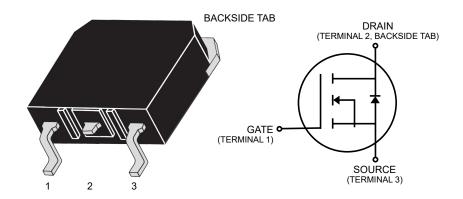
## 1200V, 40 mΩ N-Channel mSiC<sup>™</sup> MOSFET

**MSC040SMA120S** 



#### **Product Overview**

1200V, 40 m $\Omega$  typical at V<sub>GS</sub> = 20V, 45 m $\Omega$  typical at V<sub>GS</sub> = 18V, Silicon Carbide (SiC) N-Channel MOSFET, D3PAK (TO-268).



#### **Features**

- Low capacitances and low gate charge
- Fast switching speed due to low internal gate resistance (ESR)
- Stable operation at high junction temperature, T<sub>I(max)</sub> = 175 °C
- · Fast and reliable body diode
- Superior avalanche ruggedness
- · RoHS compliant

#### **Benefits**

- High efficiency to enable lighter and more compact system
- Simple to drive and easy to parallel
- Improved thermal capabilities and lower switching losses
- Eliminates the need for external freewheeling diode
- Lower system cost of ownership

#### **Applications**

- Photovoltaic (PV) inverter, converter, and industrial motor drives
- Smart grid transmission and distribution
- · Induction heating and welding
- Hybrid Electric Vehicle (HEV) powertrain and Electric Vehicle (EV) charger
- Power supply and distribution

### 1. Device Specifications

This section shows the specifications of this device.

### 1.1 Absolute Maximum Ratings

The following table shows the absolute maximum ratings of this device.

Table 1-1. Absolute Maximum Ratings

Symbol	Parameter	Ratings	Unit
$V_{DSS}$	Drain source voltage	1200	V
I <sub>D</sub>	Continuous drain current at $T_C = 25$ °C	68	Α
	Continuous drain current at T <sub>C</sub> = 100 °C	48	
I <sub>DM</sub>	Pulsed drain current <sup>1</sup>	215	
$V_{GS}$	Gate-source voltage	23 to -10	V
	Transient gate-source voltage	25 to -12	
$P_{D}$	Total power dissipation at T <sub>C</sub> = 25 °C	338	W
	Linear derating factor	2.2	W/°C

#### Note:

1. Repetitive rating: pulse width and case temperature are limited by the maximum junction temperature.

The following table shows the thermal and mechanical characteristics of this device.

Table 1-2. Thermal and Mechanical Characteristics

Symbol	Characteristic/Test Conditions	Min.	Тур.	Max.	Unit
$R_{\theta JC}$	Junction-to-case thermal resistance	_	0.34	0.44	°C/W
Tj	Operating junction temperature	-55	_	175	°C
T <sub>STG</sub>	Storage temperature	-55	_	150	
_	Reflow temperature	_	_	260	°C
Wt	Package weight	-	4.0		g

ESD practices should comply with JESD-625.

#### **1.2** Electrical Performance

The following table shows the static characteristics of this device.  $T_J = 25$  °C unless otherwise specified.

Table 1-3. Static Characteristics

Symbol	Characteristic	Test Conditions	Min.	Тур.	Max.	Unit
V <sub>(BR)DSS</sub>	Drain-source breakdown voltage	$V_{GS} = 0V$ , $I_D = 100 \mu A$	1200	_	_	V
R <sub>DS(on)</sub>	Drain-source on resistance <sup>1</sup>	$V_{GS} = 20V, I_D = 40A$	_	40	50	mΩ
		$V_{GS} = 18V, I_D = 40A$	_	45	_	
$V_{GS(th)}$	Gate-source threshold voltage	$V_{GS} = V_{DS}$ , $I_D = 2 \text{ mA}$	1.9	3.0	5.0	V
I <sub>DSS</sub>	Zero gate voltage drain current	V <sub>DS</sub> = 1200V, V <sub>GS</sub> = 0V	_	0.2	30	μΑ
		V <sub>DS</sub> = 1200V, V <sub>GS</sub> = 0V, T <sub>J</sub> = 175 °C	_	2.0	_	
I <sub>GSS</sub>	Gate-source leakage current	V <sub>GS</sub> = 20V/–10V	_	_	±100	nA

