

STDES-DABBIDIR test report

Introduction

The STDES-DABBIDIR provides a complete solution for high power bidirectional DC-DC power converters.

A dual active bridge topology based on an ACEPACK 2 SiC power module is proposed.

The STM32G474RE MCU enabling digital-intensive power control and optimized for mixed signal applications is used.

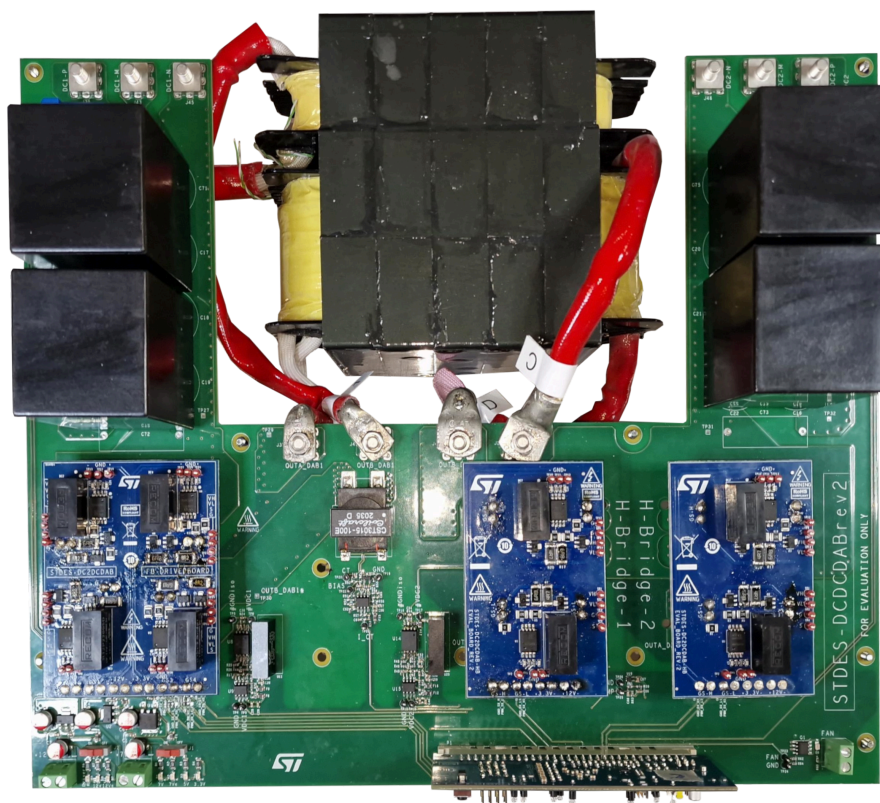
Thanks to the latest generation SiC power module and high-frequency operation (100 kHz), high performance and design optimization are reached. Soft switching DAB behavior is also managed by modulation techniques, according to the load/voltage variation.

Bidirectional mode operation supports V2G and V2L implementations as well as UPS and battery energy storage applications.

The DAB DC-DC stage consists of two full-bridges and a 25 kW single magnetic component, including the isolation transformer and the inductance. The hardware modular structure includes the following parts:

- a main power board with ACEPACK 2 SiC power modules, a full bridge A2F12M12W2-F1 for the primary HV side and two half bridges for the secondary LV side. In addition to the power modules, bulk capacitor, sensing sections and auxiliary power supply are also present
- a driver board for the full bridge ACEPACK 2 SiC power modules based on STGAP2SICS galvanically isolated 4 A single gate driver for SiC MOSFETs
- two driver boards for the half bridges ACEPACK 2 SiC power modules based on STGAP2SICS galvanically isolated 4 A single gate driver for SiC MOSFETs
- a control board based on the STM32G474RET3 series microcontroller with connectors for communication and programming, test-points, and status indicators for testing and monitoring

Figure 1. STDES-DABBIDIR reference design



1 Overview

1.1 Features

- Reference design modular kit:
 - Main power board
 - Driver board (1xHV side 2xLV side)
 - [STM32G474RET3](#) control board
- Dual active bridge DC-DC power converter:
 - Nominal DC input voltage: 800 V
 - Nominal DC output voltage: 400 V
 - Nominal power: 25 kW
 - Switching frequency: 100 kHz
 - Peak efficiency: 98.4%
- Key features
 - ACEPACK 2 SiC power module to optimize power section integration and thermal dissipation
 - Bidirectional digital power control
 - Extended soft switching mode, enabled by sophisticated modulation techniques
 - Passive elements weight and size reduction thanks to high frequency SiC MOSFETs operation
 - [STGAP2SICS](#) galvanic isolated gate driver for SiC
 - [STM32G474RET3](#) MCU for full digital solution
 - Inrush current control and soft startup

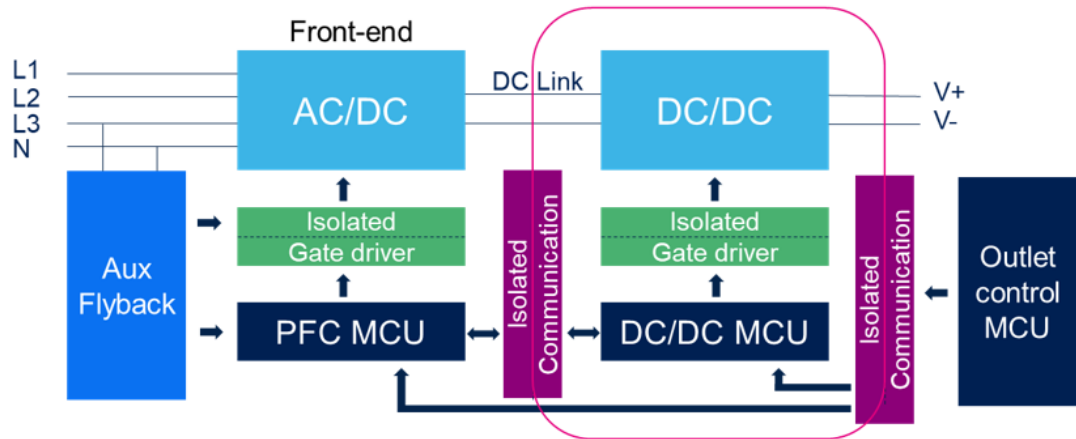
1.2 Main characteristics

Table 1. Main characteristics

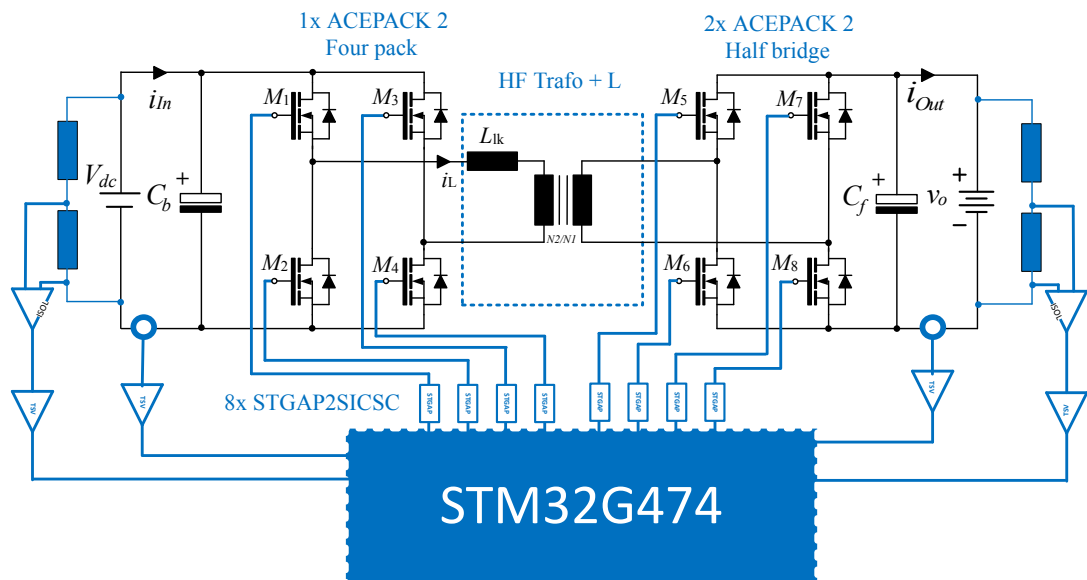
Description	Symbol	Min.	Typ.	Max.	Unit	Comments
HV DC voltage	V_{DCHV}		800		V	
LV DC voltage	V_{DCLV}		400		V	
Maximum output power	P_{OUTMAX}		25		kW	At nominal voltages
Switching frequency	f_{sw}		100		kHz	
Target efficiency	η		98		%	

1.3 Application block diagram

Typical application of the DAB power converter is represented by the EV battery DC charger. According to the power level proposed, a three-phase system is also shown in the figure below.

