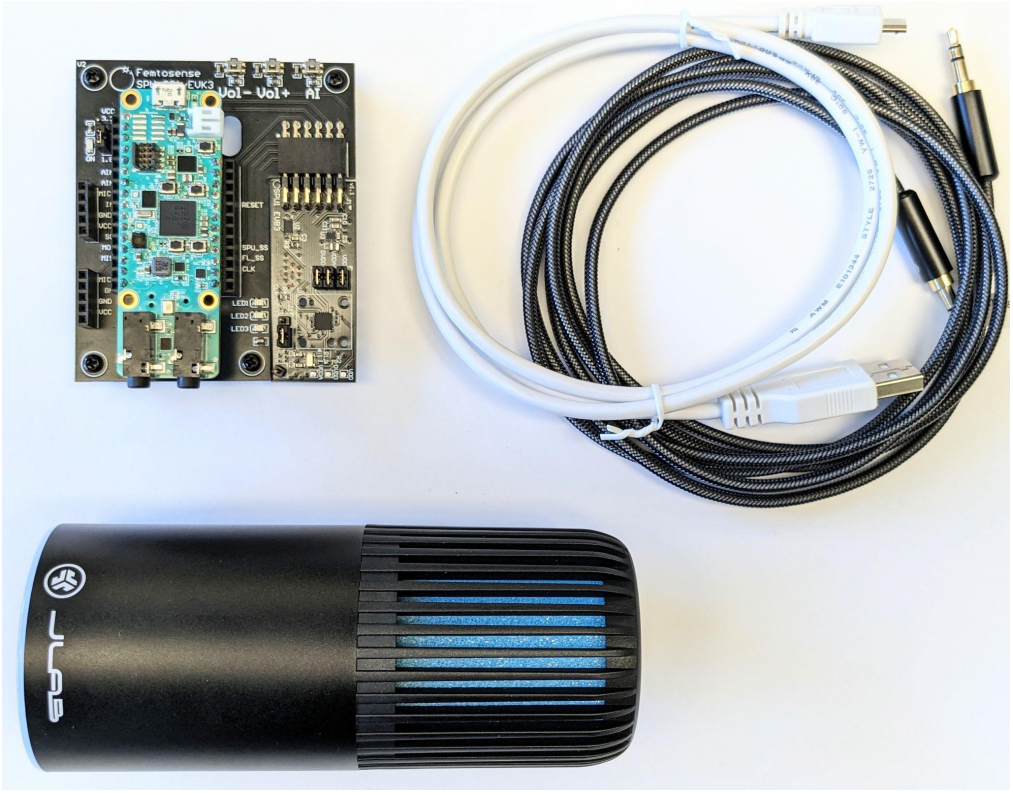
FEMTOSENSE

Quick Start Guide v1.3

In your kit, you will find the following:

EVK3 Initial Release 2023/09/23

- SPU-001 circuit board (EVB2 or EVB3)
- ADI MAX78000FTHR revA with USB programming cable
- PCB connector board with SPU-001 circuit board
- Micro SD Card (inserted into the ADI MAX78000FTHR)
- SD to MicroSD adapter
- Microphone (JLab Talk Go USB Microphone) with audio cable



You will also need:

- SD Card Reader to load new programs into the SD Card
- Headphones with 3.5mm input jack to listen to audio output (e.g. for the AI noise reduction demo)
- Optional: 3.7V Lithium Ion Battery with JST PH Connector (e.g. part #KPL623450)

Table of Contents

1. Hardware and Firmware Setup

Note: The SPU-001 EVK3 should arrive ready to use with the hardware configured correctly, and both firmware and models up-to-date. However, should any of these be modified or updated at a later point, please find below the instructions to set up the SPU-001 EVK3.

1.1. Hardware

The SPU-001 EVK3 should be assembled as depicted in Figure 1. In particular, **the jumpers should be positioned as follows**:

- VCC header on the upper position (3.3V),
- J2 jumper on the lower position (INT),
- All three J3 jumpers must be present vertically as shown.

