TEXAS INSTRUMENTS

ADS1224EVM

Evaluation Module

User's Guide

April 2004

Data Acquisition Products

SBAU095

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During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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Read This First

About This Manual

This manual describes the ADS1224EVM evaluation fixture and how to use it. Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the ADS1224EVM.

Information About Cautions and Warnings

This book contains cautions.

This is an example of a caution statement.

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Related Documentation From Texas Instruments

The following documents provide information regarding Texas Instruments integrated circuits used in the assembly of the ADS1224EVM. These documents are available from the TI web site. The last character of the literature number corresponds to the document revision, which is current at the time of the writing of this User's Guide. To obtain a copy of the following TI documents, visit our website at http://www.ti.com/ or call the Texas Instruments Literature Response Center at (800) 477−8924 or the Product Information Center at (972) 644−5580. When ordering, identify the document by both title and literature number.

Data sheet	Literature number
ADS1224 Data Sheet	SBAS286
REF1004 Data Sheet	SBVS002
OPA350 Data Sheet	SBOS099

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Chapter 1

Overview

The ADS1224EVM is an evaluation fixture for the ADS1224 24-bit delta-sigma (ΔΣ) analog-to-digital converter (ADC). The ADS1224EVM is designed for prototyping and evaluation.

Topic **Page**

1.1 Introduction

Many data converter evaluation fixtures contain a computer interface or a microcontroller, but the ADS1224EVM contains only the ADS1224 device and a few support components. All ADS1224 pins are accessible through various pins on the ADS1224EVM analog and digital connectors.

The ADS1224EVM is designed using a standard card format developed by TI. This simple, consistent design makes the ADS1224EVM very easy to connect to your own prototype system. You can even think of the ADS1224EVM as an alternate package for the ADS1224—one much larger than the device itself, but also much easier to wire up by hand on your test bench.

The ADS1224EVM can be plugged directly into suitable motherboards, such as the HPA449 MSP430 microcontroller development system from Soft-Baugh, Inc. (http://www.softbaugh.com/). See TI's web site for example code using the ADS1224EVM with the HPA449.

The ADS1224EVM, together with a motherboard and appropriate software, also forms a complete evaluation system for verifying the performance of the ADS1224 . See the ADS1224 product information folder on the Texas Instruments web site for more information and software.

1.2 Built-in Accessories

The ADS1224EVM includes a system clock oscillator and a low-noise voltage reference. Both of these components are optional; you can select an external system clock and an external reference using slide switches.

The +2.5V voltage reference is derived from a Burr-Brown REF1004-2.5, which is buffered by an OPA350 and filtered by a capacitor.

1.3 Connectors

The ADS1224 device on the ADS1224EVM is connected through four headers: the analog connector, the serial connector, the power connector, and the GPIO header. Pinouts and locations for the connectors are given in Chapter 2.

The **analog connector** (J1) carries analog I/O. The ADS1224 has a four-input differential multiplexer connected through pins 1−8. An optional external differential reference can be connected to pins 18 and 20.

The **serial connector** (J2) carries the ADS1224 serial digital interface, an optional external system clock signal, and an I^2C connection to the onboard serial EEPROM.

The **power connector** (J3) carries the power supplies. The ADS1224EVM requires a +2.7V to +5V analog supply, and a +2.7V to +3.3V digital supply. The board is designed using a single ground net connected to DGND. An AGND pin is also provided; this pin can be connected to DGND using jumper J2.

The ADS1224 uses separate supply pins for its analog and digital sections. A jumper is inserted in each supply line. These jumpers allow the current of each supply to be measured independently.

1.4 Controls

The ADS1224EVM is configured using seven slide switches and a jumper block.

Switches S1−S4 select the input signal provided to the first two multiplexer inputs on the ADS1224. For each pair of switches, one switch controls the source for the positive input, and one controls the source for the negative input. Each of these controls can be switched between external, zero, and V_{REF}.

Switches S5 and S6 select the reference input. The possible combinations allow for several different reference configurations. See Section 2.3.2 on page 2-11 for details.

