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# Automotive 750 V, 660 A Single Side Direct Cooling 6-Pack Power Module

## VE-Trac™ Direct Module NVH660S75L4SPFC

### Product Description

The NVH660S75L4SPFC is a power module from the VE-Trac™ Direct family of highly integrated power modules with industry standard footprints for Hybrid (HEV) and Electric Vehicle (EV) traction inverter application.

The module integrates six Field Stop 4 (FS4) 750 V Narrow Mesa IGBTs in a 6-pack configuration, which excels in providing high current density, while offering robust short circuit protection and increased blocking voltage. Additionally, FS4 750 V Narrow Mesa IGBTs show low power losses during lighter loads, which helps to improve overall system efficiency in automotive applications.

For assembly ease and reliability, a new generation of press-fit pins are integrated into the power module signal terminals. In addition, the power module has longer power terminals to easily integrate an external current sensor.

### Features

- Direct or Indirect Cooling w/ Flat Base Heatsink
- Ultra-low Stray Inductance
- $T_{jmax} = 175^{\circ}\text{C}$  Continuous Operation
- Low  $V_{CESAT}$  and Switching Losses
- Automotive Grade FS4 750 V Narrow Mesa IGBT
- Fast Recovery Diode Chip Technologies
- 4.2 kV Isolated DBC Substrate
- Easy to Integrate 6-pack Topology
- This Device is Pb-Free and is RoHS Compliant

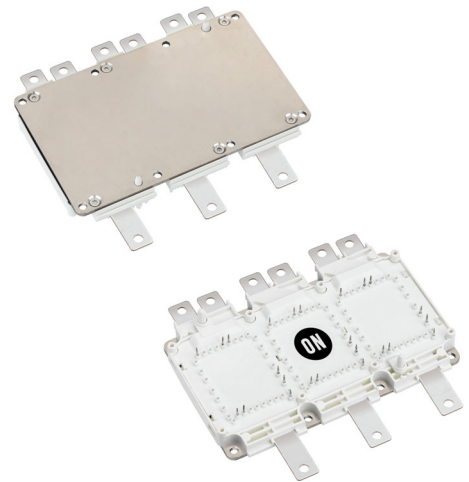
### Typical Applications

- Hybrid and Electric Vehicle Traction Inverter
- High Power Converters

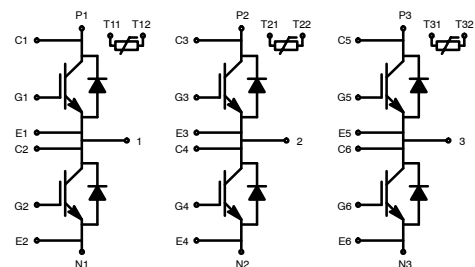


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SSDC33, 154.50x92.0 (SPFC)  
CASE 183AF



### ORDERING INFORMATION

See detailed ordering and shipping information on page 5 of this data sheet.

# VE-Trac™ Direct Module NVH660S75L4SPFC

## Pin Description

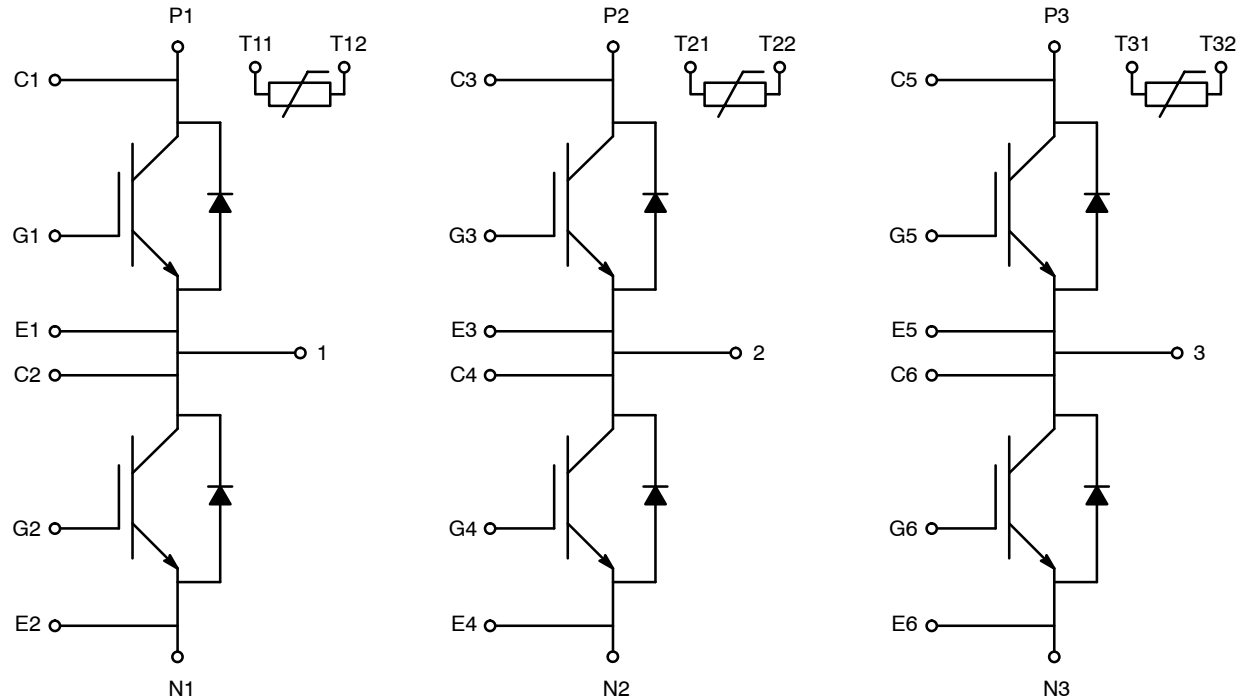


Figure 1. Pin Description

## PIN FUNCTION DESCRIPTION

Pin #	Pin Function Description
P1, P2, P3	Positive Power Terminals
N1, N2, N3	Negative Power Terminals
1	Phase 1 Output
2	Phase 2 Output
3	Phase 3 Output
G1–G6	IGBT Gate
E1–E6	IGBT Gate Return
C1–C6	Desat Detect/Collector Sense
T11, T12	Phase 1 Temperature Sensor Output
T21, T22	Phase 2 Temperature Sensor Output
T31, T32	Phase 3 Temperature Sensor Output

