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## FSB50250AB

### Smart Power Module (SPM®)

#### Features

- 500V  $R_{DS(on)}=3.8\Omega(\text{max})$  3-phase FRFET inverter including high voltage integrated circuit (HVIC)
- 3 divided negative dc-link terminals for inverter current sensing applications
- HVIC for gate driving and undervoltage protection
- 3/5V CMOS/TTL compatible, active-high interface
- Optimized for low electromagnetic interference
- Isolation voltage rating of 1500Vrms for 1min.
- HVIC temperature sensing
- Embedded bootstrap diode in the package
- RoHS compliant

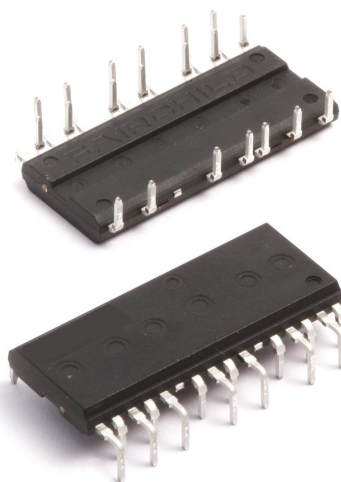


#### Applications

- Three-phase inverter driver for small power ac motor drives

#### General Description

FSB50250AB is a tiny smart power module (SPM®) based on FRFET technology as a compact inverter solution for small power motor drive applications such as fan motors and water suppliers. It is composed of 6 fast-recovery MOSFET (FRFET), and 3 half-bridge HVICs for FRFET gate driving. FSB50250AB provides low electromagnetic interference (EMI) characteristics with optimized switching speed. Moreover, since it employs FRFET as a power switch, it has much better ruggedness and larger safe operation area (SOA) than that of an IGBT-based power module or one-chip solution. The package is optimized for the thermal performance and compactness for the use in the built-in motor application and any other application where the assembly space is concerned. FSB50250AB is the best solution for the compact inverter providing the energy efficiency, compactness, and low electromagnetic interference.



## Absolute Maximum Ratings

### Inverter Part (Each FRFET Unless Otherwise Specified)

Symbol	Parameter	Conditions	Rating	Units
$V_{PN}$	DC Link Input Voltage, Drain-source Voltage of each FRFET		500	V
* $I_{D25}$	Each FRFET Drain Current, Continuous	$T_C = 25^\circ\text{C}$	1.2	A
* $I_{D80}$	Each FRFET Drain Current, Continuous	$T_C = 80^\circ\text{C}$	0.9	A
* $I_{DP}$	Each FRFET Drain Current, Peak	$T_C = 25^\circ\text{C}$ , $PW < 100\mu\text{s}$	3.1	A
* $I_{DRMS}$	Each FRFET Drain Current, Rms	$T_C = 80^\circ\text{C}$ , $F_{PWM} < 20\text{KHz}$	0.6	$A_{rms}$
* $P_D$	Maximum Power Dissipation	$T_C = 25^\circ\text{C}$ , For Each FRFET	13.4	W

### Control Part (Each HVIC Unless Otherwise Specified)

Symbol	Parameter	Conditions	Rating	Units
$V_{CC}$	Control Supply Voltage	Applied between $V_{CC}$ and COM	20	V
$V_{BS}$	High-side Bias Voltage	Applied between $V_B$ and $V_S$	20	V
$V_{IN}$	Input Signal Voltage	Applied between IN and COM	$-0.3 \sim V_{CC}+0.3$	V

### Bootstrap Diode Part (Each Bootstrap diode Unless Otherwise Specified)

Symbol	Parameter	Conditions	Rating	Units
$V_{RRMB}$	Maximum Repetitive Reverse Voltage		500	V
* $I_{FB}$	Forward Current	$T_C = 25^\circ\text{C}$	0.5	A
* $I_{FPB}$	Forward Current (Peak)	$T_C = 25^\circ\text{C}$ , Under 1ms Pulse Width	1.5	A

### Thermal Resistance

Symbol	Parameter	Conditions	Rating	Units
$R_{\theta JC}$	Junction to Case Thermal Resistance	Each FRFET under inverter operating condition (Note 1)	9.3	$^\circ\text{C/W}$

