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# Automotive 750 V, 680 A Single Side Direct Cooling 6-Pack Power Module



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## VE-Trac™ Direct Module NVH680S75L4SPC

### Product Description

The NVH680S75L4SPC 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.

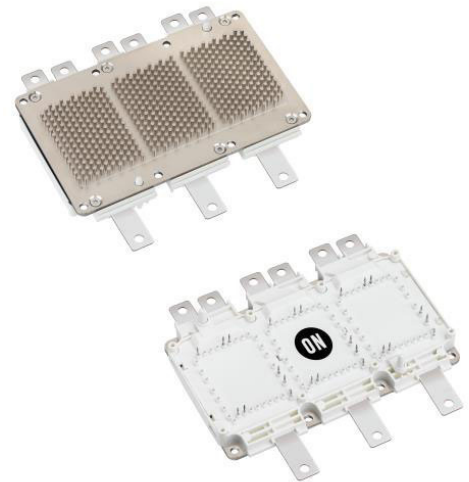
For assembly ease and reliability, a new generation of press-fit pins are integrated into the power module signal terminals. In addition, the power module has an optimized pin-fin heatsink in the baseplate and longer power terminals to easily integrate an external current sensor.

### Features

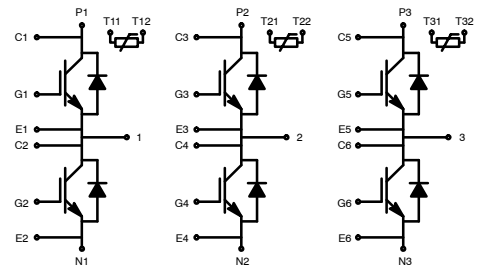
- Direct Cooling w/ Integrated Pin-fin Heatsink
- Ultra-low Stray Inductance
- $T_{jmax} = 175^{\circ}\text{C}$  Continuous Operation
- Low  $V_{CESAT}$  and Switching Losses
- Automotive Grade FS4 750 V Narrow Mesa IGBT
- Fast Recovery Diode Chip Technologies
- 4.2 kV Isolated DBC Substrate
- Easy to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

### Typical Applications

- Hybrid and Electric Vehicle Traction Inverter
- High Power Converters



**SSDC33, 154.50x92.0 (SPC)  
CASE 183AC**



### MARKING DIAGRAM

XXXXXXXXXXXXXXXXXXXXX  
ATYYWW

XXXXX = Specific Device Code  
AT = Assembly & Test Site Code  
YYWW = Year and Work Week Code

### ORDERING INFORMATION

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

# VE-Trac™ Direct Module NVH680S75L4SPC

## Pin Description

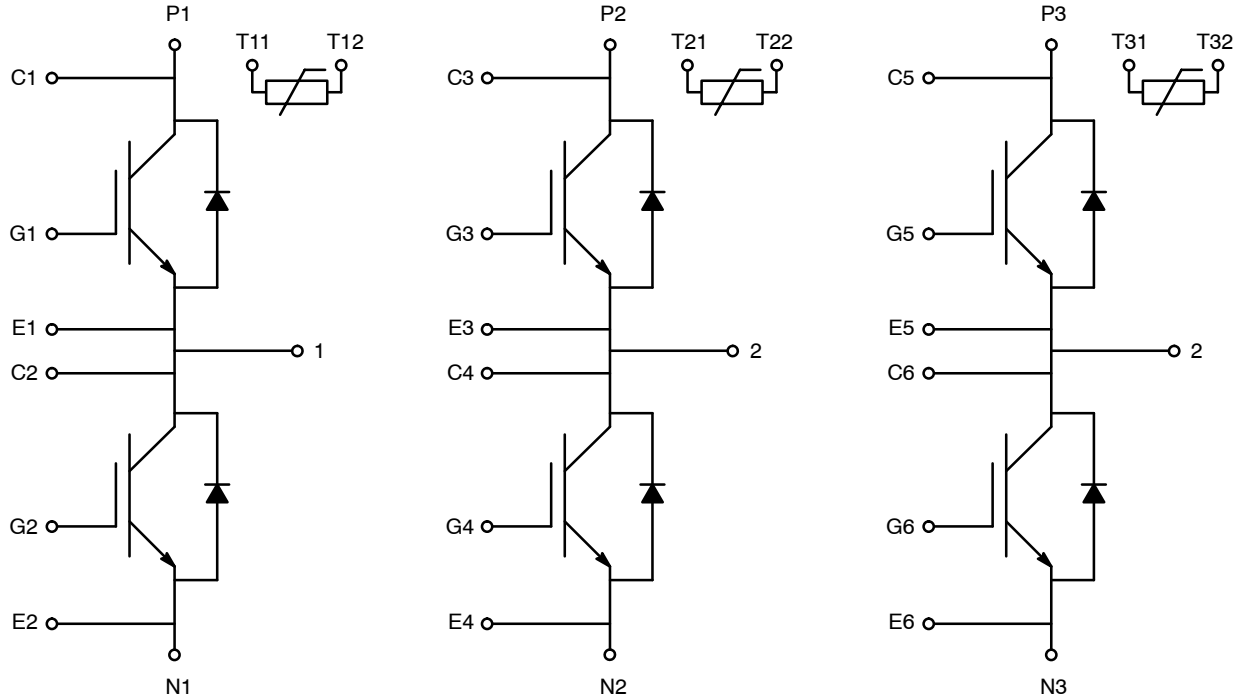


Figure 1. Pin Description

## 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

Pin-fin Base plate: Copper + Ni plating

## Flammability Information

The module frame meets UL94V-0 flammability rating.

