MAS9333

150 mA LDO Voltage Regulator IC

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

- **High PSRR still when V_{IN} is only $V_{OUT(NOM)}$ + 0.5 V**
- **Low Noise, 40 µVrms, without External Bypass Capacitor**
- **Fast Start-up Time: 21 µs**
- **Low Dropout: 124 mV @ 150 mA**
- **Low Minimum Output Capacitance Requirement: 0.23 µF**
- **Stable with Low-ESR Output Capacitors**

DESCRIPTION

MAS9333 is a low dropout voltage regulator, which offers good performance even at low V_{IN} voltage. The output noise level of MAS9333 is 40 µVrms without an external bypass capacitor. MAS9333 features very fast start-up time (typically only 21 µs from start-up to within ±1% of $V_{OUT(NOM)}$) and low dropout voltage (124 mV typical at 150 mA). Also it has a ripple rejection ability of 53 dB at 10 kHz even when V_{IN} = $V_{OUT(NOM)}$ + 0.5 V.

The very short start-up time of MAS9333 combined with good performance offers an opportunity to switch the regulator off and on even in timing critical and/or noise sensitive applications.

The Equivalent Series Resistance (ESR) range of output capacitors that can be used with MAS9333 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 MAS9333 easier and low in cost.

In order to save power the regulator goes into sleep mode when it is disabled. MAS9333 also includes an auto-discharge function, wherein a shutdown transistor turns on and discharges the output capacitor when MAS9333 is disabled.

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

FEATURES

- Good Performance at Low V_{IN} Voltage
- Pin Compatible with LP2985/LP3985
- Integrated Bypass Capacitor
- Auto-discharge Function
- Internal Thermal Shutdown
- Short Circuit Protection
- TSOT 5 or WL-CSP Package
- Several Output Voltage Options Available, see Ordering Information p.10

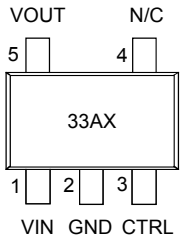
APPLICATIONS

- Cellular Phones
- Cordless Phones
- Accessories
- Wireless Systems
- Battery Powered Systems
- Portable Systems
- Radio Control Systems
- Low Voltage Systems

PIN CONFIGURATION

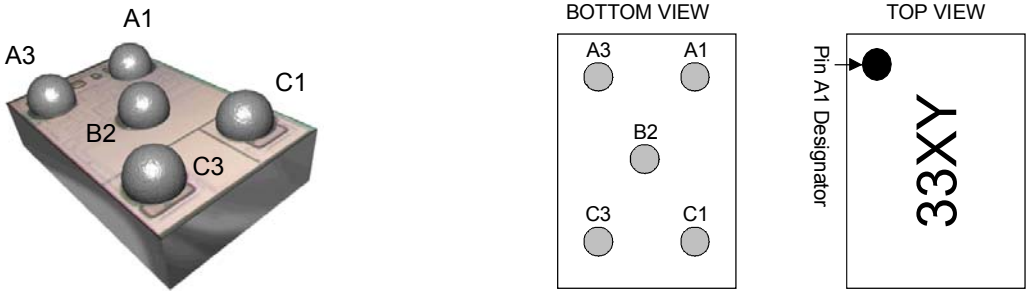
TSOT 5

Top View



For top marking information see ordering information p. 10

WL-CSP



For top marking information see ordering information p. 10

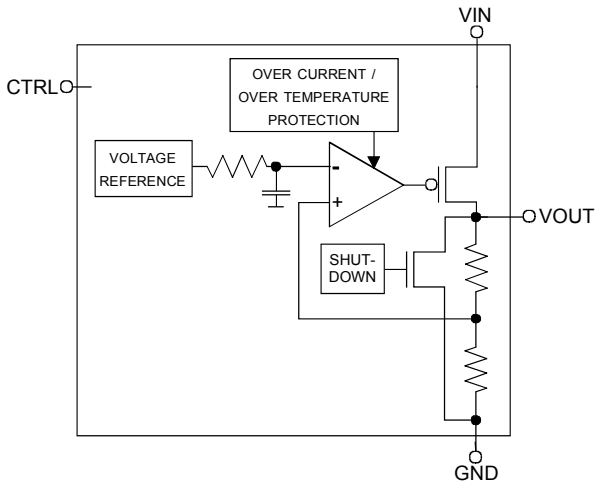
PIN DESCRIPTION

Pin Name	Pin Number in TSOT-5	Pin Number in WL-CSP Pin Order 11 Note 1	Pin Number in WL-CSP Pin Order 12 Note 2	Type	Function
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	5.3	V

