

H6.5 EVALUATION BOARD

Evaluation Board for the
flowPACK 1 H6.5 Module

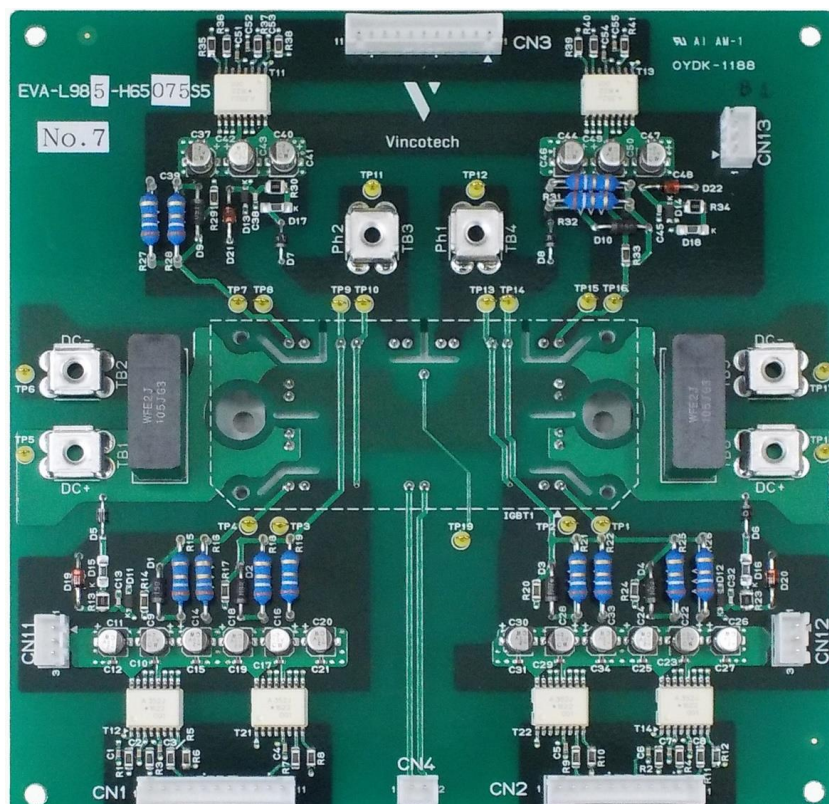


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Revision History

Date	Revision Level	Description	Page Number(s)
Nov 2017	1	First release	19
Mar 2018	1	Content update	19

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1 Abstract

This reference design document describes an evaluation board for the *flowPACK 1 H6.5* module. A gate drive optocoupler (ACPL-352J), connectors, terminals and the like are included for testing the *flowPACK 1 H6.5* module.

2 Evaluation board order number

Evaluation board order number: **EVA-L98x-PCB**

3 Target application

The target application is single-phase PV inverters up to 10 kW.

An example of application conditions in Japan follows:

- 1) $V_{CC}=350V$
- 2) $V_{ac}=202V_{rms}$
- 3) $f_c=20kHz$
- 4) $I_o=15A_{rms}\sim 50A_{rms}$

An example of application conditions in Europe/Asia follows:

- 1) $V_{CC}=400V$
- 2) $V_{ac}=240V_{rms}$
- 3) $f_c=20kHz$
- 4) $I_o=15A_{rms}\sim 50A_{rms}$

The above application is given for reference only. The H6.5 evaluation board cannot guarantee the module's suitability for it.