## Materials

DBC Substrate: Al<sub>2</sub>O<sub>3</sub> isolated substrate, basic isolation,  
and copper on both sides

Terminals: Copper + Tin electro-plating

Signal Leads: Copper + Tin plating

Flat Base plate: Copper + Ni plating

## Flammability Information

The module frame meets UL94V-0 flammability rating.

# VE-Trac™ Direct Module NVH660S75L4SPFC

## MODULE CHARACTERISTICS (T<sub>vj</sub> = 25°C, Unless Otherwise Specified)

Symbol	Parameter	Rating	Unit
T <sub>vj</sub>	Operating Junction Temperature	–40 to 175	°C
T <sub>STG</sub>	Storage Temperature	–40 to 125	°C
V <sub>ISO</sub>	Isolation Voltage (DC, 0 Hz, 1 s)	4200	V
L <sub>sCE</sub>	Stray Inductance	8	nH
RCC'+EE'	Module Lead Resistance, Terminals – Chip	0.75	mΩ
G	Module Weight	580	g
CTI	Comparative Tracking Index	>200	–
d <sub>creep</sub>	Creepage: Terminal to Heatsink Terminal to Terminal	9.0 9.0	mm
d <sub>clear</sub>	Clearance: Terminal to Heatsink Terminal to Terminal	4.5 4.5	mm

## ABSOLUTE MAXIMUM RATINGS (T<sub>vj</sub> = 25°C, Unless Otherwise Specified)

Symbol	Parameter	Rating	Unit
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### IGBT

V <sub>CES</sub>	Collector to Emitter Voltage	750	V
V <sub>GES</sub>	Gate to Emitter Voltage	±20	V
I <sub>CN</sub>	Implemented Collector Current	660	A
I <sub>C nom</sub>	Continuous DC Collector Current, T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink	450 (Note 1)	A
I <sub>CRM</sub>	Pulsed Collector Current @ V <sub>GE</sub> = 15 V, t <sub>p</sub> = 1 ms	1320	A
P <sub>tot</sub>	Total Power Dissipation T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink	733	W

### DIODE

V <sub>RRM</sub>	Repetitive Peak Reverse Voltage	750	V
I <sub>FN</sub>	Implemented Forward Current	660	A
I <sub>F</sub>	Continuous Forward Current, T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink	300 (Note 1)	A
I <sub>FRM</sub>	Repetitive Peak Forward Current, t <sub>p</sub> = 1 ms	1320	A
I <sup>2</sup> t value	Surge Current Capability, t <sub>p</sub> = 10 ms, T <sub>vj</sub> = 150°C T <sub>vj</sub> = 175°C	19000 16000	A²s

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. Verified by characterization/design, not by test.

