

**ABSTRACT**

The LMG352XEVM-04X features two LMG352XR0X0 650-V GaN FETs with an integrated driver and protection in a half-bridge configuration with all the required bias circuit and logic/power level shifting. Essential power stage and gate-driving, high-frequency current loops are fully enclosed on the board to minimize power loop parasitic inductance for reducing voltage overshoots and improving performance. The LMG352XEVM-04X is configured for a socket style external connection for easy interface with external power stages to run the LMG352XR0X0 in various applications. Refer to the LMG352XR0X0 data sheet before using this EVM.

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Trademarks

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1 General TI High Voltage Evaluation User Safety Guidelines



Always follow TI's set-up and application instructions, including the use of all interface components within the recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and the safety of those working around you. Contact TI's Product Information Center at <http://support/ti.com> for further information.

Note

Save all warnings and instructions for future reference.

Failure to follow warnings and instructions may result in personal injury, property damage, or death due to electrical shock and/or burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed PCB (printed circuit board) assembly. It is intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise, and knowledge of electrical safety risks in development and application of high-voltage electrical circuits. Any other use or application is strictly prohibited by Texas Instruments. If you are not suitably qualified, you must immediately stop from further use of the HV EVM.

- **Work Area Safety:**

- Maintain a clean and orderly work area.
- Qualified observer(s) must be present anytime circuits are energized.
- Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized; indicating operation of accessible high voltages may be present for the purpose of protecting inadvertent access.
- All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50 VRMS/75 VDC must be electrically located within a protected Emergency Power Off (EPO) power strip.
- Use a stable and non-conductive work surface.
- Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.

- **Electrical Safety:**

- As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
- De-energize the TI HV EVM and all its inputs, outputs, and electrical loads before performing any electrical or other diagnostic measurements. Confirm that TI HV EVM power has been safely de-energized.
- After confirming the EVM is de-energized, proceed with the required electrical circuit configurations, wiring, measurement equipment hook-ups, and other application needs while still assuming the EVM circuit and measuring instruments are electrically live.
- When EVM readiness is complete, energize the EVM as intended.

WARNING

While the EVM is energized, never touch the EVM or its electrical circuits as they could be at high voltages capable of causing electrical shock hazard.

- **Personal Safety:**

- Wear personal protective equipment like latex gloves and safety glasses with side shields, or protect the EVM from accidental touch in an adequate translucent plastic box with interlocks.

- **Limitation for Safe Use:**

- EVMs are not to be used as all or part of a production unit.

1.1 Safety and Precautions

The EVM is designed for professionals who have received the appropriate technical training and is designed to operate from an AC power supply or a high-voltage DC supply. Read this user guide and the safety-related documents that come with the EVM package before operating this EVM.

CAUTION



Do not leave the EVM powered when unattended.

WARNING



Hot surface! Contact may cause burns. Do not touch!

WARNING



High Voltage! Electric shock is possible when connecting board to live wire. Board must be handled with care by a professional.

For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

2 Introduction

The LMG352XEVM-04X operates as a half-bridge daughter card that can be either part of a larger custom designed system or paired with the mother board. TI provides two mother boards (LMG342X-BB-EVM and LMG34XX-BB-EVM) to interface with LMG352XEVM-04X. LMG342X-BB-EVM can support up to 4-kW, and LMG34XX-BB-EVM can provide up to 1.7-kW. The mother boards are designed to operate LMG352XR0X0 in an open-loop synchronous buck or boost converters. Probe locations are provided to measure the logic and power stage voltages.

Note

TI provides a custom interposer board that must be used when the LMG352XEVM-04X is paired with the LMG34XX-BB-EVM. The interposer board is not needed with LMG342x-BB-EVM.

2.1 LMG352XEVM-04X Daughter Card

The LMG352XEVM-04X has two LMG352XR0X0 GaN FETs in a half-bridge configuration. All the bias and level shifting components are included, which allows low-side referenced signals to control both FETs. High-frequency decoupling capacitors are included on the power stage in an optimized layout to minimize parasitic inductance and reduce voltage overshoot.

Table 2-1. EVM Version Lookup Table

EVM NAME	FEATURED GaN FET WITH INTEGRATED DRIVER AND PROTECTION
LMG3522EVM-042	LMG3522R030
LMG3525EVM-042	LMG3525R030 (with ideal diode mode)

There are 12 logic pins on the LMG352XEVM-04X.

Table 2-2. Logic Pin Function Description

PIN	PIN DESIGNATION	DESCRIPTION
LS PWM	1	Logic gate signal input for low-side LMG352XR0X0. Compatible with both 3.3-V and 5-V logic. Referenced to AGND.
HS TEMP	2	PWM TEMP output for high-side LMG352XR0X0. Referenced to AGND.
LS Fault	3	FAULT output signal for low-side LMG352XR0X0. Referenced to AGND.
HS OC	4	OC output signal for high-side LMG352XR0X0. Referenced to AGND.
LS OC	5	OC output signal for low-side LMG352XR0X0. Referenced to AGND.
HS Fault	6	FAULT output signal for high-side LMG352XR0X0. Referenced to AGND.
LS Temp	7	PWM TEMP output for low-side LMG352XR0X0. Referenced to AGND.
HS PWM	8	Logic gate signal input for high-side LMG352XR0X0. Compatible with both 3.3-V and 5-V logic. Referenced to AGND.
12V	9	Auxiliary power input for when the LMG352XEVM-04X is configured in bootstrap mode. Pin is not used when configured in isolated power mode.
5V	10	Auxiliary power input for the LMG352XEVM-04X. Used to power logic isolators. Used as input bias power of LMG352XR0X0 devices when configured in isolated power mode.
AGND	11,12	Logic and bias power ground return pin. Functionally isolated from PGND.

There are 6 power pins on the LMG352XEVM-04X.

Table 2-3. Power Pin Function Description

PIN	DESCRIPTION
SW	Switch node of the half-bridge configuration
HV	Input DC voltage of the half-bridge configuration
PGND	Power ground of the half-bridge configuration. Functionally isolated from AGND.

