D2-3(S) and D2-6 Family Audio SOC

Programmable I/O Design Guide

Abstract

The D2-3(S) and D2-6 family digital audio processor devices are complete system-on-chip audio processor and Class-D amplifier controllers that integrate Class-D PWM engines with DSP-configurable audio processing and peripheral control. Programmable hardware I/O functions of these devices are defined by the product firmware to support various system functions within the amplifier design. The D2 Audio DSP Customization GUI v3 software is a development tool that supports defining of the audio processing and I/O control definition to build firmware for these D2 audio based designs. This application note describes the D2 Audio device's programmable I/O supported by the D2 Audio Customization GUI software and provides guidance for designing systems using these programmable hardware features.

Contents

Related Literature

For a full list of related documents, visit our website:

- D2-3(S) (D2-92633, D2-92634, D2-92643, D2-92683, D2-92684) device pages
- D2-6 (D2-71083, D2-74083, D2-71583, D2-74583, D2-74383) device pages

1.   Overview

The D2-3(S) (D2-926xx) and D2-6 (D2-7xx83) families of devices support firmware-defined, programmable I/O functions, enabling flexible definition of system-specific hardware features. The configurable firmware shell structure incorporated by the D2 Audio Customization GUI software includes these features within the system firmware that is built by the D2 Audio Customization GUI for loading into the D2 Audio devices. (**Note**: The only difference between the D2-3(S) and D2-6 devices is the audio processing algorithm support. Hardware I/O features and functionality are identical for both device families.)

1.1   Supported Features and Functions

The D2 Audio device hardware can support many functions. However, the scope of the features and functions included in the configurable firmware shells is defined to include an offering of optional functions typically used and required by most amplifier system designs. The following is the list of supported hardware I/o features and functions are the following:

- Master Volume Control

- Headphone Detect

- Mute Function

- NTC Temperature Monitoring

- Over-Temperature Input Monitoring

- PWM-Channel Power Stage Protection

- Power Stage Powerdown Control

- Error Reporting Output

- Audio Format Change Output Control

- Power Supply Sync Output

- MCLK Output

- EEPROM Hardware Control

- I2C Addresses for Multi-DSP Operation

Not all system designs require or use all of these functions. Use the D2 Audio Customization GUI to select the features required or turn off those that are not needed.

1.2   Hardware I/O Design Process

Defining the I/O functionality required by the amplifier system design consists of:

- Defining which of the supported features are to be implemented in the system.

- Running the D2 Audio Customization GUI software and loading the Shell Features plug-in to enable choices of feature selection and I/O assignments.

- Verifying I/O assignment compatibility with the required features and the hardware design.

- Choosing the features and selecting which I/O assignments are to be used with those features.

- Building the D2 Audio system firmware using the D2 Audio Customization GUI program.

This document describes the specific firmware features and functions and the D2 Audio device I/O pin useage for those functions. Use the D2 Audio Customization GUI software to assign and select these functions. See the D2 Audio Customization GUI reference documentation (R32AN0002) for a full description on use of the D2 Audio Customization GUI software, and its use with the programmable shell features.

1.3   Programmable Hardware I/O Pins

Specific D2 Audio device pins have been allocated to support these features and functions. Some pins are assignable to different functions, and other pins are dedicated only to their specific function. Pins that are dedicated to only one function and cannot be reassigned can still be enabled or disabled as a user selection through the D2 Audio Customization GUI menus, when choosing whether their feature is enabled or disabled.

Table 1 on page 6 provides a list of the D2 Audio device pins that have been assigned to the firmware shell functions. The table shows the firmware function associated with the device pin, and shows the default assignment as provided in the D2 Audio Customization GUI firmware shell. See the D2 Audio device's datasheets for additional pin and device hardware descriptions (links are provided in "Related Literature" on page 1).

1.4   Pin Assignment Considerations

I/O pin usage for these functions is defined in the feature shells with 20 pins dedicated to specific functions, and an additional seven pins that are assignable to certain feature options. These optional features require a total of 10 I/O pins if they are all enabled at one time, although there are only seven pins that can be assigned to these options at any one time. However, these options have been specified such that all will likely not be required at the same time within a design, and typically the seven assignable pins are more than sufficient for use with the chosen features.

