

# EVM User's Guide: LMG3650EVM-115

## LMG3650R070 Evaluation Module



### Description

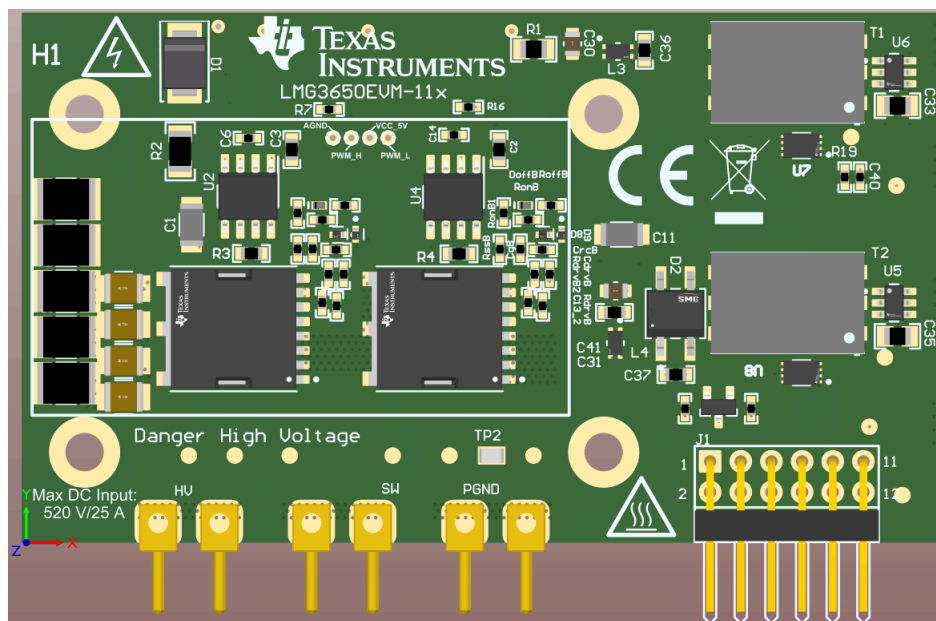
The LMG3650EVM-115 features two LMG3650R070 650V GaN FETs with an integrated driver and protection in a half-bridge configuration with all the required bias circuit and logic/power level shifting. Essential power stage and gate-driving, high-frequency current loops are fully enclosed on the board to minimize power loop parasitic inductance for reducing voltage overshoots and improving performance. The LMG3650EVM-115 is configured for a socket style external connection for easy interface with external power stages to run the LMG3650R070 in various applications. Refer to the LMG3650R070 data sheet before using this EVM.

### Features

- Two TI 650V GaN in TOLL package arranged in half bridge configuration
- Digital isolators for high side fault signal
- Isolated bias supply and bootstrap supply option
- Isolated gate driver and open component positions for layout compatibility to evaluate integrated GaN TOLL and discrete GaN TOLL
- Heat sink with fan attached for heat dissipation during testing
- Fault protection and reporting for over temperature, overcurrent, and short circuit events
- Standard daughter card pinout for compatibility with TI GaN motherboards
- Absolute maximum voltage rating of 650V

### Applications

- [Merchant network and server PSU](#)
- [Merchant telecom rectifiers](#)
- Solar inverters and industrial motor drives
- Uninterruptible power supplies



LMG3650EVM Daughter Card

# 1 Evaluation Module Overview

## 1.1 Introduction

The LMG3650EVM-115 operates as a half-bridge daughter card that can be either part of a larger custom designed system or paired with a TI GaN mother board. TI provides two mother boards (LMG342X-BB-EVM and PFC23338EVM-107) to interface with LMG3650EVM-115. LMG342X-BB-EVM is a DC/DC buck-boost converter and can support up to 4kW. PFC23338EVM-107 is an AC/DC totem-pole PFC that can support up to 3.6kW. The LMG342X-BB-EVM is designed to operate LMG3650R070 in an open-loop synchronous buck or boost converter. Probe locations are provided to measure the logic and power stage voltages. PFC23338EVM-107 is designed to operate LMG3650R070 in a closed loop totem-pole PFC.

