USER GUIDE

UG519: Si8281v2-EVB User Guide

Key Features

- Si8281 ISODrivers for 4 A or higher gate drive with current booster daughter cards
- Sockets for TO-247 package SiC FETs or IGBTs
- Capable of double pulse test
- DESAT short circuit and many other performance evaluations

Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to *Skyworks Definition of Green™*, document number SQ04–0074.

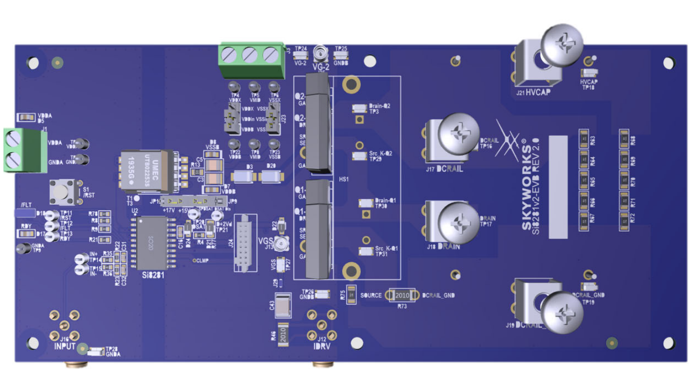
Description

The Si8281v2-EVB is a versatile platform that demonstrates the capabilities of the Si8281 SiC FET-Ready ISODriver with Safety Features and integrated dc/dc converter for driving SiC FET or IGBT power switching devices. It includes two switch device sockets, with the high-side switch device connected in the off-state to function as a diode. This setup enables the low-side SiC/IGBT switching device to work with an external inductor to support double pulse testing and switching loss measurements. The EVB can also be used to test the Si8281 gate driver capabilities, such as output current and DSAT protection circuits, by placing a SiC or IGBT switch in the low-side socket and exercising the onboard Si8281 low-side driver.

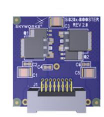
The output current of the Si828x is rated at 4 A, which is sufficient to drive most discrete SiC FETs and IGBTs. However, for applications that require a higher gate drive current, customized external bipolar transistor-based current booster circuits can be used with the Si828x gate drivers. These current booster circuits are located on a small daughter card (DC) that comes with the kit, and they can be used to drive high-power SiC/IGBT switching devices.

The Si8281v2-EVB (Evaluation Board) is equipped with solder bump jumpers that facilitate testing of the Si8281 gate driver with or without the included but optional external current booster circuit. This allows users to assess the performance of the gate driver with or without the booster circuit and determine if the booster circuit is necessary for their specific application. Also, the EVB can accommodate switching devices in 3- and 4-pin TO-247 packages; however, switching devices (Q1 and Q2) are not included in the kit. The user may acquire switching devices that are appropriate for their specific application.

The Si8281 gate drivers are powered by an integrated dc-dc converter that drives an external transformer to generate +15 V and –4 V biasing voltages. This integrated dc-dc converter enables the Si8281 isolated full-feature gate driver to provide a compact solution for medium and high-power switching applications.



Si8281v2-EVB



Booster DC

1. Schematics

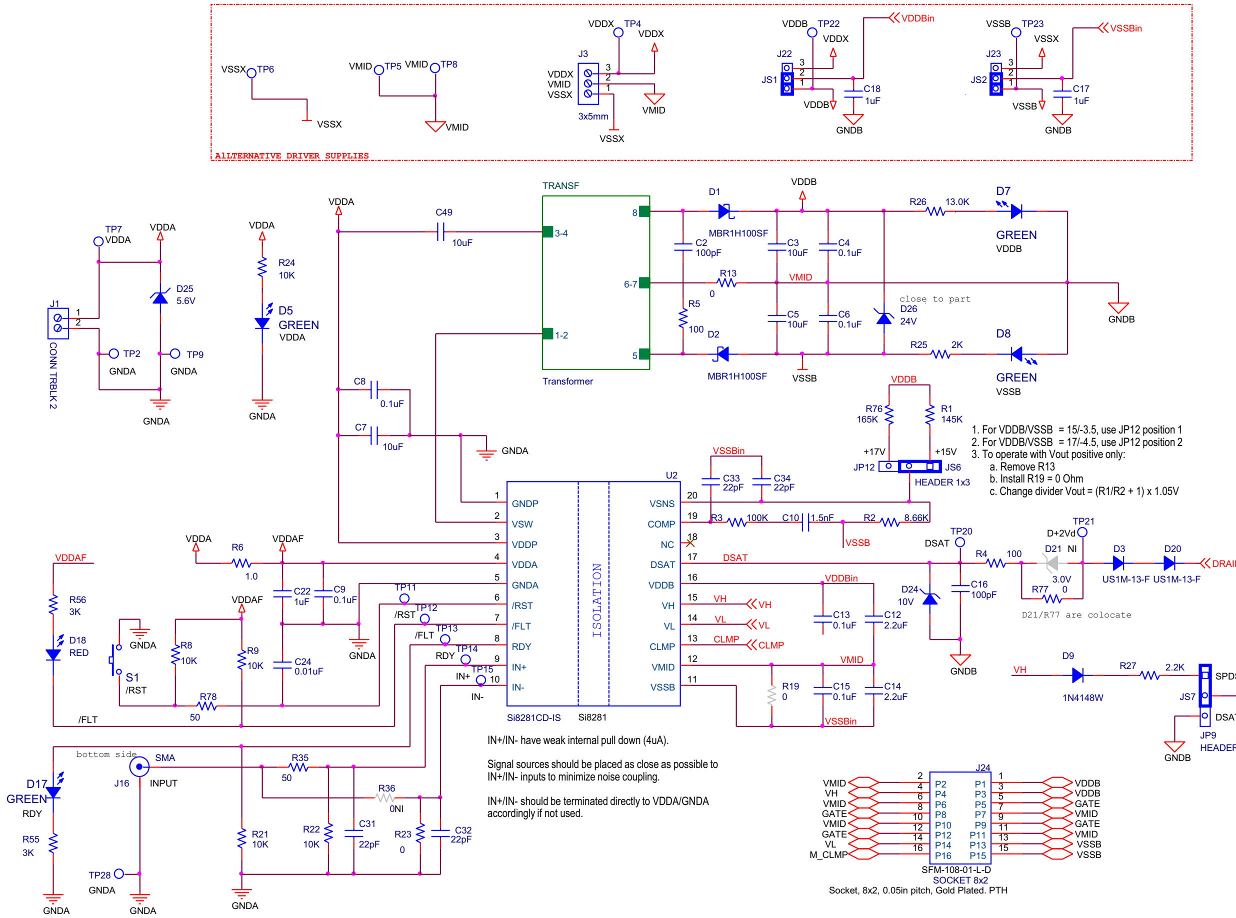


Figure 1. Si8281 Gate Driver Circuit

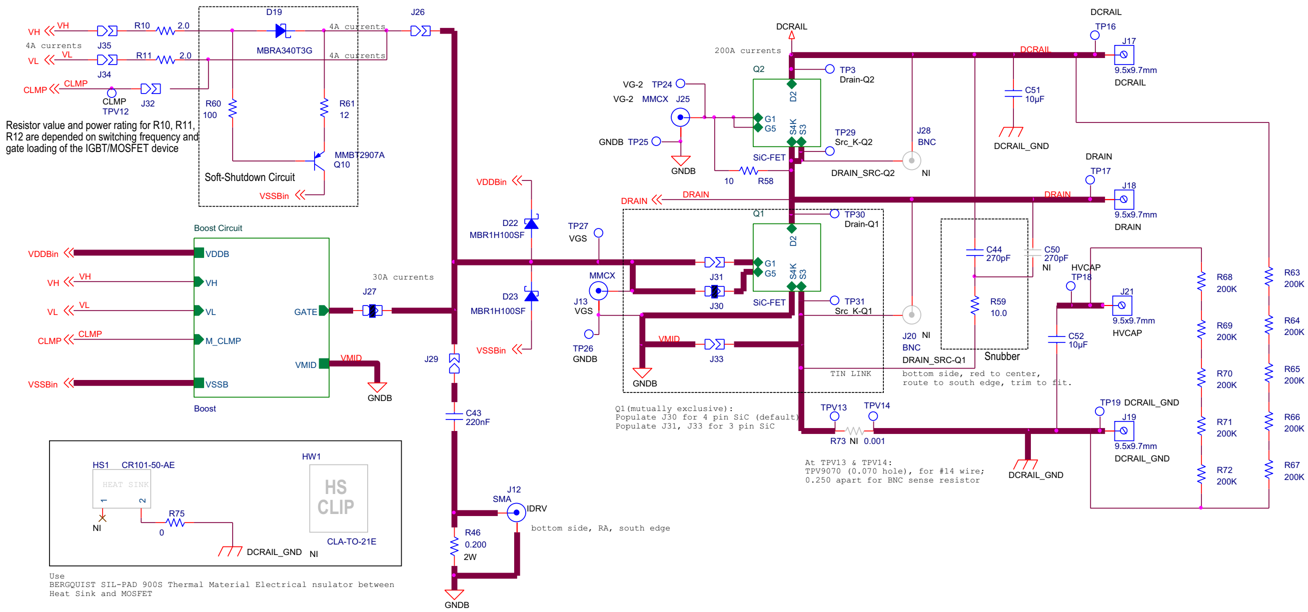


Figure 2. High Power SiC Circuit

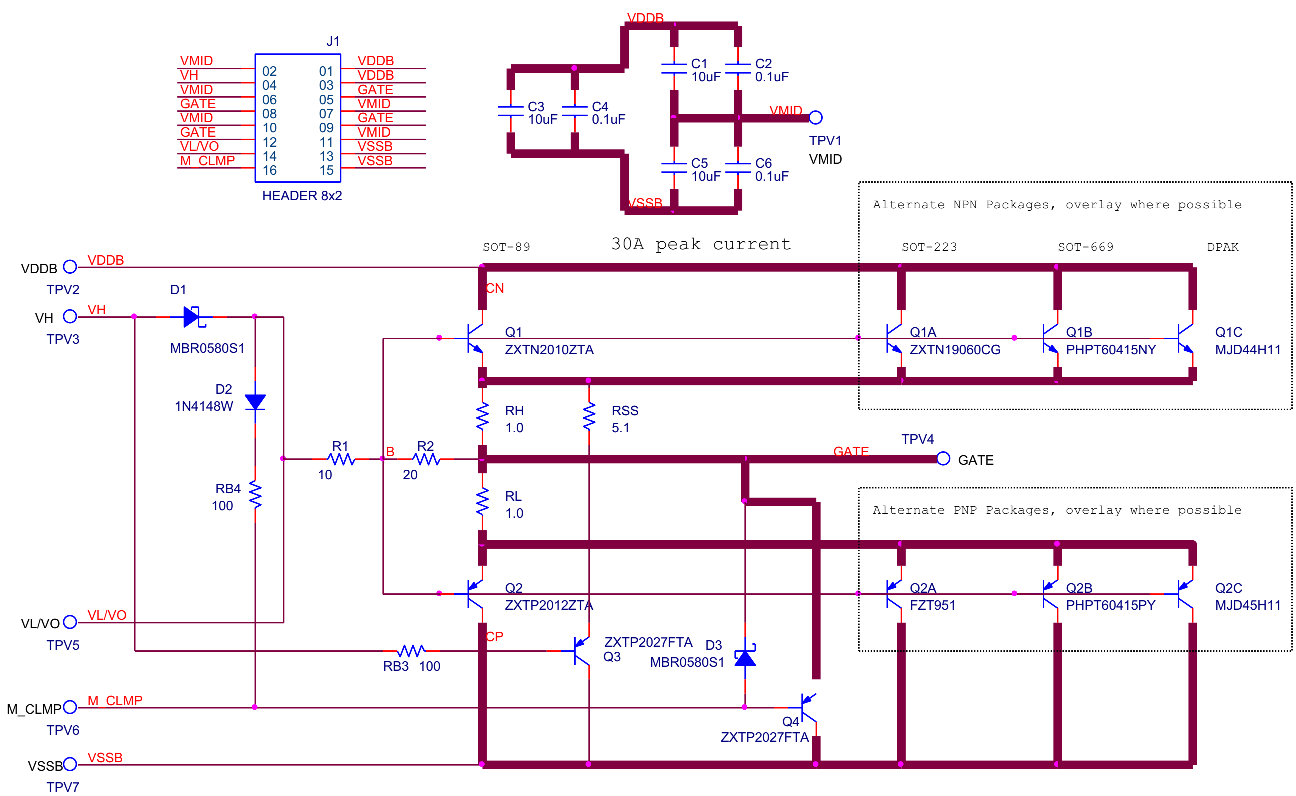


Figure 3. Current Booster Daughter Card Schematic

2. Power Up

The Si8281v2-EVB can be operated with a 5 V power supply that has a minimum current capability of 0.5 A. This is because the Si8281 integrated dc-dc controller can work with an external transformer to generate all the necessary voltages to power the gate driver and the gate of the SiC/IGBT devices.

