BOS0614 Development Kit

1 Features

- Plug and play development kit to experience piezo haptic feedback
- Low-power four-output BOS0614 integrated circuit, high voltage driver with digital interface
- Easy generation of high-voltage waveforms up to 60 V
- Enable sensing and emulate button behavior using the actuator
- Four channel output PCB
- Breakable PCB for easy prototyping
- Standard USB audio to prototype haptic effects in MATLAB®, Python®, Audacity® and many other softwares[1].
- Compatible with piezoelectric actuators such as TDK PowerHap™[2] 60 V models.

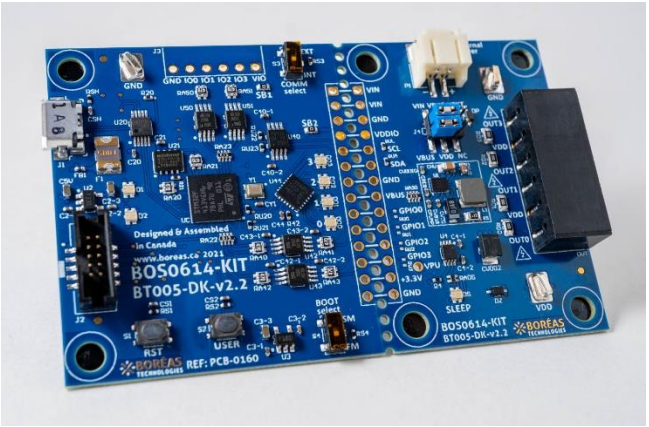


Figure 1: BOS0614-KIT overview

2 Description

The BOS0614-KIT is a Development Kit to help users get familiar with the BOS0614 Piezo Haptic Driver IC.

The PCB features a single BOS0614 with four output channels to drive multiple piezoelectric actuators from a single driver IC. The PCB is breakable allowing to separate the BOS0614 and its components enabling the users to directly control the driver using their platform.

This kit connects to associated PC software over USB for easy programming of the BOS0614 and manual generation of waveforms on the connected actuator. An Audio mode allows quick and easy generation of waveforms using existing audio software like Audacity® for haptic prototyping.

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

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

Table 1: Product information

PART NUMBER	DESCRIPTION
BOS0614-KIT-B03	Starter Set

For details see sections 3 and 12.

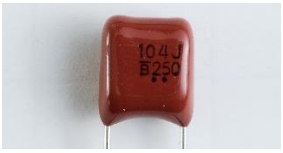
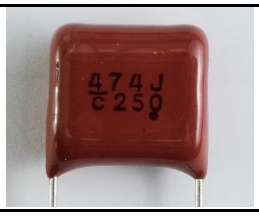
[1] MATLAB® is registered trademark of The MathWorks, Inc.
Python® is a registered trademark of the PSF
Audacity® is a registered trademark of Dominic Mazzoni

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

3 What's in the Box

The BOS0614-KIT is currently available in one package: *Starter Set*. The following table shows the content of this set.

Table 2: Starter Set BOS0614-KIT-B03 development kit content

#	ITEM	QTY	DESCRIPTION	REFERENCE
1	Evaluation PCB	1	BOS0614-KIT Board	
2	USB Cable	1	Cable to connect the evaluation PCB to a computer Stewart Connector part number SC-2AMK001F	
3	6-position terminal block connector	1	Male connector used for interfacing the piezoelectric actuator on the board. Molex part number 39510-0006	
4	14-position thru-hole header connector	1	2.54 mm pitch header connector for probing interface signals and supply. Sullins Connector Solutions PRPC014SAAN-RC or equivalent.	
5	6-position thru-hole right-angle 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.	
6	Power Connector	1	Connector and cable for external power supply connection (refer to section 8.2.5) JST Sales America Inc. part numbers PHR-2 and ASPHSPH24K51	
7	Capacitor	4	100 nF film capacitor Panasonic ECQ-E2104JB3	
8	Capacitor	4	470 nF film capacitor Panasonic ECQ-E2474JB	

4 Board Overview

The purpose of this section is to show the location of the components that allow you to interact with the BOS0614-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.

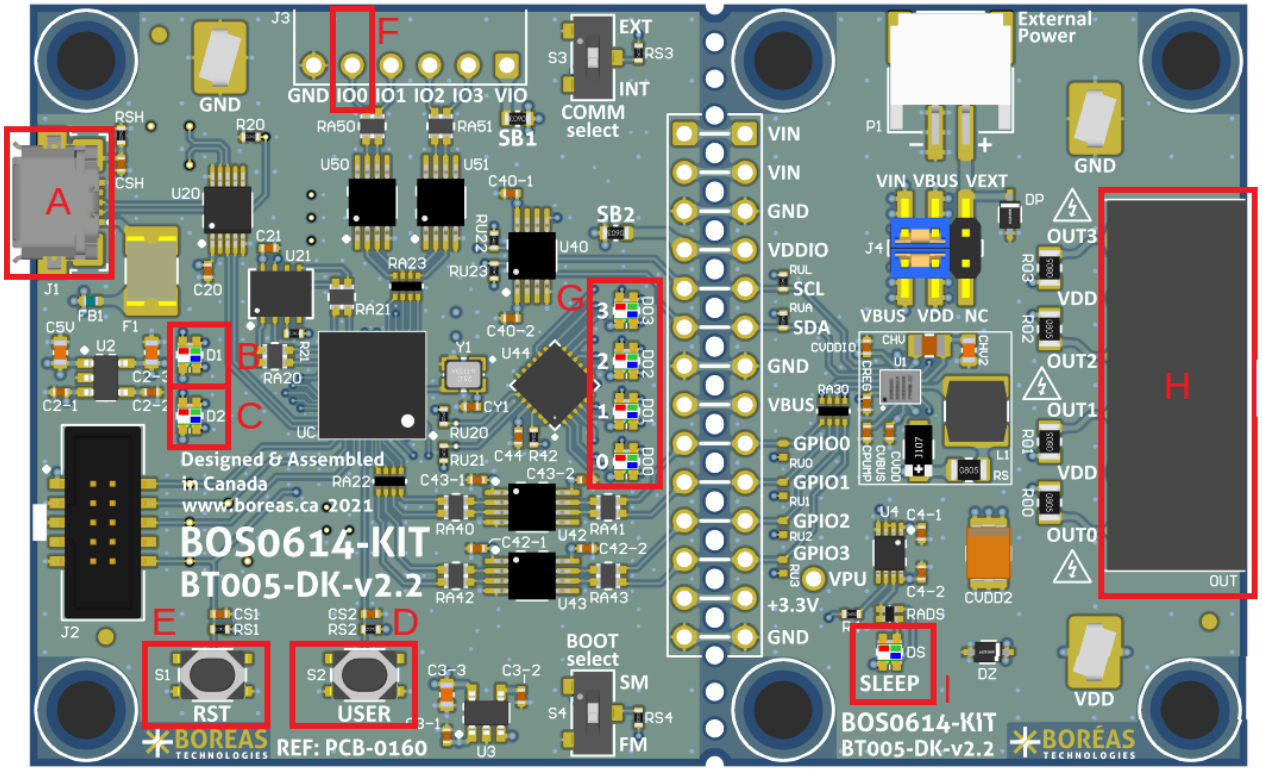


Figure 2: BOS0614-KIT board user interface

Table 3: BOS0614-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	BOS0614-KIT status LED	Stays red if an error is detected.
D	Change operation mode button	Change the current operation mode on press.
E	Reset button	Reset the microcontroller on press.
F	GPIOs	External GPIOs for customized board operation (requires custom firmware).
G	BOS0614 channel status LEDs	LEDs displaying the current state of each BOS0614 output.
H	BOS0614 piezo terminal block	Terminals where piezoelectric actuators are connected.
I	BOS0614 Sleep Mode LED	LED indicating BOS0614 is in sleep mode.

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.

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

4.2 BOS0614-KIT Status LED Details

This section describes the meaning of the different colors and state transitions of the BOS0614-KIT Status LED. If an error is detected, the BOS0614 Channel Status LEDs are used to indicate the detection of this error.

Table 5: BOS0614-KIT status LED details

Pattern	Color	Description
Always off	N/A	Working normally
Always on	Red	An error has been detected.

4.3 BOS0614 Channel Status LEDs Details

This section describes the meaning of the different colors and state transitions of the BOS0614 channel status LEDs. There is a status LED for each BOS0614 output.

Table 6: BOS0614 channel status LED details

Pattern	Color	Description
Always off	N/A	No error detected.
Always on	Red	At least one internal error has been detected by the BOS0614.
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 BOS0614.

5 Your First Piezoelectric Actuator Button Experience

The BOS0614 and a piezoelectric actuator can be used together to implement the equivalent of a button. Before being shipped, the BOS0614-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 BOS0614-KIT board, the USB cable, the terminal block plug, and a piezo actuator* or capacitor as load
2. Insert the terminal block plug into the development kit's terminal block connector.
3. Using a small slotted screwdriver, install the load the terminal block plug. **Pay attention to the polarity, using the OUTx terminal as positive and the VDD terminal as negative**. Refer to the figure below to identify location of OUTx and VDD locations on the terminal block.
4. Connect the development kit board to a USB port using the USB cable.
5. When the operation mode green LED is blinking and BOS0614 channel status LED are solid green, you are ready to go. If using a piezo actuator as load, press on the piezo* to experience the piezo actuator button. If using a capacitor as load, connect to the Haptic Studio application to play voltage waveforms, and use an oscilloscope to monitor the output.

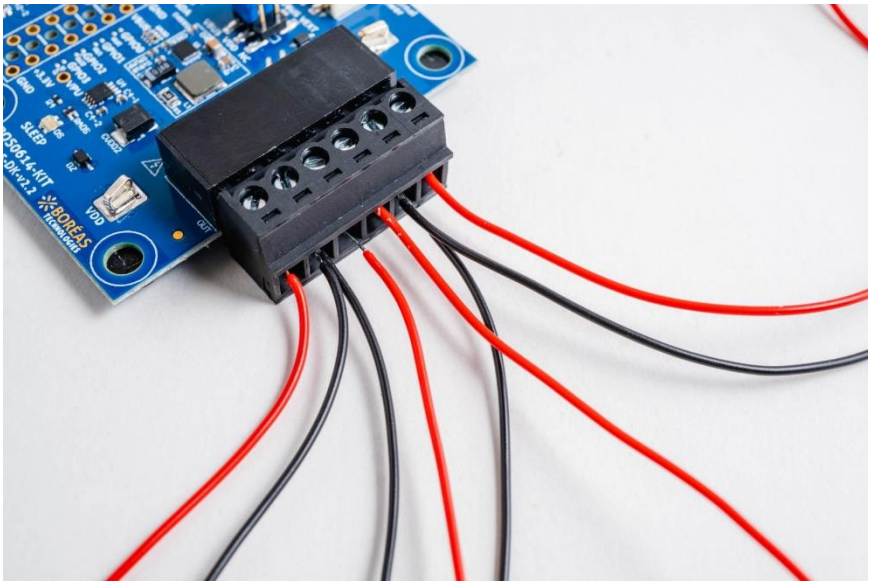


Figure 3: BOS0614-KIT piezo connector assembly

*For the piezo actuator button experience, we recommend procuring a TDK Powerhap 1204 to get familiar with the system operation.

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 BOS0614-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.

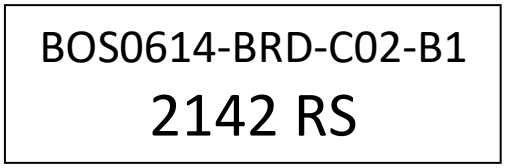


Figure 4: Label example giving board part number with BOM revision suffix, and assembly code

Table 7: BOS0614-KIT board and software compatibility list

PCB REF	PCB REVISION	BOARD P/N*	COMPATIBLE FIRMWARE	COMPATIBLE PC SOFTWARE
PCB-0273	BT005-DK-v2.3	BOS0614-BRD-C03-B1	BoreasDevKit_Release_PCB0273.hex Versions starting at 1.21.0	Haptic Studio Starting at 1.2.2

** Board P/N include BOM revision suffix*

Any PCB reference design number not listed into Table 7 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 Haptic Studio Application

Haptic Studio software is a desktop application intended to ease evaluation of the BOS0614. This application can be downloaded from Boréas website. Help instructions are provided inside the application.