4 The applied circuit and three-level operation

4.1 The *flowPACK 1* H6.5 module's internal circuit

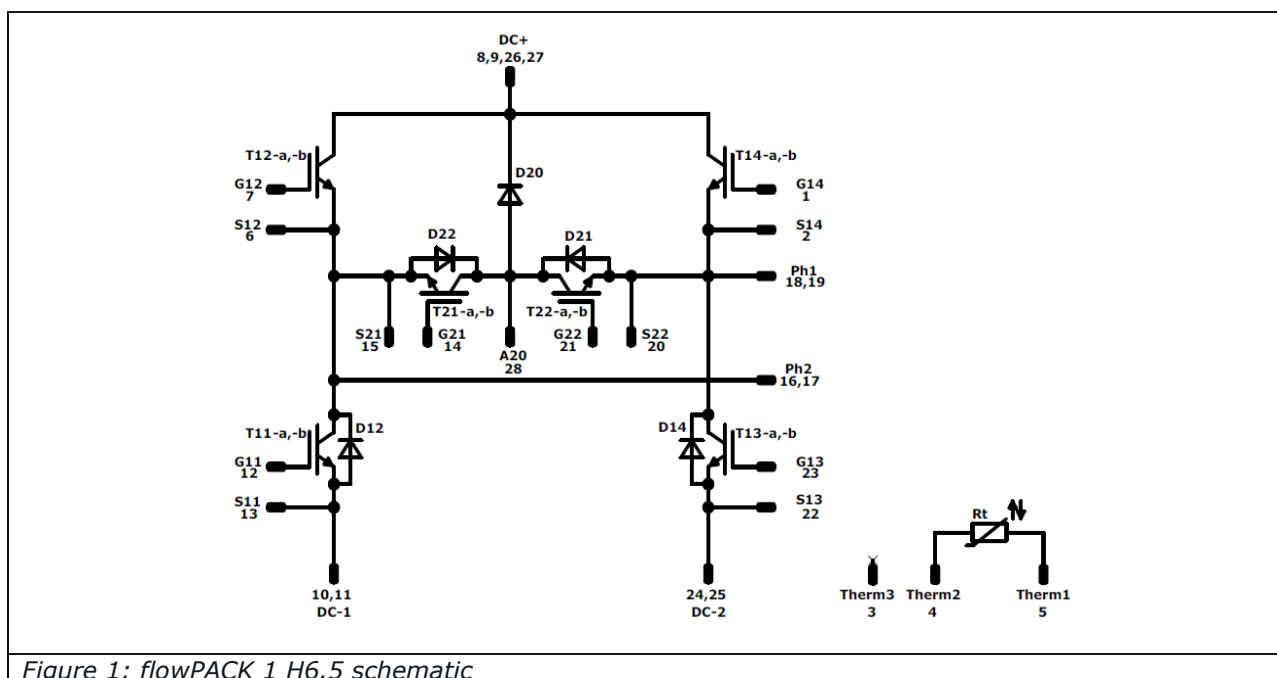


Figure 1: *flowPACK 1* H6.5 schematic

4.2 The circuit applied for the *flowPACK 1* H6.5 module

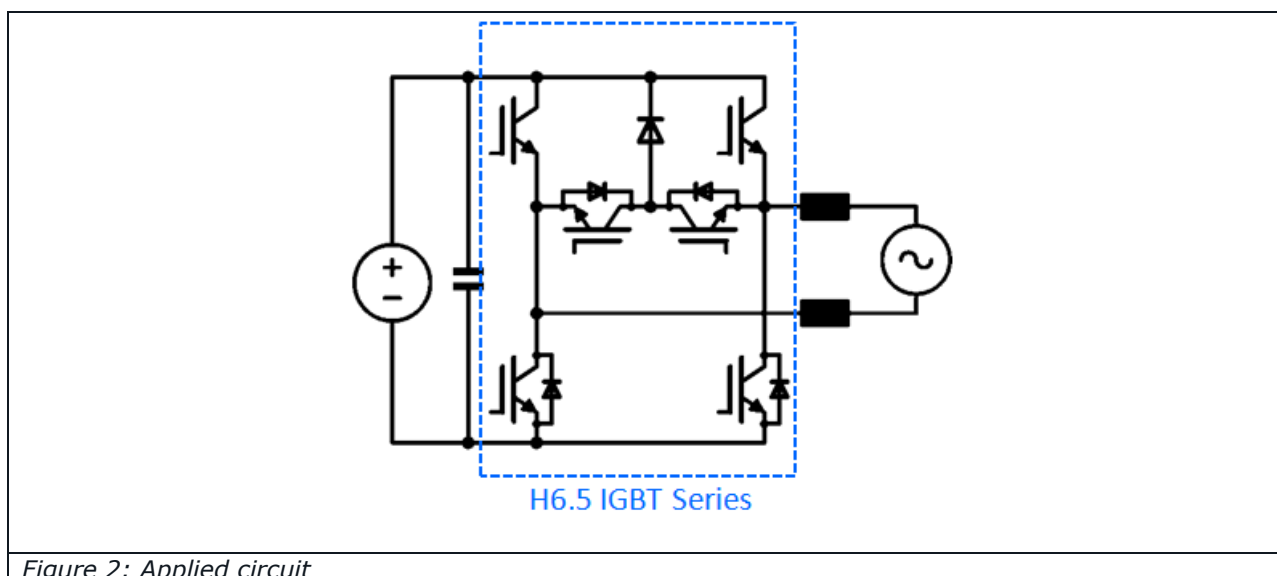
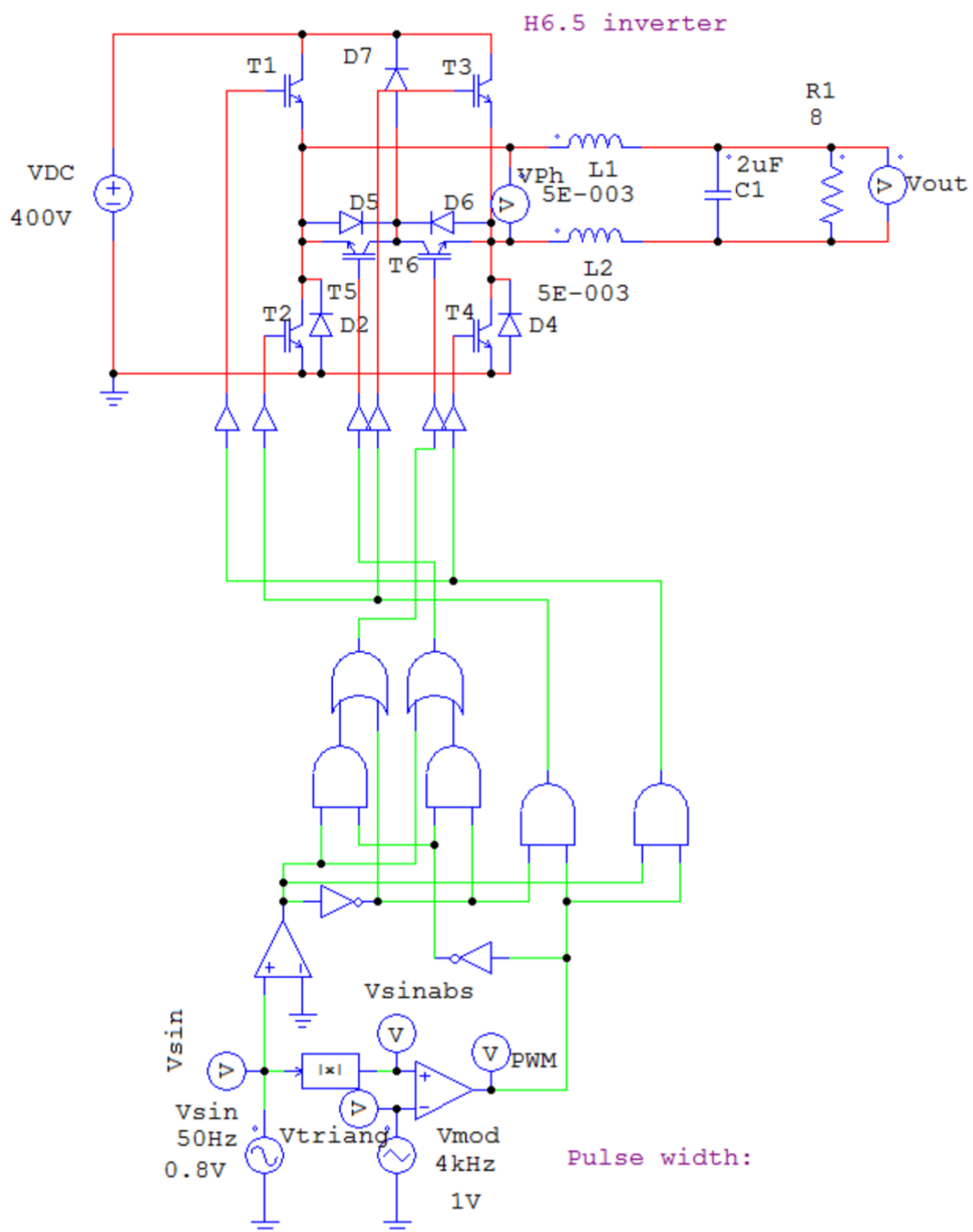


