GS66508T/GS66516T-EVBDB GaN E-HEMT Daughter Board and GS665MB-EVB Evaluation Platform

User's Guide

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DANGER!

This evaluation kit is designed for engineering evaluation in a controlled lab environment and **should be handled by qualified personnel ONLY**. High voltage will be exposed on the board during the test and even brief contact during operation may result in severe injury or death.

Never leave the board operating unattended. After it is de-energized, always wait until all capacitors are discharged before touching the board.

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 32

Overview

The GS665XXX-EVBDB daughter board style evaluation kit consists of two GaN Systems 650V GaN Enhancement-mode HEMTs (E-HEMTs) and all necessary circuits including half bridge gate drivers, isolated power supplies and optional heatsink to form a functional half bridge power stage. It allows users to easily evaluate the GaN E-HEMT performance in any half bridge-based topology, either with the universal mother board (P/N: GS665MB-EVB) or users' own system design for quick prototyping.

Features:

- Serves as a reference design and evaluation tool as well as deployment-ready solution for easy in-system evaluation.
- Vertical mount style with height of 35mm, which fits in majority of 1U design and allows evaluation of GaN E-HEMT in traditional through-hole type power supply board.
- Current shunt position for switching characterization testing
- Universal form factor and footprint for all products

The daughter board and universal mother board ordering part numbers are below:

Table 1 Ordering part numbers

Part Number	GaN E-HEMT P/N:	Description
GS66502B-EVBDB	GS66502B	GaN E-HEMT 650V/7.5A, 200mΩ
GS66504B-EVBDB	GS66504B	GaN E-HEMT 650V/15A, 100mΩ
GS66508B-EVBDB	GS66508B	GaN E-HEMT 650V/30A, 50mΩ
GS66508T-EVBDB	GS66508T	GaN E-HEMT top side cooled 650V/30A, 50mΩ
GS66516T-EVBDB	GS66516T	GaN E-HEMT top side cooled 650V/60A, 25mΩ
GS665MB-EVB	GS665MB-EVB	Universal 650V Mother Board

Control and Power I/Os:

The daughter board GS665XXX-EVBDB circuit diagram is shown in Figure 1. The control logic inputs on 2x3 pin header J1 are listed below:

Table 2 Control pins

Pin	Descriptipon
ENA	Enable input. It is internally pulled up to VCC, a low logic disables all the PWM gate drive outputs.
VCC	+5V auxillary power supply input for logic circuit and gate driver. On the daughter board there are 2 isolated 5V to 9V DC/DC power supplies for top and bottom switches.
VDRV	Optional 9V gate drive power input. This pin allows users to supply separate gate drive power supply. By default VDRV is connected to VCC on the daughter board via a 0 ohm jumper FB1. If bootstrap mode is used for high side gate drive, connect VDRV to 9V
PWMH	High side PWM logic input for top switch Q1. It is compatible wth 3.3V and 5V
PWML	Low side PWM logic input for bottom switch Q2. It is compatible wth 3.3V and 5V
0V	Logic inputs and gate drive power supply ground return.

The 3 power pins are:

- VDC+: Input DC Bus voltage
- VSW: Switching node output
- VDC-: Input DC bus voltage ground return. Note that control ground 0V is isolated from VDC-.

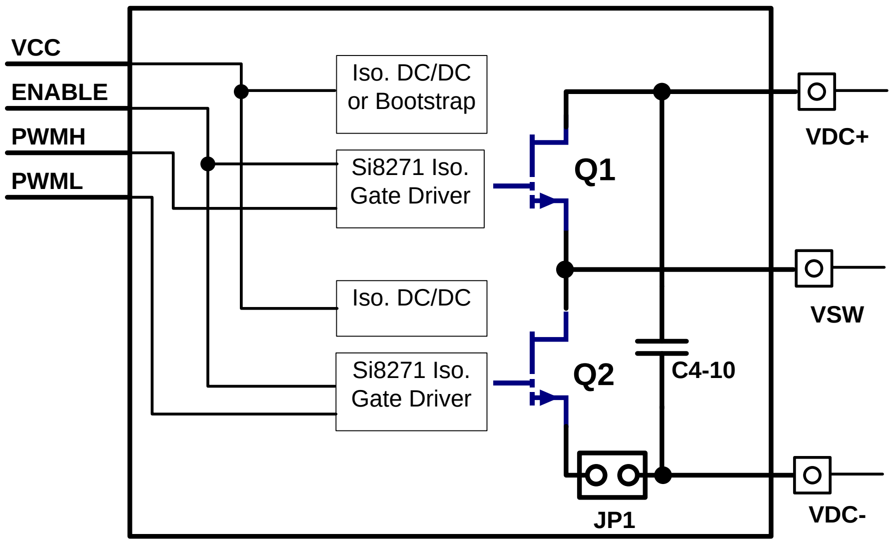

Figure 1 GS665XXX-EVBDB Evaluation Board Block Diagram

GS66508T/GS66516T-EVBDB half bridge daughter board

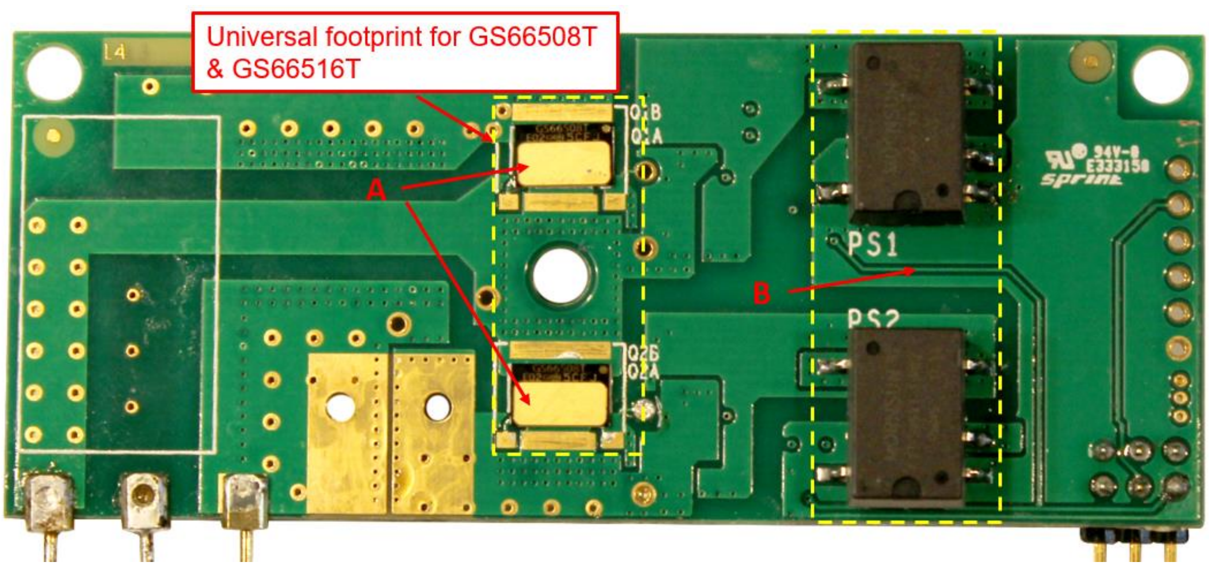

Figure 2 GS66508T/GS66516T-EVBDB bottom side (without heatsink)

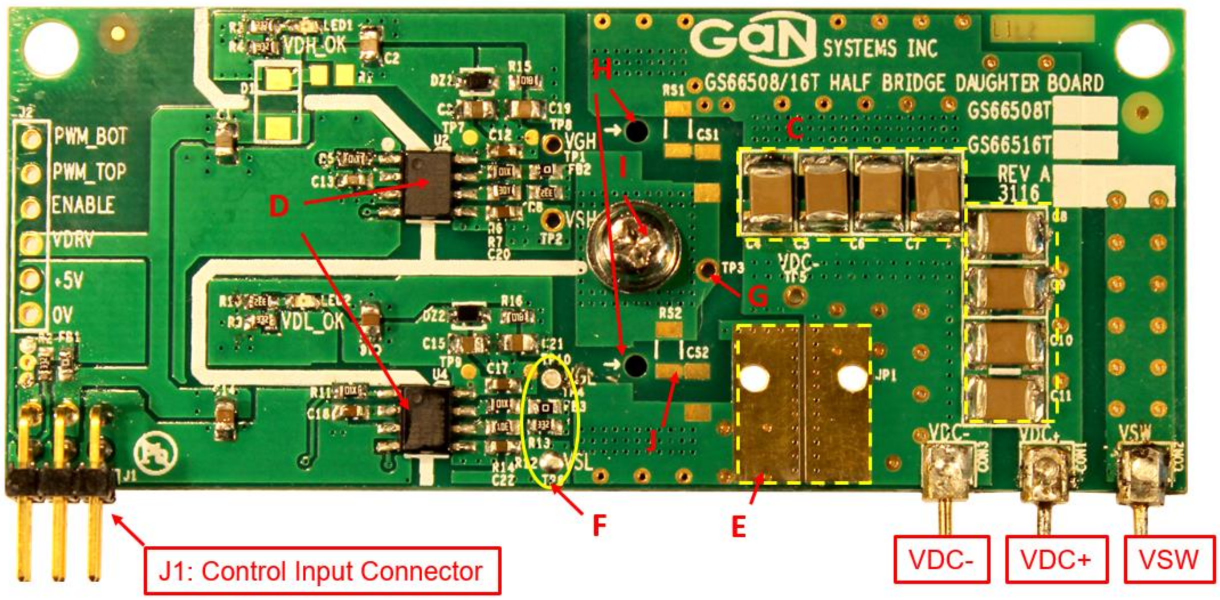

Figure 3 GS66508T/GS66516T-EVBDB top side

A. 2x GaN Systems 650V E-HEMT GS66508T(30A/50mΩ) or GS66516T (60A/25 mΩ). The PCB footprints are universal and compatible for both packages
B. 5V-9V isolated DC/DC gate drive power supply
C. Decoupling capacitors C4-C11
D. Isolated gate driver Silab Si8271
E. Optional current shunt position JP1.
F. Test points for bottom Q2 V_{GS}.
G. Recommended probing positions for Q2 V_{DS}.
H. Holes for temperature monitoring of Q1/Q2
I. M3 mounting screw for heatsink
J. (Optional) RC snubber circuit

GaN E-HEMTs:

- This daughter board includes two GaN Systems E-HEMT GS66508T (650V/30A, 50mΩ) or GS66516T (650V/60A, 25mΩ) in a GaNPx™ Top cooled T type package, . The thermal pad on the top of device is internally connected to the source. Electrical insulation will be needed for heatsink attachment. GaNPx™ T package also features dual symmetrical gate for easier paralleling and PCB layout.

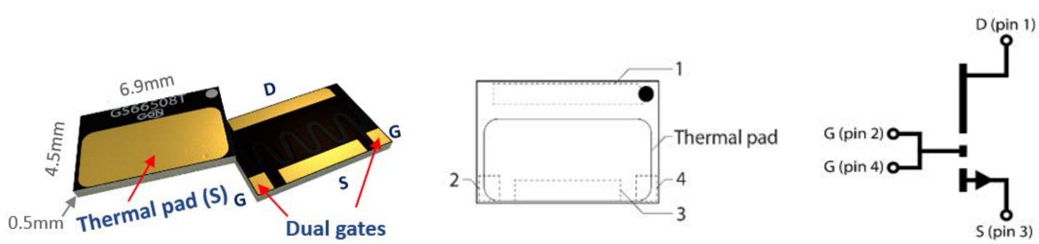

Figure 4 Package outline of GaNPx T Package

Gate drive power supply:

- Bipolar gate drive bias with +6V and -3V for turning off is chosen for this design for more robust gate drive and better noise immunity.
- 5V-9V isolated DC/DC converters are used for gate drive. 9V is then splited into +6V and -3V bias by using 6V Zener diode
- By default gate drive supply input VDRV is tied to VCC +5V via 0Ω jumper (FB1). Remove FB1 if separate gate drive input voltage is to be used.

Gate driver circuit:

- Silab SI8271-GB-IS (3V UVLO) or SI8271–AB-IS (5V UVLO) isolated gate driver can be used for this design. Both drivers are compatible with 6V/-3V gate drive and has CMTI dv/dt immunity up to 200V/ns. It has separated source and sink drive outputs which eliminates the need for additional diode.
- GaN E-HEMT switching speed and slew rate can be directly controlled by the gate resistors. By default the turn-on Rgate (R6/R12) is 10Ω and Rg_off (R7/R14) is 2Ω. User can adjust the values of gate resistors to fine tune the turn-on and off speed.
- FB1/FB2 are footprints for optional ferrite bead. By default they are populated with 0Ω jumpers. If gate oscillation is observed, it is recommended to replace them with ferrite bead with Z=10-20Ω@100MHz.

