TPS2384 Evaluation Module

This user's guide describes the TPS2384 HPA109 evaluation module (EVM) and contains the EVM schematic, bill of materials, assembly drawing, and top and bottom board layouts.

Contents

List of Figures

List of Tables

1 Related Equipment and Documentation from Texas Instruments

1.1 Related Equipment

The TI EV2400 USB-Based PC Interface Board is required to communicate with the TPS2384 EVM from the EVM's Windows-based control/monitor GUI. This interface EVM can be ordered from the TI website at www.ti.com.

1.2 Related Documentation

- Data Sheet, *TPS2384 Quad Integrated Power Sourcing Equipment Power Manager*, SLUS634.
- *EV2400 Evaluation Module Interface Board User's Guide*, SLUU446.
- USB Drivers for Windows XP and Windows 2000, SLUC578. (ZIP file, USB drivers for EV2400 board for Windows PC.)
- Software Files for TPS2384EVM, SLVC078. (ZIP file, installation files for TPS2384EVM control GUI.)

2   Introduction

This user's guide describes the setup and operation of the TPS2384 HPA109 evaluation module (EVM). Information and instruction presented throughout this document assumes user familiarity with the TPS2384 and with the IEEE 802.3af Specification for Power Over Ethernet.

3   Hardware Overview

The HPA109 EVM features the TPS2384 made by Texas Instruments. This EVM can be configured as an endpoint power sourcing equipment (PSE) or as a midspan PSE. Four-input and four-output RJ-45 connectors are provided to connect directly to an Ethernet cable.

According to the IEEE 802.3af specification, the PSE can apply power over the data lines or over the spare lines on the Ethernet cable. The HPA109 EVM has been designed with jumpers for applying power in either configuration.

The HPA109 EVM is designed such that the TPS2384 device can operate in either *Auto Mode* or *Power Management Mode*. A graphical user interface (GUI) has also been developed to read and write to the TPS2384 internal registers using the I^{2}C interface.

4   EVM Operation

4.1   Operation

An external 48-V power supply connected to J3 pin 1 (positive) and J3 pin 3 (negative) is required. JV1 is installed at the factory to apply the 48 volts coming out of the TPS2490 hot-swap controller to the TPS2384 device. JP2 and JP3 also are installed at the factory to give the user the capability to use the S1 reset switch. Depressing S1 generates a logic low signal to the PORB input of the TPS2384 which resets all internal state machines and registers.

The JMS1 jumper is also installed at the factory between pin 1 and pin 2. This sets the Mode Select (MS) to *Auto Mode*. In *Auto Mode*, the TPS2384 automatically discovers, classifies, and powers up IEEE 802.3af-compliant powered devices (PD). Power is applied to the Ethernet port on either the spare pairs or on the data lines of the RJ-45 connector. The TPS2384 EVM has jumper blocks that allow the user to configure the method in which power is applied to the PD. Table 1 can help the user to set the appropriate jumpers depending on the desired power delivery configuration. Although the table shows only the connections for the P1_OUT1 connector, the information applies to all four output RJ-45 connectors.

Table 1. Output RJ-45 Connectors

Insert 48 volts on spare pins of RJ-45 connector, P1_OUT1 (positive on pins 4 and 5 and negative on pins 7 and 8).	
Jumper Block P1P1	Install jumper between the center pin and 1P.
Jumper Block P1N1	Install jumper between the center pin and 1N.
Jumper Block P1PX1	Do not install jumper.
Jumper Block P1NX1	Do not install jumper.
Insert 48 volts on spare pins of RJ-45 connector, P1_OUT1 (positive on pins 7 and 8 and negative on pins 4 and 5).	
Jumper Block P1P1	Install jumper between the center pin and 1N.
Jumper Block P1N1	Install jumper between the center pin and 1P.
Jumper Block P1PX1	Do not install jumper.
Jumper Block P1NX1	Do not install jumper.
Insert 48 volts on data pairs of RJ-45 connector, P1_OUT1 (positive on pins 1 and 2 and negative on pins 3 and 6).	
Jumper Block P1P1	Do not install jumper.
Jumper Block P1N1	Do not install jumper.
Jumper Block P1PX1	Install jumper between center pin and 1P.
Jumper Block P1NX1	Install jumper between center pin and 1N.
Insert 48 volts on data pairs of RJ-45 connector, P1_OUT1 (positive on pins 3 and 6 and negative on pins 1 and 2).	
Jumper Block P1P1	Do not install jumper.
Jumper Block P1N1	Do not install jumper.
Jumper Block P1PX1	Install jumper between center pin and 1N.
Jumper Block P1NX1	Install jumper between center pin and 1P.

While operating in *Auto Mode*, the I^{2}C interface provided on the TPS2384 EVM can be used to monitor the internal TPS2384 registers. Information such as detection status, port status, classification status, and fault information is available over the I^{2}C interface.

In *Power Management Mode*, the I^{2}C interface can be used to manually power up and control the ports. For a complete description of *Power Management Mode* functions, see the TPS2384 data sheet (SLUS634).

4.2 Connectors

J1	I²C Connector
J2	Alternate Power Extraction Port Connector
J3	Power Input Connector
J4	Allows an external voltage source to be used instead of the VCC_I2C power on the J1 connector.
J5	Connector for an external optocoupler voltage source
J6 (V3.3)	Allows the V3.3 output of the TPS2384 to be used to drive the optocouplers.
J11	Connects PORB from the I2C interface (via the optocoupler) to the TPS2384
J7-J10	Connects the powered port LED to the respective port

4.3 Jumpers

JV1	Connects 48 volts from the output of the hot-swap controller to the TPS2384.
JP1	Connects the CT pin of the TPS2384 to ground. See the TPS2384 data sheet for further information.
JP2	Connects the manual reset switch and RC network to the POR pin of the TPS2384.
JP3	Used to connect a pullup resistor, R25, to the PORB pin of the TPS2384
JSDA_OUT1	Connects the SDA_O pin of the TPS2384 to the I²C data send optocoupler.
JSDA_IN1	Connects the SDA_I pin of the TPS2384 to the I²C data receive optocoupler.
JSCL1	Connects the SCL pin of the TPS2384 to the I²C clock receive optocoupler.
JALT1	Connects the ALT A/B pin of the TPS2384 to ground or to V3.3. See the TPS2384 data sheet for further information.
WDIS1	Connects the WD_DIS pin of the TPS2384 to ground or to V3.3. See the TPS2384 data sheet for further information.
JMS1	Connects the MS pin of the TPS2384 to ground or to V3.3. See the TPS2384 data sheet for further information.

