

EVM User's Guide: PGA854EVM

PGA854 评估模块



说明

PGA854 评估模块 (PGA854EVM) 是用于评估 [PGA854](#) 的开发平台，后者是一款具有全差分输出的精密、低噪声、高带宽、可编程增益仪表放大器 (PGIA)。[PGA854](#) 具有八种十进制 (范围) 增益设置 (从 0.5V/V 的衰减增益到最大 100V/V)，可以通过三个数字增益选择引脚进行选择。

开始使用

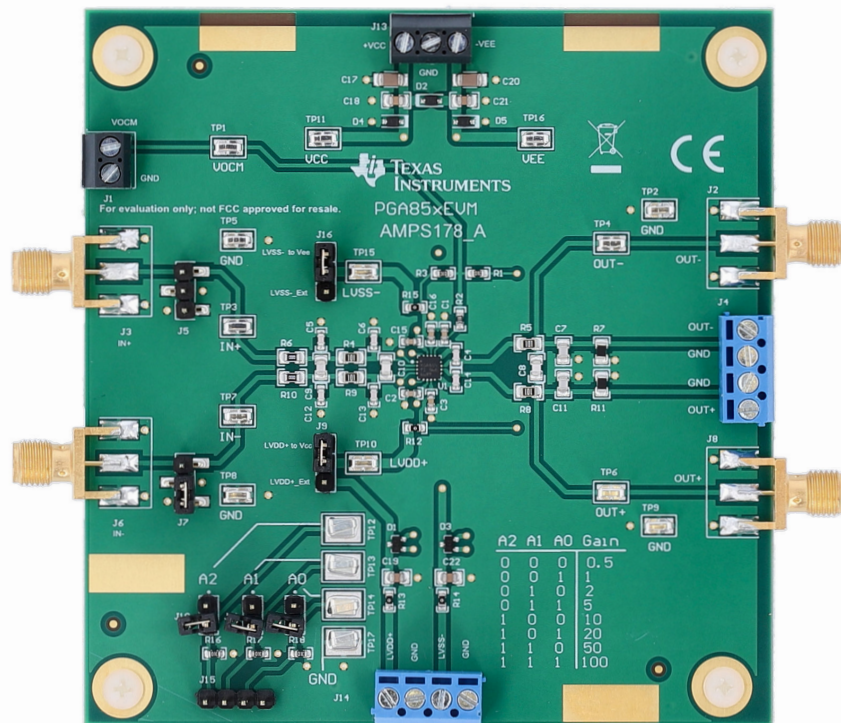
1. 订购 PGA854EVM。
2. 有关产品规格，请查阅 [PGA854 数据表](#)。
3. 有 8 个选项 (0.5、1、2、5、10、20、50、100) 可供选择来配置增益 (V/V)。
4. 连接电源、输入信号和输出设备。

特性

- 差分或单端输入仪表信号调节至差分输出
- 可选择为输入级和输出级一起或分开供电
- 可选择从外部驱动 **VOCM** 引脚，或者默认将 **VOCM** 引脚连接到输出级电源的中点
- 预留焊盘，以便灵活地在 [PGA854](#) 的输入和输出端实现噪声滤波

应用

- [工业自动化](#)
- [模拟输入模块](#)
- [精密多功能输入和输出 \(DAQ\)](#)
- [测试和测量](#)
- [参数测量单元 \(PMU\)](#)



PGA854EVM

1 评估模块概述

1.1 简介

本用户指南包含 PGA854EVM 的信息和支持文档。具体包含 PGA854EVM 的电路说明、跳线设置、所需连接、印刷电路板 (PCB) 布局、原理图和物料清单。本文档中的 *评估板*、*评估模块* 和 *EVM* 等术语均指 PGA854EVM。

1.1.1 静电放电警告

小心

PGA854EVM 上的许多元件都容易受到静电放电 (ESD) 的损坏。建议客户在开箱和搬运 EVM 时遵守适当的 ESD 处理预防措施，包括在经批准的 ESD 工作站上使用接地腕带。

1.2 套件内容

PGA854EVM 装有 PGA854 以及电源、输入端和输出端的连接器。

表 1-1. PGA854EVM 套件内容

条目	说明	数量
PGA854EVM	PCB	1

1.3 规格

PGA854EVM 提供了一种将信号连接到 [PGA854RGTR](#) 器件和从该器件输出信号的机制。印刷电路板 (PCB) 的尺寸为 3.75in × 4.50in，使用 FR4 材料。输入和输出级电源、输出端和 VOCM 引脚可通过螺纹接线端子连接器或测试点进行连接。输入和输出信号可通过 SMA 连接器或测试点接入。增益选择既可通过跳线组装实现，也可通过 J15 接口引脚 (MCU GPIO) 进行配置。

1.4 器件信息

PGA854 是一款具有差分输出的宽带宽、高电压、低噪声、可编程增益仪表放大器。超 β 输入晶体管提供低输入偏置电流，进而提供 $0.3\text{pA}/\sqrt{\text{Hz}}$ 的低输入电流噪声密度，因而 PGA854 成为几乎任何传感器类型的通用选择。输入端内置过压保护，可承受超出电源 $\pm 40\text{V}$ 的电压。低噪声电流反馈前端架构可在高频下提供增益平坦度，得益于此，PGA854 是一款出色的高阻抗传感器读出器件。

PGA855 与 PGA854 类似，但提供不同的增益选项。PGA854 和 PGA855 引脚对引脚兼容，此 EVM 可同时用于两者。表 1-2 概述了跳线和增益配置。

表 1-2. PGA854 和 PGA855 的增益选项，单位为 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 表面高温警告

警告

在大电流条件下，器件会变得很烫。操作 EVM 时要小心。

2 硬件

此 EVM 提供访问 PGA854 器件功能的方法并测量其性能。默认情况下，PGA854EVM 可编程增益放大器的增益配置为 0.5V/V。该评估板提供跳线 J10 (A2)、J11 (A1) 和 J12 (A0) 来设置 PGA854 增益。

该器件使用两组电压电源：输入级和输出级。输出级电源与输入级解耦，从而限制 PGA854 输出摆幅电压电平，保护 ADC 或下游器件免遭过驱损坏。可使用连接器 J13 访问输入级电源 VS+ 和 VS-。可使用连接器 J14 访问输出级电源 LVDD+ 和 LVSS-。可选跳线 J9 和 J16 将输出级电源电压电平设置为等于输入级电源（默认），或使用连接器 J14 将其设置为等于外部电压。

