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AN218589

External Circuit for PCMPWM Sound System with Traveo™ MCUs

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Associated Part Family: 32-bit Microcontroller Traveo™ Family

Related Documents: For a complete list, click here.

AN218589 explains how to design an external circuit for the PCMPWM sound system with Traveo™ family microcontrollers.

Contents

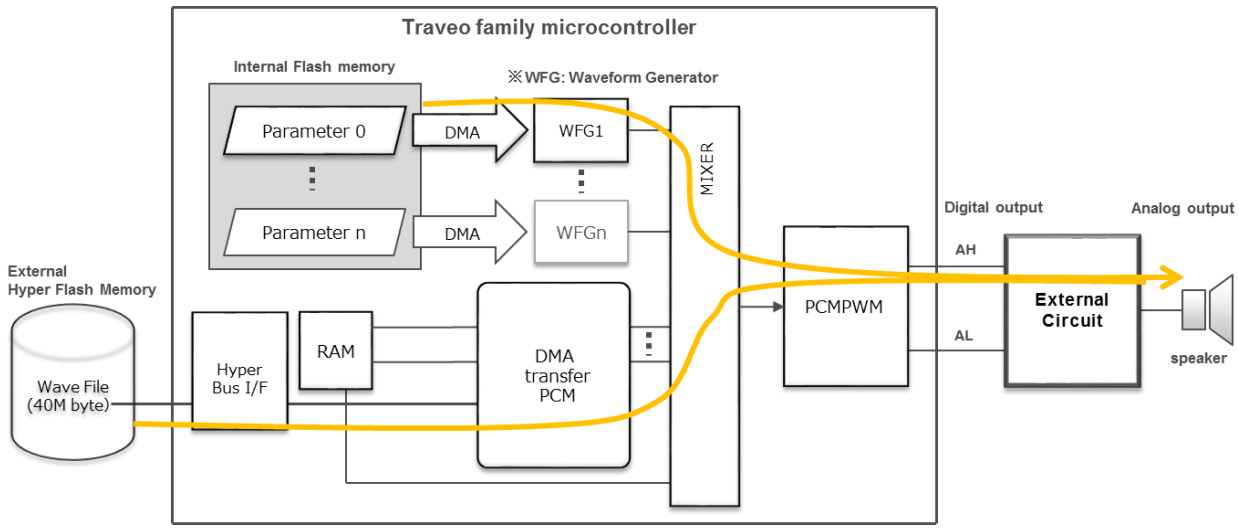
1 Introduction

An external circuit is required to implement the Pulse-Code Modulated data samples into Pulse-Width Modulated signals (PCMPWM) sound system in the Traveo™ family of microcontrollers. This application note details how to realize the PCMPWM sound system characteristics of high-quality sound, small mount area, low cost, and low current in your design of the external circuit.

2 Sound System

This section contains an overview of the Traveo family sound system with PCMPWM (Figure 1). The external circuit is necessary to convert a digital output into an analog output.

Figure 1. Traveo Family Sound System Diagram



3 PCMPWM

3.1 Overview

The PCMPWM module converts pulse-code modulated (PCM) data samples into pulse-width modulated (PWM) signals. This module provides simple audio output capabilities.

3.2 Features

- Two separate channels for stereo audio output
- Optional mono audio output mode
- Output resolution of 12 bits at a sampling frequency of 48.8 kHz (using a 200-MHz PWM clock)
- Two modes of operation for different speaker interfaces:
  - ☐ Low-pass filter output mode
  - ☐ Simplified H-bridge output mode
- Support for DMA transfer of PCM data samples using the DMA block transfer mode
- FIFO input buffer for PCM samples, with a depth of 24 bits
- Programmable clock divider for PWM cycle time
- Optional output of silence signals in debug mode and normal mode

3.3 Operation Modes

The PCMPWM module supports three general modes of operation as follows. Each mode is dedicated to a specific type of connection to the speaker. The operation mode is configured in the MODE bits of the CONTROL register (PCMPWMi_CONTROL:MODE). See the Register TRM for more information.

