

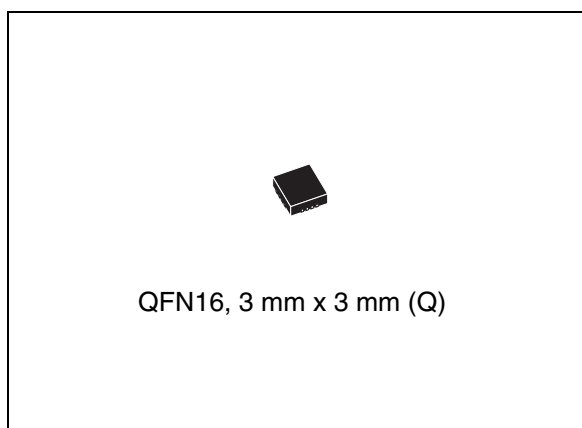


# STM1404

## 3 V FIPS-140 security supervisor with battery switchover

### Features

- STM1404 supports FIPS-140 security level 4
  - Four high-impedance physical tamper inputs
  - Over/under operating voltage detector
  - Security alarm ( $\overline{\text{SAL}}$ ) on tamper detection
  - Over/under operating temperature detector
  - Over/under temperature thresholds are customer-selectable and factory-programmed
- Supervisory functions
  - Automatic battery switchover
  - $\overline{\text{RST}}$  output (open drain)
  - Manual (push-button) reset input ( $\overline{\text{MR}}$ )
  - Power-fail comparator (PFI/ $\overline{\text{PFO}}$ )
- $\overline{\text{Vccsw}}$  ( $V_{\text{CC}}$  switch output)
  - Low when switched to  $V_{\text{CC}}$
  - High when switched to  $V_{\text{BAT}}$  (BATT ON indicator)
- Battery low voltage detector (power-up)



- Optional  $V_{\text{REF}}$  (1.237 V)
  - (Available for STM1404A only)
- Low battery supply current (5.3  $\mu\text{A}$  typ)
- Secure low profile 16-pin, 3 x 3 mm, QFN package
- RoHS compliance
  - Lead-free components compliant with the RoHS directive

Table 1. Device summary

Device	Standard supervisory functions <sup>(1)</sup>	Physical tamper inputs	Over/under voltage alarms	Over/under temperature alarms	$V_{\text{REF}}$ (1.237 V) option	$V_{\text{OUT}}$ status, during alarm	$\overline{\text{Vccsw}}$ status, during alarm
STM1404A	✓	✓	✓	✓	✓	ON	Normal mode <sup>(2)</sup>
STM1404B <sup>(3)</sup>	✓	✓	✓	✓	Note <sup>(4)</sup>	High-Z	High
STM1404C	✓	✓	✓	✓	Note <sup>(4)</sup>	Ground	High

1. Reset output, power-fail comparator, battery low detection ( $\overline{\text{SAL}}$ ,  $\overline{\text{RST}}$ ,  $\overline{\text{PFO}}$ , and  $\overline{\text{BLD}}$  are open drain).
2. Normal mode: low when  $V_{\text{OUT}}$  is internally switched to  $V_{\text{CC}}$  and high when  $V_{\text{OUT}}$  is internally switched to battery.
3. Contact local ST sales office for availability.
4. Pin 9 is the  $V_{\text{REF}}$  pin for STM1404A. It is the  $V_{\text{TPU}}$  pin for STM1404B/C.

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# 1 Description

The STM1404 family of security supervisors are a low power family of intrusion (tamper) detection chips targeted at manufacturers of POS terminals and other systems, to enable them to meet **physical and/or environmental** intrusion monitoring requirements as mandated by various standards, such as Federal Information Processing Standards (FIPS) Pub 140 entitled “Security Requirements for Cryptographic Modules,” published by the National Institute of Standards and Technology, U.S. Department of Commerce), EMVCo, ISO, ZKA, and VISA PED.

STM1404 will target the highest security level 4 and include both physical and environmental (voltage and temperature) monitoring.

The STM1404 include automatic battery switchover,  $\overline{\text{RST}}$  output (open drain), manual (push-button) reset input ( $\overline{\text{MR}}$ ), power-fail comparator (PFI/ $\overline{\text{PFO}}$ ), physical and/or environmental tamper detect/security alarm, and battery low voltage detect features.

The STM1404A also offers a  $V_{\text{REF}}$  (1.237V) as an option on pin 9. On STM1404B/C this pin is  $V_{\text{TPU}}$  (internally switched  $V_{\text{CC}}$  or  $V_{\text{BAT}}$ ).

## 1.1 $V_{\text{OUT}}$ pin modes

The STM1404 is available in three versions, corresponding to three modes of the  $V_{\text{OUT}}$  pin (supply voltage out), when the  $\overline{\text{SAL}}$  (security alarm) is asserted (active-low) upon tamper detection:

### 1.1.1 STM1404A

$V_{\text{OUT}}$  stays ON (at  $V_{\text{CC}}$  or  $V_{\text{BAT}}$ ) when  $\overline{\text{SAL}}$  is driven low (activated).

### 1.1.2 STM1404B

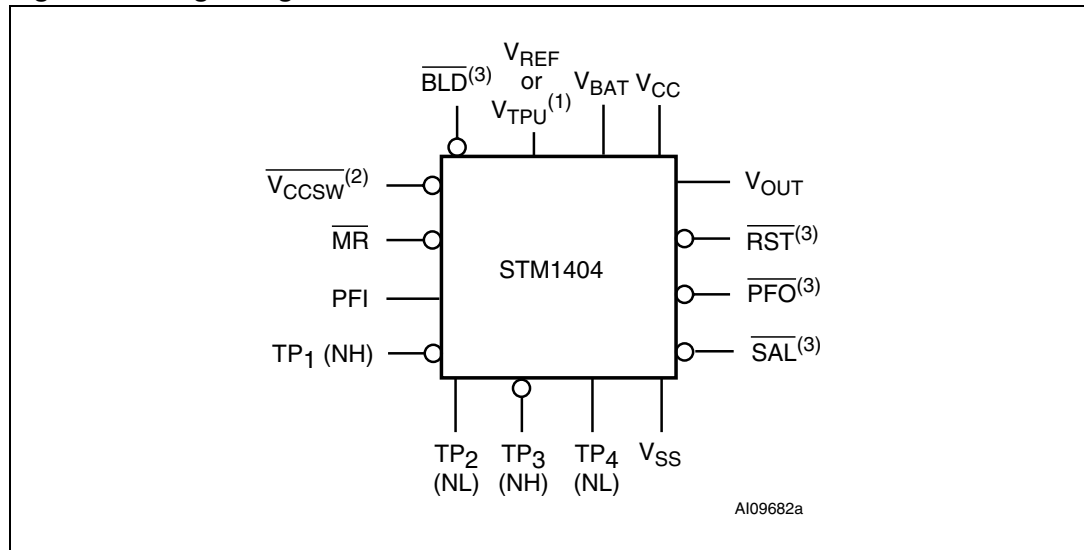
$V_{\text{OUT}}$  is set to High-Z when  $\overline{\text{SAL}}$  is driven low (activated).

### 1.1.3 STM1404C

$V_{\text{OUT}}$  is driven to ground when  $\overline{\text{SAL}}$  is activated (may be used when  $V_{\text{OUT}}$  is connected directly to the  $V_{\text{CC}}$  pin of the external SRAM that holds the cryptographic codes).

All variants (see [Table 1: Device summary](#)) are pin-compatible and available in a security-friendly, low profile, 16-pin QFN package.

**Figure 1. Logic diagram**



1.  $V_{REF}$  only for STM1404A;  $V_{TPU}$  for STM1404B/C.
2. Normal mode: low when  $V_{OUT}$  is internally switched to  $V_{CC}$  and High when  $V_{OUT}$  is internally switched to battery.
3.  $\overline{SAL}$ ,  $\overline{RST}$ ,  $\overline{PFO}$ , and  $\overline{BLD}$  are open drain.

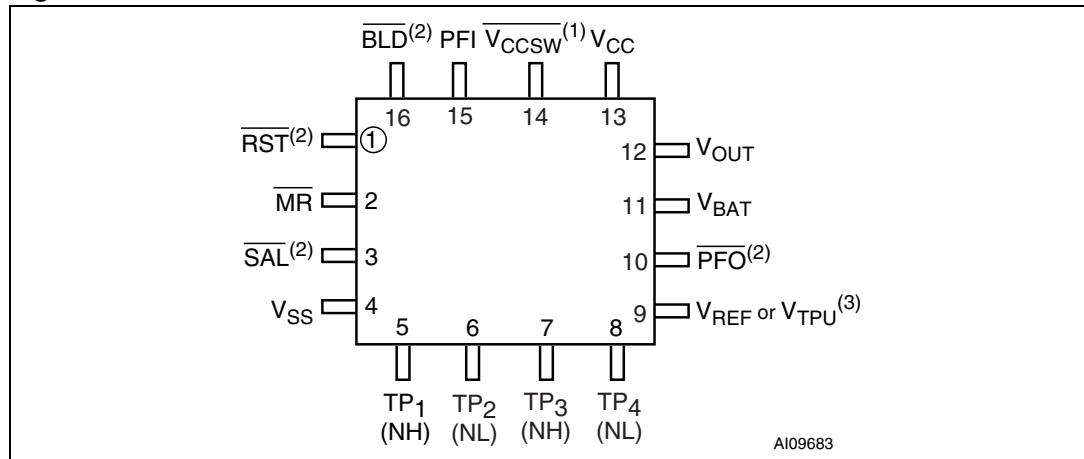
**Table 2. Signal names**

$\overline{V_{CCSW}}^{(1)}$	$V_{CC}$ switch output
$\overline{MR}$	Manual (push-button) reset input
PFI	Power-fail input
$TP_1 - TP_4$	Independent physical tamper detect pins 1 through 4
$V_{OUT}$	Supply voltage output
$\overline{RST}^{(2)}$	Active-low reset output
$\overline{PFO}^{(2)}$	Power-fail output
$\overline{SAL}^{(2)}$	Security alarm output
$\overline{BLD}^{(2)}$	Battery low voltage detect
$V_{REF}^{(3)}$	1.237 V reference voltage
$V_{TPU}^{(3)}$	Tamper pull-up ( $V_{CC}$ or $V_{BAT}$ )
$V_{BAT}$	Backup supply voltage
$V_{CC}$	Supply voltage
$V_{SS}$	Ground

1. Normal mode: low when  $V_{OUT}$  is internally switched to  $V_{CC}$  and high when  $V_{OUT}$  is internally switched to battery.
2.  $\overline{SAL}$ ,  $\overline{RST}$ ,  $\overline{PFO}$ , and  $\overline{BLD}$  are open drain.
3.  $V_{REF}$  only for STM1404A;  $V_{TPU}$  for STM1404B/C.

**Note:** See [Section 2: Pin descriptions on page 11](#) for details.

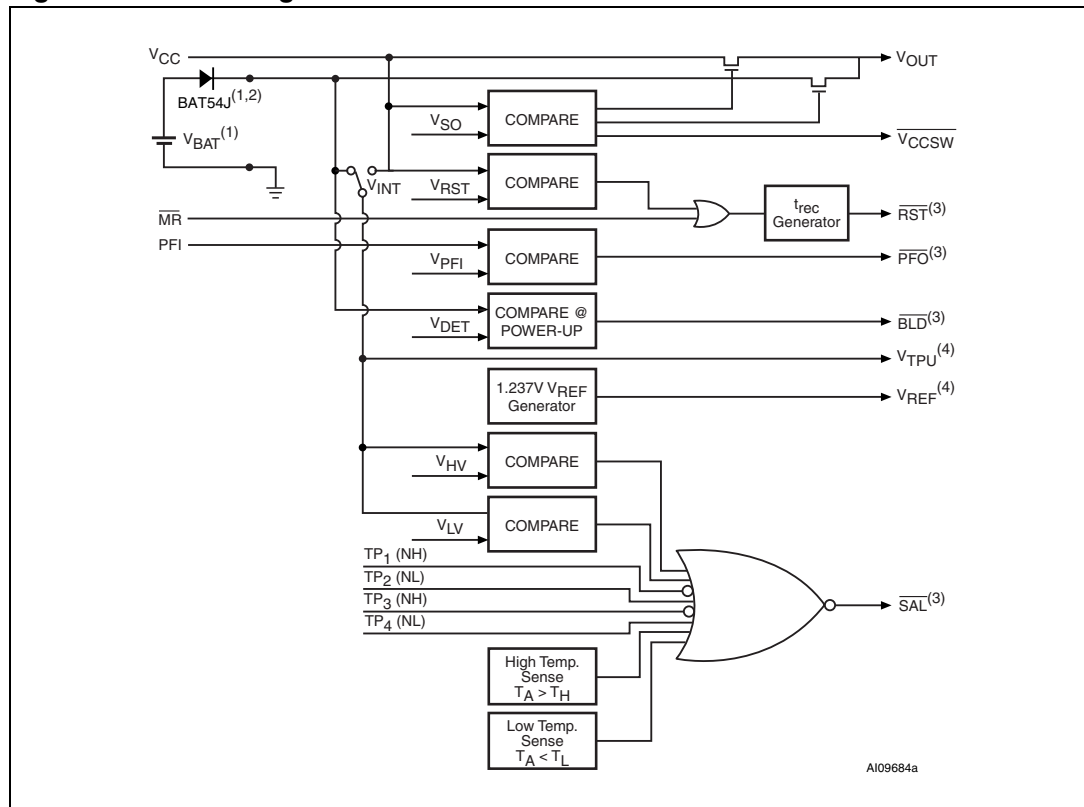
**Figure 2. QFN16 connections**



*Note:* See [Section 2: Pin descriptions on page 11](#) for details.