ELECTRICAL CHARACTERISTICS

◆ Thermal Protection

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 0.5 V (or min 3.3 V), I_{OUT} = 1.0 mA, C_{IN} = 0.47 µF, C_L = 0.47 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} = $V_{OUT(NOM)}$ + 0.5 V (or min 3.3 V), I_{OUT} = 1.0 mA, C_{IN} = 0.47 µF, C_L = 0.47 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		 0.55 V_{IN} + 0.3	V
Control Current	I_{CTRL}	V_{CTRL} = V_{IN} V_{CTRL} = 0 V		4 0	10 1	µA

If CTRL-pin is not connected, MAS9333 is in OFF state (900 kΩ pull-down resistor to ground).

◆ Voltage Parameters

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 0.5 V (or min 3.3 V), I_{OUT} = 1.0 mA, C_{IN} = 0.47 µF, C_L = 0.47 µF, V_{CTRL} = 2 V, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Tolerance	V_{OUT}	$V_{IN} \geq$ 3.05 V, $V_{OUT(NOM)}$ = 2.85 V, I_{OUT} = 10 mA	$V_{OUT(NOM)}$ – 2 %		$V_{OUT(NOM)}$ + 2 %	V
Dropout Voltage	V_{DROP}	I_{OUT} = 1 mA I_{OUT} = 75 mA I_{OUT} = 150 mA		TBD TBD 124		mV

◆ Current Parameters

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 0.5 V (or min 3.3 V), I_{OUT} = 1.0 mA, C_{IN} = 0.47 µF, C_L = 0.47 µF, V_{CTRL} = 2 V, unless otherwise specified

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Continuous Output Current	I_{OUT}				150		mA
Short Circuit Current	I_{MAX}	R_L = 0 Ω			450		mA
Peak Output Current	I_{PK}	V_{OUT} > 95%* $V_{OUT(NOM)}$			410		mA
Ground Pin Current	I_{GND}	V_{CTRL} = 2 V I_{OUT} = 0 mA I_{OUT} = 10 mA I_{OUT} = 50 mA I_{OUT} = 150 mA			 120 TBD TBD 220	 200 400	µA
Ground Pin Current, Sleep Mode	I_{GND}	V_{CTRL} = 0 V	T_A = + 27°C		0.02		µA
			T_A = + 85°C		0.2		

◆ Power Dissipation

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 0.5 V (or min 3.3 V), I_{OUT} = 1.0 mA, C_{IN} = 0.47 µF, C_L = 0.47 µF, V_{CTRL} = 2 V, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Thermal Resistance (Junction to Air)	R_{JA}	TSOT-5 package, thermal test board according to JESD51-7 (4 layers)		207		°C/W
		WL-CSP package, mounted on MAS CSP evaluation board		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} = $V_{OUT(NOM)}$ + 0.5 V (or min 3.3 V), I_{OUT} = 1.0 mA, C_{IN} = 0.47 µF, C_L = 0.47 µF, V_{CTRL} = 2 V, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Line Regulation		$V_{OUT(NOM)}$ + 0.5 V < V_{IN} < 5.3 V, I_{OUT} = 150 mA	-0.3		0.3	%
Load Regulation		I_{OUT} = 1 to 10 mA I_{OUT} = 1 to 150 mA		0.5 9		mV

