



## 192kHz Stereo Asynchronous Sample Rate Converters

### FEATURES

- AUTOMATIC SENSING OF THE INPUT-TO-OUTPUT SAMPLING RATIO
- WIDE INPUT-TO-OUTPUT SAMPLING RANGE: 16:1 to 1:16
- SUPPORTS INPUT & OUTPUT SAMPLING RATES UP TO 212kHz
- DYNAMIC RANGE: 144dB (-60dBFS input, BW = 20Hz to  $f_s/2$ , A-Weighted)
- THD+N: -140dB (0dBFS input, BW = 20Hz to  $f_s/2$ )
- ATTENUATES SAMPLING AND REFERENCE CLOCK JITTER
- HIGH PERFORMANCE, LINEAR PHASE DIGITAL FILTERING WITH BETTER THAN 140dB OF STOP BAND ATTENUATION
- FLEXIBLE AUDIO SERIAL PORTS: Master or Slave Mode Operation  
Supports I<sup>2</sup>S, Left Justified, Right Justified, and TDM Data Formats  
Supports 16, 18, 20, or 24-Bit Audio Data  
TDM Mode allows daisy chaining of up to eight devices
- SUPPORTS 24-, 20-, 18-, or 16-BIT INPUT AND OUTPUT DATA  
All output data is dithered from the internal 28-Bit data path
- LOW GROUP DELAY OPTION FOR INTERPOLATION FILTER
- DIRECT DOWNSAMPLING OPTION FOR DECIMATION FILTER (SRC4193 ONLY)
- SPI PORT PROVIDES ACCESS TO INTERNAL CONTROL REGISTERS (SRC4193 ONLY)
- SOFT MUTE FUNCTION
- BYPASS MODE
- PROGRAMMABLE DIGITAL OUTPUT ATTENUATION (SRC4193 ONLY)  
256 steps: 0dB to -127.5dB, 0.5dB/step

- POWER DOWN MODE
- OPERATES FROM A SINGLE +3.3 VOLT POWER SUPPLY
- SMALL 28-LEAD SSOP PACKAGE
- PIN COMPATIBLE WITH THE AD1896 (SRC4192 ONLY)<sup>(2)</sup>

### APPLICATIONS

- DIGITAL MIXING CONSOLES
- DIGITAL AUDIO WORKSTATIONS
- AUDIO DISTRIBUTION SYSTEMS
- BROADCAST STUDIO EQUIPMENT
- HIGH-END A/V RECEIVERS
- GENERAL DIGITAL AUDIO PROCESSING

### DESCRIPTION

The SRC4192 and SRC4193 are asynchronous sample rate converters designed for professional and broadcast audio applications. The SRC4192 and SRC4193 combine a wide input-to-output sampling ratio with outstanding dynamic range and ultra low distortion. Input and output serial ports support standard audio formats, as well as a Time Division Multiplexed (TDM) mode. Flexible audio interfaces allow the SRC4192 and SRC4193 to connect to a wide range of audio data converters, digital audio receivers and transmitters, and digital signal processors.

The SRC4192 is a standalone pin programmed device, with control pins for mode, data format, mute, bypass, and low group delay functions. The SRC4193 is a software-controlled device featuring a serial peripheral interface (SPI) port, which is utilized to program all functions via internal control registers.

The SRC4192 and SRC4193 may be operated from a single +3.3V power supply. A separate digital I/O supply ( $V_{IO}$ ) operates over the +1.65V to +3.6V supply range, allowing greater flexibility when interfacing to current and future generation signal processors and logic devices. Both the SRC4192 and SRC4193 are available in a 28-lead SSOP package.

(1) Patents Pending.

(2) Refer to the Applications Information section of this data sheet for details.

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## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Supply Voltage, $V_{DD}$ .....	-0.3V to +4.0V
Supply Voltage, $V_{IO}$ .....	-0.3V to +4.0V
Digital Input Voltage .....	-0.3V to +4.0V
Operating Temperature Range .....	-45°C to +85°C
Storage Temperature Range .....	-65°C to +150°C

NOTE: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.



## ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

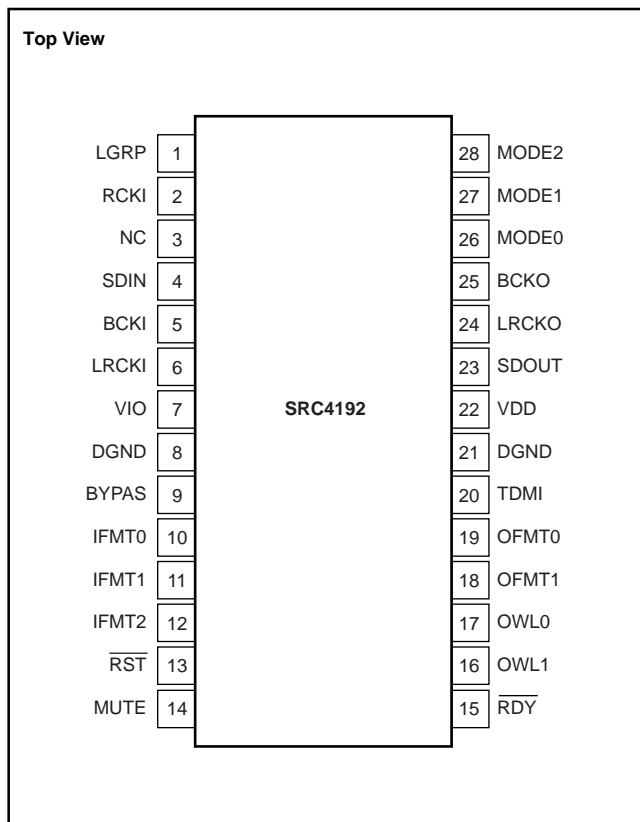
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR <sup>(1)</sup>	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
SRC4192	SSOP-28	DB	-45°C to +85°C	SRC4192I	SRC4192IDB	Rails, 50
"	"	"	"	"	SRC4192IDBR	Tape and Reel, 2000
SRC4193	SSOP-28	DB	-45°C to +85°C	SRC4193I	SRC4193IDB	Rails, 50
"	"	"	"	"	SRC4193IDBR	Tape and Reel, 2000

NOTE: (1) For the most current specifications and package information, refer to our web site at [www.ti.com](http://www.ti.com).

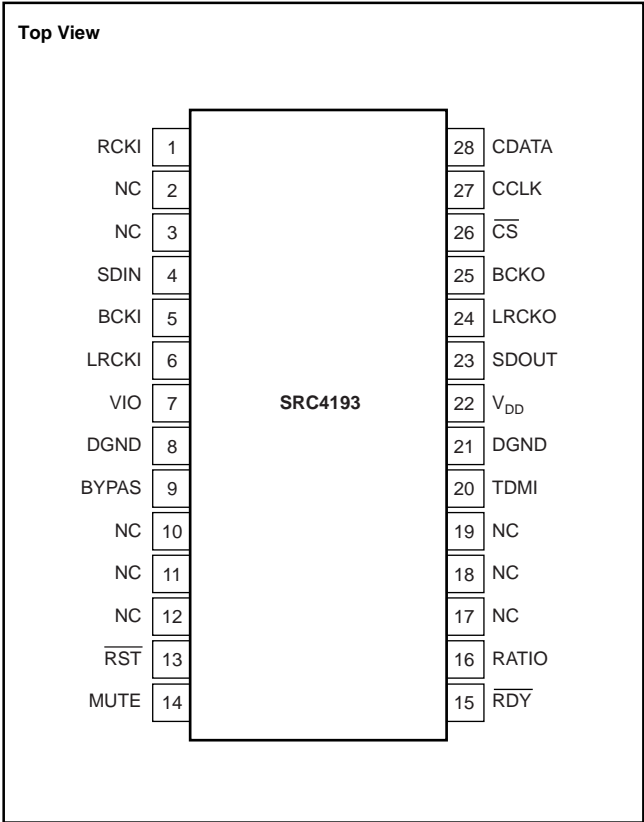
## PIN CONFIGURATION (SRC4192)



## PIN DESCRIPTIONS (SRC4192)

PIN#	NAME	DESCRIPTION
1	LGRP	Low Group Delay Control Input (Active High)
2	RCKI	Reference Clock Input
3	N.C.	No Connection
4	SDIN	Audio Serial Data Input
5	BCKI	Input Port Bit Clock I/O
6	LRCKI	Input Port Left/Right Word Clock I/O
7	$V_{IO}$	Digital I/O Supply, +1.65V to $V_{DD}$
8	DGND	Digital Ground
9	BYPAS	ASRC Bypass Control Input (Active High)
10	IFMT0	Input Port Data Format Control Input
11	IFMT1	Input Port Data Format Control Input
12	IFMT2	Input Port Data Format Control Input
13	$\overline{RST}$	Reset Input (Active Low)
14	MUTE	Output Mute Control Input (Active High)
15	$\overline{RDY}$	ASRC Ready Status Output (Active Low)
16	OWL1	Output Port Data Word Length Control Input
17	OWL0	Output Port Data Word Length Control Input
18	OFMT1	Output Port Data Format Control Input
19	OFMT0	Output Port Data Format Control Input
20	TDMI	TDM Data Input (Connect to DGND when not in use)
21	DGND	Digital Ground
22	$V_{DD}$	Digital Core Supply, +3.3V
23	SDOUT	Audio Serial Data Output
24	LRCKO	Output Port Left/Right Word Clock I/O
25	BCKO	Output Port Bit Clock I/O
26	MODE0	Serial Port Mode Control Input
27	MODE1	Serial Port Mode Control Input
28	MODE2	Serial Port Mode Control Input

PIN CONFIGURATION (SRC4193)



PIN DESCRIPTIONS (SRC4193)

PIN#	NAME	DESCRIPTION
1	RCKI	Reference Clock Input
2	N.C.	No Connection
3	N.C.	No Connection
4	SDIN	Audio Serial Data Input
5	BCKI	Input Port Bit Clock I/O
6	LRCKI	Input Port Left/Right Word Clock I/O
7	V <sub>IO</sub>	Digital I/O Supply, +1.65V to V <sub>DD</sub>
8	DGND	Digital Ground
9	BYPAS	ASRC Bypass Control Input (Active High)
10	N.C.	No Connection
11	N.C.	No Connection
12	N.C.	No Connection
13	RST	Reset Input (Active Low)
14	MUTE	Output Mute Control Input (Active High)
15	RDY	ASRC Ready Status Output (Active Low)
16	RATIO	Input-to-Output Ratio Flag Output Low output denotes Output rate lower than Input rate. High output denotes Output rate higher than Input rate.
17	N.C.	No Connection
18	N.C.	No Connection
19	N.C.	No Connection
20	TDMI	TDM Data Input (Connect to DGND when not in use)
21	DGND	Digital Ground
22	V <sub>DD</sub>	Digital Core Supply, +3.3V
23	SDOUT	Audio Serial Data Output
24	LRCKO	Output Port Left/Right Word Clock I/O
25	BCKO	Output Port Bit Clock I/O
26	CS	SPI Port Chip Select Input (Active Low)
27	CCLK	SPI Port Data Clock Input
28	CDATA	SPI Port Serial Data Input

# ELECTRICAL CHARACTERISTICS

All parameters specified with  $T_A = +25^{\circ}\text{C}$ ,  $V_{DD} = +3.3\text{V}$ , and  $V_{IO} = +3.3\text{V}$ , unless otherwise noted.

PARAMETER	CONDITION	SRC4192, SRC4193			UNITS
		MIN	TYP	MAX	
<b>DYNAMIC PERFORMANCE<sup>(1)</sup></b>					
Resolution			24		Bits
Input Sampling Frequency $f_{\text{SIN}}$		4		212	kHz
Output Sampling Frequency $f_{\text{SOUT}}$		4		212	kHz
Input: Output Sampling Ratio					
Upsampling				1:16	
Downsampling				16:1	
Dynamic Range	BW = 20Hz to $f_{\text{SOUT}}/2$ , -60dBFS Input $f_{\text{IN}} = 1\text{kHz}$ , Unweighted (add 3dB to spec for A-weighted result)				
44.1kHz; 48kHz			140		dB
48kHz; 44.1kHz			140		dB
48kHz; 96kHz			140		dB
44.1kHz; 192kHz			138		dB
96kHz; 48kHz			141		dB
192kHz; 12kHz			141		dB
192kHz; 32kHz			141		dB
192kHz; 48kHz			141		dB
32kHz; 48kHz			140		dB
12kHz; 192kHz			138		dB
Total Harmonic Distortion + Noise	BW = 20Hz to $f_{\text{SOUT}}/2$ , 0dBFS Input $f_{\text{IN}} = 1\text{kHz}$ , Unweighted				
44.1kHz; 48kHz			-140		dB
48kHz; 44.1kHz			-140		dB
48kHz; 96kHz			-140		dB
44.1kHz; 192kHz			-137		dB
96kHz; 48kHz			-140		dB
192kHz; 12kHz			-140		dB
192kHz; 32kHz			-141		dB
192kHz; 48kHz			-141		dB
32kHz; 48kHz			-140		dB
12kHz; 192kHz			-137		dB
Interchannel Gain Mismatch			0		dB
Interchannel Phase Deviation			0		Degrees
Digital Attenuation	SRC4193 Only				
Minimum			0		dB
Maximum			-127.5		dB
Step Size			0.5		dB
Mute Attenuation	24-Bit Word Length, A-weighted		-144		dB
<b>DIGITAL INTERPOLATION FILTER CHARACTERISTICS</b>					
Passband				$0.4535 \times f_{\text{SIN}}$	Hz
Passband Ripple				$\pm 0.007$	dB
Transition Band		$0.4535 \times f_{\text{SIN}}$		$0.5465 \times f_{\text{SIN}}$	Hz
Stop Band		$0.5465 \times f_{\text{SIN}}$			Hz
Stop Band Attenuation		-144			dB
Normal Group Delay (LGRP = 0)	Decimation Filter On (DFLT = 0)		$102.53125/f_{\text{SIN}}$		Seconds
Normal Group Delay (LGRP = 0)	Decimation Filter Off (DFLT = 1)		$102/f_{\text{SIN}}$		Seconds
Low Group Delay (LGRP = 1)	Decimation Filter On (DFLT = 0)		$70.53125/f_{\text{SIN}}$		Seconds
Low Group Delay (LGRP = 1)	Decimation Filter Off (DFLT = 1)		$70/f_{\text{SIN}}$		Seconds
<b>DIGITAL DECIMATION FILTER CHARACTERISTICS</b>					
Passband				$0.4535 \times f_{\text{SOUT}}$	Hz
Passband Ripple				$\pm 0.008$	dB
Transition Band		$0.4535 \times f_{\text{SOUT}}$		$0.5465 \times f_{\text{SOUT}}$	Hz
Stop Band		$0.5465 \times f_{\text{SOUT}}$			Hz
Stop Band Attenuation		-143			dB
Group Delay					
Decimation Filter	DFLT = 0 for SRC4193		$36.46875/f_{\text{SOUT}}$		Seconds
Direct Down-Sampling	SRC4193 Only, DFLT = 1		0		Seconds
<b>DIGITAL I/O CHARACTERISTICS</b>					
High-Level Input Voltage $V_{\text{IH}}$		$0.7 \times V_{\text{IO}}$		$V_{\text{IO}}$	V
Low Level Input Voltage $V_{\text{IL}}$		0		$0.3 \times V_{\text{IO}}$	V
High-Level Input Current $I_{\text{IH}}$			0.5	10	$\mu\text{A}$
Low-Level Input Current $I_{\text{IL}}$			0.5	10	$\mu\text{A}$
High-Level Output Voltage $V_{\text{OH}}$	$I_{\text{O}} = -4\text{mA}$	$0.8 \times V_{\text{IO}}$		$V_{\text{IO}}$	V
Low-Level Output Voltage $V_{\text{OL}}$	$I_{\text{O}} = +4\text{mA}$	0		$0.2 \times V_{\text{IO}}$	V
Input Capacitance $C_{\text{IN}}$			3		pF

# ELECTRICAL CHARACTERISTICS (Cont.)

All parameters specified with  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +3.3\text{V}$ , and  $V_{IO} = +3.3\text{V}$ , unless otherwise noted.

