MAS9164

50 mA LDO Voltage Regulator IC

- **Only 10 µA Ground Pin Current at 1 mA Load Current**
- **Good Transient Performance**
- **Low Dropout Voltage: 150 mV**
- **Low Noise**
- **Enable/Disable Control**
- **Stable with Low-ESR Output Capacitors**

DESCRIPTION

MAS9164 is an LDO voltage regulator with low ground pin current of 10 µA, which combined with the good overall performance, makes MAS9164 highly suitable for providing power to continuously working low power circuits. The usage of MAS9164 is beneficial especially in the applications where standby periods are long and in portable devices where long battery life is essential.

In addition to the low ground pin current, MAS9164 excels in dropout voltage (150 mV typical at 50 mA). Although MAS9164 does not use an external bypass capacitor, the noise level (100 Hz… 100 kHz) is only 100 µVrms with 1 µF output capacitor.

The Equivalent Series Resistance (ESR) range of output capacitors that can be used with MAS9164 is very wide. This ESR range from a few mΩ up to a couple of Ohms combined with no minimum output current requirement makes the usage of MAS9164 easier and low in cost.

Enable/disable pin allows MAS9164 to be turned off or on. In order to save power the device enters the sleep mode when the regulator is disabled.

An internal thermal protection circuit prevents the device from overheating. Also the maximum output current is internally limited.

FEATURES

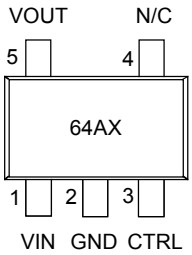
- Extremely Low Current Consumption
- Low Minimum Operating Supply Voltage
- Output Accuracy < ± 3.3%
- Internal Thermal Shutdown
- Short Circuit Protection
- Thin SOT (TSOT 5) Package
- Output Voltage Option: 1.8 V, see Ordering Information p. 10

APPLICATIONS

- Continuously Working Low Power Circuits
- Digital Circuits
- Real-Time Clocks (RTC)
- SRAMs
- CMOS Backup Power
- Cellular Phones
- Portable Systems
- Smoke Detectors

PIN CONFIGURATION

Top View



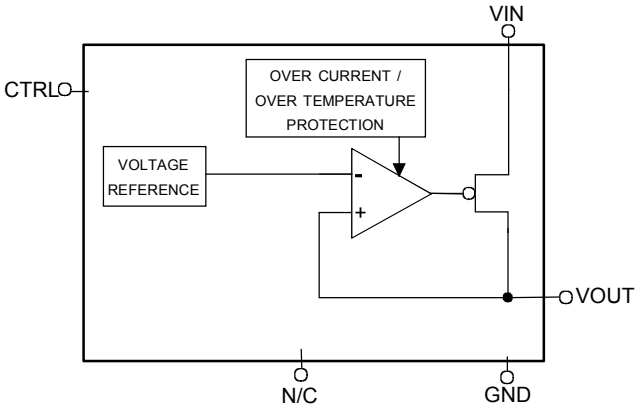
For Marking Information see Ordering Information p. 10

PIN DESCRIPTION

Pin Name	Pin	Type	Function
VIN	1	P	Power Supply Voltage
GND	2	G	Ground
CTRL	3	I	Enable/Disable Pin for Regulator
N/C	4	-	Not Connected
VOUT	5	O	Output

G = Ground, I = Input, O = Output, P = Power

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

All voltages with respect to ground.

Parameter	Symbol	Conditions	Min	Max	Unit
Supply Voltage	V_{IN}		-0.3	6	V
Voltage Range for All Pins			-0.3	V_{IN} + 0.3	V
ESD Rating		HBM		2	kV
Junction Temperature	T_{Jmax}			+175 (limited)	°C
Storage Temperature	T_S		-55	+150	°C

Stresses beyond those listed may cause permanent damage to the device. The device may not operate under these conditions, but it will not be destroyed.

RECOMMENDED OPERATING CONDITIONS

All voltages with respect to ground.

