

# TDA3683

## Multiple voltage regulator with switch and ignition buffer

Rev. 02 — 7 October 2005

Product data sheet

### 1. General description

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- The TDA3683 is a multiple output voltage regulator with a power switch and an ignition buffer. Several protections and diagnostic options are incorporated in this design.
- The TDA3683 is primarily developed to cover the complete power supply requirements in car radio applications.
- The standby regulators (regulators 1, 2 and 3) are especially designed to supply digital circuitry that has to be permanently connected e.g. Controller Area Network (CAN) bus, Digital Signal Processor (DSP) core and the microcontroller. In combination with the reset delay capacitor (pin RDC1 or pin RDC2/3) and the reset function (pin RST1 or pin RST2/3), a proper start-up sequence for a microcontroller is guaranteed. The storage capacitor (pin STC) makes the standby regulator outputs insensitive for short battery drops (e.g. during engine start-up).
- The switched regulators (regulators 4, 5, 6 and 7) are intended to be used as supply for the tuner, logic, sound processor and CD / tape control.
- The power switch (pin PSW) can be used for switching the electrically powered antenna, display unit and CD / tape drives.
- The ignition buffer is intended to produce a clean logic output signal when a polluted ignition key signal is used as input.

### 2. Features

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- Three enable pin controlled standby regulators:
  - ◆ REG1: 5 V / 600 mA controlled by the EN1 input
  - ◆ REG2: 3.3 V / 200 mA controlled by the EN2/3 input
  - ◆ REG3: 1.9 V / 150 mA controlled by the EN2/3 input
- Four mode pin controlled switched regulators:
  - ◆ REG4: 8.5 V / 350 mA
  - ◆ REG5: 5 V / 1.8 A
  - ◆ REG6: 3.3 V / 1.2 A
  - ◆ REG7: 2.4 V to 10 V / 2 A adjustable using external resistor divider
- One mode pin controlled power switch; 2.2 A continuous and 3 A surge, with delayed lower current limit so as to be less sensitive to inrush currents
- One independent ignition buffer (inverted output, open-collector) with good input protection against high transients
- A storage capacitor is included to provide back-up supply for the standby regulators in the event of loss of battery supply

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- A hold output (3-state) which can be used to communicate to a microcontroller in the event of an internal or external fault condition, such as:
  - ◆ Low supply indication in Standby mode
  - ◆ One or more switched regulators (except REG7) out of regulation
  - ◆ Power switch output short-circuited to ground
  - ◆ Load dump, thermal pre-warning and thermal shutdown
- Reset outputs (push-pull output stage) can be used to call a microcontroller in a smooth way (adjustable delay) at the first power-up
- Two supply pins that can withstand load dump pulses and negative supply voltages; the second supply pin (connected to REG5 and REG6) can be supplied from a separate external voltage (e.g. DC-to-DC downconverter) to reduce power dissipation
- All regulator and power switch outputs are short-circuit proof to ground and supply lines; the dissipation is limited in this condition since all regulators (except REG3) and power switch have a foldback current protection incorporated
- The TDA3683 has three modes of operation:
  - ◆ Sleep: all outputs disabled (very low quiescent current)
  - ◆ Standby: one or more standby regulators enabled (low quiescent current)
  - ◆ On: all outputs enabled
- The standby regulators (including the reset function) and the ignition buffer also function during load dump and thermal shutdown; the switched regulators and power switch will be disabled during these conditions
- Hysteresis is incorporated on internal switching levels
- The TDA3683 is protected against Electrostatic Discharge (ESD) on all pins
- DBS23 package with low thermal resistance and flexible leads.

### 3. Quick reference data

Table 1: Quick reference data

| Symbol              | Parameter                      | Conditions                                                                                           | Min | Typ  | Max  | Unit |
|---------------------|--------------------------------|------------------------------------------------------------------------------------------------------|-----|------|------|------|
| <b>Supplies</b>     |                                |                                                                                                      |     |      |      |      |
| V <sub>P1</sub>     | supply voltage 1               | operating                                                                                            | 9   | 14.4 | 18   | V    |
|                     |                                | reverse polarity; non-operating                                                                      | -   | -    | 18   | V    |
|                     |                                | regulators 1, 2 and 3 on                                                                             | 4.0 | 14.4 | 50   | V    |
|                     |                                | jump start; t ≤ 10 minutes                                                                           | -   | -    | 30   | V    |
|                     |                                | load dump protection; t ≤ 50 ms;<br>t <sub>r</sub> ≥ 2.5 ms                                          | -   | -    | 50   | V    |
| V <sub>P2</sub>     | supply voltage 2               | operating                                                                                            | 6.5 | 14.4 | 18   | V    |
|                     |                                | reverse polarity; non-operating                                                                      | -   | -    | 18   | V    |
|                     |                                | regulators 1, 2 and 3 on                                                                             | 0   | -    | 50   | V    |
|                     |                                | jump start; t ≤ 10 minutes                                                                           | -   | -    | 30   | V    |
|                     |                                | load dump protection; t ≤ 50 ms;<br>t <sub>r</sub> ≥ 2.5 ms                                          | -   | -    | 50   | V    |
| I <sub>q(tot)</sub> | total quiescent supply current | V <sub>EN1</sub> , V <sub>EN2/3</sub> and V <sub>MODE</sub> < 0.8 V                                  | -   | 5    | 30   | μA   |
|                     |                                | V <sub>MODE</sub> and V <sub>IGNIN</sub> < 0.8 V;<br>V <sub>EN1</sub> and V <sub>EN2/3</sub> > 2.4 V | -   | 300  | 450  | μA   |
| T <sub>j</sub>      | junction temperature           | operating                                                                                            | -40 | -    | +150 | °C   |

Table 1: Quick reference data ...continued

| Symbol                                                     | Parameter                     | Conditions                                                       | Min         | Typ       | Max         | Unit |
|------------------------------------------------------------|-------------------------------|------------------------------------------------------------------|-------------|-----------|-------------|------|
| <b>Voltage regulator; <math>V_P = 14.4\text{ V}</math></b> |                               |                                                                  |             |           |             |      |
| $V_{0(\text{REG1})}$                                       | regulator 1 output voltage    | $1\text{ mA} \leq I_{\text{REG1}} \leq 600\text{ mA}$            | 4.75        | 5.0       | 5.25        | V    |
| $V_{0(\text{REG2})}$                                       | regulator 2 output voltage    | $1\text{ mA} \leq I_{\text{REG2}} \leq 200\text{ mA}$            | 3.15        | 3.3       | 3.45        | V    |
| $V_{0(\text{REG3})}$                                       | regulator 3 output voltage    | $1\text{ mA} \leq I_{\text{REG3}} \leq 150\text{ mA}$            | 1.72        | 1.9       | 2.0         | V    |
| $V_{0(\text{REG4})}$                                       | regulator 4 output voltage    | $1\text{ mA} \leq I_{\text{REG4}} \leq 350\text{ mA}$            | 8.1         | 8.5       | 8.9         | V    |
| $V_{0(\text{REG5})}$                                       | regulator 5 output voltage    | $1\text{ mA} \leq I_{\text{REG5}} \leq 1800\text{ mA}$           | 4.75        | 5.0       | 5.25        | V    |
| $V_{0(\text{REG6})}$                                       | regulator 6 output voltage    | $1\text{ mA} \leq I_{\text{REG6}} \leq 1200\text{ mA}$           | 3.15        | 3.3       | 3.45        | V    |
| $V_{0(\text{REG7})}$                                       | output voltage of regulator 7 | $1\text{ mA} \leq I_{\text{REG7}} \leq 2000\text{ mA}$           | $V_0 - 5\%$ | 2.4 to 10 | $V_0 + 5\%$ | V    |
| <b>Power switch</b>                                        |                               |                                                                  |             |           |             |      |
| $V_{\text{drop(PSW)}}$                                     | drop-out voltage              | $I_{\text{PSW}} = 1\text{ A}; V_{P1} = V_{P2} = 13.5\text{ V}$   | -           | 0.45      | 0.65        | V    |
|                                                            |                               | $I_{\text{PSW}} = 2.2\text{ A}; V_{P1} = V_{P2} = 13.5\text{ V}$ | -           | 1.0       | 1.8         | V    |
| $I_{M(\text{PSW})}$                                        | peak current                  | $V_{P1} = V_{P2} < 17\text{ V}$                                  | 3           | -         | -           | A    |

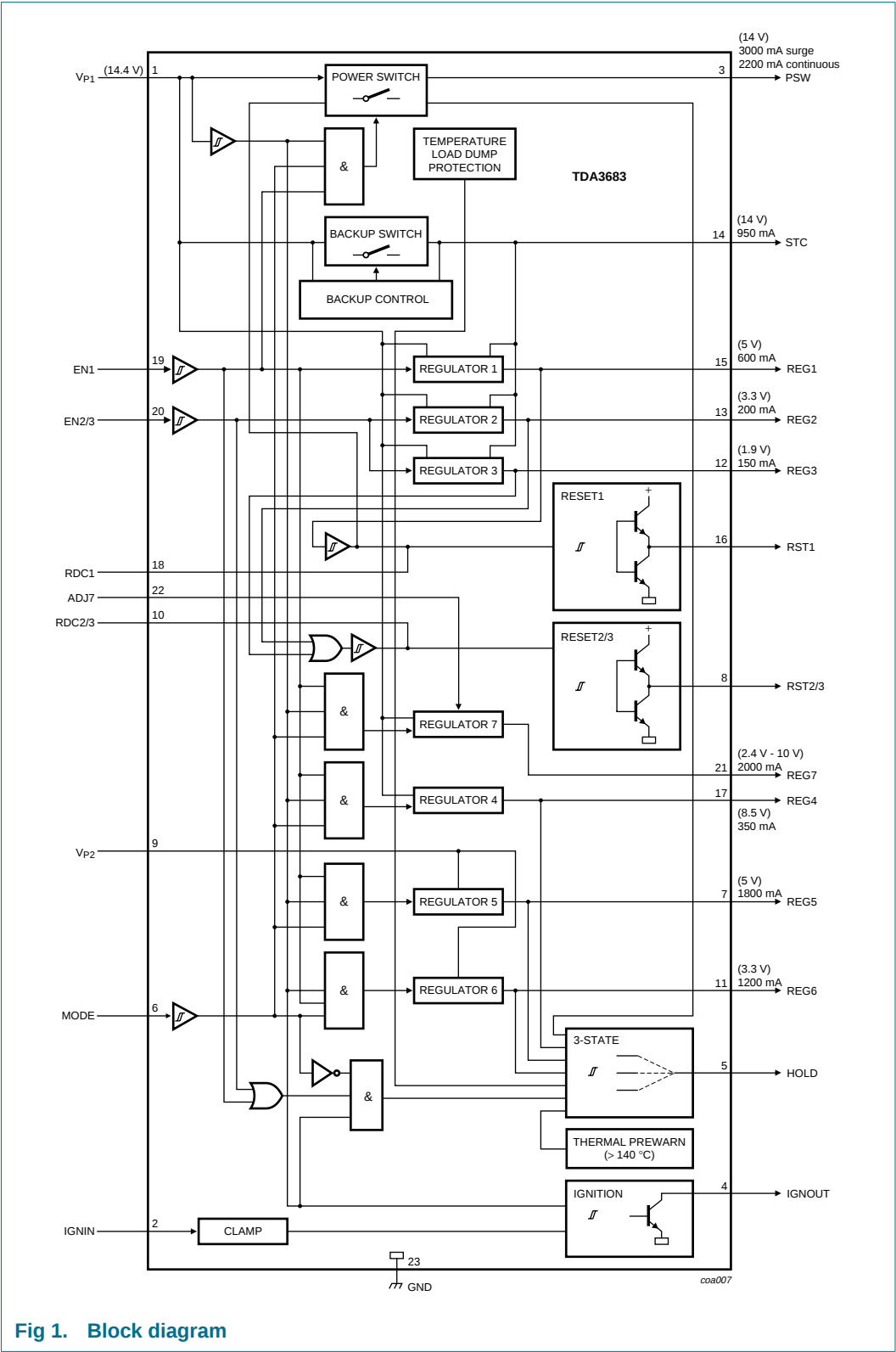
## 4. Ordering information

Table 2: Ordering information

| Type number | Package |                                                                                               |          |
|-------------|---------|-----------------------------------------------------------------------------------------------|----------|
|             | Name    | Description                                                                                   | Version  |
| TDA3683J    | DBS23P  | plastic DIL-bent-SIL power package; 23 leads (straight lead length 3.2 mm)                    | SOT411-1 |
| TDA3683SD   | RDBS23P | plastic rectangular DIL-bent-SIL (reverse bent) power package; 23 leads (row spacing 2.54 mm) | SOT889-1 |