1) Log in your Boréas account.
2) Go to the "Technical Documents" section.
3) Click on the "BOS0614-KIT Documents" link.
4) Scroll down to section BOS0614-KIT Controller (PC software).
5) Download the appropriate Haptic Studio version based on your development kit identification.
6) Double click on the installer executable you downloaded and follow the instructions.

6.4 Upgrade Development Kit Firmware

The native BOS0614-KIT board firmware includes an over-USB firmware upgrade mechanism. The BOS0614-KIT Haptic Studio software will offer to upgrade the firmware if needed on next connection with the development kit. Follow the on-screen instructions.

For installation of firmware without the use of this application, refer to Appendix A.

7 Product Overview

The BOS0614-KIT has been designed to meet a multitude of needs. The main objective is to demonstrate the capacity of the BOS0614 but also to help integrators in the development of haptic effects and in its product prototyping.

The BOS0614-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. Operation without the GUI is referred to as the development board being used autonomously. It is configured in one of these autonomous mode before shipping (see section 5). The so-called autonomous modes are detailed further in this document.

The BOS0614-KIT supports multiple operation modes:

Table 8: 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 BOS0614 performance (waveform output, power consumption) in the context of your application. • Optimize BOS0614 operation using specific registers value.
Audio	• Easily experiment with various waveform shapes and amplitudes. • Easily produce and compare various waveforms and identify the effects most suited for your application. • Play synchronous waveforms on up to two channels of BOS0614-KIT.

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

The BOS0614-KIT is used to test the capacity of the BOS0614 with various piezoelectric actuators. The trigger events that can be used are an action *Play* in the application, or an action of pressing and releasing the piezoelectric actuator.

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 BOS0614 via the USB port. Your PC can select the BOS0614-KIT as an audio card stereo output.

The BOS0614-KIT development kit can be used as a basis for the development of a prototype.

It is possible to connect an external I2C master without separating the breakable mini-board from the BOS0614-KIT. This operation requires a good knowledge of the electrical design of the BOS0614-KIT. For more details about the hardware refers to section 8.

7.1 Audio Mode Operation

When the BOS0614-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.

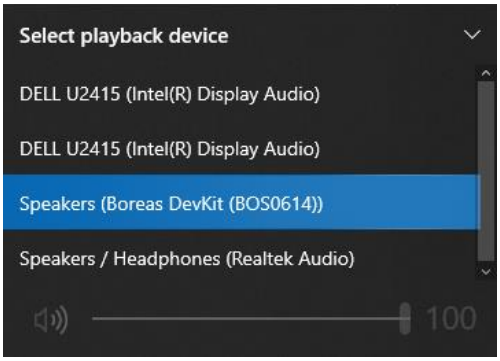


Figure 5:Boreas DevKit speaker

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.

Board channel A will play the left audio track, and board channel B plays the right channel track.

The audio level to BOS0614-KIT output voltage level is converted linearly so the maximum audio level corresponds to 60 V on the BOS0614-KIT output, 0 audio level corresponds to 0 V output.

8 Hardware

The purpose of this section is to provide information on the hardware design of the BOS0614-KIT PCB to help the integrator evaluate BOS0614 and to use it in a prototype.

8.1 Design Overview

The board is composed of two distinct sections: a microcontroller section on the left and a BOS0614 driver section on the right. Each section is clearly demarcated by dotted line which allows to physically separate the two sections if needed. It is for this reason that the terms *breakable section* or *breakable board* are sometimes used to identify the right section of the PCB.

By default, the BOS0614-KIT power supply 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 I2C and GPIO, an external supply connector to power the BOS0614 driver section, and a series of jumpers and solder bridges that can be populated or unpopulated with resistance to do the configuration.

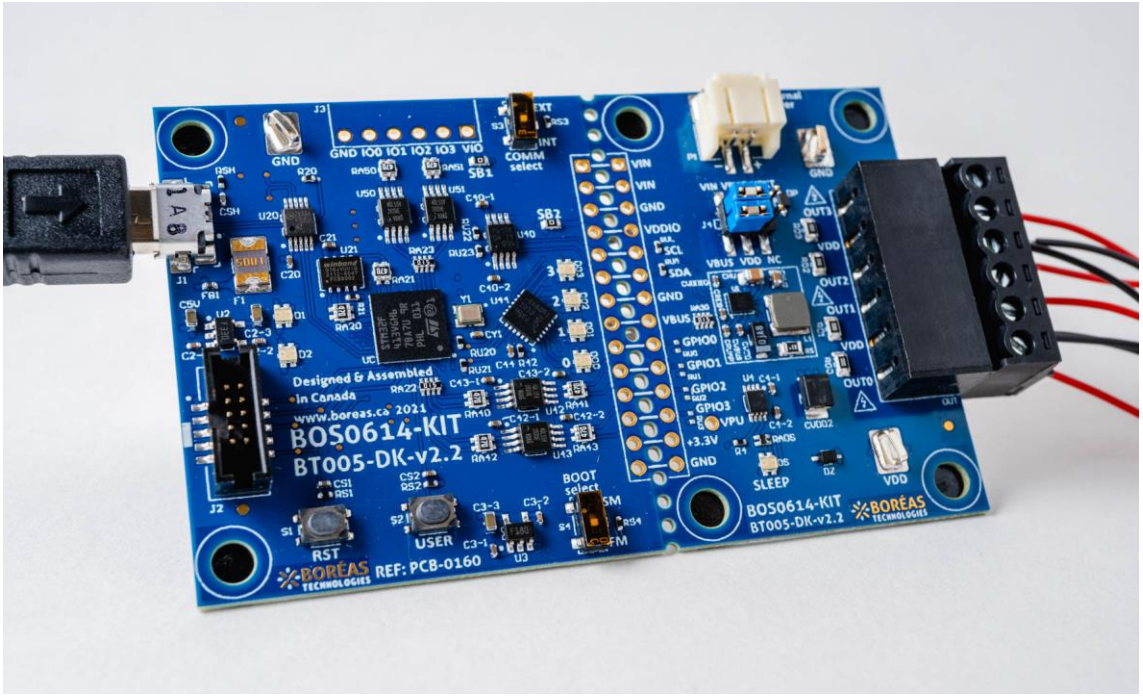


Figure 6: BOS0614-KIT PCB with connectors

8.2 Hardware Features

In this section, we will discuss the various hardware configurations. Except for section 8.2.1, it is assumed that the microcontroller section and the driver section have not been separated.

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

8.2.1 Breakable Driver Section

The use of the breakable unit with custom-made firmware is done at the user's own risk of causing damage beyond repair to the BOS0614 circuit. Boréas Technologies will not be held responsible.

One way to integrate a BOS0614 is to break the driver section and connect it to your development platform. A few strokes using an exacto knife on the dotted line will help to split the PCB.

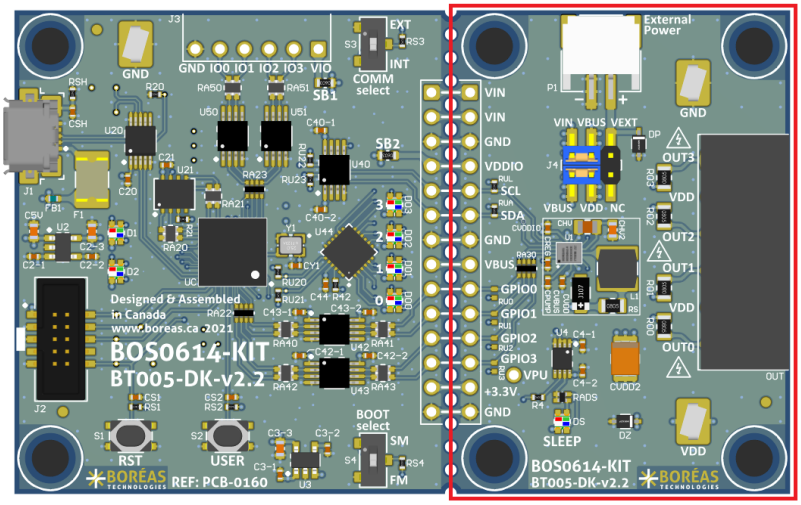


Figure 7: Breakable section location

The breakable PCB contains a BOS0614 that can be used alone with a user-preferred development platform. Not all signals must be connected to the user development platform (see table below). Refer to BOS0614 datasheet for a complete description on how to use and program the circuit.

Table 9: Breakable Driver Section signals

Signal	Description	Constraint
VIN/VEXT/VBUS	Main power supply for the BOS0614	Supply voltage between 3.0 V and 5.5 V with at least 1.33 A current drive. Connect only one and use appropriate jumper. See section 8.2.5.
GND	0 V reference	Connect all grounds.
VDDIO	Digital IO power supply	Digital signals voltage domain. Must be between 1.08 V and 1.98 V.
SCL/SDA	I2C/I3C digital signals	
GPIO0 to GPIO3	Digital input/output for each BOS0614 output	RU0 to RU3 pull-up resistors must be populated when the driver PCB section is broken.
+3.3V	LED supply	Do not connect. Not used when the driver PCB section is broken.
VPU	Pull-up supply for GPIO0 to GPIO3	VPU external supply must be used when the driver PCB section is broken.

8.2.2 Probe Hooks

Probe hooks are available around the board to ease connection of instruments for measurement of supplies when debugging. At the separation line between the microcontroller section on the left and the driver section on the right lies a header pins connector. This connector allows to probe supply levels and digital communication signals.

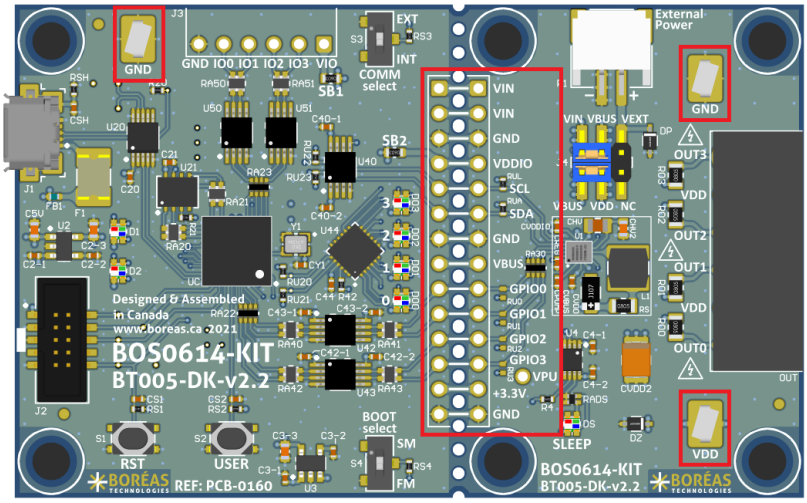


Figure 8: Probe hook locations

8.2.3 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.

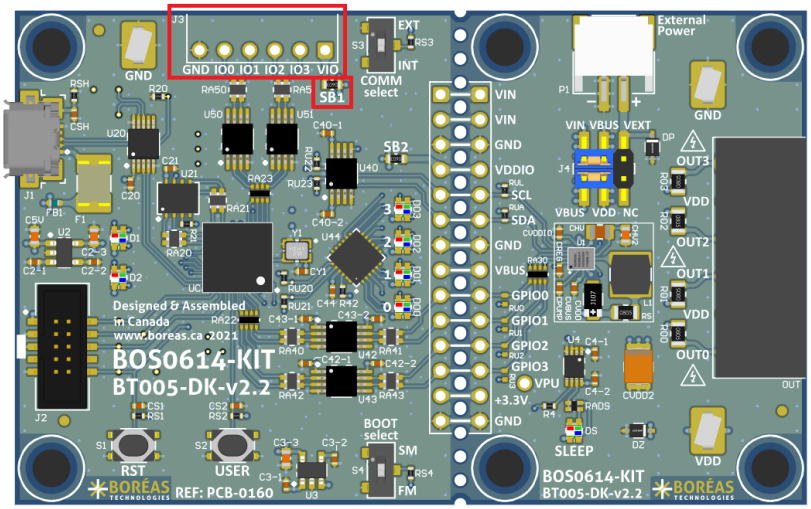


Figure 9: GPIOs and GPIOs supply voltage configuration solder bridge location

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 BOS0614-KIT PCB configuration.

