MSCSM120AM042CT6LIAG

Datasheet

Very Low Stray Inductance Phase Leg SiC MOSFET Power Module

January 2020

Microsemi

a Microchip company

Contents

1 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.

1.1 Revision 1.0

Revision 1.0 was published in January 2020. It is the first publication of this document.

2 Product Overview

The MSCSM120AM042CT6LIAG device is a 1200 V, 495 A full Silicon Carbide power module.

Figure 1 • Electrical Schematic of MSCSM120AM042CT6LIAG Device

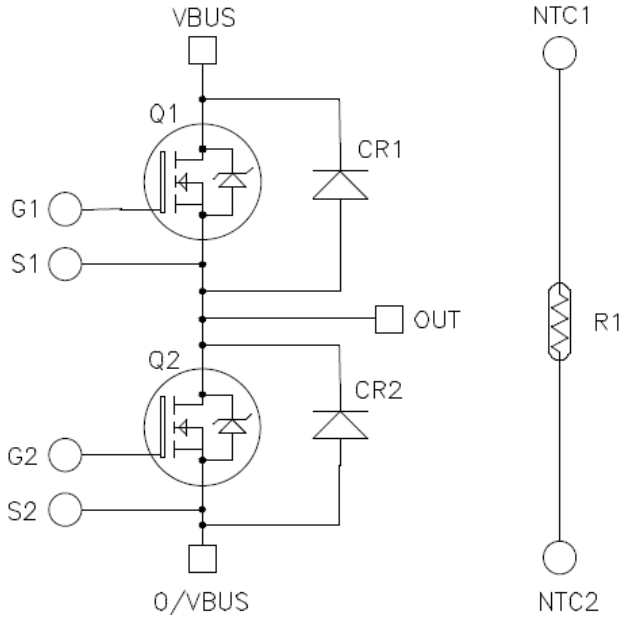
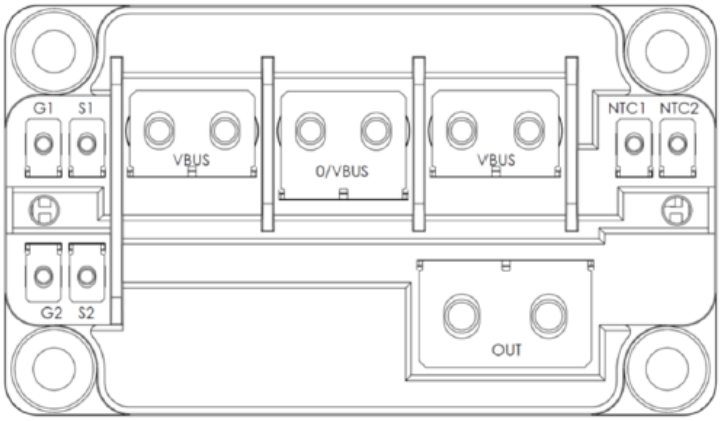


Figure 2 • Pinout Location



All ratings at Tj = 25 °C, unless otherwise specified.

Caution: These devices are sensitive to electrostatic discharge. Proper handling procedures should be followed.

2.1 Features

The following are the features of MSCSM120AM042CT6LIAG device:

- SiC power MOSFET
  - Low $R_{DS(on)}$
  - High temperature performance
- SiC Schottky diode
  - Zero reverse recovery
  - Zero forward recovery
  - Temperature independent switching behavior
  - Positive temperature coefficient on VF
- Very low stray inductance
- Internal thermistor for temperature monitoring
- M4 and M5 power connectors
- M2.5 signals connectors
- AlN substrate for improved thermal performance

2.2 Benefits

The following are the benefits of MSCSM120AM042CT6LIAG device:

- High efficiency converter
- Outstanding performance at high frequency operation
- Direct mounting to heatsink (isolated package)
- Low junction-to-case thermal resistance
- Low profile
- RoHS compliant

2.3 Applications

The following are the applications of MSCSM120AM042CT6LIAG device:

- Welding converters
- Switched mode power supplies
- Uninterruptible power supplies
- EV motor and traction drive

3 Electrical Specifications

This section provides the electrical specifications for the MSCSM120AM042CT6LIAG device.

