Application Note

Analog Input Configurations, Mixing and Muxing of TAx5x1x-Q1 Devices

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ABSTRACT

The TAx5x1x-Q1 (TAC5412-Q1, TAC5311-Q1, TAC5312-Q1, TAC5411-Q1, TAA5412-Q1) family of devices have single or dual-channel analog-to-digital converters which supports highly configurable inputs for audio applications. This application note looks at the different input configurations, the input swing, the input coupling mode as well as the mixing and muxing option that are supported in this TAx5x1x-Q1 device family. TAC5412-Q1, a stereo device is used in this application note with audio source provided at the LINE input. Microphone inputs or a mono version of this device can be configured in the similar manner.

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Trademarks

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1 Introduction

TAC5412-Q1 is a CODEC with dual-channel analog-to-digital converters whose input pins (IN1P/M and IN2P/M) are configurable as differential inputs, single-ended inputs or single-ended mux inputs in AC or DC coupling. The type of input is configured through ADC_CH1_INSRC and the AC or DC coupling mode is configured through ADC_CH1_CM_TOL [00] or ADC_CH1_CM_TOL [01].

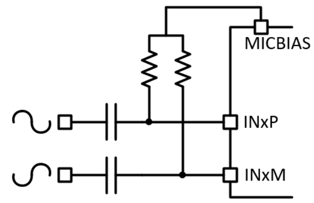
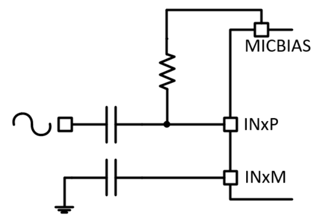
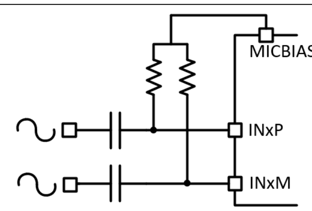
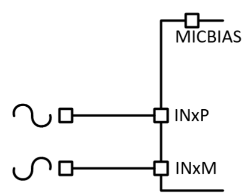
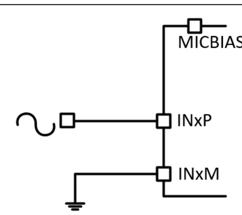
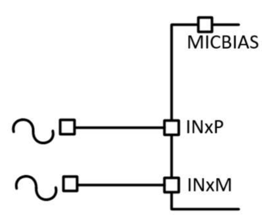
Table 1-1. Input Configuration Selection

Input Configuration Setting	B0_P0_R80 (ADC_CH1_CFG0) [7:6]	Input Channel Configuration
0	ADC_CH1_INSRC=[00]	Analog differential input
1	ADC_CH1_INSRC=[01]	Analog single-ended input
2	ADC_CH1_INSRC=[10]	Analog single-ended mux INP1 input
3	ADC_CH1_INSRC=[11]	Analog single-ended mux INM1 input

2 Analog Input Configuration

This application note shares some of these configurations and the performances. Table 2-1 provides a summary of the different input configurations for IN1 in this note, the same applies to IN2 input with the register channel change to 2.

Table 2-1. IN1 Input Configuration and Input Swing

Input Pin	Input Mode	Topology	Input Swing
IN1P-IN1M	LINE-IN Differential, AC-coupled		10 Vrms
IN1P	LINE-IN Single-Ended, AC-coupled		5 Vrms
IN1P	LINE-IN Single-Ended Mux IN1P, AC-coupled		5 Vrms
IN1M	LINE-IN Single-Ended Mux IN1M, AC-coupled		5 Vrms
IN1P-IN1M	LINE-IN Differential, DC-coupled		10 Vrms
IN1P	LINE-IN Single-ended, DC-coupled		5 Vrms
IN1P	LINE-IN Single-ended Mux IN1P, DC-coupled		5 Vrms
IN1M	LINE-IN Single-ended Mux IN1M, DC-coupled		5 Vrms

For each of the tests, audio signal is provided from APx500 analog balance or unbalanced output with the input level referenced to the full-scale swing of the device configuration for example 0dBrG is referenced to 5 Vrms single ended swing or 10 Vrms for the differential input swing.

2.1 Differential AC Coupled Configuration

In AC-Coupled differential input configuration, the common mode voltage, can be configured through an external bias resistor and MICBIAS. This Excel tool *TAX5X1X-Q1-EXT-RES-CALCULATOR* can be found from this link The tool calculates this external resistance based on input swing and the desired MICBIAS voltage.

