CS8416

192 kHz Digital Audio Interface Receiver

Features

- Complete EIAJ CP1201, IEC-60958, AES3, S/PDIF compatible receiver
- +3.3 V Analog Supply(VA)
- +3.3 V to +5.0 V Digital Interface Supply (VL)
- +3.3 V Digital Supply (VD)
- 8:2 S/PDIF Input MUX
- AES/SPDIF input pins selectable in hardware mode
- 3 General Purpose Outputs (GPO) allow signal routing
- Selectable signal routing to GPO pins
- S/PDIF to TX inputs selectable in hardware mode
- Flexible 3-wire serial digital output port
- 32 kHz to 192 kHz sample frequency range
- Low jitter clock recovery
- Pin and microcontroller read access to Channel Status and User data
- SPI or I^2C control port Software Mode and standalone Hardware Mode
- Differential cable receiver
- On-chip Channel Status data buffer memories
- Auto-detection of compressed audio input streams
- Decodes CD Q sub-code
- OMCK System Clock Mode

General Description

The CS8416 is a monolithic CMOS device which receives and decodes one of 8 channels of audio data according to the IEC60958, S/PDIF, EIAJ CP1201, or AES3 interface standards. The CS8416 has a serial digital audio output port and comprehensive control ability through a selectable control port in Software Mode or through selectable pins in Hardware Mode. Channel status data are assembled in buffers, making read access easy.

GPO pins may be assigned to route a variety of signals to output pins

A low jitter clock recovery mechanism yields a very clean recovered clock from the incoming AES3 stream.

Stand-alone operation allows systems with no microcontroller to operate the CS8416 with dedicated output pins for channel status data.

Target applications include A/V receivers, CD-R, DVD receivers, multimedia speakers, digital mixing consoles, effects processors, set-top boxes, and computer and automotive audio systems.

ORDERING INFORMATION

CS8416-CS	28-pin SOIC	-10 to +70°C
CS8416-CZ	28-pin TSSOP	-10 to +70°C
CS8416-IS	28-pin SOIC	-40 to +85°C
CS8416-IZ	28-pin TSSOP	-40 to +85°C

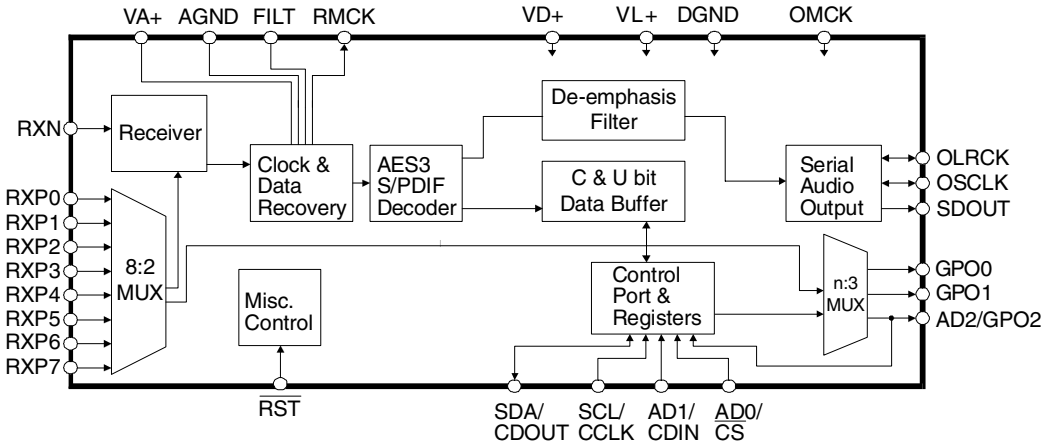

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TABLE OF CONTENTS

1 CHARACTERISTICS AND SPECIFICATIONS 5
Power and Thermal Characteristics 5
Absolute Maximum Ratings 5
Digital Characteristics 6
Switching Characteristics - Serial Audio Ports 7
Switching Characteristics - Control Port - SPI Mode 8
Switching Characteristics - Control Port- I2C format 9
2 TYPICAL CONNECTION DIAGRAMS 10
3 GENERAL DESCRIPTION 12
3.1 AES3 and S/PDIF Standards Documents 12
4 SERIAL AUDIO OUTPUT PORT 13
4.1 Slip/Repeat Behavior 13
4.2 AES11 Behavior 14
5 S/PDIF RECEIVER 16
5.1 8:2 S/PDIF Input Multiplexer 16
5.2 PLL, Jitter Attenuation, and Clock Switching 16
5.2.1 OMCK System Clock Mode 17
5.2.2 PLL External Components 17
5.3 Error Reporting and Hold Function 17
5.4 Channel Status Data Handling 18
5.5 User Data Handling 18
5.5.1 Non-Audio Auto-Detection 18
6 CONTROL PORT DESCRIPTION AND TIMING 20
6.1 SPI Mode 20
6.2 I2C Mode 21
6.3 General Purpose Outputs 22
6.4 Interrupts 22
7 CONTROL PORT REGISTER SUMMARY 23
8 CONTROL PORT REGISTER BIT DEFINITIONS 25
8.1 Control0 (00h) 25
8.2 Control1 (01h) 25

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8.3 Control2 (02h) 26
8.4 Control3 (03h) 26
8.5 Control4 (04h) 27
8.6 Serial Audio Data Format (05h) 27
8.7 Receiver Error Mask (06h) 29
8.8 Interrupt Mask (07h) 29
8.9 Interrupt Mode MSB (08h) and Interrupt Mode LSB(09h) 29
8.10 Receiver Channel Status (0Ah) 30
8.11 Format Detect Status (0Bh) 30
8.12 Receiver Error (0Ch) 31
8.13 Interrupt 1 Status (0Dh) 32
8.14 Q-Channel Subcode (0Eh - 17h) 32
8.15 OMCK/RMCK Ratio (18h) 33
8.16 Channel Status Registers (19h - 22h) 33
8.17 IEC61937 PC/PD Burst preamble (23h - 26h) 33
8.18 CS8416 I.D. and Version Register (7Fh) 33
8.19 Memory Address Pointer (MAP) 34
9. PIN DESCRIPTION - SOFTWARE MODE 35
10 HARDWARE MODE 37
10.1 Serial Audio Port Formats 37
11 PIN DESCRIPTION - HARDWARE MODE 38
11.1 Hardware Mode Function Selection 40
11.2 Hardware Mode Settings (Defaults & Controls) 40
12 APPLICATIONS 42
12.1 Reset, Power Down and Start-up 42
12.2 ID Code and Revision Code 42
12.3 Power Supply, Grounding, and PCB layout 42
13 PACKAGE DIMENSIONS 43
14 APPENDIX A: EXTERNAL AES3/SPDIF/IEC60958 RECEIVER COMPONENTS 45
14.1 AES3 Receiver External Components 45
14.2 Isolating Transformer Requirements 45
15 APPENDIX B: CHANNEL STATUS BUFFER MANAGEMENT 47
15.1 AES3 Channel Status (C) Bit Management 47
15.2 Accessing the E buffer 47
15.2.1 Serial Copy Management System (SCMS) 47

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LIST OF FIGURES

Figure 1. Audio Port Master Mode Timing 7
Figure 2. Audio Port Slave Mode and Data Input Timing 7
Figure 3. SPI Mode Timing 8
Figure 4. I2C Mode Timing 9
Figure 5. Typical Connection Diagram - Software Mode 10
Figure 6. Typical Connection Diagram - Hardware Mode 11
Figure 7. AES3 Data Format 14
Figure 8. Serial Audio Output Example Formats 15
Figure 9. C/U data outputs 19
Figure 10. De-emphasis filter 19
Figure 11. Control Port Timing In SPI Mode 20
Figure 12. Control Port Timing in I^2C Mode 21
Figure 13. Hardware Mode Data Flow 37
Figure 14. Professional Input Circuit 46
Figure 15. Transformerless Professional Input Circuit 46
Figure 16. Consumer Input Circuit 46
Figure 17. S/PDIF MUX Input Circuit 46
Figure 18. TTL/CMOS Input Circuit 46
Figure 19. Channel Status Data Buffer Structure 47
Figure 20. Flowchart for Reading the E Buffer 47

LIST OF TABLES

Table 1. Delays by Frequency Values 14
Table 2. External PLL Component Values 17
Table 3. GPO Pin Configurations 22
Table 4. Hardware Mode Serial Audio Format Select 41

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1 CHARACTERISTICS AND SPECIFICATIONS

POWER AND THERMAL CHARACTERISTICS

(AGND, DGND = 0 V, all voltages with respect to ground)

Parameter		Symbol	Min	Typ	Max	Unit
Power Supply Voltage		VA+	3.13	3.3	3.46	V
		VD+	3.13	3.3	3.46	V
		VL+	3.13	3.3	5.5	V
Supply Current at 48 KHz frame rate		IA	-	5.7	-	mA
		ID	-	5.9	-	mA
		IL	-	2.8	-	mA
Supply Current at 192 KHz frame rate	(Note 1)	IA	-	9.4	-	mA
		ID	-	23	-	mA
		IL	-	7.8	-	mA
Supply Current in Power Down		IA	-	10	-	uA
		ID	-	70	-	uA
		IL	-	10	-	uA
Ambient Operating Temperature: '-CS' & '-CZ'	(Note 2)	T_A	-10°	25°	70°	°C
'-IS' & '-IZ'	(Note 3)		-40°	-	85°	

Notes: 1. Assumes that no digital inputs are left floating. It is recommended that all digital inputs be driven high or low at all times.

2. '-CS' and '-CZ' parts are specified to operate over -10° C to 70° C but are tested at 25° C only.

3. '-IS' and '-IZ' parts are tested over the full -40° C to 85° C temperature range.

ABSOLUTE MAXIMUM RATINGS

(AGND, DGND = 0 V, all voltages with respect to ground)

Parameter	Symbol	Min	Max	Unit
Power Supply Voltage	VD+, VA+, VL+	-	6	Volts
Input Current, Any Pin Except Supplies (Note 4)	I_{in}	-10	10	mA
Input Voltage	V_{in}	-0.3	V_L +.03	Volts
Ambient Operating Temperature	T_A			
	CS8416-C	-10°	70°	°C
	CS8416-I	-40°	85°	°C

Notes: 4. Transient currents of up to 100mA will not cause SCR latch-up.

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DIGITAL CHARACTERISTICS

(T_A = 25 °C for suffixes 'CS' &'CZ', T_A = -40 to 85 °C for 'IS' & 'IZ' ; VA+ = VD+ = 3.3 V ± 5%, VL+ = 3.135 V to 5.5 V)

Parameter	Symbol	Min	Typ	Max	Units
High-Level Input Voltage except RX_n:	V_{IH}	2	-	(VL+)+0.3	Volts
Low-Level Input Voltage except RX_n:	V_{IL}	-0.3	-	0.8	Volts
Low-Level Output Voltage (I_O = 3.2 mA)	V_{OL}	-	-	0.5	Volts
High-Level Output Voltage (I_O = 3.2 mA)	V_{OH}	(VL+) - 1	-	VL+	Volts
Input hysteresis	V_H	0.25	-	1.0	Volts
Input Leakage Current	I_{IN}	-10	-	10	uA
Differential Input Sensitivity RXPn to RXN0		-	150	200	mV

SWITCHING CHARACTERISTICS

(T_A = 25 °C for suffixes 'CS' &'CZ', T_A = -40 to 85°C for 'IS' & 'IZ' ; VA+ = VD+ = 3.3 V ± 5%, VL+ = 3.135 V to 5.5 V, Inputs: Logic 0 = 0V, Logic 1 = VL+; C_L = 20 pF)

Parameter	Symbol	Min	Typ	Max	Units
RST/Pin Low Pulse Width		200	-	-	uS
PLL Clock Recovery Sample Rate Range		30	-	200	kHz
RMCK Output Jitter (Time Deviation)		-	-	200	ps RMS
RMCK Output Duty-Cycle		45	50	55	%

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SWITCHING CHARACTERISTICS - SERIAL AUDIO PORTS

(T_A = 25 °C for suffixes 'CS' & 'CZ', T_A = -40 to 85 °C for 'IS' & 'IZ' ; VA+ = VD+ = 3.3 V ± 5%, VL+ = 3.135 V to 5.5 V, Inputs: Logic 0 = 0 V, Logic 1 = VL+; C_L = 20 pF)

Parameter		Symbol	Min	Typ	Max	Units
OSCLK Active Edge to SDOUT Output Valid	(Note 5)	t_{dpd}	-	-	15	ns
Master Mode						
RMCK to OSCLK active edge delay	(Note 5)	t_{smd}	0	-	10	ns
RMCK to OLRCK delay	(Note 6)	t_{lmd}	0	-	10	ns
OSCLK and OLRCK Duty Cycle			-	50	-	%
Slave Mode						
OSCLK Period		t_{sckw}	36	-	-	ns
OSCLK Input Low Width		t_{sckl}	14	-	-	ns
OSCLK Input High Width		t_{sckh}	14	-	-	ns
OSCLK Active Edge to OLRCK Edge	(Notes 5,6,7)	t_{lrckd}	10	-	-	ns
OSCLK Edge Setup Before OSCLK Active-Edge	(Notes 5,6,8)	t_{lrcks}	10	-	-	ns

Notes:
5. In Software mode the active edges of OSCLK are programmable.
6. In Software mode the polarity of OLRCK is programmable.
7. This delay is to prevent the previous OSCLK edge from being interpreted as the first one after OLRCK has changed.
8. This setup time ensures that this OSCLK edge is interpreted as the first one after OLRCK has changed.

