MAS9165

150 mA LDO Regulator with Power Good Indicator

- **Specifically Designed for Low Output Voltages: 0.9 V to 1.2 V**
- **Power Good Indicator**
- **Short Start-up Time**
- **Low Noise: 44 µVrms**
- **Enable/Disable Control**
- **Stable with Low-ESR Output Capacitors**

DESCRIPTION

MAS9165 is a very low output voltage LDO regulator with a Power Good indicator. Enable input allows the device to be turned off or on by pulling the control to low or high.
MAS9165 has a shutdown transistor that turns on, when the device is disabled, and discharges the output capacitor.
The Equivalent Series Resistance (ESR) range of output capacitors that can be used with MAS9165 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 MAS9165 easier and low in cost.
In order to save power the device goes into 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

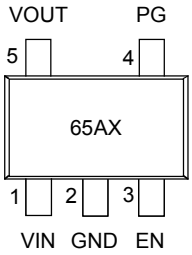
- Power Good Indicator
- Low Current Consumption
- Good Transient Performance
- Internal Thermal Shutdown
- Short Circuit Protection
- Small SOT23-5 or Thin TSOT-5 Package
- Several Output Voltage Options Available, see Ordering Information p. 12

APPLICATIONS

- Processor Power-up Sequencing
- PCMCIA V_{cc} and V_{pp} Regulation/switching
- Notebook Computers
- Laptop Computers
- Palmtop Computers

PIN CONFIGURATION

Top View



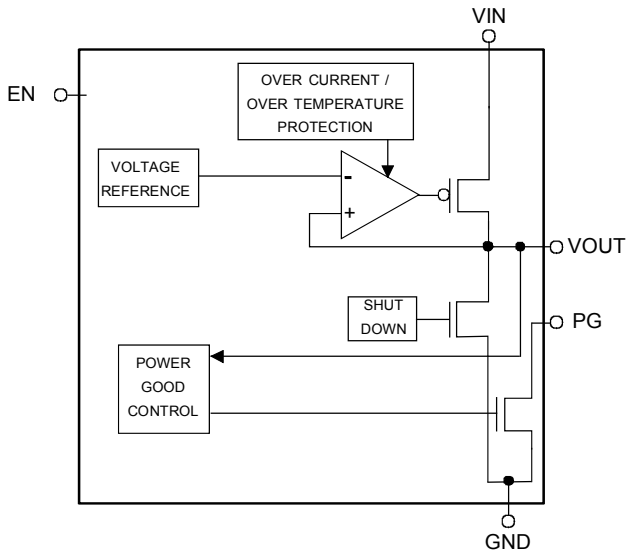
For Top Marking Information:
see Ordering Information p. 12

PIN DESCRIPTION

Pin Name	Pin	Type	Function
VIN	1	P	Power Supply Voltage
GND	2	G	Ground
EN	3	I	Enable Pin for Regulator
PG	4	O	Power Good Output
VOUT	5	O	Regulator 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}		2.5	5.3	V

ELECTRICAL CHARACTERISTICS

◆ Thermal Protection

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

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

◆ Control Terminal Specifications

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Enable Input Voltage OFF State ON State	V_{EN}		 -0.3 1.6		 0.55 V_{IN} + 0.3	V
Enable Input Current	I_{EN}	V_{EN} = V_{IN} V_{EN} = 0 V		0 0		µA

◆ Voltage Parameters

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Tolerance	V_{OUT}	2.5 V ≤ V_{IN} ≤ 5.3 V, I_{OUT} = 0.1 mA	-3		+3	%

◆ Current Parameters

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, 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		420		mA
Ground Pin Current	I_{GND}	I_{OUT} = 0 mA, V_{EN} = V_{IN} I_{OUT} = 150 mA, V_{EN} = V_{IN}		125 205	200 400	µA
Shutdown Current	I_{SD}	V_{EN} = 0 V, Without PG pin current T_J = +27°C T_J = +85°C		 0.005	 1 5	µA

◆ Power Good Specifications

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Power Good Threshold (see figure 9, p. 6)	V_{PGL} V_{PGH}	% of V_{OUT} (PG ON) % of V_{OUT} (PG OFF)	89.5		 96.5	%
Power Good Output: Logic Low Voltage	V_{PNG}	Fault condition, I_{PG} = 100 µA		0.02	0.1	V
Power Good Output: Leakage Current	I_{PGLK}	Power OK, V_{PG} = 5.3 V		0.002	0.1	µA
Delay Time To Power Good	t_{PGD}		1	2	5	ms

◆ Power Dissipation

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, 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), SOT23-5 package TSOT-5 package		 191 207		°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.