Table 10: GPIOs supply voltage solder bridge configuration

GPIOs Supply Source	SB1 State
+3.3V (MCU supply)	Populated
VIO (3.3 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 9.1 for MCU pins numbers corresponding to IO0, IO1, IO2 and IO3.

8.2.4 External I2C/I3C

The BOS0614 features an I2C/I3C communication interface. By default, each BOS0614 are connected to the MCU I2C master. It is possible to bypass the MCU and use an external I2C or I3C master without breaking the board. This can be useful when trying to connect a BOS0614 directly to an external system.

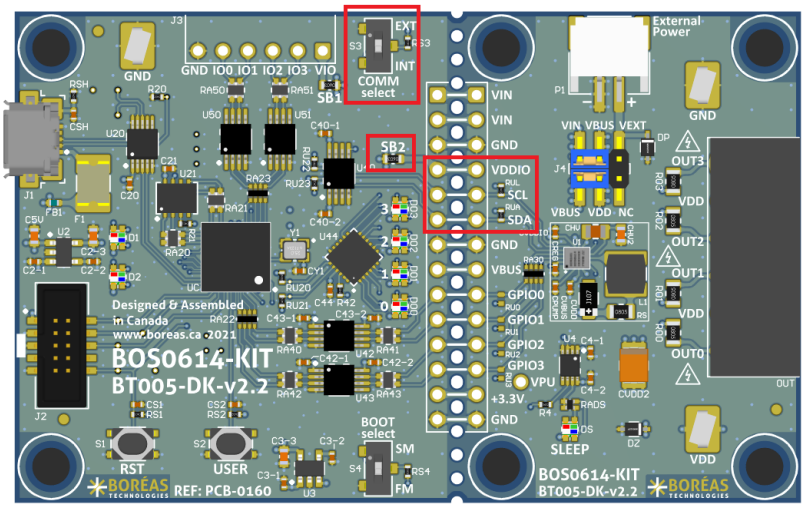


Figure 10: Comm selection switch and I2C header location

To use an external I2C/I3C master, 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.

By default, the I2C/I3C 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 BOS0614-KIT PCB configuration.

Table 11: I2C/I3C supply voltage solder bridge configuration

I2C/I3C Supply Source	SB2 State
+3.3V (MCU supply)	Populated
VDDIO (1.08 V to 1.98 V)	Unpopulated

When SB2 is unpopulated, I2C/I3C supply voltage is provided by VDDIO and GND on the header connector. The header connector is provided in the box but is not initially populated.

8.2.5 Power Supply Source and UPI Mode Operation

The driver section of the PCB can be supplied using two different sources: the USB connector and the P1 white connector. By default, the USB connector is the power source, and UPI mode is disabled.

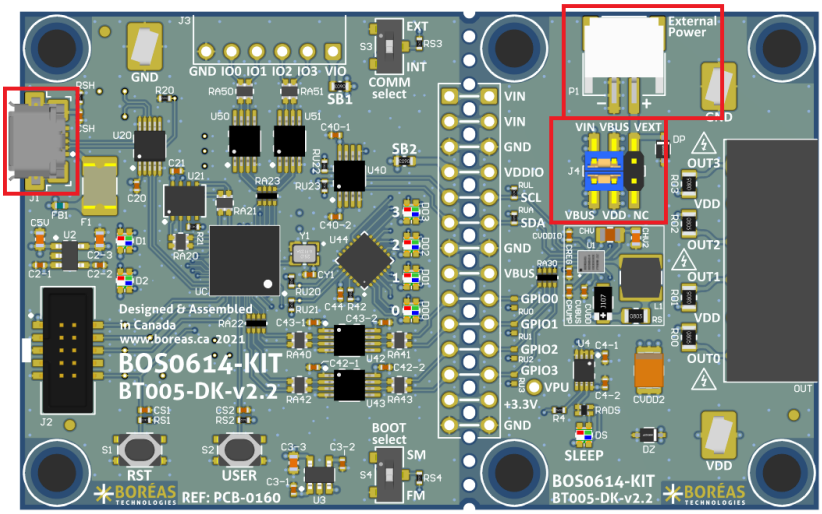


Figure 11: Driver power supply and UPI mode configuration jumper location

Table 12: Driver power supply and UPI mode configuration options

Driver Section Supply Source	UPI Mode	Jumper Configuration	
		Upper Jumper	Lower Jumper
USB connector	Disable	VIN – VBUS	VBUS – VDD
USB connector	Enable	VIN – VBUS	VDD – NC
P1 connector	Disable	VBUS – VEXT	VBUS – VDD
P1 connector	Enable	VBUS – VEXT	VDD – NC

Depending on the desired power source and UPI mode configuration, position the jumpers on J4 as indicated in the above table.

Refer to the board schematics in section 9.1 to obtain more information regarding the power supply options. Refer to the BOS0614 datasheet to get more information regarding the UPI mode.

8.2.6 Piezo Actuator Low-Pass Filter

Four 0805 resistors (RO0 to RO3) are in series with each BOS0614 output channels (OUT0 to OUT3 respectively). 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.

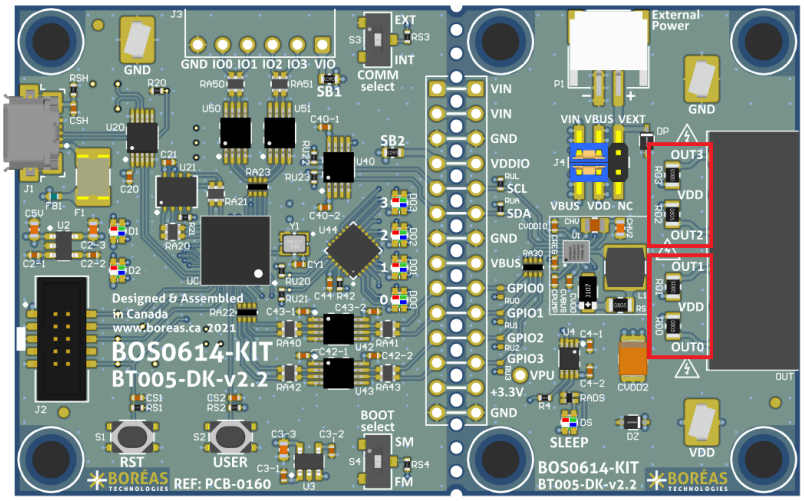
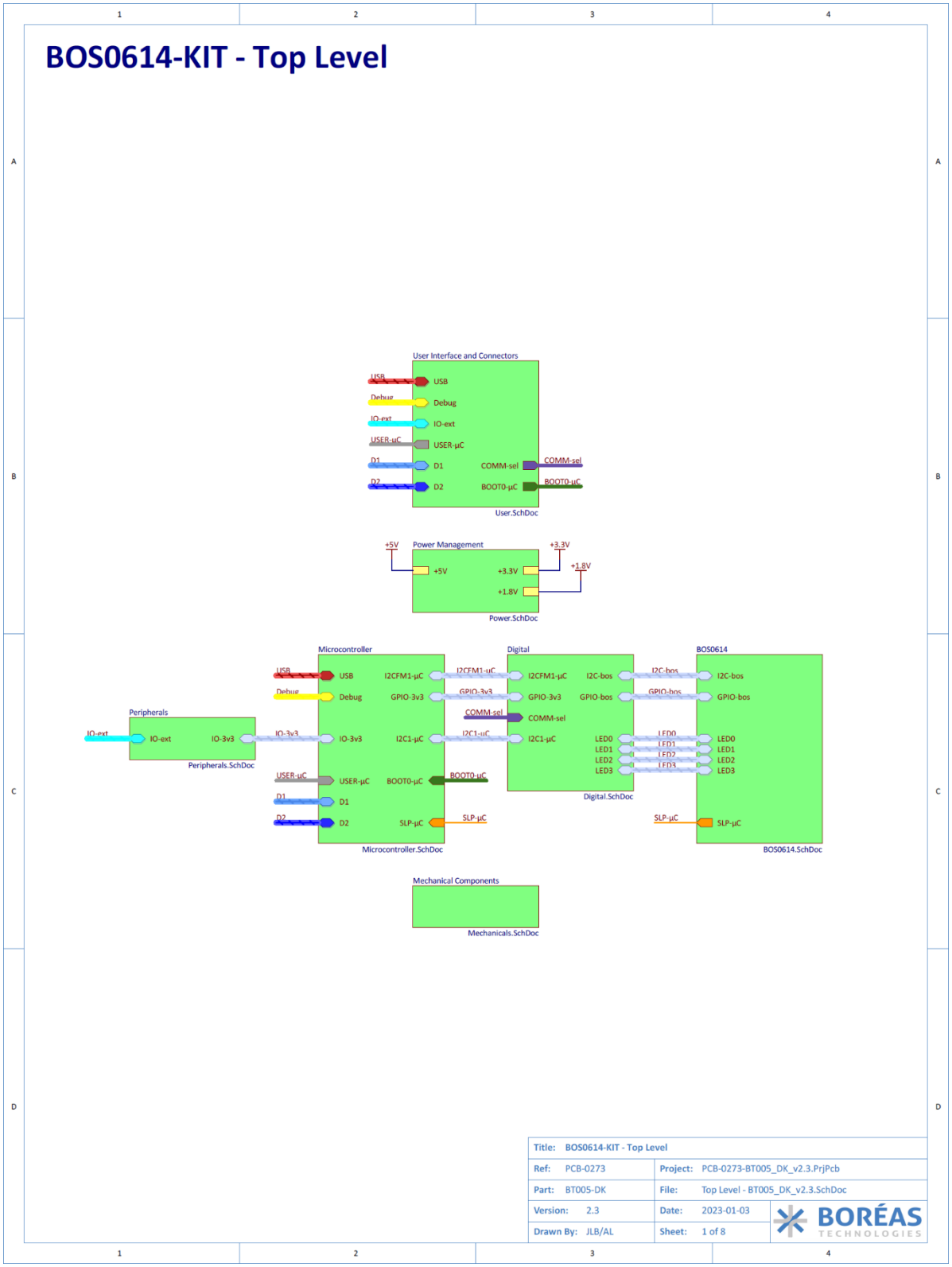


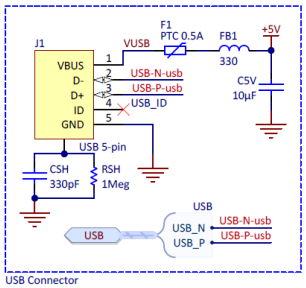
Figure 12: Low-pass filter resistors location

9 Design Reference

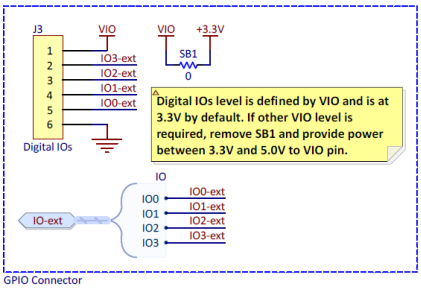
9.1 Schematics



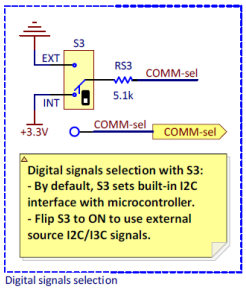
BOS0614-KIT - User Interface and Connectors



