# DATA SHEET

# TDA3603
## Multiple voltage regulator with switch

Product specification
Supersedes data of 1995 Oct 04
File under Integrated Circuits, IC01

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Philips
Semiconductors

PHILIPS

# Multiple voltage regulator with switch TDA3603

## FEATURES

### General

- One $V_P$ state controlled regulator (regulator 2)
- Regulator 2, reset and ignition buffer operate during load dump and thermal shutdown
- One control pin for switching regulator 1 and the power switch
- Supply voltage range of −18 to +50 V (operating from 9.75 V)
- Low reverse current of regulator 2
- Low quiescent current (when regulator 1, power switch and ignition input are switched off, standby)
- Ignition input/output
- Reset output
- High ripple rejection
- Power switch.

### Protections

- Reverse polarity safe (down to −18 V without high reverse current)
- Able to withstand voltages up to 18 V at the outputs (supply line may be shortened)
- ESD protected on all pins
- Thermal protection
- Load dump protection
- Foldback current limit protection for regulators 1 and 2
- Delayed second current limit protection for the power switch
- The regulator outputs and the power switch are DC short-circuited safe to ground and $V_P$.

## GENERAL DESCRIPTION

The TDA3603 is a multiple output voltage regulator with a power switch, intended for use in car radios with or without a microcontroller.

It contains one fixed voltage regulator with a foldback current protection (regulator 1) and one fixed voltage regulator (regulator 2), intended to supply a microcontroller, that also operates during load dump and thermal shutdown.

There is a power switch with protections, operated by the enable input.

The reset and ignition outputs can be used to interface by the microcontroller. The reset signal can be used to call up the microcontroller and the ignition output indicates ignition voltage available.

The supply pin can withstand load dump pulses and negative supply voltages.

Regulator 2 will be switched on at a supply voltage >6.5 V and off at a voltage of regulator 2 <1.9 V.

## ORDERING INFORMATION

| TYPE NUMBER | PACKAGE | | |
|---|---|---|---|
| | NAME | DESCRIPTION | VERSION |
| TDA3603 | SIL9MPF | plastic single in-line medium power package with fin; 9 leads | SOT110-1 |
| TDA3603P | HDIP18 | plastic heat-dissipating dual in-line package; 18 leads | SOT398-1 |

## QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| **Supply** | | | | | | |
| $V_P$ | supply voltage | | | | | |
| | operating | | 9.75 | 14.4 | 25 | V |
| | regulator 2 on | note 1 | 2.4 | 14.4 | 25 | V |
| | jump start | $t \leq 10$ minutes | – | – | 30 | V |
| | load dump protection | during 50 ms; $t_r \geq 2.5$ ms | – | – | 50 | V |
| $I_q$ | total quiescent current | standby mode | – | 400 | 500 | μA |
| $T_{vj}$ | operating virtual junction temperature | | – | – | 150 | °C |
| **Voltage regulators** | | | | | | |
| $V_{REG1}$ | output voltage regulator 1 | $0.5\ mA \leq I_{REG1} \leq 300\ mA$ | 8.65 | 9.0 | 9.35 | V |
| $V_{REG2}$ | output voltage regulator 2 | $0.5\ mA \leq I_{REG2} \leq 50\ mA$; $V_P = 14.4\ V$ | 4.8 | 5.0 | 5.2 | V |
| $V_{REGd1}$ | drop-out voltage regulator 1 | $I_{REG1} = 0.3\ A$; note 2 | – | – | 0.5 | V |
| **Power switch** | | | | | | |
| $V_{swd}$ | drop-out voltage | $I_{sw} = 0.3\ A$; note 3 | – | – | 0.9 | V |
| $I_M$ | peak current | $t \leq 10$ ms | 1.4 | – | – | A |

**Notes**

1. Minimum operating voltage, only if $V_P$ has exceeded 6.5 V.
2. The drop-out voltage of regulator 1 is measured between $V_P$ and REG1.
3. The drop-out voltage of the power switch is measured between $V_P$ and $V_{sw}$.

