SY24146S

High Performance, High Fidelity
30W Digital Audio-Power Amplifier

General Description

The SY24146S is a 2×30W, digital audio power amplifier for driving bridge-tied stereo speakers. One serial data input allows processing of up to two discrete audio channels and seamless integration to most digital audio processors. The SY24146S is an I^2S slave device receiving all clocks from the external sources.

The SY24146S has the essential audio signal processing functions like dynamic range control, loudness control and parametric equalization.

Ordering Information

SY24146□(□,□)□
- Temperature Code
- Package Code
- Optional Spec Code

Ordering Number	Package type	Note
SY24146SGAC	TQFP7×7-48E	

Applications

- LCD TV, LED TV or Monitor
- Digital Speaker, Bluetooth Speaker
- Sound Bar

Features

- 2CH Stereo(30W×2BTL)
- 2.0 BTL Mode or PBTL Mode Support
- 4.5V to 28V PVDD Range
- 32kHz to 96kHz Sample Rate Support (LJ/RJ/I^2S)
- 4 I^2C Slave Addresses
- Independent Channel Volume Controls with 48dB to Mute
- SDATA Generator (I^2S Output)
- Two DC Blocking Filters
- 18 PEQs or 12 PEQs + 6 SPEQs Each Channel for Speaker Protection and Speaker Compensation
- 3 Bands Dynamic Range Control Plus a Post Dynamic Range Control
- Loudness Control
- Power Level Meter
- 3-wire I^2S Digital Audio Interface without MCLK
- Thermal, Over Current, Short Circuit, Short Load, Open Load Protections and EQ/DRC Coefficients Checksum
- Support Automatic Audio Sample Rate Detection
- Headphone Amplifier
  - ✓ No Output DC-Blocking Capacitors
  - ✓ Wide Power Supply Range: 2.1V-5V
  - ✓ 19mW/Ch Output Power into 32Ω at 5V
  - ✓ Short-Circuit and Thermal Protection and under Voltage Protection
- Surface Mount, TQFP 48-Pin, 7mm×7mm

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Typical Application

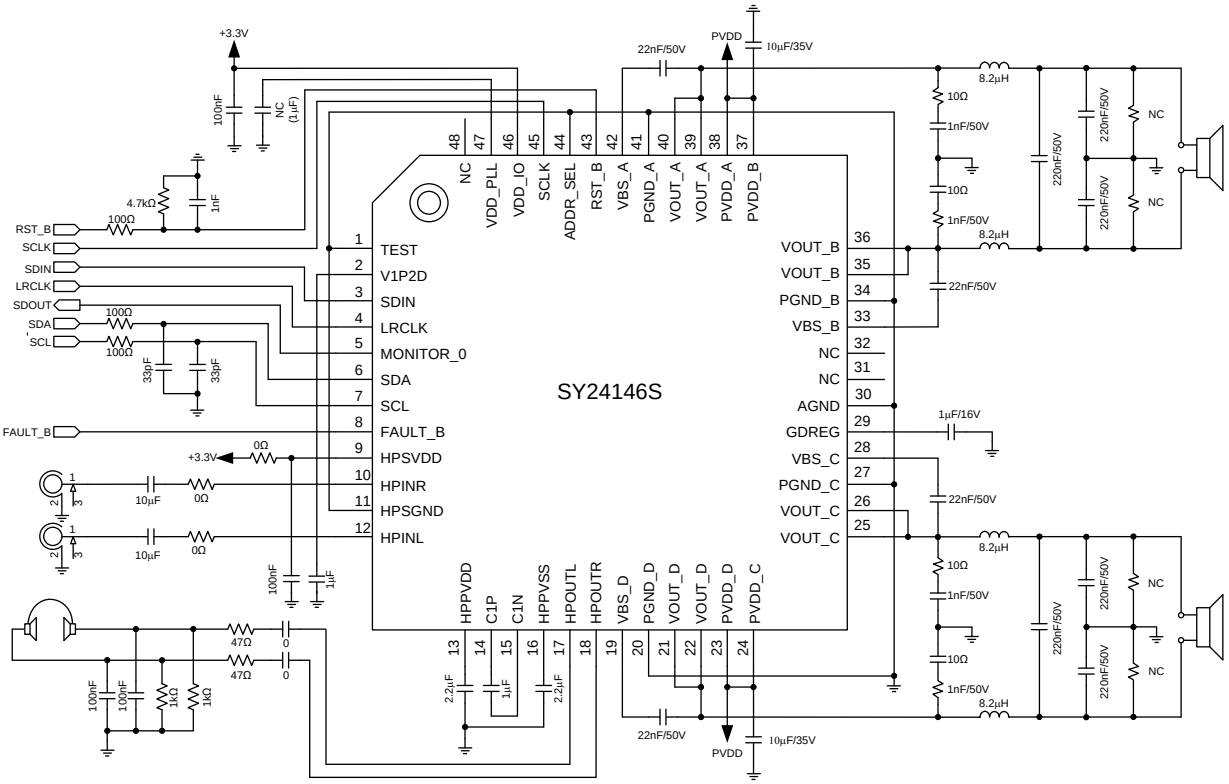

Figure1. Typical Application Circuit

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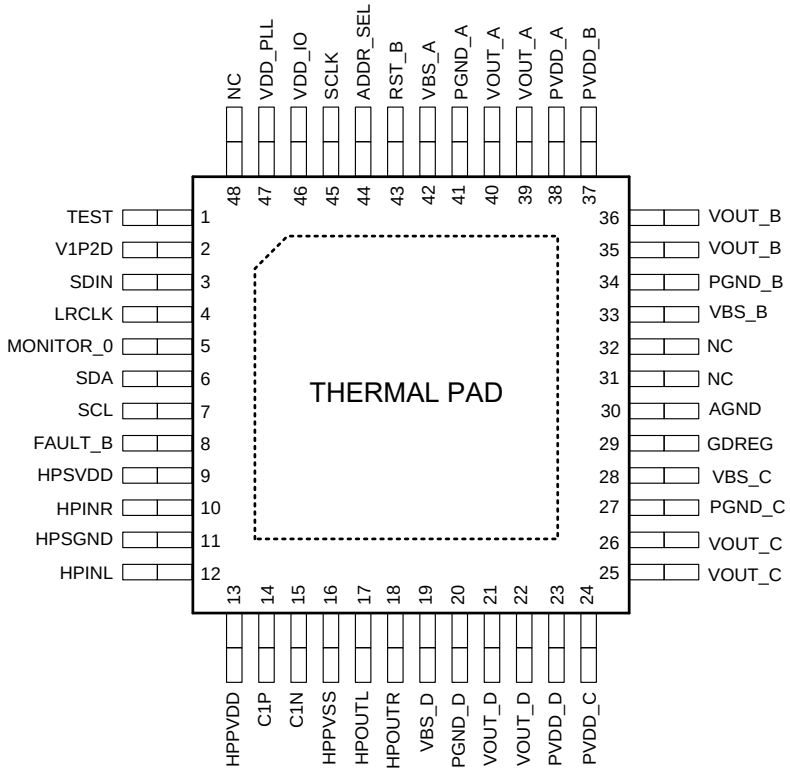
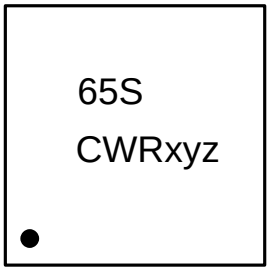
Pinout (top view)



(TQFP7×7-48E)

Marking Diagram



Note:
(1) "65S" is the partial part number, fixed.
(2) "CWRxyz" is the top marking code. **(**device code: CWR, ***x=year code, y=week code, z= lot number code)***

Pin Name	Pin Number	Type(1)	Termination(2)	Pin Description
VOUT_A	39,40	O		Half-bridge A output.
VOUT_B	35,36	O		Half-bridge B output.
VOUT_C	25,26	O		Half-bridge C output.
VOUT_D	21,22	O		Half-bridge D output.
PVDD_A	38	P		Power supply for half-bridge A.
PVDD_B	37	P		Power supply for half-bridge B.
PVDD_C	24	P		Power supply for half-bridge C.
PVDD_D	23	P		Power supply for half-bridge D.
VBS_A	42	P		High side supply offset voltage for half-bridge A.
VBS_B	33	P		High side supply offset voltage for half-bridge B.

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VBS_C	28	P		High side supply offset voltage for half-bridge C.
VBS_D	19	P		High side supply offset voltage for half-bridge D.
GDREG	29	P		Gate driver internal regulator output. This pin must not be used to drive external devices.
NC	31, 32, 48			No Connection.
VDD_IO	46	P		3.3V analog power supply.
ADDR_SEL	44	DI	Pull down	I^2C address select pin.
V1P2D	2	P		Internal regulated 1.2V digital power supply for digital core. This pin must not be used to power external devices.
VDD_PLL	47	P		Internal regulated 1.2V digital power supply for PLL. This pin must not be used to power external devices.
FAULT_B	8	DI	Pull up	This pin low means turning off the PWM signal path.
LRCLK	4	DI	Pull down	Serial audio data left or right clock input.
SCLK	45	DI	Pull down	Serial audio data bit clock input.
SDIN	3	DI	Pull down	Serial audio data input.
SDA	6	DIO	Pull up	I^2C serial control data input or output.
SCL	7	DI	Pull up	I^2C serial clock input.
MONITOR_0	5	DO		Monitoring signal out from processor block / I^2S output.
RST_B	43	DI	Pull-up	Logic low to this pin reset the system. When reset pulls low, DAP restores to its default conditions, and places the PWM in the hard mute state.
TEST	1	DI	Pull down	Test pin.
AGND	30	P		Power Stage Analog ground.
PGND_A	41	P		Power ground for half-bridge A.
PGND_B	34	P		Power ground for half-bridge B.
PGND_C	27	P		Power ground for half-bridge C.
PGND_D	20	P		Power ground for half-bridge D.
HPPVDD	13	P		Regulator output/HP-amp positive supply.
HPPVSS	16	P		Output from negative charge pump/HP-amp negative supply.
C1P	14	P		Charge pump flying capacitor positive terminal.
C1N	15	P		Charge pump flying capacitor negative terminal.
HPSVDD	9	P		Supply voltage.
HPSGND	11	P		Analog ground (connect to GND).
HPOUTL	17	O		Left audio channel output signal.
HPOUTR	18	O		Right audio channel output signal.
HPINR	10	I		Right audio channel input signal.
HPINL	12	I		Left audio channel input signal.

Note: (1) Type: A =analog; D =digital; P =power/ground/decoupling; I =input; O =output; IO=inout
(2) All pull-ups and pull-downs are weak.

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Block Diagram

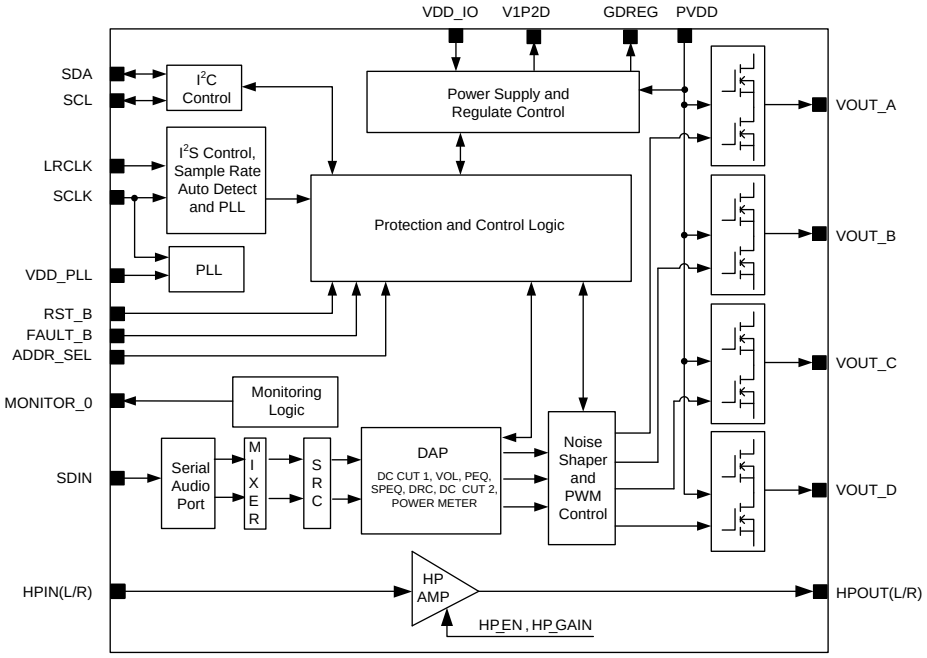

Figure2a. Audio-Power Amplifier Function Block

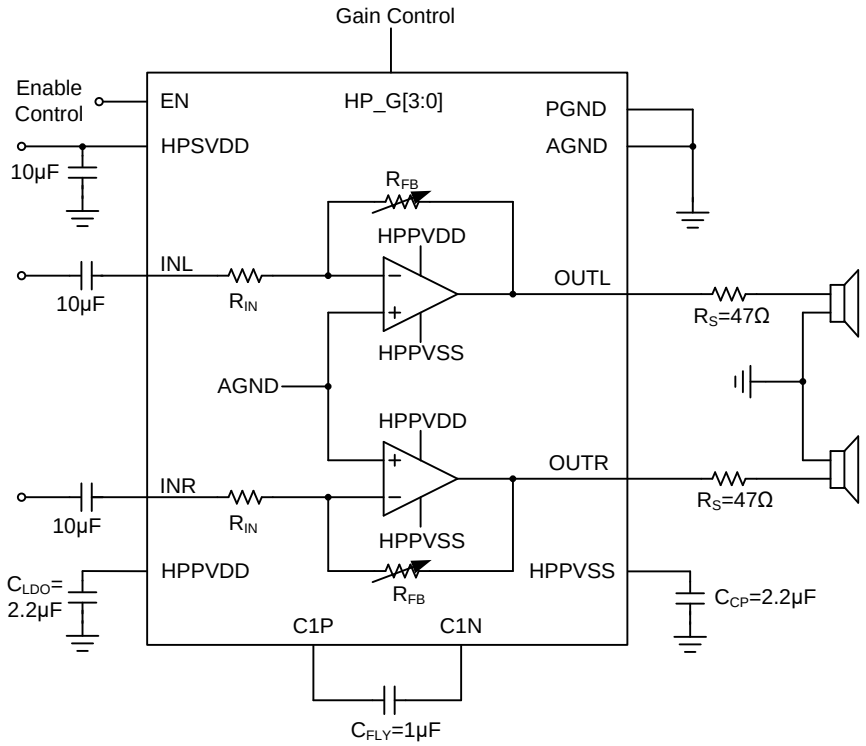

Figure2b. Headphone Driver Function Block

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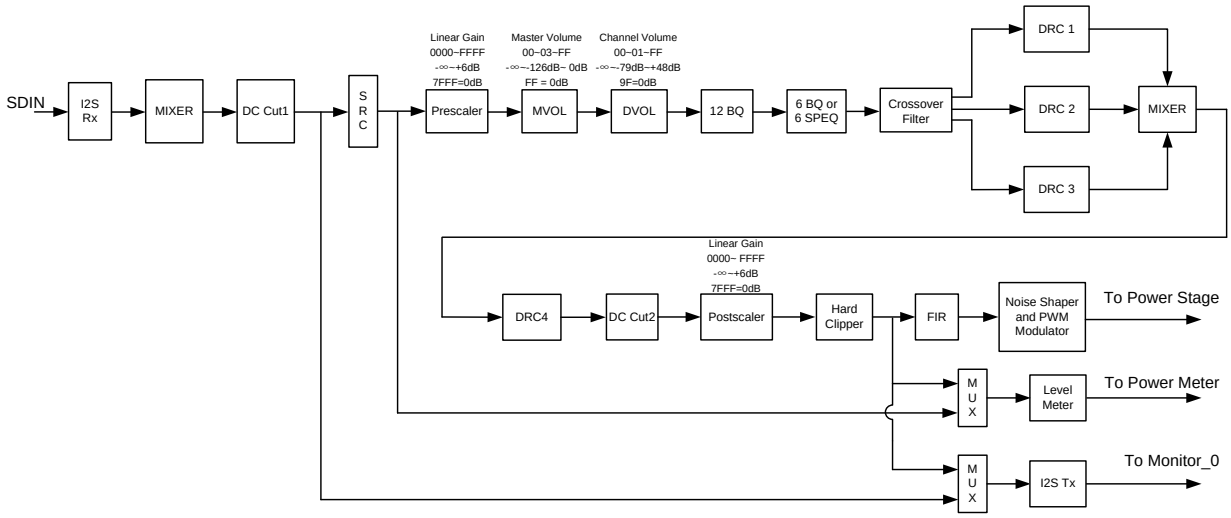

Figure2c. DAP Process Structure

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Absolute Maximum Ratings (Note 1)

VDD_IO, Power Supply for Digital Interface I/O ---------- -0.3V to 3.6V
PVDD, Half-bridge Supply Voltage (Note 2) ---------- -0.3V to 30V
Digital Input ---------- -0.5V to (VDD_IO+0.5) V
VOUT_x ---------- 30V
GDREG ---------- -0.5V to 4V
VBS_x to VOUT_x ---------- -0.5V to 4V
Power Dissipation, P_D @ T_A = 25°C, TQFP7×7-48E ---------- 5.68W
Package Thermal Resistance (Note 3)
θ_{JA} ---------- 22°C/W
θ_{JC} (top) ---------- 14.5°C/W
θ_{JB} ---------- 7°C/W
ψ_{JT} ---------- 0.2°C/W
Junction Temperature Range ---------- -10°C to 150°C
Storage Temperature Range ---------- -40°C to 125°C

Recommended Operating Conditions

VDD_IO, Power Supply for Digital Interface I/O ---------- 3.3V
PVDD, Half-bridge Supply Voltage ---------- 4.5V to 28V
$R_{L(BTL)}$, Load Impedance(BTL) ---------- 4~8Ω
$R_{L(PBTL)}$, Load Impedance(PBTL) ---------- 2~4Ω
Operating Ambient Temperature Range ---------- -10°C to 85°C
Operating Junction Temperature Range ---------- -10°C to 125°C

PWM Operation Conditions

Parameter	Test Conditions	Value	Unit
Output Sample Rate	44.1kHz data rate	352.8	kHz
	32/48/96kHz data rate	384	

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Electrical Characteristics

DC Characteristics

(T_A=25°C, PVDD=18V, VDD_IO=HPSVDD=3.3V, R_L=8Ω, f_S=48kHz, BTL Ternary Mode, $Gain_{HP}$=6dB, R_S=47Ω, R_{HP}=32Ω, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
PVDD	Half-bridge Supply Voltage		4.5		28	V
VDD_IO	Power Supply for Digital Interface I/O		3		3.6	V
GDREG	Gate Drive Supply		3.2		3.4	V
V_{IH}	High Level Input Voltage	TEST, SDIN, LRCLK, SDA, SCL, FAULT_B, RST_B, ADDR_SEL, SCLK	2			V
V_{IL}	Low Level Input Voltage	TEST, SDIN, LRCLK, SDA, SCL, FAULT_B, RST_B, ADDR_SEL, SCLK			0.8	V
I_{IL}	Low Level Input Current	TEST, SDIN, LRCLK, SDA, SCL, FAULT_B, RST_B, ADDR_SEL, SCLK			75	μA
I_{IH}	High Level Input Current	TEST, SDIN, LRCLK, SDA, SCL, FAULT_B, RST_B, ADDR_SEL, SCLK			75	μA
I_{VDD_IO}	3.3V Supply Current	No Input, No Load		11.4		mA
		Reset(RST_B = low, FAULT_B = high)		0.75		
I_{PVDD}	No Load, Half-bridge Supply Current (Without Snubber)	Normal		23.6		mA
		Reset(RST_B = low, FAULT_B = high)		1.3		
Power MOSFET						
$R_{DS(ON)}$	High Side Drain-to-source Resistance	T_j=25°C, includes metallization resistance		110		mΩ
	Low Side Drain-to-source Resistance			110		mΩ
Load Diagnostics						
OLDT	Open-load detection threshold	Including speaker wires		100		Ω
SLDT	Short-load detection threshold	Including speaker wires		1.5		
	Resistance to detect a short from OUT pin(s) to ground				100	
	Voltage to detect a short from output pin(s) to power supply		5.5			V
I/O Protection						
V_{UVP}	PVDD Falling			3.4		V
	PVDD Rising			4		
OVTP	Over Temperature Protection			150		°C
$OVTP_{HYST}$	Over Temperature Protection Hysteresis			30		°C
I_{OVC}	Over Current Protection			7.5		A
Headphone Amplifier						
I_Q	Quiescent Supply Current	EN=1, no Load		9.5		mA
		EN=0, no Load		0.5		μA

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$\|V_{OS}\|$	Output Offset Voltage	V_I=0V		1	10	mV
HPPVDD	LDO Output Voltage	No load	3.05	3.25		V
HPPVSS	Charge Pump Output Voltage	No load		-3.2	-2.95	V

AC Characteristics (Note 3)

(T_A=25°C, C_{VBS}=22nF, Audio frequency=1kHz, f_S=48kHz, AES17 filter, Snubber=10Ω+1nF, BTL ternary mode, HPSVDD=3.3V, $Gain_{HP}$=6dB, R_S=47Ω, R_{HP}=32Ω,unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Speaker Amplifier						
P_o	Output Power	BTL Mode, PVDD=12V, R_L=8Ω, 1%THD+N		8.1		W
		BTL Mode, PVDD=12V, R_L =8Ω, 10%THD+N		10.0		
		BTL Mode, PVDD=12V, R_L=6Ω, 1%THD+N		10.1		
		BTL Mode, PVDD=12V, R_L=6Ω, 10%THD+N		12.5		
		BTL Mode, PVDD=13.2V, R_L=6Ω, 1%THD+N		12.3		
		BTL Mode, PVDD=13.2V, R_L=6Ω,10%THD+N		15.2		
		BTL Mode, PVDD=18V, R_L=8Ω, 1%THD+N		18.2		
		BTL Mode, PVDD=18V, R_L=8Ω, 10%THD+N		22.4		
		BTL Mode, PVDD=18V, R_L=6Ω, 1%THD+N		22.9		
		BTL Mode, PVDD=18V, R_L=6Ω, 10%THD+N		28.1		
		BTL Mode, PVDD=24V, R_L=8Ω, 1%THD+N		32.2		
		BTL Mode, PVDD=24V, R_L=8Ω, 10%THD+N		39.5		
		PBTL Mode, PVDD=12V, R_L=4Ω,1%THD+N		16.2		
		PBTL Mode, PVDD=12V, R_L=4Ω,10%THD+N		20.0		
		PBTL Mode, PVDD=18V, R_L=4Ω,1%THD+N		36.4		
		PBTL Mode, PVDD=24V, R_L=4Ω,1%THD+N		64.2		
THD+N	Total Harmonic Distortion and Noise	PVDD=12V , R_L=8Ω , P_O=1W		0.035		%
		PVDD=13.2V , R_L=6Ω , P_O=1W		0.044		
		PVDD=18V , R_L=8Ω , P_O=1W		0.026		
		PVDD=20V , R_L=6Ω , P_O=1W		0.033		
		PVDD=24V , R_L=8Ω , P_O=1W		0.030		
V_n	Output Integrated Noise (rms)	PVDD=18V, R_L=8Ω, A-weighted		73.4		μV
CT	Crosstalk	PVDD=20V, P_o=1W , f =1kHz		79.6		dB
SNR	Signal to Noise Ratio	PVDD=20V, A-weighted, f=1kHz , Maximum power at THD+N <1%,		101.3		
BW	Bandwidth	44.1kHz data rate		20.021		kHz
		32/48/96kHz data rate		21.792		
Headphone Amplifier						
P_o	Output Power	THD+N=1%, HPSVDD =3.3V, f=1kHz		21.4		mW
		THD+N =1%, HPSVDD=5.0V, f=1kHz		22.4		
		THD+N =1%, HPSVDD =3.3V, f=1kHz, R_{HP}=16Ω		17.4		
THD+N	Total Harmonic Distortion and Noise	P_o=10mW, f=1kHz		0.017		%
		V_o=2V_{rms}, R_{HP}=47kΩ, f=1kHz		0.009		
CT	Crosstalk	P_o=10mW, f=1kHz		100		dB
		V_o=2V_{rms}, R_{HP}=47kΩ, f=1kHz		109		
V_n	Output Integrated Noise(rms)	20Hz to 22kHz, A-weighted filter, Gain=0dB		2.6		μV
SNR	Signal to Noise Ratio	P_o=10mW, A-weighted , f =1kHz		107		dB
		A-weighted , f =1kHz , maximum power at THD+N <1%		110		
		V_O=2Vrms, R_{HP}=47kΩ		110		
PSRR	Power Supply Rejection Ratio	200mV_{pp} ripple, f=1kHz		-83		dB

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Note 1: Stresses beyond the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2: DC voltage rating could be derated a little according to the possible switching spike on switching node if the snubber is not appropriate enough.