Switch S7 selects the system clock source for the ADS1224. You can select between the onboard 4MHz oscillator or an external clock.

Jumper block J4 contains jumpers for supply current measurement and digital power supply level selection. It also has a jumper for connecting the digital and analog grounds on the power connector together. See Section 2.2 on page 2-7 for details.

1.5 Setting Up

The ADS1224EVM is configured according to its use. Thus, there is no single correct procedure to follow in order configure the test fixture.

Nevertheless, it is useful to remember the following things when you are setting up the board:

- ❏ Make certain that the digital supply level is correct. The jumper block has three positions that correspond to different voltage supply lines. A shorting block must be placed on ***one***, and only one, of these supply lines for the device to operate. See Section 2.2.2 on page 2-8 for additional details.
- ❏ If you are not measuring the supply current for the ADS1224, remember to place shorting blocks in the appropriate positions on jumper block J4. Without these shorting blocks, the ADS1224 will not be powered on, and will not work properly.
- ❏ Depending on your supply configuration, you may need to place a shorting block on the analog-digital ground jumper. Some motherboards connect these grounds externally, but some do not. If there is no connection between analog and digital ground, the board will not operate.

- ❑ Check the system clock switch. If it is set to ***EXT***, and you have not connected a clock signal to the external clock input pin on J2, the ADS1224 will not operate.
- ❑ The ADS1224 has several configuration input pins connected to pins on J2. If these configuration input pins are left floating, the ADS1224 may not operate properly. See the ADS1224 data sheet for further information about these pins.

Chapter 2

Circuit Description

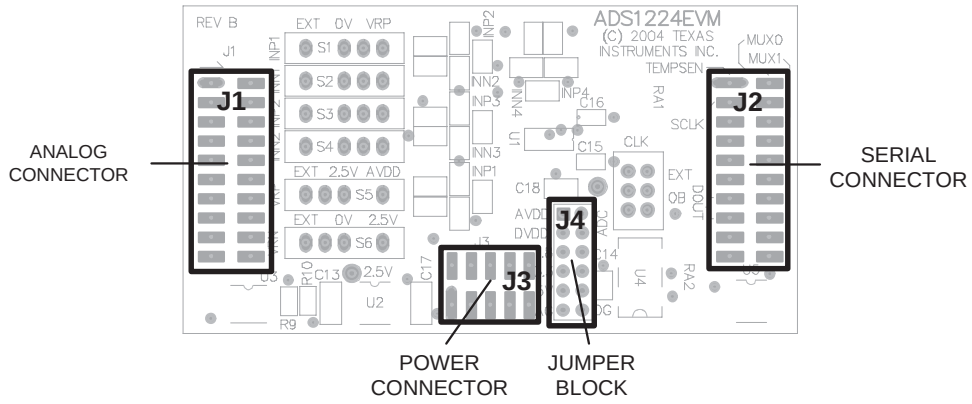
This chapter describes the connectors, controls, and circuit design of the ADS1224EVM in detail.

Topic **Page**

2.1 I/O Connectors and Testpoints

The positions and functions of the connectors and testpoints are shown in Figure 2−1.

Figure 2−1. Connectors and Jumpers



Many of the pins on the connectors are not used. On the pinout diagrams, unused pins are not marked. In the pin description tables, unused pins are not listed, and ground pins are listed together, with the exception of the power connector.

J1, J2, and J3, although each treated as a single connector, are actually mounted as connector pairs in a pass-through configuration. Each pair has a surface-mount header on the top (component) side of the board, and a corresponding surface-mount socket on the bottom (solder) side of the board. Vias in the pads connect each pin from top to bottom. The headers, mounted on top, are suffixed **A**; the sockets, mounted on bottom, are suffixed **B**.