◆ Line and Load Regulation

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Line Regulation		V_{IN} = 2.5 V to 5.3 V	-0.3		0.3	%/V
Load Regulation		I_{OUT} = 0.1 mA to 150 mA			5	%

◆ Noise and Ripple Rejection

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Noise Voltage	V_{RMS}	300 Hz < f < 50 kHz V_{OUT} = 0.9 V V_{OUT} = 1.2 V 10 Hz < f < 1 MHz V_{OUT} = 0.9 V V_{OUT} = 1.2 V		 44 57 55 73		µVrms
Output Noise Density	V_N	I_{OUT} = 150 mA, f = 1 kHz		255		$nV/\sqrt{Hz}$
PSRR		I_{OUT} = 150 mA f = 120 Hz f = 1 kHz f = 10 kHz		 60 60 55		dB

◆ Dynamic Parameters

T_J = -40°C to +125°C, typical values at T_J = +27°C, V_{IN} = 3.6 V, I_{OUT} = 1 mA, C_{IN} = 1 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Turn-ON Time (see figure 1 below)	t_{ON}	I_{OUT} = 0 mA, V_{OUT} from 1% to 99%		15		µs
Turn-OFF Time	t_{OFF}	I_{OUT} = 0 mA, V_{OUT} from 99% to 1%		60		µs
Start-up Delay (see figure 1 below)		V_{EN} = 0 V to V_{IN}, I_{OUT} = 150 mA		23		µs
Overshoot		V_{EN} = 0 V to V_{IN}			15	%

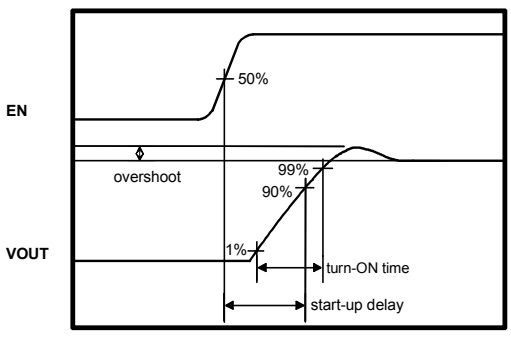


Figure 1. Definitions of turn-ON time, overshoot and start-up delay.

TYPICAL PERFORMANCE CHARACTERISTICS

DUT = MAS9165ASTS, V_{IN} = 2.5 V, T_A = +27°C, I_{OUT} = 10 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

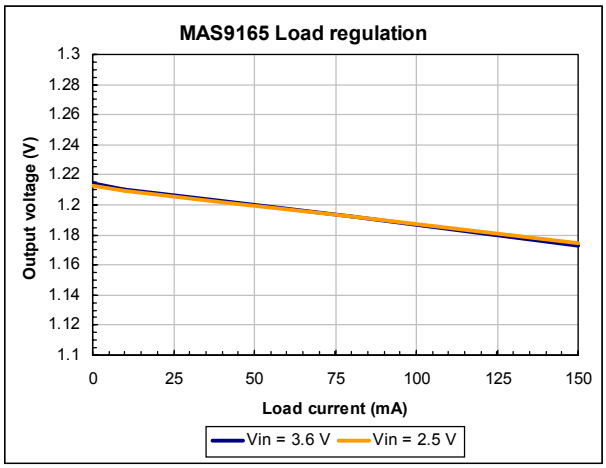


Figure 2. Load regulation.

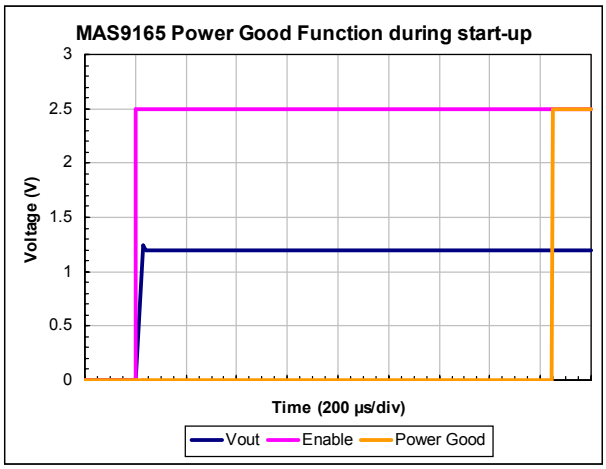


Figure 3. Power Good Function during start-up.