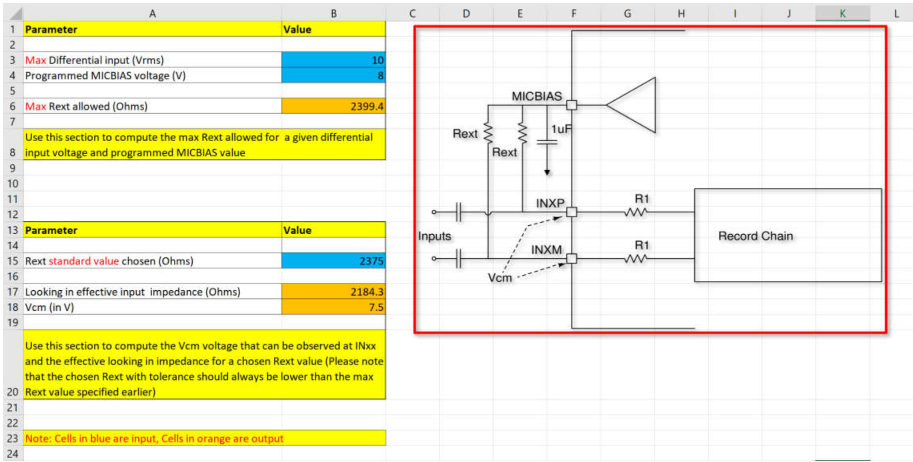


Figure 2-1. AC-Coupled External Resistor Calculator

As an example using differential input swing of 10 Vrms and 8 V MICBIAS, the maximum resistance allowed is 2399.4 Ω and the closest standard resistance is 2375 Ω. Based on this standard value resistance, the effective impedance looking into the device is about 2184 Ω. This effective input impedance forms a high pass filter with the external capacitor for these inputs and Vcm is the respective common voltage.

The following script configures the device to differential AC-Coupling mode.

```
##### Record AC-Couple IN1-IN2 path ######
# Target Mode, TDM, 32-bit
# Primary ASI only, multiple of 48KHz Sampling
#
w a0 00 00  # Set page 0
w a0 01 01  # Software Reset
w a0 02 09  # Wake up with AVDD > 2v and all VDDIO level
w a0 10 50  # Configure DOUT as Primary ASI (PASI) DOUT
w a0 19 00  # 1 data input and 1 data output for PASI
w a0 1a 30  # PASI TDM, 32 bit format
w a0 1e 20  # PASI Ch1 on slot 0
w a0 1f 21  # PASI Ch2 on slot 1
w a0 00 01  # Set page 1
w a0 73 d0  # auto device, set MICBIAS = 9V
w a0 00 00  # Set page 0
w a0 50 00  # Auto device ADC Ch1 diff input, fixed 33.3KOhm, 10Vrms ac-coupled, audio band
w a0 55 00  # Auto device ADC Ch2 diff input, fixed 33.3KOhm, 10Vrms ac-coupled, audio band
w a0 76 c0  # Enable Input Ch1 and Ch2, disable output channels
w a0 78 a0  # Power up ADC and MICBIAS
```

Figure 2-2. Differential AC-Coupled Register Setting

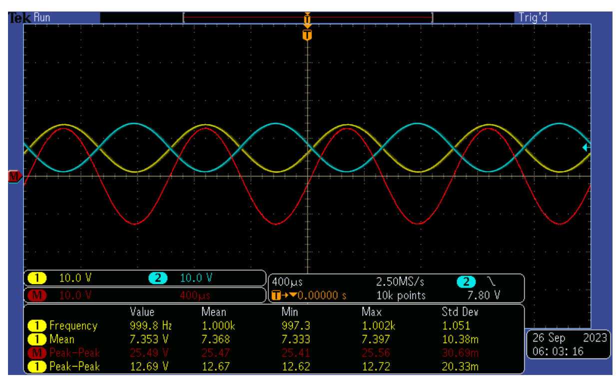


Figure 2-3. Differential AC-Coupled Input Swing at -1dBrG (0dBrG = 10Vrms)

A frequency plot of the Dynamic Range with -60dBrG input and SNR with input AC signal shorted to ground are provided here.