1. Normal mode: low when  $V_{OUT}$  is internally switched to  $V_{CC}$  and high when  $V_{OUT}$  is internally switched to battery.
2.  $\overline{SAL}$ ,  $\overline{RST}$ ,  $\overline{PFO}$ , and  $\overline{BLD}$  are open drain.
3.  $V_{REF}$  only for STM1404A;  $V_{TPU}$  for STM1404B/C.

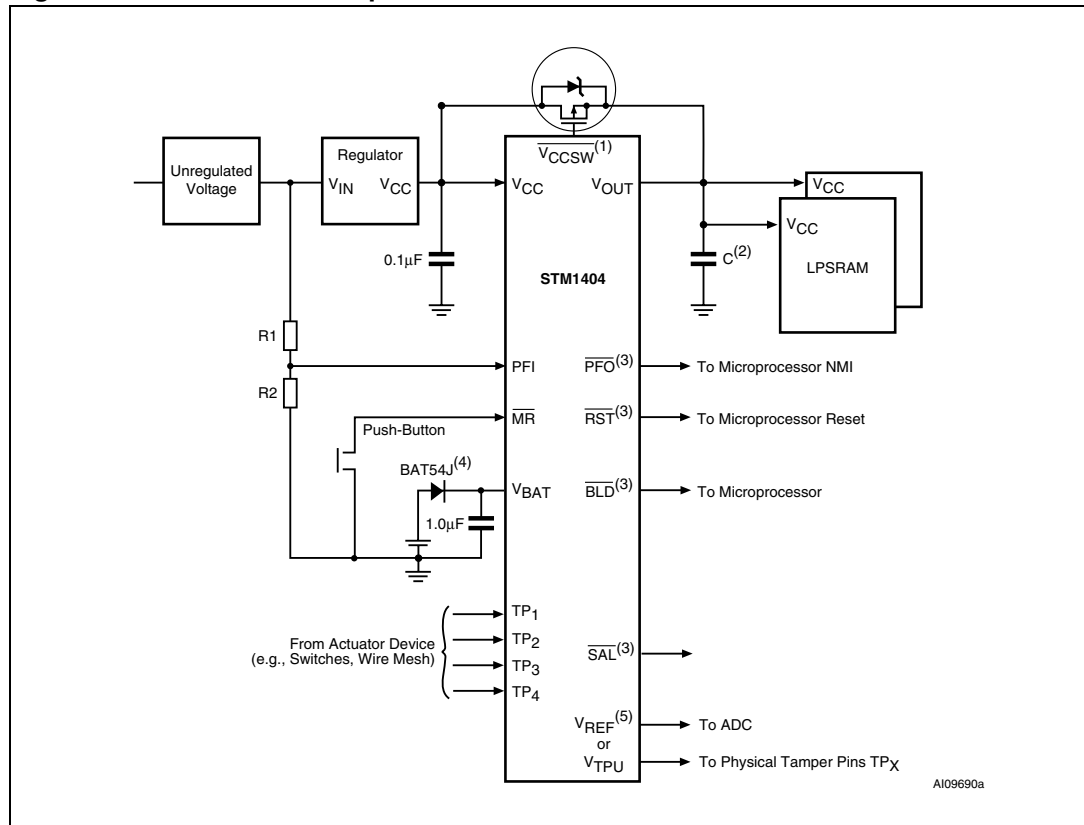
**Figure 3. Block diagram**



1. Required for battery-reverse charging protection
2. User supplied
3. Open drain
4.  $V_{REF}$  only for STM1404A;  $V_{TPU}$  for STM1404B/C

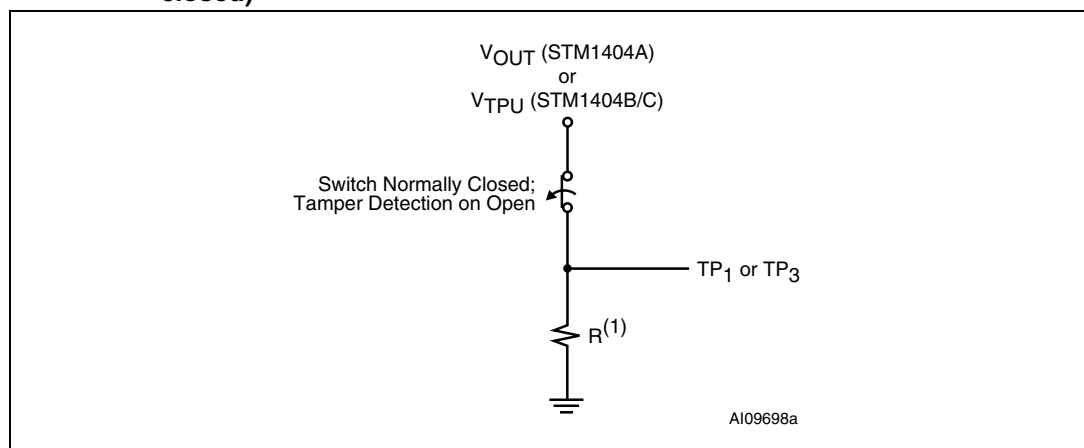


Figure 4. Hardware hookup



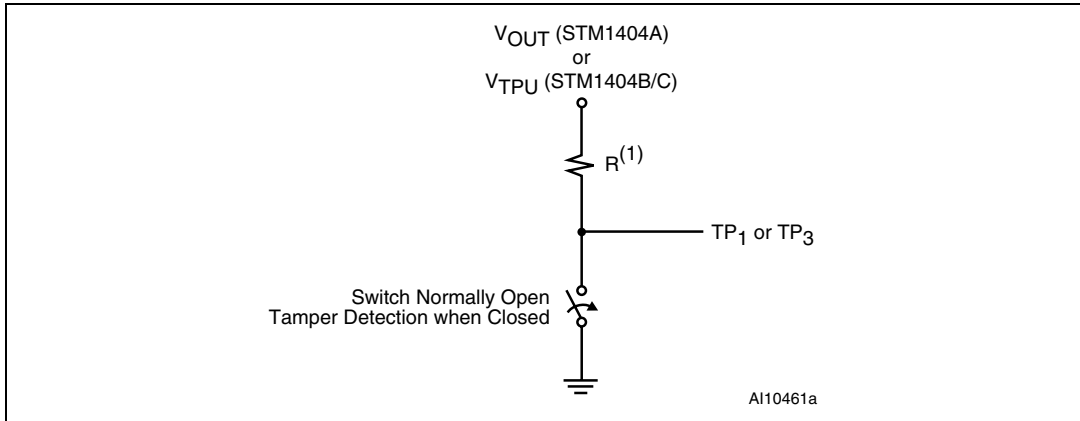
1. Normal mode: low when  $V_{OUT}$  is internally switched to  $V_{CC}$  and high when  $V_{OUT}$  is internally switched to battery.
2. Capacitor (C) is typically  $\geq 10 \mu\text{F}$ .
3. Open drain
4. Diode is required for battery reverse charge protection.
5.  $V_{REF}$  only for STM1404A;  $V_{TPU}$  for STM1404B/C

Figure 5. Tamper pin ( $TP_1$  or  $TP_3$ ) normally high (NH) external hookup (switch closed)



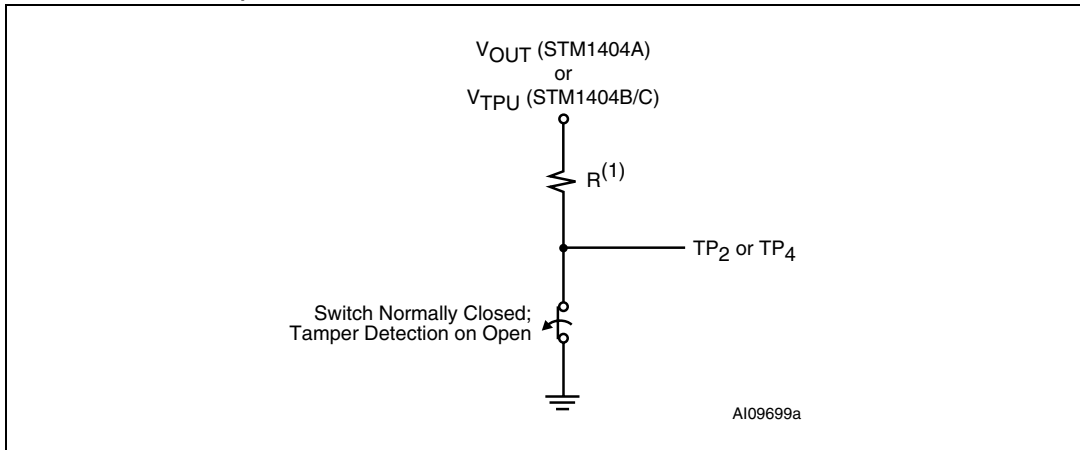
1. R typical is 10 MΩ. Resistors must be protected against conductive materials.

**Figure 6. Tamper pin (TP<sub>1</sub> or TP<sub>3</sub>) normally high (NH) external hookup (switch open)**



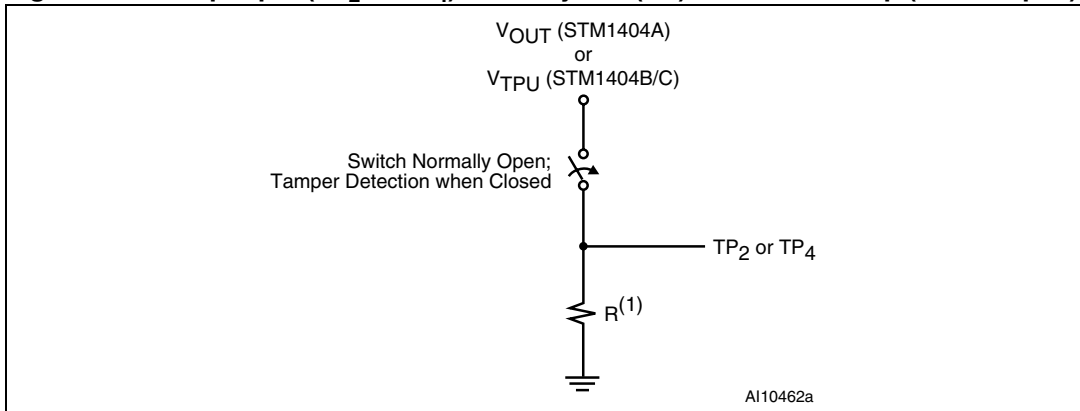
1. R typical is 10 MΩ. Resistors must be protected against conductive materials.

**Figure 7. Tamper pin (TP<sub>2</sub> or TP<sub>4</sub>) normally low (NL) external hookup (switch closed)**



1. R typical is 10 MΩ. Resistors must be protected against conductive materials.

**Figure 8. Tamper pin (TP<sub>2</sub> or TP<sub>4</sub>) normally low (NL) external hookup (switch open)**



1. R typical is 10 MΩ. Resistors must be protected against conductive materials.

## 2 Pin descriptions

See [Figure 1: Logic diagram](#) and [Table 2: Signal names](#) for a brief overview of the signals connected to this device.