Figure 2. Application block diagram


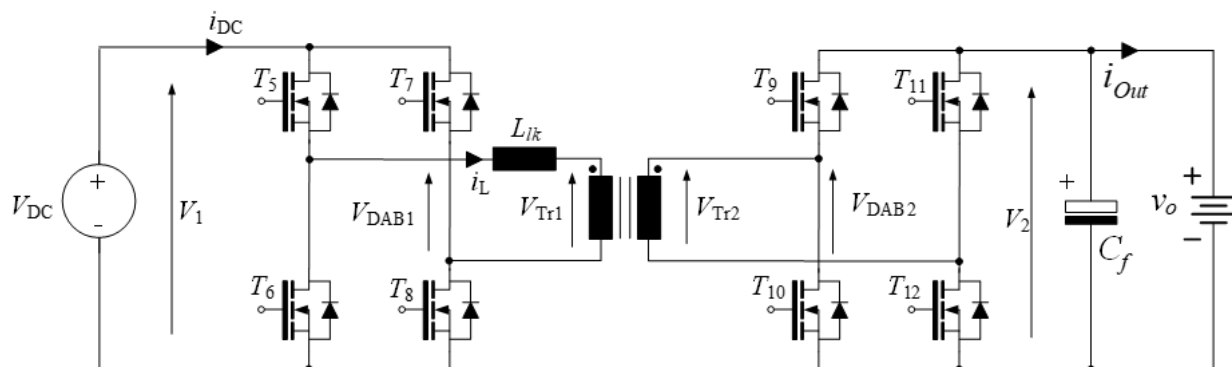
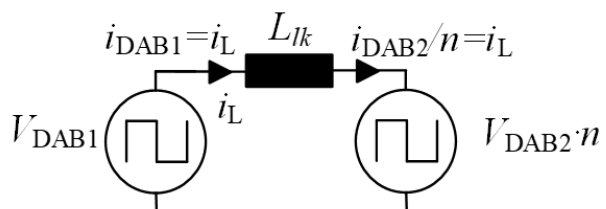
The DC fast charging supply consists of a three-phase active front end (AFE) rectifier, which provides a regulated DC link from a universal three-phase AC input, while it demands a high-quality current from the grid. Isolation and bidirectional operation are required for the downstream DC-DC converter. These requirements are fulfilled by the DAB topology. Thanks to the ACEPACK 2 SiC power modules a very high integration of the topology is achieved.

Figure 3. STDES-DABBIDIR block diagram


1.4 DAB operation

The DAB converter consists of two voltage sourced full bridge circuits that are connected to the inductor L and the high frequency transformer. To transfer power, time varying voltages $v_{AC1}(t) = v_{DAB1}(t)$ and $v_{AC2}(t) = v_{DAB2}(t)$ must be provided by the full bridge circuits to the high frequency transformer and the converter inductor L.

Thus, the voltage sourced HV and LV side full bridge circuits can be replaced by the respective voltage sources ($v_{AC1}(t) = v_{DAB1}(t)$ and $v_{AC2}(t) = v_{DAB2}(t)$) to simplify the analysis of the DAB converter, for the simplest electric DAB converter model.

Figure 4. DAB topology

Figure 5. DAB simplified diagram


2 Test setup

2.1 Safety precautions

Attention: The *STDES-DABBIDIR* is designed for demonstration purposes only and is not intended for domestic or industrial installations.

- Danger:**
- The high voltage levels used to operate the *STDES-DABBIDIR* could provoke a serious electrical shock. This reference design must be used in a suitable laboratory by qualified personnel only, familiar with the installation, use, and maintenance of power electrical systems. During operation, do not touch the board as some of its components could reach a very high temperature.

Safety precautions and protective equipment

Attention:	
Danger:	

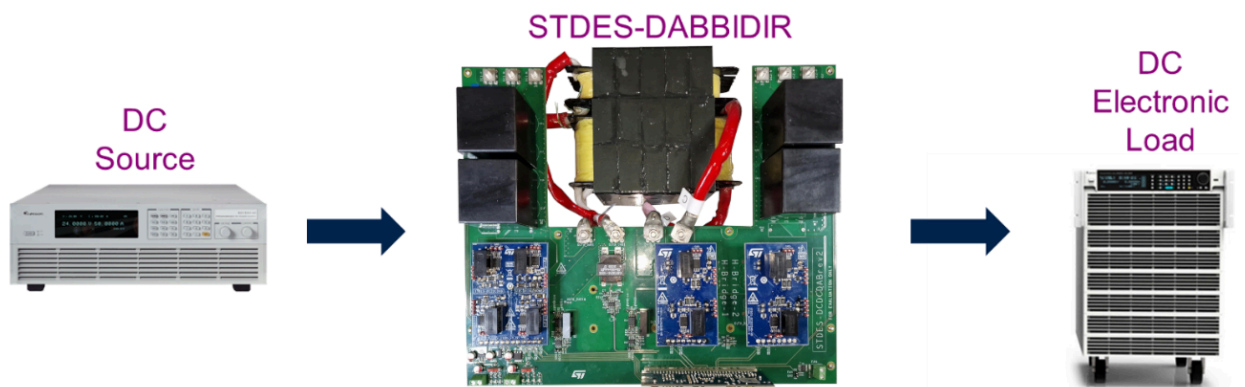
2.2 System setup requirements

To operate the *STDES-DABBIDIR*, you need the following equipment:

- Programmable DC power supply
- DC electronic load
- Power analyzer
- Digital oscilloscope

The voltage operating conditions of the *STDES-DABBIDIR* allow operating up to 850 V (high voltage side) and 500 V (low voltage side).

Figure 6. Typical test bench



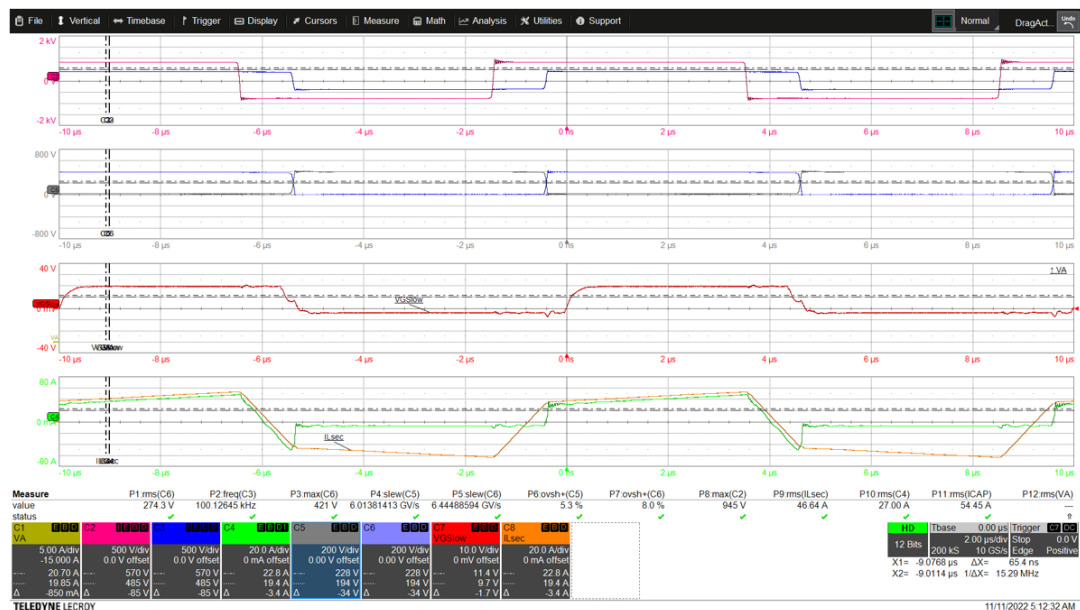
3 Measurements/waveforms/test data

3.1 Waveforms

Waveforms analysis at:

- $V_{IN} = 800\text{ V}$
- $V_{OUT} = 400\text{ V}$
- $f_{sw} = 100\text{ kHz}$
- $IDC_{LOAD} = 40\text{ A}$
- Voltage regulation operating mode
 - C1 = DC load current
 - C2 = VDAB1
 - C3 = VDAB2
 - C4 = IDM7
 - C5 = VDSM7
 - C6 = VDSM8
 - C7 = VGSM7
 - C8 = IL_{SEC}

Figure 7. Switching waveform

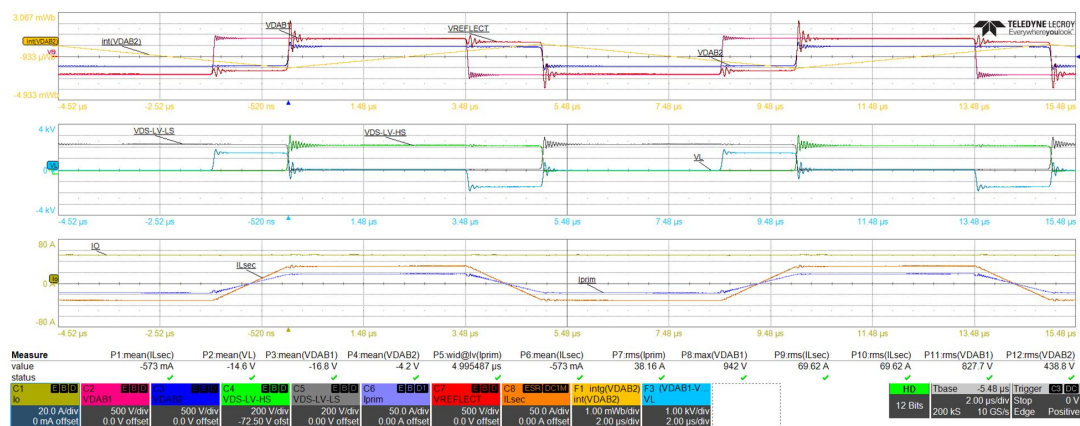


Waveforms analysis at:

- $V_{IN} = 830\text{ V}$
- $V_{OUT} = 440\text{ V}$
- $f_{sw} = 100\text{ kHz}$
- $IDC_{LOAD} = 56.3\text{ A}$

- Voltage regulation operating mode
 - C1 = DC load current
 - C2 = VDAB1
 - C3 = VDAB2
 - C4 = VDS_LV_HS
 - C5 = VDS_LV_LS
 - C6 = I_{PRIM}
 - C7 = V_{REFL}
 - C8 = I_{LSEC}
 - F3 = VL