## BLOCK DIAGRAM

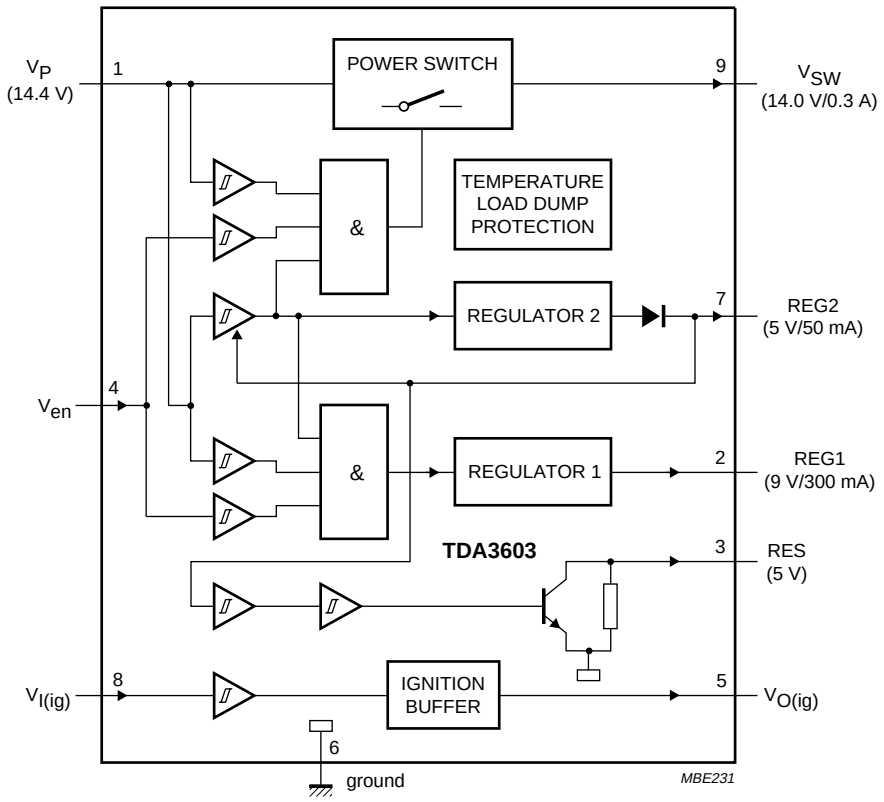



Fig.1 Block diagram (for SOT110-1).

**PINNING**

| SYMBOL | PIN | | DESCRIPTION |
|---|---|---|---|
| | SOT110-1 | SOT398-1 | |
| $V_P$ | 1 | 1 | supply voltage |
| REG1 | 2 | 2 | regulator 1 output |
| RES | 3 | 3 | reset output voltage (+5 V) |
| $V_{en}$ | 4 | 4 | enable input voltage |
| $V_{O(ig)}$ | 5 | 5 | ignition output voltage |
| GND | 6 | 6 | ground (0 V) |
| REG2 | 7 | 7 | regulator 2 output |
| $V_{I(ig)}$ | 8 | 8 | ignition input voltage |
| $V_{sw}$ | 9 | 9 | power switch output voltage |
| i.c. | – | 10 to 18 | can be connected to a heat spreader |

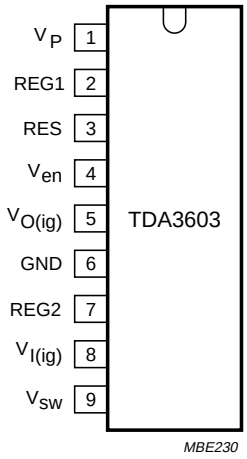
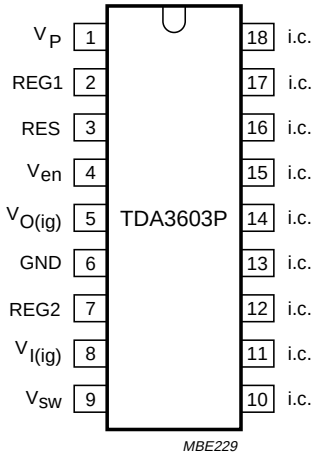



Fig.2 Pin configuration for SOT110-1.




Pins 10 to 18 can be connected to a heat spreader.

Fig.3 Pin configuration for SOT398-1.

## FUNCTIONAL DESCRIPTION

The TDA3603 is a multiple output voltage regulator with a power switch, intended for use in car radios with or without a microcontroller. Because of low-voltage operation of the car radio, low-voltage drop regulators are used.

Regulator 2 will switch on when the supply voltage exceeds 6.5 V for the first time and will switch off again when the output voltage of regulator 2 is below 1.9 V (this is below an engine start). When regulator 2 is switched on and the output voltage of this regulator is within its voltage range, the reset output will be enabled (reset will go HIGH via a pull-up resistor) to generate a reset to the microcontroller. The reset cycles can be extended by an external capacitor at the reset output (pin 3). The start-up feature is built-in to ensure a smooth start-up of the microcontroller at first connection, without uncontrolled switching of regulator 2 during the start-up sequence.

When both regulator 2 and the supply voltage ($V_P$ > 4.5 V) are available, regulator 1 and the switch can be operated by an enable input (pin 4).

All output pins are fully protected. The regulators are protected against load dump (regulator 1 will switch off at supply voltages higher than 25 V) and short-circuit (foldback current protection).
The switch contains a current protection which is delayed for ≥10 ms (in short-circuit condition). During this time the current is limited to 1.4 A ($V_P \leq 18$ V).

At supply voltages over 16.9 V the switch is clamped at 15.0 V (to avoid externally connected circuitry being damaged by an overvoltage) and the switch will switch off at load dump.

Interfacing with the microcontroller can be accomplished by an ignition Schmitt trigger and ignition output buffer, (simple full/semi on/off logic applications).

The total timing of a semi on/off logic set is shown Fig.4.

