MAS9168

150 mA LDO Voltage Regulator IC

This is preliminary information on a new product under development. Micro Analog Systems Oy reserves the right to make any changes without notice.

- **Only 15.5 µA Ground Pin Current at 1 mA Load Current**
- **Good Transient Performance**
- **Low Dropout Voltage**
- **Low Noise**
- **Enable/Disable Control**
- **Stable with Low-ESR Output Capacitors**

DESCRIPTION

MAS9168 LDO voltage regulator is optimized for operation at low ground pin current: even at 50 mA load current its ground pin current is only 40 µA. This combined with the good overall performance makes MAS9168 very suitable for providing continuous supply in low power circuits. The performance of MAS9168 benefits applications where standby periods are long and where long battery lifetime is essential.

In addition to the low ground pin current, MAS9168 excels in dropout voltage (220 mV typical at 150 mA). Even though MAS9168 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 MAS9168 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 MAS9168 easier and low in cost.

Enable/disable pin allows MAS9168 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. 12

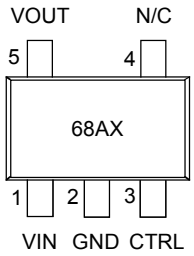
APPLICATIONS

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

PIN CONFIGURATION

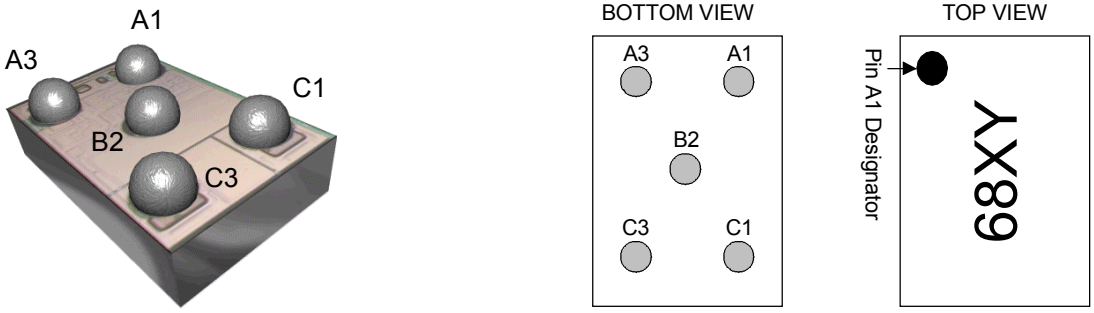
TSOT-5

Top View



For top marking information see ordering information p. 12

WL-CSP



For top marking information see ordering information p. 12

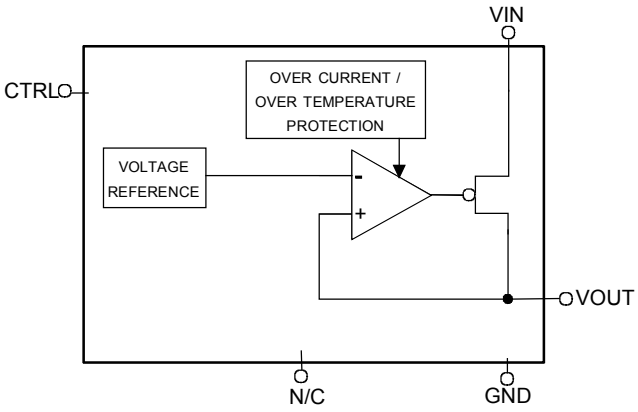
PIN DESCRIPTION

Pin Name	Pin Number in TSOT-5	Pin Number in WL-CSP		Type	Function
		Pin Order 11 Note 1	Pin Order 12 Note 2		
VIN	1	C3	C3	P	Power Supply Voltage
GND	2	B2	A1	G	Ground
CTRL	3	A1	A3	I	Enable/Disable Pin for Regulator
N/C	4	A3	B2	-	Not Connected
VOUT	5	C1	C1	O	Output

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

Note 1: WL-CSP Pin Order 11 is pin compatible with LP3985.
Note 2: WL-CSP Pin Order 12 is pin compatible with LP2985.