4.4 Test Points

TEST POINTS	DESCRIPTION
TPV10	Test point for monitoring the 10-V internal bias source.
TPV6P3	Test point for monitoring the 6.3-V internal bias source.
TP3.3	Test point for monitoring the 3.3-V voltage source.
TPV2.5	Test point for monitoring the 2.5-V internal bias source.
TPG1, TPG2	Ground test points.
TPSCL1	Test point for monitoring the I²C clock input to the TPS2384.
TPSDAI1	Test point for monitoring the I²C data input to the TPS2384.
TPSDAO1	Test point for monitoring the I²C data output from the TPS2384.
TPCINT1, TPCINT2, TPCINT3, TPCINT4	Test points for monitoring the voltage ramp on the A/D integration capacitors for each port. These are high-impedance inputs, and performance may be affected by any additional impedance. It is recommended that a low-capacitance/FET input buffer be used when monitoring these test points.
TPPORB1	Test point for monitoring the status of the PORB input to the TPS2384.
TPINT1	Test point for monitoring the INTB output of the TPS2384.
TPSYN1	Test point for monitoring the SYN pin of the TPS2384.
TPCT1	Test point for monitoring the CT input pin to the TPS2384. This is a high impedance input and performance may be affected by any additional impedance. It is recommended that a low-capacitance/FET input buffer be used when monitoring this test point.
TPWD1	Test point for monitoring the WD_DIS input pin to the TPS2384.
TPAC_HI1	Test point for monitoring the AC_HI output of the TPS2384.
TPAC_LO1	Test point for monitoring the AC_LO output of the TPS2384.

4.5 I²C Interface

The I²C interface on the TPS2384 EVM can be used to read and write to the TPS2384 internal registers. For simplicity, an EVM available from Texas Instruments, the EV2400, can be used to connect the USB port of a personal computer (PC) to the I²C interface of the TPS2384 EVM. A graphical user interface (GUI) also has been developed specifically for the TPS2384 EVM. Section 5 of this document describes the connections and operation of the TPS2384 GUI.

For I²C operation, an external 3.3-V supply must be connected to J3 pin 4 and referenced to J3 pin 3, or J6 must be installed. Also, the jumpers JSDA_OUT1, JSDA_IN1, and JSCL1 must be installed.

Ensure that S2 address select switch is set for I²C binary address of 00001 (S2-1 closed and S2-2, S2-3, S2-4, and S2-5 open).

5 TPS2384 Graphical User Interface Operation

This section describes the setup and operation of the TPS2384 GUI for the HPA109 evaluation module. Two files, TPS2384EVM and TPS2384EVM.exe, must be downloaded from the TI Web site. These files are located at http://focus.ti.com/docs/toolsw/folders/print/tps2384evm.html#supportsoftware. Click on the word *Zip* beneath Product Description, Software Support at this location.

5.1 EV2400 Software

The EV2400 software is available for download from the TI Web site at the following location:

http://focus.ti.com/docs/toolsw/folders/print/EV2400.html

5.2 Connecting the PC to the EV2400

Using a standard USB cable, connect the USB port of the PC to the USB port of the EV2400.

5.3 Connecting the EV2400 to the HPA109 EVM

Using the wiring assembly provided with the EV2400, connect one end to the I²C port of the EV2400. Connect the other end to the I²C interface connector of the HPA109 EVM as follows:

- Red wire to J1 pin 1
- White wire to J1 pin 3
- Brown wire to J1 pin 5
- Black wire to J1 pin 8

5.4 Starting the GUI

After installing all the necessary files for both the EV2400 and the HPA109, start the TPS2384 GUI by executing the TPS2384EVM.exe file.

5.5 GUI Operation for TPS2384 Auto Mode (JMS1 Jumper Connected Between Pin 1 and Pin 2)

On the TPS2384 GUI, click on the *Start access* button. The *Enable Auto Read* button should be selected (this is the default mode). As a point of reference, a screen shot of the TPS2384 GUI is shown in Figure 1. The GUI register numbers shown on the GUI screen correspond to the register numbers on the TPS2384 data sheet.

- Register *0* shows the Chip ID and Chip Revision.
- Register *100* shows the classification and port status for each of the four ports. This register also shows the *Discovery Fail* and *Function Done* for each port.
- Register *101* shows the *Detect Status* for each of the four ports along with the *AtoD Active* status of each port.
- Registers 110 to 1101 show the raw data and converted data for resistance, voltage, and current. Temperature data is not sampled in Auto Mode. Temperature data is only available in Power Management Mode.

