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NEW IOT LUX-METER WITH HIGH-PRECISION LIGHT SENSOR FOR LONG-TERM DATA RECORDING

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In this present work, we have developed a new IoT lux-meter prototype to measure illuminance with high precision, based on the NOA1305 type light sensor using a smart memory management strategy. The NOA1305 sensor device has a linear response over the range of near 0 lux to over 100k lux with programmable count times to optimize noise performance. The proposed illumination measurement prototype, based on ESP8266 Node MCU board, is associated to more compounds including SD card, LCD screen and the RTC, which allows an automatic and a real time record, display, and Wireless data communication. Furthermore, we have developed and implemented a web interface using HTML and java script language into the ESP8266 module, which is configured as a server for tele-management and supervision, via internet, of recorded In this present work, we have developed a new IoT lux-meter prototype to measure illuminance with high precision, based on the NOA1305 type light sensor using a smart memory management strategy. The NOA1305 sensor device has a linear response over the range of near 0 lux to over 100k lux with programmable count times to optimize noise performance. The proposed illumination measurement prototype, based on ESP8266 Node MCU board, is associated to more compounds including SD card, LCD screen and the RTC, which allows an automatic and a real time record, display, and Wireless data communication. Furthermore, we have developed and implemented a web interface using HTML and java script language into the ESP8266 module, which is configured as a server for tele-management and supervision, via internet, of recorded measurement data on the SD card. Finally, this new intelligent prototype was tested and validated, inside a photographic darkroom, by comparing its measurement results with those acquired by the "Spectroline NDT XR-1000 AccuMAX" digital radiometer, under the same experimental and environmental conditions.

Keywords: Wireless data communication, Lux-meter, Illuminance, NOA1305 sensor, Interface web

1. Introduction

Good lighting contributes to workplace safety and health by enabling employees to perform their jobs in a comfortable and efficient manner. In fact, the work environment should be bright enough to ensure the safety and health of all employees. Workplace lighting should provide employees with a comfortable view of what they need to perform their duties. Poor lighting makes it hard for employees to see and lead to visual fatigue and discomfort.

Poor lighting leads to eyestrain, so the term visual fatigue is usually used to describe this condition, which is redness and pain in the eyes, blurred vision, and headaches. These symptoms often occur after reading, working in front of a computer, or in work that requires concentration in vision. In fact, poor lighting at work can represent a significant cost to the business in the form of time off work as a result of accidents and injuries, increased absenteeism, and can reduce employee efficiency and productivity [1].

It is highly recommended to provide uniform illumination throughout the workplace, combining natural and artificial lighting. In fact, good lighting can improve worker productivity and efficiency by creating a pleasant atmosphere and gives employees a sense of well-being.

As a result, Illuminance measurement is essential as it affect our safety and health. In this work, we propose a new prototype of Luxmeter data logger based on NOA1305 which is a high and accurate sensor. In this project we used an ESP8266 Node MCU board, a liquid crystal display (LCD); also, an SD card is used to save data. In addition, the proposed device can send data to PC via USB

2. Photometry

Before describing the realization of the Luxmeter, it is useful to recall some notions of photometry

Light is an electromagnetic radiation visible to the human eye. The radiation we perceive as sunlight, or the visible spectrum, is a small fraction of the total electromagnetic spectrum, which includes gamma rays, X-rays, and radio waves.

Violet colored light rays at about 380 nm (nanometers) are the shortest wavelengths that humans can perceive in appreciable amounts, and red-light wavelengths at about 720 nm are the longest. Solar radiation consists of a vast spectrum of electromagnetic wavelengths at various intensities [2].

2.1. *Irradiance*

Consider a surface (S) exposed to electromagnetic radiation. A surface element ds, taken around a point M of the surface (S) receives, in the form of radiation, a power called energy flux, denoted dp, expressed in watts. The irradiance of (S), around the point M is:

$$E_e(M) = \frac{dP_e}{ds} \text{Unit: } (W.\ m^{-2}). \qquad \text{(eq.1)}$$

- Radiance is the radiant intensity emitted by a unit area of a source or scattered by a unit area of a surface. Unit: W m-2 sr-1.
- Radiant Flux is the amount of radiation coming from a source per unit time. Unit: watt, W.
- Radiant Intensity is the radiant flux leaving a point on the source, per unit solid angle of space surrounding the point. Unit: watts per steradian, W sr -1.

