BOS1921 Development Kit

1 Features

- Plug and play development kit to experience piezoelectric actuator button and haptic feedback.
- Low-power BOS1921 integrated circuit, high voltage driver with I3C/I2C digital interface.
- Power supply via the USB port.
- Graphical user interface for ease of use.
- Standard USB audio to prototype haptic effects in MATLAB®, Python®, Audacity® and many other softwares[1].
- Easy generation of high-voltage waveforms up to 190 Vpp.
- Two channel outputs for interchangeable miniature PCBs with BOS1921 drivers for prototyping.

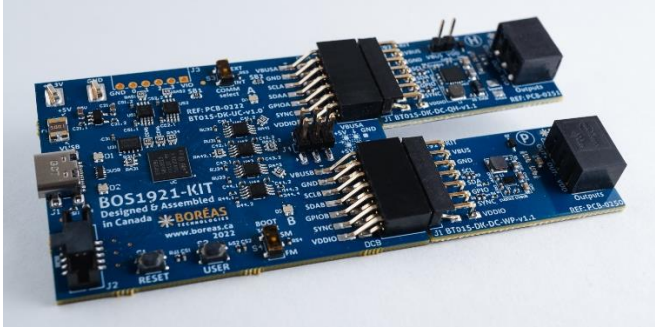


Figure 1: BOS1921-KIT overview

2 Description

The BOS1921-KIT is a development kit to get familiar with the BOS1921 Piezo Haptic Driver IC.

The USB-powered kit appears as an USB Audio device for 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.

The interchangeable miniature PCBs give access to all signals allowing the users to experiment with the BOS1921 using a development platform of their choice.

Most commercial piezo actuators can be used with this kit. Capacitor loads are also provided to test output capabilities.

Table 1: Product information

PART NUMBER	DESCRIPTION
BOS1921-KIT-B01	Starter Set: includes a haptic and a micropump driver boards, and 4 load capacitors.

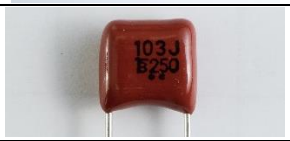
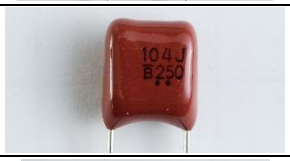
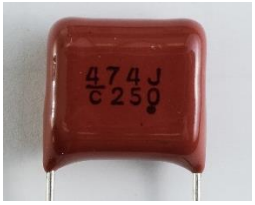
For details see sections 3 and 13.

[1] 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 BOS1921-KIT is currently available in one package: *Starter Set*. The following tables show the content of the set.

*Table 2: **Starter Set BOS1921-KIT-B01** development kit content*

#	ITEM	QTY	DESCRIPTION	REFERENCE
1	Controller Board	1	BOS1921-BRD-C01 Controller Board	
2	Driver Board Haptic	1	BOS1921-BRD-L01 Driver Board optimized for larger loads such as haptic.	
3	Driver Board Pump	1	BOS1921-BRD-S01 Driver Board optimized for smaller loads such as micropumps.	
4	USB-C Cable	1	Cable to connect the evaluation PCB to a computer Adafruit Industries LLC part number 4473	
5	Capacitor	1	10 nF film capacitor Panasonic ECQ-E2103JB	
6	Capacitor	1	47 nF film capacitor Panasonic ECQ-E2473JB3	
7	Capacitor	1	100 nF film capacitor Panasonic ECQ-E2104JB3	
8	Capacitor	1	470 nF film capacitor Panasonic ECQ-E2474JB	

#	ITEM	QTY	DESCRIPTION	REFERENCE
9	3-position terminal block connector	2	Male connector used for interfacing the piezoelectric actuator on the board. Metz Connect part number 31369103	
10	6-position thru-hole header connector	1	2.54 mm pitch header connector for connection to external system (J3 connector on PCB). Würth Electronik part number 61300611021 (6-pin) or equivalent.	

4 Board Overview

The purpose of this section is to show the location of the components that allow you to interact with the BOS1921-KIT board. This section is in a way the definition of the user interface provided by the development board. The focus is on buttons and LEDs which allow you to know and modify the current operating state.

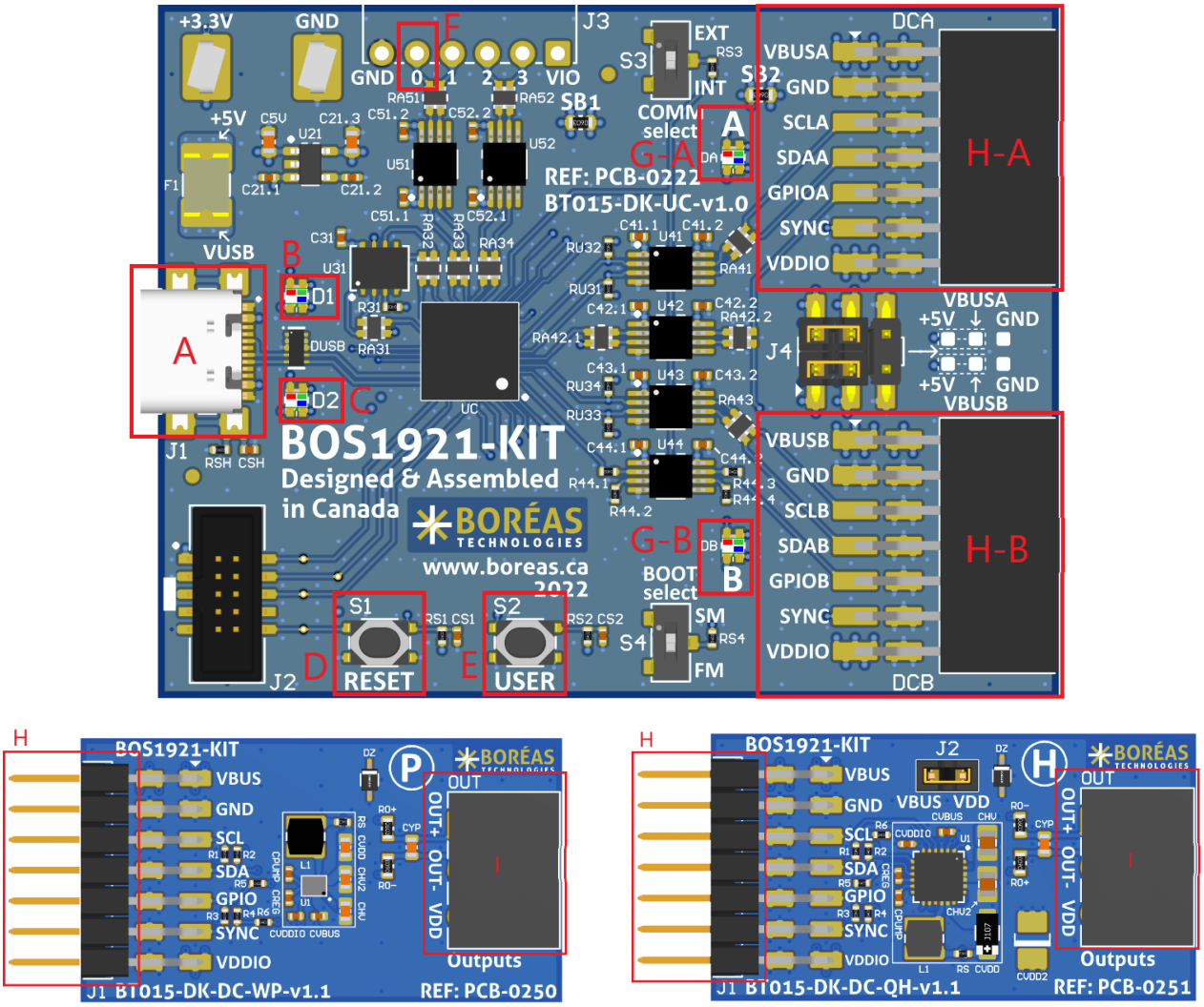


Figure 2: BOS1921-KIT board user interface

Table 3: BOS1921-KIT board user interface

Components	Name	Description
A	USB connector	Supply power and provides connectivity with the GUI.
B	Operation mode LED	Flashing if alive and color shows the current operation mode.
C	Devkit error LED	Flashing if an error is detected on any component of the devkit
D	Reset button	Reset the micro-controller on press.
E	Change operation mode button	Change the current operation mode on press.
F	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	BOS1921 A/B status LED	LEDs displaying the current state of the BOS1921.
H	BOS1921 A/B board interface	Interface connector between controller and driver boards.
I	BOS1921 A/B terminal block	Terminals where piezoelectric actuator are connected.

4.1 Operation Mode LED Details

This section describes the meaning of the different colors and state transitions of the operation mode LED.

Table 4: 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.
1 second on, 1 second off	Purple	In flash mode and working normally (Operation mode not documented)

Any other pattern or color behavior maybe caused by unofficial firmware or bug.

4.2 BOS1921 Status LED Details

This section describes the meaning of the different colors and state transitions of the BOS1921 LED. The two BOS1921 of the BOS1921-KIT board are monitored to validate the presence of an internal error. If an error is detected, the BOS1921 Error 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 5: BOS1921 error LED details

Pattern	Color	Description
Always off	N/A	No error detected on any BOS1921.
Always on	Red	At least one internal error has been detected by a BOS1921.
Always on	Green	IC operate as button and the button is in released state. When the led turn off, the button is in pressed state.
Always on	Blue	When the LED is blue, the microcontroller requested a haptic feedback to the BOS1921.

5 Quick-Start

The BOS1921 and a piezoelectric actuator can be used together to implement the equivalent of a button. Before being shipped, the BOS1921-KIT board is set up in this button mode, so that you can experience it without additional extensive configuration or software installation. If you have an actuator such as TDK 1204, you can use it directly. Otherwise, the capacitors included in the kit can be used to test the BOS1921-KIT.

1. Open the box, take the BOS1921-KIT board, the USB cable, the small driver boards, the terminals block plugs, and either a piezo actuator or a capacitor.
2. Insert one or both the driver boards into the controller board.
3. Insert the terminal block plugs into the driver board(s) terminal block.
4. Using a small slotted screwdriver, install a piezoactuator on the terminal block plugs. **Pay attention to connect the positive wire on the OUT+ terminal and the negative wire on the OUT- terminal**. Refer to Figure 2 to identify location of OUT+ and OUT- on the terminal block.
5. Connect the development kit board to a USB port using the USB cable.
6. When the operation mode green LED is blinking and BOS1921 A/B status LED are solid green, you are ready to go.
7. If using a piezo actuator : press on the piezo actuation to experience the piezo actuator button.
    a. If using a capacitor: either press the USER button on the board to set the board to *Audio* mode and use an audio software to play waveforms (see section 8.5.2), or install the GUI software to interact with the board (see section 8).

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 BOS1921-KIT Board 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.

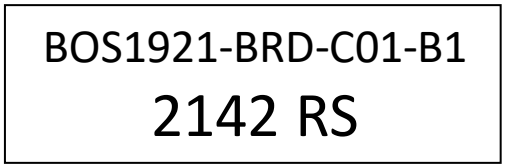


Figure 3: Label example giving board part number with BOM revision suffix, and assembly code

Table 6: BOS1921-KIT board and software compatibility list

BOARD P/N*	PCB REFERENCE	COMPATIBLE FIRMWARE	COMPATIBLE PC SOFTWARE
BOS1921-BRD-C01-B1	PCB-0222 BT015-DK-UC-V1.0	BOARD_PCB_222_B1_DEVKIT-{VERSION}.hex Version starting at 1.15.x	Starting at 2.13.x

** Board P/N include BOM revision suffix*

Any PCB reference design number not listed into Table 6 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) Log in your Boréas account.
2) Go to the "Technical Documents" section.
3) Click on the "BOS1921-KIT Documents" link.
4) Scroll down to section BOS1921-KIT Controller (PC software).
5) Download the appropriate GUI 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 BOS1921-KIT board firmware includes an over-USB firmware upgrade mechanism. The BOS1921-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 BOS1921-KIT software.
3) Select the development kit communication port into the drop-down field:

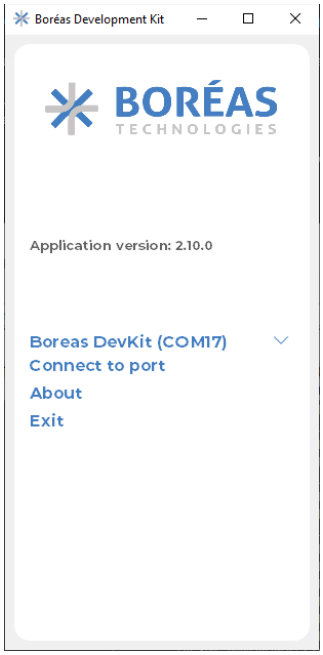


Figure 4: Connection dialog

4) Click on *Connect to port*.
5) If an upgrade is needed the BOS1921-KIT software will pop up a dialog:

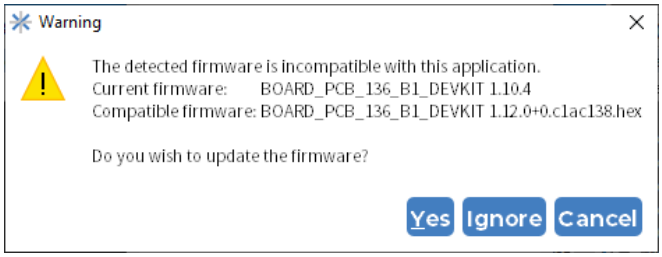


Figure 5: BOS1921-KIT Firmware upgrade dialog

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) BOS1921-KIT software will automatically start after the upgrade.
8) All is up-to-date and ready to go.

7 Product Overview

The BOS1921-KIT has been designed to meet a multitude of needs. The main objective is to demonstrate the capacity of the BOS1921 but also to help integrators in the development of haptic effects and in its product prototyping.

The BOS1921-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 BOS1921-KIT supports multiple operation modes:

Table 7: Operation mode list

Mode	Will help you 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 your application. • Evaluate BOS1921 performance (waveform output, power consumption) in the context of your application. • Optimize BOS1921 operation using specific registers value. • Command BOS1921-KIT waveform trigger from your 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 your application.

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

The BOS1921-KIT is used to test the capacity of the BOS1921 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.

We know that our customers require more flexibility and control over the waveform used for their haptic effects. For these reasons, we put at your disposal the audio mode which allows you to have complete control over the wave transmitted to the BOS1921 via the USB port. Your PC can select the BOS1921-KIT as an audio card stereo output. You can configure audio mode settings using the graphical user interface, but this mode is designed to work without the GUI. For more details about the audio mode refers to section 8.5.2.

The BOS1921-KIT development kit can be used as a basis for the development of a prototype.

It is possible to connect an external I2C or I3C master without separating the mini-boards from the BOS1921-KIT. For more details about the hardware refers to section 9.

8 Boréas Development Kit Software v2.13.x

8.1 Overview

Boréas Development Kit software is a desktop application intended to ease evaluation of the BOS1921.

In Haptic mode, the tool can be used to:

- Play a sinusoidal waveform on-demand.
- Configure the BOS1921-KIT board 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).
- Have a read/write access to the registers of the BOS1921.
- Monitor the BOS1921 status and display any error.
- Reset the BOS1921-KIT board to its factory default state.
- Change the operation mode of the BOS1921-KIT board.

In Audio mode, the tool can be used to:

- Configure the minimum and maximum voltage of each output channel.
- Reset the BOS1921-KIT board to its factory default state.
- Change the dev kit operation mode.

8.2 PC Requirements

- OS: Windows 10 or Windows 11
- 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 BOS1921-KIT board. A drop-down list allows the user to select the BOS1921-KIT board to use. (1 entry per board connected to the PC).

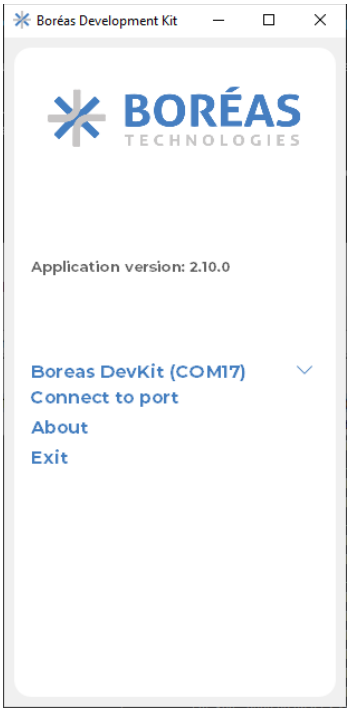


Figure 6 Application window in disconnected state

To transition to the connected state:

1. Select the communication port associated to the BOS1921-KIT 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 your development kit firmware).

The application will automatically return to the disconnected state if:

- The connection with the BOS1921-KIT board is lost.
- The BOS1921-KIT board power cycles.
- The BOS1921-KIT board is returned to factory default.
- The user presses the mode change button on the BOS1921-KIT application.
- The user presses the mode change button on the BOS1921-KIT board.