#### Note:

1. Pulse test: pulse width < 380  $\mu$ s, duty cycle < 2%.



The following table shows the dynamic characteristics of this device.  $T_J$  = 25 °C unless otherwise specified. The dynamic characteristics are characterized, not 100% tested, at the recommended operating  $V_{GS}$  = 20V/–5V.

Table 1-4. Dynamic Characteristics

Symbol	Characteristic	Test Conditions	Min.	Тур.	Max.	Unit
C <sub>iss</sub>	Input capacitance	V <sub>GS</sub> = 0V	<u> </u>	1962	_	pF
C <sub>rss</sub>	Reverse transfer capacitance	V <sub>DD</sub> = 1000V	_	11	_	
C <sub>oss</sub>	Output capacitance	$V_{AC} = 25 \text{ mV}$ f = 200 kHz	_	164	_	
Q <sub>G</sub>	Total gate charge	V <sub>GS</sub> = -5V/20V	_	137	T-	nC
$Q_{GS}$	Gate-source charge	V <sub>DD</sub> = 800V	_	29	_	
Q <sub>GD</sub>	Gate-drain charge	I <sub>D</sub> = 40A	_	31	_	
t <sub>d(on)</sub>	Turn-on delay time	V <sub>DD</sub> = 800V	_	44	_	ns
t <sub>r</sub>	Voltage rise time	$V_{GS} = -5V/20V$	_	17	_	
t <sub>d(off)</sub>	Turn-off delay time	I <sub>D</sub> = 30A	_	37	_	
t <sub>f</sub>	Voltage fall time	$R_{G(ext)} = 8\Omega$	_	21	_	
E <sub>on</sub>	Turn-on switching energy	Freewheeling diode = MSC040SMA120S (V <sub>GS</sub> = -5V);	_	1040	_	μJ
E <sub>off</sub>	Turn-off switching energy	reference Figure 1-19	_	93	_	
ESR	Gate equivalent series resistance	f = 1 MHz, 25 mV, drain short	_	1.2	<b> </b> -	Ω
SCWT	Short circuit withstand time	V <sub>DS</sub> = 960V, V <sub>GS</sub> = 20V	_	3.0	T-	μs
E <sub>AS</sub>	Avalanche energy, single pulse	I <sub>D</sub> = 40A	_	2600	_	mJ

The following table shows the body diode characteristics of this device.  $T_J = 25$  °C unless otherwise specified. The body diode reverse recovery is characterized, not 100% tested.

Table 1-5. Body Diode Characteristics

Symbol	Characteristic	Test Conditions	Min.	Тур.	Max.	Unit
$V_{SD}$	Diode forward voltage	I <sub>SD</sub> = 40A, V <sub>GS</sub> = 0V	_	3.9	_	V
		I <sub>SD</sub> = 40A, V <sub>GS</sub> = -5V	_	4.1	5.0	
t <sub>rr</sub>	Reverse recovery time	$I_{SD}$ = 30A, $V_{GS}$ = -5V, Drive $R_G$ = $4\Omega$ , $V_{DD}$ =	_	40	_	ns
Q <sub>rr</sub>	Reverse recovery charge	800V, dl/dt = -3500 A/μs	_	386	_	nC
I <sub>RRM</sub>	Reverse recovery current		_	16	_	Α



### 1.3 Typical Performance Curves

Data for performance curves are characterized, not 100% tested.