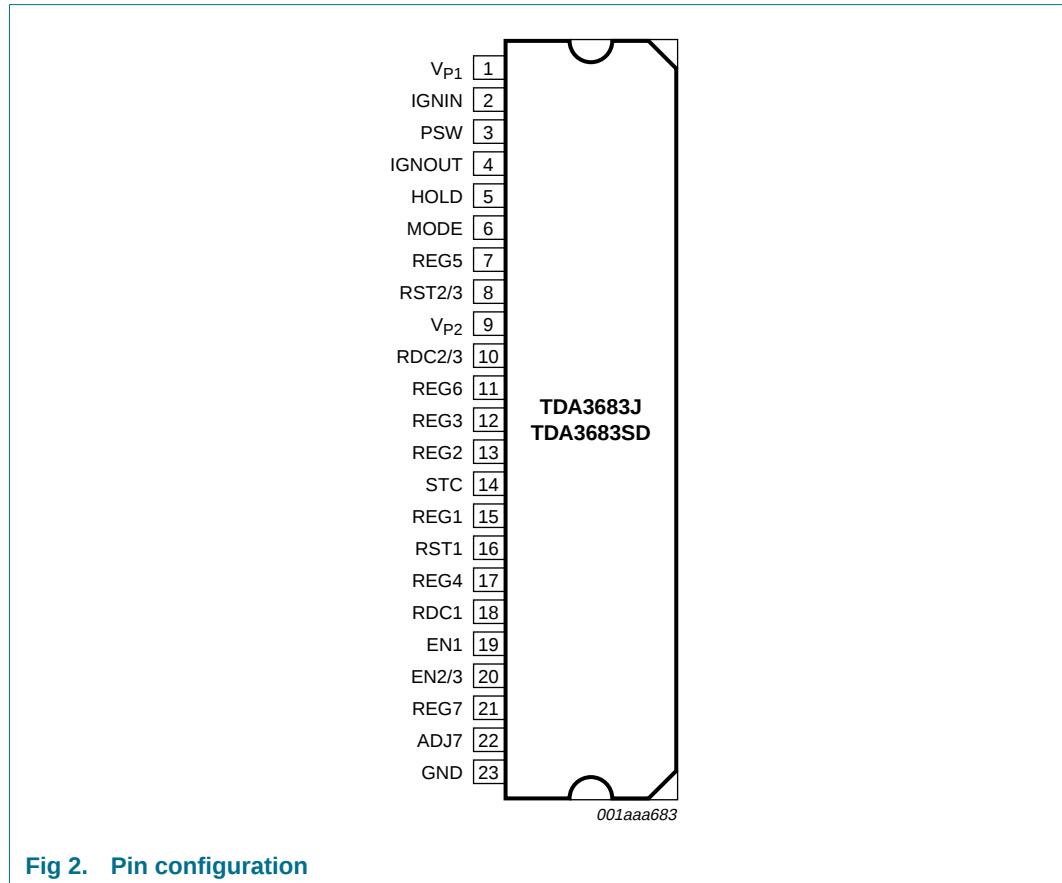


5. Block diagram



## 6. Pinning information

### 6.1 Pinning



### 6.2 Pin description

Table 3: Pin description

| Symbol          | Pin | Description                                             |
|-----------------|-----|---------------------------------------------------------|
| V <sub>P1</sub> | 1   | supply voltage 1                                        |
| IGNIN           | 2   | ignition input                                          |
| PSW             | 3   | power switch output                                     |
| IGNOUT          | 4   | ignition output                                         |
| HOLD            | 5   | hold output                                             |
| MODE            | 6   | enable input for regulators 4, 5, 6, 7 and power switch |
| REG5            | 7   | regulator 5 output                                      |
| RST2/3          | 8   | reset output for regulators 2 and 3                     |
| V <sub>P2</sub> | 9   | supply voltage 2 (for regulators 5 and 6)               |
| RDC2/3          | 10  | reset delay capacitor for regulators 2 and 3            |
| REG6            | 11  | regulator 6 output                                      |
| REG3            | 12  | regulator 3 output                                      |

Table 3: Pin description ...continued

| Symbol | Pin | Description                            |
|--------|-----|----------------------------------------|
| REG2   | 13  | regulator 2 output                     |
| STC    | 14  | storage capacitor (backup) output      |
| REG1   | 15  | regulator 1 output                     |
| RST1   | 16  | reset output for regulator 1           |
| REG4   | 17  | regulator 4 output                     |
| RDC1   | 18  | reset delay capacitor for regulator 1  |
| EN1    | 19  | enable input for regulator 1           |
| EN2/3  | 20  | enable input for regulators 2 and 3    |
| REG7   | 21  | regulator 7 output                     |
| ADJ7   | 22  | regulator 7 adjust input               |
| GND    | 23  | ground / substrate <a href="#">[1]</a> |

[1] The heat tab is internally connected to pin GND.

## 7. Functional description

The TDA3683 is a multiple output voltage regulator with a power switch and ignition buffer. The device is primarily intended for use in car radio applications. An overall functional description of the building blocks is given in the following sections.

### 7.1 Standby regulators

The standby regulators (pins REG1, REG2 and REG3) are used for digital circuitry that has to be permanently connected to a supply voltage (e.g. CAN bus DSP core or microcontroller). REG1 is controlled by its own active HIGH enable input (EN1). REG2 and REG3 have a combined enable input (EN2/3) with similar logic properties. Permanent voltage tracking will exist between REG2 and REG3 during power-up and power-down. All standby regulators have a low quiescent current and will not be switched off during thermal shutdown and load dump conditions. The outputs are protected against overload and short-circuit conditions by a current limit / foldback protection.

### 7.2 Switched regulators

The switched regulators (pins REG4, REG5, REG6 and REG7) are activated by the active HIGH mode input. The regulators are protected against overload and short-circuit conditions by a current limit / foldback protection. They will be switched off during thermal shutdown and load dump conditions. The output voltage of REG7 can be adjusted (2.4 V to 10 V) by using two external resistors connected between the regulator output, the feedback input and ground; see [Figure 10](#). REG7 has a built-in flyback clamp for use in case of inductive loads.

### 7.3 Power switch

The power switch (pin PSW) is activated by the MODE input. It is switched off during thermal shutdown and load dump conditions. The power switch output voltage is internally clamped at 16 V to protect connected application circuitry (e.g. display and CD / tape drives). The power switch has three different output current modes, depending on its output voltage, the reset capacitor (RDC1) and the junction temperature (i.e. high current, low current and foldback protection); see [Figure 7](#). In the event of an overload the power switch can maintain the maximum output current for a limited period of time (determined by the integration time of the reset delay capacitor) before it drops back to the lower output current capability. This functionality is implemented to prevent, in case of loads such as light bulbs, relays or electrical motors, the power switch from folding back on momentary high inrush currents. In the event of junction temperatures above 150 °C, the power switch will drop back to the lower output current capability. The power switch has a built-in flyback clamp for use in case of inductive loads.

### 7.4 Enable and mode inputs

The enable inputs (pins EN1 and EN2/3) are used to switch on or switch off the standby regulators. The mode input (MODE) is used to enable the switched regulators and the power switch. When all of these inputs are LOW the circuit is in Sleep mode and only the enable detection circuit and the supply overvoltage protection circuit are active. In Sleep mode the device draws a very small quiescent current from the supply. When at least one of the enable inputs is activated the circuit will operate in Standby mode. When the mode input is activated the on condition will be established; before the MODE pin can be activated at least one of the standby regulators must be activated. The enable and mode inputs are 3.3 V and 5 V CMOS logic compatible. A detailed description of the enable and mode pin dependencies is given in [Table 4](#).

**Table 4: Enable and mode pin dependencies**

| Pin |       |      | Description                                                                                                                |
|-----|-------|------|----------------------------------------------------------------------------------------------------------------------------|
| EN1 | EN2/3 | MODE |                                                                                                                            |
| 0   | 0     | 0    | standby regulators, switched regulators, power switch and ignition buffer disabled                                         |
| 0   | 0     | 1    | standby regulators, switched regulators, power switch and ignition buffer disabled                                         |
| 0   | 1     | 0    | standby regulators 2 and 3 and ignition buffer enabled; standby regulator 1, switched regulators and power switch disabled |
| 0   | 1     | 1    | standby regulators 2 and 3, switched regulators and ignition buffer enabled; standby regulator 1 and power switch disabled |
| 1   | 0     | 0    | standby regulator 1 and ignition buffer enabled; standby regulators 2 and 3, switched regulators and power switch disabled |
| 1   | 0     | 1    | standby regulator 1, switched regulators, power switch and ignition buffer enabled; standby regulators 2 and 3 disabled    |
| 1   | 1     | 0    | standby regulators and ignition buffer enabled; switched regulators and power switch disabled                              |
| 1   | 1     | 1    | standby regulators, ignition buffer, switched regulators and power switch enabled                                          |

## 7.5 Storage capacitor

The storage capacitor (pin STC) is used as a back-up supply for the standby regulators when the battery (pins  $V_{P1}$  /  $V_{P2}$ ) can no longer provide the supply. This situation may occur for cold weather engine starts. The rising and falling storage capacitor voltage threshold levels determine if the standby regulators can be switched on.

The storage capacitor pin is not intended to be used as an output (e.g. supply switch). No external load should be connected to this pin.

## 7.6 Reset delay capacitors

The reset delay capacitors (pins RDC1 and RDC2/3) are used to delay the reset pulse (RST1 and RST2/3) starting from the time the associated standby regulator output voltage comes within its regulated voltage range i.e. crosses the rising reset threshold level. An internal current source is used to charge the reset delay capacitor. The reset output will be released (output goes HIGH) when the voltage on the reset delay capacitor crosses the rising threshold level.

If the associated standby regulator voltage drops out of its regulated voltage range (drops below its falling reset threshold level) the reset delay capacitor will be discharged with a relatively high sink current. The reset output will be activated (output goes LOW) when the reset delay capacitor crosses the falling threshold level. This feature is included to secure a smooth start-up of the microcontroller at first connection, without uncontrolled switching of the relevant standby regulators during a start-up sequence. It should be noted that RDC1 is also used as a time constant for the delayed current protection of the power switch.

## 7.7 Reset outputs

The reset function depends on the reset delay capacitor voltage and includes hysteresis to avoid oscillation at the threshold level. The reset outputs are push-pull for sourcing or sinking current. The output voltage can be switched between the ground level and the output voltage of the relevant standby regulator. An external reset delay capacitor can be added if a timed reset pulse is required ( $C_{RDC1}$  or  $C_{RDC2/3}$ ).

Standby regulator 1 has an independent reset function (pins RST1 and RDC1). Standby regulators 2 and 3 have combined circuitry (pins RST2/3 and RDC2/3). The reset trigger signals from both regulators are connected using an OR function to the reset output buffer thus ensuring that both regulators can generate a reset when appropriate. The RST1 output is linked to standby regulator 1 (5 V) and, therefore, generates a 5 V HIGH-level output voltage. The RST2/3 output is linked to regulator 2 (3.3 V) and, therefore, generates a 3.3 V HIGH-level output voltage.

## 7.8 Hold output

The hold output (pin HOLD) is a combined output for the thermal pre-warning signal and all other diagnostic signals. To distinguish between these signals, the HOLD output is designed as an active HIGH 3-state output buffer. When a no failure condition is present the output is LOW. When a thermal pre-warning signal is generated (e.g. to shut down other circuits in the radio before the regulator itself shuts down) the signal rises to its MID

level. In all other warning situations, the HOLD output rises to its HIGH level. In order to generate standard CMOS logic compliant signals an external decoding circuit has to be implemented; see [Figure 9](#).

The HOLD output will be active HIGH when:

- The output voltage of one or more switched regulators is out of regulation (except REG7), due to overload or supply voltage drops
- The power switch operates in the Foldback mode
- In Standby or On mode the thermal shutdown is activated
- In Standby or On mode the load dump protection is activated
- In Standby mode a low battery voltage occurs ( $V_{P1}$ ) indicating that it is not possible to pull REG4 into regulation when switching it on.

It should be noted that there is intentionally no out-of-regulation detection for REG7 since it can be adjusted to maximum 10 V and would, in that event, activate the HOLD signal very early.

The HOLD function includes hysteresis in order to avoid oscillations when the hold threshold level is crossed. A schematic diagram of the HOLD function is illustrated in [Figure 3](#).

