

# DATA SHEET

## **TDA3665**

Very low dropout voltage/quiescent  
current 8.5 V voltage regulator

Preliminary specification  
File under Integrated Circuits, IC01

2000 Apr 25

# Very low dropout voltage/quiescent current 8.5 V voltage regulator

## TDA3665

### FEATURES

- Fixed 8.5 V, 100 mA regulator
- Supply voltage range up to 33 V (45 V)
- Very low quiescent current of 15  $\mu$ A (typical value)
- Very low dropout voltage
- High ripple rejection
- Very high stability:
  - Electrolytic capacitors: Equivalent Series Resistance (ESR) < 30  $\Omega$  at  $I_{REG} \leq 25$  mA (see Fig.6)
  - Other capacitors: 100 nF at  $200 \mu\text{A} \leq I_{REG} \leq 100$  mA.
- Pin compatible family TDA3662 to TDA3666
- Protections:
  - Reverse polarity safe (down to –25 V without high reverse current)
  - Negative transient of 50 V ( $R_S = 10 \Omega$  and  $t < 100$  ms)
  - Able to withstand voltages up to 18 V at the output (supply line may be short-circuited)

- ESD protection on all pins
- DC short-circuit safe to ground and  $V_P$  of the regulator output
- Temperature protection (at  $T_j > 150$  °C).

### GENERAL DESCRIPTION

The TDA3665 is a fixed 8.5 V voltage regulator with a very low dropout voltage and quiescent current, which operates over a wide supply voltage range.

The IC is available as:

- TDA3665:  $V_P \leq 45$  V,  $-40$  °C  $\leq T_{amb} \leq +125$  °C and SO4 package (automotive)
- TDA3665AT:  $V_P \leq 45$  V,  $-40$  °C  $\leq T_{amb} \leq +125$  °C and SO8 package (automotive).

### QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Supply</b>						
$V_P$	supply voltage	regulator on				
	TDA3665		3	14.4	45	V
	TDA3665AT		3	14.4	45	V
$I_q$	quiescent supply current	$V_P = 14.4$ V; $I_{REG} = 0$ mA	–	15	30	$\mu$ A
<b>Voltage regulator</b>						
$V_{REG}$	output voltage	$11.5 \text{ V} \leq V_P \leq 22 \text{ V}$ ; $I_{REG} = 0.5$ mA	8.08	8.5	8.92	V
		$11.5 \text{ V} \leq V_P \leq 45 \text{ V}$ ; $I_{REG} = 0.5$ mA	8.0	8.5	9.0	V
		$V_P = 14.4$ V; $0.5 \text{ mA} \leq I_{REG} \leq 100$ mA	8.0	8.5	9.0	V
$V_{REG(drop)}$	dropout voltage	$V_P = 7.9$ V; $I_{REG} = 50$ mA; $T_{amb} \leq 85$ °C	–	0.18	0.3	V

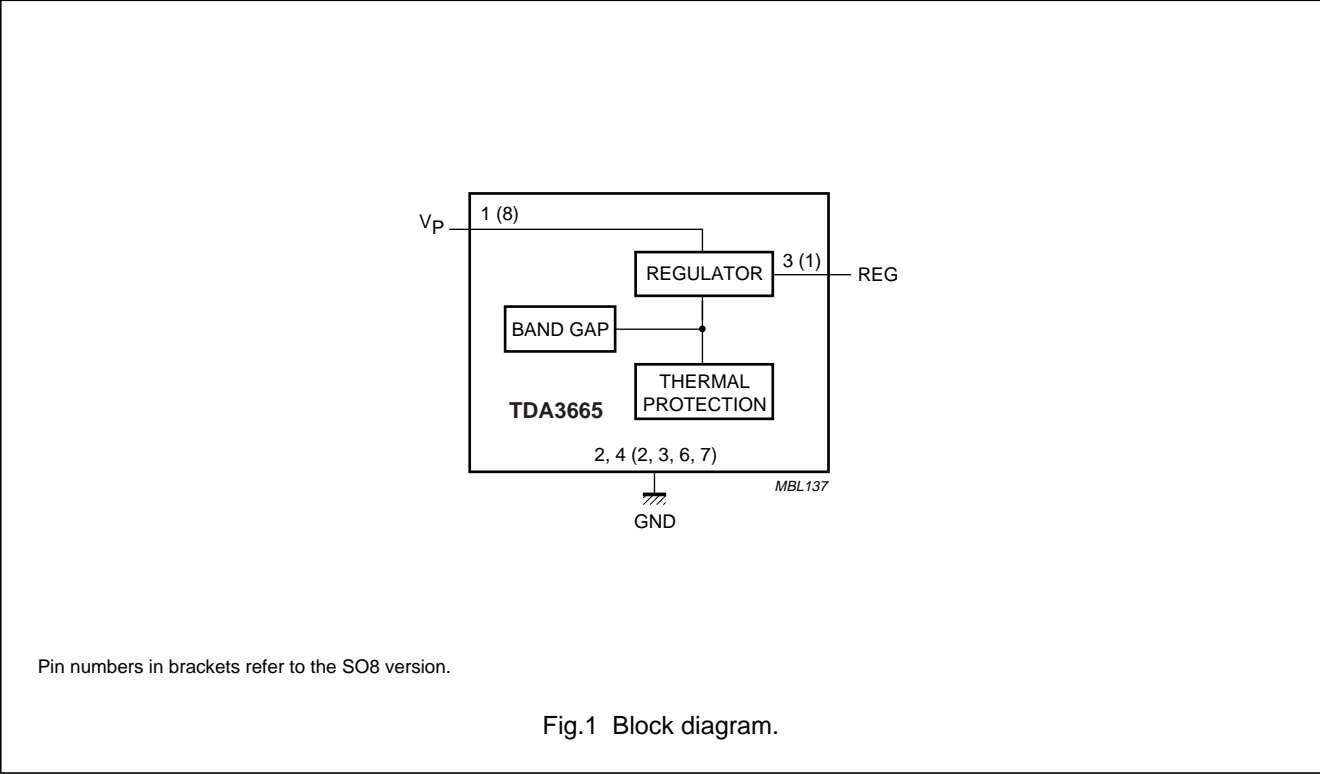
### ORDERING INFORMATION

TYPE NUMBER	PACKAGES		
	NAME	DESCRIPTION	VERSION
TDA3665	SO4	plastic small outline package; 4 leads; body width 3.5 mm	SOT223-1
TDA3665AT	SO8	plastic small outline package; 8 leads; body width 3.9 mm	SOT96-1