## 1.2 Kit Contents

This kit includes one LMG3650EVM-115 daughter card with heat sink and fan as well as the appropriate high voltage and TI EVM disclaimers.

Included on the LMG3650EVM-115 daughter card:

- Two LMG3650R070 GaN ICs
- Two isolated gate drivers to enable layout compatibility and testing with discrete GaN in TOLL
- Two digital isolators for the GaN IC fault signals
- Isolated bias supply and bootstrap supply

## 2 Hardware

### 2.1 LMG3650EVM-115 Daughter Card Variants

The LMG3650R070 is part of a family of TI GaN devices in the TOLL package, offering different Rdson values and different feature functions for pin 7. The naming convention follows below.

LMG365 X R0 ##

**Table 2-1. Pin 7 Function**

X	Pin 7 Function
0	GND
1	LDO5V
6	ZVD
7	ZCD

**Table 2-2. Rdson**

##	Rdson
25	25mΩ
35	35mΩ
70	70mΩ

There are two EVMs that support this family of devices.

**Table 2-3. EVM Variants**

EVM	Device	EVM Style
LMG3650EVM-113	LMG3650R025	1
LMG3650EVM-114	LMG3650R045	1
LMG3650EVM-115	LMG3650R070	1
LMG3650EVM-122	LMG3651R025, LMG3656R025, LMG3657R025, LMG3651R035, LMG3656R035, LMG3657R035, LMG3651R070, LMG3656R070, LMG3657R070	2

Style 1 EVMs support the LMG365 0 R0## devices where the pin 7 is connected to GND. Style 2 EVMs are able to support LMG365 1 R0##, LMG365 6 R0##, LMG365 7 R0## devices where pin 7 is configured for LDO5V, Zero-voltage detection (ZVD), or Zero-current detection (ZCD). The Rdson values will be interchangeable for each style EVM.

### 2.2 LMG3650EVM-115 Daughter Card Pin Description

The LMG3650EVM-115 uses the standard TI GaN daughter card pin interface. On the style 1 EVMs, the OC pin is connected to 5V. On the style 2 EVMs, the OC pin is connected to pin 7 signal.

