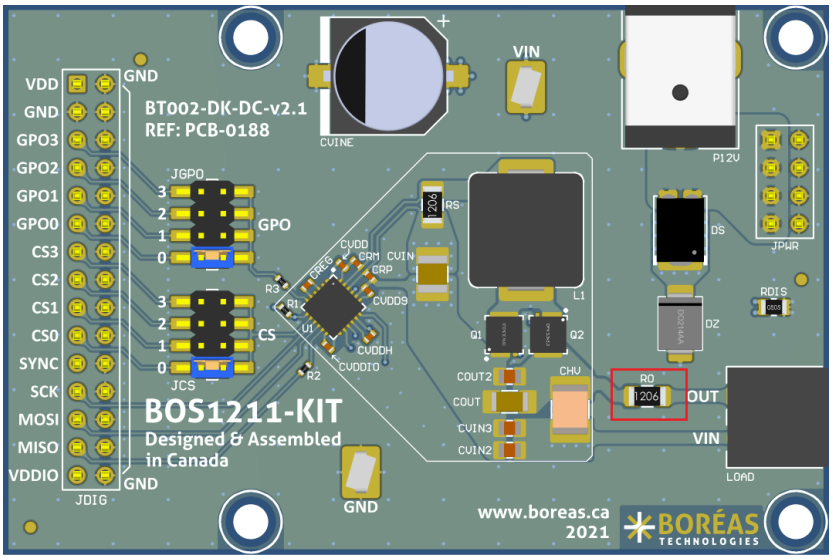


Figure 30: Low-pass filter resistor location

9.3 Piezo Actuators

TDK actuators are provided with the BOS1211-KIT with the ***Premium Set***. For each piezoelectric actuator available with the BOS1211-KIT, Boréas provides recommended presets. Each preset is available in the GUI and is identified by the brand and model number of the piezo actuator.

TDK PowerHap™ 1313H018V120 piezo actuator specifications:

Type	Cymbal design
Polarity	Red wire on "OUT" terminal Black wire on "VIN" terminal
Range	Unipolar -20 V to +120 V

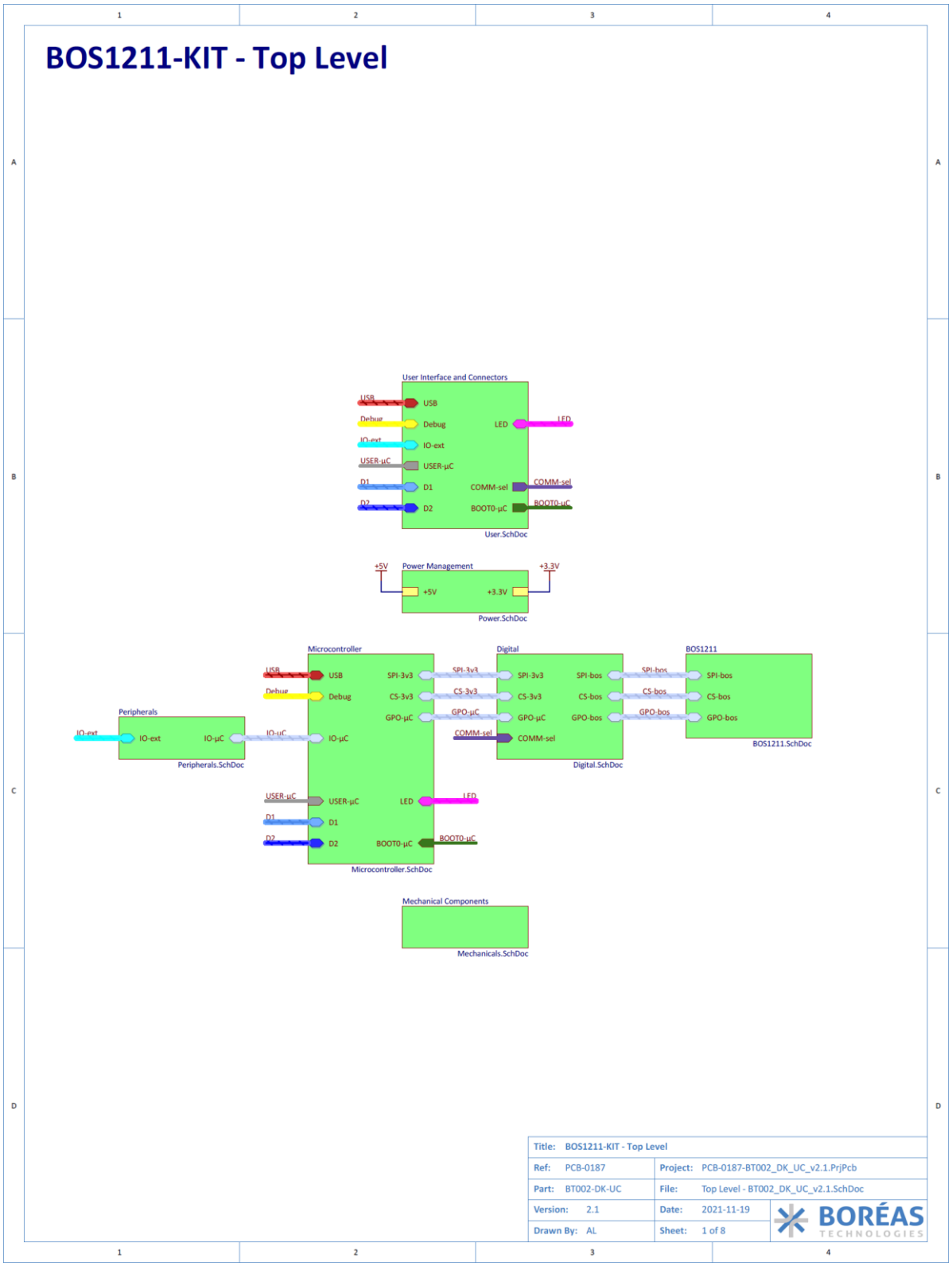
TDK PowerHap™ 6005H080V120 piezo actuator specifications:

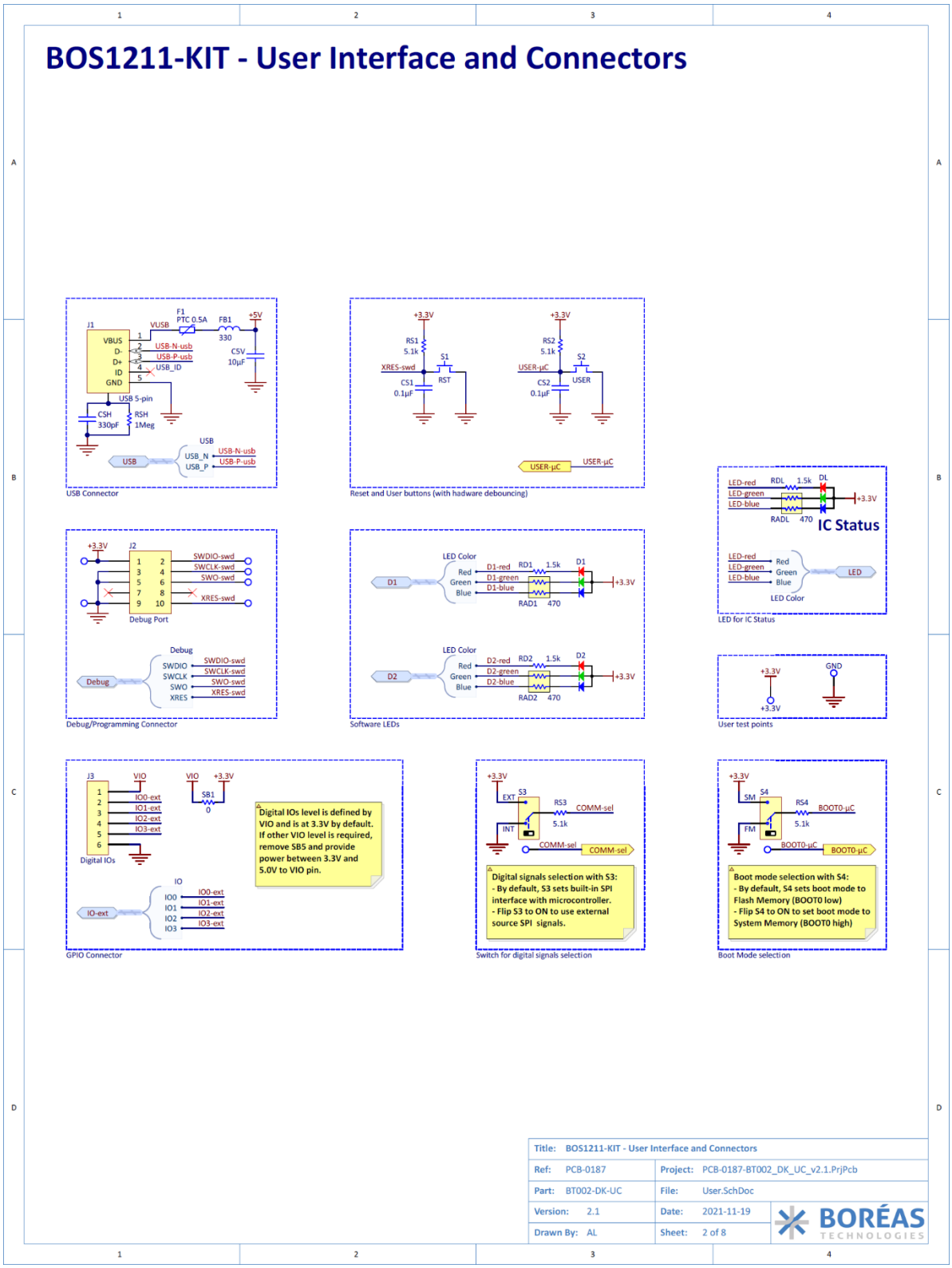
Type	Cymbal design
Polarity	Red wire on "OUT" terminal Black wire on "VIN" terminal
Range	Unipolar -20 V to +120 V

It is of utmost importance to not use the TDK PowerHap™ actuators outside their specified ranges as they can get damaged unless the waveform is properly designed to limit the output voltage between -20 V and +120 V. Example waveforms are provided on Boréas website.