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BLOCK DIAGRAM



PINNING

SYMBOL	PIN		DESCRIPTION
	SO4	SO8	
V <sub>P</sub>	1	8	supply voltage
GND	2 and 4	2, 3, 6 and 7	ground; note 1
REG	3	1	regulator output
n.c.	—	4 and 5	not connected

Note

- For the SO8 package all pins GND 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 PCB acts like a heat spreader.

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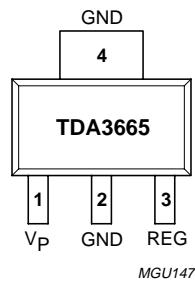


Fig.2 Pin configuration of SO4.

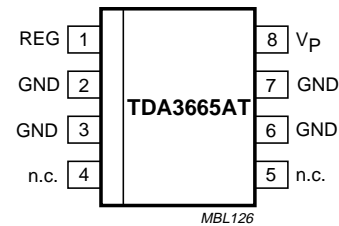


Fig.3 Pin configuration of SO8.

## FUNCTIONAL DESCRIPTION

The TDA3665 is a fixed 8.5 V regulator which can deliver output currents up to 100 mA. The regulator is available in SO8 and SO4 packages. 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 below this voltage 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 22  $\Omega$  (see Figs 5 and 6). This is very attractive as the ESR of an electrolytic capacitor increases strongly at low temperatures (no expensive tantalum capacitor is required).

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## LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_P$	supply voltage				
	TDA3665		–	45	V
	TDA3665AT		–	45	V
$V_{P(rp)}$	reverse polarity supply voltage	non-operating	–	–25	V
$P_{tot}$	total power dissipation				
	TDA3665AT	temperature of copper area is 25 °C	–	4.1	W
	TDA3665	$T_{amb} = 25\text{ °C}$	–	5	W
$T_{stg}$	storage temperature	non-operating	–55	+150	°C
$T_{amb}$	ambient temperature	operating			
	TDA3665		–40	+125	°C
	TDA3665AT		–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			
	SO8	in free air; soldered in	125	K/W
	SO4	in free air; soldered in	100	K/W
$R_{th(j-c)}$	thermal resistance from junction to case			
	SO8	to centre pins; soldered in	30	K/W
	SO4	in free air	25	K/W

## QUALITY SPECIFICATION

In accordance with “SNW-FQ-611E”.

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## CHARACTERISTICS

$V_P = 14.4\text{ V}$ ;  $T_{\text{amb}} = 25\text{ °C}$ ; measured with test circuit (see Fig.4); unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply voltage: pin V <sub>P</sub>						
V <sub>P</sub>	supply voltage	regulator operating; note 1				
	TDA3665		3	14.4	45	V
	TDA3665AT		3	14.4	45	V
I <sub>q</sub>	quiescent supply current	V <sub>P</sub> = 4.5 V; I <sub>REG</sub> = 0 mA	–	10	–	μA
		V <sub>P</sub> = 14.4 V; I <sub>REG</sub> = 0 mA	–	15	30	μA
		9.5 V ≤ V <sub>P</sub> ≤ 22 V; I <sub>REG</sub> = 10 mA	–	0.2	0.5	mA
		9.5 V ≤ V <sub>P</sub> ≤ 22 V; I <sub>REG</sub> = 50 mA	–	1.4	2.5	mA
Regulator output: pin REG; note 2						
V <sub>REG</sub>	output voltage	11.5 V ≤ V <sub>P</sub> ≤ to 22 V; I <sub>REG</sub> = 0.5 mA	8.08	8.5	8.92	V
		0.5 mA ≤ I <sub>REG</sub> ≤ 100 mA; T <sub>amb</sub> ≤ 125 °C	8.0	8.5	9.0	V
		9.5 V ≤ V <sub>P</sub> ≤ 45 V; I <sub>REG</sub> = 0.5 mA; T <sub>amb</sub> ≤ 125 °C	8.0	8.5	9.0	V
V <sub>REG(drop)</sub>	dropout voltage	V <sub>P</sub> = 7.9 V; T <sub>amb</sub> ≤ 85 °C; I <sub>REG</sub> = 50 mA	–	0.18	0.3	V
V <sub>REG(stab)</sub>	output voltage long-term stability		–	20	–	mV/1000 h
ΔV <sub>REG(line)</sub>	line input regulation voltage	10.5 V ≤ V <sub>P</sub> ≤ to 22 V; I <sub>REG</sub> = 0.5 mA	–	1	30	mV
		10.5 V ≤ V <sub>P</sub> ≤ 45 V; I <sub>REG</sub> = 0.5 mA; T <sub>amb</sub> ≤ 125 °C	–	1	50	mV
ΔV <sub>REG(load)</sub>	load output regulation voltage	0.5 mA ≤ I <sub>REG</sub> ≤ 50 mA	–	10	50	mV
SVRR	supply voltage ripple rejection	f <sub>i</sub> = 120 Hz; V <sub>i(ripple)</sub> = 1 V (RMS); I <sub>REG</sub> = 0.5 mA	50	60	–	dB
I <sub>REG(crl)</sub>	output current limit	V <sub>REG</sub> > 7.9 V	0.17	0.25	–	A
I <sub>LO(rp)</sub>	output leakage current at reverse polarity	V <sub>P</sub> = –15 V; V <sub>REG</sub> ≤ 0.3 V	–	1	500	μA

