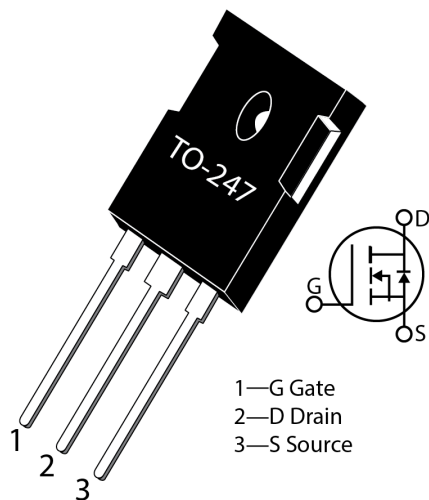


# MSC040SMA120B Silicon Carbide N-Channel Power MOSFET

## 1 Product Overview

The silicon carbide (SiC) power MOSFET product line from Microsemi increases the performance over silicon MOSFET and silicon IGBT solutions while lowering the total cost of ownership for high-voltage applications. The MSC040SMA120B device is a 1200 V, 40 mΩ SiC MOSFET in a TO-247 package.



### 1.1 Features

The following are key features of the MSC040SMA120B device:

- Low capacitances and low gate charge
- Fast switching speed due to low internal gate resistance (ESR)
- Stable operation at high junction temperature,  $T_{j(max)} = 175^{\circ}\text{C}$
- Fast and reliable body diode
- Superior avalanche ruggedness
- RoHS compliant

### 1.2 Benefits

The following are benefits of the MSC040SMA120B device:

- High efficiency to enable lighter, 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

### 1.3 Applications

The MSC040SMA120B device is designed for the following applications:

- PV inverter, converter, and industrial motor drives
- Smart grid transmission and distribution
- Induction heating and welding
- H/EV powertrain and EV charger
- Power supply and distribution

## 2 Device Specifications

This section shows the specifications for the MSC040SMA120B device.

### 2.1 Absolute Maximum Ratings

The following table shows the absolute maximum ratings for the MSC040SMA120B device.

**Table 1 • Absolute Maximum Ratings**

Symbol	Parameter	Ratings	Unit
V <sub>DSS</sub>	Drain source voltage	1200	V
I <sub>D</sub>	Continuous drain current at T <sub>c</sub> = 25 °C	66	A
	Continuous drain current at T <sub>c</sub> = 100 °C	46	
I <sub>DM</sub>	Pulsed drain current <sup>1</sup>	105	
V <sub>GS</sub>	Gate-source voltage	23 to -10	V
P <sub>D</sub>	Total power dissipation at T <sub>c</sub> = 25 °C	323	W
	Linear derating factor	2.15	W/°C

**Note:**

1. Repetitive Rating: Pulse width and case temperature limited by maximum junction temperature.

The following table shows the thermal and mechanical characteristics for the MSC040SMA120B device.

**Table 2 • Thermal and Mechanical Characteristics**

Symbol	Characteristic	Min	Typ	Max	Unit
R <sub>θJC</sub>	Junction-to-case thermal resistance		0.31	0.47	°C/W
T <sub>J</sub>	Operating junction temperature	-55		175	°C
T <sub>STG</sub>	Storage temperature	-55		150	
T <sub>L</sub>	Soldering temperature for 10 seconds (1.6 mm from case)			260	
				10	lbf-in
				1.1	N-m
Wt	Package weight		0.22		oz
			6.2		g

## 2.2 Electrical Performance

The following table shows the static characteristics for the MSC040SMA120B device.  $T_J = 25\text{ }^\circ\text{C}$  unless otherwise specified.

**Table 3 • Static Characteristics**

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}$ , $I_D = 100\text{ }\mu\text{A}$	1200			V
$R_{DS(on)}$	Drain-source on resistance <sup>1</sup>	$V_{GS} = 20\text{ V}$ , $I_D = 40\text{ A}$		40	50	m $\Omega$
$V_{GS(th)}$	Gate-source threshold voltage	$V_{GS} = V_{DS}$ , $I_D = 2\text{ mA}$	1.8	2.7		V
$\Delta V_{GS(th)} / \Delta T_J$	Threshold voltage coefficient	$V_{GS} = V_{DS}$ , $I_D = 2\text{ mA}$		-4.7		mV/ $^\circ\text{C}$
$I_{DSS}$	Zero gate voltage drain current	$V_{DS} = 1200\text{ V}$ , $V_{GS} = 0\text{ V}$			100	$\mu\text{A}$
		$V_{DS} = 1200\text{ V}$ , $V_{GS} = 0\text{ V}$ $T_J = 125\text{ }^\circ\text{C}$			500	
$I_{GSS}$	Gate-source leakage current	$V_{GS} = 20\text{ V} / -10\text{ V}$			$\pm 100$	nA

**Note:**

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

The following table shows the dynamic characteristics for the MSC040SMA120B device.  $T_J = 25\text{ }^\circ\text{C}$  unless otherwise specified.