Figure 2: Applied circuit

4.3 Three-level operation

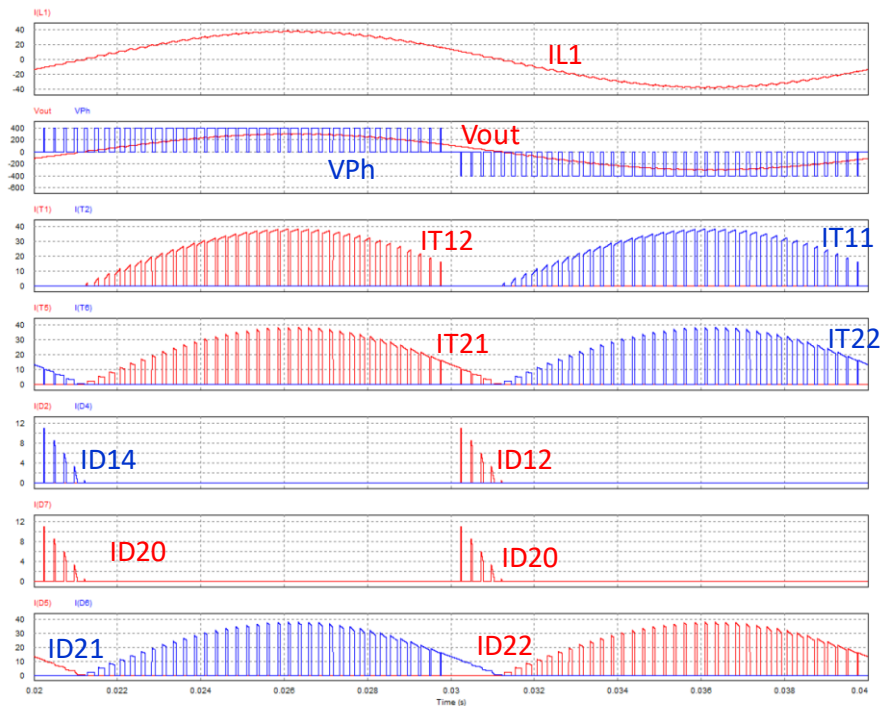
4.3.1 The operating circuit, including the control section

The figure below diagrams the logic of a basic circuit



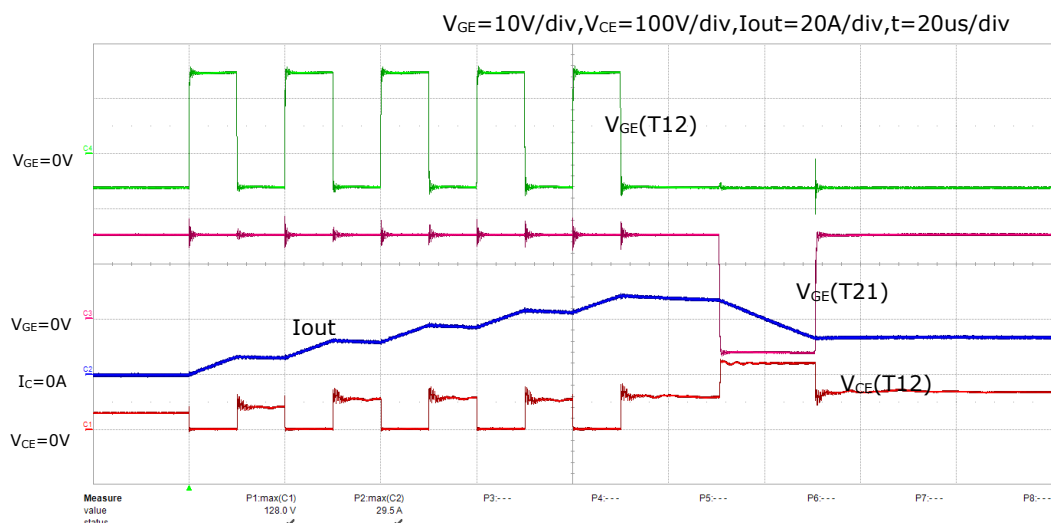
4.3.2 The operating waveform (simulation)

The figure below shows the simulated waveform.



4.3.3 An example of the tested waveform

The figure below shows the tested waveform at around V_{CE} and V_{GE} of T12, T21 and output current (I_{out}). It examines the performance in three-level operation.



DC voltage=120V, $V_{GE}=+15V/-6V$,

5 Gate driver for the IGBT module

Broadcom driver ACPL-352J

Please refer to the broadcom datasheet "pub-005817_DS_ACPL-352J_2016-08-29" for specification details.

