IRMD2214SS Demo Board

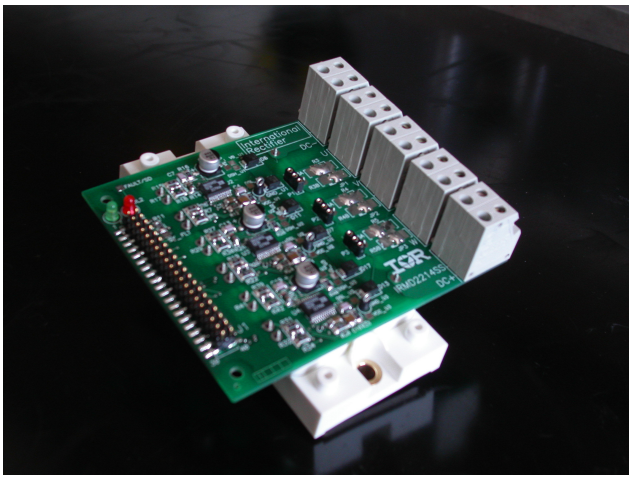
For 3-phase / 380V motor drives

IRMD2214SS Demo Board

- Up to 1200V DC-bus capability
- Up to 50A maximum phase current
- Optional on-board phase shunt resistors
- 3 x IR2214SS devices connected in 3-phase configuration
- On-board bootstrap supply for high-side gate drive
- Full protection of phase-to-phase, DC-bus and ground short circuit by monitoring IGBT de-saturation
- Fault feedback to ground level
- Internal minimum dead time
- Anti-shoot-through management
- Undervoltage lockout
- 3.3V digital input/output CMOS compatible

Power Module

- Standard ECONO2-6PACK IGBT module compatible
- IGBT short circuit rated up to 1200V/50A.
- Easy to mount heat-sink



IR2214SS Demo Board
(Shown with optional IGBT Power Module)

INTRODUCTION

The IRMD2214SS demo board is an evaluation board for IR2214SS gate driver. With three connected IR2214SS (see the device datasheet), IRMD2214SS is designed to drive 3-phase power modules with pin-out compatible to ECONO2-6PACK. The board can drive AC or Brushless motors using power modules with up to 50A output current. The board is a flexible solution for different applications and can be customized providing place for external components. The control signals are 3.3V CMOS compatible; three-phase shunt resistor (with sensing pins) can be placed for current loop control; power module short circuits are managed synchronizing the IGBT turn off in a local network. Board layout reduces the noise coupling between high and low voltage signals and EM emissions.

Application Block Diagram

(Refer to connections section to know the interface pins) This diagram shows the main blocks and connections of the demo board and the external components necessary in a typical motor drive application.

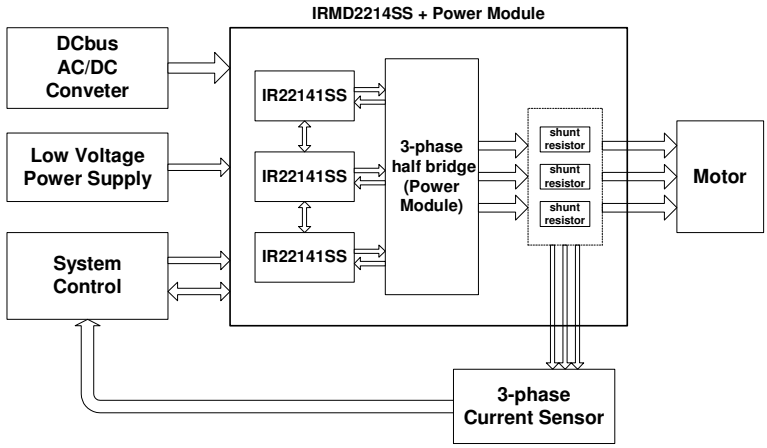


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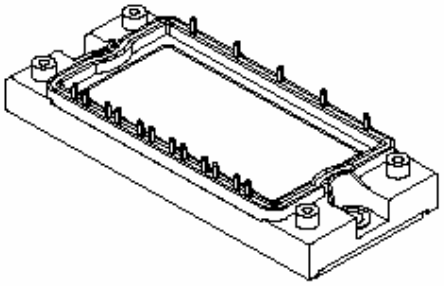
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Parameters	Values	Description, condition
Input Power		
DC+	0 to 1200V	DCBus voltage positive with 1200V power module
DC-	ground	DCbus voltage negative
Vcc	15V typ	Low voltage power supply. Follow IR2214 datasheet for supply setting
Vss	ground	Low voltage ground
Icc	100 mA	quiescent Vcc current
Output Power		
Ilmax	50A @25C	max phase dc output current
Control Inputs/Outputs		
40 pin connector J1 I/Os	3.3V to 15V compatible	see "Board Connectors" section on page 4

The IR2214SS

The IR2214SS is a half bridge gate driver suited for power switching applications. The high side driver can float up to 1200V. The IR2214SS have a high gate driving capability (2A source and 3A sink) with a low quiescent current. The device is designed to manage all the half-bridge faults by turning off smoothly the desaturated transistor through the dedicated soft shut down pin preventing over-voltages and reducing EM emissions. In a multi-phase system the drivers communicate using a dedicated local network (SY_FLT and FAULT/SD signals) to properly manage phase-to-phase short circuits. The system controller may force shutdown or read device fault state through the 3.3 V compatible CMOS I/O pin (FAULT/SD). To improve the signal immunity from DC-bus noise, the control and power ground use dedicated pins enabling low-side emitter current sensing as well. Undervoltage conditions in floating and low voltage circuits are managed independently.

For further technical information see the IR2214/IR22141 datasheet at http://www.irf.com.



ECONO2 6PACK

The power module

IRMD2214SS demo board is ECONO2 compatible with SixPack™ standard pin out.

Important Notice

IRMD2214SS demo board is supplied with a Bill Of Material suitable for a 1200V/50A@100C power module. The BOM presented on page 15 provides a suggestion for the above mentioned power module.
It is strongly recommended to customize the demo board to fit the application requirements for the power module that has been chosen.
Suggestions on passive sizing are also present in "Design Tips: Using monolithic high voltage gate drivers".

BOARD CONNECTORS

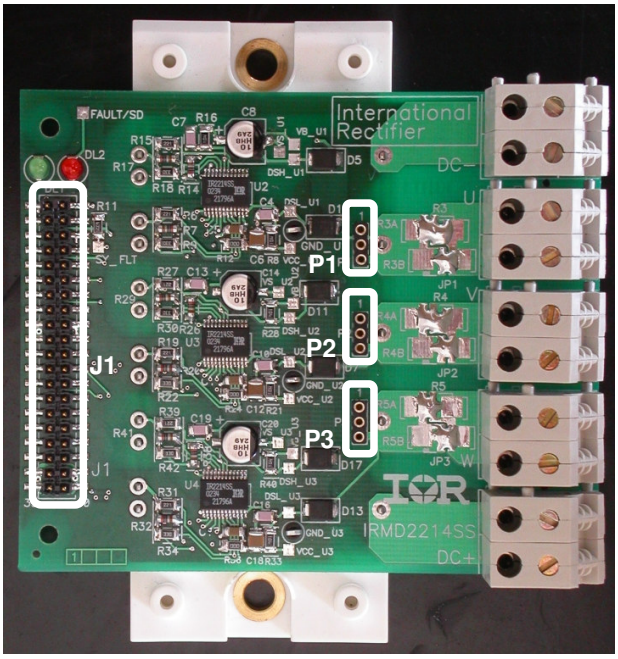


Figure 1: TOP image of board

Connection with the system controller

On board there is a 40 pins connector for the control signals. The driver board uses only 17 pins. The remaining pins are for the sensing board (IRCS2277S) that can be connected on top of IRMD2214SS board.

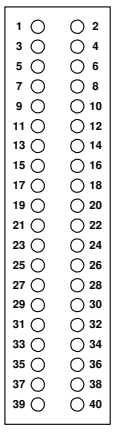
CONNECTOR J1		
HIN1	1	
LIN1	2	
HIN2	12	
LIN2	13	
HIN3	24	
LIN3	25	
FLT_CLR	3	
FAULT/SD	5/6	
VCC	37 - 40	
VSS	17 - 20	

Table 1: 40-pin connector J1

Input logical signals HIN1, LIN1, HIN2, LIN2, HIN3, LIN3 and FLT_CLR:
These logic inputs are 3.3 V compatible CMOS I/O port. The logic signals are active high with internal pull-down resistor of 10 kOhm. When both HIN and LIN of the same phase are active at the same time an internal anti-shot trough circuit turns off the output drivers. HIN turns on the high side IGBT while LIN the low side.

