

EVM User's Guide: VCA710RGR

VCA710RGR Evaluation Module



Description

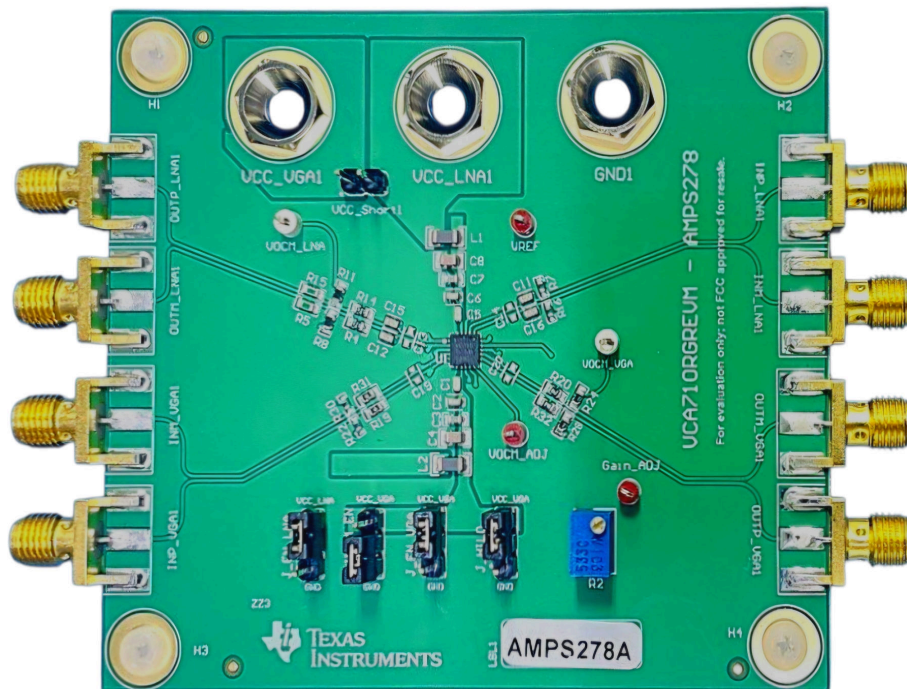
The VCA710RGREVM is an evaluation module (EVM) designed for the VCA710RGR, an analog front-end device that includes two main components: a Low Noise Amplifier (LNA) with a fixed internal gain of 20dB and a Variable Gain Amplifier (VGA). This EVM is engineered for quick and easy demonstration of the amplifier's functionality and versatility. The EVM is equipped with onboard connectors that facilitate connections to power sources, signal sources, and test instruments. It is configured for straightforward connections with standard laboratory equipment at the input and output points. Additionally, it features banana connectors for power supplies and jumpers that allow users to easily enable, disable, or configure different modes of operation. Both the input and output traces of the LNA and VGA are differentially routed with a controlled 100Ω differential impedance, ensuring optimal performance from the device.

Features

- Single supply operating range 3.3V to 5.25V
- Easy-to-use SMA connectors for all input and output signals
- Easy-to-use banana connector for device power supply
- Jumpers to configure device at different modes
- Layout configured to minimize parasitic and noise

Applications

- Optoelectronic front-ends
- Sonar systems
- Ultrasound systems
- Audio front-ends
- AGC receivers



VCA710RGREVM Board (Top View)

1 Evaluation Module Overview

1.1 Introduction

The VCA710RGR is a single-channel, low-noise, low-power variable gain amplifier (VGA) designed for high-performance signal conditioning in broadband analog front-ends. It features a low-noise amplifier (LNA) with a gain of 10 V/V (20 dB) and a bandwidth of 220 MHz, along with a VGA that offers a bandwidth of 110 MHz. This combination provides high dynamic range and flexible gain control. There are two methods to adjust the gain of the VGA: First, the fine analog gain control. This is done using the GAIN_ADJ pin, allowing for continuous gain adjustment. And the second is coarse digital gain control. This utilizes the HILO pin, which provides two gain settings. With these two gain control mechanisms, the VCA710 can achieve a gain range from -35dB to +20dB when HILO = 0, and from -15dB to +40dB when HILO = 1.

The VCA710RGREVM is designed to evaluate the performance of the VCA710RGR. The Evaluation Module includes SMA connectors for all input and output pins, banana connectors for power supplies, jumpers for configuring the device in different modes, and test point connectors for setting common mode and reference voltages. This user guide provides descriptions of the device and connectors, the schematic and the PCB layout of the board and the bill of materials.

1.2 Kit Contents

The package includes:

- VCA710RGREVM
- EVM disclaimer read me

1.3 Specification

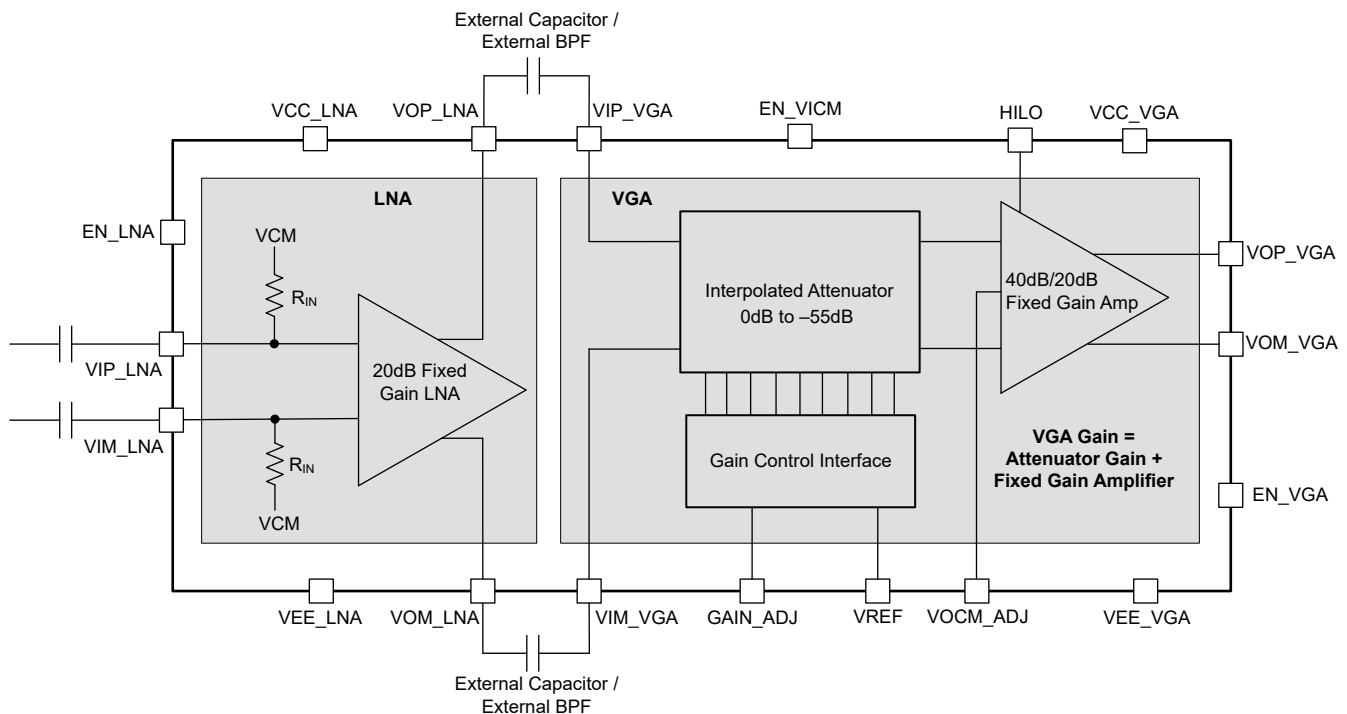


Figure 1-1. VCA710RGR Functional Block Diagram

1.4 Device Information

The VCA710RGR is an analog front-end device housed in a 20-pin VQFN package. It consists of two main components: a Low Noise Amplifier (LNA) with a fixed internal gain of 20 dB, and a Variable Gain Amplifier (VGA). The LNA accepts both differential and single-ended input signals and provides differential outputs. Note that the LNA only operates with AC-coupled signals. The VGA can accept both AC and DC signals, which can be either single-ended or differential. Both blocks can function independently due to their separate inputs and

outputs connections, and provide a separate power-down feature as well. For users needing DC coupling, it is recommended to disable the LNA and connect the inputs directly to the VGA.

A key feature of the VCA710RGR is the fine gain adjust pin, which allows users to control the gain with a programmable analog voltage ranging from 0V to 1V. In addition to the fine gain adjust, the VGA block also provides a coarse gain setting via the HILO mode pin. With the analog gain control block and the HILO pin, the VCA710RGR offers a gain range from –35 dB to +20 dB and –15 dB to +40 dB, making it highly configurable for various applications. Moreover, the device includes an internal reference voltage for applications where gain accuracy is not critical. For scenarios requiring high gain accuracy, an external precise VREF can be applied.

Both the LNA and VGA of the VCA710RGR operate on a supply voltage of 3.3V to 5.25V and are specified for an ambient operating temperature range of –55°C to +125°C.

2 Hardware

2.1 Additional Images

2.1.1 Pin Configuration

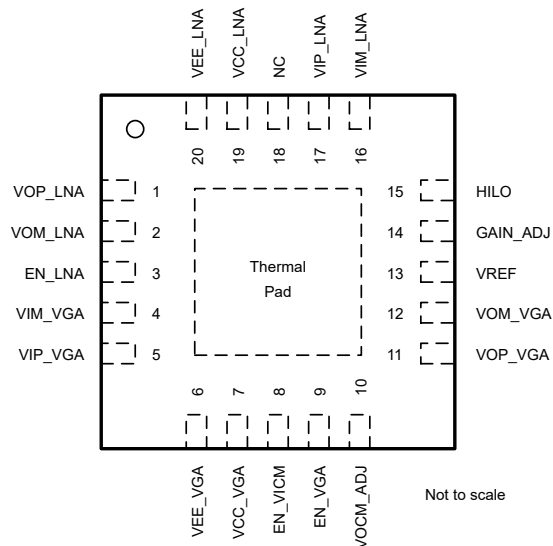


Figure 2-1. RGR Package, 20-pin VQFN (Top View)

2.2 Power Requirements

The EVM is equipped with three banana connectors: VCC_VGA1 for the VGA block power supply, VCC_LNA1 for the LNA block power supply, and GND1 for ground connection. To ensure proper operation, power the device with a supply voltage between 3.3V and 5.25V. Please note that the device and, hence, the EVM cannot operate with a split supply.