PGA854 包含用于简化与全差分 ADC 之间连接的功能。可使用 VOCM 引脚单独设置输出共模电压。如果未驱动 VOCM 连接器，则输出共模电压默认为 PGA854 输出级 1/2 Vs 值。PGA854EVM 支持通过可选电容器 C4 和 C14 来访问 FDA_IN- 和 FDA_IN+ 引脚。这些电容器与 PGA854 输出级内部反馈电阻器并联，用于实现噪声滤除。图 2-1 展示了 PGA854EVM 的简化方框图。有关 PGA854EVM 的完整原理图，请参阅图 3-6。

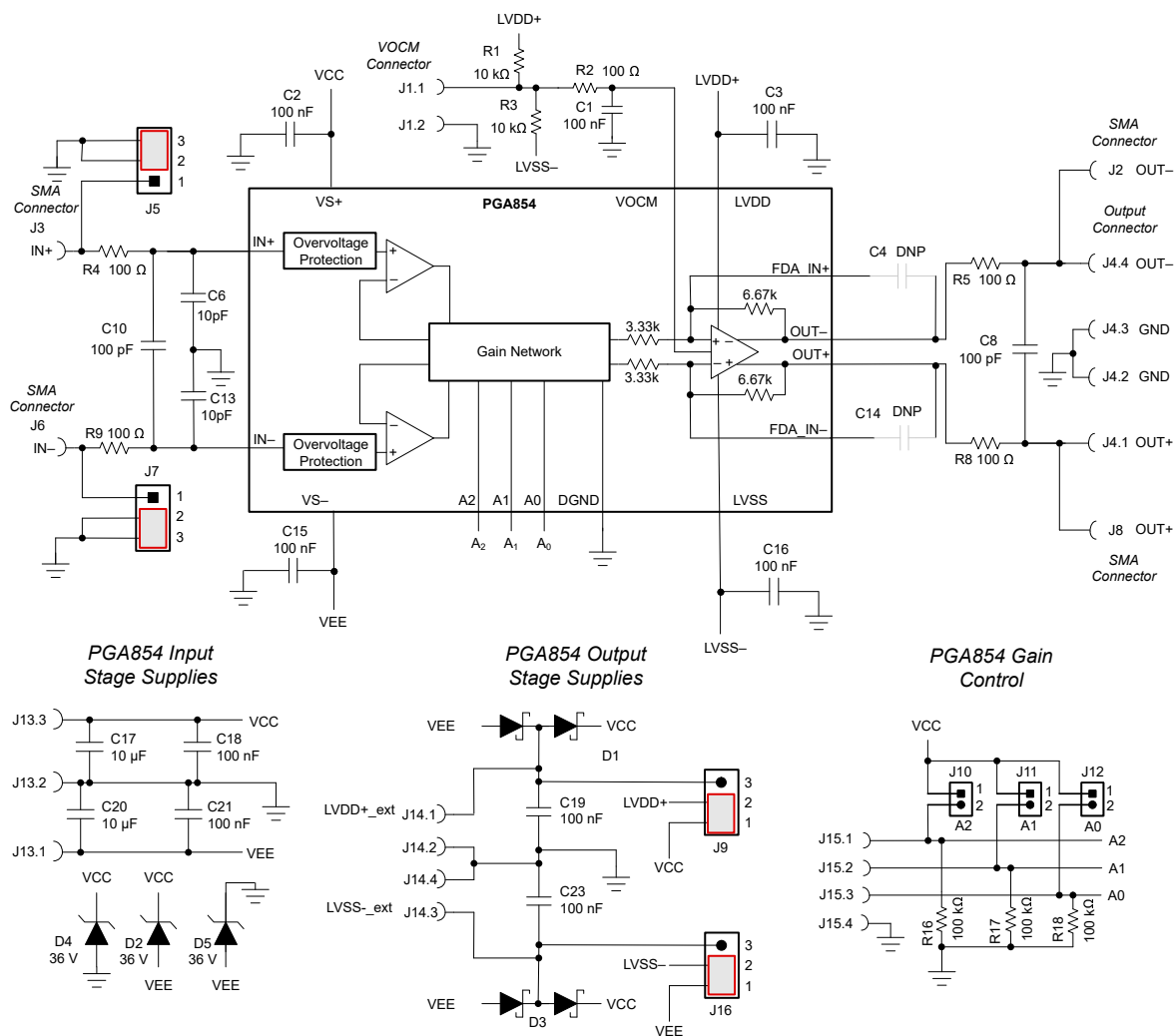


图 2-1. PGA854EVM 简化原理图

2.1 设置和连接

要设置 PGA854EVM：

1. 参考节 2.2 中的跳线配置。
2. 按节 2.3 中所述连接电源。
3. 按节 2.4 中所述连接输入和输出。
4. 如果需要，按节 2.5 中所述动态更改增益。
5. 参考节 2.6，根据需要对电路板进行修改。

在不对硬件进行修改的情况下，可以进行基本功能测试，如图 2-2 中所示。必须组装所有增益跳线 (J10、J11、J12)，产生 100 的增益 (A2:A0: 111)。±18V 电源 (在输入和输出级上) 支持 ±15V 的共模输入范围和 ±17.6V 的输出范围。PGA854 的传递函数如下面的 方程式 3 至 方程式 1 中的公式所示。

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

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

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

此示例中的输入的共模电压为 0V，差分电压为 ±50mV。VOCM 设置为输出电源的 1/2 Vs，即 0V。100 增益下的输入将输出信号范围设置为 ±5V。为了让此测试达到良好的精度，需要使用一个低噪声精密输入源。