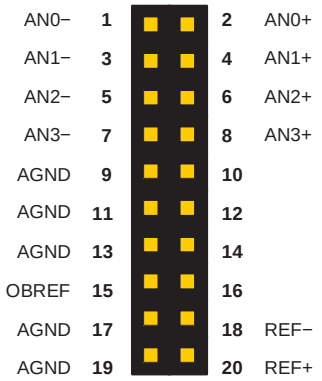
In the schematic, the connector pairs are shown as one symbol. For J1, J2, and J3, all bottom-side pins are connected to their corresponding top-side pins; for example, J1B pin 1 connects to J1A pin 1, J1B pin 2 connects to J1A pin 2, etc. This convention holds true for every pin on connectors J1, J2, and J3.

In the following descriptions, the connector pairs will be referred to as a single connector.

2.1.1 J1: Analog Connector

The analog connector pinout is shown in Figure 2−2 and described in Table 2−1.

Figure 2−2. Analog Connector Pinout



Although certain pins are described as "negative," *never* apply voltages less than −0.3V to these pins. The ADS1224 is not a bipolar-input device, and it cannot accept negative voltages below −0.3V without damaging the functional operation of the unit.

The negative input pins are so named because the voltage on such a pin is subtracted from a positive input pin during a reading.

Table 2−1. Analog Connector Pin Descriptions

Pin Number	Pin Name	Standard Name	Direction	Function	Connection
1	AN0−	AN0−	Input	Negative input 0	Through S1
2	AN0+	AN0+	Input	Positive input 0	Through S2
3	AN1−	AN1−	Input	Negative input 1	Through S3
4	AN1+	AN1+	Input	Positive input 1	Through S4
5	AN2−	AN2−	Input	Negative input 2	Direct
6	AN2+	AN2+	Input	Positive input 2	Direct
7	AN3−	AN3−	Input	Negative input 3	Direct
8	AN3+	AN3+	Input	Positive input 3	Direct
10	OBREF	VCOM	Output	Reference output/ common-mode reference	Direct
18	SYSREFN	REF−	Input	Negative reference input	Through S5
20	SYSREFP	REF+	Input	Positive reference input	Through S6
9, 11, 13, 17, 19	GND	AGND	Power	Signal ground	n/a

Note: Channels 0 and 1 are not used unless the input select switches S1−S4 are set to the appropriate positions. Channels 1 and 2 are hard-wired to the device.

2.1.2 J2: Serial Connector

The serial connector pinout diagram is shown in Figure 2−3 and described in Table 2−2.

Figure 2−3. Serial Connector Pinout

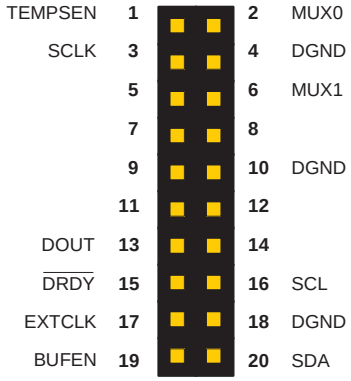


Table 2−2. Serial Connector Pin Descriptions

Pin Number	Pin Name	Standard Name	Direction	Function
1	TEMPSEN	CNTL	Input	Temperature sensor enable
2	MUX0	GPIO0	Input	Channel select, bit 0
3	SCLK	CLKX	Input	Serial clock input
6	MUX1	GPIO1	Input	Channel select, bit 1
7	$\overline{\text{CS}}$	FSX	Input	Chip select
13	DOUT	DR	Output	Serial data output
15	$\overline{\text{DRDY}}$	$\overline{\text{INT}}$	Output	Data ready signal
16	SCL	SCL	I/O	I^2C clock line
17	EXTCLK	TOUT	Input	External system clock input
19	BUFEN	GPIO5	Input	Buffer enable
20	SDA	SDA	I/O	I^2C data line
6, 12, 18	GND	DGND	Power	Signal ground

2.1.3 J3: Power Connector

The power connector pinout diagram is shown in Figure 2−4 and described in Table 2−3.

