

Pairing A Driver Amplifier with the [AD7768/AD7768-4](#) or the [AD7768-1](#)

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INTRODUCTION

A common trend in analog input/output module design is increased channel count in a smaller form factor. This trend is driven by the need to reduce cost and testing time by increasing the number of measurements achievable from a single module or a peripheral component interconnect (PCI) extension for instrumentation (PXI) card slot. The increase in channel density contributes to an increase in thermal dissipation, which is a common issue for designers in modular applications. To design within the thermal budget requirements of high density data acquisition modules, customers must consider trade-offs for speed, bandwidth, and performance.

The [AD7768/AD7768-4](#) and the [AD7768-1](#) are 8-channel, 4-channel, and single-channel, 24-bit, simultaneous sampling analog-to-digital converters (ADCs). Selectable power modes and digital filter options reconfigure the [AD7768/AD7768-4](#) and the [AD7768-1](#) to suit a wide range of applications, such as industrial input/output modules, instrumentation, audio testing, control loops, and condition monitoring.

An external driver amplifier must drive the input to the [AD7768/AD7768-4](#) or the [AD7768-1](#). Drive requirements for the analog front-end scale with the front-end sampling rate. Selectable precharge buffers on the [AD7768/AD7768-4](#) or the [AD7768-1](#) reduce the burden on front-end driver amplifiers, which allows lower power amplifiers to drive analog inputs with high sampling rates.

This application note outlines how to achieve -123.2 dB of total harmonic distortion (THD) at subsystem power levels as low as 13.25 mW per channel and compares combinations of high performance driver amplifiers and low power amplifiers with and without the assistance of the precharge buffers. These amplifiers are selected based on the suitability to drive the [AD7768/AD7768-4](#) or the [AD7768-1](#) in particular power modes for a fair and valid comparison. For example, the higher bandwidth amplifiers selected to drive the [AD7768/AD7768-4](#) or the [AD7768-1](#) in fast power mode work equally well in median or low power mode, but can burn more power than necessary depending on which system is being used. The appropriate combinations of driver amplifiers and power modes evaluated in this application note allow the design of a single data acquisition (DAQ) system platform to achieve the highest performance within specific bands of thermal or power constraints.

