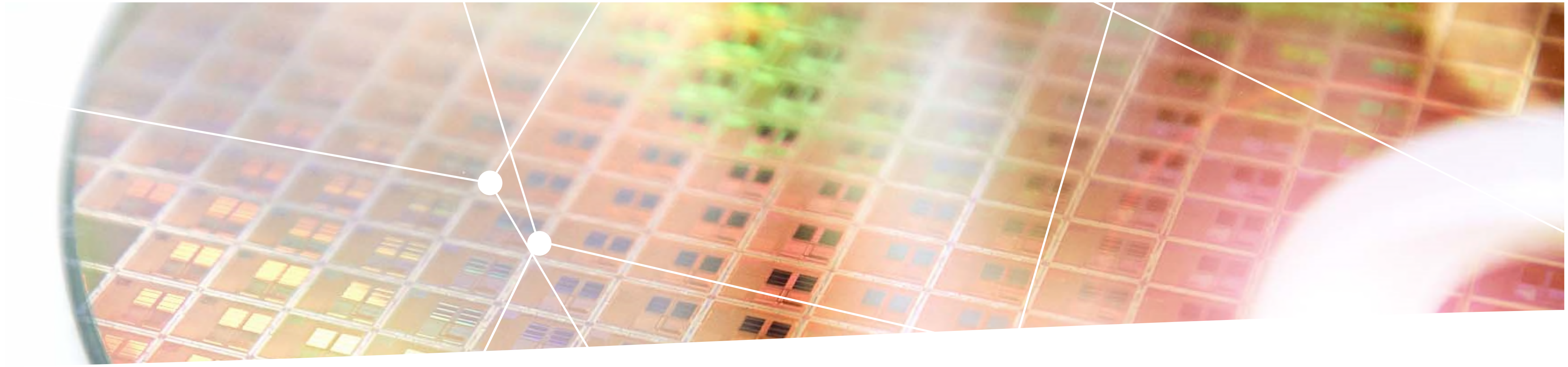

CIPOS^{TM} Tiny 3.0 IPM, IM323 series Technology Introduction

Bryan Tian (IPC TM)
May, 2022

Agenda

1	CIPOS^{TM} Tiny 3.0 IPM, IM323 series technology – IGBT technology and features
2	Comparison data based on datasheet
3	Electrical characteristic
4	Thermal performance
5	Package data

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CIPOS™ Tiny 3.0 IPM, IM323 series

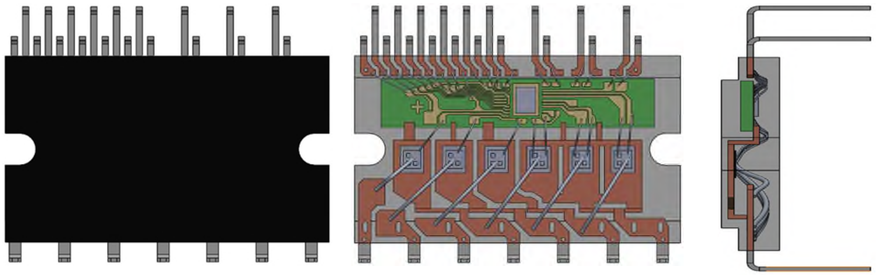
Key features

- Optimized for inverter power rating up to 1.5HP
- Latest TRENCHSTOP™ Reverse Conducting (RC) technology
- **IGBT's Maximum junction temperature 175 ℃**
- **Rugged new SOI gate driver technology, also for negative voltage spike on the motor outputs**
- **One gate driver used, can implement cross conduction prevention and also turn off all switches in case of overcurrent and under voltage**
- Enhanced protection functions to improve system-level reliability
- Switching losses is much lower, better performance at high switching frequency
- Pin-compatible solution

Different point views

- To increase accuracy, NTC was used
- Cost optimization (FP, full-pack package)

Visualization



Support and Logistics

- We are using Infineon-own Frontend and Backend, and can provide good and stable supply
- Infineon can provide full system solution including many other components, and good global technical support

Application

- ODU(Outdoor unit) for RAC (room air conditioner)
- Home appliance
- Industrial drives

CIPOS™ Tiny 3.0 IPM, IM323 nomenclature

IM 3 2 3 - L 6 G -

IM: Infineon IPM

IPM Product Family	
1	Nano
2	Micro
3	Tiny
5	Mini
8	Maxi

Switch Technology	
2	RCD2 Series
9	IR GEN9 IGBT

Function Option	
2	2 phase inverter
3	3 phase inverter

Relative Size	
S	5 A
M	10 A
L	15 A

Voltage Rating	
1	<= 100V
2	<=200V
3	<=300V
4	<=400V
5	<=500V
6	<=600V
7	<=700V
8	<=800V
9	<=900V
C	<=1200V