Figure 2−4. Power Connector Pinout

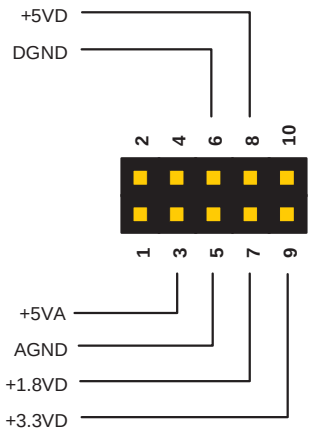


Table 2−3. Power Connector Pin Descriptions

Pin Number	Pin Name	Function	Use on ADS1224EVM
1	+VA	Positive Analog Supply, +5V to +18V	Not used
2	−VA	Negative Analog Supply, −5V to −18V	Not used
3	+5VA	Positive Analog Supply, +5V	Analog supply
4	−5VA	Negative Analog Supply, −5V	Not used
5	AGND	Analog Ground	Optional connection to DGND using J4
6	DGND	Digital Ground	Ground
7	+1.8VD	Positive Digital Supply, +1.8V	Digital supply, selected using J4
8	VD1	Positive Digital Supply	Not used
9	+3.3VD	Positive Digital Supply, +3.3V	Digital supply, selected using J4
10	+5VD	Positive Digital Supply, +5V	Digital supply, selected using J4

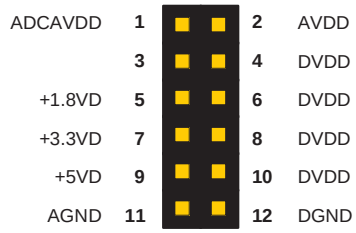
Note: The ADS1224EVM has a single ground domain. The ground is always connected to DGND. It may also be connected to AGND using J4 pins 11−12.

The ADS1224 uses an analog supply of +5V and a digital supply of +1.8V to +5.5V. +1.8V, +3.3V and +5V are all available as standard supply voltages over the power connector; the ADS1224EVM allows the user to select one of them using J4.

2.2 Jumpers

There are six jumper positions on the ADS1224EVM. All are contained in jumper block J4. The pinout of this jumper block is shown in Figure 2−5.

Figure 2−5. Jumper Block



2.2.1 J4 Pins 1−4: ADS1224 Power Supply Measurement

These jumpers can be used to measure the current of the ADS1224 power supplies. Pins 1−2 are inserted in the analog supply, and pins 3−4 are inserted in the digital supply.

For normal operation, pins 1−2 must be shorted and pins 3−4 must be shorted.

2.2.2 J4 Pins 5−10: Digital Power Supply Select

One of pin pairs 5−6, 7−8 or 9−10 must be shorted to select the digital supply level on for the ADS1224. This selection determines the level at which the ADS1224 digital lines will operate, so it is very important to set this correctly.

It is possible to measure the overall digital current of the board using these jumpers.

CAUTION

Connect only one of pin pairs 5−6, 7−8 or 9−10.

Shorting more than one of these jumpers can potentially damage your motherboard, or even damage the ADS1224EVM itself.

The ADS1224 inputs are not 5V tolerant, nor are they TTL-compatible. Although protection resistance is included in each digital line, it may be necessary to provide level translation if the ADS1224 digital supply must be powered from a different voltage than the external logic.

Note that the digital and analog supplies for the ADS1224 are independent, so level translation should rarely be needed.

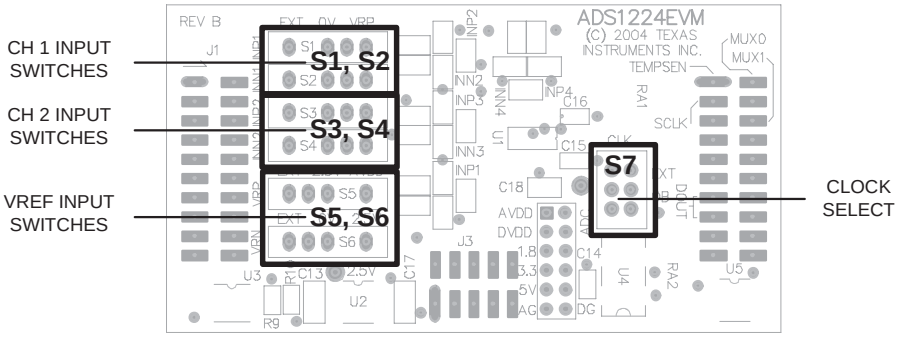
2.2.3 J4 Pins 11−12: Analog-Digital Ground Shorting Jumper

Shorting this jumper connects AGND from J3 to DGND.

