MAS9162

80 mA LDO Voltage Regulator IC

- **Low Noise, 30 µVrms, without External Bypass Capacitor**
- **Very Short Start-up Time: 10 µs**
- **Stable with Low-ESR Output Capacitors**
- **Low Minimum Output Capacitance Requirement: 0.25 µF**
- **Regulator Enable/Disable Control**

DESCRIPTION

MAS9162 is a low dropout voltage regulator, which achieves the low output noise level of 30 µVrms without an external bypass capacitor. MAS9162 features very fast start-up time (typically only 10 µs from start-up to within ±1% of $V_{OUT(NOM)}$) and low dropout voltage (80 mV typical at 50 mA).

The minimum output capacitance requirement is very low. This with the very short start-up time makes it possible to switch the regulator off and on even in timing critical and/or noise sensitive applications. In order to save power the device enters the sleep mode when the regulator is disabled.

The Equivalent Series Resistance (ESR) range of output capacitors that can be used with MAS9162 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 MAS9162 easier and low in cost.

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

FEATURES

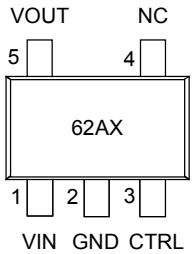
- No External Bypass Capacitor Needed
- Optimized for Fast Start-up
- Internal Thermal Shutdown
- Short Circuit Protection
- SOT23-5 Package
- Pin Compatible with MC33761
- Several Output Voltage Options Available, see Ordering Information p. 10

APPLICATION

- RF-Oscillators
- Cellular Phones
- Cordless Phones
- Pagers
- Battery Powered Systems
- Portable Systems
- Radio Control Systems

PIN CONFIGURATION

Top View



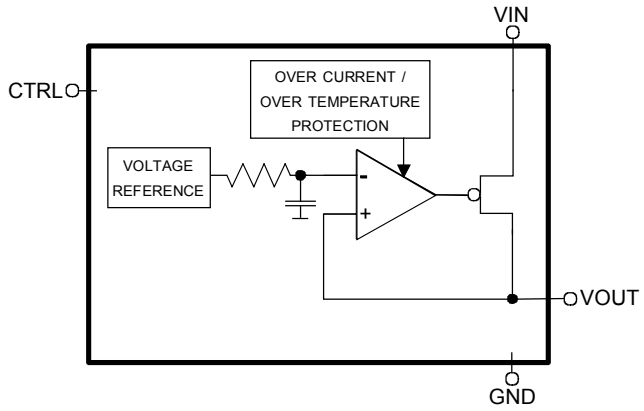
For Top Marking Information see Ordering Information p. 10

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}		$V_{OUT(NOM)}$ + 0.3	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_{OUT} = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Threshold High	T_H		145	160	175	°C
Threshold Low	T_L		135	150	165	°C

The hysteresis of 10°C prevents the device from turning on too soon after thermal shut-down.

◆ 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_{OUT} = 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 1.6		 0.55 V_{IN} + 0.3	V
Control Current	I_{CTRL}	 V_{CTRL} = V_{IN} V_{CTRL} = 0 V		 5 0	 15	µA

If CTRL-pin is not connected, MAS9162 is in OFF state (1 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_{OUT} = 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	 $V_{OUT(NOM)}$ – 0.05 $V_{OUT(NOM)}$ – 0.10		 $V_{OUT(NOM)}$ + 0.07 $V_{OUT(NOM)}$ + 0.05	V
Dropout Voltage	V_{DROP}	 I_{OUT} = 1 mA I_{OUT} = 10 mA I_{OUT} = 50 mA		 46 51 80		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_{OUT} = 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			230		mA
Peak Output Current	I_{PK}	V_{OUT} > 95% * $V_{OUT(NOM)}$			180		mA
Ground Pin Current	I_{GND}	 I_{OUT} = 0 mA I_{OUT} = 10 mA I_{OUT} = 50 mA			 190 260 300	 250 350 400	µA
Ground Pin Current, Sleep Mode	I_{GND}	V_{CTRL} = 0 V	T_A = 25°C		0.02	0.5	µA
			T_A = 85°C		0.2	2	