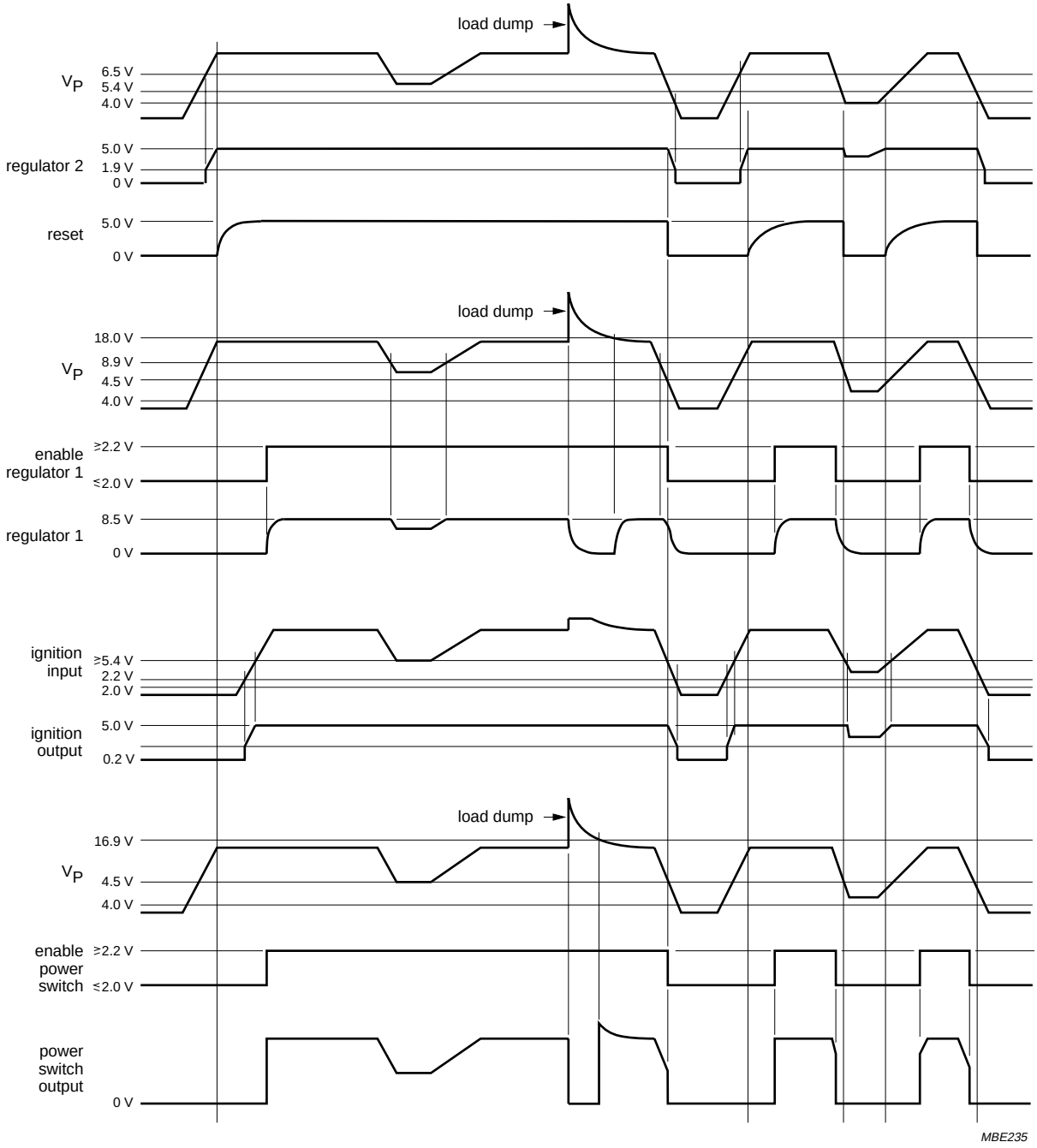



Fig.4 Timing diagrams.

## LIMITING VALUES

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

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_P$ | supply voltage | | | | |
| | operating | | – | 25 | V |
| | jump start | $t \leq 10$ minutes | – | 30 | V |
| | load dump protection | during 50 ms; $t_r \geq 2.5$ ms | – | 50 | V |
| $V_P$ | reverse battery voltage | non-operating | – | –18 | V |
| $V_{ppi}$ | positive pulse voltage at ignition buffer | $V_P$ = 14.4 V; $R_I$ = 1 kΩ | – | 50 | V |
| $V_{npi}$ | negative pulse voltage at ignition buffer | $V_P$ = 14.4 V; $R_I$ = 1 kΩ | – | –100 | V |
| $T_{stg}$ | storage temperature | non-operating | –55 | +150 | °C |
| $T_{vj}$ | operating virtual junction temperature | | –40 | +150 | °C |
| $P_{tot}$ | total power dissipation | | | | |
| | SOT110-1 | | – | 10.4 | W |
| | SOT398-1 | | – | 8.3 | W |