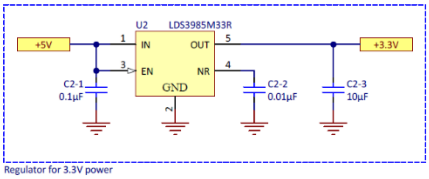
10 Design Reference

10.1 Schematics – Controller Board



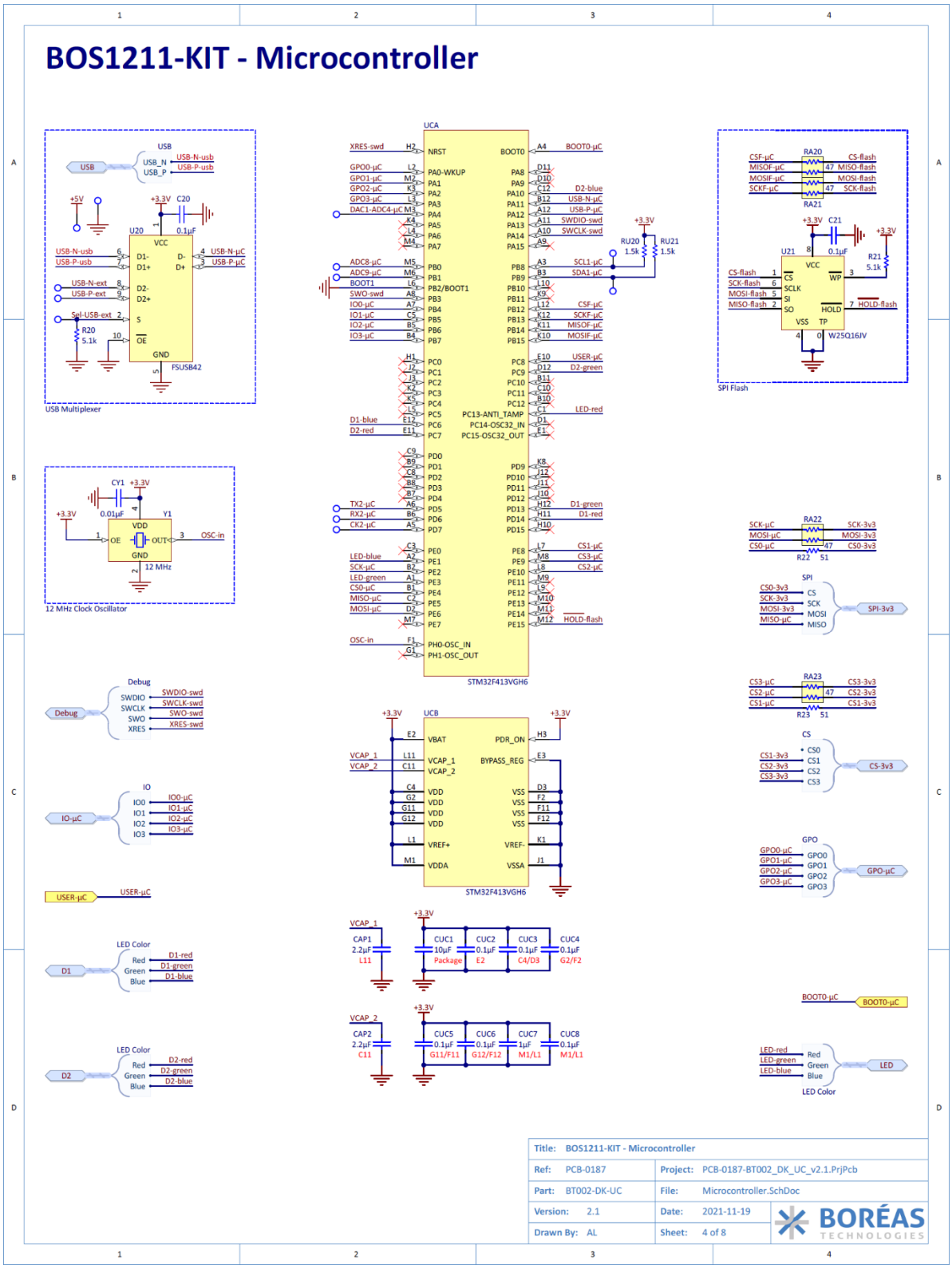


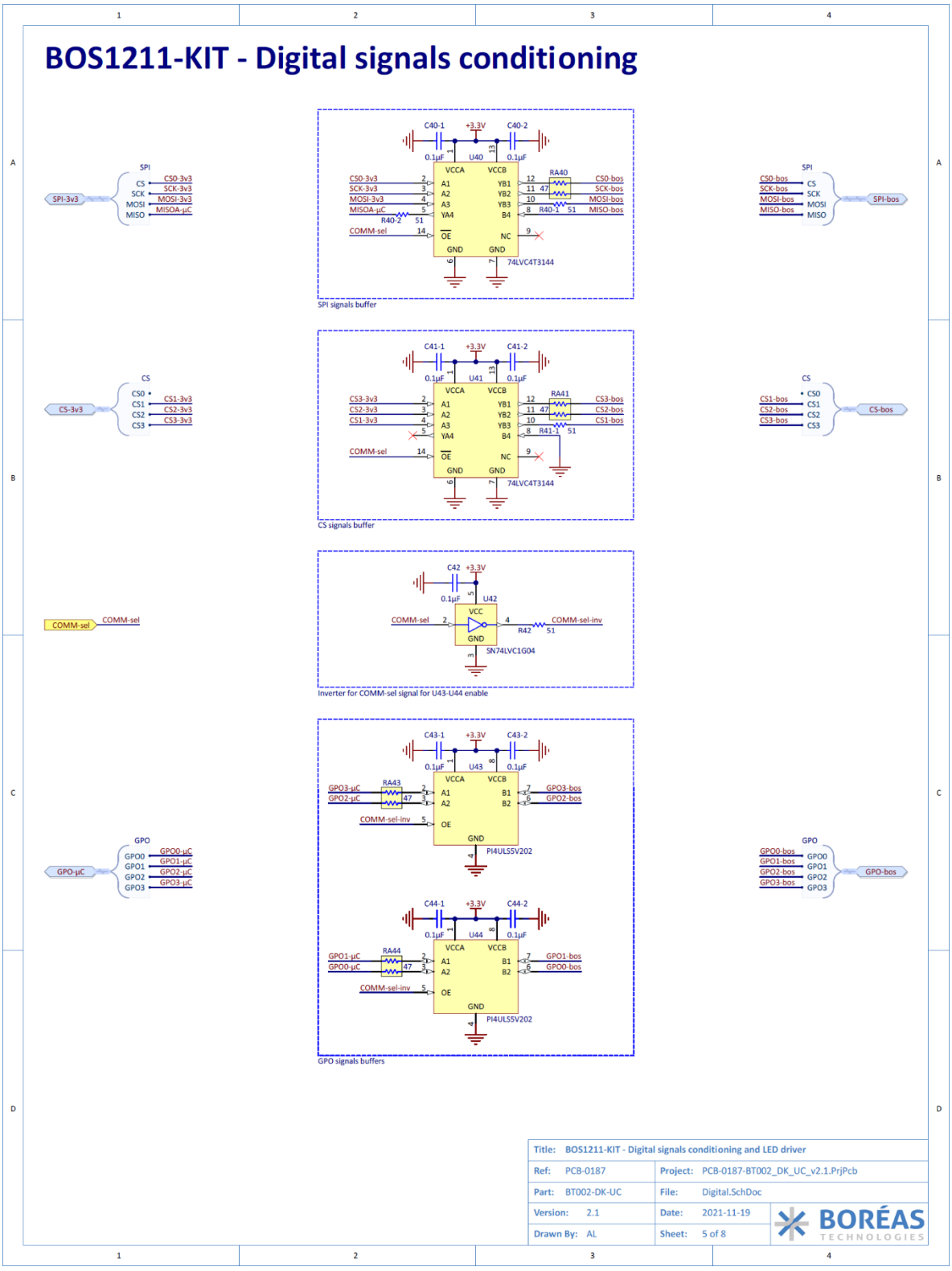
BOS1211-KIT - Power Management

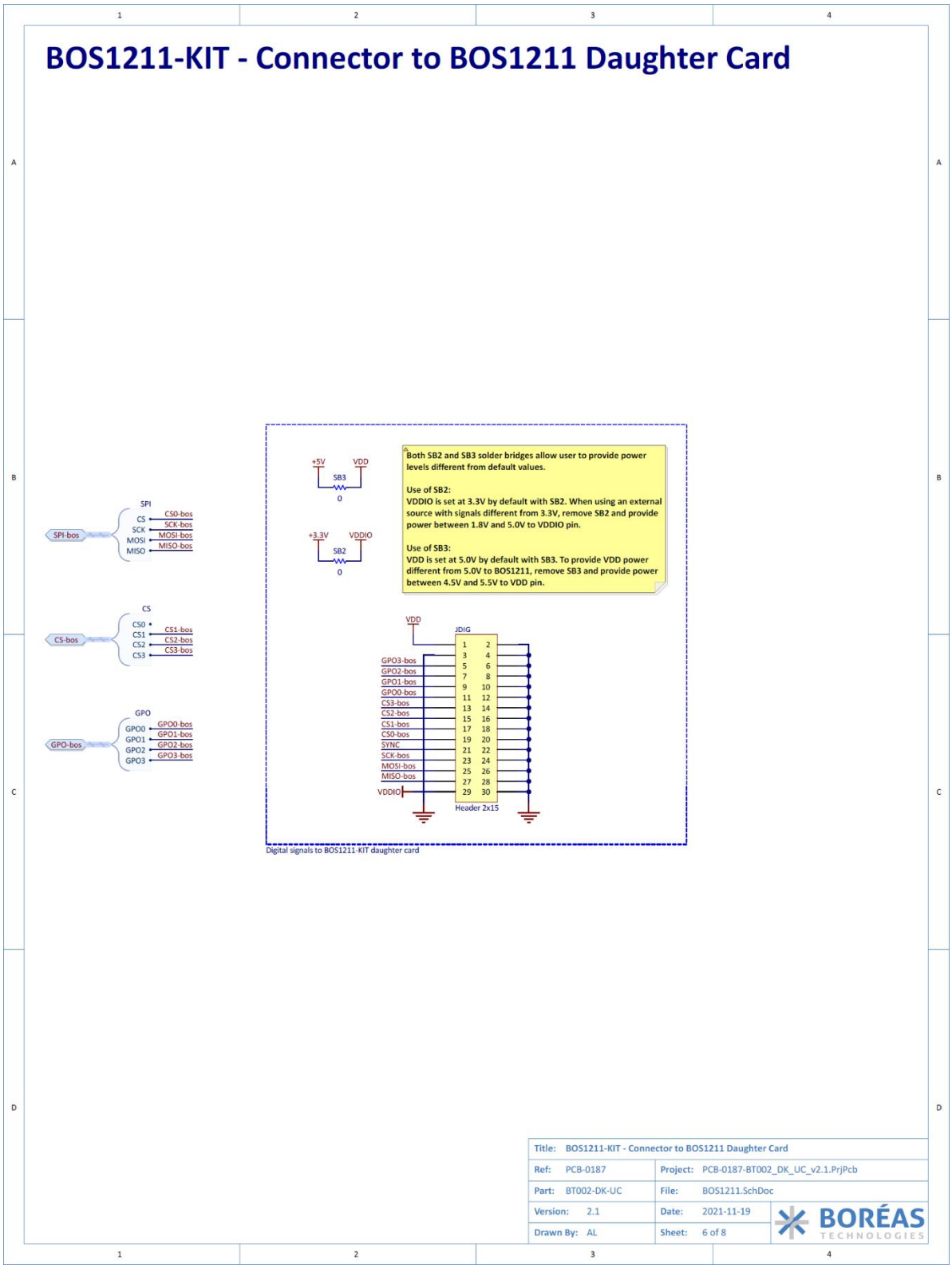


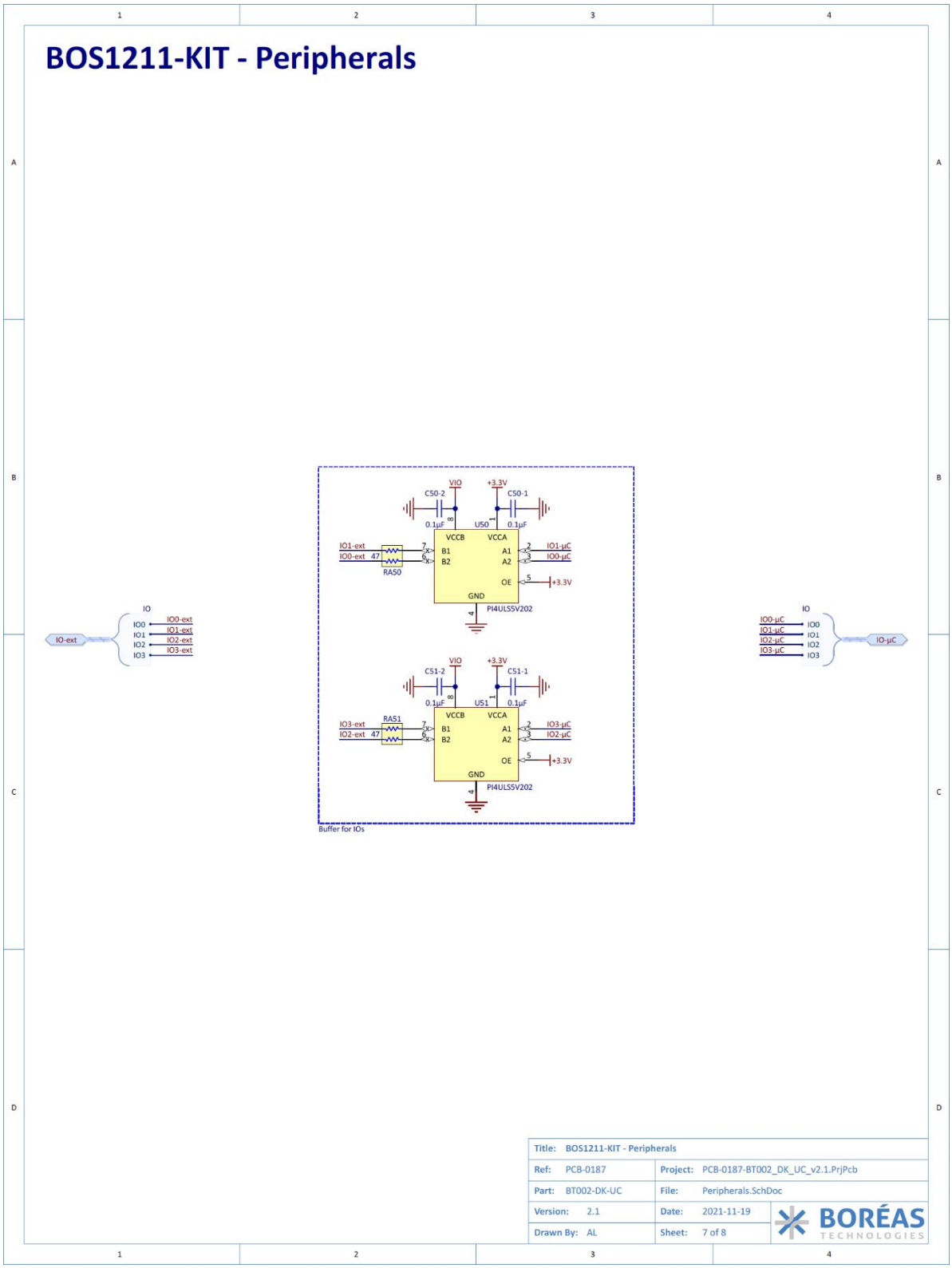
Regulator for 3.3V power

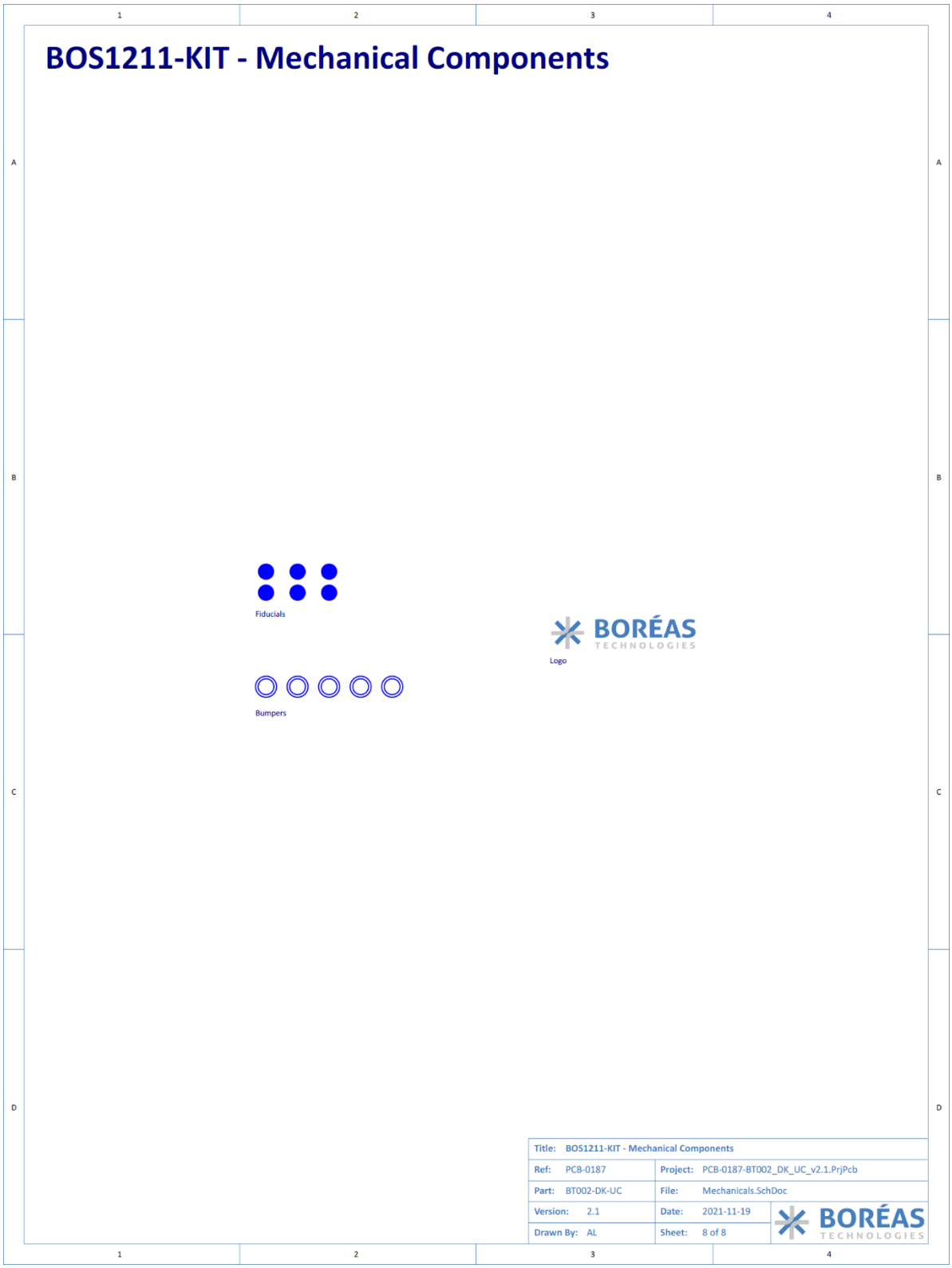