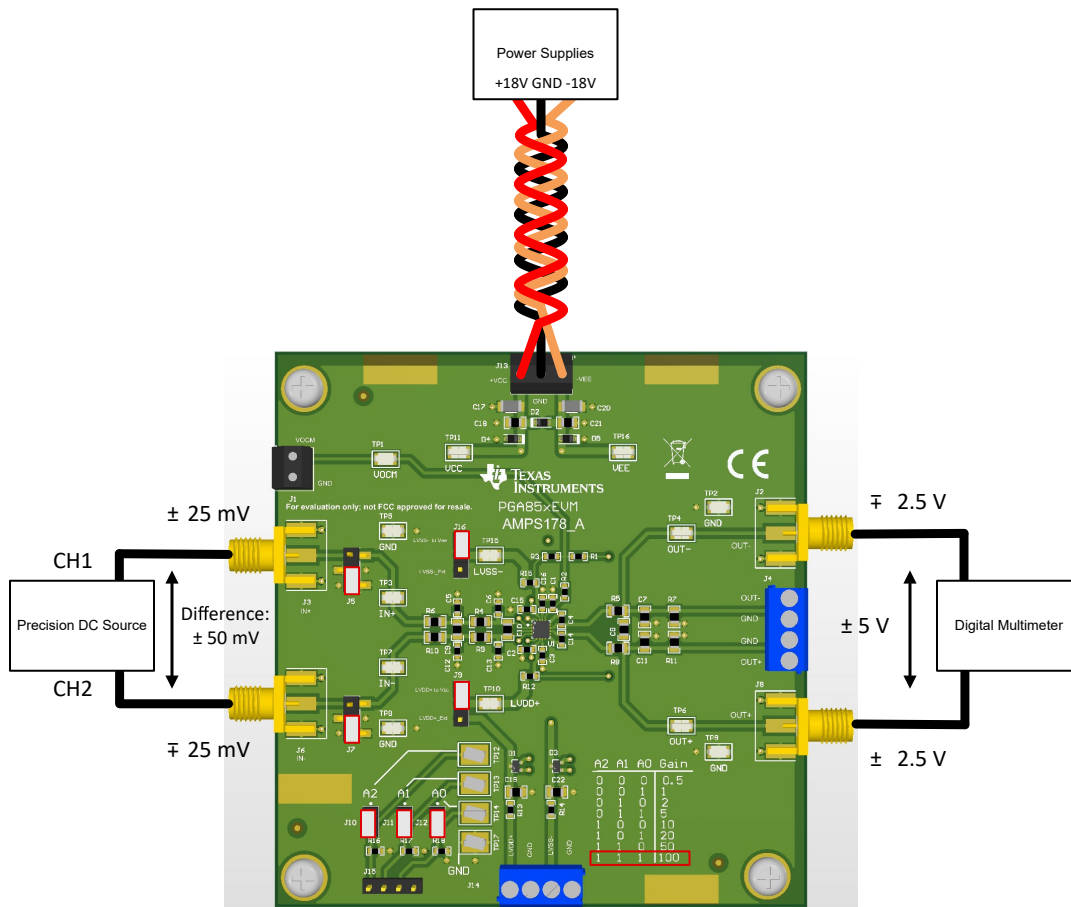


图 2-2. PGA854EVM 示例

2.2 跳线设置

图 2-3 详细展示了 PGA854EVM 的默认跳线设置。表 2-1 说明了这些跳线的配置。

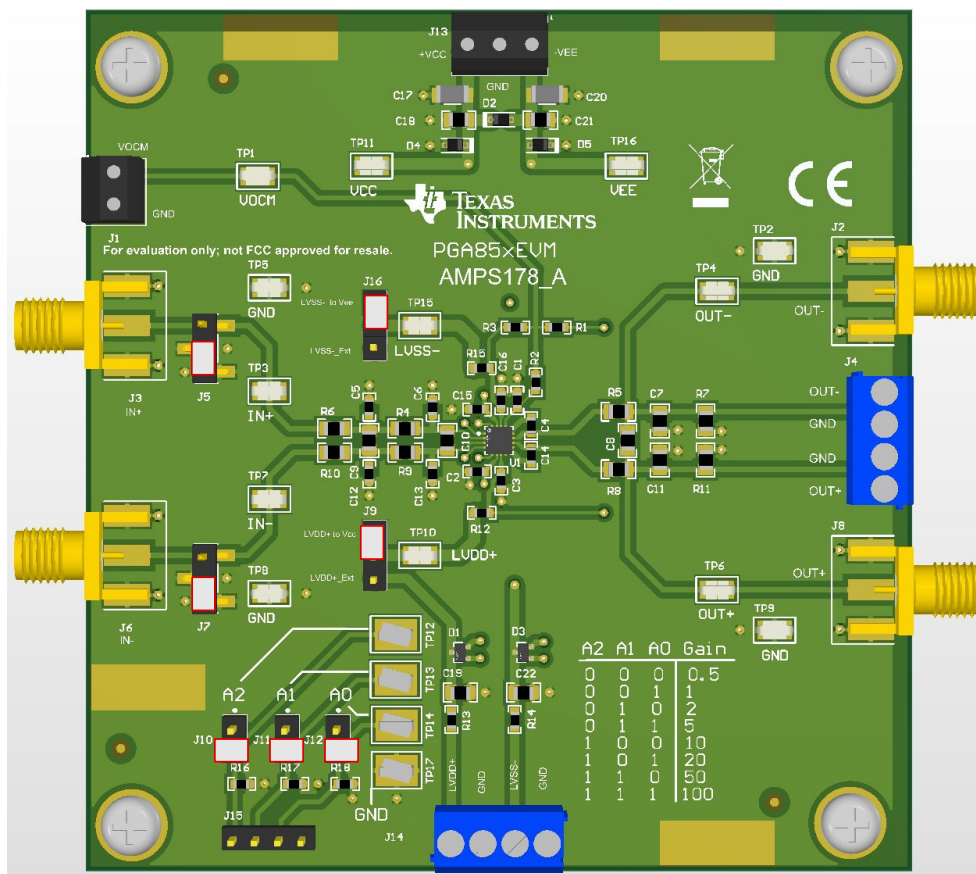


图 2-3. PGA854EVM 默认跳线设置

表 2-1. 跳线配置

跳线	功能	默认位置	说明
J5	选择 IN+	分流器 2-3	分流器 2-3：将 IN+ 连接到 SMA 连接器 J3 分流器 1-2：将 IN+ 连接到 GND
J7	选择 IN -	分流器 2-3	分流器 2-3：将 IN - 连接到 SMA 连接器 J6 分流器 1-2：将 IN - 连接到 GND
J9	选择 LVDD+	分流器 1-2	分流器 1-2：将输出级电源 LVDD+ 设置为 +VCC 电源 (VS+) 分流器 2-3：将输出级电源 LVDD+ 设置为外部连接器 J14 引脚 1
J16	选择 LVSS -	分流器 1-2	分流器 1-2：将输出级电源 LVDD - 设置为 - VEE 电源 (VS-) 分流器 2-3：将输出级电源 LVDD - 设置为外部连接器 J14 引脚 3
J10	增益选择 A2	开路	开路：将 A2 设置为 GND 或 0 (低) 分流器 1-2：将 A2 设置为 VCC 或 1 (高)
J11	增益选择 A1	开路	开路：将 A1 设置为 GND 或 0 (低) 分流器 1-2：将 A1 设置为 VCC 或 1 (高)
J12	增益选择 A0	开路	开路：将 A0 设置为 GND 或 0 (低) 分流器 1-2：将 A0 设置为 VCC 或 1 (高)

2.3 电源连接

PGA854EVM 使用两组电压电源：输入级和输出级。该器件运行时使用 $\pm 4\text{V}$ (8V) 至 $\pm 18\text{V}$ (36V) 的输入级电源和 $\pm 2.25\text{V}$ (4.5V) 至 $\pm 18\text{V}$ (36V) 的输出级电源。输出级电源电压不得超过输入级电源电压。