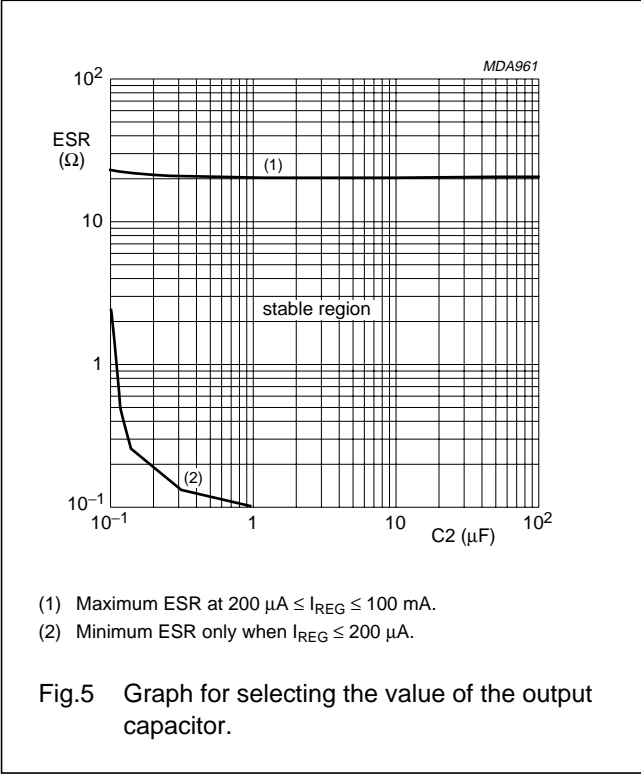
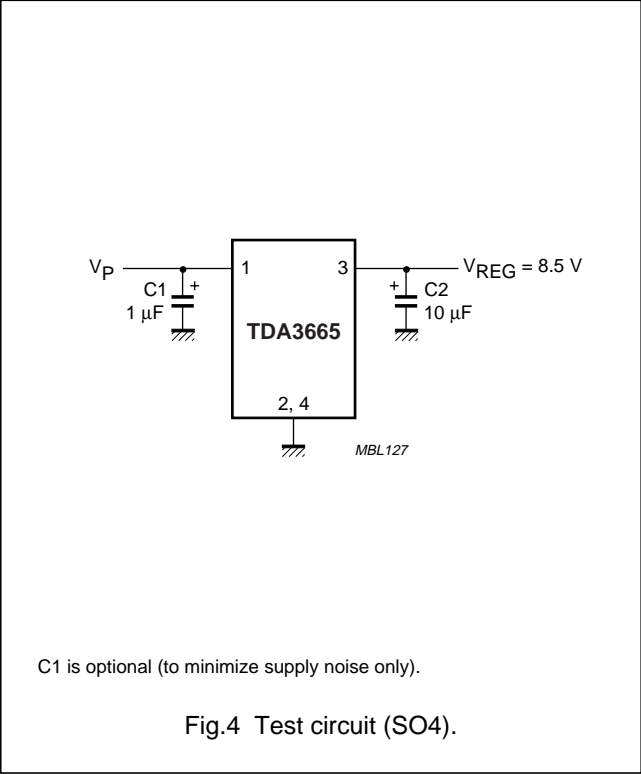
## Notes

1. The regulator output will follow  $V_P$  if  $V_P < V_{\text{REG}} + V_{\text{REG(drop)}}$ .
2. Limiting values as applicable for both device types:  $V_P \leq 45\text{ V}$  and  $-40\text{ °C} \leq T_{\text{amb}} \leq +125\text{ °C}$ .

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TEST AND APPLICATION INFORMATION



Noise

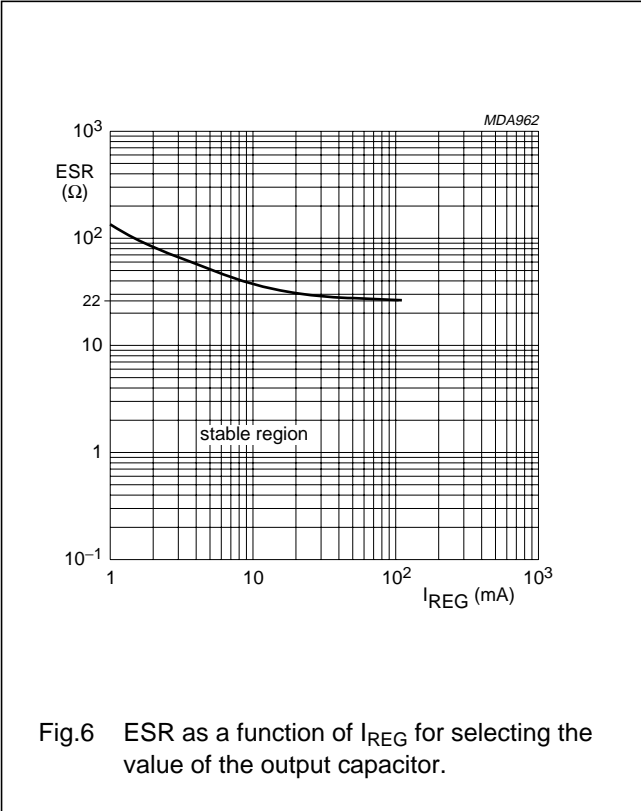
The output noise is determined by the value of the output capacitor. The noise figure is measured at a bandwidth of 10 Hz to 100 kHz (see Table 1).