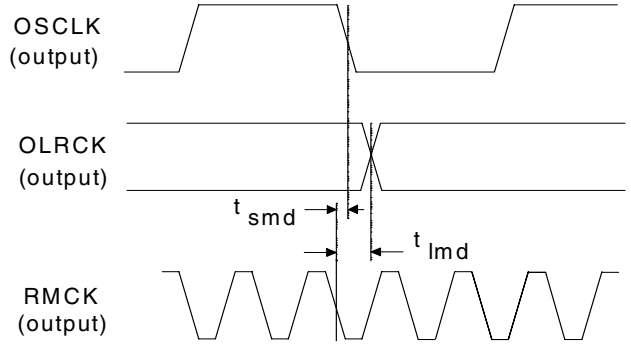

Figure 1. Audio Port Master Mode Timing

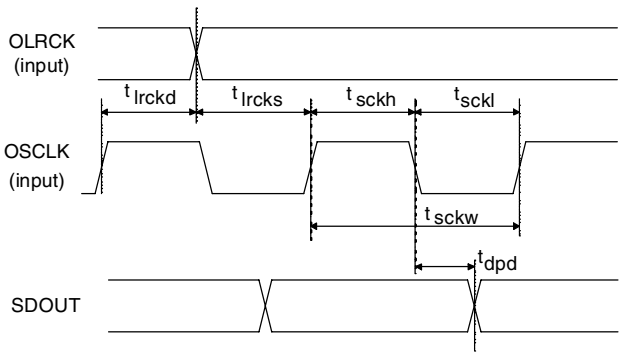

Figure 2. Audio Port Slave Mode and Data Input Timing

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SWITCHING CHARACTERISTICS - CONTROL PORT - SPI MODE

(T_A = 25 °C for suffixes 'CS' &'CZ', T_A = -40 to 85°C for 'IS' & 'IZ' ; VA+ = VD+ = 3.3 V ± 5%, VL+ = 3.135 to 5.5V, Inputs: Logic 0 = 0 V, Logic 1 = VL+; C_L = 20 pF)

Parameter		Symbol	Min	Max	Unit
CCLK Clock Frequency	(Note 9)	f_{sck}	0	6.0	MHz
$\overline{CS}$ High Time Between Transmissions		t_{csh}	1.0	-	µs
$\overline{CS}$ Falling to CCLK Edge		t_{css}	20	-	ns
CCLK Low Time		t_{scl}	66	-	ns
CCLK High Time		t_{sch}	66	-	ns
CDIN to CCLK Rising Setup Time		t_{dsu}	40	-	ns
CCLK Rising to DATA Hold Time	(Note 10)	t_{dh}	15	-	ns
CCLK Falling to CDOUT Stable		t_{pd}	-	50	ns
Rise Time of CDOUT		t_{r1}	-	25	ns
Fall Time of CDOUT		t_{f1}	-	25	ns
Rise Time of CCLK and CDIN	(Note 11)	t_{r2}	-	100	ns
Fall Time of CCLK and CDIN	(Note 11)	t_{r2}	-	100	ns

Notes: 9. If Fs is lower than 46.875 kHz, the maximum CCLK frequency should be less than 128 Fs. This is dictated by the timing requirements necessary to access the Channel Status memory. Access to the control register file can be carried out at the full 6 MHz rate. The minimum allowable input sample rate is 32 kHz, so choosing CCLK to be less than or equal to 4.1 MHz should be safe for all possible conditions.

10. Data must be held for sufficient time to bridge the transition time of CCLK.

11. For f_{sck} <1 MHz.

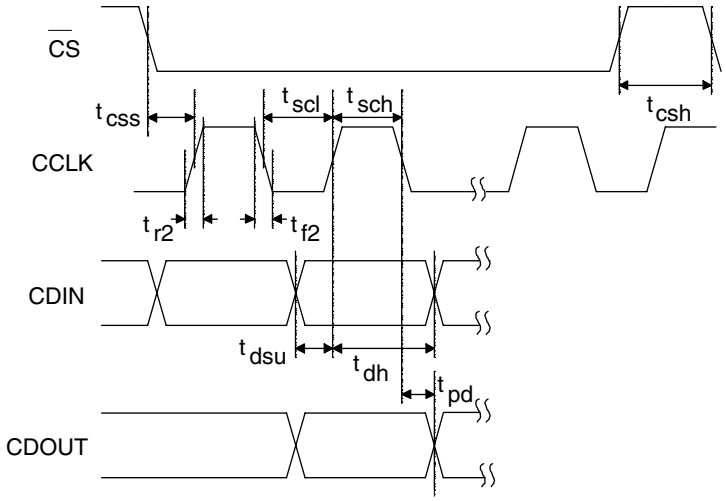

Figure 3. SPI Mode Timing

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SWITCHING CHARACTERISTICS - CONTROL PORT- I²C FORMAT

(T_A = 25° C; VA+ = VD+ = 3.3 V ± 5%, VL = 3.135 V to 5.5 V Inputs: Logic 0 = GND, Logic 1 = VL, C_L = 20 pF)

Parameter	Symbol	Min	Max	Unit
SCL Clock Frequency	f_{scl}	-	100	kHz
Bus Free Time Between Transmissions	t_{buf}	4.7	-	µs
Start Condition Hold Time (prior to first clock pulse)	t_{hdst}	4.0	-	µs
Clock Low time	t_{low}	4.7	-	µs
Clock High Time	t_{high}	4.0	-	µs
Setup Time for Repeated Start Condition	t_{sust}	4.7	-	µs
SDA Hold Time from SCL Falling (Note 12)	t_{hdd}	10	-	ns
SDA Setup time to SCL Rising	t_{sud}	250	-	ns
Rise Time of SCL and SDA	t_r	-	25	ns
Fall Time SCL and SDA	t_f	-	25	ns
Setup Time for Stop Condition	t_{susp}	4.7	-	µs

Notes: 12. Data must be held for sufficient time to bridge the 25 ns transition time of SCL.

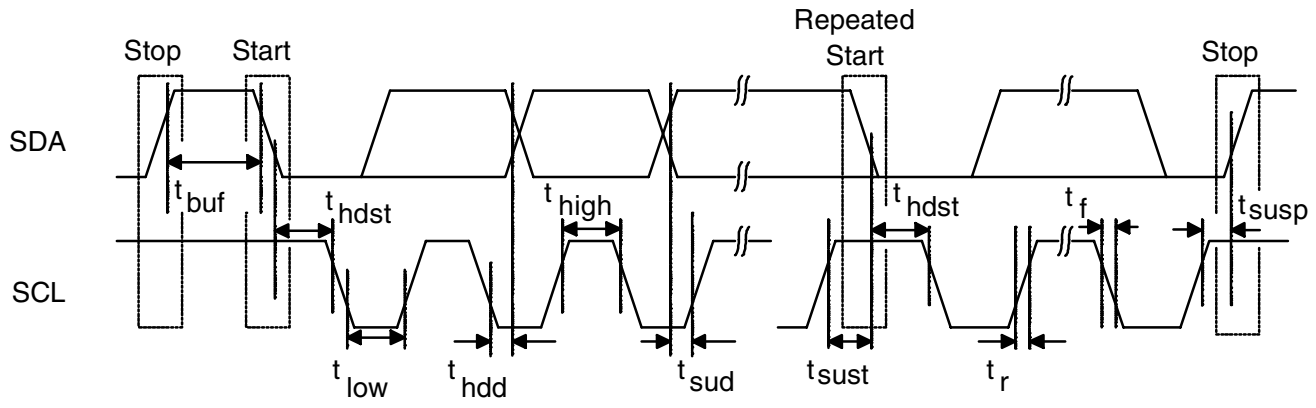

Figure 4. I²C Mode Timing

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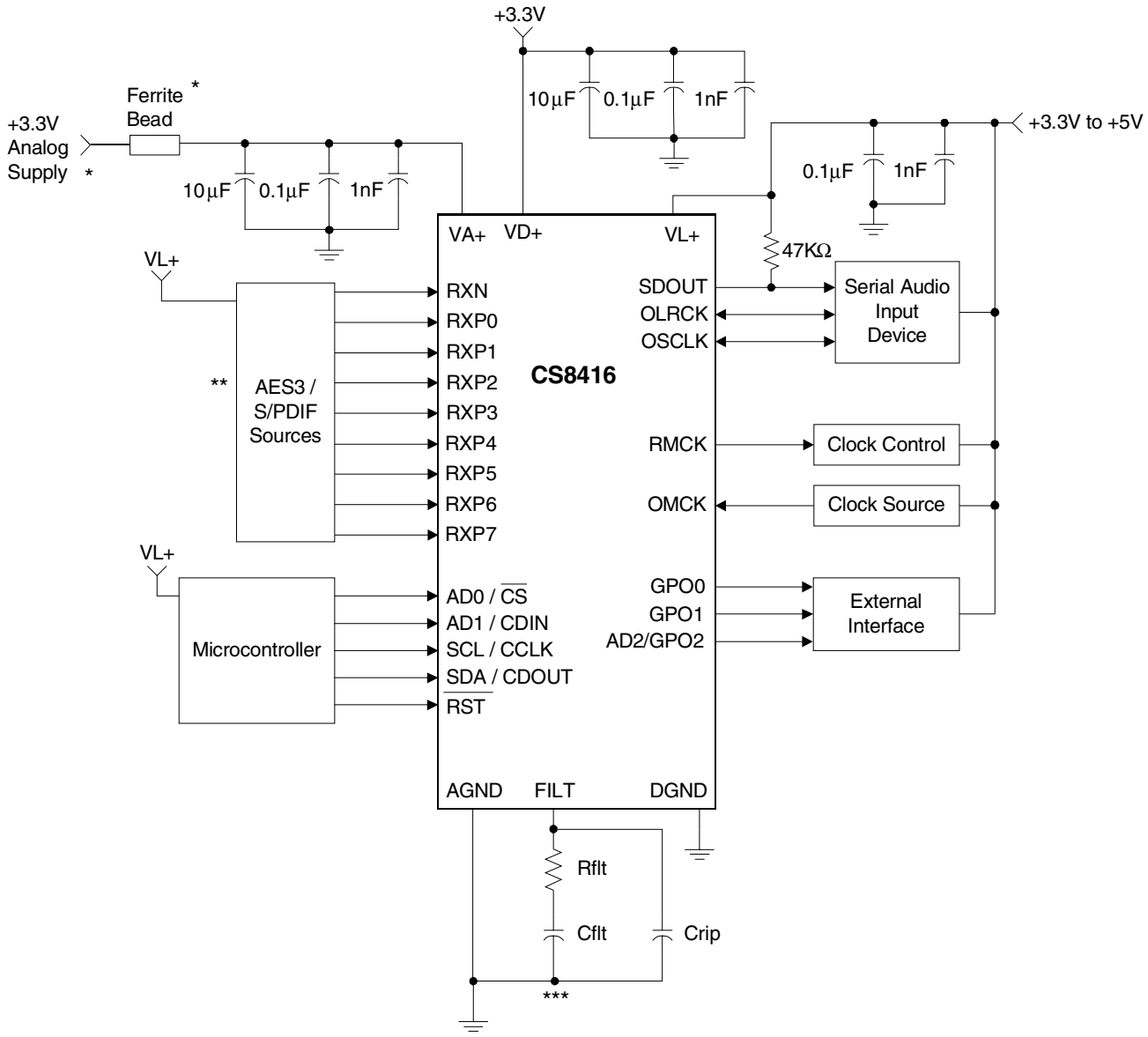
2 TYPICAL CONNECTION DIAGRAMS



* A seperate analog supply is only necessary in applications where RMCK is used for a jitter sensitive tast. For applications where RMCK is not used for a jitter sensitive task, connect VA+ to VD+ via a ferrite bead. Keep decoupling capacitors between VA+ and AGND.

** Please see section 5.1 "8:2 S/PDIF Input Multiplexer" and Appendix A for typical input configurations and recommended input circuits.

*** For best jitter performance connect the filter ground directly to the AGND pin. See Table 2 for PLL filter values.

Figure 5. Typical Connection Diagram - Software Mode

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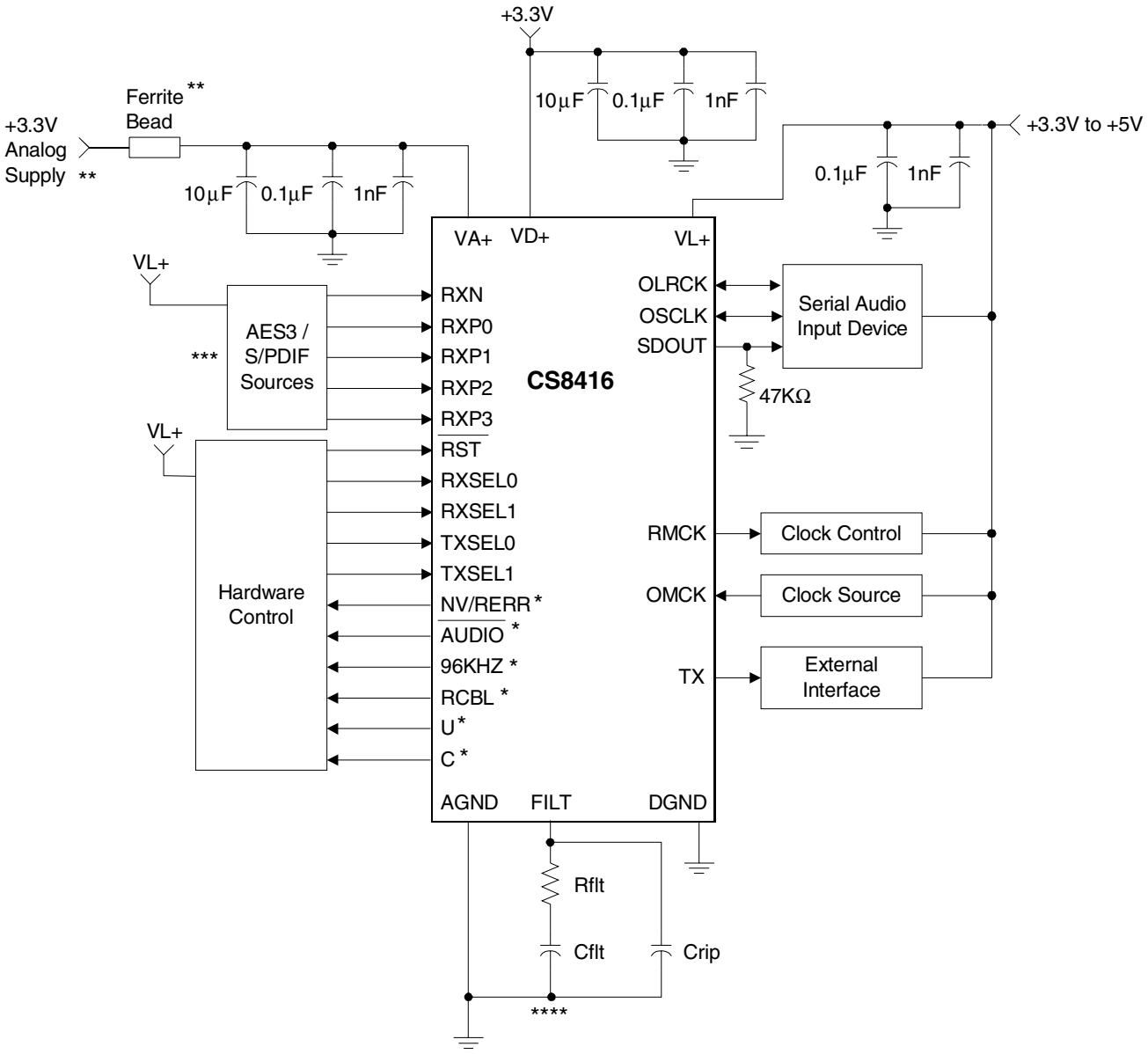

* These pins must be pulled high to VL+ or low to DGND through a 47KΩ resistor.

** A seperate analog supply is only necessary in applications where RMCK is used for a jitter sensitive tast. For applications where RMCK is not used for a jitter sensitive task, connect VA+ to VD+ via a ferrite bead. Keep decoupling capacitors between VA+ and AGND.

*** Please see section 5.1 "8:2 S/PDIF Input Multiplexer" and Appendix A for typical input configurations and recommended input circuits.

**** For best jitter performance connect the filter ground directly to the AGND pin. See Table 2 for PLL filter values.

Figure 6. Typical Connection Diagram - Hardware Mode

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3 GENERAL DESCRIPTION

The CS8416 is a monolithic CMOS device which receives and decodes audio data according to the AES3, IEC60958, S/PDIF, and EIAJ CP1201 interface standards.

