Introduction

High brightness LEDs are becoming a prominent source of lighting. Compared to conventional incandescent bulbs, high brightness LEDs (light emitting diodes) have advantages in higher light efficacy, much longer life and faster reaction time in a smaller profile. Since LEDs cannot sustain high voltage stress directly from an AC source, providing a reliable constant-current source to drive LEDs becomes fundamental. This solution provides even luminosity, reliability, the highest efficacy and the longest operating life for LEDs.

This application note describes the non-isolated offline constant-current driver based on the VIPER17HN (high frequency version). This solution operates with an AC line input range from 176 V to 264 VAC and provides 500 mA constant current from a 7 VDC source. It can illuminate two LEDs in series.

This device is an offline converter with an 800 V rugged power section, a PWM control, twice the level of overcurrent protection, overvoltage and overload protections, hysteretic thermal protection, soft-start and also safe auto-restart after any fault condition removal. The embedded brownout function protects this switch mode power supply in case the main input voltage falls below the specified minimum level for this system.

Figure 1. STEVAL-ILL017V1 demonstration board
## Contents

1. **Safety instructions** ......................................................... 5
2. **Design considerations** .................................................... 6
   2.1 Selected topology ......................................................... 6
3. **General circuit description** ............................................. 8
   3.1 Schematic diagram ....................................................... 8
   3.2 Bill of material .......................................................... 9
   3.3 PCB layout view ........................................................ 11
   3.4 Transformer design ..................................................... 11
4. **Test results and waveforms** .......................................... 13
5. **Connection of AC line and LED lamp to the demonstration board** 21
6. **Conclusion** ................................................................. 22
7. **References** ............................................................... 23
8. **Revision history** ......................................................... 24
# List of tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Specifications</td>
<td>6</td>
</tr>
<tr>
<td>Table 2</td>
<td>Bill of material</td>
<td>9</td>
</tr>
<tr>
<td>Table 3</td>
<td>Basic electrical characteristics of flyback transformer (T1)</td>
<td>11</td>
</tr>
<tr>
<td>Table 4</td>
<td>Bobbin dimensions</td>
<td>12</td>
</tr>
<tr>
<td>Table 5</td>
<td>Document revision history</td>
<td>24</td>
</tr>
</tbody>
</table>
List of figures

Figure 1. STEVAL-ILL017V1 demonstration board ................................................................. 1
Figure 2. Conventional buck converter .................................................................................... 6
Figure 3. Modified buck converter .......................................................................................... 7
Figure 4. Flyback converter ..................................................................................................... 7
Figure 5. Schematic diagram of demonstration board .............................................................. 8
Figure 6. Top view .................................................................................................................... 11
Figure 7. Bottom view with SMD parts ................................................................................... 11
Figure 8. Winding structure ..................................................................................................... 11
Figure 9. Bobbin outline ......................................................................................................... 12
Figure 10. Efficiency versus input voltage .............................................................................. 13
Figure 11. Standby power versus input voltage ...................................................................... 13
Figure 12. Vin and lin at 176 VAC, one LED .......................................................................... 14
Figure 13. Vin and lin at 176 VAC, two LEDs ........................................................................ 14
Figure 14. Vin and lin at 264 VAC, one LED .......................................................................... 14
Figure 15. Vin and lin at 264 VAC, two LEDs ........................................................................ 14
Figure 16. Inrush current at LINE IN, one LED ..................................................................... 15
Figure 17. Inrush current at LINE IN, two LEDs ................................................................. 15
Figure 18. Vds and Id at 176 VAC, one LED .......................................................................... 16
Figure 19. Vds and Id at 176 VAC, two LEDs ........................................................................ 16
Figure 20. Vds and Id at 264 VAC, one LED .......................................................................... 16
Figure 21. Vds and Id at 264 VAC, two LEDs ........................................................................ 16
Figure 22. Vo and Io at 176 VAC, one LED ........................................................................... 17
Figure 23. Vo and Io at 176 VAC, two LEDs ......................................................................... 17
Figure 24. Vo and Io at 264 VAC, one LED ........................................................................... 17
Figure 25. Vo and Io at 264 VAC, two LEDs ......................................................................... 17
Figure 26. Startup of Vo and Io at 176 VAC, one LED .......................................................... 18
Figure 27. Startup of Vo and Io at 176 VAC, two LEDs ......................................................... 18
Figure 28. Startup of Vo and Io at 264 VAC, one LED ......................................................... 18
Figure 29. Startup of Vo and Io at 264 VAC, two LEDs ......................................................... 18
Figure 30. Vdd and Vds at 264 VAC, output in short-circuit ................................................. 19
Figure 31. Io at 264 VAC, output in short-circuit .................................................................. 19
Figure 32. Vdd and Vds at 264 VAC, output in open-circuit ................................................. 20
Figure 33. Startup of Vdd and Vds at 264 VAC, output in open-circuit ................................. 20
Figure 34. Completed demonstration board connection ....................................................... 21
Figure 35. Connection of AC line .......................................................................................... 21
Figure 36. Connection of LED lamp ..................................................................................... 21
1 Safety instructions