PARAMETER	CONDITION	SRC4192, SRC4193			UNITS
		MIN	TYP	MAX	
SWITCHING CHARACTERISTICS					
Reference Clock Timing					
RCKI Frequency <sup>(2), (3)</sup>		128 x f <sub>S</sub> MIN		50	MHz
RCKI Period	t <sub>RCKIP</sub>	20		1/(128 x f <sub>S</sub> MIN)	ns
RCKI Pulsewidth High	t <sub>RCKIH</sub>	0.4 x t <sub>RCKIP</sub>			ns
RCKI Pulsewidth Low	t <sub>RCKIL</sub>	0.4 x t <sub>RCKIP</sub>			ns
Reset Timing					
RST Pulse Width Low	t <sub>RSTL</sub>	500			ns
Delay Following RST Rising Edge		500			μs
Input Serial Port Timing					
LRCKI to BCKI Setup Time	t <sub>LRIS</sub>	10			ns
BCKI Pulsewidth High	t <sub>SIH</sub>	10			ns
BCKI Pulsewidth Low	t <sub>SIL</sub>	10			ns
SDIN Data Setup Time	t <sub>LDIS</sub>	10			ns
SDIN Data Hold Time	t <sub>LDIH</sub>	10			ns
Output Serial Port Timing					
SDOUT Data Delay Time	t <sub>DOPD</sub>			10	ns
SDOUT Data Hold Time	t <sub>DOH</sub>	2			ns
BCKO Pulsewidth High	t <sub>SOH</sub>	10			ns
BCKO Pulsewidth Low	t <sub>SOL</sub>	5			ns
TDM Mode Timing					
LRCKO Setup Time	t <sub>LROS</sub>	10			ns
LRCKO Hold Time	t <sub>LROH</sub>	10			ns
TDMI Data Setup Time	t <sub>TDMS</sub>	10			ns
TDMI Data Hold Time	t <sub>TDMH</sub>	10			ns
SPI Timing					
CCLK Frequency				25	MHz
CDATA Setup Time	t <sub>CDS</sub>	12			ns
CDATA Hold Time	t <sub>CDH</sub>	8			ns
CS Falling to CCLK Rising	t <sub>CSCR</sub>	15			ns
CCLK Falling to CS Rising	t <sub>CFCS</sub>	12			ns
POWER SUPPLIES					
Operating Voltage					
V <sub>DD</sub>		3.0	+3.3	3.6	V
V <sub>IO</sub>		1.65	+3.3	3.6	V
Supply Current	V <sub>DD</sub> = +3.3V, V <sub>IO</sub> = +3.3V				
I <sub>DD</sub> , Power Down	RST = 0, No Clocks			100	μA
I <sub>DD</sub> , Power Down (SRC4193 only)	PDN Bit = 0, No Clocks		5		mA
I <sub>DD</sub> , Dynamic	f <sub>SIN</sub> = f <sub>SOUT</sub> = 192kHz		66		mA
I <sub>IO</sub> , Power Down	RST = 0, No Clocks			100	μA
I <sub>IO</sub> , Power Down (SRC4193 only)	PDN Bit = 0, No Clocks		21		μA
I <sub>IO</sub> , Dynamic	f <sub>SIN</sub> = f <sub>SOUT</sub> = 192kHz		2		mA
Total Power Dissipation	V <sub>DD</sub> = +3.3V, V <sub>IO</sub> = +3.3V				
P <sub>D</sub> , Power Down	RST = 0, No Clocks			660	μW
P <sub>D</sub> , Power Down (SRC4193)	PDN Bit = 0, No Clocks		16.6		mW
P <sub>D</sub> , Dynamic	f <sub>SIN</sub> = f <sub>SOUT</sub> = 192kHz		225		mW

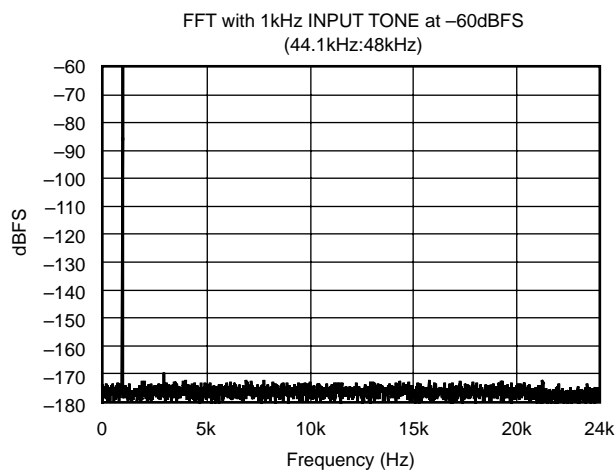
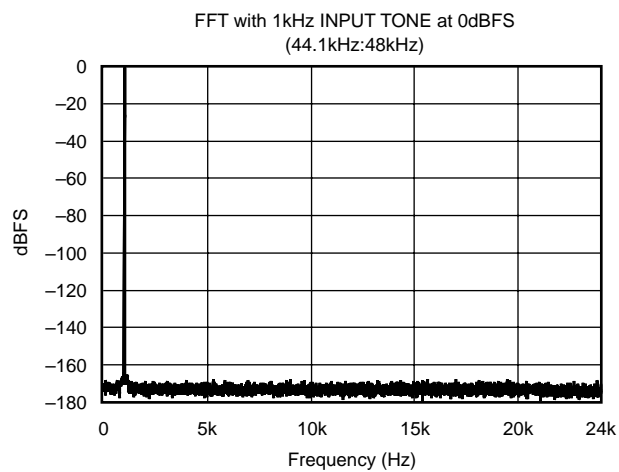
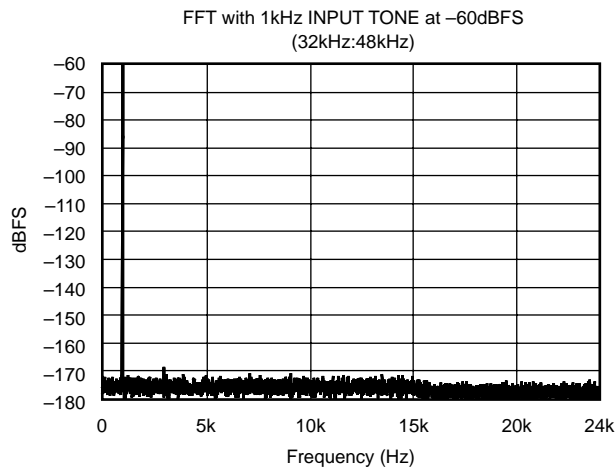
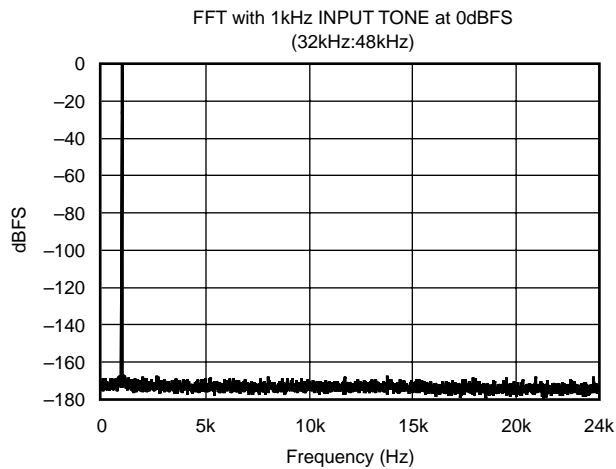
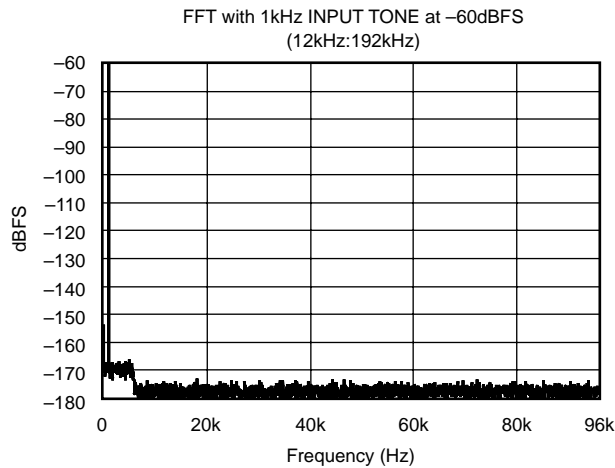
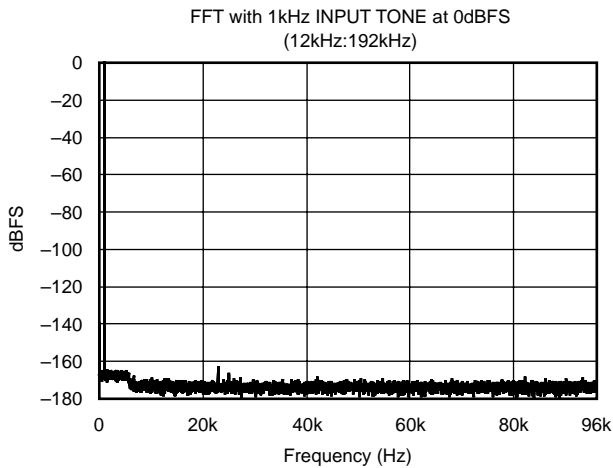
NOTES: (1) Dynamic performance measured with an Audio Precision System Two Cascade or Cascade Plus.

(2)  $f_{S\text{MIN}} = \min(f_{\text{SIN}}, f_{\text{SOUT}})$ .

(3)  $f_{S\text{MAX}} = \max(f_{\text{SIN}}, f_{\text{SOUT}})$ .

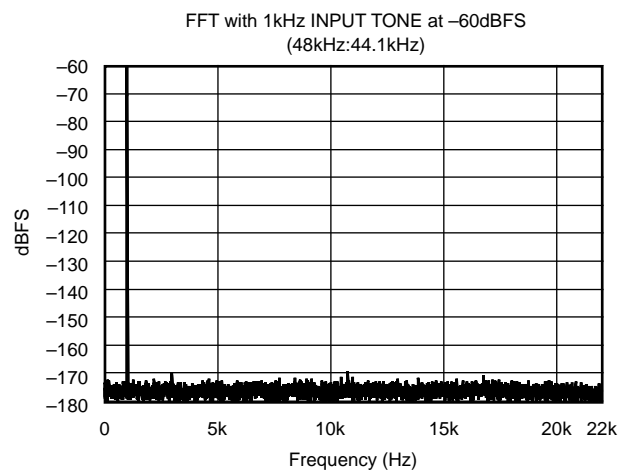
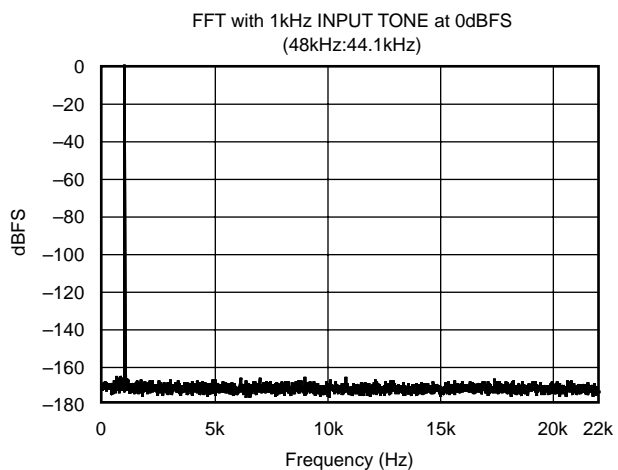
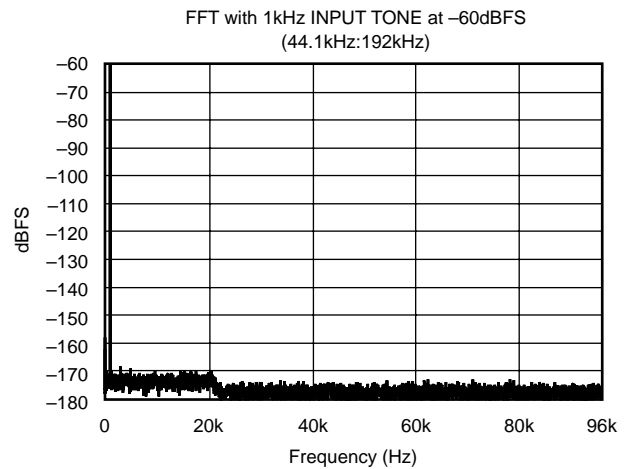
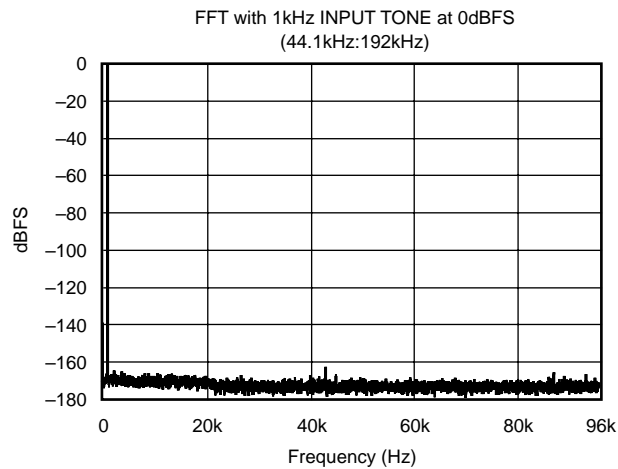
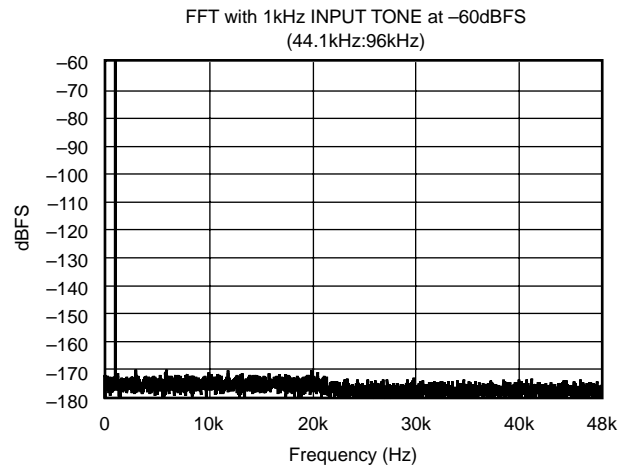
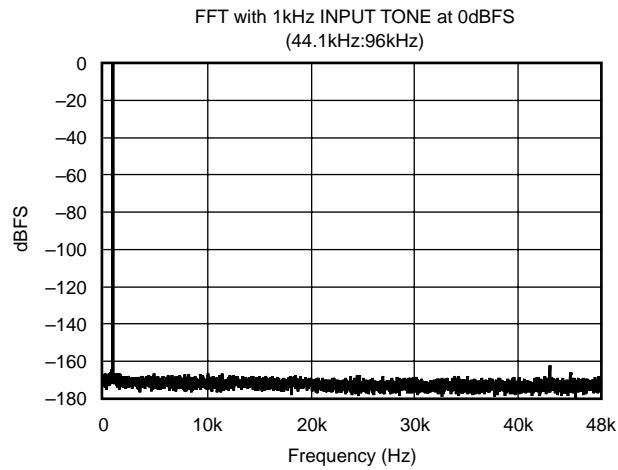
# TYPICAL CHARACTERISTICS

At  $T_A = +25^{\circ}\text{C}$ ,  $V_{DD} = +3.3\text{V}$ , and  $V_{IO} = +3.3\text{V}$ , unless otherwise noted.