5.1 Standard gate resistance

$R_{gon}, R_{goff} = 3.9\text{ohms}^{(*1)}$

Gate drive voltage $V_G = +15\text{V}/-6\text{V}$

*1) Standard value on this board

5.2 Another gate resistance

$R_{gon}, R_{goff} = 5.7\text{ohms}^{(*2)}$

Gate drive voltage $V_G = +15\text{V}/-15\text{V}$

*2) When the negative gate voltage is -15V, the gate resistance must be adjusted to 5.7 ohms.

*1), *2) $R_{gon}, R_{goff} = ((V_{G+}) - (V_{G-})) / I_{peak} - 0.3\text{ohms}$

V_{G+} signifies a positive gate voltage. V_{G-} indicates a negative gate voltage.

Gate resistance values are determined by the peak current (I_{peak}) and the ACPL-352J's internal resistance.

6 Connector

Seven connectors are used for the control signal, UVLO (under voltage lock out) and power supply.

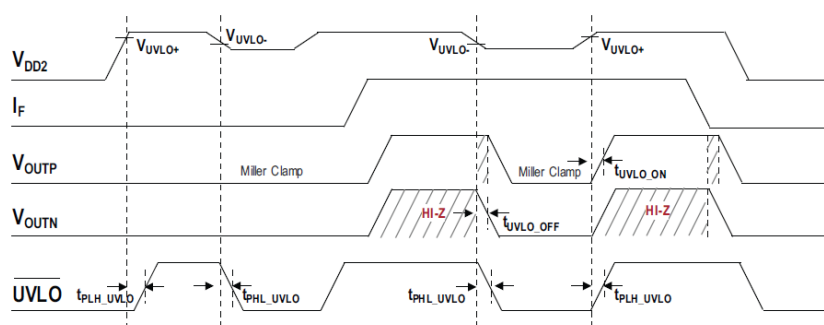
Connector no.	Name	Content
CN1	Control circuit1	Control signal for T12&T21, UVLO, 5V power supply
CN2	Control circuit2	Control signal for T14&T22, UVLO, 5V power supply
CN3	Control circuit2	Control signal for T14&T22, UVLO, 5V power supply
CN4	NTC thermistor	
CN11	Drive power supply1	Positive and negative drive power supply for T12&T21
CN12	Drive power supply2	Positive and negative drive power supply for T14&T22
CN13	Drive power supply3	Positive and negative drive power supply for T11&T13

7 Protection function

7.1 UVLO

Insufficient gate voltage to the IGBT can increase its turn-on resistance, resulting in considerable power loss and heat dissipation that can damage the IGBT. The ACPL-352J constantly monitors the VDD2 output power supply. When the output power supply is lower than the under voltage lockout (UVLO) threshold, the gate driver output shuts off to protect the IGBT from low-voltage bias. During power-up, the UVLO feature sets the gate driver output to a low value to prevent unwanted turn-on at a lower supply voltage.

Please refer to the Broadcom datasheet "pub-005817_DS_ACPL-352J_2016-08-29."



UVLO threshold	Type
VULO+	12.9V
VULO-	11.8V

7.2 Over-current protection

The H6.5 IGBT series does not come with OC protection because H6.5 IGBTs are not susceptible to short circuits.

