EVM User's Guide: PGA854EVM

PGA854 Evaluation Module

Description

The PGA854 evaluation module (PGA854EVM) is a development platform for evaluating the PGA854, a precision, low-noise, high-bandwidth programmable gain instrumentation amplifier (PGIA) with fully differential outputs. The PGA854 is equipped with eight decade (scope) gain settings, from an attenuating gain of 0.5V/V to a maximum of 100V/V, using three digital gain-selection pins.

Get Started

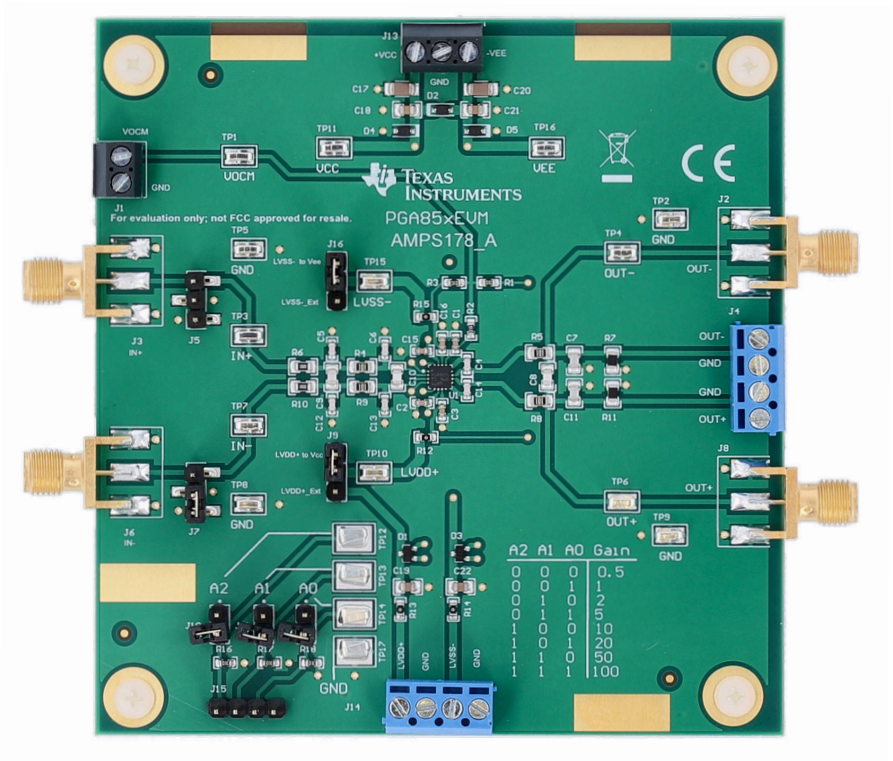
1. Order the PGA854EVM.
2. Review the PGA854 data sheet for product specifications.
3. Configure gain (V/V) between 8 options (0.5, 1, 2, 5, 10, 20, 50, 100).
4. Connect power supplies, input signals, and output equipment.

Features

- Differential or single-ended input instrumentation signal conditioning to differential output
- Option to have input and output stage power supplies together or separately
- Option to drive the VOCM pin externally, or to connect the VOCM pin to the midpoint of the output stage power supply by default
- Footprints to allow flexibility in implementing noise filtering on the input and output of the PGA854

Applications

- Industrial automation
- Analog input module
- Precision multifunction input and output (DAQ)
- Test and measurement
- Parametric measurement unit (PMU)



PGA854EVM

1 Evaluation Module Overview

1.1 Introduction

This user's guide contains information and support documentation for the PGA854EVM. Included are the circuit description, jumper settings, required connections, printed circuit board (PCB) layout, schematic, and bill of materials of the PGA854EVM. Throughout this document, the terms *evaluation board, evaluation module, and EVM* are synonymous with the PGA854EVM.

1.1.1 Electrostatic Discharge Caution

CAUTION

Many of the components on the PGA854EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

1.2 Kit Contents

The PGA854EVM comes populated with the PGA854 and connectors for power supplies, inputs, and outputs.

Table 1-1. PGA854EVM Kit Contents

Item	Description	Quantity
PGA854EVM	PCB	1

1.3 Specification

The PGA854EVM provides a mechanism for connecting signals in and out of the PGA854RGTR device. The printed circuit board (PCB) is 3.75in × 4.50in using FR4 material. The input and output stage power supplies, the outputs, and the VOCM pin are available through screw terminal connectors or test points. The input and output signals are available through SMA connectors or test points. The gain can be selected through jumper population or through J15 header pins (MCU GPIO).

1.4 Device Information

The PGA854 is a wide-bandwidth, high-voltage, low-noise, programmable gain instrumentation amplifier with differential output. The super-beta input transistors offer low input bias current, which in turn provides a low input current noise density of 0.3pA/$\sqrt{Hz}$, making the PGA854 a versatile choice for virtually any sensor type. The inputs include a built-in overvoltage protection of ±40V beyond the power supplies. The low-noise current-feedback front-end architecture offers gain flatness at high frequencies, making the PGA854 an excellent high-impedance sensor readout device.

The PGA855 is similar to the PGA854 but offers different gain options. The PGA854 and PGA855 are pin-to-pin compatible and this EVM can be used for both. Table 1-2 outlines jumper and gain configurations.

Table 1-2. Gain Options for PGA854 and PGA855 in V/V

A2 (J10)	A1 (J11)	A0 (J12)	PGA854	PGA855
0	0	0	0.5	0.125
0	0	1	1	0.25
0	1	0	2	0.5
0	1	1	5	1
1	0	0	10	2
1	0	1	20	4
1	1	0	50	8
1	1	1	100	16

1.4.1 Hot Surface Warning

WARNING

The device can become hot under high-current conditions. Take care when handling the EVM.

2 Hardware

This EVM provides access to the features and measures the performance of the PGA854 device. By default, the PGA854EVM programmable gain amplifier is configured to a gain of 0.5V/V. The evaluation board provides jumpers J10 (A2), J11 (A1), and J12 (A0) to set the PGA854 gain.

The device uses two sets of voltage supplies: input stage and output stage. The output-stage power supplies are decoupled from the input stage to limit the PGA854 output-swing voltage level protecting the ADC or downstream device against overdrive damage. The input-stage supplies, VS+ and VS–, are accessible using connector J13. The output-stage supplies, LVDD+ and LVSS–, are accessible using connector J14. Selectable jumpers J9 and J16 set the output-stage supply voltage level equal to the input-stage supplies (default), or to external voltages using connector J14.