### 2.1 $\overline{\text{SAL}}$ , security alarm output (open drain)

This signal can be generated when ANY of the following conditions occur:

- $V_{\text{INT}} > V_{\text{HV}}$ , where  $V_{\text{HV}}$  = upper voltage trip limit (4.2 V typ); and where  $V_{\text{INT}} = V_{\text{CC}}$  or  $V_{\text{BAT}}$ ;
- $V_{\text{INT}} < V_{\text{LV}}$ , where  $V_{\text{LV}}$  = lower voltage trip limit (2.0 V typ); and where  $V_{\text{INT}} = V_{\text{CC}}$  or  $V_{\text{BAT}}$ ; or
- When any of the physical tamper inputs,  $\text{TP}_1$  to  $\text{TP}_4$ , change from their normal states to the opposite (i.e., intrusion of a physical enclosure).
- $T_{\text{A}} > T_{\text{H}}$ , where  $T_{\text{H}}$  is an upper temperature trip limit specified by the customer (+80°C, +85°C, and +95°C), factory-programmed (STM1404 only);
- $T_{\text{A}} < T_{\text{L}}$ , where  $T_{\text{L}}$  is a lower temperature trip limit specified by the customer (–25°C or –35°C), factory-programmed (STM1404 only);

- Note:*
- 1 The default state of the  $\overline{\text{SAL}}$  output during initial power-up is undetermined.
  - 2 The alarm function will operate either with  $V_{\text{CC}}$  on or when the part is internally switched from  $V_{\text{CC}}$  to  $V_{\text{BAT}}$ .

### 2.2 $\text{TP}_1$ , $\text{TP}_3$

Physical tamper detect pin set normally to high (NH). They are connected externally through a closed switch or a high-impedance resistor to  $V_{\text{OUT}}$  (in the case of STM1404A) or  $V_{\text{TPU}}$  (in the case of STM1404B/C). A tamper condition will be detected when the input pin is pulled low (see [Figure 5](#) and [Figure 6 on page 10](#)). If not used, tie the pin to  $V_{\text{OUT}}$  (for STM1404A) or  $V_{\text{TPU}}$  (for STM1404B/C).

### 2.3 $\text{TP}_2$ , $\text{TP}_4$

Physical tamper detect pin set normally to low (NL). They are connected externally through a high-impedance resistor or a closed switch to  $V_{\text{SS}}$ . A tamper condition will be detected when the input pin is pulled high (see [Figure 7](#) and [Figure 8 on page 10](#)). If not used, tie the pin to  $V_{\text{SS}}$ .

#### 2.3.1 $\overline{\text{Vccsw}}$ , $V_{\text{CC}}$ switch output

This output is low when  $V_{\text{OUT}}$  (see [Section 2.10:  \$V\_{\text{OUT}}\$  on page 13](#)) is internally switched to  $V_{\text{CC}}$ ; in this mode it may be used to turn on an external p-channel MOSFET switch which can source an external device directly from  $V_{\text{CC}}$  for currents greater than 80 mA (bypassing the STM1404).

This pin goes high when  $V_{\text{OUT}}$  is internally switched to  $V_{\text{BAT}}$  and may be used as a “BATTERY ON” indicator.

If a security alarm ( $\overline{\text{SAL}}$ ) is issued on tamper, then the state of the  $\overline{\text{Vccsw}}$  pin is as follows:

1. STM1404A ( $V_{\text{OUT}}$  remains ON when  $\overline{\text{SAL}}$  is active-low):  $\overline{\text{Vccsw}}$  pin will continue to operate in normal mode;
2. STM1404B ( $V_{\text{OUT}}$  is taken to High-Z when  $\overline{\text{SAL}}$  is active-low):  $\overline{\text{Vccsw}}$  pin will be set to high when this occurs; and
3. STM1404C ( $V_{\text{OUT}}$  is driven to ground when  $\overline{\text{SAL}}$  is active-low):  $\overline{\text{Vccsw}}$  pin will be set to high when this occurs.

## 2.4 $\overline{\text{BLD}}$ , $V_{\text{BAT}}$ low voltage detect output (open drain)

This is an internally loaded test of the battery, activated only during a power-up sequence to insure that the battery is good either prior to or after encapsulation of the module. There are three customer options for  $V_{\text{DET}}$ :

- 2.3 V (2.5 V – external diode drop of about 0.2 V) for a 3 V lithium cell
- 2.5 V (2.7 V – 0.2 V) for a 3 V lithium cell or
- 3.2 V (3.4 V – 0.2 V) for a 3.68 V lithium “AA” battery

This output pin will go active-low when it detects a voltage on the  $V_{\text{BAT}}$  pin below  $V_{\text{DET}}$ .  $\overline{\text{BLD}}$  will be released when  $V_{\text{CC}}$  drops below  $V_{\text{RST}}$ .

## 2.5 Active-low $\overline{\text{RST}}$ output (open drain)

Goes low and stays low when  $V_{\text{CC}}$  drops below  $V_{\text{RST}}$  (Reset Threshold selected by the customer), or when  $\overline{\text{MR}}$  is logic low. It remains low for  $t_{\text{rec}}$  (200ms, typical) AFTER  $V_{\text{CC}}$  rises above  $V_{\text{RST}}$  and  $\overline{\text{MR}}$  goes from low to high.

## 2.6 $\overline{\text{MR}}$ , manual reset input

A logic low on  $\overline{\text{MR}}$  asserts the  $\overline{\text{RST}}$  output. The  $\overline{\text{RST}}$  output remains asserted as long as  $\overline{\text{MR}}$  is low and for  $t_{\text{rec}}$  after  $\overline{\text{MR}}$  returns to high. This active low input has an internal 40 k $\Omega$  (typical) pull-up resistor. It can be driven from a TTL or CMOS logic line or shorted to ground with a switch. Leave it open if unused.

## 2.7 $\overline{\text{PFO}}$ , power-fail output (open drain)

When PFI is less than  $V_{\text{PFI}}$  (power-fail input threshold voltage) or  $V_{\text{CC}}$  falls below  $V_{\text{SW}}$  (battery switchover threshold ~ 2.4 V),  $\overline{\text{PFO}}$  goes low, otherwise,  $\overline{\text{PFO}}$  remains high. Leave this pin open if unused.

## 2.8 PFI, power-fail input

When PFI is less than  $V_{\text{PFI}}$ , or when  $V_{\text{CC}}$  falls below  $V_{\text{SW}}$  (see  $\overline{\text{PFO}}$ , above),  $\overline{\text{PFO}}$  goes active-low. If this function is unused, connect this pin to  $V_{\text{SS}}$ .

## 2.9 $V_{REF}$ reference voltage output (1.237, typ)

This is valid only when  $V_{CC}$  is between 2.4 V and 3.6 V. When  $V_{CC}$  falls below 2.4 V ( $V_{SW}$ ),  $V_{REF}$  is pulled to ground with an internal 100 k $\Omega$  resistor. This is an optional feature available on the STM1404A. On the STM1404B/C, this pin is  $V_{TPU}$  (internally switched  $V_{CC}$  or  $V_{BAT}$ ). If unused, this pin should float.

## 2.10 $V_{OUT}$

This is the supply voltage output. When  $V_{CC}$  rises above  $V_{SO}$  (battery backup switchover voltage),  $V_{OUT}$  is supplied from  $V_{CC}$ . In this condition,  $V_{OUT}$  may be connected externally to  $V_{CC}$  through a p-channel MOSFET switch. When  $V_{CC}$  falls below the lower value of  $V_{SW}$  (~2.4 V), or  $V_{BAT}$ ,  $V_{OUT}$  is supplied from  $V_{BAT}$ . It is recommended that the  $V_{OUT}$  pin be connected externally to a capacitor that will retain a charge for a period of time, in case an intruder forces  $V_{CC}$  or  $V_{BAT}$  to ground. The rectifying diode connected from the positive terminal of the battery to the  $V_{BAT}$  pin of the STM1404 will prevent discharge of the capacitor. Three variations of parts will be offered with the following options:

1. STM1404A:  $V_{OUT}$  remains ON when  $\overline{SAL}$  is active-low;  $\overline{VCCSW}$  pin will continue to operate in normal mode (see [Section 2.3.1: Vccsw, VCC switch output on page 11](#));
2. STM1404B:  $V_{OUT}$  is taken to High-Z when  $\overline{SAL}$  is active-low;  $\overline{VCCSW}$  pin will be set to high when this occurs; and
3. STM1404C:  $V_{OUT}$  is driven to ground when  $\overline{SAL}$  is active-low;  $\overline{VCCSW}$  pin will be set to high when this occurs.

## 2.11 $V_{TPU}$

For STM1404B and STM1404C, this pin provides pull-up voltage for the physical tamper pins (TP1-4). This pin is not to be used as voltage supply source for any other purpose.

*Note:*  $V_{TPU}$  is the internally switched supply voltage from either the  $V_{CC}$  pin or the  $V_{BAT}$  pin.

## 2.12 $V_{CC}$

This is the supply voltage (2.2 V to 3.6 V).

## 2.13 $V_{BAT}$

This is the secondary (backup battery) supply voltage. The pin is connected to the positive terminal of the battery with a rectifying diode like the BAT54J from STMicroelectronics for reverse charge protection. Voltage at this pin, after diode rectification, will be approximately 0.2 V less than the battery voltage, and will depend on the type of battery used as well as the  $I_{BAT}$  being drawn. (A capacitor of at least 1.0  $\mu$ F connected between the  $V_{BAT}$  pin and  $V_{SS}$  is required.) If no battery is used, connect the  $V_{BAT}$  pin to the  $V_{CC}$  pin.

## 2.14 $V_{SS}$

Ground,  $V_{SS}$ , is the reference for the power supply. It must be connected to system ground.

## 3 Operation

### 3.1 Reset input

The STM1404 security supervisor asserts a reset signal to the MCU whenever  $V_{CC}$  goes below the reset threshold ( $V_{RST}$ ), or when the push-button reset input ( $\overline{MR}$ ) is taken low.  $\overline{RST}$  is guaranteed to be a logic low for  $0\text{ V} < V_{CC} < V_{RST}$  if  $V_{BAT}$  is greater than 1 V. Without a backup battery,  $\overline{RST}$  is guaranteed valid down to  $V_{CC} = 1\text{ V}$ .

During power-up, once  $V_{CC}$  exceeds the reset threshold an internal timer keeps  $\overline{RST}$  low for the reset time-out period,  $t_{rec}$ . After this interval  $\overline{RST}$  returns high.

If  $V_{CC}$  drops below the reset threshold,  $\overline{RST}$  goes low. Each time  $\overline{RST}$  is asserted, it stays low for at least the reset time-out period ( $t_{rec}$ ). Any time  $V_{CC}$  goes below the reset threshold the internal timer clears. The reset timer starts when  $V_{CC}$  returns above the reset threshold.

### 3.2 Push-button reset input

A logic low on  $\overline{MR}$  asserts reset. Reset remains asserted while  $\overline{MR}$  is low, and for  $t_{rec}$  (see [Figure 25 on page 24](#)) after it returns high. The  $\overline{MR}$  input has an internal 40 k $\Omega$  pull-up resistor, allowing it to be left open if not used. This input can be driven with TTL/CMOS-logic levels or with open-drain/collector outputs. Connect a normally open momentary switch from  $\overline{MR}$  to ground to create a manual reset function; external debounce circuitry is not required. If  $\overline{MR}$  is driven from long cables or the device is used in a noisy environment, connect a 0.1  $\mu\text{F}$  capacitor from  $\overline{MR}$  to  $V_{SS}$  to provide additional noise immunity.  $\overline{MR}$  may float, or be tied to  $V_{CC}$  when not used.

### 3.3 Backup battery switchover

In the event of a power failure, it may be necessary to preserve the contents of external SRAM through  $V_{OUT}$ . With a backup battery installed with voltage  $V_{BAT}$ , the devices automatically switch the SRAM to the backup supply when  $V_{CC}$  falls.

*Note:* If backup battery is not used, connect both  $V_{BAT}$  and  $V_{OUT}$  to  $V_{CC}$ .

This family of security supervisors does not always connect  $V_{BAT}$  to  $V_{OUT}$  when  $V_{BAT}$  is greater than  $V_{CC}$ .  $V_{BAT}$  connects to  $V_{OUT}$  (through a 100  $\Omega$  switch) when  $V_{CC}$  is below  $V_{SW}$  (~2.4 V) or  $V_{BAT}$  (whichever is lower). This is done to allow the backup battery (e.g., a 3.6 V battery) to have a higher voltage than  $V_{CC}$ .

