DATA SHEET

TDA3668AT
Very low dropout voltage/quiescent current 5 V regulator with overvoltage switch off

Preliminary specification
Supersedes data of 1999 Nov 23
File under Integrated Circuits, IC01

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Philips
Semiconductors

PHILIPS

Very low dropout voltage/quiescent current 5 V regulator with overvoltage switch off

TDA3668AT

FEATURES

- Fixed 5 V, 100 mA regulator
- Supply voltage range up to 50 V
- Very low quiescent current of 15 μA (typical value)
- Very low dropout voltage
- High ripple rejection
- Very high stability
  - Electrolytic capacitors: Equivalent Series Resistance (ESR) < 38 Ω at I_{REG} ≤ 25 mA
  - Other capacitors: 100 nF at 200 μA ≤ I_{REG} ≤ 100 mA.
- Pin compatible family TDA3661 to TDA3676
- Protections:
  - Reverse polarity safe (down to –25 V without high reverse current)
  - Negative transient of 50 V (R_S = 10 Ω, t < 100 ms)
  - Able to withstand voltages up to 18 V at the output (supply line may be short-circuited)
  - ESD protected for all pins
  - DC short-circuit safe to ground and V_P of regulator output
  - Temperature protection at T_j > 150 °C
  - Load dump protection, which will switch off V_{REG} during load dump.

GENERAL DESCRIPTION

The TDA3668AT is a fixed 5 V voltage regulator with a very low dropout voltage and quiescent current, which operates over a wide supply voltage range.

The regulator should use a supply voltage of V_P ≤ 50 V. It has a temperature range of –40 °C ≤ T_{amb} ≤ +125 °C, and it is available as an automotive version in an SO8 package.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply						
V_P	supply voltage	regulator on	3	14.4	24	V
		load dump; t ≤ 50 ms; t_r ≥ 2.5 ms	–	–	50	V
I_q	quiescent supply current	V_P = 14.4 V; I_{REG} = 0 mA	–	15	30	μA
Regulator output						
V_{REG}	output voltage	8 V ≤ V_P ≤ 22 V; I_{REG} = 0.5 mA	4.8	5.0	5.2	V
		6 V ≤ V_P ≤ 24 V; I_{REG} = 0.5 mA; T_{amb} ≤ 125 °C	4.75	5.0	5.25	V
		V_P = 14.4 V; 0.5 mA ≤ I_{REG} ≤ 100 mA; T_{amb} ≤ 125 °C	4.75	5.0	5.25	V
$V_{REG(drop)}$	dropout voltage	V_P = 4.5 V; I_{REG} = 50 mA	–	0.18	0.3	V

ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
TDA3668AT	SO8	plastic small outline package; 8 leads; body width 3.9 mm	SOT96-1

BLOCK DIAGRAM

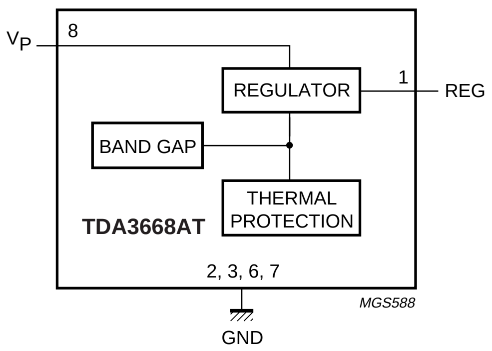


Fig.1 Block diagram.

PINNING

SYMBOL	PIN	DESCRIPTION
REG	1	regulator output
GND	2, 3, 6, and 7	ground; note 1
n.c.	4 and 5	not connected
V_P	8	supply voltage

Note

1. For the SO8 package all GND pins are connected to the lead frame and can also be used to reduce the total thermal resistance $R_{th(j-a)}$ by soldering these pins to a ground plane. The ground plane on the top side of the Printed-Circuit Board (PCB) acts like a heat spreader.

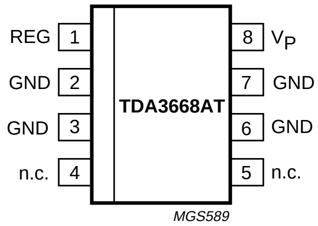


Fig.2 Pin configuration.