Warning: The demonstration board must be used in a suitable laboratory by only qualified personnel who are familiar with the installation, use, and maintenance of electrical systems.

Intended use

The demonstration board is a component designed for demonstration purposes only, and shall be used neither for domestic installation nor for industrial installation. The technical data as well as the information concerning the power supply and working conditions shall be taken from the documentation included with the demonstration board and strictly observed.

Installation

The installation of the demonstration board shall be taken from the present document and strictly observed. The components must be protected against excessive strain. In particular, no components are to be bent, or isolating distances altered during the transportation, handling or usage. The demonstration board contains electro-statically sensitive components that are prone to damage through improper use. Electrical components must not be mechanically damaged or destroyed (to avoid potential risks and health injury).

Electrical connection

Applicable national accident prevention rules must be followed when working on the mains power supply. The electrical installation shall be completed in accordance with the appropriate requirements (e.g. cross-sectional areas of conductors, fusing, and PE connections).

Board operation

A system architecture which supplies power to the demonstration board shall be equipped with additional control and protective devices in accordance with the applicable safety requirements (e.g. compliance with technical equipment and accident prevention rules).
2 Design considerations

2.1 Selected topology

This is a 500 mA constant-current source conversion from 176 VAC ~ 264 VAC line input. The specifications shown in Table 1 are for refrigerator lighting usage.

Table 1. Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC input</td>
<td>220 VAC ± 20%</td>
</tr>
<tr>
<td>Output current</td>
<td>500 mA</td>
</tr>
<tr>
<td>Output voltage</td>
<td>7 V max</td>
</tr>
<tr>
<td>Dimensions</td>
<td>30 mm x 30 mm</td>
</tr>
<tr>
<td>Isolation</td>
<td>Not required</td>
</tr>
<tr>
<td>Topology</td>
<td>Constant-current source</td>
</tr>
</tbody>
</table>

According to the specifications the maximum operating power is 3.5 watts. No power factor correction circuit is required. Therefore, both buck and flyback topologies are suitable for this application. Figure 2 shows the conventional buck converter while Figure 4 illustrates the flyback converter. To convert high voltage to low voltage, a conventional buck converter just requires a few components. Output current ripple is small due to Vout obtained from inherent filter L1 and C1, thus the voltage and current stresses on these power components are small. In order to properly drive the MOSFET (Q1), a controller and an additional transformer are required. Additional winding with L1 to bias Q1 as well as a feedback current to manage output in constant-current mode are needed.

Figure 2. Conventional buck converter

![Conventional buck converter diagram]
For ease in driving Q1 using a conventional buck converter, a modified buck converter has been introduced as shown in Figure 3. Such topology is widely used to drive LEDs. With this modified solution, the MOSFET is no longer floating. In this case the output (Vout) is not connected to ground, and it becomes quite difficult to sense the output current in the output stage directly. Compared to a buck converter, the flyback converter may be the better choice. Figure 4 shows the typical circuit of a flyback converter.

The auxiliary winding can be added to the transformer (T1) to provide bias for Q1. Unlike the buck converter, T1 provides isolation between Vin and Vout. Since such isolation is not required for this application, a current sense resistor can be placed across the primary ground and negative polarity of Vout. Thus, Vout shares the same primary ground. In this topology, the MOSFET is not floating. Thanks to VIPer17 the board is built with a high-performance low-voltage controller chip with an 800 V avalanche rugged power MOSFET. Designed with VIPer17, only a few external components are required which allows a smaller profile in the design.
3 General circuit description

3.1 Schematic diagram

Figure 5 shows the complete schematic diagram of the demonstration board. It consists of an input full-bridge rectifier with filtering circuit, flyback converter and output stage.