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 1.8 V Output Option	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 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} = 2.0 V V_{CTRL} = 3.8 V		0.35 0.70 1.50	1.5	µA

If CTRL-pin is not connected, MAS9168 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}	 I_{OUT} = 0 mA I_{OUT} = 150 mA	 $V_{OUT(NOM)}$ – 0.06 $V_{OUT(NOM)}$ – 0.10		 $V_{OUT(NOM)}$ + 0.06 $V_{OUT(NOM)}$ + 0.06	V
Dropout Voltage	V_{DROP}	I_{OUT} = 1 mA I_{OUT} = 10 mA I_{OUT} = 50 mA I_{OUT} = 150 mA		1.5 16 75 220		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}			0		150	mA
Short Circuit Current	I_{MAX}	R_L = 0 Ω				400	mA
Peak Output Current	I_{PK}	V_{OUT} > 95% * $V_{OUT(NOM)}$			350		mA
Ground Pin Current	I_{GND}	V_{CTRL} = 2.0 V I_{OUT} = 0 mA I_{OUT} = 1 mA I_{OUT} = 10 mA I_{OUT} = 50 mA I_{OUT} = 150 mA			 15 15.5 20 40 100		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 JESD51-7 (4 layers), TSOT-5 package		207		°C/W
		mounted on MAS9168 CSP evaluation board, WL-CSP package		210		
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 specified above.

◆ 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} = 60 mA		0.5		mV
Load Regulation		I_{OUT} = 1 mA to 50 mA I_{OUT} = 1 mA to 150 mA		8 22		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		 44 30 22		dB
		I_{OUT} = 150 mA f = 1 kHz f = 10 kHz f = 100 kHz		 44 30 22		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)		0.5		ms
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} = 150 mA (see figure 1 below)		1.2	3.0	ms

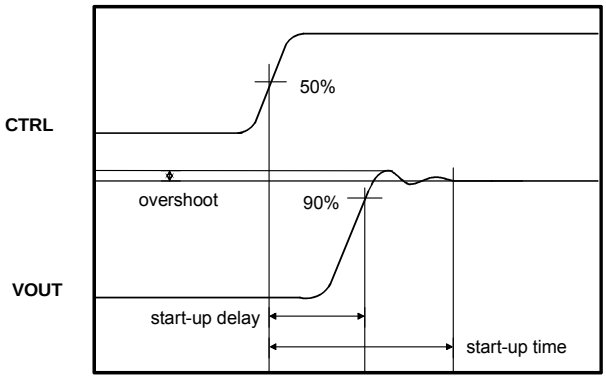
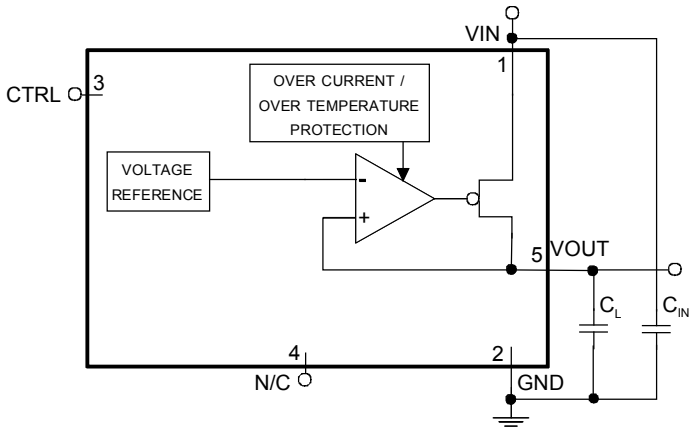


Figure 1. Definitions of start-up delay, overshoot and start-up time.

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	0.01		3	Ω	1. When within this range stable with all I_{OUT} = 0 mA…150 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 MAS9168. 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 MAS9168 is very small (< 0.1 µH) 0.47 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 capacitance requirement is met in all potential operating conditions**.

APPLICATION INFORMATION

Auto-Discharge Function

MAS9168 does not feature an auto-discharge function. The voltage in VOUT pin, when MAS9168 is turned off, depends on the load circuits leakage: if the load has big leakage current, VOUT rapidly drops to the value 0 V, but if the leakage current is non-existing, VOUT pin stays in $V_{OUT(NOM)}$ value.

Calculating Maximum Power Dissipation

Maximum power dissipation of the package may limit output current or input voltage, which can be used, especially with the combination of low output voltage and high input voltage.

