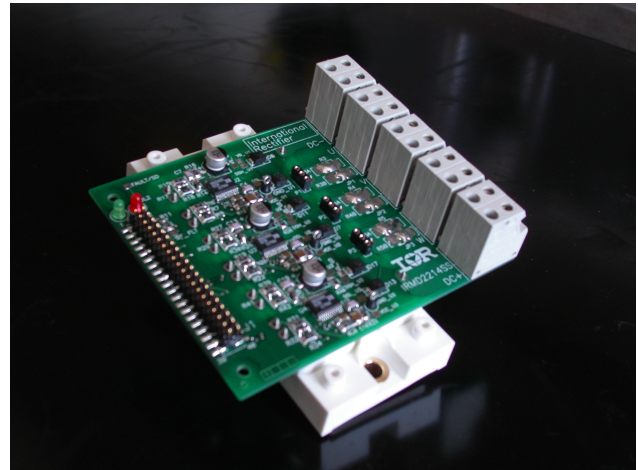


## IRMD2214SS Demo Board

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



IR2214SS Demo Board  
(Shown with optional IGBT Power Module)

### Power Module

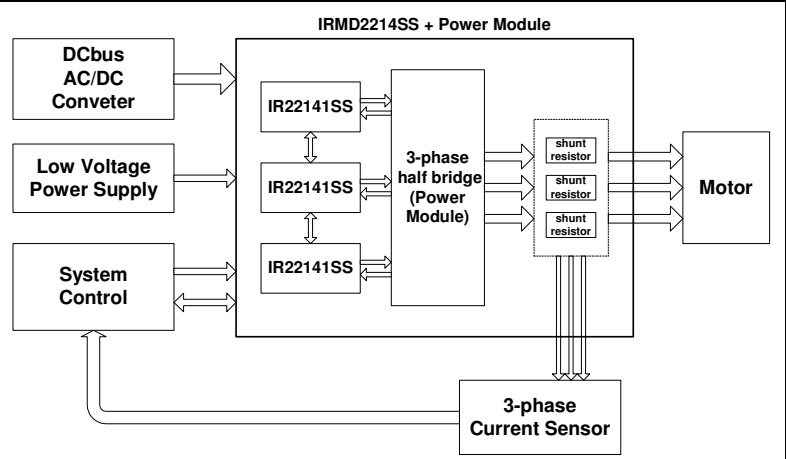
- Standard ECONO2-6PACK IGBT module compatible
- IGBT short circuit rated up to 1200V/50A.
- Easy to mount heat-sink

## 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.



## Table of contents

<b>INTRODUCTION .....</b>	<b>1</b>
<i>Table of contents.....</i>	<i>2</i>
<i>Table of figures .....</i>	<i>2</i>
<i>The IR2214SS.....</i>	<i>3</i>
<i>The power module .....</i>	<i>3</i>
<i>Important Notice.....</i>	<i>3</i>
<b>BOARD CONNECTORS.....</b>	<b>4</b>
<i>Connection with the system controller .....</i>	<i>4</i>
<i>FAULT/SD logic signal.....</i>	<i>5</i>
<i>VCC supply pin .....</i>	<i>5</i>
<i>VSS ground pin (GND).....</i>	<i>5</i>
<i>Connecting the current sensors .....</i>	<i>5</i>
<i>High power signal connector.....</i>	<i>6</i>
<i>Connecting the power module .....</i>	<i>6</i>
<i>Test Points .....</i>	<i>7</i>
<b>TEST BENCH CONNECTION .....</b>	<b>7</b>
<b>OPERATING DESCRIPTION.....</b>	<b>8</b>
<i>Power on sequence .....</i>	<i>8</i>
<i>Normal operating mode.....</i>	<i>8</i>
<i>Fault management .....</i>	<i>8</i>
<i>Multilevel board solution.....</i>	<i>9</i>
<b>BOARD SOLUTIONS.....</b>	<b>10</b>
<i>Bootstrap circuit .....</i>	<i>10</i>
<i>Gate resistances .....</i>	<i>10</i>
<b>OTHER EXTRA COMPONENTS .....</b>	<b>11</b>
<i>Desat circuit .....</i>	<i>11</i>
<i>Clamping Diode for <math>V_s</math> below ground .....</i>	<i>11</i>
<i>RC filter on com pin.....</i>	<i>12</i>
<i>Fast diode between gate and supply pin .....</i>	<i>13</i>
<i>Zener diode to preserve the IGBT gate .....</i>	<i>13</i>
<i>Optional output shunt resistor .....</i>	<i>14</i>
<i>Resistor on <math>v_{cc}</math>.....</i>	<i>14</i>
<b>BILL OF MATERIAL .....</b>	<b>15</b>
<b>LAYOUT .....</b>	<b>16</b>
<b>SCHEMATIC.....</b>	<b>22</b>