2.3 Input and Output SMA connectors

INM_LNA1 and INP_LNA1: These two SMA connectors connect to the inverting input (VIM_LNA, pin 16) and the non-inverting input (VIP_LNA, pin 17) of the LNA block of the device, respectively. The signal from these connectors is AC-coupled to the corresponding input pins of the device. By default, the connectors are configured for a differential input connection and are terminated differentially with 100Ω resistors to match the source impedance of the instruments.

INM_VGA1 and INP_VGA1: These two SMA connectors connect to the inverting input (VIM_VGA, pin 4) and the non-inverting input (VIP_VGA, pin 5) of the VGA block of the device, respectively. The signal from these connectors is DC-coupled to the respective inputs of the device through resistors R19 and R31. By default, these connectors are also configured for a differential input connection and are terminated differentially with 100Ω resistors.

OUTM_LNA1 and OUTP_LNA1: The signals from the inverting output (VOM_LNA, pin 2) and the non-inverting output (VOP_LNA, pin 1) of the LNA block are AC-coupled to the OUTM_LNA1 and OUTP_LNA1 connectors,

respectively. When a test instrument with a 100Ω differential input impedance (or 50Ω single-ended input impedance) is connected to these two connectors, the default resistive network presents a differential load of 300Ω to the LNA output. Also, the impedance looking into these connectors on the EVM is 100Ω differentially, ensuring that the impedance is matched between the EVM output connectors and the instrument input port. But please note that the resistive network attenuates the output signal by 15.58dB

OUTM_VGA1 and OUTP_VGA1: The signals from the inverting output (VOM_VGA, pin 12) and the non-inverting output (VOP_VGA, pin 11) of the VGA block are connected to the OUTM_VGA1 and OUTP_VGA1 connectors, respectively. When a test instrument with a 100Ω differential input impedance (or 50Ω single-ended input impedance) is connected to these two connectors, the default resistive network presents a differential load of 500Ω to the VGA output. The impedance looking into these connectors on the EVM is also 100Ω differentially, which ensures that the impedance is matched between the EVM output connectors and the instrument input port. But please note that the resistive network attenuates the output signal by 18.95dB

2.4 Jumper Information

J_EN_LNA: This jumper connects to the LNA enable pin (EN_LNA) of the device. To power down the LNA using this jumper, short pins 1 and 2. To enable the device, short pins 2 and 3 of J_EN_LNA.

J_EN_VGA: This jumper connects to the VGA enable pin (EN_VGA) of the device. To power down the VGA using this jumper, short pins 1 and 2. To enable the device, short pins 2 and 3 of J_EN_VGA.

J_HILO: This jumper provides option for coarse gain setting via the HILO mode pin. Short pins 1 and 2 to configure the device in low gain mode (–35 to 20dB) and short pins 2 and 3 to configure the device in high gain mode (–15 to 40dB)

J_VICM EN: This jumper is used to configure the input common mode of the VGA. Short pins 1 and 2 to set the input common mode externally and is used when the input is DC coupled. Short pins 2 and 3 to set the input common mode to mid supply. This is used for AC coupled input

2.5 Test Point connector

VOCM_ADJ: This connector connects to the VOCM_ADJ pin of the device and is used to set the output common mode of the VGA. If it is left floating, the resistive divider formed by R35 and R40 biases the VOCM_ADJ pin to the mid-supply voltage of the VGA

Gain_ADJ: This connector is used to set the gain adjust voltage of the VGA. By default, resistor R3 is populated, and the gain adjustment voltage is determined by the position of potentiometer R2. If the gain needs to be set using an external voltage, remove R3 and apply the desired voltage at this Gain_ADJ test point connector.

VREF: This connector is used to externally set a 0.5V reference voltage for the device, which is particularly important for applications requiring high gain accuracy. The voltage at the VREF pin can also be configured using an onboard external reference, REF35. To enable this, short R43 and R41. If left unconnected, the internal reference of the VGA will provide the required voltage for proper device operation.

3 Hardware Design Files

3.1 Schematics

The following figure shows the VCA710RGREVM schematic diagram.

