

ASPM 27 Series

Automotive 3-Phase 650 V 60 A Smart Power Module

NFVA36065L42

General Description

NFVA36065L42 is an advanced Automotive SPM[®] module providing a fully-featured, high-performance inverter output stage for hybrid and electric vehicles. 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

- Automotive SPM in 27 Pin DIP Package
- Preparing for AEC & AQC324 Qualified
- 650 V/60 A 3-Phase IGBT Inverter with Integral Gate Drivers and Protections
- 175°C Guaranteed Short-Circuit Rated FS Trench IGBTs with Low V_{ce(sat)} and Fast Switching
- Outstanding Thermal Resistance Using AlN DBC Substrate
- Separated Open-Emitter Pins from Low-Side IGBTs for Three-Phase Current Sensing
- Single-Grounded Power Supply
- LVIC Temperature-Sensing Built-In for Temperature Monitoring
- Isolation Rating: 2500 V_{rms}/1 min.
- Pb-Free and RoHS Compliant

Applications

- Automotive High Voltage Auxiliary Motors
 - ◆ Climate e-Compressors
 - ◆ Oil / Water Pumps
 - ◆ Super / Turbo Chargers
 - ◆ Variety Fans

Related Resources

- [AND9800](#) – Automotive Smart Power Module, 650 V ASPM27 Series
- [AN-9086](#) – SPM 3 Package Mounting Guide



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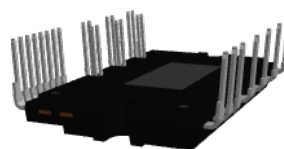
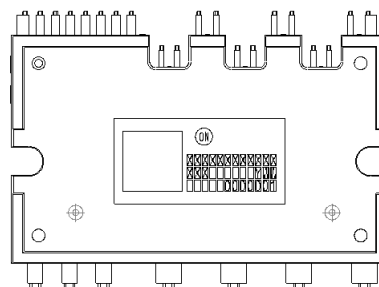


Figure 1. 3D Package Drawing
(Click to Active 3D Content)

**ASPM27-CCA
CASE MODCB**

MARKING DIAGRAM



ON	= ON Semiconductor Logo
XXXXXXXXXXXX	= Specific Device Code
XXX	= Lot Number
Y	= Year
WW	= Work Week
0000001	= Serial Number

ORDERING INFORMATION

See detailed ordering and shipping information on page 6 of this data sheet.

NFVA36065L42

Integrated Power Functions

- 650 V–60 A IGBT inverter for three–phase DC/AC power conversion (Refer to Figure 3)

Integrated Drive, Protection and System Control Functions

- For inverter high–side IGBTs: gate drive circuit, high–voltage isolated high–speed level shifting control circuit, Under–Voltage Lock–Out Protection (UVLO)
- For inverter low–side IGBTs: gate drive circuit, Short–Circuit Protection (SCP) control supply circuit, Under–Voltage Lock–Out Protection (UVLO)
- Fault signaling: corresponding to UVLO (low–side supply) and SC faults
- Input interface: active–HIGH interface, works with 3.3/5 V logic, Schmitt–trigger input