PGA854EVM 的输入级电源连接通过 EVM 顶部的连接器 J13 来提供。输入级正电源连接标记为 +VCC，负电源连接标记为 -VEE，接地连接标记为 GND。若要将电源连接到 PGA854EVM，请将电线插入 J13 的每个端子，然后拧紧螺钉以进行连接。

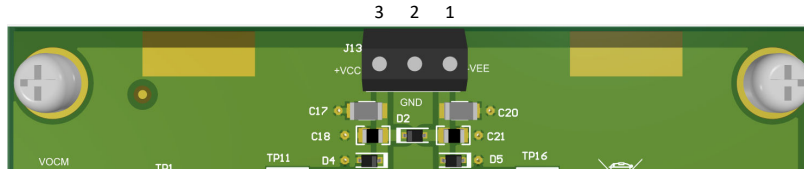


图 2-4. 输入级电源连接器 (J13)

表 2-2 总结了电源连接器 J13 的引脚定义以及每个电源连接的允许电压范围。

表 2-2. PGA854EVM 电源电压范围规格

连接器引脚编号	电源连接	电压范围
J13.3	输入级正电源 (+VCC)	单电源, $V_S = +VCC$: 8V 至 36V 双电源, $V_S = (+VCC) - (-VEE)$: 4V 至 18V
J13.2	接地	0V
J13.1	负电源 (-VEE)	单电源, $V_S = +VCC$: 0V (GND) 双电源, $V_S = (+VCC) - (-VEE)$: -4V 至 -18V
J14.1	LVDD+_ext	单电源, LVDD+_ext : 4.5V 至 36V 双电源, 输出级电源 (LVSS+) - (LVSS-) : 2.25V 至 18V
J14.2	接地	0V
J14.3	LVSS-_ext	单电源, LVSS-_ext : 0V (GND) 双电源, 输出级电源 (LVSS+) - (LVSS-) : -2.25V 至 -18V
J14.4	接地	0V

默认情况下，输出级电源电压电平 (LVDD+ 和 LVSS-) 分别设置为 PGA854 正 (+VCC) 和负 (-VEE) 电源电压。LVDD+ 引脚通过跳线 J9 1-2 连接到 +VCC，-LVSS 引脚通过 J16 1-2 连接到 -VEE。螺纹接线端子连接器 J14 提供对输出级电源引脚的访问。要使用外部电源设置 LVDD 和 LVSS 的电压电平，请使用连接器 J14.1 将分流跳线 J9 2-3 连接到 LVDD+。以类似的方式，使用连接器 J14.3 将分流跳线 J16 2-3 连接到 -LVSS 引脚。

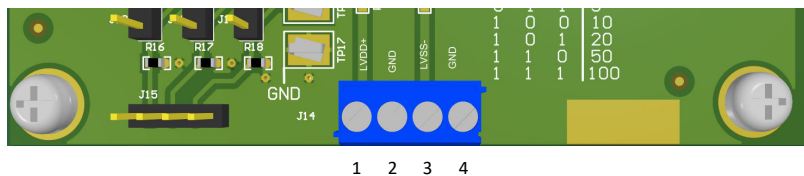


图 2-5. 输出级电源连接器 (J14)

图 2-6 展示了 PGA854EVM 电压电源连接。

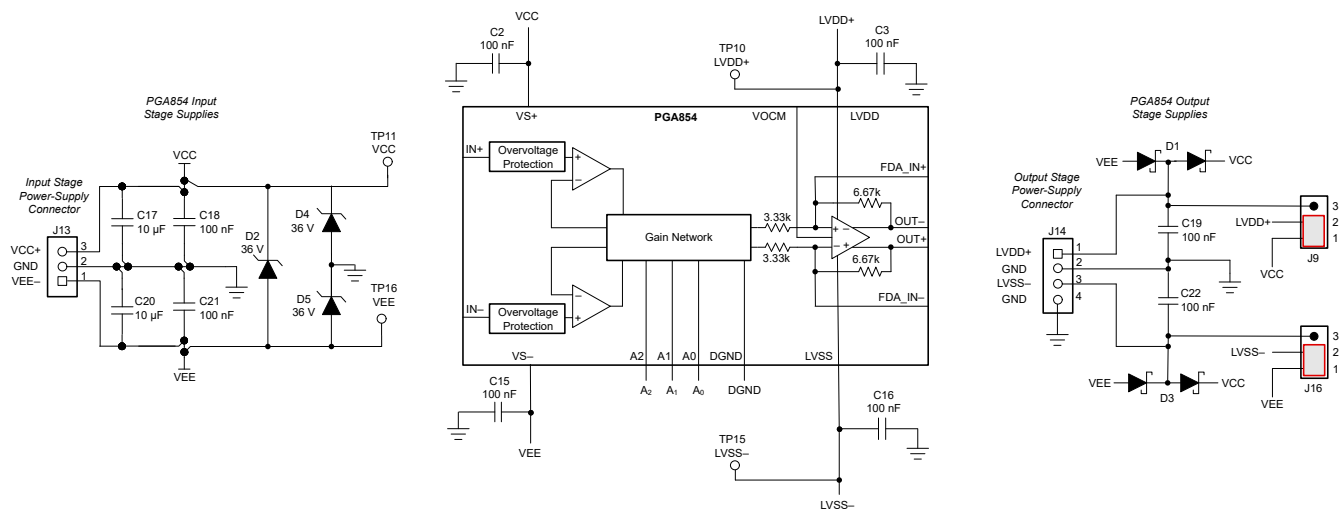


图 2-6. PGA854EVM 电压电源连接

2.4 模拟输入和输出连接

PGA854EVM 的输入信号连接通过位于 EVM 左侧的 SMA 连接器 J3 (IN+)、J6 (IN-) 以及测试点 TP3 (IN+)、TP7 (IN-) 来提供。VOCM 输入可通过位于电路板左侧的螺纹接线端子连接器 J1 来提供、默认情况下不需要驱动此引脚。

PGA854 的差分输出连接通过位于 EVM 右侧的螺纹接线端子连接器 J4.4 (OUT -) 和 J4.1 (OUT+)、SMA 连接器 J2 (OUT -) 和 J8 (OUT+) 以及测试点 TP4 (OUT -) 和 TP6 (OUT+) 来提供。图 2-7 展示了 PGA854EVM 输入和输出连接的简化图。

