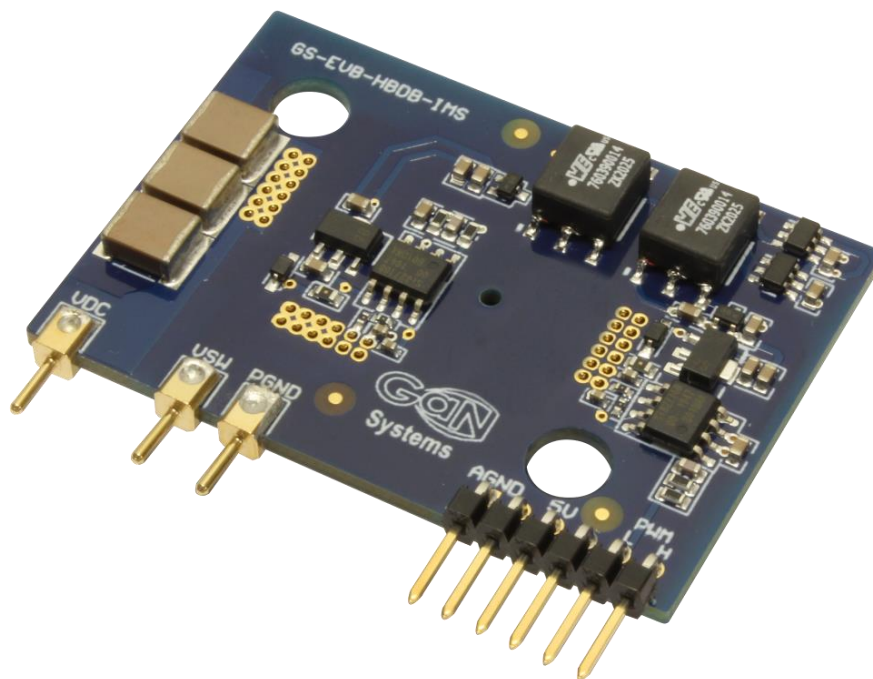


## GS-EVB-HBDB-IMS

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

#### Technical Manual



Visit [www.gansystems.com](http://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.

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# 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- $\Phi$  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