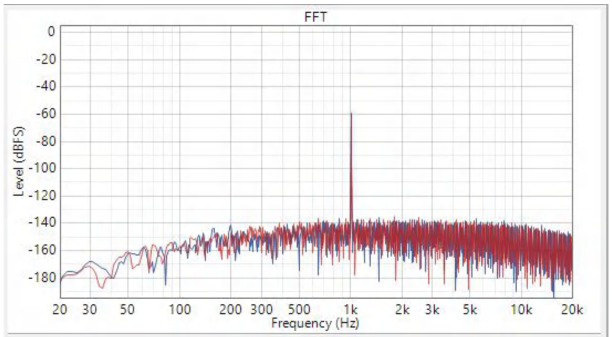


Figure 2-4. Differential AC-Coupled Dynamic Range at -60dBrG Input

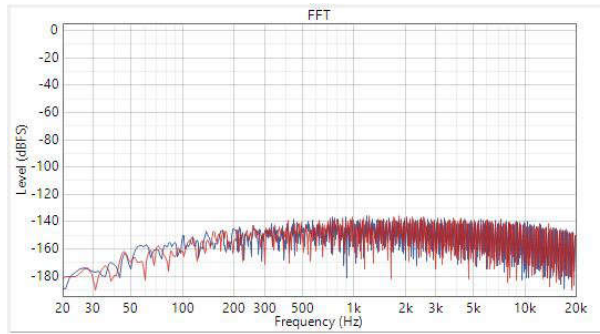


Figure 2-5. SNR with Input AC Signal shorted to GND

Table 2-2 summarizes the performances for the different device variants.

Table 2-2. Device Variants

THDN (at-1dBrG)			DR (dB)			SNR (dB)		
TAC541x	TAA541x	TAC531x	TAC541x	TAA541x	TAC531x	TAC541x	TAA541x	TAC531x
-101	-100	-89	112	112	101	112	112	101

2.2 Single Ended AC Coupled Configuration

The following script configures the device to single-ended AC-Coupling mode.

```
##### Record AC-Couple Single-Ended IN1-IN2 path ######
# Target Mode, TDM, 32-bit
# Primary ASI only, multiple of 48KHz Sampling
#
w a0 00 00  # Set page 0
w a0 01 01  # Software Reset
w a0 02 09  # Wake up with AVDD > 2v and all VDDIO level
w a0 10 50  # Configure DOUT as Primary ASI (PASI) DOUT
w a0 19 00  # 1 data input and 1 data output for PASI
w a0 1a 30  # PASI TDM, 32 bit format
w a0 1e 20  # PASI Ch1 on slot 0
w a0 1f 21  # PASI Ch2 on slot 1
w a0 00 01  # Set page 1
w a0 73 d0  # auto device, set MICBIAS = 9V
w a0 00 00  # Set page 0
w a0 50 40  # Auto device ADC Ch1 SE input, 5KOhm Impedance, ac-coupled, audio band
w a0 55 40  # Auto device ADC Ch2 SE input, 5KOhm Impedance, ac-coupled, audio band
w a0 76 c0  # Enable Input Ch1 and Ch2, disable output channels
w a0 78 a0  # Power up ADC and MICBIAS
```

Figure 2-6. Single Ended AC-Coupled Register Setting

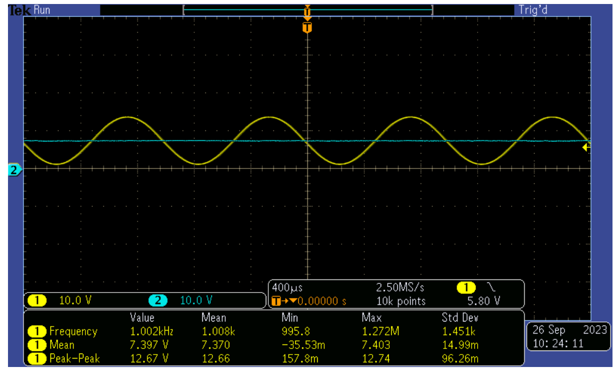


Figure 2-7. Single Ended AC-Coupled Input Swing at -1dBrG (0dBrG = 5 Vrms)

A frequency plot of the Dynamic Range with -60dBrG input and SNR with input AC signal shorted to ground are provided here.