Parameter	Symbol	Conditions	Min	Max	Unit
Operating Junction Temperature	T_J		-40	+125	°C
Operating Ambient Temperature	T_A		-40	+85	°C
Operating Supply Voltage	V_{IN}		2.2	5.3	V

ELECTRICAL CHARACTERISTICS

◆ Thermal Protection

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Threshold	T		130	150	175	°C

◆ Control Terminal Specifications

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Control Voltage OFF State ON State	V_{CTRL}		 -0.3 1.2		 0.5 V_{IN} + 0.3	V
Control Current	I_{CTRL}	V_{CTRL} = 1.2 V V_{CTRL} = 2.8 V V_{CTRL} = 5.3 V		0.07 0.37 0.84	 0.7	µA

◆ Voltage Parameters

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Tolerance	V_{OUT}	 I_{OUT} = 0 mA I_{OUT} = 50 mA	 $V_{OUT(NOM)}$ – 0.06 $V_{OUT(NOM)}$ – 0.08		 $V_{OUT(NOM)}$ + 0.06 $V_{OUT(NOM)}$ + 0.06	V
Dropout Voltage	V_{DROP}	I_{OUT} = 1 mA I_{OUT} = 10 mA I_{OUT} = 50 mA		5 50 150		mV

◆ Current Parameters

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Continuous Output Current	I_{OUT}					50	mA
Short Circuit Current	I_{MAX}	R_L = 0 Ω			150		mA
Peak Output Current	I_{PK}	V_{OUT} > 95% * $V_{OUT(NOM)}$			80		mA
Ground Pin Current	I_{GND}	 I_{OUT} = 0 mA I_{OUT} = 1 mA I_{OUT} = 10 mA I_{OUT} = 50 mA			 9 10 20 55		µA
Ground Pin Current, Sleep Mode	I_{GND}	V_{CTRL} = 0 V	T_A = + 27°C		0.01	0.5	µA
			T_A = + 85°C		0.2	4	

◆ Power Dissipation

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Thermal Resistance (Junction-to-Air)	R_{JA}	thermal test board according to JC51-7 (4 layers)		85		°C/W
Maximum Power Dissipation	P_d	any ambient temperature	$P_{dMAX} = \frac{T_{J(MAX)} - T_A}{R_{JA}}$ Note 1			W

Note 1: $T_{J(MAX)}$ denotes maximum operating junction temperature (+125°C), T_A ambient temperature, and R_{JA} junction-to-air thermal resistance (+85°C/W).

◆ Line and Load Regulation

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Line Regulation		$V_{OUT(NOM)}$ + 1 V < V_{IN} < 5.3 V, I_{OUT} = 10 mA		1.0	3	mV
Load Regulation		I_{OUT} = 1.0 to 50 mA		7.5	20	mV

◆ Noise and Ripple Rejection

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Noise Voltage	V_{RMS}	100 Hz < f < 100 kHz, I_{OUT} = 10 mA		100		µVrms
Noise Density	V_N	I_{OUT} = 10 mA, f = 10 kHz		300		$nV/\sqrt{Hz}$
PSRR		I_{OUT} = 1 mA f = 1 kHz f = 10 kHz		 50 30		dB
		I_{OUT} = 10 mA f = 1 kHz f = 10 kHz		 50 30		dB

◆ Dynamic Parameters

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Start-up Delay		V_{CTRL} = 0 to 2.4 V, I_{OUT} = 10 mA (see figure 1 below)		1.5		ms
Overshoot		V_{CTRL} = 0 to 2.4 V		1.0	8.0	%

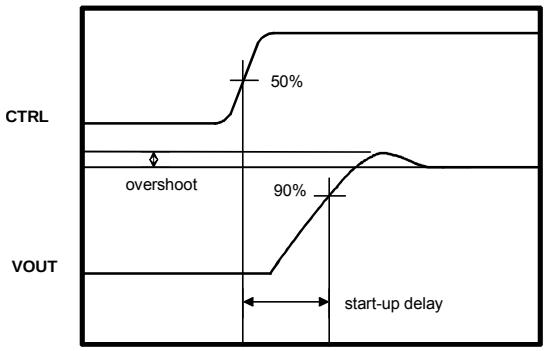


Figure 1. The definitions of overshoot and start-up delay.

TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

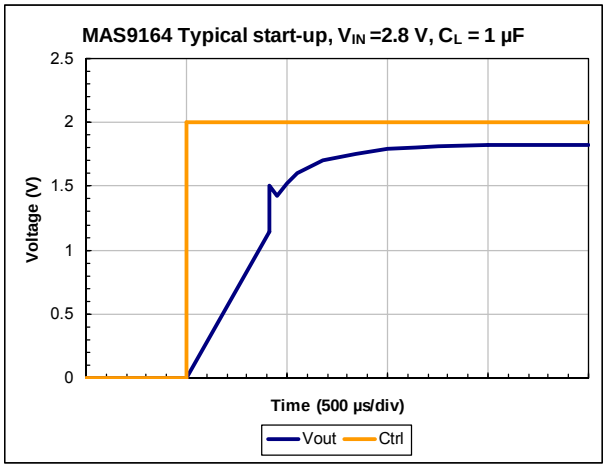


Figure 2. Typical start-up.

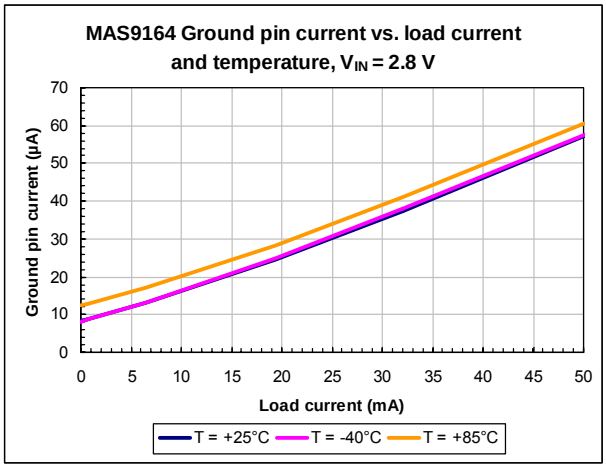


Figure 3. Ground pin current vs. load current and temperature.

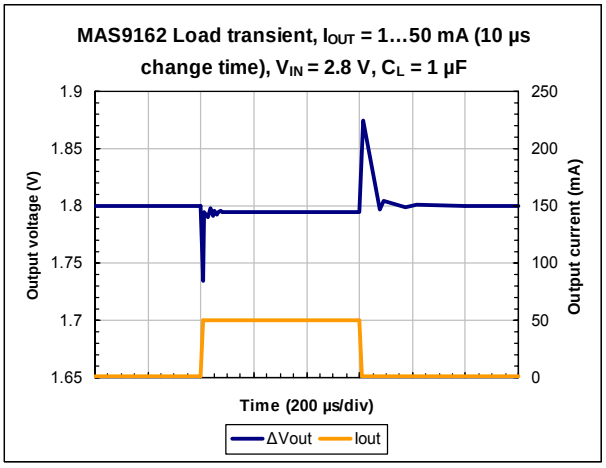


Figure 4. Load transient response.

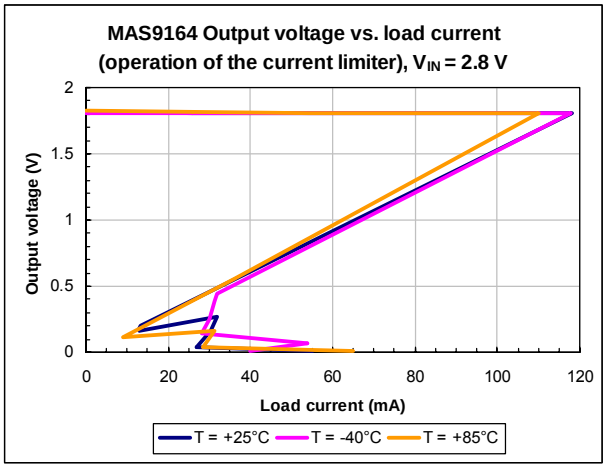


Figure 5. Output voltage vs. load current (the operation of the current limiter).