8.5 Connected State

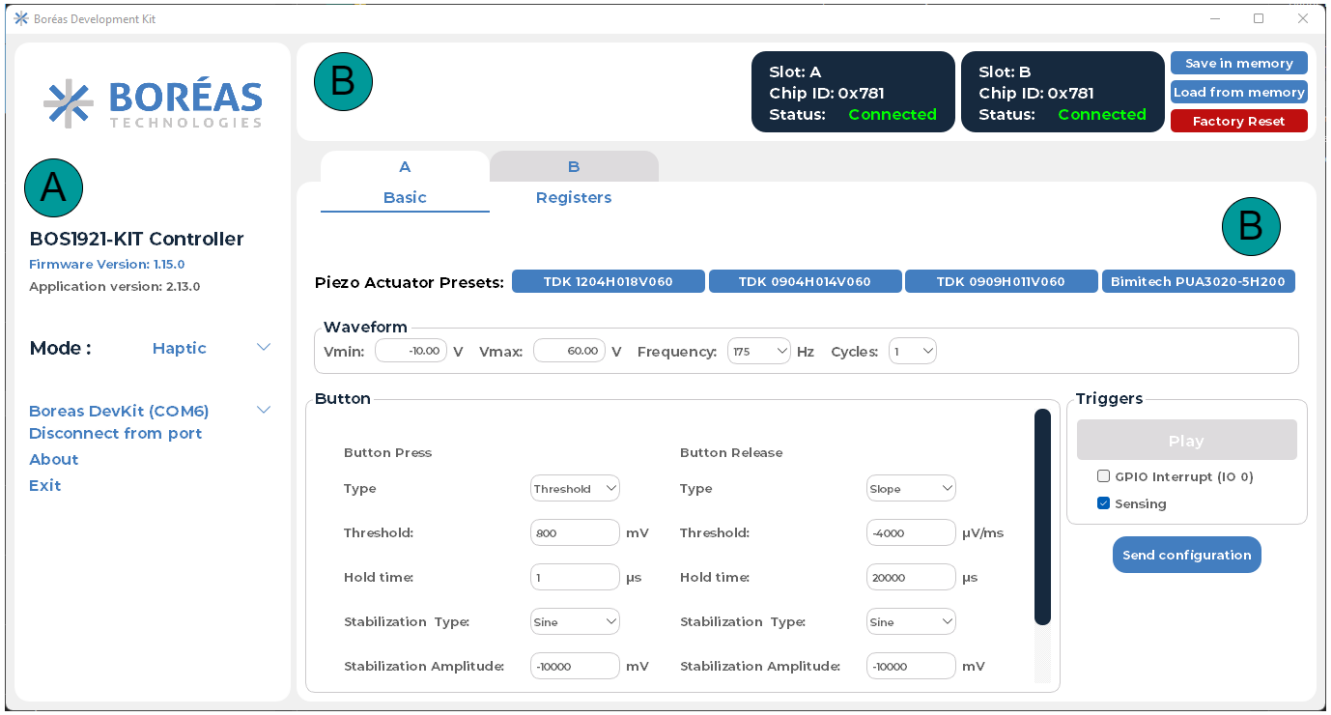


Figure 7 Application window when connected (Haptic mode)

Left Section (A): Menu

The left menu is used to present information about the BOS1921-KIT board:

- Firmware and software version
- Operation mode (*Haptic* or *Audio*)
- Communication port of the currently connected BOS1921-KIT 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 BOS1921-KIT board.
- Close the communication link with the BOS1921-KIT board (to return to the disconnected state)
- Show version information of the software.
- Exit from the application.

Right Section (B): Content

The BOS1921-KIT board 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

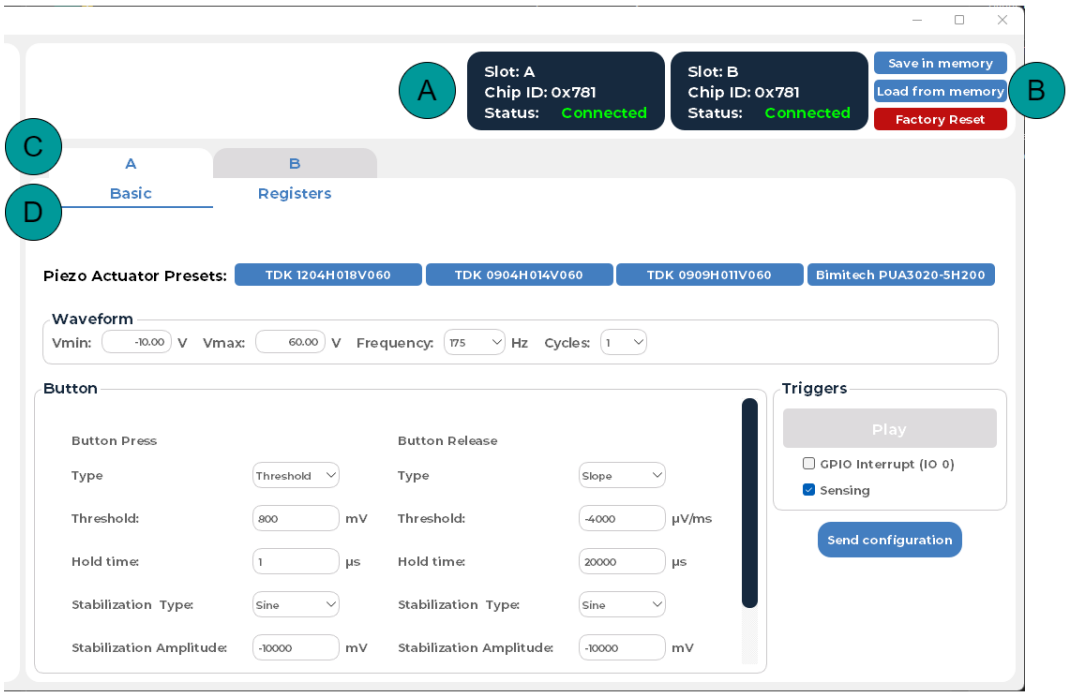


Figure 8:Panel overview – Haptic mode

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

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 BOS1921-KIT 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 BOS1921-KIT board to its default factory state. This action will also trigger a reset of the BOS1921-KIT board and the application will return to its disconnected state.

Section C: Channel Selection Tabs

Select the channel to configure (channel *A* or channel *B*)

Section D: Basic and Registers Tabs

The basic panel provides functionalities to configure the BOS1921-KIT board (configure waveform, sensing parameters and triggers).

The register panel provides a read and write access to the registers of the BOS1921. 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 (channel *A* or *B*) by pressing the *Play* button in the application.

Prerequisites

- Software is connected to the BOS1921-KIT board in *Haptic* mode.

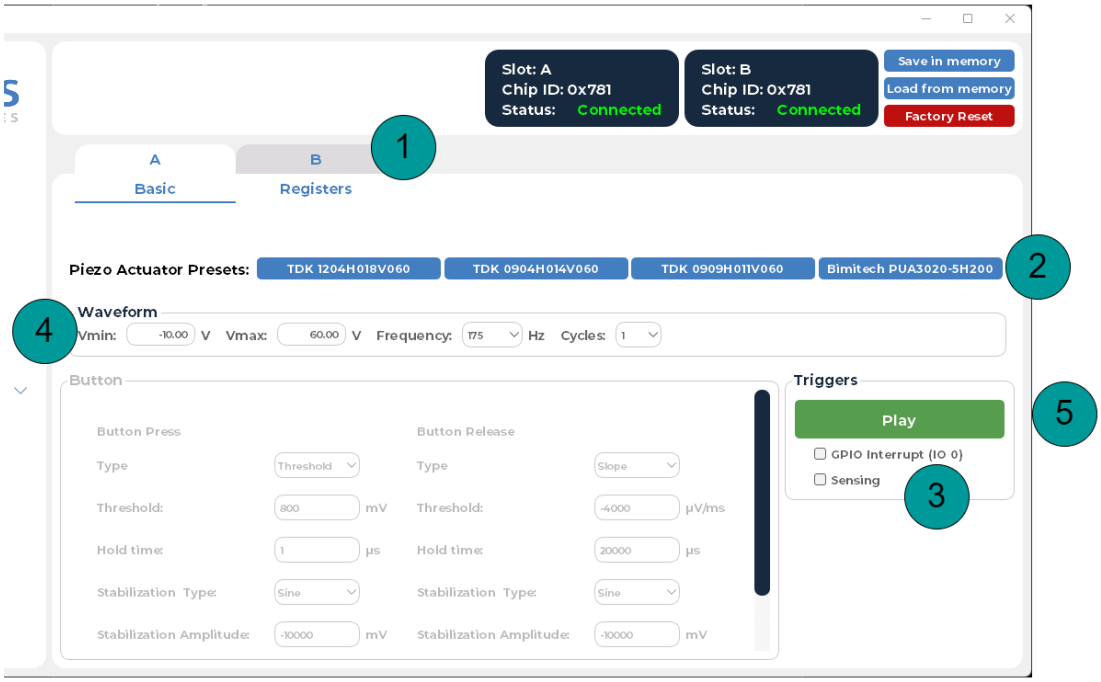


Figure 9:Play waveform – Manual trigger

Steps

1. Select a channel tab (*A* or *B*)
2. If the board is connected to a piezo actuator supplied in the BOS1921-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)
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*) 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 BOS1921-KIT 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 BOS1921-KIT board in *Haptic* mode.

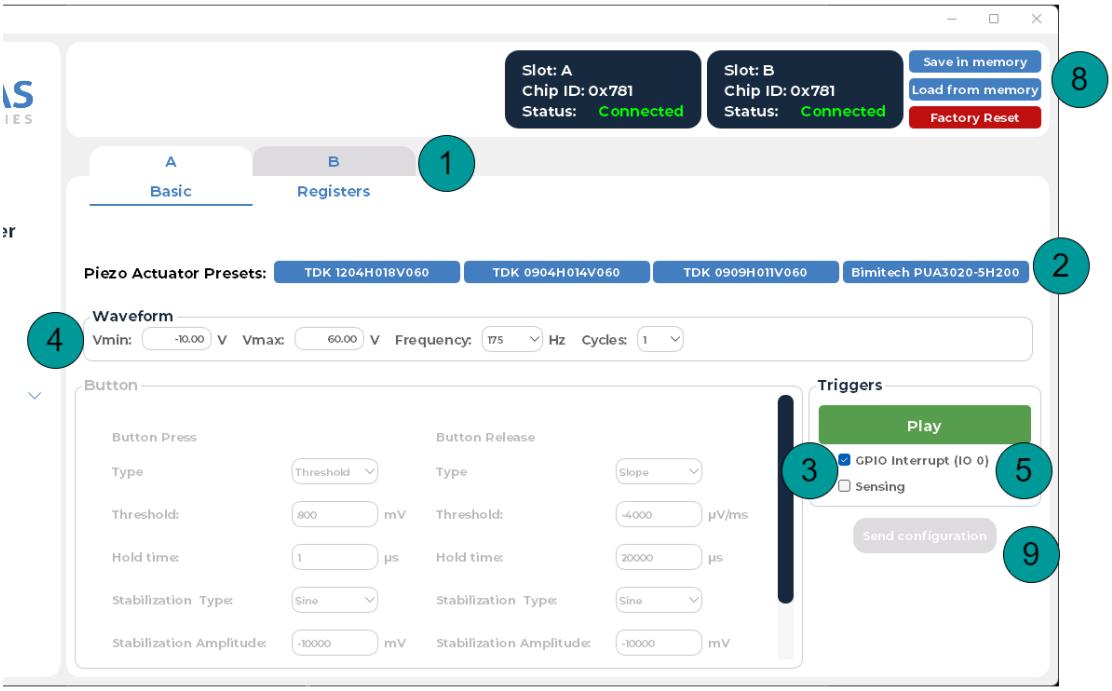


Figure 10:Play waveform – External trigger

Steps

1. Select the channel tab (*A* or *B*)
2. If the board is connected to a piezo actuator supplied in the BOS1921-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)
5. In the *Triggers* section, check *the GPIO interrupt* checkbox.
6. Connect the IO0 on the BOS1921-KIT board to the external signal you want to use to trigger the waveform feedback.
7. On detection of a failing 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 BOS1921-KIT board in memory.

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 BOS1921-KIT board.

8.5.1.4 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 BOS1921-KIT board in *Haptic* mode.

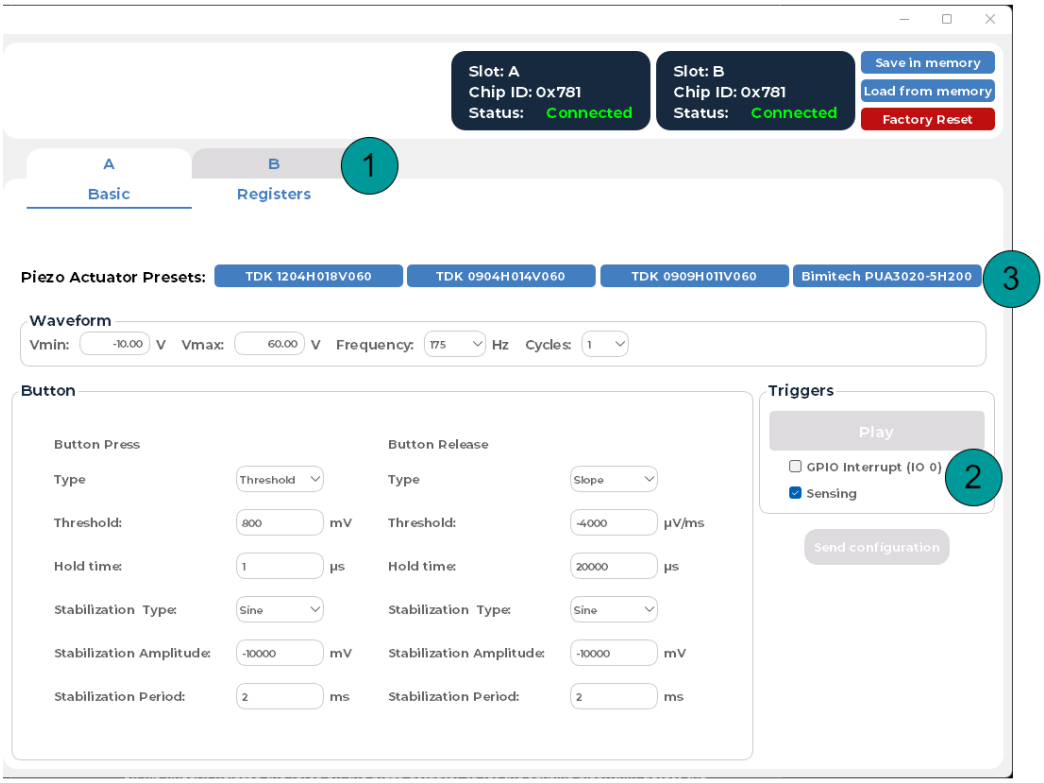


Figure 11:Button emulation

Steps

1. Select the channel tab (*A* or *B*).
2. In the *Triggers* section, check the *Sensing* checkbox to enable the sensing algorithm on the BOS1921-KIT board and the BOS1921 status LED of the channel will turned solid green.
3. If the board is connected to a piezo actuator supplied in the BOS1921-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.

8.5.1.5 Registers Access

Description

User read and optionally write registers of the connected BOS1921.

Prerequisites

- Software is connected to the BOS1921-KIT board in *Haptic* mode.

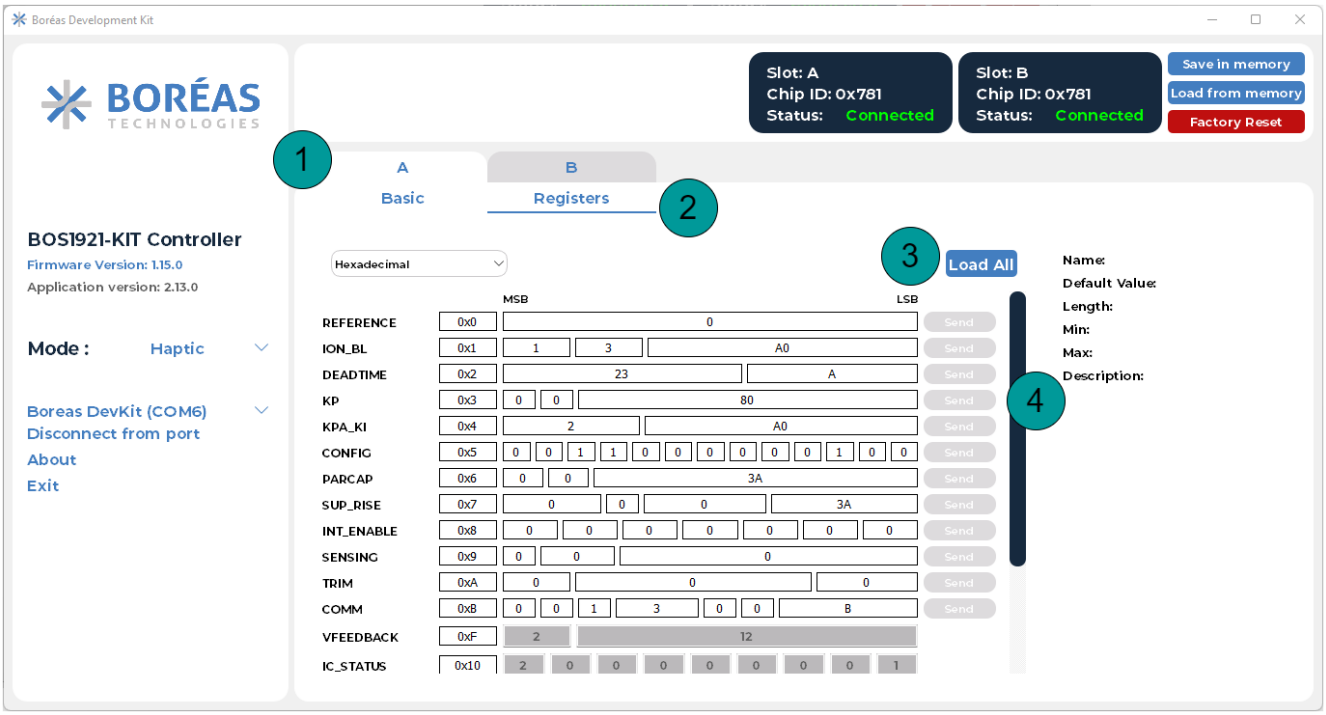


Figure 12: Register access panel

Steps

1. Select the channel tab (*A* or *B*).
2. Select the *Registers* Tab.
3. Use the *Load All* button to read all registers values from the BOS1921
4. (Optional): To change the value of a writable register, edit the parameter you want to change and press the *Send* button to write the modified register in the BOS1921.

