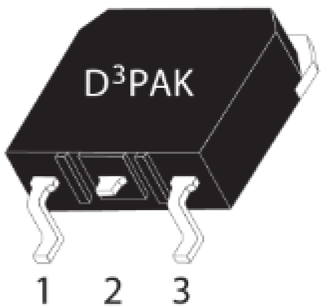
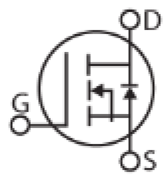
MSC040SMA120S Silicon Carbide N-Channel Power MOSFET

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 MSC040SMA120S device is a 1200 V, 40 mΩ SiC MOSFET in a TO-268 (D3PAK) package.



1—Gate
2—Drain
3—Source
Backside—Drain



1.1 Features

The following are key features of the MSC040SMA120S 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 °C
- Fast and reliable body diode
- Superior avalanche ruggedness
- RoHS compliant

1.2 Benefits

The following are benefits of the MSC040SMA120S 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 MSC040SMA120S 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 MSC040SMA120S device.

2.1 Absolute Maximum Ratings

The following table shows the absolute maximum ratings for the MSC040SMA120S device.

Table 1 • Absolute Maximum Ratings

Symbol	Parameter	Ratings	Unit
V_{DSS}	Drain source voltage	1200	V
I_D	Continuous drain current at T_C = 25 °C	64	A
	Continuous drain current at T_C = 100 °C	45	
I_{DM}	Pulsed drain current [1]	159	
V_{GS}	Gate-source voltage	23 to –10	V
P_D	Total power dissipation at T_C = 25 °C	303	W
	Linear derating factor	2.02	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 of the MSC040SMA120S device.

Table 2 • Thermal and Mechanical Characteristics

Symbol	Characteristic	Min	Typ	Max	Unit
$R_{θJC}$	Junction-to-case thermal resistance		0.33	0.50	°C/W
T_J	Operating junction temperature	–55		175	°C
T_{STG}	Storage temperature	–55		150	
T_L	Soldering temperature for 10 seconds (1.6 mm from case)			260	
Wt	Package weight		0.14		oz
			4.0		g

2.2 Electrical Performance

The following table shows the static characteristics for the MSC040SMA120S device. T_J = 25 °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 V, I_D = 100 µA	1200			V
$R_{DS(on)}$	Drain-source on resistance [1]	V_{GS} = 20 V, I_D = 40 A		40	50	mΩ
$V_{GS(th)}$	Gate-source threshold voltage	V_{GS} = V_{DS}, I_D = 2 mA	1.8	2.6		V
$\Delta V_{GS(th)}/\Delta T_J$	Threshold voltage coefficient	V_{GS} = V_{DS}, I_D = 2 mA		–4.5		mV/°C
I_{DSS}	Zero gate voltage drain current	V_{DS} = 1200 V, V_{GS} = 0 V			100	µA
		V_{DS} = 1200 V, T_J = 125 °C, V_{GS} = 0 V			500	
I_{GSS}	Gate-source leakage current	V_{GS} = 20 V/–10 V			±100	nA

Note:

1. Pulse test: pulse width < 380 µs, duty cycle < 2%.

The following table shows the dynamic characteristics for the MSC040SMA120S device. T_J = 25 °C unless otherwise specified.

