TN1427

Technical note

STDES-SICGP4 test report

Introduction

The STDES-SICGP4 reference design is based on SiC MOSFETs.

The platform contains a half-bridge structure that supports HiP247-4 (TO247-4) packages. Gate driver and isolated auxiliary supply are also assembled. The external connection of a digital signal to the gate drivers inputs allows controlling MOSFETs by switching to a half-bridge structure. For instance, this kit allows testing the switching performance of the MOSFETs, using the double-pulse test method (DPT).

This document shows an example of a switching energies test, using DPT, as well as measured waveforms and results calculated from them.

The main board specification and the input/output connection are detailed in UM3044. Read this user manual before testing the platform.

1 Test setup

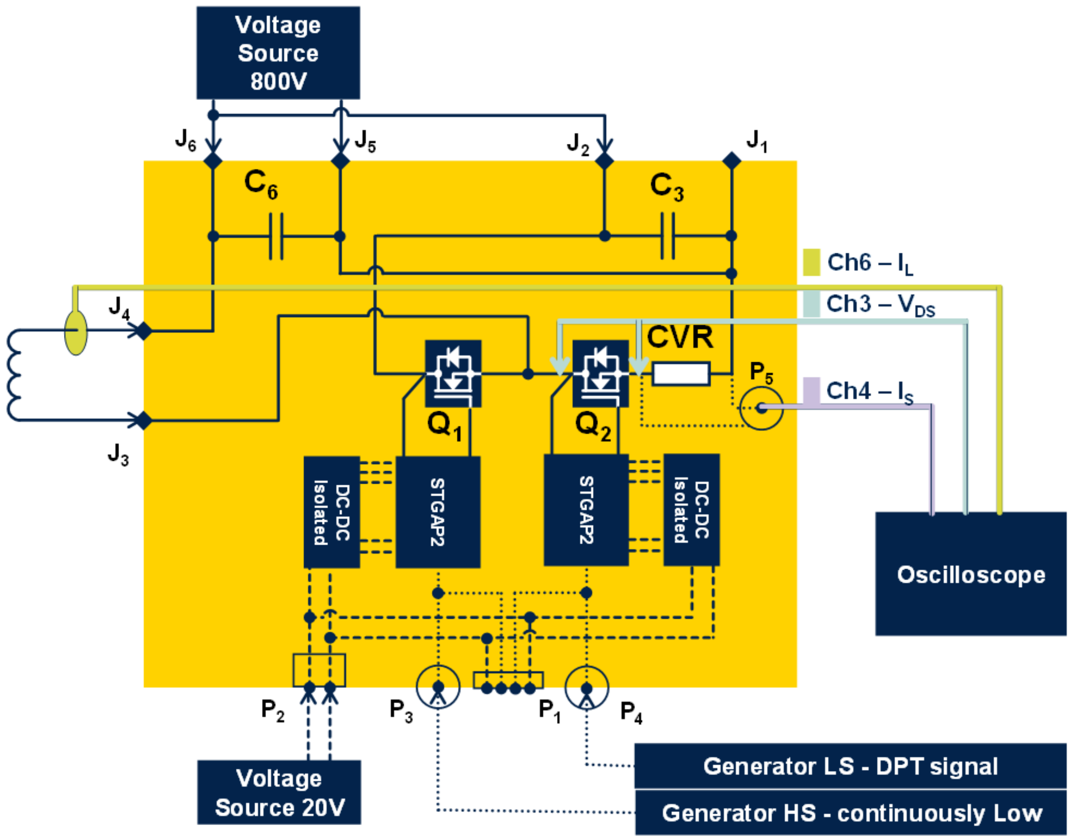
1.1 Test conditions and equipment

The switching energies have been tested for a gate resistor 10 R at 800 V for the following current points Is = 10 A, 20 A, and 40 A. The tested MOSFET is the SCTWA70N120G2V-4.

The measuring setup consists of:

- an HV power supply connected to J1, J2, J5, and J6 terminals; this power supply defines the voltage level for which the switching energy is measured
- an oscilloscope to measure signals through the low side MOSFET:
  - the HV voltage probe is connected to the drain and source
  - the coaxial shunt is applied to the source path
  - the current probe measures the current through an inductor
- a low voltage power supply for the input side of DC-DC converters and gate drivers
- a signal generator (for example, an MCU board or a single output generator with programmable rectangular waveform) to control the DPT flow

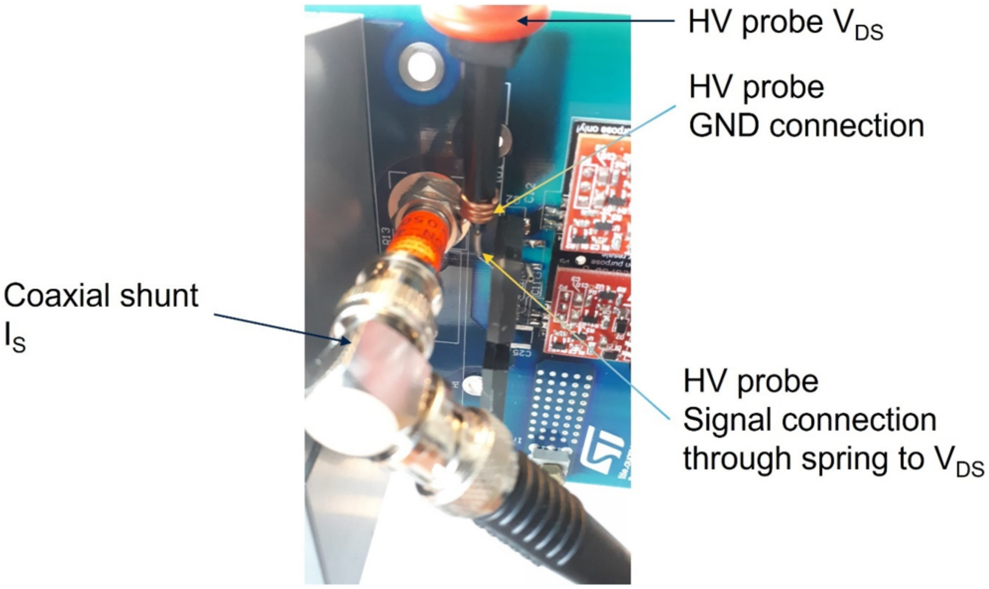
Figure 1. Measuring setup for DPT - block diagram