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

8.5.2.1 Panel Overview

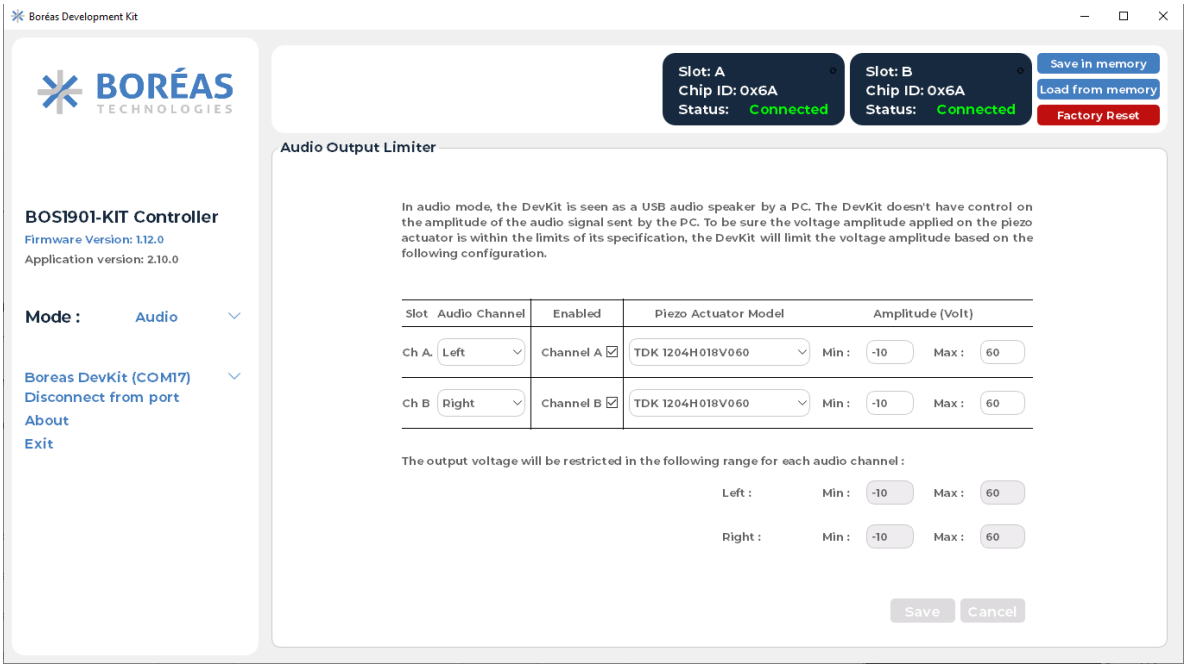


Figure 13:Panel overview - Audio mode

When the BOS1921-KIT 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.

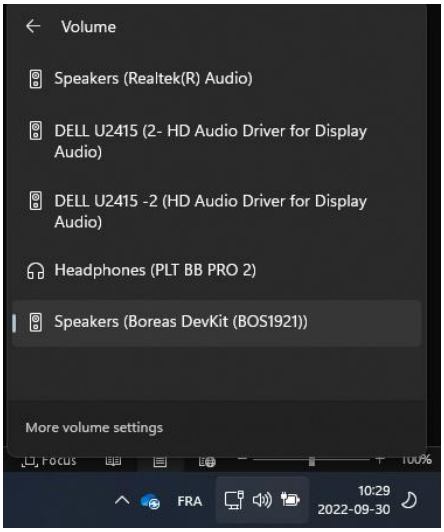


Figure 14:Boreas DevKit speaker

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, B) 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 BOS1921, the BOS1921-KIT 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 BOS1921-KIT board will limit the output voltage between -10 V and 60 V. This range can be changed to fit the actuator used.

To change the audio limiting configuration, open the BOS1921-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 BOS1921-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:

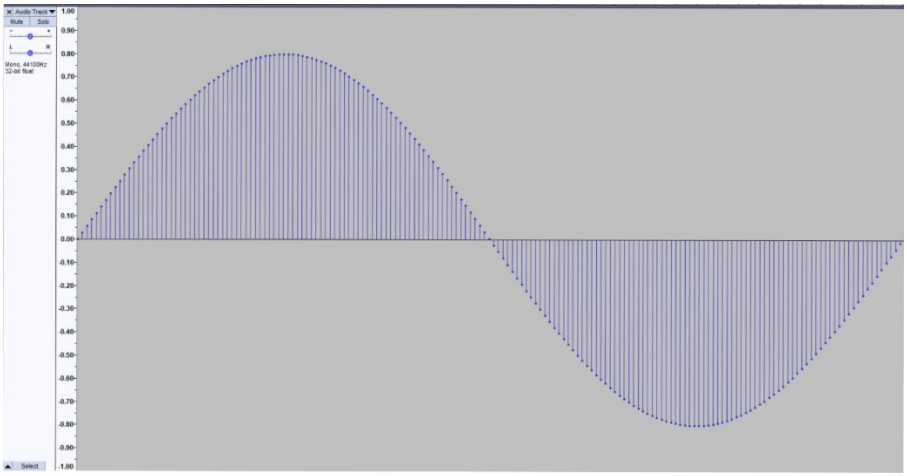


Figure 15:Original audio signal

Same signal with audio limiting set between -10 V to 60 V:

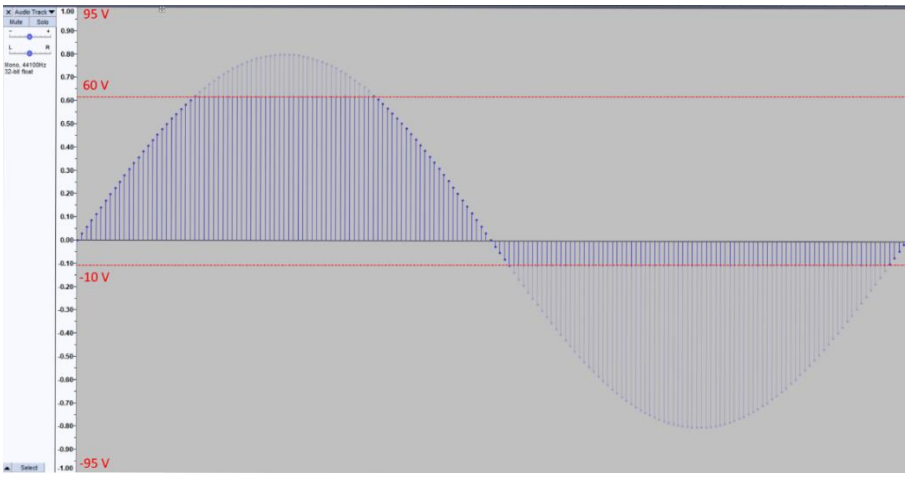


Figure 16:Audio signal with audio limiting

8.5.3 IC Status Monitoring

As displayed above, when the application is connected to the BOS1921-KIT board it shows all detected BOS1921 errors in the bottom section of the left panel.

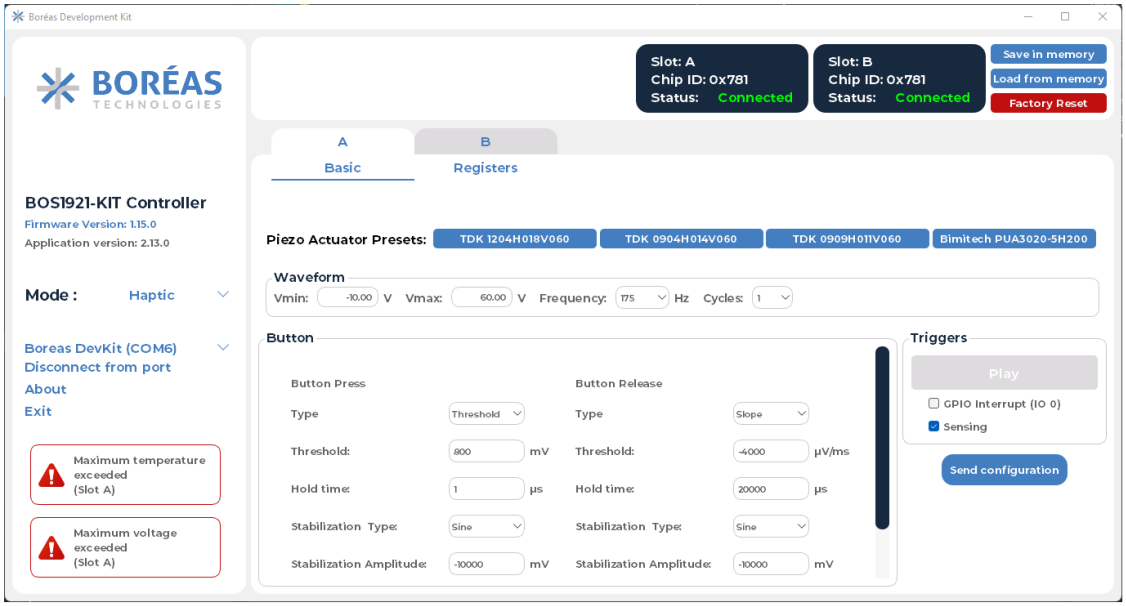


Figure 17 Errors shown in the left panel

Possible IC errors:

Table 8: BOS1921 errors

Reported Error Message	Meaning
Maximum temperature exceeded (Slot X)	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 (Slot X)	Output voltage exceeded the maximum voltage allowed on the IC.
Maximum power, distortion likely	IC has reached maximum power transfer condition. Check the output waveform for possible distortion.
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.
VDD is too low	VDD input supply is below operation range.
Short circuit detected between VOUT and VIN	IC has detected a short-circuit condition on its output.

9 Hardware

The purpose of this section is to provide information on the hardware design of the BOS1921-KIT PCB to help the integrator evaluate BOS1921 and to use it in a prototype.

9.1 Design Overview

The kit is composed of various boards: an application *controller board,* and two insertable *driver boards* each with a BOS1921 driver. The driver boards have different bill of materials:

- PCB-0251 with label H is optimized for maximum output power and enough strength for haptics applications.
- PCB-0250 with label P is optimized for low loads such a micro-pumps.

By default, the BOS1921-KIT power is supplied by the USB port. However, 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 level shifter circuit on the digital signals, and jumpers to connect an external supply connector to power the BOS1921 driver section.

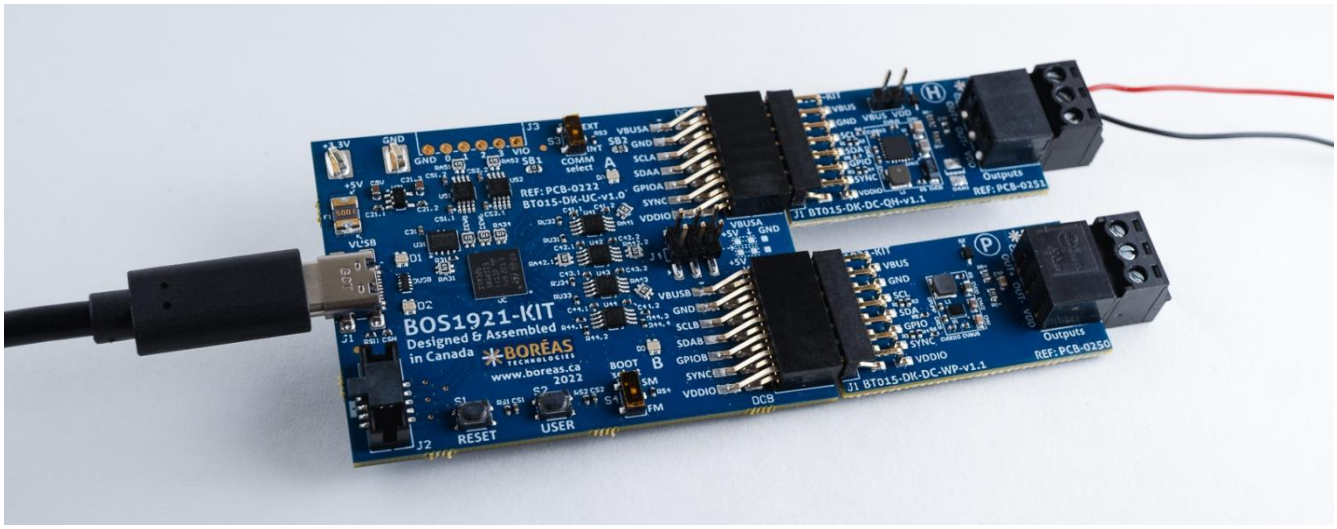


Figure 18: BOS1921-KIT PCB overview

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 driver boards are inserted into the controller board.

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.

9.2.1 Interchangeable Driver Boards

The use of the separable driver board units with custom-made firmware is done at the user's own risk of causing damage beyond repair to the BOS1921 circuit. Boréas Technologies will not be held responsible.

One way to integrate a BOS1921 into your development platform is to directly connect to its header pin connector (left-hand side).

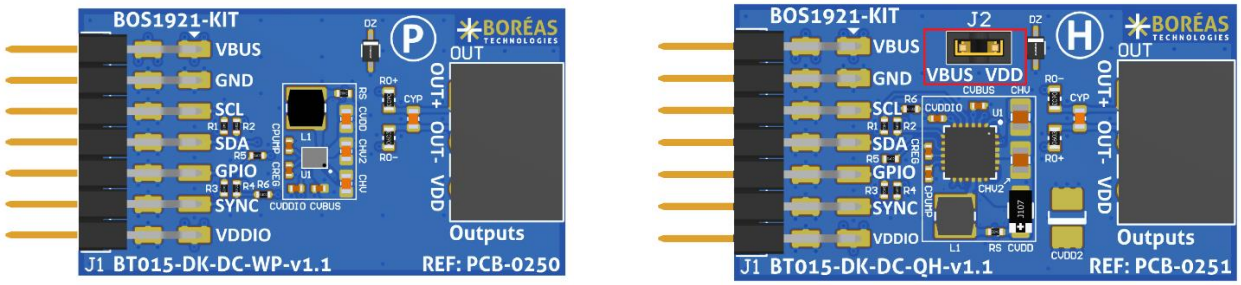


Figure 19: Driver boards

Each driver board contains a BOS1921 that can be used alone with a user-preferred development platform. All signals need to be connected to your development platform.

Table 9: Breakable Driver Section signals

Signal	Description	Constraint
VBUS	Main power supply for the BOS1921	Supply voltage between 3.0 V and 5.5 V with at least 500 mA current drive. When using the H board, use jumper J2 if using non-UPI configuration. Remove the jumper if using the UPI configuration.
GND	0 V reference	
SCL	I2C Clock signal	
SDA	I2C Data signal	
GPIO	Digital input/output	
SYNC	Synchronization pin	Used to synchronize feedback on many drivers boards.
VDDIO	Digital IO power supply	Digital signals voltage domain. Must be between 1.62 V and 5.5 V.

Refer to BOS1921 datasheet for a complete description on how to use and program the circuit.

9.2.2 Probe Hooks

Probe hooks are available around the board to ease connection of instruments for measurement of supplies when debugging. At the interface between the controller board and the driver boards lies a header pins connector. This connector allows to probe supply levels and digital signals.

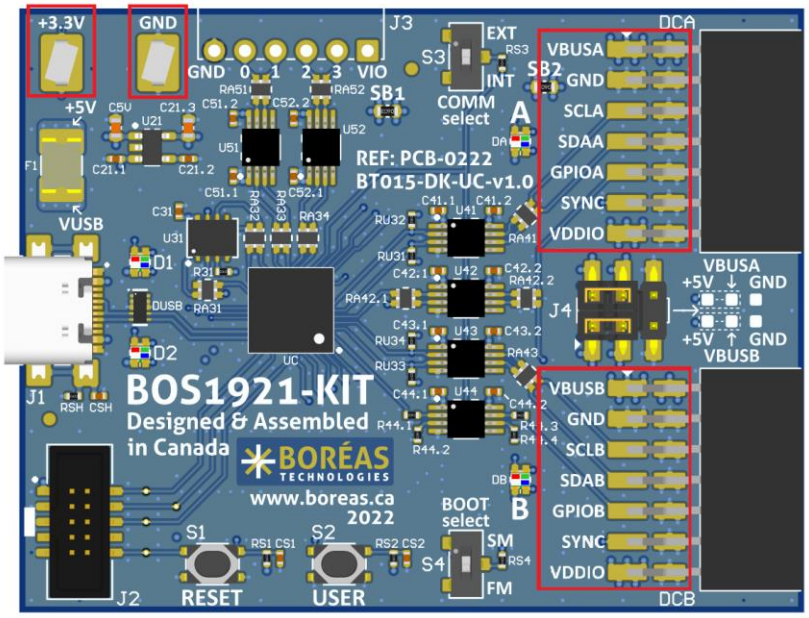


Figure 20: Probe hook location

9.2.3 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.

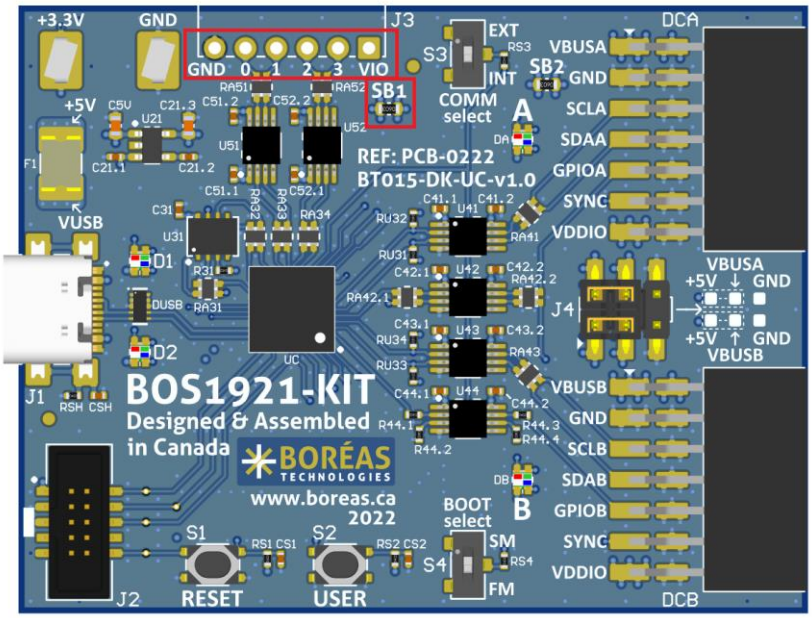


Figure 21: GPIOs and GPIOs supply voltage configuration solder bridge location

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 BOS1921-KIT PCB configuration.