### Total System

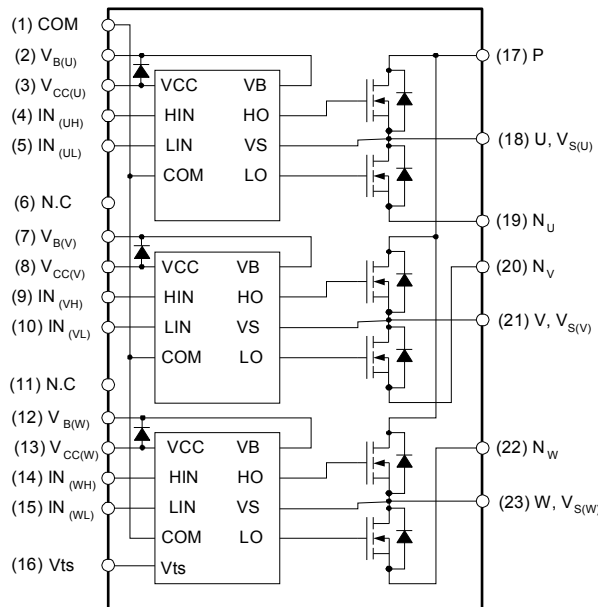
Symbol	Parameter	Conditions	Rating	Units
$T_J$	Operating Junction Temperature		$-40 \sim 150$	$^\circ\text{C}$
$T_{STG}$	Storage Temperature		$-40 \sim 125$	$^\circ\text{C}$
$V_{ISO}$	Isolation Voltage	60Hz, Sinusoidal, 1 minute, Connection pins to heatsink	1500	$V_{rms}$

#### Note:

- For the measurement point of case temperature  $T_C$ , please refer to Figure 4.
- Marking "\*" is calculation value or design factor.

### Pin descriptions

Pin Number	Pin Name	Pin Description
1	COM	IC Common Supply Ground
2	$V_{B(U)}$	Bias Voltage for U Phase High Side FRFET Driving
3	$V_{CC(U)}$	Bias Voltage for U Phase IC and Low Side FRFET Driving
4	$IN_{(UH)}$	Signal Input for U Phase High-side
5	$IN_{(UL)}$	Signal Input for U Phase Low-side
6	N.C	N.C
7	$V_{B(V)}$	Bias Voltage for V Phase High Side FRFET Driving
8	$V_{CC(V)}$	Bias Voltage for V Phase IC and Low Side FRFET Driving
9	$IN_{(VH)}$	Signal Input for V Phase High-side
10	$IN_{(VL)}$	Signal Input for V Phase Low-side
11	N.C	N.C
12	$V_{B(W)}$	Bias Voltage for W Phase High Side FRFET Driving
13	$V_{CC(W)}$	Bias Voltage for W Phase IC and Low Side FRFET Driving
14	$IN_{(WH)}$	Signal Input for W Phase High-side
15	$IN_{(WL)}$	Signal Input for W Phase Low-side
16	$V_{ts}$	Output for HVIC temperature sensing
17	P	Positive DC-Link Input
18	U, $V_{S(U)}$	Output for U Phase & Bias Voltage Ground for High Side FRFET Driving
19	$N_U$	Negative DC-Link Input for U Phase
20	$N_V$	Negative DC-Link Input for V Phase
21	V, $V_{S(V)}$	Output for V Phase & Bias Voltage Ground for High Side FRFET Driving
22	$N_W$	Negative DC-Link Input for W Phase
23	W, $V_{S(W)}$	Output for W Phase & Bias Voltage Ground for High Side FRFET Driving



**Note:**

Source terminal of each low-side MOSFET is not connected to supply ground or bias voltage ground inside SPM®. External connections should be made as indicated in Figure 3