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:

$$P_{dMAX} = \frac{T_{JMAX} - T_A}{R_{JA}}$$

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 = +55°C, V_{OUT} = 1.8 V, V_{IN} = 5.0 V and used package is TSOT-5 the equation yields:

$$P_{dMAX} = \frac{125°C - 55°C}{207°C/W} = 0.338\ W$$

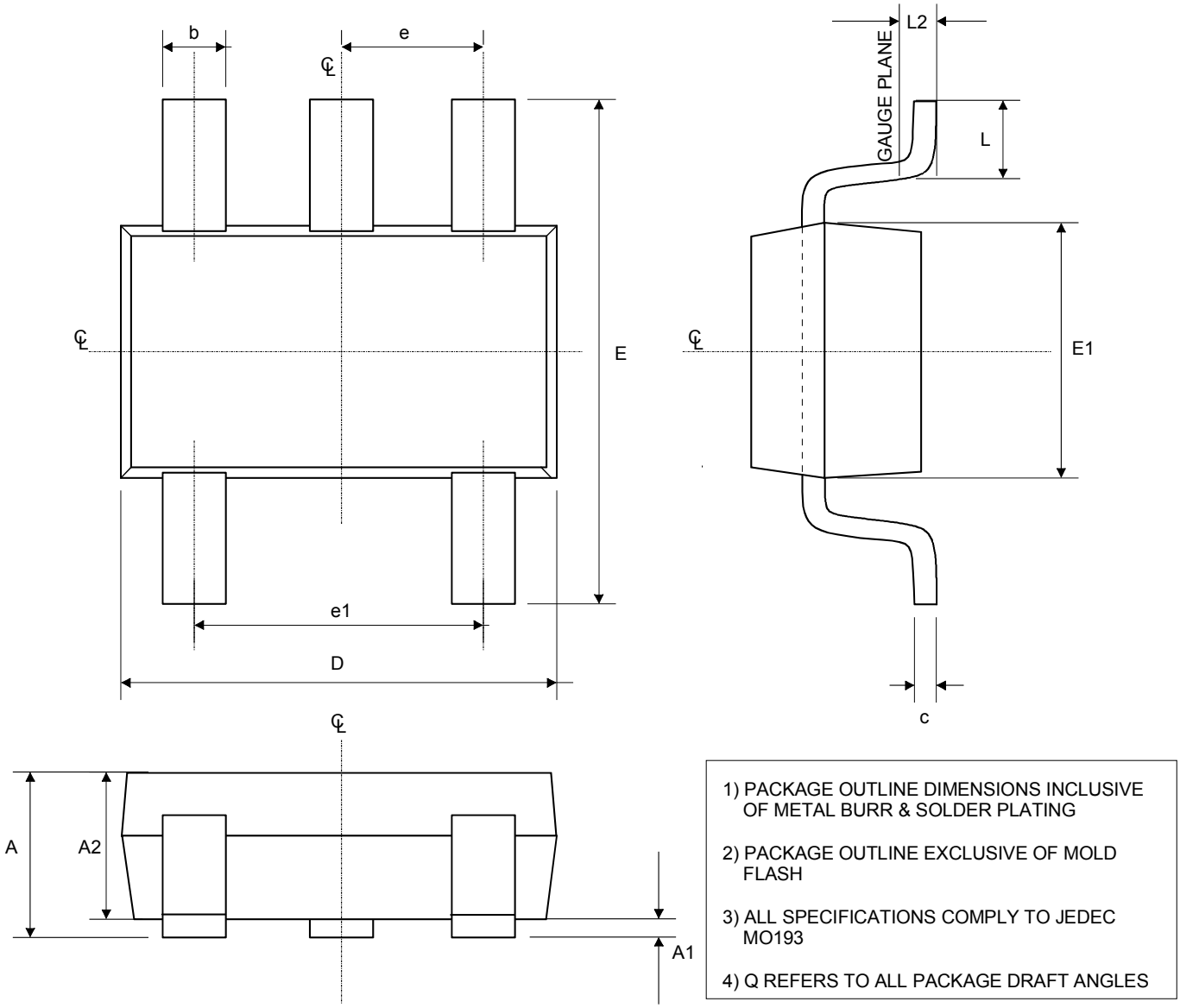
from which can be calculated:

$$I_{OUTMAX} = \frac{P_{dMAX}}{V_{IN} - V_{OUT}} = 106\ mA$$

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

Consequently, it can be seen that under these conditions the average output current should not exceed 106 mA.