3.1 SiC MOSFET Characteristics

The following table shows the absolute maximum ratings of MSCSM120AM042CT6LIAG device.

Table 1 • Absolute Maximum Ratings

Symbol	Parameters		Maximum Ratings	Unit
V_{DSS}	Drain–source voltage		1200	V
I_D	Continuous drain current	T_C = 25°C	495[1]	A
		T_C = 80°C	395[1]	
I_{DM}	Pulsed drain current		990	
V_{GS}	Gate–source voltage		–10/25	V
R_{DSon}	Drain–source ON resistance		5.2	mΩ
P_D	Power dissipation	T_C = 25°C	2031	W

Note:

1. Specification of SiC MOSFET device but output current must be limited due to size of power connectors.

The following table shows the electrical characteristics of MSCSM120AM042CT6LIAG device.

Table 2 • Electrical Characteristics

Symbol	Characteristics	Test Conditions		Min	Typ	Max	Unit
I_{DSS}	Zero gate voltage drain current	V_{GS} = 0 V ; V_{DS} = 1200 V			60	600	µA
$R_{DS(on)}$	Drain–source on resistance	V_{GS} = 20 V I_D = 240 A	T_C = 25°C		4.2	5.2	mΩ
			T_C = 175°C		6.7		
$V_{GS(th)}$	Gate threshold voltage	V_{GS} = V_{DS}, I_D = 6 mA		1.8	2.8		V
I_{GSS}	Gate–source leakage current	V_{GS} = 20 V, V_{DS} = 0 V				0.6	µA

The following table shows the dynamic characteristics of MSCSM120AM042CT6LIAG device.

Table 3 • Dynamic Characteristics

Symbol	Characteristics	Test Conditions	Min	Typ	Max	Unit
C_{iss}	Input capacitance	V_{GS} = 0 V V_{DS} = 1000 V f = 1 MHz		18.1		nF
C_{oss}	Output capacitance			1.6		
C_{rss}	Reverse transfer capacitance			0.15		
Q_g	Total gate charge	V_{GS}= –5/20 V V_{Bus} = 800 V I_D = 240 A		1392		nC
Q_{gs}	Gate–source charge			246		
Q_{gd}	Gate–drain charge			300		
$T_{d(on)}$	Turn-on delay time	V_{GS} = –5/20 V T_J= 150 °C V_{Bus} = 600 V I_D = 300 A R_G = 0.5 Ω		56		ns
T_r	Rise time			55		
$T_{d(off)}$	Turn-off delay time			166		
T_f	Fall time			67		
E_{on}	Turn on energy	Inductive switching T_J= 150 °C V_{GS} = –5/20 V V_{Bus} = 600 V I_D = 300 A R_G = 0.5 Ω		5.5		mJ
E_{off}	Turn off energy			4.97		
R_{Gint}	Internal gate resistance			1.6		Ω
R_{thJC}	Junction-to-case thermal resistance				0.074	°C/W

The following table shows the body diode ratings and characteristics of MSCSM120AM042CT6LIAG device.

Table 4 • Body Diode Ratings and Characteristics

Symbol	Characteristics	Test Conditions	Min	Typ	Max	Unit
V_{SD}	Diode forward voltage	V_{GS} = 0 V ; I_{SD} = 240 A		4		V
		V_{GS} = –5 V ; I_{SD} = 240 A		4.2		
t_{rr}	Reverse recovery time	I_{SD} = 240 A ; V_{GS} = –5 V V_R = 800 V ; di_F/dt = 6000 A/µs		90		ns
Q_{rr}	Reverse recovery charge			3.3		µC
I_{rr}	Reverse recovery current			81		A

3.2 SiC Diode Characteristics (Per SiC Diode)

The following table shows the SiC diode characteristics (per SiC diode) of MSCSM120AM042CT6LIAG device.