8 Isolation, creepage and air clearance distance

8.1 Isolation voltage

4000V, 2 seconds between the primary and secondary circuit

8.2 Creepage and air clearance distance

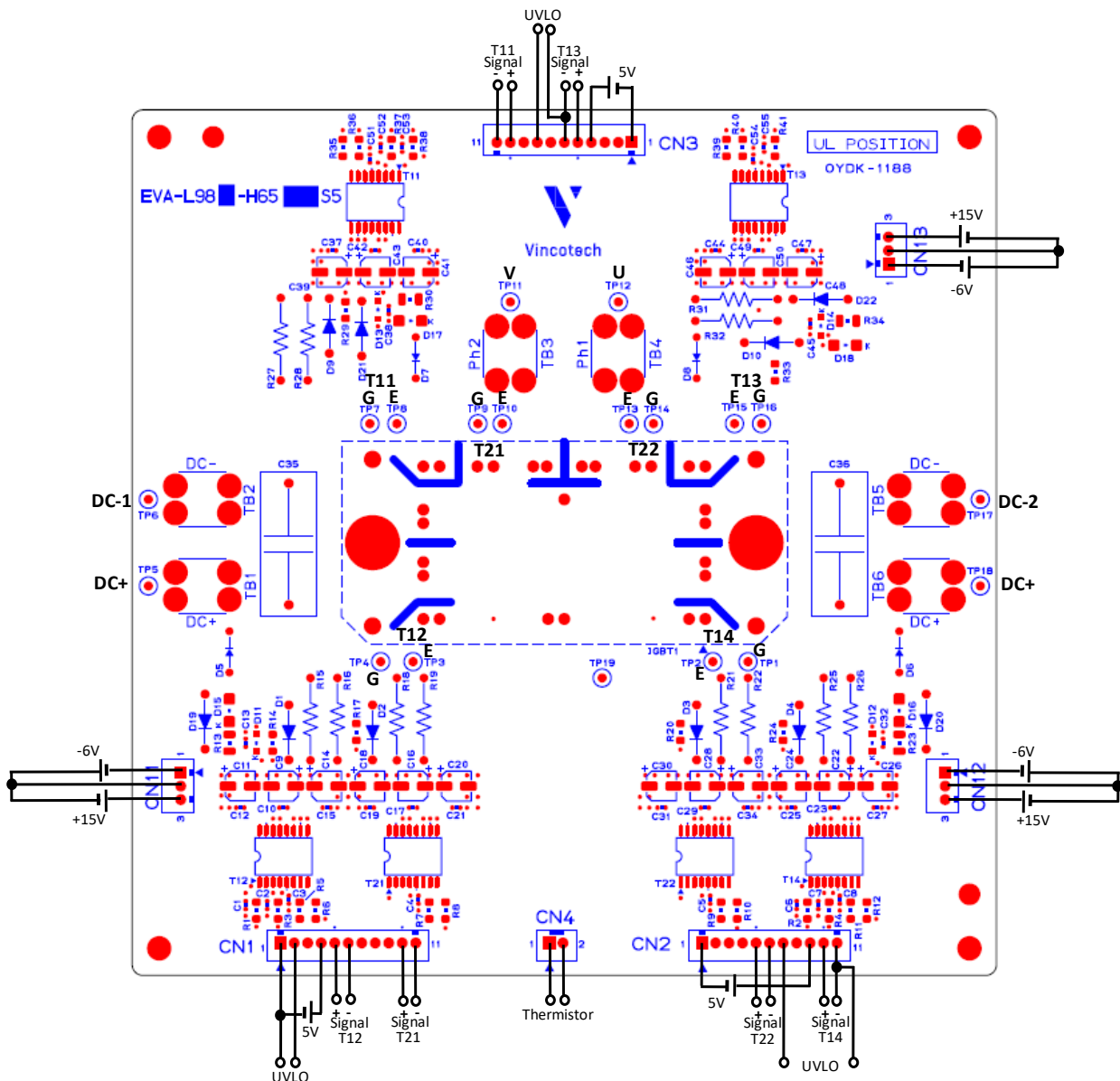
a) Creepage distance: 6 mm

b) Air clearance distance: 4 mm



9 Circuit connections

The diagram below shows the control signal and power supply connections, and gives the names of terminals.

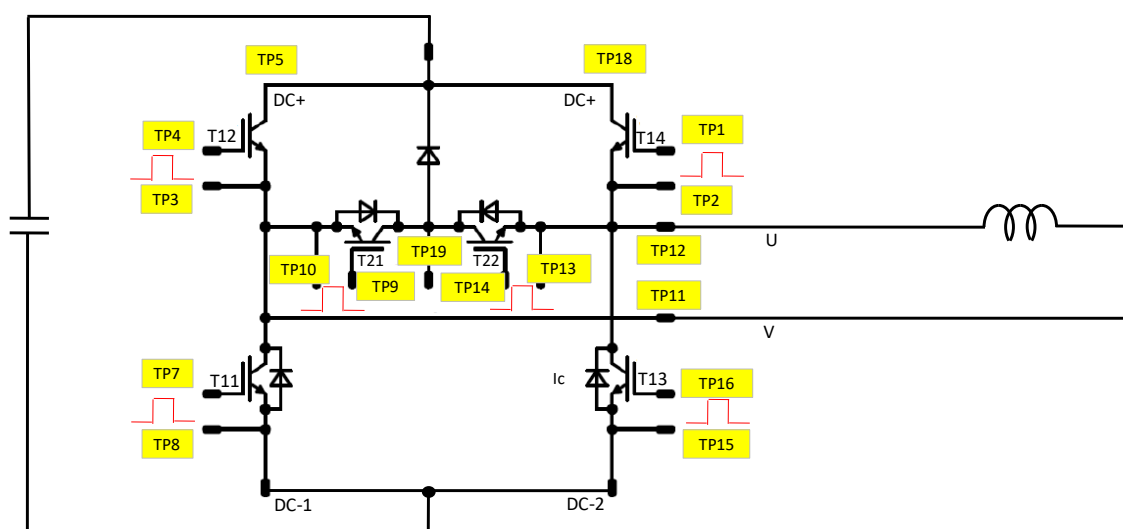


Either DC Capacitor A (on the left) or DC Capacitor B (on the right) or both can be connected. Snubber capacitors (C35 & C36) are connected to reduce the surge voltage at switching.

Pin assignments

Pin no.	Connector no.						
	CN1	CN2	CN3	CN4	CN11	CN12	CN13
1	Input power GND	Input power GND	Input power GND	Therm1	-VG	-VG	-VG
2	UV feedback	NC	NC	Therm2	GND	GND	GND
3	NC	NC	NC		+VG	+VG	+VG
4	Input power supply(+5V)	NC	Input power supply(+5V)				
5	T12 Signal(+)	T22 Signal(+)	T13 Signal(+)				
6	T12 Signal(-)	T22 Signal(-)	T13 Signal(-)				
7	NC	UV feedback	NC				
8	NC	NC	UV feedback				
9	NC	Input power supply(+5V)	NC				
10	T21 Signal(+)	T14 Signal(+)	T11 Signal(+)				
11	T21 Signal(-)	T14 Signal(-)	T11 Signal(-)				

10 Test items and test pins for measuring waveforms



Test items and test pins for measuring waveforms

Test item	Test pin	Item	Test pin
T11 V_{GE}	TP11-TP8	T14 V_{GE}	TP18-TP2
T11 V_{CE}	TP7-TP8	T14 V_{CE}	TP1-TP2
T12 V_{GE}	TP5-TP3	T21 V_{GE}	TP19-TP10
T12 V_{CE}	TP4-TP3	T21 V_{CE}	TP9-TP10
T13 V_{GE}	TP12-TP15	T22 V_{GE}	TP19-TP13
T13 V_{CE}	TP16-TP15	T22 V_{CE}	TP14-TP13

The circuit at the test pin has a greater inductance than the H6.5 IGBT module pin's terminal.
The waveform may display some ringing because of this inductance.

