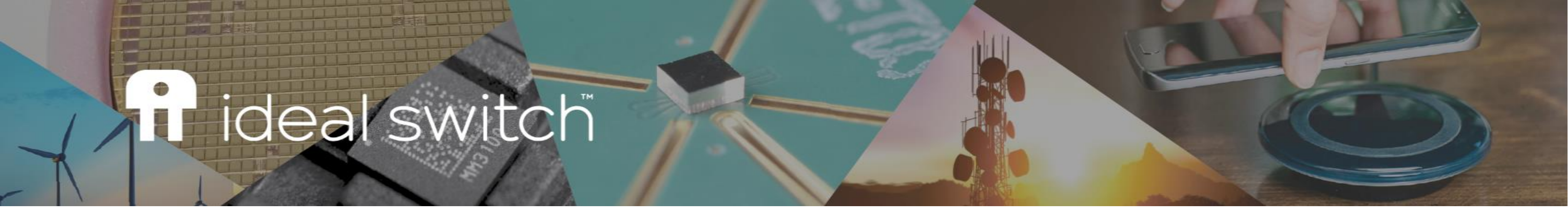


Preliminary Datasheet
MM9200 – SPST Power Switch
Product Overview

Description

The MM9200 is a high-power SPST micro-mechanical switch. The innovative Ideal Switch® technology enables highly reliable micro-mechanical switches capable of carrying high voltage and high current in a small form factor. The MM9200 provides ultra-low on-state resistance, low leakage current and high voltage stand-off, with greater than 1 billion switching cycles. Because of its long lifetime, extremely low current consumption, and small form factor, the MM9200 is an ideal solution for replacing electromechanical relays, as well as solid-state switches such as IGBT and MOSFETs where size, weight, power efficiency, and thermal management are critical system-level design parameters.

Unlike MOSFETs, the MM9200 supports bidirectional current between contacts same as electromechanical relays. The internal dual gates are controlled via the common GATE pin and requires a gate bias voltage in relation to the MIDPOINT pin to turn on the switch. Multiple MM9200 devices can be connected in series or in parallel to increase voltage rating or current rating, respectively.

Features

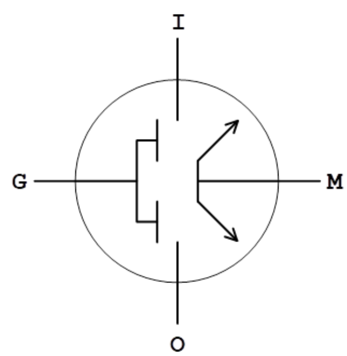
- Low On-State resistance 10 mΩ (typ.)
- Voltage standoff (AC or DC): +/- 300V
- Rated continuous current (AC or DC): +/- 10A
- Fast switching time (10µs to open, 10µs to close)
- High mechanical endurance: 1 billion operations
- QFN and low-profile 5 mm x 5 mm WL-CSP Package options available

Applications

- LV industrial controls
- Solid State Relay (SSR) replacement
- Electromechanical Relay (EMR) replacement

Markets

- Industrial automation
- Sustainable buildings
- Transport electrification
- Infrastructure modernization



Electrical Characteristics

Operating Characteristics

Absolute Maximum Ratings

Exceeding the maximum ratings as listed in Table 1 below may reduce the reliability of the device or cause permanent damage. Operation of the MM9200 should be restricted to the limits indicated in Table 2 recommended operating conditions.

Electrostatic Discharge (ESD) Safeguards

The MM9200 is a Class 0 ESD device. When handling the MM9200, observe precautions as with any other ESD sensitive device. Do not exceed the voltage ratings specified in Table 1.