Table 1 Noise figures

OUTPUT CURRENT $I_{\text{REG}}$ (mA)	NOISE FIGURE ( $\mu\text{V}$ )		
	C2 = 10 $\mu\text{F}$	C2 = 47 $\mu\text{F}$	C2 = 100 $\mu\text{F}$
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.



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### EXAMPLE 1

The regulator is stabilized with an electrolytic capacitor of 68  $\mu\text{F}$  (ESR = 0.5  $\Omega$ ). At  $T_{\text{amb}} = -40^\circ\text{C}$ , the capacitor value is decreased to 22  $\mu\text{F}$  and the ESR is increased to 3.5  $\Omega$ . The regulator will remain stable at a temperature of  $T_{\text{amb}} = -40^\circ\text{C}$ .

### EXAMPLE 2

The regulator is stabilized with an electrolytic capacitor of 10  $\mu\text{F}$  (ESR = 3.3  $\Omega$ ). At  $T_{\text{amb}} = -40^\circ\text{C}$ , the capacitor value is decreased to 3  $\mu\text{F}$  and the ESR is increased to 20  $\Omega$ . The regulator will remain stable at a temperature of  $T_{\text{amb}} = -40^\circ\text{C}$ .

### EXAMPLE 3

The regulator is stabilized with a 100 nF MKT capacitor connected to the output. When the output current is over 200  $\mu\text{A}$  full stability is guaranteed.

Because the thermal influence on the capacitor value is almost zero, the regulator will remain stable at a temperature of  $T_{\text{amb}} = -40^\circ\text{C}$ .

### EXAMPLE 4

The regulator is stabilized with a 100 nF capacitor in parallel with an electrolytic capacitor of 10  $\mu\text{F}$  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:

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

$$= \frac{150 - T_{\text{amb}}}{100 \times (V_{\text{P}} - 8.5)} (\text{mA})$$

When  $T_{\text{amb}} = 21^\circ\text{C}$  and  $V_{\text{P}} = 17.5\text{ V}$  the maximum output current equals 140 mA.

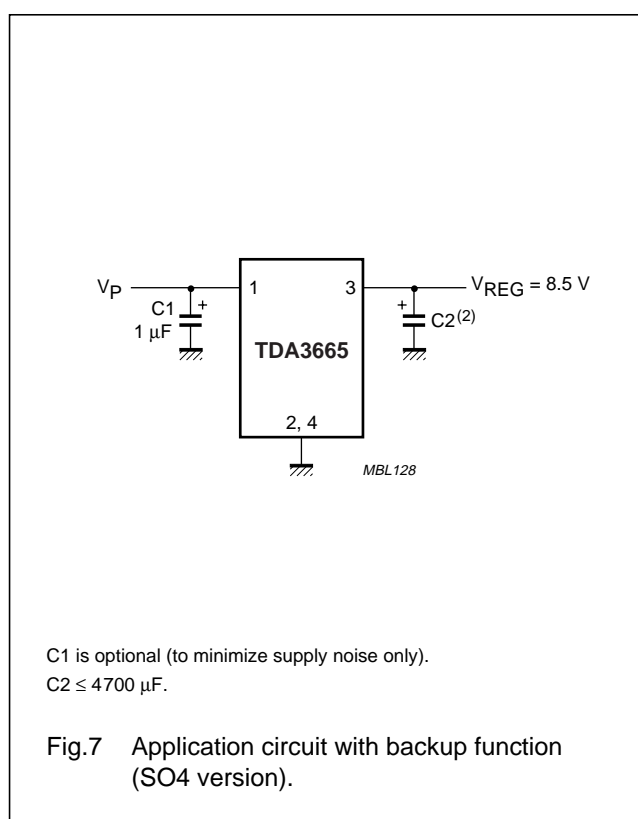
The total thermal resistance of the TDA3665 can be decreased from 125 to 50 K/W for the SO8 version. For the SO4 version it can be decreased from 100 to 40 K/W when GND pins 2 and 4 of the package are soldered to the printed-circuit board.

### 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  $-1\text{ V}$ ).

This function can easily be built with the TDA3665 by using an output capacitor with a large value. When the supply voltage is 0 V (or  $-1\text{ V}$ ), only a small current will flow into pin REG from this output capacitor (a few  $\mu\text{A}$ ).

The application circuit is given in Fig.7.