1.2 Probes implementation

- Current is sensed by a coaxial shunt. The shunt reference point is connected to the low side MOSFET source. The coaxial shunt is connected to the oscilloscope by a coaxial cable.
- The low side MOSFET voltage drain to source is measured by a passive HV probe. The reference point of the HV probe is connected by the shortest way to the body of the coaxial shunt (see Figure 2. HV probe and coaxial shunt connection). It minimizes the noise impact to the measured signal.
- Set deskew in the oscilloscope to compensate the difference in the voltage probe and coaxial shunt different cable length.

Figure 2. HV probe and coaxial shunt connection



It is useful to use the gate source signal measurement for the initial test. However, the probe should be disconnected for the energy measurement, as it partly shorts the kelvin source and MOSFET source through the oscilloscope.

2 Measurement results

The turn on/off energy is visible on the right side in measurements shown in the following figures.

Figure 3. Turn on waveform at 10 A

- Ch3 (blue) - Vds
- Ch4 (violet) - Is
- Ch6 (yellow) - inductor
- Math 1 (light blue) power = Vds

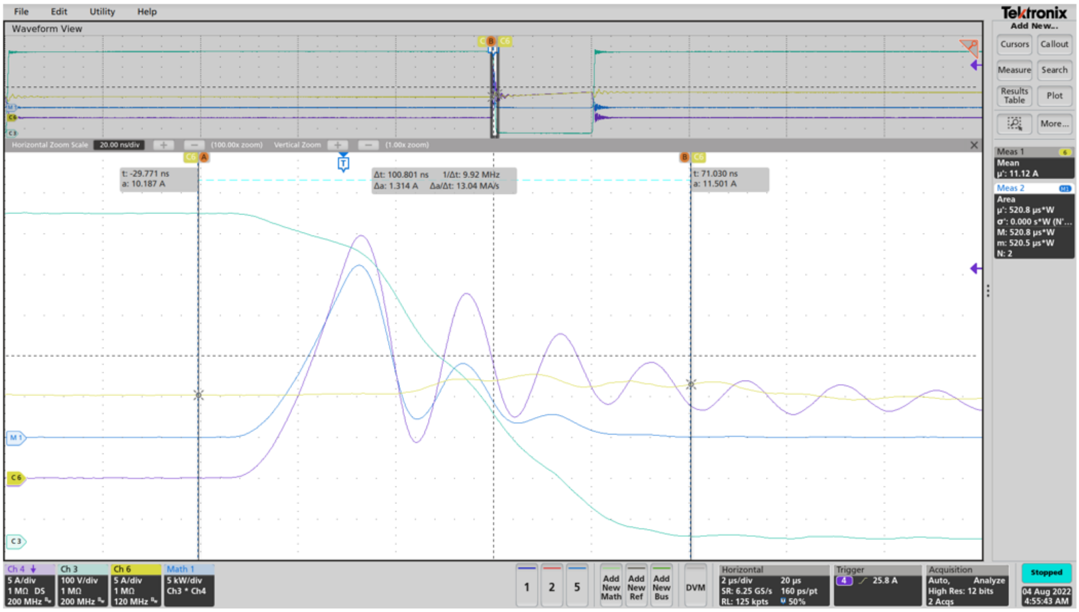


Figure 4. Turn on waveform at 20 A

- Ch3 (blue) - Vds
- Ch4 (violet) - Is
- Ch6 (yellow) - inductor
- Math 1 (light blue) power = Vds

