DATA SHEET
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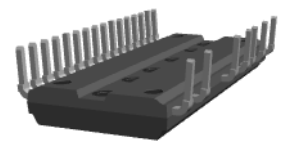
Motion SPM® 5 Series

NFA50460R4B, NFA50460R47



SPM5P−023 / 23LD, PDD STD,
FULL PACK, DIP TYPE
CASE MODEJ

SPM5Q−023 / 23LD, PDD STD,
SPM23−BD (Ver1.5) SMD TYPE
CASE MODEM

General Description

The NFA50460R4B/7 is an advanced Motion SPM5 module providing a fully featured, high performance inverter output stage for AC induction, BLDC and PMSM motors such as refrigerators, fans and pumps. These modules integrate optimized gate drive of the built−in IGBTs (FS4 RC IGBT technology) to minimize EMI and losses, while also providing multiple on−module protection features including under−voltage lockouts and thermal monitoring. The built−in high speed Driver IC 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 open emitter IGBT terminals are available for each phase to support the widest variety of control algorithms.

Features

- UL Certified No. E209204 (UL1557)
- 600 V FS4 RC IGBT 3−Phase Inverter with Gate Drivers and Protection
- Built−In Bootstrap Diodes Simplify PCB Layout
- Separate Open−Emitter Pins from Low−Side IGBTs for Three−Phase Current−Sensing
- Active−High Interface, Works with 3.3 / 5 V Logic, Schmitt−Trigger Input
- Optimized for Low Electromagnetic Interference
- Driver IC Temperature Sensing Built−In for Temperature Monitoring
- Driver IC for Gate Driving and Under−Voltage Protection
- Isolation Rating: 1500 V_{rms}/min.
- Moisture Sensitive Level (MSL) 3 for SMD PKG
- RoHS Compliant

Applications

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

Related Source

- AN−9080 – Motion SPM® 5 Series Version 2 User's Guide
- AN−9082 – Motion SPM® 5 Series Thermal Performance by Contact Pressure

MARKING DIAGRAM

$Y NFA50460R4x &Z&K&E&E&E&E&3

$Y	= **onsemi** Logo
NFA50460R4x	= Specific Device Code → x = B or 7
&Z	= Assembly Plant Code
&K	= Lot Traceability Code
&3	= Date Code (Year & Week)

ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

ORDERING INFORMATION

Device	Device Marking	Package	Packing Type†	Reel Size	Quantity
NFA50460R4B	NFA50460R4B	SPM5P−023	Rail	NA	15
NFA50460R47	NFA50460R47	SPM5Q−023	Tape & Reel	330 mm	450

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

ABSOLUTE MAXIMUM RATINGS (V_{DD} = V_{BS} = 15 V, T_C = 25°C, unless otherwise noted)

Symbol	Parameter	Conditions	Rating	Unit
INVERTER PART (Each IGBT Unless Otherwise Specified)				
V_{PN}	Supply Voltage	Applied between P − N_U, N_V, N_W	450	V
$V_{PN(Surge)}$	Supply Voltage (Surge)	Applied between P − N_U, N_V, N_W	500	V
V_{CES}	Collector − Emitter Voltage		600	V
$\pm I_C$	Each IGBT Collector Current	T_C = 25°C, V_{DD} = 15 V, T_J < 150°C	4	A
$\pm I_{CP}$	Each IGBT Collector Current, Peak	T_C = 25°C, V_{DD} = 15 V, T_J < 150°C, Under 1 ms Pulse Width (Note 2)	8	A
P_C	Collector Dissipation	T_C = 25°C per One Chip (Note 2)	10.3	W
T_J	Operating Junction Temperature		−40~150	°C
CONTROL PART (Each IC Unless Otherwise Specified)				
V_{DD}	Control Supply Voltage	Applied between V_{DD} and V_{SS}	20	V
V_{BS}	High−Side Control Bias Voltage	Applied between V_B and V_S	20	V
V_{IN}	Input Signal Voltage	Applied between HIN, LIN and V_{SS}	−0.3~V_{DD} + 0.3	V
BOOTSTRAP DIODE PART (Each Bootstrap Diode Unless Otherwise Specified)				
V_{RRM}	Maximum Repetitive Reverse Voltage		600	V
I_F	Forward Current	T_C = 25°C, T_J < 150°C (Note 2)	0.5	A
I_{FP}	Forward Current (Peak)	T_C = 25°C, T_J < 150°C, Under 1 ms Pulse Width (Note 2)	1.5	A
THERMAL RESISTANCE				
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance	Inverter IGBT Part (per 1/6 Module) (Note 1)	12.2	°C/W
TOTAL SYSTEM				
t_{SC}	Short Circuit Withstand Time	V_{DD} = V_{BS} ≤ 16.5 V, V_{PN} ≤ 400 V, T_J = 150°C, Non−repetitive	3	μs
T_J	Operating Junction Temperature		−40~150	°C
T_{STG}	Storage Temperature		−40~125	°C
V_{ISO}	Isolation Voltage	60 Hz, Sinusoidal, AC 1 minute, Connect Pins to Heat Sink Plate	1500	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.

1. For the measurement point of case temperature T_C, Please refer to Figure 4.
2. These values had been made an acquisition by the calculation considered to design factor.
3. Using continuously under heavy loads or excessive assembly conditions (e.g. the application of high temperature/ current/ voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/ current/ voltage, etc.) are within the absolute maximum ratings and the operating ranges.

