IPM Solution for Low Rated Power Application

µIPM-DIP & CIPOS Tiny without Heat-sink

"Energy saving" is applied on all power electrical systems and low rated power application is no exception to this. It can be realized to move forward from no-inverter design to inverter design. In addition, the light weight and compact size are always a concern for the product design. No heat-sink approach is in the trend. In this article, no heat-sink IPM solution with µIPM-DIP is introduced.

By Simon Kim & Pengwei Sun, Infineon Technologies, Korea & USA

Home appliance market needs

To further reducing the energy consumption, consumer market requests to speed up the inverterization. It is no exception to home appliances. Especially, home appliances with low rated power are also falling in the range gradually. Home appliance makers try to make product smaller and lighter. With these considerations, no heat-sink approach can be in the trend. Therefore, no heat-sink IPM solution is introduced with some application specifications.

Low rated power application

The definition of low rated power can be different for each application field. In this document, rated power application under 150W is reviewed with some application in home appliance. Here, fan and fridge compressor under 150W can be considered with the following specifications (refer to Table1).

App.	Power [W]	P.F	Vin [V]	Vdc [V]	Vout [V]	Iout [A]	Fs/w [kHz]	Ta [°C]
Fan	130	0.85	220	311	190	0.46	15	45
Fridge	80	0.55	220	311	190	0.44	8	50

Table1: Target specification for fan & fridge compressor

For these targeted specifications, IPM solution is considered as fast and easy solution.

Under 150W application, 600V 3A IPM can be considered. However, for both no heatsink approach and higher frequency applications (around 15[kHz]), 3A cannot be a proper solution. Hence, 600V 4A ~ 6A can be good candidates. Infineon µIPM-DIP 4A module's plastic body dimension is "29 x 12 x 2.9[mm]" and 3 package types can be supplied to customers: SOP23, DIP23 & DIP23A.

Figure 1 (bottom) shows sensor-less motor drive circuit example with Micom, IRMCF171. µIPM-DIP is composed with gate driver, IGBT and NTC. By adding bootstrap capacitor, IGBT can be operated from controller due to embedded bootstrap diode simply. Also, this IPM has open emitter type in each leg and it makes easier for developer choose between one- shunt and three-shunt solutions. 3.3V controller is compatible with this IPM. By using embedded NTC in µIPM-DIP, this module can be protected by thermal comparator. In the example circuit, external thermal comparing with 3V reference voltage allows controller to be aware of the NTC temperature inside of IPM around 115[°C]. In no heat-sink condition and steady status, this NTC value matches estimated junction temperate, 135[°C] (refer to [1]). If developer wants to set lower thermal protection level, reference level can be set in another value. In addition, NTC terminal from IPM inside is connected to controller and its value is monitored by controller directly.

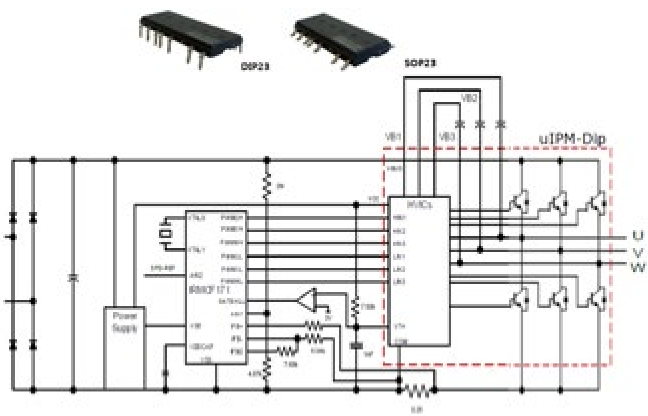


Figure 1: µIPM-DIP 600A 4A IPM package (top) & its application example circuit (bottom)

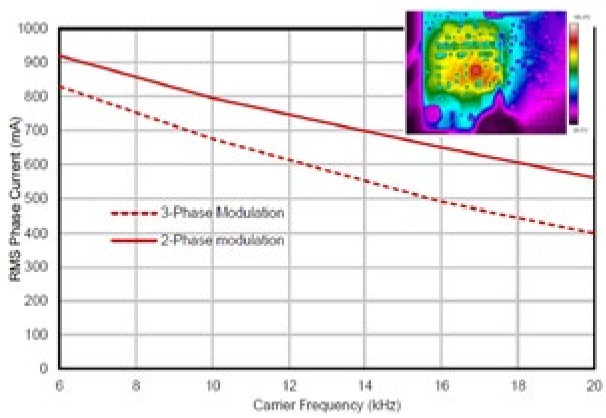
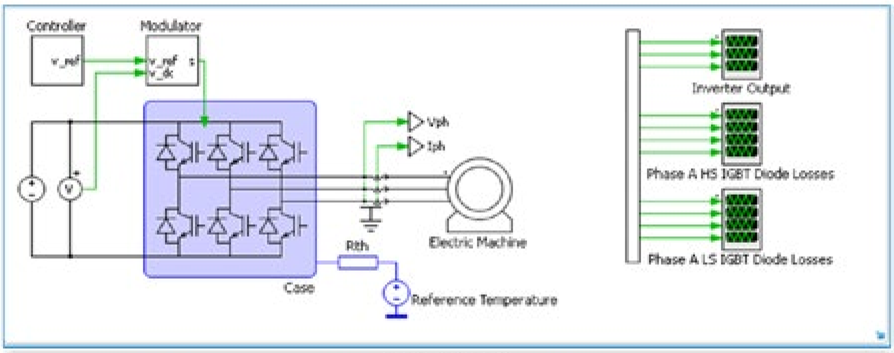