Figure 5. Schematic diagram of demonstration board
Referring to the schematic diagram in *Figure 5*, fuse1 is the input fuse to prevent hazards if the system current exceeds the fuse rating. D1 is the bridge rectifier to convert AC to DC. The filter is formed by C11, L2, and C3 that are used to attenuate the high frequency harmonic interference. T1 is the flyback transformer and U1 is formed by the PWM controller and output MOSFET. The auxiliary winding (pin 5 and 6) and diode D5 provide bias supply for each control circuit. The output stage includes D6, C9, and C13. R9 and R12 are the output current sense resistors providing current sense signal. These are connected in parallel to share the power dissipation.

The constant-current control circuit consists of U2, Q1, U1, and some passive components. The output current sense signal feeds to OP amp in U2. R7 and C7 consist of the compensation network for the output signal of U2 in order to properly drive Q1. The 0.3 V reference voltage on pin 6 of U2 is obtained by voltage divider R11 and R10. The collector junction of Q1 is connected to the feedback pin of U1 and completes the feedback loop.

The output voltage is indirectly monitored by the auxiliary winding (pin 5 and 6 of T1) and feedback to pin 3 of U1 through R1 and R4. Once the voltage at pin 3 of U1 exceeds 3 V, U1 shuts down, then enters the auto-restart mode. Thanks to U1, which includes an overload protection function, if the LED is absent in the application (no load), this solution provides a safeguard. The LED and the application board are both fully protected.

### 3.2 Bill of Material

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Rated</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1 nF</td>
<td>25 V</td>
<td>Ceramic cap [0603]</td>
</tr>
<tr>
<td>C2, C8</td>
<td>100 nF</td>
<td>25 V</td>
<td>Ceramic cap [0603]</td>
</tr>
<tr>
<td>C3, C11</td>
<td>2.2 μF</td>
<td>400 V</td>
<td>Al elcap CAPPR3.5-8X12</td>
</tr>
<tr>
<td>C4</td>
<td>56 nF</td>
<td>25 V</td>
<td>Ceramic cap [0603]</td>
</tr>
<tr>
<td>C5, C12</td>
<td>10 μF</td>
<td>25 V</td>
<td>Al elcap CAPPR2-5X11</td>
</tr>
<tr>
<td>C6</td>
<td>2.2 nF</td>
<td>25 V</td>
<td>Ceramic cap [0603]</td>
</tr>
<tr>
<td>C7</td>
<td>12 nF</td>
<td>25 V</td>
<td>Ceramic cap [0603]</td>
</tr>
<tr>
<td>C9</td>
<td>220 μF</td>
<td>16 V</td>
<td>Al elcap CAPPR3.5-8X11.5</td>
</tr>
<tr>
<td>C10</td>
<td>470 pF</td>
<td>25 V</td>
<td>Ceramic cap [0603]</td>
</tr>
<tr>
<td>C13</td>
<td>1 μF</td>
<td>25 V</td>
<td>Ceramic cap [0805]</td>
</tr>
<tr>
<td>D1</td>
<td>MB6S PKG30 E3</td>
<td>1 A 600 V bridge rectifier</td>
<td>Vishay</td>
</tr>
<tr>
<td>D3</td>
<td>BAT46JFILM</td>
<td>Small signal Schottky diode</td>
<td>STMicroelectronics [SOD323]</td>
</tr>
<tr>
<td>D5</td>
<td>STTH1R06A</td>
<td>1 A 600 V ultrafast rectifier</td>
<td>STMicroelectronics [SMA]</td>
</tr>
<tr>
<td>D6</td>
<td>STPS2H100A</td>
<td>2 A 100 V Schottky rectifier</td>
<td>STMicroelectronics [SMA]</td>
</tr>
<tr>
<td>Fuse1</td>
<td>500 mA 250 V</td>
<td>Fuse_5_8.5*8_Bel</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>LPS3314-105ML</td>
<td>1 mH, 0.1 A</td>
<td>Inductor, Coilcraft L_LP3314</td>
</tr>
<tr>
<td>Q1</td>
<td>BC817-40</td>
<td>NPN general-purpose transistor</td>
<td>[SOT-23]</td>
</tr>
<tr>
<td>R1</td>
<td>240 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
</tbody>
</table>
Table 2. Bill of material (continued)

