



January 2014

FSB50450

Motion SPM® 5 Series

Features

- UL Certified No. E209204 (UL1557)
- 500 V $R_{DS(on)} = 2.4 \Omega$ (Max) FRFET MOSFET 3-Phase Inverter with Gate Drivers
- Separate Open-Source Pins from Low-Side MOSFETs for Three-Phase Current-Sensing
- Active-HIGH Interface, Works with 3.3 / 5 V Logic, Schmitt-trigger Input
- Optimized for Low Electromagnetic Interference
- HVIC for Gate Driving and Under-Voltage Protection
- Isolation Rating: 1500 V_{rms} / min.
- RoHS Compliant

Applications

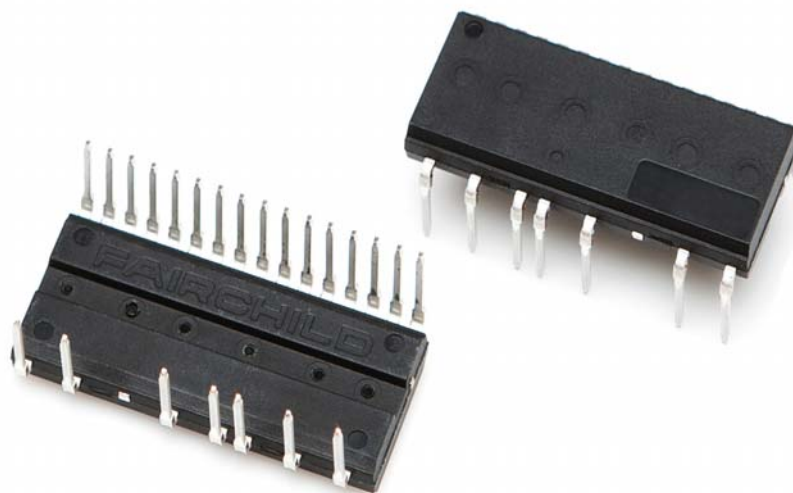
- 3-Phase Inverter Driver for Small Power AC Motor Drives

Related Source

- [AN-9082 - Motion SPM5 Series Thermal Performance by Contact Pressure](#)
- [AN-9080 - User's Guide for Motion SPM 5 Series Ver.1](#)

General Description

The FSB50450 is an advanced Motion SPM® 5 module providing a fully-featured, high-performance inverter output stage for AC Induction, BLDC and PMSM motors. These modules integrate optimized gate drive of the built-in MOSFETs (FRFET® technology) to minimize EMI and losses. 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 MOSFETs. Separate open-source MOSFET terminals are available for each phase to support the widest variety of control algorithms.



Package Marking & Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FSB50450	FSB50450	SPM5B-023	Rail	15

Absolute Maximum Ratings

Inverter Part (each MOSFET unless otherwise specified.)

Symbol	Parameter	Conditions	Rating	Unit
V_{DSS}	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	$T_C = 80^\circ\text{C}$	1.0	A
$*I_{DP}$	Each MOSFET Drain Current, Peak	$T_C = 25^\circ\text{C}$, $PW < 100\ \mu\text{s}$	3.0	A
$*P_D$	Maximum Power Dissipation	$T_C = 25^\circ\text{C}$, For Each MOSFET	4.5	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 (1st Note 1)	8.9	$^\circ\text{C/W}$

Total System

Symbol	Parameter	Conditions	Rating	Unit
T_J	Operating Junction Temperature		$-20 \sim 150$	$^\circ\text{C}$
T_{STG}	Storage Temperature		$-50 \sim 150$	$^\circ\text{C}$
V_{ISO}	Isolation Voltage	60 Hz, Sinusoidal, 1 Minute, Connect Pins to Heat Sink Plate	1500	V_{rms}

1st Notes:

- 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

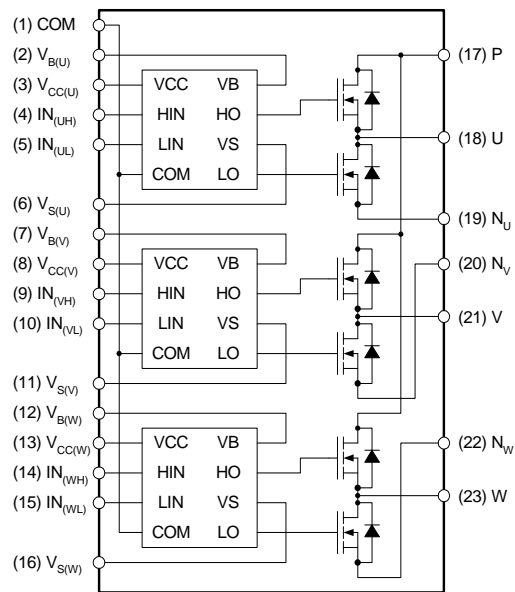


Figure 1. Pin Configuration and Internal Block Diagram (Bottom View)

1st Notes:

- Source terminal of each low-side MOSFET is not connected to supply ground or bias voltage ground inside Motion SPM® 5 product. External connections should be made as indicated in Figure 3.