FLT_CLR is active high and it is used to reset the fault state of all devices (see also the Fault management section and the IR2214SS datasheet).

FAULT/SD logic signal

This is an input/output logic signal, 3.3 V compatible CMOS I/O port. The logic signal is active low, tied to connector VCC with a 10 kΩ pull-up resistor. As an input, the signal shuts down (SD) all the drivers; as an output, it reports the power module fault (IGBT desaturation detection) or the VCC undervoltage (see also IR2214SS datasheet for more information).
On board a red LED (DL2) indicates when the signal is active; Figure 2a shows the connection.

VCC supply pin

This is the supply pin for all the devices. On board a green LED (DL1) indicates the supply power on; Figure 2b shows the connection.

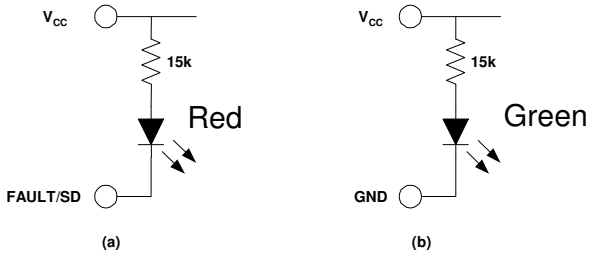


Figure 2: LED connection

VSS ground pin (GND)

The board ground is connected to the power module DC- pin. The VSS pin of the connector and the devices ground pin are star-connected to the DC- pin. DC- star connection has been chosen to reduce the noise coupled from the floating signals.

Connecting the current sensors

P1, P2 and P3 are connected with the optional shunt resistors placed on the phase output nodes.

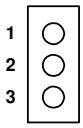
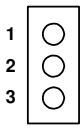
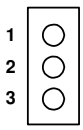
CONNECTOR P1		
SHU+ (motor side)	1	
SHU- (power module side)	2	
U	3	
CONNECTOR P2		
SHV+ (motor side)	1	
SHV- (power module side)	2	
V	3	
CONNECTOR P3		
SHW+ (motor side)	1	
SHW- (power module side)	2	
W	3	

Table 2: P1, P2 and P3 connectors for kelvin contacts to shunt signals

The SHU, SHV and SHW are sense pins connected as close as possible to the shunt resistors terminals to reduce the parasitic effects of the traces.

High power signal connector

There are two connectors dedicated to each power signal (DC+, U, V, W and DC-). Each single connector has 30 Ampere of maximal nominal dc current. DCbus traces are both on top and on one of the internal layers of the PC board in order to reduce power dissipation. Connectors, DC-bus, phase and ground wires can be soldered directly on board using the corresponding pads located under the power connectors (to be removed).

Connecting the power module

The board is fully compatible with the ECONO2-6PACK power module. The following table shows the module pin-out.

CONNECTION POINTS BETWEEN BOARD AND MODULE	
1	VGHU - phase U - high side IGBT gate
2	VEHU - phase U - high side IGBT emitter
3	VGLU - phase U - low side IGBT gate
4	VELU - phase U - low side IGBT emitter
5	VGHV - phase V - high side IGBT gate
6	VEHV - phase V - high side IGBT emitter
7	VGLV - phase V - low side IGBT gate
8	VELV - phase V - low side IGBT emitter
9	VGHW - phase W - high side IGBT gate
10	VEHW - phase W - high side IGBT emitter
11	VGLW - phase W - low side IGBT gate
12	VELW - phase W - low side IGBT emitter
13	DC+
14	Phase W
15	Phase V
16	Phase U
17	DC- (GND)

Table 3: High power module connection

Test Points

Test points on board provide signals that are not available at the connectors. See the following table:

ONE FOR EACH DEVICE (U1 -> U, U2 - > V, U3 -> W)	
V_B	High side floating supply voltage
V_S	High side floating supply offset voltage
DSH	High side desat input voltage
DSL	Low side desat input voltage
VCC	Low side and logic fixed supply voltage
GND	Device VSS
COMMON FOR ALL DEVICES	
FAULT/SD	Fault and Shut Down (or-wired)
SY_FLT	Synchronized Fault (or-wired)

Table 4: Test points

Note: the FAULT/SD signal is present on pin 5 and 6 of the 40-pin connector, too.

TEST BENCH CONNECTION

IRMD2214SS does NOT provide opto isolation.

The following picture shows the recommended connections for board evaluation. Bold lines are equipotential (DC-=Vss=gnd).

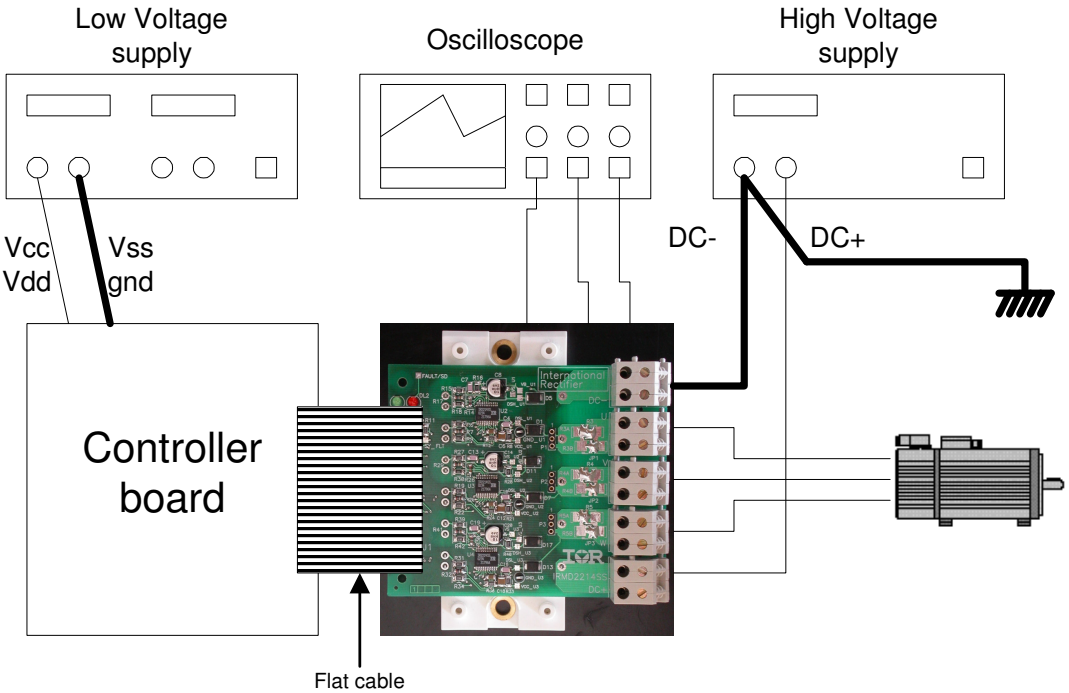


Figure 3: Test bench connection

OPERATING DESCRIPTION

Power on sequence

Before beginning the normal operating mode, it is strongly recommended to follow the power ON sequence. The purpose of this procedure is to set the internal device logic. This is achieved by charging all bootstrap capacitors for the first time with the FLT_CLR signal active. See Figure 4 for the correct procedure.

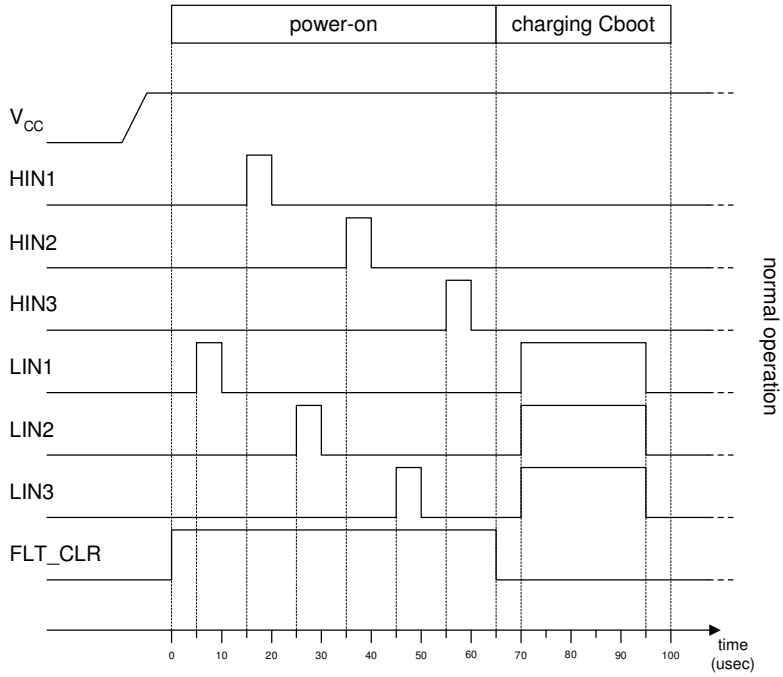


Figure 4: Power on sequence

Normal operating mode

In the normal operating mode when HIN or LIN is active the high or low side IGBT turns on respectively. Turn on and turn off propagation delays and the propagation delay matching are specified in the IR2214SS datasheet. Devices introduce also a minimum dead-time (typical 330 ns).