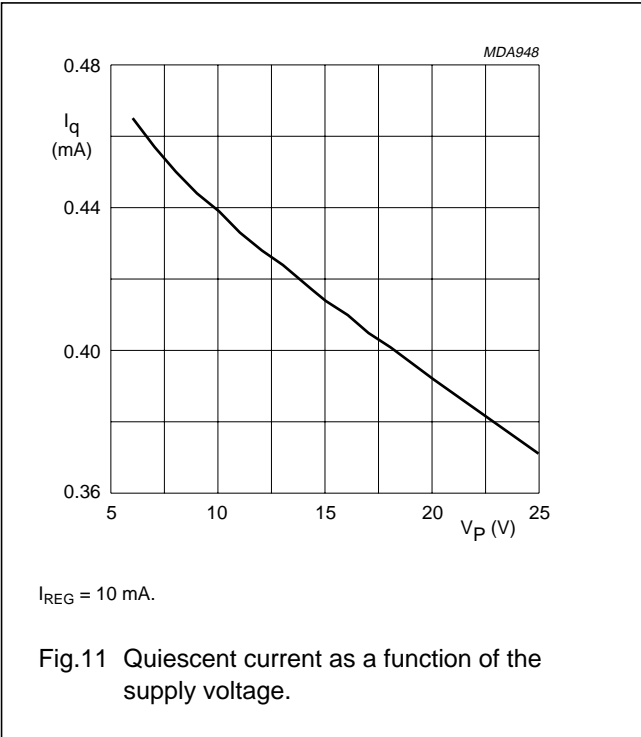
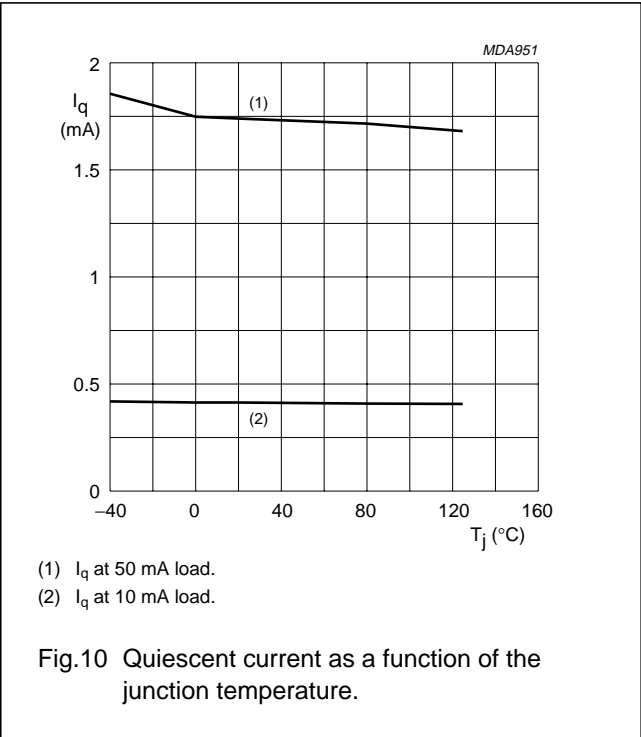
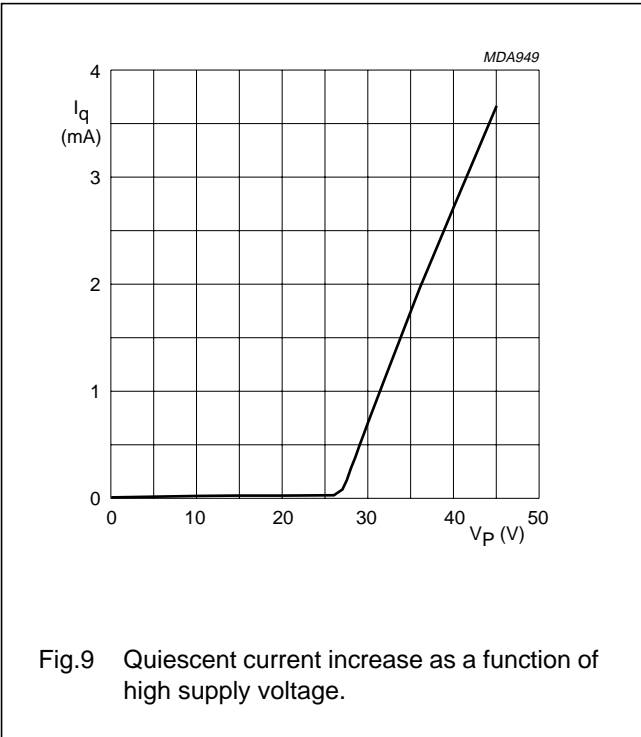
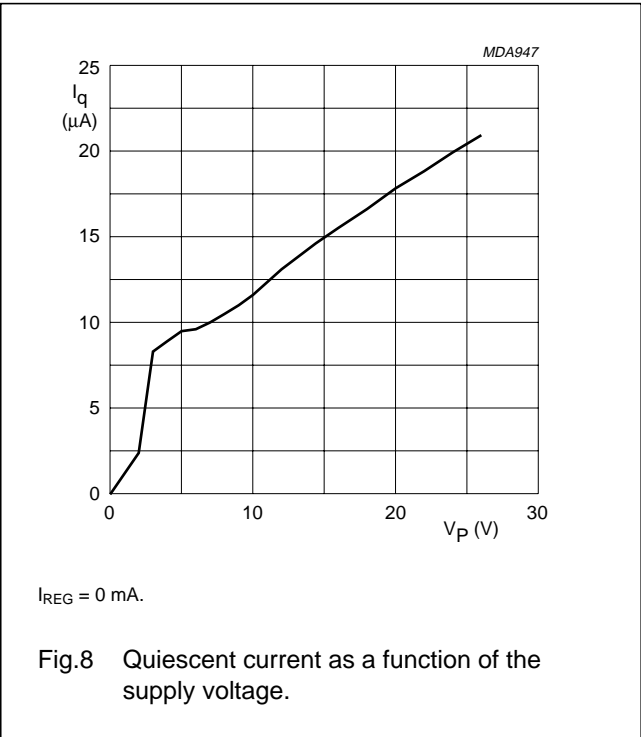


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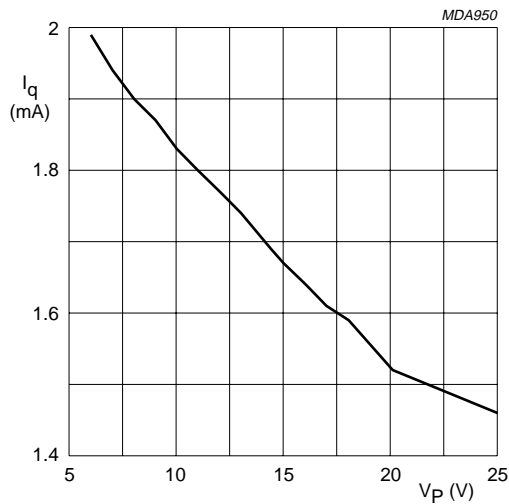
Additional application information

This section gives typical curves for various parameters measured on the TDA3665AT. Standard test conditions are:  
 $V_P = 14.4\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .



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$I_{REG} = 50\text{ mA}$ .

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

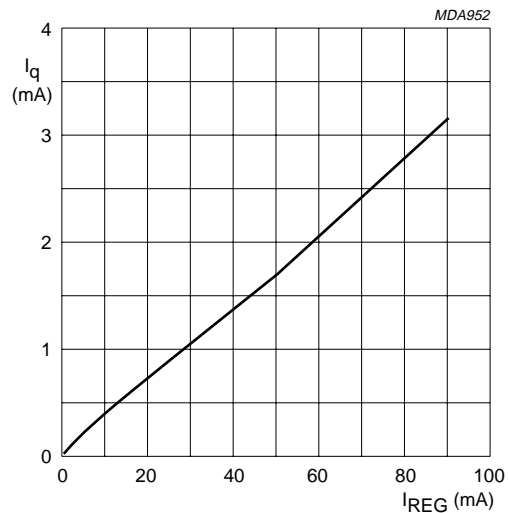
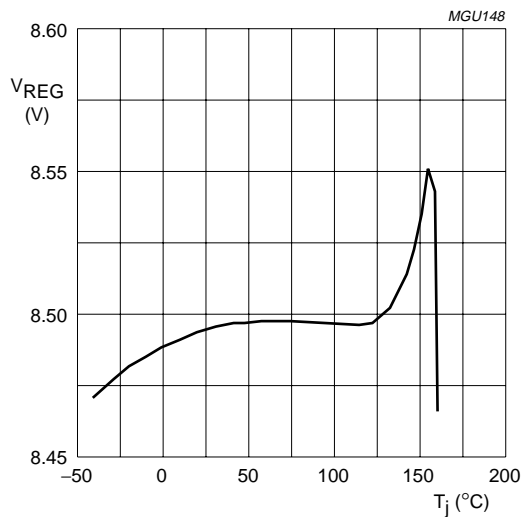
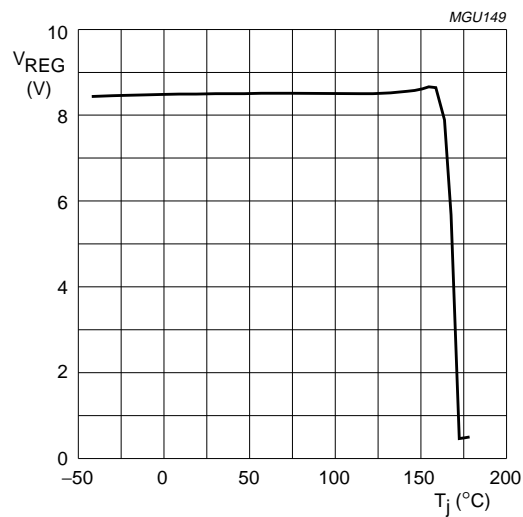


Fig.13 Quiescent current as a function of the output current.



$I_{REG} = 0\text{ mA}$ .

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

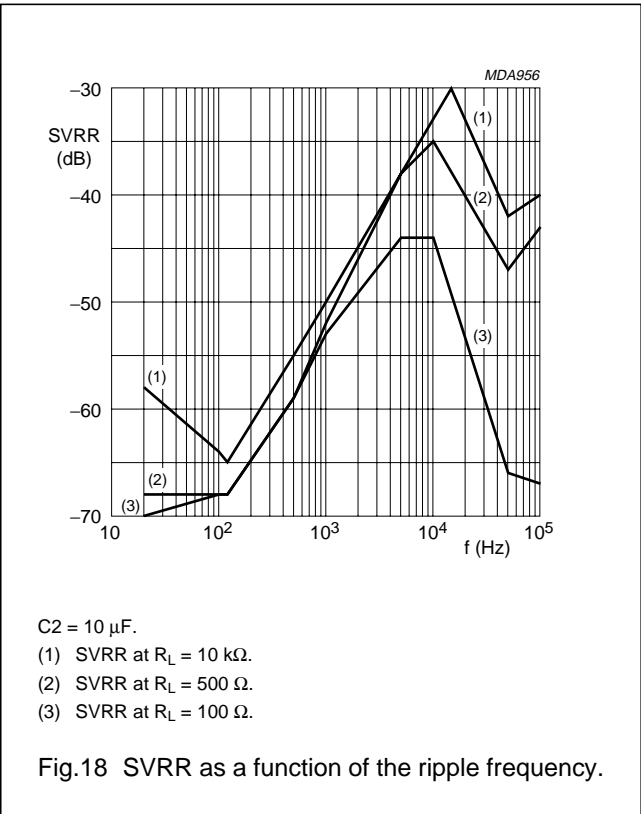
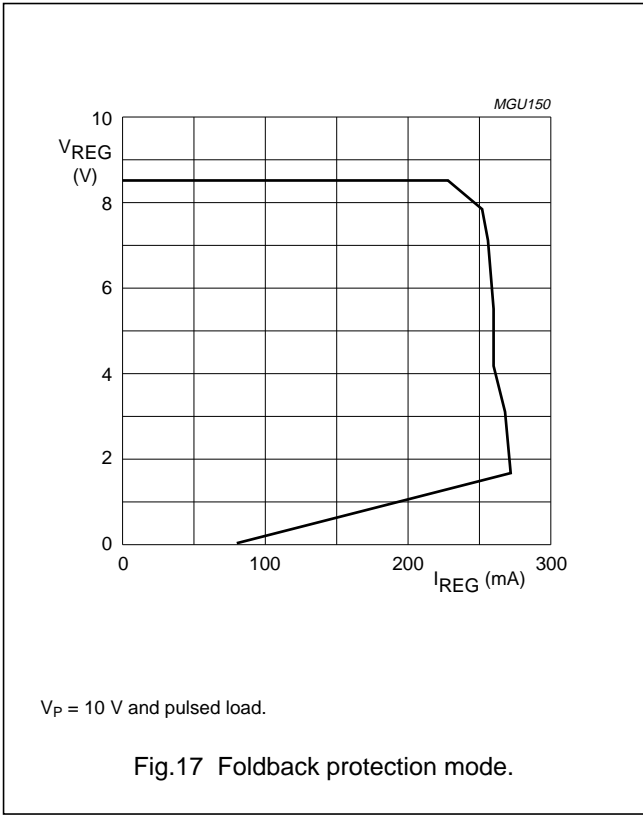
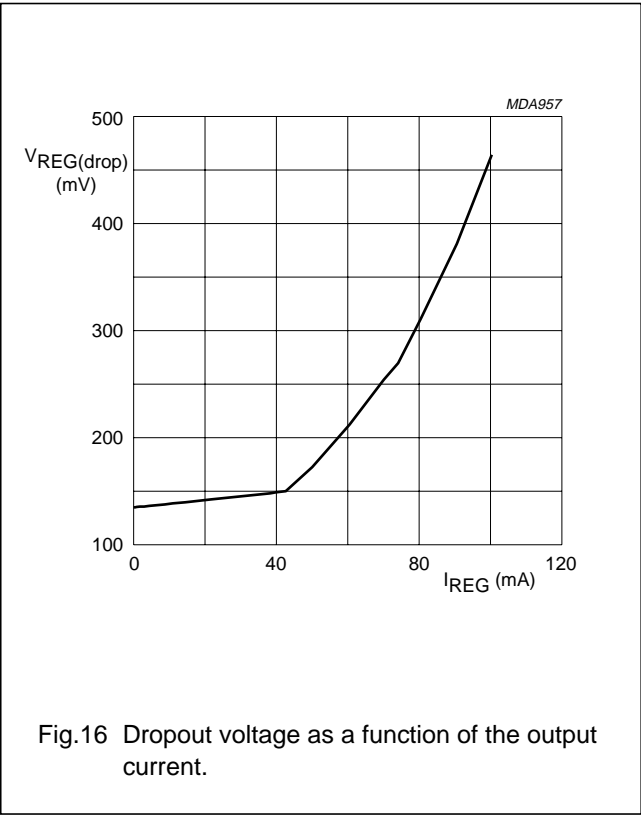


