

Intelligent Power Module (IPM)

Inverter, 1200 V, 15 A

NFAM1512L7B

General description

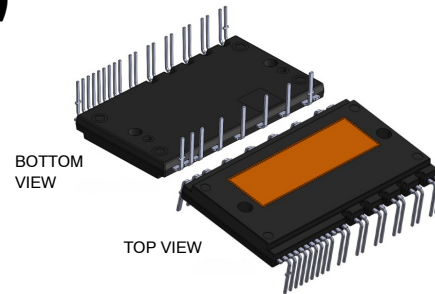
NFAM1512L7B is an advanced IPM module providing a fully-featured, high-performance inverter output stage for AC Induction, BLDC and PMSM motors. These modules integrate optimized gate drive of the built-in IGBTs to minimize EMI and losses, while also providing multiple on-module protection features including 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

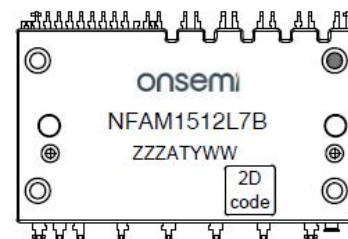
Typical Application

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



**DIP39, 54.5x31.0 EP-2
CASE MODGX**

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 |

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PIN CONFIGURATION

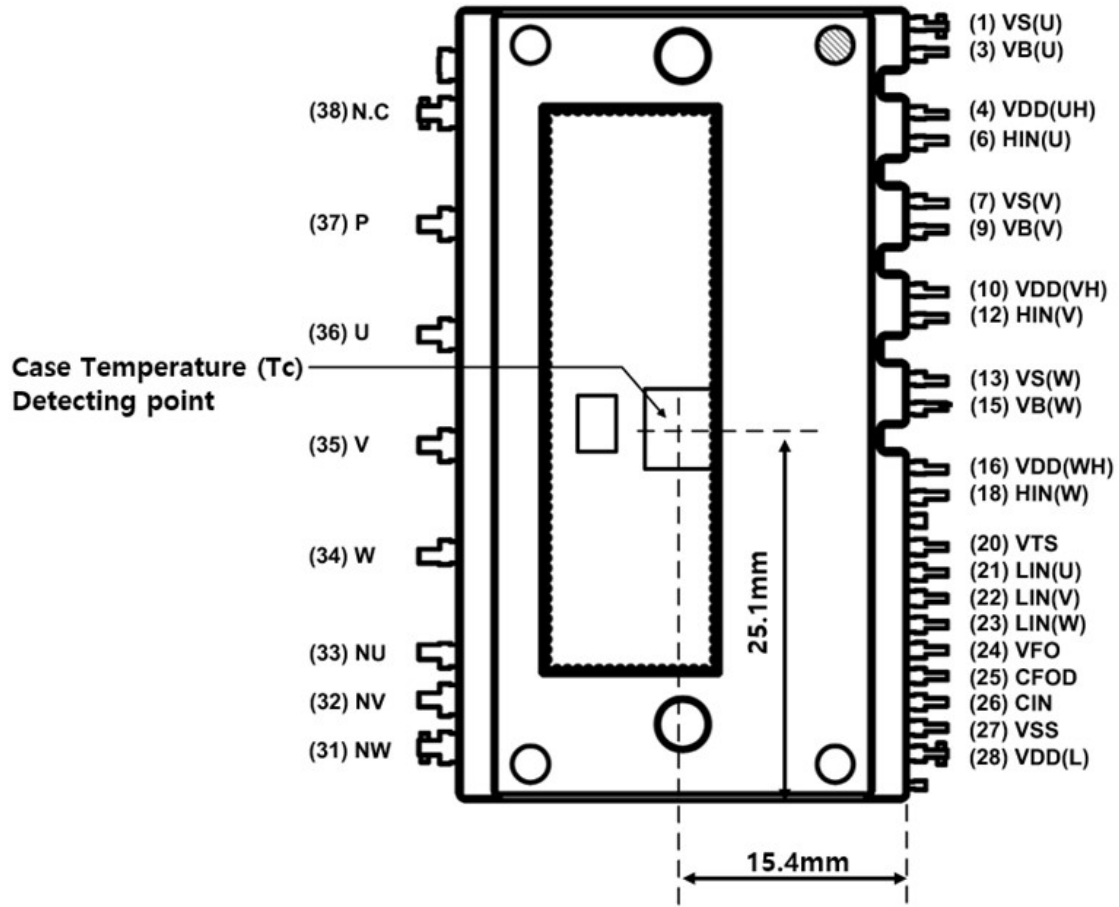


Figure 1. Pin Configuration – Top View

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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.

