ADA2200-EVALZ User Guide

UG-702

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Evaluation Board for the ADA2200 Synchronous Demodulator

EVALUATION BOARD FEATURES

Easy to use evaluation board
Simple, in-phase (I) and quadrature (Q) demodulation in a single channel
Differential or single-ended input/output
USB powered
On-board oscillator
EEPROM programmable option
Synchronization signals available for external devices

GENERAL DESCRIPTION

This user guide describes the evaluation board that contains the Analog Devices, Inc., ADA2200 sampled analog, synchronous demodulator. The circuit configurations available through the ADA2200-EVALZ enable the user to exercise its full set of features.

The ADA2200-EVALZ simplifies signal connections to standard test equipment. Inputs, outputs, supplies, and other circuit test points can be easily accessed via test clips, differential probes, or standard SMA cables. In addition, the board can be easily powered from any USB port through the included USB cable.

The ADA2200-EVALZ performs amplitude and phase measurements on the signals applied to its inputs. The selection between I and Q components is accomplished with a simple toggle switch.

The recommended configuration for initial evaluation is shown in Figure 2. See the Quick Start and Setup Procedure section for more details.

Complete specifications for the ADA2200 are available in the ADA2200 data sheet, which must be consulted in conjunction with this user guide when using the evaluation board. The data sheet and user guide are available to download from the ADA2200 and the ADA2200-EVALZ product pages at www.analog.com.

EVALUATION BOARD PHOTOGRAPH

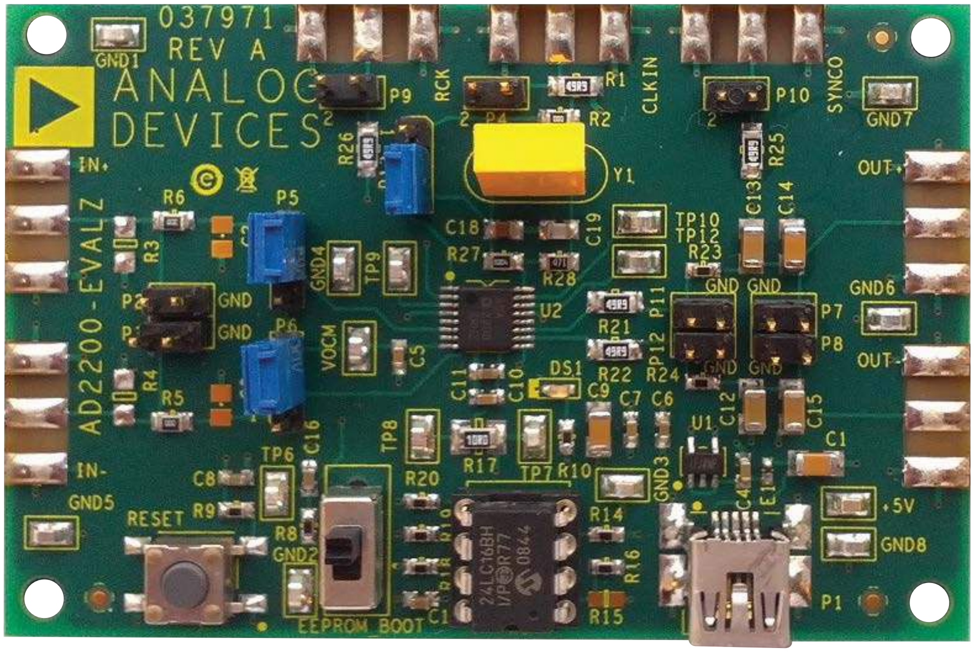

Figure 1.

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REVISION HISTORY

8/14—Revision 0: Initial Version

QUICK START AND SETUP PROCEDURE

The recommended configuration for initial evaluation is shown in Figure 2. The signal inputs can handle voltages from 0 V to 3.3 V. Power is supplied through the mini-B USB plug by connecting it to any powered USB port.