Assuming that  $V_{BAT} > 2.0\text{ V}$ , switchover at  $V_{SO}$  ensures that battery backup mode is entered before  $V_{OUT}$  gets too close to the 2.0 V minimum required to reliably retain data in most external SRAMs. When  $V_{CC}$  recovers, hysteresis is used to avoid oscillation around the  $V_{SO}$  point.  $V_{OUT}$  is connected to  $V_{CC}$  through a 3  $\Omega$  PMOS power switch.

*Note:* The backup battery may be removed while  $V_{CC}$  is valid, assuming  $V_{BAT}$  is adequately decoupled (0.1  $\mu\text{F}$  typ), without danger of triggering a reset.

**Table 3. I/O status in battery backup**

Pin	Status
V <sub>OUT</sub>	Connected to V <sub>BAT</sub> through internal switch
V <sub>CC</sub>	Disconnected from V <sub>OUT</sub>
PFI	Disabled
P $\overline{F}$ O	Logic low
M $\overline{R}$	Disabled
R $\overline{S}$ T	Logic low
V <sub>BAT</sub>	Connected to V <sub>OUT</sub>
V $\overline{C}$ CSW	Logic high
V <sub>REF</sub>	Pulled to V <sub>SS</sub> below 2.4 V (V <sub>SW</sub> )
B $\overline{L}$ D	Logic high
V <sub>TPU</sub>	Connected to V <sub>BAT</sub> through an internal switch

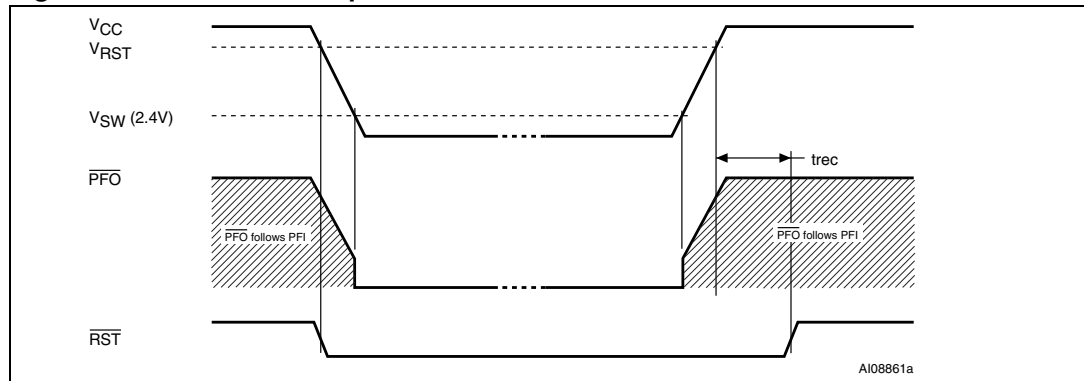
The power-fail input (PFI) is compared to an internal reference voltage (independent from the V<sub>RST</sub> comparator). If PFI is less than the power-fail threshold (V<sub>PFI</sub>), the power-fail output (P $\overline{F}$ O) will go low. This function is intended for use as an undervoltage detector to signal a failing power supply. Typically PFI is connected through an external voltage divider (see [Figure 4 on page 9](#)) to either the unregulated DC input (if it is available) or the regulated output of the V<sub>CC</sub> regulator. The voltage divider can be set up such that the voltage at PFI falls below V<sub>PFI</sub> several milliseconds before the regulated V<sub>CC</sub> input to the STM1404 or the microprocessor drops below the minimum operating voltage.

During battery backup, the power-fail comparator is turned off and P $\overline{F}$ O goes (or remains) low (see [Figure 9 on page 16](#)). This occurs after V<sub>CC</sub> drops below V<sub>SW</sub> (~2.4 V). When power returns, the power-fail comparator is enabled and P $\overline{F}$ O follows PFI. If the comparator is unused, PFI should be connected to V<sub>SS</sub> and P $\overline{F}$ O left unconnected. P $\overline{F}$ O may be connected to M $\overline{R}$  so that a low voltage on PFI will generate a reset output.

### 3.4 Applications information

These supervisor circuits are not short-circuit protected. Shorting V<sub>OUT</sub> to ground - excluding power-up transients such as charging a decoupling capacitor - destroys the device. Decouple both V<sub>CC</sub> and V<sub>BAT</sub> pins to ground by placing 0.1  $\mu$ F capacitors as close to the device as possible.

**Figure 9. Power-fail comparator waveform**

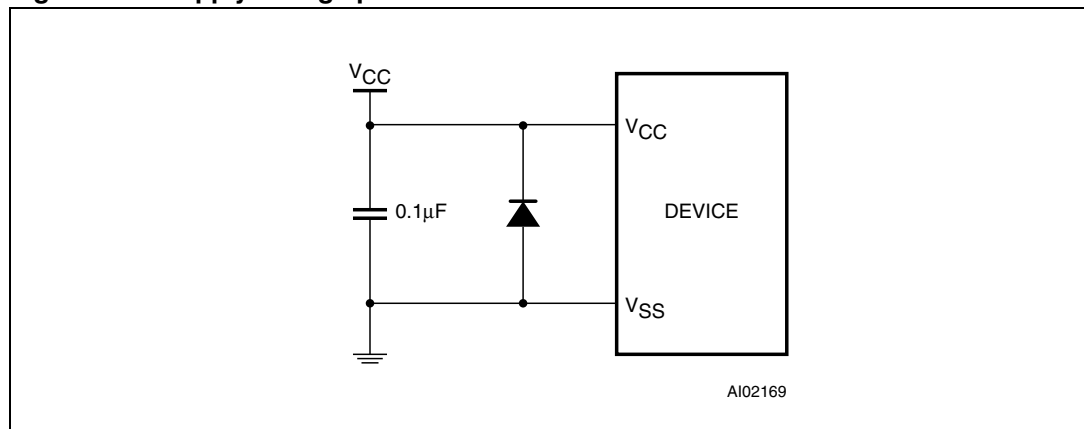


### 3.5 Negative-going $V_{CC}$ transients and undershoot

The STM1404 devices are relatively immune to negative-going  $V_{CC}$  transients (glitches). [Figure 23 on page 22](#) was generated using a negative pulse applied to  $V_{CC}$ , starting at  $V_{RST} + 0.3\text{ V}$  and ending below the reset threshold by the magnitude indicated (comparator overdrive). The graph indicates the maximum pulse width a negative  $V_{CC}$  transient can have without causing a reset pulse. As the magnitude of the transient increases (further below the threshold), the maximum allowable pulse width decreases. Any combination of duration and overdrive which lies under the curve will NOT generate a reset signal. Typically, a  $V_{CC}$  transient that goes 100 mV below the reset threshold and lasts 40  $\mu\text{s}$  or less will not cause a reset pulse. A 0.1  $\mu\text{F}$  bypass capacitor mounted as close as possible to the  $V_{CC}$  pin provides additional transient immunity (see [Figure 10](#)).

In addition to transients that are caused by normal SRAM operation, power cycling can generate negative voltage spikes on  $V_{CC}$  that drive it to values below  $V_{SS}$  by as much as one volt. These negative spikes can cause data corruption in the SRAM while in battery backup mode. To protect from these voltage spikes, STMicroelectronics recommends connecting a schottky diode from  $V_{CC}$  to  $V_{SS}$  (cathode connected to  $V_{CC}$ ; anode to  $V_{SS}$ ). Schottky diode 1N5817 is recommended for through hole and MBRS120T3 is recommended for surface mount.

**Figure 10. Supply voltage protection**





## 4 Tamper detection

### 4.1 Physical

There are four (4) high-impedance physical tamper detect input pins, 2 normally set to high (NH) and 2 normally set to low (NL). Each input is designed with a glitch immunity (see [Table 7 on page 29](#)). These inputs can be connected externally to several types of actuator devices (e.g., switches, wire mesh). A tamper on any one of the four inputs that causes its state to change will trigger the security alarm ( $\overline{\text{SAL}}$ ) and drive it to active-low. Once the tamper condition no longer exists, the  $\overline{\text{SAL}}$  will return to its normal high state.

TP<sub>1</sub> and TP<sub>3</sub> are set normally to high (NH). They are connected externally through a closed switch or a high-impedance resistor to V<sub>OUT</sub> (in the case of STM1404A or STM1404A) or V<sub>TPU</sub> (in the case of STM1404B/C). A tamper condition will be detected when the input pin is pulled low (see [Figure 5](#) and [Figure 6 on page 10](#)). If not used, tie the pin to V<sub>OUT</sub> or V<sub>TPU</sub>.

TP<sub>2</sub> and TP<sub>4</sub> are set normally to low (NL). They are connected externally through a high-impedance resistor or a closed switch to V<sub>SS</sub>. A tamper condition will be detected when the input pin is pulled high (see [Figure 7](#) and [Figure 8 on page 10](#)). If not used, tie the pin to V<sub>SS</sub>.

### 4.2 Supply voltage

The internally switched supply voltage, V<sub>INT</sub> (either V<sub>CC</sub> input or V<sub>BAT</sub> input) is continuously monitored. If V<sub>INT</sub> should exceed the over voltage trip point, V<sub>HV</sub> (set at 4.2V, typical), or should go below the under voltage trip point, V<sub>LV</sub> (set at 2.0V, typical).  $\overline{\text{SAL}}$  will be driven active-low. Once the tamper condition no longer exists, the  $\overline{\text{SAL}}$  pin will return to its normal high state.

### 4.3 Temperature

The STM1404 has a built-in, bandgap-based sensor to monitor the temperature. If a preset (customer-selectable, factory-programmed) over-temperature trip point (T<sub>H</sub>) or under-temperature trip point (T<sub>L</sub>) is exceeded, the  $\overline{\text{SAL}}$  is asserted low.

When no tamper condition exists,  $\overline{\text{SAL}}$  is normally high (see [Section 2: Pin descriptions on page 11](#)).

When a tamper is detected, the  $\overline{\text{SAL}}$  is activated (driven low), independent of the part type. V<sub>OUT</sub> can be driven to one of three states, depending on which variant of STM1404 is being used (see [Table 1 on page 1](#)):

- ON
- High-Z or
- Ground (V<sub>SS</sub>)

*Note:* The STM1404 must be initially powered above V<sub>RST</sub> to enable the tamper detection alarms. For example, if the battery is on while V<sub>CC</sub> = 0 V, no alarm condition can be detected until V<sub>CC</sub> rises above V<sub>RST</sub> (and t<sub>rec</sub> expires). From this point on, alarms can be detected either on battery or V<sub>CC</sub>. This is done to avoid false alarms when the device goes from no power to its operational state.

## 5 Typical operating characteristics

Note: Typical values are at  $T_A = 25^\circ\text{C}$ .