The CS8416 utilizes an 8:2 multiplexer to select between eight inputs for decoding and to allow an input signal to be routed to an output of the CS8416. Input data is either differential or single-ended. A low jitter clock is recovered from the incoming data using a PLL. The decoded audio data is output through a configurable, 3-wire output port. The channel status and Q-channel subcode portion of the user data are assembled in registers and may be accessed through an SPI or I^2C port.

Three General Purpose Output (GPO) pins are provided to allow a variety of signals to be accessed under software control. In hardware mode, dedicated pins are used to select audio stream inputs for decoding and transmission to a dedicated TX pin. Hardware mode also allows direct access to channel status and user data output pins.

Figure 5 and Figure 6 show the power supply and external connections to the CS8416 when configured for software and hardware modes. Please note that all I/O pins, including RXN and RXP[7:0], operate at the VL+ voltage.

3.1 AES3 and S/PDIF Standards Documents

This document assumes that the user is familiar with the AES3 and S/PDIF data formats. It is advisable to have current copies of the AES3, IEC60958, and IEC61937 specifications on hand for easy reference.

The latest AES3 standard is available from the Audio Engineering Society or ANSI at www.aes.org or at www.ansi.org. Obtain a copy of the latest IEC60958/61937 standard from ANSI or from the International Electrotechnical Commission at www.iec.ch. The latest EIAJ CP-1201 standard is available from the Japanese Electronics Bureau.

Application Note 22: *Overview of Digital Audio Interface Data Structures* contains a useful tutorial on digital audio specifications, but it should not be considered a substitute for the standards.

The paper *An Understanding and Implementation of the SCMS Serial Copy Management System for Digital Audio Transmission*, by Clifton Sanchez, is an excellent tutorial on SCMS. It is available from the AES as reprint 3518.

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4 SERIAL AUDIO OUTPUT PORT

A 3-wire serial audio output port is provided. The port can be adjusted to suit the attached device setting the control registers. The following parameters are adjustable: master or slave, serial clock frequency, audio data resolution, left or right justification of the data relative to left/right clock, optional one-bit cell delay of the first data bit, the polarity of the bit clock, and the polarity of the left/right clock. By setting the appropriate control bits, many formats are possible.

Figure 8 shows a selection of common output formats, along with the control bit settings. A special AES3 direct output format is included, which allows the serial output port access to the V, U, and C bits embedded in the serial audio data stream. The P bit, which would normally be a parity bit, is replaced by a Z bit, which is used to indicate the start of each block. The received channel status block start signal is also available as the RCBL pin in hardware mode and through a GPO pin in software mode.

In master mode, the left/right clock (OLRCK) and the serial bit clock (OSCLK) are outputs, derived from the recovered RMCK clock. In slave mode, OLRCK and OSCLK are inputs. OLRCK is normally synchronous to the appropriate master clock, but OSCLK can be asynchronous and discontinuous if required. By appropriate phasing of OLRCK and control of the serial clocks, multiple CS8416's can share one serial port. OLRCK should be continuous, but the duty cycle can be less than the specified typical value of 50% if enough serial clocks are present in each phase to clock all the data bits. When in slave mode, the serial audio output port cannot be set for right-justified data. The CS8416 allows immediate mute of the serial audio output port audio data by the MUTESAO bit of Control Register 1.

4.1 Slip/Repeat Behavior

When using the serial audio output port in slave mode with an OLRCK input that is asynchronous to the incoming AES3 data, the interrupt bit OSLIP (bit 5 in the Interrupt 1 Status register, 0Dh) is provided to indicate when repeated or dropped samples occur. Refer to Figure 7 for a AES3 data format diagram.

When the serial output port is configured as slave, depending on the relative frequency of OLRCK to the input AES3 data (Z/X) preamble frequency, the data will be slipped or repeated at the output of the CS8416.

After a fixed delay from the Z/X preamble (a few periods of the internal clock, which is running at 256Fs), the circuit will look back in time until the previous Z/X preamble:

1) If during that time, the internal data buffer was not updated, then a slip has occurred. Data from the previous frame will be output and OSLIP will be set to 1. Due to the OSLIP bit being "sticky," it will remain 1 until the register is read. It will then be reset until another slip/repeat condition occurs.

2) If during that time the internal data buffer did not update between two positive or negative edges (depending on OLRPOL) of OLRCK, then a repeat has occurred. In this case the buffer data was updated twice, so the part has lost one frame of data. This event will also trigger OSLIP to be set to 1. Due to the OSLIP bit being "sticky," it will remain 1 until the register is read. It will then be reset until another slip/repeat condition occurs.

3) If during that time, it did see a positive edge on OLRCK (or negative edge if the SOLRPOL is set to 1) then no slip or repeat has happened. Due to the OSLIP bit being "sticky," it will remain in its previous state until either the register is read or a slip/repeat condition occurs.

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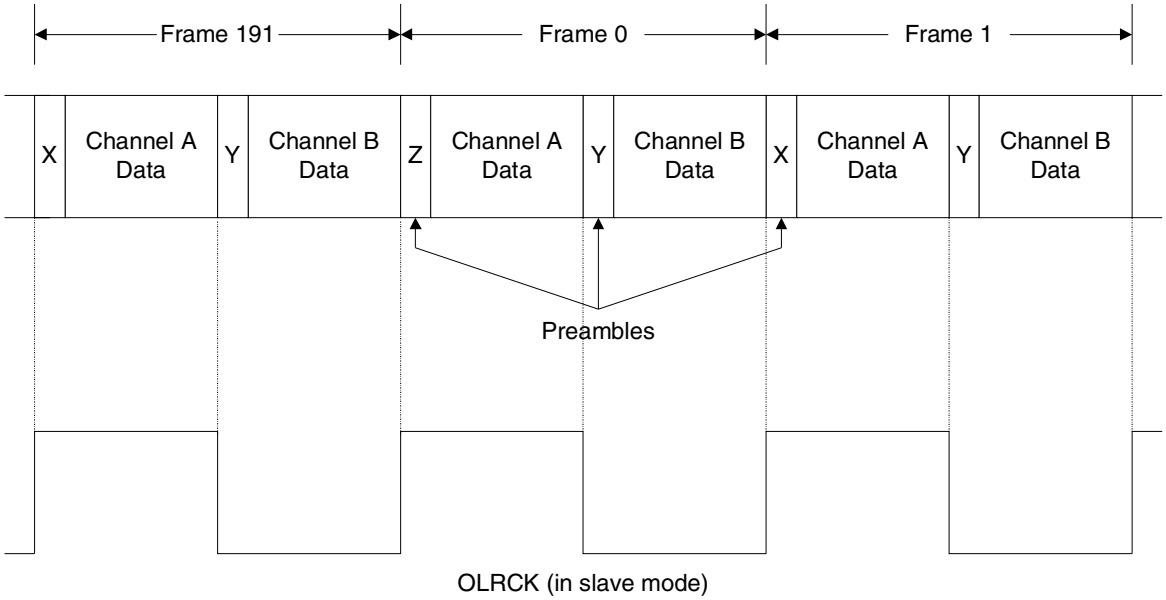

Figure 7. AES3 Data Format

If the user reads OSLIP as soon as the event triggers, over a long period of time the rate of occurring INT will be equal to the difference in frequency between the input AES data and the slave serial output LRCK. The CS8416 uses a hysteresis window when a slip/repeat event occurs. The slip/repeat is triggered when an edge of OLRCK passes a window size from the beginning of the Z/X preamble. Without the hysteresis window, jitter on OLRCK with a frequency very close to Fs could slip back and forth, causing multiple slip/repeat events. The CS8416 uses a hysteresis window to ensure that only one slip/repeat happens even with jitter on OLRCK.

4.2 AES11 Behavior

When OLRCK is configured as a master, the positive or negative edge of OLRCK (depending on the setting of SOLRPOL in register 05h) will be within -1.0%(1/Fs) to 1.1%(1/Fs) from the start of the preamble X/Z. In master mode, the latency through the part is dependent on the input sample frequency. The delay through the part from the beginning of the preamble to the active edge of OLRCK for the various sample frequencies is given in Table 1. In master mode without the de-emphasis filter engaged, the latency of the audio data will be 3 frames.

Fs (kHz)	Delay (ns)
32	96.6
44.1	78.6
48	74.6
64	60.6
96	50.6
192	TBD

Table 1. Delays by Frequency Values

When OLRCK is configured as a slave any synchronized input within +/-28%(1/Fs) from the positive or negative edge of OLRCK (depending on the setting of SOLRPOL in register 05h) will be treated as being sampled at the same time. Since the CS8416 has no control of the OLRCK in slave mode, the latency of the data through the part will be a multiple of 1/Fs plus the delay between OLRCK and the preambles.

Both of these conditions are within the tolerance range set forth in the AES11 standard.

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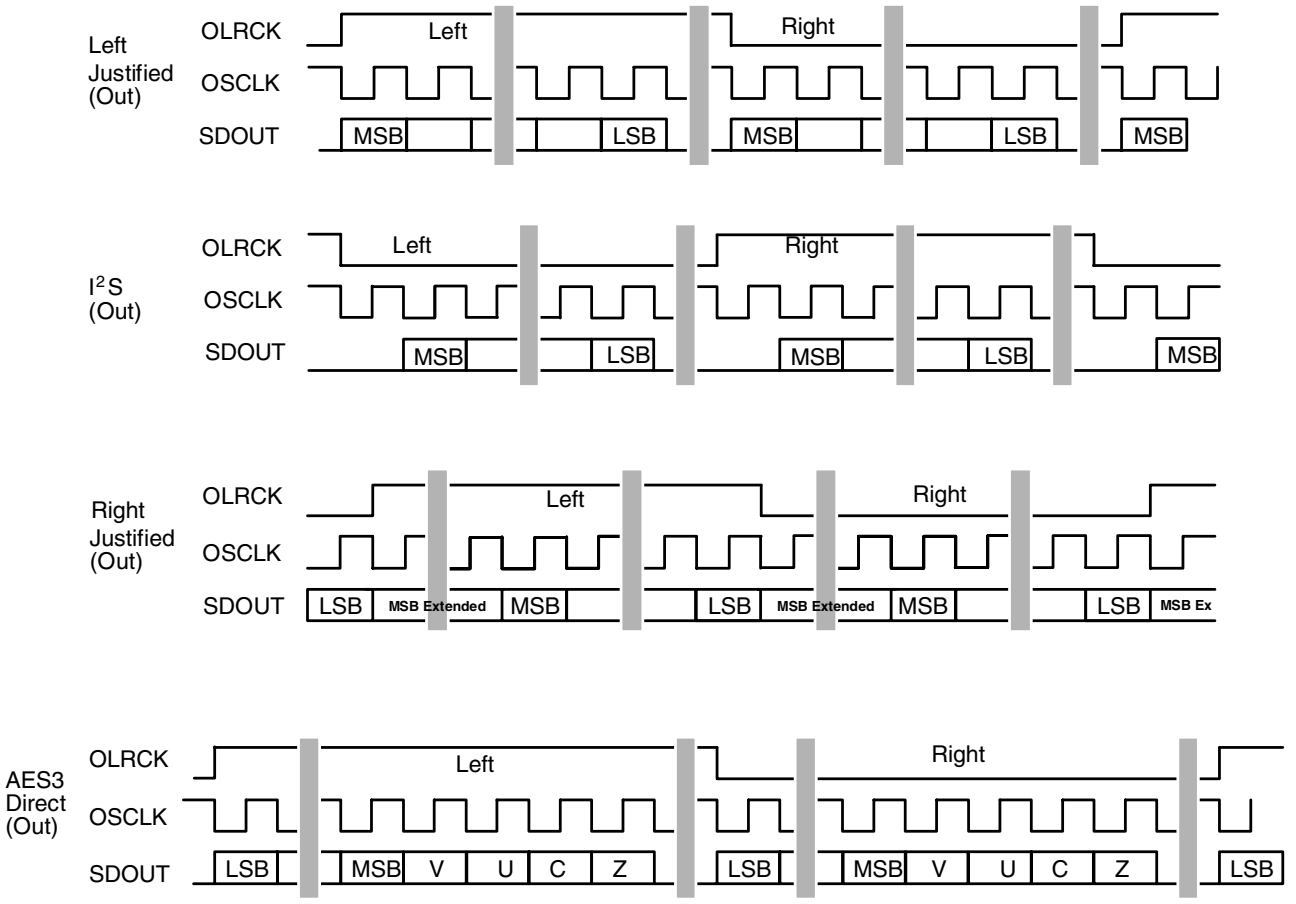

	SOMS*	SOSF*	SORES[1:0]*	SOJUST*	SODEL*	SOSPOL*	SOLRPOL*
Left Justified	X	X	XX	0	0	0	0
I^2S	X	X	XX	0	1	0	1
Right Justified	1	X	XX	1	0	0	0
AES3 Direct	X	X	11	0	0	0	0

X = don't care to match format, but does need to be set to the desired setting

* See Serial Output Data Format Register Bit Descriptions for an explanation of the meaning of each bit

Figure 8. Serial Audio Output Example Formats

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5 S/PDIF RECEIVER

The CS8416 includes an AES3/SPDIF digital audio receiver. The AES3 receiver accepts and decodes audio and digital data according to the AES3, IEC60958 (S/PDIF), and EIAJ CP-1201 interface standards. The receiver consists of an analog differential input stage, driven through analog input pins RXP0 to RXP7 and a common RXN, a PLL based clock recovery circuit, and a decoder which separates the audio data from the channel status and user data.

Software Mode

The first 5 bytes of both channels status block is stored in dedicated registers. Channel A status data is stored in control port registers 19h to 1Dh. Channel B status data is stored in control port registers 1Eh to 22h.

Q Subcode data is stored in control port registers 0Eh to 17h.

PC Burst preamble is stored in control port registers 23h and 24h. PD Burst preamble is stored in control port registers 25h and 26h.

U and C data may be selected for output on GPO pins.

External components are used to terminate and isolate the incoming data cables from the CS8416. These components are detailed in Appendix A.

Hardware Mode

U and C bits are output on pins 18 and 19 respectively. See Section "Hardware Mode Function Selection" on page 40 and "Hardware Mode Settings (Defaults & Controls)" on page 40 to configure these pins.

5.1 8:2 S/PDIF Input Multiplexer

The CS8416 employs a 8:2 S/PDIF input multiplexer to accommodate up to eight channels of input digital audio data. Digital audio data may be single- ended or differential. Differential inputs utilize RXP[0-7] and a shared RXN. Single ended signals are accommodated by using RXP inputs and AC coupling RXN to ground.

All inputs to the CS8416 8:2 input multiplexer should be coupled through a capacitor. The recommended capacitor value is 0.01uF to 0.1uF. The recommended dielectrics are COG or X7R.

Software Mode

The multiplexer select line control is accessed through bits RXSEL[2:0] in control port register 4. The multiplexer defaults to RXP0.

The second output of the input multiplexer is used to provide the selected input as a source to be output on a GPO pin via the internal TX pin. This pass through signal is selected by TXSEL[2:0] in control port register 04h. The single-ended signal is resolved to full-rail, but is not de-jittered before it is output.

Hardware Mode

In hardware mode the input to the decoder is selected by dedicated pins, RXSEL[1:0].

The pass through signal is selected by dedicated pins, TXSEL[1:0] for output on the dedicated TX pin.