2.3 Switches

The positions and functions of the EVM switches are shown in Figure 2−6.

Figure 2−6. Switches



2.3.1 S1−4: Input Select Switches

These switches control which lines are routed to the ADS1224 channel 0 (AIN0) and channel 1 (AIN1) inputs. Each switch is configured in the same way and connects to a single input pin. The positions of the switches are described in Table 2−4.

Table 2−4. AIN0−1 Input Select Switch

Board Marking	Switch Position	Input Source
EXT	Left	External (J1 pin)
0V	Right	Ground
VRP	Middle	Positive reference voltage

Note that VRP is controlled by switch S5.

Since the switches for both the negative and positive inputs for each channel have the same configuration, it is easy to set up the inputs for a variety of applications. Some examples are given in Table 2−5.

Table 2−5. Common Input Switch Settings

Setting Number	S1/3 (INP)	S2/4 (INN)	Setting	Ideal Voltage Range for VRP = 2.5V	Ideal Output Code Range (Hex 2s complement)
1	EXT	EXT	External Differential	−5V ≤ (INP − INN) ≤ 5V	0x800000 < code < 0x7FFFFF
2	EXT	0V	Single-ended, ground-referenced	0 ≤ INP ≤ 5V	0x000000 < code < 0x7FFFFF
3	EXT	VRP	Single-ended, midscale-referenced	0 ≤ INP ≤ 5V	0xC00000 < code < 0x3FFFFF
4	0V	0V	Inputs shorted to ground	N/A	N/A (near zero)
5	VRP	VRP	Inputs shorted to midscale	N/A	N/A (near zero)

To measure external differential signals, use Setting 1. To measure external 0V−5V signals, use either Setting 2 or 3. Note that for single-ended signals, approximately one bit is lost from full-scale. Note that Setting 3 may provide better headroom against full-scale clipping.

Settings 4 and 5 are useful for noise tests. When using the buffer, more accurate results may be obtained with Setting 5. Also, internal offset calibration on the ADS1224 is performed as the device is in Setting 5.

2.3.2 S5−6: Reference Select

These two switches control which signals are applied to the ADS1224 differential reference input pins. The positions of the switches are described in Table 2−6 and Table 2−7.

Some common combinations of S5 and S6 are shown in Table 2−8.

Table 2−6. VRP Select Switch

Board Marking	Switch Position	VRP Source
EXT	Left	External (J1 pin 20)
2.5V	Middle	Onboard 2.5V reference voltage
AVDD	Right	Analog supply voltage (+5V typ.)

Table 2−7. VRN Select Switch

Board Marking	Switch Position	VRN Source
EXT	Left	External (J1 pin 20)
0V	Middle	Ground
2.5V	Right	Onboard 2.5V reference voltage

Table 2−8. Common S5−6 Combination Settings

Setting Number	S6 (VRN)	S5 (VRP)	Setting	VRP and OBREF Voltage	ADS1224 Reference Voltage
1	EXT	EXT	Onboard 2.5V	2.5V	External (J1 pin 20)
2	EXT	0V	Onboard 2.5V, high common-mode	AVDD	AVDD − 2.5V
3	EXT	VRP	External	SYSREFP	SYSREFP − SYSREFN
4	0V	0V	Ratiometric	SYSREFP	SYSREFP

Setting 1 is most commonly used for the onboard reference.

Setting 2 causes the reference common-mode to be higher; in a very few situations, this may improve performance, as long as the AVDD supply is quiet. Setting 2 may also be useful for certain ratiometric connections.

Setting 4 is most often used in ratiometric sensor connections. A sensor excitation voltage can be applied to the SYSREFP pin on J1. Note that the ADS1224 performance is greatly degraded over temperature for reference voltages above 2.5V.

The voltage selected from S5 is routed to the OBREF pin on J1, and also to the rightmost position of switches S1−4. This configuration allows any of the inputs to be connected to the positive reference by moving the switches to the appropriate setting.

