Интелигентни силови модули IPM. Блокови и схемни решения. Приложения и предимства.

Introduction to Intellimod™ Intelligent Power Modules

Powerex Intellimod™ Intelligent Power Modules (IPMs) are advanced hybrid power devices that combine high speed, low loss IGBTs with optimized gate drive and protection circuitry. Highly effective over-current and short-circuit protection is realized through the use of advanced current sense IGBT chips that allow continuous monitoring of power device current. System reliability is further enhanced by the IPM's integrated over temperature and under voltage lock out protection. Compact, automatically assembled Intelligent Power Modules are designed to reduce system size, cost, and time to market. Powerex in alliance with Mitsubishi Electric introduced the first full line of Intelligent Power Modules in November, 1991.

The Powerex/Mitsubishi third generation intelligent power module family shown in Table 6.1 represents the industries most complete line of IPMs. Since their original introduction in 1993 the series has been expanded to include 36 types with ratings ranging from 10A 600V to 800A 1200V. The power semiconductors used in these modules are based on the field proven H-Series IGBT and diode processes. In Table 6.1 the third generation family has been divided into two groups, the “Low Profile Series” and “High Power Series” based on the packaging technology that is used. The third generation IPM has been optimized for minimum switching losses in order to meet industry demands for acoustically noiseless inverters with carrier frequencies up to 20kHz. The built in gate drive and protection has been carefully designed to minimize the components required for the user supplied interface circuit.

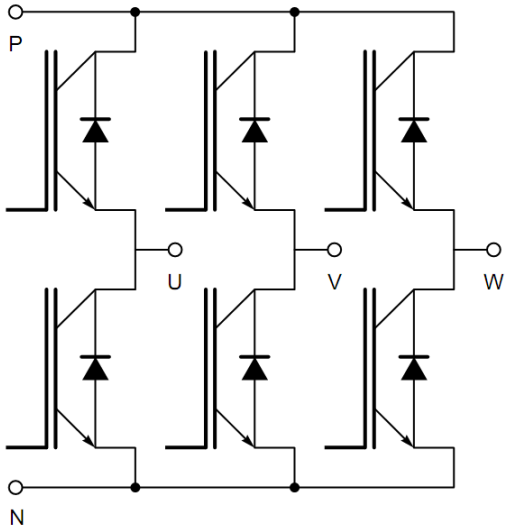
Table 6.1 Powerex Intelligent Power Modules

Type Number	Amps	Power Circuit
Third Generation Low Profile Series - 600V		
PM10CSJ060	10	Six IGBTs
PM15CSJ060	5	Six IGBTs
PM20CSJ060	20	Six IGBTs
PM30CSJ060	30	Six IGBTs
PM50RSK060	50	Six IGBTs + Brake ckt.
PM75RSK060	75	Six IGBTs + Brake ckt.
Third Generation Low Profile Series - 1200V		
PM10CZF120	10	Six IGBTs
PM10RSH120	10	Six IGBTs + Brake ckt.
PM15CZF120	15	Six IGBTs
PM15RSH120	15	Six IGBTs + Brake ckt.
PM25RSK120	25	Six IGBTs + Brake ckt.
Third Generation High Power Series - 600V		
PM75RSA060	75	Six IGBTs + Brake ckt.
PM100CSA060	100	Six IGBTs
PM100RSA060	100	Six IGBTs + Brake ckt.
PM150CSA060	150	Six IGBTs
PM150RSA060	150	Six IGBTs + Brake ckt.
PM200CSA060	200	Six IGBTs
PM200RSA060	200	Six IGBTs + Brake ckt.
PM200DSA060	200	Two IGBTs: Half Bridge
PM300DSA060	300	Two IGBTs: Half Bridge
PM400DAS060	400	Two IGBTs: Half Bridge
PM600DSA060	600	Two IGBTs: Half Bridge
PM800HSA060	800	One IGBT