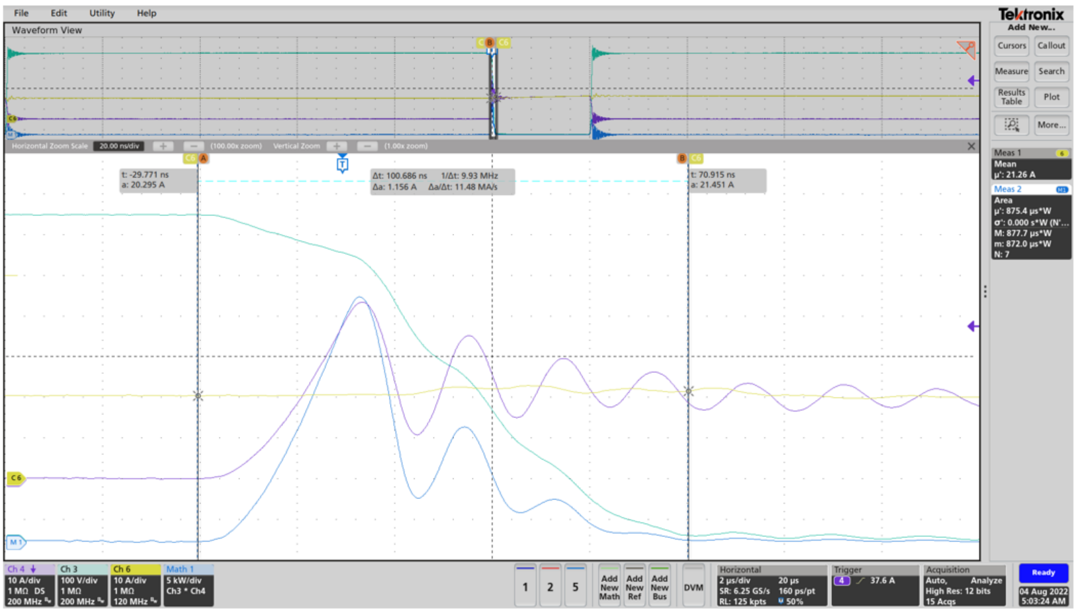


Figure 5. Turn on waveform at 40 A

- Ch3 (blue) - Vds
- Ch4 (violet) - Is
- Ch6 (yellow) - inductor
- Math 1 (light blue) power = Vds

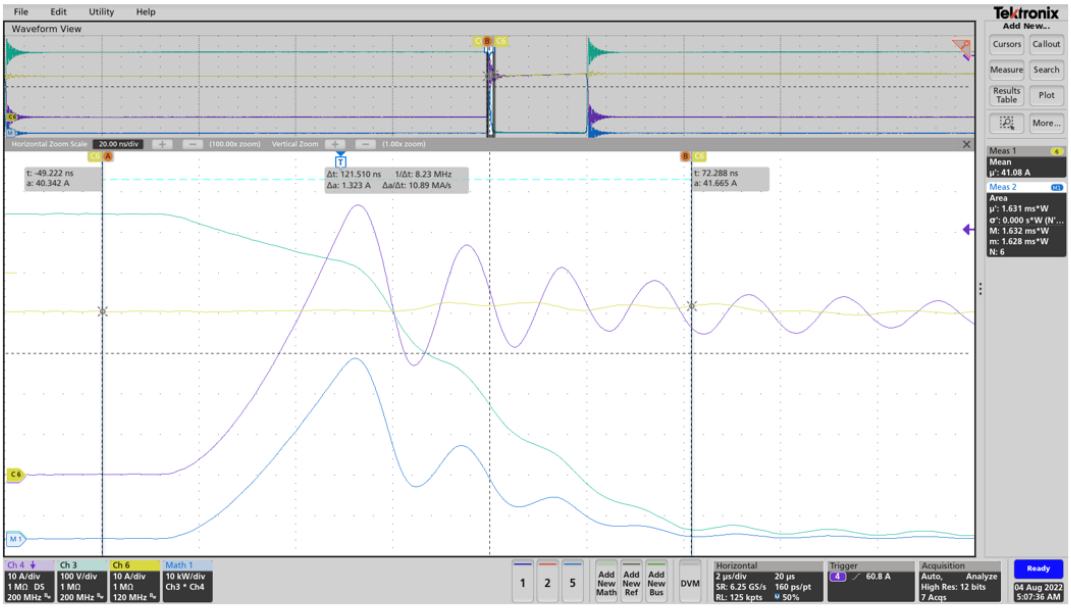


Figure 6. Turn off waveform at 10 A

- Ch3 (blue) - Vds
- Ch4 (violet) - Is
- Ch6 (yellow) - inductor
- Math 1 (light blue) power = Vds

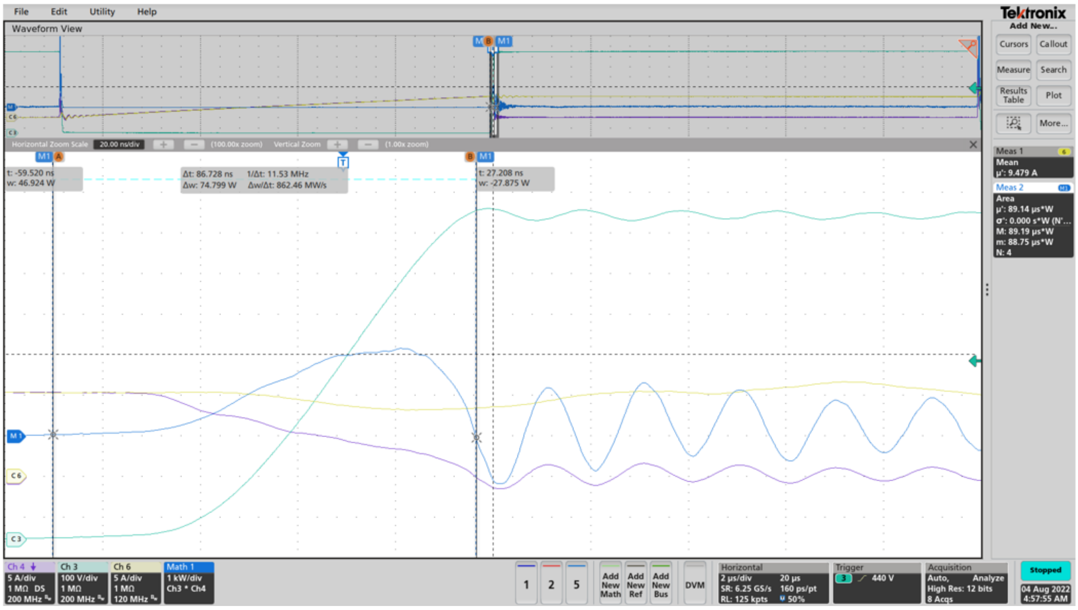


Figure 7. Turn off waveform at 20 A

- Ch3 (blue) - Vds
- Ch4 (violet) - Is
- Ch6 (yellow) - inductor
- Math 1 (light blue) power = Vds