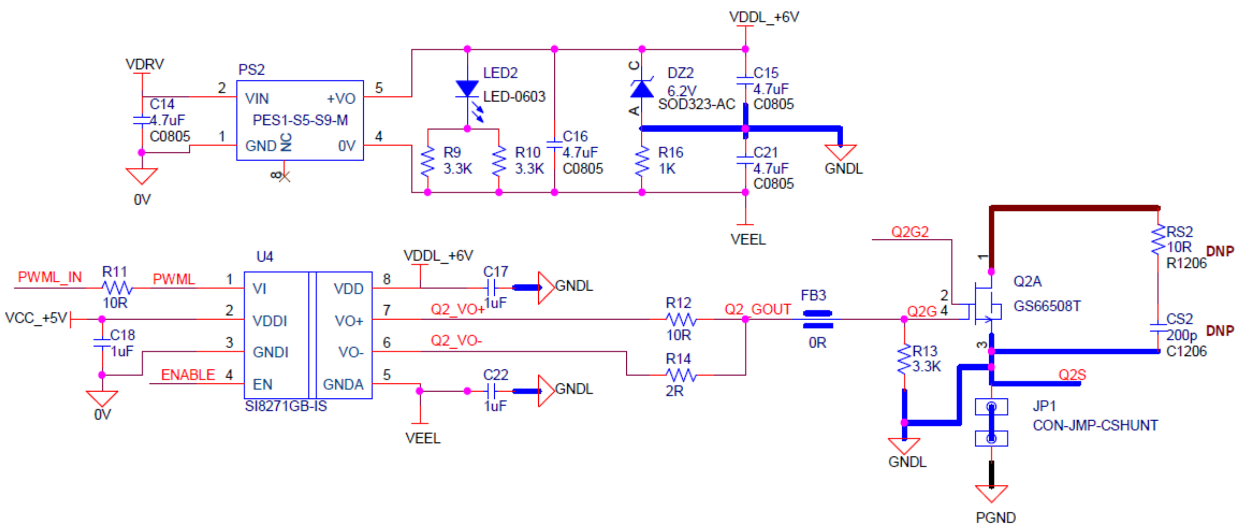

Figure 5 Gate bias and driver circuit

RC Snubber:

RS1/CS1 and RS2/CS2 are place holders to allow user to experiement with RC snubber circuit (not installed). At high frequency operation the power dissipation for RS1/RS2 needs to be closely watched and CS1/CS2 should be sized correctly. It is recommended to start with 33-47pF and 10-20Ω.

Current shunt JP1:

- The board provides an optional current shunt position JP1 between the source of Q2 and power ground return. This allows drain current measurement for switching characterization test such as Eon/Eoff measurement.
- The JP1 footprint is compatible with T&M Research SDN series coaxial current shunt (recommended P/N: SDN-414-10, 2GHz B/W, 0.1Ω)
- If current shunt is not used JP1 must be shorted. JP1 affects the power loop inductance and its inductance should be kept as low as possible. Use a copper foil or jumper with low inductance.

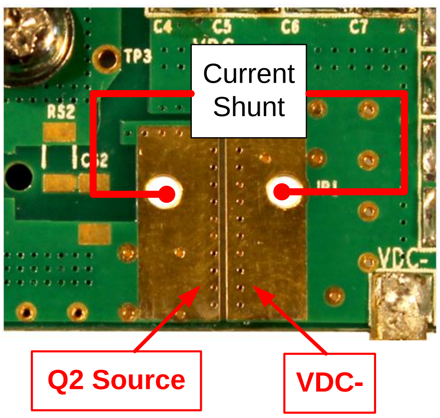

Figure 6 Recommended probe connection with current shunt

CAUTION:
Check the JP1 before the first time use. To complete the circuit JP1 needs to be either shorted or a current shunt must be inserted before powering up.

Measurement with current shunt:

1. When measuring VSW with current shunt, ensure all channel probe grounds and current shunt BNC output case are all referenced to the source end of Q2 before the current shunt. The recommended setup of probes is shown as below.
2. The output of coaxial current shunt can be connected to oscilloscope via 50Ω termination impedance to reduce the ringing.
3. The measured current is inverted and can be scaled by using: Id=Vid/Rsense.

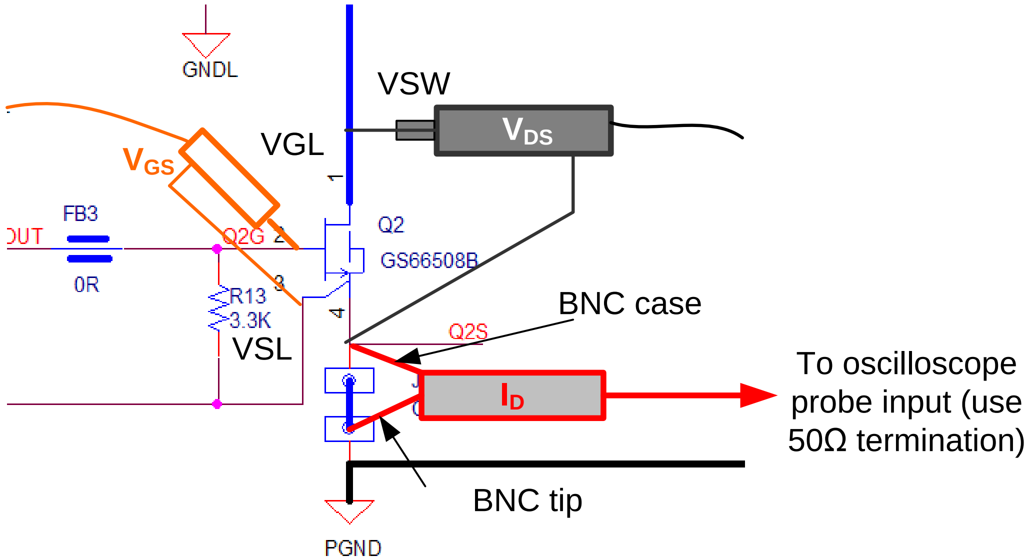

Figure 7 Recommended probe connection with current shunt

Thermal design:

1. GS66508T or GS66516T has a thermal pad at the top side for improved heat dissipation. Instead of relying on PCB for cooling, the heat can be transferred to heatsink directly from the top reducing the total thermal resistnace.
2. A heatsink can be mounted to the board using a M3 screw with lock washer and nylon insulated bushing. Thermal Interface Material (TIM) is needed to provide electrical insulation and conformance to the thermal pad surface. The daughter board evaluation kit supplies with a 35x35mm heatsink with M3 tapped hole, and other heatsinks can also be used to fit users' system design.
3. **Care should be taken during the assembly of heatsink to avoid PCB bending and mechanical stress to the GaN E-HEMT**. We recommend to limit the torque of M3 mounting screw to <1 in-lb (0.1Nm) for GS66508T and <2 in-lb (0.2Nm) for GS66516T, which translates to about ~50psi pressure on each device.

WARNING!
Over-torquing on the heatsink may create excess mechanical stress and could result in device failure. Always follow the maximum torque spec and attach the heatsink carefully to avoid any PCB bending or high pressing force on the devices.

4. To measure device case temperature, use IR camera or install thermocouple to monitor the temperature through two drilled holes from the top side as shown below:

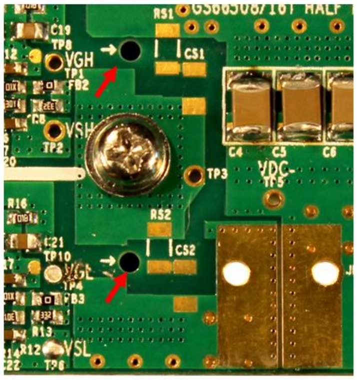

Figure 8 Location for case temperature monitoring

CAUTION:
There is no on-board over-temperature protection. Device temperature must be closely monitored during the test. Never operate the board with device temperature exceeding T_{J_MAX} (150°C)

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5. The TIM we use on this assembly is Berguist® SilPad 1500ST, the measured total thermal resistance can be found in Figure 9. Compared to bottom cooled design, T package eliminates the PCB thermal resistance and significantly improve the thermal performance. Theraml grease is typically not needed on the assembly. If thermal grease is to be applied, use non-conductive and non-capacitive type thermal grease.
6. Forced air cooling is recommended for power testing.