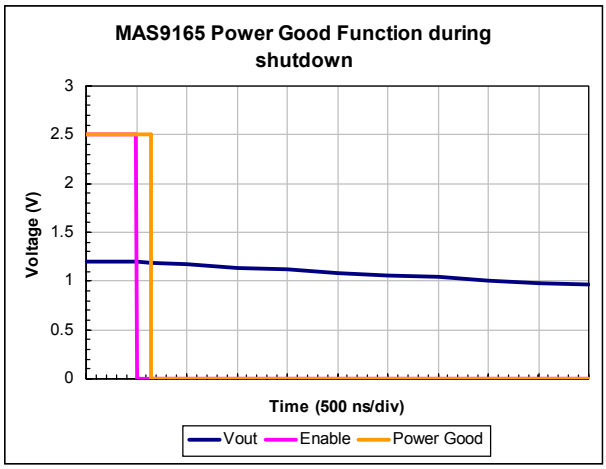


Figure 4. Power Good Function during shutdown.

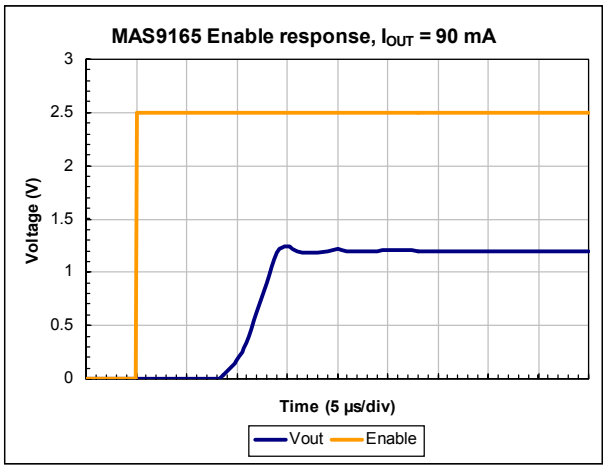


Figure 5. Enable response. I_{OUT} = 90 mA.

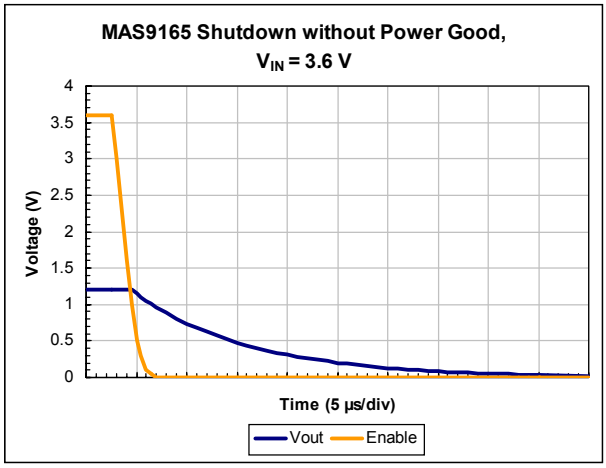


Figure 6. Shutdown without Power Good.

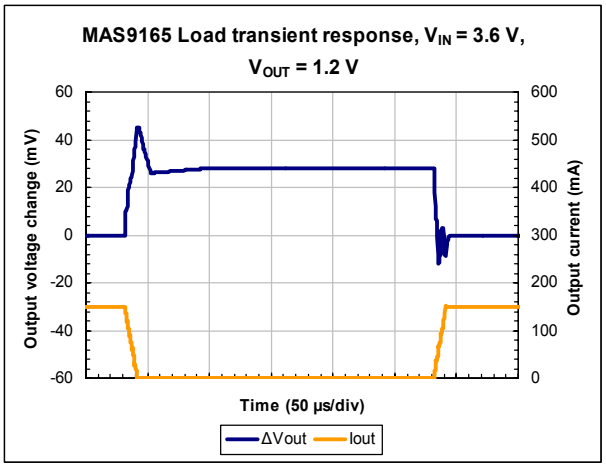


Figure 7. Load transient response. I_{OUT} = 150…1 mA, 10 µs fall/rise time, V_{OUT} = 1.2 V.