Package Description	
G	DIP 33 x19

Lead frame option	
-	Standard Lead-form
2	Short Lead-form

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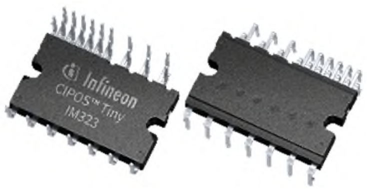
CIPOS™ Tiny 3.0 and Mini FP IPM summary

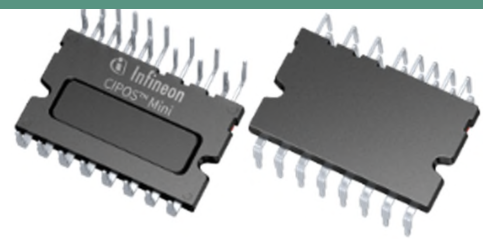
CIPOS™ Tiny 3.0



32.8 x 18.8 x 3.6 mm³

- One package platform covers wide current rating from 6 A to 15 (20) A
- Package types: **DIP 33 x 19** to support effective size for all applications
- Enhanced protection functions to improve system-level reliability
- **Pin-compatible solution**

CIPOS™ Mini FP



36 x 21 x 3.1 mm³

- One package platform covers wide current rating from 4 A to 30 A
- Package types: **DIP 36x21** to support excellent thermal performance
- Broad range of configurations from PFC to inverter

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Comparison data based on datasheet

Item			IM323-L6G	IKCM15L60GA	Remark
Package	Package dimension [mm]		32.8 x 18.8 x 3.6	36 x 21 x 3.1 (123%)	Based on datasheet
	Isolation Voltage [V_{RMS}/1min]		2000 [V]	2000 [V]	
	Thermal resistance [K/W]		4.7	4.57	
	Basic structure		1 driver + 6 IGBT(RC) + NTC	1 driver + 6 IGBT + 6 Diode + NTC	
Power device	I_C @ T_C=25 ℃		15 [A]	15 [A]	
	I_{CP} @ T_C=25ºC, less than 1ms		30 [A]	30 [A]	
	$V_{CE(SAT),Typ}$	T_J = 25 ℃	2.10 [V] @ 15 [A]	1.80 [V] @ 15 [A]	
		T_J = 150 ℃	2.45 [V] @ 15 [A]	2.20 [V] @ 15 [A]	
	$V_{F,Max}$	T_J = 25 ℃	1.93 [V] @ 15 [A]	2.00 [V] @ 15 [A]	
	Junction temperature		175 [℃]	150 [℃]	
Control part	I_{QDD}		Max 1.1 [mA]	Max. 0.9 [mA]	
	ITRIP positive going threshold		0.475 / 0.525 / 0.570 [V]	0.400 / 0.470 / 0.550 [V]	
	Fault clear time		Min. 100 [µs]	Min. 40 [µs]	
	Anti cross-conduction		Yes	Yes	
	Temperature monitor		Typ. 85 kΩ @ T_{NTC}=25°C	Typ. 85 kΩ @ T_{NTC}=25°C	

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Comparison data of GD

Item		Current GD (CIPOS^{TM} Mini)	New GD (CIPOS^{TM} Tiny 3.0)	Remark
Improved system reliability	HS UVLO level down	12.1 V typ.	11.5 V typ.	To improve system reliability considering bootstrap operation
	Sleep function	No	**Yes**	To avoid repetitive short circuit behavior after fault clear time
Additional improvements	I_{TRIP} variation	±15%	**±9.5%**	
	Fault clear time	Min. 40 µs	Min. 100 µs	To recognize fault signal more stably
	Input threshold voltage	Max. 2.4V	Max. 2.3 V	To meet 3.3V JEDEC compatibility
	Input/I_{TRIP} voltage range	-1 V ~ 10.5 V	**-5.5 V ~ V_{DD}+0.5 V**	To improve EOS by the external surge voltage
	Leakage current at V_{BS}	Max. 500 µA	**Max. 300 µA**	To consider smaller power supply
	Leakage current at V_{DD}	Max. 900 µA	Max. 1100µA	