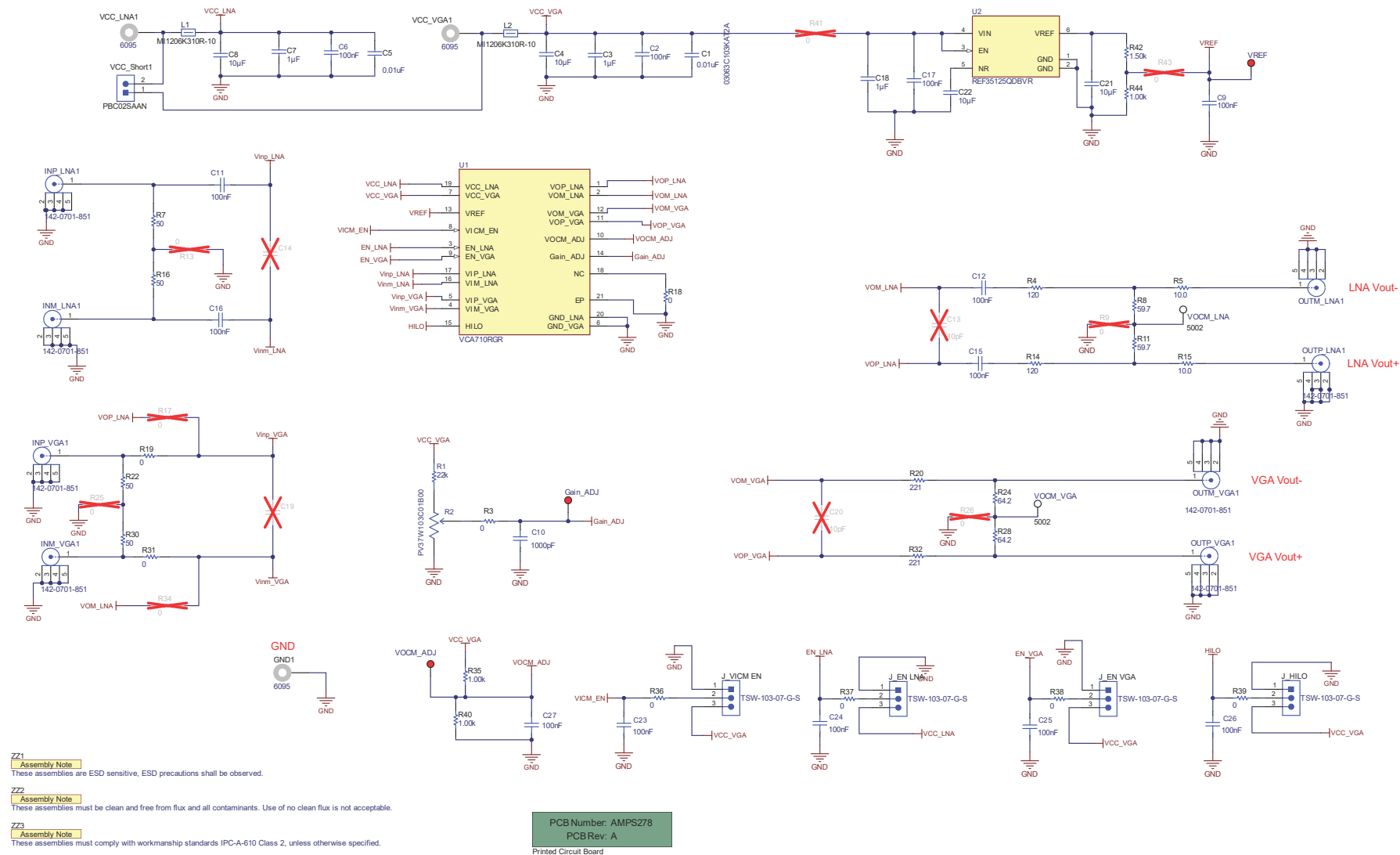


Figure 3-1. VCA710RGREVM Schematic

The following figures show the PCB layout for the VCA710RGREVM.