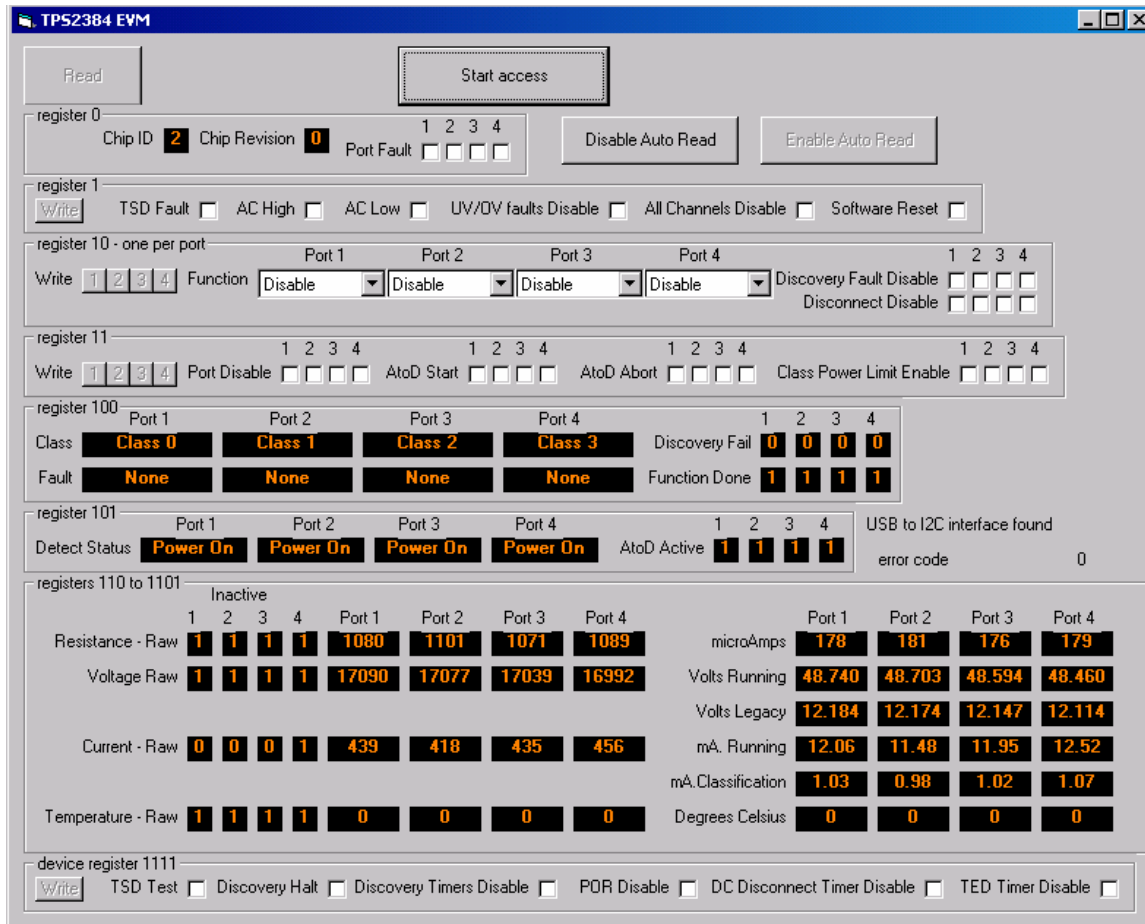In *Auto Mode*, only the read registers within the TPS2384 device are accessible.

Figure 1. Screen Shot of TPS2384 GUI – *Enable Auto Read* **Selected**

5.6 GUI Operation for TPS2384 Power Management Mode (JMS1 Jumper Connected Between Pin 2 and Pin 3)

After starting the TPS2384 GUI, click on the *Start access* button. This allows the GUI to report the TPS2384 status resisters. In order to control the TPS2384 write registers, depress the *Disable Auto Read* button.

Select the desired function in register *10* by selecting the pulldown arrow button under the desired port. The default function is shown as Disable (see Figure 2). All the functions appearing when the pulldown arrow button is selected correspond to the functions shown in the TPS2384 data sheet for the individual Port Write Control Register. For a description of each of the functions, see the *Power Management Mode* section of the TPS2384 data sheet (SLUS634).

After selecting the desired function, depress the corresponding port number on the left side of the GUI in the register *10* section. This writes the command into the TPS2384 register and thereby performs that operation.

To view the status, depress the *Read* button on the top left of the GUI. This is a one-time event that takes a snapshot of the TPS2384 status registers. For a continuous update of the status registers, depress the *Enable Auto Read* button on the GUI.
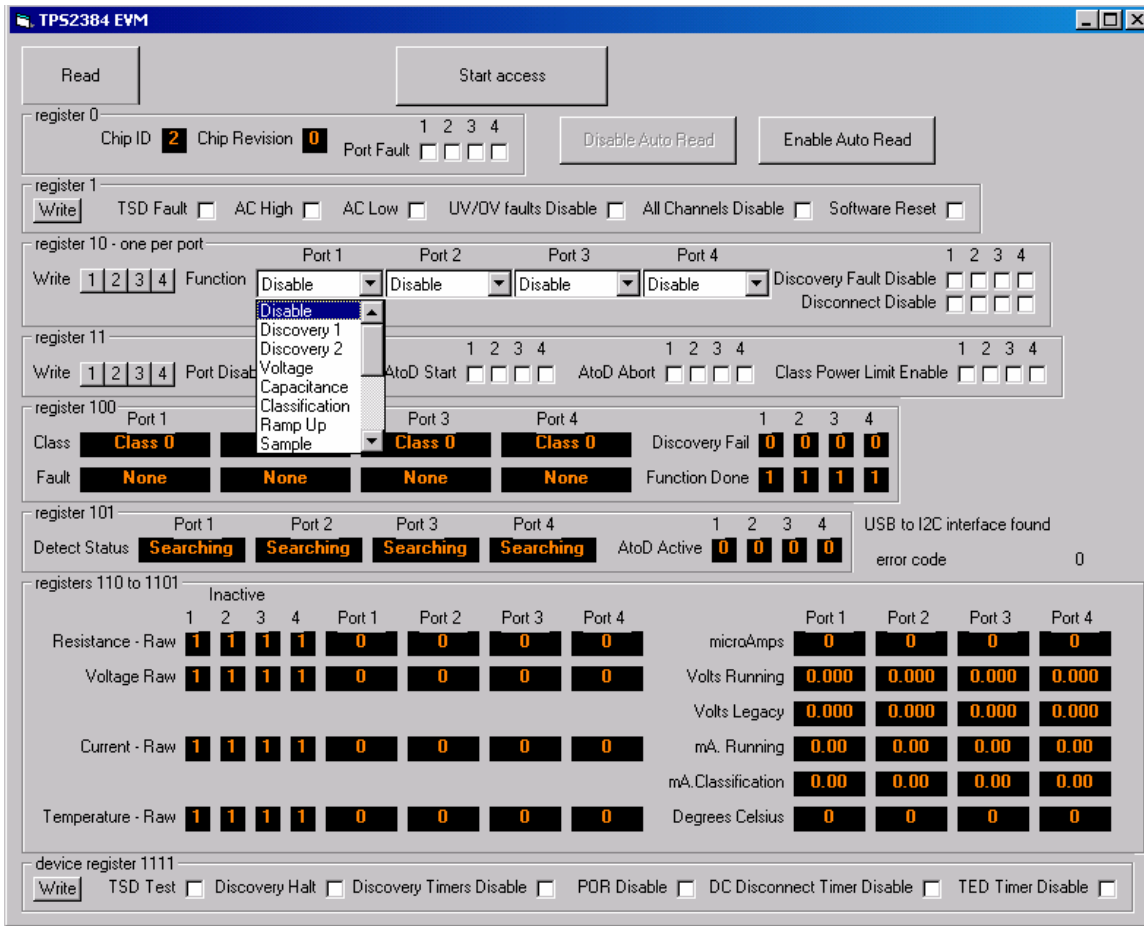
Figure 2. Screen Shot of the GUI – *Port Function Pulldown* **Selected**