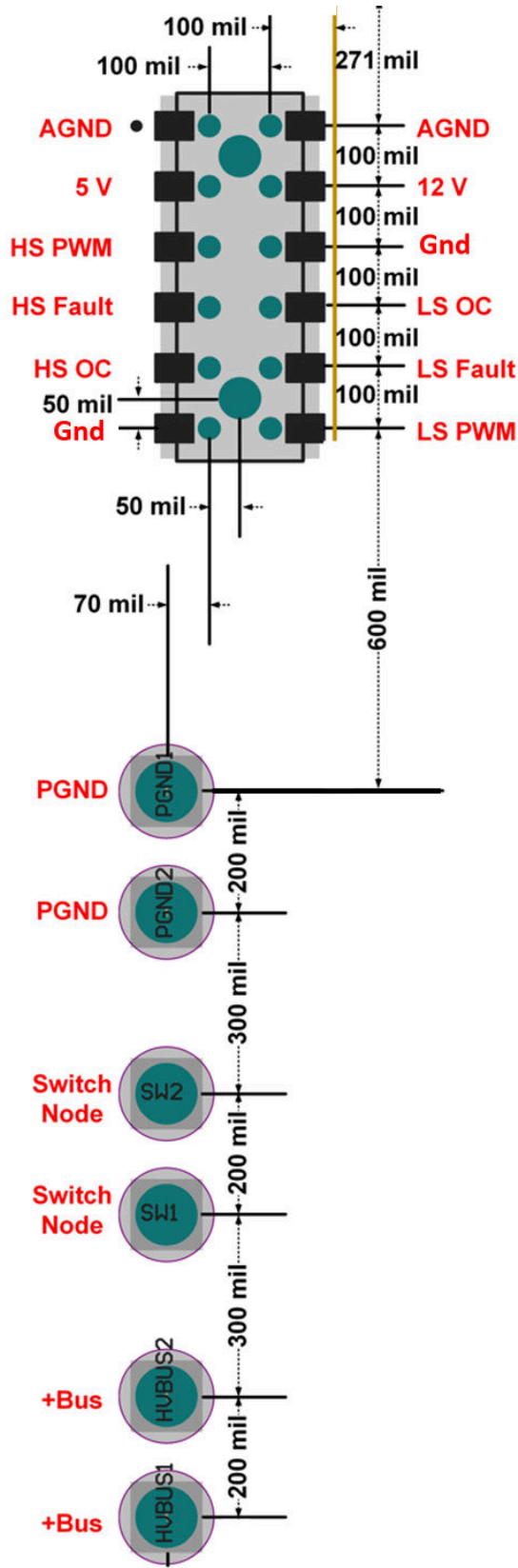


Figure 2-1. TI GaN Daughter Card Pinout

## 2.3 LMG3650EVM-115 Daughter Card Block Diagram

Style 1 EVMs include a layout compatible design with other TOLL devices that do not include an integrated gate driver or device level protections. The LMG365x family of devices are able to receive PWM signal input from a gate driver to enable this functionality.