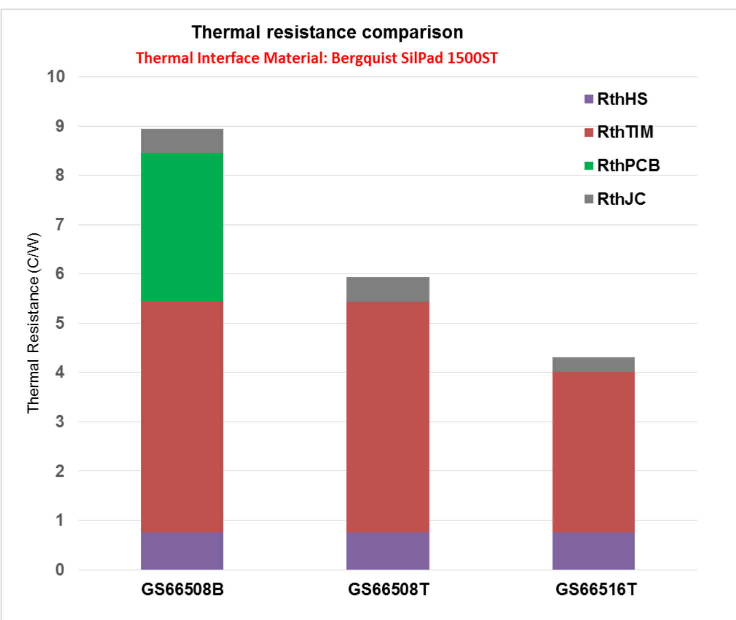


Figure 9 Evaluation board thermal resistance comparison

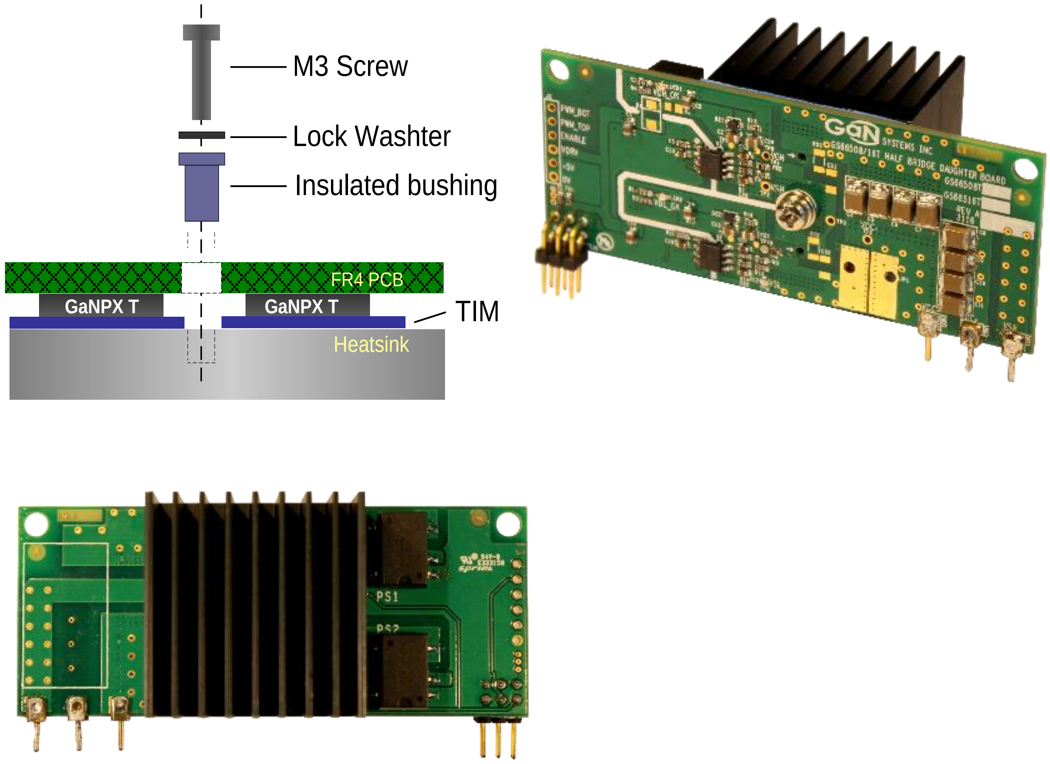


Figure 10 The daughter board assembly with heatsink attached

Using GS665XXX-EVBDB with universal mother board GS665MB-EVB

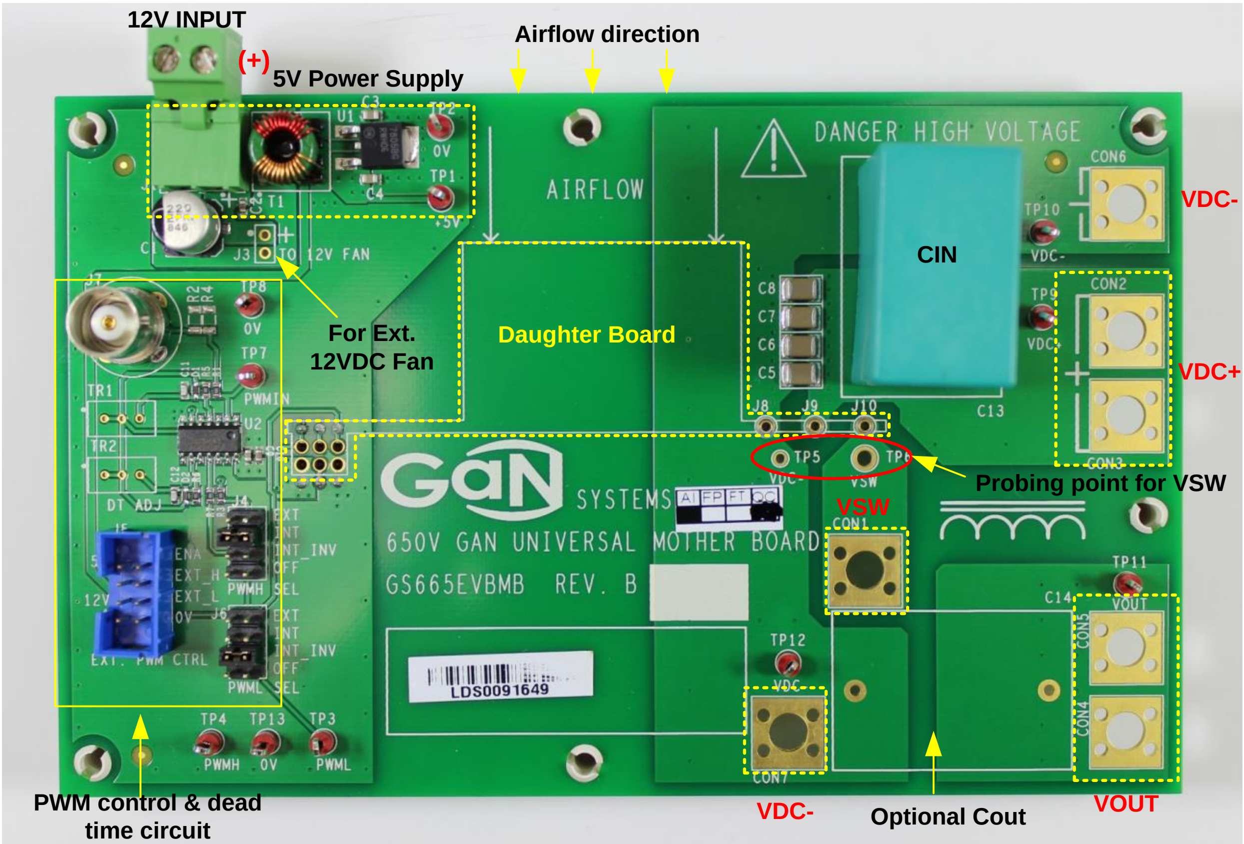


Figure 11 650V universal mother board GS665MB-EVB

GaN Systems provides a universal 650V mother board (ordering part number: GS665MB-EVB, sold separately) that can be used as the basic evaluation platform for all the daughter boards.

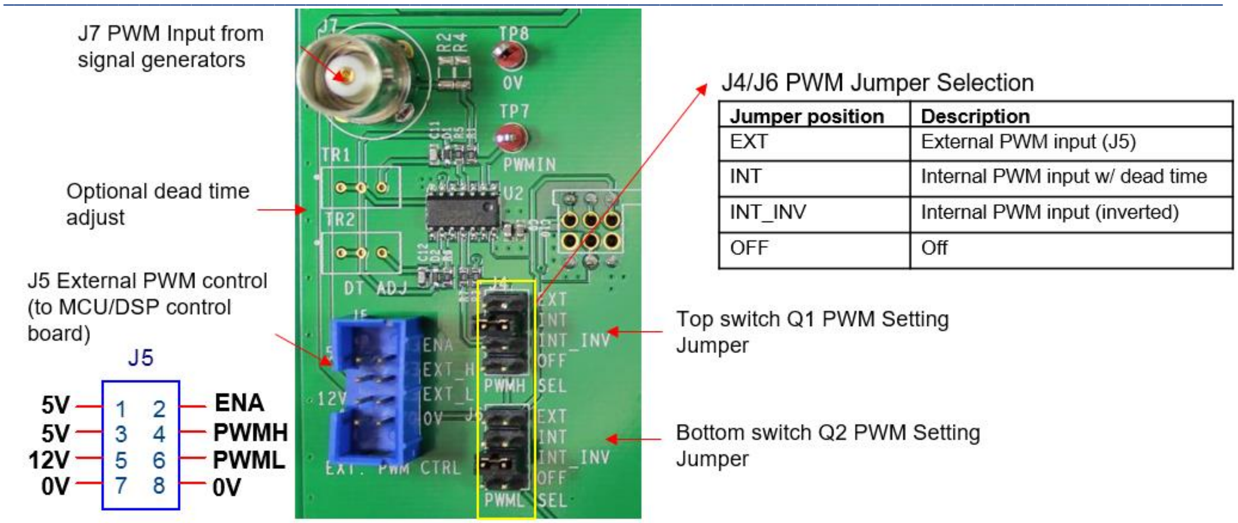
The universal 650V mother board evaluation kit includes following items:

1. Mother board GS665MB-EVB
2. 12VDC Fan

12V input:

The board can be powered by 9-12V on J1. On-board voltage regulator creates to 5V for daughter board and control logic circuits. J3 is used for external 12VDC fan.

PWM control circuit:



Jumper position	Description
EXT	External PWM input (J5)
INT	Internal PWM input w/ dead time
INT_INV	Internal PWM input (inverted)
OFF	Off

Figure 12 PWM control input and dead time circuit

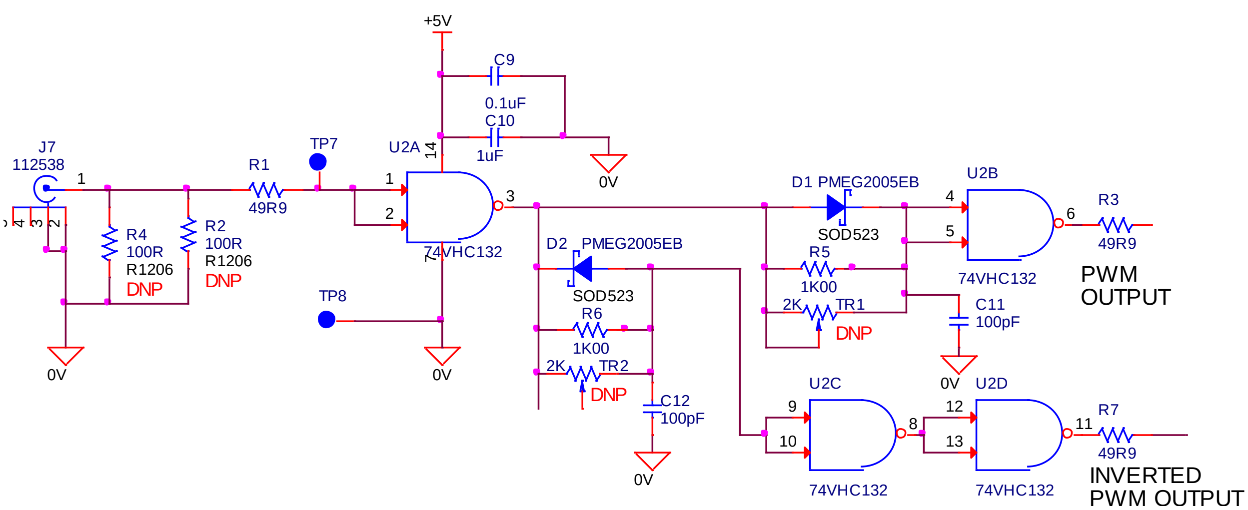


Figure 13 On board dead time generatrion circuit

The top and bottom switches PWM inputs can be individually controlled by two jumpers J4 and J6. Users can choose between a pair of complementary on-board internal PWM signals (non-inverted and inverted, controlled by J7 input) with dead time or external high/low side drive signals from J5 (users' own control board).

An on-board dead time generation circuit is included on the mother board. Dead time is controlled by two RC delay circuits, R6/C12 and R5/C11. The default dead time is set to about 100ns. Additionally two potentiometers locations are provided (TR1/TR2, not included) to allow fine adjustment of the dead time if needed.

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

Test points:

Test points are designed in groups/pairs to facilitate probing:

Test points	Name	Description
TP1/TP2	+5V/0V	5V bias power
TP7/TP8	PWMIN/0V	PWM input signal from J7
TP4/TP3/TP13	PWMH/PWML/0V	High/low side gate signals to daughter board
TP9/TP10	VDC+/VDC-	DC bus voltage
TP11/TP12	VOUT/VDC-	Output voltage
TP6/TP5	VSW/VDC-	Switching node output voltage (for HV oscilloscope probe)

Power connections:

CON1-CON7 mounting pads are designed to be compatible with following mounting terminals:

- #10-32 Screw mount,
- Banana Jack PCB mount (Keystone P/N: **575-4**), or
- PC Mount Screw Terminal (Keystone P/N: **8191**)

Output passives (L and C14)

An external power inductor (not included) can be connected between VSW (CON1) and VOUT (CON4/5) or VDC+ (CON2/3) for double pulse test. Users can choose their inductor size to meet the test requirement. Generally it is recommended to use power inductor with low inter-winding capacitance to obtain best switching performance. For the double pulse testing we use 2x 60uH/40Amp inductor (CWS, P/N: HF467-600M-40AV) in series. C14 is designed to accommodate a film capacitor as output filter.

Double pulse test mode

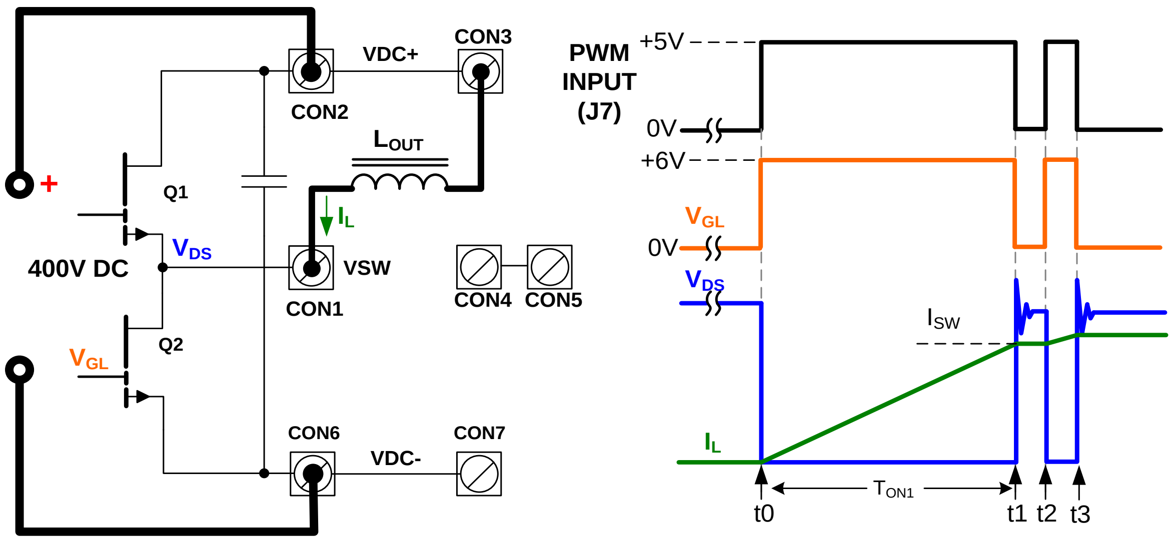


Figure 14 Double pulse test setup

Double pulse test allows easy evaluation of device switching performance at high voltage/current without the need of actually running at high power. It can also be used for switching loss (Eon/Eoff) measurement and other switching characterization parameter test.

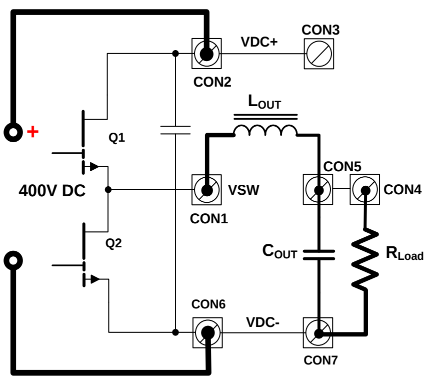
The circuit configuration and operating principle can be found in Figure 14:

1. The output inductor is connected to the VDC+.
2. At t0 when Q2 is switched on, the inductor current starts to ramp up until t1. The period of first pulse Ton1 defines the switching current $I_{SW} = (V_{DS}*T_{ON1}) / L$.
3. t1-t2 is the free wheeling period when the inductor current I_L forces Q1 to conduct in reverse.
4. t1 (turn-off) and t2 (turn-on) are of interest for this test as they are the hard switching trasients for the half bridge circuit when Q2 is under high switching stress.
5. The second pulse t2-t3 is kept short to limit the peak inductor current at t3.

