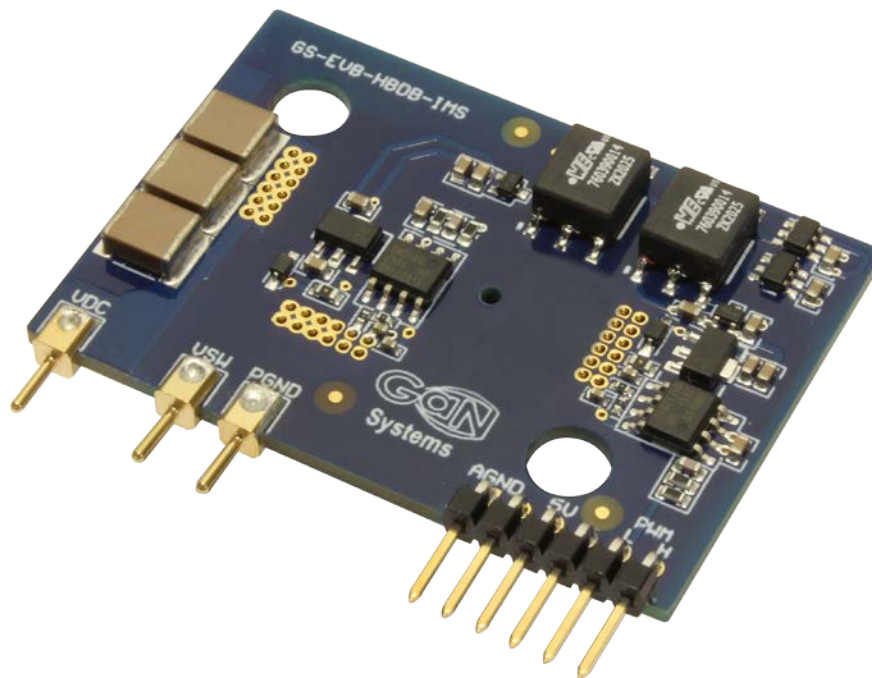


GS-EVB-HBDB-IMS

650 V Universal Half Bridge Isolated Driver Motherboard for IMS2 & IMS3

Technical Manual



Visit www.gansystems.com for the latest version of this technical manual.

DANGER

DO NOT TOUCH THE BOARD WHEN IT IS ENERGIZED AND ALLOW ALL COMPONENTS TO DISCHARGE COMPLETELY PRIOR HANDLING THE BOARD.

HIGH VOLTAGE CAN BE EXPOSED ON THE BOARD WHEN IT IS CONNECTED TO POWER SOURCE. EVEN BRIEF CONTACT DURING OPERATION MAY RESULT IN SEVERE INJURY OR DEATH.

Please sure that appropriate safety procedures are followed. This evaluation kit is designed for engineering evaluation in a controlled lab environment and should be handled by qualified personnel ONLY. Never leave the board operating unattended.

**WARNING**

Some components can be hot during and after operation. There is NO built-in electrical or thermal protection on this evaluation kit. The operating voltage, current and component temperature should be monitored closely during operation to prevent device damage.

**CAUTION**

This product contains parts that are susceptible to damage by electrostatic discharge (ESD). Always follow ESD prevention procedures when handling the product.

Contents

1	Overview.....	5
1.1	Introduction	5
1.2	Features and Benefits.....	5
1.3	Applications.....	5
1.4	Content	5
2	Motherboard Technical Specifications.....	7
2.1	Half Bridge Isolated Driver Mother Board Overview.....	7
2.2	Gate Driver Circuit.....	8
2.3	5V Input and External PWM Signals Input	8
2.4	Temperature Monitoring Hole	9
2.5	Installation of IMS Half-Bridge Daughter power board.....	9
2.6	DC Link Decoupling Capacitors	9
3	IMS Half Bridge Daughter Power Board Options.....	10
4	Test Results	12
4.1	Double Pulse Test (GS-EVB-HBDB-IMS + GS-EVB-IMS3-66508B-GS)	12
4.2	Boost Configuration Test (GS-EVB-HBDB-IMS + GS-EVB-IMS3-66508B-GS).....	14
5	GS-EVB-HBDB-IMS Schematics and BoM	16

List of Figures

Figure 1 IMS EVB motherboard GS-EVB-HBDB-IMS	6
Figure 2 Assembled IMS EVB module with heatsink.....	6
Figure 3 Circuit block diagram of IMS EVB Module	7
Figure 4 Labelled driver motherboard	7
Figure 5 Gate driver circuit (Silicon Labs P/N: Si8271).....	8
Figure 6 External 5V and PWM signals connector pin.....	8
Figure 7 Soldering pin guide.....	9
Figure 8 Cross-section view of IMS assembly showing the power loop path.....	9
Figure 9 Compatible IMS2 daughter power boards	10
Figure 10 Compatible IMS3 daughter power boards	10
Figure 11 GS66516B and GS66508B GaNPX® packaged GaN E-mode transistor	11
Figure 12 Cross-section view of a single layer IMS board	11
Figure 13 Double pulse test setup schematics	12
Figure 14 Double pulse test setup	12
Figure 15 Double pulse test waveforms (400V/30A).....	13
Figure 16 Boost configuration test setup schematics	14
Figure 17 Boost configuration test setup	14
Figure 18 Boost configuration test thermal measurement result	15
Figure 19 Test waveforms (400V _{in} , 10kHz, P _o =0.8kW).....	15

List of Tables

Table 1 GS-EVB-IMS3-665xxB-GS Evaluation Kit Contents	5
Table 2 Compatible IMS daughter power board for driver motherboard GS-EVB-HBDB-IMS.....	10
Table 3 Part numbers and description	11

1 Overview

1.1 Introduction

GS-EVB-HBDB-IMS is a 650 V universal half-bridge motherboard with 2 isolated gate drivers. The daughter power boards that are compatible with this driver motherboard are available in 2 power levels: 3kW and 6kW. This document mainly focuses on introducing the design and application of the driver motherboard. For more information about the IMS2 or the IMS3 half-bridge daughter power board, please see its individual technical manual, available on <https://gansystems.com/evaluation-boards/>

Compatible IMS2 & IMS3 half-bridge daughter power cards are of Part Numbers:

- GSP66508BHB-EVBIMS2
- GSP66516BHB-EVBIMS2
- GS-EVB-IMS3-66508B-GS
- GS-EVB-IMS3-66516B-GS

1.2 Features and Benefits

- Minimized parasitic inductance for both gate driving loop and power commutation loop
- Isolated gate drive circuits with 200V/ns CMTI
- Plug and play: easy to replace Si/SiC half-bridge power stage in power converters for performance comparison

1.3 Applications

- Automotive: 3.3kW-22kW on board charger, DC/DC, 3- Φ inverter, high power wireless charger
- Industrial: 3-7kW Photovoltaic Inverter and Energy Storage System (ESS), Motor Drive / VFD
- Server/Datacenter: 3kW Server ACDC power supply
- Consumer: Residential Energy Storage System (ESS)

1.4 Content

The GS-EVB-HBDB-IMS includes the following hardware.

