

MAS9160**2-Output LDO Voltage Regulator IC**

- **Dual Regulator: 2 × 150 mA**
- **Very Low Crosstalk**
- **Low Dropout: 70 mV**
- **High Ripple Rejection: 60 dB**
- **Low Noise: 30 μ Vrms**
- **Stable with Low-ESR Output Capacitors**
- **Separate Enable/Disable Control for Both Regulators**

DESCRIPTION

MAS9160 is a voltage regulator IC with two low dropout voltage regulators, which both have their own enable/disable pin allowing the regulators to be turned off or on separately by pulling the particular control to low or high.

Due to the low noise level of only 30 μ Vrms, MAS9160 is suitable for sensitive circuits, e.g., in portable applications. In addition to the low noise level, MAS9160 excels in dropout voltage (70 mV typical at 50 mA) and in very good crosstalk rejection. Also its ripple rejection ability of 60 dB at 1 kHz exceeds that of competition.

A wide range of values of Equivalent Series Resistance (ESR) of output capacitors can be used with MAS9160. This ESR range from a few m Ω up to a couple of Ohms combined with no minimum output current requirement makes the usage of MAS9160 easier and low in cost.

In order to save power the device goes into sleep mode when both regulators are disabled. An internal thermal protection circuit prevents the device from overheating. Also the maximum output current is internally limited.

FEATURES

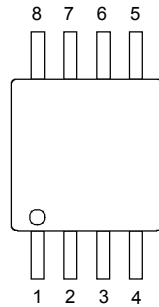
- Low Noise
- Functionally and Pin Compatible with LP2967
- Can Be Used w/o C_{BYPASS}, see p. 9
- Internal Thermal Shutdown
- Short Circuit Protection
- MSOP-8/WL-CSP Package
- Several Output Voltage Options Available, see Ordering Information p. 15

APPLICATIONS

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

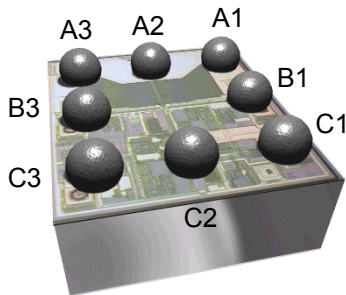
PIN CONFIGURATION

MSOP-8

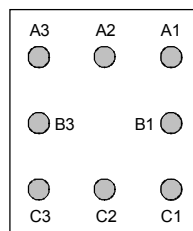


For Top Marking Information see
Ordering Information p. 15

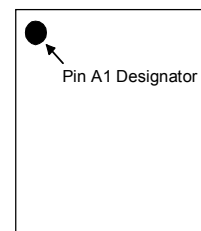
WL-CSP



BOTTOM VIEW



TOP VIEW

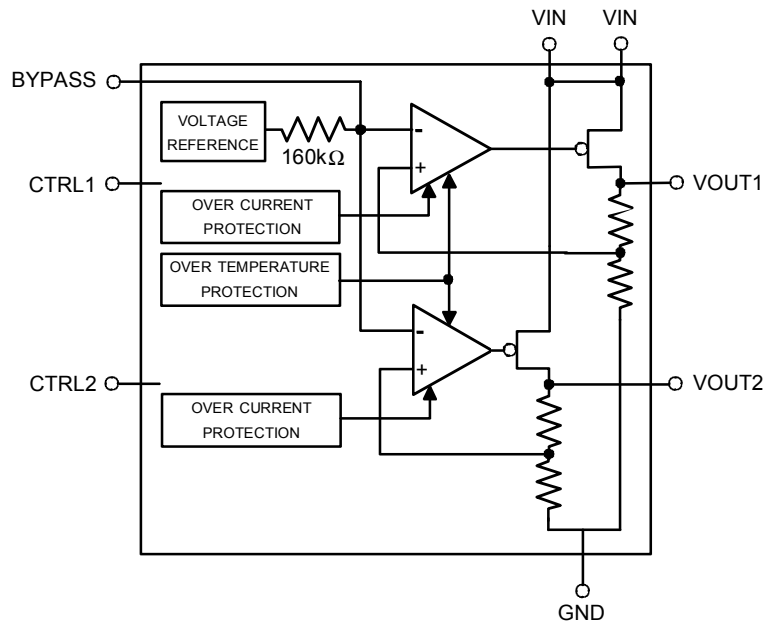


For Top Marking Information see
Ordering Information p. 15

PIN DESCRIPTION

Pin Name	Pin Number in MSOP-8	Pin Number in WL-CSP	Type	Function
VIN	1, 8	A2	P	Power Supply Voltage for Both Regulators
GND	4	C2, C3	G	Ground
CTRL1	3	B3	I	Enable/Disable Pin for the First Regulator
CTRL2	6	B1	I	Enable/Disable Pin for the Second Regulator
BYPASS	5	C1	I	Pin for Bypass Capacitor
VOUT1	2	A3	O	Output Voltage of the First Regulator
VOUT2	7	A1	O	Output Voltage of the Second Regulator

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}	$V_{OUT(NOM)} < 2.2\text{ V}$	2.5	5.3	V
		$V_{OUT(NOM)} \geq 2.2\text{ V}$	$V_{OUT(NOM)} + 0.3$		

ELECTRICAL CHARACTERISTICS

◆ Thermal Protection

$T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, typical values at $T_A = +27^{\circ}\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_L = 1.0\text{ }\mu\text{F}$, $C_{BYPASS} = 10\text{ nF}$, $V_{CTRL} = 3.8\text{ V}$, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Threshold High	T_H		140	160	175	$^{\circ}\text{C}$
Threshold Low	T_L		130	150	165	$^{\circ}\text{C}$

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

◆ Control Terminal Specifications

$T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, typical values at $T_A = +27^{\circ}\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_L = 1.0\text{ }\mu\text{F}$, $C_{BYPASS} = 10\text{ nF}$, $V_{CTRL} = 3.8\text{ V}$, 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, one control input	I_{CTRL}	$V_{CTRL} = V_{IN}$ $V_{CTRL} = 0\text{ V}$		5 0	10	μA

If CTRL-pin is not connected, the particular regulator is in OFF state (900 k Ω pull-down resistor to ground).