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	$V_{IN} = 0\text{ V}$, $I_D = 250\text{ }\mu\text{A}$ (2nd Note 1)	500	-	-	V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{IN} = 0\text{ V}$, $V_{DS} = 500\text{ V}$	-	-	250	μA
$R_{DS(on)}$	Static Drain - Source Turn-On Resistance	$V_{CC} = V_{BS} = 15\text{ V}$, $V_{IN} = 5\text{ V}$, $I_D = 0.5\text{ A}$	-	1.9	2.4	Ω
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	$V_{PN} = 300\text{ V}$, $V_{CC} = V_{BS} = 15\text{ V}$, $I_D = 0.5\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, Inductive Load $L = 3\text{ mH}$ High- and Low-Side MOSFET Switching (2nd Note 2)	-	1152	-	ns
t_{OFF}			-	600	-	ns
t_{rr}			-	185	-	ns
E_{ON}			-	85	-	μJ
E_{OFF}			-	11	-	μJ
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 (2nd 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	μA
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	μA
UV_{CCD}	Low-Side Under-Voltage Protection (Figure 8)	V_{CC} Under-Voltage Protection Detection Level	7.4	8.0	9.4	V
UV_{CCR}		V_{CC} Under-Voltage Protection Reset Level	8.0	8.9	9.8	V
UV_{BSD}	High-Side Under-Voltage Protection (Figure 9)	V_{BS} Under-Voltage Protection Detection Level	7.4	8.0	9.4	V
UV_{BSR}		V_{BS} Under-Voltage 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	μA
I_{IL}		$V_{IN} = 0\text{ V}$	-	-	2	μA

2nd Notes:

- BV_{DSS} is the absolute maximum voltage rating between drain and source terminal of each MOSFET inside Motion SPM® 5 product. V_{PN} should be sufficiently less than this value considering the effect of the stray inductance so that V_{PN} should not exceed BV_{DSS} in any case.
- t_{ON} and t_{OFF} include the propagation delay 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	Min.	Typ.	Max.	Unit
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	15.0	16.5	V
V_{BS}	High-Side Bias Voltage	Applied Between V_B and V_S	13.5	15.0	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	-	-	μs
f_{PWM}	PWM Switching Frequency	$T_J \leq 150^\circ\text{C}$	-	15	-	kHz
T_C	Case Temperature	$T_J \leq 150^\circ\text{C}$	-20	-	125	$^\circ\text{C}$

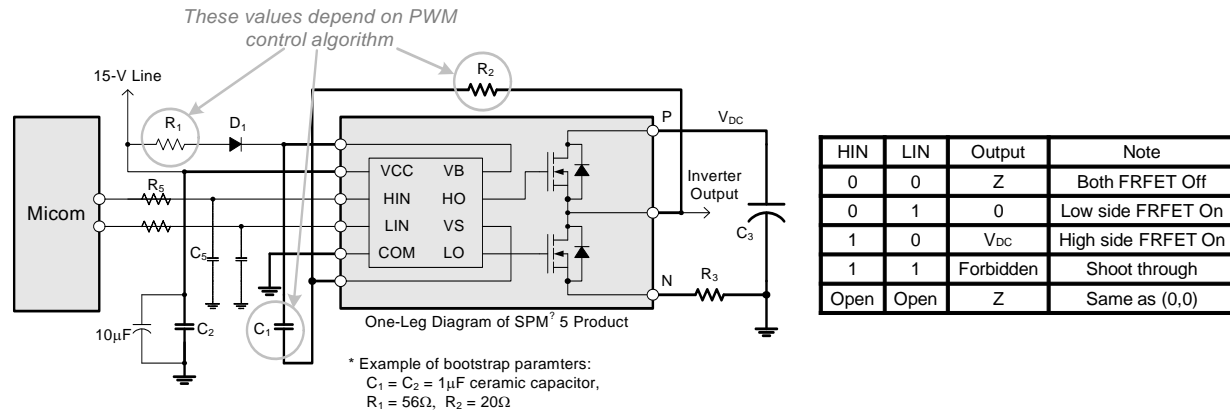


Figure 2. Recommended MCU Interface and Bootstrap Circuit with Parameters

3rd Notes:

- 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) and C_4 at each input of Motion SPM 5 product and MCU (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.

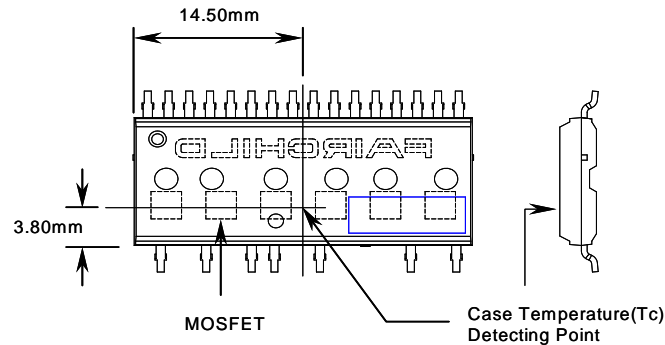


Figure 3. Case Temperature Measurement

3rd Notes:

- Attach the thermocouple on top of the heat-sink of SPM 5 package (between SPM 5 package and heatsink if applied) to get the correct temperature measurement.