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REVISION HISTORY

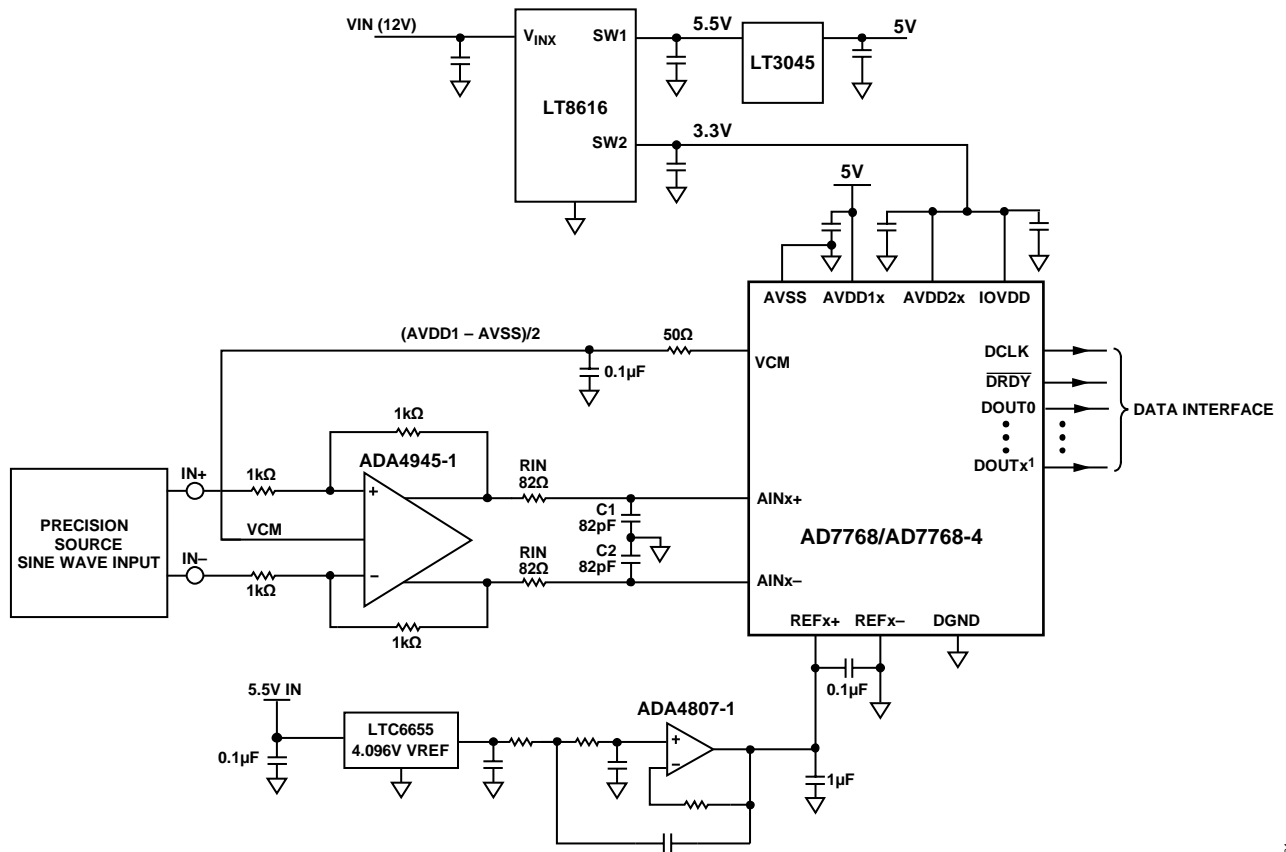
5/2019—Rev. 0 to Rev. A

Added AD7768-1	Throughout
Deleted ADA4500	Universal
Added Connection Diagrams Section	3
Changes to Figure 1	3
Added Figure 2; Renumbered Sequentially	4

Changes to Figure 2.....	4
Added Figure 3.....	6
Moved Table 5	9

12/2016—Revision 0: Initial Version

CONNECTION DIAGRAMS



¹DOUTx IS DOUT7 ON THE AD7768 AND DOUT3 ON THE AD7768-4.

Figure 1. Typical Connection Diagram for the AD7768/AD7768-4 in Fast Power Mode, with the ADA4945-1 as the Driver Amplifier

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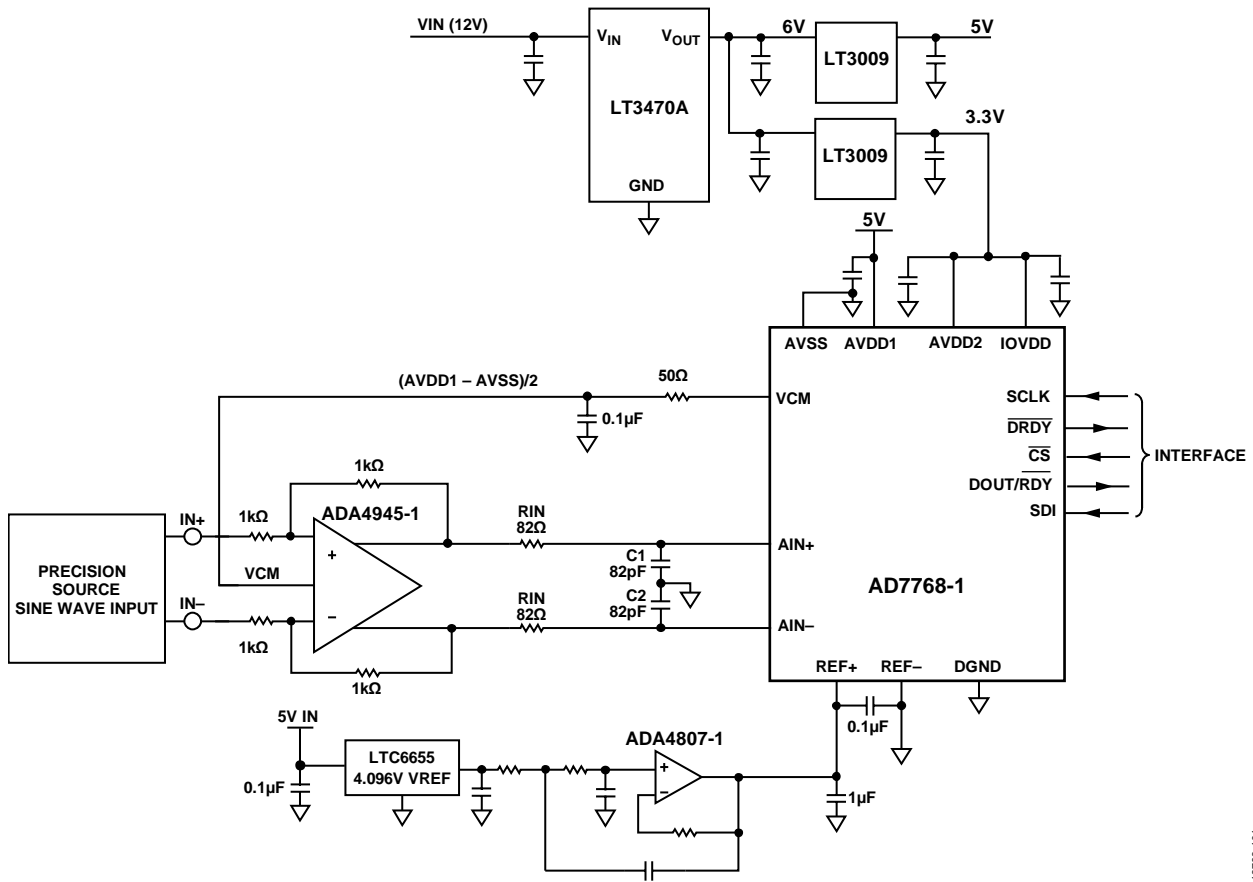