Fault management

The IR2214SS is able to detect the excessive current increase by monitoring the IGBT desaturation. The three-phase connection of the IR2214SS allows managing all power module faults using the FAULT/SD and SYNC_FLT signals in a local network.
Figure 5 shows how the devices are interconnected to each other and with the FAULT/SD pin on the connector. The fault management procedure starts when one of the drivers senses the IGBT desaturation (see Figure 5 where, as an example, only one low side IGBT is shown).
Figure 6 shows an example where the low side IGBT of U1 and U3 and the high side of U2 are on.
The procedure is totally managed by an integrated FAULT LOGIC block without the controller assistance.

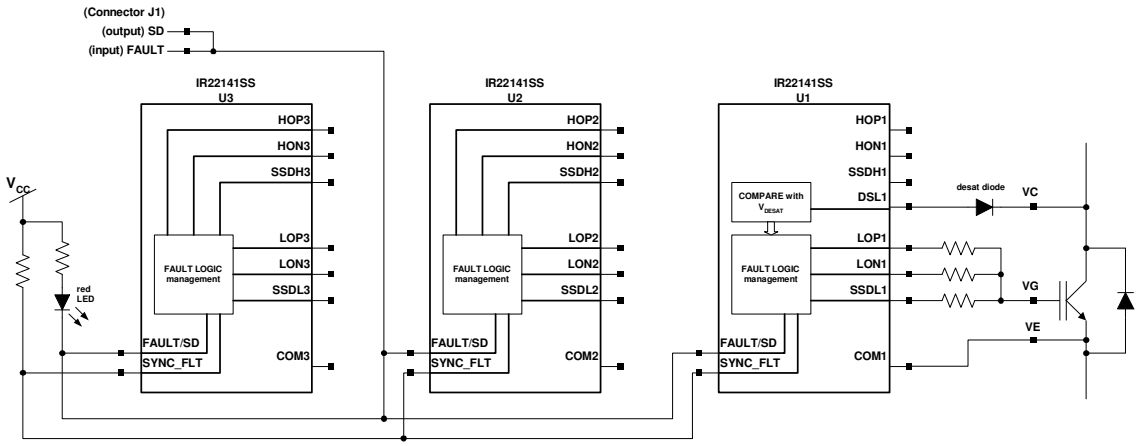


Figure 5: Three phase connection

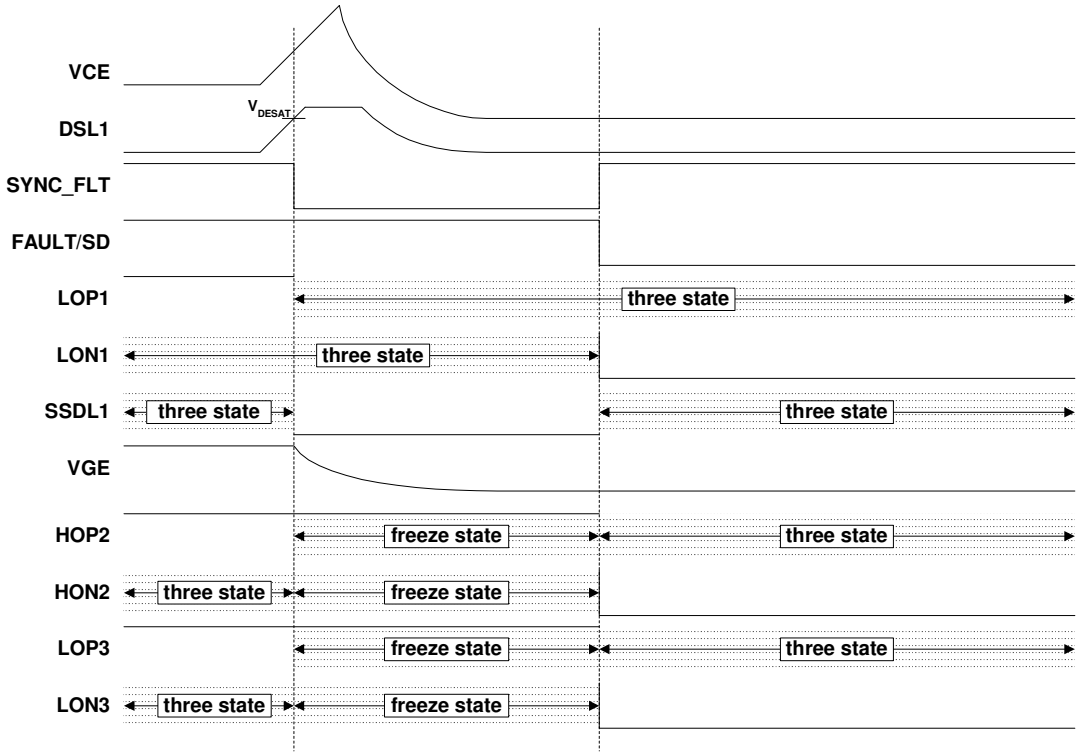


Figure 6: Example of a desaturation detection event

Multilevel board solution

With the optional shunt resistor the IRMD2214SS driver board can be connected with the IRCS2277S current sensing board through J1 and P1, P2, and P3 connectors. More information available with IRCS2277S board datasheet.

BOARD SOLUTIONS

Sizing of the components mentioned in this section is indicated in the Bill of material on page 15.

Bootstrap circuit

The high side floating supply (V_{BS}) is provided by a bootstrap capacitor. Figure 7 shows the circuit on board.

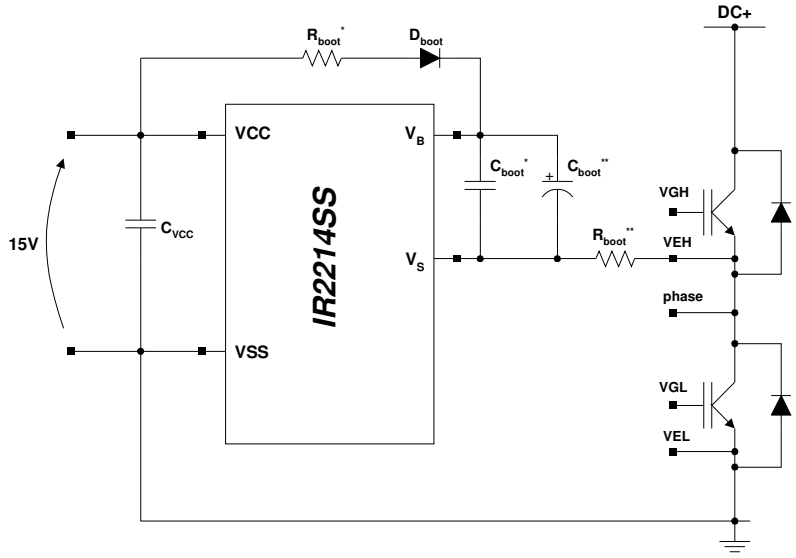


Figure 7: Bootstrap circuit

The following table shows the names of these components on board.

	U	V	W
C_{VCC}	C5	C11	C17
C_{boot}*	C9	C15	C21
C_{boot}**	C8	C14	C20
R_{boot}*	R13	R25	R37
R_{boot}**	R14	R26	R38

Gate resistances

The following table shows the names of gate resistances on board.

	U	V	W
high side gate to HOP	R18	R30	R42
high side gate to HON	R17	R29	R41
high side gate to SSDH	R15	R27	R39
low side gate to LOP	R9	R22	R34
low side gate to LON	R7	R20	R32
low side gate to SSDL	R6	R19	R31

OTHER EXTRA COMPONENTS

These components are provided to make IRMD2214SS board as customizable as possible. In many cases the extra components are not required.

