

The SABRE® ES9820 is a 2 channel 32-bit analog-to-digital (A/D) converter targeted for professional audio applications such as high-quality recording systems, mixer consoles and digital audio workstations (DAW), test equipment, instruments, audio processors, digital turntables, and consumer applications.

The ES9820 has 2 integrated ADCs which use the ESS proprietary Hyperstream® II Architecture, which delivers unprecedented SABRE HiFi® audio sound quality and specifications, including a True DNR of +117dB in mono mode and a DNR +116dB in stereo mode, THD+N of -108dB in 2 channel mode.

The SABRE® ADC supports synchronous S/PDIF, I²S master/slave, or native DSD output.

The ES9820 comes in a small compact package and consumes 80mW @ 48kHz.

The ES9820 can use preprogramed filter coefficients to match perfectly with the SABRE® PRO Series of DACs including the ES9038PRO. These complimentary filters allow for analog-digital-analog processing with the upmost audio fidelity and minimized time-domain smearing.

The Audio Signal Processor (ASP) integrated in the ADC allows for custom filtering such as RIAA presets to be implemented in the ADC, eliminating the need for re-processing later in the signal path.

The ES9820 has an Ultra-Low Noise Floor Bandwidth of 200kHz. This bandwidth is up to 10 times wider than the competition, enabling higher resolution at higher sample rates.

FEATURE	DESCRIPTION
+116dB DNR 2 channel mode +117dB DNR in mono mode -108dB THD+N 2 channel mode	Unprecedented dynamic range and ultra-low distortion
High sample rates	Up to PCM 768kHz, including 1.536MHz w/Double Data rates Up to DSD512
Audio Signal Processors (ASP)	Available for custom FIR filters for any applications, including RIAA
Multiple output formats available	PCM, TDM, DSD, S/PDIF
Customizable filter characteristics	8 preset filters for custom sound signature 2 audio signal processors for custom filter architectures and analog/digital mixing
I²C or SPI interface control	Configured by microcontroller or used as standalone
Low power Consumption	Simplifies power supply design
Low pin count standardized Packaging	5mm x 5mm, 40 pin QFN
Ultra-low noise floor bandwidth	200kHz bandwidth enabling higher resolution at higher sample rates



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Functional Block Diagram

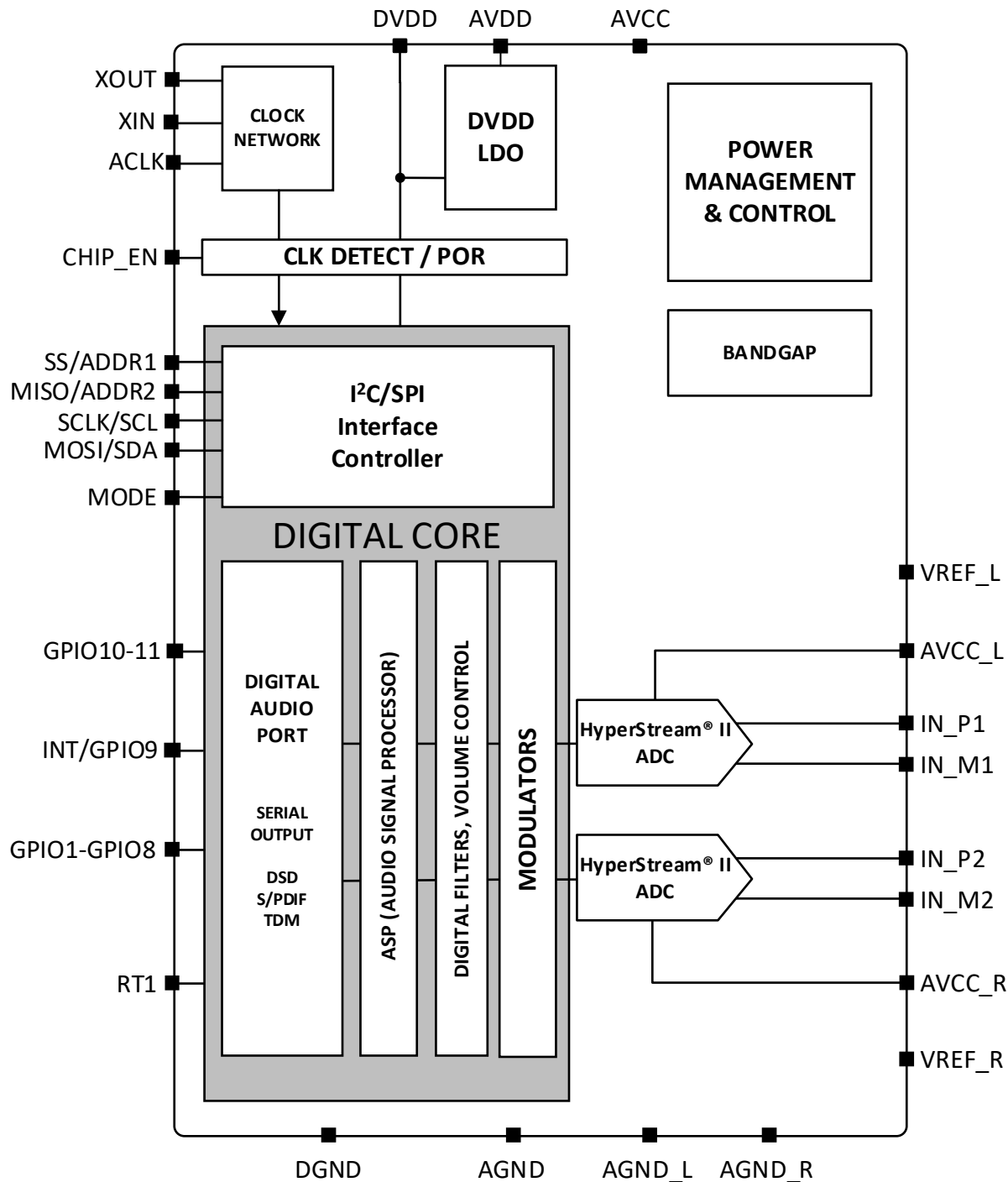


Figure 1 - ES9820 Block Diagram



ES9820Q Package

40 QFN Pinout

(Pin 41 is QFN package pad, see package dimensions)

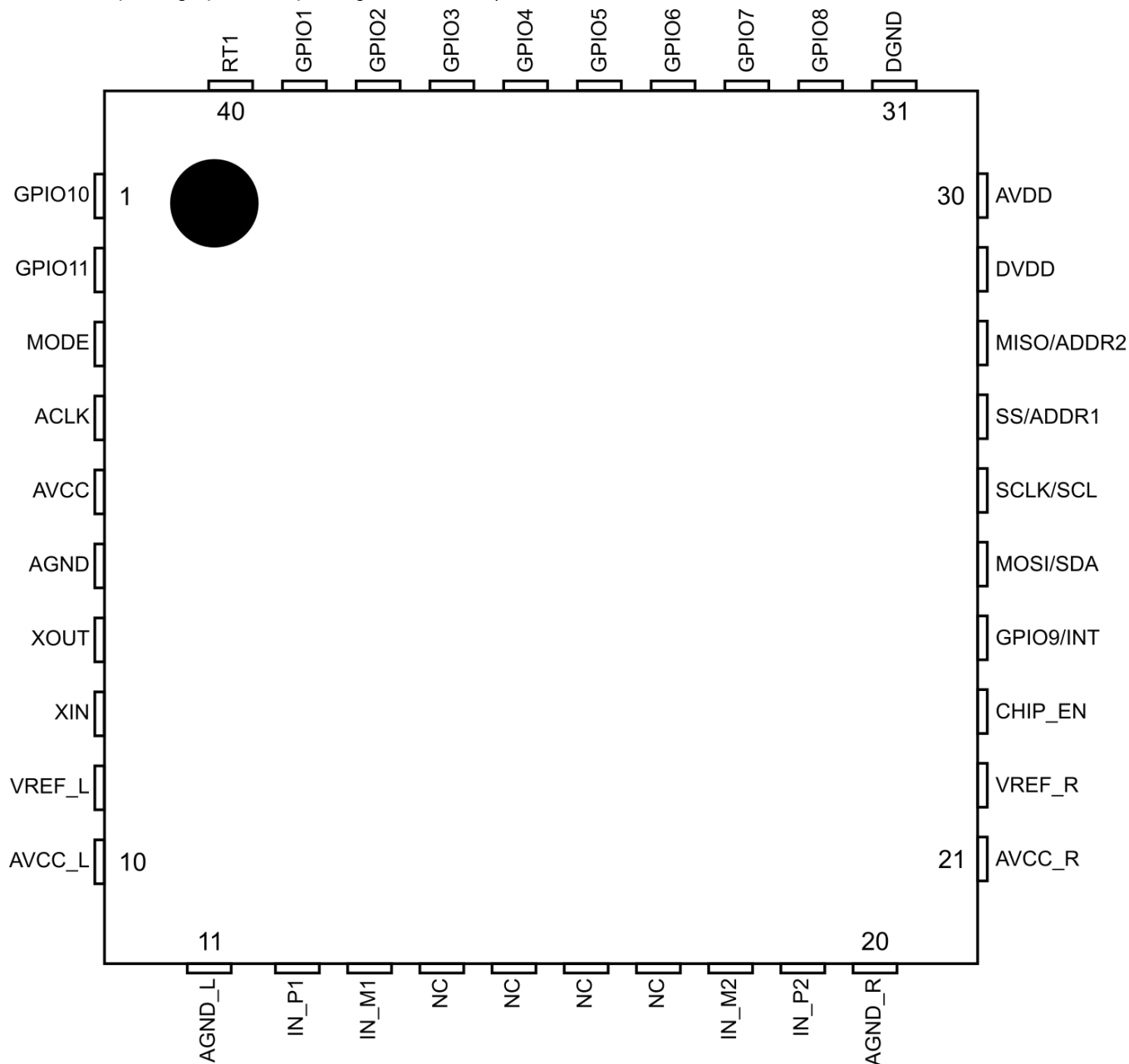


Figure 2 - 40 QFN Pinout

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40 QFN Pin List

Pin	Name	Pin Type	Reset State	Pin Description
1	GPIO10	I/O	HiZ	General I/O w/extended functions
2	GPIO11	I/O	HiZ	General I/O w/extended functions
3	MODE	I/O	HiZ	I ² C or SPI Control selection
4	ACLK ¹	AI	HiZ	Auxiliary Clock Input
5	AVCC	Power	Power	3.3V Supply
6	AGND	Ground	Ground	Analog Ground
7	XOUT	AO	HiZ	Crystal Output
8	XIN ¹	AI	HiZ	Crystal Input/Oscillator Input
9	VREF_L	Power	Power	Low Noise reference for on-chip regulator, left side
10	AVCC_L	Power	Power	ADC reference voltage (3.3V Supply)
11	AGND_L	Ground	Ground	Analog Ground
12	IN_P1	AI	HiZ	ADC Channel 1 differential positive (+) input
13	IN_M1	AI	HiZ	ADC Channel 1 differential negative (-) input
14	NC	-	-	No Connect
15	NC	-	-	No Connect
16	NC	-	-	No Connect
17	NC	-	-	No Connect
18	IN_M2	AI	HiZ	ADC Channel 2 differential negative (-) input
19	IN_P2	AI	HiZ	ADC Channel 2 differential positive (+) input
20	AGND_R	Ground	Ground	Analog Ground
21	AVCC_R	Power	Power	ADC reference voltage (3.3V Supply)
22	VREF_R	Power	Power	Low Noise reference for on-chip regulator, right side
23	CHIP_EN	I/O	HiZ	Active-high chip enable.
24	GPIO9	I/O	HiZ	General I/O w/extended functions, including INT (INTERRUPT)
25	MOSI	I/O	HiZ	SPI Main Out Sub In pin, controlled by MODE
	SDA			I ² C Serial Data pin, controlled by MODE
26	SCLK	I/O	HiZ	SPI Serial Clock pin, controlled by MODE
	SCL			I ² C Serial Clock pin, controlled by MODE
27	SS	I/O	HiZ	SPI Slave Select pin, controlled by MODE
	ADDR1			I ² C Address 1 pin, controlled by MODE
28	MISO	I/O	HiZ	SPI Main In Sub Out pin, controlled by MODE
	ADDR2			I ² C Address 2 pin, controlled by MODE
29	DVDD	Power	Power	Digital Core Supply. Internally Supplied
30	AVDD	Power	Power	3.3V, I/O Supply
31	DGND	Ground	Ground	Digital Core Ground
32	GPIO8	I/O	HiZ	General I/O w/extended functions, Serial Data 8
33	GPIO7	I/O	HiZ	General I/O w/extended functions, Serial Data 7
34	GPIO6	I/O	HiZ	General I/O w/extended functions, Serial Data 6
35	GPIO5	I/O	HiZ	General I/O w/extended functions, Serial Data 5
36	GPIO4	I/O	HiZ	General I/O w/extended functions, Serial Data 4

¹ MCLK can be connected to XIN or ACLK.



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37	GPIO3	I/O	HiZ	General I/O w/extended functions, Serial Data 3
38	GPIO2	I/O	HiZ	General I/O w/extended functions, Serial Data 2
39	GPIO1	I/O	HiZ	General I/O w/extended functions, Serial Data 1
40	RT1	I	HiZ	Reserved. Must be connected to DGND for normal operation.
41	Package Pad ¹	-	-	Not electrically connected, used for heat dissipation Connect to DGND.

Table 1 - 40 QFN Pin List

¹ Pin 41 is the package pad. See 40 QFN package dimensions for sizing. Connect to GND.

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Interface Modes

The ES9820 registers can be accessed either using a I²C or SPI interface.

The MODE pin (Pin 3) determines which interface will be used.

I²C Slave/Synchronous Slave Interface Commands

The I²C Slave/Synchronous Slave interface is used when the MODE pin (Pin 3) is pulled low.

The I²C interface can be accessed using Pin 25, 26, 27 and 28.

- Pin 25 SDA
- Pin 26 SCL
- Pin 27 ADDR1
- Pin 28 ADDR2

The ADDR1 (Pin 27) and ADDR2 (Pin 28) pins determine the I²C address.

The R/W bit determines the command type, Read (1) or Write (0).

- I²C Slave Address = [5'b01000, ADDR2, ADDR1, R/W]
- I²C Synchronous Slave Address = [5'b01001, ADDR2, ADDR1, R/W]

Note: The I²C Slave interface requires an MCLK present to function, the I²C Synchronous Slave interface does not.

I ² C Slave Address	I ² C Synchronous Slave Address	ADDR2	ADDR1
0x40	0x48	Tie Low	Tie Low
0x42	0x4A	Tie Low	Tie High
0x44	0x4C	Tie High	Tie Low
0x46	0x4E	Tie High	Tie High

Table 2 - I²C Slave/Synchronous Slave Address

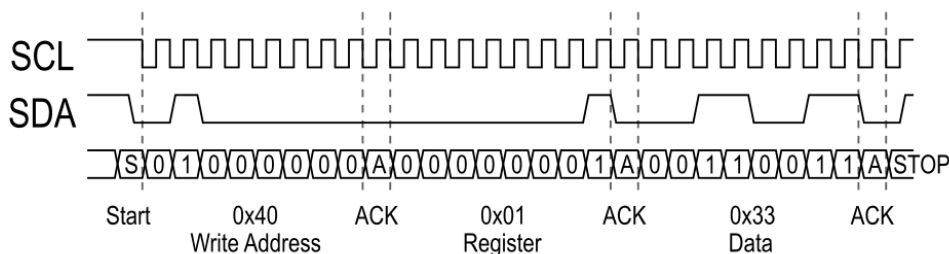


Figure 3 - I²C Write Example

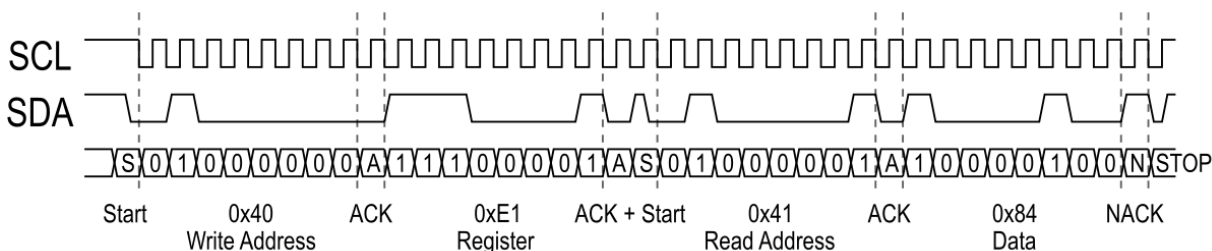


Figure 4 - I²C Read Example



SPI Slave Interface Commands

The SPI slave interface is used when the MODE pin (Pin 3) is pulled high.

The SPI Slave interface can be accessed using the Pins 25-28.

- Pin 25 MOSI
- Pin 26 SCLK
- Pin 27 SS
- Pin 28 MISO

The 4-wire SPI data format is: Command (1 byte) + Address (1 byte) + Data

SPI commands:

- 0x01: Read
- 0x03: Write
- 0x07: Write-only Register Addresses 192-194 (0xC0 - 0xC2)

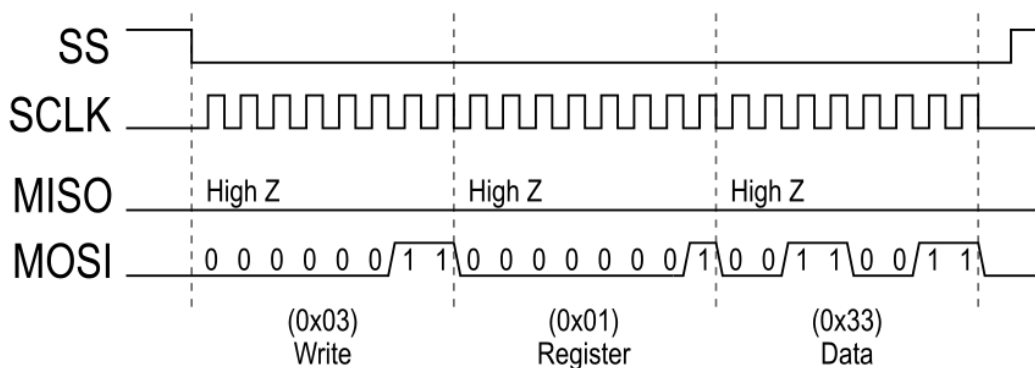


Figure 5 - SPI Single Byte Write

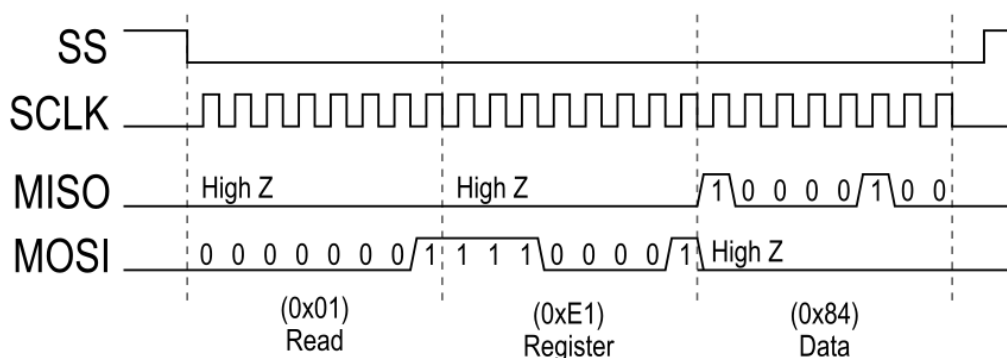


Figure 6 - SPI Single Byte Read

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Digital Features

Audio Input/Output Formats

The ES9820 supports multiple serial input/output formats. The output format is determined by Register 0[6:5] OUTPUT_SEL.

Pins are configured in Master (AUX Output) or Slave (Aux Input) mode through GPIO Configurations.

The formats include:

- PCM (Output)
 - Slave and Master mode in 16, 32 - bit widths
 - I²S, Left Justified (LJ)
 - Sample rates up to 768kHz (64fs mode)
 - Channel remapping
- PCM (Input)
 - Slave and Master mode in 16, 24 - bit widths
 - I²S
 - Sample rates up to 768kHz (64fs mode)
- TDM (Output)
 - 2 to 32 slots including daisy chain mode
 - Slave and Master mode in 16, 32 - bit widths
 - I²S, Left Justified (LJ)
 - Channel remapping
- DSD (Output)
 - Slave and master mode
 - Sample rates from DSD64 (2.8224Mbits/s, 64x44.1kHz) to DSD512
 - Channel mapping
- S/PDIF (Output)



PCM/TDM Encoder

The ES9820 integrates PCM/TDM Encoder whose output has a maximum word width of 32-bits (default) and a maximum bit depth of 32-bits (default). The encoder allows for I²S, LJ, and TDM output streams.

The PCM/TDM Encoder can support up to 32 different slots and each channel of the ADC can be mapped to any of the 32 slots.

PCM/TDM Encoder Registers

- Register 10[7:3] TDM_BIT_DELAY
- Register 10[2] TDM_VALID_EDGE
- Register 10[1] TDM_LJ
- Register 10[0] ENABLE_TDM_CLK
- Register 11[7] TDM_GPIO456
- Register 11[6] TDM_CASCADE
- Register 11[5] TDM_LENGTH
- Register 11[4:0] TDM_CH_NUM

PCM/TDM Encoder Mapping Registers

- Register 12-13[6:5] TDM_LINE_SEL_CHx
- Register 12-13[4:0] TDM_SLOT_SEL_CHx

PCM/TDM Encoder Master Mode Registers

- Register 7[7:5] MASTER_WS_SCALE
- Register 8[7] MASTER_BCK_DIV1
- Register 8[6] MASTER_WS_IDLE
- Register 8[5:4] MASTER_FRAME_LENGTH
- Register 8[3] MASTER_WS_PULSE_MODE
- Register 8[2] MASTER_BCK_INVERT
- Register 8[1] MASTER_WS_INVERT
- Register 8[0] MASTER_MODE_ENABLE
- Register 9[7] SELECT_I²S_TDM_HALF
- Register 9[6:0] SELECT_I²S_TDM_NUM

I²S Decoder and Programmable Delay

The ES9820 features a built in I²S decoder that can be mixed with the ASP. A programmable delay is also included to help with phase correction when mixing. Mixing is accomplished using the ASP. The I²S decoder input has a maximum word width of 32-bits (default) and a maximum bit depth of 24-bit (default). The Delay Line truncates the signal to 16-bit depth.

I²S Decoder Configurations Registers

- Registers 59-60: I²S DECODER CONFIG

Programmable Delay Registers

- Registers 62-61[9]: ENABLE_CLK_DL
- Registers 62-61[8:0]: PROG_DELAY_LINE

Configuration Pins for I²S Decoder

- GPIO 1: BCK
- GPIO 2: WS
- GPIO 5: DATA (would be configured as an AUX Input through the GPIO configuration)

Note: The I²S Decoder does not explicitly have a master mode enable bit and as a result will follow the same master mode setting as the PCM/TDM Encoder.

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PCM (I²S, LJ) Format

See Bit-Clock (BCK) and Word-Select (WS) Timing for timing criteria.

Configure GPIO input/output through registers 74 - 76, 86 - 89. Must have Reg 11[7] TDM_GPIO456 Enabled.

Pin Name	Function	Description
GPIO1	PCM BCLK	PCM Clock (Master or Slave)
GPIO2	PCM WS	PCM WS (Master or Slave)
GPIO3/4/5/6	PCM DATA	PCM DATA Out

Table 3 - PCM Output Pin Connections

I²S Input Format

See Bit-Clock (BCK) and Word-Select (WS) Timing for timing criteria.

Configure GPIO input/output through registers 74 - 76, 86 - 89. Must have Reg 11[7] TDM_GPIO456 Enabled.

Pin Name	Function	Description
GPIO1	I ² S BCLK	I ² S Clock (Master or Slave)
GPIO2	I ² S WS	I ² S WS (Master or Slave)
GPIO5	I ² S DATA	I ² S DATA In

Table 4 - I²S Input Pin Connections

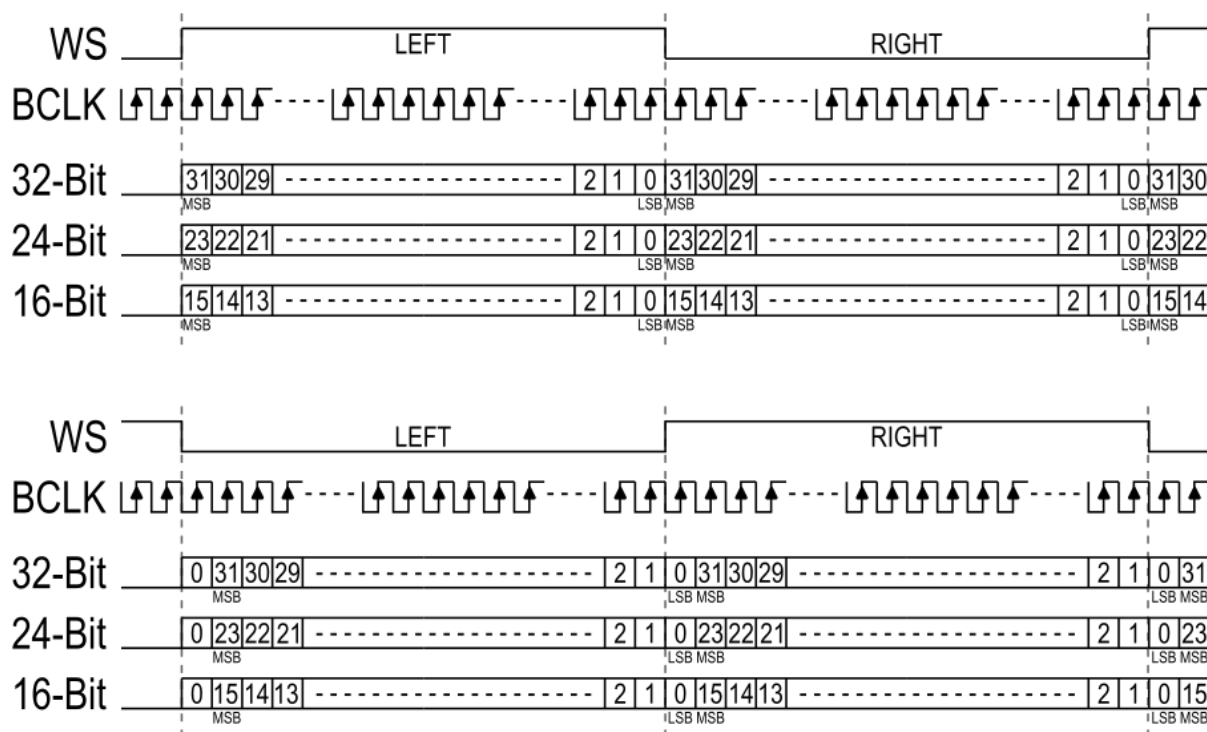


Figure 7 - LJ (top) & I²S (bottom) for 16, 24, and 32-bit Word Widths



TDM Format

See Bit-Clock (BCK) and Word-Select (WS) Timing for timing criteria.

See Register 10-13 for configuration, can select GPIO 3-6 for the datapath.

Configure GPIO input/output through registers 74 - 76, 86 - 89. Must have Reg 11[7] TDM_GPIO456 Enabled.

Pin Name	Function	Description
GPIO1	TDM BCK	TDM Clock (Master or Slave)
GPIO2	TDM WS	TDM WS (Master or Slave)
GPIO3/4/5/6	TDM DATA	TDM DATA Out (default)

Table 5 - TDM Output Pin Connections

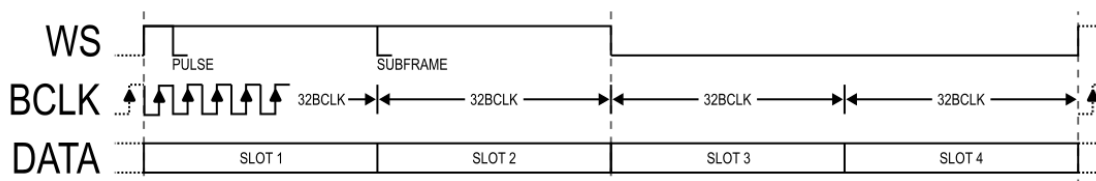


Figure 8 - TDM4 Mode

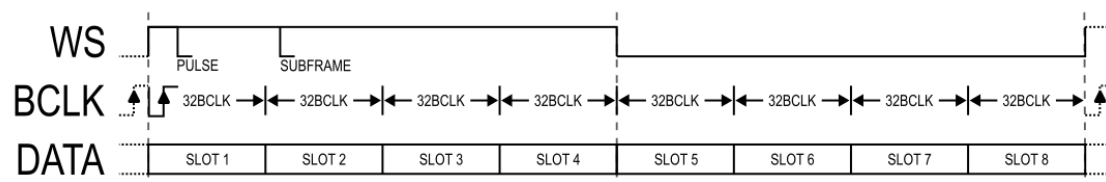


Figure 9 - TDM8 Mode

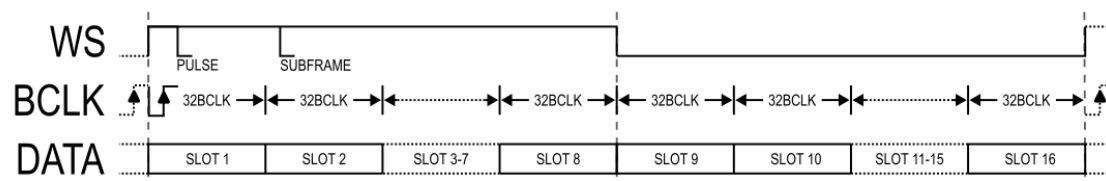


Figure 10 - TDM16 Mode

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DSD Format

In DSD mode, there is a single DSD clock line, and each channel of data is an additional DSD data line. Each DSD source can be remapped to any output channel on a GPIO by using the below registers.

Configure GPIO input/output through registers 74 - 76, 86 - 89. Must have Reg 11[7] TDM_GPIO456 Enabled.

Pin Name	Function	Description
GPIO1	DSD Clock	DSD Bit Clock (Master or Slave)
GPIO3	DSD DATA out	DSD DATA1 (Channel 1 default)
GPIO4	DSD DATA out	DSD DATA2 (Channel 2 default)

Table 6 - DSD Output Pin Connections

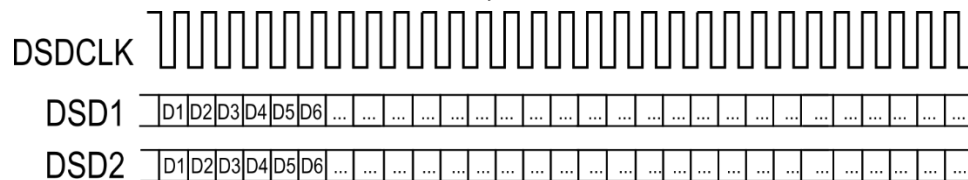


Figure 11 - 2CH DSD Format

DSD Config Registers:

- Register 6[5] DSD_DDR
- Register 6[4] DSD_MASTER_MODE
- Register 6[1] ENABLE_DSD_CLK_CH2
- Register 6[0] ENABLE_DSD_CLK_CH1
- Register 7[4] DSD_CLK_DIV2
- Register 7[3:0] SELECT_DSD_NUM

DSD Mapping Registers:

- Register 19[3:2] DSD_MAPPING_CH2
- Register 19[1:0] DSD_MAPPING_CH1

S/PDIF Format

S/PDIF output is stereo and uses Output Channel 1 and Output Channel 2.