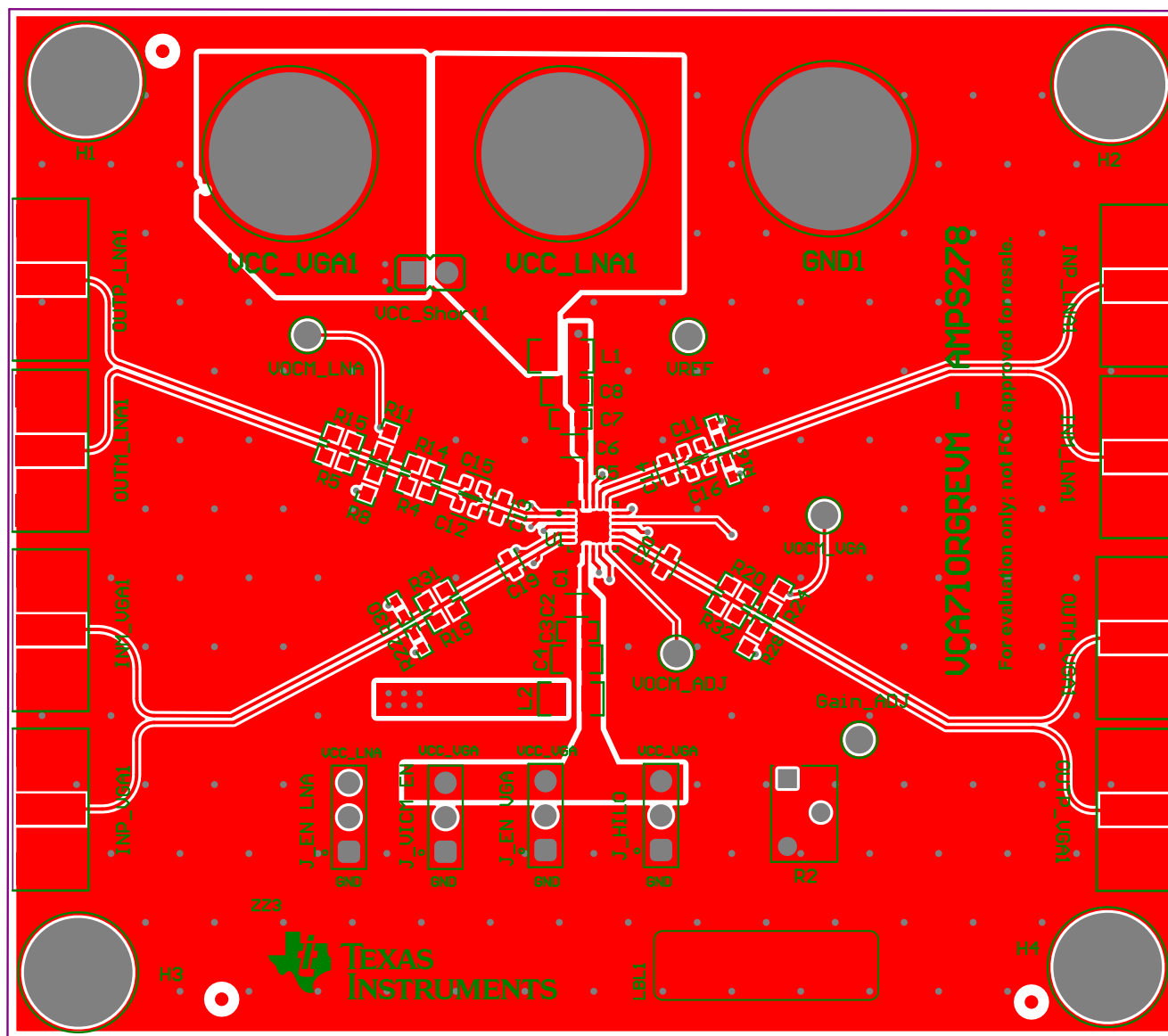


Figure 3-2. VCA710RGREVM Top Layer

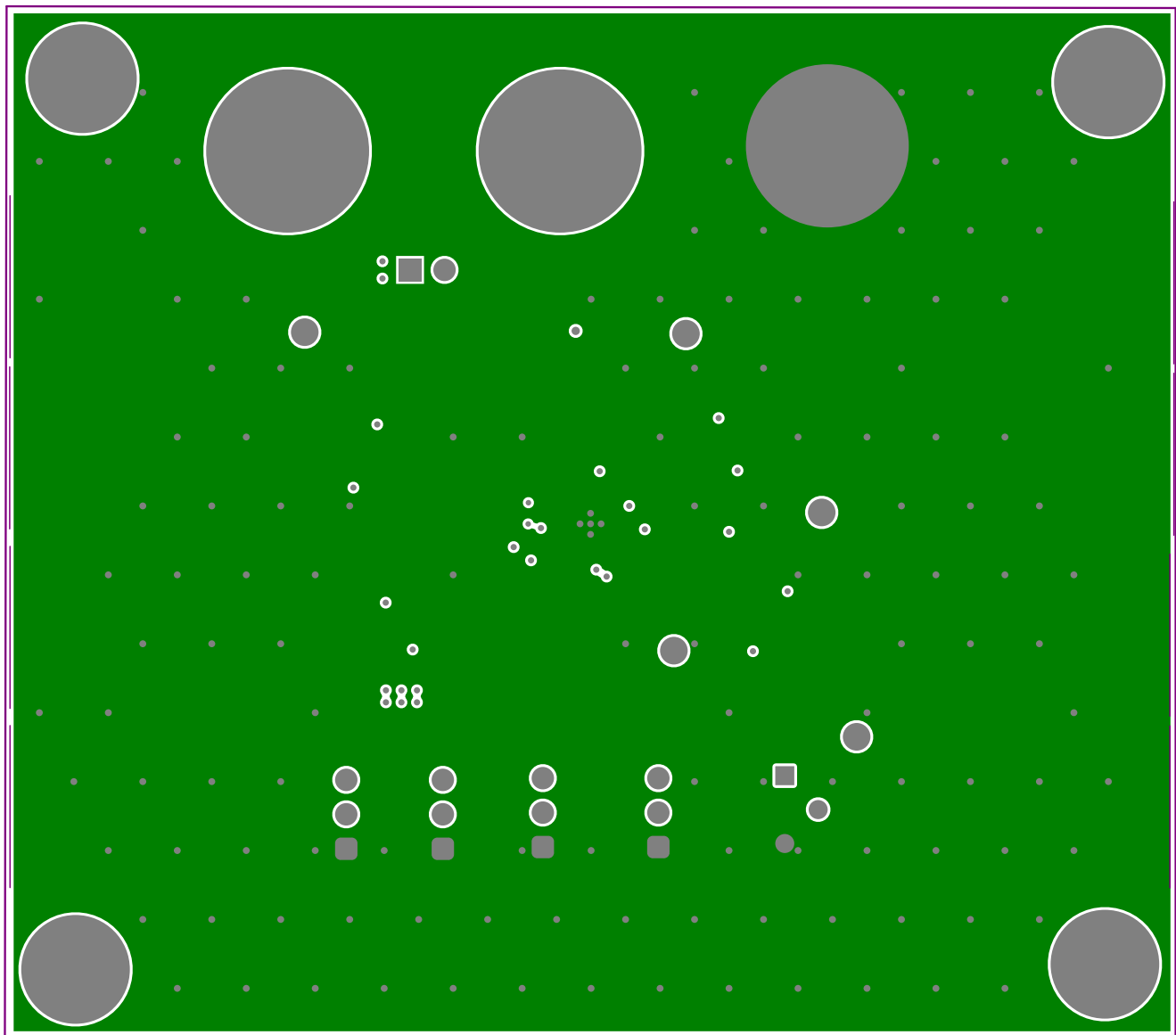


Figure 3-3. VCA710RGREVM Second Layer (Ground Plane)

