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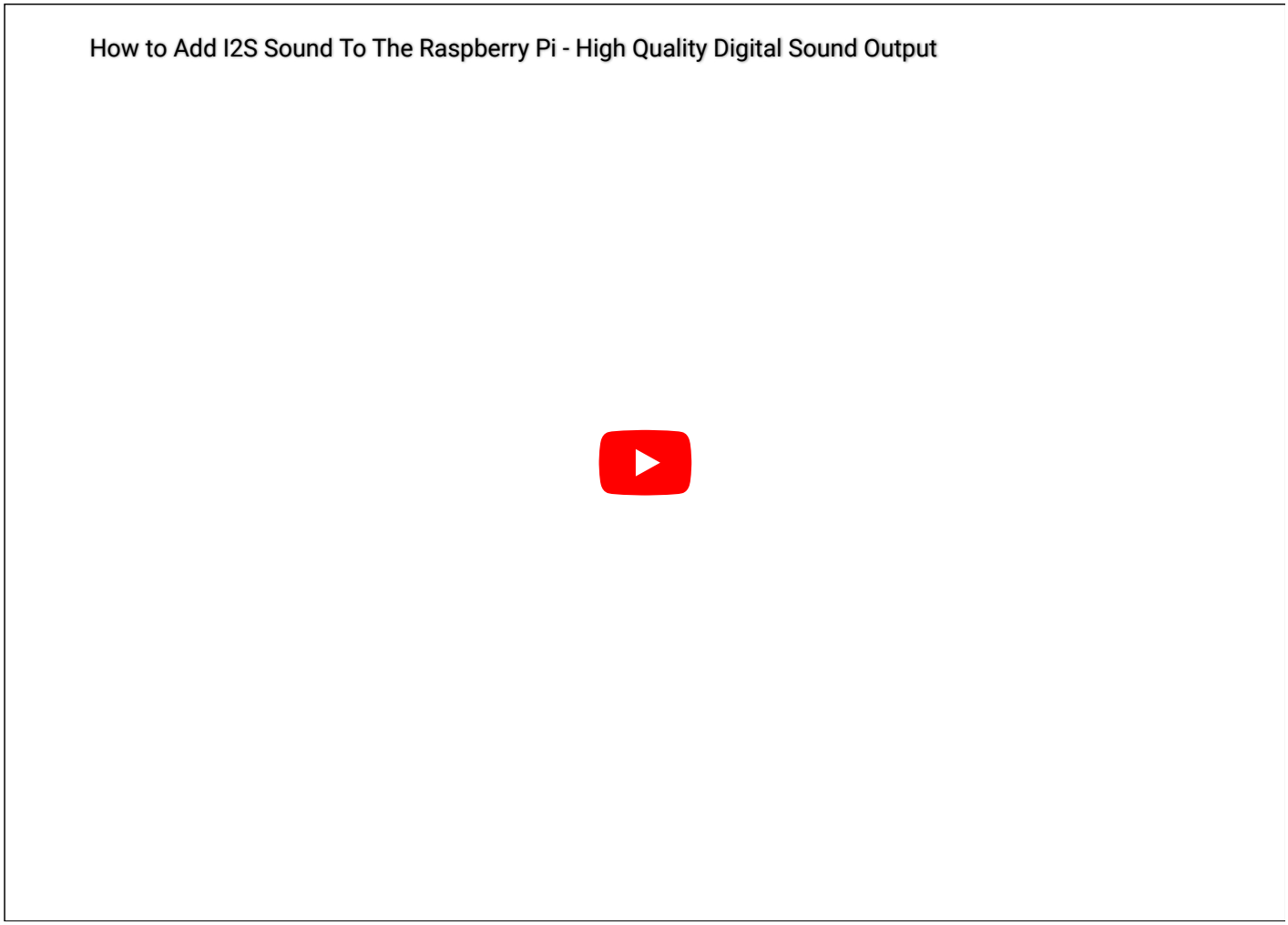
Tags Categories

Raspberry Pi I2S Sound – Add Digital Sound Output to Your Raspberry Pi

(This page is part of the Raspberry Pi Handheld Games Console series. Please click here for the full project.)