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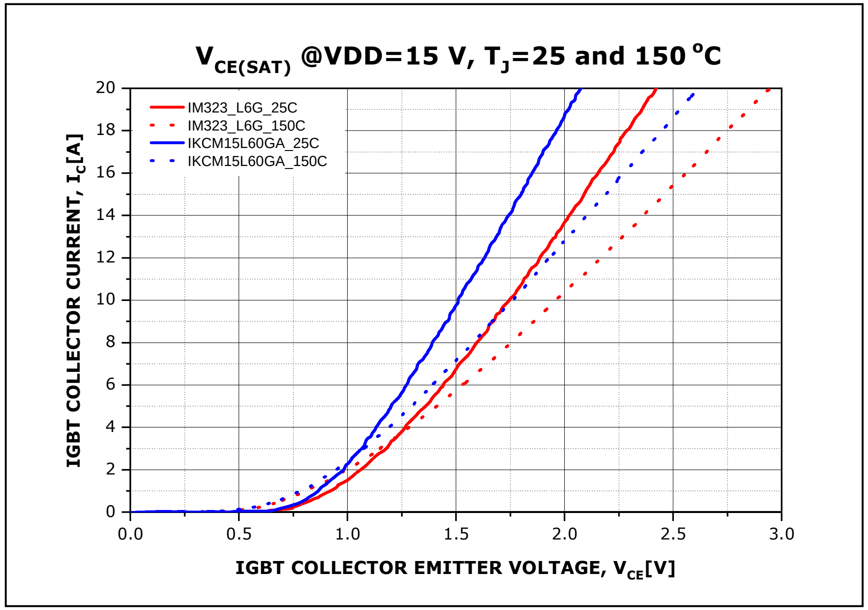
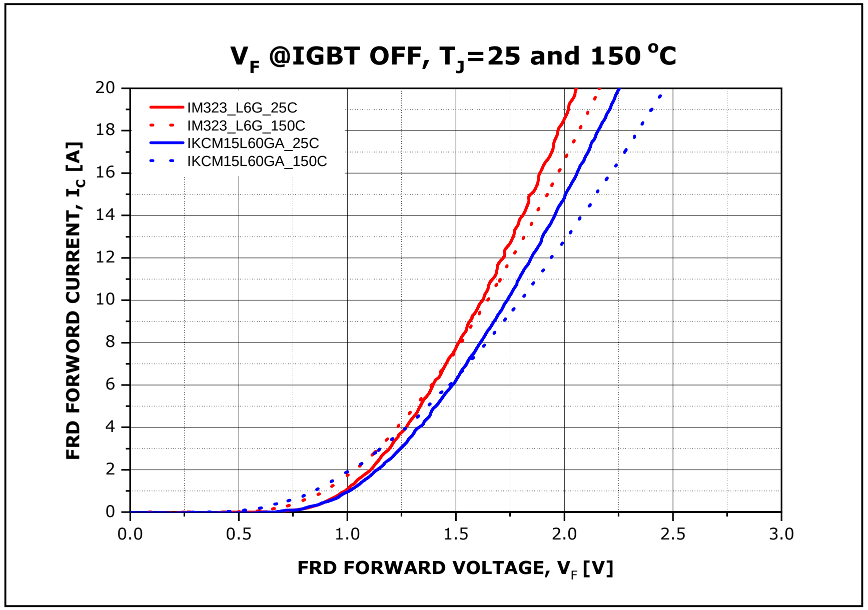
1. Electrical characteristic – Static: IGBT $V_{CE(SAT)}$ and Diode V_F

[$V_{CE(SAT)}$ Comparison]



[V_F Comparison]



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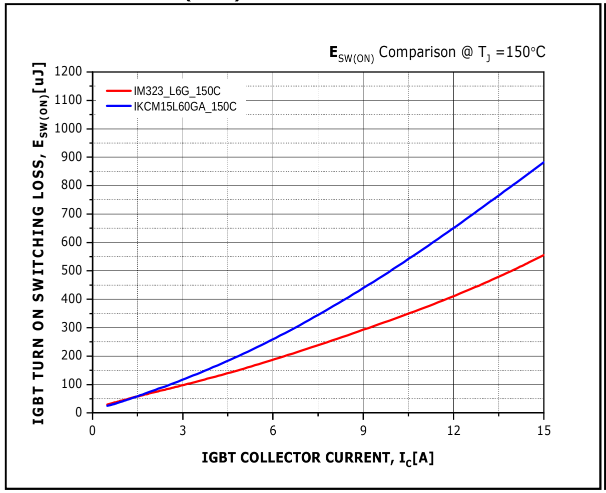
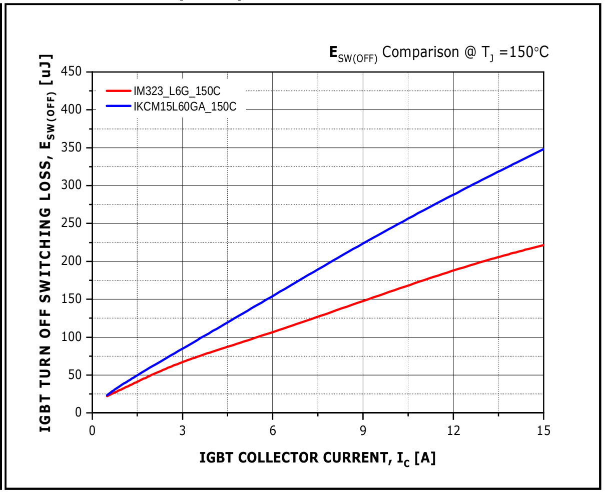
2. Electrical characteristic – Dynamic
: IGBT switching loss (E_{ON}, E_{OFF} and E_{Total})