6   Bill of Materials

Table 2 contains the bill of materials for the TPS2384 HPA109 evaluation module.

Table 2. HPA109 Bill of Materials

Count	Ref Des	Value	Size	MFR	Part Number	Description[1] [2] [3] [4] [5]
4	1GND1, 2GND1 3GND1, 4GND1	GND	SMD	Keystone	5016	Test Point, SM, 0.150 x 0.090"
7	C1, C7, C8, C10, C11, C16, C20	0.1 µF	1206	KEMET	C1206C104K1RACTU	CAP CER 0.1UF 100-V X7R 1206 ±10%
4	C12, C13, C14, C15	0.027 µF	SM	Panasonic	ECHU1H273GX5	Capacitor, Film Chip, .027-µF, 50-V, 2%
3	C17, C18, C19	0.1 µF	805	AVX Corporation	0805ZC104KAT2A	Capacitor, Ceramic, 10-V, X7R, 10%
1	C2	0.1 µF	805	KEMET	C0805C104K9RACTU	Capacitor, Ceramic, 0.1-µF, 6.3-V, X7R, 10%
4	C1A1,C2A1, C3A1, C4A1	0.22 µF	1210	Yageo	CC1210KKX7R0BB224	Capacitor, Ceramic, 0.22-µF, 100-V, X7R, 10%
1	C3	0.1 µF	1206	KEMET	C1206Y104K9RAC7800	Capacitor, Ceramic, 0.1-µF, 6.3-V, X7R, 10%
1	C4	220 µF	SMD	Panasonic	EEVFK2A221M	Capacitor, Aluminum, 220-µF, 100-V, 20%
1	C5	1 µF	805	Taiyo Yuden	UMK212B7105KG-T	CAP CER 1UF 50-V X7R 0805 ±10%
1	C6	68 µF	SMD	Panasonic	EEV-FK2A680Q	Capacitor, Aluminum, SM, 68 µF, 100-V
1	C9	220 pF	805	AVX Corporation	08051A221FAT2A	Capacitor, Ceramic, 220 pF, 100-V, NP0, 1%
8	CF1, CF2, CF5, CF6, CF9, CF10, CF13, CF14	1000 pF	1808	TDK Corporation	C4520X7R3D102K130KE	CAP CER 1000PF 2KV X7R 1808 ±10%
8	CF3, CF4, CF7, CF8, CF11, CF12, CF15, CF16	0.01 µF	805	Yageo	CX0805MRX7R0BB103	Capacitor, Ceramic, 0.01 µF, 100-V, X7R, 20%
8	D13, D14, D15, D16, D21, D22, D23, D24	GBLC03C	SOD-323	Protek Devices	GBLC03C	Diode, TVS, 19 Clamping Voltage, 350W
4	D25, D26, D27, D28	1SMB5932BT3		ON Semiconductor	1SMB5932BT3G	DIODE ZENER 20-V 3W SMB
4	D29, D30, D31, D32	SMAJ10A	SMA	Vishay Semiconductor Diodes Division	P4SMA10A-E3/61	TVS DIODE 8.55VWM 14.5VC SMA
6	D3, D7, D17, D18, D19, D20	LN1371G	SMD	Lite On	LTST-C170GKT	Diode, LED, Water Clear, 120-mA, 6-mcd
1	D33	1SMA5919BT3	SMA	ON Semiconductor	SZ1SMA5919BT3G	DIODE ZENER 5.6-V 1.5W SMA
1	D4	SMAJ58A	SMA	Vishay	SMAJ58A	Diode, Switching, 58-V, 400W
1	D8	SMAJ12A	SMA	Vishay Semiconductor Diodes Division	P4SMA12A-E3/61	TVS DIODE 10.2VWM 16.7VC SMA
8	DAC1, DAC2, DAC4, DAC5, DAC7, DAC8, DAC11, DAC13	STPS1H100A	SMA	ST	STPS1H100A	Diode, Schottky, 1-A, 100 V
1	DAC3	S2B	SMB	Diodes Inc.	ES2B-13-F	DIODE GEN PURP 100-V 2-A SMB
4	DAC6, DAC9, DAC10, DAC12	ES2B/A	SMA	Diodes, Inc.	ES2BA-13-F	DIODE GEN PURP 100-V 2-A SMA
4	F1, F2, F3, F4	RXE090	TH	Littelfuse Inc.	RXE090	POLYSWITCH RXE SERIES 0.90A HOLD
1	J1	1793840000	TH	Weidmüller	1793840000	Header, 8-pin, 150 mil spacing
1	J1 Socket	1798900000		Weidmüller	1798900000	Header, 8-pin, Socket, 150 mil spacing
1	J2	PTC36SAAN	TH	Sullins Connector Solutions	PEC36SAAN	CONN HEADER .100 SINGL STR 36POS
1	J3	1793830000	TH	Weidmüller	1793830000	Header, 6-pin, 150 mil spacing
1	J3 Socket	1798890000		Weidmüller	1798890000	Header, 6-pin, Socket, 150 mil spacing
11	J4, J5, J6, J7, J8, J9, J10, J11, JP1, JP2, JP3	PTC36SAAN	TH	Sullins Connector Solutions	PEC36SAAN	CONN HEADER .100 SINGL STR 36POS
3	JALT1, WDIS1,JMS1	PTC36SAAN	TH	Sullins Connector Solutions	PEC36SAAN	CONN HEADER .100 SINGL STR 36POS

