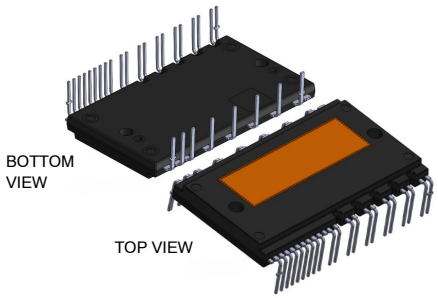
Intelligent Power Module (IPM)

Inverter, 1200 V, 15 A

NFAM1512L7B



CASE MODGX
DIP39, 54.5x31.0 EP−2

General description

NFAM1512L7B is an advanced IPM module providing a fully−featured, high−performance inverter output stage for AC Induction, BLDC and PMSM motors. These modules integrate optimized gate drive of the built−in IGBTs to minimize EMI and losses, while also providing multiple on−module protection features including under−voltage lockouts, over−current shutdown, thermal monitoring of drive IC, and fault reporting. The built−in, high−speed HVIC requires only a single supply voltage and translates the incoming logic−level gate inputs to the high−voltage, high−current drive signals required to properly drive the module's internal IGBTs. Separate negative IGBT terminals are available for each phase to support the widest variety of control algorithms.

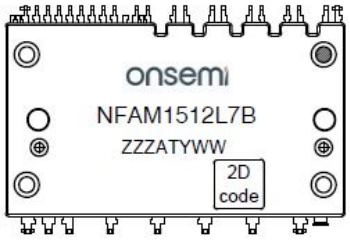
Features

- 1200 V 15 A 3−Phase FS7 IGBT Inverter, Including Control ICs for Gate Drive and Protections
- Very Low Thermal Resistance Using Al2O3 DBC Substrate
- Active Logic Interface
- Built−in Under−voltage Protection (UVP)
- Built−In Bootstrap Diodes/Resistors
- Separate Low−side IGBT Emitter Connections for Individual Current Sensing of Each Phase
- Temperature Sensor (TSU Output by LVIC)
- UL Certification: E209204
- This is a Pb−Free Device

Typical Application

- Industrial Drives
- Industrial Pumps
- Industrial Fans
- Industrial Automation

MARKING DIAGRAM



NFAM1512L7B = Specific Device Code
ZZZ = Assembly Lot Code
A = Assembly Location
T = Test Location
Y = Year
WW = Work Week

ORDERING INFORMATION

Device	Package	Shipping
NFAM1512L7B	DIP39, 31.0x54.5 (Pb−Free)	90 / BOX

PIN CONFIGURATION

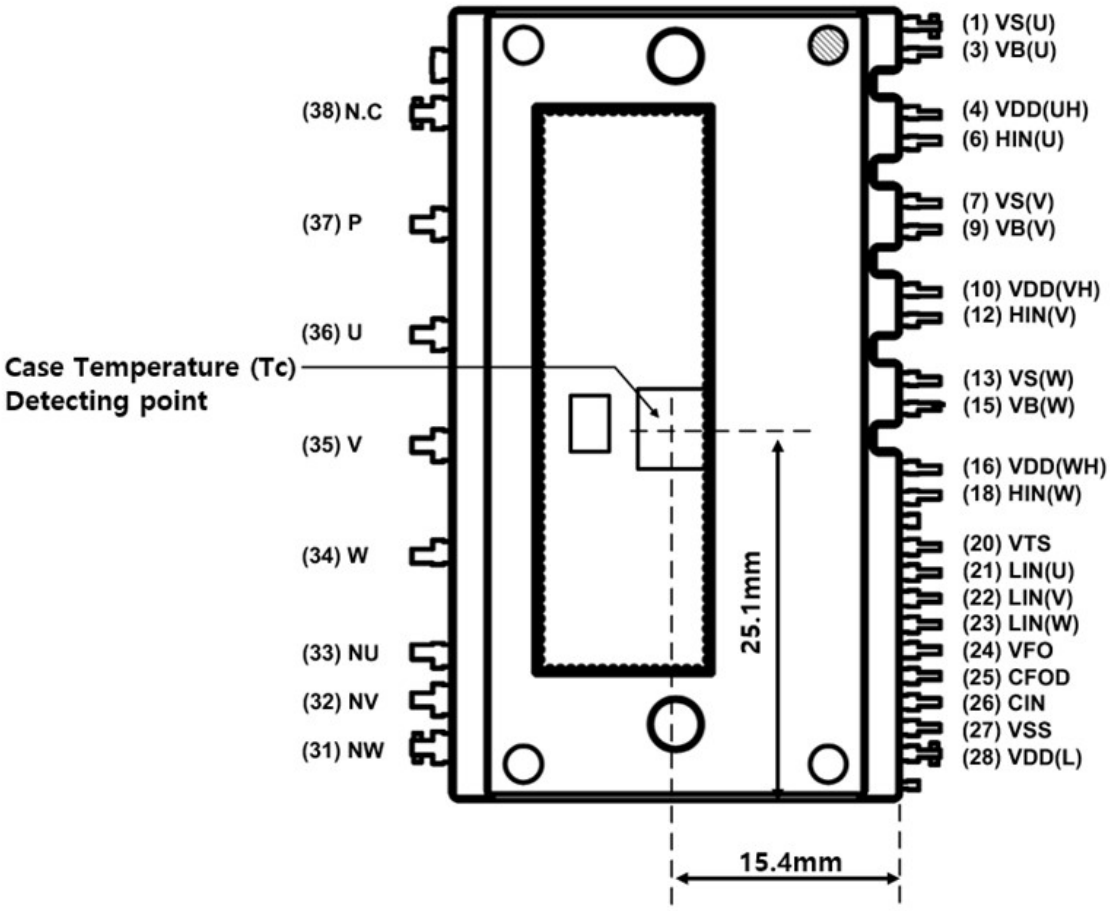


Figure 1. Pin Configuration – Top View

PIN DESCRIPTION

Pin	Name	Description
1	VS(U)	High−Side Bias Voltage Ground for U−Phase IGBT Driving
(2)	−	Dummy
3	VB(U)	High−Side Bias Voltage for U−Phase IGBT Driving
4	VDD(UH)	High−Side Bias Voltage for U−Phase IC
(5)	−	Dummy
6	HIN(U)	Signal Input for High−Side U−Phase
7	VS(V)	High−Side Bias Voltage Ground for V−Phase IGBT Driving
(8)	−	Dummy
9	VB(V)	High−Side Bias Voltage for V−Phase IGBT Driving
10	VDD(VH)	High−Side Bias Voltage for V−Phase IC
(11)	−	Dummy
12	HIN(V)	Signal Input for High−Side V−Phase
13	VS(W)	High−Side Bias Voltage Ground for W−Phase IGBT Driving
(14)	−	Dummy
15	VB(W)	High−Side Bias Voltage for W−Phase IGBT Driving
16	VDD(WH)	High−Side Bias Voltage for W−Phase IC
(17)	−	Dummy
18	HIN(W)	Signal Input for High−Side W−Phase
(19)	−	Dummy
20	VTS	Output for LVIC Temperature Sensing Voltage
21	LIN(U)	Signal Input for Low−Side U−Phase
22	LIN(V)	Signal Input for Low−Side V−Phase
23	LIN(W)	Signal Input for Low−Side W−Phase
24	VFO	Fault Output
25	CFOD	Capacitor for Fault Output Duration Selection
26	CIN	Input for Over Current Protection
27	VSS	Low−Side Common Supply Ground
28	VDD(L)	Low−Side Bias Voltage for IC and IGBTs Driving
(29)	−	Dummy
(30)	−	Dummy
31	NW	Negative DC−Link Input for W−Phase
32	NV	Negative DC−Link Input for V−Phase
33	NU	Negative DC−Link Input for U−Phase
34	W	Output for W−Phase
35	V	Output for V−Phase
36	U	Output for U−Phase
37	P	Positive DC−Link Input
38	N.C	No Connection
(39)	−	Dummy

NOTE: Pins of () are the dummy for internal connection. These pins should be no connection.

