Getting started with xCORE VocalFusion Speaker

IN THIS DOCUMENT

This document describes how to get started with the *xCORE VocalFusion Speaker* evaluation system and firmware. You will be guided through setting up the system, downloading the firmware and programming the board. It is assumed that you are familiar with the XMOS xTIMEcomposer programming tools. Additional information and documents are available at http://www.xmos.com/vfspeaker.

1 Requirements

To evaluate *xCORE VocalFusion* Speaker, the following hardware/software is required:

- **xCORE VocalFusion Speaker baseboard** version 1.1[1]

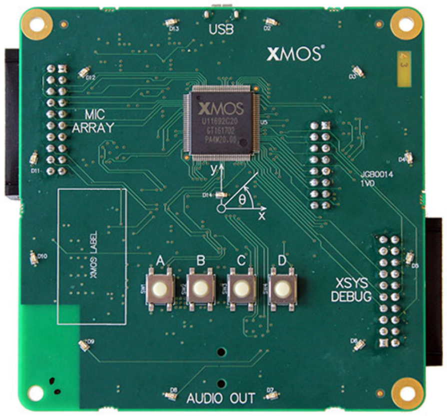


Figure 1: *xCORE VocalFusion* baseboard

[1]Version 1.0 of the baseboard may be used for USB evaluation however the I^{2}S hardware setup is different from the instructions provided in this guide as J6 is not present

- **Microphone board** - Linear or circular with ribbon cable

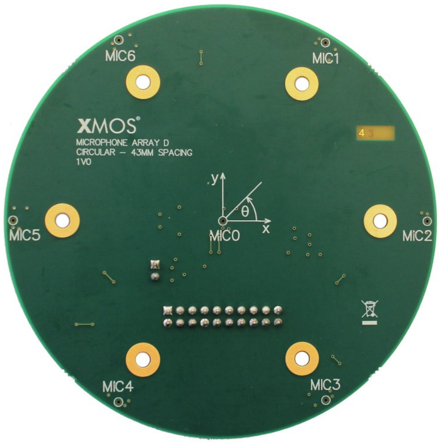


Figure 2: C43 microphone board

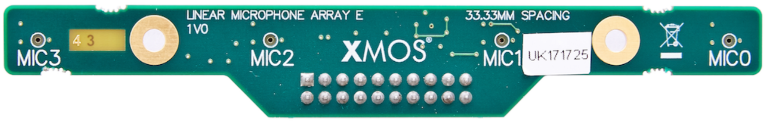


Figure 3: L33 microphone board

- **xTAG** - connects to the xTIMEcomposer tools so you can load application binaries onto the target board

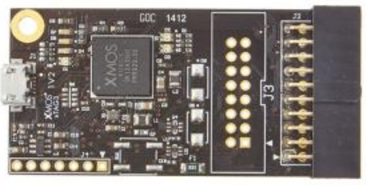


Figure 4: xTAG

- **Two micro-USB cables** - one cable provides connection to the baseboard, the other connects the xTAG debug adapter to a host computer
- **xTIMEcomposer** - the development tools provide everything you need to program, debug and simulate your applications; download free from `http://www.xmos.com/tools`[2]
- **XMOS VocalFusion firmware download** - (1.1.1 or later). Available from `http://www.xmos.com/vfspeaker`.
- **A host computer with two USB ports** - macOS and Windows are supported for USB configurations. For I^{2}S configurations an audio source with an I^{2}S master interface providing a 24.576MHz MCLK is also required

[2]Requires an xmos.com account

- **A single amplified loudspeaker** - This should have no audio enhancement functionality: any audio processing will seriously degrade AEC performance
- **Internet connection** - required to register the tools before you can use them, and to access firmware repositories from within xTIMEcomposer

Parameter control will also require a host system capable of compiling the control utility vfctrl. Please see the *VocalFusion Control Users Guide*[3] for details.

[3] http://www.xmos.com/published/vocalfusion-control-users-guide

2 *xCORE VocalFusion* Features

The following features are supported:

- Linear and circular/rectangular microphone array configurations
- 4 microphone adaptive beamformer with 180 or 360 degree coverage options
- Mono, full-duplex (barge-in) AEC with reference/far-end source from USB playback from host (also option of I^2S)
- Stationary & diffuse noise suppression (tunable up to 15dB)
- De-reverberation
- Control of microphone processing parameters via xSCOPE, USB or I2C (example command line driven host application supplied)
- 16 or 48kHz host sample rate (processed microphone output is upsampled from 16kHz to 48kHz)
- Host connection via:
  - USB Audio Class 1.0 compliant device for AEC reference/far-end input and processed mic output
  - I^2S mode for AEC reference/far-end input and processed mic output
  - Mixed mode using I^2S for reference/far-end input and USB for processed mic output

The processed output can be optimized for human communications (i.e. Internet calls) or Automatic Speech Recognition (ASR) engines. The ASR output has less processing applied which improves ASR performance but may subjectively sound worse to a human.

Three main modes of operation for USB audio input to host are provided:

- 1 channel: processed output is sent to the host (either ASR or communications optimized)
- 2 channels: processed output is sent to the host on both channels (one optimized for ASR, the other human communications)
- 6 channels: processed output, AEC reference/far-end and raw microphone data are sent to the host

The first two configurations could be used in a deployment scenario. The primary use of the third is for evaluation.

Figure 5 shows the basic layout of the processing in *xCORE VocalFusion*. It shows a stereo to mono down-mix, optional down-sampling and up-sampling as well as the main Acoustic Echo Cancellation and Beamforming & Post-processing blocks.