FUNCTIONAL DESCRIPTION

The TDA3668AT is a fixed 5 V regulator which can deliver output currents up to 100 mA. The regulator is available in an SO8 package. The regulator is intended for portable, mains, telephone and automotive applications.
To increase the lifetime of batteries, a specially built-in clamp circuit keeps the quiescent current of this regulator very low, also in dropout and full load conditions.

The regulator remains operational down to very low supply voltages and at lower voltages it switches off.

A temperature protection circuit is included, which switches off the regulator output at a junction temperature above 150 °C.

A new output circuit guarantees the stability of the regulator for a capacitor output circuit with an ESR up to 38 Ω. This is very attractive as the ESR of an electrolytic capacitor increases strongly at low temperatures (no expensive tantalum capacitor is required).

A load dump circuit (see Fig.3) and an overvoltage protection circuit is built-in which will switch off the IC above 28 V (typical value).

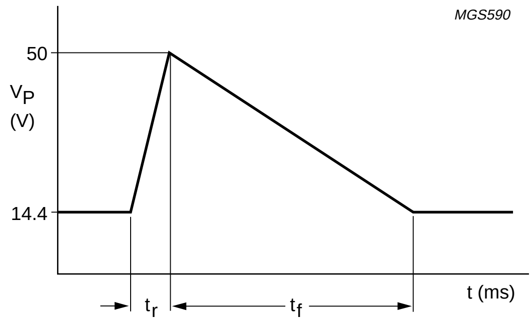


Fig.3 Load dump pulse.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_P	supply voltage	operating	–	24	V
		load dump	–	50	V
$V_{P(rp)}$	reverse polarity supply voltage	non-operating	–	–25	V
P_{tot}	total power dissipation	temperature of PCB ground plane is 25 °C	–	4.1	W
T_{stg}	storage temperature	non-operating	–55	+150	°C
T_{amb}	ambient temperature		–40	+125	°C
T_j	junction temperature	operating	–40	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air; soldered	125	K/W
$R_{th(j-c)}$	thermal resistance from junction to case	to centre pins; soldered	30	K/W

QUALITY SPECIFICATION

In accordance with *“SNW-FQ-611E”*.

CHARACTERISTICS

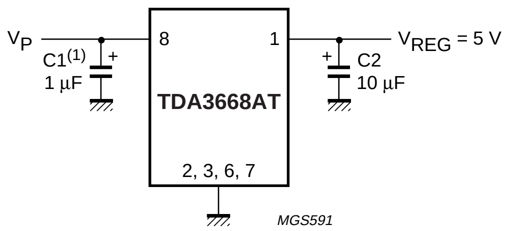
V_P = 14.4 V; T_{amb} = 25 °C; measured in test circuit of Fig.4; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply voltage: pin V_P						
V_P	supply voltage	regulator operating; note 1	3	14.4	24	V
		load dump; $t_f \leq 50$ ms; $t_r \geq 2.5$ ms	–	–	50	V
		overvoltage protection; regulator switched off	24	28	–	V
I_q	quiescent current	V_P = 4.5 V; I_{REG} = 0 mA	–	10	–	µA
		V_P = 14.4 V; I_{REG} = 0 mA	–	15	30	µA
		6 V ≤ V_P ≤ 22 V; I_{REG} = 10 mA	–	0.2	0.5	mA
		6 V ≤ V_P ≤ 22 V; I_{REG} = 50 mA	–	1.4	2.5	mA
Regulator output: pin REG; note 2						
V_{REG}	output voltage	8 V ≤ V_P ≤ 22 V; I_{REG} = 0.5 mA	4.8	5.0	5.2	V
		6 V ≤ V_P ≤ 24 V; I_{REG} = 0.5 mA; T_{amb} ≤ 125 °C	4.75	5.0	5.25	V
		0.5 mA ≤ I_{REG} ≤ 100 mA; T_{amb} ≤ 125 °C	4.75	5.0	5.25	V
$V_{REG(drop)}$	dropout voltage	V_P = 4.5 V; I_{REG} = 50 mA; T_{amb} ≤ 85 °C	–	0.18	0.3	V
$V_{REG(stab)}$	long-term stability voltage		–	20	–	mV/1000 h
$\Delta V_{REG(line)}$	line input regulation voltage	8 V ≤ V_P ≤ 22 V; I_{REG} = 0.5 mA	–	1	30	mV
		7 V ≤ V_P ≤ 22 V; I_{REG} = 0.5 mA; T_{amb} ≤ 85 °C	–	1	50	mV
$\Delta V_{REG(load)}$	load output regulation voltage	0.5 mA ≤ I_{REG} ≤ 50 mA; T_{amb} ≤ 125 °C	–	10	50	mV
SVRR	supply voltage ripple rejection	$f_{P(ripple)}$ = 120 Hz; $V_{P(ripple)(rms)}$ = 1 V; I_{REG} = 0.5 mA	50	60	–	dB
$I_{REG(crl)}$	current limit	V_{REG} > 4.5 V	0.17	0.25	–	A
$I_{LO(rp)}$	output leakage current at reverse polarity	V_P = –15 V; V_{REG} ≤ 0.3 V	–	1	500	µA