Internal equivalent circuit and input/output pins

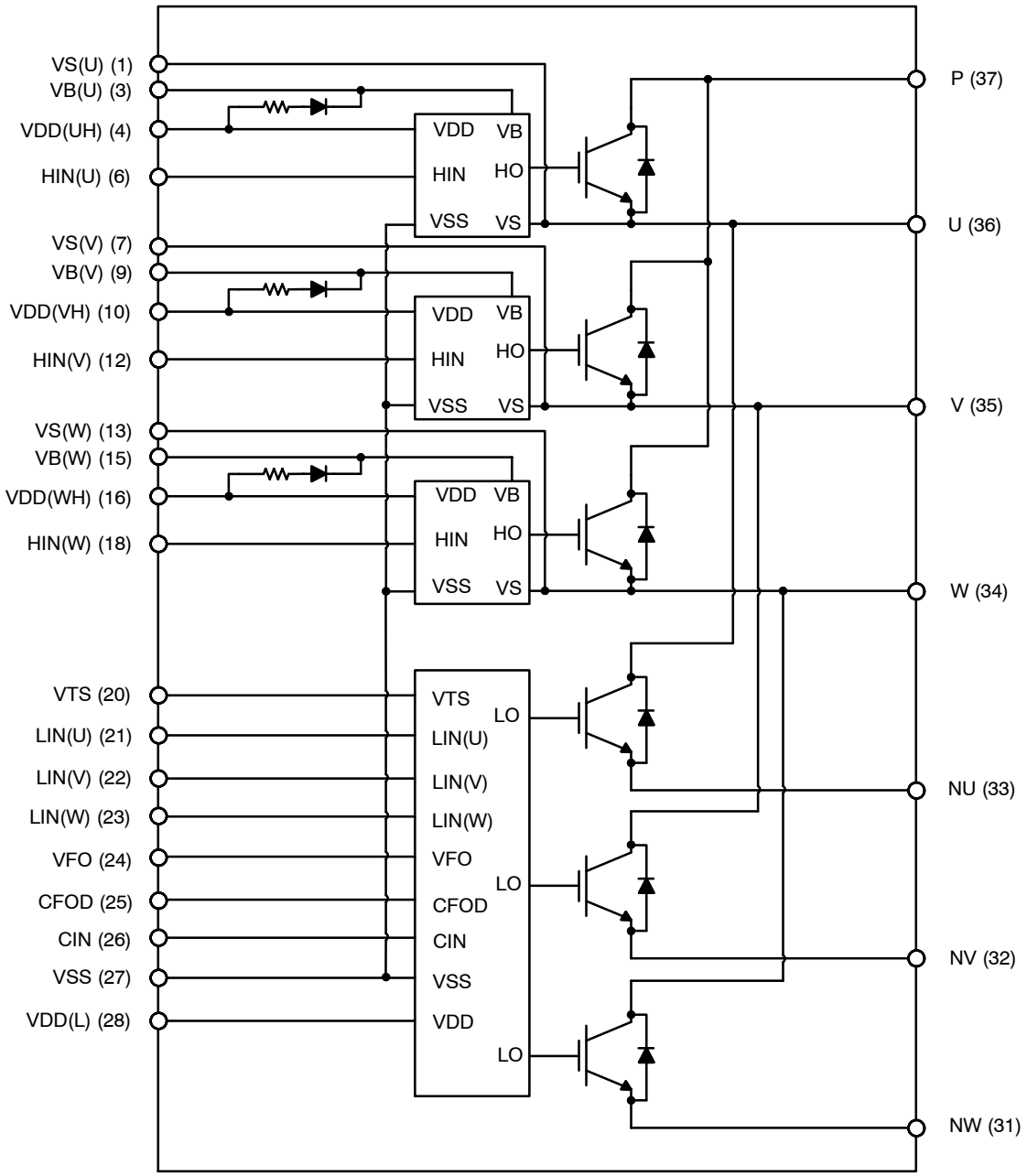


Figure 2. Internal Block Diagram

ABSOLUTE MAXIMUM RATINGS (VDD = 15 V and T_j = 25°C, Unless Otherwise Specified)

Symbol	Rating	Conditions	Value	Unit
INVERTER PART				
VPN	Supply Voltage	Applied between P – NU, NV, NW	900	V
VPN(Surge)	Supply Voltage (Surge)	Applied between P – NU, NV, NW (Note 1)	1000	V
Vces	Collector – Emitter Voltage		1200	V
VRRM	Maximum Repetitive Revers Voltage		1200	V
±Ic	Each IGBT Collector Current		15	A
±Icp	Each IGBT Collector Current (Peak)	Tc = 25°C, Tj ≤ 150°C, under 1 ms Pulse Width	30	A
Pc	Corrector Dissipation	Tc = 25°C per one chip (Note 2)	109	W
Tj	Operating Junction Temperature		–40 ~ 150	°C
CONTROL PART				
VDD	Control Supply Voltage	Applied between VDD(H), VDD(L) – VSS	20	V
VBS	High–Side Control Bias Voltage	Applied between VB(U) – VS(U), VB(V) – VS(V), VB(W) – VS(W)	20	V
VIN	Input Signal Voltage	Applied between HIN(U), HIN(V), HIN(W), LIN(U), LIN(V), LIN(W) – VSS	–0.3 ~ VDD + 0.3	V
VFO	Fault Output Supply Voltage	Applied between VFO – VSS	–0.3 ~ VDD + 0.3	V
IFO	Fault Output Current	Sink Current at VFO pin	2	mA
VCIN	Current Sensing Input Voltage	Applied between CIN – VSS	–0.3 ~ VDD + 0.3	V
TOTAL SYSTEM				
VPN(PROT)	Self–Protection Supply Voltage Limit (Short Circuit Protection Capability)	VDD = VBS = 13.5 ~ 16.5 V, Tj = 150°C, Non–repetitive, <2 μs	800	V
Tc	Case Operation Temperature	*See Figure 1*	–40 ~ 125	°C
Tstg	Storage Temperature		–40 ~ 125	°C
Viso	Isolation Voltage	60 Hz, Sinusoidal, AC 1 minute, Connection Pins to Heat Sink Plate	2500	V_{rms}

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Surge voltage developed by the switching operation due to the wiring inductance between P and NU, NV, NW terminal.
2. Calculation value considered to design factor.