PIN DESCRIPTION

Pin No.	Pin Name	Description
1	V_{SS}	IC Common Supply Ground
2	$V_{B(U)}$	High−Side Bias Voltage for U phase IGBT Driving
3	$V_{DD(U)}$	Low−Side Bias Voltage for U phase IC and IGBT Driving
4	$HIN_{(U)}$	Signal Input for High−Side U Phase
5	$LIN_{(U)}$	Signal Input for Low−Side U Phase
6	N.C	N.C
7	$V_{B(V)}$	High−Side Bias Voltage for V phase IGBT Driving
8	$V_{DD(V)}$	Low−Side Bias Voltage for V phase IC and IGBT Driving
9	$HIN_{(V)}$	Signal Input for High−Side V Phase
10	$LIN_{(V)}$	Signal Input for Low−Side V Phase
11	VTS	Voltage Output for IC Temperature Sensing Unit
12	$V_{B(W)}$	High−Side Bias Voltage for W phase IGBT Driving
13	$V_{DD(W)}$	Low−Side Bias Voltage for W phase IC and IGBT Driving
14	$HIN_{(W)}$	Signal Input for High−Side W Phase
15	$LIN_{(W)}$	Signal Input for Low−Side W Phase
16	N.C	N.C
17	P	Positive DC–Link Input
18	U, $V_{S(U)}$	Output for U Phase & High−Side Bias Voltage GND for U phase IGBT 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 & High−Side Bias Voltage GND for V phase IGBT Driving
22	N_W	Negative DC–Link Input for W Phase
23	W, $V_{S(W)}$	Output for W Phase & High−Side Bias Voltage GND for W phase IGBT Driving

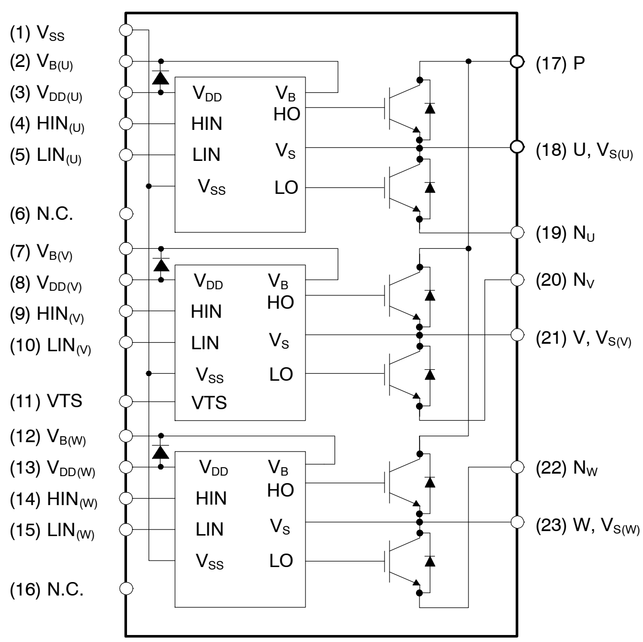


Figure 1. Pin Configuration and Internal Block Diagram (Bottom View)

NOTE:
4. Emitter terminal of each low−side IGBT 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°C, V_{DD} = V_{BS} = 15 V unless otherwise noted)

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
INVERTER PART (Each IGBT unless otherwise specified)							
BV_{CES}	Collector−Emitter Breakdown Voltage	V_{IN} = 0 V, I_D = 1 mA (Note 5)		600	–	–	V
I_{CES}	Collector−Emitter Leakage Current	V_{IN} = 0 V, V_{CE} = 600 V		–	–	1	mA
$V_{CE(SAT)}$	Collector−Emitter Saturation Voltage	V_{DD} = V_{BS} = 15 V, V_{IN} = 5 V, I_C = 4 A, T_J = 25°C		–	1.75	2.2	V
		V_{DD} = V_{BS} = 15 V, V_{IN} = 5 V, I_C = 4 A, T_J = 150°C		–	2.0	–	
V_F	Emitter−Collector Forward Voltage	V_{IN} = 0 V, I_F = 4 A, T_J = 25°C		–	1.87	2.3	V
		V_{IN} = 0 V, I_F = 4 A, T_J = 150°C		–	2.0	–	
t_{ON}	Switching Times	V_{PN} = 300 V, V_{DD} = V_{BS} = 15 V, I_C = 4 A V_{IN} = 0 V ↔ 5 V, Inductive Load, High− and Low−Side IGBT Switching (Note 6)		–	370	–	ns
t_{OFF}				–	358	–	ns
t_{rr}				–	151	–	ns
E_{ON}				–	150	–	μJ
E_{OFF}				–	35	–	μJ
RBSOA	Reverse−Bias Safe Operating Area	V_{PN} = 400 V, V_{DD} = V_{BS} = 15 V, I_C = I_{CP}, V_{CE} = BV_{CES}, T_J = 150°C High− and Low−Side IGBT Switching (Note 7)		Full Square			
CONTROL PART (Each HVIC Unless Otherwise Specified)							
I_{QDD}	Quiescent V_{DD} Current	V_{DD} = 15 V, V_{IN} = 0 V	Applied between V_{DD} and V_{SS}	–	–	200	μA
I_{QBS}	Quiescent V_{BS} Current	V_{BS} = 15 V, V_{IN} = 0 V	Applied between $V_{B(U)}$ – U, $V_{B(V)}$ – V, $V_{B(W)}$ – W	–	–	100	μA
I_{PDD}	Operating V_{DD} Supply Current	V_{DD} – V_{SS}	V_{DD} = 15 V, f_{PWM} = 20 kHz, duty = 50%, Applied to One PWM Signal Input for Low−Side	–	–	900	μA
I_{PBS}	Operating V_{BS} Supply Current	$V_{B(U)}$ – $V_{S(U)}$, $V_{B(V)}$ – $V_{S(V)}$, $V_{B(W)}$ – $V_{S(W)}$	V_{DD} = V_{BS} = 15 V, f_{PWM} = 20 kHz, Duty = 50%, Applied to One PWM Signal Input for High−Side	–	–	800	μA
UV_{DDD}	Low−Side Under−voltage Protection (Figure 8)	V_{DD} Under−voltage Protection Detection Level		7.4	8.0	9.4	V
UV_{DDR}		V_{DD} Under−voltage Protection Reset Level		8.0	8.9	9.8	V
UV_{BSD}	High−Side Under−voltage Protection (Figure 8)	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_{TS}	IC Temperature Sensing Voltage Output	V_{DD} = 15 V, T_{driver} = 25°C (Note 8)		600	790	980	mV
V_{IH}	ON Threshold Voltage	Logic HIGH Level	Applied between HIN, LIN and V_{SS}	–	–	2.9	V
V_{IL}	OFF Threshold Voltage	Logic LOW Level		0.8	–	–	V
BOOTSTRAP DIODE PART (Each bootstrap diode unless otherwise specified)							
V_{FB}	Forward Voltage	I_F = 0.1 A, T_C = 25°C (Note 9)		–	2.5	–	V
t_{rrB}	Reverse Recovery Time	I_F = 0.1 A, T_C = 25°C		–	80	–	ns

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.