Set up the ADA2200-EVALZ by completing the following steps:

1. Power the board by plugging it into a PC or powered USB hub. The green LED (DS1) turns on when power is available.
2. Verify that the jumper configuration matches the settings shown in Table 1. With this configuration, the IN+ terminal can be driven with a single-ended source.
3. Configure a signal generator to source a 6.25 kHz signal. Offset the output voltage to make sure the signal remains between 0 V and 3.3 V. An offset at midsupply (1.65 V) allows maximum signal swing.
   Note that many signal generators have a 50 Ω source impedance and are configured for 50 Ω loads. Therefore, the voltage swing doubles when the instrument is not loaded with a 50 Ω impedance. This condition applies to both the amplitude and offset setting. Verify the actual signal output with a high input impedance scope before connecting the signal generator to the ADA2200-EVALZ board.
4. Synchronize the signal generator and the board by connecting the reference clock output signal (available through the P9 pins) to a trigger input on the generator. The signal generation must be configured to start on this trigger event (burst generation) or to lock to the reference clock signal (RCK). The detailed configuration depends on the specific source used.
5. Connect the signal generator to the IN+ terminal through the P2 pins and enable the output.
6. To observe the demodulated signal, probe at P11 and P12. P11 and P12 are arranged for differential scope probes, but standard probes or clips work as well. Both the output synchronization pulse (SYNCO) and RCK can be used to trigger an oscilloscope.
7. Observe the filtered output by measuring the voltage between P7 and P8 with a digital multimeter (DMM).

Table 1. Default Jumper Settings

Designator	Position	Description
P5	1 and 2	IN+ connected to INP
P6	2 and 3	IN– connected to VOCM
P13	2 and 3	On-board clock selected

Pin 1 can be identified by the chamfered corner and number on the silkscreen.

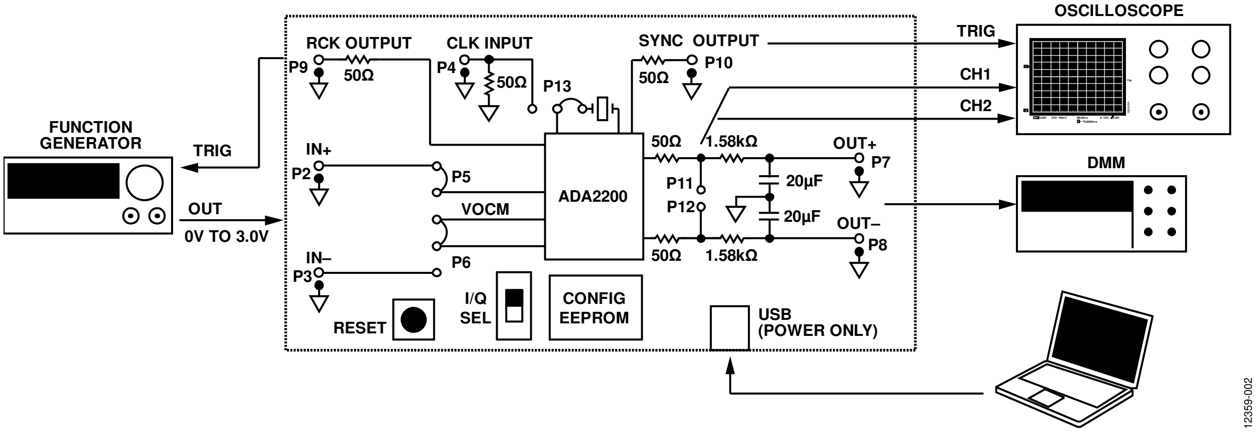

Figure 2. Suggested Configuration for Quick Start, Showing Connections to Standard Test Equipment

DETAILED BOARD DESCRIPTION

The ADA2200-EVALZ consists of the ADA2200 synchronous demodulator, powered by the ADP151 3.3 V low dropout (LDO) regulator. Power is applied through the mini-B USB jack by connecting the supplied cable to a powered USB port, or by using the +5V and GND test points adjacent to the USB port.

An on-board oscillator circuit uses a ceramic resonator (ECS, Inc. ZTB400P [Y1]) to clock the ADA2200 at 400 kHz. This oscillator circuit centers the band-pass filter at 1/64 of its clock frequency, or 6.25 kHz. A different clock source and frequency can be supplied through the CLKIN input, by placing the jumper P13 between Position 1 and Position 2.