Table 1 Absolute Maximum Ratings[1]

Parameter	Symbol	Min	Max	Unit
Voltage Standoff[2] (INPUT to OUTPUT)			+/- 300	V
Continuous Current			+/- 10	A
Voltage GATE to MIDPOINT pin			+/- 100	V
Operating Temperature Range		-40	+85	ºC
Storage Temperature Range		-65	+150	ºC
Reflow Soldering (Pb Free) Peak temperature			260	ºC
Reflow Soldering Time at Peak			30	sec
Thermal Resistance				
CSP				
Junction to Board [3]	Θ_{JB}		20.5	ºC/W
Junction to Case	Θ_{JC}		24.3	ºC/W
QFN				
Junction to Board [4]	Θ_{JB}		26.4	ºC/W
Junction to Case	Θ_{JC}		20.9	ºC/W

[1] All parameters must be within recommended operating conditions. Maximum power can only be applied during the on-state condition (cold-switched condition).
[2] Requires MIDPOINT pin biased to the average voltage between the INPUT and the OUTPUT pins.
[3] Refer to Recommended PCB Layout and SMT Parameters on page 12 for copper requirements.
[4] Refer to Recommended PCB Layout and SMT Parameters on page 12 for copper requirements.

Table 2 Recommended Operating Conditions

Parameter	Symbol	Min	Max	Unit	Conditions
Gate Bias Voltage	V_{GATE}	88 -92	92 -88	V	Gate bias is referenced to MIDPOINT, See application. Both negative and positive gate bias will turn On the device.
Voltage Standoff	$V_{STANDOFF}$	-300	+300	VDC	Requires MIDPOINT pin biased to the average voltage between the INPUT and the OUTPUT pins. The absolute maximum value of V_{INPUT} minus V_{OUTPUT} cannot exceed 300 VDC.

Table 3 DC and AC Electrical Specifications

All specifications valid over full V_{GATE} range and full operating temperature range unless otherwise noted.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
On-State Contact Resistance	R_{On}		10		mΩ	Measured from INPUT to OUTPUT pins.
Off-State Contact Isolation	R_{OFF}		5		GΩ	Measured from INPUT to OUTPUT pins. Measured at 150 V.
Off-State Contact Leakage Current			100		nA	Measured from INPUT to OUTPUT pins. Measured at 150 V. In addition to the MEMS path, there is a bias network which dominates the total leakage. The bias network can be adjusted to meet user requirements. Measured at 150 V.
Continuous Current		-10		10	A (AC/DC)	
Gate Bias Current			1		nA	
Capacitance Off-State, INPUT to OUTPUT pin	C_{IO}		0.55		pF	See Figure 1 and Figure 2 for equivalent circuit.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
Switching Time Turn-On time Turn-Off time			10 10		us	
Mechanical Endurance		$1x10^9$			Cycle	

Steady State Equivalent Circuits

Referring to the equivalent circuits shown in Figure 1 and Figure 2.

On resistance is:

$$R_{ON} = R_{MO} + R_{MI} = \sim 10m\Omega$$

Off capacitance is:

$$C_{OFF} = \sim 0.55pF$$

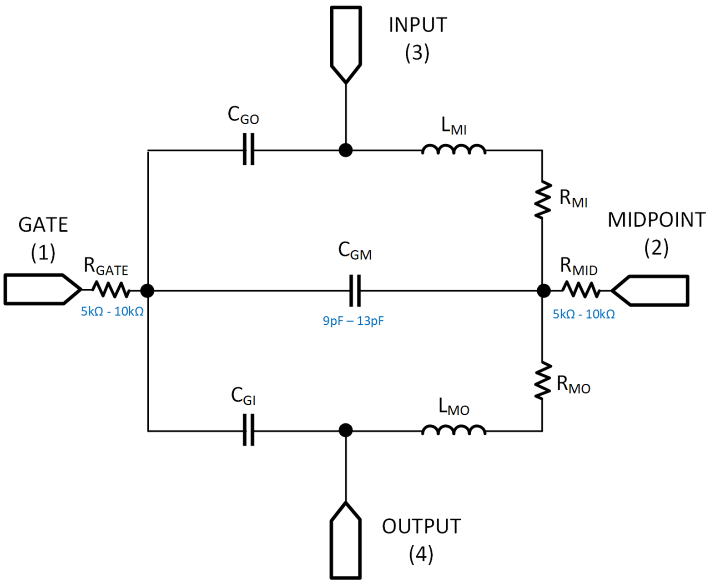


Figure 1: Equivalent Circuit Model (Switch in CLOSED position)