Figure 8. Maximum power waveforms

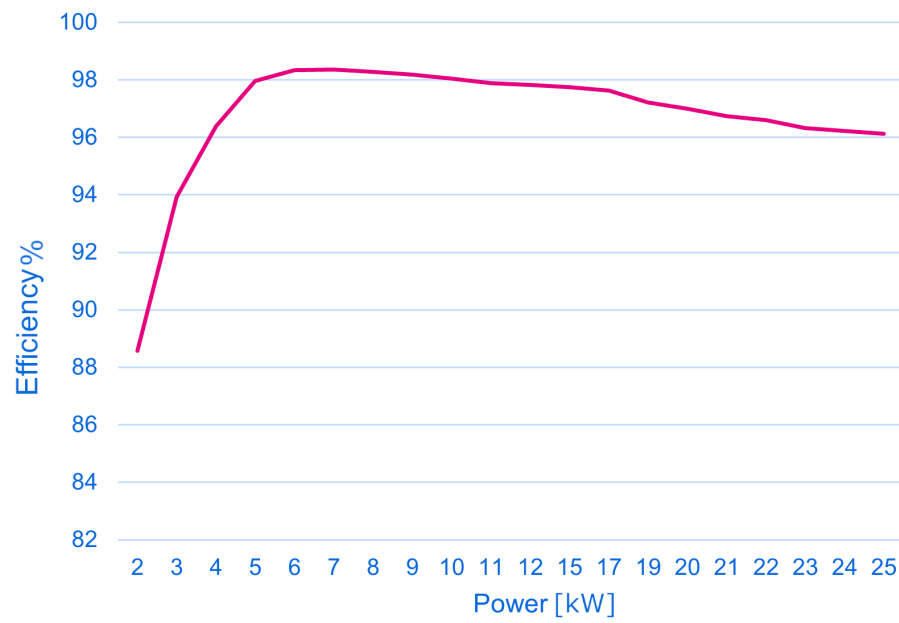


3.2 Efficiency

Efficiency characterization at:

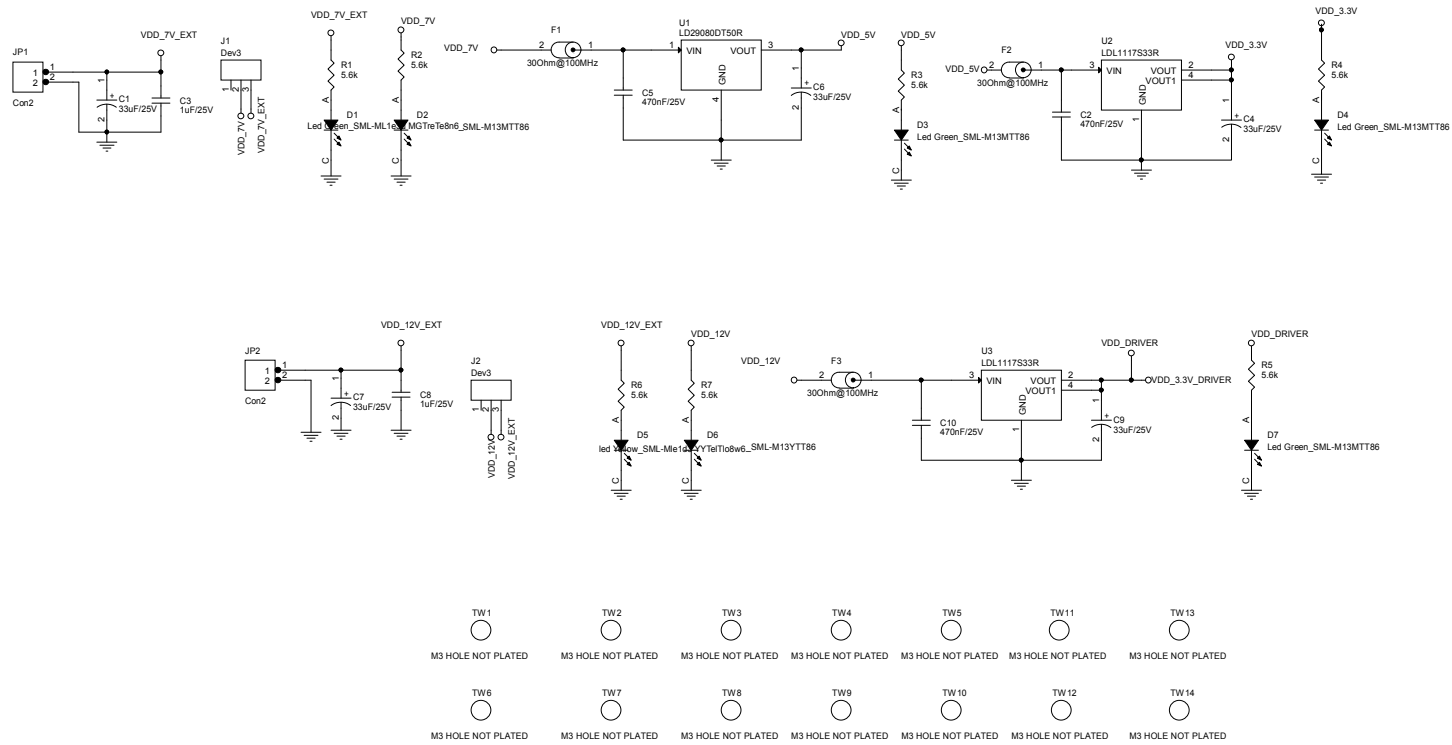
- V_{IN} = 800 V
- V_{OUT} = 400 V
- f_{sw} = 100 kHz
- Voltage regulation operating mode
- I_{LOAD} = 4.5 - 56.3 A (constant current)

Figure 9. Efficiency



Schematic diagrams

Figure 10. STDES-DABBIDIR - main board circuit schematic (1 of 6)



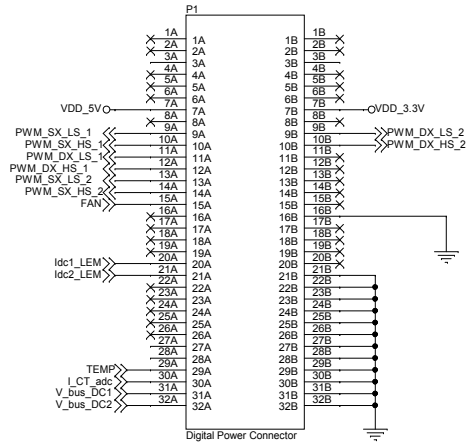


Figure 11. STDES-DABBIDIR - main board circuit schematic (2 of 6)

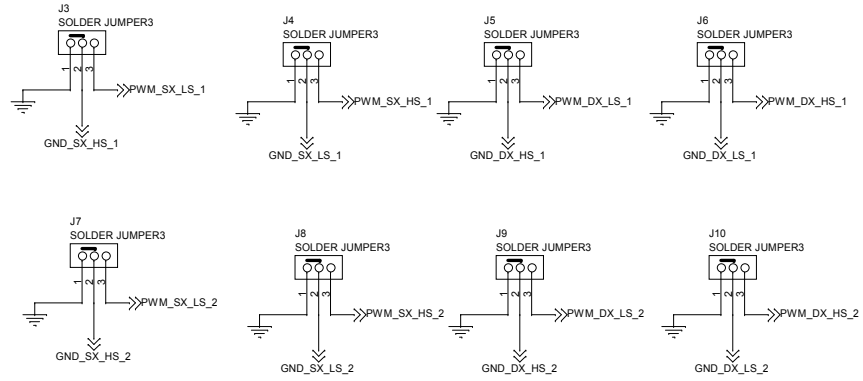


Figure 12. STDES-DABBIDIR - main board circuit schematic (3 of 6)

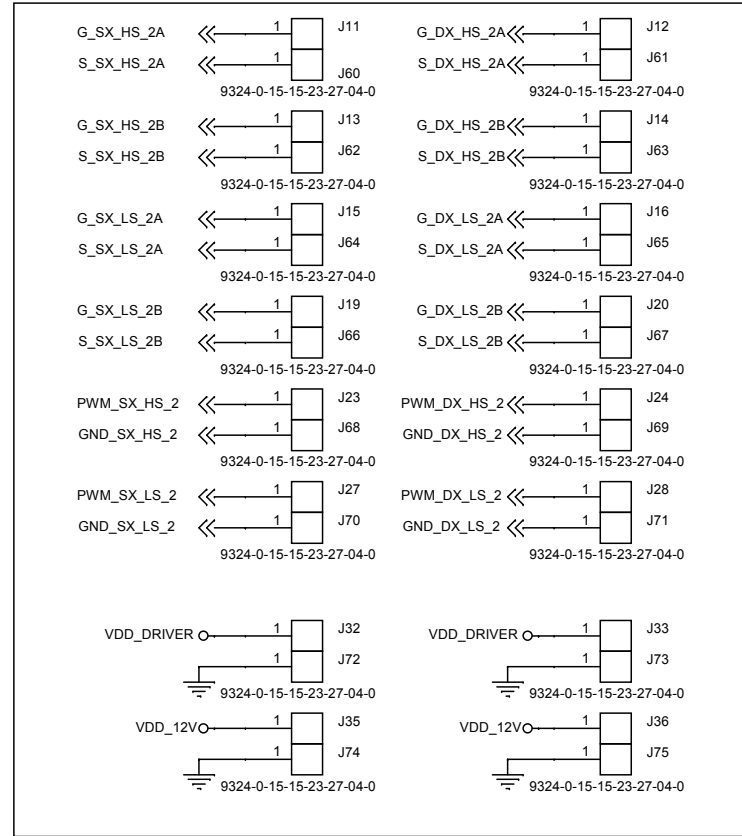
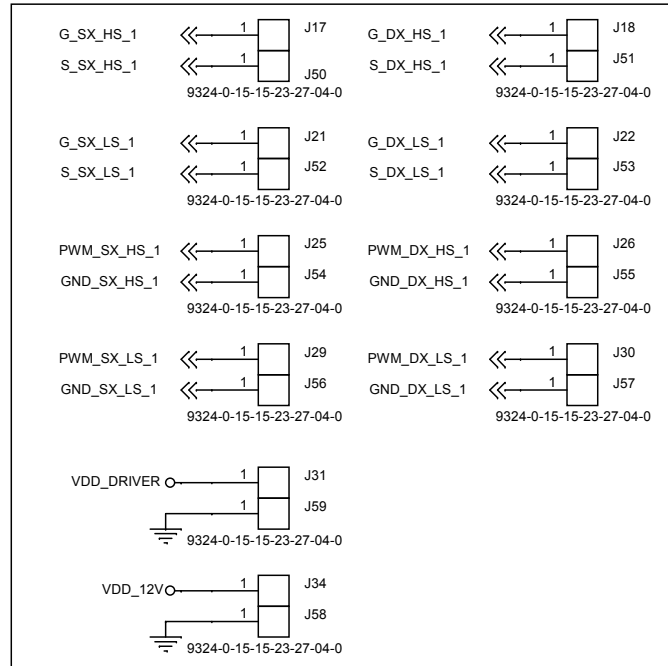


