MICRO ANALOG SYSTEMS

MAS9161

80 mA LDO Voltage Regulator IC

- **Only 10.5 µA Ground Pin Current at 1 mA Load Current**
- **Good Transient Performance**
- **Low Dropout Voltage: 200 mV**
- **Low Noise**
- **Enable/Disable Control**
- **Stable with Low-ESR Output Capacitors**

DESCRIPTION

MAS9161 LDO voltage regulator is optimized for operation at low ground pin current of just 10.5 µA. This combined with the good overall performance makes MAS9161 very suitable for providing continuous supply in low power circuits. The performance of MAS9161 benefits applications where standby periods are long and where long battery life is essential.

In addition to the low ground pin current, MAS9161 excels in dropout voltage (200 mV typical at 80 mA). Even though MAS9161 does not use an external bypass capacitor, the noise level (100 Hz…100 kHz) is only 70 µVrms with 1 µF output capacitor.

The Equivalent Series Resistance (ESR) range of output capacitors that can be used with MAS9161 is very wide. This ESR range from zero up to a couple of Ohms combined with no minimum output current requirement makes the usage of MAS9161 easier and low in cost.

Enable/disable pin allows MAS9161 to be turned off and 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

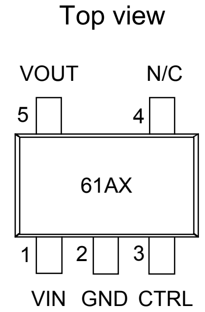
- Extremely Low Current Consumption
- Good Transient Performance
- Output Accuracy < ± 3.3%
- Internal Thermal Shutdown
- Short Circuit Protection
- Thin SOT (TSOT-5) or WL-CSP Package
- Several Output Voltage Options Available, see Ordering Information p. 14

APPLICATIONS

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

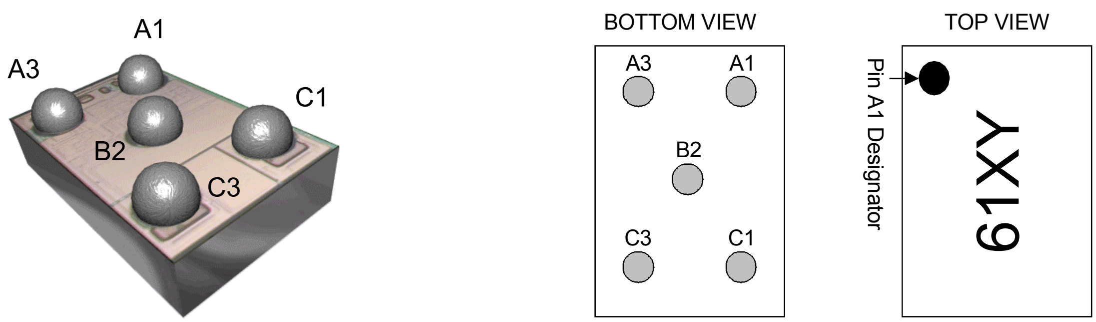
PIN CONFIGURATION

TSOT-5



For top marking information see
ordering information p. 14

WL-CSP



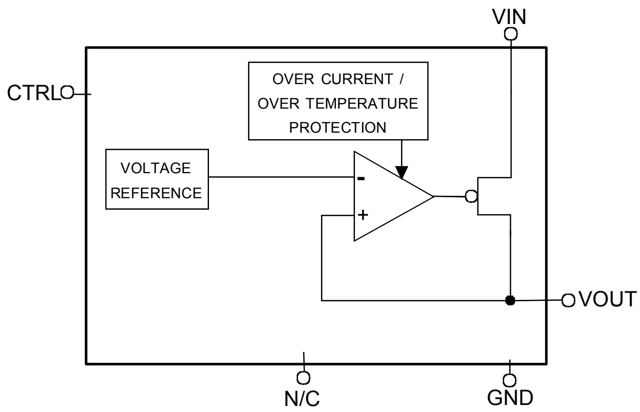
For top marking information see
ordering information p. 14

PIN DESCRIPTION

Pin Name	Pin Number in TSOT-5	Pin Number in WL-CSP	Type	Function
VIN	1	C3	P	Power Supply Voltage
GND	2	A1	G	Ground
CTRL	3	A3	I	Enable/Disable Pin for Regulator
N/C	4	B2	-	Not Connected
VOUT	5	C1	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}		$V_{OUT(NOM)}$ + 0.3 V	5.3	V
		For MAS9161A4	2.5		

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	V_{CTRL}					V
OFF State			-0.3		0.5	
ON State			1.2		V_{IN} + 0.3	
Control Current	I_{CTRL}	V_{CTRL} = 1.2 V		0.35		µA
		V_{CTRL} = 2.0 V		0.70	1.5	
		V_{CTRL} = 3.8 V		1.50		

If CTRL-pin is not connected, MAS9161 is in OFF state (4 MΩ pull-down resistor to ground).