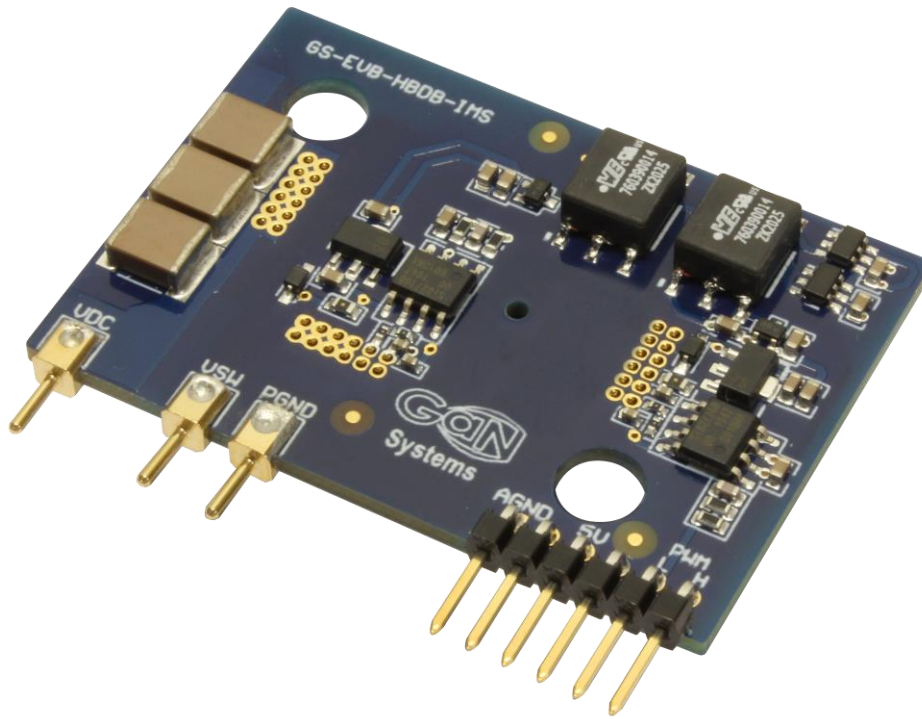


Figure 1 IMS EVB motherboard GS-EVB-HBDB-IMS

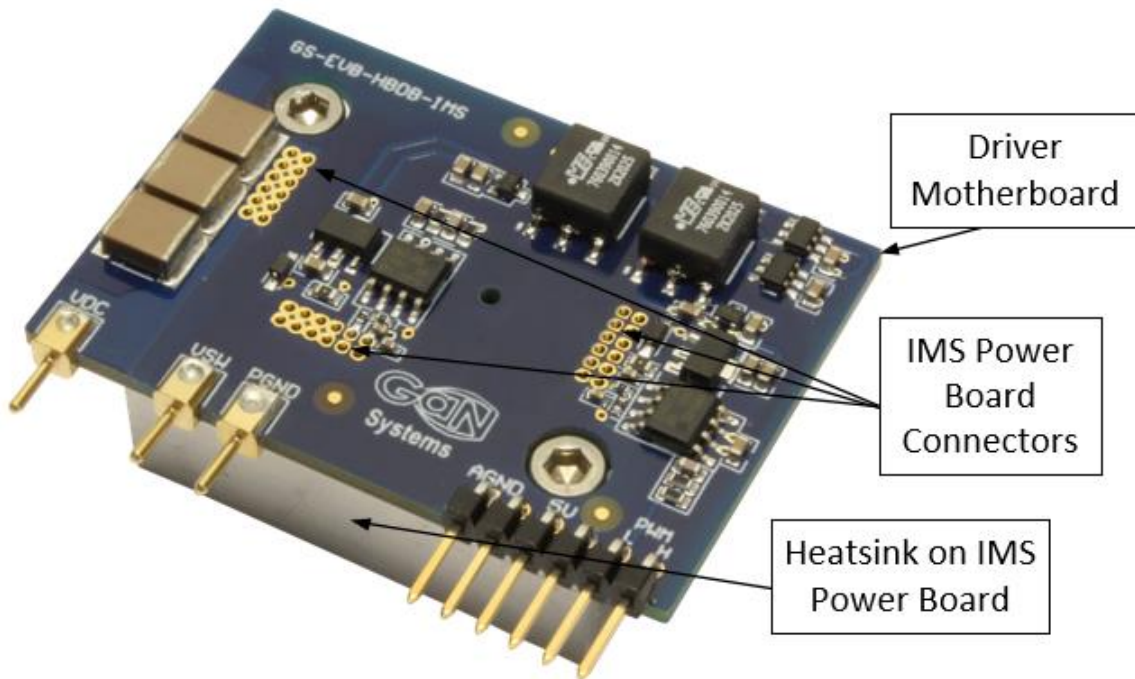


Figure 2 Assembled IMS EVB module with heatsink

## 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.

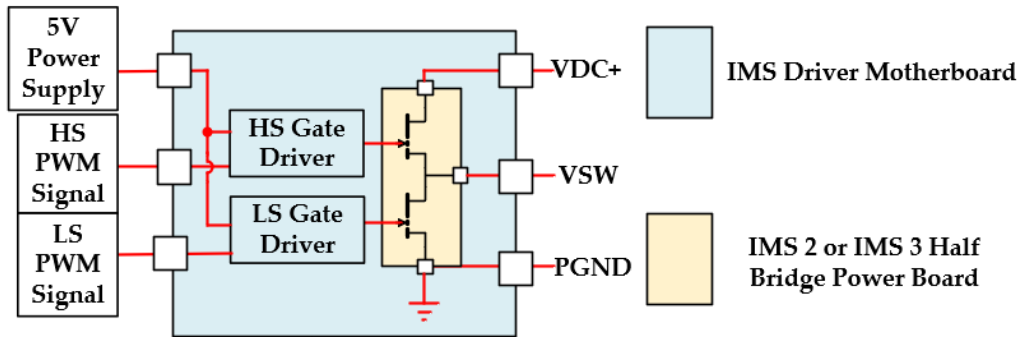


Figure 3 Circuit block diagram of IMS EVB Module

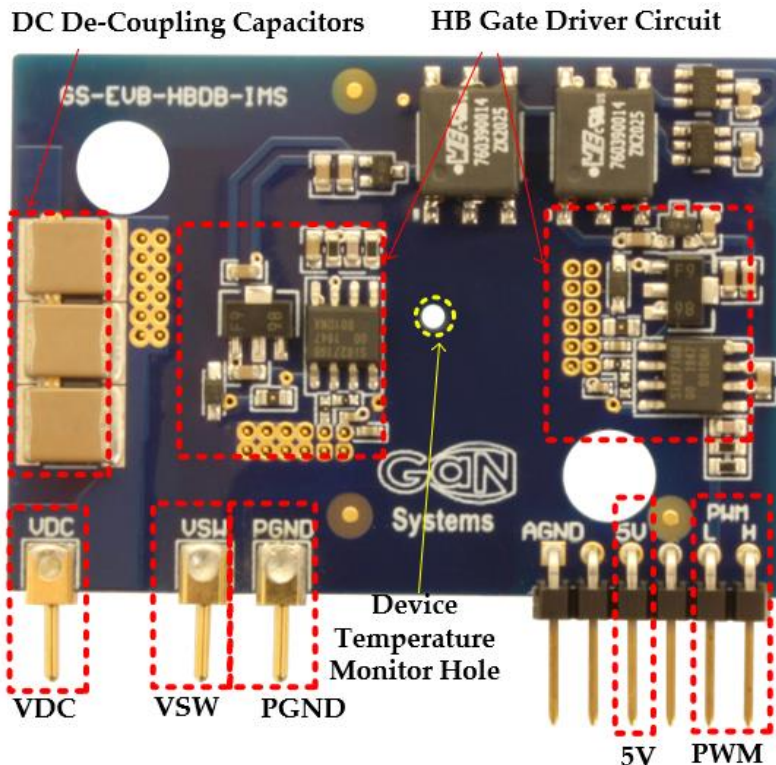


Figure 4 Labelled driver motherboard

## 2.2 Gate Driver Circuit

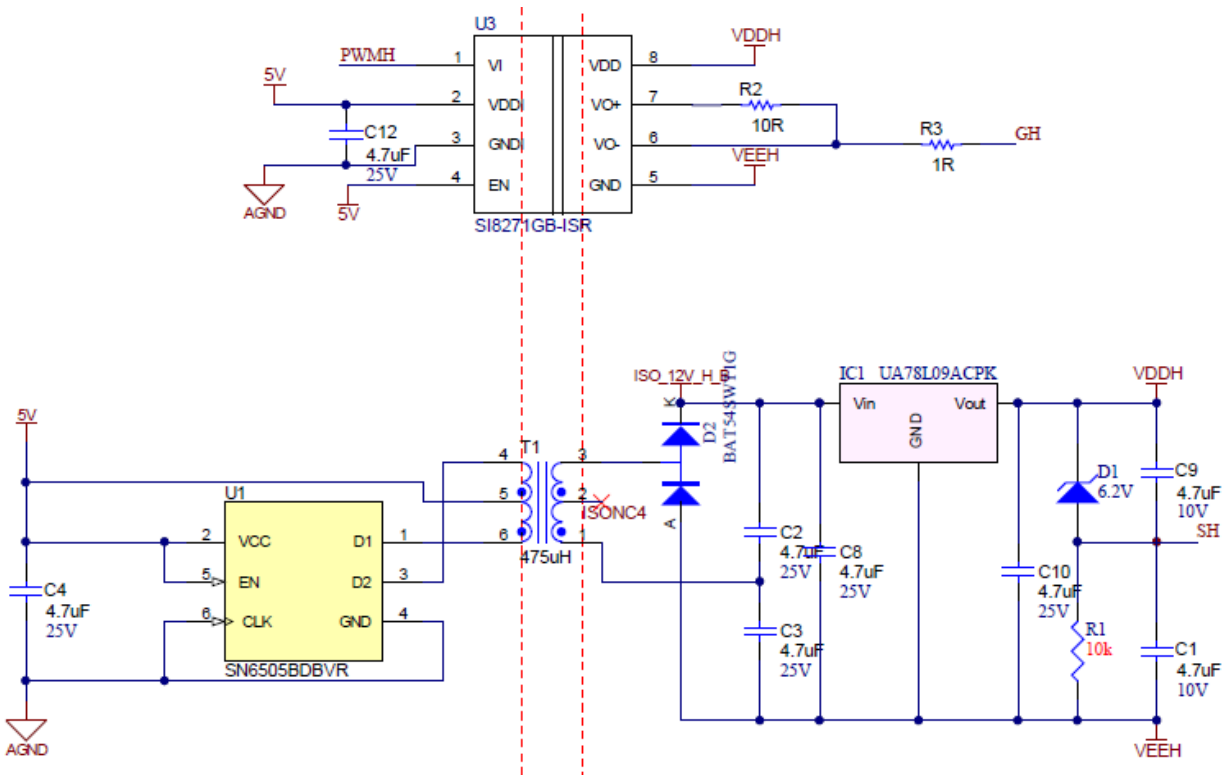


Figure 5 Gate driver circuit (Silicon Labs P/N: Si8271)

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