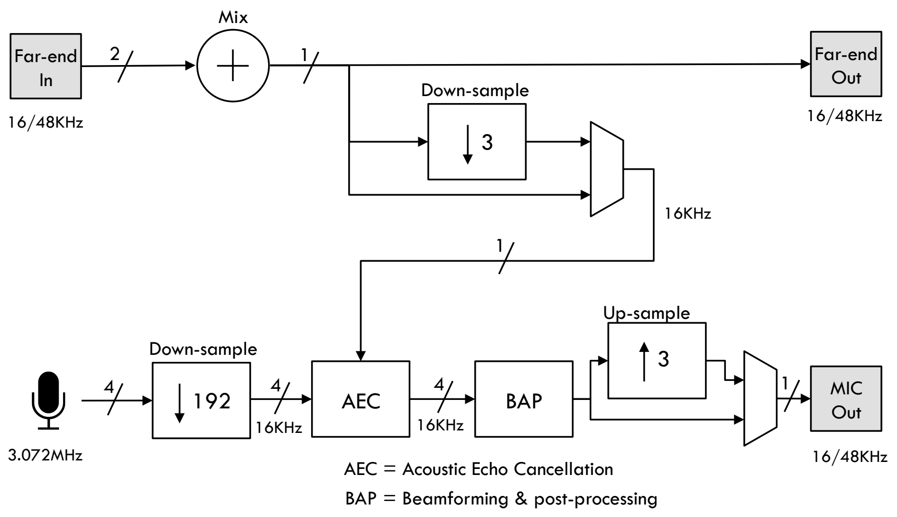


Figure 5: Block diagram of VocalFusion Speaker

3 Install xTIMEcomposer Tools

xTIMEcomposer provides everything required for programming xCORE processors.

The tools are provided free of charge to users registered on the xmos.com website. Versions are available for Windows, macOS and Linux platforms from https://www.xmos.com/support/tools.

xCORE VocalFusion requires version 14.3.2, with a Java Runtime Environment (JRE) version 1.6 or later installed. See the xTIMEcomposer download page for further information on using xTIMEcomposer and Java requirements.

4 Download the Firmware

The *xCORE VocalFusion* firmware contains source-code that includes the voice processing, control and I/O processing.

The firmware is provided as a single zip archive named sw_vocalfusion.

Download the firmware images from:

https://www.xmos.com/vfspeaker

5 Build the Firmware

You need to import the firmware source code into the tools, build it and then execute it on the target board. Build either using the xTIMEcomposer IDE or from the command line.

5.1 Build Firmware under xTIMEcomposer IDE

The following section details how to build the firmware and generate a binary.

5.1.1 Start xTIMEcomposer IDE

The first time you start xTIMEcomposer IDE you will be prompted for your MyXMOS registration details, you will need to be connected to the Internet.

When xTIMEcomposer starts you will be prompted to specify the location of your workspace. This is where your Eclipse workspace files will be kept and where the firmware will be imported to. Once the workspace location has been set you will be prompted with a project explorer window which will either contain your existing Eclipse projects or be empty if you have setup a new workspace.

You may need to close the *WHAT'S NEW in 14.0.0? RELEASE NOTES & COMPATIBILITY* window by clicking the cross at on the tab at the top

5.1.2 Import the Firmware

To import the *sw_vocalfusion* firmware zip archive, follow these steps:

1/ Select **File** ▶ **Import** (Figure 6)

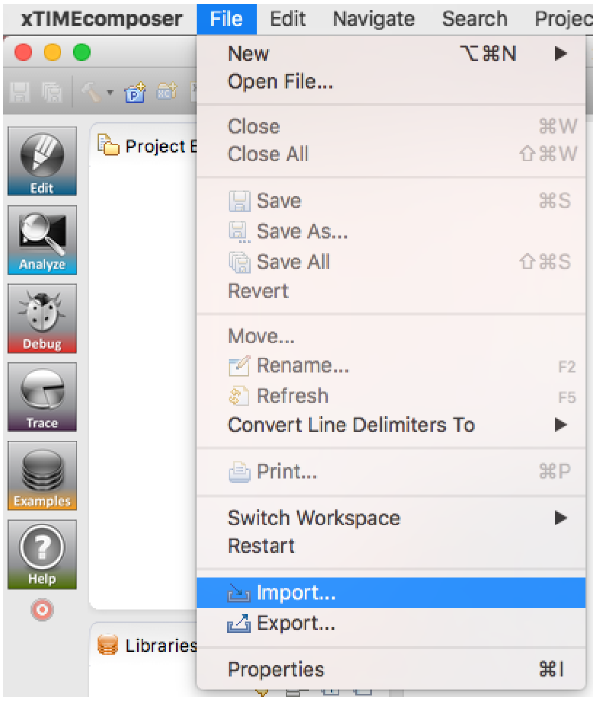


Figure 6: Firmware import

2/ Select **General ▶ Existing Projects into Workspace**, then click **Next** (Figure 7)