THERMAL CHARACTERISTICS

Symbol	Rating	Conditions	Min	Typ	Max	Unit
Rth(j–c)Q	Junction to Case Thermal Resistance (Note 3)	Inverter IGBT Part (per 1/6 Module)	–	–	1.15	°C/W
Rth(j–c)F		Inverter FWDi Part (per 1/6 Module)	–	–	1.80	°C/W

3. For the measurement point of case temperature (Tc), please refer to *Figure 1*.

ELECTRICAL CHARACTERISTICS (VDD = 15 V and T_j = 25°C, Unless Otherwise Specified)

Symbol		Parameter	Test Conditions		Min	Typ	Max	Unit
INVERTER PART								
Ices		Collector−Emitter Leakage Current	Tj = 25°C, Vce = Vces		–	–	1	mA
			Tj = 150°C, Vce = Vces		–	–	10	mA
VCE(sat)		Collector−Emitter Saturation Voltage	VDD = VBS = 15 V, Ic = 10 A, Tj = 25°C		–	1.50	1.90	V
			VDD = VBS = 15 V, Ic = 10 A, Tj = 150°C		–	1.75	–	V
VF		FWDi Forward Voltage	VIN = 0 V, IF = 10 A, Tj = 25°C		–	1.70	2.10	V
			VIN = 0 V, IF = 10 A, Tj = 150°C		–	1.65	–	V
HS	ton	High Side Switching Times	VPN = 600 V, VDD = 15 V, Ic = 10 A, Tj = 25°C, Inductive Load Switching *See Figures 3, 23, 24* (Note 4)		1.00	1.30	1.90	μs
	tc (on)				–	0.15	0.55	μs
	toff				–	1.50	2.00	μs
	tc (off)				–	0.27	0.30	μs
	trr				–	0.26	–	μs
LS	ton	Low Side Switching Times			1.00	1.45	1.90	μs
	tc (on)				–	0.17	0.55	μs
	toff				–	1.65	2.00	μs
	tc (off)				–	0.24	0.30	μs
	trr				–	0.25	–	μs
CONTROL PART								
IQDDH		Quiescent VDD Supply Current	VDD(UH,VH,WH) = 15 V, HIN(U,V,W) = 0 V	VDD(UH) − VSS VDD(VH) − VSS VDD(WH) − VSS	–	–	0.30	mA
IQDDL			VDD(L) = 15 V, LIN(U, V, W) = 0 V	VDD(L) − VSS	–	–	2.00	mA
IPDDH		Operating VDD Supply Current	VDD(UH, VH, WH) = 15 V, f_{PWM} = 20 kHz, Duty = 50%, applied to one PWM Signal Input for High−Side	VDD(UH) − VSS VDD(VH) − VSS VDD(WH) − VSS	–	–	0.40	mA
IPDDL			VDD(L) = 15 V, f_{PWM} = 20 kHz, Duty = 50%, applied to one PWM Signal Input for Low−Side	VDD(L) − VSS	–	–	5.00	mA
IQBS		Quiescent VBS Supply Current	VBS(U, V, W) = 15 V HIN(U, V, W) = 0 V	VB(U) − VS(U) VB(V) − VS(V) VB(W) − VS(W)	–	–	0.30	mA
IPBS		Operating VBS Supply Current	VDD(UH, VH, WH) = VBS = 15 V, f_{PWM} = 20 kHz, Duty = 50%, Applied to one PWM Signal Input for High−Side	VB(U) − VS(U) VB(V) − VS(V) VB(W) − VS(W)	–	–	3.50	mA
VIN(ON)		ON Threshold Voltage	HIN(U, V, W) − VSS, LIN(U, V, W) − VSS		–	–	2.60	V
VIN(OF)		OFF Threshold Voltage			0.80	–	–	V
VCIN(ref)		Over Current Trip Level	VDD = 15 V	CIN−VSS	0.46	0.48	0.50	V
UVDDD		Supply Circuit Under−Voltage Protection	Detection Level		10.30	–	12.50	V
UVDDR			Reset Level		10.80	–	13.00	V
UVBSD			Detection Level		10.00	–	12.00	V
UVBSR			Reset Level		10.50	–	12.50	V
VTS		Voltage Output for LVIC Temperature Sensing Unit	VTS−VSS = 5.1 kΩ, Temp. = 25°C (Note 5)		1.12	1.25	1.38	V

ELECTRICAL CHARACTERISTICS (VDD = 15 V and T_j = 25°C, Unless Otherwise Specified) (continued)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
CONTROL PART						
VFOH	Fault Output Voltage	VDD(L) = 0 V, CIN = 0 V, VFO Circuit: 10 kΩ to 5 V Pull−up	4.90	−	−	V
VFOL		VDD(L) = 0 V, CIN = 1 V, VFO Circuit: 10 kΩ to 5 V Pull−up	−	−	0.95	V
tFOD	Fault−Output Pulse Width	CFOD = 22 nF (Note 6)	1.60	2.40	−	ms
BOOTSTRAP PART						
VF	Bootstrap Diode Forward Current	If = 0.1 A (See Figure 6)	2.10	2.50	2.90	V
RBOOT	Built−in Limiting Resistance		12.50	15.50	18.50	Ω

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

Performance guaranteed over the indicated operating temperature range by design and/or characterization tested at Tj = Ta = 25°C. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible. Values based on design and/or characterization.

4. ton and toff include the propagation delay of the internal drive IC. tc(on) and tc(off) are the switching times of IGBT under the given gate−driving condition internally. For the detailed information, please see *Figure 3*.
5. TLVIC is the temperature of LVIC itself. VTS is only for sensing temperature of LVIC and cannot shutdown IGBTs automatically. The relationship between VTS voltage output and LVIC temperature is described in *Figure 4*. It is recommended to add 5.1 kΩ pull down resistor between VTS and VSS (Signal Ground) as described in *Figure 5* for linear output characteristics at low temperature. Refer to the application note for usage of VTS.
6. The fault−out pulse width tFOD depends on the capacitance value of CFOD according to the following approximate equation: $tFOD = 0.11 \times 10^6 \times CFOD$ [s].