Figure 13. STDES-DABBIDIR - main board circuit schematic (4 of 6)

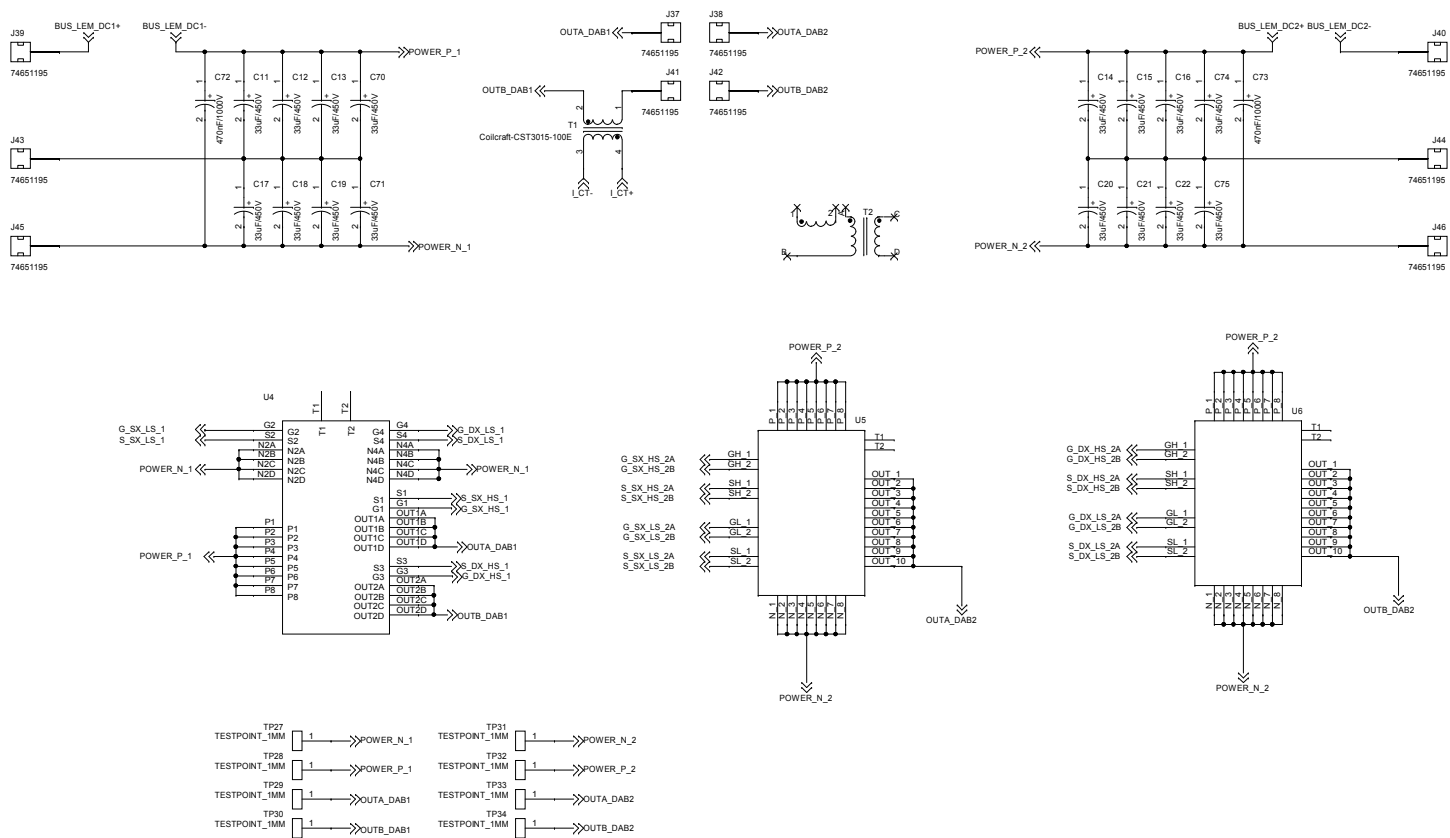


Figure 14. STDES-DABBIDIR - main board circuit schematic (5 of 6)