Note 3: θ_{JA} is measured in the natural convection at T_A = 25°C on a high effective four layer thermal conductivity test board with thermal vias in accordance with JESD51-5,-7, other thermal resistance data acquired followed JESD51-8,-14.

Note 4: Typical value tested on demonstration board is guaranteed by design.

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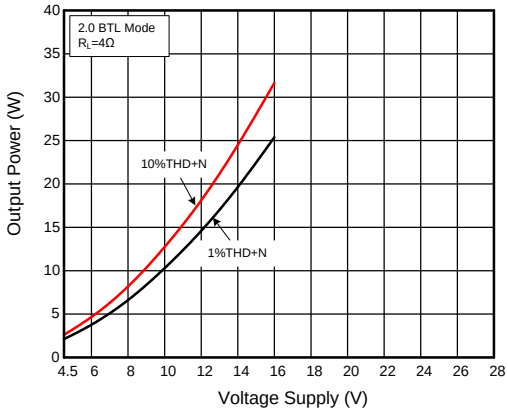
Typical Performance Characteristics

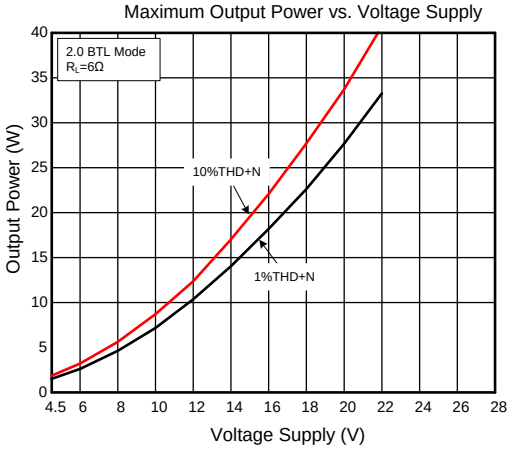
Speaker

(All Measurements taken at T_A=25°C, C_{VBS}=22nF, f_S=48kHz, AES17 filter, Snubber=10Ω+1nF, unless otherwise noted.)

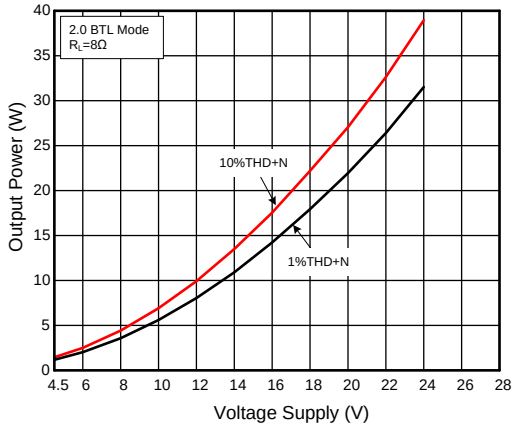
Maximum Output Power vs. Voltage Supply



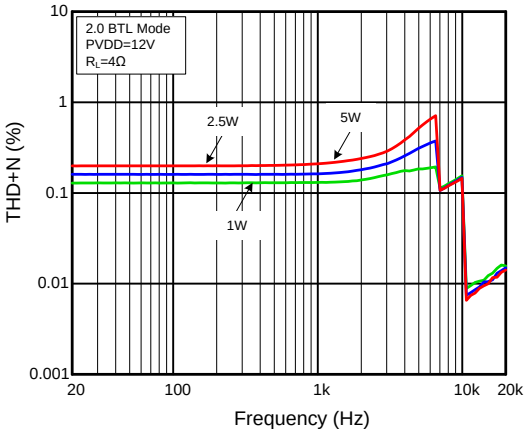
Maximum Output Power vs. Voltage Supply



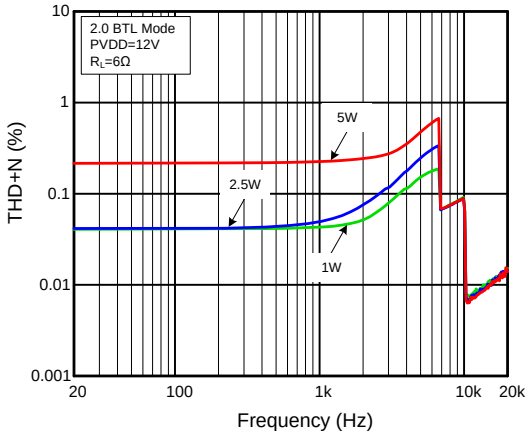
Maximum Output Power vs. Voltage Supply



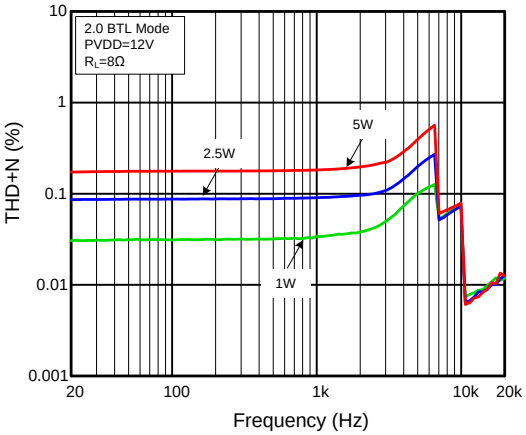
THD+N vs. Frequency



THD+N vs. Frequency



THD+N vs. Frequency



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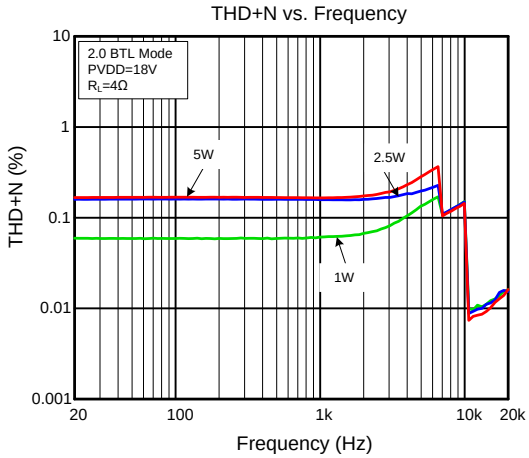

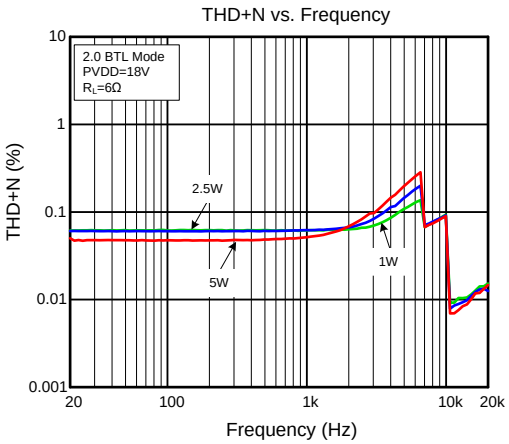

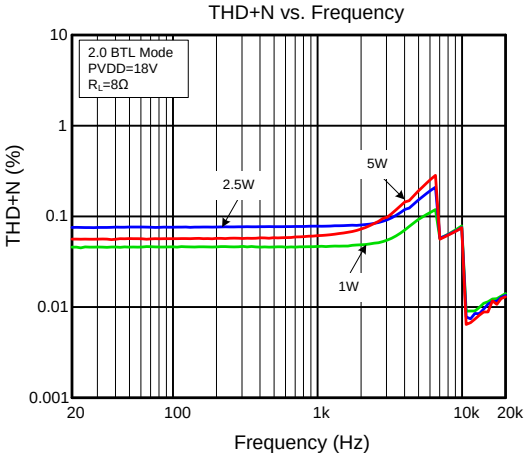

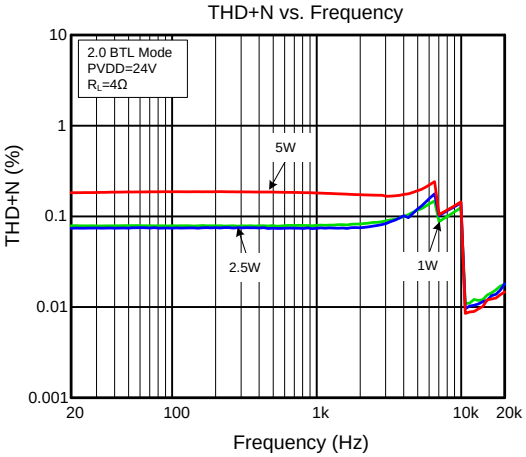

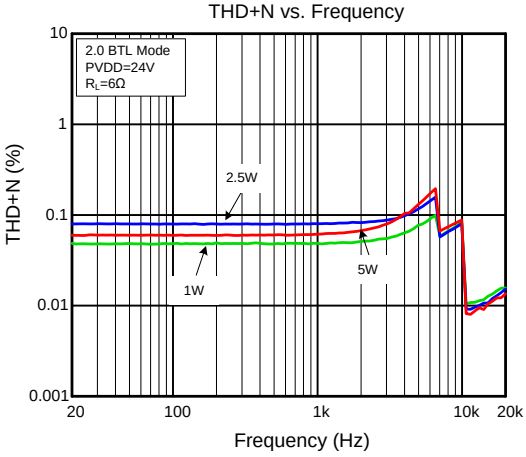

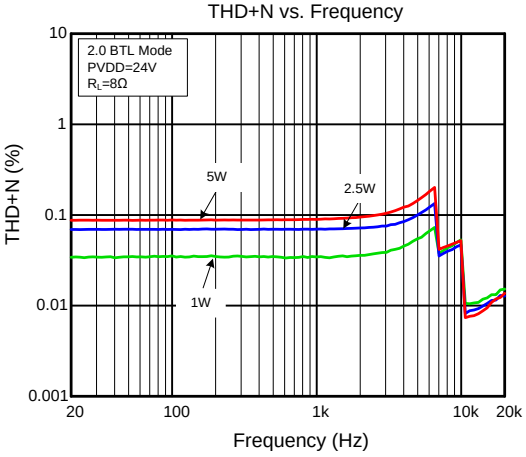

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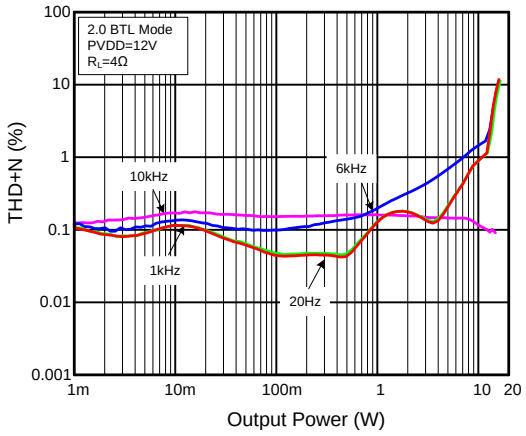
THD+N vs. Output Power



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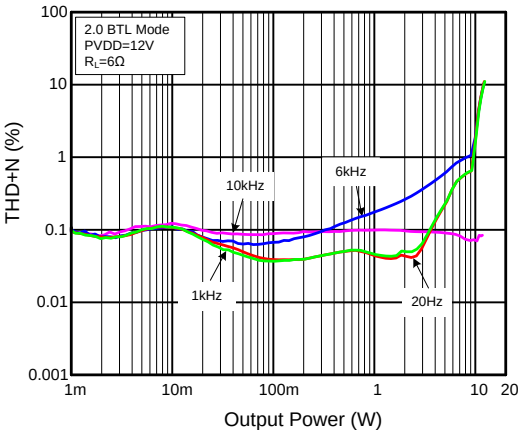
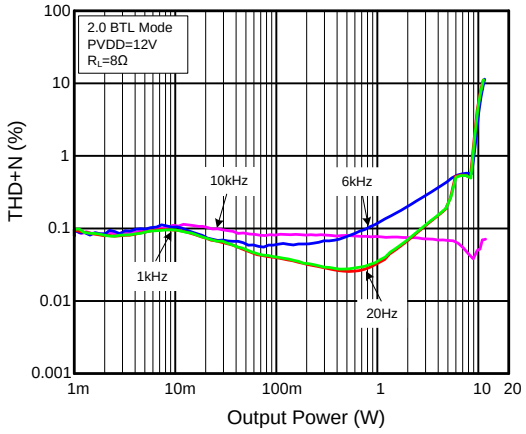
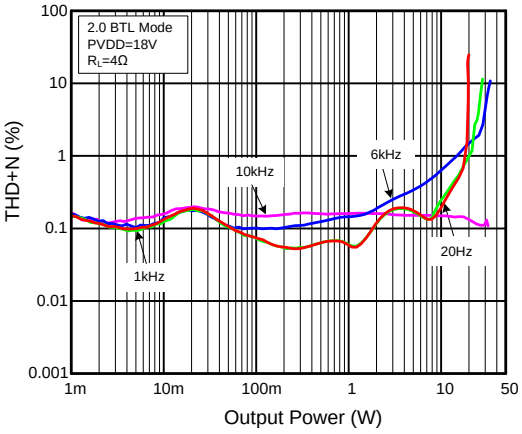


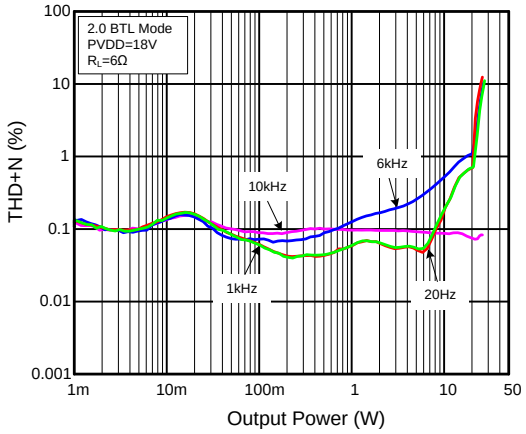
THD+N vs. Output Power



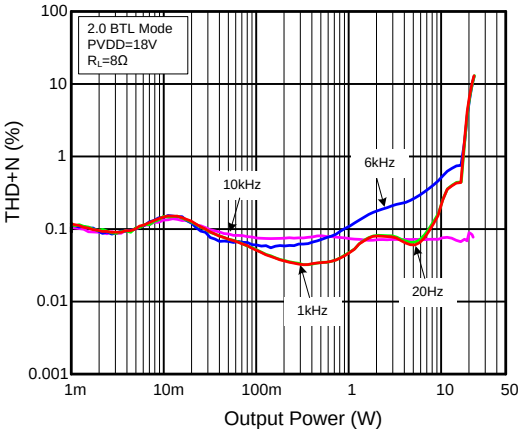
THD+N vs. Output Power



THD+N vs. Output Power



THD+N vs. Output Power



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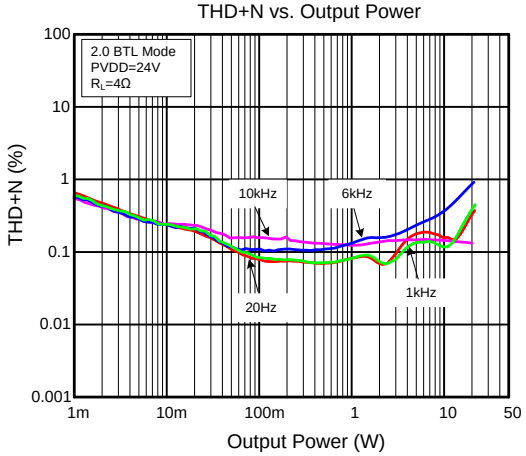
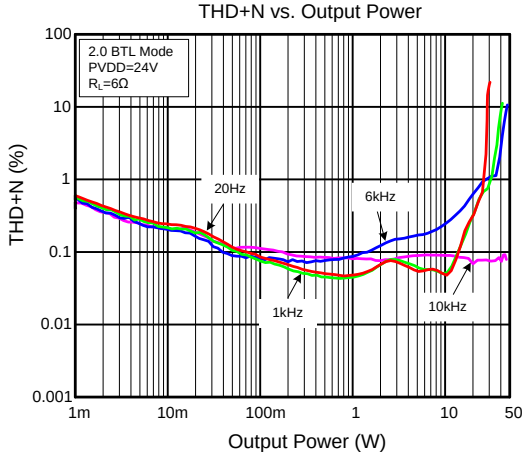
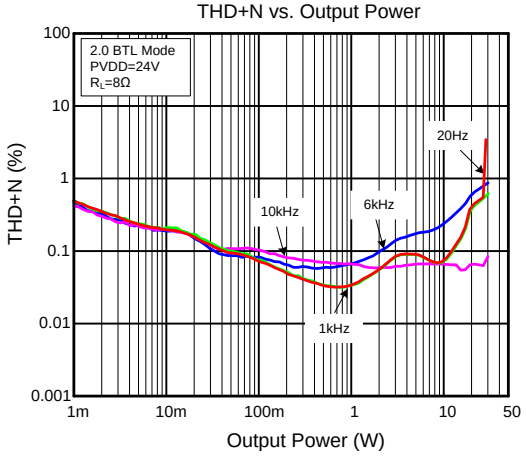
THD+N vs. Output Power



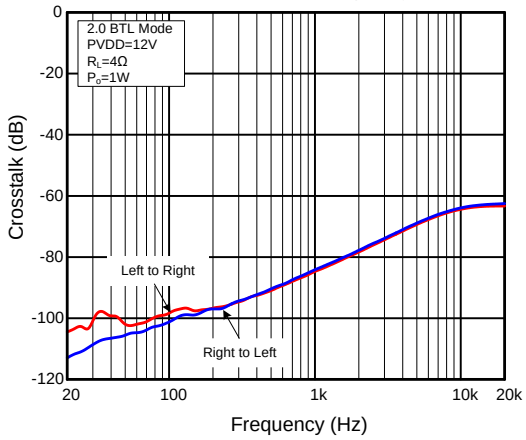
THD+N vs. Output Power



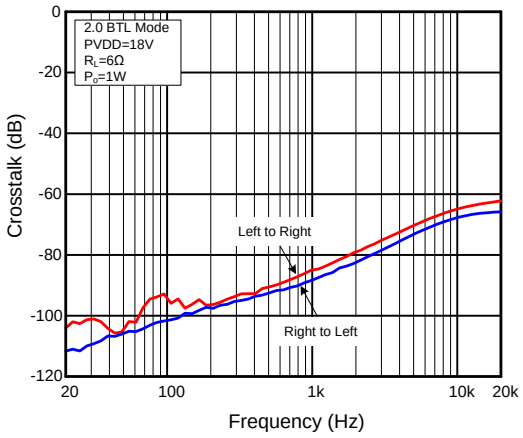
THD+N vs. Output Power



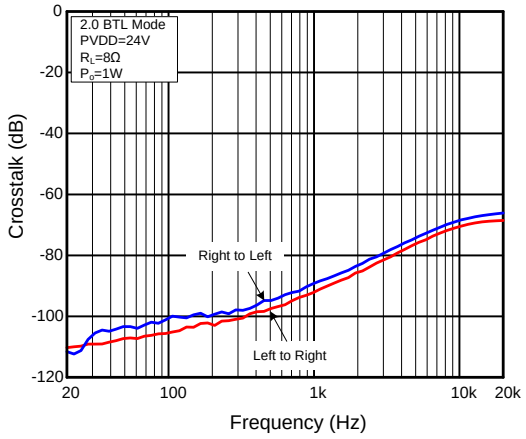
Crosstalk vs. Frequency



Crosstalk vs. Frequency



Crosstalk vs. Frequency



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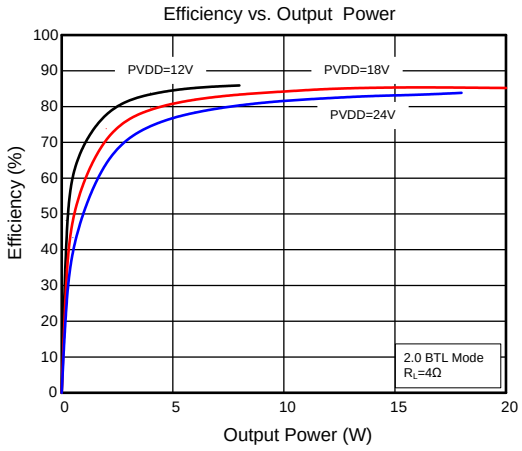

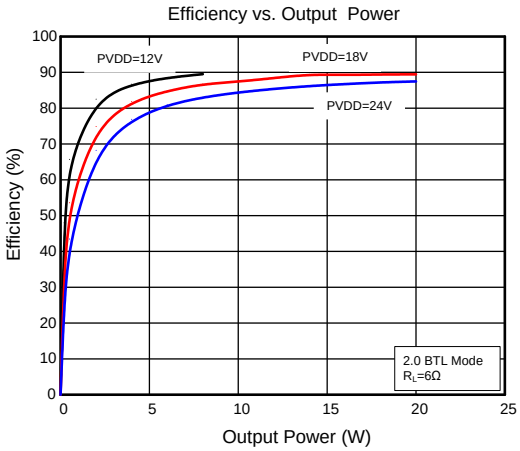

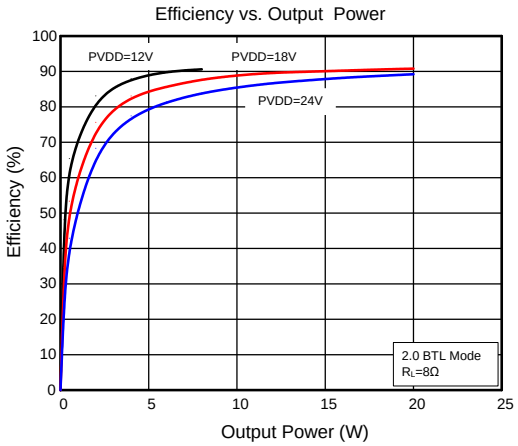

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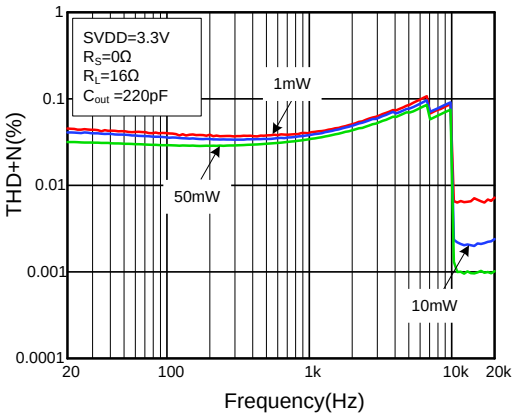
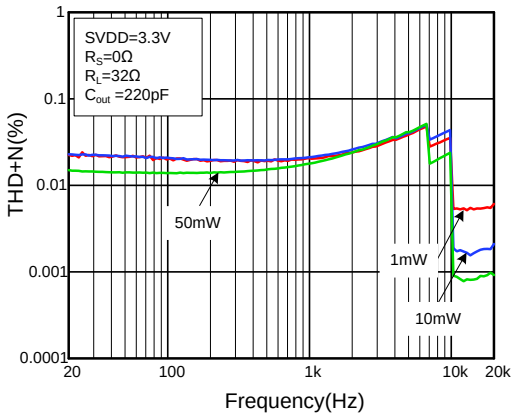
Headphone

(All Measurements taken at CLDO=2.2uF, CFLY=1uF, CCP=2.2uF, f=1kHz, Gain=6dB, unless otherwise noted.)

