

# FSB50450US

## Motion SPM® 5 FRFET® Series

### Features

- 500 V  $R_{DS(on)}$  = 2.4  $\Omega$  (Max) FRFET MOSFET 3-Phase Inverter Including HVICs
- Three Separate Negative DC-Link Terminals for Inverter Current Sensing Applications
- HVIC for Gate Driving and Undervoltage Protection
- Active-High Interface, Can Work With 3.3 V / 5 V Logic
- Optimized for Low Electromagnetic Interference
- Isolation Voltage Rating of 1500 Vrms for 1 min.
- Surface Mounted Device Package
- Moisture Sensitive Level (MSL) 3

### Applications

- 3-Phase Inverter Driver for Small Power AC Motor Drives

### General Description

FSB50450US is an Advanced Motion SPM5 Series Based on Fast-Recovery MOSFET(FRFET) Technology as a Compact Inverter Solution for Small Power Motor Drive Applications Such as Fans and Pumps. It is Composed of Six FRFET MOSFETs and Three Half-Bridge Gate Drive HVICs. FSB50450US Provides Low Electromagnetic Interference(EMI) Characteristics with Optimizing Switching Speed. Moreover, Since It Employs MOSFETs as Power Switches, It has Greater Ruggedness and a Larger Safe Operating Area(SOA) than IGBT-Based Power Modules. The Package is Optimized for Thermal Performance and Compactness for use in Applications Where Space is Limited. FSB50450US is the Right Solution for Inverters Requiring Energy Efficiency, Compactness, and Low Electromagnetic Interference.

### Related Source

- [AN9042 : Motion SPM5 Series Ver.1 User's Guide](#)
- [AN-9082 : Motion SPM5 Series Thermal Performance by Contact Pressure](#)



### Package Marking & Ordering Information

Device Marking	Device	Package	Reel Size	Packing Type	Quantity
FSB50450US	FSB50450US	SPM5H-023	330 mm	TAPE & REEL	450

## Absolute Maximum Ratings

**Inverter Part** (Each MOSFET® Unless Otherwise Specified)

Symbol	Parameter	Conditions	Rating	Unit
$V_{PN}$	DC Link Input Voltage, Drain-Source Voltage of Each MOSFET		500	V
* $I_{D 25}$	Each MOSFET Drain Current, Continuous	$T_C = 25^\circ\text{C}$	1.5	A
* $I_{D 80}$	Each MOSFET Drain Current, Continuous	$T_C = 80^\circ\text{C}$	1.1	A
* $I_{DP}$	Each MOSFET Drain Current, Peak	$T_C = 25^\circ\text{C}$ , $PW < 100 \mu\text{s}$	3.8	A
* $I_{DRMS}$	Each MOSFET Drain Current, Rms	$T_C = 80^\circ\text{C}$ , $F_{PWM} < 20 \text{ KHz}$	0.8	$A_{rms}$
* $P_D$	Maximum Power Dissipation	$T_C = 25^\circ\text{C}$ , For Each MOSFET	14	W

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

Symbol	Parameter	Conditions	Rating	Unit
$V_{CC}$	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

### Thermal Resistance

Symbol	Parameter	Conditions	Rating	Unit
$R_{\theta JC}$	Junction to Case Thermal Resistance	Each MOSFET under Inverter Operating Condition (Note 1)	8.9	$^\circ\text{C/W}$

### Total System

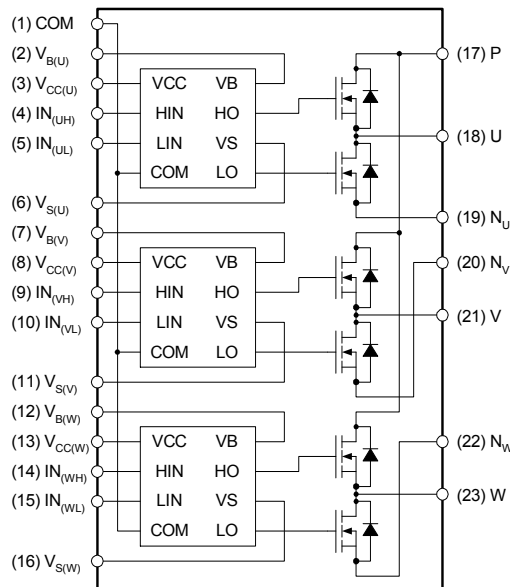
Symbol	Parameter	Conditions	Rating	Unit
$T_J$	Operating Junction Temperature		$-40 \sim 150$	$^\circ\text{C}$
$T_{STG}$	Storage Temperature		$-50 \sim 150$	$^\circ\text{C}$
$V_{ISO}$	Isolation Voltage	60 Hz, Sinusoidal, 1 minute, Connection Pins to Heatsink	1500	$V_{rms}$