Table 4 • Dynamic Characteristics

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
C_{iss}	Input capacitance	V_{GS} = 0 V, V_{DD} = 1000 V, V_{AC} = 25 mV, ƒ = 1 MHz		1990		pF
C_{rss}	Reverse transfer capacitance			17		
C_{oss}	Output capacitance			156		
Q_g	Total gate charge	V_{GS} = –5 V/20 V, V_{DD} = 800 V, I_D = 40 A		137		nC
Q_{gs}	Gate-source charge			29		
Q_{gd}	Gate-drain charge			31		
$t_{d(on)}$	Turn-on delay time	V_{DD} = 800 V, V_{GS} = –5 V/20 V, I_D = 40 A, $R_{G\,(ext)}$ = 4 Ω[1] Freewheeling diode = MSC040SMA120S (V_{GS} = –5 V)		24		ns
t_r	Current rise time			13		
$t_{d(off)}$	Turn-off delay time			46		
t_f	Current fall time			13		
E_{on}	Turn-on switching energy [2]			560		µJ
E_{off}	Turn-off switching energy			82		
$t_{d(on)}$	Turn-on delay time	V_{DD} = 800 V, V_{GS} = –5 V/20 V, I_D = 40 A, $R_{G\,(ext)}$ = 4 Ω[1] Freewheeling diode = MSC015SDA120B		23		ns
t_r	Current rise time			10		
$t_{d(off)}$	Turn-off delay time			44		
t_f	Current fall time			11		
E_{on}	Turn-on switching energy [2]			275		µJ
E_{off}	Turn-off switching energy			83		
ESR	Equivalent series resistance	f = 1 MHz, 25 mV, drain short		1.2		Ω

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
SCWT	Short circuit withstand time	V_{DS} = 960 V, V_{GS} = 20 V, T_C = 25 °C		3		µs
E_{AS}	Avalanche energy, single pulse	V_{DS} = 150 V, V_{GS} = 20 V, I_D = 40 A, T_C = 25 °C		2000		mJ

Notes:

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

2.3 Body Diode Characteristics

The following table shows the body diode characteristics for the MSC040SMA120S device. T_J = 25 °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 A, V_{GS} = 0 V		3.9		V
V_{SD}	Diode forward voltage	I_{SD} = 40 A, V_{GS} = –5 V		4.1		V
t_{rr}	Reverse recovery time	I_{SD} = 40 A, V_{GS} = –5 V V_{DD} = 800 V dI/dt = –1800 A/µs		31		ns
Q_{rr}	Reverse recovery charge			610		nC
I_{rrm}	Reverse recovery current			40		A

2.4 Typical Performance Curves

This section shows the typical performance curves for the MSC040SMA120S device.

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

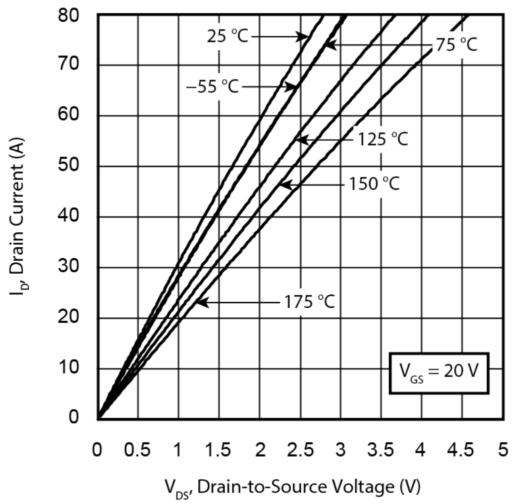


Figure 2 • Drain Current vs. Drain-to-Source Voltage.