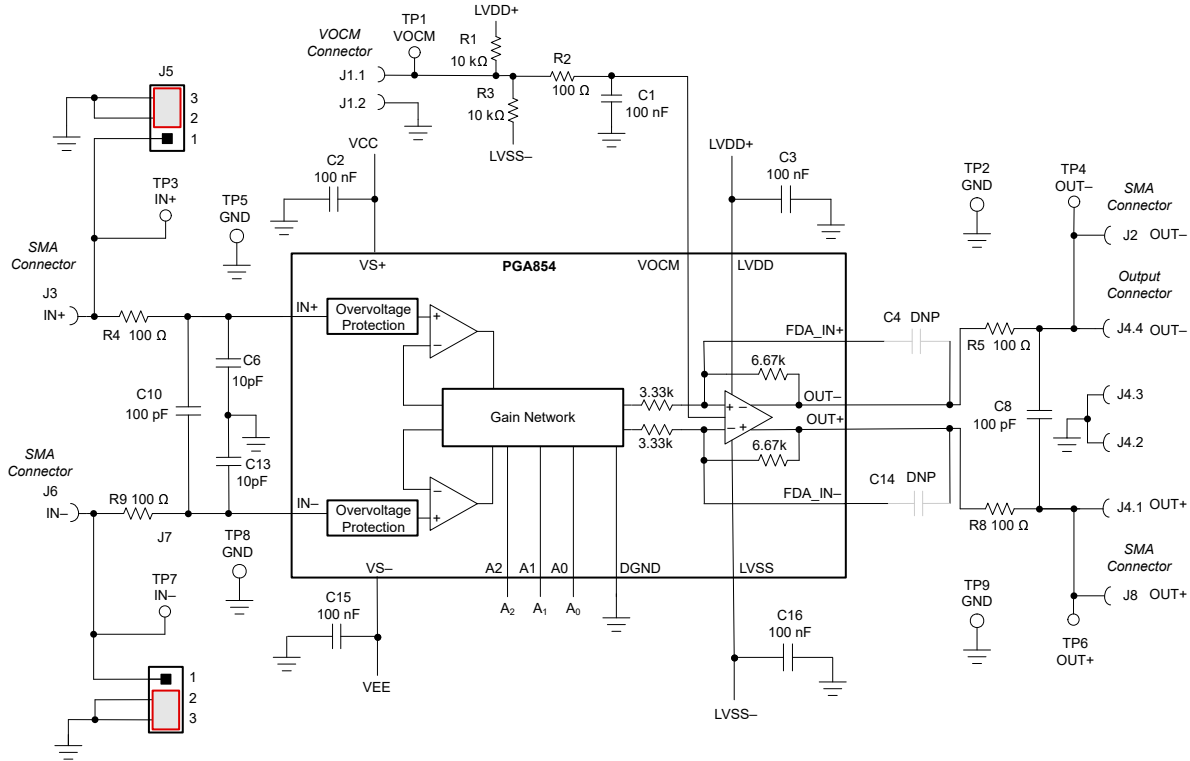


图 2-7. PGA854EVM 模拟输入和输出连接

表 2-3 总结了输入和输出连接器以及相应的测试点。

表 2-3. PGA854EVM 模拟输入和输出连接器

连接器标识符	信号	类型	测试点
J3	IN+	SMA	TP3
J6	IN -	SMA	TP7
J2	OUT-	SMA	TP4
J8	OUT+	SMA	TP6
J4.4	OUT-	螺纹接线端子	TP4
J4.3	GND	螺纹接线端子	TP2
J4.2	GND	螺纹接线端子	TP9
J4.1	OUT+	螺纹接线端子	TP6
J1.1	VOCM	螺纹接线端子	TP1
J1.2	GND	螺纹接线端子	不适用

2.5 数字输入引脚和增益控制

PGA854 提供八个十进制（范围）增益设置，从 0.5V/V 的衰减增益到最大 100V/V。该增益由三个数字选择引脚控制：A2、A1 和 A0。默认情况下，PGA854EVM 的增益配置为 0.5V/V。

该评估板提供分流跳线 J10、J11 和 J12 来设置 PGA854 增益控制选择引脚。表 2-4 列出了增益控制选项。要将增益控制引脚设置为高电平 (1)，请在相应的跳线上安装分流器。要将增益控制引脚设置为低电平 (0)，请移除分流跳线。

表 2-4. PGA854EVM 增益控制

A2 跳线 J10 连接器 J15.1	A1 跳线 J11 连接器 J15.2	A0 跳线 J12 连接器 J15.3	PGA854 增益 (V/V)
0 (开路)	0 (开路)	0 (开路)	0.5
0 (开路)	0 (开路)	1 (分流)	1
0 (开路)	1 (分流)	0 (开路)	2
0 (开路)	1 (分流)	1 (分流)	5
1 (分流)	0 (开路)	0 (开路)	10
1 (分流)	0 (开路)	1 (分流)	20
1 (分流)	1 (分流)	0 (开路)	50
1 (分流)	1 (分流)	1 (分流)	100

或者，可以通过连接器 J15 从外部驱动 A2、A1 和 A0 数字引脚。任何不由外部源驱动的引脚或任何保持断开的分流器都使用下拉电阻器在 DGND 偏置。图 2-8 展示了增益设置方框图。如果通过连接器 J15 从外部驱动增益、J10、J11 和 J12 应当保持未组装状态。

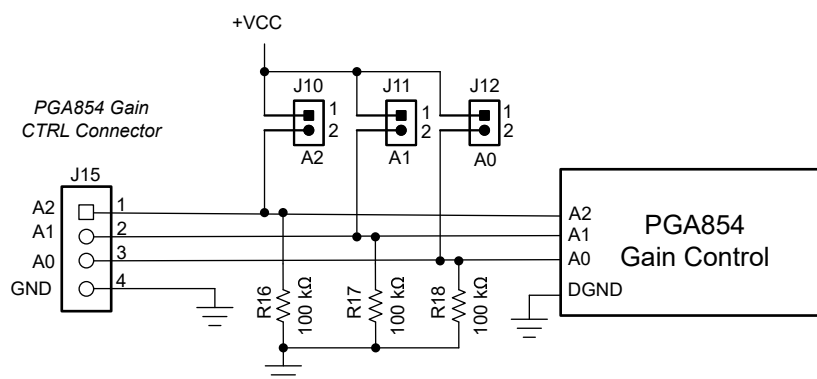


图 2-8. PGA854EVM 增益控制

2.6 更改

为了实现灵活性，EVM 提供了可选电容器 C4 和 C14。这些电容器与 PGA854 输出级内部反馈电阻器 (6.67kΩ) 并联，用于实现噪声滤波。要实现噪声滤波，须确定应用中的相关频率 (f_{oi})，然后计算反馈电容。在 f_{oi} 为 1kHz 的示例中，C4 和 C14 上组装的电容器为 2.2nF (C0G/NP0) 电容器。

