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Measurement system for precise comparison of low ohmic resistance standards

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A B S T R A C T

In this work, an automated precise measurement resistance comparison method for low resistance values in the range from 0.1 mΩ to 10 Ω is presented. The measurement method uses specially built current source, range selector, current reversal module and low cost analog to digital converter. The whole measurement procedure is controlled by LabVIEW program. The realized precise resistance measurement system has achieved precision comparable to more expensive commercial devices.

1. Introduction

Today, standard resistors are compared to each other using various methods [1–7], and many of these methods use stabilized current source [8–11]. One such current source has been specially designed for this purpose using eight MOSFETs to achieve high output current [12].

The resistance comparison method described in this paper is a standard digital voltmeter method with some modifications, including the utilization of relatively affordable 24 bit DAQ card instead of expensive digital voltmeters [13]. The measurement method can be used to compare the resistance standards in the range of 0.1 mΩ–10 Ω with a measurement uncertainty lower than 10 ppm.

The whole measurement method has been automatized using LabVIEW program that also controls special modules like range selector, current reversal module, digitizer reversal module and DAQ card.

2. Current source

The specifications for current source used in the resistance comparison measurement method includes gross-tuning of current in the range from 0.1 mA–9 A, low noise, low temperature coefficient and short term stability better than 50 ppm. Several different configurations of current sources were contemplated and simulated using the National Instruments Multisim application before choosing the final prototype IGSI as shown in Fig. 1.

The precise operational amplifier OP27 is controlled by the LT 1027 voltage reference. It replicates the reference voltage U_{REF} to the negative input pin of operational amplifier in order to regulate current I_S that is passing through high power resistor R_S (R_1, R_2, R_3, R_4, R_5 or R_6). The current I_S is practically the same as current I_0 which passes through the load (measured resistors). The high current output of current source has been achieved using several high power MOSFETs (type Sanyo 2SK1420) in parallel configuration.

The output current can be regulated through the pins A_{MRS+} and A_{MRS-} which are connected to the measurement range selection module, that connects appropriate R_S resistance for the needed current level (Fig. 1).

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At the start of operation of current source, MOSFET with highest conductivity will draw the largest current and have the highest power dissipation. This will cause the temperature rise of this particular MOSFET which will increase its drain to source resistance R_{DS} and reduce the current. Eventually, the current passing through all MOSFETs will equalize producing stable output current I_0. Temperature of MOSFETs in the current source have been measured by NI USB DAQ card 6008 and NTC thermistor type B57863S [16]. Results were compared and additionally analyzed with thermal images made with IR camera FLIR i7 [17] (see Fig. 2).

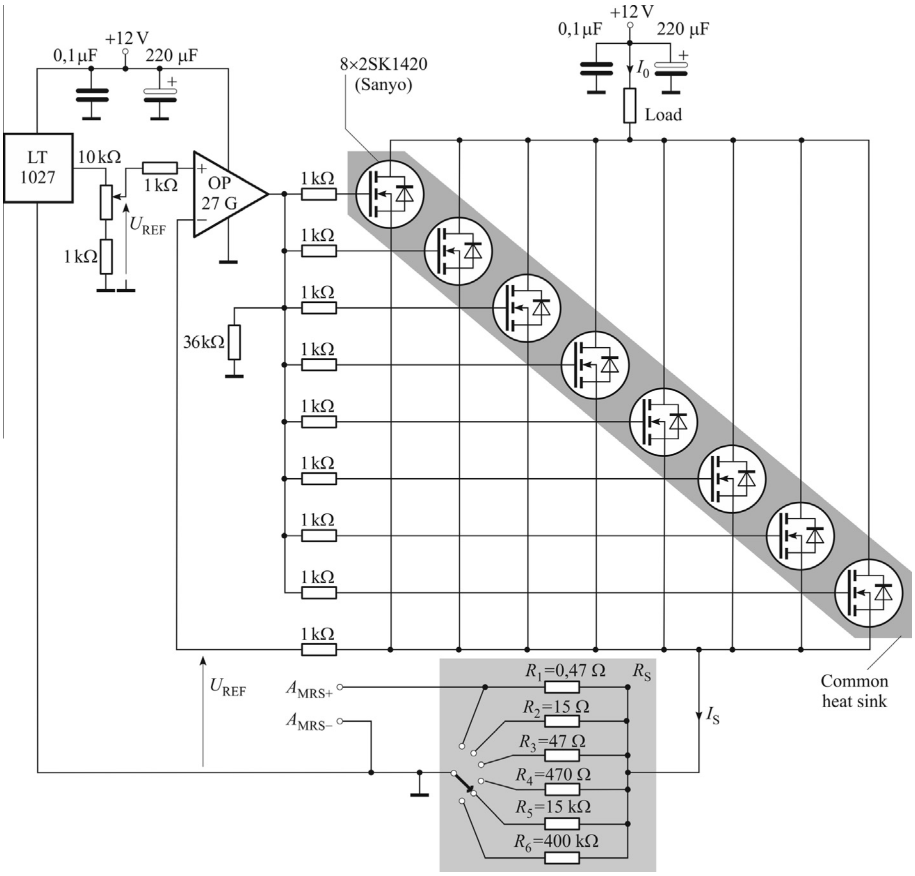

Fig. 1. Current source IGSI.

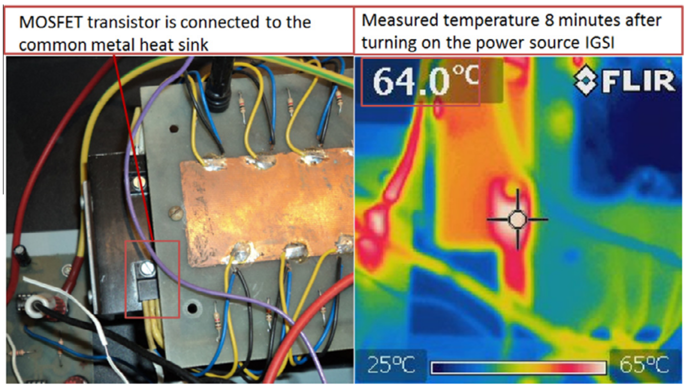

Fig. 2. Temperature measurement of MOSFET transistor in the IGSI current source (current level 9 A).