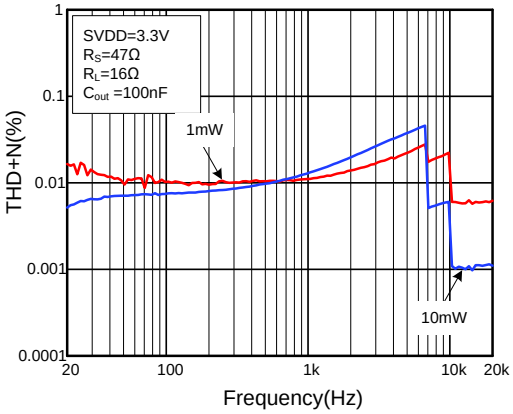
THD+N vs. Frequency



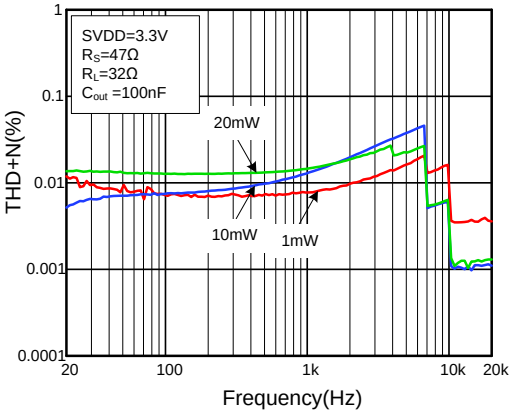
THD+N vs. Frequency



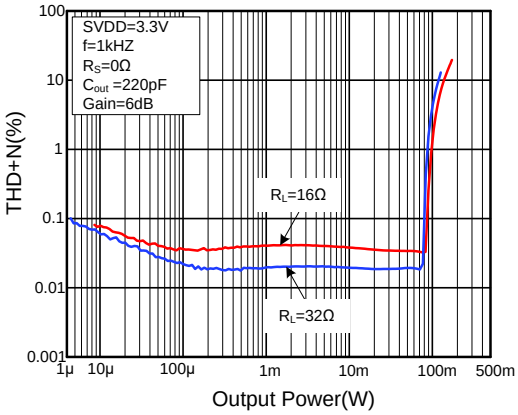
THD+N vs. Frequency



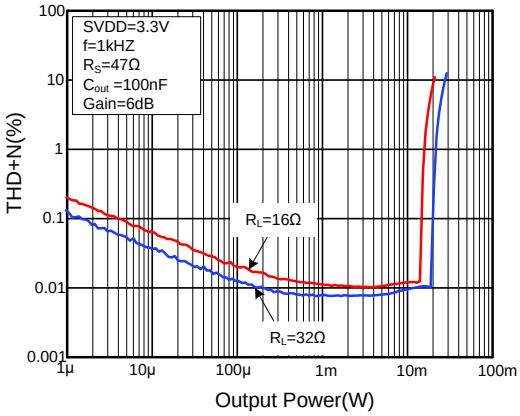
THD+N vs. Frequency



THD+N vs. Output Power



THD+N vs. Output Power



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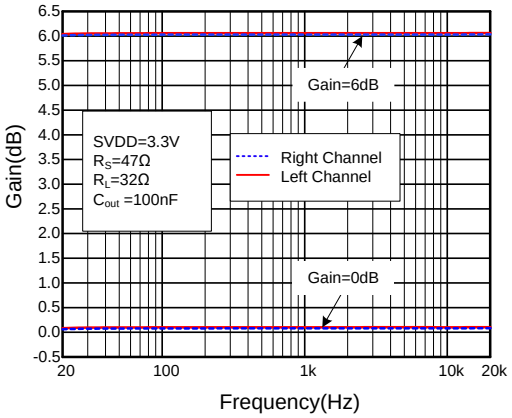
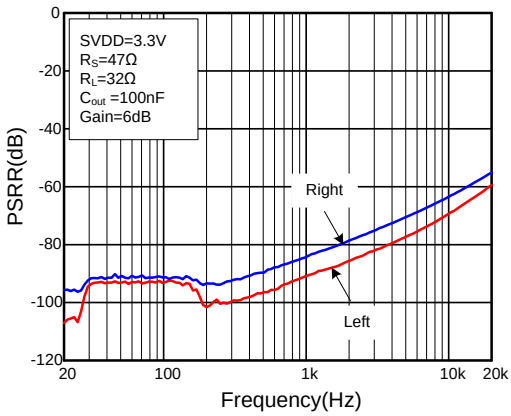
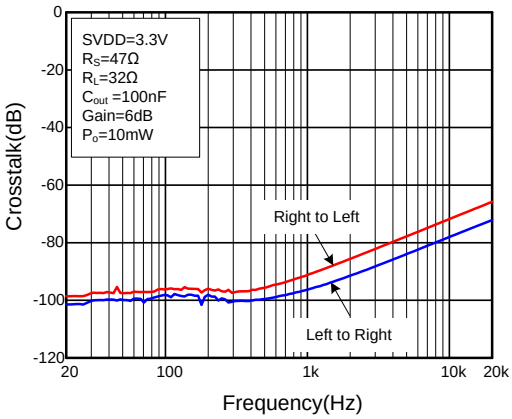
Gain vs. Frequency



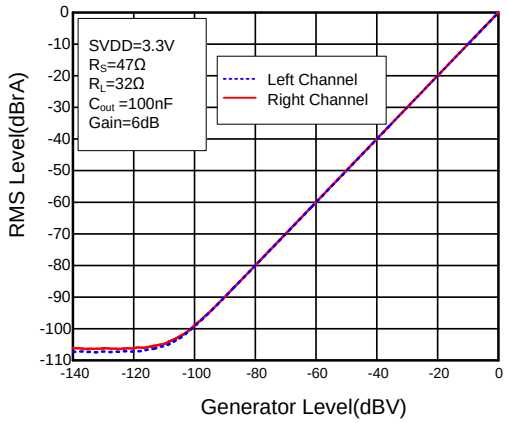
PSRR vs. Frequency



Crosstalk vs. Frequency



SNR



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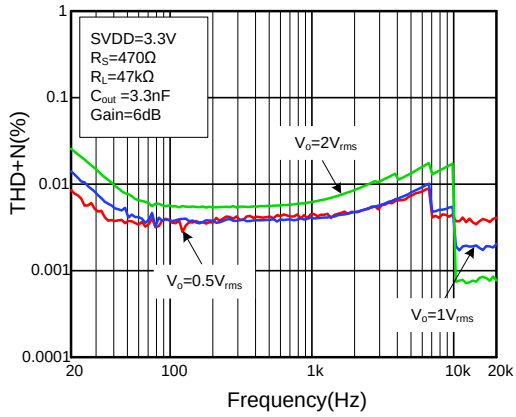
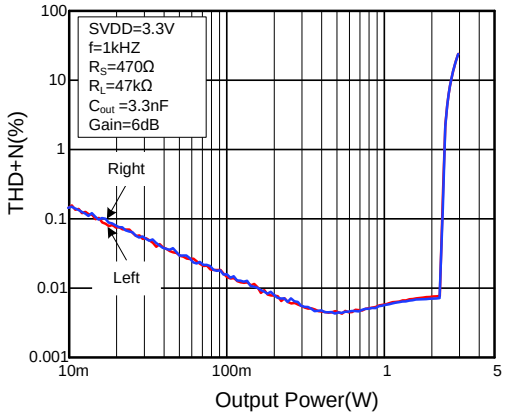
Line Out

(All Measurements taken at CLDO=2.2uF, CFLY=1uF, CCP=2.2uF, f=1 kHz, Gain=6dB, unless otherwise noted.)

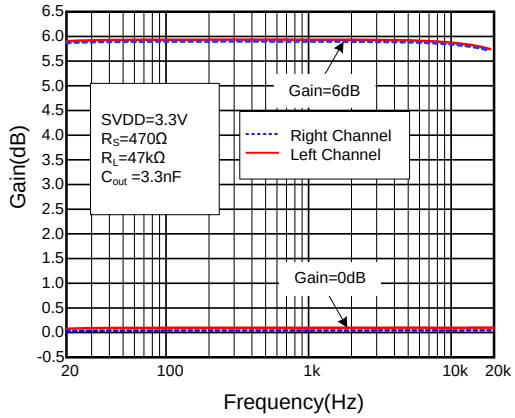
THD+N vs. Frequency



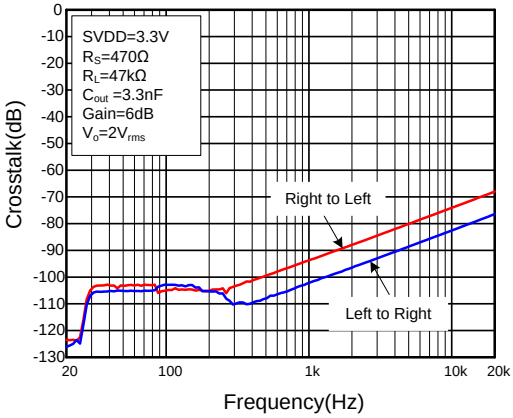
THD+N vs. Output Power



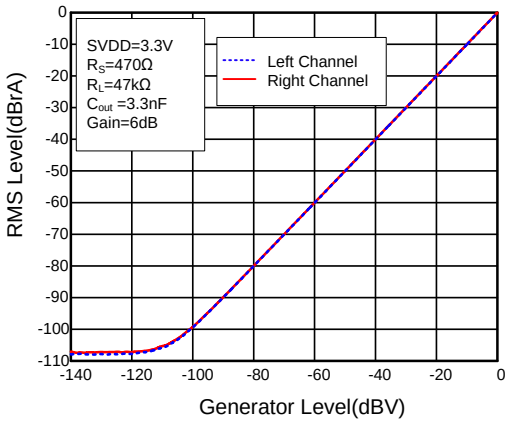
Gain vs. Frequency



Crosstalk vs. Frequency



SNR



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I²C Serial Control Port Operation

Symbol	Parameter	Conditions	Min	Max	Unit
f_{SCL}	SCL frequency	No wait states		400	kHz
t_r	SCL and SDA rise time			300	ns
t_f	SCL and SDA fall time			300	ns
t_{WH}	SCL high duration time		0.6		µs
t_{WL}	SCL low duration time		1.3		µs
t_{S1}	SDA to SCL setup time		100		ns
t_{h1}	SCL to SDA hold time		0		ns
t_{buf}	Free time between stop and start condition		1.3		µs
t_{S2}	SCL to start condition		0.6		µs
t_{h2}	Start condition to SCL hold time		0.6		µs
t_{S3}	SCL to stop condition		0.6		µs
C_{Load}	Load capacitor for each bus line			400	pF

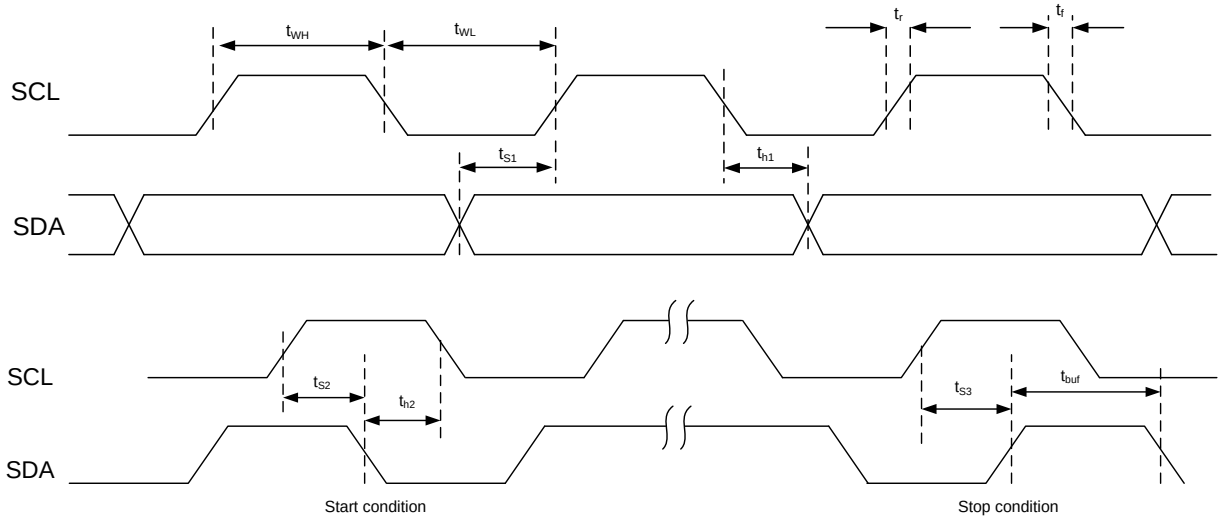

Figure 1. I²C Timing Diagram

Reset Timing (RST_B)

Symbol	Parameter	Min	Typ	Max	Unit
t_{WRST}	RESET active pulse duration	100			µs
t_{delay_I2C}	Enable I²C duration time			12.0	ms

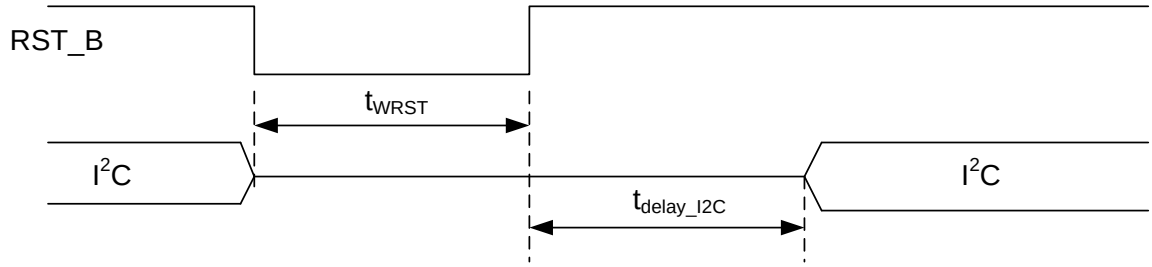

Figure 2. Reset Timing Diagram

Notes: 1. RST_B is held low for at least 100 us after VDD_IO has reached 3V on power up.

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Serial Audio Ports Slave Mode

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{SCLK}	SCLK frequency	C_{load}=30pF	2.048		6.144	MHz
t_{S4}	LRCLK to SCLK rising edge setup time		10			ns
t_{h3}	LRCLK FROM SCLK rising edge hold time		10			ns
t_{S5}	SDIN to SCLK rising edge setup time		10			ns
t_{h4}	SDIN from SCLK rising tome hold time		10			ns
f_{LRCLK}	LRCLK frequency		32	48	96	kHz
	SCLK duty cycle		40%	50%	60%	
	LRCLK duty cycle		40%	50%	60%	
t_{edge}	LRCLK edge with respect to the falling edge of SCLK		-1/4		1/4	SCLK period
t_{rs}	Rise for SCLK/LRCLK				8	ns
t_{fs}	fall time for SCLK/LRCLK				8	ns

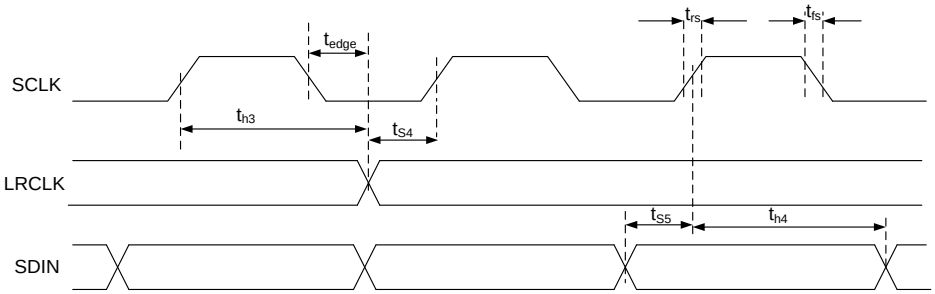

Figure 3. I²S Timing Diagram

Detailed Description and Theory of Operation

Under Voltage Protection and Power on Reset

When power on, the power on reset circuit resets the overload circuit and ensures that all circuits are fully operational when PVDD and AVDD (connected to VDD_IO internally) supply voltage reach 4.0V and 2.7V respectively. A voltage drops below the UVP threshold on AVDD or PVDD results in all half bridge outputs being set in the high impedance state, and the FAULT_B_OD being set to low.

Clock, Auto Detection and PLL

This device is a slave only device. The digital audio processor supports all the sample rates and SCLK rates that are defined in the clock control register.

The DAP only supports a 1fs LRCLK. The clock section uses SCLK or the internal oscillator clock (when SCLK is unstable, out of range, or absent) to produce the internal clock running at 512 times the PWM switching frequency. The sample rate can be set by external MCU as well as auto-detected by the DAP. If bit 4 of register 0x00 is set to 1, the sample rate should be configured by MCU. 32kHz, 44.1kHz/48kHz and 96kHz can be set by programming Bit[3:2] of register 0x00. If bit 4 of register 0x00 is set to 0, the DAP can auto detect the sample rate. The detected sample rate can be read back from the bit[7:6] of register 0x00. For example, if the sample rate is changed from 48kHz to 96kHz, the setting of PLL will be auto configured and the DAP clock and PWM frequency keeps no change.

The device has robust clock error handing that uses the built-in trimmed oscillator clock to quickly detect changes or errors. Once the system detects a clock change or error, it will mute the audio and then force PLL to limp using the internal oscillator as a reference clock. Once the clock is stable, the system will revert to normal operation. During this operation, the default volume will be restored in a single step (also called hard unmute). The ramp process can be programmed to ramp back slowly (also called soft unmute) as defined in volume register (0x06).

Serial Data Interface

Serial data is input on SDIN. The PWM outputs are derived from SDIN. The DAP accepts serial data in 16, 18, 20, or 24bit left justified, right justified, and I²S serial data formats.

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PWM Section

The device PWM section accepts 24bit PCM data from DAP and output two BTL PWM audio output channels. The PWM section has an adjustable maximum modulation limit of 96.1% to 98.2%.

Serial Interface Control and Timing

The I²S mode is set by writing to register 0x15.

I²S Timing

I²S uses LRCLK to define when the data being transmitted is for the left channel and when it is for the right channel. LRCLK is low for the left channel and high for the right channel. A clock running at 32fs/48fs/64fs is used to clock in data. There is a delay of one cycle from the time the LRCLK changes state to the first bit of data on the data lines. The data is written MSB first and is valid on the rising edge of clock. The DAP masks unused trailing data bit positions.

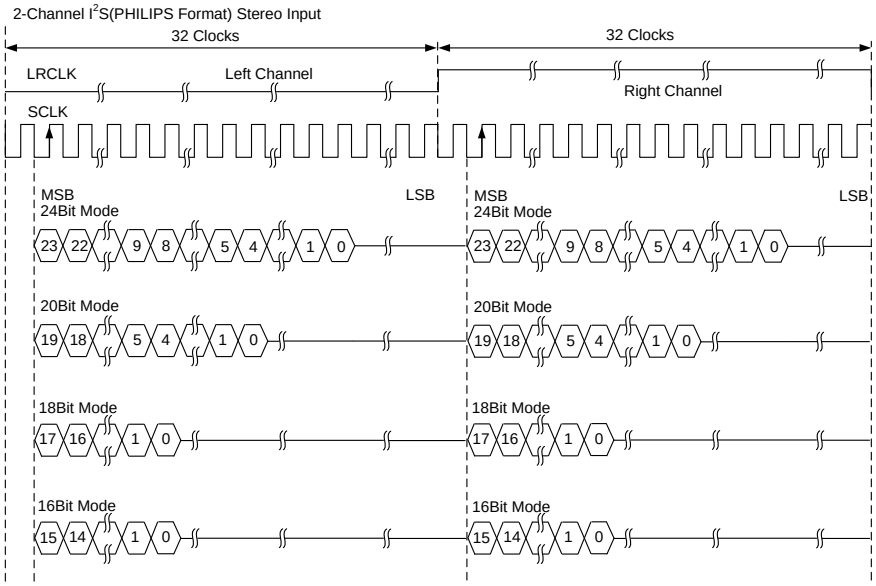

Figure6. I²S 64fs Format

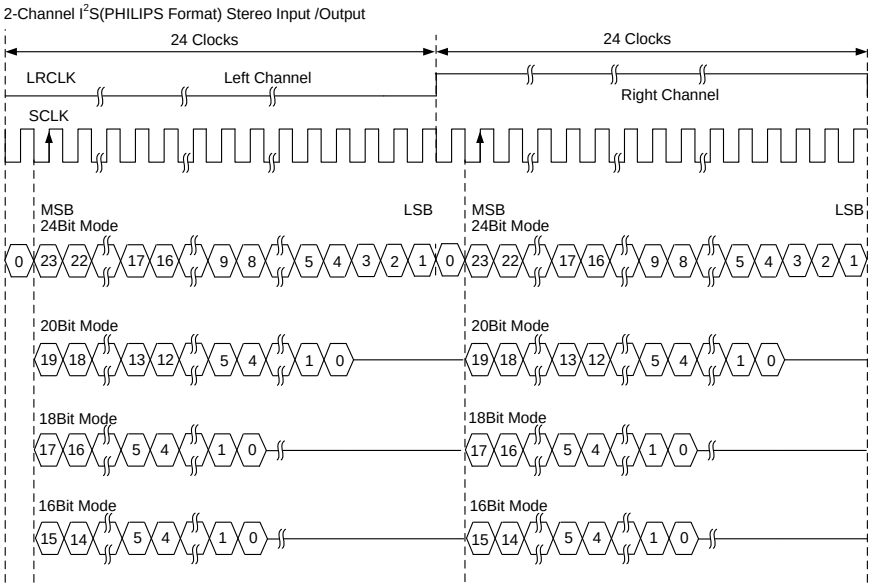

Figure7. I²S 48fs Format

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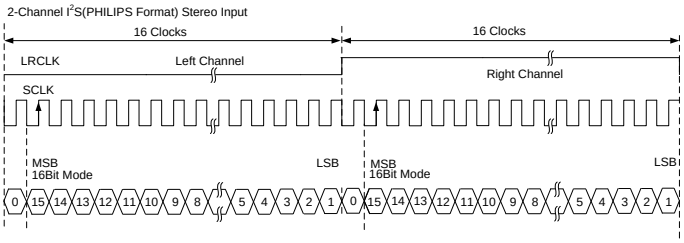

Figure8. I²S 32fs Format

Left Justified

Left Justified (LJ) timing uses LRCLK to define when the data being transmitted is for the left channel and when it is for the right channel. LRCLK is high for the left channel and low for the right channel. A clock running at 32fs/48fs/64fs is used to clock in data. The first bit of data on the data lines at the same time LRCLK toggles. The data is written MSB first and is valid on the rising edge of clock. The DAP masks unused trailing data bit positions.

