High Power IMS Evaluation Platform

Technical Manual

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Please refer to the Evaluation Board/Kit Important Notice on page 37

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 SEVERSE 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 are 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.

Please refer to the Evaluation Board/Kit Important Notice on page 37

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1 Overview

1.1 Introduction

A frequent challenge for power designers is to engineer a product that has excellent power density while simultaneously reducing the cost of the system.

This IMS evaluation platform demonstrates an inexpensive way to improve heat transfer, to increase power density and reduce system cost. An Insulated Metal Substrate PCB (IMS PCB) is used to cool GaN Systems' bottom-side cooled power transistors. An IMS PCB is also known as Metal Core/Aluminum PCB.

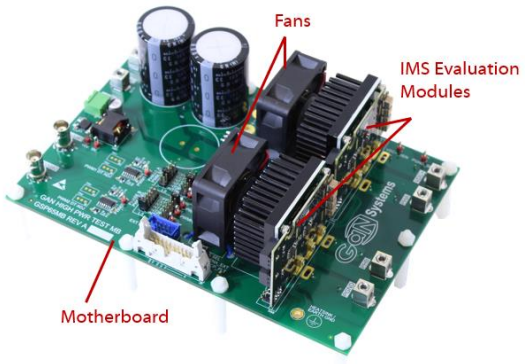
Examples of applications that have successfully used this approach include:

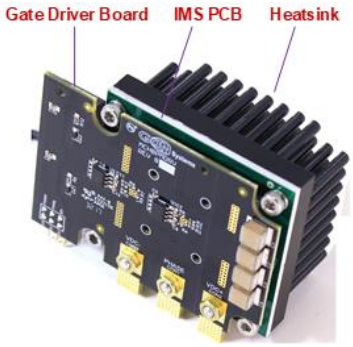
- **Automotive:** 3.3kW-22kW on board charger, DC/DC, 3-Φ inverter, high power wireless charger
- **Industrial:** 3-7kW Photovoltaic Inverter and Energy Storage System (ESS), Motor Drive / VFD
- **Server/Datacenter:** 3kW Server ACDC power supply.
- **Consumer:** Residential Energy Storage System (ESS)

This evaluation platform consists up of a motherboard and IMS evaluation modules The IMS evaluation modules are configured as a half bridge and are available in 2 power levels; 2-4kW and 4-7kW.

A suitable heatsink is included for lower power applications. For higher power applications additional heatsinking may be required. To prevent device damage, ensure adequate heatsinking through design and by monitoring the component temperatures during operation.

To assemble a heatsink, apply thermal grease to the heatsink / IMS board interface before screwing the units together. Enough thermal grease should be applied so that a small amount extrudes on all four sizes as the screws are tightened. Wipe the assembly clean.





IMS Evaluation Module

With these building blocks, the evaluation platform can be purchased in 4 different configurations: low power and high power, half bridge and full bridge. The IMS Evaluation modules can also be purchased independently to be used with the users' own board for in-system prototyping. Table 1 lists the ordering options.

Table 1 Ordering configuration and part numbers

CONFIGURATION	IMS HALF BRIDGE MODULE	MOTHERBOARD
3 kW Half Bridge	QTY 1 - GSP65R25HB-EVB	QTY 1: GSP65MB-EVB
6 kW Half Bridge	QTY 1 - GSP65R13HB-EVB	
3 kW Full Bridge	QTY 2 - GSP65R25HB-EVB	
6 kW Full Bridge	QTY 2 - GSP65R13HB-EVB	

Table 2 Part numbers and Description

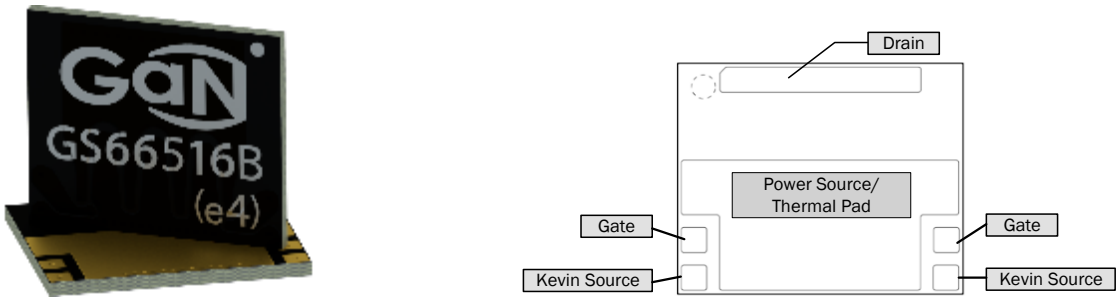
PART NUMBER	DESCRIPTION	GaN E-HEMT
GSP65MB-EVB	High Power Mother Board	N/A
GSP65R25HB-EVB	GaN E-HEMT Half Bridge Evaluation Module 650V/25mΩ	GS66516B
GSP65R13HB-EVB	GaN E-HEMT Half Bridge Evaluation Module 650V/13mΩ	2 x GS66516B

1.2 IMS Evaluation Module - Technical Description

Using this platform, power designers can evaluate the performance of GaN Systems' E-HEMT (Enhancement mode High Electron Mobility Transistor) in high power and high efficiency applications.

The IMS evaluation module is populated with GaN Systems' GS66516B, a bottom-side cooled E-HEMT, rated at 650V/25mΩ. The embedded GaN*PX*® SMD package has the following features:

- Dual symmetrical gate and source sense (kelvin source) for flexible PCB layout and paralleling.
- Large power source/thermal pad for improved thermal dissipation.
- Bottom-side cooled packaging for conventional PCB or advanced IMS/Cu inlay thermal design.
- Ultra-low inductance for high frequency switching.



a) GS66516B Package b) Footprint (view from top)

Figure 1 - GS66516B GaNPX® SMD Package

The IMS evaluation module is a two-board assembly that includes GaN E-HEMTs, gate drivers, isolated DC/DC supply, DC bus decoupling capacitors and a heatsink to form a fully functional half bridge power stage. It was designed for users to gain hands-on experience in the following ways:

- Evaluate the GaN E-HEMT 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: GSP65MB-EVB) or with the users' own board for in-system prototyping.
- Use as a thermal and electrical design reference of the GS66516B GaN*PX*® SMD package in demanding high-power applications.
- Design concept for compact GaN smart power modules (or IPMs).
- Evaluate the performance of GaN E-HEMTs in parallel, for high power applications.
- Achieve high power density with its vertical design concept.

1.3 IMS-based Power Stage Design

1.3.1 IMS Board thermal design

An IMS board assembly uses metal as the PCB core, to which a dielectric layer and copper foil layers are bonded. The metal PCB core is often aluminum. The copper foil layers can be single or double-sided. An IMS board offers superior thermal conductivity to standard FR4 PCB. It's commonly used in high power, high current applications where most of heat is concentrated in a small footprint SMT device.

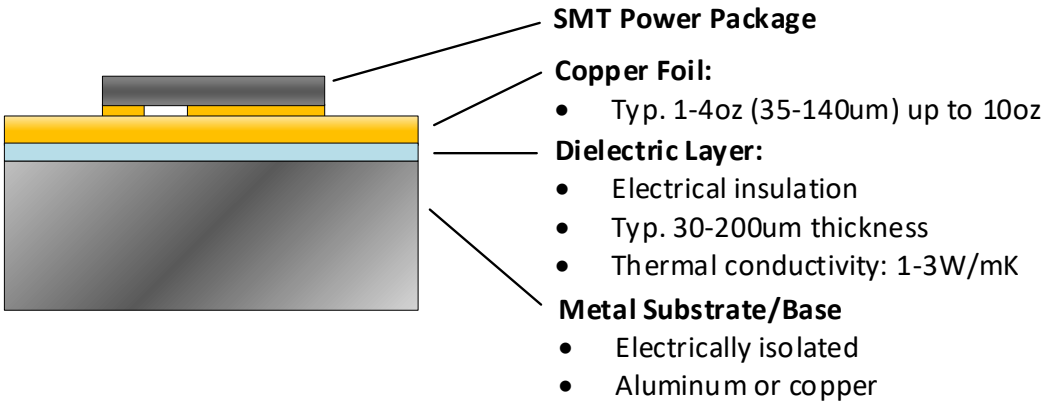


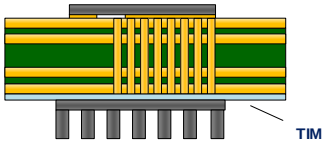
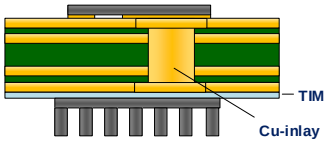
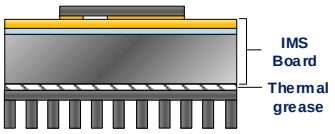
Figure 2 Cross-section view of a single layer IMS board

As high-speed Gallium Nitride power devices are adopted widely, the industry is trending away from through-hole packaging (TH), towards surface mount packaging (SMT). Traditional TH devices, such as the TO-220, are no longer the appropriate choice because their high parasitic inductance and capacitance negate the performance benefits offered by GaN E-HEMTs. SMT packaging, such as PQFN, D2PAK and GaN Systems' GaN*PX*®, by comparison, offer low inductance and low thermal impedance, enabling efficient designs at high power and high switching frequency.

Thermal management of SMT power transistors must be approached differently than TH devices. TO packages are cooled by attaching them to a heatsink, with an intermediary Thermal Interface material (TIM) sheet for electrical high voltage insulation. The traditional cooling method for SMT power devices is to use thermal vias tied to multiple copper layers in a PCB. The IMS board presents designers with another option which is especially useful for high power applications. The IMS board has a much lower junction to heatsink thermal resistance ($R_{thJ\text{-}HS}$) than FR4 PCBs, for efficient heat transfer out of the transistor. As well, assembly on an IMS board has lower assembly cost and risk than the TH alternative. The manual assembly process of a TO package onto a heatsink is costly and prone to human error.

Table 3 compares 3 different design approaches for cooling discrete SMT power devices. While the cost is lower for a FR4 PCB cooling with thermal vias, the IMS board offers the best performance for thermal management Figure 3 provides a quantitative comparison of the thermal resistance for the 3 design options. The IMS board clearly comes out ahead.

Table 3 Performance comparison of 3 thermal design options for SMT power devices

	FR4 PCB Cooling with Vias	FR4 PCB with Cu inlay	IMS PCB
			
Thermal resistance	**Good**	**Better**	Best
Electrical Insulation	No, additional TIM needed	No, additional TIM needed	Yes
Cost	Lowest	High	Low
Advantages	• Standard process • Lowest cost • Layout flexibility	• Layout flexibility • Improved thermal compared to thermal vias	• Lowest thermal resistance • Electrically isolated
Design challenges	• High PCB thermal resistance	• Cu-inlay surface coplanarity • High TIM thermal resistance	• Layout limited to 1 layer • Parasitic inductance • Coupling capacitances to the metal substrate

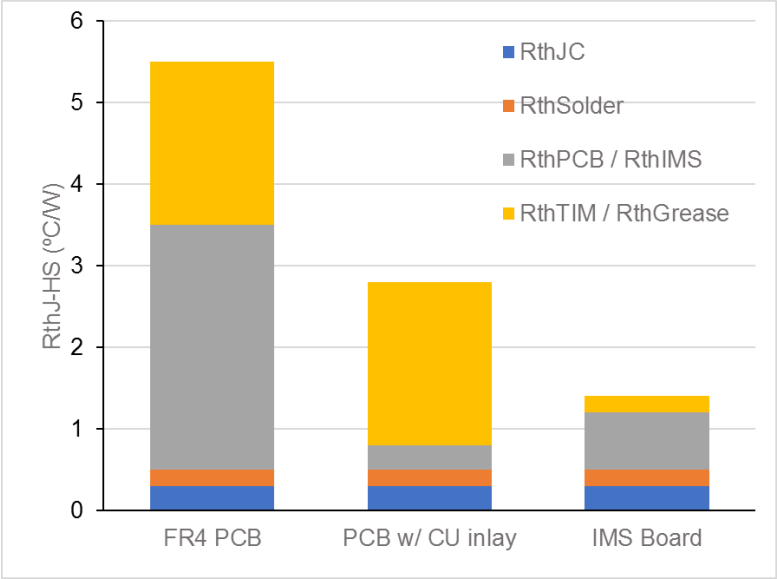


Figure 3 Comparison of Junction to Heatsink thermal resistance (R_{thJ-HS}) (Estimated based on GS66516B)

The following additional measures are taken to optimize the design further.

- The half bridge design is implemented as a two-board asssembly. The gate drive circuitry is assembled on a multi-layer FR4. This includes the gate driver ICs, an isolated DC/DC converter to power the driver IC, and DC decoupling capacitors. The GaN E-HEMTs are mounted to the IMS board. This approach addresses the shortcomings of implementing the design on a single layer IMS board.

- To mate the IMS board to the FR4 driver board, small pitch low profile SMT headers are used. The short loop lengths optimize parasitic gate inductance.

- While a large copper area is preferred to maximize heat spreading and handle high current, the area of copper at the switching node (high dv/dt) needs to be minimized to reduce the parasitic coupling capacitance to the metal substrate. An IMS board with thicker dielectric layer (100um) is chosen on this design to further reduce this effect. Refer to Figure 9 for more detail.

1.3.2 Control and power I/O

The functional block diagram of the IMS evaluation module assembly is shown in figure 4.

