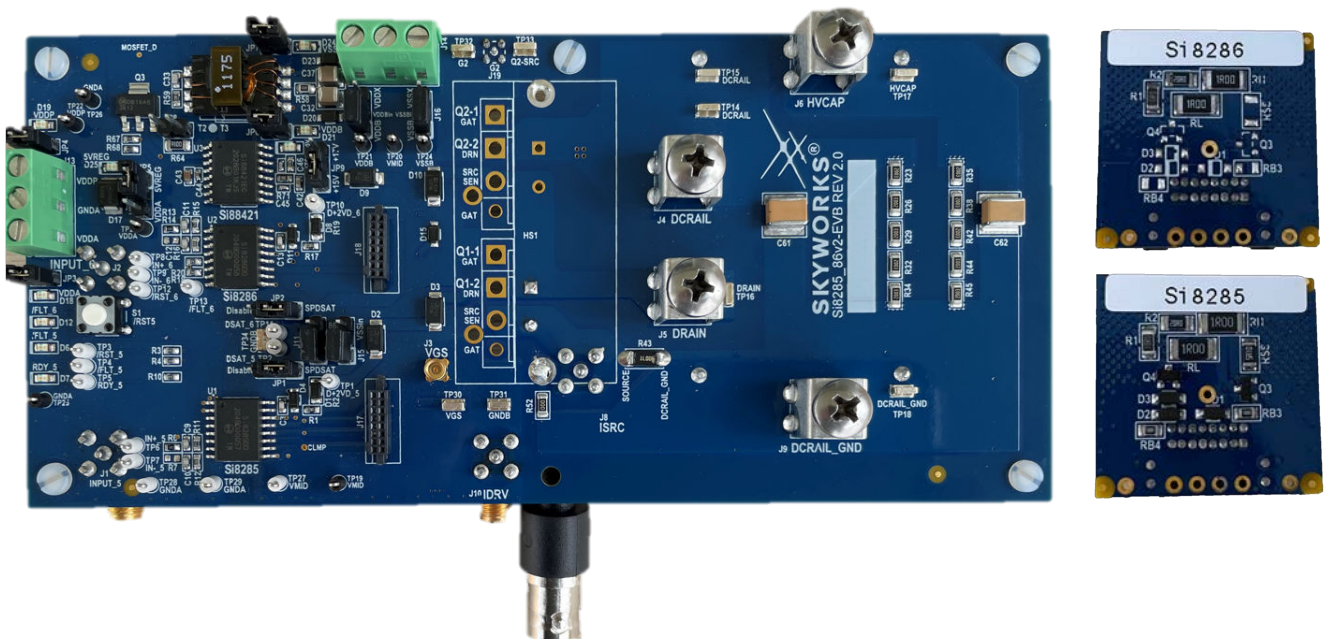# UG517: Si8285_86v2-EVB User's Guide

The Si8285_86v2-EVB is a flexible platform for demonstrating the Si8285 and Si8286 SiC FET-Ready ISODrivers with Safety Features for SiC FET or IGBT devices. The EVB contains Si8285 and Si8286 isolated gate drivers and two switch device sockets. The high side switch device is connected permanently in the off-state to operate as a diode, while onboard jumpers multiplex the Si8285 or Si8286 to drive the low side device. The body diode of the high-side SiC/IGBT and the low-side SiC/IGBT switching device can be configured with an external inductor to support double pulse testing and switching loss measurement. All Si8285 or Si8286 gate driver capabilities, including DSAT protection circuits, are tested while operating with the low-side SiC/IGBT.

KEY FEATURES

- Si8285 and Si8285 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 and many other performance evaluations

The Si828x output current is rated at 4 A to sufficiently drive most discrete SiC FETs and IGBTs. For applications that require higher gate drive current, simple external bipolar transistor-based current booster circuits are customized to operate with the Si828x gate drivers. These current booster circuits are built on small daughter cards. There are two versions of the Si828x booster cards, one to operate with the Si8285 and another with the Si8286. The current booster card can provide more than 15 A current drive capability depending on the component selections. The Si8285_86v2-EVB has flexible jumpers and matching plug attachments for the Si8285 and Si8286 daughter cards, enabling testing with and without the current booster circuits.

To power the Si828x gate drivers, the Si8285_86v2-EVB includes an isolated dc-dc circuit using Skyworks' Si88421 digital isolator with dc-dc converter. The Si88421 drives an external MOSFET and isolated transformer to generate +15 and –4 V biasing voltages. There are multiplex jumpers to power the Si8285 or Si8286 from the Si88421 dc-dc output voltages.

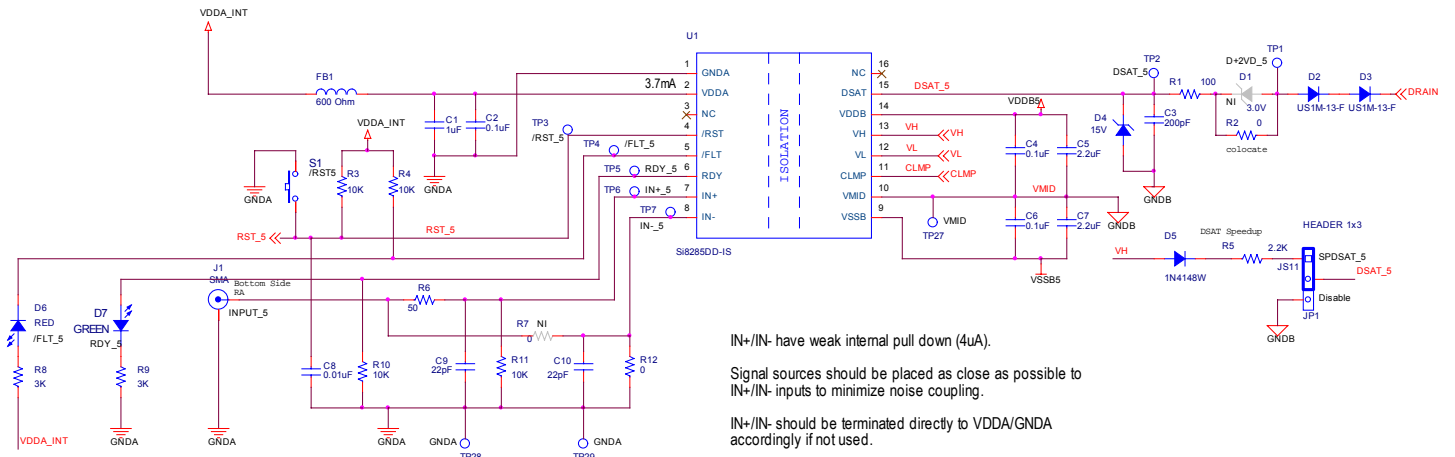# Table of Contents

1. Schematics
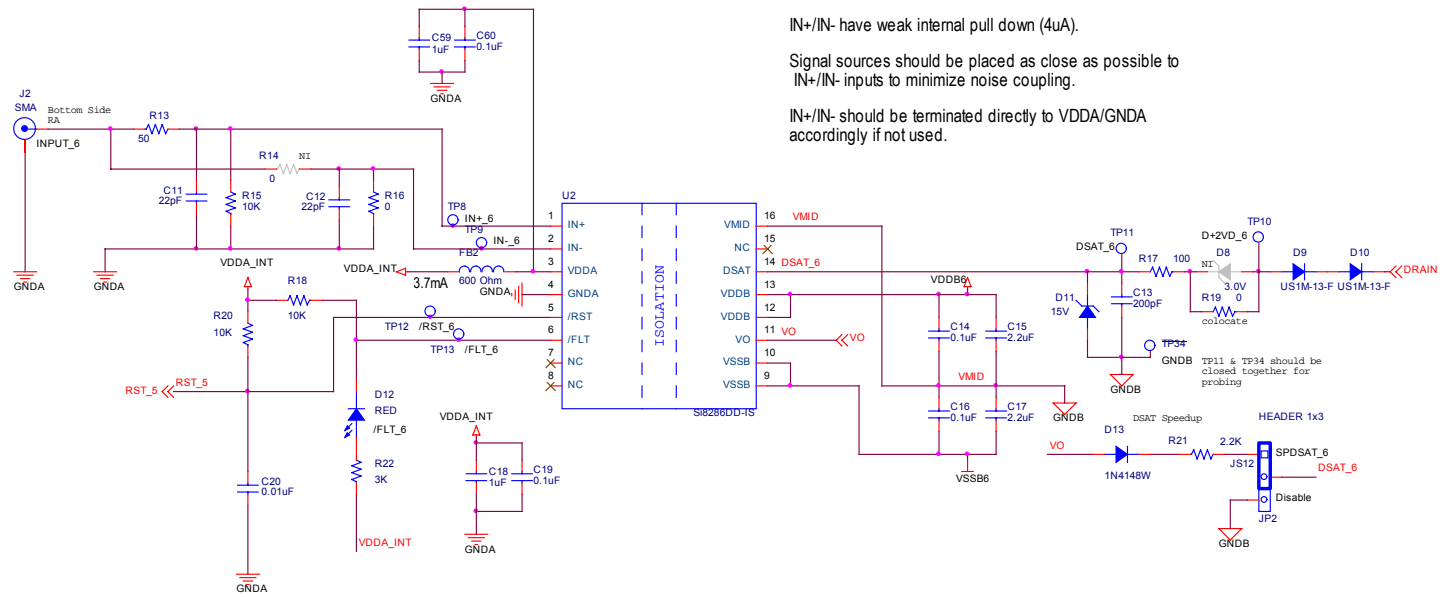

Figure 1.1. Si8285 Gate Driver
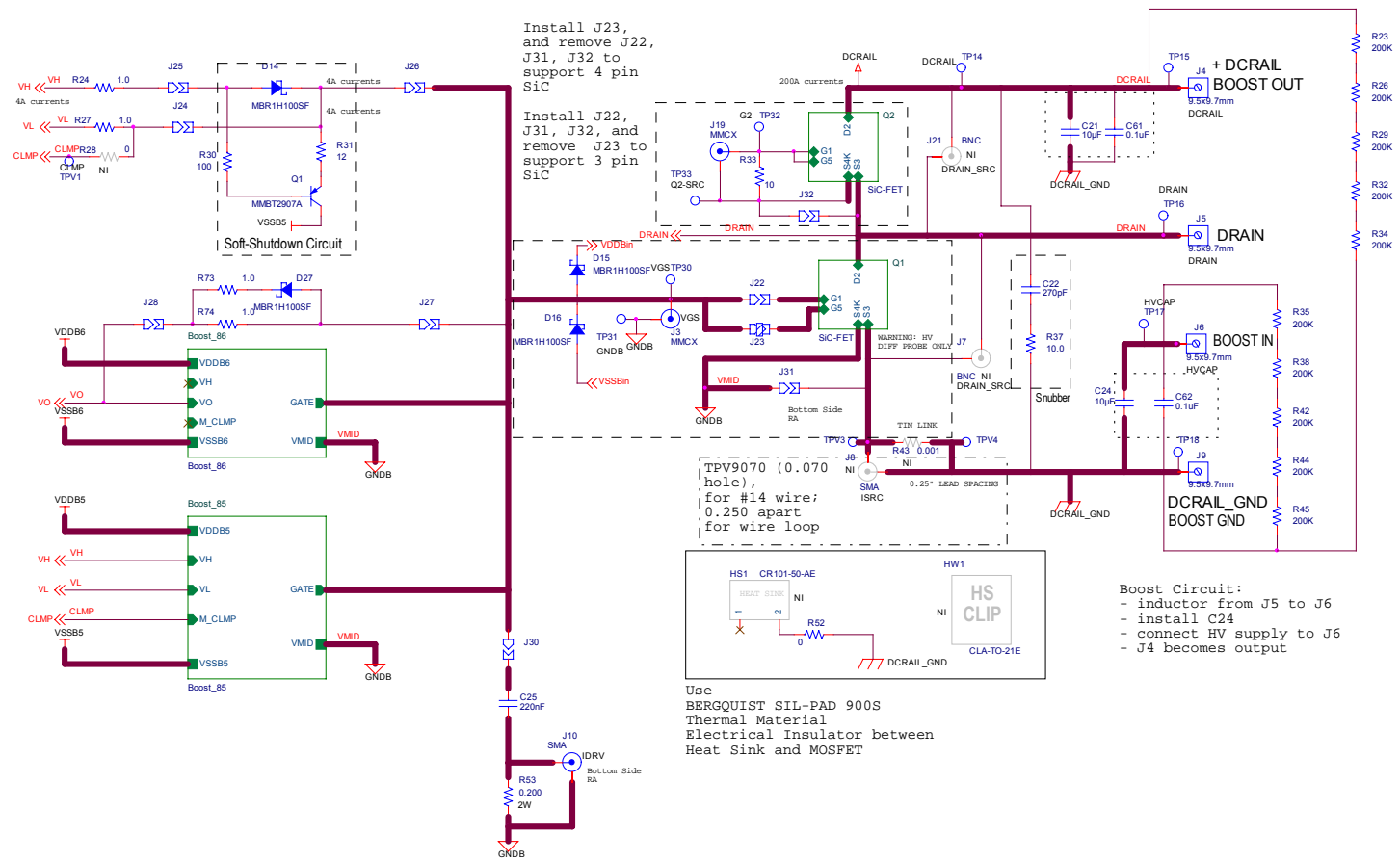

Figure 1.2. Si8286 Gate Driver

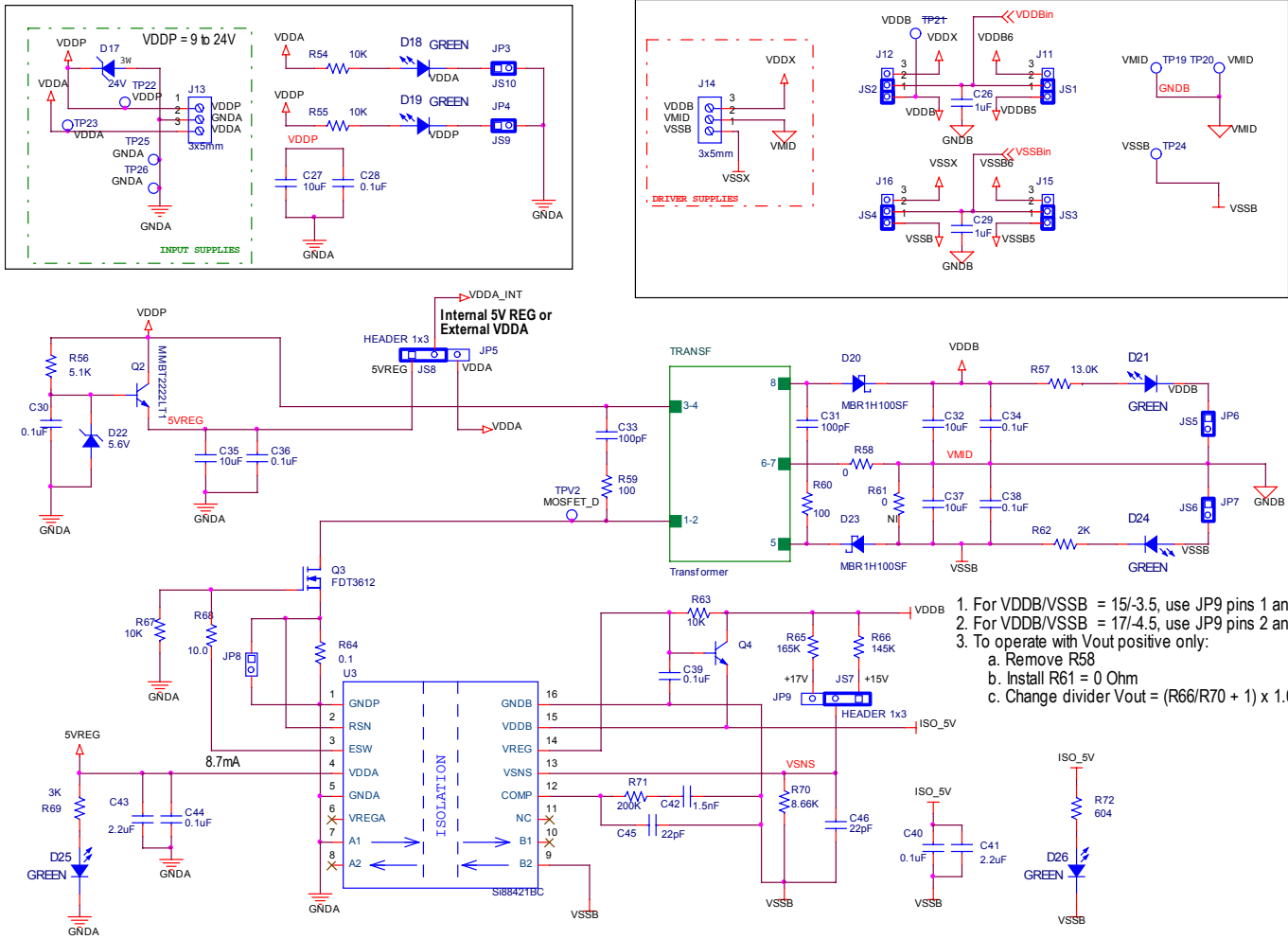**Figure 1.3. Si828x Switching Device Power Circuit**