TYPICAL PERFORMANCE CHARACTERISTICS

DUT = MAS9165ASTS, V_{IN} = 2.5 V, T_A = +27°C, I_{OUT} = 10 mA, C_{IN} = 1.0 µF, C_L = 1.0 µF, V_{EN} = V_{IN}, unless otherwise specified.

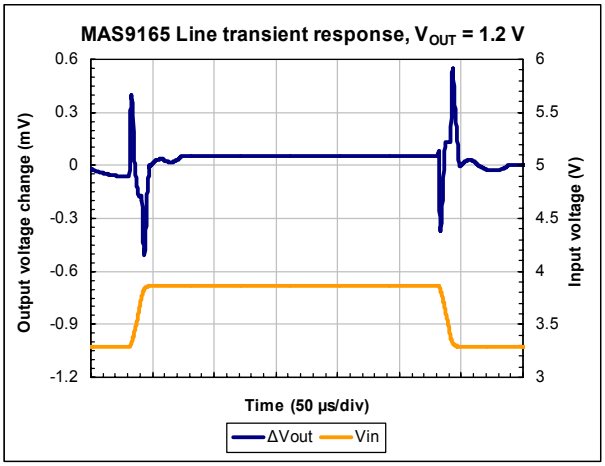


Figure 8. Line transient response. V_{IN} = 3.3…3.9 V, 10 µs rise/fall time, I_{OUT} = 150 mA, V_{OUT} = 1.2 V.

DETAILED DESCRIPTION

◆ Power Good Output

The Power Good Output pin is an open-drain output. The output of Power Good goes low, when a fault condition occurs, and goes back high, when the output voltage has reached 96.5 % of its nominal value and 2 ms (typical) delay has passed (see Figure 9 below).

◆ Auto-Discharge Function

MAS9165 has a shutdown transistor that turns on, when the device is disabled, and discharges the output capacitor.

◆ Calculating Maximum Power Dissipation

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:

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

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} = 0.9 V, and V_{IN} = 3.8 V and used package is SOT23-5 the equation yields:

$$P_{dMAX} = \frac{125°C - 55°C}{191°C/W} = 0.37\ W$$

from which can be calculated:

$$I_{OUTMAX} = \frac{P_{dMAX}}{V_{IN} - V_{OUT}} = 127\ mA$$

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 127 mA.

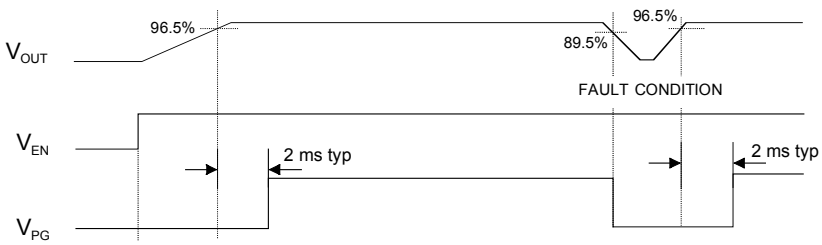
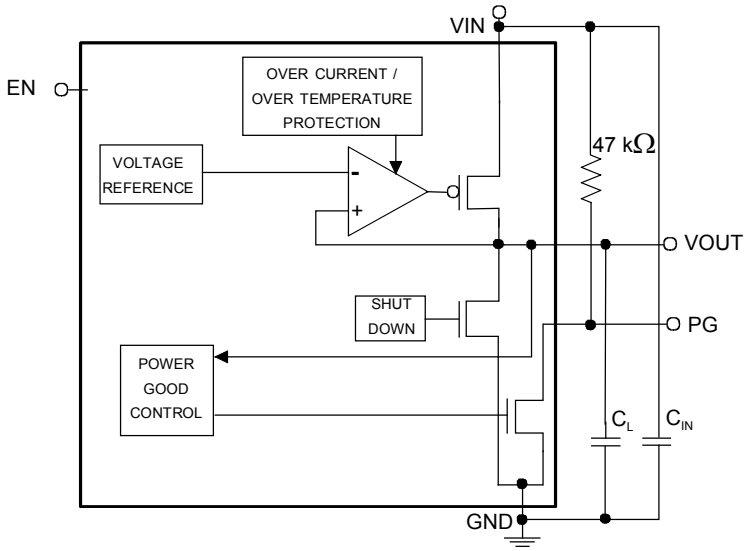


Figure 9. Timing Diagram of the Power Good Function.