[1]   These assemblies are ESD sensitive, ESD precautions shall be observed.
[2]   These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
[3]   These assemblies must comply with workmanship standards IPC-A-610 Class 2.
[4]   Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.
[5]   Add 6 rubber bumpers to the bottom side of the board.

Table 2. HPA109 Bill of Materials (continued)

Count	Ref Des	Value	Size	MFR	Part Number	Description[1] [2] [3] [4] [5]
4	JSCL1, JSDA_IN1, JSDA_OUT1, JV1	PTC36SAAN	TH	Sullins Connector Solutions	PEC36SAAN	CONN HEADER .100 SINGL STR 36POS
4	L1, L2, L3, L4	TTDLF2500	SMD	Coilcraft	TTDLF2500	Inductor, 2 Lines, 0.500A, 5 μH
8	P1_IN1, P1_OUT1, P2_IN1, P2_OUT1, P3_IN1, P3_OUT1, P4_IN1, P4_OUT1	RJ-45	TH	TE Connectivity AMP Connectors	556416-1	CONN MOD JACK 8P8C VERT UNSHLD
16	P1N1, P1NX1, P1P1, P1PX1, P2N1, P2NX1, P2P1, P2PX1, P3N1, P3NX1, P3P1, P3PX1, P4N1, P4NX1, P4P1, P4PX1	PTC36SAAN	TH	Sullins Connector Solutions	PTC36SAAN	CONN HEADER .100 SINGL STR 36POS
1	Q1	IRF540NS	D2PAK	Infineon Technologies	IRF540NSTRLPBF	MOSFET N-CH 100-V 33-A D2PAK
1	Q2	BSS119	SOT23	Fairchild semiconductor corporation	BSS123	Trans MOSFET, N-ch, 100-V, 0.17-A, 3-Pin SOT-23 T/R
1	Q3	FDV301N	SOT23	Fairchild	FDV301N	MOSFET, Nch, 25 V, 220-mA, 5 Ω
1	R1	7.15 K	805	TE Connectivity Passive Product	RN73C2A7K15BTDF	RES SMD 7.15KOHM 0.1% 1/10W 0805
4	R11, R13, R14, R15	2 K	805	Stackpole Electronics Inc.	RNCS0805BKE2K00	RES SMD 2K OHM 0.1% 1/10W 0805
4	R35, R36, R37, R38	10 K	805	Susumu	RR1220P-103-D	RES SMD 10K OHM 0.5% 1/10W 0805
1	R21	1 K	805	Susumu	RR1220P-102-D	RES SMD 1K OHM 0.5% 1/10W 0805
1	R18	0.01	2512	Bourns Inc.	CRF2512-FZ-R010ELF-ND	RES SMD 0.01 OHM 1% 2W 2512
1	R19	0.0 Ω	805	Yageo	RC0805JR-070RL	RES SMD 0.0 OHM JUMPER 1/8W 0805
3	R2, R3, R4	200 Ω	805	Susumu	RR1220P-201-D	RES SMD 200 OHM 0.5% 1/10W 0805
1	R20	330	805	Susumu	RR1220P-331-D	RES SMD 330 OHM 0.5% 1/10W 0805
1	R22	100 Ω	805	Susumu	RR1220P-101-D	RES SMD 100 OHM 0.5% 1/10W 0805
1	R25	10 K	805	Vishay Foil Resistors (Division of Vishay Precision Group)	Y162910K0000F9R	RES SMD 10K OHM 1% 1/10W 0805
1	R26	124 K	805	TE Connectivity Passive Product	RN73C2A124KBTDF	RES SMD 124K OHM 0.1% 1/10W 0805
1	R5	69.8 K	805	TE Connectivity Passive Product	RN73C2A69K8BTDF	RES SMD 69.8KOHM 0.1% 1/10W 0805
4	R6, R9, R12, R17	3.3 K	805	Susumu	RR1220P-332-D	RES SMD 3.3K OHM 0.5% 1/10W 0805
1	R7	187 K	805	Susumu	RR1220P-1873-D-M	RES SMD 187K OHM 0.5% 1/10W 0805
1	R8	100 K	805	Panasonic Electronic Components	ERJ-6GEYJ104V	RES SMD 100K OHM 5% 1/8W 0805
4	RAC1, RAC2, RAC3, RAC4	7.5 K	805	Susumu	RR1220P-752-D	RES SMD 7.5K OHM 0.5% 1/10W 0805
16	RF1, RF2, RF3, RF4, RF5, RF6, RF7, RF8, RF9, RF10, RF11, RF12, RF13, RF14, RF15, RF16	75	603	Yageo	RC0603JR-0775RL	RES SMD 75 OHM 5% 1/10W 0603
1	S1	KT11P2JM	SMD	C & K	KT11P2JM34LFS	SWITCH TACTILE SPST-NO 1VA 32 V
1	S2	76SB06S	TH	Grayhill	76SB06ST	SWITCH ROCKER DIP SPST 150MA 30 V
4	T1, T2, T3, T4	H2019	SMD	Pulse Electronics Corporation	H2019FNLT	XFRMR MAGNT MOD 1PORT POE 10/100
20	TP3.3, TPAC_HI1, TPAC_LO1, TPCINT1, TPCINT2, TPCINT3, TPCINT4, TPCT1, TPG1, TPG2, TPINT1, TPPORB1, TPSCL1, TPSDAI1, TPSDAO1, TPSYN1, TPV10, TPV6P3, TPWD1,TVP2.5	G10	TH	Keystone	5012	Test Point, White, O.062 Hole
1	U1	PS8802-1-F3-AX	SO-8	CEL	PS8802-1-F3-AX	IC, Optocoupler, Single Open Collector Out Put
1	U3	PS8802-1-F3-AX	SO-8	CEL	PS8802-1-F3-AX	IC, Optocoupler, Single Open Collector Out Put
1	U2	PS8802-2-AX	SO-8	CEL	PS8802-2-AX	OPTOISO 2.5KV 2CH TRANS 8SOIC
1	U4	TPS2490DGS	DGS10	Texas Instruments	TPS2490DGS	IC, TPS2490DGS