Figure 1: One-leg Diagram of Motion SPM® 5 Product

The diagram illustrates the UV Protection Status logic. The **Input Signal** is a periodic square wave. The **UV Protection Status** signal is **RESET** when the input signal is high and transitions to **DETECTION** when the input signal goes low. The **Low-side Supply, V_{CC}** shows a ramp-down during the **DETECTION** phase, with a threshold UV_{CDD} indicated. The **MOSFET Current** shows pulses during the **RESET** phases and zero current during the **DETECTION** phase. A threshold UV_{CCR} is also indicated on the rising edge of the supply voltage.

The diagram illustrates the UV Protection Status logic. It shows four waveforms over time:

- Input Signal:** A periodic square wave that transitions from high to low, triggering the UV protection.
- UV Protection Status:** A digital signal that transitions from **RESET** to **DETECTION** when the input signal goes low, and returns to **RESET** when the input signal returns to high.
- High-side Supply, V_{BS} :** A voltage signal that ramps down from a high level to a low level during the **DETECTION** phase. The threshold for UV protection is indicated by a dashed line labeled UV_{BSD} . When the supply voltage reaches this level, the MOSFET current drops to zero. The supply then ramps back up during the **RESET** phase. The threshold for the supply to return to normal operation is indicated by a dashed line labeled UV_{BSR} .
- MOSFET Current:** A signal that shows the MOSFET is in conduction (high current) when the supply is high and the UV protection is not active. When the UV protection is active (DETECTION phase), the current drops to zero. The current returns to its normal operating level when the UV protection is reset.

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Figure 8. Example of Application Circuit

4th Notes:

- About pin position, refer to Figure 1.
- RC-coupling (R_5 and C_5 , R_4 and C_6) and C_4 at each input of Motion SPM[®] 5 product and MCU are useful to prevent improper input signal caused by surge-noise.
- 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.
- Ground-wires and output terminals, should be thick and short in order to avoid surge-voltage and malfunction of HVIC.
- All the filter capacitors should be connected close to Motion SPM 5 product, and they should have good characteristics for rejecting high-frequency ripple current.

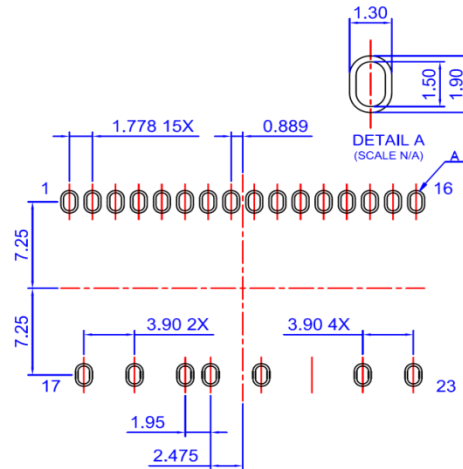
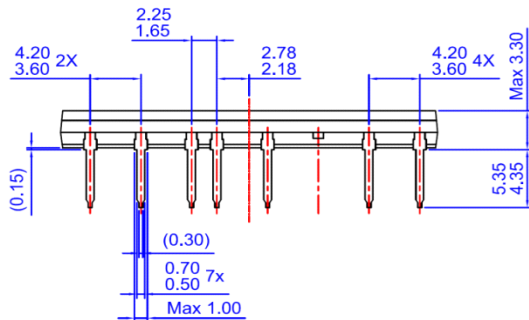
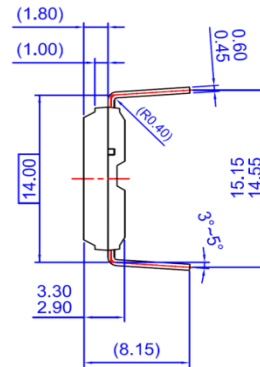
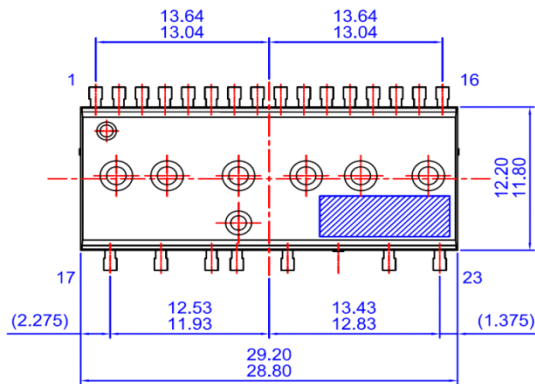
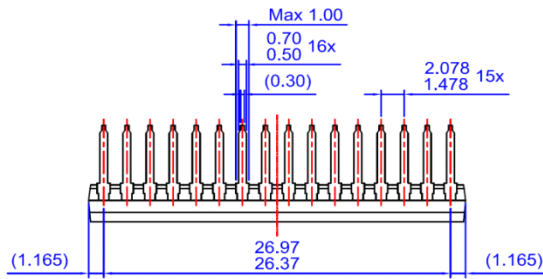
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