◆ 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_{OUT} = 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 SEMI G42-88 (single layer)		255.9		°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 (+255.9°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_{OUT} = 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} = 50 mA		0.75	2.5	mV
Load Regulation		I_{OUT} = 1 mA to 50 mA		13.5	25	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_{OUT} = 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		30		µVrms
Noise Density	V_N	I_{OUT} = 50 mA, f = 10 kHz		140		nV/√Hz
PSRR		f = 1 kHz f = 10 kHz f = 100 kHz		56 46 46		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_{OUT} = 1.0 µF, V_{CTRL} = 2 V, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Start-up Delay (from start-up to 80% of $V_{OUT(NOM)}$)		V_{CTRL} = 0 to 2.4 V, I_{OUT} = 50 mA, $C_L \leq$ 1.0 µF		7.5		µs
Overshoot		V_{CTRL} = 0 to 2.4 V		1.0	8.0	%
Start-up Time (settling time of voltage transient from start-up to within ±1% of $V_{OUT(NOM)}$)		V_{CTRL} = 0 to 2.4 V, I_{OUT} = 50 mA $C_L \leq$ 1.0 µF		10		µs

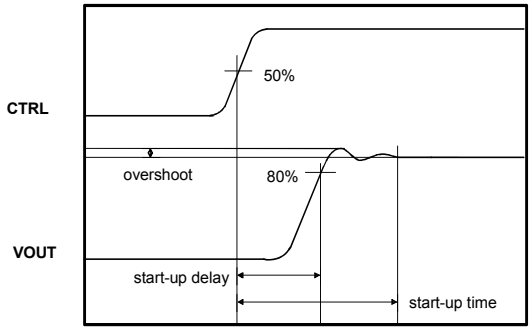


Figure1. Definitions of start-up delay, overshoot and start-up time.

TYPICAL PERFORMANCE CHARACTERISTICS

DUT = MAS9162AST2, 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.

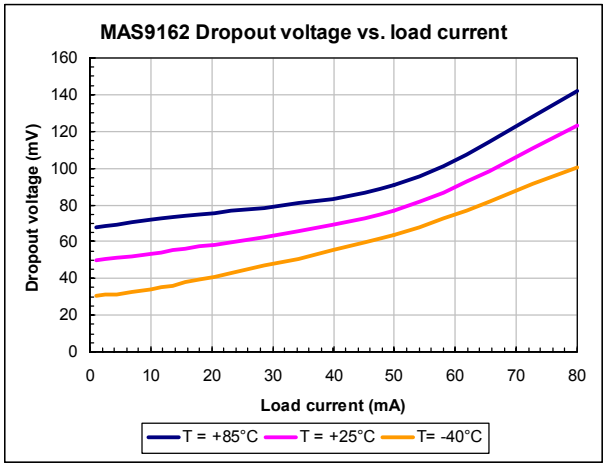


Figure 2. Dropout voltage vs. load current and temperature.

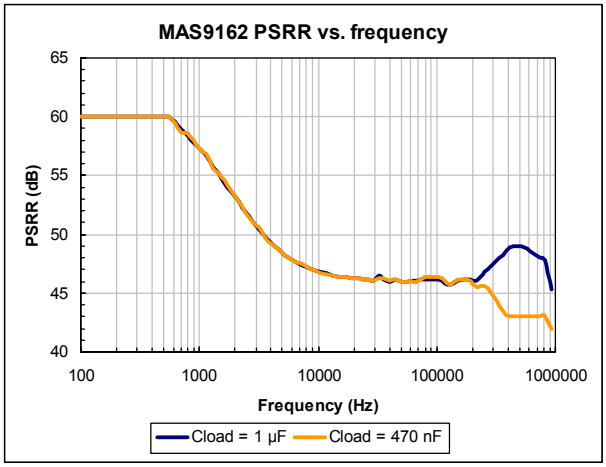


Figure 3. PSRR vs. frequency. Signal source used: C_{IN} = 0 µF, R_{SOURCE} = 50 Ω.