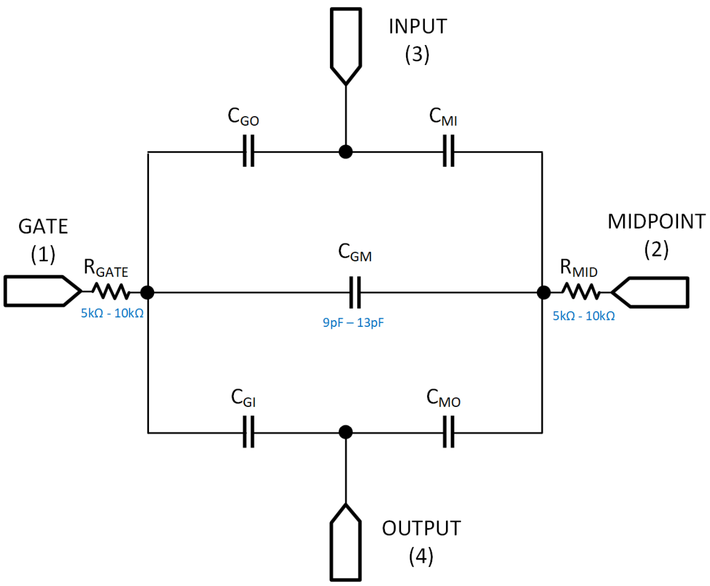


Figure 2: Equivalent Circuit Model (Switch in OPEN position)

Functional Block Diagram

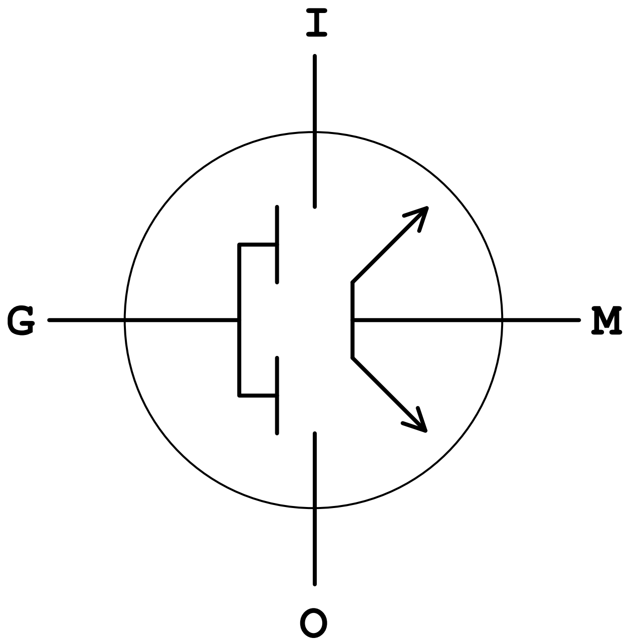


Figure 3: MM9200 Functional Diagram

Functionally, the MM9200 has two sets of contacts in series as shown in Figure 3. Each set of contacts can stand-off up to one-half of $V_{STANDOFF}$ (i.e., $V_{STANDOFF}/2$), as shown in Table 2. To be able to withstand the fully rated $V_{STANDOFF}$ Input (**I**) to Output (**O**), the MM9200 needs to be biased such that the Midpoint (**M**) is at most $V_{STANDOFF}/2$ from Input or Output. See Typical Application Circuits on page 10 for implementation details for Midpoint biasing. Both sets of contacts are actuated by applying voltage to a common Gate (**G**).