**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 MOSFET® Driving
3	$V_{CC(U)}$	Bias Voltage for U Phase IC and Low Side MOSFET Driving
4	$IN_{(UH)}$	Signal Input for U Phase High-Side
5	$IN_{(UL)}$	Signal Input for U Phase Low-Side
6	$V_{S(U)}$	Bias Voltage Ground for U Phase High Side MOSFET Driving
7	$V_{B(V)}$	Bias Voltage for V Phase High Side MOSFET Driving
8	$V_{CC(V)}$	Bias Voltage for V Phase IC and Low Side MOSFET Driving
9	$IN_{(VH)}$	Signal Input for V Phase High-Side
10	$IN_{(VL)}$	Signal Input for V Phase Low-Side
11	$V_{S(V)}$	Bias Voltage Ground for V Phase High Side MOSFET Driving
12	$V_{B(W)}$	Bias Voltage for W Phase High Side MOSFET Driving
13	$V_{CC(W)}$	Bias Voltage for W Phase IC and Low Side MOSFET Driving
14	$IN_{(WH)}$	Signal Input for W Phase High-Side
15	$IN_{(WL)}$	Signal Input for W Phase Low-Side
16	$V_{S(W)}$	Bias Voltage Ground for W Phase High Side MOSFET Driving
17	P	Positive DC-Link Input
18	U	Output for U Phase
19	$N_U$	Negative DC-Link Input for U Phase
20	$N_V$	Negative DC-Link Input for V Phase
21	V	Output for V Phase
22	$N_W$	Negative DC-Link Input for W Phase
23	W	Output for W Phase



**Note:**

Source Terminal of Each Low-Side MOSFET is Not Connected to Supply Ground or Bias Voltage Ground Inside Motion SPM®.

External Connections Should be Made as Indicated in Figure 3

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

**Electrical Characteristics** ( $T_J = 25^\circ\text{C}$ ,  $V_{CC}=V_{BS}= 15\text{ V}$  Unless Otherwise Specified)**Inverter Part** (Each MOSFET® Unless Otherwise Specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$BV_{DSS}$	Drain-Source Breakdown Voltage	$V_{IN}= 0\text{V}$ , $I_D = 1\text{ mA}$ (Note 1)	500	-	-	V
$\Delta BV_{DSS}/\Delta T_J$	Breakdown Voltage Temperature Coefficient	$I_D = 250\mu\text{A}$ , Referenced to $25^\circ\text{C}$	-	0.53	-	V
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{IN}= 0\text{V}$ , $V_{DS} = 500\text{ V}$	-	-	250	$\mu\text{A}$
$R_{DS(on)}$	Static Drain-Source On-Resistance	$V_{CC} = V_{BS} = 15\text{ V}$ , $V_{IN} = 5\text{ V}$ , $I_D = 0.5\text{ A}$	-	1.9	2.4	$\Omega$
$V_{SD}$	Drain-Source Diode Forward Voltage	$V_{CC} = V_{BS} = 15\text{V}$ , $V_{IN} = 0\text{V}$ , $I_D = -0.5\text{ A}$	-	-	1.2	V
$t_{ON}$	Switching Times	$V_{PN} = 300\text{ V}$ , $V_{CC} = V_{BS} = 15\text{ V}$ , $I_D = 1.0\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , Inductive Load $L = 3\text{ mH}$ High- and Low-Side MOSFET Switching (Note 2)	-	1250	-	ns
$t_{OFF}$			-	500	-	ns
$t_{rr}$			-	200	-	ns
$E_{ON}$			-	80	-	$\mu\text{J}$
$E_{OFF}$			-	10	-	$\mu\text{J}$
RBSOA	Reverse-Bias Safe Operating Area	$V_{PN} = 400\text{ V}$ , $V_{CC} = V_{BS} = 15\text{ V}$ , $I_D = I_{DP}$ , $V_{DS}=BV_{DSS}$ , $T_J = 150^\circ\text{C}$ High- and Low-Side MOSFET Switching (Note 3)	Full Square			