# VE-Trac™ Direct Module NVH660S75L4SPFC

## CHARACTERISTICS OF IGBT (T<sub>vj</sub> = 25°C, Unless Otherwise Specified)

Symbol	Parameters	Conditions		Min	Typ	Max	Unit
V <sub>CESAT</sub>	Collector to Emitter Saturation Voltage (Terminal)	V <sub>GE</sub> = 15 V, I <sub>C</sub> = 450 A	T <sub>vj</sub> = 25°C	–	1.19	1.44	V
	Collector to Emitter Saturation Voltage (Chip)	V <sub>GE</sub> = 15 V, I <sub>C</sub> = 450 A	T <sub>vj</sub> = 25°C T <sub>vj</sub> = 150°C T <sub>vj</sub> = 175°C	– – –	1.16 1.20 1.21	1.41 – –	
		V <sub>GE</sub> = 15 V, I <sub>C</sub> = 660 A	T <sub>vj</sub> = 25°C T <sub>vj</sub> = 150°C T <sub>vj</sub> = 175°C	– – –	1.29 1.40 1.43	– – –	
I <sub>CES</sub>	Collector to Emitter Leakage Current	V <sub>GE</sub> = 0, V <sub>CE</sub> = 750 V	T <sub>vj</sub> = 25°C T <sub>vj</sub> = 150°C	– –	– 2.0	500 –	μA mA
I <sub>GES</sub>	Gate – Emitter Leakage Current	V <sub>CE</sub> = 0, V <sub>GE</sub> = ±20 V		–	–	±300	nA
V <sub>th</sub>	Threshold Voltage	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 90 mA		4.8	5.7	6.6	V
Q <sub>G</sub>	Total Gate Charge	V <sub>GE</sub> = –8 to 15 V, V <sub>CE</sub> = 400 V		–	1.9	–	μC
R <sub>Gint</sub>	Internal Gate Resistance			–	1.7	–	Ω
C <sub>ies</sub>	Input Capacitance	V <sub>CE</sub> = 30 V, V <sub>GE</sub> = 0 V, f = 1 MHz		–	63	–	nF
C <sub>oes</sub>	Output Capacitance	V <sub>CE</sub> = 30 V, V <sub>GE</sub> = 0 V, f = 1 MHz		–	1.8	–	nF
C <sub>res</sub>	Reverse Transfer Capacitance	V <sub>CE</sub> = 30 V, V <sub>GE</sub> = 0 V, f = 1 MHz		–	0.2	–	nF
T <sub>d,on</sub>	Turn On Delay, Inductive Load	I <sub>C</sub> = 450 A, V <sub>CE</sub> = 400 V, V <sub>GE</sub> = +15/–8 V, R <sub>g,on</sub> = 4 Ω	T <sub>vj</sub> = 25°C T <sub>vj</sub> = 150°C T <sub>vj</sub> = 175°C	– – –	308 304 294	– – –	ns
T <sub>r</sub>	Rise Time, Inductive Load	I <sub>C</sub> = 450 A, V <sub>CE</sub> = 400 V, V <sub>GE</sub> = +15/–8 V, R <sub>g,on</sub> = 4 Ω	T <sub>vj</sub> = 25°C T <sub>vj</sub> = 150°C T <sub>vj</sub> = 175°C	– – –	114 133 124	– – –	ns
T <sub>d,off</sub>	Turn Off Delay, Inductive Load	I <sub>C</sub> = 450 A, V <sub>CE</sub> = 400 V, V <sub>GE</sub> = +15/–8 V, R <sub>g,off</sub> = 12 Ω	T <sub>vj</sub> = 25°C T <sub>vj</sub> = 150°C T <sub>vj</sub> = 175°C	– – –	1432 1579 1536	– – –	ns
T <sub>f</sub>	Fall Time, Inductive Load	I <sub>C</sub> = 450 A, V <sub>CE</sub> = 400 V, V <sub>GE</sub> = +15/–8 V, R <sub>g,off</sub> = 12 Ω	T <sub>vj</sub> = 25°C T <sub>vj</sub> = 150°C T <sub>vj</sub> = 175°C	– – –	169 256 246	– – –	ns
E <sub>ON</sub>	Turn-On Switching Loss (Including Diode Reverse Recovery Loss)	I <sub>C</sub> = 450 A, V <sub>CE</sub> = 400 V, V <sub>GE</sub> = +15/–8 V, L <sub>s</sub> = 22 nH, R <sub>g,on</sub> = 4 Ω	di/dt = 3.2 A/nS, T <sub>vj</sub> = 25°C di/dt = 2.7 A/nS, T <sub>vj</sub> = 150°C di/dt = 2.9 A/nS, T <sub>vj</sub> = 175°C	– – –	16 25 27	– – –	mJ
E <sub>OFF</sub>	Turn-Off Switching Loss	I <sub>C</sub> = 450 A, V <sub>CE</sub> = 400 V, V <sub>GE</sub> = +15/–8 V, L <sub>s</sub> = 22 nH, R <sub>g,off</sub> = 12 Ω	dv/dt = 2.3 V/nS, T <sub>vj</sub> = 25°C dv/dt = 1.6 V/nS, T <sub>vj</sub> = 150°C dv/dt = 1.5 V/nS, T <sub>vj</sub> = 175°C	– – –	22 33 35	– – –	mJ
E <sub>SC</sub>	Minimum Short Circuit Energy Withstand	V <sub>GE</sub> = 15 V, V <sub>CC</sub> = 400 V		8 4	– –	– –	J

# VE-Trac™ Direct Module NVH660S75L4SPFC

## CHARACTERISTICS OF INVERSE DIODE ( $T_{vj} = 25^{\circ}\text{C}$ , Unless Otherwise Specified)

Symbol	Parameters	Conditions		Min	Typ	Max	Unit
$V_F$	Diode Forward Voltage (Terminal)	$I_F = 450\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	–	1.51	1.76	V
	Diode Forward Voltage (Chip)	$I_F = 450\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	–	1.45	1.70	
			$T_{vj} = 150^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	– –	1.33 1.30	– –	
$E_{rr}$	Reverse Recovery Energy	$I_F = 450\text{ A}$ , $V_F = 400\text{ V}$ , $V_{GE} = +15/-8\text{ V}$ , $R_{g.on} = 4\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$	–	2	–	mJ
			$T_{vj} = 150^{\circ}\text{C}$	–	7	–	
			$T_{vj} = 175^{\circ}\text{C}$	–	9	–	
$Q_{rr}$	Recovered Charge	$I_F = 450\text{ A}$ , $V_F = 400\text{ V}$ , $V_{GE} = -8\text{ V}$ , $R_{g.on} = 4\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$	–	7	–	$\mu\text{C}$
			$T_{vj} = 150^{\circ}\text{C}$	–	26	–	
			$T_{vj} = 175^{\circ}\text{C}$	–	33	–	
$I_{rr}$	Peak Reverse Recovery Current	$I_F = 450\text{ A}$ , $V_F = 400\text{ V}$ , $V_{GE} = -8\text{ V}$ , $R_{g.on} = 4\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$	–	120	–	A
			$T_{vj} = 150^{\circ}\text{C}$	–	227	–	
			$T_{vj} = 175^{\circ}\text{C}$	–	264	–	