## THERMAL CHARACTERISTICS

| SYMBOL | TYPE NUMBER | PARAMETER | VALUE | UNIT |
|---|---|---|---|---|
| $R_{th\ j\text{-}c}$ | TDA3603 | thermal resistance from junction to case | 12 | K/W |
| $R_{th\ j\text{-}p}$ | TDA3603P | thermal resistance from junction to pins | 15 | K/W |

## CHARACTERISTICS

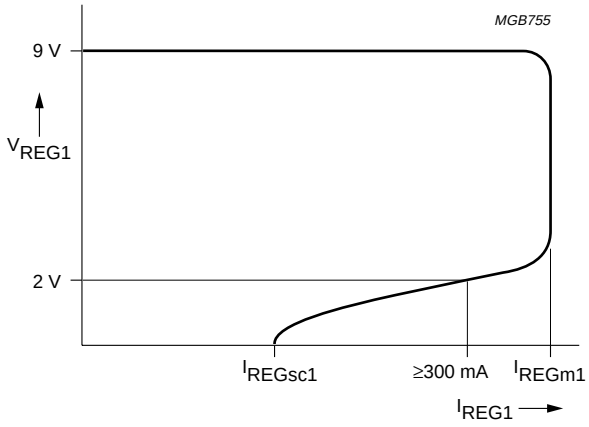
$V_P$ = 14.4 V; $T_{amb}$ = 25 °C; see Fig.7; unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| **Supply** | | | | | | |
| $V_P$ | supply voltage | | | | | |
| | operating | | 9.75 | 14.4 | 25 | V |
| | regulator 2 on | note 1 | 2.4 | 14.4 | 25 | V |
| | jump start | t ≤ 10 minutes | – | – | 30 | V |
| | load dump protection | during 50 ms; $t_r \geq 2.5$ ms | – | – | 50 | V |
| $I_q$ | quiescent current | $V_P$ = 12.4 V; note 2 | – | 400 | 500 | µA |
| | | $V_P$ = 14.4 V; note 2 | – | 420 | – | µA |
| **Schmitt trigger power supply for the power switch** | | | | | | |
| $V_{thr}$ | rising voltage threshold | | 4.0 | 4.5 | 5.0 | V |
| $V_{thf}$ | falling voltage threshold | | 3.5 | 4.0 | 4.5 | V |
| $V_{hys}$ | hysteresis | | – | 0.5 | – | V |
| **Schmitt trigger for regulator 1** | | | | | | |
| $V_{thr}$ | rising voltage threshold | | 4.0 | 4.5 | 5.0 | V |
| $V_{thf}$ | falling voltage threshold | | 3.5 | 4.0 | 4.5 | V |
| $V_{hys}$ | hysteresis | | – | 0.5 | – | V |
| **Schmitt trigger power supply for regulator 2** | | | | | | |
| $V_{thr}$ | rising voltage threshold | | 6.0 | 6.5 | 7.1 | V |
| $V_{thf}$ | falling voltage threshold | | 1.7 | 1.9 | 2.2 | V |
| $V_{hys}$ | hysteresis | | – | 4.7 | – | V |
| **Schmitt trigger for enable input** | | | | | | |
| $V_{thr}$ | rising voltage threshold | | 1.7 | 2.2 | 2.7 | V |
| $V_{thf}$ | falling voltage threshold | | 1.5 | 2.0 | 2.5 | V |
| $V_{hys}$ | hysteresis | | – | 0.2 | – | V |
| **Schmitt trigger for reset buffer** | | | | | | |
| $V_{r(REG2)}$ | rising voltage of regulator 2 | note 3 | – | $V_{REG2}$ – 0.15 | – | V |
| $V_{f(REG2)}$ | falling voltage of regulator 2 | note 3 | – | $V_{REG2}$ – 0.25 | – | V |
| $V_{spread}$ | voltage spread on tracking | note 4 | – | 10 | – | mV |
| **Schmitt trigger for ignition buffer** | | | | | | |
| $V_{thr}$ | rising voltage threshold | | 1.7 | 2.2 | 2.7 | V |
| $V_{thf}$ | falling voltage threshold | | 1.5 | 2.0 | 2.5 | V |
| $V_{hys}$ | hysteresis | | – | 0.2 | – | V |
| **Reset buffer** | | | | | | |
| $I_{sink}$ | LOW-level sink current | $V_{RES} \leq 0.8$ V | 15 | 20 | – | mA |
| $I_{leak}$ | leakage current | $V_P$ = 14.4 V; $V_{RES}$ = 5 V | 25 | 50 | 100 | µA |