PACKAGE (TSOT-5) OUTLINE



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

2) PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH

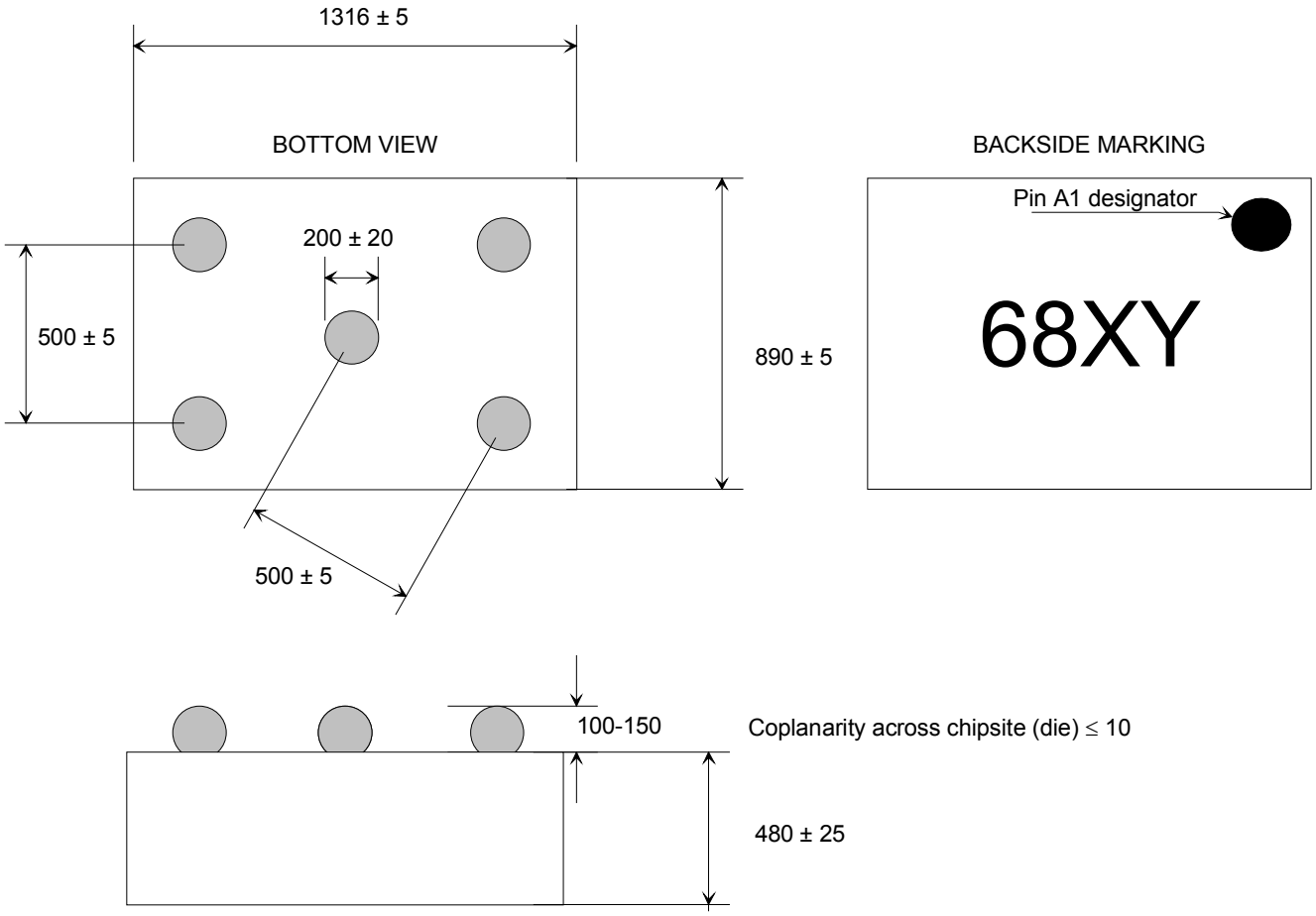
3) ALL SPECIFICATIONS COMPLY TO JEDEC MO193

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. 12):