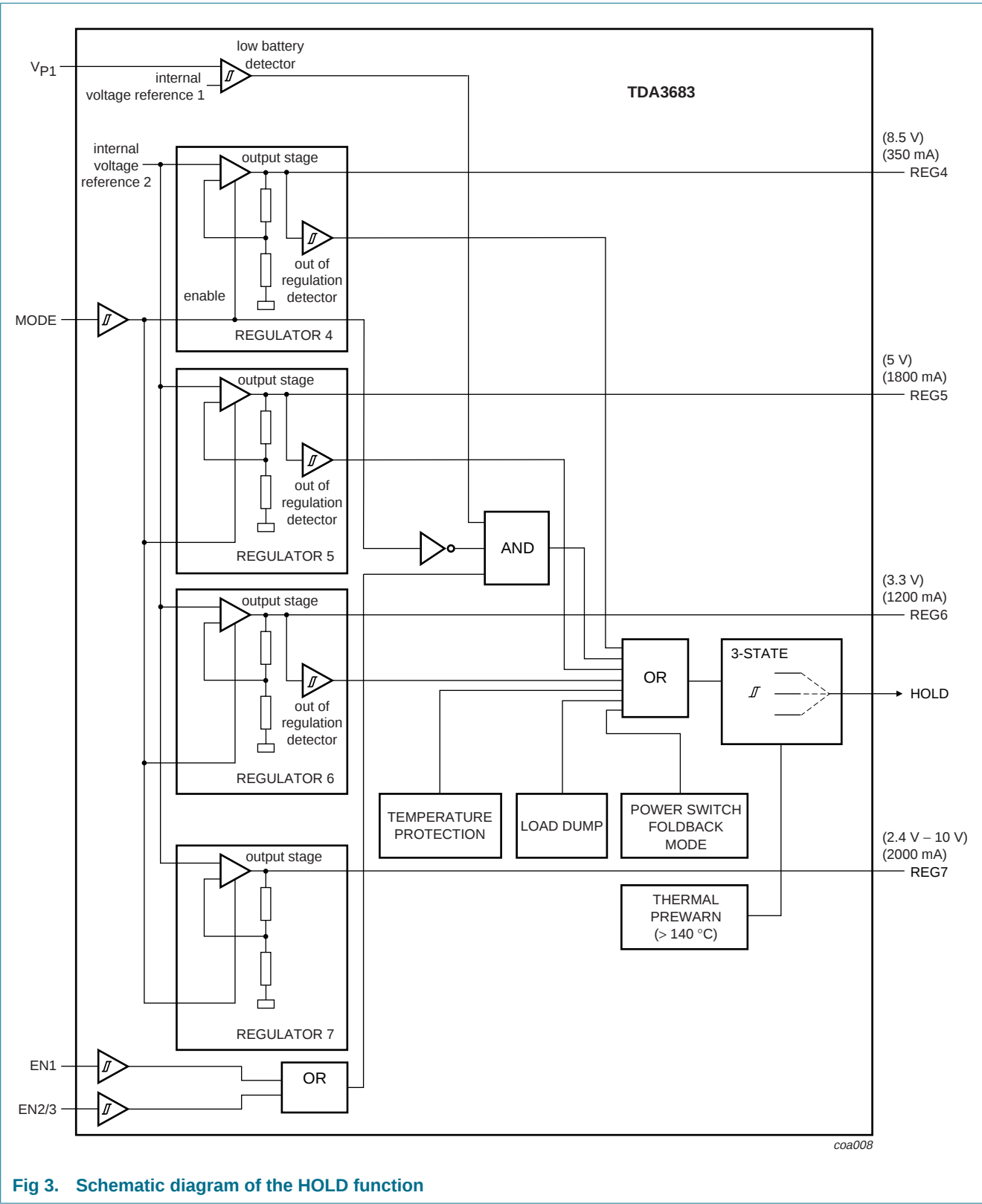


Fig 3. Schematic diagram of the HOLD function

## 7.9 Ignition buffer

The ignition buffer (pins IGNIN and IGNOUT) is an independent inverting open-collector output buffer circuit that can be used to sense the start line of the ignition key in a car. The start line will only be pulled-up to the battery voltage in the event of an engine crank resulting in a LOW at the inverting output of the ignition buffer. This output signal can be used to immediately mute an audio amplifier during the engine crank.

To guarantee a reliable LOW output signal, even in extreme cold weather crank conditions (the battery voltage may momentarily drop down to 3 V) a low supply latch function is implemented.

To make the ignition buffer input robust, for possible extreme transients present on the battery line, an input RC filter is strongly advised. A blocking diode is also recommended to prevent substrate injection in case of negative voltage spikes at the input.

## 7.10 Supply voltage inputs

The supply voltage inputs (pins  $V_{P1}$  and  $V_{P2}$ ) are intended to be connected to the battery. Both inputs are protected against load dump transients and reverse battery connections. The second supply pin ( $V_{P2}$ ) is internally connected to the high current/ low output voltage switched regulators (REG5 and REG6) and can be connected to an external DC-to-DC downconverter for reduced power dissipation and increased power supply efficiency.

Power must be applied to pin  $V_{P1}$  to ensure that the circuits are functional, since the band gaps for the switched and standby regulators are connected to this supply pin.

Rising and falling supply voltage threshold levels determine if the switched regulators and power switch can be switched on.

The timing diagrams for various regulator functions are illustrated in [Figure 4](#) and [Figure 5](#).

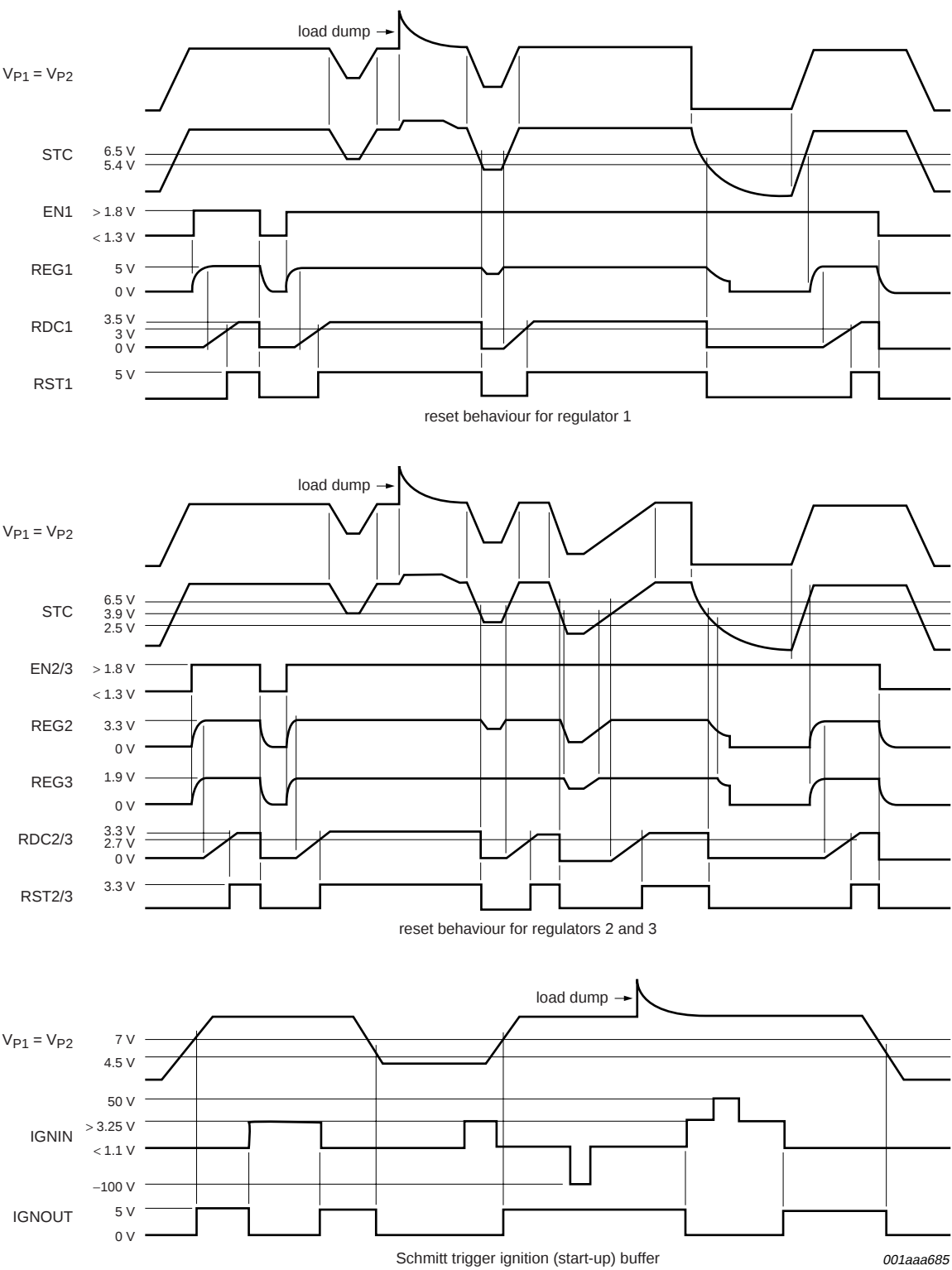


Fig 4. Timing diagram of the reset outputs for REG1, REG2 and REG3 and ignition Schmitt trigger

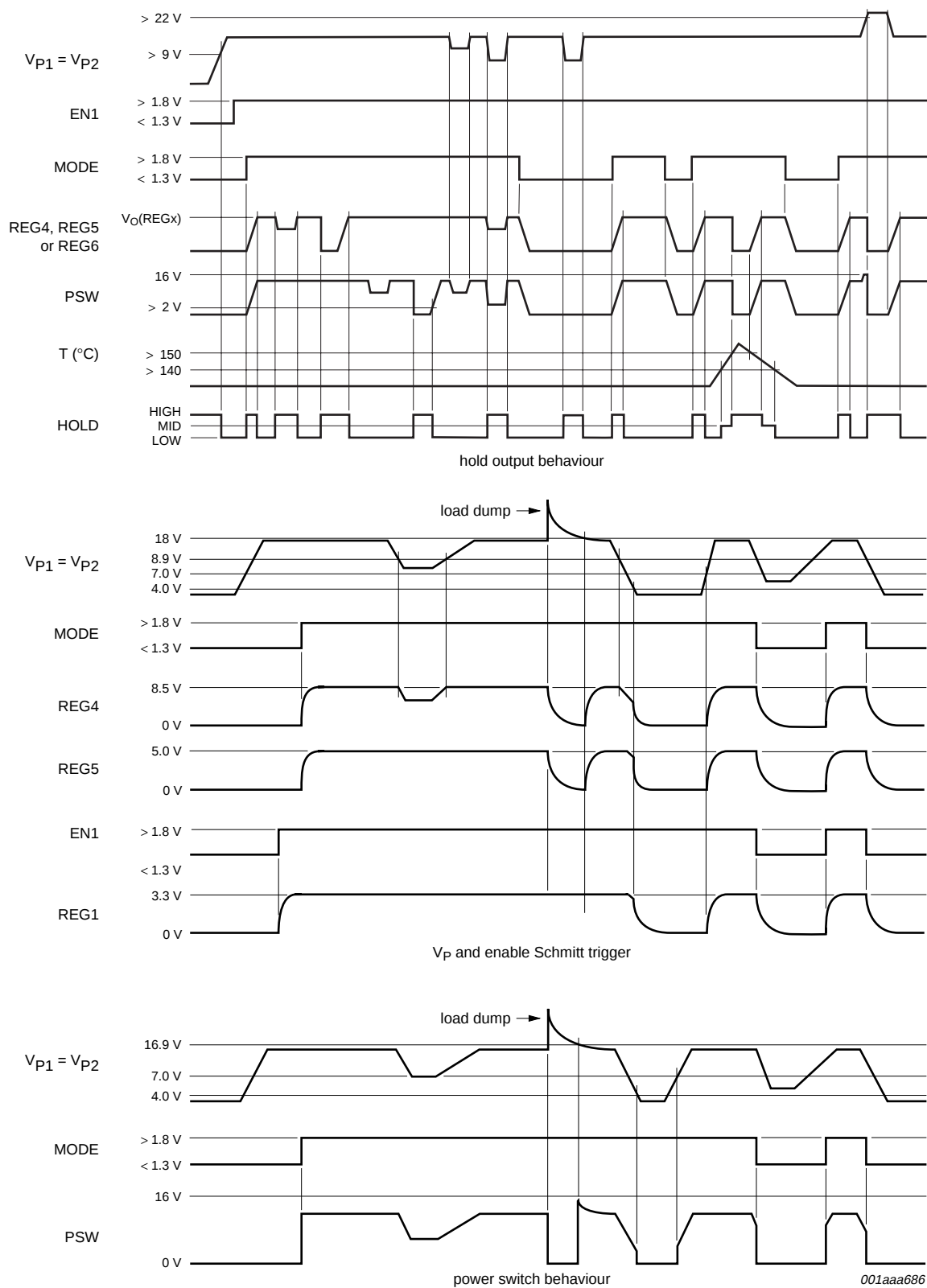


Fig 5. Timing diagram of the HOLD output, V<sub>P</sub> and Schmitt trigger and power switch

## 8. Limiting values

**Table 5: Limiting values**

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

| Symbol           | Parameter            | Conditions                                               | Min | Max  | Unit |
|------------------|----------------------|----------------------------------------------------------|-----|------|------|
| V <sub>P1</sub>  | supply voltage 1     | operating                                                | -   | 18   | V    |
|                  |                      | reverse polarity; non-operating                          | -   | 18   | V    |
|                  |                      | jump start; t ≤ 10 minutes                               | -   | 30   | V    |
|                  |                      | load dump protection; t ≤ 50 ms; t <sub>r</sub> ≥ 2.5 ms | -   | 50   | V    |
| V <sub>P2</sub>  | supply voltage 2     | operating                                                | -   | 18   | V    |
|                  |                      | reverse polarity; non-operating                          | -   | 18   | V    |
|                  |                      | jump start; t ≤ 10 minutes                               | -   | 30   | V    |
|                  |                      | load dump protection; t ≤ 50 ms; t <sub>r</sub> ≥ 2.5 ms | -   | 50   | V    |
| T <sub>stg</sub> | storage temperature  | non-operating                                            | -55 | +150 | °C   |
| T <sub>amb</sub> | ambient temperature  | operating                                                | -40 | +85  | °C   |
| T <sub>j</sub>   | junction temperature | operating                                                | -40 | +150 | °C   |

## 9. Thermal characteristics

**Table 6: Thermal characteristics**

| Symbol               | Parameter                                   | Conditions  | Typ | Unit |
|----------------------|---------------------------------------------|-------------|-----|------|
| R <sub>th(j-c)</sub> | thermal resistance from junction to case    |             | 1   | K/W  |
| R <sub>th(j-a)</sub> | thermal resistance from junction to ambient | in free air | 40  | K/W  |

## 10. Characteristics

**Table 7: Characteristics**

V<sub>P1</sub> = V<sub>P2</sub> = 14.4 V; T<sub>amb</sub> = 25 °C; R<sub>L</sub> = ∞ Ω; measured in test circuits of [Figure 8](#); unless otherwise specified.