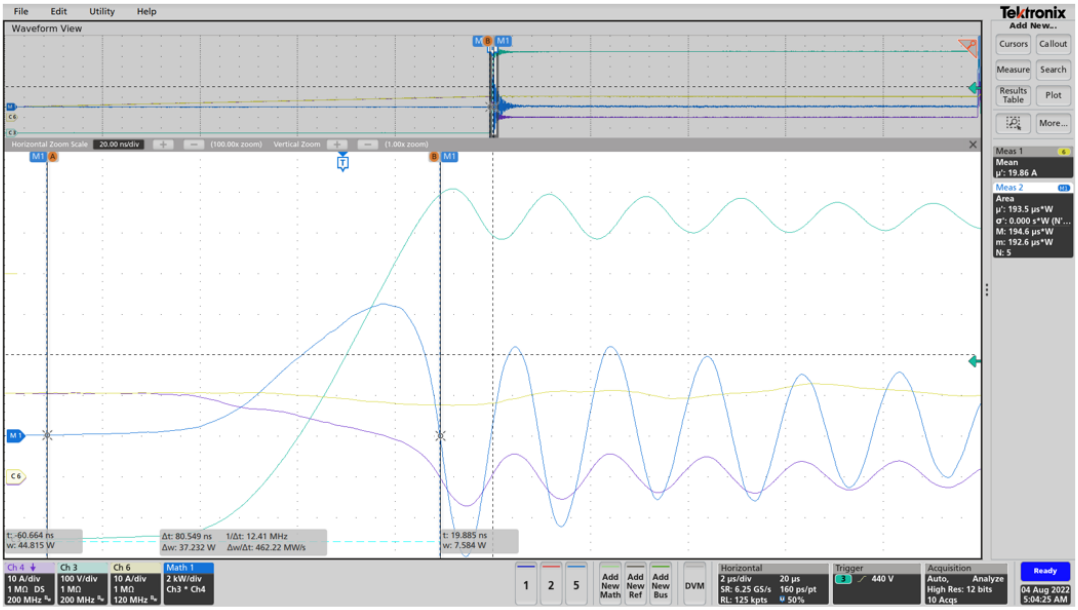
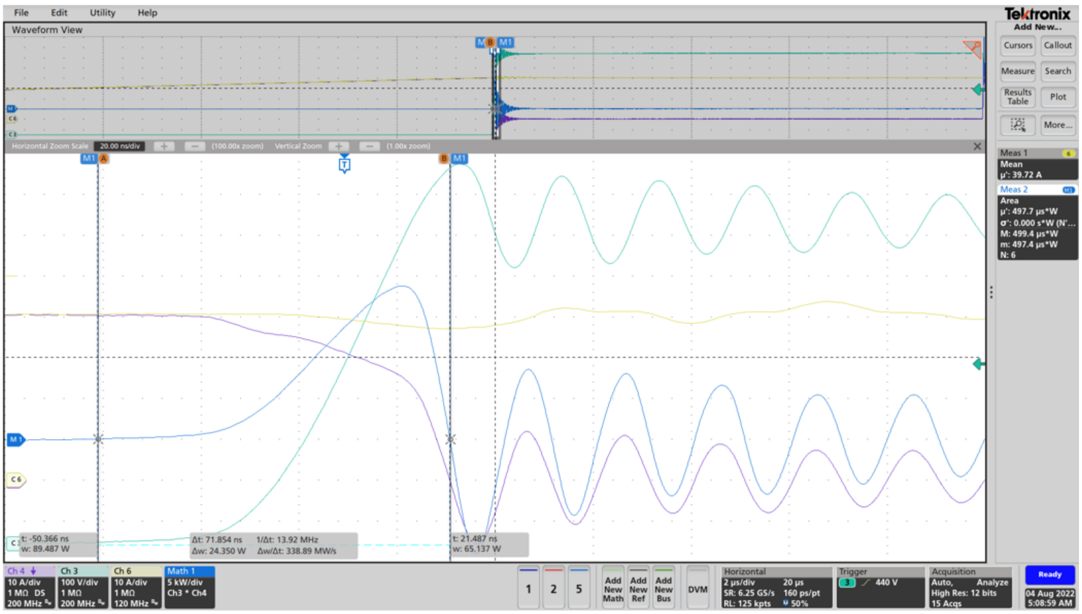


Figure 8. Turn off waveform at 40 A

- Ch3 (blue) - Vds
- Ch4 (violet) - Is
- Ch6 (yellow) - inductor
- Math 1 (light blue) power = Vds



The figures above shows the waveforms of V_{DS} and Is. The result of these values is the power generated by the MOSFET.

The current spike visible in the on characteristic is the result of the opposite MOSFET diode recovery. The energy oscillations during the turn off transient drops partly under the zero. It refers to the fact that there is a voltage spike above the bus voltage after turn off. This spike is the charge stored in the output capacitance. This charge is discharged back to the DC bus voltage. During the discharging period, the MOSFET output capacitance works as a generator. Therefore, it is possible to see the negative energy.