Figure 2. Typical Connection Diagram for the AD7768-1 in Fast Power Mode, with the ADA4945-1 as the Driver Amplifier

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CIRCUIT DESCRIPTION

Amplifier testing for the [AD7768/AD7768-4](#) and the [AD7768-1](#) is conducted using various platforms, such as the [EVAL-AD7768FMCZ](#), [EVAL-AD7768-4FMCZ](#), [EVAL-AD7768-1FMCZ](#), and various amplifier mezzanine cards (AMCs). The amplifiers populated on each AMC are listed in the Amplifier Configuration section. The [EVAL-AD7768FMCZ](#), [EVAL-AD7768-4FMCZ](#), and [EVAL-AD7768-1FMCZ](#) evaluation platforms schematics are available for download on the respective evaluation board product pages on the Analog Devices, Inc., website. These evaluation platforms can be configured to use an AMC (on one channel only) as the driver amplifier input. See the [EVAL-AD7768FMCZ](#), [EVAL-AD7768-4FMCZ](#), and [EVAL-AD7768-1FMCZ](#) user guides for more details. The AMCs available are populated with various amplifiers and are designed specifically to work with Analog Devices ADCs. The [EVAL-SDP-CH1Z](#) is connected to the [EVAL-AD7768FMCZ](#), [EVAL-AD7768-4FMCZ](#), and [EVAL-AD7768-1FMCZ](#) evaluation platforms to interface with the evaluation

software, which is supplied with the evaluation hardware. A precision audio source is used for ac analysis.

The following amplifiers selected for testing complement each of the different power modes on the [AD7768/AD7768-4](#) or the [AD7768-1](#):

- In low power mode: [ADA4805-2](#), [ADA4841-2](#), [ADA4945-1](#), and [ADA4940-1](#).
- In median mode: [ADA4805-2](#), [ADA4807-2](#), [ADA4940-1](#), and [ADA4945-1](#).
- In fast power mode: [ADA4807-2](#), [ADA4896-2](#), [ADA4899-1](#), [ADA4940-1](#), and [ADA4945-1](#).

Table 1 describes the performance and power specifications for the selected amplifiers. Some of these amplifiers are available in different package sizes and options.

Table 1. Amplifier Specifications

Amplifier	Features	Bandwidth (MHz)	Slew (V/ μ s)	Voltage Noise Density (nV/ \sqrt Hz)	Current Noise Density (pA/ \sqrt Hz)	Offset Voltage (μ V maximum)	Offset Drift (μ V/ $^{\circ}$ C) ¹	Supply (V)	Power per Amplifier (mA)
ADA4899-1	Unity gain, ultralow distortion	600	310	1	2.6	230	5	5 to 12	16
ADA4896-2	Low drift, rail-to-rail output (RRO)	230	120	1	2.8	500	0.2	\pm 3 to \pm 5	3.0
ADA4807-2	Rail-to-rail input/output (RRIO), low drift	180	225	3.1	0.7	125	0.7	\pm 3 to \pm 5	1.0
ADA4805-2	RRO, low drift	105	160	5.9	0.6	125	0.2	\pm 3 to \pm 5	0.625
ADA4940-1	RRO, differential amplifier	260	95	3.9	0.81	3.50	1.2	3 to 7	1.25 total ²
ADA4841-2	RRIO low noise and distortion	80	13	2.1	1.4	300	1	2.7 to 12	1.2
ADA4084-2	RRIO, low power	13.9	3.7	3.9	0.55	300	0.5	\pm 1.5 to \pm 15	0.625
ADA4945-1	RRO, selectable modes	80 ³ , 145 ⁴	100 ³ , 600 ⁴	3.0 ³ , 1.8 ⁴	0.6 ³ , 1.0 ⁴	\pm 115	0.5	3 to 10	1.4 ³ total ² , 4 ⁴ total ²

¹ Values are typical unless otherwise noted.

² Total power for a single channel.

³ Low power mode (see the [ADA4945-1](#) data sheet).

⁴ Full power mode (see the [ADA4945-1](#) data sheet).

SELECTING A POWER MODE

The AD7768/AD7768-4 and the AD7768-1 have three selectable power modes: low, median, and fast. These power modes select an operating point for the AD7768/AD7768-4 or the AD7768-1 in which the optimal bandwidth and power consumption is chosen while maintaining the same dynamic range.

The power mode selected is used in conjunction with the master clock divider (MCLK_DIV) to set this operating point correctly. MCLK_DIV determines the frequency the modulator runs at. The modulator output is then decimated to give the final output data rate (ODR). The recommended modulator frequency (f_{MOD}) ranges are described in Table 2

Table 3 demonstrates that the power consumption scales with speed and bandwidth.

The two basic filter options available in the AD7768/AD7768-4 and the AD7768-1 are the sinc filter or the finite impulse response (FIR) filter. Note that the FIR filters and the wideband filters used in the AD7768/AD7768-4 or the AD7768-1 have the same filter types, topology, and characteristics.