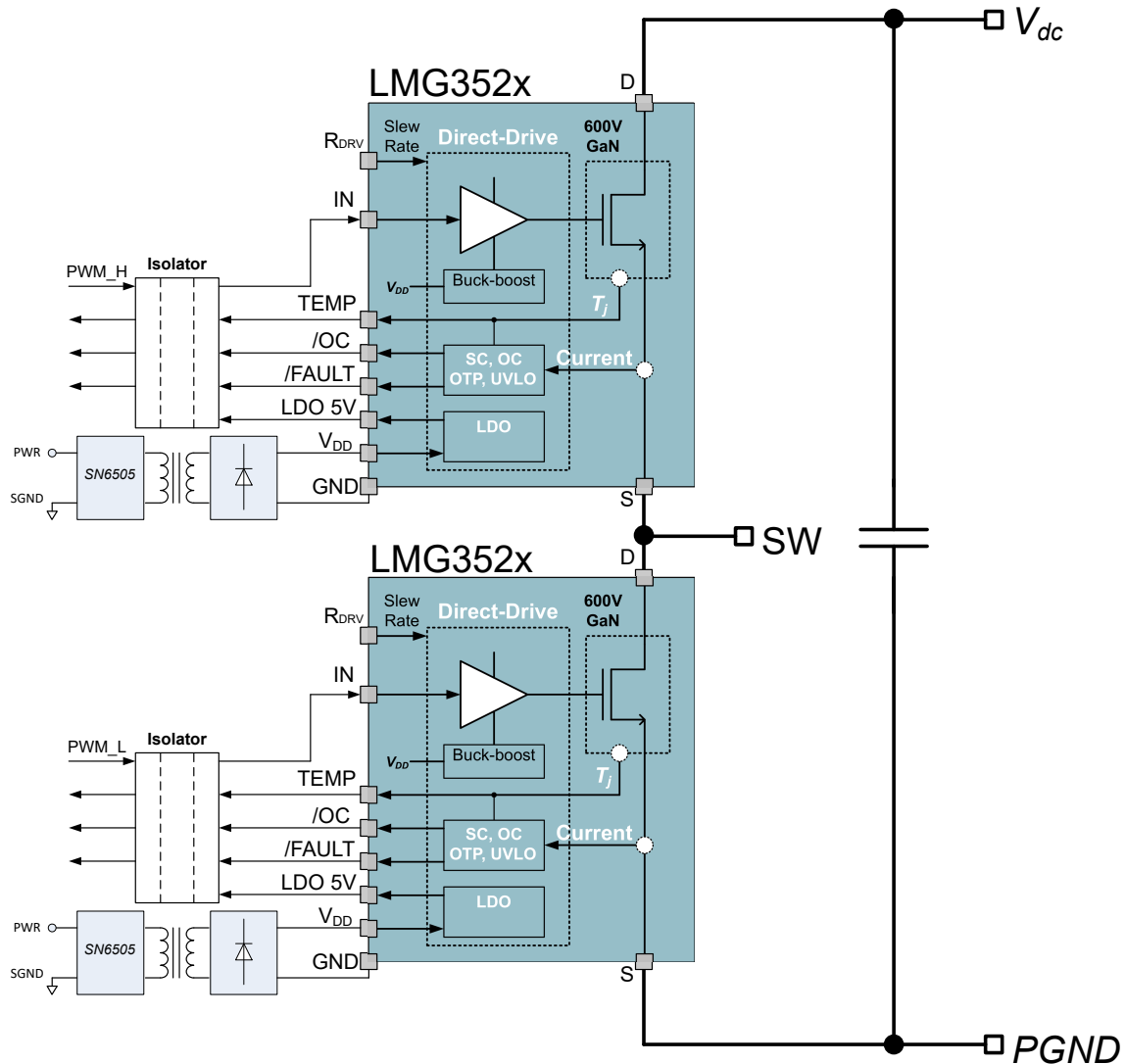


Figure 2-1. LMG352XEVM-04X Block Diagram

CAUTION

High-voltage levels are present on the evaluation module whenever it is energized. Take proper precautions when working with the EVM.

2.1.1 FAULT and OC

The FAULT and OC pins of the LMG352XEVM-04X are active low when an undervoltage lockout occurs on an auxiliary voltage rail, when an overtemperature event occurs, or when an overcurrent/short-circuit event occurs on the LMG352XR0X0. The signals are level-shifted to AGND. Refer to the LMG352XR0X0 data sheet for operation details.

CAUTION

Do NOT ignore a FAULT signal when using the LMG352XEVM-04X. Turn off both top and bottom devices if any device generates a FAULT signal. The device under a fault condition may operate in the undesired third-quadrant mode and can overheat or become damaged due to the high source-drain voltage drop if the other device is still switching.

2.1.2 Power Pins

There are some high frequency decoupling capacitors on the LMG352XEVM-04X from VDC to PGND to minimize voltage overshoot during switching, but more bulk capacitance is required to hold up the DC voltage during operation. TI recommends preventing any overlap and parasitic capacitance from VSW to VDC, PGND, and any logic pins. The two ground PGND and AGND pins are functionally isolated from each other on the LMG352XEVM-04X.

2.1.3 Bootstrap Mode

The LMG352XEVM-04X card can be modified to operate in bootstrap mode, where the 12-V bias voltage is used to power both LMG352XR0X0 devices. This can be achieved by the following modifications to the EVM:

1. Remove R1.
2. Place a 2- Ω resistor on R2.
3. Place a 650-V SMB diode on D1, such as GB01SLT06-214.
4. Adjust Rdrv resistor for the low side to be above 400 k Ω , which corresponds to a slew rate below 30 V/ns for the low side.

2.1.4 Heat Sink

The heat sink is installed to help with heat dissipation of the LMG352XR0X0. Exposed top-side thermal pads on device package are attached to heat sink with thermal interface material (TIM) pressed in between, providing a low thermal impedance path. The two exposed copper pads have a high-voltage potential difference between them, therefore an electrically isolated TIM with sufficient dielectric strength is required.

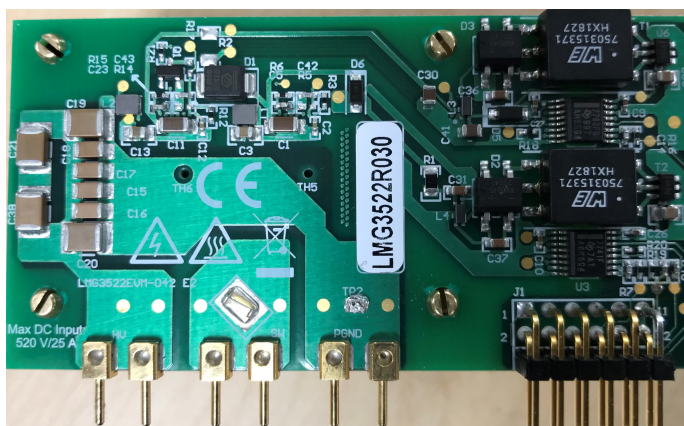


Figure 2-2. Front Side View of the EVM

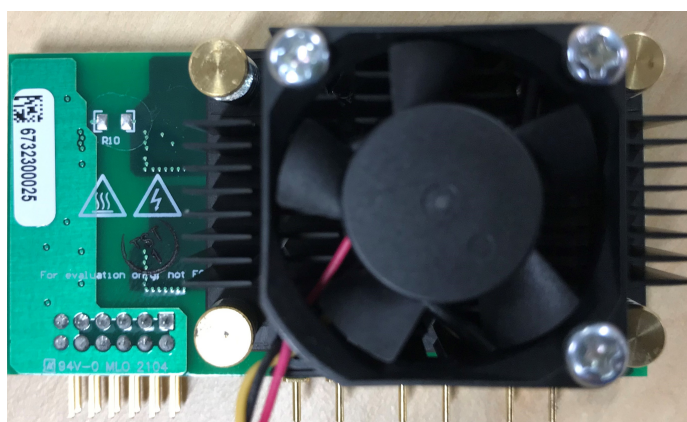


Figure 2-3. Back Side View of the EVM

2.1.5 Coldplate

In addition to the heatsink design, the LMG352XEVM-04X EVM card can also be attached to the coldplate as shown in [Figure 2-4](#). Like the heatsink design, similar thermal interface material can be applied in the coldplate design, and the thermal performance can be greatly improved. For more information of the EVM thermal design and test results, please refer to SNOAA70 application notes on thermal design. The coldplate used in LMG352XEVM-04X EVM card is custom designed, and please contact TI for more information.

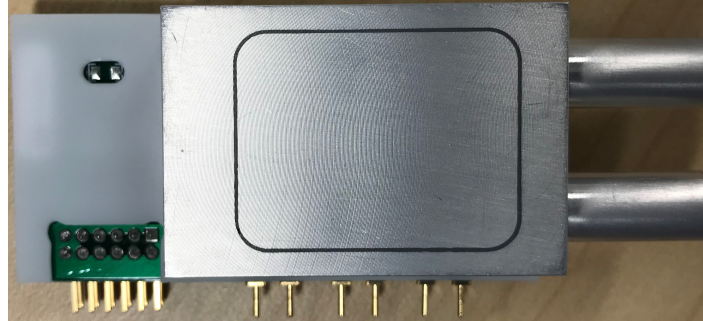


Figure 2-4. EVM on Coldplate

2.2 Mother Boards

Two mother boards are available from TI: LMG342X-BB-EVM and LMG34XX-BB-EVM.

Note

TI provides a custom interposer board that must be used when the LMG352XEVM-04X is paired with the LMG34XX-BB-EVM. The interposer board is not needed with LMG342x-BB-EVM.

2.2.1 Bias Supply

The motherboard requires one 12-V bias supply. A linear dropout regulator (in LMG34XX-BB-EVM) or buck regulator (in LMG342X-BB-EVM) steps the voltage down to a tightly regulated 5-V for the logic and auxiliary power of the LMG352XR0X0 when the LMG352XEVM-04X is configured in isolated power mode.

2.2.2 PWM Input

Both LMG342X-BB-EVM and LMG34XX-BB-EVM mother boards have on-board complementary PWM generation circuits that create a pair of complimentary PWM signals out of a single PWM input. A 0-V to 5-V square wave input is recommended. In LMG34XX-BB-EVM, the default dead time is 50ns, and other values are achievable by changing the resistance values (R1 and R5). In LMG342X-BB-EVM mother boards, the dead time can be easily adjusted by tuning the trimmer resistance values (R3 and R15).