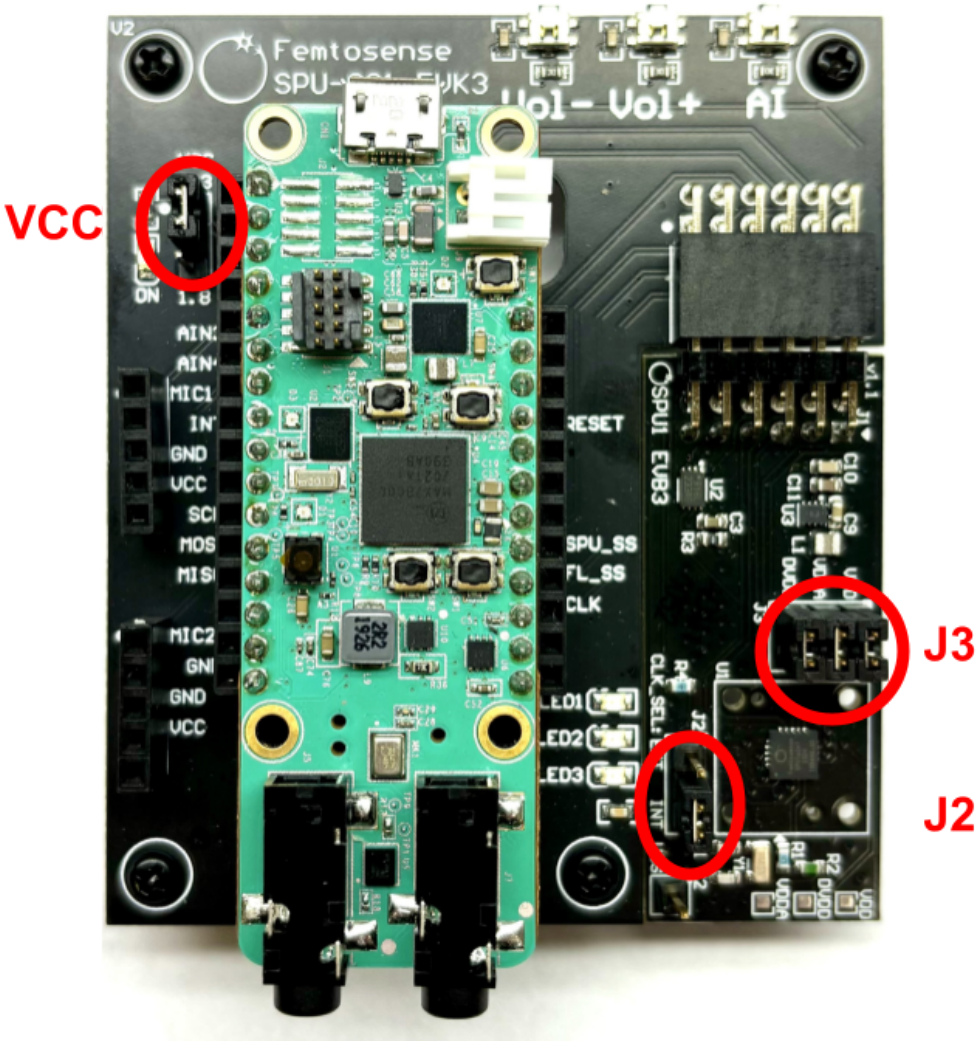


Figure 1: SPU-001 EVK3 hardware. The jumpers (in red) should be placed as recommended.

Several push buttons are available on SPU001EVK3 to allow the user to control the application, while the status LED uses colored patterns to indicate the current state (see Figure 2).