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Rated</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2</td>
<td>6.8 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R3</td>
<td>100 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R4</td>
<td>56 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R5</td>
<td>10 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R6</td>
<td>10 Ω</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R7</td>
<td>82 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R8</td>
<td>3 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R9, R12</td>
<td>1.2 Ω</td>
<td>1%</td>
<td>Resistor [1206]</td>
</tr>
<tr>
<td>R10</td>
<td>3.3 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R11</td>
<td>24 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R13</td>
<td>2.7 kΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>R14</td>
<td>1 MΩ</td>
<td>1%</td>
<td>Resistor [0603]</td>
</tr>
<tr>
<td>T1 (1)</td>
<td>T_EE10/11_TDK</td>
<td>1 mH</td>
<td>TDK flyback transformer</td>
</tr>
<tr>
<td>U1</td>
<td>VIPER17HN</td>
<td>Offline high voltage converter</td>
<td>STMicroelectronics [DIP-7]</td>
</tr>
<tr>
<td>U2</td>
<td>TSM103W</td>
<td>Dual OP and voltage reference</td>
<td>STMicroelectronics [SO-8]</td>
</tr>
</tbody>
</table>

1. T1, the transformer design, is shown in Section 3.4 on page 11. Table 3 gives the basic electrical characteristics, Figure 8 shows the winding structure, and Figure 9 illustrates the bobbin outline.
3.3 PCB layout view

The PCB views are shown in Figure 6 and Figure 7.

![Image of PCB layout view](image1)

![Image of PCB layout view](image2)

3.4 Transformer design

Table 3. Basic electrical characteristics of flyback transformer (T1)

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core type</td>
<td>EE10/11-PC40</td>
</tr>
<tr>
<td>Bobbin type</td>
<td>BE10-118CPSFR</td>
</tr>
<tr>
<td>Primary inductance</td>
<td>1 mH +/- 10%</td>
</tr>
<tr>
<td>Leakage inductance</td>
<td>10 µH typical</td>
</tr>
</tbody>
</table>

![Image of winding structure](image3)
Figure 9. Bobbin outline

Table 4. Bobbin dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.2 mm</td>
</tr>
<tr>
<td>B</td>
<td>3.5 mm</td>
</tr>
<tr>
<td>C</td>
<td>6.6 mm</td>
</tr>
<tr>
<td>E</td>
<td>3.85 mm</td>
</tr>
<tr>
<td>X</td>
<td>10.2 mm</td>
</tr>
<tr>
<td>Y</td>
<td>10.2 mm</td>
</tr>
<tr>
<td>Z</td>
<td>9 mm</td>
</tr>
<tr>
<td>P</td>
<td>0.5 mm</td>
</tr>
</tbody>
</table>
4 Test results and waveforms

Figure 10 shows the overall efficiency versus a range of AC line voltage loads with one LED and two LEDs. Under both load conditions, we can observe that the efficiency drops when input voltage increases. The maximum efficiency occurs at minimum AC line input (176 VAC). Comparing a load condition of one LED with a load condition of two LEDs in series, the efficiency increases by 7%. The efficiency with 1 LED is close to 75%.

Figure 10. Efficiency versus input voltage

Figure 11 shows us the standby power which is measured when the LED is disconnected. Standby does not mean burst mode under light load. In standby, the overvoltage protection works. Under various AC line inputs, the maximum standby power is 0.18 W at 264 V input.

Figure 11. Standby power versus input voltage

With the aid of the filter formed by C11, L2 and C3, no high-frequency interference can be observed at the input current which definitely helps in meeting the conducted EMI standard. In Figure 12 and Figure 13 the waveform is captured at 176 VAC. In Figure 14 and Figure 15 the waveform is captured at 264 VAC.

To choose the proper rating of the fuse, we always refer to the inrush current. There are two inrush current plots at the AC line input 220 V: Figure 16 with one LED and Figure 17 with two LEDs.
Figure 12. Vin and Iin at 176 VAC, one LED

Top trace: Vin (200 V/div)
Bottom trace: Iin (200 mA/div)
Time: 4 ms/div

Figure 13. Vin and Iin at 176 VAC, two LEDs

Top trace: Vin (200 V/div)
Bottom trace: Iin (200 mA/div)
Time: 4 ms/div

Figure 14. Vin and Iin at 264 VAC, one LED

Top trace: Vin (200 V/div)
Bottom trace: Iin (200 mA/div)
Time: 4 ms/div

Figure 15. Vin and Iin at 264 VAC, two LEDs

Top trace: Vin (200 V/div)
Bottom trace: Iin (200 mA/div)
Time: 4 ms/div
Figure 16. Inrush current at LINE IN, one LED

Iin: 5 A/div, 40 us/div
Max. value: 14.2 A

Figure 17. Inrush current at LINE IN, two LEDs

Iin: 5 A/div, 40 us/div
Max. value: 20.28 A
The VIPer17 integrates one 800 V MOSFET and the drain current is limited at 0.6 A. The drain-source voltage and drain current waveforms are shown in Figure 18 through 21. In Figure 18 and Figure 19 the waveform is captured at 176 VAC. In Figure 20 and Figure 21 the waveform is captured at 264 VAC. The peak drain voltage, 496 V, is obtained at 264 V load with two LEDs (see Figure 21). Under the same condition, the peak drain current is 384 mA.