1.5   Hardware Function Definitions

Each of the hardware features are defined and included within the firmware built by the D2 Audio Customization GUI program. However, each of these functions is enabled or disabled, and associated I/O assignment and parameters is defined using the D2 Audio Customization GUI Shell Features menus.

The pin assignment choices and default program settings for each of these functions are shown in Tables 1 and 2. Table 1 shows each of the D2 Audio device pins and the firmware features associated with those pins. Table 2 shows a list of the features, along with the I/O associated with supporting those features.

A brief overview of the function operation and any I/O selections for those functions are provided in the following:

1.5.1   Master Volume Control

The Master Volume control function allows two assignable inputs to be assigned to a rotary encoder, that when rotated, generates quadrature-phase input pulses that are translated to an increase or decrease of the assigned volume audio processing block.

Menu entries and selections include:

• Enable or Disable. When disabled, inputs become unassigned and the volume control routine does not operate.

• Two inputs are required to specify the I/O pins to be used. Pin choice is assignable to any two of the assignable pins.

• The menu also includes a selection to choose the specific audio processing block within the audio signal flow, to which the volume control is assigned. A compatible volume block must exist as part of the audio signal flow for the project.

1.5.2   Headphone Detect

Headphone detect uses an input to switch routing of audio processing and turn on or off PWM outputs to headphone and non-headphone output channels.

Menu entries and selections include:

• Enable or Disable.

• Input pin assignment for the pin that is wired to the headphone jack sense pin. Pin choice is assignable to any two of the assignable pins.

• Output channel designations for channels affected by the detect switching.

1.5.3   Mute Function

The mute function uses an output pin that connects to hardware that mutes the audio path. Optionally, it also uses an input pin that can be assigned to initiate the mute function.

Menu entries and selections include:

• Enable or Disable

• Input pin assignment for the pin that is used as the mute signal input. Pin choice is assignable.

• Output pin assignment for the pin that connects to the audio path circuitry to mute that path upon assertion of the mute condition. Pin choice is assignable.

1.5.4   NTC Temperature Monitoring

NTC temperature sensing uses a firmware routine to implement a resistance-ratio comparison calculation, using negative temperature coefficient resistors that are placed in heat-critical areas of the design, such as near output stages. Temperatures at the NTC locations are monitored and high temperature conditions initiate attenuation of the output levels and/or shut down the audio paths. This monitoring routine uses four to six I/O pins when enabled, and can monitor from two to four NTCs on the hardware. The attenuate or shutdown temperature is determined from the highest of the temperatures being monitored (enabled).

Attenuation occurs linearly for temperature readings between the attenuation and shutdown thresholds, with a total range of 12dB between those ranges.

Menu entries and selections include:

• Enable or Disable.

• Input pin usage selection for each of the four NTC inputs. By default, two pins are enabled, and two are not. Pin assignment choice is fixed, and the only option is to enable or disable the third and fourth pin's use.

• Attenuation threshold temperature setting. This is the temperature above which output levels begin to attenuate, in attempt to reduce overheating from high-level outputs. Default is set to 75°C but can be edited in the menu.

• Shutdown threshold temperature setting. When this temperature is reached, audio PWM outputs are shut down. Default is set to 100°C but can be edited in the menu.

• Reference resistance value. This is the value of the fixed-value resistor used in the hardware, that is compared to the variable resistance of the NTCs. Default setting is 49,900Ω but can be edited in the menu.

• NTC resistor parameters of reference temperature (25°C), reference resistance at temperature (100k), and NTC material coefficient (4250).

1.5.5   Over-Temperature Input Monitoring

The over-temperature input is an input that is typically presented from power stages to the D2 Audio device and triggers output level attenuation upon assertion of the high temperature warning.

Menu entries and selections include:

• Enable or Disable.

• Pin assignment choice is fixed, and the only option is to enable or disable the pin's use in the over-temperature function.

1.5.6 PWM Channel Power Stage Protection

Eight dedicated inputs are provided for connection to monitor an overcurrent condition for the output stages. Distinction between high-current and short-circuit detection is monitored by the firmware to determine the protection management action for either condition. These are active low inputs, such that open-drain outputs from power stages detectors can be wire-or'd together if needed to tie to one protect input.