2.3.3 S5: System Clock Select

This switch selects which of the two available clock sources on the ADS1224EVM will be provided to the ADS1224. The positions of the switch are described in Table 2−9.

Table 2−9. System Clock Select Switch

Board Marking	Switch Position	System Clock Source
EXT	Up	External (J5 pin 17)
OB	Down	Onboard 4MHz oscillator

Chapter 3

Usage

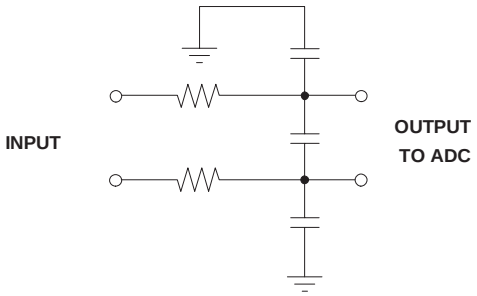
This chapter provides guidelines on using the ADS1224EVM and connecting other systems to it.

Topic **Page**

3.1 Input Filtering

Each channel pair on the ADS1224EVM has pads for a differential RC filter, as shown in Figure 3−1.

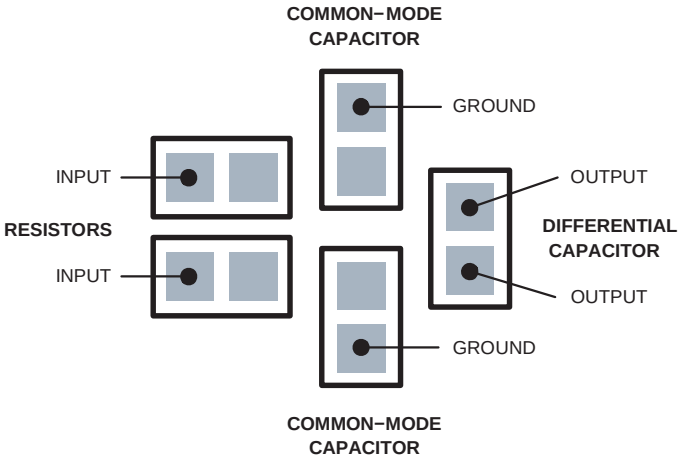
Figure 3−1. Channel Input Filter



As shipped, the resistor pads are populated with 0Ω resistors, and the capacitor pads are unpopulated. This configuration allows you to add any values you like. The pads are 0805 footprints, so it is easy to solder resistors to them by hand. If you do not have surface-mount components, it is possible to solder leaded components to these pads.

The physical layout of the components in each filter is the same, and is shown in Figure 3−2. The pads of the differential capacitor are marked on the board with the pin they are connected to.

Figure 3−2. Channel Filter Layout



3.2 Serial Interface

The ADS1224 serial interface is connected through 100Ω resistors to the ADS1224EVM serial connector. The resistors help terminate the lines and slow down fast edges that can couple into the part and reduce performance. Additionally, the resistors help protect the device against overvoltage.

The way you connect the ADS1224EVM in a prototype situation will normally be the same as the way you connect it on your final product. See the product datasheet for information on the serial interface of the ADS1224.

3.3 Serial EEPROM

The serial EEPROM is a Microchip 24LC256 32kB type. You can use it for anything you like; the chip is not programmed during manufacturing. Some possible uses include calibration data or board ID information.

Information on communicating with the EEPROM is available from Microchip Technology, Inc.

3.4 Clock Circuitry

The ADS1224 does not have a built-in clock oscillator, and requires an external clock signal in order to operate. The ADS1224EVM has a 4MHz clock oscillator chip on board to supply the clock signal.

In some cases, it is desirable to operate the ADS1224 at a different frequency. To do this, supply a clock to the EXTCLK pin on J1, and set switch S7 to EXT.

Chapter 4

Schematic and Layout

This chapter contains the complete bill of materials, schematic diagram, and printed circuit board (PCB) layout for the ADS1224EVM.