To power up the Si8281v2-EVB, you should first ensure that the jumpers are connected according to the factory default jumper positions as described in Table 2.1. Then, connect the +5 V supply to the terminal block J1 by applying +5 V to Pin 1 (VDDA) and returning GND to Pin 2.

Table 1. Default Jumper Positions (Set at Factory)

Jumper Number	Purpose
J22 Pins 1 and 2	Connecting p/s VDDB to Si8281
J23 Pins 1 and 2	Connecting p/s VSSB to Si8281
JP9 Pins 2 and 3	DESAT disable
JP12 Pins 1 and 2	Setup for VDDB = 15 V, VSSB = –3.5 V
J1	Pin 1 to 5 V, Pin 2 to GND

The Si8281v2-EVB should be powered up with the indications shown in Table 2.

Table 2. Si8281v2-EVB Power-Up Indications

Test	Passing Criteria	Associated Components
Check voltage, TP7-TP2	~5 V	D25, J1
Check +5 V p/s current (J13)	< 110 mA	Si8281, T1, D1, D2
Green LED D5 VDDA	Illuminated	J1, D25, R24
Green LED D7, VDDB	Illuminated	T1, Si8281, D1, R26
Green LED D8, VSSB	Illuminated	T1, Si8281, D2, R25
Green LED D17, RDY	Illuminated	Si8281, T1, D1, D2
Check voltage on VDDB to VMID at TP5 to TP22	+15 V	T1, D1, C3, C4, Si8281
Check voltage on VSSB to VMID at TP5 to TP523	–3.5 V	T1, D2, C5, C6, Si8281

3. Testing Si828x Gate Driver with Capacitive Load

The Si8281 gate driver and the current booster Daughter Cards offer a wide range of gate currents to drive all SiCs and IGBTs to their optimum levels. The Si8281v2-EVB supports a test apparatus that is illustrated in the circuit diagrams shown in Figure 4 and Figure 5, which can be used to measure the gate driver output current.

The current booster Daughter Card can be easily connected to the Si8281v2-EVB through the J24 connector. The solder bump jumpers SB1 (J27) and SB2 (J32, J34, J35, J26) provide flexibility in testing the Si8281 gate driver either directly or through the current booster circuit.

The gate resistors (Rg) and the configuration of the current booster circuits are used to set the Si8281 gate current drive levels, enabling circuit tuning for specific SiC and IGBT gate current requirements. This feature allows users to optimize the performance of the gate driver and current booster circuits to meet the needs of their specific applications.

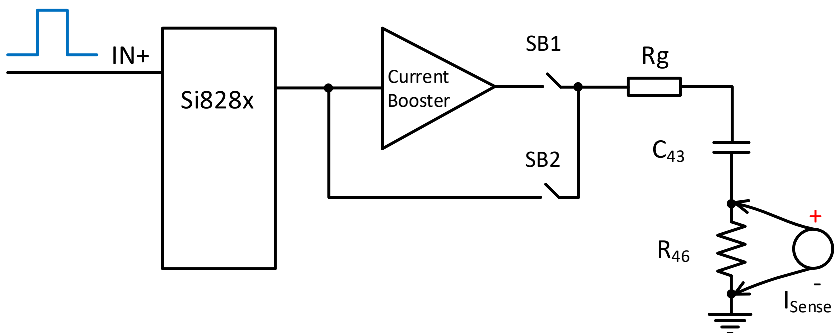


Figure 4. Gate Driver Output Current Test Circuit

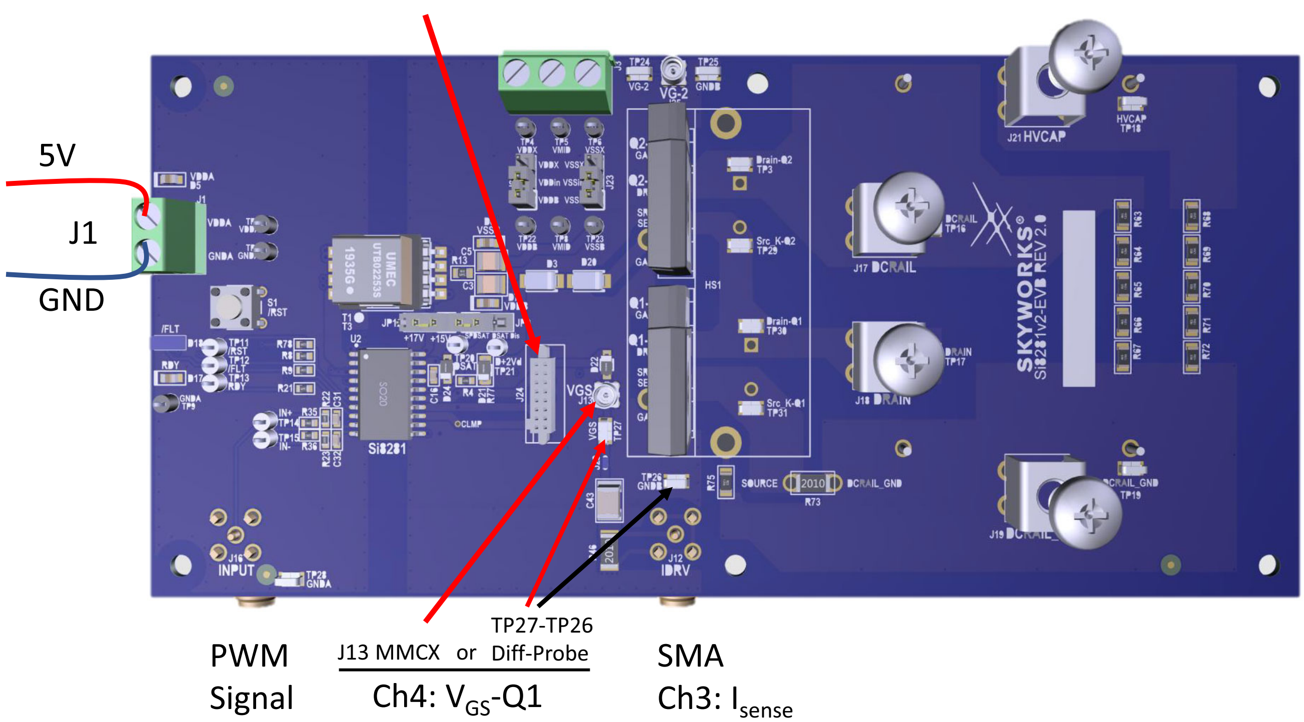


Figure 5. Connections for Si8281 Gate Current Testing with a Capacitive Load

3.1. Setup for Testing with Capacitive Load

The Si8281v2-EVB is equipped with jumpers and solder bumps (PCB trace jumpers) that allow for selective connection of the capacitive load to either the Si8281 or the current booster daughter cards' output for gate current testing. Table 3 provides the appropriate jumper connections for each specific test.

Table 3. Connections for Gate Current Testing

Testing Configuration	Si8281 Direct Drive	Si8281 with Current Booster DC
JP9	2–3	2–3
J26	Close	Open
J27	Open	Close
J29	Close	Close
J30	Open	Open
J31	Open	Open
J32	Close	Open
J33	Open	Open
J34	Close	Open
J35	Close	Open
J24	Open	Plug into the Current Booster Daughter Card
J1	P/S: Pin 1 to 5 V, Pin 2 to GND	P/S: Pin 1 to 5 V, Pin 2 to GND
J16	PWM signal	PWM signal
J12 (MMCX) or TP26-TP27	V_{Gate} Scope Probe	V_{Gate} Scope Probe
J12	SMA Voltage Probe for I_{Sense}	SMA Voltage Probe for I_{Sense}

Perform the following simple steps to conduct gate current testing:

1. Connect jumpers, solder bumpers, the booster daughter card, and instrumentation as described in Table 3.
2. Connect function generator to J16: 50 Ω output impedance, single 5 Vp-p square wave pulse (6 µs).
3. Set up the 5 V/div scope probe to view the VGS gate signal at J13 or TP27–TP26.
4. Set up the oscilloscope to trigger on the rising edge of the VGS (item #3) signal.
5. Setup a voltage scope probe to I_{Sense} current with 200 mV/A scaling.
6. Power up the 5 V power supply connected to J1.
7. Send one PWM pulse from the function generator and observe the waveforms on the oscilloscope.

3.2. Test Results

Figure 6 illustrates the Si8281 output current waveform when tested with a C43, 220 nF capacitive load and a 0 Ω gate resistor. It is noteworthy that the Si8281 is capable of sourcing 2.6 A and sinking 5.6 A of current.