ANALOG INPUT STRUCTURE

Figure 3 shows the analog input structure of the AD7768/AD7768-4 and the AD7768-1. The analog input precharge buffers are enabled on a per channel basis. When enabled, the analog input precharge buffers provide the charge to the sampling capacitors for the initial sampling period and charge the bulk of the current required to settle the sampling capacitors. The remaining charge is driven by the external amplifier, which charges the final finer settling of the sampling capacitors to achieve precision results.

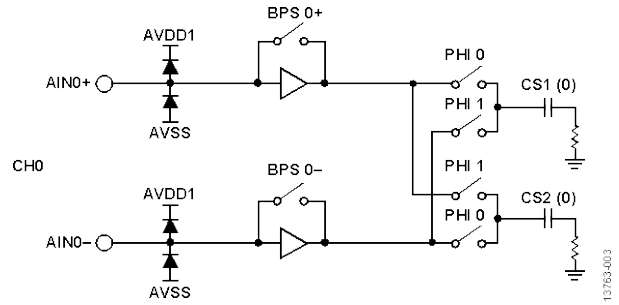


Figure 3. Analog Input Structure

The precharge buffers reduce the input current sourced from the amplifier from 320 μ A to ~25 μ A for a 5 V input at the fastest sampling rate. See the AD7768/AD7768-4 and the AD7768-1 data sheet for more information about the analog input structure.

Figure 4 shows the AMC board and Figure 5 shows the ADA4807-2 AMC connected to the AD7768/AD7768-4 and the AD7768-1 evaluation board.

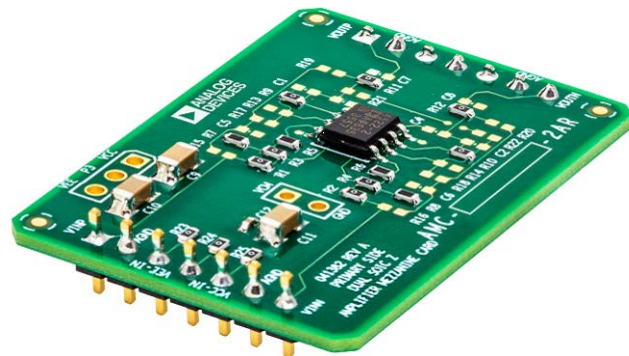


Figure 4. AMC Board

Table 2. Recommended f_{MOD} Ranges

Power Mode	Typical MCLK_DIV		Recommended f_{MOD} (MHz)
	AD7768/AD7768-4	AD7768-1	
Low	MCLK/32	MCLK/16	0.036 ¹ to 1.024
Median	MCLK/8	MCLK/4	1.024 to 4.096
Fast	MCLK/4	MCLK/2	4.096 to 8.192

¹ Recommended f_{MOD} is 0.038 MHz for the AD7768-1.

Table 3. Power Modes for the AD7768/AD7768-4 and the AD7768-1¹

Power Mode	Typical Speed (kSPS)	Bandwidth (kHz)	FIR ²		Sinc Filter		
			Power (mW)		Bandwidth (kHz)	Power (mW)	
			AD7768/AD7768-4	AD7768-1		AD7768/AD7768-4	AD7768-1
Fast	256	110.8	51.5	36.8	52.2	41	26.4
Median	128	55.4	27.5	19.7	26.1	22	14.4
Low	32	13.8	9.375	6.75	6.5	8.5	5.4

¹ See the AD7768 data sheet and the AD7768-1 data sheet for a full description of the configuration used to determine power consumption.

² FIR or wideband filter.

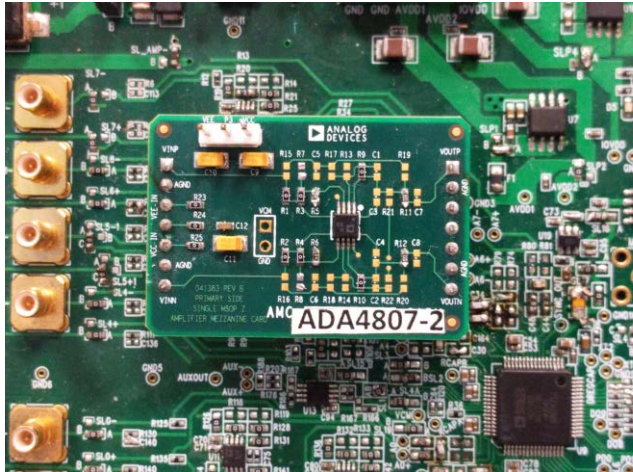


Figure 5. ADA4807-2 AMC Setup on the EVAL-AD7768FMCZ

TESTING METHOD

The AD7768/AD7768-4 or the AD7768-1 wideband filter is used during amplifier testing. The wideband filter has a brick wall filter response with a cutoff frequency of $0.433 \times \text{ODR}$. The pass-band ripple of ± 0.005 dB allows frequency domain measurements to determine the performance of drive amplifiers vs. input frequency. The sinc5 digital filter has a bandwidth of $0.2 \times \text{ODR}$ and -3 dB improvement for dynamic range but is not considered for these comparative tests.