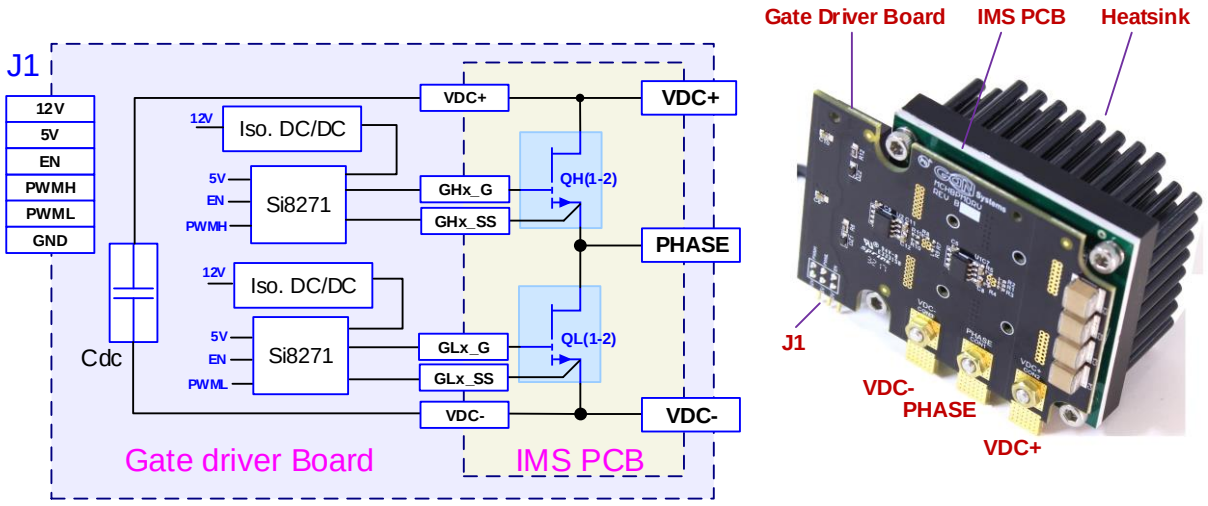


Figure 4 GSP65RxxHB-EVB Functional Block Diagram

The three power pins are

- CON1: VDC+, Input DC Bus voltage
- CON2: Phase, Switching node / phase output
- CON3**:** VDC- Input DC bus voltage ground return.
    - **Note that control ground GND on J1 is isolated from VDC- on CON3.**

The control pins on connector J1 are described in table 4.

Table 4 Description of J1 control pins

PIN	DESCRIPTION
12V	+12V bias supply for gate drive. This feeds to the input of two isolated DC/DC (12V-9V) to generate isolated +6/-3V gate drive bias.
5V	+5V bias supply for gate driver IC.
EN	Enable input. Logic low disables all the gate drive outputs. If not used the pin can be pulled up to 5V and it is recommended to add a small 0.1uF capacitor to filter noise.
PWMH	High side PWM logic input for top switch Q1. It is compatible with 3.3V and 5V
PWML	Low side PWM logic input for bottom switch Q2. It is compatible with 3.3V and 5V
GND/0V	Logic inputs and gate drive power supply common ground return.

1.3.3 IMS Board Design

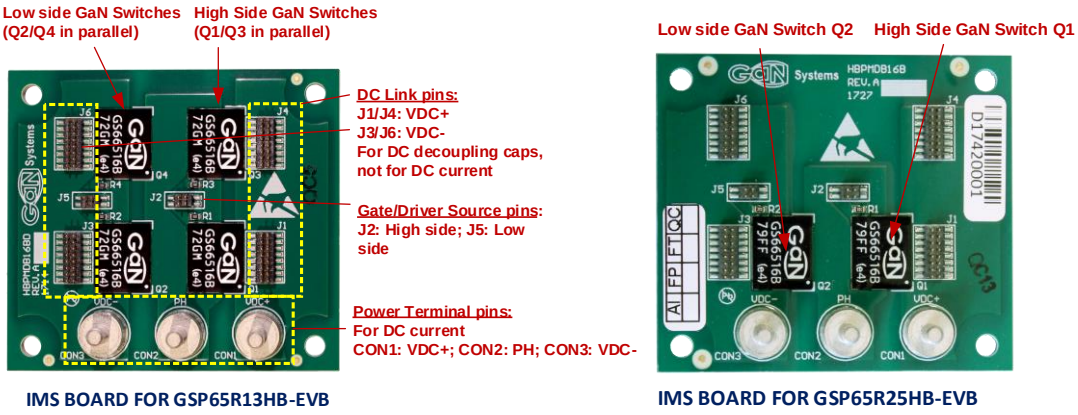


Figure 5 IMS Boards

The IMS board is populated with the following components:

- **Q1-Q4:** GS66516B E-HEMTs in a half bridge configuration.
  - 6kW GSP25R13HB-EVB: Q1/Q3 (high side) and Q2/Q4 (low side). Devices are paralleled.
  - 3kW GSP25R25HB-EVB: Only Q1 and Q2 are populated.

- **CON1, CON2, CON3:**
  - SMT M3 stud power terminals (Wurth Electronics, P/N: 7466213).
  - These terminals are designed to carry the main current.

- **J2-J5**: SMT 2x2 header (Samtec P/N: FTM-102-02-L-DV) for gate driver connections.
  - For optimum parallel operation of the GaN E-HEMTs, individual Gate (G) and Source Sense (SS) resistors should be used to ensure a symmetric gate loop layout. G and SS on each device are brought to the driver board separately by J2/J5 as shown in figure 6. By utilizing the dual gate feature on GS66516B package, an optimum symmetric gate loop

layout is easily achieved. For additional detail, refer to GaN Systems' application note GN004,

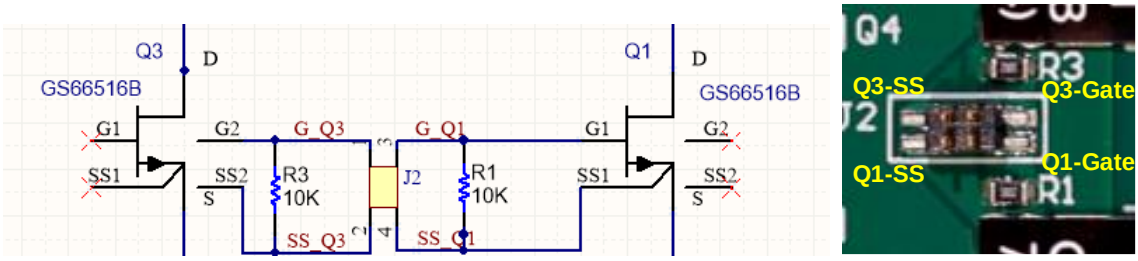


Figure 6 - J2/J5 header connection for gate drive

- **R1-R4**: 10K pull-down resistors.
  - These resistors prevent accidental gate turn-on or overvoltage induced by static or miller capacitor feedback when the gate driver circuit is not active (during start-up) or malfunctional.

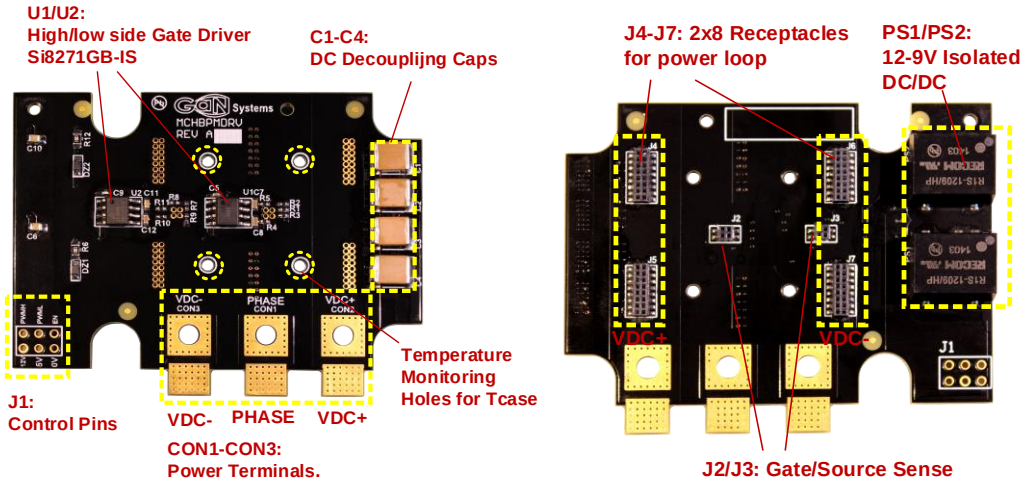
- **J1, J3, J4 and J6**: 2x8 SMT headers (Samtec P/N: FTM-108-02-L-DV-P-TR) for DC coupling capacitors.
  - **Note: These pins are NOT designed to carry DC main current.**
  - Together with the DC coupling capacitors on the driver board, they are designed to create a balanced and low inductance power loop path for high-frequency current across the half bridge.

The two versions of the IMS board can be identified by the markings described in table 5.

Table 5 IMS board identification markings

EVB PART NUMBER	GaN E-HEMT	IMS BOARD MARKINGS
GSP65R13HB-EVB	GS66516B x 2 in parallel (Q1-Q4)	HBPMDB16BD
GSP65R25HB-EVB	GS66516B x 1 (Q1, Q2)	HBPMDB16B

1.3.4 Gate driver board



a) Top view b) Bottom view

Figure 7 - IMS gate driver board

A gate driver board is designed to mate closely with the IMS board. It provides the half bridge gate drivers for the half bridge GaN E-HEMTs and DC link decoupling capacitors. It also enables the IMS board to be mounted vertically for high power density design.

- **Half bridge gate drivers:** high and low side gate drivers, fully isolated.
  - U1 and U2 are the isolated gate drivers (Silicon Labs P/N: Si8271)
  - PS1/PS2 are 12-9V isolated power supplies (RECOM P/N: R1S-1209/HP) which are then divided to +6/-3V to power the gate drivers.
  - R7, R9, R10 and R11 are small distributed gate and source resistors, used on each paralleled device to reduce gate ringing or oscillation.
  - R8 provides additional gate resistance to control the turn-on slew rate.

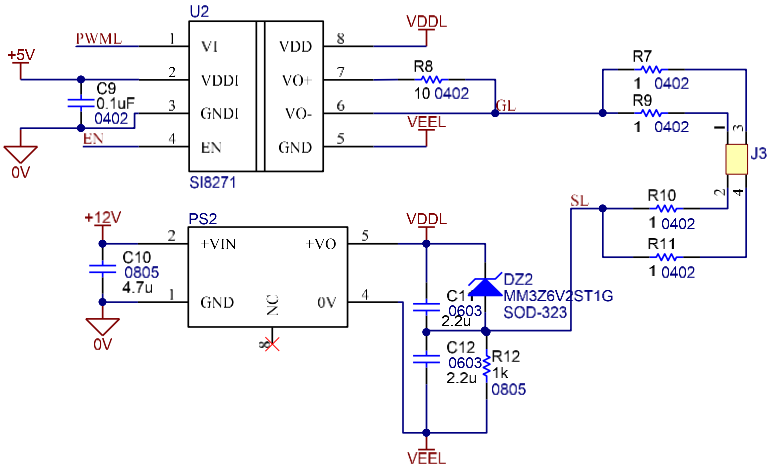


Figure 8 Gate driver circuit

- **DC link decoupling capacitors:** As it is challenging to create low inductance power loop on single-layer IMS board, DC decoupling capacitors are placed on multi-layer gate driver PCB. The power loop path is highlighted as below.

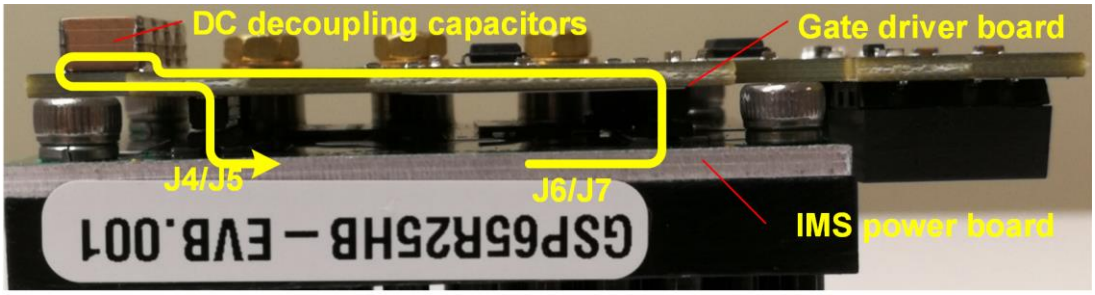


Figure 9 - Cross section view of IMS assembly showing the power Loop path

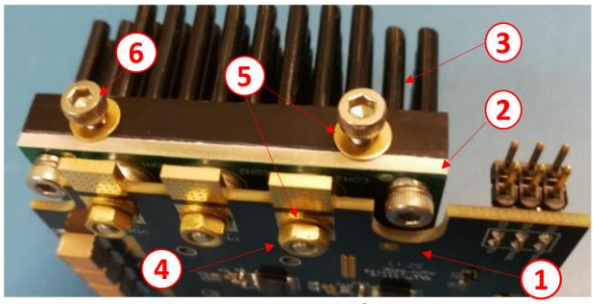
- **Power terminals and control I/O:** CON1-CON3 are designed so that the IMS evaluation module can be mounted vertically. The PCB tabs are edge-plated and can be wave-soldered to the main board. Alternatively, the power cables can be directly screwed onto the M3 screw post for power connections. J1 is populated with a 2x3 standard 0.1" pitch right angle header which be either soldered or attach to the socket on the main board.