2.2.3 Fault Protection

There is an option to disable the PWM input to the daughter card in the event of a fault signal from the LMG352XEVM-04X. When the FAULT Protect jumper is placed in the EN mode, PWM is disabled when either LMG352XR0X0 has an active fault. This disable is not latching, so PWM immediately resumes when the fault clears. If the FAULT Protect mode is not desired, that mode can be disabled by placing the jumper in the DIS position. The FAULT LED will still illuminate when either LMG352XR0X0 has an active fault, regardless of the position of FAULT Protect jumper.

2.3 Typical Applications

The LMG352XEVM-04X is designed for use in AC/DC, DC/DC and DC/AC applications:

- Totem-Pole PFC Converters
- Phase-Shifted Full Bridge or LLC Converters
- Inverters
- Buck or Boost Converters

2.4 Features

The LMG352XEVM-04X has the following features and specifications:

- Overtemperature, overcurrent, short-circuit, and undervoltage lockout protection with FAULT and OC indication that is level-shifted to an AGND referenced signal
- A real-time digital output with its duty cycle indicating the device's junction temperature
- Cycle-by-cycle overcurrent protection and latched short-circuit protection
- Gate logic input support of either 3.3-V or 5-V logic
- Maximum recommended operating voltage of 520-V and absolute maximum voltage of 650-V

The mother boards have the following features and specifications:

- Requires only a single 12-V bias supply
- Requires only a single 0-V to 5-V PWM input to generate a gate drive signal
- PWM disables in the event of a fault from the LMG352XEVM-04X
- Maximum recommended operating voltage of 520-V and absolute maximum voltage of 650-V