Table 10: GPIOs supply voltage solder bridge configuration

GPIOs Supply Source	SB1 State
+3.3V (MCU supply)	Populated
VIO (1.62 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, IO0, IO2 and IO3.

9.2.4 External I2C

The BOS1921 features an I2C communication interface. By default, each BOS1921 are connected to the MCU I2C master. It is possible to bypass the MCU and use an external I2C master without separating the board. This can be useful when trying to connect a BOS1921 directly to an external system.

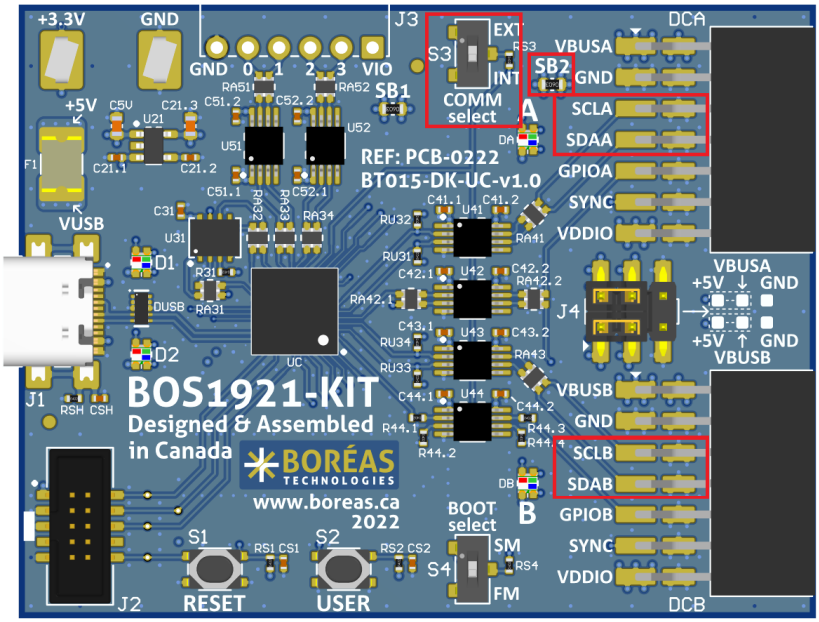


Figure 22: Comm selection switch and SPI header location

To use an external I2C, it is mandatory to enable it using the COMM Select switch on the board by setting it to EXT position. USB port must still be connected since it supplies the digital switches. When changing the position of COMM Select switch, the board must be power cycled (disconnect the USB cable and then reconnect it).

By default, the I2C signals are in the microcontroller 3.3 V supply domain. To use these signals with a system operating in another voltage domain requires modification of the BOS1921-KIT PCB configuration.

Table 11: SPIs supply voltage solder bridge configuration

I2C Supply Source	SB2 State
+3.3V (MCU supply)	Populated
VDDIO (1.62 V to 5.5 V)	Unpopulated

When SB2 is unpopulated, I2C supply voltage is provided by VDDIO and GND of the external I2C header connectors.

9.2.5 Power Supply Source and UPI Mode Operation

The driver boards can be supplied from two different sources: the USB 5V or an external source. The J4 jumpers on the controller board selects which source to use. When using the USB supply, use the jumper to connect +5V pin and VBUS pin. When using an external supply, remove the jumper and connect the external source positive terminal to the VBUS pin, and the negative terminal to the GND pin. A different source may be used for each channel (driver board). By default, the USB connector is the power source.

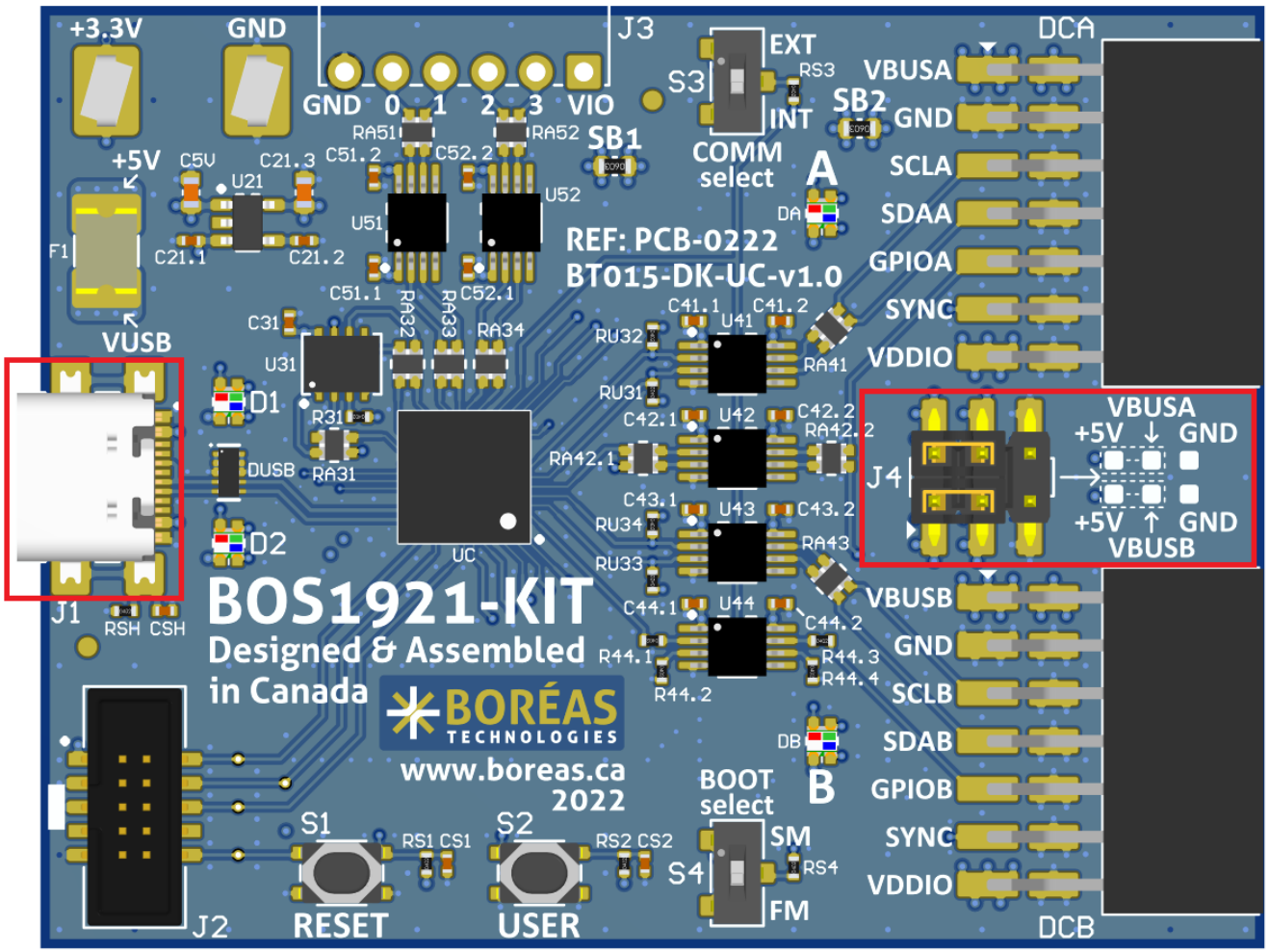


Figure 23: Power supply source selection jumper location

The H driver board supports both the UPI and non UPI configuration (see product datasheet for details). To use the non UPI mode, connect the J2 jumper, shorting VBUS and VDD. To use the UPI configuration, remove the jumper. UPI mode is disabled by default.

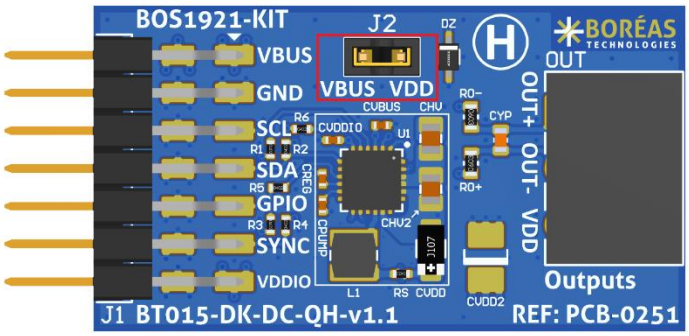


Figure 24: Driver board UPI mode configuration jumper location

Table 12: Power supply source and UPI mode configuration options

Supply Source	UPI Mode	Controller Board J4	Driver Board J2
USB 5V	Disable (non UPI)	Populated	Populated
USB 5V	Enable (UPI)	Populated	Unpopulated
External Supply	Disable (non UPI)	External	Populated
External Supply	Enable (UPI)	External	Unpopulated

Refer to the board schematics in section 10.1 to obtain more information regarding the power supply options. Refer to the BOS1921 datasheet to get more information regarding the UPI mode.

9.2.6 Piezo Actuator Low-Pass Filter

Two 0603 resistors ROx are in series with each BOS1921 output channels OUTx. They can be used to create a low-pass filter with the actuator and filter out audible noise. 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 in order to compensate it in the programmed voltage waveform. Initially, the populated values are 0 ohm. When adding such resistors, it is recommended to also increase CHV capacitance value.

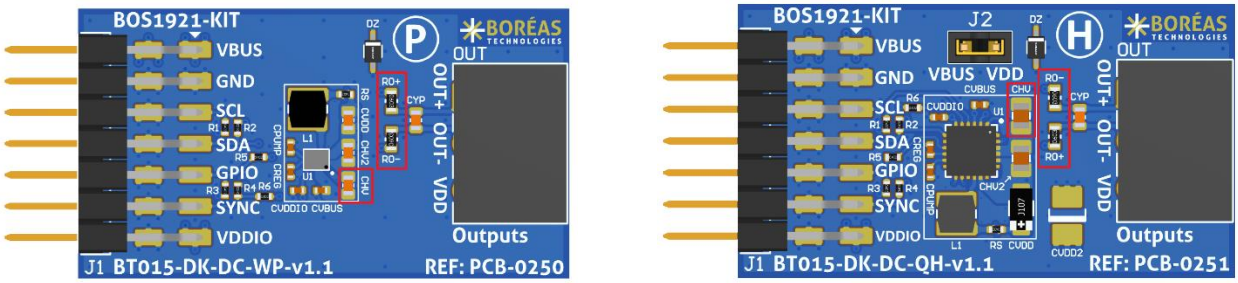
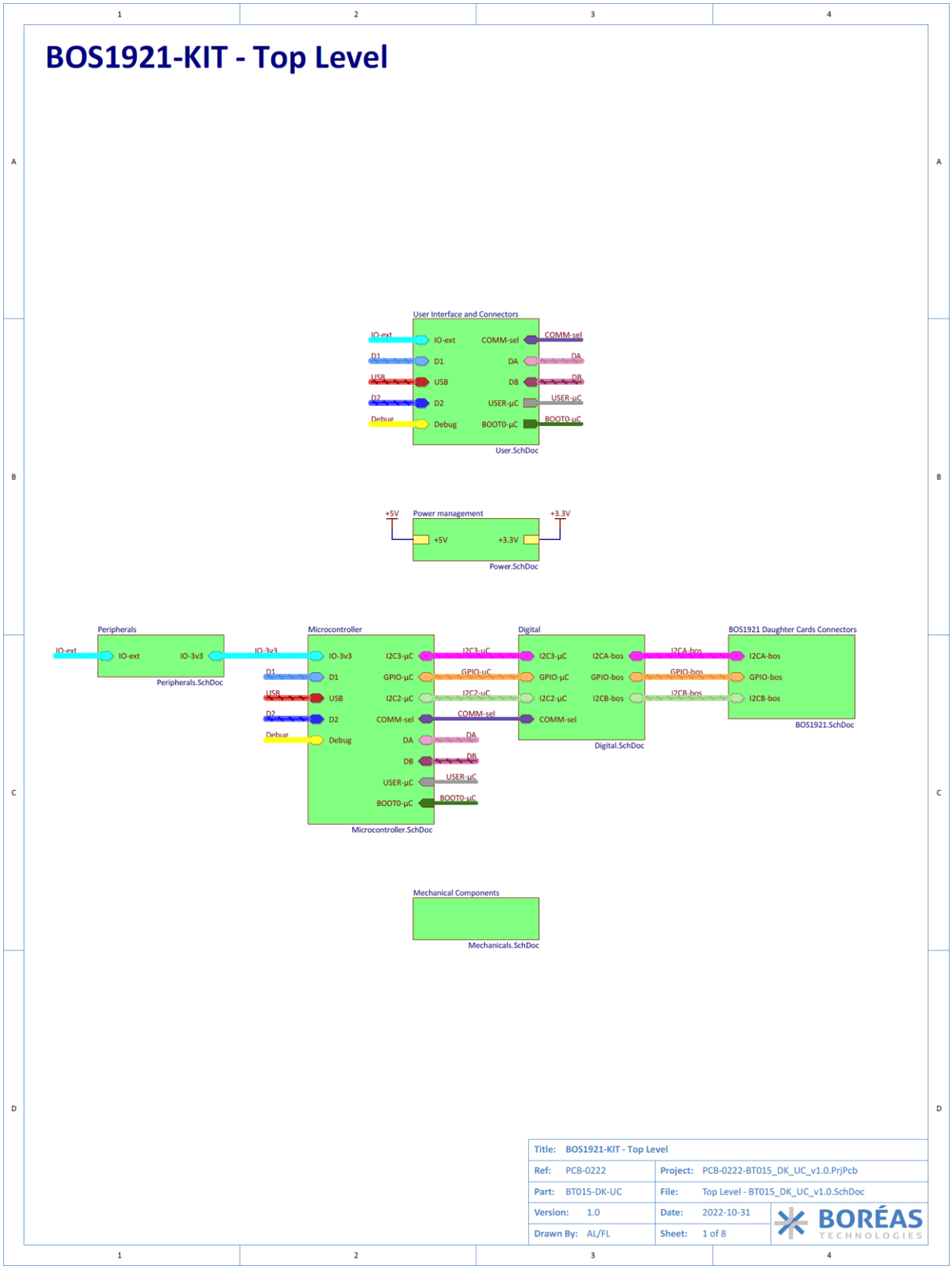


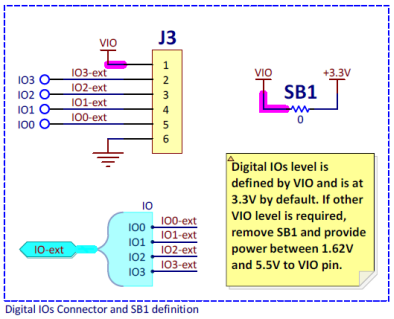
Figure 25: Low-pass filter resistors location

10 Design Reference

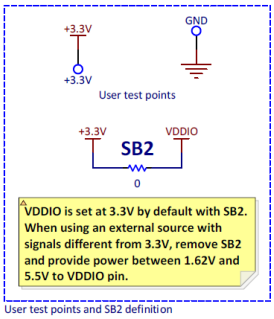
10.1 Schematics – Controller Board



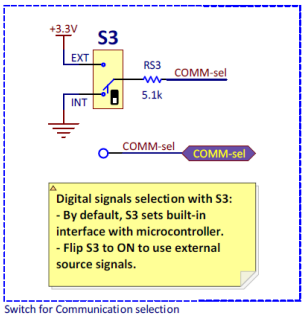
BOS1921-KIT - User Interface and Connectors



Digital IOs Connector and SB1 definition

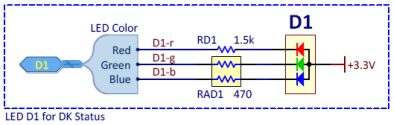


User test points and SB2 definition

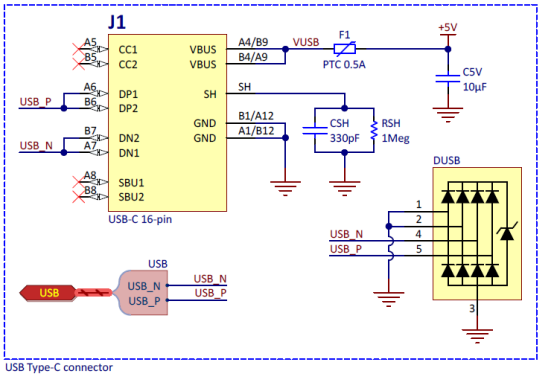


Switch for Communication selection

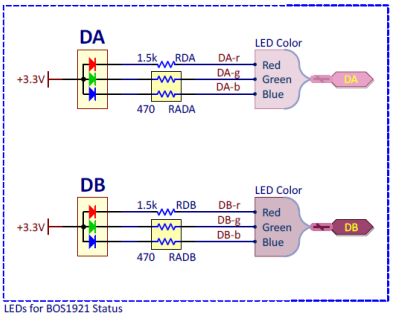
Wrong polarity of S3 switch, should be INT to +3.3V and EXT to GND. Solved by software.