# VE-Trac™ Direct Module NVH680S75L4SPC

## 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	10	nH
RCC'+EE'	Module Lead Resistance, Terminals – Chip	0.75	mΩ
G	Module Weight	700	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

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
Δp	Pressure Drop in Cooling Circuit	10 L/min, 65°C, 50/50 EGW	-	95	-	mbar
P (Note 1)	Maximum Pressure in Cooling Loop (relative)	T <sub>Baseplate</sub> < 40°C T <sub>Baseplate</sub> > 40°C	- -	- -	2.5 2.0	bar

1. EPDM rubber 50 durometer 'O' ring used.

## 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	680	A
I <sub>C nom</sub>	Continuous DC Collector Current, T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink	500 (Note 2)	A
I <sub>CRM</sub>	Pulsed Collector Current @ V <sub>GE</sub> = 15 V, t <sub>p</sub> = 1 mS	1360	A
P <sub>tot</sub>	Total Power Dissipation T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink	800	W

### DIODE

V <sub>RRM</sub>	Repetitive Peak Reverse Voltage	750	V
I <sub>FN</sub>	Implemented Forward Current	680	A
I <sub>F</sub>	Continuous Forward Current, T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink	330 (Note 2)	A
I <sub>FRM</sub>	Repetitive Peak Forward Current, t <sub>p</sub> = 1 mS	1360	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	A <sup>2</sup> s

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.

2. Verified by characterization/design, not by test.

# VE-Trac™ Direct Module NVH680S75L4SPC

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

Symbol	Parameters	Conditions	Min	Typ	Max	Unit	
$V_{CESAT}$	Collector to Emitter Saturation Voltage (Terminal)	$V_{GE} = 15\text{ V}$ , $I_C = 500\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	-	1.33	1.58	V
	Collector to Emitter Saturation Voltage (Chip)	$V_{GE} = 15\text{ V}$ , $I_C = 500\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	-	1.30	1.55	
			$T_{vj} = 150^{\circ}\text{C}$	-	1.44	-	
		$V_{GE} = 15\text{ V}$ , $I_C = 680\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	-	1.45	-	
			$T_{vj} = 150^{\circ}\text{C}$	-	1.67	-	
			$T_{vj} = 175^{\circ}\text{C}$	-	1.71	-	
$I_{CES}$	Collector to Emitter Leakage Current	$V_{GE} = 0$ , $V_{CE} = 750\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	-	-	500	$\mu\text{A}$
			$T_{vj} = 150^{\circ}\text{C}$	-	2.0	-	$\text{mA}$
$I_{GES}$	Gate – Emitter Leakage Current	$V_{CE} = 0$ , $V_{GE} = \pm 20\text{ V}$		-	-	$\pm 300$	nA
$V_{th}$	Threshold Voltage	$V_{CE} = V_{GE}$ , $I_C = 90\text{ mA}$		4.8	5.7	6.6	V
$Q_G$	Total Gate Charge	$V_{GE} = -8$ to $15\text{ V}$ , $V_{CE} = 400\text{ V}$		-	2.0	-	$\mu\text{C}$
$R_{Gint}$	Internal Gate Resistance			-	1.7	-	$\Omega$
$C_{ies}$	Input Capacitance	$V_{CE} = 30\text{ V}$ , $V_{GE} = 0\text{ V}$ , $f = 0.1\text{ MHz}$		-	48	-	nF
$C_{oes}$	Output Capacitance	$V_{CE} = 30\text{ V}$ , $V_{GE} = 0\text{ V}$ , $f = 0.1\text{ MHz}$		-	1.5	-	nF
$C_{res}$	Reverse Transfer Capacitance	$V_{CE} = 30\text{ V}$ , $V_{GE} = 0\text{ V}$ , $f = 0.1\text{ MHz}$		-	0.2	-	nF
$T_{d,on}$	Turn On Delay, Inductive Load	$I_C = 500\text{ A}$ , $V_{CE} = 400\text{ V}$ , $V_{GE} = +15/-8\text{ V}$ , $R_{g,on} = 4.7\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$	-	240	-	ns
			$T_{vj} = 150^{\circ}\text{C}$	-	228	-	
			$T_{vj} = 175^{\circ}\text{C}$	-	231	-	
$T_r$	Rise Time, Inductive Load	$I_C = 500\text{ A}$ , $V_{CE} = 400\text{ V}$ , $V_{GE} = +15/-8\text{ V}$ , $R_{g,on} = 4.7\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$	-	115	-	ns
			$T_{vj} = 150^{\circ}\text{C}$	-	134	-	
			$T_{vj} = 175^{\circ}\text{C}$	-	141	-	
$T_{d,off}$	Turn Off Delay, Inductive Load	$I_C = 500\text{ A}$ , $V_{CE} = 400\text{ V}$ , $V_{GE} = +15/-8\text{ V}$ , $R_{g,off} = 18\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$	-	1230	-	ns
			$T_{vj} = 150^{\circ}\text{C}$	-	1369	-	
			$T_{vj} = 175^{\circ}\text{C}$	-	1400	-	
$T_f$	Fall Time, Inductive Load	$I_C = 500\text{ A}$ , $V_{CE} = 400\text{ V}$ , $V_{GE} = +15/-8\text{ V}$ , $R_{g,off} = 18\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$	-	144	-	ns
			$T_{vj} = 150^{\circ}\text{C}$	-	243	-	
			$T_{vj} = 175^{\circ}\text{C}$	-	266	-	
$E_{ON}$	Turn On Switching Loss (Including Diode Reverse Recovery Loss)	$I_C = 500\text{ A}$ , $V_{CE} = 400\text{ V}$ , $V_{GE} = +15/-8\text{ V}$ , $L_s = 22\text{ nH}$ , $R_{g,on} = 4.7\ \Omega$	$di/dt = 3.5\text{ A/nS}$ , $T_{vj} = 25^{\circ}\text{C}$	-	22	-	mJ
			$di/dt = 3.0\text{ A/nS}$ , $T_{vj} = 150^{\circ}\text{C}$	-	33	-	
			$di/dt = 2.8\text{ A/nS}$ , $T_{vj} = 175^{\circ}\text{C}$	-	35	-	
$E_{OFF}$	Turn Off Switching Loss	$I_C = 500\text{ A}$ , $V_{CE} = 400\text{ V}$ , $V_{GE} = +15/-8\text{ V}$ , $L_s = 22\text{ nH}$ , $R_{g,off} = 18\ \Omega$	$dv/dt = 2.5\text{ V/nS}$ , $T_{vj} = 25^{\circ}\text{C}$	-	27	-	mJ
			$dv/dt = 1.7\text{ V/nS}$ , $T_{vj} = 150^{\circ}\text{C}$	-	41	-	
			$dv/dt = 1.6\text{ V/nS}$ , $T_{vj} = 175^{\circ}\text{C}$	-	45	-	
$E_{SC}$	Minimum Short Circuit Energy Withstand	$V_{GE} = 15\text{ V}$ , $V_{CC} = 400\text{ V}$	$T_{vj} = 175^{\circ}\text{C}$	3	-	-	J