◆ 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}					V
		I_{OUT} = 0 mA	$V_{OUT(NOM)}$ – 0.06		$V_{OUT(NOM)}$ + 0.06	
		I_{OUT} = 50 mA	$V_{OUT(NOM)}$ – 0.08		$V_{OUT(NOM)}$ + 0.06	
Dropout Voltage	V_{DROP}	I_{OUT} = 1 mA		5		mV
		I_{OUT} = 10 mA		50		
		I_{OUT} = 50 mA		150		
		I_{OUT} = 80 mA		200		

◆ 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}		0		80	mA
Short Circuit Current	I_{MAX}	R_L = 0 Ω		240		mA
Peak Output Current	I_{PK}	V_{OUT} > 95% * $V_{OUT(NOM)}$		120		mA
Ground Pin Current	I_{GND}	V_{CTRL} = 2.0 V				µA
		I_{OUT} = 0 mA		10		
		I_{OUT} = 1 mA		10.5		
		I_{OUT} = 10 mA		16		
		I_{OUT} = 80 mA		61		
Ground Pin Current, Sleep Mode	I_{GND}	V_{CTRL} = 0 V, T_A = + 27°C		0.01	0.5	µA
		V_{CTRL} = 0 V, 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), TSOT-5 package		85		°C/W
		mounted on MAS9161 CSP evaluation board, WL-CSP package		TBD		
Maximum Power Dissipation	P_d	any ambient temperature, TSOT-5 package	$P_{dMAX} = \frac{T_{J(MAX)} - T_A}{R_{JA}}$ 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 mA to 80 mA		12	24	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		70		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 f = 100 kHz		 50 30 30		dB
		I_{OUT} = 10 mA f = 1 kHz f = 10 kHz f = 100 kHz		 50 30 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	%

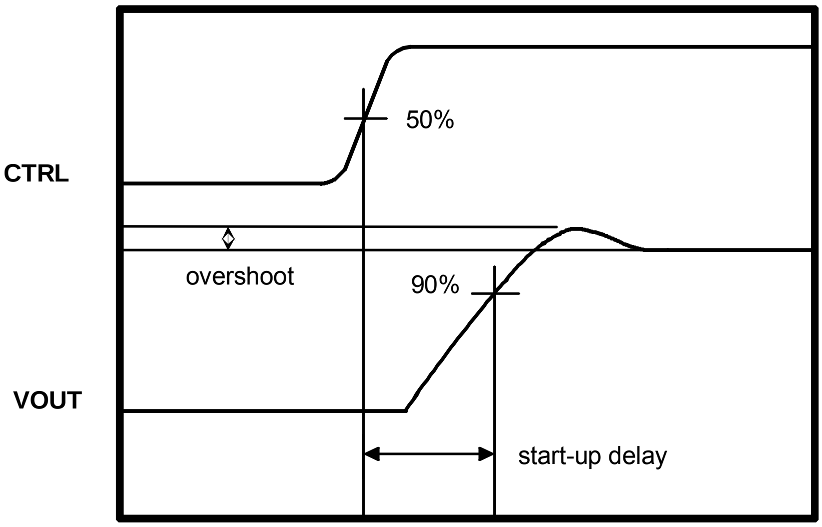


Figure 1. Definitions of overshoot and start-up delay.

TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 3.8 V, T_A = +27°C, I_{OUT} = 50 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

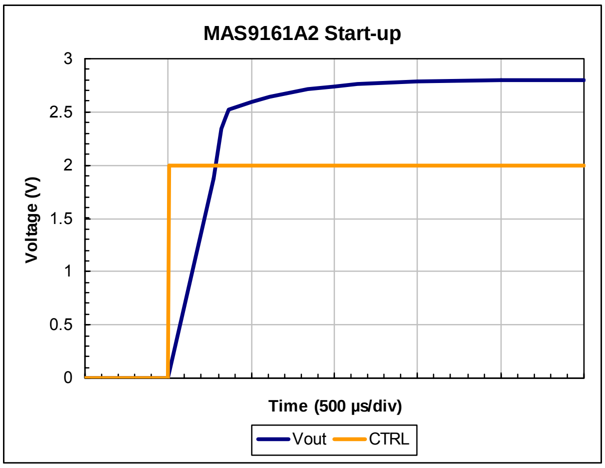


Figure 2. MAS9161A2 typical start-up.

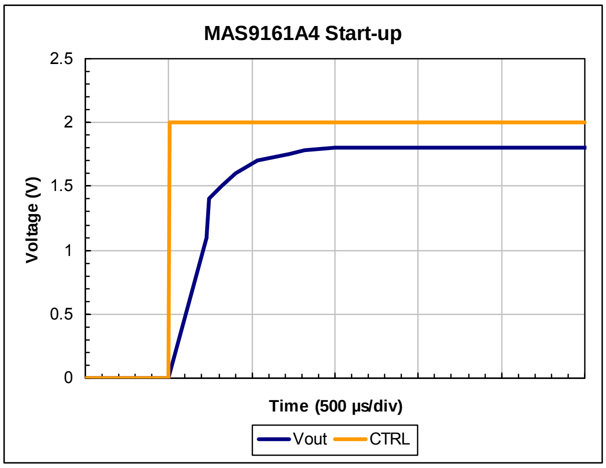


Figure 3. MAS9161A4 typical start-up. V_{IN} = 2.8 V.