Table 1 GS-EVB-HBDB-IMS Evaluation Kit Contents

Quantity	Description
1	GS-EVB-HBDB-IMS 650V Universal Half Bridge Isolated Driver Motherboard for IMS2 and IMS3

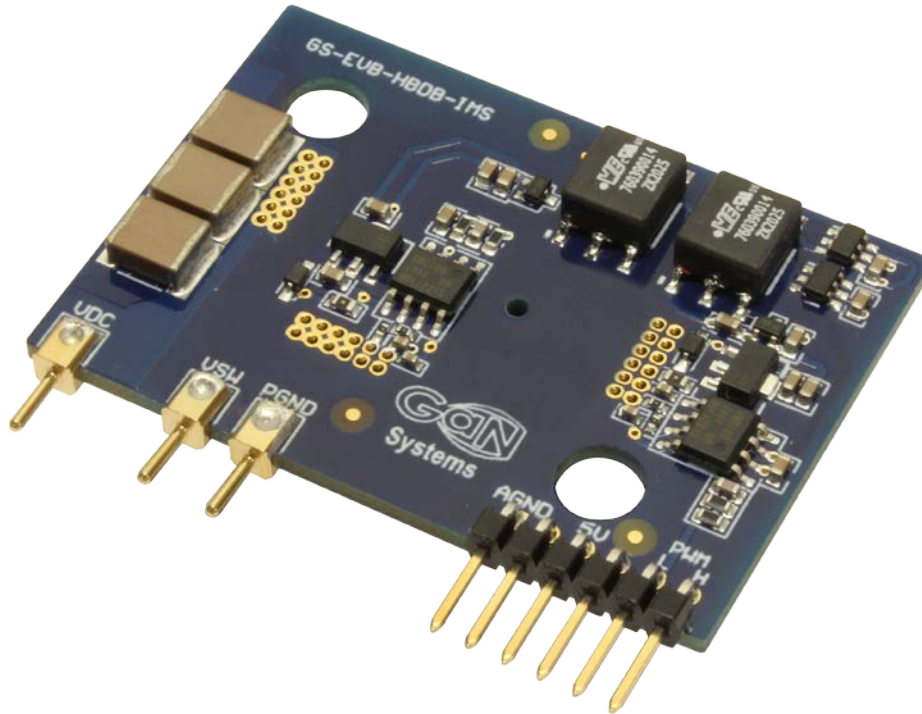


Figure 1 IMS EVB motherboard GS-EVB-HBDB-IMS

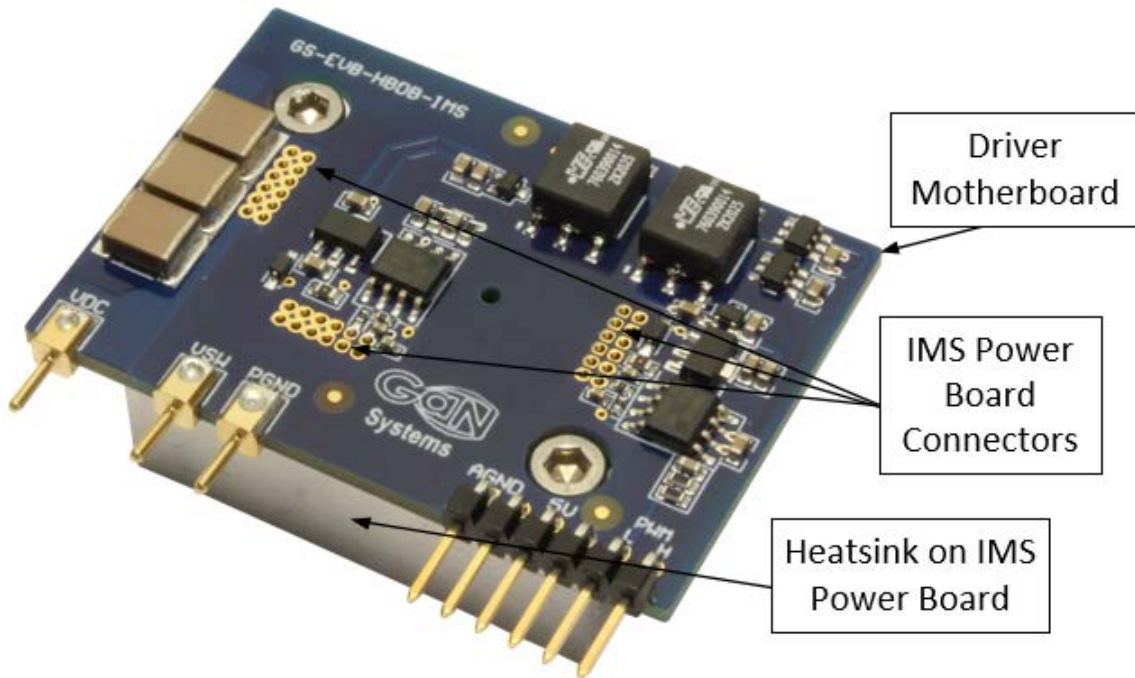


Figure 2 Assembled IMS EVB module with heatsink

2 Motherboard Technical Specifications

2.1 Half Bridge Isolated Driver Mother Board Overview

This driver motherboard can be purchased individually. It can be used to evaluate both IMS2 and IMS3 daughter power boards in a half-bridge configuration. The plug-and-play design allows the user to easily integrated the half-bridge GaN configuration into any power stage for evaluation or replace Si/SiC half-bridge power stage in power converters for performance comparison.