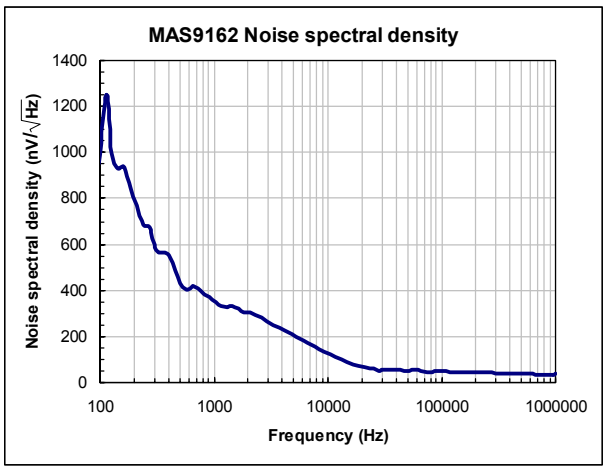


Figure 4. Output noise spectral density.

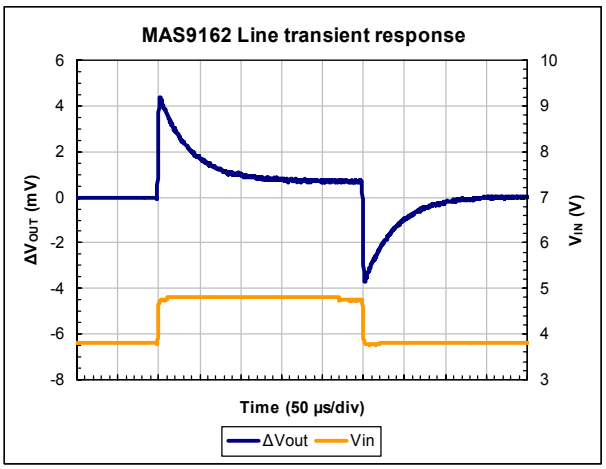


Figure 5. Line transient response. Signal source used: C_{IN} = 0 µF, R_{SOURCE} = 50 Ω, V_{IN} = 3.8 V…4.8 V in 2 µs.

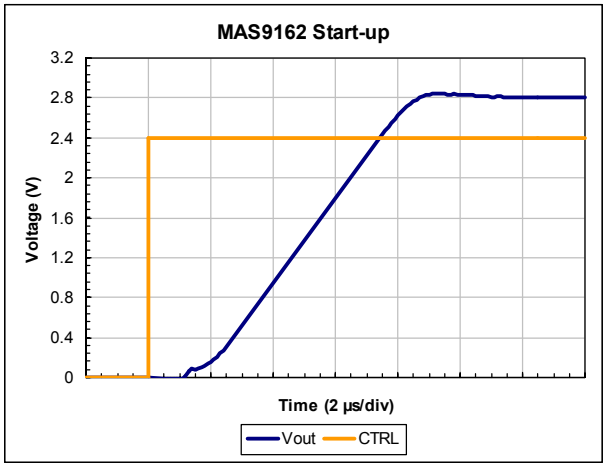


Figure 6. Start-up.

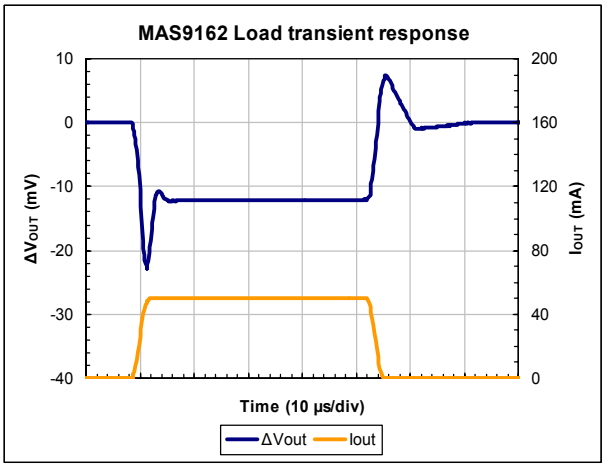


Figure 7. Load transient response. I_{OUT} = 0…50 mA in 2 µs.