**Figure 1. Pin Configuration and Internal Block Diagram (Bottom View)**

## Electrical Characteristics (T<sub>J</sub> = 25°C, V<sub>CC</sub>=V<sub>BS</sub>=15V Unless Otherwise Specified)

### Inverter Part (Each FRFET Unless Otherwise Specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV <sub>DSS</sub>	Drain-Source Breakdown Voltage	V <sub>IN</sub> = 0V, I <sub>D</sub> = 1mA (Note 1)	500	-	-	V
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	V <sub>IN</sub> = 0V, V <sub>DS</sub> = 500V	-	-	1	mA
R <sub>DS(on)</sub>	Static Drain-Source On-Resistance	V <sub>CC</sub> = V <sub>BS</sub> = 15V, V <sub>IN</sub> = 5V, I <sub>D</sub> = 0.5A	-	2.5	3.8	Ω
V <sub>SD</sub>	Drain-Source Diode Forward Voltage	V <sub>CC</sub> = V <sub>BS</sub> = 15V, V <sub>IN</sub> = 0V, I <sub>D</sub> = -0.5A	-	-	1.2	V
t <sub>ON</sub>	Switching Times	V <sub>PN</sub> = 300V, V <sub>CC</sub> = V <sub>BS</sub> = 15V, I <sub>D</sub> = 0.5A V <sub>IN</sub> = 0V ↔ 5V, Inductive load L=3mH High- and low-side FRFET switching (Note 2)	-	1150	-	ns
t <sub>OFF</sub>			-	950	-	ns
t <sub>rr</sub>			-	190	-	ns
E <sub>ON</sub>			-	40	-	μJ
E <sub>OFF</sub>			-	10	-	μJ
RBSOA	Reverse-bias Safe Operating Area	V <sub>PN</sub> = 400V, V <sub>CC</sub> = V <sub>BS</sub> = 15V, I <sub>D</sub> = I <sub>DP</sub> , V <sub>DS</sub> =BV <sub>DSS</sub> , T <sub>J</sub> = 150°C High- and low-side FRFET switching (Note 3)	Full Square			

### Control Part (Each HVIC Unless Otherwise Specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
I <sub>QCC</sub>	Quiescent V <sub>CC</sub> Current	V <sub>CC</sub> =15V, V <sub>IN</sub> =0V   Applied between V <sub>CC</sub> and COM	-	-	200	μA
I <sub>QBS</sub>	Quiescent V <sub>BS</sub> Current	V <sub>BS</sub> =15V, V <sub>IN</sub> =0V   Applied between V <sub>B(U)</sub> -U, V <sub>B(V)</sub> -V, V <sub>B(W)</sub> -W	-	-	100	μA
UV <sub>CCD</sub>	Low-side Undervoltage Protection (Figure 8)	V <sub>CC</sub> Undervoltage Protection Detection Level	7.4	8.0	9.4	V
UV <sub>CCR</sub>		V <sub>CC</sub> Undervoltage Protection Reset Level	8.0	8.9	9.8	V
UV <sub>BSD</sub>	High-side Undervoltage Protection (Figure 9)	V <sub>BS</sub> Undervoltage Protection Detection Level	7.4	8.0	9.4	V
UV <sub>BSR</sub>		V <sub>BS</sub> Undervoltage Protection Reset Level	8.0	8.9	9.8	V
V <sub>ts</sub>	HVIC Temperature sensing voltage output	V <sub>CC</sub> =15V, T <sub>HVIC</sub> =25°C(Note 4)	600	790	980	mV
V <sub>IH</sub>	ON Threshold Voltage	Logic High Level   rowspan="2">Applied between IN and COM	2.9	-	-	V
V <sub>IL</sub>	OFF Threshold Voltage	Logic Low Level	-	-	0.8	V

### Bootstrap Diode Part (Each Bootstrap diode Unless Otherwise Specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V <sub>FB</sub>	Forward Voltage	I <sub>F</sub> = 0.1A, T <sub>C</sub> = 25°C(Note 5)	-	2.5	-	V
t <sub>rrB</sub>	Reverse Recovery Time	I <sub>F</sub> = 0.1A, T <sub>C</sub> = 25°C	-	80	-	ns