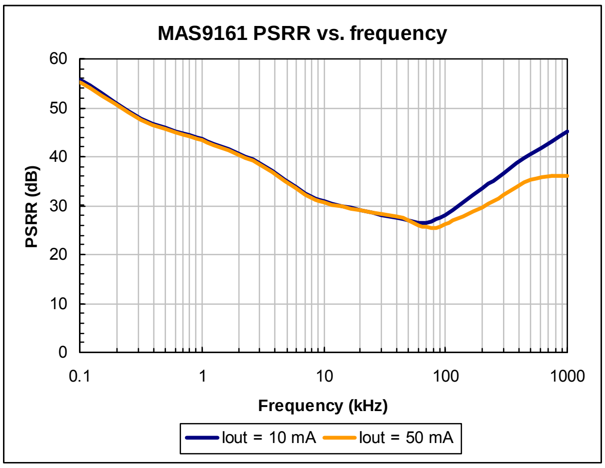


Figure 4. PSRR vs. frequency. T_A = +25°C.

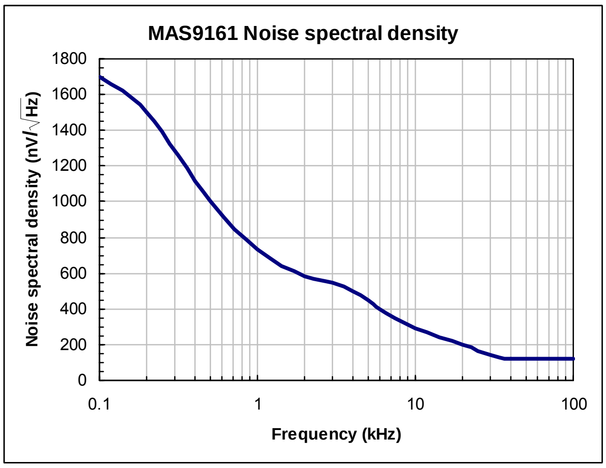


Figure 5. Output noise spectral density.

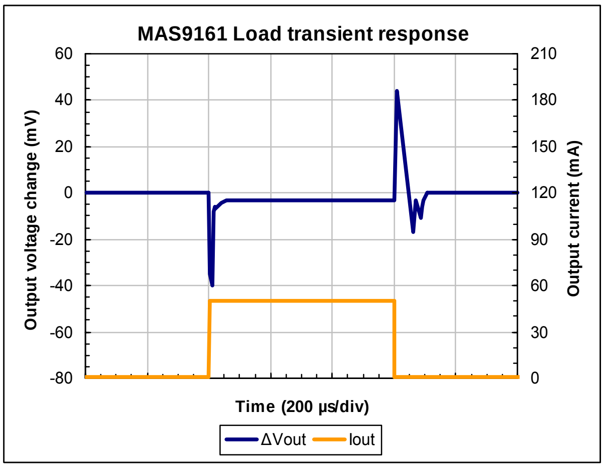


Figure 6. Load transient response. I_{OUT} = 1…50 mA in 10 µs.

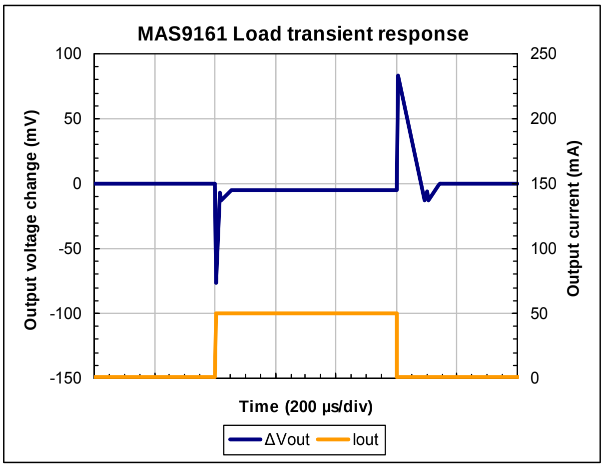


Figure 7. Load transient response. I_{OUT} = 1…50 mA in 2 µs.

TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 3.8 V, T_A = +27°C, I_{OUT} = 50 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

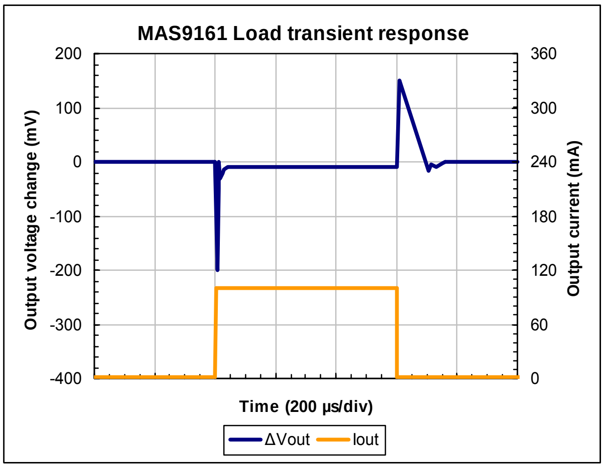


Figure 8. Load transient response. I_{OUT} = 1…100 mA in 2 µs.