The PGA854 incorporates features that simplify interfacing to a fully differential ADC. The output common-mode voltage can be independently set by using the VOCM pin. If the VOCM connector is not driven, the output common-mode voltage defaults to the PGA854 output stage mid-supply value. The PGA854EVM allows access to the FDA_IN– and FDA_IN+ pins with optional capacitors C4 and C14. These capacitors are in parallel with the PGA854 output-stage internal-feedback resistors to implement noise filtering. Figure 2-1 displays a simplified block diagram of the PGA854EVM. For a full schematic of the PGA854EVM, see Figure 3-6.

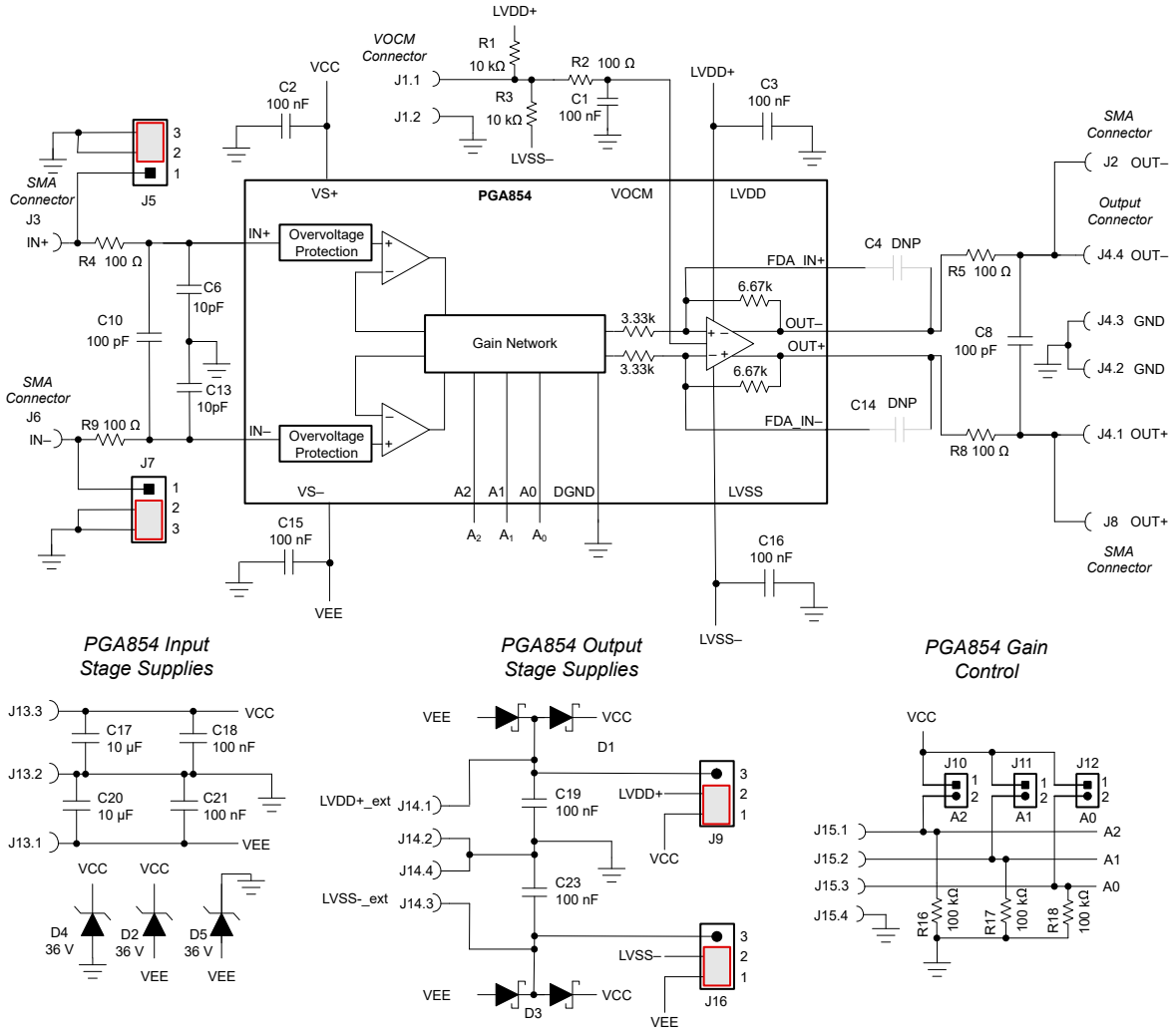


Figure 2-1. PGA854EVM Simplified Schematic

2.1 Setup and Connections

To set up the PGA854EVM:

1. Reference jumper configuration in Section 2.2.
2. Connect power supplies as described in Section 2.3.
3. Connect inputs and outputs as described in Section 2.4.
4. If desired, change the gain dynamically as described in Section 2.5.
5. Apply modifications to the board, as needed, referencing Section 2.6.

A basic functional test that can be done without modifications to the hardware is illustrated in Figure 2-2. All gain jumper must be populated (J10, J11, J12), resulting in a gain of 100 (A2:A0: 111). The ±18V supply (on the input and output stage) allows for a common-mode input range of ±15V and an output range of ±17.6V. The transfer function of the PGA854 is shown in the equations below Equation 1 through Equation 3.

$$\text{Output differential} = (\text{OUT+}) - (\text{OUT–}) = \text{G} \times [(\text{IN+}) - (\text{IN–})] \quad (1)$$

$$\text{OUT+} = {}^{\text{G}}/_{2} \times [(\text{IN+}) - (\text{IN–})] + \text{VOCM} \quad (2)$$

$$\text{OUT–} = -{}^{\text{G}}/_{2} \times [(\text{IN+}) - (\text{IN–})] + \text{VOCM} \quad (3)$$

The input in this example has a common-mode voltage of 0V, and a differential voltage of ±50mV. The VOCM is set to mid-supply of the output power supplies which is 0V. The input in a gain of 100 sets the output signal range to ±5V. To achieve good accuracy for this test, a low-noise precision input source needs to be used.