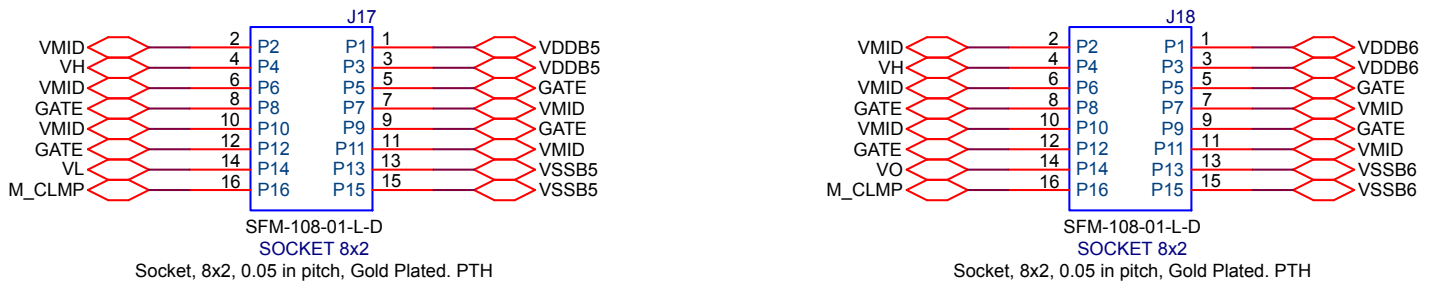**Figure 1.4. Si88421 DC-DC Circuits**

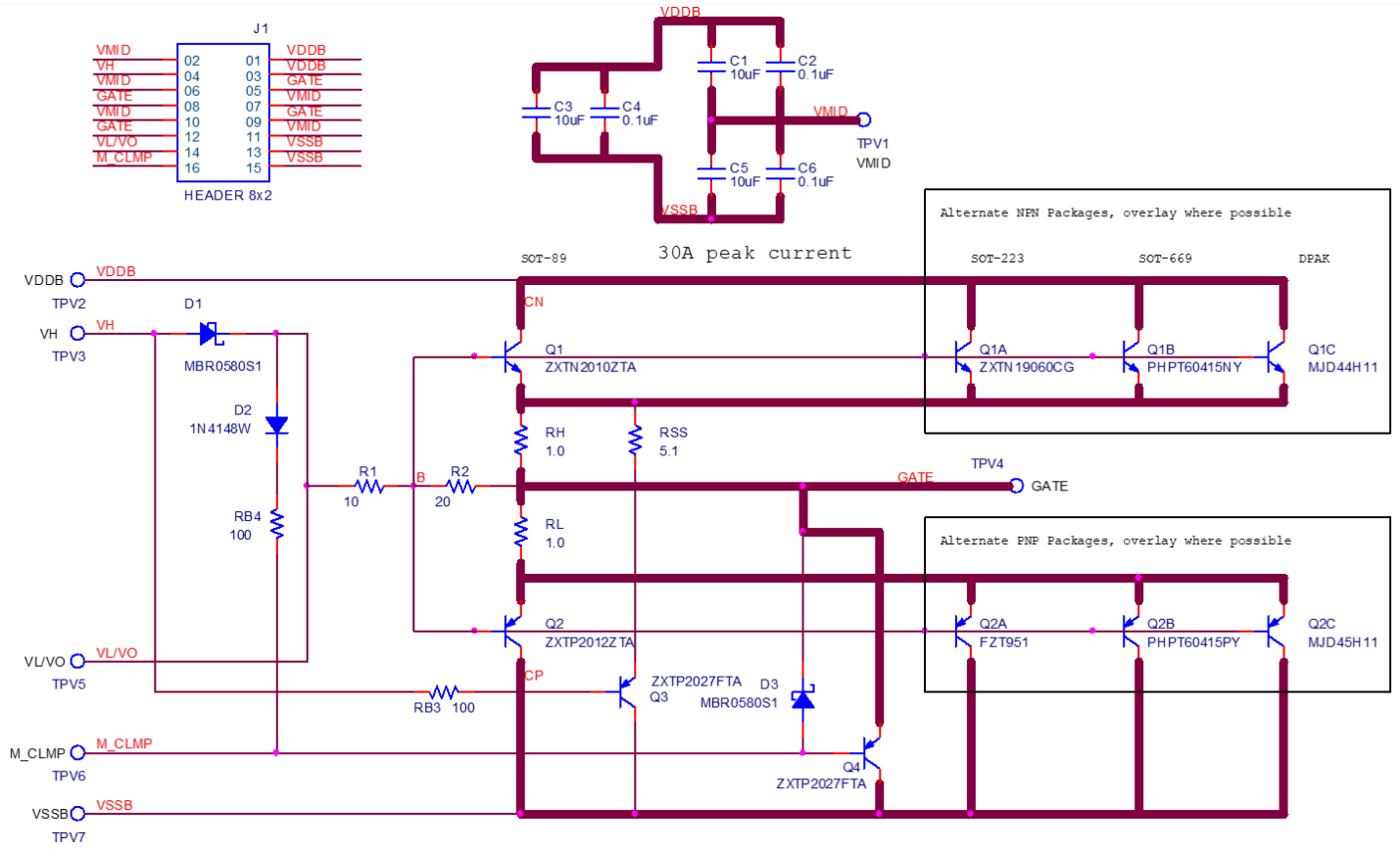**Figure 1.5. Plug for Si8285 and Si8286 Current Booster Daughter Cards**

Figure 1.6. Si8285/Si8286 Booster Daughter Cards

2. Power Up

The Si8285_86v2-EVB only requires a 12 V power supply with 0.25 A minimum current capability to operate since the onboard Si88421 dc-dc generates all voltages to power the gate drivers and SiC/IGBT devices. To power up, check to ensure that the jumpers are connected according to the factory default jumper positions described in the table below, and connect +12 V to terminal block J13 (apply +12 V to Pin 1, labeled VDDP, and the return GND at Pin 2, labeled GNDA).

Table 2.1. Default Jumper Positions (Set at the Factory)

Jumper Number	Purpose
JP1	Connect 2–3, Disable DSAT_5
JP2	Connect 2–3, Disable DSAT_6
JP3	Enable Green VDDA LED
JP4	Enable Green VDDP LED
JP5	Connect 1–2, 5VREG to VDDA
JP6	Enable Green VDDB LED
JP7	Enable Green VSSB LED
JP9	Connect 1–2, set VDDB to +15 V
J12	Connect 1–2, set VDDB to on-board +15 V
J16	Connect 1–2, set VSSB to on-board to –3.5 V

The Si8285_86v2-EVB should be powered up with the following indications:

Table 2.2. Si8285_86v2-EVB Power-Up Test Criteria and Components

Test	Passing Criteria	Associated Components
Green LED D21	Illuminated	T2, R70, R66, Q3, R64, R68, D20, C32, JP6
Green LED D24	Illuminated	T2, R70, R66, Q3, R64, R68, D23, C37, JP7
Left side supply, Pin 1 of JP5	5VREG ~ 5 V	R56, D22, Q2, C30, C35, C36, JP5
Check voltage VDDB–VMID at TP21–TP20	+15 V (±0.5 V))	T2, R70, R66, Q3, R64, R68, D20, C32
Check voltage VSSB–VMID at TP24–TP20	–4 V (±0.5 V)	T2, R70, R66, Q3, R64, R68, D23, C37

3. Testing Gate Driver with Capacitive Load

The Si8285 and Si8286 gate drivers and the current booster daughter cards provide an extensive range of gate currents to drive all SiCs and IGBTs to optimum levels. The Si8285_86v2-EVB includes a test apparatus, as illustrated in the circuit diagram in Figure 3.1, to measure the gate output current. The logical solder bump jumpers, SB1 and SB2, allow testing of the Si828x gate driver directly or through the current booster circuit. The gate resistors, Rg, and the configuration of the current booster circuits set the Si8285 and Si8286 gate current drive levels enabling circuit tuning for specific SiC and IGBT gate current requirements.
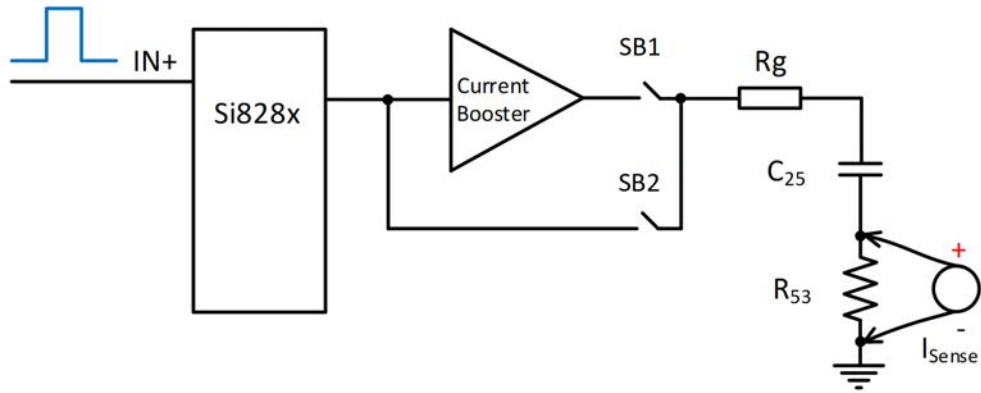

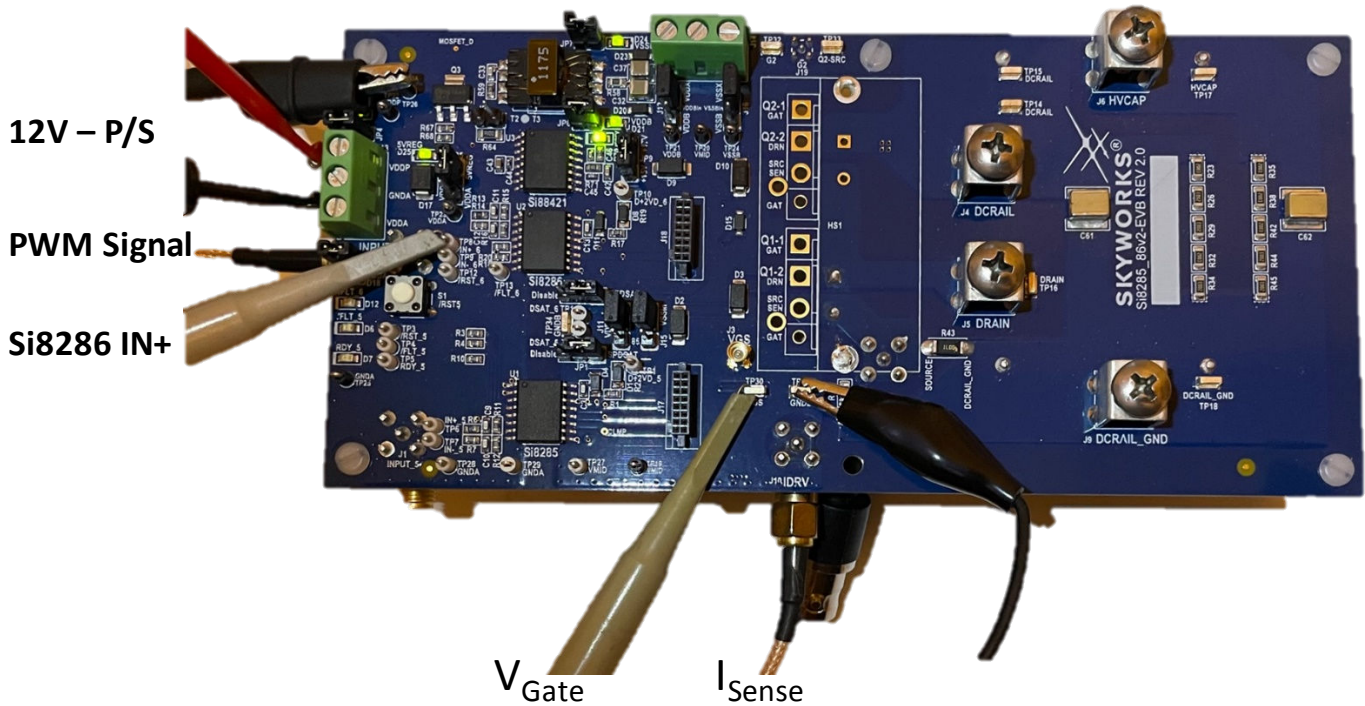**Figure 3.1. Gate Driver Output Current Test Circuit**

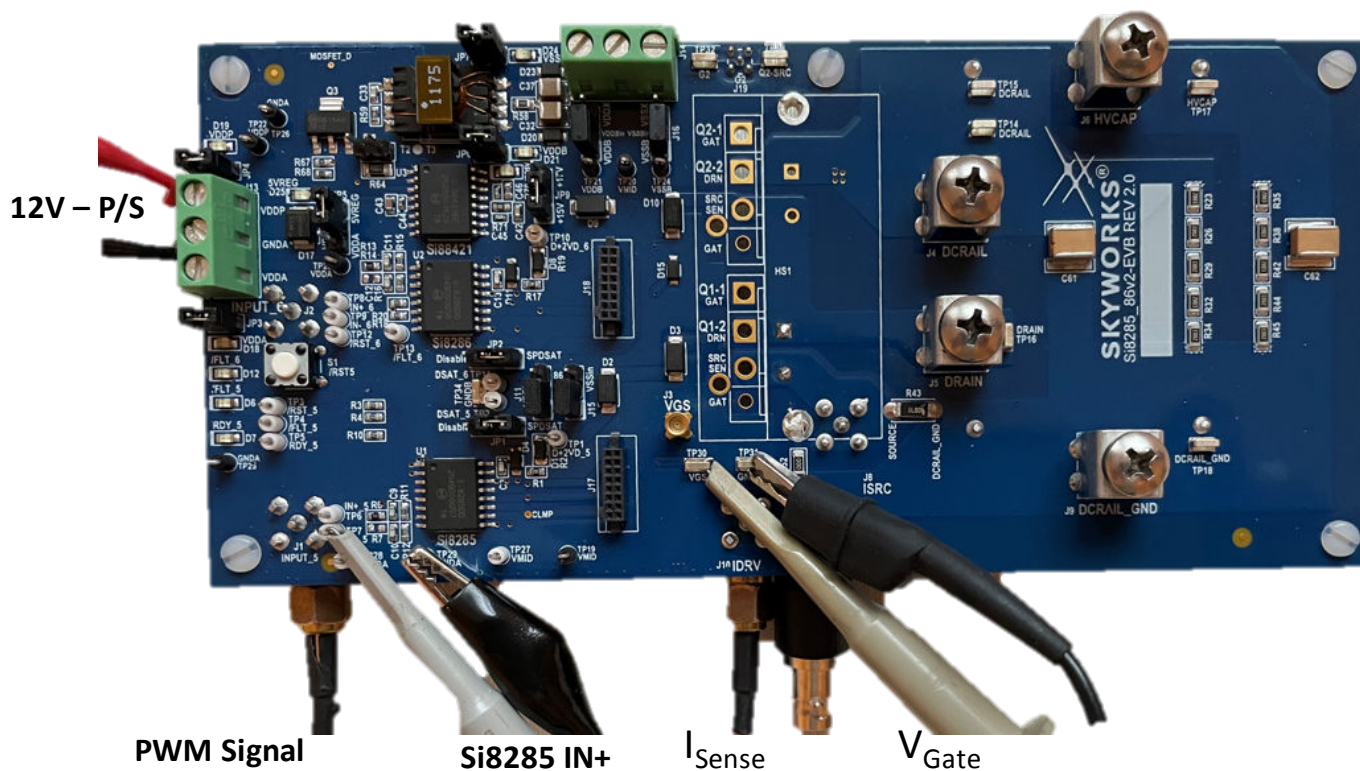**Figure 3.2. Connections for Si8286 Gate Current Testing with a Capacitive Load**

3.1 Connections for Testing with Gate Capacitive Load

The Si8285_86v2-EVB has jumpers and solder bumps (PCB trace jumpers) to selectively connect the capacitive load to the Si8285 output, Si8286 output, or the current booster daughter cards output for gate current testing. The connections are unique for each device under test, as described in the following table.