Table 2. HPA109 Bill of Materials (continued)

Count	Ref Des	Value	Size	MFR	Part Number	Description[1] [2] [3] [4] [5]
1	U5	SN74LVC06A	SO14	Texas Instruments	SN74LVC06AD	IC, High-Speed CMOS Logic Hex Inverting Schmitt Trigger
1	U6	TPS2384PAP	PQFQ-64	Texas Instruments	TPS2384PAP	IC, Quad Ethernet Power Sourcing
1	–			Any	HPA109B	PCB, 9.3 In x 4.9 In x 0.062 In
1	Shunt			3M Interconneect	929950-00	SHORTING JUMBER UNPLATED BLK

7   EVM Schematic and Layouts

The EVM schematic and top and bottom board layouts are appended.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from D Revision (July 2011) to E Revision   **Page**

•   Changed all EV2300 to EV2400 throughout the document.. 1
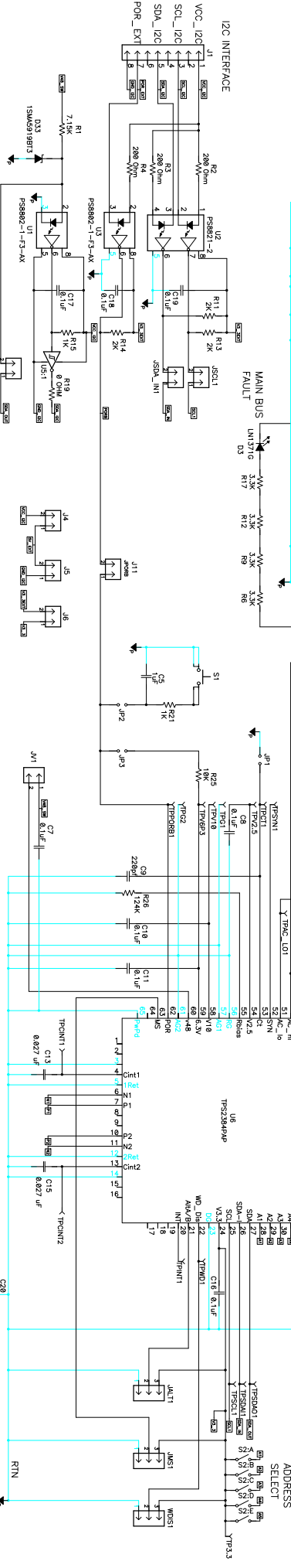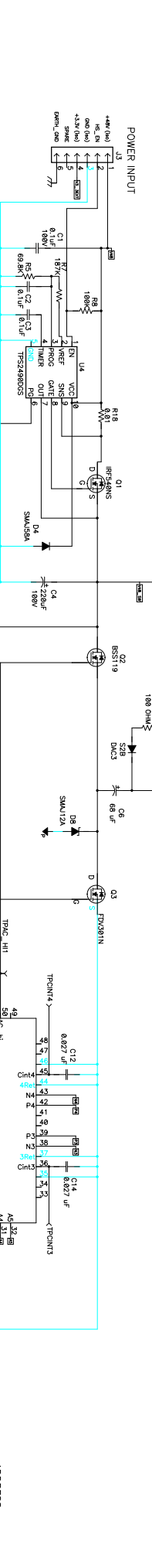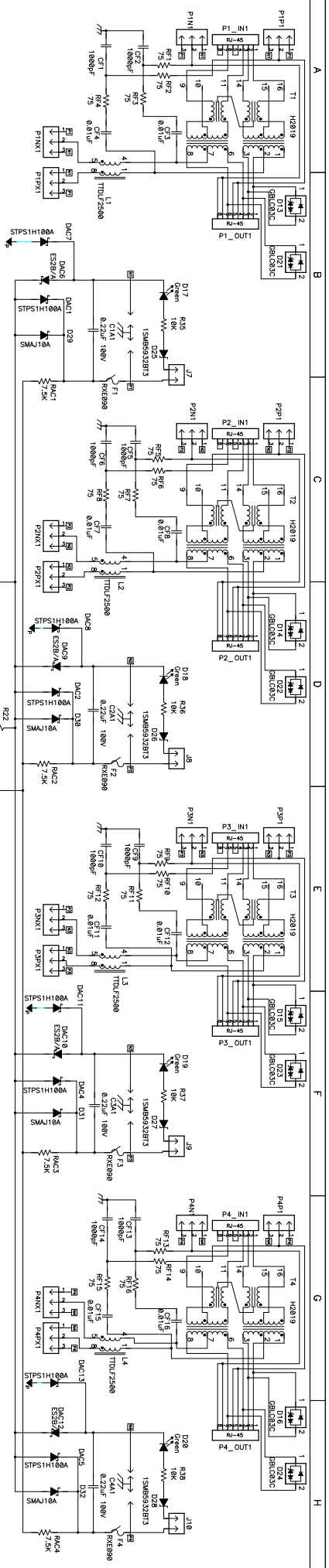
DID NOT ADD THE NEW SPARKGAPS- PER DAVID A.