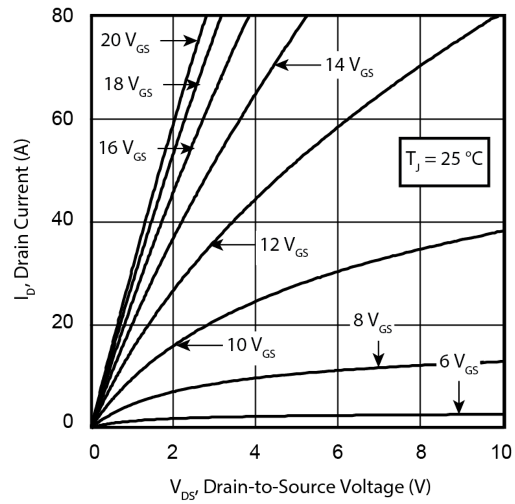


Figure 3 • Drain Current vs. Drain-to-Source Voltage

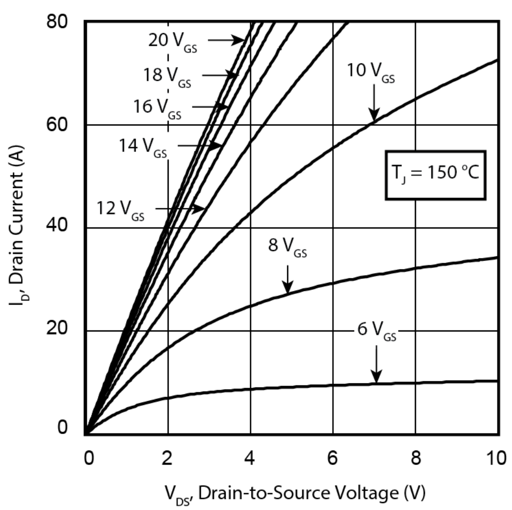


Figure 4 • Drain Current vs. Drain-to-Source Voltage

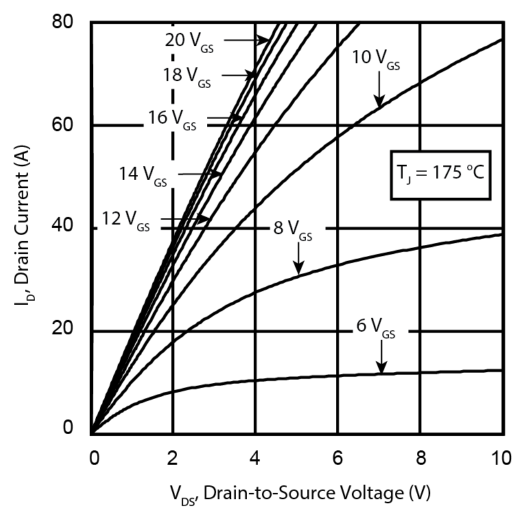


Figure 5 • RDS(on) vs. Junction Temperature

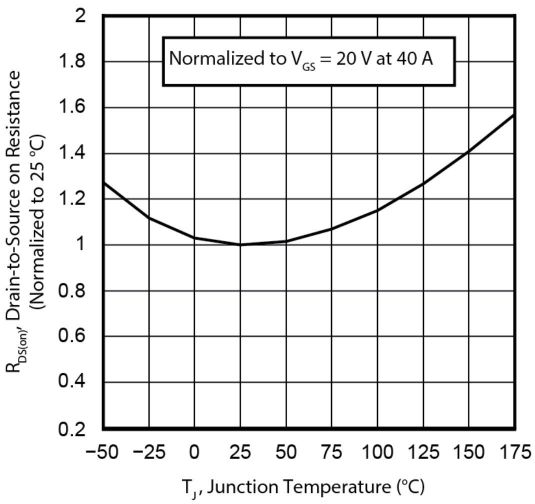