| Symbol                    | Parameter                    | Conditions                                               | Min                     | Typ  | Max | Unit |
|---------------------------|------------------------------|----------------------------------------------------------|-------------------------|------|-----|------|
| <b>Supplies</b>           |                              |                                                          |                         |      |     |      |
| V <sub>P1</sub>           | supply voltage 1             | operating                                                | 9                       | 14.4 | 18  | V    |
|                           |                              | regulators 1, 2 and 3 on                                 | <a href="#">[1]</a> 4.0 | 14.4 | 50  | V    |
|                           |                              | jump start; t ≤ 10 minutes                               | -                       | -    | 30  | V    |
|                           |                              | load dump protection; t ≤ 50 ms; t <sub>r</sub> ≥ 2.5 ms | -                       | -    | 50  | V    |
| V <sub>P2</sub>           | supply voltage 2             | operating                                                | 6.5                     | 14.4 | 18  | V    |
|                           |                              | regulators 1, 2 and 3 on                                 | 0                       | -    | 50  | V    |
|                           |                              | jump start; t ≤ 10 minutes                               | -                       | -    | 30  | V    |
|                           |                              | load dump protection; t ≤ 50 ms; t <sub>r</sub> ≥ 2.5 ms | -                       | -    | 50  | V    |
| V <sub>bat(loadump)</sub> | battery overvoltage shutdown | V <sub>P1</sub> and/or V <sub>P2</sub>                   | 18                      | 20   | 22  | V    |

**Table 7: Characteristics** ...continued

$V_{P1} = V_{P2} = 14.4$  V;  $T_{amb} = 25$  °C;  $R_L = \infty$   $\Omega$ ; measured in test circuits of [Figure 8](#); unless otherwise specified.

| Symbol                                                                    | Parameter                                | Conditions                                                                                             | Min                      | Typ                      | Max                       | Unit |
|---------------------------------------------------------------------------|------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------|--------------------------|---------------------------|------|
| I <sub>q(tot)</sub>                                                       | total quiescent supply current           | V <sub>EN1</sub> , V <sub>EN2/3</sub> and V <sub>MODE</sub> < 0.8 V                                    | -                        | 5                        | 30                        | μA   |
|                                                                           |                                          | V <sub>MODE</sub> and V <sub>IGNIN</sub> < 0.8 V; V <sub>EN1</sub> and V <sub>EN2/3</sub> > 2.4 V      | -                        | 300                      | 450                       | μA   |
|                                                                           |                                          | V <sub>MODE</sub> and V <sub>IGNIN</sub> < 0.8 V; V <sub>EN1</sub> > 2.4 V; V <sub>EN2/3</sub> < 0.8 V | -                        | 150                      | 250                       | μA   |
|                                                                           |                                          | V <sub>MODE</sub> and V <sub>IGNIN</sub> < 0.8 V; V <sub>EN1</sub> < 0.8 V; V <sub>EN2/3</sub> > 2.4 V | -                        | 225                      | 325                       | μA   |
| Schmitt trigger for power supply (regulators 4, 5, 6, 7 and power switch) |                                          |                                                                                                        |                          |                          |                           |      |
| V <sub>th(r)</sub>                                                        | rising threshold voltage                 | V <sub>P1</sub> and V <sub>P2</sub> rising                                                             | 6.5                      | 7.0                      | 7.5                       | V    |
| V <sub>th(f)</sub>                                                        | falling threshold voltage                | V <sub>P1</sub> and V <sub>P2</sub> falling                                                            | 4.0                      | 4.5                      | 5.0                       | V    |
| V <sub>hys</sub>                                                          | hysteresis voltage                       |                                                                                                        | -                        | 2.5                      | -                         | V    |
| Schmitt trigger for enable (EN1, EN2/3) and MODE inputs                   |                                          |                                                                                                        |                          |                          |                           |      |
| V <sub>th(r)</sub>                                                        | rising threshold voltage                 |                                                                                                        | 1.4                      | 1.8                      | 2.4                       | V    |
| V <sub>th(f)</sub>                                                        | falling threshold voltage                |                                                                                                        | 0.9                      | 1.3                      | 1.9                       | V    |
| V <sub>hys</sub>                                                          | hysteresis voltage                       | I <sub>REGx</sub> = I <sub>PSW</sub> = 1 mA                                                            | -                        | 0.5                      | -                         | V    |
| I <sub>LI</sub>                                                           | input leakage current                    | V <sub>ENx/MODE</sub> = 5 V                                                                            | 1                        | 5                        | 20                        | μA   |
| Reset trigger level of regulator 1                                        |                                          |                                                                                                        |                          |                          |                           |      |
| V <sub>th(r)</sub>                                                        | rising threshold voltage                 | V <sub>P1</sub> and V <sub>P2</sub> rising; I <sub>REG1</sub> = 50 mA                                  | <a href="#">[2]</a> 4.43 | V <sub>REG1</sub> – 0.15 | V <sub>REG1</sub> – 0.1   | V    |
| V <sub>th(f)</sub>                                                        | falling threshold voltage                | V <sub>P1</sub> and V <sub>P2</sub> falling; I <sub>REG1</sub> = 50 mA                                 | <a href="#">[2]</a> 4.4  | V <sub>REG1</sub> – 0.25 | V <sub>REG1</sub> – 0.13  | V    |
| Reset trigger level of regulator 2                                        |                                          |                                                                                                        |                          |                          |                           |      |
| V <sub>th(r)</sub>                                                        | rising threshold voltage                 | V <sub>P1</sub> and V <sub>P2</sub> rising; I <sub>REG2</sub> = 50 mA                                  | <a href="#">[2]</a> 3.03 | V <sub>REG2</sub> – 0.15 | V <sub>REG2</sub> – 0.1   | V    |
| V <sub>th(f)</sub>                                                        | falling threshold voltage                | V <sub>P1</sub> and V <sub>P2</sub> falling; I <sub>REG2</sub> = 50 mA                                 | <a href="#">[2]</a> 3.0  | V <sub>REG2</sub> – 0.25 | V <sub>REG2</sub> – 0.13  | V    |
| Reset trigger level of regulator 3                                        |                                          |                                                                                                        |                          |                          |                           |      |
| V <sub>th(r)</sub>                                                        | rising threshold voltage                 | V <sub>P1</sub> and V <sub>P2</sub> rising; I <sub>REG3</sub> = 50 mA                                  | <a href="#">[2]</a> 1.75 | V <sub>REG3</sub> – 0.10 | V <sub>REG3</sub> – 0.08  | V    |
| V <sub>th(f)</sub>                                                        | falling threshold voltage                | V <sub>P1</sub> and V <sub>P2</sub> falling; I <sub>REG3</sub> = 50 mA                                 | <a href="#">[2]</a> 1.72 | V <sub>REG3</sub> – 0.15 | V <sub>REG3</sub> – 0.10  | V    |
| Schmitt triggers for HOLD output                                          |                                          |                                                                                                        |                          |                          |                           |      |
| V <sub>th(r)</sub> (REG4)                                                 | rising threshold voltage of regulator 4  | V <sub>P1</sub> and V <sub>P2</sub> rising                                                             | <a href="#">[2]</a> -    | V <sub>REG4</sub> – 0.15 | V <sub>REG4</sub> – 0.075 | V    |
| V <sub>th(f)</sub> (REG4)                                                 | falling threshold voltage of regulator 4 | V <sub>P1</sub> and V <sub>P2</sub> falling                                                            | <a href="#">[2]</a> 7.9  | V <sub>REG4</sub> – 0.35 | -                         | V    |
| V <sub>hys</sub> (REG4)                                                   | hysteresis voltage due to regulator 4    |                                                                                                        | -                        | 0.2                      | -                         | V    |
| V <sub>th(r)</sub> (REG5)                                                 | rising threshold voltage of regulator 5  | V <sub>P1</sub> and V <sub>P2</sub> rising                                                             | <a href="#">[2]</a> -    | V <sub>REG5</sub> – 0.15 | V <sub>REG5</sub> – 0.075 | V    |
| V <sub>th(f)</sub> (REG5)                                                 | falling threshold voltage of regulator 5 | V <sub>P1</sub> and V <sub>P2</sub> falling                                                            | <a href="#">[2]</a> 4.3  | V <sub>REG5</sub> – 0.35 | -                         | V    |

**Table 7: Characteristics ...continued**

$V_{P1} = V_{P2} = 14.4 \text{ V}$ ;  $T_{amb} = 25^\circ \text{C}$ ;  $R_L = \infty \Omega$ ; measured in test circuits of [Figure 8](#); unless otherwise specified.

| Symbol                         | Parameter                                         | Conditions                                                                                                 | Min     | Typ               | Max                | Unit          |
|--------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------|---------|-------------------|--------------------|---------------|
| $V_{hys(REG5)}$                | hysteresis voltage due to regulator 5             |                                                                                                            | -       | 0.2               | -                  | V             |
| $V_{th(r)(REG6)}$              | rising threshold voltage of regulator 6           | $V_{P1}$ and $V_{P2}$ rising                                                                               | [2] -   | $V_{REG6} - 0.15$ | $V_{REG6} - 0.075$ | V             |
| $V_{th(f)(REG6)}$              | falling threshold voltage of regulator 6          | $V_{P1}$ and $V_{P2}$ falling                                                                              | [2] 2.7 | $V_{REG6} - 0.3$  | -                  | V             |
| $V_{hys(REG6)}$                | hysteresis voltage due to regulator 6             |                                                                                                            | -       | 0.15              | -                  | V             |
| $V_{th(r)(VP)}$                | rising threshold voltage of supply voltage        | $V_{P1}$ and $V_{P2}$ rising;<br>$V_{MODE} < 0.8 \text{ V}$ ;<br>$V_{EN1}$ or $V_{EN2/3} > 2.4 \text{ V}$  | 7.8     | 8.4               | 9                  | V             |
| $V_{th(f)(VP)}$                | falling threshold voltage of supply voltage       | $V_{P1}$ and $V_{P2}$ falling;<br>$V_{MODE} < 0.8 \text{ V}$ ;<br>$V_{EN1}$ or $V_{EN2/3} > 2.4 \text{ V}$ | 7.7     | 8.1               | 8.5                | V             |
| $V_{hys(VP)}$                  | hysteresis voltage of supply voltage              |                                                                                                            | -       | 0.3               | -                  | V             |
| <b>Hold buffer</b>             |                                                   |                                                                                                            |         |                   |                    |               |
| $V_{o(HOLD)(L)}$               | LOW-level HOLD output                             |                                                                                                            | 0       | 0.1               | 0.6                | V             |
| $I_{sink(L)}$                  | LOW-level sink current                            | $V_{HOLD} \leq 0.6 \text{ V}$                                                                              | 0.5     | -                 | -                  | mA            |
| $V_{o(HOLD)(H)}$               | HIGH-level HOLD output                            |                                                                                                            | 6.0     | 7.0               | 8.0                | V             |
| $I_{source(H)}$                | HIGH-level source current                         | $V_{HOLD} = 3.3 \text{ V}$                                                                                 | 1       | 2                 | -                  | mA            |
| $V_{o(HOLD)(M)}$               | MID-level HOLD output                             |                                                                                                            | 1.8     | 2.15              | 2.5                | V             |
| $I_{source(M)}$                | MID-level source current                          | $V_{HOLD} = 1.5 \text{ V}$                                                                                 | 1       | 2                 | -                  | mA            |
| $t_r$                          | rise time                                         | $C_L = 50 \text{ pF}$                                                                                      | -       | 7                 | 50                 | $\mu\text{s}$ |
| $t_f$                          | fall time                                         | $C_L = 50 \text{ pF}$                                                                                      | -       | 1                 | 50                 | $\mu\text{s}$ |
| <b>Reset and Reset delay 1</b> |                                                   |                                                                                                            |         |                   |                    |               |
| $I_{sink(L)}$                  | LOW-level sink current                            | $V_{RST1} \leq 0.8 \text{ V}$ ; $V_{RDC1} < 1.0 \text{ V}$                                                 | 2       | -                 | -                  | mA            |
| $I_{source(H)}$                | HIGH-level source current                         | $V_{RST1} = 4.5 \text{ V}$ ;<br>$V_{RDC1} > 3.5 \text{ V}$                                                 | 240     | 400               | 900                | $\mu\text{A}$ |
| $t_r$                          | rise time                                         | $C_L = 50 \text{ pF}$                                                                                      | -       | 7                 | 50                 | $\mu\text{s}$ |
| $t_f$                          | fall time                                         | $C_L = 50 \text{ pF}$                                                                                      | -       | 1                 | 50                 | $\mu\text{s}$ |
| $I_{ch}$                       | charge current                                    | $V_{RDC1} = 0 \text{ V}$ ; $V_{EN1} > 2.4 \text{ V}$                                                       | 2       | 4                 | 8                  | $\mu\text{A}$ |
| $I_{dch}$                      | discharge current                                 | $V_{RDC1} = 3 \text{ V}$ ;<br>$V_{P1} = V_{P2} = 4.3 \text{ V}$                                            | 1.0     | 1.6               | -                  | mA            |
| $V_{th(r)(RDC1)}$              | reset delay capacitor 1 rising voltage threshold  |                                                                                                            | [3] 2.5 | 3.0               | 3.5                | V             |
| $V_{th(f)(RDC1)}$              | reset delay capacitor 1 falling voltage threshold |                                                                                                            | [3] 1.0 | 1.2               | 1.4                | V             |
| $t_d(RST1)$                    | delay time reset signal                           | $C_{RDC1} = 47 \text{ nF}$                                                                                 | [4] 20  | 35                | 70                 | ms            |

