COMPUTING SYSTEM FOR MEASURING THE POWER OF THE PULSE LASER

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The paper presents the design and implementation of the system for measuring the power of the pulse laser. The system is based on the PC and LabVIEW program package of virtual instruments. The system is designed for measurement of the mean radiation power from 1 to 30 W. However, with slight adjustments in hardware and software, it is possible to expand the system measurement range. The system has been calibrated and tested in the laboratory conditions across the whole its measurement range, as well as on different wavelengths. The testing results have shown that the system is reliable and accurate. The user-friendly interface does not require additional training.

Keywords: pulse laser power, absorber of laser radiation, sensor measurement.

1. INTRODUCTION

Different sensors and equipment are often used for measurement of the power and the profile of the laser radiation [1]. With continuous wave lasers of lower power, the direct optical sensors are used, while the higher power lasers, especially the pulse lasers, require the indirect measurement, i.e. the measurement of the absorbed radiation energy [1—4]. Powerful pulse lasers, such as Nd-YAG are emitting energy of the 1 J order in short time intervals (order of ns or less). This paper presents the design and implementation of the system for measuring the power of the pulse laser. The system is adapted to the ns Nd-YAG laser of the Quanta System, whose parameters are [5]:

Energy of the pulse:
- 900 mJ at the 1064-nm wavelength;
- 450 mJ at the 532-nm wavelength;
- 150 mJ at the 355-nm wavelength.

Output beam diameter: 10 mm
Pulse duration ≤ 8 ns at 1064 nm.
Beam spatial profile:
- Near-field (fit to Gaussian) ≥ 0.7;
- Far-field (fit to Gaussian) ≥ 0.9.

Beam delivery: 7 mirrors articulated arm
Operating temperature: up to 50ºC.

2. TECHNICAL REQUIREMENTS

2.1. Design

The laser radiation was absorbed from the front side by the absorber (∅20×15 mm graphite roller), meanwhile all of the other sides were thermally isolated (Fig. 1). The integrated temperature sensor IC LM35 was put in direct thermal contact with the absorber [6].

Under the effect of the pulse laser with mean power P, the absorber at the moment t reaches the temperature:

$$T = T_\infty \left(1 - e^{-\frac{t}{\tau}}\right), \tag{1}$$

where T_∞ is the final temperature ($t \to \infty$); τ is thermal time constant.

The opening part of the exponential heating curve can be approximated with the tangent with a slope:

$$k = \frac{dT}{dt}(t \to 0) = \frac{T_\infty}{\tau} = k_p P, \tag{2}$$

where k_p is the constant of the proportionality depending on the mass of the absorber and the material of the absorber. Constant k_p can be directly measured or calculated. From the equation (2), the power can be determined as follows:

$$P = k / k_p. \tag{3}$$

The starting value of the k_p was determined using the laser with already known power:

$$P = 1{,}5 \text{ W} \to k_p = 29{,}45.$$

The further detailed determination of the constant k_p has been conducted by calibration using the laboratory pulse laser power sensor.

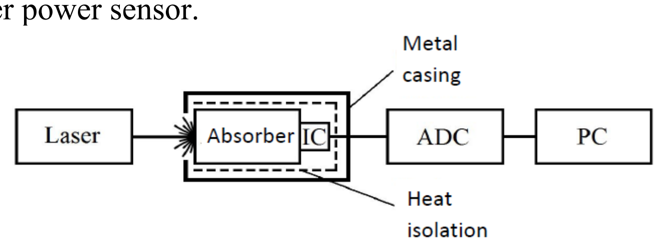

Fig. 1. Design of the pulse laser power measurer

2.2. Hardware

Fig. 2 shows the schematic diagram for the hardware of the developed device for measuring the temperature of the absorber from which the laser power is calculated.