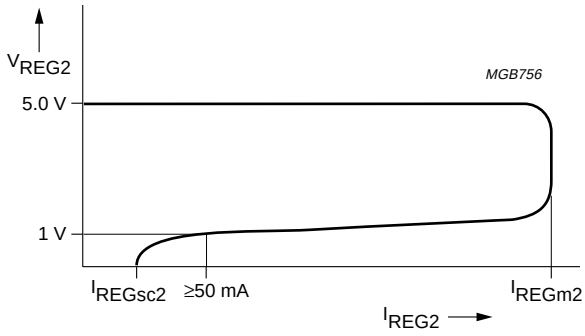
| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| **Ignition buffer** | | | | | | |
| $V_{OL}$ | LOW-level output voltage | $I_{OL}$ = 0 mA | 0 | 0.2 | 0.8 | V |
| $V_{OH}$ | HIGH-level output voltage | note 5 | – | 5.0 | 5.2 | V |
| $I_{OL}$ | LOW-level output current | $V_{OL} \leq 0.8$ V | 0.3 | 0.8 | – | mA |
| $I_{OH}$ | HIGH-level output current | $V_{OH} \geq 3$ V | 0.3 | 2.0 | – | mA |
| **Regulator 1;** note 6 | | | | | | |
| $V_{REG1}$ | output voltage off | | – | 1 | 400 | mV |
| $V_{REG1}$ | output voltage | 0.5 mA $\leq I_{REG1} \leq$ 300 mA | 8.65 | 9.0 | 9.35 | V |
| | | 10 V $\leq V_P \leq$ 18 V | 8.65 | 9.0 | 9.35 | V |
| $\Delta V_{REG1}$ | line regulation | 10 V $\leq V_P \leq$ 18 V | – | – | 50 | mV |
| $\Delta V_{REGL1}$ | load regulation | 0.5 mA $\leq I_{REG1} \leq$ 300 mA | – | – | 70 | mV |
| SVRR1 | supply voltage ripple rejection | $f_i$ = 200 Hz; $V_I$ = 2 V (p-p) | 60 | – | – | dB |
| $V_{REGd1}$ | drop-out voltage | $I_{REG1}$ = 300 mA; note 7 | – | 0.4 | 0.5 | V |
| $I_{REGm1}$ | current limit | $V_{REG1}$ > 7 V; note 8 | 0.45 | – | 1.2 | A |
| $I_{REGsc1}$ | short-circuit current | $R_L \leq 0.5\ \Omega$; note 9 | 50 | 300 | – | mA |
| $\alpha_{ct}$ | cross talk | note 10 | – | 50 | – | dB |
| **Regulator 2;** note 11 | | | | | | |
| $V_{REG2}$ | output voltage | 0.5 mA $\leq I_{REG2} \leq$ 50 mA | 4.8 | 5.0 | 5.2 | V |
| | | 7 V $\leq V_P \leq$ 18 V | 4.8 | 5.0 | 5.2 | V |
| | | 18 V $\leq V_P \leq$ 50 V | 4.75 | 5.0 | 5.25 | V |
| $\Delta V_{REG2}$ | line regulation | 7 V $\leq V_P \leq$ 18 V | – | – | 50 | mV |
| $\Delta V_{REGL2}$ | load regulation | 0.5 mA $\leq I_{REG1} \leq$ 30 mA | – | – | 50 | mV |
| SVRR2 | supply voltage ripple rejection | $f_i$ = 200 Hz; $V_I$ = 2 V (p-p) | 60 | – | – | dB |
| $V_{REGd2}$ | drop-out voltage | $I_{REG2}$ = 30 mA; note 12 | – | 0.3 | 0.4 | V |
| $I_{REGm2}$ | current limit | $V_{REG2}$ > 4.5 V; note 8 | 0.1 | – | 0.5 | A |
| $I_{REGsc2}$ | short-circuit current | $R_L \leq 0.5\ \Omega$; note 9 | – | 50 | – | mA |
| $\alpha_{ct}$ | cross talk | note 13 | – | 50 | – | dB |
| **Power switch** | | | | | | |
| $V_{swd}$ | drop-out voltage | $I_{sw}$ = 0.3 A; note 14 | – | 0.4 | 0.9 | V |
| $I_{swcc}$ | continuous current | | 0.5 | – | – | A |
| $V_{swcl}$ | clamping voltage | $V_P \geq 16.9$ V | – | 15.0 | 16.2 | V |
| $I_M$ | peak current | t ≤ 10 ms | 1.4 | – | – | A |
| $V_{swfb}$ | fly back voltage behaviour | $I_{sw}$ = –200 mA, $V_P$ = 9 V | – | – | 20 | V |
| $I_{lim(sw)}$ | current limit | $V_P$ = 14.4 V; $V_{sw}$ < 1.5 V; note 8 | 0.6 | – | 1.0 | A |

**Notes to the characteristics**

1. Minimum operating voltage, only if $V_P$ has exceeded 6.5 V.
2. Enable and ignition inputs are low and regulator 2 is unloaded.
3. Voltage drop due to load condition.
4. The spread on tracking is one sigma value.
5. Ignition output voltage will be less than or equal to the output voltage of regulator 2.
6. $I_{REG1}$ = 5 mA.
7. The drop-out voltage of regulator 1 is measured between $V_P$ and REG1.
8. At current limit, $I_{REGm}$ is held constant (see Fig.5).
9. The foldback current protection limits the dissipated power at short-circuit (see Figs 5 and 6).
10. The cross talk of regulator 1 is measured with an $I_{REG2}$ = 0.5 mA up to 30 mA with an input frequency of $f_i$ = 100 kHz.
11. $I_{REG2}$ = 5 mA.
12. The drop-out voltage of regulator 2 is measured between $V_P$ and REG2.
13. The cross talk of regulator 2 is measured with an $I_{REG1}$ = 0.5 mA up to 100 mA with an input frequency of $f_i$ = 100 kHz.
14. The drop-out voltage of the power switch is measured between $V_P$ and $V_{sw}$.




a. Regulator 1.




b. Regulator 2.