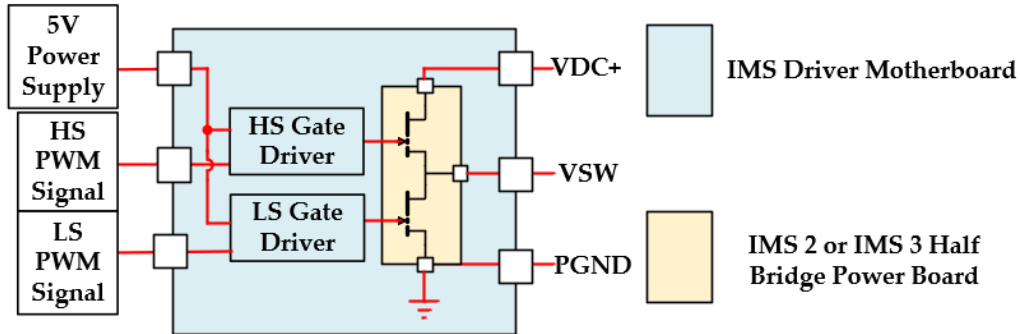


Figure 3 Circuit block diagram of IMS EVB Module

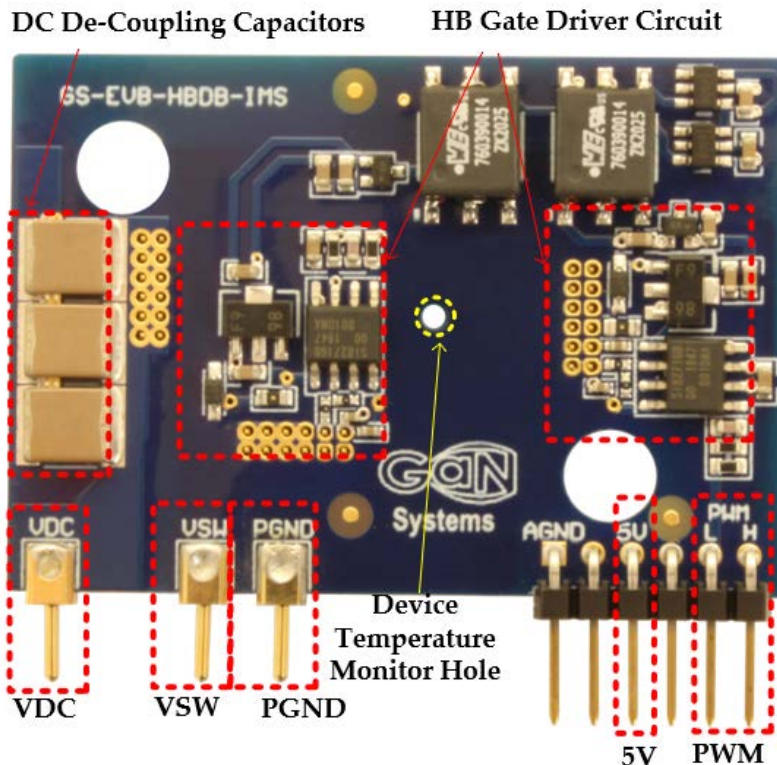


Figure 4 Labelled driver motherboard

2.2 Gate Driver Circuit

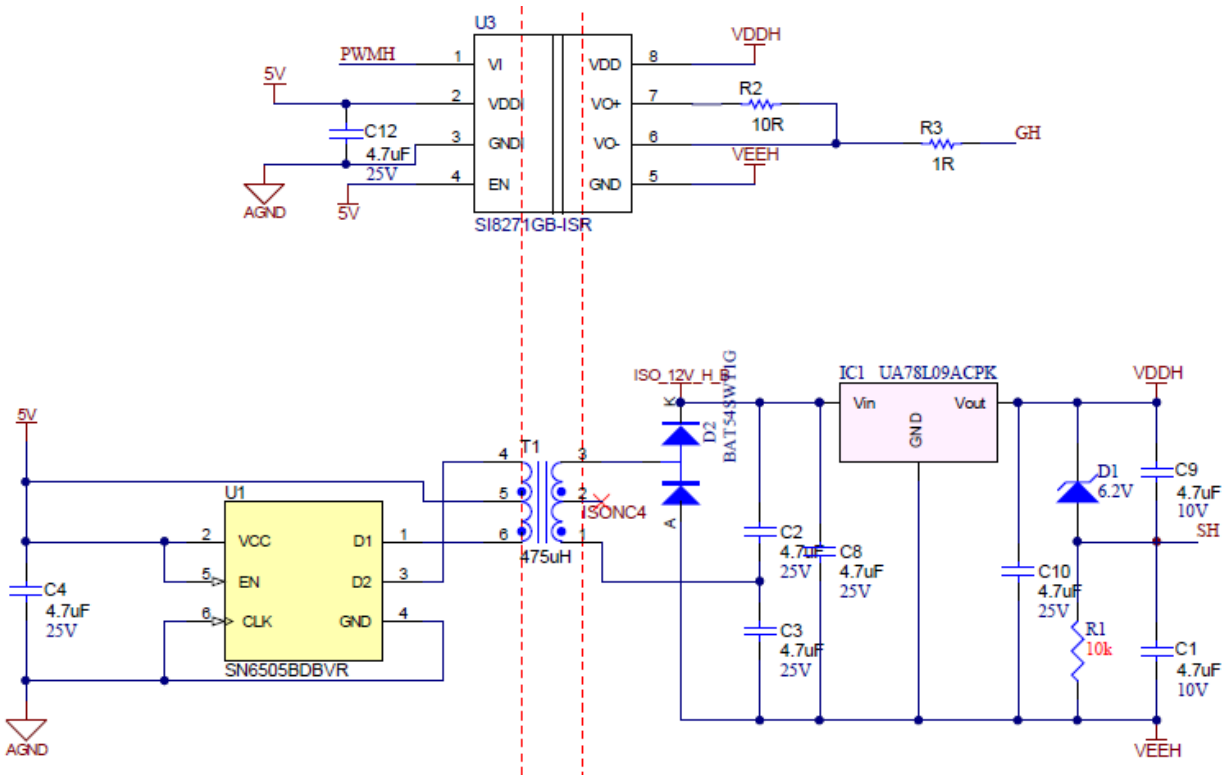


Figure 5 Gate driver circuit (Silicon Labs P/N: Si8271)

A low-cost isolated gate driver circuit is used in the IMS EVB driver motherboard for each GaN device, which is shown in Figure 5. Essential components are listed below:

- U3 is the isolated gate driver (Silicon Labs P/N: Si8271)
- U1, T1, D2, C2, C3, C8, and IC1 are the isolated push-pull power supply for the gate driver; after the LDO chip IC1, the output is divided to +6/-3V to power the gate driver.
- R2 and R3 are gate turn-on and off resistors.

2.3 5V Input and External PWM Signals Input

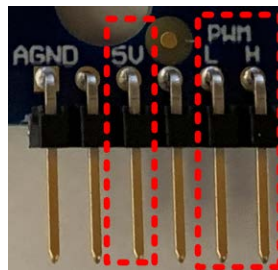


Figure 6 External 5V and PWM signals connector pin

The gate driver circuit on the IMS driver motherboard is powered from a 5V DC source, through the 5V connector pin. The PWM signals of both GaN devices come from the external PWM, also through the PWM connector pin. The deadtime of PWM signals is required and should be provided from an external source.

2.4 Temperature Monitoring Hole

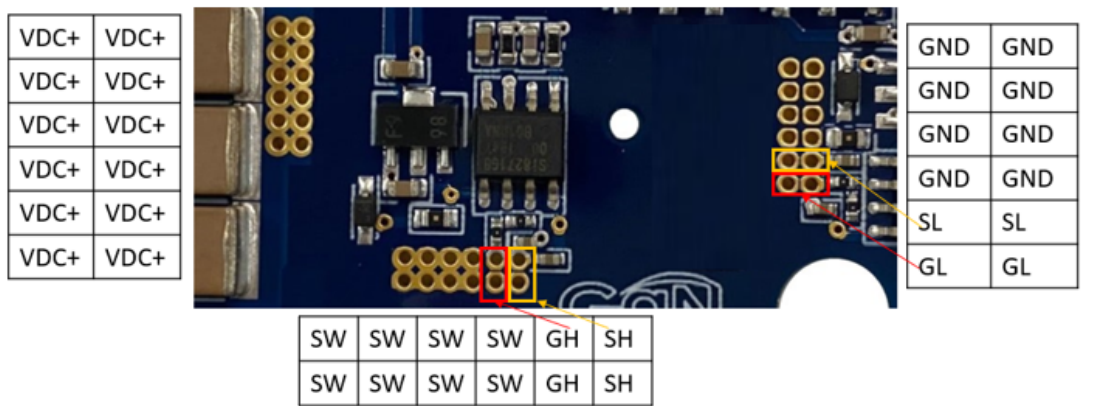
A hole is located on the center of the low-side GaN E-mode to assist with the temperature monitoring during operation. A thermal camera can be used to monitor the case temperature through the temperature monitoring hole. The temperature measured at the center of GaNPX® package will be close to the T_j .



