

Probing BOS0614 with an Oscilloscope

Oscilloscopes are very useful instruments when building applications with the BOS0614. Probing the voltage generated on BOS0614 output can convey a lot of information when used properly. However, when connected incorrectly, bad things are bound to happen.

This application note explains how to properly connect and setup an oscilloscope to probe the BOS0614 high-voltage output signals and what to avoid.

1 BOS0614 Basics

The BOS0614 is a single-chip piezo actuator driver with energy recovery, based on a patented CapDrive™ technology. It can drive actuators with up to 60 V unipolar waveforms while operating from a 3 to 5.5 V supply voltage. Low power and small size make it ideal for a variety of applications requiring minimal power consumption and heat dissipation.

When outputting any voltage waveform on a given channel (0 to 3), the associated output pin (OUT0 to OUT3) is driven relative to VDD. For example, if the programmed output voltage is 60 V, the active channel output OUTx is set to VDD+60 V. The actuator being connected between OUTx and VDD, the voltage difference seen by the actuator is 60 V.

In all situations, voltage on OUT0, OUT1, OUT2 and OUT3 is between VDD and VDD+60 V. This means both piezo terminals are above the ground and considered active.

2 What to Avoid

Before showing the proper way to connect the oscilloscope probes, let's first start by showing how not to connect them.

Never connect an oscilloscope probe ground connection to one of the actuator terminals.

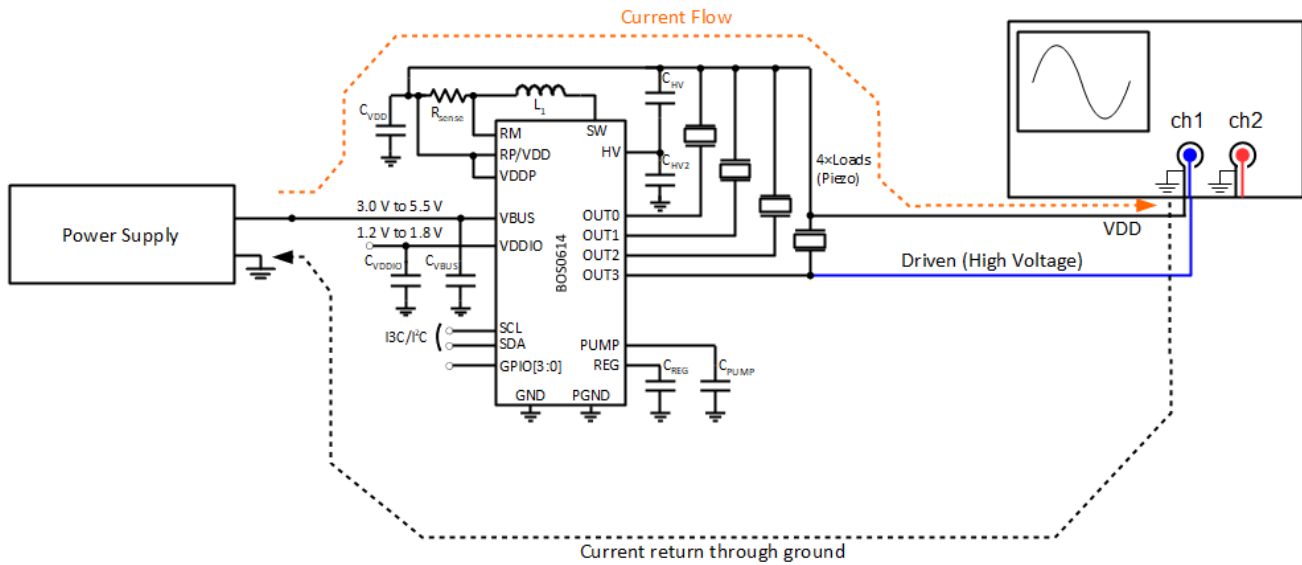


Figure 1 Incorrect oscilloscope probe connection to BOS0614

Connecting the oscilloscope probe like this creates a short-circuit between VDD and ground. An oscilloscope probe ground is shorted with the instrument internal ground connection. Through the power line, the power supply ground and oscilloscope grounds and linked. The current flowing from VDD into the oscilloscope ground presents a hazard of the oscilloscope and may damage the PCB with the driver IC on it.

3 Proper Oscilloscope Connection

The following figure shows the proper connection between an oscilloscope and a BOS0614.

Two probes must be used, each on its channel on the oscilloscope:

- a. The first probe (ch1) signal tip should be connected to the intended IC channel OUTx pin (OUT0, OUT1, OUT2 or OUT3).
- b. The second probe (ch2) signal tip should be connected to the VDD pin.
- c. Each probe ground clip should be connected to the BOS0614 GND pin.

Each oscilloscope channel will display the voltage measured on the associated terminal. Displaying the difference between channel 1 and 2 as a math channel is also useful. However, useful debugging information can still be obtained by inspecting the individual channels.