PIN CONFIGURATION

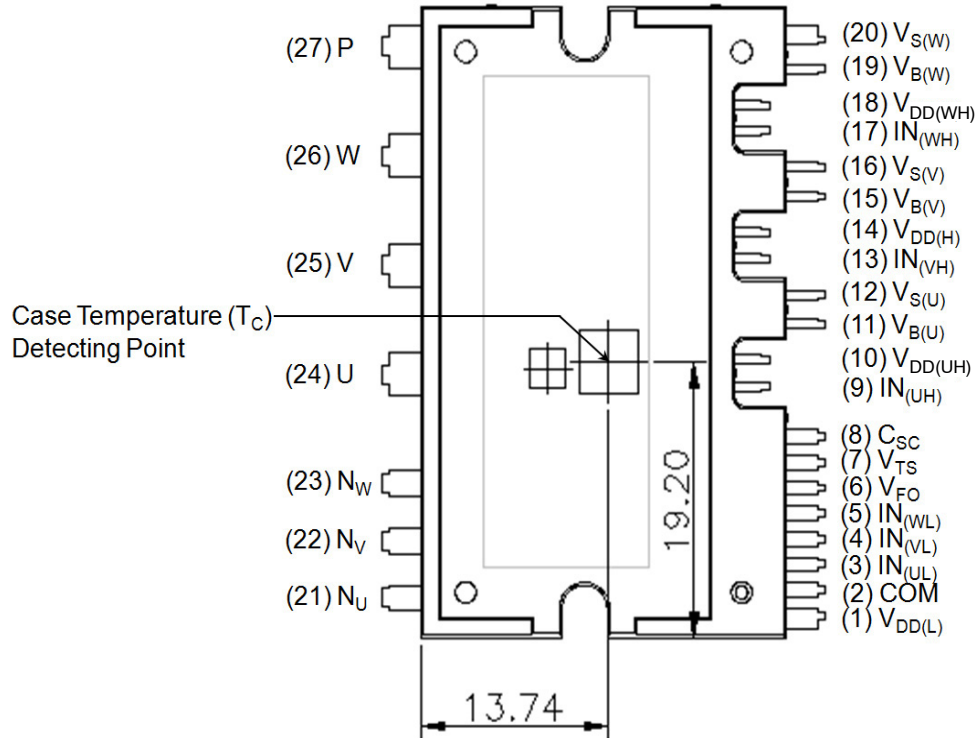


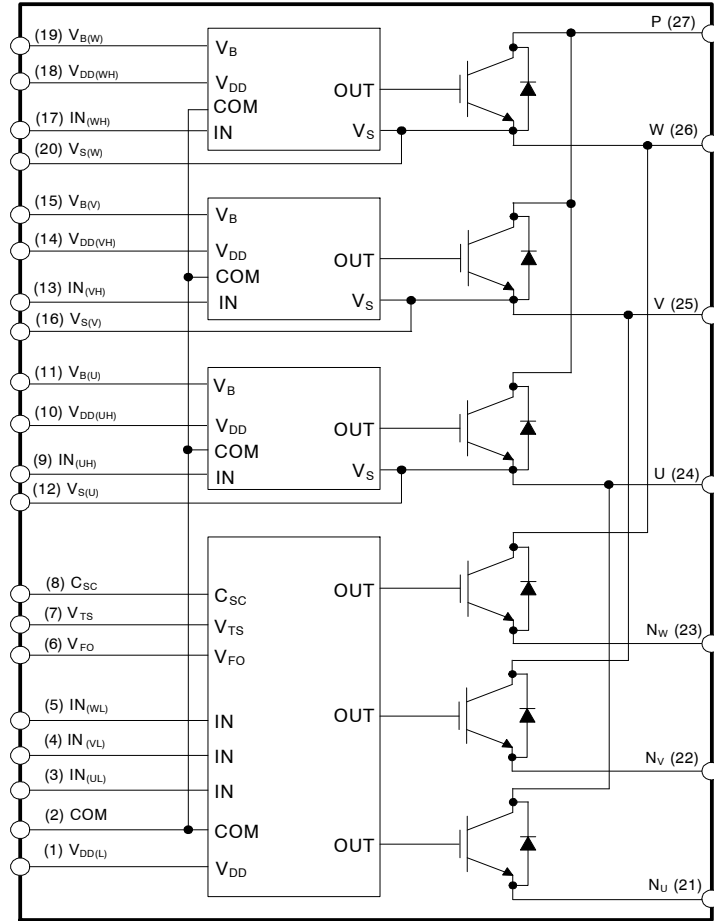
Figure 2. Top View

NFVA36065L42

PIN DESCRIPTIONS

Pin Number	Pin Name	Pin Description
1	V _{DD(L)}	Low-Side Common Bias Voltage for IC and IGBTs Driving
2	COM	Common Supply Ground
3	IN _(UL)	Signal Input for Low-Side U-Phase
4	IN _(VL)	Signal Input for Low-Side V-Phase
5	IN _(WL)	Signal Input for Low-Side W-Phase
6	V _{FO}	Fault Output
7	V _{TS}	Output for LVIC Temperature Sensing Voltage Output
8	C _{SC}	Shut Down Input for Short-Circuit Current Detection Input
9	IN _(UH)	Signal Input for High-Side V-Phase
10	V _{DD(UH)}	High-Side Common Bias Voltage for IC and IGBTs Driving
11	V _{B(U)}	High-Side Bias Voltage for U-Phase IGBT Driving
12	V _{S(U)}	High-Side Bias Voltage Ground for U-Phase IGBT Driving
13	IN _(VH)	Signal Input for High-Side V-Phase
14	V _{DD(VH)}	High-Side Common Bias Voltage for IC and IGBTs Driving
15	V _{B(V)}	High-Side Bias Voltage for V-Phase IGBT Driving
16	V _{S(V)}	High-Side Bias Voltage Ground for V-Phase IGBT Driving
17	IN _(WH)	Signal Input for High-Side W-Phase
18	V _{DD(WH)}	High-Side Common Bias Voltage for IC and IGBTs Driving
19	V _{B(W)}	High-Side Bias Voltage for W-Phase IGBT Driving
20	V _{S(W)}	High-Side Bias Voltage Ground for W-Phase IGBT Driving
21	N _U	Negative DC-Link Input for U-Phase
22	N _V	Negative DC-Link Input for V-Phase
23	N _W	Negative DC-Link Input for W-Phase
24	U	Output for U-Phase
25	V	Output for V-Phase
26	W	Output for W-Phase
27	P	Positive DC-Link Input

INTERNAL EQUIVALENT CIRCUIT AND INPUT/OUTPUT PINS



NOTES:

1. Inverter low-side is composed of three IGBTs, freewheeling diodes for each IGBT, and one control IC. It has gate drive and protection functions.
2. Inverter power side is composed of four inverter DC-link input terminals and three inverter output terminals.
3. Inverter high-side is composed of three IGBTs, freewheeling diodes, and three drive ICs for each IGBT.

Figure 3. Internal Block Diagram

NFVA36065L42

ABSOLUTE MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Symbol	Parameter	Conditions	Rating	Unit
INVERTER PART				
V _{PN}	Supply Voltage	Applied between P–N _U , N _V , N _W	500	V
V _{PN(Surge)}	Supply Voltage (Surge)	Applied between P–N _U , N _V , N _W	575	V
V _{CES}	Collector–Emitter Voltage		650	V
±I _C	Each IGBT Collector Current	T _C = 100°C, V _{DD} ≥ 15 V, T _J ≤ 175°C (Note 4)	60	A
±I _{CP}	Each IGBT Collector Current (Peak)	T _C = 25°C, T _J ≤ 175°C, Under 1 ms Pulse Width (Note 4)	120	A
P _C	Collector Dissipation	T _C = 25°C per One Chip (Note 4)	454	W
T _J	Operating Junction Temperature	IGBT and Diode	–40~175	°C
		Driver IC	–40~150	

