Raspberry Pi SBCS Single Board Computer User Guide

September 30, 2025

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SBCS Single Board Computer

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Product Information

Specifications:

- Raspberry Pi Models Supported: Pi 0, Pi 1, Pi 2, Pi 3, Pi 4, CM1, CM3, CM4, CM5, Pico, Pico2
- Audio Output Options: HDMI, Analogue PCM/3.5 mm jack, I2S-based adapter boards, USB audio, Bluetooth
- Software Support: PulseAudio, PipeWire, ALSA

Product Usage Instructions:

HDMI Audio Output:

For HDMI audio output, simply connect your Raspberry Pi to an HDMI monitor or TV with built-in speakers.

Analogue PCM/3.5 mm Jack:

Raspberry Pi models B+, 2, 3, and 4 feature a 4-pole 3.5 mm audio jack for analogue audio output. Follow the signal assignment table for correct connections.

USB Audio & Bluetooth:

For USB audio or Bluetooth output, ensure proper drivers are installed on your Raspberry Pi. Refer to the user manual for detailed setup instructions.

Software Setup:

To enable audio playback, install necessary software packages using the command line. Reboot your Raspberry Pi after installation

for changes to take effect.

Example Commands:

```
sudo apt install pipewire pipewire-pulse pipewire-audio pulseaud
sudo apt install pipewire-alsa
pactl list modules short
pactl list sinks short
```

FAQ:

Q: Which Raspberry Pi models support analogue audio output?

A: Raspberry Pi models B+, 2, 3, and 4 feature a 4-pole 3.5 mm audio jack for analogue audio output.

Q: Can I use a USB sound card with my Raspberry Pi?

A: Yes, you can use a USB sound card with your Raspberry Pi for audio output. Ensure proper drivers are installed.

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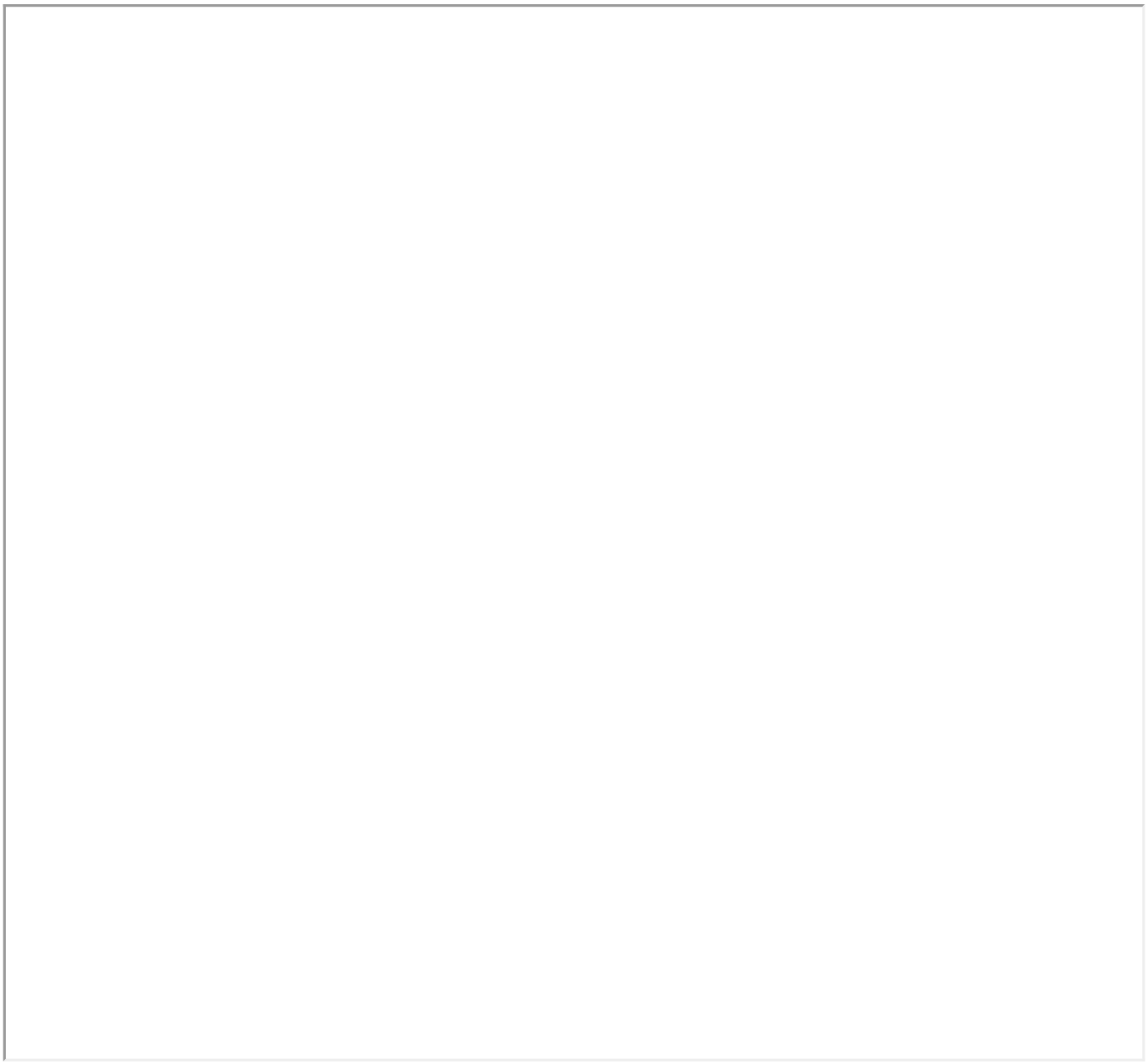
View Fullscreen