DETAILED DESCRIPTION

Maximum power dissipation of the package may limit output current or input voltage, which can be used. The power dissipation can be calculated by using the formula:

$$P_d = (V_{IN} - V_{OUT}) * I_{OUT} + V_{IN} * I_{GND}$$

It shall not exceed the maximum power dissipation, allowed by the package:

$$P_{dMAX} = \frac{T_{J(MAX)} - T_A}{R_{JA}}$$

where T_{Jmax} is maximum junction temperature (T_{Jmax} = 125°C), T_A is ambient temperature and R_{JA} is junction-to-ambient thermal resistance of the package.

When assumed that:

T_A = + 85 °C
V_{OUT} = 2.5 V
V_{IN} = 5.3 V

the equation results:

$$P_{dMAX} = \frac{125°C - 85°C}{255.9°C/W} = 0.156\ W$$

from which can be calculated:

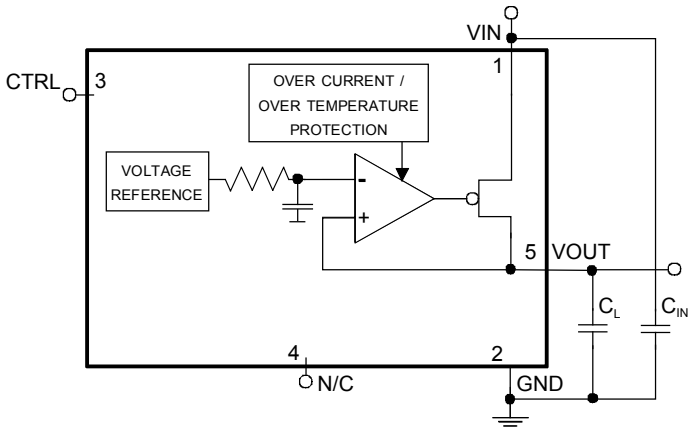
$$I_{OUTMAX} = \frac{P_{dMAX}}{V_{IN} - V_{OUT}} = 55\ mA$$

$V_{IN} * I_{GND}$ is negligible and can be omitted.

So it can be seen that under these conditions the average output current should not exceed 55 mA.

If higher power dissipation capability is needed, contact Micro Analog Systems for TSOT 5 packaging option, see Ordering Information p. 10.