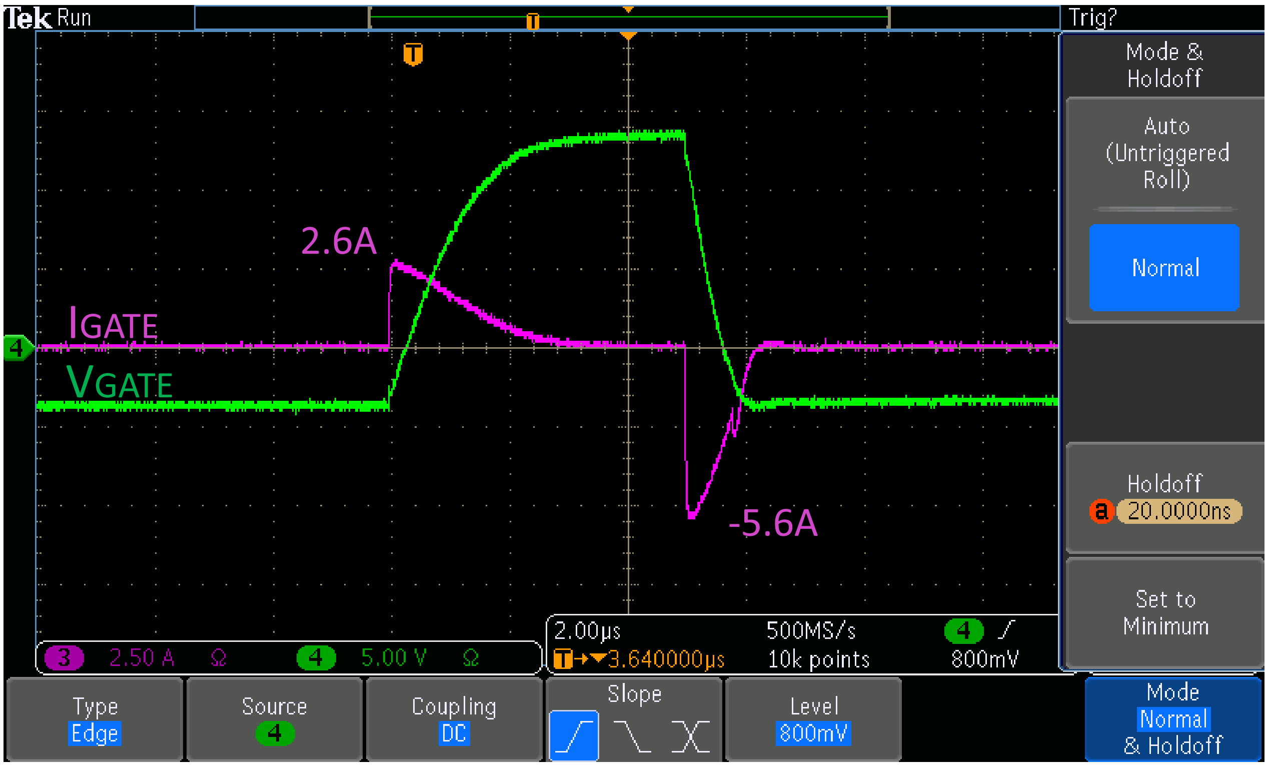


Figure 6. Gate Output Current from Si8281 and Rg = 0 Ω

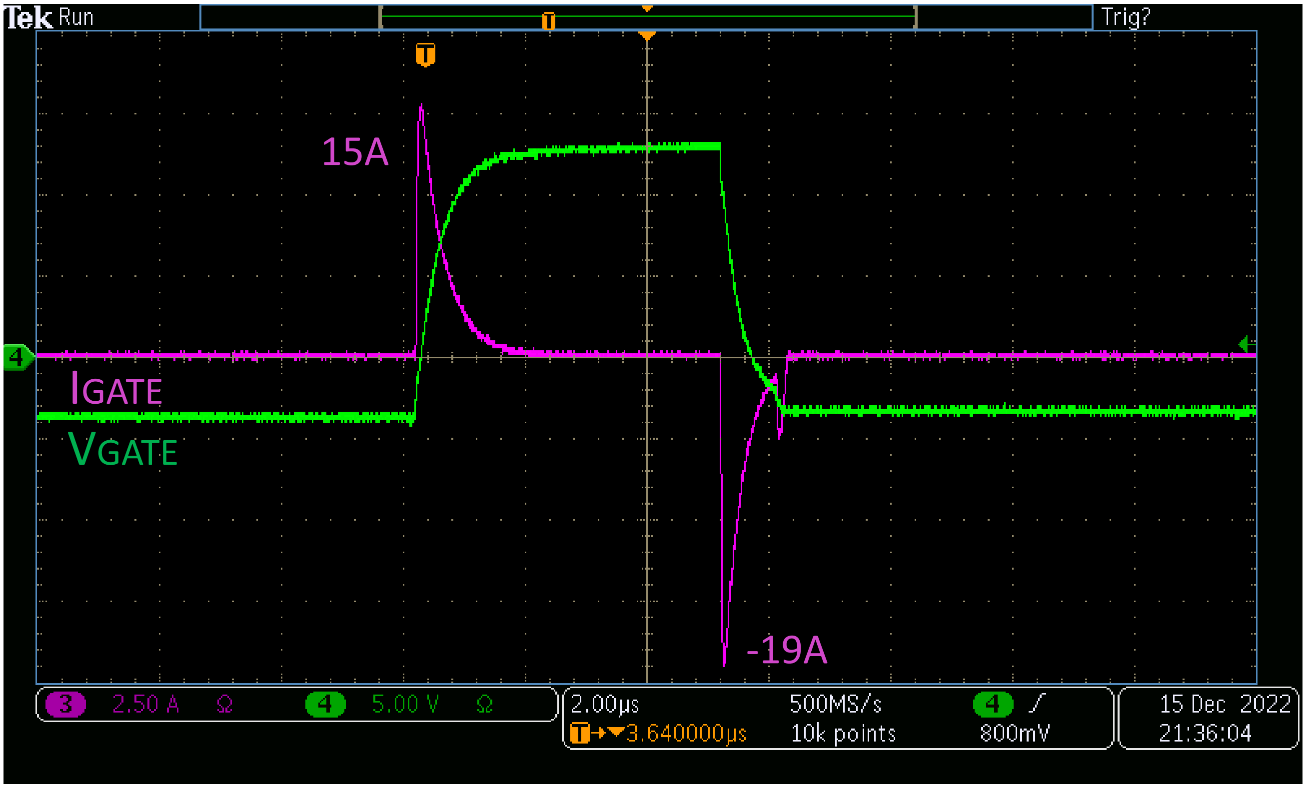


Figure 7. Gate Output Current from Si8281 with Booster Daughter Card and Rg = 0 Ω

Figure 7 illustrates that the Si8281 can generate up to +15 A of sourcing current and –19 A of sinking current when operating with the current booster to drive a C43, 220 nF capacitive load. The values of R1 and R2 on the booster daughter card (as shown in Figure 3) can be adjusted to accommodate applications that require higher gate current levels than 15 A. R1 should be set to a minimum of 1 Ω for higher output currents, while R2 should be set to a maximum of 40 Ω for increased current output.

3.3. Additional Advice

To optimize gate currents for specific SiC FET or IGBT, designers can use the Si828x external circuits, which provide flexible controls. The output current capability is determined by the values of RH, RL, R1, R2, and the gain β value of the Q1 and Q2 transistors. Before changing the Q1 and Q2 transistors, designers should explore changing the values of RH, RL, R1, and R2 since transistors with higher β gain are more expensive.

For more information on the latest Si828x current booster circuit, please review the Skyworks application note, "AN1288: Si828x External Enhancement Circuits".

4. Double Pulse Testing and Switching Loss

Figure 8 illustrates a simplified double pulse test circuit for the Si8281. During the on period of Q1, current flows from the bypass capacitor CRAIL (+RAIL) through the inductor Lo, Q1, and back to the ground terminal of CRAIL. When Q1 turns off, the current in the inductor is maintained through the body diode of Q2. The current is then ramped up again in the next switching cycle through Q1. The switching loss can be calculated as the integral of Q1's VDS multiplied by IDS during the switching transitions. This circuit allows for multiple switching cycles, enabling measurement of Q1 switching loss at different IDS current levels.

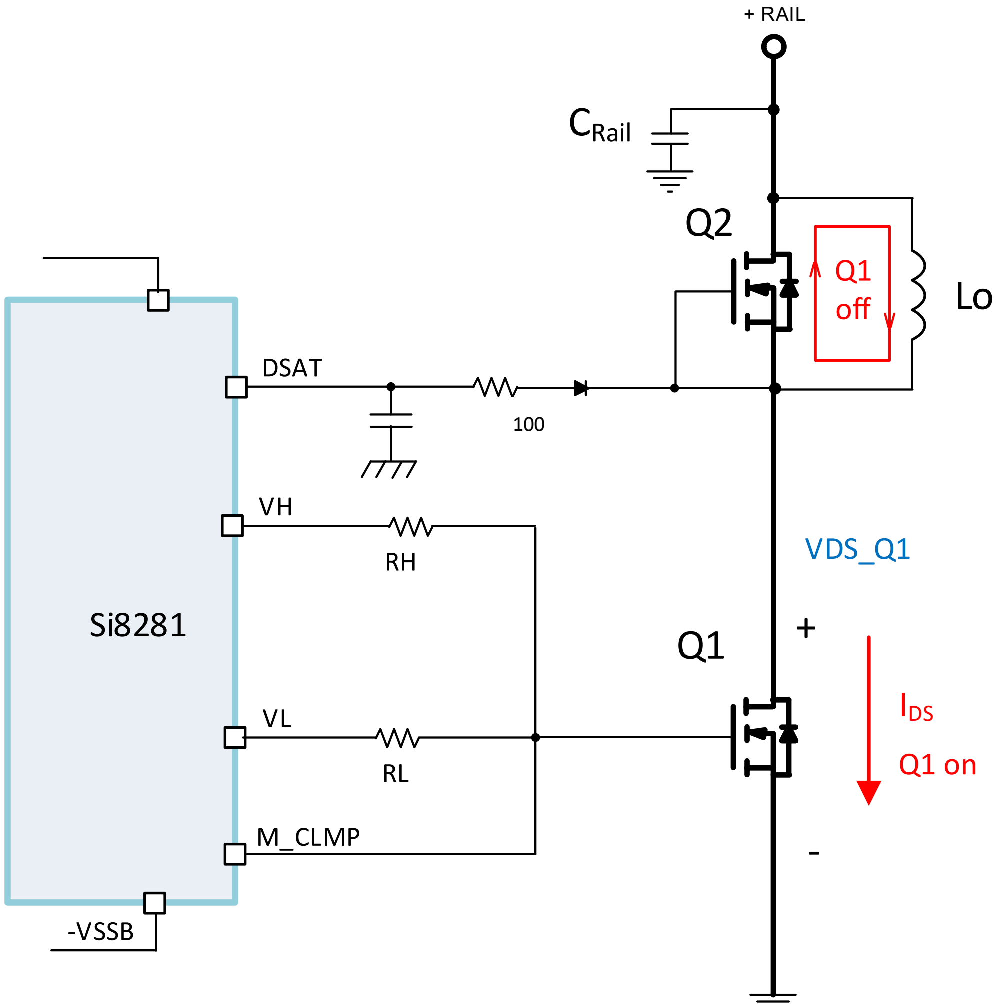


Figure 8. Si8281 Double Pulse Test Circuit

4.1. Connections for Double Pulse Switching Loss Testing

Table 4 provides a jumper map and instrumentation connections for double pulse switching loss testing. Note that this test involves high voltage, and extreme caution must be observed. Contact could result in severe shock or death.

DANGER! This board may contain high voltages up to 1000 V. Do not touch the board once the high voltage section has been energized.

Table 4. Connections for Double Pulse Switching Loss Testing

Testing Configuration	Si8281 Direct Drive	Si8281 with Current Booster DC
JP9	1–2	1–2
J24	Open	Plug into the Current Booster Daughter Card
J26	Close	Open
J27	Open	Close
J29	Open	Open
J30	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J31	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J32	Close	Open
J33	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J34	Close	Open
J35	Close	Open
J1	P/S: Pin 1 to 5 V, Pin 2 to GND	P/S: Pin 1 to 5 V, Pin 2 to GND
J16	PWM signal	PWM signal
Ch4: IsoVu or HV Diff. probe	V_{Gate}: J12 (MMCX) or TP26-TP27	V_{Gate}: J12 (MMCX) or TP26-TP27
Ch2: HV Differential Probe	VDS from TP30(+) to TP31(–)	VDS from TP30(+) to TP31(–)
Ch3: T&M Research SDN-414-01	R73: I_{Sense}	R73: I_{Sense}

Perform the following steps to conduct a double pulse test:

1. Install Q1 and Q2 and the corresponding solder bumps:
   a. Three pins SiC/IGBT package: short J31, J33; open J30.
   b. Four-pins SiC package: open J31, J33; short J30.
2. Use bus wire to short J17 through J21 (parallel C51 and C52 for higher current handling capability).
3. Connect an air-core inductor between J17 (DCRAIL) and J18 (DRAIN).
4. Connect the DC-Rail power supply (100 mA minimum current rating) to J21 (+) through J19 (–), and set the output to the appropriate voltage level.
5. Connect jumpers, solder bumpers, booster daughter card, and instrumentation as described in Table 4.

6. Set up the function generator connected to SMA J16: 50 Ω output impedance, five pulses 5 Vpp square wave.
7. Connect the isolated scope probe (IsoVu) to the J13. If the IsoVu probe is unavailable, use an HV differential voltage scope probe across TP27 (+) through TP26 (–) the Q1 VGS. Set up the oscilloscope trigger to VGS (Ch4).
8. Connect a voltage scope probe (HV differential) from the oscilloscope Ch2 to TP30 (+) through TP31 (–). Set up oscilloscope Ch2 to the appropriate voltage level for Q1 VDS.
9. Connect a coaxial cable from oscilloscope Ch3 to the T&M Research SDN-414-01 BNC connector. Set up Ch3 for 0.01 V per Ampere scale.
10. Set up the oscilloscope's math function to ∫(Ch2 × Ch3) to calculate the V_{DS} X I_{DS} switching loss.
11. Power up the 12 V power supply (connected to J1).
12. Power up the DC-Rail power supply (see Step 4).
13. Send PWM pulses from the function generator and observe the waveforms on the oscilloscope.

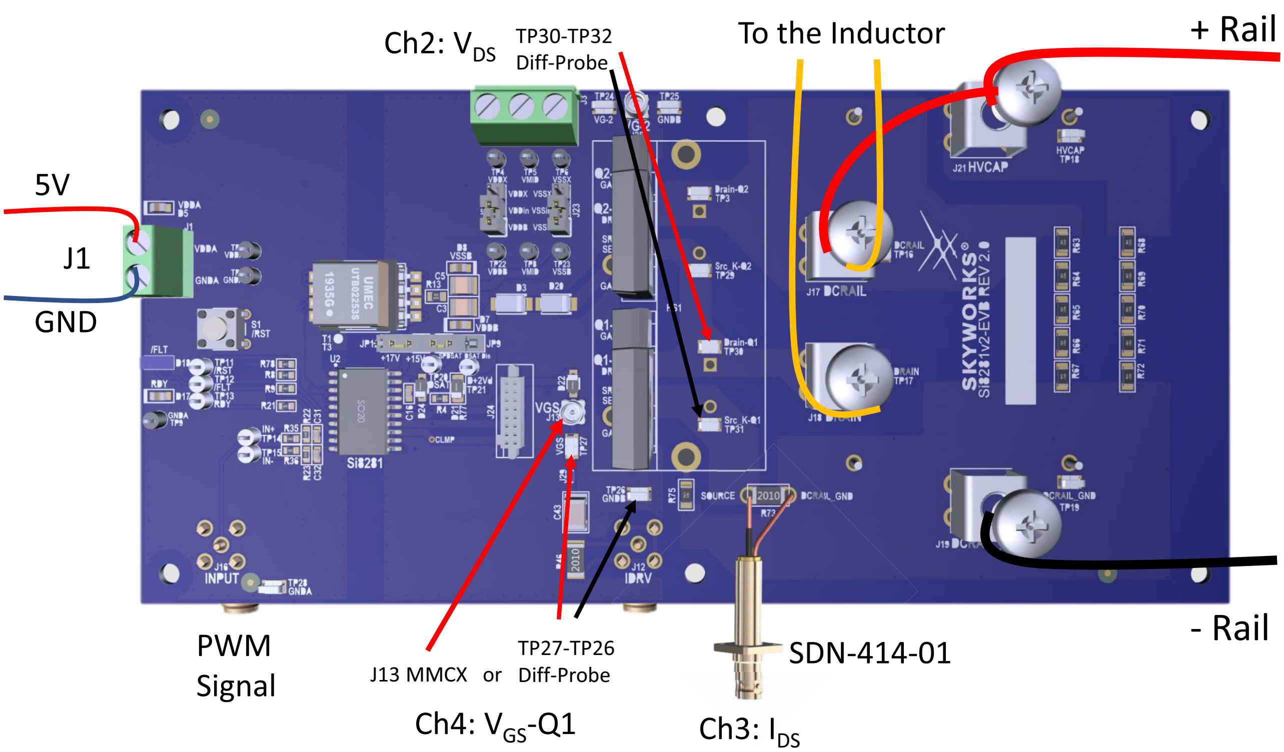


Figure 9. Double Pulse Test Connections for Si8281v2-EVB

4.2. Switching Loss Test Results

In Figure 9, the connections for the double pulse test with the Si8281 and the current booster daughter card are depicted. The switching loss data presented in this section were obtained under specific test conditions, which include:

1. Q1 and Q2: Wolfspeed C3M0016120K SiC in the 4-pin TO-247 package.
2. Rg = 1 Ω (gate resistor).
3. Lo: 24 µH air core inductor.
4. V_{DS} = 800 V.
5. With and without a current booster daughter card.
6. Five pulses of 300 kHz PWM signal to ramp IDS from 0 A to ~ 250 A.