## NTC SENSOR CHARACTERISTICS ( $T_{vj} = 25^{\circ}\text{C}$ , Unless Otherwise Specified)

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
$R_{25}$ (Note 3)	Rated Resistance	$T_C = 25^{\circ}\text{C}$	–	5147	–	$\Omega$
$\Delta R/R$	Deviation of $R_{105}$	$T_C = 105^{\circ}\text{C}$ , $R_{105} = 472\ \Omega$	5	–	5	%
$P_{25}$	Power Dissipation	$T_C = 25^{\circ}\text{C}$	–	–	32	mW
$B_{25/55}$	B-Value	$R = R_{25} \exp [B_{25/55} (1/T - 1/298)]$	–	3340	–	K
$B_{25/85}$	B-Value	$R = R_{25} \exp [B_{25/85} (1/T - 1/298)]$	–	3360	–	K
$B_{25/105}$	B-Value	$R = R_{25} \exp [B_{25/105} (1/T - 1/298)]$	–	3364	–	K

2. Measured value at terminals.

## THERMAL CHARACTERISTICS

Symbol	Parameter	Min	Typ	Max	Unit
$IGBT.R_{th,J-C}$	$R_{th}$ , Junction to Case	–	0.074	0.085	$^{\circ}\text{C/W}$
$IGBT.R_{th,J-F}$	$R_{th}$ , Junction to Fluid, 10 L/min, $65^{\circ}\text{C}$ , 50/50 EGW, Ref. Coolinig Jacket	–	0.15		$^{\circ}\text{C/W}$
$Diode.R_{th,J-C}$	$R_{th}$ , Junction to Case	–	0.13	0.15	$^{\circ}\text{C/W}$
$Diode.R_{th,J-F}$	$R_{th}$ , Junction to Fluid, 10 L/min, $65^{\circ}\text{C}$ , 50/50 EGW, Ref. Coolinig Jacket	–	0.23		$^{\circ}\text{C/W}$

## ORDERING INFORMATION

Part Number	Package	Shipping
NVH660S75L4SPFC	SSDC33, 154.50x92.0 (SPFC) (Pb-Free)	4 Units / Tray