⚠ NOT USED

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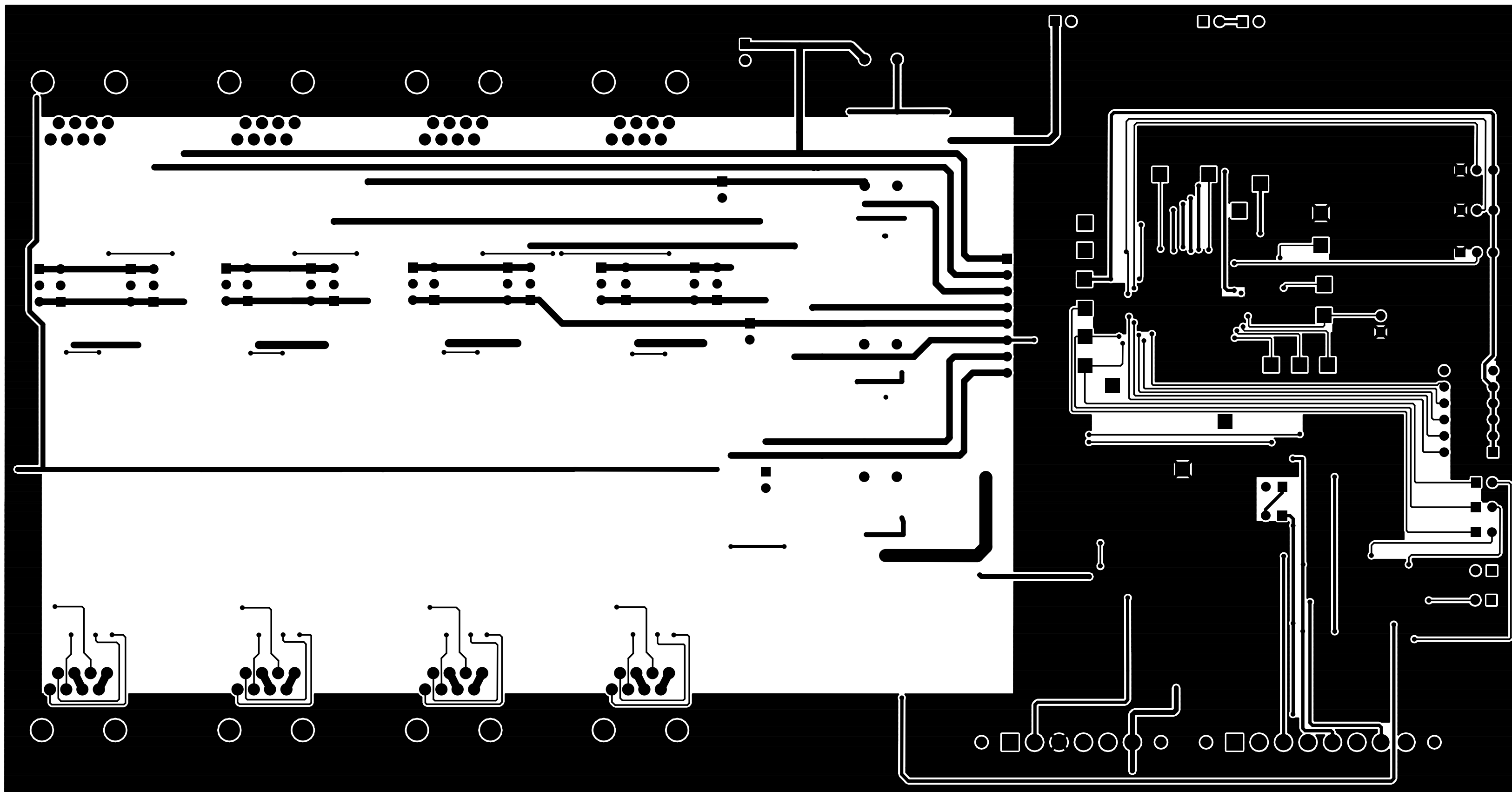
LAYER 2
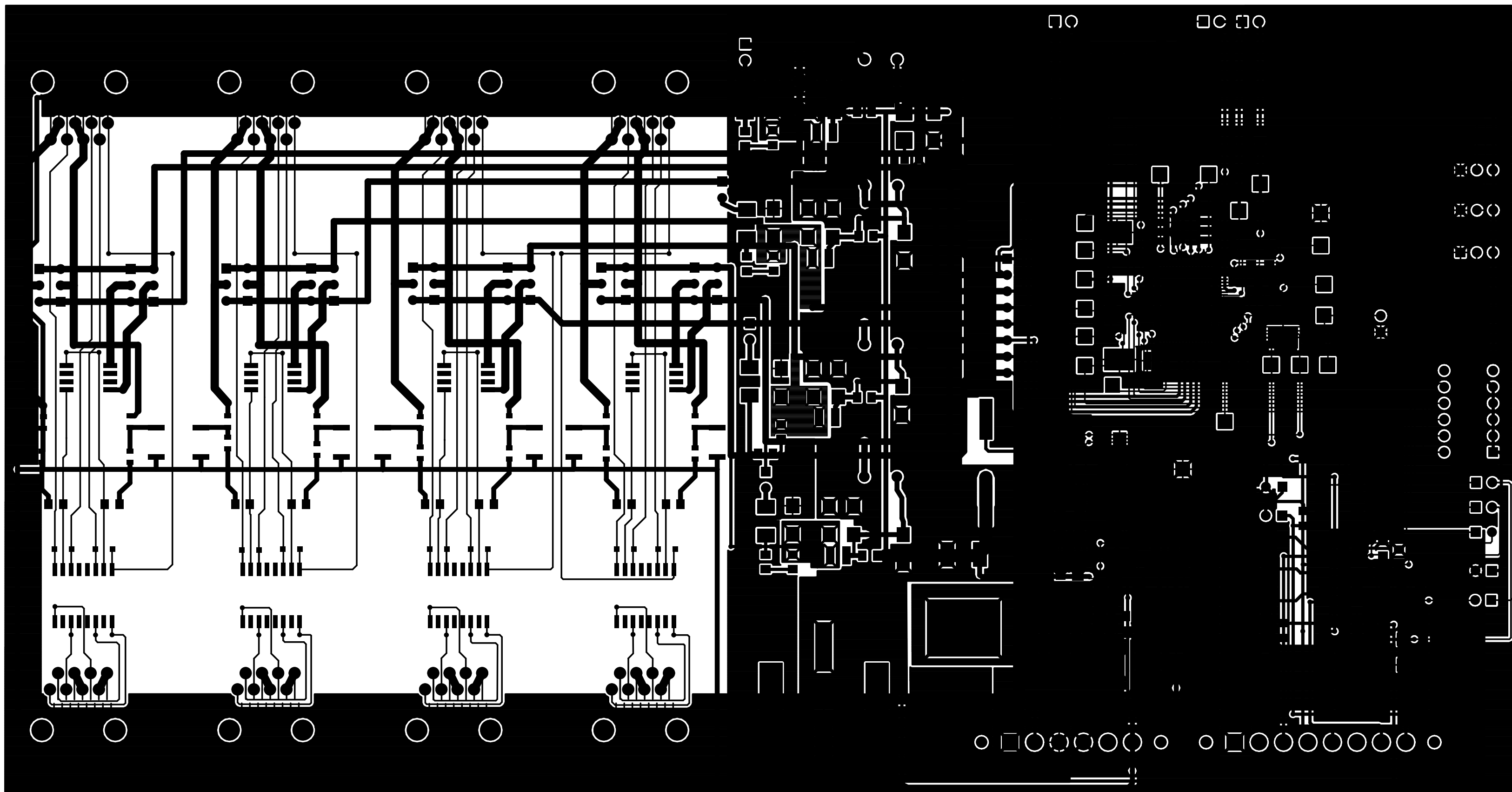
LAYER 1
LAYER 2
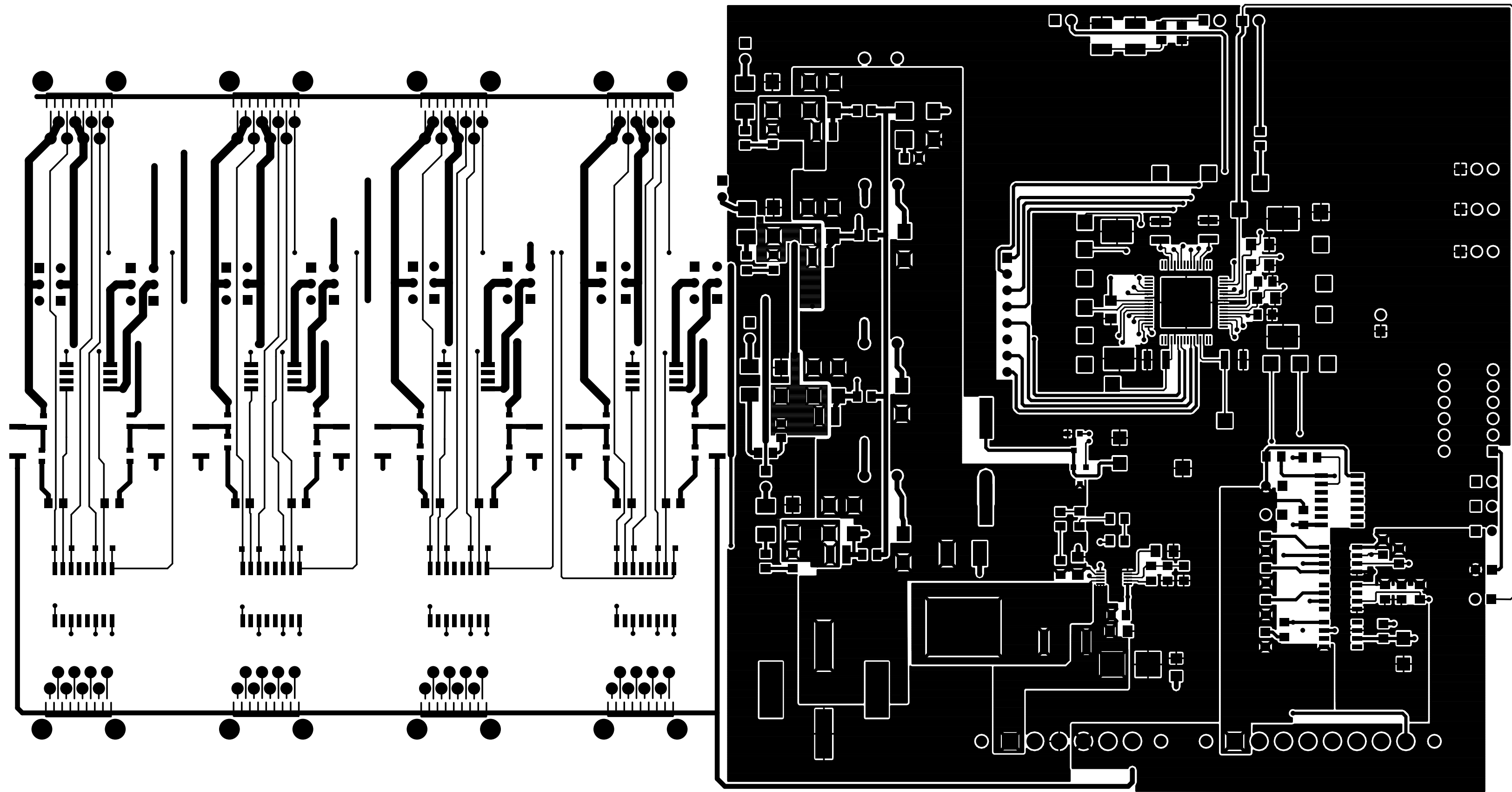
LAYER 1

Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive.**

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.**

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please contact the TI application engineer or visit www.ti.com/esh.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 44 V to 57 V and the output voltage range of 44 V to 57 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 85°C. The EVM is designed to operate properly with certain components above 85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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.

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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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。
　　　上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿６丁目２４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/lsds/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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.