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INTERNAL EQUIVALENT CIRCUIT AND INPUT/OUTPUT PINS

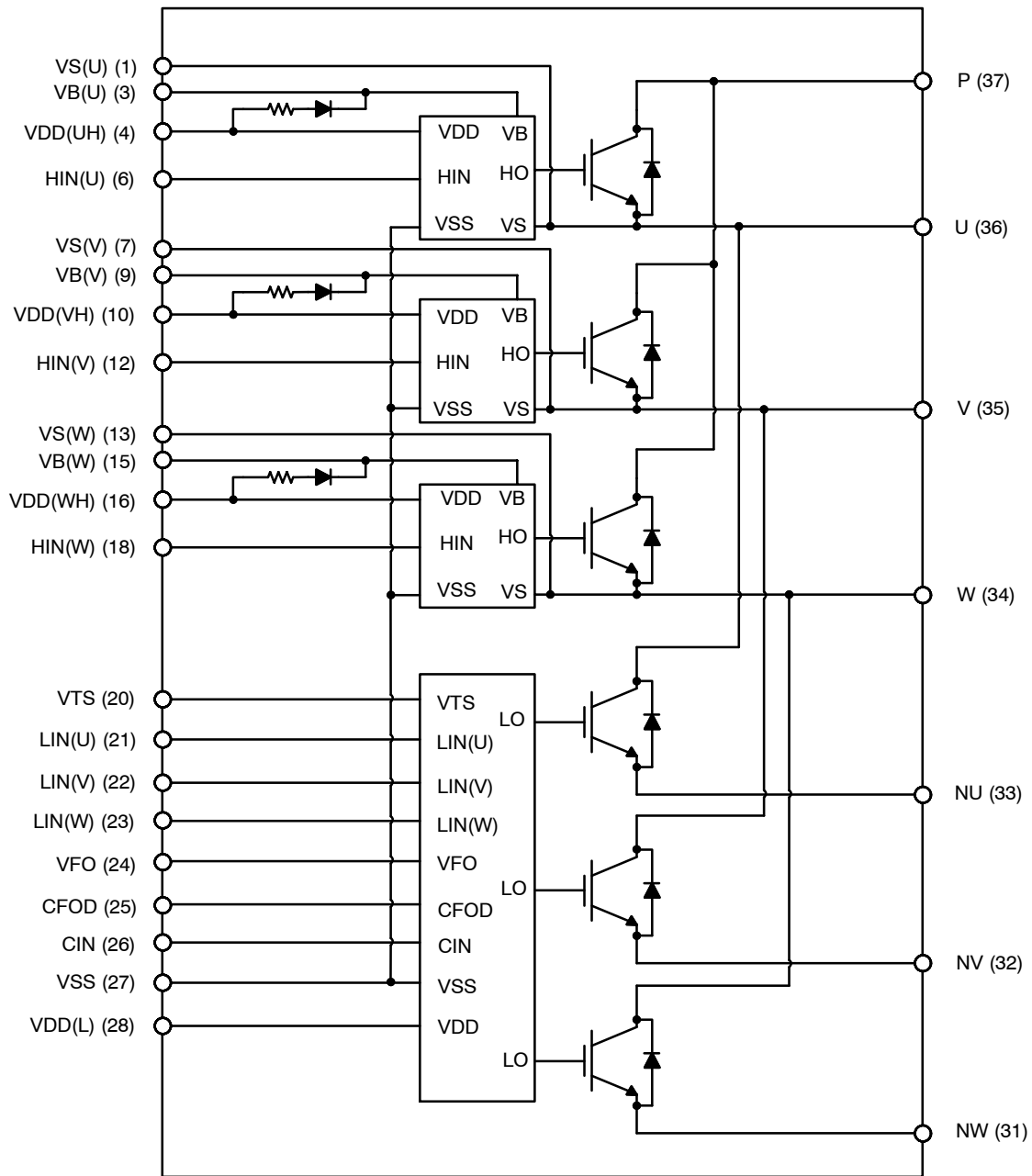


Figure 2. Internal Block Diagram

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ABSOLUTE MAXIMUM RATINGS (VDD = 15 V and Tj = 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 | Vrms |

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.

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ELECTRICAL CHARACTERISTICS (VDD = 15 V and Tj = 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 | 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 | | 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 |
| | | 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, fPWM = 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, fPWM = 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, fPWM = 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(OFF) | 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) | | 1.145 | 1.25 | 1.38 | V |

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ELECTRICAL CHARACTERISTICS (VDD = 15 V and Tj = 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.

- 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.
- 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.
- The fault-out pulse width tFOD depends on the capacitance value of CFOD according to the following approximate equation:

$$tFOD = 0.11 \times 10^6 \times CFOD [s].$$

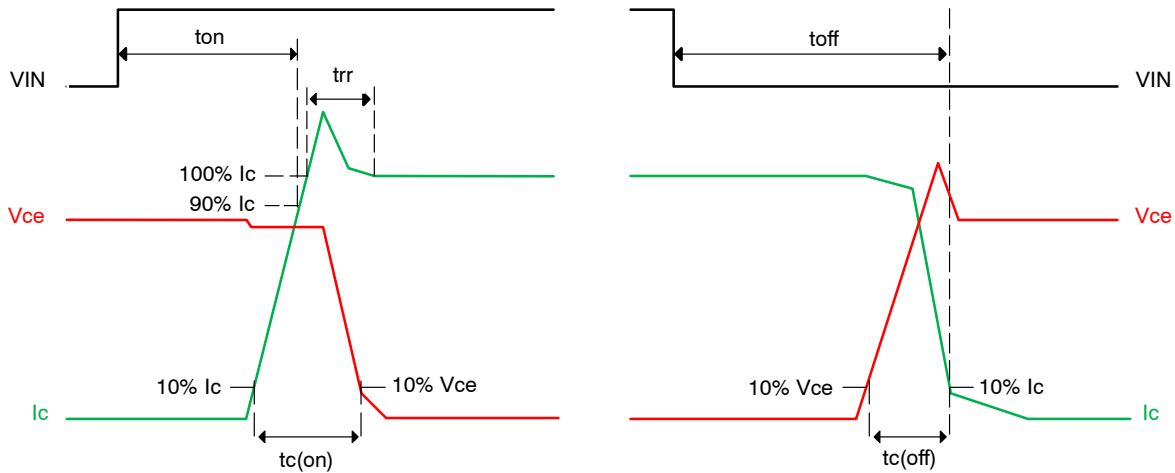


Figure 3. Switching Time Definitions

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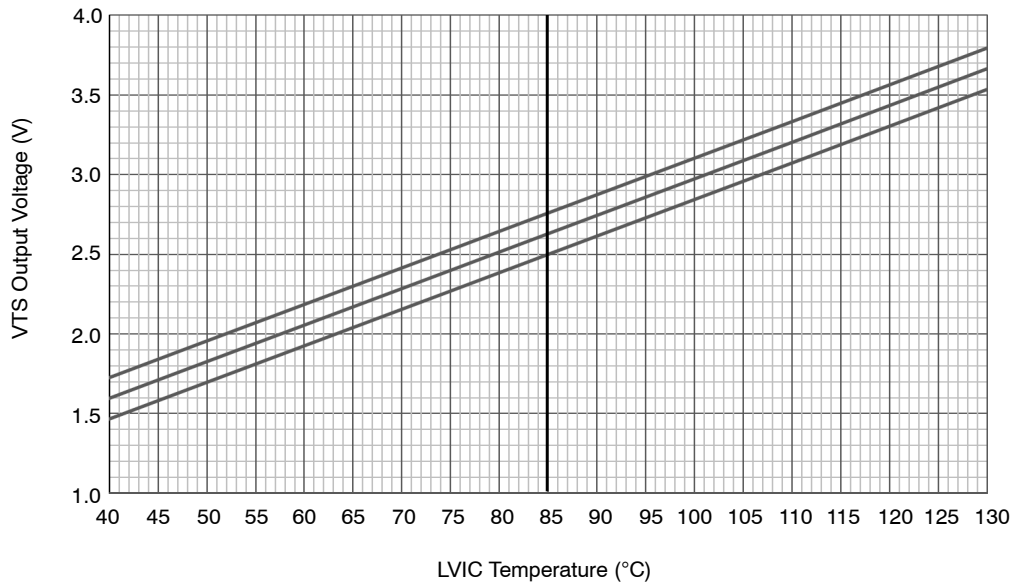