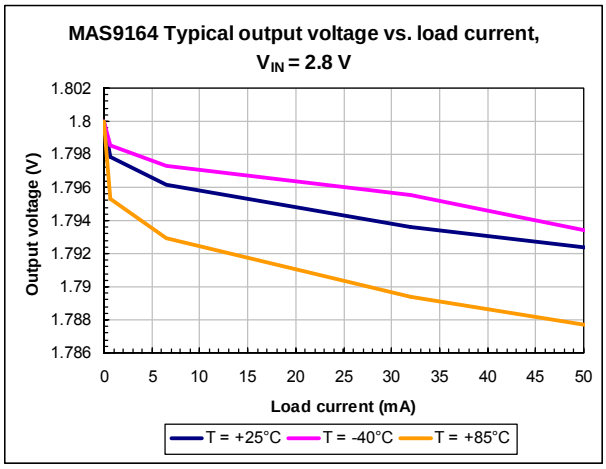


Figure 6. Typical output voltage vs. load current and temperature.

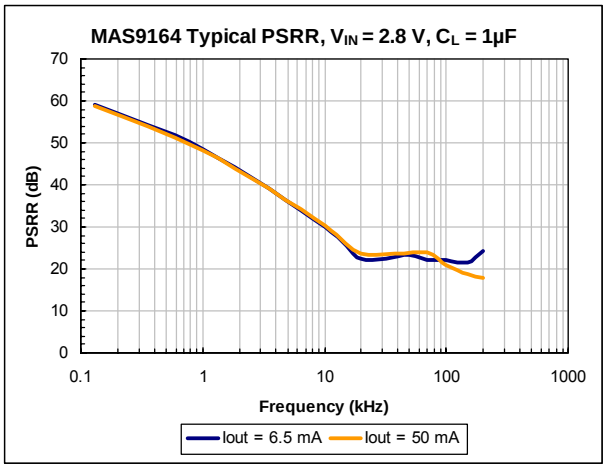


Figure 7. PSRR vs. frequency. I_{OUT} = 6.5 mA & I_{OUT} = 50 mA.

TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 1 V, I_{OUT} = 1 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

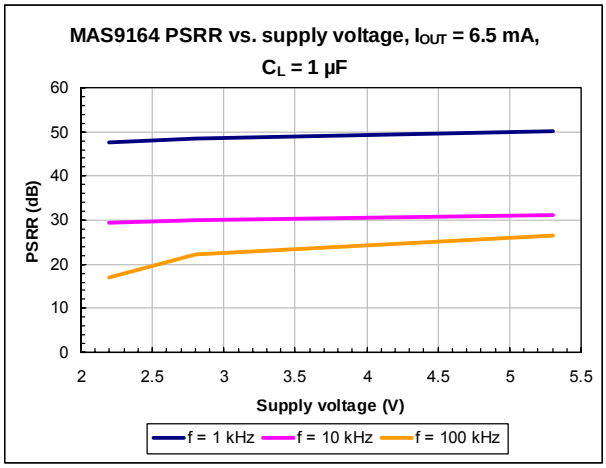


Figure 8. PSRR vs. supply voltage and frequency.

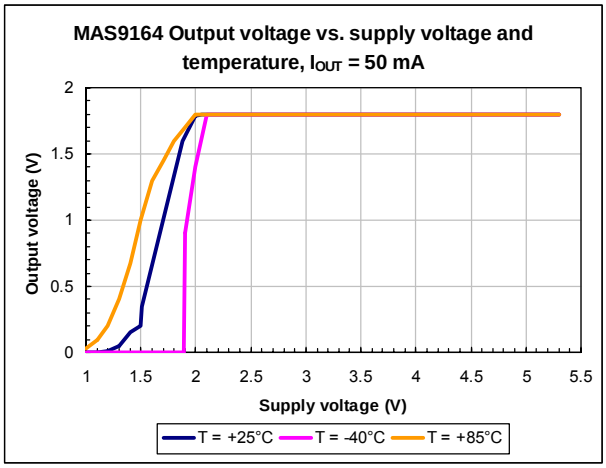


Figure 9. Output voltage vs. supply voltage and temperature.

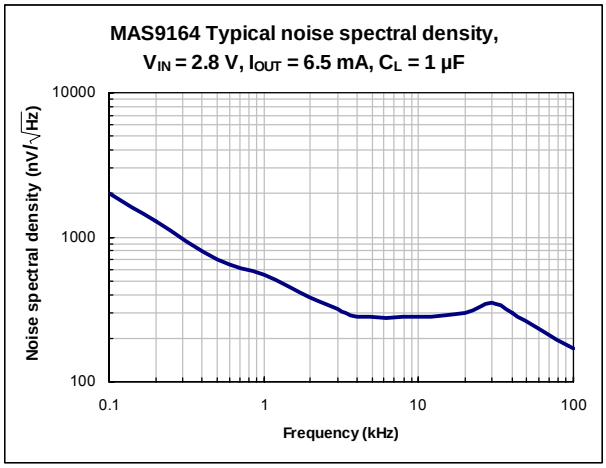


Figure 10. Typical noise spectral density, C_L = 1.0 µF.