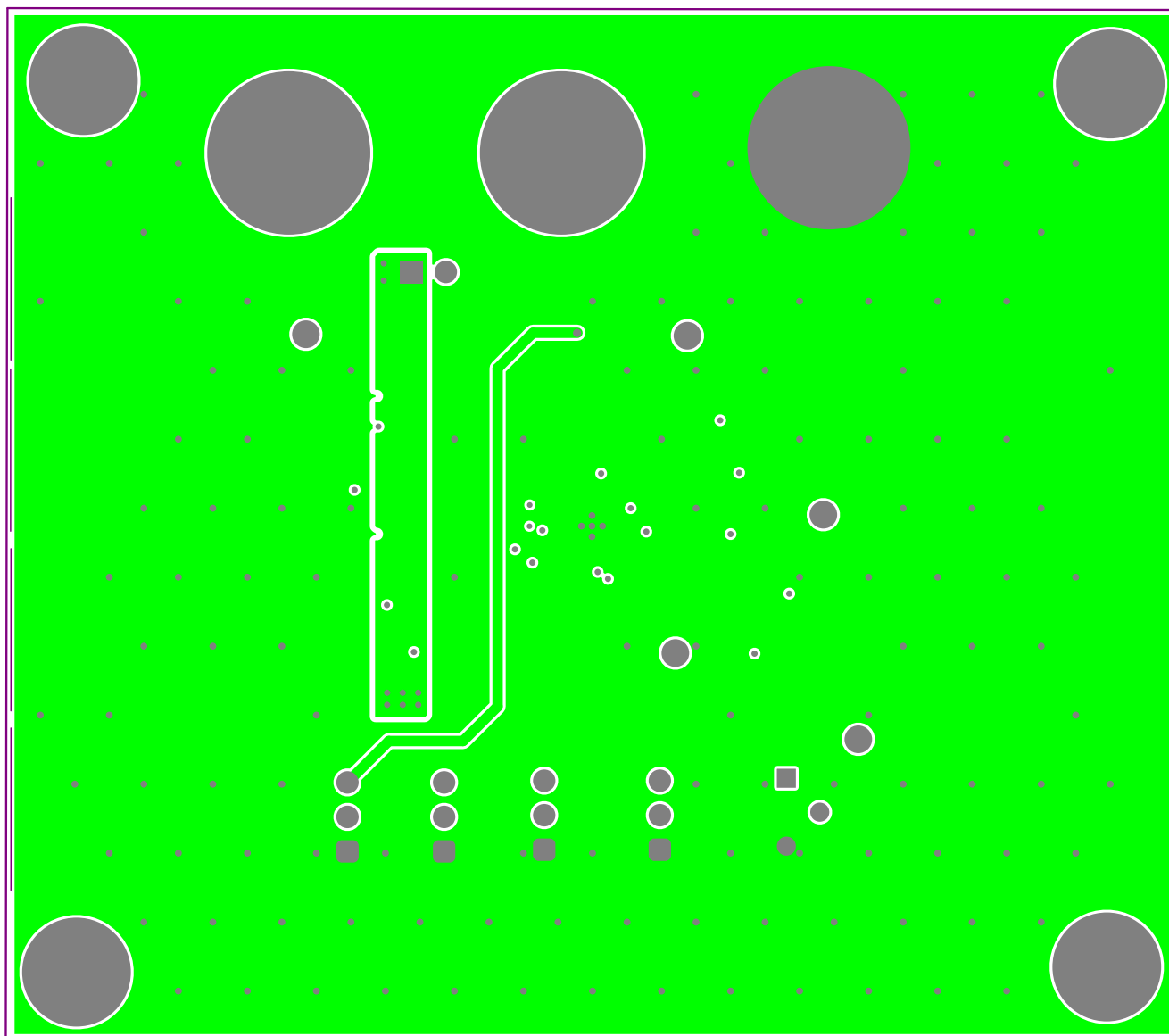


Figure 3-4. VCA710RGREVM Third Layer (Power Plane)