**Table 4 • Dynamic Characteristics**

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
$C_{iss}$	Input capacitance	$V_{GS} = 0\text{ V}$		1990		pF
$C_{rss}$	Reverse transfer capacitance	$V_{DD} = 1000\text{ V}$ $V_{AC} = 25\text{ mV}$		17		
$C_{oss}$	Output capacitance	$f = 1\text{ MHz}$		156		
$Q_g$	Total gate charge	$V_{GS} = -5\text{ V}/20\text{ V}$		137		nC
$Q_{gs}$	Gate-source charge	$V_{DD} = 800\text{ V}$ $I_D = 40\text{ A}$		29		
$Q_{gd}$	Gate-drain charge			31		
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 800\text{ V}$		24		ns
$t_r$	Current rise time	$V_{GS} = -5\text{ V}/20\text{ V}$ $I_D = 40\text{ A}$		13		
$t_{d(off)}$	Turn-off delay time	$R_{G(ext)} = 4\text{ }\Omega^1$		46		
$t_f$	Current fall time	Freewheeling diode = MSC040SMA120B ( $V_{GS} = -5\text{ V}$ )		13		
$E_{on}$	Turn-on switching energy <sup>2</sup>			560		$\mu\text{J}$
$E_{off}$	Turn-off switching energy			82		
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 800\text{ V}$		23		ns
$t_r$	Current rise time	$V_{GS} = -5\text{ V}/20\text{ V}$ $I_D = 40\text{ A}$		10		
$t_{d(off)}$	Turn-off delay time	$R_{G(ext)} = 4\text{ }\Omega^1$		44		
$t_f$	Current fall time	Freewheeling diode = MSC015SDA120B		11		
$E_{on}$	Turn-on switching energy <sup>2</sup>			275		$\mu\text{J}$
$E_{off}$	Turn-off switching energy			83		
ESR	Equivalent series resistance	$f = 1\text{ MHz}$ , 25 mV, drain short		1.2		$\Omega$
SCWT	Short circuit withstand time	$V_{DS} = 960\text{ V}$ , $V_{GS} = 20\text{ V}$ , $T_C = 25\text{ }^\circ\text{C}$		3		$\mu\text{s}$

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
$E_{AS}$	Avalanche energy, single pulse	$V_{DS} = 145\text{ V}$ , $V_{GS} = 20\text{ V}$ , $I_D = 40\text{ A}$ , $T_C = 25\text{ }^\circ\text{C}$		2000		mJ

**Notes:**

1.  $R_G$  is total gate resistance excluding internal gate driver impedance.
2.  $E_{on}$  includes energy of freewheeling diode.

The following table shows the body diode characteristics for the MSC040SMA120B device.  $T_J = 25\text{ }^\circ\text{C}$  unless otherwise specified.

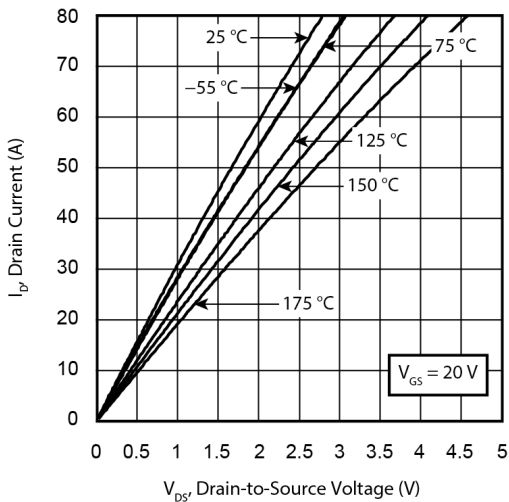
**Table 5 • Body Diode Characteristics**

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{SD}$	Diode forward voltage	$I_{SD} = 40\text{ A}$ , $V_{GS} = 0\text{ V}$		3.9		V
		$I_{SD} = 40\text{ A}$ , $V_{GS} = -5\text{ V}$		4.1		V
$t_{rr}$	Reverse recovery time	$I_{SD} = 40\text{ A}$ , $V_{GS} = -5\text{ V}$		31		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 800\text{ V}$		610		nC
$I_{RRM}$	Reverse recovery current	$di/dt = -1800\text{ A}/\mu\text{s}$		40		A