Configure GPIO input/output through registers 74 - 76, 86 - 89. Must have Reg 11[7] TDM_GPIO456 enabled if using respective pins.

Note: Respective Register 74-76 GPIOx_CFG must be set to 4'd8 (S/PDIF Output)

Pin Name	Function	Description
GPIOx	S/PDIF OUT	S/PDIF OUT

Table 7 - S/PDIF Output Pin Connections

S/PDIF Config Registers:

- Register 5[2] ENABLE_SPDIF_CLK
- Register 28-32 SPDIF_CS



GPIO

GPIO#_CONFIG	Function	I/O Direction
0	Analog Shutdown	Shutdown (default)
1	Aux Inputs	Inputs
2	Aux Outputs	Output
3	Reserved	-
4	Interrupt Ch1 Peak	Output
5	Interrupt Ch2 Peak	Output
6	Reserved	-
7	Reserved	-
8	SPDIF Data Output	Output
9	PWM1	Output
10	PWM2	Output
11	PWM3	Output
12	CLK IADC	Output
13	CLK ADC	Output
14	1'b0	Output
15	1'b1	Output

Table 8 - Standard GPIO Functions

For configuring pins and Inputs, Outputs, or Input/Outputs:

- Input Pin
 - Registers 87-86: GPIOx_IE = 1'b1 (Input Enable)
 - Registers 89-88: GPIOx_OE = 1'b0 (Output Enable)
- Output Pin
 - Register 87-86: GPIOx_IE = 1'b0
 - Register 89-88: GPIOx_OE = 1'b1
- In/Out Pin (Master Mode)
 - Register 87-86: GPIOx_IE = 1'b1
 - Register 89-88: GPIOx_OE = 1'b1

In Master Mode GPIO1 & GPIO2 should be configured as In/Out pins

Data pins may be re-mapped to other GPIO via the System Registers. When utilizing GPIO pins 4-6, it is important to enable the TDM_GPIO456 bit.

GPIO 4-6 TDM Enable Register

- Register 11[7]: TDM_GPIO456

GPIO Configuration Registers:

- Register 74: GPIO1/2 CONFIG
- Register 75: GPIO3/4 CONFIG
- Register 76: GPIO5/6 CONFIG
- Register 77: GPIO7/8 CONFIG
- Register 78: GPIO9/10 CONFIG
- Registers 80-91

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GPIO Audio Data Configurations

The following table shows the configurations possible using GPIO#_config Aux Inputs, Aux Outputs, and S/PDIF Outputs on the ES9820.

In certain modes, the data output pins may be re-mapped to GPIO pins 4-6. These scenarios are labeled “[optional]” in the table below. The channel order may also be changed in these modes. Although it is not denoted in the table, the data output in Slave Mode may also be re-mapped to the same pins.

GPIO #	4'd1 (AUX Inputs) (Slave mode)	4'd2 (AUX Outputs) (Master mode)				4'd8 (S/PDIF Output)
GPIO1	I ² S/TDM in BCK, DSD in clock	I ² S master BCK	TDM master BCK	DSD master clock out	PDM ¹ clock	S/PDIF Data
GPIO2	I ² S/TDM in WS	I ² S master WS	TDM master WS	-		
GPIO3	-	I ² S out DATA [optional] ² (default)	TDM out DATA [optional] ² (default)	DSD out DATA ³	PDM ¹ out DATA	
GPIO4	TDM cascade data input Cascade mode for multiple devices	I ² S out DATA [optional] ²	TDM out DATA [optional] ²	DSD out DATA ³	PDM ¹ out DATA	
GPIO5	I ² S decoder data input	I ² S out DATA [optional] ²	TDM out DATA [optional] ²	DSD out DATA ³	-	
GPIO6	-	I ² S out DATA [optional] ²	TDM out DATA [optional] ²	DSD out DATA ³	-	
GPIO7	-	-	-	-	-	-
GPIO8	-	-	-	-	-	-
GPIO9	-	INTERRUPT (Triggered by either of the 2 channels)				-
GPIO10	-	-	-	-	-	-
GPIO11	-	-	-	-	-	-

Table 9 - GPIO Audio Data Configurations

¹ To enable PDM mode, set Register 6[5] DSD_DDR

² Using the TDM GPIO Re-mapping Registers, the data may be configured to output GPIO pins 4-6. In order to do this Register 11 [7]: TDM_GPIO456 must also be enabled.

³ The DSD channel order can be changed via Register 19: DSD_DATA_OUTPUT_MAPPING.



Digital Signal Path

SABRE ADC DIGITAL PATH

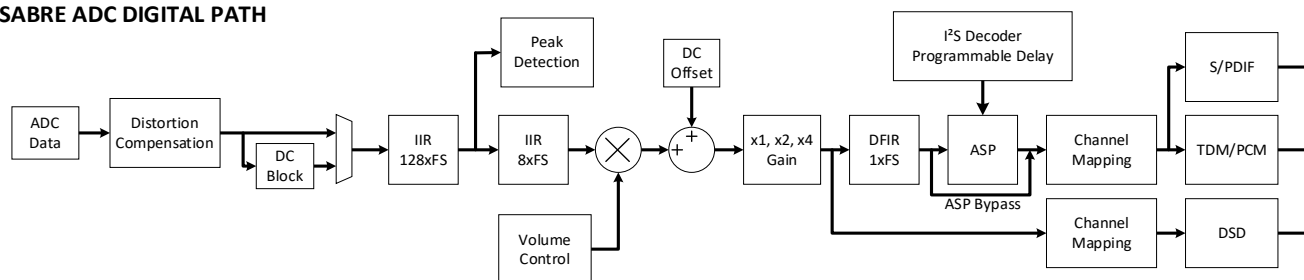


Figure 12 - Digital Signal Path

Distortion Compensation¹

Distortion Compensation minimizes the non-linearities of the analog to digital data path. The ES9820 can help compensate for system second and third harmonic distortion. For optimal results, compensation coefficients should be tuned for each device and channel.

Distortion Compensation Enable Registers

- Register 102[0]: ADC1_ENABLE_THD_COMP
- Register 119[0]: ADC2_ENABLE_THD_COMP

DC Block

The integrated DC block exhibits a high cutoff frequency (-3dB @ 30Hz).

It is recommended to use the ASP to implement customizable DC blocking filters with lower cutoff frequencies. Ask your local FAE or Distributor for the DC Blocking Filter ASP Application Note.

DC Block Enable Registers

- Register 101[2]: ADC1_ENABLE_DC_BLOCKING
- Register 118[2]: ADC2_ENABLE_DC_BLOCKING

¹ For more information on using Distortion Compensation, please reference the Distortion Compensation Application Note. Available from your local FAE upon request.

ES9820 Product Datasheet

Peak Detection¹

If the peak level of the ES9820 device's input audio stream rises above the programmed ADCx_PEAK_LEVEL value, the corresponding peak flag will be set. The level will decay at a rate based off the value of ADCx_PEAK_DECAY_RATE. The peak detection can be toggled on or off using the ADCx_ENABLE_PEAK_DETECT registers. The peak flag will stay set until it is cleared with INTERRUPT_CLEAR_CHx_PEAK_DETECTION. Any of the GPIO pins can be configured to output the state of any of the peak flags if INTERRUPT_MASK_CHx_PEAK_DETECTION is set for the corresponding channel.

Peak Level Registers:

- Register 106: ADC CH1 PEAK DETECTOR LEVEL
- Register 123: ADC CH2 PEAK DETECTOR LEVEL

Peak Decay Rate Register

- Register 105[6:2]: ADC1_PEAK_DECAY_RATE
- Register 122[6:2]: ADC2_PEAK_DECAY_RATE

$$N(t) = N_0 \exp\left(\frac{-FS * t}{2^{decay_rate}}\right)$$

$$N(t) = N_0 - \frac{20 * FS * t}{\ln(10) * 2^{decay_rate}} [dB]$$

$$\frac{dN}{dt} = -\frac{N * FS}{2^{decay_rate}} [1/s]$$

Peak Enable Register

- Register 105[0]: ADC1_ENABLE_PEAK_DETECT
- Register 122[0]: ADC2_ENABLE_PEAK_DETECT

Peak Interrupt Clear Registers:

- Register 27[5:4]: INTERRUPT_CLEAR_CHx_PEAK_DETECTION

Peak Interrupt Mask Registers

- Register 27[1:0]: INTERRUPT_MASK_CHx_PEAK_DETECTION

The GPIO READBACK register values 4'd4 and 4'd5 output the peak interrupt state for CH1 and CH2, respectively. The corresponding channel bit in Register 27[1:0] INTERRUPT_CLEAR_CHx_PEAK_DETECTION needs to be set for the GPIO to output the flag value.

¹ For further information on using Peak Detection, please reference the Peak Detector Configuration Application Note. Available from your local FAE upon request.



Volume Control

This volume control is intended for use during audio playback. Each channel can be digitally attenuated from 0dB to -84dB in 0.5dB steps. The attenuation circuit automatically uses micro-stepping between 0.5dB register settings so that no switching noise occurs during the volume control transition. When a new volume level is set, the attenuation circuit will ramp softly to the new level. Each 0.5dB step takes up to 64 intermediate steps depending on the ADC CHx VOLUME RATE setting.

Volume Level Configuration Registers

- Register 109-110: ADC CH1 VOLUME
- Register 126-127: ADC CH2 VOLUME

Volume Rate Configuration Registers

- Register 111: ADC CH1 VOLUME RATE
- Register 128: ADC CH2 VOLUME RATE

DC Offset

The ES9820 has a built in DC offset that can be used to add per channel DC offset. To achieve this, the 16-bit signed register must be set to either have a positive or negative offset. To achieve a positive DC offset, the register must be within the range of 16'h0001(-120dB) to 16'h7FFF(-30dB). To achieve a negative DC offset, the register must be within the range of 16'h8000(-30dB) to 16'hFFFF(-120dB).

The offset is set by using the following equation:

$$Offset[dB] = 20 \log_{10} \left(\frac{ADCx_DC_OFFSET}{(2^{15} - 1) * 2^5} \right)$$

DC Offset Registers

- Register 107-108: ADC1_DC_OFFSET
- Register 124-125: ADC2_DC_OFFSET

Digital Gain

The ES9820 has an additional digital gain that can be added through registers. Settings for +6dB, +12dB or +18dB gain are available for each ADC channel.

Digital Gain Registers:

- Register 112[1:0]: ADC1_DATA_GAIN
- Register 129[1:0]: ADC2_DATA_GAIN

DFIR Filters

The ES9820 has 8 preprogrammed digital filters. See Pre-Programmed Digital Filters for more information.

Note: The DFIR Filters need to be resynced after sample rate changes. See Addendum for respective resync program.



ES9820 Product Datasheet

Audio Signal Processor (ASP)¹

The ES9820 includes 2 stereo audio signal processors (ASP) which can be used to implement both custom filter coefficients as well as custom filter architectures. See Digital Signal Path diagram for location in the data path.

The ASP can be used to implement a DC blocking or high pass, parametric equalizer (PEQ), and/or a RIAA filter.

ESS recommends using the ASP for DC Blocking function. See DC Blocking Filter Application note, available from your local FAE or Distributor upon request.

ASP Registers:

- Registers 35-38

Output Channel Mapping

TDM Channel Mapping Registers

- Register 12-15: TDM SLOT CONFIG CHx

PCM Channel Mapping Registers

- Register 18: PCM DATA OUTPUT MAPPING

DSD Channel Mapping Registers

- Register 19: DSD DATA OUTPUT MAPPING

SPDIF Mapping Registers

- Register 18[1:0] OUTPUT_MAPPING_CH1
- Register 18[3:2] OUTPUT_MAPPING_CH2

¹ For help with designing with the ASP, please reference the ASP GUIDE Application Note. Available from your local FAE or Distributor upon request.



TDM Cascade Mode

The ES9820 features TDM cascade mode. Cascade mode allows the digital output from one chip to be input (through GPIO4) to the next, and the last chip on the chain outputting the final data on serial data line. To enable TDM Cascade mode, set TDM_CASCADE to 1, and configure GPIO4 as input and GPIO3 as output. The figure below shows how several ES9820 can be combined in TDM cascade mode.

Note: Cascade mode is for a minimum of an 8 channel TDM data line (TDM_CH_NUM ≥ 7).

Note: To ensure optimal performance, after setup of TDM Cascade Mode, the respective I²S or LJ Resync script must be written to all ES9820s in Slave mode. See the Resync section in the addendum for the respective script.

Note: The TDM_IN (GPIO4) to the first ES9820 must have no data on it. Ground for optimal performance.

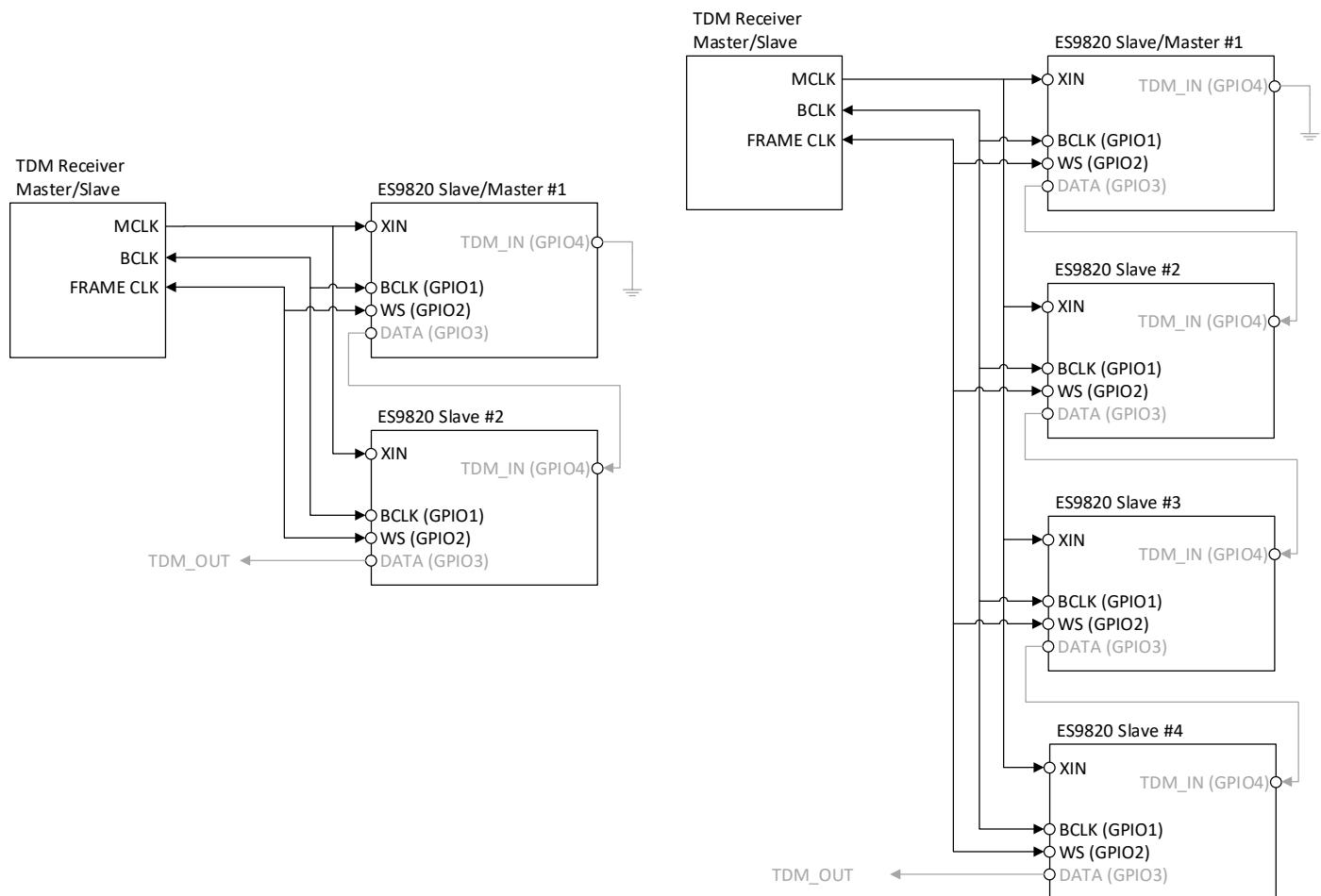


Figure 13 - Connection for TDM Cascade Mode

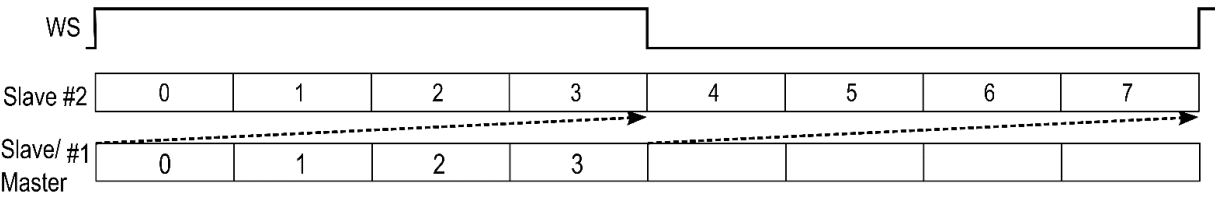
TDM Cascade Mode Registers:

- Register 11[6] TDM_CASCADE
- Register 11[4:0] TMD_CH_NUM



ES9820 Product Datasheet

8 Channel TDM:



16 Channel TDM:

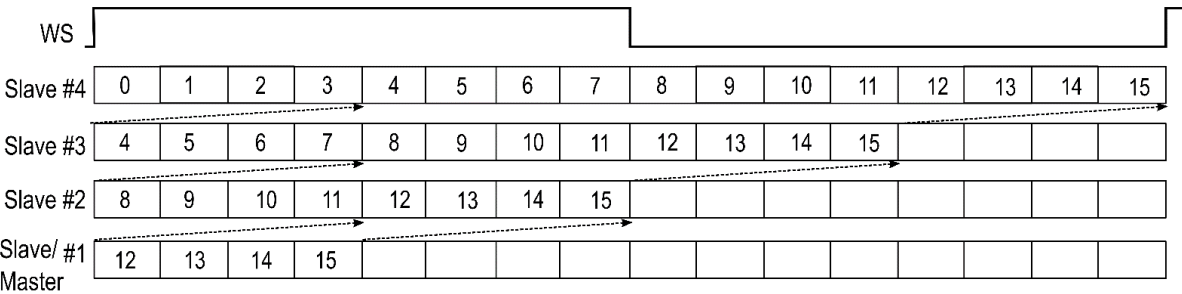


Figure 14 - Channel Cascading and Data Line Composition in TDM Cascade Mode



TDM/PCM Parallel Mode

The ES9820 also supports TDM/PCM in parallel mode. In this case, the chips will simply connect the output data line together. Each chip will output data during the designated slots during a single frame of the TDM/PCM data line, then switch to high impedance so that the next chip may output its data on to the TDM data line. To set up TDM parallel mode, no specific registers are required.

Note: Parallel mode supports TDM and I²S (TDM_CH_NUM ≥ 1).

Note: To ensure optimal performance, after setup of TDM Parallel Mode, the respective I²S or LJ Resync script must be written to all ES9820s in Slave mode. See Resync for the respective script.

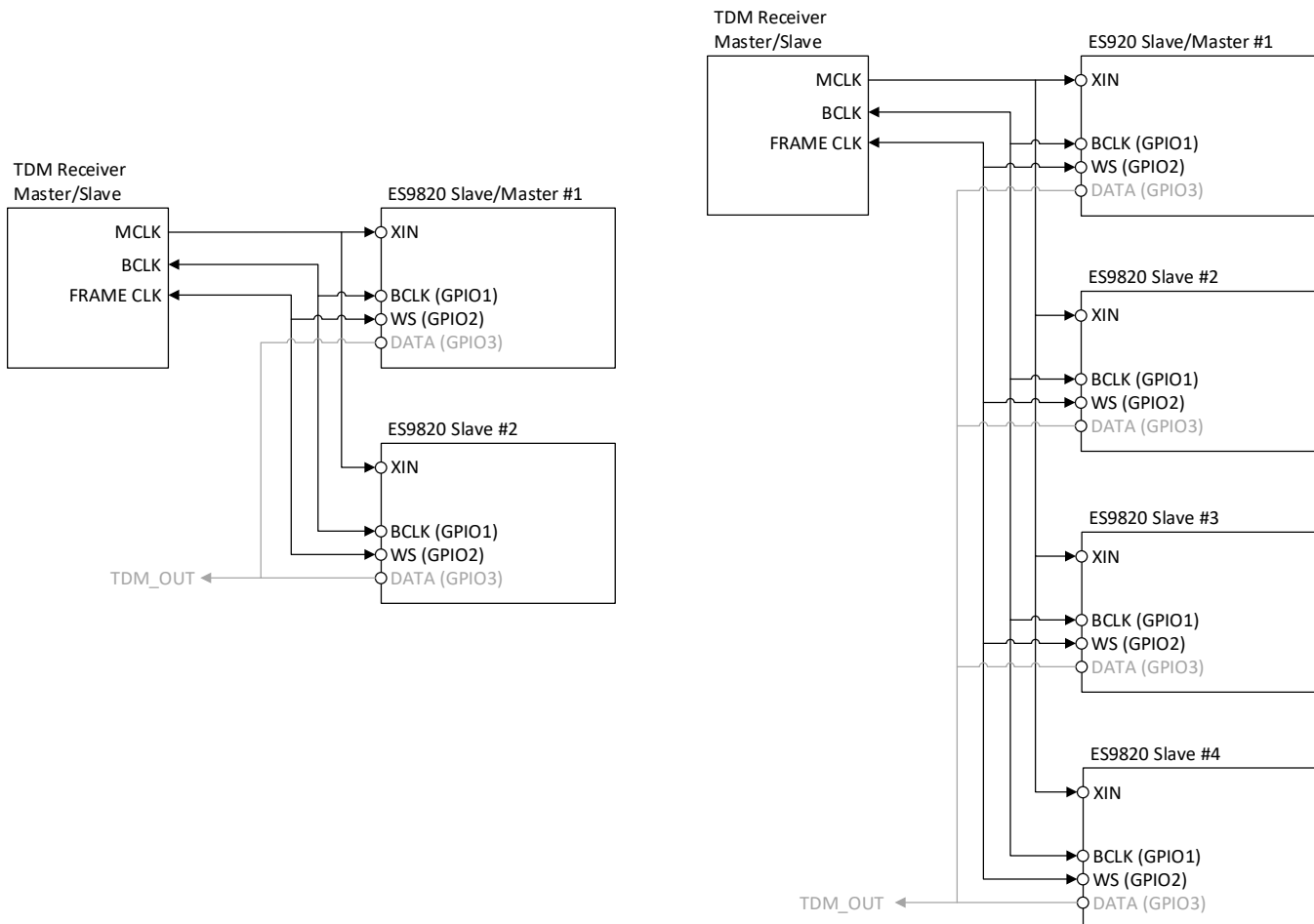
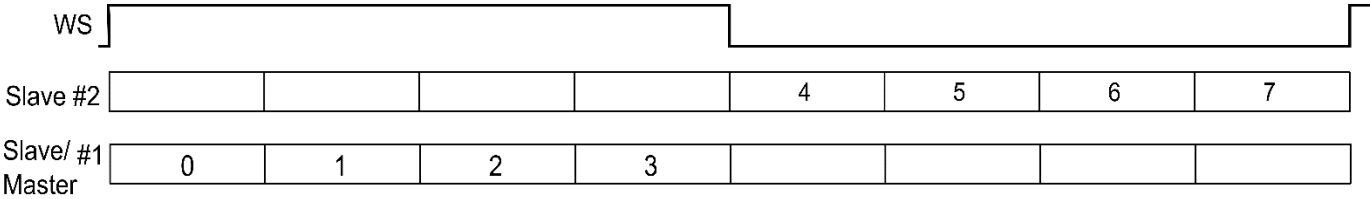


Figure 15 - Connection for Parallel TDM / PCM



ES9820 Product Datasheet

8 Channel Mode:



16 Channel Mode:

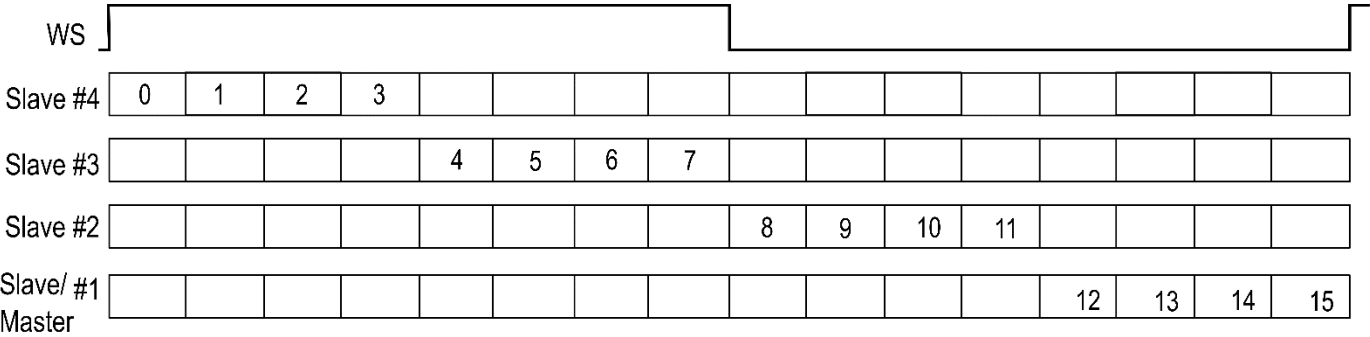


Figure 16 - Channel Mapping and Data Line Composition for TDM in Parallel Mode



Pre-Programmed Digital Filters

The ES9820 has 8 pre-programmed digital filters. The latency for each filter reduces (scales) with increasing sample rates. (See Register 113[4:2] FILTER_SHAPE for configuration)

#	Filter	Description
1	Minimum Phase (default)	Version 2 of minimum phase fast roll-off (#6) with less ripple and more image rejection
2	Linear Phase Apodizing Fast Roll-Off	Full image rejection by FS/2 to avoid any aliasing, with smooth roll-off starting before 20k.
3	Linear Phase Fast Roll-Off	Sabre legacy filter, optimized for image rejection @ 0.55FS
4	Linear Phase Fast Roll-Off Low-Ripple	Sabre legacy filter, optimized for in-band ripple
5	Linear Phase Slow Roll-Off	Sabre legacy filter, optimized for lower latency, but symmetric impulse response
6	Minimum Phase Fast Roll-Off	Low latency, minimal pre ringing and low passband ripple, image rejection @ 0.55FS
7	Minimum Phase Slow Roll-Off	Lowest latency at the cost of image rejection
8	Minimum Phase Fast Roll-Off Low Dispersion	Provides a nice balance of the low latency of minimum phase filters and the low dispersion of linear phase filters. Minimal pre-ringing is added to achieve the low dispersion in the audio band.

Table 10 - Pre-Programmed Digital Filter Descriptions

Note: Minimum phase filters are asymmetric filters that work to minimize the pre-echo of the filter, while still maintaining an excellent frequency response and they peak earlier than linear phase filters, resulting in a lower group delay. Minimum phase filters usually feature zero cycles of pre-echo, which can result in improved audio quality.

ES9820 Product Datasheet

PCM Filter Latency

The following table shows the simulated latency of each filter at 44.1kHz sampling rate. Measurements were taken from the external impulse response prior to being down sampled to 1FS. The extra sample delay to get the data encoded accounts for external processing time to serialize the data stream. Latency delay will reduce (scale) with sampling rate.

Digital Filter	Delay(us) @ FS = 44.1kHz
Minimum Phase (default)	142us
Linear Phase Apodizing Fast Roll-Off	805us
Linear Phase Fast Roll-Off	808us
Linear Phase Fast Roll-Off Low-Ripple	799us
Linear Phase Slow Roll-Off	184us
Minimum Phase Fast Roll-Off	128us
Minimum Phase Slow Roll-Off	105us
Minimum Phase Fast Roll-Off Low Dispersion	329us

Table 11 - PCM Filter Latency



PCM Filter Properties

Minimum Phase					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band	-3dB			0.48FS	Hz
Stop band	-103dB	0.55FS			Hz
Group Delay		3.43/FS		10.66/FS	s
Flatness (ripple)					dB

Linear Phase Apodizing					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band				0.41FS	Hz
Stop band	-109dB	0.50FS			Hz
Group Delay			33.25/FS		s
Flatness (ripple)	0.0022				dB

Linear Phase Fast Roll-Off					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band				0.46FS	Hz
Stop band	-115dB	0.55FS			Hz
Group Delay			33.38/FS		s
Flatness (ripple)	0.0025				dB

Linear Phase Fast Roll-Off Low Ripple					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band				0.46FS	Hz
Stop band	-82dB	0.55FS			Hz
Group Delay			33.00/FS		s
Flatness (ripple)	0.0009				dB

ES9820 Product Datasheet

Linear Phase Slow Roll-Off					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band	-3dB			0.50FS	Hz
Stop band	-84dB	0.81FS			Hz
Group Delay			5.87/FS		s
Flatness (ripple)					dB

Minimum Phase Fast Roll-Off					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band	-3dB			0.48FS	Hz
Stop band	-96dB	0.54FS			Hz
Group Delay		2.91/FS		9.28/FS	s
Flatness (ripple)					dB

Minimum Phase Slow Roll-Off					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band	-3dB			0.43FS	Hz
Stop band	-90dB	0.79FS			Hz
Group Delay		2.03/FS		3.51/FS	s
Flatness (ripple)					dB

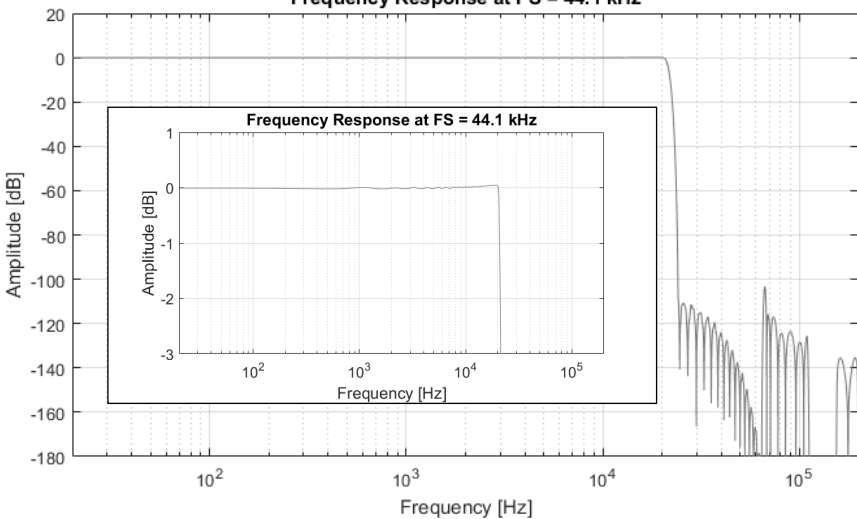
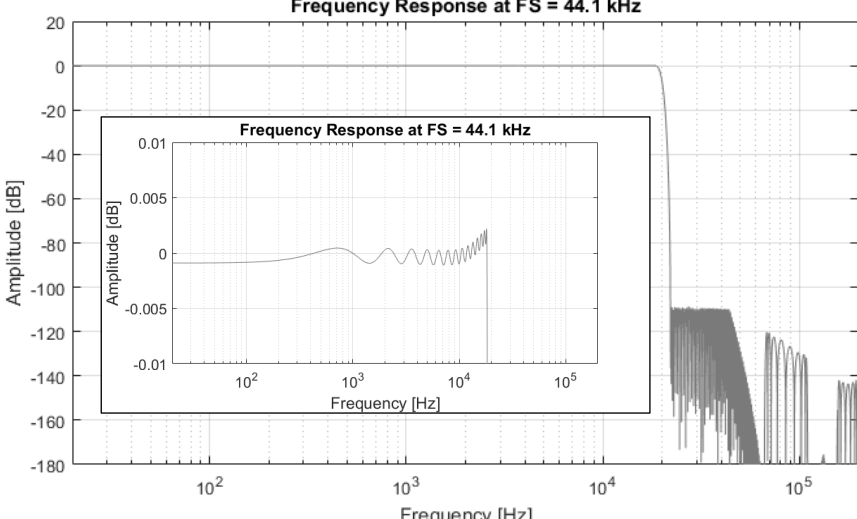
Minimum Phase Slow Roll-Off Low Dispersion					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band	-3dB			0.43FS	Hz
Stop band	-90dB	0.80FS			Hz
Group Delay		12.13/FS		12.37/FS	s
Flatness (ripple)					dB

Table 12 - PCM Filter Properties



PCM Filter Frequency Response

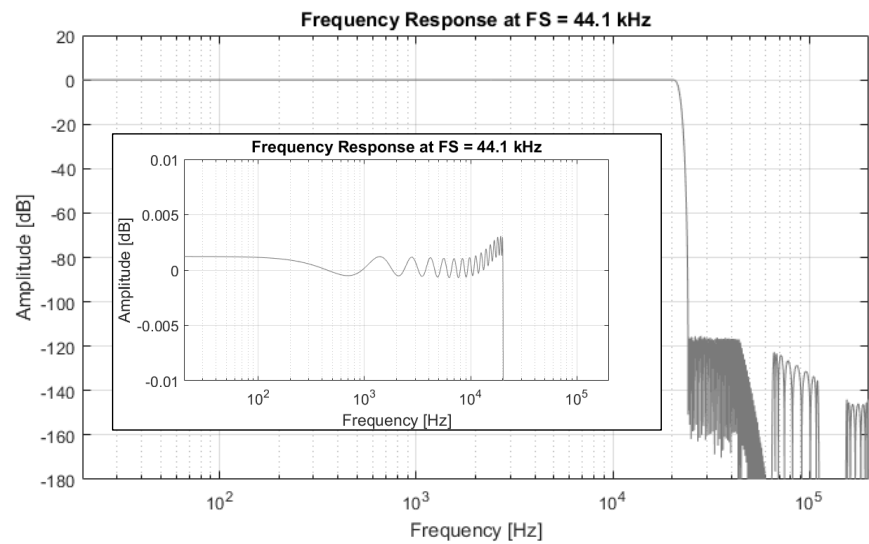
The following frequency responses were obtained from software simulations of these filters. Simulation sample rate is 44.1kHz.