Figure 10 shows the double pulse switching waveforms for the above test conditions.

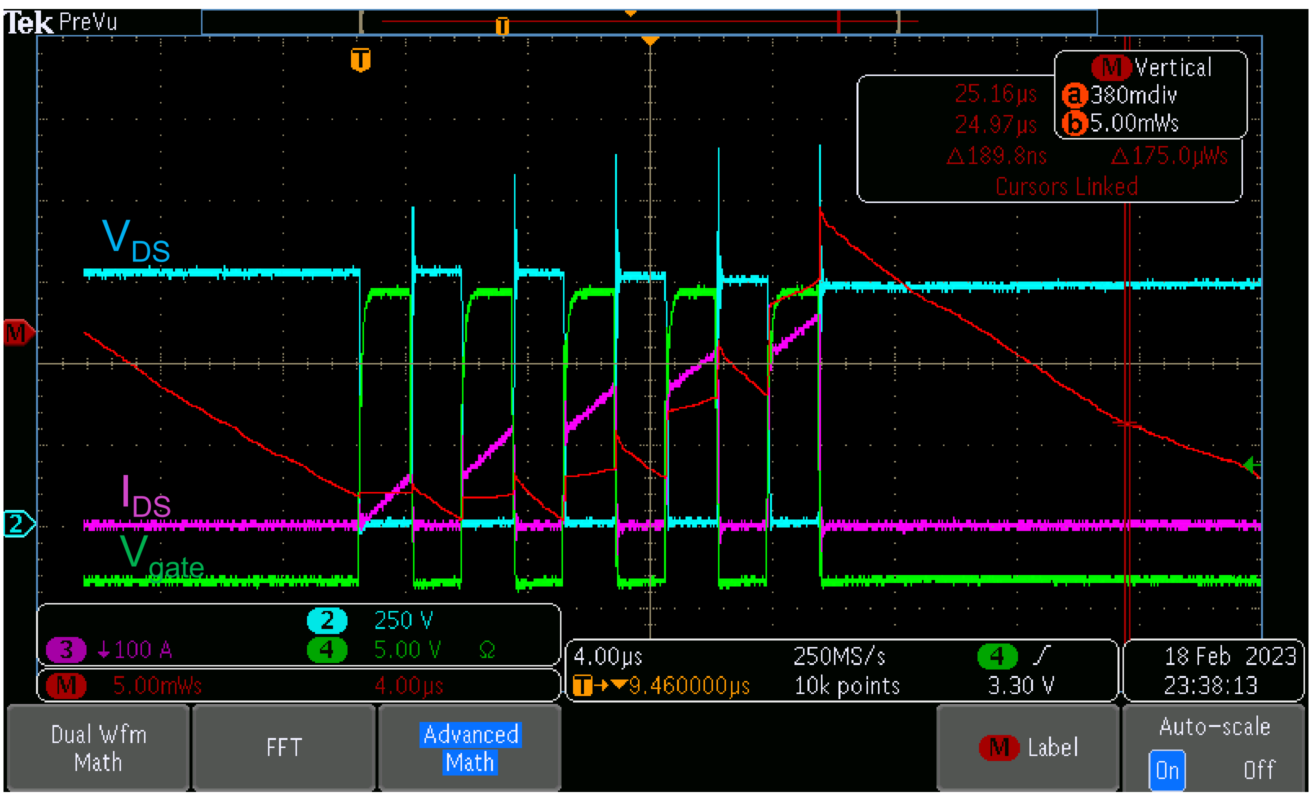


Figure 10. Double Pulse Switching Waveforms (without Current Booster)

Figure 11. Turn On Switching Waveforms at IDS = 120 A (without Current Booster)

Figure 12. Turn On Switching Waveforms at IDS =120 A (with Current Booster)

The oscilloscope math function was used to calculate the switching loss from VDS and IDS waveforms by setting it to ∫(Ch2 × Ch3). Once the cursor is placed on the math waveform across the switching transitions duration, the switching loss is calculated and displayed on the table at the top right of the scope image. Figure 11 and Figure 12 show that the turn-on switching loss of C3M0016120K is 2.53 mJ and 1.61 mJ, respectively, at IDS = 120 A, with a 36% reduction in turn-on switching loss when using an external current booster. Additionally, Figure 13 and Figure 14 provide switching loss data for C3M0016120K with and without the external current booster, while Figure 15 compares the switching loss for Si8281-C3M0016120K with and without the external current booster circuits.

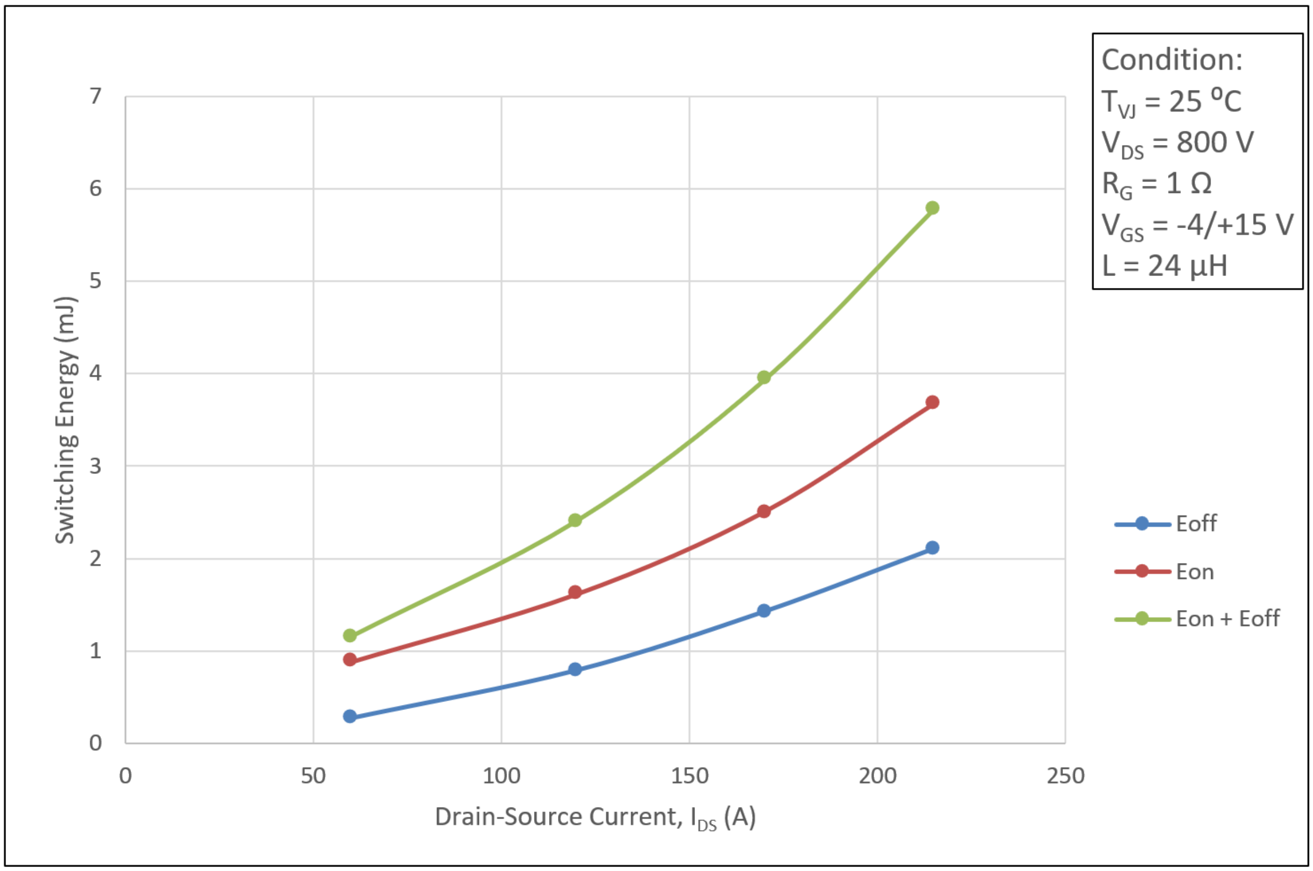


Figure 13. Switching Loss Si8281 (C3M0016120K with Current Booster Daughter Card)

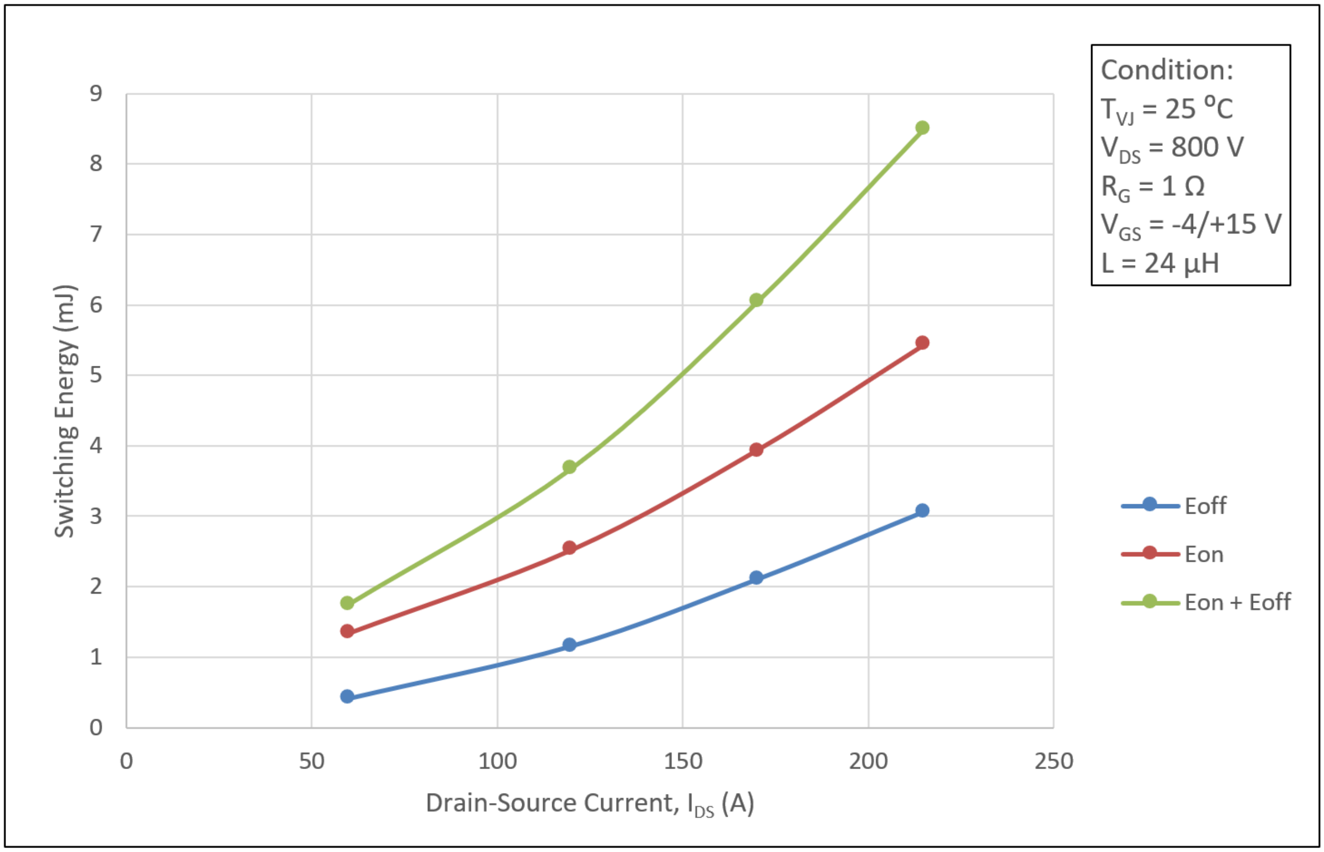


Figure 14. Switching Loss Si8281 (C3M0016120K without Current Booster Daughter Card)