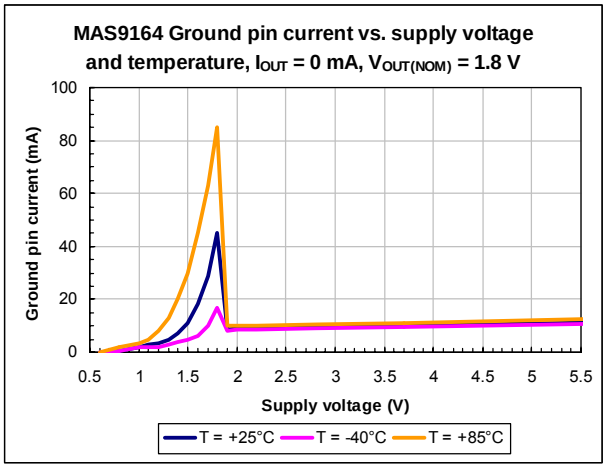
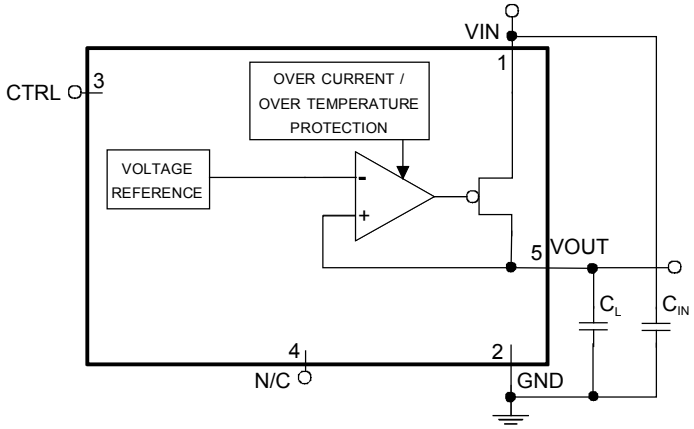


Figure 11. Ground pin current vs. supply voltage and temperature.