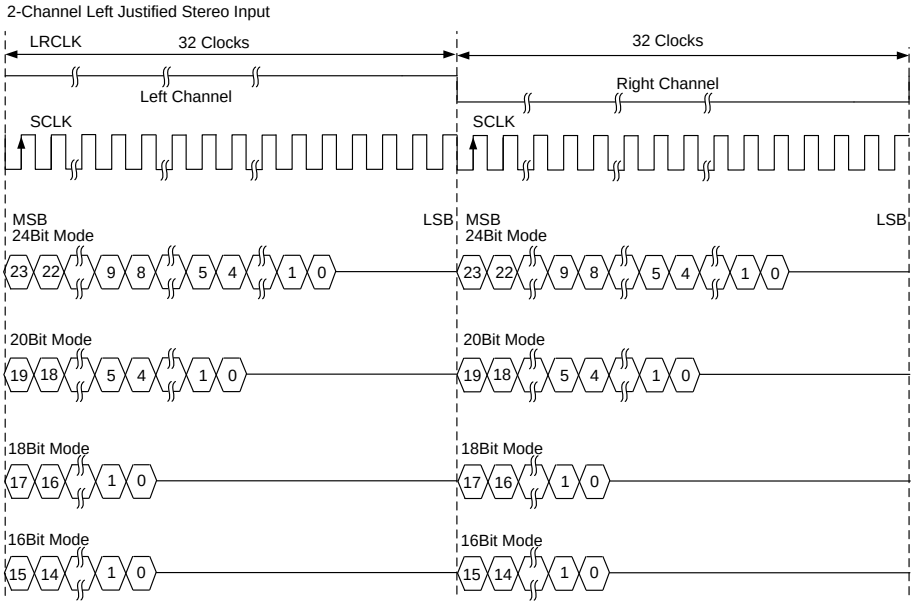

Figure9. Left Justified 64fs Format

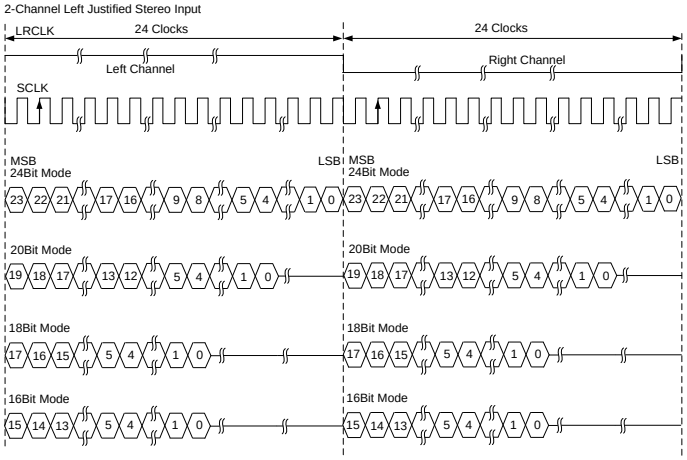

Figure10. Left Justified 48fs Format

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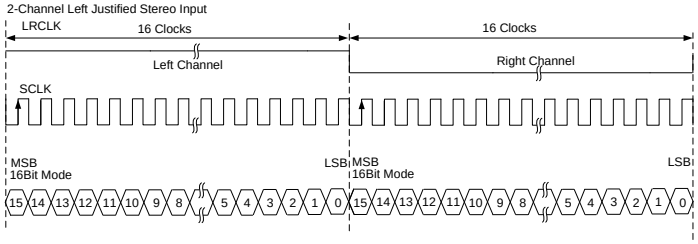

Figure11. Left Justified 32f$_s$ Format

Right Justified

Right Justified (RJ) timing uses LRCLK to define when the data being transmitted is for the left channel and when it is for the right channel. LRCLK is high for the left channel and low for the right channel. A clock running at 32fs/48fs/64fs is used to clock in data. The first bit of data on the data 8bit clock periods after LRCLK toggles. The data is written MSB first and is valid on the rising edge of clock. The DAP masks unused trailing data bit positions.

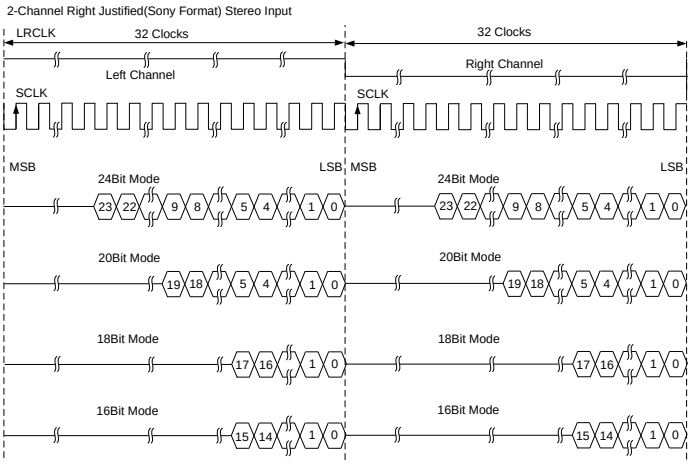

Figure12. Right Justified 64f$_s$ Format

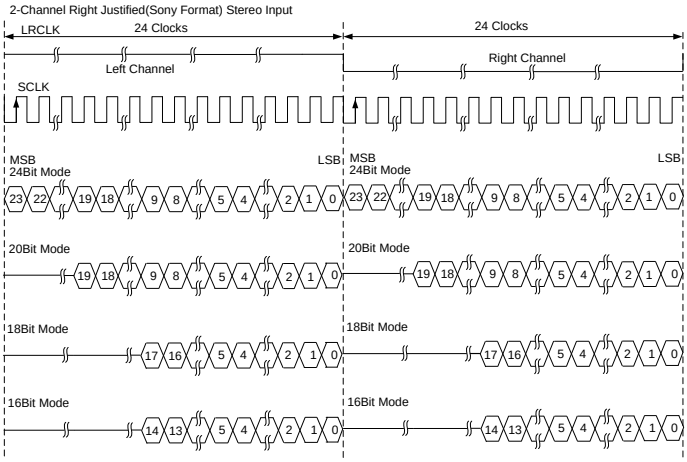

Figure13. Right Justified 48f$_s$ Format

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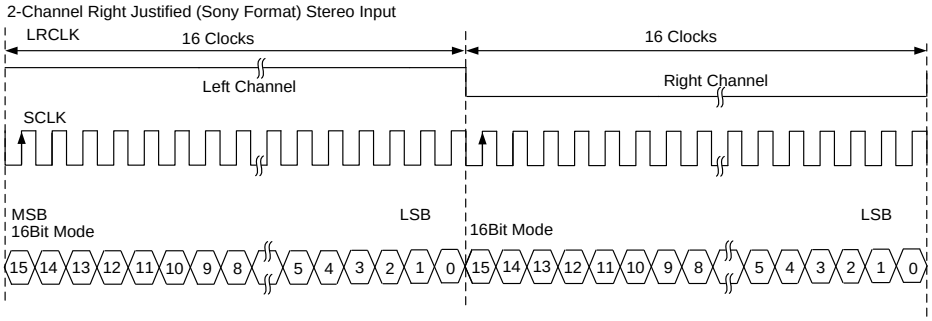

Figure14. Right Justified 32f_s Format

I²C Serial Control Interface

The device DAP has a bidirectional I²C interface that compatible with the I²C bus protocol and supports both 100kHz and 400kHz data transfer rates for single and multiple byte write and read operations. The device does not support a multi-master bus or wait state insertion. The I²C control is used to program the registers of the device and to read device status. The device performs all I²C operations without I²C wait cycles.

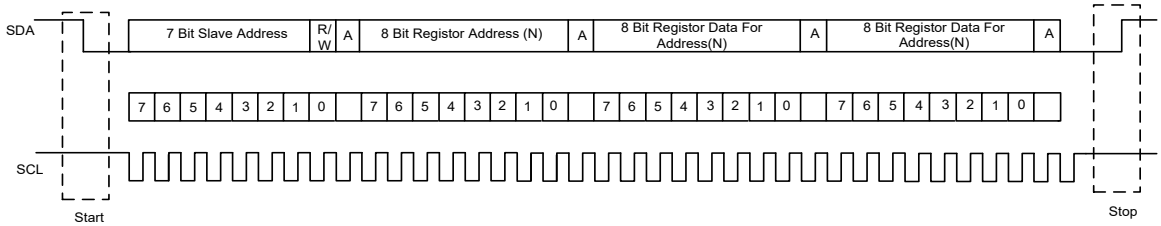

Figure15. Typical I²C Sequence

There can be many other slave devices on the I²C bus; the master will send a target slave address on the first byte. 7 bits from the 1st to 7th bit of the target slave address byte are used for the slave address. The lowest bit (the R/W bit) defines whether write (1'b0) to the slave device or read (1'b1) from the slave device.

There are up to four I²C device address in SY24146S. The ADDR_SEL pin and the initial state of MONITOR_0 pin define the address. For example, SY24146S will response with the slave address 7'b0101010 if the ADDR_SEL pin is connected to GND via a 15kΩ resistor, and the initial state of the MONITOR_0 pin is 'L'. So the first byte will be 8'b01010100 (0x54) when the data are written to the SY24146S. Refer to the following table for detailed device address configuration.

I²C Slave Address		Monitor_0		
		Pull- down('L')	Pull- up('H')	No PD/PU(Default: 'L')
ADDR_SEL	Pull-down('L')	0x54	0x58	0x54
	Pull-up('H')	0x56	0x5A	0x56

Table 1. I²CSlave Address

I²C Device Address Change Procedure

Write to device address change enable register (0xF8) with value of 0xF9A5A5A5 to enable changing I²C device address. Write to device register 0xF9 with the new address 0x0000 00XX, where XX is the new address. Any write after that should use the new device address XX.

Single and Multiple Byte Transfers

The I²C serial control interface supports both single byte and multiple byte read/write operations for sub addresses 0x00 to 0xFF.

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During the multiple byte read operations, the DAP responds with data, a byte at a time, starting at the sub address assigned, as long as the master device continues to response with acknowledges. If a particular sub address does not contain 8*N bits, the unused bits are read as logic 0.

During multiple byte write operations, the DAP compares the number of bytes transmitted to the number of bytes that are required for each specific sub address. For example, if a write command is received for a bi-quad sub address, the DAP expects to receive five 32bit words. If fewer than five 32 bit data words have been received when a stop command (or another start command) is received, the data received is discarded.

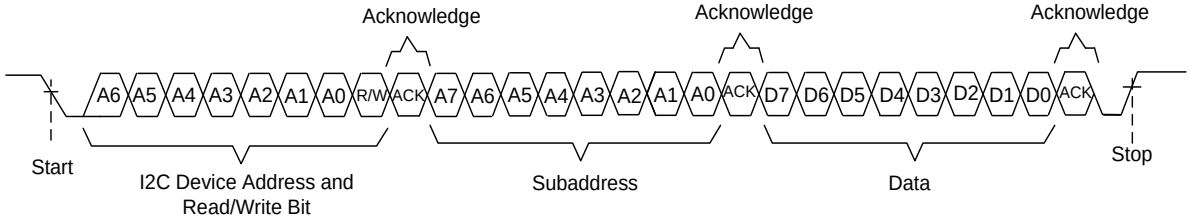

Figure16. Single Byte Write Transfer

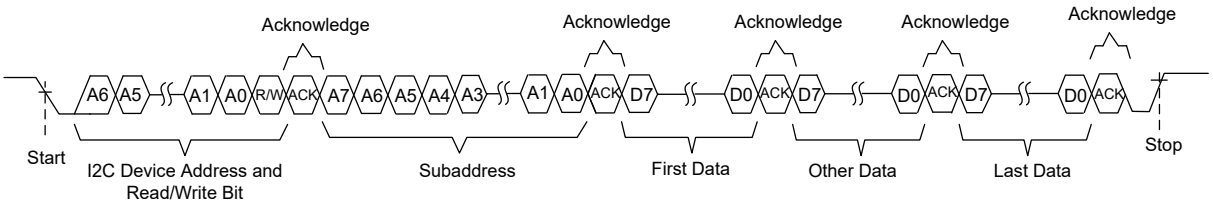

Figure17. Multiple-Byte Write Transfer

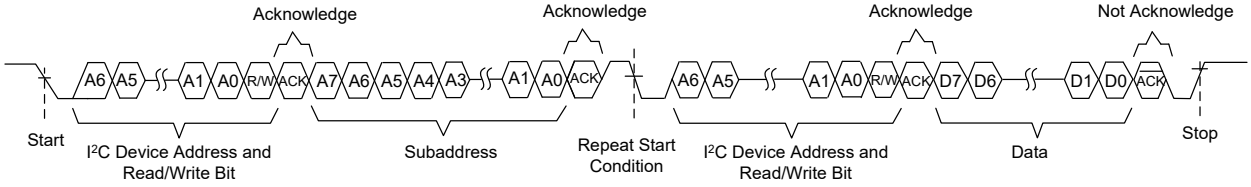

Figure18. Single Byte Read Transfer

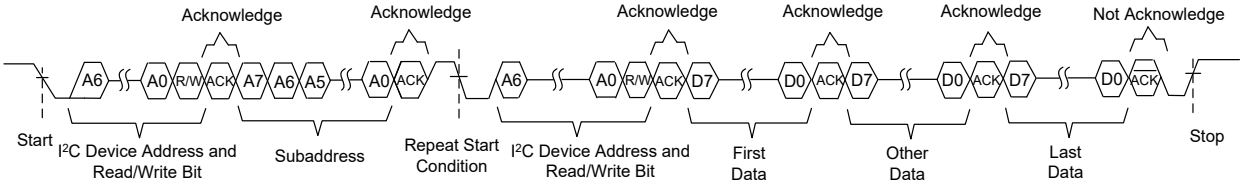

Figure19. Multiple-Byte Read Transfer

SDATA Generator

The SDATA generator of SY24146S sends out I²S out signal before or after the DAP. In order for SDATA out process to stably function, the falling of SCLK should either synchronize or occur ahead of falling or rising of LRCLK. SY24146S has a monitor pin which can be defined to output SDATA signal (0x17).

Output Mode and MUX Selection

The device supports two output modes including BTL and PBTL. In BTL mode, the bit 1 of register 0x1E should be set to 1'b0. In parallel BTL mode with OUT_A, OUT_B and OUT_C, OUT_D connected before the LC filter, the bit 1 of register 0x1E should be set 1'b1. If an over current or short condition is detected in either half bridge, all of bridges will be turned off.

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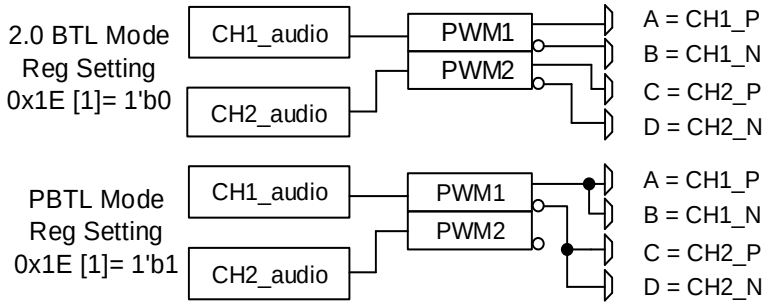

Figure20. Output Mode and MUX Selection

MIXER

The input channels can be mixed into each output channels with designated gains and polarity. Step size of mixer gain is variable according to the gain level as shown below.

Volume Range (dB)	Step (dB)
≤ -32	-∞
-6 ~ -32	1
+5.5 ~ -5.5	0.5
+18 ~ +6	1

Table2. Mixing Gain and variable Step

4 mixer gain coefficients M11, M12, M21 and M22 are defined as shown in the equation below. Each mixer gain coefficient stores volume value in dB scale, and the number values versus gain in dB are shown in the Table 2. By default, each input channel connected to each output channel directly; M11 and M22 are set as 0 dB in plus polarity, M12 and M21 are set as -∞ dB.

[Output Channels] = [Mixer Matrix] × [Input Channels]

$$\begin{bmatrix} CH1OUT \\ CH2OUT \end{bmatrix} = \begin{bmatrix} M11 & M12 \\ M21 & M22 \end{bmatrix} * \begin{bmatrix} CH1IN \\ CH2IN \end{bmatrix}$$

Table3. Serial Mixer Matrix

Refer to the register Address 0x5F in the Appendix.

Mixer Gain			
Index	**dB**	**Index**	**dB**
0x3F	18	0x1F	-4
0x3E	17	0x1E	-4.5
0x3D	16	0x1D	-5
0x3C	15	0x1C	-5.5
0x3B	14	0x1B	-6
0x3A	13	0x1A	-7
0x39	12	0x19	-8
0x38	11	0x18	-9
0x37	10	0x17	-10
0x36	9	0x16	-11
0x35	8	0x15	-12
0x34	7	0x14	-13
0x33	6	0x13	-14
0x32	5.5	0x12	-15
0x31	5	0x11	-16
0x30	4.5	0x10	-17
0x2F	4	0x0F	-18
0x2E	3.5	0x0E	-19
0x2D	3	0x0D	-20
0x2C	2.5	0x0C	-21
0x2B	2	0x0B	-22
0x2A	1.5	0x0A	-23

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0x29	1	0x09	-24
0x28	0.5	0x08	-25
0x27	0	0x07	-26
0x26	-0.5	0x06	-27
0x25	-1	0x05	-28
0x24	-1.5	0x04	-29
0x23	-2	0x03	-30
0x22	-2.5	0x02	-31
0x21	-3	0x01	-32
0x20	-3.5	0x00	mute

Table4. Mixer Gain

PRE-PROCESSING

32 Bits 6.26 Number Format

All filter coefficients are 32bit coefficients using a 6.26 number format. 6.26 number format means that there are 6 bit to the left of the decimal point and 26 bits to the right of the decimal point.

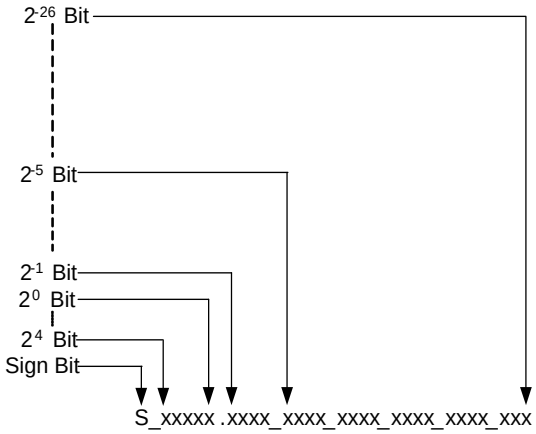

Figure21. 6.26 Number Format

If the most significant sign bit is logic 0, then the number is a positive number, the weighting shown yields the correct number.

If the most significant sign bit is logic 1, then the number is a negative number. Every bit must be inverted, then add 1 to the result, and then the weighting shown in Figure 22.

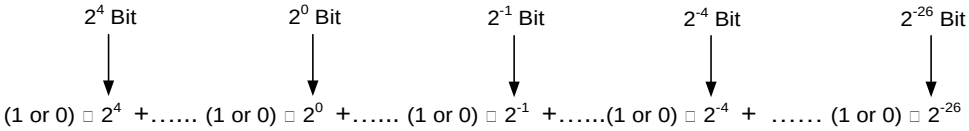

Figure22. Conversion weighting Factors—6.26 Format to Floating Point

Bi-quad Structure

Each Bi-quad has a 2nd IIR filter structure and has three coefficients on the direct path (b0, b1, b2) and 2 coefficients on feedback path (a1, a2) as shown in the diagram.

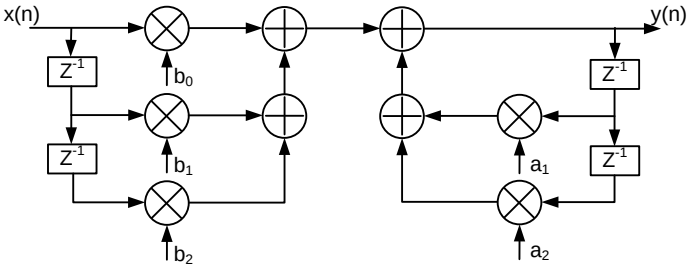

Figure23. Bi-Quad Filter Structure

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There are eighteen Bi-Quad filters linked serially in one channel. The Bi-Quad filters can be configured differently for each filter. The BQ coefficients can be separated for the two channels. To download the BQ coefficient to SY24146S, set bit 0 of register 0x03 first, then select the channel in register 0x03. BQn(n is from 0 to 17) of channel 1 and channel 2 can be separately enabled or disabled. For example, BQ1 of channel 1 is enabled while BQ1 of channel 2 is disabled. As shown in Figure 24, first three filters can be configured as loudness control with loudness gain, and last four filters can be configured as SPEQ with SPEQ control.

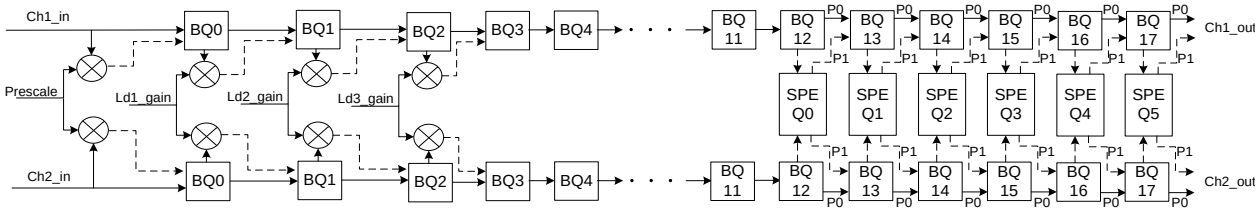

Figure24. Bi-Quad Filter Chain

Filter coefficients are 32bit binary numbers and can be downloaded through I²C interface. Write actual coefficient values to 20 register addresses in the range from 0x2F to 0x4D to download Bi-Quad filter coefficients to SY24146S. Refer to table 5. The amount of bytes for each register address is variable. For example, 20 bytes are for a BQ filter while 4 bytes are for the Pre-scaler.

The enable/disable operation of these Bi-Quad filters can be made by configuring the bits in register addresses of 0x25~0x2A. When BQn(n from 10 to 17) is configured as SPEQ or SPEQ Limit in register 0x29 and 0x2A, the BQn of both channels are functional as SPEQ or SPEQ Limit together, which can't be separately enabled or disabled for each channel. When BQn is configured as EQn, the EQn can be separately enabled or disabled for each channel.

I²C address	**0x2F**	**0x30**	**0x31**	**0x32**
Byte count	20	20	20	20
Description	BQ0 of CH1/2	BQ1 of CH1/2	BQ2 of CH1/2	BQ3 of CH1/2
I²C address	**0x33**	**0x34**	**0x35**	**0x36**
Byte count	20	20	20	20
Description	BQ4 of CH1/2	BQ5 of CH1/2	BQ6 of CH1/2	BQ7 of CH1/2
I²C address	**0x37**	**0x38**	**0x39**	**0x3A**
Byte count	20	20	20	20
Description	BQ8 of CH1/2	BQ9 of CH1/2	BQ10 of CH1/2	BQ11 of CH1/2
I²C address	**0x3B**	**0x3C**	**0x3D**	**0x3E**
Byte count	20	20	20	20
Description	BQ12 of CH1/2	BQ13 of CH1/2	BQ14 of CH1/2	BQ15 of CH1/2
I²C address	**0x3F**	**0x40**	**0x41**	**0x42**
Byte count	20	20	12	12
Description	BQ16 of CH1/2	BQ17 of CH1/2	Coefficients of SPEQ0	Coefficients of SPEQ1
I²C address	**0x43**	**0x44**	**0x45**	**0x46**
Byte count	12	12	12	12
Description	Coefficients of SPEQ2	Coefficients of SPEQ3	Coefficients of SPEQ4	Coefficients of SPEQ5

Table5. Address of Coefficients for Bi-Quad Filter Chain

Loudness Control

The frequency characteristics can be compensated in low volume level to fit the acoustic characteristics of human ears with Loudness control. The three coefficient of loudness can be downloaded through writing the 12 bytes of the register 0x57. Four bytes are for one BQ loudness gain. The loudness gain values are shared for both channel 1 and channel 2.