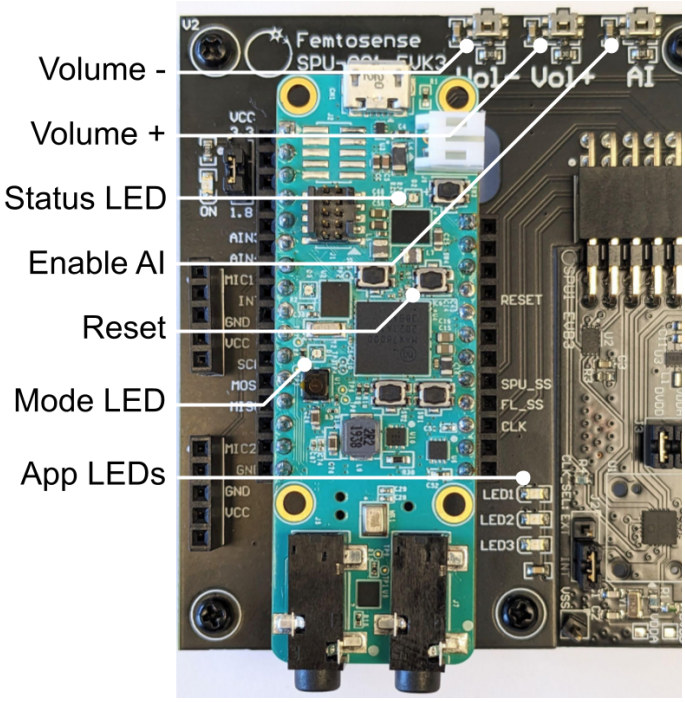


Figure 2: User controls on SPU001EVK3

- Press *Reset* to restart the program,
- Press *Volume* + to increase the volume or select the next app in app select mode,
- Press *Volume* - to decrease the volume or select the previous app in app select mode,
- Press *Enable AI* shortly to toggle on and off SPU processing, or press for 2 seconds to enter app select mode,
- Status LED blinks to indicate the current status of SPU001EVK3 (fast green for initializing, slow green for AI processing off, slow blue for AI processing on),
- Mode LED indicate the current mode of SPU001EVK3 (off: app running, green: app select mode),
- App LEDs indicate which application is currently running (1: AINR_8ms, 2: AINR_2ms, 3: GSC).

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1.2. Updating the models

Connect the micro SD card to a computer and **copy the desired model folders** (see Figure 3). Models can be found in the release package under:

```
program_files/models/
```

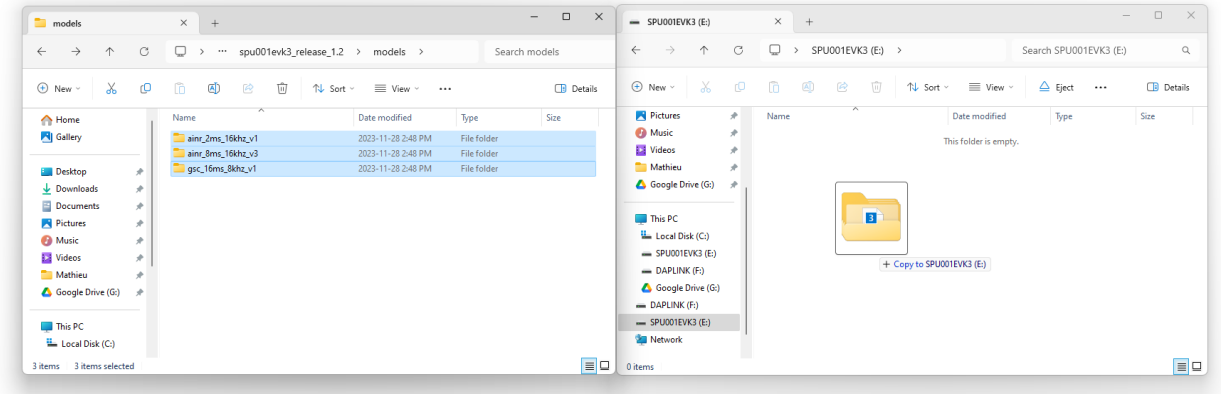


Figure 3: Update the SPU001EVK3 models by copying the model folders to the SD card (SPU001EVK3).

Each model is stored in its respective folder (e.g. `ainr_8ms_16khz_v3`) and should contain two files: `0PROG_A` and `0PROG_D`. **Please preserve the folder and file names as provided in the release package**. Only one model of each type (`ainr_8ms`, `ainr_2ms`, `gsc`) should be present at a time: **make sure to remove the previous model from the SD card**.

Insert the SD card into the SPU001EVK. **It is fully inserted when the edge of the SD card is flush with the edge of the green board** (see Figure 4).

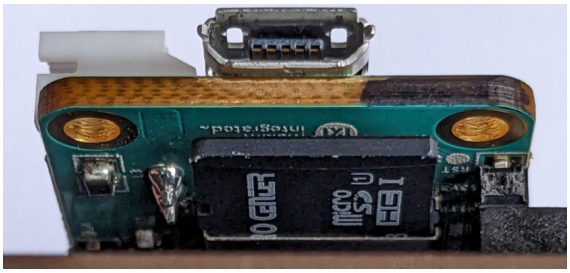


Figure 4: SD card inserted in the SPU001EVK3 .

1.3. Uploading the firmware

Connect the SPU001EVK3 to a computer using the USB cable provided. **Copy the firmware binary file on the SD CARD** (e.g. `spu001evk3_110.bin`) **into the DAPLINK removable device** (see Figure 5). A red LED will start blinking rapidly during the update, the SPU001EVK3 will then restart and start normal operation (e.g. see Section 2.1).