Figure 4. Temperature of LVIC vs. VTS Characteristics

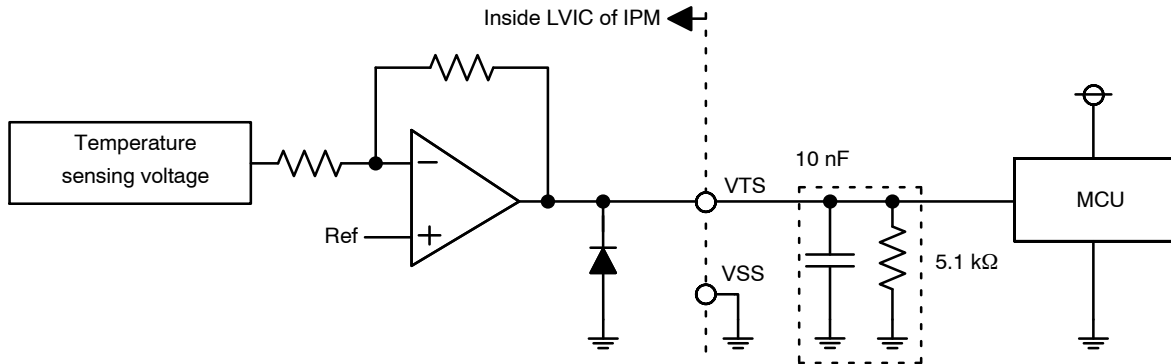


Figure 5. Internal Block Diagram and Interface Circuit of VTS

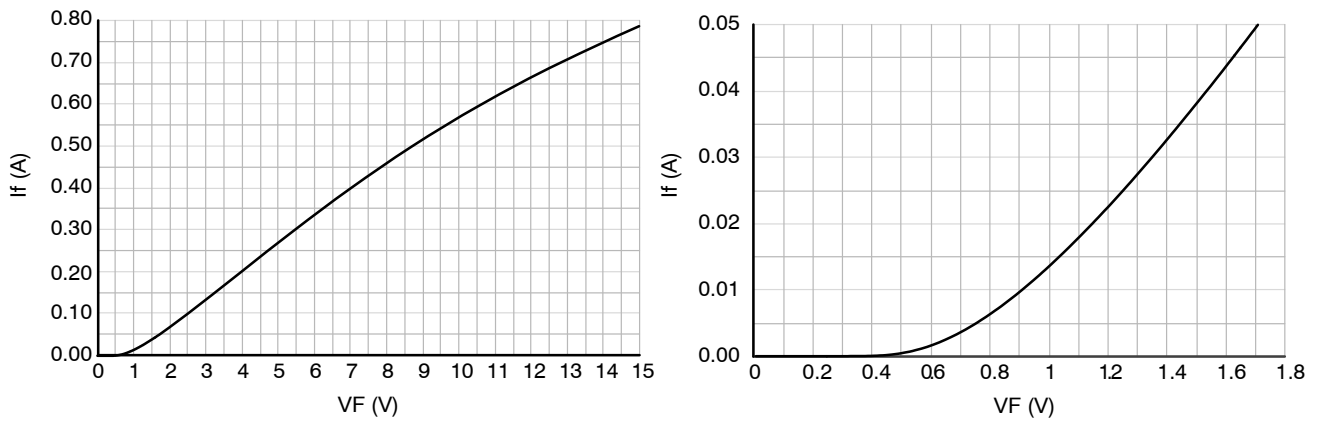


Figure 6. Characteristics of Bootstrap Diode/Resistor (Right Figure is Enlarged Figure)

RECOMMENDED OPERATING CONDITIONS

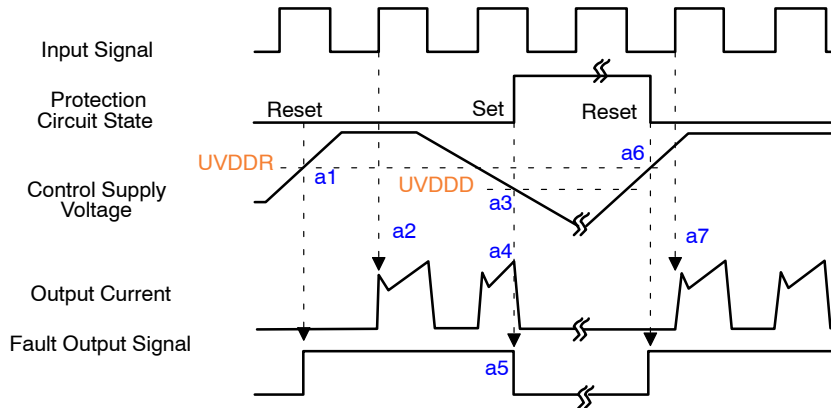
| Symbol | Description | Conditions | | Value | | | Unit |
|-------------------------|--|---|---------------|-------|-----|------|------|
| | | | | Min | Typ | Max | |
| VPN | Supply Voltage | Applied between P – NU, NV, NW | | – | 600 | 800 | V |
| VDD | Control Supply Voltage | Applied between VDD(H) – 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.

- 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.
- Product might not make response if input pulse width is less than the recommended value.

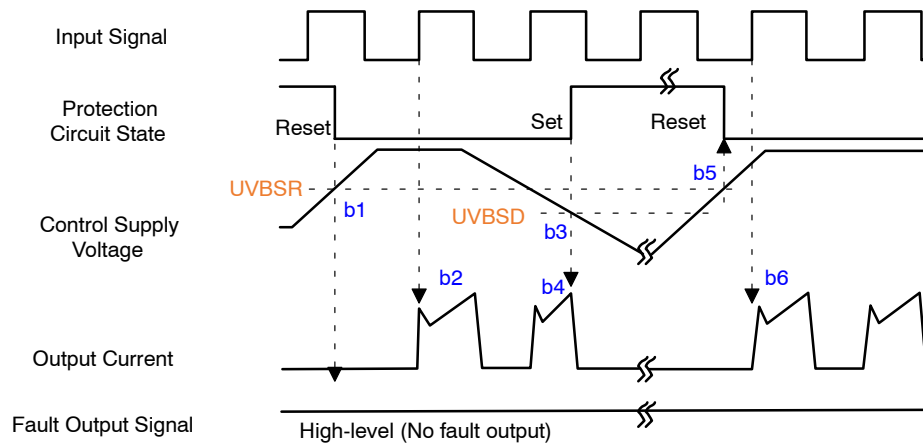
TIME CHARTS OF PROTECTIVE FUNCTION



- 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.