- **Low-pass filter mode:** In this mode, only a single output is used. The output drives an audio amplifier with a low-pass filter connected in between.
- **Simplified H-bridge mode:** In this mode, two outputs (differential) are used to drive a speaker. A pair of complementary emitter followers is connected to each output. In this mode, the signal at the PCMPWM_AL output is the inverted PCMPWM_AH signal.

The PCMPWM signal is AH0 or AL0 with a differential connection and AH0 with a single-end connection. The official signal name follows the specifications of each microcontroller

Refer to the specifications of each microcontroller for a register and the setting to use.

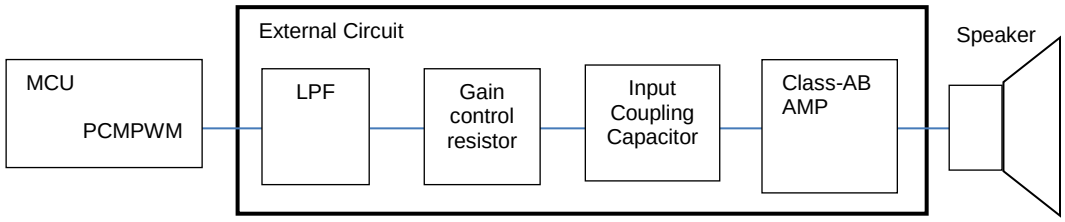
4 External Circuit

The external circuit is high-quality, low-current, and low-cost, and occupies a small mount area.

The general blocks of the PCMPWM external circuit that this application note recommends are shown in Figure 2. The main components are as follows:

- MCU (Traveo family)
  PCMPWM output
- Low-pass filter (LPF)
  2-layer RC filter: 2 kΩ + 8200 pF, 2 kΩ + 1000 pF, cutoff frequency = 5.8 kHz
- Gain control resistor
  Recommended value is from 150 kΩ to 680 kΩ. Refer to section 5.4.
- Input Coupling Capacitor
  0.47 μF: Depends on the amplifier device
- Class-AB AMP
  The device of the Class-AB amplifier. This application note recommends using Rohm BD78324EFJ-M.
- Speaker
  The connected speaker depends on the amplifier device; an example is an 8-Ω impedance speaker

Figure 2. External Circuit General Blocks



4.1 LPF

The characteristics of the LPF to use with this application note are as follows.
The frequency characteristic of LPF is shown in Figure 3.

Content	Value
First RC filter	2 kΩ, 8200 pF
Second RC filter	2 kΩ, 1000 pF
Cutoff frequency	5.8 kHz
PWM carrier attenuation	–55 dB (f_{PWM} = 48 kHz)

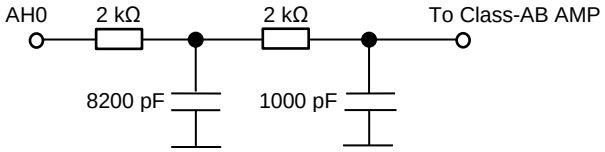
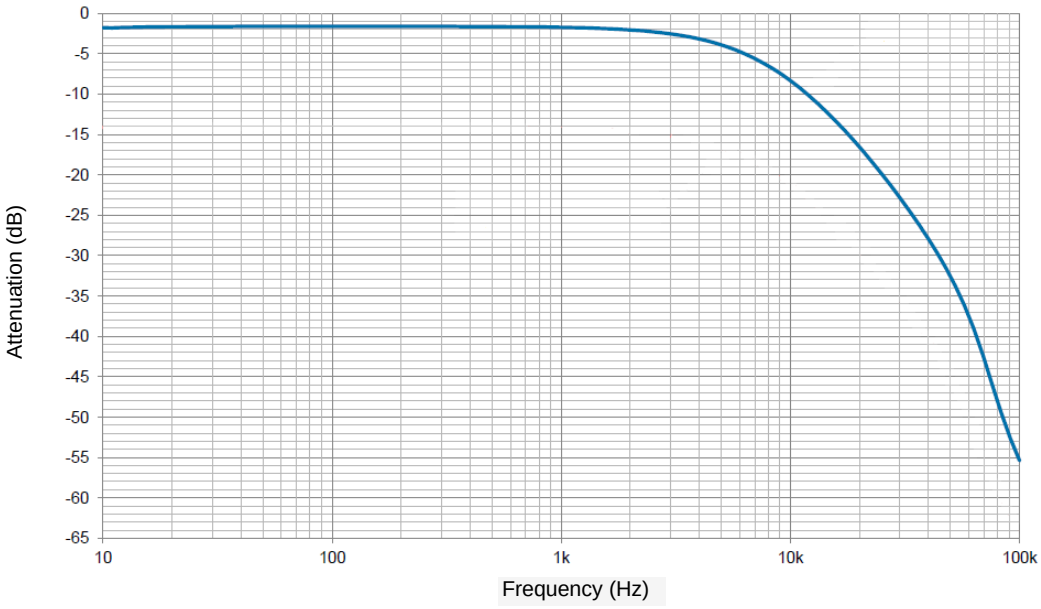