Table 5 • SiC Diode Characteristics (Per SiC Diode)

Symbol	Characteristics	Test Conditions		Min	Typ	Max	Unit
V_{RRM}	Peak repetitive reverse voltage					1200	V
I_{RM}	Reverse leakage current	V_R = 1200 V	T_J = 25°C		0.06	1.2	mA
			T_J = 175°C		0.9		
I_F	DC forward current		T_C = 95°C		180		A
V_F	Diode forward voltage	I_F = 180 A	T_J = 25°C		1.5	1.8	V
			T_J = 175°C		2.1		
Q_C	Total capacitive charge	V_R = 600 V			780		nC
C	Total capacitance	f = 1 MHz, V_R = 400 V			846		pF
		f = 1 MHz, V_R = 800 V			630		
R_{thJC}	Junction-to-case thermal resistance					0.175	°C/W

3.3 Thermal and Package Characteristics

The following table shows the package characteristics of MSCSM120AM042CT6LIAG device.

Table 6 • Package Characteristics

Symbol	Characteristics			Min	Max	Unit
V_{ISOL}	RMS isolation voltage, any terminal to case t =1 min, 50/60 Hz			4000		V
T_J	Operating junction temperature range			–40	175	°C
T_{JOP}	Recommended junction temperature under switching conditions			–40	T_{Jmax}–25	
T_{STG}	Storage temperature range			–40	125	
T_C	Operating case temperature			–40	125	
Torque	Mounting torque	For terminals	M2.5	0.4	0.6	N.m
			M4	2	3	
			M5	2	3.5	
		To heatsink	M6	3	5	
L_{DC}	Module stray inductance between V_{BUS} and 0/V_{BUS}				3	nH
Wt	Package weight				320	g

The following table shows the temperature sensor NTC of MSCSM120AM042CT6LIAG device.

Table 7 • Temperature Sensor NTC

Symbol	Characteristics		Min	Typ	Max	Unit
R_{25}	Resistance at 25°C			50		kΩ
$\Delta R_{25}/R_{25}$				5		%
$B_{25/85}$	T_{25} = 298.15 K			3952		K
ΔB/B		T_C = 100°C		4		%

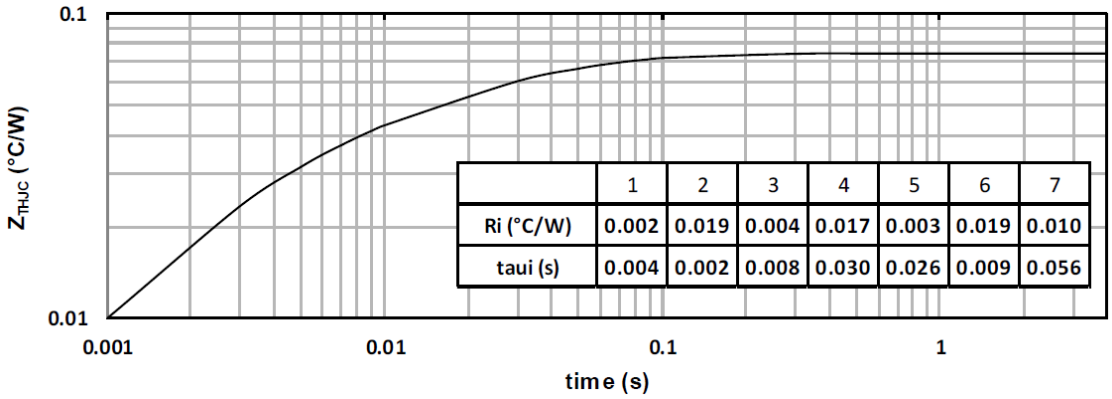
$$R_T = \frac{R_{25}}{\exp\left[B_{25/85}\left(\frac{1}{T_{25}} - \frac{1}{T}\right)\right]}$$

T: Thermistor temperature
R_T: Thermistor value at T

3.4 SiC MOSFET Performance Curves

The following images show the SiC MOSFET performance curves of the MSCSM120AM042CT6LIAG device.