3 LMG352XEVM-04X Schematic

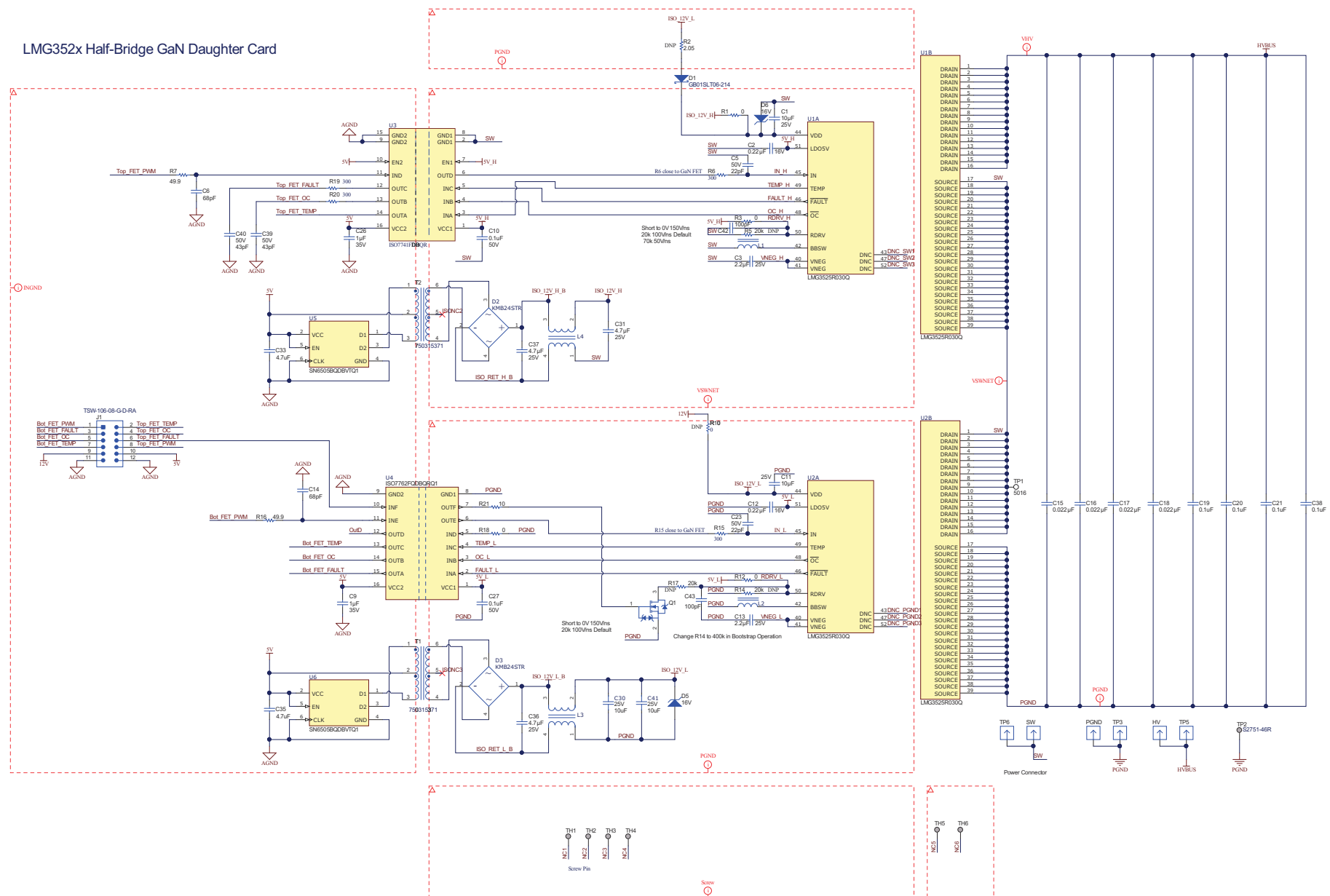


Figure 3-1. LMG352XEVM-04X Schematic

4 Mother Board Schematic

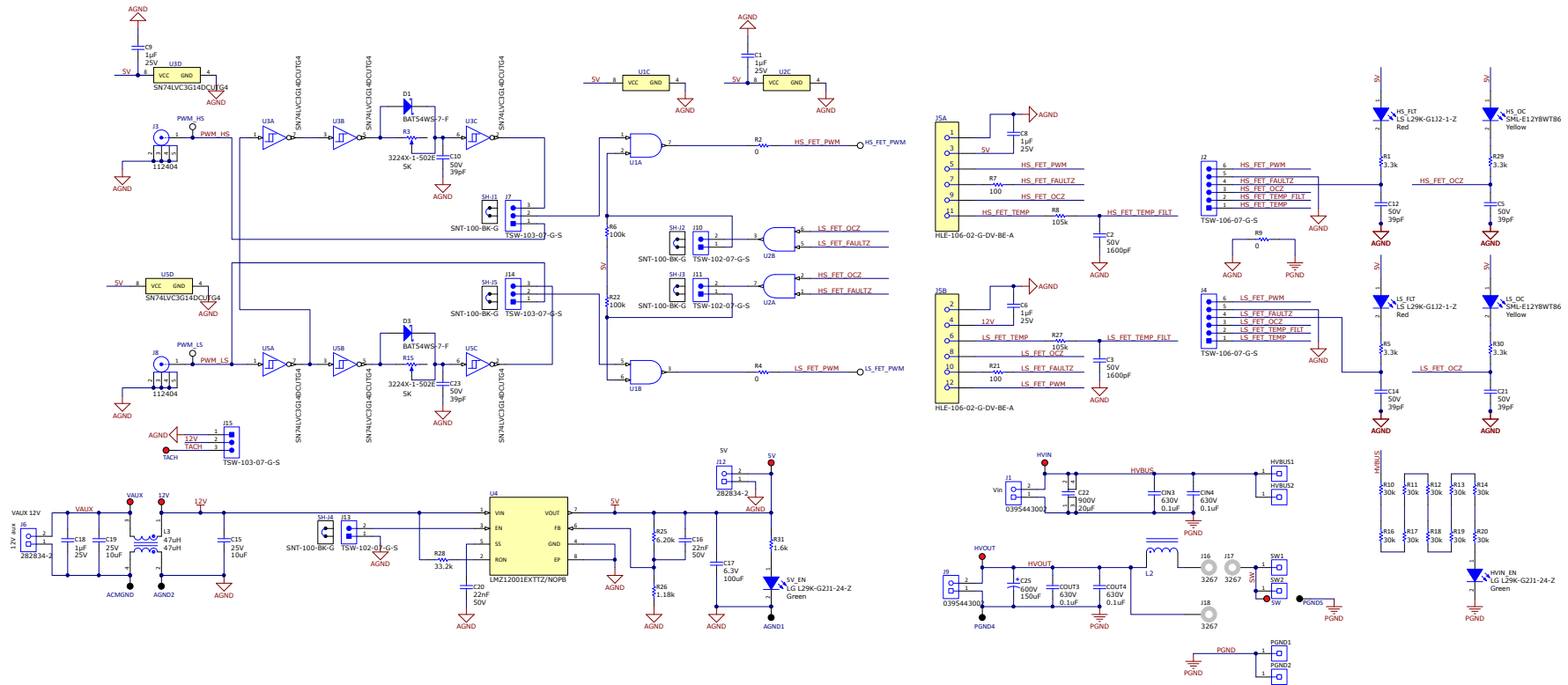
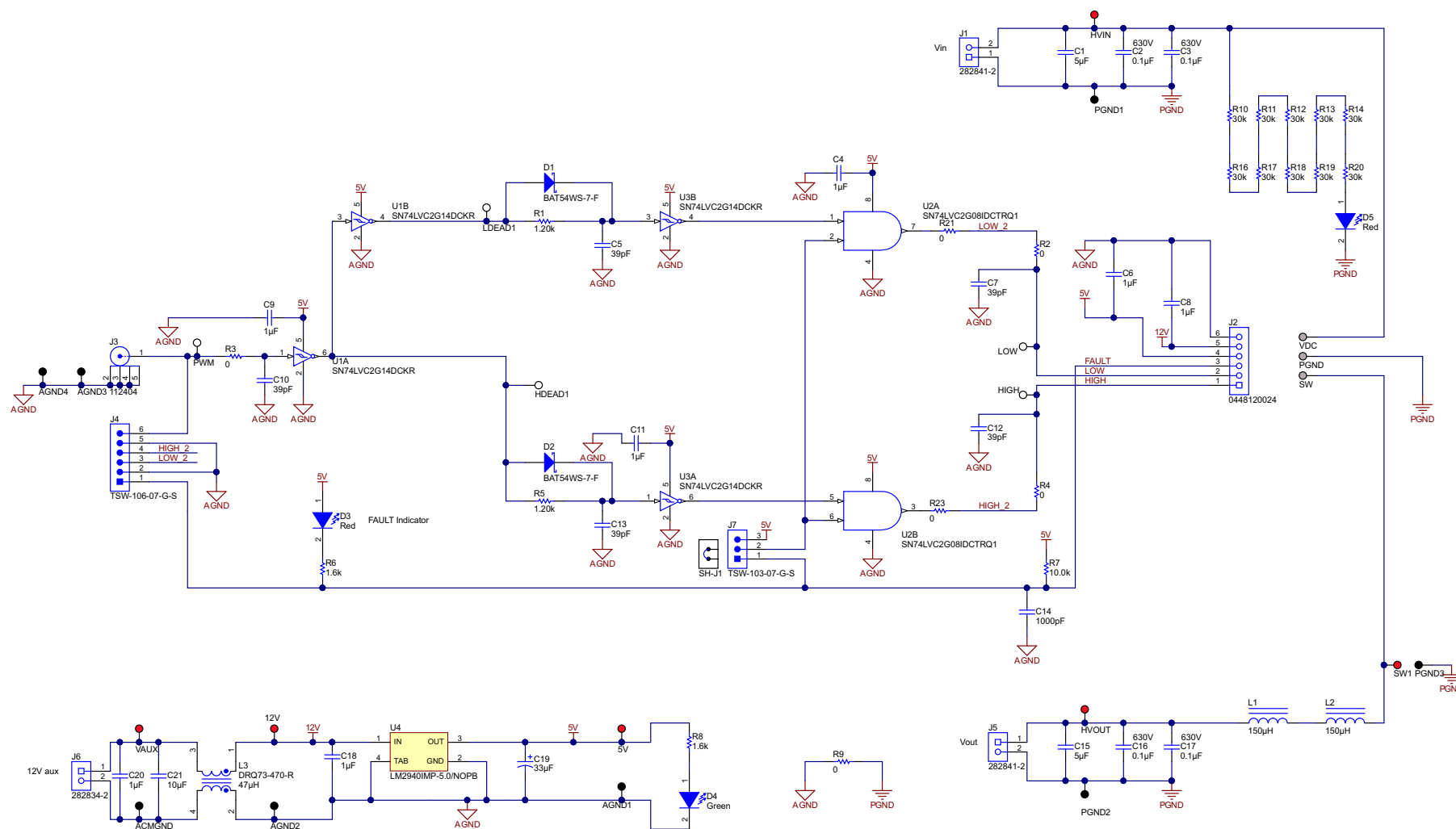


Figure 4-1. LMG342X-BB-EVM Schematic

TI HV Synchronous Buck Motherboard



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Figure 4-2. LMG34XX-BB-EVM Schematic

5 Recommended Footprint

When the EVM daughter card is used in a custom design system, the recommended footprint to interface with the LMG352XEVM-04X daughter card is shown below.

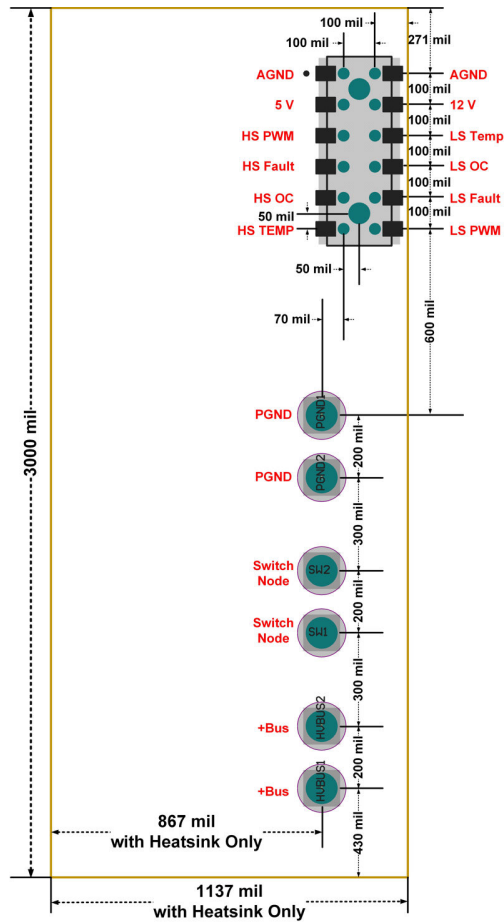


Figure 5-1. Recommended Footprint for LMG352XEVM-04X

6 Test Equipment

DC Voltage Source: Capable of supplying the input of the EVM up to 520 V.

DC Bias Source: Capable of 12-V output up to 1.5-A.

Function Generator: Capable of 0-V to 5-V square wave output with adjustable duty cycle and frequency in the operating range. TI recommends operating the LMG352XEVM-04X and mother boards with a switching frequency between 50 kHz to 200 kHz in hard-switching converters.

Note

TI provides a custom interposer board that must be used when the LMG352XEVM-04X is paired with the LMG34XX-BB-EVM. The interposer board is not needed with LMG342x-BB-EVM.

Oscilloscope: Capable of at least 200 MHz operation. A 1 GHz or greater oscilloscope and probes with short ground springs are required for accurate measurements.

DC Multimeter(s): Capable of 650-V measurement, suitable for determining operation and efficiency (if desired).

DC Load: Capable of 650-V operation at up to 20-A in current-mode operation.

Fan: For the heatsink-version EVM daughter card, a dedicated cooling fan is attached on the back side of the heatsink. Please make sure the fan is powered by the 12-V power supply before test.

7 Test Procedure When Paired With LMG342X-BB-EVM

7.1 Setup

The inductor on LMG342X-BB-EVM is capable of around 3-kW operation. For higher power levels, use an external inductor.