## Table of figures

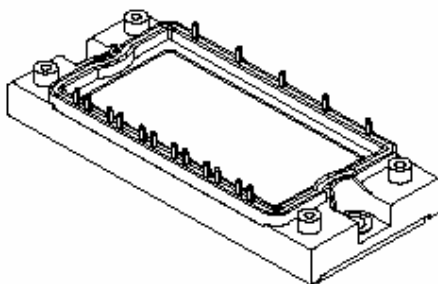
Figure 1: TOP image of board .....	4
Figure 2: LED connection .....	5
Figure 3: Test bench connection .....	7
Figure 4: Power on sequence.....	8
Figure 5: Three phase connection.....	9
Figure 6: Example of a desaturation detection event .....	9
Figure 7: Bootstrap circuit.....	10
Figure 8: Desat external filter .....	11
Figure 9: $-V_s$ clamp .....	12
Figure 10: COM below ground protection.....	12
Figure 11: Collector-Gate current protection .....	13
Figure 12: Zener clamp for IGBT gate.....	13

Parameters	Values	Description, condition
<b>Input Power</b>		
<b>DC+</b>	0 to 1200V	DCBus voltage positive with 1200V power module
<b>DC-</b>	ground	DCbus voltage negative
<b>Vcc</b>	15V typ	Low voltage power supply. Follow IR2214 datasheet for supply setting
<b>Vss</b>	ground	Low voltage ground
<b>Icc</b>	100 mA	quiescent Vcc current
<b>Output Power</b>		
<b>I<sub>lmax</sub></b>	50A @25C	max phase dc output current
<b>Control Inputs/Outputs</b>		
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

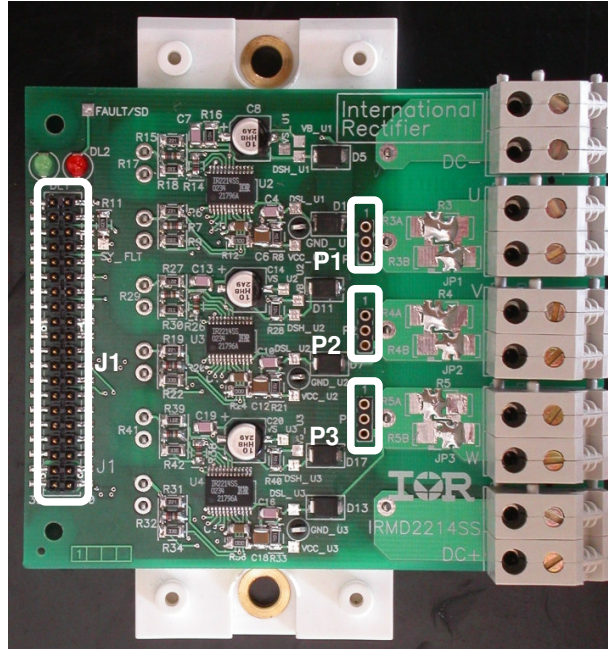


Figure 1: TOP image of board

### 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.

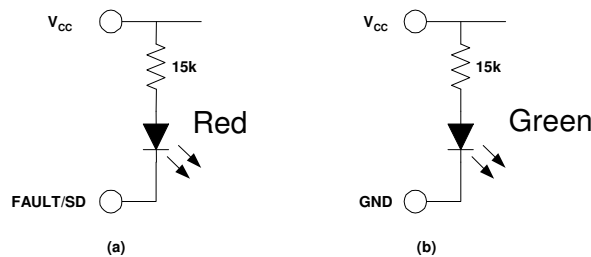


Figure 2: LED connection

### 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 <sub>B</sub>	High side floating supply voltage
V <sub>S</sub>	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)

