AN2167
Application note

Using the STPM01 with a shunt current sensor

Introduction

This document describes how a shunt current sensor can be used with the STPM01 metering device in single-phase metering applications without tamper detection.

Special considerations must be taken into account when the shunt is designed:

- The current density must be kept constant
- The power dissipation must be reduced, as it can influence the ambient temperature within the meter housing. In the event of large current overloads, this can become an explosion hazard.

Note: *Special safety precautions must be followed while the meter is connected to the power line and opened. The ground plane of the meter is at a high voltage level because the shunt has to measure the current flow through a hot conductor without any galvanic isolation. This is a safety hazard for the operators and can destroy the connected equipment.*

For more information on the STPM01, refer to the full datasheet.

October 2008 Rev 2

1 Theory of operation

A shunt is a resistor intended for relatively high current levels. This means that Ohm's law may be applied to it as a first-order approximation model and measure its response to the primary current: (see *Equation 1*).

Equation 1

$$u_S = i_p \cdot R_S$$

The first problem is that R_S is not constant, stable, or perfectly linear. It is affected by changes in temperature and current density, so a special shape and material must be used to:

1. keep all of the coefficients as low as possible
2. maintain low levels of mechanical expansion

The second problem is self-heating due to power loss in the conductive material: (see *Equation 2*)

Equation 2

$$P_S = u_S \cdot i_p = i^2{}_p \cdot R_S$$

The second equation represents the prime limiting factor to the usage of a shunt sensor. For example, if the user wants to use a 500 µΩ shunt sensor to build a class 0.5 direct meter with I_{NOM}/I_{MAX} = 10/80A_{RMS}, the voltage output level would be 40 mV_{RMS}, and the power dissipated in the shunt at I_{MAX} would be 3.2 W.

However, this meter must be able to withstand an overcurrent of 5000 A_{RMS} for 60 ms, which yields 750 J of energy. This would melt the shunt and, consequently, generate an arc and overheat the air in the sealed meter housing, causing the meter to explode.

To keep the shunt from melting, a higher volume of material must be used and power dissipation needs to be reduced. Power dissipation can be reduced by decreasing the resistance of the shunt. For a 210 µΩ shunt, the output voltage would be 16.8 mV_{RMS}, the power dissipated would be 1.344 W, and the energy level would be 315 J.

The third problem is the meter accuracy. For a class 0.5 direct meter, the accuracy of the power and energy values produced by the shunt must be within 1% or better, at 5% of nominal current (I_{NOM}). For a 210 µΩ shunt, the sensitivity of the meter must be ±1.05 μV_{RMS}.

This makes it more difficult to deal with electromagnetic interference (EMI) and new error sources (e.g., Kelvin and Peltier effects) which become important, and may include stray capacitances and mutual inductances, as well as noise generated by the preamplifier. The shunt connection to the line and the STPM01 must be assembled very carefully in order to minimize error source contributions.

2 Examples of sensor shunt usage in energy meters

2.1 Single-phase application without tamper

A shunt measures the current flow through the hot conductor of the line, so pin F becomes the local ground of the meter and the larger resistor of the voltage divider is connected to pin N of the meter. The voltage divider drop must be connected to the anti-aliasing filter input for the voltage channel of the STPM01. Both voltage pins of the shunt should be connected to the anti-aliasing filter input for the primary current channel of the STPM01, while the secondary current channel may be connected to local ground.

All of the connections to the anti-aliasing filter inputs should be implemented with the shortest wires possible, and with the smallest area of loop possible (without any other signal in the vicinity), formed by the following:

- source impedance element
- both wires
- input impedance of the filter

The STPM01 device should be configured with PST = 3 and ADDG = 1 (settings for the shunt current sensor, current amplification factor 32, and no tamper detection).

This type of metering application can operate as a standalone with a stepper display or a microcontroller may be implemented in order to access more measured results in the STPM01 using the LCD, automatic meter reading (AMR), or tariffing functions.

2.2 Single-phase application with tamper

It is not possible to connect two shunts to the STPM01 because one would generate its output at the high voltage level. Therefore, a current sensor with integral galvanic isolation must be used for the primary current channel, while another shunt is used for the secondary channel or vice-versa.

Although a shunt produces an output voltage which is proportional to the primary current like a current transformer (CT) does, it is difficult to combine a CT with a shunt in single phase metering applications with tamper detection due to differences in phase error indicators and output voltage levels. These differences must be resolved with components outside of the STPM01.

2.3 Multi-phase application with or without tamper

It would be cost-prohibitive to use three or four shunts with three or four STPM01 devices, plus the necessary three galvanic isolations and additional power supplies, as well as a microcontroller to achieve the objectives of a three-phase meter design. The other problem would be the excessive levels of power dissipation produced by three shunts operating at maximum phase currents.

3 Revision history

Table 1. Document revision history

Date	Revision	Changes
15-Feb-2006	1	Initial release
27-Oct-2008	2	Document reformatted. No content change.

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.

© 2008 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 - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com