NOTE: Thermal performance of the transistors is dependent on a number of factors including circuit configuration, ambient temperature, airflow, and heatsinking. The user is responsible for monitoring the temperature of the devices to ensure operation remains within specification.

2.5 Installation of IMS Half-Bridge Daughter power board

To achieve the lowest power loop parasitics, it is suggested to solder the IMS half-bridge daughter power board to the IMS EVB driver motherboard. When soldering by hand, it is important to avoid accidental short circuits caused by unwanted solder connection between the device gate and source, as shown in figure 7.



VDC+: Positive bus voltage
 SW: Switching node
 GND: Power loop ground

GH: Gate of high-side GaN
 SH: Source of high-side GaN

GL: Gate of low-side GaN
 SL: Source of low-side GaN

Figure 7 Soldering pin guide

2.6 DC Link Decoupling Capacitors

As it is challenging to create a low inductance power loop on a single-layer IMS board, DC decoupling capacitors are placed on a multi-layer IMS EVB PCB. The power loop path is highlighted below.

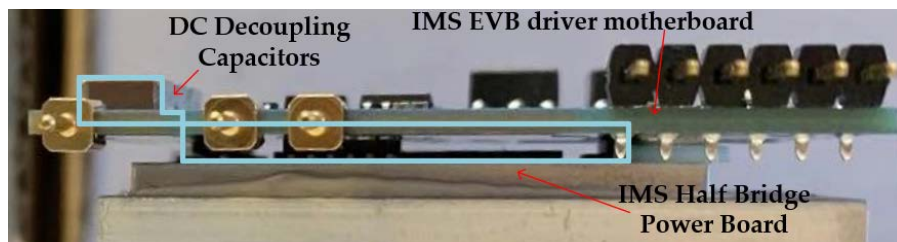


Figure 8 Cross-section view of IMS assembly showing the power loop path

3 IMS Half Bridge Daughter Power Board Options

With the driver motherboard, the evaluation platform can be purchased in 4 different configurations: low power (3 kW) and high power (6 kW), normal thermal conductivity (3K) and high thermal conductivity (7K). The ordering options are listed in table 2:

Table 2 Compatible IMS daughter power boards for driver motherboard GS-EVB-HBDB-IMS

CONFIGURATION	IMS2 and IMS3 HALF BRIDGE DAUGHTER POWER BOARD
3K 3 kW Half Bridge	GSP66508HB-EVBIMS2
3K 6 kW Half Bridge	GSP66516HB-EVBIMS2
7K 3 kW Half Bridge	GS-EVB-IMS3-66508B-GS
7K 6 kW Half Bridge	GS-EVB-IMS3-66516B-GS



a) GSP66508HB-EVBIMS2



b) GSP66516HB-EVBIMS2

Figure 9 Compatible IMS2 daughter power boards



a) GS-EVB-IMS3-66508B-GS



b) GS-EVB-IMS3-66516B-GS

Figure 10 Compatible IMS3 daughter power boards

The half-bridge daughter power board is populated with GaN Systems’ GS66516B (bottom-side cooled E-mode transistor, rated at 650 V / 25 mΩ) or GS66508B (bottom-side cooled E-mode transistor, rated at 650 V / 50 mΩ).

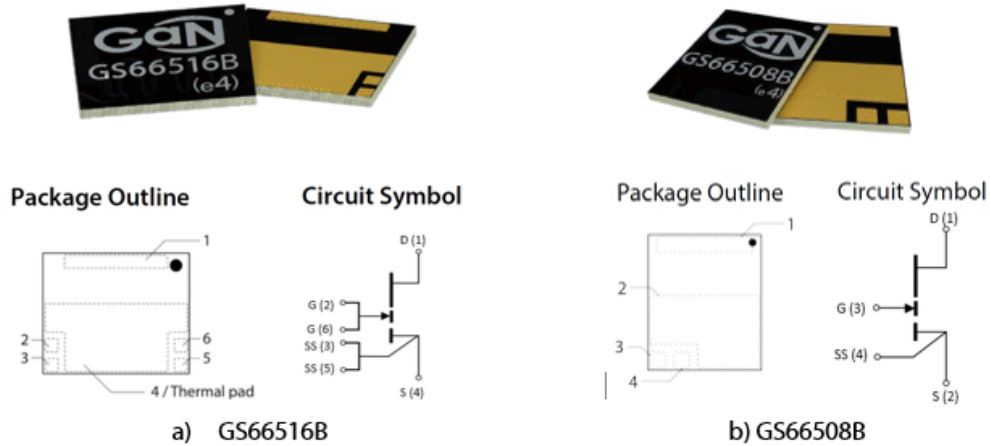


Figure 11 GS66516B and GS66508B GaNPX® packaged GaN E-mode transistor

The main difference between the IMS2 daughter power board and the IMS3 daughter power board is the thermal conductivity (K factor) of the dielectric layer of the IMS board.

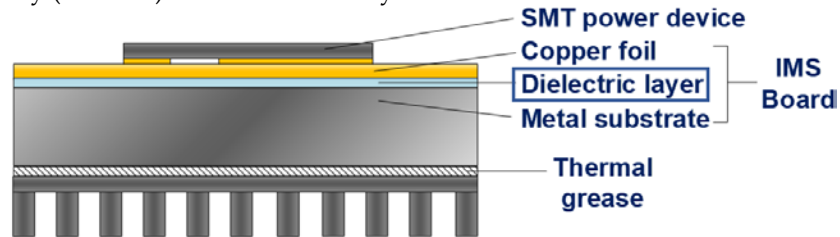


Figure 12 Cross-section view of a single layer IMS board

Using this platform power designers can evaluate the electrical and thermal performance of GaN Systems’ E-mode transistor in high power, high-efficiency applications. The ordering information are listed below:

Table 3 Part numbers and description

PART NUMBER	DESCRIPTION	GaN E-mode
GSP66508HB-EVBIMS2	650 V GaN High Power IMS2 Half Bridge	GS66508B
GSP66516HB-EVBIMS2	650 V GaN High Power IMS2 Half Bridge	GS66516B
GS-EVB-IMS3-66508B-GS	650 V GaN High Power IMS3 Half Bridge	GS66508B
GS-EVB-IMS3-66516B-GS	650 V GaN High Power IMS3 Half Bridge	GS66516B

The IMS2 and IMS3 half-bridge daughter power boards are designed for users to gain hands-on experience in the following ways:

- Evaluate the GaN E-mode performance in any half-bridge based topology, over a range of operating conditions. This can be done using either the accompanying power motherboard (P/N: GS-EVB-HBDB-IMS) or with the users’ own board for in-system prototyping.
- Use as a thermal and electrical design reference of the GS66516B or GS66508B GaNPX® package in demanding high-power and high-efficiency applications.