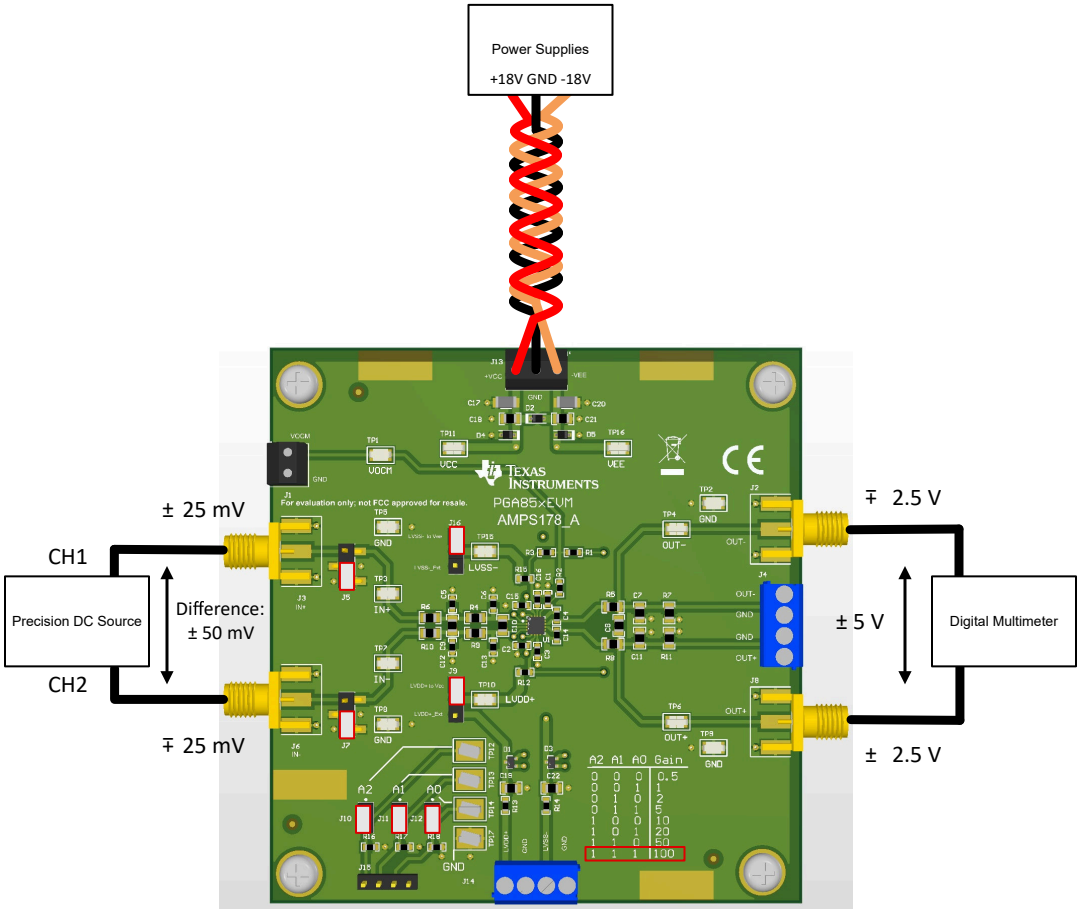


Figure 2-2. PGA854EVM Example

2.2 Jumper Settings

Figure 2-3 details the default jumper settings of the PGA854EVM. Table 2-1 explains the configuration for these jumpers.

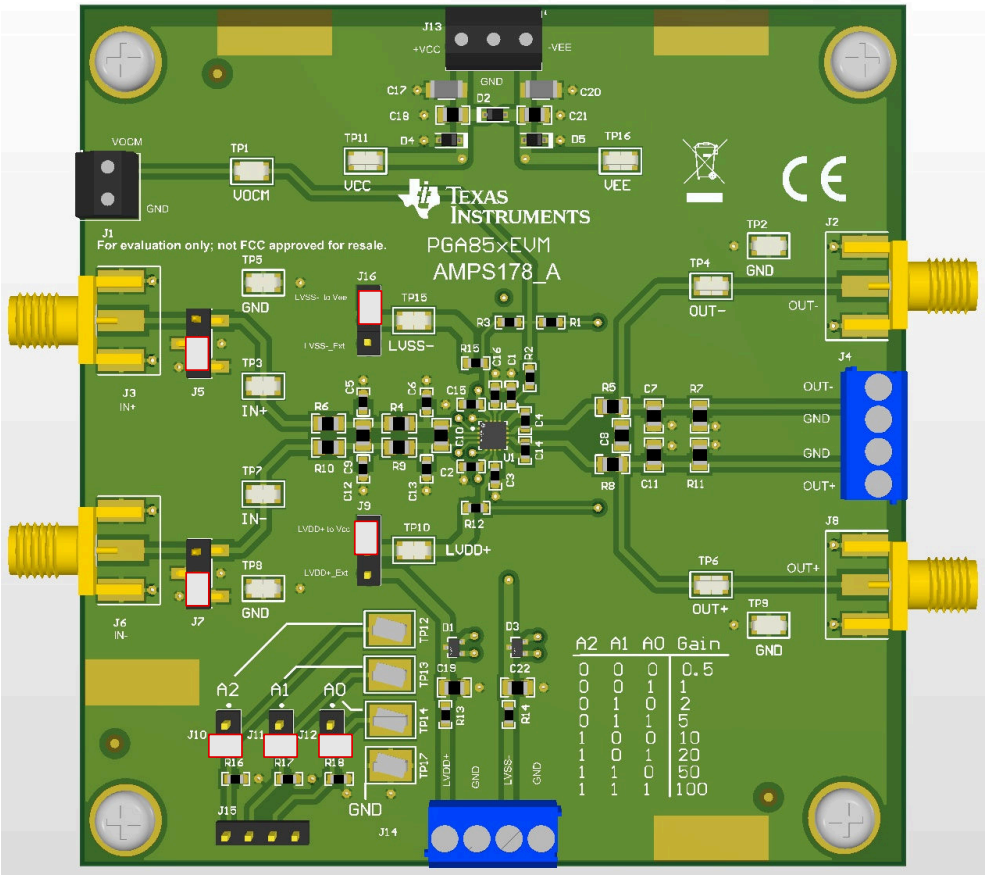


Figure 2-3. PGA854EVM Default Jumper Settings

Table 2-1. Jumper Configuration

Jumper	Function	Default Position	Description
J5	Select IN+	Shunt 2-3	Shunt 2-3: Routes IN+ to SMA connector J3 Shunt 1-2: Routes IN+ to GND
J7	Select IN–	Shunt 2-3	Shunt 2-3: Routes IN- to SMA connector J6 Shunt 1-2: Routes IN– to GND
J9	Select LVDD+	Shunt 1-2	Shunt 1-2: Sets output stage supply LVDD+ to +VCC supply (VS+) Shunt 2-3: Sets output stage supply LVDD+ to external connector J14 pin 1
J16	Select LVSS-	Shunt 1-2	Shunt 1-2: Sets output stage supply LVDD- to –VEE supply (VS-) Shunt 2-3: Sets output stage supply LVDD– to external connector J14 pin 3
J10	Gain Select A2	Open	Open: Sets A2 to GND or 0 (low) Shunt 1-2: Sets A2 to VCC or 1 (high)
J11	Gain Select A1	Open	Open: Sets A1 to GND or 0 (low) Shunt 1-2: Sets A1 to VCC or 1 (high)
J12	Gain Select A0	Open	Open: Sets A0 to GND or 0 (low) Shunt 1-2: Sets A0 to VCC or 1 (high)

2.3 Power-Supply Connections

The PGA854EVM uses two sets of voltage supplies: input stage and output stage. The device operates using input-stage power supplies from ±4V (8V) to ±18V (36V) and output-stage power supplies from ±2.25V (4.5V) to ±18V (36V). The output-stage supply voltage must not exceed the input-stage supply voltage.