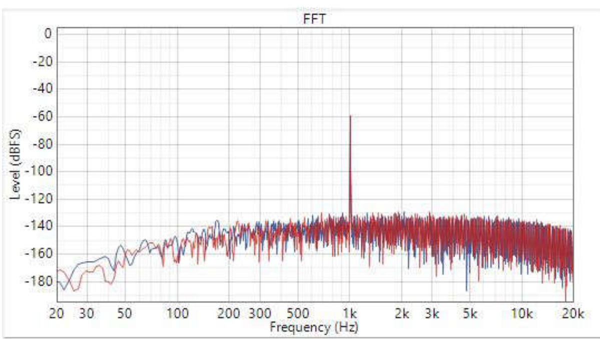


Figure 2-8. Single Ended AC-Coupled Dynamic Range at -60dBrG Input

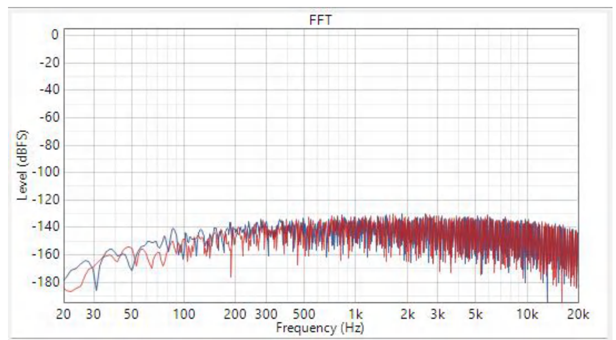


Figure 2-9. SNR with Input AC Signal shorted to GND

2.3 Differential DC Coupled Configuration

In the DC-Coupled differential input configuration, the following device register setting is used and the input waveform provided to IN1P/M for the full-scale swing with 6 V Vcm.

```
##### Record DC-Couple Differential IN1-IN2 path ######
# Target Mode, TDM, 32-bit
# Primary ASI only, multiple of 48KHz Sampling
#
w a0 00 00  # Set page 0
w a0 01 01  # Software Reset
w a0 02 09  # Wake up with AVDD > 2v and all VDDIO level
w a0 10 50  # Configure DOUT as Primary ASI (PASI) DOUT
w a0 19 00  # 1 data input and 1 data output for PASI
w a0 1a 30  # PASI TDM, 32 bit format
w a0 1e 20  # PASI Ch1 on slot 0
w a0 1f 21  # PASI Ch2 on slot 1
w a0 00 01  # Set page 1
w a0 73 d0  # auto device, set MICBIAS = 9V
w a0 00 00  # Set page 0
w a0 50 04  # Auto device ADC Ch1 diff input, fixed 33.3KOhm, 10Vrms dc-coupled, audio band
w a0 55 04  # Auto device ADC Ch2 diff input, fixed 33.3KOhm, 10Vrms dc-coupled, audio band
w a0 76 c0  # Enable Input Ch1 and Ch2, disable output channels
w a0 78 a0  # Power up ADC and MICBIAS
```

Figure 2-10. Differential DC-Coupled Register Setting

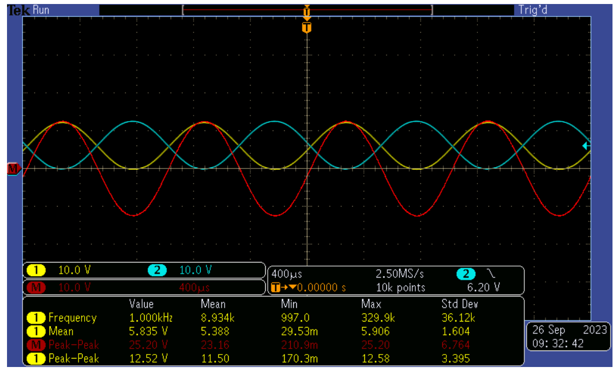


Figure 2-11. Differential DC-Coupled Input Swing at -1dBrG (0dBrG = 10Vrms)

A frequency plot of the Dynamic Range with -60dBrG input and SNR with input AC signal shorted to ground are provided here of the 1Vpp common-mode setting. A similar plot can be obtained for supply common-mode tolerances.

