

# DATA SHEET

## **TDA3616**

**Multiple voltage regulator with  
battery detection**

Product specification  
Supersedes data of 2000 Jan 14  
File under Integrated Circuits, IC01

2001 Feb 02

# Multiple voltage regulator with battery detection

## TDA3616

### FEATURES

#### General

- One  $V_P$ -state controlled regulator
- Battery detection circuit
- Regulator, reset and battery outputs operate during load dump
- Supply voltage range from  $-18$  to  $+50$  V
- Low quiescent current (battery detection switched off)
- High ripple rejection
- Dual reset output
- Backup circuit
- Adjustable reset delay timer.

#### Protections

- Reverse polarity safe (down to  $-18$  V without high reverse current)
- Able to withstand voltages up to  $18$  V at the output (supply line may be short-circuited)
- ESD protected on all pins
- Load dump protection
- Foldback current limit protection for regulator
- The regulator output is DC short-circuited safe to ground and  $V_P$ .

### GENERAL DESCRIPTION

The TDA3616 is a low power voltage regulator. It contains the following:

- One fixed voltage regulator with a foldback current protection, intended to supply a microprocessor, that also operates during load dump
- A provision for use of a reserve supply capacitor that will hold enough energy for the regulator to allow a microcontroller to prepare for loss of supply voltage
- Reset signals which can be used to interface with the microprocessor
- A supply pin that can withstand load dump pulses and negative supply voltages
- Defined start-up behaviour; regulator will be switched on at a supply voltage higher than  $7.5$  V and off when the output voltage of the regulator drops below  $2.4$  V.

### QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Supply</b>						
$V_P$	supply voltage					
	operating	regulator on	5.6	14.4	25	V
	jump start	$t \leq 10$ minutes	–	–	30	V
	load dump protection	$t \leq 50$ ms; $t_r \geq 2.5$ ms	–	–	50	V
$I_q$	quiescent supply current	standby mode	–	95	125	$\mu$ A
		standby mode; $T_{amb} = 25$ °C	–	95	120	$\mu$ A
<b>Regulator</b>						
$V_o$	output voltage	$0.5 \text{ mA} \leq I_{REG} \leq 150 \text{ mA}$ ; $7 \text{ V} \leq V_P \leq 18 \text{ V}$ ; $T_{amb} = 25$ °C	4.8	5.0	5.2	V
		$0.5 \text{ mA} \leq I_{REG} \leq 150 \text{ mA}$ ; $7 \text{ V} \leq V_P \leq 18 \text{ V}$	4.75	5.0	5.25	V
		$I_{REG} = 30 \text{ mA}$ ; $18 \text{ V} \leq V_P \leq 50 \text{ V}$ ; load dump	4.75	5.0	5.25	V
$V_{drop}$	drop-out voltage	$I_{REG} = 150 \text{ mA}$ ; $V_P = 5 \text{ V}$ ; $T_{amb} = 25$ °C	–	0.6	1.0	V



# Multiple voltage regulator with battery detection

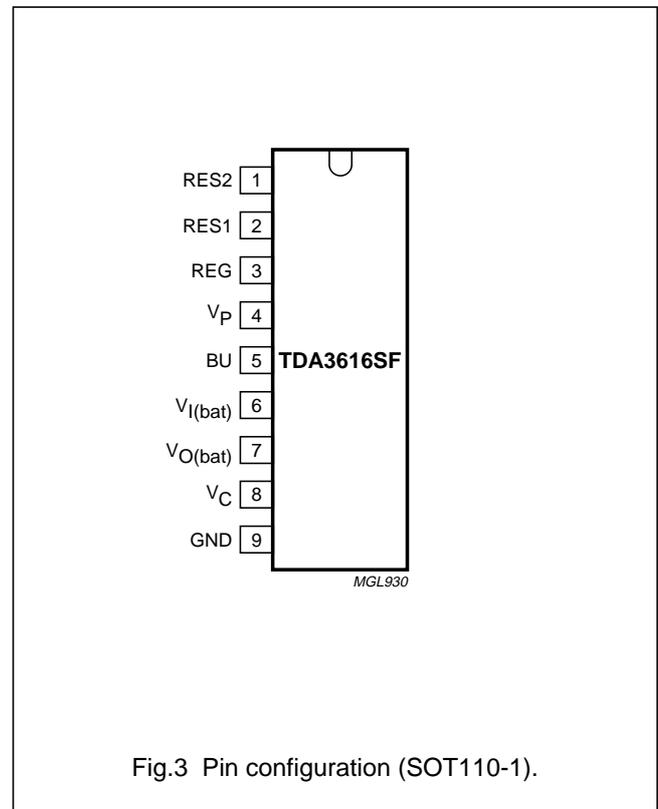
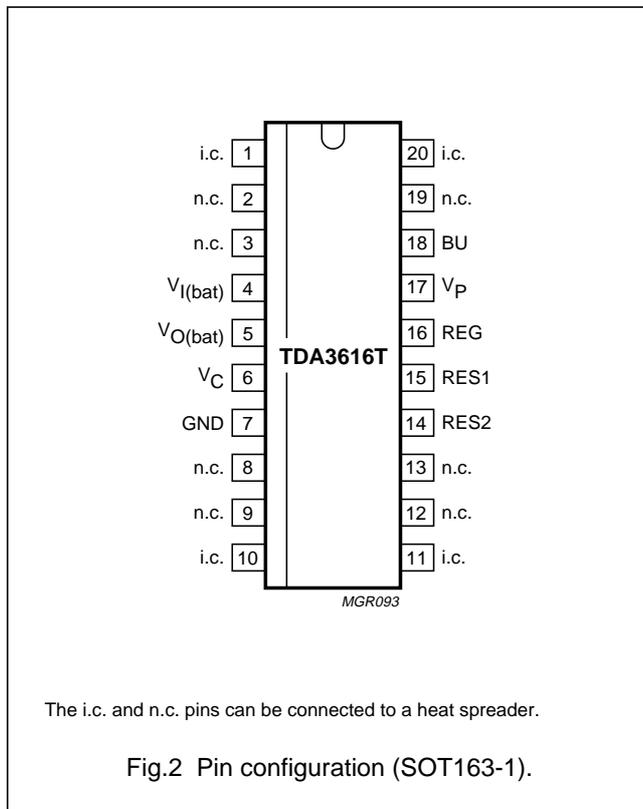
TDA3616