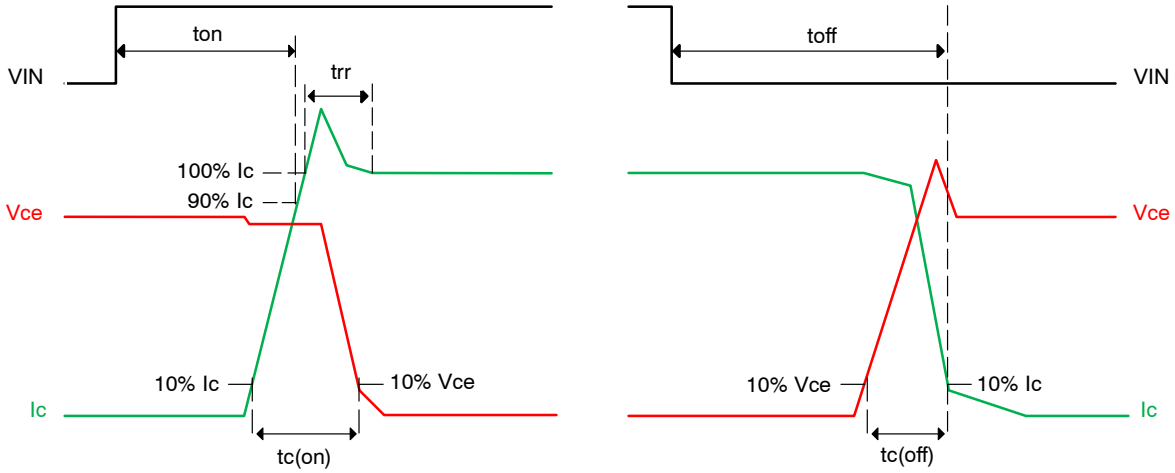


Figure 3. Switching Time Definitions

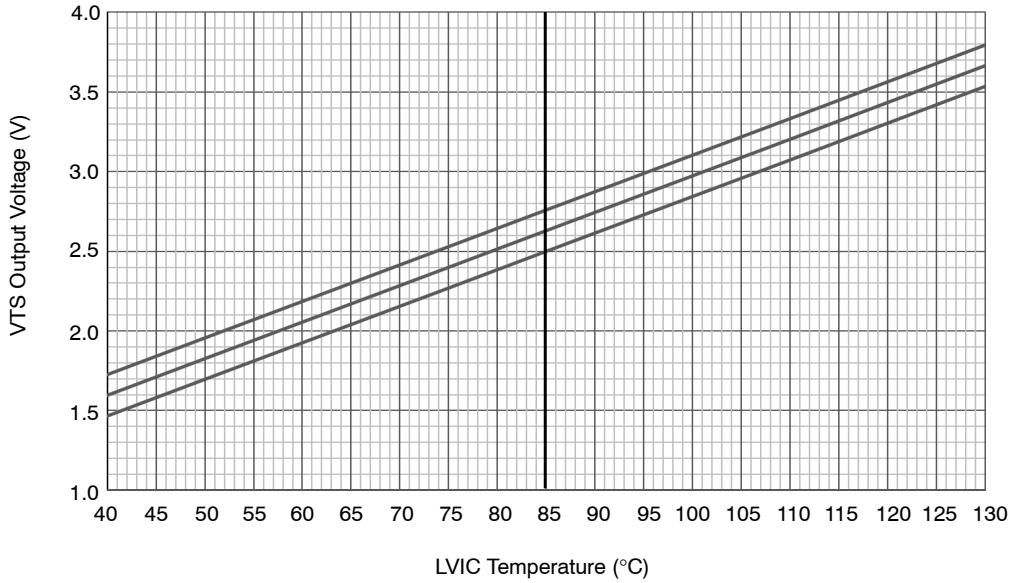


Figure 4. Temperature of LVIC vs. VTS Characteristics

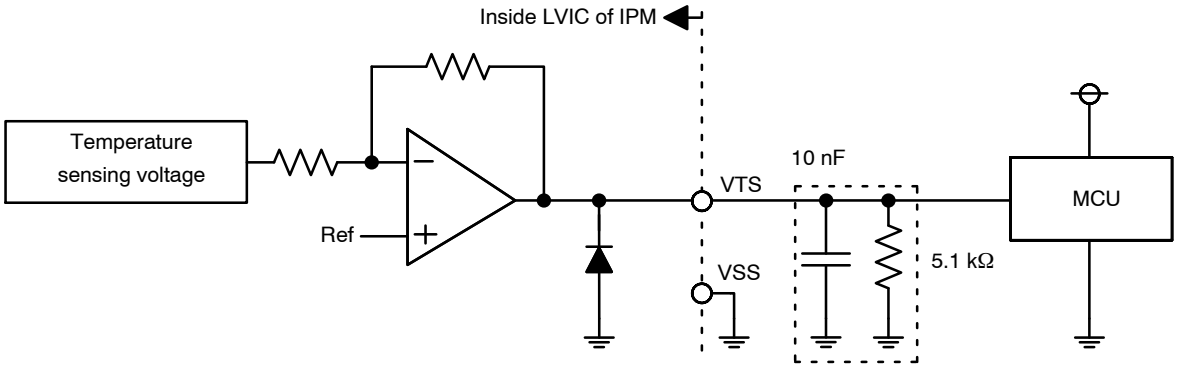


Figure 5. Internal Block Diagram and Interface Circuit of VTS

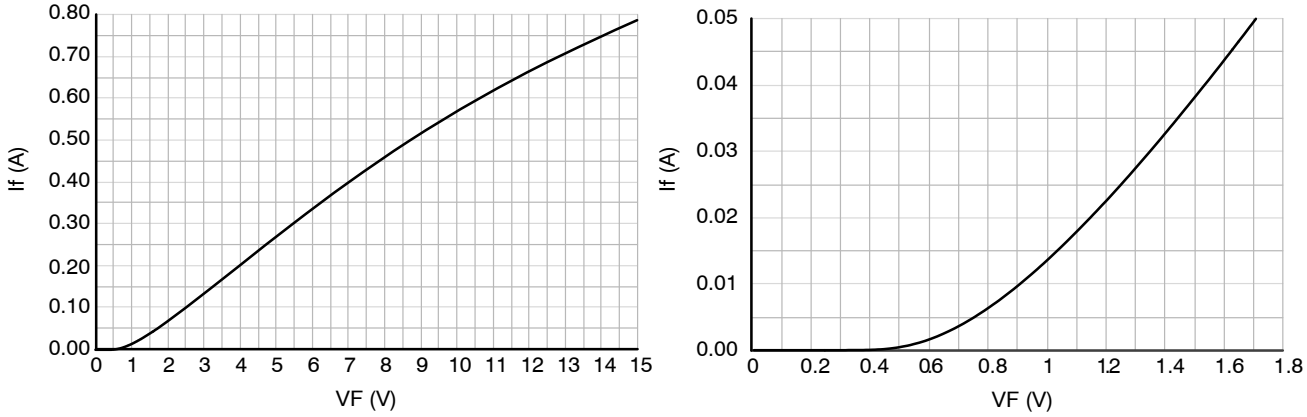


Figure 6. Characteristics of Bootstrap Diode/Resistor (Right Figure is Enlarged Figure)

RECOMMENDED OPERATING CONDITIONS

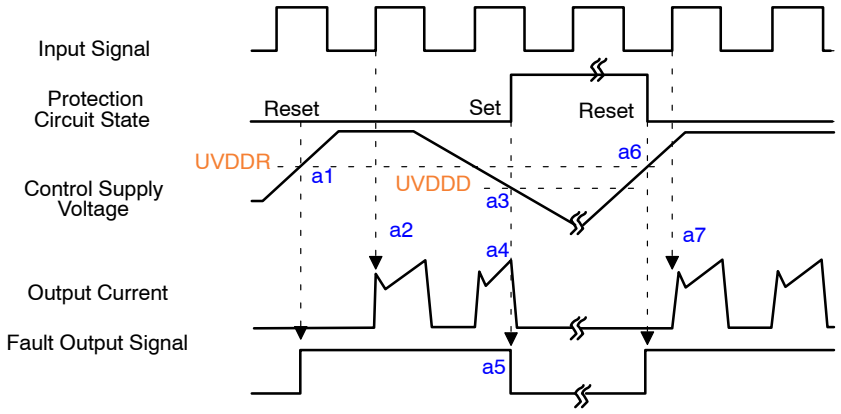
Symbol	Description	Conditions		Value Min	Value Typ	Value Max	Unit
VPN	Supply Voltage	Applied between P – NU, NV, NW		–	600	800	V
VDD	Control Supply Voltage	Applied between VDD(H) – VSS, VDD(L) – VSS		13.5	15	16.5	V
VBS	High–Side Bias Voltage	Applied between VB(U) – VS(U), VB(V) – VS(V), VB(W) – VS(W)		13.0	15	18.5	V
dVDD / dt, dVBS / dt	Control Supply Variation			–1	–	1	V/μs
Tdead	Blanking Time for Preventing Arm – Short	For Each Input Signal		1	–	–	μs
fPWM	PWM Input Signal	–40°C ≤ Tc ≤ 125°C, –40°C ≤ Tj ≤ 150°C		1	–	20	kHz
Io	Allowable r.m.s. Current	VPN = 600 V, VDD = VBS = 15 V, P.F. = 0.8, Tc ≤ 125°C, Tj ≤ 150°C (Note 7)	fPWM = 5 kHz	–	–	15.3	Arms
			fPWM = 15 kHz	–	–	9.5	Arms
PWIN(ON)	Minimum Input Pulse Width	VDD = VBS = 15 V, Wiring Inductance between NU, V, W and DC Link N < 10 nH (Note 8)		1.0	–	–	μs
PWIN(OFF)				2.0	–	–	
Package Mounting Torque		M3 Type Screw		0.6	0.7	0.9	Nm

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

Flatness tolerance of the heatsink should be within –50 μm to +100 μm.

