Application Data Sheet

Title
Self-Heating, and Ambient Temperature compensated Current Shunt Apparatus

Abstract
Many electrical devices require accurate measurement of electrical current. A resistive current shunt is typically used for this. However, to avoid temperature coefficient effects due to self-heating and ambient temperature changes a low temperature coefficient material is required for the resistor. Such materials, such as Nichrome, or Manganin require special assembly to avoid bi-metal junction effects and solder reliability issues.

The present invention utilizes a non-temperature compensated material (such as copper) and provides a method of dynamic compensation for ambient temperature and self-heating.

Inventors
Robert Heaton – Obsidian Technology – US Citizen.

Addresses
Obsidian Technology
33622 Diamond Ridge Court,
Dana Point
CA 92629.

Assignee
Robert Heaton

Date
March 19, 2006

CLAIMS
What is claimed is:

1. An apparatus that allows a common material with a significant temperature coefficient to be used for the measurement of electrical current.

2. A processing system according to claim 1 where the self heating effect of the current measuring resistor is dynamically compensated using a time domain transfer function obtained by calibration.

3. A processing system according to claim 1 where an ambient temperature sensing element is used to compensate for ambient temperature effects in the current measuring resistor without requiring intimate thermal contact.

DESCRIPTION OF PRIOR ART

A number of systems for providing temperature stabilized current measurements are in general use. These include one or more of the following techniques:

1. Use of a resistive material with a close to zero temperature coefficient. For example, Nichrome and manganin alloy metals.

2. Use of a temperature sensor in close thermal contact with the measuring resistor can be used in conjunction with a correction system for calibrating the sensed current over temperature.

3. Use of a current transformer to lower the current (and self heating) in the sensing resistor.

4. A heating system, to keep the temperature of the sensing element constant.

In addition, some applications of current measurement do not require high accuracy. An example is a device to test if current is flowing. In these cases a resistive measurement device made of a material with a high temperature coefficient, such as copper, may be used. For such applications printing circuit board (PCB) traces can be used for a low cost implementation.

DESCRIPTION OF THE INVENTION

The present invention is an apparatus for accurate measurement of electrical current using a low cost current sensing element, such as a copper wire or printed circuit board track. Most of the imperfections in the current sensing element are compensated for using a processing element, which is typically embodied as a microcomputer, or an active electronic network. The processing element provides a temporally based correction function in the z-domain or s-domain that compensates for ambient and self-heating effects in the current sensing element.

The correction function is obtained by calibration. The correction function may be extracted from the real apparatus by applying a large current step from a standard current source and recording the output response. This step response my then be transformed into an impulse response, and hence to a filter response using widely known mathematical transformations.

Since the thermal characteristics of manufactured electronic products do not vary much, a single correction function may be used for a high volume product without substantial loss of accuracy.

A generalized system diagram of the invention is shown in figure 1. A current source (101), is passed through a resistive current shunt (102) which results in a voltage. For the illustrated embodiment this voltage is digitized using an Analog to Digital Converter or ADC (103) for processing in the digital domain. Processing in the analog signal domain is also possible.

An estimation of the self-heating effect of the current shunt is obtained by the use of a Root Mean Square (RMS) power block (109). Since the input to this block represents the actual voltage across the resistive shunt any self-heating power changes due to temperature coefficient are included in the estimation.

The self-heating power estimation obtained from the RMS power block (109) is provided as input to the time domain estimation function (110). This function approximates to the effect of self-heating on the resistive current shunt (102) in the time domain.

In the mathematical s-domain the correction function generally approximates to the form x/(sy + 1). This a single pole low pass filter in which x is a scaling factor and y is the frequency of role off. s is the s-domain operator. However, the function can be obtained by calibration that includes other effects such as the effect of shunt heating on the ambient temperature.

Figure 2 illustrates the principal signals in the invention during a step current change. The data is exaggerated for the purposes of illustration. A step in input current (201) produces a shunt output (202) that represents the input plus shunt resistor self-heating error. After processing through RMS (109) and compensation function (110) block a self-heating correction signal (105) is obtained.

The self-heating correction signal (105) is then subtracted from the shunt output with a subtractor (106). After correction for ambient temperature in multiplier (107) the signal is a close representation of the original current (101) and can be utilized in such applications as a metering system (108).

The ambient temperature correction system comprises a temperature sensor (115), and Analog to Digital Converter (111), a static correction function (112), an adder (113) and a multiplier (107). The static correction function (112) models the proportional resistive shunt error with temperature and therefore generally represents a negation of the temperature coefficient.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the generalized system diagram of the invention.

Figure 2 illustrates the principal signals in the invention during a step current change.