The energy loss is calculated as the integral of the MOSFET power present during the transient. The area for the integral calculation is defined by cursors. The turn off end is considered as the first cross of the power through the zero level. The real turn on losses are higher as this method does not measure the output capacitance discharge. This energy is implemented in the turn off energy level.

Table 1. Switching energies measured at Rg = 10 R

I_S	EON	EOFF
10 A	520 µJ	89 µJ
20 A	875 µJ	195 µJ
40 A	1631 µJ	498 µJ

3 Schematic diagrams

Figure 9. STDES-SICGP4 main board circuit schematic - power section

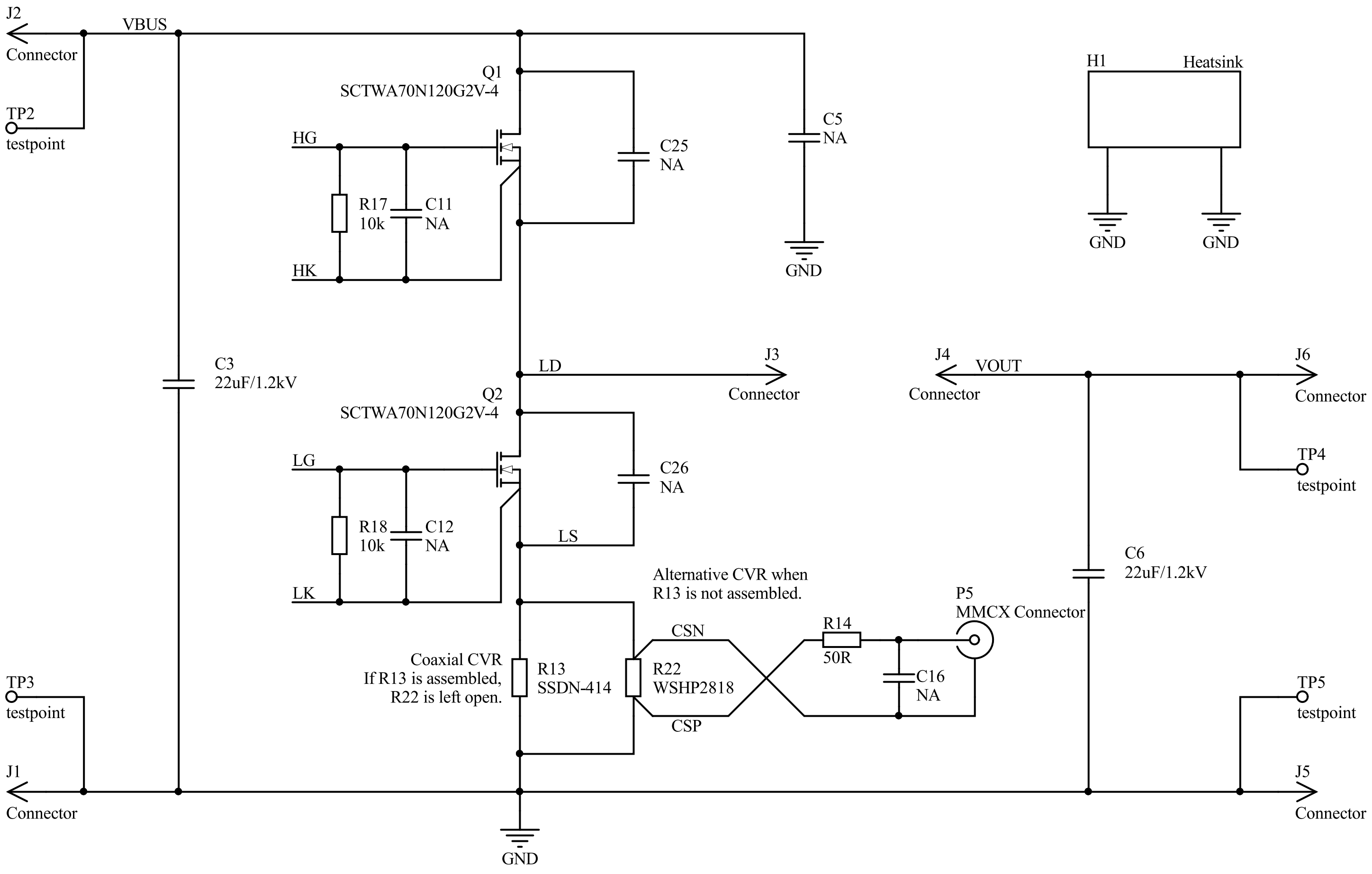
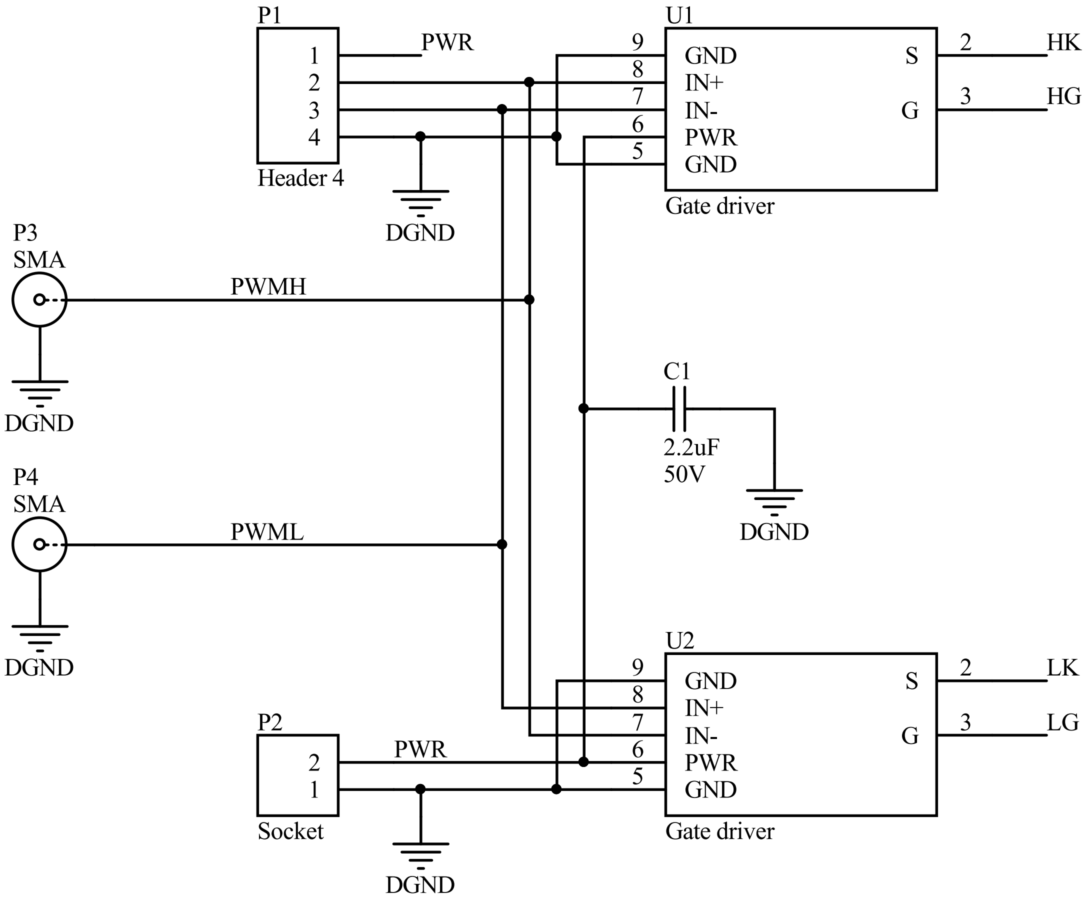