The input signal terminals are labeled IN+ and IN−. By default, the ADA2200 is configured to be driven by a fully differential source. The ADA2200 can be driven single-ended by applying the signal between IN+ and ground, and connecting IN− to VOCM through the P6 jumper (as shown in Table 1). Note that the signal range for all the inputs and outputs is 0 V to 3.3 V; exceeding this range on any input can damage the ADA2200.

There are two output signal terminals on the board. Probing P11 or P12 with a scope displays the direct output signal from the ADA2200. The P11 and P12 connectors are arranged to accept a differential oscilloscope probe, but regular clips can also be used. Connecting a voltmeter between P7 and P8 allows the user to measure the dc signal after a 10 Hz, low-pass, RC filter.

The output terminals RCK and SYNCO can be used to synchronize to the input and output signals, respectively. For details on how to generate coherent signals or achieve synchronization, refer to the Input Signal Synchronization section and Output Signal Synchronization section. A summary of the signals available on the board is shown on Table 2.

Note that the board includes pads for soldering side, launch, SMA connectors (see Table 4 and the Johnson 142-0701-851 row). These connectors are commonly available for purchase from electronic distributors.

Table 2. Terminal Description

Designator	Signal	Description
P1	+5V	Mini-B USB power connector
P2	IN+	Noninverting input
P3	IN−	Inverting input
P4	CLKIN	External clock input
P7	OUT+	Noninverted filtered output
P8	OUT−	Inverted filtered output
P9	RCK	Reference clock output
P10	SYNCO	Output synchronization pulse
P11	OUTP	Noninverted demodulated output
P12	OUTN	Inverted demodulated output
+5V	+5V	Mini-B USB power connector
GNDx	GND	Multiple ground test points
VOCM	VOCM	Output common-mode voltage I/O
TP6	$\overline{\text{BOOT}}$	Boot from EEPROM signal (digital)
TP7, TP8	ISUPPLY	10 Ω current shunt for 3.3 V supply
TP9	A0	EEPROM address selection
TP10	SCL	EEPROM clock
TP12	SDA	EEPROM data

SYNCHRONOUS DEMODULATION USING THE ADA2200

INPUT SIGNAL SYNCHRONIZATION

By default, ADA2200 filters and demodulates signals located exactly at 1/64 of its clock frequency. For example, when using the 400 kHz on-board oscillator, the demodulated signal frequency must be 6.25 kHz. Because it is difficult to achieve coherent, independently generated signals, the clock and the signal source must be synchronized. This synchronization is generally accomplished by deriving one signal from the other, or by employing a phase-locked loop.

For this purpose, the reference clock signal (RCK) is derived from the ADA2200 clock, and the default RCK frequency is $f_{CLK}/64$. Therefore, if the input signal is synchronized to RCK, the band-pass filter is automatically centered on the input signal, and the signal is properly demodulated. In addition, this configuration allows the system to track any changes in frequency, because everything is derived from a single master.

Because of these properties, it is possible to use RCK to drive a signal excitation source, to trigger a pattern generation, or as the frequency reference in a phase-locked loop generating the input signal.

OUTPUT SIGNAL SYNCHRONIZATION

An output synchronization pulse is available on the SYNCO connector. The ADA2200 generates this pulse every time the output is updated and ready to be sampled. The frequency of this pulse is 1/8 the clock frequency. By default, the pulse polarity is positive, and it is generated 6.5 clock cycles after the last output update.

When the ADA2200 is clocked by the on-board oscillator circuit, the frequency of the SYNCO pulse is 50 kHz (20 µs period); the pulse duration is one clock cycle or 2.5 µs (12.5% duty cycle); and the pulse occurs 16.25 µs after the last output update. The polarity and its occurrence relative to the output update event are programmable features.

Table 3. Default Clock Frequencies Relative to f_{CLK}

Signal	Ratio	Description
FCLK	1	Master clock
FS	1	Input sampling rate
FSN	1/2	Input sampling Nyquist rate
FD	1/8	Output sampling rate
FDN	1/16	Output sampling Nyquist rate
FSYNCO	1/8	Synchronization pulse frequency
FRCK	1/64	Reference clock frequency
FC	1/64	Band-pass filter center frequency
FC	1/64	Mixer frequency

PROGRAMMING THE ADA2200

The ADA2200 has many programmable features, such as multiple filter configurations, quadrature demodulation, and adjustable clock ratios. These features can be programmed via the serial port interface (SPI) or at power-up when booting from an I^2C EEPROM. For a complete list of features and the internal register map, refer to the ADA2200 data sheet.

