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IPMs Technology for Inverter-driven Home Appliance Applications

Byoung-Ho Choo, Jun-Bae Lee, Dae-Woong Chung,
Jung-Boong Lee, Bum-Seok Suh, Tae-Hoon Kim
Discrete Team, Fairchild Korea Semiconductor

Abstracts

Due to cost-effective and compact system design, IPM-based inverters are now being seen as an attractive alternative to conventional discrete-based inverters technique for low power ac drives, in particular, such as washing machines, refrigerators and air-conditioners. Fairchild-IPM newly developed in order to provide the advantages of the lowest cost and better performance is discussed and its specification is given.

1. Introduction

Inverter-controlled ac motor drives are used more widely for its advantages of high efficiency, high performance and silence. And more and more inverter makers are adopting Intelligent Power Modules (IPM) in their designs because of the many merits of IPMs like less parts count, good noise-immunity, compact system design and high reliability. We have newly designed and developed the IPM as shown in Fig. 1 to meet the continuous demands for further system compactness, lower cost and higher quality performance. This paper presents the first released IPM with 600V-15A ratings, which is mainly targeted at washing machines and low-power industrial applications up to 2hp/220Vac.

Fig. 1 Photograph of the IPM

2. Technologies of Assembly and Packaging

In the new IPM the multi chip assembly technology was used, in which the power chips and the control chips are assembled on the same lead-frame. This process greatly enhances the IPM productivity and reliability. These are important aspects to influence the overall cost of inverter systems particularly in the cost-sensitive home appliances. The packages are designed to guarantee the best heat transfer from the power chips to the outer heat sink by using directed molded ceramic isolators. Fig. 2 shows the cross sectional structure.

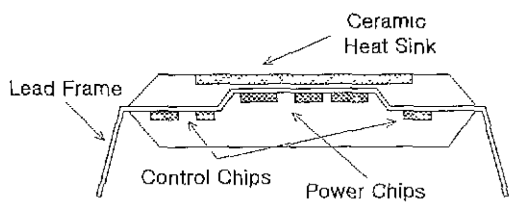

Fig. 2 Cross Section Drawing of IPM

3. Functional Descriptions

The IPM is constructed with the following functional features (refer to the functional block diagram of Fig. 3)

- Current sensing capability using sense IGBT technology
- IGBT drive circuits with direct interface capability provided by using the HVIC with level-shift feature
- Short circuit and control supply under-voltage protection with output fault signaling capability
- Temperature monitoring and feedback using built-in thermistor

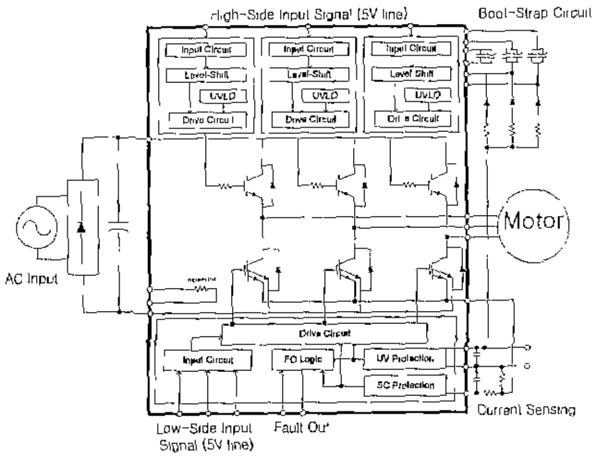

Fig. 3 Functional block diagram of IPM

4. High-Side Drive Technique

4.1 High Voltage Level Shift Circuit

The level-shift feature integrated within the HVIC provides the user with the advantage of opto-coupler-less control interface for the high-side IGBTs drive. The high voltage level-shift operating block is shown in Fig. 4.