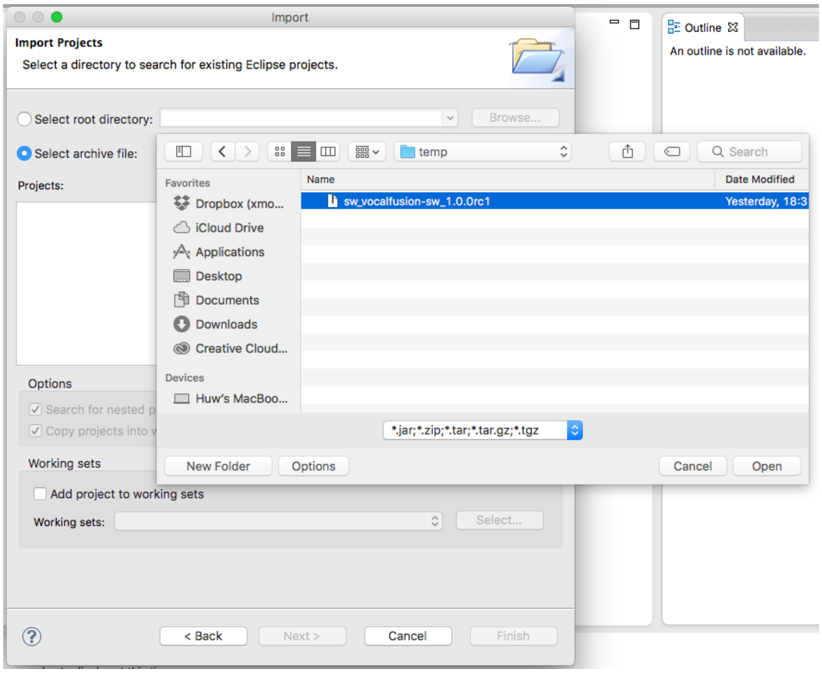
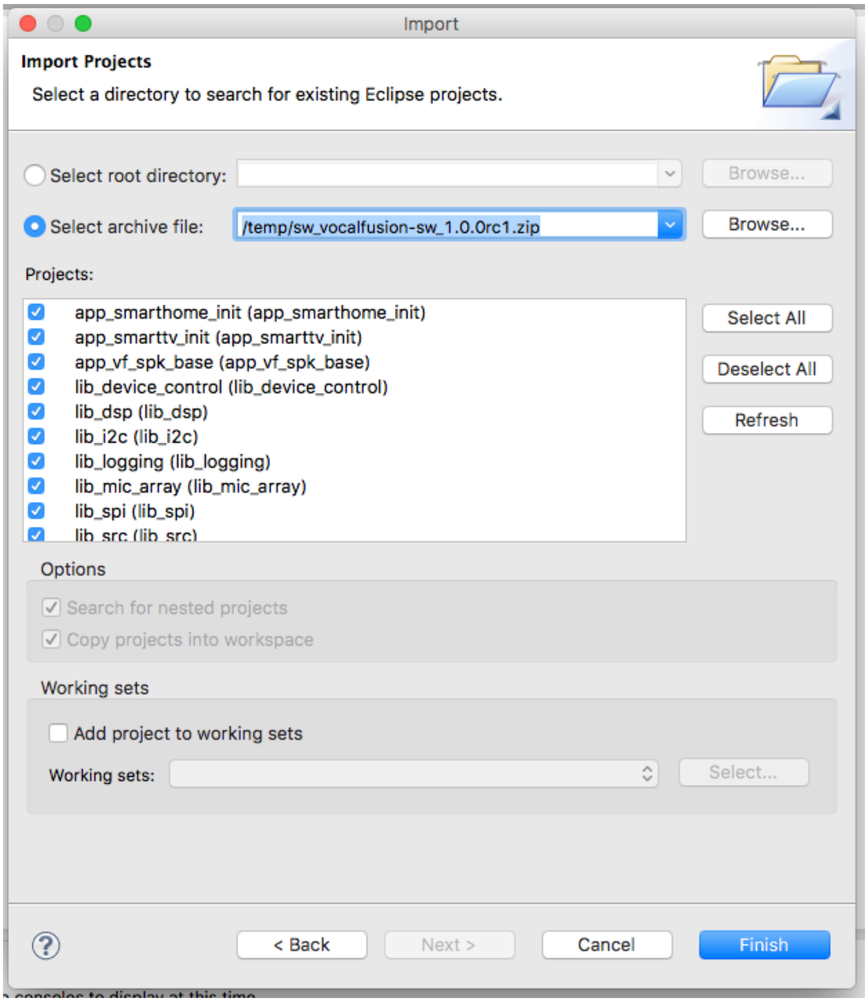


Figure 7: Firmware import type

3/ In **Select archive file**, click **Browse** and select the zip file you have just downloaded. When you have browsed to the downloaded archive and clicked **Open**, a list of available modules and applications will be seen. They should all already be selected so just click **OK** to import *xCORE VocalFusion*, if needed, and all of its modules and libraries. (Figure 8)

4/ Click **Finish** to complete the import.

A dialogue will display a warning that some configurations exist in the project but not in the makefile. If you intend to later import the TrulyHandsfree^{TM} library and build keyword enabled build configurations click “no” otherwise click “yes”.



Import

Import Projects

Select a directory to search for existing Eclipse projects.

Select root directory:

[✓ Select archive file:] /temp/sw_vocalfusion-sw_1.0.0rc1.zip

Projects:

- [✓] app_smarthome_init (app_smarthome_init)
- [✓] app_smarttv_init (app_smarttv_init)
- [✓] app_vf_spk_base (app_vf_spk_base)
- [✓] lib_device_control (lib_device_control)
- [✓] lib_dsp (lib_dsp)
- [✓] lib_i2c (lib_i2c)
- [✓] lib_logging (lib_logging)
- [✓] lib_mic_array (lib_mic_array)
- [✓] lib_spi (lib_spi)
- [✓] lib_src (lib_src)

Options

- [✓] Search for nested projects
- [✓] Copy projects into workspace

Working sets

- [ ] Add project to working sets

Working sets:

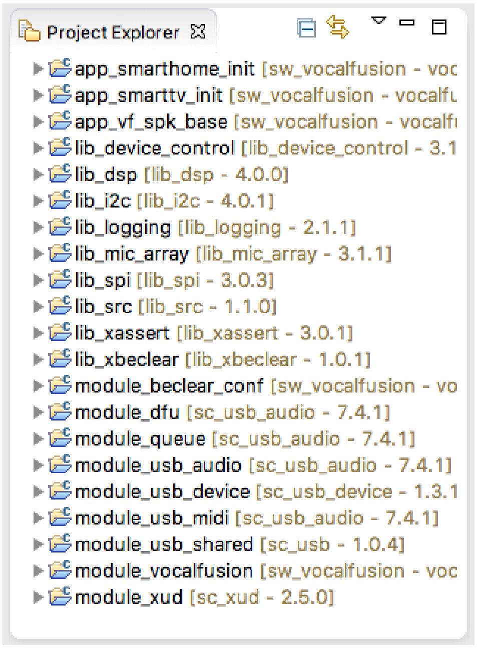
Figure 8: Firmware import selection

The projects should now appear in the *Project Explorer* window. (Figure 9)