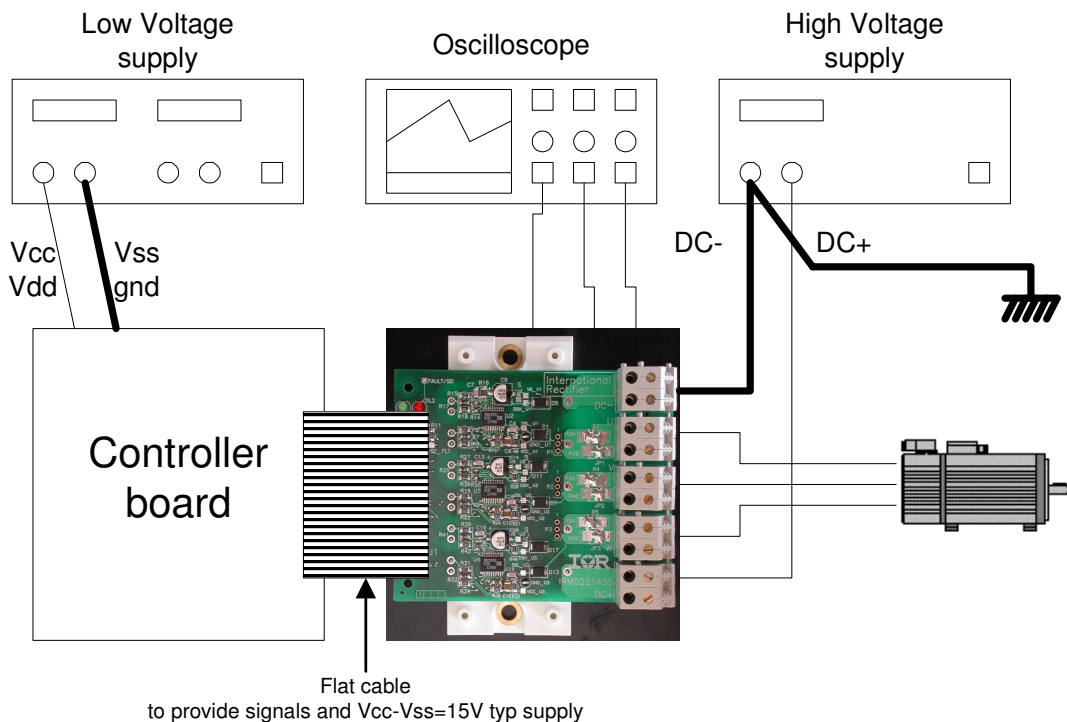
Table 4: Test points

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).