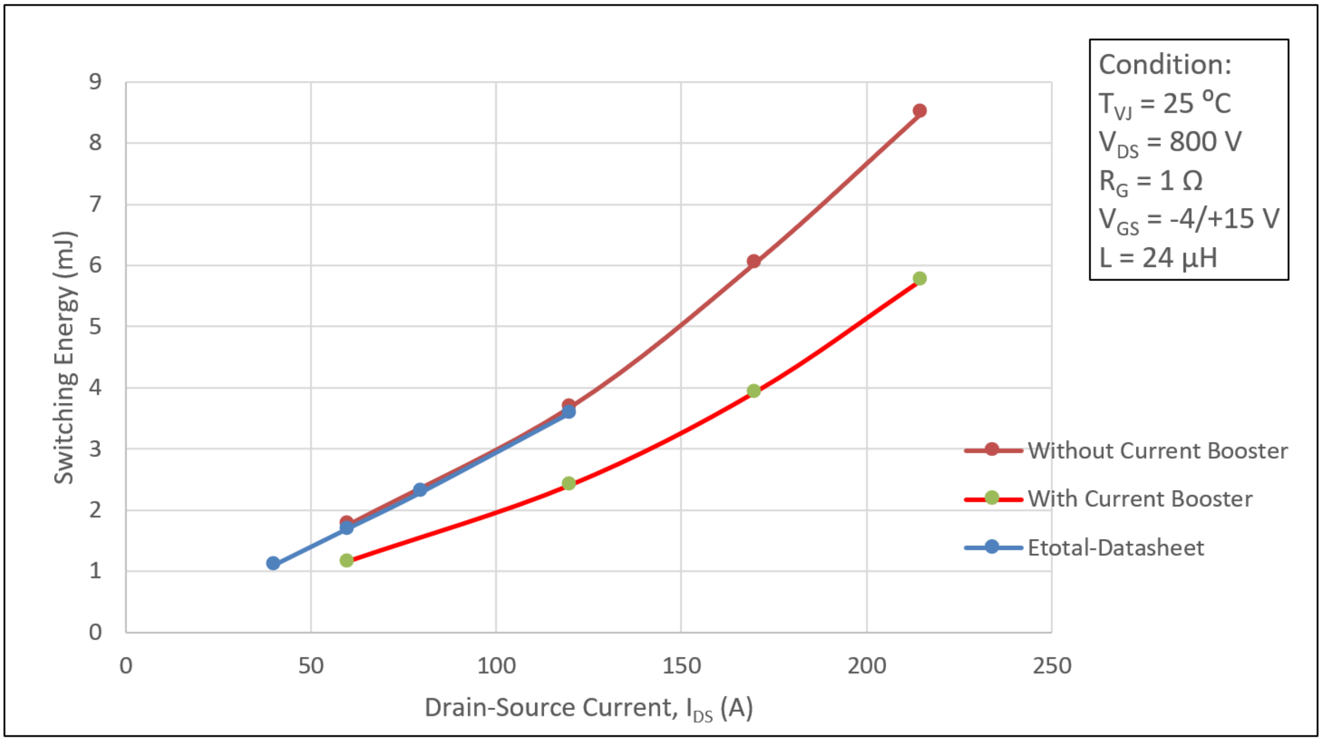


Figure 15. Switching Loss Comparison Si8281 (C3M0016120K with/without Current Booster Daughter Card)

4.3. Observations

In Figure 15, it is shown that when the C3M0016120K is operated directly with the Si8281 (without the current booster circuit), the switching loss is similar to the switching loss data in the Wolfspeed data sheet. However, when the C3M0016120K is operated with the Si8281 and its external current booster circuit, the switching loss is significantly lower.

5. DESAT Short Circuit Test

Figure 16 depicts the setup for conducting the DESAT (desaturation) test on the Si8281 and the switching device under short circuit conditions. The Q2 Drain and Source terminals are intentionally shorted to create a low-impedance path between the Q1 Drain terminal and the power +RAIL. This causes a high-voltage, high-current, short-circuit condition when Q1 is turned on. It is imperative that the Si8281's DESAT feature detects this condition and turns off Q1 within its safe duration before permanent damage occurs. For most Silicon Carbide power devices, the short-circuit response time should be less than 1 µs.

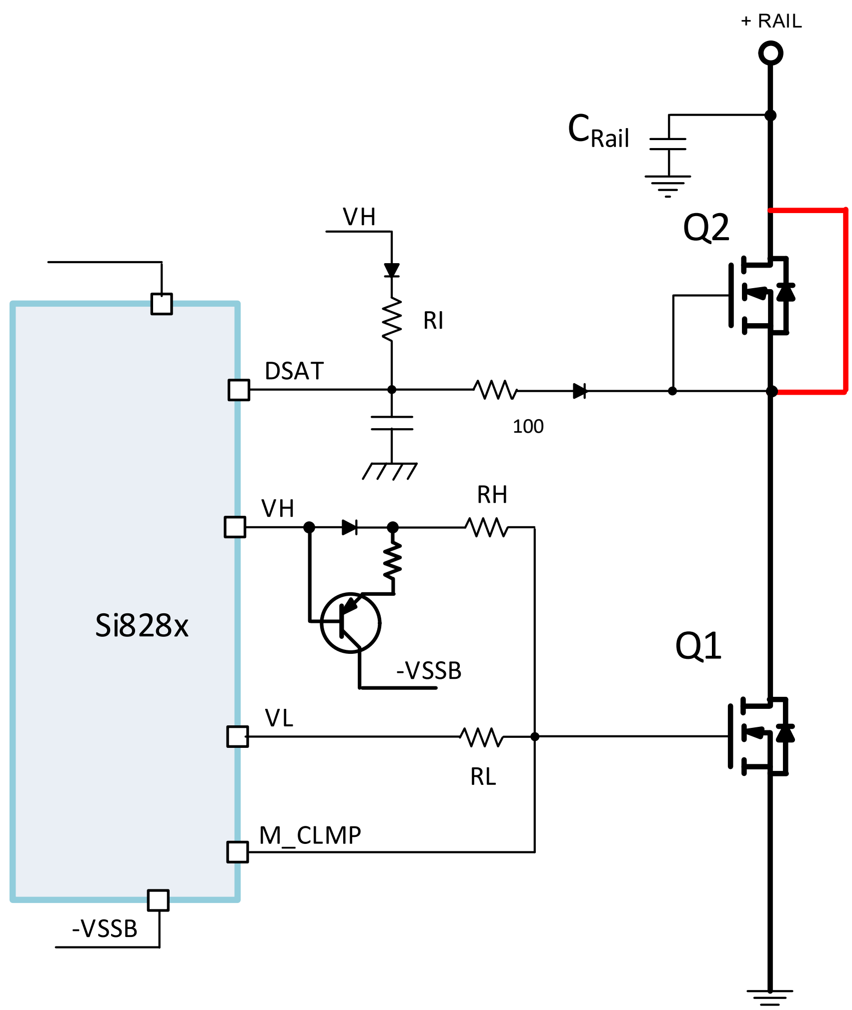


Figure 16. Si8281 DESAT Test Circuit

Figure 16 shows the DESAT test setup for the Si8281 with external components for detection, soft shutdown duration, and overall DESAT response time. The following resistors provide DESAT timing adjustments for the Si828x:

- Detection resistor: RI
  The installed value of RI on the Si8281v2-EVB is 2.2 kΩ, which sets the DESAT detection time. Lowering the value of RI decreases the detection time (minimum value is 1 kΩ). If RI is removed from the DESAT circuit (J9), the internal current source of the Si8281 sets the detection time to its maximum level.
- Soft Shutdown Resistor: RSS
  The Si8281 provides a fixed DESAT soft shutdown duration with its internal RSS of 50 Ω. However, this duration may not be suitable for all applications as it could either lengthen the response time or cause high voltage spikes during fault shutdown. To optimize the soft shutdown duration, an external bipolar transistor is used to adjust the RSS values and provide programmability. This allows designers to fine-tune the design for DESAT response time and voltage spike level to achieve optimal performance.

The above adjustments determine the DESAT response time, which is the duration required for IDS current to go from ~ 0 A back down to ~ 0 A in a short circuit event. The DESAT response time should be less than 3 µs for IGBTs and less than 1 µs for SiC FETs for robust protection.

5.1. Connections for DESAT Short Circuit Test

Table 5 provides jumper map and instrumentation connections for a Si828x DESAT short circuit test. Note that this test involves high voltage, and extreme caution must be observed. Contact could result in severe shock or death.

DANGER! This board may contain high voltages up to 1000 V. Do not touch the board once the high voltage section has been energized.

Table 5. Connections for Si828x DESAT Short Circuit Test

Testing Configuration	Si8281 Direct Drive	Si8281 with Current Booster DC
JP9	Connect Pin 1 to Pin 2	Connect Pin 1 to Pin 2
J24	Open	Plug into the Current Booster Daughter Card
J26	Close	Open
J27	Open	Close
J29	Open	Open
J30	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J31	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J32	Close	Open
J33	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J34	Close	Open
J35	Close	Open
J1	P/S: Pin 1 to 5 V, Pin 2 to GND	P/S: Pin 1 to 5 V, Pin 2 to GND
J16	PWM signal	PWM signal
Ch4: IsoVu or HV Diff. probe	V_{Gate}: J12 (MMCX) or TP26-TP27	V_{Gate}: J12 (MMCX) or TP26-TP27
Ch2: HV Differential Probe	VDS from TP30(+) to TP31(–)	VDS from TP30(+) to TP31(–)
Ch3: T&M Research SDN-414-01	R73: I_{Sense}	R73: I_{Sense}

Perform the following steps to conduct a DESAT short circuit test:

1. Install Q1 and Q2 and the corresponding solder bumps.
   a. Three pin SiC/IGBT package: short J22, J31, J32; open J23.
   b. Four pin SiC package: open J22, J31, J32; short J23.
2. Solder a bus wire across the Drain to Source terminals of Q2 (TP3-TP29).
3. Use a bus wire to short J21-J17 (parallel C51 and C52 for higher current handling capability).
4. Connect the DC-Rail power supply (100 mA minimum current capability) to J17 (+) - J19 (-) and set the output to the appropriate voltage level.
5. Connect jumpers, solder bumpers, booster daughter card, and instrumentation as described in Table 5.

6. Set up the function generator connected to SMA J16: 50 Ω output impedance, single pulse 5 Vpp square wave.
7. Set up the oscilloscope trigger to V_{GS} (Ch4), set scope Ch3 to invert and to 0.01 V per Ampere scale.
8. Setup the voltage scale of the oscilloscope ch2 to the appropriate VDS voltage level.
9. Power up the 12 V power supply that connected to J1.
10. Power up the DC-Rail power supply (see Step 4).
11. Send a single PWM pulse from the function generator and observe the waveforms on the oscilloscope.

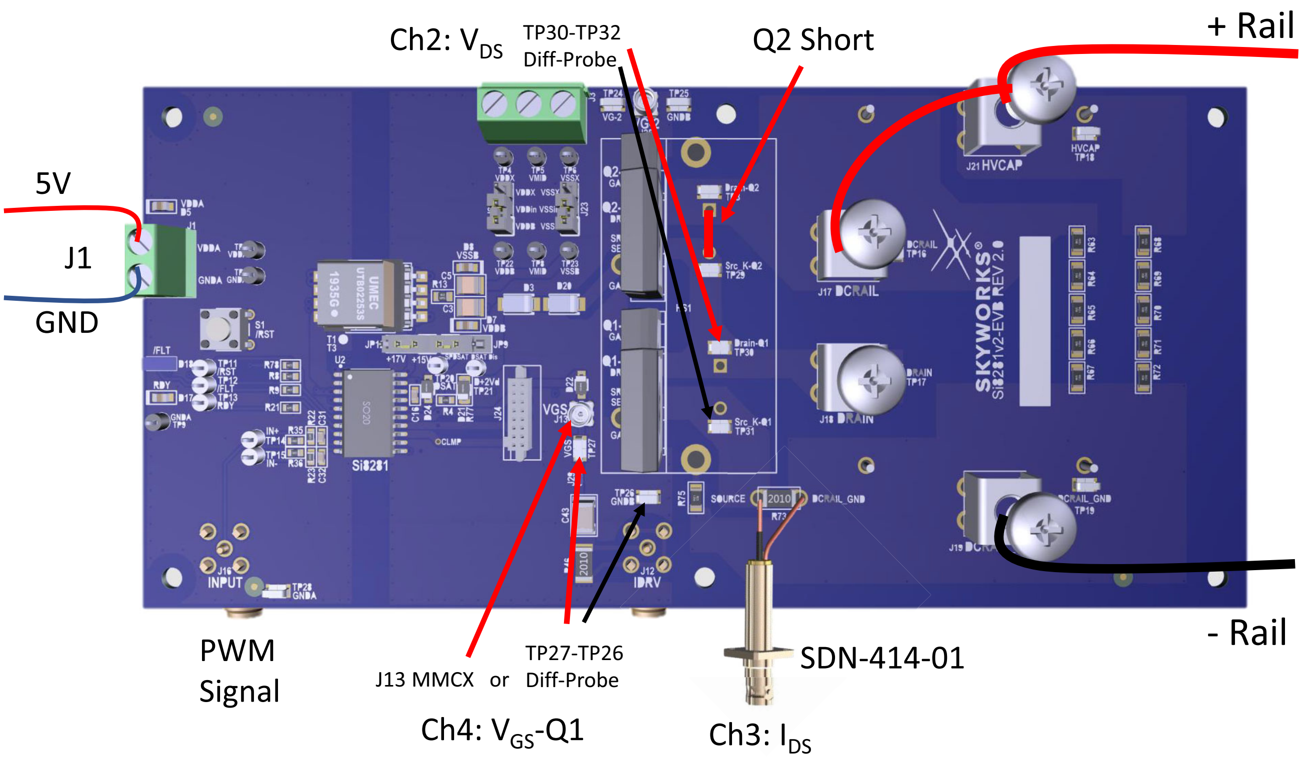


Figure 17. Physical Connections for Si8281 DESAT Test Circuit

5.2. Test Result

Figure 18 shows the Si8281 DESAT performance without the current booster daughter card, using RI = 2.2 kΩ and RSS = 12 Ω with the Wolfspeed C3M0016120K SiC FET. The short circuit response time is 500 ns, which is much less than 1 µs. However, the VDS voltage spike is 1,250 V, which is above the C3M0016120K voltage rating of 1,200 V.