The double pulse signal can be generated using programmable signal generaotor or microcontroller/DSP board. As this test involves high switching stress and high current, it is recommended to set the double pulse test gate signal as single trigger mode or use long repetition period (for example >50-100ms) to void excess stress to the switches. Q1 can be kept off during the test or driven synchronously (J4 set to OFF or INT_INV) and Q2 is set to INT (or EXT position if PWM signal is from J5).

WARNING!
Limit the maximum switching test current to 30A for GS66508T (60A for GS66516T) and ensure maximum drain voltage including ringing is below 650V for pulse testing. Exceeding this limit may cause damage to the devices.

Buck/Standard half bridge mode



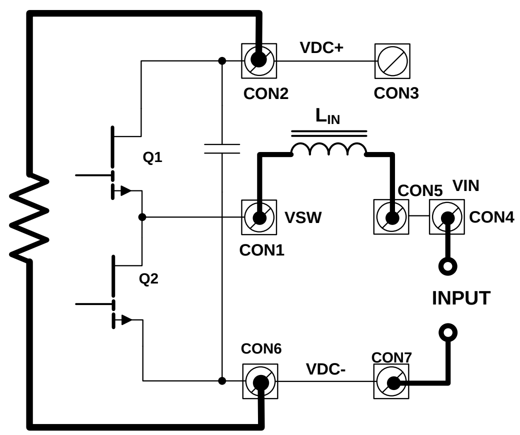
This is standard half bridge configuration that can be used in following circuits :

- Synchronous Buck DC/DC
- Single phase half bridge inverter
- ZVS half bridge LLC
- Phase leg for full bridge DC/DC or
- Phase leg for a 3-phase motor drive

Jumper setting:

- J4 (Q1): INT
- J6 (Q2): INT_INV

Boost mode



When the output becomes the input and the load is attached between VDC+ and VDC-, the board is converted into a boost mode circuit and can be used for:

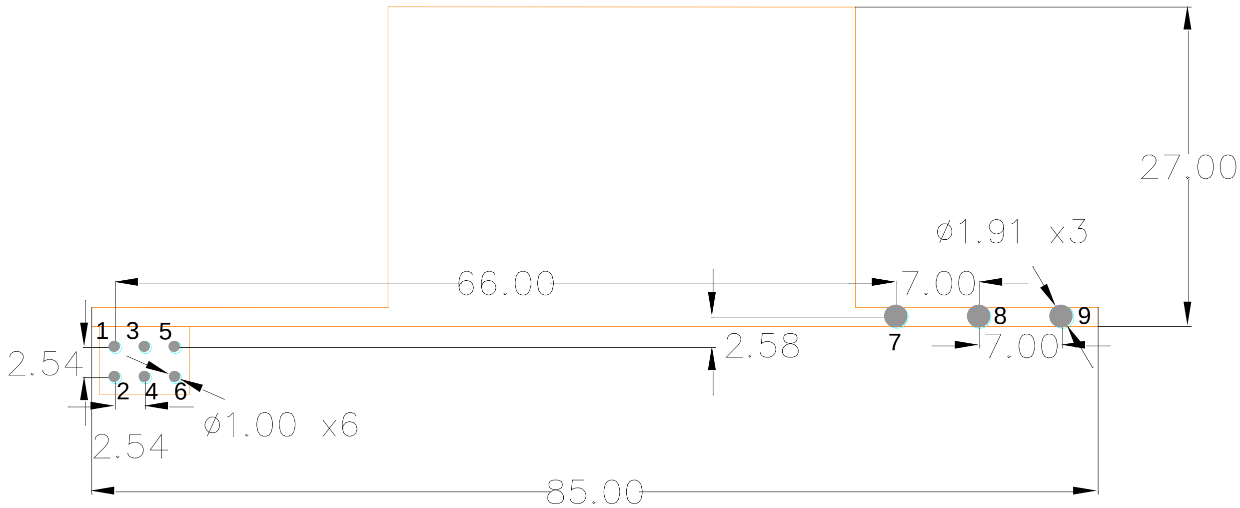
- Synchronous Boost DC/DC
- Totem pole bridgeless PFC

Jumper setting:

- J4 (Q1): INT_INV
- J6 (Q2): INT

Using GS665XXX-EVBDB in system:

The daughter board allows users to easily evaluate the GaN performance in their own systems. Refer to the footprint drawing of GS665XXX-EVBDB as shown below:



1. All units are in mm.
2. Pin 1-6: Dia. 1mm
3. Pin 7-9: 1.91mm (75mil) mounting hole for Mill-max Receptacle P/N: 0312-0-15-15-34-27-10-0.

Figure 15 Recommended footprint drawing of daughter board GS665XXX-EVBDB

Quick Start procedure – Double pulse test

Follow the instructions below to quickly get started with your evaluation of GaN E-HEMT. Equipment and components you will need:

- Four-channel oscilloscope with 500MHz bandwidth or higher
- high bandwidth (500MHz or higher) passive probe
- high bandwidth (500MHz) high voltage probe (>600V)
- AC/DC current probe for inductor current measurement
- 12V DC power supply
- Signal generator capable of creating testing pulses
- High voltage power supply (0-400VDC) with current limit.
- External power inductor (recommend toroid inductor 50-200uH)

1. Check the JP1 on daughter board GS665XXX-EVBDB. Use a copper foil and solder to short JP1.
2. Install GS665XXX-EVBDB on the mother board. Press all the way down until you feel a click. Connect probe between VGL and VSL for gate voltage measurement.
3. Set up the mother board:
   a. Connect 12VDC bias supply to J1.
   b. Connect PWM input gate signal (0-5V) to J7. If it is generated from a signal generator ensure the output mode is high-Z mode.
   c. Set J4 to OFF position and J7 to INT.
   d. Set High voltage (HV) DC supply voltage to 0V and ensure the output is OFF. Connect HV supply to **CON2** and **CON6.**
   e. Use HV probe between TP6 and TP5 for Vds measurement.
   f. Connect external inductor between **CON1** and **CON3**. Use current probe to measure inductor current IL.
4. Set up and check PWM gate signal:
   a. Turn-on 12VDC power.
   b. Check the 2 LEDs on the daughter board. They should be turned on indicating the isolated 9V is present.
   c. Set up signal generator to create the waveforms as shown in Figure 14. Use equation $I_{SW} = (V_{DS}*T_{ON1}) / L$ to calculate the pulse width of the first pulse and ensure the Isw_max is ≤30A at 400VDC.
   d. Set the operation mode to either single trigger or Burst mode with repetition period of 100ms.
   e. Turn on the PWM output and check on the oscilloscope to make sure the VGL waveform is present and matches the PWM input.
5. Power-on:
   a. Turn on the output of the HV supply. Start with low voltage and slowly ramp the voltage up until it reaches 400VDC. During the ramping period closely observe the the voltage and current waveforms on the oscilloscope.
6. Power-off:
   a. After the test is complete, slowly ramp down the HV supply voltage to 0V and turn off the output. Then turn off the 12V bias supply and signal generator output.

Please refer to the Evaluation Board/Kit Important Notice on page 32

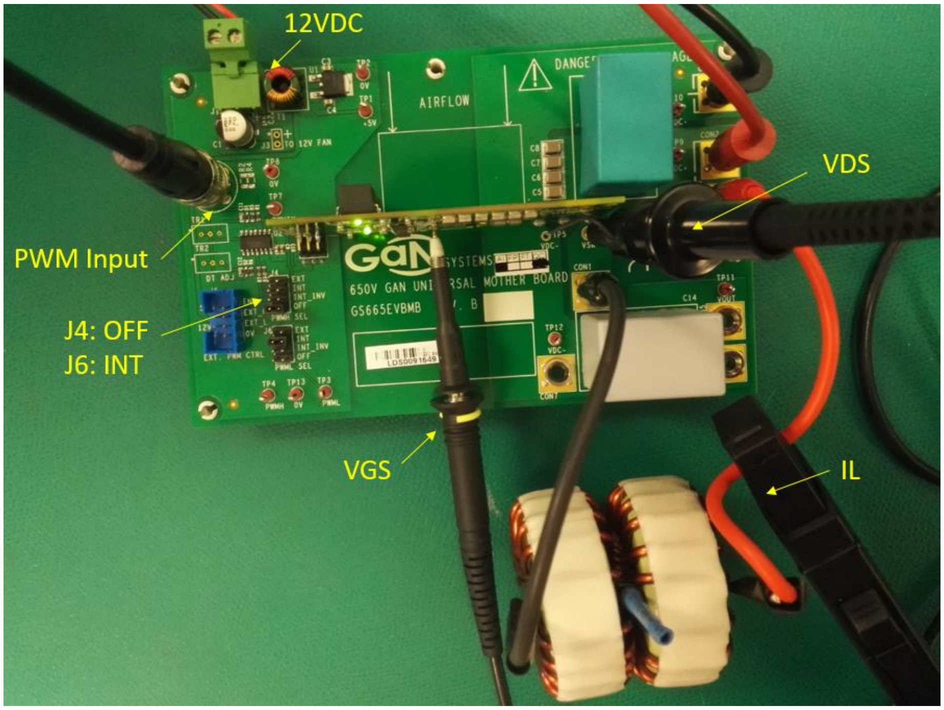


Figure 16 Double pulse test setup example

Test results

Double Pulse test (V_{DS}=400V, I_{MAX} = 30A, L=120uH, $R_{G(ON)}$=10Ω, $R_{G(OFF)}$=2Ω, V_{GS}=+6/-3V):

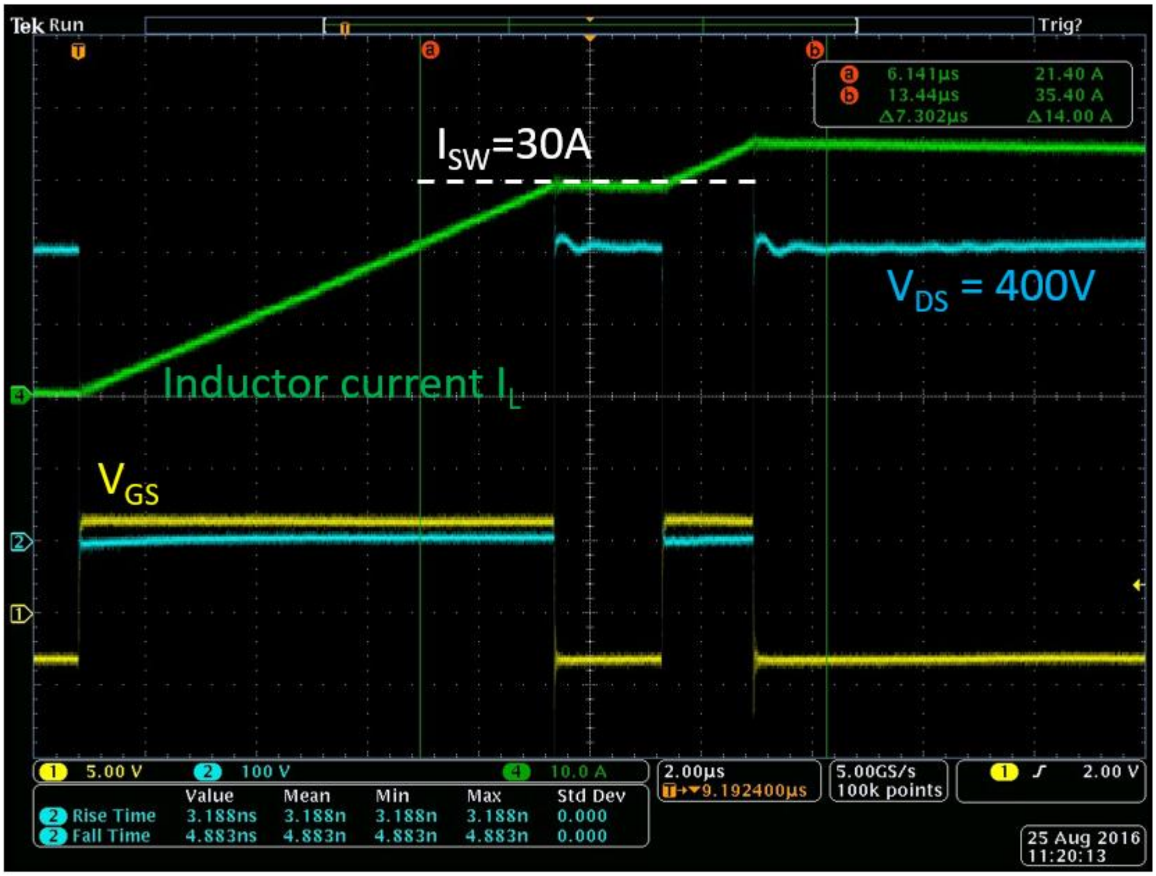
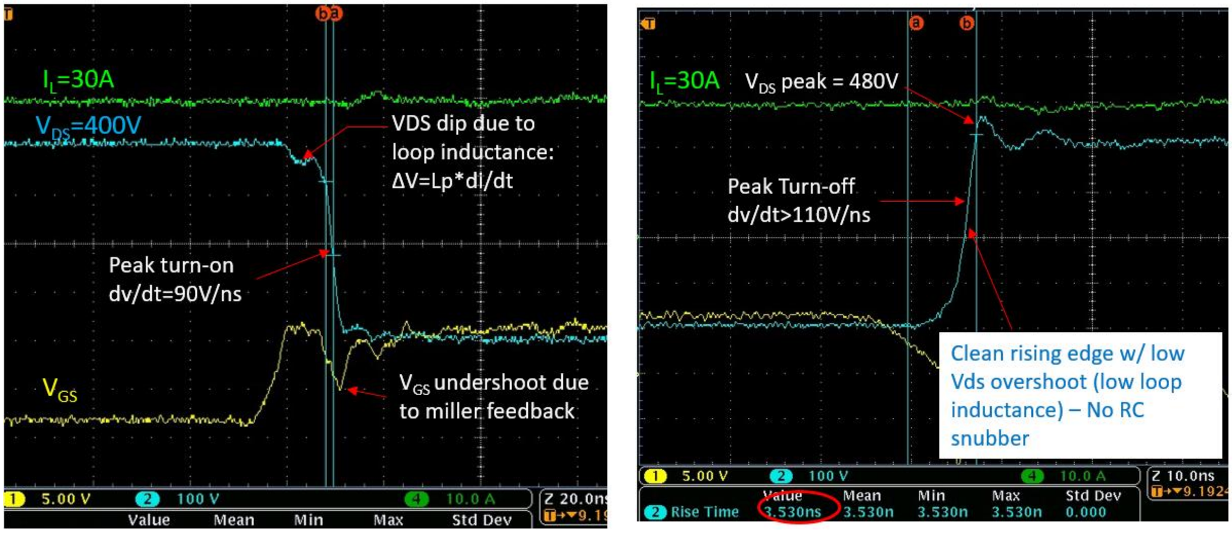