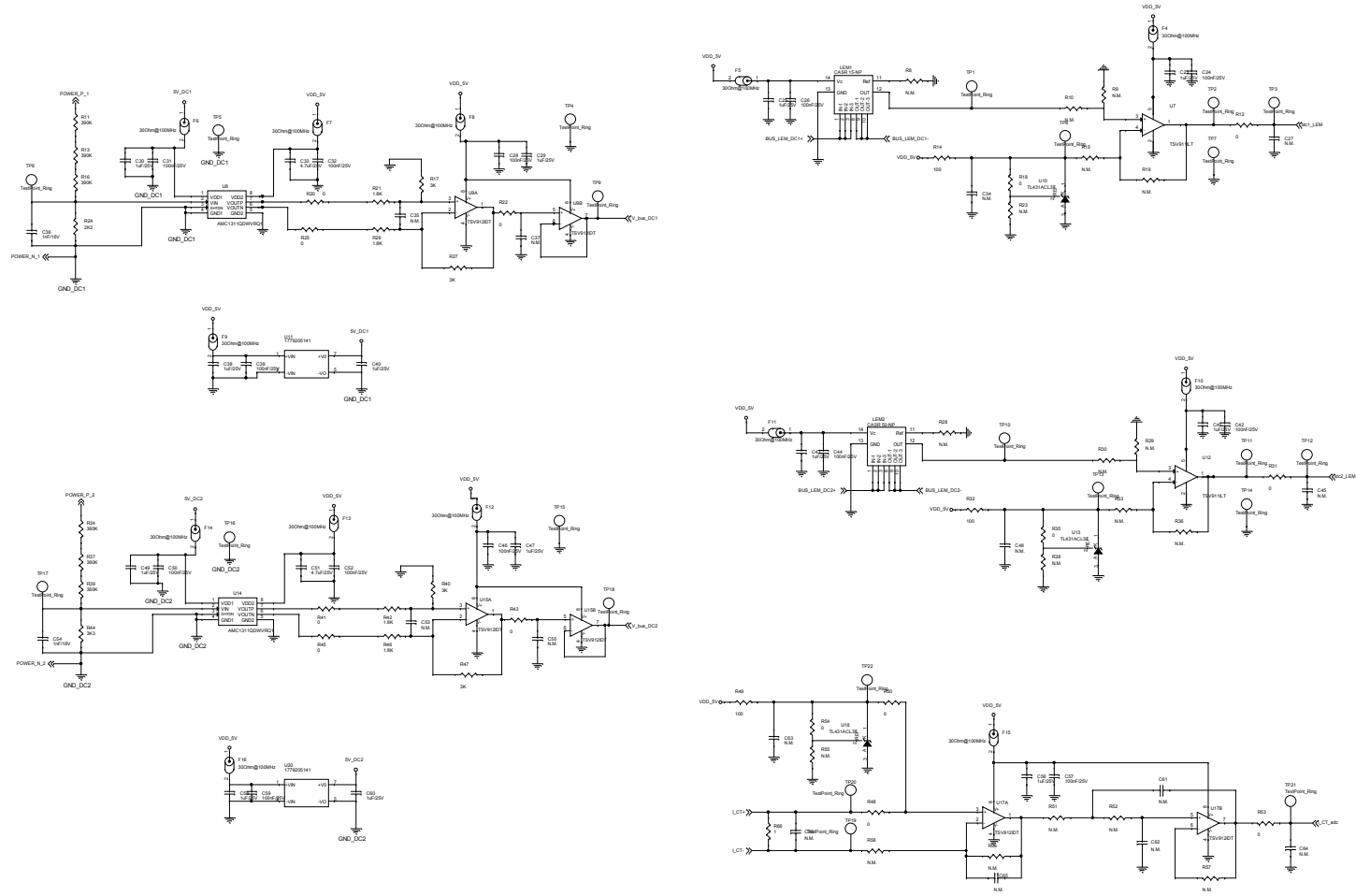


Figure 16. STDES-DABBIDIR - driver board for full bridge circuit schematic

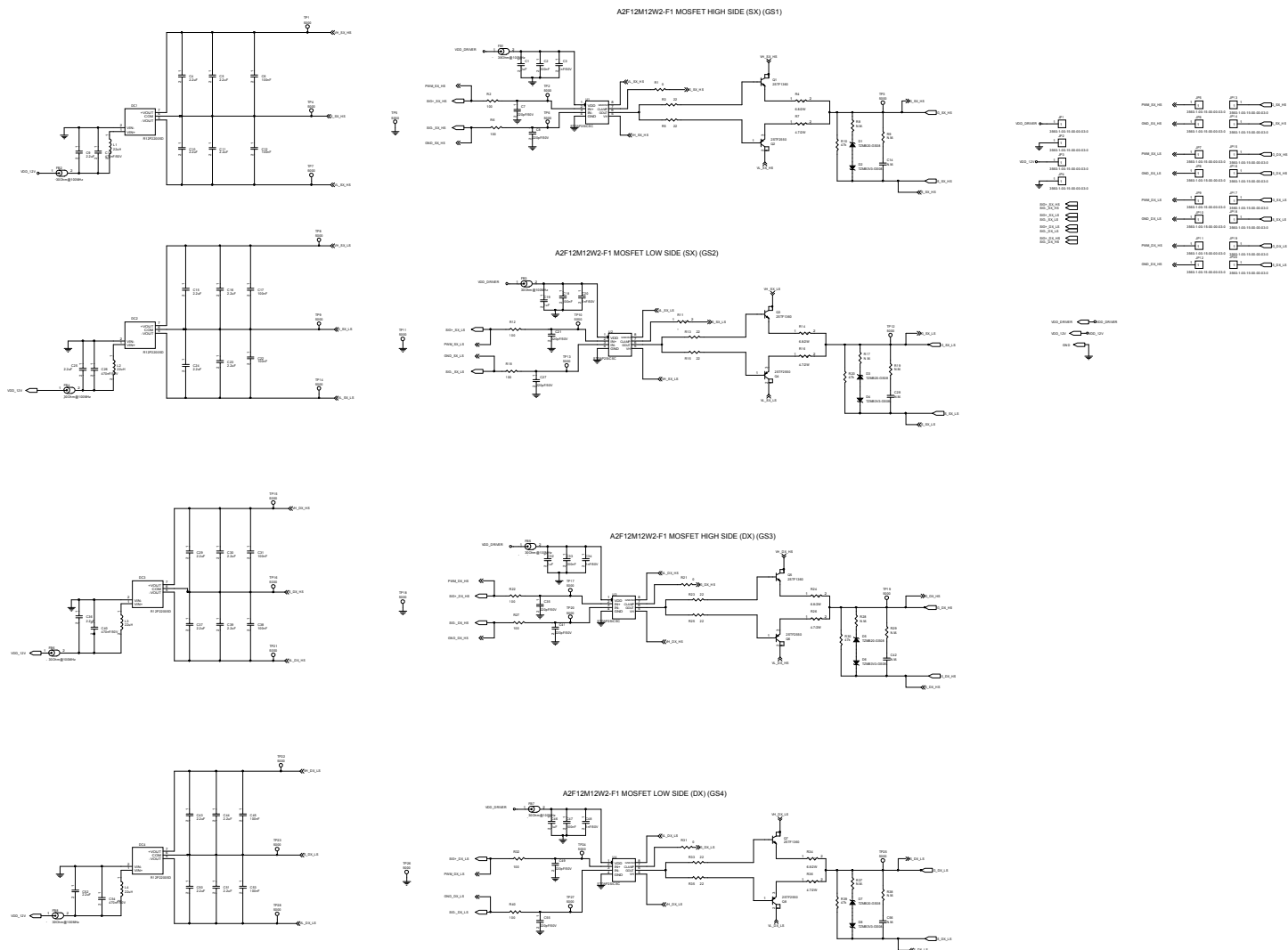


Figure 17. STDES-DABBIDIR - driver board for half bridge circuit schematic (1 of 2)

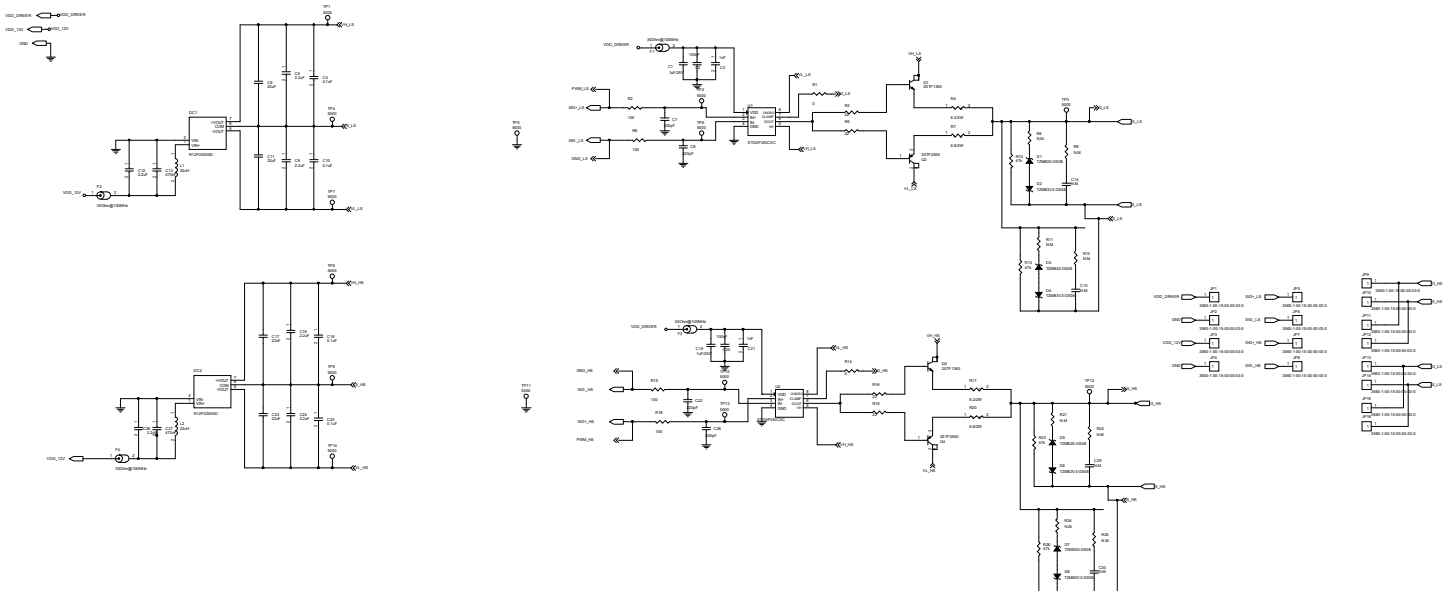


Figure 18. STDES-DABBIDIR - driver board for half bridge circuit schematic (2 of 2)

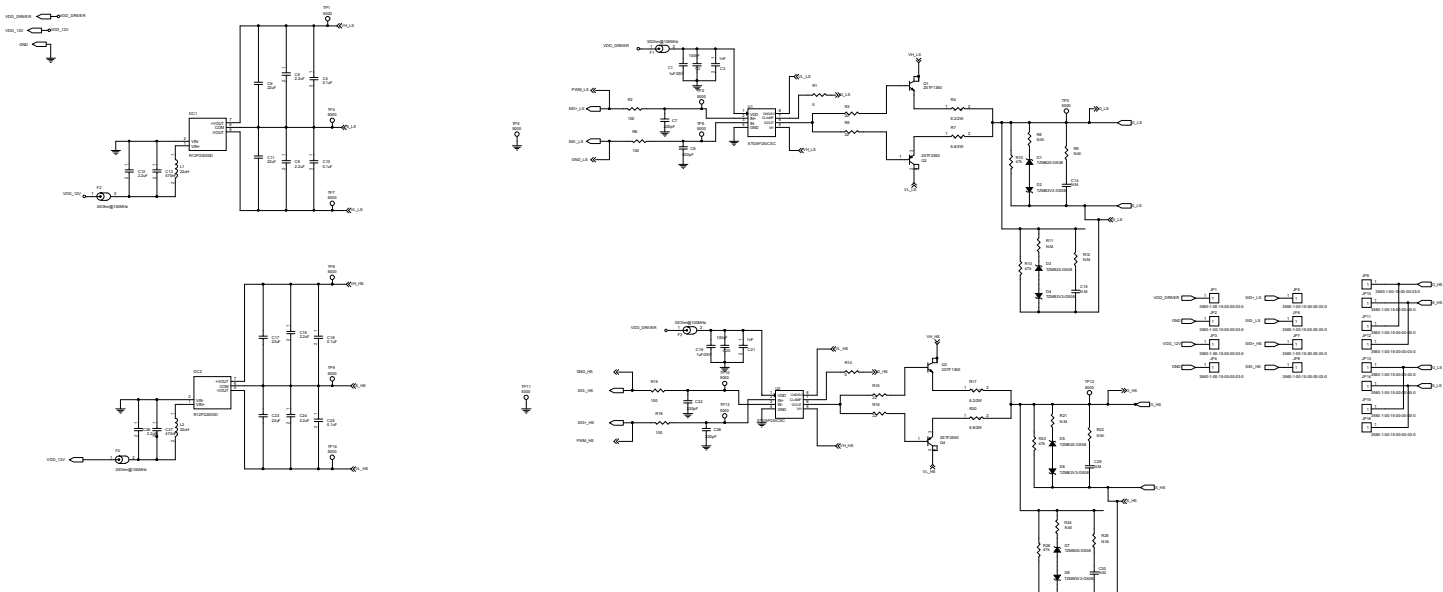
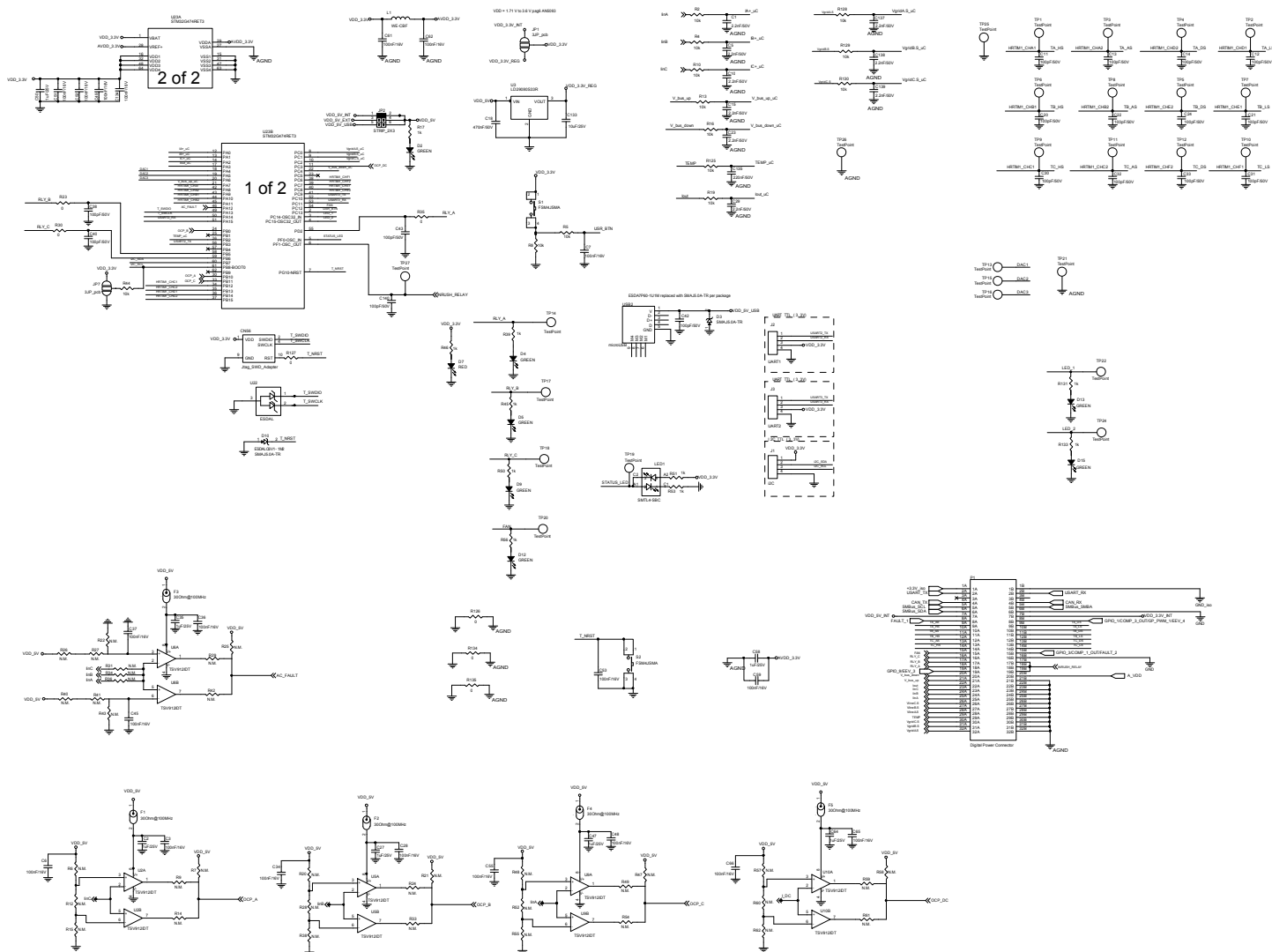