CONTROL PART

V _{DD}	Control Supply Voltage	Applied between V _{DD(H)} , V _{DD(L)} –COM	20	V
V _{BS}	High–Side Control Bias Voltage	Applied between V _{B(U)} –V _{S(U)} , V _{B(V)} –V _{S(V)} , V _{B(W)} –V _{S(W)}	20	V
V _{IN}	Input Signal Voltage	Applied between IN _(UH) , IN _(VH) , IN _(WH) , IN _(UL) , IN _(VL) , IN _(WL) –COM	–0.3–V _{DD} +0.3	V
V _{FO}	Fault Output Supply Voltage	Applied between V _{FO} –COM	–0.3–V _{DD} +0.3	V
I _{FO}	Fault Output Current	Sink Current at V _{FO} pin	2	mA
V _{SC}	Current Sensing Input Voltage	Applied between C _{SC} –COM	–0.3–V _{DD} +0.3	V

TOTAL SYSTEM

t _{SC}	Short Circuit Withstand Time	V _{DD} = V _{BS} ≤ 16.5, V _{PN} ≤ 400 V, T _J = 150°C Non–repetitive	3	μs
T _{STG}	Storage Temperature		–55~175	°C
V _{ISO}	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.

THERMAL RESISTANCE

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
R _{th(j–c)Q}	Junction to Case Thermal Resistance	Inverter IGBT part (per 1/6 module)	–	–	0.33	°C/W
R _{th(j–c)F}		Inverter FWD part (per 1/6 module)	–	–	0.76	°C/W
L _σ	Package Stray Inductance	P to N _U , N _V , N _W (Note 6)	–	24	–	nH

4. These values had been made an acquisition by the calculation considered to design factor.

5. Stray inductance per phase measured per IEC 60747–15.

ELECTRICAL CHARACTERISTICS – INVERTER PART (T_J as specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$	Collector – Emitter Saturation Voltage	$V_{DD} = V_{BS} = 15\text{ V}$, $V_{IN} = 5\text{ V}$, $I_C = 60\text{ A}$, $T_J = 25^\circ\text{C}$	–	1.80	2.30	V
		$V_{DD} = V_{BS} = 15\text{ V}$, $V_{IN} = 5\text{ V}$, $I_C = 60\text{ A}$, $T_J = 175^\circ\text{C}$		2.20	2.80	V
V_F	FWDi Forward Voltage	$V_{IN} = 0\text{ V}$, $I_F = 60\text{ A}$, $T_J = 25^\circ\text{C}$	–	1.90	2.50	V
		$V_{IN} = 0\text{ V}$, $I_F = 60\text{ A}$, $T_J = 175^\circ\text{C}$		1.85	2.45	V
HS	t_{ON}	$V_{PN} = 300\text{ V}$, $V_{DD} = 15\text{ V}$, $I_C = 60\text{ A}$, $T_J = 25^\circ\text{C}$ $V_{IN} = 0\text{ V} \Leftrightarrow 5\text{ V}$, Inductive Load See Figure 5 (Note 6)	0.95	1.35	1.95	μs
	$t_{C(ON)}$		–	0.25	0.65	μs
	t_{OFF}		–	1.35	1.85	μs
	$t_{C(OFF)}$		–	0.20	0.50	μs
	t_{rr}		–	0.15	–	μs
LS	t_{ON}	$V_{PN} = 300\text{ V}$, $V_{DD} = 15\text{ V}$, $I_C = 60\text{ A}$, $T_J = 25^\circ\text{C}$ $V_{IN} = 0\text{ V} \Leftrightarrow 5\text{ V}$, Inductive Load See Figure 5 (Note 6)	0.65	1.05	1.65	μs
	$t_{C(ON)}$		–	0.25	0.65	μs
	t_{OFF}		–	1.20	1.70	μs
	$t_{C(OFF)}$		–	0.30	0.65	μs
	t_{rr}		–	0.15	–	μs
I_{CES}	Collector–Emitter Leakage Current	$T_J = 25^\circ\text{C}$, $V_{CE} = V_{CES}$	–	–	3	mA

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.

6. t_{ON} and t_{OFF} include the propagation delay time of the internal drive IC. $t_{C(ON)}$ and $t_{C(OFF)}$ are the switching time of IGBT itself under the given gate driving condition internally. For the detailed information, please see Figure 4.

PACKAGE MARKING AND ORDERING INFORMATION

Part Number	Top Marking	Package	Packing Type	Quantity
NFVA36065L42	NFVA36065L42	ASPM27–CDA	Tube	10