## 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.

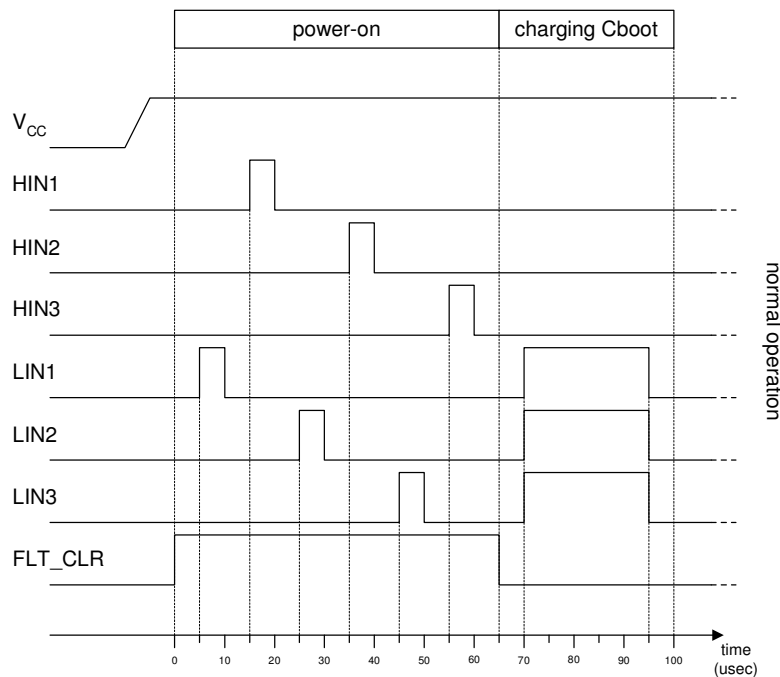


Figure 4: Power on sequence

### 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.



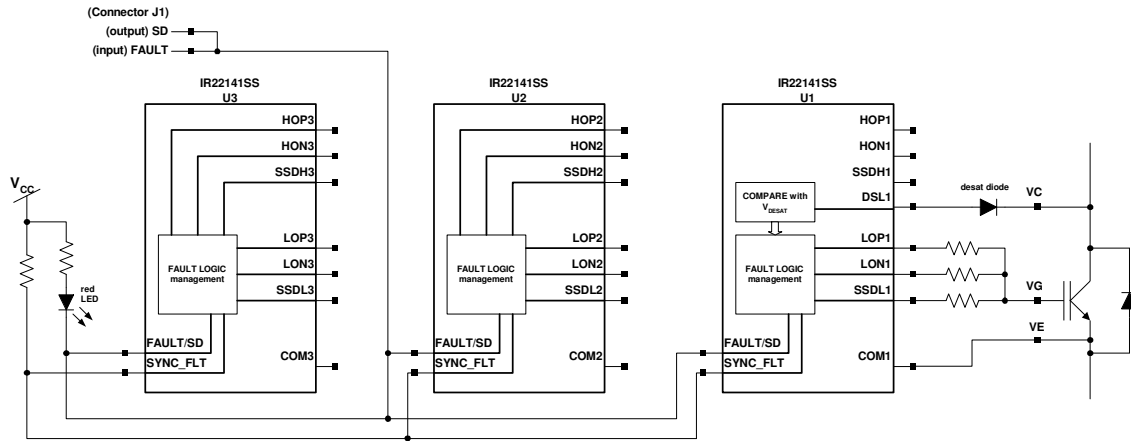


Figure 5: Three phase connection

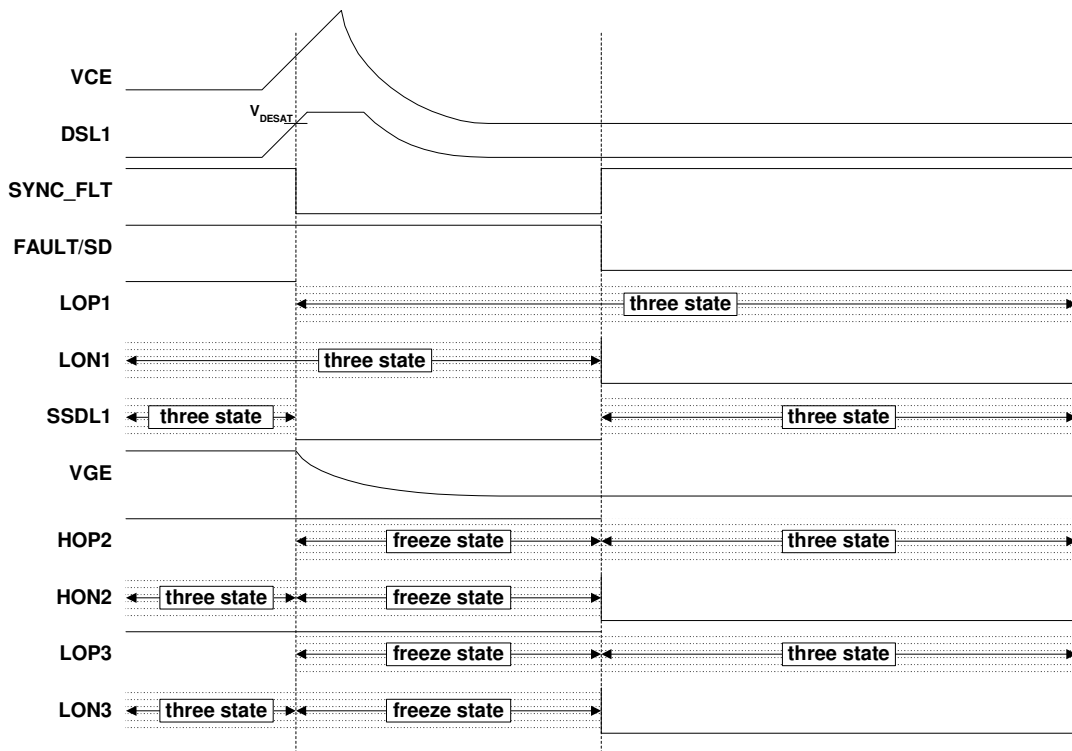


Figure 6: Example of a desaturation detection event

### 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.

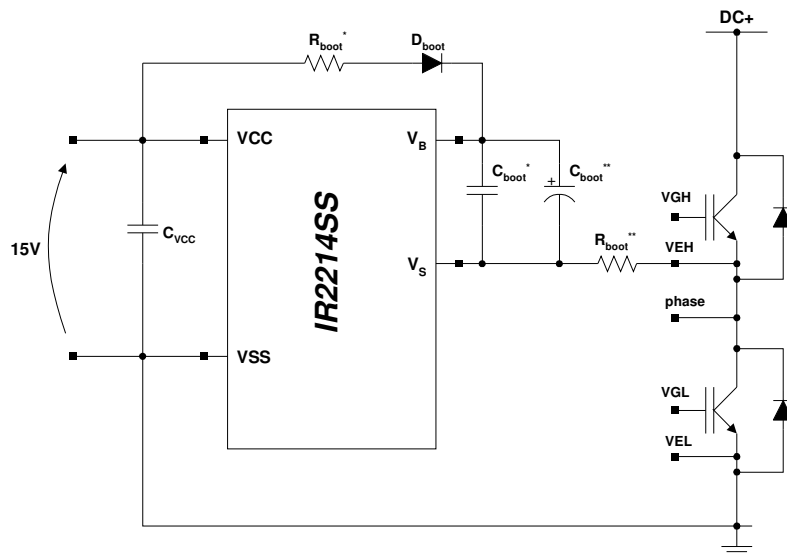


Figure 7: Bootstrap circuit