Figure 19. STDES-DABBIDIR - control board circuit schematic



- Refer to datasheet for PCB orientation of the LED1
- Solder a 22µF / 10V electrolytic capacitor in parallel to C133
- 32A-28A | 31A-27A | 30A-26A of P1 connector must be shorted.

5 Bill of materials

Table 2. STDES-DABBIDIR 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 board for full bridge bill of materials	-	Driver board for full bridge	ST	Not available for separate sale
3	2	Table 5. Driver board for half bridge bill of materials	-	Driver board for half bridge	ST	Not available for separate sale
4	1	Table 6. STDES-DABBIDIR control board	-	Control board	ST	Not available for separate sale

Table 3. Main board bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	5	C1 C4 C6 C7 C9	33uF/25V Radial,6.6x5.5mm	Cap Pol Radial (Electrolytic); 6.60 mm X 6.60 mm X 5.50 mm H body	WURTH	865230443004
2	3	C2 C5 C10	470nF/25V 0603 (1608 Metric)	CAPACITOR CERAMIC SMD 0603	WURTH	885012206075
3	15	C3 C8 C23 C25 C29 C30 C38 C40 C41 C43 C47 C49 C56 C58 C60	1uF/25V 0603 (1608 Metric)	CAPACITOR CERAMIC SMD 0603	WURTH	885012206076
4	2	C11 C12	25uF 1200	WCAP-FTDB DC-Link Capacitor,32.5mm,25uF	WURTH	890744428006CS
5	3	C14 C15 C16	40uF 600	WCAP-FTDB DC-Link Capacitor,32.5mm,40uF	WURTH	890764428004CS
6	16	C24 C26 C28 C31 C32 C39 C42 C44 C46 C50 C52 C57 C59 C66 C67 C68	100nF/25V 0603 (1608 Metric)	CAPACITOR CERAMIC SMD 0603	WURTH	885012206071
7	14	C27 C34 C35 C37 C45 C48 C53 C55 C61 C62 C63 C64 C65 C76	N.M. 0603 (1608 Metric)	CAPACITOR CERAMIC SMD 0603 (not mounted)	ANY	ANY
8	2	C33 C51	4.7uF/25V 0603 (1608 Metric)	CAPACITOR CERAMIC SMD 0603	WURTH	885012106012

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
9	2	C36 C54	1nF/16V 0603 (1608 Metric)	CAPACITOR CERAMIC SMD 0603	WURTH	885012006029
10	5	D1 D2 D3 D4 D7	Led Green_SML- M13MTT86 0805 (2012 Metric) 20mA	LED GREEN CLEAR 0805 SMD	Rohm Semiconductor	SML-M13MTT86
11	2	D5 D6	led Yellow_SML- M13YTT86 0805 (2012 Metric) 20mA	LED YELLOW CLEAR 0805 SMD	Rohm Semiconductor	SML-M13YTT86
12	1	D8	led Yellow_SML- M13YTT86 0805 (2012 Metric) 20mA	LED YELLOW CLEAR 0805 SMD	Rohm Semiconductor	SML-M13YTT86
13	16	F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15 F16	30Ohm@100M Hz 0805 (2012 Metric)	FERRITE BEAD 30 OHM 0805 1LN	WURTH	742792030
14	2	J1 J2	Dev3 500mA (DC)	SWITCH SLIDE SPDT 500MA 12V	WURTH	450301014042
15	8	J3 J4 J5 J6 J7 J8 J9 J10	SOLDER JUMPER3 0603 (3pin drop)	TIN DROP JUMPER 0603 3pin		
16	52	J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 J21 J22 J23 J24 J25 J26 J27 J28 J29 J30 J31 J32 J33 J34 J35 J36 J50 J51 J52 J53 J54 J55 J56 J57 J58 J59 J60 J61 J62 J63 J64 J65 J66 J67 J68 J69 J70 J71 J72 J73 J74 J75	9324-0-15-15-2 3-27-04-0	Circuit Board Hardware - PCB RECPT. GOLD/ NICKEL .106 IN. PRESSFIT	Mill-Max	9324-0-15-15-23-27-04-0
17	8	J37 J38 J39 J40 J41 J42 J43 J44 J45 J46	74651195	Power to the Board 10MM 40A SOLDER SCREW M4	WURTH	74651195
18	1	J47	Con2	CONN TERM BLOCK 2POS 5.08MM PCB	Phoenix Contact	1729128
19	2	JP1 JP2	Con2	CONN TERM BLOCK 2POS 5.08MM PCB	Phoenix Contact	1729128
20	1	LEM1	CASR 15-NP Ring Opening 0.126" Dia, 6 Leads	SENSOR CURRENT HALL 15A AC/DC	LEM USA Inc.	CASR 15-NP
21	1	LEM2	CASR 50-NP Ring Opening 0.126" Dia, 6 Leads	SENSOR CURRENT HALL 15A AC/DC	LEM USA Inc.	CASR 50-NP

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
22	1	P1	CON64AB	Connector Erni 284166 32X2 female	ERNI	284166
23	1	Q1	STS6NF20V SO-8	N-channel 20 V, 30 mOhm typ., 6 A, 2.7 V drive STripFET II Power MOSFET in an SO-8 package	ST	STS6NF20V
24	7	R1 R2 R3 R4 R5 R6 R7	5.6k 1206 (3216 Metric) 0.25W, 1/4W 1%	CHIP RESISTOR SMD 1% 1/4W 1206	ANY	ANY
25	18	R8 R9 R10 R15 R19 R23 R28 R29 R30 R33 R36 R38 R51 R52 R55 R56 R57 R58	N.M. 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603 (not mounted)	ANY	ANY
26	3	R11 R13 R16	390K 1206 (3216 Metric) 0.25W, 1/4W 1%	CHIP RESISTOR SMD 1% 1/4W 1206	ANY	ANY
27	14	R12 R18 R20 R22 R25 R31 R35 R41 R43 R45 R48 R50 R53 R54	0 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
28	3	R14 R32 R49	100 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
29	4	R17 R27 R40 R47	3K 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
30	4	R21 R26 R42 R46	1.8K 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
31	1	R24	2K2 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
32	3	R34 R37 R39	360K 1206 (3216 Metric) 0.25W, 1/4W 1%	CHIP RESISTOR SMD 1% 1/4W 1206	ANY	ANY
33	1	R44	3K3 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
34	1	R59	470 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
35	1	R60	5.6k 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
36	1	R61	5.1k 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
37	1	R62	22 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
38	1	R63	10k 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
39	1	R64	33k 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
40	1	R66	1 2512 (6332 metric)	CHIP RESISTOR SMD 2512	ANY	ANY
41	1	T1	Coilcraft-CST3015-100E 30x23mm	Tranf,Radio 1:100,80A	Coilcraft	CST3015-100E
42	1	T2	Frenetic_32011-04		Frenetic	32011-04
43	22	TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8 TP9 TP10 TP11 TP12 TP13 TP14 TP15 TP16 TP17 TP18 TP19 TP20 TP21 TP22	TestPoint_Ring	Test Point ring	ANY	ANY
44	4	TP23 TP24 TP25 TP26	TestPoint_Ring	Test Point ring	ANY	ANY
45	8	TP27 TP28 TP29 TP30 TP31 TP32 TP33 TP34	TESTPOINT_1 MM	Test Point ring	ANY	ANY
46	14	TW1 TW2 TW3 TW4 TW5 TW6 TW7 TW8 TW9 TW10 TW11 TW12 TW13 TW14	M3 HOLE NOT PLATED	Mounting Hole M3 not plated - Pan Head	ANY	ANY
47	1	U1	LD29080DT50R TO-252-3, D-PAK (2 Leads + Tab), SC-63	800 mA fixed and adjustable output very low drop voltage regulator	ST	LD29080DT50R
48	3	U10 U13 U18	TL431ACL3T, SOT-23	Adjustable micropower shunt voltage reference	ST	TL431ACL3T