Figure 6 • Gate Charge Characteristics

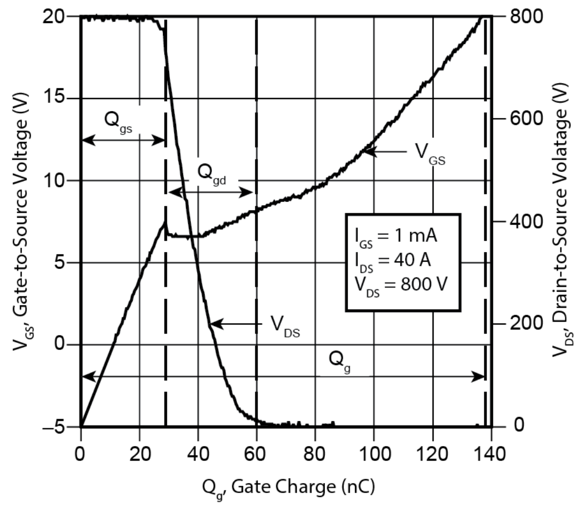


Figure 7 • Capacitance vs. Drain-to-Source Voltage

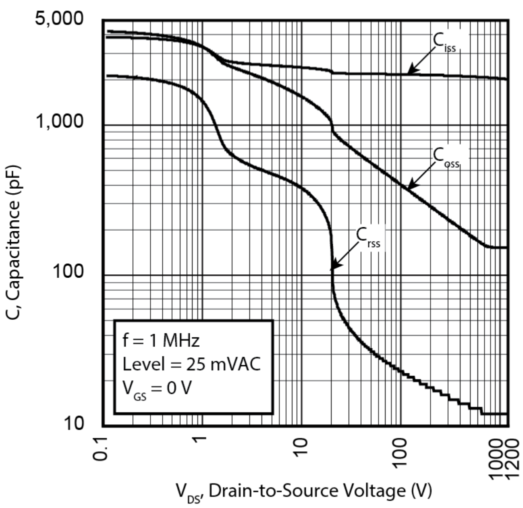


Figure 8 • IDM vs. Gate-to-Source Voltage

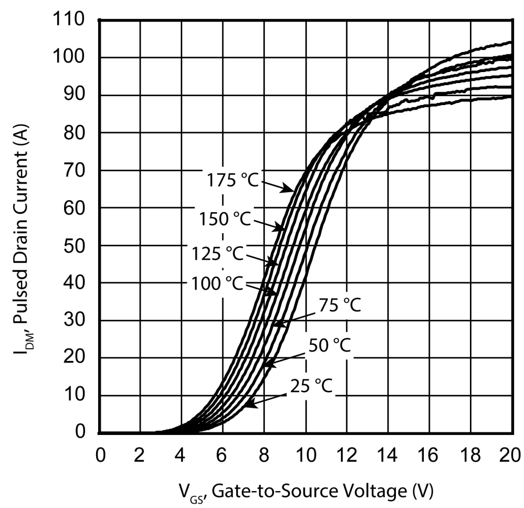


Figure 9 • IDM vs. VDS Third Quadrant Conduction