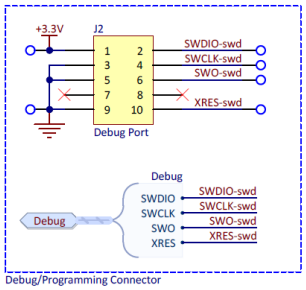
USB Connector



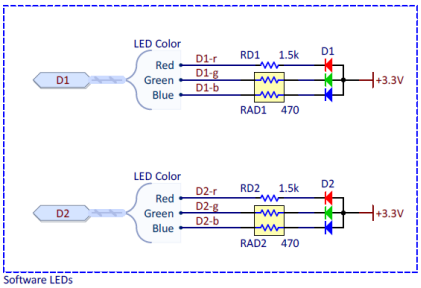
GPIO Connector



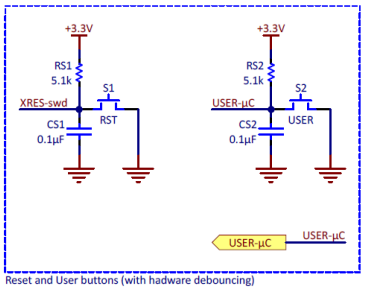
Digital signals selection



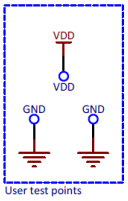
Debug/Programming Connector



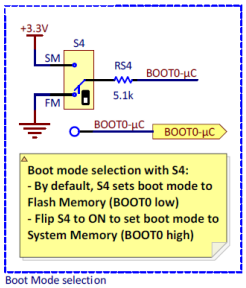
Software LEDs



Reset and User buttons (with hadware debouncing)



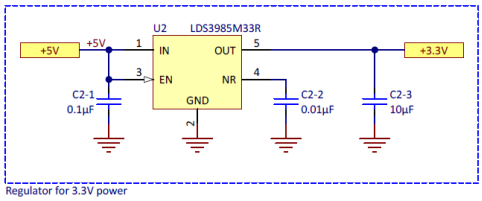
User test points



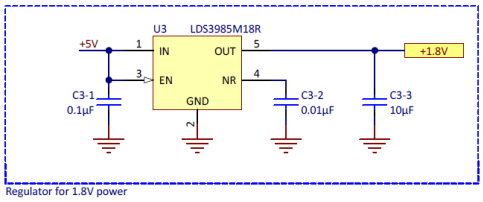
Boot Mode selection

Title:	BOS0614-KIT - User Interface and Connectors		
Ref:	PCB-0273	Project:	PCB-0273-BT005_DK_v2.3.PrjPcb
Part:	BT005-DK	File:	User.SchDoc
Version:	2.3	Date:	2023-01-03
Drawn By:	JLB/AL	Sheet:	2 of 8

BOS0614-KIT - Power Management



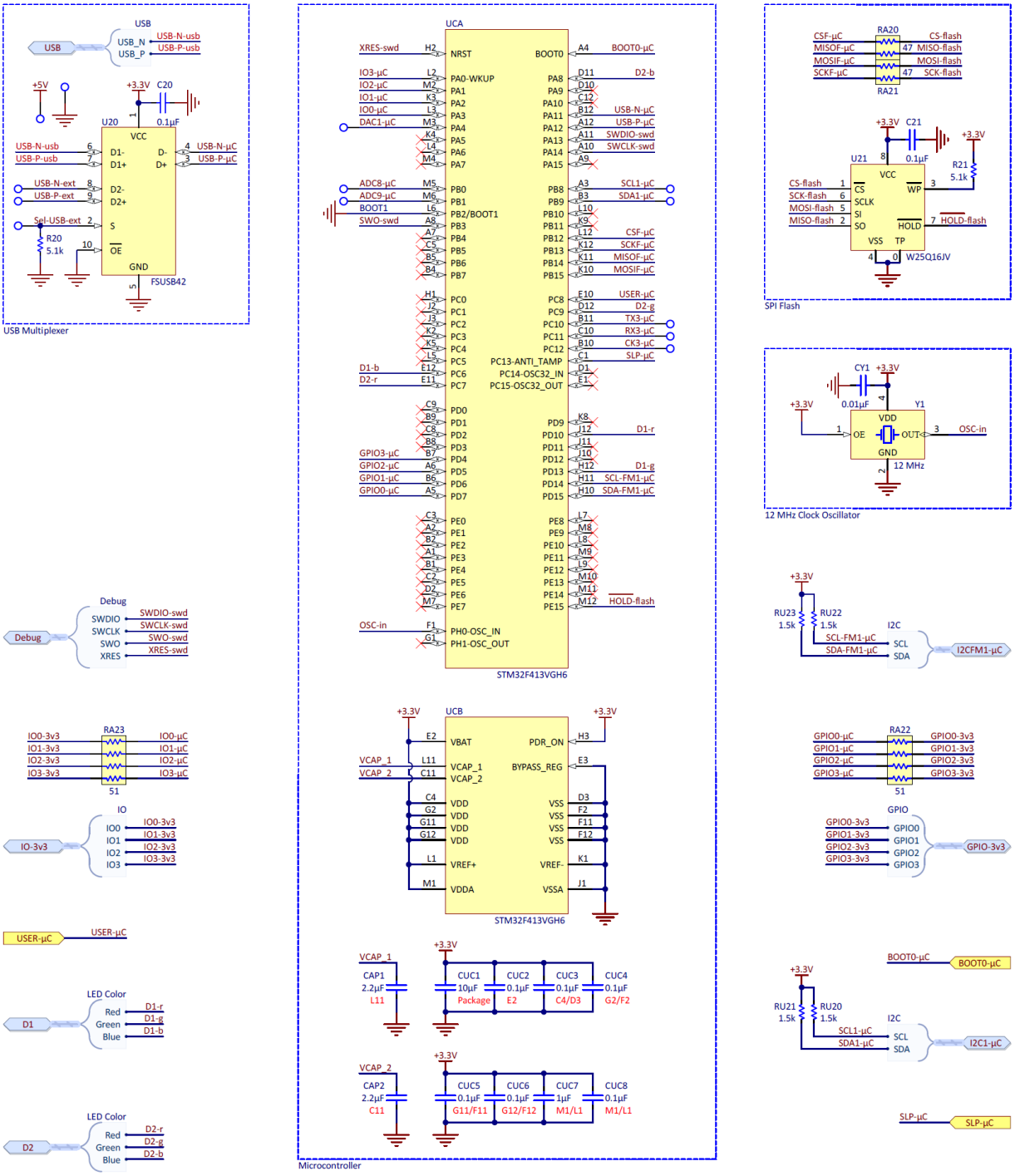
Regulator for 3.3V power



Regulator for 1.8V power

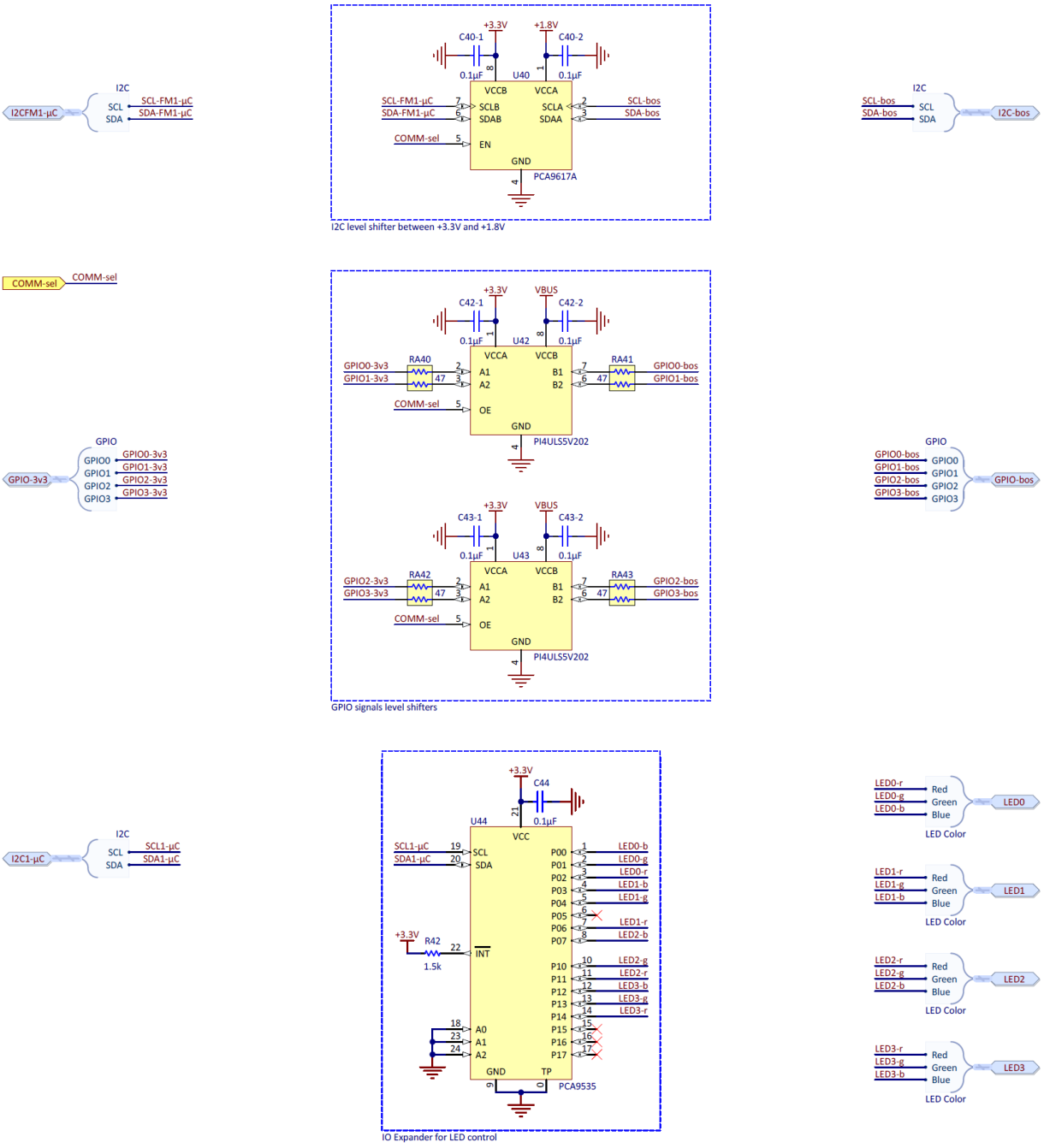
Title:	BOS0614-KIT - Power Management		
Ref:	PCB-0273	Project:	PCB-0273-BT005_DK_v2.3.PrjPcb
Part:	BT005-DK	File:	Power.SchDoc
Version:	2.3	Date:	2023-01-03
Drawn By:	JLB/AL	Sheet:	3 of 8

BOS0614-KIT - Microcontroller



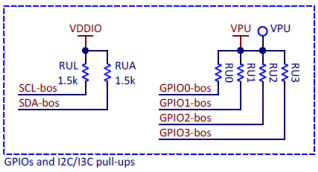
Title:	BOS0614-KIT - Microcontroller		
Ref:	PCB-0273	Project:	PCB-0273-BT005_DK_v2.3.PrjPcb
Part:	BT005-DK	File:	Microcontroller.SchDoc
Version:	2.3	Date:	2023-01-03
Drawn By:	JLB/AL	Sheet:	4 of 8

BOS0614-KIT - Digital signals conditioning and LED driver



Title:	BOS0614-KIT - Digital signals conditioning and LED driver		
Ref:	PCB-0273	Project:	PCB-0273-BT005_DK_v2.3.PrjPcb
Part:	BT005-DK	File:	Digital.SchDoc
Version:	2.3	Date:	2023-01-03
Drawn By:	JLB/AL	Sheet:	5 of 8

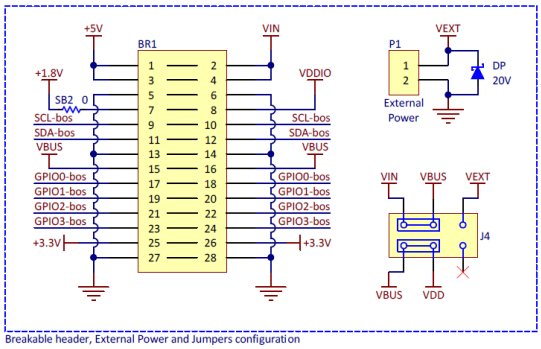
BOS0614-KIT - BOS0614 unit



GPIOs and I2C/I3C pull-ups

Use of RUL and RUA:
RUL/RUA are populated by default with 1.5 kΩ for proper I2C operation. Replace with appropriate value for I3C operation, or leave on PCB with parallel value provided by I3C driver.