Figure 3 • Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	0.002	0.019	0.004	0.017	0.003	0.019	0.010
taui (s)	0.004	0.002	0.008	0.030	0.026	0.009	0.056

Figure 4 • Output Characteristics, T_J = 25 °C

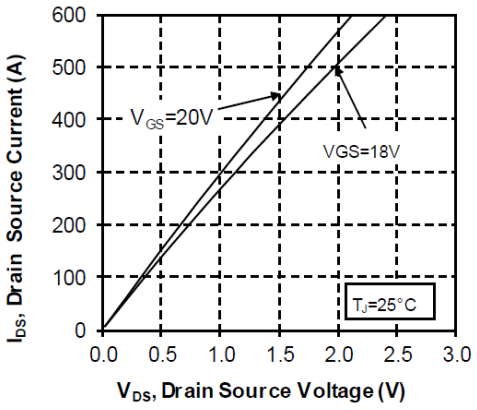


Figure 5 • Output Characteristics, T_J = 175 °C

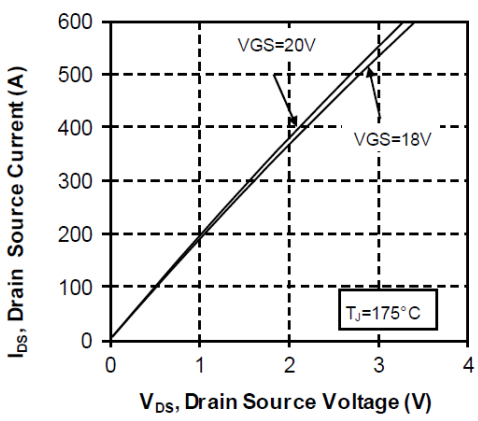


Figure 6 • Normalized $R_{DS(on)}$ vs. Temperature

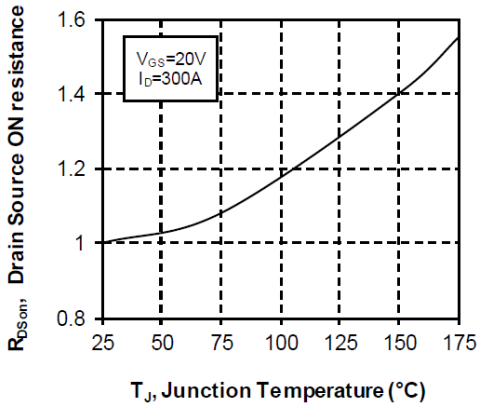


Figure 7 • Transfer Characteristics

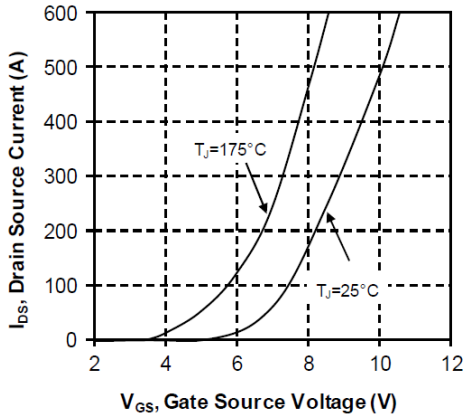


Figure 8 • Switching Energy vs. Rg