5.1.3 Build the Firmware

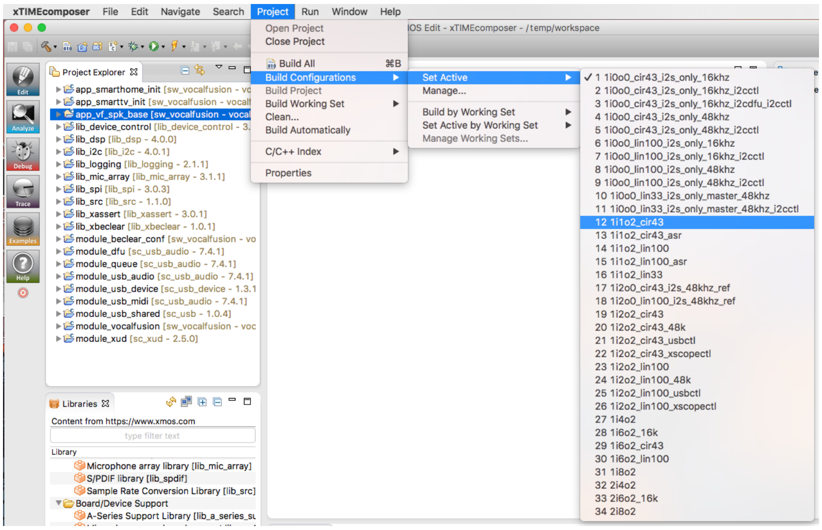
To build the firmware, you need to select the desired build configuration, for example *1i1o2_cir43*, and set it as the current project, configure the build options for `make` and then build the project.

Click on *app_vf_spk_base* in *Project Manager* and select **Project ▶ Build Configurations ▶ Set Active**. (Figure 10)



```
app_smarthome_init [sw_vocalfusion - voc
app_smarttv_init [sw_vocalfusion - vocalfu
app_vf_spk_base [sw_vocalfusion - vocalfu
lib_device_control [lib_device_control - 3.1
lib_dsp [lib_dsp - 4.0.0]
lib_i2c [lib_i2c - 4.0.1]
lib_logging [lib_logging - 2.1.1]
lib_mic_array [lib_mic_array - 3.1.1]
lib_spi [lib_spi - 3.0.3]
lib_src [lib_src - 1.1.0]
lib_xassert [lib_xassert - 3.0.1]
lib_xbeclear [lib_xbeclear - 1.0.1]
module_beclear_conf [sw_vocalfusion - vo
module_dfu [sc_usb_audio - 7.4.1]
module_queue [sc_usb_audio - 7.4.1]
module_usb_audio [sc_usb_audio - 7.4.1]
module_usb_device [sc_usb_device - 1.3.1
module_usb_midi [sc_usb_audio - 7.4.1]
module_usb_shared [sc_usb - 1.0.4]
module_vocalfusion [sw_vocalfusion - voc
module_xud [sc_xud - 2.5.0]
```

Figure 9: Firmware import selection



```
app_smarthome_init [sw_vocalfusion - vo
app_smarttv_init [sw_vocalfusion - vocalf
app_vf_spk_base [sw_vocalfusion - vocal
lib_device_control [lib_device_control - 3.
lib_dsp [lib_dsp - 4.0.0]
lib_i2c [lib_i2c - 4.0.1]
lib_logging [lib_logging - 2.1.1]
lib_mic_array [lib_mic_array - 3.1.1]
lib_spi [lib_spi - 3.0.3]
lib_src [lib_src - 1.1.0]
lib_xassert [lib_xassert - 3.0.1]
lib_xbeclear [lib_xbeclear - 1.0.1]
module_beclear_conf [sw_vocalfusion - vo
module_dfu [sc_usb_audio - 7.4.1]
module_queue [sc_usb_audio - 7.4.1]
module_usb_audio [sc_usb_audio - 7.4.1]
module_usb_device [sc_usb_device - 1.3.1
module_usb_midi [sc_usb_audio - 7.4.1]
module_usb_shared [sc_usb - 1.0.4]
module_vocalfusion [sw_vocalfusion - voc
module_xud [sc_xud - 2.5.0]
```

```
Content from https://www.xmos.com
Microphone array library [lib_mic_array]
S/PDIF library [lib_spdif]
Sample Rate Conversion Library [lib_src]
Board/Device Support
A-Series Support Library [lib_a_series_su
```

```
✓ 1 1i0o0_cir43_i2s_only_16khz
2 1i0o0_cir43_i2s_only_16khz_i2cctl
3 1i0o0_cir43_i2s_only_16khz_i2cdfu_i2cctl
4 1i0o0_cir43_i2s_only_48khz
5 1i0o0_cir43_i2s_only_48khz_i2cctl
6 1i0o0_lin100_i2s_only_16khz
7 1i0o0_lin100_i2s_only_16khz_i2cctl
8 1i0o0_lin100_i2s_only_48khz
9 1i0o0_lin100_i2s_only_48khz_i2cctl
10 1i0o0_lin33_i2s_only_master_48khz
11 1i0o0_lin33_i2s_only_master_48khz_i2cctl
12 1i1o2_cir43
13 1i1o2_cir43_asr
14 1i1o2_lin100
15 1i1o2_lin100_asr
16 1i1o2_lin33
17 1i2o0_cir43_i2s_48khz_ref
18 1i2o0_lin100_i2s_48khz_ref
19 1i2o2_cir43
20 1i2o2_cir43_48k
21 1i2o2_cir43_usbctl
22 1i2o2_cir43_xscopectl
23 1i2o2_lin100
24 1i2o2_lin100_48k
25 1i2o2_lin100_usbctl
26 1i2o2_lin100_xscopectl
27 1i4o2
28 1i6o2_16k
29 1i6o2_cir43
30 1i6o2_lin100
31 1i8o2
32 2i4o2
33 2i6o2_16k
34 2i8o2
```

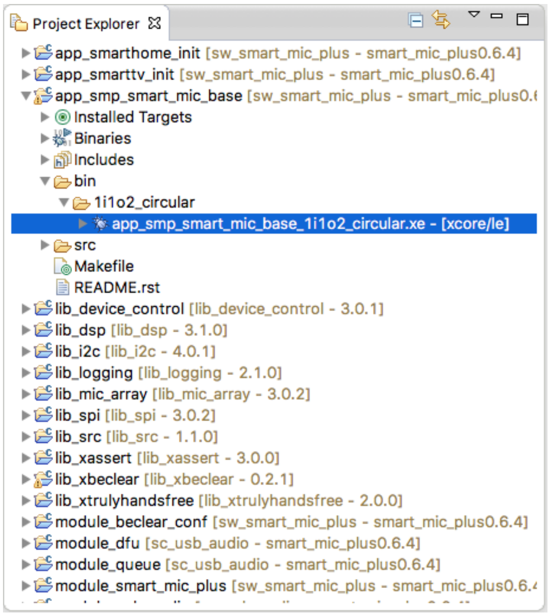
Figure 10: Selecting The Active Build Configuration

With the desired configuration selected in the menu, click to set it as the active build configuration.