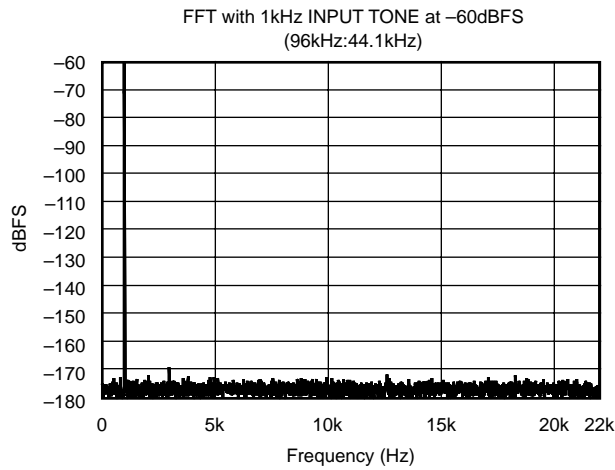
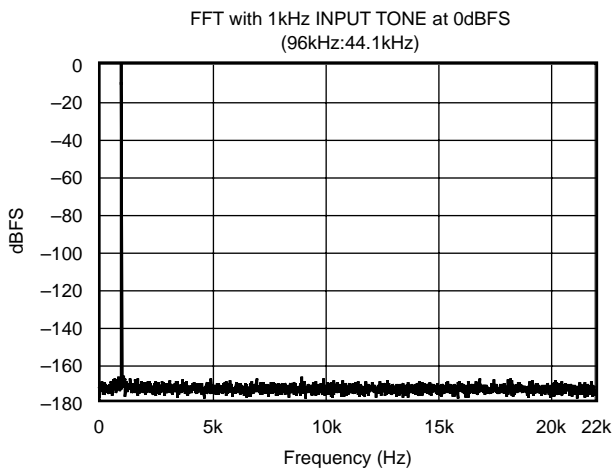
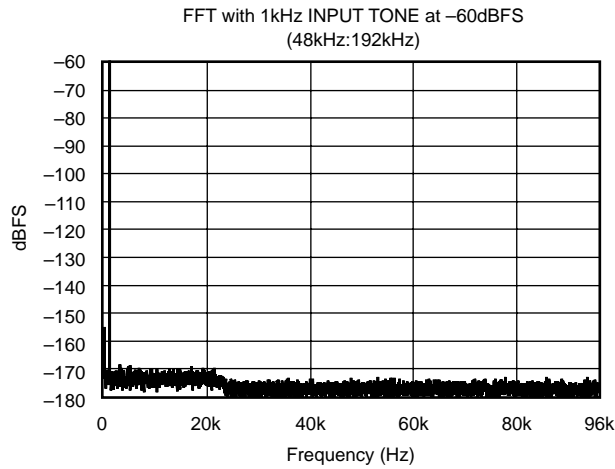
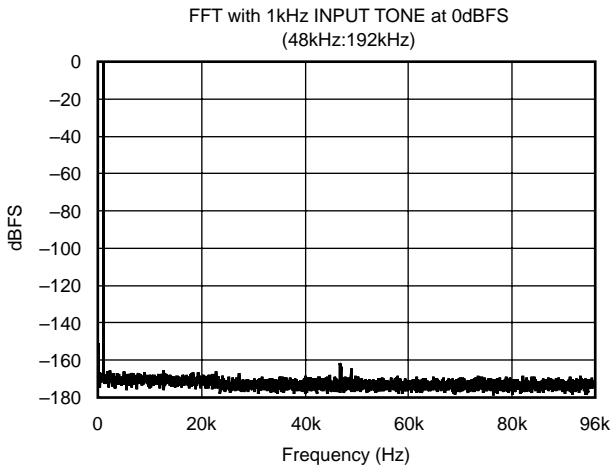
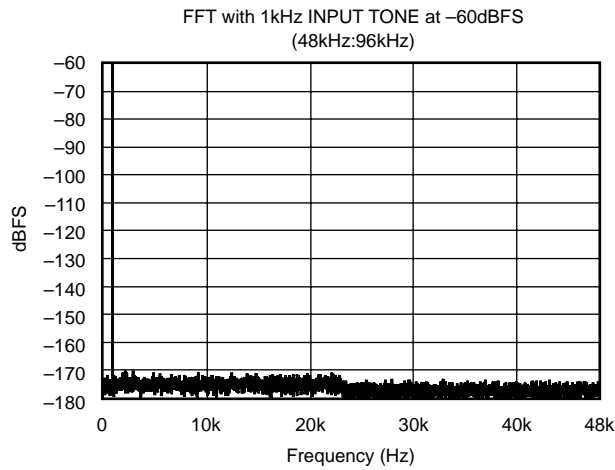
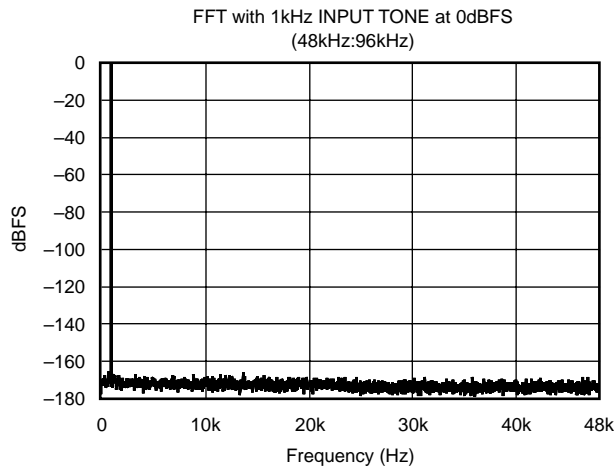
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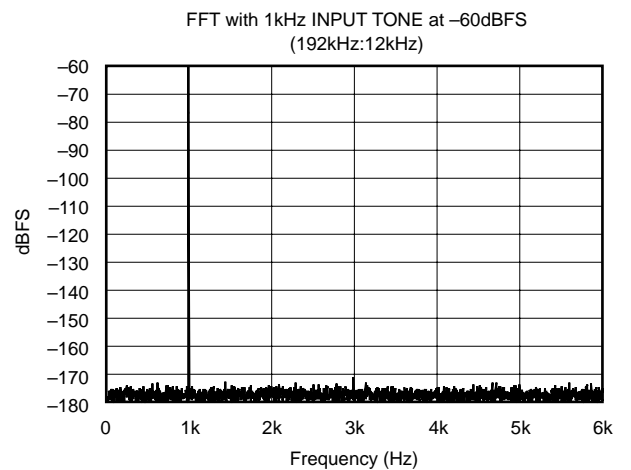
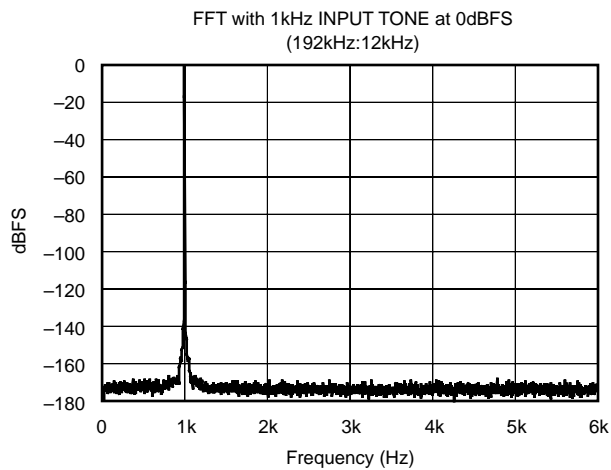
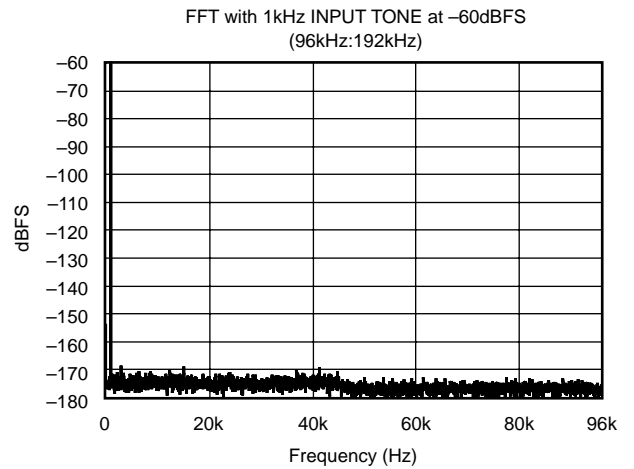
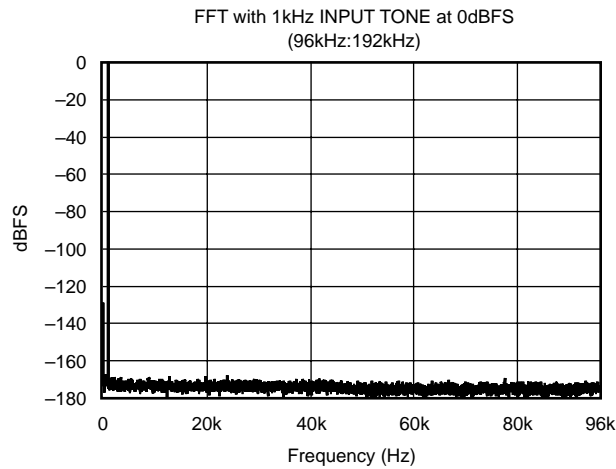
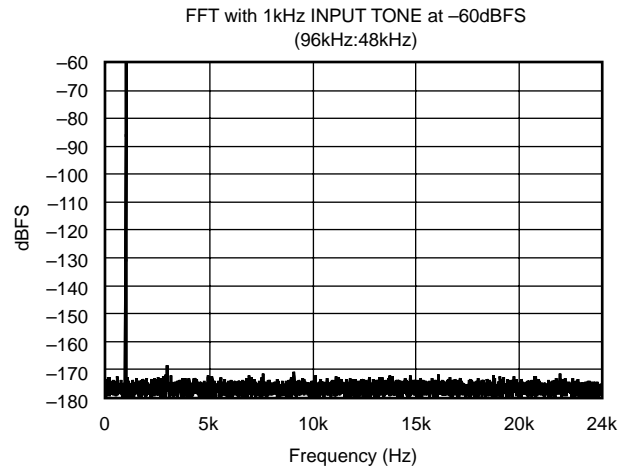
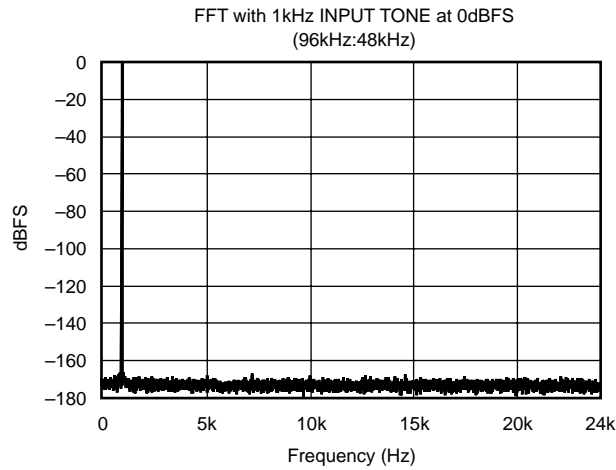
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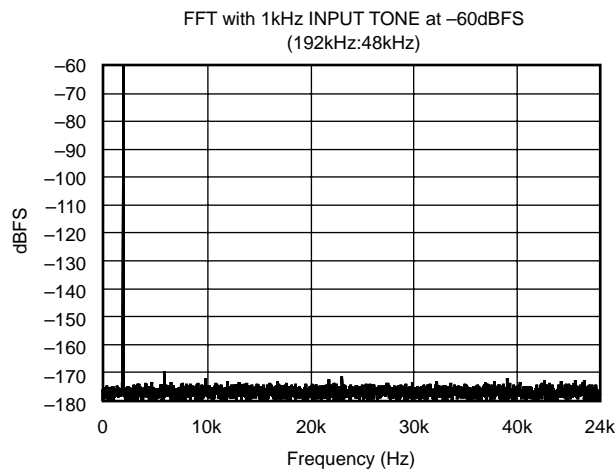
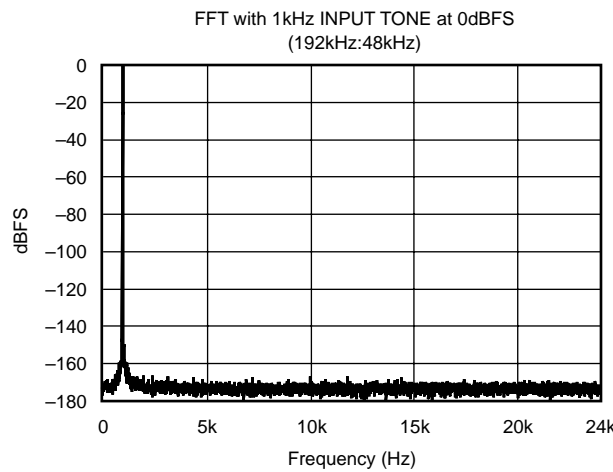
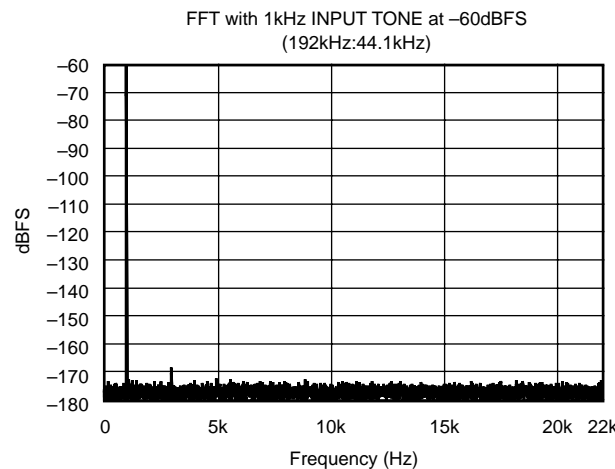
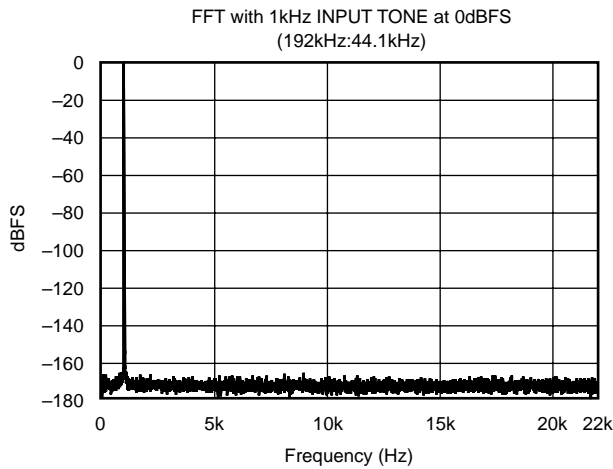
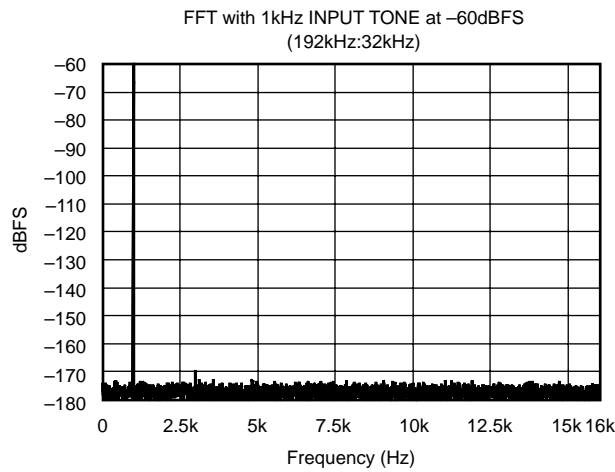
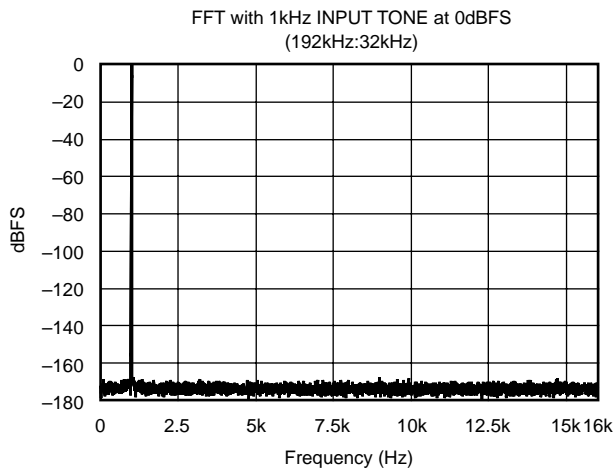
# TYPICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +3.3\text{V}$ , and  $V_{IO} = +3.3\text{V}$ , unless otherwise noted.