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

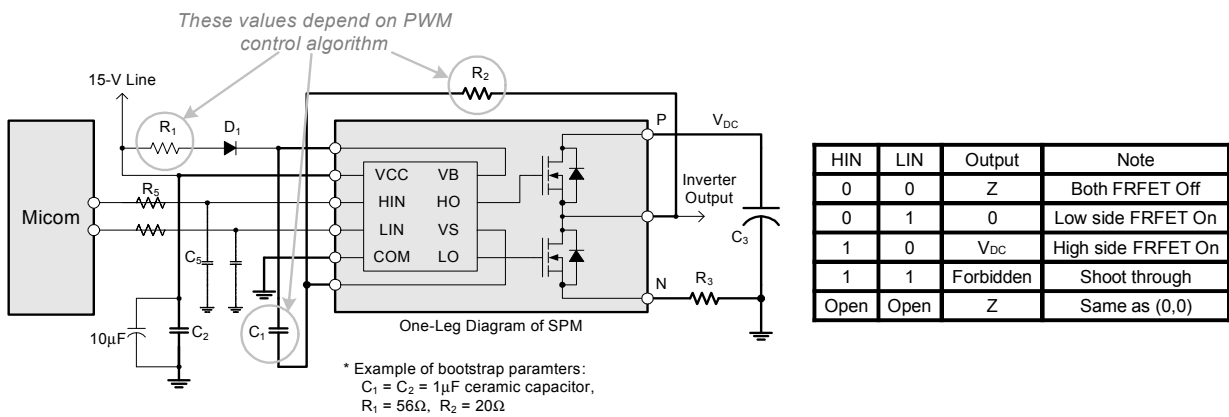
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$I_{QCC}$	Quiescent $V_{CC}$ Current	$V_{CC}=15\text{ V}$ , $V_{IN}=0\text{V}$ Applied Between $V_{CC}$ and COM	-	-	160	$\mu\text{A}$
$I_{QBS}$	Quiescent $V_{BS}$ Current	$V_{BS}=15\text{ V}$ , $V_{IN}=0\text{V}$ Applied Between $V_{B(U)-U}$ , $V_{B(V)-V}$ , $V_{B(W)-W}$	-	-	100	$\mu\text{A}$
$UV_{CCD}$	Low-Side Undervoltage Protection (Figure 6)	$V_{CC}$ Undervoltage Protection Detection Level	7.4	8.0	9.4	V
$UV_{CCR}$		$V_{CC}$ Undervoltage Protection Reset Level	8.0	8.9	9.8	V
$UV_{BSD}$	High-Side Undervoltage Protection (Figure 7)	$V_{BS}$ Undervoltage Protection Detection Level	7.4	8.0	9.4	V
$UV_{BSR}$		$V_{BS}$ Undervoltage Protection Reset Level	8.0	8.9	9.8	V
$V_{IH}$	ON Threshold Voltage	Logic High Level	3.0	-	-	V
$V_{IL}$	OFF Threshold Voltage	Logic Low Level				-
$I_{IH}$	Input Bias Current	$V_{IN} = 5\text{V}$	-	10	20	$\mu\text{A}$
$I_{IL}$		$V_{IN} = 0\text{V}$	-	-	2	$\mu\text{A}$

**Note:**

- $BV_{DSS}$  is the Absolute Maximum Voltage Rating Between Drain and Source Terminal of Each MOSFET Inside Motion SPM®.  $V_{PN}$  Should be Sufficiently Less Than This Value Considering the Effect of the Stray Inductance so that  $V_{DS}$  Should Not Exceed  $BV_{DSS}$  in Any Case.
- $t_{ON}$  and  $t_{OFF}$  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 4 for the Switching Time Definition with the Switching Test Circuit of Figure 5.
- The peak current and voltage of each MOSFET during the switching operation should be included in the safe operating area (SOA). Please see Figure 5 for the RBSOA test circuit that is same as the switching test circuit.