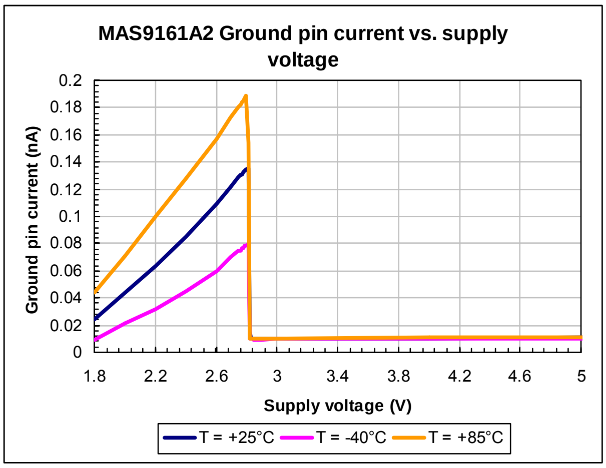


Figure 9. MAS9161A2 ground pin current against the supply voltage. I_{OUT} = 0 mA.

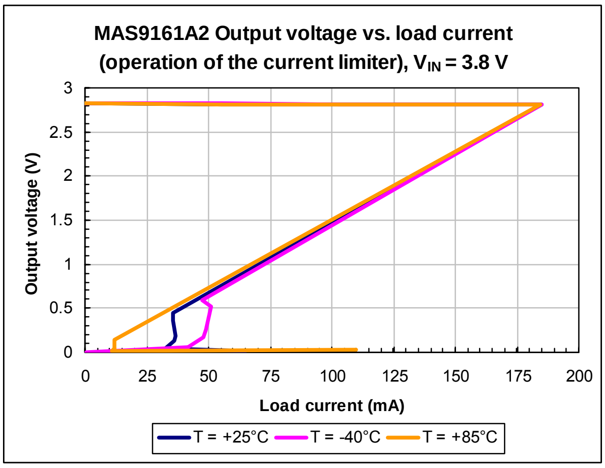


Figure 10. MAS9161A2 output voltage vs. load current (operation of the current limiter).

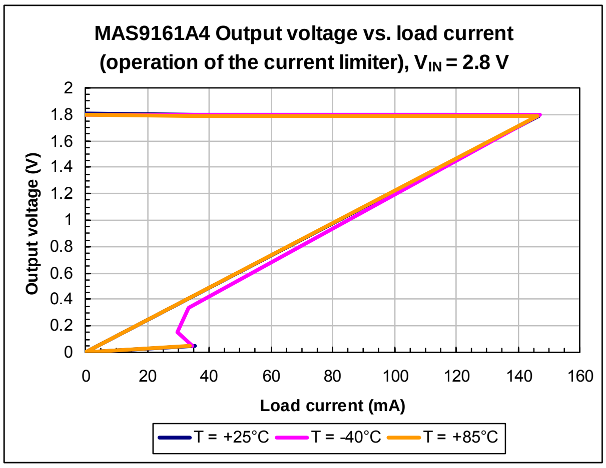


Figure 11. MAS9161A4 output voltage vs. load current (operation of the current limiter). V_{IN} = 2.8 V.

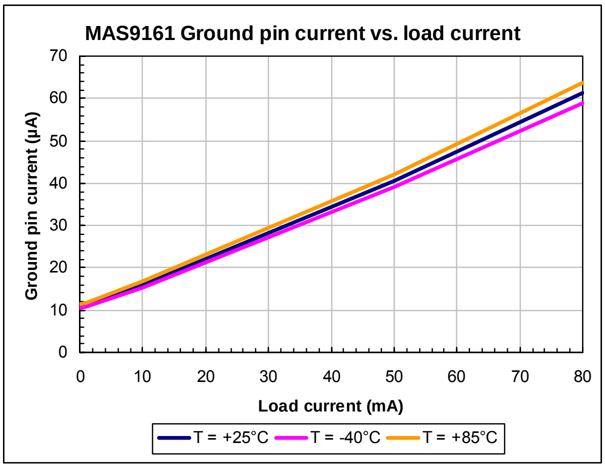


Figure 12. Ground pin current vs. load current.

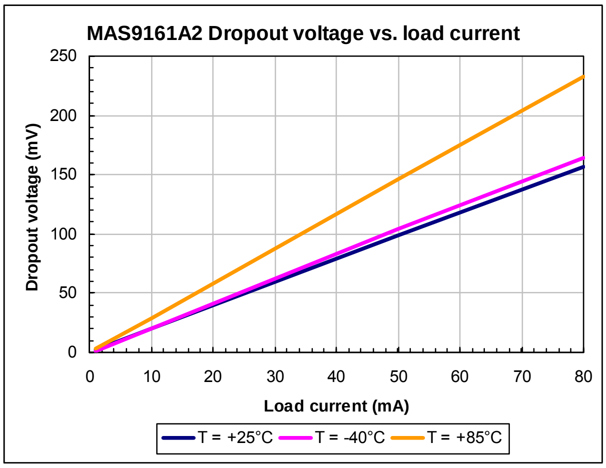


Figure 13. MAS9161A2 dropout voltage vs. load current.

TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 3.8 V, T_A = +27°C, I_{OUT} = 50 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

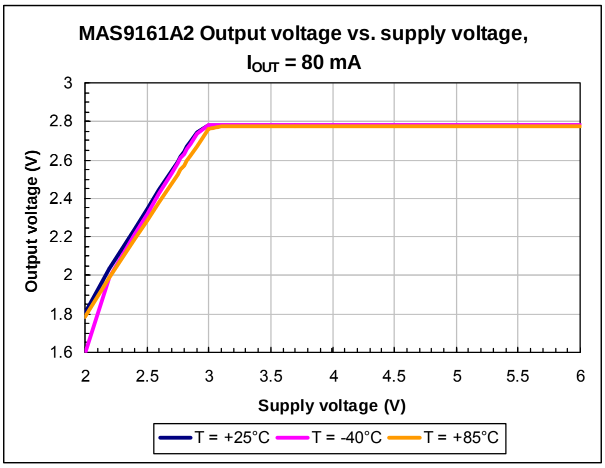


Figure 14. MAS9161A2 output voltage vs. supply voltage. I_{OUT} = 80 mA

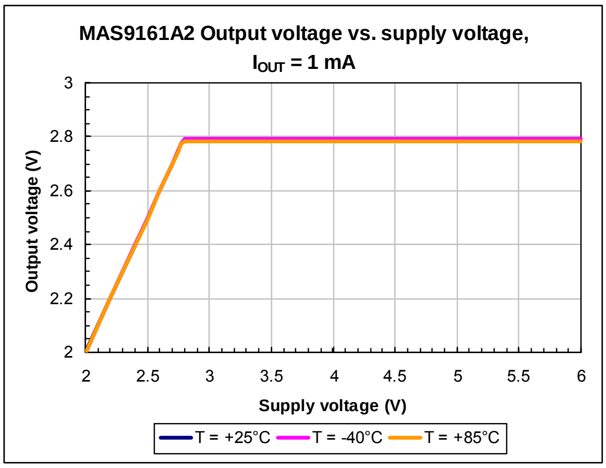


Figure 15. MAS9161A2 output voltage vs. supply voltage. I_{OUT} = 1 mA.

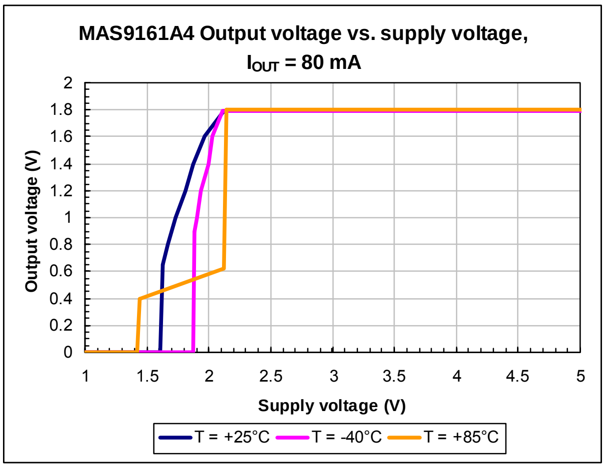


Figure 16. MAS9161A4 output voltage vs. supply voltage. I_{OUT} = 80 mA.

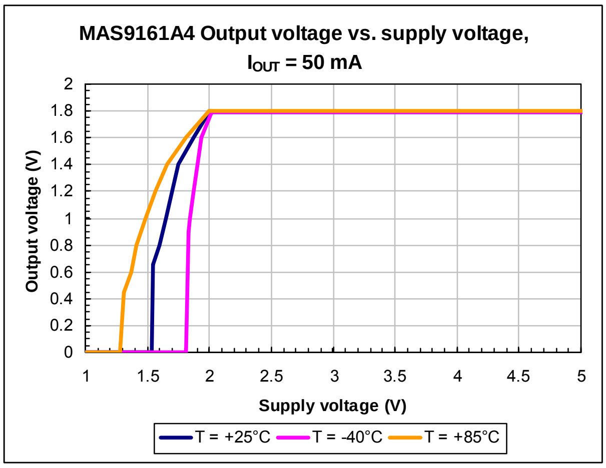


Figure 17. MAS9161A4 output voltage vs. supply voltage. I_{OUT} = 50 mA.