TI recommends the following procedure to set up the LMG342X-BB-EVM with the LMG352XEVM-04X:

1. Connect the LMG352XEVM-04X to LMG342X-BB-EVM as shown in [Figure 7-1](#). The area for connection on the mother board is shown in [Figure 7-2](#).
2. Install the LMG342X-BB-EVM inside a ventilated HV safety box.
3. Disconnect jumper J13 to enable the 12-V to 5-V on-board power conversion.
4. Disconnect jumper J12.
5. If the on-board complementary PWM generation circuits are used to generate the dead time, please connect Pin 2 to Pin 3 for header J7 and J14 with jumpers. Under this configuration, only one PWM signal is required and it can be connected to either J3 or J8.
6. If two complementary PWM signals with dead time are provided to J3 (high-side PWM) and J8 (low-side PWM), then please connect Pin 1 to Pin2 for header J7 and J14 (Pin1 of J7 and J14 are indicated in [Figure 7-2](#)). This allows the two PWM signals to directly control the high-side and low-side devices.
7. If fault interlock feature is desired, please connect jumper J10 and J11. Otherwise, disconnect them and the PWM signals can always pass through to the devices.
8. Set the signal generator to a desired frequency and duty cycle (e.g. 100 kHz, and 50% duty cycle). 5-V for high input and 0-V for low input.
9. Connect the signal generator output to the LMG342X-BB-EVM PWM input as shown in [Figure 7-2](#).
10. Connect 12-V, 2-A DC power supply to the LMG342X-BB-EVM 12-V bias supply as shown in [Figure 7-2](#).
11. Connect the high voltage power supply to the LMG342X-BB-EVM high voltage input for buck mode (High Voltage) as shown in [Figure 7-2](#).
12. Provide 12-V bias supply to fan by connecting the 3-pin power cord from fan to J15.

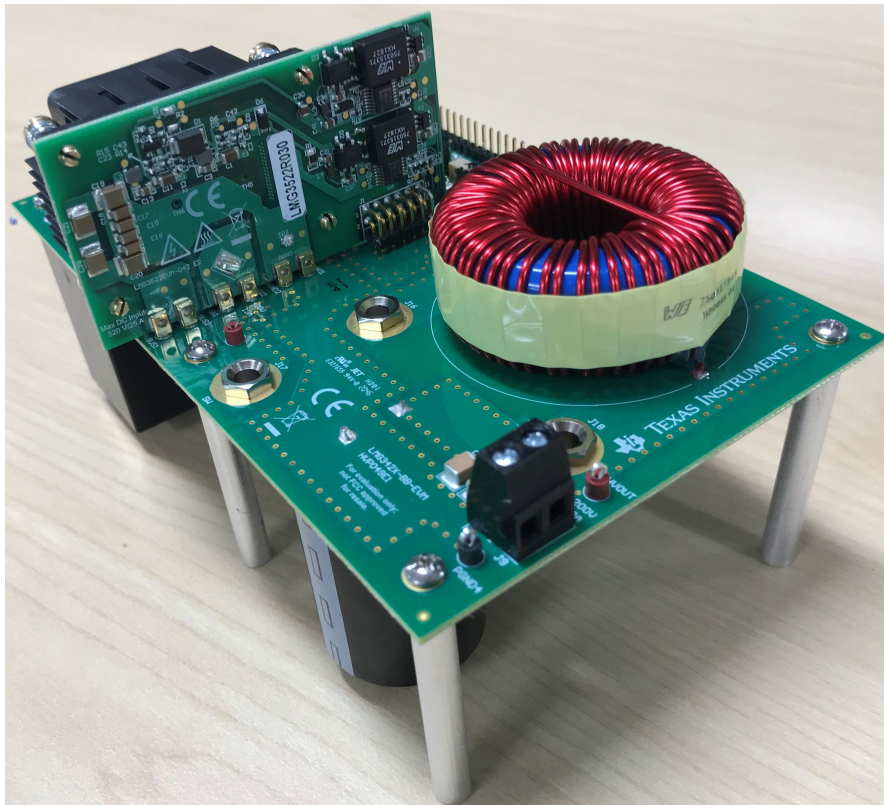


Figure 7-1. LMG342X-BB-EVM Motherboard With LMG352XEVM-04X

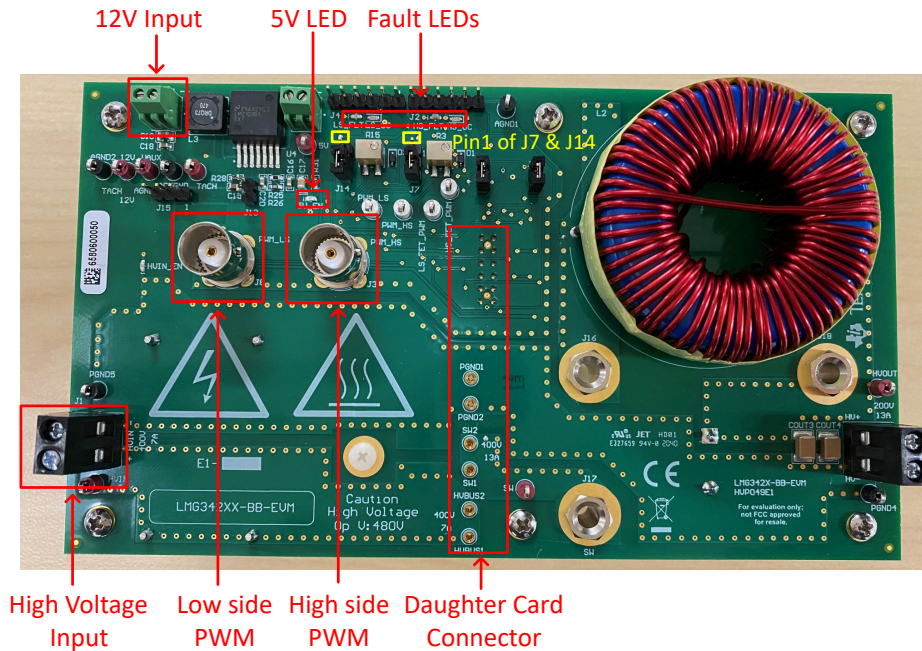


Figure 7-2. Connector and LEDs on the LMG342X-BB-EVM

7.2 Start-Up and Operating Procedure

1. Turn on +12VDC to the LMG342X-BB-EVM. Watch the power supply for the DC current to settle down after approximately 3 to 5 seconds.
2. Make sure all the fault LEDs are off and the 5-V LED is on.
3. Turn on +12VDC to enable the fan.
4. Turn on the function generator to output the continuous pulse, and check the deadtime of the PWM signals.
5. User proper probes for measurement. To measure the fast switching transient in the switch-node, it is recommended to use the high-bandwidth high-voltage passive probes with minimized ground loop connections.
6. It is recommended to add common-mode chokes to the measurement signals and to the power input/output connections.
7. Enable the high voltage power supply and make sure to ramp the voltage up gradually from 0V to the desired bus voltage (up to 520V). As the voltage is ramping up, the HV LED will turn on and become brighter.

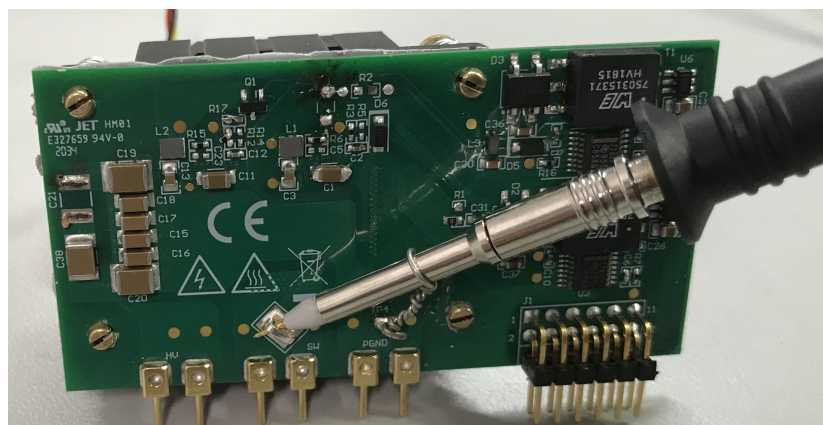


Figure 7-3. Switch-Node Voltage Measurement with High-Bandwidth Probe and Pigtail Ground Connection

WARNING

Do NOT turn on the device at the absolute maximum voltage. TI recommends to start the device at or below 520 V. Slowly increase the input voltage and monitor the VSW to ensure the peak voltage does not exceed the absolute maximum rating of 650 V.