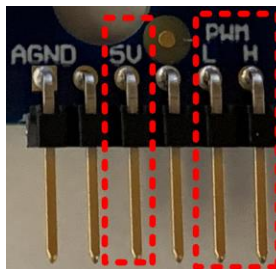


Figure 6 External 5V and PWM signals connector pin



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

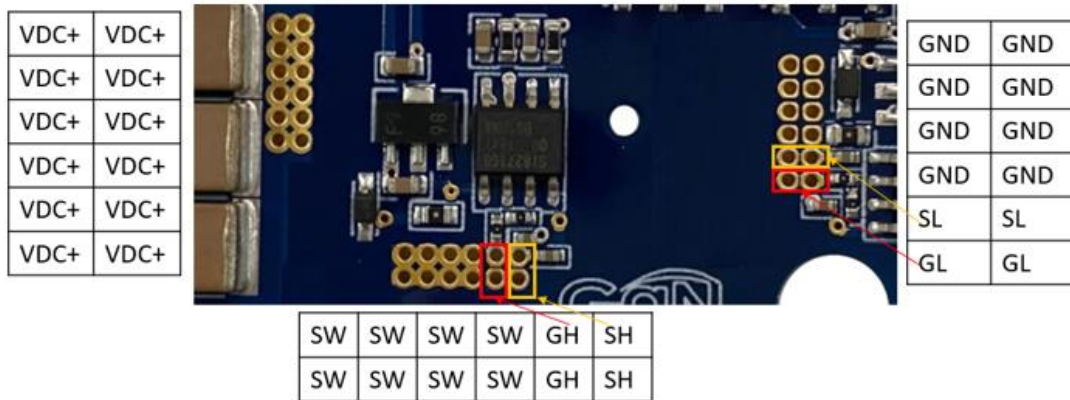
A hole is located on the center of the low-side GaN E-mode to assist with the temperature monitoring during operation. A thermal camera can be used to monitor the case temperature through the temperature monitoring hole. The temperature measured at the center of GaNPX® package will be close to the T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



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.