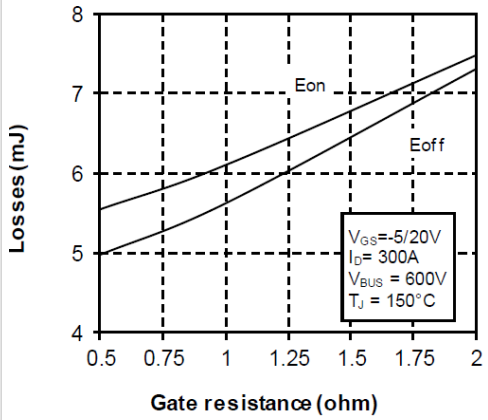


Figure 9 • Switching Energy vs. Current

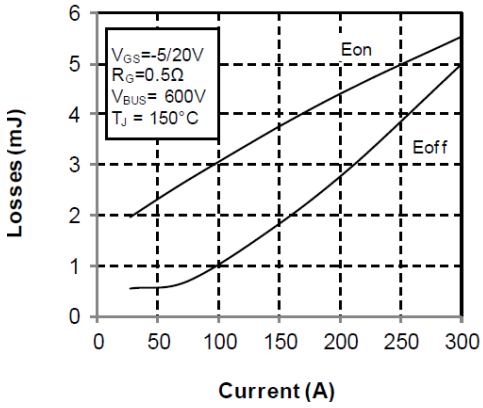


Figure 10 • Capacitance vs. Drain Source Voltage

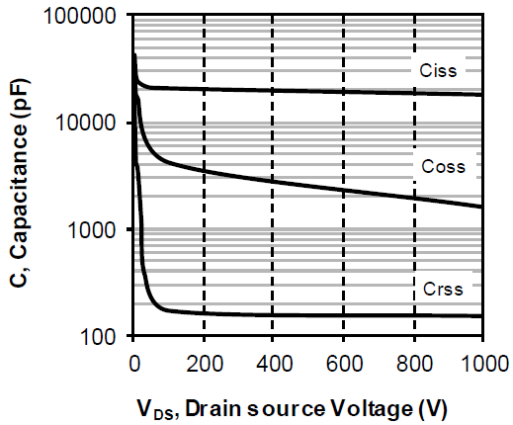


Figure 11 • Gate Charge vs. Gate Source Voltage

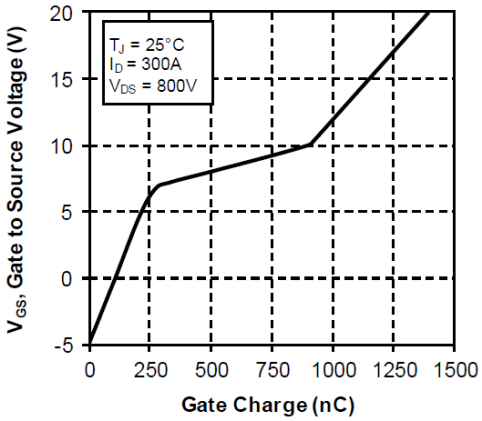


Figure 12 • Body Diode Characteristics, T_J=25 °C

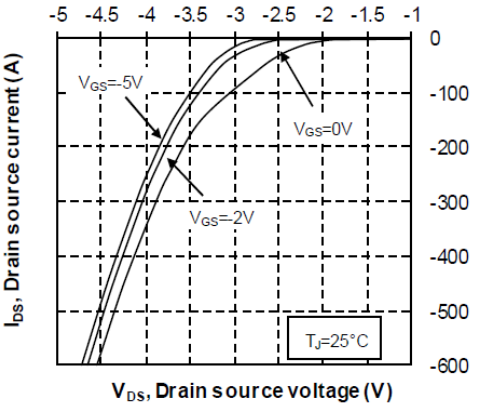


Figure 13 • 3rd Quadrant Characteristics, T_J=25 °C

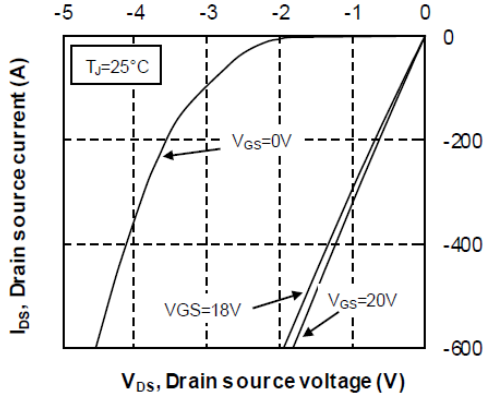


Figure 14 • Body Diode Characteristics, T_J=175 °C