There is a resistor-capacitor (RC) network between the amplifier output and the ADC input. Figure 6 shows a typical RC network used for the AD7768/AD7768-4 and the AD7768-1 for most amplifier pairings. The RC network performs a variety of tasks. C1 and C2 are charge reservoirs to the ADC and provide the ADC with fast charge current to the sampling capacitors.

The C3 capacitor removes common-mode errors between the AINx+ and AINx- inputs. These capacitors, in combination with the RIN resistor, form a low-pass filter to filter out glitches related to the input switching. The input resistance also stabilizes the amplifier when driving large capacitor loads and prevents the amplifier from oscillating.

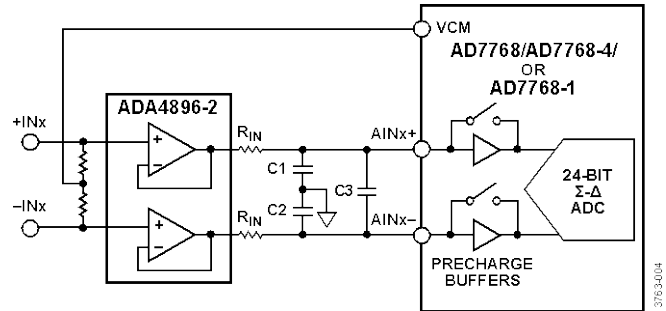


Figure 6. Typical Input Structure for an RC Network

The specific details of each of the RC antialias networks are covered in the Amplifier Configuration section. The targeted cutoff frequencies (f_c) are 6 MHz, 12 MHz, and 24 MHz for low, median, and fast power modes, respectively. Standard resistor and capacitor values were chosen to give approximately the same f_c in each power mode.

Table 4 shows the combinations of the RIN resistor, C1 and C2, and C3, which were selected to collect data in fast power mode. Faster and higher power amplifiers settle glitches on the ADC input quickly. When driving a capacitive load, low power amplifiers, such as the ADA4807-2, require larger RIN values than higher power amplifiers, such as the ADA4896-2, to prevent oscillations due to changes on the input. The switching effects of the modulator are more apparent in fast power mode and, in particular, for the lower power amplifiers. A lower value input resistor can be used when the precharge buffers are enabled. The disturbance due to the modulator switching is reduced when the precharge buffers are enabled, allowing the system to achieve less distortion.

Table 4. Example RC Antialias Filter Network in Fast Power Mode

Amplifier	RIN (Ω)	C1, C2 (pF)	C3 (pF)
ADA4899-1	5.1	270	680
ADA4896-2	10	100	270
ADA4807-2	62	120	Not inserted
ADA4805-2	82	100	Not inserted

RESULTS

LOW POWER MODE

Low power mode offers a 32 kSPS ODR and 12.8 kHz of bandwidth when using the wideband digital filter. Table 5 describes the signal-to-noise ratio (SNR), THD, and signal-to-noise-and-distortion ratio (SINAD) for the low power mode of the selected amplifiers. The input applied is a 1 kHz sine wave signal at -0.5 dB from a full-scale input with precharge buffers enabled and disabled.

Table 5 demonstrates the performance and power consumption of each amplifier tested, sorted in terms of efficiency. Power (mW) is the power consumption of the drive amplifier on a single differential channel. The precharge (mW) power consumption is the power of two precharge buffers enabled on a differential channel for the specific sampling rate. The total (mW) is the power of the drive amplifier and the precharge buffer if enabled.

The [ADA4805-2](#) with the precharge buffers disabled is the most efficient solution with 6.5 mW of power dissipated to achieve 106.5 dB SINAD. The [ADA4841-2](#) has the highest performance with 106.9 dB SINAD, requiring 13.5 mW per channel. For the same power consumed, the [ADA4841-2](#) shows almost -9 dB improved THD compared to the [ADA4940-1](#). In general, these low power amplifiers can easily drive the [AD7768/AD7768-4](#) or the [AD7768-1](#) in low power mode.

The [ADA4805-2](#) and [ADA4841-2](#) cases described previously highlight the trade-off DAQ system designers are faced with: the balance between power consumption and system performance. This trade-off is evident for all of the power modes, as shown in Table 5, Table 6, and Table 7,

The recommended amplifier pairing for the low power mode is the [ADA4805-2](#) with precharge buffers disabled. For the power it consumes, such a combination of amplifier and ADC meets thermal restrictions in the DAQ system design. The total power consumed for the amplifier and the [AD7768/AD7768-4](#) or the [AD7768-1](#) is only 15.875 mW per channel. If the [ADA4805-2](#) is used to drive the [AD7768-1](#) in low power mode, the total power consumption is only 13.25 mW.

MEDIAN POWER MODE

Median power mode offers 128 kSPS ODR with 51.2 kHz of bandwidth when using the wideband filter. The input applied is a 1 kHz sine wave signal at -0.5 dB from full scale. Table 6 is sorted in terms of efficiency.

The [ADA4805-2](#), with precharge enabled, has the highest performance with 106.7 dB SINAD, requiring 11.6 mW per channel. These results are taken with a single 6 V supply to the amplifier. If a single 5 V rail for both ADC and driver amplifier is beneficial, the [ADA4945-1](#) is an ideal choice. This amplifier has two different power modes in this case, the low power mode of the amplifier pairs well with median power mode of the ADC.