4 Test Results

4.1 Double Pulse Test (GS-EVB-HBDB-IMS + GS-EVB-IMS3-66508B-GS)

- Test condition: $V_{DS} = 400V$, $I_D = 30A$, $V_{GS} = +6V/-3V$, $L = 37\mu H$, No RC Snubber, $T_J = 25^\circ C$
- Measured peak $V_{DS} = 630V$ and $92 V/ns$ peak dV/dt
- Reliable hard switching with GS66508B is achieved at full rated current

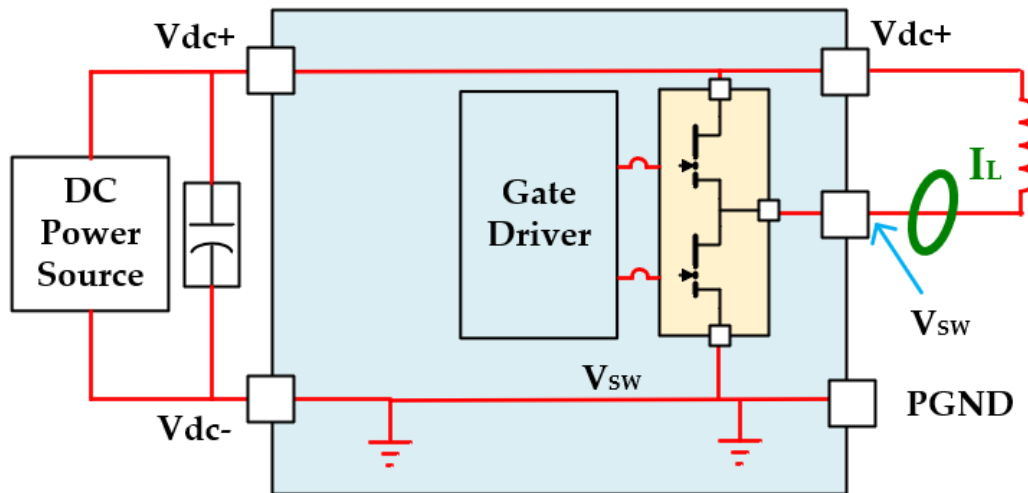


Figure 13 Double pulse test setup schematics

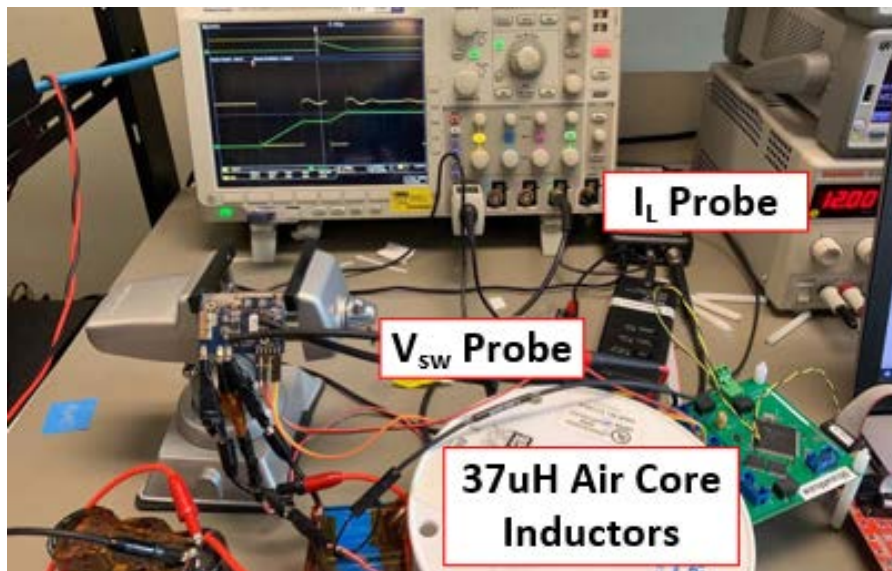


Figure 14 Double pulse test setup

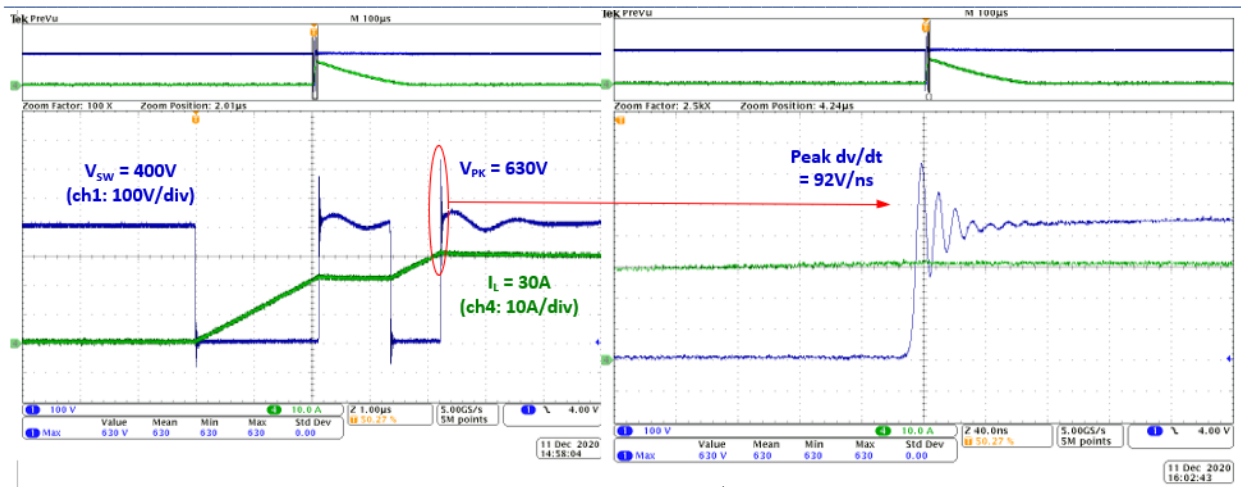


Figure 15 Double pulse test waveforms (400V/30A)

4.2 Boost Configuration Test (GS-EVB-HBDB-IMS + GS-EVB-IMS3-66508B-GS)

- Test condition: $V_{IN} = 400V$, $f_{sw} = 10kHz$, $P_O = 0.8kW$, $T_{AMB} = 25^\circ C$.
- Device case temperature $72^\circ C$