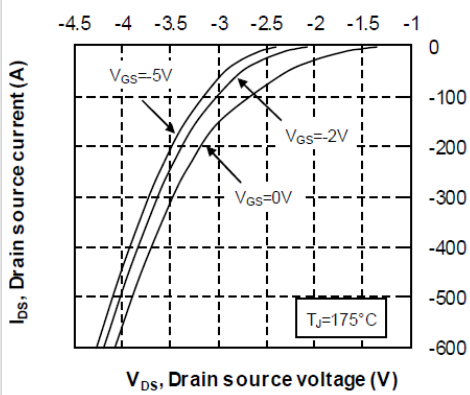


Figure 15 • 3rd Quadrant Characteristics, T_J=175 °C

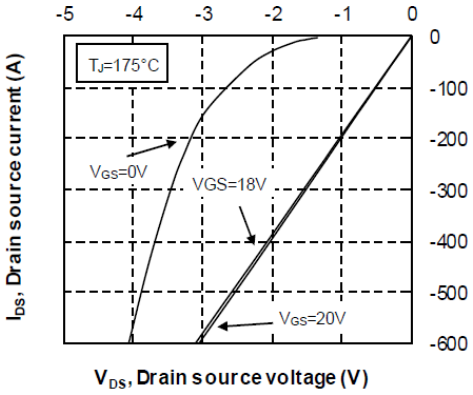
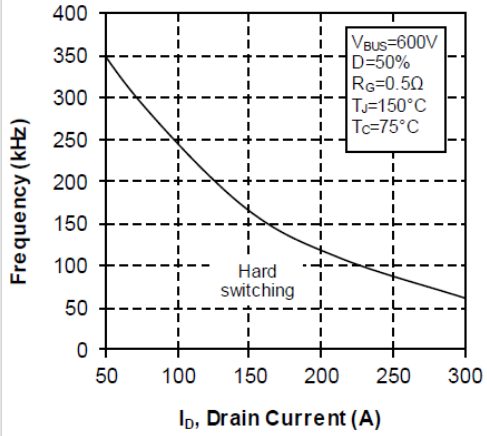


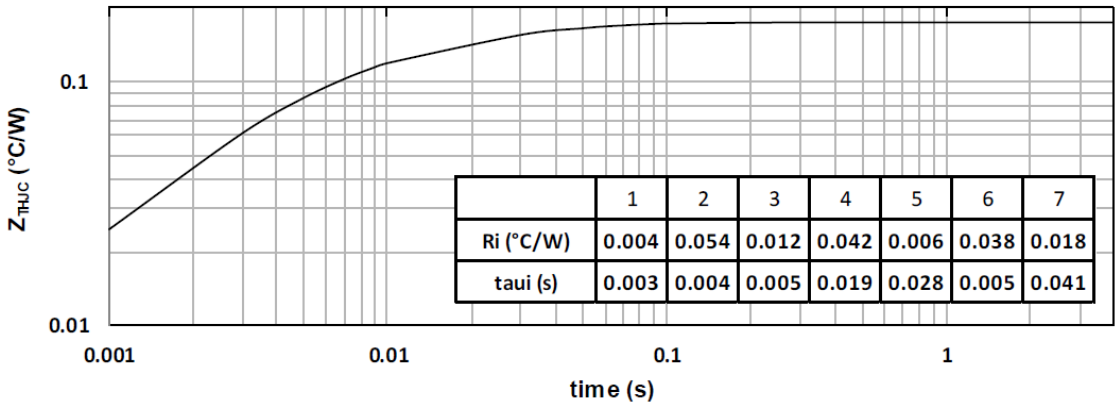
Figure 16 • Operating Frequency vs. Drain Current



3.5 SiC Diode Performance Curves

The following images show the SiC diode performance curves of MSCSM120AM042CT6LIAG device.

Figure 17 • Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	0.004	0.054	0.012	0.042	0.006	0.038	0.018
taui (s)	0.003	0.004	0.005	0.019	0.028	0.005	0.041