Use of RUx and VPU:
When DK is broken in half, pull-up resistors must be used on GPIO pins. Populate RUx with appropriate value on 0402 resistor landings, and use VPU test point to provide pull-up power.

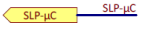


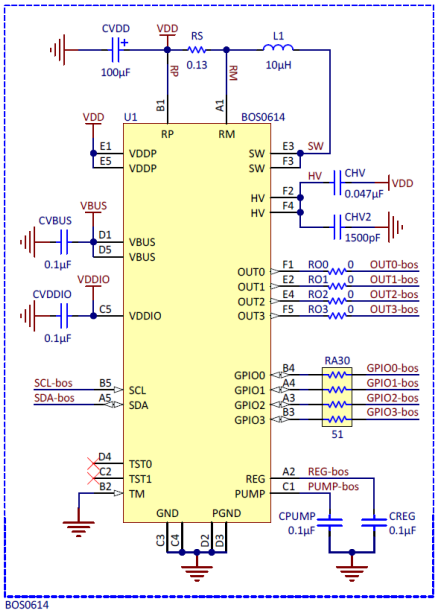
Breakable header, External Power and Jumpers configuration

Use of SB2:
VDDIO is set at 1.8V by default with SB2. When using an external I2C/I3C source (refer to S3 switch) with signal level different from 1.8V, remove SB2 and provide power between 1.2V and 1.8V to VDDIO pin.

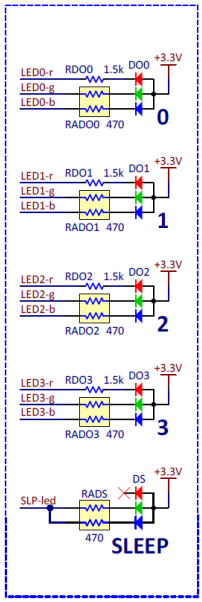
Use of external power:
Provide power to P1 connector when in External power configuration using jumpers on J4 header. Schottky diode DP acts as minimal security in case polarity is not correctly observed (see on PCB near P1 pins for polarity).

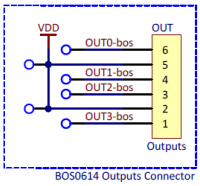
Possible configurations with J4 header:
- USB power, non-UPI mode (default)
jump VIN/VBUS, jump VBUS/VDD
- USB power, UPI mode
jump VIN/VBUS, jump VDD/NC
- External power, non-UPI mode
jump VEXT/VBUS, jump VBUS/VDD
- External power, UPI mode
jump VEXT/VBUS, jump VDD/NC



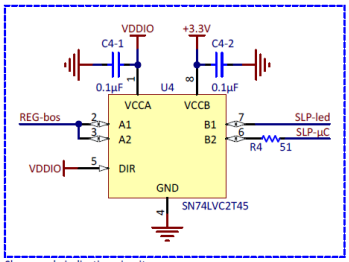


BOS0614

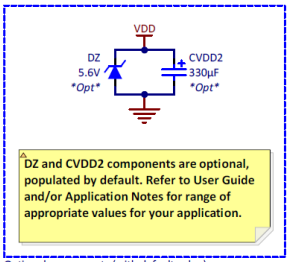




BOS0614 Outputs Connector



Sleep mode indication circuit

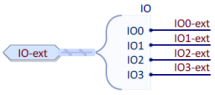


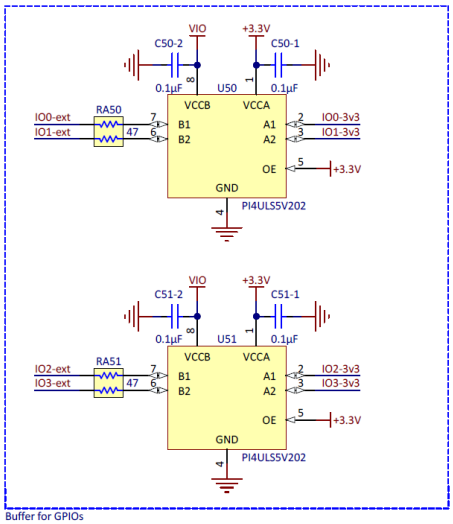
DZ and CVDD2 components are optional, populated by default. Refer to User Guide and/or Application Notes for range of appropriate values for your application.

Optional components (with default value)

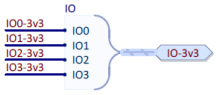
Title:	BOS0614-KIT - BOS0614 unit		
Ref:	PCB-0273	Project:	PCB-0273-BT005_DK_v2.3.PrjPcb
Part:	BT005-DK	File:	BOS0614.SchDoc
Version:	2.3	Date:	2023-01-03
Drawn By:	JLB/AL	Sheet:	6 of 8

BOS0614-KIT - Peripherals





Buffer for GPIOs



Title:	BOS0614-KIT - Peripherals		
Ref:	PCB-0273	Project:	PCB-0273-BT005_DK_v2.3.PrjPcb
Part:	BT005-DK	File:	Peripherals.SchDoc
Version:	2.3	Date:	2023-01-03
Drawn By:	JLB/AL	Sheet:	7 of 8

BOS0614-KIT - Mechanical Components

Fiducials

Bumpers

Jumpers

Logos

Title:	BOS0614-KIT - Mechanical Components		
Ref:	PCB-0273	Project:	PCB-0273-BT005_DK_v2.3.PrjPcb
Part:	BT005-DK	File:	Mechanicals.SchDoc
Version:	2.3	Date:	2023-01-03
Drawn By:	JLB/AL	Sheet:	8 of 8

9.2 PCB Layout

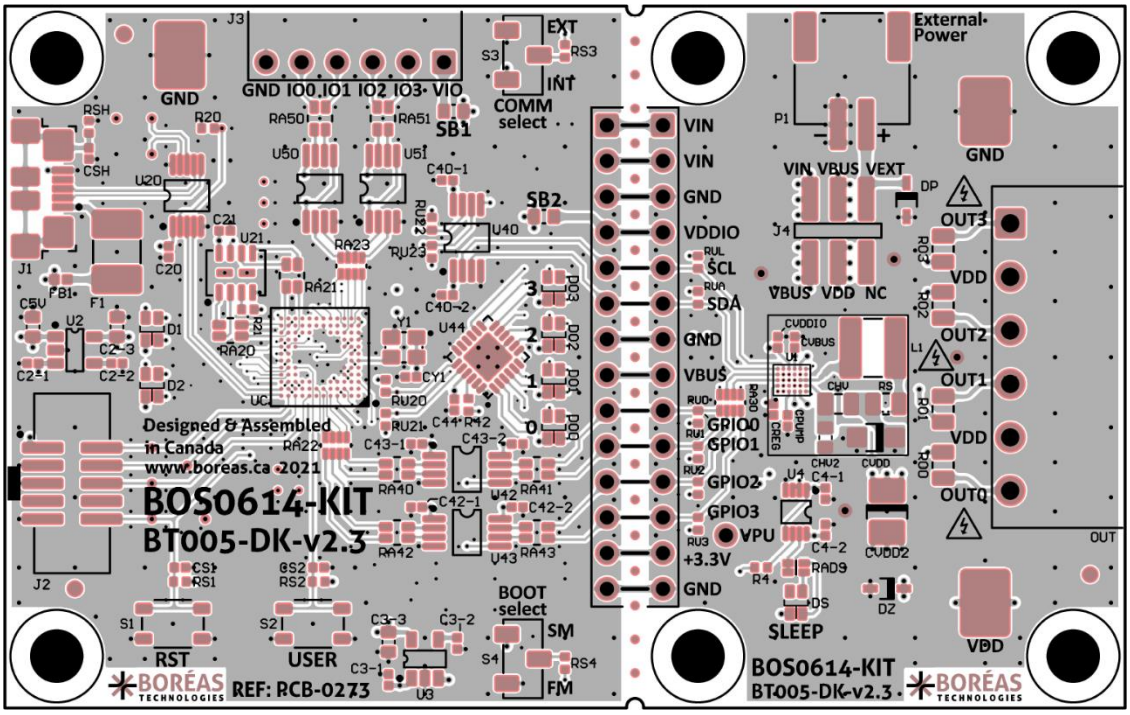


Figure 13: Layout view - Layer 1 - Top - Circuit (not to scale)

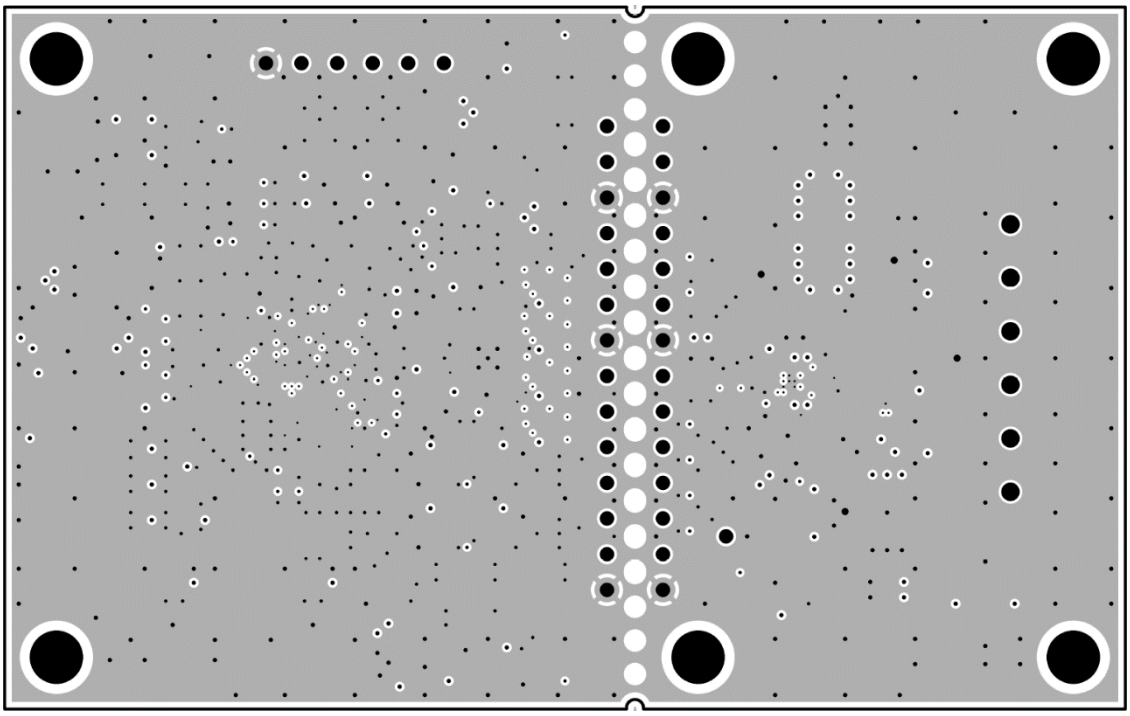


Figure 14: Layout view – Layer 2 - Internal - Ground (not to scale)