- **Temperature monitoring holes:** 4 holes are located on the center of 4 GaN E-HEMTs to assist with the temperature monitoring during operation. An IR camera can be used to monitor the case temperature through these holes. The temperature measured at the center of GaN*PX*® 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.

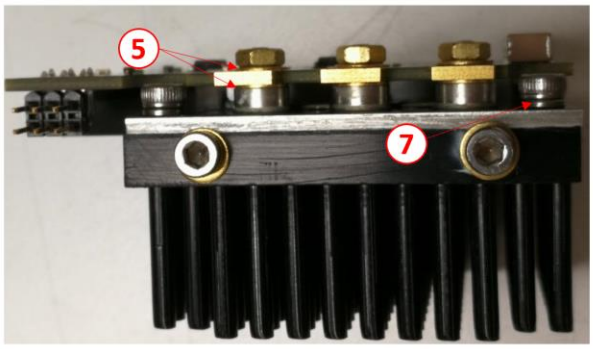
Please refer to the Evaluation Board/Kit Important Notice on page 37

1.3.5 Evaluation module assembly



Bottom view

Top View with driver board removed



Side view

Item	QTY	Description	Manufacturer	Part Number
1	1	PCBA H/B DRIVER BOARD	GAN SYSTEMS	MCHBPMDRV
2	1	PCBA GS66516B HALF BRIDGE IMS POWER BOARD	GAN SYSTEMS	MCHBPM16BD or MCHBPM16B
3	1	HEATSINK, ALU, BLK ANODIED, CUSTOMIZED	COOL INNOVATION	3-211910RS74844
4	3	BRASS M3 NUT 0.5MM	McMaster-Carr	90690A037
5	8	Brass Washer 0.5mm Thickness M3	McMaster-Carr	91635A190
6	6	M3 18-8 Stainless Steel Socket Head Screw	McMaster-Carr	91292A111
7	4	316 Stainless Steel Split Lock Washer	McMaster-Carr	94241A510

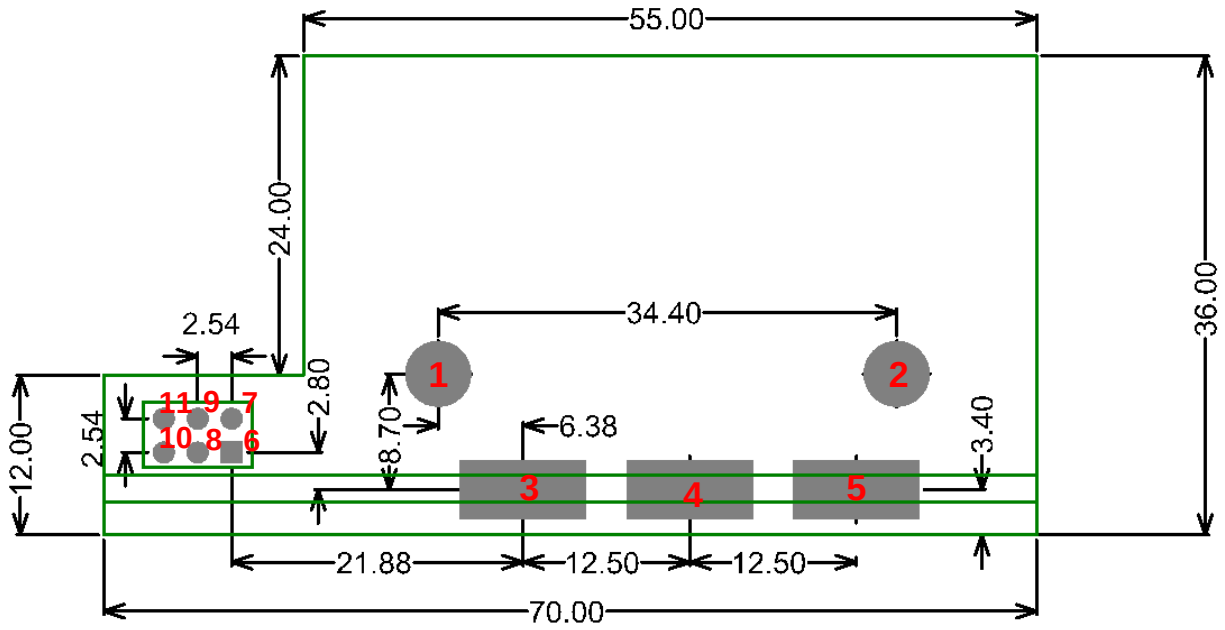
Figure 10 - IMS evaluation module assembly

The photos in Figure 10 shows show how the IMS evaluation module is assembled. The bill of materials is provided for reference.

If repair or customization is required, please note the following:

- Brass washers (#5) are required on 3 screw terminals to level off the terminals and connectors.
- When dismounting the driver board (#1):
  - Remove 3 nuts and washers.
  - To avoid damaging the SMT header pins, **gently** wiggle the driver board until the connectors are loose and pull it up straight.
- Two M3 hex screws provided on the bottom side of the heatsink are used.

The IMS evaluation module allows users to easily evaluate the GaN performance in their own systems. Refer to the recommended footprint drawing of GSP65RxxHB-EVB as shown below:



All units are in mm

Pin	Description	Hole Size	Plated	Hole type	Length
1-2	M3 Mounting	4mm	Y	Round	
3-5	Power terminal	2.5mm	Y	Slot	9mm
6-11	Signal pins	1.2mm	Y	Round	

Figure 11 Recommended footprint for GSP65RxxHB-EVB (unit: mm)

2 Using the IMS evaluation module with the mother board GSP65MB-EVB

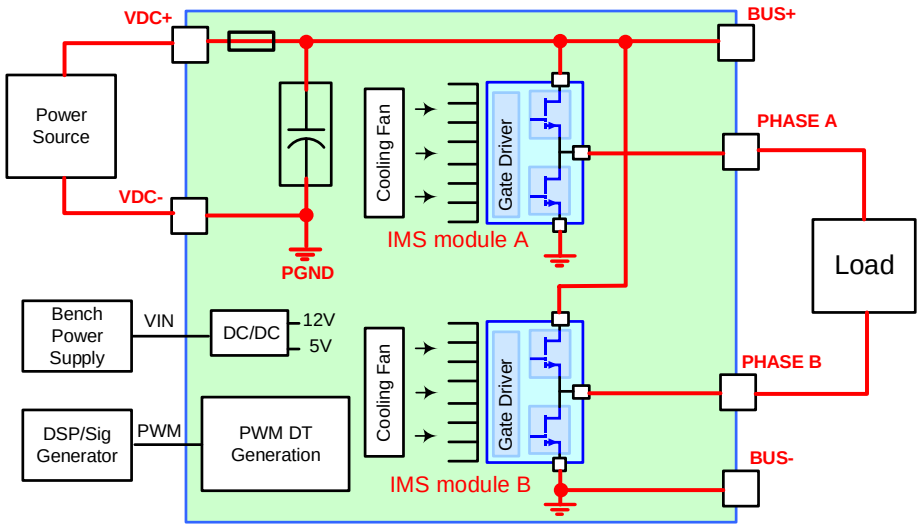


Figure 12 Circuit block diagram of IMS mother board

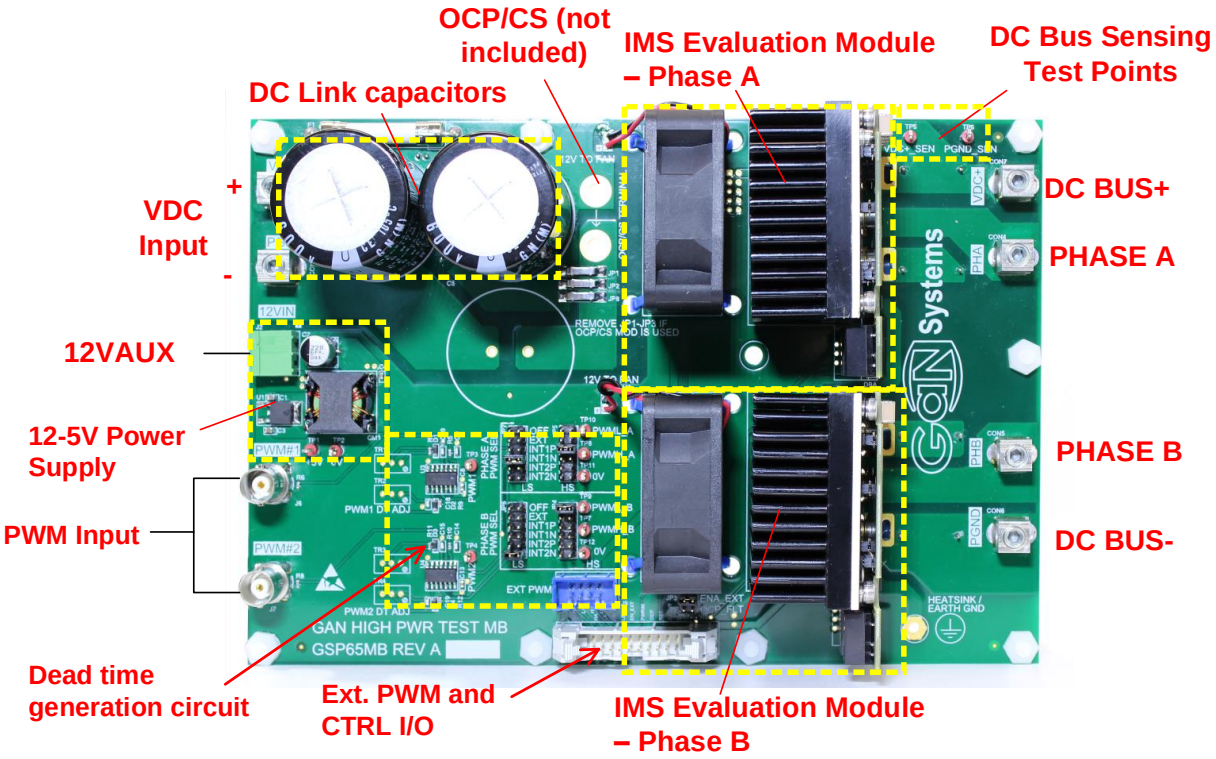


Figure 13 GSP65MB-EVB

GaN Systems offers a high-power mother board that can be purchased separately. The ordering part number is GSP65MB-EVB. It can be used as a platform for evaluating the IMS evaluation module in any half or full bridge topology.

2.1 VDC Input Fusing

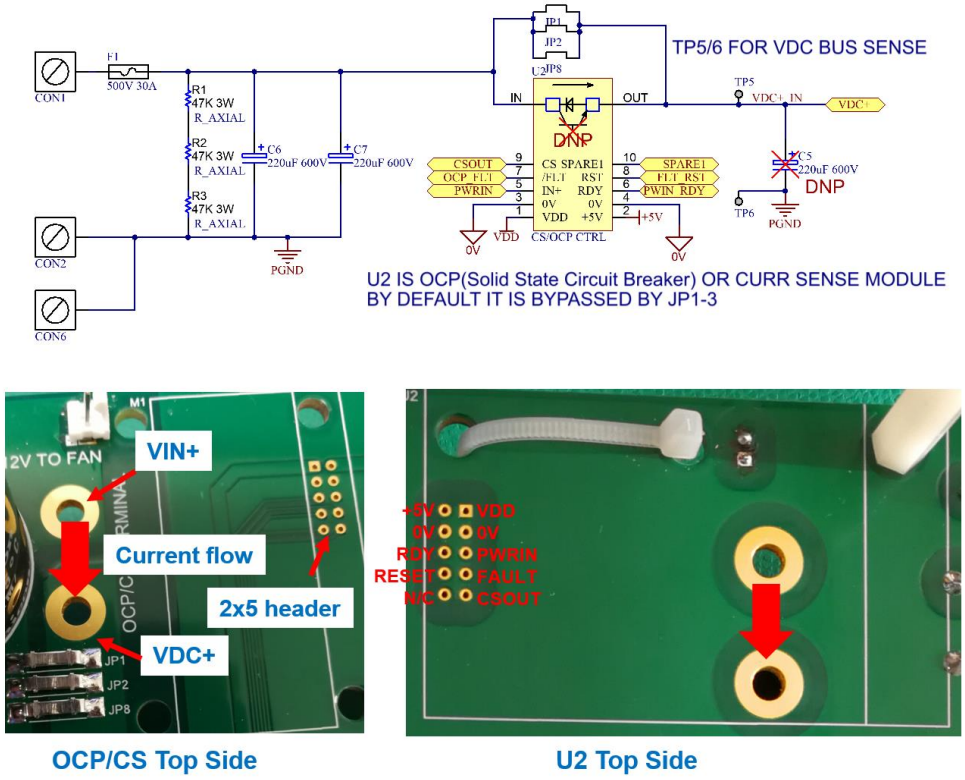


Figure 14 DC Bus input and protection circuit

The DC bus input on the motherboard are through connectors CON1 (VIN+) and CON2 (PGND). F1 is a 500V/30A-rated fuse for system protection. In case a lower DC bus voltage and higher than 30A current are required, bypass F1 and use external circuit breaker or fuse for protection.

2.2 Optional Over Current / Current Sense Protection Circuit

Note: The mother board does not ship with Over Current Protection (OCP) or Current Sense (CS) circuitry. By default, U2 is bypassed by JP1-JP3.

However, the motherboard design is provisioned for adding an externally designed fast Over Current Protection (OCP) or current sensing (CS) circuit.

A non-populated footprint is available to the user. It consists of two screw terminals and a 2x5 header as shown in figure 14. If needed, users can design their own OCP or CS circuit and connected it to the mother board using these connections.