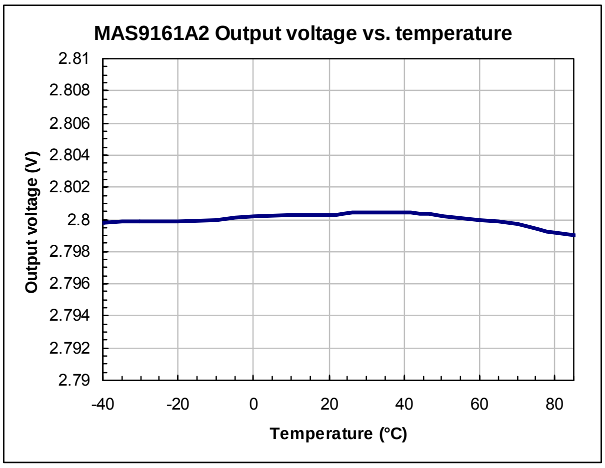


Figure 18. MAS9161A2 output voltage vs. temperature.

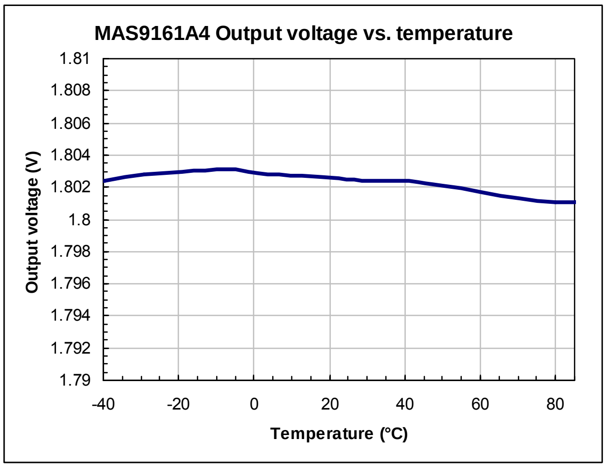
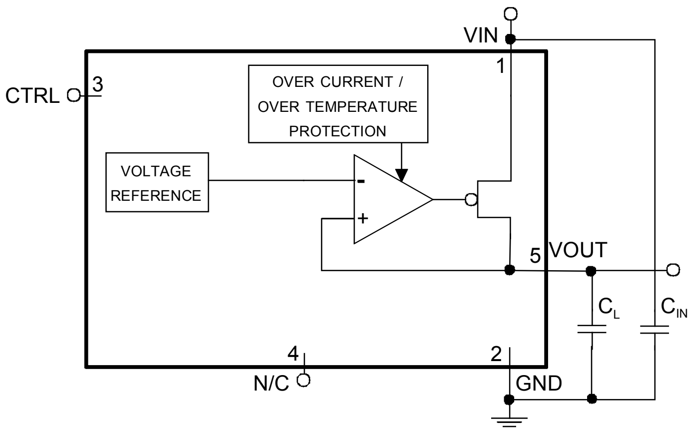


Figure 19. MAS9161A4 output voltage vs. temperature. V_{IN} = 2.8 V.