APPLICATION INFORMATION

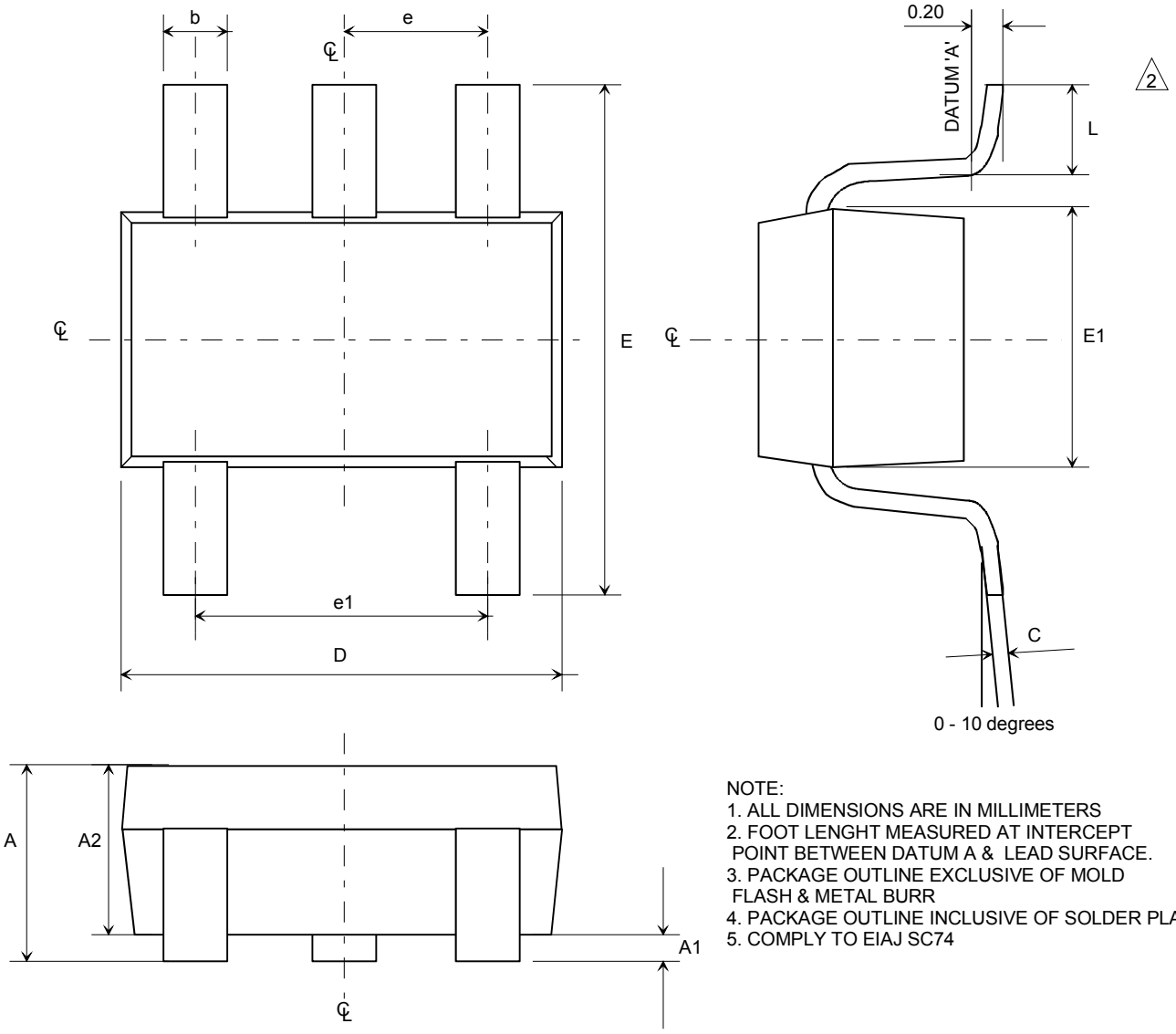


N.B.! EN pin has to be connected, i.e. it shall not be left floating.

Parameter	Symbol	Min	Typ	Max	Unit	Note
Output Capacitance	C_L	0.38	1.0	2.6	µF	1. Ceramic and film capacitors can be used.
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}	0.25			µF	1. A big enough input capacitance is needed to prevent possible impedance interactions between the supply and MAS9165. 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 MAS9165 is very small (< 0.1 µH) 0.22 µF input capacitor is sufficient.