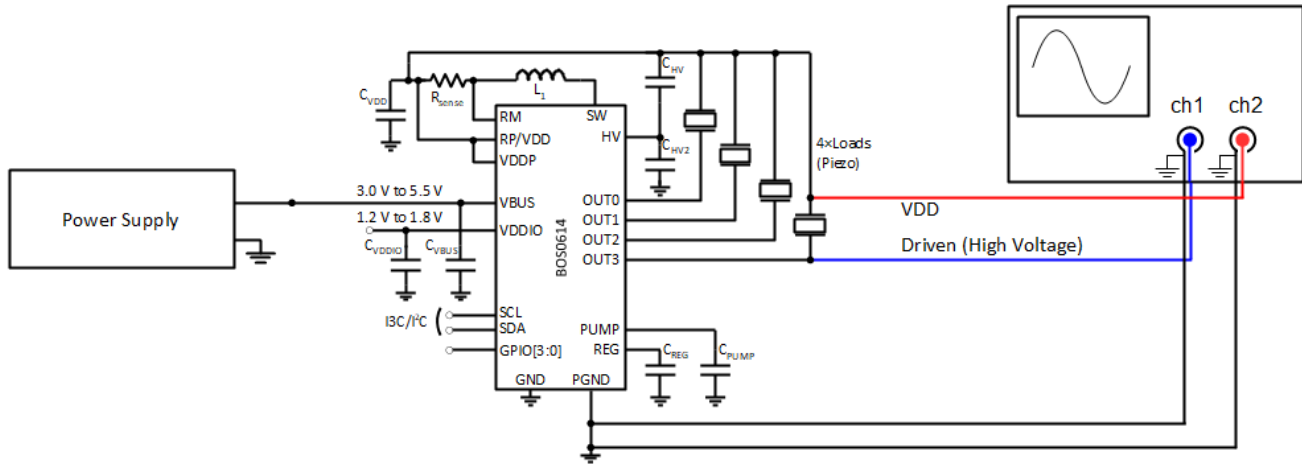


Figure 2 Correct oscilloscope probe connection to BOS0614

An alternate method is to use a differential high-voltage probe. This allows to connect both terminals of the probe directly to OUTx and VDD and then read the voltage between these nodes directly on a single channel, thereby enabling processing such as FFT on the voltage applied to the piezoelectric actuator. Note however that doing so loses the DC reference voltage component on each node, which is useful in some debug cases.

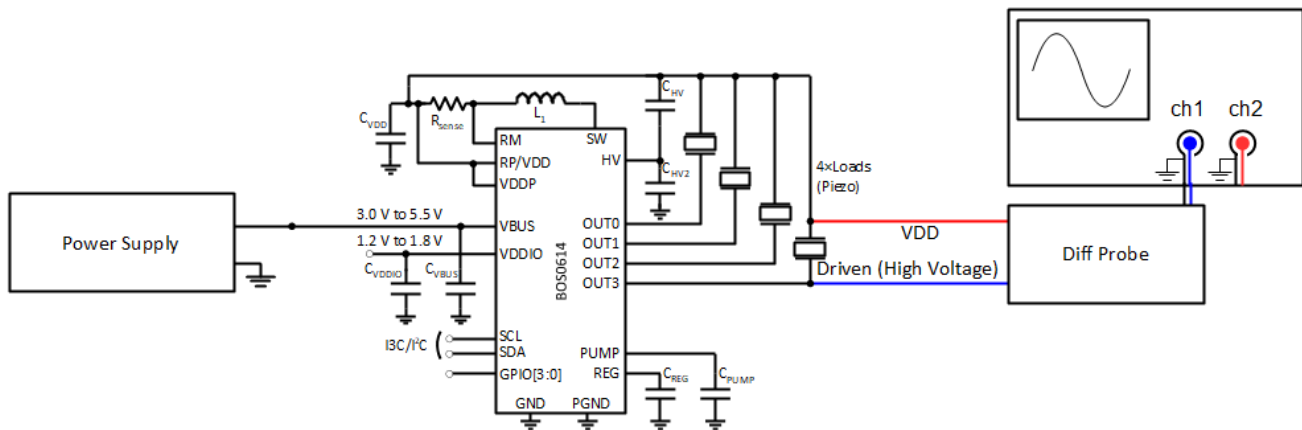


Figure 3 Oscilloscope connection to BOS0614 using a differential probe

4 Oscilloscope Settings

Set both scope channels vertical scale to DC mode, 100 V range. Setting to AC mode is possible, but doing so loses the DC offset information, and since these are large signals, the offset is a useful information when debugging.

Set the time scale accordingly to the features you wish to analyze. For example, a 100 Hz signal will have a 10 ms period. Setting the time scale between 2 and 5 ms/div is appropriate to see a few cycles over a single capture.