Fig.5 Foldback current protection of the regulators.

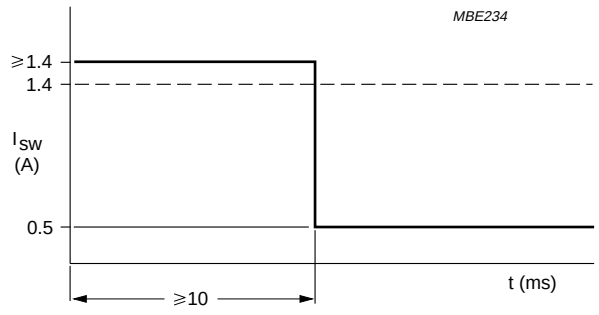
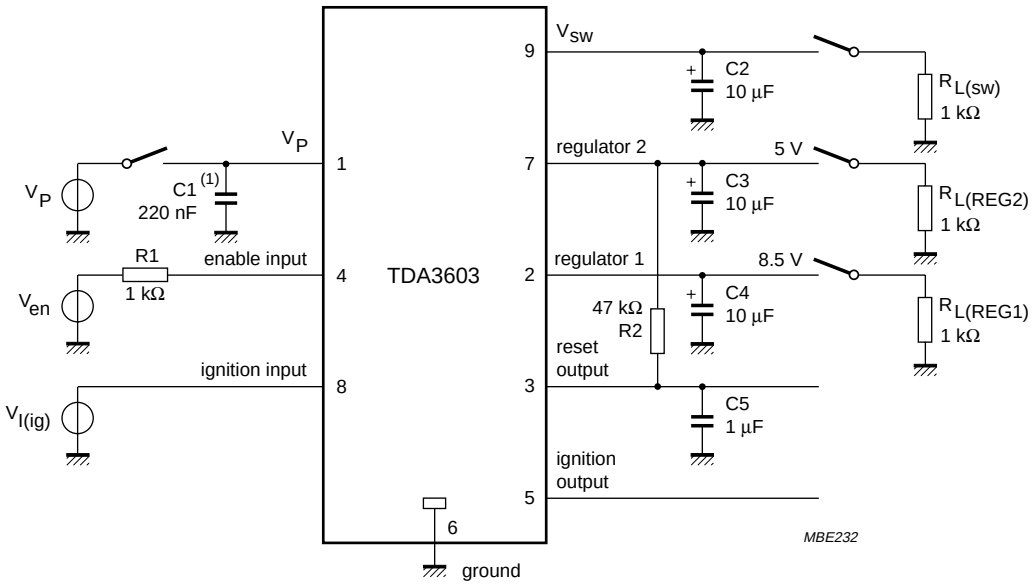



Fig.6 Foldback current protection of the power switch.

## TEST AND APPLICATION INFORMATION




(1) Capacitor not required for stability.

Fig.7 Test circuit (for SOT110-1).

### Noise information

The noise at the output of the regulators depends on the bandwidth of the regulators, which can be adjusted by the output capacitors. Table 1 shows the noise figures.

Although stability is guaranteed when $C_L$ is higher than 10 µF (over temperature range) with tan (ϕ) = 1 in the frequency range 1 to 10 kHz, however, for low noise, a 47 µF load capacitor is required. When electrolytic capacitors are used, the capacitor value will decrease and the ESR will increase much at low temperatures. To avoid oscillation a normal capacitor of 220 nF can be placed in parallel with this electrolytic capacitor.

The noise on the supply line depends on the value of the supply capacitor and is caused by a current noise (output noise of the regulators is translated into a current noise by the output capacitors). When a high frequency capacitor of 220 nF with an electrolytic capacitor of 100 µF in parallel is placed directly over pins 1 and 6 (supply and ground) the noise is minimized.

**Table 1** Noise figures

| REGULATOR | NOISE (µV)(1) | OUTPUT CAPACITOR (µF) |
|---|---|---|
| 1 | 180 | 10 |
| | 100 | 47 |
| | 80 | 100 |
| 2 | 120 | 10 |
| | 70 | 47 |
| | 70 | 100 |

**Note**

1. Bandwidth of 100 kHz.

**SHORT CIRCUIT BEHAVIOUR OF POWER SWITCH**

The short circuit behaviour of the switch with large inductive loads (switch output goes out of the radio) can be improved by replacing C2 (see Fig.7) by a larger electrolytic capacitor of 10 μF/16 V. When the temperature protection of the switch becomes active, due to a short circuit of the switch, the behaviour will be improved.