Register Address 0x57	byte count 12	bits[95:64]	3'b000,ld3_gain[28:0]
		bits[63:32]	3'b000,ld2_gain[28:0]
		bits[31:0]	3'b000,ld1_gain[28:0]

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Table6. Loudness Gain

Super Parametric Equalizer

The frequency characteristics based on input signal level can be compensated to fit the acoustic characteristics of human ears with SPEQ function.

There are a Bi-Quad filter coefficient and three additional coefficients for SPEQ. The three additional coefficients are related to gain and threshold. The Bi-Quad filter coefficient can be downloaded through writing 0x3B~0x40. The three additional coefficients can be downloaded through writing the 12 bytes of the register 0x41~0x46. There are four bytes for one coefficient. The SPEQ coefficients are shared for both channel 1 and channel 2.

It can be configured as SPEQ Limit function as well. The frequency characteristics at some frequency point can't be limited to no more than the threshold with SPEQ Limit function. The way to download the coefficient is the same as SPEQ.

Volume & Dynamic Range Control

Volume Control

The volume register 0x07, 0x08, and 0x09 correspond to master volume, channel 1 volume, and channel 2 volume.

Master Volume Control

Master volume – 0x07 (default is mute, 0x00)

Step	Range
0.5 dB	0 ~ -126 dB

Table7. Master Volume Steps

Channel Volume Control

Channel-1 volume – 0x08 (default is 0 dB, 0x9F)

Channel-2 volume – 0x09 (default is 0 dB, 0x9F)

Step	Range
0.5 dB	+48 ~ -79 dB

Table8. Channel Volume Steps

Volume Fine Control and offset

Fine control for volume is +0.125dB step up to maximum +7.875dB boost. Step size is 0.125dB. It has high accurate step size and provides an offset gain for the channel volume and master volume.

Step	Range
0.125 dB	0 ~ +7.875 dB

Table9. Volume Fine Control Steps

Mute and Soft Volume Change

The chip enters mute state by setting soft mute flag of register Address 0x06. 0x06[3] is master mute flag for both left channel and right channel. 0x06[0] is individually mute flag for left channel while 0x06[1] is individually mute flag for right channel. With soft mute, the volume gradually increases or decreases when mute is turned off or on respectively.

Dynamic Range Control

SY24146S has advanced algorithm taking input signal level, volume and threshold for dynamic gain of DRC, which provides powerful and balanced excellent sound experience.

The DRC scheme has 4 DRC blocks, of which one ganged DRC for the high-band left/right channels, one ganged DRC for the mid-band left/right channels, one ganged DRC for the low-band left/right channels, and one DRC for the mixer output of DRC1, DRC2 and DRC3.

There are 16 BQs for all of DRC bands, and the amplitude of each DRC output can be adjusted by corresponding gain control. The outputs of three bands DRC are mixed and followed by DRC4 which produces the output data with the

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fully controlled dynamic range. For detailed setting of the DRC registers, please refer to the system register addresses in Table 10.

I²C address	**0x47**	**0x48**	**0x49**	**0x4A**	**0x4B**	**0x4C**	**0x4D**	**0x4E**
byte count	20	20	20	20	20	20	20	20
description	BQ0 of DRC	BQ1 of DRC	BQ2 of DRC	BQ3 of DRC	BQ4 of DRC	BQ5 of DRC	BQ6 of DRC	BQ7 of DRC
I²C address	**0x4F**	**0x50**	**0x51**	**0x52**	**0x53**	**0x54**	**0x55**	**0x56**
byte count	20	20	20	20	20	20	20	20
description	BQ8 of DRC	BQ9 of DRC	BQ10 of DRC	BQ11 of DRC	BQ12 of DRC	BQ13 of DRC	BQ14 of DRC	BQ15 of DRC

Table 10. Coefficient Register Map for Dynamic Range Control

The DRC input/output diagram is shown in Figure 25.

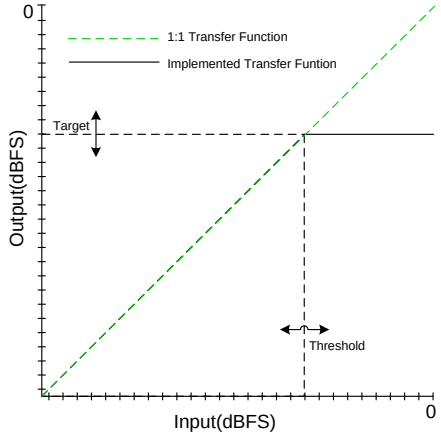

Figure25. Dynamic Range Control

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Power Meter

The power meter measures signal's energy of internal, which can be used to study the power profile. It can be configured by sending value of energy through register address 0x97 and parts of 0x98. Read the 10-bits value in dB through register address 0x58 while read the 23-bits linear value through register address 0x99.

DC Protection

The system from outputting DC signal can cause a speaker unit burnt. The chip employs three sub functions to prevent DC output, which are dynamically calculating and monitoring the memory checksum, detecting PWM DC, and cutting DC component via two hard-wired filters. The hard-wired DC cut filter removes the DC component. The other two functionalities only report the error status, and external controller may reset the chip by writing register 0x0F to assert a soft reset.

Memory Checksum

While initializing the system, the checksum data of coefficients are downloaded from the external MCU from the address 0x9A to 0x9C. This memory checksum block compares the checksum data of current memory block and the checksum data at the initial time. If there is a discrepancy between two values due to some memory fault, the error flag bit 7 or/and bit 6 of address 0x02 is set to high. The external MCU can monitor these error flags and reset the chip by setting the DC soft reset to high at address 0x0F. This DC soft reset will initialize the whole chip, and initialization process of the memory should be done thereafter

PWM DC Detection

A PWM DC detector is employed. When there is a DC component in the output, it sets PWM DC error flag of address 0x02 to high. The external controller may monitor this error flag and reset the chip by writing register 0x0F to assert a soft reset. The threshold of PWM DC detection at address 0x19 can be set to decide the level of DC monitoring.

Hard-Wired DC Cut

Two hard-wired DC cut filters are employed, which can prevent the system from outputting the signal of less than 1Hz frequency.

Dual Function Terminal

ADDR_SEL pin is an input pin to define the slave I^2C address at normal condition. But it also can be configured as an output pin to report fault(0x19). If so, when there is a fault, this pin will be pulled down.
FAULT_B pin is an input pin to turn off the PWM signal path when pulled down. It also can be defined as an output pin to report fault(0x19). If so, when there is a fault, this pin will be pulled down.

Load Detection

Load detection is a protection scheme which detects the load's connectivity to the power stage (open load, short load or Normal). If the detected resistance of the load is larger than the open load threshold(about OLDT), it will report open load error, while smaller than the short load threshold(about SLDT), as in table 11 shows. Otherwise, it will report normal load. The load detection function is enabled by the bit 0 of 0x23(1'b0:disable;1'b1:enable).

Load resistance(R_L)	Error status
R_L>OLDT	Open load error
R_L< SLDT	Short load error
SLDT≤R_L≤OLDT	Normal load.

Table 11. Load Detection Threshold

The load detection control register is 0x23, sld_old_det_en is used to enable LD detection, active high. If sld_old_try_en is low, the chip will do the load detection only at the first time when 0x00 is written into 0x22(exit shutdown). But if it is high, the chip will do the load detection each time when 0x00 is written into 0x22(exit shutdown).
If the load detection is enabled in register 0x23, after 0x00 is written into 0x22, the load detection error status will be reported in register 0x0A, if short_load_err_flag is high, it means the resistance between outputs is smaller than SLDT. If it is low, the resistance is larger than SLDT. If open_load_err_flag is high, it means the resistance between outputs is larger than OLDT. If it is low, the resistance is smaller than OLDT.If both short_load_err_flag and open_load_err_flag are low, it means the load is normal, not open or shorted.

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Set the load detection register:
(1). Enable the load detection (0x23[0]=1'b1) with other initial setting;
(2). Exit shutdown (0x22=0x00);
(3). If it is normal load (0x0A=0x00) or open load (0x0A=0x02), the chip will start up. If it is short load (0x0A=0x01), the chip will not start up to avoid big current and noise.

Recommended Command Sequences

Power up & Initialization Sequence

1) Ramp up VDD_IO to at 3.3V and ramp PVDD to at least 4.5V. There is no sequence requirement between VDD_IO and PVDD when ramping up.
2) Drive SCLK to its desired state, drive RST_B=0 at least 0.1ms, then drive RST_B=1, and wait at least 0.5ms.
3) Configure the DAP via I^2C
4) Configure remaining registers
5) Exit shutdown (0x22=0x00).

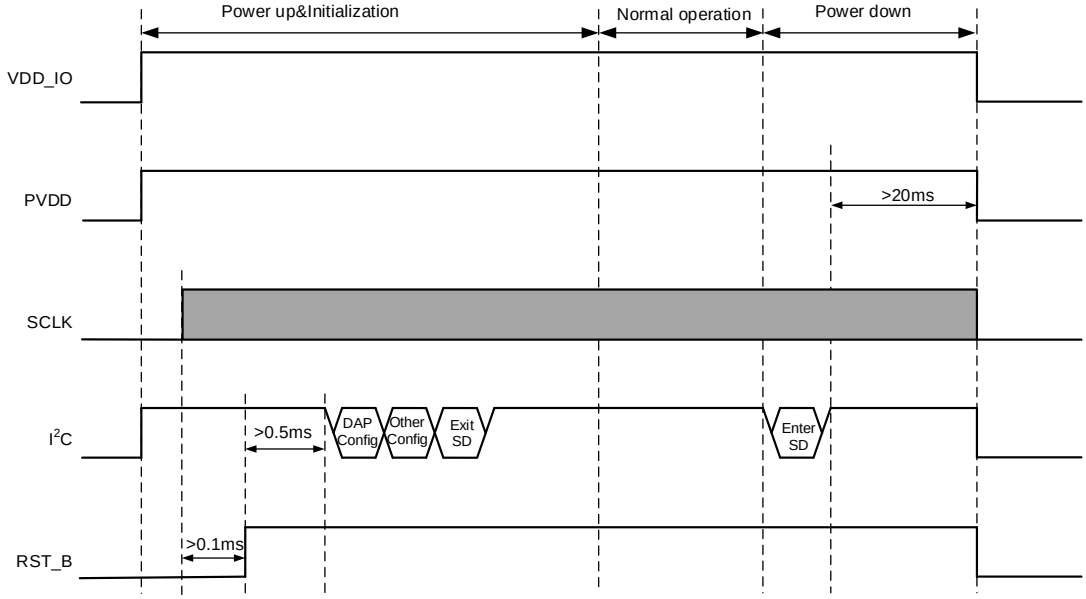

Figure26 . Recommended Command Sequence

Power down Sequence

1) Enter shutdown (0x22=0x30).
2) Wait at least 20ms.
3) Ramp down VDD_IO and PVDD.

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APPENDIX

Configuration Register Summary

Sub-address	Register name	Bytes	Contents	Initialization value
0x00	Clock control register	1	brt_sel, u[6:5], fs_cnfg_manual_en, fs_ rate_cnfg[1:0], fs_ rate_det[1:0]	0x1A
0x01	Device ID register	1	DEV_ID_REG[7:0]	0x35
0x02	Error status register	1	pbq_check_error,drc_check_error, sclk_err,lrclk_err, pwm_dc_error,short_fault, oc_fault,otuv_fault	0x00
0x03	System control register 1	1	dsp_force_reset_en, dsp_soft_reset_en, rd_bq_coef_channel_sel, soft_reset_en, fade_en, ram_ch1_en, ram_ch2_en, i2c_access_coef_ram_en	0x5F
0x04	System control register 2	1	u[7],avdd_uv_rst_en, dc_en_pre, eq_enable, dc_en_post, mixer_en, pm_en, loudness_en	0x9E
0x05	System control register 3	1	delay_line_lgth[4:0], sold_rate_sel[1:0], a_sel_mode_reg	0x7C
0x06	Soft mute register	1	u[7:6], i2c_access_ram_mute_stby_en, hard_soft_umute, mvol_mute, u[2], dvol_mute_r, dvol_mute_l	0x30
0x07	Master volume	1	mvol[7:0]	0x00(mute)
0x08	Channel 1 vol	1	dvol_l[7:0]	0x9F(0dB)
0x09	Channel 2 vol	1	dvol_r[7:0]	0x9F(0dB)
0x0A	Error status register 2	1	u[7:2], open_load_err_flag, short_load_err_flag	0x00
0x0B	mvol_fine_tune	1	u[7:6], vol_fine_tune[5:0]	0x00
0x0C~0x0E	N/A	1	Reserved	0x00
0x0F	DC soft reset Register	1	u[7:5], dsp_soft_reset,u[3:1], dc_soft_reset	0x00
0x10	Modulation limit register	1	u[7:4], pwm_mod_limit[3:0]	0x77
0x11	PWM OUTA delay	1	pwm_phaseoffset1[7:0]	0x00
0x12	PWM OUTB delay	1	pwm_phaseoffset2[7:0]	0x00
0x13	PWM OUTC delay	1	pwm_phaseoffset3[7:0]	0x00
0x14	PWM OUTD delay	1	pwm_phaseoffset4[7:0]	0x00
0x15	I2S Control	1	sel_sdout_sclk_b,i2s_sclk_inv, i2s_lr_polarity, i2s_enable, i2s_fmt[1:0], i2s_vbits[1:0]	0x10
0x16	DSP Control Register1	1	fir_roll_off_sel[2:0],dsp_fade_time_sel[1:0], ch1_en,ch2_en, u[0]	0x06
0x17	Monitor Config1	1	u[7:6], mon0_en , sda_out_loc, monitor0_cfg[3:0]	0x00
0x18	N/A	1	reserved	0x00
0x19	PWM DC Threshold	1	u[7:5],cfg_faultb_to_pdnb_en,threshold_sel[3:0]	0x05
0x1A	HP_CTRL	1	u[7:5], hp_en, hp_gain[3:0]	0x00
0x1B	Short Control Reg	1	short_try_en,fault_clr_interval[2:0], second_phase_en,retry_interval[2:0]	0xBD
0x1C	FAULT_O_TIME	1	u[7:4], bknd_err[3:0]	0x02
0x1D	N/A	1	Reserved	0x00
0x1E	OP_MODE	1	u[7:5], fs_rate_invalid_shdn_en, i2c_access_ram_ctl_manual, pbtl_digital_en, pbtl_en, ternary_mode_en	0x05
0x1F	Checksum Control Register	1	u[7:3],pwm_dc_det_en, pbq_checksum_en, drc_checksum_en	0x00
0x20	Input MUX register	1	i2s_din_sel[1:0], u[5:0]	0x00
0x21	DSP control register2	1	dsp_amute_len[2:0], dsp_amute_en, dsp_amute_flag_ch1, dsp_amute_flag_ch2, u[1:0]	0x00
0x22	PWM Control register	1	u[7:6],enter_all_shutdown, enter_all_standby, u[3:0]	0x30
0x23	FaultSelect Register	1	u[7],fault_times_sel[2:0],poweron_short_det_en, sld_old_try_en, short_mask_oc_en,sld_old_det_en	0x12
0x24	N/A	1	Reserved	0x00
0x25	CH1_EQ_CTRL1	1	ch1_eq_en[15:14],ch1_eq_en[5:0]	0x00
0x26	CH1_EQ_CTRL2	1	ch1_eq_en[13:6]	0x00
0x27	CH2_EQ_CTRL1	1	ch2_eq_en[15:14],ch2_eq_en[5:0]	0x00
0x28	CH2_EQ_CTRL2	1	ch2_eq_en[13:6]	0x00
0x29	SPEQ_CTRL_1	1	ch1_eq_en[17:16], ch2_eq_en[17:16], bq17_ctrl[1:0], bq16_ctrl[1:0]	0x00
0x2A	SPEQ_CTRL_2	1	bq15_ctrl[1:0], bq14_ctrl[1:0], bq13_ctrl[1:0], bq12_ctrl[1:0]	0x00
0x2B	SPEQ_CTRL_3	1	u[7:1], speq_det_method[0]	0x00
0x2C	PRESCALER	2	prescaler[15:0]	0x7FFF
0x2D	POSTSCALER	2	postscaler[15:0]	0x7FFF
0x2E	N/A	1	Reserved	0x00

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0x2F~0x40	bqn(n=0~17)	20	bqn_b0[31:0]	0x0400 0000
			bqn_b1[31:0]	0x0000 0000
			bqn_b2[31:0]	0x0000 0000
			bqn_a1[31:0]	0x0000 0000
			bqn_a2[31:0]	0x0000 0000
0x41~0x46	speqn_coef(n=0~5)	12	speqn_th[31:0]	0x0020 0000
			speqn_coef1[31:0](p0)	0x0400 0000
			speqn_coef2[31:0](p1)	0x0200 0000
0x47~0x56	drc_bqn(n=0~15)	20	drc_bqn_b0[31:0]	0x0400 0000
			drc_bqn_b1[31:0]	0x0000 0000
			drc_bqn_b2[31:0]	0x0000 0000
			drc_bqn_a1[31:0]	0x0000 0000
			drc_bqn_a2[31:0]	0x0000 0000
0x57	loundness	12	ld1_gain[31:0]	0x4000 0000
			ld2_gain[31:0]	0x4000 0000
			ld3_gain[31:0]	0x4000 0000
0x58~0x5C	N/A	1	Reserved	0x00
0x5D	speq_atk_rel_tc_1	18	u[143], speq5_atk_tc[22:0]	0x00 0800
			u[119], speq4_atk_tc[22:0]	0x00 0800
			u[95], speq3_atk_tc[22:0]	0x00 0800
			u[71], speq2_atk_tc[22:0]	0x00 0800
			u[47], speq1_atk_tc[22:0]	0x00 0800
			u[23], speq0_atk_tc[22:0]	0x00 0800
0x5E	speq_atk_rel_tc_2	18	u[143], speq5_rel_tc[22:0]	0x7F F800
			u[119], speq4_rel_tc[22:0]	0x7F F800
			u[95], speq3_rel_tc[22:0]	0x7F F800
			u[71], speq2_rel_tc[22:0]	0x7F F800
			u[47], speq1_rel_tc[22:0]	0x7F F800
			u[23], speq0_rel_tc[22:0]	0x7F F800
0x5F	ch12_mixer_gain	4	u[31],ch1_fch1_p,ch1_mixer_fch1_gain[5:0]	0x27
			u[23],ch1_fch2_p,ch1_mixer_fch2_gain[5:0]	0x00
			u[15],ch2_fch1_p,ch2_mixer_fch1_gain[5:0]	0x00
			u[7],ch2_fch2_p,ch2_mixer_fch2_gain[5:0]	0x27
0x60	drc_ctrl	4	u[31:25],drc_det_method, u[23:12], drc_crossover_order, drc_crossover_mode[1:0], envlp_mode, u[7:5], drc_chnnl_indpt_en, drc1_lmt_en, drc2_lmt_en, drc3_lmt_en, drc4_lmt_en	0x0100 0000
0x61	DRC1_LMT_CFG1	3	u[23:22], drc1_makeup[9:0], u[11:10], drc1_lmt_thr[9:0]	0x3C C30C
0x62	DRC1_LMT_CFG2	3	u[23], drc1_lmt_atk_tc[22:0]	0x06 0F83
0x63	DRC1_LMT_CFG3	3	u[23], drc1_lmt_rel_tc[22:0]	0x00 0122
0x64	DRC2_LMT_CFG1	3	u[23:22], drc2_makeup[9:0], u[11:10], drc2_lmt_thr[9:0]	0x3C C30C
0x65	DRC2_LMT_CFG2	3	u[23], drc2_lmt_atk_tc[22:0]	0x06 0F83
0x66	DRC2_LMT_CFG3	3	u[23], drc2_lmt_rel_tc[22:0]	0x00 0122
0x67	DRC3_LMT_CFG1	3	u[23:10], drc3_makeup[9:0], u[23:10], drc3_lmt_thr[9:0]	0x3C C30C
0x68	DRC3_LMT_CFG2	3	u[23], drc3_lmt_atk_tc[22:0]	0x06 0F83
0x69	DRC3_LMT_CFG3	3	u[23], drc3_lmt_rel_tc[22:0]	0x00 0122
0x6A	DRC4_LMT_CFG1	3	u[23:10],drc4_lmt_thr[9:0]	0x00 030C
0x6B	DRC4_LMT_CFG2	3	u[23], drc4_lmt_atk_tc[22:0]	0x06 0F83
0x6C	DRC4_LMT_CFG3	3	u[23], drc4_lmt_rel_tc[22:0]	0x00 0122
0x6D	drc_envlp_tc_up	3	u[23], drc_envlp_tc_up[22:0]	0x01 0000
0x6E	drc_envlp_tc_dn	3	u[23], drc_envlp_tc_dn[22:0]	0x7B 0000
0x6F	amute_threshold	2	amute_threshold[15:0]	0x0000
0x70	BIST Control	1	u[7], bist_mode, bist_go, bist_ram1_skip, u[3], bist_ram3_skip, bist_ram4_skip, bist_ram5_skip	0x00
0x71	PLL Status	4	sw_refclk_sel_en, sw_refclk_sel, pllc_pllclksel, pllc_pll_prog, pllc_refdiv_pll[7:0], u[19], pllc_fbdiv_pll[10:0], u[7], pllc_cp_pll[2:0], pllc_rz_pll[1:0], pllc_vcci_pll[1:0]	0x0063 002D
0x72	PLL Control	2	u[15:13], pll_enable_sel,manual_pll_enable, u[10:1], pll_osc_force_en	0x0000
0x73	spk_seq_bypass	1	u[7:3], pwm_automute_dis, spk_seq_bypass[1:0]	0x00
0x74	Func_test	1	ps_test_en_b, ps_test_mod0, u[5:4], i2s_loop_en,u[2:1], func_test	0x80
0x75	Tm_by_reg	1	u]7:5], tm_by_reg[4:0]	0x00
0x76	PROT_SYS_CNTL	1	u]7:5],poweron_retry_en, short_protect_en,otuv_protect_en, oc_protect_en,avdd_uv_protect_en	0x1F