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

此外，该评估板还为可选输入低通滤波器提供了 R6、R10、C9、C5 和 C12 的接口位置，并且为负载电阻器 R7 和 R11 提供了接口位置。

共模电容器 (C5 和 C12) 需要彼此相等，输入串联电阻器 (R6 和 R10) 也需要彼此相等。差分电容器 (C9) 容值需要是共模电容器的 10 倍。

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

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

利用布局中的这些额外元件封装结构，用户可以自定义评估电路。有关 PGA854EVM 的完整原理图，请参阅图 3-6。

3 硬件设计文件

3.1 PCB 布局

PGA854EVM 采用四层 PCB 设计。图 3-1 至图 3-5 展示了 PCB 分层图解。顶层由所有信号路径引线组成，并浇注了坚固的接地层。差分输入和输出采用对称电路板布局，以保持良好的性能匹配并提高共模噪声抑制能力。应尽可能对称地对正路径和负路径进行布线。可选的差分输入低通滤波电容放置在非常靠近 PGIA 输入的位置，以便减少外部噪声。电容器 C1 放置在靠近 VOCM 的位置，以避免注入共模噪声。去耦电容器 C2、C15、C3 和 C16 位于顶层尽可能靠近器件电源引脚的位置。第二个内部层是专用的实心 GND 平面。独立过孔位于每个元件的接地连接处，以提供低阻抗接地路径。从第三个内部层和底层进行布线，以连接输入级电源和输出级电源。