Title:	BOS1211-KIT - Power Management		
Ref:	PCB-0187	Project:	PCB-0187-BT002_DK_UC_v2.1.PrjPcb
Part:	BT002-DK-UC	File:	Power.SchDoc
Version:	2.1	Date:	2021-11-19
Drawn By:	AL	Sheet:	3 of 8



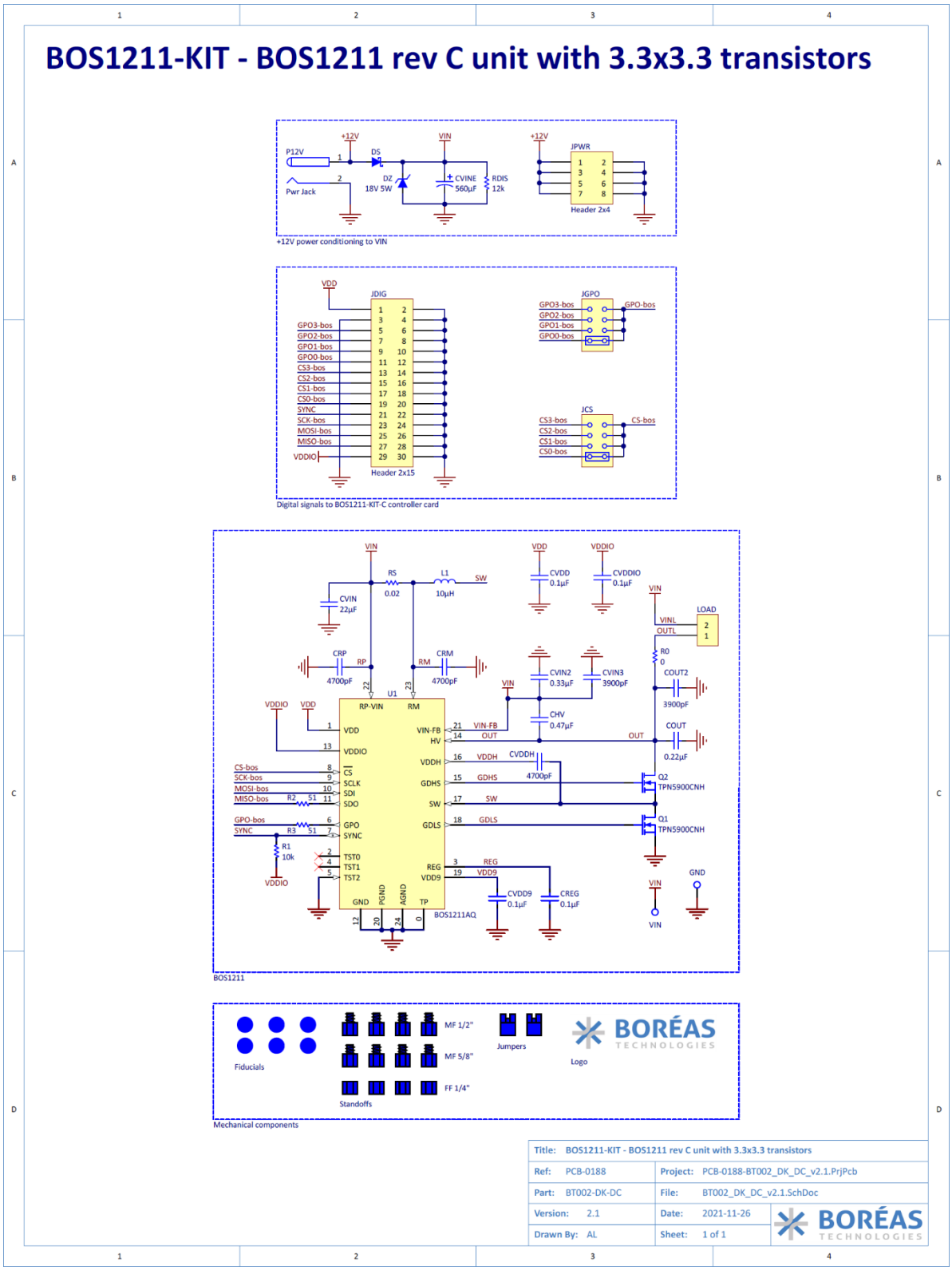








10.2 Schematics – Driver Board



10.3 PCB Layout – Controller Board

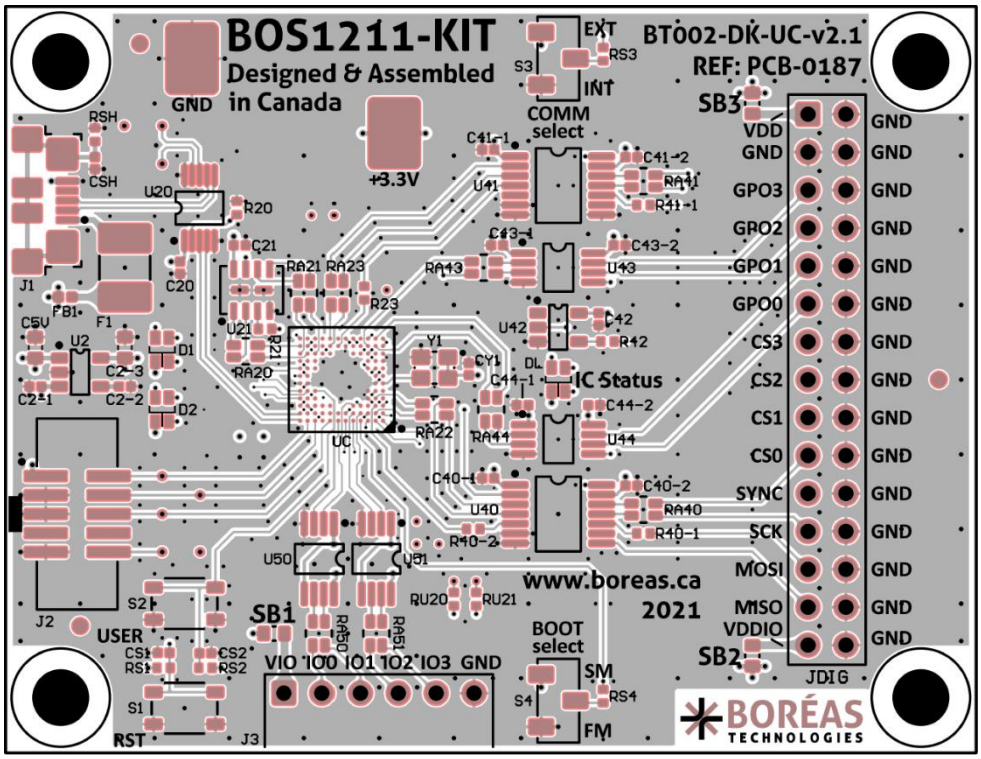


Figure 31: Layout view –Top (not to scale)