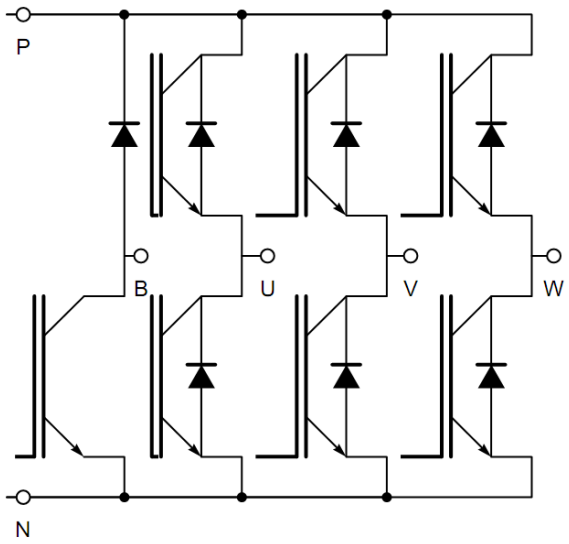
Type Number	Amps	Power Circuit
Third Generation High Power Series - 1200V		
PM25RSB120	25	Six IGBTs + Brake ckt.
PM50RSA120	50	Six IGBTs + Brake ckt.
PM75CSA120	75	Six IGBTs
PM75DSA120	75	Two IGBTs: Half Bridge
PM100CSA120	100	Six IGBTs
PM100DSA120	100	Two IGBTs: Half Bridge
PM150DSA120	150	Two IGBTs: Half Bridge
PM200DSA120	200	Two IGBTs: Half Bridge
PM300DSA120	300	Two IGBTs: Half Bridge
PM400HSA120	400	One IGBT
PM600HSA120	600	One IGBT
PM800HSA120	800	One IGBT
V-Series High Power - 600V		
PM75RVA060	75	Six IGBTs + Brake ckt.
PM100CVA060	100	Six IGBTs
PM150CVA060	150	Six IGBTs
PM200CVA060	200	Six IGBTs
PM300CVA060	300	Six IGBTs
PM400DVA060	400	Two IGBTs: Half Bridge
PM600DVA060	600	Two IGBTs: Half Bridge
V-Series High Power - 1200V		
PM50RVA120	50	Six IGBTs + Brake ckt.
PM75CVA120	75	Six IGBTs
PM100CVA120	100	Six IGBTs
PM150CVA120	150	Six IGBTs
PM200DVA120	200	Two IGBTs: Half Bridge
PM300DVA120	300	Two IGBTs: Half Bridge

Power Circuit Configuration

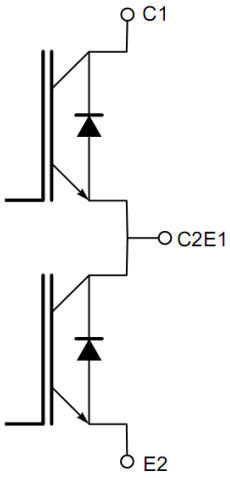
TYPE C



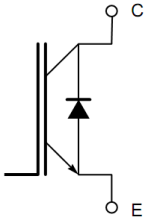
TYPE R



TYPE D

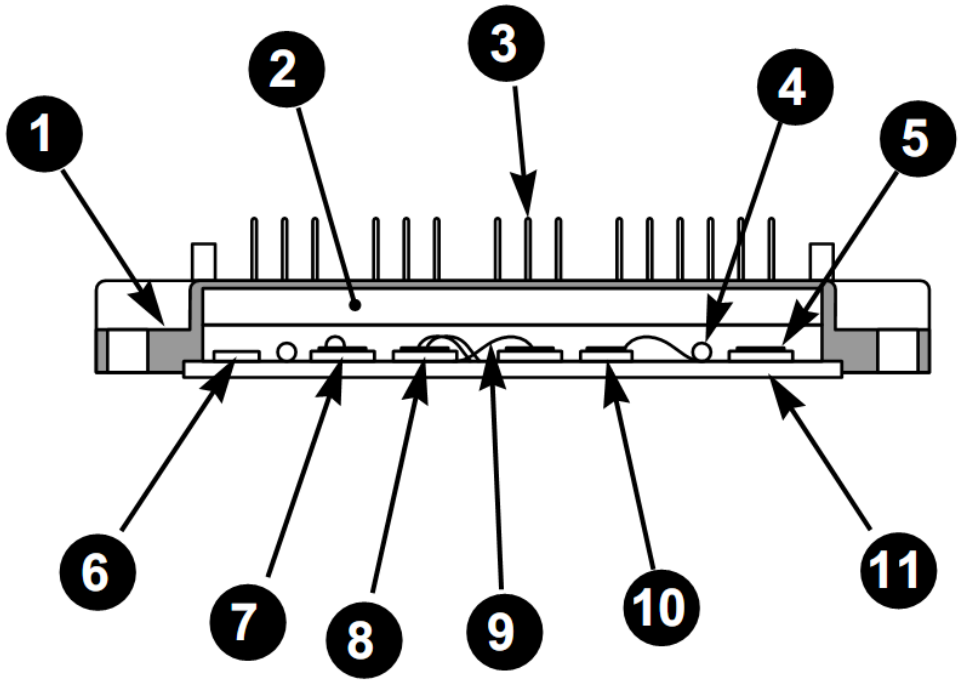


TYPE H



Multilayer Epoxy Construction

Low power Intellimods™ (10-50A, 600V and 10-15A, 1200V) use a multilayer epoxy based isolation system. In this system, alternate layers of copper and epoxy are used to create a shielded printed circuit directly on the aluminum base plate. Power chips and gate control circuit components are soldered directly to the substrate eliminating the need for a separate printed circuit board and ceramic isolation materials. Modules constructed using this technique are easily identified by their extremely low profile packages. This package design is ideally suited for consumer and industrial applications where low cost and compact size are important.