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0x77	I2C Control	1	u]7:2], i2c_dly_en,i2c_sda_timeout_en	0x03
0x78	HARD_CLIPPER	3	hard_clipper_ther[23:0]	0x7F FFFF
0x79	DRC_SKIP_CNTR	4	u[31:24], drc_gain_offset[7:0], u[15:8], drc_skip_time[7:0]	0x0003 00F0
0x7A	N/A	1	Reserved	0x00
0x7B	Oscillator trim Control	1	u[7:2], osc_trim_done, factory_trim_dis	0x01
0x7C	Oscillator trim register1	4	u[31:13], osc_trim_data[4:0], u[7:3], osc_trim_go, d2a_osc_pwd, d2a_post_trim_pwd	0x0000 1000
0x7D	Oscillator trim register2	4	u[31:22], trim_program_en, trim_program_data[4:0], u[15:14], trim_efuse_data_en, trim_efuse_data[4:0], u[7], efuse_time[5:0], trim_efuse_en	0x0010 1017
0x7E	Analog Ref_top Control	4	u[31:12], v1p8d_ctrl[1:0], d2a_ref_ib_ctrl[1:0], d2a_ref_pf[2:0], d2a_reg_avdd_ctrl[1:0], d2a_ref_pwd, d2a_reg_avdd_pwd, d2a_uv_detect_pwd	0x0000 0200
0x7F	N/A	1	Reserved	0x00
0x80	dsp_3d_coef	3	dsp_3d_coef[23:0]	0x40 0000
0x81	dsp_3d_mix	3	dsp_3d_mix[23:0]	0x40 0000
0x82	Inter_Private register	4	u[31:8], refclk_stop_reg_en, sclk_err_en, lr_err_en, refclk_stop_err_en, u[3:1], spk_scdet_en	0x0000 00F0
0x83	DRC_FTUNE	1	dc_cef[2:0],drc_ftune_sign,drc_ftune[1:0]	0x20
0x84	N/A	1	Reserved	0x00
0x85	Fault Over Current Small Detect Windows Width	4	u[31:10],ocfast_trig_en, ocdet_mannual_sel,u[7:6], ocdet_wind_width[5:0]	0x0000 0006
0x86	Fault Over Current Threshold	4	u[31:15],filter_deglitch[2:0], u[11:9],ocdet_en_num[8:0]	0x0000 2006
0x87~0x88	N/A	1	Reserved	0x00
0x89	N/A	1	u[7:4],pwm_ndc_err_ch1, pwm_pdc_err_ch1, pwm_ndc_err_ch2, pwm_pdc_err_ch2	0x00
0x8A	N/A	1	Reserved	0x00
0x8B	FUNC_CTRL	1	varied_attack_th_en, varied_attack_th_sel[2:0], u[3:2], 3d_en, hard_clipper_en	0xB0
0x8C	FUNC_DEBUG	1	func_debug[7:0]	0xC8
0x8D	N/A	1	Reserved	0x00
0x8E	drc1_envlp_tc_up	3	u[23], drc1_envlp_tc_up[22:0]	0x01 0000
0x8F	drc1_envlp_tc_dn	3	u[23], drc1_envlp_tc_dn[22:0]	0x7B 0000
0x90	drc2_envlp_tc_up	3	u[23], drc2_envlp_tc_up[22:0]	0x01 0000
0x91	drc2_envlp_tc_dn	3	u[23], drc2_envlp_tc_dn[22:0]	0x7B 0000
0x92	drc3_envlp_tc_up	3	u[23], drc3_envlp_tc_up[22:0]	0x01 0000
0x93	drc3_envlp_tc_dn	3	u[23], drc3_envlp_tc_dn[22:0]	0x7B 0000
0x94	PWM MUX register	4	u[31:21], pwm_connection_test[4:0], u[15:5], pwm_evenbit, u[3:1],pwm_ns_zr	0x0000 0000
0x95	PWM Outflip register	4	u[31],pwm_dvol_ramp_point[6:0], u[23:22],pwm_clip_mode, pwm_ad_mode_en, u[19:17], pwm_outflip_reg[12], u[15], pwm_outflip_reg[11:9], u[11], pwm_outflip_reg[8:6], u[7], pwm_outflip_reg[5:3], u[3], pwm_outflip_reg[2:0]	0x4000 3210
0x96	PWM Control register	4	u[31:29], pwm_ns_order[1:0], pwm_ns_bf_clr, pwm_roundup, pwm_768x, pwm_dither_clr, pwm_dither_en, pwm_dither_range, dither_pos[4:0], pwm_cnvt_dstep[7:0], pwm_cnvt_dvalue[7:0]	0x1000 002F
0x97	pm_coef	6	u[47], pm_coef_up[22:0], u[23], pm_coef_dn[22:0]	0x000800 7FF800
0x98	pm_crtl_rb1	3	u[23:20],pm_det_method, pm_source[1:0],pm_loc, pm_lvl_db[9:2],u[7:2], pm_lvl_db[1:0]	0x00 0000
0x99	pm_crtl_rb2	3	u[23],pm_lvl_linear_rb[22:0]	0x00 0000
0x9A	pbq_ch1_checksum	4	pbq_ch1_checksum_key[31:0]	0x0000 0000
0x9B	mdrc_checksum	4	mdrc_checksum_key[31:0]	0x4000 0000
0x9C	pbq_ch2_checksum	4	pbq_ch2_checksum_key[31:0]	0x0000 0000
0x9D	DRC1_CH2_CFG	3	u[23:10], drc1_lmt_thr[9:0]	0x00 030C
0x9E	DRC2_CH2_CFG	3	u[23:10], drc2_lmt_thr[9:0]	0x00 030C
0x9F	DRC3_CH2_CFG	3	u[23:10], drc3_lmt_thr[9:0]	0x00 030C
0xA0	DRC4_CH2_CFG	3	u[23:10], drc4_lmt_thr[9:0]	0x00 030C
0xA1~0xAF	N/A	1	Reserved	0x00
0xB0	DSP_DEBUG_REG1	1	u[31:24],drc_gain_offset_db[7:0],u[15:11],pwm_ns_gain[10:0]	0x0000 07A0
0xB1~0xBF	N/A	1	Reserved	0x00
0xC0	D2a_ref_div_pll	1	c_refdiv_pll[7:0]	0x06
0xC1	d2a_fbdiv_pll[7:0]	1	c_fbdiv_pll[7:0]	0x00
0xC2	d2a_fbdiv_pll[10:8]	1	u[7:3], c_fbdiv_pll[10:8]	0x03

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0xC3	d2a_rz_pll[1:0]	1	u[7:2], c_rz_pll[1:0]	0x03
0xC4	d2a_cp_pll[2:0]	1	u[7:3], c_cp_pll[2:0]	0x03
0xC5	d2a_vcci_pll[1:0]	1	u[7:2], c_vcci_pll[1:0]	0x01
0xC6	revid_maj_rev	1	u[7:4], c_revisionid[3:0]	0x01
0xC7	revid_mnr_rev	1	u[7:4], c_steppingid[3:0]	0x01
0xC8~0xCB	N/A	–	Reserved	0x00
0xCC	bist_fail_ram	1	u[7:6], c_bist_active, c_bist_done, c_bist_fail, c_bist_fail_ram[2:0]	0x00
0xCD	bist_fail_addr	2	{6'b0,bist_fail_addr[9:0]};	0x0000
0xCE	N/A	1	Read_only	0x00
0xCF	bist_fail_bist	6	{14'b0,bist_fail_bist[33:0]}	0x00 0000
0xD0~0xD3	N/A	1	Reserved	0x00
0xD4	LR_CNT_LOW	1	cntr_lrclk_prev_clk_cross_dly2[7:0]	0x00
0xD5	LR_CNT_HI	1	u[7:1],cntr_lrclk_prev_clk_cross_dly2[8]	0x00
0xD6	S_CNT_LOW	1	cntr_sclk_prev_clk_cross_dly2[7:0]	0x00
0xD7	S_CNT_HI	1	u[7:1],fault_lock	0x00
0xD8~0xF7	N/A	–	Reserved	0x00
0xF8	Device address enable register	4	Write 0xF9A5 A5A5 in this register to enable write to device address update (0xF9)	0x0000 0000
0xF9	Device address update register	4	u[31:8] , New Dev Id[7:1] , ZERO[0] (New Dev Id (7:1) defines the new device address)	0x0000 0054
0xFB~0xFF	N/A	4	Reserved	0x0000 0000

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Register Table

Clock control register (0x00)

Bit	7	6	5	4	3	2	1	0
Name	BS	X		FCME	FRC		FRD	

Name	Label	Type	Default	Description
FRD	fs_rate_det	R	2'b10	Sample rate detected: 2'b00: 32kHz 2'b01: 96kHz 2'b10: 44.1kHz/48kHz 2'b11: reserved
FRC	fs_rate_cnfg	RW	2'b10	Sample rate configured: 2'b00: 32kHz 2'b01: 96kHz 2'b10: 44.1kHz/48kHz 2'b11: reserved If fs_cnfg_manual_en is set to 1, the two bits are valid to configure I^2S sample rate.
FCME	fs_cnfg_manual_en	RW	1'b1	1'b0: auto detect I^2S sample rate 1'b1: configured I^2S sample rate by MCU
BS	brt_sel	RW	1'b0	1'b0:48KHz (in case of pll_ref_clk = osc_clk) 1'b1:44.1KHz (in case of pll_ref_clk = osc_clk)

Device Id register (0x01)

Bit	7	6	5	4	3	2	1	0
Name	DIR							

Name	Label	Type	Default	Description
DIR	dev_id_reg	R	8'h35	Identification Code 0x35: SY24146S/SY24145S

Error status register (0x02)

Bit	7	6	5	4	3	2	1	0
Name	PCE	DRC_CE	SCLKE	LRCLKE	PWM_DE	SF	OCF	OTF

Name	Label	Type	Default	Description
OTF	otuv_fault	RW	1'b0	1'b0: normal; 1'b1: over temperature or under voltage is detected
OCF	oc_fault	RW	1'b0	1'b0: normal; 1'b1: over current is detected
SF	short_fault	RW	1'b0	1'b0: normal; 1'b1: short is detected
PWM_DE	pwm_dc_error	RW	1'b0	1'b0: normal; 1'b1: PWM DC detected
LRCLKE	lrclk_err	RW	1'b0	1'b0: normal; 1'b1: LRCLK error
SCLKE	sclk_err	RW	1'b0	1'b0: normal; 1'b1: SCLK error
DRC_CE	drc_check_error	RW	1'b0	1'b0: normal; 1'b1: DRC checksum error
PCE	pbq_check_error	RW	1'b0	1'b0: normal; 1'b1: BQ checksum error

System control register 1 (0x03)

Bit	7	6	5	4	3	2	1	0
Name	DSP_FRE	DSP_SRE	RBCCS	DC_SRE	DFER	RCE1	RCE2	IACRE

Name	Label	Type	Default	Description
IACRE	i2c_access_coef_ram_en	RW	1'b1	1'b0: DAP access to register 0x2F~57(RAM) 1'b1: I2C bus access to register 0x2F~57(RAM)

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RCE2	ram_ch2_en	RW	1’b1	1'b1: I2C write ch2 ram on 1'b0: I2C write ch2 ram off
RCE1	ram_ch1_en	RW	1’b1	1'b1: I2C write ch1 ram on 1'b0: I2C write ch1 ram off
DFER	dsp_fade_en_reg	RW	1’b1	1'b0:Fade disabled, volume changes immediately 1'b1:Fade enabled, volume changes fades between old/new value
DC_SRE	dc_soft_reset_en	RW	1’b1	Enable or Disable the soft reset of the hole chip 1'b0:DC Soft Reset Disabled 1'b1:DC Soft Reset Enabled
RBCCS	rd_bq_coef_channel_sel	RW	1’b0	1'b0:read bq coef of channel 1 1'b1:read bq coef of channel 2
DSP_SRE	dsp_soft_reset_en	RW	1’b1	Enable or Disable the soft reset of dsp data flow——Write bit “1” to register 0x0F bit[4] 1'b0:Write register 0x0F bit[4] won't trigger DSP Soft Reset 1'b1:Write register 0x0F bit[4] will trigger DSP Soft Reset
DSP_FRE	dsp_force_reset_en	RW	1’b0	1'b0:Shutdown the speaker, won't trigger the reset of dsp data flow. 1'b1:When speaker shutdown, dsp data flow will be reset automatically.

System control register 2 (0x04)

Bit	7	6	5	4	3	2	1	0
Name	DOSE	AURE	DEPRE	EQ_E	DEPOST	ME	PE	LE

Name	Label	Type	Default	Description
LE	loudness_en	RW	1’b0	enable loudness: 1'b0: disable; 1'b1: enable
PE	pm_en	RW	1'b1	enable power meter: 1'b0: disable; 1'b1: enable
ME	mixer_en mixer_en	RW	1'b1	enable mixer: 1'b0: disable; 1'b1: enable"
DEPOST	dc_en_post	RW	1'b1	Post DC blocking enable. 1'b0: disable; 1'b1: enable
EQ_E	eq_enable	RW	1'b1	eq, speq, enable or not: 1'b0: disable; 1'b1: enable
DEPRE	dc_en_pre	RW	1'b0	Pre DC blocking enable: 1'b0: disable; 1'b1: enable
AURE	avdd_uv_rst_en_reg	RW	1'b0	AVDD under voltage will trigger a global reset or not 1'b0: won't trigger a global reset; 1'b1: trigger a global reset;
DOSE	dyn_off_speq_en	RW	1'b1	When write “1” to register 0x03 bit[0] to enable I^2C access coef ram, turn off speq simultaneously; 1'b0: turn off speq at the same time; 1'b1: won't turn off speq;

System control register 3 (0x05)

Bit	7	6	5	4	3	2	1	0
Name	DLL					SRS		ASMR

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Name	Label	Type	Default	Description
ASMR	a_sel_mode_reg	RW	1'b0	1'b0:when reset release, i2c device addr was fixed by addr_sel. 1'b1:when addr_sel configured as input, i2c device address could be changed according to addr_sel in any moment.
SRS	sold_rate_sel[1:0]	RW	2'b10	When speaker poweron, select the cost time of detecting open load/short load (if the detection eabled). 2'b00:73.6ms; 2'b01:147.2ms; 2'b10:294.4ms; 2'b11:588.5ms.
DLL	delay_line_lgth[4:0]	RW	5'h0f	Length of DRC delay line 0~20 samples.

Soft mute register (0x06)

Bit	7	6	5	4	3	2	1	0
Name	X		MSEN	HSU	DMMR	X	DDMRR	DDMLR

Name	Label	Type	Default	Description
DDMLR	dsp_dvol_mute_l_reg	RW	1'b0	1'b0:soft unmute channel 1 1'b1:soft mute channel 1
DDMRR	dsp_dvol_mute_r_reg	RW	1'b0	1'b0:soft unmute channel 2 1'b1:soft mute channel 2
DMMR	dsp_mvol_mute_reg	RW	1'b0	1'b0:master unmute 1'b1:master mute
HSU	hard_soft_umute	RW	1'b1	1'b0:soft unmute on recovery from clock error 1'b1:hard unmute on recovery from clock error
MSEN	i2c_access_ram_mute_stby_en	RW	1'b1	1'b0: Disable 1'b1: Enable

Master volume (0x07)

Bit	7	6	5	4	3	2	1	0
Name	MV							

Name	Label	Type	Default	Description
MV	mas_vol[7:0]	RW	8'h00	8'h00~8'h02: Soft mute; 8'h03: -126dB; 8'hFF: 0dB; step: 0.5dB

Channel 1 volume (0x08)

Bit	7	6	5	4	3	2	1	0
Name	VOLCH1							

Name	Label	Type	Default	Description
VOLCH1	dsp_dvol_l[7:0]	RW	8'h9F	8'h00: mute; 8'h01: -79dB; 8'h9F: 0dB; 8'hFF: 48dB; step: 0.5dB

Channel 2 volume (0x09)

Bit	7	6	5	4	3	2	1	0
Name	VOLCH2							

Name	Label	Type	Default	Description
VOLCH2	dsp_dvol_r[7:0]	RW	8'h9F	8'h00: mute; 8'h01: -79dB; 8'h9F: 0dB; 8'hFF: 48dB; step: 0.5dB

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Error Status register2 (0x0A)

Bit	7	6	5	4	3	2	1	0
Name	x						OLEF	SLEF

Name	Label	Type	Default	Description
SLEF	short_load_err_flag	R	1'b0	Active high; 1'b0: normal; 1'b1: short load
OLEF	open_load_err_flag	R	1'b0	Active high; 1'b0: normal; 1'b1: open load

VOL_FTUNE (0x0B)

Bit	7	6	5	4	3	2	1	0
Name	X		VOLFT					

Name	Label	Type	Default	Description
VOLFT	vol_fine_tune[5:0]	RW	6'h00	Volume offset and fine tune. 6'h00~6'h3f: 0dB~+7.875dB. step: 0.125dB.

Soft Reset Register (0x0F)

Bit	7	6	5	4	3	2	1	0
Name	X			DSPRST	X			DCRST

Name	Label	Type	Default	Description
DCRST	dc_soft_reset	RW	1'b0	Write this bit 1, will reset the whole chip. The bit will be automatically cleared to 1'b0 after DC soft reset is asserted.
DSPRST	dsp_reset	RW	1'b0	When register 0x03 bit[6] set “1”， dsp data flow soft reset is enable, then write this bit 1, will reset the dsp data process flow. “dsp_force_reset_en” from register 0x03 will affect the reset flow.

Modulation limit register (0x10)

Bit	7	6	5	4	3	2	1	0
Name	PWMMIN				PWMMAX			

Name	Label	Type	Default	Description
PWMMAX	pwm_mod_limt_max [3:0]	RW	4'h7	PWM modulation frequency is 384KHz set FULL = 512(384KHz) 4'h0: max = FULL-2; 4'h1: max = FULL-3; 4'h2: max = FULL-4; 4'h3: max = FULL-5; 4'h4: max = FULL-6; 4'h5: max = FULL-7; 4'h6: max = FULL-8; 4'h7: max = FULL-9; 4'h8: max = FULL-10; 4'h9: max = FULL-11; 4'ha: max = FULL-12; 4'hb: max = FULL-13; 4'hc: max = FULL-14; 4'hd: max = FULL-16; 4'he: max = FULL-18; 4'hf: max = FULL-20;

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PWMMIN	pwm_mod_limt_min[3:0]	RW	4'h7	PWM modulation frequency is 384KHz 4'h0: min = 2; 4'h1: min = 3; 4'h2: min = 4; 4'h3: min = 5; 4'h4: min = 6; 4'h5: min = 7; 4'h6: min = 8; 4'h7: min = 9; 4'h8: min =10; 4'h9: min =11; 4'ha: min =12; 4'hb: min =13; 4'hc: min =14; 4'hd: min =16; 4'he: min =18; 4'hf: min = 20;

PWM A Channel delay (0x11)

Bit	7	6	5	4	3	2	1	0
Name	PWMPD1							

Name	Label	Type	Default	Description
PWMPD1	pwm_phaseoffset1 [7:0]	RW	8'h00	Add an offset delay to PWM_CH1P , -128(lead 128 cycles) ~127(lag 127 cycles), 80H(-128)->FF(-1)->00(0)->7F(127) Step: 5.1ns 48khz base rate, 5.536ns 44.1khz base rate

PWM B Channel delay (0x12)

Bit	7	6	5	4	3	2	1	0
Name	PWMPD2							

Name	Label	Type	Default	Description
PWMPD2	pwm_phaseoffset2 [7:0]	RW	8'h00	Add an offset delay to PWM_CH1N ,-128(lead 128 cycles) ~127(lag 127 cycles), 80H(-128)->FF(-1)->00(0)->7F(127) Step: 5.1ns 48khz base rate, 5.536ns 44.1khz base rate

PWM C Channel delay (0x13)

Bit	7	6	5	4	3	2	1	0
Name	PWMPD3							

Name	Label	Type	Default	Description
PWMPD3	pwm_phaseoffset3 [7:0]	RW	8'h00	Add an offset delay to PWM_CH2P , -128(lead 128 steps) ~127(lag 127 steps), 80H(-128)->FF(-1)->00(0)->7F(127) Step: 5.1ns 48khz base rate, 5.536ns 44.1khz base rate

PWM D Channel delay (0x14)

Bit	7	6	5	4	3	2	1	0
Name	PWM_PD4							

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Name	Label	Type	Default	Description
PWM_PD4	pwm_phaseoffset4 [7:0]	RW	8'h00	Add an offset delay to PWM_CH2N , -128(lead 128 cycles) ~127(lag 127 cycles), 80H(-128)->FF(-1)->00(0)->7F(127) Step: 5.1ns 48khz base rate, 5.536ns 44.1khz base rate

I²S Control (0x15)

Bit	7	6	5	4	3	2	1	0
Name	X	I2S_SI	I2S_LI	I2S_en	I2S_FMT		I2S_BIT	

Name	Label	Type	Default	Description
I2S_BIT	i2s_vbits	RW	2'b00	2'b00: 24bits 2'b01: 20bits 2'b10: 18bits 2'b11: 16bits
I2S_FMT	i2s_fmt	RW	2'b00	2'b00: I2S 2'b01: LJ 2'b10: RJ 2'b11: Reserved
I2S_en	i2s_en	RW	1'b1	0:disable 1: enable
I2S_LI	i2s_lr_polarity	RW	1'b0	1'b0: not invert LRCLK 1'b1: invert LRCLK
I2S_SI	i2s_sclk_inv	RW	1'b0	1'b0: not invert SCLK 1'b1: invert SCLK

DSP Control Register1 (0x16)

Bit	7	6	5	4	3	2	1	0
Name	FRS			DSP_FTS		CH1_en	CH2_en	X

Name	Label	Type	Default	Description
CH2_en	ch2_en	RW	1'b1	Enable channel 2: 1'b0 disable; 1'b1: enable.
CH1_en	ch1_en	RW	1'b1	Enable channel 1: 1'b0 disable; 1'b1: enable.
DSP_FTS	dsp_fade_time_sel	RW	2'b00	2'b00: default, x1, about 8ms; 2'b01: x2; 2'b10: x4; 2'b11: x8.
FRS	fir_rolloff_sel	RW	3'b000	FIR interpolation filter select, different setting has differrent passband, stopband, passband ripple and stop band attenuation. Default 3'b000.

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Monitor Pin configured Register1 (0x17)

Bit	7	6	5	4	3	2	1	0
Name	mon0_en	X		SD_L	MON0			

Name	Label	Type	Default	Description
MON0	monitor0_cfg[3:0]	RW	4'h0	4'h0: i2s_data_out; 4'h1: pwm_out_a; 4'h2: pwm_out_b; 4'h3: pwm_out_c; 4'h4: pwm_out_d; 4'h5: stbyb; 4'h6: fault_clr_ready; 4'h7: pll_locked; 4'h8: fault_otuv; 4'h9: a2d_osc_clk; 4'ha: pll_div32; 4'hb: fault_pin_stat; 4'hc: fault_short; 4'hd: avdd_uv; 4'he: shdwb; 4'hf: fault_oc.
SD_L	sda_out_loc	RW	1'b0	I^2S data out selection. 1: select audio data prior to processing. 0: select data behind prcossing.
mon0_en	monitor0_en	RW	1'b0	Enable monitor0: 1'b0:disable; 1'b1:enable

PWM Direct Current Threshold (0x19)

Bit	7	6	5	4	3	2	1	0
Name	X	ODFE	AFOE	FBC	TH			

Name	Label	Type	Default	Description
TH	threshold_sel[3:0]	RW	4'h5	When enable PWM DC detection, the signal transient level of both left and right channel output is monitored for each pwm cycle. If the transient level is larger than the threshold for more than 500ms, a DC component is detected on PWM output. The threshold can be set as following, step is 1% of full scale PWM output: 4'h0:1% ; 4'h1:2%; …… 4'hf: 15%.
FBC	fault_b_ctrl	RW	1'b0	Fault_B control method. 1'b0: when fault_b is asserted, high level of fault_b will be active when detected by the window set in 0x1B; 1'b1: when fault_b is asserted, high level of fault_b will be active directly.
AFOE	adr_faultb_output_en	RW	1'b0	1'b0: input addr_sel ; 1'b1: output fault_b.
ODFE	open_drain_faultb_en	RW	1'b0	control open drain faultb: 1'b0: disable ; 1'b1: enable.