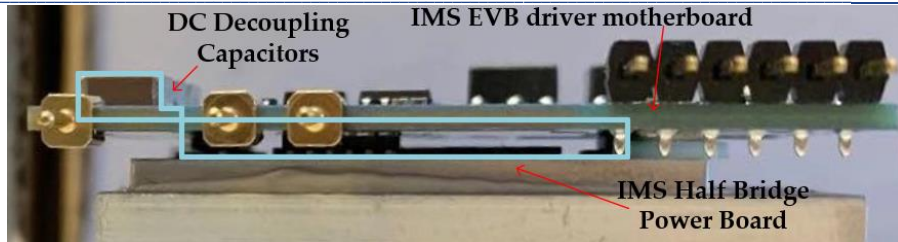


Figure 8 Cross-section view of IMS assembly showing the power loop path

### 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).

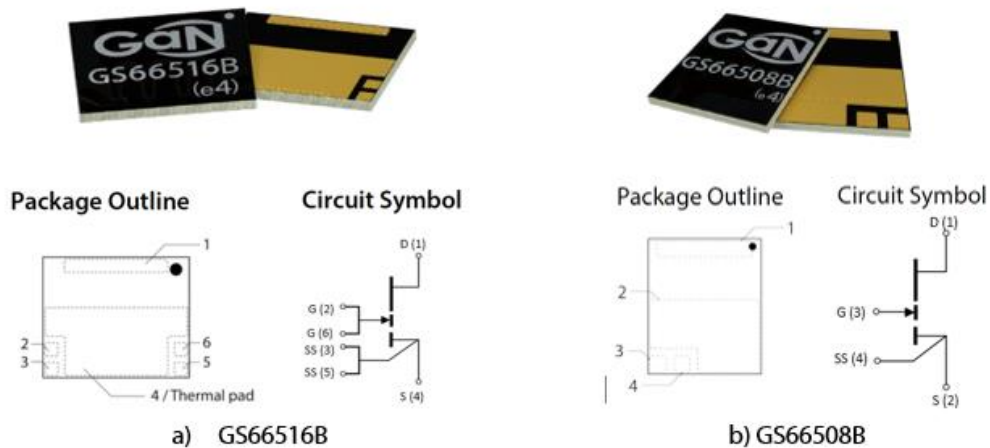


Figure 11 GS66516B and GS66508B GaNPX® packaged GaN E-mode transistor

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.

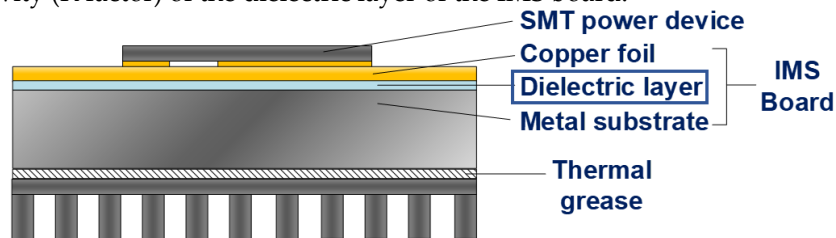


Figure 12 Cross-section view of a single layer IMS board

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 GaN<sup>PX</sup>® 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