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 1 $\mu$ sec. If this is not enough an RC filter has been placed on board (see figure 8,  $R_{DSH}$ ,  $C_{DSH}$  and  $R_{DSL}$ ,  $C_{DSL}$ ).

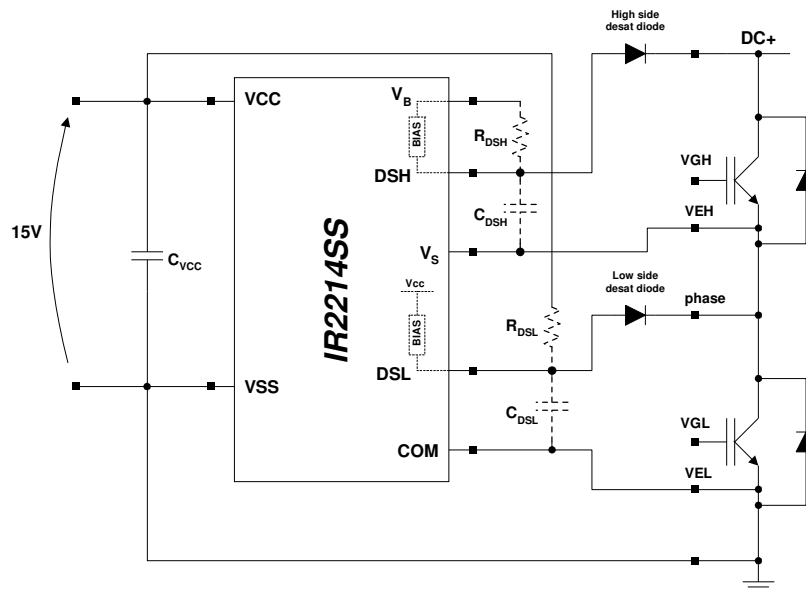


Figure 8: Desat external filter

The external resistor is in parallel with the internal bias circuit of the desat diode. If added, the external resistor may cause a 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 $V_S$ 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.