Values given in the table are minimum requirements unless otherwise specified. When selecting capacitors, tolerance and temperature coefficient must be considered to **make sure that the minimum capacitance requirement is met in all potential operating conditions**.

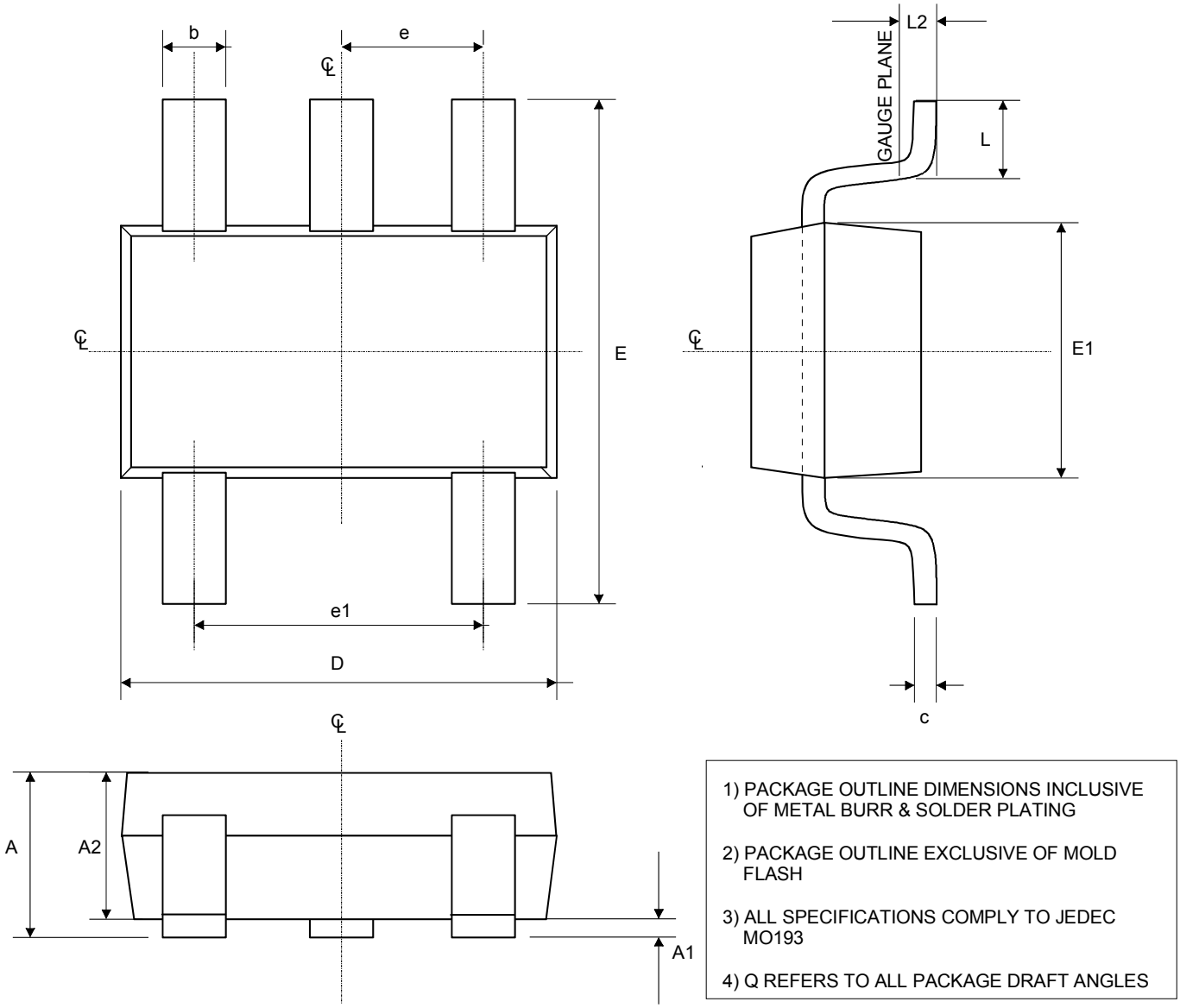
PACKAGE (SOT23-5) OUTLINE



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

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°	

SOLDERING INFORMATION

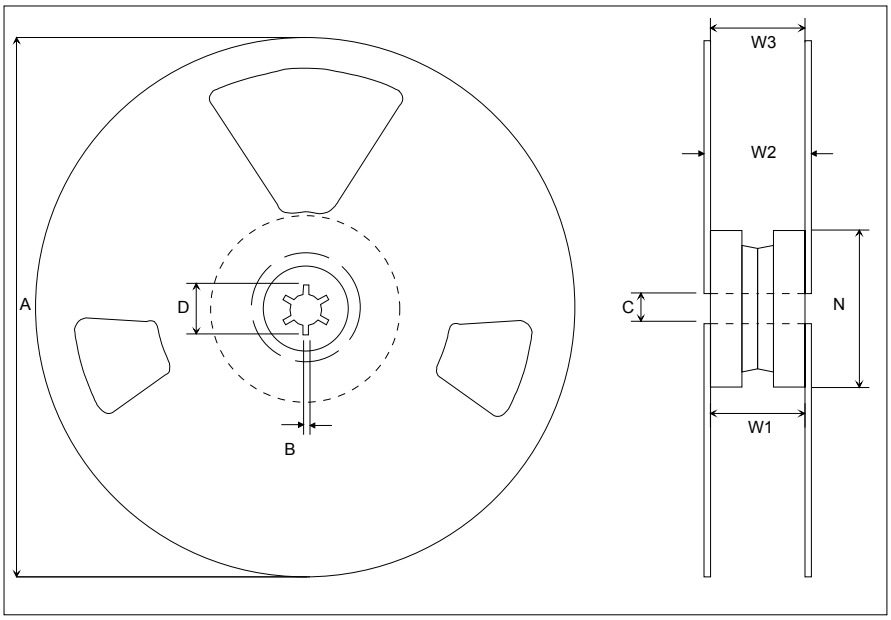
◆ **For Eutectic Sn/Pb SOT23-5**

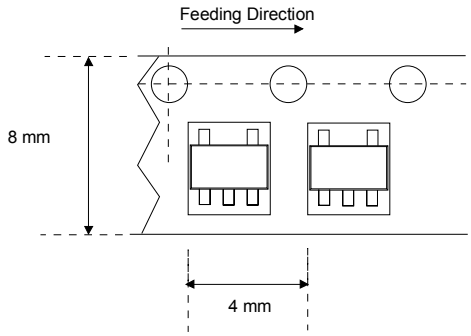
Resistance to Soldering Heat	According to RSH test IEC 68-2-58/20 2*220°C
Maximum Temperature	240°C
Maximum Number of Reflow Cycles	3
Reflow profile	Thermal profile parameters stated in JESD22-A113 should not be exceeded. http://www.jedec.org
Seating Plane Co-planarity	max 0.08 mm
Lead Finish	Solder plate 7.62 - 25.4 µm, material Sn 85% Pb 15%

◆ **For Lead-Free TSOT-5 and Lead-Free, RoHS Compliant 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 IPC/JEDEC J-STD-020 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 (SOT23-5/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	Comments