## PINNING

SYMBOL	PIN		DESCRIPTION
	SOT163-1	SOT110-1	
i.c.	1, 10, 11, and 20	–	interconnected; heat spreader; note 1
n.c.	2, 3, 8, 9, 12, 13 and 19	–	not connected; heat spreader
$V_{I(bat)}$	4	6	battery input voltage
$V_{O(bat)}$	5	7	battery detection output voltage
$V_C$	6	8	reset delay capacitor
GND	7	9	ground (0 V)
RES2	14	1	reset 2 output
RES1	15	2	reset 1 output
REG	16	3	regulator output
$V_P$	17	4	supply voltage
BU	18	5	backup

### Note

1. The i.c. pins are connected to each other by the leadframe and can be kept floating or can be connected to ground.



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## FUNCTIONAL DESCRIPTION

The TDA3616 (see Fig.1) is a voltage regulator intended to supply a microprocessor (e.g. in car radio applications). Because of low-voltage operation of the application, a low-voltage drop regulator is used.

This regulator will switch-on when the backup voltage (see Section "Backup circuit") exceeds 7.5 V for the first time and will switch-off again when the output voltage of the regulator drops below 2.4 V. When the regulator is switched on, the RES1 and RES2 outputs (RES2 can only be HIGH when RES1 is HIGH) will go HIGH after a fixed delay time (fixed by an external delay capacitor) to generate a reset to the microprocessor.

Pin RES1 will go HIGH via an internal pull-up resistor of 3.1 kΩ, and is used to initialize the microprocessor. Pin RES2 is used to indicate that the regulator output voltage is within its voltage range. This start-up feature is built-in to secure a smooth start-up of the microprocessor at first connection, without uncontrolled switching of the regulator during the start-up sequence.

The charge of the backup capacitor can be used to supply the regulator and logic circuits for a short period of time when the supply falls to 0 V (the time depends on the value of the storage capacitor). The regulator is switched off at a backup voltage of approximately 2.7 V. From this time onwards, the backup charge will only be used for maintaining reset functions. Due to this, the reset outputs will remain LOW until the output of the regulator is dropped to 0 V.

All output pins are fully protected. The regulator is protected against load dump and short-circuit (foldback current protection). At load dump, the battery detection circuit will remain operating.

Interfacing with the microprocessor can be accomplished by means of a battery Schmitt trigger and output buffer (simple full/semi on/off logic applications). The battery output will go HIGH when the battery input voltage exceeds the high threshold level.

The timing diagrams are shown in Fig.4.