Figure 17 400V/30A double pulse test waveform (GS66508T)

Figure 17 shows the hard switching on waveforms at 400V/30A. A Vds dip can be seen due to the rising drain current (di/dt in the power loop ΔV=Lpxdi/dt, where Lp is the total power loop inductance). After the drain current reaches the inductor current, the Vds starts to fall. The Vgs undershoot spike is caused by the miller feedback via Cgd under negative dv/dt.

Due to the low gate charge and small $R_{G(OFF)}$, GaN E-HEMT gate has limited control on the turn-off dv/dt. Instead the Vds rise time is determined by how fast the turn-off current charges switching node capacitance (Coss).

The low Coss of GaN E-HEMT and low parasitic inductance of GaNPX™ package together with optimized PCB layout, enables a fast and clean turn-off Vds waveform with only 50V the turn-off Vds overshoot at dv/dt > 100V/ns. The measured rise time is 3.9ns at 400V and 30A hard turn-off。



a) hard switching turn-on 400V/30A

b) hard switching turn-off 400V/30A

Figure 18 Double puls test switching transient waveforms (GS66508T)

Switching Loss energy (Eon/Eoff) measurement

A T&M search coaxial current shunt (SDN-414-10, 0.1Ω) is installed for switching loss measurement as shown below.

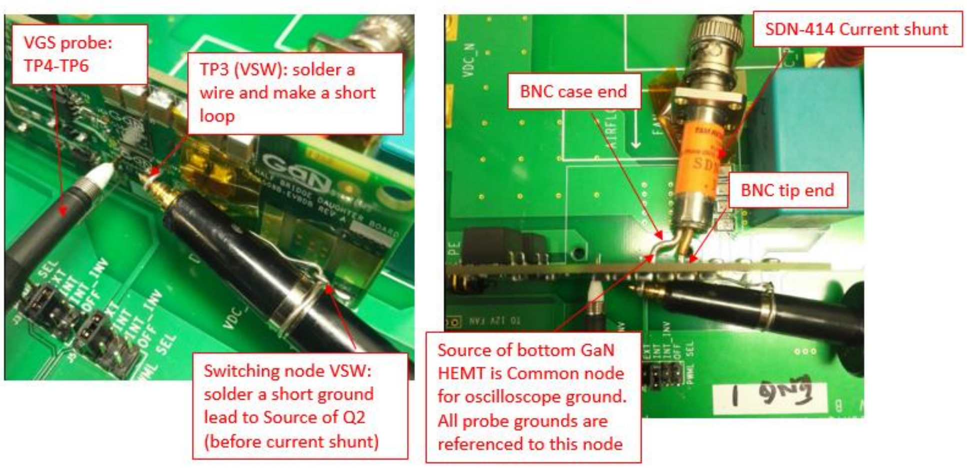


Figure 19 Eon/Eoff measurement probe connection with current shunt

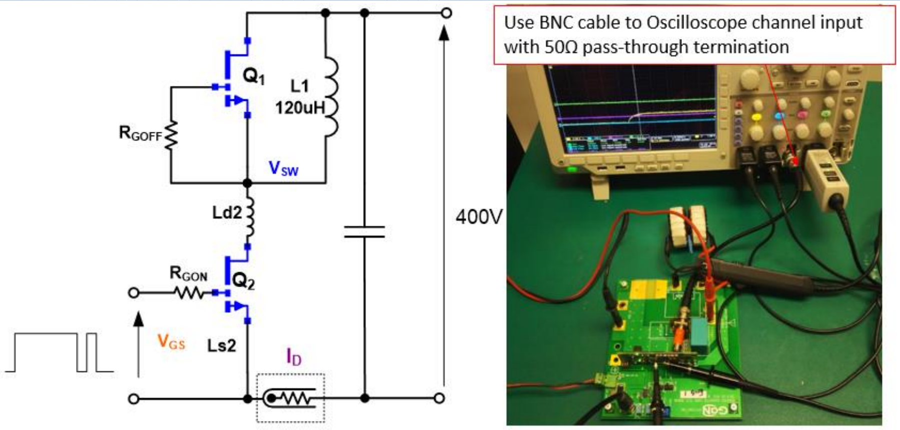


Figure 20 Eon/Eoff measurement and test bench setup

The switching energy can be calculated from the measured switching waveform Psw = Vds*Id. The integral of the Psw during switching period is the measured switching loss. The channel deskewing is critical for measurement accurary. It is recommended to manually deskew Id against Vds as shown in Figure 21. The drain current spike is caused by charging the high side switch Coss (Qoss loss).

Figure 21 Turn-on switching loss measurement (Eon=87uJ, 400V/30A, T_J=25°C)

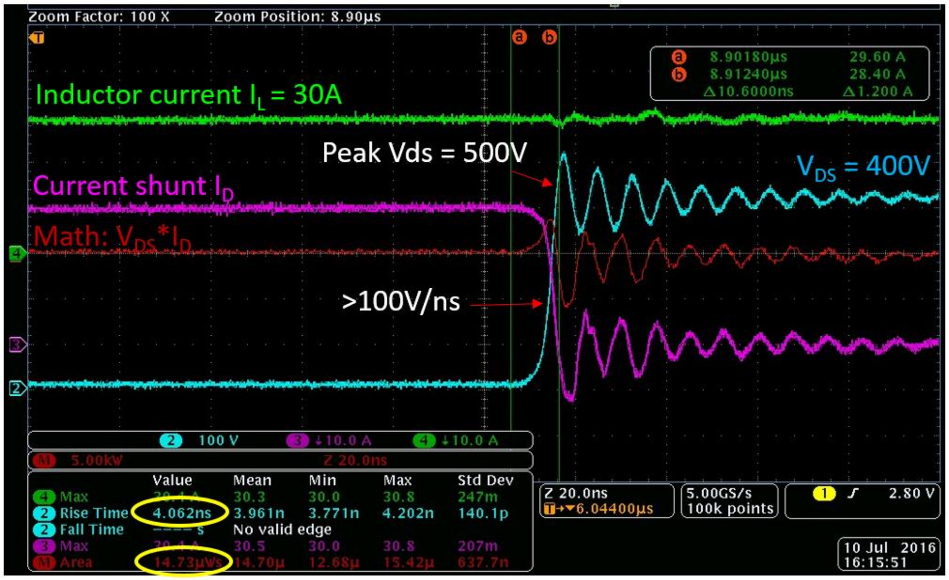


Figure 22 Turn-off switching loss measurement (Eoff=15uJ, 400V/30A, T_J=25°C)

The switching loss measurements with drain current from 0 to 30A for GS66508T or up to 60A for GS66516T can be found in Figure 23. The turn-on loss dominates the overall hard switching loss. Eon at 0A is the Qoss loss caused by the Coss at high side switch.

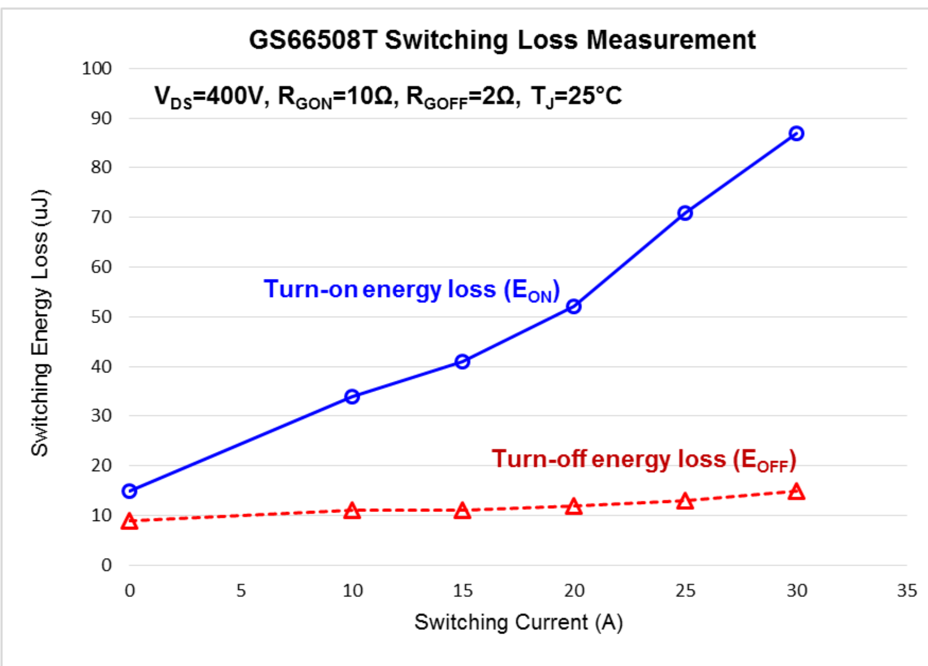


Figure 23 GS66508T Switching Loss Measurement (V_{DS} = 400V, T_J=25°C)

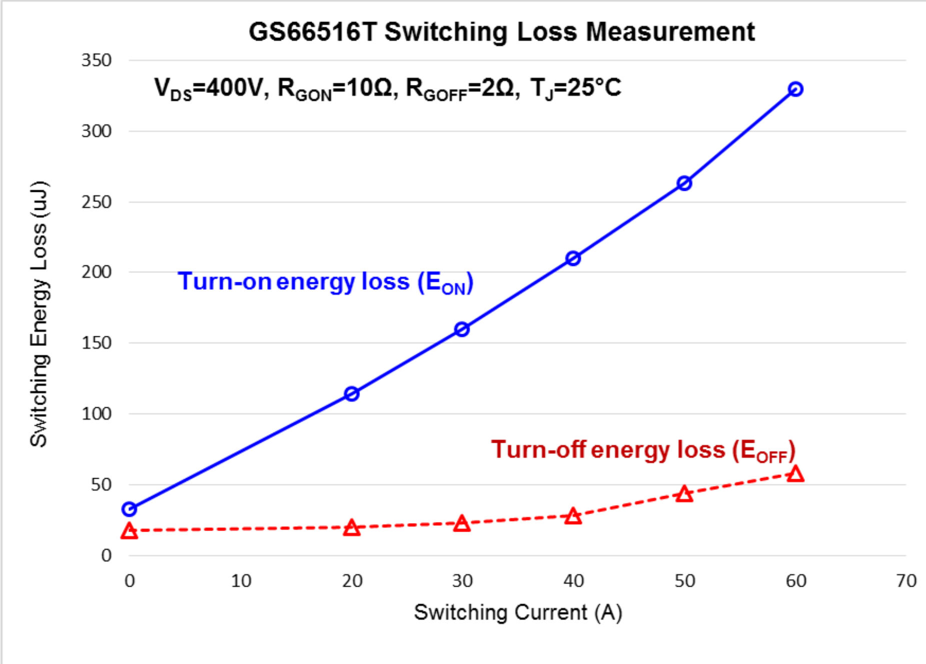


Figure 24 GS66516T Switching Loss Measurement (V_{DS} = 400V, T_J=25°C)

Synchronous Buck Test (L=120uH, VIN=400V, VOUT=200V, D=50%, FSW=100 kHz, POUT =0-2.4kW)
The board is converted to a synchronous buck DC/DC converter and demonstrates efficiency close to 99% at 2kW. With forced air cooling, the board is tested up to 2kW for GS66508T with device temperature Tjmax = 75 °C and 2.4kW for GS66516T with Tjmax <70°C.