Notes

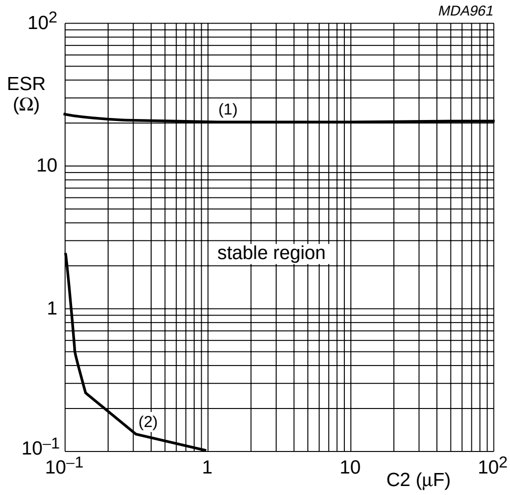
1. The regulator output will follow V_P if $V_P < V_{REG} + V_{REG(drop)}$.
2. Limiting values as applicable for device type: V_P ≤ 50 V and –40 °C ≤ T_{amb} ≤ +125 °C.

TEST AND APPLICATION INFORMATION



(1) C1 is optional (to minimize supply noise only).

Fig.4 Test circuit.



(1) Maximum ESR at 200 μA ≤ I_{REG} ≤ 100 mA.

(2) Minimum ESR only when I_{REG} ≤ 200 μA.

Fig.5 Curve for selecting the value of the output capacitor.

Noise

The output noise is determined by the value of the output capacitor. The noise figure is measured at a bandwidth of 10 Hz to 100 kHz (see Table 1).

Table 1 Noise figures

OUTPUT CURRENT I_{REG} (mA)	NOISE FIGURE (μV)		
	C2 = 10 μF	C2 = 47 μF	C2 = 100 μF
0.5	550	320	300
50	650	400	400

Stability

The regulator is stabilized with an external capacitor connected to the output. The value of this capacitor can be selected using the diagrams shown in Figs 5 and 6.

The following four examples show the effects of the stabilization circuit using different values for the output capacitor.

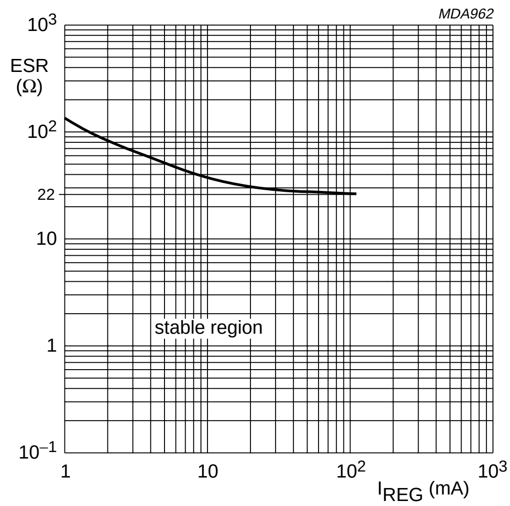


Fig.6 ESR as a function of I_{REG} for selecting the value of the output capacitor.

EXAMPLE 1

The regulator is stabilized with an electrolytic capacitor of 68 µF (ESR = 0.5 Ω). At T_{amb} = –40 °C, the capacitor value is decreased to 22 µF and the ESR is increased to 3.5 Ω. The regulator will remain stable at a temperature of T_{amb} = –40 °C.

EXAMPLE 2

The regulator is stabilized with an electrolytic capacitor of 10 µF (ESR = 3.3 Ω). At T_{amb} = –40 °C, the capacitor value is decreased to 3 µF and the ESR is increased to 20 Ω. The regulator will remain stable at a temperature of T_{amb} = –40 °C.