**Note:**

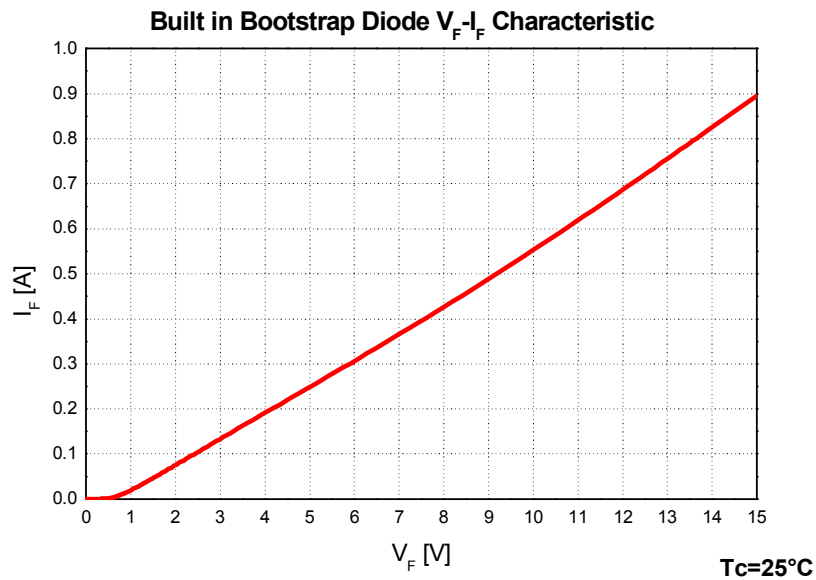
- BV<sub>DSS</sub> is the absolute maximum voltage rating between drain and source terminal of each FRFET inside SPM®. V<sub>PN</sub> should be sufficiently less than this value considering the effect of the stray inductance so that V<sub>DS</sub> should not exceed BV<sub>DSS</sub> in any case.
- t<sub>ON</sub> and t<sub>OFF</sub> include the propagation delay time of the internal drive IC. Listed values are measured at the laboratory test condition, and they can be different according to the field applications due to the effect of different printed circuit boards and wirings. Please see Figure 6 for the switching time definition with the switching test circuit of Figure 7.
- The peak current and voltage of each FRFET during the switching operation should be included in the safe operating area (SOA). Please see Figure 7 for the RBSOA test circuit that is same as the switching test circuit.
- V<sub>ts</sub> is only for sensing temperature of module and cannot shutdown MOSFETs automatically.
- Built in bootstrap diode includes around 15Ω resistance characteristic. Please refer to Figure 2.

### Recommended Operating Condition

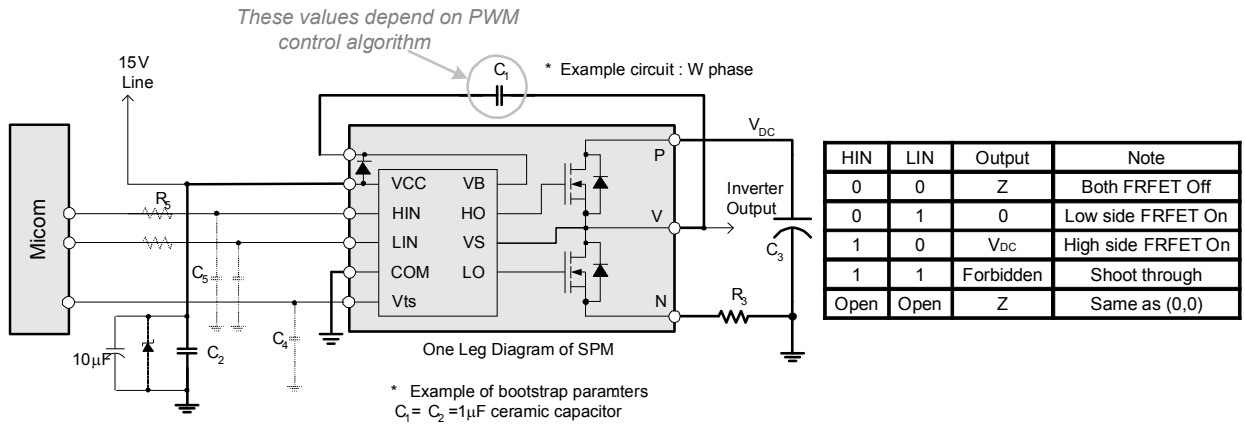
Symbol	Parameter	Conditions	Value			Units
			Min.	Typ.	Max.	
$V_{PN}$	Supply Voltage	Applied between P and N	-	300	400	V
$V_{CC}$	Control Supply Voltage	Applied between $V_{CC}$ and COM	13.5	15	16.5	V
$V_{BS}$	High-side Bias Voltage	Applied between $V_B$ and $V_S$	13.5	15	16.5	V
$V_{IN(ON)}$	Input ON Threshold Voltage	Applied between IN and COM	3.0	-	$V_{CC}$	V
$V_{IN(OFF)}$	Input OFF Threshold Voltage		0	-	0.6	V
$t_{dead}$	Blanking Time for Preventing Arm-short	$V_{CC}=V_{BS}=13.5 \sim 16.5V, T_J \leq 150^\circ C$	1.0	-	-	$\mu s$
$f_{PWM}$	PWM Switching Frequency	$T_J \leq 150^\circ C$	-	15	-	kHz