Table 3.1. Connections for Gate Current Testing

Device under Test (DUT)	Si8285	Si8285 + Booster	Si8286	Si8286 + Booster
J13 (1–2)	+12 V	+12 V	+12 V	+12 V
J2 (SMA: Function Generator)	Open	Open	5 V PWM	5 V PWM
J1 (SMA: Function Generator)	5 V PWM	5 V PWM	Open	Open
Solder bumps: J27, J28	Open	Open	Short	Open
Solder bumps: J24, J25, J26	Short	Open	Open	Open
Solder bump: J30	Short	Short	Short	Short
R28 (0 Ω)	Populated	Removed	N/A	N/A
JP1, JP2 (spd-up/DESAT disable)	Pin 2–3	Pin 2–3	Pin 2–3	Pin 2–3
J11 (VDDB)	Pin 1–2	Pin 1–2	Pin 2–3	Pin 2–3
J15 (VSSB)	Pin 1–2	Pin 1–2	Pin 2–3	Pin 2–3
Booster Daughter	Not populated	Si8285 DC to J17	Not populated	Si8286 DC to J18
IN+ scope probe (PWM)	TP6–TP29	TP6–TP29	TP8–TP26	TP8–TP26
Vgate scope probe	TP30–TP31	TP30–TP31	TP30–TP31	TP30–TP31
Isense SMA (0.2 Ω)	J10 (IDRV)	J10 (IDRV)	J10 (IDRV)	J10 (IDRV)

Figure 3.3. Connections for Si8285 Gate Current Testing with Capacitive Load

The Si8285_86v2-EVB is shipped with the default jumper connections for Si8285 testing as described in the second column of Table 3.1 Connections for Gate Current Testing on page 9. The image in the above figure shows the jumpers and instrumentation connections for testing the Si8285 driver with the onboard capacitive load. The following are simple steps for conducting gate current testing:

1. Connect jumpers, solder bumpers, the booster daughtercard, and instrumentation as described in Table 3.1 Connections for Gate Current Testing on page 9.
2. Power up the 12 V power supply that connected to JB13.
3. Set up the function generator connected to SMA J1 or J2: 50 Ω output impedance, single 6 µs 5 Vpp square wave pulse.
4. Set up the oscilloscope to trigger on the IN+ signal (5 V/div).
5. Set up the V_{GS} scope probe 5 V/div to view the gate signal.
6. Set the scope probe that is connected to J10 to 0.2 V per Ampere scale.
7. Send the PWM pulse from the function generator and observe the waveforms on the oscilloscope. Below are some waveforms captured with the Si8285 device.

3.2 Test Results from Testing Gate Driver with Capacitive Load

Figure 3.4 below depicts the Si8285 output current waveform when tested with a capacitive load. Notice the Miller Clamp current spike as the Vgate voltage approaches 2 V (references to VSSB). This behavior indicates the proper operation of the Si8285 Miller clamp circuit.

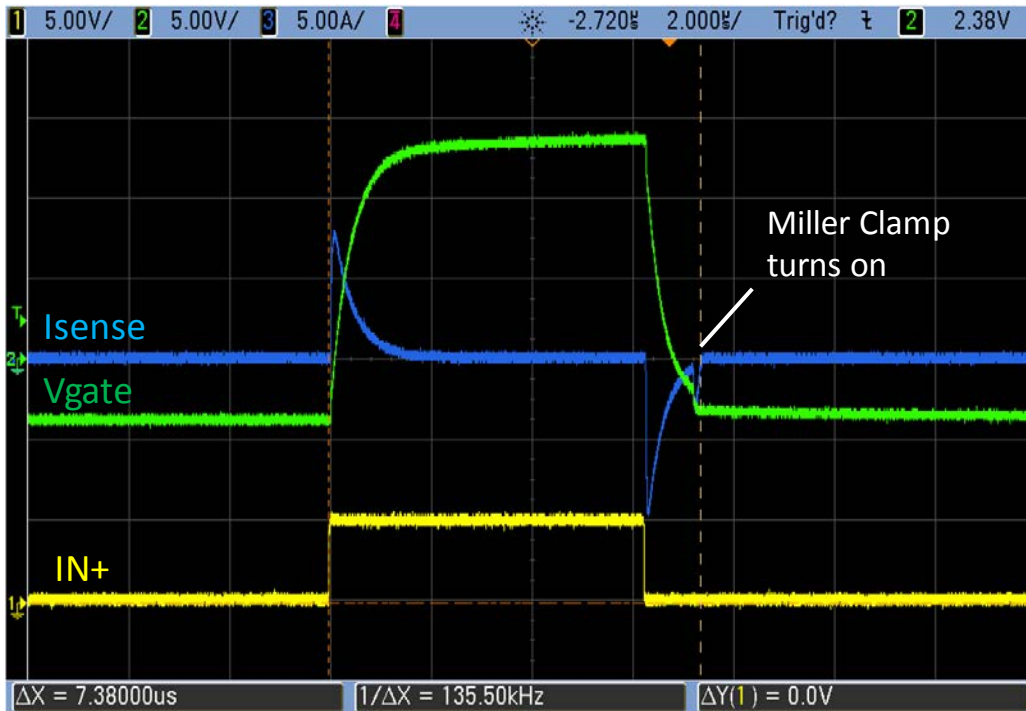**Figure 3.4. Si8285 Gate Driver Output Current**

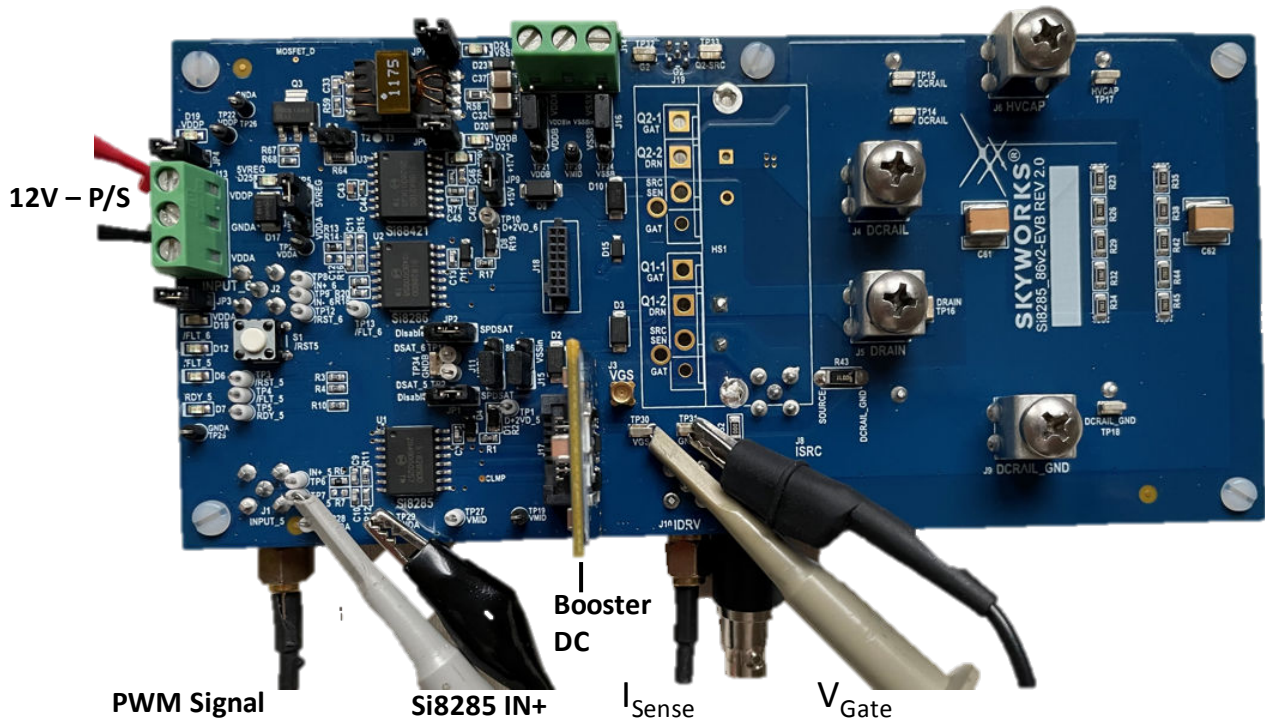Figure 3.5 illustrates the test setup.

Figure 3.5. Testing Connections for Si8285 with Booster DC Gate Current and Capacitive Load

Figure 3.7 Gate Output Current from Si8285 with Booster Daughter Card and Rg = 0 Ω on page 12 shows a higher output current waveform when testing the Si8285 gate driver with the booster current daughter card.
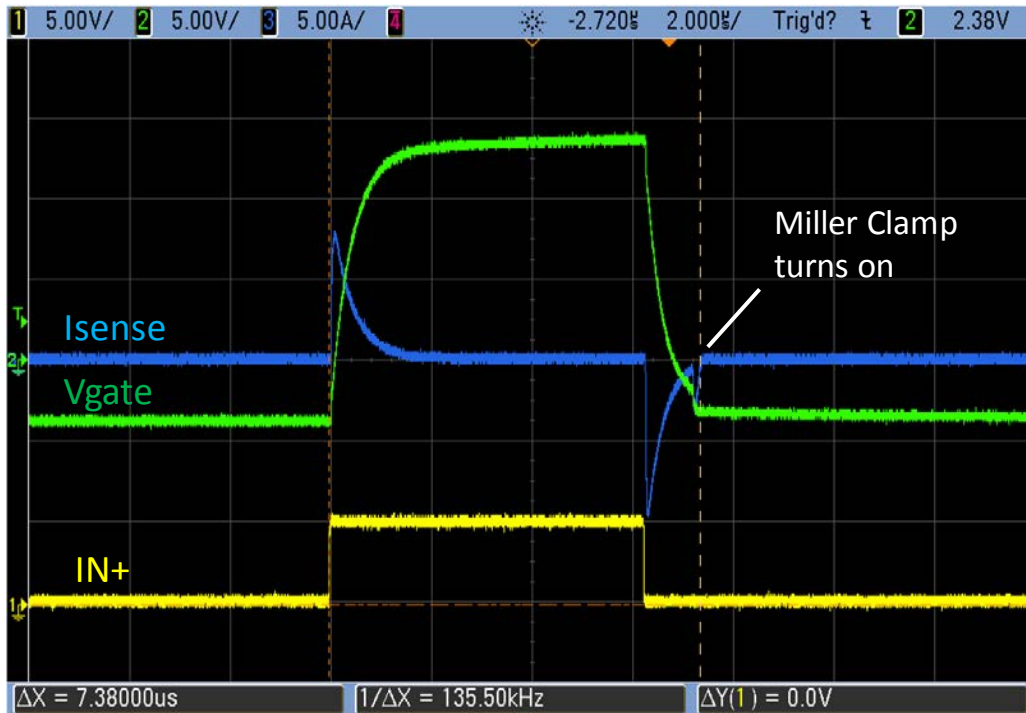
Figure 3.6. Gate Output Current from Si8285 with Booster Daughter Card and Rg = 1 Ω

Figure 3.7 shows that the gate current reaches ~ ± 15 A when RH and RL's gate resistors on the booster daughter card are reduced to 0 Ω.
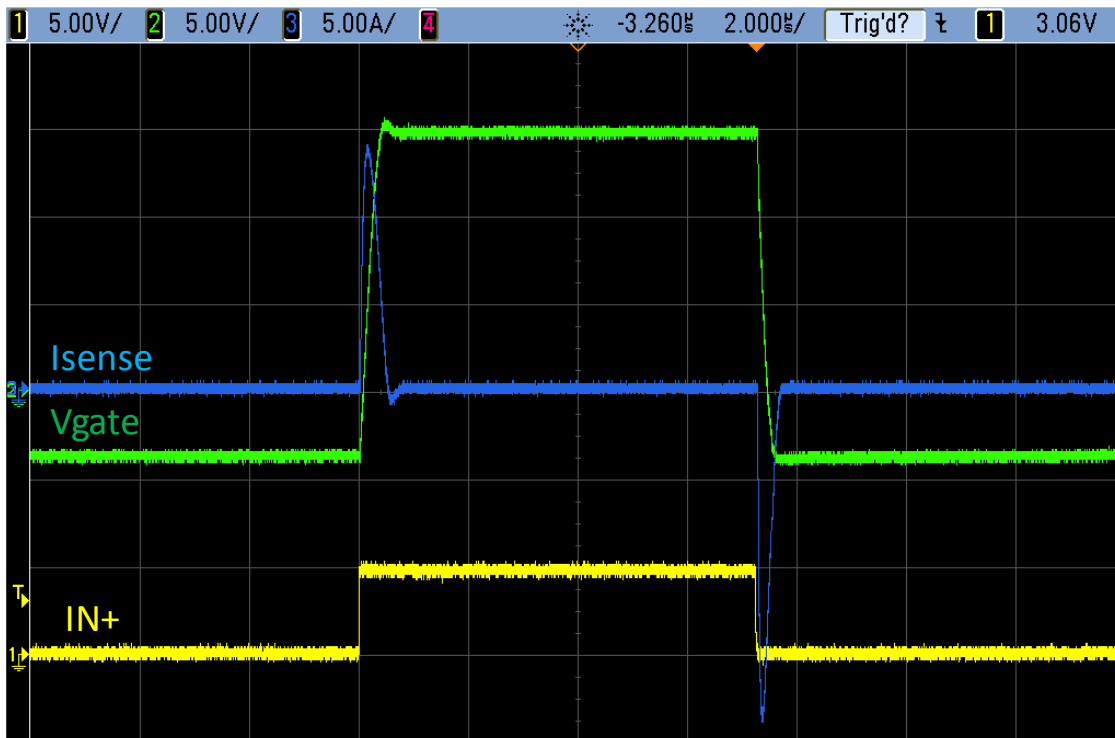
Figure 3.7. Gate Output Current from Si8285 with Booster Daughter Card and Rg = 0 Ω

The values of R1 and R2 on the booster daughter card (see Figure 1.6 Si8285/Si8286 Booster Daughter Cards on page 6) can be adjusted to support applications that require gate current above 15 A. Below are the minimum and maximum values for R1 and R2:

• R1: minimum 1 Ω (a lower value for higher output current)

• R2: Maximum 40 Ω (a higher value for higher current output)

3.3 Additional Advice

The values of the RH, RL, the gain β value of the Q1, Q2 transistors, and R1 and R2 set the output current. These flexible controls allow the user to fine tune gate current for the specific SiC FET or IGBT device being driven. Designers should explore changing the values of the RH, RL, R1, and R2 before changing the Q1 and Q2 transistors since higher gain β bipolar transistor cost more.