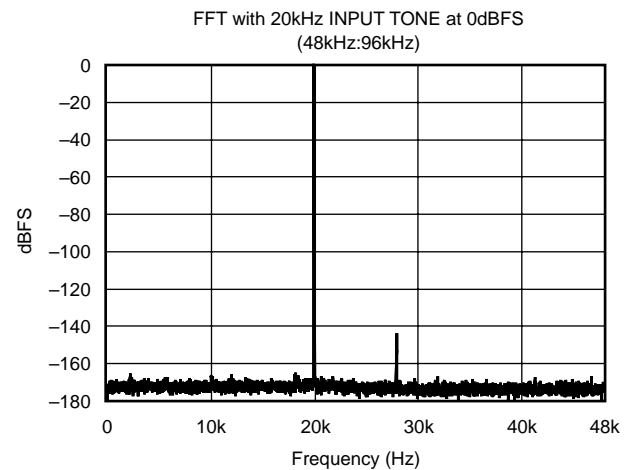
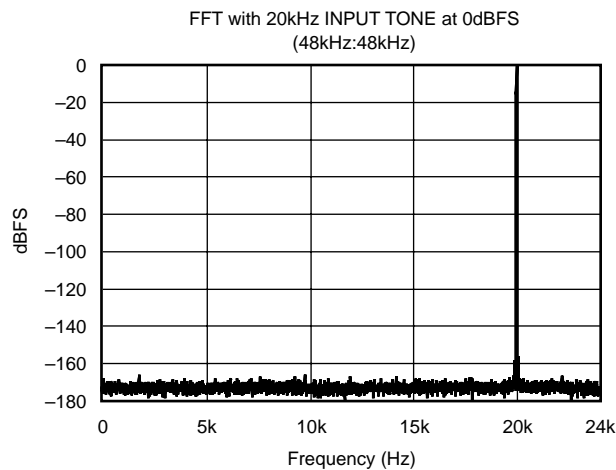
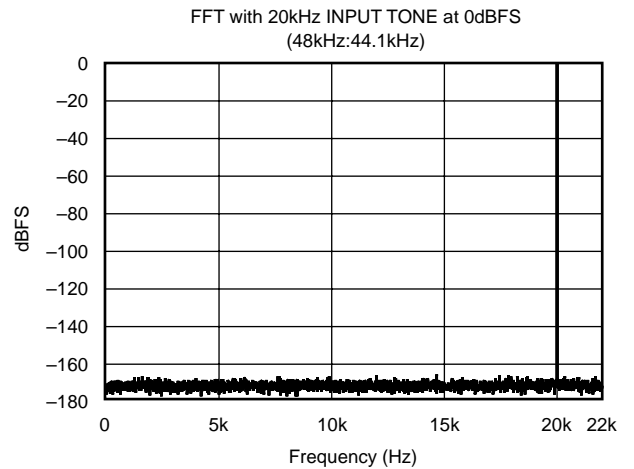
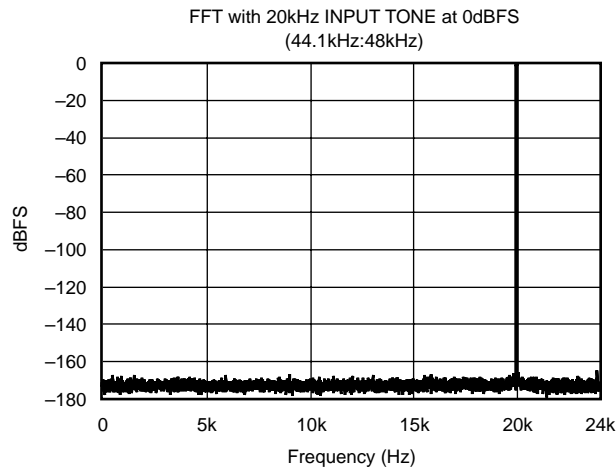
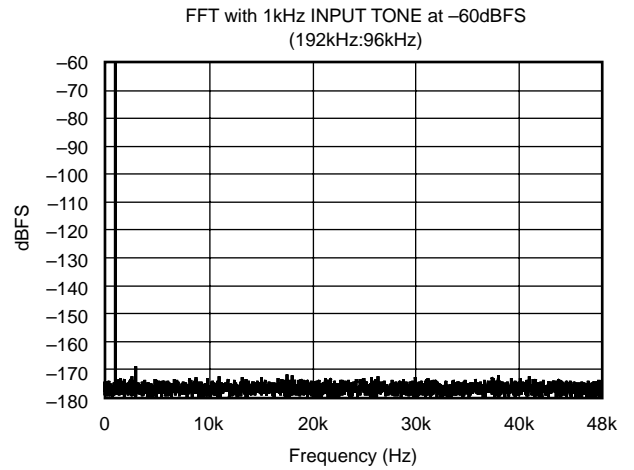
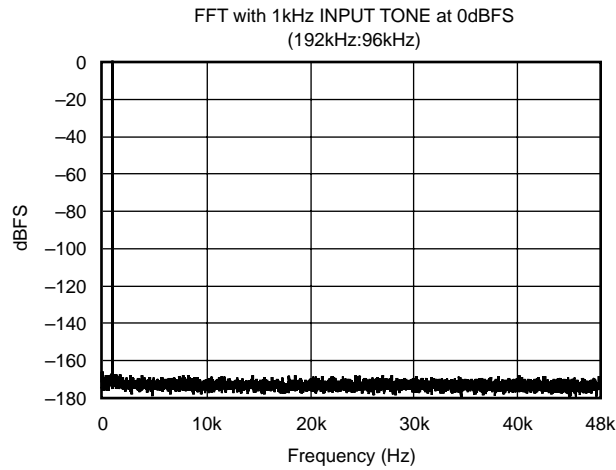
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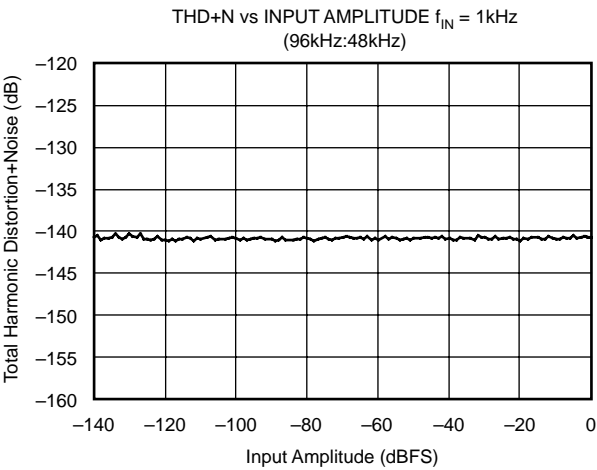
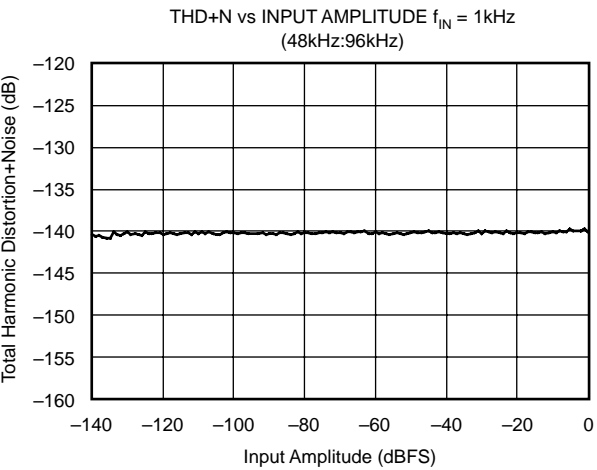
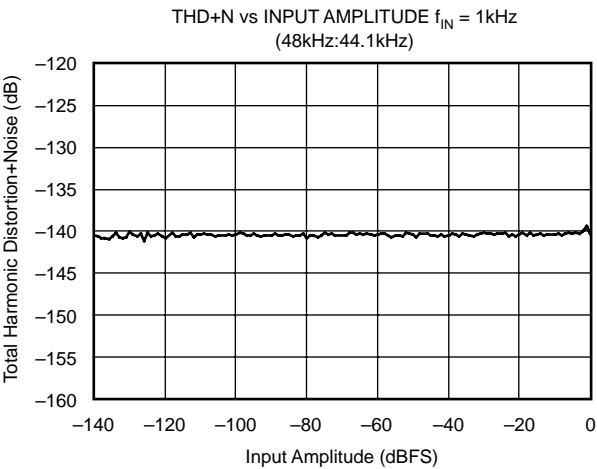
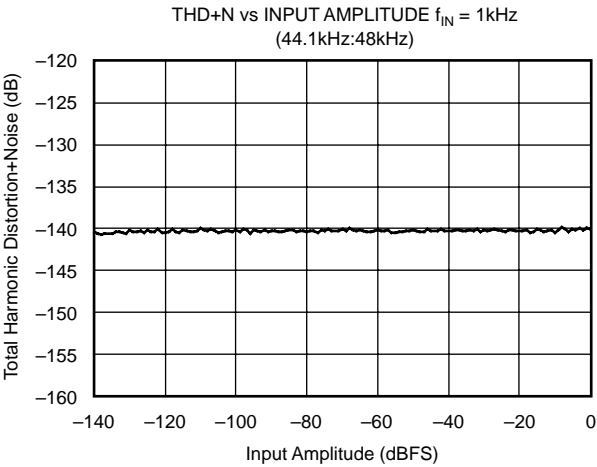
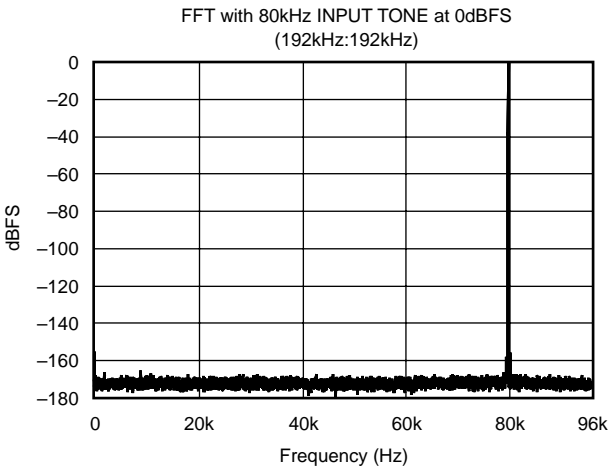
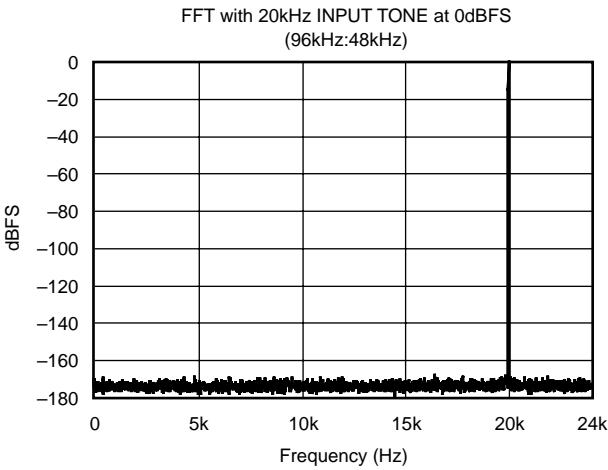
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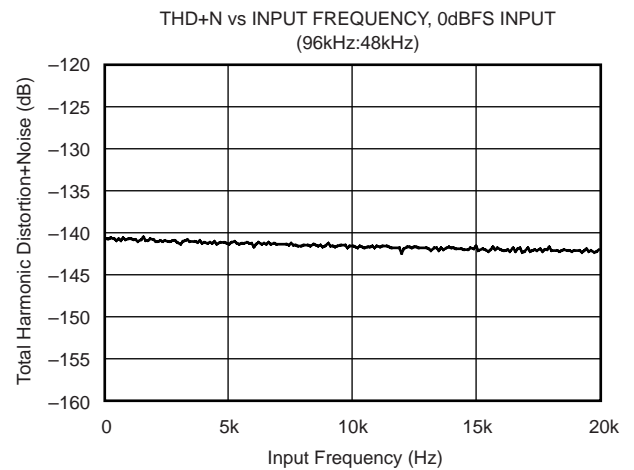
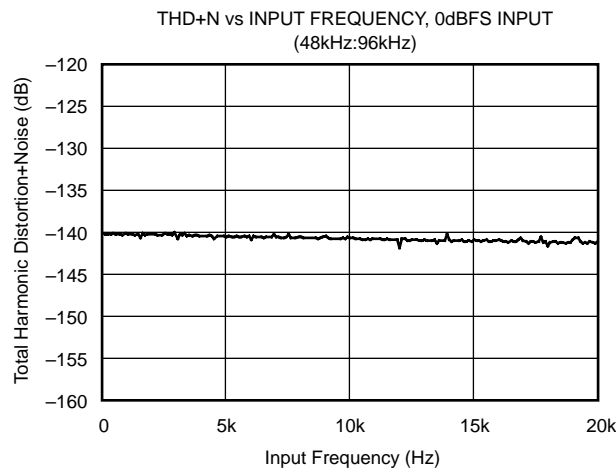
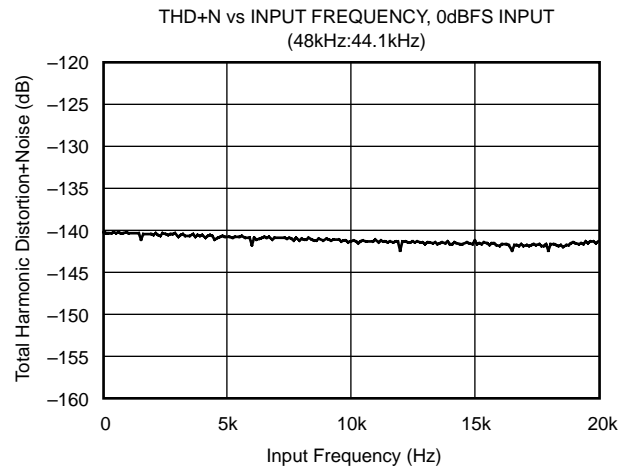
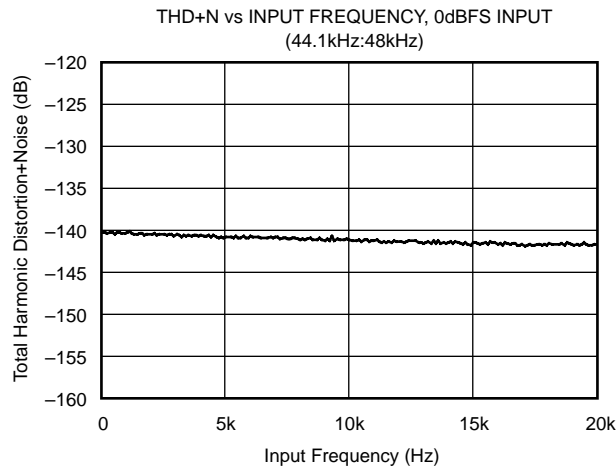
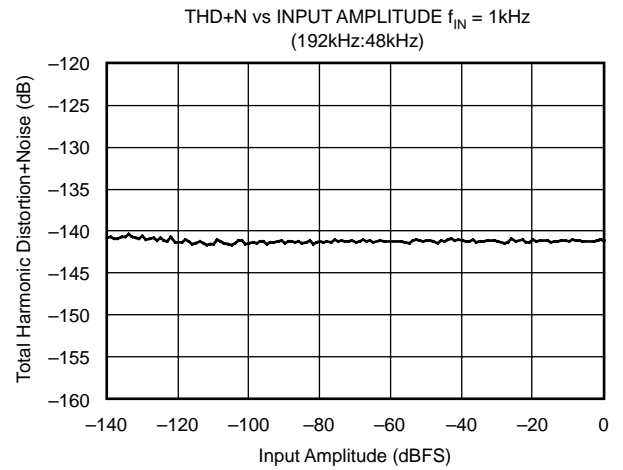
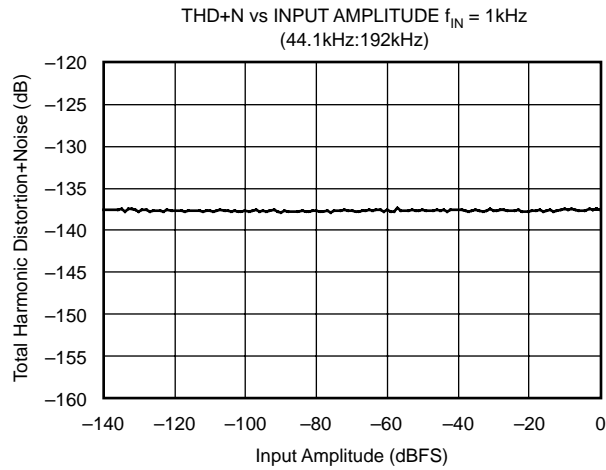
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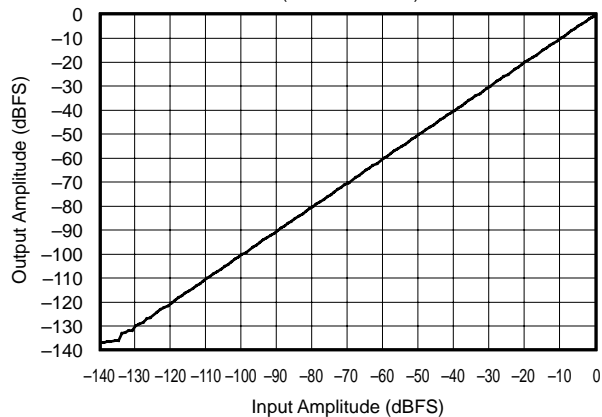
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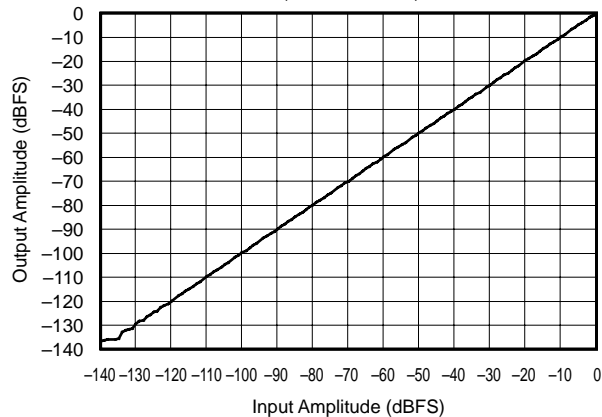
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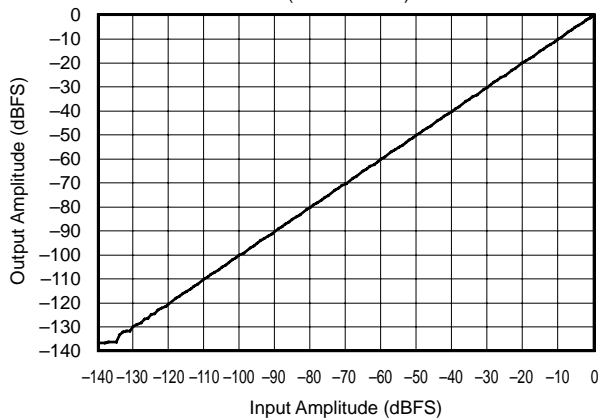
LINEARITY with  $f_{IN} = 200\text{Hz}$   
(44.1kHz:48kHz)



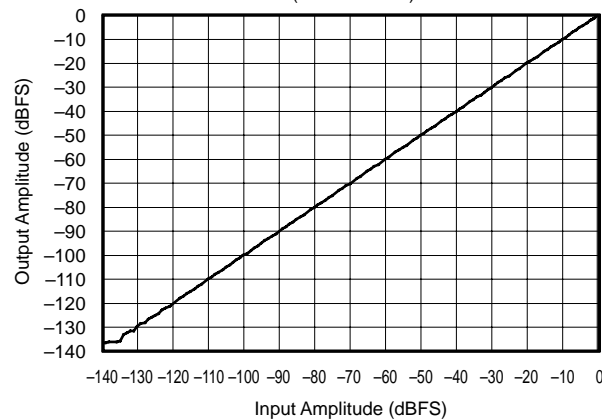
LINEARITY with  $f_{IN} = 200\text{Hz}$   
(48kHz:44.1kHz)



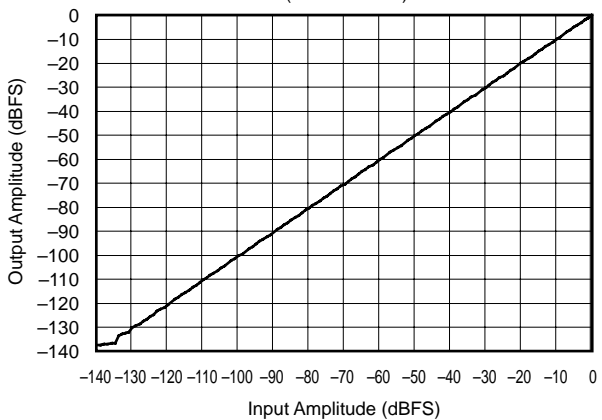
LINEARITY with  $f_{IN} = 200\text{Hz}$   
(48kHz:48kHz)



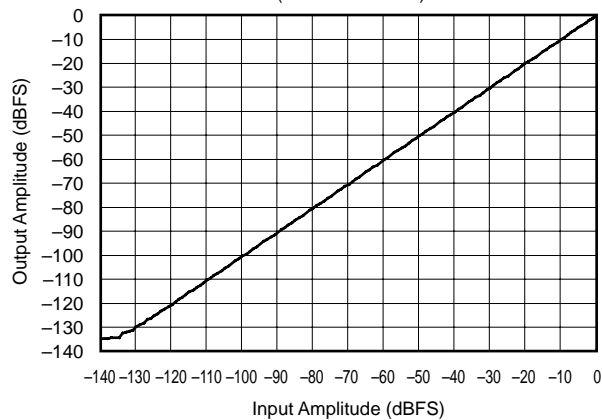
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(48kHz:96kHz)



LINEARITY with  $f_{IN} = 200\text{Hz}$   
(96kHz:48kHz)

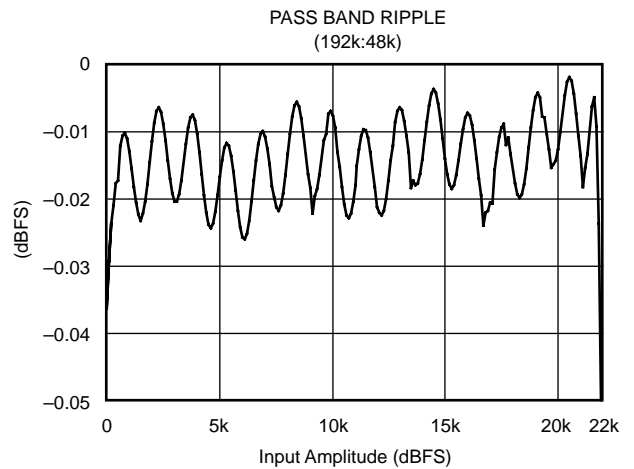
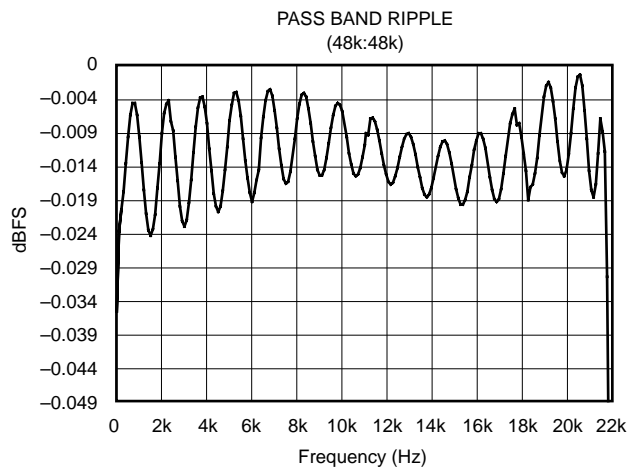
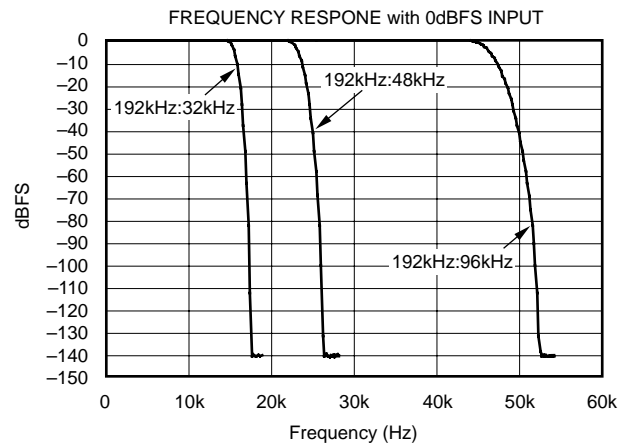
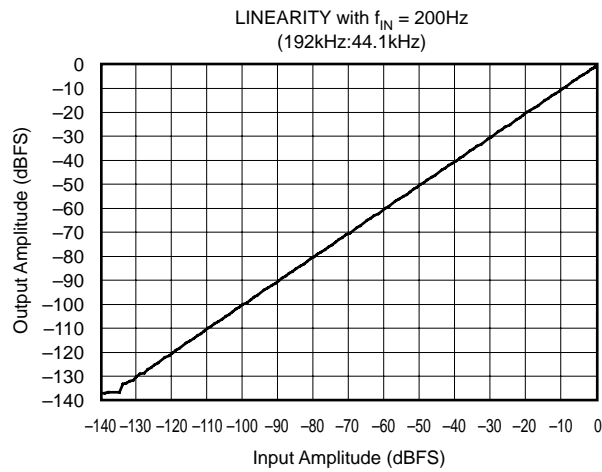


LINEARITY with  $f_{IN} = 200\text{Hz}$   
(44.1kHz:192kHz)



# TYPICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +3.3\text{V}$ , and  $V_{IO} = +3.3\text{V}$ , unless otherwise noted.