The input-stage power-supply connections for the PGA854EVM are provided through connector J13 at the top of the EVM. The input-stage positive power-supply connection is labeled +VCC, the negative power-supply connection is labeled –VEE, and the ground connection is labeled GND. To connect power to the PGA854EVM, insert wires into each terminal of J13 and then tighten the screws to make the connection.

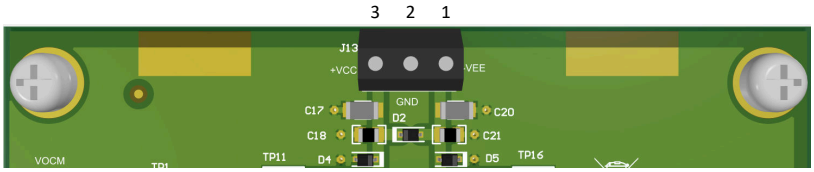


Figure 2-4. Input Stage Power Supply Connector (J13)

Table 2-2 summarizes the pin definition for supply connector J13 and the allowed voltage range for each supply connection.

Table 2-2. PGA854EVM Supply-Range Specifications

Connector Pin Number	Supply Connection	Voltage Range
J13.3	Input-stage positive supply (+VCC)	Single supply, V_S = +VCC: 8V to 36V Dual supply, V_S = (+VCC) – (–VEE): 4V to 18V
J13.2	Ground	0V
J13.1	Negative supply (–VEE)	Single supply, V_S = +VCC: 0V (GND) Dual supply, V_S = (+VCC) – (–VEE): –4V to –18V
J14.1	LVDD+_ext	Single supply, LVDD+_ext: 4.5V to 36V Dual supply, output stage supply (LVSS+) – (LVSS–): 2.25V to 18V
J14.2	Ground	0V
J14.3	LVSS–_ext	Single supply, LVSS–_ext: 0V (GND) Dual supply, output stage supply (LVSS+) – (LVSS–): –2.25V to –18V
J14.4	Ground	0V

By default, the output-stage supply-voltage levels (LVDD+ and LVSS-) are set to the PGA854 positive (+VCC) and negative (–VEE) supplies, respectively. The LVDD+ pin is connected to +VCC through jumper J9 1-2, and the –LVSS pin is connected to –VEE through J16 1-2. Screw terminal connector J14 provides access to the output-stage supply pins. To set the voltage level of LVDD and LVSS with an external supply, shunt jumper J9 2-3 to access the LVDD+ using connector J14.1. In a similar fashion, shunt jumper J16 2-3 to access the –LVSS pin using connector J14.3.

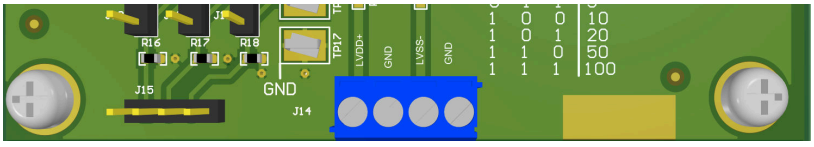


Figure 2-5. Output Stage Power Supply Connector (J14)

Figure 2-6 shows the PGA854EVM voltage supply connections.

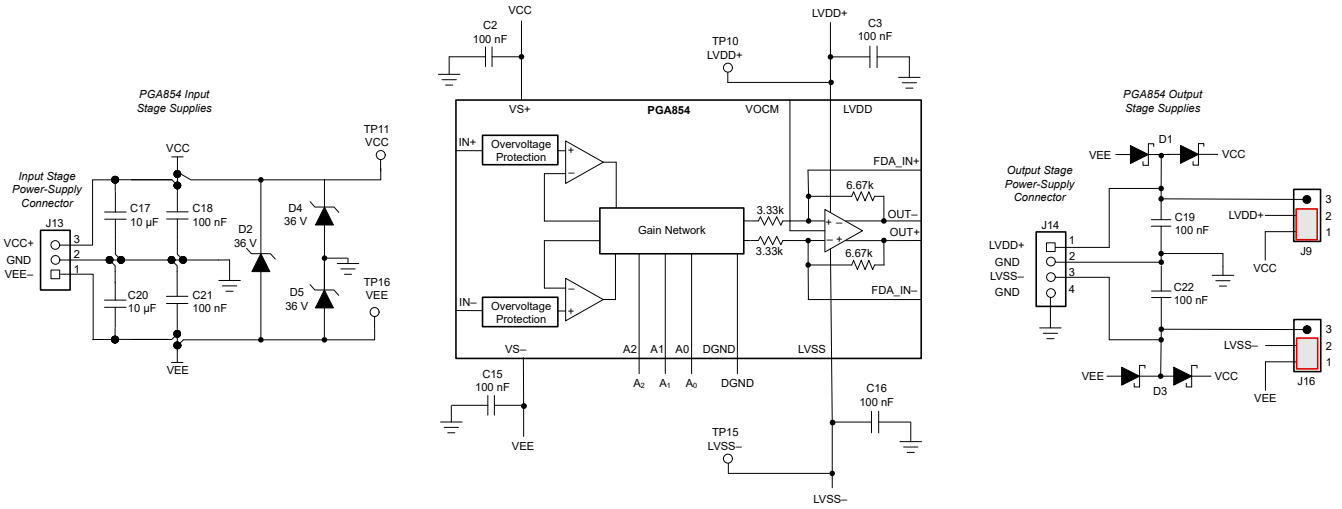


Figure 2-6. PGA854EVM Voltage Supply Connections

2.4 Analog Input and Output Connections

The input signal connections for the PGA854EVM are provided through the use of SMA connectors J3 (IN+), J6 (IN–), and test points TP3 (IN+), TP7 (IN–), located at the left of the EVM. The VOCM input can be provided through screw-terminal connector J1, located on the left of the board, and by default this pin does not need to be driven.

The differential output connections of PGA854 are available through screw-terminal connector J4.4 (OUT–) and J4.1 (OUT+), SMA connectors J2 (OUT–) and J8 (OUT+), and test points TP4 (OUT–) and TP6 (OUT+), located at the right side of the EVM. Figure 2-7 displays a simplified diagram of the PGA854EVM input and output connections.