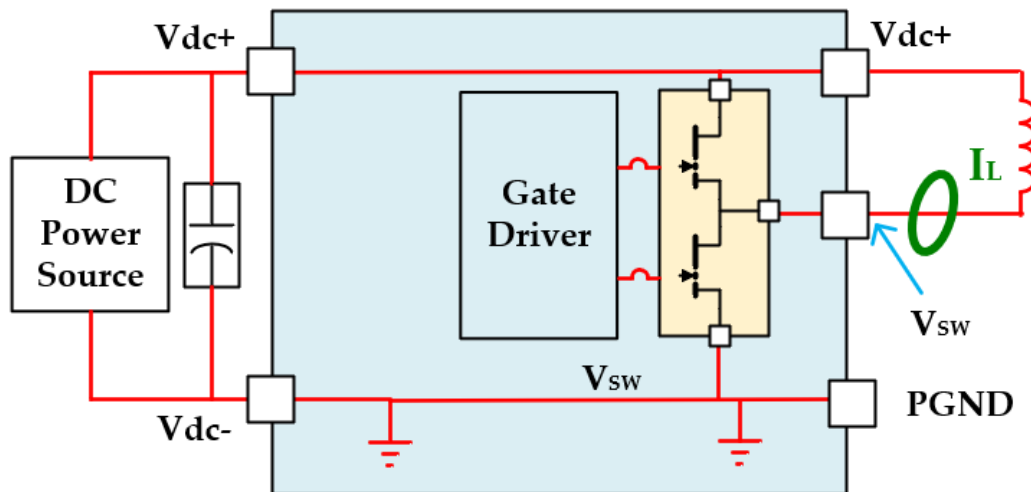


Figure 13 Double pulse test setup schematics

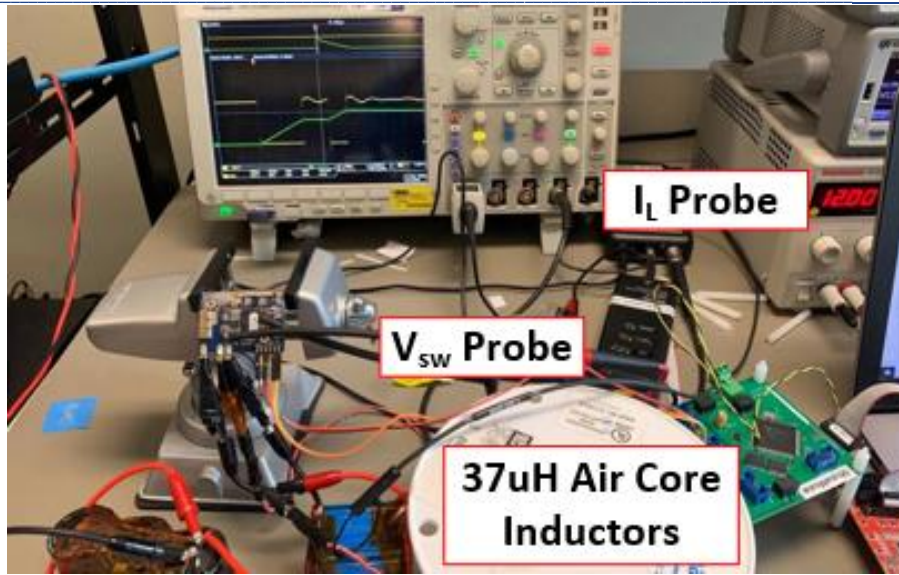


Figure 14 Double pulse test setup

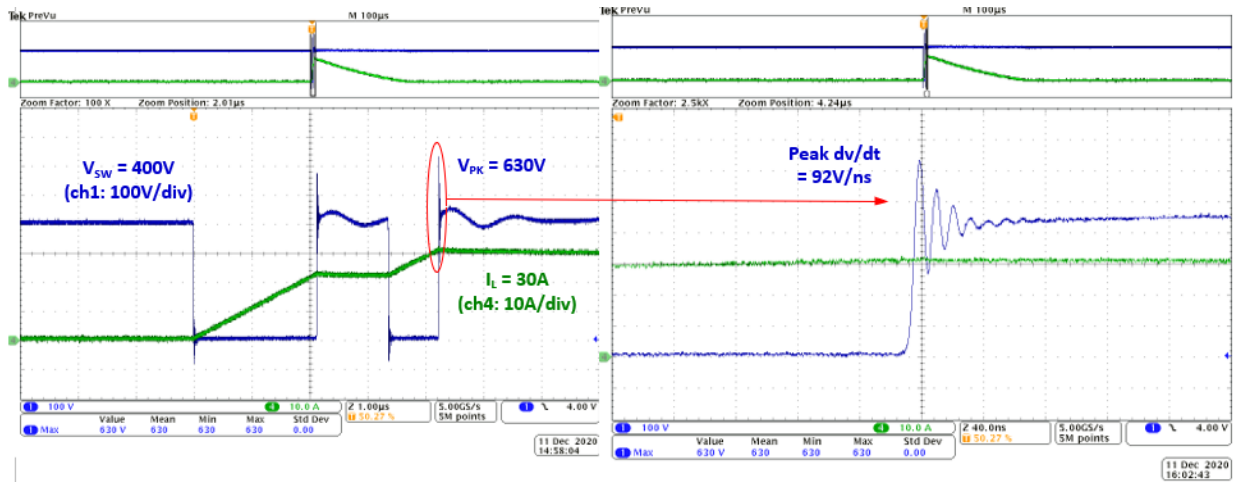


Figure 15 Double pulse test waveforms (400V/30A)

