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LOW COST THERMAL PYRANOMETER USING DALLAS DS18B20 SENSOR AND ARDUINO

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Abstract. *The worldwide search for economically sustainable energy sources has been leading to a greater use of solar energy in its various forms. Thus, it is extremely important to possess the knowledge of the available solar irradiation, both for the correct size of the system, as well as the performance evaluation and improvement proposals. This work aims to construct and calibrate a low cost thermal pyranometer for measuring solar irradiation, using Dallas DS18B20 sensor connected to an Arduino board.*

Keywords: *Thermal pyranometer, DS18B20, Arduino*

1. INTRODUCTION

The worldwide search for economically sustainable energy sources has been leading to a greater use of solar energy in its various forms. Thus, it is extremely important to possess the knowledge of the available solar irradiation, both for the correct size of the system, as well as the performance evaluation and improvement proposals.

The measurement of the available solar irradiation can be performed by two basic methodologies: from calculations based on available historical data or with direct measurement using a pyranometer.

Pyranometers, also known as radiometers, are instruments used for measuring the total available solar irradiation. They present two types of basic sensors: thermal and photo sensors.

The photo sensors are based on the principle known as photovoltaic effect in which the incident electromagnetic radiation on the sensor generates an electric current (Baltazar *et al.*, 2015; Bilguun *et al.*, 2016; Scalon *et al.*, 2017).

The thermal sensors are based on the principle of the increase in temperature on a surface with high absorptivity exposed to solar irradiation as function of the radiation magnitude (Ji *et al.*, 2011; Boyd, 2015; Avallone *et al.*, 2018).

This work aims to construct and calibrate a low cost thermal pyranometer for measuring solar irradiation, using Dallas DS18B20 sensor connected to an Arduino board.

2. EXPERIMENTAL SETUP

The proposed pyranometer is based on the principle in which a surface exposed to solar irradiation presents a temperature higher than an unexposed region. The development of the pyranometer has the following components.

2.1 Exposed irradiation surface

The sensitivity of the pyranometer is affected by the ability of the exposed irradiation surface, called absorber surface, to change its temperature according to the variation of incident radiation. The absorber surface must have high absorptivity and thermal diffusivity. Based on these parameters, the absorber surface consists of a 20 mm diameter and a 0.5 mm thick aluminum disc, blackened with Sumaterm ink with 95% absorptivity.

2.2 Temperature Sensors

Two Dallas DS18B20 temperature sensors (Maxim, 2015) are used in the pyranometer. The first is in thermal contact with the absorber surface. The second is located in a pipe not exposed to irradiation and with forced air circulation, in order to capture the environment temperature.

2.3 Encapsulation

An encapsulation was printed in acrylonitrile butadiene styrene (ABS) to shelter and give mechanical support to all elements of the pyranometer. A 53 mm diameter and a 3 mm thick glass cover was installed above the absorber surface, leaving a 3 mm space between them in order to reduce convective heat transfer. Figure 1 shows the components assembled in the encapsulation. The location of the temperature sensor is shown in Fig. 1a and Fig. 1b shows the final assembling process, containing the absorber surface and the glass cover.

(a) Temperature sensor (b) Final assembling

Figure 1. Assembled pyranometer

2.4 Colecting data

The collection of data was performed by an Arduino Mega board (Arduino, 2018). The RTC-Module and SD CARD peripherals were used to acquire the time instants of the measurements and to storage data, respectively. Figure 2 shows the electronic circuit connections of the temperature sensors and peripherals to the Arduino.

2.5 Reference pyranometer

The reference pyranometer is a CMP22 (Kipp & Zonen, 2016), with broad spectral range from 200 to 3600 nm and directional error less than 5 W/m^2 .

3. RESULTS

The calibration was performed by comparison (ISO 9847, 1992) at the Instituto de Pesquisas Meteorológicas de Bauru (IPMET), at the Universidade Estadual Paulista "Júlio de Mesquita Filho" - Campus Bauru. The proposed pyranometer was assembled in a structure near to the reference model to ensure that both were exposed to the same level of irradiation (Fig. 3).