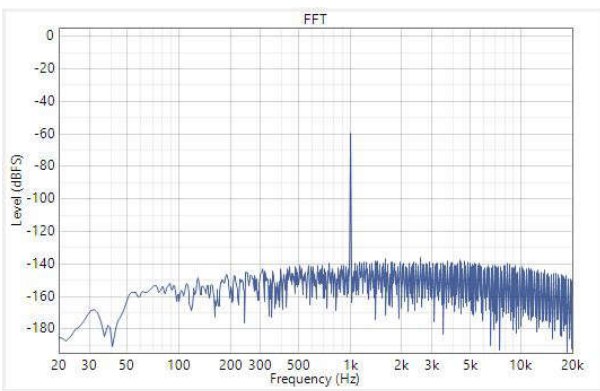


Figure 2-12. Differential DC-Coupled Dynamic Range at -60dBrG Input

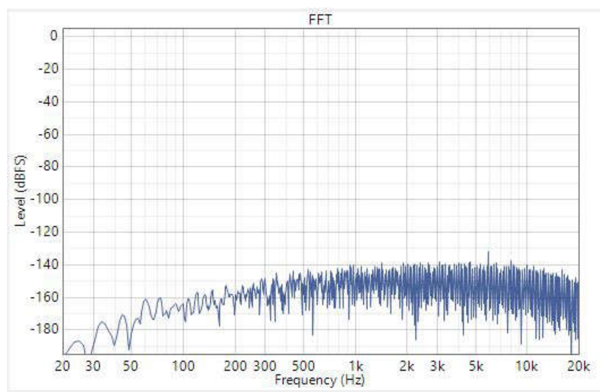


Figure 2-13. SNR with Input AC Signal shorted to GND

Table 2-3 summarizes the performances for the different device variants.

Table 2-3. Device Variants

THDN (at-1dBrG)			DR (dB)			SNR (dB)		
TAC541x	TAA541x	TAC531x	TAC541x	TAA541x	TAC531x	TAC541x	TAA541x	TAC531x
-101	-100	-89	112	112	101	112	112	101

2.4 Single Ended DC Coupled Configuration

In the DC-Coupled single-ended input configuration, the following device register setting is used and the respective input waveform provided to IN1P for the full-scale swing.

```
##### Record DC-Couple Single-Ended IN1-IN2 path ######
# Target Mode, TDM, 32-bit
# Primary ASI only, multiple of 48KHz Sampling
#
w a0 00 00  # Set page 0
w a0 01 01  # Software Reset
w a0 02 09  # Wake up with AVDD > 2v and all VDDIO level
w a0 10 50  # Configure DOUT as Primary ASI (PASI) DOUT
w a0 19 00  # 1 data input and 1 data output for PASI
w a0 1a 30  # PASI TDM, 32 bit format
w a0 1e 20  # PASI Ch1 on slot 0
w a0 1f 21  # PASI Ch2 on slot 1
w a0 00 01  # Set page 1
w a0 73 d0  # auto device, set MICBIAS = 9V
w a0 00 00  # Set page 0
w a0 50 44  # Auto device ADC Ch1 SE input, 5KOhm Impedance, dc-coupled, audio band
w a0 55 44  # Auto device ADC Ch2 SE input, 5KOhm Impedance, dc-coupled, audio band
w a0 76 c0  # Enable Input Ch1 and Ch2, disable output channels
w a0 78 a0  # Power up ADC and MICBIAS
```

Figure 2-14. Single Ended DC-Coupled Register Setting

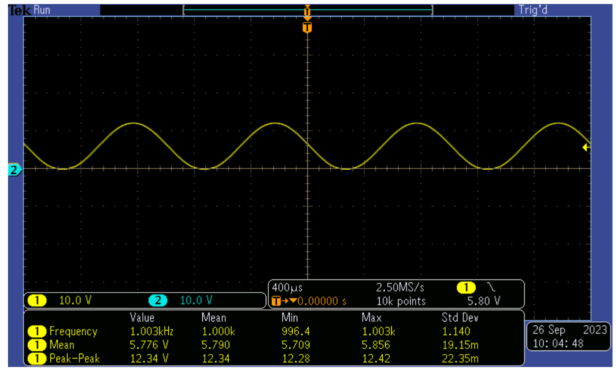


Figure 2-15. Single Ended DC-Coupled Input Swing at -1dBrG (0dBrG = 5Vrms)

A frequency plot of the Dynamic Range with -60dBrG input and SNR with input AC signal shorted to ground are provided here.