Filter	Frequency Response
Minimum Phase	Frequency Response at FS = 44.1 kHz 
Linear Phase Apodizing	Frequency Response at FS = 44.1 kHz 

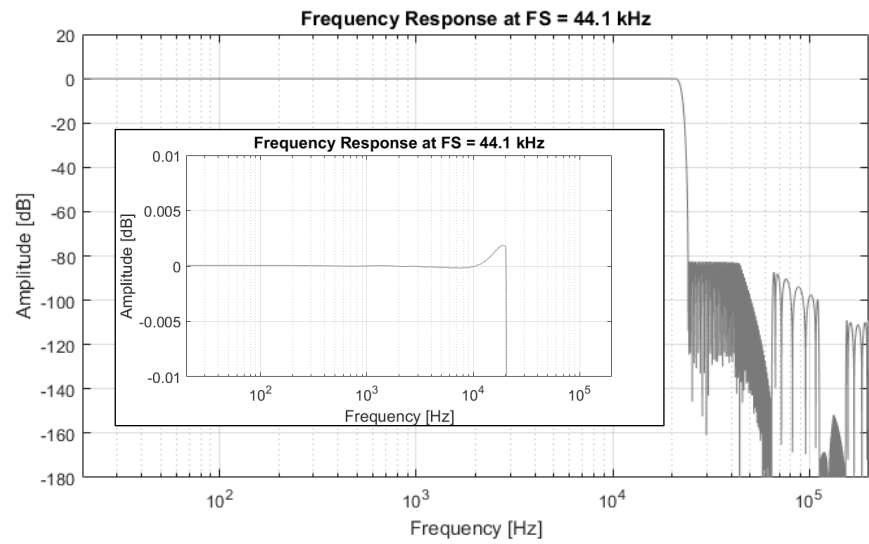


ES9820 Product Datasheet

Linear Phase Fast Roll-Off



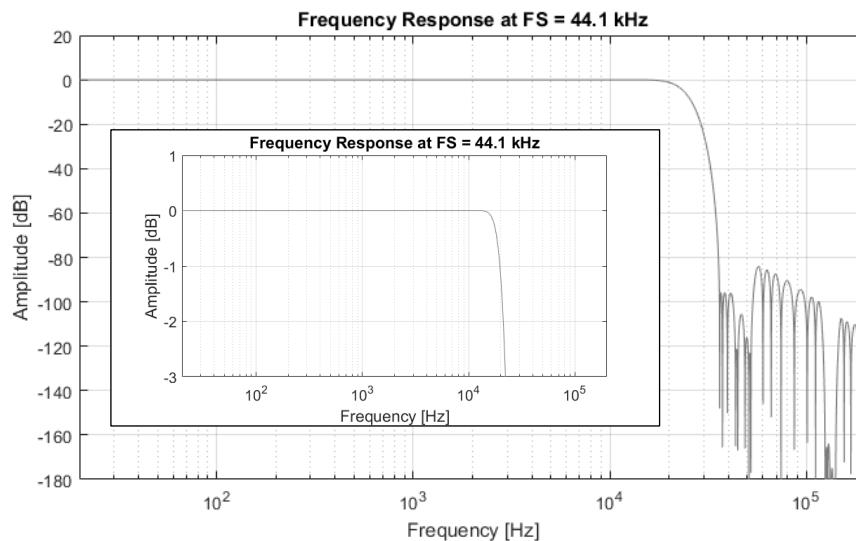
Linear Phase Fast Roll-Off
Low Ripple



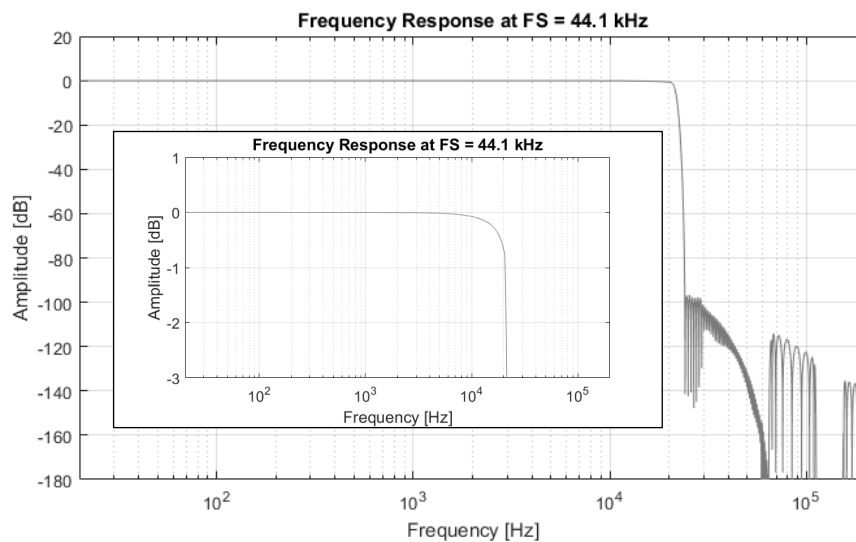


ES9820 Product Datasheet

Linear Phase Slow Roll-Off



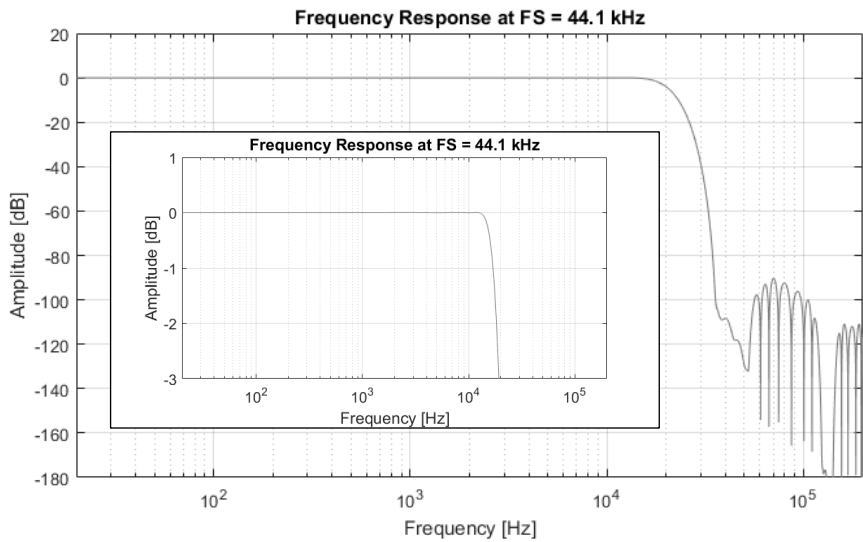
Minimum Phase Fast Roll-Off





ES9820 Product Datasheet

Minimum Phase Slow Roll-Off



Minimum Phase Slow Roll-Off Low Dispersion

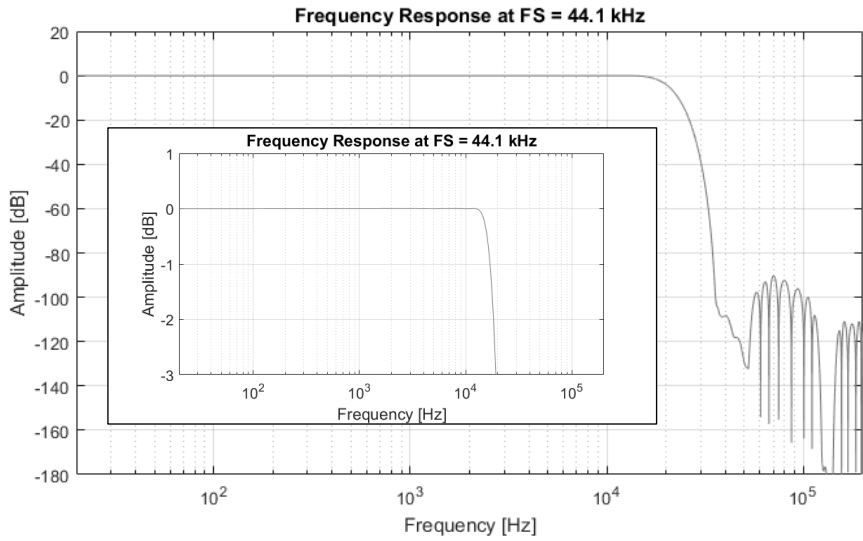
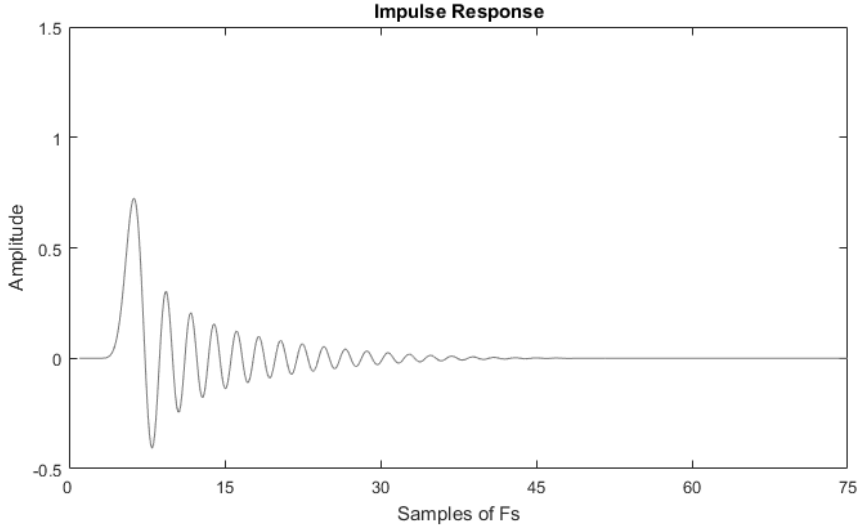
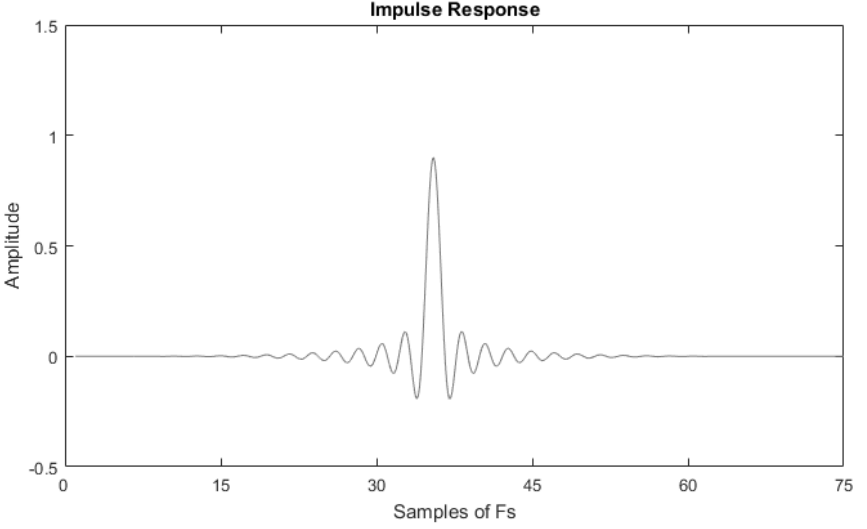


Table 13 - PCM Filter Frequency Response



PCM Filter Impulse Response

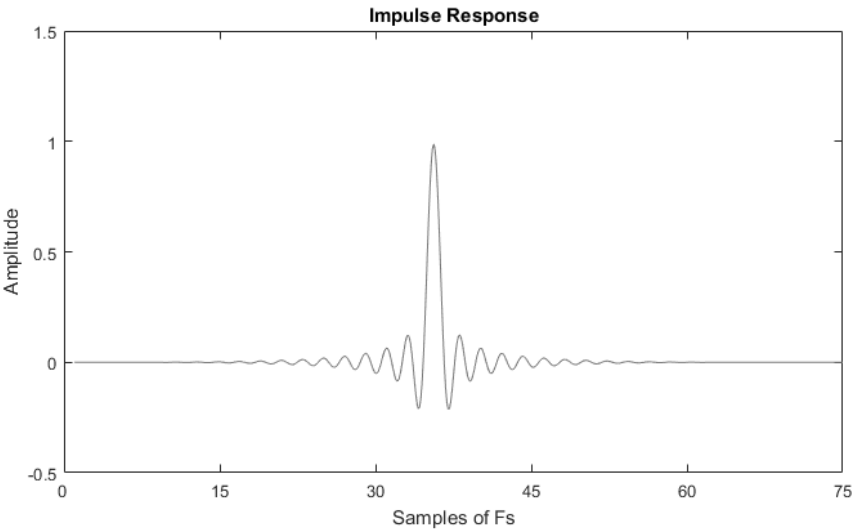
The following impulse responses were obtained from software simulations of these filters. They show the decimation path prior to down-sampling to 1FS and are scaled accordingly. The extra sample delay to get the data encoded accounts for external processing time to serialize data stream.

Filter	Impulse Response
Minimum Phase	
Linear Phase Apodizing	

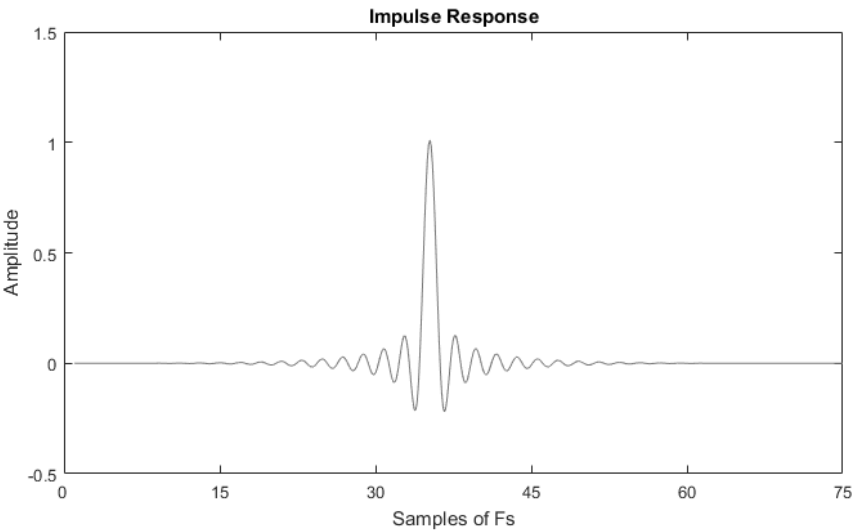


ES9820 Product Datasheet

Linear Phase Fast Roll-Off



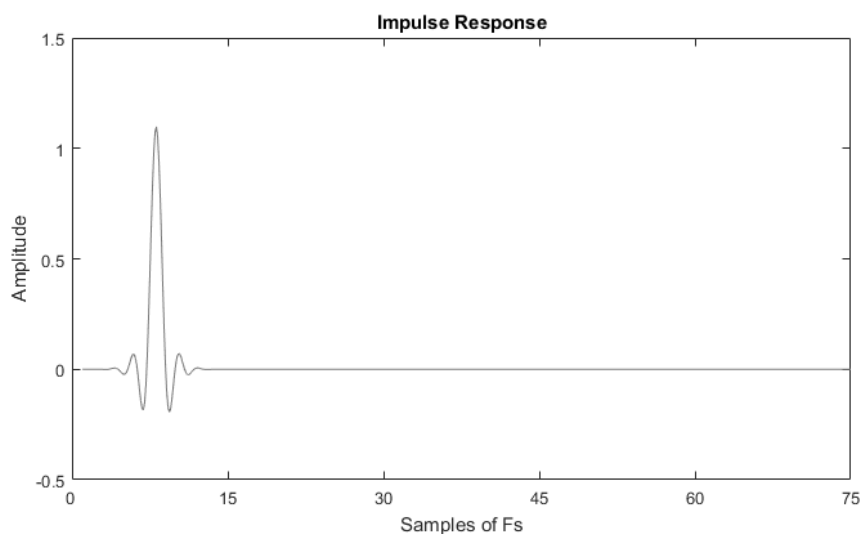
Linear Phase Fast Roll-Off
Low Ripple



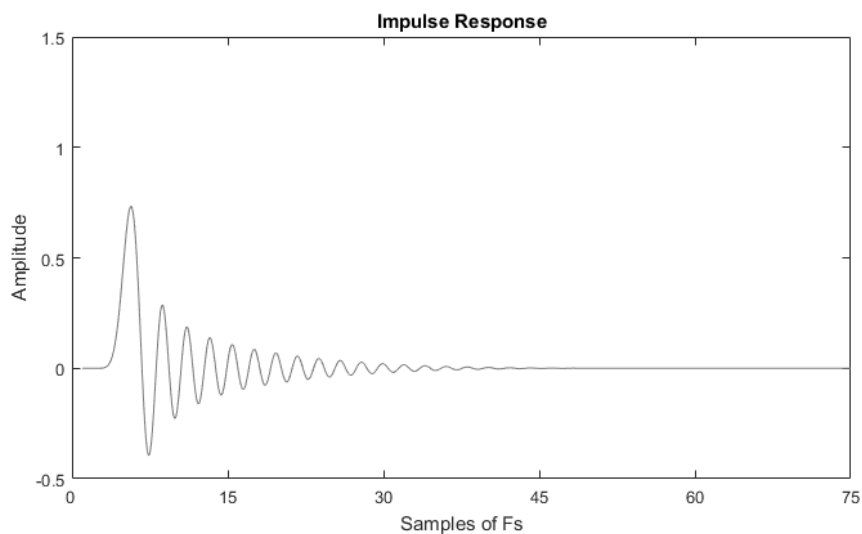


ES9820 Product Datasheet

Linear Phase Slow Roll-Off



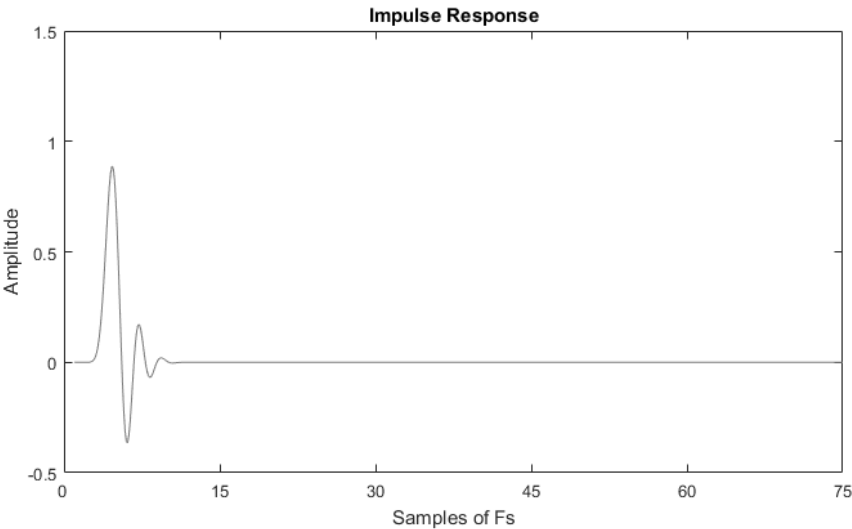
Minimum Phase Fast Roll-Off





ES9820 Product Datasheet

Minimum Phase Slow Roll-Off



Minimum Phase Slow Roll-Off Low Dispersion

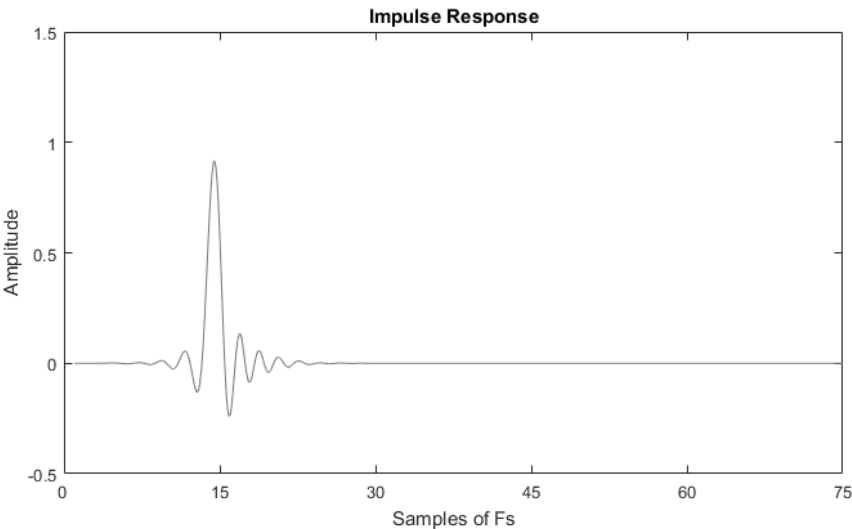


Table 14 - PCM Filter Impulse Response



64FS Mode

When the MCLK/FS ratio is required to be 64, it is necessary for the ES9820 to be running in 64FS Mode. 64FS Mode can be entered by setting:

Software Register

- Register 0[3] ENABLE_64FS_MODE = 1'b1
 - Use for 64FS ratios, including 705.6/768kHz sample rates.

This mode enables the Minimum Phase 64FS filter. See filter properties below.

Minimum Phase 64FS Mode Latency

The following table shows the simulated latency at 705.6kHz sampling rate and is very similar at 768kHz. Measurements were taken from the external impulse response prior to being down sampled to 1FS. The extra sample delay to get the data encoded accounts for external processing time to serialize the data stream. Latency delay will reduce (scale) with sampling rate.

Digital Filter	Delay(us) @ FS = 705.6 kHz
Minimum Phase 64FS	9.2us

Table 15 - Minimum Phase 64FS Latency

Minimum Phase 64FS Properties

Minimum Phase 64FS Mode					
Parameter	Conditions	MIN	TYP	MAX	UNIT
Pass band	-3dB			0.55FS	Hz
Stop band	-100dB	0.91FS			Hz
Group Delay		2.24/FS		4.03/FS	s
Flatness (ripple)					dB

Table 16 - Minimum Phase 64FS Properties

ES9820 Product Datasheet

Minimum Phase 64FS Frequency Response

This filter gets selected automatically when $MCLK/FS = 64$. The following frequency response was obtained from software simulations with a sample rate of 705.6kHz.

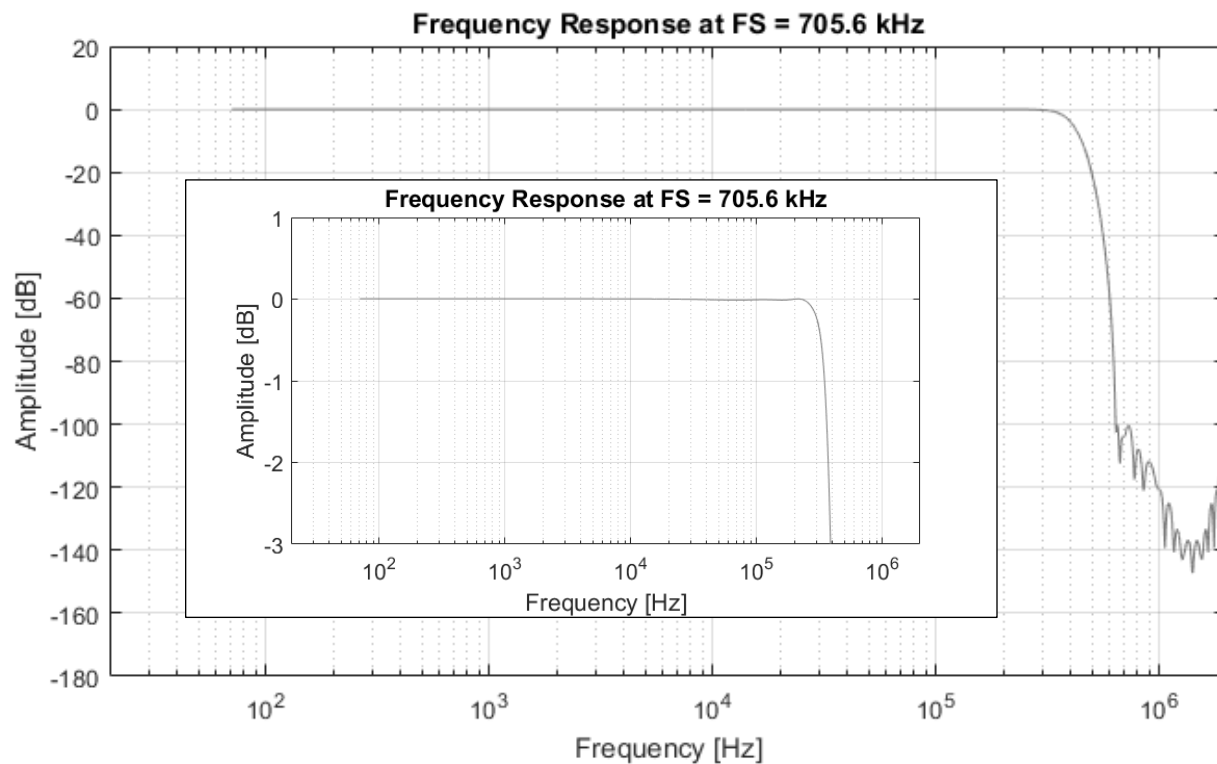


Figure 17 - Minimum Phase 64FS Frequency Response



Minimum Phase 64FS Impulse Response

The following impulse responses were obtained from software simulations of these filters. They show the decimation path prior to down-sampling to 1FS and are scaled accordingly. The extra sample delay to get the data encoded accounts for external processing time to serialize data stream.

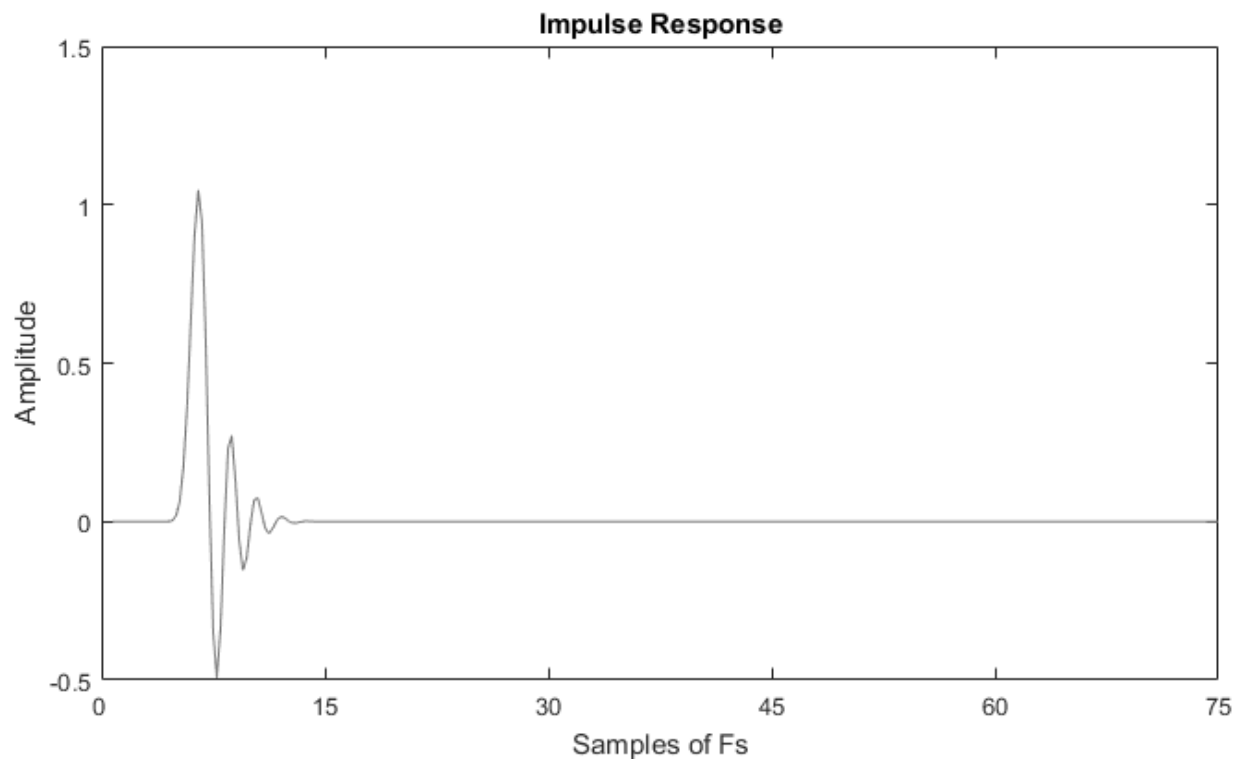


Figure 18 - Minimum Phase 64FS Impulse Response

ES9820 Product Datasheet

Clock Distribution

The ES9820 includes features for selecting and manipulating the input clock source.

The minimum MCLK frequency is 22.579MHz.

When using 24.576MHz or 22.578MHz, it is preferable to use GPIO4-6 as the data output.