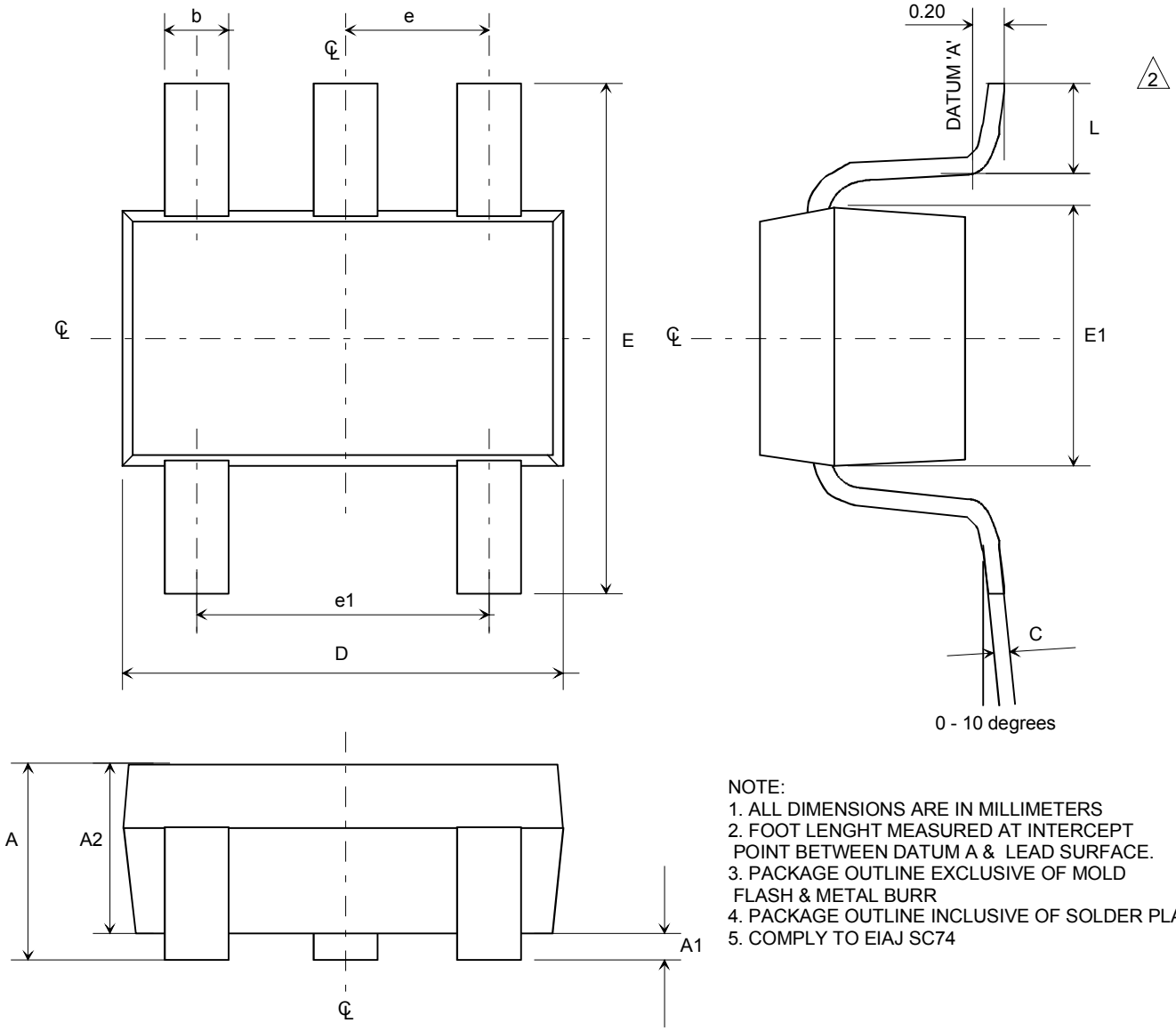
APPLICATION INFORMATION



Parameter	Symbol	Min	Typ	Max	Unit	Note
Output Capacitance	C_L	0.25	1.0		µF	1. Ceramic and film capacitors can be used. 2. The value of C_L should be smaller than or equal to the value of C_{IN}.
Effective Series Resistance	ESR	0.01		2	Ohm	1. When within this range stable with all I_{OUT} = 0 mA… 80 mA values.
Input Capacitance	C_{IN}	0.5			µF	1. A big enough input capacitance is needed to prevent possible impedance interactions between the supply and MAS9162. 2. Ceramic, tantalum, and film capacitors can be used. If a tantalum capacitor is used, it should be checked that the surge current rating is sufficient for the application. 3. In the case that the inductance between a **battery** and MAS9162 is very small (< 0.1 µH) 0.47 µF input capacitor is sufficient. 4. The value of C_{IN} should not be smaller than the value of C_L.

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 (SOT23-5) OUTLINE



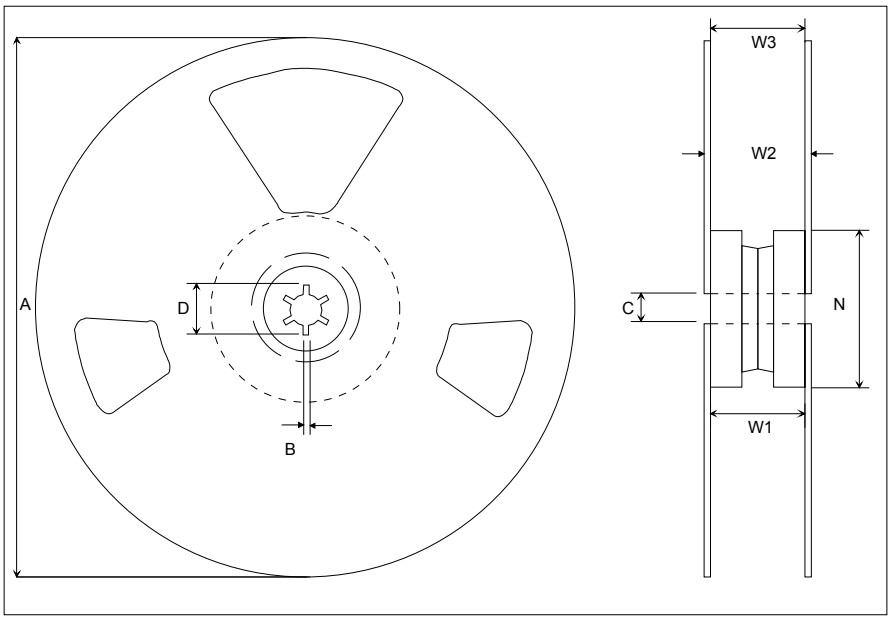
NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS
2. FOOT LENGHT MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. COMPLY TO EIAJ SC74