**Table 7: Characteristics ...continued**

$V_{P1} = V_{P2} = 14.4 \text{ V}$ ;  $T_{amb} = 25 \text{ }^{\circ}\text{C}$ ;  $R_L = \infty \text{ } \Omega$ ; measured in test circuits of [Figure 8](#); unless otherwise specified.

| Symbol                                                                                | Parameter                                           | Conditions                                                          | Min     | Typ  | Max  | Unit          |
|---------------------------------------------------------------------------------------|-----------------------------------------------------|---------------------------------------------------------------------|---------|------|------|---------------|
| $t_{d(PSW)}$                                                                          | delay time power switch foldback protection         | $C_{RDC1} = 47 \text{ nF}$                                          | [5] 8   | 17.5 | 40   | ms            |
| $V_{OH(RST1)}$                                                                        | HIGH-level output voltage on pin RST1               | $I_{RST1} = 0 \text{ A}$                                            | 4.5     | 5    | 5.25 | V             |
| $V_{OL(RST1)}$                                                                        | LOW-level output voltage on pin RST1                | $I_{RST1} = 0 \text{ A}$                                            | 0       | 0.2  | 0.8  | V             |
| <b>Reset and reset delay 2/3</b>                                                      |                                                     |                                                                     |         |      |      |               |
| $I_{sink(L)}$                                                                         | LOW-level sink current                              | $V_{RST2/3} \leq 0.6 \text{ V}$ ;<br>$V_{RDC2/3} < 1.0 \text{ V}$   | 2       | -    | -    | mA            |
| $I_{source(H)}$                                                                       | HIGH-level source current                           | $V_{RST2/3} = 2.7 \text{ V}$ ;<br>$V_{RDC2/3} > 3.2 \text{ V}$      | 240     | 400  | 900  | $\mu\text{A}$ |
| $t_r$                                                                                 | rise time                                           | $C_L = 50 \text{ pF}$                                               | -       | 7    | 50   | $\mu\text{s}$ |
| $t_f$                                                                                 | fall time                                           | $C_L = 50 \text{ pF}$                                               | -       | 1    | 50   | $\mu\text{s}$ |
| $I_{ch}$                                                                              | charge current                                      | $V_{RDC2/3} = 0 \text{ V}$ ; $V_{EN2/3} > 2.4 \text{ V}$            | 2       | 4    | 8    | $\mu\text{A}$ |
| $I_{dch}$                                                                             | discharge current                                   | $V_{RDC2/3} = 2.7 \text{ V}$ ;<br>$V_{P1} = V_{P2} = 3 \text{ V}$   | 1.0     | 1.6  | -    | mA            |
| $V_{th(r)(RDC2/3)}$                                                                   | reset delay capacitor 2/3 rising voltage threshold  |                                                                     | [6] 2.2 | 2.7  | 3.2  | V             |
| $V_{th(f)(RDC2/3)}$                                                                   | reset delay capacitor 2/3 falling voltage threshold |                                                                     | [6] 1.0 | 1.2  | 1.4  | V             |
| $V_{OH(RST2/3)}$                                                                      | HIGH-level output voltage on pin RST2/3             | $I_{RST2/3} = 0 \text{ A}$                                          | 3.0     | 3.3  | 3.45 | V             |
| $V_{OL(RST2/3)}$                                                                      | LOW-level output voltage on pin RST2/3              | $I_{RST2/3} = 0 \text{ A}$                                          | 0       | 0.2  | 0.6  | V             |
| $t_{d(RST2/3)}$                                                                       | delay time reset signal                             | $C_{RDC2/3} = 47 \text{ nF}$                                        | [4] 20  | 35   | 70   | ms            |
| <b>Regulator 1 (<math>I_{REG1} = 5 \text{ mA}</math>; unless otherwise specified)</b> |                                                     |                                                                     |         |      |      |               |
| $V_{O(REG1)}$                                                                         | output voltage                                      | $1 \text{ mA} \leq I_{REG1} \leq 600 \text{ mA}$                    | 4.75    | 5.0  | 5.25 | V             |
|                                                                                       |                                                     | $7 \text{ V} \leq V_{P1/2} \leq 18 \text{ V}$                       | 4.75    | 5.0  | 5.25 | V             |
|                                                                                       |                                                     | $18 \text{ V} \leq V_{P1/2} \leq 50 \text{ V}$                      | 4.75    | 5.0  | 5.25 | V             |
| $\Delta V$                                                                            | line regulation                                     | $7 \text{ V} \leq V_{P1/2} \leq 18 \text{ V}$                       | -       | 2    | 100  | mV            |
| $\Delta V_L$                                                                          | load regulation                                     | $1 \text{ mA} \leq I_{REG1} \leq 300 \text{ mA}$                    | -       | 20   | 50   | mV            |
|                                                                                       |                                                     | $1 \text{ mA} \leq I_{REG1} \leq 600 \text{ mA}$                    | -       | -    | 100  | mV            |
| PSRR                                                                                  | supply voltage ripple rejection                     | $f_i = 3 \text{ kHz}$ ; $V_i = 2 \text{ V (p-p)}$                   | 40      | 45   | -    | dB            |
| $V_{drop(REG1)}$                                                                      | drop-out voltage                                    | $I_{REG1} = 300 \text{ mA}$ ;<br>$V_{P1} = V_{P2} = 4.75 \text{ V}$ | [7] -   | 0.4  | 0.6  | V             |
|                                                                                       |                                                     | $I_{REG1} = 600 \text{ mA}$ ;<br>$V_{P1} = V_{P2} = 5.75 \text{ V}$ | [7] -   | 0.8  | 1.2  | V             |
|                                                                                       |                                                     | $I_{REG1} = 300 \text{ mA}$ ;<br>$V_{STC} = 4.75 \text{ V}$         | [8] -   | 0.2  | 0.5  | V             |
|                                                                                       |                                                     | $I_{REG1} = 600 \text{ mA}$ ;<br>$V_{STC} = 5.75 \text{ V}$         | [8] -   | 0.8  | 1.0  | V             |

**Table 7: Characteristics ...continued**

$V_{P1} = V_{P2} = 14.4 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ;  $R_L = \infty \Omega$ ; measured in test circuits of [Figure 8](#); unless otherwise specified.

| Symbol                                                                                | Parameter                            | Conditions                                                         | Min      | Typ  | Max  | Unit |
|---------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------|----------|------|------|------|
| $I_{m(REG1)}$                                                                         | current limit                        | $V_{REG1} > 4.5 \text{ V}$                                         | [9] 640  | 1400 | 2500 | mA   |
| $I_{st(REG1)}$                                                                        | start-up current                     | $V_{REG1} \leq 1.5 \text{ V}$                                      | 120      | -    | -    | mA   |
| $I_{sc(REG1)}$                                                                        | short-circuit current                | $R_L \leq 0.5 \Omega$                                              | [10] 160 | 250  | -    | mA   |
| <b>Regulator 2 (<math>I_{REG2} = 5 \text{ mA}</math>; unless otherwise specified)</b> |                                      |                                                                    |          |      |      |      |
| $V_{o(REG2)}$                                                                         | output voltage                       | $1 \text{ mA} \leq I_{REG2} \leq 200 \text{ mA}$                   | 3.15     | 3.3  | 3.45 | V    |
|                                                                                       |                                      | $7 \text{ V} \leq V_{P1/2} \leq 18 \text{ V}$                      | 3.15     | 3.3  | 3.45 | V    |
|                                                                                       |                                      | $18 \text{ V} \leq V_{P1/2} \leq 50 \text{ V}$                     | 3.15     | 3.3  | 3.45 | V    |
| $\Delta V$                                                                            | line regulation                      | $7 \text{ V} \leq V_{P1/2} \leq 18 \text{ V}$                      | -        | 2    | 50   | mV   |
| $\Delta V_L$                                                                          | load regulation                      | $1 \text{ mA} \leq I_{REG2} \leq 100 \text{ mA}$                   | -        | 20   | 50   | mV   |
|                                                                                       |                                      | $1 \text{ mA} \leq I_{REG2} \leq 200 \text{ mA}$                   | -        | -    | 100  | mV   |
| PSRR                                                                                  | supply voltage ripple rejection      | $f_i = 3 \text{ kHz}$ ; $V_i = 2 \text{ V (p-p)}$                  | 45       | 50   | -    | dB   |
| $V_{drop(REG2)}$                                                                      | drop-out voltage                     | $I_{REG2} = 200 \text{ mA}$ ;<br>$V_{P1} = V_{P2} = 4.0 \text{ V}$ | [7] -    | 0.75 | 0.85 | V    |
|                                                                                       |                                      | $I_{REG2} = 200 \text{ mA}$ ;<br>$V_{STC} = 4.0 \text{ V}$         | [8] -    | 0.75 | 0.85 | V    |
| $I_{m(REG2)}$                                                                         | current limit                        | $V_{REG2} > 3 \text{ V}$                                           | [9] 225  | 800  | 1500 | mA   |
| $I_{sc(REG2)}$                                                                        | short-circuit current                | $R_L \leq 0.5 \Omega$                                              | [10] 75  | 200  | -    | mA   |
| <b>Regulator 3 (<math>I_{REG3} = 5 \text{ mA}</math>; unless otherwise specified)</b> |                                      |                                                                    |          |      |      |      |
| $V_{o(REG3)}$                                                                         | output voltage                       | $1 \text{ mA} \leq I_{REG3} \leq 150 \text{ mA}$                   | 1.72     | 1.9  | 2.0  | V    |
|                                                                                       |                                      | $4.0 \text{ V} \leq V_{P1/2} \leq 18 \text{ V}$                    | 1.72     | 1.9  | 2.0  | V    |
|                                                                                       |                                      | $18 \text{ V} \leq V_{P1/2} \leq 50 \text{ V}$                     | 1.72     | 1.9  | 2.0  | V    |
| $\Delta V$                                                                            | line regulation                      | $7 \text{ V} \leq V_{P1/2} \leq 18 \text{ V}$                      | -        | 2    | 50   | mV   |
| $\Delta V_L$                                                                          | load regulation                      | $1 \text{ mA} \leq I_{REG3} \leq 50 \text{ mA}$                    | -        | 20   | 50   | mV   |
|                                                                                       |                                      | $1 \text{ mA} \leq I_{REG3} \leq 150 \text{ mA}$                   | -        | -    | 100  | mV   |
| PSRR                                                                                  | supply voltage ripple rejection      | $f_i = 3 \text{ kHz}$ ; $V_i = 2 \text{ V (p-p)}$                  | 50       | 55   | -    | dB   |
| $V_{drop(REG3)}$                                                                      | drop-out voltage                     | $I_{REG3} = 150 \text{ mA}$ ;<br>$V_{P1} = V_{P2} = 4.0 \text{ V}$ | [7] -    | 2.20 | 2.28 | V    |
|                                                                                       |                                      | $I_{REG3} = 150 \text{ mA}$ ;<br>$V_{STC} = 4.0 \text{ V}$         | [8] -    | 2.20 | 2.28 | V    |
| $I_{m(REG3)}$                                                                         | current limit                        | $V_{REG3} > 1.6 \text{ V}$                                         | [9] 160  | 600  | 1000 | mA   |
| $I_{sc(REG3)}$                                                                        | short-circuit current                | $R_L \leq 0.5 \Omega$                                              | [10] 160 | 200  | -    | mA   |
| $V_{o(REG2)} - V_{o(REG3)}$                                                           | output voltage tracking REG3 to REG2 | $0 \leq V_{P1/2} \leq 18 \text{ V}$                                | -        | -    | 2.8  | V    |
| <b>Regulator 4 (<math>I_{REG4} = 5 \text{ mA}</math>; unless otherwise specified)</b> |                                      |                                                                    |          |      |      |      |
| $V_{o(off)}$                                                                          | output voltage off                   |                                                                    | -        | 1    | 400  | mV   |
| $V_{o(REG4)}$                                                                         | output voltage                       | $1 \text{ mA} \leq I_{REG4} \leq 350 \text{ mA}$                   | 8.1      | 8.5  | 8.9  | V    |
|                                                                                       |                                      | $9.5 \text{ V} \leq V_{P1/2} \leq 18 \text{ V}$                    | 8.1      | 8.5  | 8.9  | V    |
| $\Delta V$                                                                            | line regulation                      | $9.5 \text{ V} \leq V_{P1/2} \leq 18 \text{ V}$                    | -        | 2    | 50   | mV   |
| $\Delta V_L$                                                                          | load regulation                      | $1 \text{ mA} \leq I_{REG4} \leq 350 \text{ mA}$                   | -        | 20   | 85   | mV   |

**Table 7: Characteristics** ...continued

$V_{P1} = V_{P2} = 14.4$  V;  $T_{amb} = 25$  °C;  $R_L = \infty$   $\Omega$ ; measured in test circuits of [Figure 8](#); unless otherwise specified.