**Figure 18.** Vds and Id at 176 VAC, one LED

**Figure 19.** Vds and Id at 176 VAC, two LEDs

**Figure 20.** Vds and Id at 264 VAC, one LED

**Figure 21.** Vds and Id at 264 VAC, two LEDs
The current sense circuit (R9 and R12 in Figure 5) is one portion of output voltage. The additional voltage drop is 300 mV. The following figures show the output voltage and current waveforms for the load (one LED vs. two LEDs). In Figure 22 and Figure 23 the waveform is captured at 176 VAC. In Figure 24 and Figure 25 the waveform is captured at 264 VAC. We can observe that the output ripple current always less than 30 mA. Independent of the load condition, the output current is regulated at precisely 500 mA.

Figure 22. Vo and Io at 176 VAC, one LED

Figure 23. Vo and Io at 176 VAC, two LEDs

Figure 24. Vo and Io at 264 VAC, one LED

Figure 25. Vo and Io at 264 VAC, two LEDs
During the startup phase the output voltage response is optimized. No output voltage overshoot nor voltage spike has occurred thanks to the soft-start function and optimum regulation performance provided by the VIPer17. In Figure 26 and Figure 27 the waveform is captured at 176 VAC. In Figure 28 and Figure 29 the waveform is captured at 264 VAC.

Figure 26. Startup of Vo and Io at 176 VAC, one LED

Figure 27. Startup of Vo and Io at 176 VAC, two LEDs

Figure 28. Startup of Vo and Io at 264 VAC, one LED

Figure 29. Startup of Vo and Io at 264 VAC, two LEDs
The load can be open-circuit (LED absent or wrong polarity at installation) or short-circuit due to the system undergoing installation or an operating anomaly. The LED lamp can be damaged due to overtemperature, for example. The system should be able to withstand damage until removal of the anomaly, thanks to the VIPer17 which provides full protection against output short-circuit as well as output open-circuit. In Figure 30 and Figure 31 the waveform from the short-circuit load condition is captured at the highest AC line input 264 V, which is the most hazardous condition to the system board. In Figure 32 and Figure 33 the waveforms are captured at the highest AC line input 264 V with the output load in open-circuit condition.

**Figure 30.** Vdd and Vds at 264 VAC, output in short-circuit

Top trace: Vdd (10 V/div)  
Bottom trace: Vds (100 V/div)  
Time: 100 ms/div

**Figure 31.** Io at 264 VAC, output in short-circuit

Io: 200 mA/div  
Time: 100 ms/div
Figure 32. Vdd and Vds at 264 VAC, output in open-circuit

Top trace: Vdd (10 V/div)
Bottom trace: Vds (100 V/div)
Time: 200 ms/div

Figure 33. Startup of Vdd and Vds at 264 VAC, output in open-circuit

Top trace: Vdd (10 V/div)
Bottom trace: Vds (100 V/div)
Time: 10 ms/div
5 Connection of AC line and LED lamp to the demonstration board

Figure 34. Completed demonstration board connection

Figure 35. Connection of AC line

Figure 36. Connection of LED lamp
6 Conclusion

This document introduces a non-isolated offline constant-current LED driver based on the VIPer17. The input range is 220 VAC +/- 20% and the device is capable of driving two 500 mA white light LEDs. The LED current is sensed and regulated through the TSM103W and attains a constant output current. By using resistors with 1% precision, the output current achieves a maximum tolerance less than 5%. The input fuse and input filter are built on a 30 mm x 30 mm PCB. Overtemperature protection, LED open-circuit and LED short-circuit protection are all integrated functions which enhance the reliability of the device.
7 References

- VIPer17, off-line high voltage converter (datasheet)
- TSM103W, dual operational amplifier and voltage reference (datasheet)
- STPS2H100A, power Schottky diode (datasheet)
- STTH1R06A, turbo 2 ultrafast high voltage rectifier (datasheet)
- BAT46JFILM, small signal Schottky diode (datasheet)
8 Revision history

Table 5. Document revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-Jun-2009</td>
<td>1</td>
<td>Initial release</td>
</tr>
</tbody>
</table>
Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST’s terms and conditions of sale. Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST’S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS “AUTOMOTIVE GRADE” MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER’S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2009 STMicroelectronics - All rights reserved

STMicroelectronics group of companies
Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com