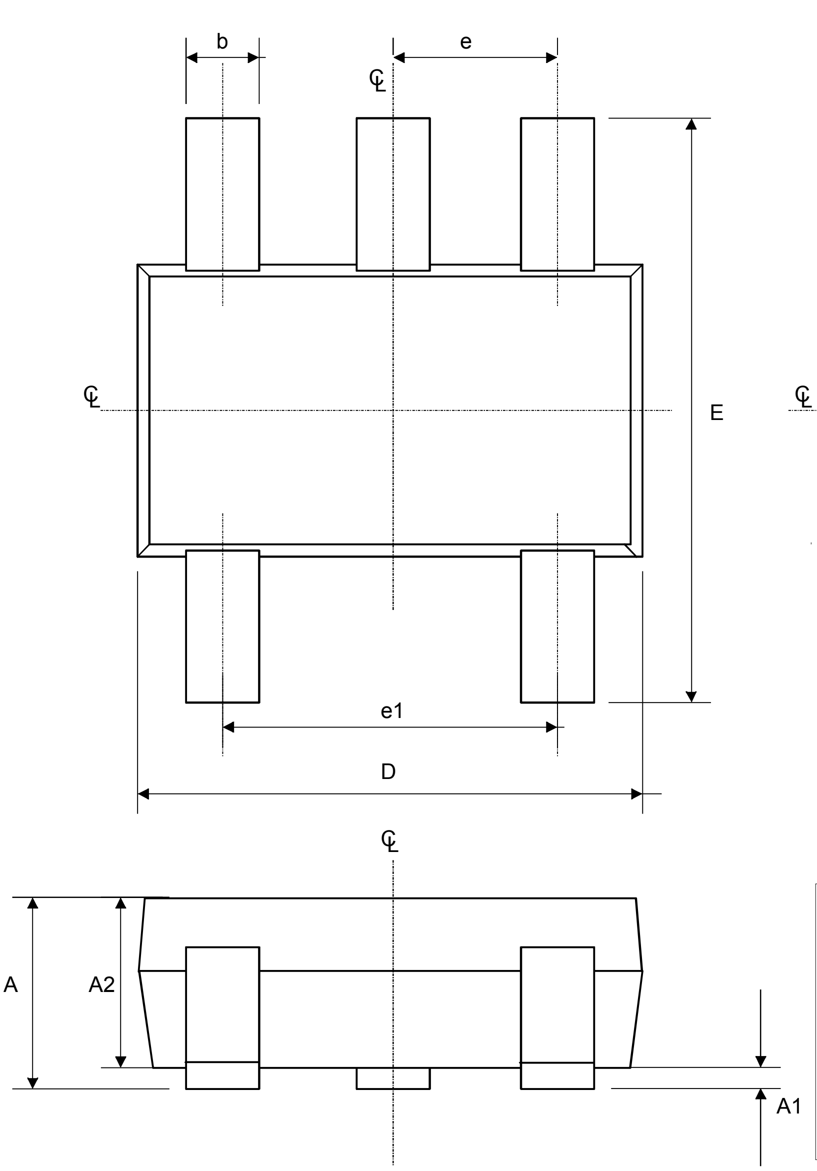
APPLICATION INFORMATION



Parameter	Symbol	Min	Typ	Max	Unit	Note
Output Capacitance	C_L	0.6	1.0		µF	1. Ceramic and film capacitors can be used.
Effective Series Resistance	ESR	0		3	Ω	1. When within this range stable with all I_{OUT} = 0 mA…80 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 MAS9161. 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. In the case that the inductance between a battery and MAS9161 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

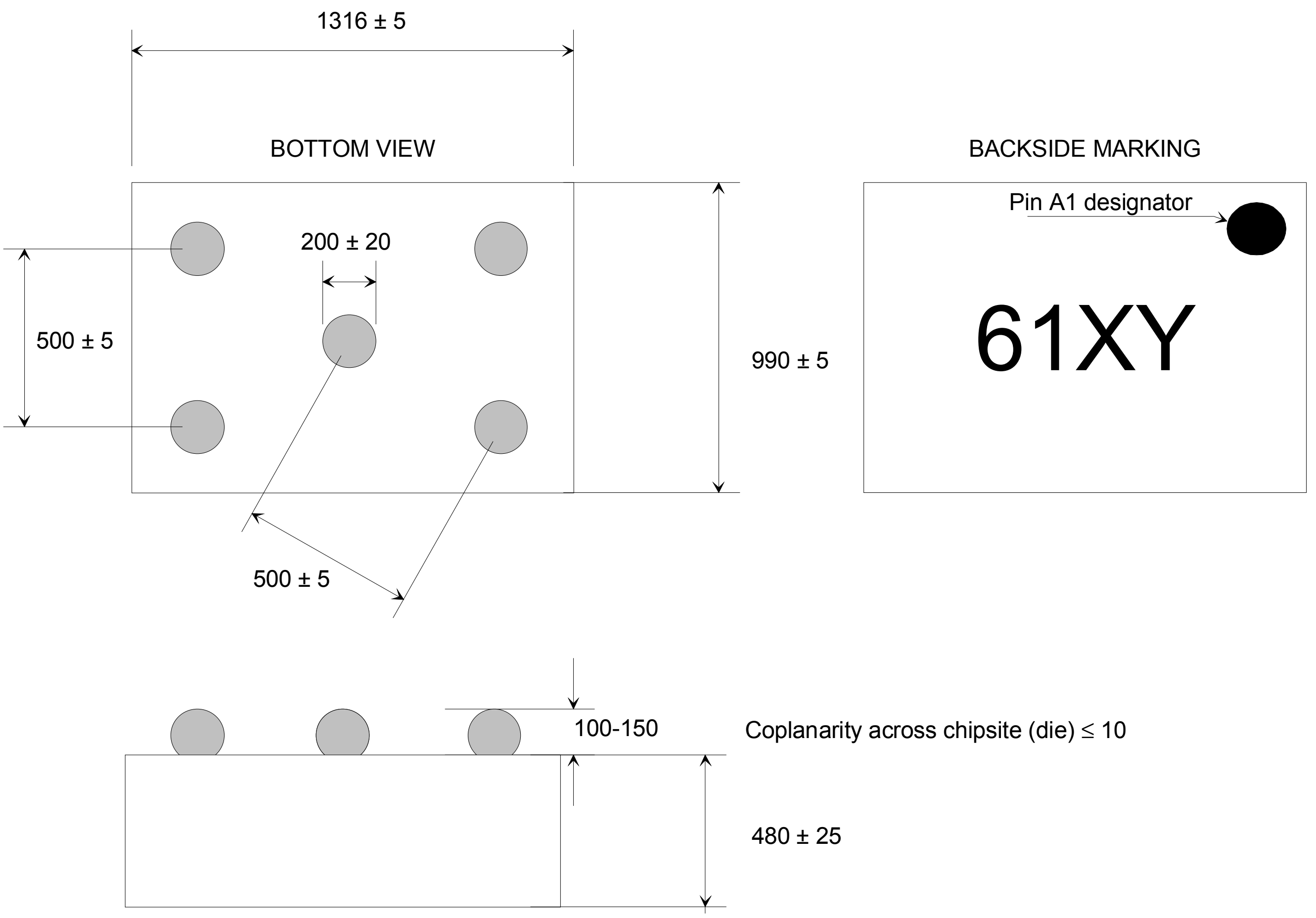
3) ALL SPECIFICATIONS COMPLY TO JEDEC MO193

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°	

PACKAGE (WL-CSP) OUTLINE

All dimensions in microns, drawings not to scale.