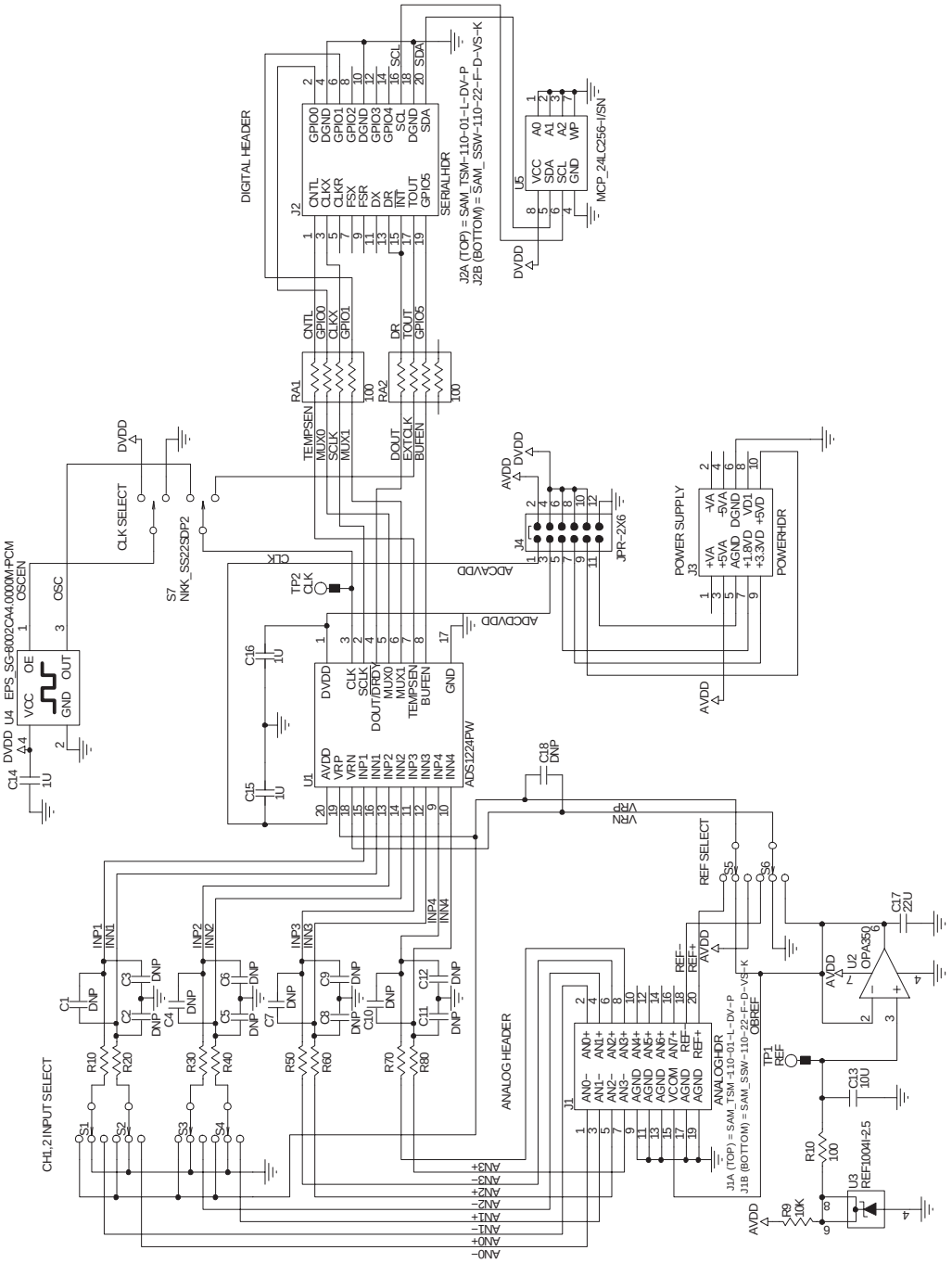
Note:

Board layouts are not to scale. They are intended to show how the board is laid out; they are not intended to be used for manufacturing ADS1224EVM PCBs.