TYPICAL CHARACTERISTICS

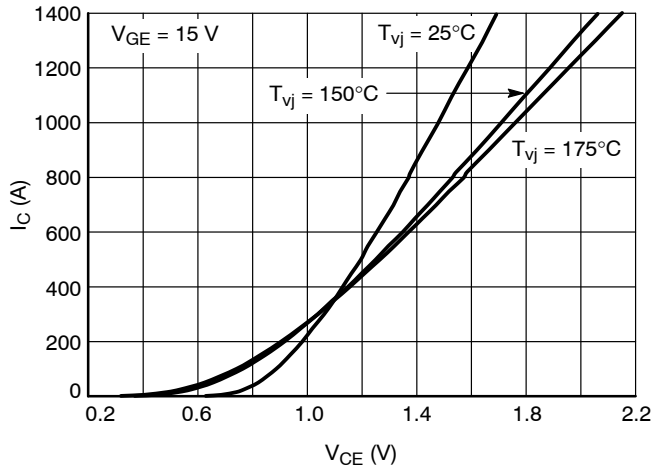


Figure 2. IGBT Output Characteristic

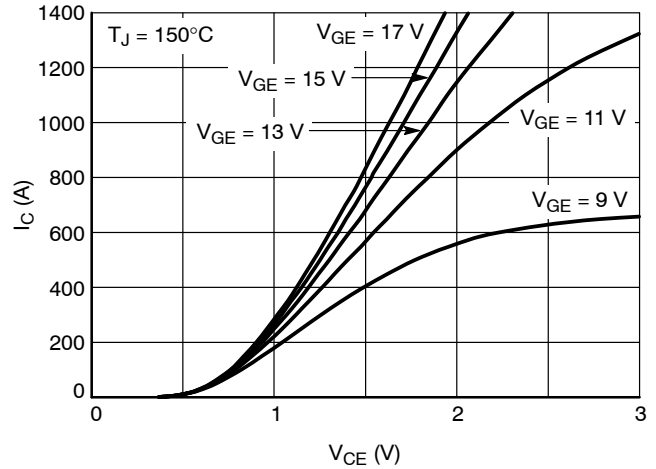


Figure 3. IGBT Output Characteristic

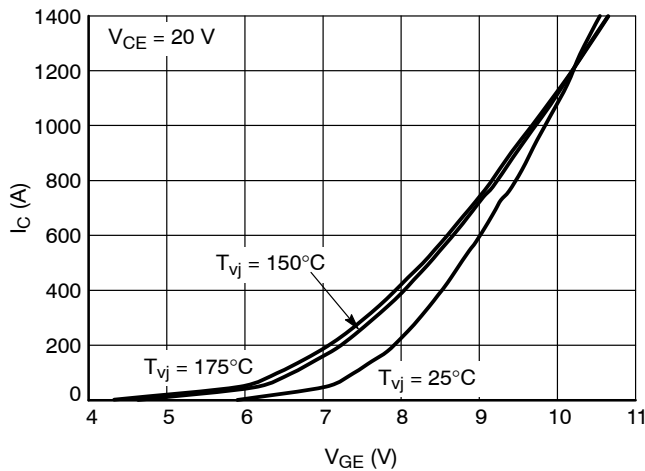


Figure 4. IGBT Transfer Characteristic

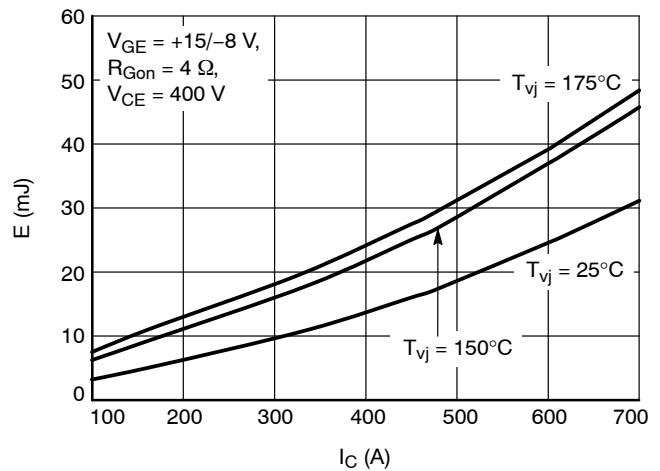


Figure 5. IGBT Turn-on Losses vs.  $I_C$

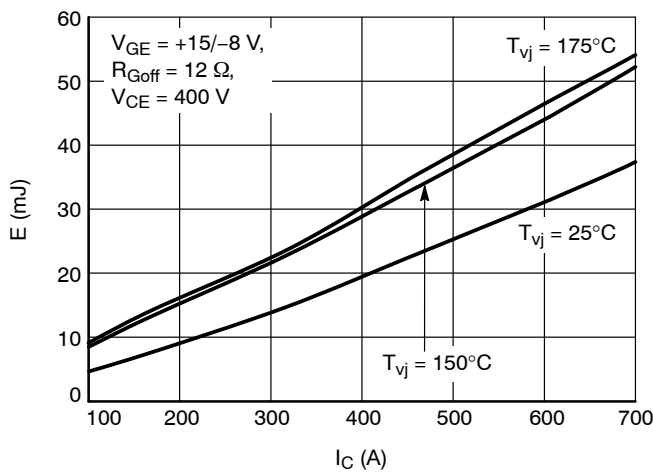


Figure 6. IGBT Turn-off Losses vs.  $I_C$

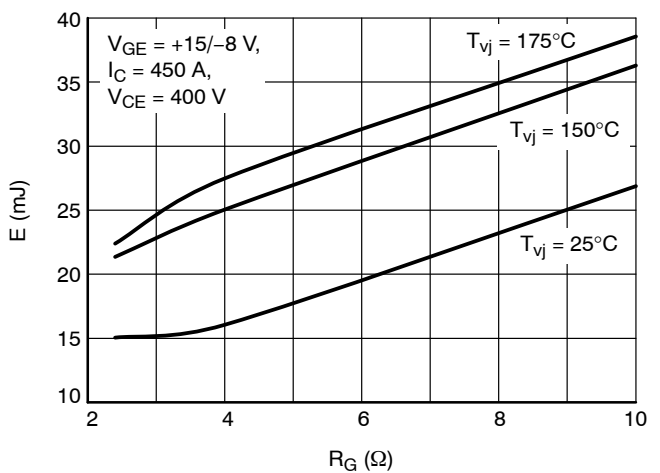


Figure 7.  $E_{ON}$  vs.  $R_G$

TYPICAL CHARACTERISTICS