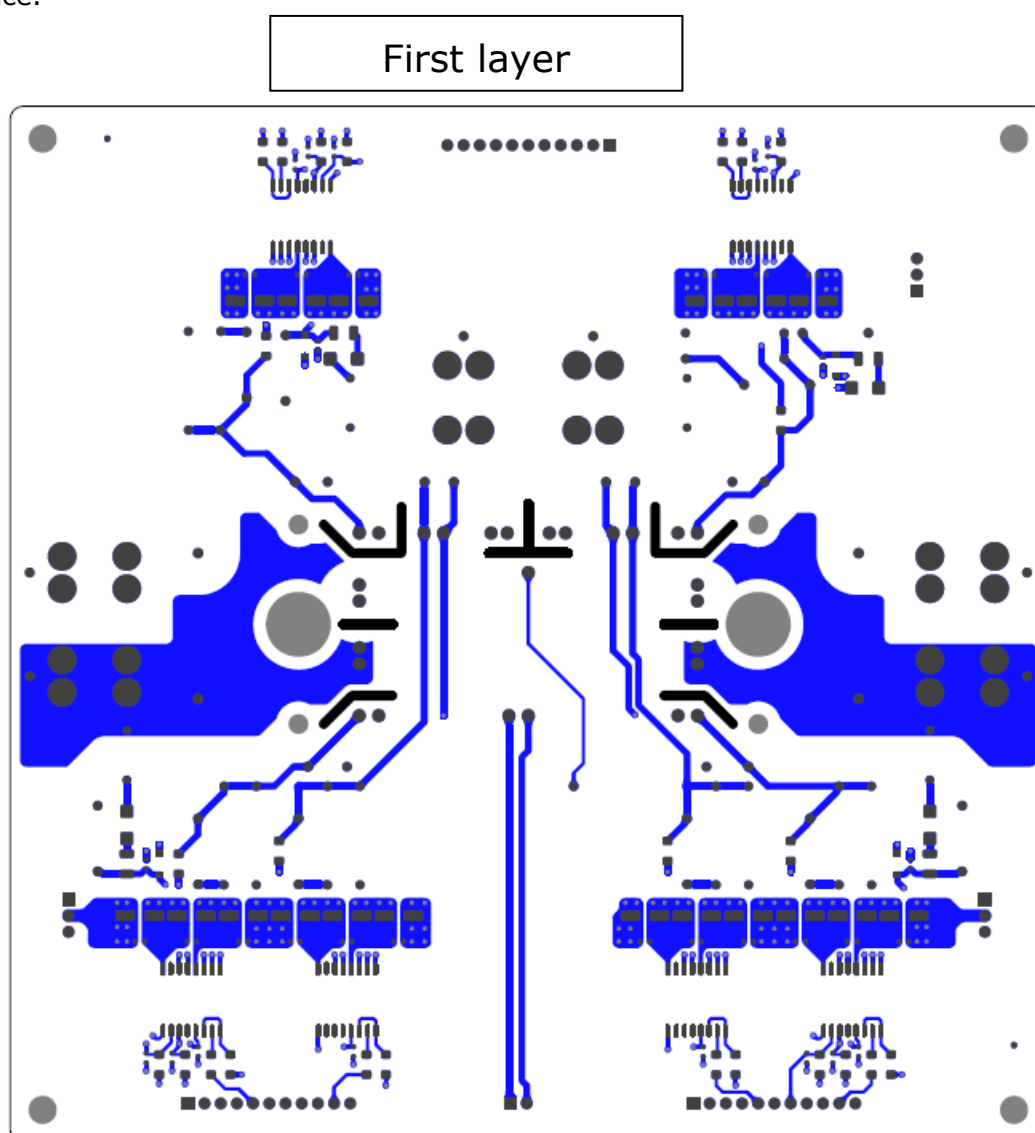
11 Layout of PCB

The following section illustrates four layers of PCB patterns (pages 10 to 13).

Both DC+ sides are connected in the H6.5 IGBT series' internal circuit.

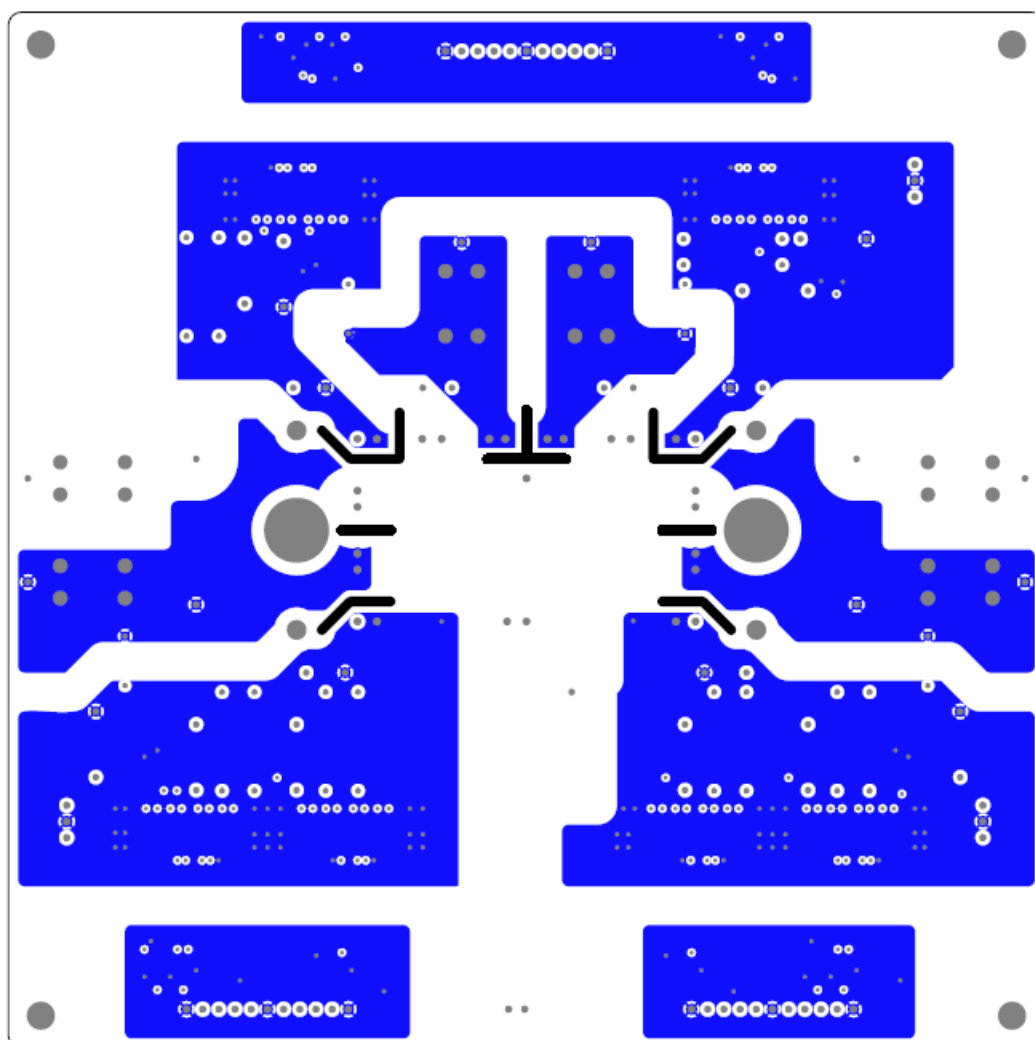
The H6.5 IGBT series' DC-1 and DC-2 are connected in the PCB pattern (see pages 12 and 13).

