MATLAB ALGORITHMS FOR THE LIGHTING CONTROL
ON THE CONSTANT VALUE

Abstract: The solar energy as the part of the state energy management is increasingly going into a lead of analysis and planning by alternative ways of obtaining energy. Without doubts it is one of the cleanest forms of energy. However, its usage entails a number of disadvantages as the seasonality and the dependence on the weather conditions. It is necessary to take these specificities into account during designing the systems involved in using this forms of energy. This contribution is orientated on simulation of light conditions during summer and winter days for needs in development and measurement lightening systems in covered areas. The results from laboratory conditions are going to be used by improvement of greenhouse lightening systems.

Key words: solar energy, lighting control, Matlab

1. INTRODUCTION

The Solar energy is inherent part of our existence on the Earth. Its influence on the planet follows us almost everywhere. The production of energies which are necessary for our life (biomass energy, dry mass of economically significant plants) or energies useful for functioning of society is closely linked to the sunlight radiation. Almost all kinds of alternative energy sources are direct or indirect effect of sunlight energy (wind energy, water energy, or energy of biomass).

On the Earth surface falls continually energy flow 1,8 1017 of Watts. When we re-count this flow into the time units, we get the number 1,52 109 TW.h.y-1. It means that the sun emits in one hour more energy that human society consumes in one year. On the 1 m2 of surface falls approximately 1,373 kW (it depends on the position location). This number is called “solar constant”.

The amount of emission impacted on the unit of earth’s surface is not equal to the solar constant. It is mainly affected by the sun location in the sky (above the horizon during the day), seasons, weather conditions and also the amount of impurities in the air. Therefore, the amount of incident energy per unit area varies during the year. We can divide this radiation in three components like a direct sunlight (not changing the direction), diffuse (it disperses on particles of water vapor and dust and reflected (from buildings, objects, water levels and ground).

Plants use the light spectral area between 400 – 710 nm (Photosynthetically Active Radiation PAR). This area is most useful for its growth. In the spectral area between 750 – 1200 nm plants reflected 40 – 60% of incident radiation. (KOSTREJ A KOL, 1992)

On the PAR assignation we can use the common equation:

\[
\text{PAR} = 0.46 \times \text{GR}
\]

Fig. 1 PAR area for individual color components.

2. MATERIALS AND METHODS

For the algorithms development we used existing knowledge about day light conditions for the specific area (the south – west part of Slovakia). On this base we created the simulation model which serves for algorithms development in laboratory conditions. Simulation algorithm use equations represented the day summer light conditions for the common growing unit. With using of mathematical statistic methods we become equation (figure 2) for the day light conditions simulation.
Obtained equation is with using of MATLAB function recounted on the simulation interval and in simulation, circuit (figure 3) converted into simulated day light course. This circuit use 10-bit digital to analog converter implemented in microcontroller SILABS C8051F330 and subsequently controlling of halide lamp (U=230V, P=500W) with using of smart switching relay. The final simulating course is in the sense of the original course (simulation points programmed into microcontroller).

On the PAR measurement we will use the calibrated sensor and MATLAB conversion which enable us to reach the results in appropriate units of radiation (W.m⁻²). The illumination sensor was developed at Department of Electrical engineering, Automation and Informatics of Faculty of Agricultural engineering of Slovak Agricultural University in Nitra. It is semiconductor pyranometer based on silicon photodiode with enhanced sensitivity in the shortwave spectral area (400 – 700nm) which is installed in the capsule under interference filter. The filter does not transmit the radiation under 400nm and above 700nm in the whole area of diode sensibility. The combination of correction filters and their thickness were designed with computer program to ensure the minimal aberrance from ideal course. The sensor is by calibration protocol loaded with resistance R=3300 Ω. Then the voltage 1mV on the sensor output means PAR radiation 4, 32 W.m⁻².

Measuring board which ensures data collection from sensor and additive thermometers was developed at the department too. Its base is microcontroller communicatoried with PC through USB interface. 24 bits delta - sigma analog to digital converter serves on converting the voltage value from optical sensor. The microcontroller sends data from thermometers and converter into PC. In the MATLAB program was developed chain for measuring and regulating of artificial lightening (figure 4).
3.1 The control of illumination on the constant PAR value

On the constant PAR value control we use actuating device and halide low voltage lamp \((U=24V, \ P=150W)\) set in simulating and measurement MATLAB function so that by the maximal control PWM bit \((PWM = 255)\) what is the maximal light power of the bulb is the corresponding PAR intensity \(20W.m^{-2}\). On this PAR value is set the control in the MATLAB algorithm too. The simulation is set for the maximal simulated PAR value \(25W.m^{-2}\). The algorithm for the constant value PAR control use measured data about actual illumination in the system and with using of the differential variable is continuously adding the actuating intervention (PWM controlling bit) and approximates actual PAR value to the requested. The setting of requested PAR value is directly MATLAB program with entering the differential constant into the controlling function. For the higher values of illumination in the laboratory conditions is necessary to use more powerful light sources.

The actuating device for switching of the additional light source consists of MOS FET transistor and isolating optocoupler. The controlling PWM information comes directly from measuring PC, MATLAB program. With using of the measuring board and this actuating device is converted on the electric current through the bulb.

3.2 Measurement of lighting control to a constant value of FAR

Measurement was made in laboratory conditions and the constant value of PAR light was \(20 \ W.m^{-2}\). By measurement we used the measuring and controlling board, the circuit for the daylight simulation, circuit for controlling the output actuating value and the MATLAB algorithms for collecting data and counting the results of PWM byte and sending it into actuating device. The measuring period was approximately 5 minutes and during this period two simulation cycles of day and night were changed (from the view of daylight conditions simulation). On the figure 5, we can see the dependence between PWM controlling bit from the changing simulated illumination as an attempt of the system to preserve the constant set value of the lightening.
4. CONCLUSION

From the course on the figure 6, we can see the slow reaction of the system after starting the light regulation. The reaching of the PAR value 20 W.m⁻² is in the area of 20th measuring sample after start what means by the sample period duration 1 s the time 20 s. From the long time view and for the slowly changing actions will be this speed sufficient. However by the fast actions as the light changing is, could be this speed insufficient. By plants and greenhouse, illumination for the need for ensuring sufficient light could be this speed adequate. From measurements displayed on the figure 5, we can see PWM course (blue one) calculated with our algorithm, its increase and attempt to hold the illumination on the requested value. As we can see from courses, the slow speed influence of algorithm is visible mainly by fast changes of simulated illumination. Here occurs variable overshoot of system (we can see the wavy course). In the area behind sample, number 200 is the outdoor simulated illumination falling and the task for system is to hold the set value. In this area is possible to see pulse overshoot into the negative values (by comparison with set value 20 W.m⁻²). For removing of these limitations is possible to make some arrangements like program adaptability into the algorithm. The adaptability will by the predefined changes (rising or falling) make more suitable regulating interventions. General removal of this insufficiency will be reach with using of fuzzy regulation algorithms with predefined regulating rules. For adaptive illumination regulation in greenhouses is this design applicable. The big income by using this type of algorithm will be the energy saving in cases when the illumination it greenhouse area reach the value over the plants needs for their best growing.

5. REFERENCES


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ACKNOWLEDGEMENTS

Note: This project has been founded by VEGA Agency of Ministry of Education, Science, Research and Sport of the Slovak Republic as a project No. 1 0696/11 - The impact of external factors on the effectiveness of photovoltaic cells under real conditions. This paper presents a part of researching at the CEEPUS project “ Renewable energy resources” Project number CIII-SK-0405-03-1112.