Figure 3. LPF (2 Layer RC Filter) Frequency Characteristic



4.2 Gain Control Resistor

The value of the gain control resistor depends on the amplifier IC used and the speaker to connect. You must adjust the gain control resistor value based on the target volume for your system.

In this application note, the recommended value of the gain resistor is from 150 kΩ to 680 kΩ.

4.3 Input Coupling Capacitor

The value of the Input Coupling Capacitor is according to the datasheet of the AMP device. Verify for your system. For example, for a Rohm device, the value of the Input Coupling Capacitor is 0.47 µF.

4.4 Class-AB AMP

Rohm BD78324EFJ-M is a Class-AB monaural speaker amplifier.

Input: differential or single-ended

Output: positive / negative speaker out

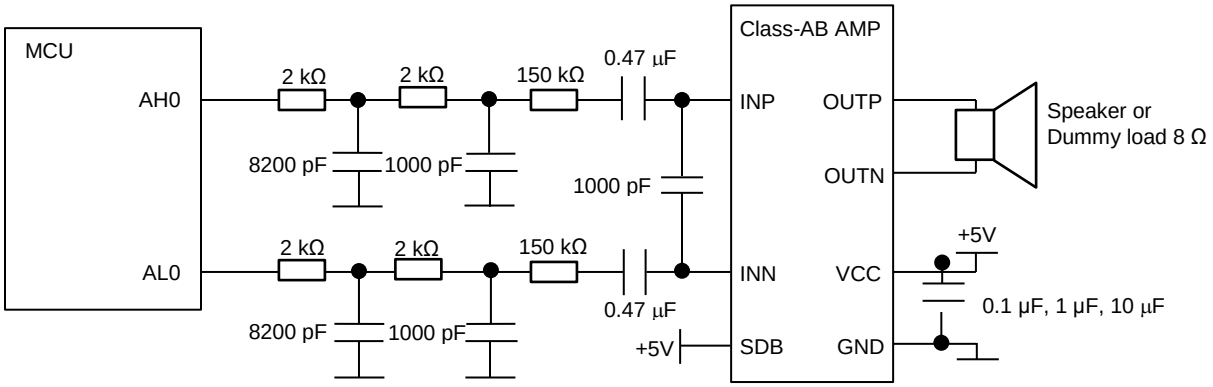
5 External Circuit Details

The following are the details of the external circuit for the PCMPWM sound system.

5.1 Differential Connection

For a differential connection, the PCMPWM terminal of the microcontroller uses two pins with the half-bridge mode, as required for noise tolerance. The schematic is shown in Figure 4.