There are several ways of getting sound out of your Raspberry Pi and Raspberry Pi Zero. In a previous episode I showed you how to get analogue audio out of the Raspberry Pi Zero using the alternative functions on some of the GPIO pins. In this tutorial I'll show you how to use the I2S digital audio signal to add sound to our handheld games console.

s an I2S Signal?

I2S stands for Inter IC Sound. It was designed as a way of sending sound information between parts of the circuit board as a digital data stream avoiding all the noise issues associated with analogue signals. To send the sound signal you need a minimum of three signal wires. One wire acts as a bit clock to synchronise the individual bits of data, one acts as a left/right clock to specify whether the data being sent is for the left or right channels, and a data wire for the digital data.

	GPIO	Pull	ALT Func0	ALT Func1	ALT Func2	ALT Func3	ALT Func4	ALT Func5	Mapping Used
Bank 0	GPIO0	High	SDA0	SA5	PCLK	AVEOUT_VCLK	AVEIN_VCLK		
	GPIO1	High	SCL0	SA4	DE	AVEOUT_DSYNC	AVEIN_DSYNC		
	GPIO2	High	SDA1	SA3	LCD_VSYNC	AVEOUT_VSYNC	AVEIN_VSYNC		
	GPIO3	High	SCL1	SA2	LCD_HSYNC	AVEOUT_HSYNC	AVEIN_HSYNC		
	GPIO4	High	GPCLK0	SA1	DPI_D0	AVEOUT_VID0	AVEIN_VID0	ARM_TDI	
	GPIO5	High	GPCLK1	SA0	DPI_D1	AVEOUT_VID1	AVEIN_VID1	ARM_TDO	
	GPIO6	High	GPCLK2	SOE_N / SE	DPI_D2	AVEOUT_VID2	AVEIN_VID2	ARM_RTCK	
	GPIO7	High	SPI0_CE1_N	SWE_N / SRW_N	DPI_D3	AVEOUT_VID3	AVEIN_VID3		
	GPIO8	High	SPI0_CE0_N	SD0	DPI_D4	AVEOUT_VID4	AVEIN_VID4		
	GPIO9	Low	SPI0_MISO	SD1	DPI_D5	AVEOUT_VID5	AVEIN_VID5		
	GPIO10	Low	SPI0_MOSI	SD2	DPI_D6	AVEOUT_VID6	AVEIN_VID6		
	GPIO11	Low	SPI0_SCLK	SD3	DPI_D7	AVEOUT_VID7	AVEIN_VID7		
	GPIO12	Low	PWM0	SD4	DPI_D8	AVEOUT_VID8	AVEIN_VID8	ARM_TMS	
	GPIO13	Low	PWM1	SD5	DPI_D9	AVEOUT_VID9	AVEIN_VID9	ARM_TCK	
	GPIO14	Low	TXD0	SD6	DPI_D10	AVEOUT_VID10	AVEIN_VID10	TXD1	
	GPIO15	Low	RXD0	SD7	DPI_D11	AVEOUT_VID11	AVEIN_VID11	RXD1	
	GPIO16	Low	FL0	SD8	DPI_D12	CTS0	SPI1_CE2_N	CTS1	
	GPIO17	Low	FL1	SD9	DPI_D13	RTS0	SPI1_CE1_N	RTS1	
	GPIO18	Low	PCM_CLK	SD10	DPI_D14	I2CSL SDA / MOSI	SPI1_CE0_N	PWM0	
	GPIO19	Low	PCM_FS	SD11	DPI_D15	I2CSL SCL / SCLK	SPI1_MISO	PWM1	
	GPIO20	Low	PCM_DIN	SD12	DPI_D16	I2CSL / MISO	SPI1_MOSI	GPCLK0	
	GPIO21	Low	PCM_DOUT	SD13	DPI_D17	I2CSL / CE_N	SPI1_SCLK	GPCLK1	
	GPIO22	Low	SD0_CLK	SD14	DPI_D18	SD1_CLK	ARM_TRST		
	GPIO23	Low	SD0_CMD	SD15	DPI_D19	SD1_CMD	ARM_RTCK		
	GPIO24	Low	SD0_DAT0	SD16	DPI_D20	SD1_DAT0	ARM_TDO		
	GPIO25	Low	SD0_DAT1	SD17	DPI_D21	SD1_DAT1	ARM_TCK		
	GPIO26	Low	SD0_DAT2	TE0	DPI_D22	SD1_DAT2	ARM_TDI		
	GPIO27	Low	SD0_DAT3	TE1	DPI_D23	SD1_DAT3	ARM_TMS		

