GS-EVB-HBDB-IMS
650 V Universal Half Bridge Isolated Driver Motherboard for IMS2 & IMS3

Technical Manual

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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:
- GSP66508BH-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

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GS-EVB-HBDB-IMS 650V Universal Half Bridge Isolated Driver Motherboard for IMS2 and IMS3</td>
</tr>
</tbody>
</table>
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.
2.2 Gate Driver Circuit

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](image)
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.

![Soldering pin guide](image)

**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.
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

<table>
<thead>
<tr>
<th>CONFIGURATION</th>
<th>IMS2 and IMS3 HALF BRIDGE DAUGHTER POWER BOARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3K 3 kW Half Bridge</td>
<td>GSP66508HB-EVBIMS2</td>
</tr>
<tr>
<td>3K 6 kW Half Bridge</td>
<td>GSP66516HB-EVBIMS2</td>
</tr>
<tr>
<td>7K 3 kW Half Bridge</td>
<td>GS-EVB-IMS3-66508B-GS</td>
</tr>
<tr>
<td>7K 6 kW Half Bridge</td>
<td>GS-EVB-IMS3-66516B-GS</td>
</tr>
</tbody>
</table>

![Figure 8 Cross-section view of IMS assembly showing the power loop path](image)

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

![Figure 9 Compatible IMS2 daughter power boards](image)

Figure 9 Compatible IMS2 daughter power boards

a) GSP66508HB-EVBIMS2

b) GSP66516HB-EVBIMS2
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).

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.

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

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>GaN E-mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSP66508HB-EVBIMS2</td>
<td>650 V GaN High Power IMS2 Half Bridge</td>
<td>GS66508B</td>
</tr>
<tr>
<td>GSP66516HB-EVBIMS2</td>
<td>650 V GaN High Power IMS2 Half Bridge</td>
<td>GS66516B</td>
</tr>
<tr>
<td>GS-EVB-IMS3-66508B-GS</td>
<td>650 V GaN High Power IMS3 Half Bridge</td>
<td>GS66508B</td>
</tr>
<tr>
<td>GS-EVB-IMS3-66516B-GS</td>
<td>650 V GaN High Power IMS3 Half Bridge</td>
<td>GS66516B</td>
</tr>
</tbody>
</table>

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

![Double pulse test setup schematics](image)

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-HDB-IMS + GS-EVB-IMS3-66508B-GS)

- Test condition: \( V_{IN} = 400V, \ f_{sw}=10kHz, \ Po=0.8kW, \ T_{AMB} = 25^\circ C \)
- Device case temperature 72\(^\circ\)C
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 Bill of Materials (BOM)

<table>
<thead>
<tr>
<th>Designator</th>
<th>Description</th>
<th>Quantity</th>
<th>Manufacturer</th>
<th>Manufacturer Part Number</th>
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<tr>
<td>C1, C9, C16, C18</td>
<td>CAP CER 4.7UF 10V XSR 0402</td>
<td>4</td>
<td>Samsung Electro-</td>
<td>CL05A475MP7NRB8</td>
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<tr>
<td>C2, C3, C4, C8, C10, C11, C12, C13, C19, C20, C21, C22</td>
<td>CAP CER 4.7UF 25V XSR 0603</td>
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<td>SZMM3Z6V2T1G</td>
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<tr>
<td>D2, D6</td>
<td>DIODE ARRAY SCHOTTKY 30V SOT323</td>
<td>2</td>
<td>ON Semiconductor</td>
<td>BAT545WT1G</td>
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<tr>
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<td>Texas Instruments</td>
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<td>J1</td>
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<td>Rohm Semiconductor</td>
<td>ESR03EZPF1002</td>
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<tr>
<td>R2, R4</td>
<td>RES 10 OHM 5% 1/10W 0402</td>
<td>2</td>
<td>Panasonic Electronic Components</td>
<td>ERJ-U02J100X</td>
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<td>R3, R5</td>
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<td>R6, R9</td>
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<td>RNCF0603DTE49K9</td>
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<td>R7, R12</td>
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<td>T1, T2</td>
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<td>TP1, TP2, TP3</td>
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<td>3</td>
<td>Mill-Max Manufacturing Corp.</td>
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<td>U1, U2</td>
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<td>SN65058DBBVR</td>
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<td>U3, U4</td>
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<td>2</td>
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<td>SI8271GB-IS</td>
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