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

4. Double Pulse Testing and Switching Loss

Figure 4.1 below shows a simplified Si8285 double pulse test circuit. When Q1 is on, the current flow begins from the bypass cap, C_{RAIL}, (+RAIL) across the inductor Lo, through Q1, and back to the ground terminal of C_{RAIL}. During the Q1 off period, the Lo current is maintained through the Q2 body diode. The Lo current is ramped up again through Q1 in the next switching cycle. The switching loss is the integral of Q1's V_{DS} times its I_{DS} during the switching transitions. The circuit below can operate with multiple switching cycles enabling Q1 switching loss measurement at different I_{DS} current levels.
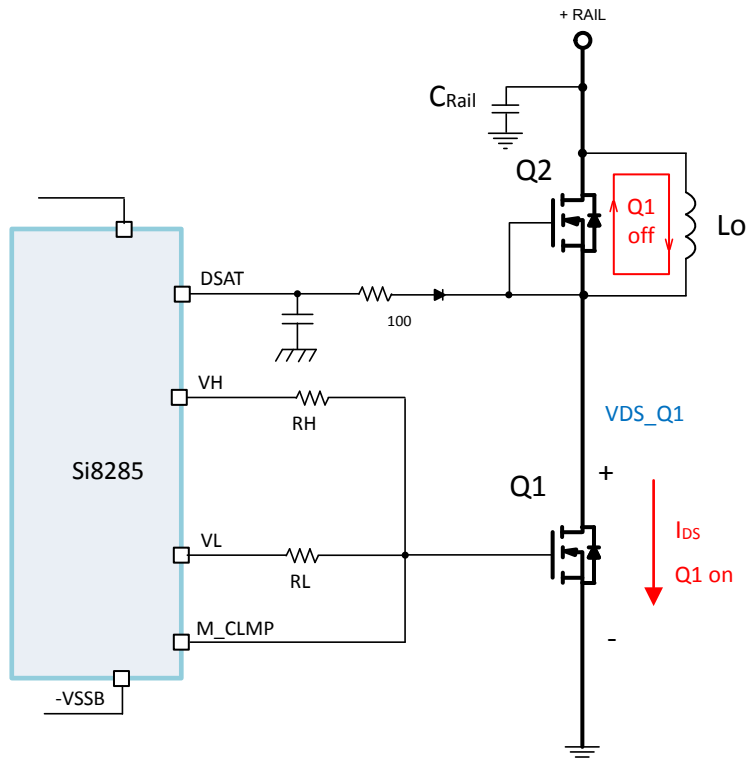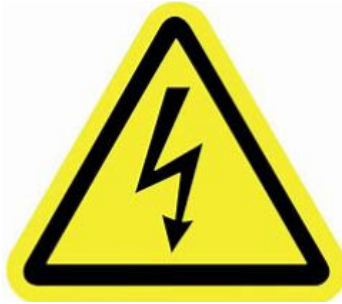

Figure 4.1. Si8285 Double Pulse Test Circuit

4.1 Connections for Double Pulse Switching Loss Testing

Table 4.1 below lists 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 of up to 1000 V.
Do not touch the board once the high-voltage section has been energized.**

Table 4.1. Connections for Double Pulse Switching Loss Testing

Device Under Test (DUT)	Si8285	Si8285 + Booster	Si8286	Si8286 + Booster
J13 (1–2)	+12 V	+12 V	+12 V	+12 V
J2 (SMA: Function Generator)	Open	Open	5 V PWM	5 V PWM
J1 (SMA: Function Generator)	5 V PWM	5 V PWM	Open	Open
Solder bumps: J27, J28	Open	Open	Short	Open
Solder bumps: J24, J25, J26	Short	Open	Open	Open
Solder bump: J30	Open	Open	Open	Open
R28 (0 Ω)	Populated	Removed	N/A	N/A
JP1, JP2 (spd-up/DESAT disable)	Pin 1–2	Pin 1–2	Pin 1–2	Pin 1–2
J11 (VDDB)	Pin 1–2	Pin 1–2	Pin 2–3	Pin 2–3
J15 (VSSB)	Pin 1–2	Pin 1–2	Pin 2–3	Pin 2–3
Booster Daughter	Not populated	Si8285 DC to J17	Not populated	Si8286 DC to J18
Ch4 IsoVU Probe: VGS	J3: MMCX	J3: MMCX	J3: MMCX	J3: MMCX
Ch2 HV Differential Probe	J7: Q1 D–S	J7: Q1 D–S	J7: Q1 D–S	J7: Q1 D–S
Ch3 T&M Research SDN-414-01	R43: I_{SENSE}	R43: I_{SENSE}	R43: I_{SENSE}	R43: I_{SENSE}

The following are steps for conducting a double pulse test:

1. Install Q1 and Q2 and the corresponding solder bumps.
   a. Three pins 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 daughtercard, and instrumentation as described in Table 4.1 above.
3. Use bus wire to short J4–J6 (parallel C21 and C24 for higher current handling capability).
4. Connect an air-core inductor between J4 (DC-Rail) and J5 (Drain).
5. Connect DC-Rail power supply (100 mA minimum current rating) to J6 (+) to J9 (–) and set the output to the appropriate voltage level.
6. Set up the function generator connected to SMA J1 or J2: 50Ω output impedance, five pulses 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 oscilloscope Ch2 to appropriate voltage level for Q1 V_{DS}.
9. Set up the oscilloscope's math function to $\int (ch2 \times\times ch3)$ to calculate the $V_{DS} \times I_{DS}$ switching loss.

10. Power up the 12 V power supply that is connected to JB13 and the DC-Rail power supply (see Step 4).
11. Send PWM pulses from the function generator and observe the waveforms on the oscilloscope.
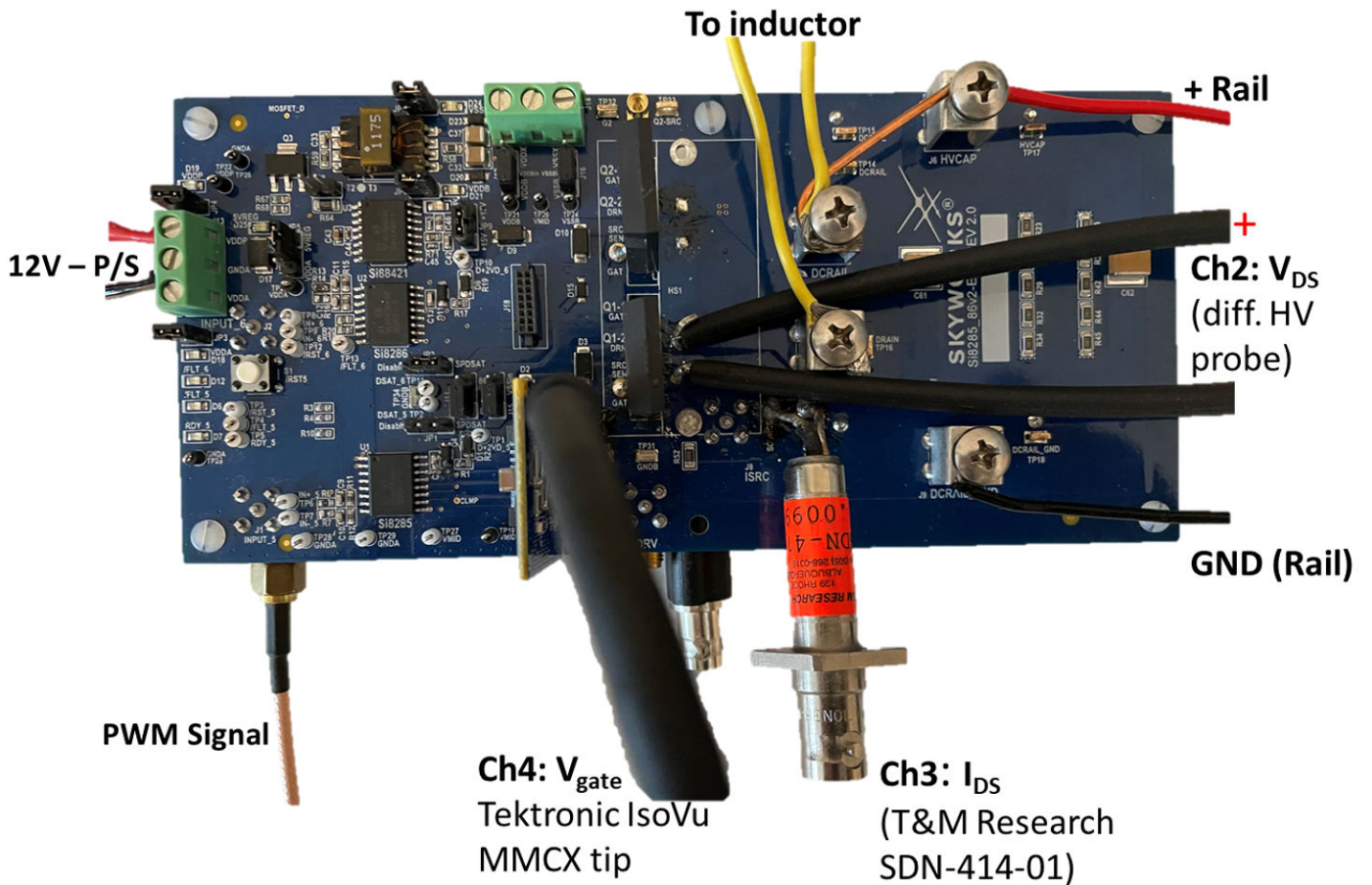

Figure 4.2. Double Pulse Test Connections for Si8285 with Current Booster Card

4.2 Switching Loss Test Results

Figure 4.2 Double Pulse Test Connections for Si8285 with Current Booster Card on page 16 illustrates the connections for the double pulse test with the Si8285 and current booster daughter card. The switching loss data presented in this section were collected under the following test conditions:

1. Q1 and Q2: Wolfspeed C3M0016120K SiC in the 4-pin TO-247 package
2. Rgate = 1 Ω
3. Lo: 24 µH air core inductor
4. V_{DS} = 800 V
5. Five pulses of 350 kHz PWM signal to ramp IDS from 0 A to ~ 200 A

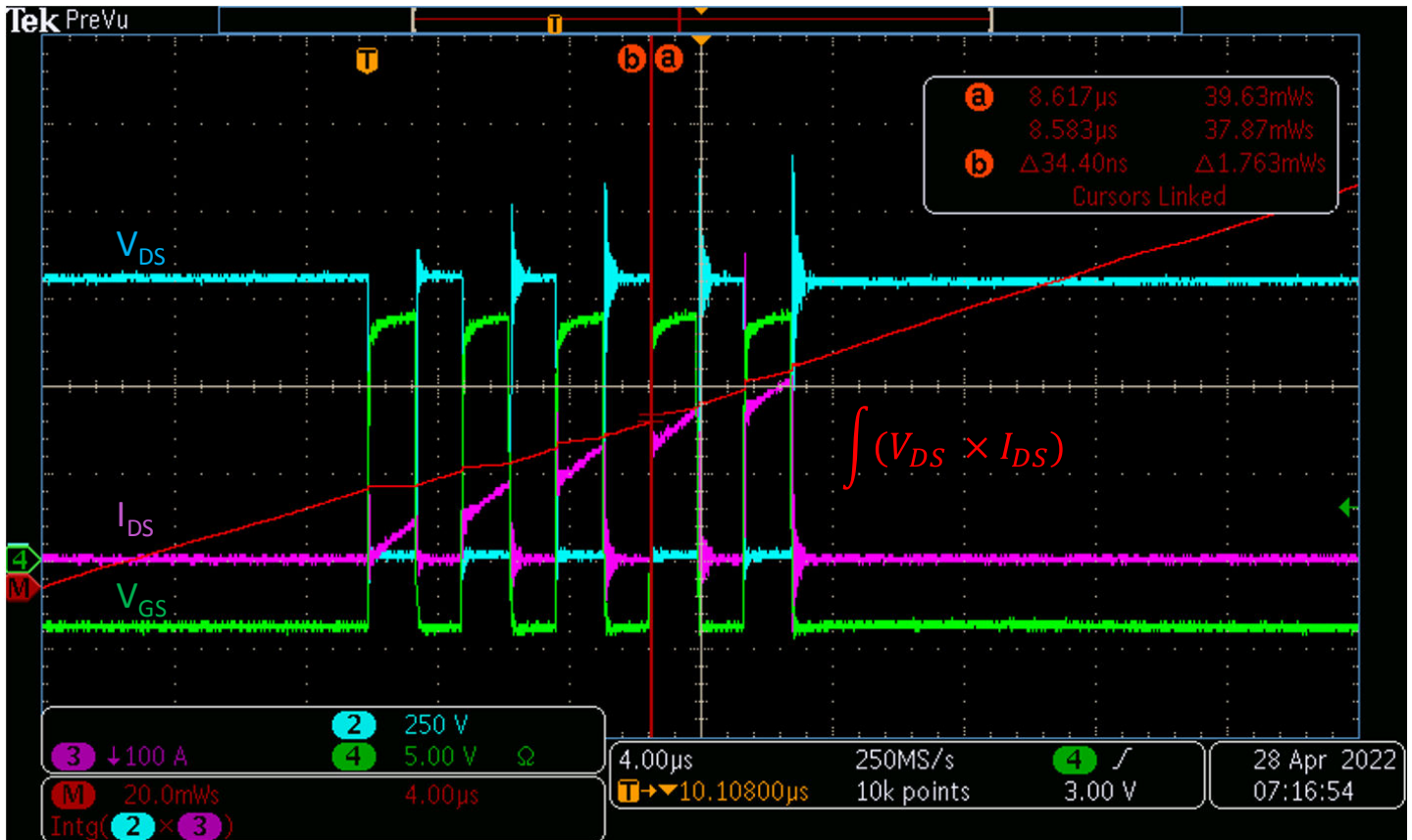Figure 4.3 below shows the double pulse switching waveforms for the above test conditions:

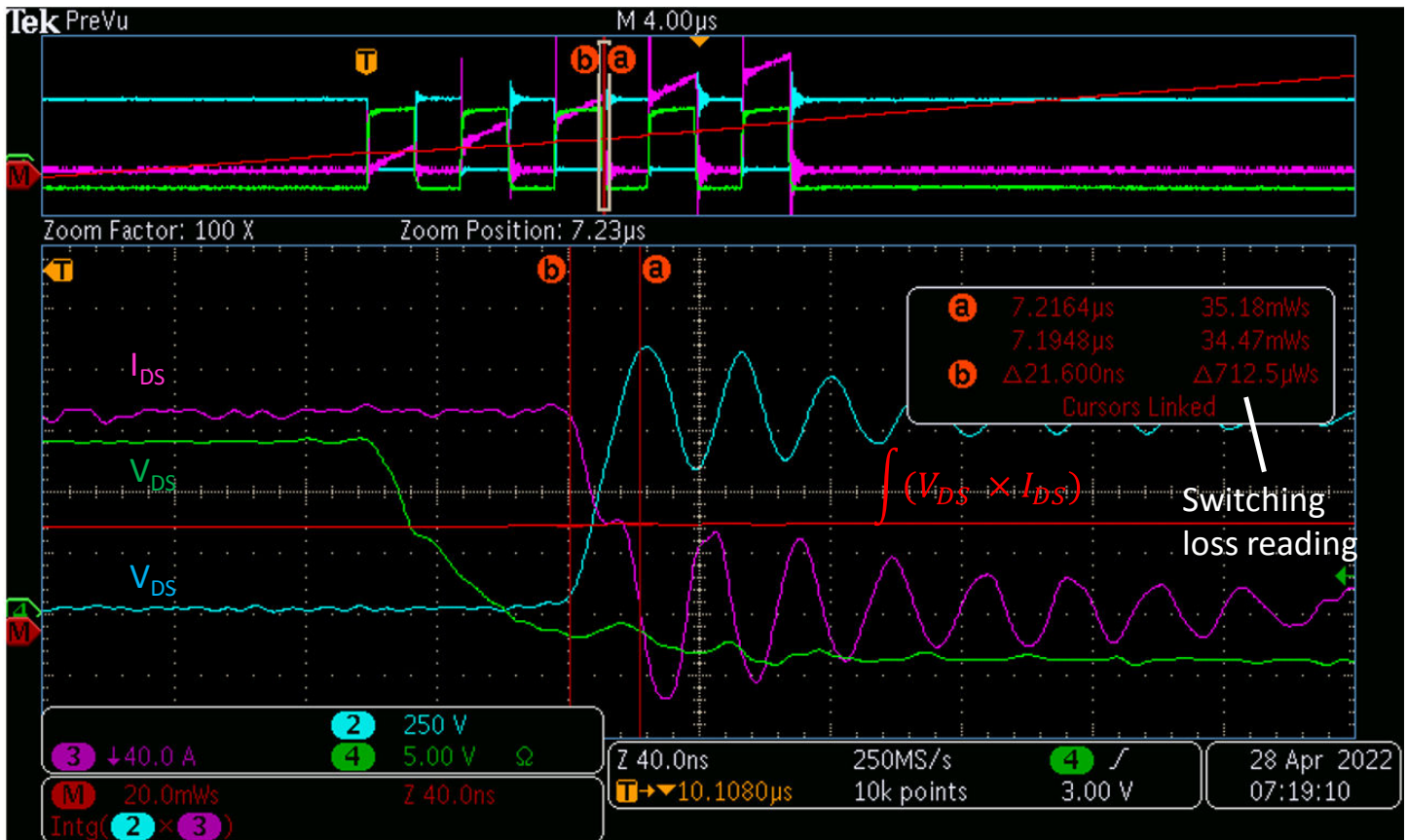**Figure 4.3. Double Pulse Switching Waveforms**

Figure 4.4. Turn Off Switching Waveforms at IDS = 135 A

The oscilloscope math function was set to $\int(ch2 \times\!\!\times ch3)$ to calculate the switching loss from the V_{DS} and I_{DS} waveforms. When the oscilloscope's cursor is placed on the math waveform across the turn-off transition, the scope image in Figure 4.3 Double Pulse Switching Waveforms on page 17 provides the turn-off switching loss of 0.721 mJ reading at I_{DS} = 135 A. This cursor inspection was repeated at every switching transition; the switching loss data is recorded in Table 4.2 and plotted in Figure 4.5 Wolfspeed C3M0016120K SiC Switching Loss Driven by the Si8285 and the Current Booster Card on page 19.

Table 4.2. Si8285 with Current Booster Card Switching Loss[1]

I_{DS}	50	90	128	180
Eoff	0.248	0.43	0.712	1.081
Eon	0.956	1.38	1.763	2.27
Etotal	1.204	1.81	2.475	3.351

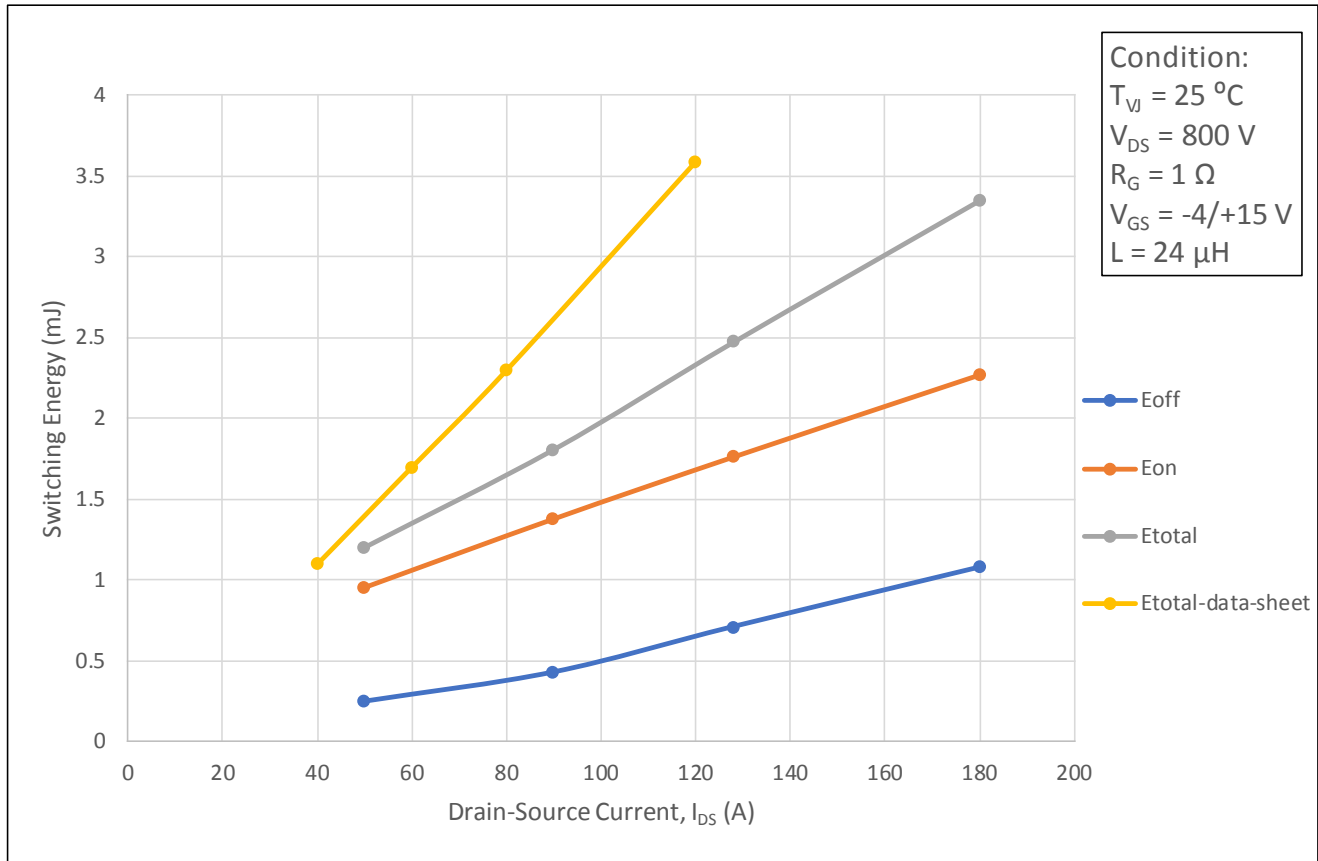Note:
1. Si8285 with DC Rg = 1, 800 V.

Figure 4.5. Wolfspeed C3M0016120K SiC Switching Loss Driven by the Si8285 and the Current Booster Card

4.3 Observations

Note that the above switching loss is lower than the switching loss shown in Figure 24, page 7, of the Wolfspeed C3M0016120K data sheet. Figure 4.5 above includes the total switching loss from the C3M0016120K data sheet (curve with square markers, Etotal-datasheet) and the switching loss when tested with the Si8285 + daughter card (curve with diamond marker, Etotal). Clearly, at 100 A operating current, the Si8285 + booster circuit total switching loss Etotal is 31% (1.9 mJ versus 2.8 mJ) lower than the total switching loss, Etotal-data-sheet published in the Wolfspeed C3M0016120K data sheet. This result is based on a difference in test conditions and the significant reduction in switching loss that the Current Booster Daughter Card provides.

5. DESAT Short Circuit Test

The short circuit testing was performed by creating a low-impedance connection from the Drain of the switching device Q1 to the +RAIL (see figure below). When Q1 is turned on, it will be exposed to a high-voltage, high-current, short-circuit condition. The Si828x gate driver must detect this condition with the DESAT feature and turn off Q1 within its short-circuit withstand time (safe duration before permanent damage).
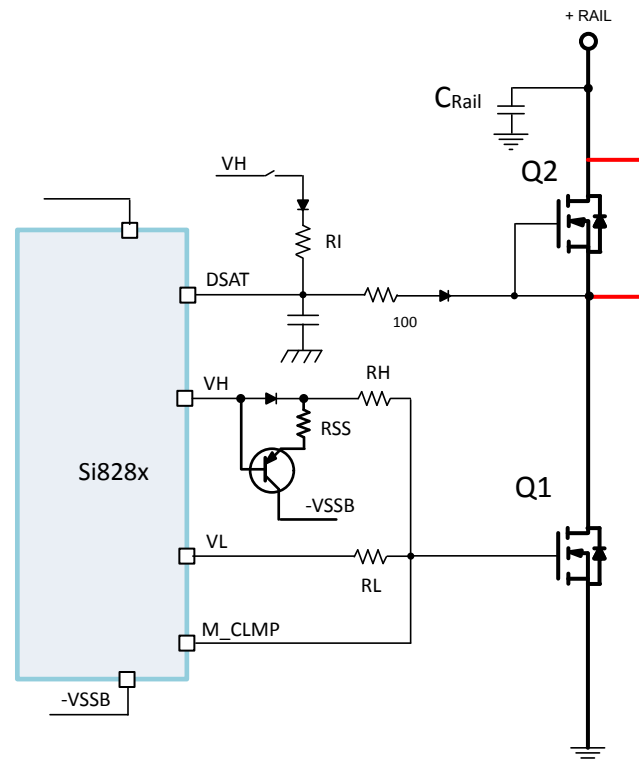
Figure 5.1. Si8285 DESAT Test Circuit

The Si828x with the external components provides adjustments for detection, soft shutdown durations, and total DESAT response time. Below is a list of the resistors that provide Si828x DESAT timing adjustments.

1. **Detection: RI**
   The Si8285_86v2-EVB comes with the installed RI value of 2.2 kΩ. The value of the RI sets the DESAT detection time; the lower the RI value, the faster the DESAT detection timing (minimum value is 1 kΩ). If RI is removed from the DESAT circuit (JP1 and JP2), the internal Si828x current source and the value of the capacitor on the DSAT pin sets the detection time to its maximum value.

2. **Soft Shutdown: RSS**
   The Si828x has a fixed internal RSS of 50 Ω. The value of the RSS is directly proportional to the DESAT soft shutdown, the lower the RSS value, the shorter the soft shutdown duration. An external bipolar transistor operates with the Si8285 to provide adjustment to the RSS value (Figure 5.1 Si8285 DESAT Test Circuit on page 20). The locations of the RSS-s are depended on the Si8285 testing configuration. For testing with the Si8285 driver only, R31 on the Si8285_86v2-EVB is the RSS. However, when testing the Si8285 driver with the current booster card, R5 on the current booster card is the RSS. Note that the Si8286 driver has only one output pin and does not support the external RSS adjustment circuit.

The above two adjustments set the DESAT protection response time, defined as the duration where the I_{DS} current goes from ~ 0 A back down to ~ 0 A in a short circuit event. For robust protection, the DESAT protection response time should be less than 3 µs for IGBTs or 1 µs for SiC FETs.

5.1 Connections for DESAT Short Circuit Test

Table 5.1 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.
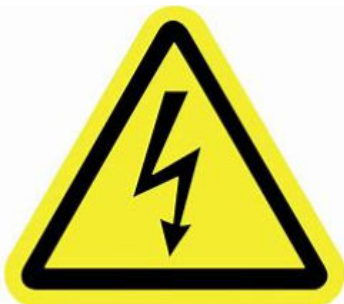
**DANGER! This board may contain high voltages of up to 1000 V.
Do not touch the board once the high-voltage section has been energized.**

Table 5.1. Connections for Si828x DESAT Short-Circuit Test

Device Under Test (DUT)	Si8285	Si8285 + Booster	Si8286	Si8286 + Booster
J13 (1–2)	+12 V	+12 V	+12 V	+12 V
J2 (SMA: Function Generator)	Open	Open	5 V PWM	5 V PWM
J1 (SMA: Function Generator)	5 V PWM	5 V PWM	Open	Open
Solder bumps: J27, J28	Open	Open	Short	Open
Solder bumps: J24, J25, J26	Short	Open	Open	Open
Solder bump: J30	Open	Open	Open	Open
R28 (0 Ω)	Populated	Removed	N/A	N/A
JP1, JP2 (spd-up/DESAT disable)	Pin 1–2	Pin 1–2	Pin 1–2	Pin 1–2
J11 (VDDB)	Pin 1–2	Pin 1–2	Pin 2–3	Pin 2–3
J15 (VSSB)	Pin 1–2	Pin 1–2	Pin 2–3	Pin 2–3
Booster Daughter	Not populated	Si8285 DC to J17	Not populated	Si8286 DC to J18
Ch4 IsoVU Probe: VGS	J3: MMCX	J3: MMCX	J3: MMCX	J3: MMCX
Ch2 HV Differential Probe	J7: Q1 D–S	J7: Q1 D–S	J7: Q1 D–S	J7: Q1 D–S
Ch3 T&M Research SDN-414-01	R43: I_{SENSE}	R43: I_{SENSE}	R43: I_{SENSE}	R43: I_{SENSE}

The following are the steps for conducting a double pulse test:

1. Install Q1 and Q2 and the corresponding solder bumps.
   a. Three pins 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 daughtercard, and instrumentation as described in Table 5.1 above.
3. Solder a bus wire across the Drain to Source terminals of Q2 (see Figure 5.2 Connections for Si8285 DESAT Test Circuit on page 22).
4. Use a bus wire to short J4–J6 (parallel C21 and C24 for higher current handling capability).
5. Connect the DC-Rail power supply (100 mA minimum current capability) to J6 (+) to J9 (–) and set the output to the appropriate voltage level.
6. Set up the function generator connected to SMA J1 or J2: 50 Ω output impedance, single 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 V_{DS} voltage level.
9. Power up the 12 V power supply that connected to JB13 and the DC-Rail power supply (see Step 4).

