Use Nuvoton Audio PA to amplify a ChipCorder device's PWM output

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1. Introduction

In many applications it is often desired to use an audio power amplifier to amplify the PWM output from an ISD ChipCOrder device, to further boost the final sound output volume. In this app note a simple filter circuit is given. It first converts the PWM output from a Nuvonton ISD Chipcorder device into analog signal, and then feeds the signal to the input of a Nuvoton audio power amplifier device, single-ended or differential. Also, the component choosing, cut-off frequency and attenuation calculation are explained in this document.

2. Description

2.1 Need for an interface

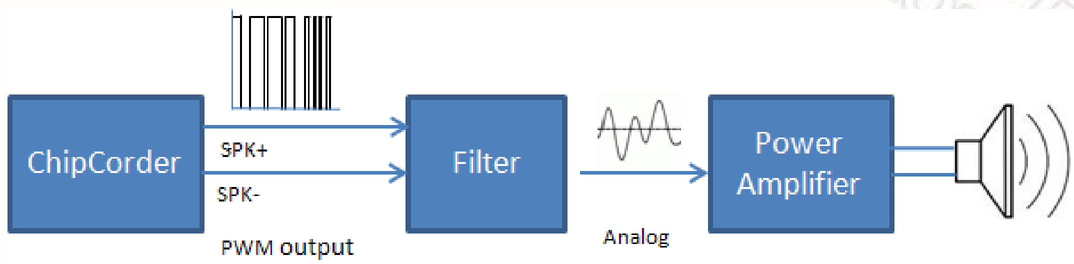


Figure_1 A filter is needed between PWM output and an audio PA

The PWM output signal from a ChipCorder device swings between ground and VCCSPK. It cannot be directly amplified otherwise overshooting and distortion can happen. To amplify a PWM signal, a low pass filter circuit is needed. The low pass filter converts the PWM signal into analog signal which then can be amplified by an audio power amplifier.

2.2 Nuvoton Parts Selection Table

ChipCorder Part Name	Output type	Output Power
ISD15100/3900/15C00	PWM, AUX, AUD,	MAX: 360MW
ISD3800/15D00	PWM, AUX,	MAX: 1W@5V
ISD2100	PWM only	MAX: 360mW
ISD2360	PWM only	MAX: 1W @5V.

` Table-1: Nuvoton Digital ChipCorder quick look-up table.

Nuvoton PA	Input type	Output type	Output Power
ISD8101	Single ended or differential	BTL	8Ω Load, 1.5W @6.8V
ISD8102	Single ended	BTL	4Ω Load, 2W @5V
			8Ω Load, 1.4W @5V
ISD8104	Single ended or differential	BTL	4Ω Load, 2W @5V
			8Ω Load, 1.4W @5V
NAU82039	Single ended or differential *with fix gain of 12dB	Class D PWM	4Ω Load, 3.2W @6.8V
			8Ω Load, 1.8W @6.8V
NAU82011	Single ended or differential	Class D PWM	4Ω Load, 2.9W @5V
			8Ω Load, 1.7W @5V

Table-2: Nuvoton audio power amplifier quick look-up table.

2.3 Low Pass Filter circuit

- *Filter Schematic*

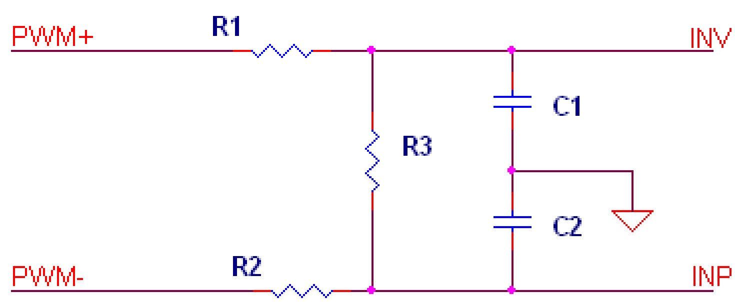


Figure-2 Low Pass Filter schematic

- *Analysis*

The low pass filter shown in figure-2 can be simplified to the equivalent circuit shown below.