## Recommended Operating Condition

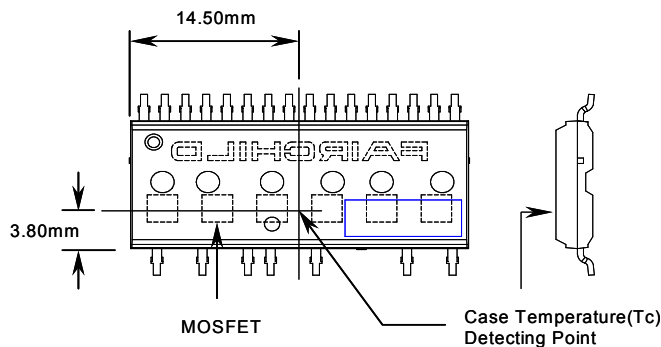
Symbol	Parameter	Conditions	Value			Unit
			Min.	Typ.	Max.	
$V_{PN}$	Supply Voltage	Applied Between P and N	-	300	400	V
$V_{CC}$	Control Supply Voltage	Applied Between $V_{CC}$ and COM	13.5	15	16.5	V
$V_{BS}$	High-Side Bias Voltage	Applied Between $V_B$ and $V_S$	13.5	15	16.5	V
$V_{IN(ON)}$	Input ON 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	$V_{CC}=V_{BS}= 13.5 \sim 16.5 \text{ V}, T_J \leq 150^\circ\text{C}$	1.0	-	-	$\mu\text{s}$
$f_{PWM}$	PWM Switching Frequency	$T_J \leq 150^\circ\text{C}$	-	15	-	kHz



**Note:**

- It is Recommended the Bootstrap Diode  $D_1$  to Have Soft and Fast Recovery Characteristics with 600-V Rating.
- 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 ( $R_5$  and  $C_5$ ) at Each Input of Motion SPM® and Microm (Indicated as Dotted Lines) May be Used to Prevent Improper Signal Due to Surge Noise.
- 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  $C_1, C_2$  and  $C_3$  Should Have Good High-Frequency characteristics to Absorb High-Frequency Ripple Current.

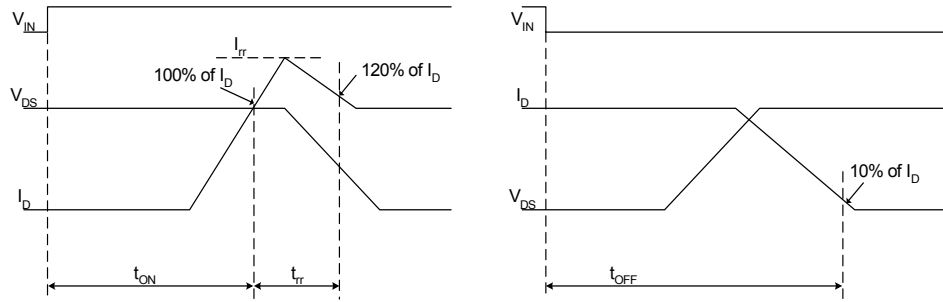
**Figure 2. Recommended MCU Interface and Bootstrap Circuit with Parameters**