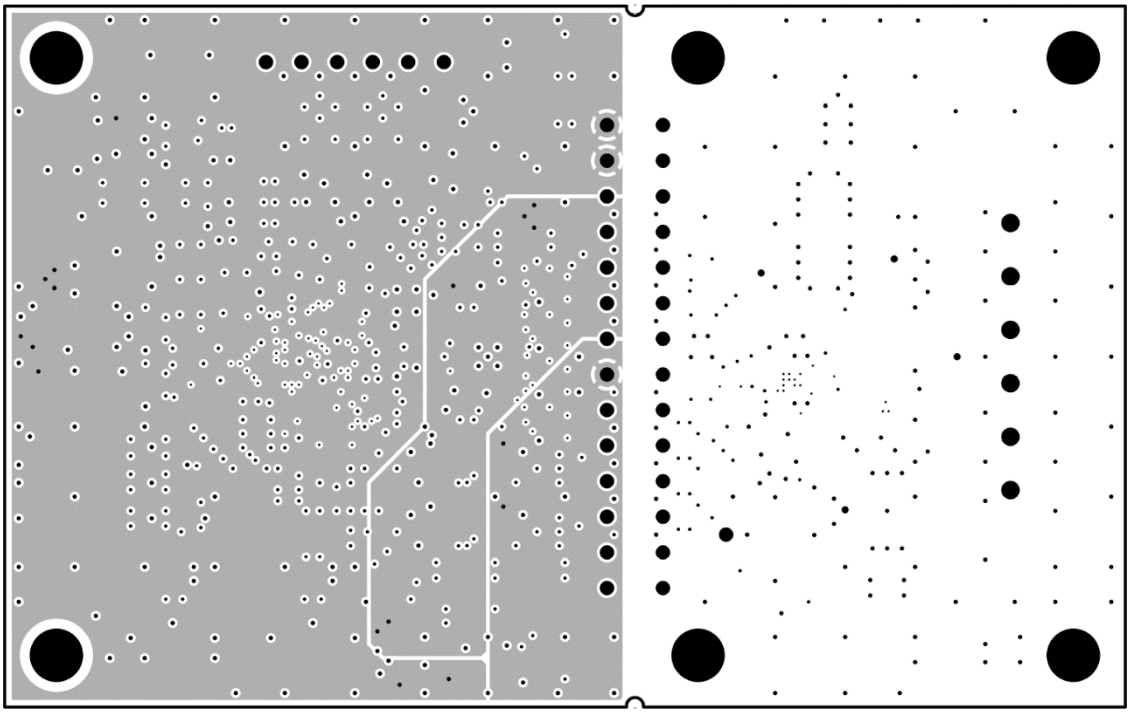


Figure 15: Layout view – Layer 3 - Internal - Power (not to scale)

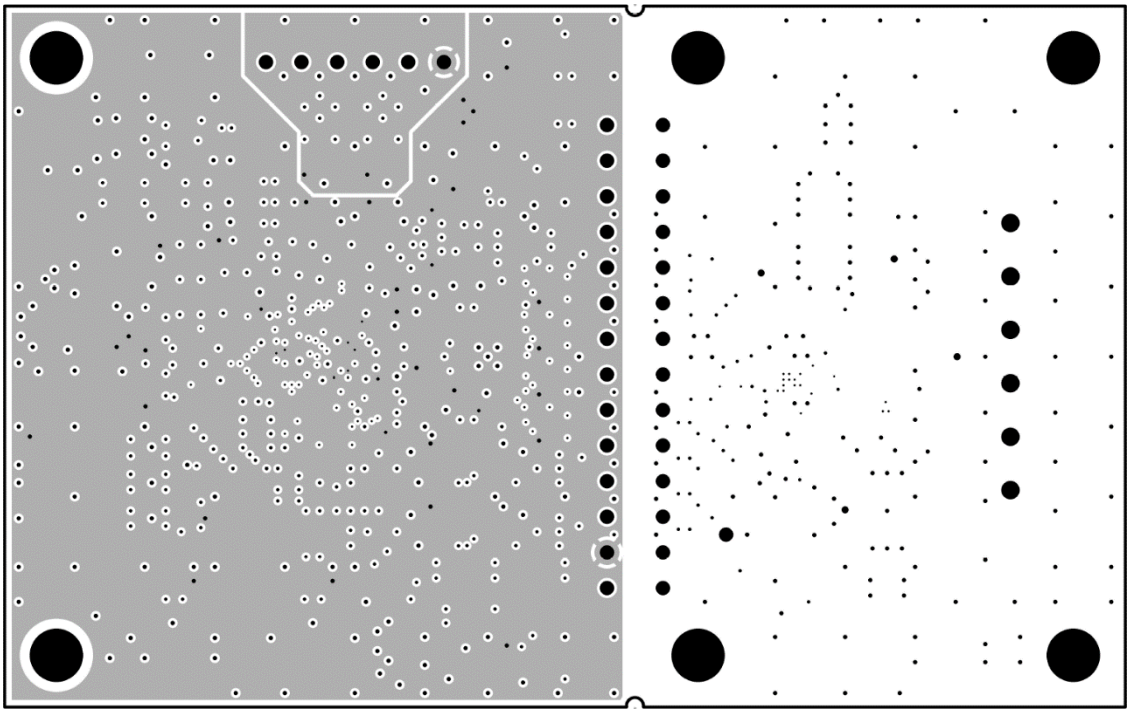


Figure 16: Layout view – Layer 4 - Internal - Power (not to scale)

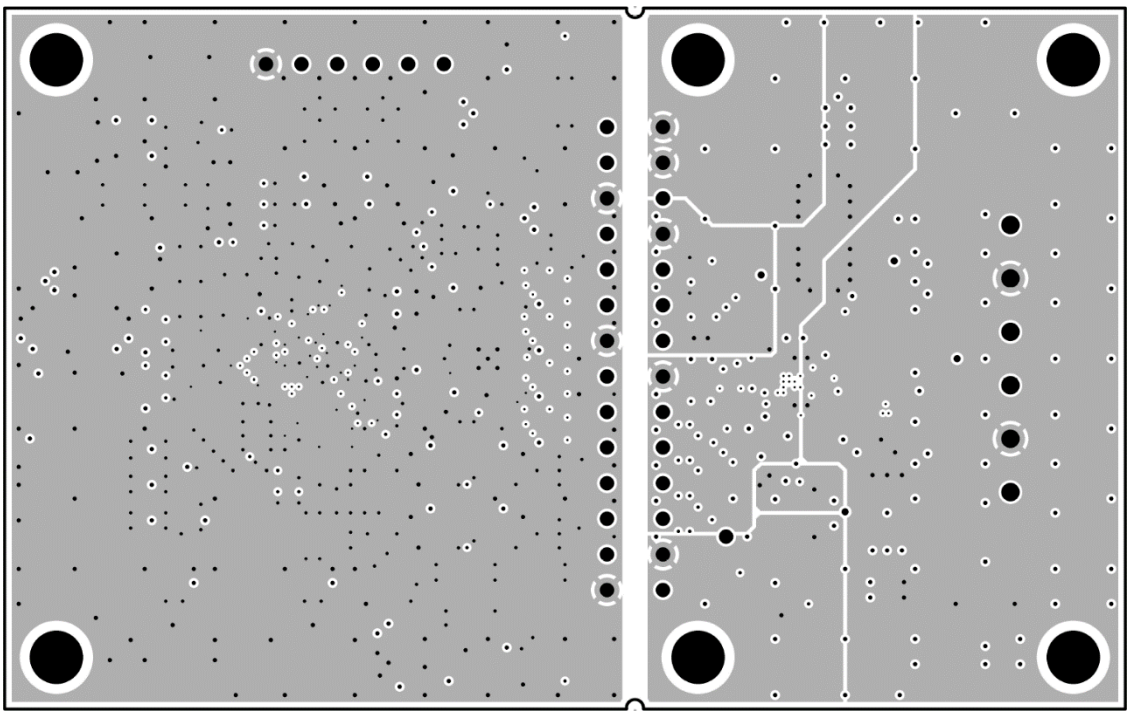


Figure 17: Layout view – Layer 5 - Internal – Ground and Power (not to scale)

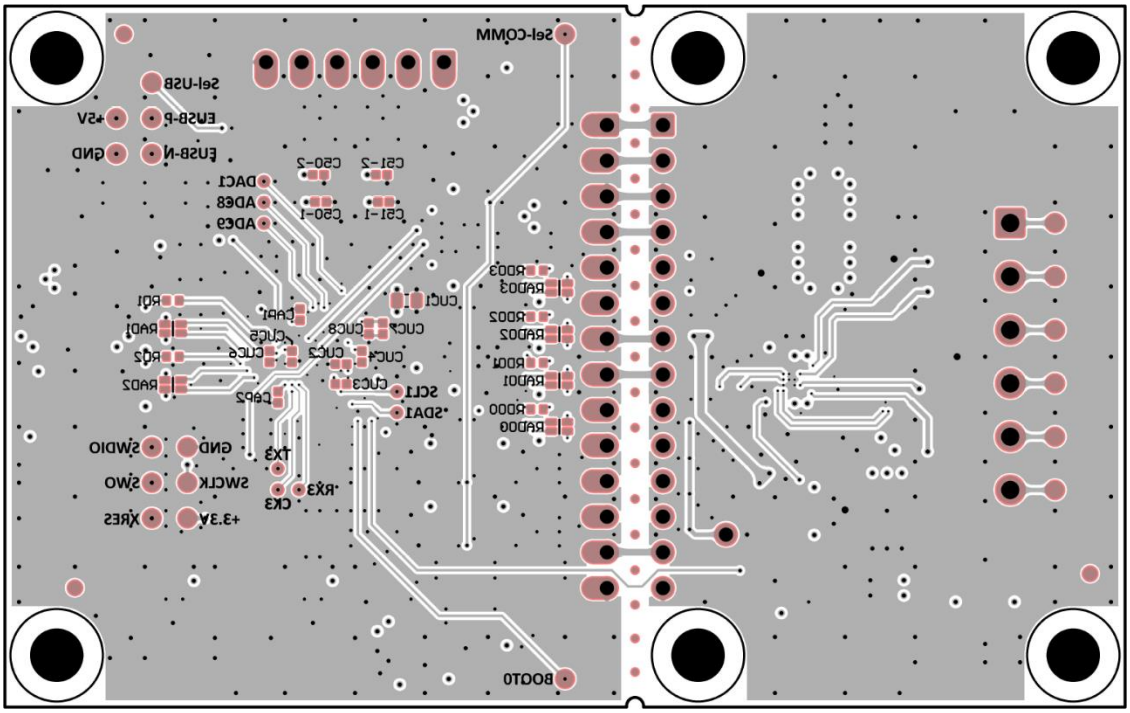


Figure 18: Layout view – Layer 6 - Bottom – Signals, Routing (not to scale, top view)

9.3 Bill of Materials

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 BOS0614-BRD-C02-B1

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
BUMP1, BUMP2, BUMP3, BUMP4, BUMP5, BUMP6	6		BUMPER CYLINDRICAL 0.25" DIA BLK	Keystone Electronics	783-B
C2-1, C3-1, C4-1, C4-2, C20, C21, C40-1, C40-2, C42-1, C42-2, C43-1, C43-2, C44, C50-1, C50-2, C51-1, C51-2, CPUMP, CREG, CS1, CS2, CUC2, CUC3, CUC4, CUC5, CUC6, CUC8, CVBUS, CVDDIO	29	0.1µF	CAP CER 0.1UF 25V X5R 0402	Taiyo Yuden	TMK105BJ104KV-F
C2-2, C3-2, CY1	3	0.01µF	CAP CER 10000PF 50V X7R 0402	Taiyo Yuden	UMK105B7103KV-F
C2-3, C3-3, C5V, CUC1	4	10µF	CAP CER 10UF 25V X5R 0603	Taiyo Yuden	TMK107BBJ106MA-T
CAP1, CAP2	2	2.2µF	CAP CER 2.2UF 16V X5R 0402	Taiyo Yuden	EMK105ABJ225KV-F
CHV	1	0.047µF	CAP CER 0.047UF 250V X7T 0805	TDK Corporation	C2012X7T2E473K125AE
CHV2	1	1500pF	CAP CER 1500PF 100V X7R 0603	Yageo	CC0603JRX7R0BB152
CSH	1	330pF	CAP CER 330PF 250V C0G/NP0 0402	KEMET	C0402C331JAGACAUTO
CUC7	1	1µF	CAP CER 1UF 16V X5R 0402	TDK Corporation	CGB2A1X5R1C105K033BC
CVDD	1	100µF	CAP TANT POLY 100UF 6.3V 1206	KEMET	T527I107M006ATE070
CVDD2	1	330µF	CAP TANT POLY 330UF 6.3V 1411	KEMET	T520B337M006ATE040
D1, D2, DO0, DO1, DO2, DO3, DS	7		LED RGB 0606 SMD	Dialight	5977715607F
DP	1	20V	DIODE SCHOTTKY 20V 1A SOD323F	Nexperia USA Inc.	PMEG2010AEJ,115
DZ	1	5.6V	DIODE ZENER 5.6V 500MW SOD-323F	Rohm Semiconductor	UFZVFHTE-175.6B
F1	1	0.5A	PTC RESET FUSE 15V 500MA 1812	Schurter Inc.	PFMF.050.2