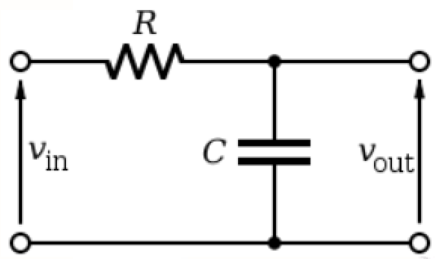


Figure-3 Simplified RC filter circuit

R3 is added for the attenuation purpose which helps to make sure the filter output signal swing in the desired range. Depends on the PWM output signal strength and the input requirement imposed by the following power amplifier, R3 may or may not be needed.

- When R3 is presented:
  R = (R1 + R2) in parallel with R3. So R = (R1+R2)*R3/(R1+R2+R3).
  C = C1 = C2.
  The cutoff frequency F= 1/(2*3.14*R*C).
  Attenuation can be calculated by Ratio = R/(R+R2). For example: if ratio = 0.5, then the attenuation is -6dB; if ratio = 0.25, then it is corresponding to -12dB attenuation.

- When R3 is not presented (open).
  R = R1 = R2.
  C= C1 = C2
  The cutoff frequency F= 1/(2*3.14*R*C).
  There is no attenuation.

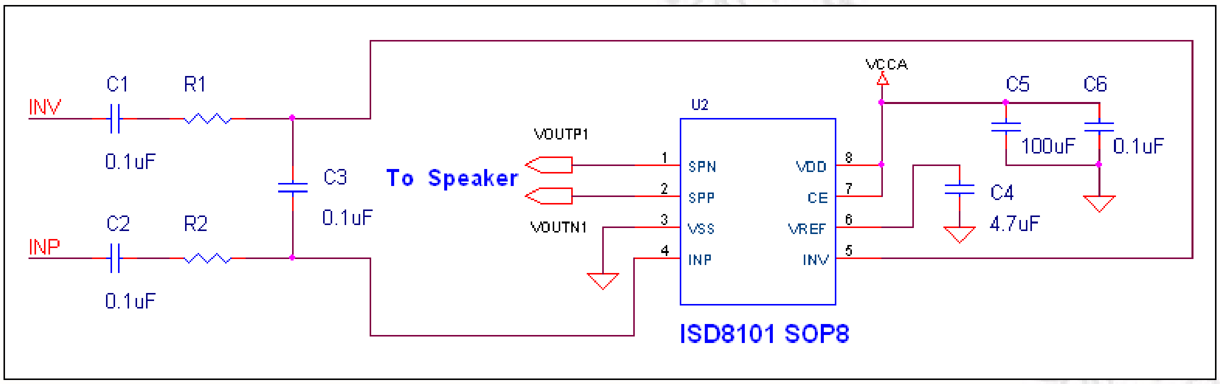
Sample values for filter circuit:

- Example 1: if R1 = R2 = 1KΩ, R3 = 2KΩ, C1 = C2 = 4.7nF; then R = 1KΩ. Attenuation is -6dB. Cutoff frequency = 1/(2*3.14*1 KΩ*4.7nF) ~= 34KHz.

- Example 2: if R1 = R2 = 1K, R3 = 667Ω, C1 = C2 = 10nF; then R = 1K. Attenuation is -12dB. Cutoff frequency = 1/(2*3.14*0.5 KΩ*10nF) ~= 32KHz.