On all Raspberry Pi's the GPIO header provides these data signals as ALT0 functions on its GPIO pins

GPIO18 = Bit Clock
GPIO19 = Left Right Clock
GPIO20 = Data In
GPIO21 = Data Out

For our setup we don't need the Data In connection as the Raspberry Pi will only be sending sound data, not receiving it.

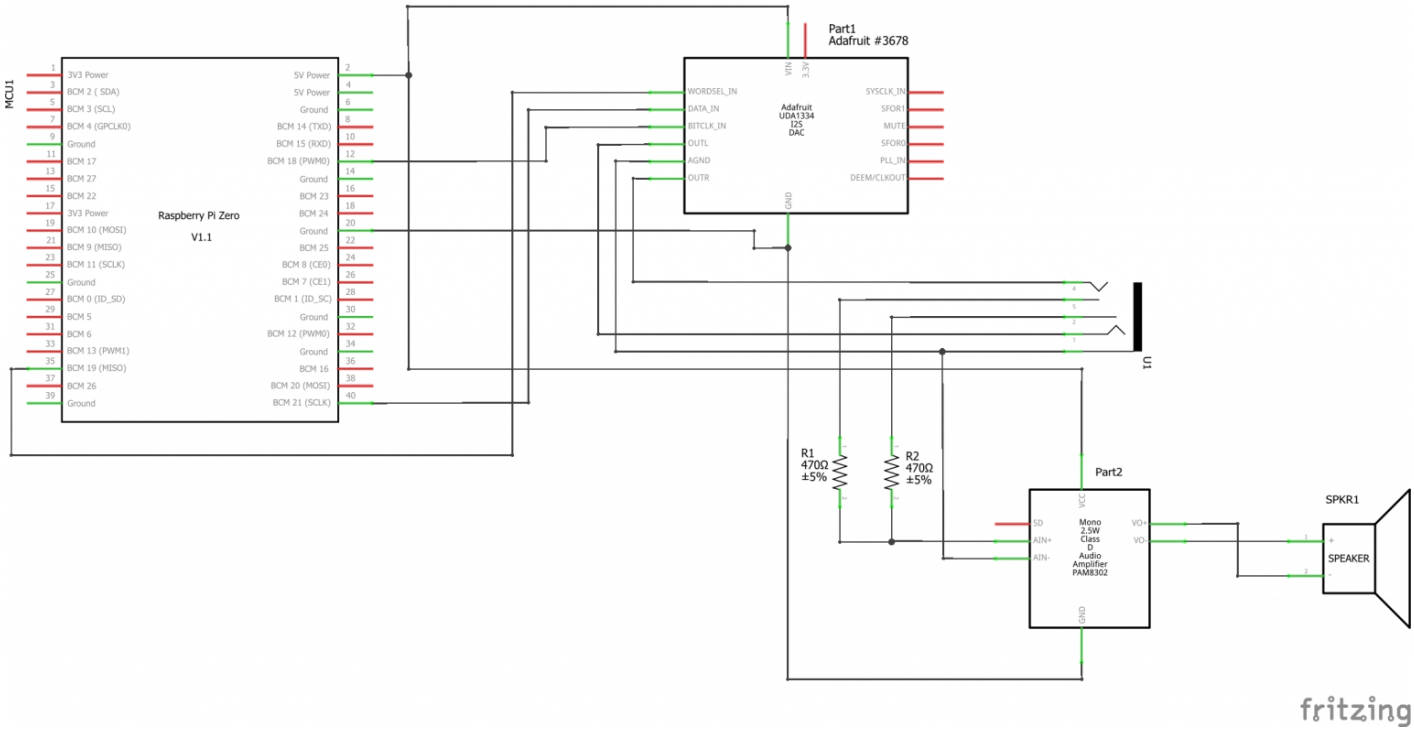
Hardware Needed for I2S Sound

The signals coming out for GPIO pins are the digital data and clock signals. We need some external hardware to convert these to sound.

The first part of our circuit needs to be an I2S Digital to Analogue Converter (DAC) which can decode the I2S signal and convert it to an analogue, stereo sound signal. As we want to be able to have both a headphone output and a loudspeaker, we'll need this first conversion stage to provide a signal suitable for our headphones rather than a fully amplified signal designed for a loudspeaker.

Once we have this line level output we can then feed it to a headphone jack socket and then into an audio amplifier before finally sending it to our speaker.

The circuit I've used for testing the system is shown below.