RECOMMENDED OPERATING CONDITION

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{PN}	Supply Voltage	Applied between P and N	> V_{DD}	300	450	V
V_{DD}	Control Supply Voltage	Applied between V_{DD} and V_{SS}	14.0	15.0	16.5	V
V_{BS}	High−Side Bias Voltage	Applied between V_B and V_S	13.0	15.0	18.5	V
$V_{IN(ON)}$	Input ON Threshold Voltage	Applied between HIN, LIN and V_{SS}	3.0	−	V_{DD}	V
$V_{IN(OFF)}$	Input OFF Threshold Voltage		0	−	0.6	V
t_{dead}	Blanking Time for Preventing Arm−Short	$V_{DD} = V_{BS} = 13.5$~16.5 V, $T_J \leq 150°C$	1.0	−	−	μs
f_{PWM}	PWM Switching Frequency	$T_J \leq 150°C$	−	−	20	kHz

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.

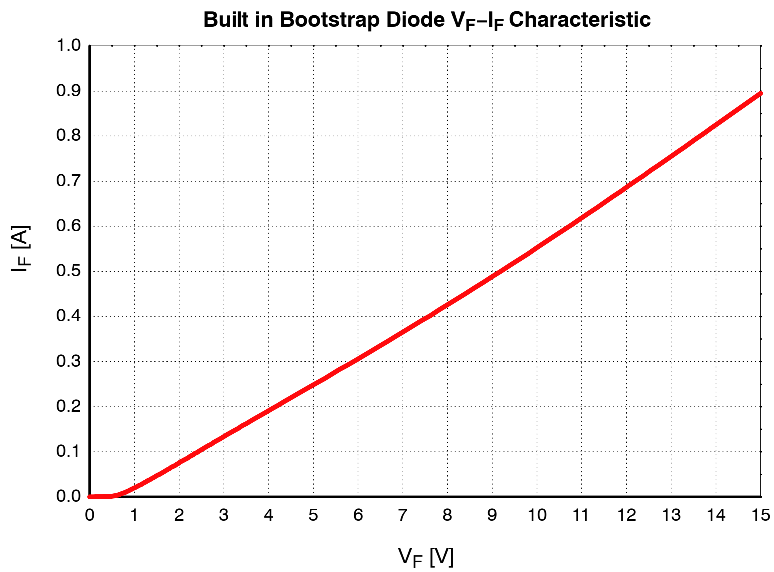
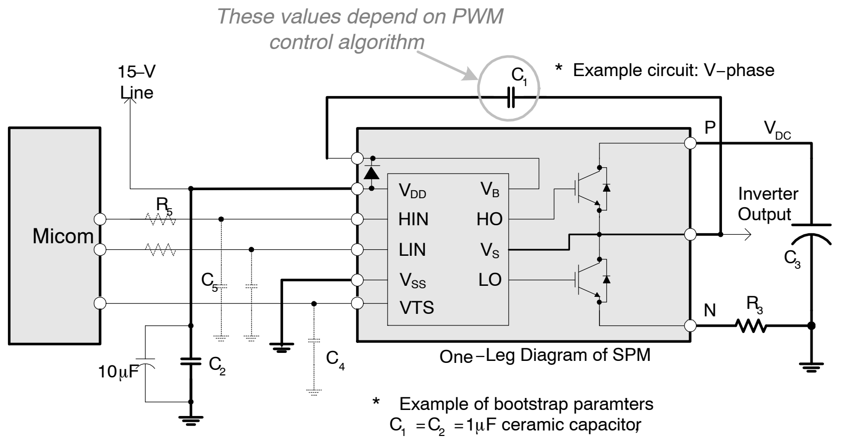


Figure 2. Built−in Bootstrap Diode Characteristics (Typical)

NOTES:
5. BV_{CES} is the absolute maximum voltage rating between collector and emitter terminal of each IGBT inside Motion SPM 5 product. V_{PN} should be sufficiently less than this value considering the effect of the stray inductance so that V_{CE} should not exceed BV_{CES} in any case.
6. t_{ON} and t_{OFF} include the propagation delay time of the internal driver 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.
7. The peak current and voltage of each IGBT 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.
8. VTS is only for sensing temperature of module and cannot shutdown IGBTs automatically.
9. Built in bootstrap diode includes around 15 Ω resistance characteristic. Please refer to Figure 2.



HIN	LIN	Output	Note
0	0	Z	Both IGBT Off
0	1	0	Low−side IGBT On
1	0	V_{DC}	High−side IGBT On
1	1	Forbidden	Shoot−through
Open	Open	Z	Same as (0,0)

Figure 3. Recommended CPU Interface and Bootstrap Circuit with Parameters

NOTES:
10. Parameters for bootstrap circuit elements are dependent on PWM algorithm. Typical example of parameters is shown above.
11. RC coupling (R_5 and C_5) and C_4 at each input of SPM and Micom (Indicated as dotted lines) may be used to prevent improper signal due to surge noise.
12. 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.