◆ Voltage Parameters

$T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, typical values at $T_A = +27^{\circ}\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_L = 1.0\text{ }\mu\text{F}$, $C_{BYPASS} = 10\text{ nF}$, $V_{CTRL} = 3.8\text{ V}$, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Tolerance	V_{OUT}	$I_{OUT} = 0\text{ mA}$ $I_{OUT} = 150\text{ mA}$	$V_{OUT(NOM)} - 0.05$ $V_{OUT(NOM)} - 0.10$		$V_{OUT(NOM)} + 0.05$ $V_{OUT(NOM)} + 0.05$	V
Dropout Voltage	V_{DROP}	$I_{OUT} = 1\text{ mA}$ $I_{OUT} = 50\text{ mA}$ $I_{OUT} = 150\text{ mA}$		2 70 200		mV

◆ Current Parameters

$T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, typical values at $T_A = +27^{\circ}\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_L = 1.0\text{ }\mu\text{F}$, $C_{BYPASS} = 10\text{ nF}$, $V_{CTRL} = 3.8\text{ V}$, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Continuous Output Current	I_{OUT}			150		mA
Short Circuit Current	I_{MAX}	$R_L = 0\text{ }\Omega$		450		mA
Peak Output Current	I_{PK}	$V_{OUT} > 95\% * V_{OUT(NOM)}$		410		mA
Ground Pin Current	I_{GND}	one regulator on $I_{OUT} = 0\text{ mA}$ $I_{OUT} = 10\text{ mA}$ $I_{OUT} = 50\text{ mA}$ $I_{OUT} = 150\text{ mA}$		140 145 170 235		μA
Ground Pin Current	I_{GND}	both regulators on $I_{OUT} = 0\text{ mA}$ $I_{OUT} = 10\text{ mA}$ $I_{OUT} = 50\text{ mA}$ $I_{OUT} = 150\text{ mA}$		215 230 280 410		μA
Ground Pin Current, Sleep Mode	I_{GND}	$V_{CTRL1,2} = 0\text{ V}$	$T_A = 27^{\circ}\text{C}$ $T_A = 85^{\circ}\text{C}$	0.03 0.5	1.0 5.0	μA

◆ Power Dissipation
 $T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, typical values at $T_A = +27^{\circ}\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_L = 1.0\text{ }\mu\text{F}$, $C_{BYPASS} = 10\text{ nF}$, $V_{CTRL} = 3.8\text{ V}$, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Junction to Case Thermal Resistance	R_{JC}	MSOP-8 package		39		$^{\circ}\text{C/W}$
Junction to Ambient Thermal Resistance	R_{JA}	typical PC board mounting, still air, MSOP-8 package		206		$^{\circ}\text{C/W}$
		mounted on MAS9160 CSP evaluation board, WL-CSP package		235 Note 1		
Maximum Power Dissipation	P_d	any ambient temperature, MSOP-8 package	$P_{dMAX} = \frac{T_{J(MAX)} - T_A}{R_{JA}}$ Note 2			W

Note 1: The R_{JA} value for a WL-CSP package is strongly influenced by the PCB layout.

Note 2: $T_{J(MAX)}$ denotes maximum operating junction temperature ($+125^{\circ}\text{C}$), T_A ambient temperature, and R_{JA} junction-to-ambient thermal resistance ($+206^{\circ}\text{C/W}$).

◆ Line and Load Regulation
 $T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, typical values at $T_A = +27^{\circ}\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_L = 1.0\text{ }\mu\text{F}$, $C_{BYPASS} = 10\text{ nF}$, $V_{CTRL} = 3.8\text{ V}$, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Line Regulation		$V_{OUT(NOM)} + 1\text{ V} < V_{IN} < 5.3\text{ V}$, $I_{OUT} = 60\text{ mA}$		0.7		mV
Load Regulation		$I_{OUT} = 1.0$ to 50 mA $I_{OUT} = 1.0$ to 150 mA		9 24	20 45	mV

◆ Noise and Ripple Rejection
 $T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, typical values at $T_A = +27^{\circ}\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_L = 1.0\text{ }\mu\text{F}$, $C_{BYPASS} = 10\text{ nF}$, $V_{CTRL} = 3.8\text{ V}$, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Noise Voltage	V_{RMS}	$300\text{ Hz} < f < 50\text{ kHz}$ $C_{BYPASS} = 10\text{ nF}$ w/o C_{BYPASS}		30 154		μV_{rms}
Noise Density	V_N	$I_{OUT} = 50\text{ mA}$, $f = 1.0\text{ kHz}$		150		$\text{nV}/\sqrt{\text{Hz}}$
PSRR		$I_{OUT} = 50\text{ mA}$ $f = 1\text{ kHz}$ $f = 10\text{ kHz}$ $f = 100\text{ kHz}$		60 55 35		dB

◆ **Dynamic Parameters**

$T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, typical values at $T_A = +27^{\circ}\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_L = 1.0\text{ }\mu\text{F}$, $C_{BYPASS} = 10\text{ nF}$, $V_{CTRL} = 3.8\text{ V}$, unless otherwise specified

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Rise Time (10%...90%)		$V_{CTRL} = 0$ to 2.4 V , $I_{OUT} = 30\text{ mA}$ $C_{BYPASS} = 10\text{ nF}$ w/o C_{BYPASS}		4 16		ms μs
Overshoot		$V_{CTRL} = 0$ to 2.4 V , w/o C_{BYPASS}		3	5	%
Start-up Delay (from start-up to 90% * $V_{OUT(NOM)}$)		one regulator on, w/o C_{BYPASS}		26		μs