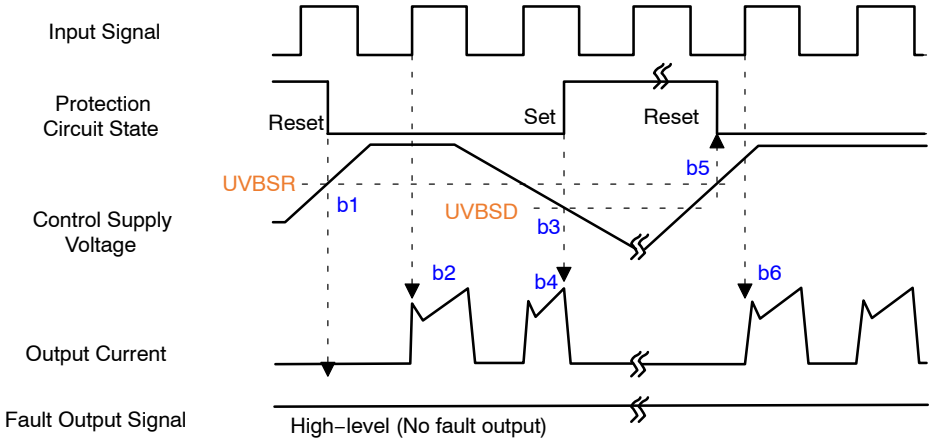
7. Allowable output current value is the reference data for the safe operation of this product. This may be different from the actual application and operating condition.
8. Product might not make response if input pulse width is less than the recommended value.

Time charts of protective function



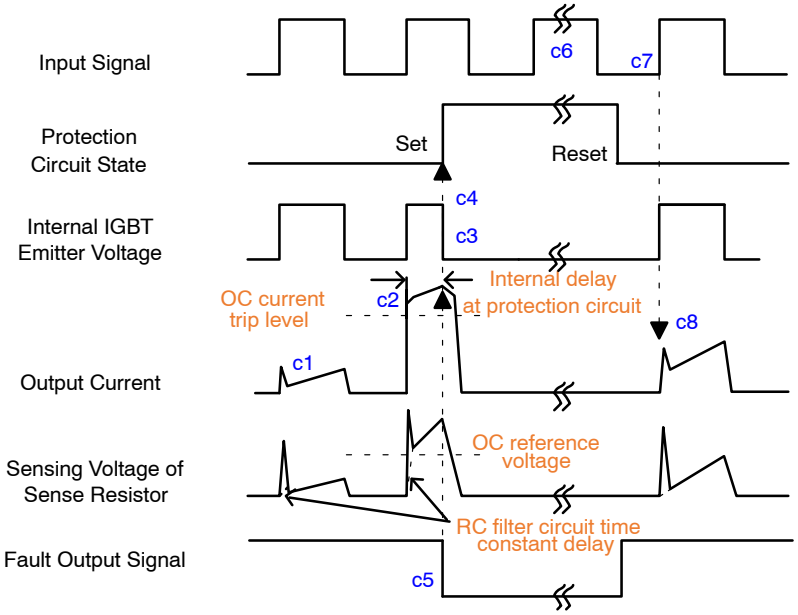
a1: Control supply voltage rises: After the voltage rises UVDDR, the circuits start to operate when next input is applied.
a2: Normal operation: IGBT ON and carrying current.
a3: Under voltage detection (UVDDD).
a4: IGBT OFF in spite of control input condition.
a5: Fault output operation starts with a fixed pulse width. a6 : Under voltage reset (UVDDR).
a7: Normal operation: IGBT ON and carrying current by triggering next signal from LOW to HIGH.

Figure 7. Under–Voltage Protection (Low–Side)



b1 : Control supply voltage rises: After the voltage reaches UVBSR, the circuits start to operate when next input is applied.
b2 : Normal operation: IGBT ON and carrying current.
b3 : Under voltage detection (UVBSD).
b4 : IGBT OFF in spite of control input condition, but there is no fault output signal.
b5 : Under voltage reset (UVBSR).
b6 : Normal operation: IGBT ON and carrying current by triggering next signal from LOW to HIGH.

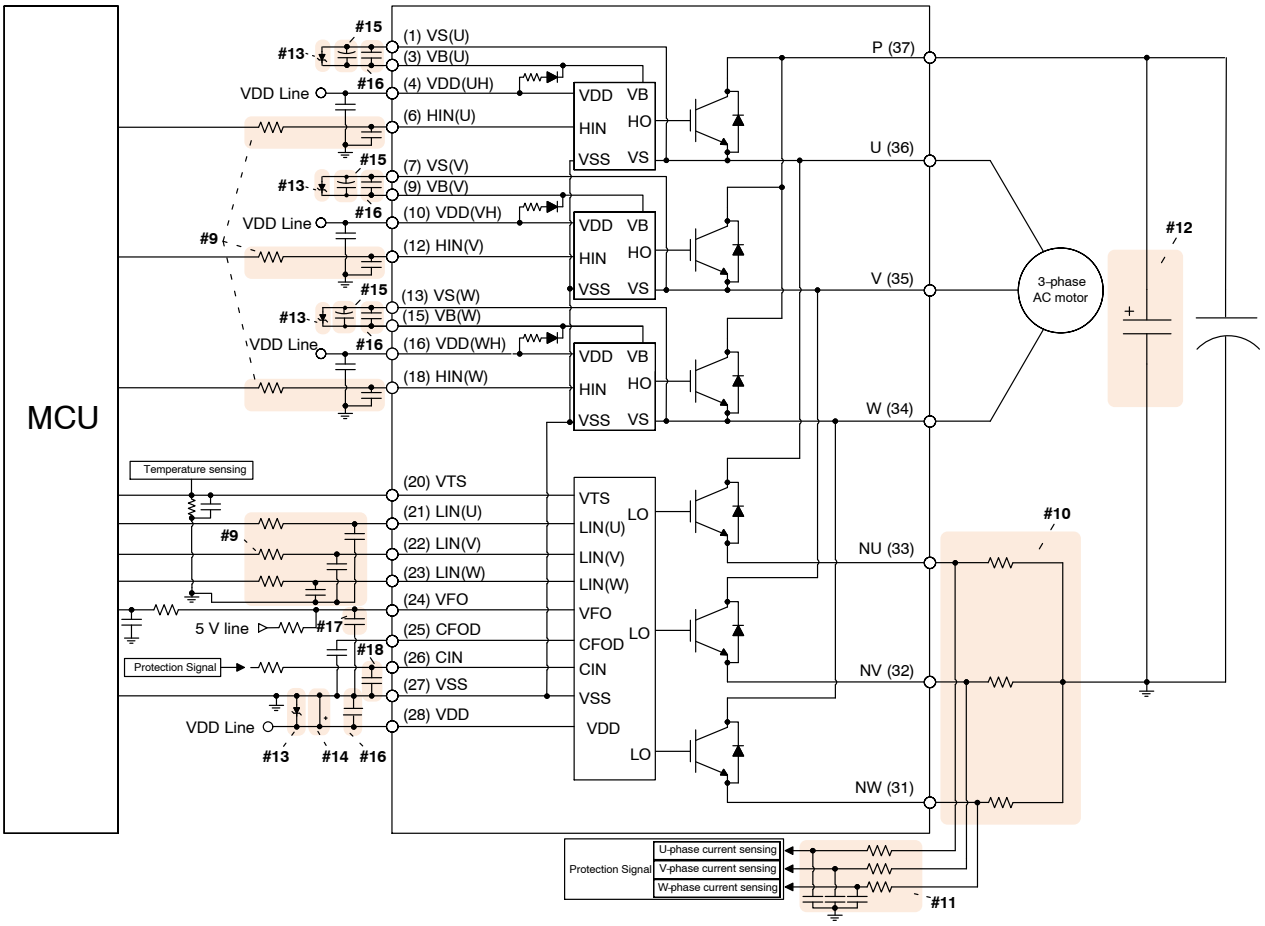
Figure 8. Under−Voltage Protection (High−Side)



(with the external sense resistance and RC filter connection)
c1 : Normal operation: IGBT ON and carrying current.
c2 : Over current detection (OC trigger).
c3 : All low−side IGBT's gate are hard interrupted.
c4 : All low−side IGBTs turn OFF.
c5 : Fault output operation starts with a fixed pulse width.
c6 : Input HIGH: IGBT ON state, but during the active period of fault output the IGBT doesn't turn ON.
c7 : Fault output operation finishes, but IGBT doesn't turn on until triggering next signal from LOW to HIGH.
c8 : Normal operation: IGBT ON and carrying current.