The signal from the integrated temperature sensor IC LM35 propagates to the filtration block. After filtration (10 nF capacitors) and adjustments (resistors 10 kΩ), the signal from the thermocouple is conducted to the input channel (AI CH1) of the analog-to-digital converter (ADC USB 6008) [7]. The received digital signal is transmitted to the computer (PC) via the USB port and then software-processed.

The operating range of the temperature sensor is from –40 to 110 °C, therefore no additional adjustments are required.

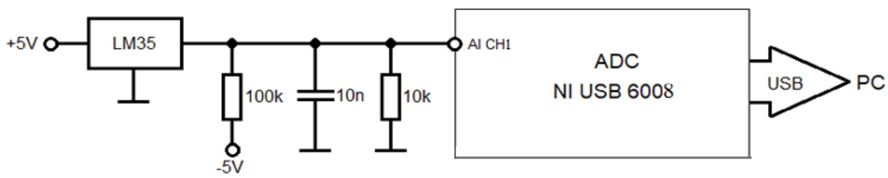

Fig. 2. Schematic diagram of the hardware

2.3. Software

In order to measure, display and store the temperature data from the absorber in the LabVIEW software package, an application was developed [8—10].

The graphic code (block diagram) of the application is presented in Fig. 3, while Fig. 4 shows the front panel of the virtual instrument. DAQ Assistant, a standard module for the LabVIEW Package data acquisition, was used to measure the analogue signals from the thermocouple. The data were then separated into eight channels, averaged (MEAN) and multiplied by 100 in order to be transformed into a temperature in °C (output from LM35 is 10 mV/°C). The obtained temperatures are shown on the display T [°C] and the diagram (XY T), and stored in the form of a text file. The text file name is assigned before the start of the measurement. The program can be stopped at any time by clicking on the STOP button. By further processing of the measured values and calculating the inclination of the initial part of the heating curve, the laser power of P [W] is obtained.