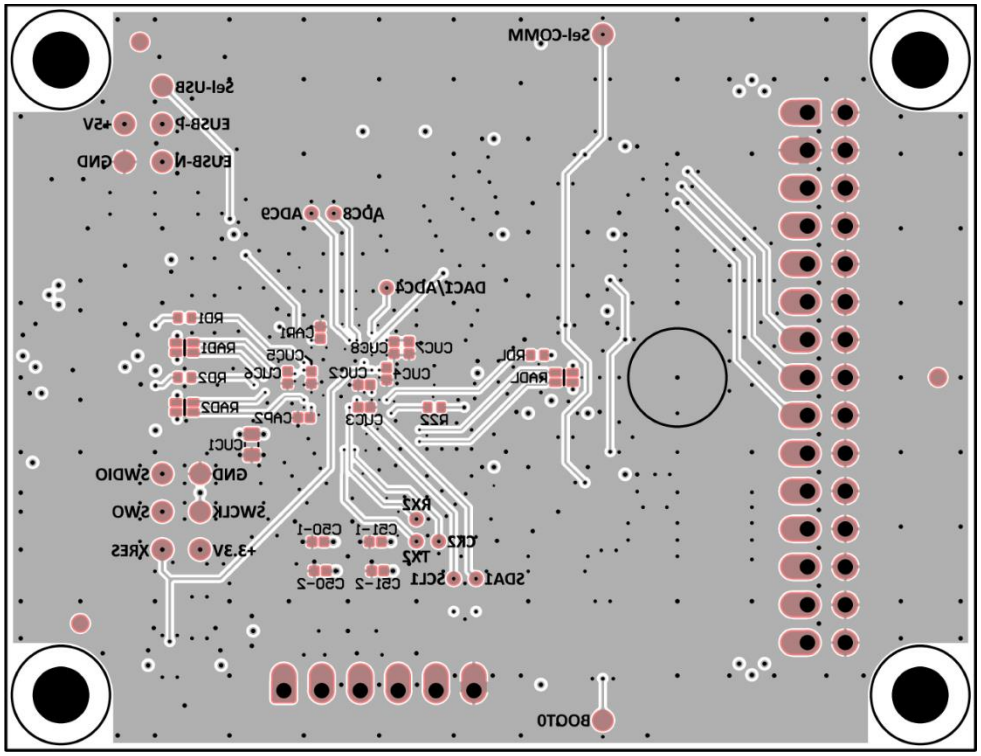


Figure 32: Layout view – Bottom (not to scale)

10.4 PCB Layout – Driver Board

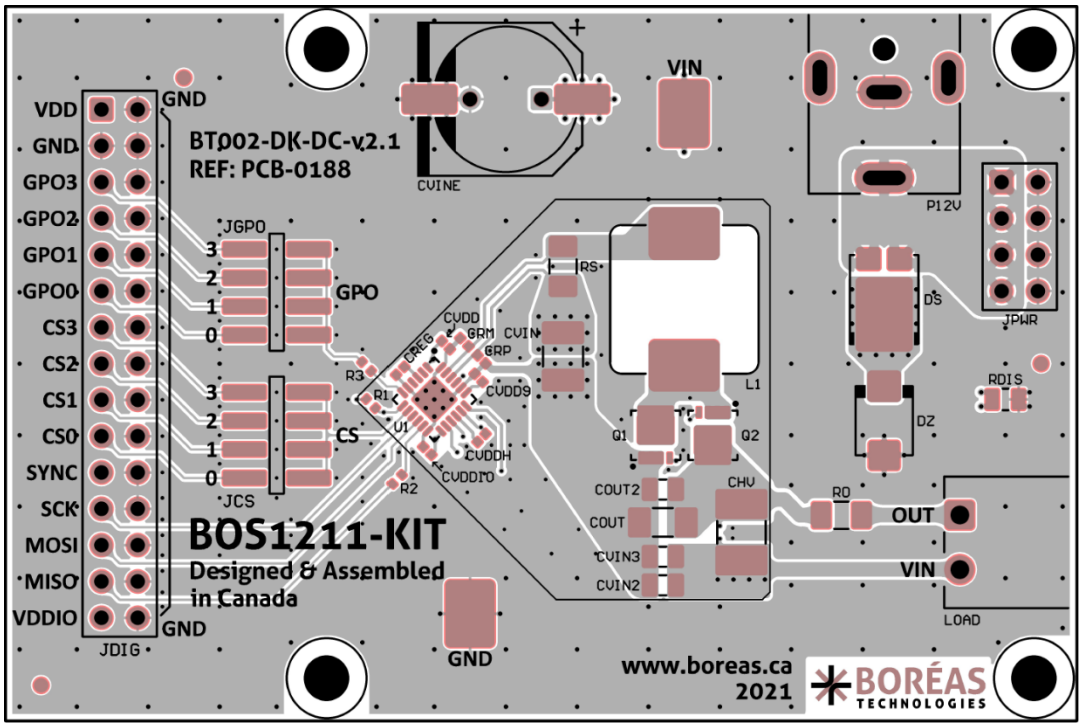


Figure 33: Layout view – Layer 1 – Top (not to scale)

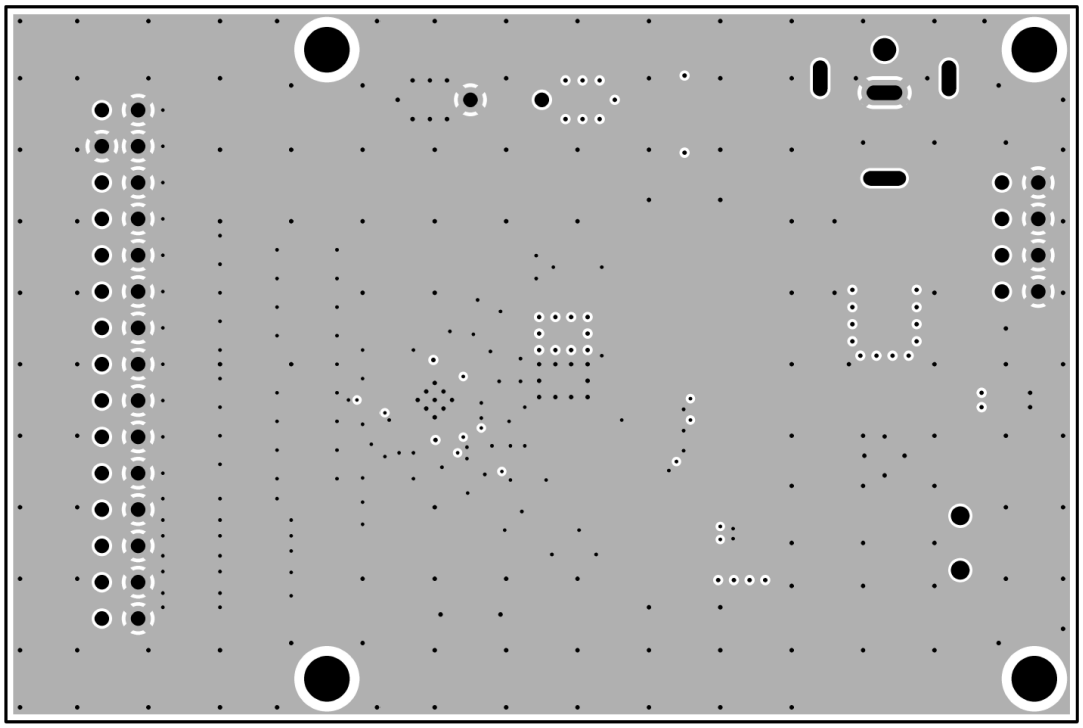


Figure 34: Layout view – Layer 2 – Ground (not to scale)

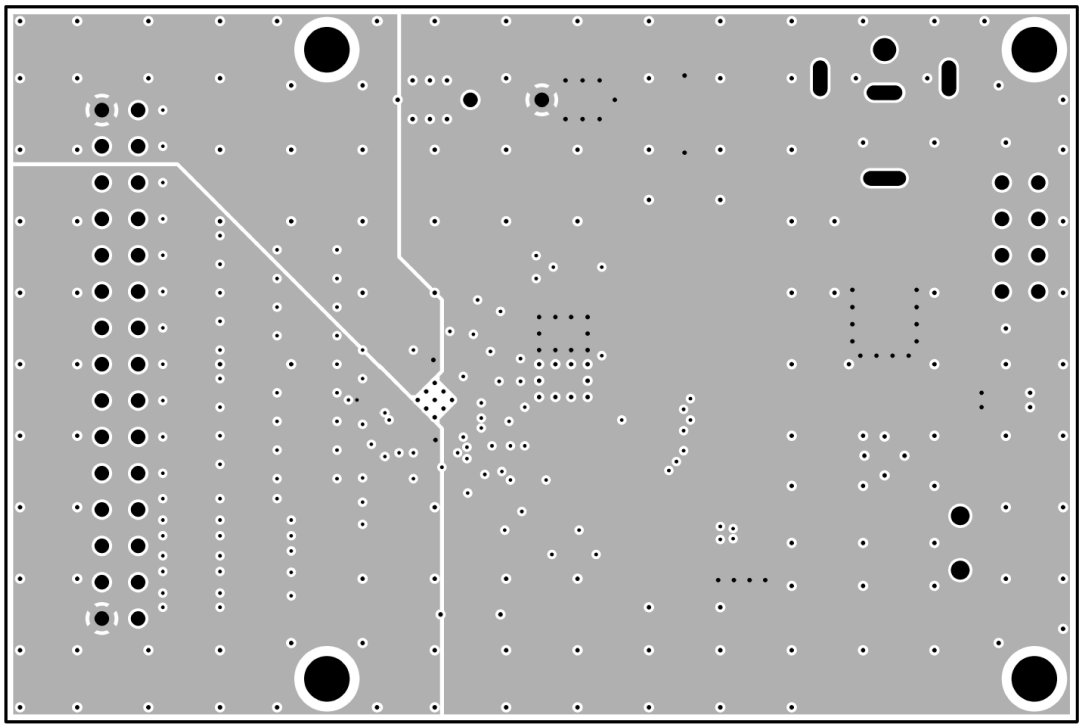


Figure 35: Layout view – Layer 3 – Power planes (not to scale)