Desat circuit

The IR2214S is able to detect the IGBT desaturation. To reject the noise on the desat pins the IR2214SS have an internal filter of 1µsec. If this is not enough an RC filter has been placed on board (see figure 8, R_{DSH}, C_{DSH} and R_{DSL}, C_{DSL}).

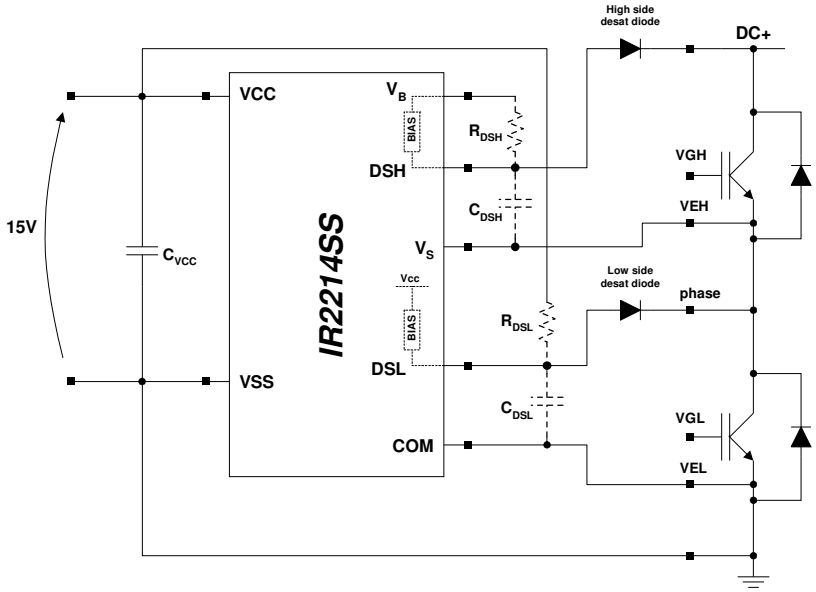


Figure 8: Desat external filter

The external resistor is in parallel with the internal bias circuit of the desat diode. If added, the external resistor may cause an higher diode bias current that must be taken into account in bootstrap capacitor sizing.
External RC filter delays desaturation detection, that causes a delay in turning the IGBT off. Consider this delay when sizing the soft-shut-down resistors.

The following table shows the names of these components on board.

	U	V	W
C_{DSH}	C7	C13	C19
R_{DSH}	R16	R28	R40
C_{DSL}	C4	C10	C16
R_{DSL}	R8	R21	R33

Clamping Diode for Vs below ground

This solution preserves the device when the V_S pin goes below ground out of the device absolute maximum ratings. The V_S voltage is clamped to the maximum value allowed by a zener diode.

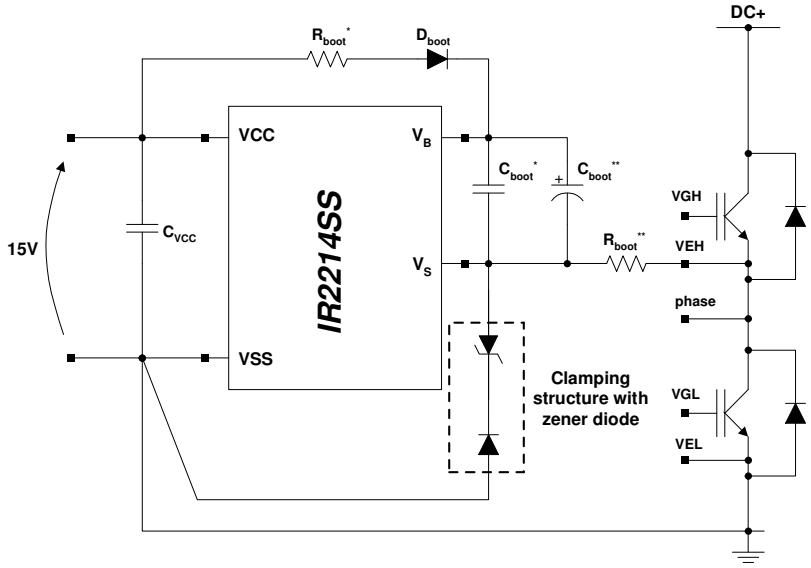


Figure 9: -V_s clamp

The following table shows the names of these components on board.

	U	V	W
DIODE	D4	D10	D16
ZENER	Z2	Z5	Z8

RC filter on com pin

An RC filter (R_{COM}, C_{COM}) is provided to preserve the IC device from low side IGBT emitter undervoltage spikes.

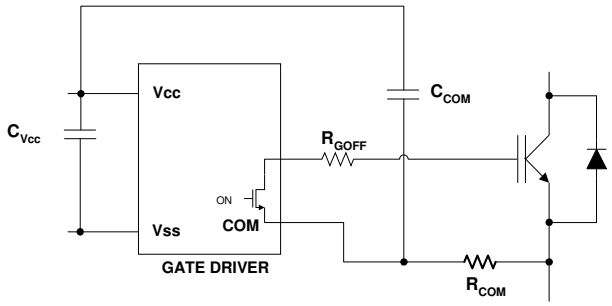


Figure 10: COM below ground protection

The following table shows the names of these components on board.

	U	V	W
C_{COM}	C6	C12	C18
R_{COM}	R10	R23	R35

Fast diode between gate and supply pin

On all low and high side drivers a fast diode is provided to clamp the gate coming over the V_{CC} or V_B supply pins and to recover the current coming from the collector node through the gate-collector capacitance.

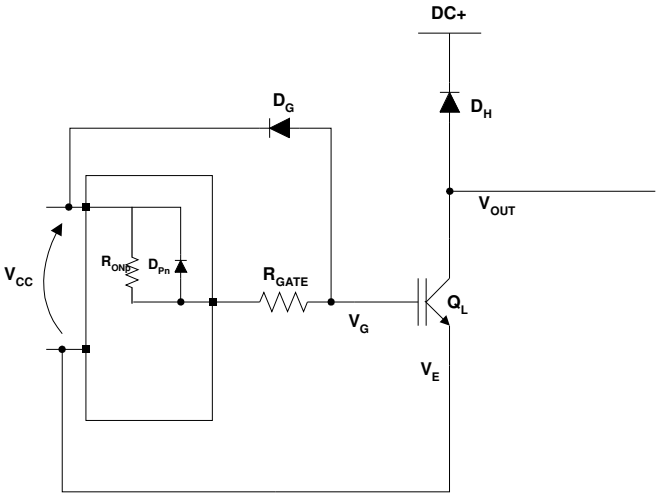


Figure 11: Collector-Gate current protection

The following table shows the names of these components on board.

	U	V	W
(high side) D_G	D6	D12	D18
(low side) D_G	D2	D8	D14

Zener diode to preserve the IGBT gate

To avoid a V_{GE} increasing over the absolute maximum rating a zener diode is connected between gate and emitter pins on all the IGBTs.

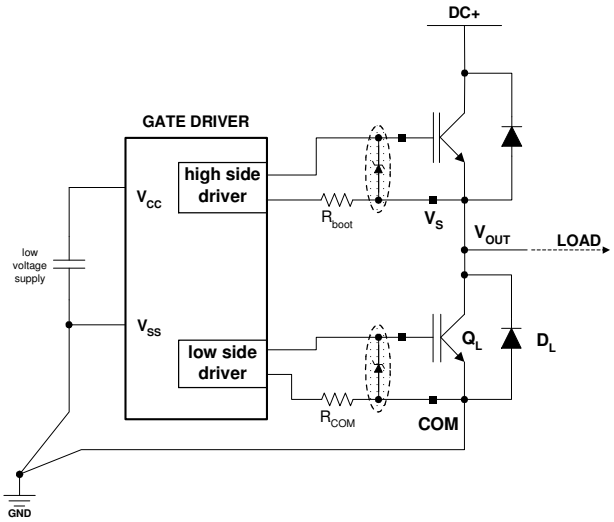


Figure 12: Zener clamp for IGBT gate

The following table shows the names of these components on board.

	U	V	W
(high side) ZENER	Z3	Z6	Z9
(low side) ZENER	Z1	Z4	Z7

Optional output shunt resistor

Two type of output shunt resistor, for current sensor, are possible see the following table:

	U	V	W
TO220 or	R3	R4	R5
OARS-1	R3A // R3B	R4A // R4B	R5A // R5B

The OARS-1 type (A and B) are connected in parallel.

Resistor on v_{cc}

Provided to decouple VCC_U1, VCC_U2 and VCC_U3 from supply line.