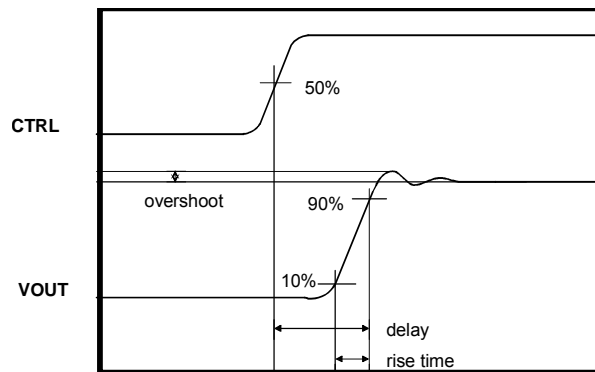


Figure1. Definitions of rise time, overshoot and start-up delay.

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$, typical values at $T_A = +27^\circ\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\ \mu\text{F}$, $C_L = 1.0\ \mu\text{F}$, $C_{BYPASS} = 10\ \text{nF}$, $V_{CTRL} = 3.8\text{ V}$, unless otherwise specified

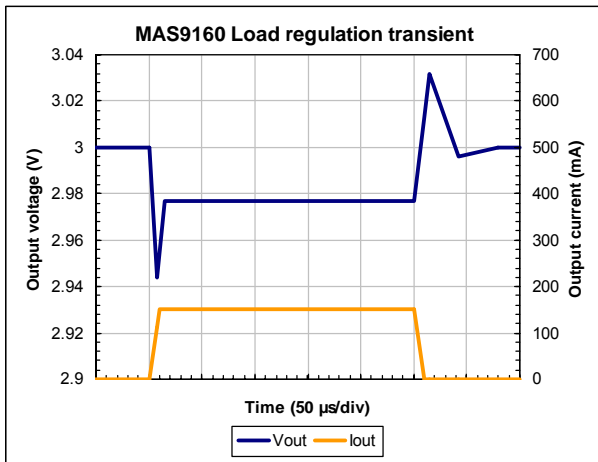


Figure 2. Typical load regulation transient. $I_{OUT} = 0\dots150\text{ mA}$ in $10\ \mu\text{s}$.

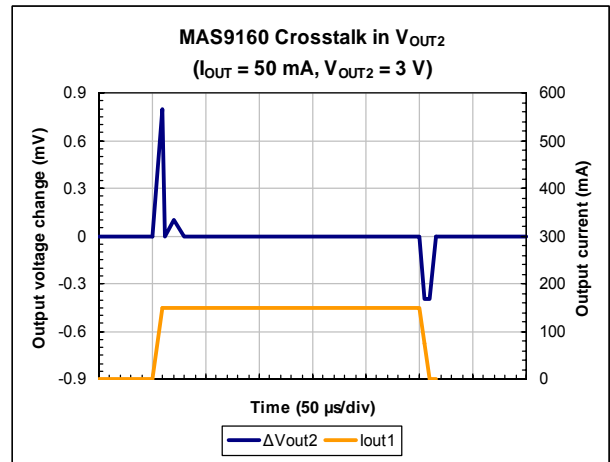


Figure 3. Typical cross-coupling at load regulation transient. $I_{OUT1} = 0\dots150\text{ mA}$ in $10\ \mu\text{s}$ (Figure 2).

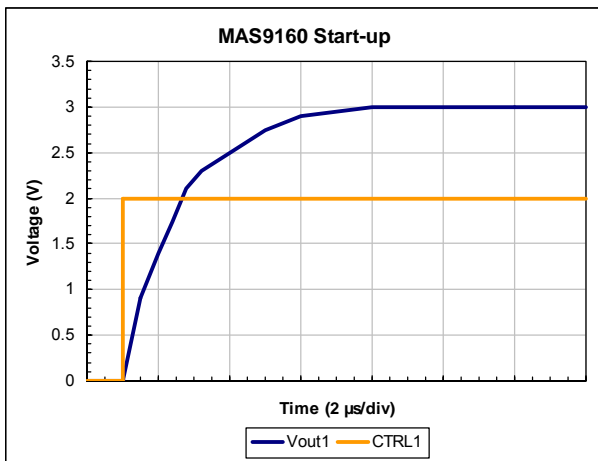


Figure 4. Start-up. $C_{BYPASS} = 10\ \text{nF}$, $CTRL2 = 0\text{ V}$ (i.e. regulator 2 in power off).

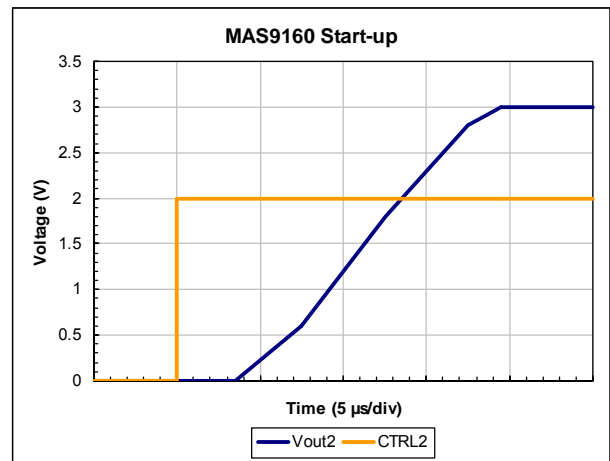


Figure 5. Start-up. $C_{BYPASS} = 10\ \text{nF}$, $CTRL1 = 2\text{ V}$ (i.e. regulator 1 in power on).