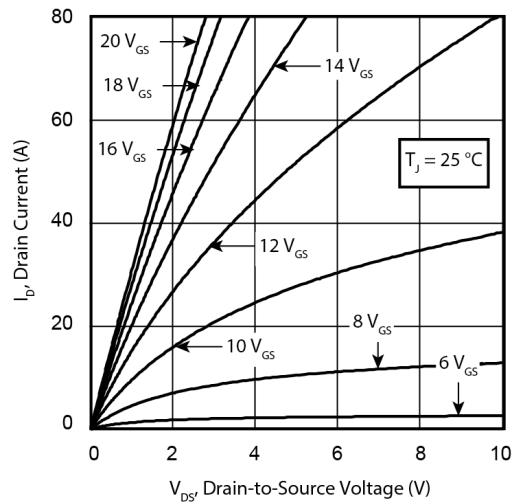
## 2.3 Typical Performance Curves

This section shows the typical performance curves for the MSC040SMA120B device.

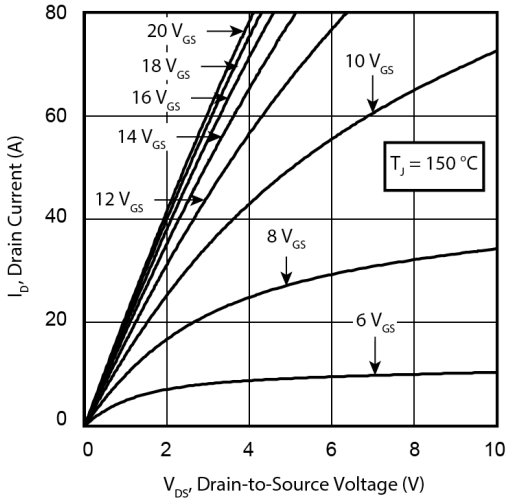
**Figure 1 • Drain Current vs. Drain-to-Source Voltage**



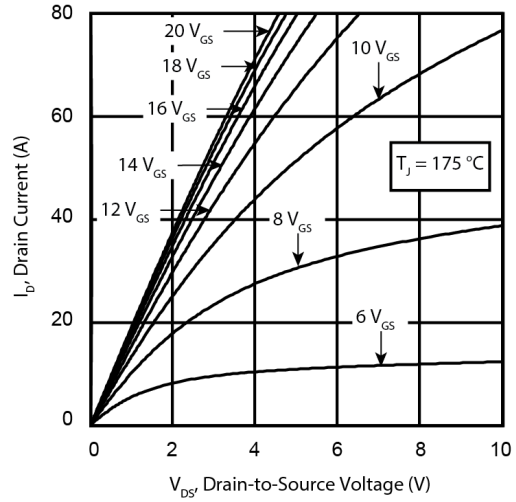
**Figure 2 • Drain Current vs. Drain-to-Source Voltage.**



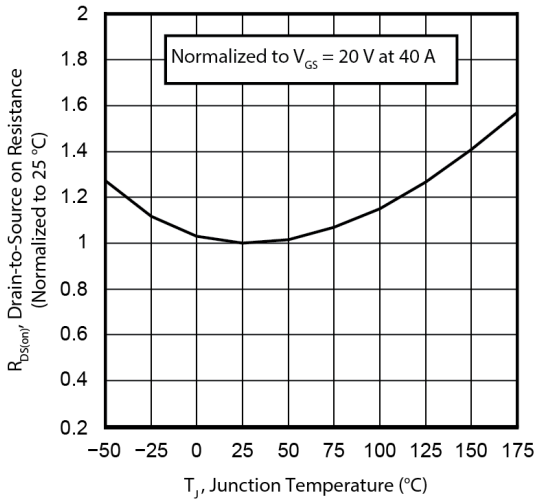
**Figure 3 • Drain Current vs. Drain-to-Source Voltage**