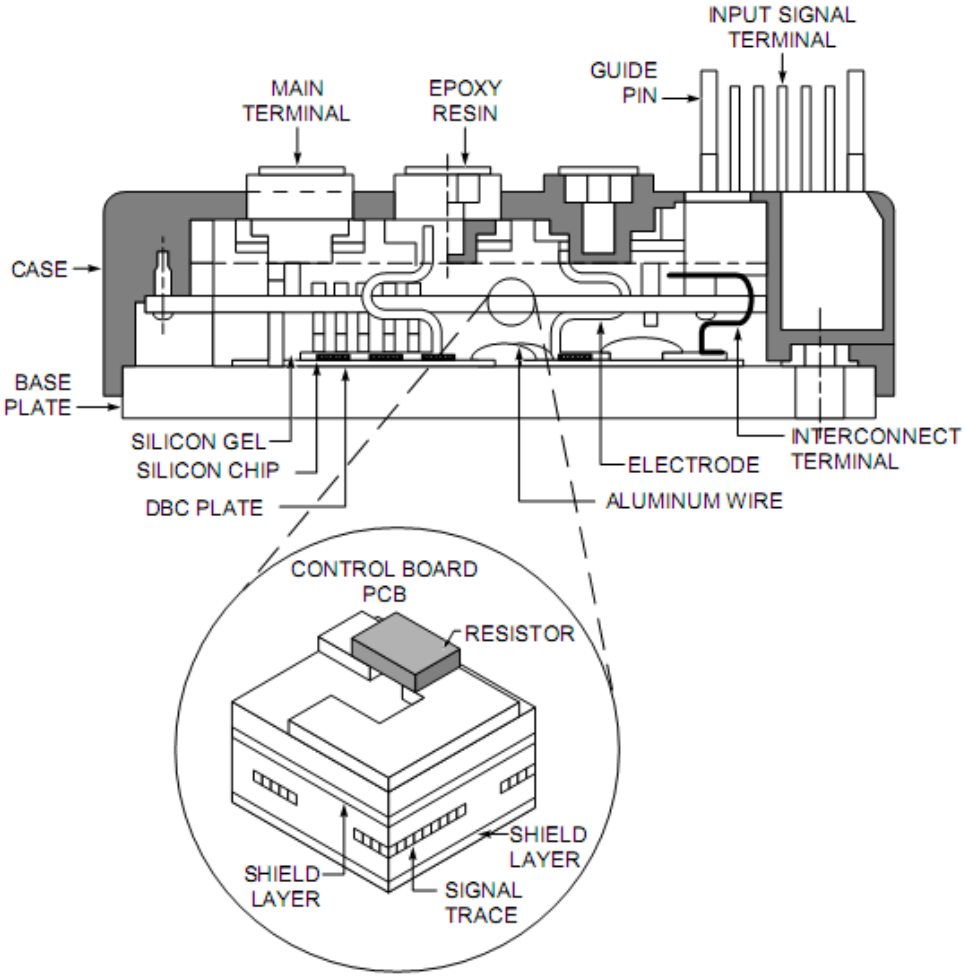


Cross section of this type of Intellimod package.

1. Case
2. Epoxy Resin
3. Input Signal Terminal
4. SMT Resistor
5. Gate Control IC
6. SMT Capacitor
7. IGBT Chip
8. Free-wheel Diode Chip
9. Bond Wire
10. Copper Block
11. Baseplate with Epoxy Based Isolation

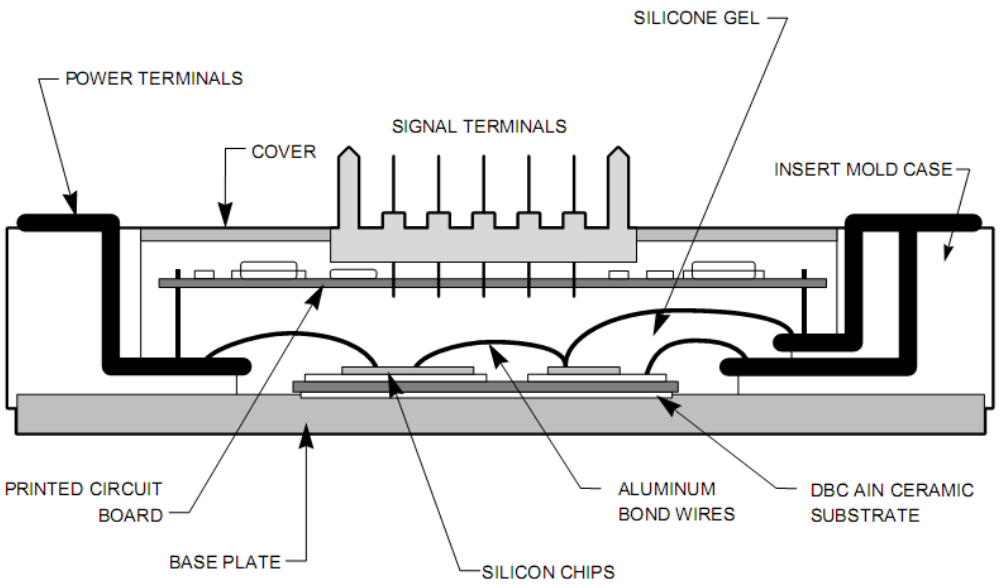
Ceramic Isolation Construction

Higher power IPMs are constructed using ceramic isolation material. A direct bond copper process in which copper patterns are bonded directly to the ceramic substrate without the use of solder is used in these modules. This substrate provides the improved thermal characteristics and greater current carrying capabilities that are needec in these higher power devices. Gate drive and control
circuits are contained on a separate PCB mounted directly above the power devices. The PCB is a multilayer construction with special shield layers for EMI noise immunity.