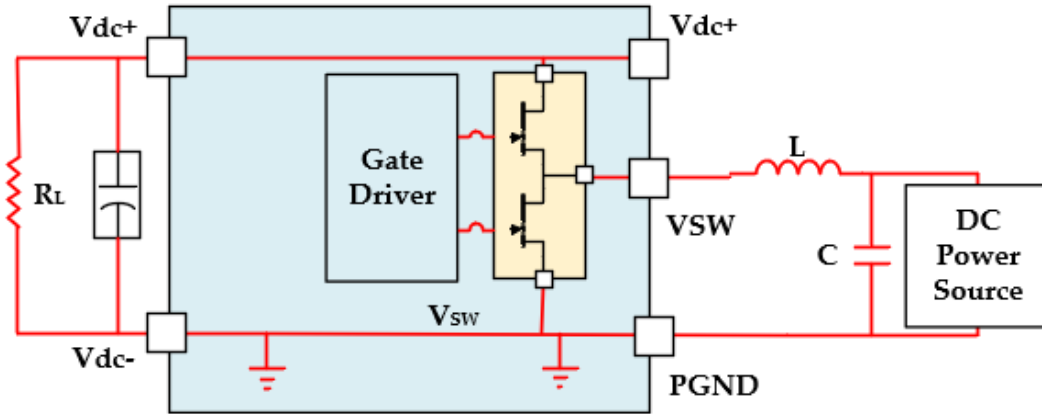


Figure 16 Boost configuration test setup schematics

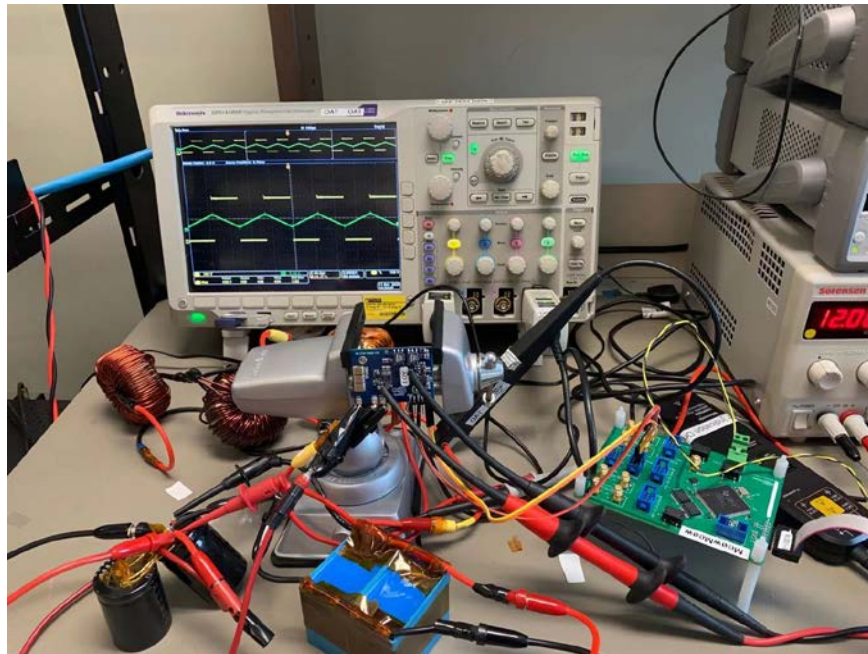


Figure 17 Boost configuration test setup

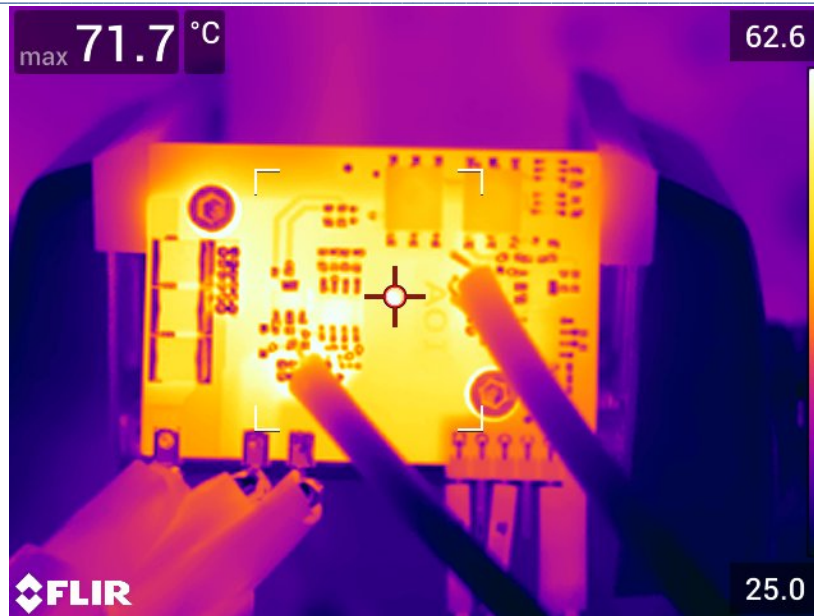


Figure 18 Boost configuration test thermal measurement result