A few examples of how this can be used are

- Use an IGBT driver with de-sat protection as a solid-state circuit breaker for input power control and OCP.
- For current sensing, a hall effect sensor can be added to the circuit to feed the CSOUT output to a DSP controller board.

- For current monitoring with a scope probe, a simple wire loop can be soldered across the two terminals.

2.3 12V input

The motherboard is powered from a 12V source, through connector J2. An on-board voltage regulator provides 5V for the IMS evaluation modules and control logic circuits. J1 and J3 provide 12V to power the cooling fans.

2.4 PWM control circuit

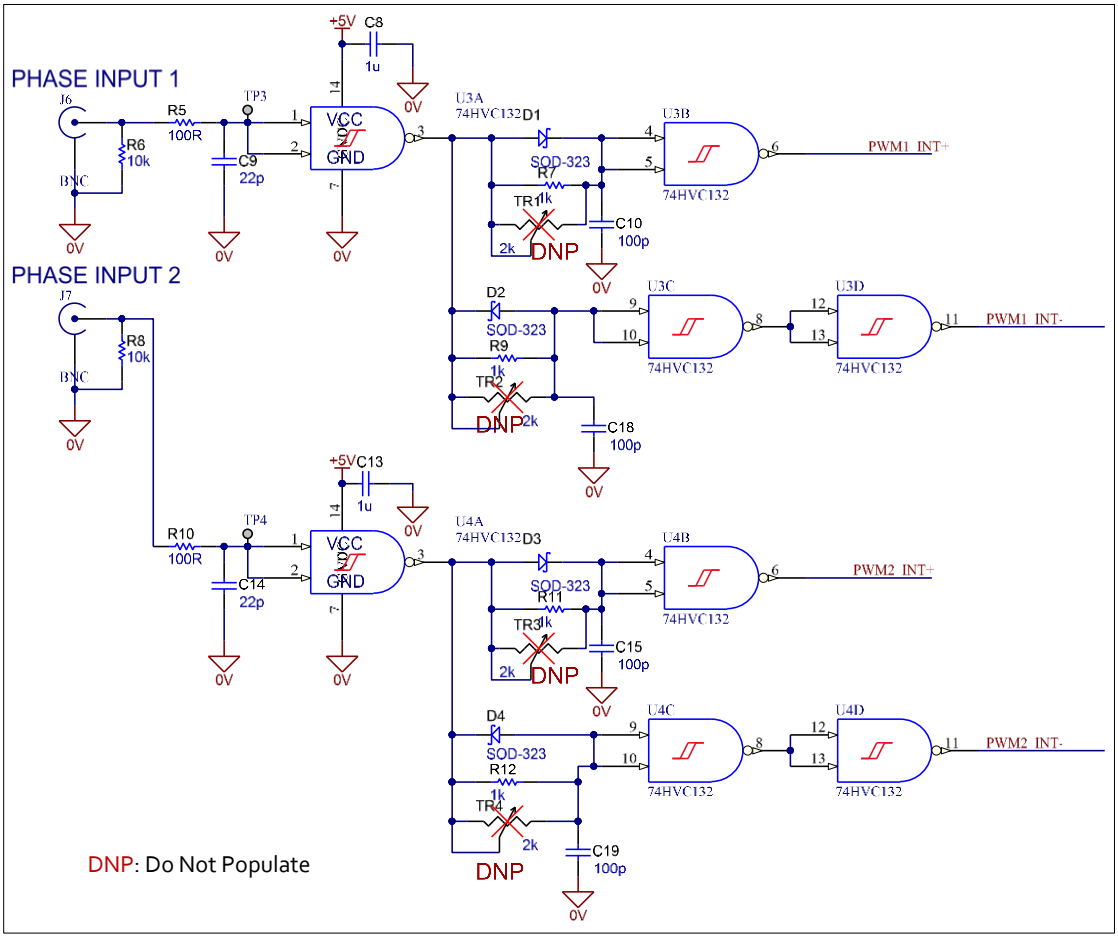


Figure 15 PWM control input and dead time circuit

Please refer to the Evaluation Board/Kit Important Notice on page 37

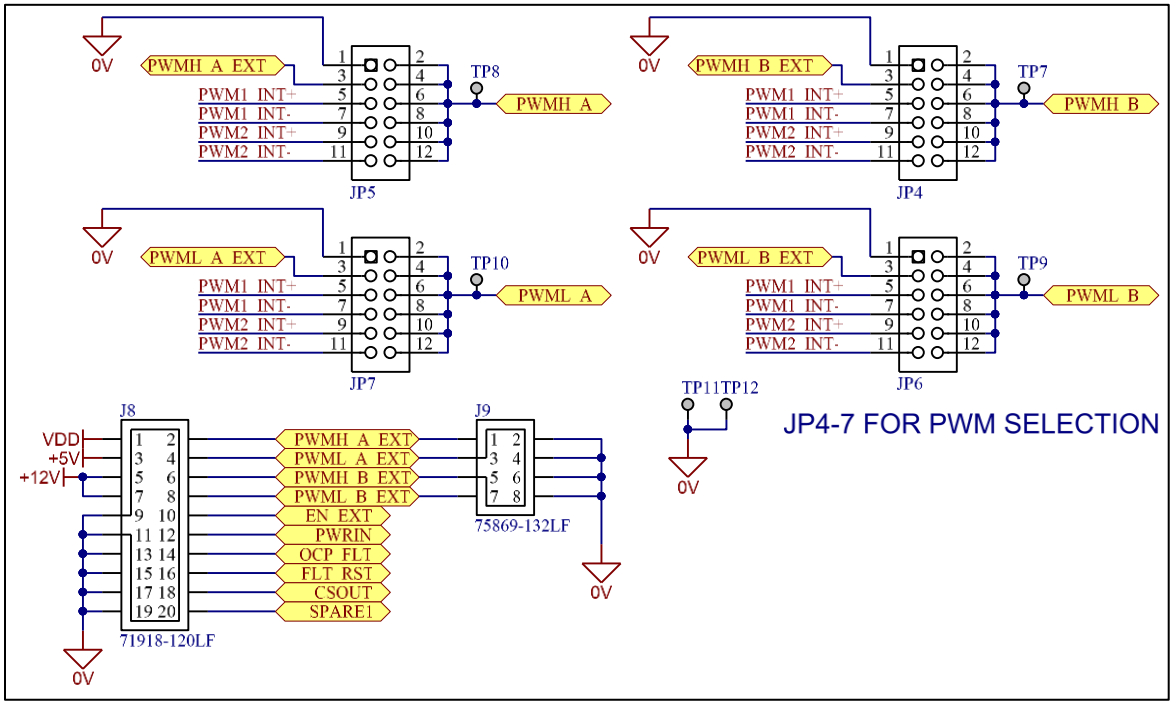


Figure 16 External PWM input and selection circuits

The PWM signals of top and bottom switches on both phase legs can be individually selected by the jumpers JP4-JP7. Users can choose between 2 pairs of independent complementary on-board internal PWM signals (non-inverted and inverted) with dead time or external high/low side drive signals from J8 or J9.

Two channels of independent on-board dead time generation circuits are included on the mother board. Dead time is controlled by RC delay circuits. The default dead time is set to approxmimately 100ns. Potentiometers locations are provided (TR1-TR4, not populated) to allow fine adjustment of the dead time if needed.

WARNING!
ALWAYS double check the jumper setting and probe PWM signals before applying power. Incorrect PWM inputs or jumper settings may cause device failures.

Table 6 List of PWM selection jumpers

Phase Leg	Switch position	Jumper	Name	Probe test points
Phase A	High side	JP5	PWMH_A	TP8
	Low side	JP7	PWML_A	TP10
Phase B	High side	JP4	PWMH_B	TP7
	Low side	JP6	PWML_B	TP9

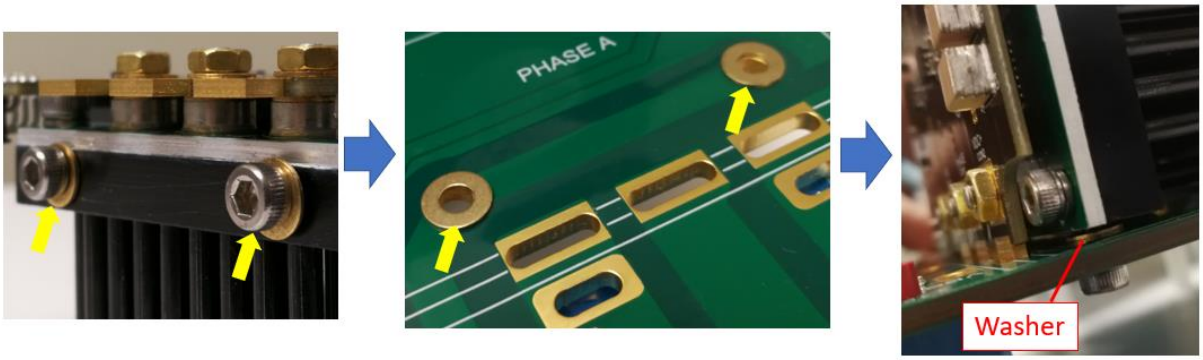
Table 7 Jumper settings for JP4-JP7

Position	Jumper Setting	Description	Source
1	OFF	Disabled	
2	EXT	External PWM Signal	J8/J9
3	INT1P	Internal Phase #1 non-inverted	J6: Phase Input 1
4	INT1N	Internal Phase #1 inverted	J6: Phase Input 1
5	INT1P	Internal Phase #2 non-inverted	J7: Phase Input 2
6	INT1N	Internal Phase # 2 inverted	J7: Phase Input 2

2.5 Installation of IMS evaluation module

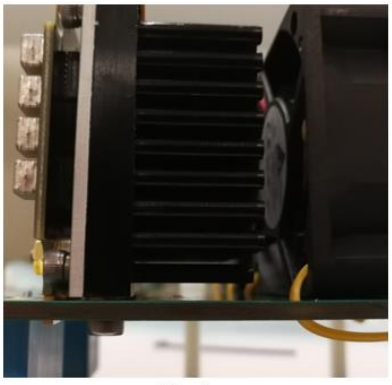
Follow the steps below to install the IMS evaluation module onto the motherboard:

1. Remove M3 hex screws and washers on the bottom side of module.
2. Place the brass washer onto the 2 matching mounting holes on mother board and then insert the IMS evaluation module.
3. Install the M3 screws from the bottom side. Ensure that 2 washers are in place between the heatsink and mother board as they are needed to level off J1 and 3 power terminal tabs.



4. Tighten the screws, and solder J1 and 3 power terminals from the bottom side.

Top view

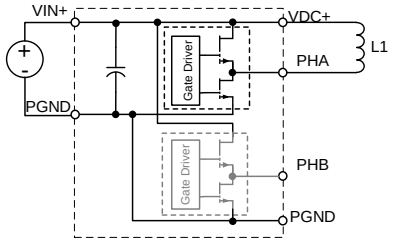
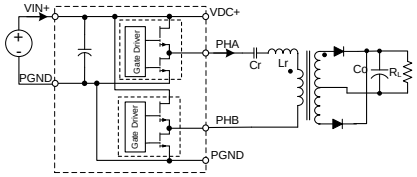
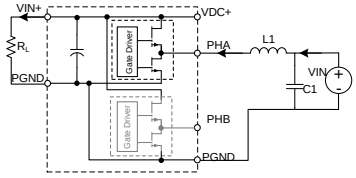
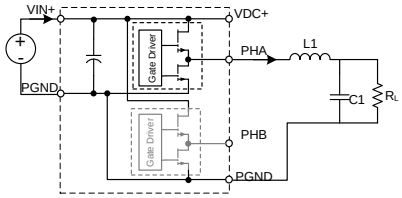
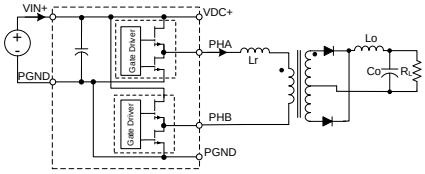
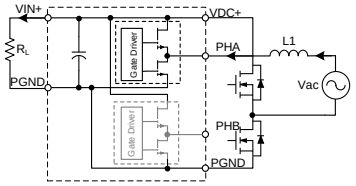
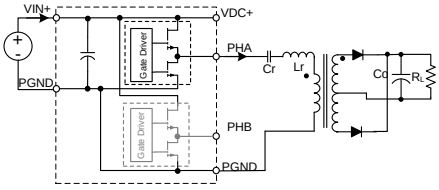
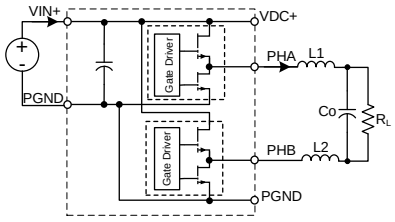
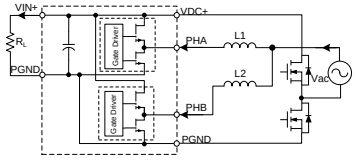
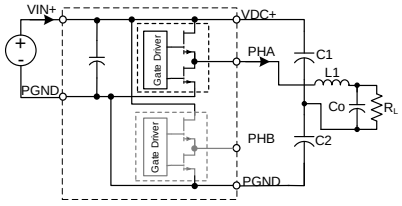
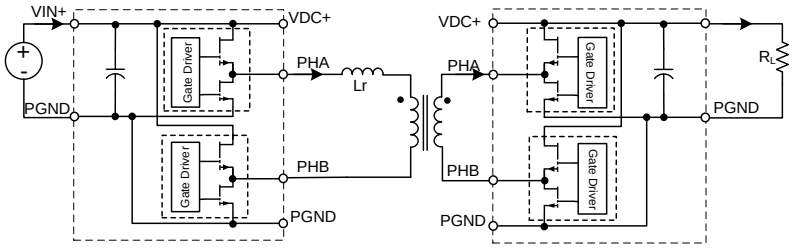