# VE-Trac™ Direct Module NVH680S75L4SPC

## 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)	$I_F = 500\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	-	1.60	1.85	V
	Diode Forward Voltage (Chip)	$I_F = 500\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	-	1.53	1.78	
			$T_{vj} = 150^{\circ}\text{C}$	-	1.45	-	
		$I_F = 680\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	-	1.65	-	
			$T_{vj} = 150^{\circ}\text{C}$	-	1.61	-	
			$T_{vj} = 175^{\circ}\text{C}$	-	1.57	-	
$E_{rr}$	Reverse Recovery Energy	$I_F = 500\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = +15/-8\text{ V}$ , $R_{g,on} = 4.7\ \Omega$	$di/dt = 3.5\text{ A/nS}$ , $T_{vj} = 25^{\circ}\text{C}$	-	3	-	mJ
			$di/dt = 3.0\text{ A/nS}$ , $T_{vj} = 150^{\circ}\text{C}$	-	8	-	
			$di/dt = 2.8\text{ A/nS}$ , $T_{vj} = 175^{\circ}\text{C}$	-	10	-	
$Q_{RR}$	Recovered Charge	$I_F = 500\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = -8\text{ V}$ , $R_{g,on} = 4.7\ \Omega$	$di/dt = 3.5\text{ A/nS}$ , $T_{vj} = 25^{\circ}\text{C}$	-	11	-	$\mu\text{C}$
			$di/dt = 3.0\text{ A/nS}$ , $T_{vj} = 150^{\circ}\text{C}$	-	32	-	
			$di/dt = 2.8\text{ A/nS}$ , $T_{vj} = 175^{\circ}\text{C}$	-	38	-	
$I_{rr}$	Peak Reverse Recovery Current	$I_F = 500\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = -8\text{ V}$ , $R_{g,on} = 4.7\ \Omega$	$di/dt = 3.5\text{ A/nS}$ , $T_{vj} = 25^{\circ}\text{C}$	-	141	-	A
			$di/dt = 3.0\text{ A/nS}$ , $T_{vj} = 150^{\circ}\text{C}$	-	247	-	
			$di/dt = 2.8\text{ A/nS}$ , $T_{vj} = 175^{\circ}\text{C}$	-	265	-	

## 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

3. Measured value at terminals.

## THERMAL CHARACTERISTICS

Symbol	Parameter	Min	Typ	Max	Unit
IGBT. $R_{th,J-F}$	$R_{th}$ , Junction to Fluid, 10 L/min, 65°C, 50/50 EGW	-	0.14	0.16	$^{\circ}\text{C/W}$
Diode. $R_{th,J-F}$	$R_{th}$ , Junction to Fluid, 10 L/min, 65°C, 50/50 EGW	-	0.20	0.23	$^{\circ}\text{C/W}$

## ORDERING INFORMATION

Part Number	Package	Shipping
NVH680S75L4SPC	SSDC33, 154.50x92.0 (SPC) (Pb-Free)	4 Units / Tray