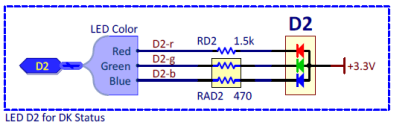
LED D1 for DK Status



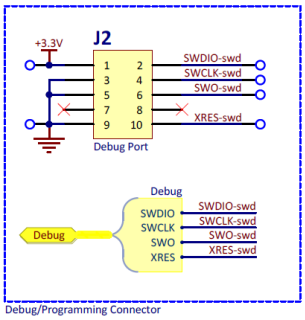
USB Type-C connector



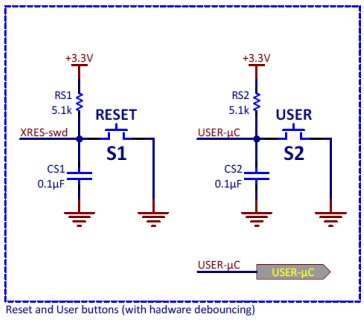
LEDs for BOS1921 Status



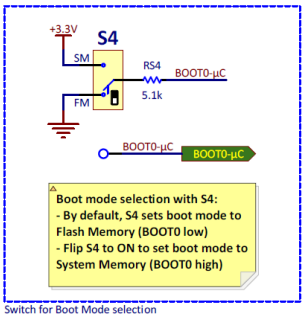
LED D2 for DK Status



Debug/Programming Connector



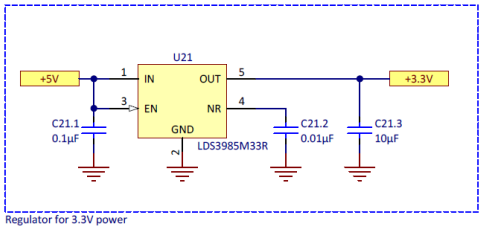
Reset and User buttons (with hadware debouncing)



Switch for Boot Mode selection

Title:	BOS1921-KIT - User Interface and Connectors		
Ref:	PCB-0222	Project:	PCB-0222-BT015_DK_UC_v1.0.PrjPcb
Part:	BT015-DK-UC	File:	User.SchDoc
Version:	1.0	Date:	2022-10-31
Drawn By:	AL/FL	Sheet:	2 of 8

BOS1921-KIT - Power Management



Regulator for 3.3V power

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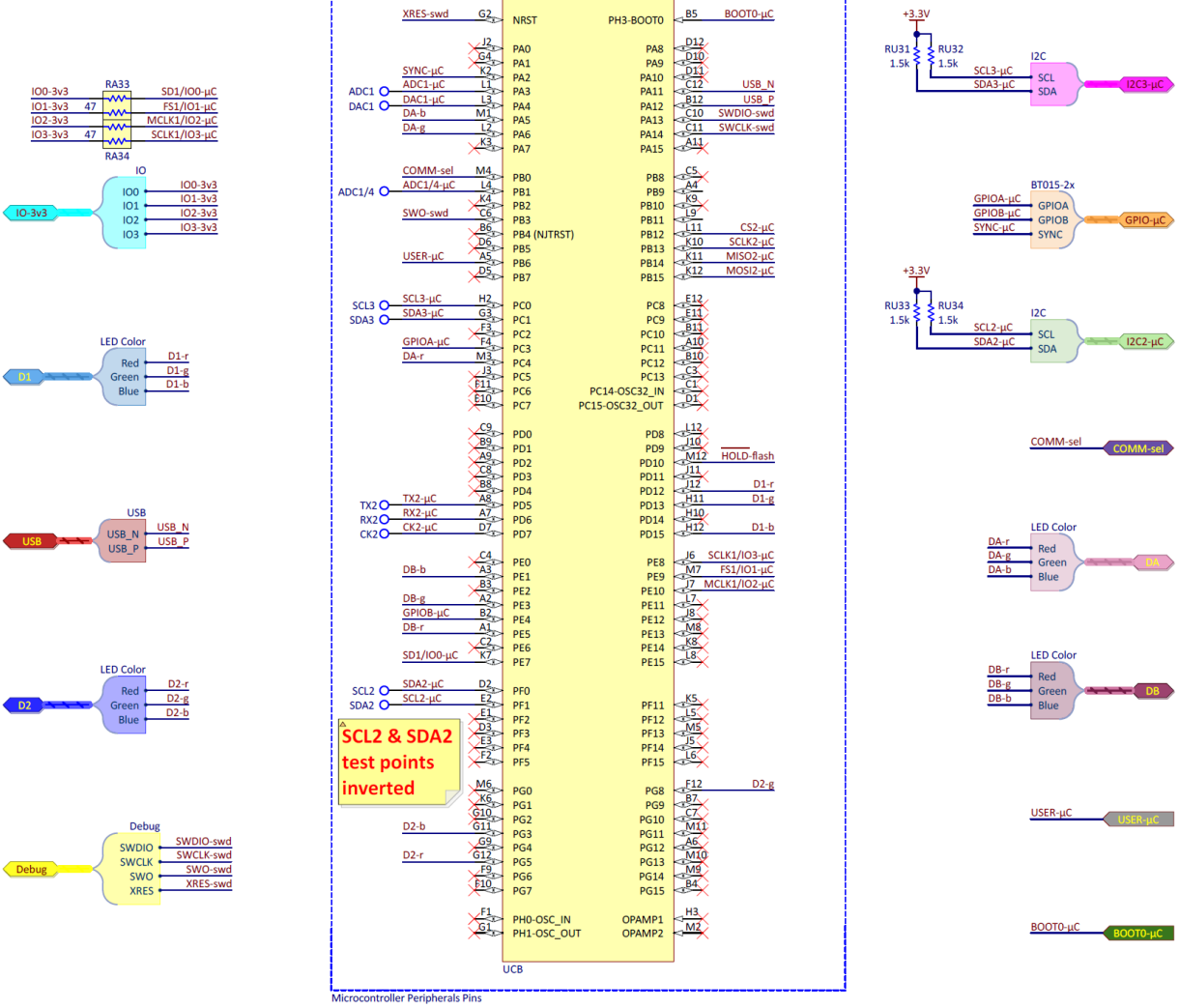
Part:	BT015-DK-UC	File:	Power.SchDoc
Version:	1.0	Date:	2022-10-31
Drawn By:	AL/FL	Sheet:	3 of 8

BOS1921-KIT - Microcontroller



Title:	BOS1921-KIT - Microcontroller		
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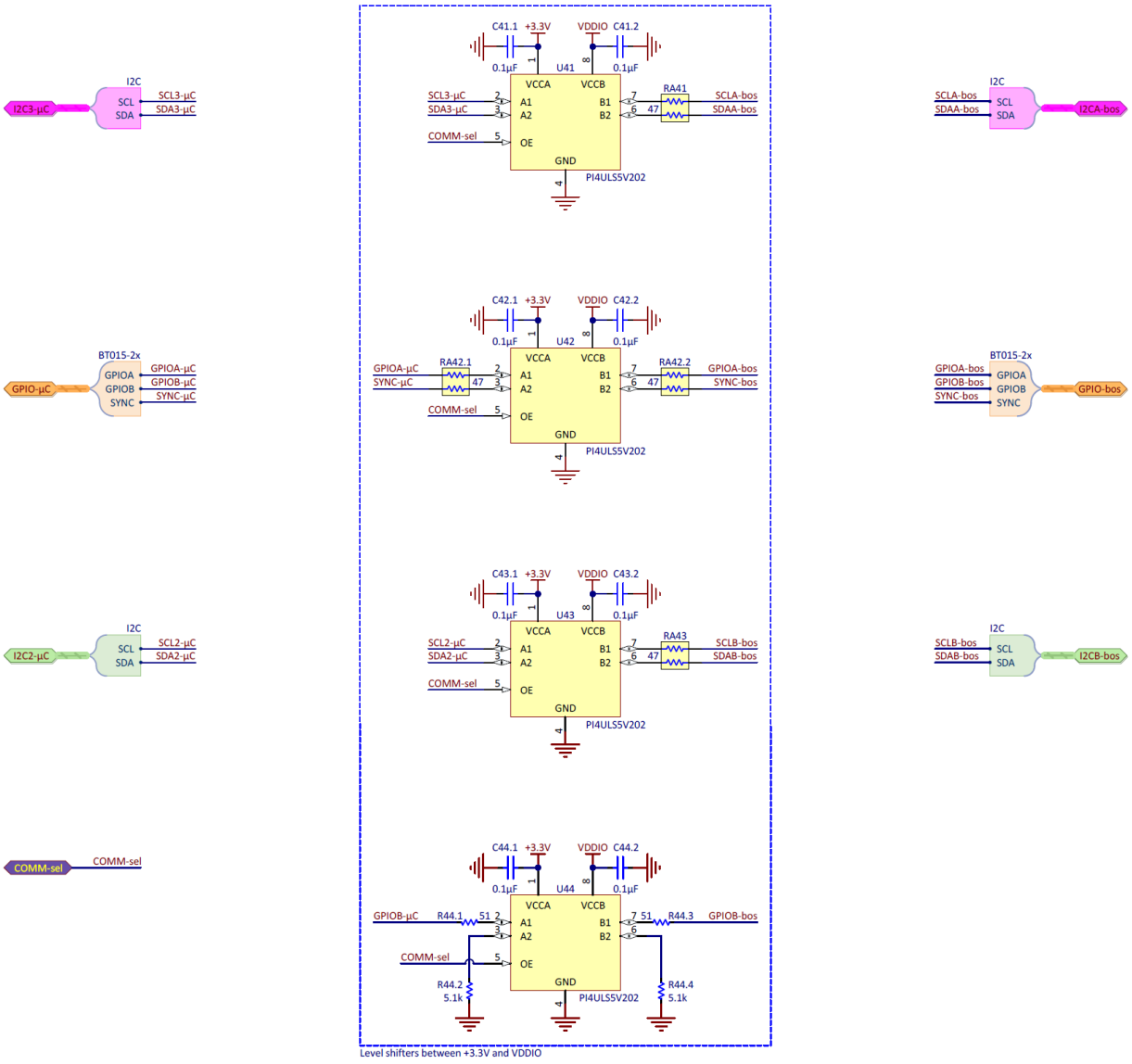
Part:	BT015-DK-UC	File:	Microcontroller.SchDoc
Version:	1.0	Date:	2022-10-31
Drawn By:	AL/FL	Sheet:	4 of 8

BOS1921-KIT - Digital signals conditioning



Level shifters between +3.3V and VDDIO

Title:	BOS1921-KIT - Digital signals conditioning		
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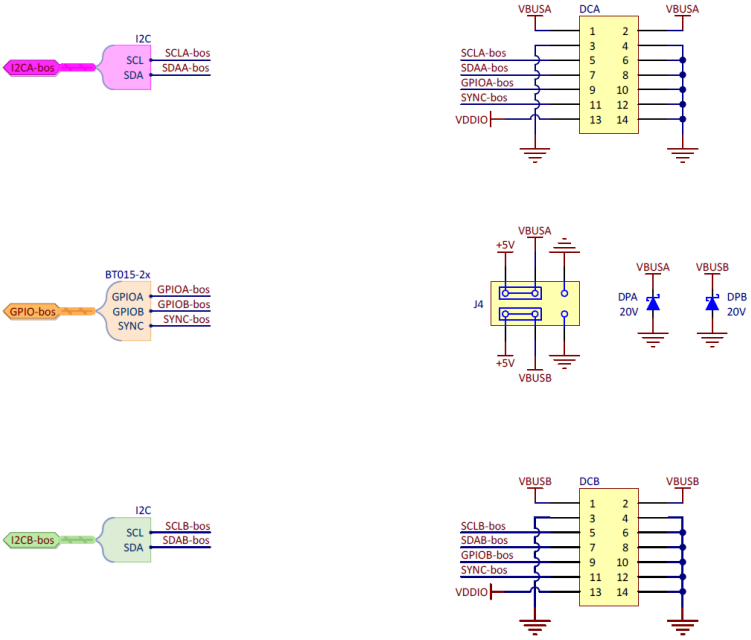
Part:	BT015-DK-UC	File:	Digital.SchDoc
Version:	1.0	Date:	2022-10-31
Drawn By:	AL/FL	Sheet:	5 of 8

BOS1921-KIT - Connectors to BOS1921 Daughter Cards



Title:	BOS1921-KIT - Connectors to BOS1921 Daughter Cards		
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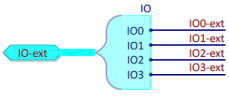
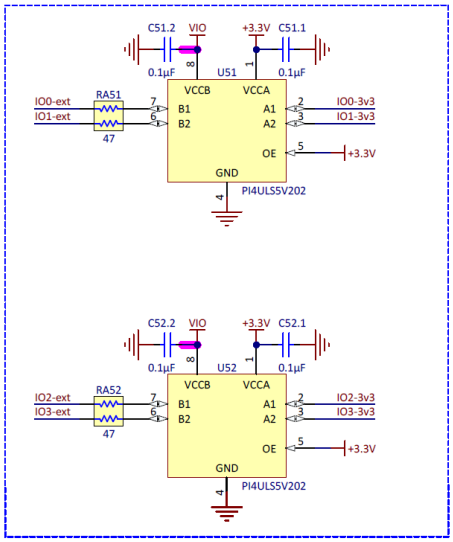
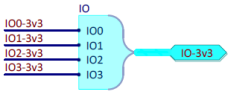
Part:	BT015-DK-UC	File:	BOS1921.SchDoc
Version:	1.0	Date:	2022-10-31
Drawn By:	AL/FL	Sheet:	6 of 8

BOS1921 Dev Kit - External Peripherals







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Part:	BT015-DK-UC	File:	Peripherals.SchDoc
Version:	1.0	Date:	2022-10-31
Drawn By:	AL/FL	Sheet:	7 of 8

BOS1921-KIT - Mechanical Components

Bumpers

Fiducials

Jumpers

Logo

Title:	BOS1921-KIT - Mechanical Components		
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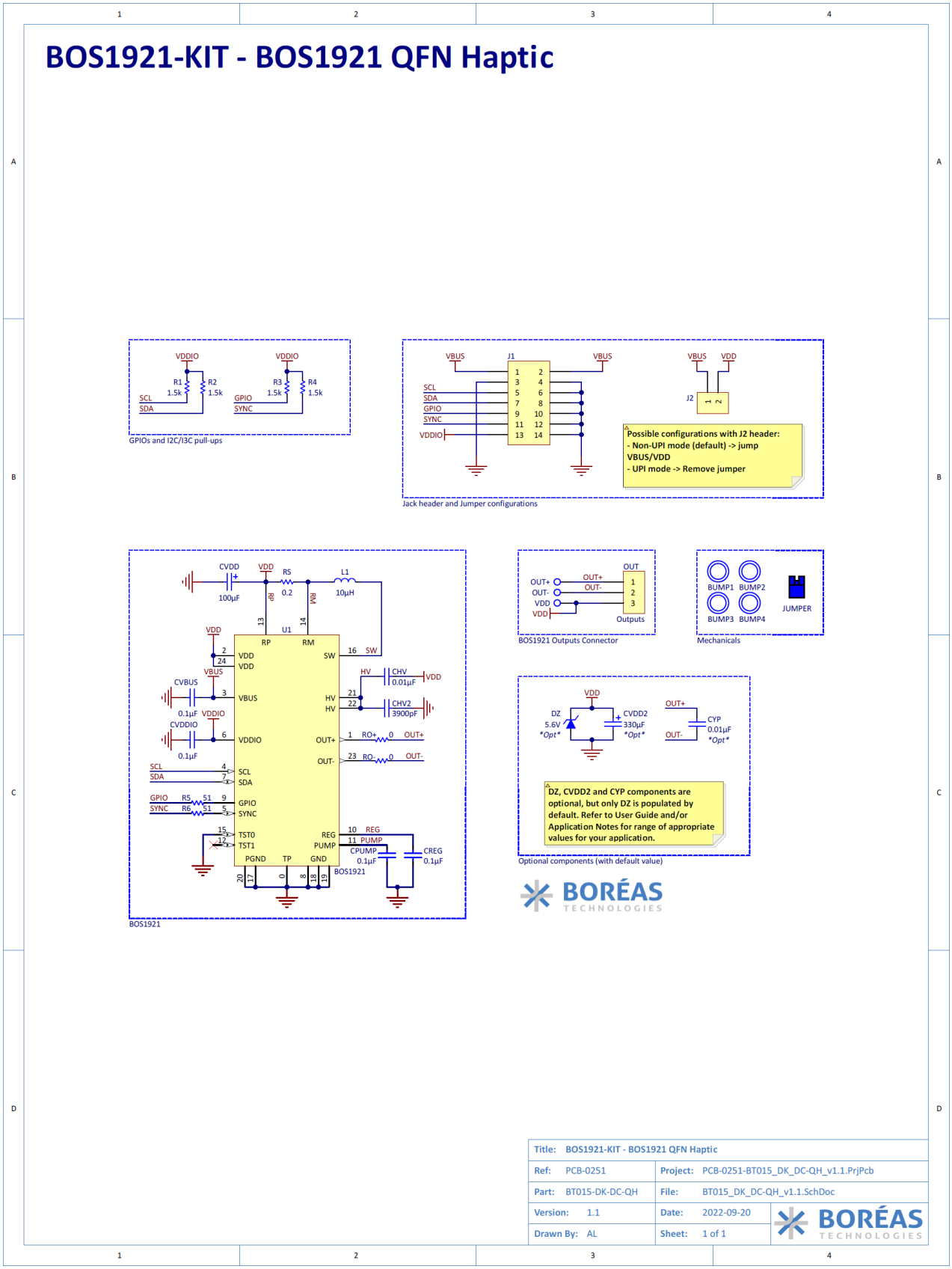
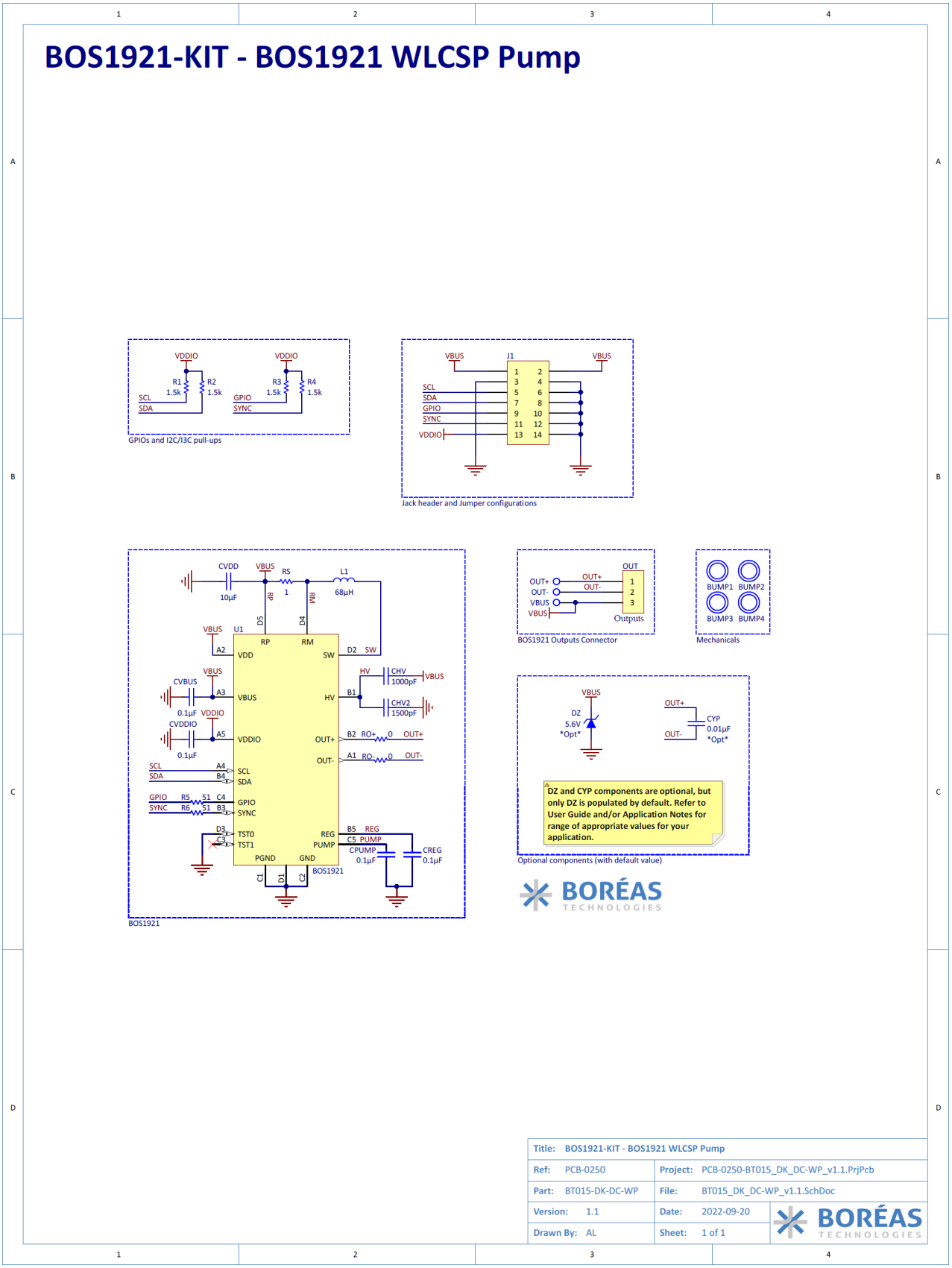
Part:	BT015-DK-UC	File:	Mechanicals.SchDoc
Version:	1.0	Date:	2022-10-31
Drawn By:	AL/FL	Sheet:	8 of 8