Figure 9. Over Current Protection (Low−Side Operation only)

Typical application circuit



To avoid malfunction, the wiring of each input should be as short as possible (less than 2−3 cm). Each capacitor should be mounted as close to the pins of the product as possible. VFO output is open−drain type. This signal line should be pulled up to the positive side of the MCU or control power supply with a resistor that makes IFO up to 1mA. Please refer to Figure 5.

9. Input signal is active−HIGH type. There is a 5 kΩ resistor inside the IC to pull−down each input signal line to GND. RC coupling circuits should be adopted for the prevention of input signal oscillation. RC time constant should be selected in the range 50 ~ 150 ns. (Recommended R = 100 Ω , C = 1 nF)
10. Each wiring pattern inductance should be minimized (Recommend less than 10 nH). Use the shunt resistor of surface mounted (SMD) type to reduce wiring inductance. To prevent malfunction, wiring should be connected to the terminal of the shunt resistor as close as possible.
11. In the short−circuit protection circuit, please select the RC time constant in the range 1.5 ~ 2 μs. Do enough evaluation on the real system because short−circuit protection time may vary wiring pattern layout and value of the RC time constant.
12. To prevent surge destruction, the wiring between the snubber capacitor and the P & GND pins should be as short as possible. The use of a high−frequency non−inductive capacitor of around 0.1 ~ 0.22 μF between the P & GND pins is recommended.
13. The zener diode or transient voltage suppressor should be adopted for the protection of ICs from the surge destruction between each pair of control supply terminals (Recommended zener diode is 22 V / 1 W, which has the lower zener impedance characteristic than about 15 Ω).
14. VDD electrolytic capacitor is recommended around 7 times larger than VBS electrolytic bootstrap capacitor.
15. Please choose the VBS electrolytic bootstrap capacitor with good temperature characteristic.
16. 0.1 ~ 0.2 μF R−category ceramic capacitors with good temperature and frequency characteristics is recommended.
17. Fault out pulse width can be adjusted by capacitor connected to the CFOD terminal.
18. To prevent protection function errors, CIN capacitor should be placed as close to CIN and VSS pins as possible.