	U	V	W
Vcc decoupling	R12	R24	R36

BILL OF MATERIAL

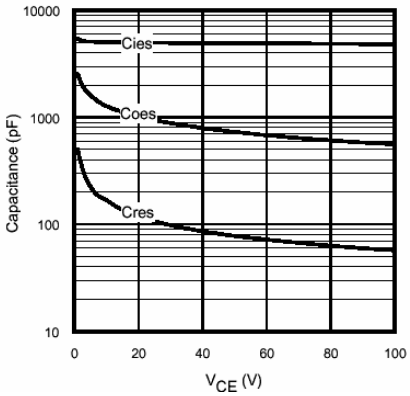
The hereafter provided BOMs represent a suggestion based on the IGBT characteristics shown below.

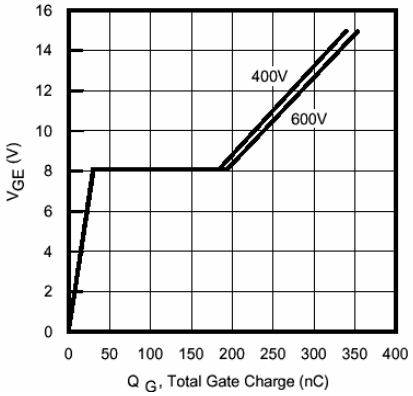
V_{CES} = 1200V

I_C = 50A, T_C=80°C

t_{sc} > 10µs, T_J=150°C

$V_{CE(on)}$ typ. = 2.45V



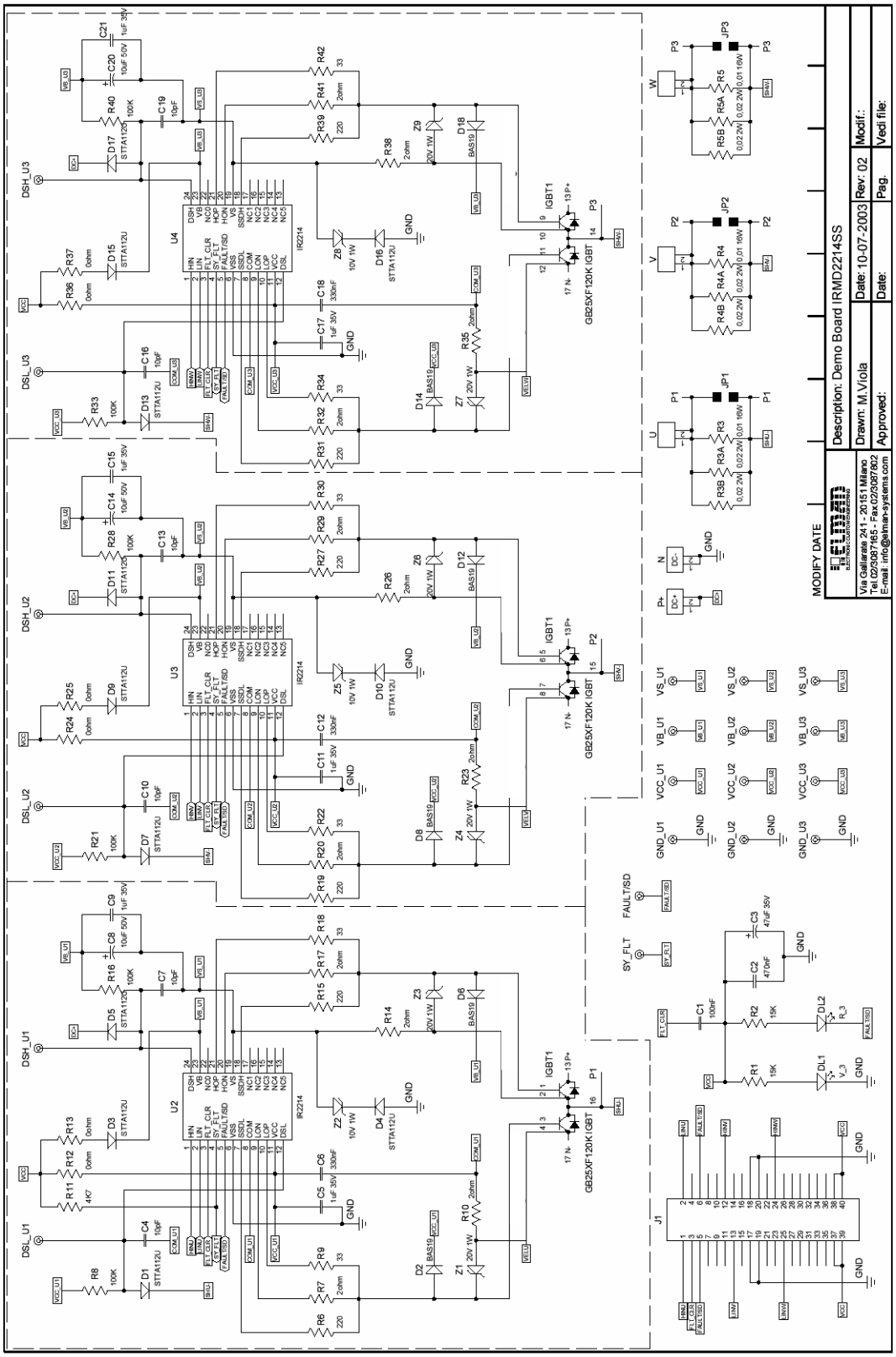


$V_{CE(ON)}$	Collector-to-Emitter Voltage	-	2.45	2.65	V	I_C = 50A V_{GE} = 15V
		-	2.85	3.15		I_C = 75A V_{GE} = 15V
		-	2.85	-		I_C = 50A V_{GE} = 15V T_J = 125°C
		-	3.45	-		I_C =75A V_{GE} = 15V T_J = 125°C
$V_{GE(th)}$	Gate Threshold Voltage	4.0	4.9	6.0		V_{CE} = V_{GE} IC = 250µA

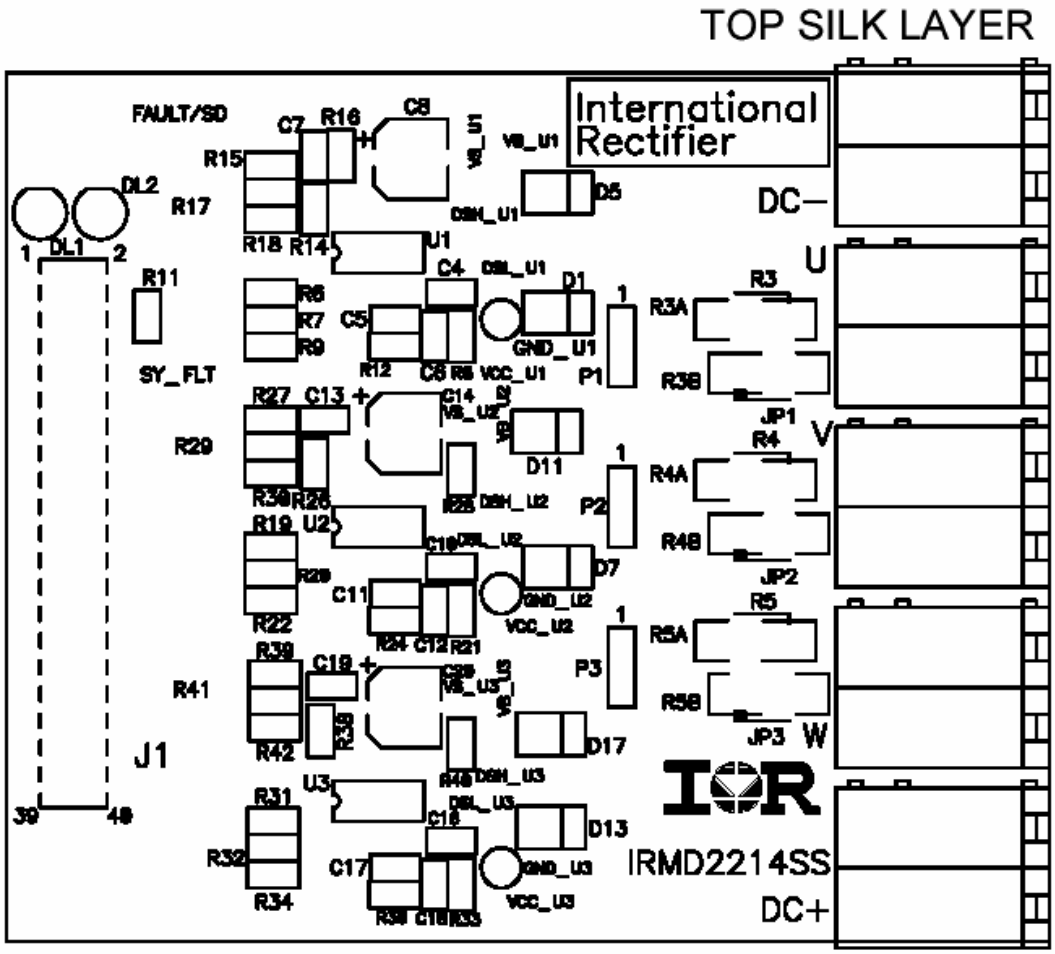
Numeration	Description	Value
R01	Supply LED bias	15k
R02	pull-up FAULT/SD and fault LED bias	15k
R06	Driver U1 - gate SSDL	330
R07	Driver U1 - gate LON	2R2
R08	Driver U1 - Noise filter on DSL	-
R09	Driver U1 - gate LOP	33
R10	Driver U1 - COM resistor	2R2
R11	pull-up del SYNC_FLT	4.7k
R12	Driver U1 - Noise filter on VCC	0
R13	Driver U1 - Bootstrap resistor	0
R14	Driver U1 - Vs resistor	2R2
R15	Driver U1 - gate SSDH	330
R16	Driver U1 - Noise filter on DSH	-
R17	Driver U1 - gate HON	2R2
R18	Driver U1 - gate HOP	33
R19	Driver U2 - gate SSDL	330
R20	Driver U2 - gate LON	2R2
R21	Driver U2 - Noise filter on DSL	-
R22	Driver U2 - gate LOP	33
R23	Driver U2 - resistenza sul COM	2R2
R24	Driver U2 - Noise filter on VCC	0
R25	Driver U2 - Bootstrap resistor	0
R26	Driver U2 - Vs resistor	2R2
R27	Driver U2 - gate SSDH	330
R28	Driver U2 - Noise filter on DSH	-
R29	Driver U2 - gate HON	2R2
R30	Driver U2 - gate HOP	33
R31	Driver U3 - gate SSDL	330
R32	Driver U3 - gate LON	2R2
R33	Driver U3 - Noise filter on DSL	-
R34	Driver U3 - gate LOP	33
R35	Driver U3 - resistenza sul COM	2R2
R36	Driver U3 - Noise filter on VCC	0
R37	Driver U3 - Bootstrap resistor	0
R38	Driver U3 - Vs resistor	2R2
R39	Driver U3 - gate SSDH	330
R40	Driver U3 - Noise filter on DSH	-
R41	Driver U3 - gate HON	2R2
R42	Driver U3 - gate HOP	33