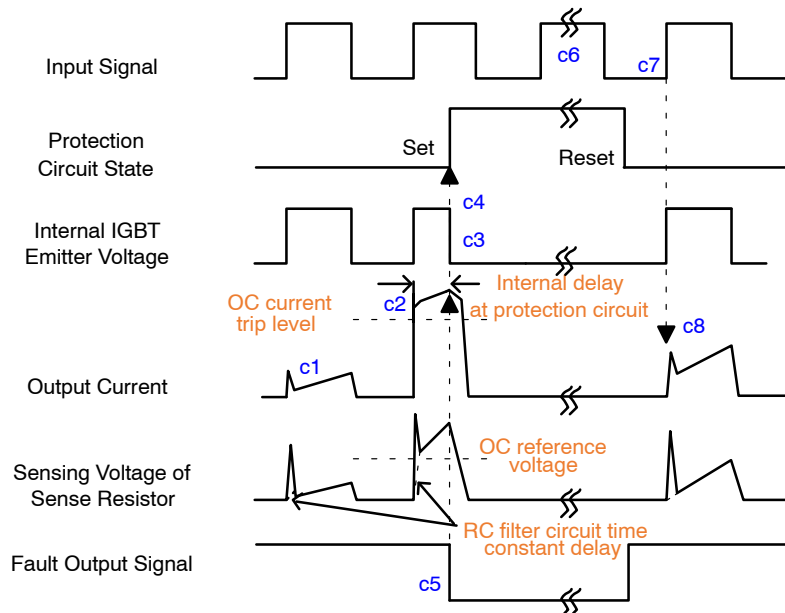
Figure 7. Under-Voltage Protection (Low-Side)

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- 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