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
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 *d	1		CONN HEADER R/A 6POS 2.54MM	Würth Elektronik	61300611021
J4	1		CONN HEADER SMD 6POS 2MM	TE Connectivity AMP Connectors	2842143-3
JP1, JP2	2		CONN JUMPER SHORTING GOLD BLUE	Keystone Electronics	M22-1910005
L1	1	10µH	FIXED IND 10UH 1.82A 338MOHM SMD	TDK Corporation	VLS4012HBX-100M
OUT	1		TERM BLOCK HDR 6POS 90DEG 3.81MM	Molex	395121006
P1	1		CONN HEADER SMD R/A 2POS 2MM	JST Sales America Inc.	S2B-PH-SM4-TB(LF)(SN)
R4	1	51	RES SMD 51 OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ510X
R20, R21, RS1, RS2, RS3, RS4	6	5.1k	RES SMD 5.1K OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ512X
R42, RD1, RD2, RDO0, RDO1, RDO2, RDO3, RU20, RU21, RU22, RU23, RUA, RUL	13	1.5k	RES SMD 1.5K OHM 5% 1/16W 0402	Yageo	AC0402JR-071K5L
RA20, RA21, RA40, RA41, RA42, RA43, RA50, RA51	8	47	RES ARRAY 2 RES 47 OHM 0606	Panasonic Electronic Components	EXB-V4V470JV
RA22, RA23, RA30	3	51	RES ARRAY 4 RES 51 OHM 0804	Yageo	YC124-JR-0751RL
RAD1, RAD2, RADO0, RADO1, RADO2, RADO3, RADS	7	470	RES ARRAY 2 RES 470 OHM 0404	Panasonic Electronic Components	EXB-24V471JX
RO0, RO1, RO2, RO3	4	0	RES SMD 0 OHM JUMPER 1/8W 0805	Panasonic Electronic Components	ERJ-6GEY0R00V
RS	1	0.13	RES 0.13 OHM 1% 1/2W 0805	Panasonic Electronic Components	ERJ-6DSFR13V
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

DESIGNATOR	QTY	VALUE	DESCRIPTION	MANUFACTURER	PART NUMBER
TPGND2, TPGND3, TPVDD3	3		PC TEST POINT COMPACT	Keystone Electronics	5016
U1	1		PIEZO HAPTIC DRIVER 60V	Boreas Technologies	BOS0614CW
U2	1	3.3V	IC REG LINEAR 3.3V 300MA SOT23-5	STMicroelectronics	LDS3985M33R
U3	1	1.8V	IC REG LINEAR 1.8V 300MA SOT23-5	STMicroelectronics	LDS3985M18R
U4	1		IC TRNSLTR BIDIRECTIONAL US8	Texas Instruments	SN74LVC2T45DCUR
U20	1		IC USB SWITCH DPDT 10MSOP	ON Semiconductor	FSUSB42MUX
U21	1		IC FLASH 16MBIT SPI/QUAD 8USON	Winbond Electronics	W25Q16JVUUIQ TR
U40	1		IC REDRIVER I2C 1CH 1MHZ 8TSSOP	NXP USA Inc.	PCA9617ADPJ
U42, U43, U50, U51	4		IC TRNSLTR BIDIRECTIONAL 8MSOP	Diodes Incorporated	PI4ULS5V202UEX
U44	1		IC I/O EXPANDER I2C 16B 24HVQFN	NXP USA Inc.	PCA9535BS,118
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 FAQ and Troubleshooting

Please refer to Boréas website for FAQ and Troubleshooting information, which will be maintained throughout the BOS0614-KIT lifecycle. It will also contain application note documents that will be helpful for the user writing his/her own code to operate the BOS0614.

11 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 OUTx and VDD. 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 BOS0614-KIT and/or your oscilloscope.

12 Ordering Information

Table 14: Ordering information

	ORDERING PART NUMBER	PACKAGE	PACKING FORMAT	QUANTITY
1	BOS0614-KIT-B03 (Starter Set)	Entire PCB 80x50 mm Breakout PCB 35x50 mm	Box ($5^{1/4}$x$3^{1/2}$x$1^{1/4}$)”	1/box 8 Capacitors

Contact sales@boreas.ca to order.

13 Document History

ISSUE	DATE	Document Number	CHANGES
7	August 2024	BT005FUG01.03	Kit contents updated.
6	August 2024	BT005FUG01.02	BOS0614-KIT-B03 replaces BOS0614-KIT-B02. Removed BOS0614-KIT-X02. Kit contents updated. Haptic Studio support.

Appendix A. Firmware Upgrade using STM32CubeProgrammer

The BOS0614-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 BOS0614-KIT board microcontroller needs to execute DFU application in the system memory. The boot selection switch allows to select the system memory.

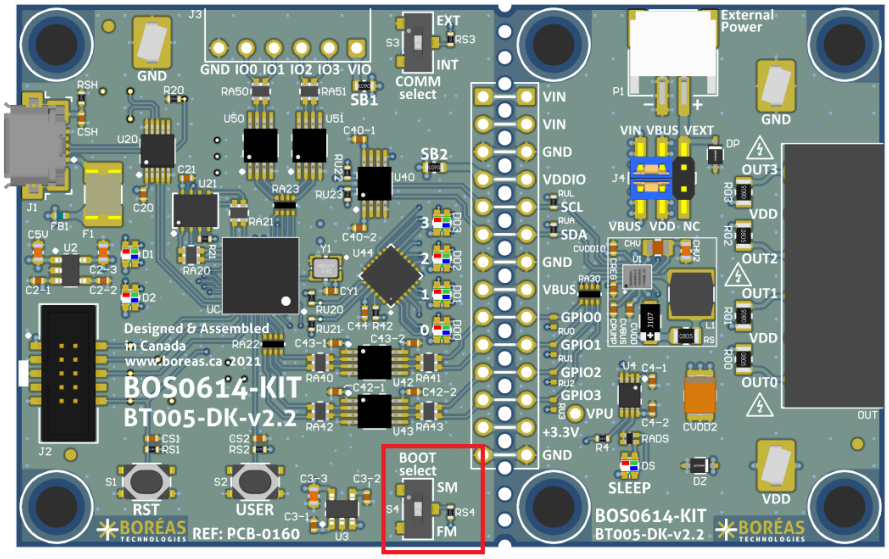


Figure 19 : Boot selection switch position

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 BOS0614-KIT board to a PC using a USB cable.
5. Start SMT32CubeProgrammer.
6. Reset the BOS0614-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.

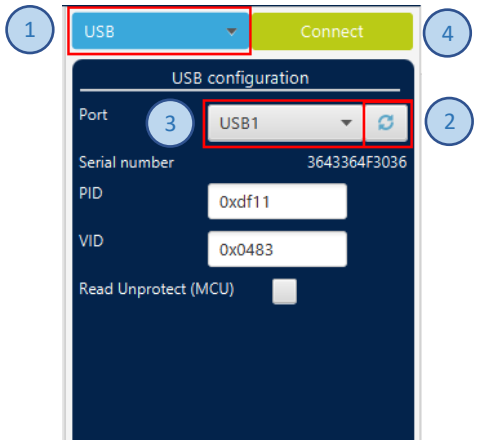


Figure 20: STM32CubeProgrammer connection setting

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.

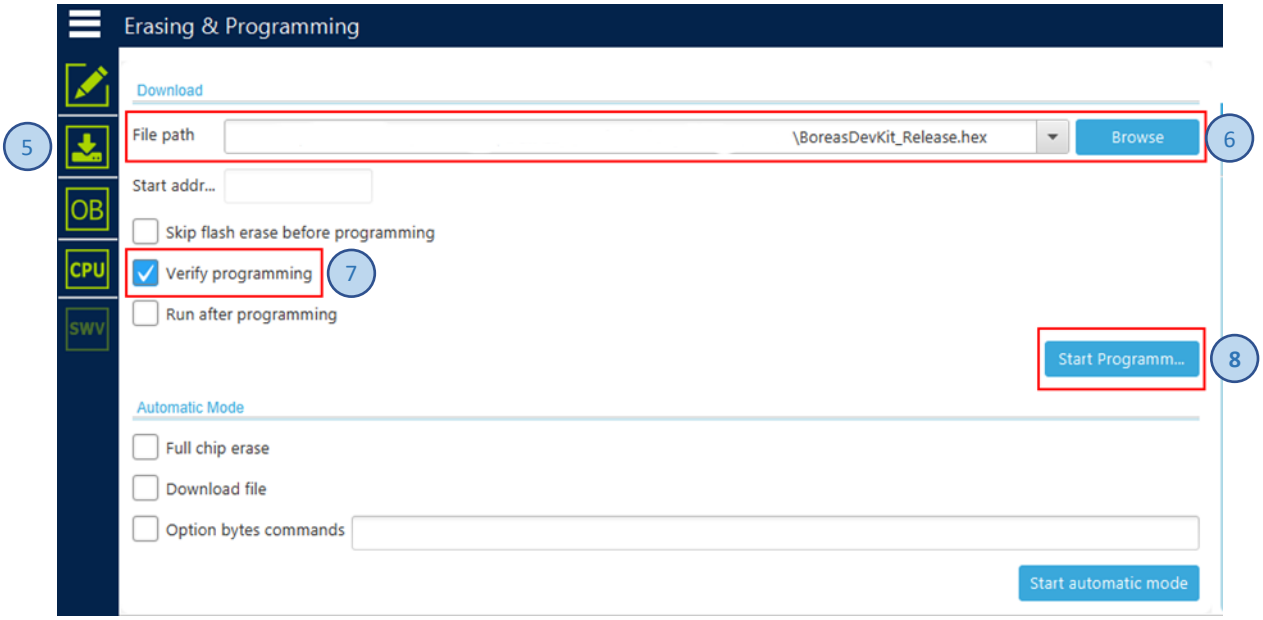


Figure 21: STM32CubeProgrammer programming setting

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

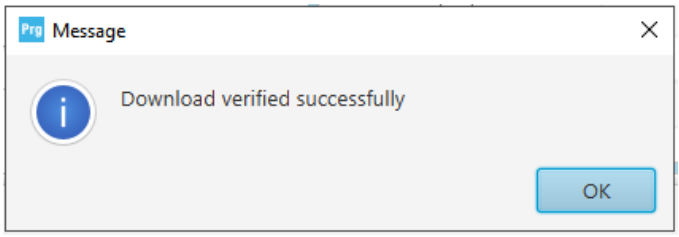


Figure 22: STM32CubeProgrammer upgrade completed dialog.

10. Move the Boot Select switch in Flash Memory (FM) position.
11. Reset the development kit using the RST button.

Appendix B. Audio Mode using Audacity® Software

This appendix explains how Audacity® software can be used to create and play waveforms on the BOS0614-KIT.