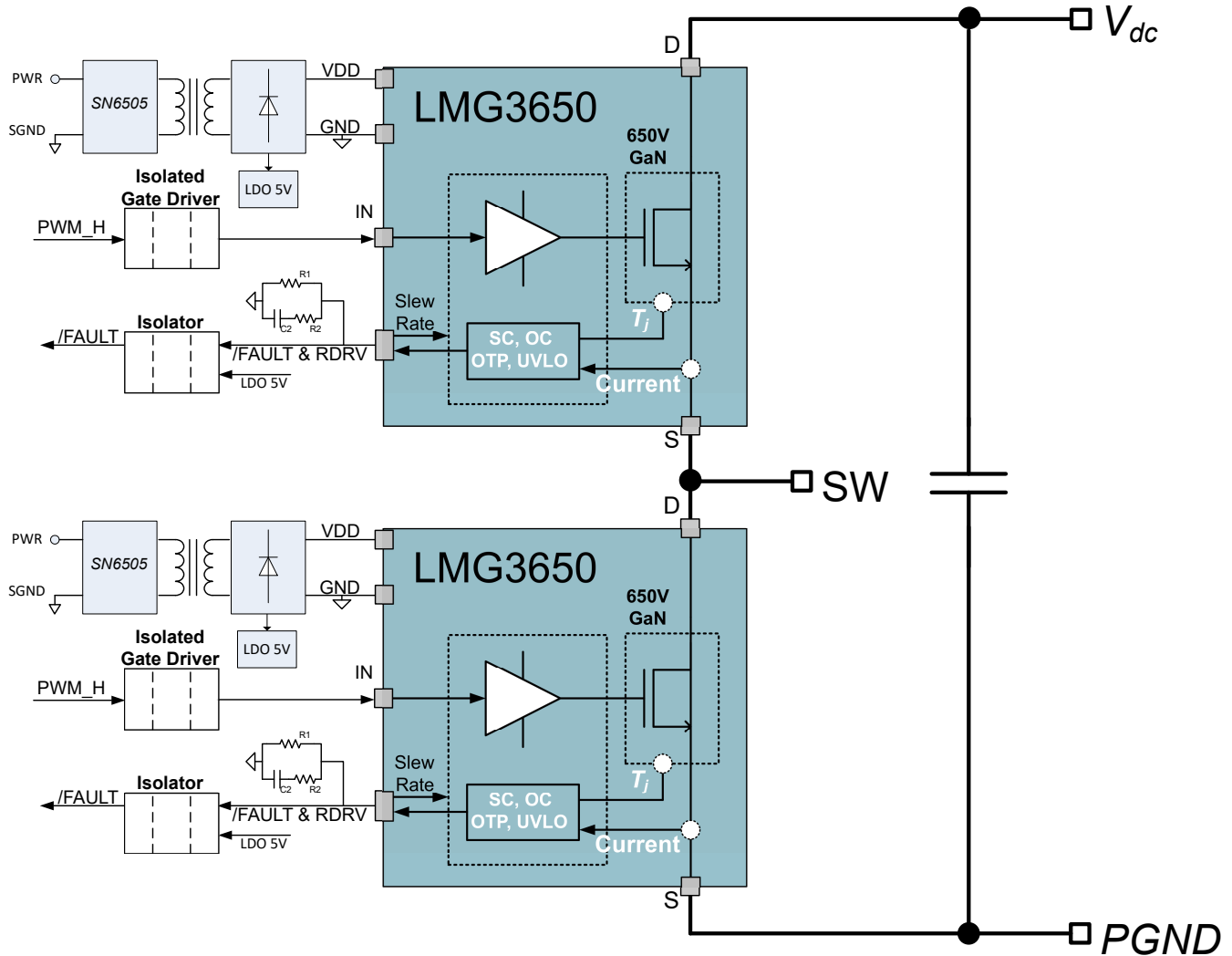


Figure 2-2. LMG3650EVM-115 Block Diagram

## 2.4 LMG3650EVM-115 Fault

The LMG3650EVM-115 outputs faults for the high side and low side devices. These are active low signals and correspond to the fault outputs outlined in the LMG3650R070 data sheet. These signals are referenced to Agnd via digital isolator on the daughter card.

## 2.5 LMG3650EVM-115 Bootstrap Mode

LMG3650EVM-115 is shipped setup with isolated bias supply for the high side and low side devices. It is also equipped with bootstrap power supply for the high side device, that is not connected. To switch from isolated bias supply to bootstrap supply:

- Remove R1
- Place  $2\Omega$ , 1206 resistor at R2
- Place  $0\Omega$ , 1206 resistor at R1

## 2.6 LMG3650EVM-115 Heat Sink

The LMG3650EVM-115 comes with a heatsink installed for heat dissipation. The LMG3650R070 is cooled through the bottom side cooling pad of the device. The heat is transferred through vias in the PCB to exposed copper on the back side of the PCB. These vias are filled and capped (IPC-4761 Type-7) so the solder doesn't fill into them creating solder voids underneath the LMG3650R070. There is an electrically isolating thermal interface material to thermally connect the heatsink to the PCB.

The heatsink has a fan attached for better thermal dissipation. The LMG342X-BB-EVM can power the fan by plugging it into header J15. For other motherboards the fan can be plugged into an external supply. The fan is powered through a 12V power supply (red – 12V, black – Ground, yellow – no connect).

## 3 Implementation Results

### 3.1 Test Equipment

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

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

**Function Generator:** Capable of 0V to 5V square wave output with adjustable duty cycle and frequency in the operating range.

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

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

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

**Fan:** A dedicated cooling fan is attached on the back side of the heat sink. Greater cooling is needed, an additional fan can be directed towards the EVM.