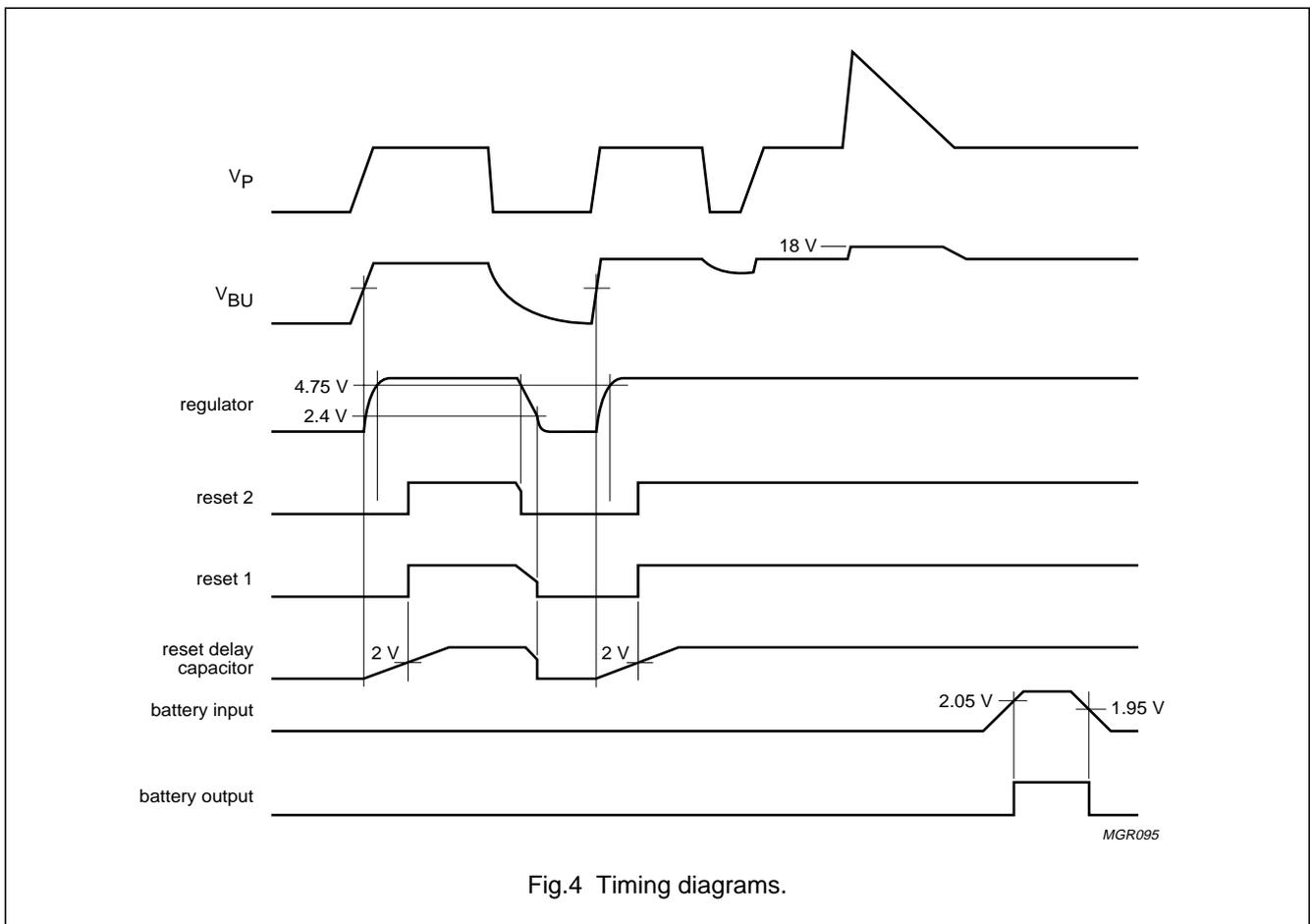


Fig.4 Timing diagrams.

# Multiple voltage regulator with battery detection

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## LIMITING VALUES

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

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V <sub>P</sub>	supply voltage	regulator on	–	25	V
	operating	t ≤ 10 minutes	–	30	V
	jump start	t ≤ 50 ms; t <sub>r</sub> ≥ 2.5 ms	–	50	V
V <sub>rp</sub>	reverse polarity voltage	non-operating	–	–18	V
V <sub>I(bat)p</sub>	positive pulse voltage at battery input	V <sub>P</sub> = 14.4 V; R <sub>I</sub> = 5 kΩ	–	50	V
V <sub>I(bat)n</sub>	negative pulse voltage at battery input	V <sub>P</sub> = 14.4 V; R <sub>I</sub> = 10 kΩ; C <sub>I</sub> = 1 nF	–	–100	V
P <sub>tot</sub>	total power dissipation	V <sub>P</sub> = 12.4 V	–	2.5	W
T <sub>stg</sub>	storage temperature	non-operating	–55	+150	°C
T <sub>amb</sub>	ambient temperature	operating	–40	+105	°C
T <sub>j</sub>	junction temperature	operating	–40	+150	°C

## THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
R <sub>th(j-p)</sub>	thermal resistance from junction to pin/tab			
	TDA3616T		20	K/W
	TDA3616SF		12	K/W
R <sub>th(j-a)</sub>	thermal resistance from junction to ambient			
	TDA3616T	10 cm <sup>2</sup> 2-sided copper area connected to pins	50	K/W
	TDA3616SF	in free air	50	K/W

## QUALITY SPECIFICATION

Quality specification in accordance with "SNW-FQ-611E".

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## CHARACTERISTICS

$V_P = 14.4\text{ V}$ ;  $I_{REG} = 0.5\text{ mA}$ ;  $-40\text{ °C} < T_{amb} < +105\text{ °C}$ ; measurements taken in test circuit of Fig.7; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Supply</b>						
$V_P$	supply voltage					
	operating	regulator on; note 1	5.6	14.4	25	V
	jump start	$t \leq 10$ minutes	–	–	30	V
	load dump protection	$t \leq 50\text{ ms}$ ; $t_r \geq 2.5\text{ ms}$	–	–	50	V
$I_q$	quiescent supply current	$V_P = 12.4\text{ V}$ ; $T_{amb} = 25\text{ °C}$ ; note 2	–	95	120	$\mu\text{A}$
		$V_P = 12.4\text{ V}$ ; note 2	–	95	125	$\mu\text{A}$
		$V_P = 14.4\text{ V}$ ; note 2	–	100	–	$\mu\text{A}$
		$V_P = 50\text{ V}$ ; load dump	–	5	20	mA
<b>Schmitt trigger for regulator and reset 1</b>						
$V_{th(r)}$	rising threshold voltage	$R_{L(REG)} = 1\text{ k}\Omega$	6.2	7.5	8.1	V
$V_{th(f)}$	falling threshold voltage	$I_{REG} = 5\text{ mA}$	2.1	2.4	2.7	V
		$I_{REG} = 30\text{ mA}$	–	2.25	–	V
$V_{hys}$	hysteresis voltage		–	5.1	–	V
<b>Schmitt trigger for battery detection</b>						
$V_{th(r)}$	rising threshold voltage	$T_{amb} = 25\text{ °C}$	2.0	2.1	2.2	V
			2.0	2.1	2.25	V
$V_{th(f)}$	falling threshold voltage	$T_{amb} = 25\text{ °C}$	1.9	2.0	2.1	V
			1.9	2.0	2.15	V
$V_{hys}$	hysteresis voltage		–	0.1	–	V
<b>Schmitt trigger for reset 2</b>						
$V_{th(r)}$	rising threshold voltage	note 3	4.55	4.8	5.05	V
$V_{th(f)}$	falling threshold voltage	note 3	4.5	4.75	5.0	V
$V_{hys}$	hysteresis voltage		–	0.05	–	V
$\Delta V_{track}$	voltage tracking with $V_{REG}$	$I_{sink} = 0\text{ mA}$ ; note 4	–65	0	+65	mV
<b>Reset 1 and reset 2 buffers</b>						
$I_{sink(L)}$	LOW-level sink current	$V_{RES} \leq 0.5\text{ V}$ ; note 3	2	15	–	mA
$R_{pu(int)}$	internal pull-up resistance	$T_{amb} = 25\text{ °C}$	2.2	3.1	4.0	$\text{k}\Omega$
			1.9	3.1	4.6	$\text{k}\Omega$
<b>Reset delay</b>						
$R_{pu(int)}$	internal pull-up resistance	$T_{amb} = 25\text{ °C}$ ; note 5	–	47	–	$\text{k}\Omega$
$V_{th(r)}$	rising threshold voltage		1.4	2.0	2.8	V
$t_d$	delay time	$C_d = 100\text{ nF}$ ; note 6; see Fig.9	–	2.6	–	ms
<b>Battery buffer</b>						
$V_{OL}$	LOW-level output voltage	$I_l = 0\text{ mA}$	0	0.05	0.5	V
$V_{OH}$	HIGH-level output voltage	$I_o = 5\text{ }\mu\text{A}$ ; note 7	–	5.0	5.2	V
$I_{OL}$	LOW-level output current	$V_{OL} \leq 0.5\text{ V}$	0.2	0.5	–	mA
$I_{OH}$	HIGH-level output current	$V_{OH} \geq 4\text{ V}$ ; see Fig.6	1	12	–	mA