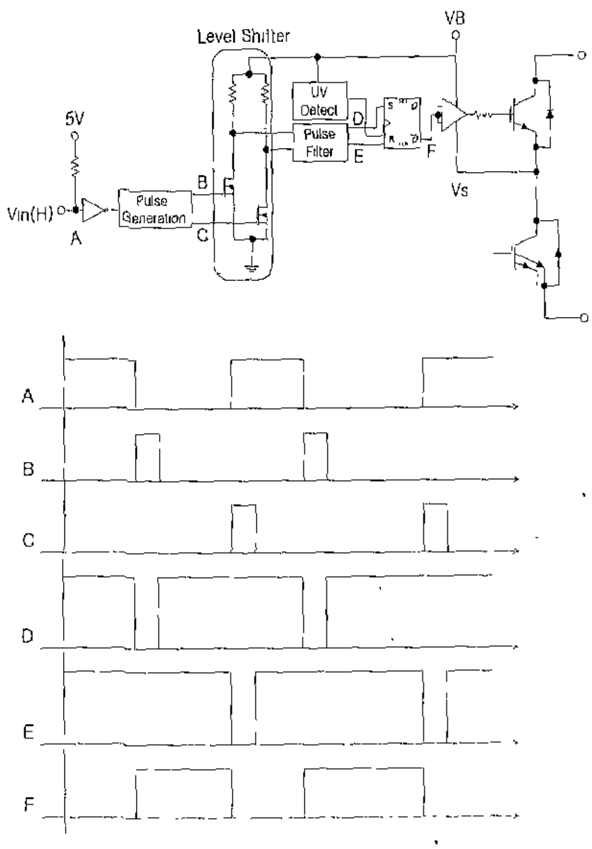

Fig. 4 The High Voltage Level Shift Circuit and Time Chart

The falling edge and the rising edge of the high-side IGBT control input (signal A) activates the one-shot pulse generator which in turn provides the turn-on pulses for the integrated high-voltage MOSFETs (signal B and C). In order to reduce power consumption with the HVIC, the MOSFETs are turned on only for the one-shot pulse duration. The MOSFETs' turn-on pulls down the floating supply voltage level (through the integrated resistors) and accordingly the driver latch circuit is either Set or Reset (signals D and E). In this way, the input control signal A is transferred to provide the drive trigger pulse (signal F) for the high-side IGBT.

4.2 Boot-Strap Circuit

It is possible to operate all 6 IGBTs within the IPM using only one drive supply (15V) without negative bias. To do that, the user has to apply the Boot-Strap components (capacitors, diodes and resistors) as it is shown in the external section labeled Boot-strap Circuit in the block diagram of Fig. 3. The operation principle of the

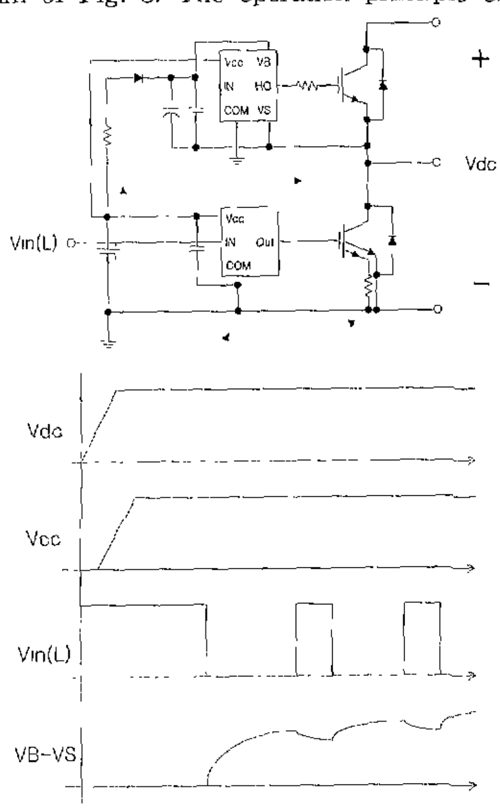

Fig.5 The Boot-Strap Circuit Operation and Time Chart

boot-strap circuit can be simply described as shown in Fig. 5.

The charging-loop indicated in the figure shows the current flow path from the control drive supply (V_{CC}) to establish the high-side drive voltage (V_B-V_S) across the boot-strap capacitor. As elucidated in the figure current flows through the low-side IGBT. Therefore, it is necessary that sufficient on-pulse duration should be assured to the low-side IGBTs (Vin(L)) to precharge the boot-strap capacitors before starting the PWM operation. Instead of a single long pulse, a train of short pulses can be an alternative approach for precharging operation. The total number of these on-pulses and their width depend on the size of boot-strap capacitor.

5. Electrical Characteristics

5.1 General test results

The typical values of other standard electrical tests showing the main characteristics of the IPM are summarized in Table 1.

Table 1 Electrical characteristics of the IPM

Parameter	Test Condition	Value	
Vce(sat.)	Vcc=15V, Vin=0V, Ic=15A, Tj=25℃	2.7V(max.)	
V_F	Ic=15A, Tj=25℃	1.60V (typ.)	
ton/toff	Vd=300V, Ic=15A, Vin=5V-0V, Tj=25℃	390ns/450ns(typ.)	
tcon/tcoff	Vd=300V, Ic=15A, Vin=5V-0V, Tj=25℃	110ns/120ns(typ.)	
UV	Tj=25℃	HS	9V(typ.)
		LS	12V(typ.)
Vsc	Rcs=82Ω, Ic=15A	0.42V(typ.)	

5.2 Protective functions

The IPM provides two main protective functions with generating fault out signal.

- Control supply under-voltage (UV)
- Short Circuit Current (I_{SC})

The Operation principles of these protective functions are described in the time chart of Fig. 6.