- Register 74-91 (GPIOx/x_CONFIG) - Set desired GPIO as AUX output and enable output mode
- Register 12-13[6:5] (TDM_LINE_SEL_CHx) - Change TDM Line Select to desired GPIO
- Register 11[7] (TDM_GPIO456) - Enable TDM on GPIO456

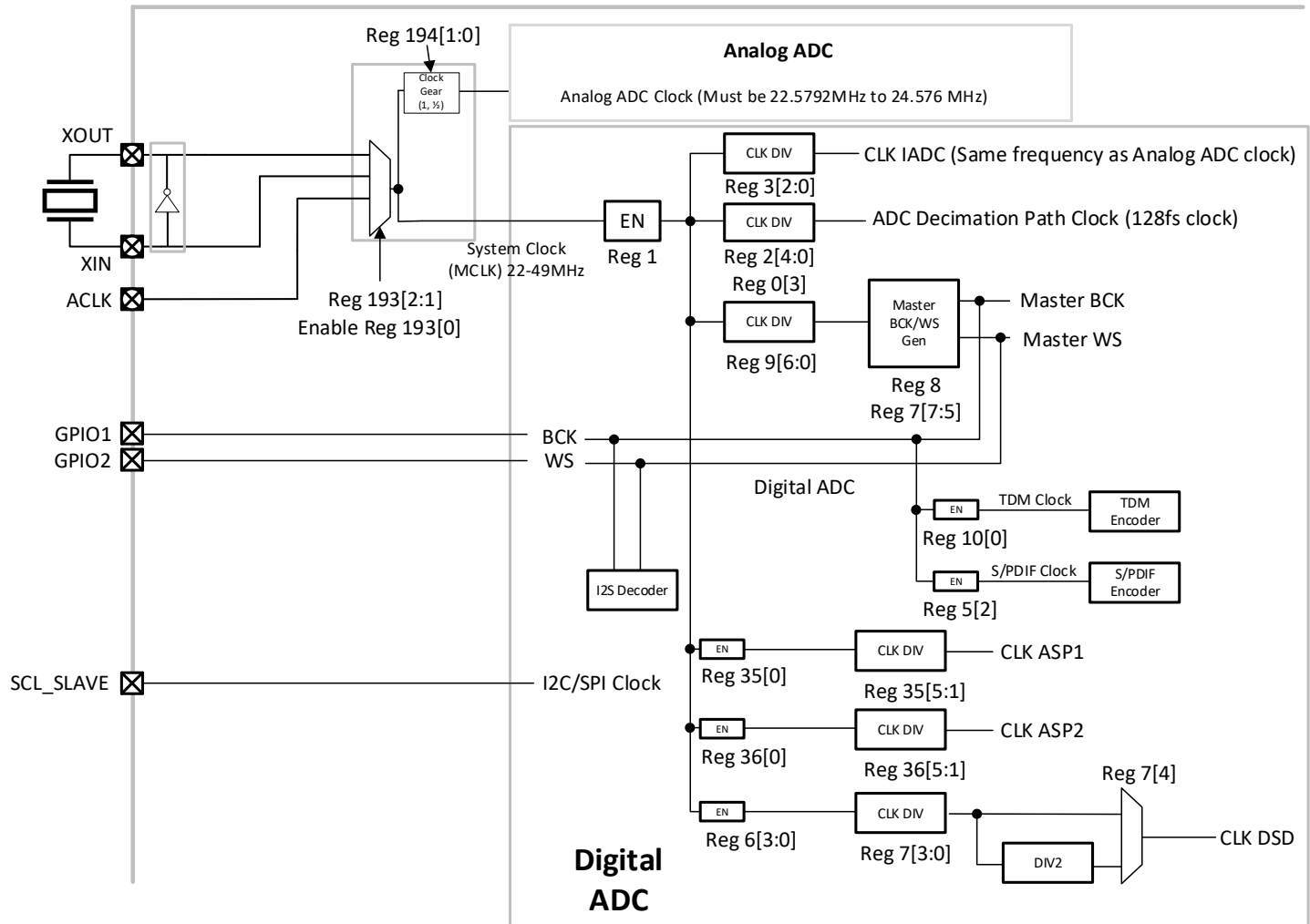


Figure 19 - ES9820 Clock Distribution



The following list shows the various clocks of the ES9820 and the associated registers for configuration.

Analog ADC Clock

ADC clock must be maintained to be between 22.5792MHz & 24.576MHz

- Register 194[1:0] SEL_CLK_DIV
- Register 193[2:1] SEL_SYSCLK_IN
- Register 193[0] EN_ANA_CLKIN

IADC Clock

Should be set to the same clock frequency as the analog ADC clock, sampling Analog ADC.

- Register 3[2:0] SELECT_IADC_NUM
 - Set this so it matches Analog ADC clock of 22.5792 or 24.576MHz.
- Register 1 ADC CLOCK CONFIG1
 - Dependent on channels required.
- Register 193[2:1] SEL_SYSCLK_IN
- Register 193[0] EN_ANA_CLKIN

ADC Decimation Path Clock

- Register 2[4:0] SELECT_ADC_NUM
- Register 1 ADC CLOCK CONFIG 1
 - Dependent on channels required.
- Register 9[6:0] SELECT_I²S_TDM_NUM
- Register 193[2:1] SEL_SYSCLK_IN
- Register 193[0] EN_ANA_CLKIN

Master BCK & WS

- Register 8 I²S/TDM MASTER MODE CONFIG
- Register 7[7:5] MASTER_WS_SCALE
- Register 9[6:0] SELECT_I²S_TDM_NUM
- Register 193[2:1] SEL_SYSCLK_IN
- Register 193[0] EN_ANA_CLKIN

TDM Clock

- Register 10[0] ENABLE_TDM_CLK

S/PDIF Clock

- Register 5[2] ENABLE_SPDIF_CLK

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ASP1 Clock

- Register 35[0] ENABLE_ASP1_CLK
- Register 35[5:1] SELECT_ASP1_NUM
- Register 1 ADC CLOCK CONFIG1
 - Dependent on channels required.
- Register 193[2:1] SEL_SYSCLK_IN
- Register 193[0] EN_ANA_CLKIN

ASP2 Clock

- Register 36[0] ENABLE_ASP1_CLK
- Register 36[5:1]
- Register 1 ADC CLOCK CONFIG1
 - Dependent on channels required.
- Register 193[2:1] SEL_SYSCLK_IN
- Register 193[0] EN_ANA_CLKIN

I²S Decoder Clock

- Uses BCK / WS



I²S Master Clock Rate Configurations

WS can be scaled down further than shown via Register 7[7:5] MASTER_WS_SCALE.

MCLK Frequency	WS [kHz]	BCK [MHz]	Bits	Channels	Register 2 [4:0] SELECT_ADC_NUM		Register 9 [6:0] SELECT_I ² S_TDM_NUM		Register 11 [5] TDM_LENGTH	
					Value	Divider	Value	Divider	Value	Length
22.579 MHz	44.1	2.822	32	2	5'd3	4	7'd3	4	1'b0	32
	88.2	5.645		2	5'd1	2	7'd1	2	1'b0	32
	176.4	11.290		2	5'd0	1	7'd0	1	1'b0	32
	44.1	1.411	16	2	5'd3	4	7'd3	4	1'b1	16
	88.2	2.822		2	5'd1	2	7'd1	2	1'b1	16
	176.4	5.645		2	5'd0	1	7'd0	1	1'b1	16
24.576 MHz	48	3.072	32	2	5'd3	4	7'd3	4	1'b0	32
	96	6.144		2	5'd1	2	7'd1	2	1'b0	32
	192	12.288		2	5'd0	1	7'd0	1	1'b0	32
	48	1.536	16	2	5'd3	4	7'd3	4	1'b1	16
	96	3.072		2	5'd1	2	7'd1	2	1'b1	16
	192	6.144		2	5'd0	1	7'd0	1	1'b1	16
45.158 MHz	44.1	2.822	32	2	5'd7	8	7'd7	8	1'b0	32
	88.2	5.645		2	5'd3	4	7'd3	4	1'b0	32
	176.4	11.290		2	5'd1	2	7'd1	2	1'b0	32
	352.8	22.579		2	5'd0	1	7'd0	1	1'b0	32
	44.1	1.411	16	2	5'd7	8	7'd7	8	1'b1	16
	88.2	2.822		2	5'd3	4	7'd3	4	1'b1	16
	176.4	5.645		2	5'd1	2	7'd1	2	1'b1	16
	352.8	11.290		2	5'd0	1	7'd0	1	1'b1	16
49.152 MHz	48	3.072	32	2	5'd7	8	7'd7	8	1'b0	32
	96	6.144		2	5'd3	4	7'd3	4	1'b0	32
	192	12.288		2	5'd1	2	7'd1	2	1'b0	32
	384	24.576		2	5'd0	1	7'd0	1	1'b0	32
	48	1.536	16	2	5'd7	8	7'd7	8	1'b1	16
	96	3.072		2	5'd3	4	7'd3	4	1'b1	16
	192	6.144		2	5'd1	2	7'd1	2	1'b1	16
	384	12.288		2	5'd0	1	7'd0	1	1'b1	16

Table 17 - I²S Master Clock Rate Configurations

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I²S Slave Clock Rate Configurations

MCLK Frequency	WS [kHz]	BCK	Channels	Register 2 [4:0] SELECT_ADC_NUM		Register 0 [3] ENABLE_64FS_MODE	
				Value	Divider	Value	Multiplier
22.579 MHz	44.1	512FS	2	7'd3	4	1'b0	1x
	88.2	256FS	2	7'd1	2	1'b0	1x
	176.4	128FS	2	7'd0	1	1'b0	1x
	352.8	64FS	2	7'd0	1	1'b1	2x
24.576 MHz	48	512FS	2	7'd3	4	1'b0	1x
	96	256FS	2	7'd1	2	1'b0	1x
	192	128FS	2	7'd0	1	1'b0	1x
	384	64FS	2	7'd0	1	1'b1	2x
45.158 MHz	44.1	1024FS	2	7'd7	8	1'b0	1x
	88.2	512FS	2	7'd3	4	1'b0	1x
	176.4	256FS	2	7'd1	2	1'b0	1x
	352.8	128FS	2	7'd0	1	1'b0	1x
49.152 MHz	48	1024FS	2	7'd7	8	1'b0	1x
	96	512FS	2	7'd3	4	1'b0	1x
	192	256FS	2	7'd1	2	1'b0	1x
	384	128FS	2	7'd0	1	1'b0	1x

Table 18 - I²S Slave Clock Rate Configurations



TDM Master Clock Rate Configurations

All configurations are 32-bit.

When using left justified mode (Register 10[1] TDM_LJ = 1'b1) remember to enable Register 33[7] SYNC_POSEDGE_FRAME to correct for phase differences.

MCLK Frequency	WS [kHz]	BCK [MHz]	TDM Mode	Channels	Register 2 [4:0] SELECT_ADC_NUM		Register 9 [6:0] SELECT_I²S_TDM_NUM		Register 7 [7:5] MASTER_WS_SCALE		Register 8 [7] MASTER_BCK_DIV1	
					Value	Divider	Value	Divider	Value	Divider	Value	Divider
22.579 MHz	44.1	5.645	TDM 128	4	5'd3	4	7'd1	2	3'd1	2	1'b0	2
	88.2	11.290		4	5'd1	2	7'd0	1	3'd1	2	1'b0	2
	176.4	22.579		4	5'd0	1	7'd0	1	3'd0	1	1'b1	1
	44.1	11.290	TDM 256	8	5'd3	4	7'd0	1	3'd2	4	1'b0	2
	88.2	22.579		8	5'd1	2	7'd0	1	3'd1	2	1'b1	1
	44.1	22.579	TDM 512	16	5'd3	4	7'd0	1	3'd2	4	1'b1	1
24.576 MHz	48	6.144	TDM 128	4	5'd3	4	7'd1	2	3'd1	2	1'b0	2
	96	12.288		4	5'd1	2	7'd0	1	3'd1	2	1'b0	2
	192	24.576		4	5'd0	1	7'd0	1	3'd0	1	1'b1	1
	48	12.288	TDM 256	8	5'd3	4	7'd0	1	3'd2	4	1'b0	2
	96	24.576		8	5'd1	2	7'd0	1	3'd1	2	1'b1	1
	48	24.576	TDM 512	16	5'd3	4	7'd0	1	3'd2	4	1'b1	1
45.158 MHz	44.1	5.645	TDM 128	4	5'd7	8	7'd3	4	3'd1	2	1'b0	2
	88.2	11.290		4	5'd3	4	7'd1	2	3'd1	2	1'b0	2
	176.4	22.579		4	5'd1	2	7'd0	1	3'd1	2	1'b0	2
	44.1	11.290	TDM 256	8	5'd7	8	7'd1	2	3'd2	4	1'b0	2
	88.2	22.579		8	5'd3	4	7'd0	1	3'd2	4	1'b0	2
	44.1	22.579	TDM 512	16	5'd7	8	7'd0	1	3'd3	8	1'b0	2
49.152 MHz	48	6.144	TDM 128	4	5'd7	8	7'd3	4	3'd1	2	1'b0	2
	96	12.288		4	5'd3	4	7'd1	2	3'd1	2	1'b0	2
	192	24.576		4	5'd1	2	7'd0	1	3'd1	2	1'b0	2
	48	12.288	TDM 256	8	5'd7	8	7'd1	2	3'd2	4	1'b0	2
	96	24.576		8	5'd3	4	7'd0	1	3'd2	4	1'b0	2
	48	24.576	TDM 512	16	5'd7	8	7'd0	1	3'd3	8	1'b0	2

Table 19 - TDM Master Clock Rate Configurations

ES9820 Product Datasheet

TDM Slave Clock Rate Configurations

All configurations are 32-bit.

When using left justified mode (Register 10[1] TDM_LJ = 1'b1) remember to enable Register 33[7] SYNC_POSEDGE_FRAME to correct for phase differences.

MCLK Frequency	WS [kHz]	BCK [MHz]	TDM Mode	Channels	Register 2 [4:0] SELECT_ADC_NUM	
					Value	Divider
22.579 MHz	44.1	5.645	TDM 128	4	5'd3	4
	88.2	11.290		4	5'd1	2
	176.4	22.579		4	5'd0	1
	44.1	11.290	TDM 256	8	5'd3	4
	88.2	22.579		8	5'd1	2
	44.1	22.579	TDM 512	16	5'd3	4
24.576 MHz	48	6.144	TDM 128	4	5'd3	4
	96	12.288		4	5'd1	2
	192	24.576		4	5'd0	1
	48	12.288	TDM 256	8	5'd3	4
	96	24.576		8	5'd1	2
	48	24.576	TDM 512	16	5'd3	4
45.158 MHz	44.1	5.645	TDM 128	4	5'd7	8
	88.2	11.290		4	5'd3	4
	176.4	22.579		4	5'd1	2
	44.1	11.290	TDM 256	8	5'd7	8
	88.2	22.579		8	5'd3	4
	44.1	22.579	TDM 512	16	5'd7	8
49.152 MHz	48	6.144	TDM 128	4	5'd7	8
	96	12.288		4	5'd3	4
	192	24.576		4	5'd1	2
	48	12.288	TDM 256	8	5'd7	8
	96	24.576		8	5'd3	4
	48	24.576	TDM 512	16	5'd7	8

Table 20 - TDM Slave Clock Rate Configurations



DSD Master Clock Rate Configurations

MCLK Frequency	BCK [MHz]	FS [kHz]	DSD Mode	Register 7 [3:0] SELECT_DSD_NUM		Register 7 [4] DSD_CLK_DIV2		Reg 2 [4:0] SELECT_ADC_NUM	
				Value	Divider	Value	Divider	Value	Divider
22.579 MHz	2.822	44.1	DSD 64	5'd3	4	1'b1	2	5'd7	8
	5.645	44.1	DSD 128	5'd1	2	1'b1	2	5'd7	8
	11.290	44.1	DSD 256	5'd0	1	1'b1	2	5'd7	8
45.158 MHz	2.822	44.1	DSD 64	5'd7	8	1'b1	2	5'd7	8
	5.645	44.1	DSD 128	5'd3	4	1'b1	2	5'd7	8
	11.290	44.1	DSD 256	5'd1	2	1'b1	2	5'd7	8
	22.579	44.1	DSD 512	5'd0	1	1'b1	2	5'd7	8

Table 21 - DSD Master Clock Rate Configurations

ES9820 Product Datasheet

Absolute Maximum Ratings

PARAMETER	RATING
Positive Supply Voltage • AVCC_R/AVCC_L • AVCC • AVDD • DVDD Note: AVCC, AVCC_L/R and AVDD absolute negative max voltage is -0.3V	• +3.6V with respect to Ground • +3.6V with respect to Ground • +3.6V with respect to Ground • +1.4V with respect to Ground
Storage Temperature	-65°C to +150°C
Operating Junction Temperature	+125°C
Voltage Range for Digital Input Pins	-0.3V to AVDD (nom) + 0.3V
Maximum/Minimum Input Voltage on IN_P IN_M pins	-0.4 to AVCC (nom) + 1.5V
ESD Protection	
Human Body Model (HBM)	2kV
Charge Device Model (CDM)	500V

Table 22 - Absolute Maximum Ratings

WARNING: Stresses beyond those listed under here may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied.

WARNING: Electrostatic Discharge (ESD) can damage this device. Proper procedures must be followed to avoid ESD when handling this device.

IO Electrical Characteristics

PARAMETER	SYMBOL	MINIMUM	MAXIMUM	UNIT	COMMENTS
High-Level Input Voltage	VIH	$(AVDD / 2) + 0.4$		V	
Low-Level Input Voltage	VIL		0.4	V	
High-Level Output Voltage	VOH	AVDD - 0.2		V	IOH = $(AVDD / 2) + 1.4$ [mA]
Low-Level Output Voltage	VOL		0.2	V	IOL = $(AVDD / 2) + 1.7$ [mA]

Table 23 - IO Electrical Characteristics



Switching Characteristics

Test Conditions (unless otherwise noted)

$T_A = 25^\circ\text{C}$, $AVCC = AVCC_L = AVCC_R = AVDD = +3.3\text{V}$, $f_s = 48\text{kHz}$, $MCLK = 49.152\text{MHz}$, I²S output.

PARAMETER	SYMBOL	MINIMUM	TYPICAL	MAXIMUM	UNIT
MCLK timing					
Frequency	f_{MCLK}	20	-	50	MHz
Analog ADC ¹	f_{ADC}	20	-	25	MHz
Duty Cycle	-	45	50	55	%
Bit Clock Frequency					
PCM (LJ/I ² S) Mode	f_{bCLK}	-	$2 \times f_s \times \text{TDM_LENGTH}$	$MCLK/2$	MHz
PCM (LJ/I ² S) + Enable_64FS Mode	f_{bCLK}	-	-	$MCLK$	MHz
TDM4 (4ch data line)	f_{bCLK}	-	$4 \times f_s \times \text{TDM_LENGTH}$	$MCLK$	MHz
TDM8 (8ch data line)	f_{bCLK}	-	$8 \times f_s \times \text{TDM_LENGTH}$	$MCLK$	MHz
TDM16 (16ch data line)	f_{bCLK}	-	$16 \times f_s \times \text{TDM_LENGTH}$	$MCLK$	MHz
Frame Clock Normal Frequency					
PCM (LJ/I ² S) Mode	WS	$MCLK/4096$	-	$MCLK/128$	kHz
PCM (LJ/I ² S) + Enable_64FS Mode	WS	-	-	$MCLK/64$	kHz
TDM4 (4ch data line)	WS	$MCLK/4096$	-	$MCLK/128$	kHz
TDM8 (8ch data line)	WS	$MCLK/4096$	-	$MCLK/256$	kHz
TDM16 (16ch data line)	WS	$MCLK/4096$	-	$MCLK/512$	kHz

Table 24 - Switching Characteristics

Note: The DFIR Filters need to be resynced after sample rate changes. See Addendum for respective resync program.

¹ Analog ADC (f_{ADC}) on the clock distribution diagram must be between 20-25MHz. MCLK used must be divided by 1 or 2 to create f_{ADC} .

ES9820 Product Datasheet

Timing Characteristics

Bit-Clock (BCK) and Word-Select (WS) Timing

PARAMETER	SYMBOL	MINIMUM	TYPICAL	MAXIMUM	UNIT
LJ/I²S Mode or TDM modes					
Slave Mode					
BCLK Period	tb	20	-	-	ns
BCLK High Duration	tbH	9	-	-	ns
BCLK Low Duration	tbL	9	-	-	ns
BCLK Fall to Frame Transition	tbsr	-6	0	6	ns
BCLK Fall to Serial Data Out	tbsdo	-	13.8	-	ns
Data in Setup Time	tsdisu	-	-	-	ns
Data in Hold Time	tsdihold	-	-	-	ns
Master Mode					
BCLK Period	tb	20	-	-	ns
BCLK High Duration	tbH	9	-	-	ns
BCLK Low Duration	tbL	9	-	-	ns
BCLK Fall to Frame Transition	tbsr	-	0	-	ns
BCLK Fall to Serial Data Out	tbsdo	-	13.2	-	ns
Data in Setup Time	tsdisu	-	-	-	-
Data in Hold Time	tsdihold	-	-	-	-

Table 25 - Audio Interface Timing Requirements

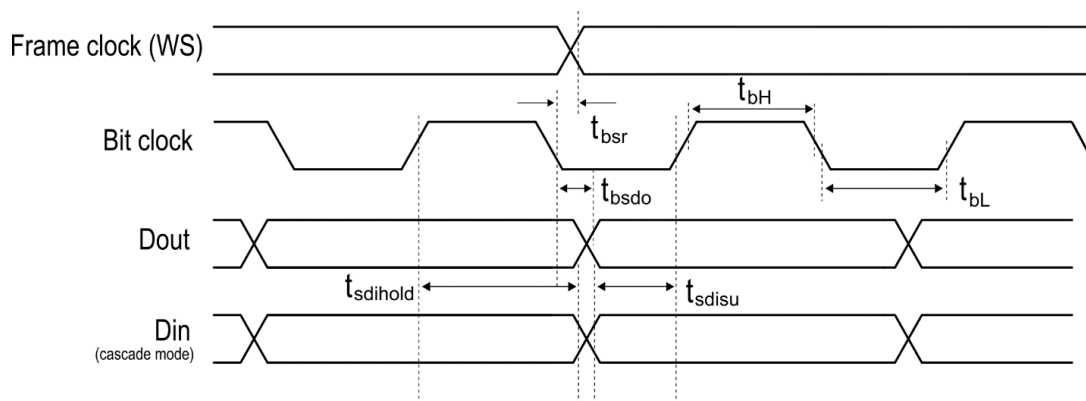


Figure 20 - Audio Interface Timing Requirements



Master Clock (MCLK) and Bit-Clock (BCK) Timing

The ES9820 has a phase relationship requirement between MCLK (System Clock) and BCK (Bit Clock). The internal ADC_CLK (which must be 24.576/22.5792MHz) is derived from the provided MCLK. In slave mode, the ES9820 requires the BCK transition to be within a specific range of the MCLK period. This is due to the synchronization circuitry that aligns the output samples with the input clocks. The table below specifies the amount of time required between the bit clock transition and the MCLK falling edge. To achieve this, follow the MCLK to BCK timing outlined below.

45/49MHz MCLK

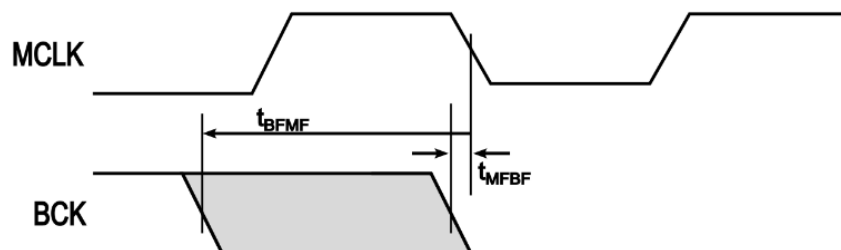


Figure 21 - 45/49MHz MCLK with BCK Phase Relationship

	Symbol	MCLK [MHz]	Minimum	Maximum	Unit
BCK "↓" to MCLK "↓"	t_{bfmf}	49.152 / 45.1584	-	10	ns
MCLK "↓" to BCK "↓"	t_{mfbf}		4	-	ns

Table 26 - Timing Relationship for 45/49MHz MCLK & BCK

22/24MHz MCLK

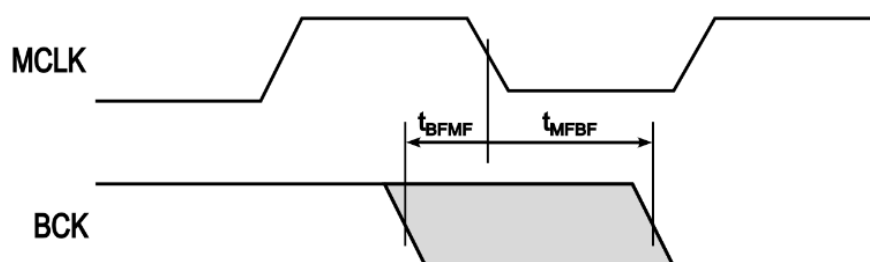


Figure 22 - 22/24MHz MCLK with BCK Phase Relationship

	Symbol	MCLK [MHz]	Minimum	Maximum	Unit
BCK "↓" to MCLK "↓"	t_{bfmf}	24.576 / 22.5792	-	5	ns
MCLK "↓" to BCK "↓"	t_{mfbf}		-	7	ns

Table 27 - Timing Relationship for 22/24MHz MCLK & BCK

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I²C Slave/Synchronous Slave Interface Timing

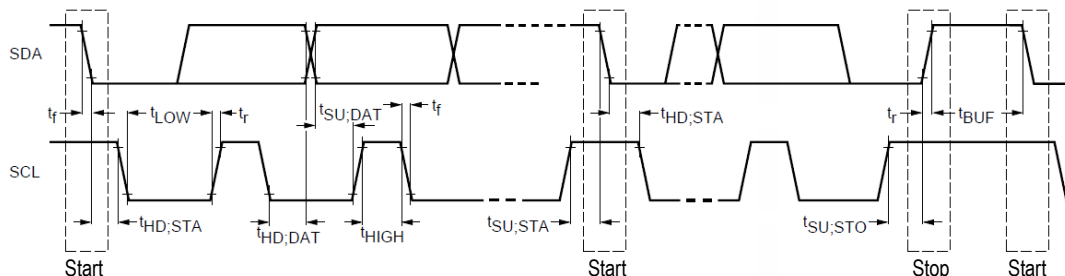


Figure 23 - I²C Slave/Synchronous Slave Control Interface Timing Diagram

Parameter	Symbol	CLK Constraint	Standard-Mode		Fast-Mode		Unit
			MIN	MAX	MIN	MAX	
SCL Clock Frequency	f_{SCL}	$< CLK/20$	0	100	0	400	kHz
START condition hold time	$t_{HD,STA}$		4.0	-	0.6	-	μs
LOW period of SCL	t_{LOW}	$>10/CLK$	4.7	-	1.3	-	μs
HIGH period of SCL ($>10/CLK$)	t_{HIGH}	$>10/CLK$	4.0	-	0.6	-	μs
START condition setup time (repeat)	$t_{SU,STA}$		4.7	-	0.6	-	μs
SDA hold time from SCL falling - All except NACK read - NACK read only	$t_{HD,DAT}$		0 2/CLK	-	0 2/CLK	-	μs s
SDA setup time from SCL rising	$t_{SU,DAT}$		250	-	100	-	ns
Rise time of SDA and SCL	t_r		-	1000	-	300	ns
Fall time of SDA and SCL	t_f		-	300	-	300	ns
STOP condition setup time	$t_{SU,STO}$		4	-	0.6	-	μs
Bus free time between transmissions	t_{BUF}		4.7	-	1.3	-	μs
Capacitive load for each bus line	C_b		-	400	-	400	pF

Table 28 - I²C Slave/Synchronous Slave Control Interface Timing Definitions



SPI Slave Interface Timing

The SPI slave interface is used when the MODE pin (Pin 3) is pulled high.

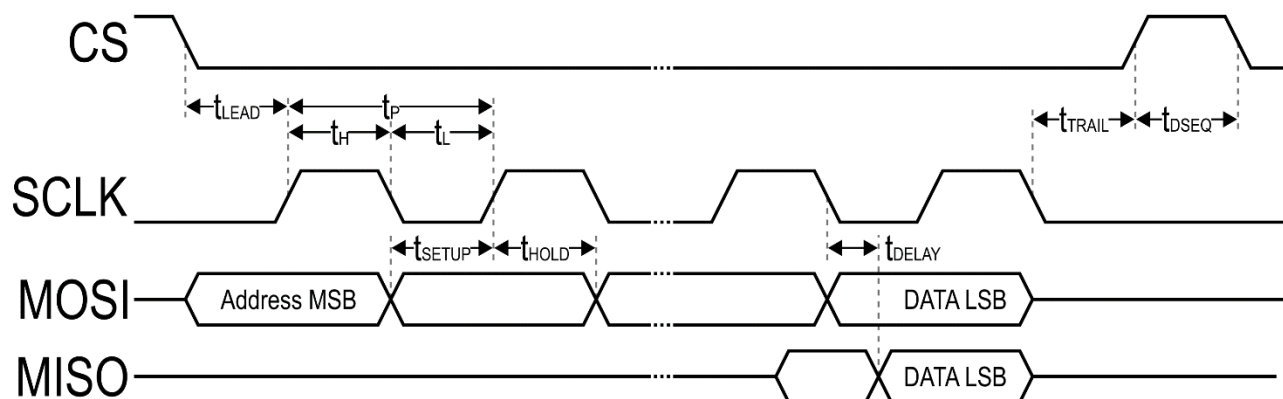


Figure 24 - SPI Slave Interface Timing

Parameter	Symbol	Min [ns]	Max [ns]
CS Lead Time (SCLK rising edge)	t_{LEAD}	10	-
CS Trail Time (SCLK falling edge)	t_{TRAIL}	10	-
MOSI Data Setup Time	t_{SETUP_MOSI}	-30	-
MOSI Data Hold Time	t_{HOLD_MOSI}	65	-
SCLK-MISO Delay Time	t_{DELAY_MISO}	-	65
SCLK Period	t_{P_SCLK}	170	-
SCLK High Pulse Duration	t_{H_SCLK}	60	-
SCLK Low Pulse Duration	t_{L_SCLK}	90	-
Sequential Transfer Delay	t_{DSEQ}	45	-

Table 29 - SPI Slave Interface Timing

ES9820 Product Datasheet

Recommended Operating Conditions

These are the recommended operating conditions for the ES9820.

The minimum MCLK is 22MHz. Below this frequency, the device will not function.

PARAMETER	SYMBOL	CONDITIONS
Operating temperature	T _A	-20°C to +85°C
AVCC		3.3V
AVDD		3.3V
AVCC_L		3.3V
AVCC_R		3.3V
VREF_L		Internal
VREF_R		Internal
DVDD		Internal 1.2V

Table 30 - Recommended Operating Conditions



Recommended Power Up/Down Sequences

The recommended power up/down sequences are shown in the following diagram. Supplies and MCLK should be stable before CHIP_EN is asserted.