Right-click on the project in the *Project Explorer* and select **Build Project**.

Expect build time of 2-3 minutes, depending on selected configuration. You will note build warnings in the build. These do not affect functionality, and will be removed in a future release of the firware.

Navigate to the **app_vf_spk_base ▶ bin ▶ 1i1o2_cir43** folder in *Project Explorer* where the compiled binary app_vfspk_base_1i1o2_cir43.xe has been generated. (Figure 11)



Project Explorer

```
▶ app_smarthome_init [sw_smart_mic_plus - smart_mic_plus0.6.4]
▶ app_smarttv_init [sw_smart_mic_plus - smart_mic_plus0.6.4]
▼ app_smp_smart_mic_base [sw_smart_mic_plus - smart_mic_plus0.
    ▶ Installed Targets
    ▶ Binaries
    ▶ Includes
    ▼ bin
        ▼ 1i1o2_circular
            ▶ app_smp_smart_mic_base_1i1o2_circular.xe - [xcore/le]
    ▶ src
      Makefile
      README.rst
▶ lib_device_control [lib_device_control - 3.0.1]
▶ lib_dsp [lib_dsp - 3.1.0]
▶ lib_i2c [lib_i2c - 4.0.1]
▶ lib_logging [lib_logging - 2.1.0]
▶ lib_mic_array [lib_mic_array - 3.0.2]
▶ lib_spi [lib_spi - 3.0.2]
▶ lib_src [lib_src - 1.1.0]
▶ lib_xassert [lib_xassert - 3.0.0]
▶ lib_xbeclear [lib_xbeclear - 0.2.1]
▶ lib_xtrulyhandsfree [lib_xtrulyhandsfree - 2.0.0]
▶ module_beclear_conf [sw_smart_mic_plus - smart_mic_plus0.6.4]
▶ module_dfu [sc_usb_audio - smart_mic_plus0.6.4]
▶ module_queue [sc_usb_audio - smart_mic_plus0.6.4]
▶ module_smart_mic_plus [sw_smart_mic_plus - smart_mic_plus0.6.
```

Figure 11: Compiled binary in Project Explorer

5.2 Build from Command Line

First open an xTIMEcomposer command prompt. This will automatically setup the required environment and paths to allow the compiler to run. Next navigate to the following directory which can be found in the firmware package:

```
sw_vocalfusion/app_vf_spk_base
```

To build the firmware of your choice, you need to specify the desired configuration, for example, *1i1o2_cir43*. This is then passed via the `CONFIG` variable on the command line. For example:

```
xmake CONFIG=1i1o2_cir43
```

To see a list of supported build configurations type *xmake allconfigs*

Be sure to choose a build config that matches the microphone topology you are using - both arrangement and spacing

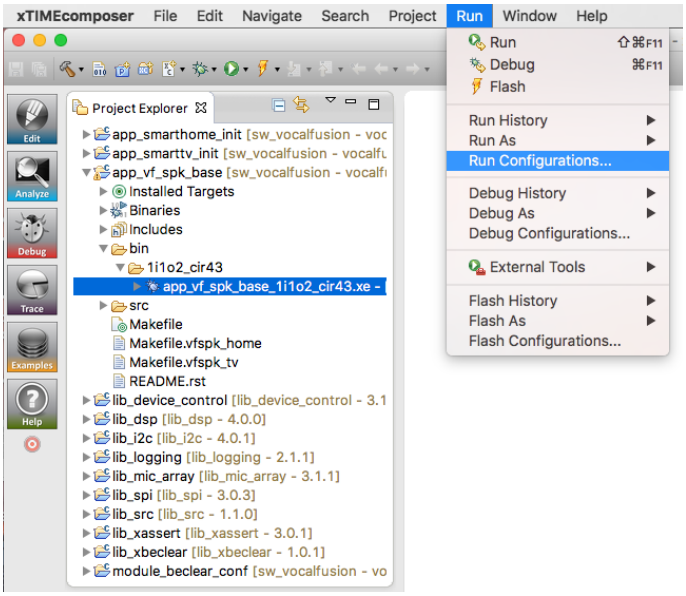
6 Run the Firmware

The following section details how to run the compiled firmware binary.

6.1 Running from xTIMEComposer

To run the firmware you need to set up a *Run Configuration* for the *xCORE VocalFusion* project.

Click **Run ▶ Run Configurations** in the top menu bar. (Figure 12)



xTIMEcomposer File Edit Navigate Search Project Run Window Help
Run ⇧⌘F11
Debug ⌘F11
Flash
Run History
Run As
Run Configurations...
Debug History
Debug As
Debug Configurations...
External Tools
Flash History
Flash As
Flash Configurations...
Edit
Analyze
Debug
Trace
Examples
Help
Project Explorer
app_smarthome_init [sw_vocalfusion - voc
app_smarttv_init [sw_vocalfusion - vocalfu
app_vf_spk_base [sw_vocalfusion - vocalfu
Installed Targets
Binaries
Includes
bin
1i1o2_cir43
app_vf_spk_base_1i1o2_cir43.xe -
src
Makefile
Makefile.vfspk_home
Makefile.vfspk_tv
README.rst
lib_device_control [lib_device_control - 3.1
lib_dsp [lib_dsp - 4.0.0]
lib_i2c [lib_i2c - 4.0.1]
lib_logging [lib_logging - 2.1.1]
lib_mic_array [lib_mic_array - 3.1.1]
lib_spi [lib_spi - 3.0.3]
lib_src [lib_src - 1.1.0]
lib_xassert [lib_xassert - 3.0.1]
lib_xbeclear [lib_xbeclear - 1.0.1]
module_beclear_conf [sw_vocalfusion - vo