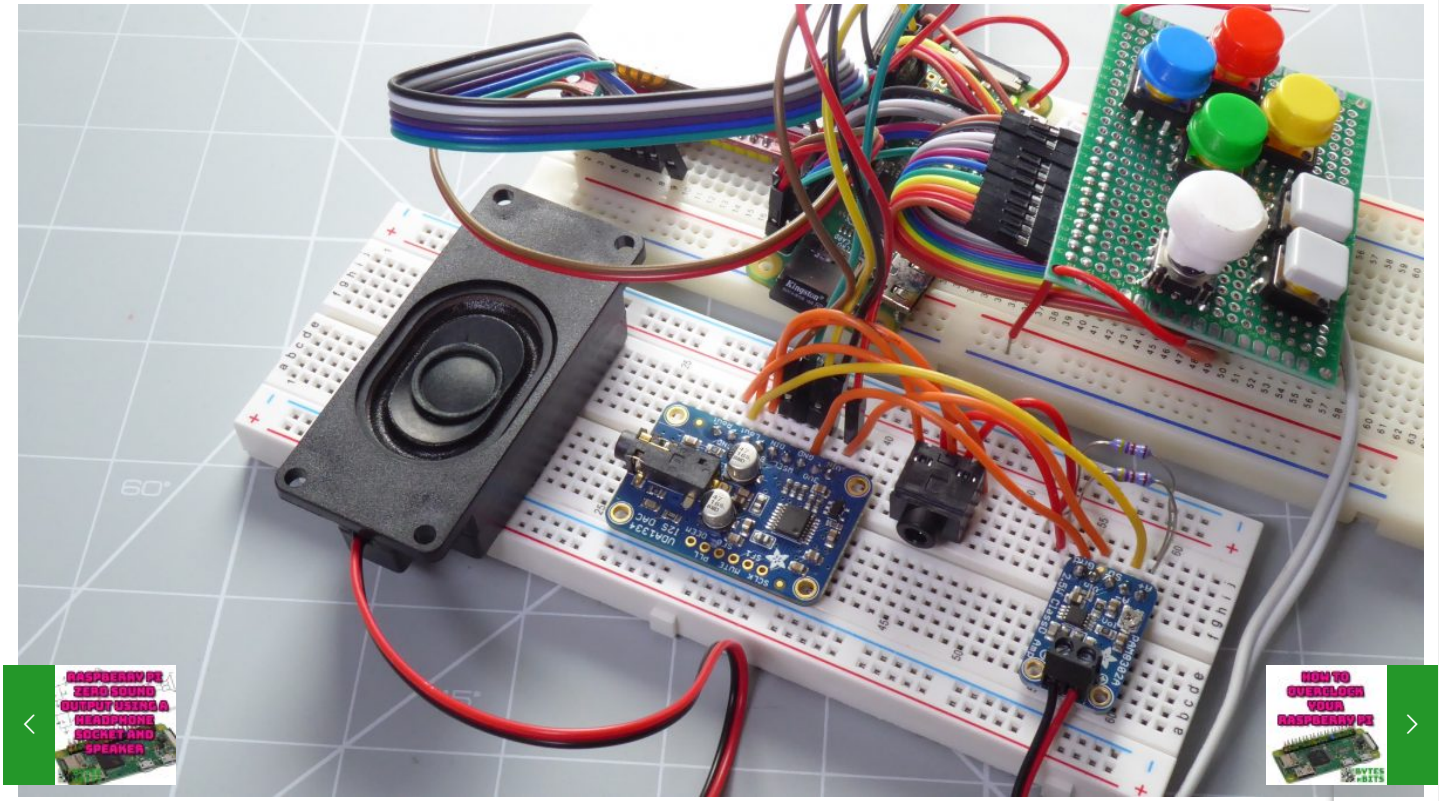


I've used two ready-made modules from AdaFruit for the DAC and amplifier. The output from the DAC is fed into the headphone socket as it can drive headphones directly. Although the module has its own headphone socket this does not provide a switched output to the amplifier. I'm using a separate headphone socket with a switched output. This output is then fed through 2 resistors to combine the stereo signal into a single mono channel. This is then fed into the mono amplifier which can then power the speakers.

This arrangement on the headphone socket means that when we plug in a set of headphones the amplifier signal is disconnected so the speaker falls silent.

Building the Circuit

For the testing phase I'm building the circuit on breadboard. Once I've got everything working, I'll then design a custom PCB to put everything onto one board.



Software Setup

By default, the Raspberry Pi does not output the I2S signal. We'll need to configure the board to generate I2S and send this out via the GPIO pins.

The following setup is taken from the Adafruit tutorial for the UDA1334A board at

https://learn.adafruit.com/adafruit-i2s-stereo-decoder-uda1334a/raspberry-pi-usage

I had a couple of problems using this setup procedure so please have a read through these tips to get things working as quickly as possible.

The main issue I found was that the fast installation script provided on the above page caused a permissions issue with some of the software. Once installed the Alsa sound module needed to be run with raised permissions. You had to use sudo for the commands to give it access to some of the files required to work. When RetroPie tried to access the sound system it was then unable to run under raised permissions so the sound failed.