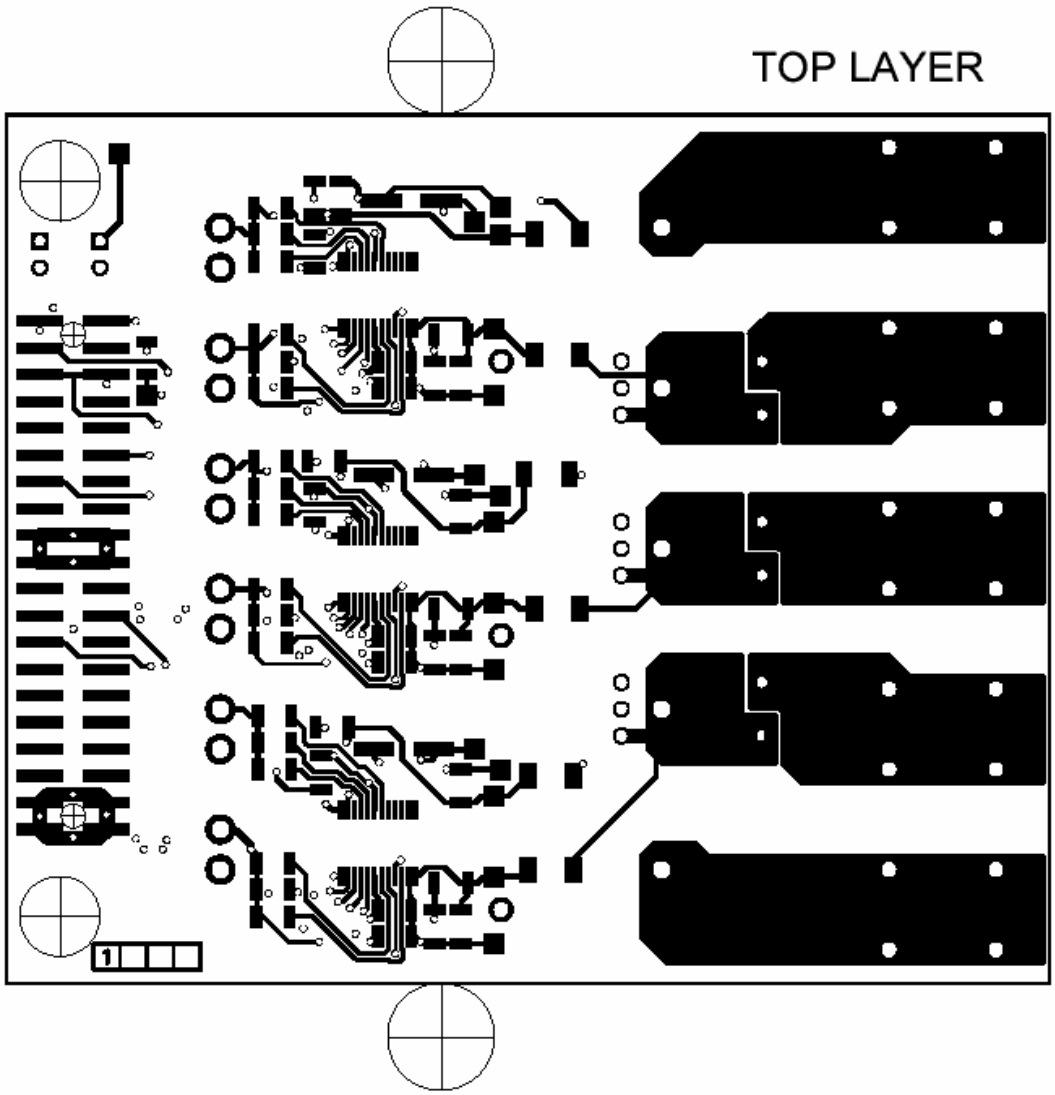
Numeration	Description	Value
C01	power on reset flt_clr	-
C02	15V connector supply (ceramic)	1uF - 35V
C03	15V connector supply (electrolitic)	47uF - 35V
C04	Driver U1 - Noise filter on DSL	-
C05	Driver U1 - Noise filter on VCC (ceramic)	1uF - 35V
C06	Driver U1 - Vcc to COM (ceramic)	330nF -35V
C07	Driver U1 - Noise filter on DSH	-
C08	Driver U1 - high side supply (electrolitic)	-
C09	Driver U1 - high side supply (ceramic)	1uF - 35V
C10	Driver U2 - Noise filter on DSL	-
C11	Driver U2 - Noise filter on VCC (ceramic)	1uF - 35V
C12	Driver U2 - loop corto tra COM e VCC (ceramic)	330nF -35V
C13	Driver U2 - Noise filter on DSH	-
C14	Driver U2 - high side supply (electrolitic)	-
C15	Driver U2 - high side supply (ceramic)	1uF - 35V
C16	Driver U3 - Noise filter on DSL	-
C17	Driver U3 - Noise filter on VCC (ceramic)	1uF - 35V
C18	Driver U3 - loop corto tra COM e VCC (ceramic)	330nF -35V
C19	Driver U3 - Noise filter on DSH	-
C20	Driver U3 - high side supply (electrolitic)	-
C21	Driver U3 - high side supply (ceramic)	1uF - 35V
D01	Driver U1 - DSL	1200V - low recovery
D02	Driver U1 - gate to supply diode Cgc_L	fast
D03	Driver U1 - Bootstrap	1200V - low recovery
D04	Driver U1 - VS undershoot	1200V - low recovery
D05	Driver U1 - DSH	1200V - low recovery
D06	Driver U1 - gate to supply diode Cgc_H	fast
D07	Driver U2 - DSL	1200V - low recovery
D08	Driver U2 - gate to supply diode Cgc_L	fast
D09	Driver U2 - Bootstrap	1200V - low recovery
D10	Driver U2 - VS undershoot	1200V - low recovery
D11	Driver U2 - DSH	1200V - low recovery
D12	Driver U2 - gate to supply diode Cgc_H	fast
D13	Driver U3 - DSL	1200V - low recovery
D14	Driver U3 - gate to supply diode Cgc_L	fast
D15	Driver U3 - Bootstrap	1200V - low recovery
D16	Driver U3 - VS undershoot	1200V - low recovery
D17	Driver U3 - DSH	1200V - low recovery
D18	Driver U3 - gate to supply diode Cgc_H	fast
DL1	green LED for +15V supply	
DL2	red LED for FAULT/SD	
Z01	Driver U1 - zener clamp Vge_L	-
Z02	Driver U1 - zener clamp for VS undershoot	10V - 1W
Z03	Driver U1 - zener clamp Vge_H	-
Z04	Driver U2 - zener clamp Vge_L	-
Z05	Driver U2 - zener clamp for VS undershoot	10V - 1W
Z06	Driver U2 - zener clamp Vge_H	-
Z07	Driver U3 - zener clamp Vge_L	-
Z08	Driver U3 - zener clamp for VS undershoot	10V - 1W
Z09	Driver U3 - zener clamp Vge_H	-