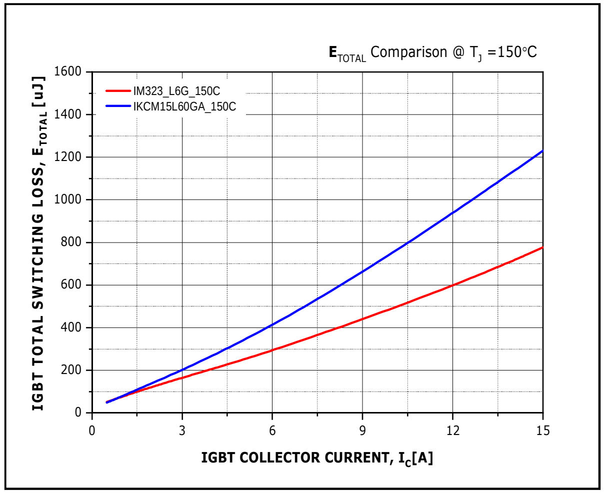
[$E_{SW(ON)}$ comparison]



[$E_{SW(OFF)}$ comparison]



[Total loss comparison]



LOSS	IM323-L6G	IKCM15L60GA	REMARK
$E_{SW(ON)}$ [μJ]	555	882	@ I_C = 15 A, T_J = 150°C
$E_{SW(OFF)}$ [μJ]	221.6	348.3	
Total loss [μJ]	776.6	1230.3	

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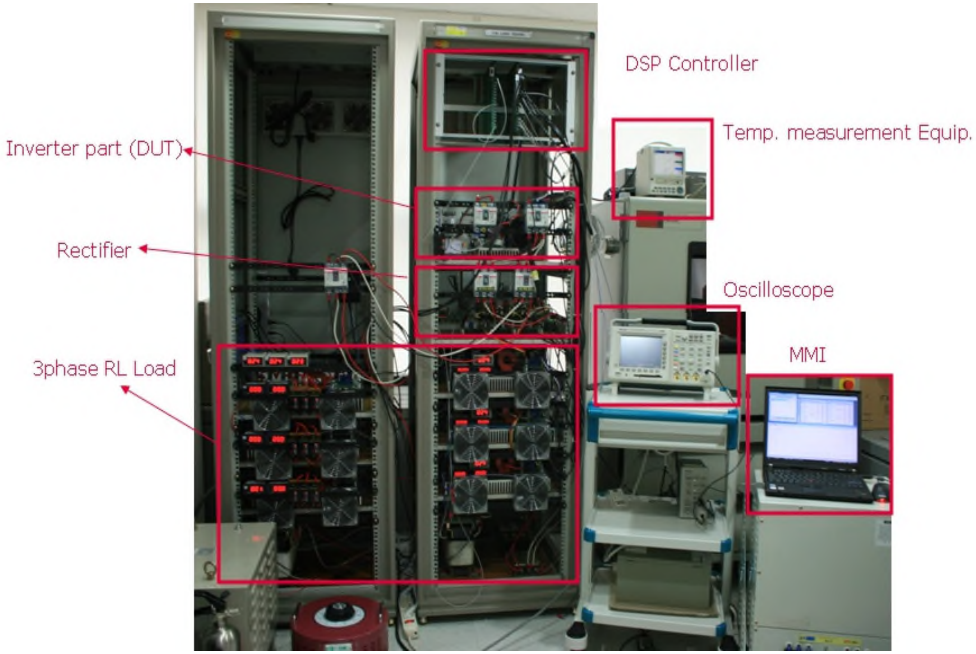
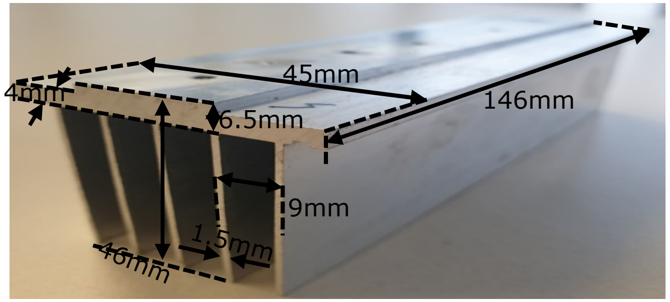
Test environment