The only way around this was to completely rebuild the RetroPie installation and install the sound script first before adding the LCD or GPIO controller software. Even then it was a bit twitchy.

My recommendation is to use the manual installation and to do it on top of a fresh RetroPie setup if possible. Adding the LCD and GPIO controller software first works fine but switching over from an analogue sound setup to I2S again seemed to be an issue – at least during my tests!

Manual Software Setup

Remove Any Blockages to I2S Sound

We first need to make sure that the analogue sound hardware and drivers are disabled.

The first file we need to check is, **/etc/modprobe.d/raspi-blacklist.conf**, which can contain a list of software modules that the system will ignore.

```
sudo nano /etc/modprobe.d/raspi-blacklist.conf
```

If the file is empty just use ctrl+X to exit. If you see any of the following lines just comment them out by putting a # in front of the line.

```
blacklist i2c-bcm2708
blacklist snd-soc-pcm512x
blacklist snd-soc-wm8804
```

Then use ctrl+X , Y to save the file.

We then need to disable the headphone analogue sound output software module.

```
sudo nano /etc/modules
```

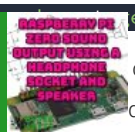
The file will have a coupe of modules listed (if you're using RetroPie). The sound module is **snd_bcm2835**. If you see this listed just comment it out by putting a # at the start of the line.

Again ctrl+X, Y to save and exit.