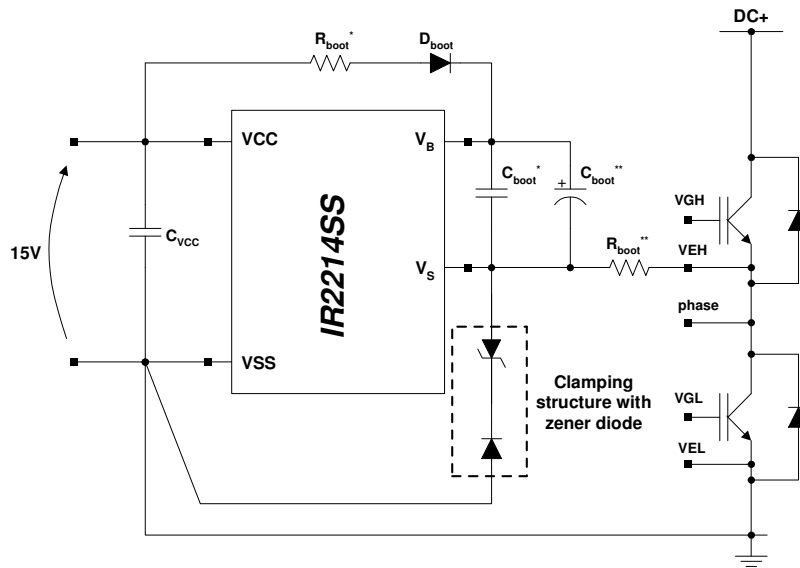


Figure 9: -Vs clamp

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.

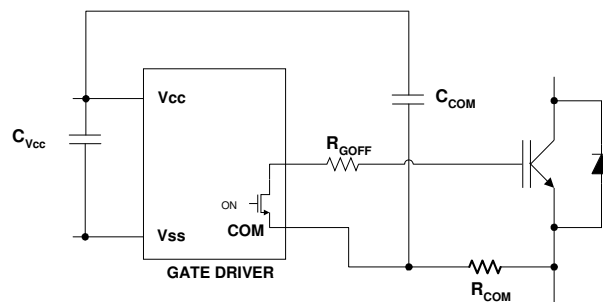


Figure 10: COM below ground protection

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.

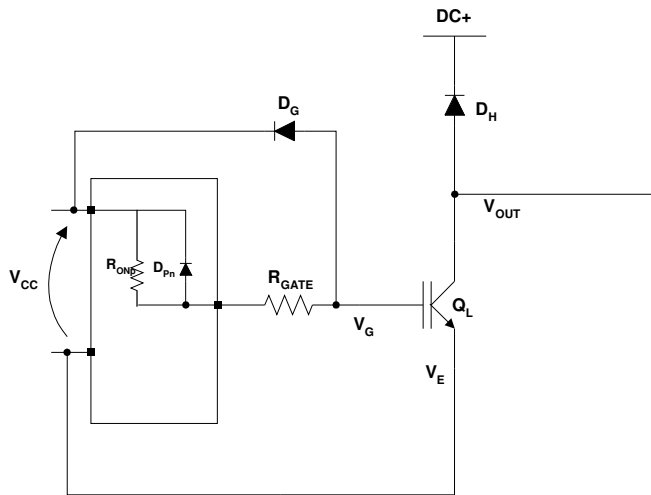


Figure 11: Collector-Gate current protection

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.

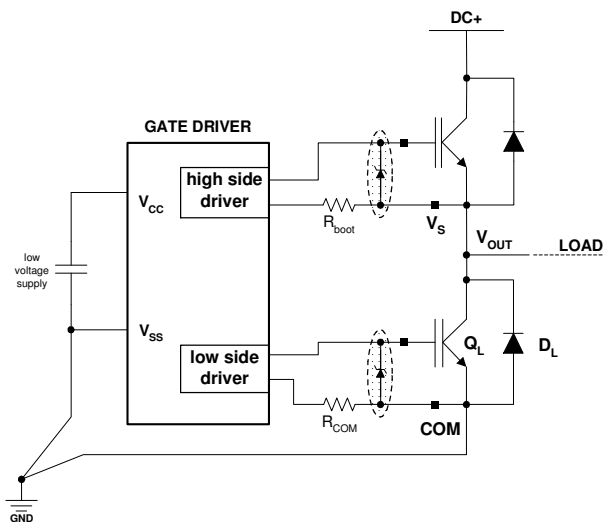


Figure 12: Zener clamp for IGBT gate

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.