◆ Noise and Ripple Rejection

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 0.5 V (or min 3.3 V), I_{OUT} = 150 mA, C_{IN} = 0.47 µF, C_L = 0.47 µF, V_{CTRL} = 2 V, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Noise Voltage	V_{RMS}	100Hz < f < 100kHz		40		µVrms
Noise Density	V_N	I_{OUT} = 50 mA, f = 1 kHz		480		$nV/\sqrt{Hz}$
PSRR		f = 1 kHz f = 10 kHz f = 100 kHz		60 53 40		dB

◆ Dynamic Parameters

T_A = -40°C to +85°C, typical values at T_A = +27°C, V_{IN} = $V_{OUT(NOM)}$ + 0.5 V (or min 3.3 V), I_{OUT} = 1.0 mA, C_{IN} = 0.47 µF, C_L = 0.47 µF, V_{CTRL} = 2 V, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Rise Time (10%…90%)		V_{CTRL} = 0 to 2 V, I_{OUT} = 30 mA		14		µs
Overshoot		V_{CTRL} = 0 to 2 V		1.2	10	%
Start-up Time (settling time of voltage transient from start-up to within ±1% of $V_{OUT(NOM)}$)		V_{CTRL} = 0 to 2 V (see figure 1 below)		21		µs

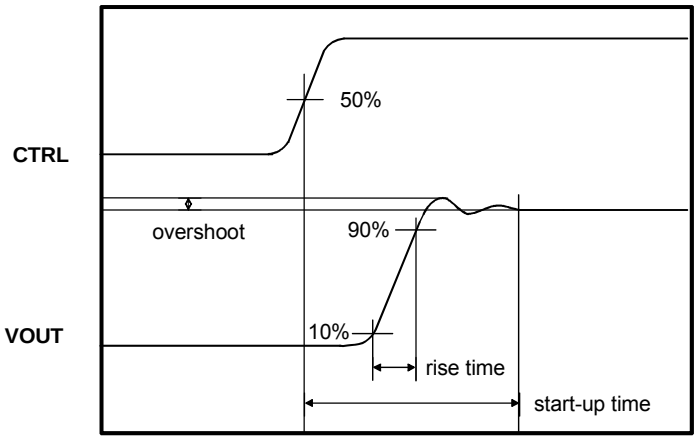
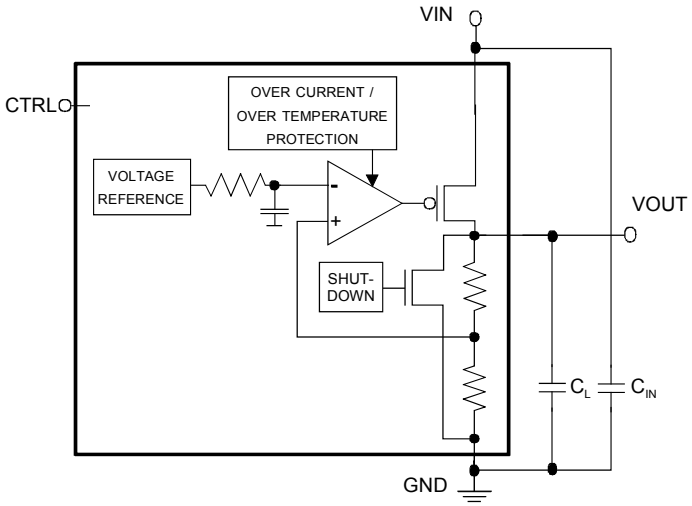


Figure1. Definitions of rise time, overshoot and start-up time.