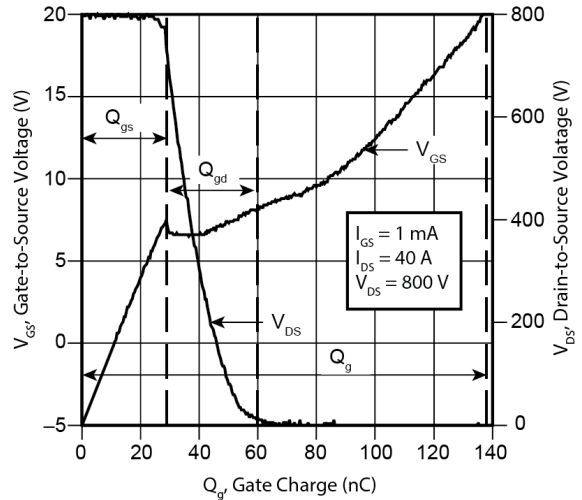
**Figure 4 • Drain Current vs. Drain-to-Source Voltage**



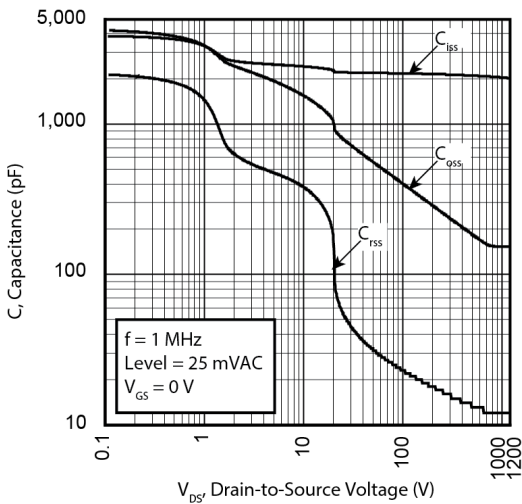
**Figure 5 • RDS(on) vs. Junction Temperature**



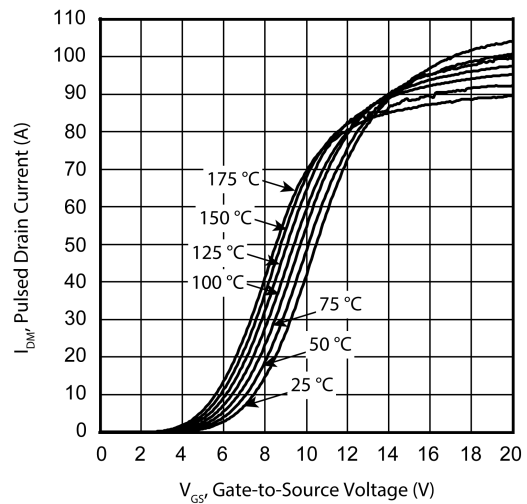
**Figure 6 • Gate Charge Characteristics**



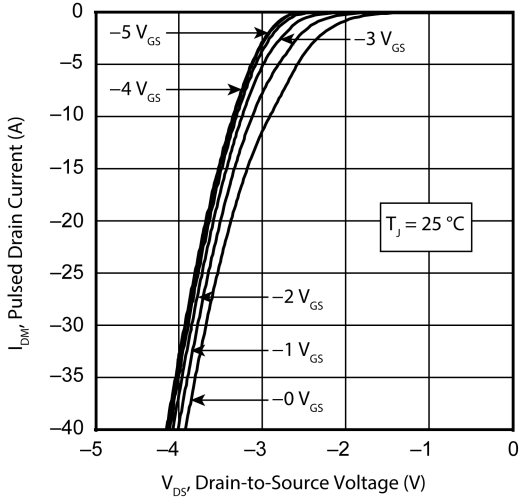
**Figure 7 • Capacitance vs. Drain-to-Source Voltage**



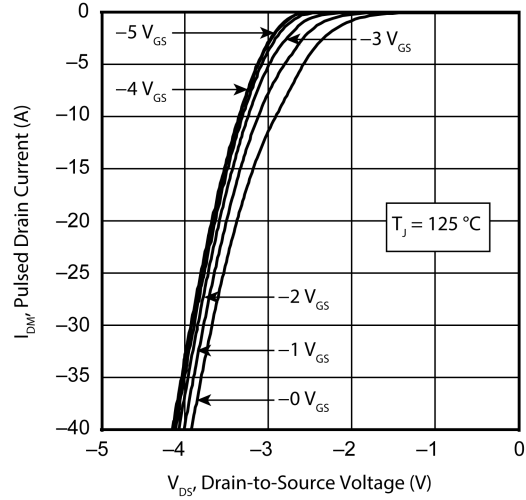
**Figure 8 • IDM vs. Gate-to-Source Voltage**