**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  $72^\circ C$

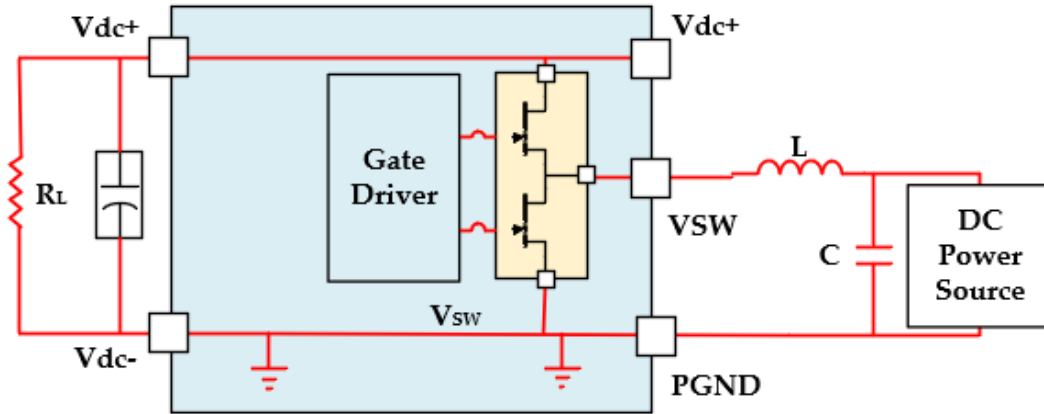


Figure 16 Boost configuration test setup schematics

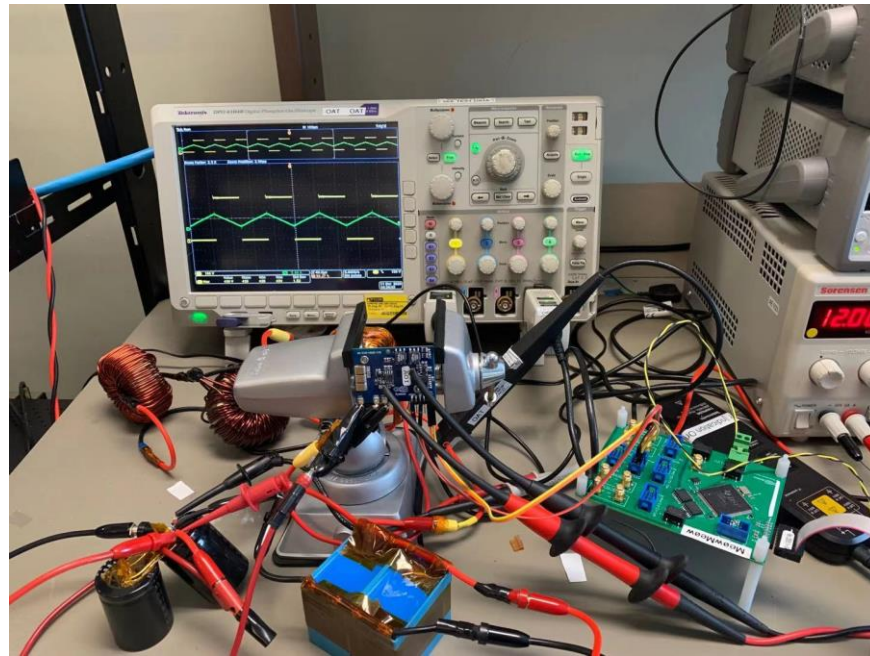


Figure 17 Boost configuration test setup

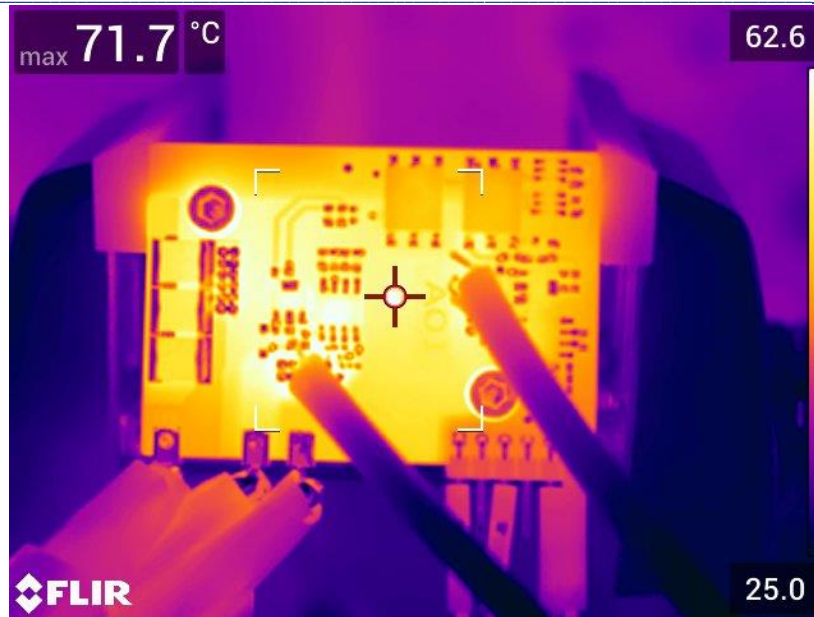