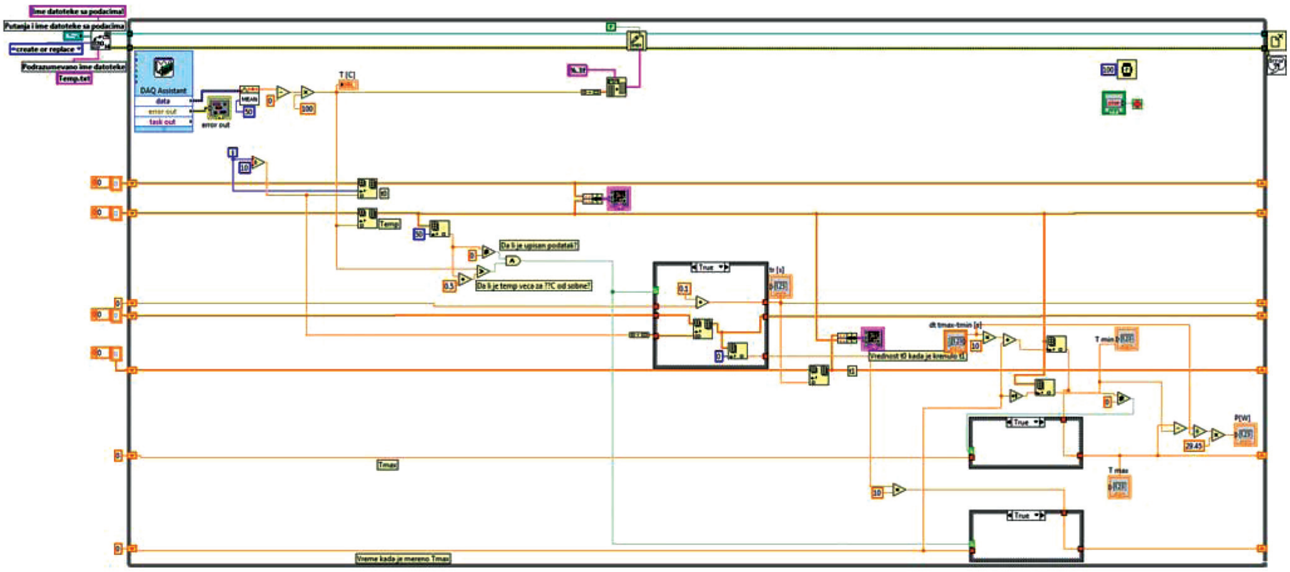

Fig. 3. The graphic code (block diagram) of the application

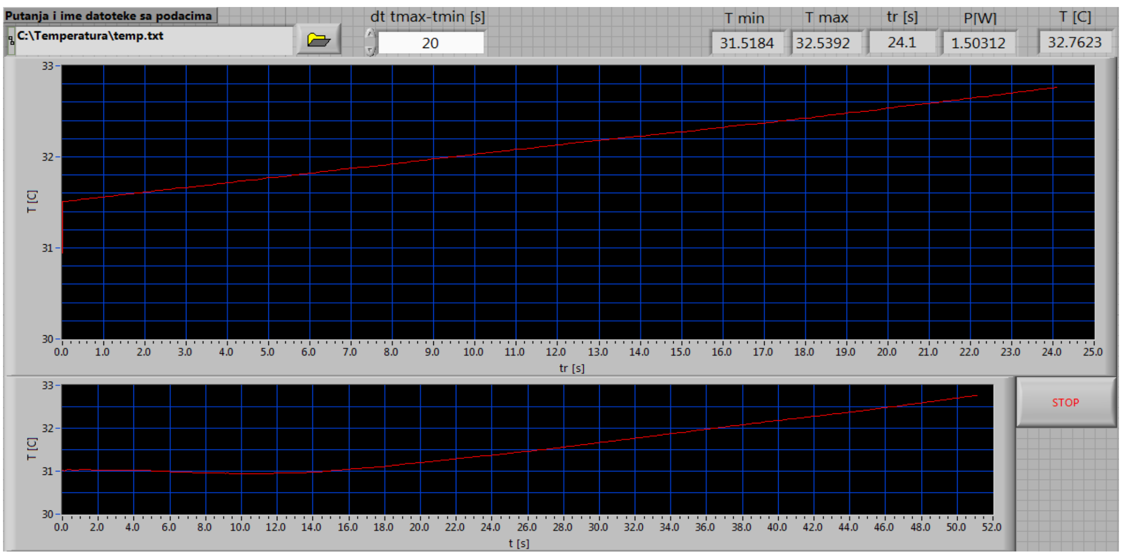

Fig. 4. Front panel of the virtual instrument

The initial calibration was carried out using the semiconductor laser with known power (1,5 W). However, the final calibration has been conducted using the Coherent PM30, the laboratory pulse laser power sensor [11].

3. CONCLUSION

A personal computer equipped with the adequate hardware (measurement and control interface) together with the software developed in the LabVIEW program package presents a very powerful and adaptive measurement system that can be applicable in scientific and research laboratories. Due to its characteristics, low price and open architecture, it is possible to replace specialized and very often high-priced pieces of equipment. The testing of the developed system for measuring the power of the pulsed laser has shown that the system is reliable and accurate.

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Вычислительная система для измерения мощности импульсного лазера

В данной работе разработана и реализована система измерения мощности импульсного лазера на базе ПК и программный пакет LabVIEW виртуальных приборов. Система предназначена для измерения средней мощности излучения от 1 до 30 Вт. Вместе с тем, небольшие изменения в аппаратном и программном обеспечении позволяют расширить диапазон измерения системы. Система была откалибрована и испытана в лабораторных условиях во всем диапазоне измерений, а также на разных длинах волн. Результаты тестирования показали, что система надежна и точна. Удобный пользовательский интерфейс не требует от пользователя прохождения специального обучения.

Ключевые слова: импульсная мощность лазера, поглотитель лазерного излучения, измерительный сенсор.