## Multiple voltage regulator with battery detection

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Regulator (<math>I_{REG} = 5 \text{ mA}</math>; unless otherwise specified)</b>						
$V_o$	output voltage	$0.5 \text{ mA} \leq I_{REG} \leq 150 \text{ mA}$ ; $7 \text{ V} \leq V_P \leq 18 \text{ V}$ ; $T_{amb} = 25 \text{ }^\circ\text{C}$	4.8	5.0	5.2	V
		$0.5 \text{ mA} \leq I_{REG} \leq 150 \text{ mA}$ ; $7 \text{ V} \leq V_P \leq 18 \text{ V}$	4.75	5.0	5.25	V
		$I_{REG} = 30 \text{ mA}$ ; $18 \text{ V} \leq V_P \leq 50 \text{ V}$ ; load dump	4.75	5.0	5.25	V
$I_o$	output current	$V_P > 25 \text{ V}$ ; load dump	–	–	100	mA
$\Delta V_{LN}$	line voltage regulation	$7 \text{ V} \leq V_P \leq 18 \text{ V}$	–	3	50	mV
$\Delta V_L$	load voltage regulation	$0.5 \text{ mA} \leq I_{REG} \leq 150 \text{ mA}$ ; $T_{amb} = 25 \text{ }^\circ\text{C}$	–	–	70	mV
		$0.5 \text{ mA} \leq I_{REG} \leq 150 \text{ mA}$	–	–	85	mV
SVRR	supply voltage ripple rejection	$f_i = 200 \text{ Hz}$ ; $V_i = 2 \text{ V (p-p)}$ ; $I_o = 5 \text{ mA}$	55	60	–	dB
$V_{drop}$	drop-out voltage	$I_{REG} = 150 \text{ mA}$ ; $V_P = 5 \text{ V}$ ; $T_{amb} = 25 \text{ }^\circ\text{C}$ ; note 8	–	0.6	1.0	V
		$I_{REG} = 150 \text{ mA}$ ; $V_P = 5.5 \text{ V}$ ; note 8	–	0.9	1.2	V
$I_l$	current limit	$V_{REG} > 4.5 \text{ V}$ ; $V_P > 10 \text{ V}$ ; note 9	0.25	0.6	1	A
$I_{sc}$	short-circuit current	$R_{L(REG)} \leq 0.5 \text{ } \Omega$ ; $T_{amb} = 25 \text{ }^\circ\text{C}$ ; note 10	40	80	–	mA
<b>Backup switch</b>						
$I_{DC}$	DC continuous current	$V_{BU} > 5 \text{ V}$ ; note 11	0.1	0.2	–	A
$I_r$	reverse current	$V_P = 0 \text{ V}$ ; $V_{BU} = 12.4 \text{ V}$	–	–	200	$\mu\text{A}$

**Notes**

- Minimum operating voltage, only if  $V_P$  has exceeded 7.5 V.
- The quiescent current is measured in standby mode. Therefore, the battery input is connected to a low voltage source and  $R_{L(REG)} = \infty$ .
- The voltage of the regulator sinks as a result of a supply voltage drop.
- Only one band gap circuit is used as a reference for both regulator and Schmitt trigger for reset. Due to this a tracking exists between the reset Schmitt trigger levels and the output voltage of the regulator.
- The temperature coefficient of the internal resistor is 0.2%/K.
- The delay time can be calculated with the following formula:  $t_d = R_{pu(int)} \times C_d \times \ln\left(\frac{V_{REG}}{(V_{REG} - V_{thr})}\right)$
- The battery output voltage will be equal or less than the output voltage of the regulator.
- The drop-out voltage of the regulator is measured between  $V_P$  and  $V_{REG}$ .
- At current limit,  $I_l$  is held constant (behaviour according to dashed line in Fig.5).
- The foldback current protection limits the dissipated power at short-circuit (see Fig.5).
- The backup switch can deliver an additional current of 100 mA, guaranteed when the regulator is loaded with nominal loads ( $I_{REG} \leq 150 \text{ mA}$ ).