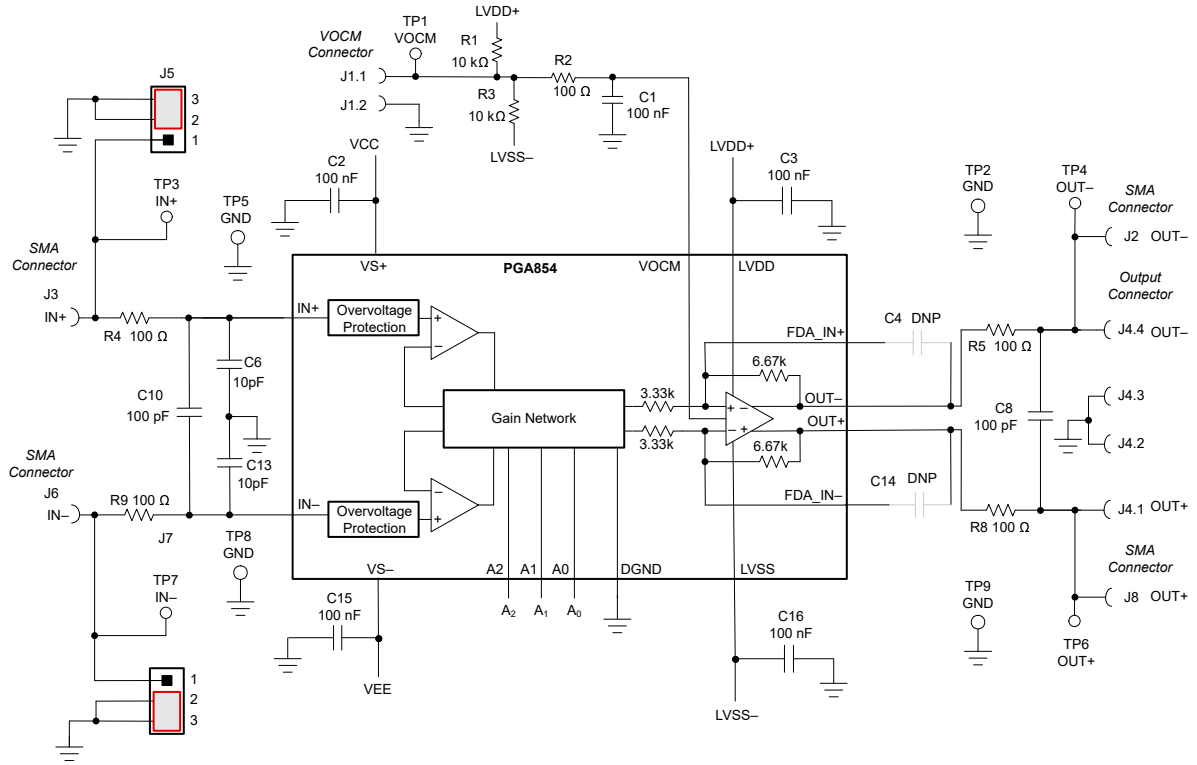


Figure 2-7. PGA854EVM Analog Input and Output Connections

Table 2-3 summarizes the input and output connectors and corresponding test points.

Table 2-3. PGA854EVM Analog Input and Output Connectors

Connector Designator	Signal	Type	Test Point
J3	IN+	SMA	TP3
J6	IN–	SMA	TP7
J2	OUT–	SMA	TP4
J8	OUT+	SMA	TP6
J4.4	OUT–	Screw terminal	TP4
J4.3	GND	Screw terminal	TP2
J4.2	GND	Screw terminal	TP9
J4.1	OUT+	Screw terminal	TP6
J1.1	VOCM	Screw terminal	TP1
J1.2	GND	Screw terminal	N/A

2.5 Digital Input Pins and Gain Control

The PGA854 provides eight decade (scope) gain settings, from an attenuating gain of 0.5V/V to a maximum of 100V/V. The gain is controlled by three digital selection pins: A2, A1, and A0. By default, the PGA854EVM is configured to a gain of 0.5V/V.

The evaluation board provides shunt jumpers J10, J11, and J12 to set the PGA854 gain-control selection pins. Table 2-4 lists the gain-control options. To set the gain-control pin high (1), install the shunt on the corresponding jumper. To set the gain-control pin low (0), remove the shunt jumper.

Table 2-4. PGA854EVM Gain Control

A2 Jumper J10 Connector J15.1	A1 Jumper J11 Connector J15.2	A0 Jumper J12 Connector J15.3	PGA854 Gain (V/V)
0 (Open)	0 (Open)	0 (Open)	0.5
0 (Open)	0 (Open)	1 (Shunt)	1
0 (Open)	1 (Shunt)	0 (Open)	2
0 (Open)	1 (Shunt)	1 (Shunt)	5
1 (Shunt)	0 (Open)	0 (Open)	10
1 (Shunt)	0 (Open)	1 (Shunt)	20
1 (Shunt)	1 (Shunt)	0 (Open)	50
1 (Shunt)	1 (Shunt)	1 (Shunt)	100

Alternatively, the A2, A1, and A0 digital pins can be driven externally through connector J15. Any pin that is not driven by an external source, or any shunt that is left open, is biased at DGND using pulldown resistors. Figure 2-8 shows the gain-setting block diagram. J10, J11, and J12 should be unpopulated if driving the gain externally through connector J15.

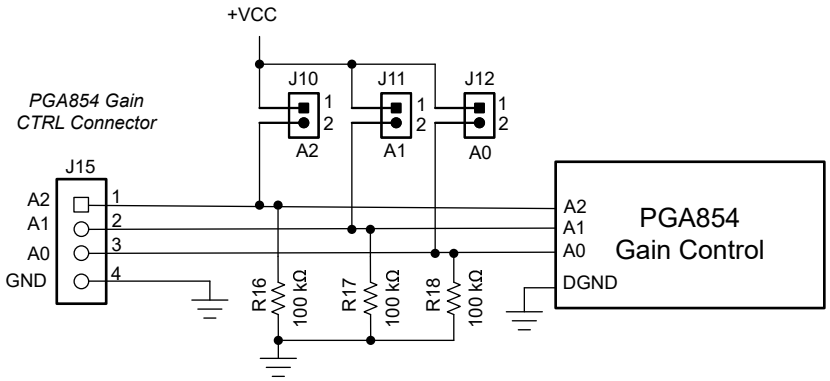


Figure 2-8. PGA854EVM Gain Control

2.6 Modifications

For flexibility, the EVM provides optional capacitors C4 and C14. These capacitors are in parallel with the PGA854 output-stage internal-feedback resistors (6.67kΩ) to implement noise filtering. To implement noise filtering, establish a frequency of interest (f_{oi}) in the application and calculate the feedback capacitor. In an example where the f_{oi} is 1kHz, the capacitor populated on C4 and C14 is 2.2nF (C0G/NP0) capacitor.

$$C_4 \text{ and } C_{14} = \frac{1}{2\pi \times 6.67\text{k}\Omega \times 10 \times f_{oi}} = \frac{1}{2\pi \times 6.67\ \text{k}\Omega \times 10 \times 1\ \text{kHz}} = 2.39\text{nF} \cong 2.2\text{nF} \quad (4)$$

In addition, the evaluation board provides footprints R6, R10, C9, C5, and C12 for optional input low-pass filters, and footprints for load resistors R7 and R11.