To reduce the voltage spike below the 1,200 V level, the value of RSS is increased to 33 Ω, while all other settings remain the same as the test condition for Figure 18. Increasing the RSS value increases the response time but lowers the voltage spike level, as illustrated in Figure 19. With this change, the response time is increased from 500 ns to 650 ns (still less than 1 µs), while the VDS voltage spike is reduced to below 1,200 V. This trade-off between response time and voltage spike allows the designer to fine-tune the power switching circuit for optimum protection while meeting the switching device voltage rating.

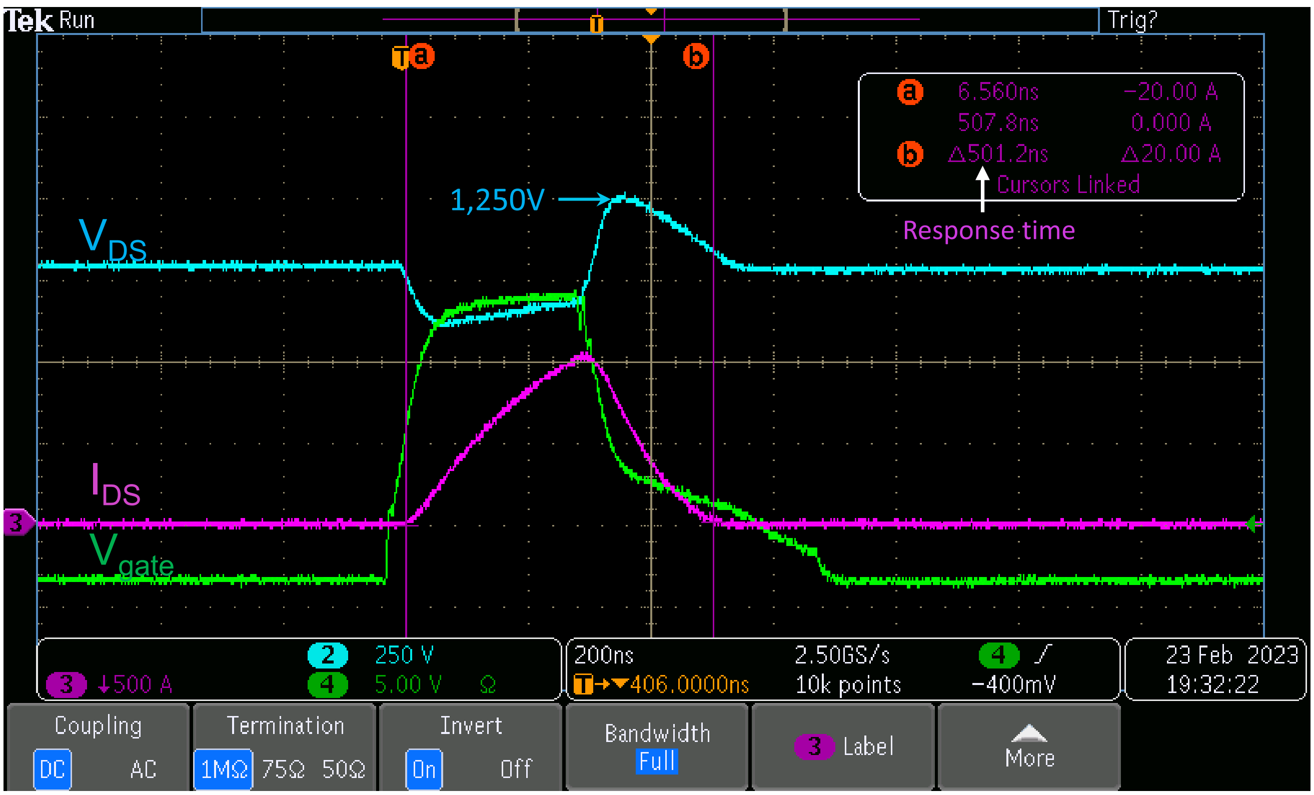


Figure 18. Si8281 DESAT Waveform with VRail = 800 V, RSS = 12 Ω, and C3M0016120K SiC

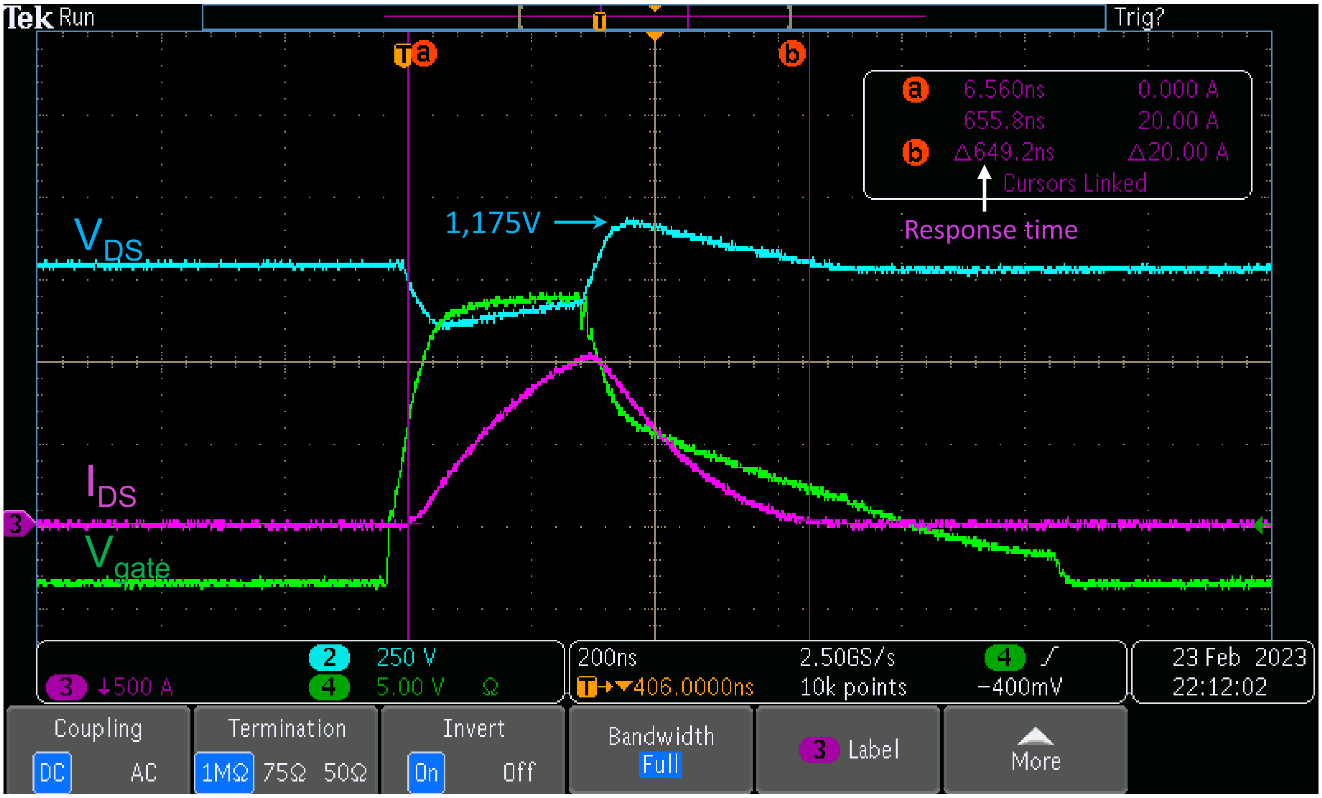


Figure 19. Si8281 DESAT Waveform with VRail = 800 V, RSS = 33 Ω, and C3M0016120K SiC

6. Boost DC-DC Converter Test

Figure 20 depicts the configuration of the Si8281v2-EVB in a boost dc-dc converter circuit. During the on-time, Q1 ramps up the input current from +Vin across the Lo inductor, and during the off-time, the Lo current flows through the Q2 body diode to the output. The output voltage, Vout, is always higher than Vin, as per the definition of a boost dc-dc converter. This setup enables performance testing of the Si8281 gate driver and power switching device in a realistic boost dc-dc converter application.

However, it is essential to note that for output power greater than 100 W, adequate heat dissipation and airflow to Q1 and Q2 are necessary to maintain the temperature within the recommended levels for the switching devices. Failure to ensure proper cooling may result in device overheating, reduced lifespan, and ultimately, failure.

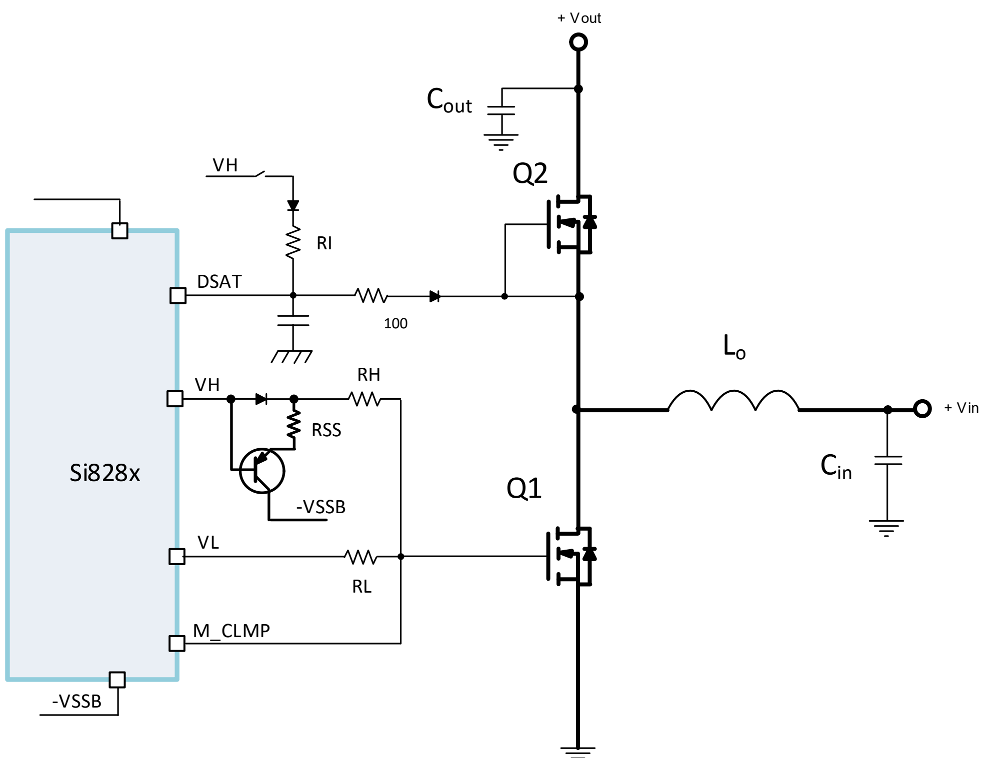


Figure 20. Si8281 in Boost DC-DC Converter Test Circuit

6.1. Connections for Si828x Boost DC-DC Converter Test Circuit

Table 6 provides the jumper map and instrumentation connections for a Si828x boost dc-dc converter test. Note that this test involves high voltage, and extreme caution must be observed. Contact could result in severe shock or death.

DANGER! This board may contain high voltages up to 1000 V. Do not touch the board once the high voltage section has been energized.