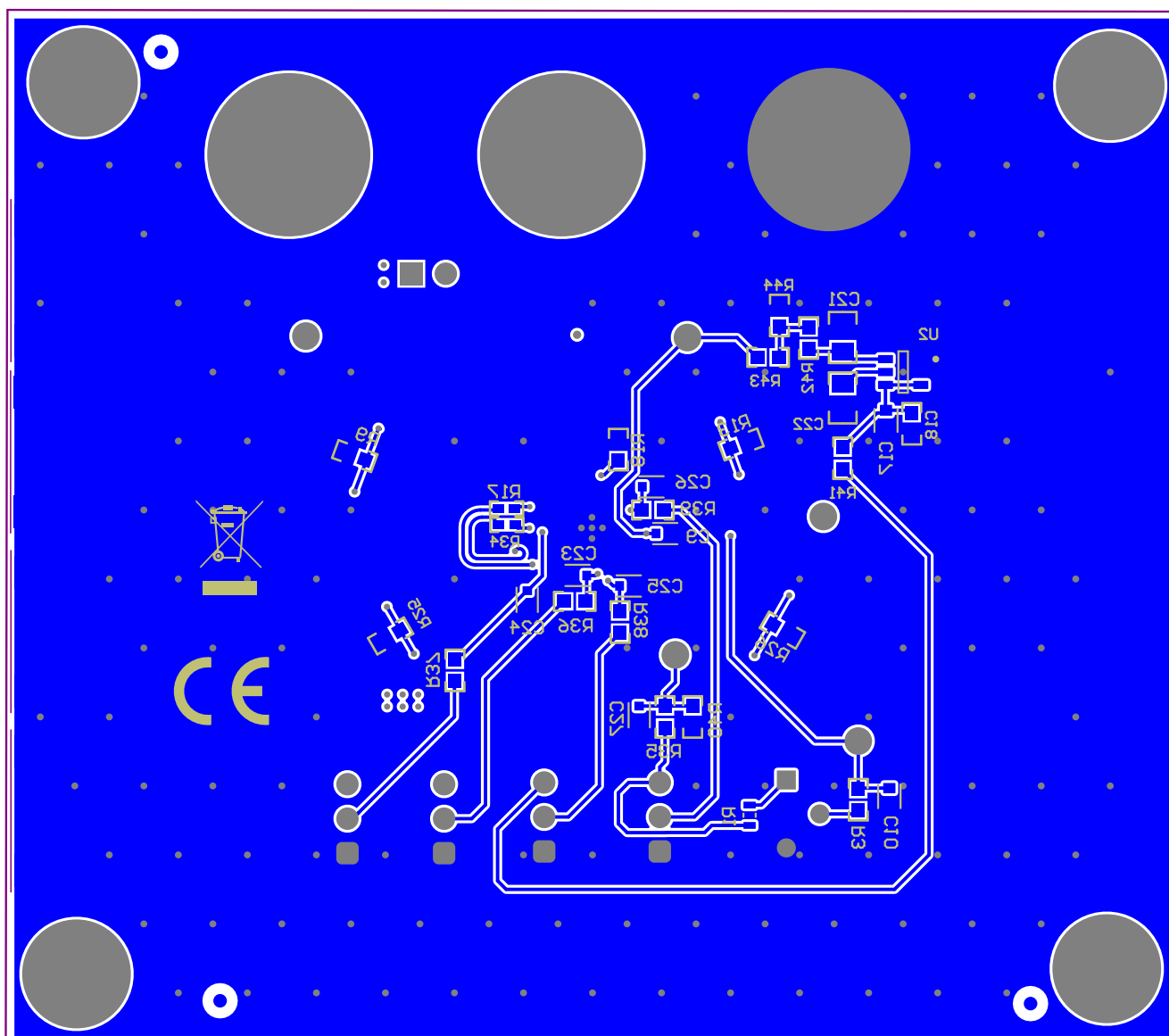


Figure 3-5. VCA710RGREVM Bottom Layer

3.3 Bill of Materials (BOM)

Table 3-1. VCA710RGREVM BOM

Item	Designator	Description	Manufacturer	PartNumber	Quantity
1	IPCB1	Printed Circuit Board	Any	AMPS278	1
2	IPCB2	Printed Circuit Board	Any	AMPS278	1
3	C1	CAP CER 10000PF 25V X7R 0306	KYOCERA AVX	03063C103KAT2A	1
4	C2	0.1 μ F $\pm$ 5% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	Yageo	CC0603JRX7R9BB104	1
5	C3	CAP, CERM, 1 μ F, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	MuRata	GCM188R71C105KA64J	1
6	C4	CAP, CERM, 10 μ F, 10 V, +/- 10%, X7R, 0805	MuRata	GCM21BR71A106KE22L	1
7	C5	CAP CER 10000PF 25V X7R 0306	KYOCERA AVX	03063C103KAT2A	1
8	C6	0.1 μ F $\pm$ 5% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	Yageo	CC0603JRX7R9BB104	1
9	C7	CAP, CERM, 1 μ F, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	MuRata	GCM188R71C105KA64J	1
10	C8	CAP, CERM, 10 μ F, 10 V, +/- 10%, X7R, 0805	MuRata	GCM21BR71A106KE22L	1
11	C9	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
12	C10	Cap Ceramic 0.001 μ F 16V C0G 1% SMD 0603 125°C Paper T/R	KEMET	C0603C102F4GAC7867	1
13	C11	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
14	C12	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
15	C15	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
16	C16	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
17	C17	0.1 μ F $\pm$ 5% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	Yageo	CC0603JRX7R9BB104	1
18	C18	CAP, CERM, 1 μ F, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	MuRata	GCM188R71C105KA64J	1
19	C21	CAP, CERM, 10 μ F, 10 V, +/- 10%, X7R, 0805	MuRata	GCM21BR71A106KE22L	1
20	C22	CAP, CERM, 10 μ F, 10 V, +/- 10%, X7R, 0805	MuRata	GCM21BR71A106KE22L	1
21	C23	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
22	C24	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
23	C25	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
24	C26	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
25	C27	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	1
26	FID1	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	1
27	FID2	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	1
28	FID3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	1
29	FID4	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	1
30	FID5	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	1

Table 3-1. VCA710RGREVM BOM (continued)