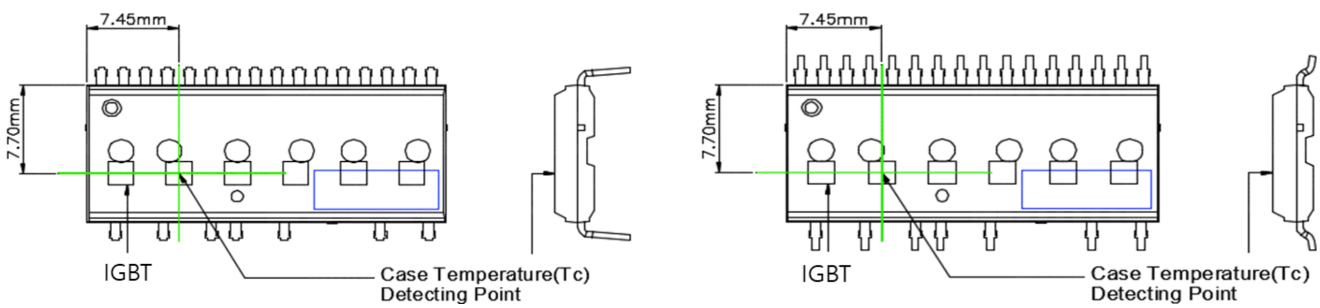


Figure 4. Case Temperature Measurement

NOTE:
13. Attach the thermocouple on top of the heatsink−side of SPM (between SPM and heatsink if applied) to get the correct temperature measurement.

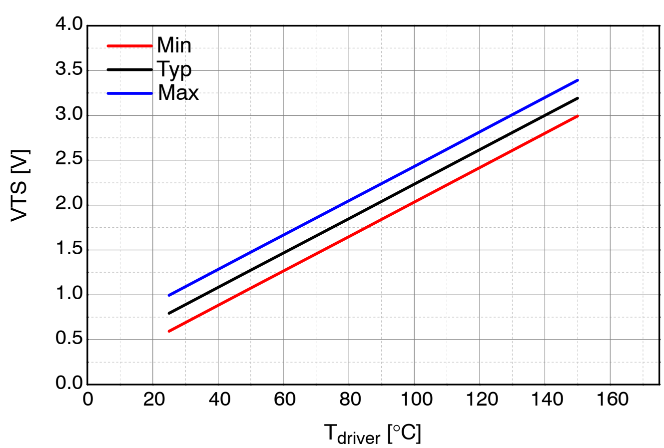


Figure 5. Temperature Profile of VTS

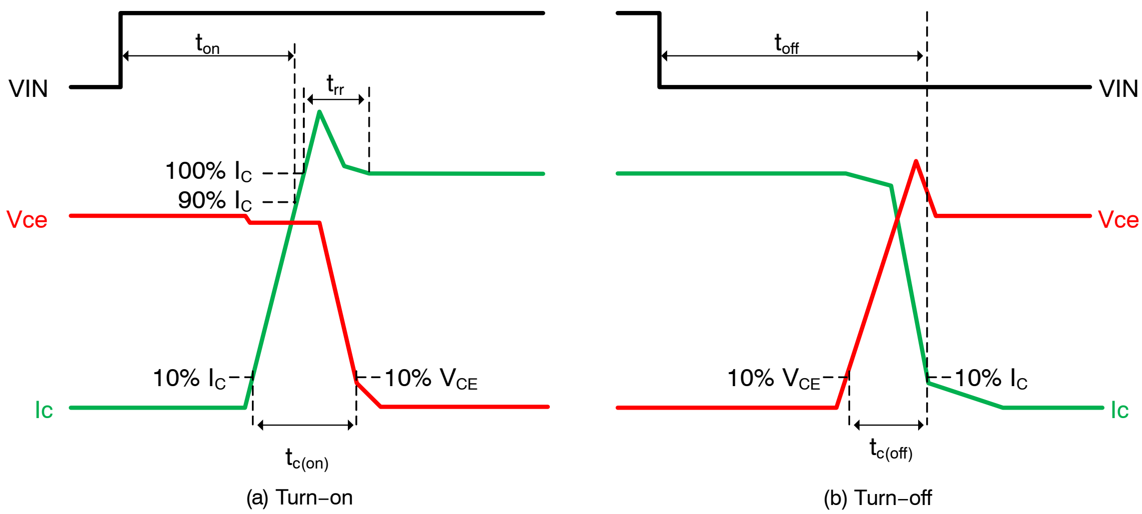


Figure 6. Switching Time Definitions

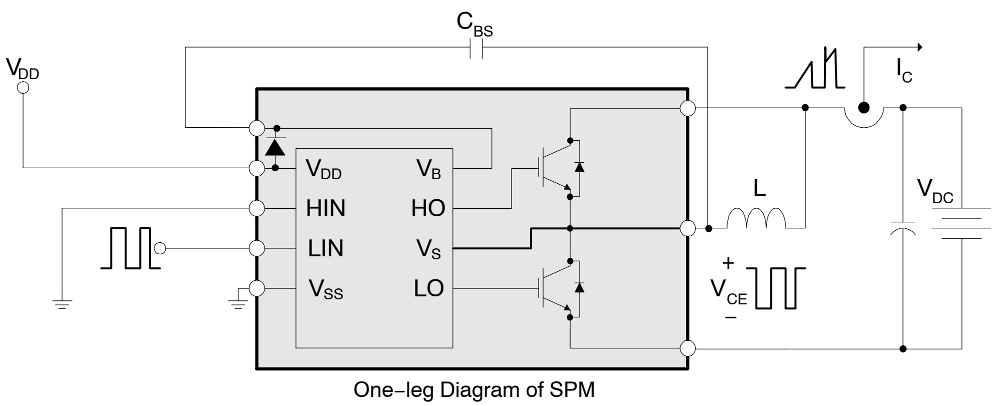


Figure 7. Switching and RBSOA (Single−pulse) Test Circuit (Low−side)