- Test bench



- Heatsink size
  - For RAC (with Fan)



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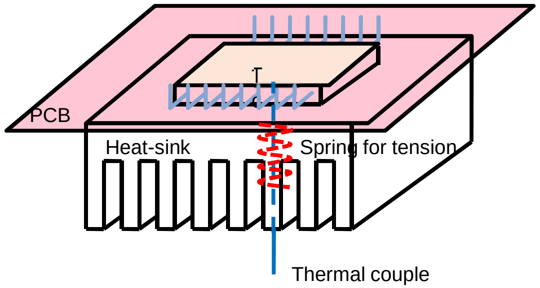
Test condition – RAC condition (IM323-L6G vs. IKCM15L60GA)

› Test conditions

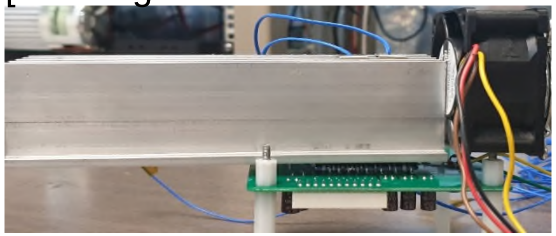
- V_{DC} = 340 V, V_{DD} = 15 V, F_{SW} = 5 kHz, F_O = 60 Hz, PF = 0.8, PWM = SVPWM, T_{dead} = 1µs, 3-Phase R-L Load,
- Force cooling by fan, MI = 0.6, R = 10 Ω, L=16 mH, I_O = 7.07 Arms (10 Apeak), operation time = 10 min.
- DUT: IM322-L6G, IKCM15L60GA

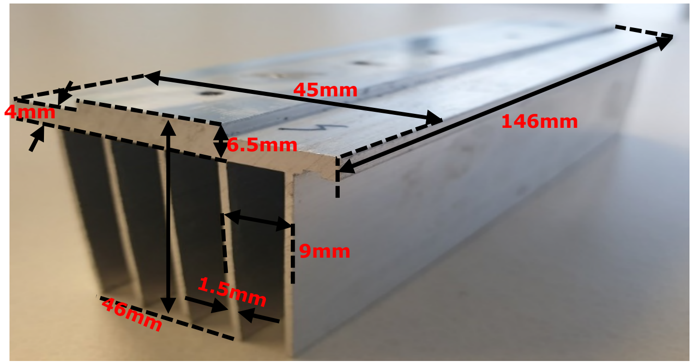
› Temperature measurement

- T_C = Case Temp. (Low-side U phase IGBT)
- T_A = Ambient Temp.
- T_{SCP} = Screw Temp of "P" area
- T_{SCN} = Screw Temp of "N" area
- $\Delta T_{C-A} = T_C - T_A$



[Cooling condition – Idle condition]





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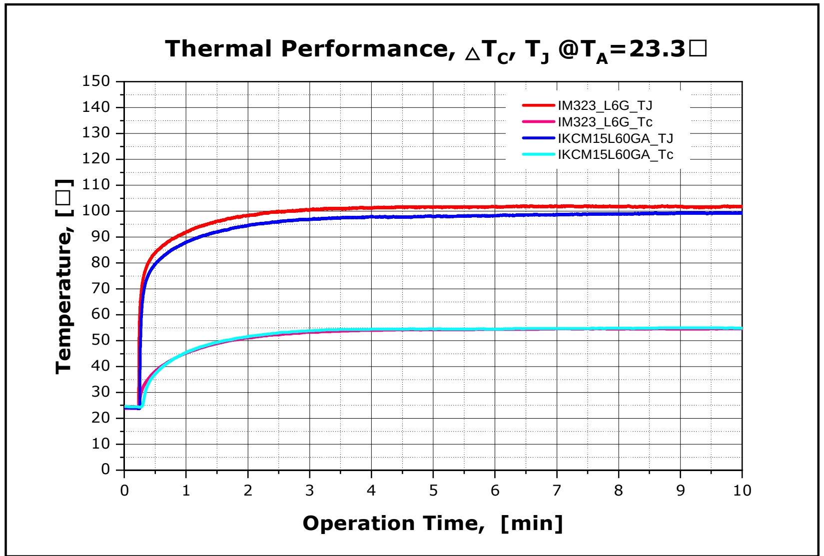
Test results – RAC condition (IM323-L6G vs. IKCM15L60GA)

