Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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Annals of DAAAM International

EMBEDDED SYSTEM FOR MEASUREMENT OF SMALL ELECTRIC INPUT POWER

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Abstract: *The contribution deals with measurement of low electric input power for research purposes in the machinability of materials. Requirements for measurement are high accuracy and high sensitivity. An analog device with differential measurement was designed and constructed. This approach measures only changes of the input values instead of their high input values and thus increase the sensitivity. The proposed solution uses only analog circuits and analog multiplier of the effective voltage and current. The device was subsequently checked in the lab environment and gradually modified. The results obtained from measurements with developed analog device showed insufficient accuracy. The new goal is to reconstruct the analog device to a digital one with a microcontroller.*

Key words: *power consumption, differential measurement, analog multiplier, microcontroller*

1. INTRODUCTION

To solve a specific problem oriented to machining of polymeric materials, more precisely suitability for machining of the material, an analog device for measurement of low electric input power was designed and constructed.

During the dynamic machining the major components of the process are compared, e.g. cutting resistance, torque or power input of the machine. Determination of the cutting resistance can be performed in two ways. The first one is based on analytical dependencies and requires precise knowledge of geometric and kinematic values of the cutting process. Alternatively, an indirect method based on the evaluation of electric input power of the machine can be used. It enables to derive the cutting force from the measured electric input power (Hruška & Lukovics, 2004).

In practice there are many other applications and appliances, which cannot use the common technical means of electric power and energy measurement, e.g. dynamic or static watt-meters, because of their large measuring ranges and low sensitivity.

The measurement of low electric input power is particularly subject to the requirements of high sensitivity and high accuracy. With this goal, the proposed circuit has undergone a series of verification and subsequent modifications and reconstructions, which are presented in this paper.

2. THEROETICAL BACKGROUND

The designed device for indirect measurement of the cutting resistance is based on simple balance equation. Total electric input power P_c is equal to sum of power lost in drive unit P_P and power spent for cutting P_o (Hruška & Lukovics, 2004):

$$P_c = P_p + P_o = k.U.I.\cos\varphi \qquad (1)$$

where k is conversion constant (-), U is effective value of supply voltage (V), I is effective value of current (A), φ is phase shift (rad).

Electric input power can be derived from equation (1) if the input voltage U, current I and phase shift φ are measured.

Proposed solution is shown in Fig. 1. The input phase voltage $U_{1,ef}$ and current $I_{1,ef}$ go through multiplier into effective-value to DC-voltage conversion unit and then into output amplifier. The output value is unified signal U_{out} in range from 0 to10 V DC. This output voltage is proportional to the alternate electric effective power. Phase shift is omitted in this method (Hruška & Lukovics, 2004).

Scanning and amplifying of electric current and voltage effective values is shown in Fig. 2. This figure demonstrates the impedance match and separation via small transformers and amplification by operational amplifiers.

Single-phase electric current flows through the supply wire which cause voltage decrease in shunt resistor. This alternate (sinus wave) power supply voltage is separated, subsequently transformed via transformer TR_I and connected to the amplifier. It provides voltage equal to the value of effective electric current I_{ef}. Similar method is used to connect voltage measuring part. Separation and impedance match is again designed via transformer TR_U and circuit with operational amplifier which produces voltage U_{ef} proportional to measured variable (Hruška & Lukovics, 2004).

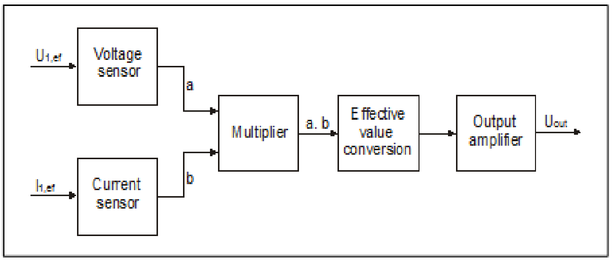

Fig. 1. Block circuit diagram for small electric input power evaluation

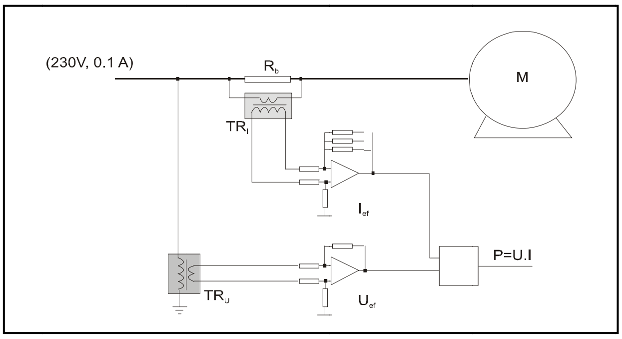

Fig. 2. The circuit for effective voltage and current measurement and small electric power input evaluation

3. DESIGN OF THE CIRCUIT FOR SMALL ELECTRIC INPUT POWER MEASUREMENT

Results from measurements on the version - 1 of the circuit showed the suitability of the method for small electric input power measurement. The positive features are linearity and repeatability of measurements. However, there are also disadvantages such as (Skočík & Hruška, 2005):

- part of the measurement is using bridge connection and rectification which may not produce the value of U_{ef},
- resistor shut is heated up extremely,
- small output range (-0.8 to 0.8V), the whole range ±10V is not used,
- wide difference in the range 250-300 W.