Figure 18 Boost configuration test thermal measurement result

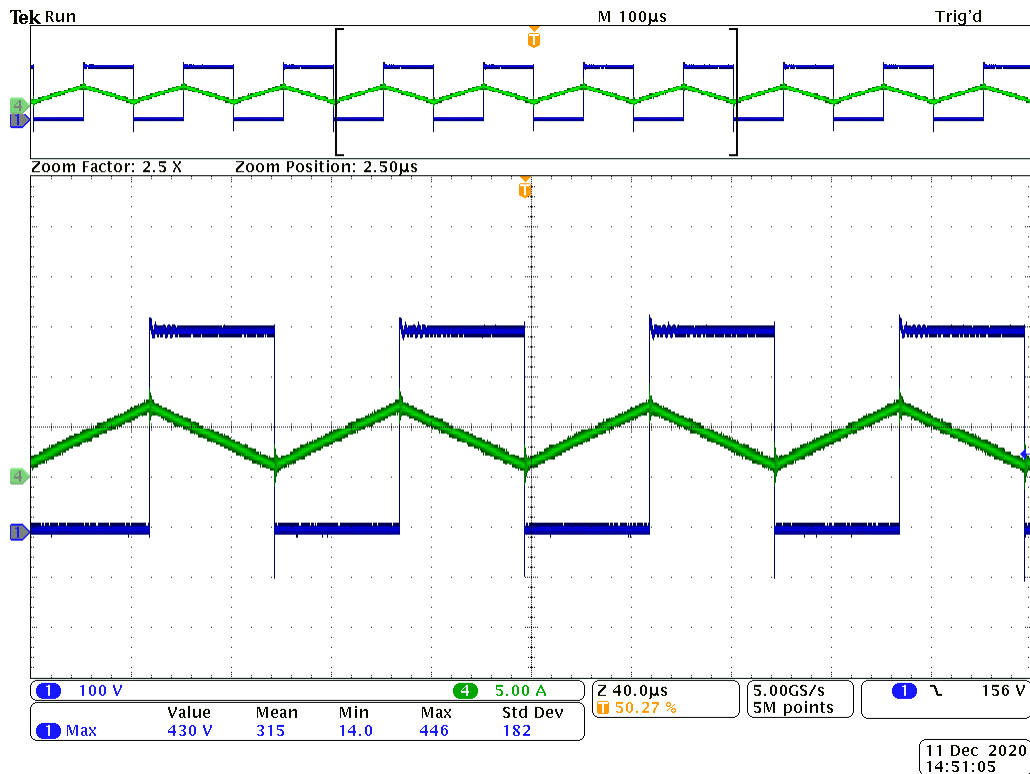
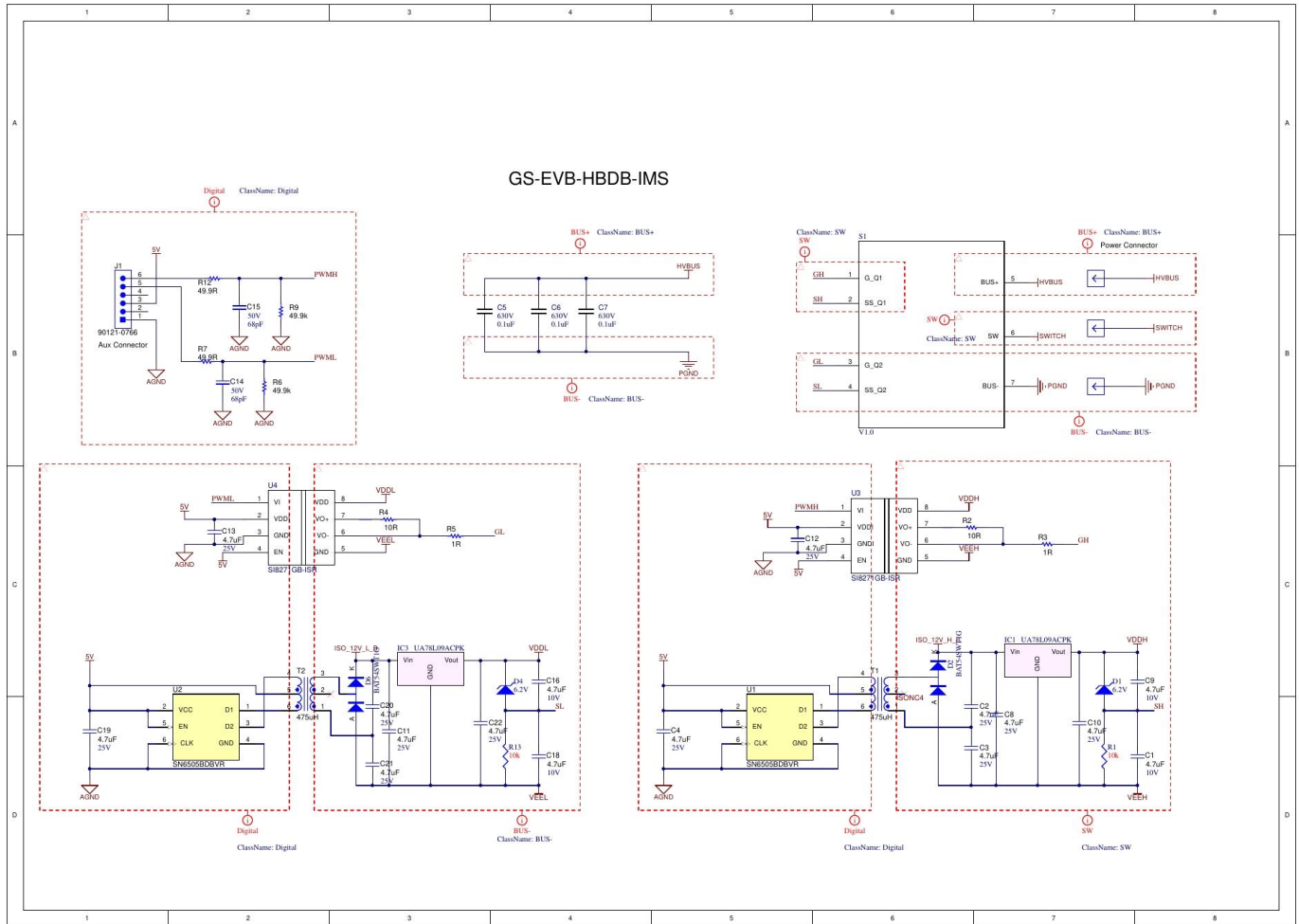


Figure 19 Test waveforms (400Vin, 10kHz, Po=0.8kW)

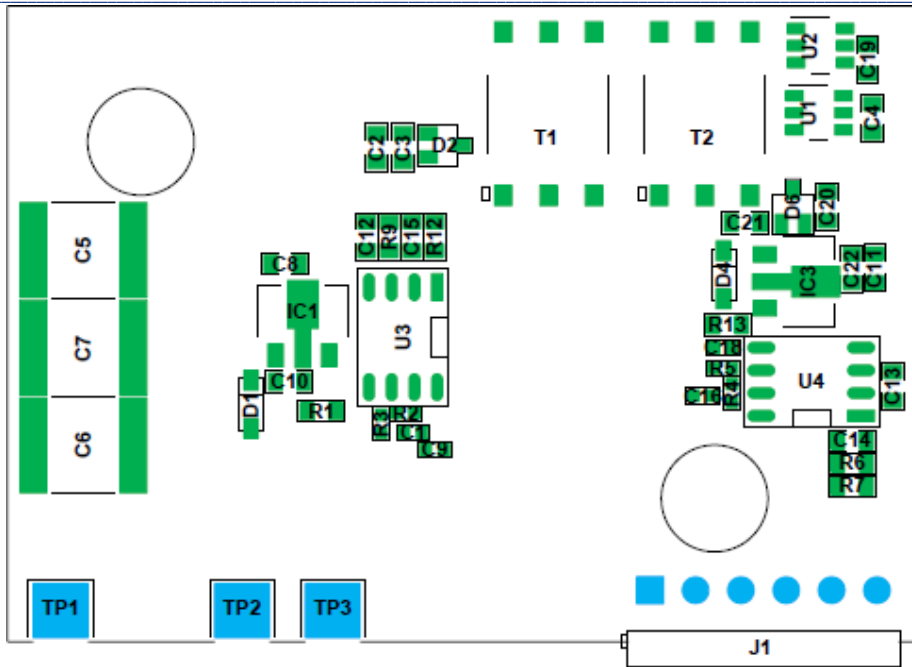
Ch#1 (blue): Drain-source voltage, 100V/div  
Ch#4 (green): Inductor current, 5A/div