Package / Pinout Information

The MM9200 is available in QFN and low-profile 5 mm x 5 mm WL-CSP packaging options. The packages abide to IEC creepage guidelines.

QFN Package Pin Out

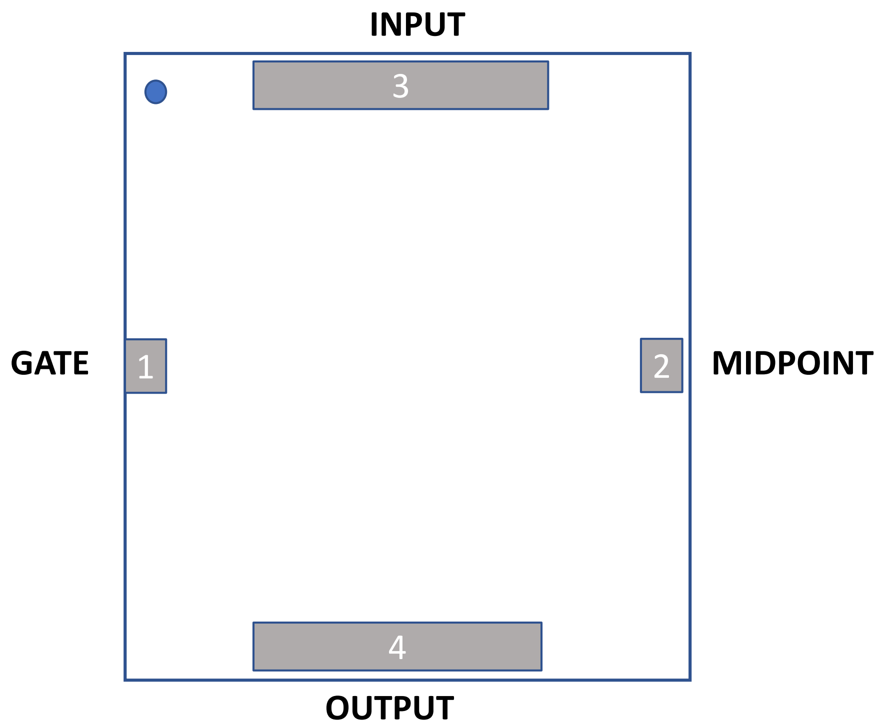


Figure 4: MM9200 QFN Top-Down Pin Layout

Table 4 QFN Detailed Pin Description

Pin #	Pin Name	Description
1	GATE	Gate control to turn switch on/off, referenced to MIDPOINT pin.
2	MIDPOINT	Beams Reference
3	INPUT	Switch Input Pin
4	OUTPUT	Switch Output Pin