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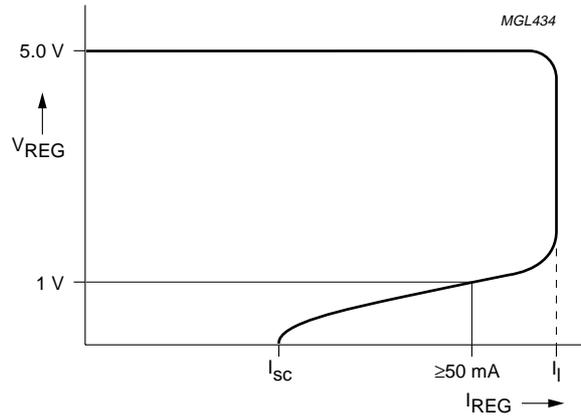
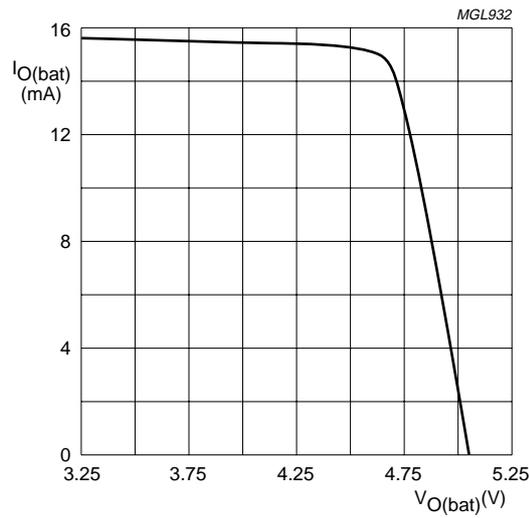


Fig.5 Foldback current protection.



$T_{amb} = 27^\circ \text{ C}$ .

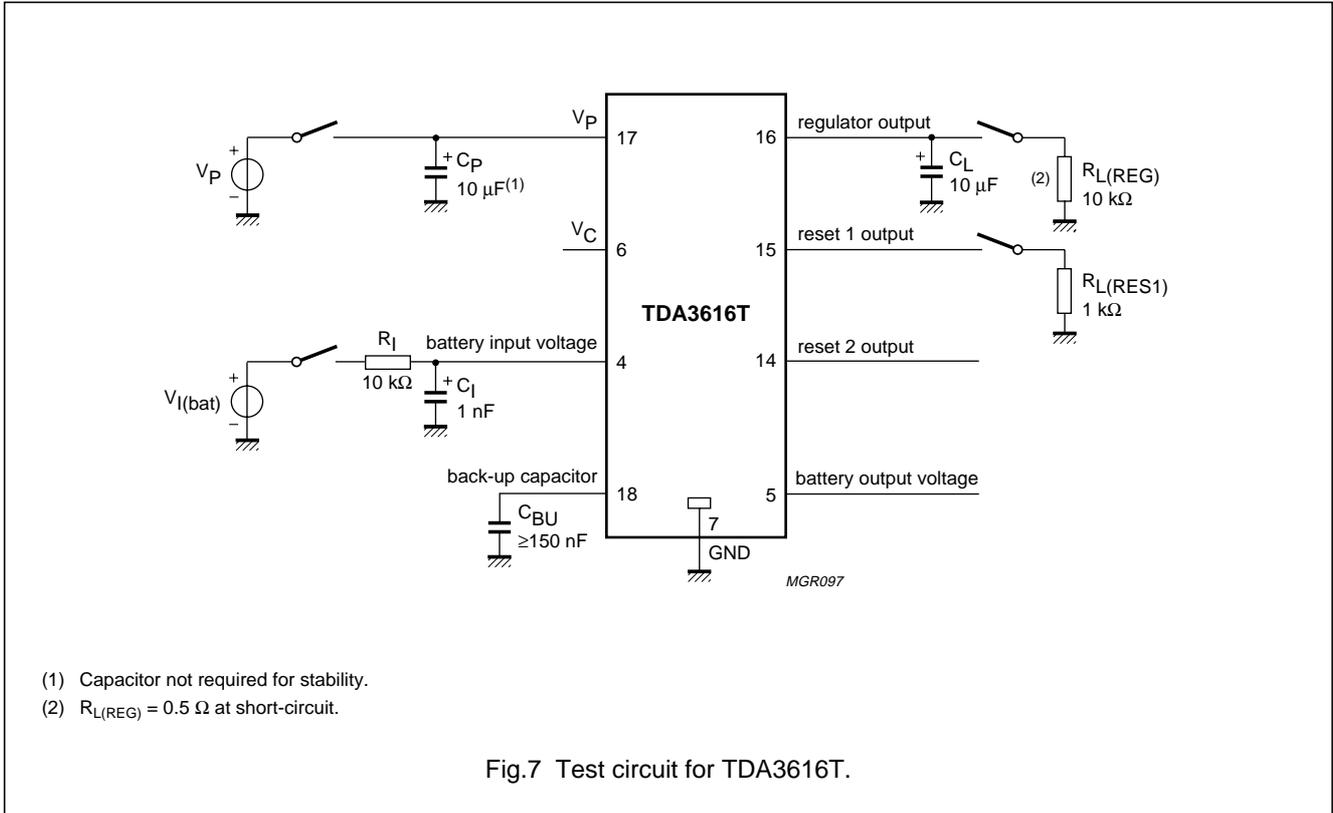
Fig.6 Battery buffer HIGH-level output current as a function of  $V_{O(bat)}$ .

# Multiple voltage regulator with battery detection

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## TEST AND APPLICATION INFORMATION

### Test information



# Multiple voltage regulator with battery detection

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## Application information

### NOISE

The noise at the output of the regulator depends on the bandwidth of the regulator, which can be adjusted by the output capacitor  $C_L$ . Table 1 shows the noise figures.

The noise on the supply line depends on the value of the supply capacitor  $C_P$  and is caused by a current noise (the output noise of the regulator is translated into a current noise by the output capacitor). When a high frequency capacitor of 220 nF (with an electrolytic capacitor of 100  $\mu$ F connected in parallel) is connected directly between pins  $V_P$  and GND the noise is minimized.

**Table 1** Noise figures

$I_o$ (mA)	NOISE FIGURE ( $\mu$ V) <sup>(1)</sup>		
	$C_L = 10 \mu$ F	$C_L = 47 \mu$ F	$C_L = 100 \mu$ F
0.5	58	50	45
50	250	200	180

### Note

1. Measured at a bandwidth of 10 Hz to 100 kHz.

### STABILITY

The regulator is stabilized by the output capacitor  $C_L$ . The value of the output capacitor can be selected using the diagram shown in Fig.8. The following two examples show the effects of the stabilization circuit using different values for the output capacitor.