## 5 GS-EVB-HBDB-IMS Schematics and BoM

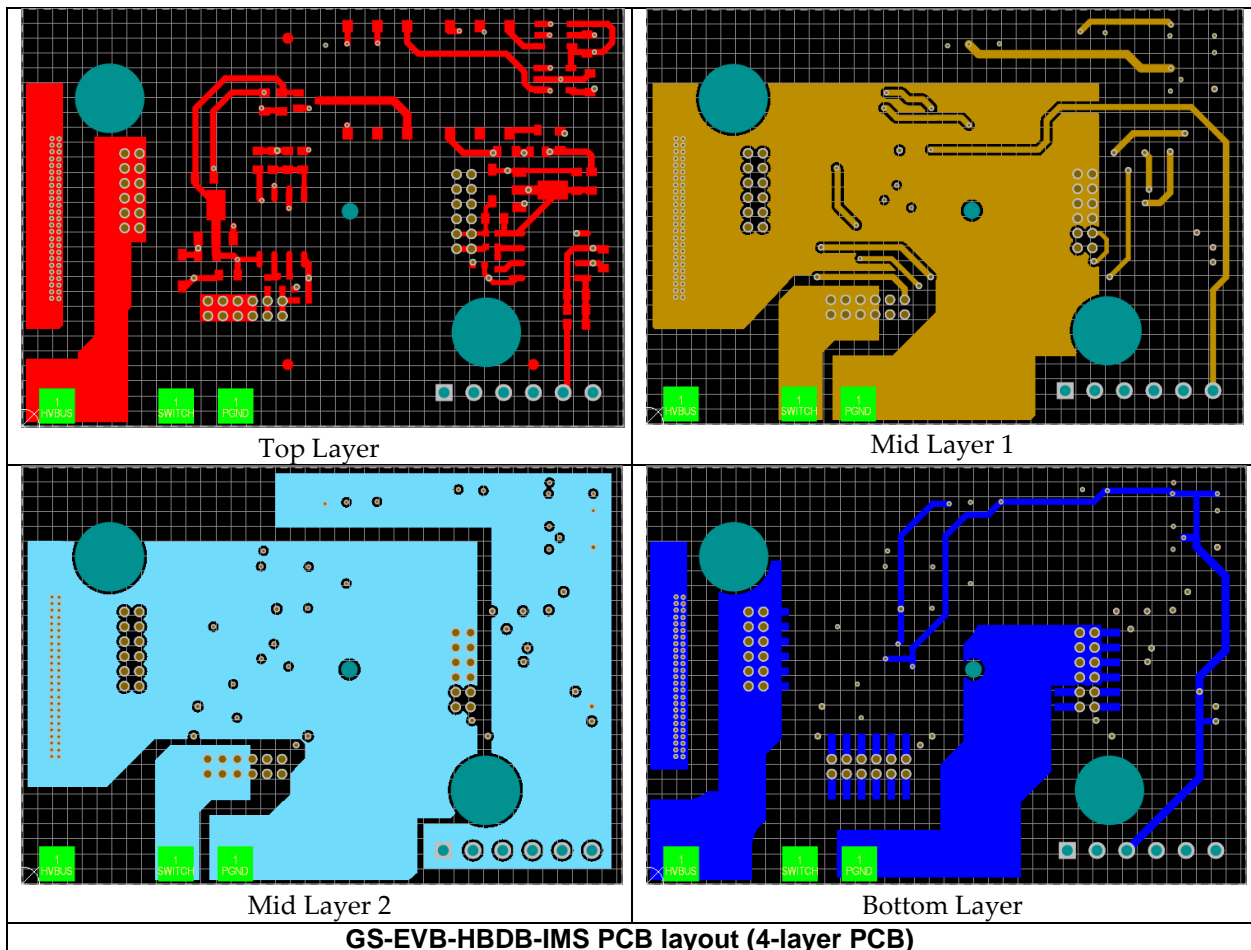


**GS-EVB-HBDB-IMS motherboard schematics**





**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	TDK Corporation	C1608X5R1E475M080AC
C5, C6, C7	CAP CER 0.1UF 630V X7R 2220	3	KEMET	C2220C104KBRAC7800
C14, C15	CAP CER 68PF 50V COG/NPO 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	UA78L09ACP
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% 1/10W 0402	2	Panasonic Electronic Components	ERJ-U02J100X
R3, R5	RES 1 OHM 5% 1/16W 0402	2	Stackpole Electronics Inc	RMCF0402JT1R00
R6, R9	RES SMD 49.9K OHM 0.5% 1/10W 0603	2	Stackpole Electronics Inc	RNCF0603DTE49K9
R7, R12	RES SMD 49.9 OHM 1% 1/10W 0603	2	Stackpole Electronics Inc	RMCF0603FT49R9
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-IS

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