Definitions (see ordering information p. 14):

X = Package option
Y = Output voltage option

SOLDERING INFORMATION

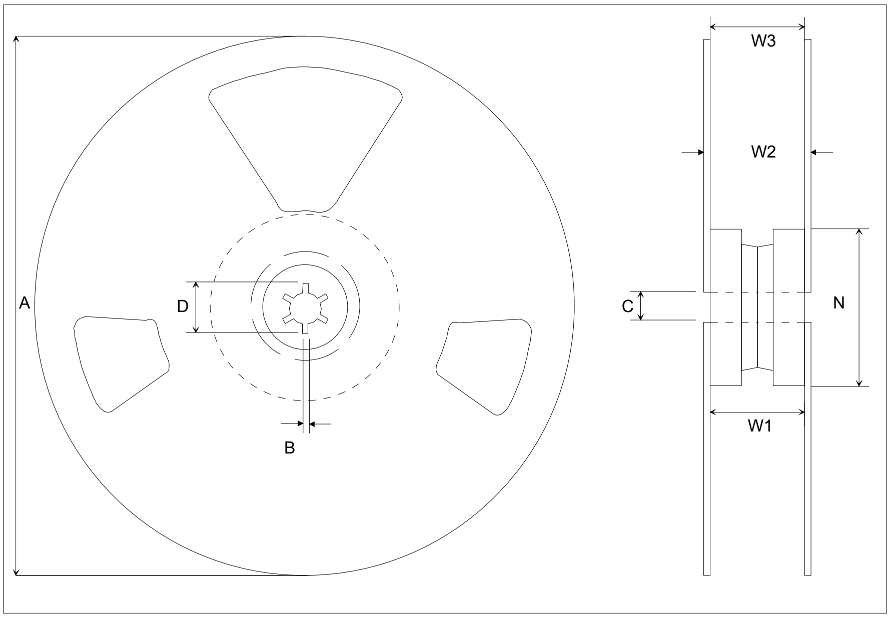
◆ For Eutectic Sn/Pb TSOT-5 and WL-CSP

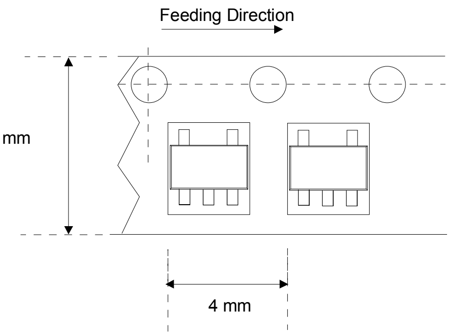
Resistance to Soldering Heat	According to RSH test IEC 68-2-58/20 2*220°C
Maximum Reflow Temperature	235°C
Maximum Number of Reflow Cycles	3
Seating Plane Co-planarity	max 0.08 mm
Lead Finish	Solder plate 7.62 - 25.4 µm, material Sn 85% Pb 15%
WL-CSP Balls	Material Sn 63% Pb 37% (eutectic)

◆ 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 (TSOT-5)





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
MAS9161AGA4-T	1.8 V Voltage Regulator IC	61A4	TSOT-5	Tape and Reel
MAS9161AGB4-T	1.8 V Voltage Regulator IC	61A4 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9161A4CA12	1.8 V Voltage Regulator IC	61Z4	WL-CSP	Under Qualification
MAS9161AGA3-T	2.5 V Voltage Regulator IC	61A3	TSOT-5	Tape and Reel
MAS9161AGB3-T	2.5 V Voltage Regulator IC	61A3 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9161AGAE-T	2.65 V Voltage Regulator IC	61AE	TSOT-5	Tape and Reel
MAS9161AGBE-T	2.65 V Voltage Regulator IC	61AE (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9161AGA2-T	2.8 V Voltage Regulator IC	61A2	TSOT-5	Tape and Reel
MAS9161AGB2-T	2.8 V Voltage Regulator IC	61A2 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9161AGA7-T	2.9 V Voltage Regulator IC	61A7	TSOT-5	Tape and Reel
MAS9161AGB7-T	2.9 V Voltage Regulator IC	61A7 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9161AGA6-T	3.0 V Voltage Regulator IC	61A6	TSOT-5	Tape and Reel
MAS9161AGB6-T	3.0 V Voltage Regulator IC	61A6 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9161AGAD-T	3.1 V Voltage Regulator IC	61AD	TSOT-5	Tape and Reel
MAS9161AGBD-T	3.1 V Voltage Regulator IC	61AD (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9161AGA1-T	3.3 V Voltage Regulator IC	61A1	TSOT-5	Tape and Reel
MAS9161AGB1-T	3.3 V Voltage Regulator IC	61A1 (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.

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