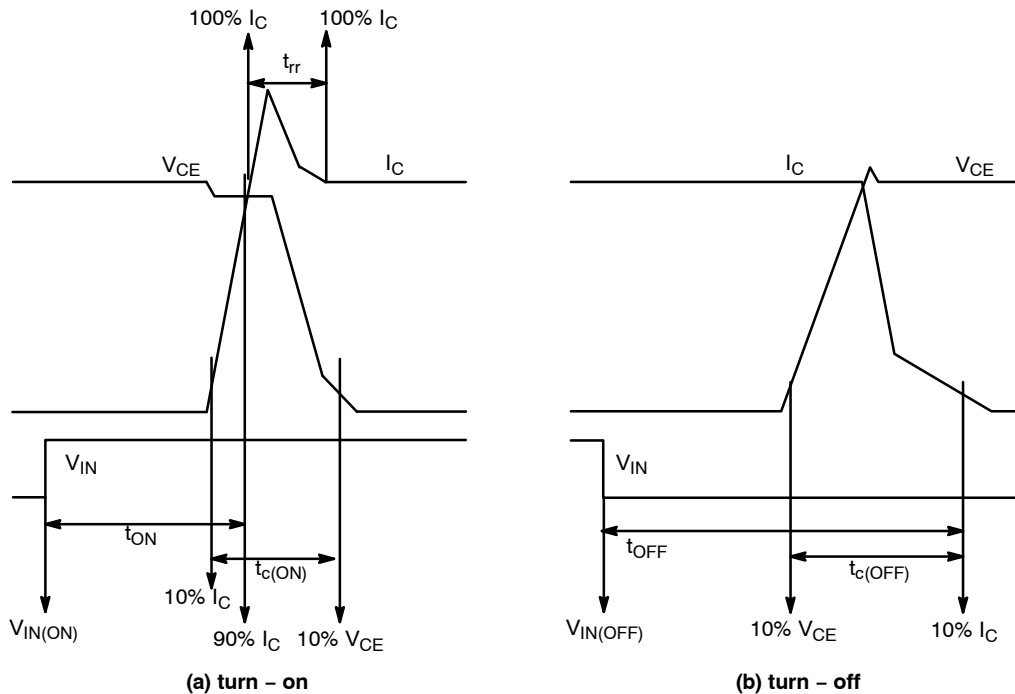


Figure 4. Switching Time Definition

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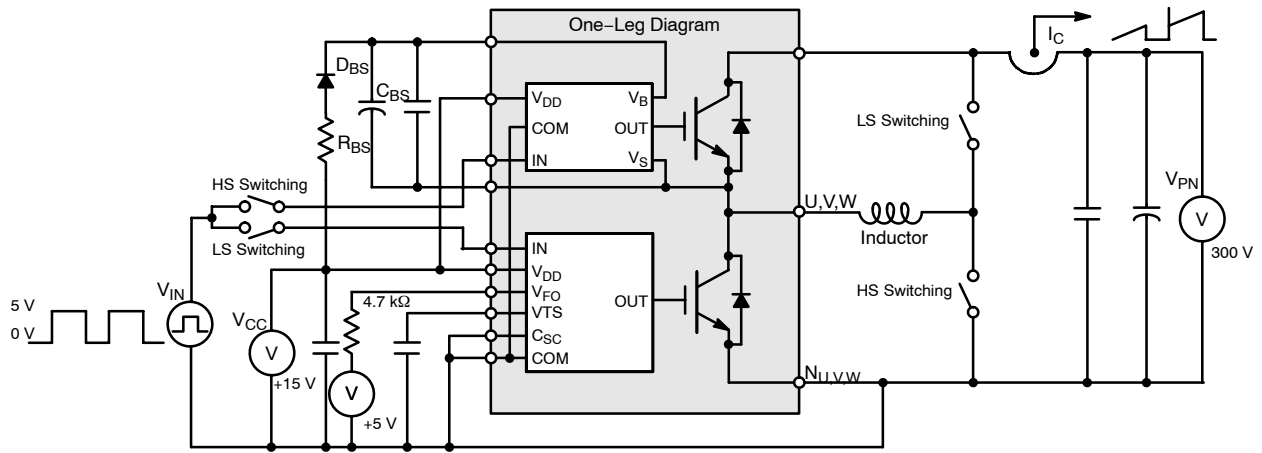


Figure 5. Example Circuit for Switching Test

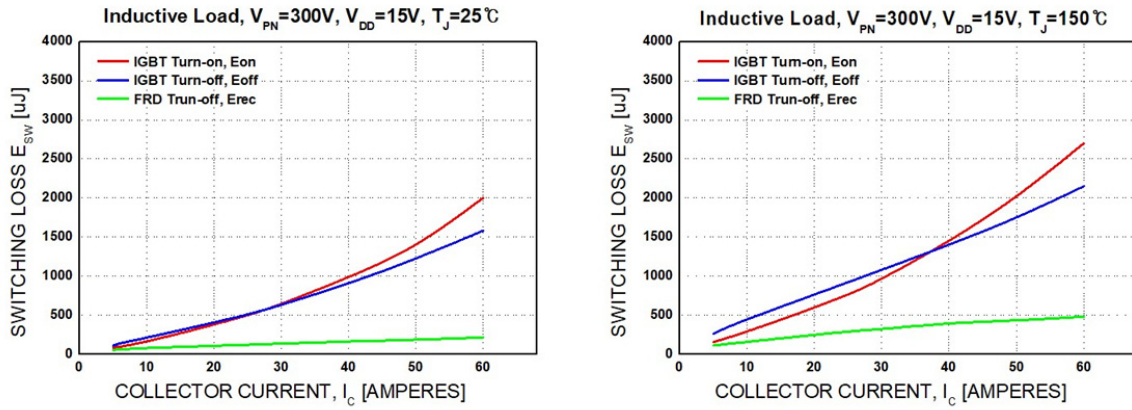


Figure 6. Switching Loss Characteristics

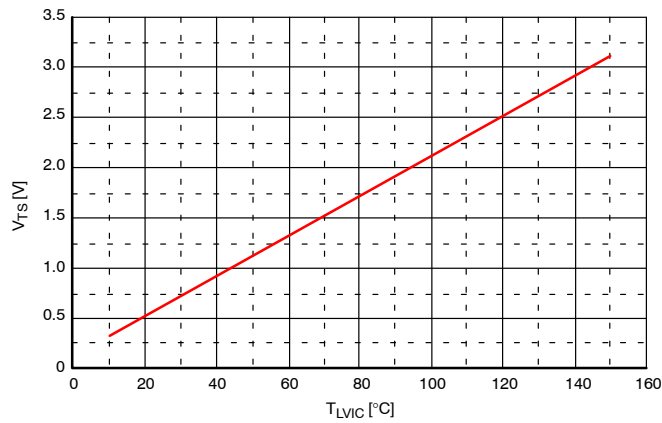


Figure 7. Temperature Profile of V_{TS} (Typical)