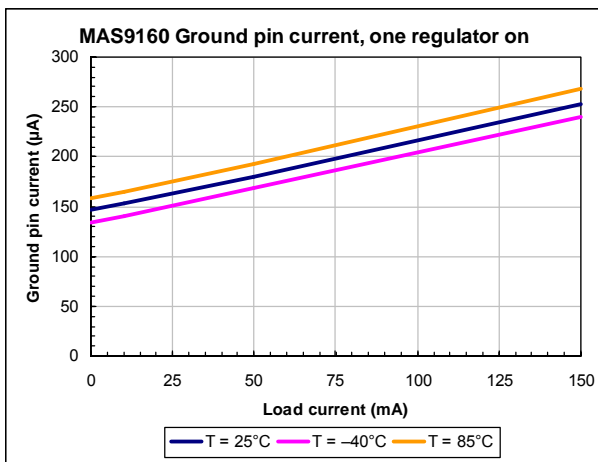


Figure 6. Current consumption vs. load current and temperature. One regulator is on.

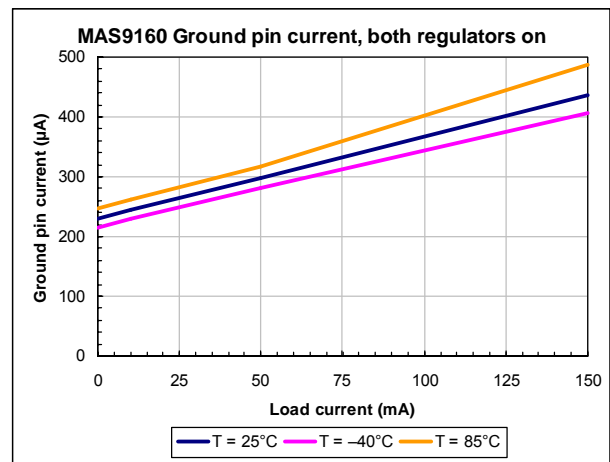


Figure 7. Current consumption vs. load current and temperature. Both regulators are on.

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$, typical values at $T_A = +27^\circ\text{C}$, $V_{IN} = V_{OUT(NOM)} + 1.0\text{ V}$, $I_{OUT} = 1.0\text{ mA}$, $C_{IN} = 1.0\ \mu\text{F}$, $C_L = 1.0\ \mu\text{F}$, $C_{BYPASS} = 10\ \text{nF}$, $V_{CTRL} = 3.8\ \text{V}$, unless otherwise specified

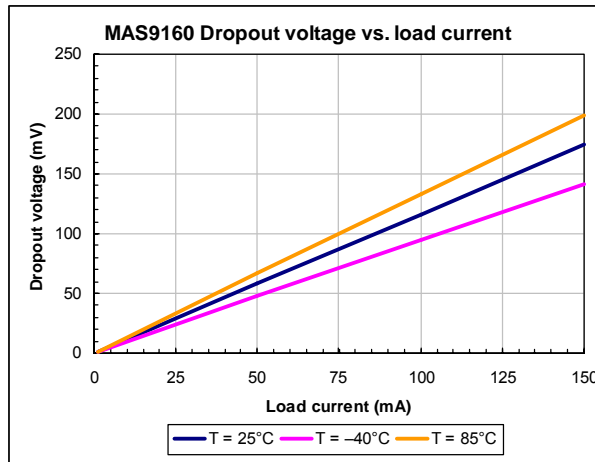


Figure 8. Dropout voltage vs. load current and temperature.

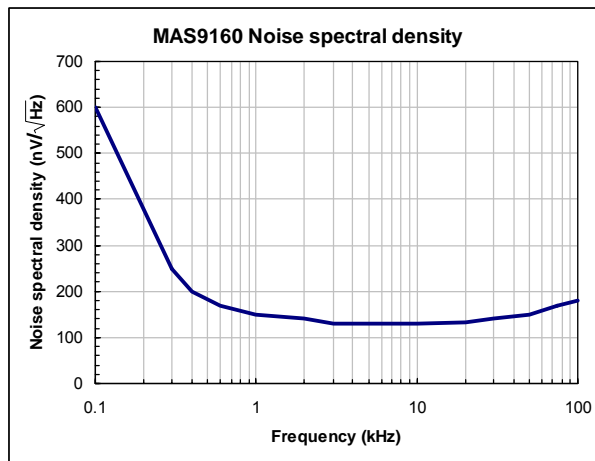


Figure 9. Output noise spectral density. $C_{BYPASS} = 10\ \text{nF}$, $C_L = 1\ \mu\text{F}$, $I_{OUT} = 50\ \text{mA}$.