DUT	I_O	T_A [ºC]	T_C [ºC]	T_{SCP} [ºC]	$T_{J(AVG)}$ [ºC]	ΔT_{CA} [ºC]	ΔT_{SCP-A} [ºC]	$\Delta T_{J(AVG)-A}$ [ºC]	Remark
IM323-L6G	10 Apeak (7.0 Arms)	23.3	54.7	46.6	102.2	31.4	23.3	78.9	
IKCM15L60GA		23.3	55.0	48.0	99.5	31.7	24.7	76.2	



Test conditions

- Condition : V_{DC} = 340 V, V_{DD} =15 V, F_{SW} = 5 kHz, F_O = 60 Hz, MI = 0.6, PF=0.8, SVPWM, T_{dead} = 1 µs, 3-Phase R-L Load
- Cooling condition: Force cooling by fan (voltage = 10 V, $R_{th(ca)}$ = 0.62 K/W)
- Output current : I_O = 10 Apeak (7.07 Arms)

Test results

- Case temperature (ΔT_{CA}) is almost same (54.7°C vs. 55.0°C = -0.3°C)
- Junction temperature ($\Delta T_{J(AVG)}$) is a little higher (102.2°C vs. 99.5°C = +2.7°C)

Expected response from market

- **IM323 is showing same performance with Mini FP**
- **If customer used Mini FP(IKCM15L60GA) in RAC, customer can be used in same platform.**

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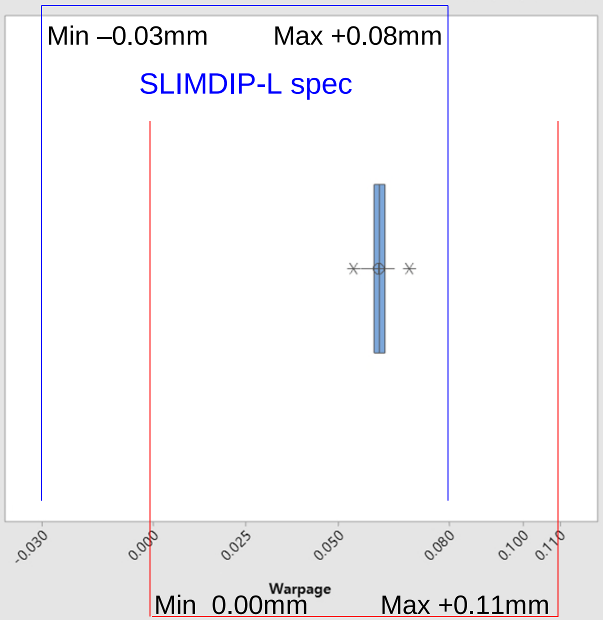
1. Warpage (or Flatness)

Boxplot of Warpage
Summary Report

[unit : mm]

Distribution of Data
Locate the center (mean and median). Assess the variability and identify any outliers.



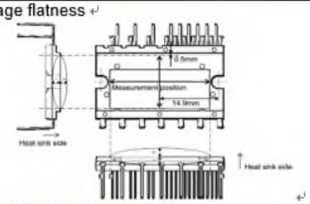
IM323-L6G spec (target spec)

Descriptive Statistics

N	29
Mean	0.060931
Standard deviation	0.0033693
Minimum	0.054
5th percentile	0.055
25th percentile	0.0595
Median	0.061
75th percentile	0.0625
95th percentile	0.069
Maximum	0.069
Range	0.015

Min : 54 µm
Max : 69 µm

Sample :
PG-MDIP-26-1
2S118000400

RS-39b	Prio 1	Terminal bending strength (internal margin) Need real data of competitor's	Comparable with SLIMDIP
RS-40	Prio 1	Package flatness  Need real data of competitor's	Min -30µm ~ Max +80µm (Or Min 0µm ~ Max 110µm)
RS-41	Must	x, lead length option (Standard,	10.8 mm (standard version)