Figure 11.  $V_{\text{BAT}}$  -to- $V_{\text{OUT}}$  on-resistance vs. temperature

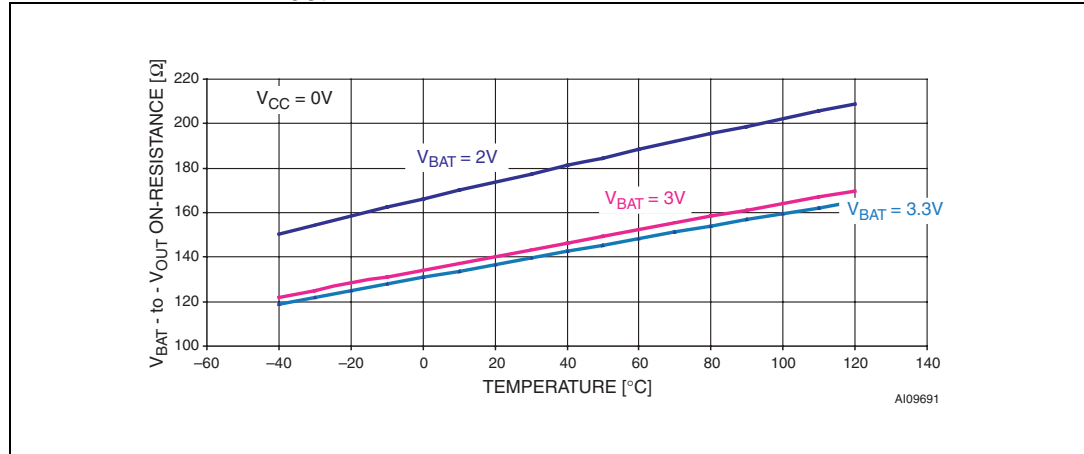


Figure 12. Supply current vs. temperature (no load)

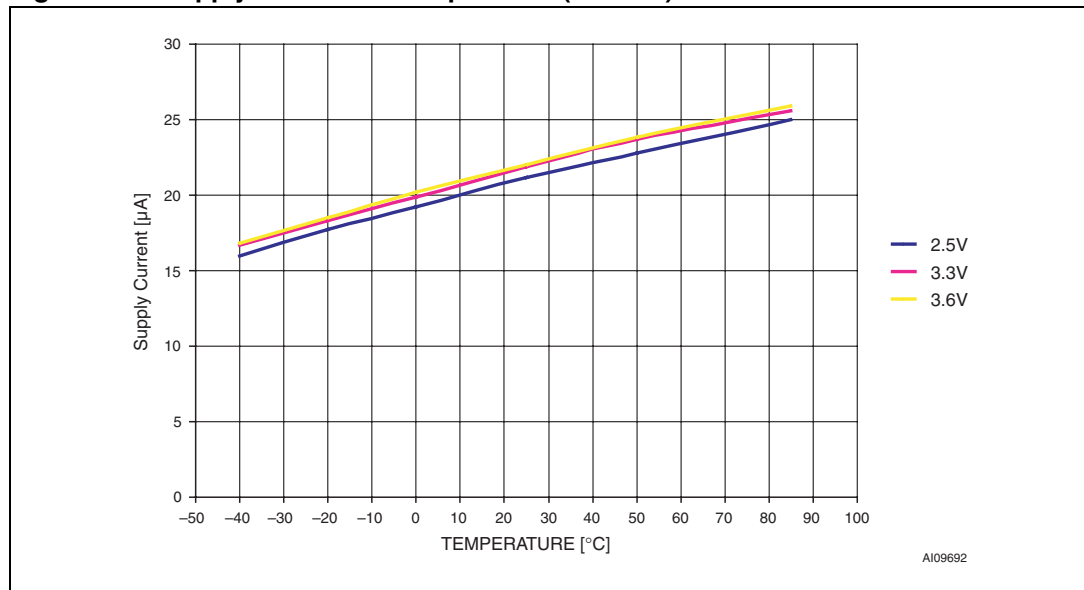


Figure 13.  $V_{PFI}$  threshold vs. temperature

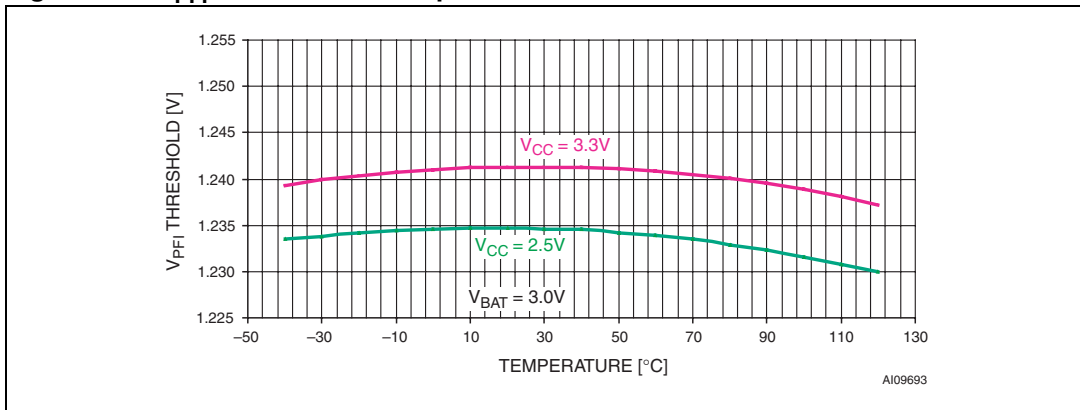


Figure 14. Reset comparator propagation delay vs. temperature

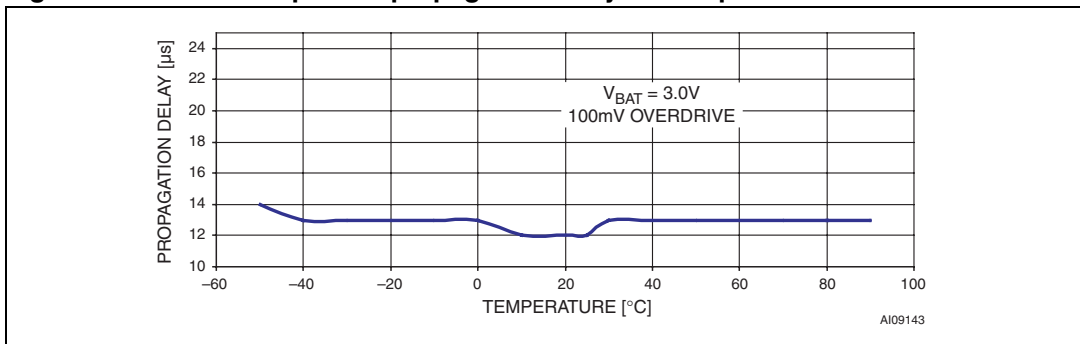


Figure 15. Power-up  $t_{rec}$  vs. temperature

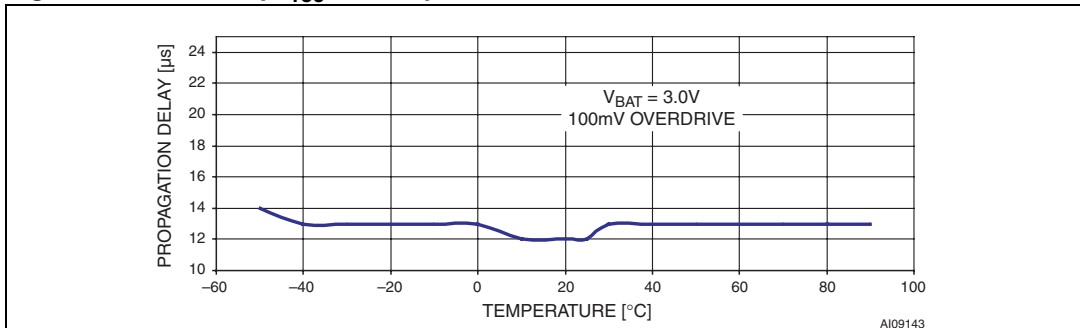


Figure 16. Normalized reset threshold vs. temperature

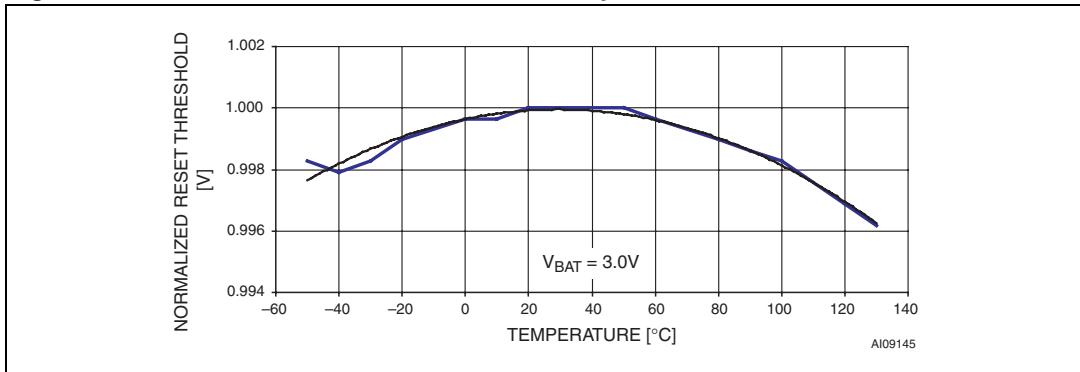


Figure 17. PFI to  $\overline{\text{PFO}}$  propagation delay vs. temperature

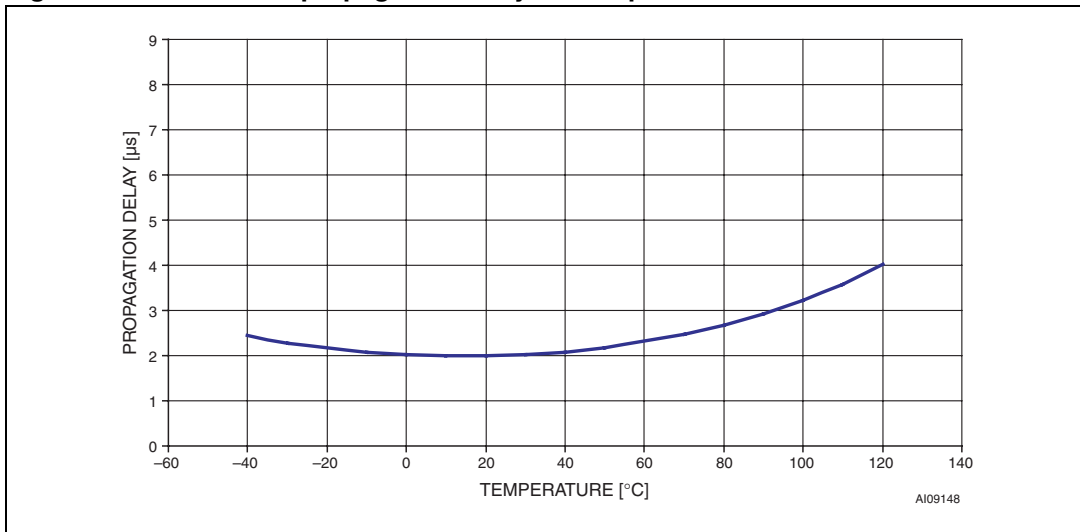


Figure 18.  $\overline{\text{RST}}$  output voltage vs. supply voltage

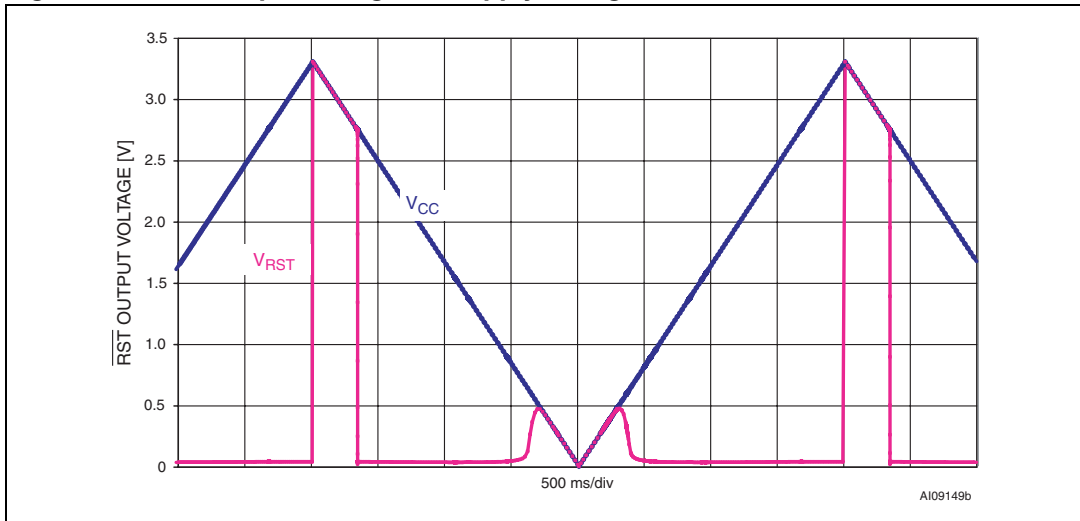


Figure 19.  $\overline{\text{RST}}$  response time (assertion)

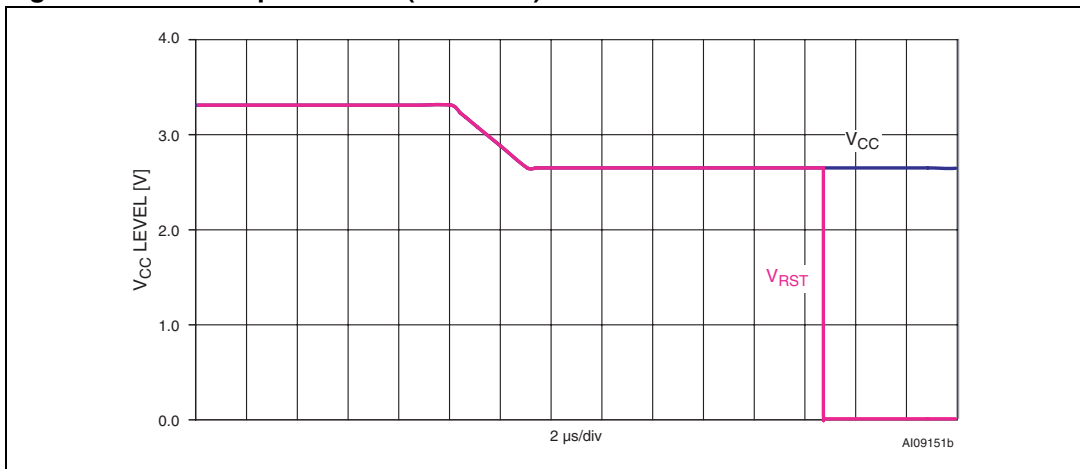


Figure 20. Power-fail comparator response time (assertion)