WL-CSP Package Pin Out

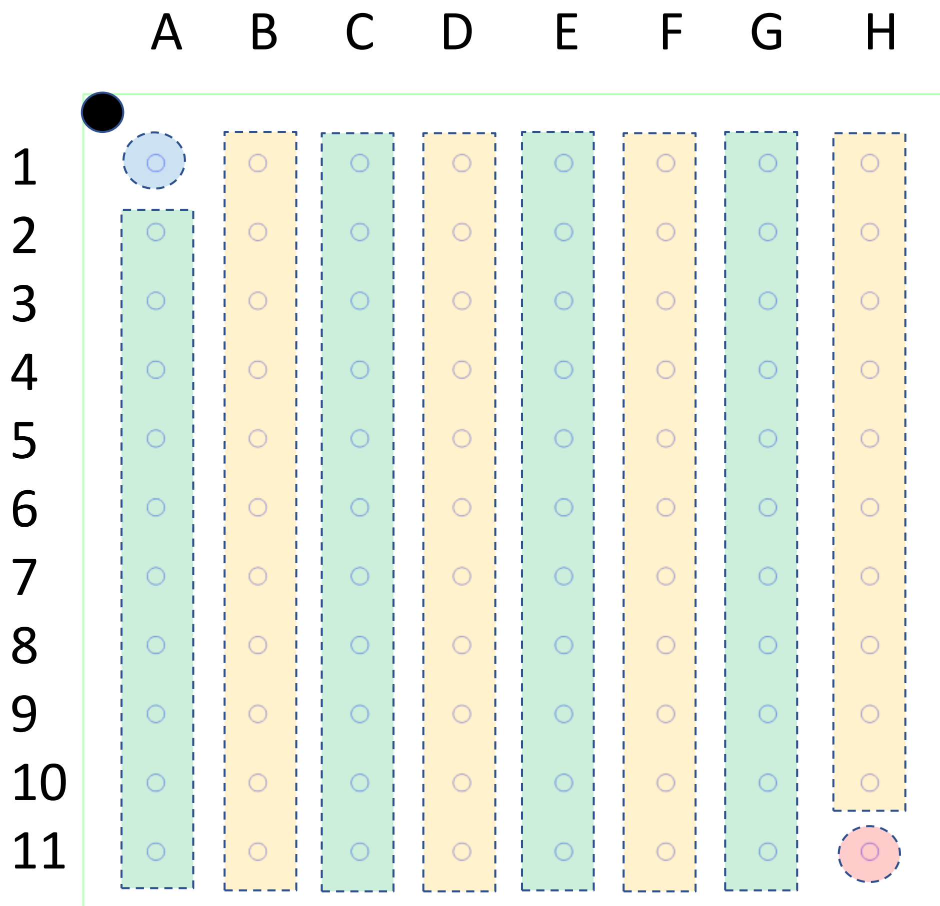


Figure 5: MM9200 WF-CSP Pinout (Top View)

Table 5 WL-CSP Detailed Pin Description

Pin #	Pin Name	Description
A1	GATE	Gate control to turn switch on/off, referenced to MIDPOINT pin
H11	MIDPOINT	Beams Reference
A2..A11, C1..C11, E1..E11,G1..G11	INPUT	Switch Input Pins (tied together)
B1..B11, D1..D11, F1..F11,H1..H10	OUTPUT	Switch Output Pin (tied together)

Performance

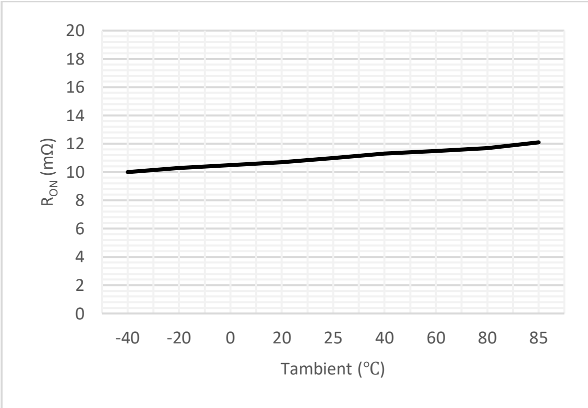


Figure 6: On-State Resistance over Ambient Temperature[5]

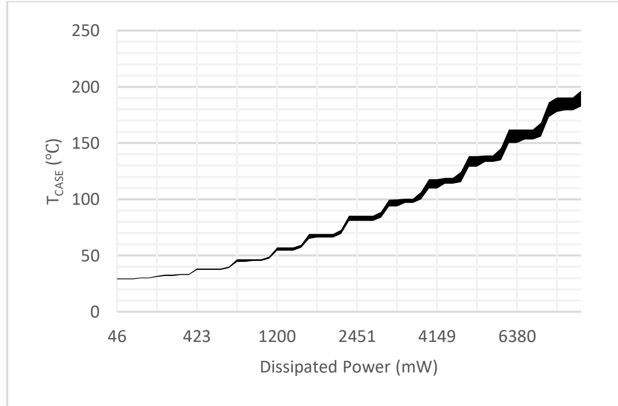


Figure 7: Power Dissipation over Case Temperature[6]