When the switch is clamped an minimum output capacitor of 10 μF is needed.

The power switch is not protected against ‘loss of ground’ condition (= short of the switch to ground with floating ground pin of the TDA3603 itself). A ‘loss of ground’ situation can in practice only occur when the switch output goes outside the car-radio box.

There is an application solution to protect against ‘loss of ground’ (see Fig.8).

It is advisable to limit the dissipation at short circuit condition by monitoring the output of the power switch. The microprocessor can switch of the power switch when the switch was enabled and the switch output remains low due to a short circuit condition.

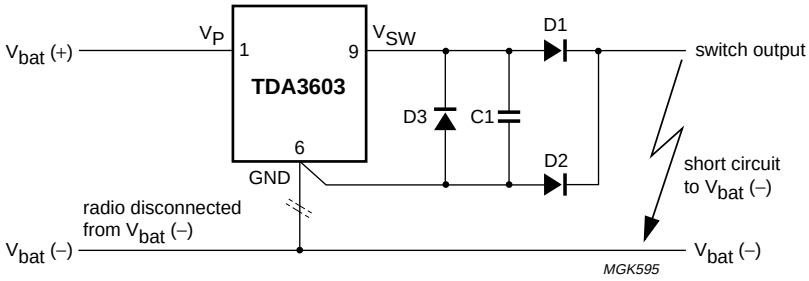
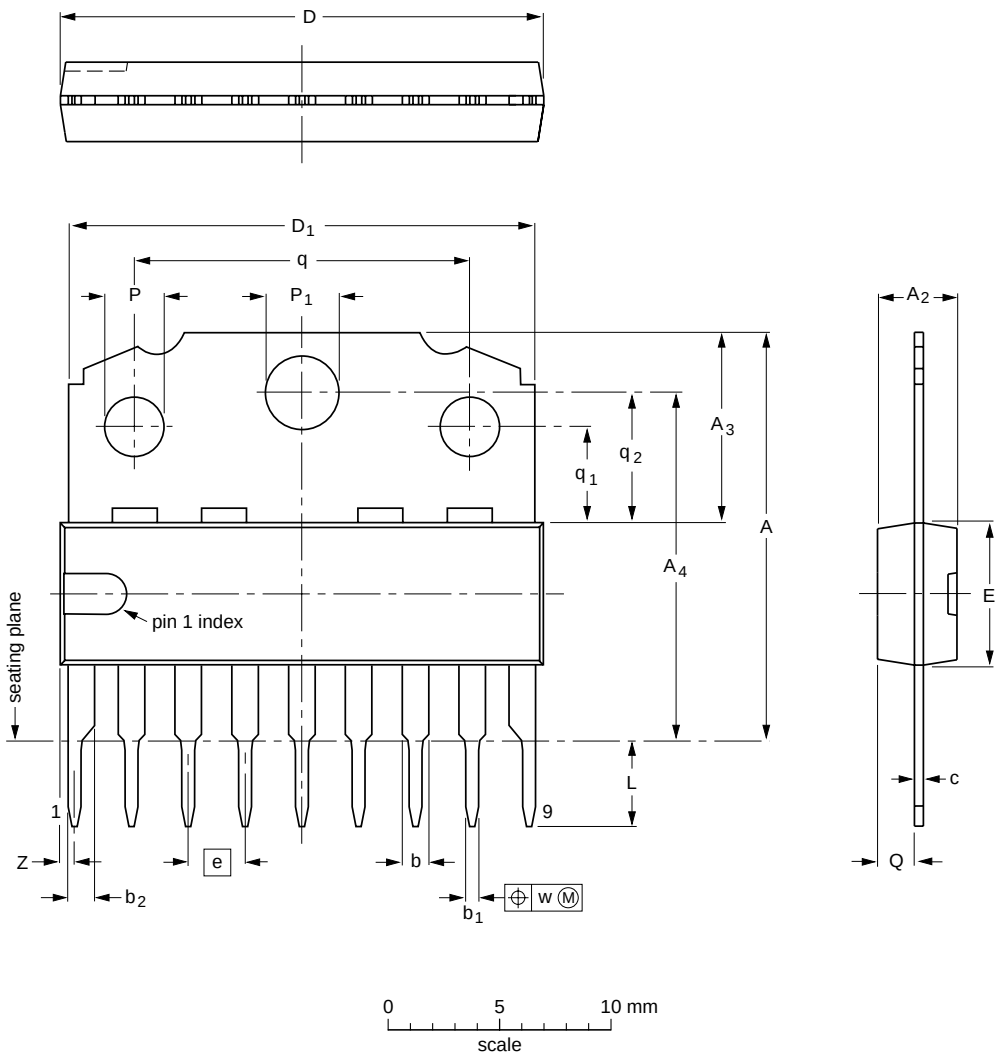



Fig.8 ‘Loss of ground’ protection.