10.2 Schematics – H Driver Board



10.3 Schematic – P Driver Board



10.4 PCB Layout – Controller Board

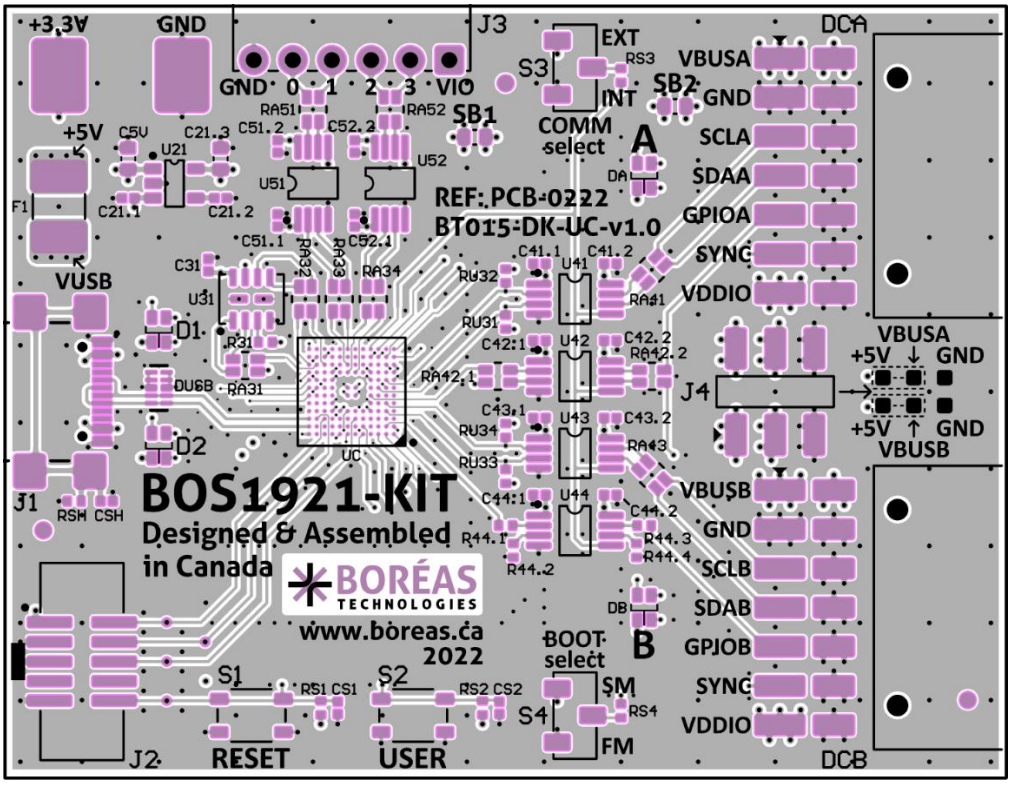


Figure 26: Layout view - Top Layer (not to scale)

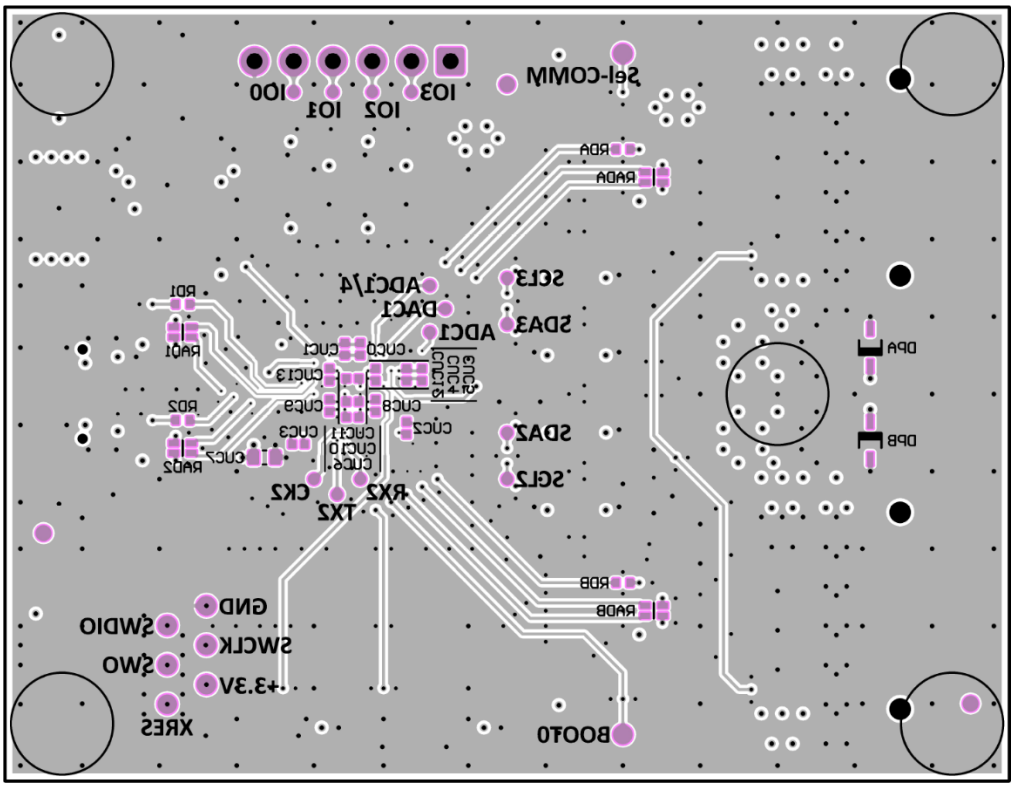


Figure 27: Layout view - Bottom Layer (not to scale)

10.5 PCB Layout – H Driver Board

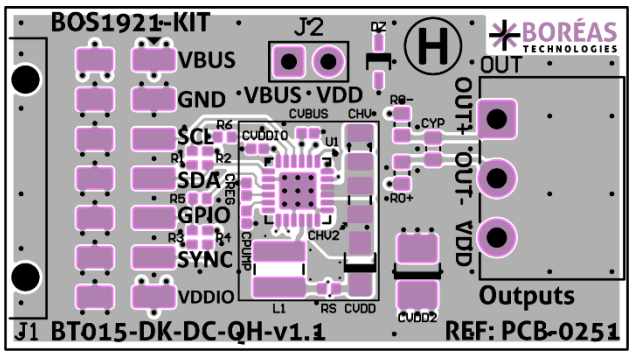


Figure 28: Layout view - Top Layer (not to scale)

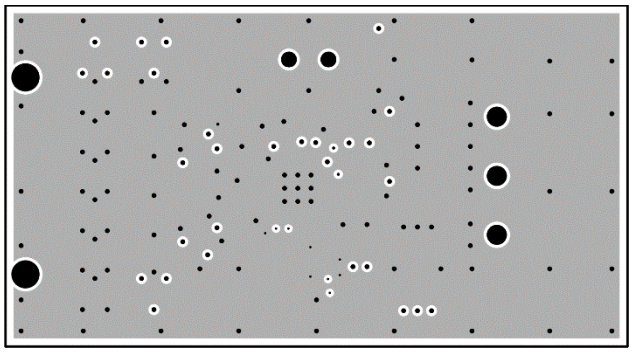


Figure 29: Layout view - Second Layer (not to scale)

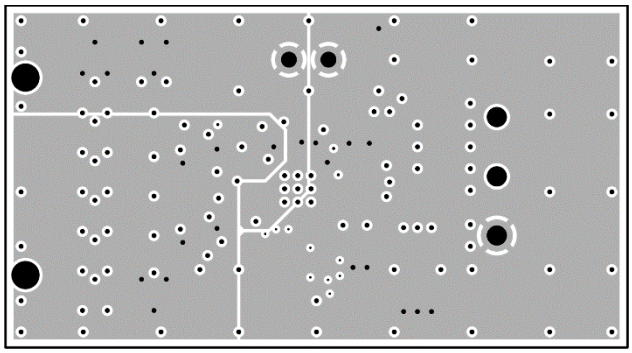


Figure 30: Layout view - Third Layer (not to scale)

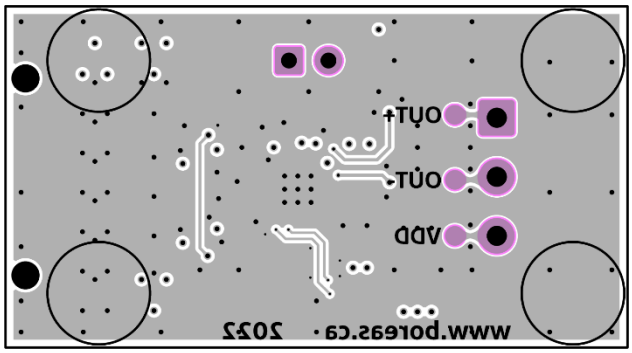


Figure 31: Layout view - Bottom Layer (not to scale)

10.6 PCB Layout – P Driver Board

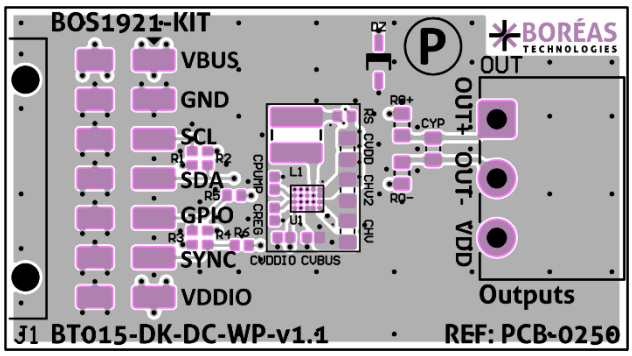


Figure 32: Layout view - Top Layer (not to scale)

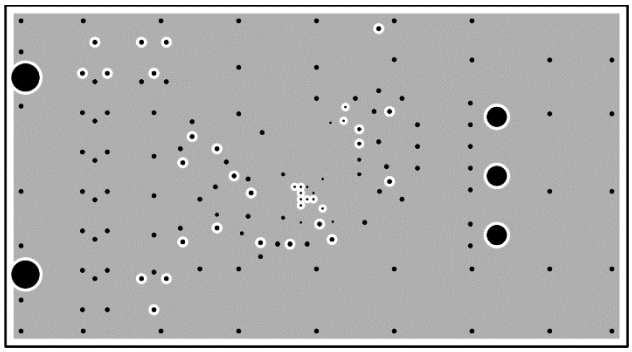


Figure 33: Layout view - Second Layer (not to scale)

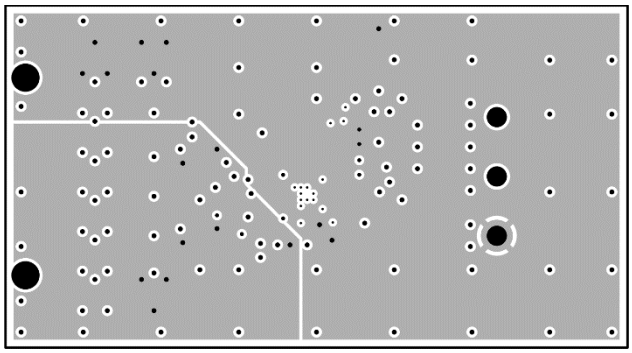


Figure 34: Layout view - Third Layer (not to scale)

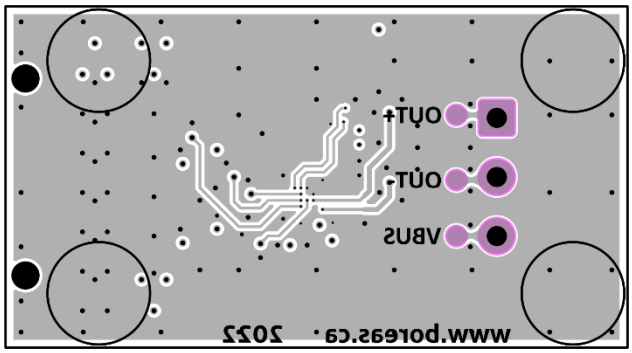


Figure 35: Layout view - Bottom Layer (not to scale)

10.7 Bill of Materials – Controller Board

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

Table 13: Bill of Materials for BOS1921-BRD-C01-B1

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
BUMP1, BUMP2, BUMP3, BUMP4, BUMP5	5		BUMPER CYLINDRICAL 0.25" DIA BLK	Keystone Electronics	783-B
C5V, C21.3, CUC7	3	10µF	CAP CER 10UF 25V X5R 0603	Taiyo Yuden	TMK107BBJ106MA-T
C21.1, C31, C41.1, C41.2, C42.1, C42.2, C43.1, C43.2, C44.1, C44.2, C51.1, C51.2, C52.1, C52.2, CS1, CS2, CUC1, CUC2, CUC3, CUC4, CUC6, CUC8, CUC9, CUC10, CUC11, CUC12, CUC13	27	0.1µF	CAP CER 0.1UF 25V X5R 0402	Taiyo Yuden	TMK105BJ104KV-F
C21.2	1	0.01µF	CAP CER 10000PF 50V X7R 0402	Taiyo Yuden	UMK105B7103KV-F
CSH	1	330pF	CAP CER 330PF 250V C0G/NP0 0402	KEMET	C0402C331JAGACAUTO
CUC0	1	4.7µF	CAP CER 4.7UF 6.3V X5R 0402	Murata Electronics	GRM155R60J475ME87D
CUC5	1	1µF	CAP CER 1UF 16V X5R 0402	TDK Corporation	CGB2A1X5R1C105K033BC
D1, D2, DA, DB	4		LED RGB 0606 SMD	Dialight	5977715607F
DCA, DCB	2		CONN HDR 14POS 0.1 GOLD SMD R/A	Würth Elektronik	610114249221
DPA, DPB	2	20V	DIODE SCHOTTKY 20V 1A SOD323F	Nexperia USA Inc.	PMEG2010AEJ,115
DUSB	1	5.5V	TVS DIODE 5.5V 14V 10USON	Texas Instruments	TPD4E05U06QDQARQ1
F1	1	0.5A	PTC RESET FUSE 15V 500MA 1812	Schurter Inc.	PFMF.050.2
J1	1		CONN RCP USB2.0 TYP C 24P SMD RA	GCT	USB4110-GF-A
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