The common-mode capacitors (C5 and C12) need to be equal to one another, and the input series resistors (R6 and R10) need to be equal to one another. The differential capacitor (C9) needs to be ten times larger than the common-mode capacitors.

$$f_{CM} = \frac{1}{2\pi \times R_{IN} \times C_{CM}} = \frac{1}{2\pi \times R6 \times C5} \quad (5)$$

$$f_{Diff} = \frac{1}{2\pi \times 2R_{IN} \times \left(C_{DIFF} + {C_{CM}}/{2}\right)} = \frac{1}{4\pi \times R6 \times \left(C9 + {C5}/{2}\right)} \quad (6)$$

These additional component footprints in the layout allow the user to customize the evaluation circuit. For a full schematic of the PGA854EVM, see Figure 3-6.

3 Hardware Design Files

3.1 PCB Layout

The PGA854EVM is a four-layer PCB design. Figure 3-1 to Figure 3-5 show the PCB layer illustrations. The top layer consists of all signal path traces, and is poured with a solid ground plane. A symmetrical board layout is used at the differential inputs and outputs to keep good performance matching and improve common-mode noise rejection. Route traces as symmetrically as possible for both positive and negative pathways. The optional differential input low-pass filter capacitor is placed in very close proximity to the PGIA inputs to reduce extrinsic noise. Capacitor C1 is placed in close proximity to VOCM to avoid injecting common-mode noise. Decoupling capacitors C2, C15, C3, and C16 are positioned on the top layer as close as possible to the power-supply pins of the device. The second internal layer is a dedicated solid GND plane. Independent vias are placed at the ground connection of every component to provide a low-impedance path to ground. The third internal layer and bottom layer route the input stage power supplies and the output-stage supply connections.