The oscilloscope sampling rate is not required to be very high since the signals are generally not higher than a few hundred hertz. A 100 kHz sampling rate is generally enough in most cases.

5 Scope Capture Examples

The following figure shows a scope capture of a 100 Hz sine wave using the full range of operation. The blue curve is the active channel output (OUTx), connected to the piezo actuator positive terminal, the red curve is VDD, connected to the piezo actuator negative and the purple curve is the differential voltage (OUTx minus VDD). We can see OUTx voltage only go down to the VDD supply level of 5 V while the difference varies between 0 and 60 V.

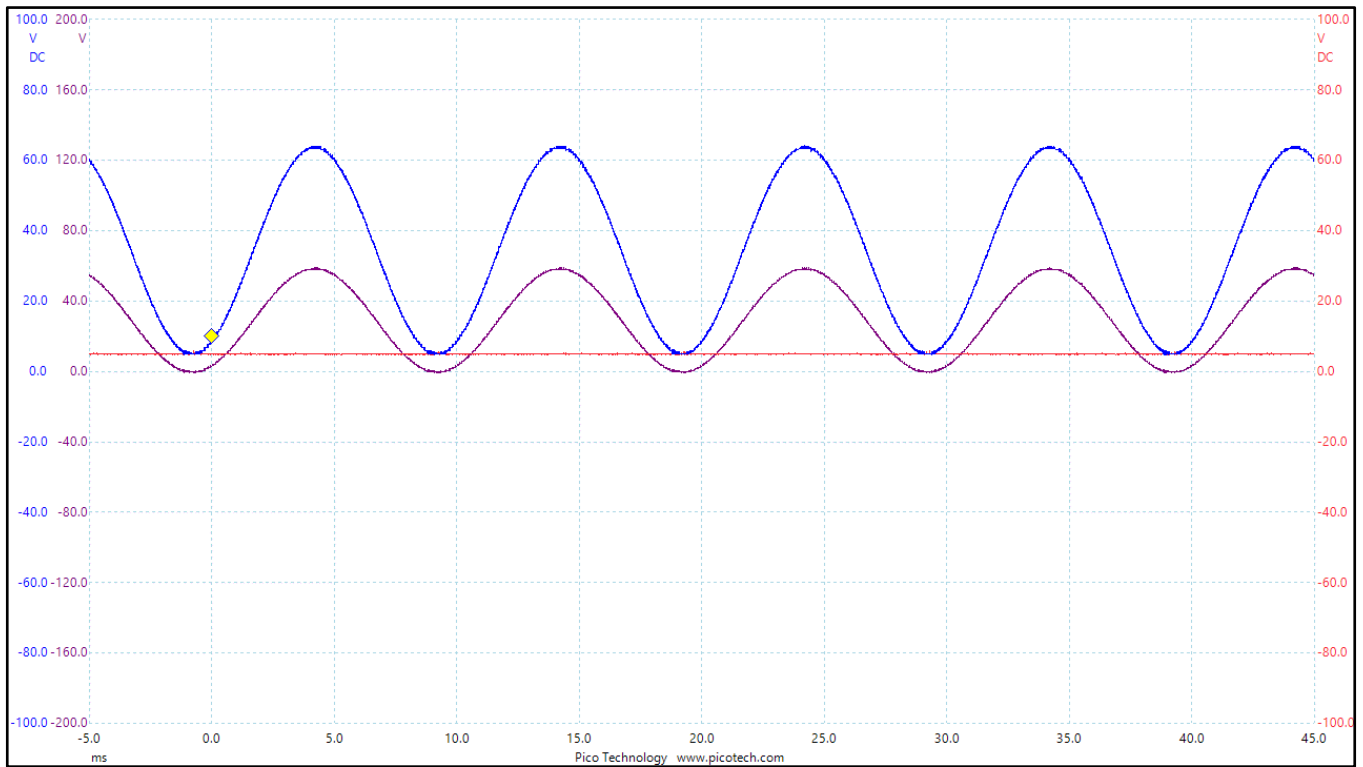


Figure 4 0 to 60 V sine wave

6 Conclusion

Oscilloscopes are very useful instruments either when building or debugging application code. However, they must be correctly connected and set up to avoid damage to the prototype and the instrument.

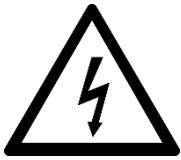
7 Related Products

	PRODUCT NAME	DESCRIPTION
1	BOS0614	Four-Channel Piezo Haptic Driver with Integrated Sensing

8 Document History

ISSUE	DATE	DOCUMENT NUMBER	CHANGES
1	October 2022	BT005EAN01.01	Original document.

9 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.



ESD Caution

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 sides of the actuator (OUTx and VDD) 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 the actuator terminals. Doing so might damage the BOS0614-KIT and/or your oscilloscope.

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