Selectable inputs are restricted to RXP0 to RXP3 for both the receiver and the TX output pin. These inputs are selected by RXSEL[1:0] and TXSEL[1:0] respectively.

General

Unused multiplexer inputs should be left floating or grounded.

The input voltage range for the input multiplexer is set by the I/O power supply pin, VL+. The input voltage of the RXP and RXN pins is also set by the level of VL+.

5.2 PLL, Jitter Attenuation, and Clock Switching

An on-chip Phase Locked Loop (PLL) is used to recover the clock from the incoming data stream.

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There are some applications where low jitter in the recovered clock, presented on the RMCK pin, is important. For this reason, the PLL has been designed to have good jitter attenuation characteristics. In addition, the PLL has been designed to only use the preambles of the AES3 or S/PDIF stream to provide lock update information to the PLL. This results in the PLL being immune to data dependent jitter affects because the AES3 or S/PDIF preambles do not vary with the data.

In applications where jitter must be minimized, special attention should be given to reducing the noise on the analog power supply and ground for the PLL filter components. Connecting the filter components directly to AGND will help decrease jitter.

The PLL has the ability to lock onto a wide range of input sample rates with no external component changes.

5.2.1 OMCK System Clock Mode

A special clock switching mode is available that allows the OMCK clock input to replace RMCK when the PLL becomes unlocked.

In Software mode this feature is enabled by setting SWCLK bit in Control1 register to a "1".

In Hardware Mode this feature is always active.

Clock switching is accomplished without spurious transitions or glitches on RMCK.

OSCLK and OLRCK are derived from the OMCK input when the clock has been switched and the serial port is in master mode.

When the PLL loses lock, the frequency of the VCO drops to ~500 kHz. When this system clock mode is not enabled, the OSCLK and OLRCK will be based on the VCO when the PLL is not locked

5.2.2 PLL External Components

The PLL behavior is affected by the external filter component values. Figure 5 and Figure 6 show the recommended configuration of the two capacitors and one resistor required. There are two sets of component values recommended, depending on the sample rate of the application. (See Table 2.) The default set, called "fast", accommodates input sample rates of 96 KHz to 192 Hz with no component changes. It has the highest corner frequency jitter attenuation curve, and takes the shortest time to lock. The alternate component set, called "medium" allows the lowest input sample rate to be 32 kHz, and increases the lock time of the PLL. Lock times are worst case for an Fs transition from unlocked state to locking to 192 kHz.

Range (kHz)	Rflt	Cflt	Crip	Settling Time	
32 - 192	1 KΩ	220 nF	10 nF	11ms	medium
96 - 192	3 KΩ	22 nF	1 nF	4ms	fast

Table 2. External PLL Component Values

It is important to treat the PLL FLT pin as a low level analog input. It is suggested that the ground end of the PLL filter be returned directly to the AGND pin independently of the digital ground plane.

5.3 Error Reporting and Hold Function

Software Mode

While decoding the incoming AES3 data stream, the CS8416 can identify several kinds of error, indicated in the Receiver Error register (0Ch).

The errors indicated are:

1) QCRC – CRC error in Q subcode data
2) CCRC – CRC error in channel status data
3) UNLOCK – PLL is not locked to incoming data stream
4) V – Data Validity bit is set
5) CONF – Input data stream is near error condition due to jitter degradation
6) BIP – Biphase encoding error
7) PAR – Parity error in incoming data

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The error bits are "sticky"; they are set on the first occurrence of the associated error and will remain set until the user reads the register through the control port. This enables the register to log all unmasked errors that occurred since the last time the register was read.

As a result of the bits "stickiness", it is necessary to perform two reads on these registers to see if the error condition still exists.

The Receiver Error Mask register (06h) allows masking of individual errors. The bits in this register default to 00h and serve as masks for the corresponding bits of the Receiver Error register. If a mask bit is set to 1, the error is unmasked, which implies the following: its occurrence will be reported in the receiver error register, induce a pulse on RERR, invoke the occurrence of a RERR interrupt, and affect the current audio sample according to the status of the HOLD bits. The exceptions are the QCRC and CCRC errors, which do not affect the current audio sample, even if unmasked.

The HOLD bits allow a choice of:

- Holding the previous sample
- Replacing the current sample with zero (mute)

OR

- Not changing the current audio sample

RERR – The logical OR of all unmasked receiver error bits, not 'sticky". RERR may be selected for output on a GPO pin.

NVERR – Non-Validity Receiver error

Hardware Mode

In Hardware mode the user may choose between NVERR or RERR by pulling the NV/RERR pin low or high respectively.

5.4 Channel Status Data Handling

Software Mode

The first 5 bytes of the Channel Status block are decoded into the Receiver Channel Status Registers 19h - 22h. Registers 19h - 1Dh contain the A channel status data. Registers 1Eh - 22h contain the B channel status data.

The $\overline{\text{EMPH}}$, C, and U bits may be selected on GPO pins by appropriately setting the GPOxSEL bits in control port registers 02h and 03h.

The encoded channel status bits which indicate sample word length are decoded according to AES3-1992 or IEC 60958. The number of auxiliary bits are reported in bits 7 to 4 of the Receiver Channel Status register.

Appendix B describes the overall handling of Channel Status and User data.

5.5 User Data Handling

Received User data may also be output to the U pin under the control of a control register bit. VLRCK (a virtual word clock, available through GPO pins, that can used to frame the C/U output) and OLRCK in serial port master mode can be made available to qualify the U data output in software mode. Figure 9 illustrates the timing. In hardware mode, only OLRCK in master mode is available to qualify the U output. If the incoming user data bits have been encoded as Q- channel subcode, the data is decoded, buffered, and presented in 10 consecutive register locations. An interrupt may be enabled to indicate the decoding of a new Q-channel block, which may be read through the control port.

5.5.1 Non-Audio Auto-Detection

An AES3 data stream may be used to convey non-audio data, thus it is important to know whether the incoming AES3 data stream is digital audio or not. This information is typically conveyed in channel status bit 1 ($\overline{\text{AUDIO}}$), which is extracted automatically by the CS8416. However, certain non-audio sources, such as AC-3 or MPEG encoders, may not adhere to this convention, and the bit may not be properly set. The CS8416 AES3 receiver can detect such non-audio data through the use of an autodetect module. The autodetect module is similar to

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autodetect software used in Cirrus Logic DSPs. If the AES3 stream contains sync codes in the proper format for IEC61937 or DTS data transmission, an internal AUTODETECT signal will be asserted. If the sync codes no longer appear after a certain amount of time, autodetection will time-out and AUTODETECT will be de-asserted until another format is detected. In Hardware Mode, the $\overline{\text{AUDIO}}$ pin is the logical OR of AUTODETECT and the received channel status bit 1. In Software mode the $\overline{\text{AUDIO}}$ pin is available through the GPO pins. Also, the specific data or audio format found by the autodetect module is available in register 0Bh. Additionally, the Pc/Pd burst preambles are available in registers 23h-26h. If non-audio data is detected, the data is still processed exactly as if it were normal audio. The exception is the use of de-emphasis auto-select feature which will bypass the de-emphasis filter if the input stream is detected to be non-audio. It is up to the user to mute the outputs as required.

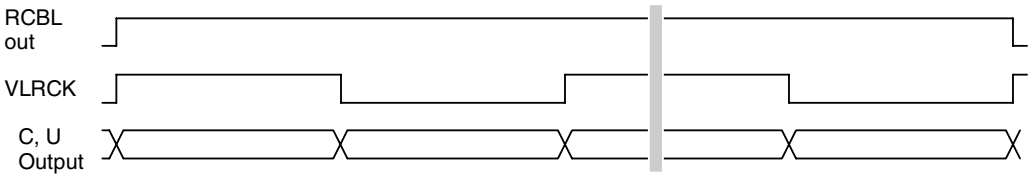

Figure 9. C/U data outputs

RCBL goes high 2 frames after receipt of a Z pre-amble, and is high for 16 frames.
VLRCK is a virtual word clock, available through GPO pins, that can used to frame the C/U ouput.
VLRCK duty cycle is 50%. VLRCK frequency is always equal to the incoming frame rate.
If the serial audio output port is in master mode, VLRCK = OLRCK.
C, U transitions are aligned within ±1% of VLRCK period to VLRCK edges

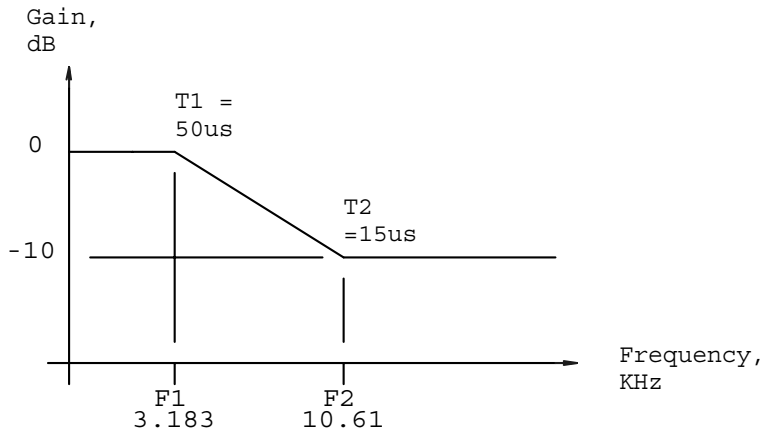

Figure 10. De-emphasis filter

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6 CONTROL PORT DESCRIPTION AND TIMING

The control port is used to access the registers, allowing the CS8416 to be configured for the desired operational modes and formats. In addition, Channel Status and User data may be read through the control port. The operation of the control port may be completely asynchronous with respect to the audio sample rates. However, to avoid potential interference problems, the control port pins should remain static if no operation is required.

The control port has 2 modes: SPI and I^2C, with the CS8416 acting as a slave device in both modes. SPI mode is selected if there is a high to low transition on the AD0/$\overline{CS}$ pin, after the $\overline{RST}$ pin has been brought high. I^2C mode is selected by connecting the AD0/$\overline{CS}$ pin to VL+ or DGND, thereby permanently selecting the desired AD0 bit address state.

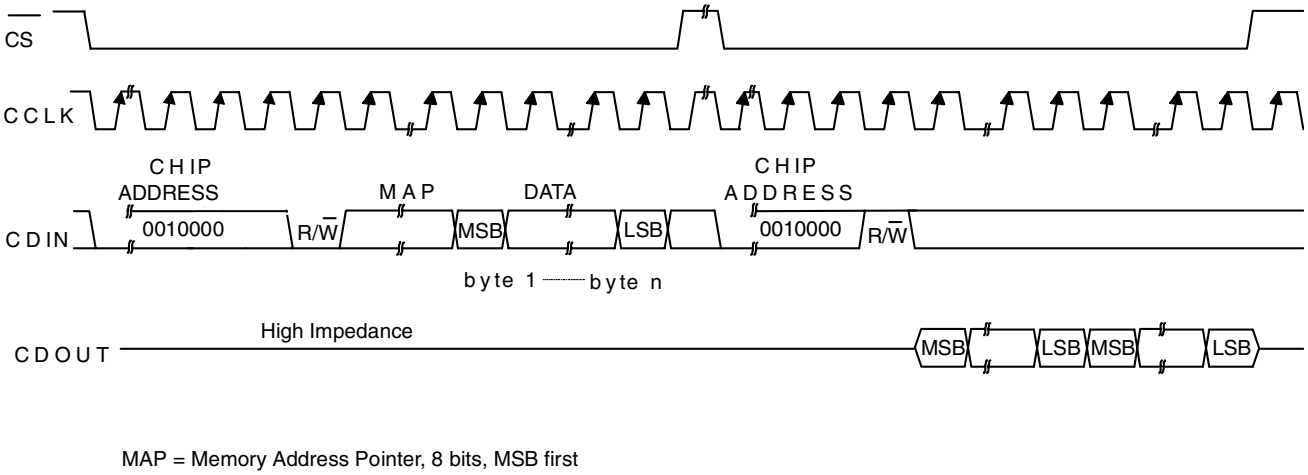
6.1 SPI Mode

In SPI mode, $\overline{CS}$ is the CS8416 chip select signal, CCLK is the control port bit clock (input into the CS8416 from the microcontroller), CDIN is the input data line from the microcontroller, CDOUT is the output data line to the microcontroller. Data is clocked in on the rising edge of CCLK and out on the falling edge.

Figure 11 shows the operation of the control port in SPI mode. To write to a register, bring $\overline{CS}$ low. The first seven bits on CDIN form the chip address and must be 0010000. The eighth bit is a read/write indicator (R/$\overline{W}$), which should be low to write. The next eight bits form the Memory Address Pointer (MAP), which is set to the address of the register that is to be updated. The next eight bits are the data which will be placed into the register designated by the MAP. During writes, the CDOUT output stays in the Hi-Z state. It may be externally pulled high or low with a 47 KΩ resistor, if desired.

There is a MAP auto increment capability, enabled by the INCR bit in the MAP register. If INCR is a zero, the MAP will stay constant for successive read or writes. If INCR is set to a 1, the MAP will auto increment after each byte is read or written, allowing block reads or writes of successive registers. In the autoincrement mode, the MAP is incremented in a linear fashion. Allowance must be made for unused registers.

To read a register, the MAP has to be set to the correct address by executing a partial write cycle which finishes ($\overline{CS}$ high) immediately after the MAP byte. The MAP auto increment bit (INCR) may be set or not, as desired. To begin a read, bring $\overline{CS}$ low, send out the chip address and set the



MAP = Memory Address Pointer, 8 bits, MSB first

Figure 11. Control Port Timing In SPI Mode

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read/write bit (R/$\overline{W}$) high. The next falling edge of CCLK will clock out the MSB of the addressed register (CDOUT will leave the high impedance state). If the MAP auto increment bit is set to 1, the data for successive registers will appear consecutively.

The auto increment function is strictly linear. This may result in operations on undefined registers. Reads from undefined registers will produce indeterminate results. Writing to undefined registers will be ignored.

6.2 I²C Mode

In I²C mode, SDA is a bidirectional data line. Data is clocked into and out of the part by the clock, SCL, with the clock to data relationship as shown in Figure 12. There is no $\overline{CS}$ pin. Each individual CS8416 is given a unique address. Pins AD0 and AD1 form the two least significant bits of the chip address and should be connected to VL+ or DGND as desired. The GPO2 pin is used to set the AD2 bit by connecting a 47K resistor from the GPO2 pin to VL+ or to DGND. The state of the pin is sensed while the CS8416 is being reset. The upper 4 bits of the 7-bit address field are fixed at 0010. To communicate with a CS8416, the chip address field, which is the first byte sent to the CS8416, should match 0010 followed by the settings of the GPO2, AD1, and AD0. The eighth bit of the address is the R/$\overline{W}$ bit. If the operation is a write, the next byte is the Memory Address Pointer (MAP) which selects the register to be read or written. If the operation is a read, the contents of the register pointed to by the MAP will be output. Setting the auto increment bit in MAP allows successive reads or writes of consecutive registers. Each byte is separated by an acknowledge bit. The ACK bit is output from the CS8416 after each input byte is read, and is input to the CS8416 from the microcontroller after each transmitted byte.