Figure 1-1. Drain Current vs.  $V_{DS}$  at  $T_{J}$ 

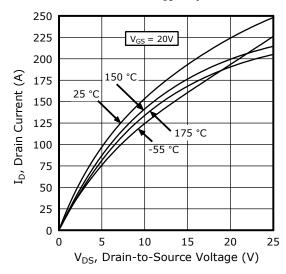


Figure 1-2. Drain Current vs. V<sub>DS</sub> at V<sub>GS</sub>

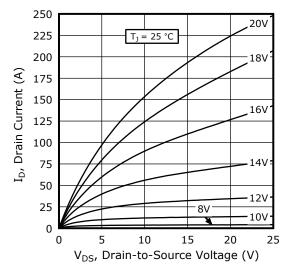


Figure 1-3. Drain Current vs.  $V_{DS}$  at  $V_{GS}$ 

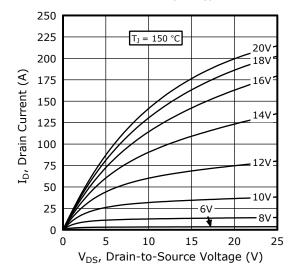


Figure 1-4. Drain Current vs. V<sub>DS</sub> at V<sub>GS</sub>

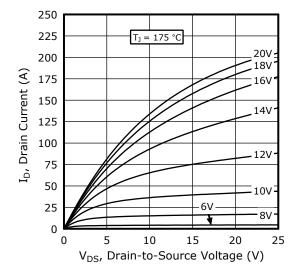




Figure 1-5. R<sub>DS(on)</sub> vs. Junction Temperature

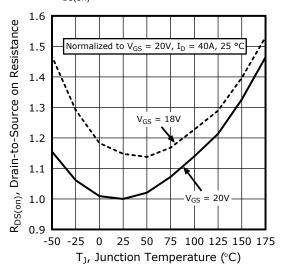


Figure 1-6. Gate Charge Characteristics

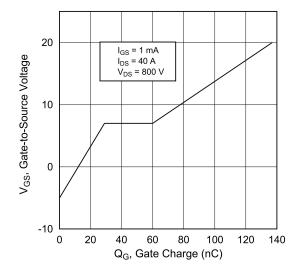


Figure 1-7. Capacitance vs. Drain-to-Source Voltage

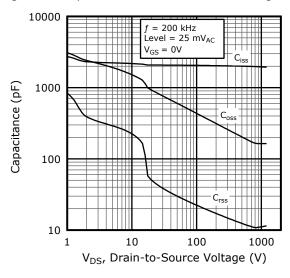


Figure 1-8. Output Charge vs. Drain-to-Source Voltage

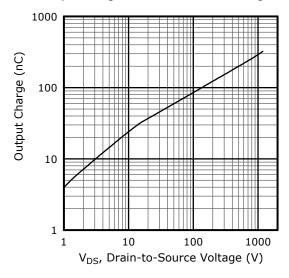




Figure 1-9. Output Stored Energy vs. V<sub>DS</sub>

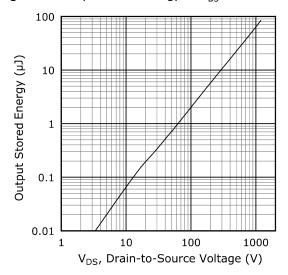


Figure 1-10.  $I_D$  vs.  $V_{DS}$  3<sup>rd</sup> Quadrant Conduction

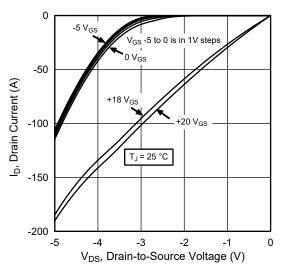


Figure 1-11.  $I_D$  vs.  $V_{DS}$   $3^{rd}$  Quadrant Conduction