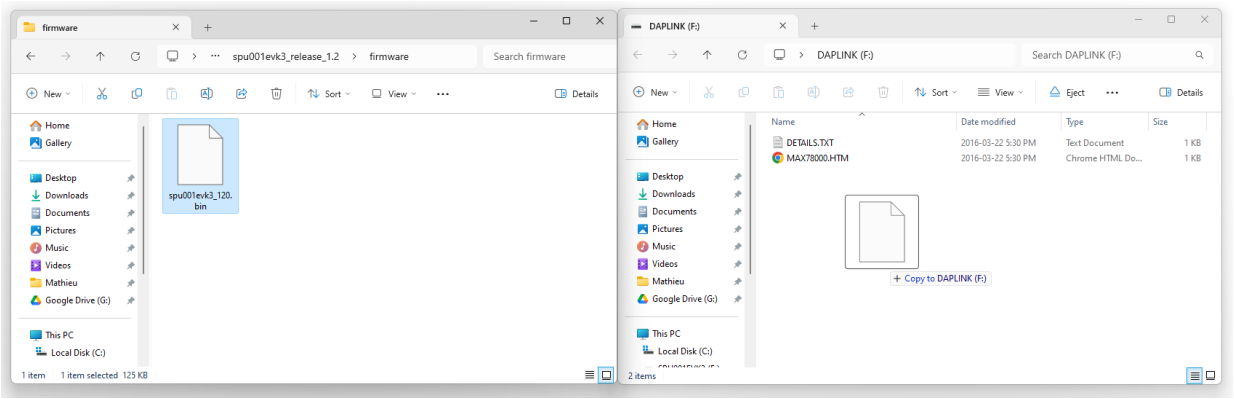


Figure 5: Update the SPU001EVK3 firmware by copying the binary file in the DAPLINK device.

The firmware binary file can be found in the release package under:

`program_files/firmware/`

2. Running the applications

The default application is AINR_8ms and will be loaded the first time SPU001EVK3 is used. With the SD card inserted, connect the USB cable to the SPU001EVK3 to power it up. **The program takes between 15 and 20 seconds to start**, you will see the status LED blink green rapidly during the start process. Once finalized, **the status LED will blink slowly in green**.

SPU001EVK3 provides debug and execution information on the USB port when connected to a computer. **You can open the matching serial port** (115200 baud, 8-N-1) using a serial terminal (e.g. Tera Term, Putty) to display this information.

2.1. Selecting the application

SPU001EVK3 currently supports 3 applications: AINR_8ms, AINR_2ms and GSC. To start the app select mode, **press the *Enable AI* button until the mode LED turns green** (about 2 seconds). You can then **use the Volume - and Volume + buttons to select the desired application**, the matching app LED will turn on to indicate the current selection:
app 1: AINR_8ms, app 2: AINR_2ms, app 3: GSC. Note that the applications list is currently not customizable. **Press the *Enable AI* button for another 2 seconds to validate the selection**, the matching app LED with blink to confirm the selection. SPU001EVK3 will then restart and load the application selected.

SPU001EVK3's configuration is stored in non-volatile memory and restored upon power-up. SPU001EVK3 will start the last application used.

2.2. AI Noise Reduction (AINR)

Connect the microphone to a computer using the USB-C cable, and **connect the microphone headphone output to the SPU001EVK3 line-in connector** (see Figure 6) using the audio cable. **Plug your headphones into the line-out connector** to hear the processed audio.

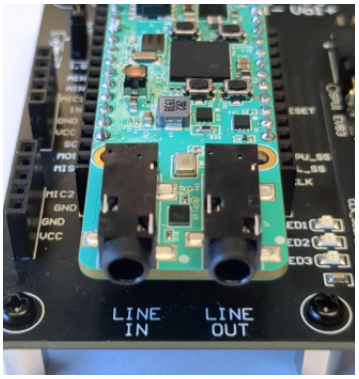


Figure 6: Audio connectors on the SPU001EVK3.

Figure 7: Microphone knob volume control (on the left), and pickup pattern selection indicator (cardioid in blue and omni in green).

The output volume can be adjusted using the two buttons (*Volume* + and *Volume* -) as illustrated in Figure 2. **AINR processing can be turned on and off by pressing the *Enable AI* button**. When AINR processing is enabled, **the status LED will blink slowly in blue**. **Human speech will be audible, and background noise significantly reduced**.