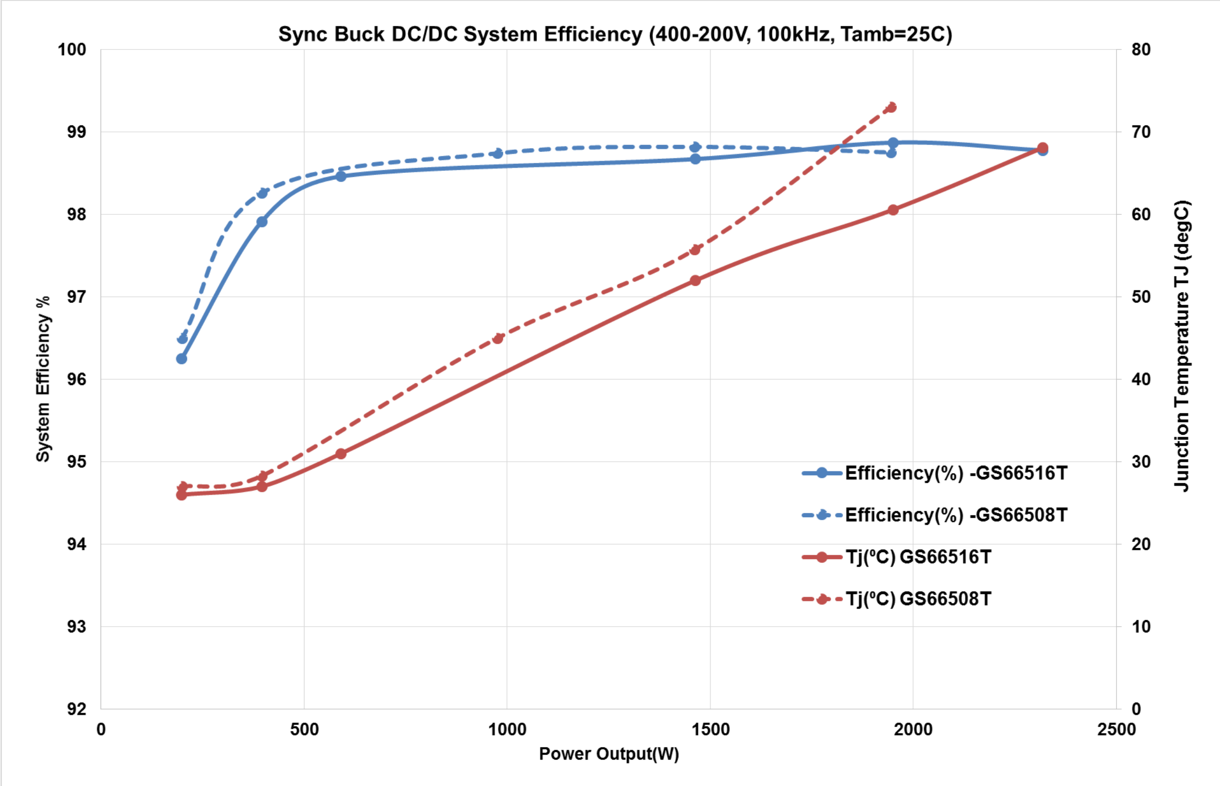


Figure 25 Synchronous Buck Efficiency and thermal measurement

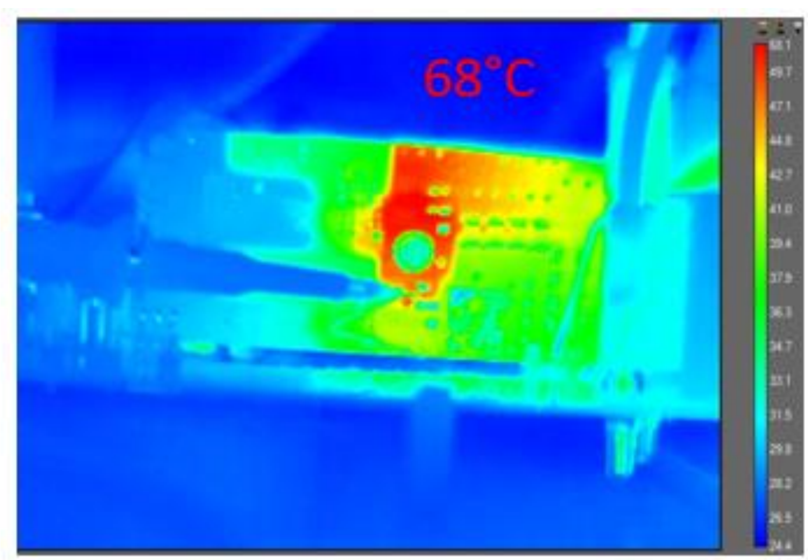
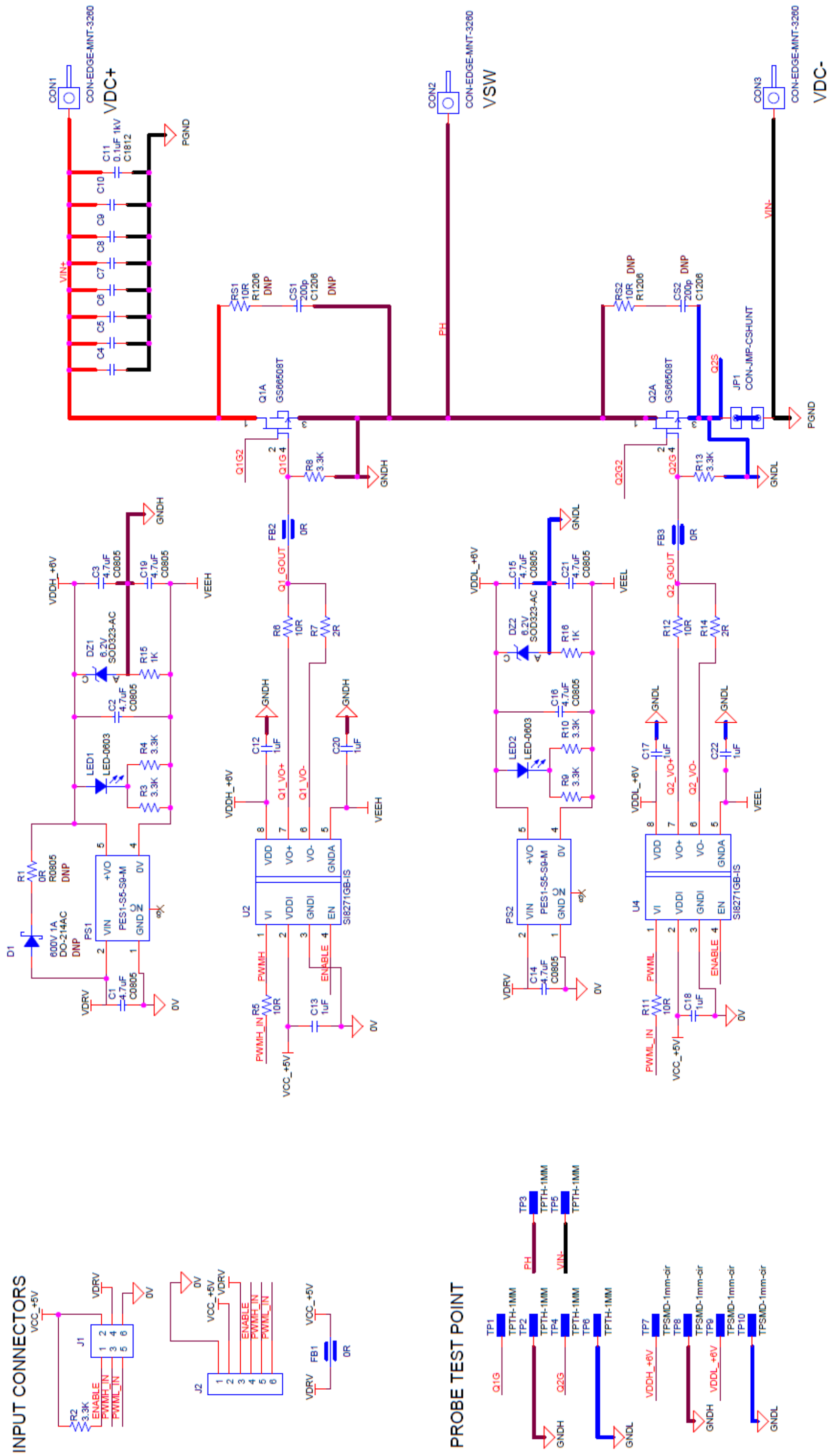


Figure 26 Thermal image (GS66516T, Pout=2.4kW)

Appendix A - GS66508T/GS66516T-EVBDB

Circuit schematics-GS66508T EVBDB



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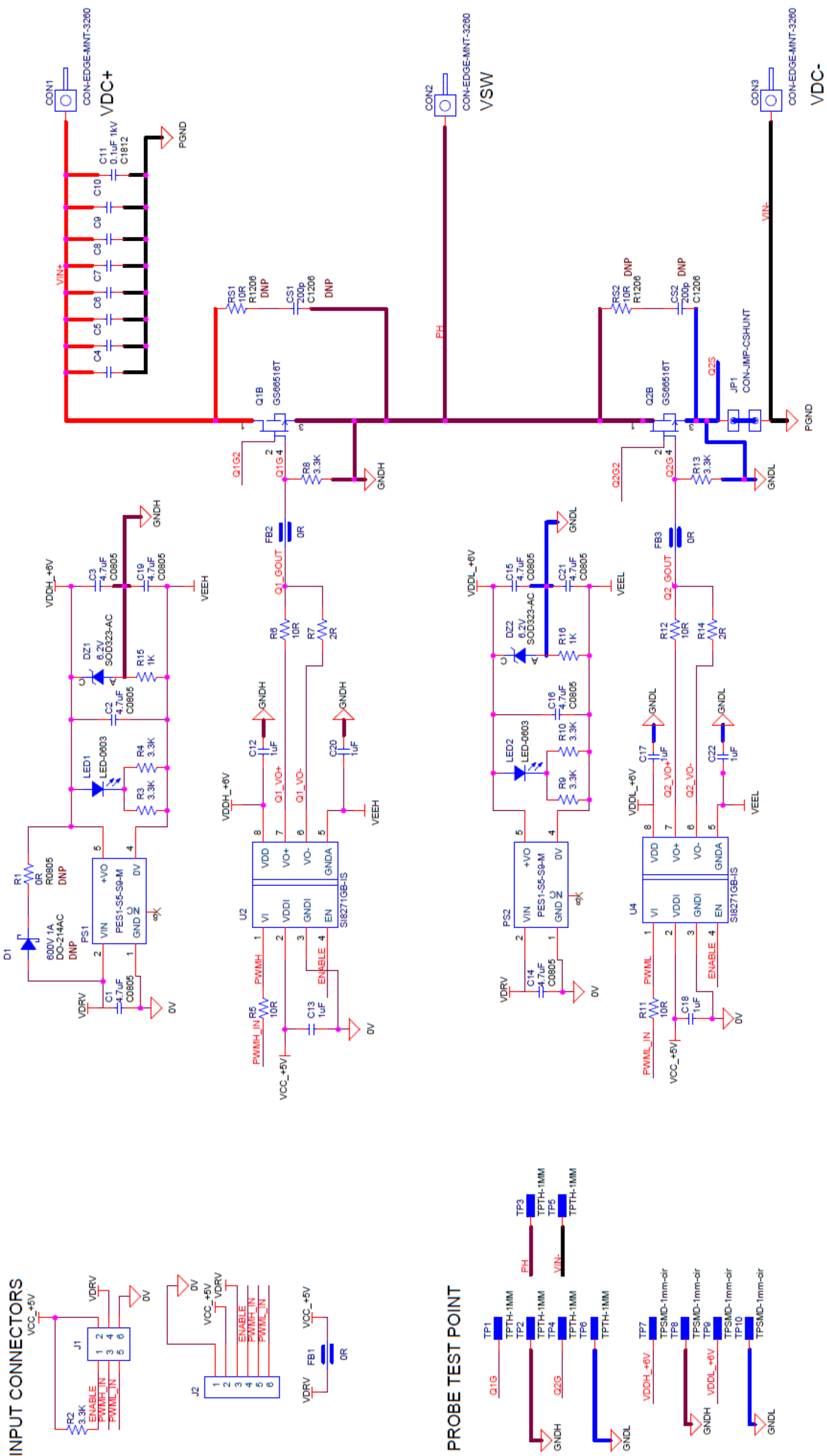
Circuit schematics-GS66516T EVBDB