APPLICATION INFORMATION

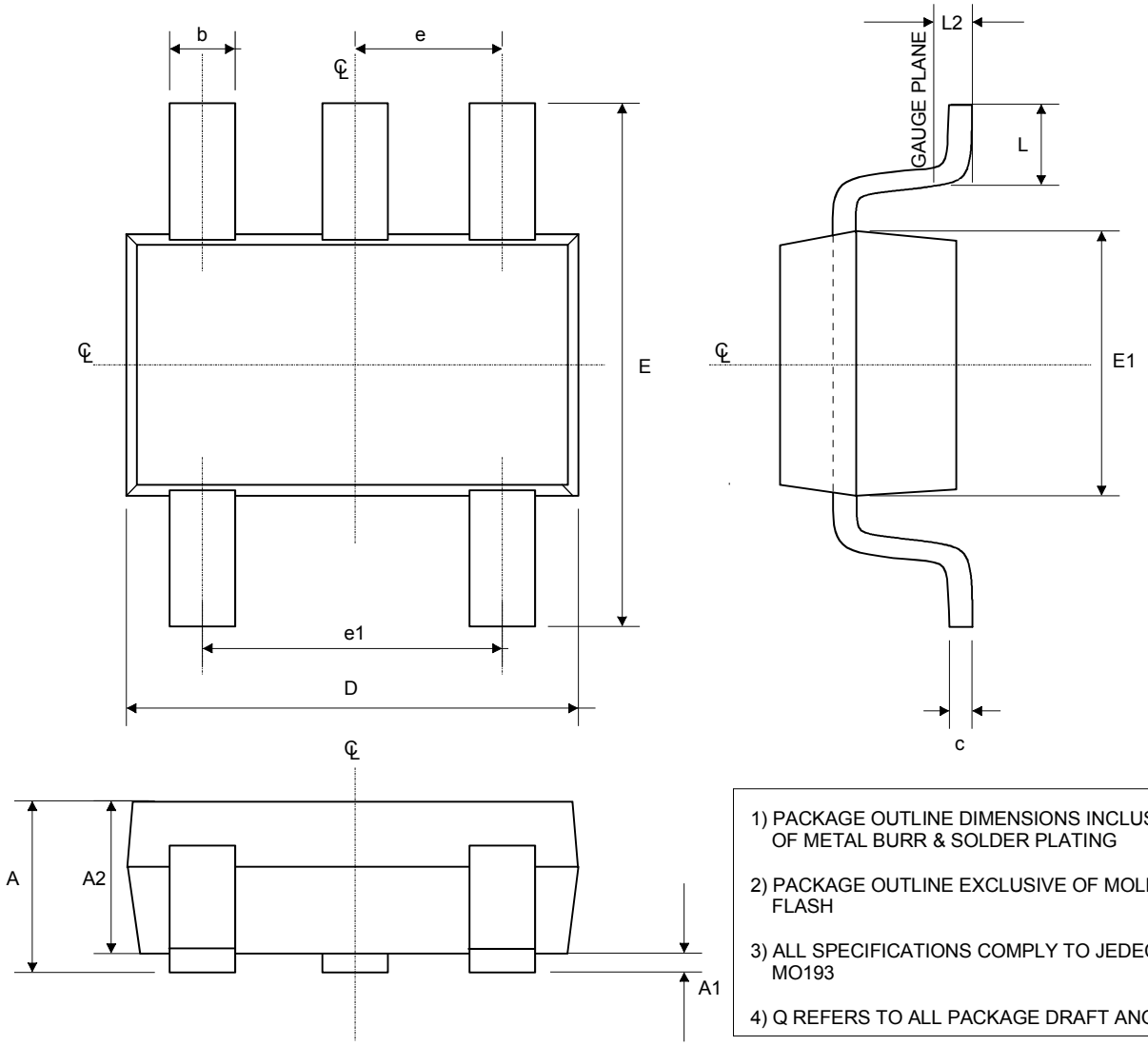
MAS9333 includes an auto-discharge function, wherein a shutdown transistor turns on and discharges the output capacitor, when MAS9333 is turned off. Thus VOUT pin reaches the value 0 V fast after shut-down.