Raspberry Pi

A Whitepaper Giving a High-Level Overview of Audio Options on Raspberry Pi SBCs

Raspberry Pi Ltd

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Colophon

 Version 1.0 Build date: 28/05/2025

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A Whitepaper Giving a High-Level Overview of Audio Options on Raspberry Pi SBCs

Document version history

Release Date

Description

1.0

1 Apr 2025 Initial release

Scope of document

This document applies to the following Raspberry Pi products:

Pi 0

Pi 1

Pi 2

Pi Pi Pi Pi Pi CM1 CM3 CM4 CM5 Pico Pico2

3

4 400 5 500

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Scope of document

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A Whitepaper Giving a High-Level Overview of Audio Options on Raspberry Pi SBCs

Introduction

Over the years, the options available for audio output on Raspberry Pi SBCs (single-board computers) have become more numerous, and the way they are driven from software has changed. This document will go through many of the available options for audio output on your Raspberry Pi device and provide instructions on how to use audio options from the desktop and the command line. This whitepaper assumes that the Raspberry Pi device is running Raspberry Pi OS and is fully up to date with the latest firmware and kernels.

Raspberry Pi audio hardware

HDMI

All Raspberry Pi SBCs have an HDMI connector that supports HDMI audio. Connecting your Raspberry Pi SBC to a monitor or television with speakers will automatically enable HDMI audio output through those speakers. HDMI audio is a high-quality digital signal, so the results can be very good, and multichannel audio like DTS is supported. If you are using HDMI video but want the audio signal to split off — for example, to an amplifier that does not support HDMI input — then you will need to use an additional piece of hardware called a splitter to extract the audio signal from the HDMI signal. This can be expensive, but there are other options, and these are described below.

Analogue PCM/3.5 mm jack

Raspberry Pi models B+, 2, 3, and 4 feature a 4-pole 3.5 mm audio jack that can support audio and composite video signals. This is a low-quality analogue output generated from a PCM (pulse-code modulation) signal, but it is still suitable for headphones and desktop speakers.

NOTE There is no analogue audio output on Raspberry Pi 5.

The jack plug signals are defined in the following table, starting from the cable end and ending at the tip. Cables are available with different assignments, so make sure you have the correct one.

Jack segment Signal

Sleeve

Video

Ring 2

Ground

Ring 1

Right

Tip

Left

I2S-based adapter boards

All models of Raspberry Pi SBCs have an I2S peripheral available on the GPIO header. I2S is an electrical serial bus interface standard used to connect digital audio devices and communicate PCM audio data between peripherals in an electronic device. Raspberry Pi Ltd manufactures a range of audio boards that connect to the GPIO header and use the I2S interface to transfer audio data from the SoC (system on a chip) to the add-on board. Note: Add-on boards that connect via the GPIO header and adhere to the appropriate specifications are known as HATs (Hardware Attached on Top). Their specifications can be found here: https://datasheets.raspberrypi.com/ The full range of audio HATs can be seen on the Raspberry Pi Ltd website: https://www.raspberrypi.com/products/ There are also a large number of third-party HATs available for audio output, for example from Pimoroni, HiFiBerry, Adafruit, etc., and these provide a multitude of different features.