Figure 10. STDES-SICGP4 main board circuit schematic - signal section



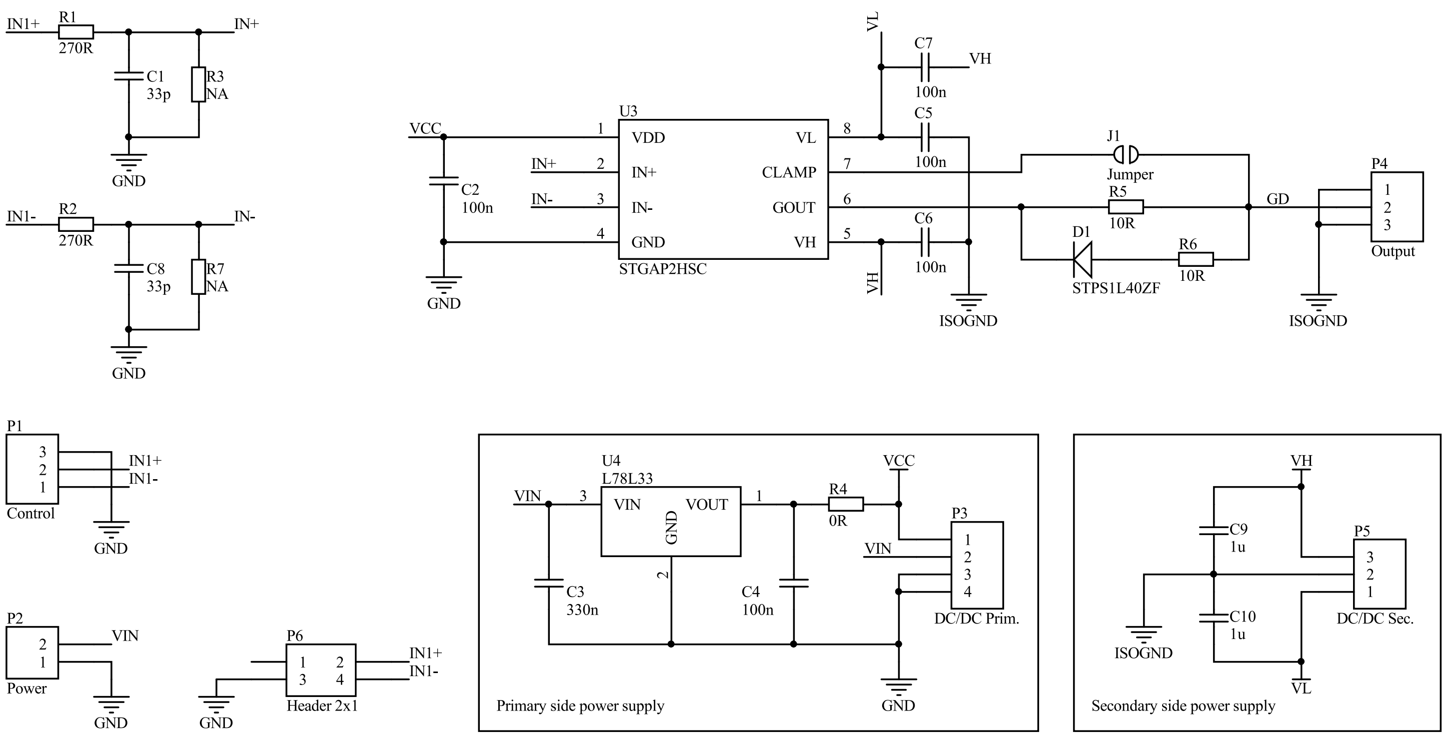
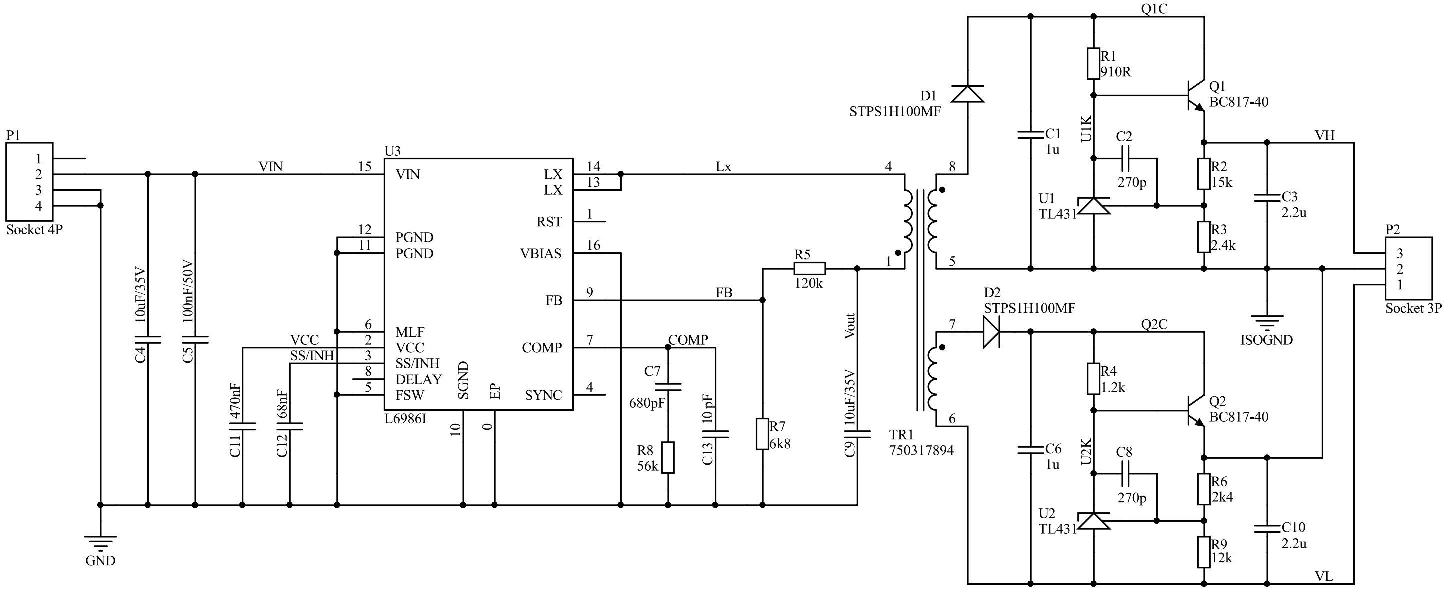