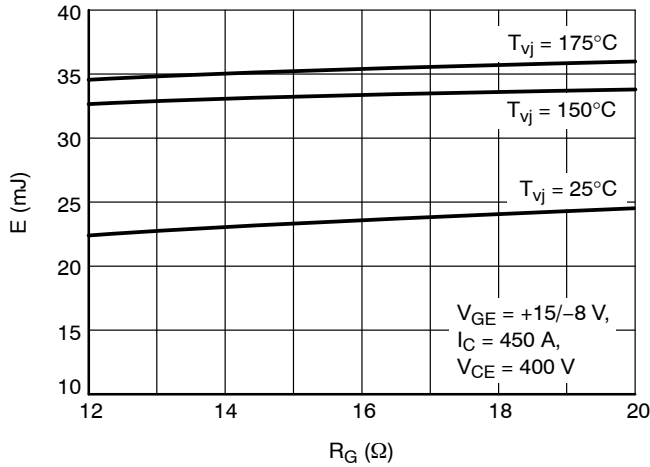


Figure 8.  $E_{OFF}$  vs.  $R_G$

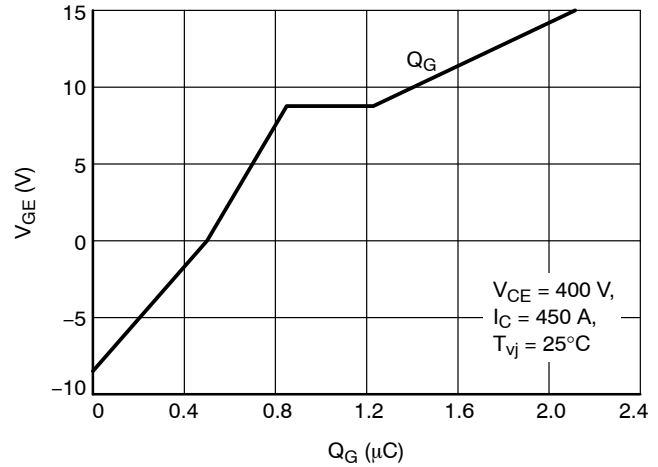


Figure 9. Gate Charge Characteristic

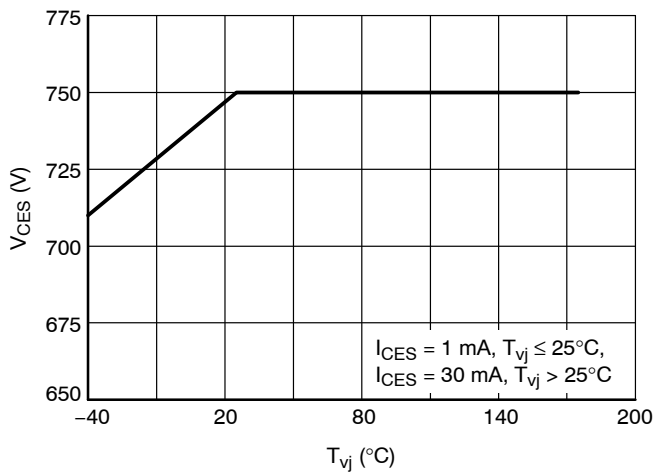


Figure 10. Maximum Allowed  $V_{CE}$

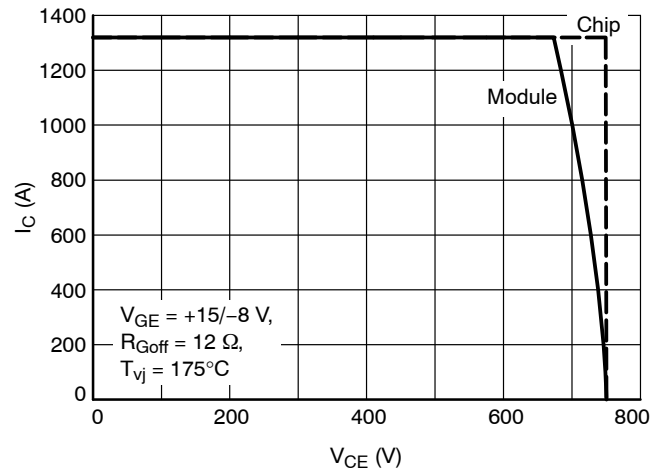


Figure 11. Reverse Bias Safe Operating Area

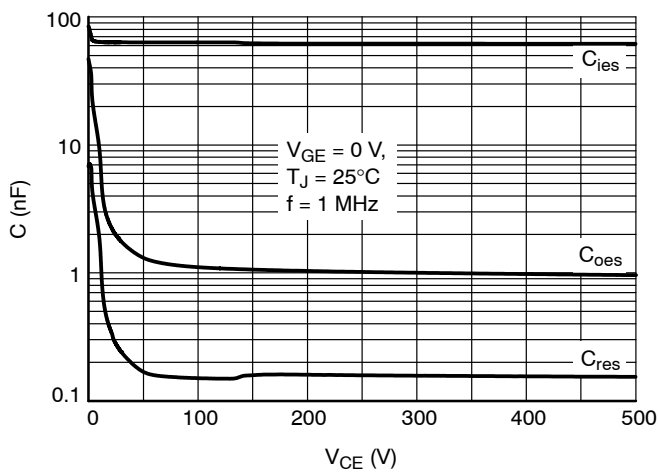


Figure 12. Capacitance Characteristic

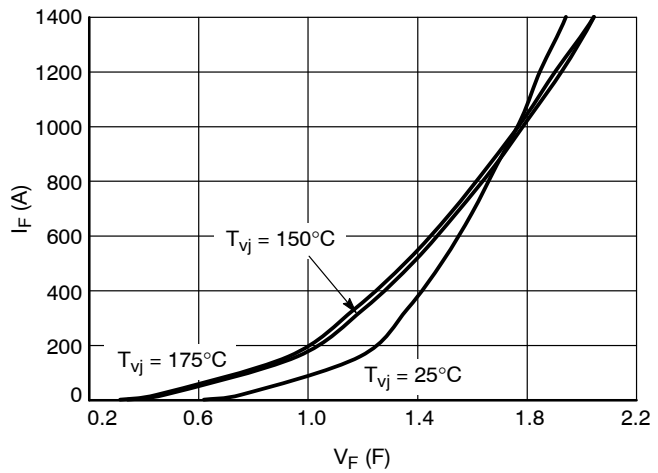


Figure 13. Diode Forward Characteristic



TYPICAL CHARACTERISTICS