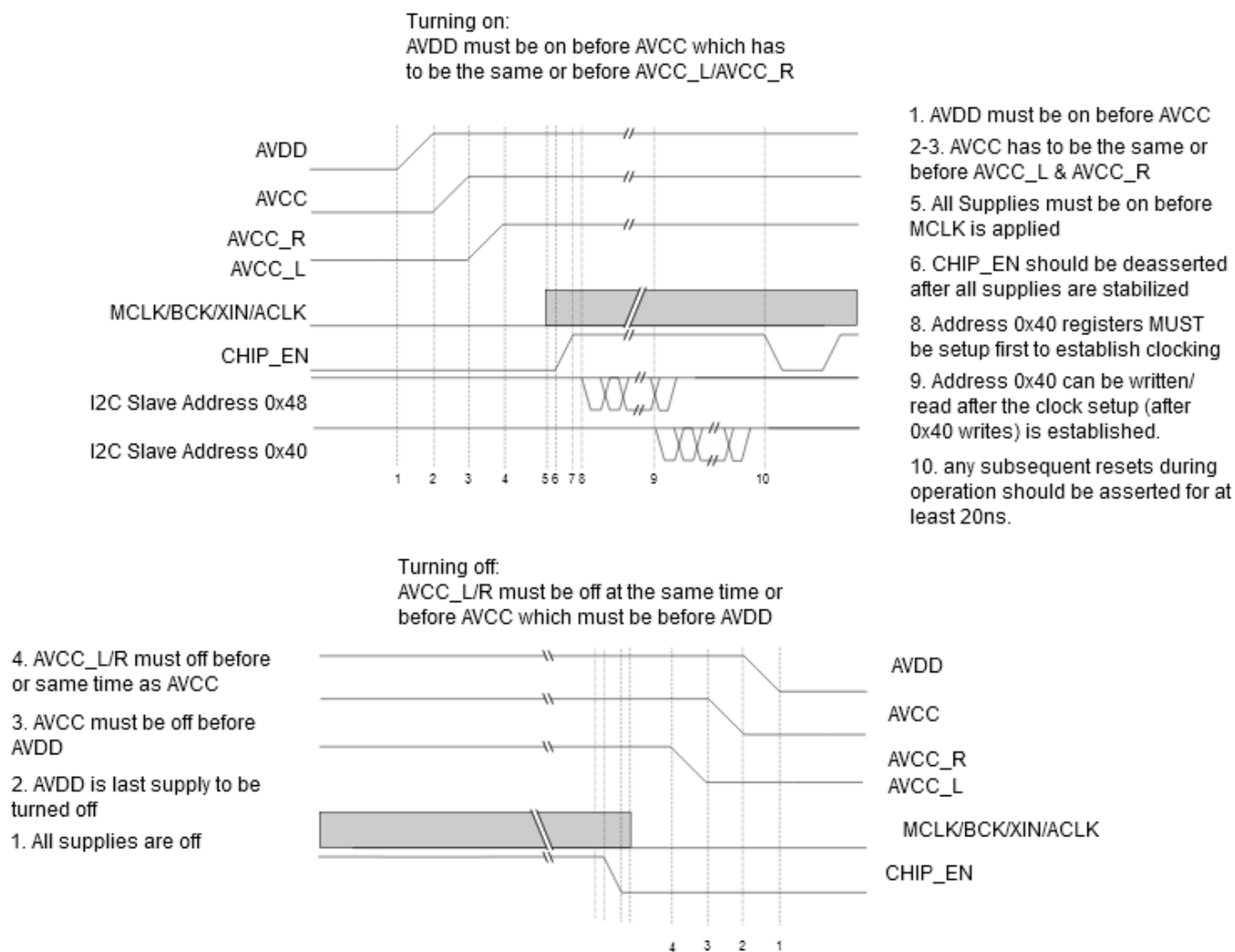


Figure 25 - Recommended Power Up/Down Sequences

ES9820 Product Datasheet

Power Consumption

Test Conditions (unless otherwise noted)

$T_A = 25^{\circ}\text{C}$, $\text{AVCC} = \text{AVCCL} = \text{AVCCR} = \text{AVDD} = +3.3\text{V}$, $f_s = 48\text{kHz}$, I²S output, with -1dBFS input signal. AVDD supply includes DVDD current.

Parameter	Min	Typ.	Max	Unit
Standby				
AVCC, AVCC_L, AVCC_R		3		μA
AVDD		0.02		μA
MCLK = 49.152MHz				
Supply Current during 48kHz 2ch mode				
AVCC		4.7		mA
AVCC_L, AVCC_R		6.3		mA
AVDD		12.7		mA
Supply Current during 192kHz 2ch mode				
AVCC		4.7		mA
AVCC_L, AVCC_R		6.3		mA
AVDD		20.3		mA
MCLK = 24.576MHz				
Supply Current during 48kHz 2ch mode				
AVCC		4.7		mA
AVCC_L, AVCC_R		6.3		mA
AVDD		10.3		mA
Supply Current during 192kHz 2ch mode				
AVCC		4.7		mA
AVCC_L, AVCC_R		6.3		mA
AVDD		18.1		mA

Table 31 - Power Consumption



Performance

Test Conditions (unless otherwise noted).

$T_A = 25^\circ\text{C}$, $AVCC = AVCC_L = AVCC_R = AVDD = +3.3\text{V}$, $f_s = 48\text{kHz}$, $MCLK = 49.152\text{MHz}$, $I^2\text{S}$ output.

Parameter			Min	Typ.	Max	Unit
Resolution				32		Bit
0dBFS Input Voltage				2.35		Vrms
THD+N Ratio @ fs=48kHz, BW = 20Hz-20kHz	2 ch mode	-1dBFS		-108	-106	dB
	1 ch mode			-109		dB
THD+N Ratio @ fs=96kHz, BW = 20Hz-20kHz	2 ch mode	-1dBFS		-106		dB
	1 ch mode			-108		dB
THD+N Ratio @ fs=192kHz, BW = 20Hz-20kHz	2 ch mode	-1dBFS		-104		dB
	1 ch mode			-108		dB
DNR A-weighted	2ch mode	-60dBFS	114	117		dB
	1ch mode		115	118		dB
Inter-channel Gain Mismatch				±0.05	±0.4	dB
Input DC Common Mode				AVCC_L/2 AVCC_R/2		V
Input Impedance				860±14%		Ω
Cin (Input Capacitance)				~10		pF

Table 32 - Performance

ES9820 Product Datasheet

Register Overview

I²C Slave Interface (Device Address 0x40, 0x42, 0x44, 0x46)

This interface contains Read/Write and Read-only registers. A system clock must be enabled through the write-only registers to read/write these registers.

Multi-byte registers must be written from LSB to MSB. Data is latched when MSB is written.

Multi-byte registers must be read from LSB to MSB. Data is latched when LSB is read.

MSB is always stored in the highest register address.

Read/Write Register Addresses

Registers 0-179 (0x00 - 0xB3) are read/write registers.

Read-only Register Addresses

Registers 224 - 253 (0xE0 - 0xFD) are read only registers.

I²C Synchronous Slave Interface (Device Address 0x48, 0x4A, 0x4C, 0x4E)

This interface contains Write-only registers. These registers can be written even when there is no system clock present. These registers must be written to enable read and write access to the rest of the registers.

When the device is inactive, all peripherals are automatically disabled, and all clocks are stopped. An interrupt or a reset can wake the ES9820.

Write-only Register Addresses

Registers 192 - 194 (0xC0 - 0xC2) are write only registers.

Multi-Byte Registers

Multi-byte registers must be written from LSB to MSB. Data is latched when MSB is written.

MSB is always stored in the highest register address.



Register Map

Addr (Hex)	Addr (Dec)	Register	7	6	5	4	3	2	1	0	
0x00	0	SYS CONFIG	SOFT_RESET	OUTPUT_SEL		RESERVED	ENABLE_64FS_ MODE	RESERVED	MONO_MODE	RESERVED	
0x01	1	ADC CLOCK CONFIG1	RESERVED		ENABLE_DATA_ IN_CH2	ENABLE_DATA_ IN_CH1	RESERVED		ENABLE_ADC_ CH2	ENABLE_ADC_ CH1	
0x02	2	ADC CLOCK CONFIG2	RESERVED		SELECT_ADC_ HALF	SELECT_ADC_NUM					
0x03	3	ADC CLOCK CONFIG3	OUTPUT2_SEL		FORCE_ OUTPUT2	INVERT_FIRST_ CLK_SAMPLE2	SELECT_IADC_ HALF	SELECT_IADC_NUM			
0x04	4	ADC CLOCK CONFIG4	FORCE_PHASE_ CLK_IADC	PHASE_CLK_IADC			RESERVED		INVERT_ SAMPLE_ CLOCK_CH2	INVERT_ SAMPLE_ CLOCK_CH1	
0x05	5	SPDIF CONFIG	RESERVED					ENABLE_SPDIF_ CLK	RESERVED		
0x06	6	DSD CONFIG	RESERVED		DSD_DDR	DSD_MASTER_ MODE	RESERVED		ENABLE_DSD_ CLK_CH2	ENABLE_DSD_ CLK_CH1	
0x07	7	DSD AND I2S/TDM MASTER CLK CONFIG	MASTER_WS_SCALE			DSD_CLK_DIV2	SELECT_DSD_NUM				
0x08	8	I2S/TDM MASTER MODE CONFIG	MASTER_BCK_ DIV1	MASTER_WS_ IDLE	MASTER_FRAME_LENGTH		MASTER_WS_ PULSE_MODE	MASTER_BCK_ INVERT	MASTER_WS_ INVERT	MASTER_MODE_ _ENABLE	
0x09	9	I2S/TDM MASTER CLK CONFIG	SELECT_I2S_ TDM_HALF	SELECT_I2S_TDM_NUM							
0x0A	10	TDM CONFIG1	TDM_BIT_DELAY					TDM_VALID_ EDGE	TDM_LJ	ENABLE_TDM_ CLK	
0x0B	11	TDM CONFIG2	TDM_GPIO456	TDM_CASCADE	TDM_LENGTH	TDM_CH_NUM					
0x0C	12	TDM SLOT CONFIG CH1	RESERVED	TDM_LINE_SEL_CH1		TDM_SLOT_SEL_CH1					
0x0D	13	TDM SLOT CONFIG CH2	RESERVED	TDM_LINE_SEL_CH2		TDM_SLOT_SEL_CH2					
0x0E-0x11	14-17	RESERVED	RESERVED								
0x12	18	PCM DATA OUTPUT MAPPING	RESERVED				OUTPUT_MAPPING_CH2		OUTPUT_MAPPING_CH1		
0x13	19	DSD DATA OUTPUT MAPPING	RESERVED				DSD_MAPPING_CH2		DSD_MAPPING_CH1		
0x14	20	TPDF DITHER LEVEL	RESERVED			DITHER_SCALE					
0x15	21	DITHER MASK	DITHER_MASK								
0x16	22		DITHER_MASK								
0x17	23	FS GEN PHASE CONTROL	DSD_SYNC_TO_1FS	FS_PHASE							
0x18-0x1A	24-26	RESERVED	RESERVED								
0x1B	27	INTERRUPT	RESERVED		INTERRUPT_ CLEAR_CH2_ PEAK_DETECT	INTERRUPT_ CLEAR_CH1_ PEAK_DETECT	RESERVED		INTERRUPT_ MASK_CH2_ PEAK_DETECT	INTERRUPT_ MASK_CH1_ PEAK_DETECT	
0x1C	28	SPDIF SUBCODE CONFIG	SPDIF_CS								
0x1D	29		SPDIF_CS								
0x1E	30		SPDIF_CS								
0x1F	31		SPDIF_CS								
0x20	32		SPDIF_CS								
0x21	33	DSD DITHER SCALE & SYNC CONTROL	SYNC_ POSEDGE_ FRAME	DISABLE_SYNC_ REF	FORCE_FIR_ SYNC	DSD_DITHER_SCALE					
0x22	34	SYNC CONTROL	AUTO_ADC_ CLKDIV_SYNC	AUTO_CLK_ IADC_PHASE_ SYNC	AUTO_DSD_ PHASE_SYNC	AUTO_WS_ PHASE_SYNC	AUTO_ICG_EN_ SYNC	AUTO_ICG_ SYNC	AUTO_FIR_ SYNC	AUTO_FS_ SYNC	
0x23	35	ASP1 CONFIG	RESERVED		SELECT_ASP1_NUM					ENABLE_ASP1_ CLK	
0x24	36	ASP2 CONFIG	RESERVED		SELECT_ASP2_NUM					ENABLE_ASP2_ CLK	
0x25	37	ASP ENABLE & PROGRAM CONTROL	ASP2_COEFF_ WE	ASP1_COEFF_ WE	ASP2_ PROGRAM_WE	ASP1_ PROGRAM_WE	ASP2_ PROGRAM_EN	ASP1_ PROGRAM_EN	ENABLE_ASP2	ENABLE_ASP1	
0x26	38	ASP PROGRAM ADDR	ASP_PROGRAM_ADDR								
0x27	39		RESERVED								ASP_PROGRAM_ADDR
0x28	40	ASP PROGRAM	ASP_PROGRAM_IN								
0x29	41		RESERVED	ASP_PROGRAM_IN							
0x2A	42	ASP COEFF ADDR	RESERVED		ASP_COEFF_ADDR						
0x2B	43	ASP COEFF	ASP_COEFF_LSB								
0x2C	44		ASP_COEFF_LSB								
0x2D	45		ASP_COEFF_LSB								
0x2E	46		ASP_COEFF_LSB								
0x2F	47		ASP_COEFF_MSB								
0x30	48		ASP_COEFF_MSB								
0x31	49		ASP_COEFF_MSB								
0x32	50		ASP_COEFF_MSB								
0x33	51		ASP1 CH1 STEP SIZE	RESERVED				ASP1_CH1_STEP_SIZE			
0x34	52		ASP1 CH2 STEP SIZE	RESERVED				ASP1_CH2_STEP_SIZE			
0x35	53	ASP2 CH1 STEP SIZE	RESERVED				ASP2_CH1_STEP_SIZE				
0x36	54	ASP2 CH2 STEP SIZE	RESERVED				ASP2_CH2_STEP_SIZE				
0x37	55	ASP1 CUSTOM ADDR	RESERVED		ASP1_CUSTOM_ADDR						
0x38	56	ASP1 CUSTOM ADDR2	RESERVED		ASP1_CUSTOM_ADDR2						
0x39	57	ASP2 CUSTOM ADDR	RESERVED		ASP2_CUSTOM_ADDR						



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0x3A	58	ASP2_CUSTOM_ADDR2	RESERVED		ASP2_CUSTOM_ADDR2					
0x3B	59		I2S_DECODER_BIT_START							
0x3C	60	I2S DECODER CONFIG	I2S_DECODER_WORD_WIDTH	I2S_DECODER_BIT_DEPTH		I2S_DECODER_POSEDGE_FRAME	ENABLE_I2S_DECODER	I2S_DECODER_BIT_START		
0x3D	61	DELAY LINE CONFIG	PROG_DELAY_LINE							
0x3E	62		RESERVED					ENABLE_CLK_DL	PROG_DELAY_LINE	
0x3F	63	ADC CH1 CONFIG 1	ADC_INT2_SEL_CH1	ADC_INT1_SEL_CH1		ADC_EN_FB_CH1	RESERVED	ADC_EN_INT_CH1	ADC_EN_CH1	
0x40	64	ADC CH1 CONFIG 2	ADC_COMP_SEL_CH1		ADC_SUM_SEL_CH1		ADC_USE_DITHER_EXT_CH1	ADC_USE_DITHER_CH1	ADC_USE_STATE_CH1	
0x41	65	ADC CH2 CONFIG 1	ADC_INT2_SEL_CH2	ADC_INT1_SEL_CH2		ADC_EN_FB_CH2	RESERVED	ADC_EN_INT_CH2	ADC_EN_CH2	
0x42	66	ADC CH2 CONFIG 2	ADC_COMP_SEL_CH2		ADC_SUM_SEL_CH2		ADC_USE_DITHER_EXT_CH2	ADC_USE_DITHER_CH2	ADC_USE_STATE_CH2	
0x43-0x46	67-70	RESERVED	RESERVED							
0x47	71	ADC COMMON MODE CONFIG	RESERVED			ADC_CM_AMP_SEL_CH2	ADC_CM_INT_SEL_CH2	ADC_CM_AMP_SEL_CH1	ADC_CM_INT_SEL_CH1	
0x48-0x49	72-73	RESERVED	RESERVED							
0x4A	74	GPIO1/2 CONFIG	GPIO2_CFG			GPIO1_CFG				
0x4B	75	GPIO3/4 CONFIG	GPIO4_CFG			GPIO3_CFG				
0x4C	76	GPIO5/6 CONFIG	GPIO6_CFG			GPIO5_CFG				
0x4D	77	GPIO7/8 CONFIG	GPIO8_CFG			GPIO7_CFG				
0x4E	78	GPIO9/10 CONFIG	GPIO10_CFG			GPIO9_CFG				
0x4F	79	GPIO11 CONFIG	RESERVED			GPIO11_CFG				
0x50-0x51	80-81	RESERVED	RESERVED							
0x52	82	INVERT GPIO	INVERT_GPIO8	INVERT_GPIO7	INVERT_GPIO6	INVERT_GPIO5	INVERT_GPIO4	INVERT_GPIO3	INVERT_GPIO2	INVERT_GPIO1
0x53	83		RESERVED					INVERT_GPIO11	INVERT_GPIO10	INVERT_GPIO9
0x54	84	GPIO WEAK ENABLE	GPIO8_WK_EN	GPIO7_WK_EN	GPIO6_WK_EN	GPIO5_WK_EN	GPIO4_WK_EN	GPIO3_WK_EN	GPIO2_WK_EN	GPIO1_WK_EN
0x55	85		RESERVED					GPIO11_WK_EN	GPIO10_WK_EN	GPIO9_WK_EN
0x56	86	GPIO IE	GPIO8_IE	GPIO7_IE	GPIO6_IE	GPIO5_IE	GPIO4_IE	GPIO3_IE	GPIO2_IE	GPIO1_IE
0x57	87		RESERVED					GPIO11_IE	GPIO10_IE	GPIO9_IE
0x58	88	GPIO OE	GPIO8_OE	GPIO7_OE	GPIO6_OE	GPIO5_OE	GPIO4_OE	GPIO3_OE	GPIO2_OE	GPIO1_OE
0x59	89		RESERVED					GPIO11_OE	GPIO10_OE	GPIO9_OE
0x5A	90	GPIO READ	GPIO8_READ	GPIO7_READ	GPIO6_READ	GPIO5_READ	GPIO4_READ	GPIO3_READ	GPIO2_READ	GPIO1_READ
0x5B	91		RESERVED					GPIO11_READ	GPIO10_READ	GPIO9_READ
0x5C	92	PWM1 COUNT	PWM1_COUNT							
0x5D	93	PWM1 FREQUENCY	PWM1_FREQ							
0x5E	94		PWM1_FREQ							
0x5F	95	PWM2 COUNT	PWM2_COUNT							
0x60	96	PWM2 FREQUENCY	PWM2_FREQ							
0x61	97		PWM2_FREQ							
0x62	98	PWM3 COUNT	PWM3_COUNT							
0x63	99	PWM3 FREQUENCY	PWM3_FREQ							
0x64	100		PWM3_FREQ							
0x65	101	ADC CH1 DATAPATH CONTROL	ADC1_BYPASS_FIR2X	ADC1_BYPASS_FIR4X	RESERVED		ADC1_ENABLE_DC_BLOCKING	RESERVED	ADC1_NEG_SEL	
0x66	102	ADC CH1 THD COMP CONFIG	ADC1_CORRECTION_ADDR					ADC1_CORRECTION_WE	ADC1_ENABLE_THD_COMP	
0x67	103	ADC CH1 THD COMP DATA	ADC1_CORRECTION_DATA							
0x68	104		ADC1_CORRECTION_DATA							
0x69	105	ADC CH1 PEAK DETECTOR CONFIG	ADC1_LOCK_PEAK	ADC1_PEAK_DECAY_RATE				RESERVED	ADC1_ENABLE_PEAK_DETECT	
0x6A	106	ADC CH1 PEAK DETECTOR LEVEL	ADC1_PEAK_THRESH							
0x6B	107	ADC CH1 DC OFFSET	ADC1_DC_OFFSET							
0x6C	108		ADC1_DC_OFFSET							
0x6D	109	ADC CH1 VOLUME	ADC1_VOLUME							
0x6E	110		ADC1_VOLUME							
0x6F	111	ADC CH1 VOLUME RATE	ADC1_VOLUME_RATE							
0x70	112	ADC CH1 GAIN	RESERVED					ADC1_DATA_GAIN		
0x71	113	ADC CH1 PROG FILTER	RESERVED		ADC1_FILTER_SHAPE			RESERVED		
0x72-0x75	114-117	RESERVED	RESERVED							
0x76	118	ADC CH2 DATAPATH CONTROL	ADC2_BYPASS_FIR2X	ADC2_BYPASS_FIR4X	RESERVED		ADC2_ENABLE_DC_BLOCKING	RESERVED	ADC2_NEG_SEL	
0x77	119	ADC CH2 THD COMP CONFIG	ADC2_CORRECTION_ADDR					ADC2_CORRECTION_WE	ADC2_ENABLE_THD_COMP	
0x78	120	ADC CH2 THD COMP DATA	ADC2_CORRECTION_DATA							
0x79	121		ADC2_CORRECTION_DATA							
0x7A	122	ADC CH2 PEAK DETECTOR CONFIG	ADC2_LOCK_PEAK	ADC2_PEAK_DECAY_RATE				RESERVED	ADC2_ENABLE_PEAK_DETECT	
0x7B	123	ADC CH2 PEAK DETECTOR LEVEL	ADC2_PEAK_THRESH							
0x7C	124	ADC CH2 DC OFFSET	ADC2_DC_OFFSET							



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0x7D	125		ADC2_DC_OFFSET							
0x7E	126	ADC CH2 VOLUME	ADC2_VOLUME							
0x7F	127		ADC2_VOLUME							
0x80	128	ADC CH2 VOLUME RATE	ADC2_VOLUME_RATE							
0x81	129	ADC CH2 GAIN	RESERVED						ADC2_DATA_GAIN	
0x82	130	ADC CH2 PROG FILTER	RESERVED			ADC2_FILTER_SHAPE			RESERVED	
0x83- 0x98	131- 152	RESERVED	RESERVED							
0xC0	192	SOFT RESET	AO_SOFT_RESET	RESERVED						
0xC1	193	CLK SELECT	RESERVED					SEL_SYSCLK_IN		EN_ANA_CLKIN
0xC2	194	ADC CLOCK DIVIDE	RESERVED						SEL_CLK_DIV	
0xC3- 0xCB	195- 205	RESERVED	RESERVED							
0xE0	224	READ SYSTEM REGISTER 0	RESERVED				MODE	ADDR2	ADDR1	RESERVED
0xE1	225	CHIP ID	CHIP_ID							
0xE2- 0xE4	226- 228	RESERVED	RESERVED							
0xE5	229	PEAK FLAG	RESERVED						PEAK_FLAG_C H2	PEAK_FLAG_C H1
0xE6	230	RESERVED	RESERVED							
0xE7	231	READ SYSTEM REGISTER 5	ASP2_INIT_DONE	ASP1_INIT_DONE	RESERVED	TDM_VALID	RESERVED			
0xE8	232	GPIO READBACK REGISTERS	GPIO8_READBACK	GPIO7_READBACK	GPIO6_READBACK	GPIO5_READBACK	GPIO4_READBACK	GPIO3_READBACK	GPIO2_READBACK	GPIO1_READBACK
0xE9	233		RESERVED					GPIO11_READBACK	GPIO10_READBACK	GPIO9_READBACK
0xEA- 0xEC	234- 236	RESERVED	RESERVED							
0xED	237	ADC CH1 PEAK	ADC1_PEAK							
0xEE	238		ADC1_PEAK							
0xEF- 0xF1	239- 241	RESERVED	RESERVED							
0xF2	242	ADC CH2 PEAK	ADC2_PEAK							
0xF3	243		ADC2_PEAK							

Table 33 - Register Map

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Register Listing

System Registers

Register 0: SYS CONFIG

Bits	[7]	[6:5]	[4]	[3]	[2]	[1]	[0]
Default	1'b0	2'b00	1'b0	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7]	SOFT_RESET	Performs soft reset to the digital core. 1'b0: Normal operation 1'b1: Reset digital core
[6:5]	OUTPUT_SEL	Selects output data format. 2'd0: I2S output (default) 2'd1: S/PDIF output 2'd2: TDM output 2'd3: DSD output
[4]	RESERVED	N/A
[3]	ENABLE_64FS_MODE	Enables 64FS mode for 768k sample rate. 1'b0: 64FS mode disabled (default) 1'b1: 64FS mode enabled
[2]	RESERVED	N/A
[1]	MONO_MODE	Enables mono mode. Both channels data are mixed into Ch1. For Ch1, mono mode has higher priority than two channel mode. Note: All Channels require an input for Mono mode to function 1'b0: Mono mode disabled (default) 1'b1: Mono mode enabled
[0]	RESERVED	N/A



Register 1: ADC CLOCK CONFIG1

Bits	[7:6]	[5]	[4]	[3:2]	[1]	[0]
Default	2'b00	1'b0	1'b0	2'b00	1'b0	1'b0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5]	ENABLE_DATA_IN_CH2	Enables Ch2 data input clock (before decimation path) for data mixing. 1'b0: Clock disabled (default) 1'b1: Clock enabled
[4]	ENABLE_DATA_IN_CH1	Enables Ch1 data input clock (before decimation path) for data mixing. 1'b0: Clock disabled (default) 1'b1: Clock enabled
[3:2]	RESERVED	N/A
[1]	ENABLE_ADC_CH2	Enables ADC Ch2 decimation path clock. 1'b0: Clock disabled (default) 1'b1: Clock enabled
[0]	ENABLE_ADC_CH1	Enables ADC Ch1 decimation path clock. 1'b0: Clock disabled (default) 1'b1: Clock enabled

Register 2: ADC CLOCK CONFIG2

Bits	[7:6]	[5]	[4:0]
Default	2'b00	1'b0	5'd3

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5]	SELECT_ADC_HALF	1'b0: Divide by SELECT_ADC_NUM + 1 (default) 1'b1: Divide by half of SELECT_ADC_NUM + 1 Note: Can only produce half of an odd number divide
[4:0]	SELECT_ADC_NUM	Whole number divide value + 1 for CLK_ADC (SYS_CLK/divide_value). 5'd0: Whole number divide value + 1 = 1 5'd1: Whole number divide value + 1 = 2 5'd31: Whole number divide value + 1 = 32

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Register 3: ADC CLOCK CONFIG3

Bits	[7:6]	[5]	[4]	[3]	[2:0]
Default	2'd0	1'b0	1'b0	1'b0	3'd0

Bits	Mnemonic	Description
[7:6]	OUTPUT2_SEL	Selects DATA2 output (GPIO4) when FORCE_OUTPUT2 is set. 2'd0: I2S output (default) 2'd1: S/PDIF output 2'd2: TDM output 2'd3: DSD output
[5]	FORCE_OUTPUT2	Forces DATA2 output (GPIO4) to output from a different source, controlled by OUTPUT2_SEL. 1'b0: Use OUTPUT_SEL (default) 1'b1: Use OUTPUT2_SEL
[4]	INVERT_FIRST_CLK_SAMPLE2	Firstly, use neg edge of CLK_SAMPLE2 to sample adc_data_r1. Only used when different CLK_SAMPLE1 edges are used for the 2ch to ensure phase alignment. 1'b0: Use pos edge of CLK_SAMPLE2 to sample adc_data_r1 (default) 1'b1: Use neg edge of CLK_SAMPLE2 to sample adc_data_r1
[3]	SELECT_IADC_HALF	1'b0: Divide by SELECT_IADC_NUM + 1 (default) 1'b1: Divide by half of SELECT_IADC_NUM + 1 Note: Can only produce half of an odd number divide
[2:0]	SELECT_IADC_NUM	Whole number divide value + 1 for CLK_IADC (SYS_CLK/divide_value). 3'd0: Whole number divide value + 1 = 1 (default) 3'd1: Whole number divide value + 1 = 2 3'd7: Whole number divide value + 1 = 8



Register 4: ADC CLOCK CONFIG4

Bits	[7]	[6:4]	[3:2]	[1]	[0]
Default	1'b0	3'd0	2'd0	1'b0	1'b0

Bits	Mnemonic	Description
[7]	FORCE_PHASE_CLK_IADC	Sets phase of CLK_IADC by PHASE_CLK_IADC. 1'b0: Auto phase tuning if AUTO_CLK_IADC_PHASE_SYNC is set (default) 1'b1: Sets phase by PHASE_CLK_IADC
[6:4]	PHASE_CLK_IADC	Sets phase of CLK_IADC relative to SYS_CLK when FORCE_PHASE_CLK_IADC is set. For 48M SYS_CLK and 24M CLK_IADC only. 3'd0: Phase 0 (default) 3'd1: Phase 1 - Others: Reserved
[3:2]	RESERVED	N/A
[1]	INVERT_SAMPLE_CLOCK_CH2	Inverts ADC Ch2 data sampling clock. 1'b0: Not inverted (default) 1'b1: Inverted
[0]	INVERT_SAMPLE_CLOCK_CH1	Inverts ADC Ch1 data sampling clock. 1'b0: Not inverted (default) 1'b1: Inverted

Register 5: SPDIF CONFIG

Bits	[7:3]	[2]	[1:0]
Default	5'b00000	1'b0	2'd0

Bits	Mnemonic	Description
[7:3]	RESERVED	N/A
[2]	ENABLE_SPDIF_CLK	Enables S/PDIF encoding clock. 1'b0: S/PDIF clock disabled (default) 1'b1: S/PDIF clock enabled
[1:0]	RESERVED	N/A



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Register 6: DSD CONFIG

Bits	[7:6]	[5]	[4]	[3:2]	[1]	[0]
Default	2'b00	1'b0	1'b0	2'd0	1'b0	1'b0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5]	DSD_DDR	Enables DSD double-data-rate (DDR) output. In the DDR mode, DSD data is valid on both pos/neg edges of DSD clock. Otherwise, DSD data is valid only on positive edge of DSD clock.
[4]	DSD_MASTER_MODE	Enables DSD master mode and generates DSD clock. 1'b0: Disabled (default) 1'b1: Enabled
[3:2]	RESERVED	N/A
[1]	ENABLE_DSD_CLK_CH2	Enables Ch2 DSD encoding clock. 1'b0: DSD clock disabled (default) 1'b1: DSD clock enabled
[0]	ENABLE_DSD_CLK_CH1	Enables Ch1 DSD encoding clock. 1'b0: DSD clock disabled (default) 1'b1: DSD clock enabled



Register 7: DSD AND I2S/TDM MASTER CLK CONFIG

Bits	[7:5]	[4]	[3:0]
Default	3'd0	1'b0	4'd0

Bits	Mnemonic	Description
[7:5]	MASTER_WS_SCALE	In I2S/TDM master mode, tunes master BCK/WS ratio by scaling master WS. It allows more TDM slots in a fixed frame. 3'd0: No scale (default) 3'd1: Scale down WS by 2 3'd2: Scale down WS by 4 3'd3: Scale down WS by 8 3'd4: Scale down WS by 16 - others: Reserved
[4]	DSD_CLK_DIV2	Further divides the DSD clock by 2 (after divided by SELECT_DSD_NUM+1) to create a 50% duty cycle DSD clock. 1'b0: No divide (default) 1'b1: Further divides the DSD clock by 2
[3:0]	SELECT_DSD_NUM	Whole number divide value + 1 for DSD clock (SYS_CLK/divide_value). When SELECT_DSD_NUM is larger than 0, the divided clock is not a 50% duty cycle clock. 4'd0: Whole number divide value + 1 = 1 (default) 4'd1: Whole number divide value + 1 = 2 4'd15: Whole number divide value + 1 = 16