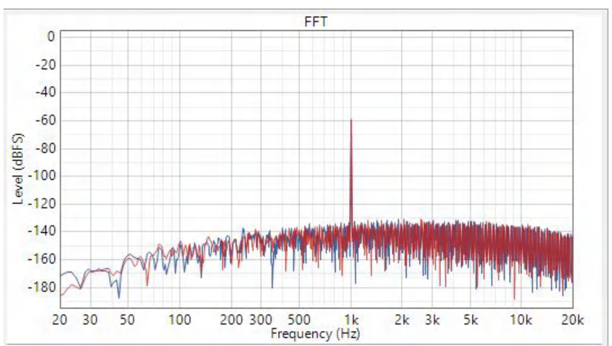


Figure 2-16. Single Ended DC Coupling Dynamic Range with -60dBrG Input

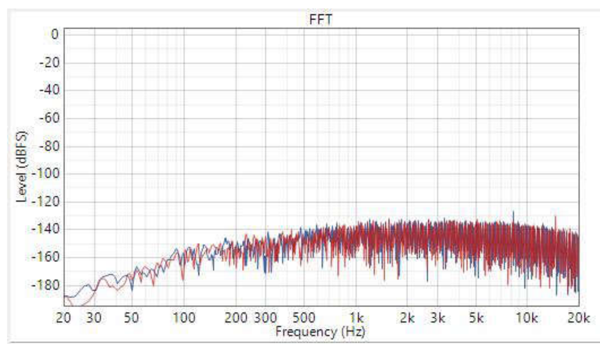


Figure 2-17. Single Ended DC Coupling SNR

Table 2-4 summarizes the performances for each of the configuration previously.

Table 2-4. Input Configuration Performance Summaries

Input Configuration	DR (dB) (-60dBrG)	SNR (dB) (Input AC short to GND)	THD+N (dB) (-1dBrG)
Differential AC-Coupled	112	112	-96
Differential DC-Coupled	112	113	-96
Single-Ended AC-Coupled	106	106	-80
Single-Ended DC-Coupled	106	107	-83

2.5 Analog Input Mux Configuration

Analog mux input allows input selection either from IN1P or IN1M into the ADC path. The device needs to be configured in the respective mux setting in register B0_P0_R80 (0x50) ADC_CH1_INSRC. In this configuration, either IN1P or IN1M be the input to the ADC signal chain, they are independent source. In this example, IN1P is a 1 KHz tone at -1 dBrG and IN1M is a 1250 Hz tone at -1 dBrG; 0 dBrG = 5 Vrms Single-Ended Full-scale.

```
##### Record AC-Couple Single-Ended Mux IN1P path ######
# Target Mode, TDM, 32-bit
# Primary ASI only, multiple of 48KHz Sampling
#
w a0 00 00  # Set page 0
w a0 01 01  # Software Reset
w a0 02 09  # Wake up with AVDD > 2v and all VDDIO level
w a0 10 50  # Configure DOUT as Primary ASI (PASI) DOUT
w a0 19 00  # 1 data input and 1 data output for PASI
w a0 1a 30  # PASI TDM, 32 bit format
w a0 1e 20  # PASI Ch1 on slot 0
w a0 1f 21  # PASI Ch2 on slot 1
w a0 00 01  # Set page 1
w a0 73 d0  # auto device, set MICBIAS = 9V
w a0 00 00  # Set page 0
w a0 50 80  # Auto device ADC Ch1 SE MUX IN1P input, 5KOhm Impedance, ac-coupled, audio band
w a0 55 00  # Auto device ADC Ch2 default Diff input, 5KOhm Impedance, ac-coupled, audio band
w a0 76 c0  # Enable Input Ch1 and Ch2, disable output channels
w a0 78 a0  # Power up ADC and MICBIAS
```

Figure 2-18. IN1P Mux Input Register Setting

```
##### Record AC-Couple Single-Ended Mux IN1M path ######
# Target Mode, TDM, 32-bit
# Primary ASI only, multiple of 48KHz Sampling
#
w a0 00 00  # Set page 0
w a0 01 01  # Software Reset
w a0 02 09  # Wake up with AVDD > 2v and all VDDIO level
w a0 10 50  # Configure DOUT as Primary ASI (PASI) DOUT
w a0 19 00  # 1 data input and 1 data output for PASI
w a0 1a 30  # PASI TDM, 32 bit format
w a0 1e 20  # PASI Ch1 on slot 0
w a0 1f 21  # PASI Ch2 on slot 1
w a0 00 01  # Set page 1
w a0 73 d0  # auto device, set MICBIAS = 9V
w a0 00 00  # Set page 0
w a0 50 c0  # Auto device ADC Ch1 SE MUX IN1M input, 5KOhm Impedance, ac-coupled, audio band
w a0 55 00  # Auto device ADC Ch2 default Diff input, 5KOhm Impedance, ac-coupled, audio band
w a0 76 c0  # Enable Input Ch1 and Ch2, disable output channels
w a0 78 a0  # Power up ADC and MICBIAS
```