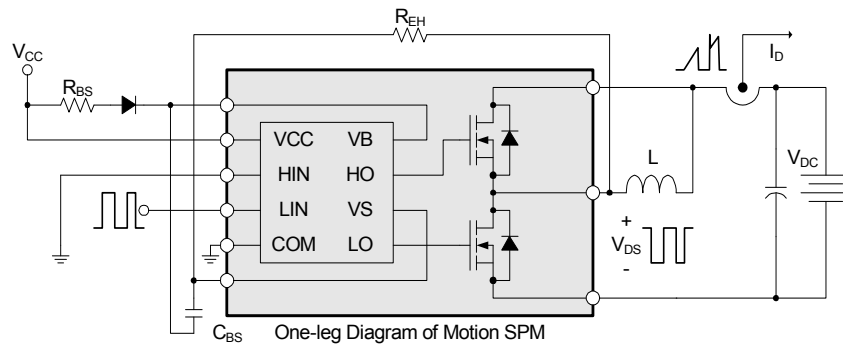
**Note:**

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

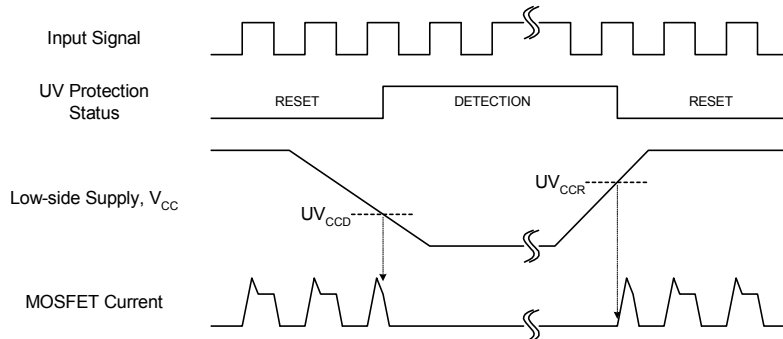
**Figure 3. Case Temperature Measurement**



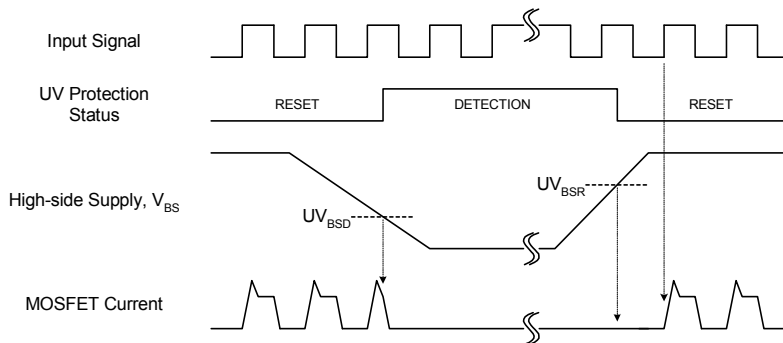
(a) Turn-on (b) Turn-off  
**Figure 4. Switching Time Definitions**



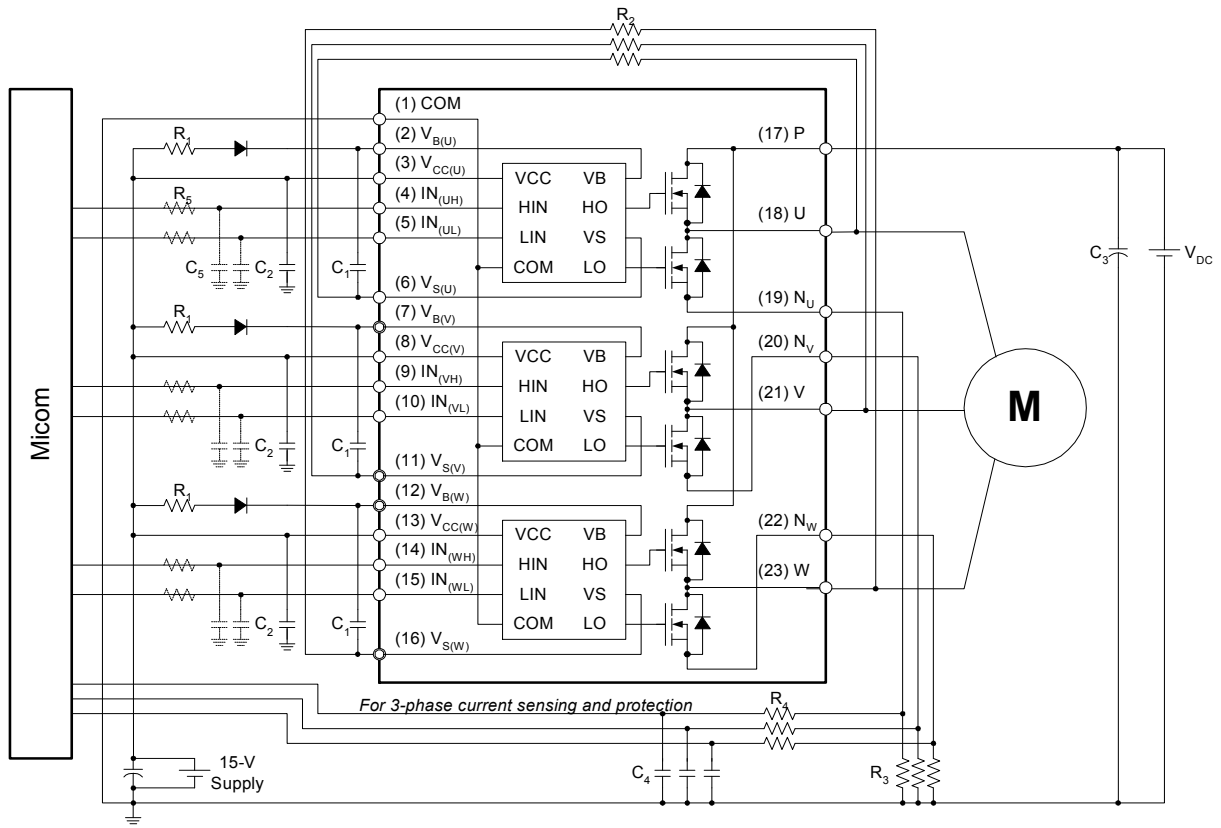
**Figure 5. Switching and RBSOA (Single-pulse) Test Circuit (Low-side)**