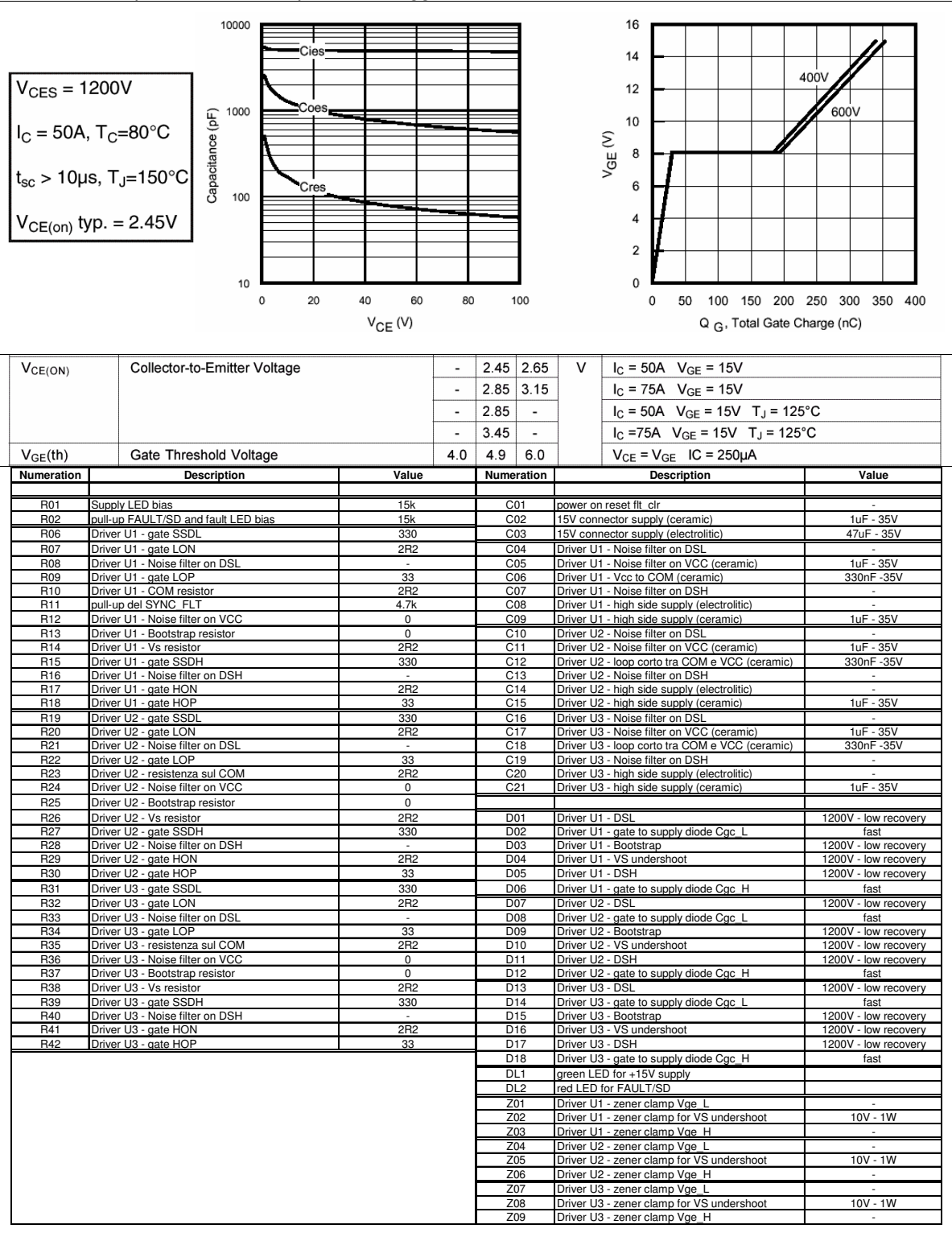
### Resistor on v<sub>cc</sub>

Provided to decouple VCC\_U1, VCC\_U2 and VCC\_U3 from supply line.