Figure 2-19. IN1M Mux Input Register Setting

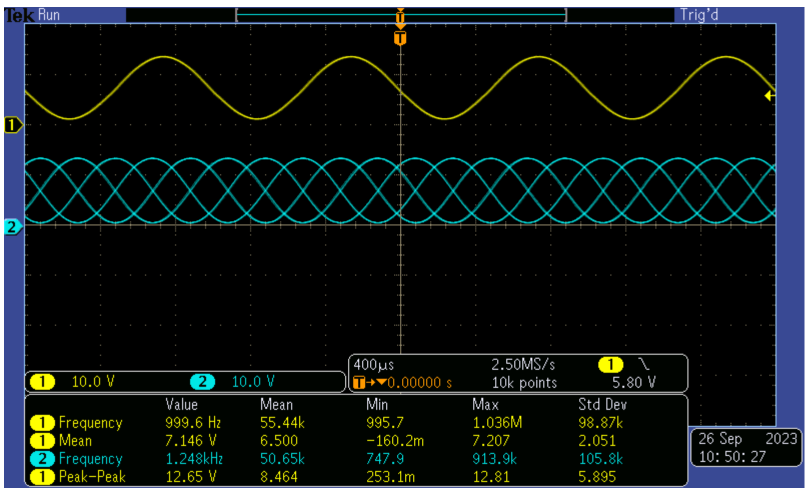


Figure 2-20. IN1P and IN1M Mux Input at -1dBrG (0 dBrG = 5Vrms)

The output of the respective setting shows the desired signal and the suppression of the other input signal.

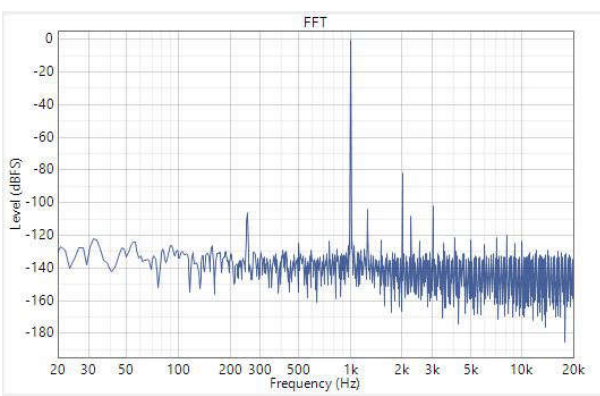


Figure 2-21. Output with IN1P Mux Input Configured

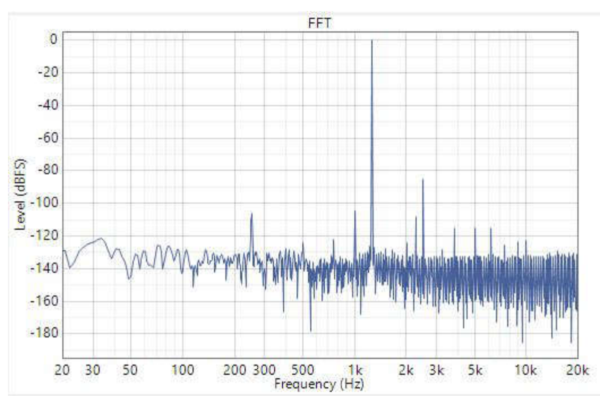


Figure 2-22. Output with IN1M Mux Input Configured

3 Analog Mixing

When mixing of analog audio signal is desired, this device provides capability of mixing from various input channels with programmable mixer feature and scale factor to generate the final output channels. In this example, an input from single ended IN1P and IN1M with different tone and input swing are mixed as shown in the register setting and the input waveforms. IN1P is a 1 KHz tone at -10 dBrG and IN1M is a 750 Hz tone at -20 dBrG; 0 dBrG = 5 Vrms Full-scale.

```
##### Record Mix AC-Couple SE IN1P and IN1M Input path ######
# Target Mode, TDM, 32-bit
# Primary ASI only, multiple of 48KHz Sampling
#
w a0 00 00  # Set page 0
w a0 01 01  # Software Reset
w a0 02 09  # Wake up with AVDD > 2v and all VDDIO level
w a0 10 50  # Configure DOUT as Primary ASI (PASI) DOUT
w a0 19 00  # 1 data input and 1 data output for PASI
w a0 1a 30  # PASI TDM, 32 bit format
w a0 1e 20  # PASI Ch1 on slot 0
w a0 1f 21  # PASI Ch2 on slot 1
w a0 00 01  # Set page 1
w a0 73 d0  # auto device, set MICBIAS = 9V
w a0 2c 20  # Enable ADC Mixer
w a0 00 00  # Set page 0
w a0 50 40  # Auto device ADC Ch1 SE input, 5KOhm Impedance, ac-coupled, audio band
w a0 55 00  # Auto device ADC Ch2 default Diff input, 5KOhm Impedance, ac-coupled, audio band
w a0 76 c0  # Enable Input Ch1 and Ch2, disable output channels
w a0 78 a0  # Power up ADC and MICBIAS
```