B.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.

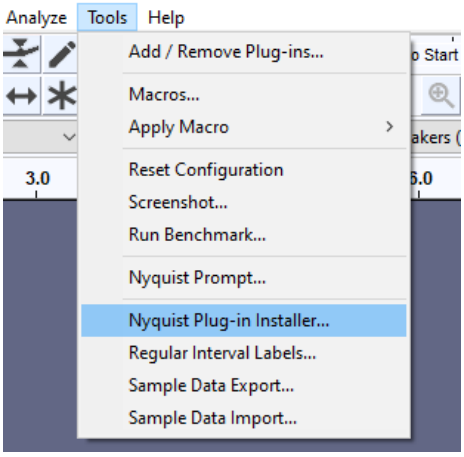


Figure 23: dc-offset plugin installation

3. Ensure the plugin is enabled.

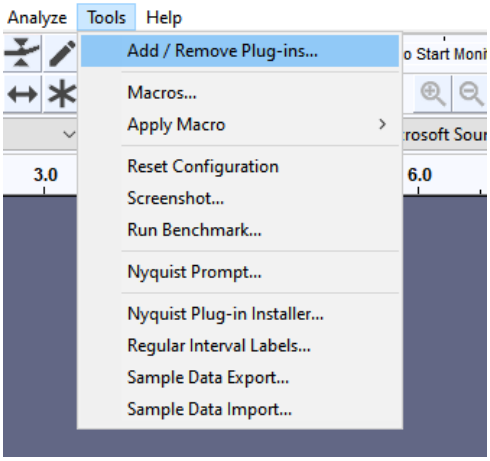


Figure 24: Access plugin management window

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

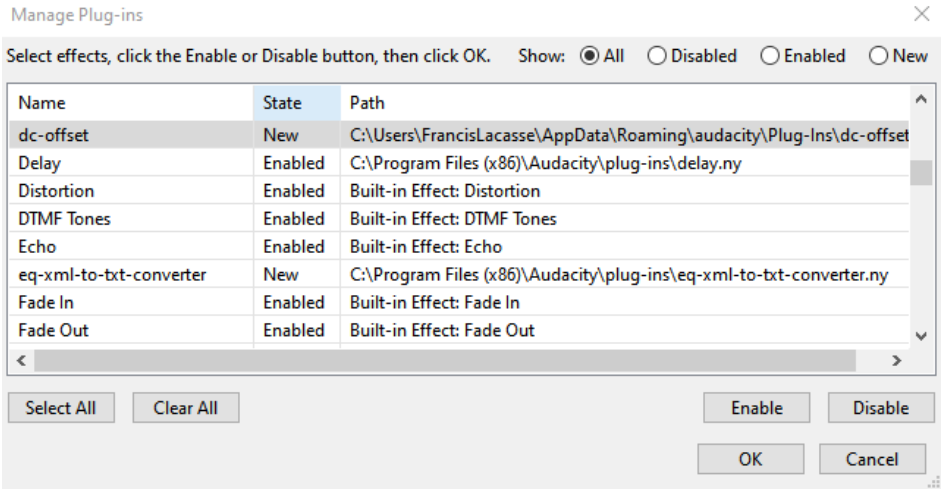


Figure 25: Plugin management window

B.2 Use Audacity to Play WAV Files

Description

Download waveform samples from Boréas website and use Audacity® to play them on the BOS0614-KIT.

Prerequisites

- BOS0614-KIT board is in *Audio* mode.
- Using the BOS0614-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)

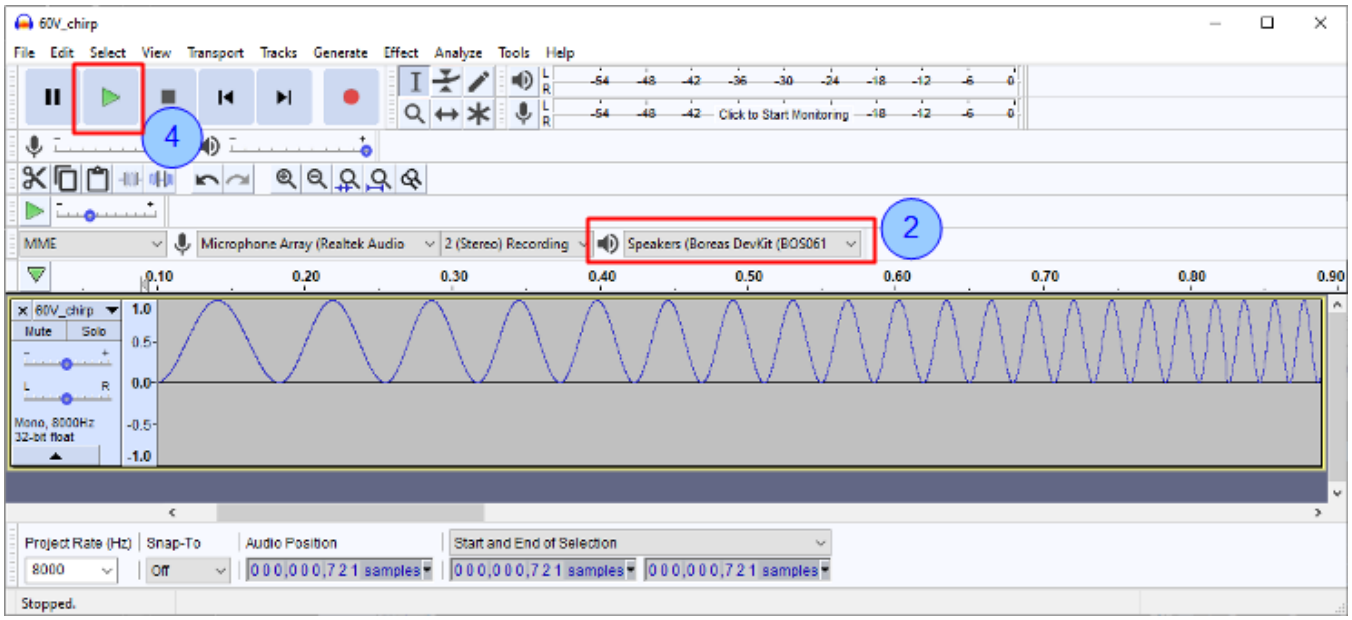


Figure 26: Use audacity to play a WAV file

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 into Audacity to add a new audio track.
4. Press the play button to start playing the waveform on the piezo actuator.

B.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 = 45 V
- Piezo Vmax = 45 V
- Piezo Vmin = 0 V
- Frequency = 125 Hz
- Duration = 1 sec

Prerequisites

- BOS0614-KIT board is in audio mode.
- The audio limiting settings of the board are properly configured.
- Audacity and the dc-offset plugin are installed.

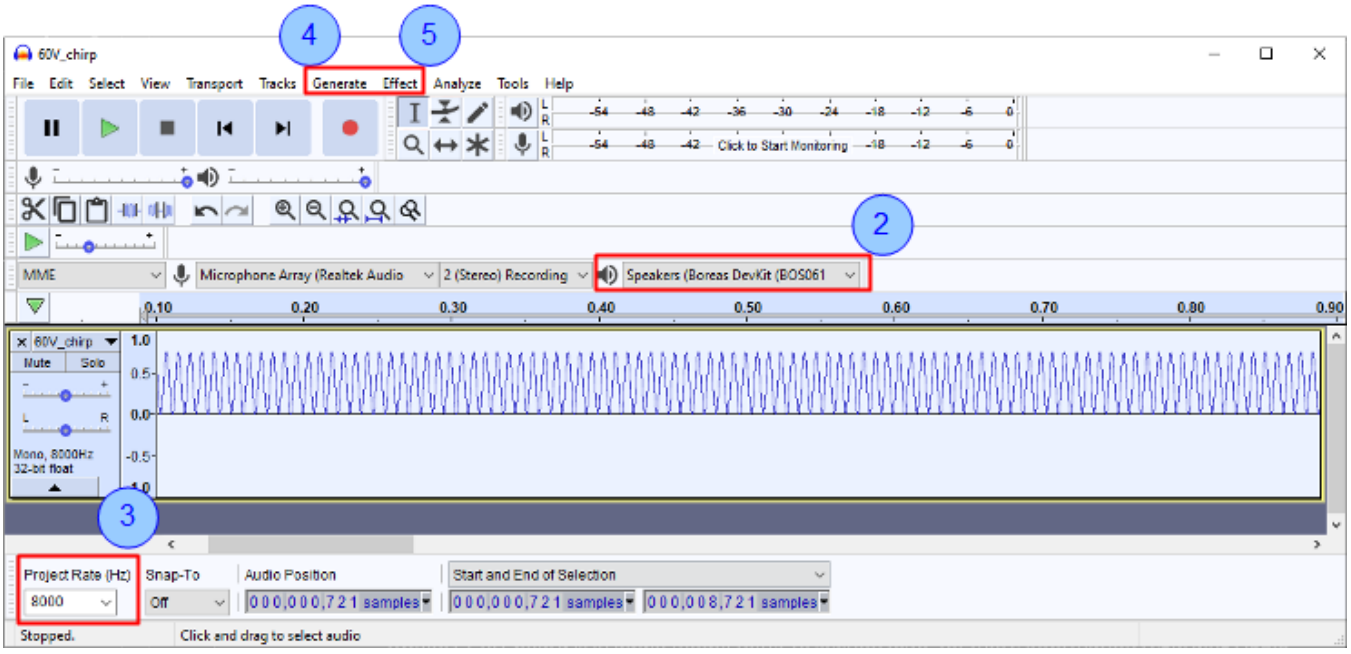


Figure 27: Audacity – simple waveform creation

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:

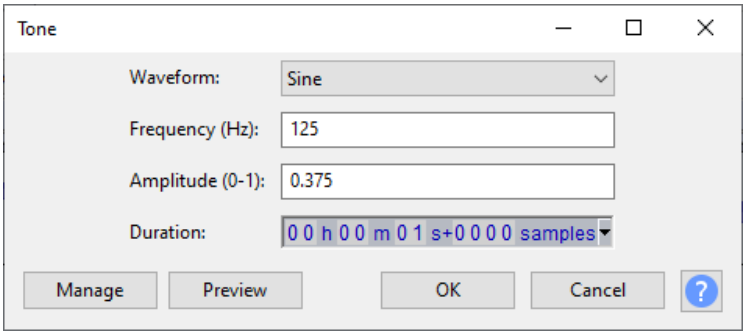


Figure 28: Tone parameters

The amplitude value is calculated with the following formula:

$$\text{Amplitude} = \frac{\text{Peak to Peak Amplitude}}{Boreas\ IC\ amplitude\ max} => \frac{(45)\ \text{V} - (0)\ V}{2{\times}60V} => 0.375$$

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

$$\text{Offset} = \frac{\text{Piezo } Vmax + \text{Piezo } Vmin}{Boreas\ IC\ amplitude\ max} => \frac{(45)\ \text{V} + (0)\ V}{2{\times}60V} => 0.375$$

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

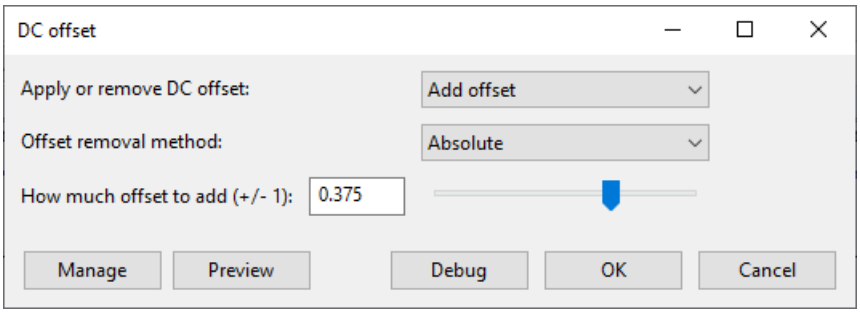


Figure 29: Add dc-offset

6. Play the wave using the play button.