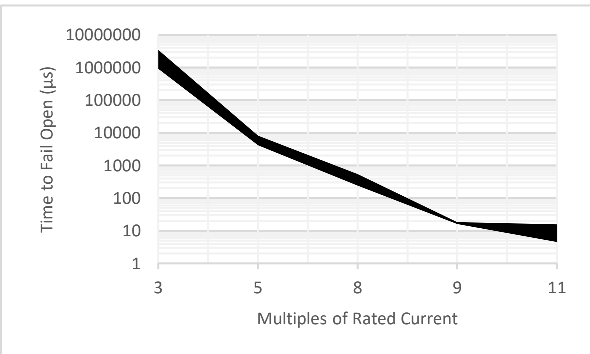


Figure 8: Fuse Curve[7]

[5] Measured on MM5130 (will be updated per MM9200 characterization plan)
[6] Measured on MM5130 (will be updated per MM9200 characterization plan)
[7] Measured on MM5130 @25℃ (will be updated per MM9200 characterization plan)

Typical Application Circuits

INPUT Pins

The MM9200 WL-CSP package has multiple input pins named INPUT, QFN package has only one. In the WF-CSP, they are internally connected inside the package; however, they shall be externally connected in the application as close as possible to the package.

OUTPUT Pins

The MM9200 WL-CSP package has multiple output pins are named OUTPUT, QFN package has only one. Like the WL-CSP package INPUT pins, they are internally connected inside the package and shall also be externally connected in the application as close as possible to the package.

GATE Pin

The gate pin is connected to the electrostatic actuation electrode used to close the two switch elements. The counter electrode is connected to the MIDPOINT pin that serves as the reference voltage for the actuation voltage applied at the GATE pin. The allowable voltages on the GATE pin are 0 V and 90 V (nominal, see V_{GATE} specification).

MIDPOINT Pin

To ensure that the MIDPOINT pin operates at the correct DC voltage based on the INPUT and OUTPUT pin DC voltages, it is recommended to use a resistive divider as shown in Figure 9. This ensures that the DC voltage applied to the MIDPOINT pin is correct for the Off/open state, as well as for proper switch actuation and On/closed state closure.

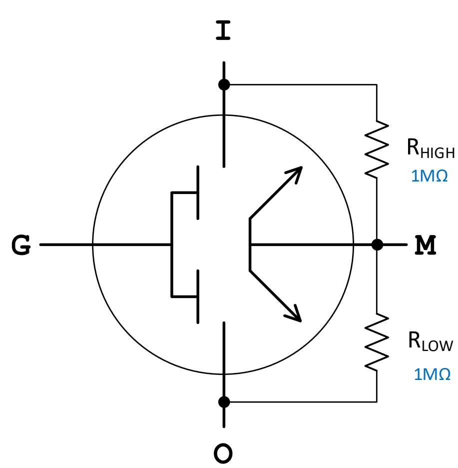
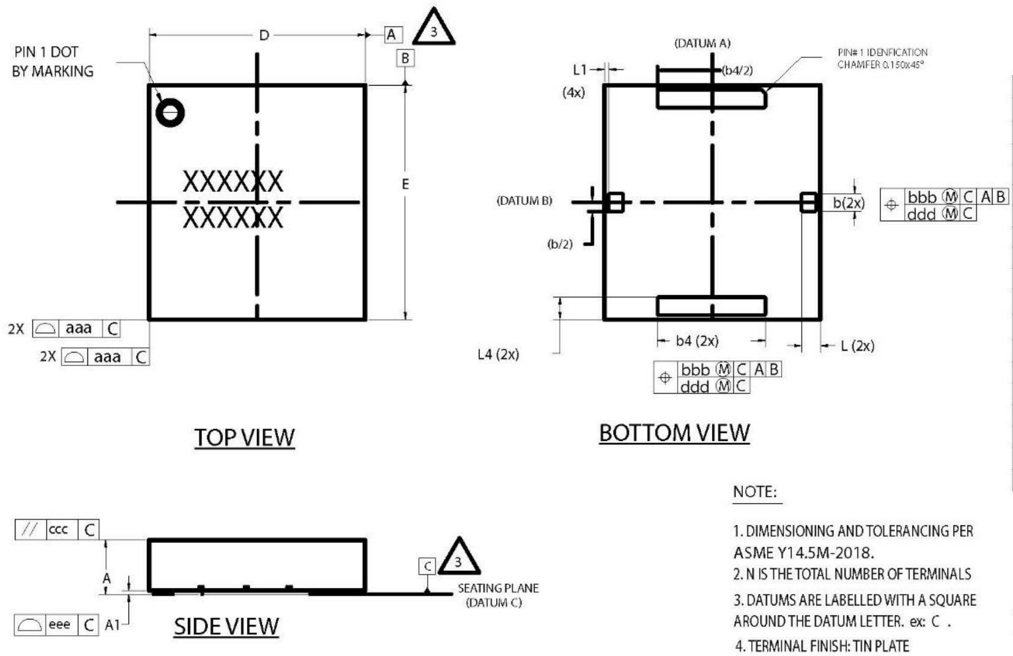