### Package Marking & Ordering Information

Device Marking	Device	Package	Reel Size	Packing Type	Quantity
FSB50250AB	FSB50250AB	SPM23DD-21L	-	-	15



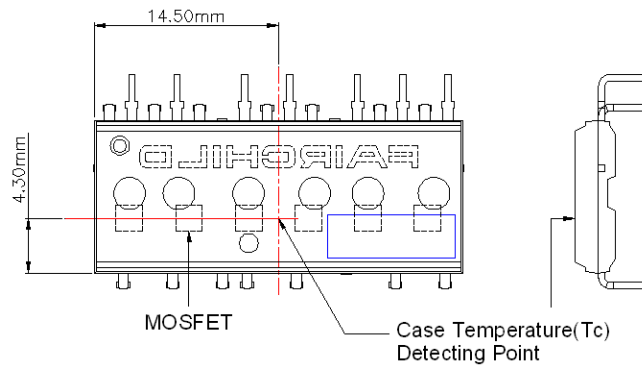
**Figure 2. Built in Bootstrap Diode Characteristics(typ.)**



**Note:**

- Parameters for bootstrap circuit elements are dependent on PWM algorithm. For 15 kHz of switching frequency, typical example of parameters is shown above.
- RC coupling (R<sub>5</sub> and C<sub>5</sub>) and C<sub>4</sub> at each input of SPM® and Microm (indicated as dotted lines) may be used to prevent improper signal due to surge noise. Signal input of SPM® is compatible with standard CMOS or LSTTL outputs.
- Bold lines should be short and thick in PCB pattern to have small stray inductance of circuit, which results in the reduction of surge voltage. Bypass capacitors such as C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> should have good high-frequency characteristics to absorb high-frequency ripple current.

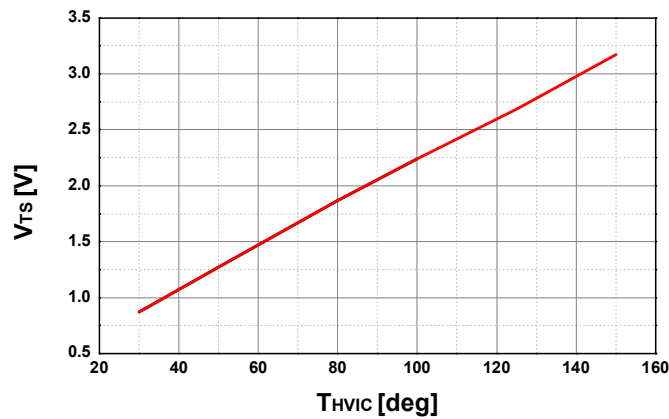
**Figure 3. Recommended CPU Interface and Bootstrap Circuit with Parameters**