It's very simple to sense the value of the main

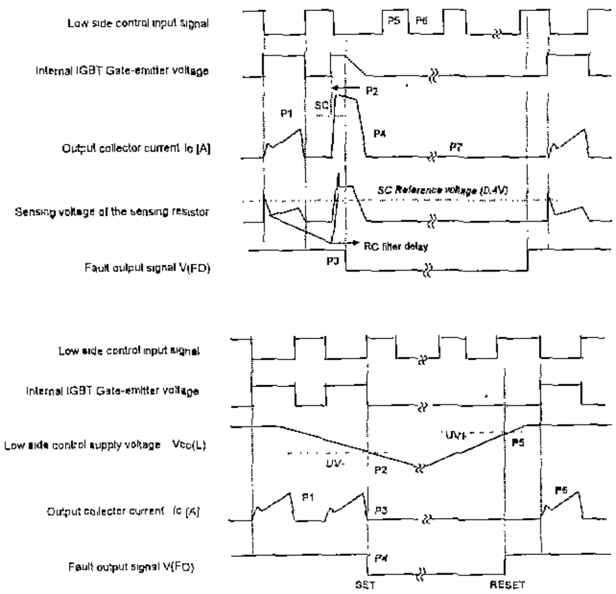

Fig. 6 Time Chart and Operation Under Voltage and Short Circuit Protection

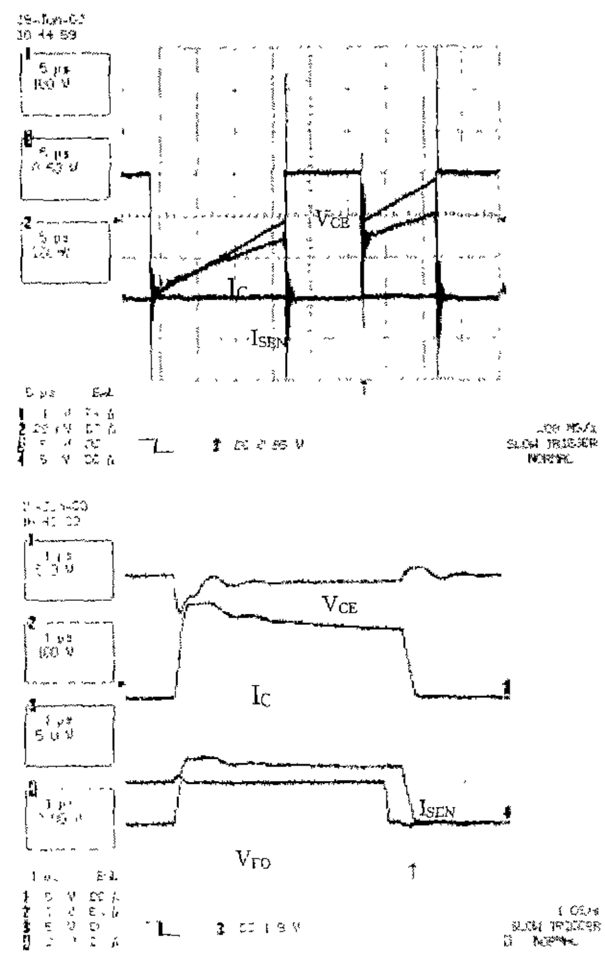

Fig. 7 The Experimental Results of the Current Sensing Characteristics and SC Protection Operation

current, because sense IGBTs are adopted in this

IPM. This current sensing method gives good noise immunity characteristics. The experimental results of the sensing characteristics and short circuit protection operation are shown in Fig. 7.

6. Typical Application Example

The circuit configuration for a typical application of the IPM is shown in Fig. 8.

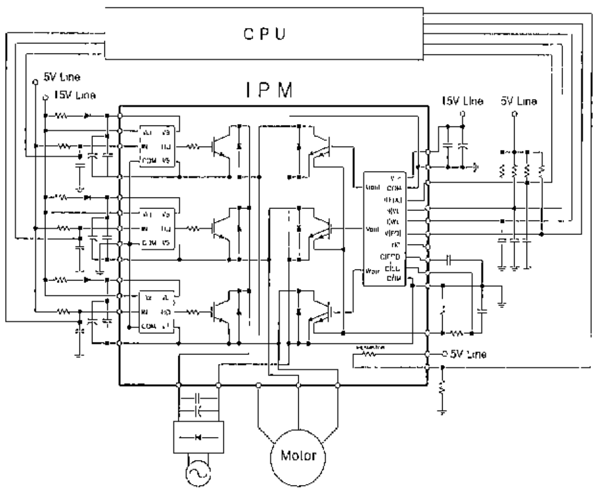

Fig. 8 typical Application circuit Example of the IPM

A single-supply voltage (15V) drives the low-side IGBTs directly and charges the boot-strap circuitry for the HVICs. The integrated 5V CMOS/TTL compatible Schmitt trigger input conditioning circuit enables an opto-coupler-less interfacing of the PWM output signals provided that N-potential of DC-bus voltage is regarded as reference voltage for the control part.

Short circuit is detected by sensing the filtered sense resistor voltage drop.

Two failure modes, SC current and under-voltage of the supply, are sensed by the LVIC to block command signals from controller and generate a fault signal.

7. Conclusion

The new IPM from Fairchild Korea Semiconductor has been introduced. The IPM was developed to target the low power inverter-driven motor applications, particularly home appliances like washing machines. This IPM will lead the power module assembly, packaging and power semiconductors development technology to very compact sizes, lower cost and higher reliability. We, Fairchild Korea Semiconductor, intend to supply one-module solutions for complex systems.

References

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