2.2. *Luminous Flux*

Equal powers of radiation, infrared, yellow or ultraviolet do not produce the same effects on the eye. It may be necessary to compare the visual effects produced by radiation of different spectral compositions. The curve of relative spectral sensitivity of the eye (fig. 1) shows that the sensitivity of the eye is maximum for $\lambda = 0.555\ \mu.\ m$ in daytime vision.

- Luminous Flux is the amount of radiation coming from a source per unit time, evaluated in terms of a standardized visual response. Unit: lumen, lm.
- Luminous Intensity is the luminous flux per unit solid angle in the direction in question. Unit: candela, cd. One candela is one lmsr -1.
- Luminance is the quotient of the luminous flux at an element of the surface surrounding the point and propagated in directions defined by an elementary cone containing the given direction, by the product of the solid angle of the cone and the area of the orthogonal

projection of the element of the surface on a plane perpendicular to the given direction. Unit: cd m-2; also, lmsr -1 m-2. This unit is also called the nit.

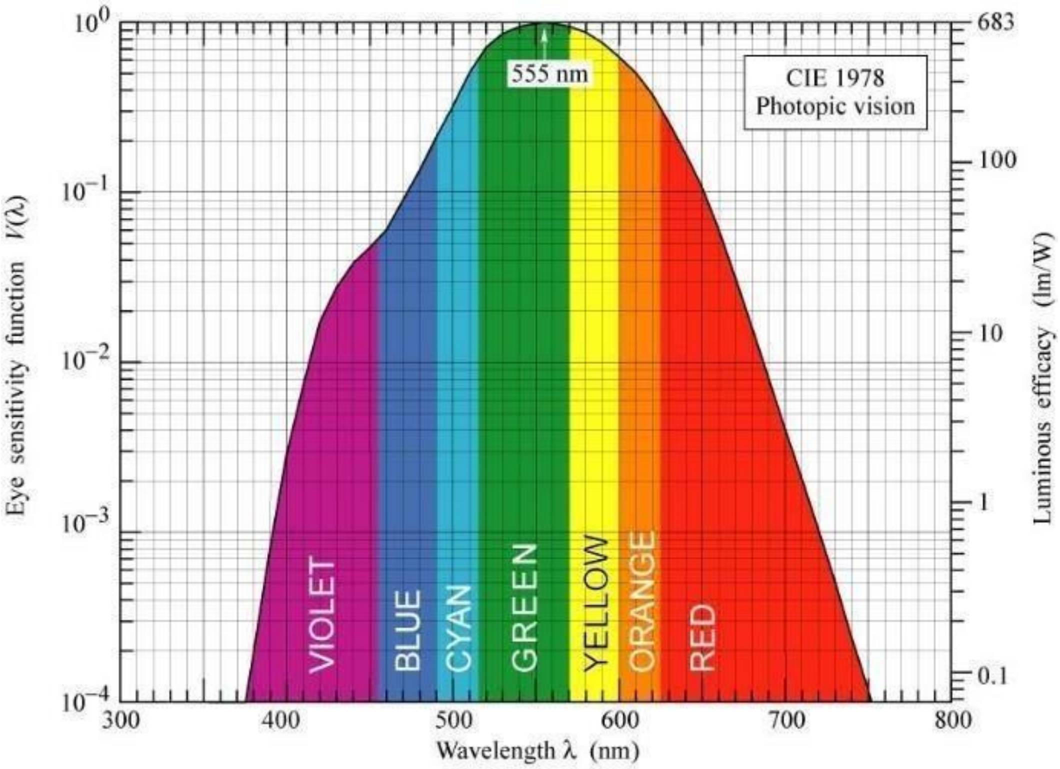

Fig. 1. Human Eye Sensitivity Function CIE 1978 Photopic Vision [3].