Figure 2.Max phase current vs carrier frequency, no heat-sink. Space Vector Modulation, V+=320V, Ta=28°C, Tj=128°C

Fan application in air conditioning system

Thermal result for estimated 130W fan application can be expected from the followed Figure 2. This shows "carrier frequency vs RMS phase current" with fixed junction tempature. This graph was made and based on thermal tests. Test was done with two different control modulations: 3-phase & 2-phase modulations. Junction temperature was monitored by IR camera. Junction tempature was controlled around Tj=128°C. Estimated 130W fan is operated in fs/w = 15[kHz] & Iout = 460[mA] in Table 1. Figure 2 shows that 530[mA] is achieveable in 15[kHz] around Tj=128[°C]. So, in operation for estimated 130W fan, this IPM's junction temperature can be lower than Tj=128[°C].



Inverter Losses				
	Part Name	Total	Efficiency	
IGBTs	IRSM506-076	2.260 W		
Diodes	IRSM506-076	0.4639 W		
Inverter	IRSM506-076	2.724 W	97.88 %	

Phase A High Side Device Losses and Maximum Junction Temperatures				
	Part Name	Switching	Conduction	Device maximum junction temperature
IGBT	IRSM506-076	0.3165 W	0.1563 W	132.6 °C
Diode	IRSM506-076	0.02211 W	0.01243 W	129.8 °C

Phase A Low Side Device Losses				
	Part Name	Switching	Conduction	
IGBT	IRSM506-076	0.08846 W	0.1923 W	
Diode	IRSM506-076	0.07752 W	0.04255 W	

Figure 3: Expected simulation result for 130W fan with 15[kHz]

To estimate junction temperature with targeted customer operation conditions, Infineon IPM simulation tool can be supported as online simulation [2]. Especially, no heatsink simulation is possible. First, user should select "No heatsink needed". Put Ta=28°C in Reference temperature and 0.53[A] in "Motor driver phase current RMS". Then, put the value in "thermal resistance (case to reference)" and adjust this value till simulation result in Tj=128°C. In this case, this value would be around 30.5[k/w]. This value is high due to no heat-sink condition and highly depends on customers' PCB design. With "thermal resistance (case to reference)" value, the maximum junction temperature for 130W fan without heatsink operation can be calculated in Ta = 45[°C] and the value would be around 132[°C] (Refer to Figure 3.). It is in the thermal safe area.

Fridge Compressor applications

In addition, 80W Fridge compressor application can be reviewed with Figure 4.

Estimated thermal result for 80W fridge can be calculated by Infineon simulation tool. In Ta = 50 [°C], the estimated max junction temperature is around 113[°C] It is in the thermal safe area as well.

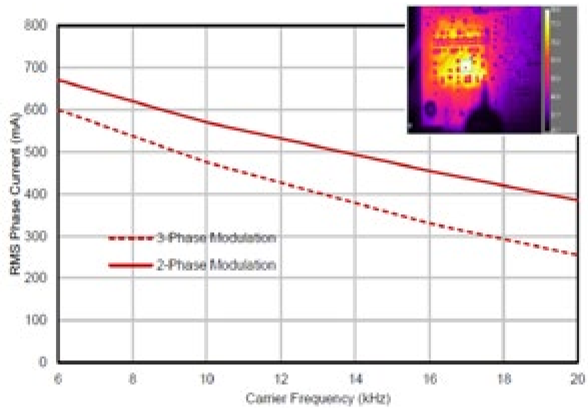


Figure 4.Max phase current vs carrier frequency, no heat- sink. Space Vector Modulation, V+=320V, Ta=28°C, Tj=98°C