V-Series IPM Construction

V-Series IPMs are similar to the ceramic isolated types described in Section 6.1.2 except that an insert molded case similar to the U-Series IGBT is used. The V-Series IPM has lower internal inductance and improved power cycle durability. Figure 6.6 is a cross section drawing showing the construction of the V-Series IPM. The insert molded case makes the V-Series IPM is easier to manufacture and lower in cost. Figure 6.7 shows a PM150CVA120 which is a 150A
1200V V-Series IPM.



Advantages of Intelligent Power Module

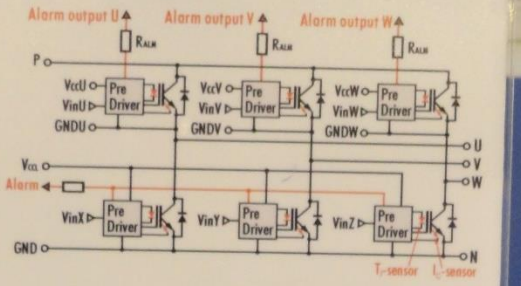
Intellimod™ Intelligent Power Module products were designed and developed to provide advantages to OEMs by reducing :

- design development,
- manufacturing costs ,
- time to market,
- test and reduction in the number of components that must be purchased, stored, and assembled

as well as providing

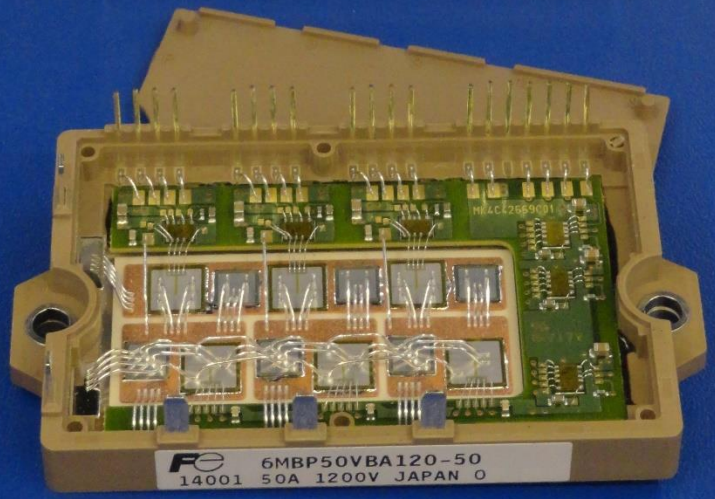
- improvement in system performance
- increased system reliability through automated IPM assembly
- system size can be reduced through smaller heatsink requirements as a result of lower on-state and switching losses
- extension of the product line without additional drive circuit design (same standardized gate control interface)
- self protect in fault situations reduce the chance of device destruction during development testing as well as in field stress situations.