Table 6. Connections for Si8281v2-EVB Boost DC-DC Converter Circuit Testing

Testing Configuration	Si8281 Direct Drive	Si8281 with Current Booster DC
JP9	Connect Pin 1 to Pin 2	Connect Pin 1 to Pin 2
J24	Open	Plug into the Current Booster Daughter Card
J26	Close	Open
J27	Open	Close
J29	Open	Open
J30	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J31	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J32	Close	Open
J33	See below (three vs. four pins SiC)	See below (three vs. four pins SiC)
J34	Close	Open
J35	Close	Open
J1	P/S: Pin 1 to 5 V, Pin 2 to GND	P/S: Pin 1 to 5 V, Pin 2 to GND
J16	PWM signal	PWM signal
Ch1: HV Differential Probe	Vout on TP16(+) to TP19(–)	Vout on TP16(+) to TP19(–)
Ch2: HV Differential Probe	VDS on TP30(+) to TP31(–)	VDS on TP30(+) to TP31(–)
Ch3: T&M Research SDN-414-01	R73: I_{Sense}	R73: I_{Sense}
Ch4: IsoVu or HV Diff. probe	V_{Gate}: J12 (MMCX) or TP26 to TP27	V_{Gate}: J12 (MMCX) or TP26 to TP27

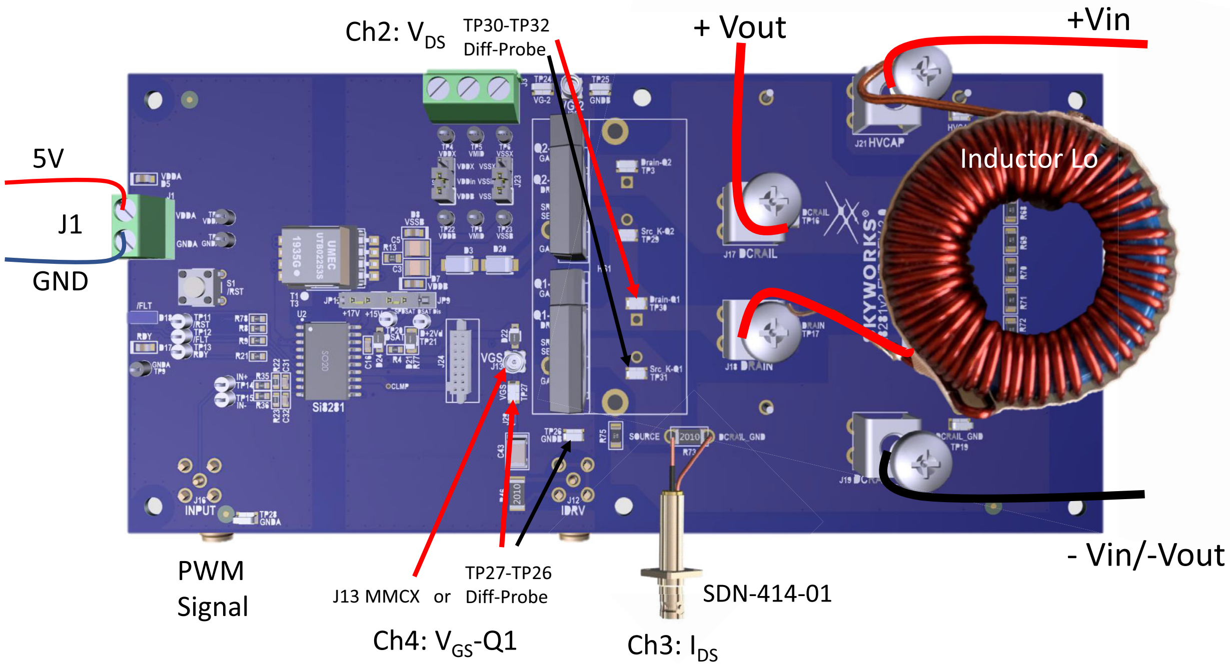


Figure 21. Connections for Si8281v2-EVB Boost DC-DC Converter Testing

The image in Figure 21 provides the physical connections for the Si8281v2-EVB in boost dc-dc converter testing. Perform the following steps to conduct the Si8281 and the boost dc-dc converter test:

1. Install Q1 and Q2 and the corresponding solder bumps.
   a. Three pin SiC/IGBT package: short J22, J31, J32; open J23.
   b. Four pin SiC package: open J22, J31, J32; short J23.
2. Connect jumpers, solder bumpers, booster daughter card, and instrumentations as described in Table 6.
3. Install inductor Lo between J18 and J21 (Lo should be selected to support input, output voltages and maximum output power).
4. Connect +Vin power supply with sufficient voltage and current for the desired power output to J21, +Vin and J19, –Vin.
5. Connect a resistive load to the boost dc-dc converter output: +Vout, J17 and -Vout J19.
6. Set up the function generator connected to SMA J16: 50 Ω output impedance, continuous 10 kHz 5 Vpp square wave.
7. Set scope Ch3 to inverted, 50 Ω impedance, and 0.01 V/A scale.
8. Set up the oscilloscope to trigger on the VGS signal (Ch4).
9. Setup the scope's Ch2 to appropriate voltage level for Q1 VDS.
10. Power up the 12 V power supply that connected to J1.
11. Power up Vin (DC-Rail) power supply (see Step 4).
12. Activate the PWM function generator and observe the waveforms on the oscilloscope.
13. Measure the input and output power.

6.2. Test Results

The following is a list of the specific component selections, testing parameters, and test results for the Skyworks' Si8281 gate driver and Wolfspeed C3M0016120K SiC FET power switching device operating in the boost dc-dc converter circuit:

- Lo inductor: CWS toroidal HF400-651M-8.0AH, 330 µH (at 8 A)
- Q1, Q2: Wolfspeed C3M0016120K SiC
- Gate Driver: Si8281 with current booster daughter card
- Switching frequency: 10 kHz
- Input power: 150 V, 0.745 A, 111.75 W
- Output power: 330 V, 0.32 A, 105.6 W
- Efficiency: (105.6/111.75) x 100 = 94.5%

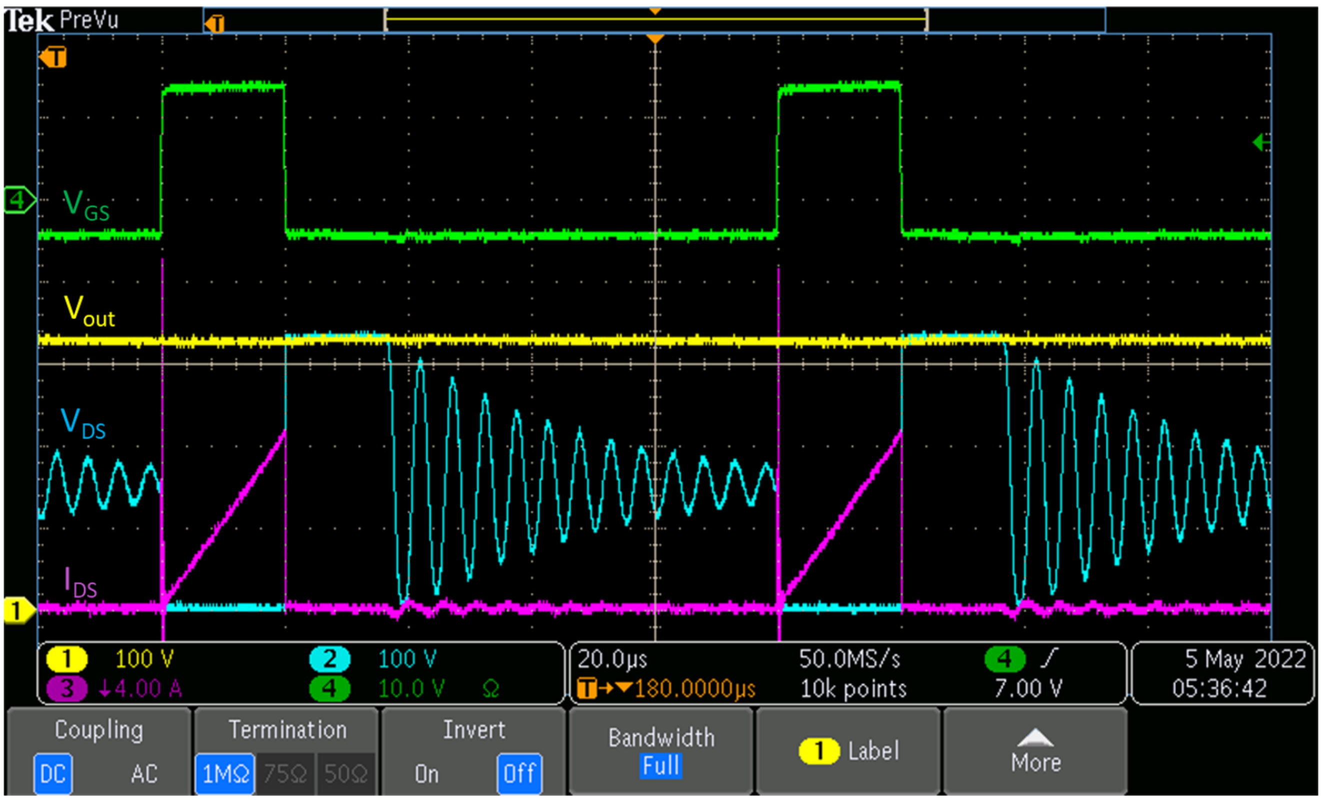


Figure 22. Boost DC-DC Converter Waveforms

6.3. Observations

The Si8281v2-EVB is a flexible platform that is well-suited for use with the Wolfspeed C3M0016120K SiC FET. In our testing, even at low power output levels (e.g., 109 W), the circuit was able to achieve an impressive power conversion efficiency of 94.5%. One of the key benefits of this test setup is its simplicity and flexibility, which allows it to be easily adapted to support different types of switching devices and Si8281 configurations.

7. Conclusion

The Si8281v2 EVB offers a versatile platform for showcasing the capabilities of the Si8281 gate drivers with both IGBT and SiC FET devices. With the aid of the Si8281 and external current booster circuits, abundant gate current is provided to drive all IGBT and SiC switching devices to their optimal level, resulting in maximum efficiency. Results from “4.2. Switching Loss Test Results” on page 12 demonstrate that the Wolfspeed C3M0016120K SiC, when operated with the Si8281 and current booster circuit, has 31% lower switching loss than that published in the Wolfspeed C3M0016120K data sheet.

The Si828x's DESAT protection circuit has a rapid response time (less than 1 µs), minimizing IDS peak current and power dissipation on the switching device while reliably protecting it under repeated extreme shorted conditions. Furthermore, the Si8281's DESAT circuits provide flexible control, enabling designers to set the response timing, soft shutdown timing, and voltage spike levels for optimized protection for both SiC and slower IGBT switching devices.