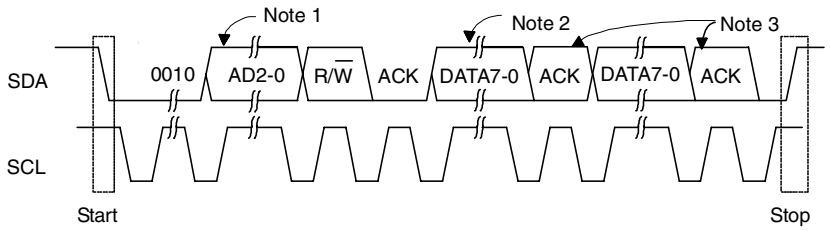

Figure 12. Control Port Timing in I²C Mode

Notes:
1. AD2 is derived from a resistor attached to the GPO2 pin. AD1 and AD0 are determined by the state of the corresponding pins.
2. If operation is a write, this byte contains the Memory Address Pointer, MAP.
3. If operation is a read, the last bit of the read should be NACK (high).

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6.3 General Purpose Outputs

Three General Purpose outputs are provided to allow the equipment designer flexibility in configuring the CS8416.

Fourteen signals are available to be routed to the GPOs.

GPO pins may be configured to provide the following data:

Function	Code	Definition
TX	0000	AES/SPDIF input selected by TXSEL[2:0]
$\overline{\text{EMPH}}$	0001	State of EMPH bit in incoming stream. Same polarity as EMPHb bit.
INT	0010	CS8416 interrupt
C	0011	Channel status bit
U	0100	User data bit
RERR	0101	Receiver Error
NVERR	0110	Non-Validity Receiver Error
RCBL	0111	Receiver Channel Status Block
96KHZ	1000	Input $F_S \geq 88.1$
$\overline{\text{AUDIO}}$	1001	Non-audio indicator for decoded input stream
VLRCK	1010	Virtual LRCK
GND	1011	Fixed low Level
VDD	1100	VDD fixed high level
HRMCK	1101	F_S X 512 (Note 13)

Codes 1110 to 1111 - Reserved

Table 3. GPO Pin Configurations

Notes: 13. Frequency = 25 MHz Max, duty cycle not guaranteed, target duty cycle = 50% @ F_S = 48 kHz.

6.4 Interrupts

The CS8416 has a comprehensive interrupt capability. The INT pin may be set to be active low, active high or active low with no active pull-up transistor. This last mode is used for active low, wired-OR hook- ups, with multiple peripherals connected to the microcontroller interrupt input pin.

Many conditions can cause an interrupt, as listed in the interrupt status register descriptions. Each source may be masked off through mask register bits. In addition, each source may be set to rising edge, falling edge, or level sensitive. Combined with the option of level sensitive or edge sensitive modes within the microcontroller, many different configurations are possible, depending on the needs of the equipment designer.

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7 CONTROL PORT REGISTER SUMMARY

Addr (HEX)	R/W	Function	7	6	5	4	3	2	1	0
00	R/W	Control 0	0	0	0	0	0	TRUNC	Reserved	Reserved
01	R/W	Control1	SWCLK	MUTSAO	INT1	INT0	HOLD1	HOLD0	RMCKF	CHS
02	R/W	Control2	DETCI	EMPH_CNTL2	EMPH_CNTL1	EMPH_CNTL0	GPO0SEL3	GPO0SEL2	GPO0SEL1	GPO0SEL0
03	R/W	Control3	GPO1SEL3	GPO1SEL2	GPO1SEL1	GPO1SEL0	GPO2SEL3	GPO2SEL2	GPO2SEL1	GPO2SEL0
04	R/W	Control4	RUN	RXD	RXSEL2	RXSEL1	RXSEL0	TXSEL2	TXSEL1	TXSEL0
05	R/W	Serial Audio Data Format	SOMS	SOSF	SORES1	SORES0	SOJUST	SODEL	SOSPOL	SOLR-POL
06	R/W	Receiver Error Mask	0	QCRCM	CCRCM	UNLOCKM	VM	CONFM	BIPM	PARM
07	R/W	Interrupt Mask	0	PCCHM	OSLIPM	DETCM	CCHM	RERRM	QCHM	FCHM
08	R/W	Interrupt Mode MSB	0	PCCH1	OSLIP1	DETC1	CCH1	RERR1	QCH1	FCH1
09	R/W	Interrupt Mode LSB	0	PCCH0	OSLIP0	DETC0	CCH0	RERR0	QCH0	FCH0
0A	R	Receiver Channel Status	AUX3	AUX2	AUX1	AUX0	PRO	COPY	ORIG	EMPH
0B	R	Audio Format Detect	0	PCM	IEC61937	DTS_LD	DTS_CD	Reserved	DGTL_SIL	96KHZ
0C	R	Receiver Error	0	QCRC	CCRC	UNLOCK	V	CONF	BIP	PAR
0D	R	Interrupt Status	0	PCCH	OSLIP	DETC	CCH	RERR	QCH	FCH
0E	R	Q-Channel Subcode [0:7]	CON-TROL	CON-TROL	CON-TROL	CON-TROL	ADDRESS	ADDRESS	ADDRESS	ADDRESS
0F	R	[8:15]	TRACK	TRACK	TRACK	TRACK	TRACK	TRACK	TRACK	TRACK
10	R	[16:23]	INDEX	INDEX	INDEX	INDEX	INDEX	INDEX	INDEX	INDEX
11	R	[24:31]	MINUTE	MINUTE	MINUTE	MINUTE	MINUTE	MINUTE	MINUTE	MINUTE
12	R	[32:39]	SECOND	SECOND	SECOND	SECOND	SECOND	SECOND	SECOND	SECOND
13	R	[40:47]	FRAME	FRAME	FRAME	FRAME	FRAME	FRAME	FRAME	FRAME
14	R	[48:55]	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO
15	R	[56:63]	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE
16	R	[64:71]	ABS SEC-OND	ABS SEC-OND	ABS SEC-OND	ABS SEC-OND	ABS SEC-OND	ABS SEC-OND	ABS SEC-OND	ABS SEC-OND
17	R	[72:79]	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME
18	R	OMCK_RMCK Ratio	ORR7	ORR6	ORR5	ORR4	ORR3	ORR2	ORR1	ORR0
19	R	Channel A Status	AC0[7]	AC0[6]	AC0[5]	AC0[4]	AC0[3]	AC0[2]	AC0[1]	AC0[0]
1A	R	Channel A Status	AC1[7]	AC1[6]	AC1[5]	AC1[4]	AC1[3]	AC1[2]	AC1[1]	AC1[0]
1B	R	Channel A Status	AC2[7]	AC2[6]	AC2[5]	AC2[4]	AC2[3]	AC2[2]	AC2[1]	AC2[0]
1C	R	Channel A Status	AC3[7]	AC3[6]	AC3[5]	AC3[4]	AC3[3]	AC3[2]	AC3[1]	AC3[0]
1D	R	Channel A Status	AC4[7]	AC4[6]	AC4[5]	AC4[4]	AC4[3]	AC4[2]	AC4[1]	AC4[0]
1E	R	Channel B Status	BC0[7]	BC0[6]	BC0[5]	BC0[4]	BC0[3]	BC0[2]	BC0[1]	BC0[0]
1F	R	Channel B Status	BC1[7]	BC1[6]	BC1[5]	BC1[4]	BC1[3]	BC1[2]	BC1[1]	BC1[0]
20	R	Channel B Status	BC2[7]	BC2[6]	BC2[5]	BC2[4]	BC2[3]	BC2[2]	BC2[1]	BC2[0]
21	R	Channel B Status	BC3[7]	BC3[6]	BC3[5]	BC3[4]	BC3[3]	BC3[2]	BC3[1]	BC3[0]
22	R	Channel B Status	BC4[7]	BC4[6]	BC4[5]	BC4[4]	BC4[3]	BC4[2]	BC4[1]	BC4[0]
23	R	Burst Preamble PC Byte 0	PC0[7]	PC0[6]	PC0[5]	PC0[4]	PC0[3]	PC0[2]	PC0[1]	PC0[0]

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Addr (HEX)	R/W	Function	7	6	5	4	3	2	1	0
24	R	Burst Preamble PC Byte 1	PC1[7]	PC1[6]	PC1[5]	PC1[4]	PC1[3]	PC1[2]	PC1[1]	PC1[0]
25	R	Burst Preamble PD Byte 0	PD0[7]	PD0[6]	PD0[5]	PD0[4]	PD0[3]	PD0[2]	PD0[1]	PD0[0]
26	R	Burst Preamble PD Byte 1	PD1[7]	PD1[6]	PD1[5]	PD1[4]	PD1[3]	PD1[2]	PD1[1]	PD1[0]
7F	R	ID & Version	ID3	ID2	ID1	ID0	VER3	VER2	VER1	VER0

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8 CONTROL PORT REGISTER BIT DEFINITIONS

8.1 Control0 (00h)

7	6	5	4	3	2	1	0
0	0	0	0	0	TRUNC	Reserved	Reserved

TRUNC – Determines if the audio word length is set according to the incoming channel status data as decoded by the AUX[3:0] bits. The resulting word length in bits is 24-AUX[3:0].

Default = 0

0 – incoming data is not truncated

1 – incoming data is truncated according to the length specified in the channel status data

Truncation occurs before the de-emphasis filter. TRUNC has no effect on output data if de-emphasis filter is not used.

Reserved[1:0] – These bits may change state depending on the input audio data.

8.2 Control1 (01h)

7	6	5	4	3	2	1	0
SWCLK	MUTESAO	INT1	INT0	HOLD1	HOLD0	RMCKF	CHS

SWCLK - Lets OMCK determine RMCK, OSCLK, OLRCK when PLL loses lock

Default = '0'

0 – Output clocks determined by PLL
1 – Output clocks determined by OMCK

RMCKF – Recovered Master Clock Frequency

Default = "0"

0 – Frequency is 256 FS

1 – Frequency is 128 FS

MUTESAO - Mute control for the serial audio output port

Default = '0'

0 - SDOUT (Not Muted)
1 – SDOUT (Muted)

HOLD[1:0] – Determine how received audio sample is affected when a receive error occurs

Default = "00"

00 – hold last audio sample

01 – replace the current audio sample with 00 (mute)

10- do not change the received audio sample

11 - reserved

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INT[1:0] - Interrupt output pin (INT) control

Default = '00'

00 - Active high; high output indicates interrupt condition has occurred
01 - Active low, low output indicates an interrupt condition has occurred
10 - Open drain, active low. Requires an external pull-up resistor on the INT pin. Thus it is not recommended to multiplex INT onto GPO2 in I^2C control port mode since an external resistor is required on GPO2 to specify the AD2 bit of the chip address.
11 – Reserved

CHS – Sets which channel's C data is decoded in the Receiver Channel Status register

0 – A channel

1 – B channel

8.3 Control2 (02h)

7	6	5	4	3	2	1	0
DETCI	EMPH_CNTL2	EMPH_CNTL1	EMPH_CNTL0	GPO0SEL3	GPO0SEL2	GPO0SEL1	GPO0SEL0

DETCI – D to E status transfer inhibit

Default = '0'

0 – Allow update

1 – Inhibit update

Emph_CNTL[2:0] – De-emphasis filter control

Default = 000

000 – De-emphasis filter off

001 – 32 KHz setting

010 – 44.1 KHz setting

011 – 48 KHz

100 – 50us/15us de-emphasis filter auto-select on. Coefficients(32, 44.1 or 48 KHz or no de-emphasis filter at all) match the pre-emphasis and sample frequency indicators in the channel status bits of Channel A. Thus it is impossible to have de-emphasis applied to one channel but not the other. Also it turns off the de-emphasis filter if the audio data is detected to be non-linear data.

GPO0SEL[3:0] – GPO0 Source select. See GPO section in main text for settings table.

Default = 0000

8.4 Control3 (03h)

7	6	5	4	3	2	1	0
GPO1SEL3	GPO1SEL2	GPO1SEL1	GPO1SEL0	GPO2SEL3	GPO2SEL2	GPO2SEL1	GPO2SEL0

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GPO1SEL[3:0] – GPO1 Source select

Default = 0000

GPO2SEL[3:0] – GPO2 source select

Default = 0000

8.5 Control4 (04h)

7	6	5	4	3	2	1	0
RUN	RXD	RXSEL2	RXSEL1	RXSEL0	TXSEL2	TXSEL1	TXSEL0

RUN - Controls the internal clocks, allowing the CS8416 to be placed in a “powered down”, low current consumption, state.

Default = ‘0’

0 - Internal clocks are stopped. Internal state machines are reset. The fully static control port is operational, allowing registers to be read or changed. Power consumption is low.

1 - Normal part operation. This bit must be written to the 1 state to allow the CS8416 to begin operation. All input clocks should be stable in frequency and phase when RUN is set to 1.

RXD – RMCK High-Z

Default = “0”

0 -RMCK is an output, Clock is derived from input frame rate

1 – RMCK becomes high impedance

RX_SEL[2:0] – Selects RXP0 to RXP7 for input to the receiver

Default =000

000 – RXP0

001 – RXP1, etc

TX_SEL[2:0] – Selects RXP0 to RXP7 as the input for GPO TX source

Default =000

000 – RXP0

001 – RXP1, etc

8.6 Serial Audio Data Format (05h)

7	6	5	4	3	2	1	0
SOMS	SOSF	SORES1	SORES0	SOJUST	SODEL	SOSPOL	SOLRPOL

SOMS - Master/Slave Mode Selector

Default = ‘0’

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0 - Serial audio output port is in slave mode
1 - Serial audio output port is in master mode

SOSF - OSCLK frequency (for master mode)

Default = '0'

0 - 64*Fs
1 - 128*Fs

SORES[1:0] - Resolution of the output data on SDOUT

Default = '00'

00 - 24-bit resolution

01 - 20-bit resolution

10 - 16-bit resolution

11 - Direct copy of the received NRZ data from the AES3 receiver including C, U, and V bits. The time slot occupied by the Z bit is used to indicate the location of the block start. This setting forces the SOJUST bit to be "0".

SOJUST - Justification of SDOUT data relative to OLRCK

Default = '0'

0 - Left-justified
1 - Right-justified (master mode only and SORES ≠11)

SODEL - Delay of SDOUT data relative to OLRCK, for left-justified data formats

(This control is only valid in left justified mode)

Default = '0'

0 - MSB of SDOUT data occurs in the first OSCLK period after the OLRCK edge
1 - MSB of SDOUT data occurs in the second OSCLK period after the OLRCK edge

SOSPOL - OSCLK clock polarity

Default = '0'

0 - SDOUT sampled on rising edges of OSCLK
1 - SDOUT sampled on falling edges of OSCLK

SOLRPOL - OLRCK clock polarity

Default = '0'

0 - SDOUT data is for the left channel when OLRCK is high
1 - SDOUT data is for the right channel when OLRCK is high

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8.7 Receiver Error Mask (06h)

7	6	5	4	3	2	1	0
0	QCRCM	CCRCM	UNLOCKM	VM	CONFM	BIPM	PARM

The bits in this register serve as masks for the corresponding bits of the Receiver Error Register. If a mask bit is set to 1, the error is unmasked, meaning that its occurrence will appear in the receiver error register, will affect the RERR pin, will affect the RERR interrupt, and will affect the current audio sample according to the status of the HOLD bit. If a mask bit is set to 0, the error is masked, meaning that its occurrence will not appear in the receiver error register, will not affect the RERR pin, will not affect the RERR interrupt, and will not affect the current audio sample. The CCRC and QCRC bits behave differently from the other bits: they do not affect the current audio sample even when unmasked. This register defaults to 00h.