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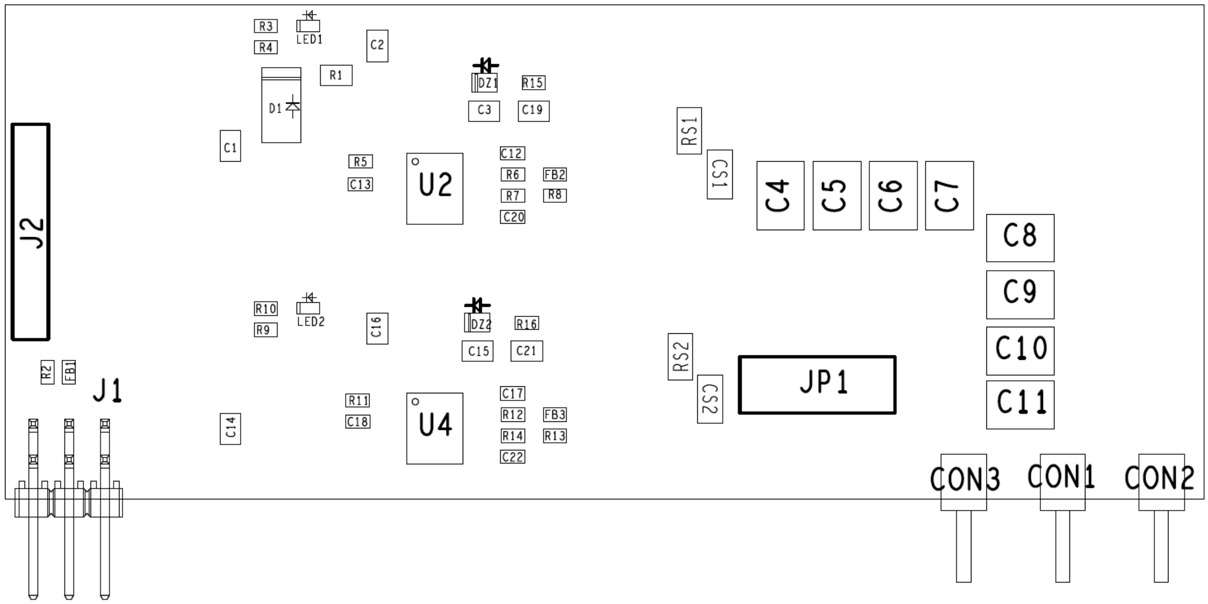
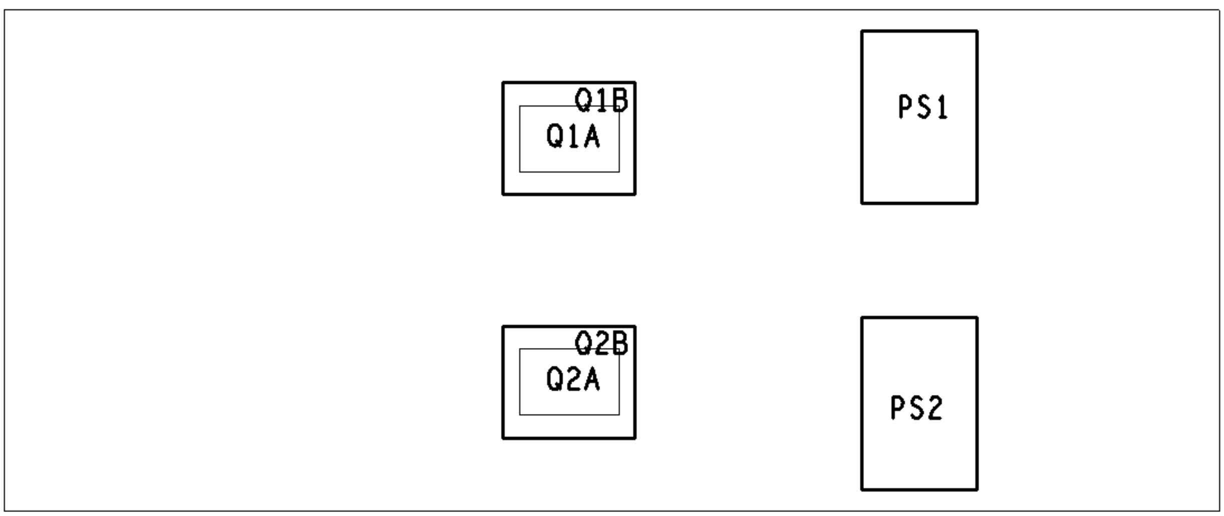
Assembly Drawing (Top)

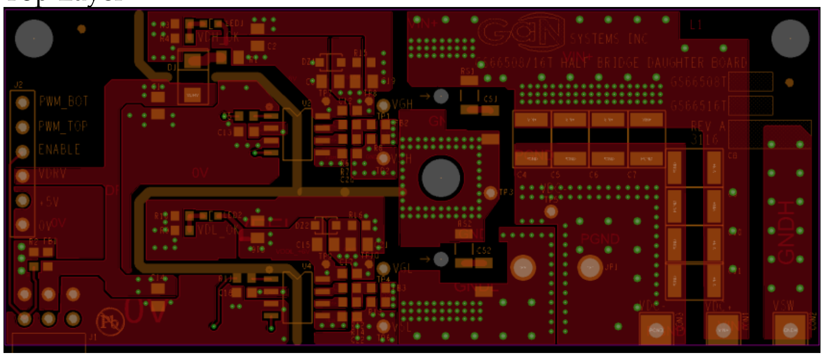


Assembly Drawing (Bottom)