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CONTROL PART (T_J = 25°C)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
I _{QDDH}	Quiescent V _{DD} Supply Current	V _{DD(H)} = 15 V, I _{N(UH,VH,WH)} = 0 V	V _{DD(H)} – COM	–	–	0.40	mA
I _{QDDL}		V _{DD(L)} = 15 V, I _{N(UL,VL,WL)} = 0 V	V _{DD(L)} – COM	–	–	4.80	mA
I _{PDDH}	Operating V _{DD} Supply Current	V _{DD(H)} = 15 V, f _{PWM} = 20 kHz, duty = 50%, applied to one PWM signal input for High-Side	V _{DD(H)} – COM	–	–	0.48	mA
I _{PDDL}		V _{DD(L)} = 15 V, f _{PWM} = 20 kHz, duty = 50%, applied to one PWM signal input for Low-Side	V _{DD(L)} – COM	–	–	8.80	mA
I _{QBS}	Quiescent V _{BS} Supply Current	V _{BS} = 15 V, I _{N(UH,VH,WH)} = 0 V	V _{B(U)} – V _{S(U)} , V _{B(V)} – V _{S(V)} , V _{B(W)} – V _{S(W)} ,	–	–	0.24	mA
I _{PBS}	Operating V _{BS} Supply Current	V _{DD} = V _{BS} = 15 V, f _{PWM} = 20 kHz, duty = 50%, applied to one PWM signal input for High-Side	V _{B(U)} – V _{S(U)} , V _{B(V)} – V _{S(V)} , V _{B(W)} – V _{S(W)} ,	–	–	4.40	mA
V _{FOH}	Fault Output Voltage	V _{DD} = 15 V, V _{SC} = 0 V, V _{FO} Circuit: 4.7 kΩ to 5 V Pull-up		4.5	–	–	V
V _{FOL}		V _{DD} = 15 V, V _{SC} = 1 V, V _{FO} Circuit: 4.7 kΩ to 5 V Pull-up		–	–	0.50	V
V _{SC(ref)}	Short Circuit Trip Level	V _{DD} = 15 V (Note 7)	C _{SC} – COM _(L)	0.45	0.50	0.55	V
UV _{DDD}	Supply Circuit Under-Voltage Protection	Detection Level		9.8	–	13.3	V
UV _{DDR}		Reset Level		10.3	–	13.8	V
UV _{BSD}		Detection Level		9.0	–	12.5	V
UV _{BSR}		Reset Level		9.5	–	13.0	V
t _{FOD}	Fault-Out Pulse Width			50	–	–	μs
V _{TS}	LVIC Temperature Sensing Voltage Output	V _{DD(L)} = 15 V, T _{LVIC} = 25°C (Note 8) See Figure 7		540	640	740	mV
V _{IN(ON)}	ON Threshold Voltage	Applied between I _{N(UH,VH,WH)} – COM I _{N(UL,VL,WL)} – COM		–	–	2.6	V
V _{IN(OFF)}	OFF Threshold Voltage			0.8	–	–	V

7. Short-circuit current protection is functioning only at the low-sides.

8. T_{LVIC} is the temperature of LVIC itself. V_{TS} is only for sensing temperature of LVIC and can not shutdown IGBTs automatically.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Conditions	Value			Unit
			Min.	Typ.	Max.	
V _{PN}	Supply Voltage	Applied between P – N _U , N _V , N _W	–	300	400	V
V _{DD}	Control Supply Voltage	Applied between V _{DD(H)} – COM, V _{DD(L)} – COM	14.0	15	16.5	V
V _{BS}	High-Side Bias Voltage	Applied between V _{B(U)} – V _{S(U)} , V _{B(V)} – V _{S(V)} , V _{B(W)} – V _{S(W)}	13.0	15	18.5	V
dV _{DD} /dt, dV _{BS} /dt,	Control Supply Variation		–1	–	1	V/μs
t _{dead}	Blanking Time for Preventing Arm-Short	For Each Input Signal	2.0	–	–	μs
f _{PWM}	PWM Input Signal	–40°C ≤ T _C ≤ 125°C, –40°C ≤ T _J ≤ 150°C	–	–	40	kHz
V _{SEN}	Voltage for Current Sensing	Applied between N _U , N _V , N _W – COM (Including Surge Voltage)	–5	–	5	V

RECOMMENDED OPERATING CONDITIONS (continued)

PW _{IN(ON)}	Minimum Input Pulse Width	V _{DD} = V _{BS} = 15 V, I _C ≤ 60 A, Wiring Inductance between N _{U,V,W} and DC Link N < 10 nH (Note 9)	2.0	–	–	μs
PW _{IN(OFF)}			2.0	–	–	
PW _{IN(ON)}		V _{DD} = V _{BS} = 15 V, 60 A ≤ I _C ≤ 120 A, Wiring Inductance between N _{U,V,W} and DC Link N < 10 nH (Note 9)	2.5	–	–	μs
PW _{IN(OFF)}			2.5	–	–	
T _J	Junction Temperature		–40	–	150	°C

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.