8.8 Interrupt Mask (07h)

7	6	5	4	3	2	1	0
0	PCCHM	OSLIPM	DETCM	CCHM	RERRM	QCHM	FCHM

The bits of this register serve as a mask for the Interrupt Status register. If a mask bit is set to 1, the error is unmasked, meaning that its occurrence will affect the INT pin and the status register. If a mask bit is set to 0, the error is masked, meaning that its occurrence will not affect the internal INT signal or the status register. The bit positions align with the corresponding bits in Interrupt Status register. This register defaults to 00h.

The INT signal may be selected to appear on the GPO pins.

8.9 Interrupt Mode MSB (08h) and Interrupt Mode LSB(09h)

7	6	5	4	3	2	1	0
0	PCCH1	OSLIP1	DETC1	CCH1	RERR1	QCH1	FCH1
0	PCCH0	OSLIP0	DETC0	CCH0	RERR0	QCH0	FCH0

The two Interrupt Mode registers form a 2-bit code for each Interrupt Status register function. There are three ways to set the INT pin active in accordance with the interrupt condition. In the Rising edge active mode, the INT pin becomes active on the arrival of the interrupt condition. In the Falling edge active mode, the INT pin becomes active on the removal of the interrupt condition. In Level active mode, the INT interrupt pin becomes active during the interrupt condition. Be aware that the active level(Active High or Low) only depends on the INT[1:0] bits. These registers default to 00h.

00 - Rising edge active
01 - Falling edge active
10 - Level active
11 - Reserved

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8.10 Receiver Channel Status (0Ah)

7	6	5	4	3	2	1	0
AUX3	AUX2	AUX1	AUX0	PRO	COPY	ORIG	$\overline{\text{EMPH}}$

The bits in this register can be associated with either channel A or B of the received data. The desired channel is selected with the CHS bit of the Control1 register.

AUX3:0 - Incoming auxiliary data field width, as indicated by the incoming channel status bits, decoded according to IEC60958 and AES3.

0000 - Auxiliary data is not present
0001 - Auxiliary data is 1 bit long
0010 - Auxiliary data is 2 bits long
0011 - Auxiliary data is 3 bits long
0100 - Auxiliary data is 4 bits long
0101 - Auxiliary data is 5 bits long
0110 - Auxiliary data is 6 bits long
0111 - Auxiliary data is 7 bits long
1000 - Auxiliary data is 8 bits long
1001 - 1111 Reserved

PRO - Channel status block format indicator

0 - Received channel status block is in consumer format
1 - Received channel status block is in professional format

COPY - SCMS copyright indicator

0 - Copyright asserted
1 - Copyright not asserted If the category code is set to General in the incoming AES3 stream, copyright will always be indicated by COPY, even when the stream indicates no copyright.

ORIG - SCMS generation indicator, decoded from the category code and the L bit.

0 - Received data is 1st generation or higher
1 - Received data is original
Note: COPY and ORIG will both be set to 1 if incoming data is flagged as professional or if the receiver is not in use.

$\overline{\text{EMPH}}$ – Indicates whether the input audio data has been pre-emphasized. Also indicates turning on of the de-emphasis filter during de-emphasis auto-select mode.

0 – 50us/15us pre-emphasis indicated
1 – 50us/15us pre-emphasis not indicated

8.11 Format Detect Status (0Bh)

7	6	5	4	3	2	1	0
0	PCM	IEC61937	DTS_LD	DTS_CD	Reserved	DGTL_SIL	96KHZ

Note: PCM, DTS_LD, DTS_CD and IEC61937 are mutually exclusive.

PCM – Uncompressed PCM data was detected

IEC61937 – IEC61937 data was detected

DTS_LD – DTS_LD data was detected

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DTS_CD – DTS_CD data was detected

Reserved – This bit may change state depending on the input audio data.

DGTL_SIL – Digital Silence was detected: at least 2047 consecutive constant samples of the same 24-bit audio data on both channels.

96KHZ – if input sample rate is ≤ 48 KHz, outputs a “0”. Outputs a “1” if the sample rate is ≥ 88.1 KHz. Otherwise output indeterminate.

8.12 Receiver Error (0Ch)

7	6	5	4	3	2	1	0
0	QCRC	CCRC	UNLOCK	V	CONF	BIP	PAR

This register contains the AES3 receiver and PLL status bits. Unmasked bits will go high on occurrence of the error, and will stay high until the register is read. Reading the register resets all bits to 0, unless the error source is still true. Bits that are masked off in the receiver error mask register will always be 0 in this register.

QCRC - Q-subcode data CRC error indicator. Updated on Q-subcode block boundaries

0 - No error
1 - Error

CCRC - Channel Status Block Cyclic Redundancy Check bit. Updated on CS block boundaries, valid in Pro mode

0 - No error
1 - Error

UNLOCK - PLL lock status bit. Updated on CS block boundaries.

0 - PLL locked
1 - PLL out of lock

V - Received AES3 Validity bit status. Updated on sub-frame boundaries.

0 - Data is valid and is normally linear coded PCM audio
1 - Data is invalid, or may be valid compressed audio

CONF - Confidence bit. Updated on sub-frame boundaries.

0 - No error
1 - Confidence error. This indicates that the received data eye opening is less than half a bit period, indicating a poor link that is not meeting specifications.

BIP - Bi-phase error bit. Updated on sub-frame boundaries.

0 - No error
1 - Bi-phase error. This indicates an error in the received bi-phase coding.

PAR - Parity bit. Updated on sub-frame boundaries.

0 - No error
1 - Parity error

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8.13 Interrupt 1 Status (0Dh)

7	6	5	4	3	2	1	0
0	PCCH	OSLIP	DETC	CCH	RERR	QCH	FCH

For all bits in this register, a “1” means the associated interrupt condition has occurred at least once since the register was last read. A “0” means the associated interrupt condition has NOT occurred since the last reading of the register. Reading the register resets all bits to 0, unless the interrupt mode is set to level and the interrupt source is still true. Status bits that are masked off in the associated mask register will always be “0” in this register.

PCCH – PC burst preamble change.

Indicates that the PC byte has changed from its previous value. The user has TBD frames to read new value before it can potentially be overwritten again. If the IEC61937 bit in the Format Detect Status register goes high, it will cause a PCCH interrupt even if the PC byte hasn't changed since the last time the IEC61937 bit went high.

OSLIP - Serial audio output port data slip interrupt

When the serial audio output port is in slave mode, and OLRCK is asynchronous to the port data source, This bit will go high every time a data sample is dropped or repeated.

DETC - D to E C-buffer transfer interrupt.

The source for this bit is true during the D to E buffer transfer in the C bit buffer management process.

C_CHANGE -Indicates that the current 10 bytes of channel status is different from the previous 10 bytes. (5 bytes per channel)

RERR - A receiver error has occurred.

The Receiver Error register may be read to determine the nature of the error which caused the interrupt.

QCH – A new block of Q-subcode is available for reading. The data must be read within 588 AES3 frames after the interrupt occurs to avoid corruption of the data by the next block.

FCH – Format Change: Goes high when the PCM, IEC61937, DTS_LD, DTS_CD, or DGTL_SIL bits in the Format Detect Status register transition from 0 to 1. When these bits in the Format Detect Status register transition from 1 to 0, an interrupt will not be generated.

8.14 Q-Channel Subcode (0Eh - 17h)

7	6	5	4	3	2	1	0
CONTROL	CONTROL	CONTROL	CONTROL	ADDRESS	ADDRESS	ADDRESS	ADDRESS
TRACK	TRACK	TRACK	TRACK	TRACK	TRACK	TRACK	TRACK
INDEX	INDEX	INDEX	INDEX	INDEX	INDEX	INDEX	INDEX
MINUTE	MINUTE	MINUTE	MINUTE	MINUTE	MINUTE	MINUTE	MINUTE
SECOND	SECOND	SECOND	SECOND	SECOND	SECOND	SECOND	SECOND
FRAME	FRAME	FRAME	FRAME	FRAME	FRAME	FRAME	FRAME
ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO	ZERO
ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE	ABS MINUTE
ABS SECOND	ABS SECOND	ABS SECOND	ABS SECOND	ABS SECOND	ABS SECOND	ABS SECOND	ABS SECOND
ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME	ABS FRAME

Each byte is LSB first with respect to the 80 Q-subcode bits Q[79:0]. Thus bit 7 of address 0Eh is Q[0] while bit 0 of address 0Eh is Q[7]. Similarly bit 0 of address 17h corresponds to Q[79].

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8.15 OMCK/RMCK Ratio (18h)

7	6	5	4	3	2	1	0
ORR7	ORR6	ORR5	ORR4	ORR3	ORR2	ORR1	ORR0

This register allows the calculation of the incoming sample rate by the host microcontroller from the equation ORR=Fso/Fsi. The Fso is determined by OMCK, whose frequency is assumed to be 256 Fso. ORR is represented as an unsigned 2-bit integer and a 6-bit fractional part. The value is meaningful only after the PLL has reached lock. For example, if the OMCK is 12.288MHz, Fso would be 48KHz (48KHz = 12.288MHz/256). Then if the input sample rate is also 48KHz, you would get 1.0 from the ORR register.(The value from the ORR register is hexadecimal, so the actual value you will get is 40h). If $F_{SO}/F_{SI} > 3\ ^{63}/_{64}$, ORR will saturate at the value FFh. Also, there is no hysteresis on ORR. Therefore a small amount of jitter on either clock can cause the LSB ORR[0] to oscillate.

ORR[7:6] - Integer part of the ratio (Integer value=Integer(SRR[7:6]))

ORR[5:0] - Fractional part of the ratio (Fraction value=Integer(SRR[5:0])/64)

8.16 Channel Status Registers (19h - 22h)

25	Channel A Status Byte 0	AC0[7]	AC0[6]	AC0[5]	AC0[4]	AC0[3]	AC0[2]	AC0[1]	AC0[0]
26	Channel A Status Byte 1	AC1[7]	AC1[6]	AC1[5]	AC1[4]	AC1[3]	AC1[2]	AC1[1]	AC1[0]
27	Channel A Status Byte 2	AC2[7]	AC2[6]	AC2[5]	AC2[4]	AC2[3]	AC2[2]	AC2[1]	AC2[0]
28	Channel A Status Byte 3	AC3[7]	AC3[6]	AC3[5]	AC3[4]	AC3[3]	AC3[2]	AC3[1]	AC3[0]
29	Channel A Status Byte 4	AC4[7]	AC4[6]	AC4[5]	AC4[4]	AC4[3]	AC4[2]	AC4[1]	AC4[0]
30	Channel B Status Byte 0	BC0[7]	BC0[6]	BC0[5]	BC0[4]	BC0[3]	BC0[2]	BC0[1]	BC0[0]
31	Channel B Status Byte 1	BC1[7]	BC1[6]	BC1[5]	BC1[4]	BC1[3]	BC1[2]	BC1[1]	BC1[0]
32	Channel B Status Byte 2	BC2[7]	BC2[6]	BC2[5]	BC2[4]	BC2[3]	BC2[2]	BC2[1]	BC2[0]
33	Channel B Status Byte 3	BC3[7]	BC3[6]	BC3[5]	BC3[4]	BC3[3]	BC3[2]	BC3[1]	BC3[0]
34	Channel B Status Byte 4	BC4[7]	BC4[6]	BC4[5]	BC4[4]	BC4[3]	BC4[2]	BC4[1]	BC4[0]

8.17 IEC61937 PC/PD Burst preamble (23h - 26h)

35	Burst Preamble PC Byte 0	PC0[7]	PC0[6]	PC0[5]	PC0[4]	PC0[3]	PC0[2]	PC0[1]	PC0[0]
36	Burst Preamble PC Byte 1	PC1[7]	PC1[6]	PC1[5]	PC0[4]	PC1[3]	PC1[2]	PC1[1]	PC1[0]
37	Burst Preamble PD Byte 0	PD0[7]	PD0[6]	PD0[5]	PC0[4]	PD0[3]	PD0[2]	PD0[1]	PD0[0]
38	Burst Preamble PD Byte 1	PD1[7]	PD1[6]	PD1[5]	PD1[4]	PD1[3]	PD1[2]	PD1[1]	PD1[0]

8.18 CS8416 I.D. and Version Register (7Fh)

7	6	5	4	3	2	1	0
ID3	ID2	ID1	ID0	VER3	VER2	VER1	VER0

ID[3:0]= 0010

VER[3:0] = 0001 (revision A)

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8.19 Memory Address Pointer (MAP)

7	6	5	4	3	2	1	0
INCR	MAP6	MAP5	MAP4	MAP3	MAP2	MAP1	MAP0

INCR - Auto Increment Address Control Bit

Default = '0'

0 - Disabled
1 - Enabled

MAP6:MAP0 - Register address

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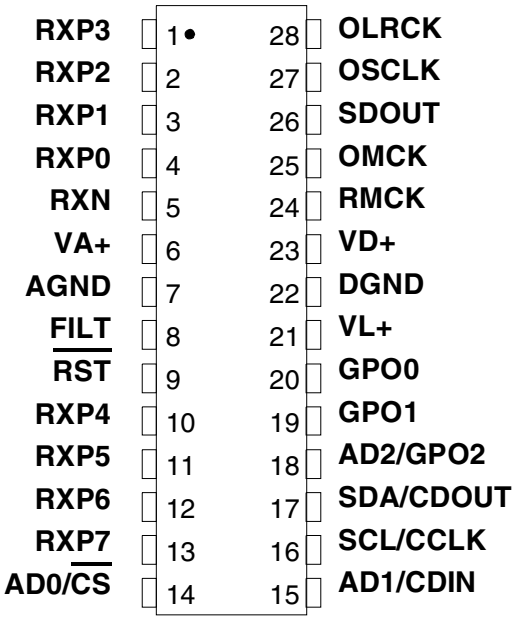
9. PIN DESCRIPTION - SOFTWARE MODE



RXP[7:0]	13 12 11 10 1 2 3 4	**Additional AES3/SPDIF Receiver Port** (*Input*) - Single-ended receiver inputs carrying AES3 or S/PDIF digital data. These inputs comprise the 8:2 S/PDIF Input Multiplexer. The select line control is accessed using the Control 4 register. Please note that any unused inputs can be left floating or tied to ground. See Appendix A for recommended input circuits.
RXN	5	**AES/SPDIF input** - Used along with RXP[X] to form an AES3 differential input. In single-ended operation this should be capacitively coupled to ground.
VA+	6	**Positive Analog Power** - Positive supply for the analog section. Nominally +3.3 V. This supply should be as quiet as possible since noise on this pin will directly affect the jitter performance of the recovered clock
VD+	23	**Positive Digital Power** – Nominally 3.3 V
VL+	21	**Positive – Interface Power** – 3.3 V to 5.0 V: this supply sets the CS8416 I/O levels, including RXPx & RXN
AGND	6	**Analog Ground** - Ground for the analog circuitry in the chip. AGND and DGND should be con nected to a common ground area under the chip.
DGND	22	**Digital & I/O Ground**
FILT	8	**PLL Loop Filter** (*Output*) - An RC network should be connected between this pin and analog ground. For minimum PLL jitter, return the ground end of the filter network directly to AGND