7.3 Test Results

In this test example, a synchronous buck converter operation is implemented. The input voltage is 400V, and the output voltage is 200V with 50% duty cycle. With the heatsink-version EVM, the inductor current goes to 20A in this test, and an output power of 4-kW is achieved. The continuous operation waveform is shown in Figure 7-4. The slew-rate is set to highest by connecting the Rdrv pin to ground. From the experimental result shown in Figure 7-5, a turn-on voltage slew-rate of 148 V/ns is observed at 400V/20A switching conditions.

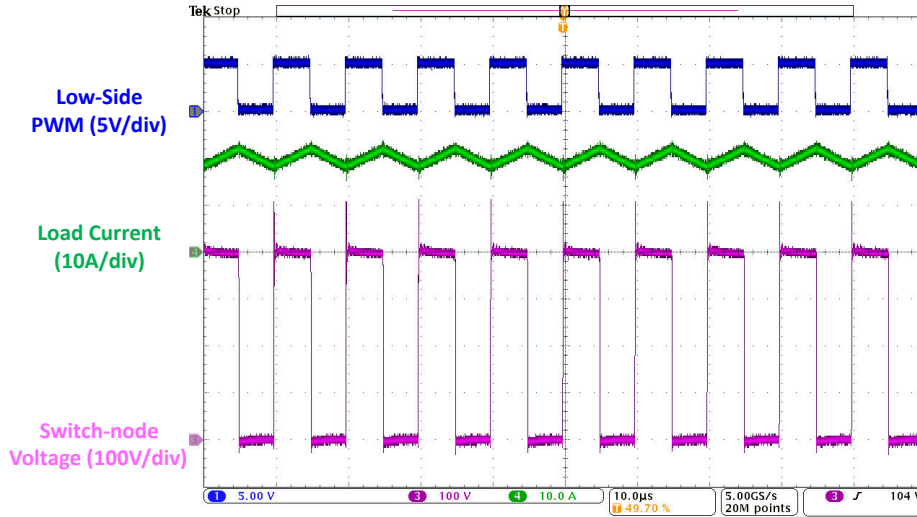


Figure 7-4. Continuous Buck Operation at 4 kW

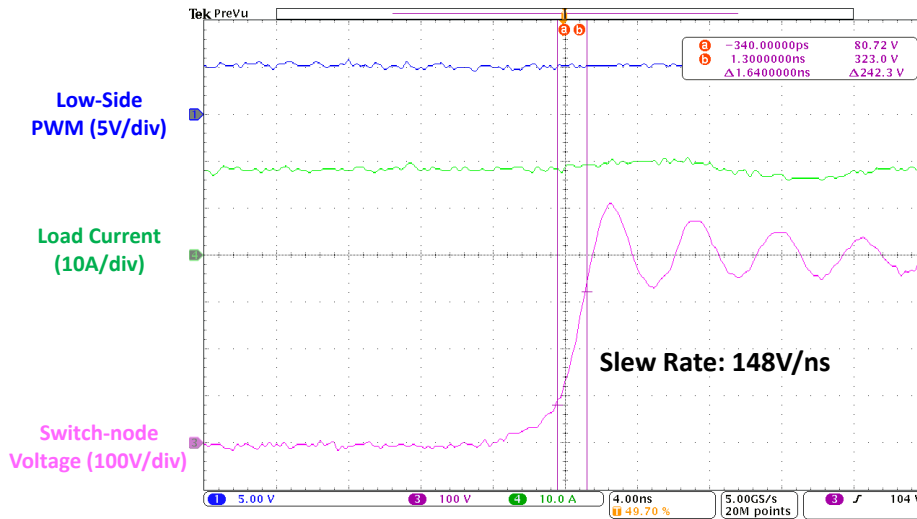


Figure 7-5. Fast Slew Rate at 400V/20A Switching Conditions

The turn-on slew-rate of the device can be easily adjusted (from 30V/ns to 150V/ns) by changing the Rdrv resistance values. This is also verified from the test results shown in Figure 7-6 to Figure 7-9. The adjustable slew-rate feature provides the customer a flexibility to adapt the device’s switching speed in different applications.

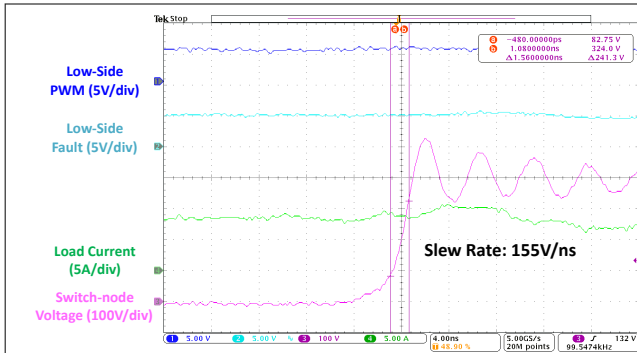


Figure 7-6. 155V/ns at 400V/10A

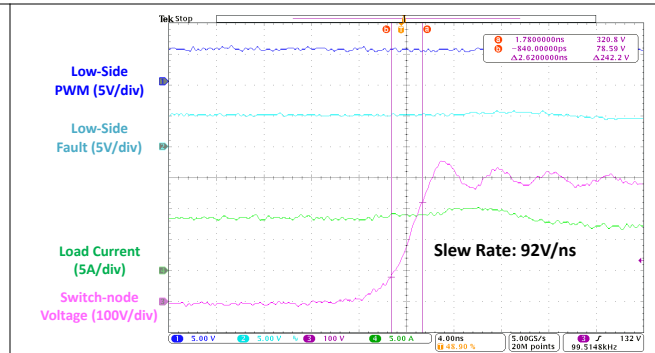


Figure 7-7. 92V/ns at 400V/10A

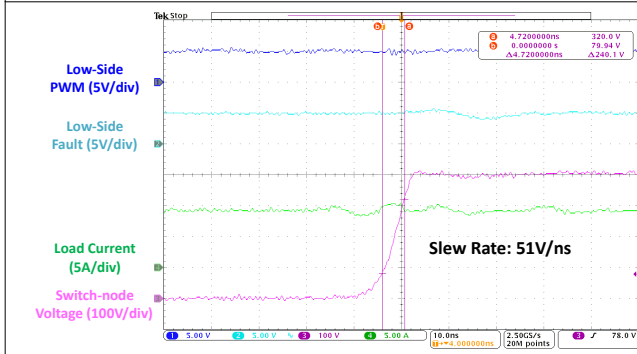


Figure 7-8. 51V/ns at 400V/10A

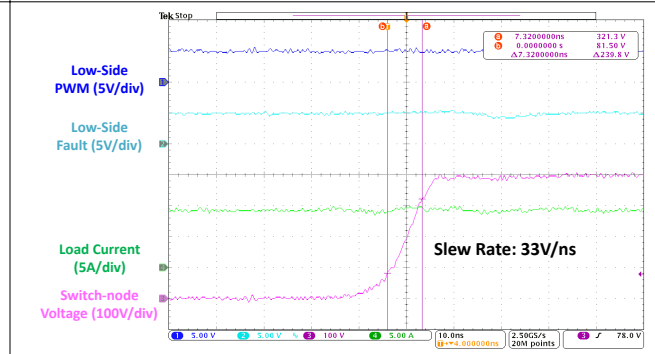


Figure 7-9. 33V/ns at 400V/10A

7.4 Shutdown Procedure

1. Turn off the high voltage power supply then PWM. Wait until red “HV Enable” LED turns off.
2. Disable the 12-V bias supply.

7.5 Additional Operating Notes

- Fault protection on the LMG342X-BB-EVM is not latching, therefore PWM will resume if a fault clears and the LMG342X-BB-EVM is still operational.

8 Test Procedure When Paired With LMG34XX-BB-EVM

8.1 Setup

The following procedure is recommended to set up the LMG34XX-BB-EVM with the LMG352XEVM-04X. The inductor on the LMG34XX-BB-EVM is capable of up to 1.7-kW operation. For a higher power level, use an external inductor.

Figure 8-1 shows the LMG352XEVM-04X connected to the LMG34XX-BB-EVM.