	U	V	W
Vcc decoupling	R12	R24	R36

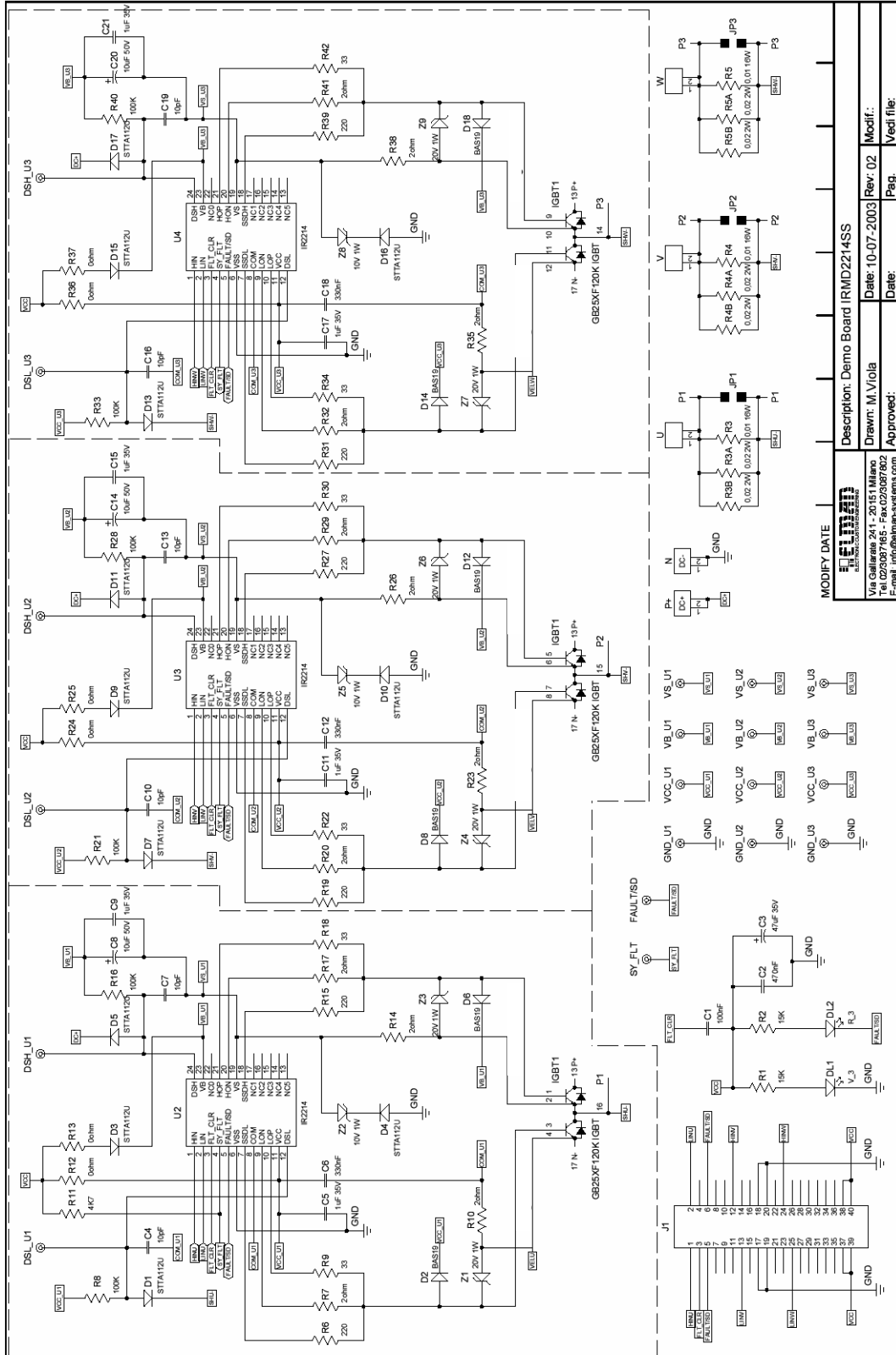
## BILL OF MATERIAL

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





**SCHEMATIC**



Description: Demo Board IRMD2214SS	
Drawn: M.Viola	Date: 10-07-2003
Approved:	Rev: 02
Date:	Modif:
Page:	Vedi file:

**LAYOUT**

TOP SILK LAYER