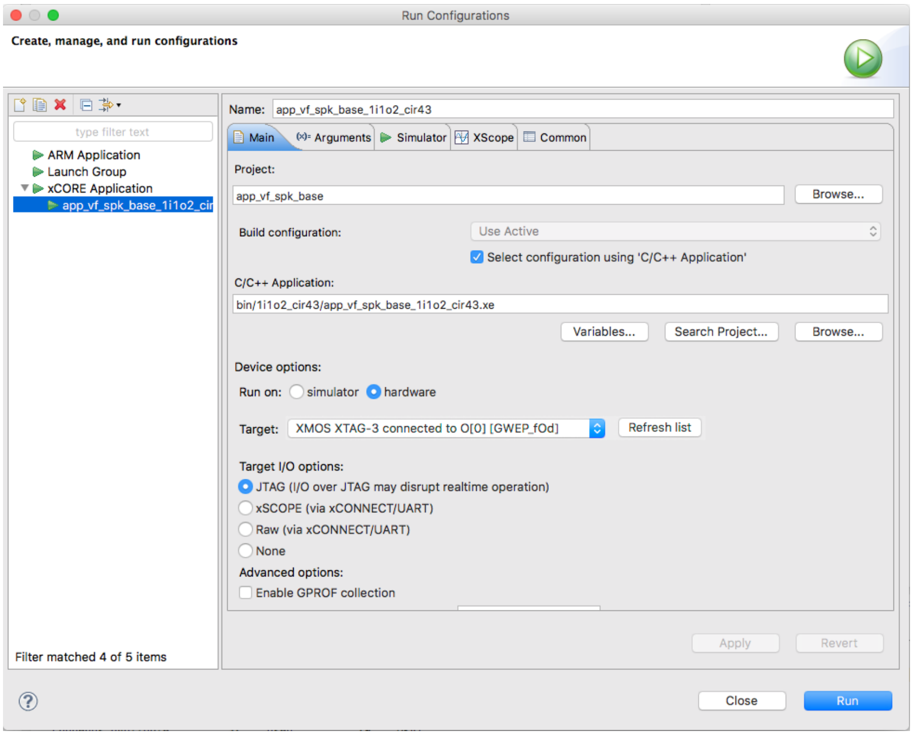
Figure 12: Selecting Run Configurations

In the *Run Configurations* window, double-click **xCORE Application**.

If *C/C++ Application* is not auto-completed, click **Browse** and navigate to the compiled binary in your project. For example:

`app_vf_spk_base/bin/1i1o2_cir43/app_vf_spk_base_1i1o2_cir43.xe.`

Your *Run Configuration* should now appear similar to the following (Figure 13):



Run Configurations

Create, manage, and run configurations

type filter text

- ARM Application
- Launch Group
- xCORE Application
  - app_vf_spk_base_1i1o2_cir

Filter matched 4 of 5 items

Name: app_vf_spk_base_1i1o2_cir43

Main | Arguments | Simulator | XScope | Common

Project: app_vf_spk_base

Build configuration: Use Active

[✓] Select configuration using 'C/C++ Application'

C/C++ Application: bin/1i1o2_cir43/app_vf_spk_base_1i1o2_cir43.xe

Device options:

Run on: simulator [✓ hardware]

Target: XMOS XTAG-3 connected to O[0] [GWEP_fOd]

Target I/O options:

[✓ JTAG (I/O over JTAG may disrupt realtime operation)]
xSCOPE (via xCONNECT/UART)
Raw (via xCONNECT/UART)
None

Advanced options:

[ ] Enable GPROF collection

Figure 13: Run Configuration settings

Check that *Target* is set correctly, as shown in (Figure 13). If this is not the case, ensure that the device is connected correctly and click on **Refresh list**. If this is not enough, try to unplug and plug the xTAG adapter and use the **Refresh list** button again.

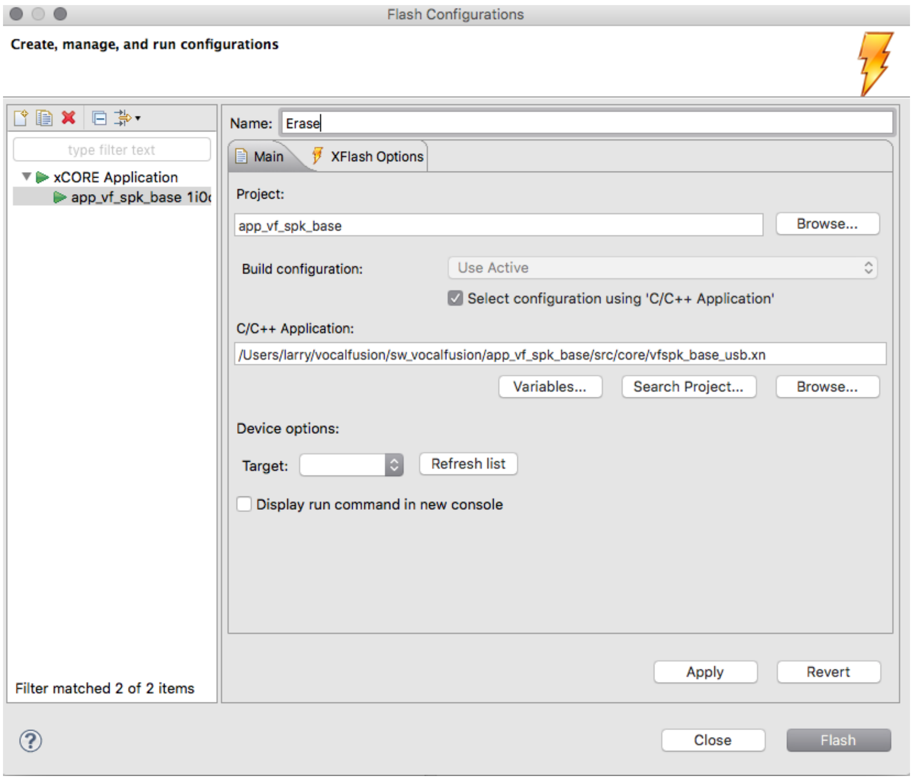
Click **Apply** to save the configuration.