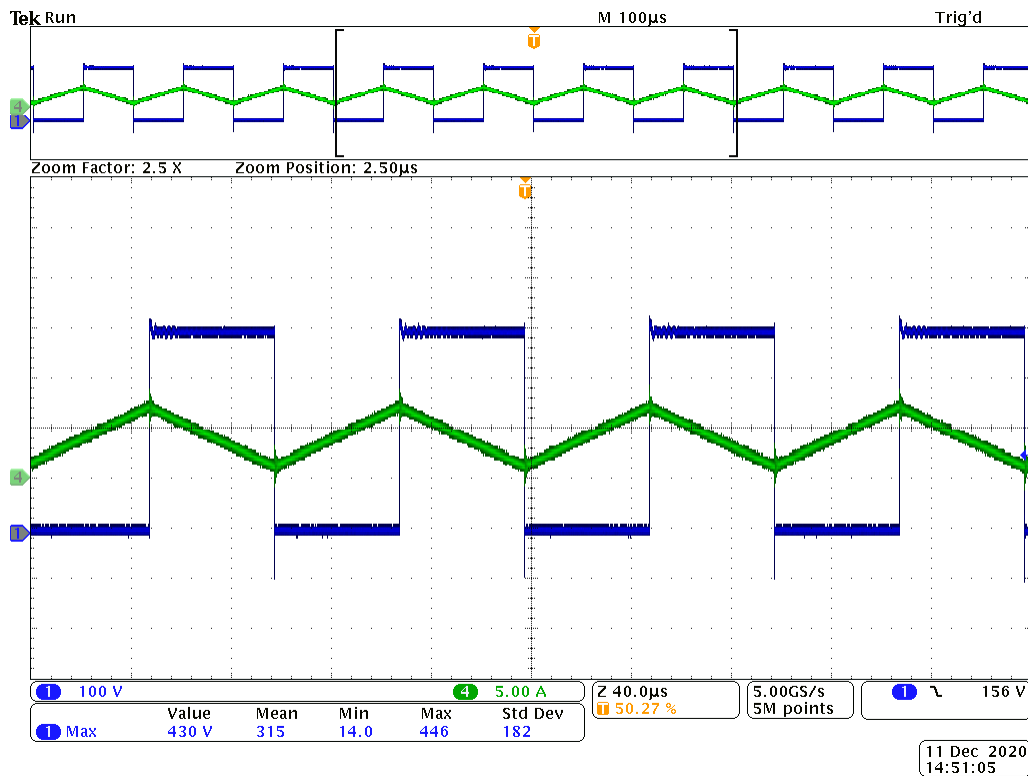
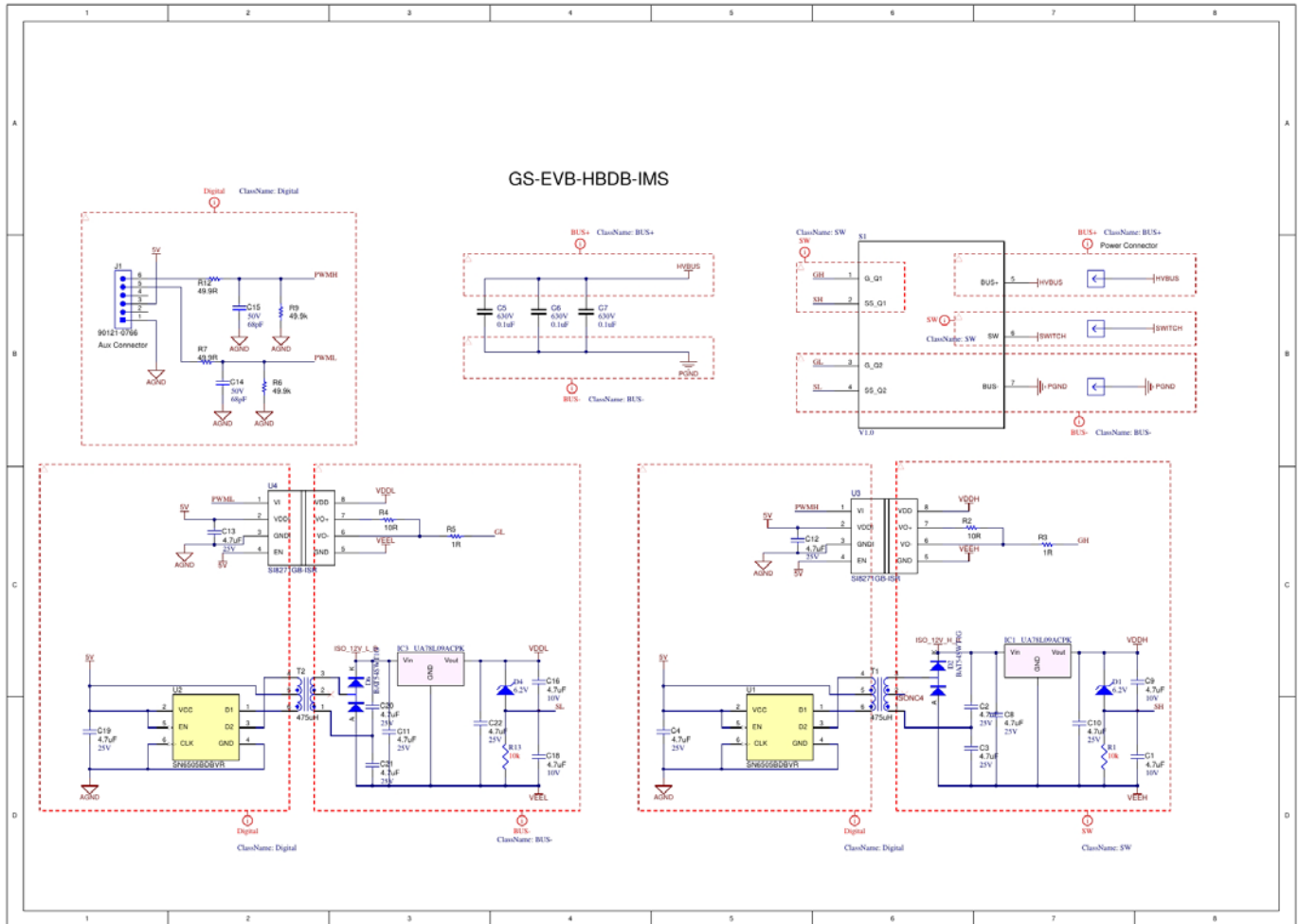


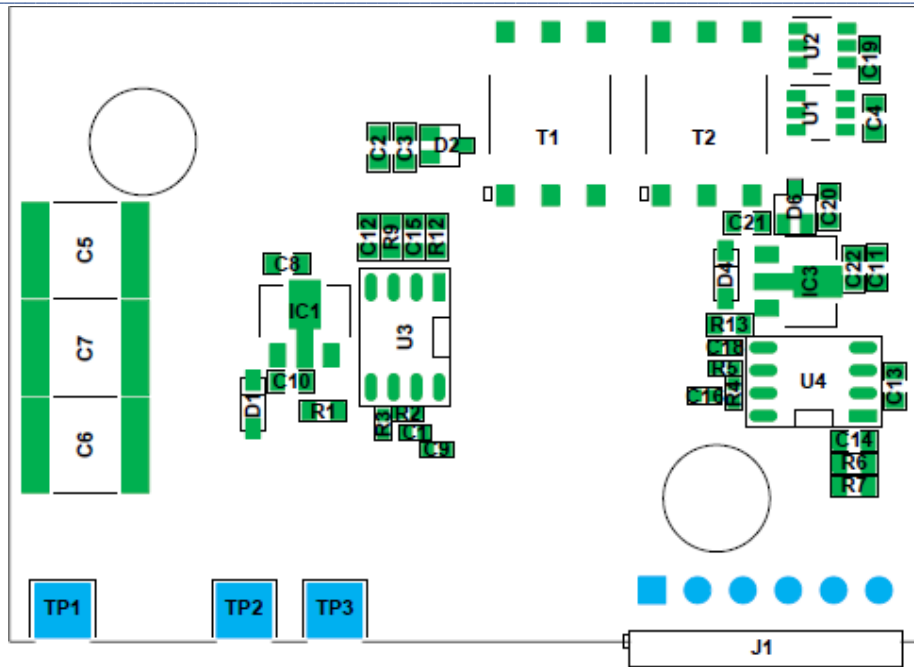
Figure 19 Test waveforms (400Vin, 10kHz, Po=0.8kW)

Ch#1 (blue): Drain-source voltage, 100V/div
Ch#4 (green): Inductor current, 5A/div