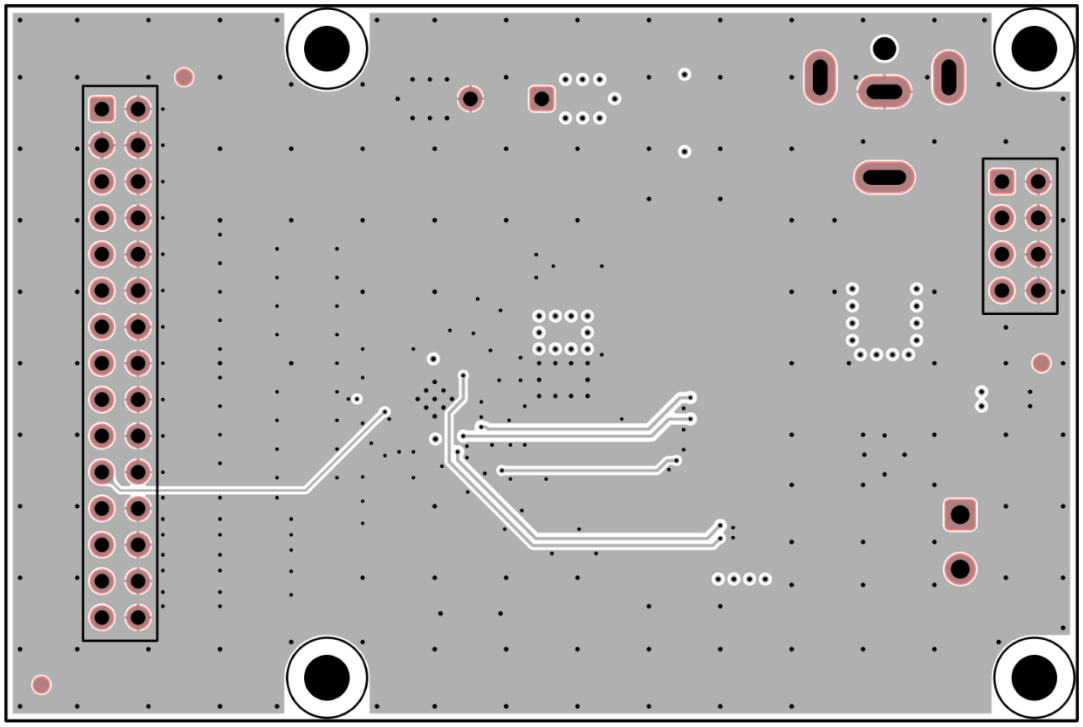


Figure 36: Layout view – Layer 4 - Bottom (not to scale)

10.5 Bill of Materials – Controller Board

The following is a list of the components that populate the controller board. Due to availability, some components with equivalent performance/characteristics may be installed on the actual PCB. If the exact part number is not available, the components can be replaced by ones with equivalent package and specifications.

Table 16: Bill of Materials for BOS1211-BRD-C02-B1

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
BUMP1, BUMP2, BUMP3, BUMP4, BUMP5	5	-	BUMPER CYLINDRICAL 0.25" DIA BLK	Keystone Electronics	783-B
C2-1, C20, C21, C40-1, C40-2, C41-1, C41-2, C42, C43-1, C43-2, C44-1, C44-2, C50-1, C50-2, C51-1, C51-2, CS1, CS2, CUC2, CUC3, CUC4, CUC5, CUC6, CUC8	24	0.1µF	CAP CER 0.1UF 25V X5R 0402	Taiyo Yuden	TMK105BJ104KV-F
C2-2, CY1	2	0.01µF	CAP CER 10000PF 50V X7R 0402	Taiyo Yuden	UMK105B7103KV-F
C2-3, C5V, CUC1	3	10µF	CAP CER 10UF 25V X5R 0603	Murata Electronics	ZRB18AR61E106ME01L
CAP1, CAP2	2	2.2µF	CAP CER 2.2UF 25V X5R 0402	Taiyo Yuden	TMK105CBJ225KV-F
CSH	1	330pF	CAP CER 330PF 250V C0G/NP0 0402	KEMET	C0402C331JAGACAUTO
CUC7	1	1µF	CAP CER 1UF 16V X5R 0402	TDK Corporation	CGB2A1X5R1C105K033BC
D1, D2, DL	3	-	LED RGB 0606 SMD	Dialight	5977715607F
F1	1	0.5A	PTC RESET FUSE 15V 500MA 1812	Schurter Inc.	PFMF.050.2
FB1	1	330	FERRITE BEAD 330 OHM 0402 1LN	Murata Electronics	BLM15PX331SN1D
J1	1	-	CONN RCPT USB2.0 MICRO B SMD R/A	Hirose Electric Co Ltd	ZX62R-B-5P(30)
J2	1	-	CONN HEADER SMD 10POS 1.27MM	CNC Tech	3221-10-0300-00-TR
J3*	1	-	CONN HEADER R/A 6POS 2.54MM	Würth Elektronik	61300611021
JDIG	1	-	CONN HEADER VERT 30POS 2.54MM	Würth Elektronik	61303021121

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
R20, R21, RS1, RS2, RS3, RS4	6	5.1k	RES SMD 5.1K OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ512X
R22, R23, R40-1, R40-2, R41-1, R42	6	51	RES SMD 51 OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ510X
RA20, RA21, RA22, RA23, RA40, RA41, RA43, RA44, RA50, RA51	10	47	RES ARRAY 2 RES 47 OHM 0606	Panasonic Electronic Components	EXB-V4V470JV
RAD1, RAD2, RADL	3	470	RES ARRAY 2 RES 470 OHM 0404	Panasonic Electronic Components	EXB-24V471JX
RD1, RD2, RDL, RU20, RU21	5	1.5k	RES SMD 1.5K OHM 5% 1/16W 0402	Yageo	AC0402JR-071K5L
RSH	1	1Meg	RES SMD 1M OHM 1% 1/16W 0402	Yageo	RC0402FR-071ML
S1, S2	2	-	SWITCH TACTILE SPST-NO 0.05A 16V	Würth Elektronik	434133025816
S3, S4	2	-	SWITCH SLIDE SPDT 100MA 6V	Nidec Copal Electronics	CAS-120TA
SB1, SB2, SB3	3	0	RES SMD 0 OHM JUMPER 1/10W 0603	Yageo	RC0603JR-070RL
TP3V3, TPGND3	2	-	PC TEST POINT COMPACT	Keystone Electronics	5016
U2	1	-	IC REG LINEAR 3.3V 300MA SOT23-5	STMicroelectronics	LDS3985M33R
U20	1	-	IC USB SWITCH DPDT 10MSOP	ON Semiconductor	FSUSB42MUX
U21	1	-	IC FLASH 16MBIT SPI/QUAD 8USON	Winbond Electronics	W25Q16JVUUIQ TR
U40, U41	2		IC BUF NON-INVERT 5.5V 14TSSOP	Nexperia USA Inc.	74LVC4T3144PW-Q10J
U42	1	-	IC INVERTER 1CH 1-INP SOT23-5	Texas Instruments	SN74LVC1G04DBVR
U43, U44, U50, U51	4	-	IC TRNSLTR BIDIRECTIONAL 8MSOP	Diodes Incorporated	PI4ULS5V202UEX
UC	1	-	IC MCU 32BIT 1MB FLASH 100UFBGA	STMicroelectronics	STM32F413VGH6
Y1	1	12 MHz	XTAL OSC XO 12.0000MHZ CMOS SMD	Kyocera International Inc. Electronic Components	KC2520Z12.0000C15XXK

* These components are not populated on the PCB, the proposed part numbers are for reference only.

10.6 Bill of Materials – Driver Board

The following is a list of the components that populate the driver board. Due to availability, some components with equivalent performance/characteristics may be installed on the actual PCB. If the exact part number is not available, the components can be replaced by ones with equivalent package and specifications.

Table 17: Bill of Materials for BOS1211-BRD-L02-B1

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
CHV	1	0.47µF	CAP CER 0.47UF 250V X7R 1812	TDK Corporation	C4532X7R2E474K230KA
COUT	1	0.22µF	CAP CER 0.22UF 250V X7T 1206	TDK Corporation	C3216X7T2E224K160AA
COUT2, CVIN3	2	3900pF	CAP CER 3900PF 250V C0G/NP0 0805	TDK Corporation	C2012C0G2E392J125AE
CREG, CVDD, CVDD9, CVDDIO	4	0.1µF	CAP CER 0.1UF 25V X7R 0402	Murata Electronics	GRM155R71E104KE14D
CRM, CRP, CVDDH	3	4700pF	CAP CER 4700PF 50V X7R 0402	Murata Electronics	GRM155R71H472KA01D
CVIN	1	22µF	CAP CER 22UF 25V X7R 1210	TDK Corporation	C3225X7R1E226M250AB
CVIN2	1	0.33µF	CAP CER 0.33UF 100V X7R 0805	AVX Corporation	08051C334KAT2A
CVINE	1	560µF	CAP ALUM POLY 560UF 20% 20V SMD	Nichicon	PCR1D561MCL1GS
DS	1	45V 10A	DIODE SCHOTTKY 45V 10A CFP15	Nexperia USA Inc.	PMEG45U10EPDZ
DZ	1	18V 5W	DIODE ZENER 18V 5W DO214AA	Micro Commercial Co	SMBJ5355B-TP
JCS, JGPO	2		CONN HEADER SMD 8POS 2MM	TE Connectivity AMP Connectors	2842143-4
JDIG	1		CONN RCPT 30POS 0.1 GOLD PCB	Samtec Inc.	SSQ-115-03-G-D
JP1, JP2	2		CONN JUMPER SHORTING GOLD BLUE	Keystone Electronics	M22-1910005
JPWR	1		CONN RCPT 8POS 0.1 GOLD PCB	Samtec Inc.	SSQ-104-03-G-D
L1	1	10µH	FIXED IND 10UH 8.5A 32 MOHM SMD	Bourns Inc.	SRP1038C-100M
LOAD	1		TERM BLOCK HDR 2POS 90DEG 3.81MM	Molex	0395121002
MH1, MH2, MH3, MH4	4		HEX STANDOFF #4-40 ALUMINUM 1/2"	RAF Electronic Hardware	4505-440-AL-7
MH5, MH6, MH7, MH8	4		HEX STANDOFF #4-40 ALUMINUM 5/8"	RAF Electronic Hardware	4507-440-AL

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
MH9, MH10, MH11, MH12	4		3/16 HEX X 1/4 LENGTH	RAF Electronic Hardware	2053-440-AL
P12V	1		CONN PWR JACK 2X5.5MM SOLDER	CUI Devices	PJ-063AH
Q1, Q2	2		MOSFET N-CH 150V 9A 8TSON	Toshiba Semiconductor and Storage	TPN5900CNH,L1Q
R0	1	0	RES 0 OHM JUMPER 1/2W 1206	YAGEO	RC1206JR-7W0RL
R1	1	10k	RES 10K OHM 5% 1/8W 0402	YAGEO	RC0402JR-7W10KL
R2, R3	2	51	RES SMD 51 OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ510X
RDIS	1	12k	RES SMD 12K OHM 5% 1/2W 0805	Panasonic Electronic Components	ERJ-P06J123V
RS	1	0.02	RES 0.02 OHM 1% 1W 1206	Ohmite	LVT12R0200FER
TPGND, TPVIN	2		PC TEST POINT COMPACT	Keystone Electronics	5016
U1	1		PIEZO HAPTIC DRIVER 120V	Boreas Technologies	BOS1211AQ

* These components are not populated on the PCB, the proposed part numbers are for reference only.