Click **Run** to download the application to the *xCORE VocalFusion* board, and run it.

The board will now running the desired firmware.

6.1.1 Erase board

If the board is reset or power cycled, it will boot into any firmware programmed in its flash. If firmware is ran rather than flashed, it is good practice to erase the flash first. Should the board reset or power cycle after run, empty flash ensures it will not run another version unexpectedly.


Flash Configurations

Create, manage, and run configurations

type filter text

xCORE Application

app_vf_spk_base 1i0

Filter matched 2 of 2 items

Name: Erase

Main | XFlash Options

Project: app_vf_spk_base

Build configuration: Use Active

Select configuration using 'C/C++ Application' ✓

C/C++ Application: /Users/larry/vocalfusion/sw_vocalfusion/app_vf_spk_base/src/core/vfspk_base_usb.xn

Device options:

Target:

Display run command in new console ☐

Figure 14: Flash configuration for erase, page 1

The erase command is listed in §6.2. An alternative to using the command line is to create a pseudo flash configuration in xTIMEcomposer.

- Select **Run ▶ Flash Configurations** (Figure 14). In *Flash Configurations*, double-click **xCORE Application**.
- Now select the application's XN file for *C/C++ Application*; click **Browse** and navigate to:

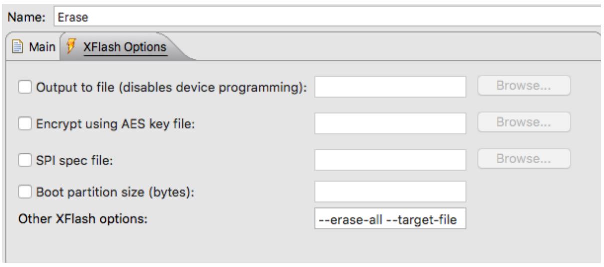
  ```
  app_vf_spk_base/src/core/vfspk_base_usb.xn
  ```

- Switch to **XFlash Options** tab (Figure 15), and enter the following in *Other XFlash Options*:

  ```
  --erase-all --target-file
  ```

- Check that Target is set correctly. If this is not the case, ensure that the device is connected correctly and click on Refresh list. If this is not enough, try to unplug and plug the xTAG adapter and use the Refresh list button again.
- Click **Apply** to save the configuration.

- Click **Run** to execute the erase. Console output will indicate *terminated* once erasing is done.



Name: Erase

- [ ] Output to file (disables device programming):
- [ ] Encrypt using AES key file:
- [ ] SPI spec file:
- [ ] Boot partition size (bytes):

Other XFlash options: --erase-all --target-file

Figure 15: Flash configuration for erase, page 2

6.2 Running from the Command Line

Optionally the XE file can be run on a target outside of the xTIMEComposer IDE. From a xTIMEComposer command prompt, run the chosen XE file on the target using the command:

```
xrun <file_name>.xe
```

Ensure that the relevant binary is run for the connected microphone configuration (i.e. circular vs linear and spacing)

If the board is reset or power cycled, it will boot into any firmware programmed in its flash. If using *xrun* rather than *xflash* to run firmware, it is good practice to erase the flash first. Should the board reset or power cycle after *xrun*, empty flash ensures it will not run another version unexpectedly:

```
xflash --erase-all --target-file app_vf_spk_base/src/core/vfspk_base_usb.xn
```

7 Evaluation Procedure

The following section contains specific information about how to demonstrate *xCORE VocalFusion*. Please jump to the relevant section that matches your audio host connection:

- Full USB Configuration
- Full I2S Configuration
- USB with I2S AEC Reference

7.1 Full USB Configuration

The default configuration is fully USB based and allows evaluation of the key *xCORE VocalFusion* features. It uses USB Audio Class 1.0 transport to stream the microphone signal(s) to the host and playback the AEC reference/far-end signal from the host to the on-board DAC. This evaluation will be using the following build:

- 1i2o2_lin33_48khz/1i2o2_cir43_48khz: 2 channel input, 2 channel output

This build has processed output for communications (optimized for human listening) on channel 0 and processed output for ASR (optimized for machine listening) on channel 1.

7.1.1 Hardware Setup

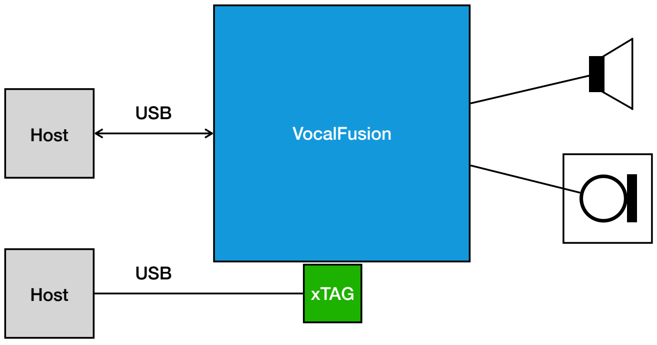


Figure 16: Connection diagram (USB)

According to Figure 16:

- Connect the *xCORE VocalFusion* Base Board to your computer using the micro-USB cable provided
- Connect the xTAG adapter to the *xCORE VocalFusion* Base Board via the xSYS DEBUG connector

- Use the second USB cable to connect the USB receptacle on the xTAG to a host computer with xTIMEComposer installed
- Connect the 3.5mm AUDIO OUT on the *xCORE VocalFusion* Base Board to an amplified speaker - once again ensuring the speaker has no audio processing enabled.

For best AEC performance ensure that the microphone board is protected from vibrations resulting from the loudspeaker operation. Layer of suitable soft material between the speaker and the microphone board will dampen vibrations.

For best performance the linear microphone array should be facing towards the user(s)

7.1.2 Evaluation Procedure

You will play a sound track through loudspeaker into the room, speak or use another loudspeaker as near-end speech, and record output of *xCORE VocalFusion*. The output will have echo cancellation applied, beamforming and further postprocessing such as echo suppression. It will leave the near-end speech sounding much clearer than it would in the raw microphone recording.