USB audio

If it is not possible to install a HAT, or you are looking for a quick and easy way to attach a jack plug for a headphone output or a microphone input, then a USB audio adapter is a good choice. These are simple, cheap devices that plug into one of the USB-A ports on the Raspberry Pi SBC. Raspberry Pi OS includes drivers for USB audio by default; as soon as a device is plugged in, it should show up on the device menu that appears when the speaker icon on the taskbar is right-clicked. The system will also automatically detect if the attached USB device has a microphone input and enable the appropriate support.

USB audio

Bluetooth

Bluetooth audio refers to the wireless transmission of sound data via Bluetooth technology, which is very widely used. It enables the Raspberry Pi SBC to talk to Bluetooth speakers and headphones/earbuds, or any other audio device with Bluetooth support. The range is fairly short — about 10 m maximum. Bluetooth devices need to be `paired' with the Raspberry Pi SBC and will appear in the audio settings on the desktop once this is done. Bluetooth is installed by default on Raspberry Pi OS, with the Bluetooth logo appearing on the desktop taskbar on any devices that have Bluetooth hardware installed (either built in or via a Bluetooth USB dongle). When Bluetooth is enabled, the icon will be blue; when it is disabled, the icon will be grey.

Bluetooth

Software support

The underlying audio support software has changed considerably in the full Raspberry Pi OS image, and, for the end user, these changes are mostly transparent. The original sound subsystem used was ALSA. PulseAudio succeeded ALSA, before being replaced

by the current system, which is called PipeWire. This system has the same functionality as PulseAudio, and a compatible API, but it also has extensions to handle video and other features, making the integration of video and audio much easier. Because PipeWire uses the same API as PulseAudio, PulseAudio utilities work fine on a PipeWire system. These utilities are used in the examples below. To keep the image size down, Raspberry Pi OS Lite still uses ALSA to provide audio support and does not include any PipeWire, PulseAudio, or Bluetooth audio libraries. However, it is possible to install the appropriate libraries to add those features as required, and this process is also described below.

Desktop

As mentioned above, audio operations are handled via the speaker icon on the desktop taskbar. Left-clicking on the icon brings up the volume slider and mute button, whilst right-clicking brings up a list of available audio devices. Simply click on the audio device that you want to use. There is also an option, via right-click, to change the profiles used by each device. These profiles usually provide different quality levels. If microphone support is enabled, a microphone icon will appear on the menu; right-clicking on this will bring up microphonespecific menu options, such as input device selection, whilst left-clicking brings up input level settings. Bluetooth To pair a Bluetooth device, left-click on the Bluetooth icon on the taskbar, then select `Add Device'. The system will then start looking for available devices, which will need to be put into `Discover' mode to be seen. Click on the device when it appears in the list and the devices should then pair. Once paired, the audio device will appear in the menu, which is selected by clicking the speaker icon on the taskbar.

Command line

Because PipeWire uses the same API as PulseAudio, the majority of the PulseAudio commands used to control audio work on PipeWire. pactl is the standard way of controlling PulseAudio: type man pactl into the command line for more details. Prerequisites for Raspberry Pi OS Lite On a full installation of Raspberry Pi OS, all the required command line applications and libraries are already installed. On the Lite version, however, PipeWire is not installed by default and must be manually installed to be able to play back sound. To install the required libraries for PipeWire on Raspberry Pi OS Lite, please input the following:

```
sudo apt install pipewire pipewire-pulse pipewire-audio pulseaudio-utils
```

If you intend on running applications that use ALSA, you will also need to install the

following:
sudo apt install pipewire-alsa
Rebooting after installation is the easiest way to get everything up and running. Audio playback examples Display a list of installed PulseAudio modules in short form (the long form contains a lot of information and is difficult to read):
$ pactl list modules short
Display a list of PulseAudio sinks in short form:

Command line

$ pactl list sinks short
On a Raspberry Pi 5 connected to an HDMI monitor with built-in audio and an additional USB sound card, this command gives the following output:
$ pactl list sinks short 179 alsa_output.platform-107c701400.hdmi.hdmi-stereo PipeWire s32le 2ch 48000Hz SUSPENDED 265 alsa_output.usb-C-Media_Electronics_Inc._USB_PnP_Sound_Device-00.analog-stereo-output PipeWire s16le 2ch 48000Hz SUSPENDED
NOTE Raspberry Pi 5 does not have analogue out. For a Raspberry Pi OS Lite install on a Raspberry Pi 4 — which has HDMI and analogue out — the following is returned:
$ pactl list sinks short 69 alsa_output.platform-bcm2835_audio.stereo-fallback PipeWire s16le 2ch 48000Hz SUSPENDED 70 alsa_output.platform-107c701400.hdmi.hdmi-stereo PipeWire s32le 2ch 48000Hz SUSPENDED
To display and change the default sink to HDMI audio (noting that it may already be the default) on this installation of Raspberry Pi OS Lite, type in:
$ pactl get-default-sink alsa_output.platform-bcm2835_audio.stereo-fallback $ pactl set-default-sink 70 $ pactl get-default-sink alsa_output.platform-107c701400.hdmi.hdmi-stereo
To play back a sample, it first needs to be uploaded to the sample cache, in this case on the default sink. You can change the sink by adding its name to the end of the pactl play-sample command:
$ pactl upload-sample sample.mp3 samplename $ pactl play-sample samplename

There is a PulseAudio command that is even easier to use to play back audio:
$ paplay sample.mp3
pactl has an option to set the volume for the playback. Because the desktop uses PulseAudio utilities to get and set audio information, the execution of these command line changes will also be reflected in the volume slider on the desktop. This example reduces the volume by 10%:
$ pactl set-sink-volume @DEFAULT_SINK@ -10%
This example sets the volume to 50%:
$ pactl set-sink-volume @DEFAULT_SINK@ 50%
There are many, many PulseAudio commands that are not mentioned here. The PulseAudio website (https://www. freedesktop.org/wiki/Software/PulseAudio/) and the man pages for each command offer extensive information about the system.

Command line

Bluetooth Controlling Bluetooth from the command line can be a complicated process. When using Raspberry Pi OS Lite, the appropriate commands are already installed. The most useful command is bluetoothctl, and some examples of it in use are provided below. Make the device discoverable to other devices:
$ bluetoothctl discoverable on
Make the device pairable with other devices:
$ bluetoothctl pairable on
Scan for Bluetooth devices in range:
$ bluetoothctl scan on
Turn off scanning:
$ bluetoothctl scan off
bluetoothctl also has an interactive mode, which is invoked by using the command with no parameters. The following example runs the interactive mode, where the list command is entered and the results shown, on a Raspberry Pi 4 running Raspberry Pi OS Lite Bookworm:
$ bluetoothctl Agent registered [bluetooth]# list Controller D8:3A:DD:3B:00:00 Pi4Lite

[default] [bluetooth]#
You can now type commands into the interpreter and they will be executed. A typical process for pairing with, and then connecting to, a device may read as follows:
$ bluetoothctl Agent registered [bluetooth]# discoverable on Changing discoverable on succeeded [CHG] Controller D8:3A:DD:3B:00:00 Discoverable on [bluetooth]# pairable on Changing pairable on succeeded [CHG] Controller D8:3A:DD:3B:00:00 Pairable on [bluetooth]# scan on
< could be a long list of devices in the vicinity >
[bluetooth]# pair [mac address of device, from the scan command or from the device itself, in the form xx:xx:xx:xx:xx:xx] [bluetooth]# scan off [bluetooth]# connect [same mac address] The Bluetooth device should now appear in the list of sinks, as shown in this example from a Raspberry Pi OS Lite installation:
$ pactl list sinks short 69 alsa_output.platform-bcm2835_audio.stereo-fallback PipeWire s16le 2ch 48000Hz SUSPENDED 70 alsa_output.platform-107c701400.hdmi.hdmi-stereo PipeWire s32le 2ch 48000Hz SUSPENDED 71 bluez_output.CA_3A_B2_CA_7C_55.1 PipeWire s32le 2ch 48000Hz SUSPENDED

Command line

$ pactl set-default-sink 71 $ paplay <example_audio_file>
You can now make this the default and play back audio on it.

Command line

Conclusions
There are a number of different ways to produce an audio output from Raspberry Pi Ltd devices, catering to the vast majority of user requirements. This whitepaper has outlined those mechanisms and provided information about many of them. It is hoped that the advice presented here will help the end user choose the right audio output scheme for

their project. Simple examples of how to use the audio systems have been provided, but the reader should consult the manuals and man pages for the audio and Bluetooth commands for more detail.

Conclusions

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Documents / Resources

	Raspberry Pi SBCS Single Board Computer [pdf] User Guide SBCS Single Board Computer, SBCS, Single Board Computer, Board Computer, Computer

References

- User Manual

Raspberry Pi Board Computer, Computer, Raspberry Pi, SBCs, SBCS Single Board Computer, Single Board Computer

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