11 FAQ and Troubleshooting

Please refer to Boréas website for FAQ and Troubleshooting information, which will be maintained throughout the BOS1211-KIT lifecycle. It will also contain application note documents that will be helpful for the user writing his/her own code to operate the BOS1211.

12 Notice and Warning

Danger High Voltage!

Electric shock possible when connecting board to live wire. Board should be handled with care by a professional. For safety, use of isolated test equipment with overvoltage and/or overcurrent protection is highly recommended.

This product uses semiconductors that can be damaged by electrostatic discharge (ESD). When handling, care must be taken so that the devices are not damaged. Damage due to inappropriate handling is not covered by the warranty.

The following precautions must be taken:

- Do not open the protective conductive packaging until you have read the following and are at an approved anti-static workstation.
- Use a conductive wrist strap attached to a good earth ground.
- If working on a prototyping board, use a soldering iron or station that is marked as ESD-safe.
- Always disconnect the microcontroller from the prototyping board when it is being worked on.
- Always discharge yourself by touching a grounded bare metal surface or approved anti-static mat before picking up an ESD - sensitive electronic component.
- Use an approved anti-static mat to cover your work surface.

Oscilloscope measurements:

The piezoelectric actuator is connected between OUT and VIN. When measuring these signals using an oscilloscope, use a separate probe on each node. Never connect the ground of a probe to one of the actuator terminals. Doing so might damage the BOS1211-KIT and/or your oscilloscope.

13 Ordering Information

Table 18: Ordering information

	Orderable Device	Package	Packing Format	Standard Quantity	ACTUATORS	ROHS Compliant
1	BOS1211-KIT-A02 (Premium Set)	Controller Board 65x50 mm Driver Board 75x50 mm	Box ($6^{3/4}$x$6^{1/4}$x$1^{1/4}$)”	1 controller board 2 driver boards 2 Actuators	TDK PowerHap™: 1313H018V120 6005H080V120	Yes
2	BOS1211-KIT-X02 (Basic Set)	Controller Board 65x50 mm Driver Board 75x50 mm	Box ($6^{3/4}$x$6^{1/4}$x$1^{1/4}$)”	1 controller board 1 driver board	None	Yes
3	BOS1211-KIT-D02 (Driver Board)	Driver Board 75x50 mm	Box ($6^{3/4}$x$6^{1/4}$x$1^{1/4}$)”	1 driver board	None	Yes

14 Document History

ISSUE	DATE	Document Number	CHANGES
7	February 2023	BT002CDK01.02	Power on and off sequences.
6	January 2022	BT002CDK01.01	Major hardware changes. New kit content. Updated GUI interface.

Appendix A. Button Emulation: Sensing Algorithm

The purpose of this section is to provide more details about the algorithm used for the detection of press and release events on the piezoelectric actuator. The parameters of the graphical user interface are represented in this diagram in italics.

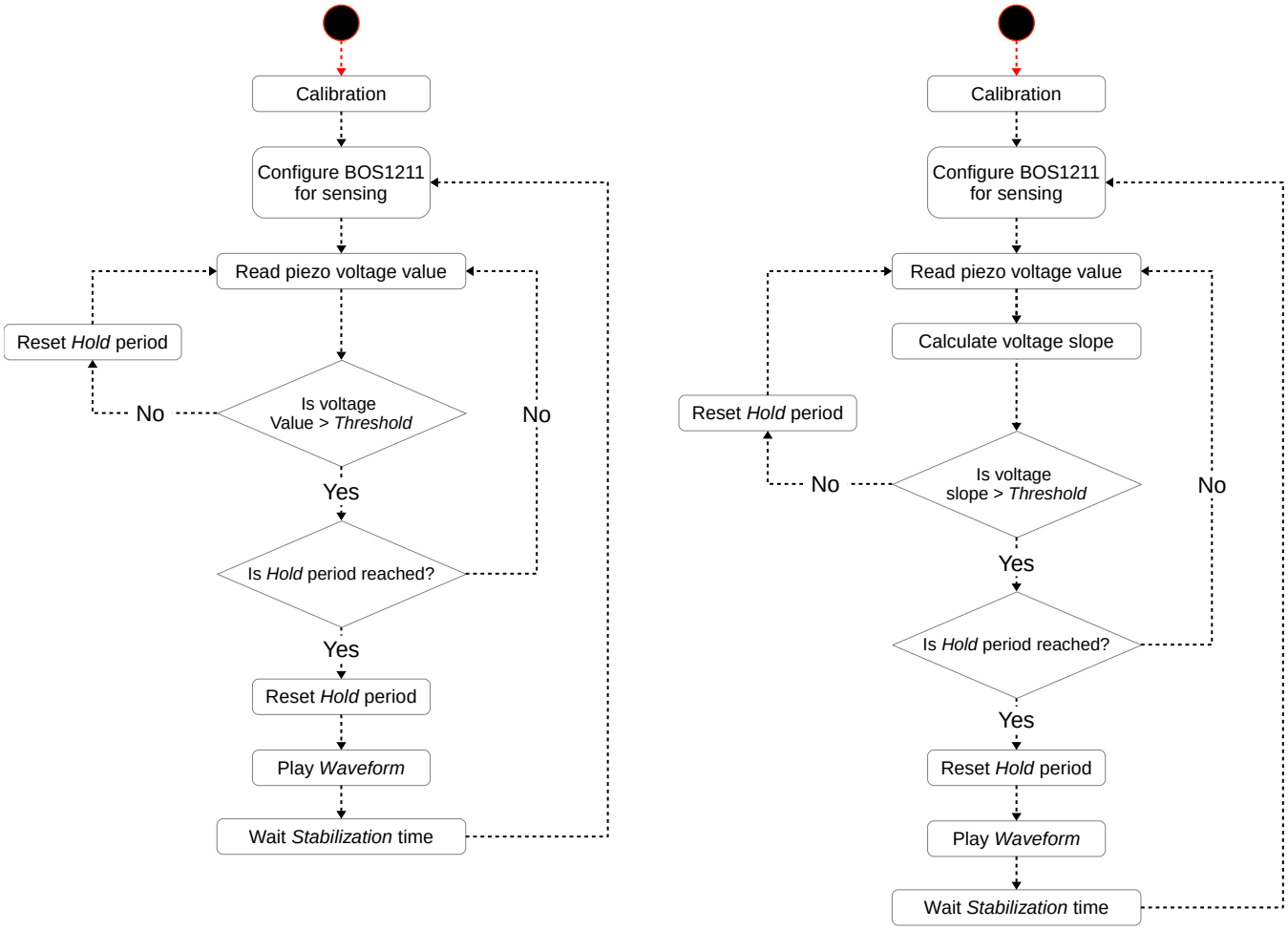


Figure 37: Threshold (left) and slope (right) sensing algorithm flow charts

This image shows the differential voltage between both terminals of the piezoelectric actuator during a press event and feedback. On this scale it is impossible to see the details of the press event because it occurs at much lower voltages and over a longer period.

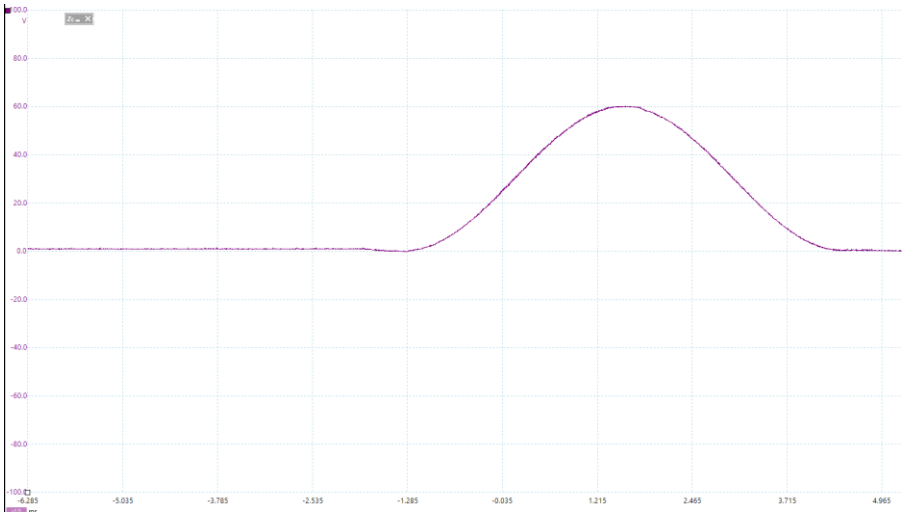


Figure 38: Sensing algorithm: differential voltage across the actuator

In the following capture, the voltage was scaled down to a few volts and the timescale increased so it is possible to see the increase in voltage caused by the force applied on the piezo actuator. We can see where the various parameters of the algorithm apply. Here is an example with 1.2 V threshold and 20 ms hold time:

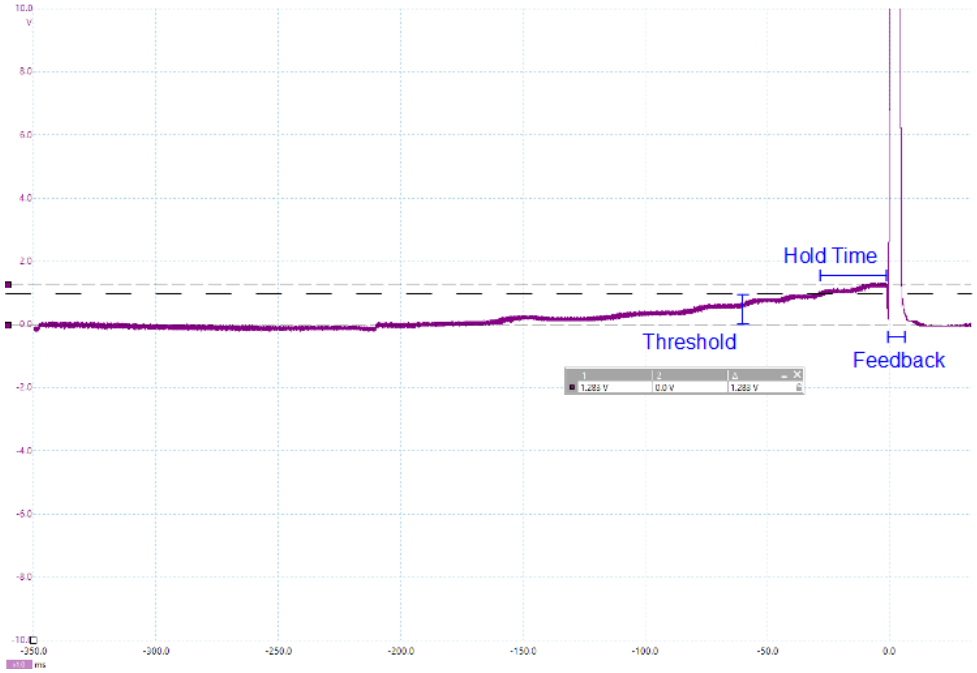


Figure 39: Sensing algorithm: threshold, hold time and feedback.