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Register 8: I2S/TDM MASTER MODE CONFIG

Bits	[7]	[6]	[5:4]	[3]	[2]	[1]	[0]
Default	1'b0	1'b0	2'd0	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7]	MASTER_BCK_DIV1	When enabled, master BCK is I2S/TDM master encoding clock. Otherwise, BCK is less than or equal to (I2S/TDM master encoding clock)/2 (unless ENABLE_64FS_MODE is set). 1'b0: BCK is not I2S/TDM master encoding clock (default) 1'b1: BCK is I2S/TDM master encoding clock
[6]	MASTER_WS_IDLE	Sets the value of master WS when WS is idle. 1'b0: WS is 0 when idle (default) 1'b1: WS is 1 when idle
[5:4]	MASTER_FRAME_LENGTH	Selects the bit length in each I2S/TDM channel in master mode. 2'd0: 32 bit (default) 2'd2: 16 bit - others: Reserved
[3]	MASTER_WS_PULSE_MODE	When enabled, master WS is a pulse signal instead of a 50% duty cycle signal. The pulse width is 1 BCK cycle. 1'b0: 50% duty cycle WS signal (default) 1'b1: Pulse WS signal
[2]	MASTER_BCK_INVERT	Inverts master BCK. 1'b0: Non-inverted (default) 1'b1: Inverted
[1]	MASTER_WS_INVERT	Inverts master WS. 1'b0: Non-inverted (default) 1'b1: Inverted
[0]	MASTER_MODE_ENABLE	Enables I2S/TDM master mode and generates master BCK and master WS. 1'b0: Disabled (default) 1'b1: Enabled



Register 9: I2S/TDM MASTER CLK CONFIG

Bits	[7]	[6:0]
Default	1'b0	7'd3

Bits	Mnemonic	Description
[7]	SELECT_I2S_TDM_HALF	1'b0: Divide by SELECT_I2S_TDM_NUM + 1 (default) 1'b1: Divide by half of SELECT_I2S_TDM_NUM + 1 Note: Can only produce half of an odd number divide
[6:0]	SELECT_I2S_TDM_NUM	Whole number divide value + 1 for I2S/TDM master encoding clock (SYS_CLK/divide_value). 7'd0: Whole number divide value + 1 = 1 (default) 7'd1: Whole number divide value + 1 = 2 7'd127: Whole number divide value + 1 = 128

Register 10: TDM CONFIG1

Bits	[7:3]	[2]	[1]	[0]
Default	5'd0	1'b1	1'b0	1'b1

Bits	Mnemonic	Description
[7:3]	TDM_BIT_DELAY	Indicates the MSB-2 position of the data from the frame start. Valid from 5'd0 to 5'd31.
[2]	TDM_VALID_EDGE	Sets on which WS edge the frame starts. 1'b0: Frame starts on posedge of WS 1'b1: Frame starts on negedge of WS (default)
[1]	TDM_LJ	Sets left-justified mode. 1'b0: No left-justified (default) 1'b1: Left-justified
[0]	ENABLE_TDM_CLK	Enables I2S/TDM encoding clock. 1'b0: I2S/TDM clock disabled 1'b1: I2S/TDM clock enabled (default)

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Register 11: TDM CONFIG2

Bits	[7]	[6]	[5]	[4:0]
Default	1'b0	1'b0	1'b0	5'd1

Bits	Mnemonic	Description
[7]	TDM_GPIO456	Allows GPIO 4,5,6 to output TDM ADC data Allows GPIO 4,5,6 to output TDM ADC data 1'b0: Disabled (default), TDM data uses GPIO3 1'b1: Enabled, allows TDM data on GPIO3-6
[6]	TDM_CASCADE	Enables TDM cascade mode. In TDM cascade mode, GPIO4 is used as the cascade data input. 1'b0: Disabled (default) 1'b1: Enabled
[5]	TDM_LENGTH	Sets data length in each channel. 1'b0: 32 bits (default) 1'b1: 16 bits
[4:0]	TDM_CH_NUM	Sets number of channels in each frame. 5'd0: 1 channel 5'd1: 2 channels (default) 5'd31: 32 channels

Register 12: TDM SLOT CONFIG CH1

Bits	[7]	[6:5]	[4:0]
Default	1'b0	2'd0	5'd0

Bits	Mnemonic	Description
[7]	RESERVED	N/A
[6:5]	TDM_LINE_SEL_CH1	Selects ADC Ch1 data is presented on which TDM data line. 2'd0: TDM data line 1 - GPIO3 (default) 2'd1: TDM data line 2 - GPIO4 2'd2: TDM data line 3 - GPIO5 2'd3: TDM data line 4 - GPIO6
[4:0]	TDM_SLOT_SEL_CH1	Selects which TDM channel slot is filled by ADC Ch1 data. 5'd0: Slot 1 (default) 5'd1: Slot 2 5'd31: Slot 32



Register 13: TDM SLOT CONFIG CH2

Bits	[7]	[6:5]	[4:0]
Default	1'b0	2'd0	5'd1

Bits	Mnemonic	Description
[7]	RESERVED	N/A
[6:5]	TDM_LINE_SEL_CH2	Selects ADC Ch2 data is presented on which TDM data line. 2'd0: TDM data line 1 - GPIO3 (default) 2'd1: TDM data line 2 - GPIO4 2'd2: TDM data line 3 - GPIO5 2'd3: TDM data line 4 - GPIO6
[4:0]	TDM_SLOT_SEL_CH2	Selects which TDM channel slot is filled by ADC Ch2 data. 5'd0: Slot 1 5'd1: Slot 2 (default) 5'd31: Slot 32

Register 17-14: RESERVED

Register 18: PCM DATA OUTPUT MAPPING

Bits	[7:4]	[3:2]	[1:0]
Default	4'd5	2'd1	2'd0

Bits	Mnemonic	Description
[7:4]	RESERVED	N/A
[3:2]	OUTPUT_MAPPING_CH2	Re-maps Ch2 PCM data output from either Ch1 or Ch2 ADC decimation paths or ASP outputs (when ASP is enabled). 2'd0: Ch2 PCM data output is from ADC decimation path Ch1 or ASP output Ch1 2'd1: Ch2 PCM data output is from ADC decimation path Ch2 or ASP output Ch2 (default) - Others: Reserved
[1:0]	OUTPUT_MAPPING_CH1	Re-maps Ch1 PCM data output from either Ch1 or Ch2 ADC decimation paths or ASP outputs (when ASP is enabled). 2'd0: Ch1 PCM data output is from ADC decimation path Ch1 or ASP output Ch1 (default) 2'd1: Ch1 PCM data output is from ADC decimation path Ch2 or ASP output Ch2 - Others: Reserved



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Register 19: DSD DATA OUTPUT MAPPING

Bits	[7:4]	[3:2]	[1:0]
Default	4'd5	2'd1	2'd0

Bits	Mnemonic	Description
[7:4]	RESERVED	N/A
[3:2]	DSD_MAPPING_CH2	Re-maps Ch2 DSD data output from either Ch1 or Ch2 the ADC decimation paths. 2'd0: Ch2 DSD data output is from ADC decimation path Ch1 2'd1: Ch2 DSD data output is from ADC decimation path Ch2 (default) - Others: Reserved
[1:0]	DSD_MAPPING_CH1	Re-maps Ch1 DSD data output from either Ch1 or Ch2 of the ADC decimation paths. 2'd0: Ch1 DSD data output is from ADC decimation path Ch1 (default) 2'd1: Ch1 DSD data output is from ADC decimation path Ch2 - Others: Reserved



Register 20: TPDF DITHER LEVEL

Bits	[7:5]	[4:0]
Default	3'd0	5'd16

Bits	Mnemonic	Description
[7:5]	RESERVED	N/A
[4:0]	DITHER_SCALE	TPDF dither level: • 5'd0: 16 bits • 5'd1: 17 bits • 5'd2: 18 bits • 5'd3: 19 bits • 5'd4: 20 bits • 5'd5: 21 bits • 5'd6: 22 bits • 5'd7: 23 bits • 5'd8: 24 bits • 5'd9: 25 bits • 5'd10: 26 bits • 5'd11: 27 bits • 5'd12: 28 bits • 5'd13: 29 bits • 5'd14: 30 bits • 5'd15: 31 bits • 5'd16: 32 bits (TPDF dither disabled) (default) • Others: Reserved

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Register 22-21: DITHER MASK

Bits	[15:0]
Default	16'hFFFF

Bits	Mnemonic	Description
[15:0]	DITHER_MASK	Mask off the LSB's of PCM data output. • 16'h0000: Quantized to 16 bits • 16'h8000: Quantized to 17 bits • 16'hC000: Quantized to 18 bits • 16'hE000: Quantized to 19 bits • 16'hF000: Quantized to 20 bits • 16'hF800: Quantized to 21 bits • 16'hFC00: Quantized to 22 bits • 16'hFE00: Quantized to 23 bits • 16'hFF00: Quantized to 24 bits • 16'hFF80: Quantized to 25 bits • 16'hFFC0: Quantized to 26 bits • 16'hFFE0: Quantized to 27 bits • 16'hFFF0: Quantized to 28 bits • 16'hFFF8: Quantized to 29 bits • 16'hFFFC: Quantized to 30 bits • 16'hFFFE: Quantized to 31 bits • 16'hFFFF: Quantized to 32 bits (default) • Others: Reserved



Register 23: FS GEN PHASE CONTROL

Bits	[7]	[6:0]
Default	1'b0	7'd4

Bits	Mnemonic	Description
[7]	DSD_SYNC_TO_1FS	In DSD mode, when enabled, DSD logic is sync to an 1FS signal input from GPIO2. When not enabled, DSD logic is sync to DSD clock input from GPIO1. 1'b0: DSD logic is sync to DSD clock input from GPIO1 (default) 1'b1: DSD logic is sync to 1FS signal input from GPIO2
[6:0]	FS_PHASE	Controls phase of the generated FS signals. Valid from 7'd0 to 7'd127 Note: Should be set to 7'd10 for phase alignment of all sample rates and serial modes

Register 26-24: RESERVED

Register 27: INTERRUPT

Bits	[7:6]	[5]	[4]	[3:2]	[1]	[0]
Default	2'b00	1'b0	1'b0	2'b00	1'b0	1'b0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5]	INTERRUPT_CLEAR_CH2_PEAK_DETECT	Clears the peak detector interrupt of ADC Ch2. 1'b0: Interrupt held if asserted and not masked (default) 1'b1: Interrupt cleared
[4]	INTERRUPT_CLEAR_CH1_PEAK_DETECT	Clears the peak detector interrupt of ADC Ch1. 1'b0: Interrupt held if asserted and not masked (default) 1'b1: Interrupt cleared
[3:2]	RESERVED	N/A
[1]	INTERRUPT_MASK_CH2_PEAK_DETECT	Masks the peak detector interrupt of ADC Ch2. 1'b0: Interrupt masked (default) 1'b1: Interrupt held if asserted
[0]	INTERRUPT_MASK_CH1_PEAK_DETECT	Masks the peak detector interrupt of ADC Ch1. 1'b0: Interrupt masked (default) 1'b1: Interrupt held if asserted

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Register 32-28: SPDIF SUBCODE CONFIG

Bits	[39:0]
Default	40'd0

Bits	Mnemonic	Description
[39:0]	SPDIF_CS	Configures SPDIF sub-code bits.

Register 33: DSD DITHER SCALE & SYNC CONTROL

Bits	[7]	[6]	[5]	[4:0]
Default	1'b0	1'b0	1'b0	5'd21

Bits	Mnemonic	Description
[7]	SYNC_POSEDGE_FRAME	Selects the logic is sync to which edge of the sync reference signal. 1'b0: Sync to negative edge of the sync reference (default) 1'b1: Sync to positive edge of the sync reference
[6]	DISABLE_SYNC_REF	Disables the sync reference. 1'b0: Sync reference enabled (default) 1'b1: Sync reference disabled
[5]	FORCE_FIR_SYNC	Forces FIR to re-sync to the reference. 1'b0: No force (default) 1'b1: Forces FIR to re-sync
[4:0]	DSD_DITHER_SCALE	DSD noise shaped dither scale.



Register 34: SYNC CONTROL

Bits	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Default	1'b0	1'b0	1'b0	1'b1	1'b1	1'b1	1'b1	1'b1

Bits	Mnemonic	Description
[7]	AUTO_ADC_CLKDIV_SYNC	When enabled, the analog ADC clock divider is only allowed to change synchronously to the reference. 1'b0: Auto sync disabled (default) 1'b1: Auto sync enabled
[6]	AUTO_CLK_IADC_PHASE_SYNC	Allows phase of CLK_IADC to be tuned automatically according to ADC input data. Only used when SYS_CLK is faster than CLK_IADC. 1'b0: CLK_IADC phase tuning disabled (default) 1'b1: Auto CLK_IADC phase tuning
[5]	AUTO_DSD_PHASE_SYNC	Uses DSD clock input from GPIO1 as the sync reference, unless DSD_SYNC_TO_1FS is set. 1'b0: DSD clock is not the sync reference (default) 1'b1: DSD clock is the sync reference, unless DSD_SYNC_TO_1FS is set
[4]	AUTO_WS_PHASE_SYNC	Uses WS input from GPIO2 as the sync reference, if AUTO_DSD_PHASE_SYNC is not set. 1'b0: WS is not the sync reference 1'b1: WS is the sync reference, if AUTO_DSD_PHASE_SYNC is not set (default)
[3]	AUTO_ICG_EN_SYNC	When enabled, the clock dividers and ADC enables are only allowed to change synchronously to the reference. 1'b0: Auto sync disabled 1'b1: Auto sync enabled (default)
[2]	AUTO_ICG_SYNC	Allows programmable clock dividers to auto sync to the reference. 1'b0: Auto sync disabled 1'b1: Auto sync enabled (default)
[1]	AUTO_FIR_SYNC	Allows FIR to auto sync to the reference. 1'b0: Auto sync disabled 1'b1: Auto sync enabled (default)
[0]	AUTO_FS_SYNC	Allows FS signals to auto sync to the reference. 1'b0: Auto sync disabled 1'b1: Auto sync enabled (default)

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ASP Registers

Register 35: ASP1 CONFIG

Bits	[7:6]	[5:1]	[0]
Default	2'b00	5'd0	1'b0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5:1]	SELECT_ASP1_NUM	Whole number divide value + 1 for ASP1 clock (SYS_CLK/divide_value). 5'd0: Whole number divide value + 1 = 1 (default) 5'd1: Whole number divide value + 1 = 2 5'd31: Whole number divide value + 1 = 32
[0]	ENABLE_ASP1_CLK	Enables ASP1 clock. 1'b0: Disabled (default) 1'b1: Enabled

Register 36: ASP2 CONFIG

Bits	[7:6]	[5:1]	[0]
Default	2'b00	5'd0	1'b0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5:1]	SELECT_ASP2_NUM	Whole number divide value + 1 for ASP2 clock (SYS_CLK/divide_value). 5'd0: Whole number divide value + 1 = 1 (default) 5'd1: Whole number divide value + 1 = 2 5'd31: Whole number divide value + 1 = 32
[0]	ENABLE_ASP2_CLK	Enables ASP2 clock. 1'b0: Disabled (default) 1'b1: Enabled



Register 37: ASP ENABLE & PROGRAM CONTROL

Bits	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Default	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7]	ASP2_COEFF_WE	Enables writing to the ASP2 coeff RAM. 1'b0: Writing disabled (default) 1'b1: Writing enabled
[6]	ASP1_COEFF_WE	Enables writing to the ASP1 coeff RAM. 1'b0: Writing disabled (default) 1'b1: Writing enabled
[5]	ASP2_PROGRAM_WE	Enables writing to the ASP2 program memory. 1'b0: Writing disabled (default) 1'b1: Writing enabled
[4]	ASP1_PROGRAM_WE	Enables writing to the ASP1 program memory. 1'b0: Writing disabled (default) 1'b1: Writing enabled
[3]	ASP2_PROGRAM_EN	Enables ASP2 program memory and coeff RAM programming before its output is enabled and used in the signal path. 1'b0: Programming disabled (default) 1'b1: Programming enabled
[2]	ASP1_PROGRAM_EN	Enables ASP1 program memory and coeff RAM programming before its output is enabled and used in the signal path. 1'b0: Programming disabled (default) 1'b1: Programming enabled
[1]	ENABLE_ASP2	Selects whether ASP2 is enabled and used in the signal path or disabled and bypassed. 1'b0: ASP2 is disabled and bypassed (default) 1'b1: ASP2 is enabled. Data is processed by ASP2 before output
[0]	ENABLE_ASP1	Selects whether ASP1 is enabled and used in the signal path or disabled and bypassed. 1'b0: ASP1 is disabled and bypassed (default) 1'b1: ASP1 is enabled. Data is processed by ASP1 before output

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Register 39-38: ASP PROGRAM ADDR

Bits	[15:9]	[8:0]
Default	7'd0	9'd0

Bits	Mnemonic	Description
[15:9]	RESERVED	N/A
[8:0]	ASP_PROGRAM_ADDR	Selects the program address when writing custom program codes for either ASP.

Register 41-40: ASP PROGRAM

Bits	[15:14]	[13:0]
Default	2'd0	14'd0

Bits	Mnemonic	Description
[15:14]	RESERVED	N/A
[13:0]	ASP_PROGRAM_IN	A 14 bits program instruction that will be written to the address of either ASP defined by ASP_PROGRAM_ADDR.

Register 42: ASP COEFF ADDR

Bits	[7:6]	[5:0]
Default	2'd0	6'd0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5:0]	ASP_COEFF_ADDR	Selects the coefficient address when writing custom coefficient for either ASP.

**Register 50-43: ASP COEFF**

Bits	[63:32]	[31:0]
Default	32'd0	32'd0

Bits	Mnemonic	Description
[63:32]	ASP_COEFF_MSB	A 32 bits coefficient that will be written to the address defined by ASP_COEFF_ADDR. These last 32 bits are typically used for the channel 2 data.
[31:0]	ASP_COEFF_LSB	A 32 bits coefficient that will be written to the address defined by ASP_COEFF_ADDR. These first 32 bits are typically used for the channel 1 data.

Register 51: ASP1 CH1 STEP SIZE

Bits	[7:0]
Default	8'd0

Bits	Mnemonic	Description
[7:0]	ASP1_CH1_STEP_SIZE	Programmable value to be used in multiplications for Ch1 within ASP1.

Register 52: ASP1 CH2 STEP SIZE

Bits	[7:0]
Default	8'd0

Bits	Mnemonic	Description
[7:0]	ASP1_CH2_STEP_SIZE	Programmable value to be used in multiplications for Ch2 within ASP1.

Register 53: ASP2 CH1 STEP SIZE

Bits	[7:0]
Default	8'd0

Bits	Mnemonic	Description
[7:0]	ASP2_CH1_STEP_SIZE	Programmable value to be used in multiplications for Ch1 within ASP2.



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Register 54: ASP2 CH2 STEP SIZE

Bits	[7:0]
Default	8'd0

Bits	Mnemonic	Description
[7:0]	ASP2_CH2_STEP_SIZE	Programmable value to be used in multiplications for Ch2 within ASP2.

Register 55: ASP1 CUSTOM ADDR

Bits	[7:6]	[5:0]
Default	2'd0	6'd0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5:0]	ASP1_CUSTOM_ADDR	Custom address that can be accessed through the MOV_RAM1_ADDR instruction in ASP1.

Register 56: ASP1 CUSTOM ADDR2

Bits	[7:6]	[5:0]
Default	2'd0	6'd0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5:0]	ASP1_CUSTOM_ADDR2	Custom address that can be accessed through the MOV_RAM2_ADDR instruction in ASP1.

Register 57: ASP2 CUSTOM ADDR

Bits	[7:6]	[5:0]
Default	2'd0	6'd0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5:0]	ASP2_CUSTOM_ADDR	Custom address that can be accessed through the MOV_RAM1_ADDR instruction in ASP2.



Register 58: ASP2 CUSTOM ADDR2

Bits	[7:6]	[5:0]
Default	2'd0	6'd0

Bits	Mnemonic	Description
[7:6]	RESERVED	N/A
[5:0]	ASP2_CUSTOM_ADDR2	Custom address that can be accessed through the MOV_RAM2_ADDR instruction in ASP2.

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Delay Line Registers

Register 60-59: I2S DECODER CONFIG

Bits	[15:14]	[13:12]	[11]	[10]	[9:0]
Default	2'd0	2'd0	1'b0	1'b0	10'd0

Bits	Mnemonic	Description
[15:14]	I2S_DECODER_WORD_WIDTH	Sets the number of bits in a channel 2'd0: 32 bits (default) 2'd1: 24 bits 2'd2: 16 bits 2'd3: Reserved
[13:12]	I2S_DECODER_BIT_DEPTH	Sets the number of bits of data 2'd0: 24 bits (default) 2'd2: 16 bits - Others: Reserved
[11]	I2S_DECODER_POSEDGE_FRAME	Sets where the frame starts 1'b0: Indicates frame starts on negedge of WS (default) 1'b1: Indicates frame starts on posedge of WS
[10]	ENABLE_I2S_DECODER	Enables I2S decoder. 1'b0: Disabled (default) 1'b1: Enabled
[9:0]	I2S_DECODER_BIT_START	Indicates the MSB-2 position of the data from the frame start. Valid from 10'h000 to 10'h3FF.



Register 62-61: DELAY LINE CONFIG

Bits	[15:10]	[9]	[8:0]
Default	6'b101000	1'b0	9'd0

Bits	Mnemonic	Description
[15:10]	RESERVED	N/A
[9]	ENABLE_CLK_DL	Enables delay line clock and data output. 1'b0: Disabled (default) 1'b1: Enabled
[8:0]	PROG_DELAY_LINE	Sets the length of the delay line. 9'd0: No delay (default) 9'd1: Delay the I2S input data by 1 sample 9'd2: Delay the I2S input data by 2 samples 9'd511: Delay the I2S input data by 511 samples

Register 63: ADC CH1 CONFIG 1

Bits	[7:6]	[5:4]	[3]	[2]	[1]	[0]
Default	2'b00	2'b00	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7:6]	ADC_INT2_SEL_CH1	ADC integrator control for Channel 1 Program to 2'b10 for optimum performance
[5:4]	ADC_INT1_SEL_CH1	ADC integrator control for Channel 1 Program to 2'b11 for optimum performance
[3]	ADC_EN_FB_CH1	Enable ADC1 feedback path. 1'b0: Disabled (default) 1'b1: Enabled
[2]	RESERVED	N/A
[1]	ADC_EN_INT_CH1	Enable for INT for Channel 1. 1'b0: Disabled (default) 1'b1: Enabled
[0]	ADC_EN_CH1	Enable for Comparator and Logic for Channel 1. 1'b0: Disabled (default) 1'b1: Enabled

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Register 64: ADC CH1 CONFIG 2

Bits	[7:5]	[4:3]	[2]	[1]	[0]
Default	3'b000	2'b00	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7:5]	ADC_COMP_SEL_CH1	Sets the gain of the comparator for Channel 1. Program to 3'b001 for optimum performance
[4:3]	ADC_SUM_SEL_CH1	Sets the bandwidth of the summing amplifier for Channel 1. Program to 2'b11 for optimum performance
[2]	ADC_USE_DITHER_EXT_CH1	Enable the external dither for Channel 1. 1'b0: Disabled (default) 1'b1: Enabled
[1]	ADC_USE_DITHER_CH1	Enable the dither for Channel 1. 1'b0: Disabled (default) 1'b1: Enabled
[0]	ADC_USE_STATE_CH1	Use state as logic output for Channel 1. Default value is 0.

Register 65: ADC CH2 CONFIG 1

Bits	[7:6]	[5:4]	[3]	[2]	[1]	[0]
Default	2'b00	2'b00	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7:6]	ADC_INT2_SEL_CH2	ADC integrator control for Channel 2 Program to 2'b10 for optimum performance
[5:4]	ADC_INT1_SEL_CH2	ADC integrator control for Channel 2 Program to 2'b11 for optimum performance
[3]	ADC_EN_FB_CH2	Enable ADC2 feedback path. 1'b0: Disabled (default) 1'b1: Enabled
[2]	RESERVED	N/A
[1]	ADC_EN_INT_CH2	Enable for INT for Channel 2. 1'b0: Disabled (default) 1'b1: Enabled
[0]	ADC_EN_CH2	Enable for Comparator and Logic for Channel 2. 1'b0: Disabled (default) 1'b1: Enabled



Register 66: ADC CH2 CONFIG 2

Bits	[7:5]	[4:3]	[2]	[1]	[0]
Default	3'b000	2'b00	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7:5]	ADC_COMP_SEL_CH2	Sets the gain of the comparator for Channel 2. Program to 3'b001 for optimum performance
[4:3]	ADC_SUM_SEL_CH2	Sets the bandwidth of the summing amplifier for Channel 2. Program to 2'b11 for optimum performance
[2]	ADC_USE_DITHER_EXT_CH2	Enable the external dither for Channel 2. 1'b0: Disabled (default) 1'b1: Enabled
[1]	ADC_USE_DITHER_CH2	Enable the dither for Channel 2. 1'b0: Disabled (default) 1'b1: Enabled
[0]	ADC_USE_STATE_CH2	Use state as logic output for Channel 2. Default value is 0.

Register 70-67: RESERVED

Register 71: ADC COMMON MODE CONFIG

Bits	[7:4]	[3]	[2]	[1]	[0]
Default	4'd0	1'd0	1'd0	1'd0	1'd0

Bits	Mnemonic	Description
[7:4]	RESERVED	N/A
[3]	ADC_CM_AMP_SEL_CH2	Set the common mode voltage of the summing amplifiers for Channel 2. Set to 1'b1 for optimal operation
[2]	ADC_CM_INT_SEL_CH2	Set the common mode voltages of the integrators for Channel 2. Set to 1'b1 for optimal operation
[1]	ADC_CM_AMP_SEL_CH1	Set the common mode voltage of the summing amplifiers for Channel 1. Set to 1'b1 for optimal operation
[0]	ADC_CM_INT_SEL_CH1	Set the common mode voltages of the integrators for Channel 1. Set to 1'b1 for optimal operation

Register 73-72: RESERVED

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GPIO Registers

Register 74: GPIO1/2 CONFIG

Bits	[7:4]	[3:0]
Default	4'd0	4'd0

Bits	Mnemonic	Description
[7:4]	GPIO2_CFG	Configure GPIO2 4'd0: Analog outputs off - shutdown (default) 4'd1: Aux inputs - input 4'd2: Aux outputs - output 4'd3: Reserved 4'd4: Ch1 peak flag interrupt - output 4'd5: Ch2 peak flag interrupt - output 4'd6: Reserved 4'd7: Reserved 4'd8: S/PDIF stream - output 4'd9: PWM1 signal - output 4'd10: PWM2 signal - output 4'd11: PWM3 signal - output 4'd12: CLK_IADC - output 4'd13: CLK_ADC - output 4'd14: Output 0 - output 4'd15: Output 1 - output
[3:0]	GPIO1_CFG	Configure GPIO1 4'd0: Analog outputs off - shutdown (default) 4'd1: Aux inputs - input 4'd2: Aux outputs - output 4'd3: Reserved 4'd4: Ch1 peak flag interrupt - output 4'd5: Ch2 peak flag interrupt - output 4'd6: Reserved 4'd7: Reserved 4'd8: S/PDIF stream - output 4'd9: PWM1 signal - output 4'd10: PWM2 signal - output 4'd11: PWM3 signal - output 4'd12: CLK_IADC - output 4'd13: CLK_ADC - output 4'd14: Output 0 - output 4'd15: Output 1 - output



Register 75: GPIO3/4 CONFIG

Bits	[7:4]	[3:0]
Default	4'd0	4'd0

Bits	Mnemonic	Description
[7:4]	GPIO4_CFG	Configure GPIO4 • 4'd0: Analog outputs off - shutdown (default) • 4'd1: Aux inputs - input • 4'd2: Aux outputs - output • 4'd3: Reserved • 4'd4: Ch1 peak flag interrupt - output • 4'd5: Ch2 peak flag interrupt - output • 4'd6: Reserved • 4'd7: Reserved • 4'd8: S/PDIF stream - output • 4'd9: PWM1 signal - output • 4'd10: PWM2 signal - output • 4'd11: PWM3 signal - output • 4'd12: CLK_IADC - output • 4'd13: CLK_ADC - output • 4'd14: Output 0 - output • 4'd15: Output 1 - output
[3:0]	GPIO3_CFG	Configure GPIO3 • 4'd0: Analog outputs off - shutdown (default) • 4'd1: Aux inputs - input • 4'd2: Aux outputs - output • 4'd3: Reserved • 4'd4: Ch1 peak flag interrupt - output • 4'd5: Ch2 peak flag interrupt - output • 4'd6: Reserved • 4'd7: Reserved • 4'd8: S/PDIF stream - output • 4'd9: PWM1 signal - output • 4'd10: PWM2 signal - output • 4'd11: PWM3 signal - output • 4'd12: CLK_IADC - output • 4'd13: CLK_ADC - output • 4'd14: Output 0 - output • 4'd15: Output 1 - output

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Register 76: GPIO5/6 CONFIG

Bits	[7:4]	[3:0]
Default	4'd0	4'd0

Bits	Mnemonic	Description
[7:4]	GPIO6_CFG	Configure GPIO6 4'd0: Analog outputs off - shutdown (default) 4'd1: Aux inputs - input 4'd2: Aux outputs - output 4'd3: Reserved 4'd4: Ch1 peak flag interrupt - output 4'd5: Ch2 peak flag interrupt - output 4'd6: Reserved 4'd7: Reserved 4'd8: S/PDIF stream - output 4'd9: PWM1 signal - output 4'd10: PWM2 signal - output 4'd11: PWM3 signal - output 4'd12: CLK_IADC - output 4'd13: CLK_ADC - output 4'd14: Output 0 - output 4'd15: Output 1 - output
[3:0]	GPIO5_CFG	Configure GPIO5 4'd0: Analog outputs off - shutdown (default) 4'd1: Aux inputs - input 4'd2: Aux outputs - output 4'd3: Reserved 4'd4: Ch1 peak flag interrupt - output 4'd5: Ch2 peak flag interrupt - output 4'd6: Reserved 4'd7: Reserved 4'd8: S/PDIF stream - output 4'd9: PWM1 signal - output 4'd10: PWM2 signal - output 4'd11: PWM3 signal - output 4'd12: CLK_IADC - output 4'd13: CLK_ADC - output 4'd14: Output 0 - output 4'd15: Output 1 - output



Register 77: GPIO7/8 CONFIG

Bits	[7:4]	[3:0]
Default	4'd0	4'd0

Bits	Mnemonic	Description
[7:4]	GPIO8_CFG	Configure GPIO8 • 4'd0: Analog outputs off - shutdown (default) • 4'd1: Aux inputs - input • 4'd2: Aux outputs - output • 4'd3: Reserved • 4'd4: Ch1 peak flag interrupt - output • 4'd5: Ch2 peak flag interrupt - output • 4'd6: Reserved • 4'd7: Reserved • 4'd8: S/PDIF stream - output • 4'd9: PWM1 signal - output • 4'd10: PWM2 signal - output • 4'd11: PWM3 signal - output • 4'd12: CLK_IADC - output • 4'd13: CLK_ADC - output • 4'd14: Output 0 - output • 4'd15: Output 1 - output
[3:0]	GPIO7_CFG	Configure GPIO7 • 4'd0: Analog outputs off - shutdown (default) • 4'd1: Aux inputs - input • 4'd2: Aux outputs - output • 4'd3: Reserved • 4'd4: Ch1 peak flag interrupt - output • 4'd5: Ch2 peak flag interrupt - output • 4'd6: Reserved • 4'd7: Reserved • 4'd8: S/PDIF stream - output • 4'd9: PWM1 signal - output • 4'd10: PWM2 signal - output • 4'd11: PWM3 signal - output • 4'd12: CLK_IADC - output • 4'd13: CLK_ADC - output • 4'd14: Output 0 - output • 4'd15: Output 1 - output