Note

TI provides a custom interposer board that must be used when the LMG352XEVM-04X is paired with the LMG34XX-BB-EVM. The interposer board is not needed with LMG342x-BB-EVM.



Figure 8-1. LMG352XEVM-04X Connected to the LMG34XX-BB-EVM

Figure 8-2 shows the LMG34XX-BB-EVM power and probe connection points.

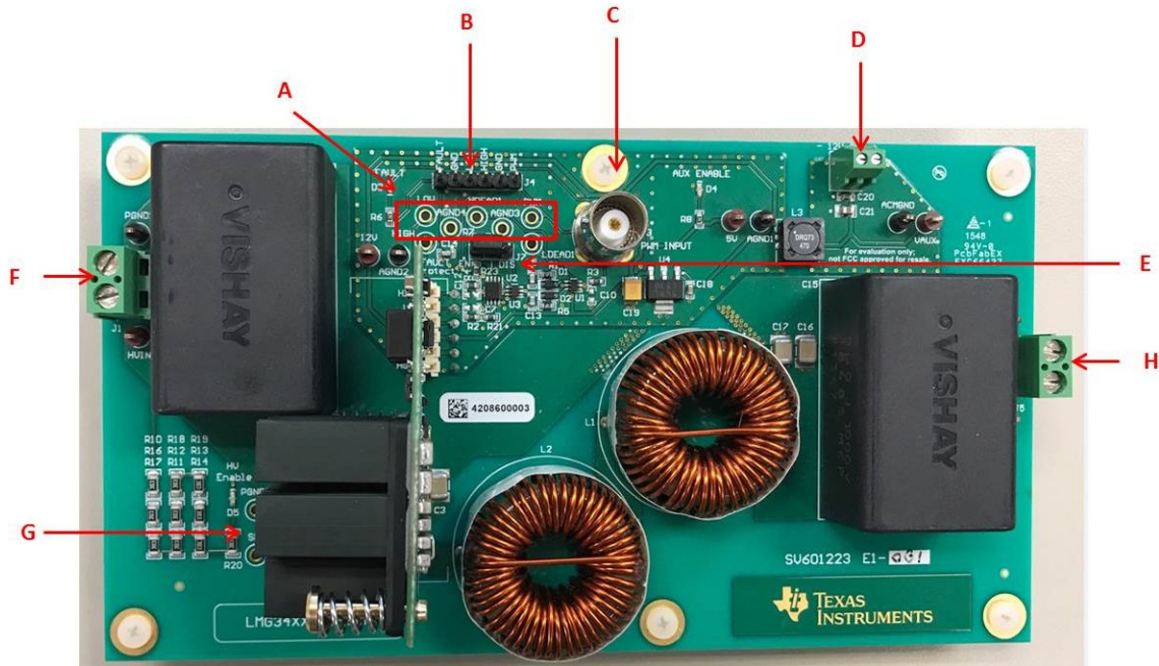


Figure 8-2. Recommended Connection Points

PCB Notes:

- A: Probe points for gate drive logic
- B: 100-mil header for PWM input, PWM signals to LMG352XEVM-04X and FAULT output
- C: BNC connector for PWM input
- D: 12-V bias supply input
- E: FAULT protection option header
- F: Power stage high voltage input
- G: Probe point for power stage switch node
- H: Power stage high voltage output

To connect the LMG352XEVM-04X to the LMG34XX-BB-EVM:

1. Connect the oscilloscope or multimeter probes to the desired test points in A or G.
2. Connect the 12-V bias supply, connect load to output, and connect the input supply to input.
3. Connect the function generator to either the BNC connector PWM input at C or 100-mil header connector input at pin 6 (PWM) and pin 5 (GND) at B.
4. Connect 12-V bias supply to the fan attached on the EVM, or enable an external fan to direct airflow across the heat sink attached to the LMG352XEVM-04X.

8.1.1 List of Test Points

Key test points on this EVM are designed for oscilloscope probes with short ground springs. Using short ground springs instead of alligator ground leads will minimize measurement error and produce a cleaner signal with the fast switching GaN devices used on this EVM. The data in this user guide uses this measurement method.

Table 8-1. Test Point Functional Description

NAME	DESCRIPTION
VAUX	12-V bias input connection before filter
ACMGND	Ground for 12-V bias input before filter
5V	5-V bias
AGND1	Analog ground for logic
PWM	Single input PWM signal
LDEAD1	Low-side PWM signal before dead time generation
AGND3	Analog ground for logic
HDEAD1	High-side PWM signal before dead time generation
AGND4	Analog ground for logic
LOW	Low-side PWM signal with dead time
HIGH	High-side PWM signal with dead time
AGND2	Analog ground for logic
12V	12-V bias after filter
PGND1	Power ground
HVIN	DC input voltage
PGND2	Power ground
HVOUT	DC output voltage
PGND3	Power ground
SW1	Switch node voltage

For this EVM version, not all the test points are available on the motherboard due to the size of the daughter card. To probe the switching node, TI recommends using a pigtail on the daughter card on PGND pin. A probe could use the PGND pigtail and SW test point on the daughter card to complete the measurement.

8.1.2 List of Terminals

Table 8-2. List of Terminals

TERMINAL	NAME	DESCRIPTION
J1	VIN	Input DC voltage input
J5	VOUT	Output DC voltage output
J6	12V AUX	12-V bias voltage input
J3	PWM INPUT	Single 0-V to 5-V PWM input for gate
J4	LOGIC	Header to connect PWM, FAULT logic
J2	HB Card PIN	Connector to interface LMG352XEVM-04X board

8.2 Start-Up and Operating Procedure

The following procedure is recommended to enable the LMG352XEVM-04X with the LMG352XEVM-04X:

1. Power up the 12-V bias supply. Ensure the top right green “Aux Enable” LED is illuminated.
2. Enable PWM on the function generator.
3. Power up the high voltage input supply. Ensure the red “HV Enable” LED is illuminated when the input supply is above 20 V.

WARNING

Do NOT turn on device at absolute maximum voltage. TI recommends starting at voltages at or below 520 V, and then increase the input voltage slowly while monitoring VSW to insure the peak voltage does not exceed the absolute maximum rating of 650 V.

8.3 Shutdown Procedure

1. Turn off the high voltage power supply then PWM. Wait until the red “HV Enable” LED turns off.
2. Disable the 12-V bias supply.

8.4 Additional Operation Notes

- Fault protection on the LMG34XX-BB-EVM is not latching, therefore PWM will resume if a fault clears and the LMG34XX-BB- EVM is still operational.