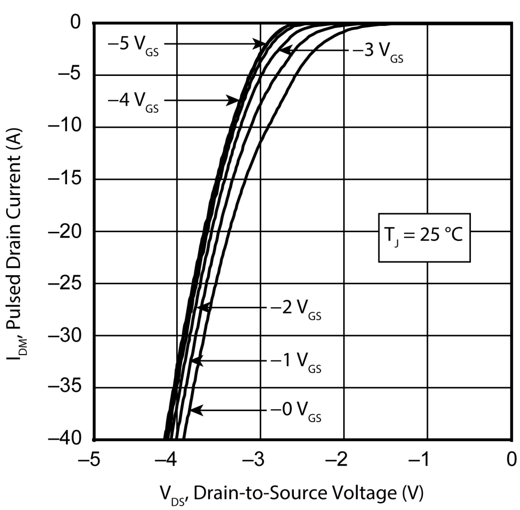


Figure 10 • IDM vs. VDS Third Quadrant Conduction

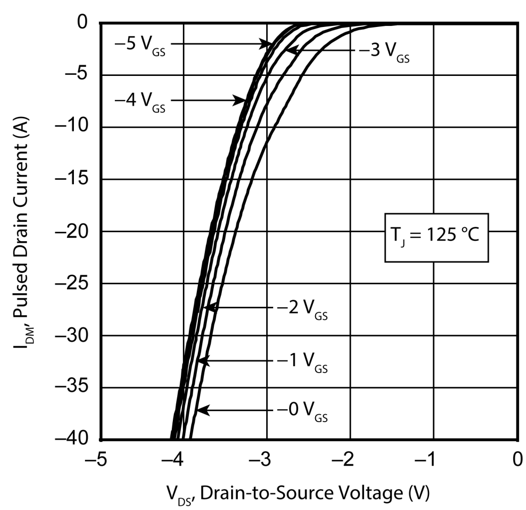


Figure 11 • VGS(th) vs. Junction Temperature

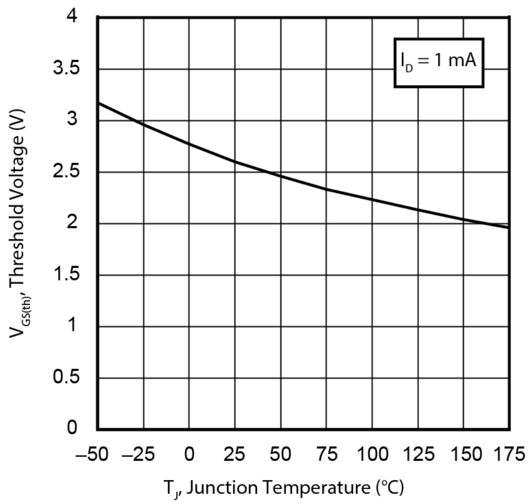


Figure 12 • Forward Safe Operating Area

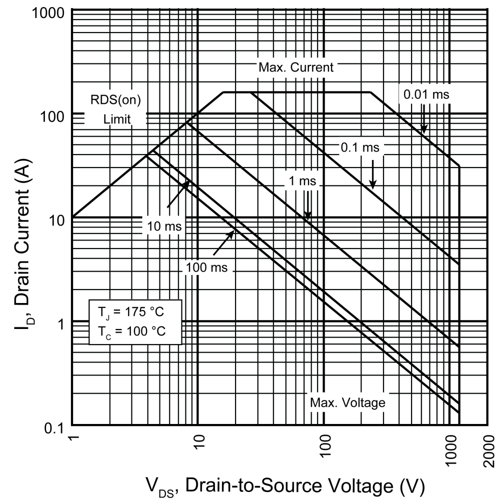
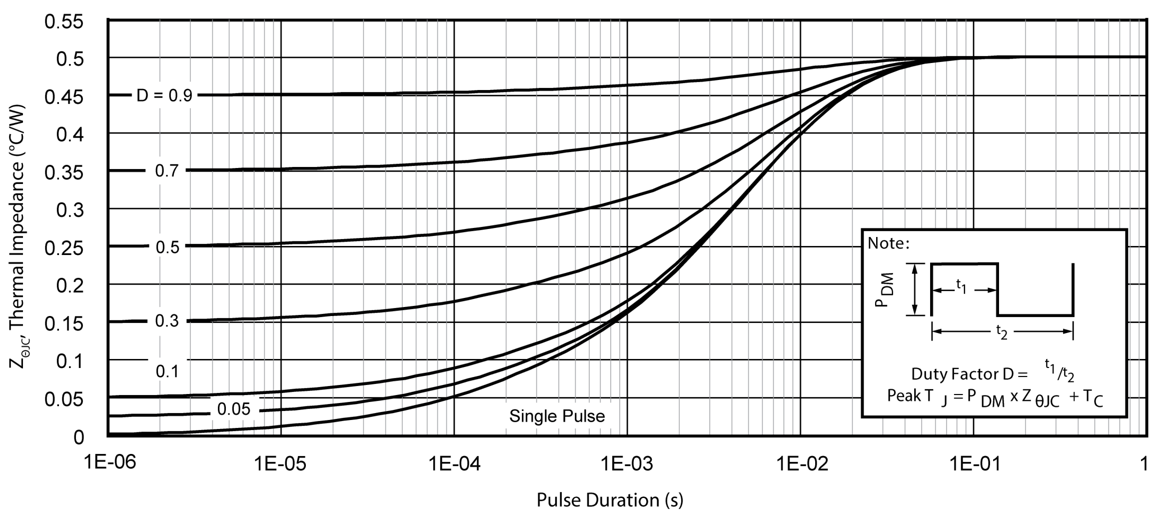