2.3. *Illuminance*

Illuminance is defined as the density of the luminous flux incident at a point on a surface. Average illuminance is the quotient of the luminous flux incident on a surface by the area of the surface.

A surface elementds, taken around point M, receives a luminous fluxdP_v; the illumination, in M, is by definition:

$$E_v(M) = \frac{dP_v}{ds} \quad \text{Expressed in lux} \quad \text{(eq.2)}$$

- We have the equivalence: 1 lux = 1lm.m^{-2}
- For a surface oriented perpendicular to the sun's rays: E_v can reach 10^5 lux in summer (blue sky).
- Inside a living or working room: $E_v$varies from 50 to 400 lux.

3. Block diagram and characteristics

3.1. *Sensor description*

The NOA1305 integrates a wide dynamic range (ALS) ambient light sensor with a 16-bit ADC and an I2C digital interface. It provides a linear response over the range from near 0 lux to well over 100k lux with programmable integration times to optimize noise performance. The sensor employs ON Semiconductor's proprietary CMOS image sensing technology which provides low noise, high dynamic range output signals and light response similar to the response of the human eye. The NOA1302 works as an I2C slave device and supports commands to set options in the device and read the number of ambient light intensities [3].

All data transactions on the bus are 8 bits long. Each data byte transmitted is followed by an acknowledgment bit. The data is first transmitted with the MSB. The sequence consists of a complete I2C write command which sets the address pointer in preparation for the I2C read command since the read command itself does not include a register address.

3.2. *Operating modes*

The NOA1305 can be placed into one of the following operating modes by programming registers on the I2C bus: Interrupt Driven Mode, Polling mode and Power off mode. In the interrupt mode, when the ambient light intensity exceeds the threshold value, the device reports an interrupt on the INT pin. In polling mode, the NOA1305 continuously measures and the I2C master host reads the most recent count whenever it wants. In power-down mode, the NOA1305 stops taking ambient light measurements and turns off most internal circuitry and the INT pin is disabled.

3.3. *Programming*

Ambient light intensity counting is obtained from the NOA1305 by issuing a fixed sequence of I2C commands. The integration time is programmable by writing different values to the integration time register. The following pseudo code (Fig.1) configures the NOA1305 ambient light sensor and then runs it in polling mode. The controller can read the data from the device permanently, and then display the obtained value and the data-time on the LCD screen. The average of light intensity in each minute is receded in the SD card. In addition, and if it is necessarily, the controller sets the integration time to achieve the high possible resolution. Finally, the ESP8266 is configured to act as a web server that allows us to retrieve the data stored in the SD card and to follow the values acquired by the sensor online.