MAS9165ASTS-T	1.20 V	65AS	SOT23-5	Tape and Reel
MAS9165ASGB06	1.20 V	65AS (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9124ASGC06	1.20 V	65AS (G in the bottom marking to indicate lead-free, RoHS compliant)	TSOT-5 lead-free, RoHS compliant	Tape and Reel
MAS9165ASTR-T	1.10 V	65AR	SOT23-5	Tape and Reel
MAS9165ARGB06	1.10 V	65AR (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9124ARGC06	1.10 V	65AR (G in the bottom marking to indicate lead-free, RoHS compliant)	TSOT-5 lead-free, RoHS compliant	Tape and Reel
MAS9165ASTQ-T	1.00 V	65AQ	SOT23-5	Tape and Reel
MAS9165AQGB06	1.00 V	65AQ (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9124AQGC06	1.00 V	65AQ (G in the bottom marking to indicate lead-free, RoHS compliant)	TSOT-5 lead-free, RoHS compliant	Tape and Reel
MAS9165ASTP-T	0.90 V	65AP	SOT23-5	Tape and Reel
MAS9165APGB06	0.90 V	65AP (B in the bottom marking to indicate lead-free)	TSOT-5 lead-free	Tape and Reel
MAS9124APGC06	0.90 V	65AP (G in the bottom marking to indicate lead-free, RoHS compliant)	TSOT-5 lead-free, RoHS compliant	Tape and Reel