Side view

Please refer to the Evaluation Board/Kit Important Notice on page 37

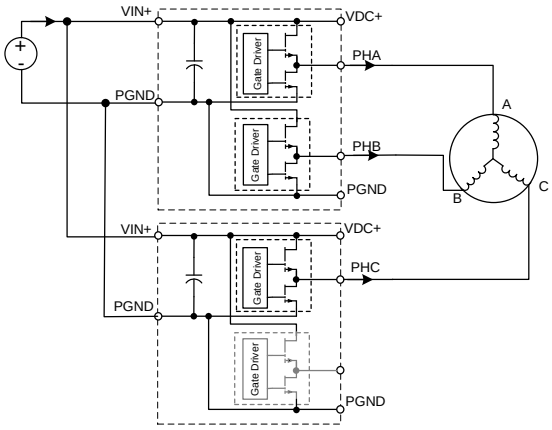
2.6 Operation modes

The Evaluation Platform can be configured into different topologies and operation modes as shown below

Table 8 Evaluation Platform Configurations

HALF BRIDGE	FULL BRIDGE	BOOST MODE
Double Pulse Test	**Full Bridge LLC**	**Synchronous Boost DC/DC**
		
Synchronous Buck DC/DC	**Phase Shift Full Bridge**	**Totem Pole PFC**
		
Half Bridge LLC	**Full Bridge Inverter**	**Interleaved Totem Pole PFC**
		
Single Phase Half Bridge Inverter	**DUAL ACTIVE BRIDGE**	
	Dual Active Bridge (with 2 mother boards)	
		

Please refer to the Evaluation Board/Kit Important Notice on page 37

HALF BRIDGE	3 PHASE MOTOR DRIVE
NOTE: In operating modes where the DC bus is on the output side (Boost, PFC etc.), it is recommended to bypass fuse F1 and OCP circuit on the mother board. Additional circuit protection can be installed on the input side if needed.	**3-Phase Motor Drive (with 2 mother boards)** 

3 Test Results

3.1 Double pulse test (GSP65R13HB-EVB, 650V/13mΩ)

- Test condition: V_{DS} = 400V, I_D = 120A, V_{GS} = +6V/-3V, L = 40uH, No RC Snubber, T_J =25℃
- Measured peak V_{DS} = 520V and 80V/ns dv/dt
- Reliable hard switching with 2 x GS66516B in parallel is achieved at full rated current

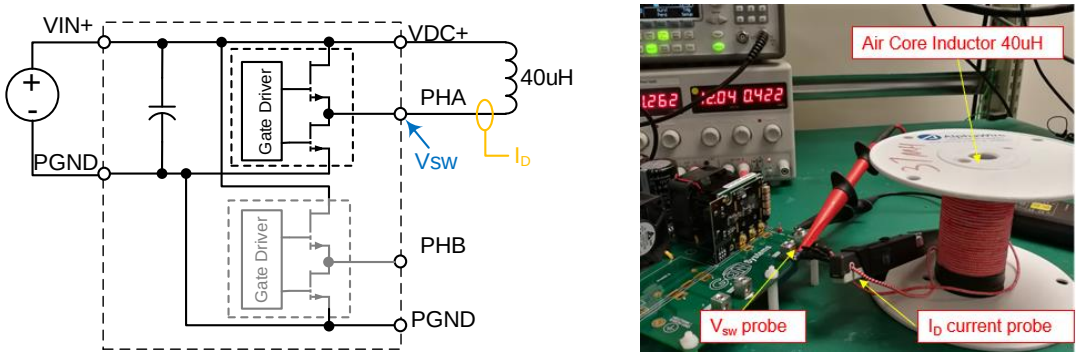


Figure 17 Double pulse test setup

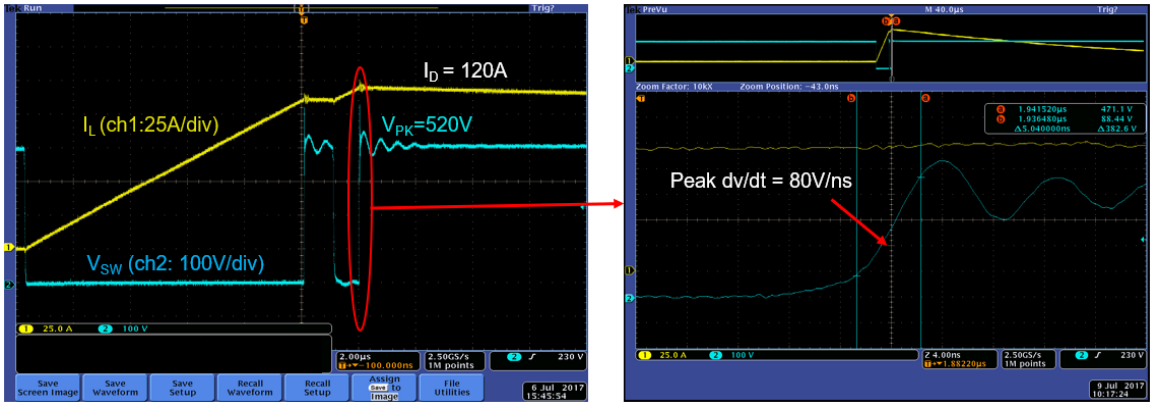


Figure 18 Double pulse test waveforms (400V/120A)

3.2 Open-loop Synchronous Buck DC/DC operation (GSP65R25HB-EVB, 650V/25mΩ)

- Test condition: V_{IN} = 400V, V_{OUT} = 200V, f_{sw}=80kHz, Po=2.4kW, T_{AMB} = 25℃.
- Peak efficiency 98.8%; Device case temperature 65℃ @ full load

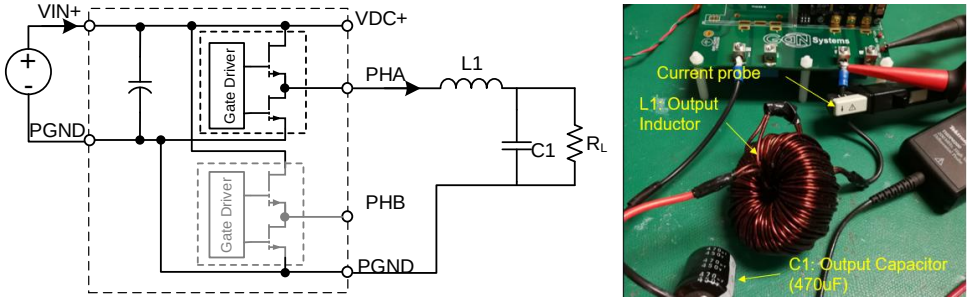
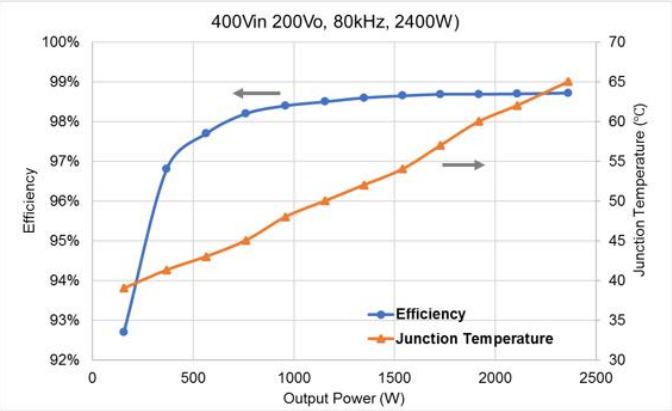


Figure 19 Open Loop Buck DC/DC Test Setup



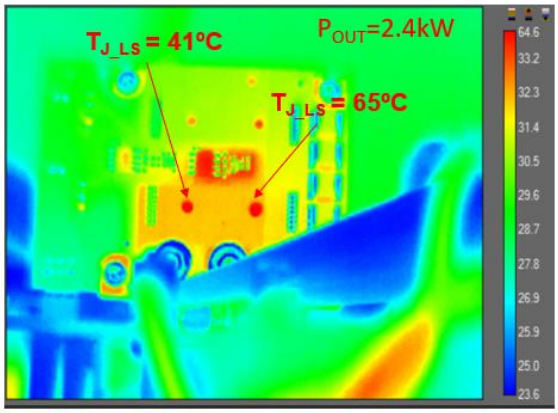
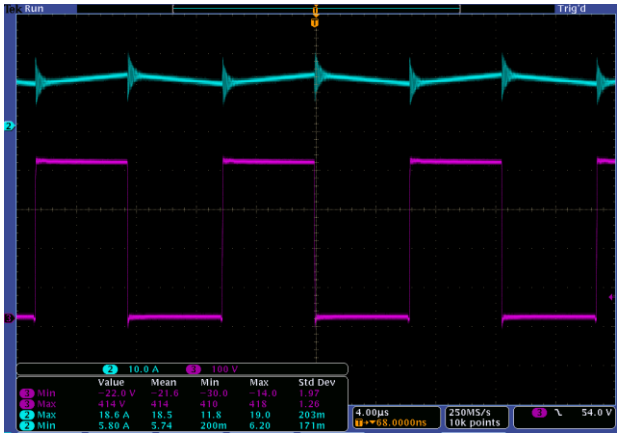
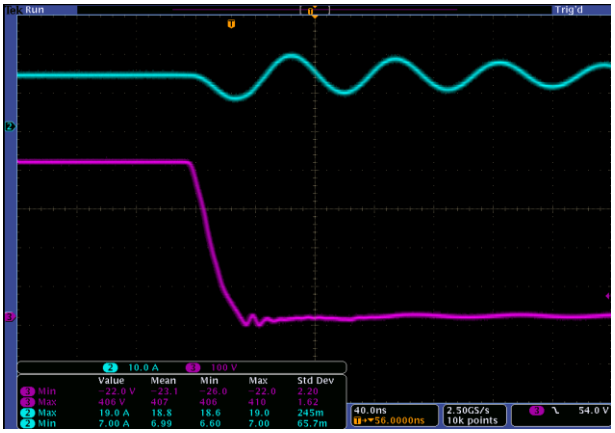


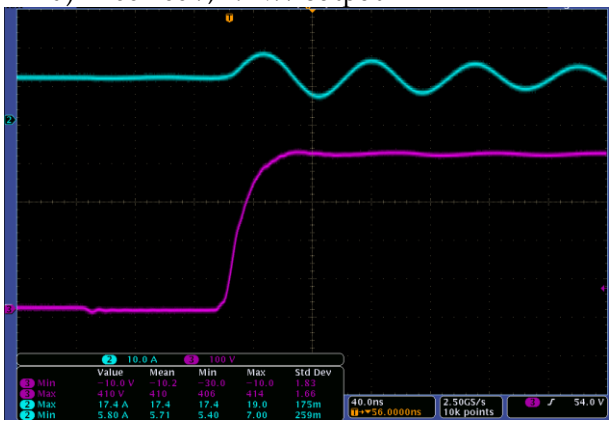
Figure 20 Buck DC/DC Efficiency and thermal measurement (400-200V, 80kHz, 0-2.4kW)



a) 400-200V, 2.4kW output



b) Zoom in at high side turn-off



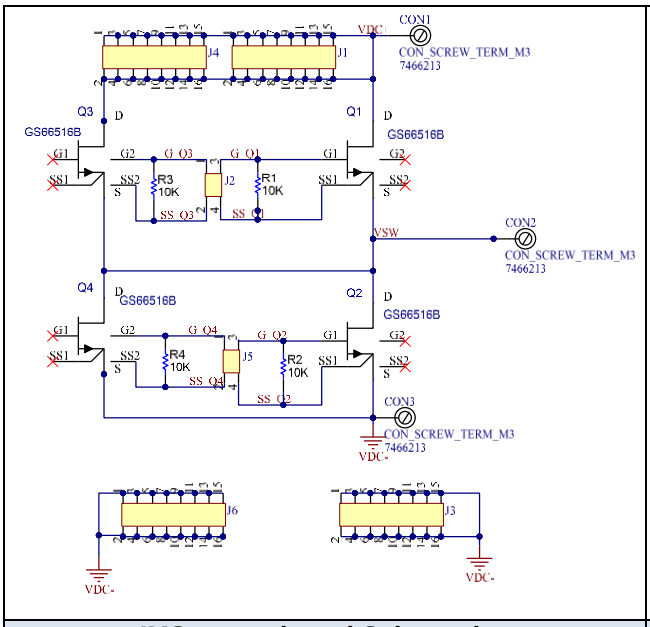
c) Zoom in at high side turn-on

Ch#2 (blue): Inductor current, 10A/div
Ch#3 (purple): Switching node Voltage, 100V/div

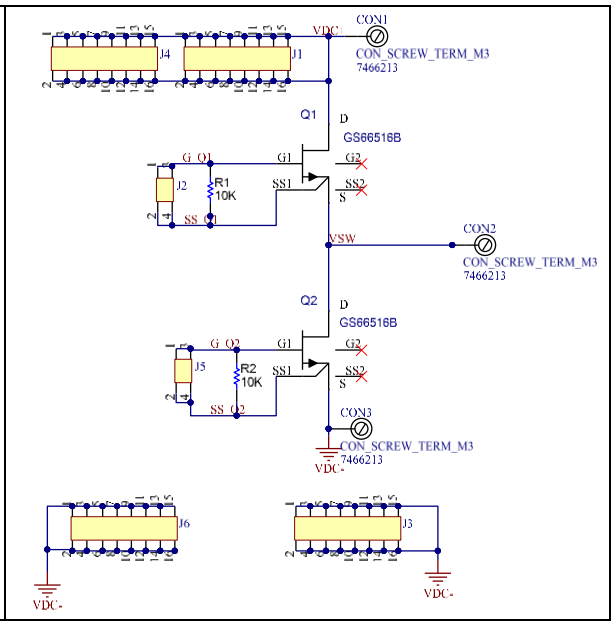
Figure 21 Test waveforms (400Vin, 200Vo, 80kHz, Po=2.4kW)