Item	Designator	Description	Manufacturer	PartNumber	Quantity
31	FID6	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	1
32	Gain_ADJ	Test Point, Miniature, Red, TH	Keystone	5000	1
33	GND1	Standard Banana Jack, Uninsulated	Keystone	6095	1
34	H1	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	1
35	H2	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	1
36	H3	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	1
37	H4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	1
38	H5	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	1
39	H6	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	1
40	H7	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	1
41	H8	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	1
42	INM_LNA1	Connector, End launch SMA, 50 ohm, SMT	Cinch Connectivity	142-0701-851	1
43	INM_VGA1	Connector, End launch SMA, 50 ohm, SMT	Cinch Connectivity	142-0701-851	1
44	INP_LNA1	Connector, End launch SMA, 50 ohm, SMT	Cinch Connectivity	142-0701-851	1
45	INP_VGA1	Connector, End launch SMA, 50 ohm, SMT	Cinch Connectivity	142-0701-851	1
46	J_EN LNA	Header, 100mil, 3x1, Gold, TH	Samtec	TSW-103-07-G-S	1
47	J_EN VGA	Header, 100mil, 3x1, Gold, TH	Samtec	TSW-103-07-G-S	1
48	J_HILO	Header, 100mil, 3x1, Gold, TH	Samtec	TSW-103-07-G-S	1
49	J_VICM EN	Header, 100mil, 3x1, Gold, TH	Samtec	TSW-103-07-G-S	1
50	L1	Ferrite Bead, 31 ohm @ 100 MHz, 1.5 A, 1206	Laird-Signal Integrity Products	MI1206K310R-10	1
51	L2	Ferrite Bead, 31 ohm @ 100 MHz, 1.5 A, 1206	Laird-Signal Integrity Products	MI1206K310R-10	1
52	LBL1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Brady	THT-14-423-10	1
53	OUTM_LNA1	Connector, End launch SMA, 50 ohm, SMT	Cinch Connectivity	142-0701-851	1
54	OUTM_VGA1	Connector, End launch SMA, 50 ohm, SMT	Cinch Connectivity	142-0701-851	1
55	OUTP_LNA1	Connector, End launch SMA, 50 ohm, SMT	Cinch Connectivity	142-0701-851	1
56	OUTP_VGA1	Connector, End launch SMA, 50 ohm, SMT	Cinch Connectivity	142-0701-851	1
57	R1	22 kOhms $\pm 1\%$ 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Thick Film	Vishay	CRCW060322K0FKEAC	1
58	R2	10 kOhms 0.25W, 1/4W PC Pins Through Hole Trimmer Potentiometer Cermet 12 Turn Top Adjustment	Bourns	PV37W103C01B00	1
59	R3	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	1
60	R4	RES, 120, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD07120RL	1
61	R5	RES, 10.0, 0.1%, 0.1 W, 0603	Vishay-Dale	TNPW060310R0BEEA	1
62	R7	RES, 50, 0.1%, 0.05 W, 0402	Vishay-Dale	FC0402E50R0BST1	1

Table 3-1. VCA710RGREVM BOM (continued)

Item	Designator	Description	Manufacturer	PartNumber	Quantity
63	R8	RES, 59.7, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD0759R7L	1
64	R11	RES, 59.7, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD0759R7L	1
65	R14	RES, 120, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD07120RL	1
66	R15	RES, 10.0, 0.1%, 0.1 W, 0603	Vishay-Dale	TNPW060310R0BEEA	1
67	R16	RES, 50, 0.1%, 0.05 W, 0402	Vishay-Dale	FC0402E50R0BST1	1
68	R18	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	1
69	R19	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	1
70	R20	RES, 221, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD07221RL	1
71	R22	RES, 50, 0.1%, 0.05 W, 0402	Vishay-Dale	FC0402E50R0BST1	1
72	R24	RES, 64.2, 0.1%, 0.1 W, 0603	KOA Speer Electronics, Inc.	RN73R1JTTD64R2B25	1
73	R28	RES, 64.2, 0.1%, 0.1 W, 0603	KOA Speer Electronics, Inc.	RN73R1JTTD64R2B25	1
74	R30	RES, 50, 0.1%, 0.05 W, 0402	Vishay-Dale	FC0402E50R0BST1	1
75	R31	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	1
76	R32	RES, 221, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD07221RL	1
77	R35	RES SMD 1K OHM 0.1% 1/10W 0603	Panasonic	ERA-3AEB102V	1
78	R36	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	1
79	R37	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	1
80	R38	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	1
81	R39	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	1
82	R40	RES SMD 1K OHM 0.1% 1/10W 0603	Panasonic	ERA-3AEB102V	1
83	R42	RES 1.5K OHM 0.05% 1/8W 0603	Panasonic Electronic Components	ERA-3VRW1501V	1
84	R44	RES SMD 1K OHM 0.02% 1/10W 0603	Susumu	RG1608P-102-P-T1	1
85	U1	VCA710RGR	Texas Instruments	VCA710RGR	1
86	U2	Ultra Low-Power, High-Precision Voltage Reference	Texas Instruments	REF35125QDBVR	1
87	VCC_LNA1	Standard Banana Jack, Uninsulated	Keystone	6095	1
88	VCC_Short1	Header, 100mil, 2x1, Gold, TH	Sullins Connector Solutions	PBC02SAAN	1
89	VCC_VGA1	Standard Banana Jack, Uninsulated	Keystone	6095	1
90	VOCM_ADJ	Test Point, Miniature, Red, TH	Keystone	5000	1
91	VOCM_LNA	Test Point, Miniature, White, TH	Keystone	5002	1
92	VOCM_VGA	Test Point, Miniature, White, TH	Keystone	5002	1
93	VREF	Test Point, Miniature, Red, TH	Keystone	5000	1
94	C13	10pF $\pm 5\%$ 25V Ceramic Capacitor C0G, NP0 0603 (1608 Metric)	AVX	06033A100JAT2A	0
95	C14	0.1 μ F $\pm 10\%$ 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	0

Table 3-1. VCA710RGREVM BOM (continued)

Item	Designator	Description	Manufacturer	PartNumber	Quantity
96	C19	0.1 μ F $\pm$ 10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	Murata Electronics North America	GCJ188R71C104KA01D	0
97	C20	10pF $\pm$ 5% 25V Ceramic Capacitor C0G, NP0 0603 (1608 Metric)	AVX	06033A100JAT2A	0
98	R9	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	0
99	R13	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	0
100	R17	RES, 0, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04020000Z0ED	0
101	R25	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	0
102	R26	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	0
103	R34	RES, 0, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04020000Z0ED	0
104	R41	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	0
105	R43	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V	0

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

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.
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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 instructions, 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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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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