Figure 18 • Forward Characteristics

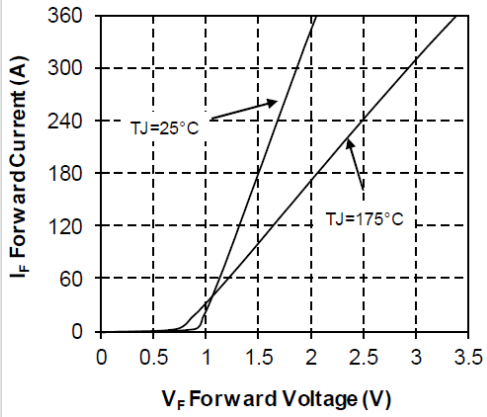
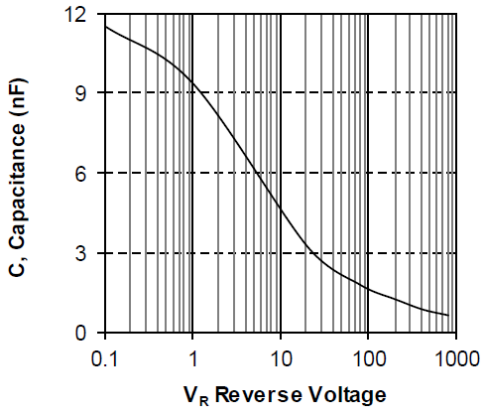


Figure 19 • Capacitance vs. Reverse Voltage



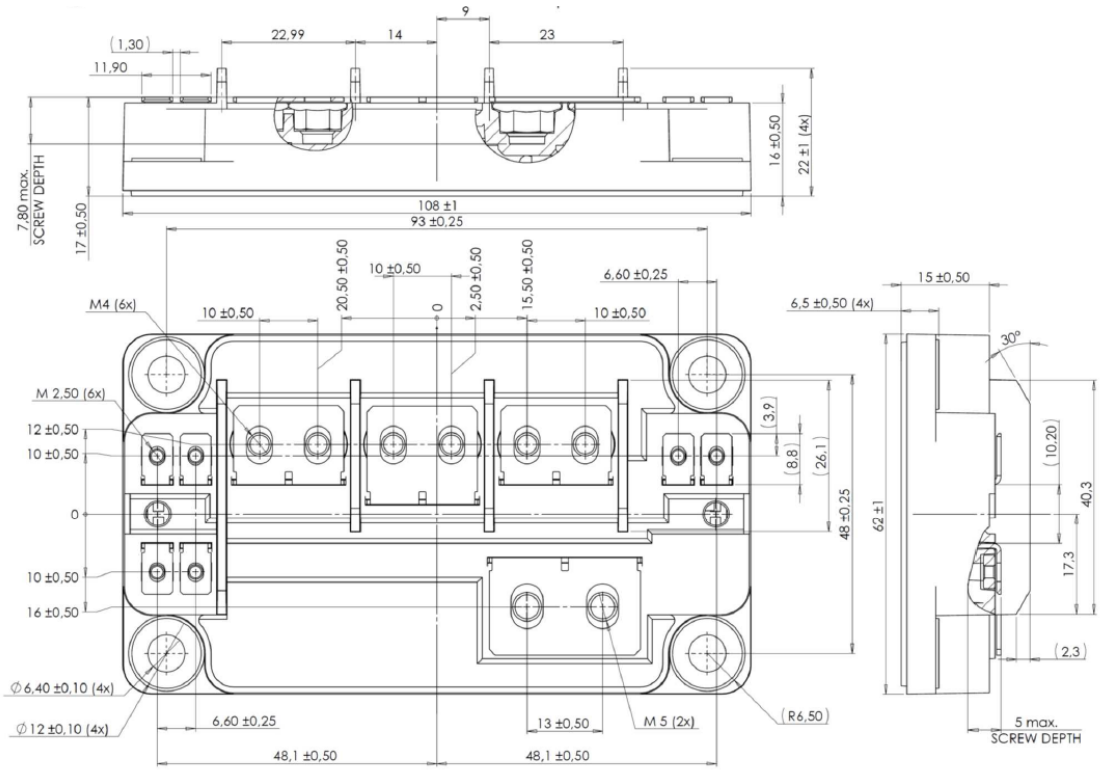
4 Package Specification

The following section shows the package specification of MSCSM120AM042CT6LIAG device.

4.1 Package Outline Drawing

The following image illustrates the package outline drawing of MSCSM120AM042CT6LIAG device. The dimensions are in millimeters.

Figure 20 • Package Outline Drawing



Note:

See *AN1911—Mounting instructions for SP6 Low inductance Power Module* application note.