2.4 Interface with Nuvoton audio power amplifiers

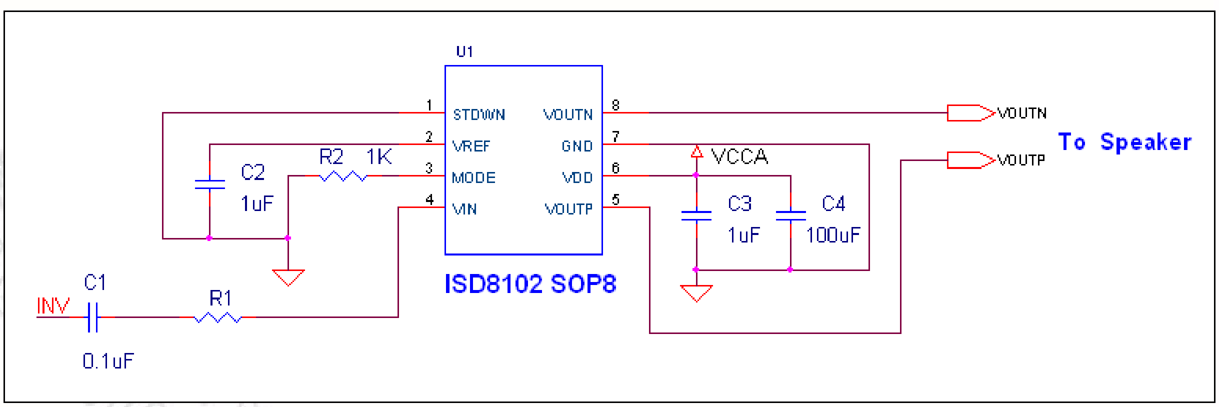
- *To ISD8101 differential input*



Gain[1] = 55 KΩ/(5.5 KΩ + R1)

Example 1: R1 = 0 Ω; gain = 10, i.e. 20dB.
Example 2: R1 = 22 KΩ; gain ~= 2, i.e. 6dB.

- *To ISD8102 single ended input*



[1] R1 and R2 are optional. Refer to ISD8101 Datasheet.

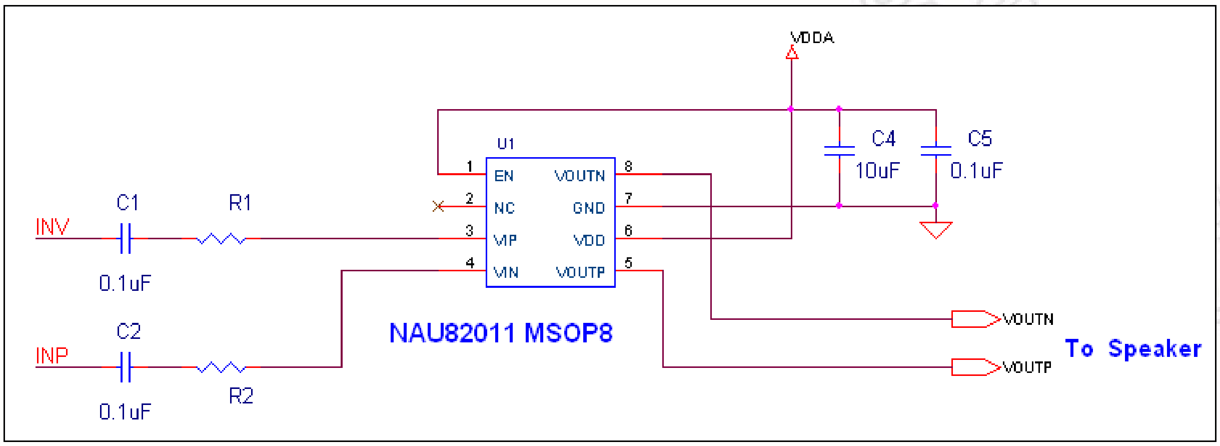
Note: For this single ended input connection, please leave the INP output from filter NC.

Gain[2] = 2* 20 KΩ/(2 KΩ + R1).

Example 1: R1 = 0Ω; gain = 20, i.e. 26dB.

Example 2: R1 = 18 KΩ; gain = 2, i.e. 6dB.

- *To NAU82011 differential input*



Gain[3] = 300 KΩ/ R1.

[2] R1 is optional. Refer to ISD8102/8104 Datasheet.

[3] R1 is required. Refer to NAU82011WG Datasheet.

3. Revision History

VERSION	DATE	REMARK
Ver_0.1	March 11, 2013	Initial draft