X = Package option
Y = Output voltage option

SOLDERING INFORMATION

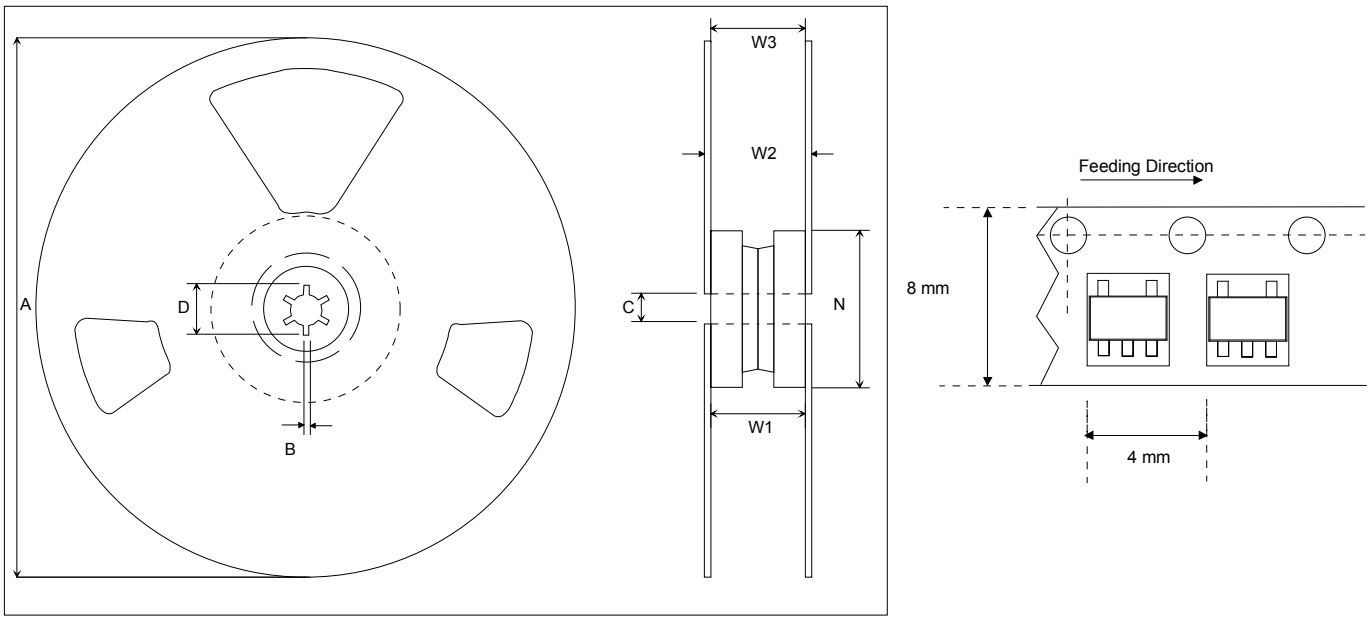
◆ **For Eutectic Sn/Pb TSOT-5 and WL-CSP**

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

For Pin Order definition see the pin description on page 2.

Product Code	Output Voltage	Top Marking	Package	Pin Order	Comments
MAS9168A4GA06	1.8 V	68A4 (68T3)	TSOT-5		Tape and Reel
MAS9168A4GB06	1.8 V	68A4 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9168A4CA11	1.8 V	68A4	WL-CSP	11	Tape and Reel
MAS9168A4CA12	1.8 V	68Z4	WL-CSP	12	Tape and Reel
MAS9168A3GA06	2.5 V	68A3 (68T4)	TSOT-5		Tape and Reel
MAS9168A3GB06	2.5 V	68A3 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9168A3CA11	2.5 V	68A3	WL-CSP	11	Tape and Reel
MAS9168A3CA12	2.5 V	68Z3	WL-CSP	12	Tape and Reel
MAS9168AEGA06	2.65 V	68AE	TSOT-5		Tape and Reel
MAS9168AEGB06	2.65 V	68AE (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9168AECA11	2.65 V	68AE	WL-CSP	11	Tape and Reel
MAS9168AECA12	2.65 V	68ZE	WL-CSP	12	Tape and Reel
MAS9168A2GA06	2.8 V	68A2 (68T2)	TSOT-5		Tape and Reel
MAS9168A2GB06	2.8 V	68A2 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9168A2CA11	2.8 V	68A2	WL-CSP	11	Tape and Reel
MAS9168A2CA12	2.8 V	68Z2	WL-CSP	12	Tape and Reel
MAS9168A8GA06	2.85 V	68A8	TSOT-5		Tape and Reel
MAS9168A8GB06	2.85 V	68A8 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9168A8CA11	2.85 V	68A8	WL-CSP	11	Tape and Reel
MAS9168A8CA12	2.85 V	68Z8	WL-CSP	12	Tape and Reel
MAS9168A6GA06	3.0 V	68A6 (68T5)	TSOT-5		Tape and Reel
MAS9168A6GB06	3.0 V	68A6 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9168A6CA11	3.0 V	68A6	WL-CSP	11	Tape and Reel
MAS9168A6CA12	3.0 V	68Z6	WL-CSP	12	Tape and Reel
MAS9168ADGA06	3.1 V	68AD	TSOT-5		Tape and Reel
MAS9168ADGB06	3.1 V	68AD (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9168ADCA11	3.1 V	68AD	WL-CSP	11	Tape and Reel
MAS9168ADCA12	3.1 V	68ZD	WL-CSP	12	Tape and Reel
MAS9168A1GA06	3.3 V	68A1	TSOT-5		Tape and Reel
MAS9168A1GB06	3.3 V	68A1 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9168A1CA11	3.3 V	68A1	WL-CSP	11	Tape and Reel
MAS9168A1CA12	3.3 V	68Z1	WL-CSP	12	Tape and Reel

For more voltage or other package options contact Micro Analog Systems Oy.

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