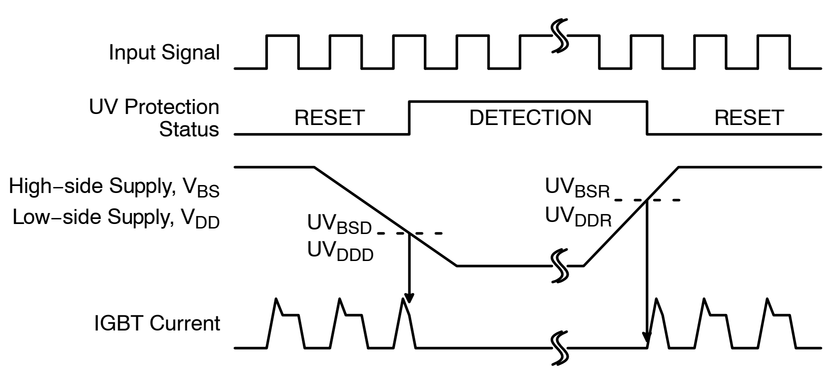


Figure 8. Under−Voltage Protection (High−side and Low−side)

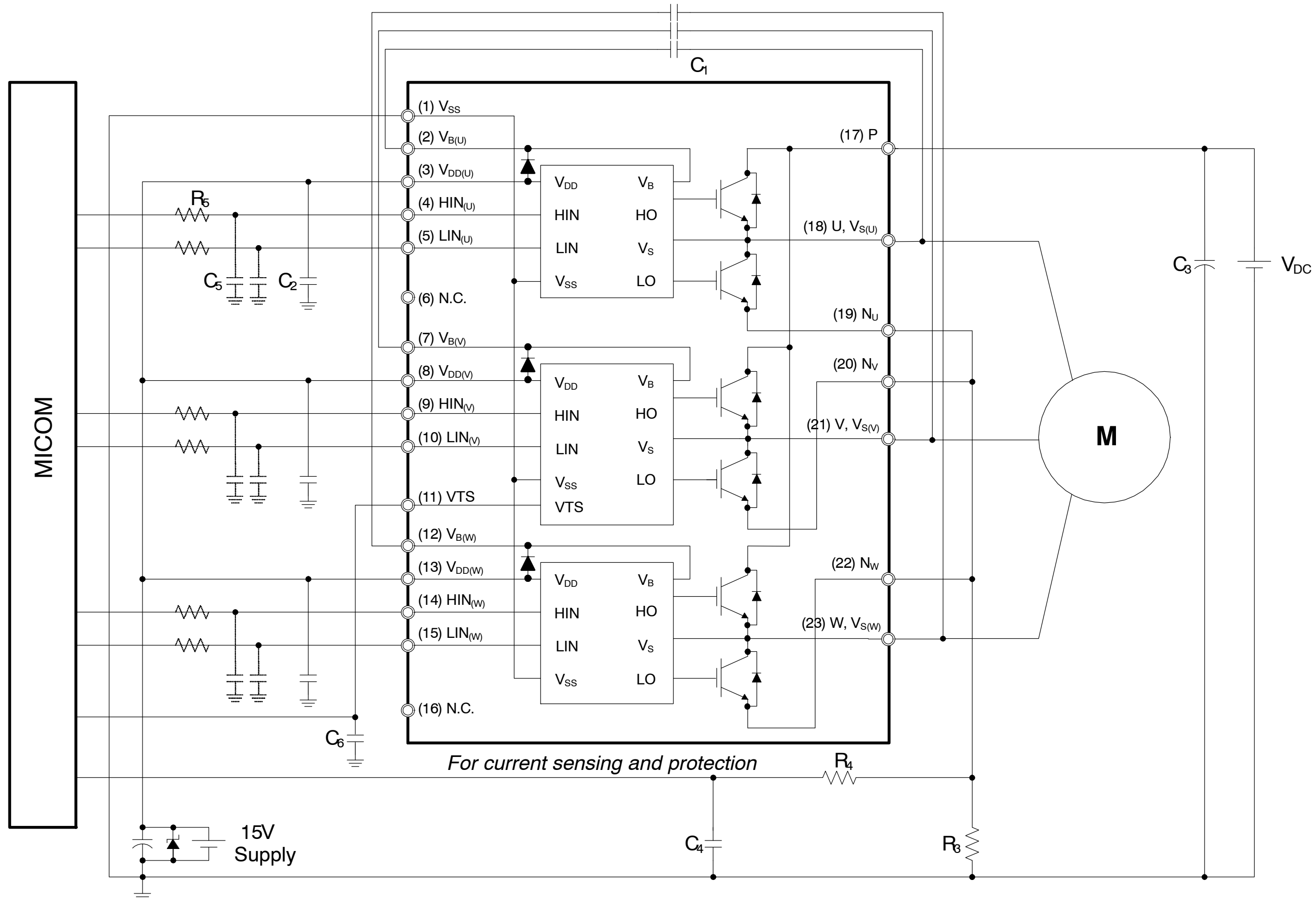


Figure 9. Example of Application Circuit

NOTES:

14. About pin position, refer to Figure 1.
15. RC coupling (R_5 and C_5, R_4 and C_4) and C_6 at each input of Motion SPM 5 product and Micom are useful to prevent improper input signal caused by surge noise.
16. The voltage drop across R_3 affects the low side switching performance and the bootstrap characteristics since it is placed between V_{SS} and the emitter terminal of the low side IGBT. For this reason, the voltage drop across R_3 should be less than 1 V in the steady−state.
17. Ground wires and output terminals, should be thick and short in order to avoid surge voltage and malfunction of IC.
18. 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.