Figure 13 • Maximum Transient Thermal Impedance



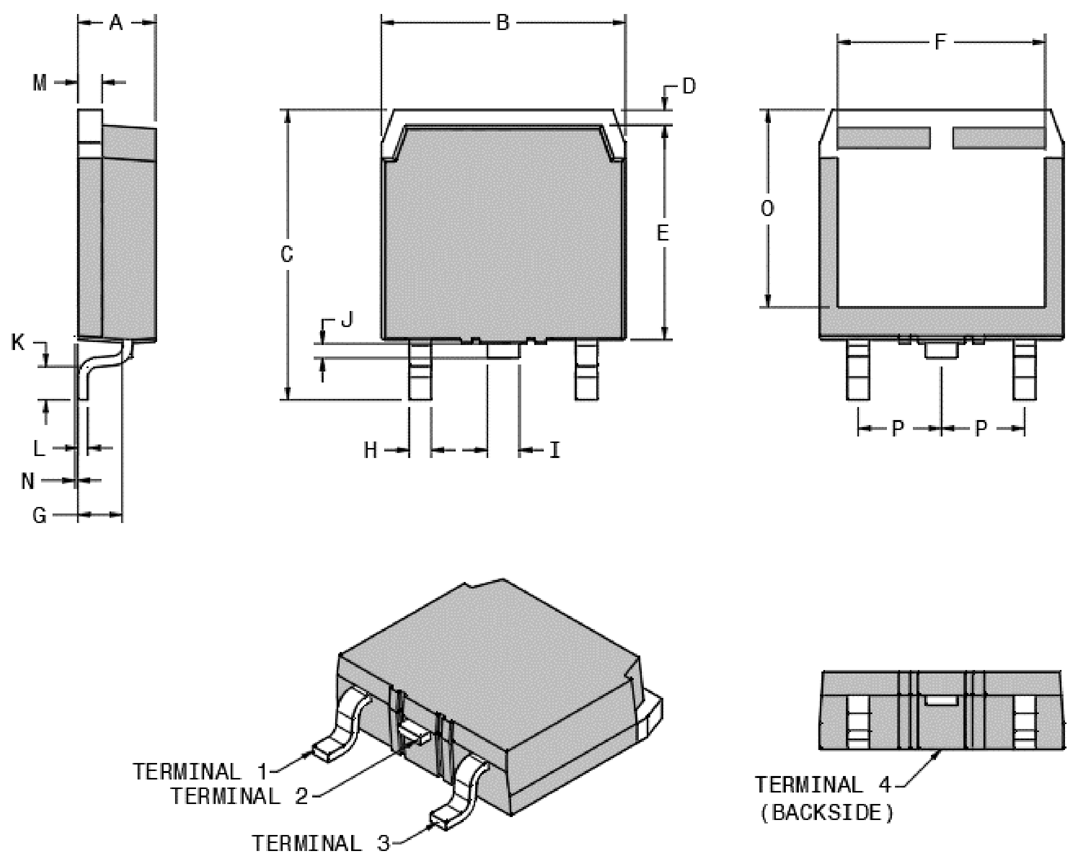
3 Package Specification

This section shows the package specification for the MSC040SMA120S device.

3.1 Package Outline Drawing

The following figure illustrates the TO-268 package outline of the MSC040SMA120S device.

Figure 14 • Package Outline Drawing



The following table lists the TO-268 dimensions and should be used in conjunction with the package outline drawing.

Table 6 • TO-268 Dimensions

Symbol	Min (mm)	Max (mm)	Min (in.)	Max (in.)
A	4.90	5.10	0.193	0.201
B	15.85	16.20	0.624	0.638
C	18.70	19.10	0.736	0.752
D	1.00	1.25	0.039	0.049
E	13.80	14.00	0.543	0.551
F	13.30	13.60	0.524	0.535
G	2.70	2.90	0.106	0.114
H	1.15	1.45	0.045	0.057
I	1.95	2.21	0.077	0.087
J	0.94	1.40	0.037	0.055
K	2.40	2.70	0.094	0.106
L	0.40	0.60	0.016	0.024
M	1.45	1.60	0.057	0.063
N	0.00	0.18	0.000	0.007
O	12.40	12.70	0.488	0.500
P	5.45 BSC (nom.)		0.215 BSC (nom.)	
Terminal 1	Gate			
Terminal 2	Drain			
Terminal 3	Source			
Terminal 4	Drain			

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