On the ADA2200-EVALZ board, the SPI configuration option is not directly available. The device can be reprogrammed through the EEPROM option only. A valid configuration must be loaded on the EEPROM, and the toggle switch must be on the EEPROM_BOOT position at power up.

The internal configuration memory is volatile, and the device returns to its default value if it does not boot from the EEPROM. Therefore, it is possible to toggle between the default and the EEPROM configurations by selecting the appropriate position of the toggle switch and by then pressing the **RESET** button.

To program the ADA2200 via the SPI, use the ADA2200SDP-EVALZ evaluation board.

SELECTING BETWEEN I AND Q DEMODULATION COMPONENTS

By default, the ADA2200 performs synchronous demodulation of the in-phase signal component (I). To demodulate the quadrature component (Q), set the toggle switch to the EEPROM_BOOT position and press the **RESET** button. The EEPROM contains the same default configuration as the ADA2200, but sets the quadrature demodulation bit.

The EEPROM must be configured to the factory contents. Changing the EEPROM contents changes the behavior of the device after switching the toggle switch.

DEFAULT FILTER CONFIGURATION

The ADA2200 internal filter is configured by default as a second-order, band-pass filter, as shown in Figure 3.

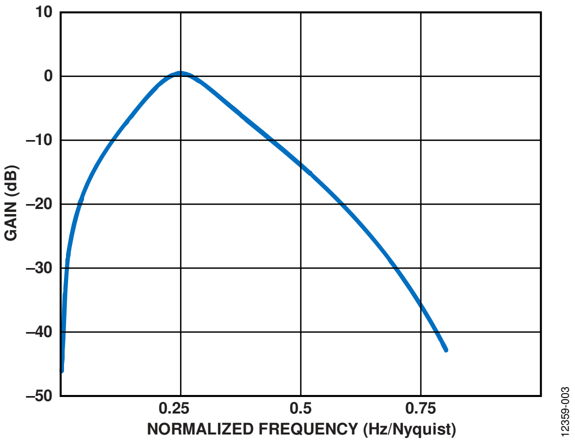

Figure 3. ADA2200 Filter Transfer Function, Normalized to Half the Output Sampling Rate

The center frequency of the filter is located at 1/64 of the clock frequency. As shown in Table 3, this is equivalent to 1/4 of the Nyquist frequency of the output rate. With the on-board 400 kHz oscillator, this center frequency is located at 6.25 kHz.

The filter transfer function scales with the input clock frequency. Valid input clock frequencies range from 10 kHz to 1 MHz. Sweeping the input clock frequency in this range sweeps the filter center frequency from 156.25 Hz to 15.625 kHz. The filter Q remains constant at 1.7 for any CLKIN frequency.

Connect Pin 1 and Pin 2 on P13 to use an external clock with the device.

Programming Different Filter Configurations

If the desired filter is different from the default definition, the ADA2200 must boot from an EEPROM previously programmed with valid contents for all the user registers. For additional details on how to boot from EEPROM, refer to the Programming the ADA2200 section.

For information on programming the EEPROM with a different filter function, contact technical support.

SIGNAL MEASUREMENTS

The signal present at the output of the ADA2200 depends on the amplitude and phase (relative to the reference clock) of the signal applied at its inputs. When either the amplitude or phase is known and constant, any output variations can be attributed to the modulated parameter.

This dependence is shown in Figure 4. In any of these cases, the ADA2200 is performing either amplitude or phase demodulation.