TYPICAL CHARACTERISTICS

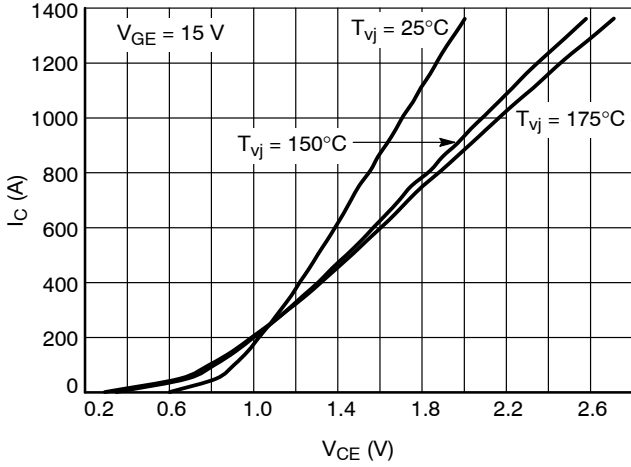


Figure 2. IGBT Output Characteristic

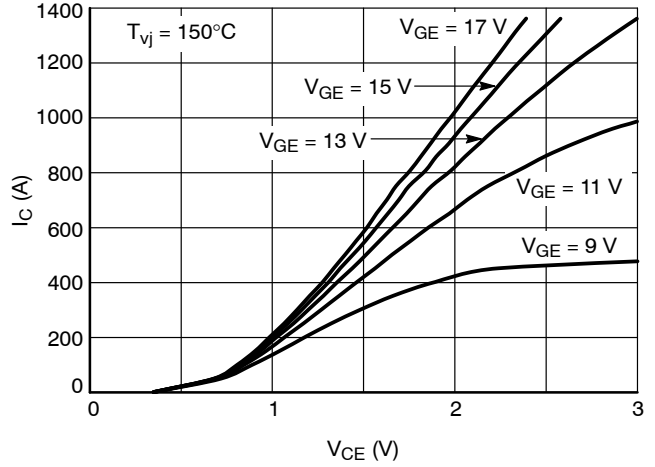


Figure 3. IGBT Output Characteristic

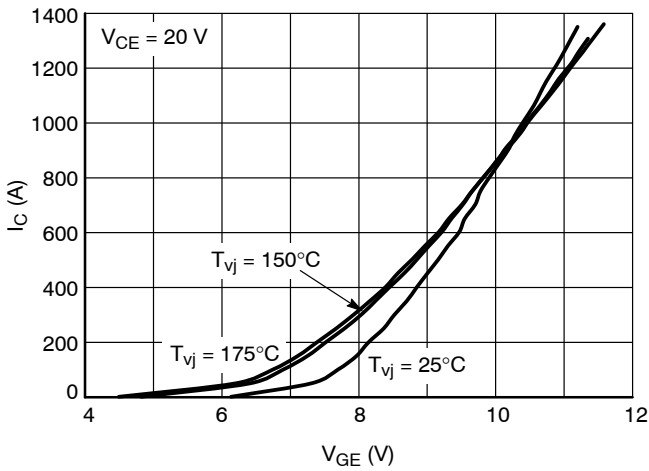


Figure 4. IGBT Transfer Characteristic

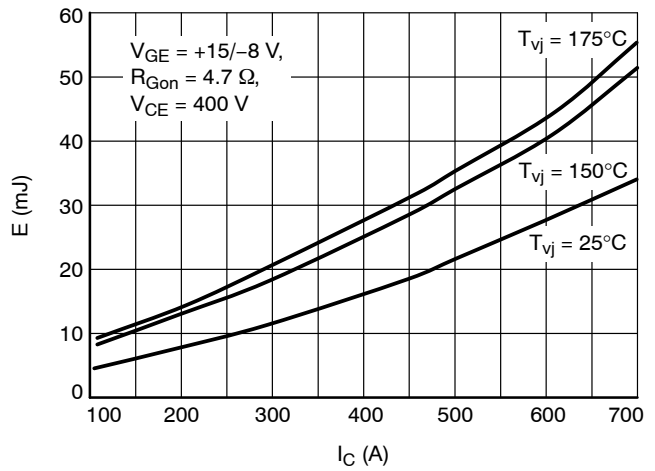


Figure 5. IGBT Turn-on Losses vs. Ic

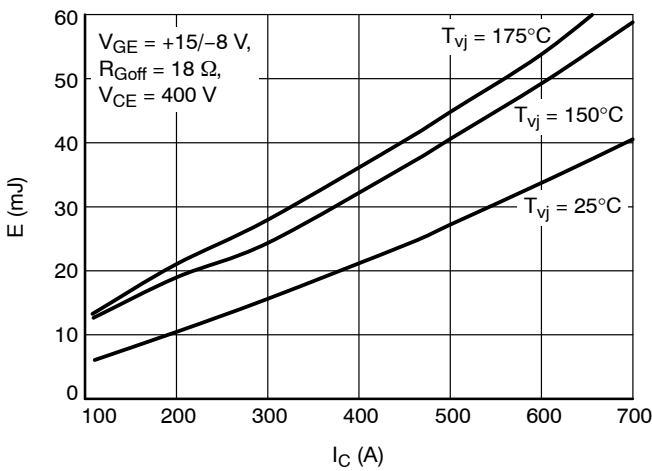


Figure 6. IGBT Turn-off Losses vs. Ic

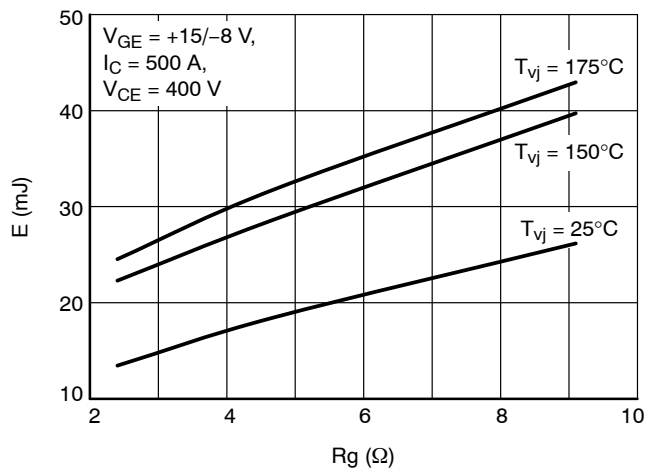


Figure 7. Eon vs. Rg