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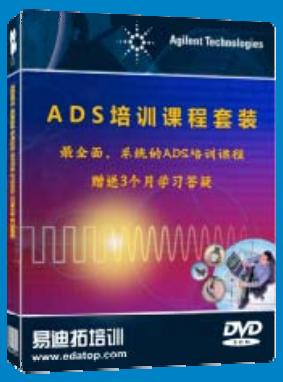
射频工程师养成培训课程套装

该套装精选了射频专业基础培训课程、射频仿真设计培训课程和射频电路测量培训课程三个类别共 30 门视频培训课程和 3 本图书教材；旨在引领学员全面学习一个射频工程师需要熟悉、理解和掌握的专业知识和研发设计能力。通过套装的学习，能够让学员完全达到和胜任一个合格的射频工程师的要求…

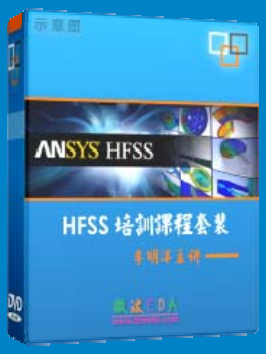
课程网址：http://www.edatop.com/peixun/rfe/110.html

ADS 学习培训课程套装



该套装是迄今国内最全面、最权威的 ADS 培训教程，共包含 10 门 ADS 学习培训课程。课程是由具有多年 ADS 使用经验的微波射频与通信系统设计领域资深专家讲解，并多结合设计实例，由浅入深、详细而又全面地讲解了 ADS 在微波射频电路设计、通信系统设计和电磁仿真设计方面的内容。能让您在最短的时间内学会使用 ADS，迅速提升个人技术能力，把 ADS 真正应用到实际研发工作中去，成为 ADS 设计专家...

课程网址： http://www.edatop.com/peixun/ads/13.html



HFSS 学习培训课程套装

该套课程套装包含了本站全部 HFSS 培训课程，是迄今国内最全面、最专业的 HFSS 培训教程套装，可以帮助您从零开始，全面深入学习 HFSS 的各项功能和在多个方面的工程应用。购买套装，更可超值赠送 3 个月免费学习答疑，随时解答您学习过程中遇到的棘手问题，让您的 HFSS 学习更加轻松顺畅…

课程网址：http://www.edatop.com/peixun/hfss/11.html

CST 学习培训课程套装

该培训套装由易迪拓培训联合微波 EDA 网共同推出，是最全面、系统、专业的 CST 微波工作室培训课程套装，所有课程都由经验丰富的专家授课，视频教学，可以帮助您从零开始，全面系统地学习 CST 微波工作的各项功能及其在微波射频、天线设计等领域的设计应用。且购买该套装，还可超值赠送 3 个月免费学习答疑…

课程网址：http://www.edatop.com/peixun/cst/24.html

HFSS 天线设计培训课程套装

套装包含 6 门视频课程和 1 本图书，课程从基础讲起，内容由浅入深，理论介绍和实际操作讲解相结合，全面系统的讲解了 HFSS 天线设计的全过程。是国内最全面、最专业的 HFSS 天线设计课程，可以帮助您快速学习掌握如何使用 HFSS 设计天线，让天线设计不再难…

课程网址：http://www.edatop.com/peixun/hfss/122.html

13.56MHz NFC/RFID 线圈天线设计培训课程套装

套装包含 4 门视频培训课程，培训将 13.56MHz 线圈天线设计原理和仿真设计实践相结合，全面系统地讲解了 13.56MHz 线圈天线的工作原理、设计方法、设计考量以及使用 HFSS 和 CST 仿真分析线圈天线的具体操作，同时还介绍了 13.56MHz 线圈天线匹配电路的设计和调试。通过该套课程的学习，可以帮助您快速学习掌握 13.56MHz 线圈天线及其匹配电路的原理、设计和调试…

详情浏览：http://www.edatop.com/peixun/antenna/116.html

我们的课程优势：

※ 成立于 2004 年，10 多年丰富的行业经验，

※ 一直致力并专注于微波射频和天线设计工程师的培养，更了解该行业对人才的要求

※ 经验丰富的一线资深工程师讲授，结合实际工程案例，直观、实用、易学

联系我们：

※ 易迪拓培训官网：http://www.edatop.com

※ 微波 EDA 网：http://www.mweda.com

※ 官方淘宝店：http://shop36920890.taobao.com