Menu entries and selections include:

- Enable or Disable each input pin assignment. Assignment is fixed to the designated pin only, with the only choice to enable or disable that input's functionality.
- Audio output channel designation. Each protect input by default correlates to its own output channel being monitored. However, one pin can be used as the protect input to more than one audio channel.

1.5.7 Power Stage Powerdown Control

The power stage powerdown is an assignable output that can connect to, and power down output power stages in the design. When enabled, the output becomes active when a temperature and/or short-circuit condition is detected by the protection logic.

This is a supplemental output that can connect to powerdown inputs of power stages to turn them off. During a high current or high temperature condition as monitored by other protection features, audio output is turned off by shutting down the PWM drive from the D2 Audio device. This supplemental powerdown output asserts at the same time as the PWM shutdown, but provides the ability to also turn off outputs such as integrated power stages.

Menu entries and selections include:

- Enable or Disable.
- Output pin assignment. Pin choice is assignable.

1.5.8 Error Reporting Output

Error reporting provides indication of a fault condition detected by the D2 Audio device. Conditions include over-temperature shutdown, over-temperature warning, channel shutdown, and high current detect.

Menu entries and selections include:

- Enable or Disable.
- Output pin assignment. Pin choice is assignable.

1.5.9 Audio Format Change Output Control

The audio format change output control, an optional output, detects changes in audio format and signals those changes to indicators or controllers.

Menu entries and selections include:

- Enable or Disable.
- Output pin assignment. Pin choice is assignable.

1.5.10 Power Supply Sync Output

Power supply sync outputs provide a clock signal to DC/DC converters, where the clock is synchronized to the D2 Audio device's PWM output switching rate. Synchronizing other converters eliminates beat frequency types of in-band audio interference between non-synchronous clock signals. Two different pins are provided.

Menu entries and selections include:

• Enable or disable the sync output function.

• Enable or disable the second output pin. The first pin is enabled and disabled with this function. The second output pin only operates when it is also enabled. Assignment is fixed to the designated pin only, with the only choice to enable or disable the output to the pin.

• Frequency selection. The sync frequency can be specified by selecting the presets of 96kHz, 192kHz, 384kHz, 768kHz, 1152kHz, or 1536kHz.

1.5.11 MCLK Output

MCLK provides a clock, synchronized to the D2 Audio device's on-chip serial digital audio (I^2S) inputs or outputs that are connected to an external ADC or DAC. Selection choice is for disable and frequency only. Pin assignment is fixed and not assignable.

Menu entries and selections include:

• Disable.

• Enable at 12.288MHz, or at 24.576MHz.

1.5.12 EEPROM Hardware Control

The EEPROM hardware control is an optional output that provides a write protect to an on-board I^2C EEPROM. Options include only to enable or disable, and firmware functions are processed based on whether the feature is enabled. Pin assignment is fixed, and is not assignable.

1.5.13 I^2C Addresses for Multi-DSP Operation

Two optional I/Os are used for address identification in systems using multiple D2 Audio devices. One pin designates DSP_ADDR0, and the other designates DSP_ADDR1. These I/O pins are assignable.

1.6   D2 Audio Device Pins for Programmable I/O Features

Table 1 provides a list of the D2 Audio device pins that are used for the programmable and optional firmware features.

See the D2 Audio device datasheet for additional pin references of the devices. Of all 128 device pins, only those shown in this table are programmable for the features described.

Table 1.   D2 Audio Device Pin Firmware Shell Assignments

Pin No.	Pin Name	I/O	Assignable or Fixed Function	Firmware Function	Default Assignment
126	GPIO0	I/O	Assignable	Assignable	Volume Encoder Input 0 (VOL0)
66	GPIO1	I/O	Assignable	Assignable	Volume Encoder Input 1 (VOL1)
32	GPIO2	I/O	Assignable	Assignable	Unassigned, Not Enabled
33	GPIO4	I/O	Assignable	Assignable	Headphone Detect Input
34	GPIO5	I/O	Assignable	Assignable	Mute Output
35	GPIO6	I/O	Assignable	Assignable	Power Down Output to Power Stages
30	GPIO7	I/O	Assignable	Assignable	Unassigned, Not Enabled
27	TIO1	I/O	Fixed	NTC Temperature Monitor Common	NTC Temperature Monitor Common
54	PUMPHI	I	Fixed	NTC Temp Reference Input	NTC Temp Reference Input