TYPICAL PERFORMANCE CHARACTERISTICS

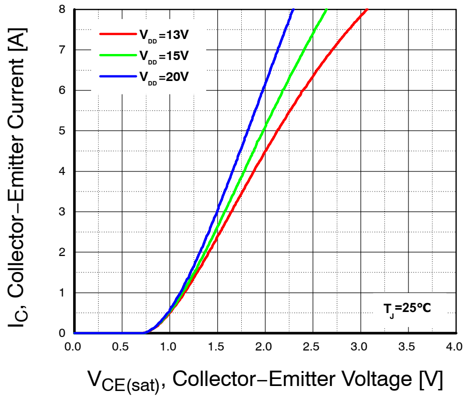


Figure 10. Typ. Collector−Emitter Saturation Voltage

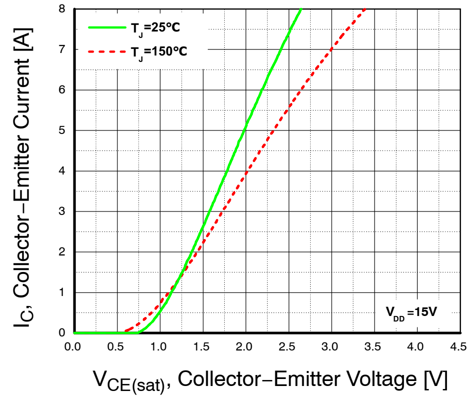


Figure 11. Typ. Collector−Emitter Saturation Voltage

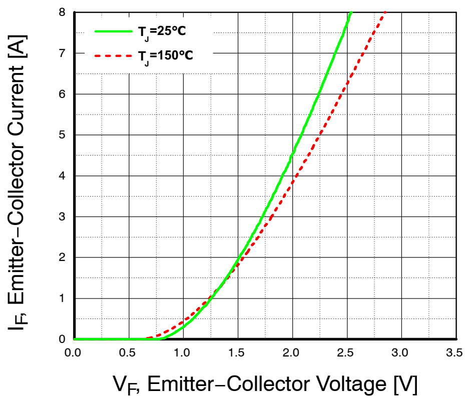


Figure 12. Typ. Emitter−Collector Forward Voltage

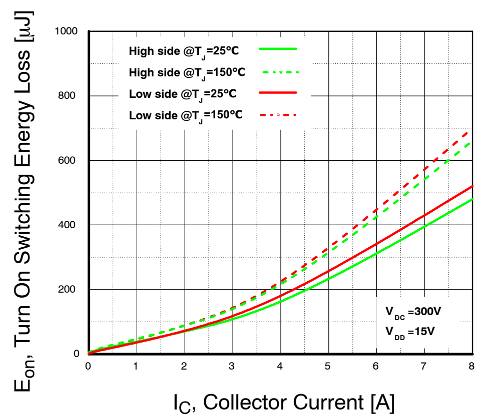


Figure 13. Typ. Turn On Switching Energy Loss

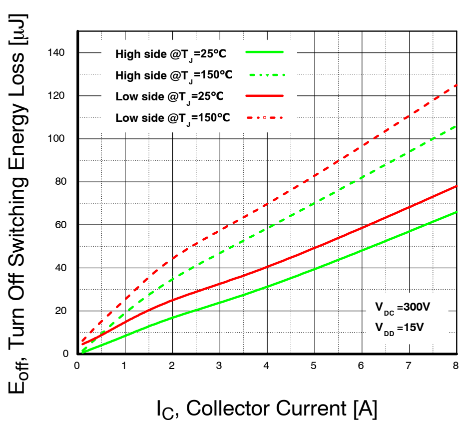


Figure 14. Typ. Turn Off Switching Energy Loss

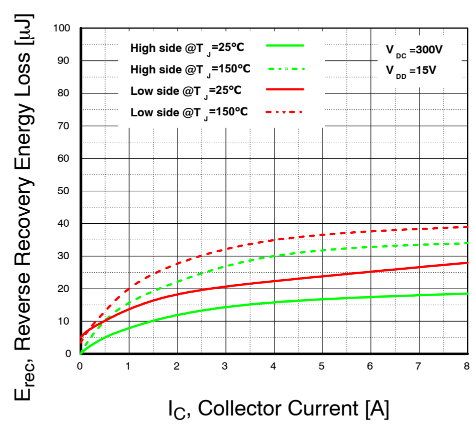


Figure 15. Typ. Reverse Recovery Energy Loss

TYPICAL PERFORMANCE CHARACTERISTICS

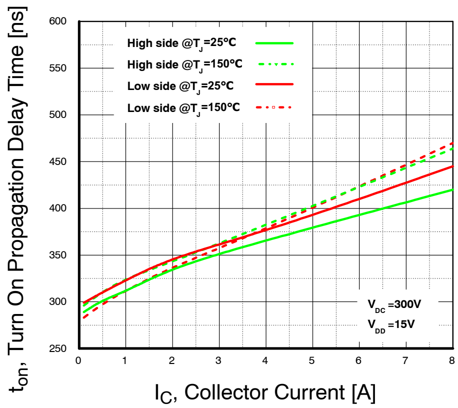