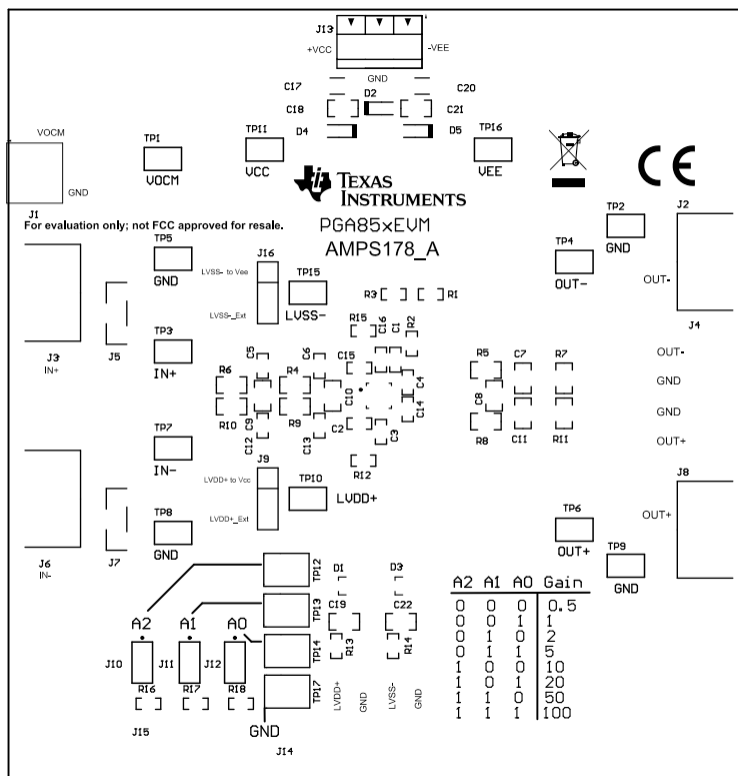


图 3-1. 顶部覆盖层 PCB 布局

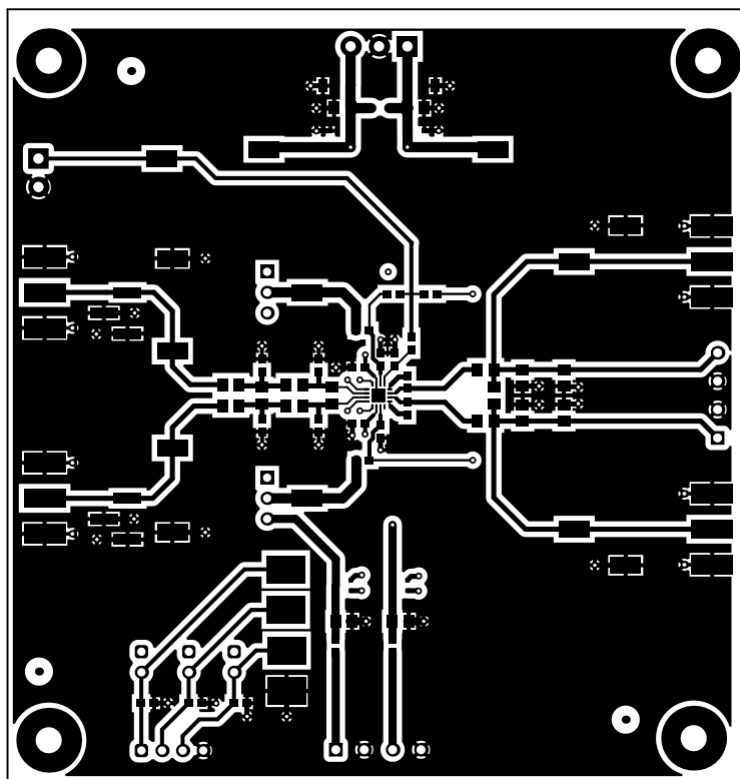


图 3-2. 顶层 PCB 布局

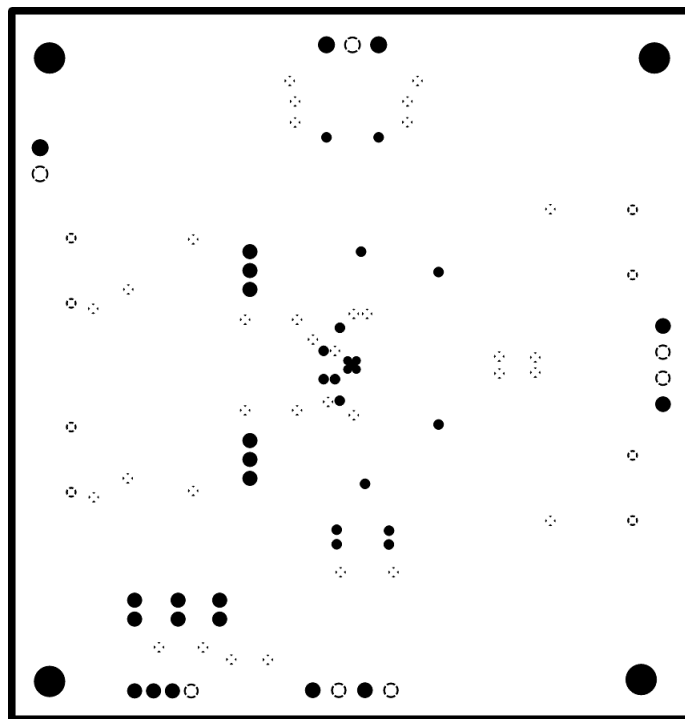


图 3-3. 接地层 PCB 布局

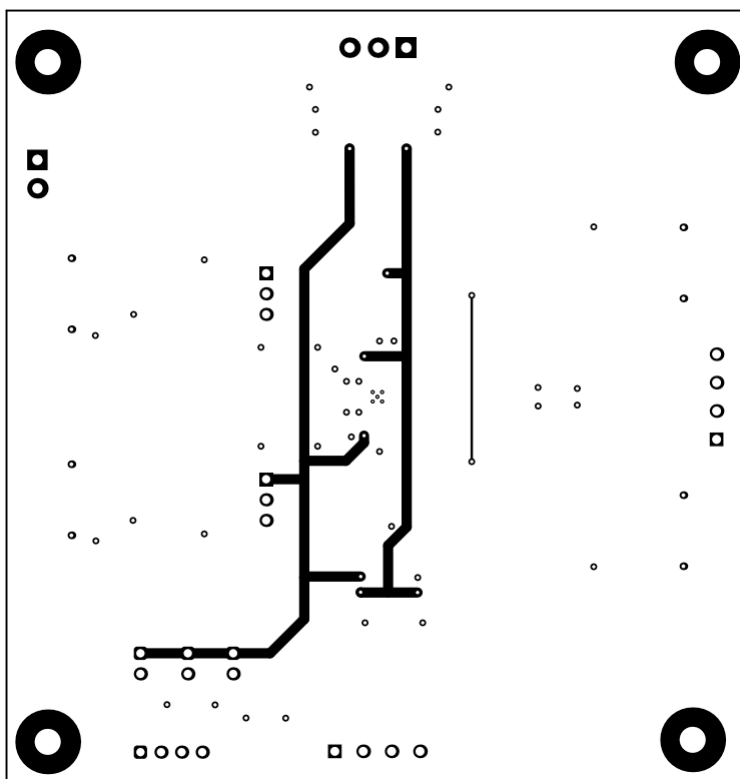


图 3-4. 电源层 PCB 布局

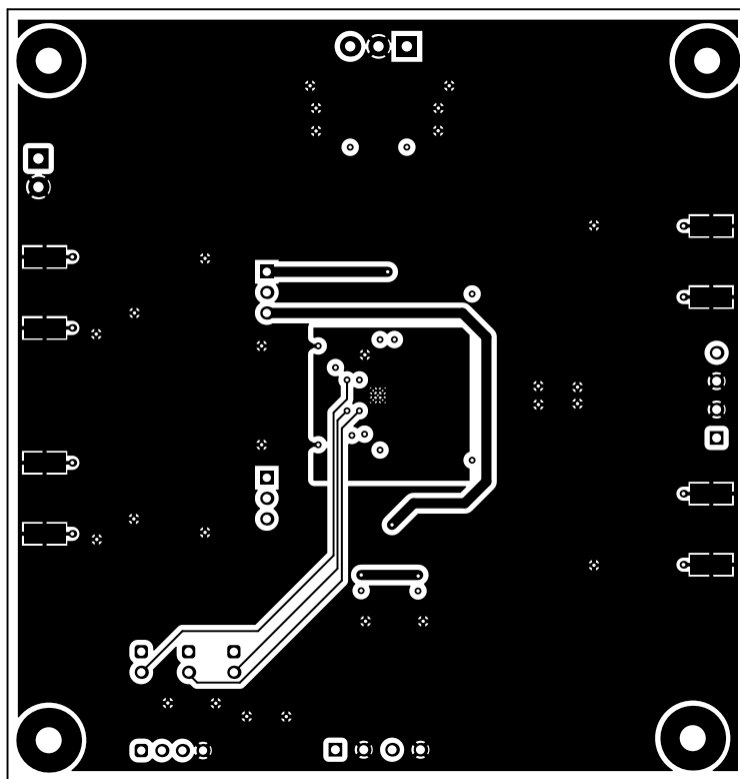
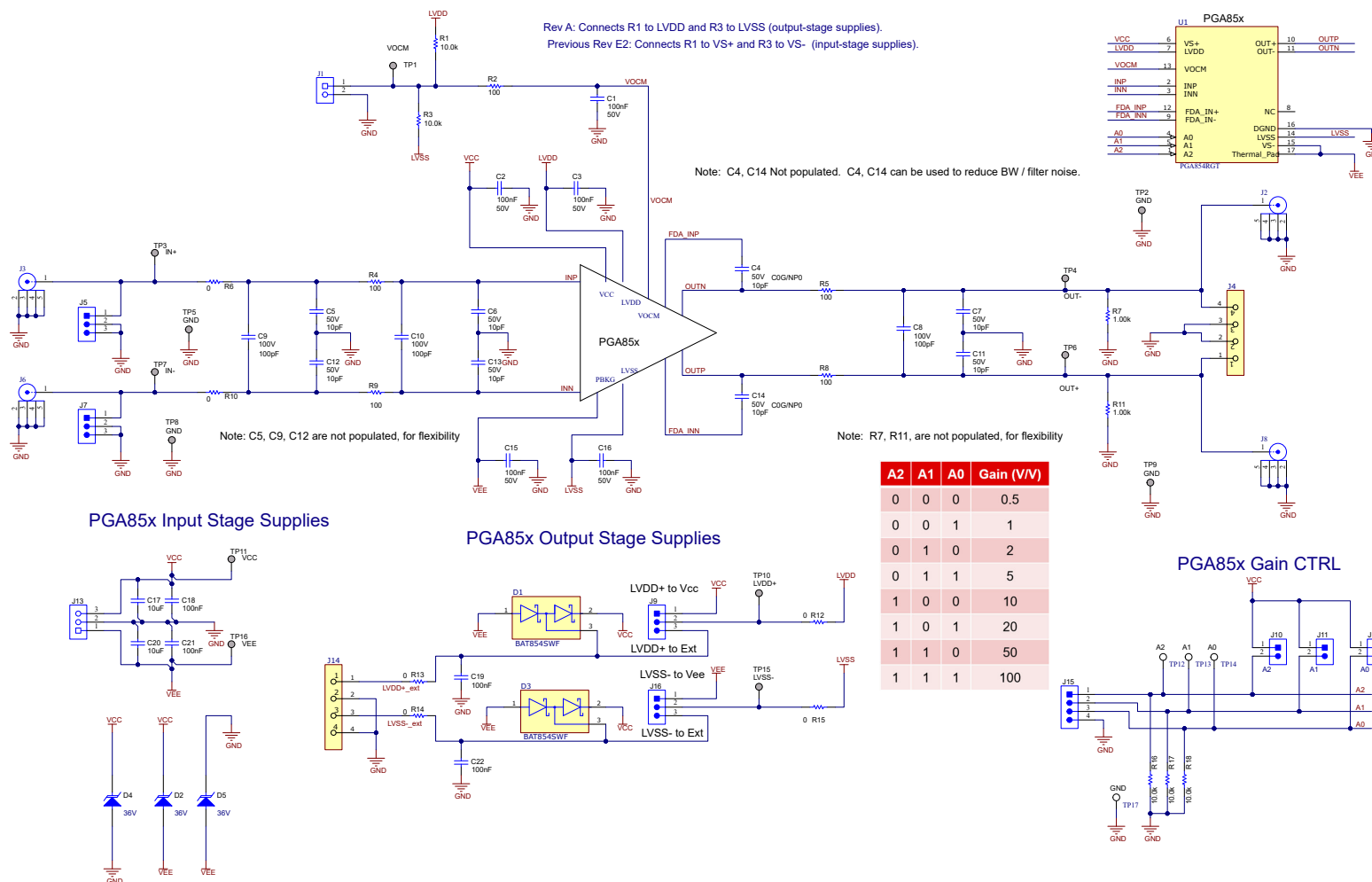