Figure 10. Typical Application Circuit

TYPICAL CHARACTERISTICS

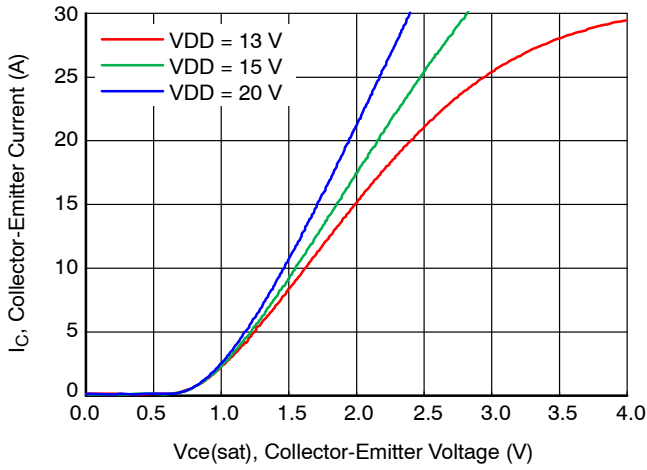


Figure 11. Typ. Collector-Emitter Saturation Voltage

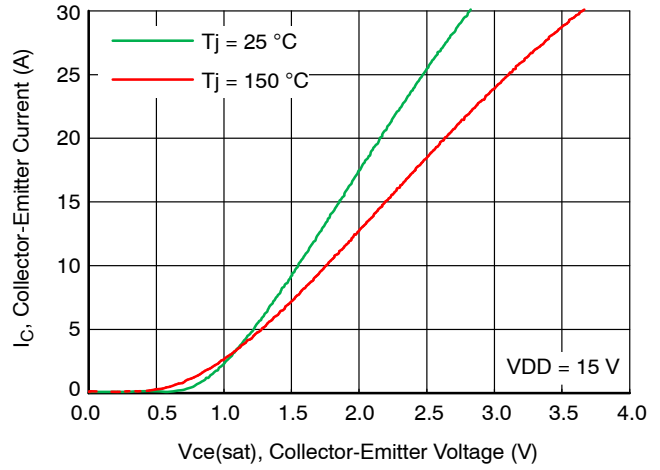


Figure 12. Typ. Collector-Emitter Saturation Voltage

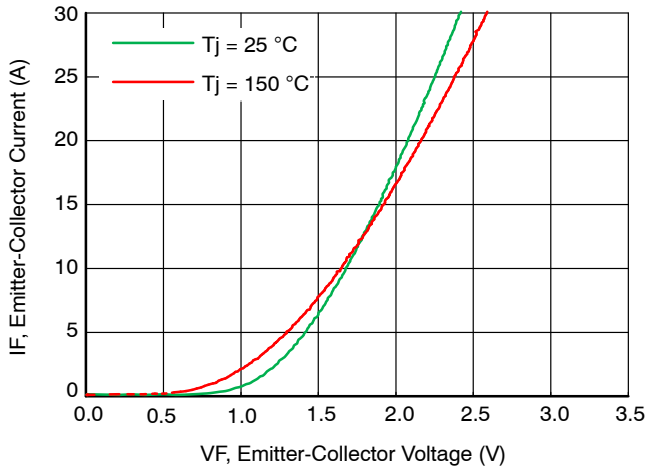


Figure 13. Typ. Emitter-Collector Forward Voltage

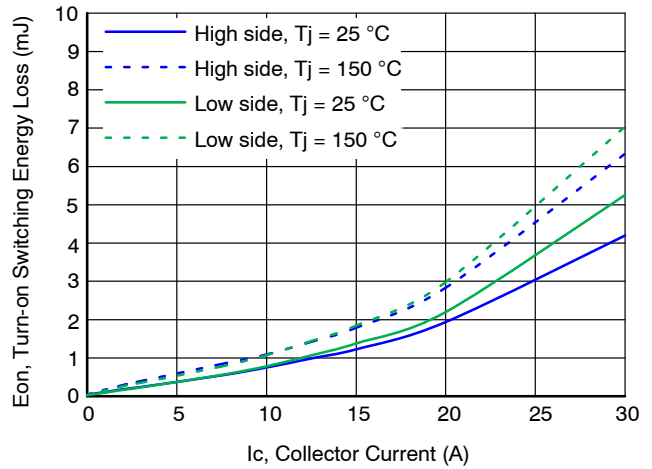


Figure 14. Typ. Turn-on Switching Energy Loss

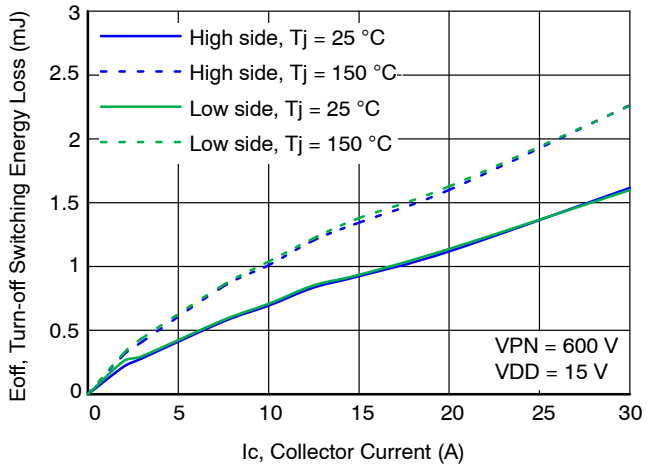


Figure 15. Typ. Turn-off Switching Energy Loss

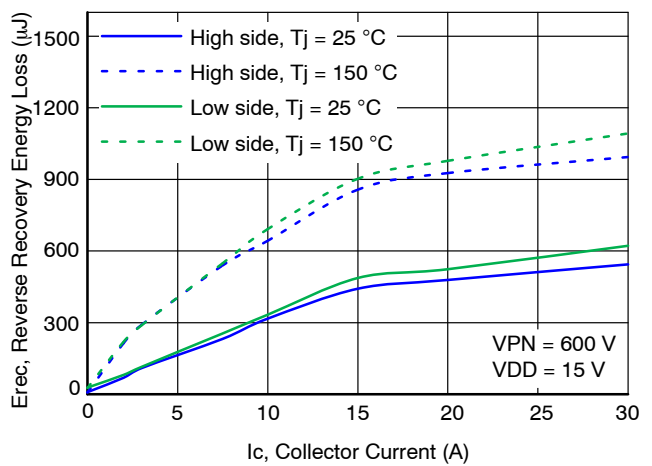


Figure 16. Typ. Reverse Recovery Energy Loss

TYPICAL CHARACTERISTICS (CONTINUED)