11.2 Backside Curvature Measurement Point

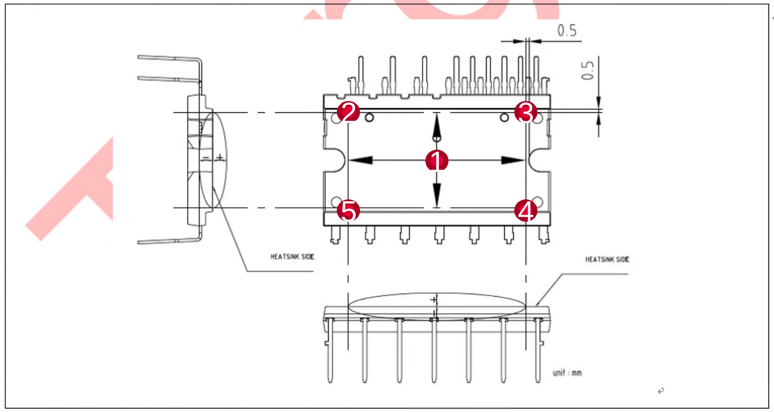


Figure 7 Backside curvature measurement position

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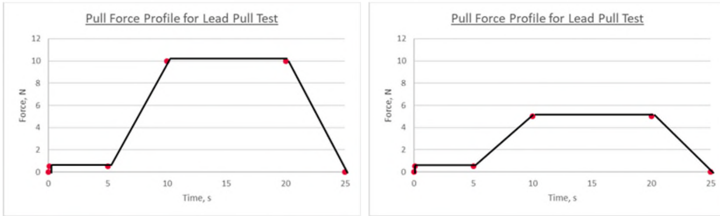
2.1 Package data – Pulling and bending test condition and standard

Package	Lead	Lead Nominal Dimension	Lead Nominal Cross section Area	Lead Pull Force / N	Lead Bend Load / g
				Hold for 10 s	Bend 2x cycle
Slimdip	PL	0.40 x 0.60	0.24	10 N	*2 5N
	SL	0.40 x 0.45	0.18	5 N	*1 2.5 N
Tiny 3.0	PL	0.40 x 0.60	0.26	10 N	*2 5N
	SL	0.40 x 0.45	0.18	5 N	*1 2.5 N
MiniFP	PL	0.60 x 0.50	0.30	10 N	*2 5N
	SL	0.60 x 0.50	0.32	10 N	*2 5N

Lead Pull Force Profile



Note:

- Test parameter is according to EIAJ ED-4701/400 standards
- After lead pull test or lead bend test, samples is inspected between 10x -20x magnification for any evidence of breakage, loosening, or relative motion between lead and package.

*1 250g of load is used.

*2 500g of load is used.

Datasheet spec

Terminal pulling strength	Control terminal: Load 5N Power terminal: Load 10N	JEITA-ED-4701	10	-	-	s
Terminal bending strength	Control terminal: Load 2.5N Power terminal: Load 5N 90deg. bend	JEITA-ED-4701	2	-	-	times

Recommendations from EIAJ ED-4701/400 standards

TABLE 2 METHOD I PULL TEST CONDITIONS

Nominal cross-sectional area (S) mm^2	Nominal lead wire diameter (d) (In the case of circular cross section) mm	Pull force N
$0.03 < S \leq 0.05$	$0.2 < d \leq 0.25$	1
$0.05 < S \leq 0.07$	$0.25 < d \leq 0.3$	2.5
$0.07 < S \leq 0.2$	$0.3 < d \leq 0.5$	5
$0.2 < S \leq 0.5$	$0.5 < d \leq 0.8$	10
$0.5 < S \leq 1.2$	$0.8 < d \leq 1.25$	20
$1.2 < S$	$1.25 < d$	40

TABLE 5 METHOD III BENDING TEST LOAD

Nominal cross-sectional area (S) mm^2	Nominal lead wire diameter (d) (In the case of circular cross section) mm	Load N
$0.03 < S \leq 0.05$	$0.2 < d \leq 0.25$	0.5
$0.05 < S \leq 0.07$	$0.25 < d \leq 0.3$	1.25
$0.07 < S \leq 0.2$	$0.3 < d \leq 0.5$	2.5
$0.2 < S \leq 0.5$	$0.5 < d \leq 0.8$	5
$0.5 < S \leq 1.2$	$0.8 < d \leq 1.25$	10
$1.2 < S$	$1.25 < d$	20