The measurements were taken during from 10:00 am to 3:00 pm were considered in order to avoid shadows over the

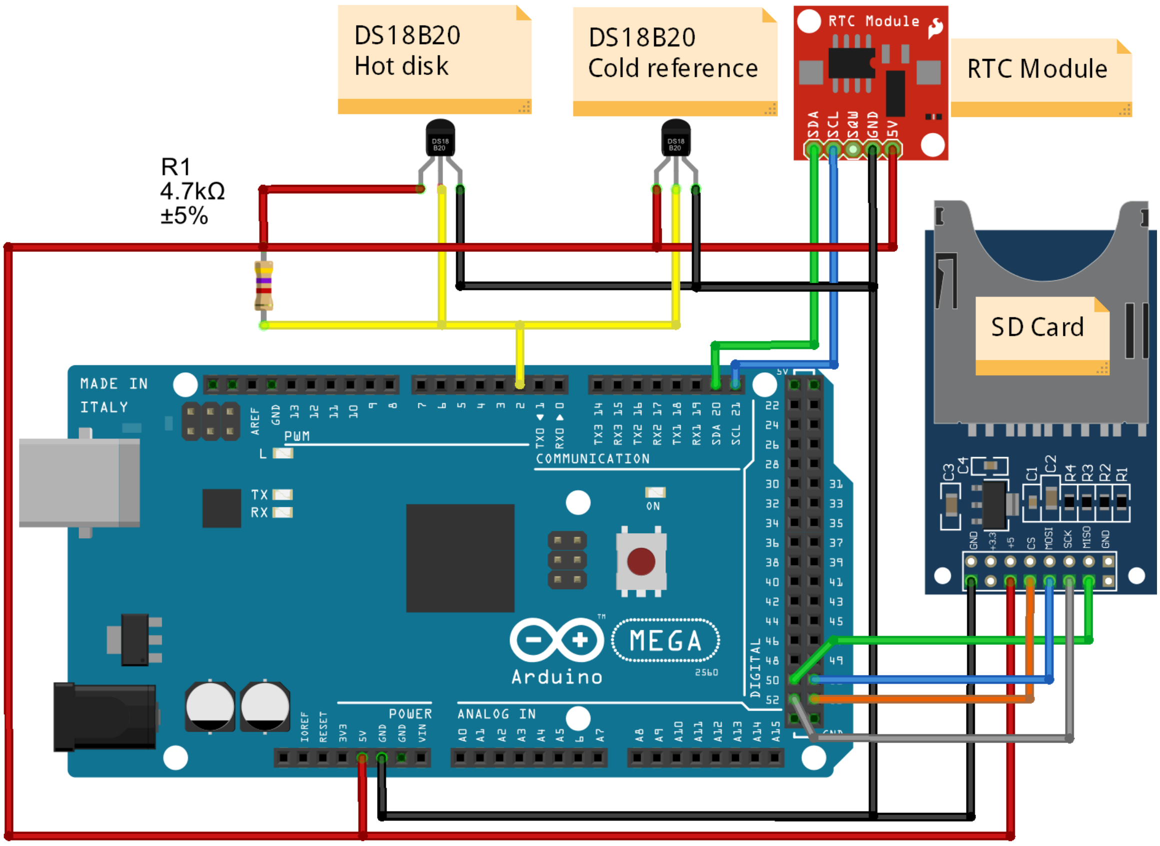

Figure 2. Circuit

Figure 3. Pyranometer calibration in IPMET

reference sensor.

Figure 4 shows the sparse points used for pyranometer calibration. Equation 1 is the result of the linear regression applied to the experimental data.

$$Rad[\mathrm{W/m^2}] = 37.6 \times T[^\circ\mathrm{C}] + 0.0 \tag{1}$$

Figure 5 compares the curves obtained by the reference pyranometer to the proposed one, calibrated with 1.