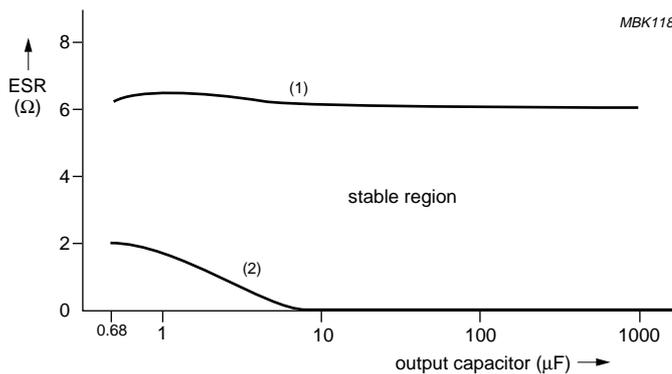
**Remark:** The behaviour of ESR as a function of the temperature must be known.

#### Example 1

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

#### Example 2

The regulator is stabilized using an electrolytic output capacitor of 10  $\mu$ F (ESR = 3.3  $\Omega$ ). At  $T_{amb} = -40 \text{ }^\circ\text{C}$  the capacitor value is decreased to 3  $\mu$ F and the ESR is increased to 23.1  $\Omega$ . The regulator will be unstable at a temperature of  $T_{amb} = -40 \text{ }^\circ\text{C}$ . This can be solved by using a tantalum capacitor of 10  $\mu$ F.



- (1) Maximum Equivalent Series Resistance (ESR).
- (2) Minimum ESR.

Fig.8 Curve for selecting the value of the output capacitor.

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## APPLICATION CIRCUIT

In Fig.9 the total quiescent current equals  $I_q + I_{R_{divisor}}$ . The specified quiescent current equals  $I_q$ . When the supply voltage is connected, the regulator will switch-on when the supply voltage exceeds 7.5 V. With a timing capacitor connected to pin  $V_C$  the reset can be delayed (the timer starts at the same moment as the regulator is switched on).

Forced reset can be accomplished by short-circuiting the timer capacitor by using the push-button switch. When the push-button is released again, the timer restarts (only when the regulator is on) causing a second reset on both RES1 and RES2.

The maximum output current of the regulator equals:

$$I_{O(max)} = \frac{150 - T_{amb}}{R_{th(j-a)} \times (V_P - V_{REG})} = \frac{150 - T_{amb}}{50 \times (V_P - 5)} \text{ [mA]}$$

When  $T_{amb} = 85 \text{ }^\circ\text{C}$  and  $V_P = 16 \text{ V}$ , the maximum output current equals 118 mA. At lower ambient temperature ( $T_{amb} < 0$ ) the maximum output current equals 250 mA.

For successful operation of the IC (maximum output current capability), special attention has to be paid to the copper area required as heatsink (connected to pins 1, 10, 11 and 20), the thermal capacity of the heatsink and its ability to transfer heat to the external environment.

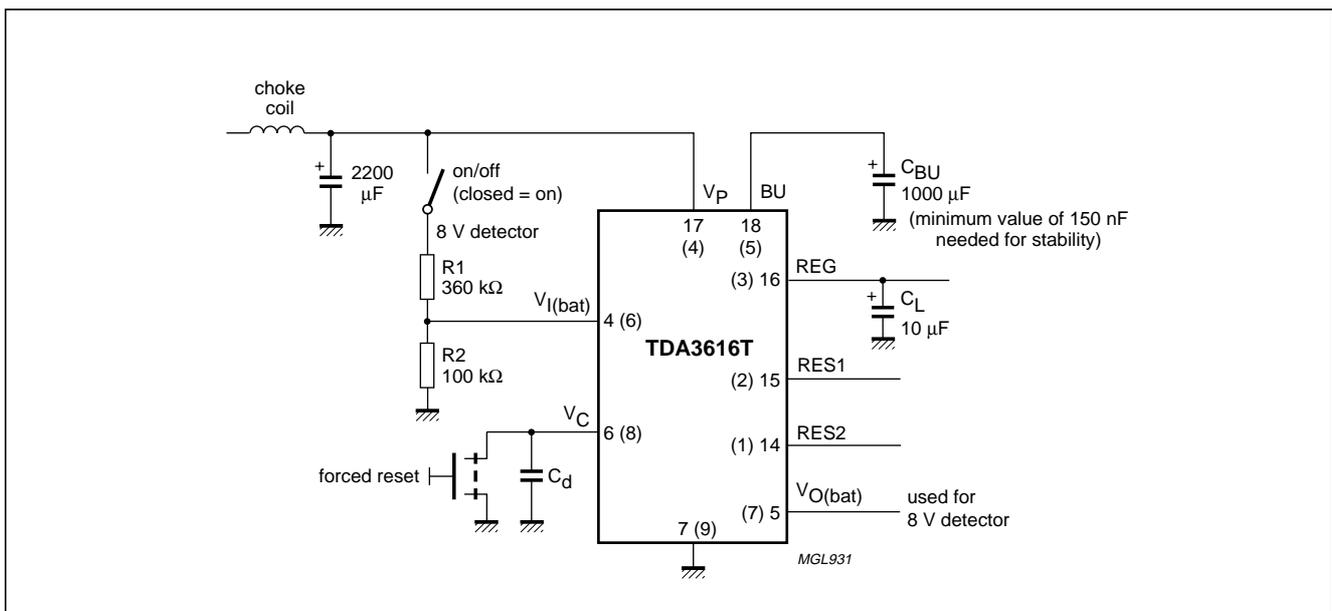
It is possible to reduce the total thermal resistance from 120 K/W to 50 K/W).