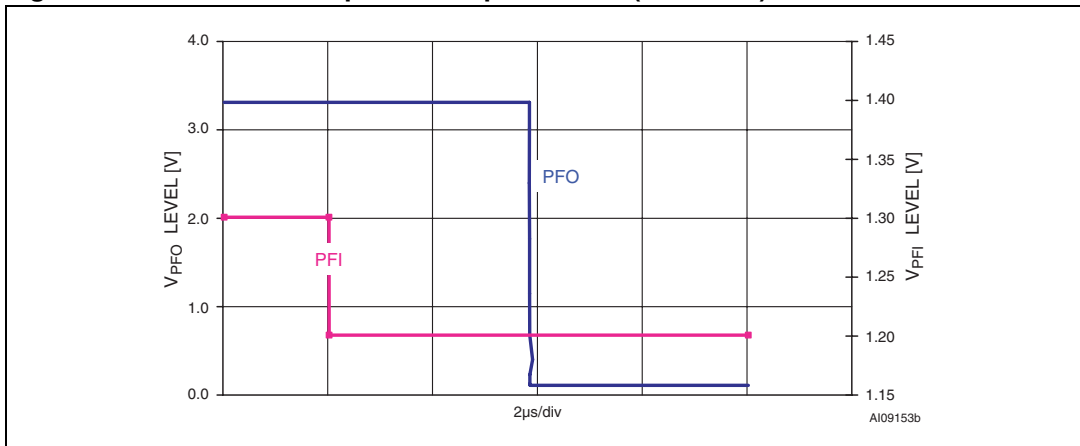


Figure 21. Power-fail comparator response time (de-assertion)

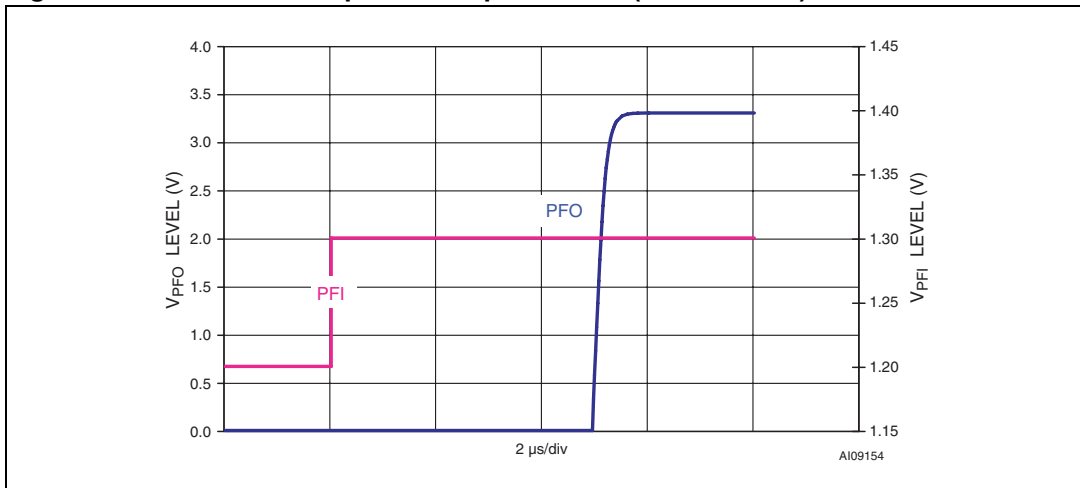


Figure 22.  $V_{CC}$  to reset propagation delay vs. temperature

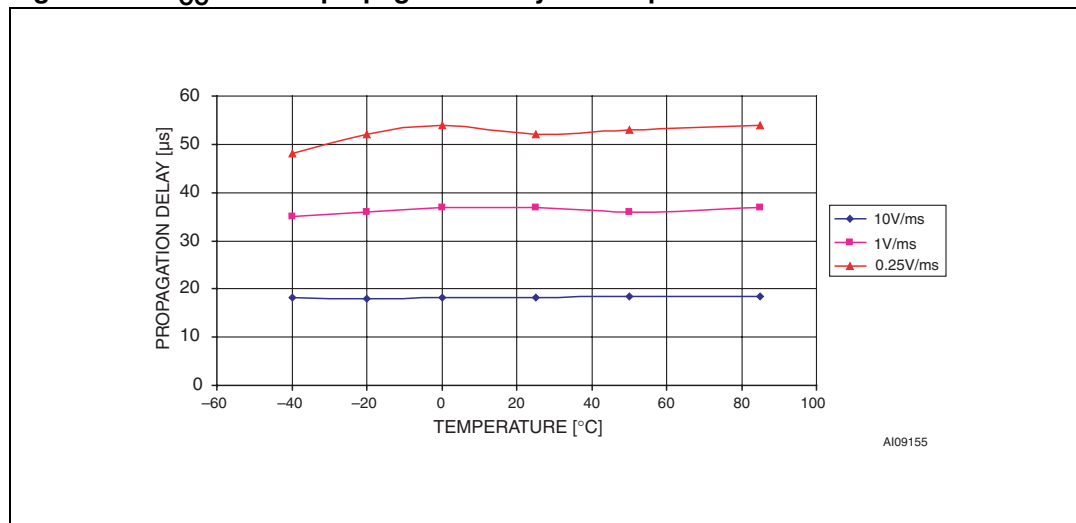
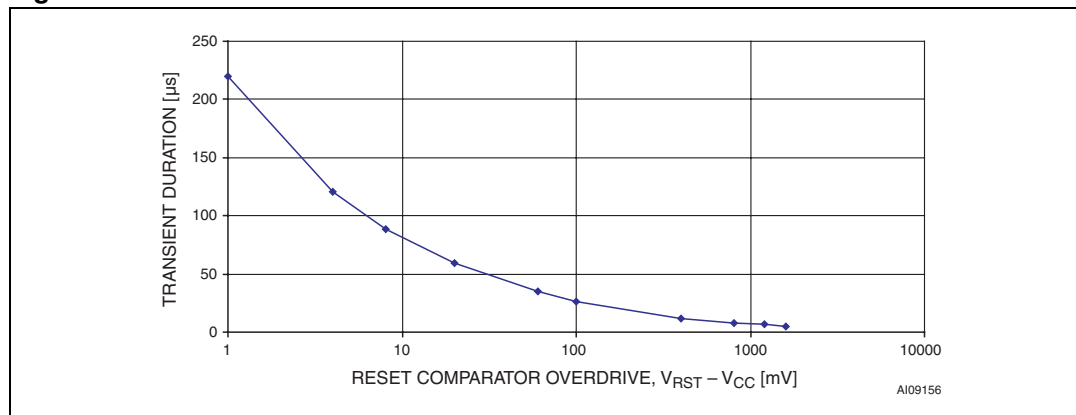


Figure 23. Maximum transient duration vs. reset threshold overdrive



## 6 Maximum ratings

Stressing the device above the rating listed in the absolute maximum ratings table may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics SURE Program and other relevant quality documents.

**Table 4. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$T_{STG}$	Storage temperature ( $V_{CC}$ off, $V_{BAT}$ off)	-55 to 150	°C
$T_{SLD}^{(1)}$	Lead solder temperature for 10 seconds	260	°C
$V_{IO}$	Input or output voltage	-0.3 to $V_{CC} + 0.3$	V
$V_{CC}/V_{BAT}$	Supply voltage	-0.3 to 4.5	V
$I_O$	Output current	20	mA
$P_D$	Power dissipation	320	mW

1. Reflow at peak temperature of 255°C to 260°C for < 30 seconds (total thermal budget not to exceed 180°C for between 90 to 150 seconds).

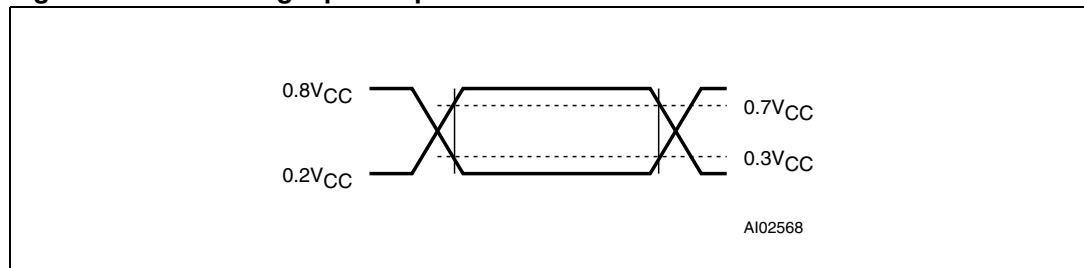
## 7 DC and AC parameters

This section summarizes the operating measurement conditions, and the DC and AC characteristics of the device. The parameters in the DC and AC characteristics tables that follow, are derived from tests performed under the measurement conditions summarized in [Table 5: Operating and AC measurement conditions](#). Designers should check that the operating conditions in their circuit match the operating conditions when relying on the quoted parameters.

**Table 5. Operating and AC measurement conditions**

Parameter	STM1404	Unit
V <sub>CC</sub> /V <sub>BAT</sub> supply voltage	2.2 to 3.6	V
Ambient operating temperature (T <sub>A</sub> )	-40 to 85	°C
Input rise and fall times	≤ 5	ns
Input pulse voltages	0.2 to 0.8V <sub>CC</sub>	V
Input and output timing ref. voltages	0.3 to 0.7V <sub>CC</sub>	V

**Figure 24. AC testing input/output waveforms**



**Figure 25. MR timing waveform**

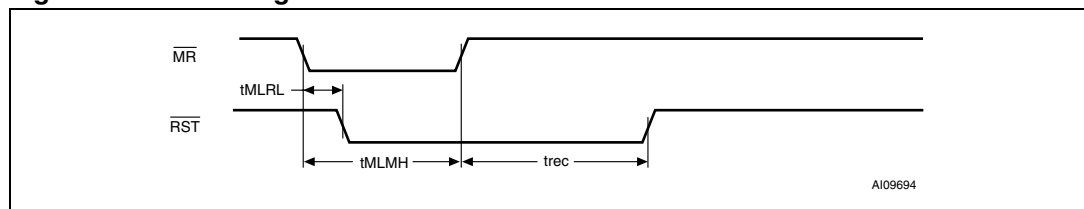




Figure 26. STM1404 switchover diagram, condition A ( $V_{BAT} < V_{SW}$ )

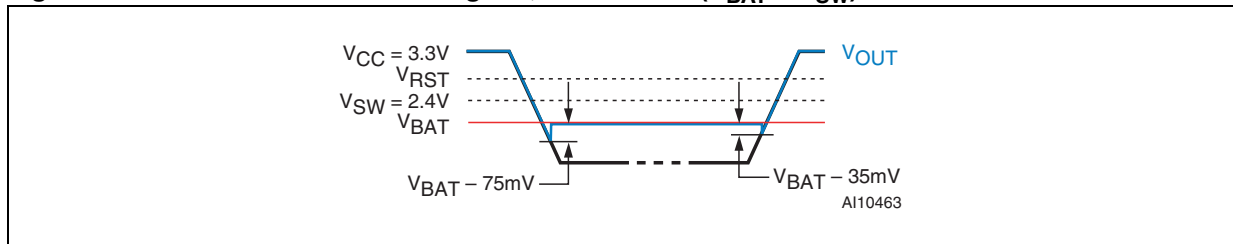


Figure 27. STM1404 switchover diagram, condition B ( $V_{BAT} > V_{SW}$ )