## 4 Hardware Design Files

### 4.1 Schematics

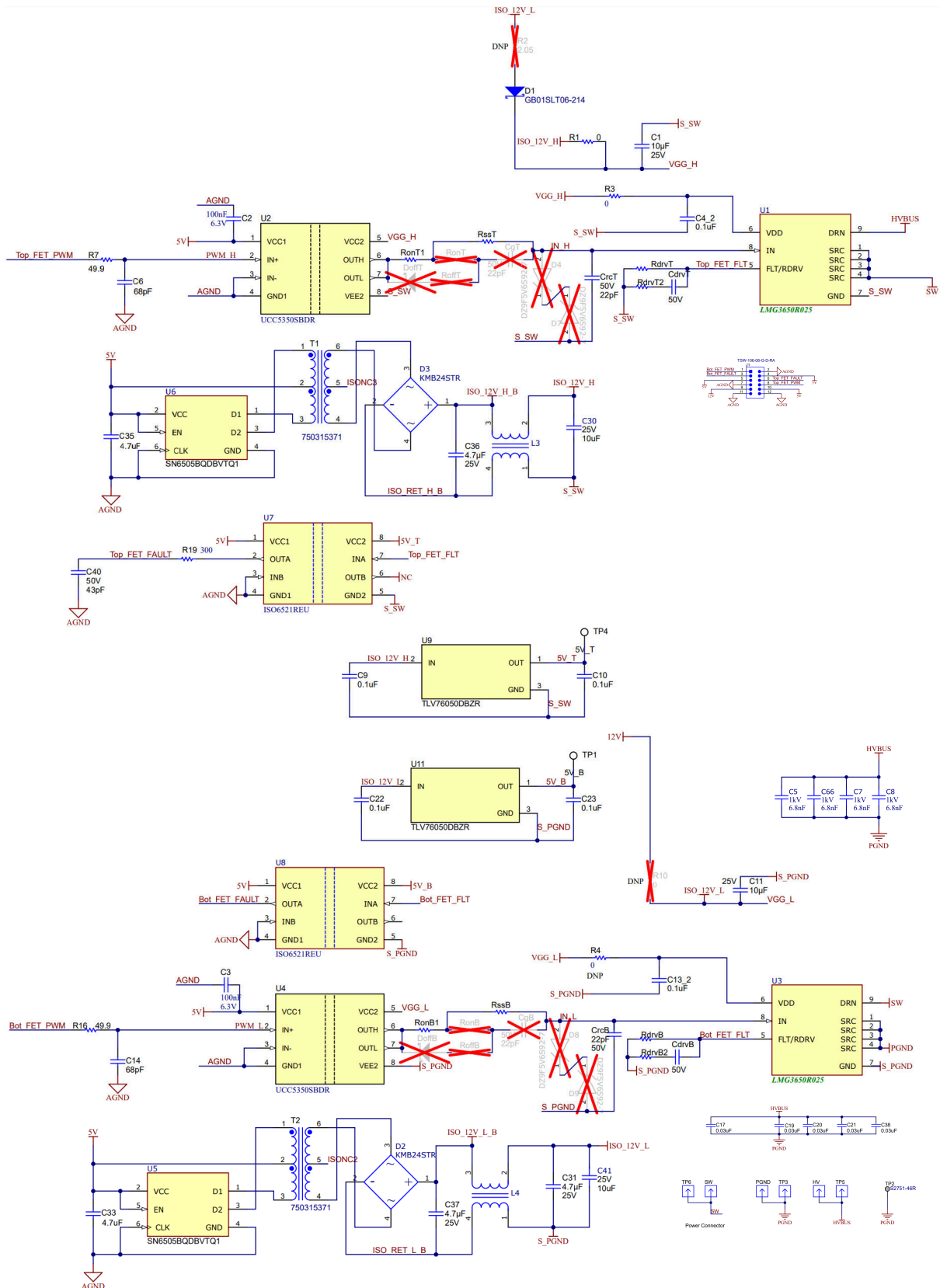


Figure 4-1. LMG3650EVM Schematic



## 4.2 PCB Layouts

Design files are included in zip folder on the EVM page on TI.com.