The benefits of the precharge buffers are described in the THD results in Table 6. The [ADA4805-2](#) with precharge buffers disabled is an efficient solution with 6.9 mW power dissipated. When the precharge buffers are enabled, this yields an almost 8 dB improvement in THD.

Generally, when using the precharge buffers with amplifiers that have enough power and bandwidth, the precharge buffers only offer small improvements in performance. The real benefit of the precharge buffers is shown when low power, low bandwidth amplifiers perform in a power mode they otherwise struggle to perform in.

The [ADA4805-2](#) with precharge buffers enabled is the recommended amplifier for median power mode. The total power consumed in this case for both the [ADA4805-2](#) and the [AD7768/AD7768-4](#) is 39.6 mW per channel. The combination of the [AD7768-1](#) and the [ADA4805-2](#) in median power mode consumes 31.3 mW

FAST POWER MODE

Fast power mode offers 256 kSPS ODR with a 102.4 kHz of bandwidth when using the wideband filter. Table 7 is sorted in terms of efficiency and displays the performance and power consumption of each amplifier tested, with and without precharge assistance.

The [AD7768/AD7768-4](#) or the [AD7768-1](#) in fast power mode achieves the greatest benefits of the precharge buffers. The precharge buffers enable high performance, even with the high modulator rates in fast power mode. The benefit of the precharge buffers is an increase in THD performance in all amplifiers. The [ADA4807-2](#) shows the most improvement in THD performance when the precharge buffers are enabled.

The [ADA4940-1](#) with precharge buffers disabled is an efficient solution with 14.4 mW of power dissipation, although performance must be sacrificed slightly to achieve this result. The recommended amplifier for power savings in fast power mode is the [ADA4940-1](#). The total power consumed for the [ADA4940-1](#) and the [AD7768/AD7768-4](#) or the [AD7768-1](#) is 65.9 mW per channel.

Overall, when designing a general-purpose configurable DAQ system, the [ADA4896-2](#) shows excellent performance across all three power modes. However, if the power consumption of the whole DAQ system is limited, some of the lower power amplifiers shown in Table 5 and Table 6 can offer a more efficient solution for low and median power modes, respectively.

If a differential amplifier is required, the [ADA4945-1](#) ADC driver is the amplifier recommended for use. This amplifier has two power modes available, which when used with the power modes available on the [AD7768/AD7768-4](#) or the [AD7768-1](#), enable users to optimize their designs for a particular power budget.

Table 5. Low Power Mode Performance vs. Power

Amplifier	Precharge Buffer	Power (mW)	Precharge (mW) ¹	Total (mW)	SNR (dB)	THD (dB)	SINAD (dB)
ADA4805-2	Disabled	6.50	Not applicable	6.5	106.9	-123.2	106.8
ADA4841-2	Disabled	13.45	Not applicable	13.5	107.0	-129.7	106.9
ADA4940-1	Disabled	13.53	Not applicable	13.5	107.0	-121.0	106.8
ADA4841-2	Enabled	13.38	1.31	14.7	106.9	-131.1	106.8
ADA4940-1	Enabled	13.56	1.31	14.9	106.5	-122.3	106.3
ADA4945-1 ²	Disabled	18.45	Not applicable	18.45	106.7	-114.8	106.2
ADA4945-1 ²	Enabled	18.35	1.31	19.66	107.0	-115.2	106.5

¹ Precharge buffer power consumption per channel.

² Low power mode of the ADA4945-1.

Table 6. Median Power Mode Performance vs. Power

Amplifier	Precharge Buffer	Power (mW)	Precharge (mW) ¹	Total (mW)	SNR (dB)	THD (dB)	SINAD (dB)
ADA4805-2	Disabled	6.91	Not applicable	6.9	106.4	-120.8	106.2
ADA4805-2	Enabled	6.87	4.75	11.6	106.7	-128.5	106.7
ADA4940-1	Disabled	13.86	Not applicable	13.9	106.3	-120.7	106.1
ADA4940-1	Enabled	13.37	4.75	18.2	106.0	-121.6	105.8
ADA4945-1 ²	Disabled	18.8	Not applicable	18.8	106.7	-117.7	106.4
ADA4945-1 ²	Enabled	18.3	4.75	23.05	106.6	-117.3	106.3
ADA4807-2	Disabled	28.01	Not applicable	28.0	106.6	-125.8	106.5
ADA4807-2	Enabled	27.67	4.75	32.4	106.1	-128.6	106.1

¹ Precharge buffer power consumption per channel.

² Low power mode of the ADA4945-1.