TYPICAL CHARACTERISTICS

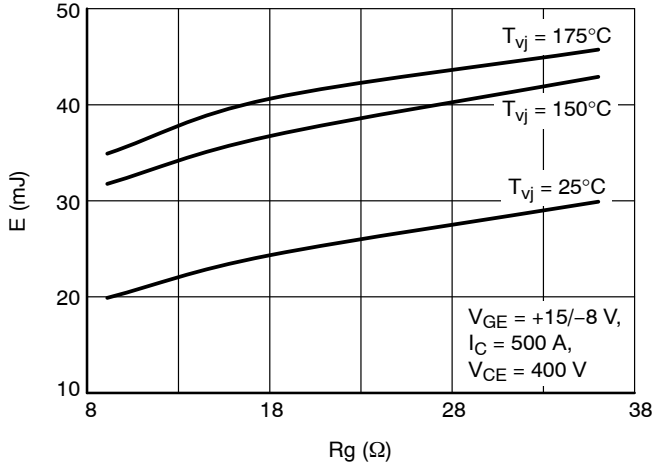


Figure 8. Eoff vs. Rg

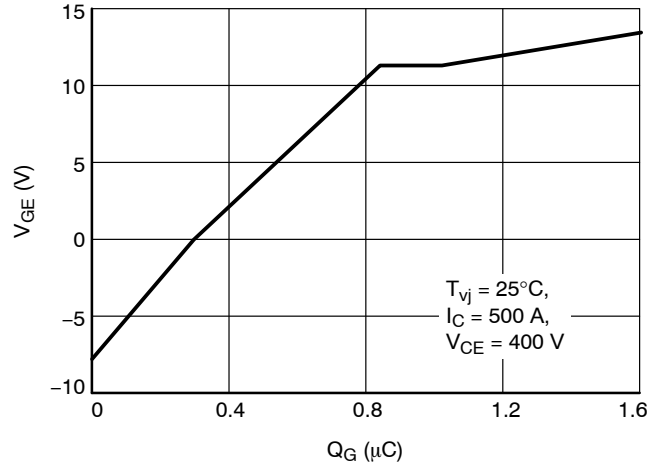


Figure 9. Gate Charge Characteristic

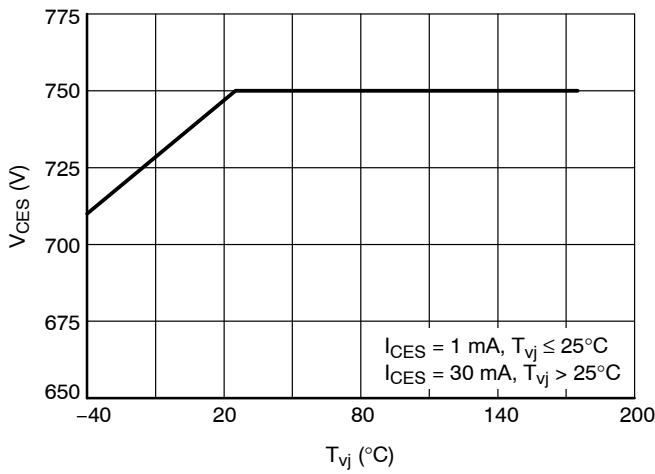


Figure 10. Maximum Allowed  $V_{CE}$

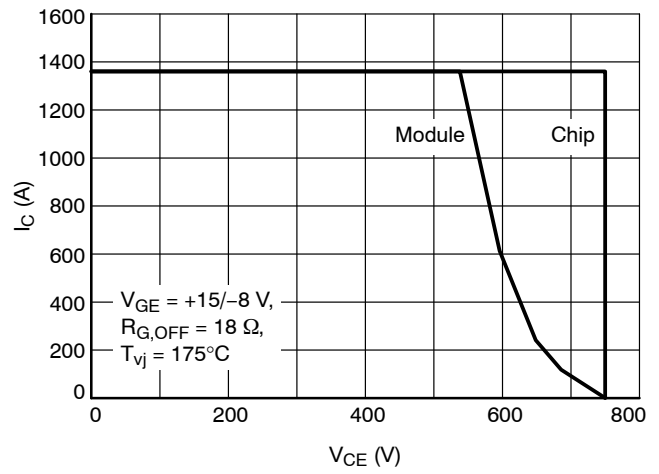


Figure 11. Reverse Bias Safe Operating Area

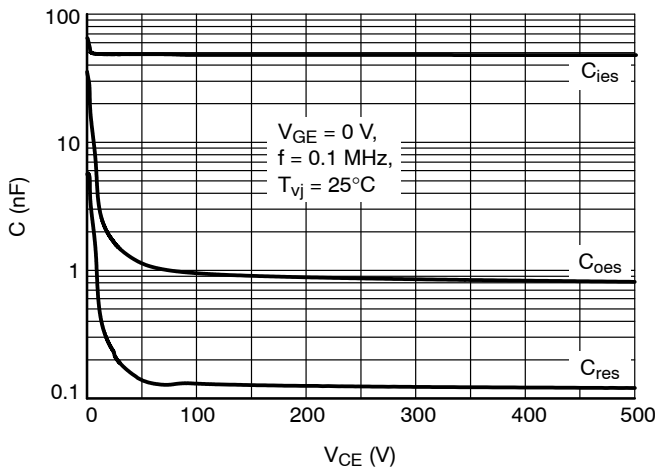


Figure 12. Capacitance Characteristic

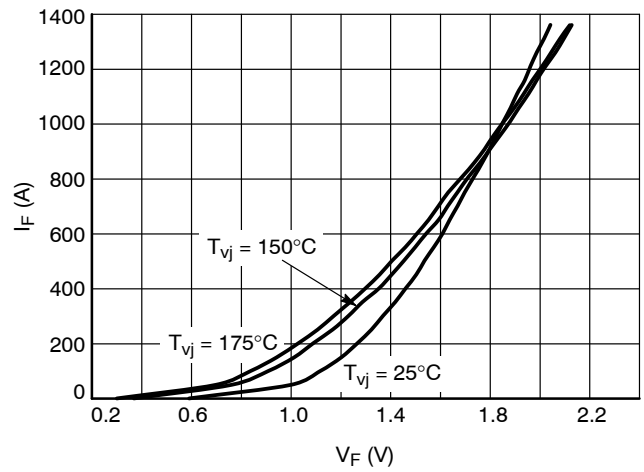


Figure 13. Diode Forward Characteristic