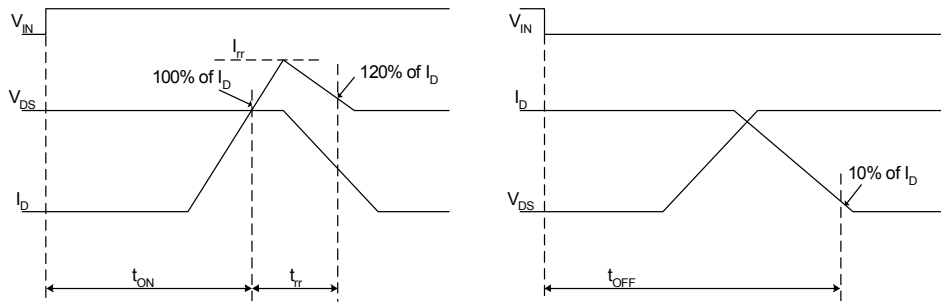
**Note:**

Attach the thermocouple on top of the heatsink-side of SPM® (between SPM® and heatsink if applied) to get the correct temperature measurement.

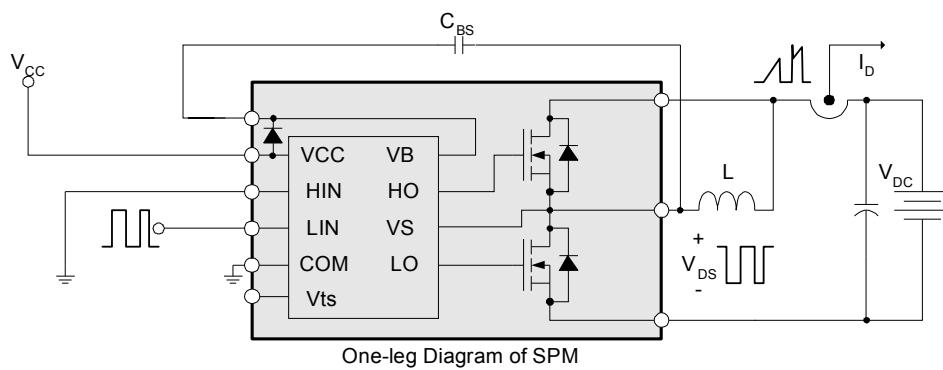
**Figure 4. Case Temperature Measurement**



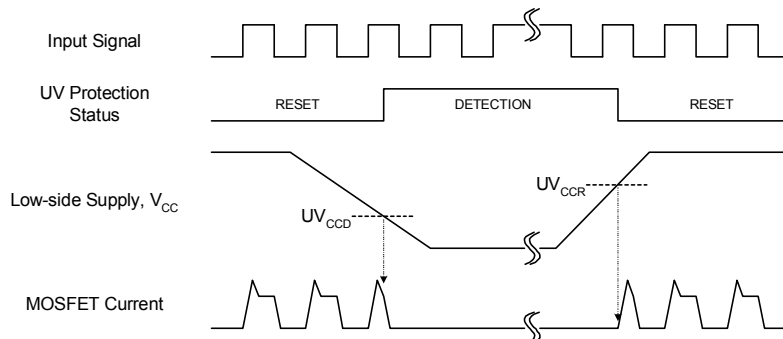
**Figure 5. Temperature profile of V<sub>ts</sub>(typ.)**



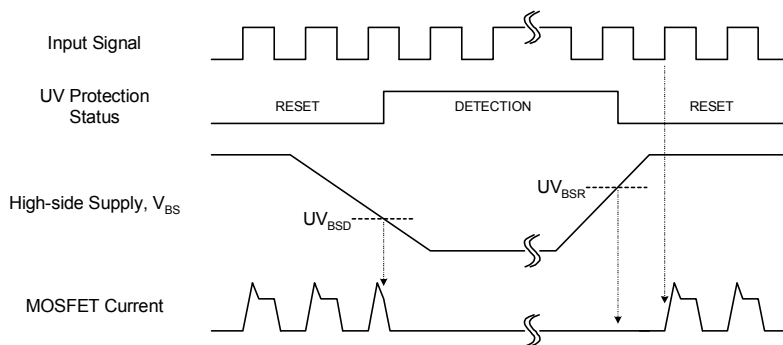
(a) Turn-on (b) Turn-off  
**Figure 6. Switching Time Definition**