### Backup circuit

The backup function is used for supplying the regulator and logic circuits (reset 1 and 2) when the supply voltage is disconnected. For stability a **minimum capacitor value of 150 nF** is needed.

With a supply voltage of 14.4 V the backup capacitor will be fully charged until approximately 14.2 V. At the moment the supply voltage is lower than the voltage on pin BU the backup switch will be opened (this backup switch acts like an ideal diode) and the charge of the backup capacitor is used for supplying the regulator and the logic circuits. The backup capacitor is mainly discharged by the load of the regulator. After a certain period of time the regulator output will be disabled and the backup capacitor will only be discharged by the quiescent current of the IC itself.

In combination with the battery detection Schmitt trigger, an early warning can be given to the microprocessor to indicate that the battery voltage has dropped down to an unacceptable low value, causing the microcontroller to run on backup charge. The early warning level can be programmed with resistors R1 and R2; see Fig.9.



The pin numbers given in parenthesis refer to the TDA3616SF version.

Fig.9 Typical application.

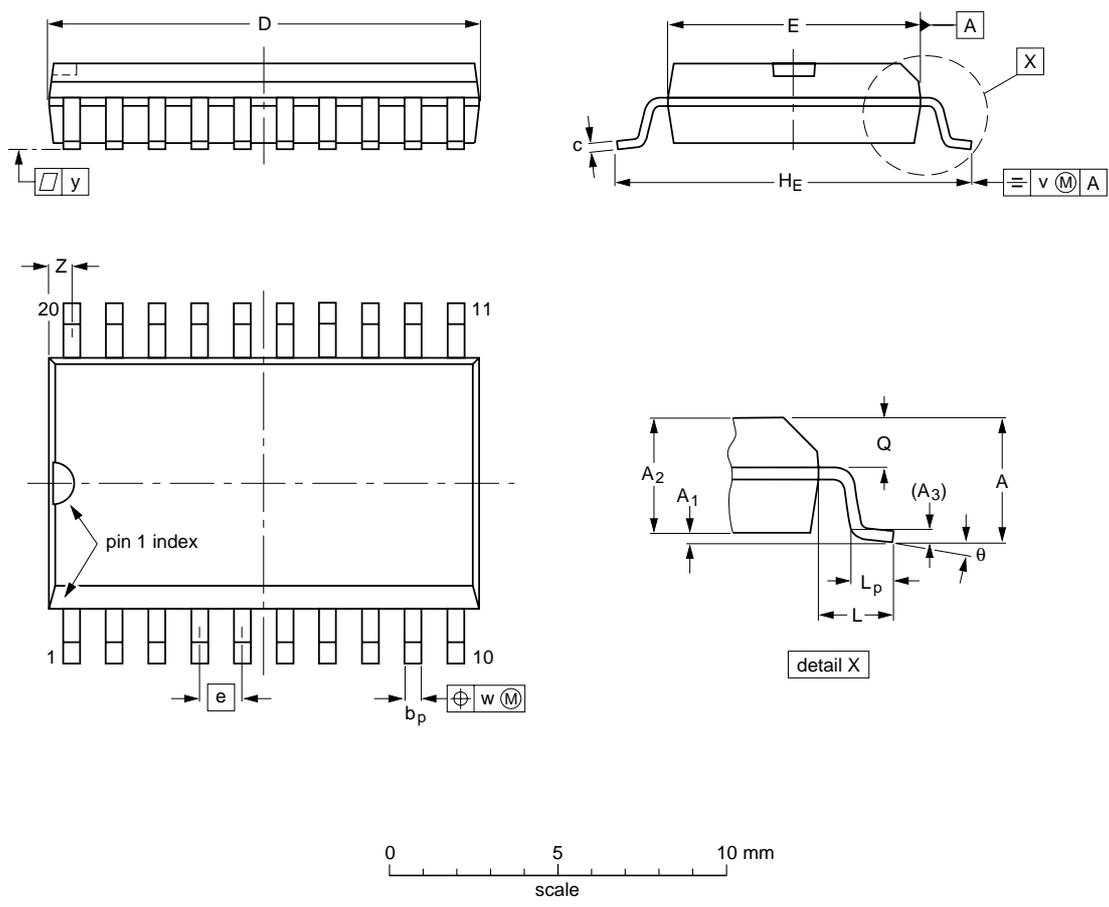
# Multiple voltage regulator with battery detection

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## PACKAGE OUTLINES

SO20: plastic small outline package; 20 leads; body width 7.5 mm

SOT163-1



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

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	z <sup>(1)</sup>	θ
mm	2.65	0.30 0.10	2.45 2.25	0.25	0.49 0.36	0.32 0.23	13.0 12.6	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8° 0°
inches	0.10	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.51 0.49	0.30 0.29	0.050	0.419 0.394	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