TYPICAL CHARACTERISTICS

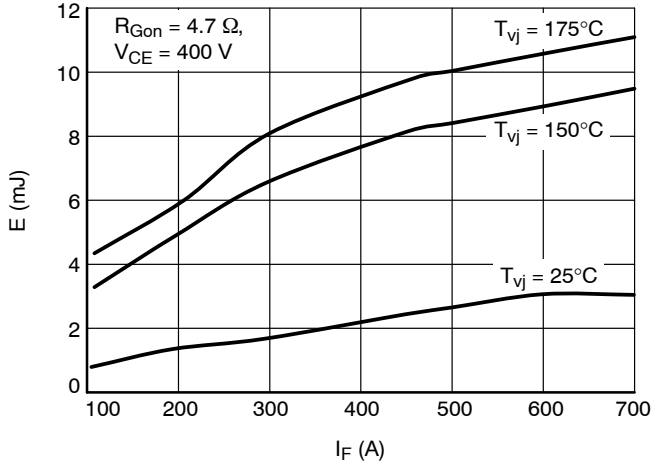


Figure 14. Diode Switching Losses vs. I<sub>F</sub>

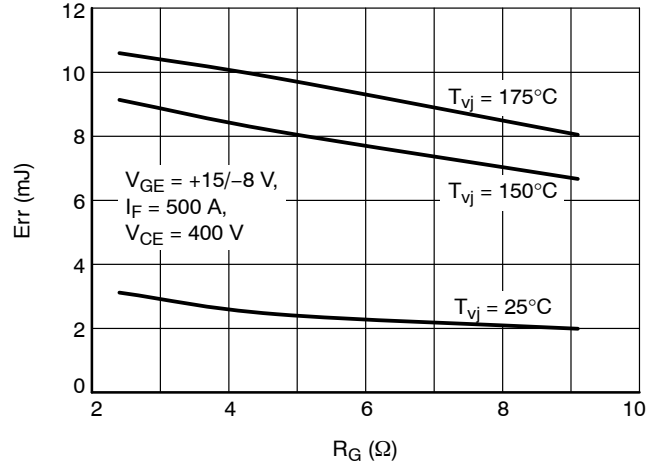


Figure 15. Diode Switching Losses vs. R<sub>G</sub>

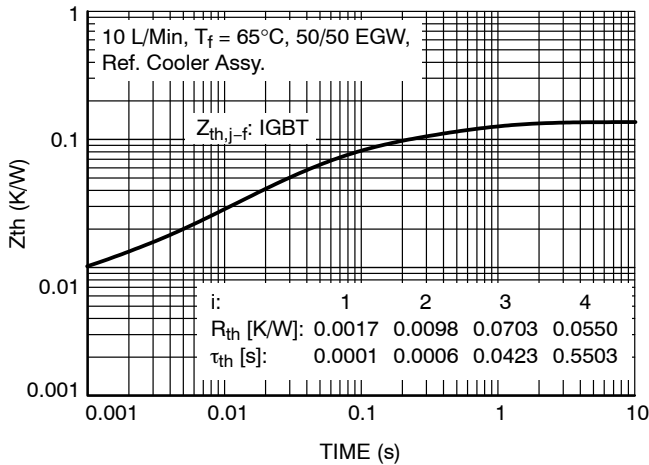


Figure 16. IGBT Transient Thermal Impedance (Typ.)

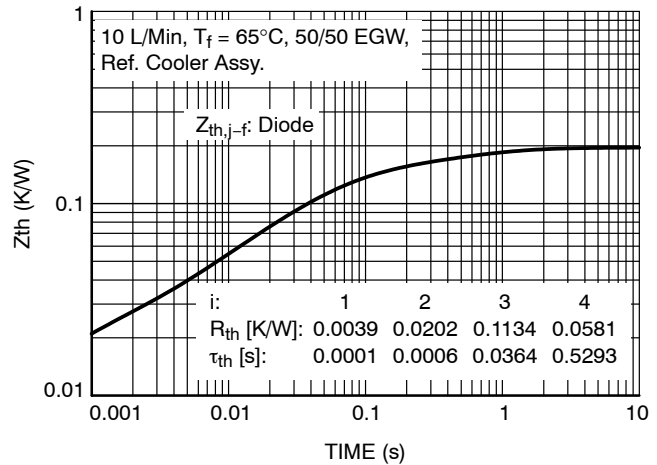


Figure 17. Diode Transient Thermal Impedance (Typ.)

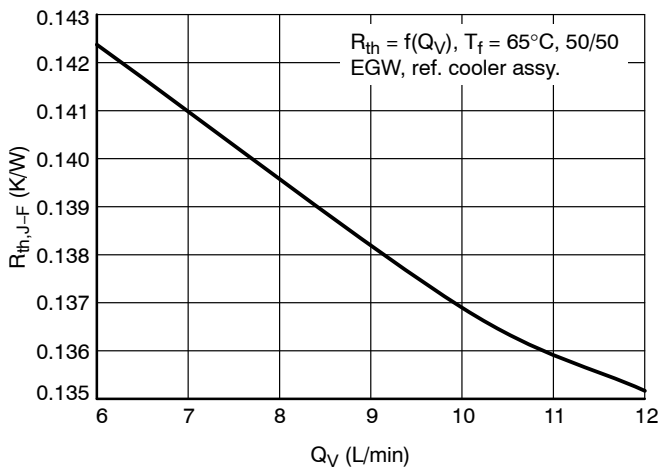


Figure 18. IGBT, Thermal Resistance (Typ)