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Register 78: GPIO9/10 CONFIG

Bits	[7:4]	[3:0]
Default	4'd0	4'd0

Bits	Mnemonic	Description
[7:4]	GPIO10_CFG	Configure GPIO10 4'd0: Analog outputs off - shutdown (default) 4'd1: Aux inputs - input 4'd2: Aux outputs - output 4'd3: Reserved 4'd4: Ch1 peak flag interrupt - output 4'd5: Ch2 peak flag interrupt - output 4'd6: Reserved 4'd7: Reserved 4'd8: S/PDIF stream - output 4'd9: PWM1 signal - output 4'd10: PWM2 signal - output 4'd11: PWM3 signal - output 4'd12: CLK_IADC - output 4'd13: CLK_ADC - output 4'd14: Output 0 - output 4'd15: Output 1 - output
[3:0]	GPIO9_CFG	Configure GPIO9 4'd0: Analog outputs off - shutdown (default) 4'd1: Aux inputs - input 4'd2: Aux outputs - output 4'd3: Reserved 4'd4: Ch1 peak flag interrupt - output 4'd5: Ch2 peak flag interrupt - output 4'd6: Reserved 4'd7: Reserved 4'd8: S/PDIF stream - output 4'd9: PWM1 signal - output 4'd10: PWM2 signal - output 4'd11: PWM3 signal - output 4'd12: CLK_IADC - output 4'd13: CLK_ADC - output 4'd14: Output 0 - output 4'd15: Output 1 - output



Register 79: GPIO11 CONFIG

Bits	[7:4]	[3:0]
Default	4'd0	4'd0

Bits	Mnemonic	Description
[7:4]	RESERVED	N/A
[3:0]	GPIO11_CFG	Configure GPIO11 • 4'd0: Analog outputs off - shutdown (default) • 4'd1: Aux inputs - input • 4'd2: Aux outputs - output • 4'd3: Reserved • 4'd4: Ch1 peak flag interrupt - output • 4'd5: Ch2 peak flag interrupt - output • 4'd6: Reserved • 4'd7: Reserved • 4'd8: S/PDIF stream - output • 4'd9: PWM1 signal - output • 4'd10: PWM2 signal - output • 4'd11: PWM3 signal - output • 4'd12: CLK_IADC - output • 4'd13: CLK_ADC - output • 4'd14: Output 0 - output • 4'd15: Output 1 - output

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Register 81-80: RESERVED

Register 83-82: INVERT GPIO

Bits	[15:11]	[10]	[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Default	5'b00000	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[15:11]	RESERVED	N/A
[10]	INVERT_GPIO11	1'b0: Non-invert (default) 1'b1: Invert GPIO11 output
[9]	INVERT_GPIO10	1'b0: Non-invert (default) 1'b1: Invert GPIO10 output
[8]	INVERT_GPIO9	1'b0: Non-invert (default) 1'b1: Invert GPIO9 output
[7]	INVERT_GPIO8	1'b0: Non-invert (default) 1'b1: Invert GPIO8 output
[6]	INVERT_GPIO7	1'b0: Non-invert (default) 1'b1: Invert GPIO7 output
[5]	INVERT_GPIO6	1'b0: Non-invert (default) 1'b1: Invert GPIO6 output
[4]	INVERT_GPIO5	1'b0: Non-invert (default) 1'b1: Invert GPIO5 output
[3]	INVERT_GPIO4	1'b0: Non-invert (default) 1'b1: Invert GPIO4 output
[2]	INVERT_GPIO3	1'b0: Non-invert (default) 1'b1: Invert GPIO3 output
[1]	INVERT_GPIO2	1'b0: Non-invert (default) 1'b1: Invert GPIO2 output
[0]	INVERT_GPIO1	1'b0: Non-invert (default) 1'b1: Invert GPIO1 output



Register 85-84: GPIO WEAK ENABLE

Bits	[15:11]	[10]	[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Default	5'b00000	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[15:11]	RESERVED	N/A
[10]	GPIO11_WK_EN	1'b0: GPIO11 weak keeper disabled (default) 1'b1: GPIO11 weak keeper enabled
[9]	GPIO10_WK_EN	1'b0: GPIO10 weak keeper disabled (default) 1'b1: GPIO10 weak keeper enabled
[8]	GPIO9_WK_EN	1'b0: GPIO9 weak keeper disabled (default) 1'b1: GPIO9 weak keeper enabled
[7]	GPIO8_WK_EN	1'b0: GPIO8 weak keeper disabled (default) 1'b1: GPIO8 weak keeper enabled
[6]	GPIO7_WK_EN	1'b0: GPIO7 weak keeper disabled (default) 1'b1: GPIO7 weak keeper enabled
[5]	GPIO6_WK_EN	1'b0: GPIO6 weak keeper disabled (default) 1'b1: GPIO6 weak keeper enabled
[4]	GPIO5_WK_EN	1'b0: GPIO5 weak keeper disabled (default) 1'b1: GPIO5 weak keeper enabled
[3]	GPIO4_WK_EN	1'b0: GPIO4 weak keeper disabled (default) 1'b1: GPIO4 weak keeper enabled
[2]	GPIO3_WK_EN	1'b0: GPIO3 weak keeper disabled (default) 1'b1: GPIO3 weak keeper enabled
[1]	GPIO2_WK_EN	1'b0: GPIO2 weak keeper disabled (default) 1'b1: GPIO2 weak keeper enabled
[0]	GPIO1_WK_EN	1'b0: GPIO1 weak keeper disabled (default) 1'b1: GPIO1 weak keeper enabled

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Register 87-86: GPIO IE

Bits	[15:11]	[10]	[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Default	5'b00000	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[15:11]	RESERVED	N/A
[10]	GPIO11_IE	1'b0: GPIO11 input disabled (default) 1'b1: GPIO11 input enabled
[9]	GPIO10_IE	1'b0: GPIO10 input disabled (default) 1'b1: GPIO10 input enabled
[8]	GPIO9_IE	1'b0: GPIO9 input disabled (default) 1'b1: GPIO9 input enabled
[7]	GPIO8_IE	1'b0: GPIO8 input disabled (default) 1'b1: GPIO8 input enabled
[6]	GPIO7_IE	1'b0: GPIO7 input disabled (default) 1'b1: GPIO7 input enabled
[5]	GPIO6_IE	1'b0: GPIO6 input disabled (default) 1'b1: GPIO6 input enabled
[4]	GPIO5_IE	1'b0: GPIO5 input disabled (default) 1'b1: GPIO5 input enabled
[3]	GPIO4_IE	1'b0: GPIO4 input disabled (default) 1'b1: GPIO4 input enabled
[2]	GPIO3_IE	1'b0: GPIO3 input disabled (default) 1'b1: GPIO3 input enabled
[1]	GPIO2_IE	1'b0: GPIO2 input disabled (default) 1'b1: GPIO2 input enabled
[0]	GPIO1_IE	1'b0: GPIO1 input disabled (default) 1'b1: GPIO1 input enabled



Register 89-88: GPIO OE

Bits	[15:11]	[10]	[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Default	5'b00000	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[15:11]	RESERVED	N/A
[10]	GPIO11_OE	1'b0: Tristate GPIO11 output (default) 1'b1: GPIO11 output enabled
[9]	GPIO10_OE	1'b0: Tristate GPIO10 output (default) 1'b1: GPIO10 output enabled
[8]	GPIO9_OE	1'b0: Tristate GPIO9 output (default) 1'b1: GPIO9 output enabled
[7]	GPIO8_OE	1'b0: Tristate GPIO8 output (default) 1'b1: GPIO8 output enabled
[6]	GPIO7_OE	1'b0: Tristate GPIO7 output (default) 1'b1: GPIO7 output enabled
[5]	GPIO6_OE	1'b0: Tristate GPIO6 output (default) 1'b1: GPIO6 output enabled
[4]	GPIO5_OE	1'b0: Tristate GPIO5 output (default) 1'b1: GPIO5 output enabled
[3]	GPIO4_OE	1'b0: Tristate GPIO4 output (default) 1'b1: GPIO4 output enabled
[2]	GPIO3_OE	1'b0: Tristate GPIO3 output (default) 1'b1: GPIO3 output enabled
[1]	GPIO2_OE	1'b0: Tristate GPIO2 output (default) 1'b1: GPIO2 output enabled
[0]	GPIO1_OE	1'b0: Tristate GPIO1 output (default) 1'b1: GPIO1 output enabled

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Register 91-90: GPIO READ

Bits	[15:11]	[10]	[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Default	5'b00000	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[15:11]	RESERVED	N/A
[10]	GPIO11_READ	1'b0: GPIO11 readback disabled (default) 1'b1: Allows readback of GPIO11 input
[9]	GPIO10_READ	1'b0: GPIO10 readback disabled (default) 1'b1: Allows readback of GPIO10 input
[8]	GPIO9_READ	1'b0: GPIO9 readback disabled (default) 1'b1: Allows readback of GPIO9 input
[7]	GPIO8_READ	1'b0: GPIO8 readback disabled (default) 1'b1: Allows readback of GPIO8 input
[6]	GPIO7_READ	1'b0: GPIO7 readback disabled (default) 1'b1: Allows readback of GPIO7 input
[5]	GPIO6_READ	1'b0: GPIO6 readback disabled (default) 1'b1: Allows readback of GPIO6 input
[4]	GPIO5_READ	1'b0: GPIO5 readback disabled (default) 1'b1: Allows readback of GPIO5 input
[3]	GPIO4_READ	1'b0: GPIO4 readback disabled (default) 1'b1: Allows readback of GPIO4 input
[2]	GPIO3_READ	1'b0: GPIO3 readback disabled (default) 1'b1: Allows readback of GPIO3 input
[1]	GPIO2_READ	1'b0: GPIO2 readback disabled (default) 1'b1: Allows readback of GPIO2 input
[0]	GPIO1_READ	1'b0: GPIO1 readback disabled (default) 1'b1: Allows readback of GPIO1 input

Register 92: PWM1 COUNT

Bits	[7:0]
Default	8'h00

Bits	Mnemonic	Description
[7:0]	PWM1_COUNT	8-bit value to set the number of SYS_CLK periods the PWM signal is high for. 8'h00: Disabled (default) 8'h01: Minimum 8'hFF: Maximum



Register 94-93: PWM1 FREQUENCY

Bits	[15:0]
Default	16'h0000

Bits	Mnemonic	Description
[15:0]	PWM1_FREQ	16-bit value to set the frequency of the PWM signal in terms of SYS_CLK divisions. 16'h0000: Disabled (default) 16'h0001: Minimum 16'hFFFF: Maximum $\text{frequency [Hz]} = \frac{\text{SYS_CLK}}{\text{PWM1_FREQ} + 1}$ $\text{Duty Cycle [\%]} = \frac{\text{PWM1_COUNT}}{\text{PWM1_FREQ} + 1} \cdot 100$

Register 95: PWM2 COUNT

Bits	[7:0]
Default	8'h00

Bits	Mnemonic	Description
[7:0]	PWM2_COUNT	8-bit value to set the number of SYS_CLK periods the PWM signal is high for. 8'h00: Disabled (default) 8'h01: Minimum 8'hFF: Maximum

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Register 97-96: PWM2 FREQUENCY

Bits	[15:0]
Default	16'h0000

Bits	Mnemonic	Description
[15:0]	PWM2_FREQ	16-bit value to set the frequency of the PWM signal in terms of SYS_CLK divisions. 16'h0000: Disabled (default) 16'h0001: Minimum 16'hFFFF: Maximum $\text{frequency [Hz]} = \frac{\text{SYS_CLK}}{\text{PWM2_FREQ} + 1}$ $\text{Duty Cycle [\%]} = \frac{\text{PWM2_COUNT}}{\text{PWM2_FREQ} + 1} \cdot 100$

Register 98: PWM3 COUNT

Bits	[7:0]
Default	8'h00

Bits	Mnemonic	Description
[7:0]	PWM3_COUNT	8-bit value to set the number of SYS_CLK periods the PWM signal is high for. 8'h00: Disabled (default) 8'h01: Minimum 8'hFF: Maximum



Register 100-99: PWM3 FREQUENCY

Bits	[15:0]
Default	16'h0000

Bits	Mnemonic	Description
[15:0]	PWM3_FREQ	16-bit value to set the frequency of the PWM signal in terms of SYS_CLK divisions. 16'h0000: Disabled (default) 16'h0001: Minimum 16'hFFFF: Maximum $\text{frequency [Hz]} = \frac{\text{SYS_CLK}}{\text{PWM3_FREQ} + 1}$ $\text{Duty Cycle [\%]} = \frac{\text{PWM3_COUNT}}{\text{PWM3_FREQ} + 1} \cdot 100$

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ADC CH1 Registers

Register 101: ADC CH1 DATAPATH CONTROL

Bits	[7]	[6]	[5:3]	[2]	[1]	[0]
Default	1'b0	1'b0	3'b000	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7]	ADC1_BYPASS_FIR2X	1'b0: Non-bypass (default) 1'b1: Bypass DFir_2x
[6]	ADC1_BYPASS_FIR4X	1'b0: Non-bypass (default) 1'b1: Bypass DFir_4x
[5:3]	RESERVED	N/A
[2]	ADC1_ENABLE_DC_BLOCKING	Enables DC blocking path. 1'b0: Disabled (default) 1'b1: Enabled
[1]	RESERVED	N/A
[0]	ADC1_NEG_SEL	Inverts data input from analog ADC. 1'b0: No inversion (default) 1'b1: Inverts input data

Register 102: ADC CH1 THD COMP CONFIG

Bits	[7:2]	[1]	[0]
Default	6'd0	1'b0	1'b0

Bits	Mnemonic	Description
[7:2]	ADC1_CORRECTION_ADDR	Selects the address when writing the THD compensation RAM.
[1]	ADC1_CORRECTION_WE	Enables writing to the THD compensation RAM. 1'b0: Writing disabled (default) 1'b1: Writing enabled
[0]	ADC1_ENABLE_THD_COMP	Enables the THD compensation on ADC CH1. 1'b0: Disabled and bypassed (default) 1'b1: Enabled



Register 104-103: ADC CH1 THD COMP DATA

Bits	[15:0]
Default	16'h0000

Bits	Mnemonic	Description
[15:0]	ADC1_CORRECTION_DATA	A 16 bits THD corrected value that will be written to the address of the THD compensation RAM. Maximum -42dB (16'hFFFF).

Register 105: ADC CH1 PEAK DETECTOR CONFIG

Bits	[7]	[6:2]	[1]	[0]
Default	1'b0	5'd10	1'b0	1'b0

Bits	Mnemonic	Description
[7]	ADC1_LOCK_PEAK	Locks the stored value of the peak detector for reading back. 1'b0: Stored value is allowed to update (default) 1'b1: Stored value is locked
[6:2]	ADC1_PEAK_DECAY_RATE	Sets the speed at which the peak detector value will decay when greater than the input signal. 5'd0: Instant decay (default) 5'd1: Fastest decay 5'd10: Default value 5'd22: Slowest decay - Others: Reserved
[1]	RESERVED	N/A
[0]	ADC1_ENABLE_PEAK_DETECT	Enables the ADC signal peak detector. 1'b0: Disabled (default) 1'b1: Enabled

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Register 106: ADC CH1 PEAK DETECTOR LEVEL

Bits	[7:0]
Default	8'hFF

Bits	Mnemonic	Description
[7:0]	ADC1_PEAK_THRESH	Threshold value to trigger the PEAK_FLAG in the CH1 peak detector. Triggers if the input signal > ADC1_PEAK_THRESH. 8'h01: -48dB 8'hFF: 0dB (default) $\text{threshold [dB]} = 20 \cdot \log_{10} \frac{\text{ADC1_PEAK_THRESH}}{2^8 - 1}$

Register 108-107: ADC CH1 DC OFFSET

Bits	[15:0]
Default	16'h0000

Bits	Mnemonic	Description
[15:0]	ADC1_DC_OFFSET	Signed ADC CH1 DC offset coefficient. Positive offset is valid from 16'h7FFF (-30dB) to 16'h0001 (-120dB). Negative offset is valid from 16'h8000 (-30dB) to 16'hFFFF (-120dB). 16'h0000 corresponds to zero offset. $\text{offset [dB]} = 20 \cdot \log_{10} \frac{\text{ADC1_DC_OFFSET}}{(2^{15} - 1) \cdot 2^5}$



Register 110-109: ADC CH1 VOLUME

Bits	[15:0]
Default	16'h7FFF

Bits	Mnemonic	Description
[15:0]	ADC1_VOLUME	Signed value for the next desired ADC CH1 volume coefficient. 16'h0001: -90dB 16'h7FFF: 0dB (default) 16'h0000: Mute Note: 16'h8000 to 16'hFFFF is a phase inverted version of the volume. $\text{volume [dB]} = 20 \cdot \log_{10} \frac{\text{ADC1_VOLUME}}{2^{15} - 1}$

Register 111: ADC CH1 VOLUME RATE

Bits	[7:0]
Default	8'h00

Bits	Mnemonic	Description
[7:0]	ADC1_VOLUME_RATE	Value by which the old coefficient value is incremented/decremented to reach the new coefficient. 8'h00: Instant change (default) 8'h01: Slowest change 8'hFF: Fastest change

Register 112: ADC CH1 GAIN

Bits	[7:2]	[1:0]
Default	6'd36	2'd0

Bits	Mnemonic	Description
[7:2]	RESERVED	N/A
[1:0]	ADC1_DATA_GAIN	ADC data gain. 2'd0: +0dB 2'd1: +6dB 2'd2: +12dB 2'd3: +18dB

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Register 113: ADC CH1 PROG FILTER

Bits	[7:5]	[4:2]	[1:0]
Default	3'd4	3'd0	2'b00

Bits	Mnemonic	Description
[7:5]	RESERVED	N/A
[4:2]	ADC1_FILTER_SHAPE	Selects the 8x decimation FIR filter shape. 3'd0: Minimum phase (default) 3'd1: Linear phase apodizing fast roll-off 3'd2: Linear phase fast roll-off 3'd3: Linear phase fast roll-off low ripple 3'd4: Linear phase slow roll-off 3'd5: Minimum phase fast roll-off 3'd6: Minimum phase slow roll-off 3'd7: Minimum phase slow roll-off low dispersion
[1:0]	RESERVED	N/A

Register 117-114: RESERVED



ADC CH2 Registers

Register 118: ADC CH2 DATAPATH CONTROL

Bits	[7]	[6]	[5:3]	[2]	[1]	[0]
Default	1'b0	1'b0	3'b000	1'b0	1'b0	1'b0

Bits	Mnemonic	Description
[7]	ADC2_BYPASS_FIR2X	1'b0: Non-bypass (default) 1'b1: Bypass DFir_2x
[6]	ADC2_BYPASS_FIR4X	1'b0: Non-bypass (default) 1'b1: Bypass DFir_4x
[5:3]	RESERVED	N/A
[2]	ADC2_ENABLE_DC_BLOCKING	Enables DC blocking path. 1'b0: Disabled (default) 1'b1: Enabled
[1]	RESERVED	N/A
[0]	ADC2_NEG_SEL	Inverts data input from analog ADC. 1'b0: No inversion (default) 1'b1: Inverts input data

Register 119: ADC CH2 THD COMP CONFIG

Bits	[7:2]	[1]	[0]
Default	6'd0	1'b0	1'b0

Bits	Mnemonic	Description
[7:2]	ADC2_CORRECTION_ADDR	Selects the address when writing the THD compensation RAM.
[1]	ADC2_CORRECTION_WE	Enables writing to the THD compensation RAM. 1'b0: Writing disabled (default) 1'b1: Writing enabled
[0]	ADC2_ENABLE_THD_COMP	Enables the THD compensation on ADC CH2. 1'b0: Disabled and bypassed (default) 1'b1: Enabled

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Register 121-120: ADC CH2 THD COMP DATA

Bits	[15:0]
Default	16'h0000

Bits	Mnemonic	Description
[15:0]	ADC2_CORRECTION_DATA	A 16 bits THD corrected value that will be written to the address of the THD compensation RAM. Maximum -42dB (16'hFFFF).

Register 122: ADC CH2 PEAK DETECTOR CONFIG

Bits	[7]	[6:2]	[1]	[0]
Default	1'b0	5'd10	1'b0	1'b0

Bits	Mnemonic	Description
[7]	ADC2_LOCK_PEAK	Locks the stored value of the peak detector for reading back. 1'b0: Stored value is allowed to update (default) 1'b1: Stored value is locked
[6:2]	ADC2_PEAK_DECAY_RATE	Sets the speed at which the peak detector value will decay when greater than the input signal. 5'd0: Instant decay 5'd1: Fastest decay 5'd10: Default value 5'd22: Slowest decay - Others: Reserved
[1]	RESERVED	N/A
[0]	ADC2_ENABLE_PEAK_DETECT	Enables the ADC signal peak detector. 1'b0: Disabled (default) 1'b1: Enabled



Register 123: ADC CH2 PEAK DETECTOR LEVEL

Bits	[7:0]
Default	8'hFF

Bits	Mnemonic	Description
[7:0]	ADC2_PEAK_THRESH	Threshold value to trigger the PEAK_FLAG in the CH2 peak detector. Triggers if the input signal > ADC2_PEAK_THRESH. 8'h01: -48dB 8'hFF: 0dB (default) $\text{threshold [dB]} = 20 \cdot \log_{10} \frac{\text{ADC2_PEAK_THRESH}}{2^8 - 1}$

Register 125-124: ADC CH2 DC OFFSET

Bits	[15:0]
Default	16'h0000

Bits	Mnemonic	Description
[15:0]	ADC2_DC_OFFSET	Signed ADC CH2 DC offset coefficient. Positive offset is valid from 16'h7FFF (-30dB) to 16'h0001 (-120dB). Negative offset is valid from 16'h8000 (-30dB) to 16'hFFFF (-120dB). 16'h0000 corresponds to zero offset. $\text{offset [dB]} = 20 \cdot \log_{10} \frac{\text{ADC2_DC_OFFSET}}{(2^{15} - 1) \cdot 2^5}$

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Register 127-126: ADC CH2 VOLUME

Bits	[15:0]
Default	16'h7FFF

Bits	Mnemonic	Description
[15:0]	ADC2_VOLUME	Signed value for the next desired ADC CH2 volume coefficient. 16'h0001: -90dB 16'h7FFF: 0dB (default) 16'h0000: Mute Note: 16'h8000 to 16'hFFFF is a phase inverted version of the volume. $\text{volume [dB]} = 20 \cdot \log_{10} \frac{\text{ADC2_VOLUME}}{2^{15} - 1}$

Register 128: ADC CH2 VOLUME RATE

Bits	[7:0]
Default	8'h00

Bits	Mnemonic	Description
[7:0]	ADC2_VOLUME_RATE	Value by which the old coefficient value is incremented/decremented to reach the new coefficient. 8'h00: Instant change (default) 8'h01: Slowest change 8'hFF: Fastest change

Register 129: ADC CH2 GAIN

Bits	[7:2]	[1:0]
Default	6'd36	2'd0

Bits	Mnemonic	Description
[7:2]	RESERVED	N/A
[1:0]	ADC2_DATA_GAIN	ADC data gain. 2'd0: +0dB 2'd1: +6dB 2'd2: +12dB 2'd3: +18dB

**Register 130: ADC CH2 PROG FILTER**

Bits	[7:5]	[4:2]	[1:0]
Default	3'd4	3'd0	2'b00

Bits	Mnemonic	Description
[7:5]	RESERVED	N/A
[4:2]	ADC2_FILTER_SHAPE	Selects the 8x decimation FIR filter shape. • 3'd0: Minimum phase (default) • 3'd1: Linear phase apodizing fast roll-off • 3'd2: Linear phase fast roll-off • 3'd3: Linear phase fast roll-off low ripple • 3'd4: Linear phase slow roll-off • 3'd5: Minimum phase fast roll-off • 3'd6: Minimum phase slow roll-off • 3'd7: Minimum phase slow roll-off low dispersion
[1:0]	RESERVED	N/A

Register 152-131: RESERVED

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Synchronous Slave Interface Registers

Register 192: SOFT RESET

Bits	[7]	[6:0]
Default	1'b0	7'b00000000

Bits	Mnemonic	Description
[7]	AO_SOFT_RESET	Performs soft reset to digital core except for the synchronous registers.
[6:0]	RESERVED	N/A

Register 193: CLK SELECT

Bits	[7:3]	[2:1]	[0]
Default	5'b000000	2'd0	1'b0

Bits	Mnemonic	Description
[7:3]	RESERVED	N/A
[2:1]	SEL_SYSCLK_IN	Selects digital core and ADC clock source when EN_ANA_CLKIN is set. 2'd0: XTAL (default) 2'd1: MCLK 2'd2: ACLK 2'd3: Reserved
[0]	EN_ANA_CLKIN	Enables clock outputs to the digital core and ADC. 1'b0: Disabled (default) 1'b1: Enabled

**Register 194: ADC CLOCK DIVIDE**

Bits	[7:2]	[1:0]
Default	6'b000000	2'd0

Bits	Mnemonic	Description
[7:2]	RESERVED	N/A
[1:0]	SEL_CLK_DIV	Sets ADC clock rate: • 2'd0: full-rate (Divide by 1) (default) • 2'd1: 1/2 rate (Divide by 2) • 2'd2: 1/4 rate (Divide by 4) • 2'd3: 1/8 rate (Divide by 8)

Register 203-195: RESERVED

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Readback Registers

Register 224: READ SYSTEM REGISTER 0

Bits	[7:4]	[3]	[2]	[1]	[0]
Default		-	-	-	-

Bits	Mnemonic	Description
[7:4]	RESERVED	N/A
[3]	MODE	Readback MODE pin
[2]	ADDR2	Readback ADDR2 pin
[1]	ADDR1	Readback ADDR1 pin
[0]	RESERVED	N/A

Register 225: CHIP ID

Bits	[7:0]
Default	8'h84

Bits	Mnemonic	Description
[7:0]	CHIP_ID	ES9820: 0x84

Register 228-226: RESERVED

Register 229: PEAK FLAG

Bits	[7:2]	[1]	[0]
Default	-	-	-

Bits	Mnemonic	Description
[7:2]	RESERVED	N/A
[1]	PEAK_FLAG_CH2	ADC CH2 peak detector flag
[0]	PEAK_FLAG_CH1	ADC CH1 peak detector flag

**Register 230: RESERVED****Register 231: READ SYSTEM REGISTER 5**

Bits	[7]	[6]	[5]	[4]	[3:0]
Default	-	-	-	-	-

Bits	Mnemonic	Description
[7]	ASP2_INIT_DONE	ASP2 initialize is done
[6]	ASP1_INIT_DONE	ASP1 initialize is done
[5]	RESERVED	N/A
[4]	TDM_VALID	TDM valid flag
[3:0]	RESERVED	N/A

Register 233-232: GPIO READBACK REGISTERS

Bits	[15:11]	[10]	[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Default		-	-	-	-	-	-	-	-	-	-	-

Bits	Mnemonic	Description
[15:11]	RESERVED	N/A
[10]	GPIO11_READBACK	GPIO 11 Readback
[9]	GPIO10_READBACK	GPIO 10 Readback
[8]	GPIO9_READBACK	GPIO 9 Readback
[7]	GPIO8_READBACK	GPIO 8 Readback
[6]	GPIO7_READBACK	GPIO 7 Readback
[5]	GPIO6_READBACK	GPIO 6 Readback
[4]	GPIO5_READBACK	GPIO 5 Readback
[3]	GPIO4_READBACK	GPIO 4 Readback
[2]	GPIO3_READBACK	GPIO 3 Readback
[1]	GPIO2_READBACK	GPIO 2 Readback
[0]	GPIO1_READBACK	GPIO 1 Readback



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Register 236-234: RESERVED

Register 238-237: ADC CH1 PEAK

Bits	[15:0]
Default	-

Bits	Mnemonic	Description
[15:0]	ADC1_PEAK	Detected peak value readback

Register 241-239: RESERVED

Register 243-242: ADC CH2 PEAK

Bits	[15:0]
Default	-

Bits	Mnemonic	Description
[15:0]	ADC2_PEAK	Detected peak value readback



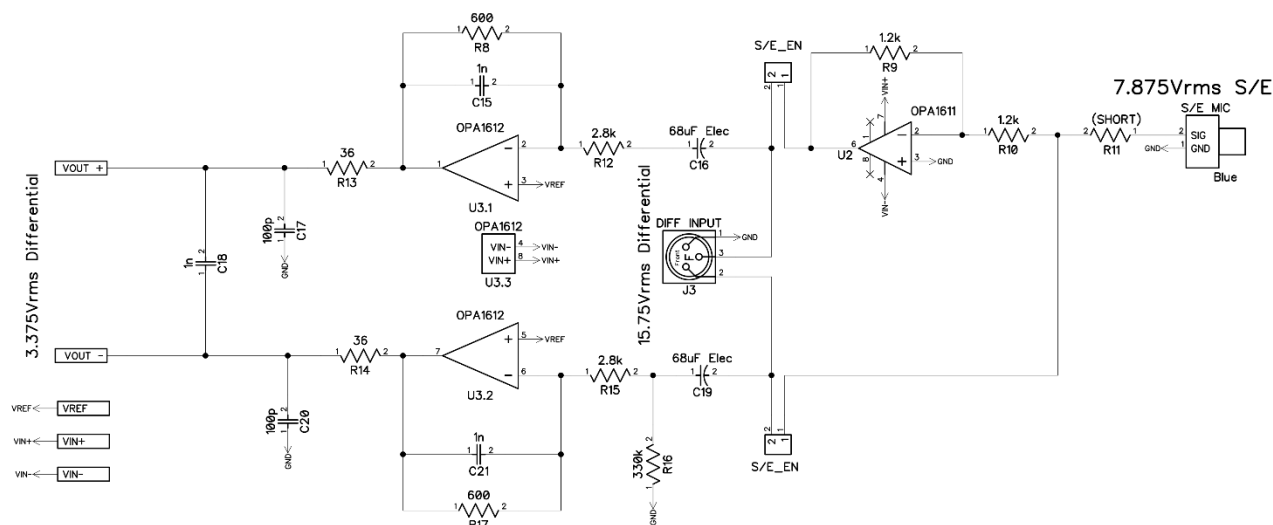


Figure 27 - Reference Schematic ADC Input Stage for Single Ended (S/E) and Differential Input

***Note: All resistors are thin-film, and all caps are COG/NPO unless otherwise specified.**

Note: OPA1612 can be replaced with an OPA1602 if required.

This diagram shows the configuration of the ES9312Q with an output of 3.3V.