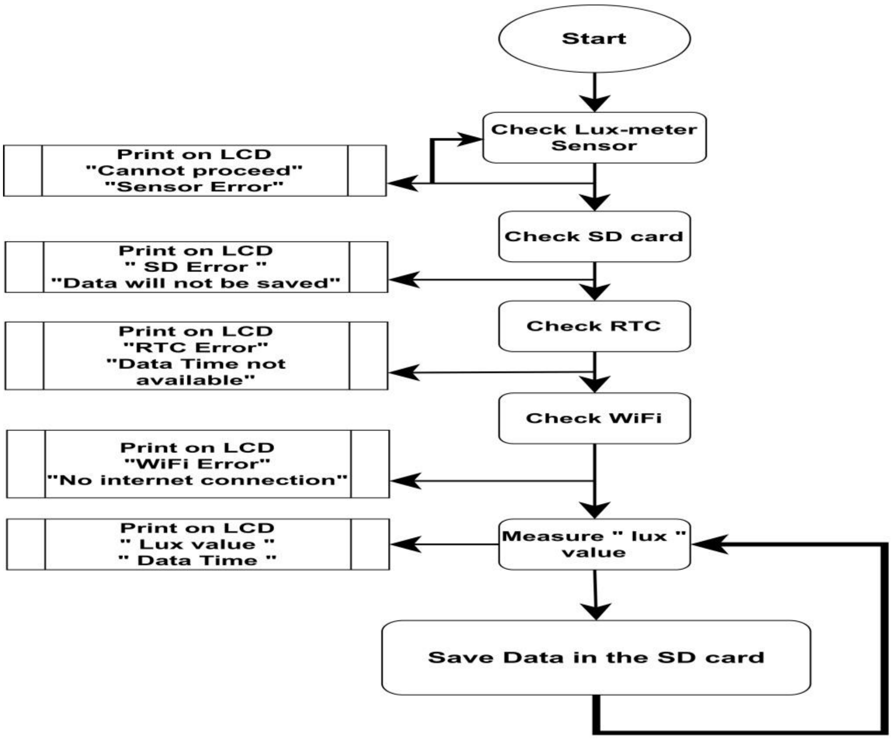

Fig. 2. Algorithm organization

4. Experimental measurements

4.1. *Indoor experiment*

In this experience Spectroline NDT XR-1000 AccuMAX Digital Radiometers [4] was the reference meter, based on which the obtained data was evaluated. Test was done in an industrial photography experiment darkroom and a fluorescent lamp (11W/220V) at different high was used. Table 1 summarizes the obtained results; the equation 3 was used to calculate the difference percentage.

$$PD = \frac{|Our\ prototype\ - \text{NDT XR}-1000\ \text{AccuMAX}\ |}{\text{NDT XR}-1000\ \text{AccuMAX}} \times 100 \qquad \text{(eq.3)}$$

TABLE I. INDOOR EXPERIMENT

Distance between sensors and lamp (in cm)	**Spectroline NDT XR-1000 AccuMAX (lux)**	**Our prototype(lux)**	**PD**
100	230	231	0.43
80	415	417	0.48
60	700	702	0.28
40	1715	1730	0.87
20	**OVER RANGE**	6215	

As was expected, the used sensor (NOA1305) achieves high accuracy compared at a professional Luxmeter, which makes it suitable for indoor use.

4.2. *Outdoor experiment*

From the previous experiment, and at certain illumination levels, the reference Luxmeter (NDT XR-1000) cannot operate because the permissible illumination level is exceeded, and for this reason it cannot be used outdoors.

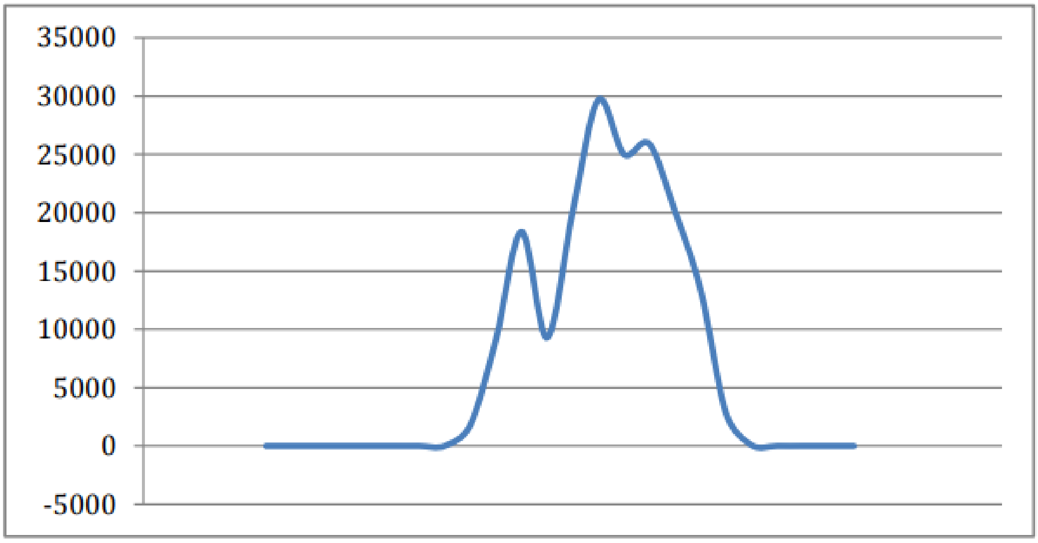

Fig. 3. Variation in the intensity of direct sunlight corresponding to 12/31/2022

4.3. *Wireless data acquisition*

Send sensor readings with the ESP8266 NodeMCU board to user via WIFI. The proposed prototype allows us to publish the sensor readings to our website and plot them in charts with timestamps. The user can access readings from anywhere in the world. The following figure provides an overview of the web interface we developed to display what the data looks like, and of course access the data store in the memory card, in order to download the stored data without having to pull the memory card out of the device.