Figure 4. Differential Connection

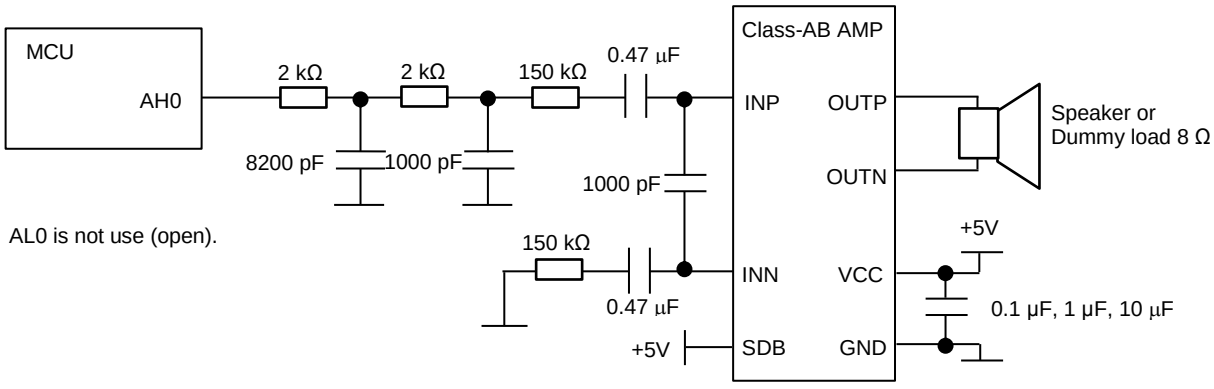


Ensure that all capacitors have a low equivalent series resistance (ESR),. Example values are 0.1 µF and 1 µF and 10 µF.

5.2 Single-Ended Connection

For a single-ended connection, the PCMPWM terminal of the microcomputer uses only one pin. Therefore, the circuit is simplified, reducing the cost. In addition, the sound quality is not affected. The schematic is shown in Figure 5.

Figure 5. Single-End Connection

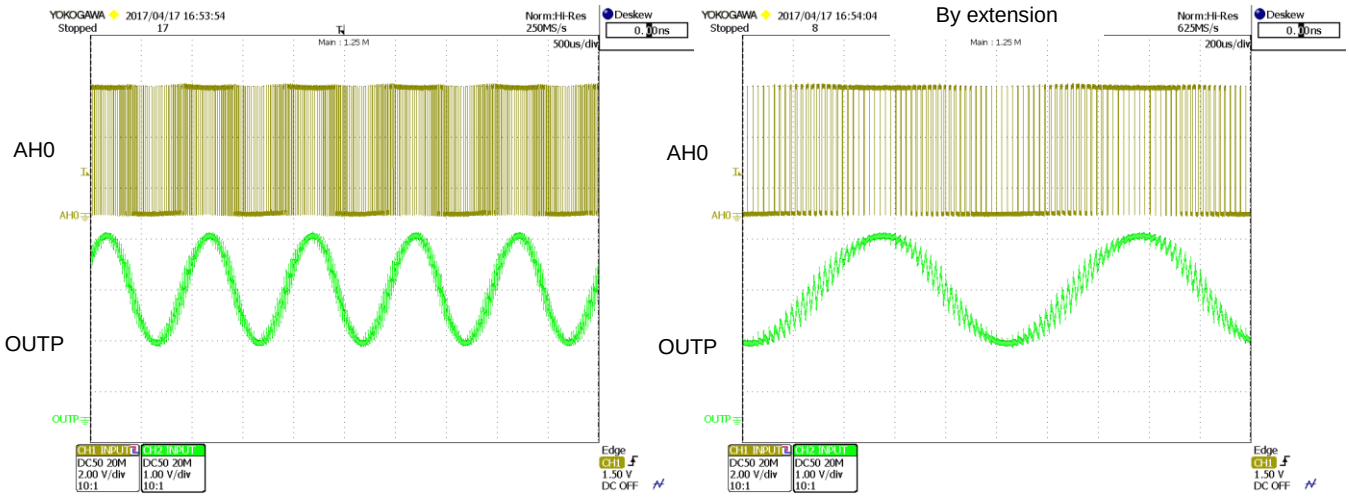


In case of single-ended connection, AL0 is not used. You can use GPIO instead of AL0 such as SDB pin.

Ensure that all capacitors have a low-ESR value. Example values are 0.1 µF and 1 µF and 10 µF.