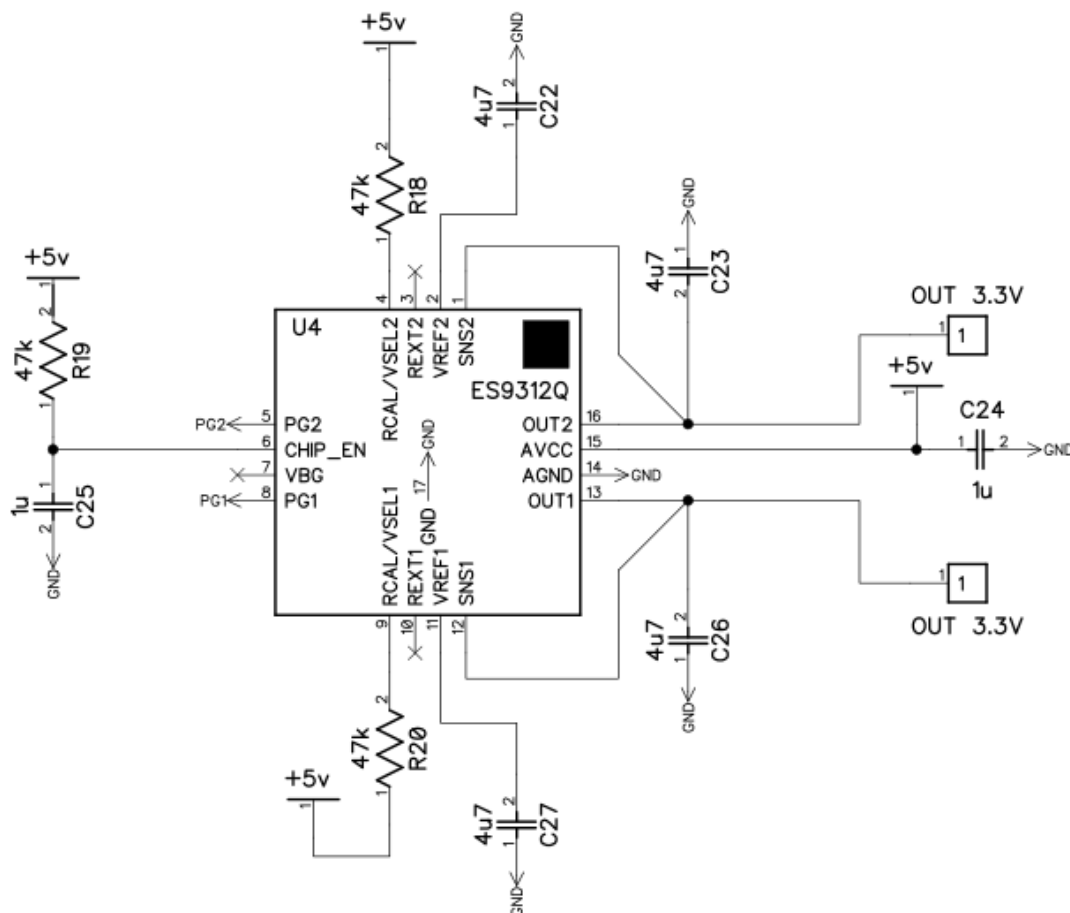
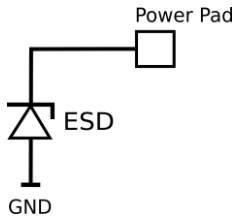
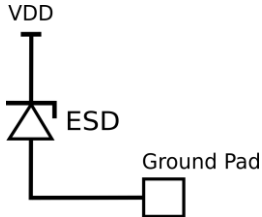
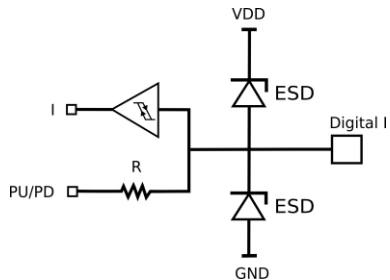


Figure 28 - ES9312Q Reference Voltage Regulator Schematic



Internal Pad Circuitry

Pin Name	Type	Pin	Equivalent Circuit
AVCC AVCC_L AVCC_R DVDD AVDD	Power (Positive)	5 10 21 29 30	
AGND AGND_L AGND_R DGND	Ground	6 11 20 31	
CHIP_EN	Reset	23	

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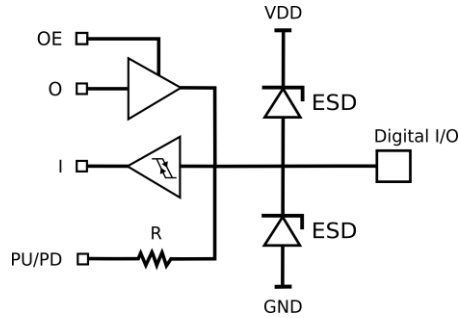
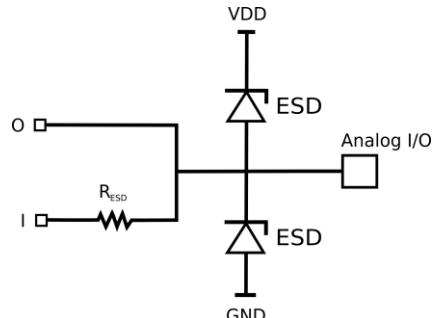
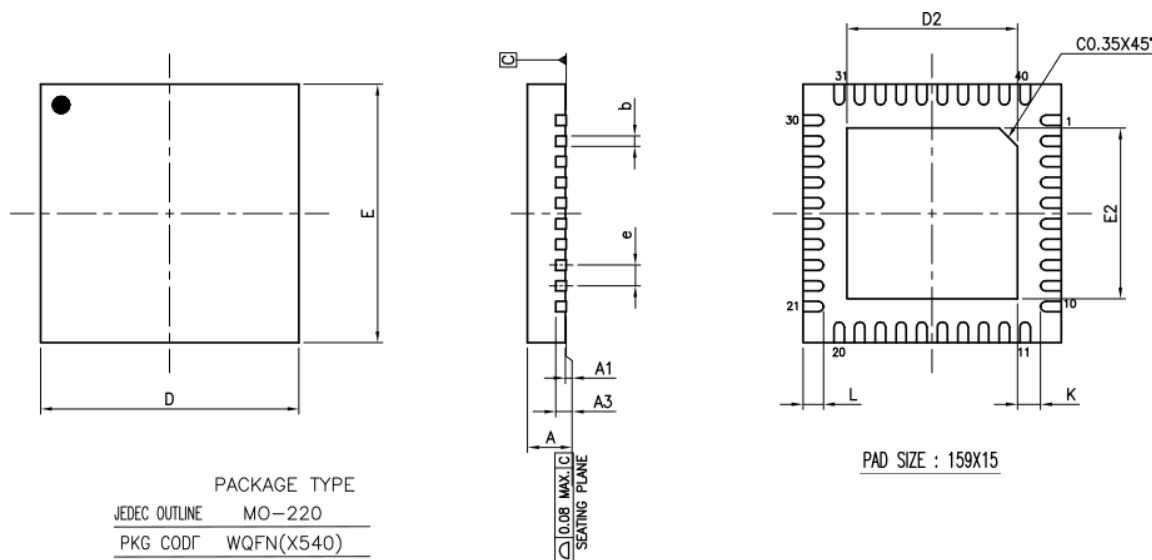
GPIO10	Digital I/O	1	 The diagram shows the internal circuitry for a digital I/O pad. It includes an output driver with an OE (Output Enable) control, an output node O, an input node I with a pull-up resistor R, and a PU/PD (Pull-up/Pull-down) control. The pad is connected to VDD and GND through ESD protection diodes. The output is connected to a Digital I/O pin.
GPIO11		2	
MODE		3	
ACLK		4	
GPIO9/INT		24	
MOSI/SDA		25	
SCLK/SCL		26	
SS/ADDR1		27	
MISO/ADDR2		28	
GPIO8		32	
GPIO7		33	
GPIO6		34	
GPIO5		35	
GPIO4		36	
GPIO3		37	
GPIO2		38	
GPIO1		39	
RT1		40	
XOUT	Analog IO	7	 The diagram shows the internal circuitry for an analog I/O pad. It includes an output node O and an input node I with a resistor R_{ESD}. The pad is connected to VDD and GND through ESD protection diodes. The output is connected to an Analog I/O pin.
XIN		8	
VREF_L		9	
IN_P1		12	
IN_M1		13	
IN_M2		18	
IN_P2		19	
VREF_R		22	

Table 34 - Internal Pad Circuitry



40 QFN Package Dimensions



NOTES :

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.15mm AND 0.30mm FROM THE TERMINAL TIP. IF THE TERMINAL HAS THE OPTIONAL RADIUS ON THE OTHER END OF THE TERMINAL, THE DIMENSION b SHOULD NOT BE MEASURED IN THAT RADIUS AREA.
3. BILATERAL COPLANARITY ZONE APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.

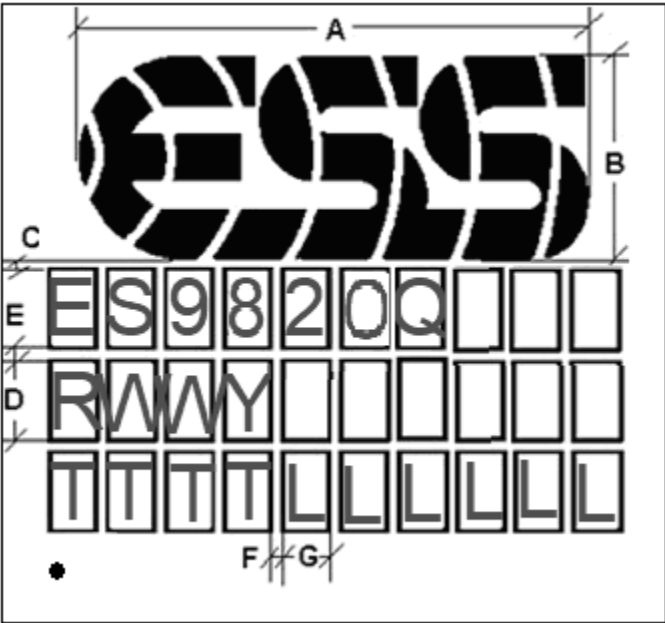
PAD SIZE	D2			E2			L		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
159X15* MIL	3.74	3.79	3.84	3.74	3.79	3.84	0.25	0.30	0.35

Figure 29 - 40 QFN Package Dimensions



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40 QFN Top View Marking



Package Type	Dimension in mm						
	A	B	C	D	E	F	G
QFN 5mm x 5mm	4.0	1.6	0.2	0.4	0.2	0.1	0.3

T	Tracking number
W	Work week
Y	Last Digit of year
L	Lot number
R	Silicon revision

Marking is subject to change. This drawing is not to scale.

Figure 30 - ES9820 QFN Marking



Reflow Process Considerations

Temperature Controlled

For lead-free soldering, the characterization and optimization of the reflow process is the most important factor to consider. The lead-free alloy solder has a melting point of 217°C. This alloy requires a minimum reflow temperature of 235°C to ensure good wetting. The maximum reflow temperature is in the 245°C to 260°C range, depending on the package size (RPC-2 Pb-Free Process - Classification Temperatures (T_c)). This narrows the process window for lead-free soldering to 10°C to 20°C.

The increase in peak reflow temperature in combination with the narrow process window makes the development of an optimal reflow profile a critical factor for ensuring a successful lead-free assembly process. The major factors contributing to the development of an optimal thermal profile are the size and weight of the assembly, the density of the components, the mix of large and small components, and the paste chemistry being used.

Reflow profiling needs to be performed by attaching calibrated thermocouples well adhered to the device as well as other critical locations on the board to ensure that all components are heated to temperatures above the minimum reflow temperatures and that smaller components do not exceed the maximum temperature limits (Table RPC-2).

To ensure that all packages can be successfully and reliably assembled, the reflow profiles studied and recommended by ESS are based on the JEDEC/IPC standard J-STD-020 revision D.1.

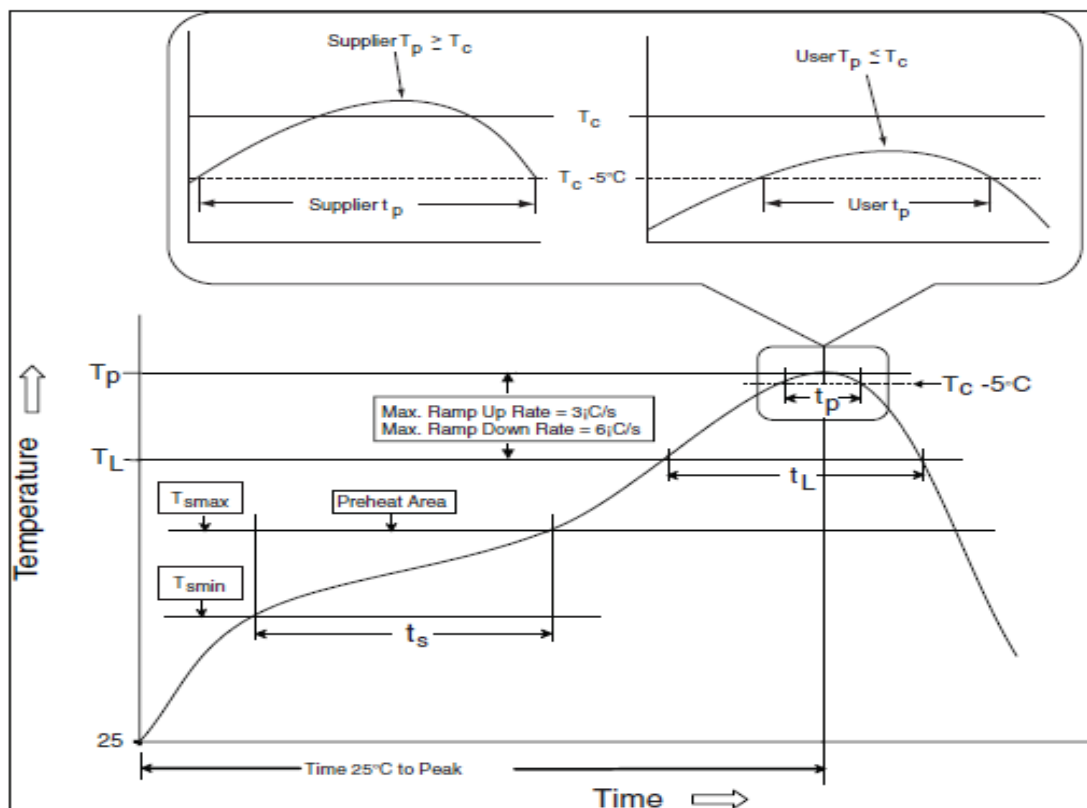


Figure 31 - IR/Convection Reflow Profile (IPC/JEDEC J-STD-020D.1)

Reflow is allowed 3 times. Caution must be taken to ensure time between re-flow runs does not exceed the allowed time by the moisture sensitivity label. If the time elapsed between the re-flows exceeds the moisture sensitivity time bake the board according to the moisture sensitivity label instructions.

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Manual

Allowed up to 2 times with maximum temperature of 350°C no longer than 3 seconds.

RPC-1 Classification Reflow Profile

Profile Feature	Pb-Free Assembly
Preheat/Soak	
Temperature Min (T _{smin})	150°C
Temperature Max (T _{smax})	200°C
Time (ts) from (T _{smin} to T _{smax})	60-120 seconds
Ramp-up rate (TL to Tp)	3°C / second maximum
Liquidous temperature (TL)	217°C
Time (tL) maintained above TL	60-150 seconds
Peak package body temperature (Tp)	For users Tp must not exceed the classification temp in Table RPC-2. For suppliers Tp must equal or exceed the Classification temp in Table RPC-2.
Time (tp)* within 5°C of the specified classification temperature (Tc), see Figure 31	30* seconds
Ramp-down rate (Tp to TL)	6°C / second maximum
Time 25°C to peak temperature	8 minutes maximum
* Tolerance for peak profile temperature (Tp) is defined as a supplier minimum and a user maximum.	

Table 35 - RPC-1 Classification Reflow Profile

All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow (e.g., live-bug). If parts are reflowed in other than the normal live-bug assembly reflow orientation (i.e., dead-bug), Tp shall be within $\pm 2^\circ\text{C}$ of the live-bug Tp and still meet the Tc requirements, otherwise, the profile shall be adjusted to achieve the latter. To accurately measure actual peak package body temperatures, refer to JEP140 for recommended thermocouple use.

Reflow profiles in this document are for classification/preconditioning and are not meant to specify board assembly profiles. Actual board assembly profiles should be developed based on specific process needs and board designs and should not exceed the parameters in Table RPC-1.

For example, if Tc is 260°C and time tp is 30 seconds, this means the following for the supplier and the user.

For a supplier: The peak temperature must be at least 260°C. The time above 255°C must be at least 30 seconds.

For a user: The peak temperature must not exceed 260°C. The time above 255°C must not exceed 30 seconds.

All components in the test load shall meet the classification profile requirements.

**RPC-2 Pb-Free Process - Classification Temperatures (Tc)**

Package Thickness	Volume mm3, <350	Volume mm3, 350 to 2000	Volume mm3, >2000
<1.6 mm	260°C	260°C	260°C
1.6 mm - 2.5 mm	260°C	250°C	245°C
>2.5 mm	250°C	245°C	245°C

Table 36 - RPC-2 Pb-Free Process

At the discretion of the device manufacturer, but not the board assembler/user, the maximum peak package body temperature (Tp) can exceed the values specified in Table RPC-2. The use of a higher Tp does not change the classification temperature (Tc).

Package volume excludes external terminals (e.g., balls, bumps, lands, leads) and/or nonintegral heat sinks.

The maximum component temperature reached during reflow depends on package thickness and volume. The use of convection reflow processes reduces the thermal gradients between packages. However, thermal gradients due to differences in thermal mass of SMD packages may still exist.



ES9820 Product Datasheet

Ordering Information

Part Number	Description	Package
ES9820Q	SABRE 32-bit 2 Channel ADC with Built in Digital Filters, ASP, and Multiple Output Formats.	5mm x 5mm 40 QFN

Table 37 - Ordering Information



Addendum

The following subsections outline the recommended configuration for common I²S and TDM modes in s2m format.

I²S Master

FS=48kHz, 2 Channel, MCLK=49.152MHz

```

w 0x48 193 0x01;    //SEL_SYSCLK_IN = 00 (XTAL), EN_ANA_CLKIN = 1
//w 0x48 193 0x05; //SEL_SYSCLK_IN = 10 (ACLK), EN_ANA_CLKIN = 1
w 0x48 194 0x01;    //SEL_CLK_DIV = 1/2 (for 49.152/45.1584MHz, this sets ADC clock rate, must be
22 or 24MHz)

w 0x40 0 0x00;      //OUTPUT_SEL = 00 (I2S)
w 0x40 1 0x33;      //ENABLE_ADC_CH and ENABLE_DATA_IN_CH
w 0x40 2 0x07;      //SELECT_ADC_NUM = 7 for 48k/44.1k, 3 for 96k, 1 for 192k
w 0x40 3 0x01;      //SELECT_IADC_NUM = 1, should match SEL_CLK_DIV
w 0x40 8 0x07;      //MASTER_BCK_DIV1 = 0, MASTER_MODE_ENABLE = 1
w 0x40 9 0x07;      //SELECT_I2S_TDM_NUM = 7 for 48k/44.1k, 3 for 96k, 1 for 192k (must match Reg 2)
w 0x40 10 0x05;     //TDM_VALID_EDGE = 1, ENABLE_TDM_CLK = 1
w 0x40 11 0x01;     //TDM_CH_NUM = 1 (# of channels = 1+ TDM_CH_NUM)
w 0x40 12 0x00;     //TDM_LINE_SEL_CH1: 00 (GPIO3), TDM_SLOT_SEL_CH1: 0 (slot 0)
w 0x40 13 0x01;     //TDM_LINE_SEL_CH2: 00 (GPIO3), TDM_SLOT_SEL_CH2: 1 (slot 1)
w 0x40 23 0x0A;     //FS_PHASE = 10

//GPIO enabling
w 0x40 74 0x22;     //GPIO1_CFG and GPIO2_CFG set to AUX output (clocks out)
w 0x40 75 0x02;     //GPIO3_CFG set to AUX output (data out)
w 0x40 86 0x03;     //GPIO1_IE and GPIO2_IE input enabled
w 0x40 88 0x07;     //GPIO1_OE and GPIO2_OE and GPIO3_OE output enabled

//ADC CONFIG
w 0x40 63 0xBB;     //ADC Ch1 Config
w 0x40 64 0x38;
w 0x40 65 0xBB;     //ADC Ch2 Config
w 0x40 66 0x38;
w 0x40 71 0x0F;     //set common mode to 3

//ADC filter and datapath registers
w 0x40 113 0x98;    //ADC1_FILTER_SHAPE = Minimum phase slow roll off
w 0x40 130 0x98;    //ADC2_FILTER_SHAPE = Minimum phase slow roll off

```

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I²S Slave

FS=48kHz, 2 Channel, MCLK=49.152MHz

```
w 0x48 193 0x01;    //SEL_SYSCLK_IN = 00 (XTAL), EN_ANA_CLKIN = 1
//w 0x48 193 0x05;  //SEL_SYSCLK_IN = 10 (ACLK), EN_ANA_CLKIN = 1
w 0x48 194 0x01;    //SEL_CLK_DIV = 1/2 (for 49.152/45.1584MHz, this sets ADC clock rate, must be
22 or 24MHz)
```

```
w 0x40 0 0x00;      //OUTPUT_SEL = 00 (I2S)
w 0x40 1 0x33;      //ENABLE_ADC_CH and ENABLE_DATA_IN_CH
w 0x40 2 0x07;      //SELECT_ADC_NUM = 7 for 48k/44.1k, 3 for 96k, 1 for 192k
w 0x40 3 0x01;      //SELECT_IADC_NUM = 1, should match SEL_CLK_DIV
w 0x40 8 0x00;      //MASTER_BCK_DIV1 = 0, MASTER_MODE_ENABLE = 0
w 0x40 9 0x00;      //master mode is disabled
w 0x40 10 0x05;     //TDM_VALID_EDGE = 1, ENALE_TDM_CLK = 1
w 0x40 11 0x01;     //TDM_CH_NUM = 1 (# of channels = 1 + TDM_CH_NUM)
w 0x40 12 0x00;     //TDM_LINE_SEL_CH1: 00 (GPIO3), TDM_SLOT_SEL_CH1: 0 (slot 0)
w 0x40 13 0x01;     //TDM_LINE_SEL_CH2: 00 (GPIO3), TDM_SLOT_SEL_CH2: 1 (slot 1)
w 0x40 23 0x0A;     //FS_PHASE = 10
```

//GPIO enabling

```
w 0x40 74 0x11;     //GPIO1 and GPIO2 set to AUX input (slave mode)
w 0x40 75 0x02;     //GPIO3 set to AUX output
w 0x40 86 0x03;     //GPIO1 and GPIO2 input enabled
w 0x40 88 0x04;     //GPIO3 output enabled
```

//ADC CONFIG

```
w 0x40 63 0xBB;     //ADC Ch1 Config
w 0x40 64 0x38;
w 0x40 65 0xBB;     //ADC Ch2 Config
w 0x40 66 0x38;
w 0x40 71 0x0F;     //set common mode to 3
```

//ADC filter and datapath registers

```
w 0x40 113 0x98;    //ADC1_FILTER_SHAPE = Minimum phase slow roll off
w 0x40 130 0x98;    //ADC2_FILTER_SHAPE = Minimum phase slow roll off
```



TDM Master

FS=48kHz, 2 Channel, MCLK=49.152MHz

```

w 0x48 193 0x01; //SEL_SYSCLK_IN = 00 (XTAL), EN_ANA_CLKIN = 1
//w 0x48 193 0x05; //SEL_SYSCLK_IN = 10 (ACLK), EN_ANA_CLKIN = 1
w 0x48 194 0x01; //SEL_CLK_DIV = 1/2 (for 49.152/45.1584MHz, this sets ADC clock rate, must be 22
or 24MHz)

w 0x40 0 0x40; //OUTPUT_SEL = 10 (TDM)
w 0x40 1 0x33; //ENABLE_ADC_CH and ENABLE_DATA_IN_CH
w 0x40 2 0x07; //SELECT_ADC_NUM = 7 for 48k/44.1k, 3 for 96k, 1 for 192k
w 0x40 3 0x01; //SELECT_IADC_NUM = 1, should match SEL_CLK_DIV
w 0x40 8 0x07; //MASTER_BCK_DIV1 = 0, MASTER_MODE_ENABLE = 1
w 0x40 9 0x07; //SELECT_I2S_TDM_NUM = 7 for 48k/44.1k, 3 for 96k, 1 for 192k (must match Reg
2)
w 0x40 10 0x03; //TDMLJ format: TDM_LJ = 1, TDM_VALID_EDGE = 0, ENABLE_TDM_CLK = 1
//w 0x40 10 0x05; //TDMI2S format: TDM_LJ = 0, TDM_VALID_EDGE = 1, ENABLE_TDM_CLK = 1
w 0x40 11 0x01; //TDM_CH_NUM = 1 (# of channels = 1 + TDM_CH_NUM)
w 0x40 12 0x00; //TDM_LINE_SEL_CH1: 00 (GPIO3), TDM_SLOT_SEL_CH1: 0 (slot 0)
w 0x40 13 0x01; //TDM_LINE_SEL_CH2: 00 (GPIO3), TDM_SLOT_SEL_CH2: 1 (slot 1)
w 0x40 23 0x0A; //FS_PHASE = 10
w 0x40 33 0x95; //TDMLJ format: SYNC_POSEDGE_FRAME = 1
//w 0x40 33 0x15; //TDMI2S format: SYNC_POSEDGE_FRAME = 0

//GPIO enabling
w 0x40 74 0x22; //GPIO1_CFG and GPIO2_CFG set to AUX output (clocks out)
w 0x40 75 0x02; //GPIO3_CFG set to AUX output (data out)
w 0x40 86 0x03; //GPIO1_IE and GPIO2_IE input enabled
w 0x40 88 0x07; //GPIO1_OE and GPIO2_OE and GPIO3_OE output enabled

//ADC CONFIG
w 0x40 63 0xBB; //ADC Ch1 Config
w 0x40 64 0x38;
w 0x40 65 0xBB; //ADC Ch2 Config
w 0x40 66 0x38;
w 0x40 71 0x0F; //set common mode to 3

//ADC filter and datapath registers
w 0x40 113 0x98; //ADC1_FILTER_SHAPE = Minimum phase slow roll off
w 0x40 130 0x98; //ADC2_FILTER_SHAPE = Minimum phase slow roll off

```

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TDM Slave

FS=28kHz, 2 Channel, MCLK=49.152MHz

```

w 0x48 193 0x01;    //SEL_SYSCLK_IN = 00 (XTAL), EN_ANA_CLKIN = 1
//w 0x48 193 0x05; //SEL_SYSCLK_IN = 10 (ACLK), EN_ANA_CLKIN = 1
w 0x48 194 0x01;    //SEL_CLK_DIV = 1/2 (for 49.152/45.1584MHz, this sets ADC clock rate, must be
22 or 24MHz)

w 0x40 0 0x40;      //OUTPUT_SEL = 10 (TDM)
w 0x40 1 0x33;      //ENABLE_ADC_CH and ENABLE_DATA_IN_CH
w 0x40 2 0x07;      //SELECT_ADC_NUM = 7 for 48k/44.1k, 3 for 96k, 1 for 192k
w 0x40 3 0x01;      //SELECT_IADC_NUM = 1, should match SEL_CLK_DIV
w 0x40 8 0x00;      //MASTER_BCK_DIV1 = 0, MASTER_MODE_ENABLE = 0
w 0x40 9 0x00;      //master mode is disabled
w 0x40 10 0x03;     //TDMLJ format: TDM_LJ = 1, TDM_VALID_EDGE = 0, ENABLE_TDM_CLK = 1
//w 0x40 10 0x05;   //TDMI²S format: TDM_LJ = 0, TDM_VALID_EDGE = 1, ENABLE_TDM_CLK = 1
w 0x40 11 0x01;     //TDM_CH_NUM = 1 (# of channels = 1 + TDM_CH_NUM)
w 0x40 12 0x00;     //TDM_LINE_SEL_CH1: 00 (GPIO3), TDM_SLOT_SEL_CH1: 0 (slot 0)
w 0x40 13 0x01;     //TDM_LINE_SEL_CH2: 00 (GPIO3), TDM_SLOT_SEL_CH2: 1 (slot 1)
w 0x40 23 0x0A;     //FS_PHASE = 10
w 0x40 33 0x95;     //TDMLJ format: SYNC_POSEDGE_FRAME = 1
//w 0x40 33 0x15;   //TDMI²S format: SYNC_POSEDGE_FRAME = 0

//GPIO enabling
w 0x40 74 0x11;     //GPIO1 and GPIO2 set to AUX input (slave mode)
w 0x40 75 0x02;     //GPIO3 set to AUX output
w 0x40 86 0x03;     //GPIO1 and GPIO2 input enabled
w 0x40 88 0x04;     //GPIO3 output enabled

//ADC CONFIG
w 0x40 63 0xBB;     //ADC Ch1 Config
w 0x40 64 0x38;
w 0x40 65 0xBB;     //ADC Ch2 Config
w 0x40 66 0x38;
w 0x40 71 0x0F;     //set common mode to 3

//ADC filter and datapath registers
w 0x40 113 0x98;    //ADC1_FILTER_SHAPE = Minimum phase slow roll off
w 0x40 130 0x98;    //ADC2_FILTER_SHAPE = Minimum phase slow roll off

```



Resync

The respective s2m script is to be run on all slave mode ES9820s in TDM Cascade or Parallel mode after clocks from the master have been initialized. This is to ensure all chips are properly synchronized with each other for optimal performance.

I²S Resync

```
w 34 0x1D; // Turn off AUTO_FIR_SYNC
w 33 0x35; // FORCE_FIR_SYNC = 1'b1
w 33 0x15; // FORCE_FIR_SYNC = 1'b0
w 34 0x1F; // Turn on AUTO_FIR_SYNC
```

LJ Resync

```
w 34 0x1D; // Turn off AUTO_FIR_SYNC
w 33 0x35; // FORCE_FIR_SYNC = 1'b1
w 33 0x95; // FORCE_FIR_SYNC = 1'b0
w 34 0x1F; // Turn on AUTO_FIR_SYNC
```



ES9820 Product Datasheet

Revision History

Current Version 0.5.1

Rev.	Date	Notes
0.1.2	November, 2020	Initial release
0.5.1	October, 2025	• Updated Formatting • Renamed 2x mode to 64FS mode and all “clip” references to “peak” • Updated Audio Input/Output Formats • Updated Digital Signal Path subsections • Added DC Offset, Gain, DFIR Filters and Channel Mapping sections • Updated Absolute Maximum Ratings • Updated Switching characteristics • Added Timing Characteristics for MCLK to BCK & SPI • Added resync registers in the addendum • Updated interface modes • Added TDM cascade and parallel sections • Updated Reference Schematic to use ES9312Q regulator • Description updated Reg 0[1] Mono Mode • Updated defaults for registers 112, 129 (Reserved Bits) • Description Update Reg 59-60[15:14,13:12], 63[7:4, 3], 64[2, 1], 65[7:4, 3], 66[2, 1], 67[7:4], 69[7:4], 71, (Delay Line) • Description Updated Reg 92, 93:94, 95, 96:97, 98, 99:100 (PWM) • Description Updated Reg 102[0], 119[0] (THD Comp) • Updated Reg 105[6:2], 106, 108-107, 110-109, 111, 112, 113 (ADC1 Config) • Updated Reg 122[6:2], 123, 125-124, 127-126, 128, 129, 130 (ADC2 Config) • Unreserved 11[7], 23[6:0]

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