10. Send a single PWM pulse from the function generator and observe the waveforms on the oscilloscope.
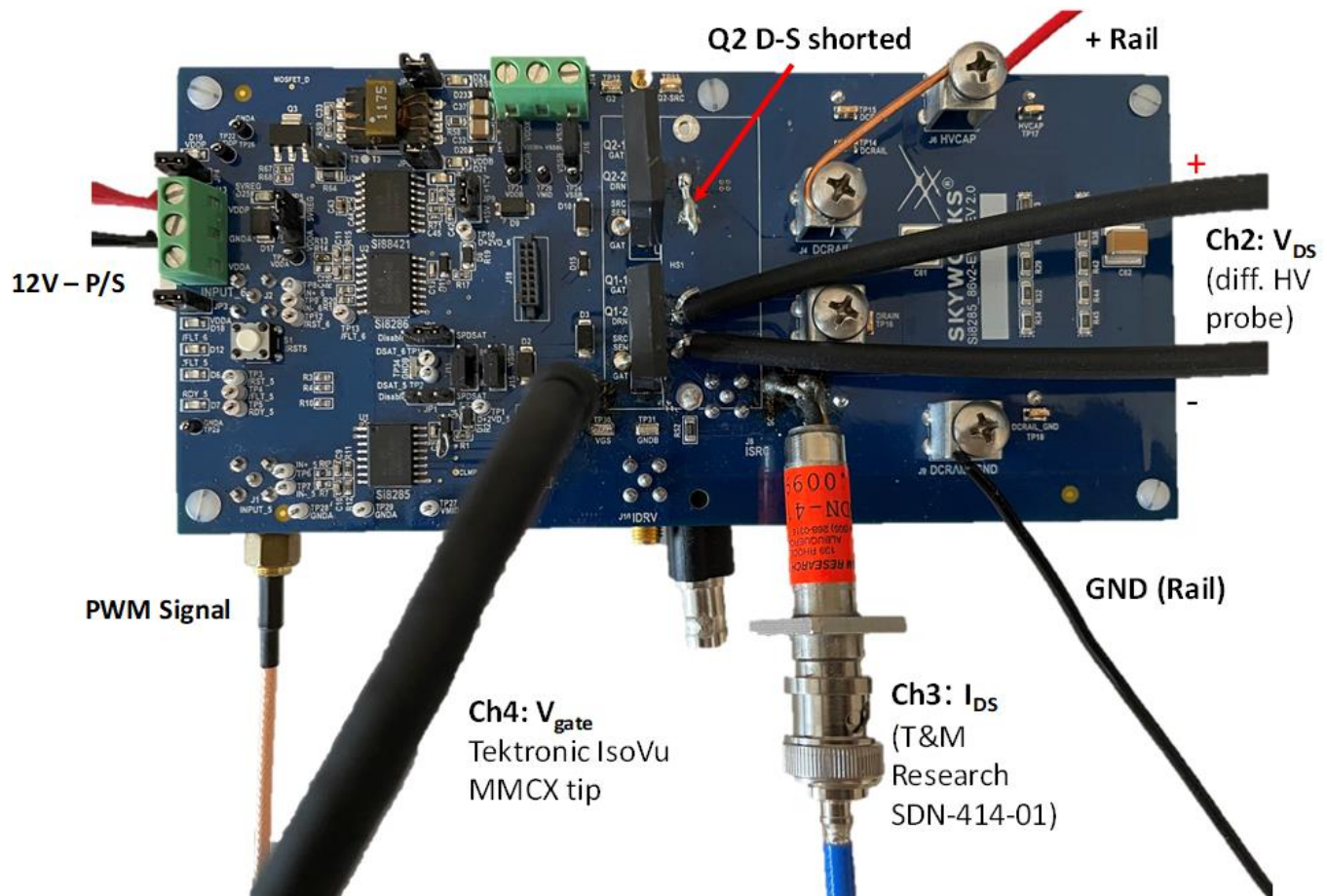

Figure 5.2. Connections for Si8285 DESAT Test Circuit

5.2 DESAT Short Circuit Test Results

Figure 5.3 below illustrates the Si8285 DESAT performance when testing with the daughter card, RI = 2.2 kΩ, RSS = 5.1 Ω, and Wolfspeed C3M0016120K SiC FET. Notice that the short circuit response time is 570 nS (less than 1µS), and the V_{DS} voltage spike is 325 V.

Figure 5.4 illustrates the Si8285 DESAT characteristics when testing with the daughter card, RI = 2.2 kΩ and RSS = 22 Ω. Note that the larger RSS value increases the response time from 570 ns to 680 ns while reducing the V_{DS} voltage spike from 325 V to 240 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 5.5 illustrates the Si8285 DESAT characteristics that were fine tuned for an IGBT device. The jumper on JP1 is removed to disconnect the RI from the DESAT circuit, and the internal Si8285 current source sets the DESAT detection time to the maximum. This setting resulted in a DESAT response time of 2.2 µs, which is within the IGBT maximum short circuit response time requirement of 3 µs.
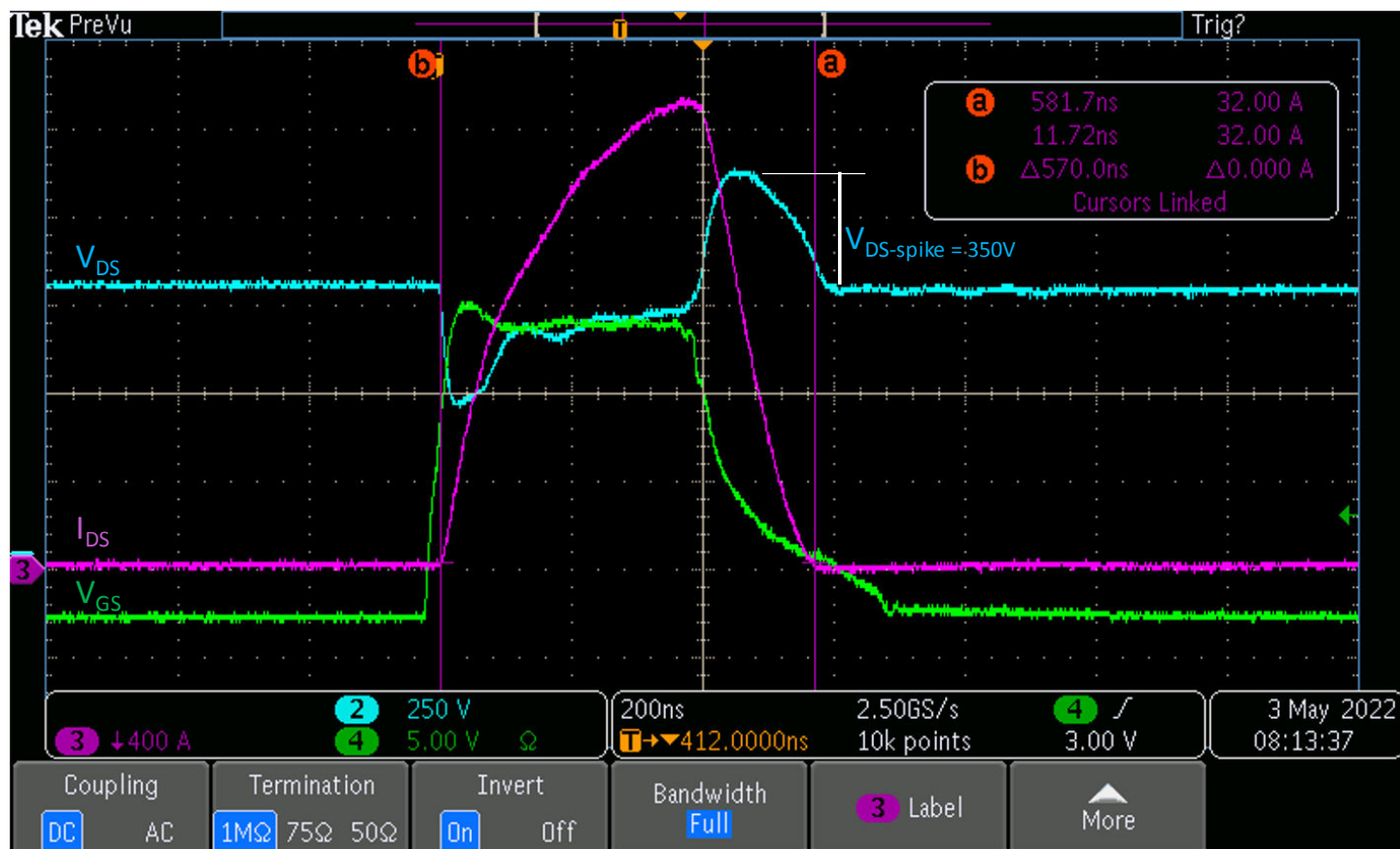

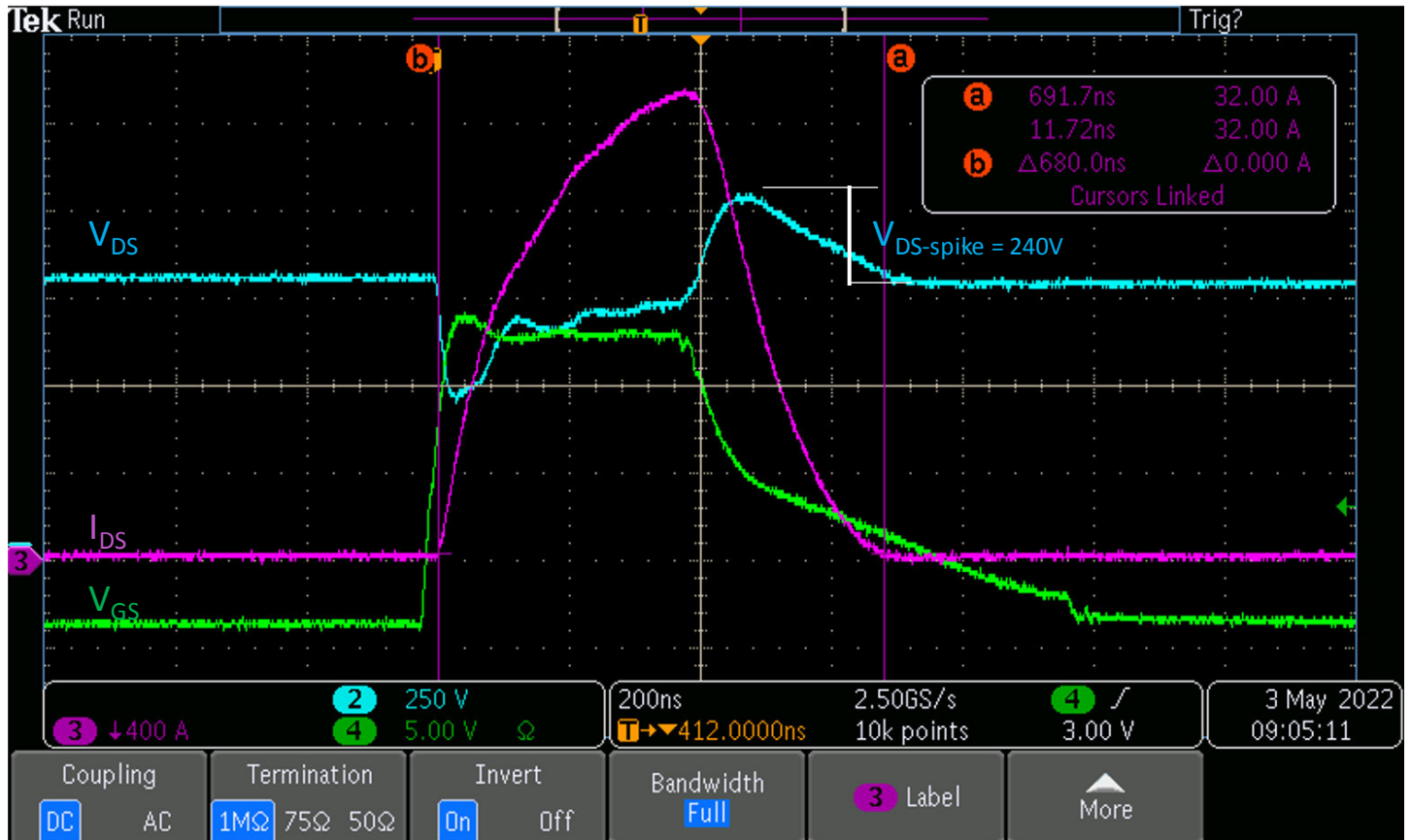**Figure 5.3. Si8285 DESAT Waveform with V_{Rail} = 800 V and RSS = 4.5 Ω, and C3M0016120K SiC**

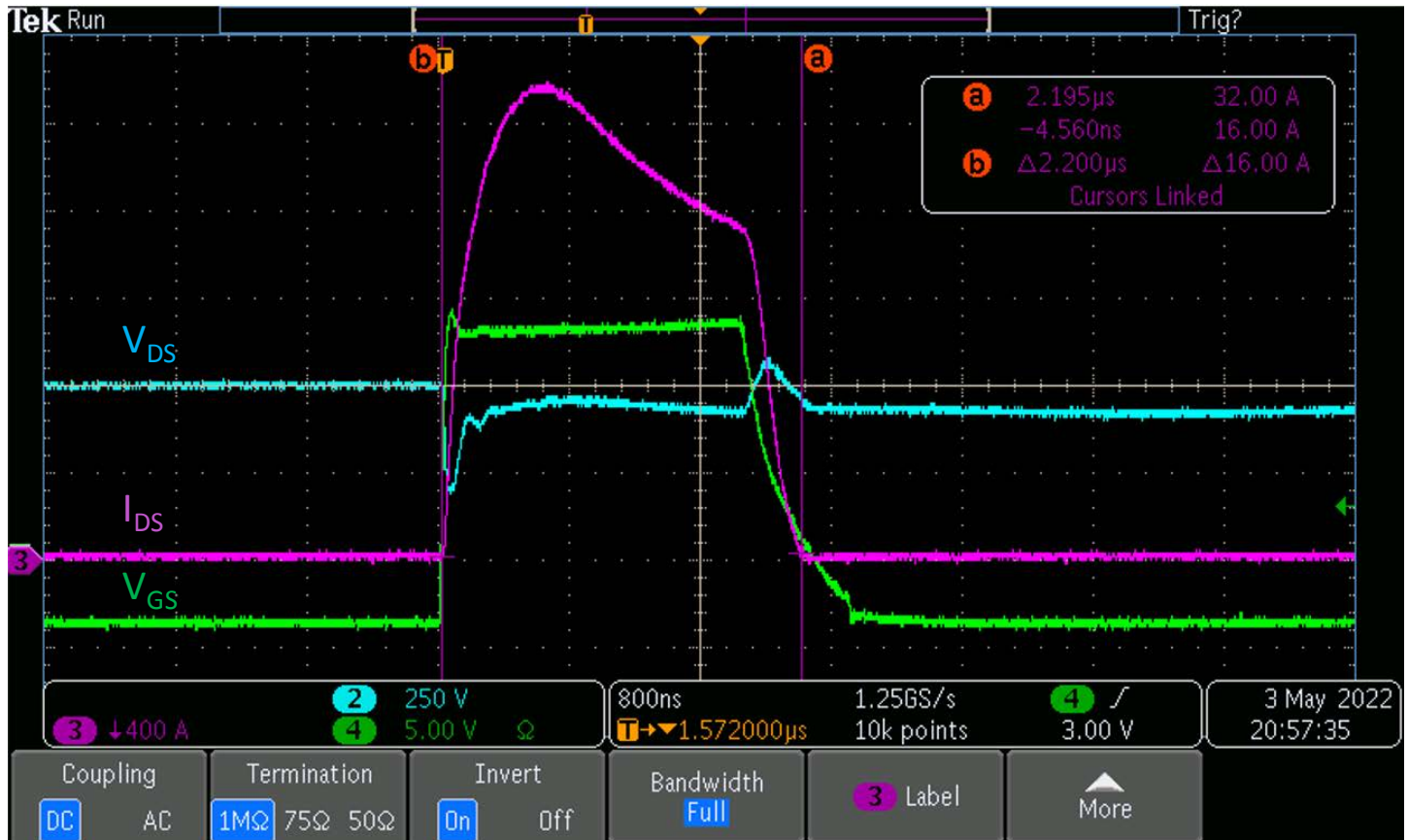**Figure 5.4. Si8285 DESAT Waveform with V_{Rail} = 800 V, RSS = 22 Ω, and C3M0016120K SiC**

**Figure 5.5. Si8285 DESAT Waveform with V_{Rail} = 800 V and RSS = 22 Ω, and without RI (Setting for IGBT)**

5.3 DESAT Short Circuit Test Conclusions

The Si828x gate driver circuits provide flexible adjustments to optimize the DESAT protection feature for all switching devices and power converter applications.

6. Boost DC-DC Converter Test

The Si8285_Si8286-EVB can be configured as shown in Figure 6.1 below to connect the Si828x and switch devices in the boost dc-dc converter circuit. Q1 ramps the input current from + Vin across the Lo inductor during the on-time. The Lo current flows through the Q2 body diode to the output during the off time. According to the circuit in the figure below, the Vout comprises of the Vin plus the inductor voltage; thus, Vout is always larger than the Vin (definition of the booster dc-dc converter). This circuit enables performance testing of the Si828x gate driver and power switching device in a real boost dc-dc converter application.