EXAMPLE 3

The regulator is stabilized with a 100 nF MKT capacitor connected to the output. Full stability is guaranteed when the output current is larger then 200 µA. Because the thermal influence on this capacitor value is almost zero, the regulator will remain stable at a temperature of T_{amb} = –40 °C.

EXAMPLE 4

The regulator is stabilized with a 100 nF capacitor in parallel with an electrolytic capacitor of 10 µF connected to the output.

The regulator is now stable under all conditions and independent of:

- The ESR of the electrolytic capacitor
- The value of the electrolytic capacitor
- The output current.

Application circuits

The maximum output current of the regulator equals:

$$I_{REG(max)} = \frac{150 - T_{amb}}{R_{th(j-a)} \times (V_P - V_{REG})}$$

$$= \frac{150 - T_{amb}}{100 \times (V_P - 5)}\ \text{(mA)}$$

When T_{amb} = 21 °C and V_P = 14 V the maximum output current equals 140 mA.

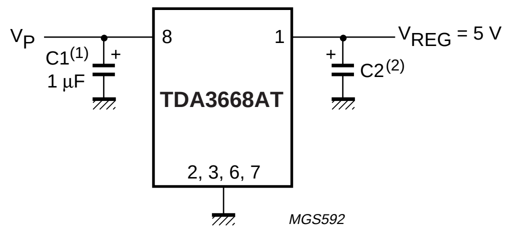
For successful operation of the IC (maximum output current capability) special attention has to be given to the PCB ground plane required as heatsink, the thermal capacity of the heatsink and its ability to transfer heat to the external environment. For the SO8 package it is possible to reduce the total thermal resistance from 125 to 50 K/W.

APPLICATION CIRCUIT WITH BACKUP FUNCTION

Sometimes a backup function is needed to supply, for example, a microcontroller for a short period of time when the supply voltage spikes to 0 V (or even –1 V).

This function can easily be built with the TDA3668AT by using an output capacitor with a large value. When the supply voltage is 0 V (or –1 V), only a small current will flow into pin REG from this output capacitor (a few µA).

The application circuit is given in Fig.7.



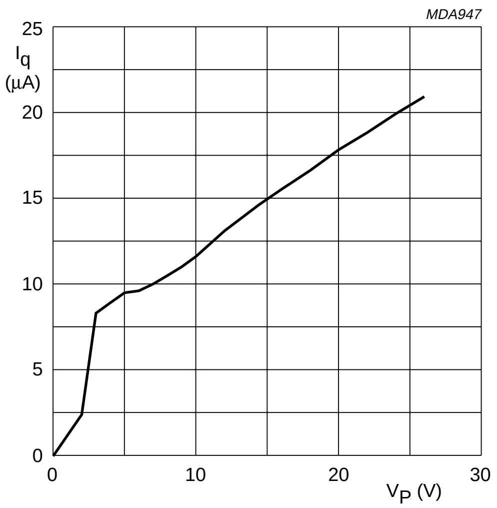
(1) C1 is optional (to minimize supply noise only).

(2) C2 ≤ 4700 µF.

Fig.7 Application circuit with backup function.

Additional application information

This section gives typical curves for various parameters measured on the TDA3668AT. Standard test conditions are: V_P = 14.4 V; T_{amb} = 25 °C.



I_{REG} = 0 mA.

Fig.8 Quiescent current as a function of the supply voltage.