Figure 16. Typ. Turn On Propagation Delay Time

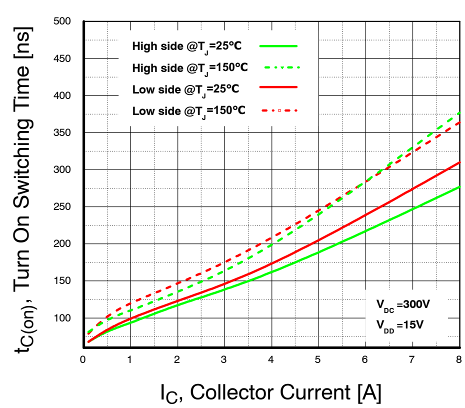


Figure 17. Typ. Turn On Switching Time

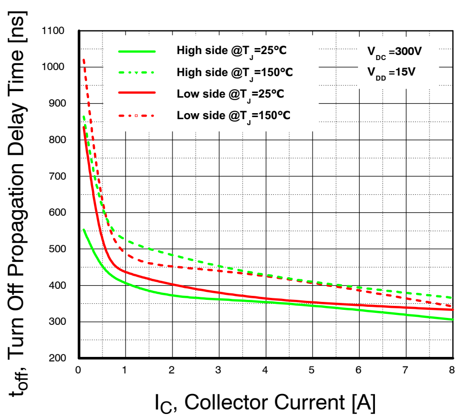


Figure 18. Typ. Turn Off Propagation Delay Time

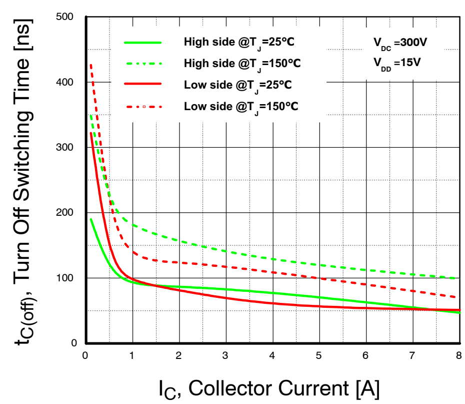


Figure 19. Typ. Turn Off Switching Time

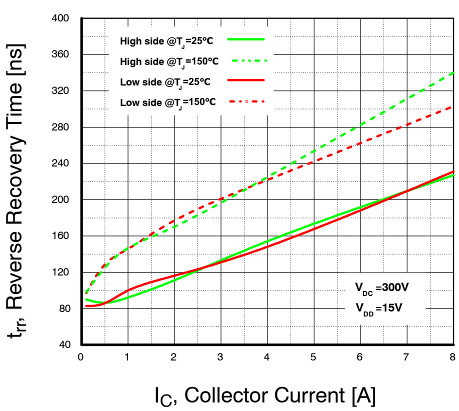


Figure 20. Typ. Reverse Recovery Time

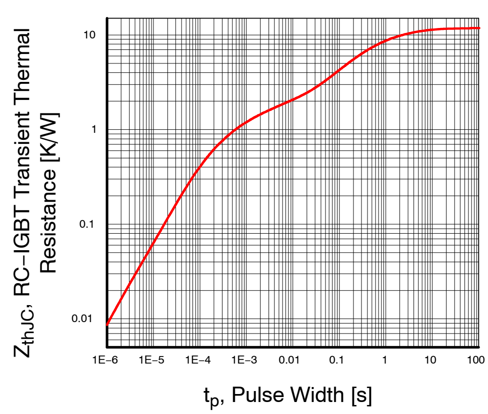


Figure 21. RC−IGBT Transient Thermal Resistance

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SPM5E−023 / 23LD, PDD STD, FULL PACK, DIP TYPE
CASE MODEJ
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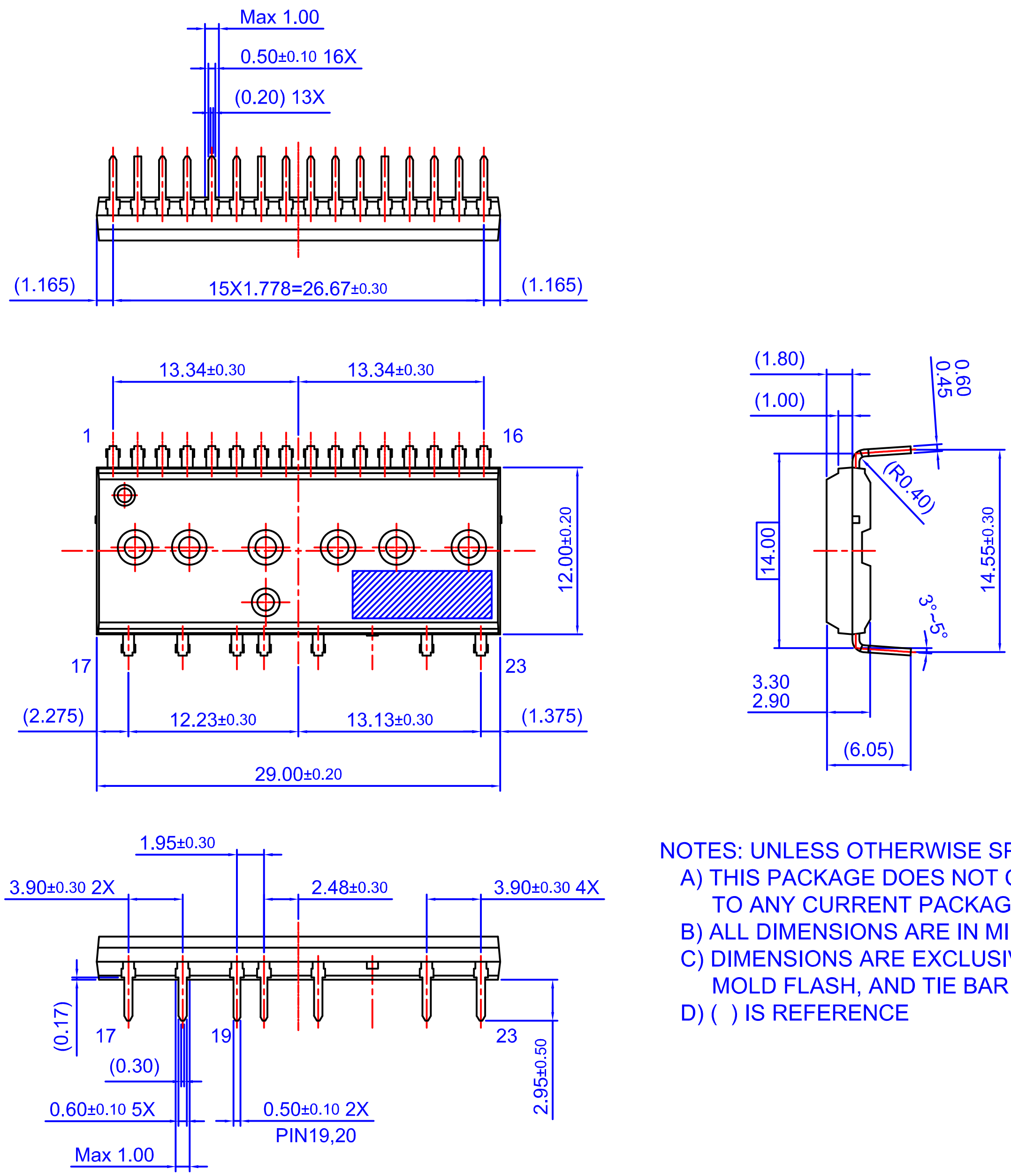
DATE 31 JAN 2017