DC+ and DC- have two layers of the PCB pattern to secure the current flow area and lower inductance.

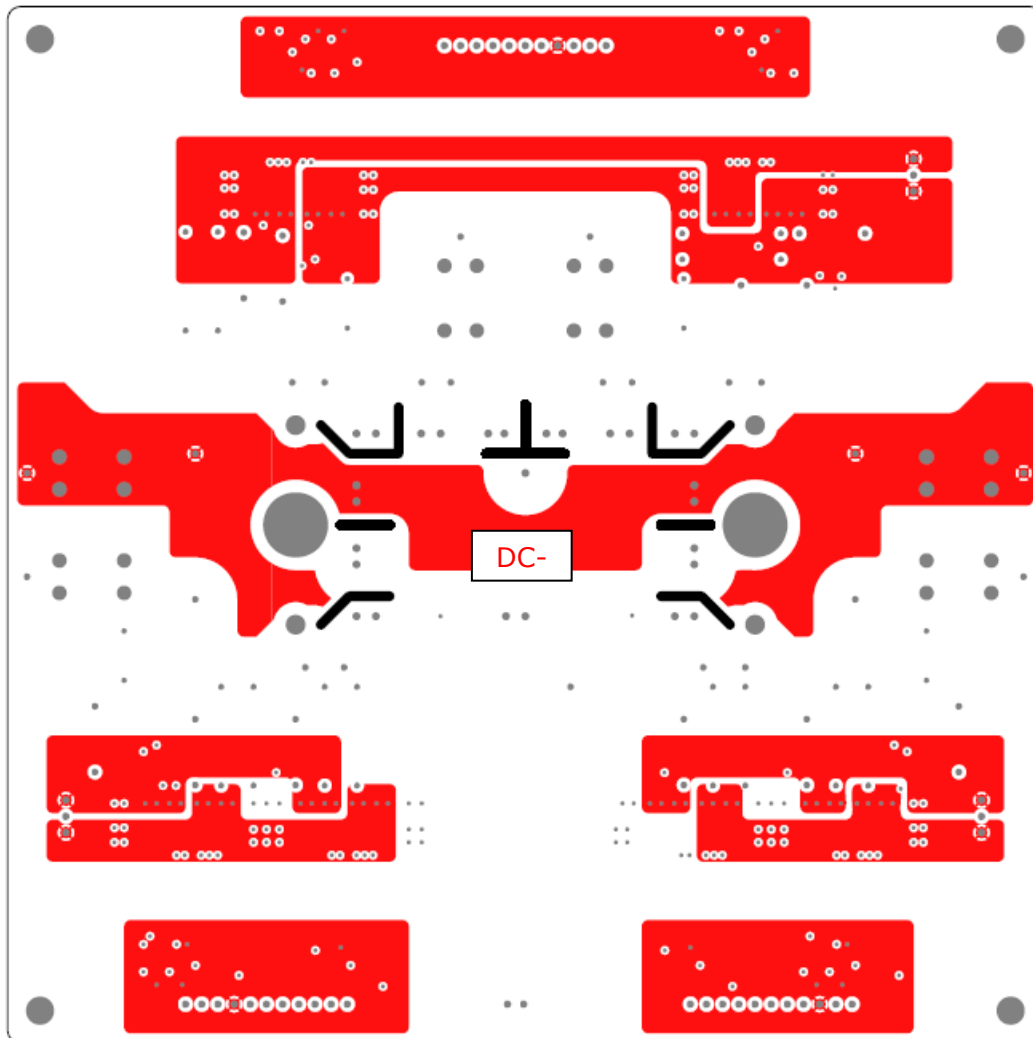


PCB: 160 mm x 160 mm x 1.6 mm t

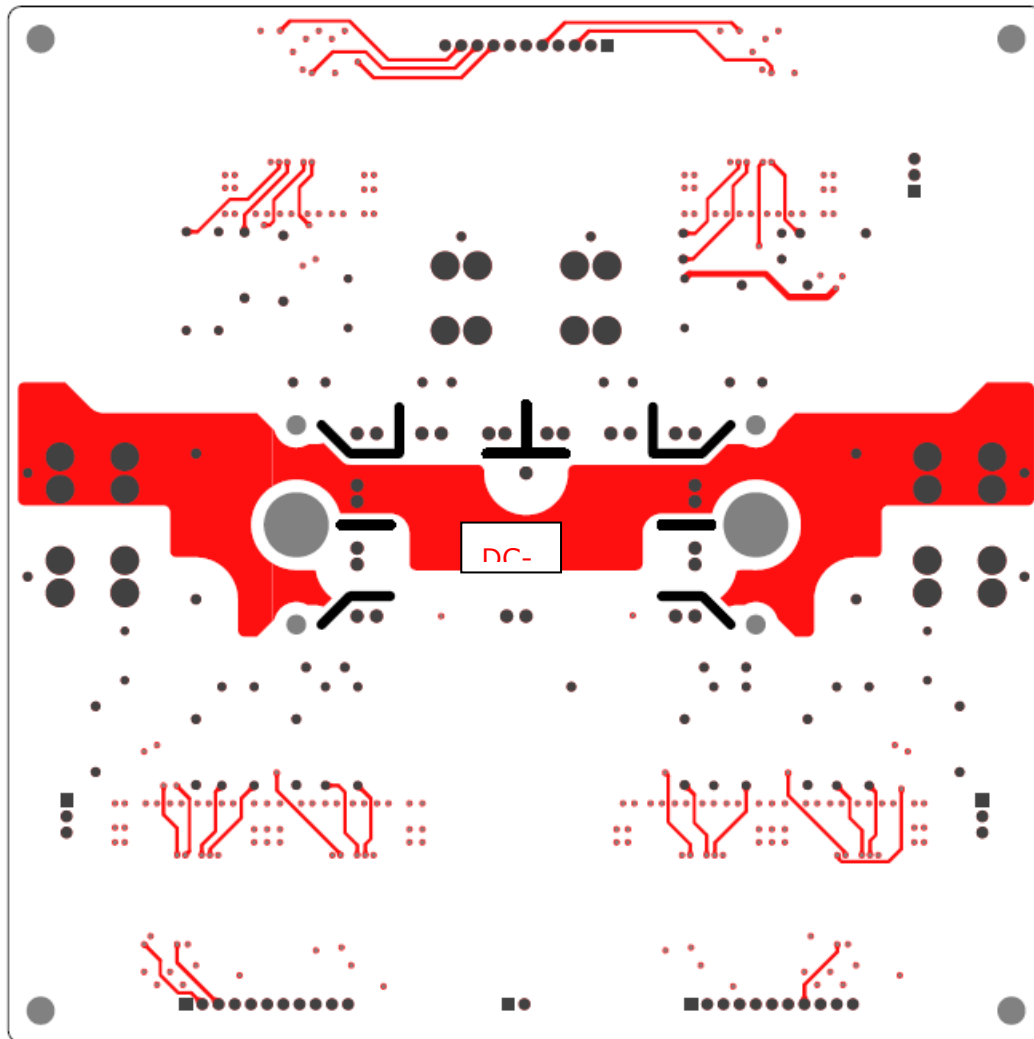
Second layer



Third layer



Fourth layer





12 Variables and units (change according the topic)

No.	Name	Type	Manufacturer	Qty	Location
1	1nF	GRM188R11H102KA01D	Murata	7	C1,C2,C6,C7,C52,C53,C55
2	0.1nF	GRM188B31H104KA92D	Murata	18	C10,C12,C15,C17,C19,C21, C23,C25,C27,C29,C31,C34, C37,C40,C42,C44,C47,C49
3	220pF	GRM1882C1H221JA01D	Murata	4	C13,C32,C38,C45
4	1uF	GRM188R61H105KAALD	Murata	6	C3,C4,C5,C8,C51,C54
5	630V 1uF	ECWFE2J105JA	Panasonic	2	C35,C36
6	35V 10uF	UCW1V100MCL1GS	Nichicon	18	C9,C11,C14,C16,C18,C20, C22,C24,C26,C28,C30,C33, C39,C41,C43,C46,C48,C50
7	CN-11P	B11B-XH-A(LF)(SN)	JST	3	CN1,CN2,CN3
8	CN-3P	B3B-XH-A(LF)(SN)	JST	3	CN11,CN12,CN13
9	CN-2P	B2B-XH-A(LF)(SN)	JST	1	CN4
10	Schottky diode	MBR150G	ON SEMI	6	D1,D2,D3,D4,D9,D10
11	Schottky diode	MBR0540	ON SEMI	4	D11,D12,D13,D14