**Figure 7. Switching and RBSOA(Single-pulse) Test Circuit (Low-side)**

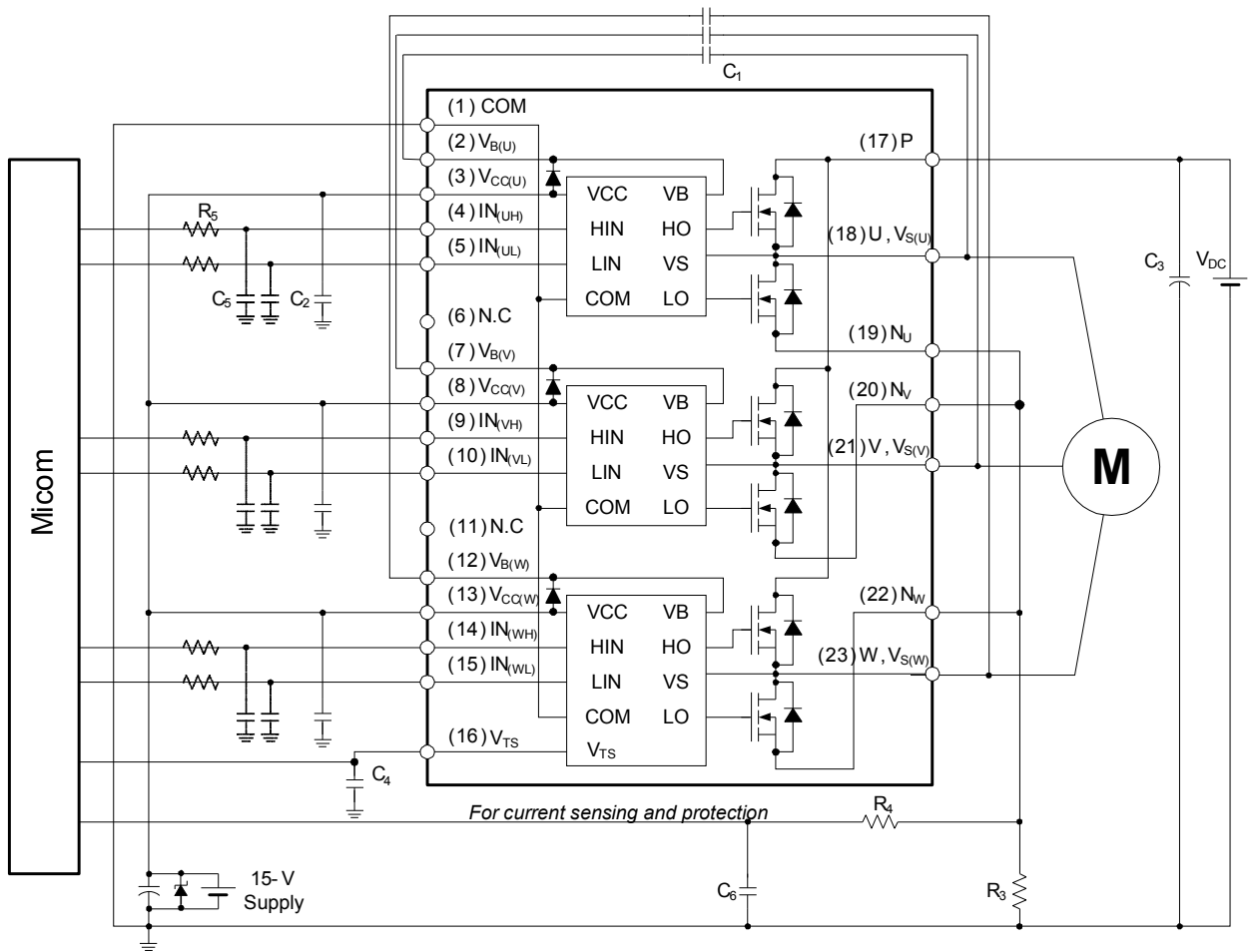


**Figure 8. Undervoltage Protection (Low-side)**



**Figure 9. Undervoltage Protection (High-side)**



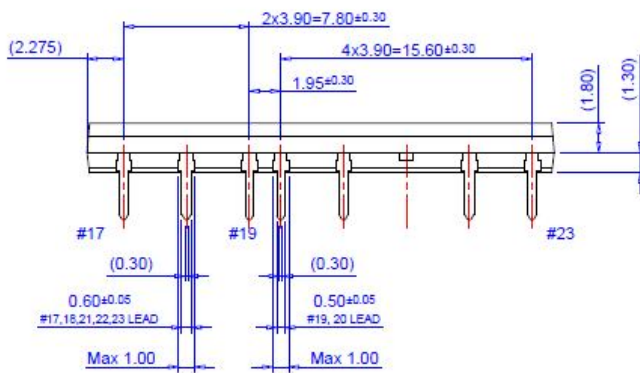
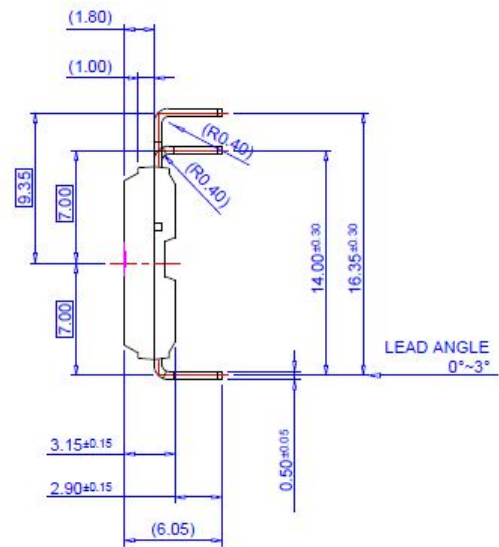
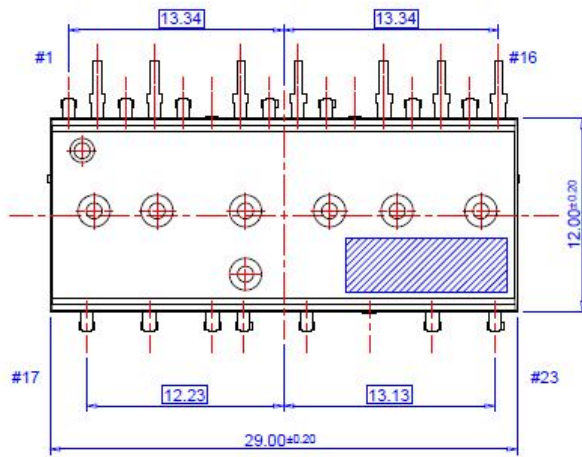
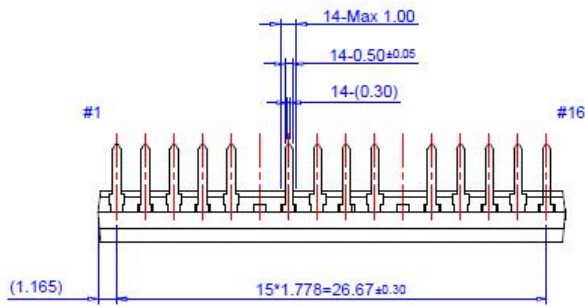


**Note:**

1. About pin position, refer to Figure 2.
2. RC coupling ( $R_5$  and  $C_5$ ,  $R_4$  and  $C_6$ ) and  $C_4$  at each input of SPM® and Micom are useful to prevent improper input signal caused by surge noise.
3. The voltage drop across  $R_3$  affects the low side switching performance and the bootstrap characteristics since it is placed between COM and the source terminal of the low side MOSFET. For this reason, the voltage drop across  $R_3$  should be less than 1V in the steady-state.
4. Ground wires and output terminals, should be thick and short in order to avoid surge voltage and malfunction of HVIC.
5. All the filter capacitors should be connected close to SPM®, and they should have good characteristics for rejecting high-frequency ripple current.

**Figure 10. Example of Application Circuit**

Detailed Package Outline Drawings









Dimension unit : [mm]



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