DRAWINGS

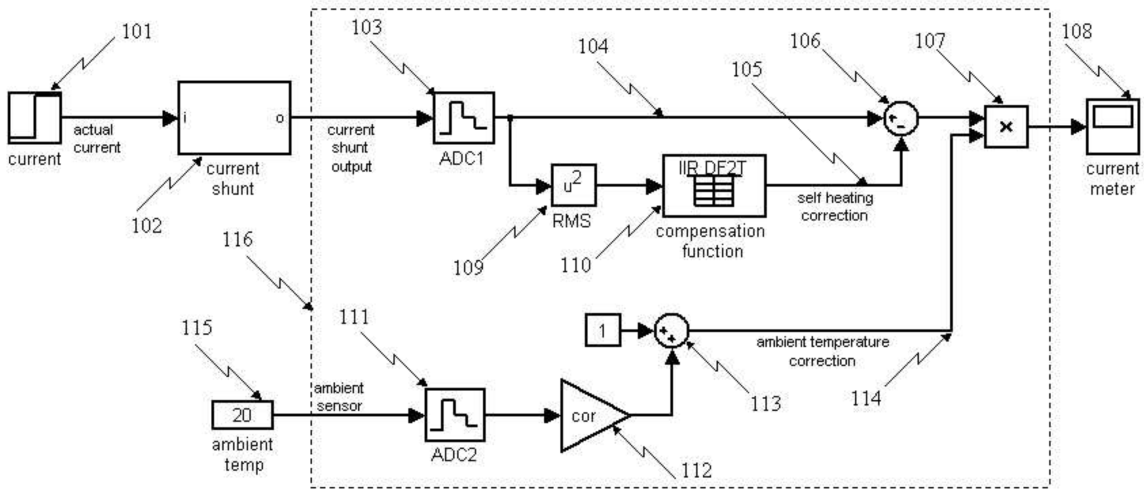

Figure 1

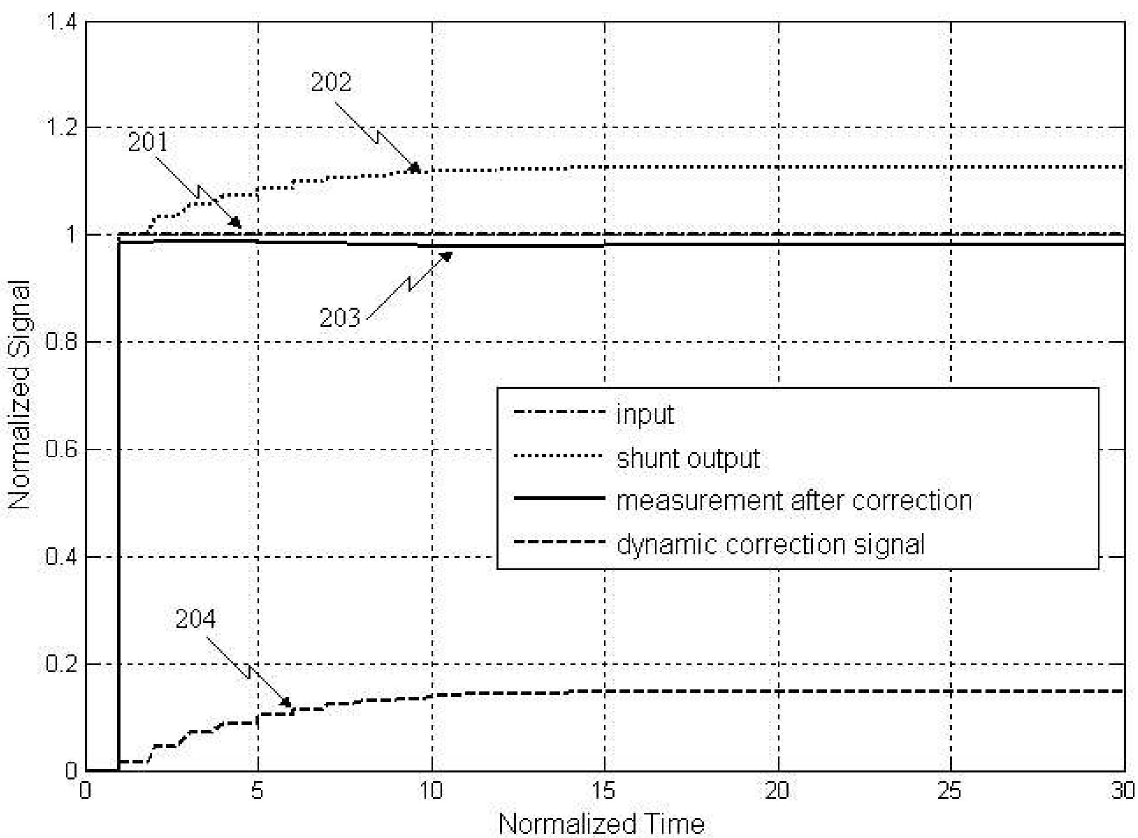

Figure 2