These negative points were the reason for the construction changes which lead to the expansion by the differential measurement. This new version - 2 of the circuit is shown in Fig. 4 (Skočík & Hruška, 2006).

The program environment Micro-Cap, which serves for the electronic circuit analysis, was used for the verification of the circuit version - 2 (***, 2008). The simulation was focused on verification of the circuit parts for measurement of effective values. These parts are highlighted in Fig. 4. The circuit for current measurement (block number 1) and voltage measurement (block number 2). The simulation was performed for both parts separately. Results from the simulation showed that the output is not the voltage/current effective value, but only the rectified one. Due to this fact, both blocks (1 and 2) need to be reconstructed and replaced by different circuits.

The redesign of the mentioned parts can be seen in Fig. 5. The parts from Fig. 4 were replaced by the integrated circuit AD637. This circuit transforms the harmonic signal to its effective value. The proper function of the integrated circuit AD637 was verified by developing and constructing the testing circuit and measuring in laboratory environment (Skočík & Hruška, 2009).

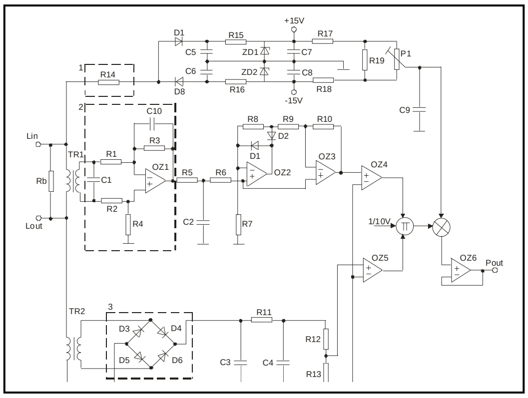

Fig. 3. Circuit diagram version – 1

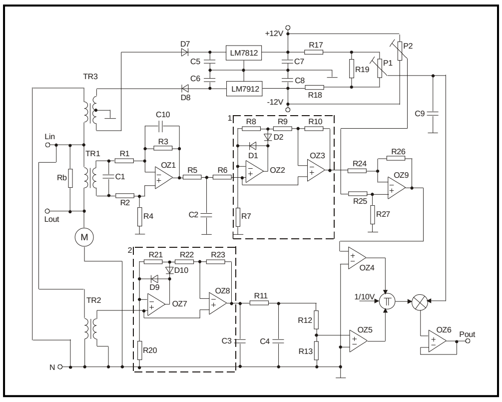

Fig. 4. Circuit diagram version – 2

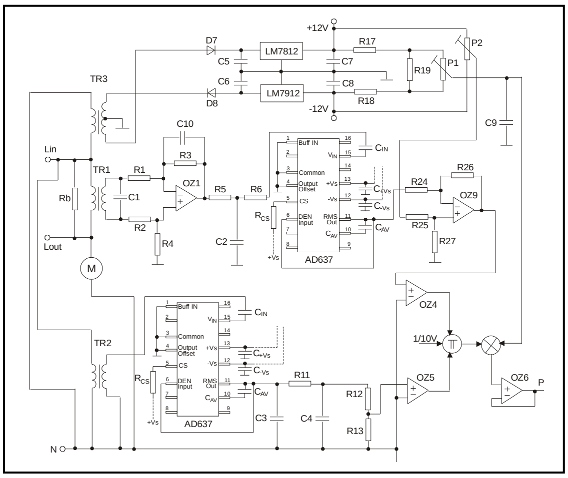

Fig. 5. Redesign of the circuit version – 2

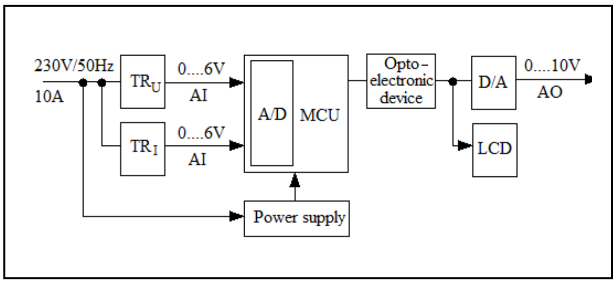

Fig. 6. Proposed block circuit diagram with microcontroller

4. CONCLUSION

Results from the verification of each version of the analog circuits for measurement of low electric input power point to the suitability of the method, but also discovered the need to improve the sensitivity and accuracy. Required measuring accuracy cannot be achieved through the analog circuits and requires digital approach to the evaluation part, a microcontroller. Suggested solution can be seen in Fig. 6.

5. ACKNOWLEDGEMENT

This work was accomplished with financial support by Research Projects of the Ministry of Youth, Education and Sports of the Czech Republic: MSM 7088352102.

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