Figure 3-1. Analog Single Ended Mix Register Setting

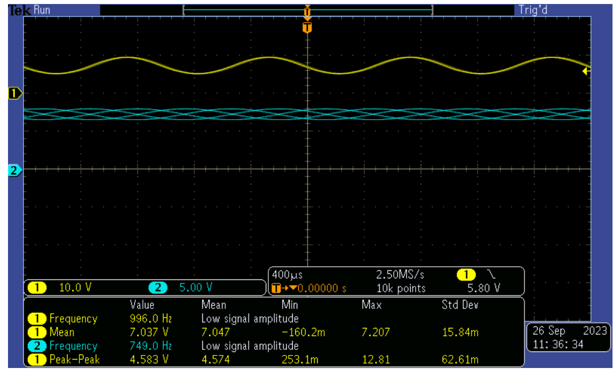


Figure 3-2. IN1P and IN1M Input Signal

The corresponding mixed output frequency respond is shown in Figure 3-3.

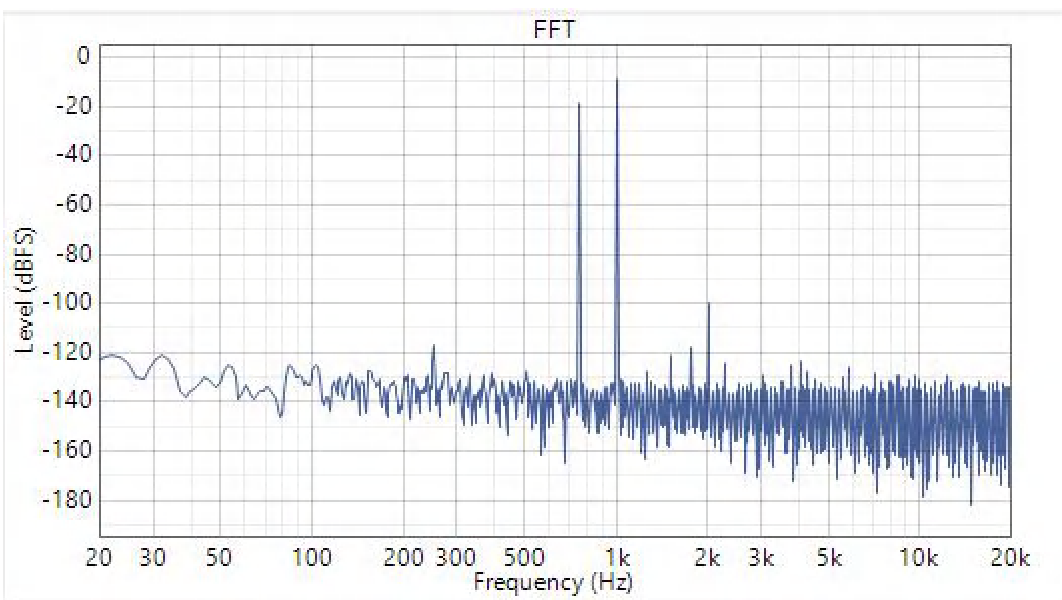


Figure 3-3. Mixed Analog Input of IN1P and IN1M

4 Summary

The TAx5x1x-Q1 family of devices offers very flexible input configuration with muxing and mixing capability making the devices designed for a wide range of applications.

5 References

- Texas Instruments, *TAC5412-Q1 Automotive Low Power Stereo Audio Codec with Integrated Programmable Boost, Micbias and Diagnostics*, data sheet.
- Texas Instruments, *TAC5411-Q1 Automotive Low Power Mono Audio Codec with Integrated Programmable Boost, Micbias and Diagnostics*, data sheet.
- Texas Instruments, *TAC5312-Q1 Automotive Low Power Stereo Audio Codec with Integrated Programmable Boost, Micbias and Diagnostics*, data sheet.
- Texas Instruments, *TAC5311-Q1 Automotive Low Power Mono Audio Codec with Integrated Programmable Boost, Micbias and Diagnostics*, data sheet.
- Texas Instruments, *TAA5412-Q1 Automotive, 2-Channel, 768-kHz, Audio ADC With Integrated Microphone Bias and Input Fault Diagnostics*, data sheet.