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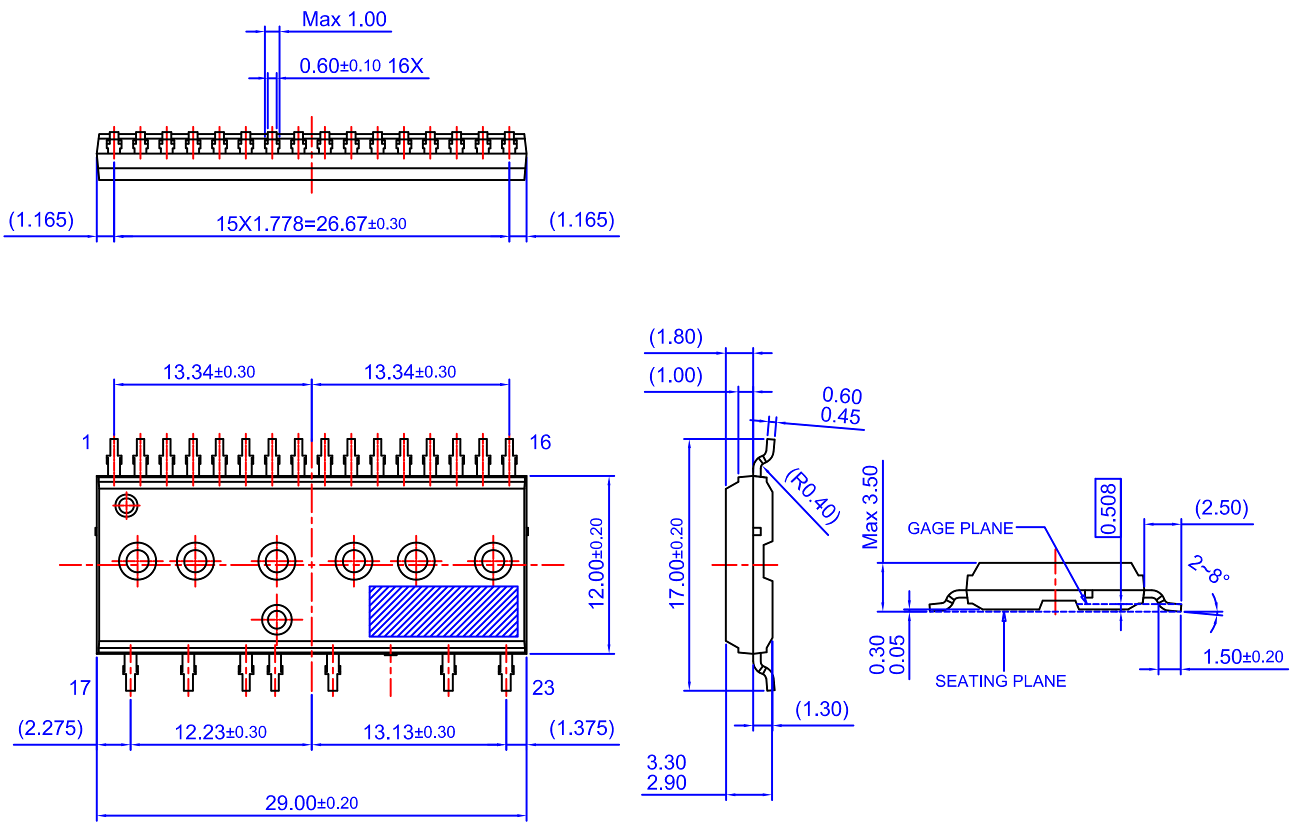
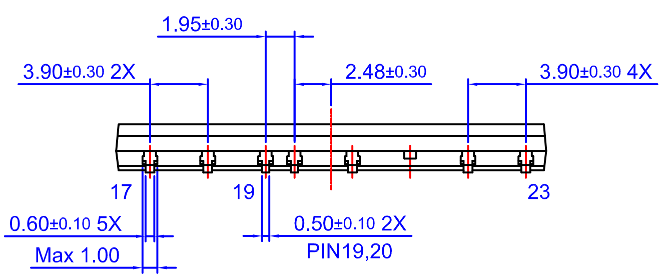
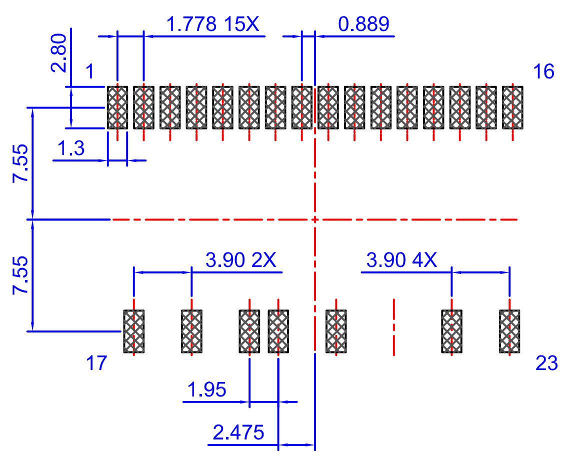
SPM5H−023 / 23LD, PDD STD, SPM23−BD (Ver1.5) SMD TYPE
CASE MODEM
ISSUE O

DATE 31 JAN 2017







LAND PATTERN RECOMMENDATIONS

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