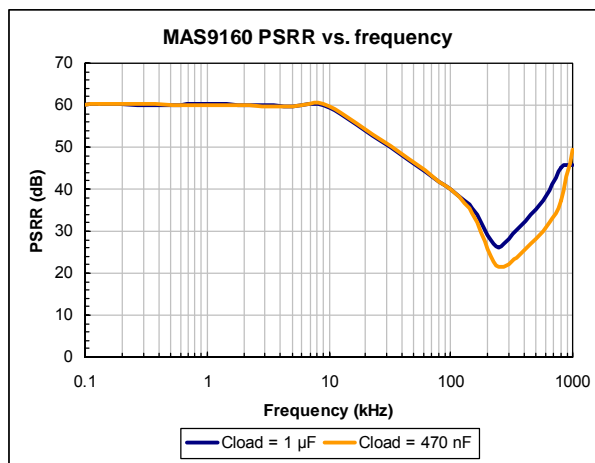
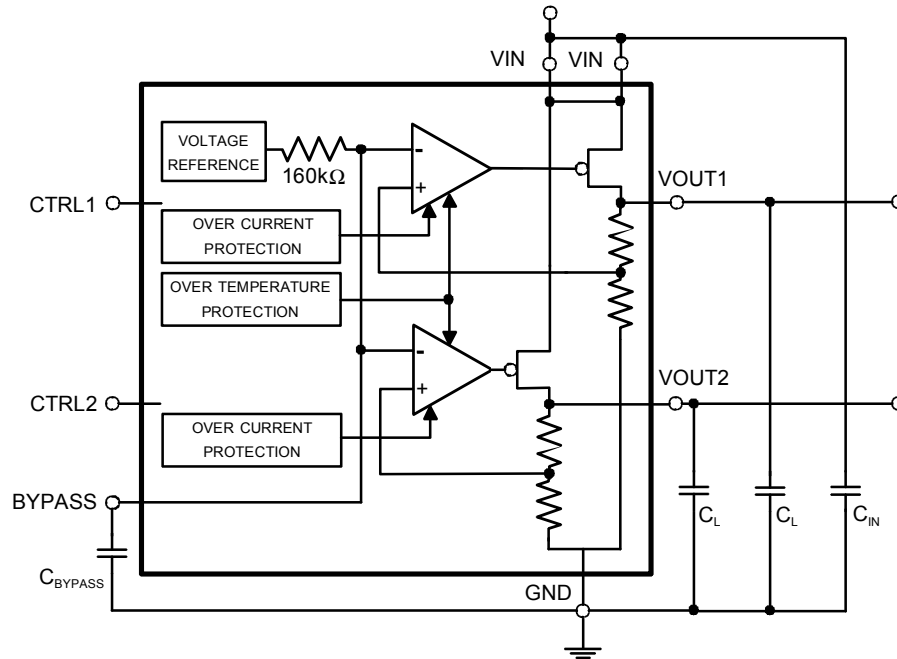
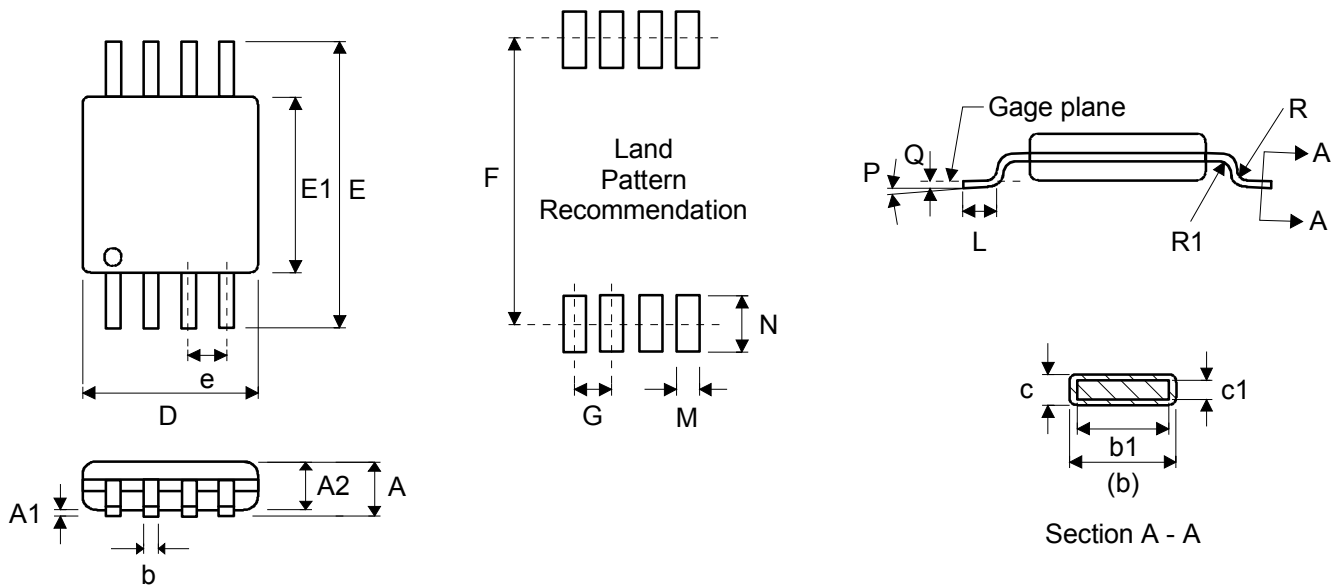


Figure 10. PSRR vs. frequency. $C_{BYPASS} = 10\ \text{nF}$, $I_{OUT} = 50\ \text{mA}$.

APPLICATION INFORMATION


Parameter	Symbol	Min	Max	Unit	Note
Output Capacitance	C_L	0.22		μF	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 1. When within this range, stable with all $I_{OUT} = 0 \text{ mA} \dots 150 \text{ mA}$ values.
Bypass Capacitance (Optional: if C_{BYPASS} is not used, noise performance and PSRR decline, but rise time is improved. If one of the regulators is already on, C_{BYPASS} does not have effect on rise time.)	C_{BYPASS}	Typically 0.01		μF	<ol style="list-style-type: none"> 1. Ceramic and film capacitors are best suited. For maximum output voltage accuracy DC leakage current through capacitor should be kept as low as possible. In any case DC leakage current must be below 100 nA.
Input Capacitance	C_{IN}	0.5		μF	<ol style="list-style-type: none"> 1. A big enough input capacitance is needed to prevent possible impedance interactions between the supply and MAS9160. 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 MAS9160 is very small ($< 0.1 \mu\text{H}$) $0.47 \mu\text{F}$ 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.**