| Symbol                                                                        | Parameter                       | Conditions                                                        | Min         | Typ       | Max         | Unit |
|-------------------------------------------------------------------------------|---------------------------------|-------------------------------------------------------------------|-------------|-----------|-------------|------|
| PSRR                                                                          | supply voltage ripple rejection | $f_i = 3$ kHz; $V_i = 2$ V (p-p)                                  | 60          | 70        | -           | dB   |
| $V_{drop(REG4)}$                                                              | drop-out voltage                | $I_{REG4} = 350$ mA;<br>$V_{P1} = V_{P2} = 8.55$ V                | [7] -       | 0.4       | 0.7         | V    |
| $I_{m(REG4)}$                                                                 | current limit                   | $V_{REG4} > 7$ V                                                  | [9] 400     | 1300      | 2000        | mA   |
| $I_{sc(REG4)}$                                                                | short-circuit current           | $R_L \leq 0.5$ $\Omega$                                           | [10] 125    | 200       | -           | mA   |
| <b>Regulator 5 (<math>I_{REG5} = 5</math> mA; unless otherwise specified)</b> |                                 |                                                                   |             |           |             |      |
| $V_{o(off)}$                                                                  | output voltage off              |                                                                   | -           | 1         | 400         | mV   |
| $V_{o(REG5)}$                                                                 | output voltage                  | $1 \text{ mA} \leq I_{REG5} \leq 1800$ mA                         | 4.75        | 5.0       | 5.25        | V    |
|                                                                               |                                 | $7 \text{ V} \leq V_{P1/2} \leq 18$ V                             | 4.75        | 5.0       | 5.25        | V    |
| $\Delta V$                                                                    | line regulation                 | $7 \text{ V} \leq V_{P2} \leq 18$ V                               | -           | 2         | 50          | mV   |
| $\Delta V_L$                                                                  | load regulation                 | $1 \text{ mA} \leq I_{REG5} \leq 1800$ mA                         | -           | 20        | 150         | mV   |
| PSRR                                                                          | supply voltage ripple rejection | $f_i = 3$ kHz; $V_i = 2$ V (p-p)                                  | 60          | 70        | -           | dB   |
| $V_{drop(REG5)}$                                                              | drop-out voltage                | $I_{REG5} = 1800$ mA; $V_{P2} = 6$ V                              | [7] -       | 1         | 1.5         | V    |
| $I_{m(REG5)}$                                                                 | current limit                   | $V_{REG5} > 4.5$ V                                                | [9] 2.0     | 4.5       | 6.25        | A    |
| $I_{sc(REG5)}$                                                                | short-circuit current           | $R_L \leq 0.5$ $\Omega$                                           | [10] 1.0    | 1.2       | -           | A    |
| <b>Regulator 6 (<math>I_{REG6} = 5</math> mA; unless otherwise specified)</b> |                                 |                                                                   |             |           |             |      |
| $V_{o(off)}$                                                                  | output voltage off              |                                                                   | -           | 1         | 400         | mV   |
| $V_{o(REG6)}$                                                                 | output voltage                  | $1 \text{ mA} \leq I_{REG6} \leq 1200$ mA                         | 3.15        | 3.3       | 3.45        | V    |
|                                                                               |                                 | $7 \text{ V} \leq V_{P1/2} \leq 18$ V                             | 3.15        | 3.3       | 3.45        | V    |
| $\Delta V$                                                                    | line regulation                 | $5 \text{ V} \leq V_{P2} \leq 18$ V; $V_{P1} = 7$ V               | -           | 2         | 50          | mV   |
| $\Delta V_L$                                                                  | load regulation                 | $1 \text{ mA} \leq I_{REG6} \leq 1200$ mA;<br>$T_{amb} > 0$ °C    | -           | 20        | 50          | mV   |
|                                                                               |                                 | $1 \text{ mA} \leq I_{REG6} \leq 1200$ mA;<br>$T_{amb} \leq 0$ °C | -           | 35        | 70          | mV   |
| PSRR                                                                          | supply voltage ripple rejection | $f_i = 3$ kHz; $V_i = 2$ V (p-p)                                  | 60          | 75        | -           | dB   |
| $V_{drop(REG6)}$                                                              | drop-out voltage                | $I_{REG6} = 1200$ mA ; $V_{P2} = 5$ V                             | [7] -       | 1.7       | 2.2         | V    |
| $I_{m(REG6)}$                                                                 | current limit                   | $V_{REG6} > 3.0$ V                                                | [9] 1.3     | 2.9       | 4.0         | A    |
| $I_{sc(REG6)}$                                                                | short-circuit current           | $R_L \leq 0.5$ $\Omega$                                           | [10] 0.8    | 0.9       | -           | A    |
| <b>Regulator 7 (<math>I_{REG7} = 5</math> mA; unless otherwise specified)</b> |                                 |                                                                   |             |           |             |      |
| $V_{o(off)}$                                                                  | output voltage off              |                                                                   | -           | 1         | 400         | mV   |
| $V_{o(REG7)}$                                                                 | output voltage                  | $1 \text{ mA} \leq I_{REG7} \leq 2000$ mA                         | $V_o - 5\%$ | 2.4 to 10 | $V_o + 5\%$ | V    |
|                                                                               |                                 | $11 \text{ V} \leq V_{P1/2} \leq 18$ V                            | $V_o - 5\%$ | 2.4 to 10 | $V_o + 5\%$ | V    |
| $\Delta V$                                                                    | line regulation                 | $11 \text{ V} \leq V_{P1/2} \leq 18$ V                            | -           | 2         | 50          | mV   |
| $\Delta V_L$                                                                  | load regulation                 | $1 \text{ mA} \leq I_{REG7} \leq 2000$ mA                         | -           | 20        | 150         | mV   |
| PSRR                                                                          | supply voltage ripple rejection | $f_i = 3$ kHz; $V_i = 2$ V (p-p)                                  | 45          | 50        | -           | dB   |

**Table 7: Characteristics ...continued**

$V_{P1} = V_{P2} = 14.4$  V;  $T_{amb} = 25$  °C;  $R_L = \infty$   $\Omega$ ; measured in test circuits of [Figure 8](#); unless otherwise specified.

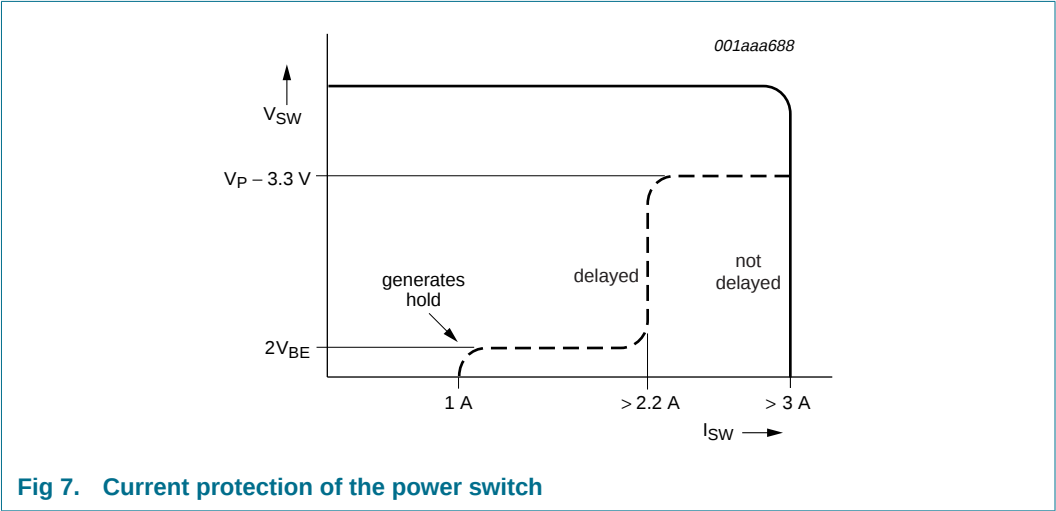
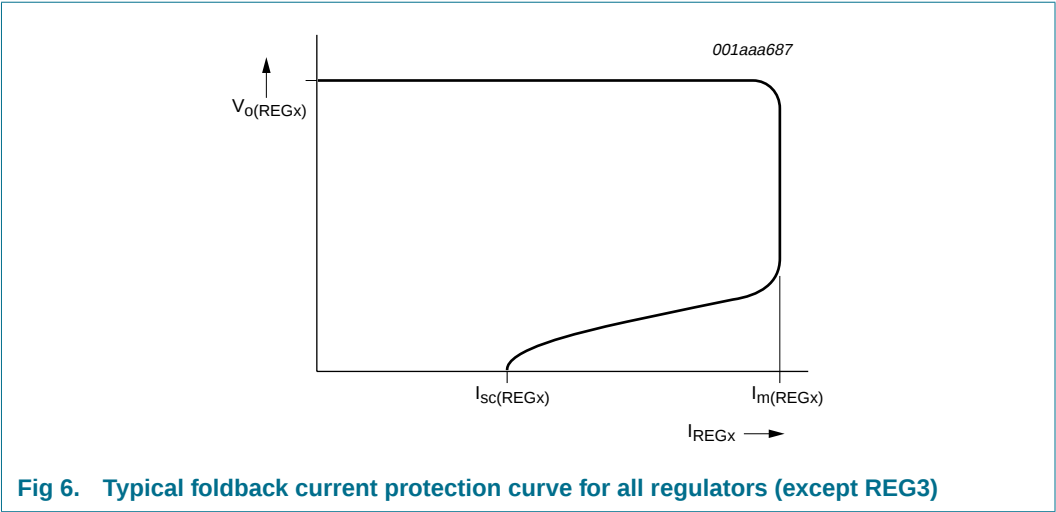
| Symbol                                              | Parameter                                   | Conditions                                                                      | Min       | Typ          | Max  | Unit    |
|-----------------------------------------------------|---------------------------------------------|---------------------------------------------------------------------------------|-----------|--------------|------|---------|
| $V_{drop(REG7)}$                                    | drop-out voltage                            | $I_{REG7} = 1000$ mA; $V_0 = 10$ V; $V_{P1} = V_{P2} = 10.75$ V                 | [7] -     | 1.0          | 1.25 | V       |
|                                                     |                                             | $I_{REG7} = 2000$ mA; $V_0 = 10$ V; $V_{P1} = V_{P2} = 10.75$ V                 | [7] -     | 1.25         | 1.5  | V       |
|                                                     |                                             | $I_{REG7} = 1000$ mA; $V_0 = 5$ V; $V_{P1} = V_{P2} = 5.75$ V                   | [7] -     | 1.0          | 1.25 | V       |
|                                                     |                                             | $I_{REG7} = 2000$ mA; $V_0 = 5$ V; $V_{P1} = V_{P2} = 5.75$ V                   | [7] -     | 1.25         | 1.5  | V       |
|                                                     |                                             | $I_{REG7} = 1000$ mA; $V_0 = 2.4$ V; $V_{P1} = V_{P2} = 5$ V                    | [7] -     | 2.6          | 3.1  | V       |
|                                                     |                                             | $I_{REG7} = 2000$ mA; $V_0 = 2.4$ V; $V_{P1} = V_{P2} = 5$ V                    | [7] -     | 2.6          | 3.4  | V       |
| $I_m(REG7)$                                         | current limit                               | $V_{REG7} > 8.0$ V at $V_0 = 10$ V<br>or<br>$V_{REG7} > 1.9$ V at $V_0 = 2.4$ V | [9] 2.1   | 3.7          | 5.5  | A       |
| $I_{sc(REG7)}$                                      | short-circuit current                       | $R_L \leq 0.5$ $\Omega$                                                         | [10] 1.35 | 1.8          | -    | A       |
| $V_{fb(REG7)}$                                      | flyback voltage                             | $I_{REG7} = -1000$ mA                                                           | -         | $V_{P1} + 3$ | 22   | V       |
| <b>Power switch</b>                                 |                                             |                                                                                 |           |              |      |         |
| $V_{drop(PSW)}$                                     | drop-out voltage                            | $I_{PSW} = 1$ A; $V_{P1} = V_{P2} = 13.5$ V                                     | [11] -    | 0.45         | 0.65 | V       |
|                                                     |                                             | $I_{PSW} = 2.2$ A; $V_{P1} = V_{P2} = 13.5$ V                                   | [11] -    | 1.0          | 1.8  | V       |
| $I_{DC(PSW)}$                                       | continuous current                          | $V_{P1} = V_{P2} = 16$ V; $V_{PSW} = 13.5$ V                                    | 2.2       | 4.3          | 6.0  | A       |
| $V_{clamp(PSW)}$                                    | clamping voltage                            | $V_{P1} = V_{P2} \geq 17$ V;<br>$1$ mA $< I_{PSW} < 2.2$ A                      | 13.5      | 15.0         | 16.0 | V       |
| $I_M(PSW)$                                          | peak current                                | $V_{P1} = V_{P2} < 17$ V                                                        | [5] 3     | -            | -    | A       |
| $V_{fb(PSW)}$                                       | flyback voltage                             | $I_{PSW} = -1000$ mA                                                            | -         | $V_{P1} + 3$ | 22   | V       |
| $I_{sc(PSW)}$                                       | short-circuit current                       | $V_{P1} = 14.4$ V; $V_{PSW} < 1.0$ V                                            | 0.75      | 1.0          | -    | A       |
| <b>Storage capacitor switch</b>                     |                                             |                                                                                 |           |              |      |         |
| $I_{DC(STC)}$                                       | continuous current                          | $V_{STC} > 5$ V                                                                 | 0.95      | 1.0          | -    | A       |
| $V_{clamp(STC)}$                                    | clamping voltage                            | $V_{P1} = V_{P2} \geq 16.7$ V;<br>$I_{STC} = 100$ mA                            | -         | -            | 16   | V       |
| $I_r(STC)$                                          | reverse current                             | $V_{P1} = V_{P2} = 0$ V;<br>$V_{STC} = 12.4$ V                                  | -         | -            | 100  | $\mu$ A |
| $V_{th(STC)}$                                       | regulator enable threshold voltage          | $V_{EN1}$ or $V_{EN2/3} > 2.4$ V                                                | [12] 5.5  | 6.5          | 7.5  | V       |
| <b>Schmitt trigger for enable input of ignition</b> |                                             |                                                                                 |           |              |      |         |
| $V_{th(r)}$                                         | rising threshold voltage of ignition input  | $V_{EN1}$ or $V_{EN2/3} > 2.4$ V                                                | 2.75      | 3.25         | 3.75 | V       |
| $V_{th(f)}$                                         | falling threshold voltage of ignition input | $V_{EN1}$ or $V_{EN2/3} > 2.4$ V                                                | 0.8       | 1.1          | 1.3  | V       |
| $V_{hys}$                                           | hysteresis voltage                          | $V_{EN1}$ or $V_{EN2/3} > 2.4$ V                                                | 1.5       | -            | -    | V       |
| $I_{LI}$                                            | input leakage current                       | $V_{IGNIN} = 5$ V                                                               | -         | -            | 1.0  | $\mu$ A |
| $I_{I(clamp)}$                                      | input clamping current                      | $V_{IGNIN} > 50$ V                                                              | -         | -            | 50   | mA      |