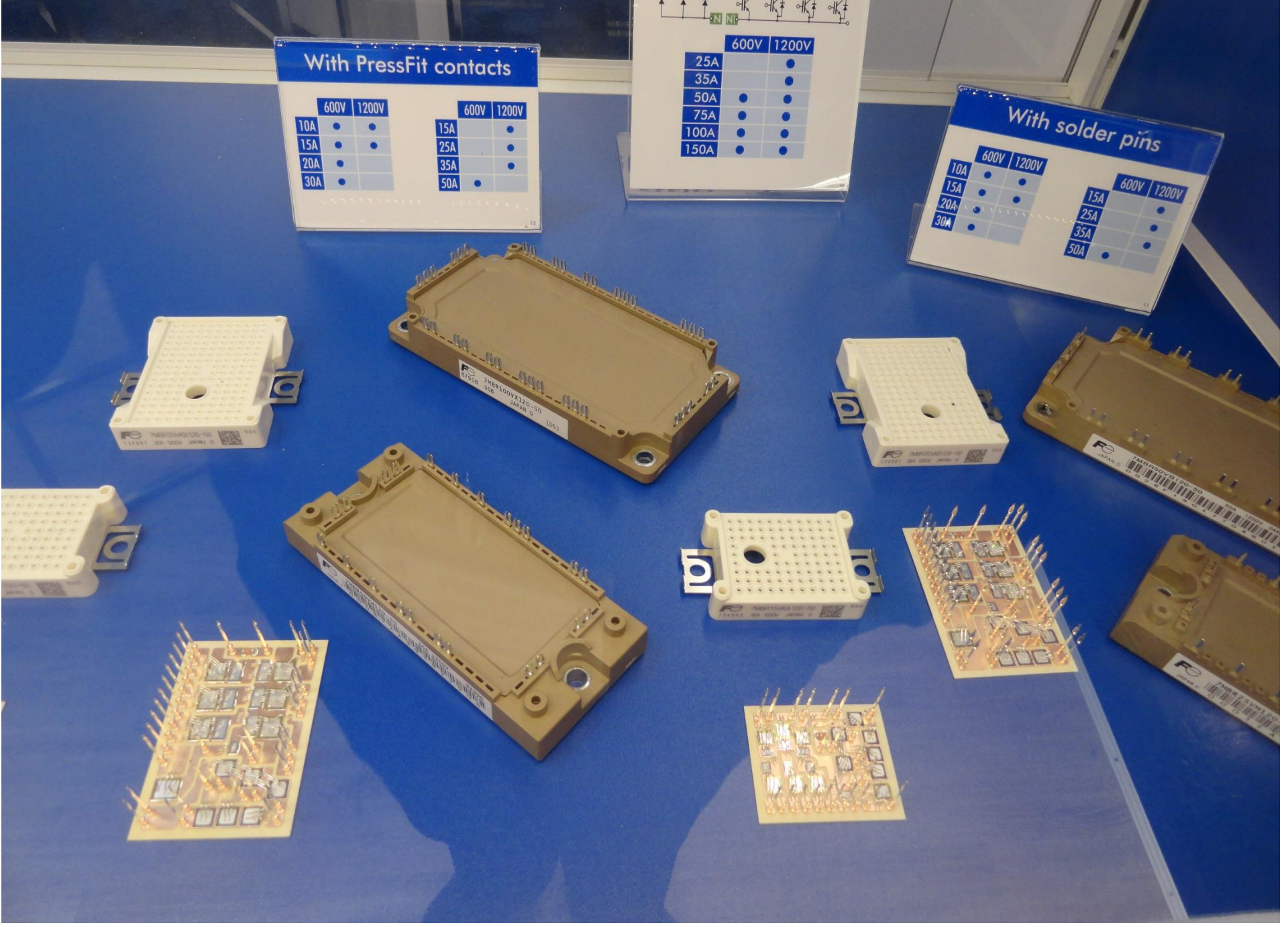
IPM
Intelligent Power Module



	600V	1200V
25A		●
35A		●
50A	●	●
75A	●	

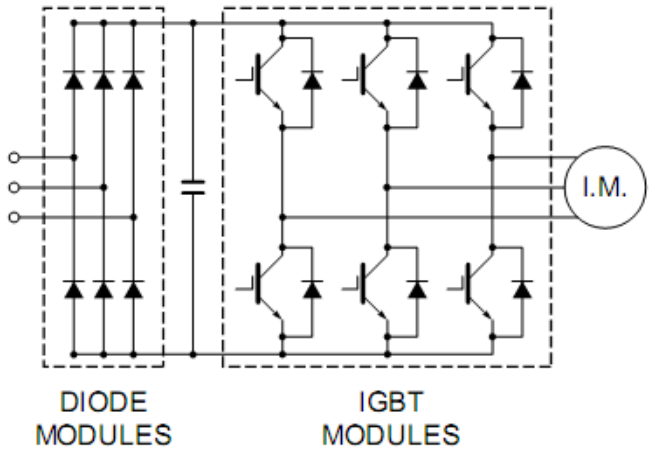
27



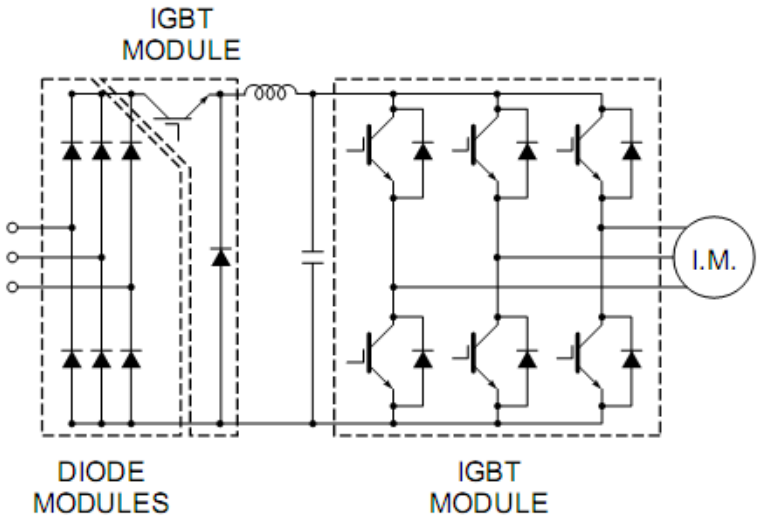

With PressFit contacts
600V 1200V
10A
15A
20A
30A
600V 1200V
15A
25A
35A
50A
600V 1200V
25A
35A
50A
75A
100A
150A
With solder pins
600V 1200V
10A
15A
20A
30A
600V 1200V
15A
25A
35A
50A