Topic **Page**

4.1 Schematic

Figure 4−1. Schematic



4.2 Printed Circuit Board Layout

The ADS1224EVM is a four-layer PCB. The layer stack order, from top to bottom, is component (top) layer, ground plane, power plane, and solder (bottom) layer.

Four layers were necessary to accommodate the many components on the board. Four layers are not necessary for high performance with the ADS1224; the same level of performance can also be achieved on a two-layer board.

Figure 4−2. Top Side Layout

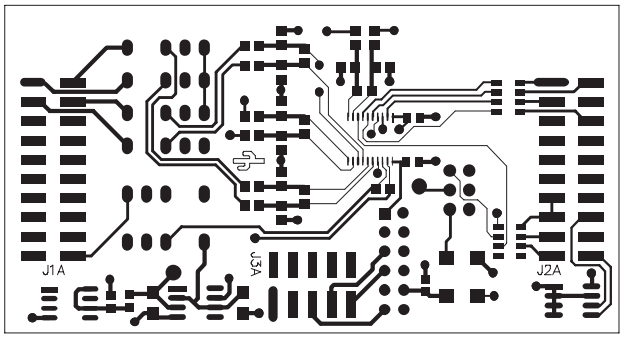
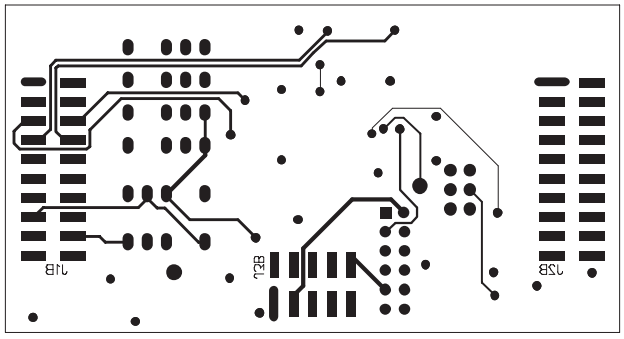


Figure 4−3. Bottom Side Layout



4.3 Bill of Materials

Table 4−1. Bill of Materials

Reference Designator	Description	Vendor	Part Number
R1, R2, R3, R4, R5, R6, R7, R8	0805-size shunt	Panasonic	ERJ−3GEY0R00V
R9	1/16W 5% 10kΩ chip resistor	Panasonic	ERJ−3GEYJ103V
R10	1/16W 5% 100kΩ chip resistor	Panasonic	ERJ−3GEYJ101V
RA1, RA2	100Ω 4-position resistor array	CTS	744C083101JTR
C13	10μF ceramic chip capacitor, ±10%, X7R, 6.3V	Murata	GRM31CR70J106KA01L
C14, C15, C16	1μF ceramic chip capacitor, ±10%, X5R, 0603, 10V	Murata	GRM188R61A105KA61D
C17	22μF ceramic chip capacitor, ±10%, X5R, 6.3V	Murata	GRM31CR60J226KE19L
U1	Analog-to-digital converter	Texas Instruments	ADS1224IPW
U2	Operational amplifier	Texas Instruments	OPA350UA
U3	Voltage reference, 2.5V	Texas Instruments	REF1004I−2.5
U4	EEPROM, 1^2C, 256K bits	Microchip	24LC256-I/SN
U5	Oscillator	Epson	SG-8002CA-PWT
J1A, J2A	SMT header, 20-pin, dual-row	Samtec	TSM-110-01-L-DV-P
J1B, J2B	SMT socket, 20-pin, dual-row	Samtec	SSW-110-22-F-D-VS-K
J3A	SMT header, 10-pin, dual-row	Samtec	TSM-105-01-L-DV-P
J3B	SMT socket, 10-pin, dual-row	Samtec	SSW-105-22-F-D-VS-K
J4	Header, 12-pin, dual-row	Samtec	TSW-106-07-L-D
S7	DPDT slide switch	NKK	SS22SDP2
S1, S2, S3, S4, S5, S6	DP3T slide switch	NKK	SS14MDP2