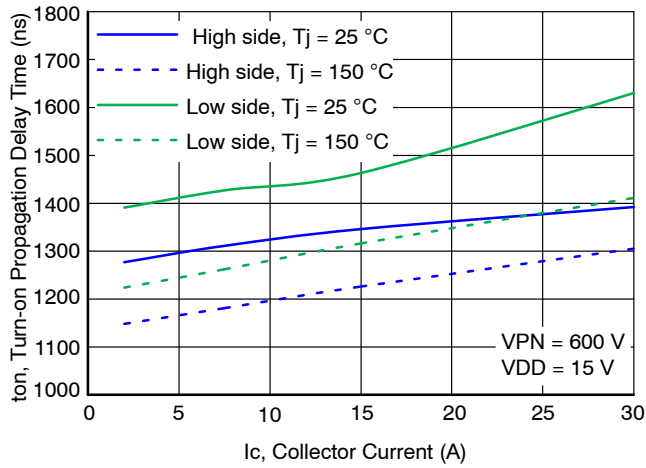


Figure 17. Typ. Turn-on Propagation Delay Time

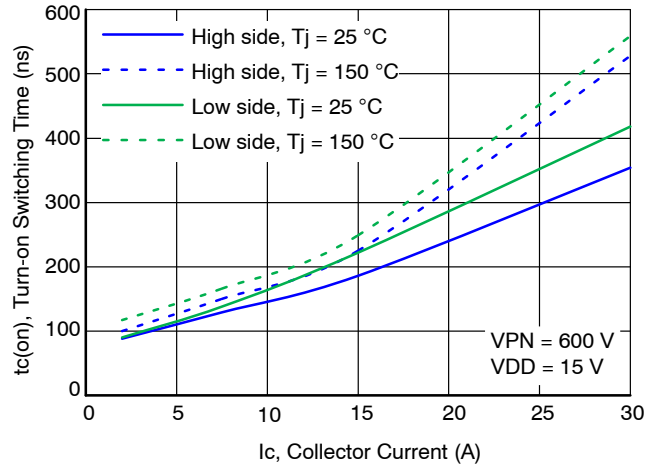


Figure 18. Typ. Turn-on Switching Time

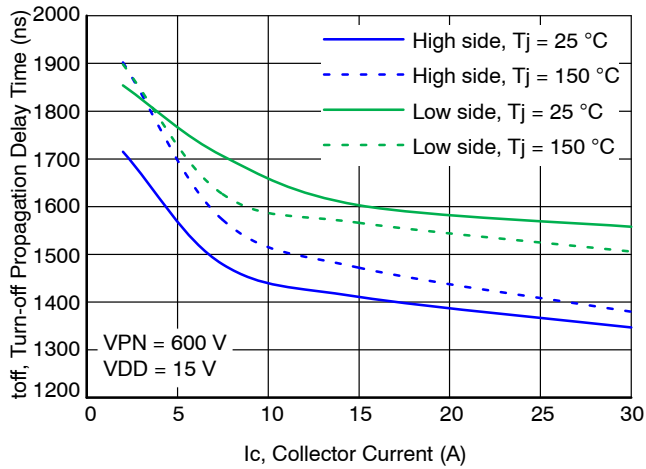


Figure 19. Typ. Turn-off Propagation Delay Time

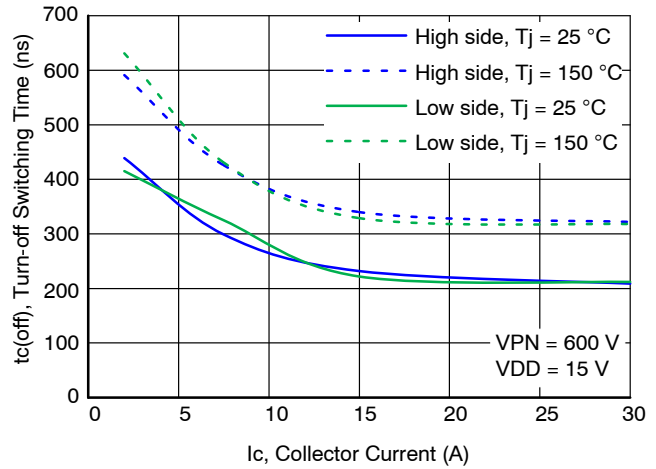


Figure 20. Typ. Turn-off Switching Time

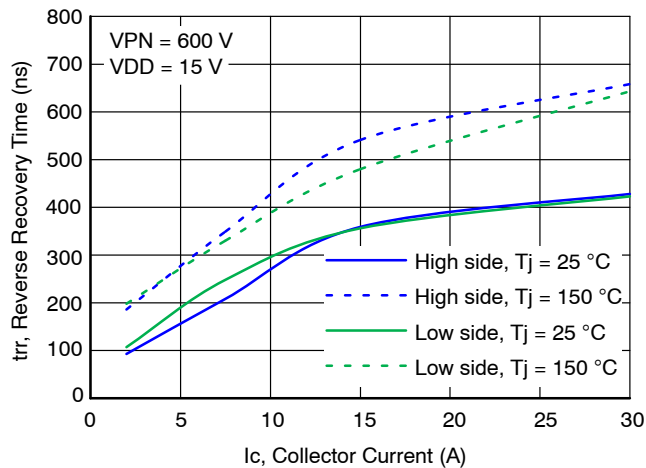


Figure 21. Typ. Reverse Recovery Time

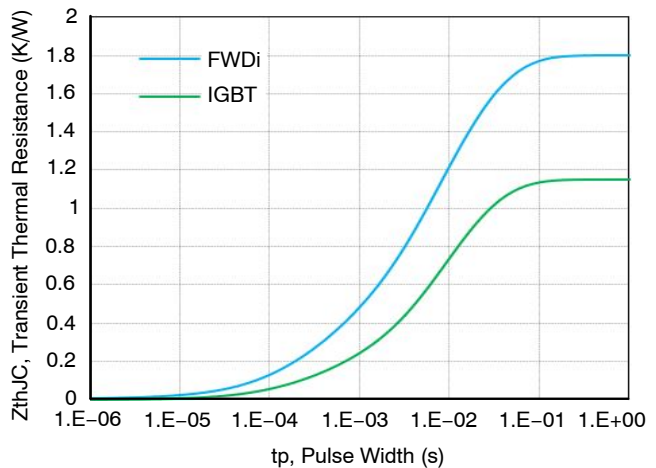


Figure 22. Transient Thermal Resistance

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TURN-ON/OFF SWITCHING WAVEFORM

SWITCHING CONDITION: $V_{DC} = 600\text{ V}$, $V_{DD} = 15\text{ V}$, $T_J = 25\text{ }^{\circ}\text{C}$, $I_C = 10\text{ A}$.