Figure 9: Midpoint biasing to balance voltage

Package Drawing

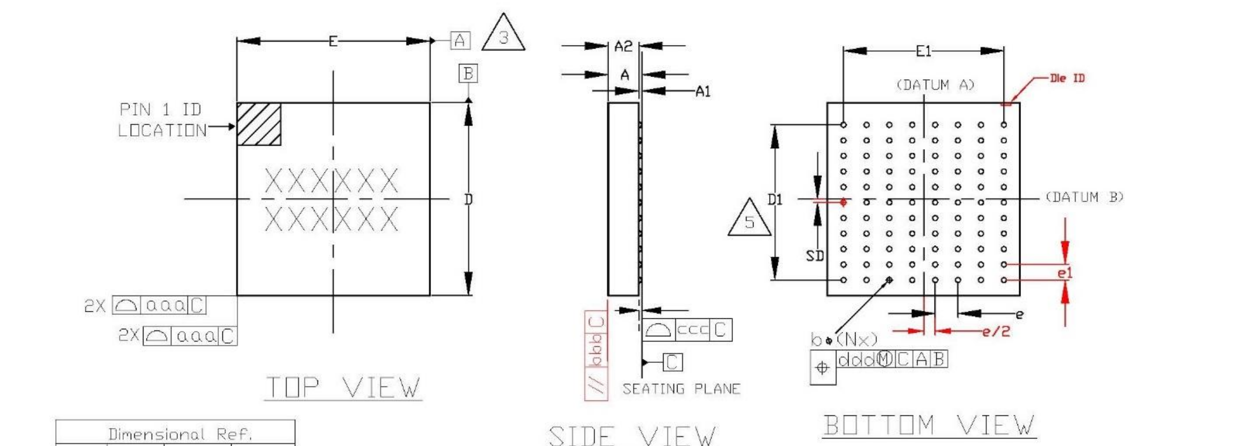
QFN Package Options



Dimensional Ref.			
REF.	Min.	Nom	Max.
A	1.450	1.500	1.550
A1	0.000	—	0.050
D	6.000 BSC		
E	6.500 BSC		
N	4		
b	0.450	0.500	0.550
b4	2.950	3.000	3.050
L	0.470	0.520	0.570
L4	0.570	0.620	0.670
L1	-	-	0.120
Dimensional Tol.			
aaa	0.050		
bbb	0.100		
ccc	0.050		
ddd	0.050		
eee	0.080		
fff	0.050		

Figure 10: MM9200 QFN Package Drawing (Bottom View, units are mm)