## PACKAGE OUTLINES

**SIL9MPF: plastic single in-line medium power package with fin; 9 leads** **SOT110-1**




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

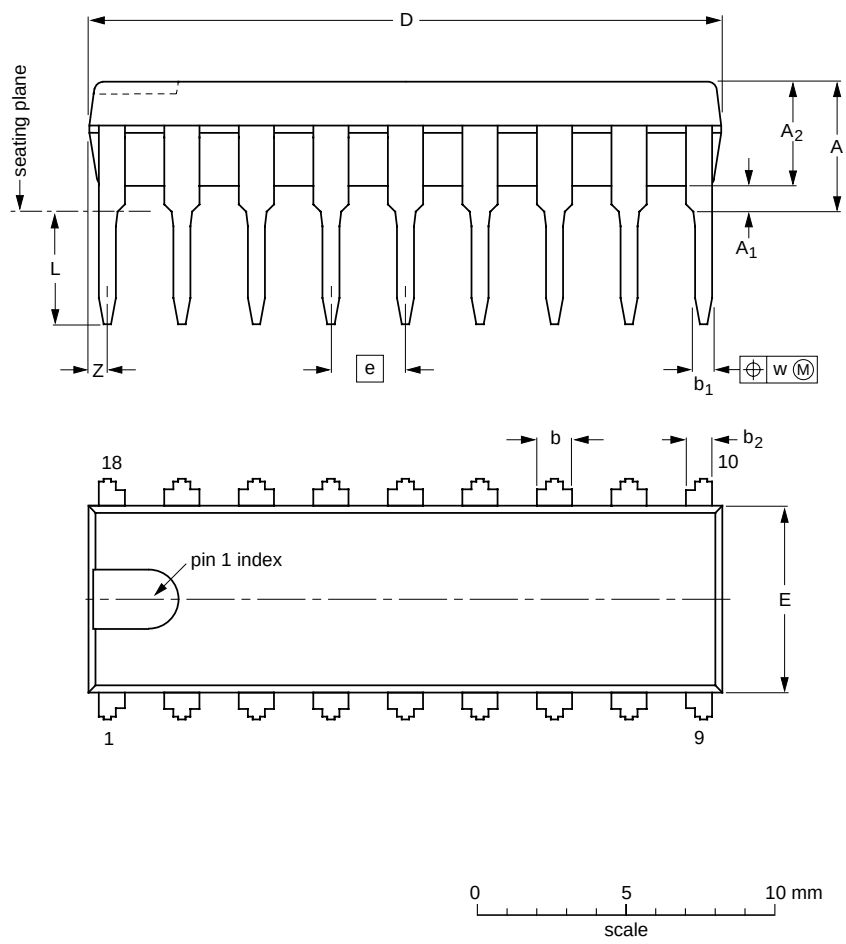
| UNIT | A | $A_2$ max. | $A_3$ | $A_4$ | b | $b_1$ | $b_2$ | c | $D^{(1)}$ | $D_1$ | $E^{(1)}$ | e | L | P | $P_1$ | Q | q | $q_1$ | $q_2$ | w | $Z^{(1)}$ max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 18.5<br>17.8 | 3.7 | 8.7<br>8.0 | 15.8<br>15.4 | 1.40<br>1.14 | 0.67<br>0.50 | 1.40<br>1.14 | 0.48<br>0.38 | 21.8<br>21.4 | 21.4<br>20.7 | 6.48<br>6.20 | 2.54 | 3.9<br>3.4 | 2.75<br>2.50 | 3.4<br>3.2 | 1.75<br>1.55 | 15.1<br>14.9 | 4.4<br>4.2 | 5.9<br>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~~<br>95-02-25 |

**HDIP18: plastic heat-dissipating dual in-line package; 18 leads** **SOT398-1**




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

| UNIT | A max. | $A_1$ min. | $A_2$ max. | b | $b_1$ | $b_2$ | c | D (1) | E (1) | e | $e_1$ | L | $M_E$ | $M_H$ | w | Z (1) max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 4.7 | 0.51 | 3.7 | 1.40<br>1.14 | 0.67<br>0.50 | 1.05<br>0.75 | 0.47<br>0.38 | 21.85<br>21.35 | 6.5<br>6.2 | 2.54 | 7.62 | 3.9<br>3.1 | 8.32<br>8.02 | 8.7<br>7.7 | 0.25 | 1.0 |
| inches | 0.19 | 0.02 | 0.15 | 0.06<br>0.04 | 0.03<br>0.02 | 0.04<br>0.03 | 0.02<br>0.01 | 0.87<br>0.84 | 0.26<br>0.24 | 0.10 | 0.30 | 0.15<br>0.12 | 0.33<br>0.32 | 0.34<br>0.30 | 0.01 | 0.04 |

**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 | | | |
| SOT398-1 | | | | | | ~~94-04-13~~<br>95-01-25 |

## SOLDERING

### Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"IC Package Databook"* (order code 9398 652 90011).

### Soldering by dipping or by wave

The maximum permissible temperature of the solder is 260 °C; solder at this temperature must not be in contact with the joint 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.

### Repairing soldered joints

Apply a low voltage soldering iron (less than 24 V) to the lead(s) of the package, 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.

## 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**

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