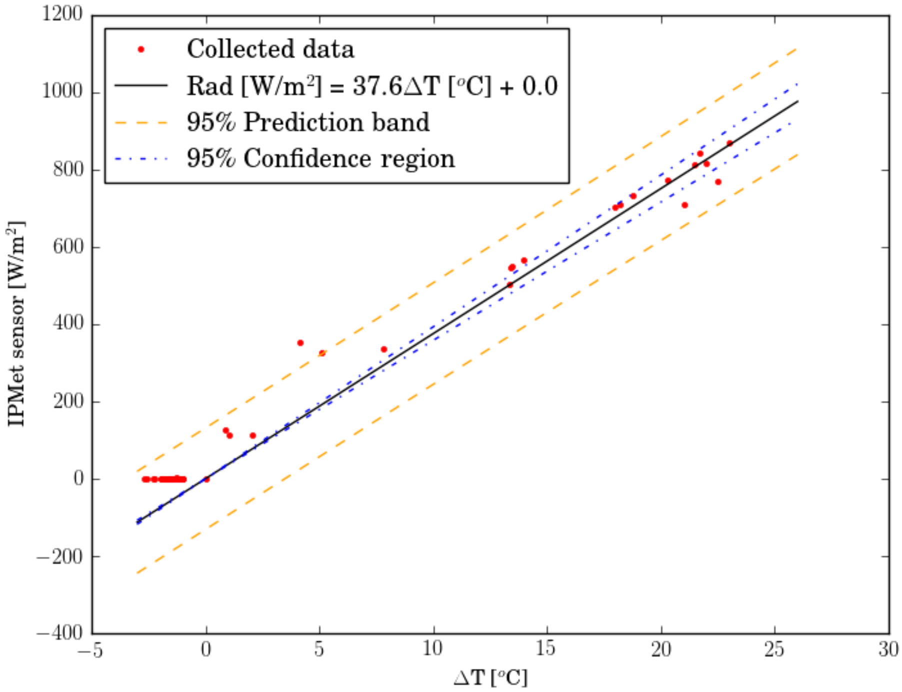

Figure 4. Pyranometer calibration curve

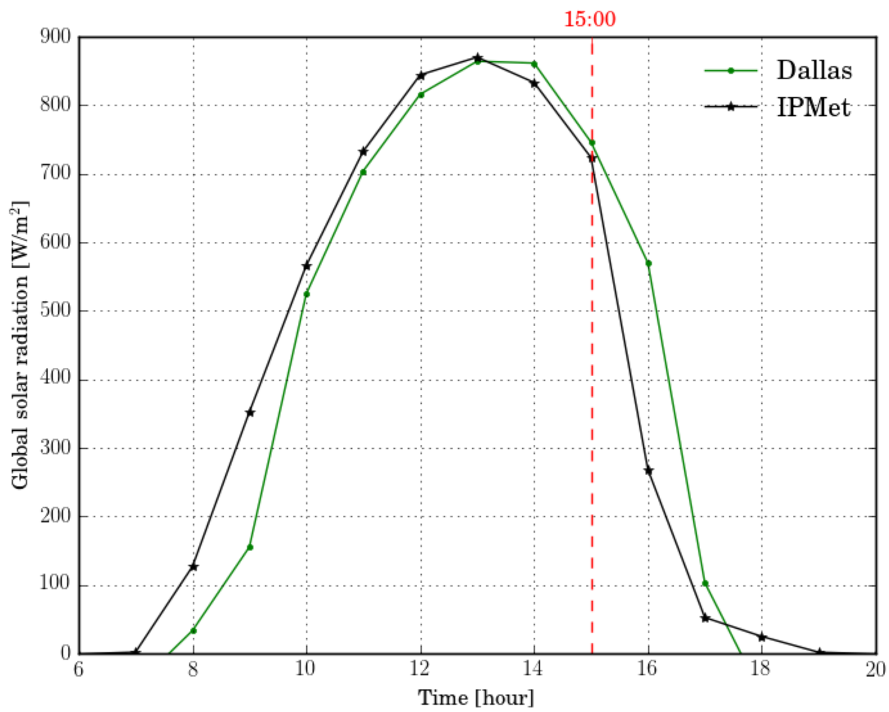

Figure 5. Comparison between the proposed pyranometer and the reference pyranometer

4. CONCLUSIONS

The proposed pyranometer shows good agreement with the reference pyranometer proving to be a good alternative for irradiation measurement.

5. ACKNOWLEDGEMENTS

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