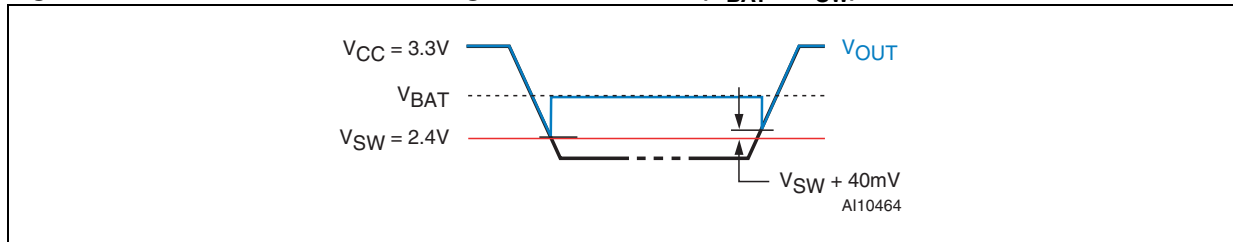


Table 6. DC and AC characteristics

Sym	Alternative	Description	Test condition <sup>(1)</sup>	Min	Typ	Max	Unit
$V_{CC}, V_{BAT}^{(2)}$		Operating voltage	$T_A = -40$ to $+85^\circ\text{C}$	2.2		3.6	V
$I_{CC}$		$V_{CC}$ supply current (STM1404A)	Typ @ 3.3 V, $25^\circ\text{C}$		50	65	$\mu\text{A}$
		$V_{CC}$ supply current (STM1404B,C)			35	50	$\mu\text{A}$
		$V_{CC}$ supply current in battery backup mode	Excluding $I_{OUT}$ ( $V_{BAT} = 2.3$ V, $V_{CC} = 2.0$ V, $MR = V_{CC}$ )		25	35	$\mu\text{A}$
$I_{BAT}^{(3)}$		$V_{BAT}$ supply current in battery backup mode	Excluding $I_{OUT}$ ( $V_{BAT} = 3.6$ V)		5.3	8.0	$\mu\text{A}$
$V_{OUT1}$		$V_{OUT}$ voltage (active)	$I_{OUT1} = 5$ mA <sup>(4)</sup> ( $V_{CC} > V_{SW}$ )	$V_{CC} - 0.03$	$V_{CC} - 0.015$		V
			$I_{OUT1} = 80$ mA ( $V_{CC} > V_{SW}$ )	$V_{CC} - 0.3$	$V_{CC} - 0.15$		V
			$I_{OUT1} = 250$ $\mu\text{A}$ , $V_{CC} > V_{SW}$ <sup>(4)</sup>	$V_{CC} - 0.0015$	$V_{CC} - 0.0006$		V
$V_{OUT2}$		$V_{OUT}$ voltage (battery backup)	$I_{OUT2} = 250$ $\mu\text{A}$ , $V_{BAT} = 2.2$ V	$V_{BAT} - 0.1$	$V_{BAT} - 0.04$		V
			$I_{OUT2} = 1$ mA, $V_{BAT} = 2.2$ V		$V_{BAT} - 0.16$		V
$V_{TPU1}$		Internal switched supply voltage (active)	$I_{SOURCE} = 5$ mA ( $V_{CC} > V_{SW}$ )	$V_{CC} - 0.3$			V

Table 6. DC and AC characteristics (continued)

Sym	Alternative	Description	Test condition <sup>(1)</sup>	Min	Typ	Max	Unit
V <sub>TPU2</sub>		Internal switched supply voltage (battery backup)	I <sub>SOURCE</sub> = 1 mA (V <sub>BAT</sub> = 2.2 V)		V <sub>BAT</sub> - 0.10		V
I <sub>LI</sub>		Input leakage current (MR)	$\overline{MR} = 0\text{ V}; V_{CC} = 3\text{ V}$	20	75	350	μA
		Input leakage current (PFI)	0 V = V <sub>IN</sub> = V <sub>CC</sub>	-25	2	+25	nA
		Input leakage current (TP1-TP4)	0 V = V <sub>IN</sub> = V <sub>CC</sub>	-1		+1	μA
I <sub>LO</sub>		Output leakage current	0 V = V <sub>IN</sub> = V <sub>CC</sub> <sup>(5)</sup>	-1		+1	μA
V <sub>IH</sub>		Input high voltage ( $\overline{MR}$ )	V <sub>RST</sub> (max) < V <sub>CC</sub> < 3.6 V	0.7V <sub>CC</sub>			V
V <sub>IL</sub>		Input low voltage ( $\overline{MR}$ )				0.3V <sub>CC</sub>	V
V <sub>OL</sub>		Output low voltage (PFO, RST, V <sub>CCSW</sub> , SAL, BLD)	V <sub>CC</sub> = V <sub>RST</sub> (max), I <sub>SINK</sub> = 3.2 mA			0.3	V
V <sub>OL</sub>		Output low voltage (RST)	I <sub>OL</sub> = 40 μA; V <sub>CC</sub> = 1.0 V; V <sub>BAT</sub> = V <sub>CC</sub> ; T <sub>A</sub> = 0°C to 85°C			0.3	V
			I <sub>OL</sub> = 200 μA; V <sub>CC</sub> = 1.2 V; V <sub>BAT</sub> = V <sub>CC</sub>			0.3	V

Table 6. DC and AC characteristics (continued)

Sym	Alternative	Description	Test condition <sup>(1)</sup>	Min	Typ	Max	Unit	
V <sub>OHB</sub>		V <sub>OH</sub> battery backup (V <sub>CCSW</sub> )	I <sub>SOURCE</sub> = 100 µA	0.8V <sub>BAT</sub>			V	
		Pull-up supply voltage (open drain)	$\overline{RST}$ , $\overline{SAL}$ , $\overline{BLD}$ , $\overline{PFO}$			3.6	V	
<b>Power-fail comparator</b>								
V <sub>PFI</sub>		PFI input threshold	PFI falling (V <sub>CC</sub> < 3.6 V)	1.212	1.237	1.262	V	
		PFI hysteresis	PFI rising (V <sub>CC</sub> < 3.6 V)		10	20	mV	
t <sub>PFD</sub>		PFI to $\overline{PFO}$ propagation delay			2		µs	
<b>Battery switchover</b>								
V <sub>SO</sub>		Battery backup switchover voltage <sup>(6)(7)</sup>	Power-down	V <sub>BAT</sub> > V <sub>SW</sub>		V <sub>SW</sub>	V	
				V <sub>BAT</sub> < V <sub>SW</sub>		V <sub>BAT</sub>	V	
			Power-up	V <sub>BAT</sub> > V <sub>SW</sub>		V <sub>SW</sub>	V	
				V <sub>BAT</sub> < V <sub>SW</sub>		V <sub>BAT</sub>	V	
		V <sub>SW</sub>			2.4		V	
	Hysteresis			40		mV		
<b>Battery low voltage detect</b>								
V <sub>DET</sub>		Battery detect threshold	On power-up only	M	2.25	2.30	2.34	V
				N	2.45	2.50	2.55	V
				O	3.14	3.20	3.26	V
<b>Voltage reference (option for STM1404A)<sup>(8)</sup></b>								
V <sub>REF</sub>		Voltage reference (see <a href="#">Section 2.9: V<sub>REF</sub> reference voltage output (1.237, typ) on page 13</a> )	0°C to 85°C	1.212	1.237	1.262	V	
			-40° to 0°C	1.200	1.237	1.274	V	
I <sub>REF+</sub>		Source current	0°C to 85°C	15	25		µA	
			-40° to 0°C	10	15		µA	
I <sub>REF-</sub>		Sink current		10	13		µA	
V <sub>n</sub>		Output voltage noise	f = 100 Hz to 100 kHz		10-100		µV <sub>rms</sub>	

Table 6. DC and AC characteristics (continued)

Sym	Alter-native	Description	Test condition <sup>(1)</sup>	Min	Typ	Max	Unit	
<b>Reset thresholds</b>								
V <sub>RST</sub> <sup>(9)</sup>		Reset threshold	T	V <sub>CC</sub> falling	3.00	3.075	3.15	V
				V <sub>CC</sub> rising	3.00	3.085	3.17	V
			S	V <sub>CC</sub> falling	2.85	2.925	3.00	V
				V <sub>CC</sub> rising	2.85	2.935	3.02	V
			R	V <sub>CC</sub> falling	2.55	2.625	2.70	V
				V <sub>CC</sub> rising	2.55	2.635	2.72	V
t <sub>rec</sub>		$\overline{RST}$ pulse width		140	200	280	ms	
<b>Push-button reset input</b>								
t <sub>MLMH</sub>	t <sub>MR</sub>	$\overline{MR}$ pulse width		100			ns	
t <sub>MLRL</sub>	t <sub>MRD</sub>	$\overline{MR}$ to $\overline{RST}$ output delay			60	500	ns	

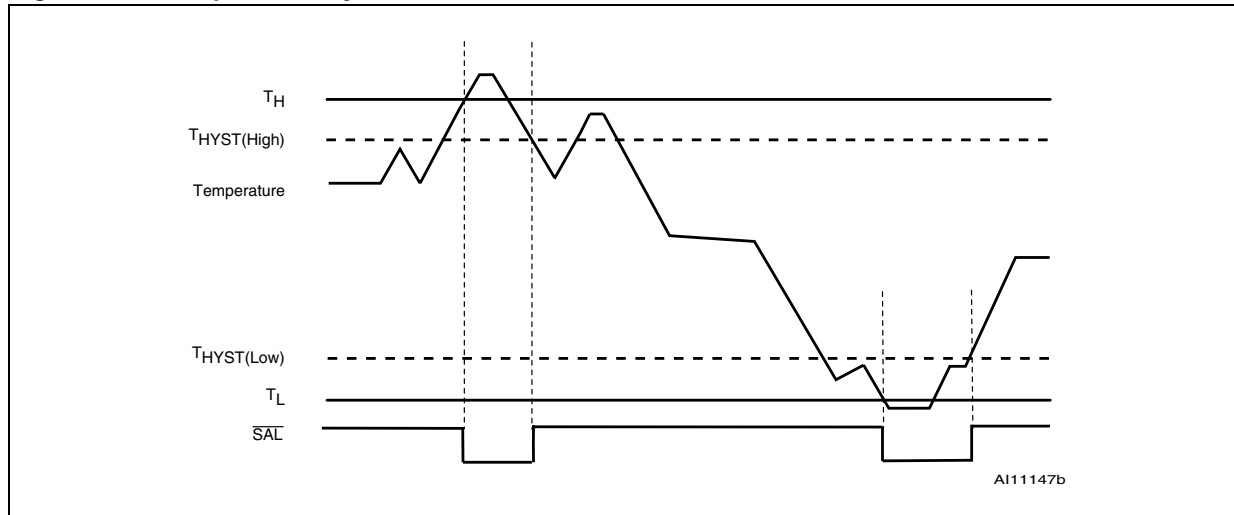
- Valid for ambient operating temperature: T<sub>A</sub> = -40 to 85°C; V<sub>CC</sub> = V<sub>RST</sub> (max) to 3.6 V; and V<sub>BAT</sub> = 2.8 V (except where noted); typical values are for 3.3 V and 25°C.
- V<sub>CC</sub> supply current, logic input leakage, push-button reset functionality, PFI functionality, state of  $\overline{RST}$  tested at V<sub>BAT</sub> = 3.6 V, and V<sub>CC</sub> = 3.6 V. The state of  $\overline{RST}$  and  $\overline{PFO}$  is tested at V<sub>CC</sub> = V<sub>CC</sub> (min). V<sub>BAT</sub> is voltage measured at the pin.
- Tested at V<sub>BAT</sub> = 3.6 V, and V<sub>CC</sub> = 0 V.
- Guaranteed by design.
- The leakage current measured on the  $\overline{RST}$ ,  $\overline{SAL}$ ,  $\overline{PFO}$ , and  $\overline{BLD}$  pins are tested with the output not asserted (output high impedance).
- When V<sub>BAT</sub> > V<sub>CC</sub> > V<sub>SW</sub>, V<sub>OUT</sub> remains connected to V<sub>CC</sub> until V<sub>CC</sub> drops below V<sub>SW</sub>.
- When V<sub>SW</sub> > V<sub>CC</sub> > V<sub>BAT</sub>, V<sub>OUT</sub> remains connected to V<sub>CC</sub> until V<sub>CC</sub> drops below the battery voltage (V<sub>BAT</sub>) – 75 mV.
- Maximum external capacitive load on V<sub>REF</sub> pin cannot exceed 1 nF.
- The reset threshold tolerance is wider for V<sub>CC</sub> rising than for V<sub>CC</sub> falling due to the 10 mV (typ) hysteresis, which prevents internal oscillation.