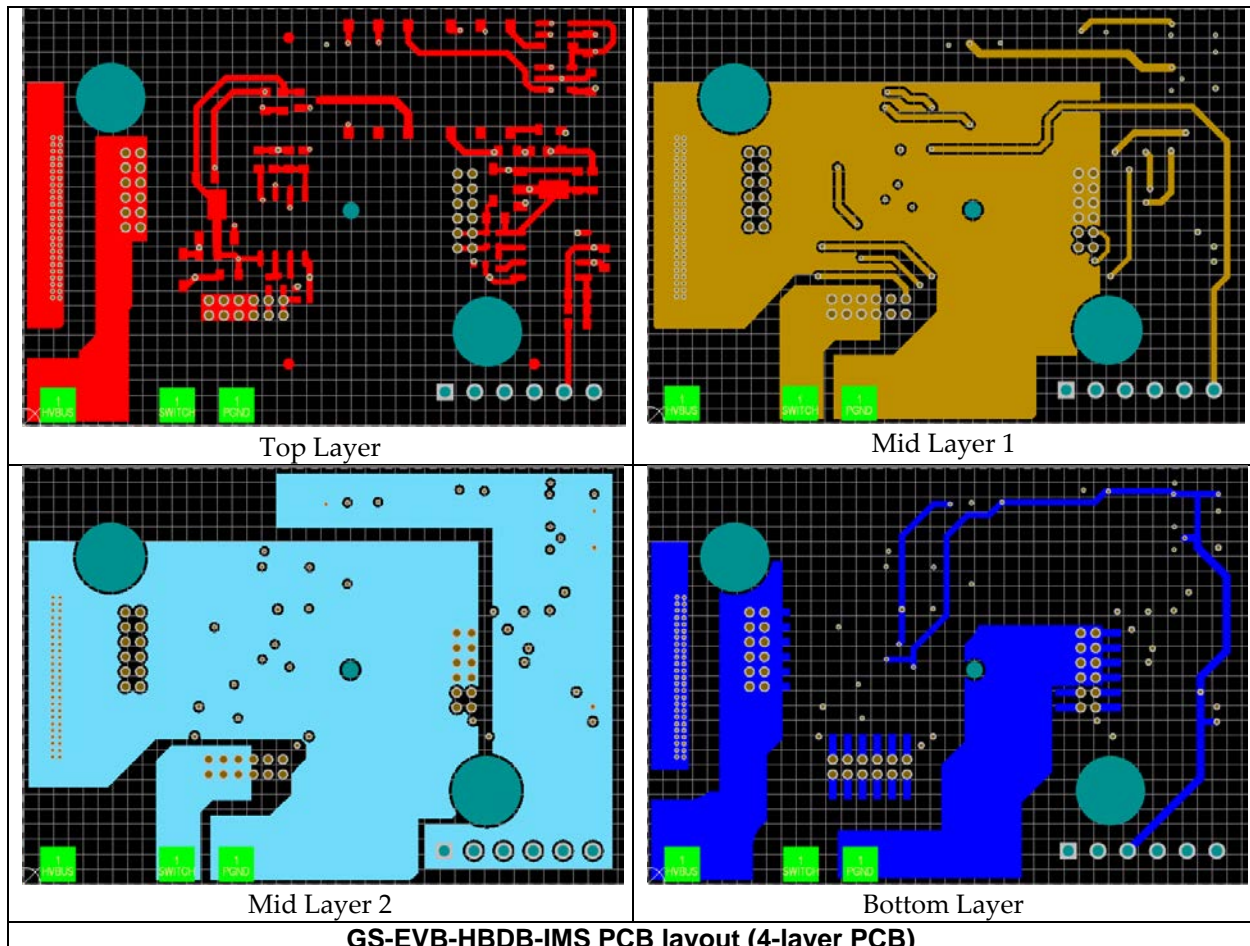
5 GS-EVB-HBDB-IMS Schematics and BoM



GS-EVB-HBDB-IMS motherboard schematics



GS-EVB-HBDB-IMS assembly drawing (top layer)



GS-EVB-HBDB-IMS PCB layout (4-layer PCB)

GS-EVB-HBDB-IMS Bill of Materials (BOM)

Designator	Description	Quantity	Manufacturer	Manufacturer Part Number
C1, C9, C16, C18	CAP CER 4.7UF 10V X5R 0402	4	Samsung Electro-Mechanics	CL05A475MP7NRB8
C2, C3, C4, C8, C10, C11, C12, C13, C19, C20, C21, C22	CAP CER 4.7UF 25V X5R 0603	12	Samsung Electro-Mechanics	CL10A475KA8NQNC
C5, C6, C7	CAP CER 0.1UF 630V X7R 2220	3	KEMET	C2220C104KBRAC7800
C14, C15	CAP CER 68PF 50V COG/NP0 0603	2	Samsung Electro-Mechanics	CL10C680JB8NNNC
D1, D4	DIODE ZENER 6.2V 300MW SOD323	2	ON Semiconductor	SZMM3Z6V2T1G
D2, D6	DIODE ARRAY SCHOTTKY 30V SOT323	2	ON Semiconductor	BAT54SWT1G
IC1, IC3	IC REG LINEAR 9V 100MA SOT89-3	2	Texas Instruments	UA78L09ACPK
J1	Header, 2.54mm, 6x1, Gold, R/A, TH	1	Molex	901210766
R1, R13	RES SMD 10K OHM 1% 1/4W 0603	2	Rohm Semiconductor	ESR03EZPF1002
R2, R4	RES 10 OHM 5% 1/16W 0402	2	Samsung Electro-Mechanics	RCS1005J100CS
R3, R5	RES 1 OHM 5% 1/16W 0402	2	Samsung Electro-Mechanics	RCS1005J1R0CS
R6, R9	RES SMD 49.9K OHM 1% 1/10W 0603	2	Panasonic Electronic Components	ERJ-3EKF4992V
R7, R12	RES SMD 49.9 OHM 1% 1/10W 0603	2	Panasonic Electronic Components	ERJ-3EKF49R9V
T1, T2	Transformer, 475uH, SMT	2	Würth Elektronik	760390014
TP1, TP2, TP3	CONN PC PIN CIRC 0.040DIA GOLD	3	Mill-Max Manufacturing Corp.	3620-2-32-15-00-00-08-0
U1, U2	IC TRANSFORMER DRIVER 6SOT-23	2	Texas Instruments	SN6505BDBVR
U3, U4	DGTL ISO 2.5KV GATE DRVR 8SOIC	2	Silicon Labs	SI8271GB-ISR

Evaluation Board/kit Important Notice

GaN Systems Inc. (GaN Systems) provides the enclosed product(s) under the following **AS IS** conditions:

This evaluation board/kit being sold or provided by GaN Systems is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, and OR EVALUATION PURPOSES ONLY** and is not considered by GaN Systems to be a finished end-product fit for general consumer use. As such, the goods being sold or provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to 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 regulations.

If this evaluation board/kit does not meet the specifications indicated in the Technical Manual, 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 THE 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. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies GaN Systems 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.

No License is granted under any patent right or other intellectual property right of GaN Systems whatsoever. **GaN Systems assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or any other intellectual property rights of any kind.**

GaN Systems currently services a variety of customers for products around the world, and therefore this transaction **is not exclusive.**

Please read the Technical Manual and, specifically, the Warnings and Restrictions notice in the Technical Manual prior to handling the product. Persons handling the product(s) must have electronics training and observe good engineering practice standards.

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a GaN Systems' application engineer.

In Canada:
GaN Systems Inc.
1145 Innovation Drive Suite 101
Ottawa, Ontario, Canada K2K 3G8
T +1 613-686-1996

In Europe:
GaN Systems Ltd., German Branch
Terminalstrasse Mitte 18,
85356 München, Germany
T +49 (0) 8165 9822 7260

In the United States:
GaN Systems Corp. 2723 South State Street,
Suite 150, Ann Arbor, MI. USA 48104 T +1 248-
609-7643

www.gansystems.com

Important Notice – Unless expressly approved in writing by an authorized representative of GaN Systems, GaN Systems components are not designed, authorized or warranted for use in lifesaving, life sustaining, military, aircraft, or space applications, nor in products or systems where failure or malfunction may result in personal injury, death, or property or environmental damage. The information given in this document shall not in any event be regarded as a guarantee of performance. GaN Systems hereby disclaims any or all warranties and liabilities of any kind, including but not limited to warranties of non-infringement of intellectual property rights. All other brand and product names are trademarks or registered trademarks of their respective owners. Information provided herein is intended as a guide only and is subject to change without notice. The information contained herein or any use of such information does not grant, explicitly, or implicitly, to any party any patent rights, licenses, or any other intellectual property rights. General Sales and Terms Conditions apply.

© 2009-2019 GaN Systems Inc. All rights reserved.