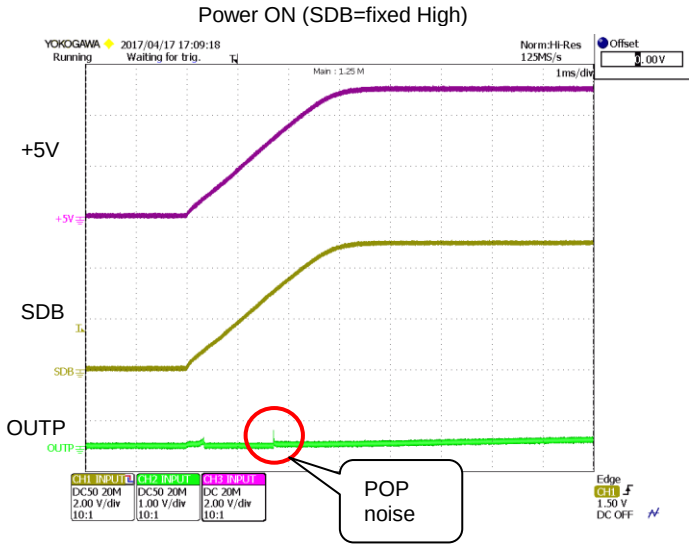
The waveform of the input and output is shown in Figure 6.

Figure 6. Input and Output



However, it has the Pop Noise issue at power on. In this case, SDB is fixed high.
The waveform is as shown in Figure 7.

Figure 7. POP Noise

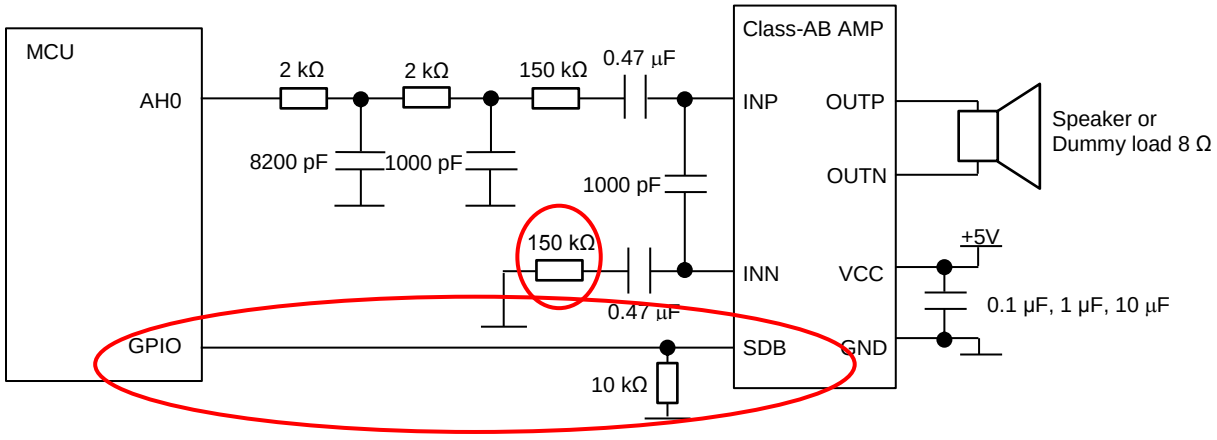


5.3 POP Noise Solution

In the circuit of the single-ended connection, the gain control resistor is determined by the pop noise solution. The value of the gain control resistor is the same as on the INP pin side. The schematic is shown in Figure 8.

In addition, the gain control resistor is controlled via an enable pin of the amplifier in the GPIO of the MCU after a power supply is turned on.