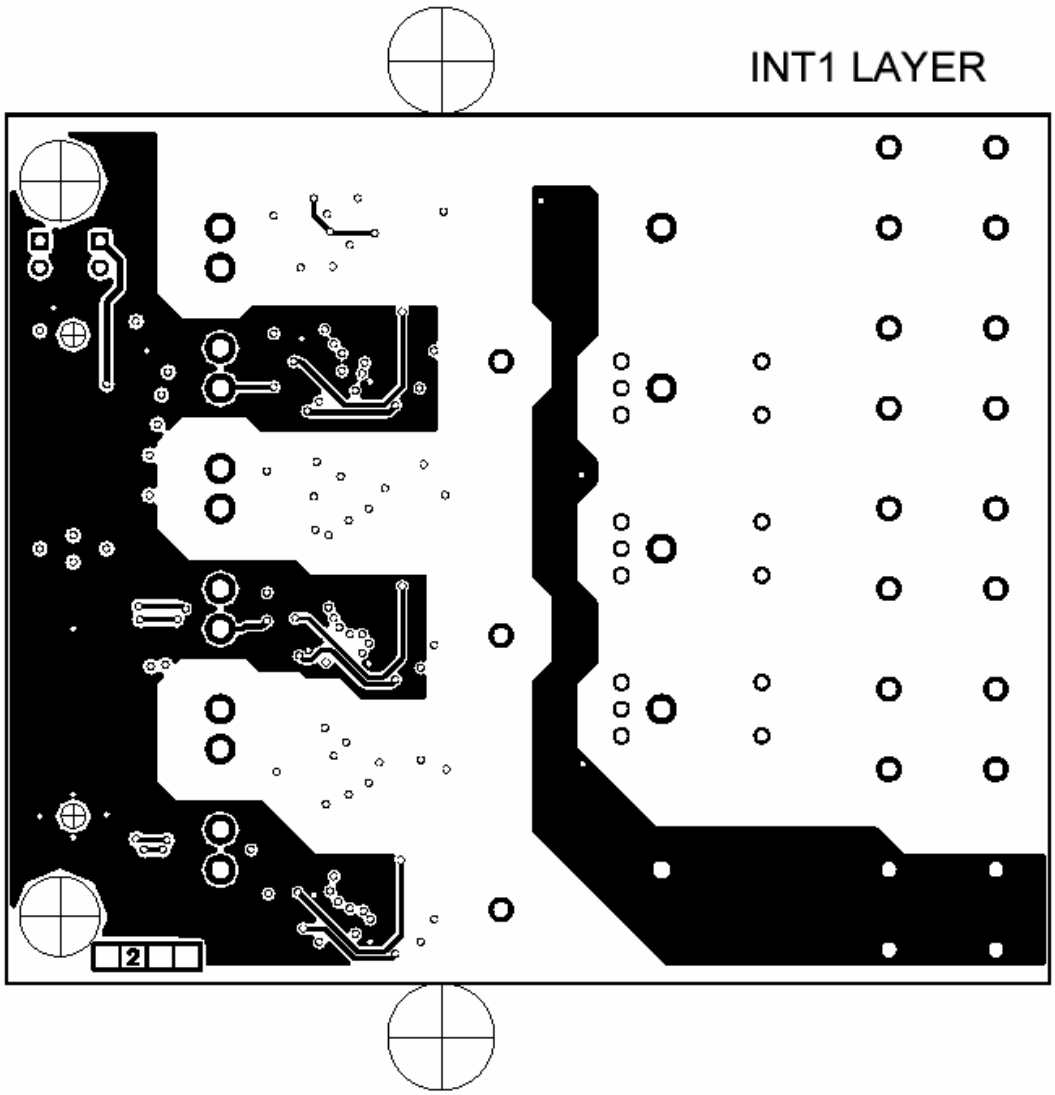
SCHEMATIC

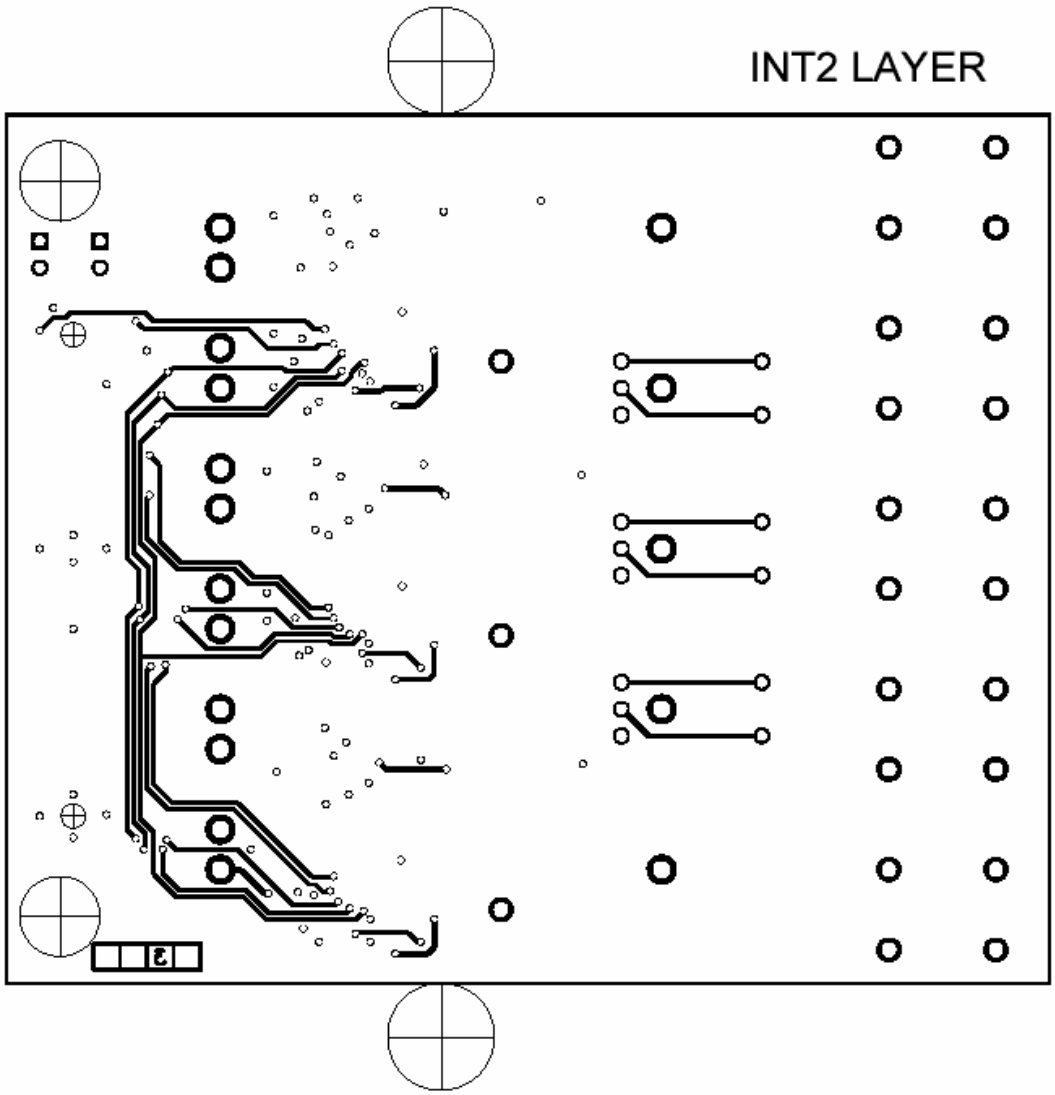

Description: Demo Board IRMD2214SS
Drawn: M.Viola
Date: 10-07-2003
Rev: 02
Modif.:
Approved:
Date:
Pag.
Vedi file:
MODIFY DATE
Via Gallarate 241 - 20151 Milano
Tel 02/3087165 - Fax 02/3087402
E-mail: info@elman-systems.com
DSH_U3
DSL_U3
DSH_U2
DSL_U2
DSH_U1
DSL_U1
IRS2214
GB25XF120K IGBT
STTA112U
BAS19
SY_FLT
FAULT/SD
J1