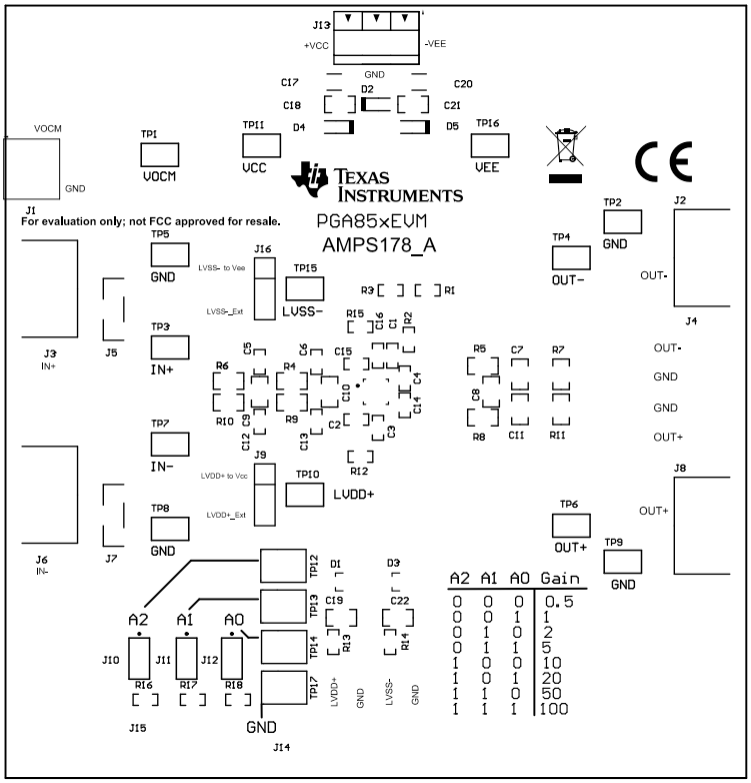


Figure 3-1. Top Overlay PCB Layout

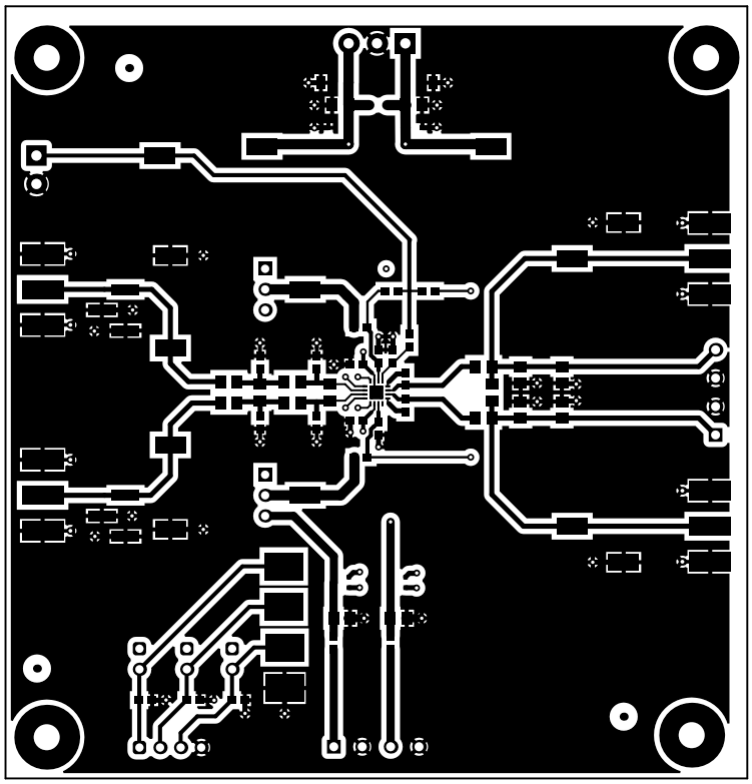


Figure 3-2. Top Layer PCB Layout

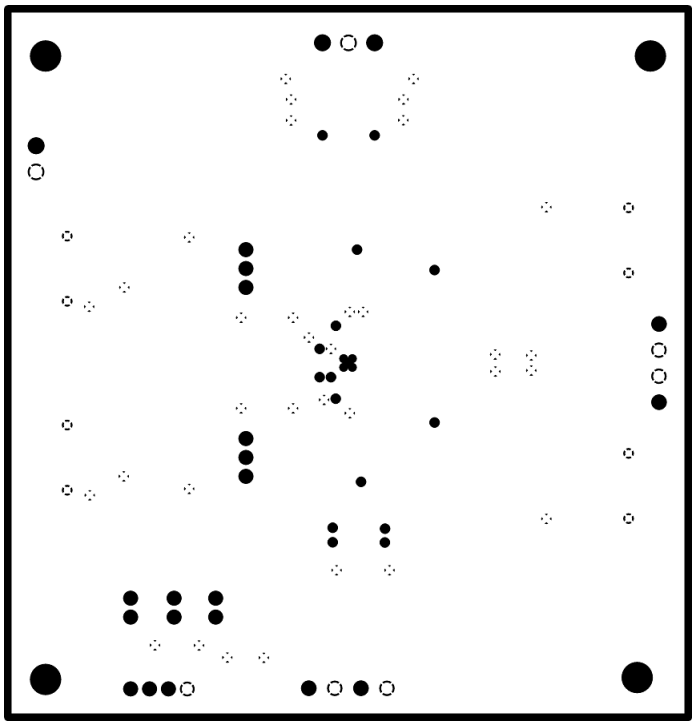


Figure 3-3. Ground Layer PCB Layout

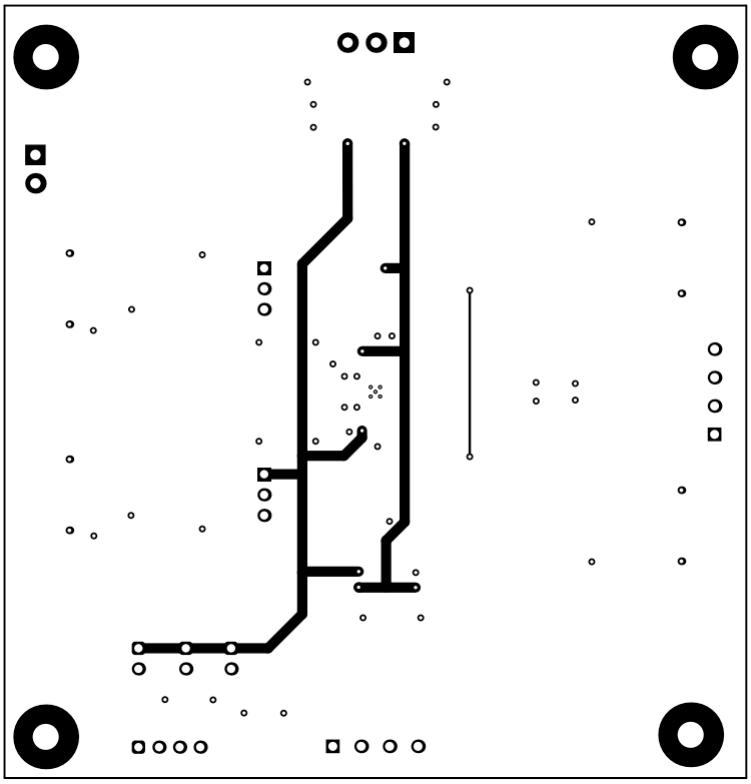


Figure 3-4. Power Layer PCB Layout

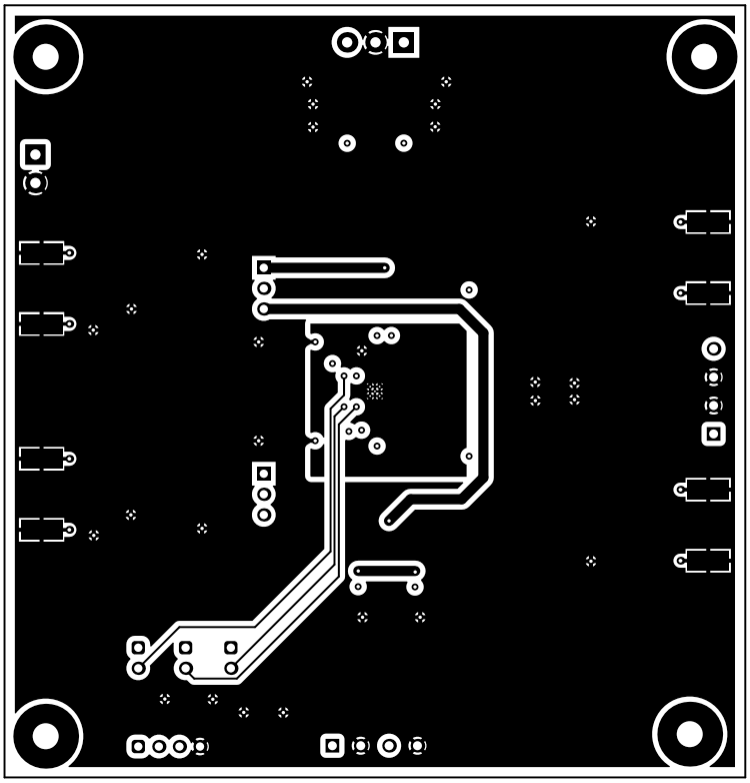
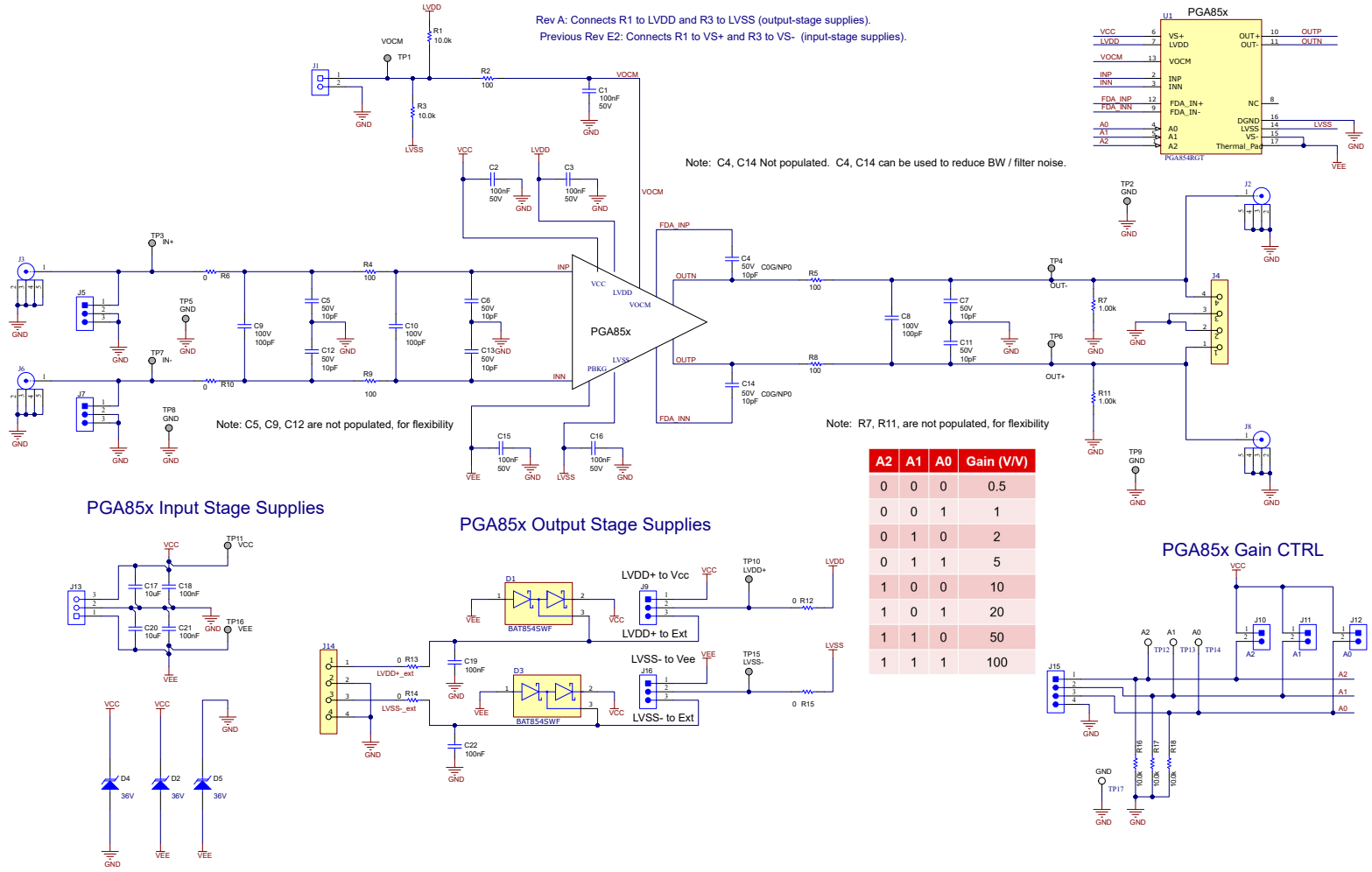