Figure 11. **STDES-SICGP4 driver circuit schematic**

Figure 12. STDES-SICGP4 DC-DC isolated converter circuit schematic



4 Bill of materials

Table 2. STDES-SICGP4 bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	1	Table 3. Main board bill of materials	-	Main board	ST	Not available for separate sale
2	1	Table 4. Driver bill of materials	-	Driver	ST	Not available for separate sale
3	1	Table 5. DC-DC converter bill of materials	-	DC-DC converter	ST	Not available for separate sale

Table 3. Main board bill of materials

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
1	1	C1	CAP CER 1206 2.2uF 50V X7R 20%, 1206	Ceramic capacitor	Any	Any
2	2	C3, C6	CAP FOIL RBOX 22uF 1.2kV PP 5%	Foil capacitor	Vishay	MKP1848H62212JY5
3	1	C5 Not Assembled	CAP 22.5-26x13	Foil capacitor	Any	Any
4	2	C11, C12	CAP CER 0805 50V, 0805	Ceramic capacitor	Any	Any
5	1	C16	CAP CER 0603 X7R, 0603	Ceramic capacitor	Any	Any
6	2	C25, C26 Not Assembled	CAP CER 2220 C0G, 2220	Ceramic capacitor	Any	Any
7	1	H1	SK 575 84 SA	Heatsink	Fischer Elektronik	SK 575 84 SA
8	6	J1, J2, J3, J4, J5, J6	CONN WP-THRBU, M4, 8p, 10x10mm	Connector	Wurth Elektronik	74650094R
9	1	P1	CON HDR 2.54mm 4pin 1row	Header 4	Any	Any
10	1	P2	CON PCB TERMINAL 2-pole 5mm	Socket	Wurth Elektronik	691213710002
11	2	P3, P4	CON SMA THR ANGLE PLUG	SMA	Wurth Elektronik	60311002111526
12	1	P5	CON MMCX SMD STRAIGHT PLUG	MMCX Connector	Amphenol	908-NM22109
13	2	Q1, Q2	SCTWA70N120G2V-4, HiP-247-4	Silicon carbide power MOSFET	ST	SCTWA70N120G2V-4
14	1	R13 Not Assembled	SSDN-414 Coaxial CVR	Coaxial shunt	Billmann Engineering	-
15	1	R14	RES 0603 50R 1% 125mW, 0603	Resistor	Any	Any
16	2	R17, R18	RES 0805 10k 250mW 1%, 0805	Resistor	Any	Any
17	1	R22	RES 2818 20mR 10W 1%, 2818	Resistor	Vishay	WSHP2818R0200FEB
18	4	TP2, TP3, TP4, TP5	TP THR 1.6mm	Test point	Keystone Electronics	5011
19	2	U1, U2	Gate driver module	Sub board	Any	Any
20	2	-	Retaining springs for transistors	Spring	Fischer Elektronik	THFU 4