4 Appendix

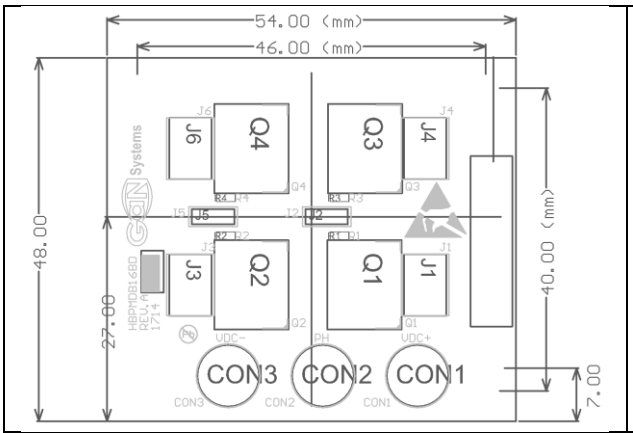
4.1 IMS Power Board



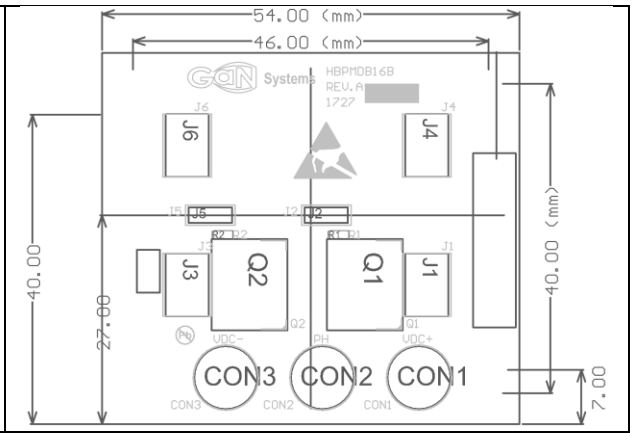
IMS power board Schematics (for GSP65R13HB-EVB)



IMS power board Schematics (for GSP65R25HB-EVB)

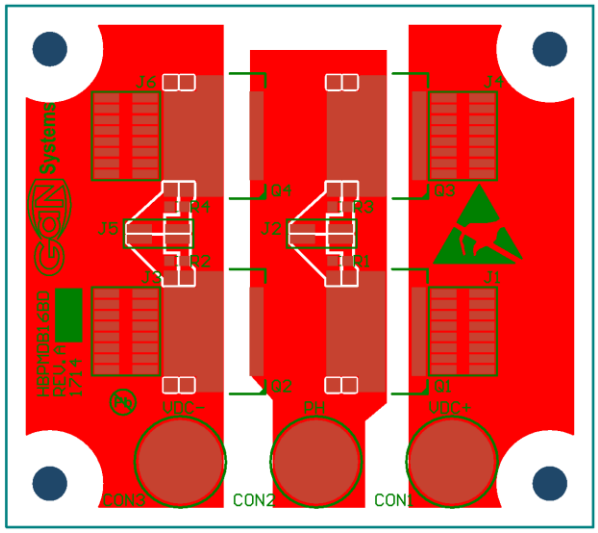


IMS power board Assembly Drawing (for GSP65R13HB-EVB)

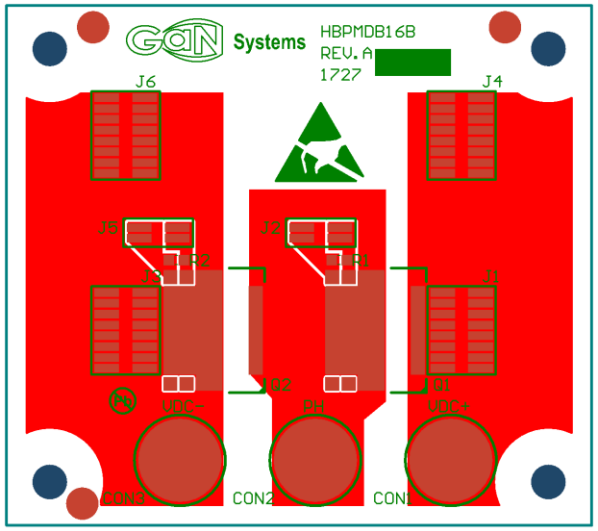


IMS power board Assembly Drawing (for GSP65R25HB-EVB)

Please refer to the Evaluation Board/Kit Important Notice on page 37



IMS power board Top Layer
(for GSP65R13HB-EVB)

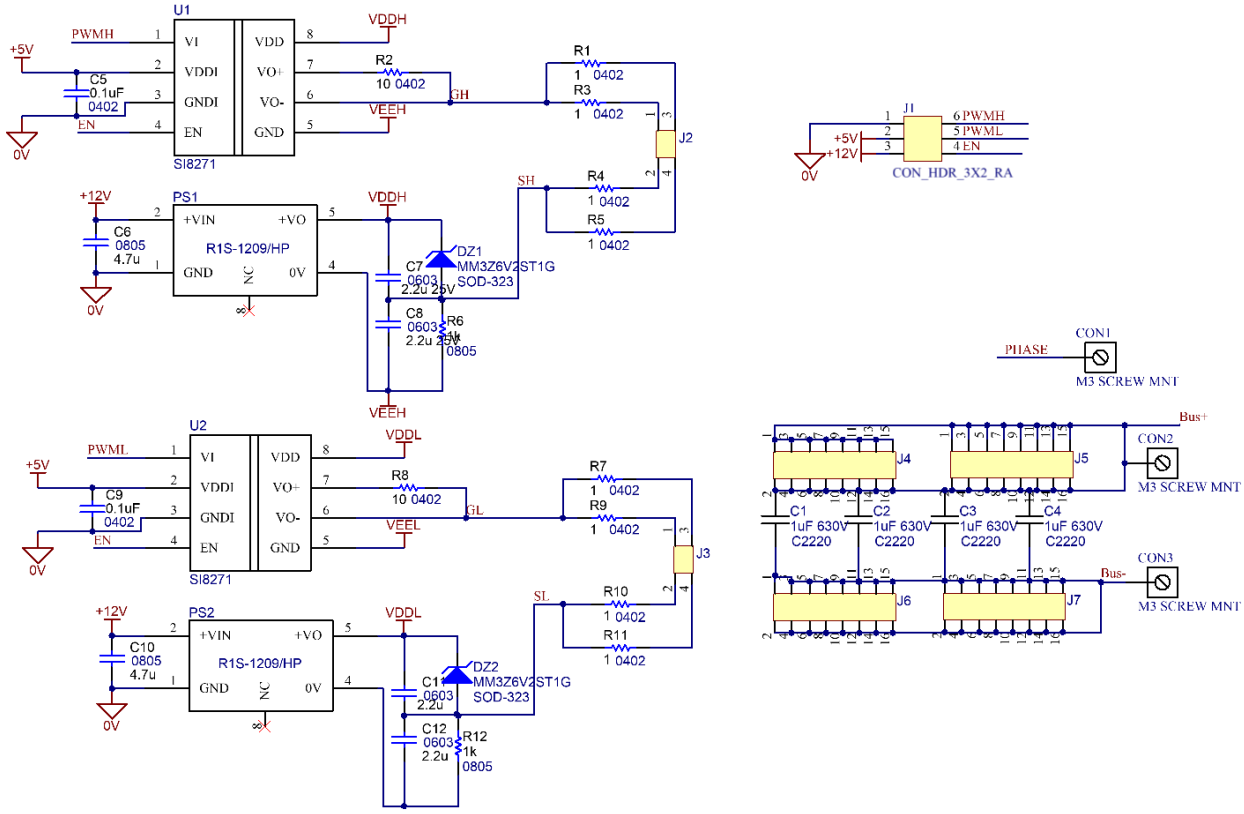


IMS power board Top Layer
(for GSP65R25HB-EVB)

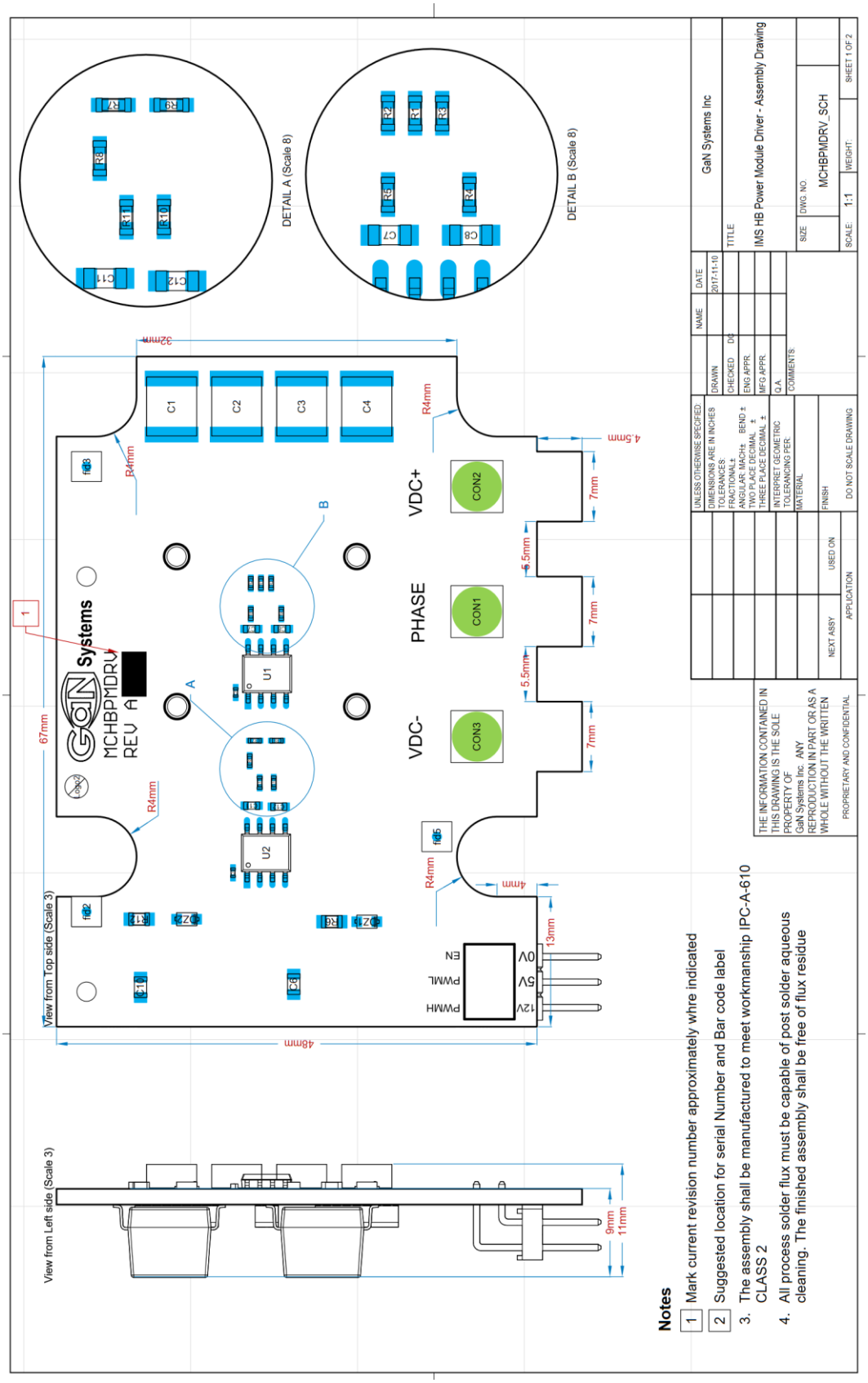
IMS Power board bill of materials

Description	Manufacturer	Manufacturer P/N	GSP65R13HB-EVB		GSP65R25HB-EVB	
			Designator	QTY	Designator	QTY
SMT POWER TERM M3	Wurth Electronics	7466213	CON1, CON2, CON3	3	CON1, CON2, CON3	3
Connector header 1mm pitch SMT 2x8	SAMTEC	FTM-108-02-L-DV-P-TR	J1, J3, J4, J6	4	J1, J3, J4, J6	4
Connector header 1mm pitch SMT 2x2	SAMTEC	FTM-102-02-L-DV	J2, J5	2	J2, J5	2
GAN TRANS E-MODE 650V 60A BOT SIDE COOL	gan systems	GS66516B	Q1, Q2, Q3, Q4	4	Q1, Q2	2
RES, 1%, 0603	generic	generic 0603 1%	R1, R2, R3, R4	4	R1, R2	2