Figure 8. Circuit of POP Noise Solution

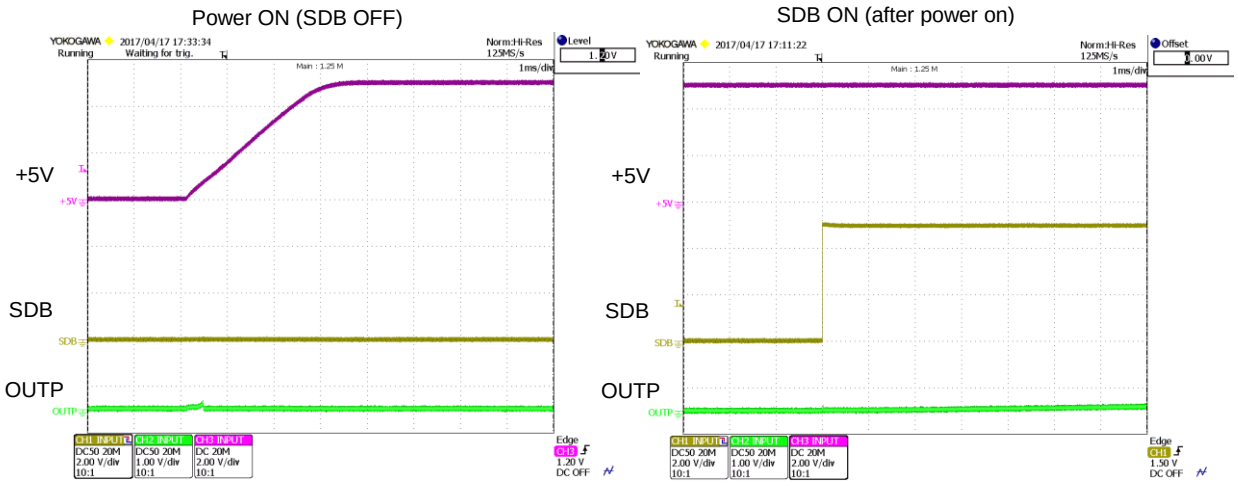


When you are using a single-ended input, put a resistor before an AC cut capacitor for gain limits; also put one on the signal terminal side that you are not using for signal input.

Only when you are using an AC cut capacitor is there a possibility of pop noise cancellation by the EN control (SDB terminal EN of BD78324EFJ-M).

The waveform is as shown in Figure 9.

Figure 9. Waveform of POP Noise Solution

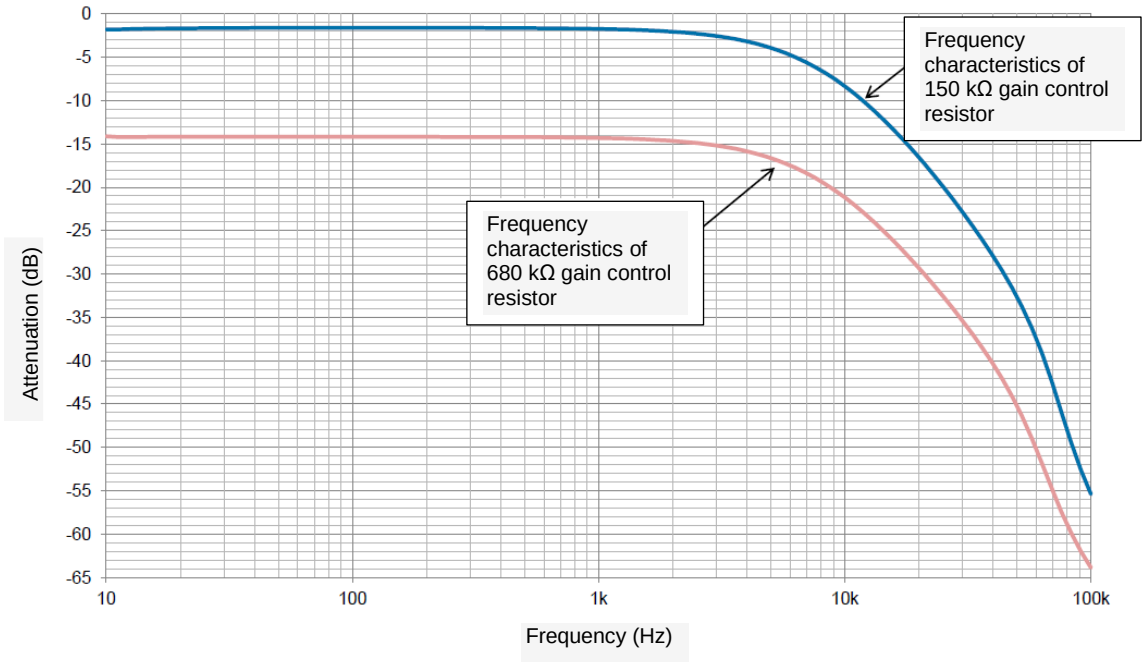


5.4 Gain Control

The value of the gain control resistor depends on the amplifier IC being used and the speaker to be connected. You may need to adjust this value depending on the target volume.