Parameter	Symbol	Min	Max	Unit	Note
Output Capacitance	C_L	0.23		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	3	Ohm	1. When within this range, stable with all I_{OUT} = 0 mA…150 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 MAS9333. 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 MAS9333 is very small (< 0.1 µH), a 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 (TSOT-5) OUTLINE



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

2) PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH

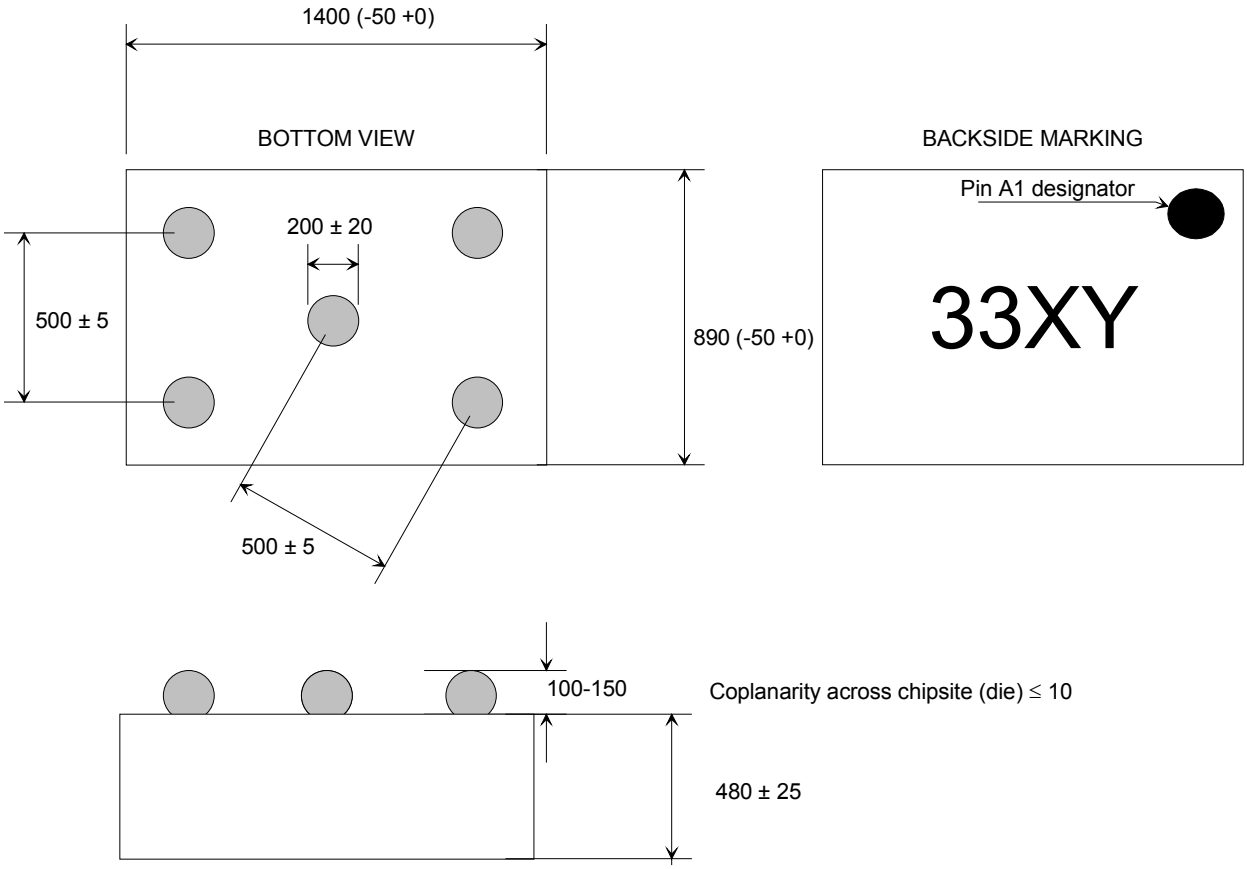
3) ALL SPECIFICATIONS COMPLY TO JEDEC MO193

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.10):