After the feedback, there is a stabilization phase. In constant stabilization, the output of the BOS1211 is maintained at a fixed voltage for a period of time. Here is an example:

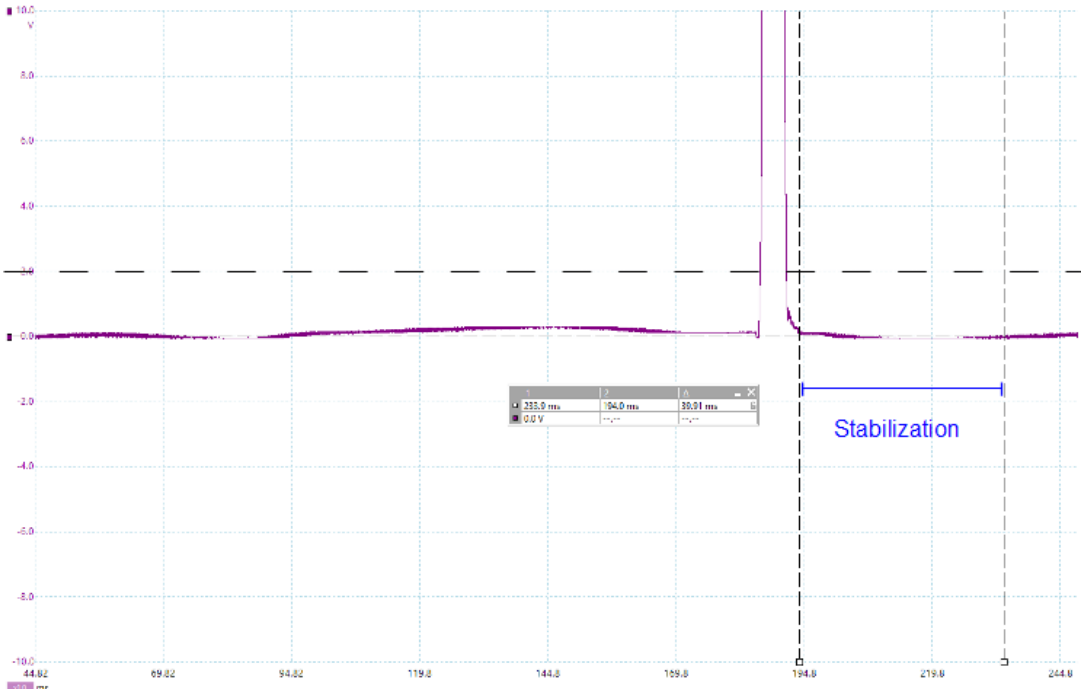


Figure 40: Sensing algorithm: constant stabilization (40 ms, 0 mV)

Appendix B. Firmware Upgrade using STM32CubeProgrammer

The BOS1211-KIT board supports a standard USB endpoint named "Device firmware upgrade" (DFU). This endpoint is used to transfer firmware to the development kit using the USB port and a DFU transfer software. To advertise the DFU endpoint on the USB port, the BOS1211-KIT board microcontroller needs to execute DFU application in the system memory. The boot selection switch allows to select the system memory.

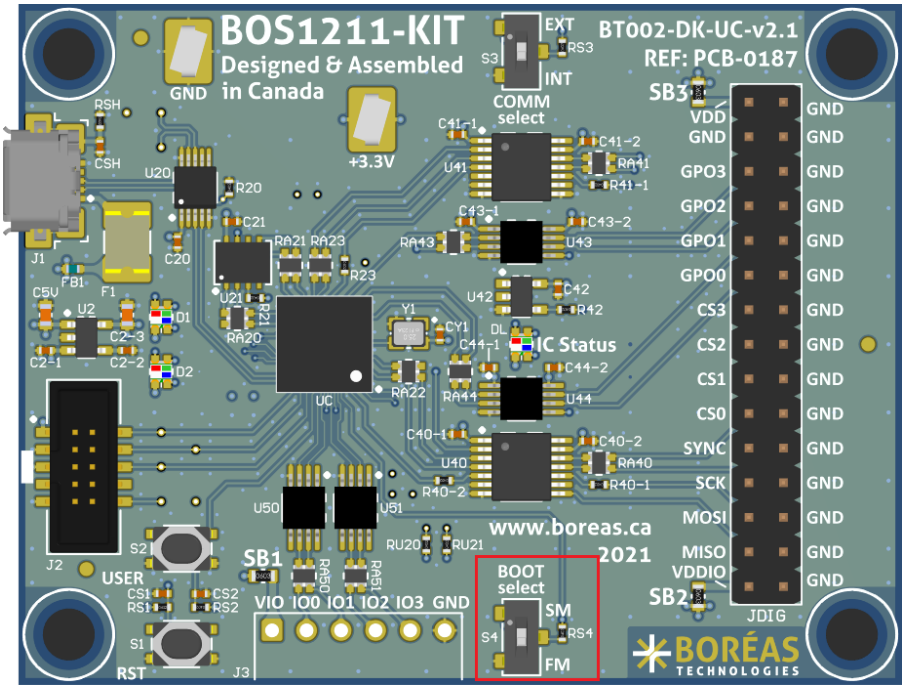


Figure 41 : Boot selection switch position

Prerequisites

1. Download STM32CubeProgramme using this link and follow web page instruction.
2. Install STM32CubeProgrammer.
3. Move the Boot Select switch in System Memory (SM) position.
4. Connect the BOS1211-KIT board to a PC using a USB cable.
5. Start SMT32CubeProgrammer.
6. Reset the BOS1211-KIT board using the RST button.
7. Have the appropriate firmware binary file (.hex) handy. The firmware compatible with the Software are located in the installation directory (C:\Program Files (x86)\Boréas Development Kit\firmware). Older firmware revisions can be downloaded on the Boréas website.

Procedure

1. Select *USB* connection mode in the drop box.
2. Refresh the *Port* list using the button: 
3. Select USB1 port in the *Port* drop box. (Note: If more than one development kit are connected on the same PC the *Port* drop box will contains more than one entry. USB1 may not be the right device.)
4. Click on *Connect* button.

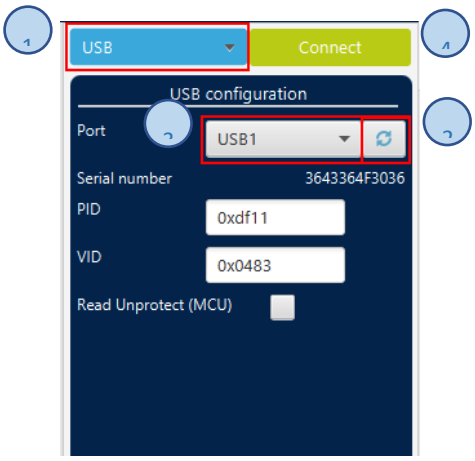


Figure 42: STM32CubeProgrammer connection setting

5. Click on this icon  on the left side of the interface to open the *Erase & Programming* panel.
6. Enter the path to the firmware file (.hex) into the *File Path* text field.
7. Check the *Verify programming* checkbox.
8. Click on *Start Programming* button.

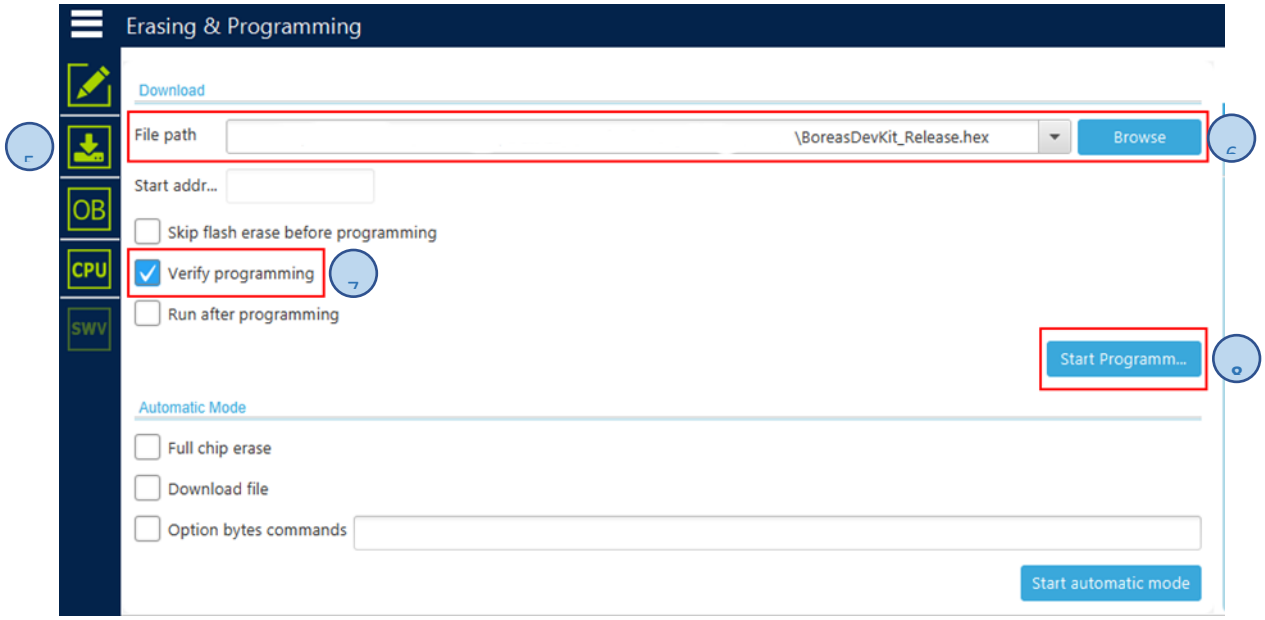


Figure 43: STM32CubeProgrammer programming setting

9. Wait the pop-up message indicating the upgrade completion.

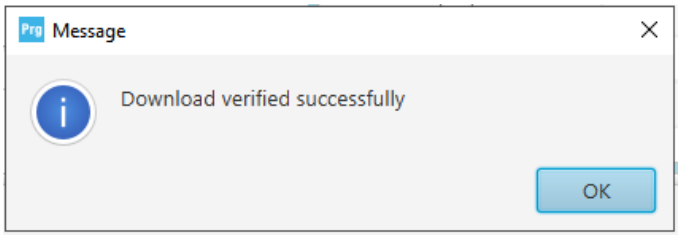


Figure 44: STM32CubeProgrammer upgrade completed dialog.

10. Move the Boot Select switch in Flash Memory (FM) position.

11. Reset the development kit using the RST button.

Appendix C. Audio Mode using Audacity® Software

This appendix explains how Audacity® software can be used to create and play waveforms on the BOS1211-KIT.

C.1 Software Installation Procedure

Audacity is free of use and can be found at: link

Please follow the Audacity® installation procedure.

Refer to https://www.audacityteam.org/about/license/ for the terms of GNU General Public License (GPL) for Audacity® use.

dc-offset Plugin Installation (optional)

This plugin will be useful to create waveforms for unipolar piezo actuators or for piezo actuators that have an asymmetrical voltage range (like the TDK piezo supplied with the kit).