8. Bill of Materials

8.1. Si8281v2-EVB-UG Bill of Materials

Table 7. Si8281v2-EVB-UG Bill of Materials

Item	Reference	Qty	Description	Mfr	Mfr Part Number
1	C2	1	CAP, 100 pF, 50 V, ±20%, C0G, 0603	Venkel	C0603C0G500-101M
2	C3, C5, C7, C49	4	CAP, 10 µF, 50 V, ±20%, X7R, 1210	Venkel	C1210X7R500-106M
3	C4, C6, C8, C9, C13, C15	6	CAP, 0.1 µF, 50 V, ±10%, X7R, 0805	Venkel	C0805X7R500-104K
4	C10	1	CAP, 1.5 nF, 250 V, ±10%, X7R, 0805	Venkel	C0805X7R251-152K
5	C12, C14	2	CAP, 2.2 µF, 50 V, ±10%, X7R, 1210	Kemet	C1210C225K5RACTU
6	C16	1	CAP, 100 pF, 50 V, ±5%, NP0, 0603	AVX	06035A101JAT2A
7	C17, C18	2	CAP, 1 µF, 10 V, ±10%, X7R, 0603	Murata	GRM188R71A105KA61D
8	C22	1	CAP, 1 µF, 25V, ±20%, X7R, 1206	Venkel	C1206X7R250-105M
9	C24	1	CAP, 0.01 µF, 10 V, ±20%, X7R, 0603	Venkel	C0603X7R100-103M
10	C31, C32	2	CAP, 22 pF, 50 V, ±5%, C0G, 0603	Kemet	C0603C220J5GAC7013
11	C33, C34	2	CAP, 22 pF, 50 V, ±5%, C0G, 0603	Venkel	C0603C0G500-220J
12	C43	1	CAP, 220 nF, 50 V, ±5%, C0G, 1812	Venkel	C1812C0G500-224JNE
13	C44	1	CAP, 270 pF, 2500 V, ±5%, C0G, 1812	Kemet	C1812C271JZGACTU
14	C51, C52	2	CAP, 10 µF, 1000 V, ±5%, PolyFilm, PTH	Vishay	MKP1848S61010JY2B
15	D1, D2, D22, D23	4	DIO, Schottky, 100 V, 1A, SOD123	On Semi	MBR1H100SF
16	D3, D20	2	DIO, DIODE, 1000 V, 1A, SMA	Diodes Incorporated	US1M-13-F
17	D5, D7, D8, D17	4	LED, GREEN, 0805	LITE_ON INC	LTST-C170GKT
18	D9	1	DIO, fAST, 100 V, 2A, SOD123	Diodes Inc.	1N4148W
19	D18	1	LED, RED, 631 nM, 30 mA, 2 V, 54mcd, 0805	LITE-ON TECHNOLOGY	LTST-C170KRKT
20	D19	1	DIO, SCHOTTKY, 40 V, 3 A, SMA	On Semiconductor	MBRA340T3G
22	D24	1	DIO, ZENER, 10 V, 500 mW, SOD123	On Semi	MMSZ4697T1G
23	D25	1	DIO, ZENER, 5.6 V, 3 W, SMB	On Semi	1SMB5919BT3
24	D26	1	DIO, ZENER, 24 V, 3 W, SMB	On Semi	1SMB5934BT3
28	J3	1	Terminal Block, 3 pos, 5 mm, 14-30AWG, 300 V, 10 A	Phoenix Contact	1729021
29	J12, J16	2	CONN, SMA 50 Ω, Right Angle PC Mount Jack Receptacle	Johnson Components	142-0701-301
30	J13, J25	2	CONN, MMCX, 50 Ω, Straight, PTH	Molex	734151471
31	J17, J18, J19, J21	4	CONN, TERM SCREW, 10-32, PTH	Keystone Electronics	8174
33	J22, J23	2	Header, 3x1, 0.1 in pitch, 10 µ Au Plated, Gold Flash on balance, TH	Samtec	TSW-103-07-G-S
34	J24	1	Socket, 8x2, 0.05in pitch, Gold Plated. PTH	Samtec	SFM-108-01-L-D
35	J26, J29, J31, J32, J33, J34, J35	7	SOLDER BUMP JUMPER, NO, 0603	N/A	SB0603-NO
36	J27, J30	2	SOLDER BUMP JUMPER, NC, 0603	N/A	SB0603-NC
37	JP9, JP12	2	Header, 3x1, 0.1in pitch, gold/tin	Samtec	TSW-103-07-L-S
38	JS1, JS2, JS6, JS7	4	Shunt, 1x2, 0.1in pitch, Tin plating	Samtec	SNT-100-BK-T
39	MH1, MH2, MH3, MH4, MH5, MH6	6	HDW, SCREW, 4-40 x 1/4 in. Pan Head, Slotted, Nylon	Richco Plastic Co.	NSS-4-4-01
40	PCB1	1	PCB, BARE BOARD, Si8281v2-EVB REV 1.0	Skyworks	Si8281v2-EVB REV 1.0
43	Q10	1	TRANSISTOR, PNP, 60 V, 600mA, SOT23	Diodes Inc.	MMBT2907A
44	R1	1	RES, 145 kΩ, 1/10 W, ±1%, MetalFilm, 0603	KOA Speer	RN73H1JTTD1453F100
45	R2	1	RES, 8.66 kΩ, 1/16 W, ±1%, ThickFilm, 0603	Venkel	CR0603-16W-8661F
46	R3	1	RES, 100 kΩ, 1/10 W, ±1%, ThickFilm, 0603	Venkel	CR0603-10W-1003F

Table 7. Si8281v2-EVB-UG Bill of Materials (Continued)

Item	Reference	Qty	Description	Mfr	Mfr Part Number
47	R4, R5	2	RES, 100 Ω, 1/10 W, ±1%, ThickFilm, 0603	Venkel	CR0603-10W-1000F
48	R6	1	RES, 1.0 Ω, 1/10 W, ±1%, ThickFilm, 0805	Venkel	CR0805-10W-1R00F
49	R8, R9, R21, R24	4	RES, 10 kΩ, 1/16 W, ±1%, ThickFilm, 0603	Venkel	CR0603-16W-1002F
50	R10, R11	2	RES, 2.0 Ω, 1/4 W, ±1%, ThickFilm, 1206	Venkel	CR1206-4W-2R00FT
51	R13	1	RES, 0 Ω, 2 A, ThickFilm, 0805	Venkel	CR0805-10W-000
52	R22	1	RES, 10 kΩ, 1/10 W, ±5%, ThickFilm, 0603	Venkel	CR0603-10W-103J
53	R23	1	RES, 0 Ω, 1 A, ThickFilm, 0603	Venkel	CR0603-16W-000
54	R25	1	RES, 2 kΩ, 1/10 W, ±1%, ThickFilm, 0603	Venkel	CR0603-10W-2001F
55	R26	1	RES, 13.0 kΩ, 1/16 W, ±1%, ThickFilm, 0603	Venkel	CR0603-16W-1302F
56	R27	1	RES, 2.2 kΩ, 1/10 W, ±5%, ThickFilm, 0805	Venkel	CR0805-10W-222J
57	R35, R78	2	RES, 50 Ω, 1/10 W, ±1%, ThickFilm, 0603	Vishay Dale	CRCW060350R0FKEA
58	R46	1	RES, 0.200 Ω, 2 W, ±1%, Metal Plate, 2010	VishayDale	WFMB2010R2000FEA
59	R55, R56	2	RES, 3 kΩ, 1/4 W, ±1%, ThickFilm, 1206	Panasonic	ERJ-8ENF3001V
60	R58	1	RES, 10 Ω, 1/4 W, ±1%, ThickFilm, 1206	Venkel	CR1206-4W-10R0F
61	R59	1	RES, 10.0 Ω, 2 W, ±0.5%, ThickFilm, 2512	Venkel	CR2512-2W-10R0D
62	R60	1	RES, 100 Ω, 1/10 W, ±1%, ThickFilm, 0805	Venkel	CR0805-10W-1000F
63	R61	1	RES, 12 Ω, 1/4 ΩW, ±5%, ThickFilm, 1206	Venkel	CR1206-4W-120J
64	R63, R64, R65, R66, R67, R68, R69, R70, R71, R72	10	RES, 200 kΩ, 1/4 W, ±1%, ThickFilm, 1206	Venkel	RC1206FR-07200KL
66	R75, R77	2	RES, 0 Ω, 2 A, ThickFilm, 1206	Venkel	CR1206-4W-000
67	R76	1	RES, 165 kΩ, 1/16 W, ±1%, ThickFilm, 0603	Venkel	CR0603-16W-1653F
68	S1	1	SWITCH, PB, NO, MOMENTARY, TACTILE, LIGHT TOUCH 130GF, 6MM, PTH	Panasonic Corp.	EVQ-PAD04M
69	SO1, SO2, SO3, SO4, SO5, SO6	6	HDW, STANDOFF, 1/4 IN. HEX, 4-40x3/4 IN., NYLON	Keystone Electronics	1902D
70	T1	1	TRANSFORMER, POWER, FLYBACK, 5 kV ISOLATED, 1.5 µH, 125 nH LEAKAGE, 1:15:5, SMT	Mentech	TTER09-0569S1
72	TP2, TP4, TP5, TP6, TP7, TP8, TP9, TP22, TP23	9	TESTPOINT, BLACK, PTH	Kobiconn	151-203-RC
73	TP3, TP16, TP17, TP18, TP19, TP24, TP25, TP26, TP27, TP28, TP29, TP30, TP31	13	TESTPOINT, MINIATURE, SMD	Keystone	5019
74	TP11, TP12, TP13, TP14, TP15, TP20, TP21	7	TESTPOINT, WHITE, PTH	Kobiconn	151-201-RC
75	TPV12	1	TESTPOINT Via	N/A	N/A
76	TPV13, TPV14	2	PCB Feature, TP, 0.100" PAD, 0.070" HOLE, PTH	N/A	TPVIA[10070]
77	U2	1	IC, 4 AMP ISODRIVER WITH ISOVOLT, SO20 WB	Skyworks	Si8281CD-IS

Table 7. Si8281v2-EVB-UG Bill of Materials (Continued)

Item	Reference	Qty	Description	Mfr	Mfr Part Number
Not Installed Components					
41	Q1-1, Q2-1	2	TRANSISTOR, MOSFET, N-CHNL, 1200 V, 115 A, 16 mΩ, SiC, Switching, TO-247	Wolfspeed	C3M0016120D
42	Q1-2, Q2-2	2	TRANSISTOR, MOSFET, N-CHNL, 1200 V, 115 A, 16 mΩ, SiC, Switching, TO-247	Wolfspeed	C3M0016120K
51	R19	1	RES, 0 Ω, 2 A, ThickFilm, 0805	Venkel	CR0805-10W-000
53	R36	1	RES, 0 Ω, 1 A, ThickFilm, 0603	Venkel	CR0603-16W-000
65	R73	1	RES, 0.001 Ω, 1 ΩW, ±1%, ±100ppm, 2010	Rohm	PMR50HZPFV1L00
71	T3	1	TRANSFORMER, POWER, FLYBACK, 5 kV ISOLATED, 2.5 µH, 100 nH LEAKAGE, 7:1, 5:1, SMT	UMEC	UTB02241s
25	HS1	1	HEATSINK, TO-247, 50 mm WIDE, PTH	Ohmite	CR101-50-AE
26	HW1	1	HEATSINK CAM CLIP, TH (TO-247)	Ohmite	CLA-TO-21E
13	C50	1	CAP, 270 pF, 2500 V, ±5%, C0G, 1812	Kemet	C1812C271JZGACTU
21	D21	1	DIO, ZENER, 3.0 V, 500 mW, SOD123	On Semi	MMSZ4683T1G
32	J20, J28	2	CONN, BNC, TEST LEAD, 4in. LEADS , PTH	Mueller Electric Co.	BU-5200-A-4-0

8.2. Current Booster Card Bill of Materials

Table 8. Current Booster Card Bill of Materials

Reference	Qty	Description	Mfr	Mfr Part Number
C1, C3, C5	3	CAP, 10 µF, 50 V, ±20%, X7R, 1210	Venkel	C1210X7R500-106M
C2, C4, C6	3	CAP, 0.1 µF, 50 V, ±10%, X7R, 0603	Yageo	CC0603KPX7R9BB104
D1, D3	2	DIO, Schottky, 80 V, 0.5 A, SOD123	Diodes Inc.	MBR0580S1-7
D2	1	DIO, Fast, 100 V, 2 A, SOD123	Diodes Inc.	1N4148W
J1	1	Header, 8 x 2, 0.05 in pitch, Gold Plated, RA, PTH	Samtec	TFM-108-01-L-D-RE1-WT
LB1	1	LABEL, PDB, POLYIMIDE, WHITE, 1.00 in. X 0.187 in., FONT 2	Silabs	Si828x-Booster-Circuit Rev 2.0 LAB Si8285
PCB1	1	PCB, BARE BOARD, Si828x-Booster-Circuit Rev 2.0	Silabs	Si828x-Booster-Circuit Rev 2.0
Q1	1	TRANSISTOR, NPN, 60 V, 5 A, LO SAT, SOT89	Diodes Inc.	ZXTN2010Z
Q2	1	TRANSISTOR, PNP, –60 V, –4.3 A, MEDIUM POWER LOW SAT, SOT89	Zetex	ZXTP2012Z
Q3, Q4	2	TRANSISTOR, PNP, –60 V, –4 A, MEDIUM POWER, SOT23	Diodes Inc.	ZXTP2027FTA
R1	1	RES, 10 Ω, 1/4 W, ±1%, ThickFilm, 1206	Venkel	CR1206-4W-10R0F
R2	1	RES, 20 Ω, 1/4 W, ±1%, ThickFilm, 1206	Venkel	CR1206-4W-20R0FT
RB3, RB4	2	RES, 100 Ω, 1/10 W, ±1%, ThickFilm, 0805	Venkel	CR0805-10W-1000F
RH, RL	2	RES, 1.0 Ω, 1 W, ±1%, ThickFilm, 2010	Vishay	CRCW20101R00FKEFHP
RSS	1	RES, 5.1 Ω, 1/4 W, ±1%, ThickFilm, 1206	Yageo	RC1206FR-075R1L
TPV1, TPV2, TPV3, TPV4, TPV5, TPV6, TPV7	7	PCB Feature, TP, 0.080" PAD, 0.040" HOLE, PTH	N/A	TPVIA[8040]
Not Installed Components				
Q1A	1	TRANSISTOR, NPN, 60 V, 7 A, LO SAT, SOT223	Diodes Inc.	ZXTN19060CG
Q1B	1	TRANSISTOR, NPN, 40 V, 25 W, SOT669	Nexperia	PHPT60415NY
Q1C	1	TRANSISTOR, NPN, 80 V, 20 W, DPAK	On Semi	MJD44H11
Q2A	1	TRANSISTOR, PNP, –60 V, –5 A, MEDIUM POWER LOW SAT, SOT223	Diodes Inc.	FZT951
Q2B	1	TRANSISTOR, PNP, –40 V, 25 W, SOT669	Nexperia	PHPT60415PY
Q2C	1	TRANSISTOR, PNP, –80 V, 20 W, DPAK	On Semi	MJD45H11

9. Ordering Information

Full schematic, BOM, and layout Gerber files are available for download at the KIT link listed below under Ordering Part Number.

Table 9. Ordering Guide

Ordering Part Number (OPN)	Description
Si8281v2-KIT	Si8281 Isolated gate driver evaluation kit