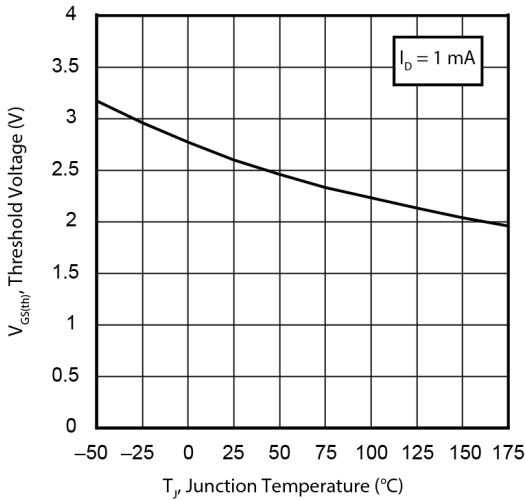
**Figure 9 • IDM vs. VDS Third Quadrant Conduction**



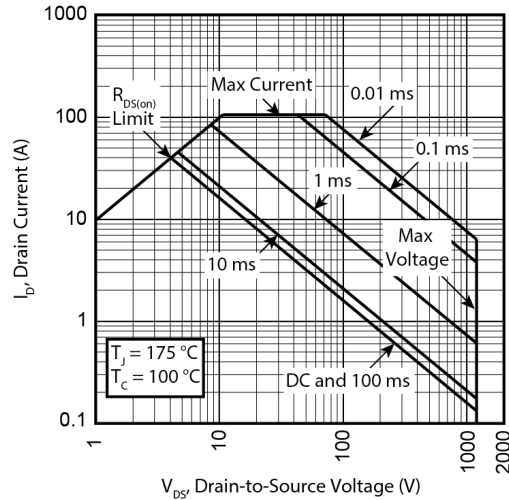
**Figure 10 • IDM vs. VDS Third Quadrant Conduction**



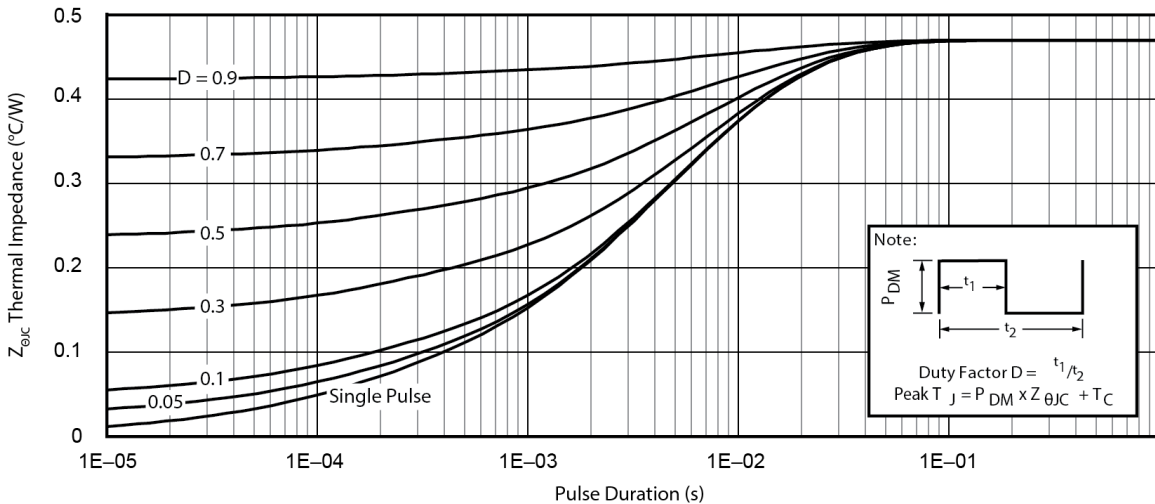
**Figure 11 • VGS(th) vs. Junction Temperature**