## 4.3 Bill of Materials (BOM)

Designator	Description	Part Number	Quantity
C1, C11	CAP, CERM, 10 $\mu$ F, 25V, $\pm$ 10%, X7R, AEC-Q200 Grade 1, 1206	TMK316AB7106KLHT	2
C2, C3	CAP, CERM, 0.1 $\mu$ F, 6.3V, $\pm$ 10%, X7R, 0603	KGM15AR70J104KM	2
C4_2, C9, C10, C13_2, C22, C23	CAP, CERM, 0.1 $\mu$ F, 50V, $\pm$ 10%, X7R, 0402	C1005X7R1H104K050BB	6
C5, C7, C8, C66	Cap Ceramic 6.8nF 1000V C0G 5% Pad SMD 1210 +125°C Automotive T/R	CGA6M1C0G3A682J200AE	4
C6, C14	CAP, CERM, 68pF, 50V, $\pm$ 5%, C0G/NP0, 0402	C1005C0G1H680J050BA	2
C17, C19, C20, C21, C38	0.03 $\mu$ F $\pm$ 10% 1000V (1kV) Ceramic Capacitor C0G, NP0 1812 (4532 Metric)	C1812C303KDGLCAUTO	5
C30, C41	Cap Ceramic 10 $\mu$ F 25V X7S 10% Pad SMD 0805 +125°C Automotive T/R	CGA4J1X7S1E106K125AC	2
C31, C36, C37	CAP, CERM, 4.7 $\mu$ F, 25V, $\pm$ 10%, X6S, AEC-Q200 Grade 2, 0603	GRT188C81E475KE13D	3
C33, C35	CAP, CERM, 4.7 $\mu$ F, 16V, $\pm$ 10%, X7R, AEC-Q200 Grade 1, 0805	GCM21BR71C475KA73L	2
C40	CAP, CERM, 43pF, 50V, $\pm$ 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	GCQ1555C1H430JB01D	1
CdrvB, CdrvT, CrcB, CrcT	CAP, CERM, 22pF, 50V, $\pm$ 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	GCM1555C1H220JA16D	4
D1	Diode, Schottky, 650V, 1A, SMB	GB01SLT06-214	1
D2, D3	Bridge Rectifier Single Phase Schottky 40V Surface Mount MBS	KMB24STR	2
H1	Heat Sink, Black Anodized, 35 x 50mm, 20mm high, with Push Pin and Spring	S05MZZ13	1
H2	Thermal Interface Material	GR80A-0H-50GY	1
HV, PGND, SW, TP3, TP5, TP6		3621-0-32-15-00-00-08-0	6
J1	Header, 100mil, 6x2, Gold, R/A, TH	TSW-106-08-G-D-RA	1
L3, L4	2 Line Common Mode Choke Surface Mount 90 Ohms @ 100MHz 400mA DCR 190mOhm	ACM2012-900-2P-T001	2

Designator	Description	Part Number	Quantity
LBL1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	1
R1	RES, 0, 5%, 0.333 W, AEC-Q200 Grade 0, 0805	CRCW08050000Z0EAHP	1
R3, R4	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	2
R7, R16	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040249R9FKED	2
R19	RES, 300, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402300RJNED	1
RdrvB, RdrvB2, RdrvT, RdrvT2	RES, 20 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	ERJ-2GEJ203X	4
RonB1, RonT1, RssB, RssT	RES, 9.1, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04029R10JNED	4
T1, T2	Transformer, 105 $\mu$ H, TH	750315371	2
TP2	Test Point, SMT	S2751-46R	1
U1, U3	LMG3650R025	LMG3650R025	2
U2, U4	3kVRMS Single-Channel Isolated Gate Drivers, D0008B (SOIC-8)	UCC5350SBDP	2
U5, U6	Transformer Driver PMIC SOT-23-6	SN6505BQDBVTQ1	2
U7, U8	General Purpose Dual-Channel Functional Isolators	ISO6521REU	2
U9, U11	100mA, 30V, Fixed-Output, Linear-Voltage Regulator, DBZ0003A (SOT-23-3)	TLV76050DBZR	2

## **5 Additional Information**

### **5.1 Trademarks**

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