In this application note, the recommended value of the gain resistor is from 150 kΩ to 680 kΩ. The frequency characteristics of the 680-kΩ and 150-kΩ gain control resistors are shown in Figure 10. You must adjust the value in accordance with your system evaluation result.

Figure 10. Output Attenuation-Frequency Properties with Gain Control



6 Example Evaluation Using S6J328CLS Microcontroller

The following example demonstrates evaluating the most suitable external circuit (using the S6J328 microcontroller) and comparing the sound characteristics of various external circuits attached to the PCMPWM sound system (Figure 8). Evaluation results are summarized in Table 1.

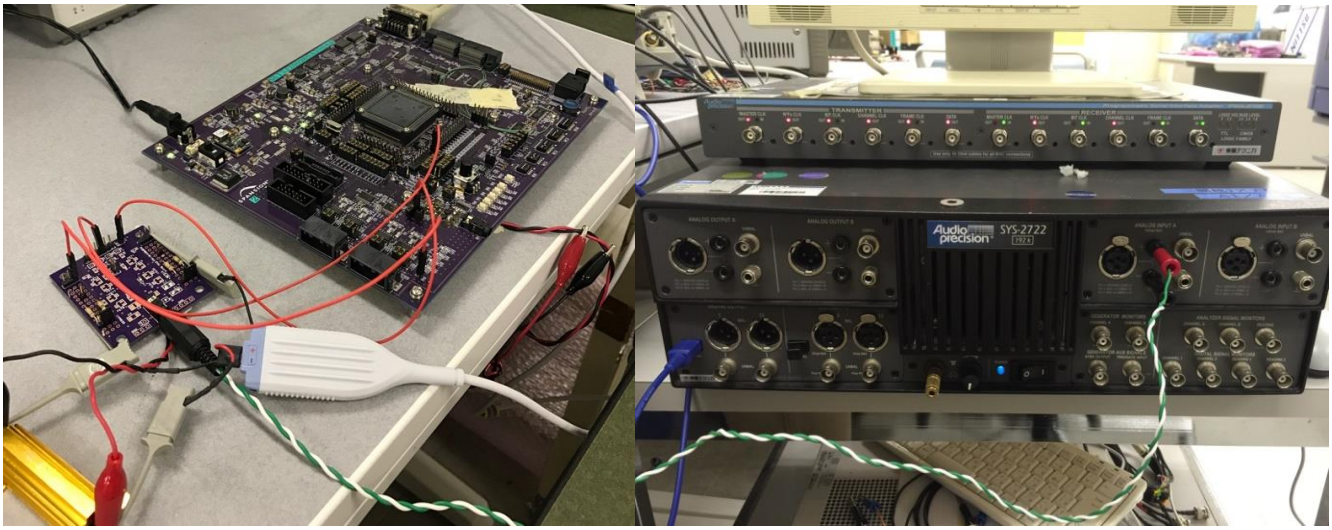
Table 1. Result of PCMPWM External Circuit Evaluation

Type	Single-Ended Connection Class-AB Amplifier RC Filter	Remarks
Sound characteristic THD+N	–59.8 dB	Terminating resistor: 8 Ω SWFG=1 kHz Temperature condition: Room temp
SNR	70.5 dB	
Dynamic Range	116.65 dB	
Implementation area	ROHM BD78324EFJ-M (SOP-8) LPFx1	
Power consumption	150 mA max	
Measuring instrument	Audio Precision SYS-2722	

The external circuit which this application note recommends realizes high-quality sound, a small mount area, low cost, and low current.

Figure 11 shows the test environment.

Figure 11. The Evaluation Environment



7 Related Documents

S6J3200 Series Hardware Manual (Doc. No. 002-04852)

S6J3200 Series Datasheet (Doc. No. 002-05682)

BD78324EFJ-M Datasheet (Rohm)

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