The microphone provides controls to adjust its parameters. **Adjust the volume of the microphone to best account for the ambient sound level**. Additionally, **ensure that the microphone pickup mode is set on omni to capture sound from all directions** (see Figure 7) by pressing the center button for a few seconds until the microphone light turns on in green.

Two AINR applications are available: AINR_8ms and AINR_2ms. The former is the standard AINR model and compromises latency for high noise reduction and reduced power consumption. The latter provides low latency noise reduction, at the expense of noise reduction and power consumption.

See the Troubleshooting section below for known issues.

2.3. Google Speech Commands (GSC)

Using the same setup as Section 2.1, SPU001EVK3 will listen for one of the commands listed in Table 1 to be said. SPU001EVK3 will send the command recognized over the USB serial port (see Section 2's introduction regarding how to display this information).

YES
NO
ON
OFF
LEFT
RIGHT
UP
DOWN
STOP
GO
HEY SNIPS

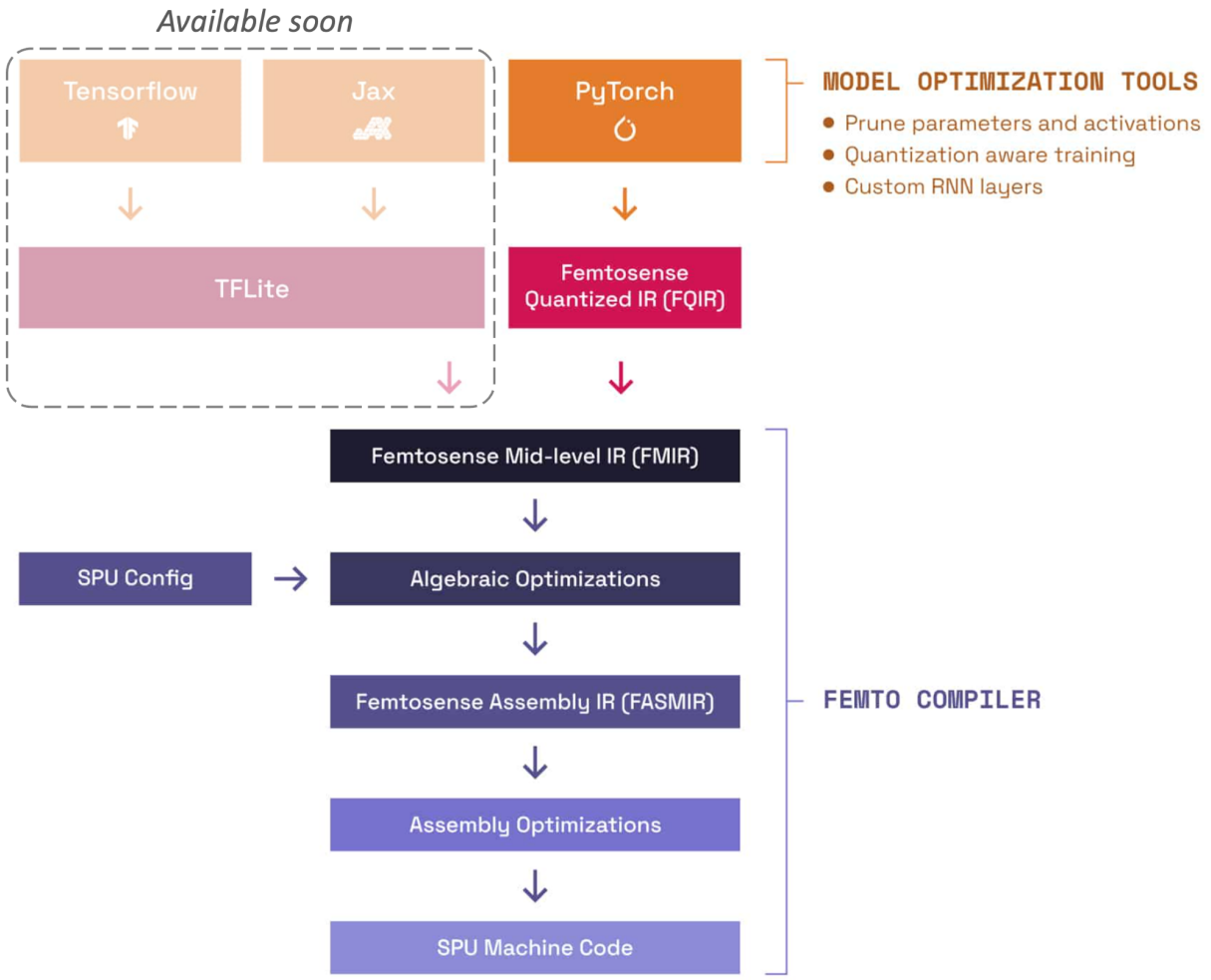
Table 1: commands available in the Google Speech application.