**Figure 12 • Forward Safe Operating Area**



**Figure 13 • Maximum Transient Thermal Impedance**



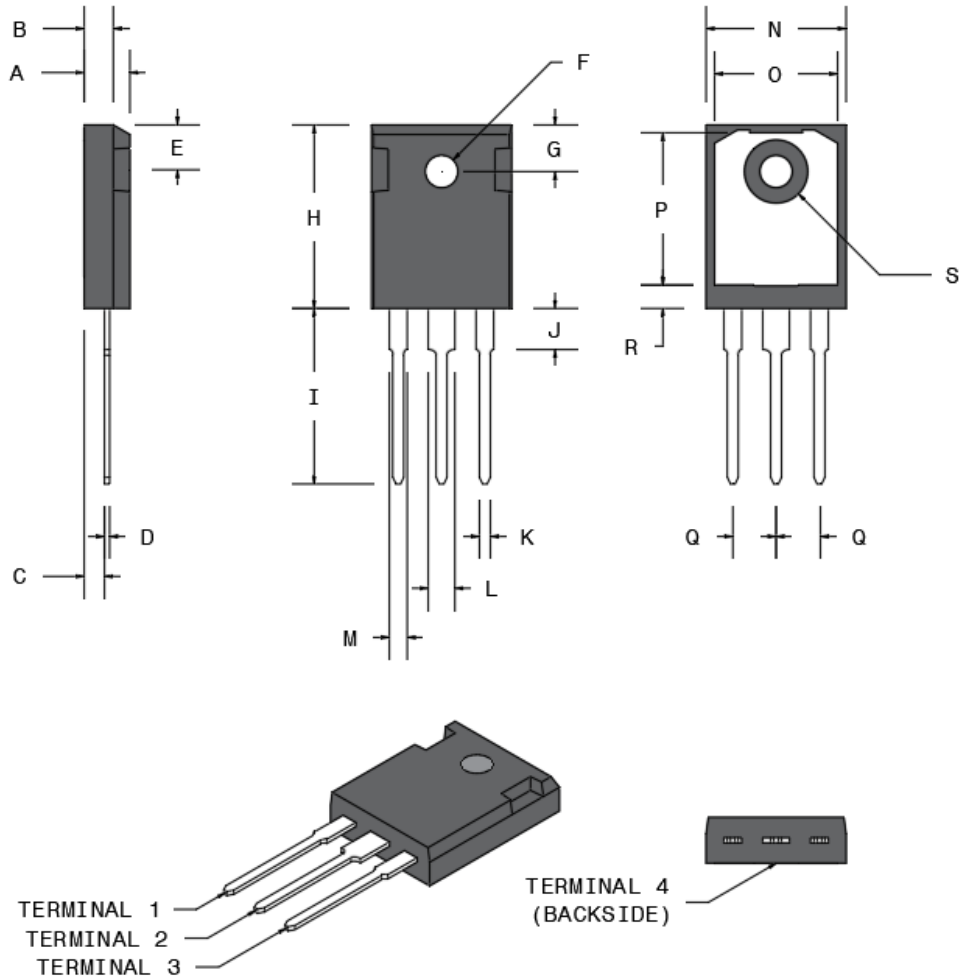
### 3 Package Specification

This section shows the package specification for the MSC040SMA120B device.

#### 3.1 Package Outline Drawing

The following figure illustrates the TO-247 package drawing for the MSC040SMA120B device. The dimensions in the figure below are in millimeters and (inches).

Figure 14 • Package Outline Drawing



The following table shows the MSC040SMA120B dimensions and should be used in conjunction with the package outline drawing.

**Table 6 • TO-247 Dimensions**

Symbol	Min (mm)	Max (mm)	Min (in.)	Max (in.)
A	4.69	5.31	0.185	0.209
B	1.49	2.49	0.059	0.098
C	2.21	2.59	0.087	0.102
D	0.40	0.79	0.016	0.031
E	5.38	6.20	0.212	0.244
F	3.50	3.81	0.138	0.150
G	6.15 BSC		0.242 BSC	
H	20.80	21.46	0.819	0.845
I	19.81	20.32	0.780	0.800
J	4.00	4.50	0.157	0.177
K	1.01	1.40	0.040	0.055
L	2.87	3.12	0.113	0.123
M	1.65	2.13	0.065	0.084
N	15.49	16.26	0.610	0.640
O	13.50	14.50	0.531	0.571
P	16.50	17.50	0.650	0.689
Q	5.45 BSC		0.215 BSC	
R	2.00	2.75	0.079	0.108
S	7.10	7.50	0.280	0.295
Terminal 1	Gate			
Terminal 2	Drain			
Terminal 3	Source			
Terminal 4	Drain			



A MICROCHIP CORPORATION

**Microsemi Headquarters**

One Enterprise, Aliso Viejo,  
CA 92656 USA  
Within the USA: +1 (800) 713-4113  
Outside the USA: +1 (949) 380-6100  
Sales: +1 (949) 380-6136  
Fax: +1 (949) 215-4996  
Email: [sales.support@microsemi.com](mailto:sales.support@microsemi.com)  
[www.microsemi.com](http://www.microsemi.com)

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