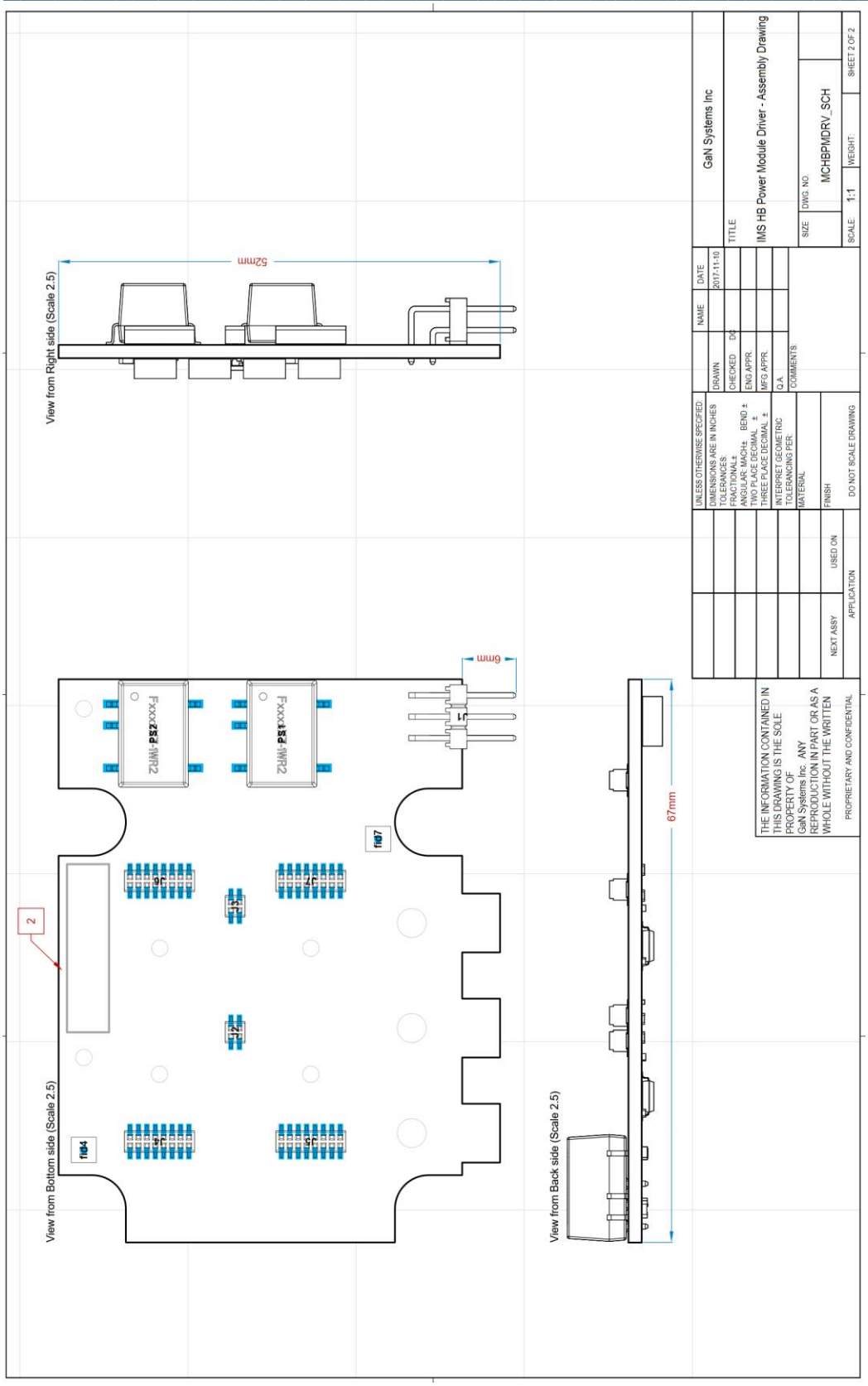
4.2 IMS Gate driver board



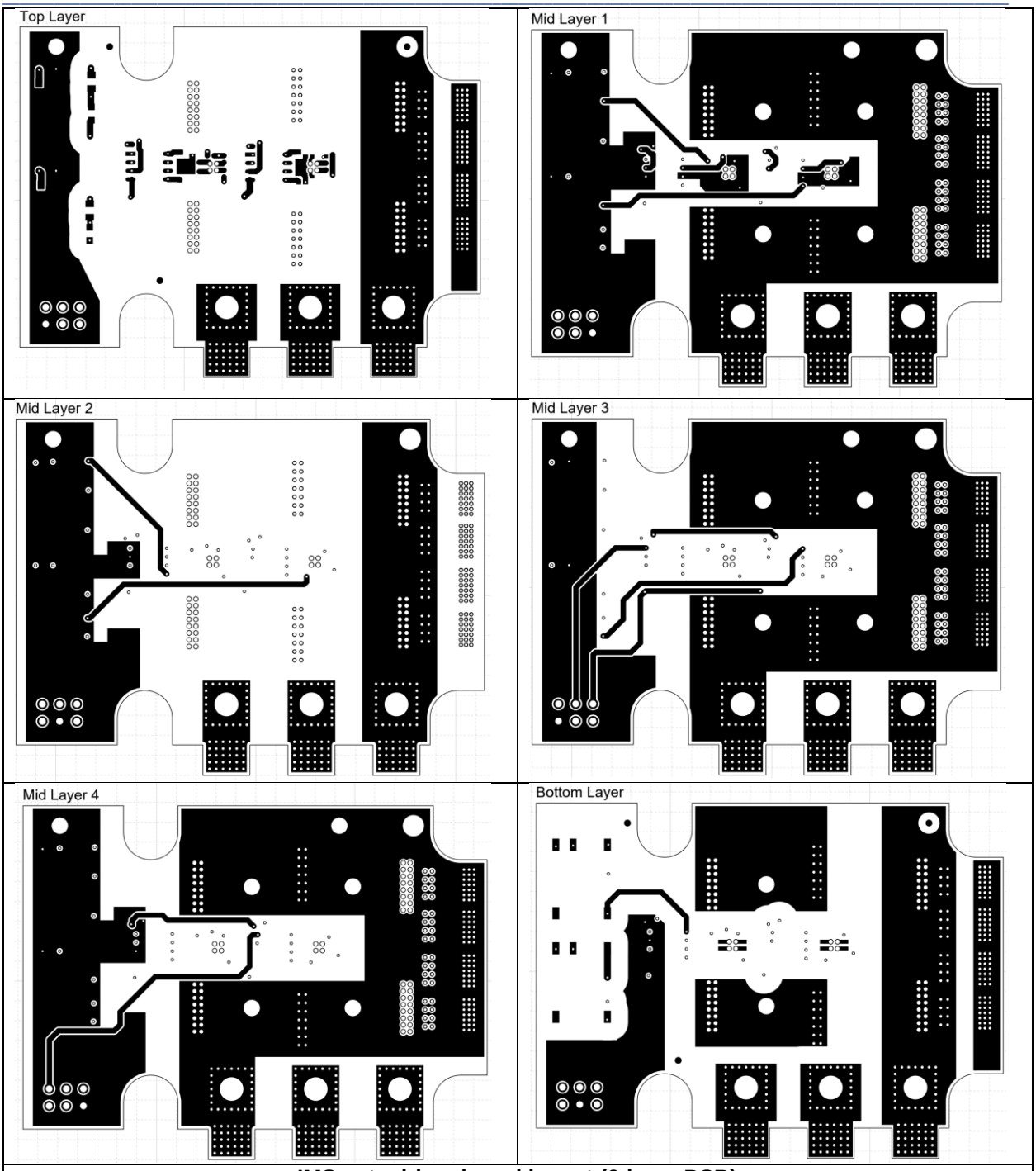
IMS gate driver board schematics



Top assembly drawing



Bottom assembly drawing



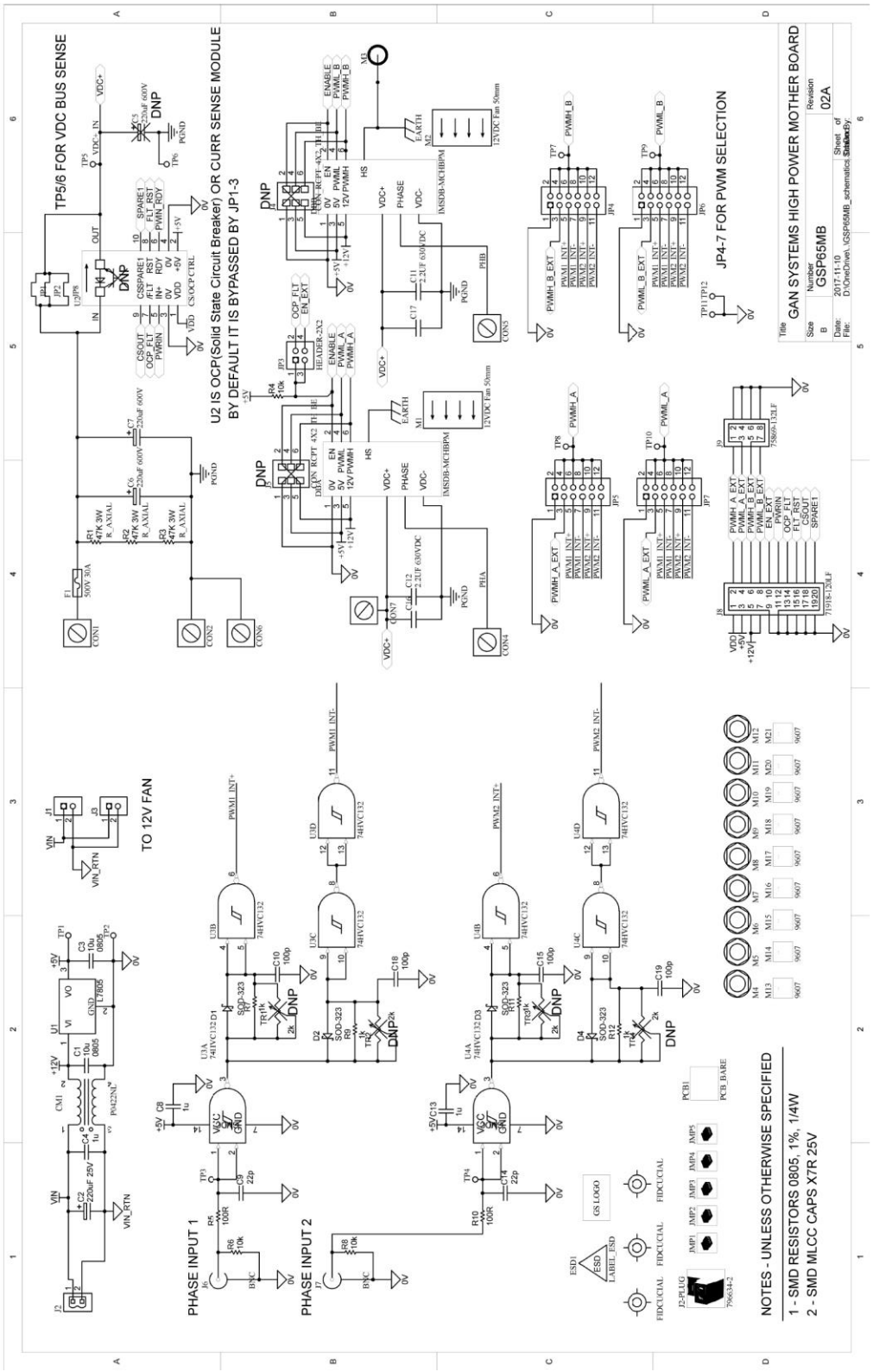
IMS gate driver board layout (6-layer PCB)

Please refer to the Evaluation Board/Kit Important Notice on page 37

IMS gate driver board bill of materials

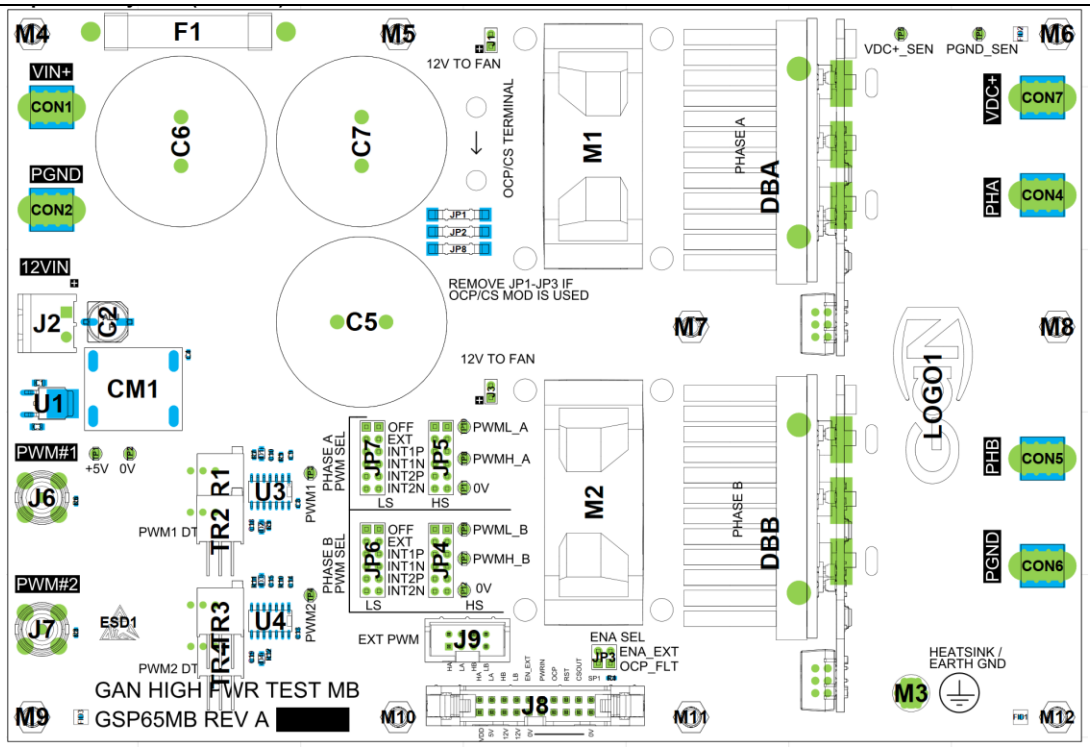
DESCRIPTION	DESIGNATOR	QTY	MANUFACTURER	PARTNUMBER
1µF ±10% 630V Ceramic Capacitor X7R 2220 (5750 Metric)	C1,C2, C3, C4	4	Knowles Syfer	2220Y6300105KXTWS2
CAP, CERM, 0.1uF,10V +/-10%, X7R, 0402	C5, C9	2	AVX Corporation	0402ZD104KAT2A
CAP, CERM, 0.1uF,16V +/-10%, X7R, 0805	C6, C10	2	Samsung	CL21B104KOANNNC
CAP CER 2.2UF 16V X5R 0603	C7, C8,C11, C12	4	Murata	GRM188R61C225KE15D
DIODE ZENER 6.2V	DZ1, DZ2	2	ON Semiconductor	MM3Z6V2ST1G
HEADER PIN 2X3 R/A	J1	1	Samtec	TSW-103-08-L-D-RA
2x2 Sucket	J2, J3	2	Samtec	CLM-102-02-F-D-TR
2x8 Sucket	J4, J5, J6, J7	4	Samtec	CLM-108-02-F-D-P-TR
DC/DC CONV SMD 1W	PS1, PS2	2	CUI	PDS1-S12-S9-M-TR
RES SMD 1 OHM 1% 1/16W 0402	R1, R3, R4, R5, R7, R9, R10, R11	8	Yageo	RC0402FR-071RL
RES SMD 10 OHM 1% 1/16W 0402	R2, R8	2	Yageo	RC0402FR-0710RL
RES SMD 1K OHM 1% 1/8W 0805	R6, R12	2	Yageo	RC0805FR-071KL
IC ISOL GATE DRIVER SINGLE	U1, U2	2	Silicon Labs	SI8271AB-ISR
PCB for MCHPMDRV	PCB	1	Shenzhen Sprint PCB	