12	Zener diode	MCR18EZPJ000 0-ohm resistor	Rohm	4	D15,D16,D17,D18 Pad is same as PTZTFTE2512B Zener diode may be substituted to control the desat level
13	Diode	AG01A	Sanken	4	D5,D6,D7,D8
14	H6.5 IGBT	10-FY07HVA050S5-L984F08 10-FY07HVA075S5-L985F08 10-FY07HVA100S5-L986F08	Vincotech	1	IGBT1
15	Resistor 10k ohm	MCR18EZHF1002	Rohm	7	R1,R2,R3,R4,R37,R38,R41
16	Resistor 1k-ohm	MCR25JZHF1001	Rohm	4	R13,R23,R30,R34
17	Resistor 200 ohms	MCR18EZHF2000	Rohm	6	R14,R17,R20,R24,R29,R33
18	Resistor 3.9 ohms	ROX1SJ3R9	TE	12	R15,R16,R18,R19,R21,R22, R25,R26,R27,R28,R31,R32
19	Resistor 330 ohms	MCR18EZHF3300	Rohm	6	R5,R7,R9,R11,R36,R40
20	Resistor 110 ohms	MCR18EZHF1100	Rohm	6	R6,R8,R10,R12,R35,R39

No.	Name	Type	Manufacturer	Qty	Location
21	Opto coupler	ACPL-352J	Broadcom	6	T11,T12,T13,T14,T21,T22
22	Terminal	OT-053-4L-M4	Osada	6	TB1,TB2,TB3,TB4,TB5,TB6
23	TEST pin	LC-22-G Yellow	Mac8	19	TP1,TP2,TP3,TP4,TP5,TP6,
					TP7,TP8,TP9,TP10,TP11,
					TP12,TP13,TP14,TP15,TP16,
					TP17,TP18,TP19
24	Zener diode	1N4740A	Vishay	4	D19,D20,D21,D22