Basic Circuit Examples of Main Power Module Applications

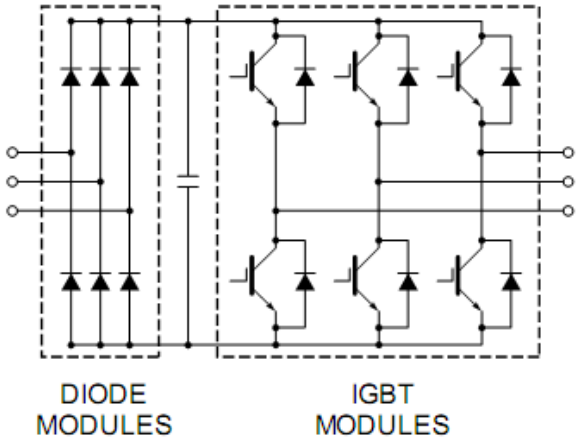
VVVF INVERTER (PWM)



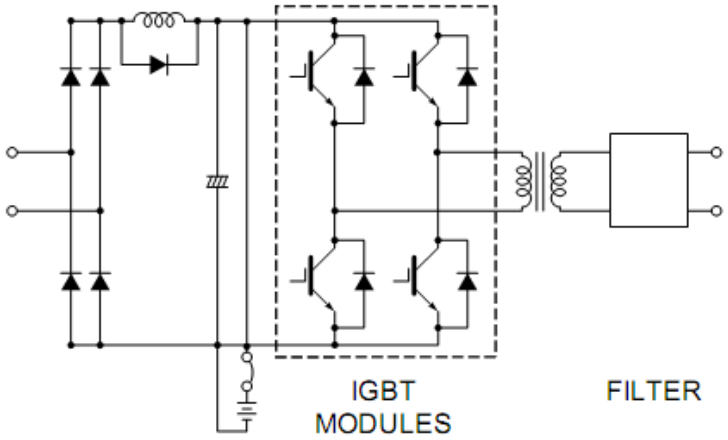
VVVF INVERTER (PAM)



CVCF INVERTER (UPS)

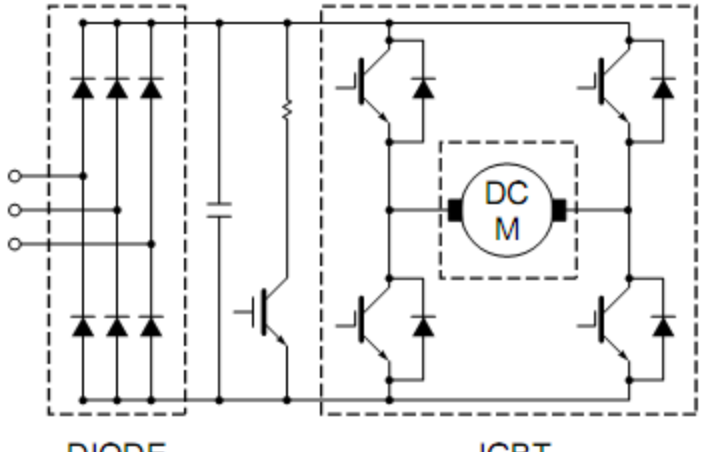


LOW POWER CVCF INVERTER (UPS)

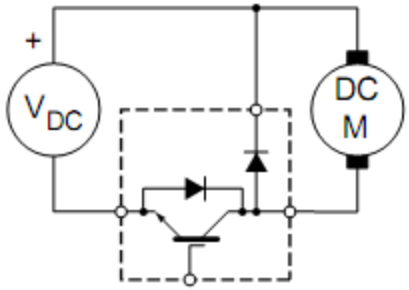


Basic Circuit Examples of Main Power Module Applications

DC SERVO (NC, ROBOTS)