**Figure 6. Undervoltage Protection (Low-side)**



**Figure 7. Undervoltage Protection (High-side)**

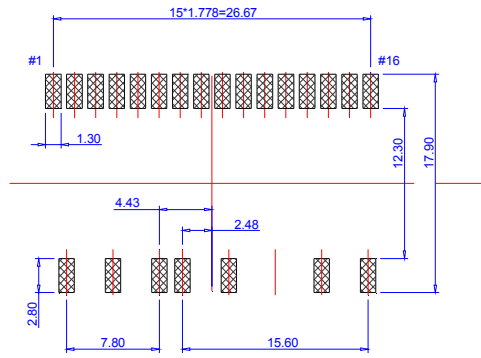
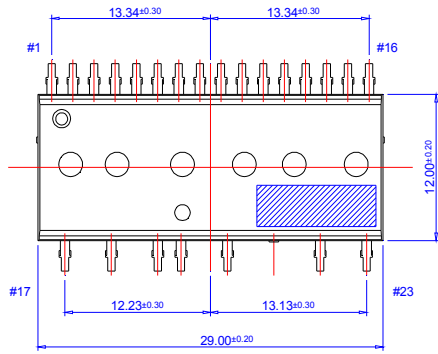
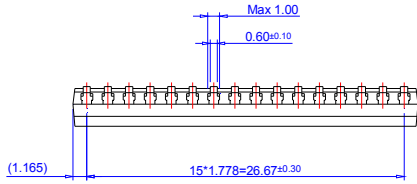


**Note:**

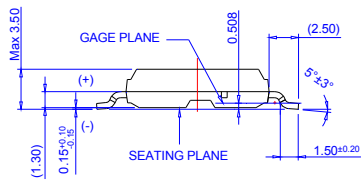
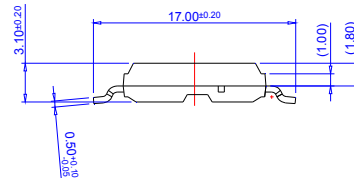
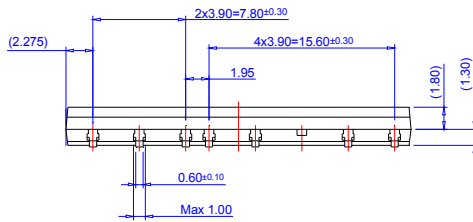
1. About Pin Position, Refer to Figure 1.
2. RC Coupling ( $R_5$  and  $C_5$ ,  $R_4$  and  $C_4$ ) at Each Input of Motion SPM® and Microm are Useful to Prevent Improper Input Signal Caused by Surge Noise.
3. The voltage Drop Across  $R_3$  Affects the Low Side Switching Performance and the Bootstrap 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 1 V 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 Motion SPM, and They Should Have Good Characteristics for Rejecting High-Frequency Ripple Current.

**Figure 8. Example of Application Circuit**

### Detailed Package Outline Drawings





LAND PATTERN RECOMMENDATIONS







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