Table 1.   D2 Audio Device Pin Firmware Shell Assignments (Continued)

Pin No.	Pin Name	I/O	Assignable or Fixed Function	Firmware Function	Default Assignment
57	PSTEMP	I	Fixed	NTC Temperature Input 1	NTC temperature input 1
58	PSCURR	I	Fixed	NTC Temperature Input 2	NTC temperature input 2
22	SRD0	I	Fixed	NTC Temperature Input 3	Unassigned, not enabled
23	SC00	I	Fixed	NTC Temperature Input 4	Unassigned, not enabled
125	PROTECT0	I	Fixed	PWM Protection Input	PWM Channel 1 overcurrent input
124	PROTECT1	I	Fixed	PWM Protection Input	PWM Channel 2 overcurrent input
65	PROTECT2	I	Fixed	PWM Protection Input	PWM Channel 3 overcurrent input
60	PROTECT3	I	Fixed	PWM Protection Input	PWM Channel 4 overcurrent input
61	PROTECT4	I	Fixed	PWM Protection Input	PWM Channel 5 overcurrent input
62	PROTECT5	I	Fixed	PWM Protection Input	PWM Channel 6 and 7 overcurrent input
63	PROTECT6	I	Fixed	PWM Protection Input	Unassigned, not enabled
64	PROTECT7	I	Fixed	PWM Protection Input	Unassigned, not enabled
38	PROTECT9	I	Fixed	Over-Temperature Warning Input	Over-temperature warning input
56	PSSYNC	O	Fixed	Power Supply Sync Output 1	Power supply sync output, enabled, at 384kHz
55	PUMPLO	O	Fixed	Power Supply Sync Output 2	Unassigned, not enabled
7	MCLK	O	Fixed	MCLK Enabled or Frequency Select	Enabled, clock set to 24.576MHz
47	TIO2	O	Fixed	Audio Format Change Control Output	Unassigned, not enabled
31	GPIO3	O	Fixed	EEPROM Write Protect Output	Unassigned, not enabled

1.7   Programmable I/O Features

Table 2 provides a list of the optional firmware features supported by the programmable features and functions described in this document. The table shows which features use assignable or fixed pin assignment, and the default assignments.

Table 2.   Feature and Corresponding I/O Pin Requirements with Defaults

Feature/Function	Assignable or Fixed Pin Assignment	Pins Required	Feature Enabled by Default	Default Function and Pin Assignments
Master Volume Control	Assignable	2 Inputs	Yes	Two inputs enabled, Pins 66, 126
Headphone Detect	Assignable	1 Input	Yes	One input enabled, Pin 33
Mute Function	Assignable	1 Input, 1 Output	Yes	One output enabled, Pin 34
Power Stages Powerdown Control Output	Assignable	1 Output	Yes	One output enabled, Pin 35
Error Reporting Output	Assignable	1 Output	No	Unassigned, not enabled
Audio Format Change Output Control	Assignable	1 Output	No	Unassigned, not enabled
I^2C Addresses For Multi-DSP Operation	Assignable	2 I/O	No	Unassigned, not enabled
NTC Temperature Monitoring	Fixed	4 to 6	Yes	Two NTC inputs enabled, two unassigned, plus reference and common pins enabled, Pins 27, 54, 57, 58
Over-Temperature Input Monitoring	Fixed	1 Input	Yes	One input enabled, Pin 38
PWM-Channel Power Stage Protection Inputs	Fixed	8 Inputs	Yes	Six inputs enabled, two unassigned, Pins 125, 124, 65, 60, 61, 62

Table 2.   Feature and Corresponding I/O Pin Requirements with Defaults (Continued)

Feature/Function	Assignable or Fixed Pin Assignment	Pins Required	Feature Enabled by Default	Default Function and Pin Assignments
Power Supply Sync Output	Fixed	2 Outputs	Yes	One output enabled, Pin 56, Sync Frequency = 384kHz
MCLK Output	Fixed	1 Output	Yes	Output enabled: MCLK = 24.576MHz = [(F_{XTAL}) * 1.0]
EEPROM Write Protect Output	Fixed	1 Output	No	Unassigned, Not enabled

2.   Revision History

Rev.	Date	Description
1.00	May.24.19	Initial release

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