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
J4	1		CONN HEADER SMD 6POS 2.54MM	Amphenol ICC (FCI)	95278-101A06LF
JP1, JP2	2		CONN JUMPER SHORTING .100" GOLD	Sullins Connector Solutions	QPC02SXGN-RC
R31, R44.2, R44.4, RS1, RS2, RS3, RS4	7	5.1k	RES SMD 5.1K OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ512X
R44.1, R44.3	2	51	RES SMD 51 OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ510X
RA31, RA32, RA33, RA34, RA41, RA42.1, RA42.2, RA43, RA51, RA52	10	47	RES ARRAY 2 RES 47 OHM 0606	Panasonic Electronic Components	EXB-V4V470JV
RAD1, RAD2, RADA, RADB	4	470	RES ARRAY 2 RES 470 OHM 0404	Panasonic Electronic Components	EXB-24V471JX
RD1, RD2, RDA, RDB, RU31, RU32, RU33, RU34	8	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	2	0	RES SMD 0 OHM JUMPER 1/10W 0603	Yageo	RC0603JR-070RL
TP3V3, TPGND3	2		PC TEST POINT COMPACT	Keystone Electronics	5016
U21	1	3.3V	IC REG LINEAR 3.3V 300MA SOT23-5	STMicroelectronics	LDS3985M33R
U31	1		IC FLASH 16MBIT SPI/QUAD 8USON	Winbond Electronics	W25Q16JVUUIQ TR
U41, U42, U43, U44, U51, U52	6		IC TRNSLTR BIDIRECTIONAL 8MSOP	Diodes Incorporated	PI4ULS5V202UEX
UC	1		IC MCU 32BIT 2MB FLASH 132-UFBGA	STMicroelectronics	STM32U585QII3

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

10.8 Bill of Materials – H Driver Board

Table 14: Bill of Materials for BOS1921-BRD-L01-B1

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
BUMP1, BUMP2, BUMP3, BUMP4	4		BUMPER CYLINDRICAL 0.25" DIA BLK	Keystone Electronics	783-B
CHV	1	0.01µF	CAP CER 10000PF 250V X7R 0805	TDK Corporation	CGA4J3X7R2E103K125AA
CHV2	1	3900pF	CAP CER 3900PF 250V C0G/NP0 0805	TDK Corporation	C2012C0G2E392J125AE
CPUMP, CREG, CVBUS, CVDDIO	4	0.1µF	CAP CER 0.1UF 25V X5R 0402	Taiyo Yuden	TMK105BJ104KV-F
CVDD	1	100µF	CAP TANT POLY 100UF 6.3V 1206	KEMET	T527I107M006ATE070
CVDD2	*	330µF	CAP TANT POLY 330UF 6.3V 1411	KEMET	T520B337M006ATE040
CYP	*	0.01µF	CAP CER 10000PF 250V X7R 0603	Würth Elektronik	885342206006
DZ	1	5.6V	DIODE ZENER 5.6V 500MW SOD-323F	Rohm Semiconductor	UFZVFHTE-175.6B
J1	1		CONN HEADER SMD R/A 14POS 2.54MM	Würth Elektronik	610114249121
J2	1		CONN HEADER VERT 2POS 2.54MM	Sullins Connector Solutions	PRPC002SAAN-RC
JUMPER	1		CONN JUMPER SHORTING .100" GOLD	Sullins Connector Solutions	QPC02SXGN-RC
L1	1	10µH	FIXED IND 10UH 1.48A 415 MOHM	TDK Corporation	VLS3012HBX-100M
OUT	1		TERM BLOCK HDR 3POS 90DEG 3.81MM	Molex	395121003
R1, R2, R3, R4	4	1.5k	RES SMD 1.5K OHM 5% 1/16W 0402	Yageo	AC0402JR-071K5L
R5, R6	2	51	RES SMD 51 OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ510X
RO-, RO+	2	0	RES SMD 0 OHM JUMPER 1/10W 0603	Yageo	RC0603JR-070RL
RS	1	0.2	RES 0.2 OHM 1% 1/8W 0402	TE Connectivity Passive Product	RLP73N1ER20FTDF
U1	1		PIEZO HAPTIC DRIVER 190V	Boreas Technologies	BOS1921CQ

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

10.9 Bill of Materials – P Driver Board

Table 15: Bill of Materials for BOS1921-BRD-S01-B1

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
BUMP1, BUMP2, BUMP3, BUMP4	4		BUMPER CYLINDRICAL 0.25" DIA BLK	Keystone Electronics	783-B
CHV	1	1000pF	CAP CER 1000PF 200V X7R 0603	Walsin Technology Corporation	0603B102K201CT
CHV2	1	1500pF	CAP CER 1500PF 100V X7R 0603	Yageo	CC0603JRX7R0BB152
CPUMP, CREG, CVBUS, CVDDIO	4	0.1µF	CAP CER 0.1UF 25V X5R 0402	Taiyo Yuden	TMK105BJ104KV-F
CVDD	1	10µF	CAP CER 10UF 25V X5R 0603	TDK Corporation	C1608X5R1E106M080AC
CYP	*	0.01µF	CAP CER 10000PF 250V X7R 0603	Würth Elektronik	885342206006
DZ	1	5.6V	DIODE ZENER 5.6V 500MW SOD-323F	Rohm Semiconductor	UFZVFHTE-175.6B
J1	1		CONN HEADER SMD R/A 14POS 2.54MM	Würth Elektronik	610114249121
L1	1	68µH	FIXED IND 68UH 430MA 2.362OHM SM	TDK Corporation	VLS3012CX-680M-1
OUT	1		TERM BLOCK HDR 3POS 90DEG 3.81MM	Molex	395121003
R1, R2, R3, R4	4	1.5k	RES SMD 1.5K OHM 5% 1/16W 0402	Yageo	AC0402JR-071K5L
R5, R6	2	51	RES SMD 51 OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ510X
RO-, RO+	2	0	RES SMD 0 OHM JUMPER 1/10W 0603	Yageo	RC0603JR-070RL
RS	1	1	RES SMD 1 OHM 1% 1/6W 0402	Panasonic Electronic Components	ERJ-2BQF1R0X
U1	1		PIEZO HAPTIC DRIVER 190V	Boreas Technologies	BOS1921CW

* 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 BOS1921-KIT lifecycle. It will also contain application note documents that will be helpful for the user writing his/her own code to operate the BOS1921.

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:

Both OUT+ and OUT- are active outputs. When measuring these signals using an oscilloscope, use a separate probe on each output. Never connect the ground of a probe to one of these outputs. Doing so might damage the BOS1921-KIT and/or your oscilloscope. For more information, please consult the *Probing BOS1921 with an Oscilloscope* application note available for download on https://www.boreas.ca/pages/support.

13 Ordering Information

Table 16: Ordering information

	ORDERING PART NUMBER	DIMENSIONS	PACKING FORMAT	QUANTITY	ACCESSORIES
1	BOS1921-KIT-B01 (Starter Set)	Controller PCB 65x50 mm Driver PCBs 40x22 mm	Box ($6^{3/4}$x$6^{1/2}$x$1^{1/4}$)"	1 controller 1 haptic card 1 pump card 4 load capacitors	4 load capacitors (10nF, 47nF, 100nF, 470nF)

14 Document History

ISSUE	DATE	Document Number	CHANGES
1	December 2022	BT015AUG01.01	Original Document.

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.

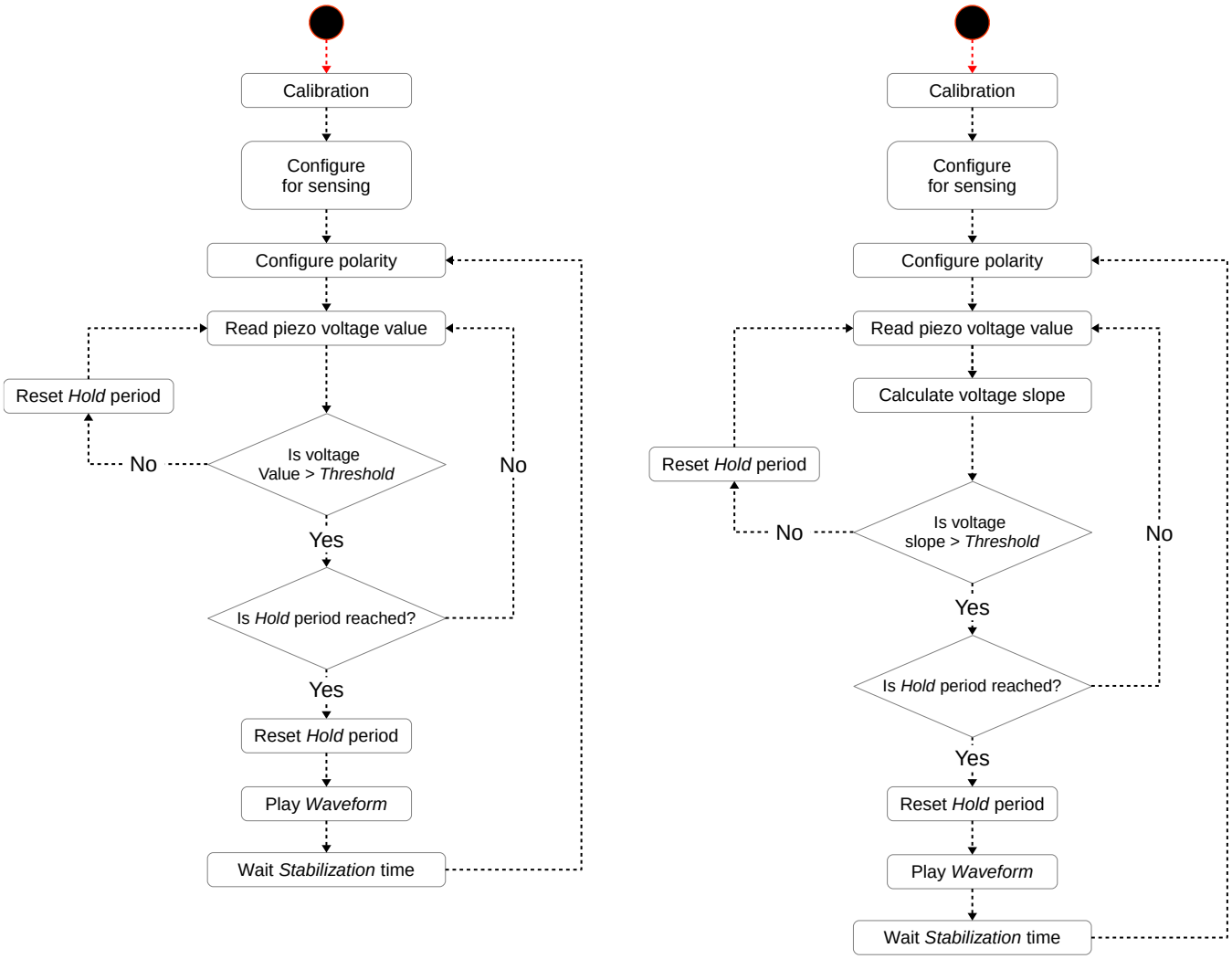


Figure 36: Threshold (left) and slope (right) sensing algorithm flow charts

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.

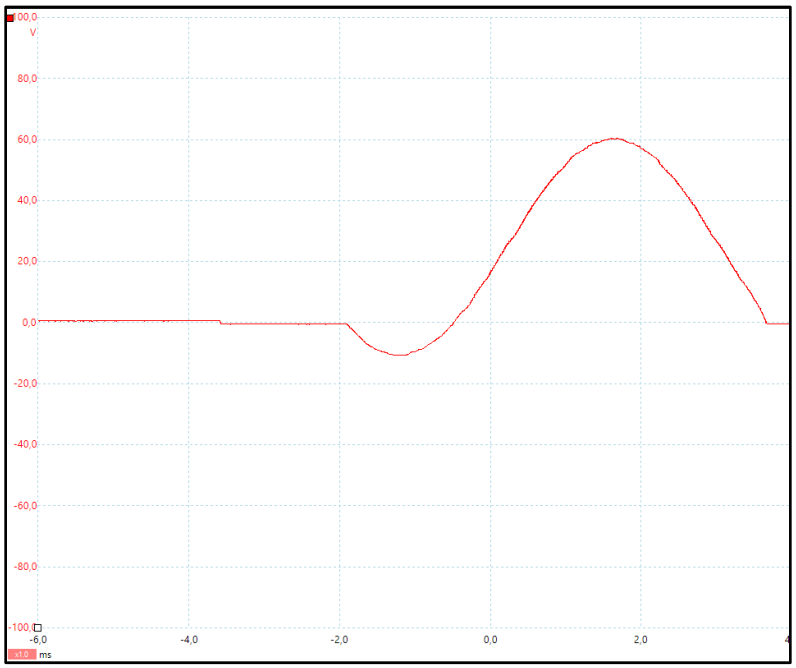


Figure 37: Sensing algorithm: differential voltage across the actuator

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 1.3 V threshold and 10 ms hold time:

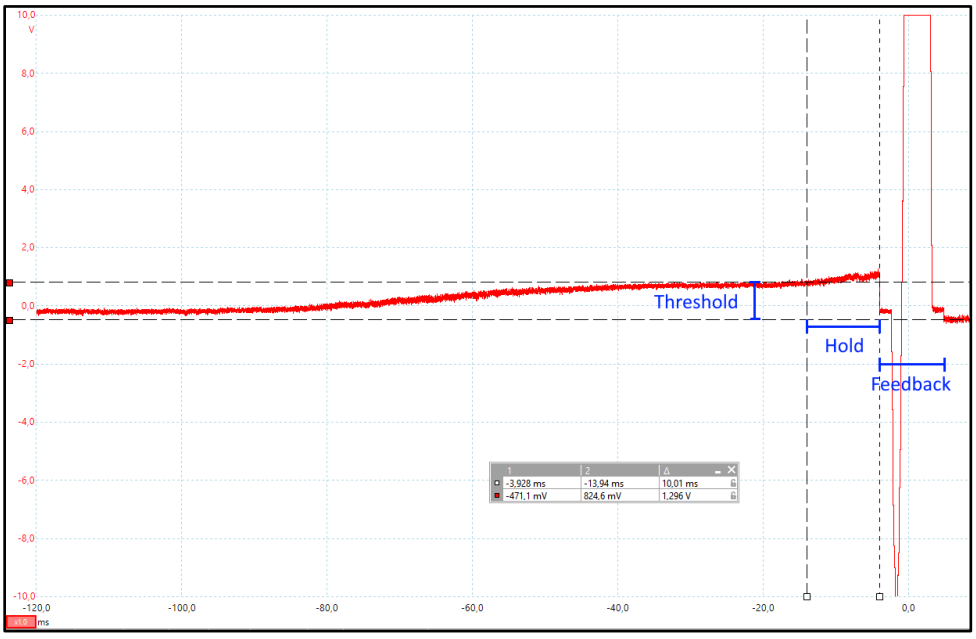


Figure 38: Sensing algorithm: threshold, hold time and feedback.

After the feedback, there is a stabilization phase. In constant stabilization, the output of the BOS1921 is maintained at a fixed voltage for a period of time. In sine stabilization, the output of the BOS1921 follows a sine shaped waveform of a certain amplitude for the stabilization time. Here are some examples:

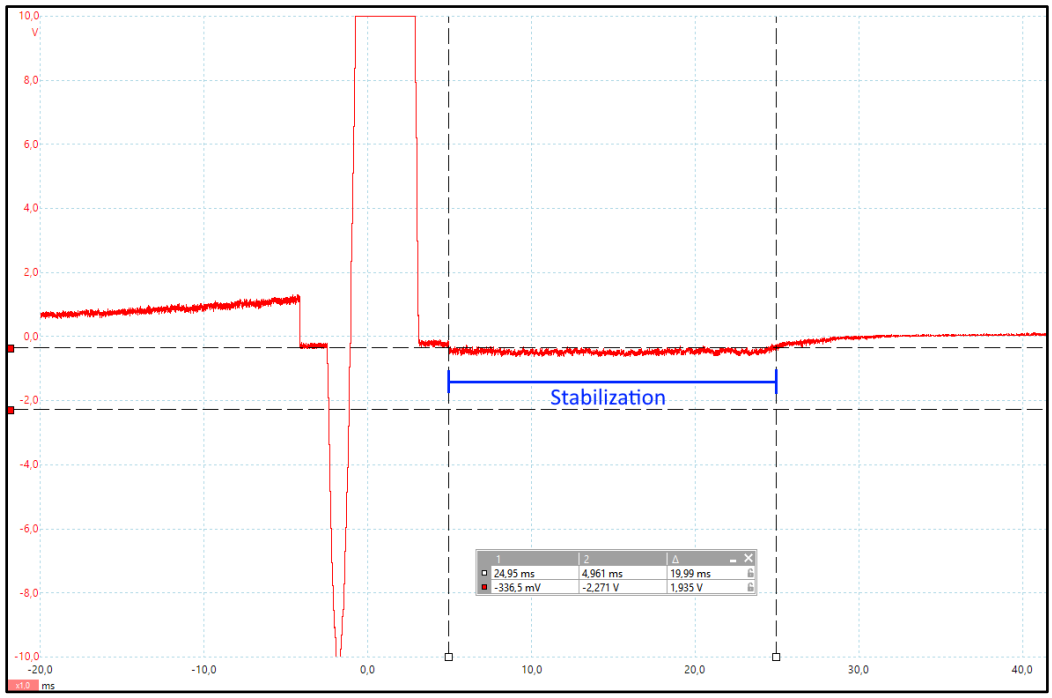


Figure 39: Sensing algorithm: constant stabilization (20 ms, -100 mV)

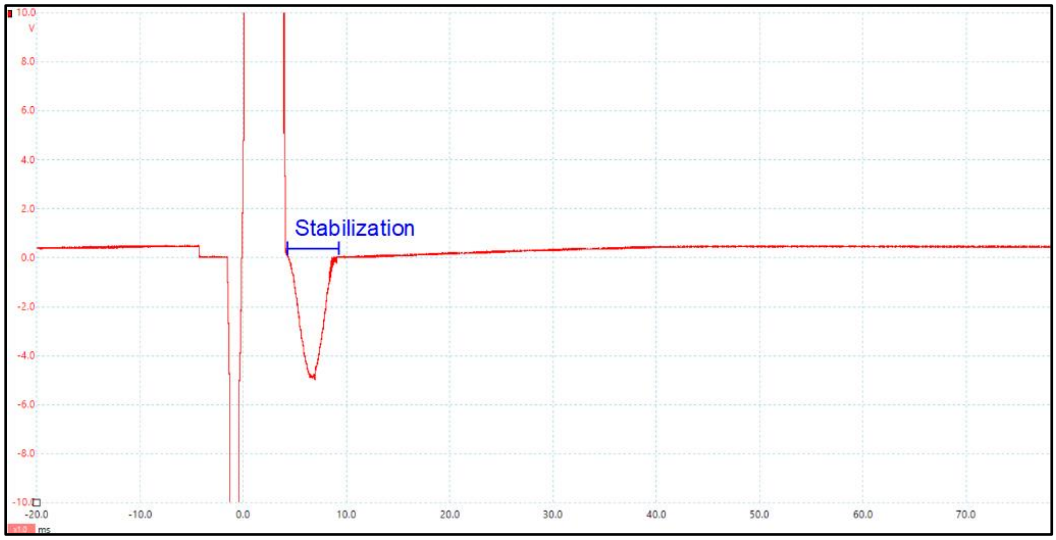


Figure 40: Sensing algorithm: sine stabilization (5 ms, -5 V)

Appendix B. Firmware Upgrade using STM32CubeProgrammer

The BOS1921-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 BOS1921-KIT board microcontroller needs to execute DFU application in the system memory. The boot selection switch allows to select the system memory.