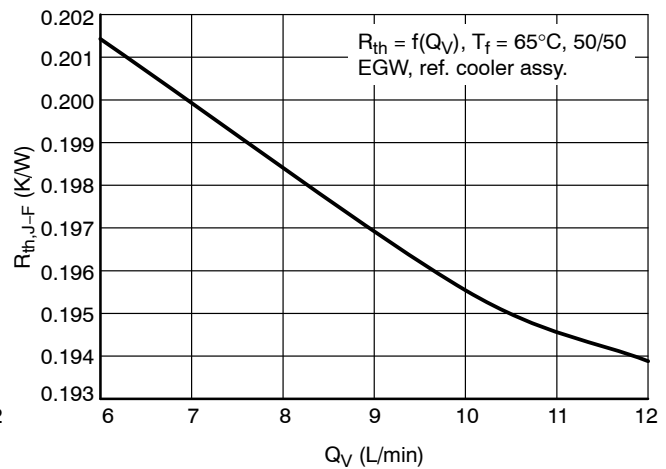


Figure 19. Diode, Thermal Resistance (Typ)

# VE-Trac™ Direct Module NVH680S75L4SPC

## TYPICAL CHARACTERISTICS

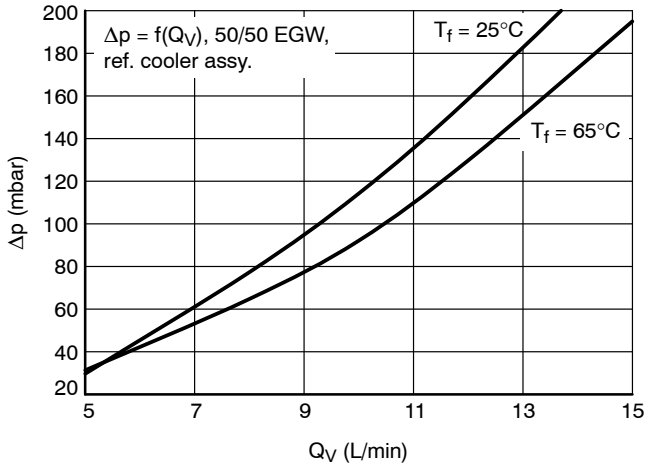


Figure 20. Pressure Drop In Cooling Circuit

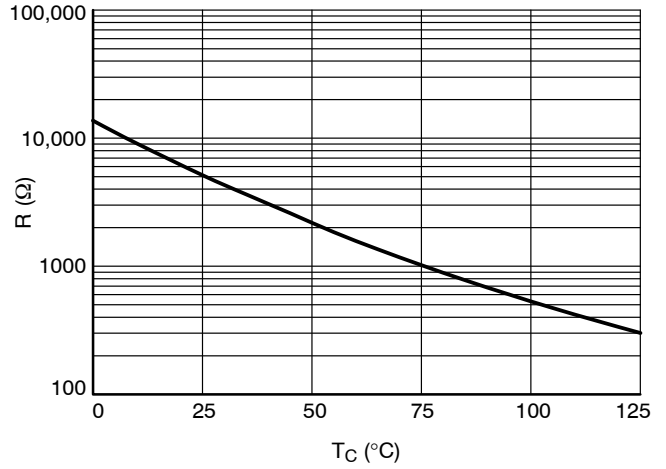


Figure 21. NTC Thermistor - Temperature Characteristic (Typical)