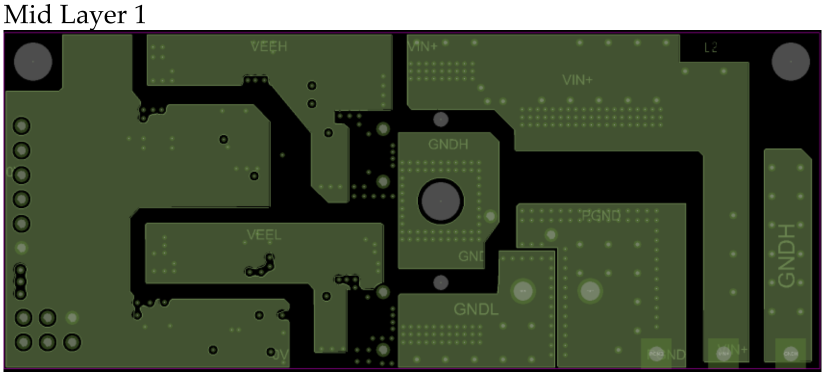


PCB layout

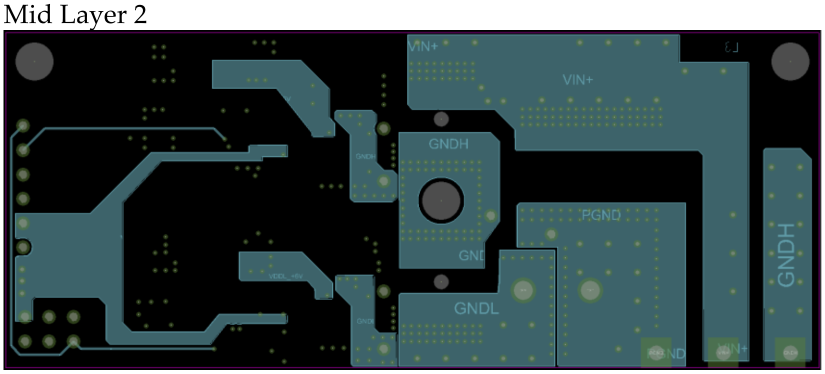
Top Layer



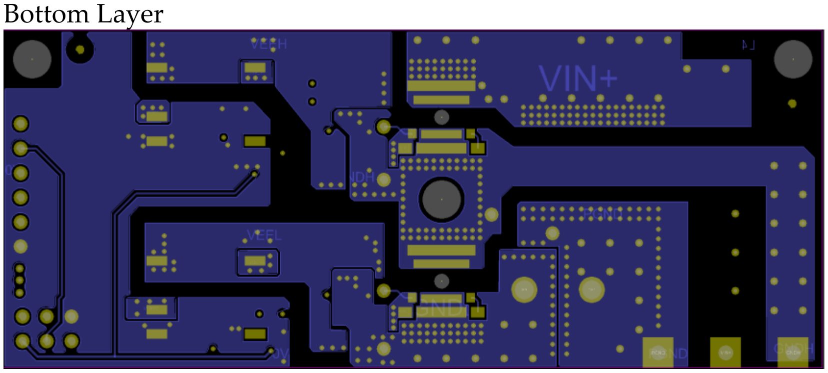
Mid Layer 1



Mid Layer 2



Bottom Layer

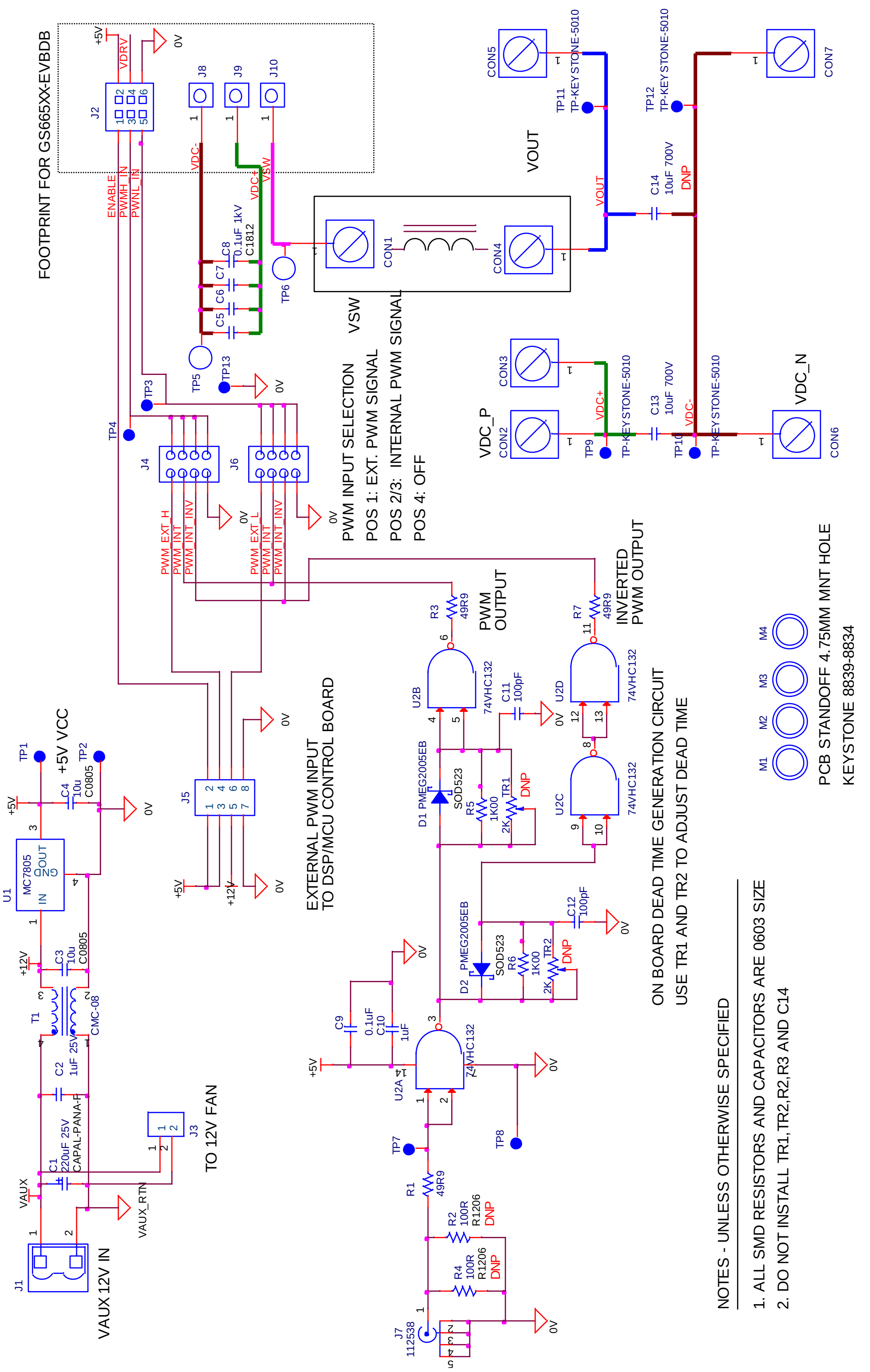


Bill of Materials

Qt	Reference	Description	Value	Manufacturer	Part number	GS66508T-EVBDB	GS66516T-EVBDB	Assembly Note
1	PCB	PCB bare 4-layer 2oz Cu.				•	•	
3	CON1,CON2,CON3	CONN PC PIN EDGE MNT	CON-EDGE-MNT-3260	Mill-Max	3620-2-32-15-00-00-08-0	•	•	Mating receptacle:0312-0-15-15-34-27-10-0 on mother board
2	CS1, CS2	CAP, CER, 200p, 1kV, 1206						DO NOT INSTALL
8	C1,C2,C3,C14,C15,C16,C19,C21	CAP, CER, 4.7UF, 25V, +/-10%, X7R, 0805	4.7uF	TAIYO YUDEN	TMK212AB7475KG-T	•	•	
8	C4,C5,C6,C7,C8,C9,C10,C11	CAP, CER, 0.1UF,1KV, +/-10%, X7R, 1812	0.1uF 1kV	KEMET	C1812C104KDRAC7800	•	•	
6	C12,C13,C17,C18,C20,C22	CAP, CER, 1UF, 25V, +/-10%, X7R, 0603	1uF	TAIYO YUDEN	TMK107B7105KA-T	•	•	
2	DZ1,DZ2	DIODE ZENER 6.2V 200MW SOD323	6.2V zener	ON SEMI	MM3Z6V2ST1G	•	•	
1	D1	DIODE ULTRAFAST 600V 1A SMA	600V 1A	FAIRCHILD	ES1J			For bootstrap mode, DO NOT INSTALL
3	FB1,FB2,FB3	RES, 0R JUMPER, 1%, 0603	30R 3A	generic	generic	•	•	Use 0 OHM JUMPER
1	JP1	CURRENT SHUNT JUMPER	CON-JMP-CSHUNT					For current measurement, footprint compatible with T&M SDN-414-010 current shunt. Use wide copper foil to short the connection if not used, DO NOT INSTALL
1	J1	CONN 3PIN DUAL ROW, 0.1" PITCH, R/A	CON-HDR-2X3	SAMTEC	TSW-103-08-G-D-RA	•	•	
1	J2		CON-6POS					FOR FCT TEST POINTS, DO NOT INSTALL
2	LED1,LED2	LED, GREEN, SMD 0603	LED-SMD-0603	LITEON	LTST-C191KGKT	•	•	
2	PS1,PS2	ISO. DC/DC 5-9V, 1W	PES1-S5-S9-M	CUI	PES1-S5-S9-M	•	•	ALT. PART MOURNSUN F0509XT-1WR2
2	Q1A,Q2A	GaN E-HEMT 650V/30A TOP COOL	GS66508T	GaN Systems	GS66508T	•		
2	Q1B,Q2B	GaN E-HEMT 650V/60A TOP COOL	GS66516T	GaN Systems	GS66516T		•	
2	RS1. RS2	RES, 10R, 1%, 1206	10R					DO NOT INSTALL
1	R1	RES, 0R, 1%, 0805	0R	generic	generic			For bootstrap mode, DO NOT INSTALL
7	R2,R3,R4,R8,R9,R10,R13	RES, 3.3K, 1%,1/10W, 0603	3K3	generic	generic	•	•	
4	R5,R6,R11,R12	RES, 10R, 1%,1/10W, 0603	10R	generic	generic	•	•	
2	R7,R14	RES, 2R, 1%,1/10W, 0603	2R	generic	generic	•	•	
2	R15,R16	RES, 1K, 1%,1/10W, 0603	1K0	generic	generic	•	•	
6	TP1,TP2,TP3,TP4,TP5,TP6	Probe test point	CON-TP-1POS					DO NOT INSTALL
4	TP7,TP8,TP9,TP10	Probe test point	CON-TP-1POS					DO NOT INSTALL
2	U2,U4	IC ISO GATE DRIVER 2.5KV HIGH CMTI	SI8271GB-IS	SILICON LABS	SI8271GB-IS	•	•	alt. Si8271AB-IS
1		heatsink, 35x35mmx25.4mm, customized		SHENZHEN MINGZHI	PY16-020-1	•	•	
2		M3 screw w/ insulated sleeve				•	•	
1		Electrically insulated Thermal pad		BERGQUIST	SILPAD 1500ST	•	•	

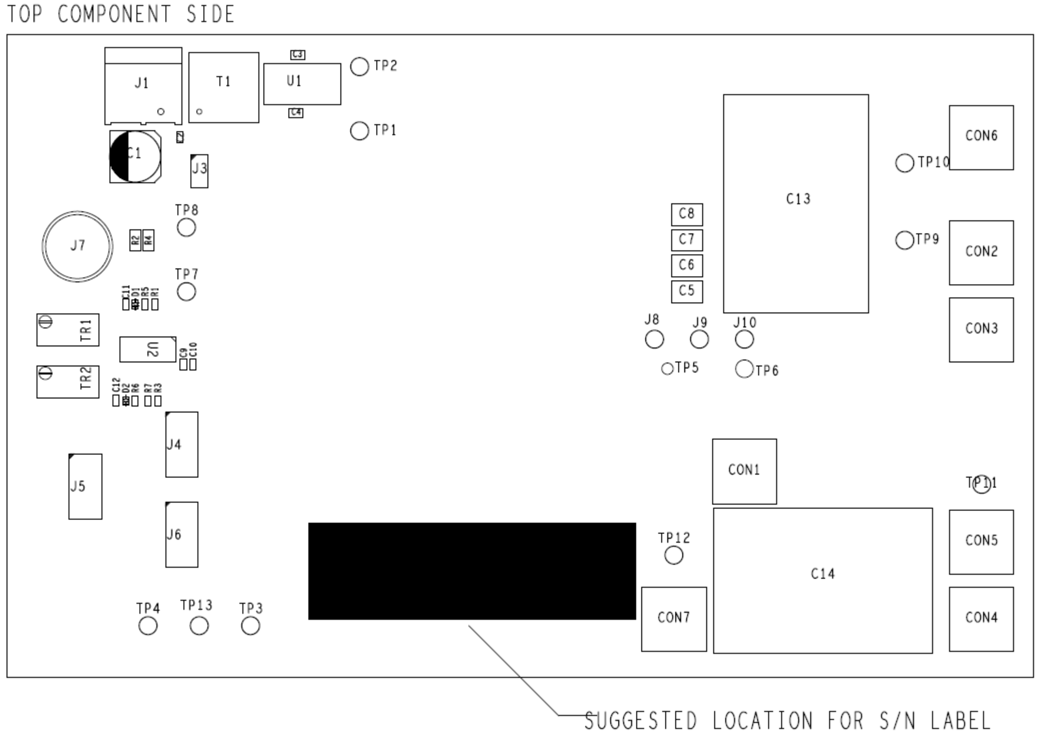
Appendix B - GS665MB-EVB

Circuit schematics

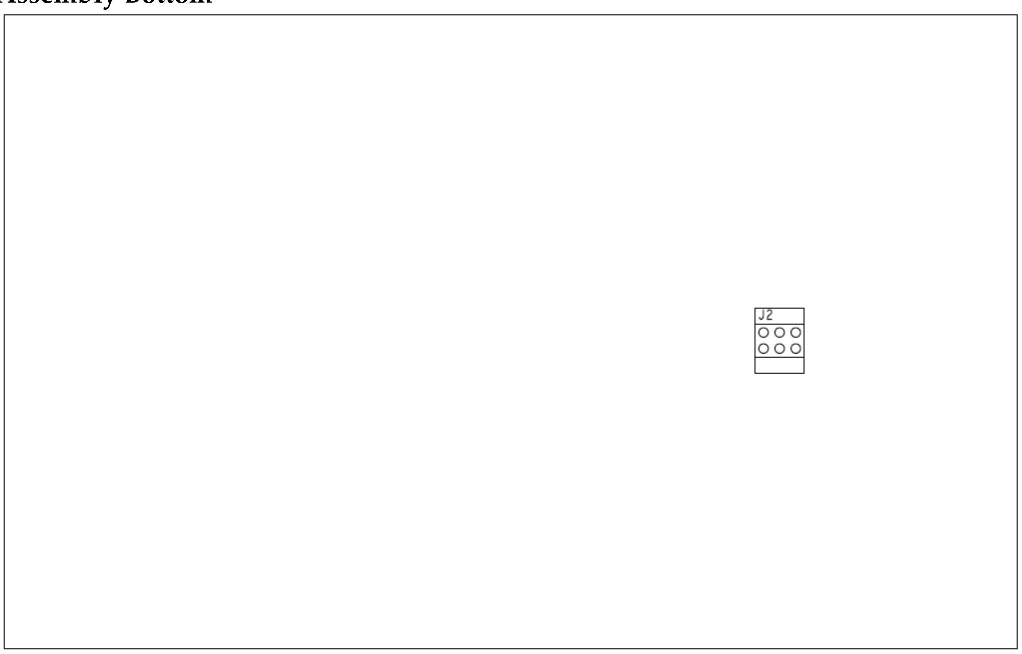


Assembly drawing

Assembly Top



Assembly Bottom



Bill of Materials

	Quantity	Reference	Description	Value	Manufacturer	Part number	Assembly Note
GAN SYSTEMS 650V GAN UNIVERSAL MOTHER BOATRD							
BOARD P/N:		GS665EVBMB					
Revision		B1					
Last Update		6/30/2016					
	1	PCB	PCB bare 2-layer 2oz Cu.				
1	7	CON1,CON2,CON3,CON4,CON5,CON6,CON7	TERMINAL SCREW VERTICAL PC MNT	CON-10-32-SCRWMNT	KEYSTONE	8191	DO NOT INSTALL
2	1	C1	CAP ALUM 220UF 20% 25V SMD	220uF 25V	Panasonic	EEE-FK1E221P	
3	1	C2,C10	GENERIC 1UF/25V, 10% X7R SMD 0603	1uF	TAIYO YUDEN	TMK107B7105KA-T	
4	2	C3,C4	GENERIC 10UF/25V, 10% SMD 0805	10uF	TAIYO YUDEN	TMK212BBJ106KG-T	
5	4	C5,C6,C7,C8	GENERIC 0.1uF/1000V, SMD 1812	0.1uF 1kV	KEMET	C1812C104KDRAC7800	
6	1	C9	GENERIC 0.1UF/25V, 10% X7R SMD 0603	0.1uF	TAIYO YUDEN	TMJ107BB7104KAHT	
7	2	C11,C12	GENERIC 100PF/25V 5% NP0 SMD 0603	100pF	KEMET	C0603C101J3GACTU	
8	1	C13,~~C14~~	CAP FILM 10UF/600VDC 5%, 27.5MM LEAD SPACING	10uF 700V	KEMET	C4AEHBU5100A11J	DO NOT INSTALL C14
9	2	D1,D2	DIODE SCHOTTKY 20V 500MA SOD523	PMEG2005EB	NXP	PMEG2005EB,115	
10	1	J1	TERM BLOCK HDR 2POS R/A 5.08MM	CON-TERM-BLK-2POS-RA	TE CONNECTIVITY	796638-2	
11	1	J1-PLUG	TERM BLOCK BLUG 2POS 5.08MM		TE CONNECTIVITY	796634-2	
12	1	J2	CONN RCPT 6POS .100 DBL STR PCB	CON-RCPT-2X3-BOT	HARWIN	M20-7850342	MOUNT FROM BOTTOM SIDE
13	1	J3		CON-2POS			CONNECTOR FOR 12V FAN, DO NOT INSTALL
14	2	J4,J6	CONN HEADER 8POS DUAL VERT PCB	CON-JMP-4POS	HARWIN	M20-9980445	
15	1	J5	CONN 8-POS, DUAL ROW 2.54MM	CON-HDR-4X2	AMPHENOL	75869-132LF	
16	1	J7	CONN BNC JACK STR 50 OHM PCB	112538	AMPHENOL	112538	
17	3	J8,J9,J10	CONN RECEPT PIN .032-.046" .075"	CON-RCPT-EDGEMNT	MILLMAX	0312-0-15-15-34-27-10-0	MATING SOCKET FOR MILLMAX EDGE MNT PIN
18	3	R1,R3,R7	generic 1% smd 0603	49R9	VISHAY DALE	CRCW060349R9FKEA	
19	2	R2,R4	generic 1% smd 1206	100R			DO NOT INSTALL
20	2	R5,R6	generic 1% snd 0603	1K00	VISHAY DALE	CRCW06031K00FKEA	
21	11	TP1,TP2,TP3,TP4,TP7,TP8,TP9,TP10,TP11,TP12,TP13	TEST POINT PCB	TP-KEYSTONE-5010	KEYSTONE	5010	
22	2	TR1,TR2		2K	RECOM	CMC-08	DO NOT INSTALL
23	1	T1	COMM MODE CHOKE 5.2A T/H	CMC-08			
24	1	U1	IC REG LDO 5V 1A DPAK	MC7805	ON SEMI	MC7805BDTRKG	
25	1	U2	1 IC GATE NAND 4CH 2-INP 14-SOIC	74VHC132	FAIRCHILD	74VHC132MX	
Off the board components:							
26	6	M1,M2,M3,M4,M5,M6	PCB STANDOFF NYLON STACKABLE 4.75M	MECH-STDOFF-KEYSTONE-8	KEYSTONE	8833	PCB SPACER, INSTALL FROM BOTTOM SIDE
27	1	FAN	FAN AXIAL 38X20MM 12VDC WIRE		SUNON FANS	PMD1238PKB1-A.(2).GN	SUPPLY LOOSE, DO NOT INSTALL ON THE ASSEMBLY
28	2	JUMPER	JUMPER SHUNT GENERIC		TE CONNECTIVITY	382811-8	INSTALL ON J4 "INT" POSITION AND J6 "INT_INV" POSITION

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