- Once successfully enumerated the device will appear as a USB Audio Device named *XMOS VocalFusion Spk (UAC1.0)*
- Select the new sound card as your computers default audio device. On a Mac use Audio MIDI Setup or alt-click on the sound icon in the tool bar. In Windows uses the sound preferences in Control Panel
- It is best to allow the program to adjust to the acoustics of the room before playing an AEC reference/far-end (typically 10 seconds of talking).
- Play the AEC reference/far-end signal from any audio program (e.g. iTunes) to the board - ensure it can be heard being played out of the speaker.
- Use your favorite application (e.g. Audacity) to record from the device and playback the results of the processed audio.

In both cases the AEC reference/far-end signal played to the device over USB is down-mixed to mono and output to the *right* speaker only. Output to the left speaker is muted.

7.1.3 Windows Specific

You can use any sound subsystem on Windows such as MME, DirectSound and WASAPI. With WASAPI in Audacity, if you get no sound and level meters not moving, check that the Audacity project sample rate matches the USB device's sample rate.

Windows includes a USB Audio Class 1.0 driver to support the *xCORE VocalFusion* device.

When a configured evaluation kit is connected to a Windows PC, the native driver is installed and the device details are stored in Windows' USB cache. If subsequently a different version of the evaluation kit is connected (for example, an evaluation kit with a firmware using the same VID and PID but exposing a different configuration of audio channels) then the Windows' USB cache is not updated and the USB audio connection to the evaluation kit will not operate correctly.

If this occurs, typically when changing between 16kHz and 48kHz firmware configurations, disconnect the evaluation kit and use the USBDeview utility (freeware available from http://www.nirsoft.net/utils/usb_devices_view.html) to uninstall all instances of XMOS USB audio devices. Then re-connect the evaluation kit; fresh instances of the UAC1 driver will then be correctly installed.

7.2 Full I2S Configuration

The device can optionally receive the AEC reference/far-end signal via I^2S (slave/-master) and also output the processed microphone output over I^2S (slave/master). The sample rate for the I^2S interface can be either 48kHz or 16kHz. The host rate of 48kHz is used in this example to allow high quality audio to be played back.

The below procedure uses following configurations:

- 1i0o0_lin33_i2s_only_48khz/1i0o0_cir43_i2s_only_48khz: 2 channel input, 1 channel output

Note that *xCORE VocalFusion* is I^2S slave in these configurations, and will require an external 24.576MHz master clock.

7.2.1 Hardware Setup

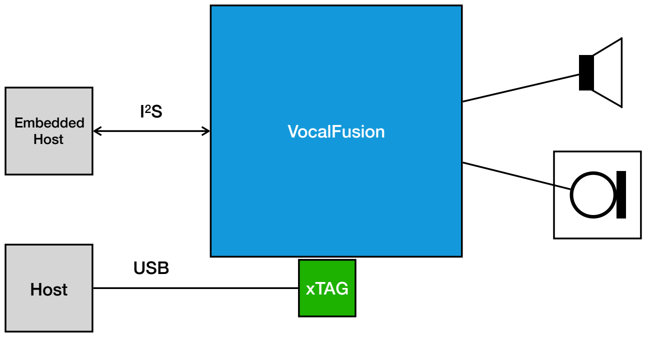


Figure 17: Connection diagram (I^2S)

In order to demonstrate I^2S being used for input and output put the AEC reference/far-end signal and the processed microphone signal the following modifications must be made to the *xCORE VocalFusion* board. According to Figure 17:

- Move resistor R67 to R17 - this bypasses the on-board master-clock (MCLK) generation to allow the use of an external master-clock source
- Attach an external MCLK to pin 15 of Expansion Header J5
- Attach an external I2S data-line to pin 10 of Expansion Header J6 (marked `I2S`). AEC reference/far-end data should be presented on this I/O
- Attach an external LRCLK to pin 1 of Expansion Header J6
- Attach an external SCLK to pin 6 of Expansion Header J6
- Ground should also be shared between the external I^{2}S AEC reference/far-end signal source and the *xCORE VocalFusion* Base Board. Ground is available on *xCORE VocalFusion* Base Board on pins 2, 6, 8, 11, 14, 15, 16 of Expansion Header J5 and pins 2, 5, 8 of Expansion Header J6
- Attach an external I2S data-line to pin 9 of Expansion Header J6. Processed microphone data will be presented on this I/O.
- Board connected via USB to a host for power

The device only uses the *right* channel as the AEC reference/far-end signal

The USB interface is disabled in this build configuration, so the device will not show in the host computers device manager. The USB port is simply acting as a power supply.

7.2.2 Evaluation Procedure

The evaluation procedure is the same as the USB demo but AEC reference/far-end signal is played via external I^{2}S source. The output on the left channel is the processed output and the right is the AEC reference/far-end.

For optimal AEC operation ensure that your speaker only plays the right channel as provided via I^{2}S!

Due to the possible signal integrity issues resulting from the use of unbuffered flying leads it is recommended that this setup is used for basic evaluation only.

7.3 USB with I2S AEC Reference

The device can optionally receive the far-end/AEC signal via I^{2}S (slave) instead of from a USB host. This mode can be used to evaluate the *xCORE VocalFusion* in an environment where the AEC reference/far-end must be tapped off from an I^{2}S signal to an existing I^{2}S amplifier in a system. The builds used in this configuration are one of the following:

- 1i2o0_lin33_i2s_48khz_ref/1i2o0_cir43_i2s_48khz_ref: 2 channel input, 1 channel output

7.3.1 Hardware Setup

The hardware setup is the same as the Full I2S Configuration except that the USB connection to the *xCORE VocalFusion* Board must be provided by a suitable host which can enumerate it as a USB Audio Class 1 device.

7.3.2 Evaluation Procedure

The evaluation procedure is the same as for Full USB Configuration but the AEC reference/far-end signal is played from an external I^{2}S source (e.g. a XMOS xCORE-200 MC Audio board)

For optimal AEC operation ensure that your speaker only plays the right channel as provided via I^{2}S!

Playback via USB is disabled in build configurations with I^{2}S sourced AEC reference/far-end

Due to the possible signal integrity issues resulting from the use of unbuffered flying leads it is recommended that this setup is used for basic evaluation only.