Configure the I2S Sound Software

Our system will use the Alsa-project software to drive the I2S signal and sound system. This is usually installed by default but we can use the command below to make sure it's up to date.

```
et install alsa-utils
```



create a configuration file for the Alsa sound system. This will define a number of audio devices and how they sh

d system can then use them to generate and output the sound signals.


```
sudo nano /etc/asound.conf
```

Paste the following code into this file.

```
pcm.speakerbonnet {
   type hw card 0
}

pcm.dmixer {
   type dmix
   ipc_key 1024
   ipc_perm 0666
   slave {
     pcm "speakerbonnet"
     period_time 0
     period_size 1024
     buffer_size 8192
     rate 44100
     channels 2
   }
}

ctl.dmixer {
    type hw card 0
}

pcm.softvol {
    type softvol
    slave.pcm "dmixer"
    control.name "PCM"
    control.card 0
}

ctl.softvol {
    type hw card 0
}

pcm.!default {
    type             plug
    slave.pcm       "softvol"
}
```

This basically sets up a PCM audio device along with a mixer device to allow us to adjust the volume in software.

The final step is to edit the config.txt file to load the device tree overlays at start up.

```
sudo nano /boot/config.txt
```

First look for the line

```
dtparam=audio=on
```

This turns on the standard headphone outputs so we need to disable it by commenting out this line – just put a # at the start of the line.

Then at the bottom of the file we need to add the I2S overlays.

```
dtoverlay=hifiberry-dac
dtoverlay=i2s-mmap
```

Ctrl+X, Y to save and exit and then we need to reboot the Raspberry Pi to get all the changes loaded.

Testing the I2S sound Output

With the hardware connected and the software installed it's time to test!

The speaker-test script lets you quickly test the setup.

```
speaker-test -c2
```

is the simplest test where white noise (a hissing sound) is played though the left and right channels one after the other. If you can hear this on

s and speaker it means it's all working.

playing a simple WAV file.

```
speaker-test -c2 --test=wav -w /usr/share/sounds/alsa/Front_Center.wav
```

This should give you a lady saving, “Front, Centre” repeatedly.

If that’s all working, we’re almost ready to go.

Adjusting the Volume

In the circuit diagram shown above I didn’t add a volume control – I’ll probably add that in when designing the final circuit. Volume adjustments will have to be made in the software setup. The Alsa sound package has a mixer script.

```
alsamixer
```

This should bring up a screen with a volume bar. You can use the up and down arrows to control the sound level. Once you’ve got that at the right level, you’ll need to save the setting by running this command.

```
sudo alsactl store
```

Sound Output in RetroPie

If everything is working OK it’s time to set up RetroPie. Reboot the system and go into the RetroPie settings (press the start button). Go to Audio Settings.

For AUDIO CARD we need to select DEFAULT.

For AUDIO DEVICE select PCM.

For OMX PLAYER AUDIO DEVICE select BOTH.

Set your volume to your own preference.

Once you’ve set these values you should be good to go.

Boot up a game and enjoy the full sound experience!

Next Step

In this Raspberry Pi Zero, handheld, retro games console project we’ve now got the emulator running on the Raspberry Pi, a full speed screen running on a cheap SPI LCD screen, our own GPIO connected game controller and finally a digital sound output through headphones and speaker.

This current setup gives a fully playable system, but it needs a USB power supply.

The next step is to add the option for both USB power, and battery power, with the built-in batteries being recharged by the same USB connection.

Bob

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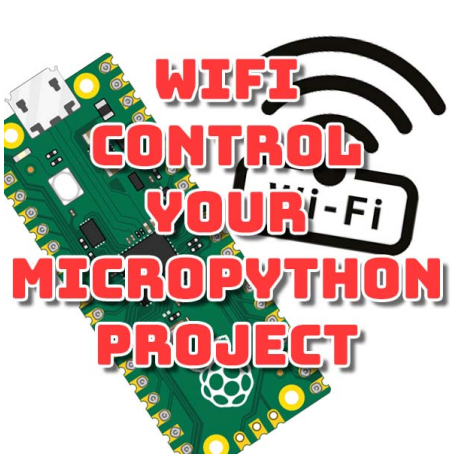

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