**Table 7. Physical and environmental tamper detection levels**

Sym	Parameter	Test conditions <sup>(1)</sup>	Min	Typ	Max	Unit
V <sub>HV</sub>	Overvoltage trip level		4.0	4.2	4.4	V
V <sub>LV</sub>	Undervoltage trip level		1.9	2.0	2.1	V
	$\overline{\text{SAL}}$ propagation delay time (after over/under voltage detection)	V <sub>HV</sub> + 200 mV or V <sub>LV</sub> - 200 mV		25	50	μs
V <sub>HTP</sub>	Trip point for NH physical tamper input pins (TP <sub>1</sub> or TP <sub>3</sub> )		V <sub>OUT</sub> - 1.3 <sup>(2)</sup>		V <sub>OUT</sub> - 0.3 <sup>(2)</sup>	V
V <sub>LTP</sub>	Trip point for NL physical tamper input pins (TP <sub>2</sub> or TP <sub>4</sub> )		0.3		1.0	V
	$\overline{\text{SAL}}$ propagation delay time <sup>(3)</sup> (after physical tamper pin detection)	V <sub>HTP</sub> = V <sub>OUT</sub> /V <sub>TPU</sub> ; V <sub>LTP</sub> = V <sub>SS</sub> V <sub>DD</sub> = 3.6		30	50	μs
	Physical tamper input (TP <sub>X</sub> ) glitch immunity			15		μs
T <sub>H</sub>	Factory-programmed	I <sub>OUT</sub> = 0 mA	-5	80, 85, 95	+5	°C
T <sub>L</sub>			-5	-25, -35	+5	°C
T <sub>HYST</sub>	Temperature hysteresis			10		°C

- Valid for ambient operating temperature: T<sub>A</sub> = -40 to 85°C; V<sub>CC</sub> = V<sub>LV</sub> to V<sub>HV</sub> (except where noted). All physical and environmental tamper functions are operational across the full temperature alarm range for STM1404.
- In the case of STM1404A, physical tamper input pins (TP<sub>X</sub>) are referenced to V<sub>OUT</sub> (pin 12). In the case of STM1404B or C, TP<sub>X</sub> are referenced to V<sub>TPU</sub> pin (pin 9).
- V<sub>CC</sub> = V<sub>RST</sub> (max) to 3.6 V

**Figure 28. Temperature hysteresis**

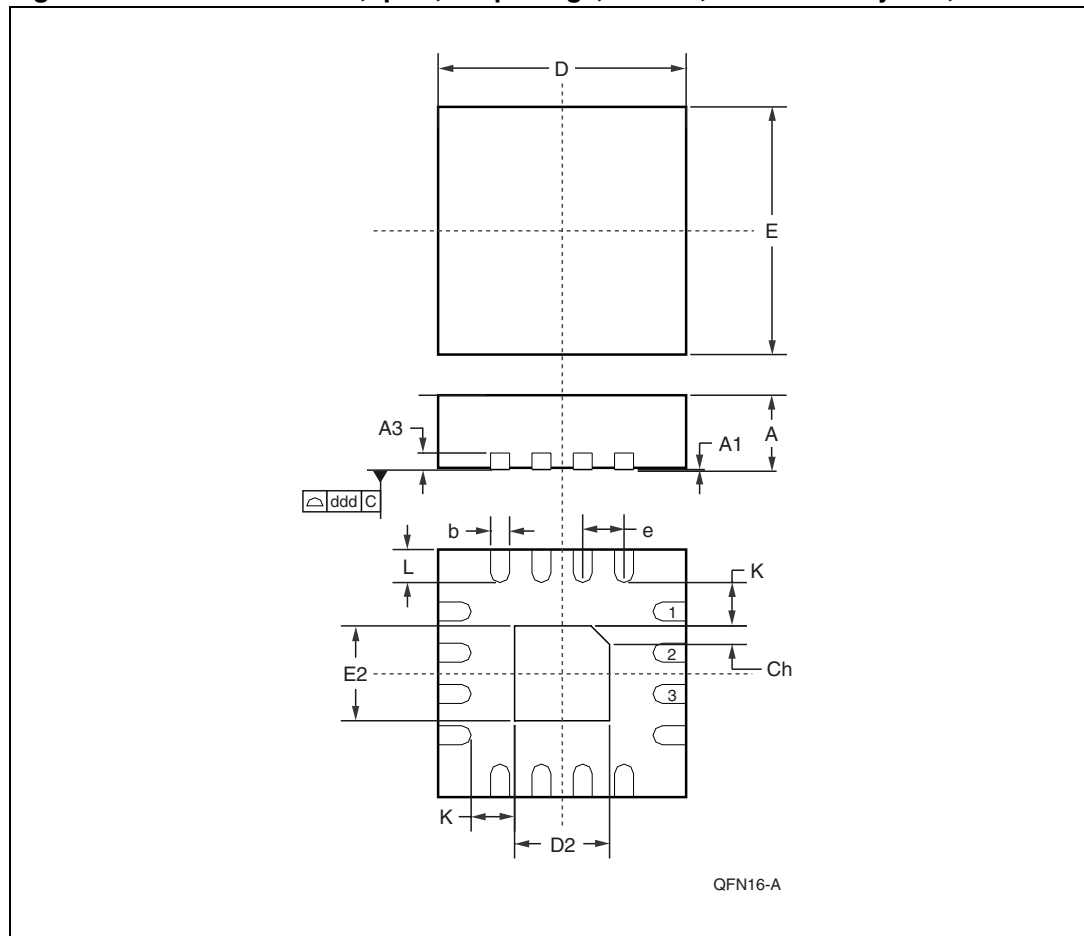


## 8 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK<sup>®</sup> packages. These packages have a Lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97.

The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

**Figure 29. QFN16 – 16-lead, quad, flat package, no lead, 3 x 3 mm body size, outline**

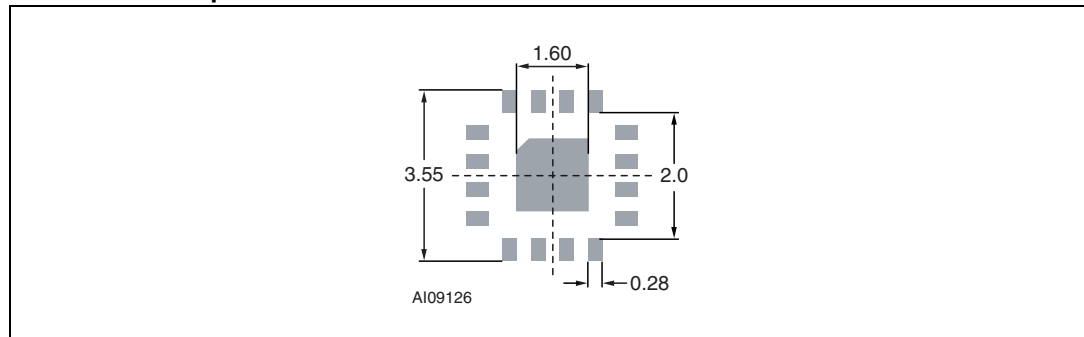


Note: Drawing is not to scale.

**Table 8. QFN16 – 16-lead, quad, flat package, no lead, 3 x 3 mm body size mechanical data**

Symb	mm			inches		
	Typ	Min	Max	Typ	Min	Max
A	0.90	0.80	1.00	0.035	0.032	0.039
A1	0.02	0.00	0.05	0.001	0.000	0.002
A3	0.20	–	–	0.008	–	–
b	0.25	0.18	0.30	0.010	0.007	0.012
D	3.00	2.90	3.10	0.118	0.114	0.122
D2	1.70	1.55	1.80	0.067	0.061	0.071
E	3.00	2.90	3.10	0.118	0.114	0.122
E2	1.70	1.55	1.80	0.067	0.061	0.071
e	0.50	–	–	0.020	–	–
K	0.20	–	–	0.008	–	–
L	0.40	0.30	0.50	0.016	0.012	0.020
ddd	–	0.08	–	–	0.003	–
Ch	–	0.33	–	–	0.013	–
N	16			16		

**Figure 30. QFN16 – 16-lead, quad, flat package, no lead, 3 x 3 mm, recommended footprint**



*Note:* Substrate pad should be tied to  $V_{SS}$ .

## 9 Part numbering

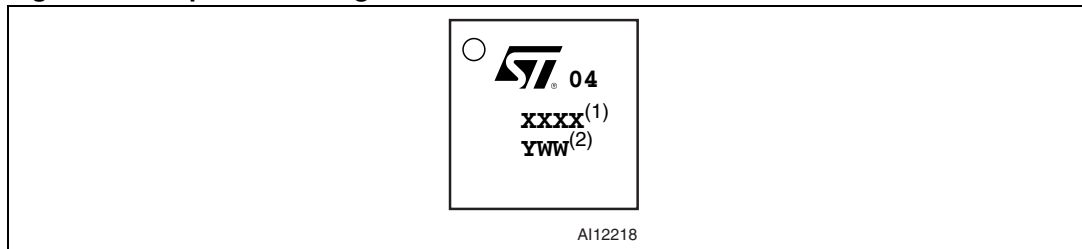
**Table 9. Ordering information scheme (see [Figure 31 on page 33](#) for marking information)**

Example:	STM1404	A	T	M	D	Q	6	F
<b>Device type</b> STM1404: over/under temperature detect								
<b>V<sub>OUT</sub> status (<math>\overline{\text{SAL}}</math> = active-low)</b> A: V <sub>OUT</sub> = ON; $\overline{\text{Vccsw}}$ = normal mode B <sup>(1)</sup> : V <sub>OUT</sub> = High-Z; $\overline{\text{Vccsw}}$ = high C: V <sub>OUT</sub> = ground; $\overline{\text{Vccsw}}$ = high								
<b>Reset threshold voltage</b> T: V <sub>RST</sub> = 3.00 V to 3.15 V S: V <sub>RST</sub> = 2.85 V to 3.00 V R: V <sub>RST</sub> = 2.55 V to 2.70 V								
<b>Battery low voltage detect threshold (V<sub>DET</sub>)</b> M: V <sub>DET</sub> = 2.3 V (typ) N: V <sub>DET</sub> = 2.5 V (typ) O: V <sub>DET</sub> = 3.2 V (typ)								
<b>Under (TL)/over (TH) temperature alarm thresholds (STM1404 only)</b> B: -25/+80°C    H: -35/+80°C C: -25/+85°C    I: -35/+85°C D: -25/+95°C    J: -35/+95°C								
<b>Package</b> Q = QFN16 (3 mm x 3 mm)								
<b>Temperature range</b> 6 = -40 to 85°C								
<b>Shipping method</b> F = ECOPACK <sup>®</sup> package, tape & reel								

1. Contact local ST sales office for availability.

For other options, or for more information on any aspect of this device, please contact the ST sales office nearest you.



**Figure 31. Topside marking information**

1. Options codes:

X = A, B, or C (for  $V_{OUT}$ )

X = T, S, or R (for reset threshold)

X = M, N, or O (for battery low voltage detect threshold)

X = B, C, D, H, I, or J (for temperature alarm threshold)

2. Traceability codes

Y = Year

WW = Work Week

## 10 Revision history

**Table 10. Document revision history**

Date	Revision	Changes
11-Oct-2004	1	First edition
26-Nov-2004	1.1	Corrected footprint dimensions; update characteristics (Figure 1, 2, 3, 4, 5, 6, 7, 8, 26, 27, 30 and Table 1, 2, 3, 6, 7).
22-Dec-2004	1.2	Update characteristics (Figure 4, Tables 6, 7, 9).
03-Feb-2005	1.3	Update characteristics (Figure 4, Tables 6, 7).
25-Feb-2005	1.4	Update temperature trip limits (Table 9)
06-May-2005	1.5	Update characteristics (Figure 3, 4, 28 and Table 6, 7).
05-Aug-2005	2	Removed STM1403 references (Figure 1, 2, 3, 4, 5, 6, 7, 8, 26, 27, 28 and Table 1, 2, 5, 6, 7, 9).
06-Jan-2006	3	Update status, characteristics, lead-free text, marking (Figure 4, 31 and Table 6, 7, 9).
08-Feb-2007	4	Update cover page, Figure 3: Block diagram, Table 7: Physical and environmental tamper detection levels, Figure 28: Temperature hysteresis, and part numbering (Table 9.)
21-Aug-2008	5	Minor formatting changes; updated Table 1, 7 and Section 8.

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