9. This product might not make response if input pulse width is less than the recommended value.

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Conditions		Value			Unit
			Min.	Typ.	Max.	
Device Flatness	See Figure 8		0	–	+150	μm
Mounting Torque	Mounting Screw: M3 See Figure 9	Recommended 0.7 N•m	0.6	0.7	0.8	N•m
		Recommended 7.1 kg•cm	6.2	7.1	8.1	kg•cm
Terminal Pulling Strength	Load 19.8 N		10	–	–	s
Terminal Bending Strength	Load 9.8 N 90 deg. bend		2	–	–	times
Weight			–	15	–	g

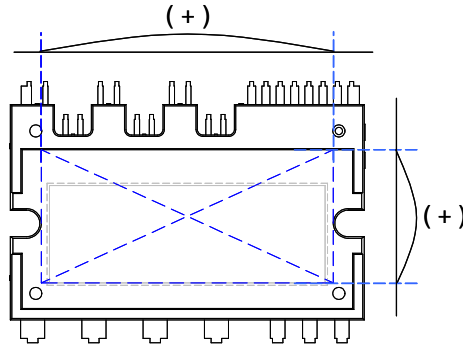
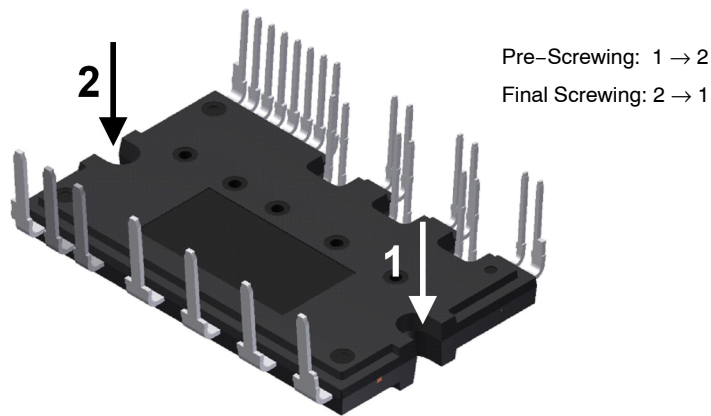


Figure 8. Flatness Measurement Position

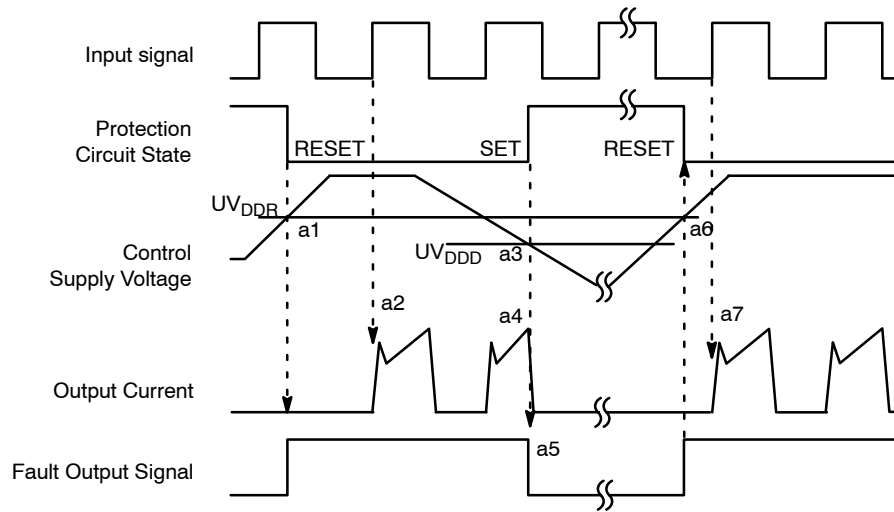


NOTES:

10. Do not make over torque when mounting screws. Much mounting torque may cause DBC cracks, as well as bolts and Al heat-sink destruction
11. Avoid one-sided tightening stress. Figure 9 shows the recommended torque order for mounting screws. Uneven mounting can cause the DBC substrate of package to be damaged. The pre-screwing torque is set to 20 ~ 30% of maximum torque rating.

Figure 9. Mounting Screws Torque Order

NFVA36065L42



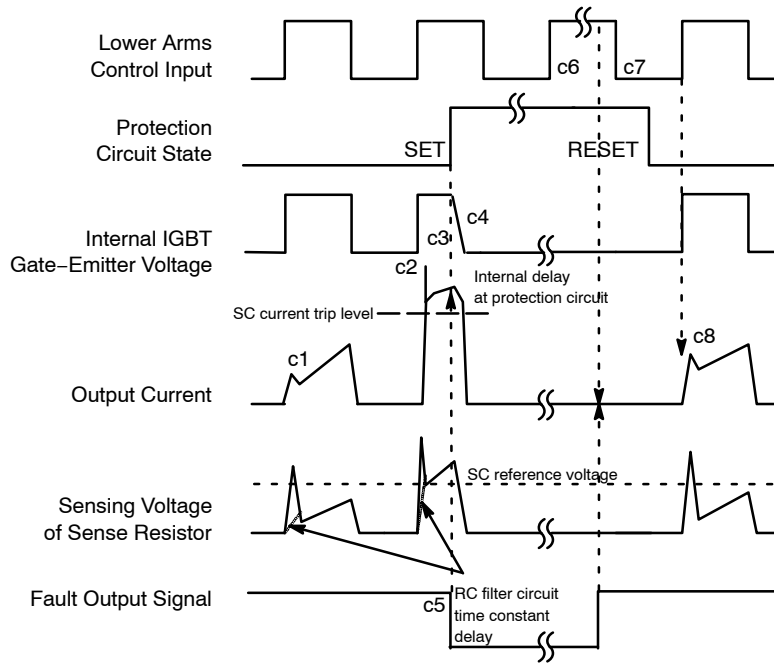
- a1: Control supply voltage rises: After the voltage rises UV_{DDR} , the circuits start to operate when next input is applied.
- a2: Normal operation: IGBT ON and carrying current.
- a3: Under voltage detection (UV_{DDD}).
- a4: IGBT OFF in spite of control input condition.
- a5: Fault output operation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