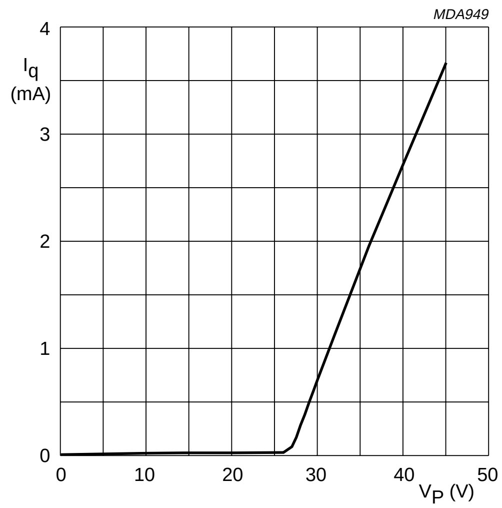
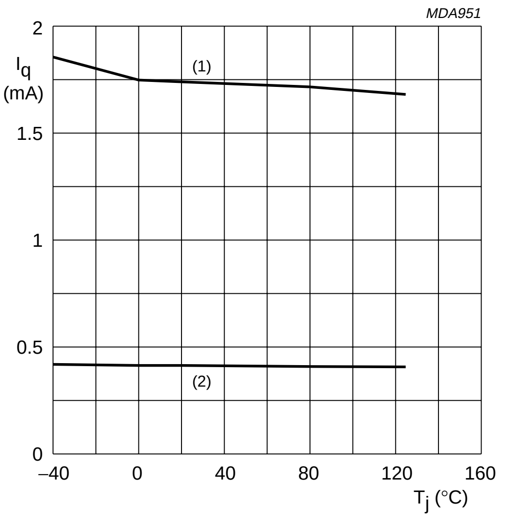
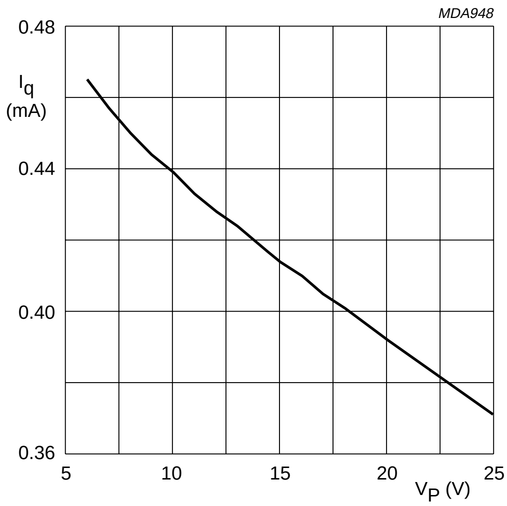


Fig.9 Quiescent current increase as a function of high supply voltage.



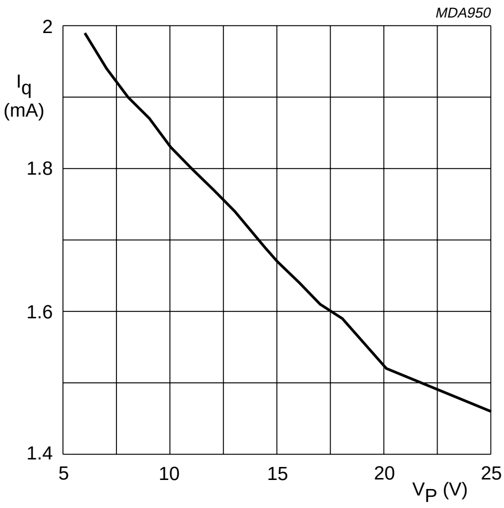
(1) I_q at 50 mA load.
(2) I_q at 10 mA load.

Fig.10 Quiescent current as a function of the junction temperature.



I_{REG} = 10 mA.

Fig.11 Quiescent current as a function of the supply voltage.



I_{REG} = 50 mA.

Fig.12 Quiescent current as a function of the supply voltage.