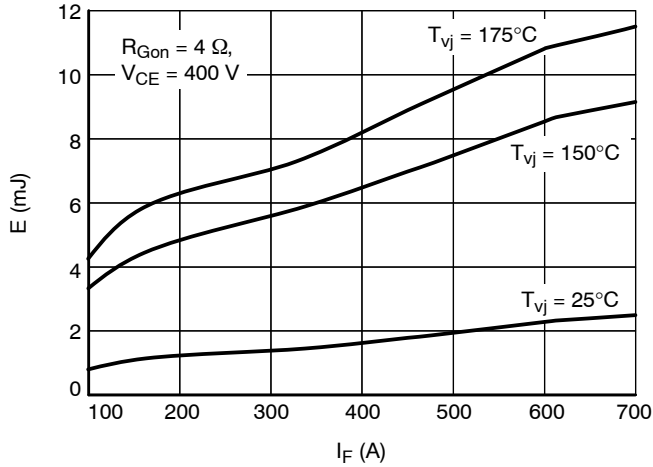


Figure 14. Diode Switching Losses vs.  $I_F$

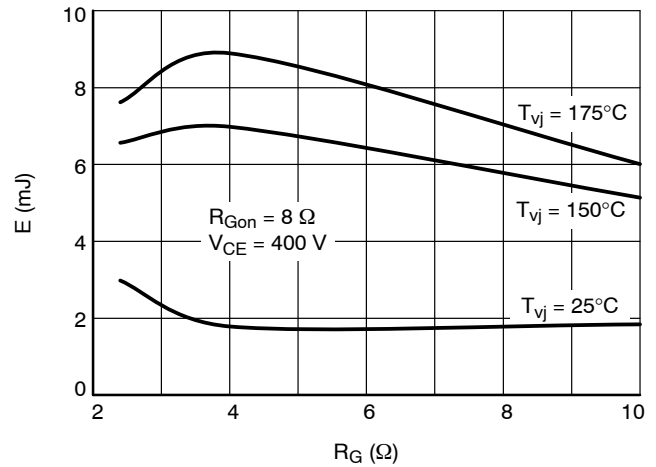


Figure 15. Diode Switching Losses vs.  $R_G$

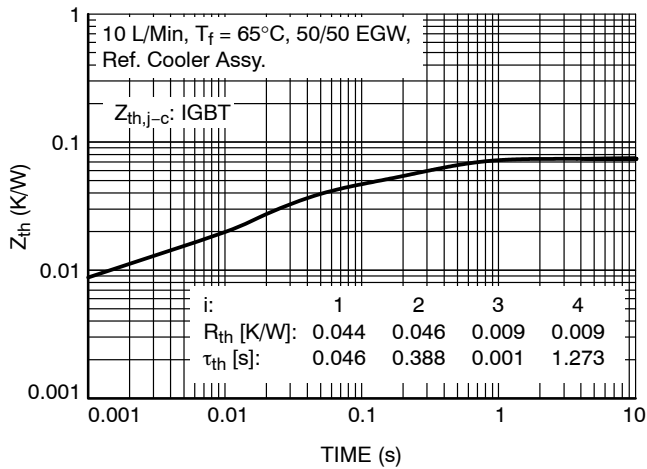


Figure 16. IGBT Transient Thermal Impedance (Typ.)

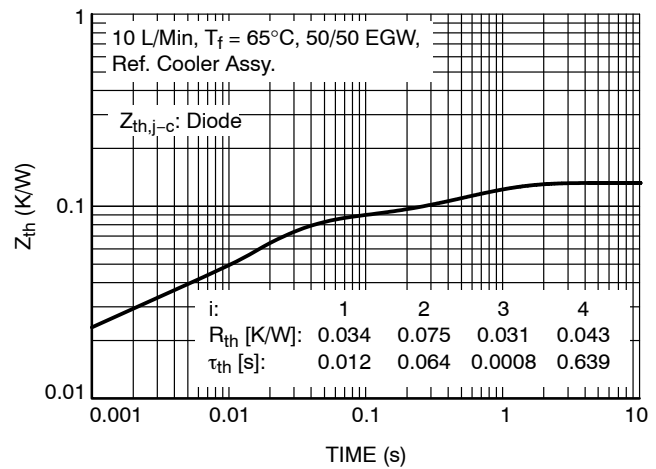


Figure 17. Diode Transient Thermal Impedance (Typ.)

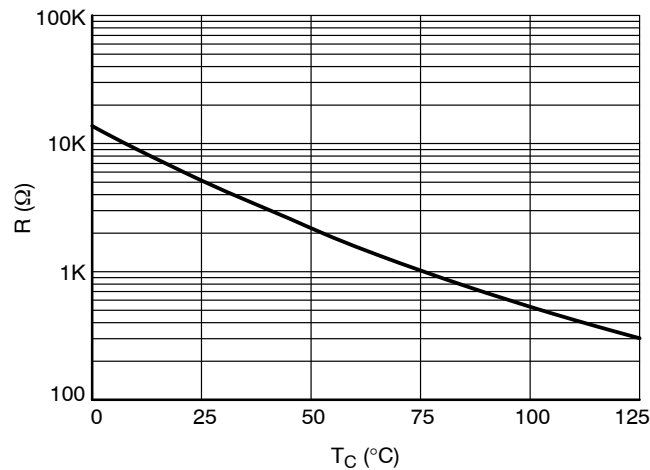


Figure 18. NTC Thermistor - Temperature Characteristic (Typical)

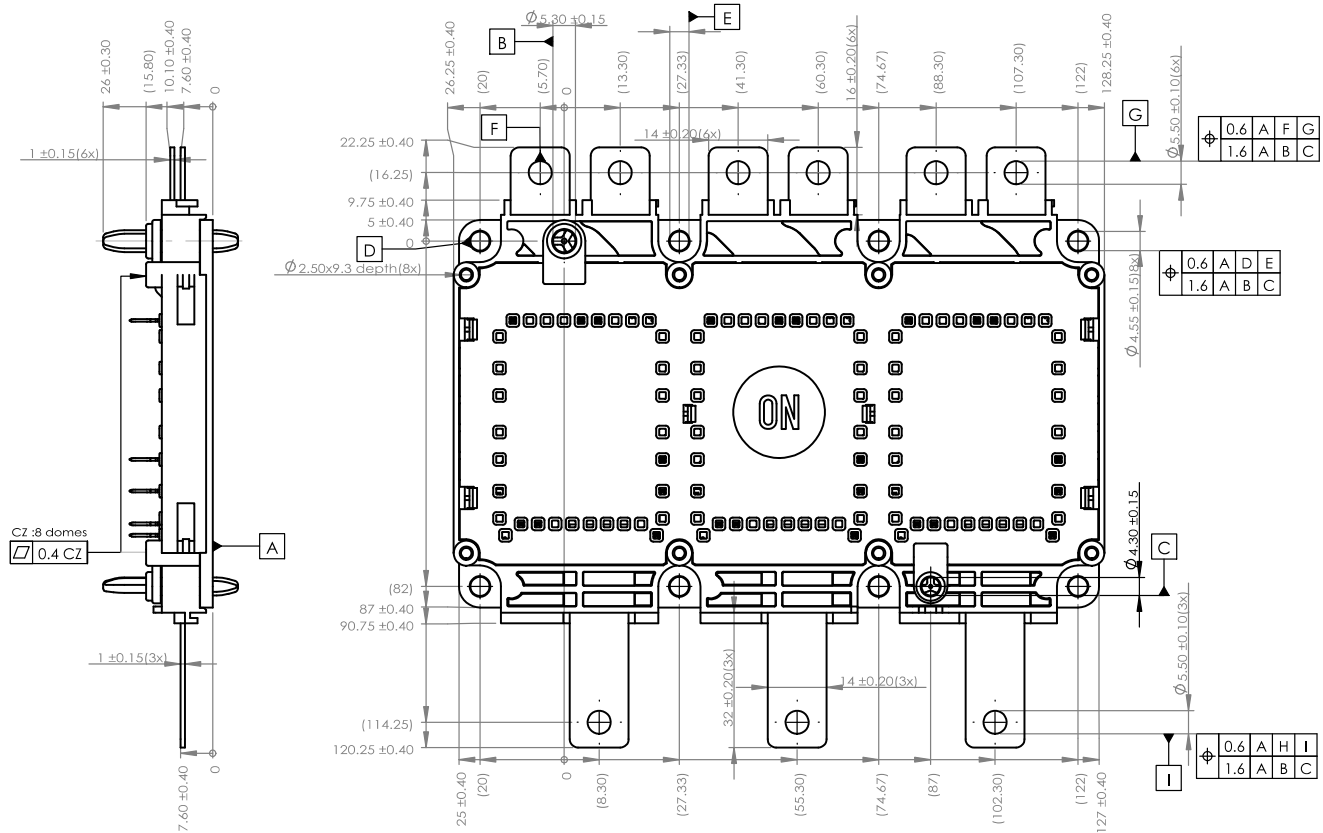
## VE-Trac™ Direct Module NVH660S75L4SPFC