Figure 10. Under-Voltage Protection (Low-Side)



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

Figure 11. Under-Voltage Protection (High-Side)



(with the external sense resistance and RC filter connection)

c1: Normal operation: IGBT ON and carrying current.

c2: Short circuit current detection (SC trigger).

c3: All low-side IGBT's gate are hard interrupted.

c4: All low-side IGBTs turn OFF.

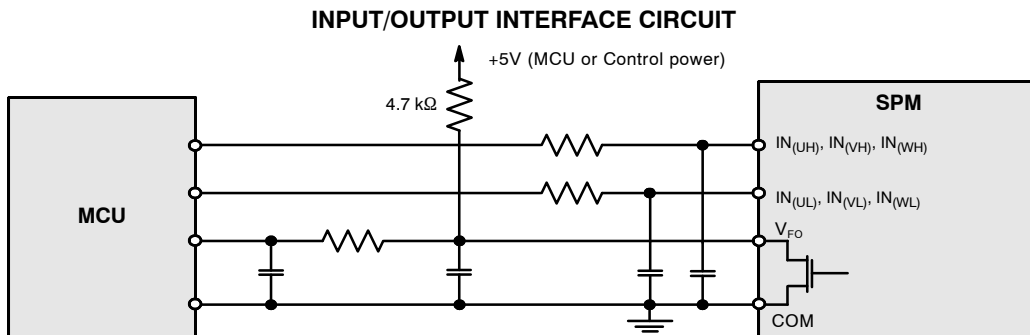
c5: Fault output operation starts with a fixed pulse width.

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.

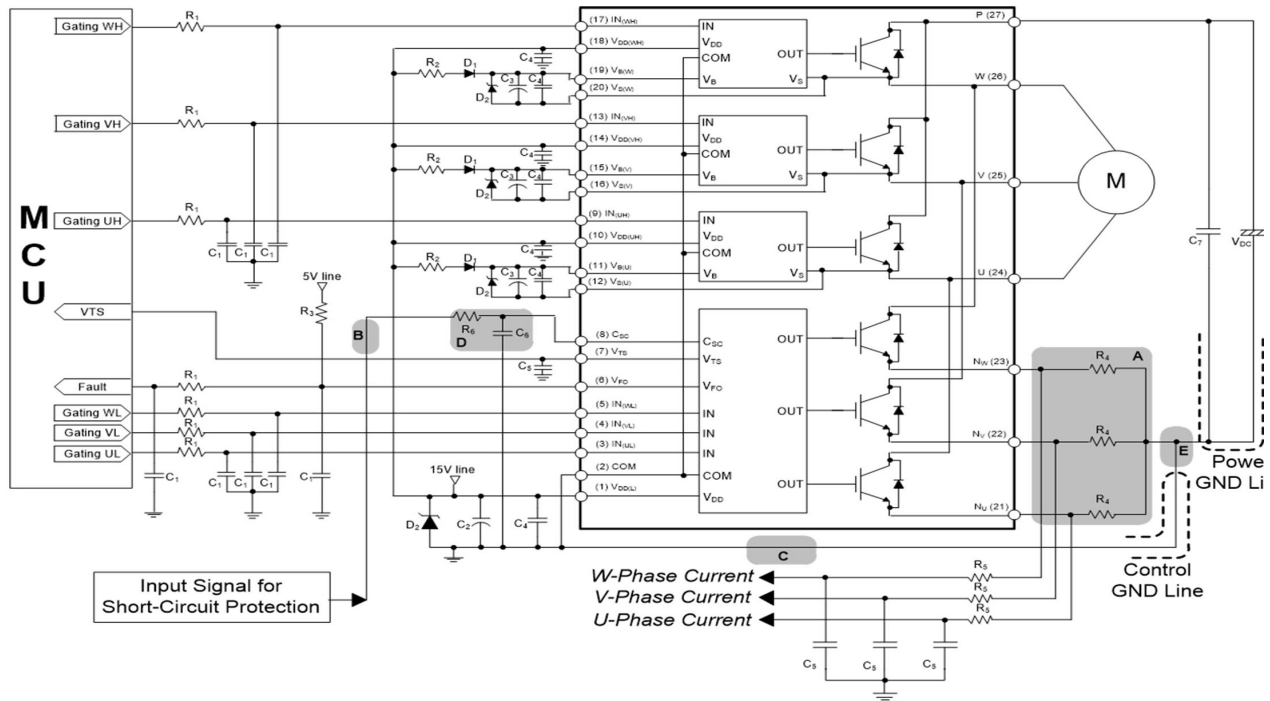
Figure 12. Short-Circuit Current Protection (Low-Side Operation Only)



NOTE:

12.RC coupling at each input might change depending on the PWM control scheme used in the application and the wiring impedance of the application's printed circuit board. The input signal section of the Motion SPM 3 product integrates 5kΩ (typ.) pull-down resistor. Therefore, when using an external filtering resistor, please pay attention to the signal voltage drop at input terminal.