# PRODUCT OVERVIEW

The SRC4192 and SRC4193 are asynchronous sample rate converters (ASRC) designed for professional audio applications. Operation at input and output sampling frequencies up to 212kHz is supported, with an input/output sampling ratio range of 16:1 to 1:16. Excellent dynamic range and Total Harmonic Distortion + Noise (THD+N) are achieved by employing high performance, linear phase digital filtering with better than 140dB of image rejection. Digital filtering options allow for lower group delay processing. These include a low group delay option for the interpolation and re-sampler function, as well as a direct down-sampling option for the decimation function (SRC4193 only).

The audio input and output ports support standard audio data formats, as well as a TDM interface mode. Word lengths of 24-, 20-, 18-, and 16-bits are supported. Both ports may operate in Slave mode, deriving their word and bit clocks from external input and output devices. Alternatively, one port may operate in Master mode while the other remains in Slave mode. In Master mode, the LRCK and BCK clocks are derived from the reference clock input, RCKI. The flexible configuration of the input and output ports allows connection to a wide variety of audio data converters, interface devices, digital signal processors, and programmable logic.

A bypass mode is included, which allows audio data to be passed directly from the input port to the output port, bypassing the ASRC function. The bypass option is useful for passing through encoded or compressed audio data, or non-audio control or status data.

A soft mute function is available on both the SRC4192 and SRC4193. Digital output attenuation is available only for the SRC4193. Both soft mute and digital attenuation functions provide artifact-free operation, while allowing muting or level adjustment of the audio output signal. The mute attenuation is typically -144dB, while the digital attenuation control is adjustable from 0dB to -127.5dB in 0.5dB steps.

The SRC4193 includes a three-wire SPI port, which is used to access on-chip control registers for configuration of internal functions. The port can be easily interfaced to microprocessors or digital signal processors with synchronous serial port peripherals.

## FUNCTIONAL BLOCK DIAGRAM

Figure 1 shows a functional block diagram of the SRC4192 and SRC4193. Audio data is received at the input port, clocked by either the audio data source in Slave mode, or by the SRC4192/4193 in Master mode. The output port data is clocked by either the audio data source in Slave mode, or by

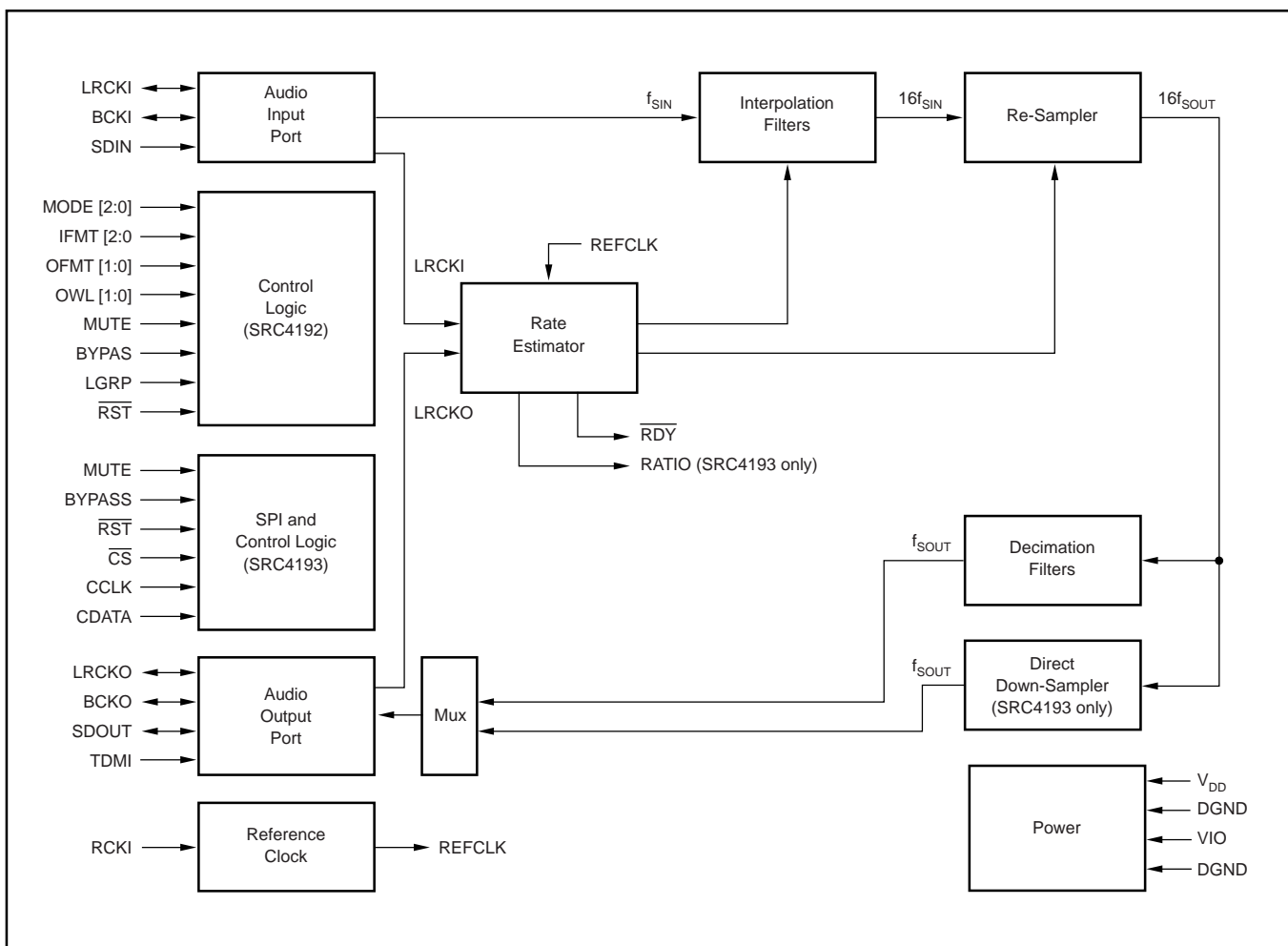


FIGURE 1. SRC4192/4193 Functional Block Diagram.



the SRC4192/4193 in Master mode. The input data is passed through interpolation filters which up-sample the data, which is then passed on to the re-sampler. The rate estimator compares the input and output sampling frequencies by comparing LRCKI, LRCKO, and a reference clock. The results include an offset for the FIFO pointer and the coefficients needed for re-sampling function.

The output of the re-sampler is passed on to either the decimation filter or direct down-sampler function. The decimation filter performs down-sampling and anti-alias filtering functions, and is required when the output sampling frequency is lower than the input sampling frequency. The direct down-sampler function does not provide any filtering, and may be used in cases when aliasing is not an issue. This includes the case when the output sampling frequency is equal to or greater than the input sampling frequency. The advantage of direct down-sampling is a significant reduction in the group delay associated with the decimation filter, allowing lower latency sample rate conversion. The direct down-sampler function is available only for the SRC4193.

## REFERENCE CLOCK

The SRC4192 and SRC4193 require a reference clock for operation. The reference clock is applied at the RCKI input (pin 1 for the SRC4193, pin 2 for the SRC4192). Figure 2 illustrates the reference clock connections and requirements for the SRC4192 and SRC4193. The reference clock may operate at  $128f_s$ ,  $256f_s$ , or  $512f_s$ , where  $f_s$  are the input or output sampling frequency. The maximum external reference clock input frequency is 50 MHz.

## RESET AND POWER DOWN OPERATION

The SRC4192 and SRC4193 may be reset using the  $\overline{RST}$  input (pin 13). There is no internal power on reset, so the user should force a reset sequence after power up in order to initialize the device. In order to force a reset, the reference clock input must be active, with an external clock source supplying a valid reference clock signal (refer to Figure 2). The user must assert  $\overline{RST}$  low for a minimum of 500 nanoseconds and then bring  $\overline{RST}$  high again to force a reset. Figure 3 shows the reset timing for the SRC4192 and SRC4193.

For the SRC4193, there is an additional 500 microsecond delay after the  $\overline{RST}$  rising edge, due to internal logic requirements. The customer should wait at least 500 microseconds after the  $\overline{RST}$  rising edge before attempting to write to the SPI port of the SRC4193.

The SRC4192 and SRC4193 also support a power-down mode. Power-down mode may be set by either holding the  $\overline{RST}$  input low (SRC4192 and SRC4193), or by setting the  $\overline{PDN}$  bit in Control Register 1 to zero (SRC4193 only). The SRC4193 will be in power-down mode by default after an external reset has been issued. In order to enable normal operation for the SRC4193, the customer must disable power down mode by writing a 1 to the  $\overline{PDN}$  bit in Control Register 1. Finally, for the SRC4193, when using the  $\overline{PDN}$  bit in Control Register 1 to enable power-down mode, the current state of the control registers is maintained through the power down/power up transition.

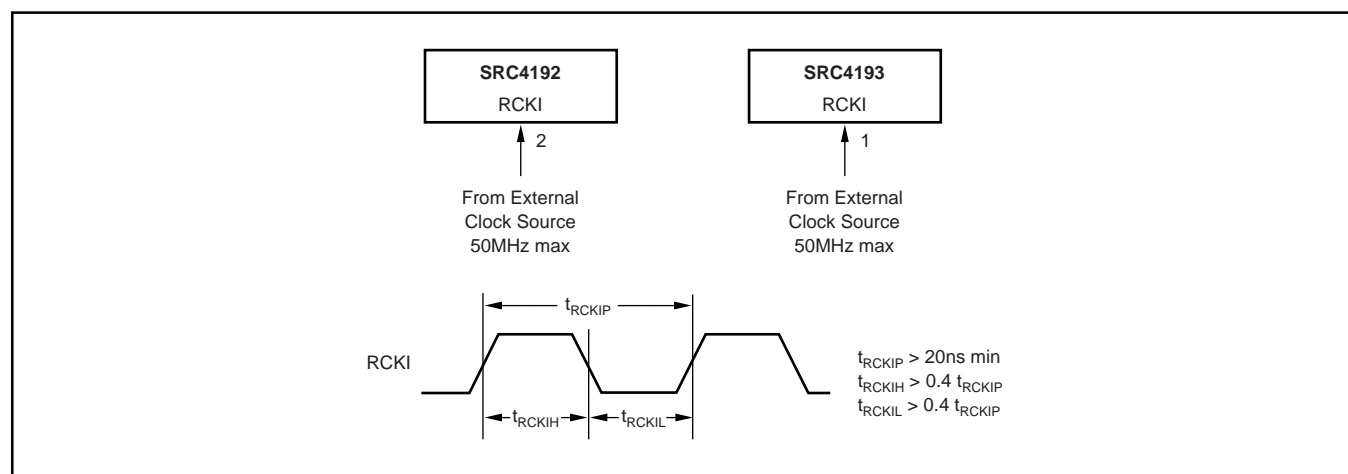


FIGURE 2. Reference Clock Input Connections and Timing Requirements.

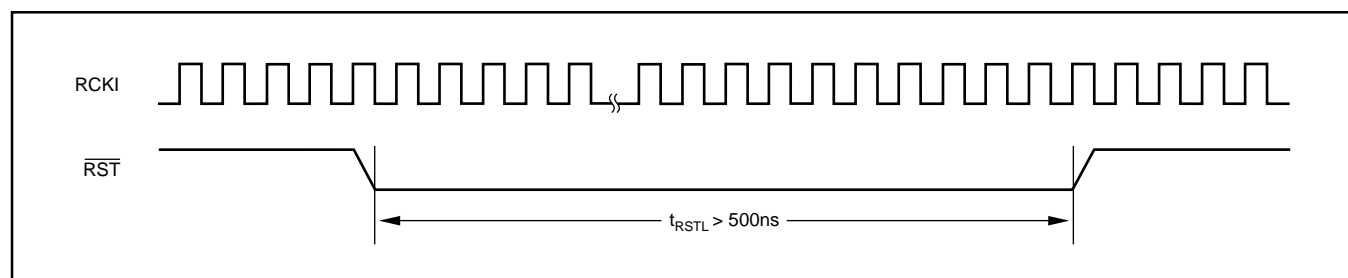


FIGURE 3. Reset Pulse Width Requirement.

AUDIO PORT MODES

The SRC4192 and SRC4193 both support seven serial port modes, which are shown in Table 1. For the SRC4192, the audio port mode is selected using the MODE0 (pin 26), MODE1 (pin 27), and MODE2 (pin 28) inputs. For the SRC4193, the mode is selected using the MODE[2:0] bits in Control Register 1. The default mode setting for the SRC4193 is both input and output ports set to Slave mode.

In Slave mode, the port LRCK and BCK clocks are configured as inputs, and receive their clocks from an external audio device. In Master mode, the LRCK and BCK clocks are configured as outputs, being derived from the reference clock input (RCKI). Only one port can be set to Master mode at any given time, as indicated in Table 1.

MODE2	MODE1	MODE0	SERIAL PORT MODE
0	0	0	Both Input and Output Ports are Slave mode
0	0	1	Output Port is Master mode with RCKI = 128f <sub>S</sub>
0	1	0	Output Port is Master mode with RCKI = 512f <sub>S</sub>
0	1	1	Output Port is Master mode with RCKI = 256f <sub>S</sub>
1	0	0	Both Input and Output Ports are Slave Mode
1	0	1	Input Port is Master mode with RCKI = 128f <sub>S</sub>
1	1	0	Input Port is Master mode with RCKI = 512f <sub>S</sub>
1	1	1	Input Port is Master mode with RCKI = 256f <sub>S</sub>

TABLE 1. Setting the Serial Port Modes.

INPUT PORT OPERATION

The audio input port is a three-wire synchronous serial interface that may operate in either Slave or Master mode. The SDIN input (pin 4) is the serial audio data input. Audio data is input at this pin in one of three standard audio data formats: Philips I<sup>2</sup>S, Left Justified, or Right Justified. The audio data word length may be up to 24-bits for I<sup>2</sup>S and Left Justified formats, while the Right Justified format supports 16-, 18-, 20-, or 24-bit data. The data formats are shown in Figure 4, while critical timing parameters are shown in Figure 5 and listed in the Electrical Characteristics table.

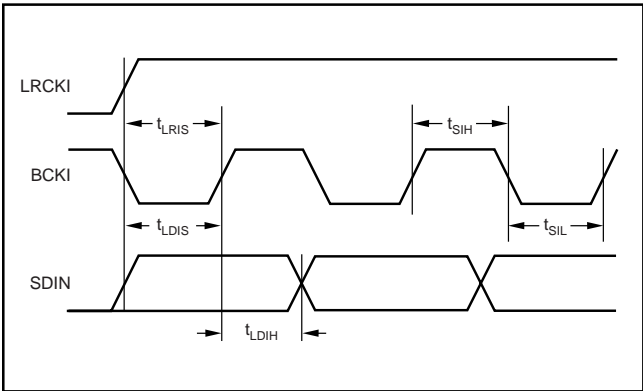


FIGURE 5. Input Port Timing.