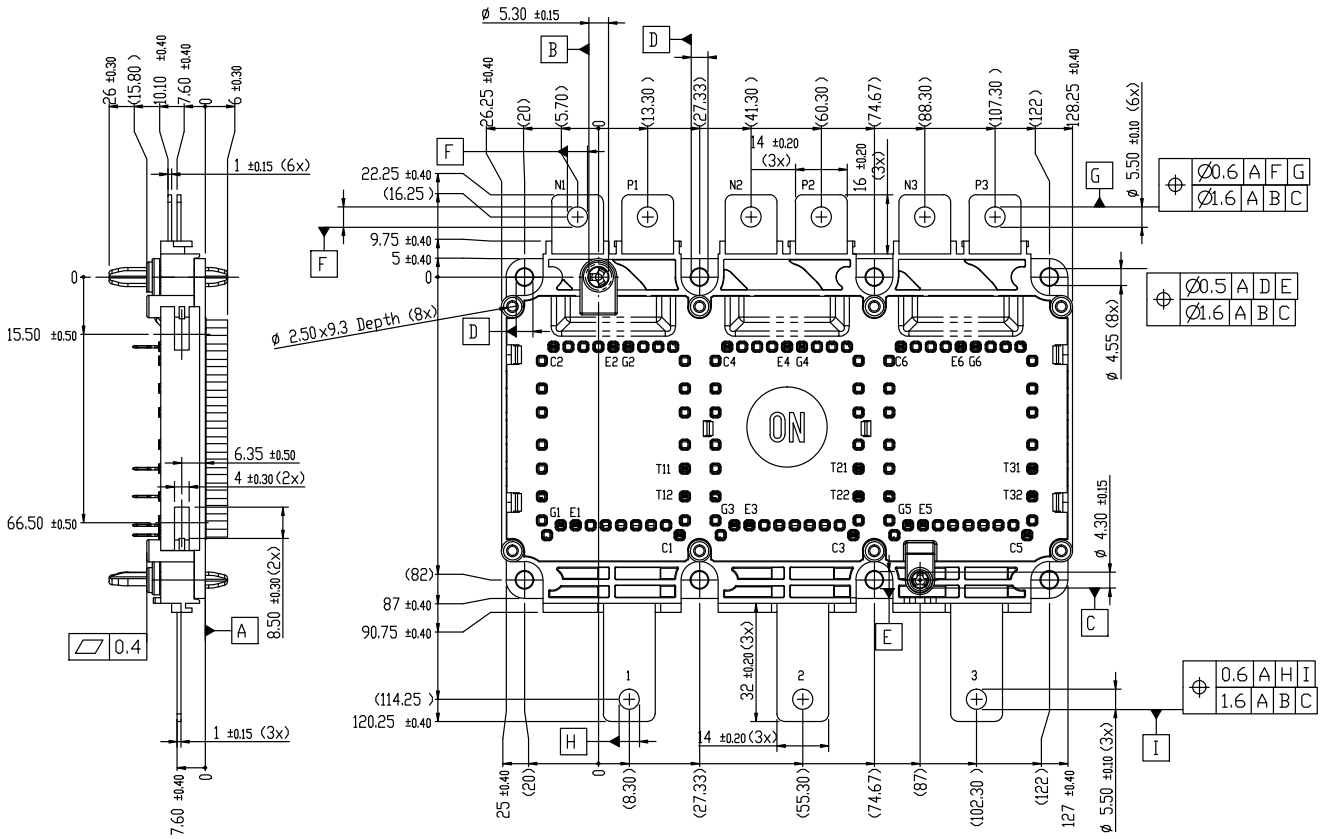
# VE-Trac™ Direct Module NVH680S75L4SPC

## PACKAGE DIMENSIONS

SSDC33, 154.50x92.0 (SPC)

CASE 183AC

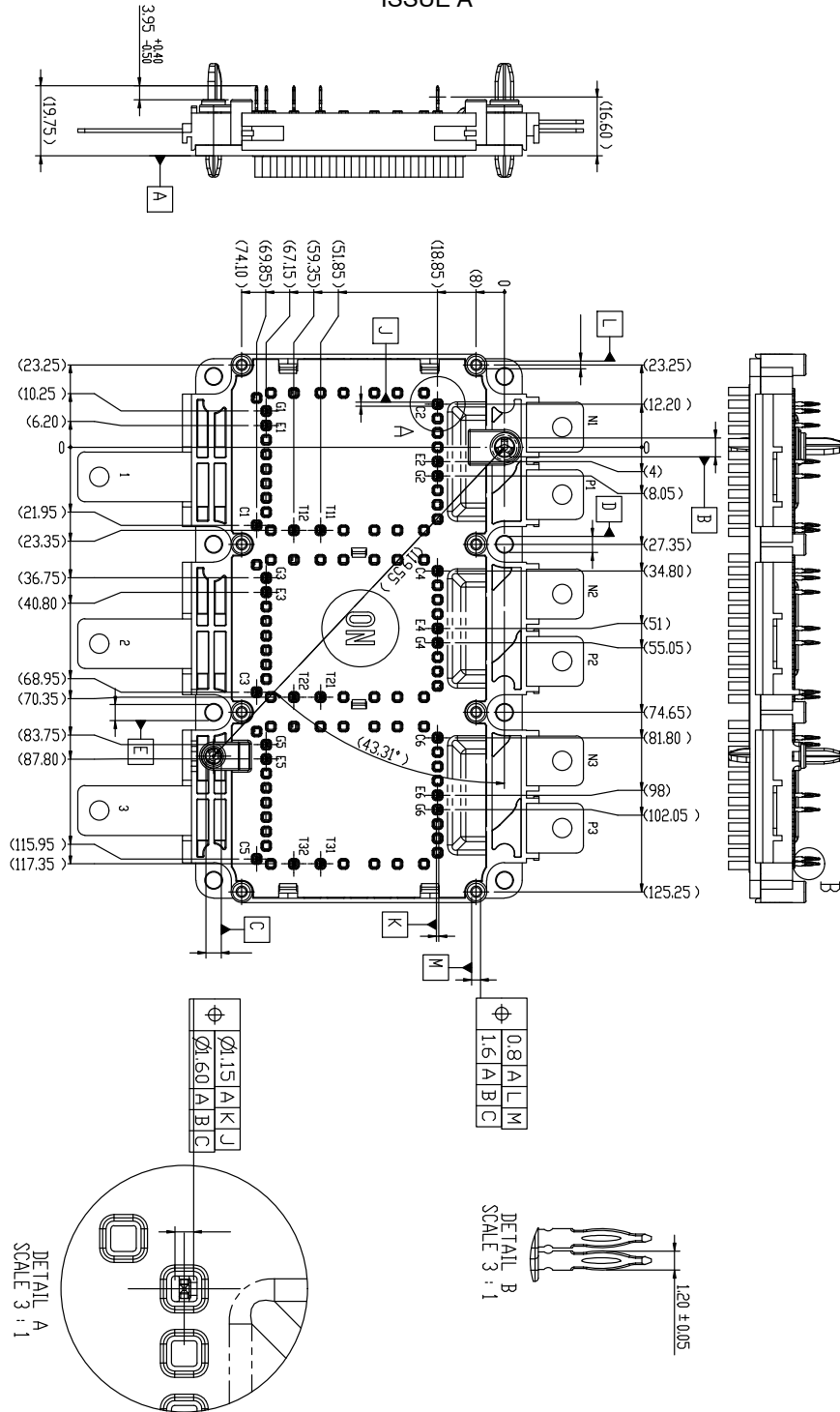
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# VE-Trac™ Direct Module NVH680S75L4SPC

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