Table 7. Fast Power Mode Performance vs. Power

Amplifier	Precharge Buffer	Power (mW)	Precharge (mW) ¹	Total (mW)	SNR (dB)	THD (dB)	SINAD (dB)
ADA4940-1	Disabled	14.36	Not applicable	14.4	105.4	-114.5	105.0
ADA4940-1	Enabled	13.4	9.3	22.7	105.2	-120.4	105.1
ADA4807-2	Disabled	28.38	Not applicable	28.38	105.1	-105.7	102.6
ADA4945-1 ²	Disabled	30.5	Not applicable	30.5	105.9	-116.6	105.6
ADA4896-2	Disabled	36.94	Not applicable	36.9	106.7	-118.0	106.5
ADA4807-2	Enabled	27.78	9.3	37.08	104.9	-123.7	104.8
ADA4945-1 ²	Enabled	29.65	9.3	38.95	106.0	-120.7	105.8
ADA4896-2	Enabled	36.35	9.3	45.7	106.5	-130	106.4
ADA4899-1	Disabled	378.12	Not applicable	378.1	106.8	-117.9	106.5
ADA4899-1	Enabled	377.16	9.3	386.5	106.8	-120.9	106.6

¹ Precharge buffer power consumption per channel.

² Full power mode of the ADA4945-1.

SINGLE DAQ FOOTPRINT

The results in Table 5 describe the [ADA4805-2](#) as a power efficient front-end combination tested with the [AD7768/AD7768-4](#) and the [AD7768-1](#). The [ADA4805-2](#) can help meet power requirements and data sheet specifications. The combination of power scaling and precharge buffers enables the DAQ footprint to achieve minimum power consumption. Figure 7 provides an example of a low power DAQ footprint.

Table 8 lists the total power dissipation for the [AD7768](#) single DAQ footprint.

The ADC power specifications in Table 8 are for 5 V AVDD1x, 2.5 V AVDD2x, IOVDD, 32.768 MHz MCLK, and a wideband filter, decimated by 32.

Total driver requirements for the low power and median power modes in Table 8 are for an 8-channel ADC with both 6 V and 10 V supplies.

Reference and reference buffers consumption are for the [ADR444](#) and the [ADA4841-1](#) operating on a 6 V supply rail.

Figure 7 shows the minimum form factor for eight channels of [AD7768](#). The form factor includes the [AD7768](#), 8 × [ADA4805-2](#), [ADR444](#), [ADA4841-1](#), and 3 × [ADP7118](#) low dropout (LDO) regulators. The 8-channel acquisition system can be achieved on 49.4 mm × 64.1 mm of printed circuit board (PCB) with a total power dissipation of 148.6 mW. A similarly sized footprint can be used in a higher power DAQ module where greater bandwidth is required.

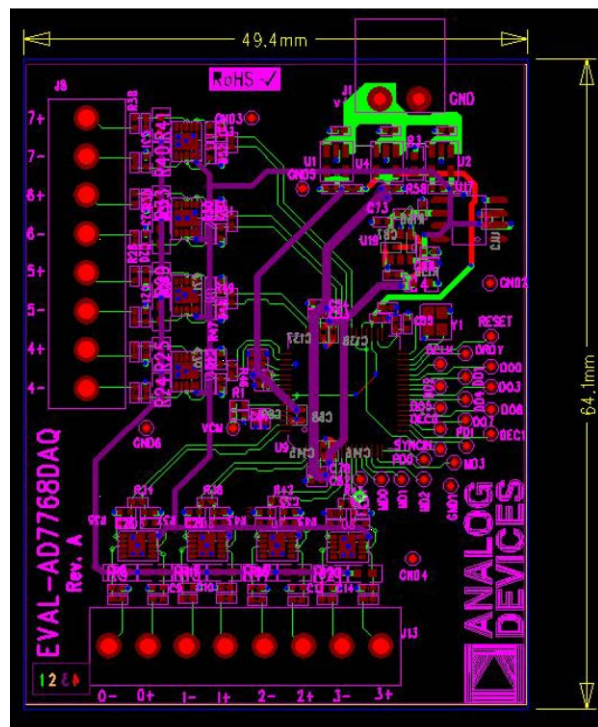


Figure 7. Example DAQ Footprint for the [AD7768](#) and the [ADA4805-2](#)

Table 8. Total Power Dissipation for Single DAQ Footprint

Power Mode	8-Channel ADC (mW)	Total Drive Requirements (mW)	Reference Buffer (mW)	Total Power (mW)	Power per Channel (mW)
Low Power (6 V Amplifier Supply, Precharge Buffers Disabled)	75	52	29.1	156.1	19.5
Low Power (10 V Amplifier Supply, Precharge Buffers Disabled)	75	99.8	29.1	203.9	25.5
Median Power (10V Amplifier Supply, Precharge Buffers Enabled)	260	106.5	29.1	395.6	49.4

AMPLIFIER CONFIGURATION

Figure 8 shows a typical amplifier configuration, with the exception of the [ADA4940-1](#) and the [ADA4945-1](#), which are fully differential amplifiers. The [ADA4899-1](#) requires a 25 Ω resistor on the noninverting input, for stability purposes, when operating with a gain of 1 (not shown in Figure 8).