Figure 10. Typical Application Circuit

Typical Characteristics

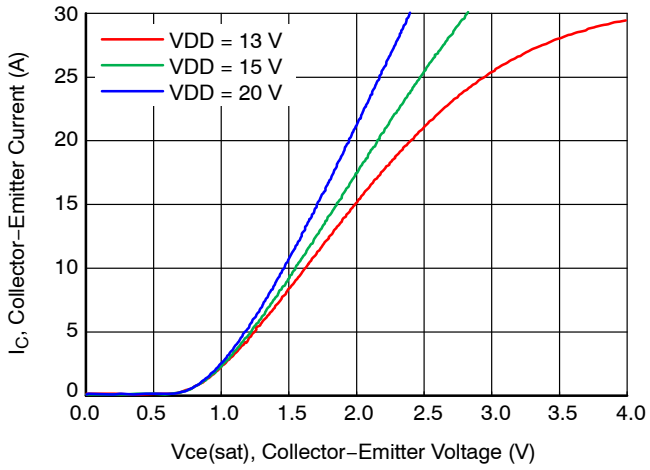


Figure 11. Typ. Collector−Emitter Saturation Voltage

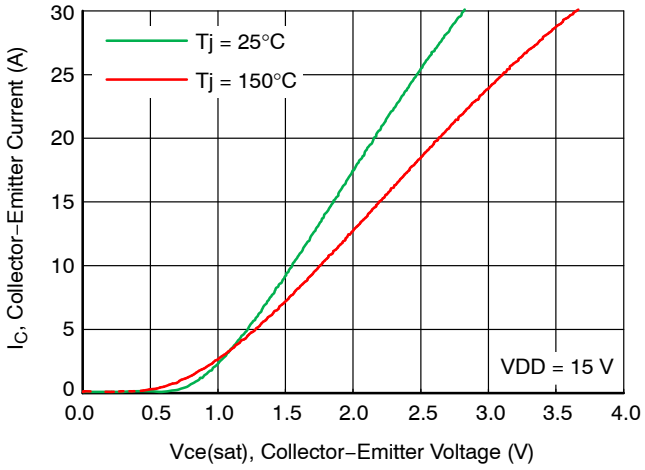


Figure 12. Typ. Collector−Emitter Saturation Voltage

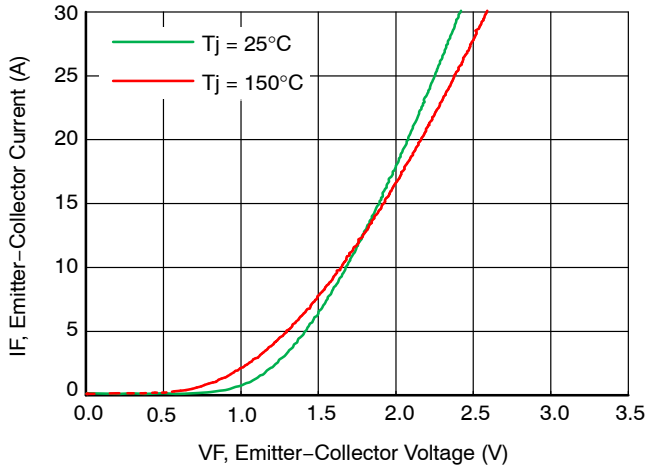


Figure 13. Typ. Emitter−Collector Forward Voltage

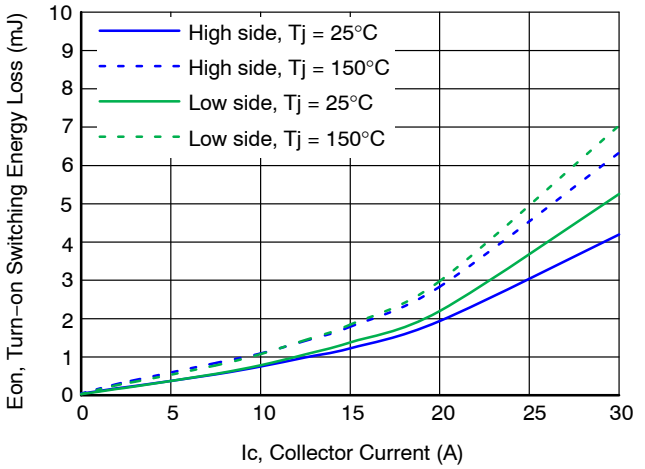


Figure 14. Typ. Turn−on Switching Energy Loss

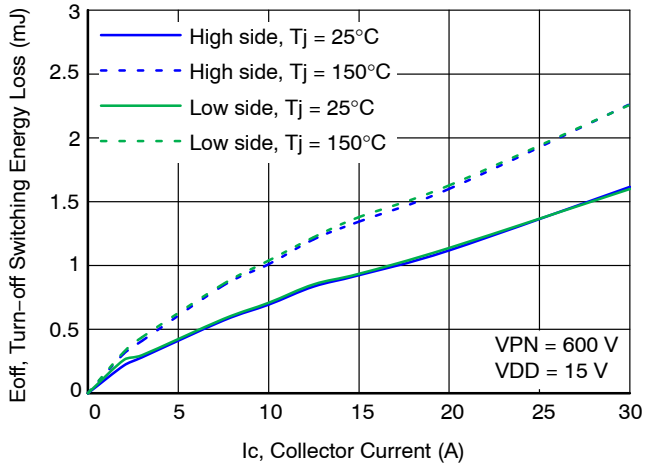


Figure 15. Typ. Turn−off Switching Energy Loss

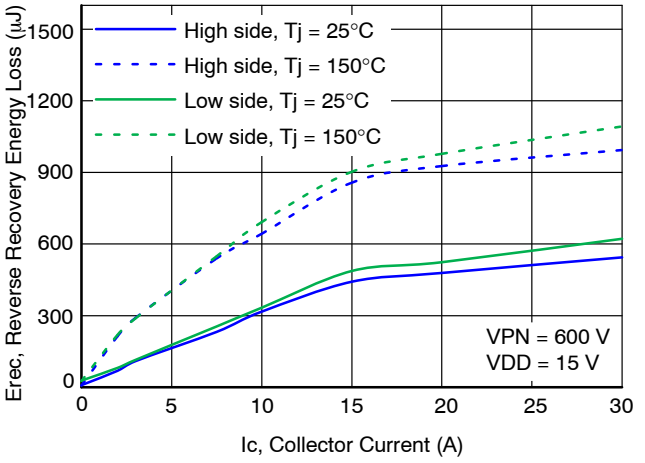


Figure 16. Typ. Reverse Recovery Energy Loss

Typical Characteristics (continued)

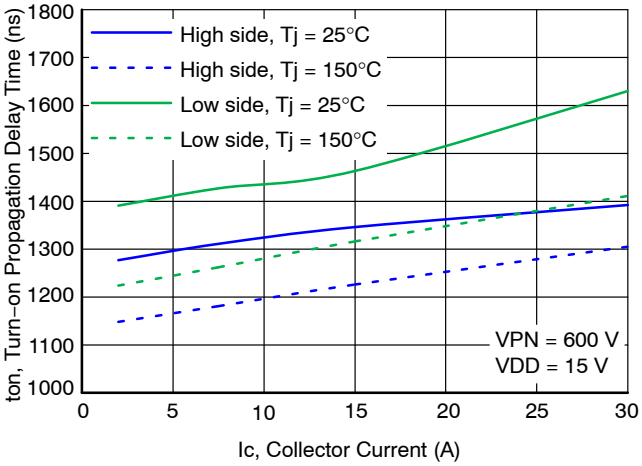


Figure 17. Typ. Turn−on Propagation Delay Time

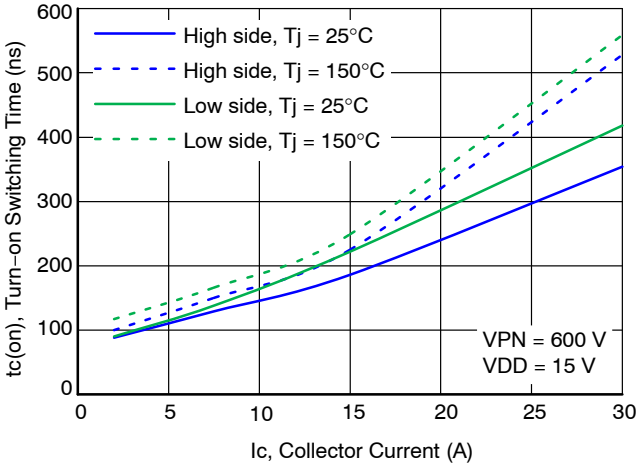


Figure 18. Typ. Turn−on Switching Time

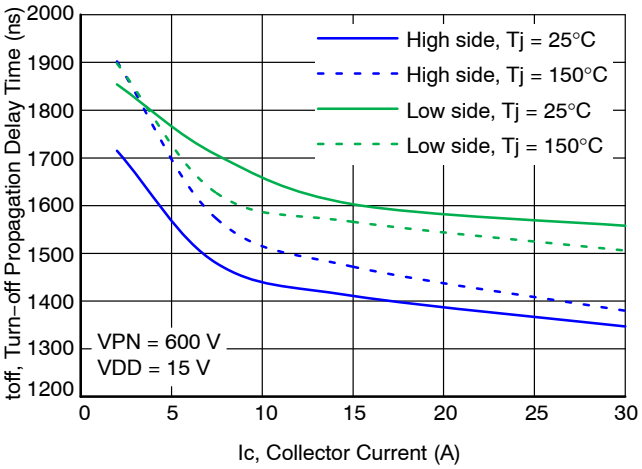


Figure 19. Typ. Turn−off Propagation Delay Time

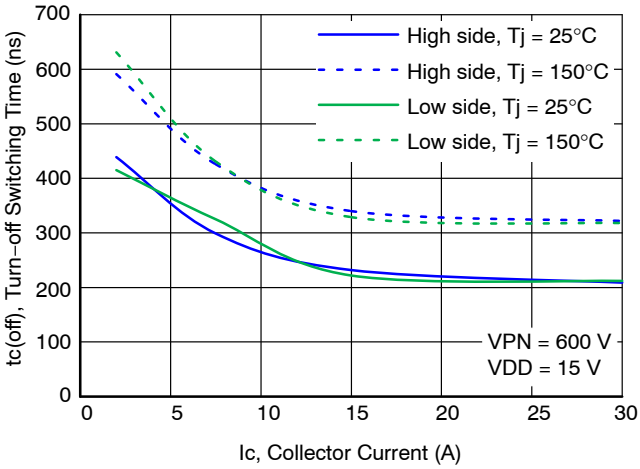


Figure 20. Typ. Turn−off Switching Time

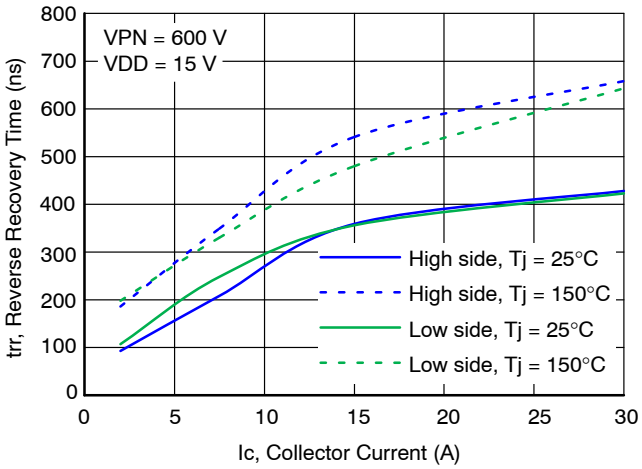


Figure 21. Typ. Reverse Recovery Time

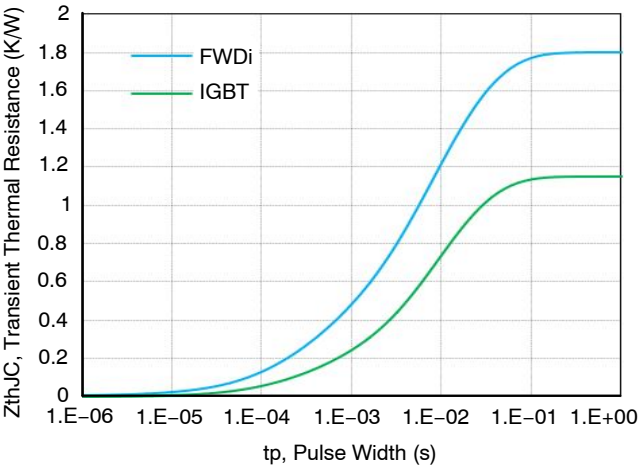


Figure 22. Transient Thermal Resistance

Turn−on/off Switching Waveform

Switching condition: VDC = 600 V, VDD = 15 V, Tj = 25°C, Ic = 10 A.