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$\overline{\text{RST}}$	9	**Reset** (*Input*) - When $\overline{\text{RST}}$ is low, the CS8416 enters a low power mode and all internal states are reset. On initial power up, $\overline{\text{RST}}$ must be held low until the power supply is stable, and all input clocks are stable in frequency and phase.
AD0/$\overline{\text{CS}}$	14	**Address Bit 0 (I^2C) / Control Port Chip Select (SPI)** (*Input)* - A falling edge on this pin puts the CS8416 into SPI control port mode. With no falling edge, the CS8416 defaults to I^2C mode. In I^2C mode, AD0 is a chip address pin. In SPI mode, $\overline{\text{CS}}$ is used to enable the control port interface on the CS8416
AD1/CDIN	15	**Address Bit 1 (I^2C) / Serial Control Data in (SPI)** (*Input*) - In I^2C mode, AD1 is a chip address pin. In SPI mode, CDIN is the input data line for the control port interface
SCL/CCLK	16	**Control Port Clock** (*Input*) - Serial control interface clock and is used to clock control data bits into and out of the CS8416.
SDA/ CDOUT	17	**Serial Control Data I/O (I^2C) / Data Out (SPI)** (*Input/Output*) - In I^2C mode, SDA is the control I/O data line. SDA is open drain and requires an external pull-up resistor to VL+. In SPI mode, CDOUT is the output data from the control port interface on the CS8416
AD2/GPO2	18	**General Purpose Output 2** *(Output)* - If using the I^2C control port, this pin must be pulled high or low through a 47 kΩ resistor. See "General Purpose Outputs" on page 22 for GPO functions.
GPO1	19	**General Purpose Output 1** *(Output)* See "General Purpose Outputs" on page 22 for GPO functions.
GPO0	20	**General Purpose Output 0** *(Output)* See "General Purpose Outputs" on page 22 for GPO functions.
SDOUT	26	**Serial Audio Output Data** (*Output*) - Audio data serial output pin. This pin must be pulled high to VL+ through a 47 KΩ resistor to place the part in Software Mode.
OLRCK	28	**Serial Audio Output Left/Right Clock** (*Input/Output*) - Word rate clock for the audio data on the SDOUT pin. Frequency will be the output sample rate (Fs)
OSCLK	27	**Serial Audio Output Bit Clock** (*Input/Output*) - Serial bit clock for audio data on the SDOUT pin
OMCK	25	**System Clock** (*Input*) - When the OMCK System Clock Mode is enabled using the SWCLK bit in the Control 1 register, the clock signal input on this pin is output through RMCK. OMCK serves as reference signal for OMCK/RMCK ratio expressed in register 24
RMCK	24	**Input Section Recovered Master Clock** (*Output*) - Input section recovered master clock output when PLL is used. Frequency defaults to 256x the sample rate (Fs) and may be set to 128x. It may also be tri-stated by the RXD bit in the Control 4 register (04h).

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10 HARDWARE MODE

The CS8416 has a hardware mode which allows using the device without a microcontroller. Hardware mode is selected by connecting the 47K pull-up/down resistor on the SDOUT pin to ground. Various pins change function in hardware mode, described in the hardware mode pin definition section (Section 11).

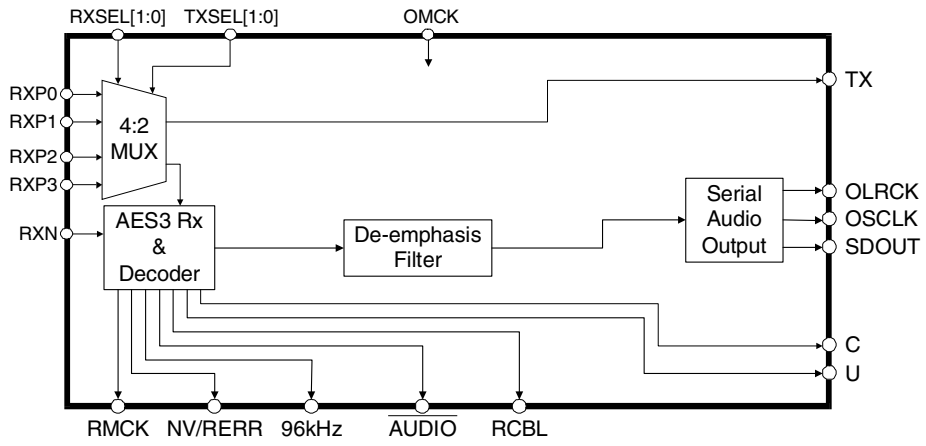
Hardware mode data flow is shown in Figure 13. Audio data is input through the AES3/SPDIF receiver, and routed to the serial audio output port. The decoded C and U bits are also output, clocked at both edges of OLRCK (master mode only, see Figure 9).

An error in the incoming audio stream will be indicated on the NV/RERR. This pin can be configured in one of two ways. If RERR is chosen by pulling NV/RERR to ground, the previous audio sample is held and passed to the serial audio output port if the validity bit is high, or a parity, bi-phase, confidence or PLL lock error occurs during the current sample. If NVERR is chosen by pulling NV/RERR to VL+, only parity, bi-phase, confidence or PLL lock error cause the previous audio sample to be held.

10.1 Serial Audio Port Formats

In hardware mode, only a limited number of alternative serial audio port formats are available. Table 4 defines the equivalent software mode bit settings for each format.

The start-up options, shown in Table 4, allow choice of the serial audio output port as a master or slave, and the serial audio port format.



Power supply pins (VA+, VD+, VL+, AGND, DGND, the reset pin ($\overline{RST}$) and the PLL filter pin (FILT) are omitted from the diagram. Please refer to the Typical Connection Diagram for connection details.

Figure 13. Hardware Mode Data Flow

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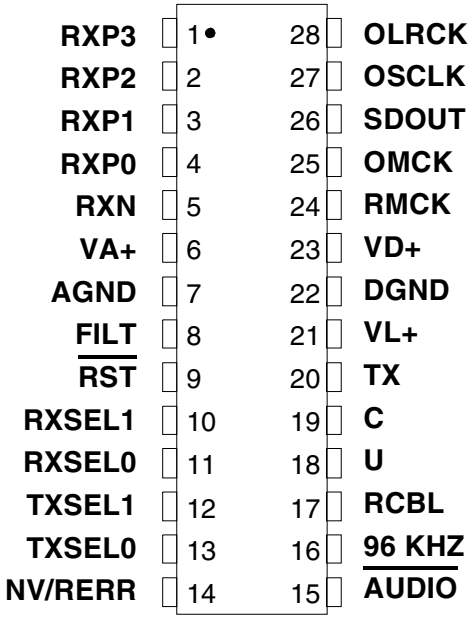
11 PIN DESCRIPTION - HARDWARE MODE



RXP[3:0]	1 2 3 4	**Additional AES3/SPDIF Receiver Port** (*Input*) - Single-ended receiver inputs carrying AES3 or S/PDIF digital data. These inputs comprise the 4:2 S/PDIF Input Multiplexer. The select line control is the RXSEL[1:0] pins. Please note that any unused inputs can be left floating. See Appendix A for recommended input circuits.
RXN	5	**AES/SPDIF Input -** Used along with RXP[X] to form an AES3 differential input. In single-ended operation this should be capacitively coupled to ground**.**
VD+	23	**Positive Digital Power** – 3.3 V
VA+	6	**Positive Analog Power –**3.3 V
VL+	21	**Positive Interface Power –** 3.3 V – 5.0 V
DGND	22	**Digital/Interface Ground**
AGND	7	**Analog Ground**
RX_SEL0 **RX_SEL1**	10 11	**Receiver_MUX Selector** *(Input)* - used to select which pin, RXP[3:0], is used for the receiver input.
TX_SEL0 **TX_SEL1**	12 13	**TX Pin MUX SELECTION***(Input)* - used to select which pin, RXP[3:0], is used for the TX pin output.
FILT	8	**PLL Filter Pin –** A RC network should be connected from this pin to AGND. For best PLL jitter performance, this pin should be returned directly to the AGND pin
$\overline{\text{RST}}$	9	**RESET***(Input)* **–** active low input . Resets CS8416 to default state, configuration pins are read on the rising edge of this pin
NV/RERR	14	**Non-Validity Receiver Error/Receiver Error** *(output)*

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$\overline{\text{AUDIO}}$	15	**Audio Channel Status Bit***(output)* **–** When low, a valid linear PCM audio stream is indicated.
96KHZ	16	**96 khz Sample Rate Detect***(output)* - if input sample rate is ≤ 48 KHz, ouputs a “0”. Outputs a “1” if the sample rate is ≥ 88.1 KHz. Otherwise output indeterminate.
RCBL	17	**Receiver Channel Status Block** *(Output)* -Indicates the beginning of a received channel status block. RCBL goes high two frames after the reception of a Z preamble, remains high for 16 frames and then returns low for the remainder of the block. RCBL changes on rising edges of RMCK.
U	18	**User Data** (*Output*) - Outputs user data from the AES3 receiver, clocked by the rising and falling edges of OLRCK.
C	19	**Channel Status Data** (*Output*) - Outputs channel status data from the AES3 receiver, clocked by the ris ing and falling edges of OLRCK.
TX	20	**S/PDIF MUX Pass through** (*Output)*
SDOUT	26	**Serial Audio Output Data** (*Output*) - Audio data serial output pin. This pin must be pulled to low to DGND through a 47 KΩ resistor.
OLRCK	28	**Serial Audio Output Left/Right Clock** (*Input*/*Output*) - Word rate clock for the audio data on the SDOUT pin. Frequency will be the output sample rate (Fs).
OSCLK	27	**Serial Audio Output Bit Clock** (*Input*/*Output*) - Serial bit clock for audio data on the SDOUT pin.
OMCK	25	**System Clock** (*Input*) - When the OMCK System Clock Mode is enabled using the SWCLK bit in the Control 1 register, the clock signal input on this pin is output through RMCK. OMCK serves as reference signal for OMCK/RMCK ratio expressed in register 24
RMCK	24	**Recovered Master Clock** (*Output*) - Recovered master clock output when PLL is locked to the incoming AES3 stream. Frequency is 128/256x the sample rate (Fs).

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11.1 Hardware Mode Function Selection

Hardware Mode and several options for that mode are selected by pulling CS8416 pins up or down immediately after $\overline{\text{RST}}$ is released.

1) SDOUT – Hardware/Software Mode select
2) RCBL – Serial Port slave/master select
3) NV/RERR – NVERR/RERR select
4) $\overline{\text{AUDIO}}$ – Serial Port Format select[1] (0/1)
5) C – Serial Port Format select[0] (0/1)
6) U – RMCK Frequency Select (256/128)
7) 96KHZ – Emphasis Audio Match Off/On

For these pins, the first option is selected by using a pulldown. The second option is selected via a pullup.

11.2 Hardware Mode Settings (Defaults & Controls)

Control Register 0

TRUNC = 0
FS[1:0] = 00

Control Register 1

SWCLK = 1
MUTSAO = 0
INT = N/A, there is no interrupt pin in hardware mode
HOLD[1:0] = 00
RMCKF = Set by U pin pull-up/down at startup
CHS = 0

Control Register 2

DETCI = N/A
EMPH_CNTL[2] = set by 96KHZ pull-up/down at startup
EMPH_CNTL[1:0] = 00
GPO0SEL[3:0] = N/A

Control Register 3

GPO1SEL[3:0] = N/A
GPO2SEL[3:0] = N/A

Control Register 4

RUN = 1
RXD = 0

RX_SEL[2] = 0
RX_SEL[1:0] = RX_SEL[1:0] pins

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TX_SEL[2] = 0
TX_SEL[1:0] = TX_SEL[1:0] pins

Control Register 5 - Serial Port Format

SOSM: set by RCBL pullup/pulldown at startup.

bits[6:0]: Set by startup pull up/Pull down on $\overline{\text{AUDIO}}$ & C at startup:

Serial Port Format Select [1:0]	SOSF	SORES[1:0]	SOJUST	SODEL	SOSPOL	SOLRPOL
00 (left justified)	0	00	0	0	0	0
01(I2S 24 bit)	0	00	0	1	0	1
10 (Right justified)	0	00	1	0	0	0
11 (Direct AES3)	0	11	0	0	0	0

Table 4. Hardware Mode Serial Audio Format Select

Control Register 6 – Receiver Error Mask

{QCRCM,CRCM} = 00

{UNLOCKM,CONFM,BIPM,PARM} = 1111

VM set by pullup/pulldown on NV/RERR select

Control Register 7 - Interrupt Status Mask

N/A

Control Register 8,9 - Interrupt Mode

N/A

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12 APPLICATIONS

12.1 Reset, Power Down and Start-up

When $\overline{RST}$ is low, the CS8416 enters a low power mode and all internal states are reset, including the control port and registers, and the outputs are muted. In Software Mode, when $\overline{RST}$ is high, the control port becomes operational and the desired settings should be loaded into the control registers. Writing a 1 to the RUN bit will then cause the part to leave the low power state and begin operation. After the PLL has settled, the serial audio outputs will be enabled.

Some options within the CS8416 are controlled by a start-up mechanism. During the reset state, some of the pins are reconfigured internally to be inputs. Immediately upon exiting the reset state, the level of these pins is sensed. The pins are then switched to be outputs. This mechanism allows output pins to be used to set alternative modes in the CS8416 by connecting a 47K resistor to between the pin and either VL+ (HI) or DGND (LO). For each mode, every start-up option select pin MUST have an external pull-up or pull-down resistor. In software mode, the only start-up option pins are GPO2, which are used to set a chip address bit for the control port in I^2C mode, and SDOUT, which selects between Hardware and Software Modes. The hardware mode uses many start-up options, which are detailed in the hardware definition section at the end of this data sheet.

12.2 ID Code and Revision Code

The CS8416 has a register that contains a 4-bit code to indicate that the addressed device is a CS8416. This is useful when other CS84XX family members are resident in the same system, allowing common software modules.

The CS8416 4-bit revision code is also available. This allows the software driver for the CS8416 to identify which revision of the device is in a particular system, and modify its behavior accordingly. To allow for future revisions, it is strongly recommend that the revision code is read into a variable area within the microcontroller, and used wherever appropriate as revision details become known.

12.3 Power Supply, Grounding, and PCB layout

For most applications, the CS8416 can be operated from a single +3.3 V supply, following normal supply decoupling practices. (See Figure 5 and Figure 6). For applications where the recovered input clock, output on the RMCK pin, is required to be low jitter, then use a separate, quiet, analog +3.3 V supply for VA+, decoupled to AGND. In addition, a separate region of analog ground plane around the FILT, AGND, VA+, RXP0-7 and RXN pins is recommended. VL+ sets the level for the digital inputs and outputs, as well as the AES/SPDIF inputs.