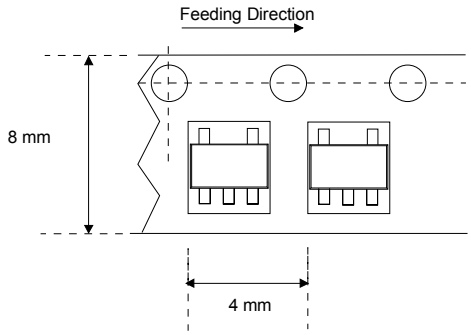
Symbol	Min	Max	Unit
A	0.90	1.45	mm
A1	0.00	0.15	mm
A2	0.90	1.30	mm
b	0.25	0.50	mm
C	0.09	0.20	mm
D	2.80	3.10	mm
E	2.60	3.00	mm
E1	1.50	1.75	mm
L	0.35	0.55	mm
e	0.95ref		mm
e1	1.90ref		mm

SOLDERING INFORMATION

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	2
Seating Plane Co-planarity	max 0.08 mm
Lead Finish	Solder plate 7.62 - 25.4 µm, material Sn 85% Pb 15%

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
MAS9162AST3-T	2.50 V Voltage Regulator IC	62A3	SOT23-5	Tape and Reel
MAS9162AST9-T	2.70 V Voltage Regulator IC	62A9	SOT23-5	Tape and Reel
MAS9162AST2-T	2.80 V Voltage Regulator IC	62A2	SOT23-5	Tape and Reel
MAS9162AST6-T	3.00 V Voltage Regulator IC	62A6	SOT23-5	Tape and Reel
MAS9162AST1-T	3.30 V Voltage Regulator IC	62A1	SOT23-5	Tape and Reel
MAS9162AGA3-T	2.50 V Voltage Regulator IC	62A3	TSOT 5	Under Qualification
MAS9162AGA9-T	2.70 V Voltage Regulator IC	62A9	TSOT 5	Under Qualification
MAS9162AGA2-T	2.80 V Voltage Regulator IC	62A2	TSOT 5	Under Qualification
MAS9162AGA6-T	3.00 V Voltage Regulator IC	62A6	TSOT 5	Under Qualification
MAS9162AGA1-T	3.30 V Voltage Regulator IC	62A1	TSOT 5	Under Qualification
MAS9162AGB3-T	2.50 V Voltage Regulator IC	62A3 (B in the bottom marking to indicate lead-free)	TSOT 5 lead-free	Under Qualification
MAS9162AGB9-T	2.70 V Voltage Regulator IC	62A9 (B in the bottom marking to indicate lead-free)	TSOT 5 lead-free	Under Qualification
MAS9162AGB2-T	2.80 V Voltage Regulator IC	62A2 (B in the bottom marking to indicate lead-free)	TSOT 5 lead-free	Under Qualification
MAS9162AGB6-T	3.00 V Voltage Regulator IC	62A6 (B in the bottom marking to indicate lead-free)	TSOT 5 lead-free	Under Qualification
MAS9162AGB1-T	3.30 V Voltage Regulator IC	62A1 (B in the bottom marking to indicate lead-free)	TSOT 5 lead-free	Under Qualification

For more voltage options contact Micro Analog Systems Oy.

LOCAL DISTRIBUTOR

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