Notice that, for output power higher than 100 W, sufficient heat sink and airflow to Q1 and Q2 is needed to keep the temperature on the switching devices within recommended parameters.
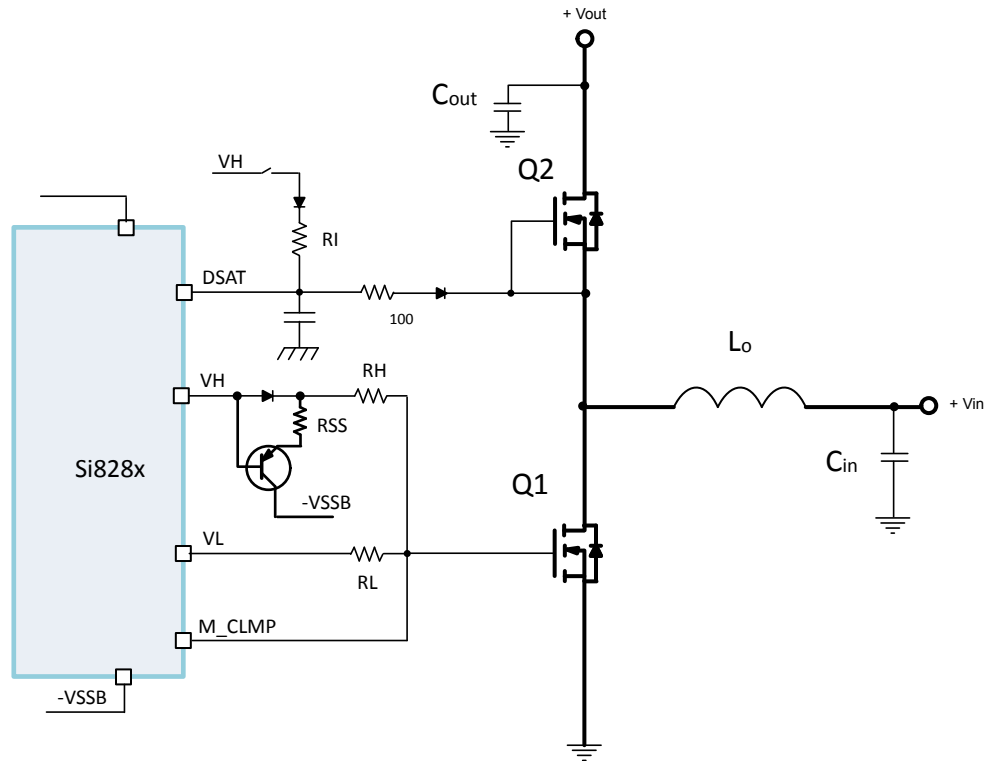
Figure 6.1. Si8285 in Boost DC-DC Converter Test Circuit

6.1 Connections for Si828x Boost DC-DC Converter Test Circuit

Table 6.1 below 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 of up to 1000 V.
**Do not touch the board once the high-voltage section has been energized.**

Table 6.1. Connections for Si8285 Boost DC-DC Converter Circuit Test

Device Under Test (DUT)	Si8285	Si8285 + Booster	Si8286	Si8286 + Booster
J13 (1–2)	+12 V	+12 V	+12 V	+12 V
J2 (SMA: Function Generator)	Open	Open	5 V PWM	5 V PWM
J1 (SMA: Function Generator)	5 V PWM	5 V PWM	Open	Open
Solder bumps: J27, J28	Open	Open	Short	Open
Solder bumps: J24, J25, J26	Short	Open	Open	Open
Solder bump: J30	Open	Open	Open	Open
R28 (0 Ω)	Populated	Removed	N/A	N/A
JP1, JP2 (spd-up/DESAT disable)	Pin 1–2	Pin 1–2	Pin 1–2	Pin 1–2
J11 (VDDB)	Pin 1–2	Pin 1–2	Pin 2–3	Pin 2–3
J15 (VSSB)	Pin 1–2	Pin 1–2	Pin 2–3	Pin 2–3
Booster Daughter	Not populated	Si8285 DC to J17	Not populated	Si8286 DC to J18
Ch4 IsoVU Probe: VGS	J3: MMCX	J3: MMCX	J3: MMCX	J3: MMCX
Ch2 HV Differential Probe	J7: Q1 D–S	J7: Q1 D–S	J7: Q1 D–S	J7: Q1 D–S
Ch3 T&M Research SDN-414-01	R43: I_{SENSE}	R43: I_{SENSE}	R43: I_{SENSE}	R43: I_{SENSE}

Figure 6.2 Connections for Si8285 Boost DC-DC Converter Test Circuit on page 28 shows the physical connections for the Si8285_Si8286v2-EVB in boost dc-dc converter testing. The steps for conducting the Si828x boost dc-dc converter test are as follows:

1. Install Q1 and Q2 and the corresponding solder bumps.
   a. Three pins 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 daughtercard, and instrumentation as described in Table 6.1 above.
3. Install inductor Lo between J5 and J6.
4. Connect +Vin power supply with sufficient voltage and current for the desired power output to J6 (+) and J9 (–).
5. Connect a resistive load to the boost dc-dc converter Vout, J4 (+) and J9 (–).
6. Set up the function generator connected to SMA J1 or J2: 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 V_{GS} signal (Ch4).
9. Setup the scope's ch 2 to appropriate voltage level for Q1 V_{DS}.

10. Power up the 12 V power supply that connected to JB13 and the DC-Rail power supply (see Step 4).

11. Activate the PWM function generator and observe the waveforms on the oscilloscope.

12. Measure the input and output power.
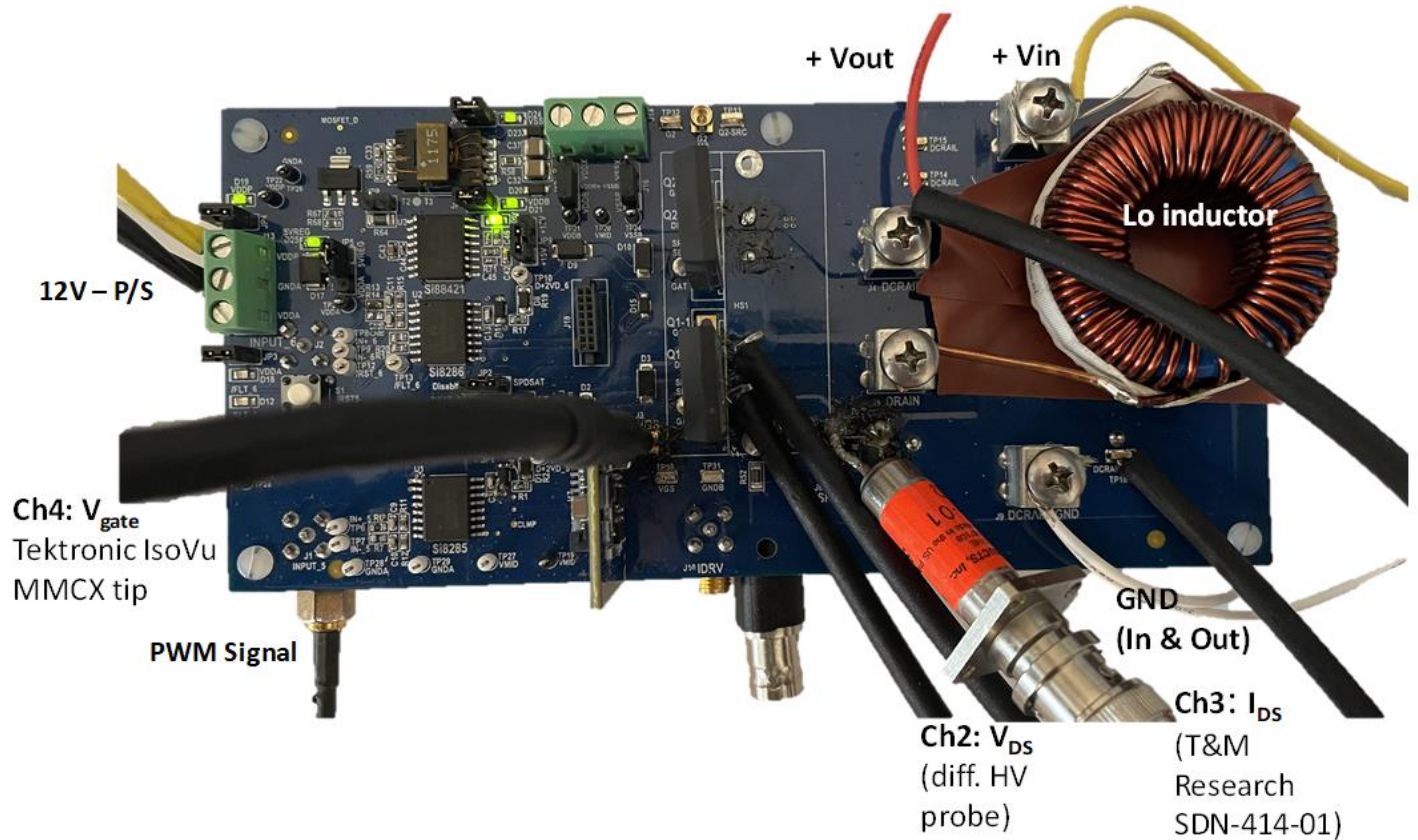
Figure 6.2. Connections for Si8285 Boost DC-DC Converter Test Circuit

6.2 Boost DC-DC Converter Test Results

Below are the specific component selections, testing parameters, and test results for the Skyworks' Si8285 and Wolfspeed C3M0016120K SiC FET switching devices 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: Si8285 with current booster daughter card
- Switching frequency: 10 kHz
- Input power: 150 V, 0.75 A, 112.5 W
- Output power: 330 V, 1 kΩ, 109 W
- Efficiency: (109/112.5) x 100 = 96.88%
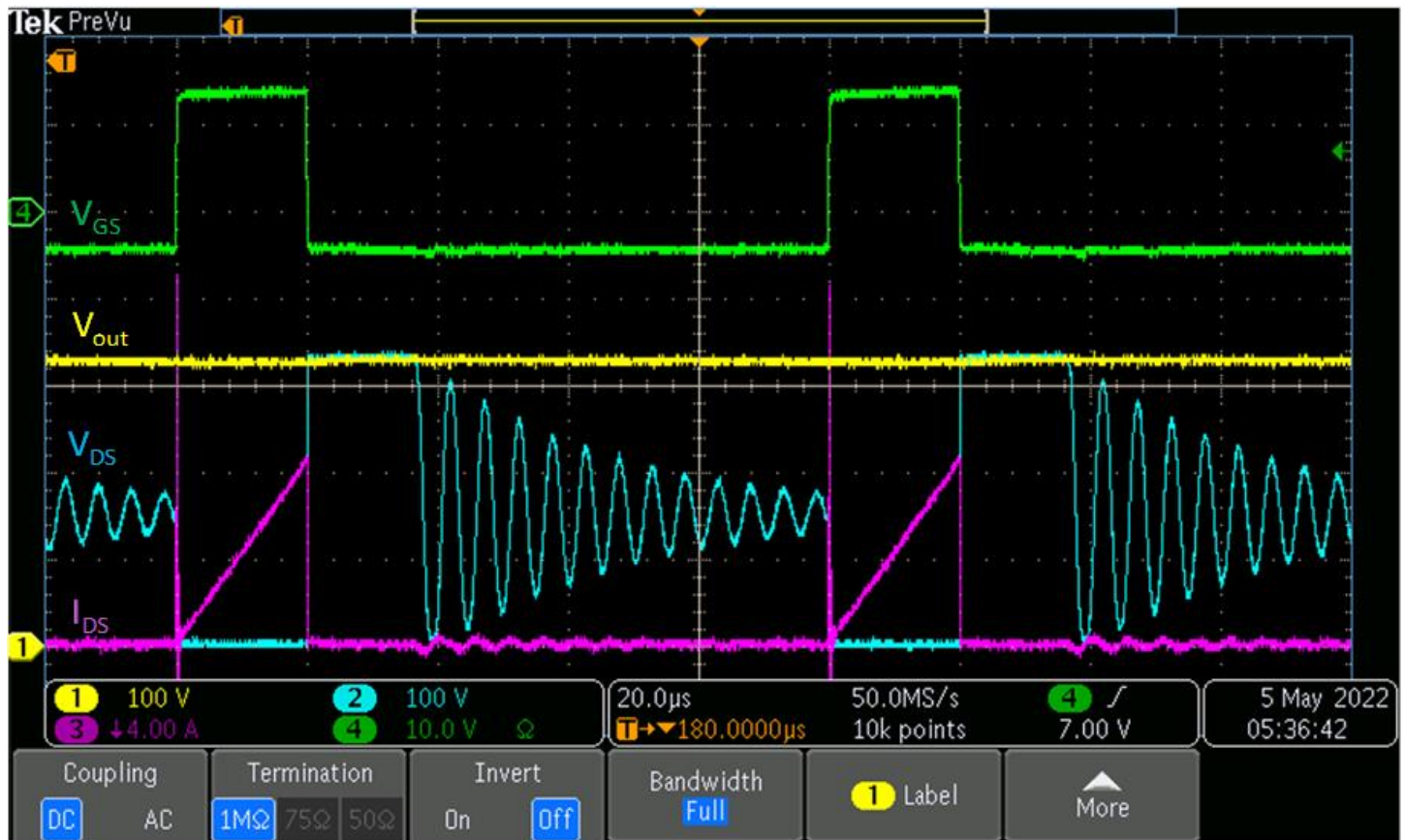
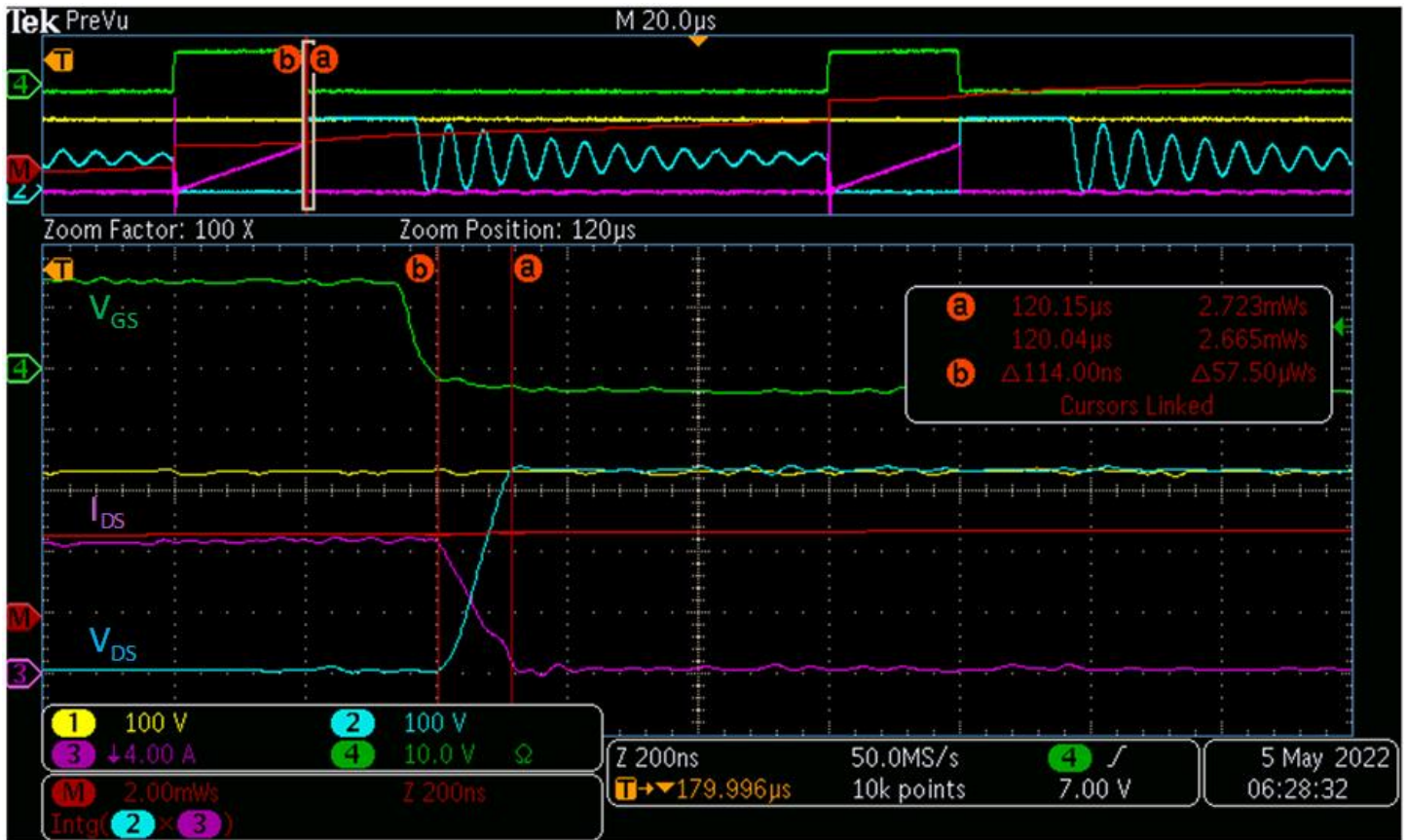**Figure 6.3. Turn-Off Boost DC-DC Converter Switching Waveforms**

Figure 6.4. Turn-Off Transition Boost DC-DC Converter Switching Waveforms

6.3 Boost DC-DC Converter Test Conclusions

The Si8285_86v2-EVB operates well with the Wolfspeed C3M0016120K SiC FET. Even at the low power output of 109 W, the circuit achieves a robust power conversion efficiency of 96.88%. The test setup is simple, flexible, and supports various types of switching devices and Si828x configurations.