Figure 3-5. Bottom Layer PCB Layout

3.2 Schematic

Figure 3-6 illustrates the EVM schematic.



A2	A1	A0	Gain (V/V)
0	0	0	0.5
0	0	1	1
0	1	0	2
0	1	1	5
1	0	0	10
1	0	1	20
1	1	0	50
1	1	1	100

Note: DNP components are not populated.

Figure 3-6. PGA854EVM Schematic

3.3 Bill of Materials

Table 3-1 lists the PGA854EVM bill of materials (BOM).

Table 3-1. PGA854EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		AMPS178	Any
C1, C2, C3, C15, C16	5	0.1 µF	CAP, CERM, 0.1 uF, 50 V, +/- 5%, X7R, 0603	603	C0603C104J5RACTU	Kemet
C4, C5, C6, C13, C14	2	10 pF	CAP, CERM, 10 pF, 50 V, +/- 1%, C0G/NP0, 0603	603	C0603C100F5GAC7867	Kemet
C7, C11	2	10 pF	CAP, CERM, 10 pF, 50 V, +/- 5%, C0G/NP0, 0805	805	08055A100JAT2A	AVX
C8, C9, C10	2	100 pF	CAP, CERM, 100 pF, 100 V, +/- 5%, C0G/NP0, 0805	805	C0805C101J1GACTU	Kemet
C17, C20	2	10 µF	CAP, CERM, 10 uF, 35 V, +/- 10%, X7R, 1206	1206	C3216X7R1V106K160AC	TDK
C18, C19, C21, C22	4	0.1 µF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0805	805	08055C104KAT2A	AVX
D1, D3	2		Diode Array 1 Pair Series Connection Schottky 40 V 200 mA (DC) Surface Mount SC-70, SOT-323	SOT-323	BAT854SWF	Nexperia
D2, D4, D5	3	36 V	Diode, TVS, Uni, 36 V, 75 Vc, SOD-323	SOD-323	CDSOD323-T36S	Bourns
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1	1		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
J2, J3, J6, J8	4		Connector, End launch SMA, 50 ohm, SMT	End Launch SMA	142-0701-801	Cinch Connectivity
J4, J14	2		TERM BLOCK 3.5MM VERT 4POS PCB	HDR4	OSTTE040104	On Shore Technology
J5, J7	2		Header, 100mil, 3x1, Gold, SMT	Samtec_TSM-103-01-X-SV	TSM-103-01-L-SV	Samtec
J9, J16	2		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J10, J11, J12	3		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
J13	1		Terminal Block, 3.5mm Pitch, 3x1, TH	10.5x8.2x6.5mm	ED555/3DS	On-Shore Technology
J15	1		Header, 100mil, 4x1, Gold, TH	4x1 Header	TSW-104-07-G-S	Samtec
R1, R3	2	10 kΩ	RES, 10.0 k, 1%, 0.1 W, 0603	603	ERJ-3EKF1002V	Panasonic
R2	1	100 Ω	RES, 100, 1%, 0.1 W, 0603	603	RC0603FR-07100RL	Yageo
R4, R5, R8, R9	4	100 Ω	RES, 0, 0.1%, 0.125 W, 0805	805	RT0805BRD07100RL	Yageo America
R6, R10	2	0 Ω	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	805	ERJ-6GEY0R00V	Panasonic
R12, R13, R14, R15	4	0 Ω	RES, 0, 5%, 0.1 W, 0603	603	RC0603JR-070RL	Yageo
R16, R17, R18	3	10.0 kΩ	RES, 10.0 k, 1%, 0.1 W, 0603	603	RCG060310K0FKEA	Vishay Draloric

Table 3-1. PGA854EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
SH-J1, SH-J2, SH-J3,SH-J4 ,SH-J5,SH-J6	6	1 × 2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP15, TP16	13		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone
TP12, TP13, TP14, TP17	4		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone
U1	1		Low-Noise, Wide-Bandwidth, Fully Differential Output, Programmable Gain Amplifier	VQFN17	PGA854RGT	Texas Instruments

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

5 Related Documentation

This document provides information regarding Texas Instruments integrated circuits used in the assembly of the PGA854EVM. This user's guide is available from the TI website under literature number SLVUDF8. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document.

Table 5-1. Related Documentation

Device	Literature Number
PGA854	SBOSAN2
PGA855	SBOSAE0
PGA855EVM	SBOU296

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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