Extensive use of power and ground planes, ground plane fill in unused areas and surface mount decoupling capacitors are recommended. Decoupling capacitors should be mounted on the same side of the board as the CS8416 to minimize inductance effects, and all decoupling capacitors should be as close to the CS8416 as possible. Refer to AN159 for examples of proper techniques.

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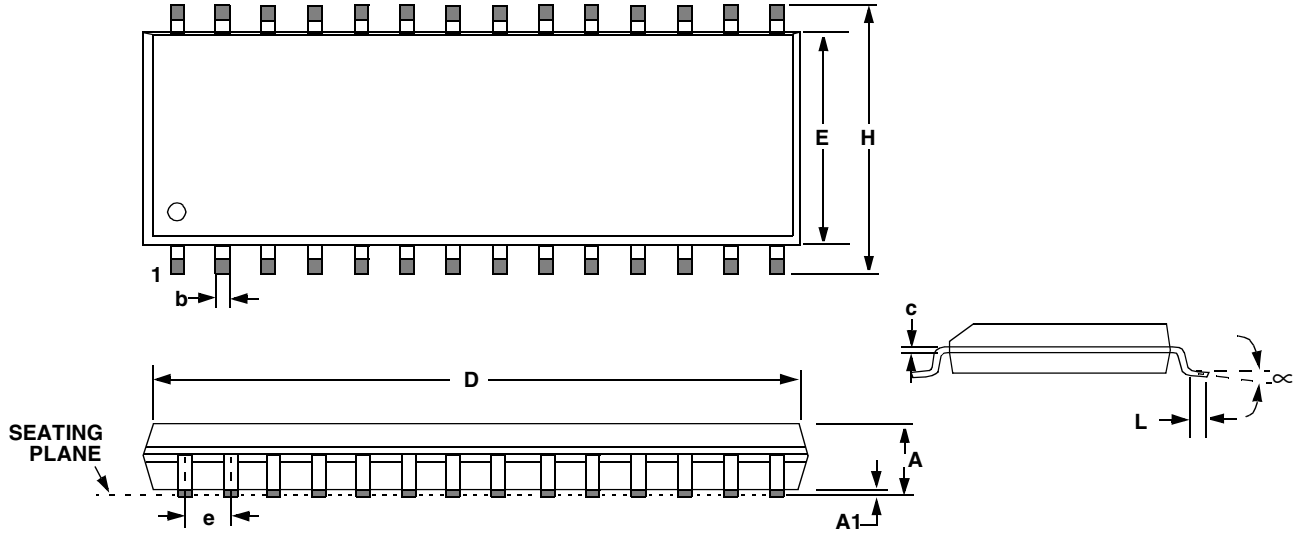
13 PACKAGE DIMENSIONS

28L SOIC (300 MIL BODY) PACKAGE DRAWING



	INCHES			MILLIMETERS		
DIM	MIN	NOM	MAX	MIN	NOM	MAX
A	0.093	0.098	0.104	2.35	2.50	2.65
A1	0.004	0.008	0.012	0.10	0.20	0.30
b	0.013	0.017	0.020	0.33	0.42	0.51
C	0.009	0.011	0.013	0.23	0.28	0.32
D	0.697	0.705	0.713	17.70	17.90	18.10
E	0.291	0.295	0.299	7.40	7.50	7.60
e	0.040	0.050	0.060	1.02	1.27	1.52
H	0.394	0.407	0.419	10.00	10.34	10.65
L	0.016	0.026	0.050	0.40	0.65	1.27
∝	0°	4°	8°	0°	4°	8°

JEDEC #: MS-013

Controlling Dimension is Millimeters

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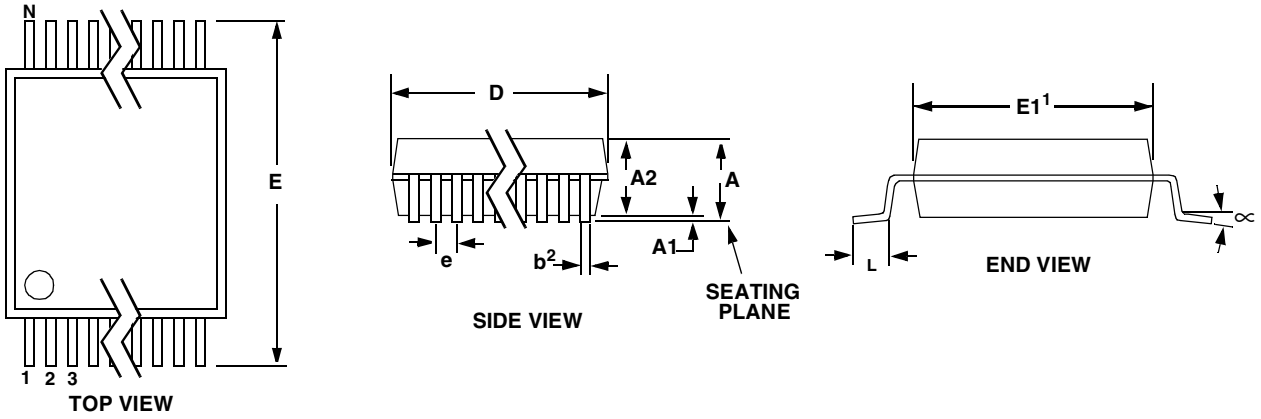
28L TSSOP (4.4 mm BODY) PACKAGE DRAWING



	INCHES			MILLIMETERS			NOTE
DIM	MIN	NOM	MAX	MIN	NOM	MAX	
A	--	--	0.47	--	--	1.20	
A1	0.002	0.004	0.006	0.05	0.10	0.15	
A2	0.03150	0.035	0.04	0.80	0.90	1.00	
b	0.00748	0.0096	0.012	0.19	0.245	0.30	2,3
D	0.378 BSC	0.382 BSC	0.386 BSC	9.60 BSC	9.70 BSC	9.80 BSC	1
E	0.248	0.2519	0.256	6.30	6.40	6.50	
E1	0.169	0.1732	0.177	4.30	4.40	4.50	1
e	--	0.026 BSC	--	--	0.65 BSC	--	
L	0.020	0.024	0.029	0.50	0.60	0.75	
∝	0°	4°	8°	0°	4°	8°	

JEDEC #: MO-153

Controlling Dimension is Millimeters.

Notes:
1. "D" and "E1" are reference datums and do not included mold flash or protrusions, but do include mold mismatch and are measured at the parting line, mold flash or protrusions shall not exceed 0.20 mm per side.
2. Dimension "b" does not include dambar protrusion/intrusion. Allowable dambar protrusion shall be 0.13 mm total in excess of "b" dimension at maximum material condition. Dambar intrusion shall not reduce dimension "b" by more than 0.07 mm at least material condition.
3. These dimensions apply to the flat section of the lead between 0.10 and 0.25 mm from lead tips.

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14 APPENDIX A: EXTERNAL AES3/SPDIF/IEC60958 RECEIVER COMPONENTS

14.1 AES3 Receiver External Components

The CS8416 AES3 receiver is designed to accept both the professional and consumer interfaces. The digital audio specifications for professional use call for a balanced receiver, using XLR connectors, with 110 Ω ±20% impedance. The XLR connector on the receiver should have female pins with a male shell. Since the receiver has a very high input impedance, a 110 Ω resistor should be placed across the receiver terminals to match the line impedance, as shown in Figure 14 and Figure 15. Although transformers are not required by the AES, they are, however, strongly recommended.

If some isolation is desired without the use of transformers, a 0.01µF capacitor should be placed in series with each input pin (RXP0 and RXN0) as shown in Figure . However, if a transformer is not used, high frequency energy could be coupled into the receiver, causing degradation in analog performance.

Figure 14 and Figure 15 show an optional DC blocking capacitor (0.1µF to 0.47 µF) in series with the cable input. This improves the robustness of the receiver, preventing the saturation of the transformer, or any DC current flow, if a DC voltage is present on the cable.

In the configuration of systems, it is important to avoid ground loops and DC current flowing down the shield of the cable that could result when boxes with different ground potentials are connected. Generally, it is good practice to ground the shield to the chassis of the transmitting unit, and connect the shield through a capacitor to chassis ground at the receiver. However, in some cases it is advantageous to have the ground of two boxes held to the same potential, and the cable shield might be depended upon to make that electrical connection. Generally, it may be a good idea to provide the option of grounding or capacitively coupling the shield to the chassis.

In the case of the consumer interface, the standards call for an unbalanced circuit having a receiver impedance of 75 Ω ±5%. The connector for the consumer interface is an RCA phono socket. The receiver circuit for the consumer interface is shown in Figure . Figure shows an implementation of the Input S/PDIF Multiplexer using the consumer interface.

The circuit shown in Figure may be used when external RS422 receivers, optical receivers or other TTL/CMOS logic outputs drive the CS8416 receiver section.

14.2 Isolating Transformer Requirements

Please refer to the application note AN134: *AES and SPDIF Recommended Transformers* for resources on transformer selection.

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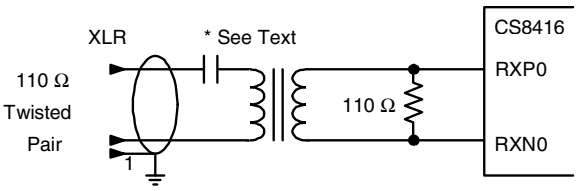

Figure 14. Professional Input Circuit

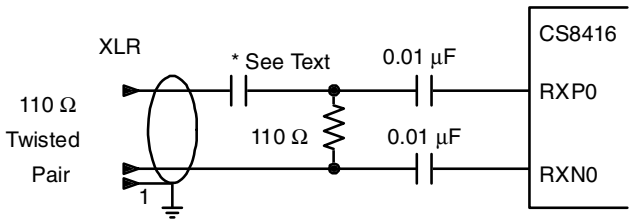

Figure 15. Transformerless Professional Input Circuit

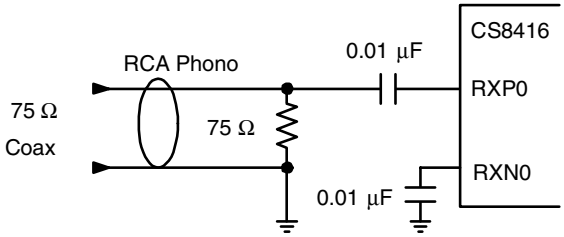

Figure 16. Consumer Input Circuit

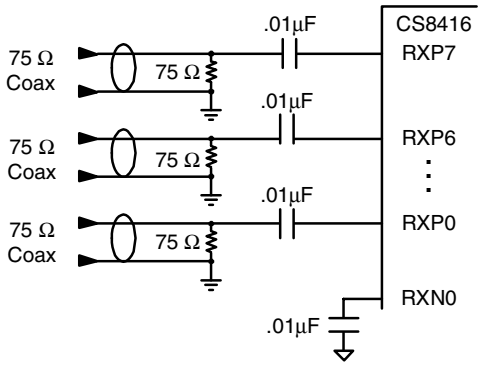

Figure 17. S/PDIF MUX Input Circuit

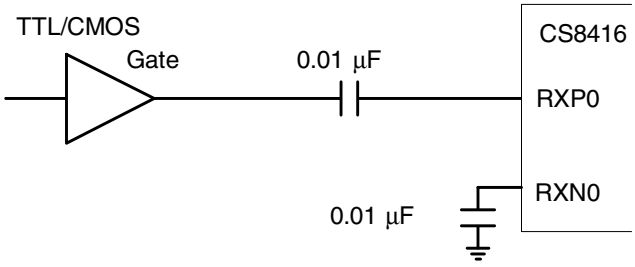

Figure 18. TTL/CMOS Input Circuit

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15 APPENDIX B: CHANNEL STATUS BUFFER MANAGEMENT

15.1 AES3 Channel Status (C) Bit Management

The CS8416 contains sufficient RAM to store the first 5 bytes of C data for both A and B channels (5 x 2 x 8 = 80 bits). The user may read from this buffer's RAM through the control port.

The buffering scheme involves 2 80-bit buffers, named D and E, as shown in Figure 19. The MSB of each byte represents the first bit in the serial C data stream. For example, the MSB of byte 0 (which is at control port address 32) is the consumer/professional bit for channel status block A.

The first buffer (D) accepts incoming C data from the AES receiver. The 2nd buffer (E) accepts entire blocks of data from the D buffer. The E buffer is also accessible from the control port, allowing reading of the C data.

15.2 Accessing the E buffer

The user can monitor the incoming data by reading the E buffer, which is mapped into the register space of the CS8416, through the control port.

The user can configure the interrupt enable register to cause interrupts to occur whenever D to E buffer transfers occur. This allows determination of the allowable time periods to interact with the E buffer.

Also provided is a D to E inhibit bit. This may be used whenever "long" control port interactions are occurring.

A flowchart for reading the E buffer is shown in Figure 20. Since a D to E interrupt just occurred after reading, there is a substantial time interval until the next D to E transfer (approximately 192 frames worth of time). This is usually plenty of time to access the E data without having to inhibit the next transfer.

15.2.1 Serial Copy Management System (SCMS)

In software mode, the CS8416 allows read access to all the channel status bits. For consumer mode SCMS compliance, the host microcontroller needs to read and interpret the Category Code, Copy bit and L bit appropriately.

In hardware mode, the SCMS protocol can be followed by either using the COPY and ORIG output pins, or by using the C bit serial output pin. These options are documented in the hardware mode section of this data sheet.

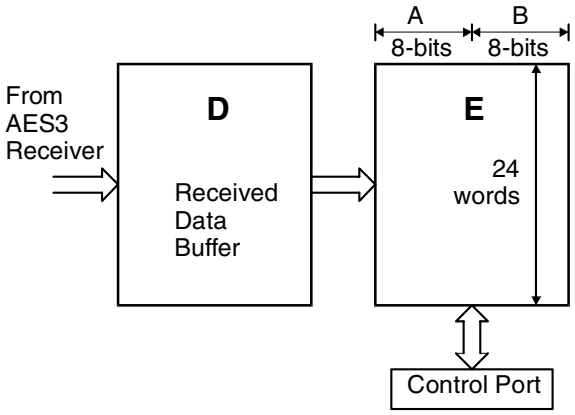

Figure 19. Channel Status Data Buffer Structure

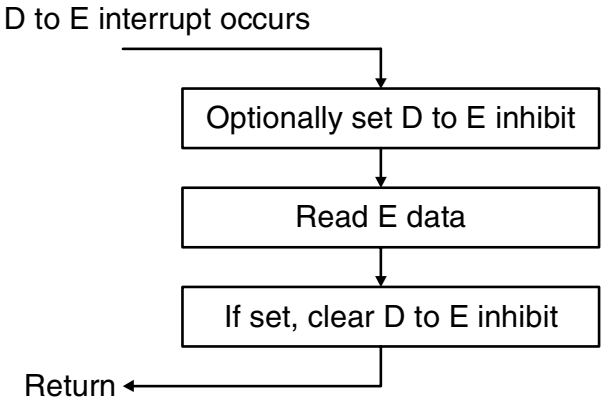

Figure 20. Flowchart for Reading the E Buffer

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