7. Conclusion

The Si8285_86v2 EVB is a flexible platform for demonstrating the features of the Si8285 and Si8286 gate drivers with IGBT and SiC FET devices. On the current drive capability, the Si828x and the external current booster circuits provide abundant gate current to drive all IGBT and SiC switching devices to optimum levels for maximum efficiency. Data collected (see 4.2 Switching Loss Test Results) on the Wolfspeed C3M0016120K SiC indicates that, when operating with the larger gate drive current generated by the Si828x and current booster circuit, the switching loss is 31% lower than the switching loss published in the Wolfspeed C3M0016120K data sheet.

The Si828x's DESAT protection circuit has a fast response time (less than 1 μs) to minimize IDS peak current and power dissipation on the switching device and reliably protects it under extreme short-circuit conditions. The Si828x's DESAT circuits also provide flexible control allowing designers to set response timing, soft shutdown timing, and voltage spike levels for optimized protection for the SiC and the slower IGBT switching devices.

8. Bill of Materials

Table 8.1. Si8285/86v2-EVB Bill of Materials

Part Reference	Quantity	Description	Manufacturer	Manufacturer PN
C1, C18, C59	3	CAP, 1 µF, 100 V, ±10%, X7R, 1210	Venkel	C1210X7R101-105K
C2, C4, C6, C14, C16, C19, C28, C34, C38, C60	10	CAP, 0.1 µF, 50 V, ±10%, X7R, 0805	Venkel	C0805X7R500-104K
C3, C13	2	CAP, 200 pF, 50 V, ±5%, C0G, 0603	Venkel	C0603C0G500-201JNE
C5, C7, C15, C17	4	CAP, 2.2 µF, 50 V, ±10%, X7R, 1210	Kemet	C1210C225K5RACTU
C8, C20	2	CAP, 0.01 µF, 10 V, ±20%, X7R, 0603	Venkel	C0603X7R100-103M
C9, C10, C11, C12	4	CAP, 22 pF, 50 V, ±5%, C0G, 0603	Kemet	C0603C220J5GAC7013
C21, C24	2	CAP, 10 µF, 1000 V, ±5%, Poly-Film, PTH	Vishay	MKP1848S61010JY2B
C22	1	CAP, 270 pF, 2500 V, ±5%, C0G, 1812	Kemet	C1812C271JZGACTU
C25	1	CAP, 220 nF, 50 V, ±5%, C0G, 1812	Venkel	C1812C0G500-224JNE
C26, C29	2	CAP, 1 µF, 10 V, ±10%, X7R, 0603	Murata	GRM188R71A105KA61D
C27, C32, C37	3	CAP, 10 µF, 50 V, ±20%, X7R, 1210	Venkel	C1210X7R500-106M
C30, C36, C39	3	CAP, 0.1 µF, 25 V, ±10%, X7R, 0603	Venkel	C0603X7R250-104K
C31, C33	2	CAP, 100 pF, 50 V, ±20%, C0G, 0603	Venkel	C0603C0G500-101M
C35	1	CAP, 10 µF, 50 V, +80/–20%, Y5V, 1210	Murata North America	GRM32DF51H106ZA01L
C40, C44	2	CAP, 0.1 µF, 16 V, ±10%, X7R, 0402	Venkel	C0402X7R160-104K
C41, C43	2	CAP, 2.2 µF, 50 V, ±20%, X5R, 0603	Murata	GRT188R61H225ME13D
C42	1	CAP, 1.5 nF, 16 V, ±10%, X7R, 0603	Venkel	C0603X7R160-152K
C45, C46	2	CAP, 22 pF, 50 V, ±2%, C0G, 0402	Murata	GRM1555C1H220GA01
C61, C62	2	CAP, 0.1 µF, 1000 V, ±10%, X7R, 1825	AVX	1825AC104KAT1A
D2, D3, D9, D10	4	DIO, DIODE, 1000 V, 1 A, SMA	Diodes Incorporated	US1M-13-F
D4, D11	2	DIO, ZENER, 15 V, 500 mW, SOD123	On Semi	MMSZ4702T1G
D5, D13	2	DIO, fAST, 100 V, 2 A, SOD123	Diodes Inc.	1N4148W

Part Reference	Quantity	Description	Manufacturer	Manufacturer PN
D6, D12	2	LED, RED, 631nM, 30 mA, 2 V, 54mcd, 0805	LITE-ON TECHNOLOGY	LTST-C170KRKT
D7, D18, D19, D21, D24, D25, D26	7	LED, GREEN, 0805	LITE_ON INC	LTST-C170GKT
D14, D15, D16, D20, D23, D27	6	DIO, Schottky, 100 V, 1 A, SOD123	On Semi	MBR1H100SF
D17	1	DIO, ZENER, 24 V, 3 W, SMB	On Semi	1SMB5934BT3
D22	1	DIO, ZENER, 5.6 V, 200 mW, SOD323	Diodes Inc.	BZT52C5V6S-F-7
FB1, FB2	2	FERRITE BEAD, 600 Ω @100 MHZ, 1206	Wurth	742792118
J1, J2, J10	3	CONN, SMA 50 Ω, Right Angle PC Mount Jack Receptacle	Johnson Components	142-0701-301
J3, J19	2	CONN, MMCX, 50 Ω, Straight, PTH	Molex	734151471
J4, J5, J6, J9	4	CONN, TERM SCREW, 10-32, PTH	Keystone Electronics	8174
J11, J12, J15, J16	4	Header, 3x1, 0.1in pitch, 10u Au Plated, Gold Flash on balance, TH	Samtec	TSW-103-07-G-S
J13, J14	2	Terminal Block, 3 pos, 5 mm, 14-30AWG, 300 V, 10 A	Phoenix Contact	1729021
J17, J18	2	Socket, 8x2, 0.05in pitch, Gold Plated. PTH	Samtec	SFM-108-01-L-D
J22, J24, J25, J26, J27, J28, J30, J31, J32	9	SOLDER BUMP JUMPER, NO, 0603	N/A	SB0603-NO
J23	1	SOLDER BUMP JUMPER, NC, 0603	N/A	SB0603-NC
JP1, JP2, JP5, JP9	4	Header, 3x1, 0.1in pitch, gold/tin	Samtec	TSW-103-07-L-S
JP3, JP4, JP6, JP7, JP8	5	Header, 2x1, 0.1in pitch, Tin Plated	Samtec	TSW-102-07-T-S
JS1, JS2, JS3, JS4, JS5, JS6, JS7, JS8, JS9, JS10, JS11, JS12	12	Shunt, 1x2, 0.1in pitch, Tin Plated	Samtec	SNT-100-BK-T
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
PCB1	1	PCB, BARE BOARD, Si8285_86v2-EVB REV 1.0	Skyworks	Si8285_86v2-EVB REV 1.0
Q1	1	TRANSISTOR, PNP, 60 V, 600 mA, SOT23	Diodes Inc.	MMBT2907A
Q2, Q4	2	TRANSISTOR, NPN, 30 V, 600 mA, SOT23	On Semi	MMBT2222LT1
Q3	1	TRANSISTOR, MOSFET, N-CHNL, 100 V, 3.7 A, 3 W, Switching, SOT223	Fairchild	FDT3612
R1, R17, R59, R60	4	RES, 100 Ω, 1/10 W, ±1%, ThickFilm, 0603	Venkel	CR0603-10W-1000F

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Part Reference	Quantity	Description	Manufacturer	Manufacturer PN
R2, R19, R28, R52	4	RES, 0 Ω, 2 A, ThickFilm, 1206	Venkel	CR1206-4W-000
R3, R4, R10, R18, R20, R54, R55	7	RES, 10 kΩ, 1/16 W, ±1%, ThickFilm, 0603	Venkel	CR0603-16W-1002F
R5, R21	2	RES, 2.2 kΩ, 1/10 W, ±5%, ThickFilm, 0805	Venkel	CR0805-10W-222J
R6, R13	2	RES, 50 Ω, 1/10 W, ±1%, ThickFilm, 0603	Vishay Dale	CRCW060350R0FKEA
R12, R16	2	RES, 0 Ω, 1 A, ThickFilm, 0603	Venkel	CR0603-16W-000
R8, R9, R22, R69	4	RES, 3 kΩ, ¼ W, ±1%, ThickFilm, 1206	Panasonic	ERJ-8ENF3001V
R11, R15	2	RES, 10 kΩ, 1/10 W, ±5%, ThickFilm, 0603	Venkel	CR0603-10W-103J
R23, R26, R29, R32, R34, R35, R38, R42, R44, R45	10	RES, 200 kΩ, 1/4 W, ±1%, ThickFilm, 1206	Venkel	RC1206FR-07200KL
R24, R27	2	RES, 1.0 Ω, 1/4 W, ±5%, ThickFilm, 1206	Venkel	CR1206-4W-1R0J
R30	1	RES, 100 Ω, 1/10 W, ±1%, ThickFilm, 0805	Venkel	CR0805-10W-1000F
R31	1	RES, 12 Ω, 1/4 W, ±5%, ThickFilm, 1206	Venkel	CR1206-4W-120J
R33	1	RES, 10 Ω, 1/4 W, ±1%, ThickFilm, 1206	Venkel	CR1206-4W-10R0F
R37	1	RES, 10.0 Ω, 2 W, ±0.5%, ThickFilm, 2512	Venkel	CR2512-2W-10R0D
R53	1	RES, 0.200 Ω, 2W, ±1%, Metal Plate, 2010	VishayDale	WFMB2010R2000FEA
R56	1	RES, 5.1 kΩ, 1/4 W, ±1%, ThickFilm, 0805	KOA Speer	RK73H2ATTD5101F
R57	1	RES, 13.0 kΩ, 1/16 W, ±1%, ThickFilm, 0603	Venkel	CR0603-16W-1302F
R61	2	RES, 0 Ω, 2 A, ThickFilm, 0805	Venkel	CR0805-10W-000
R62	1	RES, 2 kΩ, 1/10 W, ±1%, ThickFilm, 0603	Venkel	CR0603-10W-2001F
R63	1	RES, 10 kΩ, 1/16 W, ±5%, ThickFilm, 0402	Venkel	CR0402-16W-103J
R64	1	RES, 0.1 Ω, ½ W, ±1%, ThickFilm, 1206	Venkel	LCR1206-R100F
R65	1	RES, 165 kΩ, 1/16 W, ±1%, ThickFilm, 0603	Venkel	CR0603-16W-1653F
R66	1	RES, 145 kΩ, 1/10 W, ±1%, MetalFilm, 0603	KOA Speer	RN73H1JTTD1453F100
R67	1	RES, 10 kΩ, 1/10 W, ±1%, ThickFilm, 0603	Venkel	CR0603-10W-1002F
R68	1	RES, 10.0 Ω, 1/10 W, ±1%, ThickFilm, 0603	Panasonic	ERJ-3EKF10R0V

Part Reference	Quantity	Description	Manufacturer	Manufacturer PN
R70	1	RES, 8.66 kΩ, 1/16 W, ±1%, ThickFilm, 0603	Venkel	CR0603-16W-8661F
R71	1	RES, 200 kΩ, 1/10 W, ±1%, ThickFilm, 0603	Venkel	CR0603-10W-2003F
R72	1	RES, 604 Ω, 1/16 W, ±1%, ThickFilm, 0402	Venkel	CR0402-16W-6040F
R73, R74	2	RES, 1.0 Ω, ½ W, ±1%, ThickFilm, 1210	Venkel	CR1210-2W-1R00F
S1	1	SWITCH, PB, NO, MOMENTARY, TACTILE, LIGHT TOUCH 130GF, 6 mm, PTH	Panasonic Corp.	EVQ-PAD04M
SO1, SO2, SO3, SO4, SO5, SO6	6	HDW, STANDOFF, 1/4 IN. HEX, 4–40x3/4 IN., NYLON	Keystone Electronics	1902D
T2	1	TRANSFORMER, POWER, FLYBACK, 5 kV ISOLATED, 20 µH PRIMARY, 3 windings N1 = 17, N2 = 11, N3 = 3, SMT	Mentech	TTER09-1175SG
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP27, TP28, TP29	16	TESTPOINT, WHITE, PTH	Kobiconn	151-201-RC
TP14, TP15, TP16, TP17, TP18, TP30, TP31, TP32, TP33, TP34	10	TESTPOINT, MINIATURE, SMD	Keystone	5019
TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26	8	TESTPOINT, BLACK, PTH	Kobiconn	151-203-RC
TPV1, TPV2	2	TESTPOINT Via	N/A	N/A
TPV3, TPV4	2	PCB Feature, TP, 0.100" PAD, 0.070" HOLE, PTH	N/A	TPVIA[10070]
U1	1	IC, 4 AMP ISODRIVER, 13V UVLO, 5 kV, SOW16	Skyworks	Si8285DD-IS
U2	1	IC, 4 AMP ISODRIVER, 13V UVLO, 5 kV, SOW16	Skyworks	Si8286DD-IS
U3	1	IC, ISOLATOR, IsoVolt, External Switch, 2 Digital Ch (1 Forward/1 Reverse), SO16 WB	Skyworks	Si88421BC-IS
Not-Installed Components				
D1, D8	2	DIO, ZENER, 3.0 V, 500 mW, SOD123	On Semi	MMSZ4683T1G
HS1	1	HEATSINK, TO-247, 50 mm WIDE, PTH	Ohmite	CR101-50-AE
HW1	1	HEATSINK CAM CLIP, TH (TO-247)	Ohmite	CLA-TO-21E
J7, J21	2	CONN, BNC, TEST LEAD, 4in. LEADS , PTH	Mueller Electric Co	BU-5200-A-4-0
J8	1	CONN, SMA 50 Ω, Right Angle PC Mount Jack Receptacle	Johnson Components	142-0701-301

Part Reference	Quantity	Description	Manufacturer	Manufacturer PN
Q1-1, Q2-1	2	TRANSISTOR, MOSFET, N-CHNL, 1200 V, 115A, 16 mΩ, SiC, Switching, TO-247	Wolfspeed	C3M0016120D
Q1–2, Q2–2	2	TRANSISTOR, MOSFET, N-CHNL, 1200 V, 115A, 16 mΩ, SiC, Switching, TO-247	Wolfspeed	C3M0016120K
R43	1	RES, 0.001 Ω, 1 W, ±1%, ±100 ppm, 2010	Rohm	PMR50HZPFV1L00
R61	1	RES, 0 Ω, 2 A, ThickFilm, 0805	Venkel	CR0805-10W-000
R7, R14	2	RES, 0 Ω, 1A, ThickFilm, 0603	Venkel	CR0603-16W-000
T1	1	TRANSFORMER, POWER, FLY-BACK, 5 kV ISOLATED, 25 μH PRIMARY, 2 windings N = 2, N = 1.21, SMT	UMEC	UTB02253s

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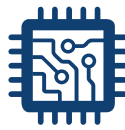
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