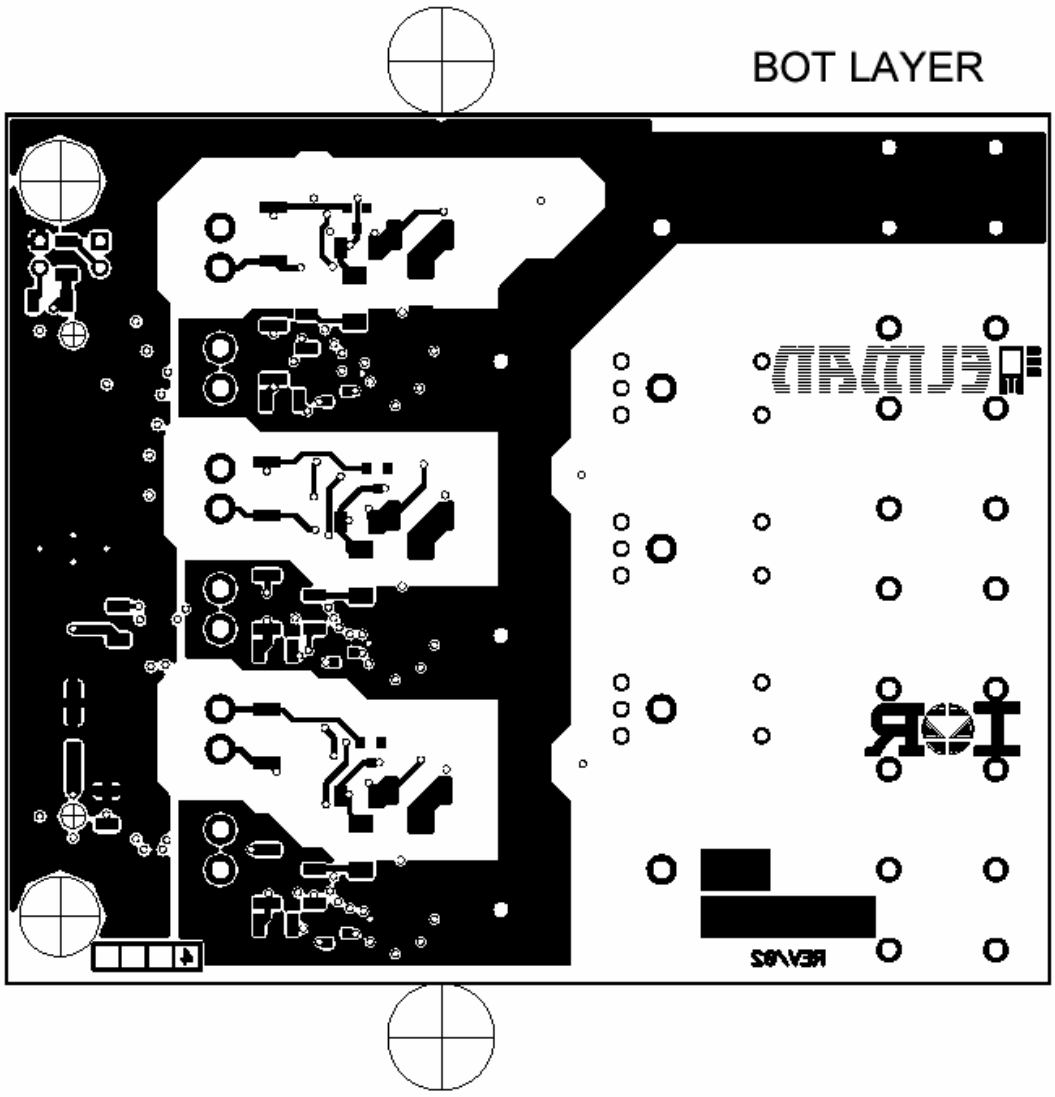
LAYOUT

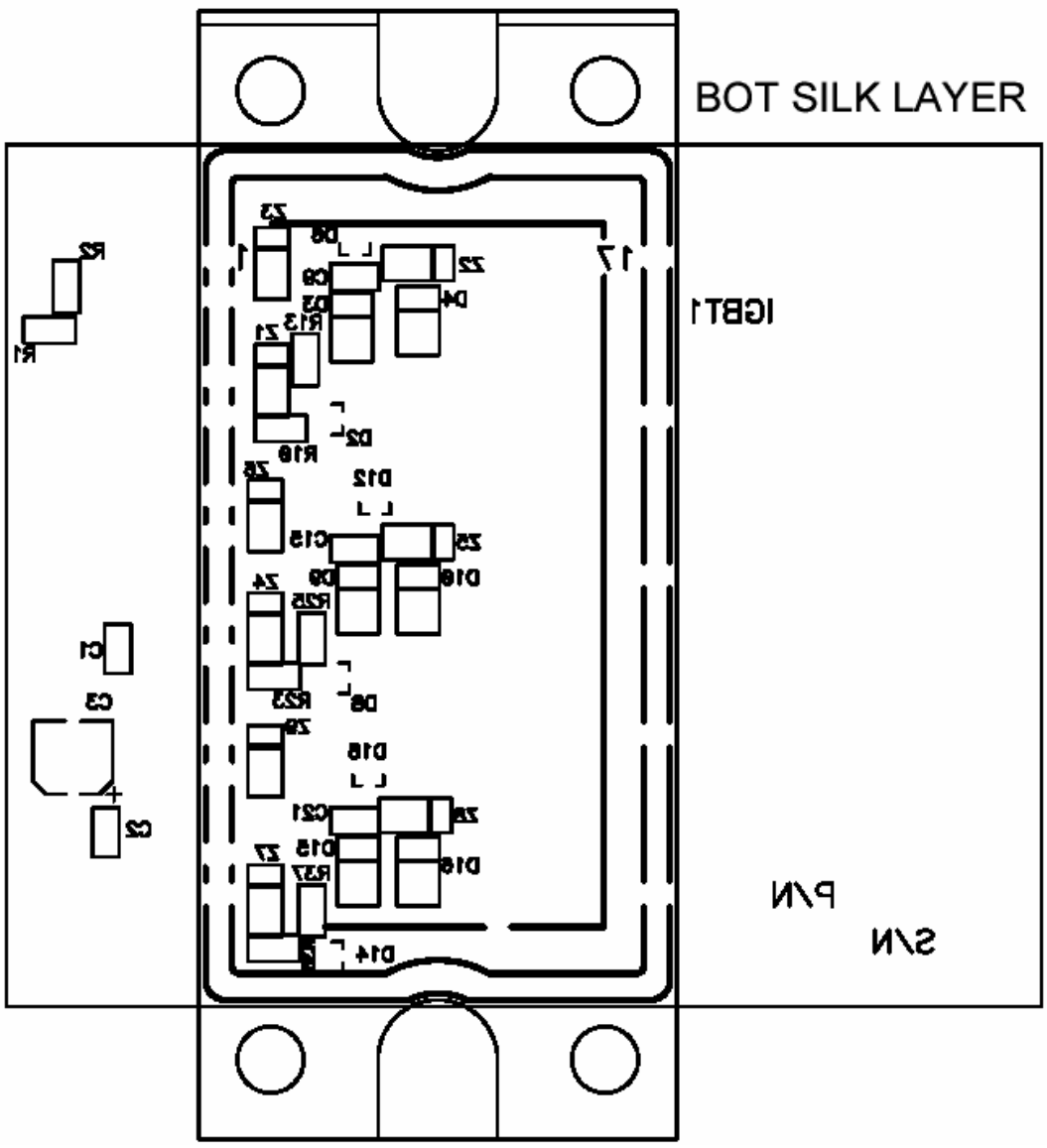

TOP SILK LAYER
International
Rectifier
FAULT/SD
DC−
U
V
W
DC+
IRMD2214SS
J1
SY_FLT


TOP LAYER
1


INT1 LAYER
2


INT2 LAYER


BOT LAYER


BOT SILK LAYER
IGBT1
P/N
S/N