9 Bill of Materials

Table 9-1. Bill of Materials for LMG352XEVM-04X

DESIGNATOR	QTY	DESCRIPTION	PART NUMBER
C1, C11	2	CAP, CERM, 10 μ F, 25 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	TMK316AB7106KLHT
C2, C12	2	CAP, CERM, 0.22 μ F, 16 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0402	GCM155R71C224KE02D
C3, C13	2	CAP, CERM, 2.2 μ F, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	CGA4J3X7R1E225K125AB
C5, C23	2	CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	GCM1555C1H220JA16D
C6, C14	2	CAP, CERM, 68 pF, 50 V, +/- 5%, C0G/NP0, 0402	GCM1555C1H680JA16D
C9, C26	2	CAP, CERM, 1 μ F, 35 V,+/- 10%, X5R, AEC-Q200 Grade 3, 0402	GRT155R6YA105KE13D
C10, C27	2	CAP, CERM, 0.1 μ F, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	GCM155R71H104KE02D
C15, C16, C17, C18	4	CAP, CERM, 0.022 μ F, 1000 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	C1206C223KDRACTU
C19, C20, C21, C38	4	CAP, CERM, 0.1 μ F, 1000 V, +/- 10%, X7R, 1812	C1812X104KDRACAUTO
C30, C41	2	Cap Ceramic 10uF 25V X7S 10% Pad SMD 0805 +125°C Automotive T/R	CGA4J1X7S1E106K125AC
C31, C36, C37	3	CAP, CERM, 4.7 μ F, 25 V,+/- 10%, X6S, AEC-Q200 Grade 2, 0603	GRT188C81E475KE13D
C33, C35	2	CAP, CERM, 4.7 μ F, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	GCM21BR71C475KA73L
C39, C40	2	CAP, CERM, 43 pF, 50 V,+/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	GCQ1555C1H430JB01D
C42, C43	2	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	CGA2B2C0G1H101J050BA
D1	1	Diode, Schottky, 650 V, 1 A, SMB	GB01SLT06-214
D2, D3	2	Bridge Rectifier Single Phase Schottky 40V Surface Mount MBS	KMB24STR
D5, D6	2	Diode, Zener, 16 V, 500 mW, AEC-Q101, SOD-123	BZT52C16-7-F
H1	1	Heat Sink, Black Anodized, 35 x 50 mm, 20 mm high, with Push Pin and Spring, [NoValue]	S05MZZ14
HV, PGND, SW, TP3, TP5, TP6	6		3621-0-32-15-00-00-08-0
J1	1	Header, 100mil, 6x2, Gold, R/A, TH	TSW-106-08-G-D-RA
L1, L2	2	4.7 μ H Shielded Molded Inductor 1.22A 262mOhm Max 1008 (2520 Metric)	MPIA2510V2-4R7-R
L3, L4	2	2 Line Common Mode Choke Surface Mount 90 Ohms @ 100MHz 400mA DCR 190mOhm	ACM2012-900-2P-T001
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10
Q1	1	MOSFET, N-CH, 20 V, 2.8 A, AEC-Q101, SOT-23	DMG2302UK-7
R1	1	RES, 0, 5%, 0.333 W, AEC-Q200 Grade 0, 0805	CRCW08050000Z0EAHP
R2	1	RES, 2.05, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	CRCW12062R05FKEA
R3, R12, R18	3	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	ERJ-2GE0R00X
R5, R14, R17	3	RES, 20 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	ERJ-2GEJ203X

Table 9-1. Bill of Materials for LMG352XEVM-04X (continued)

DESIGNATOR	QTY	DESCRIPTION	PART NUMBER
R6, R15, R19, R20	4	RES, 300, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402300RJNED
R7, R16	2	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040249R9FKED
R10	1	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	ERJ-8GEY0R00V
R21	1	RES, 10, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040210R0JNED
T1, T2	2	Transformer, 105uH, TH	750315371
TP1	1	Test Point, Compact, SMT	5016
TP2	1	Test Point, SMT	S2751-46R
U1, U2	2	650-V 30-mΩ GaN FET with Integrated Driver and Protection	LMG3522R030Q
U3	1	Automotive, high-speed, robust-EMC quad-channel digital isolators 16-SSOP -40 to 125	ISO7741FQDBQQ1
U4	1	Automotive, robust EMC, six-channel, 4/2, reinforced digital isolator 16-SSOP -40 to 125	ISO7762FQDBQRQ1
U5, U6	2	Transformer Driver PMIC SOT-23-6	SN6505BQDBVTQ1

Table 9-2. Bill of Materials for LMG342X-BB-EVM

DESIGNATOR	QTY	DESCRIPTION	PART NUMBER
5V, 12V, HVIN, HVOUT, SW, TACH, VAUX	7	Test Point, Compact, Red, TH	5005
5V_EN, HVIN_EN	2	LED, Green, SMD	LG L29K-G2J1-24-Z
ACMGND, AGND1, AGND2, PGND4, PGND5	5	Test Point, Compact, Black, TH	5006
C1, C6, C8, C9, C18	5	CAP, CERM, 1 μF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E1X7R1E105K080AD
C2, C3	2	CAP, CERM, 1600 pF, 50 V, +/- 5%, C0G/NP0, 0603	GRM1885C1H162JA01D
C5, C10, C12, C14, C21, C23	6	CAP, CERM, 39 pF, 50 V, +/- 5%, C0G/NP0, 0603	GRM1885C1H390JA01D
C15	1	CAP, CERM, 10 uF, 25 V, +/- 20%, X5R, 0603	GRT188R61E106ME13D
C16, C20	2	CAP, CERM, 0.022 uF, 50 V, +/- 10%, X7R, 0603	885012206091
C17	1	CAP, CERM, 100 uF, 6.3 V, +/- 20%, X5R, 0805	GRM21BR60J107M
C19	1	CAP, CERM, 10 uF, 25 V, +/- 10%, X5R, 0805	CL21A106KAFN3NE
C22	1	CAP, Film, 20 μF, 900 V, +/- 10%, 0.0055 ohm, TH	FE37M6C0206KB
C25	1	CAP, AL, 150 uF, 600 V, +/- 20%, TH	LGN2X151MELB50
CIN3, CIN4, COUT3, COUT4	4	CAP, CERM, 0.1 uF, 630 V, +/- 10%, X7R, 1812	GRM43DR72J104KW01L
D1, D3	2	Diode, Schottky, 30 V, 0.2 A, SOD-323	BAT54WS-7-F
H1, H8, H9, H10, H11, H12	6		3484
H2, H3, H4, H5, H6, H7	6	MACHINE SCREW PAN PHILLIPS 4-40	PMSSS 440 0025 PH
H13	1	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH
H14	1		1902C
HS_FET_PWM, LS_FET_PWM, PWM_HS, PWM_LS	4	Test Point, Compact, White, TH	5007

Table 9-2. Bill of Materials for LMG342X-BB-EVM (continued)

DESIGNATOR	QTY	DESCRIPTION	PART NUMBER
HS_FLT, LS_FLT	2	LED, Red, SMD	LS L29K-G1J2-1-Z
HS_OC, LS_OC	2	LED, Yellow, SMD	SML-E12Y8WT86
HVBUS1, HVBUS2, PGND1, PGND2, SW1, SW2	6	Receptacle, 1 Pos, Gold, TH	0435-0-15-15-03-27-10-0
J1, J9	2	Terminal Block, 5.08mm, 2x1, TH	0395443002
J2, J4	2	Header, 100mil, 6x1, Gold, TH	TSW-106-07-G-S
J3, J8	2	Connector, TH, BNC	112404
J5	1	12 Position Receptacle, Bottom Entry Connector Surface Mount	HLE-106-02-G-DV-BE-A
J6, J12	2	Terminal Block, 2x1, 2.54mm, TH	282834-2
J7, J14, J15	3	Header, 100mil, 3x1, Gold, TH	TSW-103-07-G-S
J10, J11, J13	3	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S
J16, J17, J18	3	Standard Banana Jack, Uninsulated	3267
L2	1	INDUCTOR 570uH 13A	750317345
L3	1	Coupled inductor, 47 uH, 1.14 A, 0.4825 ohm, SMD	DRQ73-470-R
LBL1	1	Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	THT-13-457-10
R1, R5, R29, R30	4	RES, 3.3 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06033K30JNEA
R2, R4, R9	3	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA
R3, R15	2	Trimmer, 5 K, 0.25 W, SMD	3224X-1-502E
R6, R22	2	RES, 100 k, 5%, 0.1 W, 0603	CRCW0603100KJNEAC
R7, R21	2	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603100RJNEA
R8, R27	2	RES, 105 k, 1%, 0.1 W, 0603	RC0603FR-07105KL
R10, R11, R12, R13, R14, R16, R17, R18, R19, R20	10	RES, 30 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	CRCW120630K0JNEA
R25	1	RES, 6.20 k, 1%, 0.1 W, 0603	RC0603FR-076K2L
R26	1	RES, 1.18 k, 1%, 0.1 W, 0603	RC0603FR-071K18L
R28	1	RES, 33.2 k, 0.1%, 0.1 W, 0603	RT0603BRD0733K2L
R31	1	RES, 1.6 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031K60JNEA
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5	5	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G
U1, U2	2	Automotive Catalog Dual 2-Input Positive-AND Gate, DCT0008A, LARGE T&R	
U3, U5	2	Triple Schmitt-Trigger Inverter, DCU0008A (VSSOP-8)	SN74LVC3G14DCUTG4
U4	1	1A SIMPLE SWITCHER® Power Module with 20V Maximum Input Voltage for Military and Rugged Applications, 7 pin TO-PMOD	LMZ12001EXTTZ/NOPB

10 Revision History

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

DATE	REVISION	NOTES
February 2021	*	Initial Public Release

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/lstds/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/lstds/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 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/lstds/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/lstds/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.

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- 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.
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