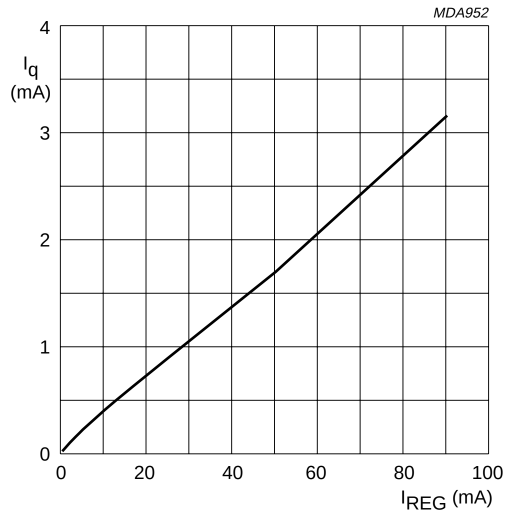
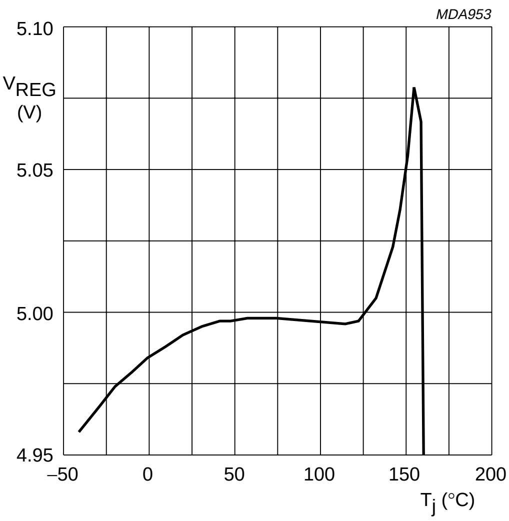
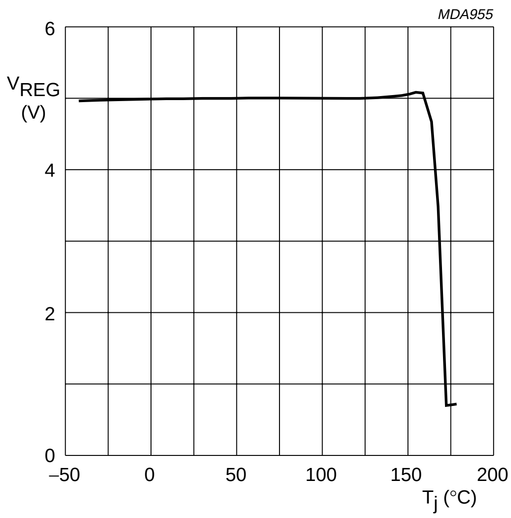


Fig.13 Quiescent current as a function of the output current.



I_{REG} = 0 mA.

Fig.14 Output voltage as a function of the junction temperature.



I_{REG} = 0 mA.

Fig.15 Output voltage thermal protection as a function of the junction temperature.

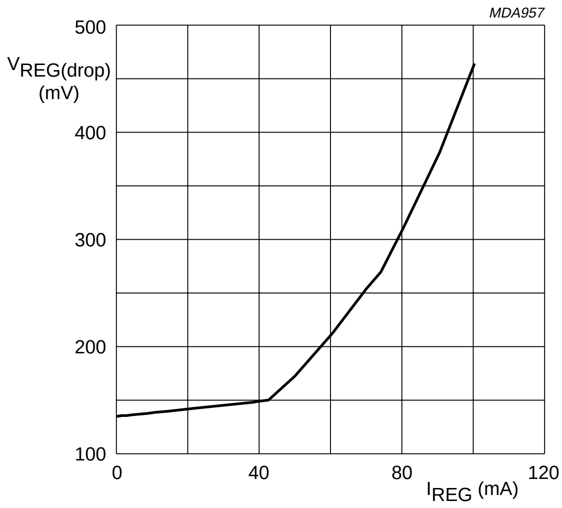
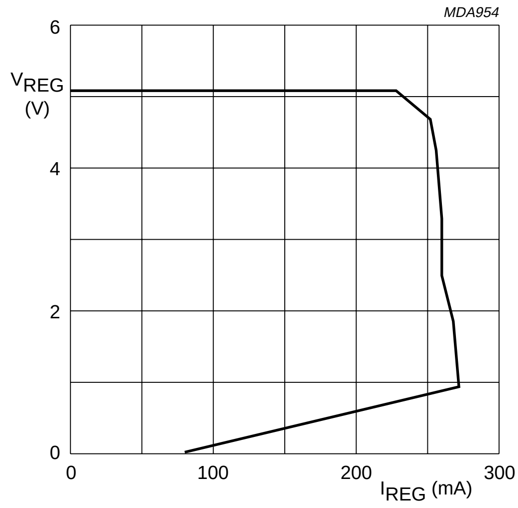
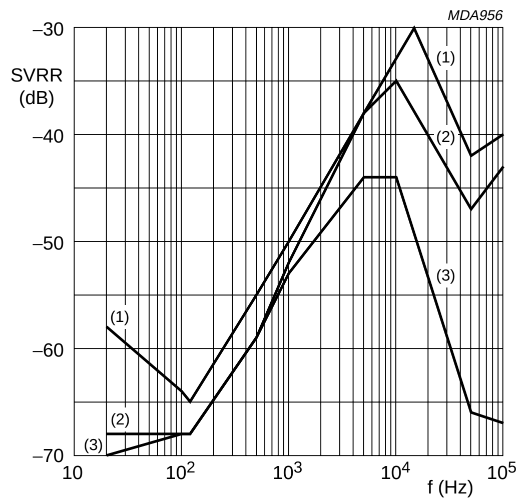


Fig.16 Dropout voltage as a function of the output current.