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
49	3	U15 U17 U9	TSV912IDT SO-8 (0.154", 3.90mm Width)	Wide-bandwidth (8MHz) rail to rail input/output 5V CMOS Op- Amps, dual	ST	TSV912IDT
50	2	U2 U3	LDL1117S33R, SOT-223	1.2 A High PSRR low dropout linear voltage regulator	ST	LDL1117S33R
51	1	U4	A2F12M12W2- F1 ACEPACK 2	ACEPACK 2 power module, fourpack topology, 1200 V, 13 mOhm typ. SiC Power MOSFET gen.2 with NTC	ST	A2F12M12W2-F1
52	2	U5 U6	ACEPACK 2 1200V	ACEPACK 2 - Half-bridge - 1200V, 6mOhm SiC MOSFET Gen3 with NTC	ST	For the half-bridge ACEPACK 2 power module, contact ST
53	2	U7 U12	TSV911ILT, SOT23-5L	Wide-bandwidth (8MHz) rail to rail input/output 5V CMOS Op- Amp, single	ST	TSV911ILT
54	2	U8 U14	AMC1311QDW VRQ1 8-SOIC (0.295", 7.50mm Width)	IC ISOLATION 8SOIC	Texas Instruments	AMC1311QDWVRQ1
55	2	U11 U20	1779205141 7- SIP Module, 4 Leads 1W	DC DC CONVERTER 5V 1W	WURTH	1779205141
56	1	U19	STLM20W87F SOT323-5L	Analog temperature sensor, ultra-low current 2.4 V, high precision	ST	STLM20W87F

Table 4. Driver board for full bridge bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	4	C1 C19 C32 C46	1uF 0603 (1608 Metric) 25V 0.1	CAPACITOR CERAMIC SMD 0603	Wurth Electronics Inc.	885012206076
2	12	C2 C6 C12 C17 C18 C22 C31 C33 C38 C45 C47 C53	100nF 0603 (1608 Metric) 50V 0.1	CAPACITOR CERAMIC SMD 0603	Wurth Electronics Inc.	885012206095
3	4	C3 C20 C34 C48	1nF/50V 0603 (1608 Metric) 50V 0.05	CAPACITOR CERAMIC SMD 0603	Wurth Electronics Inc.	885012006063

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
4	20	C4 C5 C9 C10 C11 C15 C16 C23 C24 C25 C29 C30 C36 C37 C39 C43 C44 C50 C51 C52	2.2uF 0805 (2012 Metric) 25V 0.1	CAPACITOR CERAMIC SMD 0805	Würth Electronics Inc.	885012207079
5	8	C7 C8 C21 C27 C35 C41 C49 C55	220pF/50V 0603 (1608 Metric) 50V 0.05	CAPACITOR CERAMIC SMD 0603	Würth Electronics Inc.	885012006059
6	4	C13 C26 C40 C54	470nF/50V 0805 (2012 Metric) 50V 0.05	CAPACITOR CERAMIC SMD 0805	Würth Electronics Inc.	885012207102
7	4	C14 C28 C42 C56	N.M. N.M.	N.M.	ANY	
8	4	D1 D3 D5 D7	TZMB20-GS08 DO-213AC, MINI-MELF, SOD-80	DIODE ZENER 20V 500MW SOD80	Vishay Semiconductor Diodes Division	TZMB20-GS08
9	4	D2 D4 D6 D8	TZMB3V3- GS08 DO-213AC, MINI-MELF, SOD-80	DIODE ZENER 3.3V 500MW SOD80	Vishay Semiconductor Diodes Division	TZMB3V3-GS08
10	4	DC1 DC2 DC3 DC4	R12P22005D 0.77" L x 0.39" W x 0.49" H (19.5mm x 9.8mm x 12.5mm)	CONV DC/DC 2W 12VIN +20/-5VOUT T	Recom Power	R12P22005D
11	8	FB1 FB2 FB3 FB4 FB5 FB6 FB7 FB8	30Ohm@100M Hz 0805 (2012 Metric)	FERRITE BEAD 30 OHM 0805 1LN	Würth Electronics Inc.	74279206
12	20	JP1 JP2 JP3 JP4 JP5 JP6 JP7 JP8 JP9 JP10 JP11 JP12 JP13 JP14 JP15 JP16 JP17 JP18 JP19 JP20	3560-1-00-15-0 0-00-03-0	IC & Component Sockets .060" Dia St Pins	Mill-Max	3560-1-00-15-00-00-03-0
13	4	L1 L2 L3 L4	22uH 0805 (2012 Metric) 0.2	FIXED IND 22UH 130MA 3.7 OHM SMD	Taiyo Yuden	LBC2012T220M
14	4	Q1 Q3 Q5 Q7	2STF1360 TO-243AA	TRANS NPN 60V 3A SOT-89	ST	2STF1360
15	4	Q2 Q4 Q6 Q8	2STF2550 SOT-89	Low voltage high performance PNP power transistor	ST	2STF2550
16	3	R1 R21 R31	0 1210 (3225 Metric)	CHIP RESISTOR SMD	ANY	ANY

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
17	8	R2 R6 R12 R18 R22 R27 R32 R40	100 0603 (1608 Metric) 0.1W, 1/10W 0.01	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
18	8	R3 R5 R13 R15 R23 R25 R33 R35	22 1210 (3225 Metric)	CHIP RESISTOR SMD	ANY	ANY
19	4	R4 R14 R24 R34	6.8/2W 2512 (6332 metric) 2W	CHIP RESISTOR SMD	ANY	ANY
20	4	R7 R16 R26 R36	4.7/2W 2512 (6332 metric) 2W	CHIP RESISTOR SMD	ANY	ANY
21	8	R8 R9 R17 R19 R28 R29 R37 R38	N.M. 0603 (1608 Metric) 0.1W, 1/10W 0.01	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
22	4	R10 R20 R30 R39	47k 0603 (1608 Metric) 0.1W, 1/10W 0.01	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
23	1	R11	0 1206 (3216 Metric) 0.25W, 1/4W 0.05	CHIP RESISTOR SMD 5% 1/4W 1206	ANY	ANY
24	28	TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8 TP9 TP10 TP11 TP12 TP13 TP14 TP15 TP16 TP17 TP18 TP19 TP20 TP21 TP22 TP23 TP24 TP25 TP26 TP27 TP28	TestPoint 0.100" Dia x 0.180" L (2.54mm x 4.57mm)	TEST POINT PC MINI .040"D RED	ANY	ANY
25	4	U1 U2 U3 U4	STGAP2SICS SO 8 WIDE 300 (0.295", 7.50mm Width)	Galvanically isolated 4 A single gate driver for SiC MOSFETs	ST	STGAP2SICS

Table 5. Driver board for half bridge bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	2	C1 C19	1uF/25V 0603 (1608 Metric) 10% 25V	CAPACITOR CERAMIC SMD 0603 (MLCC) GRM 1uF, ±10%, 25V cc, SMD	Wurth Electronics Inc.	885012206076
2	2	C2 C20	100nF 0603 (1608 Metric) 10% 25V	CAPACITOR CERAMIC SMD 0603 (MLCC) GRM 100nF, ±10%, 25V cc, SMD	Wurth Electronics Inc.	885012206071

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
3	1	C3	1nF 0603 (1608 Metric) 10% 25V	CAPACITOR CERAMIC SMD 0603 (MLCC) C 1nF, ±10%, 25V cc, SMD	Würth Electronics Inc.	885012006044
4	4	C4 C10 C18 C25	0.1uF 0603 (1608 Metric) 5% 50V	CAP CER 0.1UF 50V X7R 0603	Würth Electronics Inc.	885012206095
5	6	C5 C9 C12 C16 C24 C26	2.2uF 0805 (2012 Metric) 10% 25V	CAP CER 2.2UF 50V X7R 0805	Würth Electronics Inc.	885012207079
6	4	C6 C11 C17 C23	22uF 1210 (3225 Metric) 20% 25V	CAP CER 22UF 25V X5R 1210	Würth Elektronik	885012109014
7	4	C7 C8 C22 C28	220pF 0603 (1608 Metric) 5% 50V	CAPACITOR CERAMIC SMD 0603 (MLCC) C 220pF, ±5%, 1kV cc, SMD	Würth Electronics Inc.	885012006059
8	2	C13 C27	470nF 0805 (2012 Metric) 10% 50V	CAPACITOR CERAMIC SMD 0805	Würth Electronics Inc.	885012207102
9	4	C14 C15 C29 C30	N.M.	N.M.	ANY	
10	1	C21	1nF 0603 (1608 Metric) 10% 25V	CAPACITOR CERAMIC SMD 0603 (MLCC) C 1nF, ±10%, 25V cc, SMD	Würth Electronics Inc.	885012006044
	4	D1 D3 D5 D7	TZMB20-GS08 DO-213AC, MINI-MELF, SOD-80	DIODE ZENER 20V 500MW SOD80	Vishay Semiconductor Diodes Division	TZMB20-GS08
12	4	D2 D4 D6 D8	TZMB3V3-GS08 DO-213AC, MINI-MELF, SOD-80	DIODE ZENER 3.3V 500MW SOD80	Vishay Semiconductor Diodes Division	TZMB3V3-GS08
13	2	DC1 DC2	R12P22005D 0.77" L x 0.39" W x 0.49" H (19.5mm x 9.8mm x 12.5mm)	CONV DC/DC 2W 12VIN +20/-5VOUT T	RECOM	R12P22005D
14	4	F1 F2 F3 F4	30Ohm@100M Hz 0805 (2012 Metric)	FERRITE BEAD 30 OHM 0805 1LN	Würth Electronics Inc.	742792030
15	16	JP1 JP2 JP3 JP4 JP5 JP6 JP7 JP8 JP9 JP10 JP11 JP12 JP13 JP14 JP15 JP16	3560-1-00-15-0 0-00-03-0	IC & Component Sockets .060" Dia St Pins	Mill-Max	3560-1-00-15-00-00-03-0
16	2	L1 L2	22uH 0805 (2012 Metric) 20%	FIXED IND 22UH 130MA 3.7 OHM SMD	Taiyo Yuden	LBC2012T220M

