



# Audio with embedded Linux training

On-line seminar, 4 sessions of 4 hours

Latest update: September 21, 2023

<b>Title</b>	<b>Audio with embedded Linux training</b>
<b>Training objectives</b>	<ul style="list-style-type: none"><li>• Be able to understand the basics of audio theory: analog vs. digital, sampling theory, audio formats and audio hardware</li><li>• Be able to understand the architecture of ASoC, the Linux kernel subsystem for audio devices used in embedded systems, the role of the different drivers and the Device Tree representation</li><li>• Be able to write a Device Tree describing the topology of audio hardware on an embedded Linux system</li><li>• Be able to use complex audio routing capabilities, audio power management capabilities, and complex audio components such as auxiliary devices or amplifiers</li><li>• Be able to configure the ALSA user-space components and ALSA audio widgets</li><li>• Be able to use the available user-space APIs for playing and capturing audio, as well as the PipeWire audio server and the GStreamer multimedia pipeline library</li></ul>
<b>Duration</b>	<b>Four</b> half days - 16 hours (4 hours per half day)
<b>Pedagogics</b>	<ul style="list-style-type: none"><li>• Lectures delivered by the trainer, over video-conference. Participants can ask questions at any time.</li><li>• Practical demonstrations done by the trainer, over video-conference. Participants can ask questions at any time.</li><li>• Instant messaging for questions between sessions (replies under 24h, outside of week-ends and bank holidays).</li><li>• Electronic copies of presentations, lab instructions and data files. They are freely available at <a href="https://bootlin.com/doc/training/audio">https://bootlin.com/doc/training/audio</a>.</li></ul>
<b>Trainer</b>	One of the engineers listed on: <a href="https://bootlin.com/training/trainers/">https://bootlin.com/training/trainers/</a>
<b>Language</b>	Oral lectures: English, French. Materials: English.



<b>Audience</b>	Engineers who need a detailed level of understanding of audio concepts, audio hardware components used in typical embedded systems and how the audio stack works in Linux.
<b>Prerequisites</b>	<ul style="list-style-type: none"><li>• <b>Knowledge and practice of UNIX or GNU/Linux commands:</b> participants must be familiar with the Linux command line. Participants lacking experience on this topic should get trained by themselves, for example with our freely available on-line slides at <a href="http://bootlin.com/blog/command-line/">bootlin.com/blog/command-line/</a>.</li><li>• <b>Minimal experience in embedded Linux development:</b> participants should have a minimal understanding of the architecture of embedded Linux systems: role of the Linux kernel vs. user-space, development of Linux user-space applications in C. Following Bootlin's <i>Embedded Linux</i> course at <a href="http://bootlin.com/training/embedded-linux/">bootlin.com/training/embedded-linux/</a> allows to fulfill this pre-requisite.</li><li>• <b>Minimal English language level: B1</b>, according to the <i>Common European Framework of References for Languages</i>, for our sessions in English. See <a href="http://bootlin.com/pub/training/cefr-grid.pdf">bootlin.com/pub/training/cefr-grid.pdf</a> for self-evaluation.</li></ul>
<b>Required equipment</b>	<ul style="list-style-type: none"><li>• Computer with the operating system of your choice, with the Google Chrome or Chromium browser for videoconferencing.</li><li>• Webcam and microphone (preferably from an audio headset)</li><li>• High speed access to the Internet</li></ul>
<b>Certificate</b>	Only the participants who have attended all training sessions, and who have scored over 50% of correct answers at the final evaluation will receive a training certificate from Bootlin.
<b>Disabilities</b>	Participants with disabilities who have special needs are invited to contact us at <a href="mailto:training@bootlin.com">training@bootlin.com</a> to discuss adaptations to the training course.



## Half day 1

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### Lecture - Digital Audio Representation

- What is sound?
- Sampling theory
- Sample size, sample rate
- Audio formats: I2S, LJ, RJ, DSPA, DSPB
- AC97
- IEC 61937 (S/PDIF and HDMI)
- PDM

*Introducing the basic notions used for representing audio waveforms.*

### Lecture - Hardware

- Signals
- CPU Digital Audio Interfaces
- CODEC Digital Audio Interfaces
- Amplifiers
- Clocks and clock providers

*Presenting the hardware involved in the audio playback or capture.*

### Lecture - Linux kernel ASoC subsystem

- ASoC: the ALSA System-on-Chip subsystem in the Linux kernel
- Describing audio cards with Device Tree: *audio-graph-card*, *simple-audio-card*
- Linux kernel drivers for audio cards
- Linux kernel drivers for audio codecs
- Controls
- Linux kernel drivers for CPU audio interfaces

*Introducing the Linux kernel subsystem for audio on embedded systems.*

## Half day 2

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### Lecture - Linux kernel helpers

- *regmap*, *regcache*
- DMA handling

*Presenting the common helper APIs.*

### Lecture - More audio components

- Auxiliary devices, amplifiers, muxing
- Jack detection
- Asynchronous Sample Rate Converter

*Presenting more components of the sound cards.*



## Lecture - Routing

- Routing audio
- DAPM: Dynamic Audio Power Management

*Presenting the audio routes and power management.*

## Half day 3

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### Lecture - Userspace, hardware configuration

- ALSA plugins
- `asound.conf`
- Sound card configuration

*Configuring the userspace audio paths and effects.*

### Demo - Card configuration examples

- Reordering channels
- Splitting channels
- Resampling
- Mixing
- LADSPA

*Exercising the ALSA plugins.*

### Lecture - Userspace, controls configuration

- `amixer`
- `alsamixer`
- Userspace API
- Saving state: `alsactl`, `asound.state`

*Configuring the userspace audio paths and effects.*

### Demo - Configuring controls

- `alsamixer` demonstration
- `asound.state` examples
- Custom application

*Configuring the sound card controls.*

### Lecture - Userspace, playing and capturing audio

- Userspace ALSA API

*Playing and capturing audio samples.*



## Half day 4

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### Lecture - Troubleshooting

- Debugging
- *vizdpm*

*Presenting how to debug common issues.*

### Demo - Debugging

- Examples of common issues and their resolutions

### Lecture - Pipewire

- Pipewire introduction
- Pipewire configuration
- Pipewire tools (*pwdump*, *pw-cli*, ...)
- Pipewire session and policy management
- Pipewire modules and filtering
- *WirePlumber*

*Using Pipewire as the sound server.*

### Demo - Pipewire

- Running pipewire on the target
- Inspecting the configuration and setting properties
- Dynamic routing and patchbay
- Using modules and Filter-Chain

*Running Pipewire and exercising advanced configuration.*

### Lecture - The GStreamer multimedia framework

- *GStreamer*
- GStreamer pipelines
- GStreamer plugins

*Using Gstreamer for audio capture and playback.*

### Demo - GStreamer

- Running gstreamer on the target
- Creating multiple pipelines

*Running Gstreamer using different audio pipelines.*