**Table 7: Characteristics ...continued**

$V_{P1} = V_{P2} = 14.4$  V;  $T_{amb} = 25$  °C;  $R_L = \infty$  Ω; measured in test circuits of [Figure 8](#); unless otherwise specified.

| Symbol                                              | Parameter                                         | Conditions                                        | Min   | Typ | Max  | Unit |
|-----------------------------------------------------|---------------------------------------------------|---------------------------------------------------|-------|-----|------|------|
| $V_{IH(clamp)}$                                     | HIGH-level input clamping voltage                 | $V_{IGNIN} = 50$ V                                | $V_P$ | -   | 50   | V    |
| $V_{IL(clamp)}$                                     | LOW-level input clamping voltage                  | $V_{IGNIN} = -100$ V                              | -0.6  | -   | 0    | V    |
| <b>Schmitt trigger for power supply of ignition</b> |                                                   |                                                   |       |     |      |      |
| $V_{th(r)}$                                         | rising threshold voltage                          |                                                   | 6.5   | 7.0 | 7.5  | V    |
| $V_{th(f)}$                                         | falling threshold voltage                         | $V_{IGNOUT} = \text{LOW};$<br>$V_{IGNIN} > 1.2$ V | 4.0   | 4.5 | 5.0  | V    |
| <b>Ignition buffer</b>                              |                                                   |                                                   |       |     |      |      |
| $V_{OL}$                                            | LOW-level output voltage                          | $I_{IGNOUT} = 0$ mA                               | 0     | 0.2 | 0.8  | V    |
| $V_{OH}$                                            | HIGH-level output voltage                         | $I_{IGNOUT} = 0$ mA                               | 4.5   | 5.0 | 5.25 | V    |
| $I_{O(sink)(L)}$                                    | LOW-level output sink current                     | $V_{IGNOUT} \leq 0.8$ V                           | 0.6   | 0.8 | -    | mA   |
| $I_{LO}$                                            | output leakage current                            | $V_{IGNOUT} = 5$ V; $V_{IGNIN} = 0$ V             | -     | -   | 1.0  | μA   |
| <b>Temperature protection</b>                       |                                                   |                                                   |       |     |      |      |
| $T_{j(sd)}$                                         | junction temperature for shutdown                 |                                                   | 150   | 160 | 170  | °C   |
| $T_{j(HOLD)}$                                       | junction temperature for HOLD thermal pre-warning |                                                   | 140   | 150 | 160  | °C   |
| $\Delta T_j$                                        | delta junction temperature pre-warning / shutdown |                                                   | 10    | -   | -    | °C   |

- [1] Minimum operating voltage, only if  $V_{P1}$  has first exceeded 6.5 V.
- [2] The voltage of the regulators 1, 2, 3, 4 and 7 drops as a result of decreasing  $V_{P1}$  voltage. The output voltage of regulators 5 and 6 drops as a result of decreasing  $V_{P2}$  voltage.
- [3] Pin RST1 goes HIGH when  $V_{th(r)(RDC1)}$  is reached and goes LOW when reaching  $V_{th(f)(RDC1)}$ .
- [4] The delay time depends on the value of  $C_{RDC1}$  or  $C_{RDC2/3}$ :  $t_d = \frac{C}{I_{ch}} \times V_{C(th)} = C \times (750 \times 10^3)[s]$
- [5] The delay time depends on the value of  $C_{RDC1}$ :  $t_{d\_high\ current} = \frac{C}{I_{ch}} \times V_{C(th)} = C \times (375 \times 10^3)[s]$
- [6] Pin RST2/3 goes HIGH when  $V_{th(r)(RDC2/3)}$  is reached and goes LOW when reaching  $V_{th(f)(RDC2/3)}$ .
- [7] The drop-out voltage of regulators 1,2,3,4 and 7 is measured between  $V_{P1}$  and REG1, REG2, REG3, REG4 or REG7, the drop-out voltage of regulators 5 and 6 is measured between  $V_{P2}$  and REG5 or REG6.
- [8] The drop-out voltage is measured between pins STC and REG1, REG2 and REG3.
- [9] At current limit,  $I_{m(REGn)}$  is held constant; see [Figure 6](#).
- [10] The foldback current protection limits the dissipated power at short circuit; see [Figure 6](#).
- [11] The drop-out voltage of the power switch is measured between pins  $V_{P1}$  and PSW; see [Figure 7](#).
- [12] Standby regulators are enabled when the increasing storage capacitor voltage reaches this threshold voltage at first power-up.





11. Application information

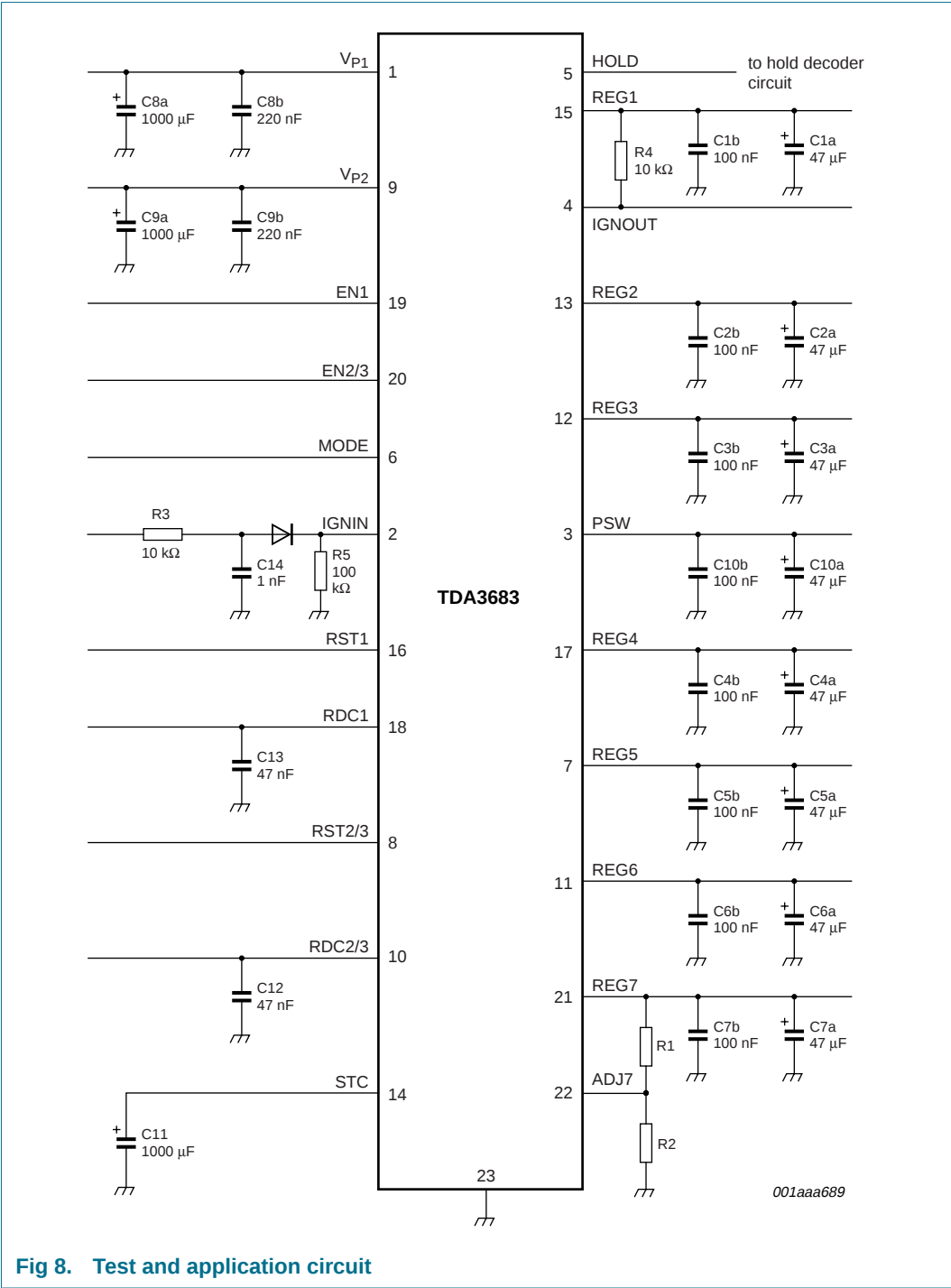
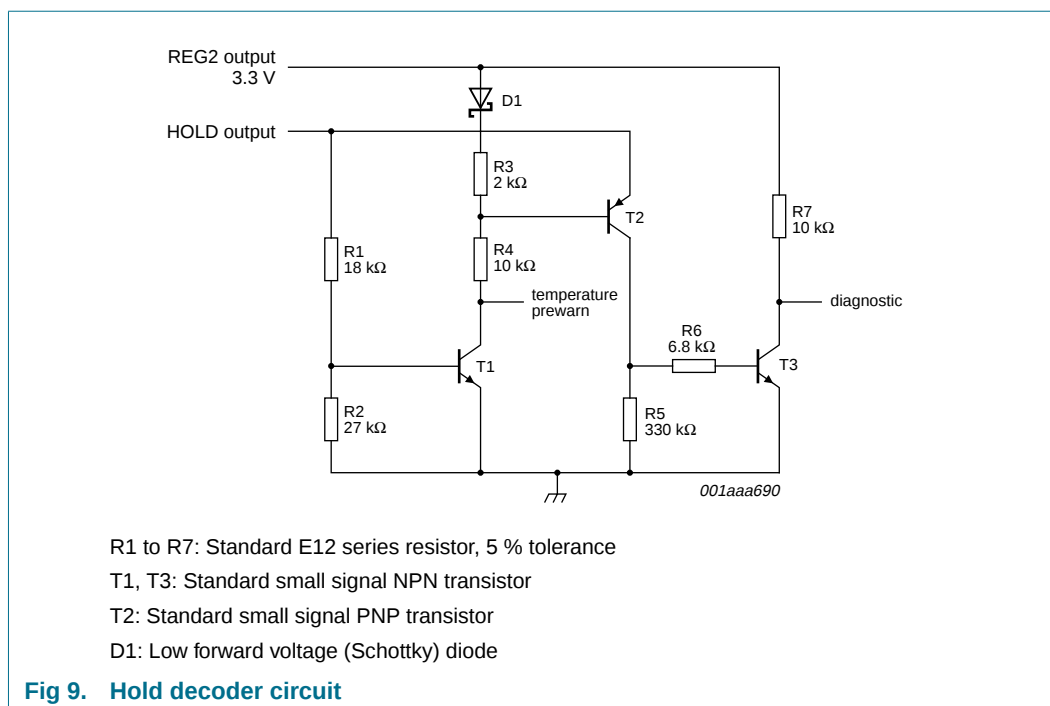


Fig 8. Test and application circuit



## 11.1 Application notes

- A ceramic capacitor of 220 nF must be connected to both supply pins to guarantee stability over the ambient temperature range. For improved noise performance it is also recommended to connect a standard electrolytic capacitor of 2200  $\mu$ F close to the supply pins.
- A ceramic capacitor of 220 nF must be connected to the storage capacitor pin when the back-up function is not used to guarantee stability over the ambient temperature range. There are basically no restrictions for the maximum value of the storage capacitor, but the required value depends on the actual output currents of the three standby regulators and the length of time that their outputs must be maintained after the supply voltage collapsed ( $V_{P1} = V_{P2} = 0$  V).
- A standard electrolytic capacitor of 10  $\mu$ F, or more, must be connected to the output of the power switch to guarantee stability over the ambient temperature range. A ceramic capacitor of 100 nF can be added in parallel with the electrolytic capacitor to provide improved HF performance.
- An electrolytic capacitor of 10  $\mu$ F, or more, must be connected to each regulator output to guarantee stability over the ambient temperature range. There are restrictions concerning the maximum ESR of the electrolytic capacitors that are used; see [Table 8](#). Usually the nominal value of electrolytic capacitors increases and the ESR decreases with temperature so the worst case condition for stability (i.e. minimum capacitance and maximum ESR) exists at low temperatures. Depending on the specified temperature range of the radio set, some of the regulator outputs may need low ESR type electrolytic or tantalum capacitors. A ceramic capacitor of 100 nF can be added in parallel with the electrolytic or tantalum capacitor to provide improved HF performance. However, in the case of the standby regulators (REG1 to REG3) these additional ceramic capacitors should preferably not be connected very close to the device pins to avoid stability issues.