V_P = 8 V with pulsed load.

Fig.17 Fold back protection mode.

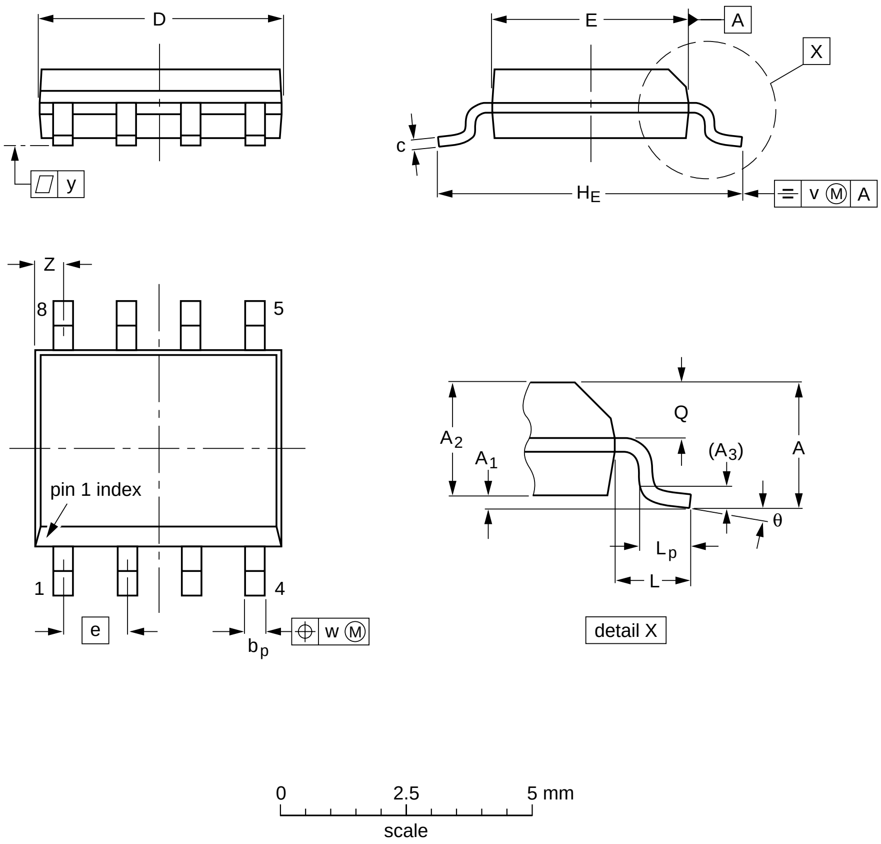


I_{REG} = 10 mA; C2 = 10 μF.
(1) SVRR at R_L = 100 Ω.
(2) SVRR at R_L = 500 Ω.
(3) SVRR at R_L = 10 kΩ.

Fig.18 SVRR as a function of the ripple frequency.

PACKAGE OUTLINE

SO8: plastic small outline package; 8 leads; body width 3.9 mm **SOT96-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (2)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8^o 0^o
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT96-1	076E03	MS-012				~~97-05-22~~ 99-12-27

SOLDERING

Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, infrared/convection heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferable be kept below 230 °C.

Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
  – larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
  – smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

  The footprint must incorporate solder thieves at the downstream end.
- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250 °C.
A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

Suitability of surface mount IC packages for wave and reflow soldering methods

PACKAGE	SOLDERING METHOD	
	WAVE	REFLOW(1)
BGA, LFBGA, SQFP, TFBGA	not suitable	suitable
HBCC, HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, SMS	not suitable(2)	suitable
PLCC(3), SO, SOJ	suitable	suitable
LQFP, QFP, TQFP	not recommended(3)(4)	suitable
SSOP, TSSOP, VSO	not recommended(5)	suitable

Notes

1. All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the *"Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods"*.
2. These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
3. If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
4. Wave soldering is only suitable for LQFP, TQFP and QFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
5. Wave soldering is only suitable for SSOP and TSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

NOTES

NOTES

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