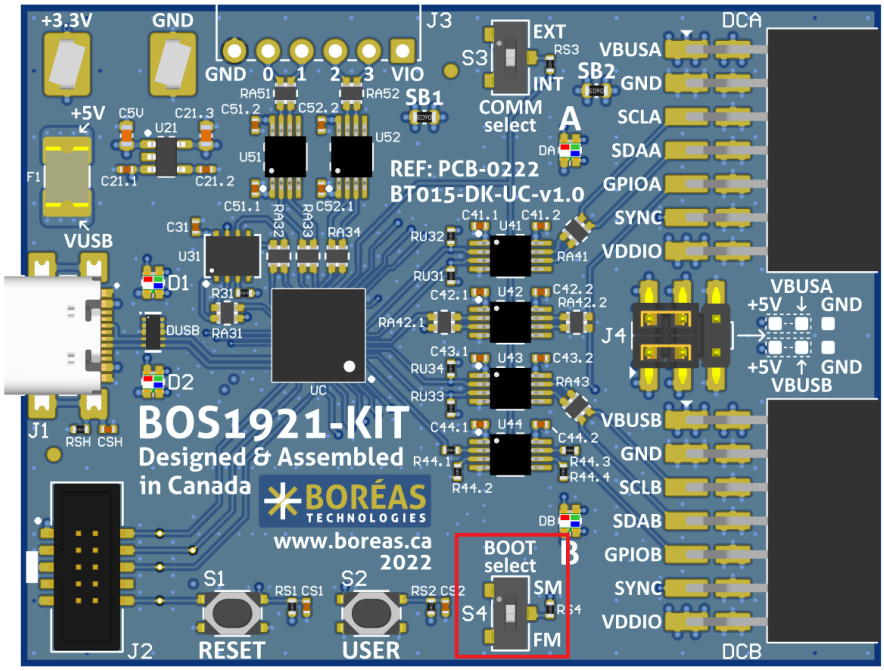


Figure 41 : Boot selection switch position

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 BOS1921-KIT board to a PC using a USB cable.
5. Start SMT32CubeProgrammer.
6. Reset the BOS1921-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.

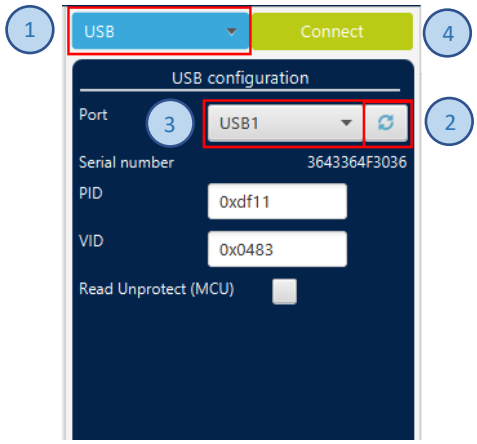


Figure 42: STM32CubeProgrammer connection setting

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.

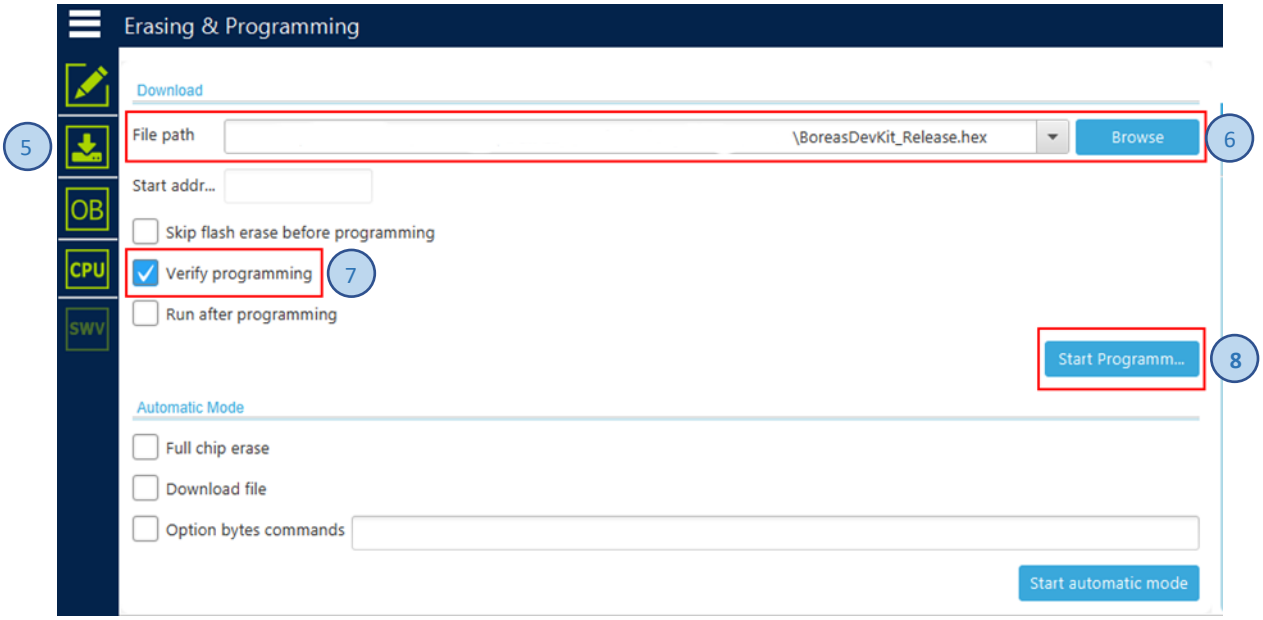


Figure 43: STM32CubeProgrammer programming setting

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

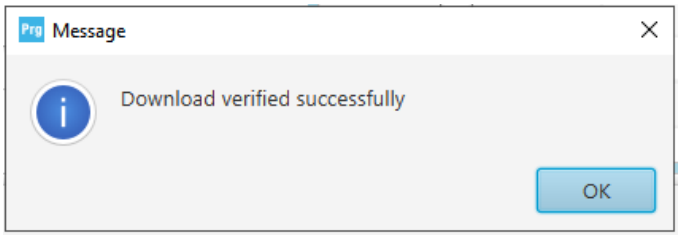


Figure 44: STM32CubeProgrammer upgrade completed dialog.

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 BOS1921-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.

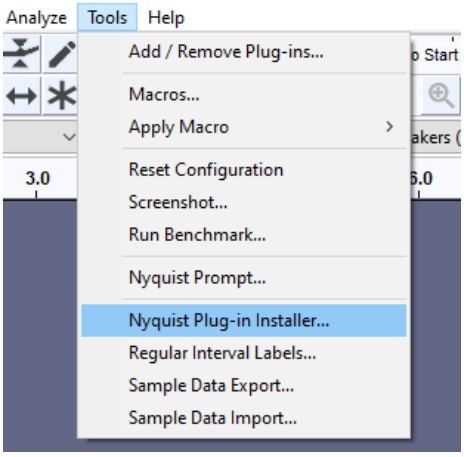


Figure 45: dc-offset plugin installation

3. Ensure the plugin is enabled.

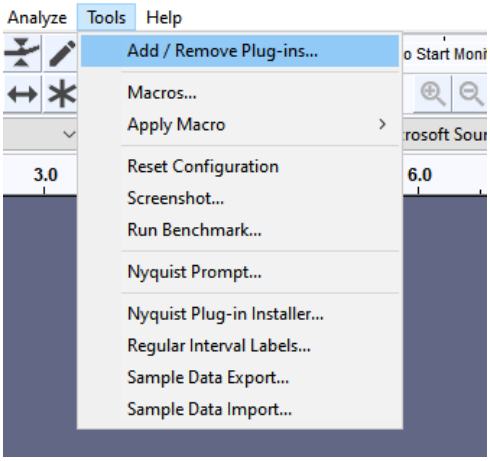


Figure 46: Access plugin management window

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

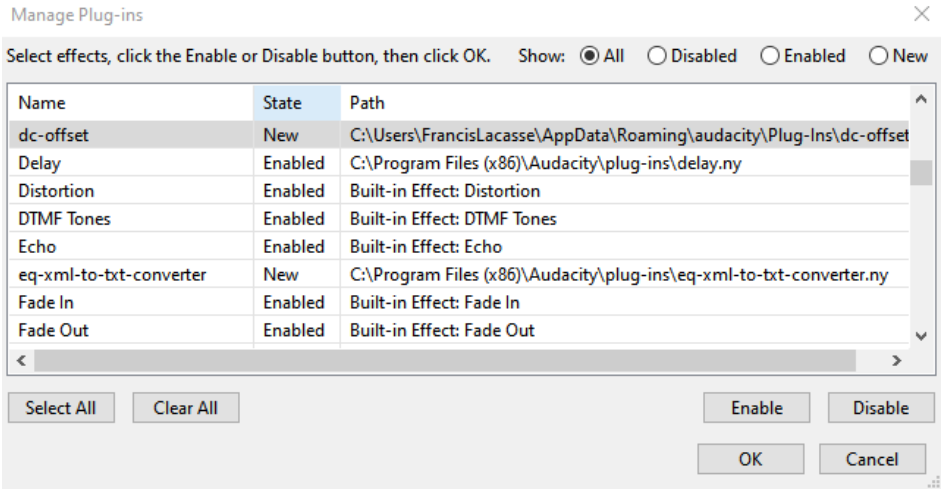


Figure 47: Plugin management window

C.2 Use Audacity to Play WAV Files

Description

Download waveform samples from Boréas website and use Audacity® to play them on the BOS1921-KIT.

Prerequisites

- BOS1921-KIT board is in *Audio* mode. Refer to section 8.5.2 for more information regarding *Audio* mode.
- Using the BOS1921-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)

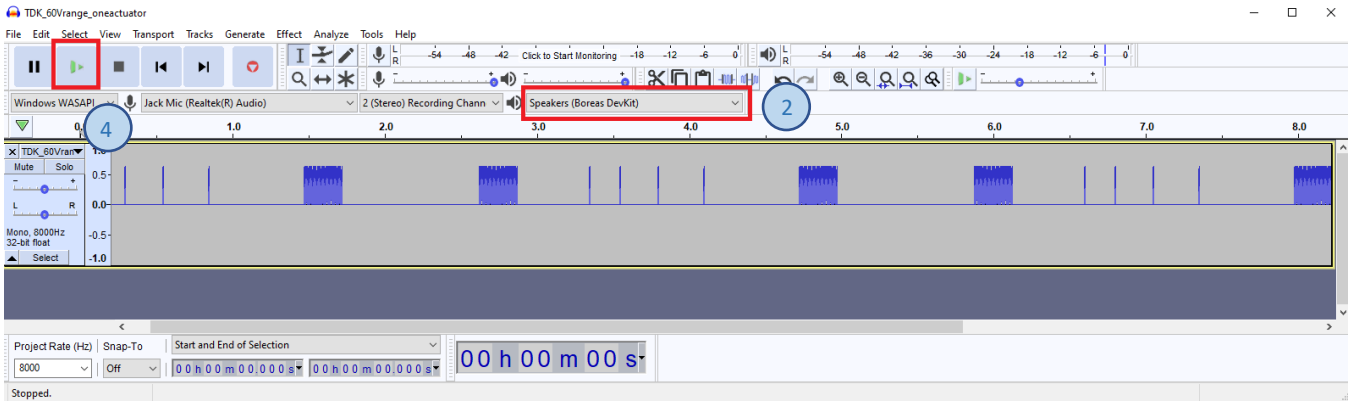


Figure 48: Use audacity to play a WAV file

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: TDK_60Vrange_oneactuator.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 (-10 V to 60 V).

In this example the waveform parameters are:

- Amplitude peak to peak = Piezo Vmax – Piezo Vmin = 60 – (-10) = 70 V
- Frequency = 125 Hz
- Duration = 10 sec

Prerequisites

- BOS1921-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.

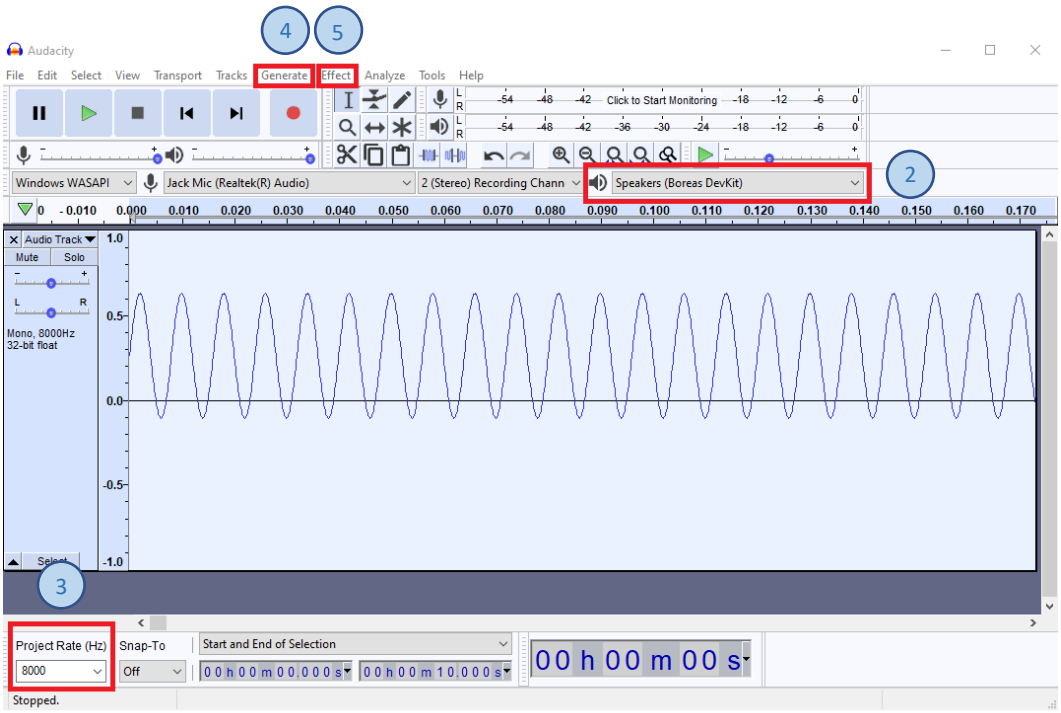


Figure 49: Audacity – simple waveform creation

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:

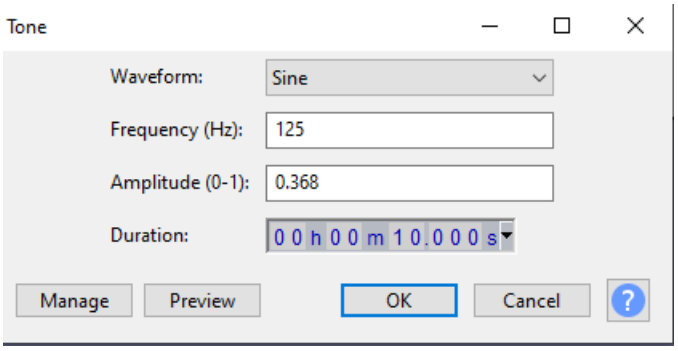


Figure 50: Tone parameters

The amplitude value is calculated with the following formula:

$$\text{Amplitude} = \frac{\text{Peak to Peak Amplitude}}{Boreas\ IC\ amplitude\ max} => \frac{(60)\ \text{V} - (-10)\ V}{190\ V} => 0.368$$

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

$$\frac{Piezo\ Vmax\ +\ Piezo\ Vmin}{Boreas\ IC\ amplitude\ max} => \frac{60\ V\ +\ (-10\ V)}{190\ V} => 0.263$$

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

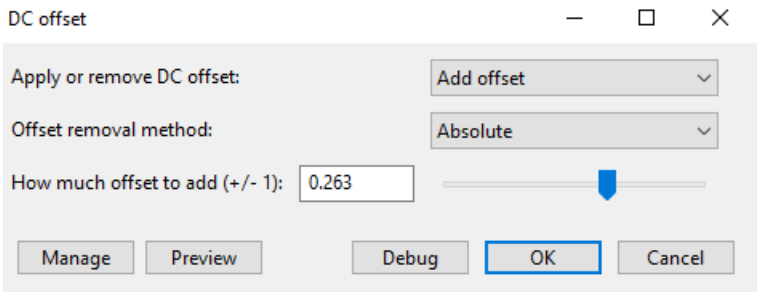


Figure 51: Add dc-offset

6. Play the wave using the play button.