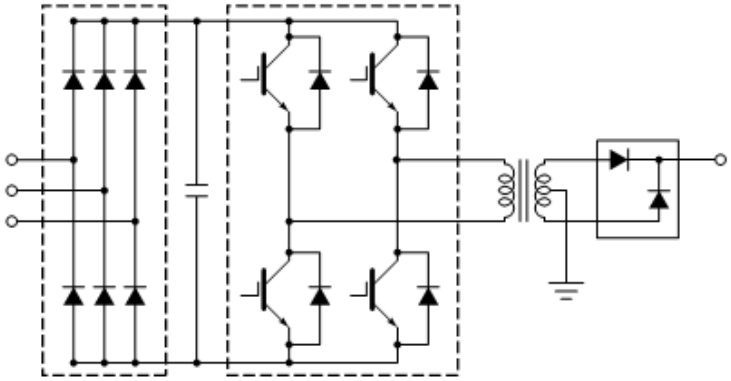


DC CHOPPER



CHOPPER
MODULE

WELDER

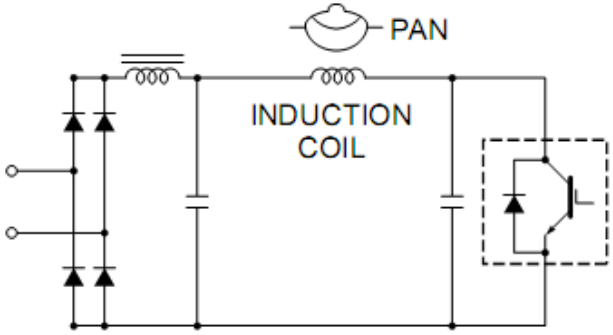


DIODE
MODULES

IGBT
MODULES

FAST RECOVERY
DIODE MODULE

INDUCTION HEATER FOR COOKING



IGBT
MODULE

IPM Solution

Apart from the better known advantages of modules (smaller, more reliable, single component) compared with discrete solutions, the IPM modules relieve the designer from several pitfalls often associated with IGBT inverter designs:

- Lower circuit inductance than discrete solutions results in voltage spike reduction and the ability to operate at higher switching frequency with lower switch losses.
- Simple power connection, just V+, the emitter connections Le1, Le2 and Le3 and the motor connections U,V and W.
- The integrated driver requires only 6 logic level inputs. (includes 3.3V logic) and 3 bootstrap capacitors selected for the switching frequency.
- Propagation delays for all low-side and high-side IGBTs are matched to prevent DC core flux from being applied to the motor.
- Built in dead time control prevents conduction overlap between high-side and low-side IGBTs.
- Fail-safe operation is ensured by built in shut down features for over current and over temperature.
- Analog temperature monitor and phase leg current pins are provided.

IPM System Description

The primary advantage in using the IPM modules is the ease in which an optimized, reliable motor drive system can be implemented. The designer is relieved of the following headaches:

- How to provide sufficient dead time to prevent shoot through failures.
- How to design an overcurrent protection circuit to protect the IGBT switches.
- How to design an over-temperature detection circuit that actually monitors IGBT temperature.
- How to match propagation delay times in the drive circuits to prevent DC current flow in the
- motor windings.
- How to select the optimum switch times to minimize EMI generation and maximize efficiency.
- How to minimize inductive loop size for minimum turn-off voltage overshoots in the IGBTs.

The IRAMS module provides answers to all the above questions in a compact, electrically isolated package.