X = Package option
Y = Output voltage option

SOLDERING INFORMATION

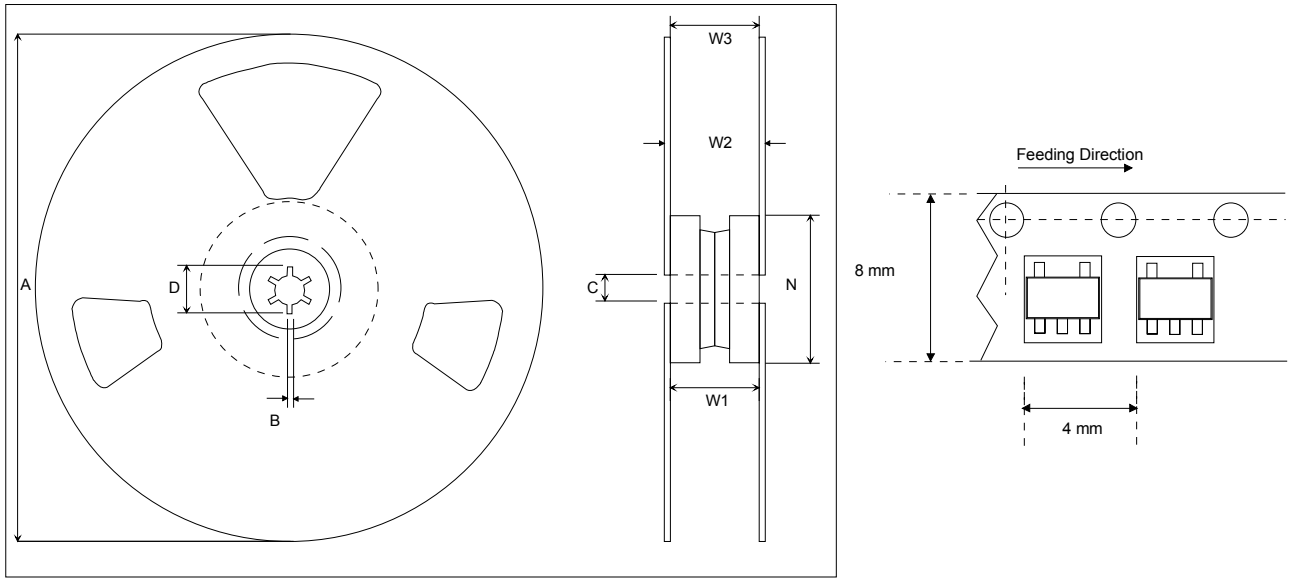
◆ **For Eutectic Sn/Pb TSOT-5 and WL-CSP**

Resistance to Soldering Heat	According to RSH test IEC 68-2-58/20 2*220°C
Maximum Temperature	240°C
Maximum Number of Reflow Cycles	3
Reflow profile	Thermal profile parameters stated in JESD22-A113 should not be exceeded. http://www.jedec.org
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 Temperature	260°C
Maximum Number of Reflow Cycles	3
Reflow profile	Thermal profile parameters stated in JESD22-A113 should not be exceeded. http://www.jedec.org
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	Output Voltage	Top Marking	Package	Pin Order Note 1	Comments
MAS9333A2GB06	2.80 V	33A2 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9333A2CA12	2.80 V	33Z2	WL-CSP	12	Under Qualification
MAS9333A2CA11	2.80 V	33A2	WL-CSP	11	Under Qualification
MAS9333A8GB06	2.85 V	33A8 (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free		Tape and Reel
MAS9333A8CA12	2.85 V	33Z8	WL-CSP	12	Under Qualification
MAS9333A8CA11	2.85 V	33A8	WL-CSP	11	Under Qualification

Note 1: See the pin description on page 2.

For more voltage and package options contact Micro Analog Systems Oy.

Offered in North America by

EVOX RIFA

Evox Rifa, Inc.
300 Tri-State International, Suite 375
Lincolnshire, IL 60069 USA
Tel: 1 847 948 9511
Fax: 1 847 948 9320
Email: service@evoxrifa.com
Web: http://www.evoxrifa.com/n_america

MICRO ANALOG SYSTEMS OY CONTACTS

Micro Analog Systems Oy Kamreerintie 2, P.O.Box 51 FIN-02771 Espoo, FINLAND http://www.mas-oy.com	Tel. (09) 80 521 Tel. Int. +358 9 80 521 Telefax +358 9 805 3213 E-mail: info@mas-oy.com