图 3-5. 底层 PCB 布局

3.2 原理图

图 3-6 所示为 EVM 原理图。



注意：未组装 DNP 元件。

图 3-6. PGA854EVM 原理图

3.3 物料清单

表 3-1 列出了 PGA854EVM 物料清单 (BOM)。

表 3-1. PGA854EVM 物料清单

位号	数量	值	说明	封装参考	器件型号	制造商
!PCB1	1		印刷电路板		AMPS178	不限
C1、C2、C3、C15、C16	5	0.1μF	电容, 陶瓷, 0.1 μF, 50V, +/-5%, X7R, 0603	603	C0603C104J5RACTU	Kemet
C4、C5、C6、C13、C14	2	10pF	电容, 陶瓷, 10pF, 50V, +/-1%, C0G/NP0, 0603	603	C0603C100F5GAC7867	Kemet
C7、C11	2	10pF	电容, 陶瓷, 10pF, 50V, +/-5%, C0G/NP0, 0805	805	08055A100JAT2A	AVX
C8、C9、C10	2	100pF	电容, 陶瓷, 100pF, 100V, +/-5%, C0G/NP0, 0805	805	C0805C101J1GACTU	Kemet
C17、C20	2	10μF	电容, 陶瓷, 10uF, 35V, +/-10%, X7R, 1206	1206	C3216X7R1V106K160AC	TDK
C18、C19、C21、C22	4	0.1μF	电容, 陶瓷, 0.1μF, 50V, +/-10%, X7R, 0805	805	08055C104KAT2A	AVX
D1、D3	2		二极管阵列, 1 对串联肖特基, 40V, 200mA (直流), 表面贴装 SC-70, SOT-323	SOT-323	BAT854SWF	Nexperia
D2、D4、D5	3	36V	二极管, TVS, 单向, 36V, 75Vc, SOD-323	SOD-323	CDSOD323-T36S	Bourns
H1、H2、H3、H4	4		机械螺钉, 圆头, #4-40 x 1/4, 尼龙, 飞利浦盘形头	螺钉	NY PMS 440 0025 PH	B&F Fastener Supply
H5、H6、H7、H8	4		六角螺柱, 0.5"L #4-40, 尼龙	螺柱	1902C	Keystone
J1	1		端子块, 3.5mm 间距, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
J2、J3、J6、J8	4		连接器, 末端发射 SMA, 50 欧姆, SMT	末端发射 SMA	142-0701-801	Cinch Connectivity
J4、J14	2		端子块, 3.5mm, 垂直, 4 位置 PCB	HDR4	OSTTE040104	On Shore Technology
J5、J7	2		接头, 100mil, 3x1, 金, SMT	Samtec_TSM-103-01-X-SV	TSM-103-01-L-SV	Samtec
J9、J16	2		接头, 100mil, 3x1, 金, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J10、J11、J12	3		接头, 100mil, 2x1, 金, TH	2x1 接头	TSW-102-07-G-S	Samtec
J13	1		端子块, 3.5mm 间距, 3x1, TH	10.5x8.2x6.5mm	ED555/3DS	On-Shore Technology
J15	1		接头, 100mil, 4x1, 金, TH	4x1 接头	TSW-104-07-G-S	Samtec
R1、R3	2	10k Ω	电阻, 10.0k, 1%, 0.1W, 0603	603	ERJ-3EKF1002V	Panasonic
R2	1	100 Ω	电阻, 100, 1%, 0.1W, 0603	603	RC0603FR-07100RL	Yageo
R4、R5、R8、R9	4	100 Ω	电阻, 0, 0.1%, 0.125W, 0805	805	RT0805BRD07100RL	Yageo America
R6、R10	2	0 Ω	电阻, 0, 5%, 0.125W, AEC-Q200 0 级, 0805	805	ERJ-6GEY0R00V	Panasonic

表 3-1. PGA854EVM 物料清单 (续)

位号	数量	值	说明	封装参考	器件型号	制造商
R12、R13、R14、R15	4	0 Ω	电阻, 0, 5%, 0.1W, 0603	603	RC0603JR-070RL	Yageo
R16、R17、R18	3	10.0k Ω	电阻, 10.0k, 1%, 0.1W, 0603	603	RCG060310K0FKEA	Vishay Draloric
SH-J1, SH-J2, SH-J3, SH-J4 、SH-J5、SH-J6	6	1 $\times$ 2	分流器, 100mil, 镀金, 黑色	顶部闭合 100mil 分流器	SPC02SYAN	Sullins Connector Solutions
TP1、TP2、TP3、TP4、TP5、TP6、TP7、TP8、TP9、TP10、TP11、TP15、TP16	13		测试点, 微型, SMT	测试点, 微型, SMT	5019	Keystone
TP12、TP13、TP14、TP17	4		测试点, 紧凑型, SMT	Testpoint_Keystone_Compact	5016	Keystone
U1	1		低噪声、宽带宽、全差分输出、可编程增益放大器	VQFN17	PGA854RGT	德州仪器 (TI)

4 其他信息

4.1 商标

所有商标均为其各自所有者的财产。

5 相关文档

该文档提供了有关 PGA854EVM 装配件中所用德州仪器 (TI) 集成电路的信息。本用户指南可从 TI 网站获得，文献编号为 SLVUDF8。附加到文献编号的任何字母对应于撰写本文档时已有的最新文档修订版。

表 5-1. 相关文档

器件	文献编号
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 DEGRADATION 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/sds/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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2. 実験局の免許を取得後ご使用いただく。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_02.page

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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.

6. *Disclaimers:*

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.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.
10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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