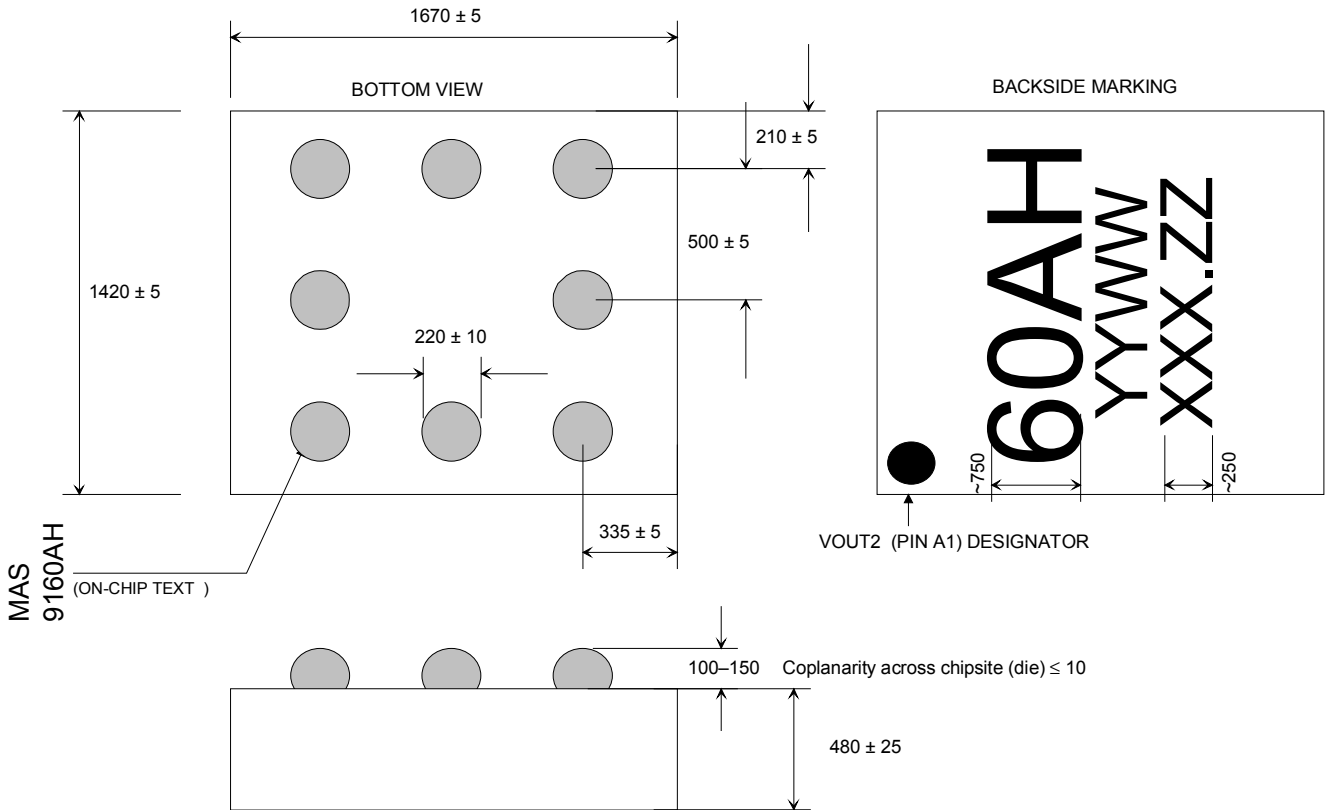
PACKAGE OUTLINE (MSOP-8)


Symbol	Min	Nom	Max	Unit
A			1.10	mm
A1	0		0.15	mm
A2	0.75	0.85	0.95	mm
b	0.22		0.38	mm
b1	0.22	0.30	0.33	mm
c	0.08		0.23	mm
c1	0.08		0.18	mm
D		3.00 BSC		mm
E		4.90 BSC		mm
E1		3.00 BSC		mm
e		0.65 BSC		mm
F		4.8		mm
G		0.65		mm
L	0.40	0.60	0.80	mm
(Terminal length for soldering)				
M		0.41		mm
N		1.02		mm
P	0°		8°	
Q		0.25 BSC		mm
R	0.07			mm
R1	0.07			mm

Dimensions do not include mold or interlead flash, protrusions or gate burrs.
 All measurement according to JEDEC standard MO-187.

PACKAGE OUTLINE (WL-CSP)

All dimensions in microns



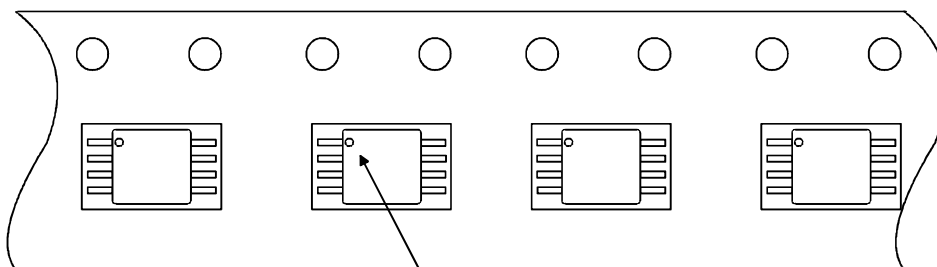
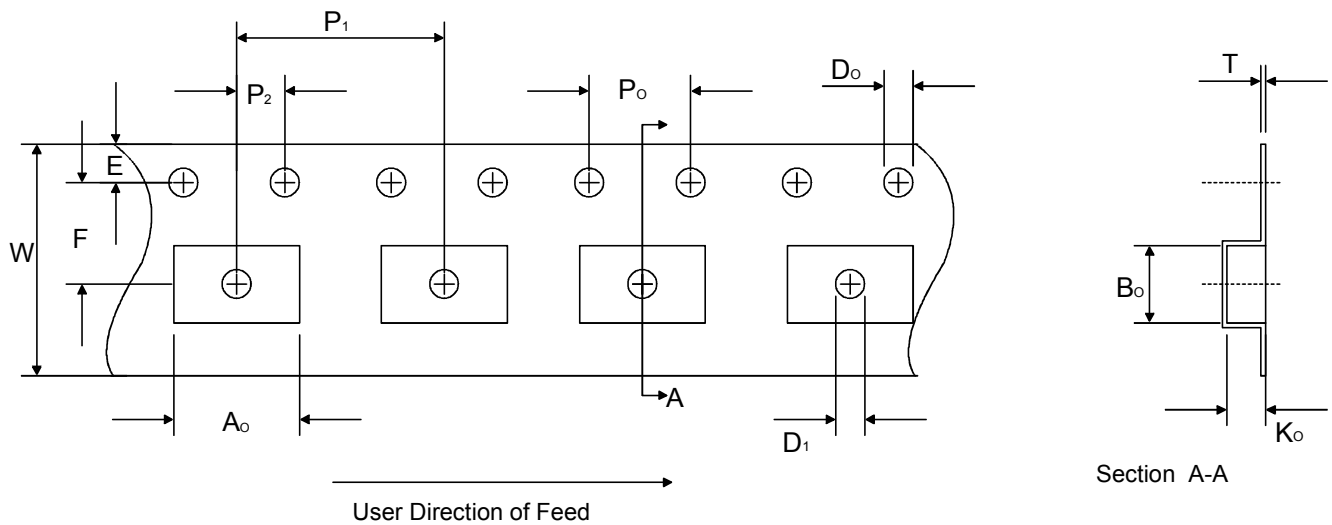
Definitions:

- YYWW = Year and week
- XXX = MAS lot number last three numbers
- ZZ = Wafer number

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%
WL-CSP Balls	Material Sn 63% Pb 37% (eutectic)

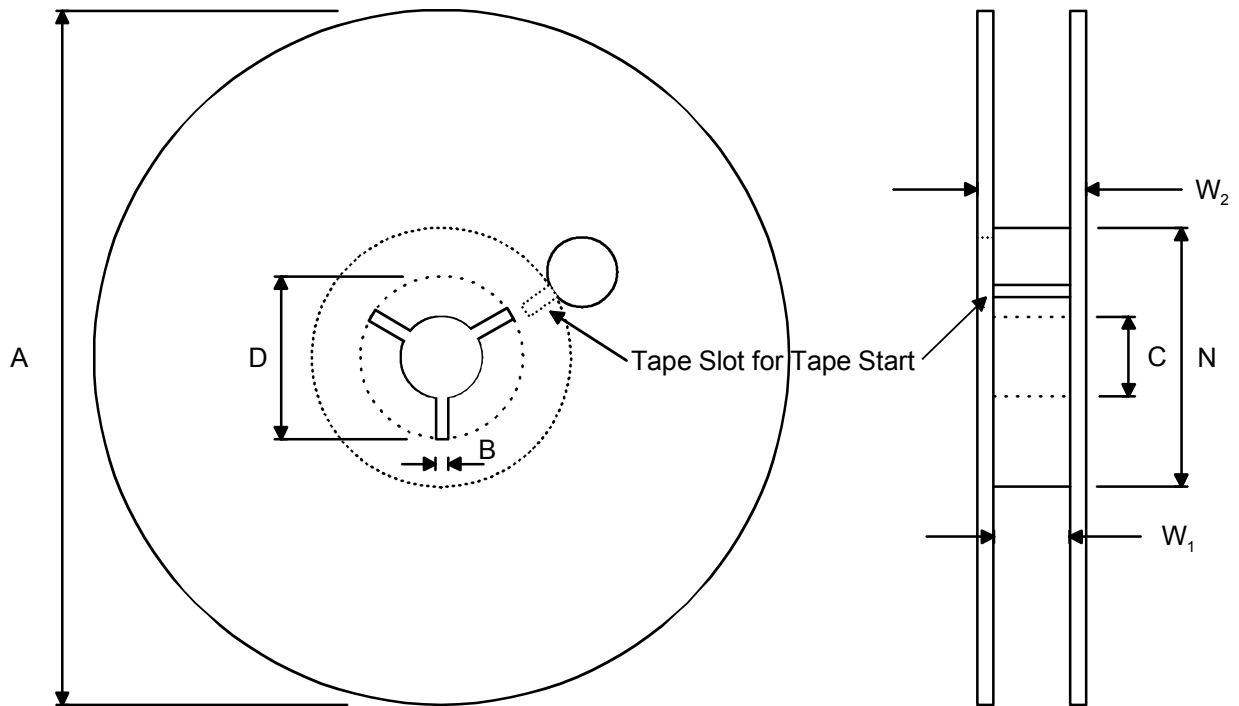
EMBOSED TAPE SPECIFICATIONS (MSOP-8)



Pin 1 Designator

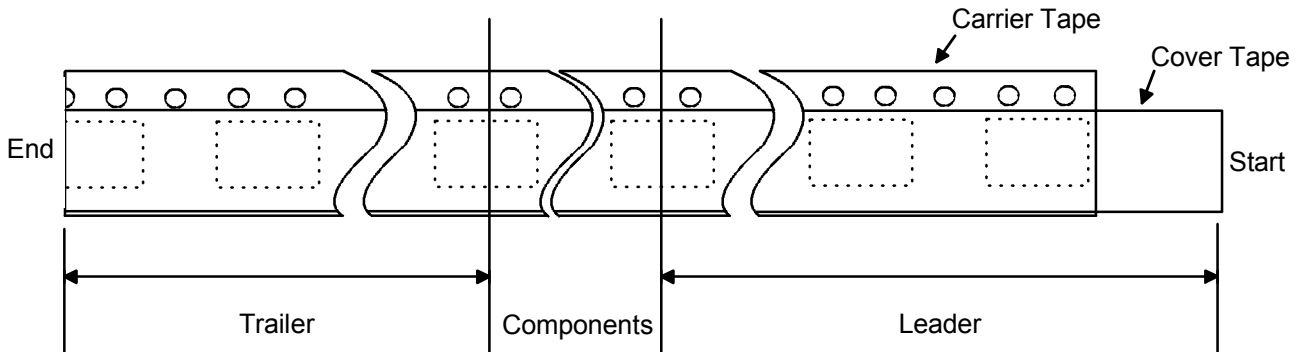
Dimension	Min/Max	Unit
A_0	5.00 ± 0.10	mm
B_0	3.20 ± 0.10	mm
D_0	1.50 $+0.1/-0.0$	mm
D_1	1.50 min	mm
E	1.75	mm
F	5.50 ± 0.05	mm
K_0	1.45 ± 0.10	mm
P_0	4.0	mm
P_1	8.0 ± 0.10	mm
P_2	2.0 ± 0.05	mm
T	0.3 ± 0.05	mm
W	12.00 $+0.30/-0.10$	mm

