

Zen Flute Instruction Manual

I. Theory of Operation

The Zen Flute acts like a mouth theremin, responding to changes in the volume of your mouth to control the pitch of the instrument. While the mouth muscle movements required are similar to those used while whistling, you should not blow into the mouthpiece. Rather allow the sound from the mouthpiece to enter your mouth and shape it with your tongue and jaw movement. Leave some gap between the mouthpiece and your lips during the shaping so air can escape.

Your oral cavity acts like a Helmholtz resonator, providing a resonant cavity whose frequency of resonance is determined by the cavity volume and shape. The principle is the same as that producing the sound obtained by blowing over the lip of a bottle where the volume and size of the bottle determine the pitch

In operation, a small speaker near the mouthpiece of the Zen flute creates sound that causes the air in your mouth to resonate and this resonance is picked up by small microphone also near the mouthpiece. At resonance, the signal strength received by the microphone will increase and a characteristic phase shift between the speaker signal and the microphone signal will occur. The circuitry of the Zen flute moves the speaker frequency to track the acoustic resonant of the oral cavity.

The Zen flute provides an internal procedural synthesizer for a flute like instrument (Shakuhachi) developed by the Faust Project (<https://faustlibraries.grame.fr/about/>). The Zen flute also provides for MIDI output to control other synthesizers and is particularly tuned for the SWAM procedural synthesizer (<https://audiomodeling.com/swam-engine/solo-woodwinds/swam-saxophones>). A nice MIDI flute sound is available at low cost in the Native Flute VST available here: (<https://www.adsrsounds.com/product/software/infinet-essentials-native-flute-vst-sampler-plugin/>) using the Native Sustained setting. When using MIDI synthesizers, long attack-time instruments tend to sound better than short attack time, percussive instruments.

The Zen Flute has been tested using Ableton as a DAW for these VST plugins with the ASIO4All driver which provides very low latency and is available here (<https://asio4all.org/>). Going to Preferences/Hardware Setup/in Ableton allows you to connect to the MIDI and the audio coming from the Zen Flute which assumes the avatar of “Teensy MIDI/Audio”.

II. Controls

1. Mouthpiece

The mouthpiece provides a lip stop positioning your mouth in close proximity to the microphone and speaker while allowing air from your mouth to escape. Without this gap, air pressure would pin the speaker or microphone interfering with their operation. The lip stop is held to the mouthpiece of the Zen flute by a magnetic catch and can be readily

released for cleaning for example in warm soapy water. The mouthpiece provides separate channels for an underlying speaker and microphone to reduce cross talk

Underneath the mouthpiece is the microphone and speaker. The speaker presents an outer foil surface which is extremely fragile and should not be touched.

2. The USB connector

The mini USB cable attached to the Zen Flute provides three different functions. First, the USB connector provides power to the Zen Flute. The LED visible through the bell of the Zen Flute should light up when you have power. Second, the USB connector outputs MIDI signals that can be used by a computer-based synthesizer or digital audio workstation (DAW). In addition, the USB connector outputs digital audio from the internal synthesizer which can be recorded by a DAW or similar program such as Audacity.

3. Analog audio out put (right side)

To the left of the USB connector when viewing the mouthpiece is a 2.5 mm stereo sub miniature phono plug which outputs analog audio of the procedural Shakuhachi flute. This output allows individual play through headphones without a supporting computer DAW or through amplified speakers or the like for performance or busking.

4 Analog audio out put (left side)

To the right of the USB connector when viewing the mouthpiece are two a 2.5 mm stereo sub miniature photo plugs. The closest plug to the mouthpiece outputs the same tone as output through the mouth speaker. This provides a monitor output that can be provided to headphones for playing in a noisy environment. The second plug further from the mouthpiece provides for low-voltage analog MIDI. The logic sense of this MIDI is B type (<https://minimidi.world/#types>) but this can be converted to A type by cutting internal jumpers and re-soldering them if you're brave.

5. Joystick/mode selection button

The joystick currently controls the volume and expression of the internal procedural synthesizer and provides MIDI control outputs. Pressing the joystick inward implements a mode selection. Exactly what modes are implemented is in constant flux but currently this operating mode changes the scale according to the following table. The side indicator light shows a different color to indicate the current mode. Some note playing logic is also changed. Refer to the software listing for more details.

Scale	Indicator light
C major/Eb heptonic	Blue
C major Persian harmonic	Red
C major Japanese Hirajoshi	Green
C major Hawaiian	Aqua
D minor	Yellow
F major	Fuchsia
	Violet

-	Orange
-	White
-	No color

6. Push Button Key Switch

The push button controls the initiation of a note (start the note envelope) whose pitch is determined by the resonance tracking of the player's oral cavity. Put your mouth against the mouthpiece before pressing this button. There will be a short pop before the correct frequency is selected (a wideband signal interrogating your current mouth volume) and not until the second button pressing will sound output occur.

After a first pressing of this button, the mouth speaker is activated and continues to be activated for a period of time so long as there are continuous presses of the button. The continuous tracking of the oral cavity resonance allows near instantaneous response in generating a note when the first button is pressed.

7. Reset button plug

The bottom surface of the Zen flute provides a plug allowing access to a reset button on the internal microprocessor. Normally this reset button will not be used unless reprogramming of the Zen flute is being performed. Then in certain instances the reset button must be pressed in order to initiate a loading of a program. If the Zen flute crashes, unplugging the USB cable to remove power will provide a complete reset.

8. General hardware notes

The components of the Zen flute are identified in the schematic. The microprocessor is a Teensy 4.0. See the schematic for additional information.

9. License

This software is open source under the MIT license and I encourage modifications, experimentations, questions etc. If you come up with something good feel free to sell it to me or other users of the Zen Flute.

10. Safety Warnings and Legal notifications

As with most electrical products, you should keep the Zen Flute away from water and sources of heat such as radiators or the like. If the Zen Flute gets wet, immediately disconnect it from power and turn off the power switch and allow it to thoroughly dry.

When charging the Zen Flute, use the included USB cable and an approved 5 V USB compatible power source.

When the mouthpiece is removed for cleaning, the speaker membrane (square of silver foil) is exposed and should not be pressed as it can be damaged.

The Zen Flute has small detachable parts and should be kept out of reach of children and pets.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: —Reorient or relocate the receiving antenna. —Increase the separation between the equipment and receiver. —Connect the equipment into an outlet on a circuit different from that to which the receiver is connected. —Consult the dealer or an experienced radio/ TV technician for help.