$I_{REG} = 0\text{ mA}$ .

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

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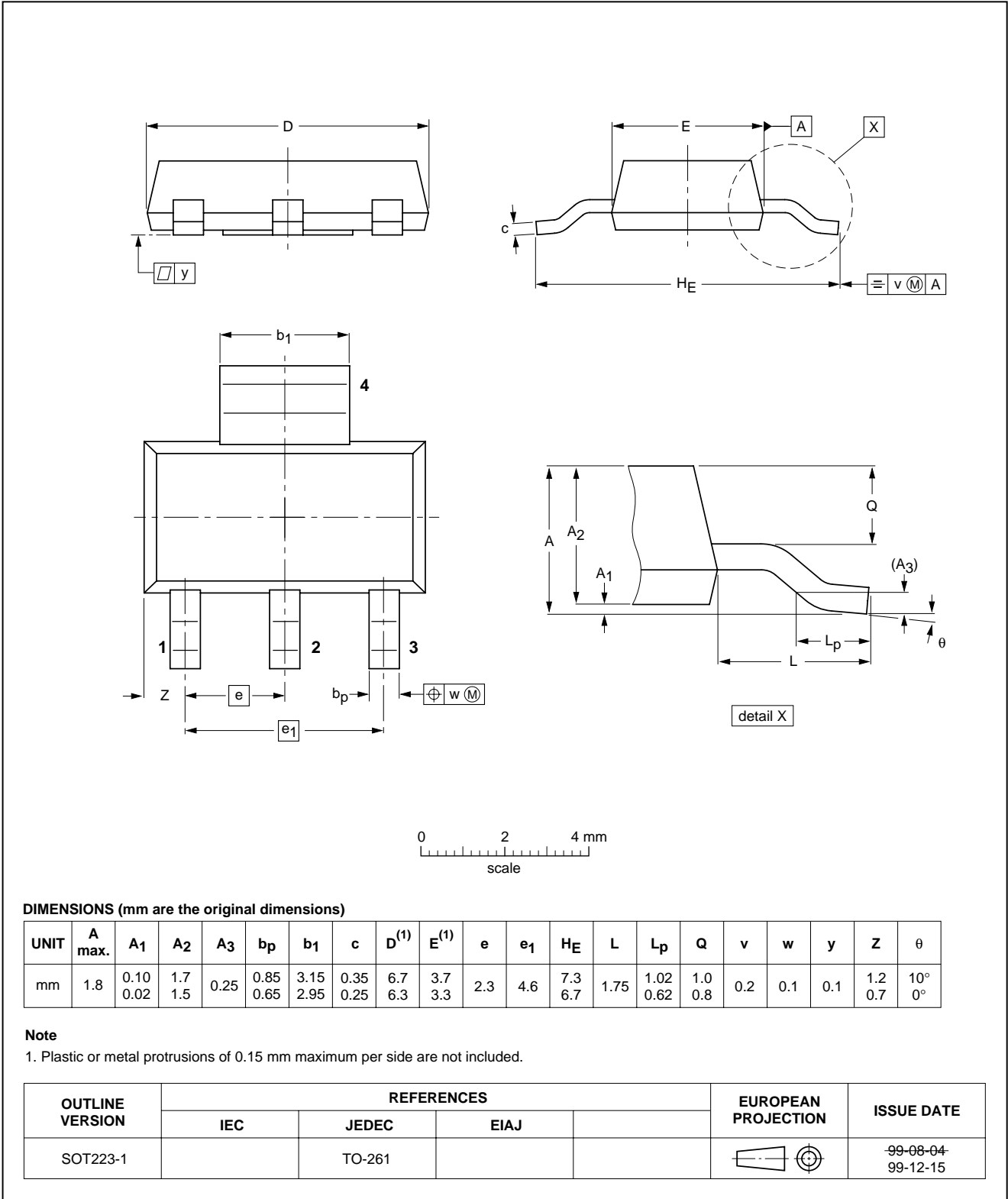
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PACKAGE OUTLINES