REEL SPECIFICATIONS (MSOP-8)



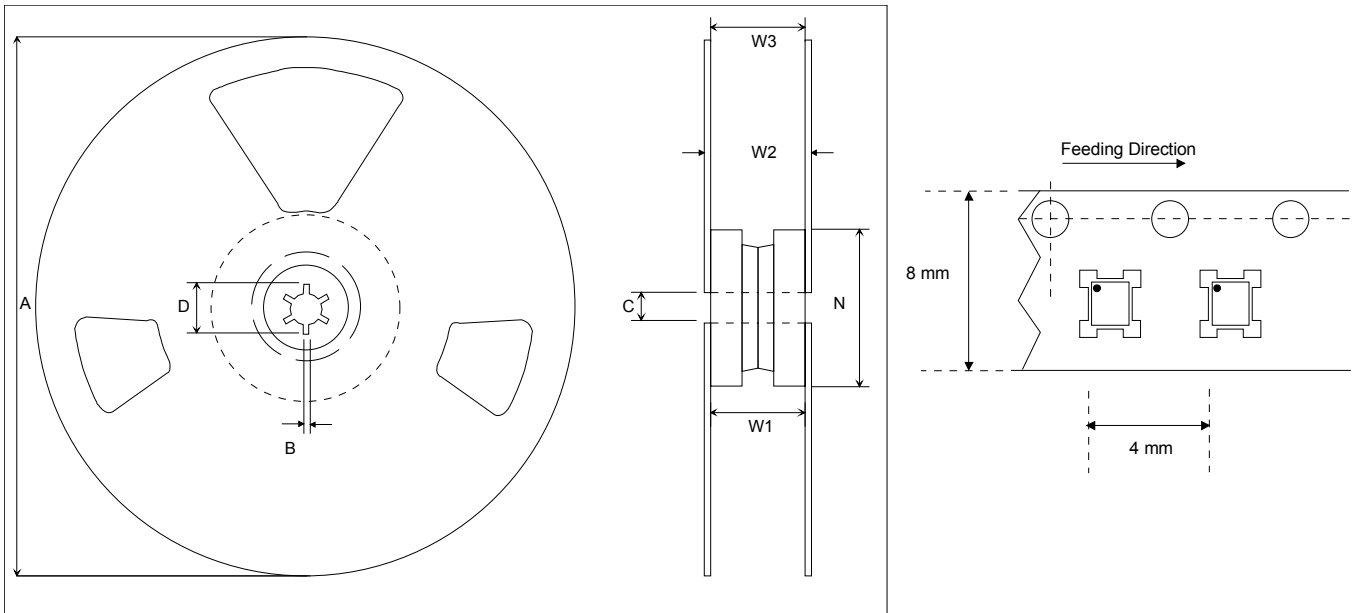
5000 Components on Each Reel

Reel Material: Conductive, Plastic Antistatic or Static Dissipative
Carrier Tape Material: Conductive
Cover Tape Material: Static Dissipative



Dimension	Min	Max	Unit
A		330	mm
B	1.5		mm
C	12.80	13.50	mm
D	20.2		mm
N	50		mm
W ₁ (measured at hub)	12.4	14.4	mm
W ₂ (measured at hub)		18.4	mm
Trailer	160		mm
Leader	390, of which minimum 160 mm of empty carrier tape sealed with cover tape		mm
Weight		1500	g

TAPE & REEL SPECIFICATIONS (WL-CSP)



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
Trailer	160		mm
Leader	390, of which minimum 160 mm of empty carrier tape sealed with cover tape		mm

ORDERING INFORMATION

Product Code	Product	V _{OUT1(NOM)}	V _{OUT2(NOM)}	Top Marking	Package	Comments
MAS9160ASM4-T	Voltage Regulator IC	1.8 V	1.8 V	60A4	MSOP-8	Tape and Reel
MAS9160ASMH-T	Voltage Regulator IC	1.8 V	2.8 V	60AH	MSOP-8	Tape and Reel
MAS9160ASM3-T	Voltage Regulator IC	2.5 V	2.5 V	60A3	MSOP-8	Tape and Reel
MAS9160ASMJ-T	Voltage Regulator IC	2.5 V	2.8 V	60AJ	MSOP-8	Tape and Reel
MAS9160ASM2-T	Voltage Regulator IC	2.8 V	2.8 V	60A2	MSOP-8	Tape and Reel
MAS9160ASM6-T	Voltage Regulator IC	3.0 V	3.0 V	60A6	MSOP-8	Tape and Reel
MAS9160ASM1-T	Voltage Regulator IC	3.3 V	3.3 V	60A1	MSOP-8	Tape and Reel
MAS9160ACAH-T	Voltage Regulator IC	1.8 V	2.8 V	60AH	WL-CSP	Under Qualification
MAS9160ACA2-T	Voltage Regulator IC	2.8 V	2.8 V	60A2	WL-CSP	Under Qualification

For more voltage options contact Micro Analog Systems Oy.

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