3. For Machine Learning Developers

3.1 The SPU Development Kit

Femtosense provides a SPU-Development Kit (SPUDKIT) to help users compress and deploy their own models to the EVK or SPU.

Users can use our packages to go from PyTorch and produce a serialized format of their quantized models. From there, they can use our compiler to produce deployable binaries. The user flow is represented by the graph below:



Note that these tools are not necessary to run the demos above but rather for developing and deploying your own model to the EVK.

3.2 Setting up the Software Development Kit

Femtosense provides the Python software packages listed below for model development and deployment.

Package	Source	Description	Documentation[1]
fmot	PyPI	The PyTorch frontend for Femtosense	https://fmot.femtosense.ai/
femtocrux	PyPI	The Femtosense compiler	https://femtocrux.femtosense.ai/
femtodriverpub	Github	Utilities to package up compiler output for firmware	See README in github repository

As prerequisite to installation, you will need the following on your system

- Python version 3.10 or later
- Docker

Make sure these are installed before installing the Femtosense packages. Femtosense packages are hosted on the PyPI and can be installed with `pip`. For example:

```
Unset
pip install fmot femtocrux
```

Note that when you run `femtocrux` for the first time (or after an update), you will be prompted for a password to download the docker image containing the compiler internals. Contact your Femtosense representative if you do not have or cannot find your password.

`femtodriverpub` is cloned directly from github.

To deploy a custom model to the EVK, we recommend starting with the `femtocrux` documentation.

[1] Use your Femtosense-provided password to access the documentation. Contact your Femtosense representative if you cannot find or do not have a password.

4. Troubleshooting

4.1 Failed firmware upload

In case this step fails, a file `fail.txt` will appear on the DAPLINK removable device. To address this, disconnect the USB cable from SPU001EKV3, reconnect it after a few seconds, and repeat the copy operation above.

4.2 Unexpected behaviors

- Status LED blinks red: this indicates that SPU001EVK3 configuration failed. Please verify that the hardware is set up as described in Section 1.1 and that the models are present on the SD card as described in Section 1.2.

Debug information can be gleaned by connecting the SPU001EVK3 USB to a computer and reading the matching serial port (115200 baud, 8-N-1) using a serial terminal (e.g. Tera Term, Putty). SPU001EVK3 will provide event logging to help diagnose potential issue root causes.

4.3 AINR Example

Objective

The output audio should preserve human speech while removing background noise.

Troubleshooting

You should expect the algorithm to perform well in positive SNR noise conditions.

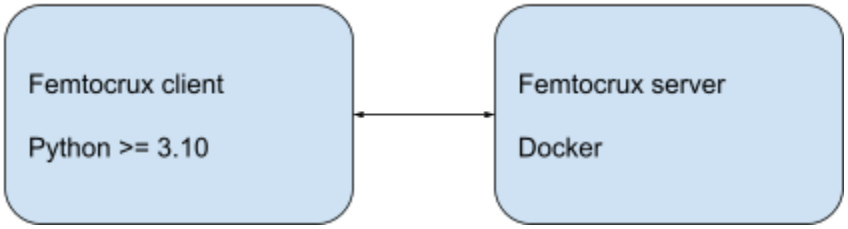
If you are experiencing distortions of speech, make sure that your testing environment is not too reverberant.

If the output is too quiet, adjust the output volume on the microphone (see Figure 7) and on the SPU001EVK3 using the buttons (see Figure 2).

A. Appendix

A.1 Femtocrux Windows Setup Guide

Note: Femtocrux has been tested on Linux and Window systems. The following guide is for the Windows operating system, but similar steps apply to other systems as well. See here for the recommended way to install Docker on your system.



This guide explains how to install Femtosense's Femtocrux compiler on the Windows operating system. There are three main steps.