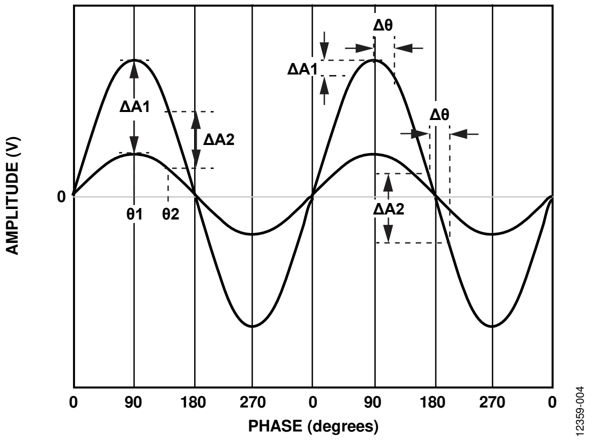

Figure 4. Measurement Dependence on Phase and Amplitude Variations

The ADA2200-EVALZ includes a 10 Hz low-pass filter, which converts the demodulated signal to a dc voltage level. This conversion makes it possible to use a simple voltmeter to perform amplitude and phase measurements.

Amplitude Measurements

If the phase of the signal present at the inputs of ADA2200 remains constant, the output behaves as a linear function of the signal amplitude. In other words, if the amplitude of the signal doubles, the output voltage also doubles.

The relationship between the signal amplitude and the output level depends on the relative phase between RCLK and the signal. This relationship is analogous to measuring the amplitude of a signal by looking at its crest (maximum amplitude point) or zero crossing. When the signal amplitude changes, the voltage at the crest sees the greatest change. In contrast, the zero crossing remains at zero. Because these two points are 90 degrees from each other, they are in quadrature.

If the relative phase of the signal makes the amplitude measurement too small to measure, toggle the switch labeled EEPROM_BOOT and press the **RESET** button. This action allows the ADA2200 to boot with the EEPROM contents, which are the same as the default configuration, except that the ADA2200 demodulates the quadrature component instead.

Phase Measurements

If the amplitude of the signal present at the inputs of ADA2200 remains constant, the output varies as a function of the relative phase between the signal and the reference clock (RCLK).

As long as the phase shifts are small, this relationship is approximately linear; however, the gain (slope) of this relationship depends on the relative phase shift between the signal and RCLK. For example, if the phase shift occurs around the crest of the signal, the change at the output is barely noticeable. In addition, the user is not able to distinguish between a positive and a negative shift. In contrast, the maximum phase sensitivity is achieved when the phase shift happens around the zero crossing. Because these two points are 90° from each other, they are in quadrature.

If the relative phase of the signal makes the phase measurement too small to measure, toggle the EEPROM_BOOT switch and press the **RESET** button. This combination allows the ADA2200 to boot with the EEPROM contents, which are the same as the default configuration, except that the ADA2200 demodulates the quadrature component instead.

Amplitude and Phase Measurements

When the amplitude and phase are unknown, it is necessary to obtain two orthogonal components of the signal to determine its amplitude, phase, or both. These two components are in phase and in quadrature relative to each other; the popular nomenclature used for these component is I and Q.

A signal with two known rectangular components can be represented as a phase vector or phasor with an associated amplitude and phase. This representation is show in Figure 5.

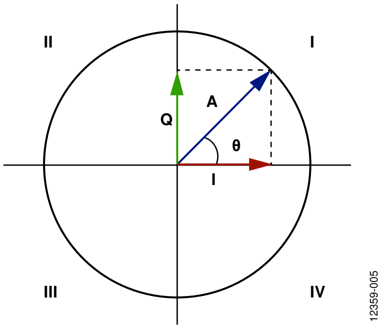

Figure 5. Signal Represented as Phasor

If the signal amplitude and phase are relatively constant for the duration of the measurement, it is possible to switch the ADA2200 to return the I and Q components. On the ADA2200-EVALZ, this switching is accomplished by toggling the EEPROM_BOOT switch and pressing the **RESET** button. The dc voltage at the output represents the I and Q components. Perform the following calculations to find the amplitude and phase:

$$A = \sqrt{I^2 + Q^2}$$

$$\theta = \sin^{-1}(Q/A)$$

Or, alternatively:

$$\theta = \cos^{-1}(I/A)$$

The inverse sine or inverse cosine functions involving the I and Q components linearize the relationship between the phase of the signal and the measured angle. This calculation also makes it possible to separate the effects of amplitude and phase variations.