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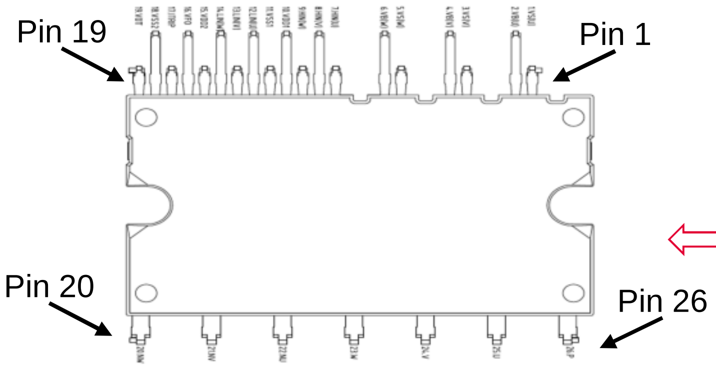
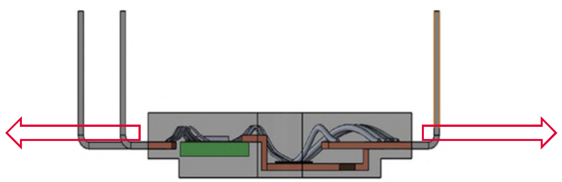
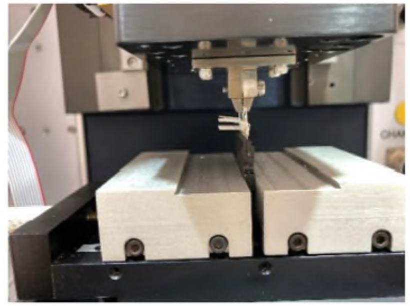
2.2 Package data – Pulling test (Horizontal)



[Pulling direction]



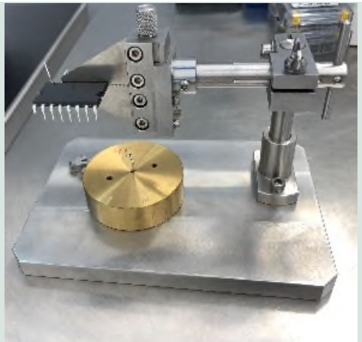
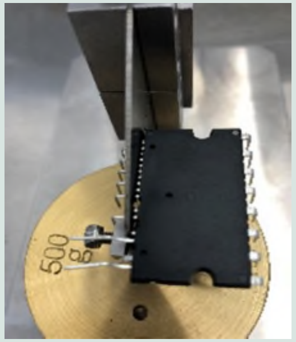
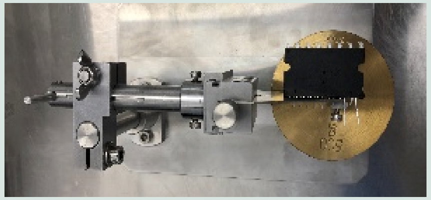
Lead Pull Test / Horizontal



PKG	Datasheet spec	Test result (Standard)	Measurement data, Min (N) (until pull out and lead cut)				Remark (Test method)
			Control terminal		Power terminal		
			Pin1	Pin 19	Pin 20	Pin 26	
IM323_L6G (Thickness : 0.38 T)	Control terminal : Load 5N Power terminal : Load 10N	Passed (11/11pcs)	56.8		73.5		JEITA-ED-7401
M – Company (Thickness : 0.38 T)	Control terminal : Load 5N Power terminal : Load 10N	Passed (11/11pcs)	59.5		74.5		JEITA-ED-7401
Mini FP (Thickness : 0.5 T)	No data	Passed (11/11pcs)	90.7		92.1		JEITA-ED-7401

3. Package data – Lead bend test

› Test method

1. Clamp the specimen at the terminal end so that the lead wire terminal become vertical	2. Hang the load at the extremity of the terminal	3. Rotate the clamp assembly by 90deg.	4. Rotate the clamp assembly back to original state. Repeat step 3 & step 4, total is 2x cycle
			

› Bending test result

PKG	Datasheet spec	Limit	Test result	Remark
Tiny3.0	Control terminal : Load 2.5N, 90deg.bending Power terminal : Load 5N, 90deg.bending	Min : 2times	Passed (11/11pcs)	JEITA-ED-7401
M – Company	Control terminal : Load 2.5N, 90deg.bending Power terminal : Load 5N, 90deg.bending	Min : 2times	Passed (11/11pcs)	JEITA-ED-7401
Mini FP	No data	Min : 2times	Passed (11/11pcs)	JEITA-ED-7401

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4. Package data – Torque test

PKG	Datasheet spec	Measurement data (until PKG broken and chipping)					Remark
		w/o shim					
		0.78Nm	1.0Nm	1.1Nm	1.2Nm	1.3Nm	
Tiny3.0	Max: 0.78Nm	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	All pass
M – Company	Max: 0.78Nm	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	

PKG	Datasheet spec	Measurement data (until PKG broken and chipping)					Remark
		With shim (thickness : 100um, width 2.0 / 12.7 mm)					
		0.78Nm	1.0Nm	1.1Nm	1.2Nm	1.3Nm	
Tiny3.0	Max: 0.78Nm	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	All pass
M – Company	Max: 0.78Nm	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	

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