CONFIGURATION OF THE [AD7768/AD7768-4](#) OR THE [AD7768-1](#)

The [AD7768/AD7768-4](#) and the [AD7768-1](#) is set up with $IOVDD = 3.3$ V, $AVDD1x$ and $AVDD2x = 5$ V, [AD7768/AD7768-4](#) MCLK = 32.768 MHz, [AD7768-1](#) MCLK = 16.384 MHz, $VREF = 4.096$ V, wideband filter, precharge reference buffers disabled, analog input precharge buffers enabled/disabled, all channels enabled, and the chopping frequency ($f_{CHOP} = f_{MOD}$) is decimated by 32.

The evaluation boards used are the [EVAL-AD7768FMCZ](#), [EVAL-AD7768-4FMCZ](#), and the [EVAL-AD7768-1FMCZ](#).

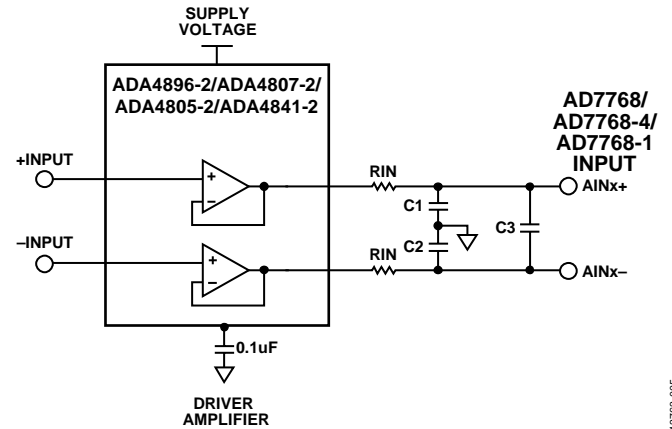


Figure 8. Typical Drive Amplifier Configuration

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Table 9. Configuration of Amplifiers for Each Power Mode

Amplifier	Power Mode	RIN (Ω)	C1, C2 (pF)	C3 (pF)	f_c (MHz)	Supply Voltage (V)
ADA4899-1	Fast	5.1	270	680	19.1	-4 and +8
ADA4896-2	Fast	10	100	270	24.9	0 and 8
ADA4807-2	Fast	62	120	Do not insert	21.4	0 and 6
	Median	62	220	Do not insert	11.7	0 and 6
ADA4940-1	Fast	82	68	Do not insert	28.5	0 and 5
	Median	33	56	180	11.6	0 and 5
	Low	33	120	330	6.2	0 and 5
ADA4805-2	Fast	82	100	Do not insert	19.4	0 and 6
	Median	82	220	Do not insert	8.8	0 and 6
	Low	82	470	Do not insert	4.1	0 and 6
ADA4841-2	Low	33	120	330	6.2	0 and 6
ADA4084-2	Low	82	470	Do not insert	4.1	0 and 6
ADA4945-1	Fast ¹	82	82	Do not insert	23.7	0 and 5
	Median ²	82	120	Do not insert	16.2	0 and 5
	Low ²	82	470	Do not insert	4.1	0 and 5

¹ Full power mode of the [ADA4945-1](#).

² Low power mode of the [ADA4945-1](#).

CONCLUSION

This application note simplifies the amplifier selection process in a DAQ system design based on the Σ - Δ ADCs, the [AD7768/AD7768-4](#) or the [AD7768-1](#), with consideration for system bandwidth, performance requirements, and power constraints. The [AD7768/AD7768-4](#) or the [AD7768-1](#) are suitable for acquisition of both ac and dc signals and are highly customizable to suit bandwidths from dc up to 110 kHz. As a result, these ADCs are suitable for a wide variety of applications. By changing the selected power mode and decimation rate, a system designer can match the required operating point for both power consumption and noise performance. For systems that are required to be adaptable, the power mode and decimation rates are software configurable. The information presented throughout this application note serves as a starting point to begin optimizing a DAQ design that fulfills those key design challenges.

A more complex front-end filter can potentially improve the results for a specific bandwidth, because all noise figures given are not band limited. The switching input structure requires high bandwidth amplifiers, particularly in fast power mode. These driver amplifiers are required to settle the effect of fast switching transients before the next modulator sample takes place. The precharge input buffers can help in some instances to allow lower power amplifiers to be used. In general, enabling the

precharge buffers improves THD. The precharge buffers reduce the analog input current and help reduce the analog input current dependency on input voltage. Therefore, the precharge buffers reduce any error that is produced by a voltage drop across the RIN resistor in the input RC filter.

The solutions discussed can be chosen for system power requirements, performance requirements, or single-supply operation.

The optimum driver amplifiers for each of these requirements of power, performance, and supply are as follows:

- The [ADA4805-2](#) is suited for low power, particularly in low power mode.
- The [ADA4945-1](#) is suited for single-supply operation and is the recommended fully differential amplifier to drive the [AD7768/AD7768-4](#) or the [AD7768-1](#).
- For optimum performance in fast power mode, the [ADA4896-2](#) performs well, although not consuming the same power as the [ADA4899-1](#).
- The [ADA4896-2](#) or [ADA4945-1](#) are also suitable for a general-purpose DAQ module, which can be configured for all three power modes.