Because the inverse sine and inverse cosine are only defined in two quadrants, the sign of the I and Q components must be taken into account to map the result to cover the entire 360°.

It is not recommended to use the inverse tangent function to extract the phase information, because the function is not defined at +90° and −90°. This function causes the phase measurement to become very sensitive to measurement errors and noise.

EVALUATION BOARD SCHEMATIC

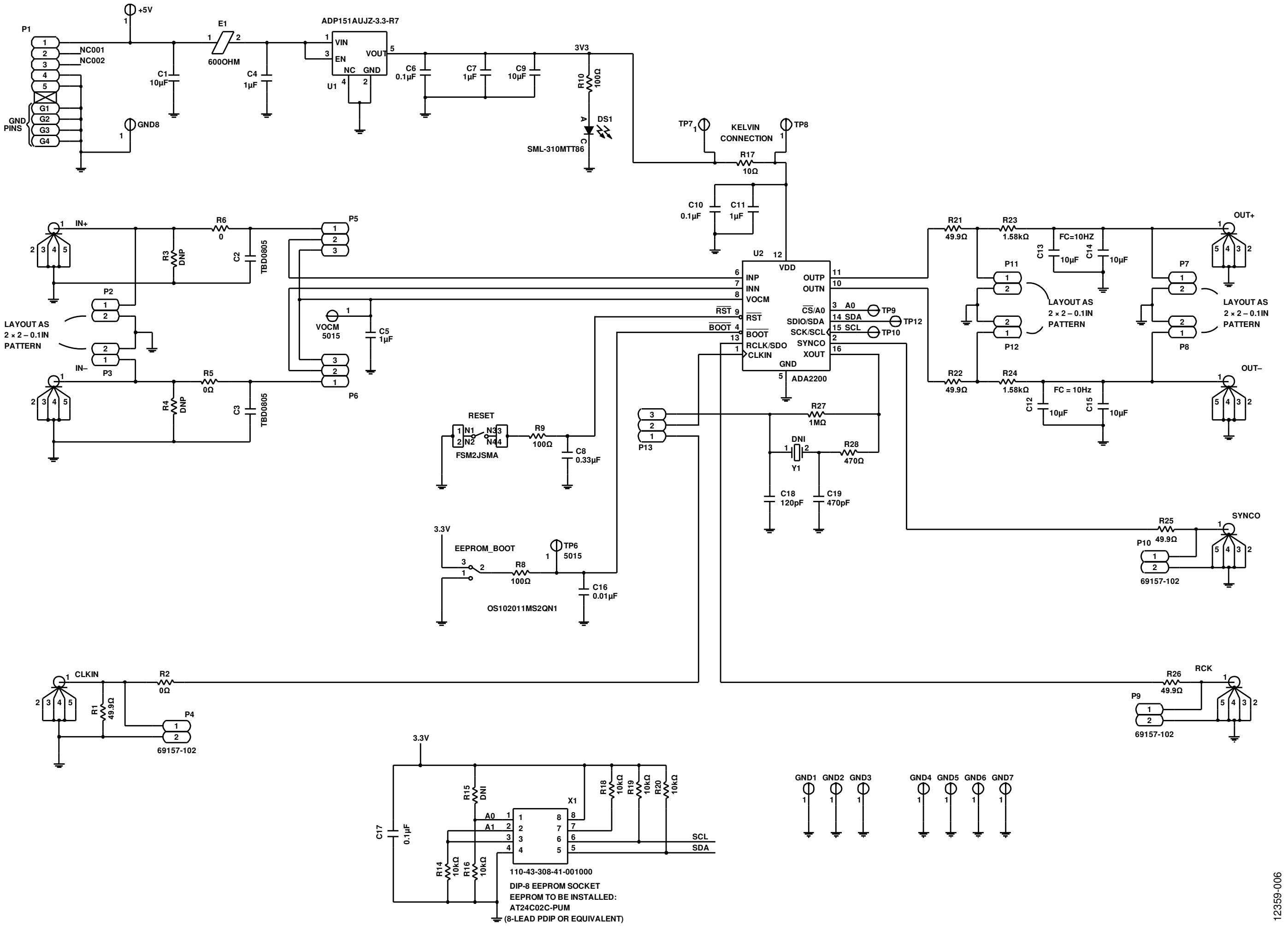

Figure 6. ADA2200-EVALZ Schematic

ORDERING INFORMATION

BILL OF MATERIALS

Table 4.