1. Download the plugin: link.
2. Install the plugin downloaded using the Nyquist Plug-in Installer.

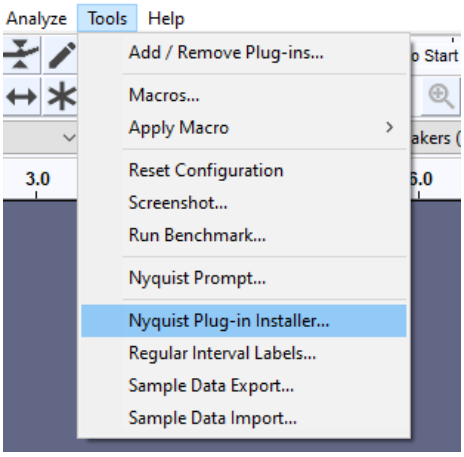


Figure 45: dc-offset plugin installation

3. Ensure the plugin is enabled.

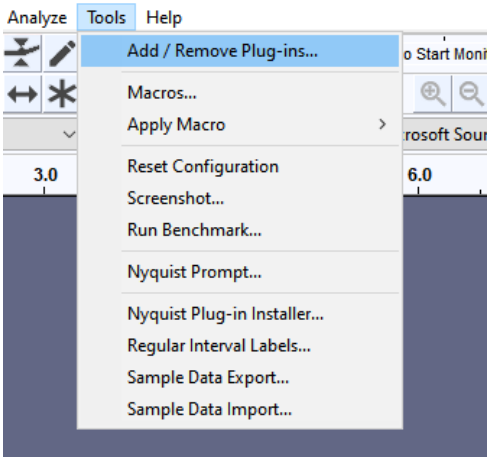


Figure 46: Access plugin management window

4. Select dc-offset in the plugin list and click on *Enable* button, then click on *OK*.

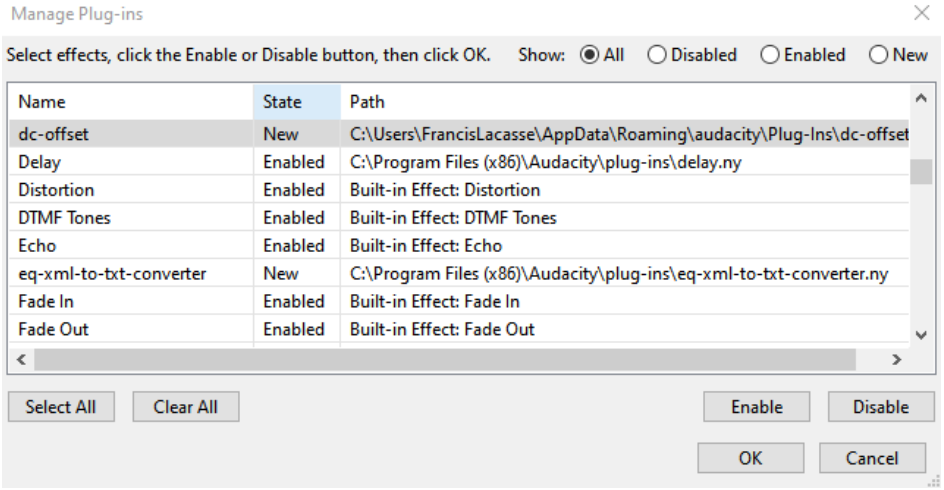


Figure 47: Plugin management window

C.2 Use Audacity to Play WAV Files

Description

Download waveform samples from Boréas website and use Audacity® to play them on the BOS1211-KIT.

Prerequisites

- BOS1211-KIT board is in *Audio* mode. Refer to section 8.5.2 for more information regarding *Audio* mode.
- Using the BOS1211-KIT software, user has configured the audio limiting settings of the board (see details here)
- Download the waveform examples from the Boréas web site (link)

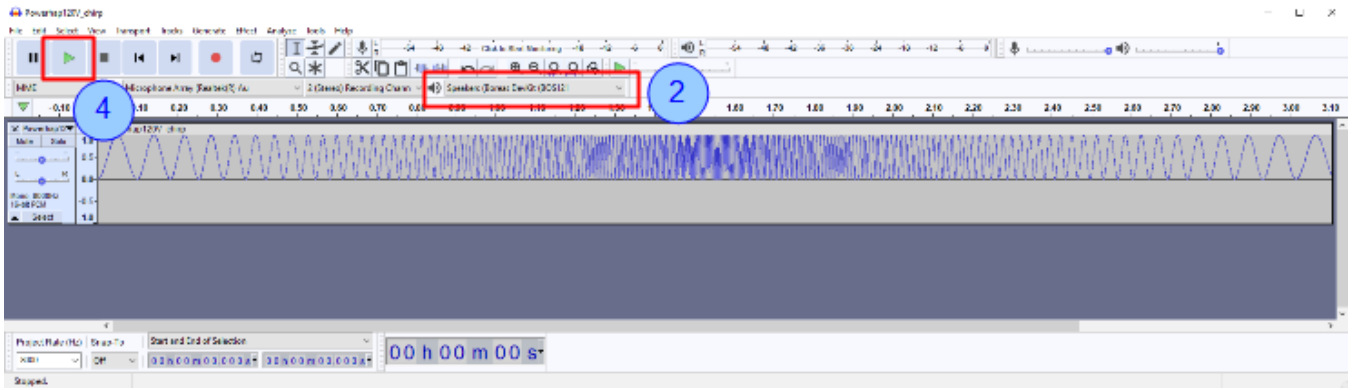


Figure 48: Use audacity to play a WAV file

Steps

1. Start Audacity software.
2. Select the Speakers (Boreas DevKit) from the playback device selection menu.
   If the Boreas DevKit is not shown in the list, validate that the device kit in in audio mode and that it is connected to the PC. Then from the Audacity menu, click on *Transport / Rescan Audio Devices*.
3. Drag the desired WAV file (Ex: Powerhap120V_chirp.wav) into Audacity to add a new audio track.
4. Press the play button to start playing the waveform on the piezo actuator.

C.3 Use Audacity and dc-offset Plugin to Create a New Waveform.

Description

In this example, we explain how Audacity can be used to create a new sinusoidal waveform in the range of the TDK piezo supplied with the kit (-20 V to 120 V).

In this example the waveform parameters are:

- Amplitude peak to peak = 120 V
- Piezo Vmax = 90 V
- Piezo Vmin = 0 V
- Frequency = 110 Hz
- Duration = 1 sec

Prerequisites

- BOS1211-KIT board is in audio mode. Refer to section 8.5.2 for more information regarding *Audio* mode.
- The audio limiting settings of the board are properly configured (Details section 8.5.2.2)
- Audacity and the dc-offset plugin are installed.

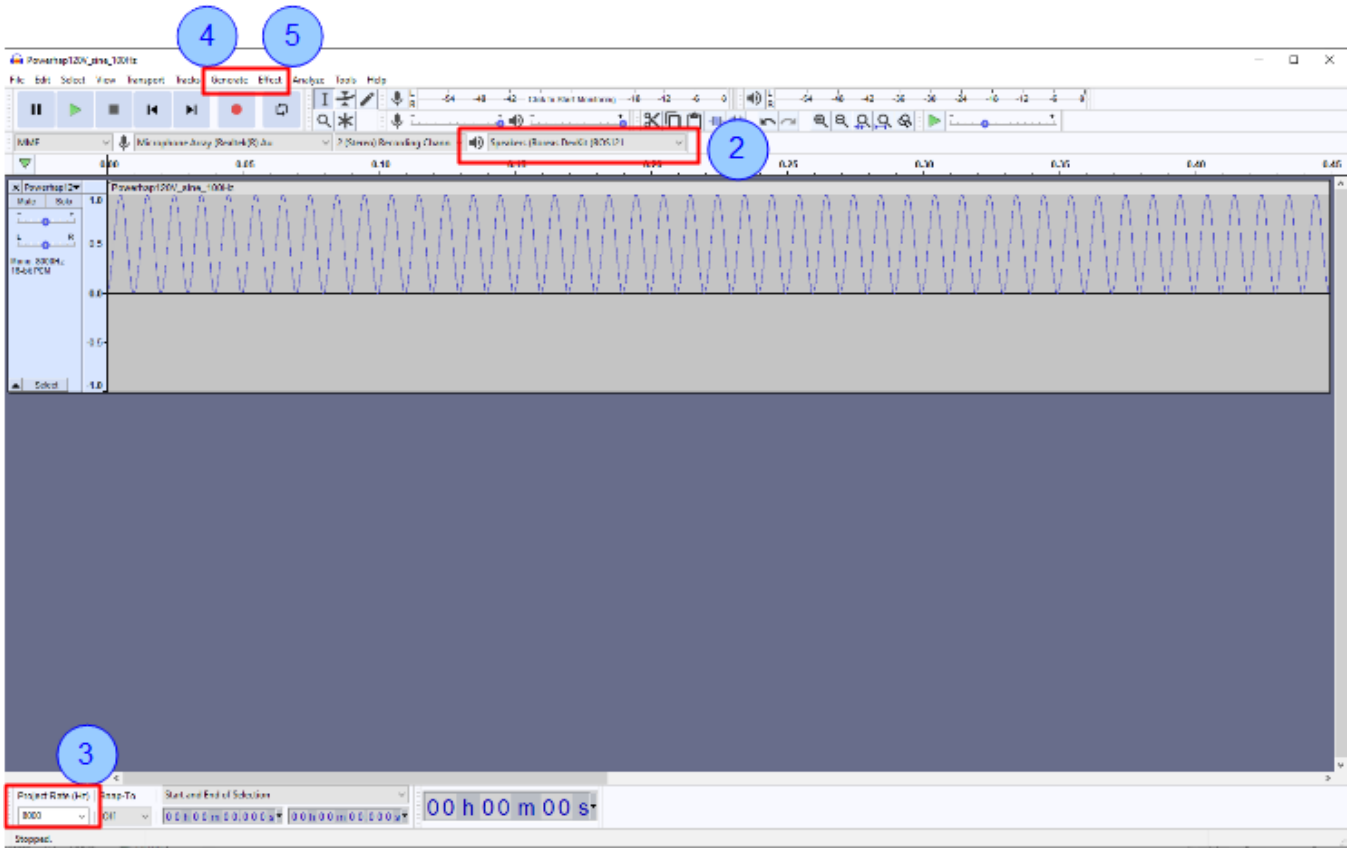


Figure 49: Audacity – simple waveform creation

Steps

1. Open Audacity.
2. Select the Speakers (Boreas DevKit) from the playback device selection menu.
3. In the bottom left corner of Audacity, set the project rate to 8000 Hz.
4. In the application menu, select the Option “Generate / Tone”.
   To create the waveform with the parameters mentioned in the description, use the following tone values:

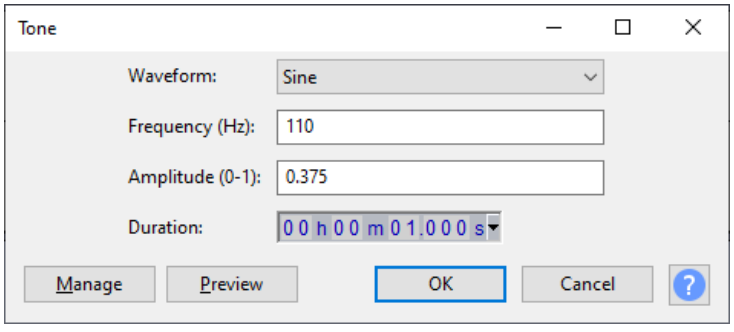


Figure 50: Tone parameters

The amplitude value is calculated with the following formula:

$$\text{Amplitude} = \frac{\text{Peak to Peak Amplitude}}{\textit{Boreas IC amplitude max}} => \frac{(90)\ \text{V} - (0)\ V}{2{\times}120\ V} => 0.375$$

5. Use dc-offset plugin to offset the signal in the piezo range:
   Offset computation:

$$\text{Offset} = \frac{\text{Piezo } Vmax + \text{Piezo } Vmin}{Boreas\ IC\ amplitude\ max} => \frac{(90)\ \text{V} + (0)\ V}{2{\times}120\ V} => 0.375$$

   From the application menu, select *Effect / DC offset…* and enter the value calculated above.

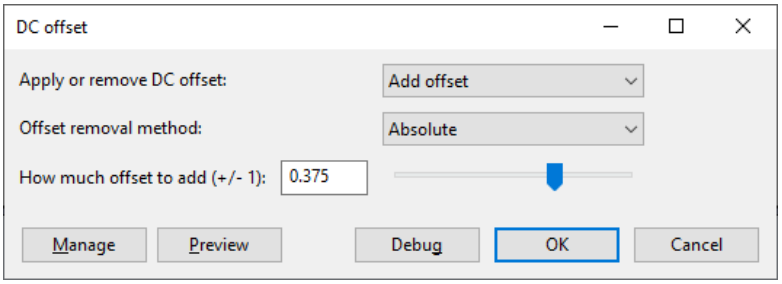


Figure 51: Add dc-offset

6. Play the wave using the play button.

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