SO4: plastic small outline package; 4 leads; body width 3.5 mm

SOT223-1

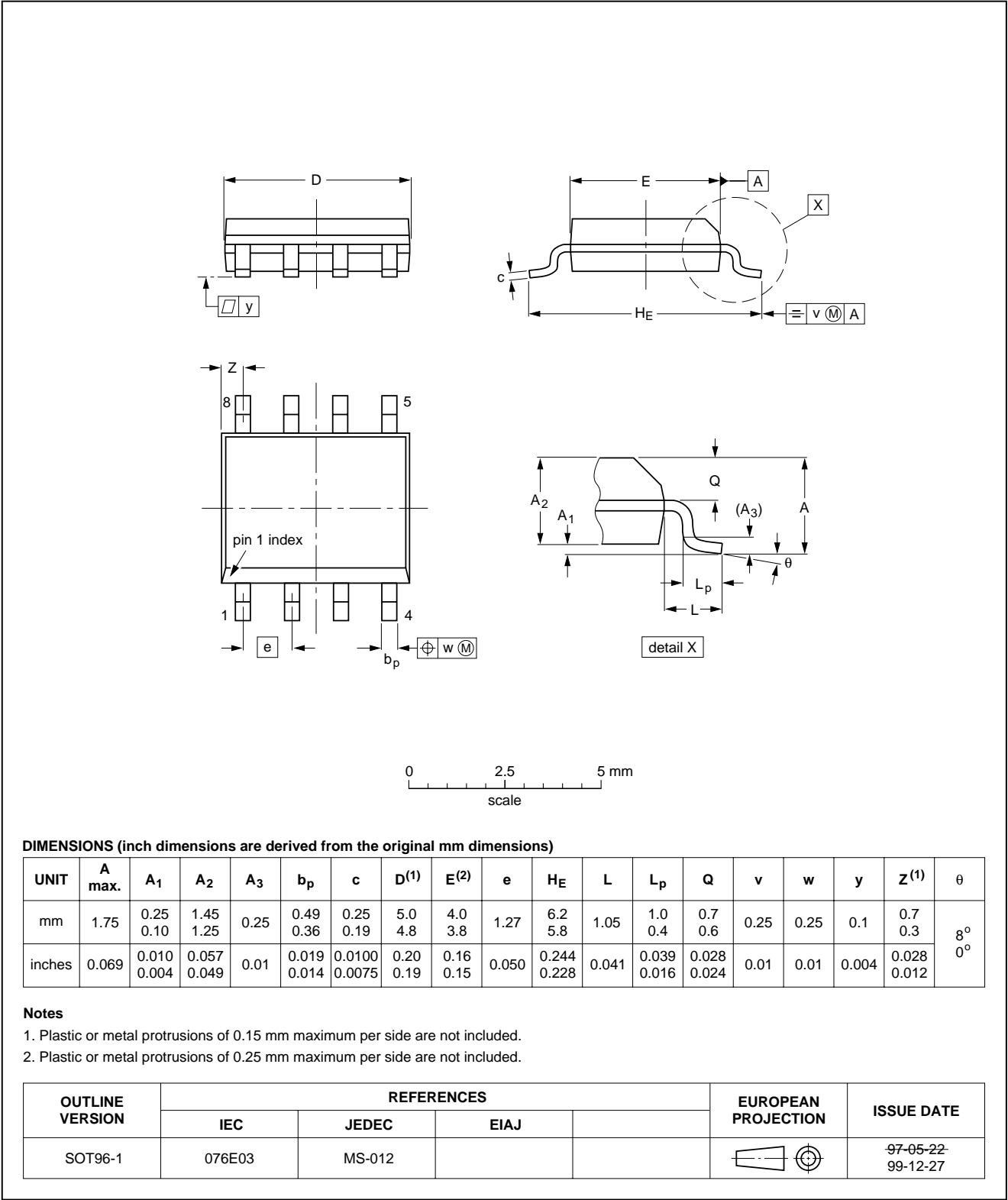


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SO8: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1



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### 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 preferably 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.

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

PACKAGE	SOLDERING METHOD	
	WAVE	REFLOW <sup>(1)</sup>
BGA, SQFP	not suitable	suitable
HLQFP, HSQFP, HSOP, HTSSOP, SMS	not suitable <sup>(2)</sup>	suitable
PLCC <sup>(3)</sup> , SO, SOJ	suitable	suitable
LQFP, QFP, TQFP	not recommended <sup>(3)(4)</sup>	suitable
SSOP, TSSOP, VSO	not recommended <sup>(5)</sup>	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.

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## DATA SHEET STATUS

DATA SHEET STATUS	PRODUCT STATUS	DEFINITIONS <sup>(1)</sup>
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
Preliminary specification	Qualification	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Product specification	Production	This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

### Note

1. Please consult the most recently issued data sheet before initiating or completing a design.

## DEFINITIONS

**Short-form specification** — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). 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** — Applications that are described herein for any of these products are for illustrative purposes only. Philips Semiconductors make no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

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**NOTES**

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**NOTES**

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