4.3 Full bridge Mother Board GSP65MB-EVB)

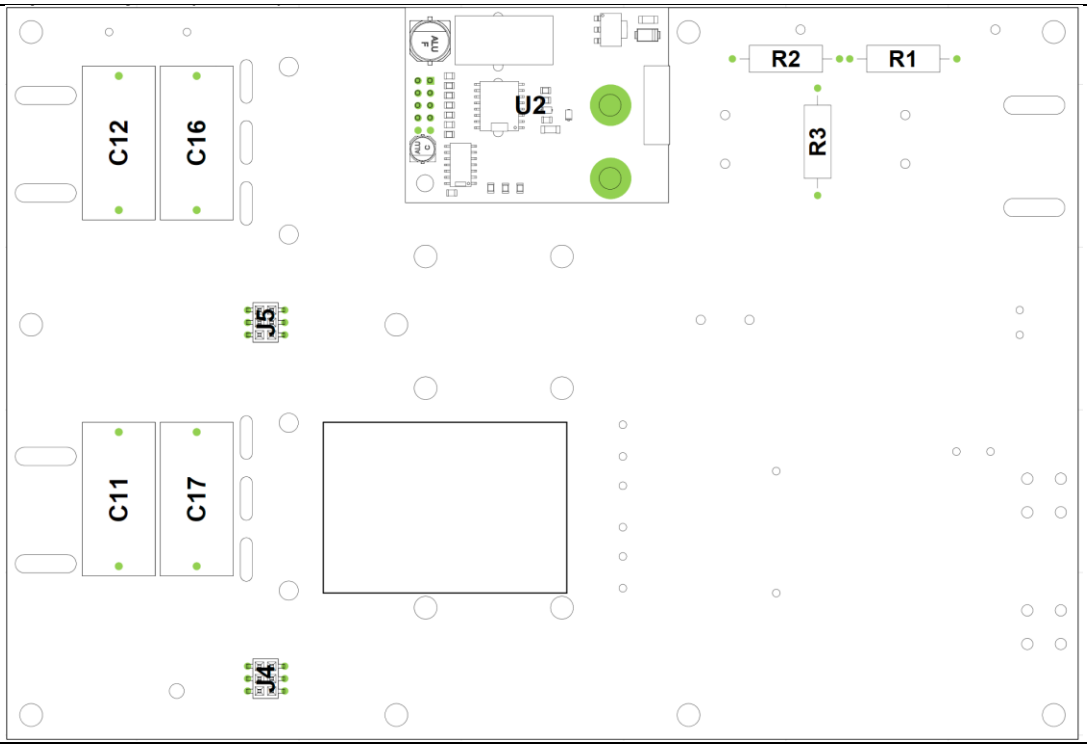


GSP65MB-EVB Schematics

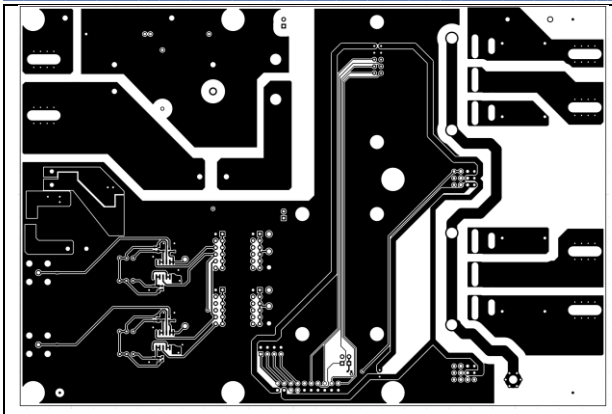
Please refer to the Evaluation Board/Kit Important Notice on page 37



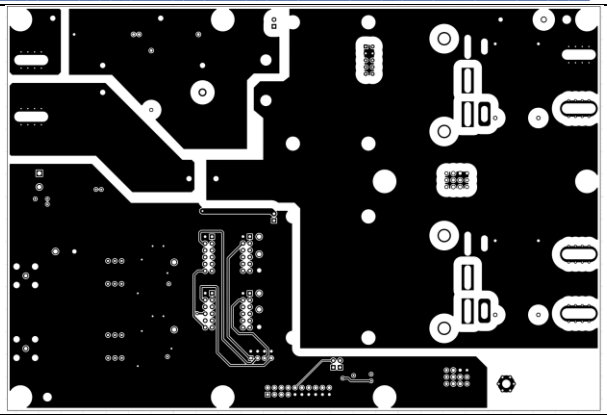
GSP65MB-EVB Assembly Drawing (Top component side)



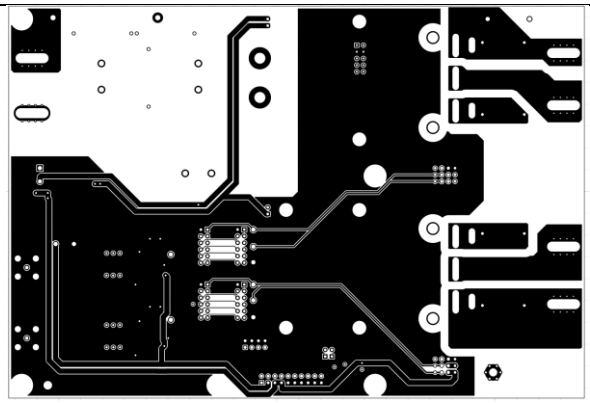
GSP65MB-EVB Assembly Drawing (Bottom side)



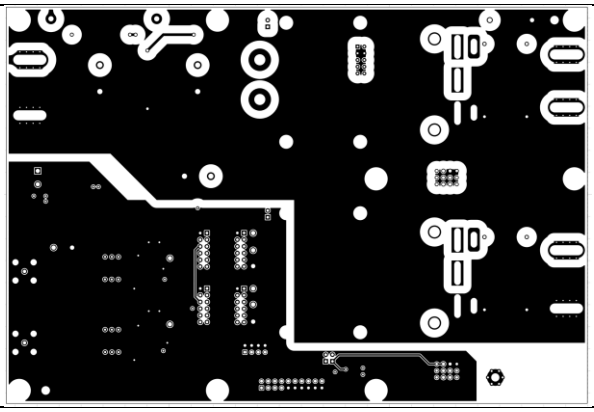
Top layer



Mid layer 1



Mid layer 1



Bottom layer

GSP65MB-EVB PCB layout

Please refer to the Evaluation Board/Kit Important Notice on page 37

GSP65MB-EVB Bill of Materials

Quantity	Reference	Description	Manufacturer	Part number	Assembly Note
1	PCB1	PCB BARE	Shenzhen Sprint PCB		
2	C1, C3	CAP, CERM, 10 uF, +/-10%, X7R, 0805	Samsung Electro-Mechanics America, Inc.	CL21A106KAYNNNE	
1	C2	CAP ALUM 220UF 20% 25V SMD	Panasonic ECG	EEE-FK1E221P	
3	C4, C8, C13	CAP, CERM, 1uF, +/-10%, X7R, 0603	Samsung Electro-Mechanics America, Inc.	CL10B105KA8NNNC	
2	~~C5,~~ C6, C7	GENERIC CAPACITOR POLARISED	Nichicon	LGN2X221MELC50	DO NOT INSTALL C5
2	C9, C14	CAP, CERM, 0.022uF, +/-10%, X7R, 0603	Kyocera AVX	06035C220JAT2A	
4	C10, C15, C18, C19	CAP, CERM, 100pF,25V +/-10%, X7R, 0603	KEMET	C0603C101J3GACTU	
4	C11, C12, C16, C17	CAP, FILM, 2.2uF, +/-10%, LS=27.5mm	KEMET	F862FN225K310ZV054	
1	CM1	COMMON MODE CHOKE 4.7A 2LN SMD	Pulse Electronics	P0422NLT	
6	CON1, CON2, CON4, CON5, CON6, CON7	PCB WIRE LUG HIGH CURRENT 6-16AWG	Lugs Direct	B6A-PCB-HEX	
4	D1, D2, D3, D4	DIODE SCHOTTKY 30V 200MA SOD323	Diodes	BAT54WS-E3-08	
2	DBA, DBB	650V GAN HIGH BRIDGE IMS DEMO KIT	GaN Systems		DO NOT INSTALL
1	F1	FUSE 3AB 1/4 DIA	Littelfuse	0505030.MXEP	
2	J1, J3	CONN HEADER VERT 2POS .100 TIN	TE Connectivity	640456-2	
1	J2	TERM BLK HDR 2POS R/A 5.08MM	TE Connectivity	796638-2	
2	J4, J5	03+03 DIL BTM ENTRY SKT	Harwin	M20-7850342	DO NOT INSTALL
2	J6, J7	BNC JACK STR 50OHM PCB NMT	Amphenol Connex	112538	
1	J8	CONN HEADER 20POS DUAL VERT PCB	Amphenol FCI	71918-120LF	
1	J9	CON HDR 8POS DUAL VERT	Amphenol FCI	75869-132LF	
3	JP1, JP2, JP8	JUMPER SMD	Harwin	S1621-46R	
1	JP3	CONN HEADER .100" DUAL STR 4POS	Sullins	PRPC002DAAN-RC	
4	JP4, JP5, JP6, JP7	CONN HEADER .100" DUAL STR 12POS	Sullins	PRPC006DAAN-RC	
2	M1, M2	FAN AXIAL 50X20MM 12VDC WIRE	Delta	AFB0512VHD	USE TIE WRAP TO MOUNT M1/M2.
2	RCPT1, RCPT2	CONN RECEPT 2POS 24AWG MTA100	TE Connectivity	3-640441-2	CRIMP WIRES FROM FAN TO RCPT1/RCPT2, RED(+) at Pin1, and connect to J1/J3
3	R1, R2, R3	RES AXIAL 6 MM DIA L=15.5MM	KOA Speer	MOS3CT631R473J	
3	R4, R6, R8	RES, 0.05 %, 0603	Vishay / Dale	TNPU060310K0AWEN00	
2	R5, R10	RES, 1%, 0603	Yageo	RC0603FR-07100RL	
4	R7, R9, R11, R12	RES, 1%, 0603	Philips Mepco	RC0603FR-071KL	
12	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12	TESTPOINT SCOPE GRABBER	Keystone Electronics	5010	
4	TR1, TR2, TR3, TR4	TRIMMABLE RESISTOR	Bourns	PV36W202C01B00	DO NOT INSTALL
1	U1	LINEAR REGULATOR 5.0V	STMicroelectronics	L7805CDT-TR	
1	U2	OCP/SSCB MODULE	GAN SYSTEMS		DO NOT INSTALL
2	U3, U4	QUAD 2-IN POS NAND SCH	Fairchild Semiconductor	74VHC132MX	
1	J2-PLUG	TERM BLOCK BLUG 2POS 5.08MM	TE Connectivity	796634-2	INSTALL ON J2
5	JMP1, JMP2, JMP3, JMP4, JMP5	JUMPER SHUNT SHUNT	TE Connectivity	382811-8	
8	M4, M5, M6, M7, M8, M9, M10, M11	MNT HOLE STDOFF 8/32 1-1/2" NYLON	Keystone Electronics	4838	INSTALL STDOFF ON BOTTOM SIDE
8	M13, M14, M15, M16, M17, M18, M19, M20,	HEX NUT 5/16" NYLON 8-32	Keystone Electronics	9607	
1	C20	CAP CER 0.1UF 25V X7R RADIAL	Murata	RDER71E104K0P1H03B	FOLLOW ASSEMBLY PROCEDURES FOR INSTALLATION OF C20

Please refer to the Evaluation Board/Kit Important Notice on page 37

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