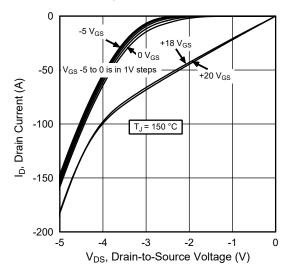


Figure 1-12. Switching Energy  $E_{on}$  vs.  $V_{DS} \& I_{D}$ 

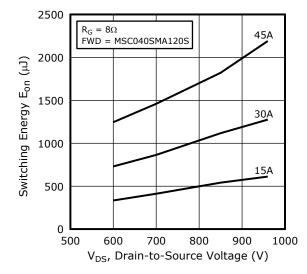




Figure 1-13. Switching Energy  $E_{off}$  vs.  $V_{DS} \& I_{D}$ 

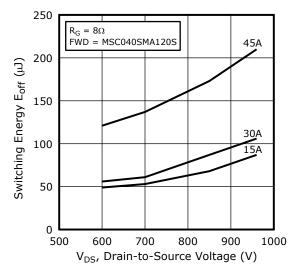


Figure 1-14. Switching Energy vs. R<sub>G</sub>

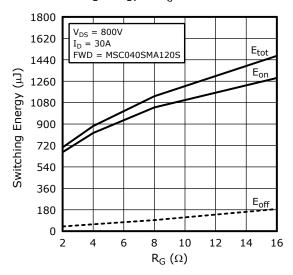


Figure 1-15. Switching Energy vs. Junction Temperature

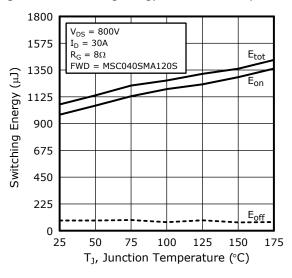


Figure 1-16. Threshold Voltage vs. Junction Temperature

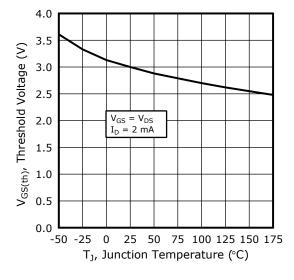




Figure 1-17. Forward Safe Operating Area

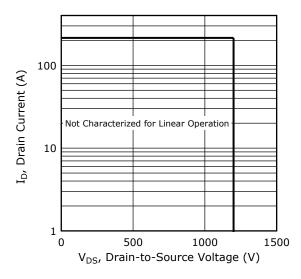
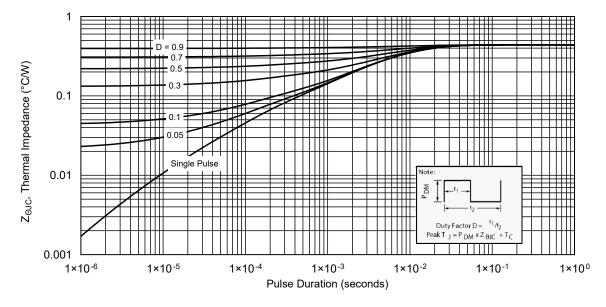
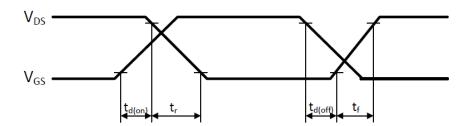


Figure 1-18. Maximum Transient Thermal Impedance



The following figure shows the switching waveform diagram of this device.

Figure 1-19. Switching Waveform





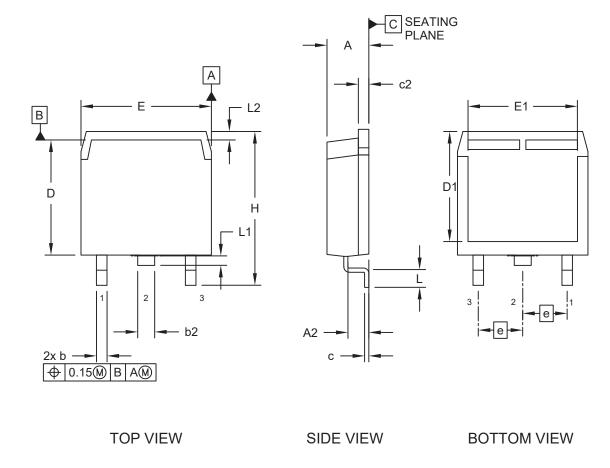
## 2. Package Specification

This section shows the package specification of this device.