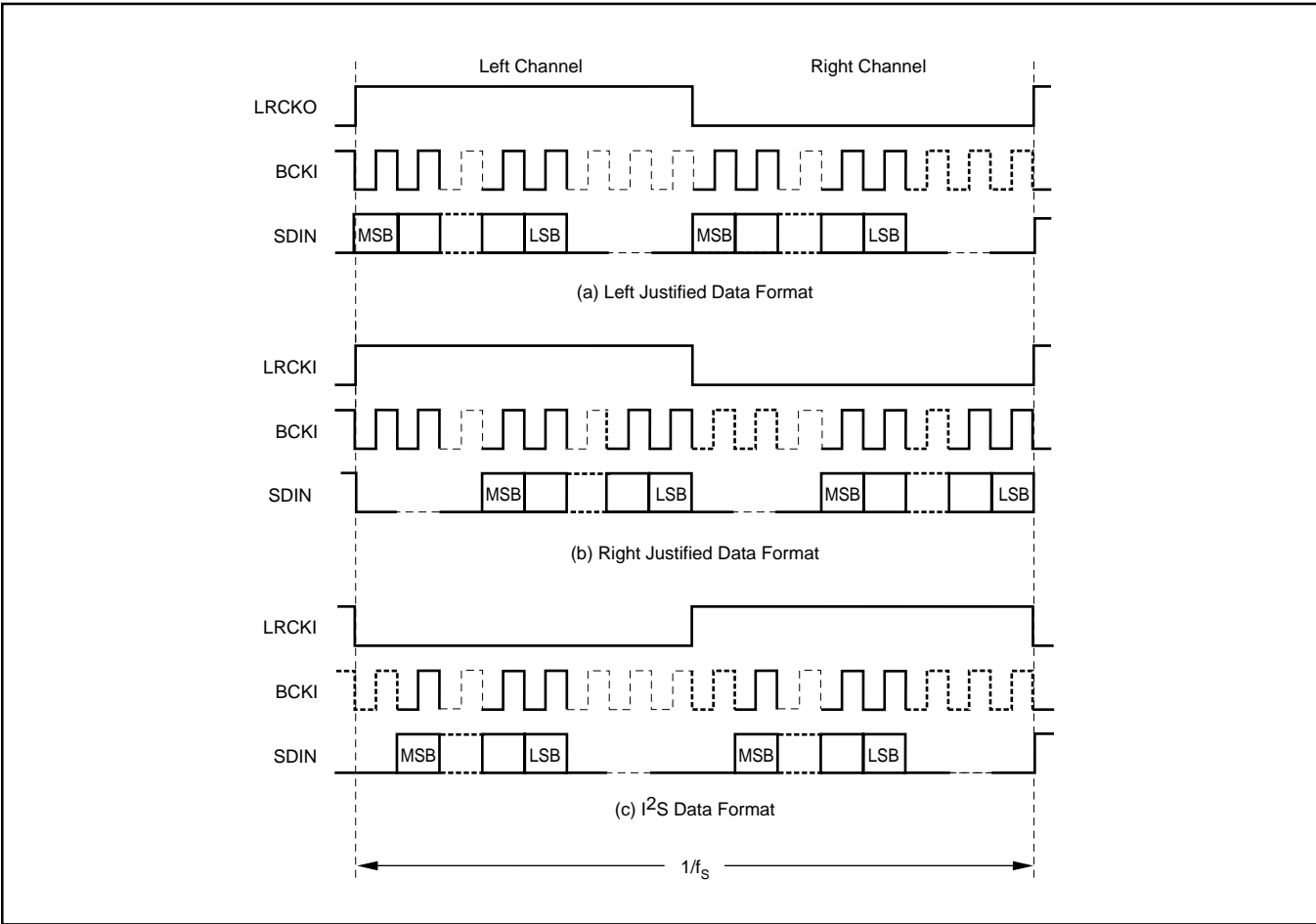


FIGURE 4. Input Data Formats.

The bit clock is either an input or output at BCKI (pin 5). In slave mode, BCKI is configured as an input pin, and may operate at rates from  $32f_s$  to  $128f_s$ , with a minimum of one clock cycle per data bit. In Master mode, BCKI operates at a fixed rate of  $64f_s$ .

The left/right word clock, LRCKI (pin 6), may be configured as an input or output pin. In Slave mode, LRCKI is an input pin, while in Master mode LRCKI is an output pin. In either case, the clock rate is equal to  $f_s$ , the input sampling frequency. The LRCKI duty cycle is fixed to 50% for Master mode operation.

Table 2 illustrates data format selection for the input port. For the SRC4192, the IFMT0 (pin 10), IFMT1 (pin 11), and IFMT2 (pin 12) inputs are utilized to set the input port data format. For the SRC4193, the IFMT[2:0] bits in Control Register 3 are used to select the data format.

IFMT2	IFMT1	IFMT0	INPUT PORT DATA FORMAT
0	0	0	24-Bit Left Justified
0	0	1	24-Bit I2S
0	1	0	Unused
0	1	1	Unused
1	0	0	16-Bit Right Justified
1	0	1	18-Bit Right Justified
1	1	0	20-Bit Right Justified
1	1	1	24-Bit Right Justified

TABLE 2. Input Port Data Format Selection.

### OUTPUT PORT OPERATION

The audio output port is a four-wire synchronous serial interface that may operate in either Slave or Master mode. The SDOUT output (pin 23) is the serial audio data output. Audio data is output at this pin in one of four data formats: Philips I<sup>2</sup>S, Left Justified, Right Justified, or TDM. The audio data word length may be 16-, 18-, 20-, or 24-bits. For all word lengths, the data is triangular PDF dithered from the internal 28-bit data path. The data formats (with the exception of TDM mode) are shown in Figure 6, while critical timing parameters are shown in Figure 7 and listed in the Electrical Characteristics table. The TDM format and timing are shown in Figures 14 and 15, respectively, while examples of standard TDM configurations are shown in Figures 16 and 17.

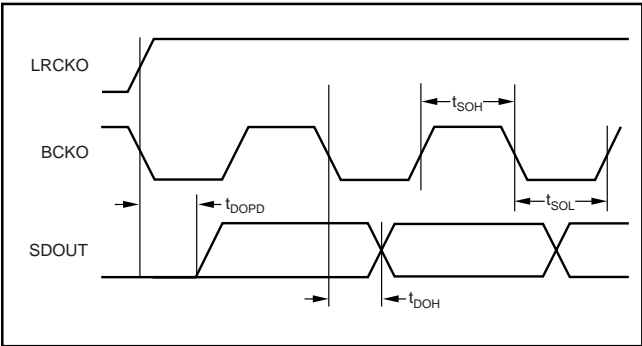


FIGURE 7. Output Port Timing.

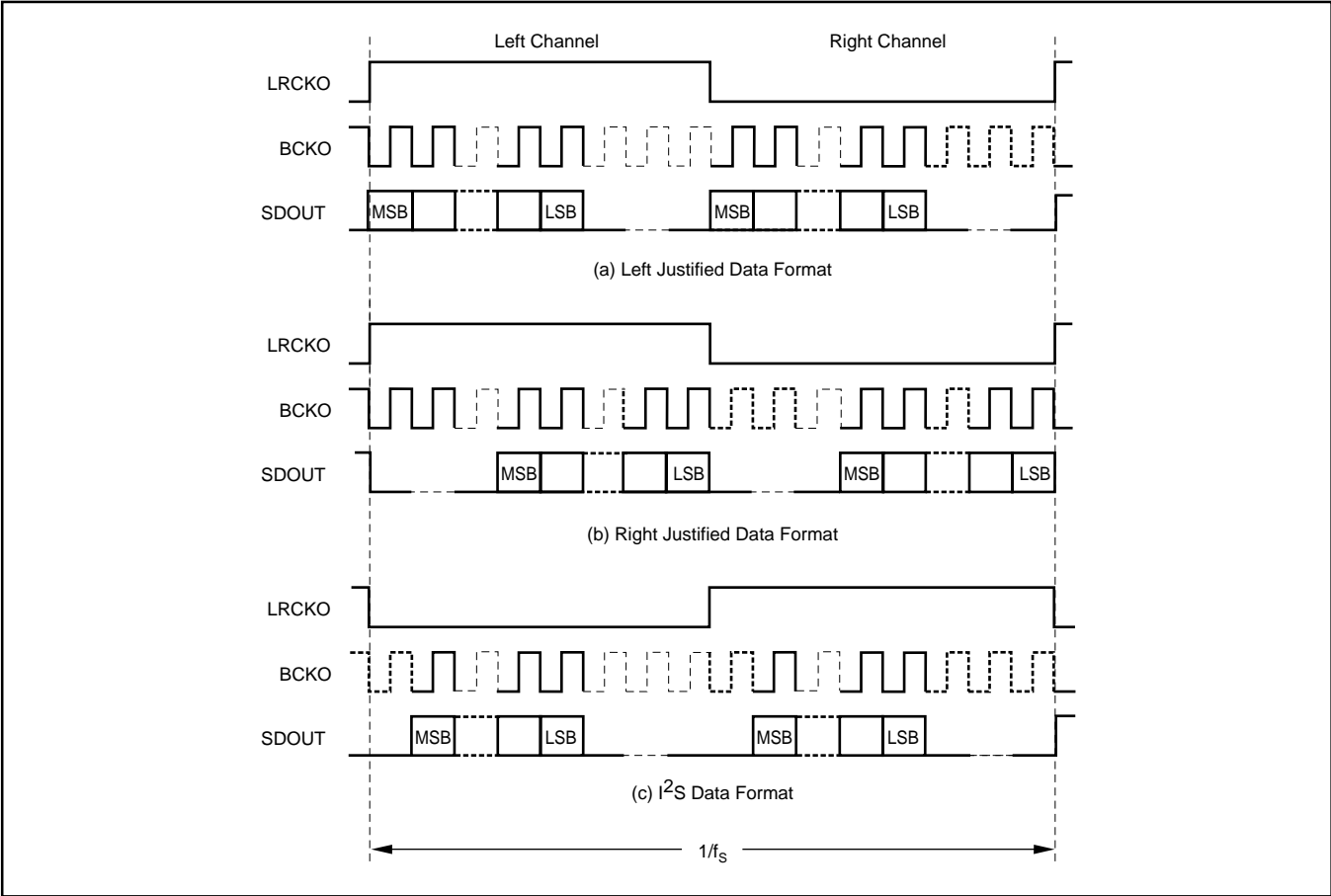


FIGURE 6. Output Data Formats.

The bit clock is either input or output at BCKO (pin 25). In Slave mode, BCKO is configured as an input pin, and may operate at rates from  $32f_s$  to  $128f_s$ , with a minimum of one clock cycle for each data bit. The exception is the TDM mode, where the BCKO must operate at  $N \times 64f_s$ , where N is equal to the number of SRC4192 or SRC4193 devices included on the TDM interface. In Master mode, BCKO operates at a fixed rate of  $64f_s$  for all data formats except TDM, where BCKO operates at the reference clock (RCKI) frequency. Additional information regarding TDM mode operation is included in the Applications Information section of this data sheet.

The left/right word clock, LRCKO (pin 24), may be configured as an input or output pin. In Slave mode, LRCKO is an input pin, while in Master mode it is an output pin. In either case, the clock rate is equal to  $f_s$ , the output sampling frequency. The clock duty cycle is fixed to 50% for I<sup>2</sup>S, Left justified, and Right Justified formats in Master mode. The LRCKO pulse width is fixed to 32 BCKO cycles for the TDM format in Master mode.

Table 3 illustrates data format selection for the output port. For the SRC4192, the OFMT0 (pin 19), OFMT1 (pin 18), OWL0 (pin 17), and OWL1 (pin 16) inputs are utilized to set the output port data format and word length. For the SRC4193, the OFMT[1:0] and OWL[1:0] bits in Control Register 3 are used to select the data format and word length.

OFMT1	OFMT0	OUTPUT PORT DATA FORMAT
0	0	Left Justified
0	1	I <sup>2</sup> S
1	0	TDM
1	1	Right Justified
OWL1	OWL0	OUTPUT PORT DATA WORD LENGTH
0	0	24-Bits
0	1	20-Bits
1	0	18-Bits
1	1	16-Bits

TABLE 2. Output Port Data Format Selection.

## BYPASS MODE

The SRC4192 and SRC4193 include a bypass function, which routes the input port data directly to the output port, bypassing the ASRC function. Bypass mode may be invoked by forcing the BYPAS input (pin 9) high for either the SRC4192 or SRC4193. For the SRC4193, the bypass mode may also be accessed using the BYPAS bit in Control Register 1. For normal ASRC operation, the BYPAS pin and control bit should be set to 0.

No dithering is applied to the output data in bypass mode, and the digital attenuation and mute functions are also unavailable.

## SOFT MUTE FUNCTION

The soft mute function of the SRC4192 and SRC4193 may be invoked by forcing the MUTE input (pin 14) high. For the SRC4193, the mute function may also be accessed using the MUTE bit in Control Register 1. The Soft mute function slowly attenuates the output signal level down to all zeroes plus  $\pm 1$ LSB of dither. This provides an artifact-free muting of the audio output port.

## DIGITAL ATTENUATION (SRC4193 ONLY)

The SRC4193 includes independent digital attenuation for the Left and Right audio channels. The attenuation ranges from 0dB (or unity) to -127.5dB in 0.5dB steps. The attenuation settings are programmed using Control Registers 4 and 5, corresponding to the Left and Right channels, respectively.

The TRACK bit in Control Register 1 is used to select Independent or Tracking attenuation modes. When TRACK = 0, the Left and Right channels are controlled independently. When TRACK = 1, the attenuation setting for the Left channel is also used for the Right channel, and the Right channel is said to track the Left channel attenuation setting.

## READY OUTPUT

The SRC4192 and SRC4193 include an active low ready output named  $\overline{RDY}$  (pin 15). This is an output from the rate estimator block, which indicates that the input-to-output sampling frequency ratio has been determined. The ready signal can be used as a flag or indicator output. The ready signal can also be connected to the active high MUTE input (pin 14) to provide an auto-mute function, so that the output port is muted when the rate estimator is in transition.

## RATIO OUTPUT (SRC4193 ONLY)

The SRC4193 includes a simple ratio flag output named RATIO (pin 16). When RATIO is low, it indicates that the output sampling frequency is lower than the input sampling frequency. When RATIO is high, it indicates that the output sampling frequency is higher than the input sampling frequency. The ratio output can be used as an indicator or flag output for an LED or host device.

## SERIAL PERIPHERAL INTERFACE (SPI) PORT: SRC4193 ONLY

The SPI port is a three-wire synchronous serial interface used to access the on-chip control registers of the SRC4193. The interface is comprised of a serial data clock input, CCLK (pin 27), a serial data input, CDATA (pin 28), and an active low chip-select input,  $\overline{CS}$  (pin 26). Figure 8 illustrates the protocol for writing control registers via the serial control port. Figure 9 shows the critical timing parameters for the SPI port interface, which are also listed in the Electrical Characteristics table.

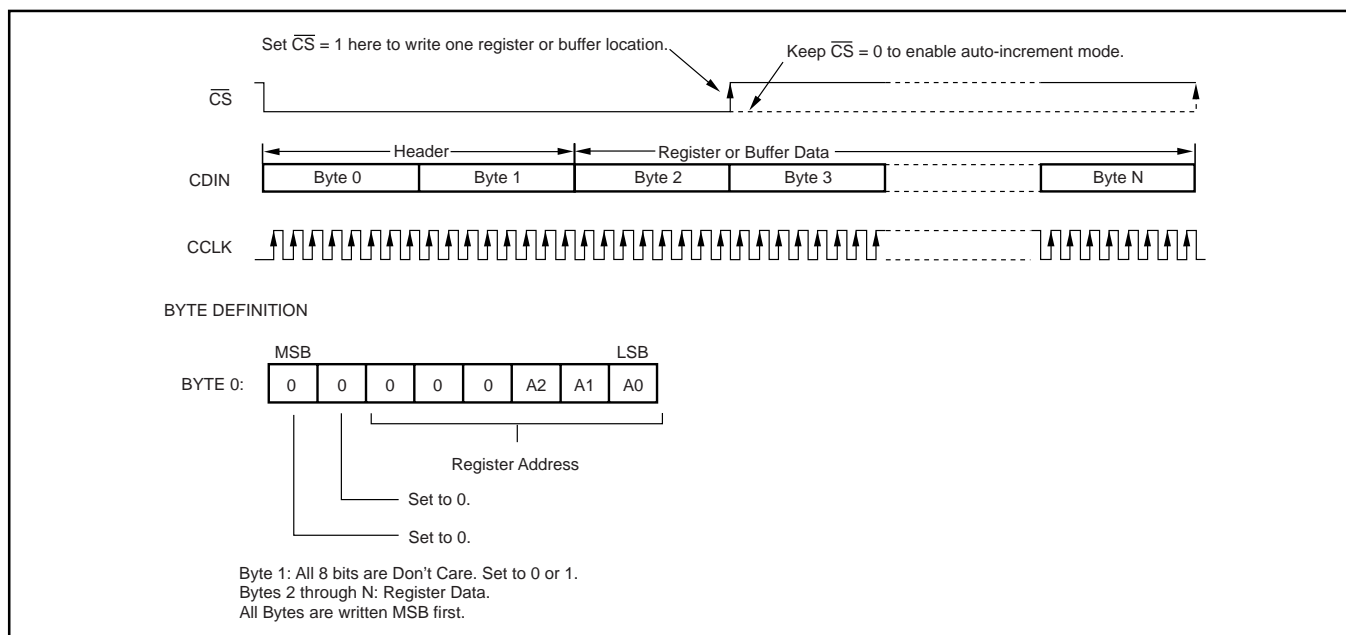


FIGURE 8. SPI Port Protocol.