**Note**

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

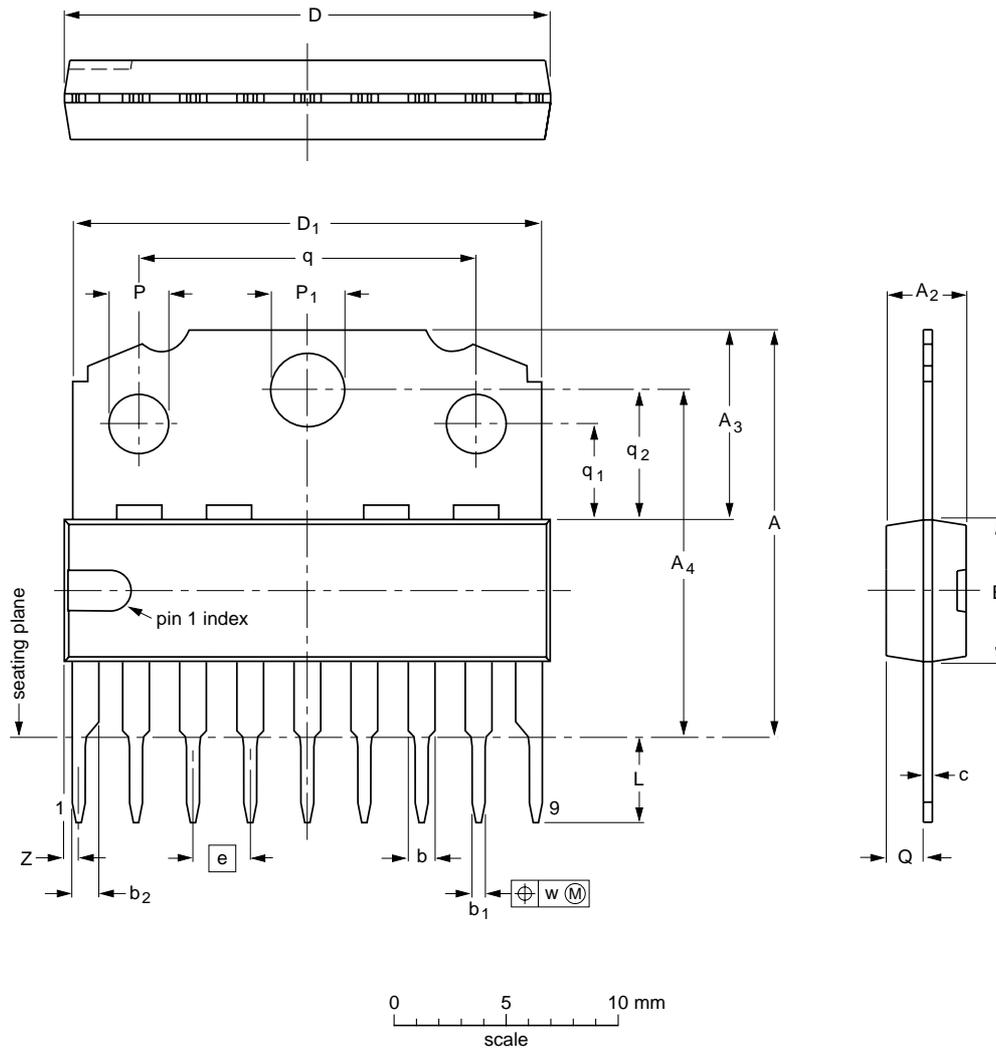
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT163-1	075E04	MS-013				97-05-22 99-12-27

Multiple voltage regulator with battery detection

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SIL9MPF: plastic single in-line medium power package with fin; 9 leads

SOT110-1



**DIMENSIONS (mm are the original dimensions)**

UNIT	A	A <sub>2</sub> max.	A <sub>3</sub>	A <sub>4</sub>	b	b <sub>1</sub>	b <sub>2</sub>	c	D <sup>(1)</sup>	D <sub>1</sub>	E <sup>(1)</sup>	e	L	P	P <sub>1</sub>	Q	q	q <sub>1</sub>	q <sub>2</sub>	w	Z <sup>(1)</sup> max.
mm	18.5 17.8	3.7	8.7 8.0	15.8 15.4	1.40 1.14	0.67 0.50	1.40 1.14	0.48 0.38	21.8 21.4	21.4 20.7	6.48 6.20	2.54	3.9 3.4	2.75 2.50	3.4 3.2	1.75 1.55	15.1 14.9	4.4 4.2	5.9 5.7	0.25	1.0

**Note**

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

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT110-1						92-11-17 95-02-25

## Multiple voltage regulator with battery detection

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### SOLDERING

#### Introduction

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 IC packages. Wave soldering is often preferred when through-hole and surface mount components are mixed on one printed-circuit board. Wave soldering can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended.

#### Through-hole mount packages

##### SOLDERING BY DIPPING OR BY SOLDER WAVE

The maximum permissible temperature of the solder is 260 °C; solder at this temperature must not be in contact with the joints for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified maximum storage temperature ( $T_{stg(max)}$ ). If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

##### MANUAL SOLDERING

Apply the soldering iron (24 V or less) to the lead(s) of the package, either below the seating plane or not more than 2 mm above it. If the temperature of the soldering iron bit is less than 300 °C it may remain in contact for up to 10 seconds. If the bit temperature is between 300 and 400 °C, contact may be up to 5 seconds.

#### Surface mount packages

##### 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, convection or convection/infrared 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 220 °C for thick/large packages, and below 235 °C for small/thin packages.

##### 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 IC packages for wave, reflow and dipping soldering methods

MOUNTING	PACKAGE	SOLDERING METHOD		
		WAVE	REFLOW <sup>(1)</sup>	DIPPING
Through-hole mount	DBS, DIP, HDIP, SDIP, SIL	suitable <sup>(2)</sup>	–	suitable
Surface mount	BGA, HBGA, LFBGA, SQFP, TFBGA	not suitable	suitable	–
	HBCC, HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, HVQFN, SMS	not suitable <sup>(3)</sup>	suitable	–
	PLCC <sup>(4)</sup> , SO, SOJ	suitable	suitable	–
	LQFP, QFP, TQFP	not recommended <sup>(4)(5)</sup>	suitable	–
	SSOP, TSSOP, VSO	not recommended <sup>(6)</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. For SDIP packages, the longitudinal axis must be parallel to the transport direction of the printed-circuit board.
3. 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).
4. 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.
5. Wave soldering is only suitable for LQFP, QFP and TQFP 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.
6. 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.

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**NOTES**

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**NOTES**

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