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
21	2	-	Insulation foil for transistors	Isolation foil	Fischer Elektronik	WS 247 1

Table 4. Driver bill of materials

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
1	2	C1, C8	33p, 0603	Ceramic capacitor	Any	Any
2	4	C2, C5, C6, C7	100n, 0603	Ceramic capacitor	Any	Any
3	1	C3	330n, 0805	Ceramic capacitor	Any	Any
4	1	C4	100n, 0805	Ceramic capacitor	Any	Any
5	2	C9, C10	1u, 0805	Ceramic capacitor	Any	Any
6	1	D1	STPS1L40ZF, SOD123 Flat	40 V, 1 A low drop power Schottky rectifier	ST	STPS1L40ZF
7	1	J1	Jumper	PCB Jumper	Any	Any
8	1	P1	Control	PCB connector	Any	Any
9	1	P2	Power	PCB connector	Any	Any
10	1	P3	DC/DC Prim., 4 pin x 1	Header 2.54 4pin x 1	Any	Any
11	1	P4	Output	PCB connector	Any	Any
12	1	P5	DC/DC Sec., 3 pin x 1	Header 2.54 3pin x 1	Any	Any
13	1	P6	Header 2x1, 2 pin x 2	Header 2.54 2pin x 2	Any	Any
14	2	R1, R2	270R, 0603	Resistor	Any	Any
15	2	R3, R7 Not Assembled	NA, 0603	Resistor	Any	Any
16	1	R4	0R, 0805	Resistor	Any	Any
17	2	R5, R6	10R, 1210	Resistor	Any	Any
18	1	U3	STGAP2HSCMTR, SO 8 WIDE 300	Galvanically isolated 4 A single gate driver	ST	STGAP2HSCMTR
19	1	U4	L78L33ABUTR, SOT-89	Positive voltage regulator	ST	L78L33ABUTR

Table 5. DC-DC converter bill of materials

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
1	2	C1, C6	CAP CER 0805 1uF 50V X7R 10%, 0805	Ceramic capacitor	Any	Any
2	2	C2, C8	CAP CER 270p 0603 50V C0G 10%, 0603	Ceramic capacitor	Any	Any
3	2	C3, C10	CAP CER 0805 2.2uF 50V X7R 10%, 0805	Ceramic capacitor	Any	Any
4	2	C4, C9	CAP CER 10uF 35V 1206 X7R 10%, 1206	Ceramic capacitor	Any	Any
5	1	C5	CAP CER 100nF 50V 1206 X7R 10%, 1206	Ceramic capacitor	Any	Any
6	1	C7	CAP CER 680pF 50V 0603 C0G 10%, 0603	Ceramic capacitor	Any	Any
7	1	C11	CAP CER 470nF 50V 0603 X7R 10%, 0603	Ceramic capacitor	Any	Any
8	1	C12	CAP CER 68nF 50V 0603 X7R 10%, 0603	Ceramic capacitor	Any	Any

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
9	1	C13	CAP CER 10pF 50V 0603 C0G 10%, 0603	Ceramic capacitor	Any	Any
10	2	D1, D2	STPS1H100MF, STmiteFLAT	00 V, 1 A STmite flat power Schottky rectifier	ST	STPS1H100MF
11	1	P1	CON SOCK 2.54mm 4pin 1row	Header Receptacle 4 pins 1 row	Any	Any
12	1	P2	CON SOCK 2.54mm 3pin 1row	Header Receptacle 3 pins 1 row	Any	Any
13	2	Q1, Q2	BC817-40, SOT23	NPN Transistor	Any	Any
14	1	R1	RES 910R 0805 125mW 1%, 0805	Resistor	Any	Any
15	1	R2	RES 15k 0603 100mW 1%, 0603	Resistor	Any	Any
16	1	R3	RES 2.4k 0805 125mW 1%, 0805	Resistor	Any	Any
17	1	R4	RES 1.2k 0805 125mW 1%, 0805	Resistor	Any	Any
18	1	R5	RES 120k 0603 100mW 1%, 0603	Resistor	Any	Any
19	1	R6	RES 2k4 0603 100mW 1%, 0603	Resistor	Any	Any
20	1	R7	RES 6k8 0603 100mW 1%, 0603	Resistor	Any	Any
21	2	R8, R9	RES 12k 0603 100mW 1%, 0603	Resistor	Any	Any
22	1	TR1	WE-AGDT gate drive transformer, SMD	Transformer	Wurth Elektronik	750317894
23	2	U1, U2	TL431ACL3T, SOT23	Adjustable micropower shunt voltage reference	ST	TL431ACL3T
24	1	U3	L6986ITR, HTSSOP16	38 V, 5 W synchronous iso-buck converter	ST	L6986ITR

5 Conclusions

Appendix A Reference design warnings, restrictions and disclaimer

Important: *The reference design is not a complete product. It is intended exclusively for evaluation in laboratory/ development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical/mechanical components, systems and subsystems.*

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Revision history

Table 6. **Document revision history**

Date	Revision	Changes
05-Oct-2022	1	Initial release.

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