### 2.1 Package Outline Drawing

The following figure illustrates the D3PAK (TO-268) package outline of this device.

Figure 2-1. Package Outline Drawing



The following table shows the D3PAK (TO-268) dimensions and should be used in conjunction with the package outline drawing.

Table 2-1. D3PAK (TO-268) Dimensions

Symbol	Description	Min. (mm)	Max. (mm)
N	Number of leads	3	
е	Pitch	5.46 BSC	
Α	Overall height	4.90	5.11
A2	Seating plane to lead	2.69	2.90
b	Lead width	1.14	1.45
b2	Center lead width	1.96	2.21
Н	Overall package length	18.69	19.10
С	Lead thickness	0.41	0.61
c2	Tab thickness	1.45	1.60



con	continued				
Symbol	Description	Min. (mm)	Max. (mm)		
L	Foot length	2.39	2.69		
L1	Center lead length	0.94	1.40		
L2	Tab length	0.99	1.24		
D	Molded body length	13.79	14.00		
D1	Thermal pad length	12.40	12.70		
Е	Total width	15.85	16.21		
E1	Thermal pad width	13.31	13.59		

#### Note:

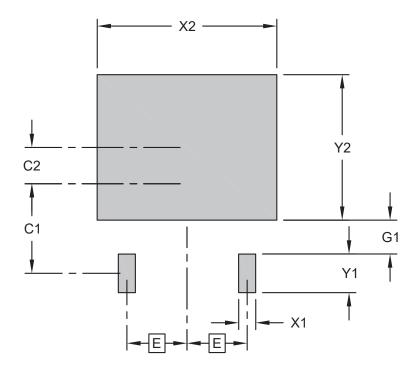
Dimensioning and tolerancing per ASME Y14.5M.

• BSC: Basic dimension. Theoretically exact value shown without tolerances.

### 2.2 Recommended Land Pattern

The following figure illustrates the recommended land pattern of this device.

Figure 2-2. Recommended Land Pattern



The following table shows the recommended land pattern dimensions.

Table 2-2. Recommended Land Pattern Dimensions

Symbol	Description	Min. (mm)	Nom. (mm)	Max. (mm)	
Е	Contact pitch	5.46 BSC	<del>-</del>		
X2	Center pad width	_	_	16.28	
Y2	Center pad length	_	_	13.18	
C1	Contact pad spacing	_	8.13	_	
C2	Contact pad spacing	_	3.28	_	
X1	Contact pad width (X2)	_	_	1.55	



co	continued				
Symbol	Description	Min. (mm)	Nom. (mm)	Max. (mm)	
Y1	Contact pad length (X2)	_	_	3.48	
G1	Contact pad to center pad (X2)	7.87	_	_	

#### **Notes:**

- Dimensioning and tolerancing per ASME Y14.5M.
  - BSC: Basic dimension. Theoretically exact value shown without tolerances.
- For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process.



## 3. Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

Table 3-1. Revision History

Revision	Date	Description
Α	07/2024	The following changes are made in this revision of the document:
		Document migrated from Microsemi template to Microchip template; Assigned Microchip literature number DS-00005285A, which replaces the previous Microsemi literature number 050-7740.
		Added Figure 1-9.
		Added 2.2. Recommended Land Pattern.
Initial release (Microsemi Revision A)	10/2019	Document created.



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ISBN: 978-1-6683-4435-4

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Fax: 905-695-2078			Fax: 44-118-921-5820