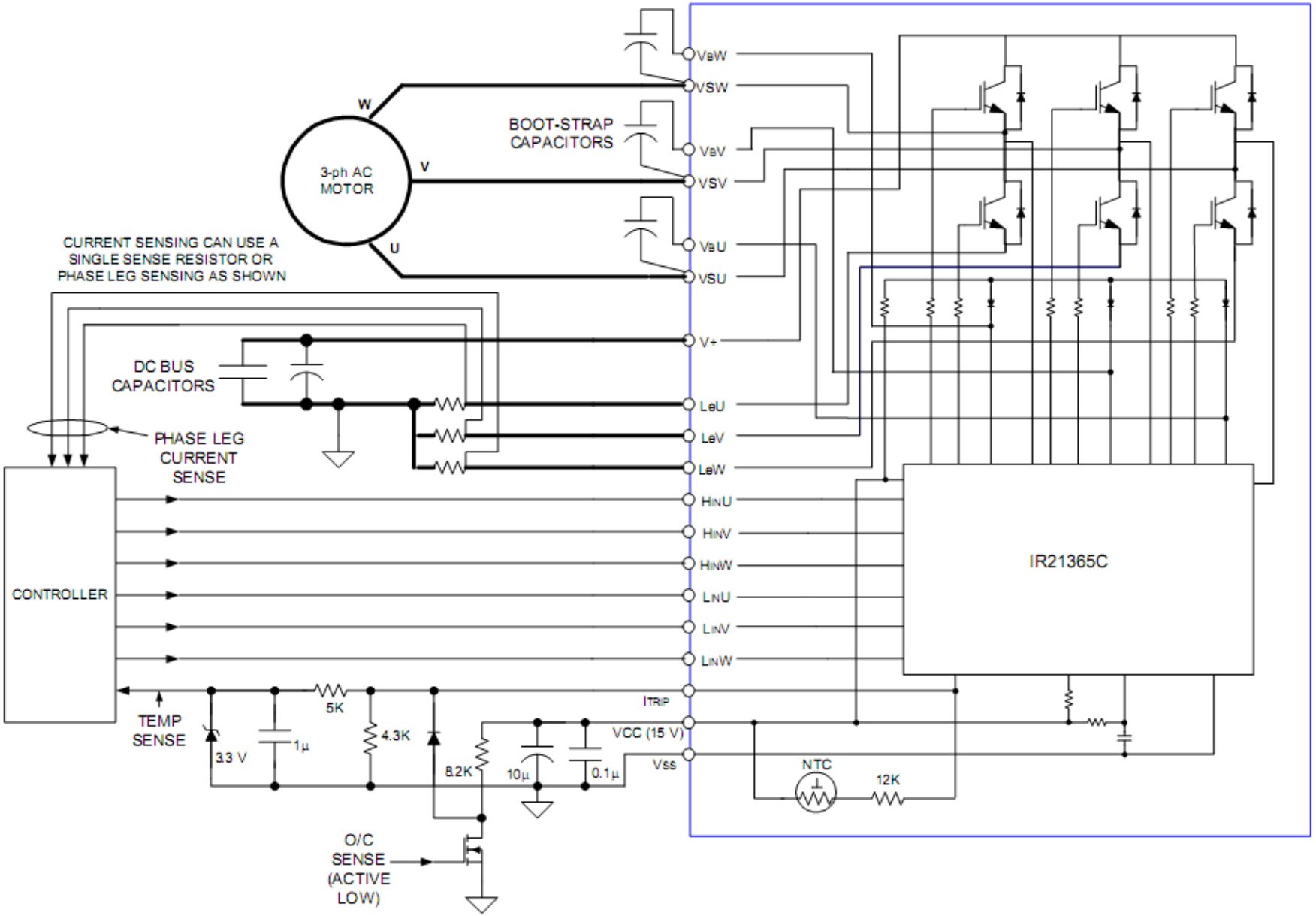
Internal circuitry

The 600V IRAMS module contains:

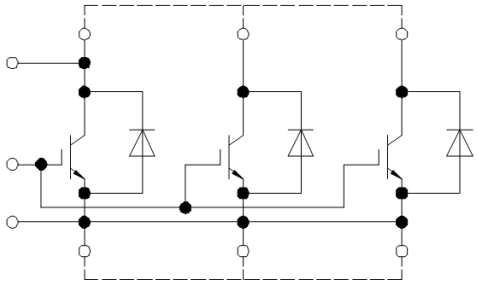
- six IGBT die each with its own discrete gate resistor,
- six commutation diode die,
- one three phase monolithic,
- level shifting driver chip,
- Three bootstrap diodes with current limiting resistor
- and an NTC thermistor/resistor pair for over temperature trip.

The over current trip circuit responds to an input voltage generated from an external sense element such as a current transformer or sense resistor. The input pin for the trip circuit performs a dual function:

- Input pin for over current trip voltage.
- Output pin for module analog temperature sensing thermistor.


W
V
U
3-ph AC MOTOR
BOOT-STRAP CAPACITORS
CURRENT SENSING CAN USE A SINGLE SENSE RESISTOR OR PHASE LEG SENSING AS SHOWN
DC BUS CAPACITORS
PHASE LEG CURRENT SENSE
CONTROLLER
TEMP SENSE
3.3 V
1µ
5K
4.3K
8.2K
10µ
0.1µ
O/C SENSE (ACTIVE LOW)
VBW
VSW
VBV
VSV
VBU
VSU
V+
LEU
LEV
LEW
HINU
HINV
HINW
LINU
LINV
LINW
ITRIP
VCC (15 V)
Vss
NTC
12K
IR21365C

FZ1500R33HL3 2800 euro



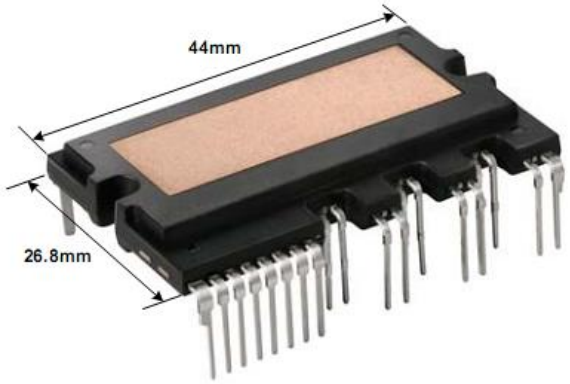
external connection
(to be done)

V_{CES} = 3300V

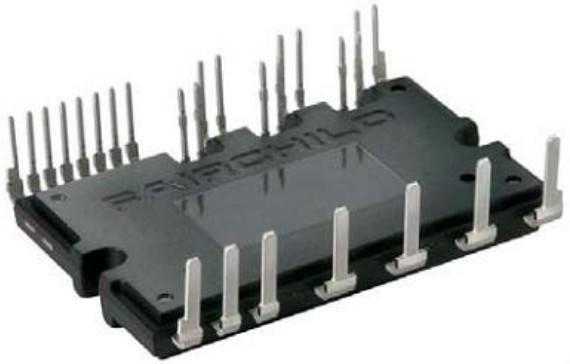
$I_{C\ nom}$ = 1500A / I_{CRM} = 3000A

FSBB15CH60C 12 euro

Top View



Bottom View



600V-15A 3-phase IGBT inverter bridge including control Ics for gate driving and protection