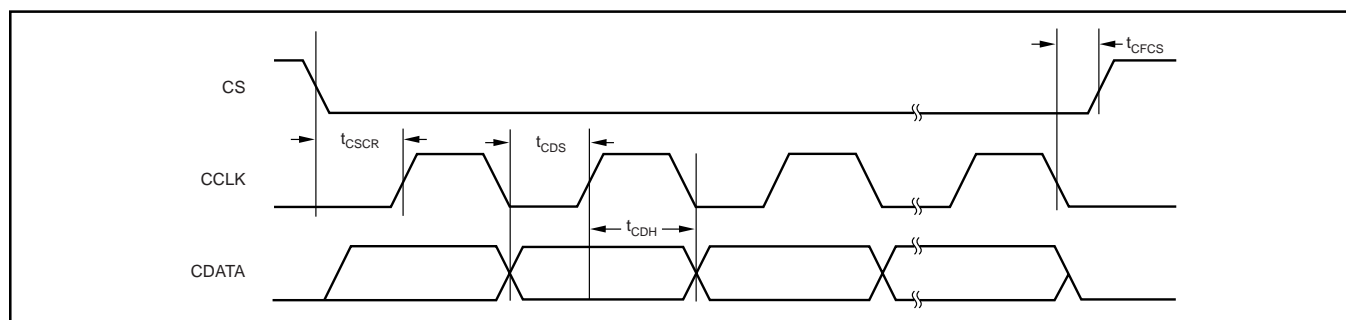


FIGURE 9. SPI Port Timing.

Byte 0 indicates the address of the control register to be written. The two most significant bits are set to 0, while the six least significant bits contain the control register address. Byte 1 is a *don't care* byte. This byte is included in the protocol in order to maintain compatibility with current and future Texas Instruments' digital audio products, including the DIT4096 and DIT4192 digital audio transmitters. Byte 2 contains the 8-bit data for the control register addressed in Byte 0.

As shown in Figure 8, a write sequence starts by bringing the  $\overline{CS}$  input low. Bytes 0, 1, and 2 are then written to program a single control register. Bringing the  $\overline{CS}$  input high after the third byte will write just one register. However, if  $\overline{CS}$  remains low after writing the first control byte, the port will auto-increment the address by 1, allowing successive addresses

to be written. The address is automatically incremented by 1 after each byte is written as long as the  $\overline{CS}$  input remains low. This is referred to as auto-increment operation, and is always enabled for the SPI port.

### CONTROL REGISTER MAP (SRC4193 ONLY)

The control register map for the SRC4193 is shown in Table 4. Register 0 is reserved for factory use and defaults to all zeros upon reset. The user should avoid writing this register, as unexpected operation may result if Register 0 is programmed to an arbitrary value. Registers 1 through 5 contain control bits, which are used to configure the internal functions of the SRC4193. All other register addresses are reserved and should not be used in customer applications.

Register Address (Dec/Hex)	D7 (MSB)	D6	D5	D4	D3	D2	D1	D0 (LSB)
0	0	0	0	0	0	0	0	0
1	$\overline{PDN}$	TRACK	0	MUTE	BYPAS	MODE2	MODE1	MODE0
2	0	0	0	0	0	0	DFLT	LGRP
3	OWL1	OWL0	OFMT1	OFMT0	0	IFMT2	IFMT1	IFMT0
4	AL7	AL6	AL5	AL4	AL3	AL2	AL1	AL0
5	AR7	AR6	AR5	AR4	AR3	AR2	AR1	AR0

TABLE 4. The SRC4193 Control Register Map.

# CONTROL REGISTER DEFINITIONS (SRC4193 ONLY)

This section contains detailed descriptions for each control register. Reset defaults are also defined for each register bit.

## Register 1: System Control Register

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
$\overline{\text{PDN}}$	TRACK	0	MUTE	BYPAS	MODE2	MODE1	MODE0

### MODE[2:0] Audio Serial Port Mode

MODE2	MODE1	MODE0	Audio Serial Port Mode
0	0	0	Both Serial Ports are in Slave Mode (Default)
0	0	1	Output Serial Port is Master with RCKI = 128fs
0	1	0	Output Serial Port is Master with RCKI = 512fs
0	1	1	Output Serial Port is Master with RCKI = 256fs
1	0	0	Both Serial Ports are in Slave Mode
1	0	1	Input Serial Port is Master with RCKI = 128fs
1	1	0	Input Serial Port is Master with RCKI = 512fs
1	1	1	Input Serial Port is Master with RCKI = 256fs

### BYPAS Bypass Mode

This bit is logically OR'd with the BYPAS input (pin 9)

BYPAS	Function
0	Bypass Mode Disabled with normal ASRC operation. (Default)
1	Bypass Mode Enabled with data routed directly from the input port to the output port, bypassing the ARSC function.

### MUTE Output Soft Mute

This bit is logically OR'd with the MUTE input (pin 14)

MUTE	Output Mute Function
0	Soft Mute Disabled (Default)
1	Soft Mute Enabled with data attenuated to all 0's

### TRACK Digital Attenuation Tracking

TRACK	Attenuation Tracking
0	Tracking Off: Attenuation for the Left and Right channels is controlled independently. (Default)
1	Tracking On: Left channel attenuation setting is used for both channels.

### $\overline{\text{PDN}}$ Power Down

Setting this bit to 0 will set the SRC4193 to the power-down state. All other register settings are preserved and the SPI port remains active. (Default)

Setting this bit to 1 will power up the SRC4193 using the current register settings.

**Register 2: Filter Control Register**

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
0	0	0	0	0	0	DFLT	LGRP

**LGRP Low Group Delay**

This bit is used to select the number of input audio samples to be stored in the data buffer before the ASRC starts processing the audio data.

<u>LGRP</u>	<u>Group Delay</u>
0	Normal Delay, 64 samples. (Default)
1	Low Delay, 32 samples.

**DFLT Decimation Filtering / Direct Down-Sampling**

The DFLT bit is used to enable or disable the direct down-sampling function.

<u>DFLT</u>	<u>Decimation Filter Operation</u>
0	Decimation Filter Enabled (Default) (Must be used when $f_{sOUT}$ is less than $f_{sIN}$ )
1	Direct Down-Sampling enabled without filtering. (May be enabled when $f_{sOUT}$ is equal to or greater than $f_{sIN}$ )

**Register 3: Audio Data Format Register**

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
OWL1	OWL0	OFMT1	OFMT0	0	IFMT2	IFMT1	IFMT0

**IFMT[2:0] Input Port Data Format**

<u>IFMT2</u>	<u>IFMT1</u>	<u>IFMT0</u>	<u>Input Format</u>
0	0	0	24-Bit Left Justified (Default)
0	0	1	24-Bit I <sup>2</sup> S
0	1	0	- Not Used -
0	1	1	- Not Used -
1	0	0	Right Justified, 16-Bit Data
1	0	1	Right Justified, 18-Bit Data
1	1	0	Right Justified, 20-Bit Data
1	1	1	Right Justified, 24-Bit Data

**OFMT[1:0] Output Port Data Format**

<u>OFMT1</u>	<u>OFMT0</u>	<u>Output Format</u>
0	0	Left Justified (Default)
0	1	I <sup>2</sup> S
1	0	TDM
1	1	Right Justified

**OWL[1:0] Output Port Data Word Length**

<u>OWL1</u>	<u>OWL0</u>	<u>Output Word Length</u>
0	0	24-Bits (Default)
0	1	20-Bits
1	0	18-Bits
1	1	16-Bits

#### Register 4: Digital Attenuation Register – Left Channel

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
AL7	AL6	AL5	AL4	AL3	AL2	AL1	AL0

Register defaults to 00<sub>HEX</sub>, or 0dB (unity gain).

Output Attenuation (dB) =  $(-N \times 0.5)$ , where  $N = AL[7:0]_{DEC}$

#### Register 5: Digital Attenuation Register – Right Channel

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
AR7	AR6	AR5	AR4	AR3	AR2	AR1	AR0

Register defaults to 00<sub>HEX</sub>, or 0dB (unity gain).

Output Attenuation (dB) =  $(-N \times 0.5)$ , where  $N = AR[7:0]_{DEC}$

When the TRACK bit in Control Register 1 is set to 1, the Left Channel attenuation setting will be used for the Right Channel attenuation.

## APPLICATIONS INFORMATION

This section of the data sheet provides practical applications information for hardware and systems engineers who will be designing the SRC4192 and SRC4193 into their end equipment.

## RECOMMENDED CIRCUIT CONFIGURATION

Typical connection diagrams for the SRC4192 and SRC4193 are shown in Figures 10 and 11, respectively. Recommended values for power supply bypass capacitors are included. These capacitors should be placed as close to the IC package as possible.

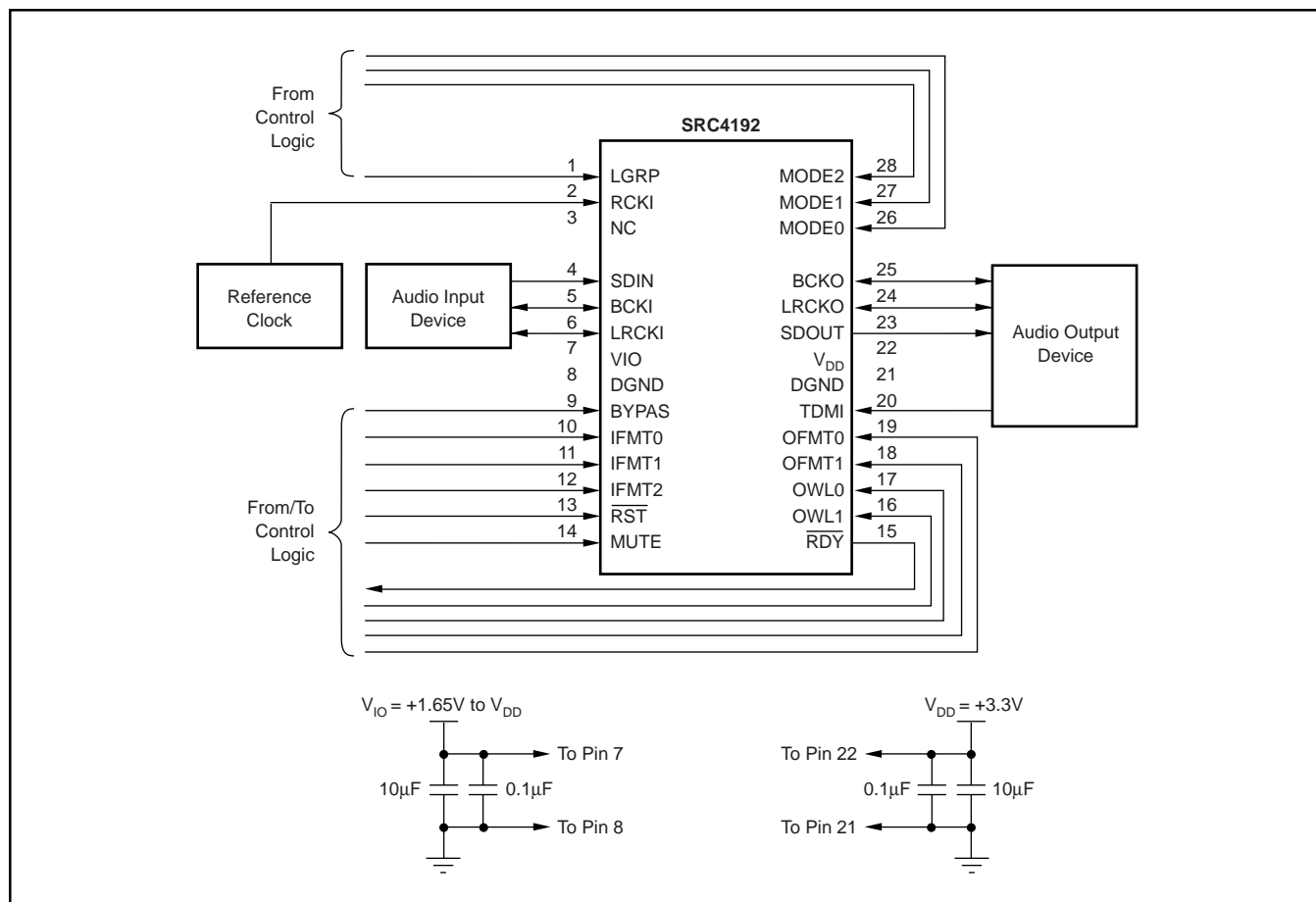


FIGURE 10. Typical Connection Diagram for the SRC4192.



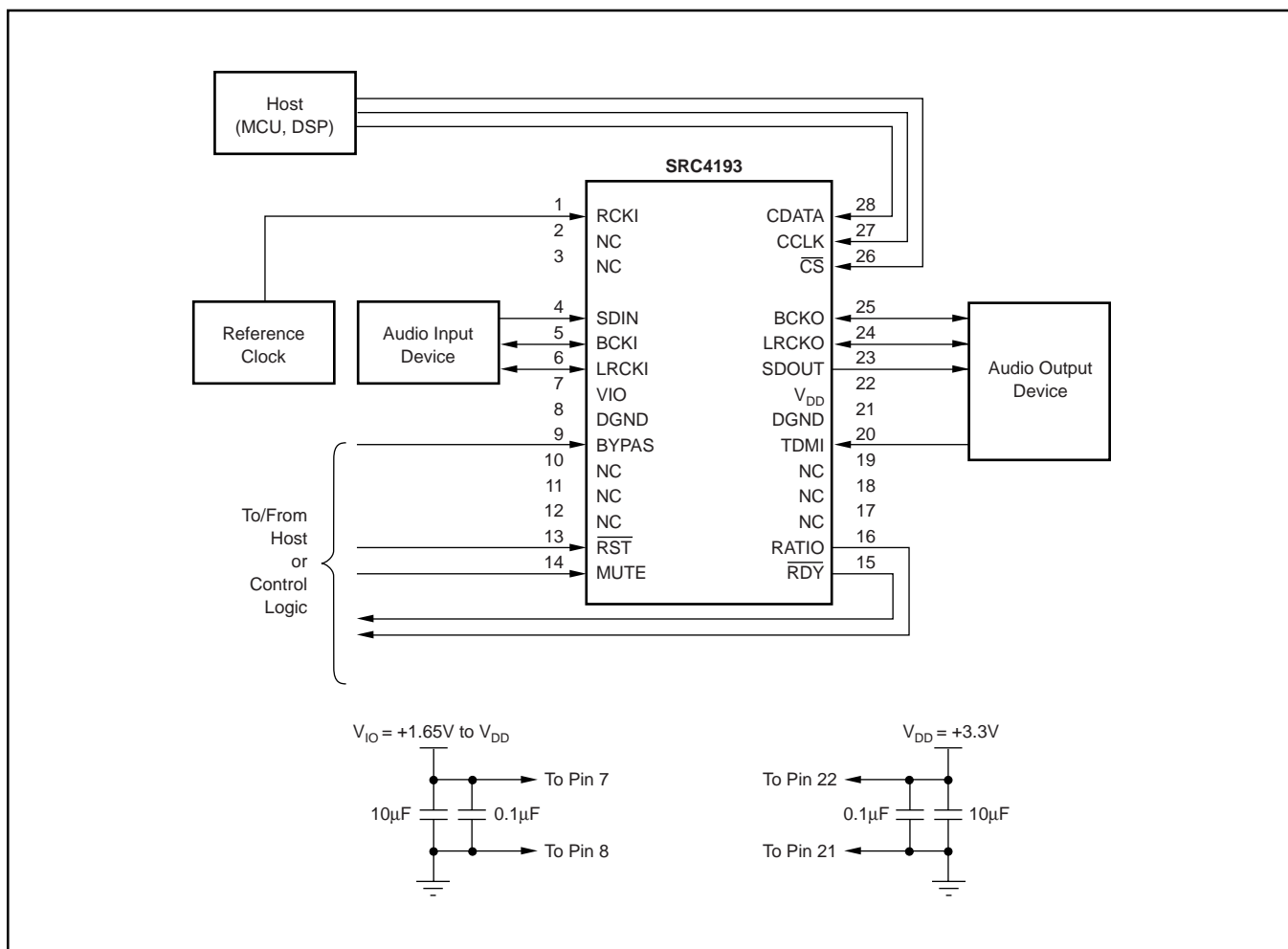


FIGURE 11. Typical Connection Diagram for the SRC4193.

## INTERFACING TO DIGITAL AUDIO RECEIVERS AND TRANSMITTERS

The SRC4192 and SRC4193 input and output ports are designed to interface to a variety of audio devices, including receivers and transmitters commonly used for AES/EBU, S/PDIF, and CP1201 communications.

Texas Instruments manufactures the DIR1703 digital audio interface receiver and DIT4096/4192 digital audio transmitters to address these applications.

Figure 12 illustrates interfacing the DIR1703 to the SRC4192 or SRC4193 input port. The DIR1703 operates from a single +3.3V supply, which requires the  $V_{IO}$  supply (pin 7) for the SRC4192 or SRC4193 to be set to +3.3V for interface compatibility.

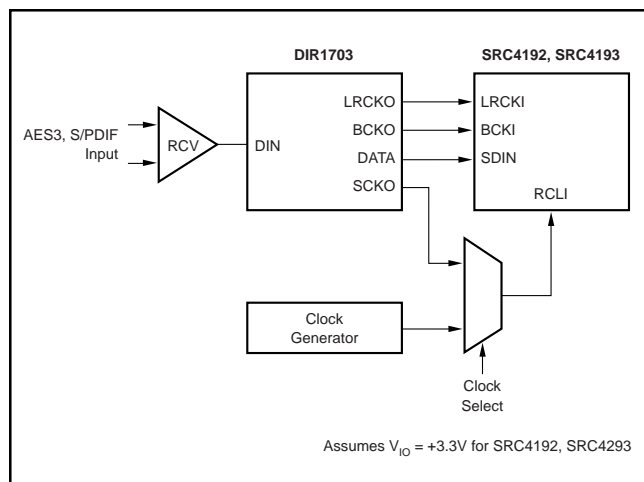


FIGURE 12. Interfacing the SRC4193 to the DIR1703 Digital Audio Interface Receiver.

Figure 13 shows the interface between the SRC4192 or SRC4193 output port and the DIT4096 or DIT4192 audio serial port. Once again, the  $V_{IO}$  supplies for both the SRC4192/4193 and DIT4096/4192 are set to +3.3V for compatibility.