APPLICATION INFORMATION

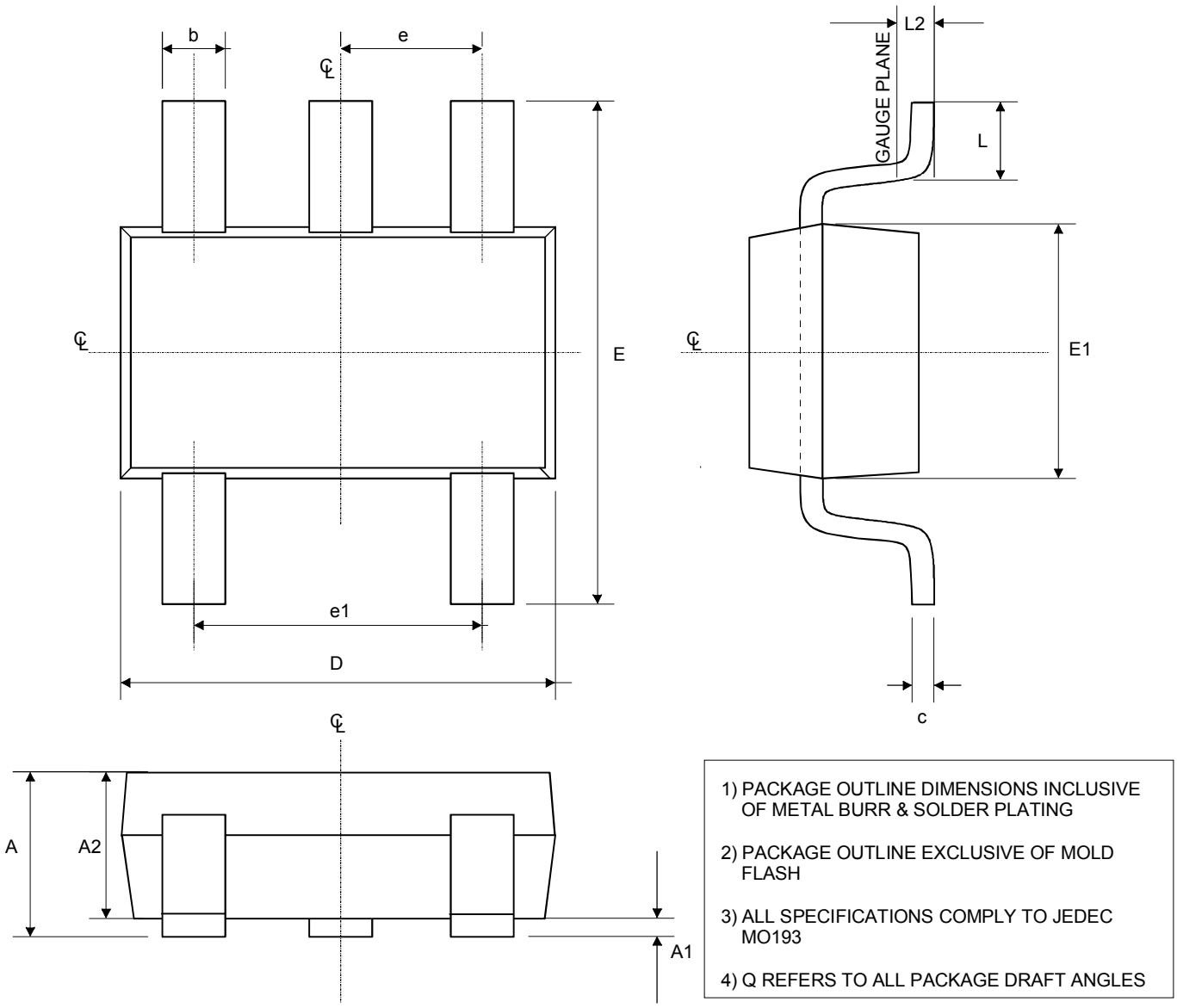


N.B.! CTRL-pin has to be connected, i.e., it shall not be left floating.

Parameter	Symbol	Min	Typ	Max	Unit	Note
Output Capacitance	C_L	0.6	1.0		µF	1. Ceramic, film capacitors can be used.
Effective Series Resistance	ESR	0.005		3	Ohm	1. When within this range stable with all I_{OUT} = 0 mA… 50 mA values
Input Capacitance	C_{IN}	0.23			µF	1. A big enough input capacitance is needed to prevent possible impedance interactions between the supply and MAS9164. 2. Ceramic, tantalum, and film capacitors can be used. If using a tantalum capacitor, it should be checked that surge current rating is sufficient for the application. 3. In the case that the inductance between a battery and MAS9164 is very small (< 0.1 µH) 0.22 µF input capacitor is sufficient.

Values given on the table are minimum requirements unless otherwise specified. When selecting capacitors, tolerance and temperature coefficient must be considered to **make sure that the requirement is met in all potential operating conditions**.

PACKAGE (TSOT 5) OUTLINE



1) PACKAGE OUTLINE DIMENSIONS INCLUSIVE OF METAL BURR & SOLDER PLATING

2) PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH

3) ALL SPECIFICATIONS COMPLY TO JEDEC MO193

4) Q REFERS TO ALL PACKAGE DRAFT ANGLES

Symbol	Min	Nom	Max	Unit
A	--	--	1.00	mm
A1	0.01	0.05	0.10	mm
A2	0.84	0.87	0.90	mm
b	0.30	--	0.45	mm
c	0.12	0.127	0.20	mm
D		2.90BSC		mm
E		2.80BSC		mm
E1		1.60BSC		mm
e		0.95BSC		mm
e1		1.90BSC		mm
L	0.30	0.40	0.50	mm
L2		0.25BSC		mm
Q	4°	10°	12°	