Figure 13. Recommended CPU I/O Interface Circuit



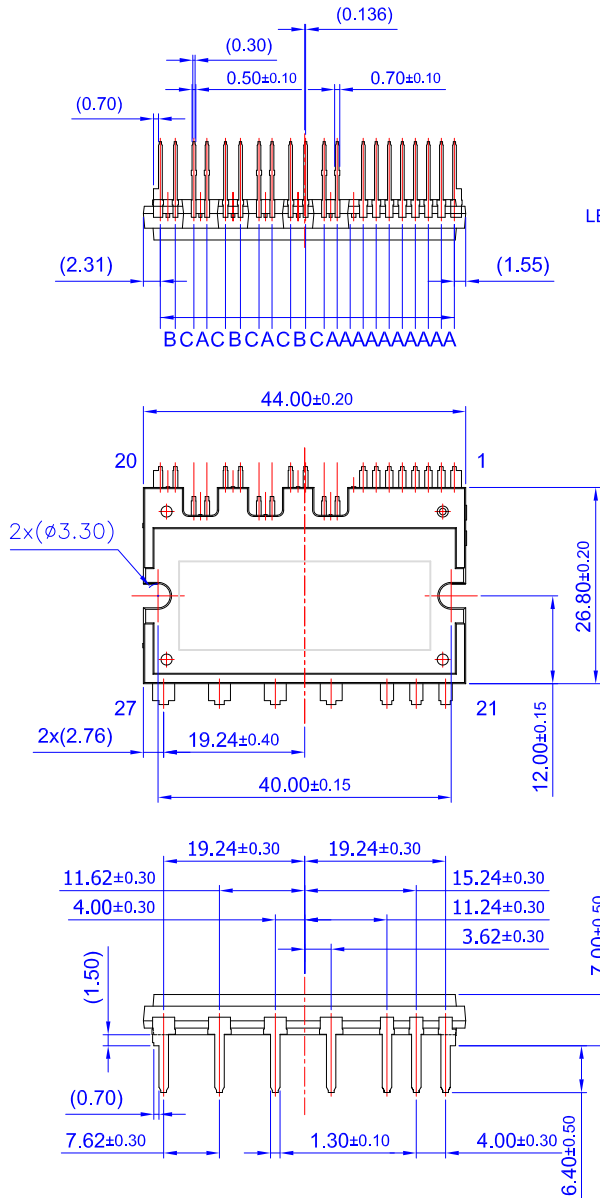
NOTES:

13. To avoid malfunction, the wiring of each input should be as short as possible. (less than 2–3 cm)
14. V_{FO} output is open–drain type. The signal line should be pulled up to the positive side of the MCU or control power supply with a resistor that makes I_{FO} up to 2mA. Refer to Figure 13.
15. Input signal is active–HIGH type. There is a 5 k Ω 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. R_1C_1 time constant should be selected in the range 50–150 ns. (Recommended $R_1 = 100 \Omega$, $C_1 = 1 \text{ nF}$)
16. Each wiring pattern inductance of A point should be minimized (Recommended less than 10 nH). Use the shunt resistor R_4 of surface mounted (SMD) type to reduce wiring inductance. To prevent malfunction, wiring of point E should be connected to the terminal of the shunt resistor R_4 as close as possible.
17. To prevent errors of the protection function, the wiring of B, C and D point should be as short as possible.
18. In the short–circuit protection circuit, please select the R_6C_6 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 R_6C_6 time constant.
19. Each capacitor should be mounted as close to the pins of the ASPM27 product as possible.
20. To prevent surge destruction, the wiring between the smoothing capacitor C_7 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.
21. Relays are used at almost every systems of electrical equipment at industrial application. In these cases, there should be sufficient distance between the CPU and the relays.
22. 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).
23. C_2 of around 7 times larger than bootstrap capacitor C_3 is recommended.
24. Choose the electrolytic capacitor with good temperature characteristic in C_3 . Also choose 0.1–0.2 μF R–category ceramic capacitors with good temperature and frequency characteristics in C_4 .

Figure 14. Typical Application Circuit

PACKAGE DIMENSIONS

27LD MODULE PDD STD
CASE MODCB
ISSUE O

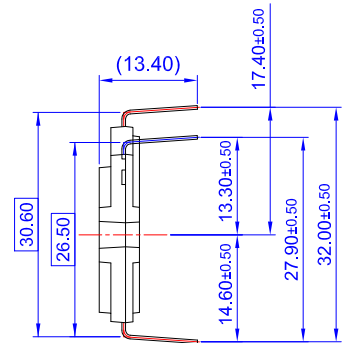
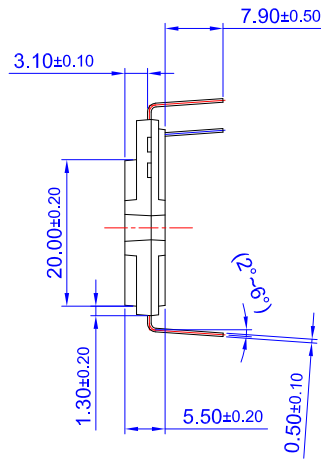


LEAD PITCH (TOLERANCE : ±0.30)

A : 1.778

B : 2.050

C : 2.531



NOTES: UNLESS OTHERWISE SPECIFIED

- A) THIS PACKAGE DOES NOT COMPLY TO ANY CURRENT PACKAGING STANDARD
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.
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