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System Control Register 3 (0x1A)

Bit	7	6	5	4	3	2	1	0
Name	X			HP_en	HP_G			

Name	Label	Type	Default	Description
HP_G	hp_gain[3:0]	RW	4'b0000	Headphone gain: 4'b0000: 0dB; 4'b0001: 5dB; 4'b0010: 6dB; 4'b0011: 7dB; 4'b0100: 8dB; 4'b0101: 9dB; 4'b0110: 10dB; 4'b0111: 11dB; 4'b1000: 12dB; 4'b1001: 13dB; 4'b1010: 14dB; 4'b1011: 15dB; 4'b1100: 16dB; 4'b1101: 17dB; 4'b1110: 18dB; 4'b1111: 19dB.
HP_en	hp_en	RW	1'b0	Enable headphone 1'b0: disable; 1'b1: enable.

Short Control Register (0x1B)

Bit	7	6	5	4	3	2	1	0
Name	STE	FCI			SPE	RI		

Name	Label	Type	Default	Description
RI	retry_interval	RW	3'b101	3'd0: 100ms; 3'd1: 200ms; 3'd2: 400ms; 3'd3: 600ms; 3'd4: 800ms; 3'd5: 1second; 3'd6: 2second; 3'd7: 4second.
SPE	second_phase_en	RW	1'b1	1'b0: disable; 1'b1: enable.
FCI	fault_clr_interval	RW	3'b011	3'd2: 2ms; 3'd3: 4ms; 3'd4: 8ms; 3'd5: 16ms; 3'd6: 32ms; Others: 4ms.
STE	short_try_en	RW	1'b1	When short is detected after power on, enable check that if the pin short to PVDD or ground. 1'b1: enable; 1'b0: disable.

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Fault Output Time (0x1C)

Bit	7	6	5	4	3	2	1	0
Name	X				BKND			

Name	Label	Type	Default	Description
BKND	bknd[3:0]	RW	4'h2	After pad_adr_fault_b is configured as output, any fault of oc, otuv, avdd_uv, short, and short load, will trigger pad_adr_fault_b output a negative pulse; the pulse width has a lower limit. If the fault release earlier than the lower limit time, pad_adr_fault_b will release at the lower limit time, else it will release togather with these faults 4'h2: 299ms; 4'h3: 499ms; 4'h4: 598ms; 4'h5: 748ms; 4'h6: 898ms; 4'h7: 1047ms; 4'h8: 1197ms; 4'h9: 1346ms; others: 1496ms;

Operation Mode (0x1E)

Bit	7	6	5	4	3	2	1	0
Name	X					PBTL_DE	PBTL_en	TM_en

Name	Label	Type	Default	Description
TM_en	ternary_mode_en	RW	1'b1	1'b0: Reserved mode 1'b1: Ternary mode
PBTL_en	pbtl_en	RW	1'b0	1'b0: btl mode; 1'b1: pbtl mode
PBTL_DE	pbtl_digital_en	RW	1'b1	Enable the digital die of re-selecting the output from PWMA~D to work as pbtl mode 1'b0: disable; 1'b1: enable
I2C_MAN	i2c_access_ram_ctl_manual	RW	1'b0	Auto switch i2c access to RAM or DSP access to RAM enable. 1'b0: disable; 1'b1: enable.

Checksum Control Register (0x1F)

Bit	7	6	5	4	3	2	1	0
Name	X				I2C_MAN	PDDE	PCE	DCE

Name	Label	Type	Default	Description
DCE	drc_checksum_en	RW	1'b0	1'b0: disable; 1'b1: check the DRC coefficient part of memory (from 0x47 to 0x57).
PCE	pbq_checksum_en	RW	1'b0	1'b0: disable; 1'b1: check the PBQ coefficient part of memory , channel 1 & 2 independently (from 0x2f to 0x46 of channel 1 ram, from 0x2f to 0x40 of channel 2 ram).
PDDE	pwm_dc_det_en	RW	1'b0	1'b0: disable the DC detection on PWM; 1'b1: enable the DC detection.

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Input MUX Register (0x20)

Bit	7	6	5	4	3	2	1	0
Name	CSS		X					

Name	Label	Type	Default	Description
CSS	ch_src_sel[1:0]	RW	2'b00	2'b00:I²S Left channel data for ch1, right channel data for ch2; 2'b01:I²S right channel data for ch1, left channel data for ch2; 2'b10: (right + left)/2 for ch1 and ch2; 2'b11:data = 0.

DSP Control register2 (0x21)

Bit	7	6	5	4	3	2	1	0
Name	DAL			DAE	DC1AF	DC2AF	X	

Name	Label	Type	Default	Description
DC2AF	dsp_ch2_amute_flag	R	1'b0	DSP right channel auto mute flag, read only.
DC1AF	dsp_ch1_amute_flag	R	1'b0	DSP left channel auto mute flag, read only.
DAE	dsp_amute_en	RW	1'b0	1'b0: DSP auto mute disabled; 1'b1: DSP auto mute enabled.
DAL	dsp_amute_len[2:0]	RW	3'b000	3'b000: auto mute zero detect length, 512; 3'b001: auto mute zero detect length, 1024; 3'b010: auto mute zero detect length, 2048; 3'b011: auto mute zero detect length, 4096; 3'b100: auto mute zero detect length, 4096*2; 3'b101: auto mute zero detect length, 4096*4; 3'b110: auto mute zero detect length, 4096*8; 3'b111: auto mute zero detect length, 4096*16.

PWM Control register (0x22)

Bit	7	6	5	4	3	2	1	0
Name	X		SDOWN	SBY	X			

Name	Label	Type	Default	Description
SBY	enter_all_standby	RW	1'b1	1'b0:exit all-channel standby; 1'b1:enter all-channel standby (hard mute, hiz, sound off).
SDOWN	enter_all_shutdown	RW	1'b1	1'b0:exit all-channel shutdown (normal operation); 1'b1:enter all-channel shutdown (hard mute, hiz).

Fault Select Register (0x23)

Bit	7	6	5	4	3	2	1	0
Name	X	FCTS			X	SOTE	SMOE	SODE

Name	Label	Type	Default	Description
SODE	sld_old_det_en	RW	1'b0	1'b0: disable; 1'b1: enable;
SMOE	short_mask_oc_en	RW	1'b1	1'b0: disable; 1'b1: enable;

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SOTE	sld_old_try_en	RW	1'b0	1'b0: disable; 1'b1: enable;
FCTS	fault_clr_times_sel[2:0]	RW	3'b001	3'b000: fault detected 2 times, fault_lock active 3'b001: fault detected 5 times, fault_lock active 3'b010: fault detected 10 times, fault_lock active 3'b011: fault detected 15 times, fault_lock active 3'b100: fault detected 20 times, fault_lock active 3'b101: fault detected 25 times, fault_lock active 3'b110: fault detected 30 times, fault_lock active 3'b111: fault detected infinte times, fault_lock active

Channel1 EQ Filter Control Register 1 (0x25)

Bit	7	6	5	4	3	2	1	0
Name	EQ15	EQ14	EQ5	EQ4	EQ3	EQ2	EQ1	EQ0

Name	Label	Type	Default	Description
EQ0	ch1_eq0_en	RW	1'b0	Ch1 EQ0, 1'b0: bypass, 1'b1: enable
EQ1	ch1_eq1_en	RW	1'b0	Ch1 EQ1, 1'b0: bypass, 1'b1: enable
EQ2	ch1_eq2_en	RW	1'b0	Ch1 EQ2, 1'b0: bypass, 1'b1: enable
EQ3	ch1_eq3_en	RW	1'b0	Ch1 EQ3, 1'b0: bypass, 1'b1: enable
EQ4	ch1_eq4_en	RW	1'b0	Ch1 EQ4, 1'b0: bypass, 1'b1: enable
EQ5	ch1_eq5_en	RW	1'b0	Ch1 EQ5, 1'b0: bypass, 1'b1: enable
EQ14	ch1_eq14_en	RW	1'b0	Ch1 EQ14, 1'b0: bypass, 1'b1: enable
EQ15	ch1_eq15_en	RW	1'b0	Ch1 EQ15, 1'b0: bypass, 1'b1: enable

Channel1 EQ Filter Control Register 2 (0x26)

Bit	7	6	5	4	3	2	1	0
Name	EQ13	EQ12	EQ11	EQ10	EQ9	EQ8	EQ7	EQ6

Name	Label	Type	Default	Description
EQ6	ch1_eq6_en	RW	1'b0	Ch1 EQ6, 1'b0: bypass, 1'b1: enable
EQ7	ch1_eq7_en	RW	1'b0	Ch1 EQ7, 1'b0: bypass, 1'b1: enable
EQ8	ch1_eq8_en	RW	1'b0	Ch1 EQ8, 1'b0: bypass, 1'b1: enable
EQ9	ch1_eq9_en	RW	1'b0	Ch1 EQ9, 1'b0: bypass, 1'b1: enable
EQ10	ch1_eq10_en	RW	1'b0	Ch1 EQ10, 1'b0: bypass, 1'b1: enable
EQ11	ch1_eq11_en	RW	1'b0	Ch1 EQ11, 1'b0: bypass, 1'b1: enable
EQ12	ch1_eq12_en	RW	1'b0	Ch1 EQ12, 1'b0: bypass, 1'b1: enable
EQ13	ch1_eq13_en	RW	1'b0	Ch1 EQ13, 1'b0: bypass, 1'b1: enable

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Channel2 EQ Filter Control Register 1 (0x27)

Bit	7	6	5	4	3	2	1	0
Name	EQ15	EQ14	EQ5	EQ4	EQ3	EQ2	EQ1	EQ0

Name	Label	Type	Default	Description
EQ0	ch2_eq0_en	RW	1'b0	Ch2 EQ0, 1'b0: bypass, 1'b1: enable
EQ1	ch2_eq1_en	RW	1'b0	Ch2 EQ1, 1'b0: bypass, 1'b1: enable
EQ2	ch2_eq2_en	RW	1'b0	Ch2 EQ2, 1'b0: bypass, 1'b1: enable
EQ3	ch2_eq3_en	RW	1'b0	Ch2 EQ3, 1'b0: bypass, 1'b1: enable
EQ4	ch2_eq4_en	RW	1'b0	Ch2 EQ4, 1'b0: bypass, 1'b1: enable
EQ5	ch2_eq5_en	RW	1'b0	Ch2 EQ5, 1'b0: bypass, 1'b1: enable
EQ14	ch2_eq14_en	RW	1'b0	Ch2 EQ14, 1'b0: bypass, 1'b1: enable
EQ15	ch2_eq15_en	RW	1'b0	Ch2 EQ15, 1'b0: bypass, 1'b1: enable

Channel2 EQ Filter Control Register 2 (0x28)

Bit	7	6	5	4	3	2	1	0
Name	EQ13	EQ12	EQ11	EQ10	EQ9	EQ8	EQ7	EQ6

Name	Label	Type	Default	Description
EQ6	ch2_eq6_en	RW	1'b0	Ch2 EQ6, 1'b0: bypass, 1'b1: enable.
EQ7	ch2_eq7_en	RW	1'b0	Ch2 EQ7, 1'b0: bypass, 1'b1: enable.
EQ8	ch2_eq8_en	RW	1'b0	Ch2 EQ8, 1'b0: bypass, 1'b1: enable.
EQ9	ch2_eq9_en	RW	1'b0	Ch2 EQ9, 1'b0: bypass, 1'b1: enable.
EQ10	ch2_eq10_en	RW	1'b0	Ch2 EQ10, 1'b0: bypass, 1'b1: enable.
EQ11	ch2_eq11_en	RW	1'b0	Ch2 EQ11, 1'b0: bypass, 1'b1: enable.
EQ12	ch2_eq12_en	RW	1'b0	Ch2 EQ12, 1'b0: bypass, 1'b1: enable.
EQ13	ch2_eq13_en	RW	1'b0	Ch2 EQ13, 1'b0: bypass, 1'b1: enable.

SPEQ Filter Control Register1 (0x29)

Bit	7	6	5	4	3	2	1	0
Name	CH1_EQ17	CH1_EQ16	CH2_EQ17	CH2_EQ16	BQ17_ctrl		BQ16_ctrl	

Name	Label	Type	Default	Description
BQ16_ctrl	bq16_ctrl[1:0]	RW	2'b00	2'b00: bq16 configured as EQ16; 2'b01: bq16 configured as SPEQ4; 2'b10: bq16 configured as SPEQ4 Limit; 2'b11: reserved.
BQ17_ctrl	bq17_ctrl[1:0]	RW	2'b00	2'b00: bq17 configured as EQ17; 2'b01: bq17 configured as SPEQ5; 2'b10: bq17 configured as SPEQ5 Limit; 2'b11: reserved.
CH2_EQ16	ch2_eq16_en	RW	1'b0	Ch2 EQ16, 1'b0: bypass, 1'b1: enable.
CH2_EQ17	ch2_eq17_en	RW	1'b0	Ch2 EQ17, 1'b0: bypass, 1'b1: enable.
CH1_EQ16	ch1_eq16_en	RW	1'b0	Ch1 EQ16, 1'b0: bypass, 1'b1: enable.
CH1_EQ17	ch1_eq17_en	RW	1'b0	Ch1 EQ17, 1'b0: bypass, 1'b1: enable.

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SPEQ Filter Control Register2 (0x2A)

Bit	7	6	5	4	3	2	1	0
Name	BQ15_ctrl		BQ14_ctrl		BQ13_ctrl		BQ12_ctrl	

Name	Label	Type	Default	Description
BQ12_ctrl	bq12_ctrl[1:0]	RW	2'b00	2'b00: bq12 configured as EQ12; 2'b01: bq12 configured as SPEQ0; 2'b10: bq12 configured as SPEQ0 Limit; 2'b11: reserved.
BQ13_ctrl	bq13_ctrl[1:0]	RW	2'b00	2'b00: bq13 configured as EQ13; 2'b01: bq13 configured as SPEQ1; 2'b10: bq13 configured as SPEQ1 Limit; 2'b11: reserved.
BQ14_ctrl	bq14_ctrl[1:0]	RW	2'b00	2'b00: bq14 configured as EQ14; 2'b01: bq14 configured as SPEQ2; 2'b10: bq14 configured as SPEQ2 Limit; 2'b11: reserved.
BQ15_ctrl	bq15_ctrl[1:0]	RW	2'b00	2'b00: bq15 configured as EQ15; 2'b01: bq15 configured as SPEQ3; 2'b10: bq15 configured as SPEQ3 Limit; 2'b11: reserved.

SPEQ Filter Control Register3 (0x2B)

Bit	7	6	5	4	3	2	1	0
Name	X							SDM

Name	Label	Type	Default	Description
SDM	speq_det_method	RW	1'b0	1'b0: envelope 1'b1: rms

Prescaler (0x2C)

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PRE															

Name	Label	Type	Default	Description
PRE	prescaler[15:0]	RW	16'h7FFF	0000~FFFF, pre scale. Linear gain, 7FFF is x1(0dB). FFFF is x2(6dB)

Postscaler (0x2D)

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	POST															

Name	Label	Type	Default	Description
POST	postscaler[15:0]	RW	16'h7FFF	0000~FFFF, post scale. Linear gain, 7FFF is x1(0dB). FFFF is x2(6dB)

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BQn(n=0,1,2…17) (0x2F~0x40)

Bit	159:128	127:96	95:64	63:32	31:0
Name	A2	A1	B2	B1	B0

Name	Label	Type	Default	Description
B0	bqn_b0[31:0]	RW	0x0400_0000	BQ coefficient,
B1	bqn_b1[31:0]	RW	0x0000_0000	BQ coefficient,
B2	bqn_b2[31:0]	RW	0x0000_0000	BQ coefficient,
A1	bqn_a1[31:0]	RW	0x0000_0000	BQ coefficient,
A2	bqn_a2[31:0]	RW	0x0000_0000	BQ coefficient,

SPEQn(n=0,1,2…5) (0x41~46)

Bit	95:64	63:32	31:0
Name	COEF2	COEF1	TH

Name	Label	Type	Default	Description
TH	speqn_th[31:0]	RW	0x0020_0000	SPEQn threshold
COEF1	speqn_coef1[31:0]	RW	0x0400_0000	SPEQn coefficient 1
COEF2	speqn_coef2[31:0]	RW	0x0200_0000	SPEQn coefficient 2

DRC BQn(n=0,1,2…15) (0x47~56)

Bit	159:128	127:96	95:64	63:32	31:0
Name	A2	A1	B2	B1	B0

Name	Label	Type	Default	Description
B0	drcn_bq0_b0[31:0]	RW	0x0400_0000	BQ coefficient, [31:29] is reserved
B1	drcn_bq0_b1[31:0]	RW	0x0000_0000	BQ coefficient, [31:29] is reserved
B2	drcn_bq0_b2[31:0]	RW	0x0000_0000	BQ coefficient, [31:29] is reserved
A1	drcn_bq0_a1[31:0]	RW	0x0000_0000	BQ coefficient, [31:29] is reserved
A2	drcn_bq0_a2[31:0]	RW	0x0000_0000	BQ coefficient, [31:29] is reserved

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Channel 1&2 Loudness (0x57)

Bit	95:64	63:32	31:0
Name	LD3_G	LD2_G	LD1_G

Name	Label	Type	Default	Description
LD1_G	ld1_gain[31:0]	RW	0x4000_0000	loudness gain of BQ1, only positive. 0x0000_0000(-inf)~0x0800_0000(x1, 0dB)~0x0FFF_FFFF(x2, +6dB)
LD2_G	ld2_gain[31:0]	RW	0x4000_0000	loudness gain of BQ2, only positive. 0x0000_0000(-inf)~0x0800_0000(x1, 0dB)~0x0FFF_FFFF(x2, +6dB)
LD3_G	ld3_gain[31:0]	RW	0x4000_0000	loudness gain of BQ3, only positive. 0x0000_0000(-inf)~0x0800_0000(x1, 0dB)~0x0FFF_FFFF(x2, +6dB)

SPEQ_ATK_REL_TC_1 (0x5D)

Bit	143	142:120	119	118:96	95	94:72	71	70:48	47	46:24	23	22:0
Name	X	SPEQ5	X	SPEQ4	X	SPEQ3	X	SPEQ2	X	SPEQ1	X	SPEQ0

Name	Label	Type	Default	Description
SPEQ0AT	speq0_atk_tc[22:0]	RW	23'h000_800	Attack time control
SPEQ1AT	speq1_atk_tc[22:0]	RW	23'h000_800	Attack time control
SPEQ2AT	speq2_atk_tc[22:0]	RW	23'h000_800	Attack time control
SPEQ3AT	speq3_atk_tc[22:0]	RW	23'h000_800	Attack time control
SPEQ4AT	speq3_atk_tc[22:0]	RW	23'h000_800	Attack time control
SPEQ5AT	speq3_atk_tc[22:0]	RW	23'h000_800	Attack time control

SPEQ_ATK_REL_TC_2 (0x5E)

Bit	143	142:120	119	118:96	95	94:72	71	70:48	47	46:24	23	22:0
Name	X	SPEQ5	X	SPEQ4	X	SPEQ3	X	SPEQ2	X	SPEQ1	X	SPEQ0

Name	Label	Type	Default	Description
SPEQ0RT	speq0_rel_tc[22:0]	RW	23'h7FF800	Release time control
SPEQ1RT	speq1_rel_tc[22:0]	RW	23'h7FF800	Release time control
SPEQ2RT	speq2_rel_tc[22:0]	RW	23'h7FF800	Release time control
SPEQ3RT	speq3_rel_tc[22:0]	RW	23'h7FF800	Release time control
SPEQ4RT	speq3_rel_tc[22:0]	RW	23'h7FF800	Release time control
SPEQ5RT	speq3_rel_tc[22:0]	RW	23'h7FF800	Release time control

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ch12_mixer_gain (0x5F)

Bit	31	30	29:24	23	22	21:16	15	14	13:8	7	6	5:0
Name	X	P11	G11	X	P12	G12	X	P21	G21	X	P22	G22

Name	Label	Type	Default	Description
G22	ch2_mixer_fch2_gain [5:0]	RW	6'h27	Refer to mixer gain table
P22	ch2_mixer_fch2_polarity	RW	1'b0	1'b0: plus 1'b1: minus
G21	ch2_mixer_fch1_gain [5:0]	RW	6'h00	Refer to mixer gain table
P21	ch2_mixer_fch1_polarity	RW	1'b0	1'b0: plus 1'b1: minus
G12	ch1_mixer_fch2_gain [5:0]	RW	6'h00	Refer to mixer gain table
P12	ch1_mixer_fch2_polarity	RW	1'b0	1'b0: plus 1'b1: minus
G11	ch1_mixer_fch1_gain [5:0]	RW	6'h27	Refer to mixer gain table
P11	ch1_mixer_fch1_polarity	RW	1'b0	1'b0: plus 1'b1: minus

DRC Control (0x60)

Bit	31:25	24	23:10	11	10:9	8	7:4	3	2	1	0
Name	X	DDM	X	DCO	DCM	EM	X	LLE	MLE	HLE	PLE

Name	Label	Type	Default	Description
PLE	drc4_lmt_en	RW	1'b0	0:disable 1: enable
HLE	drc3_lmt_en	RW	1'b0	0:disable 1: enable
MLE	drc2_lmt_en	RW	1'b0	0:disable 1: enable
LLE	drc1_lmt_en	RW	1'b0	0:disable 1: enable
EM	envlp_mode	RW	1'b0	Envelope detection method selection. 0: classic method, 1: new method.
DCM	drc_crossover_mode[1:0]	RW	2'b00	DRC crossover filter mode selection. 2'b00: tree mode 2'b01: sum mode. 2'b10: seperated mode 2'b11: reserved
DCO	drc_crossover_order	RW	1'b0	1'b0: low order 1'b1: high order
DDM	drc_det_method	RW	1'b1	1'b0: envelope 1'b1: rms

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DRCx_LMT_CFG1(x=1,2,3) (0x61/64/67)

Bit	23:22	21:12	11:10	9:0
Name	X	MGx	X	THx

Name	Label	Type	Default	Description
THx	drcx_lmt_thr[9:0]	RW	10'h30C	DRC limit threshold, 10'h000(-97.5dB)~10'h3FC(30dB), step is 0.125dB 10'h30C = 0dB, 10'h3FC = 30dB
MGx	drcx_makeup[9:0]	RW	10'h3CC	Gain control of DRC band. 10'h000(-121.5dB)~10'h3FC(6dB), step is 0.125dB 10'h3FC = 6dB, 10'h3CC = 0dB

DRC4_LMT_CFG1 (0x6A)

Bit	23:10	9:0
Name	X	PTH

Name	Label	Type	Default	Description
PTH	drc4_lmt_thr[9:0]	RW	10'h30C	DRC limit threshold, 10'h000(-97.5dB)~10'h3FC(30dB), step is 0.125dB 10'h30C = 0dB, 10'h3FC = 30dB

DRCx_LMT_CFG2(x=1,2,3,4) (0x62/65/68/6B)

Bit	23	22:0
Name	X	ATx

Name	Label	Type	Default	Description
ATx	drcx_lmt_atk_tc[[22:0]	RW	23'h06_0F83	Attack time control

DRCx_LMT_CFG3(x=1,2,3,4) (0x63/66/69/6C)

Bit	23	22:0
Name	X	RTx

Name	Label	Type	Default	Description
RTx	drc1_lmt_rel_tc[22:0]	RW	24'h00_0122	Release time control

drc_envlp_tc_up (0x6D)

Bit	23	22:0
Name	X	DETU

Name	Label	Type	Default	Description
DETU	drc_envlp_tc_up[22:0]	RW	23'h01_0000	The attack coefficient of drc signal level envelop detection

drc_envlp_tc_dn (0x6E)

Bit	23	22:0
Name	X	DETD

Name	Label	Type	Default	Description
DETD	drc_envlp_tc_dn[22:0]	RW	23'h7B_0000	The release coefficient of drc signal level envelop detection

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auto mute threshold (0x6F)

Bit	23:16	15:0
Name	X	AM_TH

Name	Label	Type	Default	Description
AM_TH	dsp_amute_thr[15:0]	RW	16'h00	DSP auto mute threshold

SPK Sequence Bypass (0x73)

Bit	7	6	5	4	3	2	1	0
Name	X					PAMD	C2SB1	C1SB1

Name	Label	Type	Default	Description
C1SB1	ch1_seq_bypass_1ms	RW	1'b0	1'b0:channel 1 spk_state bypass disable 1'b1:channel 1 spk_state bypass, (not wait 1ms)
C2SB1	ch2_seq_bypass_1ms	RW	1'b0	1'b0:channel 2 spk_state bypass disable 1'b1:channel 2 spk_state bypass (not wait 1ms)
PAMD	pwm_automute_dis	RW	1'b0	1'b0: pwm auto mute enable 1'b1: pwm auto mute disable

protection system control (0x76)

Bit	7	6	5	4	3	2	1	0
Name	X			PRE	SPE	OTPE	OCPE	AUPE

Name	Label	Type	Default	Description
AUPE	avdd_uv_protect_en	RW	1'b1	1'b0: disable; 1'b1: enable.
OCPE	oc_protect_en	RW	1'b1	1'b0: disable; 1'b1: enable.
OTPE	otuv_protect_en	RW	1'b1	1'b0: disable; 1'b1: enable.
SPE	short_protect_en	RW	1'b1	1'b0: disable; 1'b1: enable.
PRE	poweron_retry_en	RW	1'b1	1'b0: disable; 1'b1: enable.