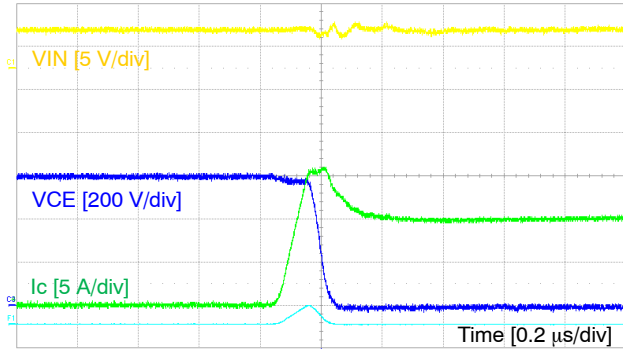


Figure 23. Turn-on Switching Waveform

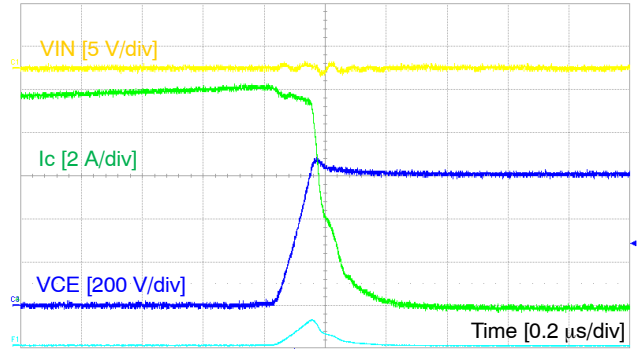


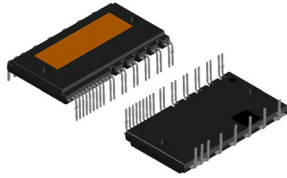
Figure 24. Turn-off Switching Waveform

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REVISION HISTORY

| Revision | Description of Changes | Date |
|----------|--|----------|
| 4 | Updated MIN limit spec of VTS item in the Electrical Characteristics Table (CONTROL PART SECTION) on page 6. | 7/1/2025 |

This document has undergone updates prior to the inclusion of this revision history table. The changes tracked here only reflect updates made on the noted approval dates.



DIP39, 54.50x31.00x5.60, 1.78P EP-2
CASE MODGX
ISSUE B

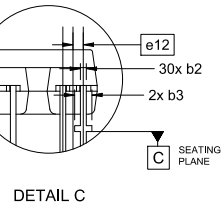
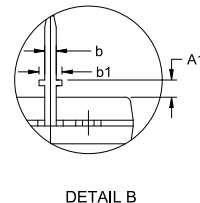
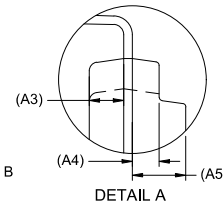
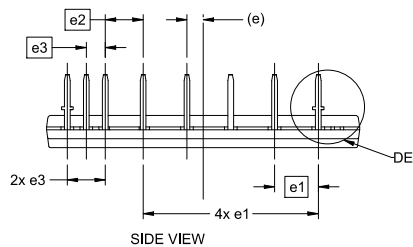
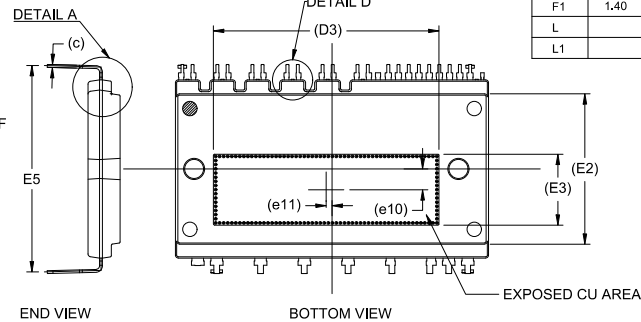
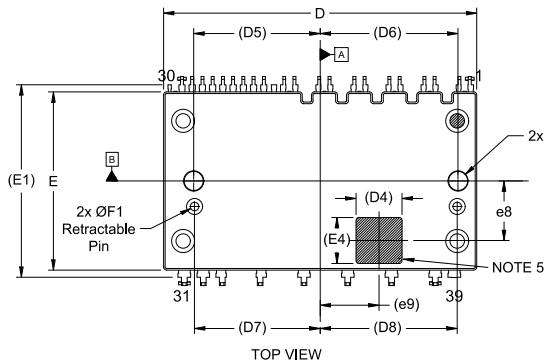
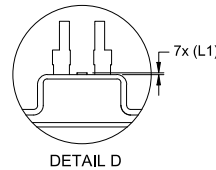
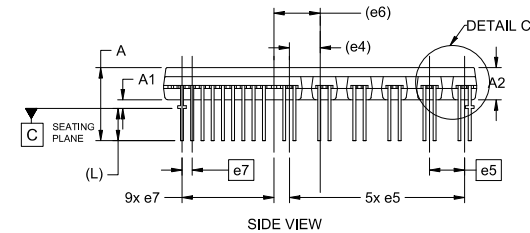
DATE 05 MAY 2025

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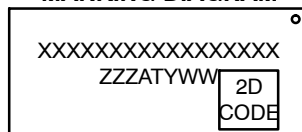
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b and c APPLY TO THE PLATED LEADS AND ARE MEASURED BETWEEN 1.00 AND 2.00 FROM THE LEAD TIP
4. POSITION OF THE LEAD IS DETERMINED AT THE BASE OF THE LEAD WHERE IT EXITS THE PACKAGE BODY
5. AREA FOR 2D BAR CODE
6. SHORTENED/CUT PINS ARE 2.5, 8, 11, 14, 17, 19, 29, 30 AND 39
7. DIMENSIONS "D" AND "E" DO NOT INCLUDE THE SIDE FLASH PROTRUSION WHICH IS ~0.12 FOR EACH SIDE

| 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 | |



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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