SOLDERING INFORMATION

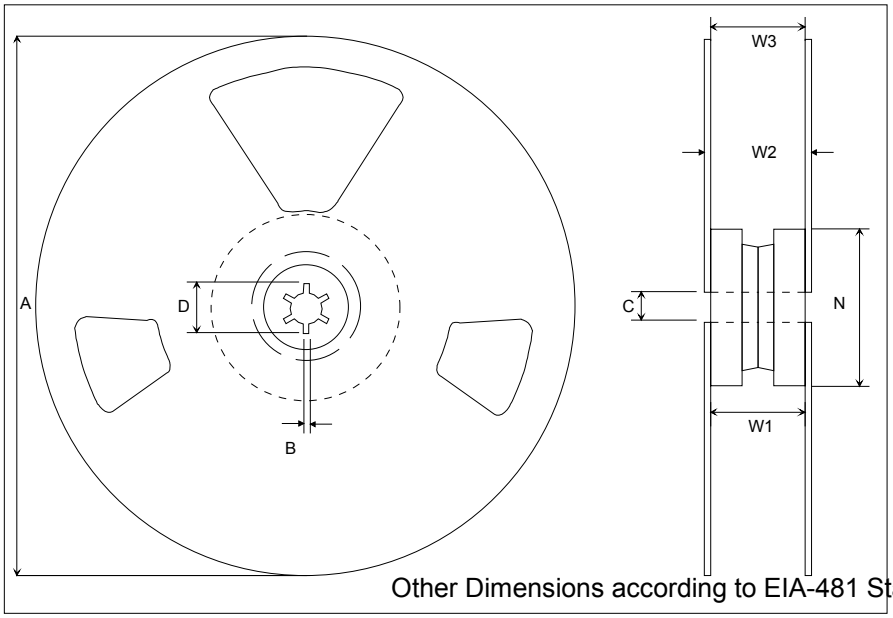
◆ **For Eutectic Sn/Pb TSOT-5**

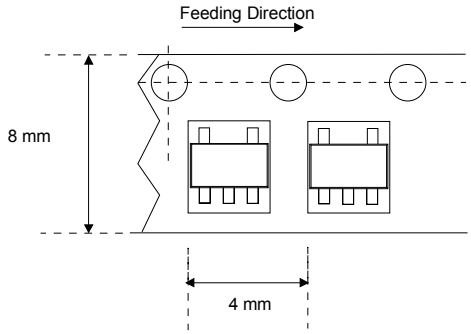
Resistance to Soldering Heat	According to RSH test IEC 68-2-58/20 2*220°C
Maximum Reflow Temperature	235°C
Maximum Number of Reflow Cycles	3
Seating Plane Co-planarity	max 0.08 mm
Lead Finish	Solder plate 7.62 - 25.4 µm, material Sn 85% Pb 15%

◆ **For Lead-free TSOT-5**

Resistance to Soldering Heat	According to RSH test IEC 68-2-58/20
Maximum Reflow Temperature	260 °C
Maximum Number of Reflow Cycles	3
Seating Plane Co-planarity	max 0.08 mm
Lead Finish	Solder plate 7.62 - 25.4 µm, material Matte Tin

TAPE & REEL SPECIFICATIONS





Other Dimensions according to EIA-481 Standard

3000 Components on Each Reel

Dimension	Min	Max	Unit
A		178	mm
B	1.5		mm
C	12.80	13.50	mm
D	20.2		mm
N	50		mm
W_1 (measured at hub)	8.4	9.9	mm
W_2 (measured at hub)		14.4	mm
W_3 (includes flange distortion at outer edge)	7.9	10.9	mm
Trailer	160		mm
Leader	390, of which minimum 160 mm of empty carrier tape sealed with cover tape		mm

ORDERING INFORMATION

Product Code	Product	Top Marking	Package	Comments
MAS9164AGA4-T	1.80 V Voltage Regulator IC	64A4	TSOT 5	Tape and Reel
MAS9164AGB4-T	1.80 V Voltage Regulator IC	64A4 (B in the bottom marking to indicate lead-free)	TSOT 5 lead-free	Tape and Reel

For more voltage options contact Micro Analog Systems Oy.

For a low quiescent current regulator with the output voltages between 2.5 V and 3.5 V, see the data sheet of MAS9161.

LOCAL DISTRIBUTOR

MICRO ANALOG SYSTEMS OY CONTACTS

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