I2C Control Register (0x78)

Bit	23:0
Name	HCTH

Name	Label	Type	Default	Description
HCTH	hard_clipper_thr[23:0]	RW	24'h7FF_FFF	Hard clipper threshold. Default 24'h7FF_FFF.

Dsp_3d_coef (0x80)

Bit	23:0
Name	3DCOEF

Name	Label	Type	Default	Description
3DCOEF	dsp_3d_coef[23:0]	RW	0x400000	3D coefficient, linear gain. 2's complement, 0(-inf) ~ 0x7FFFFF(2), 0x800000(-2)~0xFFFFFF(near -0), 0x400000 =1, 0x7FFFFF = 2, 0xc00000 = -1.

Dsp_3d_mix (0x81)

Bit	23:0

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Name	3DMIX

Name	Label	Type	Default	Description
3DMIX	dsp_3d_mix[23:0]	RW	0x400000	3D mix gain, linear gain. 2's complement, 0(-inf) ~ 0x7FFFFF(2), 0x800000(-2)~0xFFFFFF(near -0), 0x400000 =1, 0x7FFFFF = 2, 0xc00000 = -1.

Inter Private register(0x82)

Bit	31:8	7	6	5	4:1	0
Name	X	RSRE	SEE	LEE	X	SSE

Name	Label	Type	Default	Description
SSE	spk_scdet_en	RW	1'b0	1'b0: spk_scdet_en, enable All channel should be set Binary mode; 1'b1: pwm_outA=pwm_outB= CH1_P_SIDE; pwm_outC = pwm_outD = CH2_P_SIDE.
LEE	lrclk_err_en	RW	1'b1	1'b0: lr_clk_error would not be shown in 0x02(bit[4]); 1'b1: lr_clk_error would be shown in 0x02(bit[4]).
SEE	sclk_err_en	RW	1'b1	1'b0: sclk error would not be shown in 0x02 (bit[5]); 1'b1: sclk error would be show in 0x02(bit[5]).
RSRE	refclk_stop_reg_en	RW	1'b1	1'b0: sclk_stop error would be not shown in 0x02 (bit[5]) 1'b1: sclk_stop error would show in 0x02(bit[5])

OC Detect Window Width (0x85)

Bit	31:10	9	8	7:6	5:0
Name	X	OTE	OMS	X	OWW

Name	Label	Type	Default	Description
OWW	ocdet_wind_width[5:0]	RW	6'h06	ocdet_wind_width
OMS	ocdet_mannual_sel	RW	1'b0	ocdet_mannual_sel
OTE	ocfast_trig_en	RW	1'b0	oc fast trigger

Fault Over Current Threshold (0x86)

Bit	31:15	14:12	11:9	8:0
Name	X	FD	X	OEN

Name	Label	Type	Default	Description
OEN	ocdet_en_num[8:0]	RW	9'h006	Threshold of total cycles that "fault_oc" be counted in large detect window. A counted number over the threshold will trigger an oc fault
FD	filter_deglitch[2:0]	RW	3'b010	Deglitch all the fault_oc signal pulse if its width is smaller than this configured cycle number

Error Status (0x89)

Bit	7	6	5	4	3	2	1	0
Name	X				PNEC1	PPEC1	PNEC2	PPEC2

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Name	Label	Type	Default	Description
PPEC2	pwm_pdc_err_ch2	R	1'b0	1'b1: channel 2 has an p-side DC error; 1'b0: no such error;
PNEC2	pwm_ndc_err_ch2	R	1'b0	1'b1: channel 2 has an n-side DC error; 1'b0: no such error;
PPEC1	pwm_pdc_err_ch1	R	1'b0	1'b1: channel 1 has an p-side DC error; 1'b0: no such error;
PNEC1	pwm_ndc_err_ch1	R	1'b0	1'b1: channel 1 has an n-side DC error; 1'b0: no such error;

DSP Control Register 3 (0x8B)

Bit	7	6	5	4	3	2	1	0
Name	X						3D_en	HC_en

Name	Label	Type	Default	Description
HC_en	hard_clipper_en	RW	1'b0	Hard clipper enable. 1'b0: disable 1'b1: enable
3D_en	3d_en	RW	1'b0	3d enable: 1'b0:disable 1'b1:enable

FUNC DEBUG Register (0x8C)

Bit	7	6	5	4	3	2	1	0
Name	FD							

Name	Label	Type	Default	Description
FD	func_debug	rw	8h'C8	[7]: new_tc = 1 - tc/g mode enable, active high. This bit shall be used when bit6 is high. [6]: Attck exponential control mode, release linear control mode enable, active high [5]: Reserved [4]: tc offset mode enable, active high. [3]: Linear drc gain control method 1 enable, active high. [2]: Linear drc gain control method 1 enable, active high. [1]: 1, force using envelope level detection method. 0, level detection mode decided by each function. [0]: 1, Select left channel level for for both channel DRC. 0, left channel signal level for left channel, right for right.

drc1_envlp_tc_up (0x8E)

Bit	23	22:0
Name	X	LETU

Name	Label	Type	Default	Description
LETU	drc1_envlp_tc_up[22:0]	RW	23'h01 _0000	The attack coefficient of drc signal level envelop detection

drc1_envlp_tc_dn (0x8F)

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Bit	23	22:0
Name	X	LETD

Name	Label	Type	Default	Description
LETD	drc1_envlp_tc_dn[22:0]	RW	23'h7B_0000	The release coefficient of drc signal level envelop detection

drc2_envlp_tc_up (0x90)

Bit	23	22:0
Name	X	METU

Name	Label	Type	Default	Description
METU	drc2_envlp_tc_up[22:0]	RW	23'h01_0000	The attack coefficient of drc signal level envelop detection

drc2_envlp_tc_dn (0x91)

Bit	23	22:0
Name	X	METD

Name	Label	Type	Default	Description
METD	drc2_envlp_tc_dn[22:0]	RW	23'h7B_0000	The release coefficient of drc signal level envelop detection

drc3_envlp_tc_up (0x92)

Bit	23	22:0
Name	X	HETU

Name	Label	Type	Default	Description
HETU	drc3_envlp_tc_up[22:0]	RW	23'h01_0000	The attack coefficient of drc signal level envelop detection

drc3_envlp_tc_dn (0x93)

Bit	23	22:0
Name	X	HETD

Name	Label	Type	Default	Description
HETD	drc3_envlp_tc_dn[22:0]	RW	23'h7B_0000	The release coefficient of drc signal level envelop detection

PWM MUX register (0x94)

Bit	31:21	20	19	18	17	16	15:5	4	3:1	0
Name	X	PCT[4]	PCT[3]	PCT[2]	PCT[1]	PCT[0]	X	PE	X	PNZ

Name	Label	Type	Default	Description
PNZ	pwm_ns_zr	RW	1'b0	1'b0: normal 1'b1: add zero to fs/2 to desrease high frequency noise
PE	pwm_evenbit	RW	1'b0	1: quantize, input data even, tri-mode, (10bit, {[23,15],1'b0}). quantize, input data even, bin-mode (9

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				bit ,{[23:16],2'b0}) 0: quantize, input data not even, tri-mode, (10bit, {[23,14]}). quantize, input data not even, bin-mode (9 bit ,{[23:15],1'b0})
PCT[0]	pwm_connection_test[0]	RW	1'b0	1'b0: pwm_out_a = 0 1'b1: control pwm_out_a in case of pwm_conection enable, used to test analog connection. pwm_out_a = 1
PCT[1]	pwm_connection_test[1]	RW	1'b0	1'b0: pwm_out_b = 0 1'b1: pwm_out_b = 1
PCT[2]	pwm_connection_test[2]	RW	1'b0	1'b0: pwm_out_c= 0 1'b1: pwm_out_c= 1
PCT[3]	pwm_connection_test[3]	RW	1'b0	1'b0: pwm_out_d= 0 1'b1: pwm_out_d= 1
PCT[4]	pwm_connection_test[4]	RW	1'b0	1'b0: pwm connection test disable 1'b1: pwm_connection test enable

PWM Outflip register (0x95)

Bit	31	30:24	23:22	21	20	19:17	16	15	14;12	11	10:8	7	6:4	3	2:0
Name	X	PDRP	X	PCM	PAME	X	POR[12]	X	POR[11:9]	X	POR[8:6]	X	POR[5:3]	X	POR[2:0]

Name	Label	Type	Default	Description
POR[2:0]	pwm_outflip_reg[2:0]	RW	3'b000	3'b000: pwm_outflip[2:0]: pwm_outa = side1_p 3'b001: pwm_outflip[2:0]: pwm_outa = side1_n 3'b010: pwm_outflip[2:0]: pwm_outa = side2_p 3'b011: pwm_outflip[2:0]: pwm_outa = side2_n others: reserved
POR[5:3]	pwm_outflip_reg[5:3]	RW	3'b001	3'b000: pwm_outflip[5:3]: pwm_outb = side1_p 3'b001: pwm_outflip[5:3]: pwm_outb = side1_n 3'b010: pwm_outflip[5:3]: pwm_outb = side2_p 3'b011: pwm_outflip[5:3]: pwm_outb = side2_n others: reserved
POR[8:6]	pwm_outflip_reg[8:6]	RW	3'b010	3'b000: pwm_outflip[7:6]: pwm_outc = side1_p 3'b001: pwm_outflip[7:6]: pwm_outc = side1_n 3'b010: pwm_outflip[7:6]: pwm_outc = side2_p 3'b011: pwm_outflip[7:6]: pwm_outc = side2_n others: reserved
POR[11:9]	pwm_outflip_reg[11:9]	RW	3'b011	3'b000: pwm_outflip[11:9]: pwm_outd = side1_p 3'b001: pwm_outflip[11:9]: pwm_outd = side1_n 3'b010: pwm_outflip[11:9]: pwm_outd = side2_p 3'b011: pwm_outflip[11:9]: pwm_outd = side2_n others: reserved
POR[12]	pwm_outflip_reg[12]	RW	1'b0	1'b0: pwm_outflip[12] disable 1'b1: pwm outflip[12] enable

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PAME	pwm_ad_mode_en	RW	1'b0	1'b0: tri-mode 1'b1: binary mode
PCM	pwm_clip_mode	RW	1'b0	1'b0: trunck to 0 1'b1: clip to pwm_mod_limt[2:0]
PDRP	pwm_dval_ramp_point [6:0]	RW	7'h40	Start point to decrease the pwm compensation pulse

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PWM Outflip register (0x96)

Bit	31:29	28:27	26	25	24	23	22	21	20:16	15:8	7:0
Name	X	PNO	PNBC	PR	P7	PDC	PDE	PDR	PDP	PCDS	PCDV

Name	Label	Type	Default	Description
PCDV	pwm_cnvt_dvalue[7:0]	RW	8'h2F	pwm_cnvt_dvalue [5:0], differential value
PCDS	pwm_cnvt_dstep[7:0]	RW	8'h00	pwm_cnvt_dstep[5:0], differential step value,
PDP	pwm_dither_pos[4:0]	RW	5'h00	5'd0: shift the dither[23:0] to right 0 bit, and complementary "0" 5'd1: shift to right 0 bit 5'd2: shift to right 0 bit 5'd3: shift to right 1 bit 5'd4: shift to right 2 bit 5'd5: shift to right 3 bit 5'dx: pwm_dither_pos[4:0], shift the dither to where the lsb of the quantizer will be. (shift to right (x-2) bits) 5'd18: shift to right 16 bit 5'd19: shift to right 17 bit others: shift 0 bit
PDR	pwm_dither_range	RW	1'b0	1'b0: pwm_dither_range, -3 to 3 1'b1: pwm_dither_range, -1 to 1
PDE	pwm_dither_en	RW	1'b0	1'b0: pwm_dither_en, disable dither 1'b1: pwm_dither_en, enable dither
PDC	pwm_dither_clr	RW	1'b0	1'b0: pwm_dither_clr 1'b1: pwm_dither_clr, clear dither module generate a triangular
P7	pwm_768x	RW	1'b0	pwm modulation frequency select. 1'b0: 384khz 1'b1: 768khz
PR	pwm_roundup	RW	1'b0	1'b0: pwm_roundup, quantize to 9 or 10 bits, truncate 1'b1: pwm_roundup, quantize to 9 or 10 bits, roundup
PNBC	pwm_ns_bf_clr	RW	1'b0	1'b0: pwm_ns_bf_clr 1'b1: pwm_ns_bf_clr, clear noise shaper sate counter
PNO	pwm_ns_order	RW	2'b10	PWM noise shipping order select. 2'b00: 1rst order. 2'b01: 2nd order. 2'b10: 3rd order. 2'b11: 4th order.

PM_COEF (0x97)

Bit	47	46:24	23	22:0
Name	X	PCU	X	PCD

Name	Label	Type	Default	Description
PCD	pm_coef_dn[22:0]	RW	23'h7FF800	Power meter envelop detection release coefficient
PCU	pm_coef_up[22:0]	RW	23'h000800	Power meter envelop detection attack coefficient

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Power Meter Control rb1 (0x98)

Bit	23:20	19	18:17	16	15:8	7:2	1:0
Name	X	PDM	PS	PL	PLD[9:2]	X	PLD[1:0]

Name	Label	Type	Default	Description
PLD[1:0]	pm_lvl_db[1:0]	R	2'd0	10'h000 ~ 10'h3fc: -127.875db~0db, step is 0.125db
PLD[9:2]	pm_lvl_db[9:2]	R	8'd0	8'h00 ~ 8'hff: -127.5db~0db, step is 0.5db
PL	pm_loc	RW	1'b0	1'b0: after volume 1'b1: before volume
PS	pm_source[1:0]	RW	2'b00	00: (l+r)/2, 01: left channel, 10: right channel, 11:reserved
PDM	pm_det_method	RW	1'b0	1'b0: envelope 1'b1: rms

Power Meter Control rb2 (0x99)

Bit	23	22:0
Name	X	PLL

Name	Label	Type	Default	Description
PLL	pm_lvl_linear[22:0]	R	23'd0	23'h000000 ~ 23'h7fffff: 2^(-23)~1

PBQ checksum (0x9A)

Bit	31:0
Name	PCK

Name	Label	Type	Default	Description
PCK	pbq_checksum_key[31:0]	RW	32'h0000_0000	The reference value of pbq memory checksum result

MDRC checksum (0x9B)

Bit	31:0
Name	MCK

Name	Label	Type	Default	Description
MCK	mdrc_checksum_key[31:0]	RW	32'h4000_0000	The reference value of drc memory checksum result

amute threshold (0x9C)

Bit	31:0
Name	PC2CK

Name	Label	Type	Default	Description
PC2CK	mdrc_checksum_key[31:0]	RW	32'h0000_0000	The reference value of drc memory checksum result

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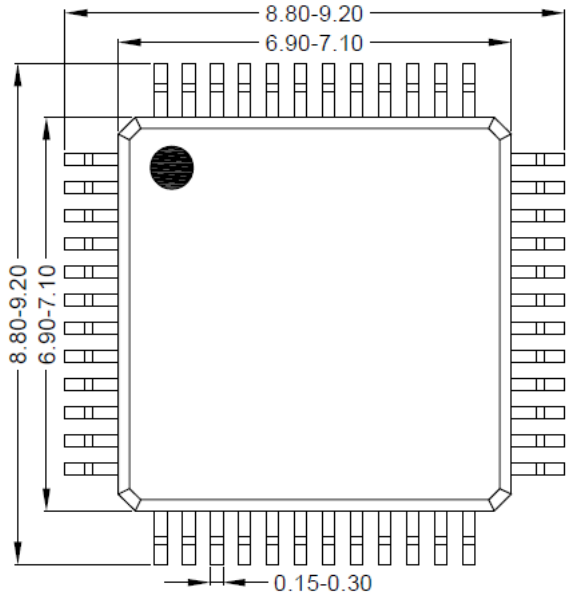
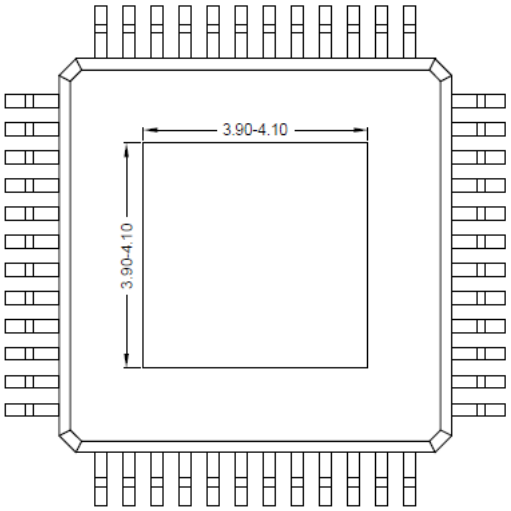
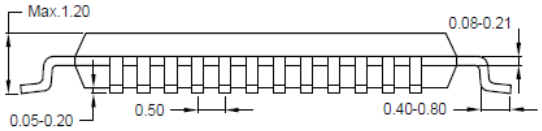
TQFP7×7-48E Package Outline Drawing



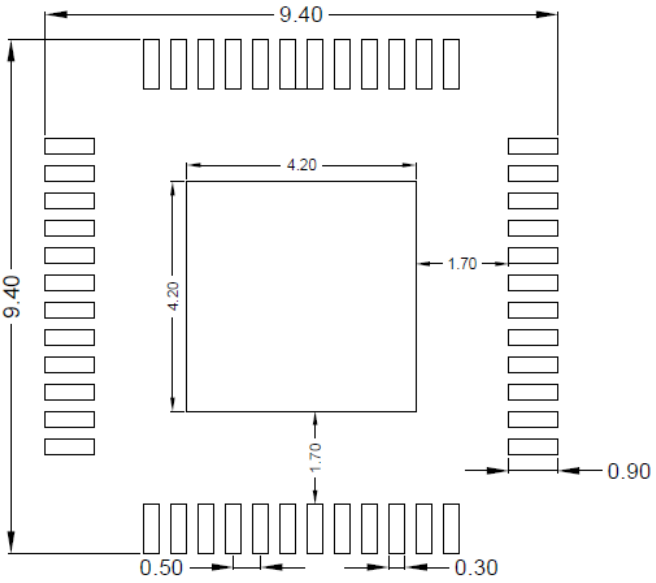
Top view



Bottom view



Front view



Recommended PCB Layout

Notes: All dimension in millimeter and exclude mold flash & metal burr.

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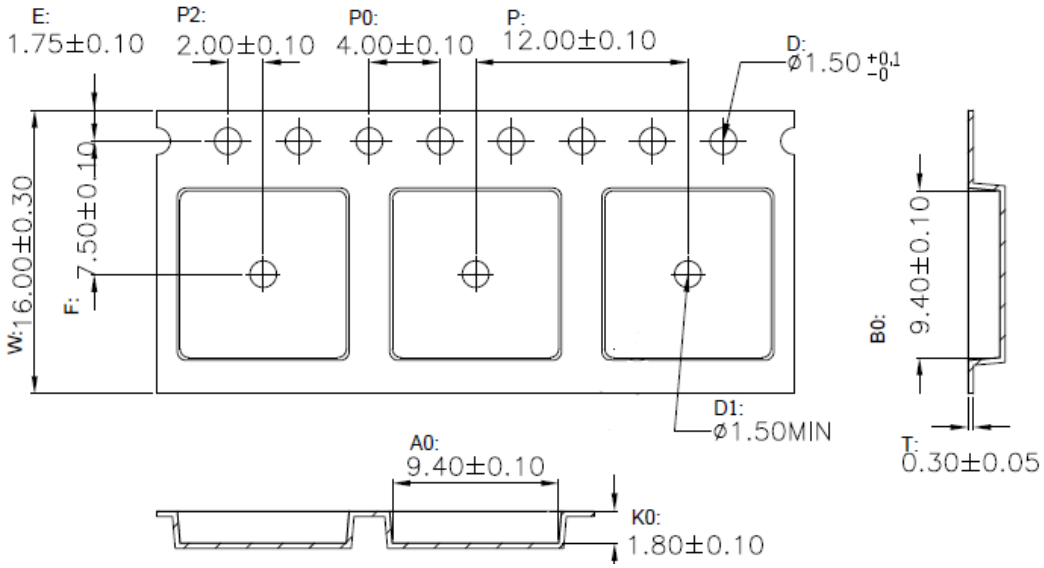
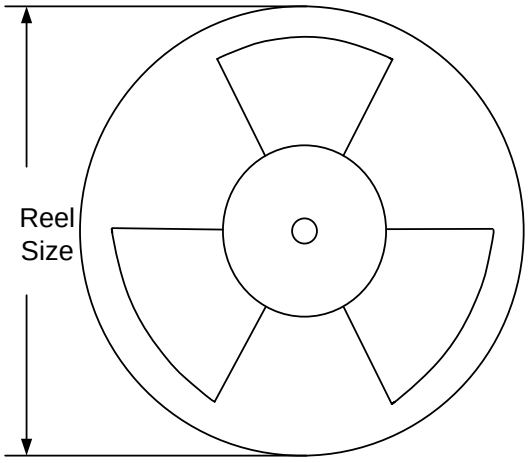
Taping & Reel Specification

1. Taping orientation

TQFP7×7-48E



2. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer * length(mm)	Leader * length (mm)	Qty per reel (pcs)
TQFP7×7-48E	16	12	13	400	400	2000

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Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
Mar.11, 2022	Revision 1.0	Production Release
Mar.11, 2021	Revision 0.9C	1. Delete single filter in Feature 2. Delete the description of BD or Ternary mode support 3. Delete the Block in the description of DRC
Mar.20, 2020	Revision 0.9B	Update the Feature from "I^2C Serial Control Interface Operational without MCLK" to "3-wire I^2S Digital Audio Interface without MCLK"
Nov.8, 2019	Revision 0.9A	Change the top mark.
Oct. 15, 2019	Revision 0.9	Initial Release

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