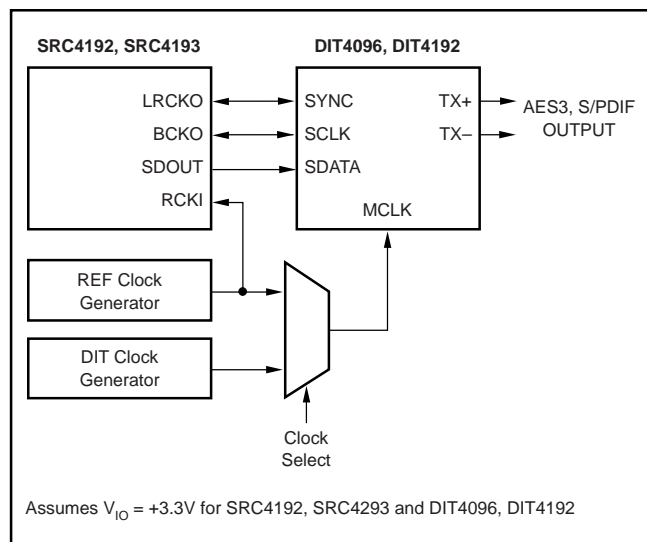


FIGURE 13. Interfacing the SRC4193 to the DIT4096/4192 Digital Audio Interface Transmitter.

Like the SRC4192 or SRC4193 output port, the DIT4096 and DIT4192 audio serial port may be configured as a Master or Slave. In cases where the SRC4192/4193 output port is set to Master mode, it is recommended to use the reference clock source (RCKI) as the master clock source (MCLK) for the DIT4096/4192, to ensure that the transmitter is synchronized to the SRC4192/4193 output port data.

## TDM APPLICATIONS

The SRC4192 and SRC4193 support a TDM output mode, which allows multiple devices to be daisy-chained together to create a serial frame. Each device occupies one sub-frame within a frame, and each sub-frame carries two channels (Left followed by Right). Each sub-frame is 64 bits long, with 32 bits allotted for each channel. The audio data for each channel is left justified within the allotted 32 bits. Figure 14 illustrates the TDM frame format, while Figure 15 shows TDM input timing parameters, which are listed in the Electrical Characteristics table of this data sheet.

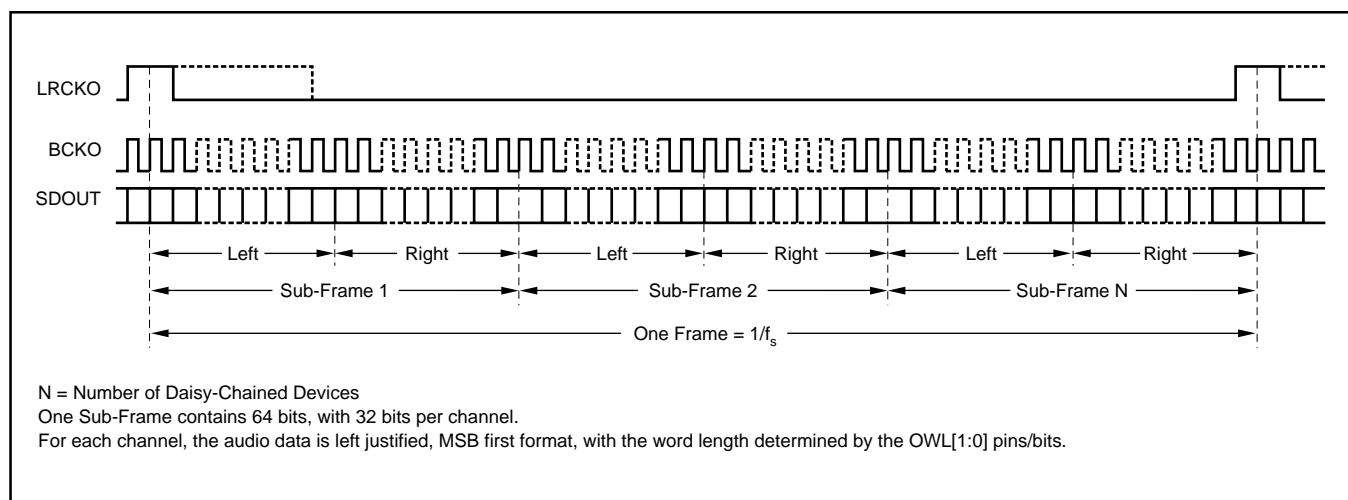


FIGURE 14. TDM Frame Format.

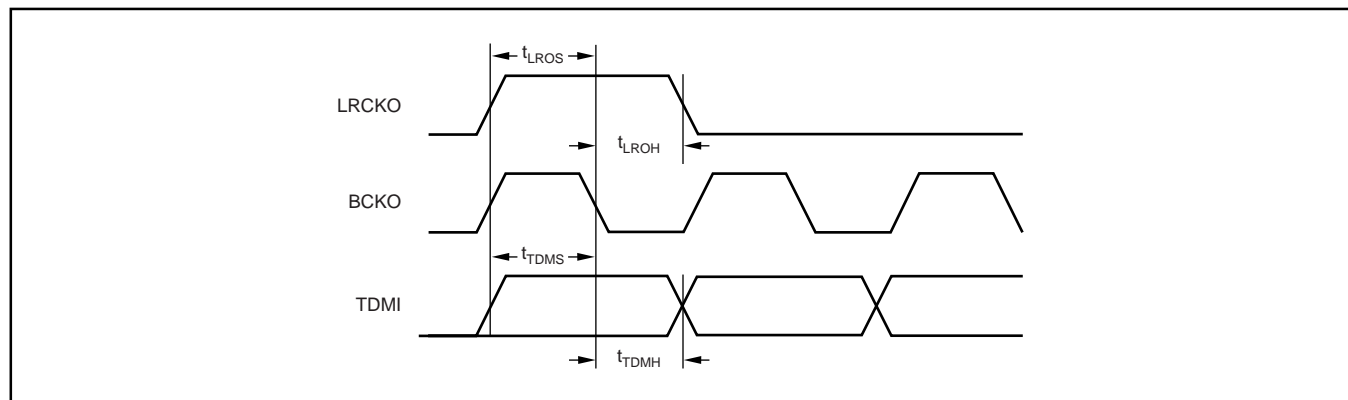


FIGURE 15. Input Timing for TDM Mode.

The frame rate is equal to the output sampling frequency,  $f_s$ . The BCKO frequency for the TDM interface is  $N \cdot 64 f_s$ , where  $N$  is the number of devices included in the daisy chain. For Master mode, the output BCKO frequency is fixed to the reference clock (RCKI) input frequency. The number of devices that can be daisy-chained in TDM mode is dependent upon the output sampling frequency and the BCKO frequency, leading to the following numerical relationship:

$$\text{Number of Daisy-Chained Devices} = (f_{\text{BCKO}} / f_s) / 64$$

Where:

$f_{\text{BCKO}}$  = Output Port Bit Clock (BCKO), 27.648 MHz maximum

$f_s$  = Output Port Sampling (or LRCKO) Frequency, 216kHz maximum.

This relationship holds true for both Slave and Master modes.

Figures 16 and 17 show typical connection schemes for TDM mode. Although the TMS320C671x DSP family is shown as the audio processing engine in these figures, other TI digital signal processors with a multi-channel buffered serial port (McBSP™) may also function with this arrangement. Interfacing to processors from other manufacturers is also possible. Refer to Figure 7 in this data sheet, along with the equivalent serial port timing diagrams shown in the DSP data sheet, to determine compatibility.

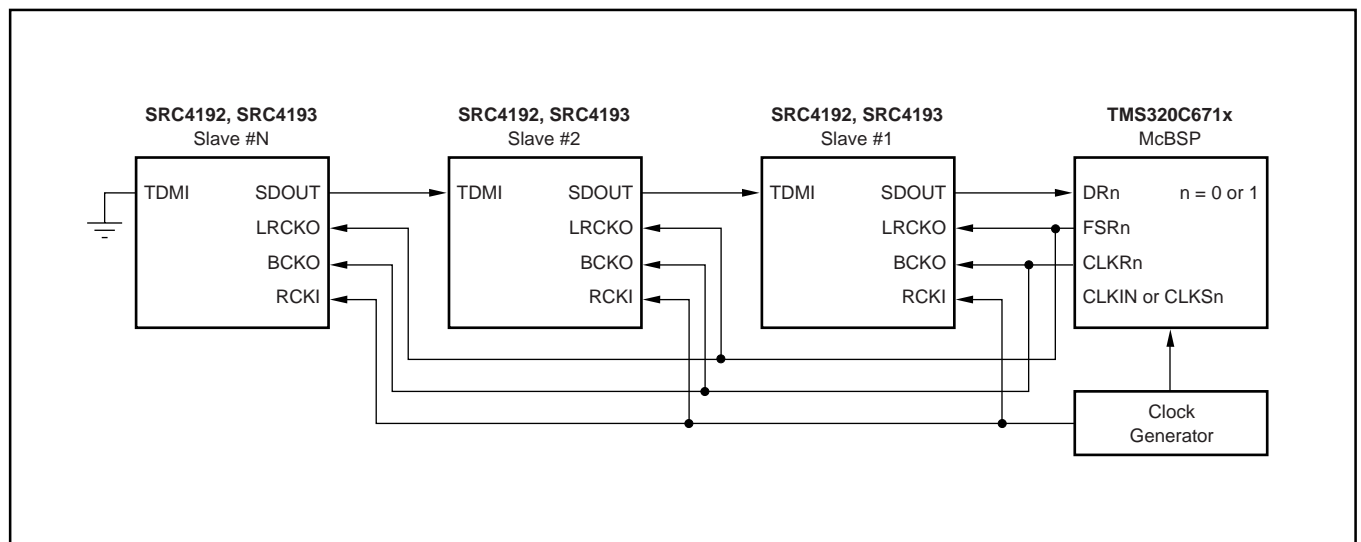


FIGURE 16. TDM Interface where all Devices are Slaves.

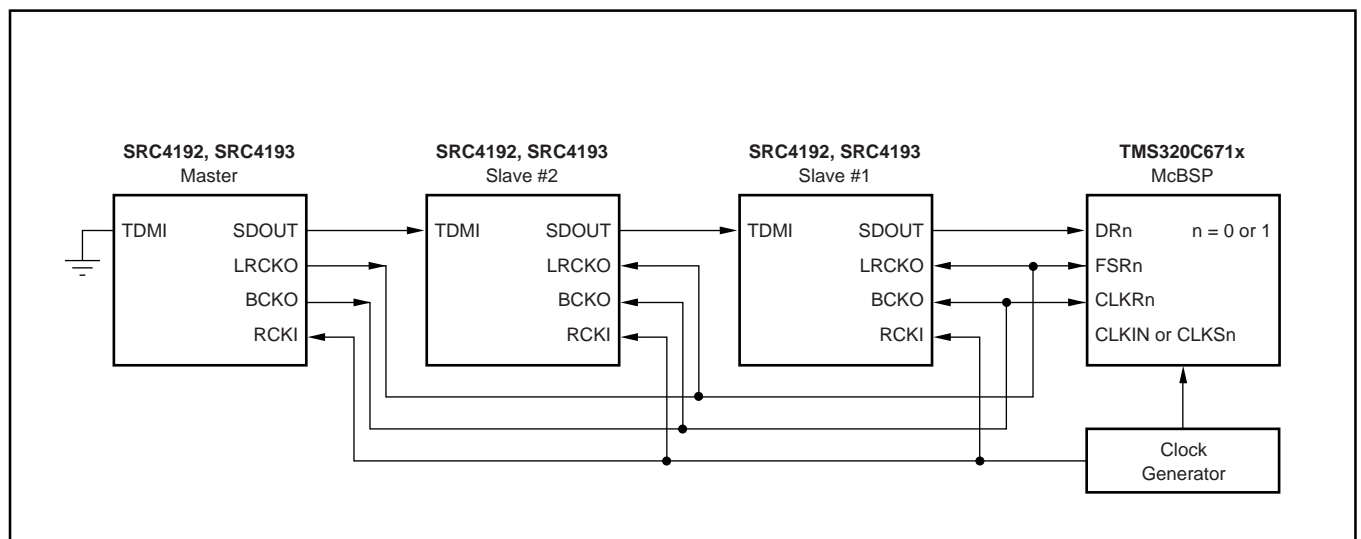


FIGURE 17. TDM Interface where one Device is Master to Multiple Slaves.

## PIN COMPATIBILITY WITH THE ANALOG DEVICES AD1896 (SRC4192 ONLY)

The SRC4192 is pin-and function-compatible with the AD1896 when observing the guidelines indicated in the following paragraphs.

**Power Supplies.** To ensure compatibility, the VDD\_IO and VDD\_CORE supplies of the AD1896 must be set to +3.3V, while the V<sub>IO</sub> and V<sub>DD</sub> supplies of the SRC4192 must be set to +3.3V.

**Crystal Oscillator.** The SRC4192 does not have an on-chip crystal oscillator. An external reference clock is required at the RCKI input (pin 2).

**Reference Clock Frequency.** The reference clock input frequency for the SRC4192 must be no higher than 30 MHz, in order to match the master clock frequency specification of the AD1896. In addition, the SRC4192 does not support the 768f<sub>S</sub> reference clock rate.

**Master Mode Maximum Sampling Frequency.** When the input or output ports are set to Master mode, the maximum sampling frequency must be limited to 96kHz in order to support the AD1896 specification. This is despite the fact that the SRC4192 supports a maximum sampling frequency of 212kHz in Master mode. The user should consider building an option into his or her design to support the higher sampling frequency of the SRC4192.

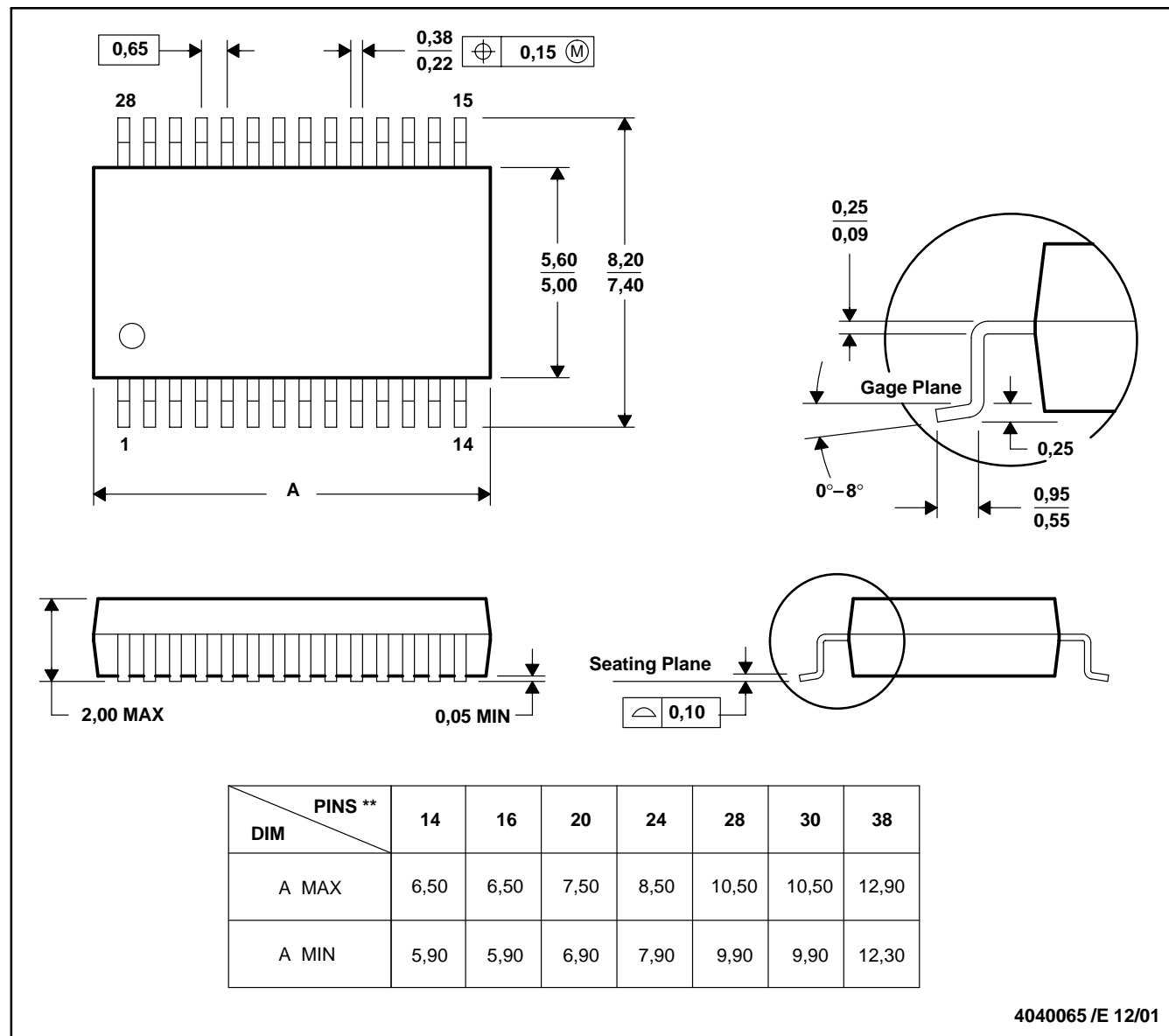
**Matched Phase Mode.** Due to the internal architecture of the SRC4192, it does not require or support the matched phase mode of the AD1896. Given multiple SRC4192 devices, if all reference clock (RCKI) inputs are driven from the same clock source, the devices will be phase matched.

# PACKAGE DRAWING

DB (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE

28 PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
  - D. Falls within JEDEC MO-150

**PACKAGING INFORMATION**

ORDERABLE DEVICE	STATUS(1)	PACKAGE TYPE	PACKAGE DRAWING	PINS	PACKAGE QTY
SRC4192IDB	ACTIVE	SSOP	DB	28	50
SRC4192IDBR	ACTIVE	SSOP	DB	28	2000
SRC4193IDB	ACTIVE	SSOP	DB	28	50
SRC4193IDBR	ACTIVE	SSOP	DB	28	2000

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

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DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>

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Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
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