WL-CSP Package Option



Dimensional Ref.			
REF.	Min.	Nom	Max.
A	0.847	0.880	0.913
A1	0.072	0.080	0.088
A2	0.775	0.800	0.825
D	5.020 BSC		
E	5.020 BSC		
N	88		
b	0.119	0.140	0.161
D1	4.020 BSC		
E1	4.158 BSC		
SD	0.088 BSC		
e	0.594 BSC		
e1	0.402 BSC		

Dimensional Tol.	
aaa	0.030
bbb	0.060
ccc	0.050
ddd	0.015

NOTES:

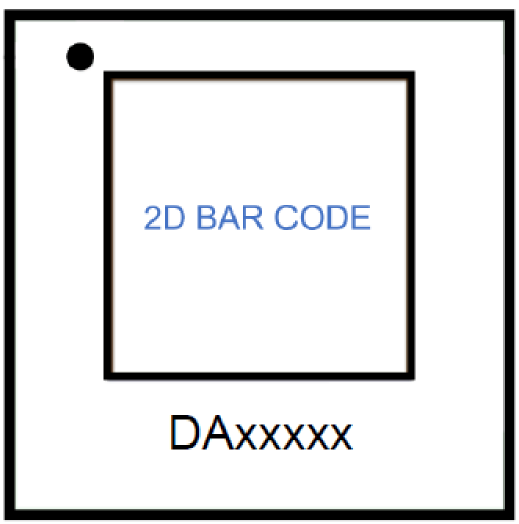
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-2018 AND JEDEC DESIGN GUIDE 4.18
2. N IS THE TOTAL NUMBER OF TERMINALS
3. DATUMS ARE LABELLED WITH A SQUARE AROUND THE DATUM LETTER. ex: C .
4. TERMINAL FINISH: SAC305
5. TERMINAL GRID (IN D DIRECTION) SHIFTED DOWNWARD FROM PKG CENTERLINE BY DIMENSION SD.

Figure 11: MM9200 WL-CSP Package Drawing (Bottom View/Bumps Up)

Recommended PCB Layout and SMT Parameters

- Electroless Nickel Immersion Gold (ENIG) pad surface finish
- 20 micron (µm) thick solder mask.
- Type 3 or higher solder paste with no clean flux.
- Component placement force not to exceed 100 grams.
- Recommending 1 or 2 oz copper weight to minimize interconnect resistance.
- Ensure the substrate x/y coefficient of thermal expansion (CTE) is 15 ppm/C or lower.
- For QFN, follow Moisture Sensitivity Level (MSL) 3 handling precautions specified in IPC/JEDEC J-STD-020.

Package Marking Information



Dot ● = Pin 1 Indicator
Line 1 = 2D Bar Code
Line 2 = Human-readable product code

Package Materials Information

The MM9200 is shipped in tape and reel.

Package Options and Ordering Information

Part Number	Package	Temperature Range	Device Marking[8]
MM9200-02NDE	300V/10A - SPST - 6mm x 6mm QFN	-40C to 85C	DAxxxxx
MM9200-02NDE-TR	300V/10A - SPST - 6mm x 6mm QFN, Tape and Reel (Qty 250)		DAxxxxx
MM9200-03NDE	300V/10A - SPST - 5mm x 5mm WL-CSP	-40C to 85C	DAxxxxx
MM9200-03NDE-TR	300V/10A - SPST - 5mm x 5mm WL-CSP, Tape and Reel (Qty 250)		DAxxxxx
MM9200EVK1	MM9200 Evaluation Board		

Legacy Product Name	NEW Product Name BULK Tape and Reel **	
MM9200-02	MM9200-02NDE	MM9200-02NDE-TR
MM9200-03	MM9200-03NDE	MM9200-03NDE-TR
**250pcs standard tape and reel increment		

[8] Additional markings may be present, including logo or lot trace code information. This information may be a 2D barcode or other human-readable markings. Note that ‘x’ is place holder for 5-digit numerical code.

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