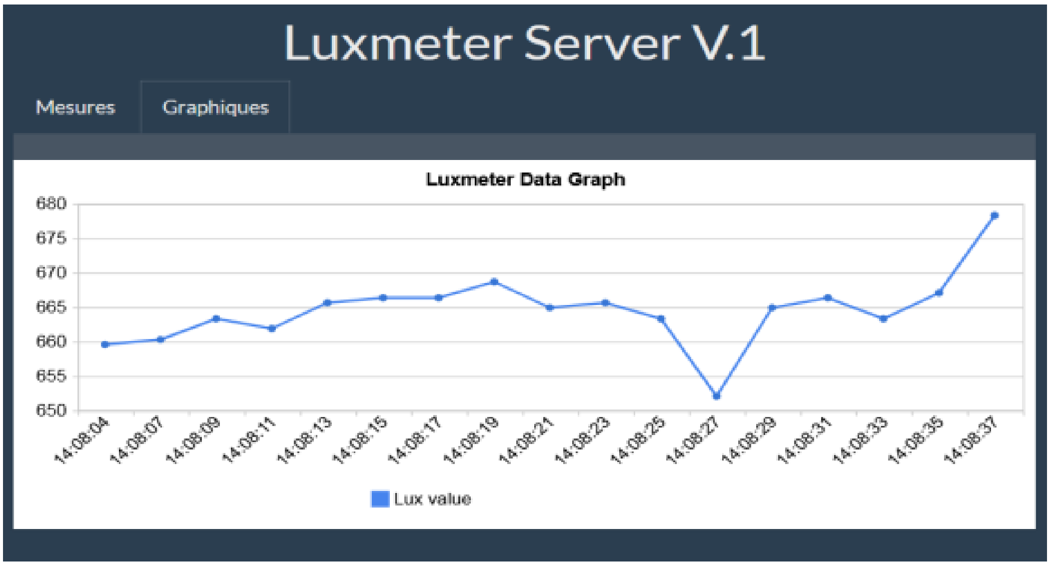

Fig. 4. Web interface to display the Luxmeter data

5. Conclusion

The proposed Luxmeter data logger described in this article provides very good results and can be used in indoor and outdoor applications. It includes a professional photometric sensor with a bunch of settings and options, for example, it allows data logging to SD card and online in real time. In addition, it is adequate for long-term automatic measurements, which distinguishes it from the rest of the devices available on the market.

For testing propose, Spectroline NDT XR-1000 AccuMAX Digital Radiometers, which is a commercial Luxmeter, was used to compare the obtained results. Tests were done in an industrial photography experiment darkroom and a fluorescent lamp, for indoor test, the percentage difference is less than 1%. At certain illumination levels, the reference Luxmeter (NDT XR-1000) cannot operate because the permissible illumination level is exceeded. For the outdoor test, the proposed prototype can reach 128 Klux.

6. Acknowledgments

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7. References

[1] H. N. M. binti Yusoff, « Guidelines on Occupational Safety and Health for Lighting at Workplace ». Department of Occupational Safety and Health Malaysia Putrajaya, Malaysia, 2018.

[2] « P/N 980-15606 8/15 2nd Edition -.

[3] P. M. Pattison, « 2018 DOE Solid-State Lighting R&D Opportunities », Tech. Rep. US Dep. Energy, 2019.

[4] W. O. V. Range et W. O. T. Range, « Ambient Light Sensor with I 2 C Interface and Dark Current Compensation », 2012.

[5] « Spectroline NDT XR-1000 AccuMAX Digital Radiometers ». https://www.itm.com/fr/produit/spectroline-xr1000-accumax-digital-radiometers .