- The output voltage of regulator 7 can be adjusted between 2.4 V and 10 V using two external resistors (R1 and R2); see [Figure 10](#). The following equation can be used for global calculations to determine the output voltage at a given value of R1 and R2:

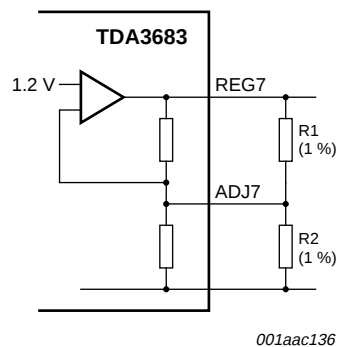
$$V_{REG7} = 1.2 \times \left(1 + \frac{R1}{R2}\right)$$

To meet an overall accuracy of 5 % the external resistors should have a 1 % tolerance and the total resistance of the external resistors should have a value maximum 2 kΩ.

In the event that no external resistors are used the output voltage will be determined only by the internal feedback resistors. The output voltage will be as follows:  $V_o = 10 \text{ V } (\pm 5 \%)$ .

**Table 8: ESR restrictions**

| Output of regulator | Maximum ESR |
|---------------------|-------------|
| Regulator 1         | 3 Ω         |
| Regulator 2         | 3 Ω         |
| Regulator 3         | 6 Ω         |
| Regulator 4         | 20 Ω        |
| Regulator 5         | 6 Ω         |
| Regulator 6         | 14 Ω        |
| Regulator 7         | 10 Ω        |



**Fig 10. Application diagram for REG7**

12. Package outline

DBS23P: plastic DIL-bent-SIL power package; 23 leads (straight lead length 3.2 mm) SOT411-1

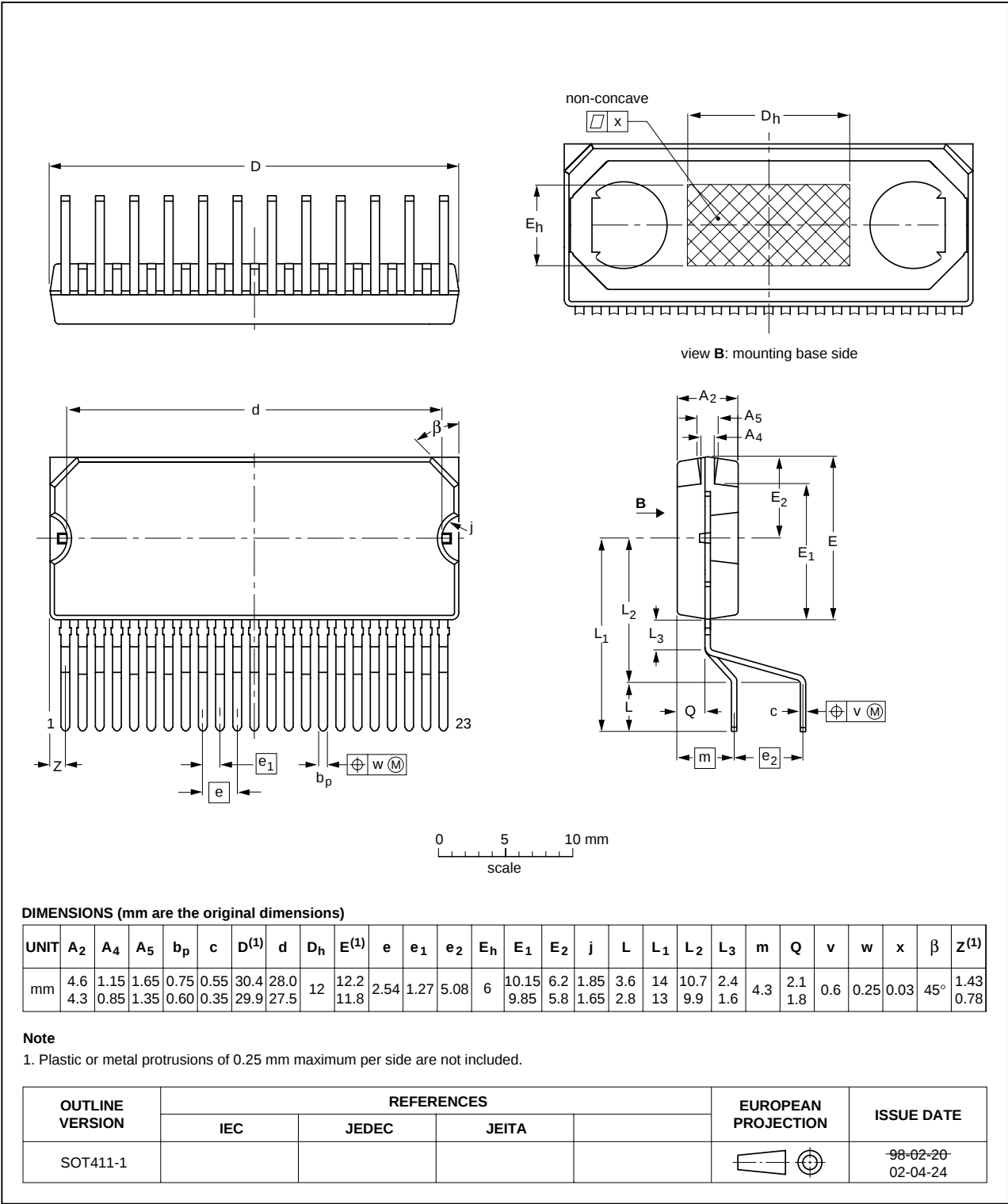


Fig 11. Package outline SOT411-1 (DBS23P)

RDBS23P: plastic rectangular-DIL-bent-SIL (reverse bent) power package; 23 leads  
(row spacing 2.54 mm)

SOT889-1

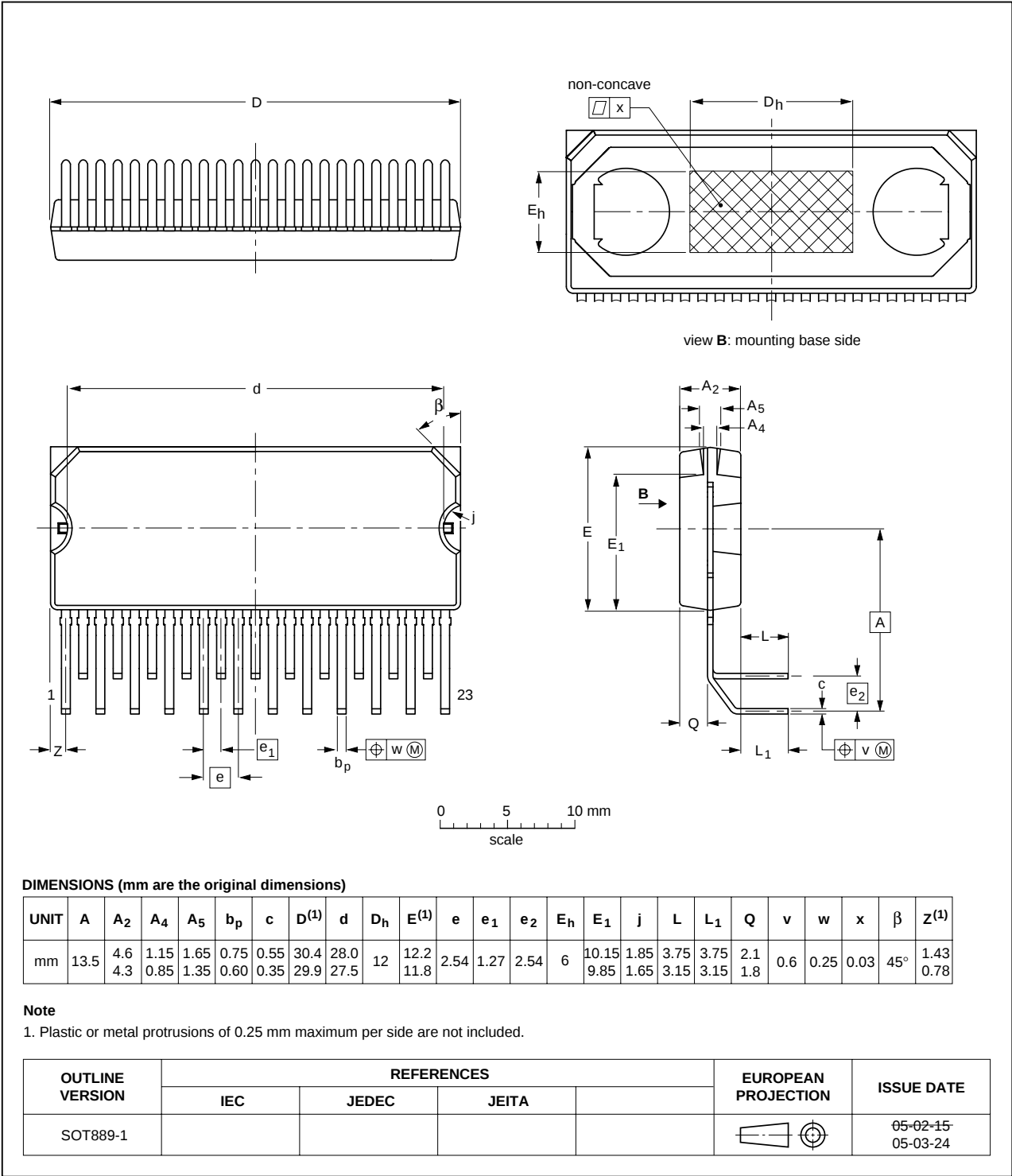


Fig 12. Package outline SOT889-1 (RDBS23P)

## 13. Soldering

### 13.1 Introduction to soldering through-hole mount packages

This text gives a brief insight to wave, dip and manual soldering. 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).

Wave soldering is the preferred method for mounting of through-hole mount IC packages on a printed-circuit board.

### 13.2 Soldering by dipping or by solder wave

Driven by legislation and environmental forces the worldwide use of lead-free solder pastes is increasing. Typical dwell time of the leads in the wave ranges from 3 seconds to 4 seconds at 250 °C or 265 °C, depending on solder material applied, SnPb or Pb-free respectively.

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.

### 13.3 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 °C and 400 °C, contact may be up to 5 seconds.

### 13.4 Package related soldering information

**Table 9: Suitability of through-hole mount IC packages for dipping and wave soldering methods**

| Package                         | Soldering method |                              |
|---------------------------------|------------------|------------------------------|
|                                 | Dipping          | Wave                         |
| CPGA, HCPGA                     | -                | suitable                     |
| DBS, DIP, HDIP, RDBS, SDIP, SIL | suitable         | suitable <a href="#">[1]</a> |
| PMFP <a href="#">[2]</a>        | -                | not suitable                 |

[1] For SDIP packages, the longitudinal axis must be parallel to the transport direction of the printed-circuit board.

[2] For PMFP packages hot bar soldering or manual soldering is suitable.

## 14. Revision history

Table 10: Revision history

| Document ID                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Release date | Data sheet status      | Change notice | Doc. number    | Supersedes |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------------------------|---------------|----------------|------------|
| TDA3683_2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 20051007     | Product data sheet     | -             | -              | TDA3683J_1 |
| Modifications:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |              |                        |               |                |            |
| <ul style="list-style-type: none"> <li>Replaced through the document TDA3683J with TDA3683</li> <li><a href="#">Section 4 "Ordering information"</a>: Added TDA3683SD (SOT889-1 package)</li> <li><a href="#">Section 7.5 "Storage capacitor"</a>: Added last paragraph</li> <li><a href="#">Section 10 "Characteristics"</a> <ul style="list-style-type: none"> <li>Added on page 15 two values to <math>I_{q(tot)}</math></li> <li>Changed on page 16 symbols <math>V_{th(r)(RST1)}</math> and <math>V_{th(f)(RST1)}</math> to <math>V_{th(r)(RDC1)}</math> and <math>V_{th(f)(RDC1)}</math> with adapted parameter description</li> <li>Added on page 16 parameters <math>V_{OH(RST1)}</math> and <math>V_{OL(RST1)}</math></li> <li>Changed on page 17 symbols <math>V_{th(r)(RST2/3)}</math> and <math>V_{th(f)(RST2/3)}</math> to <math>V_{th(r)(RDC2/3)}</math> and <math>V_{th(f)(RDC2/3)}</math> with adapted parameter description</li> <li>Added on page 17 parameters <math>V_{OH(RST2/3)}</math> and <math>V_{OL(RST2/3)}</math></li> <li>Changed on page 18 to 20 the values of <math>I_{m(REG1)}</math> to <math>I_{m(REG7)}</math> and <math>I_{DC(PSW)}</math></li> </ul> </li> <li><a href="#">Figure 9</a>: Added a figure note with component specifications</li> <li><a href="#">Section 12 "Package outline"</a>: Added SOT889-1 drawing</li> </ul> |              |                        |               |                |            |
| TDA3683J_1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 20041213     | Preliminary data sheet | -             | 9397 750 13057 | -          |

## 15. Data sheet status

| Level | Data sheet status <sup>[1]</sup> | Product status <sup>[2] [3]</sup> | Definition                                                                                                                                                                                                                                                                                     |
|-------|----------------------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I     | Objective data                   | Development                       | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.                                                                                                    |
| II    | Preliminary data                 | Qualification                     | This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.             |
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| <b>15</b> | <b>Data sheet status</b> . . . . .                              | <b>30</b> |
| <b>16</b> | <b>Definitions</b> . . . . .                                    | <b>30</b> |
| <b>17</b> | <b>Disclaimers</b> . . . . .                                    | <b>30</b> |
| <b>18</b> | <b>Trademarks</b> . . . . .                                     | <b>30</b> |
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