Qty.	Designator	Description	Manufacturer	Part No.
16	+5 V, TP6 to TP10, GND1 to GND8, TP12, VOCM	Conn, printed circuit board (PCB) SMT test points	Keystone Electronics Corp.	5015
6	C1, C9, C12 to C15	Capacitor, ceramic, monolithic, X5R, 25 V	Murata	GRM31CR61E106KA12L
4	C4, C5, C7, C11	Capacitor, ceramic, monolithic, X5R, 25 V	Murata	GRM188R61E105KA12D
3	C6, C10, C17	Capacitor, ceramic, X7R, 0603, 50 V	AVX	06035C104KAT2A
1	C16	Capacitor, ceramic, chip, C0G, 0603, 25 V	Kemet	C0603C103J3GACTU
1	C18	Capacitor, ceramic, NP0, 0805, 50 V	AVX	08055A121JAT2A
1	C19	Capacitor, ceramic, NP0, 50 V	Phycomp (Yageo)	2238 861 15471
1	C8	Capacitor, ceramic, X5R, 16 V	AVX	0603YD334KAT2A
1	DS1	LED, green, surface mount	ROHM	SML-310MTT86
1	E1	Inductor chip ferrite bead	Murata	BLM15AX601SN1D
1	EEPROM_BOOT	Switch, SPDT, PCB mounted slide	ITT	OS102011MS2QN1
1	P1	Conn, PCB USB mini-B, receptacle ASSY SMT	Molex	54819-0572
9	P2 to P4,P7 to P12	Conn, PCB Berg jumper, ST, male, 2-pin	Berg	69157-102
3	P5, P6, P13	Conn, PCB Berg header, ST, male, 3-pin	Samtec	TSW-103-08-G-S
5	R1, R21, R22, R25, R26	Resistor, precision thick film chip, R1206	Panasonic	ERJ-8ENF49R9V
3	R8 to R10	Resistor, precision thick film chip, R0603	Multicomp	MC 0.063 W, 0603, 1%, 100 Ω
5	R14, R16, R18 to R20	Resistor, precision thick film chip, R0603	Panasonic	ERJ-3EKF1002V
1	R17	Resistor, antisurge thick film chip	Panasonic	ERJP14F10R0U
3	R2, R5, R6	Resistor, thick film chip	Panasonic	ERJ-6GEY0R00V
1	R27	Resistor, precision thick film chip, R0805	Panasonic	ERJ-6ENF1004V
1	R28	Resistor, metal film chip, 0.1%	Panasonic	ERA-6AEB471V
1	RESET	Switch, tactile, SPST NO	TE Connectivity	FSM2JSMA
1	U1	IC, CMOS linear regulator, LDO, 3.3 V	Analog Devices	ADP151AUJZ-3.3-R7
1	U2	IC, sampled analog filter, synchronous demodulator	Analog Devices	ADA2200
1	X1	Socket, 8-pin, DIP	Mill-Max	110-43-308-41-001000
1	Y1	Ceramic resonator, 400 kHz	ECS	ZTB400P
4	Corners	Bump on, cylindrical, 0.312X.200, black	3M	SJ61A1
2	R23, R24	Resistor, precision thin film chip, R0603	Panasonic	ERA-3AEB1581V
1	Y1	IC, EEPROM, 2 kb, 1 MHz, 8-DIP	ATMEL	AT24C02C-PUM
7	IN+, IN−, RCK, OUT+, OUT−, CLKIN, SYNCO	Conn, PCB, coaxial, SMA end launch (not installed)	Johnson	142-0701-851
2	C2, C3	Not installed (TBD_C0805)	TBD0805	TBD0805
2	R3, R4	Not installed (TBD_R1206)	Panasonic	ERJ-8ENF49R9V
1	R15	Not installed (TBD_R0603)	Panasonic	ERJ-3EKF1002V

NOTES

I^{2}C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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