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
17	2	Q1 Q3	2STF1360, SOT-89	Low voltage fast-switching NPN power transistor	ST	2STF1360
18	2	Q2 Q4	2STF2550, SOT-89	Low voltage high performance PNP power transistor	ST	2STF2550
19	2	R1 R14	0 1210 (3225 Metric)	CHIP RESISTOR SMD	ANY	ANY
20	4	R2 R6 R15 R19	100 1210 (3225 Metric) 1%	Resistore SMD Bourns 100O ±1%, 0,1W, 0603, serie CR0603	ANY	ANY
21	4	R3 R5 R16 R18	22 2512 (6332 metric)	CHIP RESISTOR SMD	ANY	ANY
22	2	R4 R17	8.2/2W 2512 (6332 metric)	CHIP RESISTOR SMD	ANY	ANY
23	2	R7 R20	6.8/2W 2512 (6332 metric)	CHIP RESISTOR SMD	ANY	ANY
24	8	R8 R9 R11 R12 R21 R22 R24 R25	N.M.	N.M.	N.M.	N.M.
25	4	R10 R13 R23 R26	47k 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
26	14	TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8 TP9 TP10 TP11 TP12 TP13 TP14	5000	TEST POINT PC MINI .040"D RED	ANY	ANY
27	2	U1 U2	STGAP2SICSC, SO 8 WIDE 300	Galvanically isolated 4 A single gate driver for SiC MOSFETs	ST	STGAP2SICSC

Table 6. STDES-DABBIDIR control board

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
1	1	CN56	Jtag_SWD_Adapter,	10-way, 2-row, vertical pin header	Wurth	62201021121

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
2	20	C3,C6, C7,C2 8,C34, C36,C 37,C45 ,C48,C 49,C51 ,C52,C 53,C55 ,C59,C 61,C62 ,C65,C 66,C13 4	100 nF, 603, 16 V, $\pm 10\%$,	Multilayer ceramic capacitors	Wurth	885012206046
3	7	C2,C2 7,C35, C47,C 50,C58 ,C64	1 μ F, 603, 25 V	Multilayer ceramic capacitors	Wurth	885012206076
4	17	C11,C 12,C13 ,C14,C 20,C21 ,C22,C 24,C30 ,C31,C 32,C33 ,C38,C 40,C42 ,C43,C 140	100 pF, 603, 50 V	Multilayer ceramic capacitors	Wurth	885012006057
5	1	C135	220nF, 603, 50 V	Multilayer ceramic capacitor	ANY	ANY
6	1	C18	470 nF, 805, 50 V	Multilayer ceramic capacitor	Wurth	885012207102
7	3	C15,C 23,C29	2.2 nF, 603, 50 V, $\pm 5\%$	Multilayer ceramic capacitors	KEMET	C0603C222J5GACT U
8	1	C133	10 μ F, 805, 25 V	Multilayer ceramic capacitor	ANY	ANY
9	7	D2,D4, D5,D9, D12,D 13,D15	GREEN, SMD 0805, 2.8 V	Green LED	Wurth	150080GS75000
10	2	D3,D1 0	SMAJ5.0A-TR, SMA, 400 W	Uni-directional TVS Diode,	ST	SMAJ5.0A-TR
11	1	D7	RED, SMD 0805, 2.4 V	Red LED	Wurth	150080RS75000
12	5	F1,F2, F3,F4, F5	22 Ohm@100 MHz, 6 A	Ferrite beads	Wurth	742792021
13	2	JP1,JP 7 N.A.	3JP_pcb	Solder jumper selectors (not assembled)	ANY	ANY
14	1	JP2 N.A.	STRIP_2X3	Solder jumper selector (not assembled)	ANY	ANY
15	1	J1	i2C, strip4_100m_v	4-way, 1-row, straight pin header	Wurth	61300411121

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
16	2	J2,J3	CON4, strip4_100m_v,	4-way, 1 row, straight pin header	Würth	61300411121
17	1	LED1	SMTL4-SBC, 2 V, SMD	LED	BIVAR	SMTL4-SBC
18	1	L1	WE-CBF, 603, 500 m A, $\pm 25\%$	Ferrite bead	Würth	74279262
19	1	P1	CON 64 male	Multipole plug	ERNI	533406
20	13	R2,R4, R5,R8, R10,R 13,R16 ,R19,R 44,R12 5,R128 ,R129, R130	10 k, 603, 0.1 W, $\pm 1\%$	Thick film SMD resistors	ANY	ANY
21	36	R6,R7, R9,R1 2,R14, R15,R 20,R21 ,R22,R 24,R25 ,R26,R 27,R28 ,R29,R 31,R33 ,R34,R 36,R38 ,R40,R 41,R42 ,R43,R 47,R48 ,R49,R 52,R54 ,R55,R 57,R58 ,R59,R 60,R61 ,R62 N.A.	N.M., 603	Resistors (not mounted)	ANY	ANY
22	10	R17,R 39,R45 ,R46,R 50,R51 ,R53,R 56,R13 1,R133	1 k, 603, 0.1 W, $\pm 1\%$	Thick film SMD resistors	ANY	ANY
23	7	R23,R 30,R35 ,R126, R127, R134, R135	0, 603, 0.1 W, $\pm 1\%$	Thick film SMD resistors	ANY	ANY
24	2	S1,S2	te_fsm4jsma, None	Button tactile switch, single pole single throw (SPST)	TE Connectivity	FSM4JSMATR

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
25	26	TP1,T P2,TP 3,TP4, TP5,T P6,TP 7,TP8, TP9,T P10,T P11,TP 12,TP1 3,TP14 ,TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP24, TP25, TP26, TP27	TestPoint	Test terminals	ANY	ANY
26	1	USB2	microUSB	Micro USB connector receptacle	MOLEX	47346-0001
27	5	U2,U5, U6,U9, U10	TSV912IDT, SO-8	Wide-bandwidth (8 MHz) rail-to-rail input/output 5 V CMOS op-amp	ST	TSV912IDT
28	1	U3	LD29080, 3.3 V, 800 mA	800 mA fixed and adjustable output very low drop voltage regulator	ST	LD29080
29	1	U23	STM32G474RET3, LQFP 64	Mainstream Arm Cortex-M4 MCU	ST	STM32G474RET3
30	1	U22	ESDAL, 300 W, SOT23-3L	Dual-Element Uni-Directional TVS Diode	ST	ESDA6V1L
31	1	PCB	FR4 4 LAYER, 98x48x1.6mm	PCB FR4- 4 Layer size 98x48x1.6mm	-	-

Appendix A Reference design warnings, restrictions and disclaimer

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Revision history

Table 7. Document revision history

Date	Revision	Changes
16-Dec-2022	1	Initial release.

Contents

1	Overview	2
1.1	Features	2
1.2	Main characteristics	2
1.3	Application block diagram	2
1.4	DAB operation	3
2	Test setup	5
2.1	Safety precautions	5
2.2	System setup requirements	5
3	Measurements/waveforms/test data	6
3.1	Waveforms	6
3.2	Efficiency	7
4	Schematic diagrams	9
5	Bill of materials	18
Appendix A	Reference design warnings, restrictions and disclaimer	30
	Revision history	31
	List of tables	33
	List of figures	34

List of tables

Table 1.	Main characteristics	2
Table 2.	STDES-DABBIDIR bill of materials	18
Table 3.	Main board bill of materials	18
Table 4.	Driver board for full bridge bill of materials	22
Table 5.	Driver board for half bridge bill of materials	24
Table 6.	STDES-DABBIDIR control board	26
Table 7.	Document revision history	31

List of figures

Figure 1.	STDES-DABBIDIR reference design	1
Figure 2.	Application block diagram	3
Figure 3.	STDES-DABBIDIR block diagram	3
Figure 4.	DAB topology	4
Figure 5.	DAB simplified diagram	4
Figure 6.	Typical test bench	5
Figure 7.	Switching waveform	6
Figure 8.	Maximum power waveforms	7
Figure 9.	Efficiency	8
Figure 10.	STDES-DABBIDIR - main board circuit schematic (1 of 6)	9
Figure 11.	STDES-DABBIDIR - main board circuit schematic (2 of 6)	10
Figure 12.	STDES-DABBIDIR - main board circuit schematic (3 of 6)	11
Figure 13.	STDES-DABBIDIR - main board circuit schematic (4 of 6)	12
Figure 14.	STDES-DABBIDIR - main board circuit schematic (5 of 6)	13
Figure 15.	STDES-DABBIDIR - main board circuit schematic (6 of 6)	14
Figure 16.	STDES-DABBIDIR - driver board for full bridge circuit schematic.	15
Figure 17.	STDES-DABBIDIR - driver board for half bridge circuit schematic (1 of 2).	16
Figure 18.	STDES-DABBIDIR - driver board for half bridge circuit schematic (2 of 2).	16
Figure 19.	STDES-DABBIDIR - control board circuit schematic	17

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