1. Install Docker, and configure for Linux containers
2. Install Python 3.10
3. Install Femtocrux client and pull Docker image

Install and configure Docker Desktop

Femtocrux's backend runs in a Docker Linux container. To run it on a Windows machine, we first need to install Docker Desktop, then configure it to run Linux containers.

Install Docker Desktop

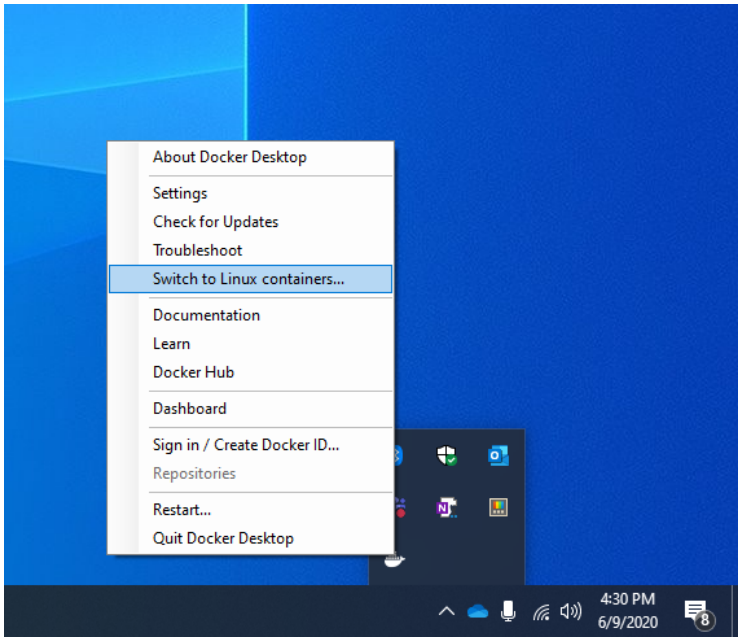
First, install Docker Desktop by following these instructions.

- Download the Docker Desktop installer.
- Click through and install.
    - Docker supports two different backends for Windows: WSL and Hyper-V. Some systems only support one or the other. Although both should work, our internal testing uses Hyper-V.

Configure Docker to use Linux containers

Right click on Docker Desktop, and select "Run as Administrator." Once Docker Desktop starts, you should see a small whale icon in the taskbar in the lower right corner of your screen.

Next, configure Docker to use Linux containers by right-clicking on the whale icon. See this guide for more info.



Install Python 3.10

Femtocrux's client requires Python (version >= 3.10) to run. The installer can be downloaded here. For most systems, we recommend choosing "Windows Installer (64-bit)." Simply download the installer and click through it, choosing to add Python to your system's PATH.

To check that your Python installation is discoverable from the command line, run the command:

```
C:\Users\Administrator>python --version
Python 3.10.11
```

Install Femtocrux

The following commands install the Femtocrux client and server.

Install Femtocrux client

The Femtocrux client is available on pypi. To install the latest version, run the following command.

```
Unset
python -m pip install femtocrux
```

Install Femtocrux server docker image

To check that Femtocrux works, you can try running the following command.

```
Unset
python -c “from femtocrux import CompilerClient; CompilerClient()”
```

If this is your first time running this version of Femtocrux, you will be prompted to log in to Github Container Registry and pull the Docker image.

```
C:\Users\Administrator>python -c "from femtocrux import CompilerClient; CompilerClient()"
Failed to find the docker image ghcr.io/femtosense/femtocrux:0.2.8-1 locally.

            Attempting to pull docker image from remote.

            Alternatively, you can pull the image yourself with the command:
                docker pull ghcr.io/femtosense/femtocrux:0.2.8-1

Please enter your Femtosense-provided key:
```

At this point, please copy and paste the password provided to you by Femtosense, and press enter. If authentication succeeds, the client will start pulling the Femtocrux Docker image. This may take a few minutes to complete.

Once the download completes, you can run the same command to verify that the server is working.

```
C:\Users\Administrator>python -c "from femtocrux import CompilerClient; CompilerClient()"
Checking container status...
Container started successfully.
Container passed health check.
Created gRPC channel at 172.22.6.19:50051
Waiting to establish a connection...
Connection successful.
```

Change Log

Version	Release Date	Description
1.0	2023-08-22	Initial release
1.1	2023-09-13	Update figures and information related to controls to reflected updated hardware (EVB3).
1.2	2023-10-25	Update figures related to model/firmware file structure.
1.3	2023-11-28	Modified instructions to reflect the single firmware, including instructions for model selection.