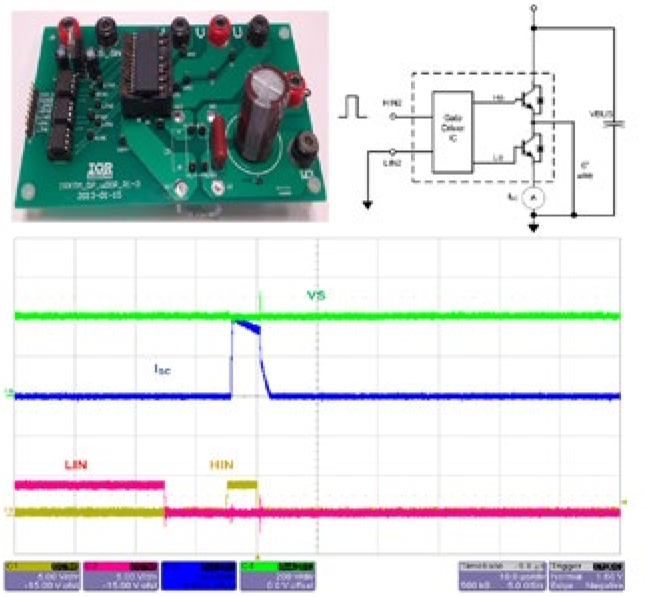


Figure 5: Test board & Test circuit with u-IPM-Dip(Top) and Test graph for short circuit test in Vdc = 400[V] & Isc = 20[A] peak(bottom)

For system safety, short circuit capability must be reviewed and tested. In this test, AC line and (-) terminal was in common by wire and then one pulse was applied on Top IGBT in Infineon µIPM-DIP 4A module. Test condition was with Vdc = 400[V] and Isc = 20[A] for 5[µs]. The IPM was passed without any failure (Refer to Figure 5).

For short circuit or over current protection, controller does monitoring the voltage on shunt in software protection. Or, for hardware protection, external comparator can be applied with some voltage reference level (current trip level) additionally.

Additional solutions

If customer wants to use IPM with error feed-back to controller, Infineon suggests CIPOS Tiny (Refer to Figure 6).

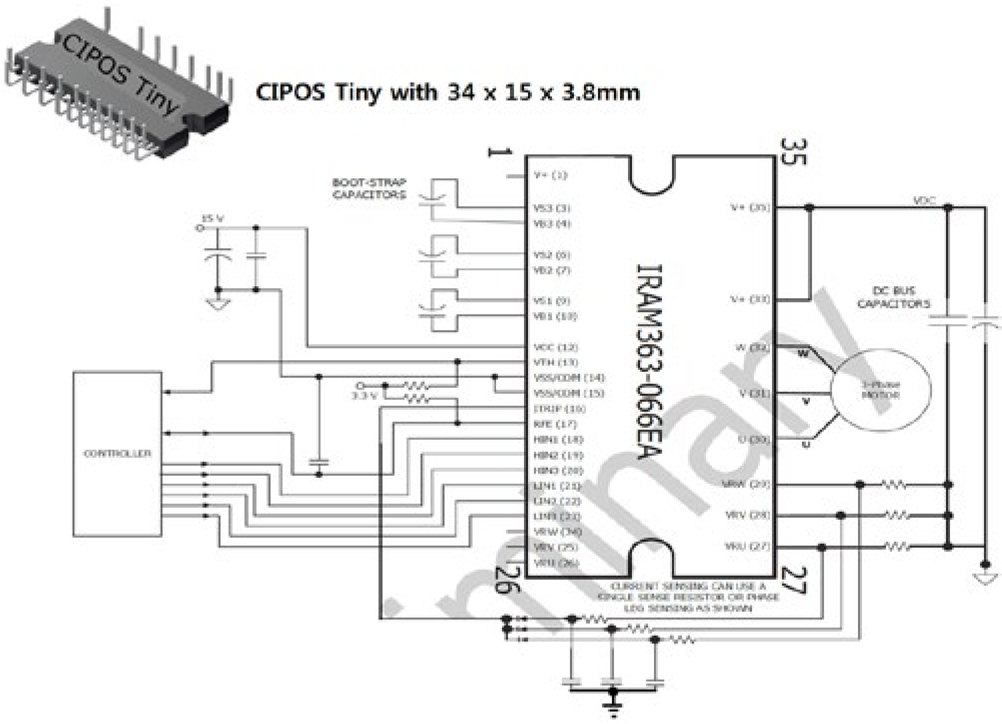


Figure 6: CIPOS tiny's body dimension(top) and it circuit example with Error feedback

Conclusion

In this article, for low rated power applications under 150W without heat-sink approach, 600V 4A µIPM-DIP was proposed. It showed good short circuit capability and thermal margin with both applications: 130W Fan and 80W Fridge compressor applications. For Error Feedback from IPM to controller, CIPOS Tiny can be a solution.

Reference

[1] IRSM506-076, uIPM-DIP (600V 4A IPM) data sheet

[2] Web Infineon IPM Motor Drive Simulator: https://plex.infineon.com/plexim/ipmmotor.html

[3] IRAM363-066EA, CIPOS Tiny (600V 6A IPM) data sheet

www.infineon.com/power