## PACKAGE DIMENSIONS

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CASE 183AF

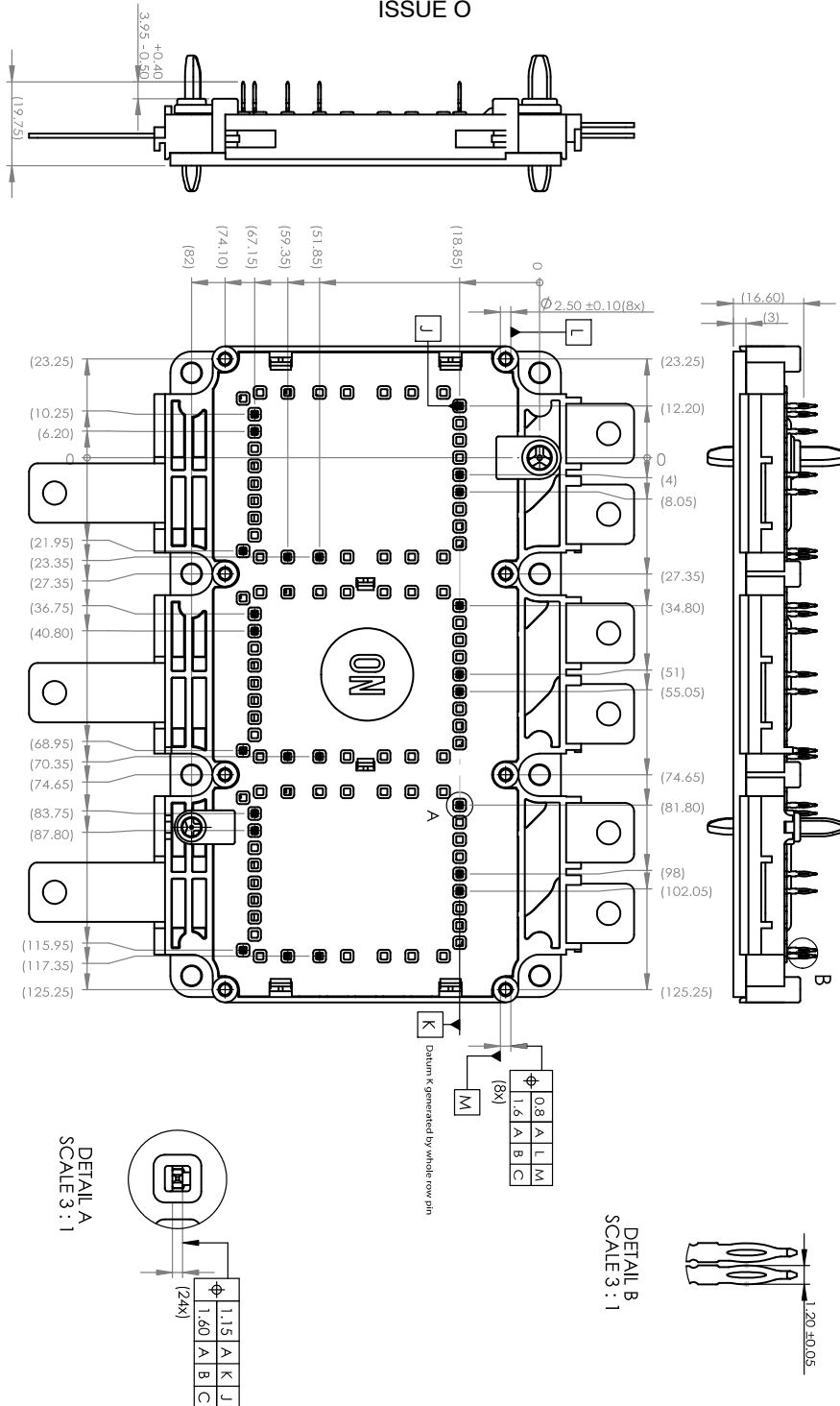
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