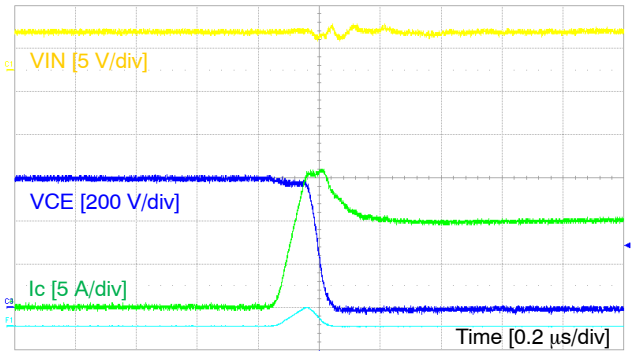


Figure 23. Turn−on Switching Waveform

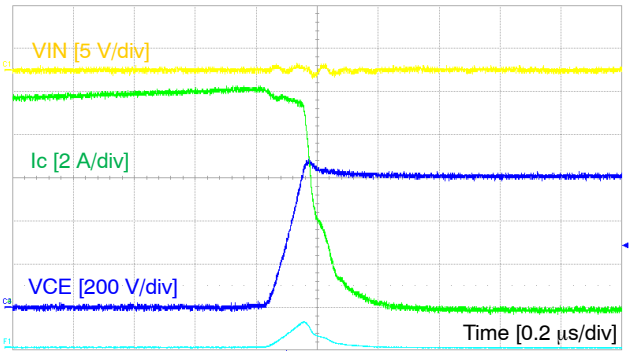
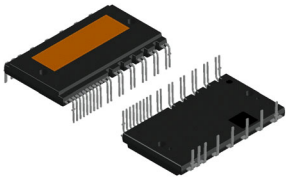


Figure 24. Turn−off Switching Waveform

MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS



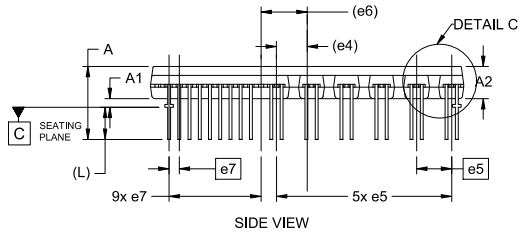
DIP39, 54.50x31.00x5.60, 1.78P EP−2
CASE MODGX
ISSUE A

DATE 20 DEC 2023

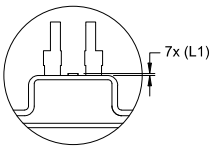
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b and c APPLY TO THE PLATED LEADS AND ARE MEASURED BETWEEN 1.00 AND 2.00 FROM THE LEAD TIP
4. POSITION OF THE LEAD IS DETERMINED AT THE BASE OF THE LEAD WHERE IT EXITS THE PACKAGE BODY
5. AREA FOR 2D BAR CODE
6. SHORTENED/CUT PINS ARE 2,5,8,11,14,17,19,29, 30 AND 39

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	12.20	12.7	13.2
A1	1.00	1.50	2.00
A2	5.50	5.60	5.70
A3		2.00 REF	
A4		1.55 REF	
A5		3.10 REF	
b	0.90	1.00	1.10
b1	1.90	2.00	2.10
b2	0.40	0.50	0.60
b3	1.40	1.50	1.60
c		0.50 REF	
D	54.40	54.50	54.60
D3		39.25 REF	
D4		8.00 REF	
D5		22.00 REF	
D6		24.00 REF	
D7		21.85 REF	
D8		23.85 REF	

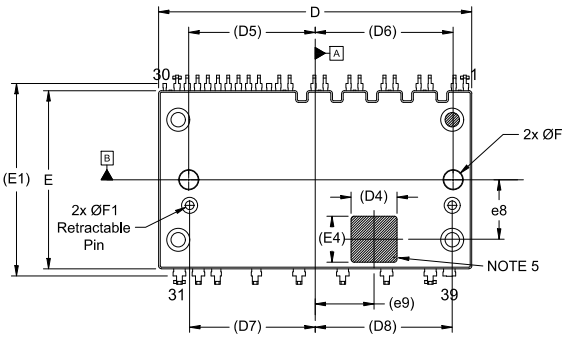
DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
E	30.90	31.00	31.10
E1		33.50 REF	
E2		26.14 REF	
E3		12.35 REF	
E4		8.00 REF	
E5	35.40	35.90	36.40
e		2.81 REF	
e1		7.62 BSC	
e2		6.60 BSC	
e3		3.30 BSC	
e4		5.35 REF	
e5		6.10 BSC	
e6		8.02 REF	
e7		1.78 BSC	
e8		10.35 REF	
e9		10.25 REF	
e10		3.60 REF	
e11		1.00 REF	
e12		0.89 BSC	
F	3.20	3.30	3.40
F1	1.40	1.50	1.60
L		5.60 REF	
L1		0.10 REF	



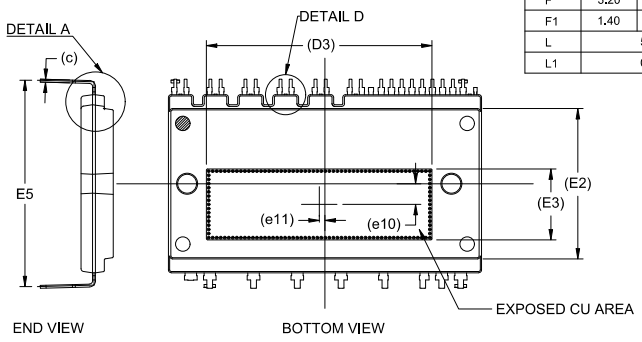
SIDE VIEW



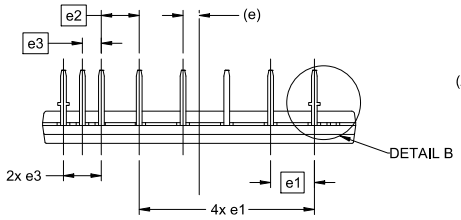
DETAIL D



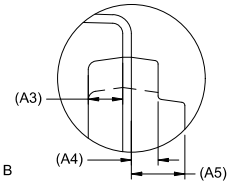
TOP VIEW



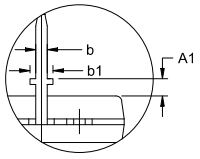
END VIEW
BOTTOM VIEW



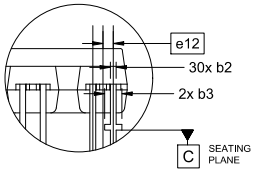
SIDE VIEW



DETAIL A

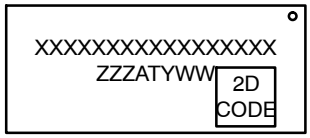


DETAIL B



DETAIL C

GENERIC MARKING DIAGRAM*



XXXXX = Specific Device Code
ZZZ = Assembly Lot Code
AT = Assembly & Test Location
Y = Year
WW = Work Week

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “▪”, may or may not be present. Some products may not follow the Generic Marking.

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