Avrupa Bilim ve Teknoloji Dergisi
Özel Sayı, S. 445-454, Eylül 2020

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
Special Issue, pp. 445-454, September 2020

Research Article

LabVIEW Based Modelling System Applied in Maximum Power Point Tracking Techniques

Abdulkadir Mühendis[1], Ahmet Afşin Kulaksiz[2]

[1]Konya Teknik Üniversitesi, Mühendislik Ve Doğa Bilimleri Fakültesi, Elektrik-Elektronik Mühendisliği Bölümü, Konya, Türkiye (ORCID: 0000-0001-8531-257X)
[2]Konya Teknik Üniversitesi, Mühendislik Ve Doğa Bilimleri Fakültesi, Elektrik-Elektronik Mühendisliği Bölümü, Konya, Türkiye (ORCID: 0000-0003-3216-8185)

(1^{st} International Conference on Computer, Electrical and Electronic Sciences ICCEES 2020 – 8-10 October 2020)

(**DOI:** 10.31590/ejosat.809517)

ATIF/REFERENCE: Mühendis, A. & Kulaksız, A. A. (2020). LabVIEW Based Modelling System Applied in Maximum Power Point Tracking Techniques. *European Journal of Science and Technology*, (Special Issue), 445-454.

Abstract

Photovoltaic is the process that converts the sunlight directly into electric power depending on irradiance and temperature. The monitoring system in photovoltaic power plants is very important to interface the whole system and critical in some cases for analyzing since it has to be in real-time for troubleshooting responses. This paper presents an analysis study of the photovoltaic modules based on LabVIEW which is one of the well known graphical programming environment known as a parallel programming as well. The main role of using LabVIEW environment to analyze the performance of the system is to be able to track the amount of energy which is produced by the photovoltaic system in real-time and to ensure the forecasted conversion efficiency for continuous power tracking most of the time. In this paper, the proposed modelling system is designed and implemented to analyze the performance of the applied perturbation and observation algorithm which provides the maximum power point tracking. Photovoltaic panel characteristics have been demonstrated based on LabVIEW environment using data acquisiton circuit. LabVIEW environment is a system design environment which has supportive tools which are used to create a multitude of the application in much less time using parallel programming language platform. The process of designing and analysing the system has been carried out in real time simulation using the designed electronic circuit. The obtained results from the system have been compared with a real sun-simulator device results and it was shown that they are very close to the existing datasheet results.

Keywords: LabVIEW, Maximum Power Point Tracking, Parallel programming, Photovoltaic, Real Time Analysis

Maksimum Güç Noktası İzleme Tekniklerinde Uygulanan LabVIEW Tabanlı Modelleme Sistemi

Öz

Fotovoltaik, güneş ışığını doğrudan elektriğe dönüştürme işlemidir. İlk yatırım maliyeti yüksek olsa da güneş enerjisi temiz ve yenilenebilir bir enerji kaynağı sunar. Fotovoltaik sistem kullanılarak elektrik enerjisi üretmek için; sistemin bulunduğu konum, ortam sıcaklığı ve dönüşüm sisteminin verimliliği gibi parametrelerin bilinmesi sistemin optimum çalışabilmesi için önemlidir. Bu sistemler tek panel ile kullanılabildiği gibi büyük enerji santrallerinde çok sayıda panelin birbirine bağlanması ile de kullanılabilir. Bu tarz bir sistem oluşturulurken hücrelerin güneşten aldığı enerjiye göre ürettiği gerilim ve akım değerleri kritik derecede önemlidir. Bu sistemlerin maksimum verimde çalışabilmesi için, sistem performansının analiz edilebildiği bir izleme sistemi kullanmak, fotovoltaik sistem tarafından üretilen enerji miktarını gerçek zamanlı olarak takip edebilmek ve öngörülen dönüşüm verimliliğinin, maksimum güç noktasını belirlemek son derece mühimdir. Bu çalışmada, LabVIEW programı kullanılarak fotovoltaik hücrelerin karakteristikleri, sistemin ürettiği elektrik enerjisi ve maksimum güç noktasının belirlenmesi için gerçek zamanlı ölçümlerin laboratuvar ortamında yapılması amacıyla kullanılacak bir donanım ve yazılım geliştirilmiştir. LabVIEW, endüstriyel olarak veri toplama sistemleri, test ve ölçüm cihazları gibi ihtiyaçları karşılamak için sıklıkla kullanılmaktadır. Sistemde kullanılan sensörlerden gelen bilgi, maksimum güç noktası izleme cihazı olarak kullanılan DC-DC dönüştürücüsünden okunmuştur. Elde edilen tüm veriler LabVIEW'ın arayüzünde, donanımda kullanılan mikrodenetleyiciye bağlı sensörlerden ve toplanan verilerin analiz edilebilmesi için LabVIEW ortamında hazırlanan görsel arayüz programı vasıtasıyla izlenmiştir. Önerilen sistem analiz ve veri toplama uygulamalarında kabul edilebilir bir performansa sahip olduğu görülmüştür.

Anahtar Kelimeler: LabVIEW, Maksimum Güç Noktası Takibi, Paralel Programlama, Fotovoltaik, Gerçek Zamanlı Analiz

1. Introduction

Photovoltaics today is one of the most reliable and sustainable form of renewable energy resources. Though expensive to implement, solar energy offers a clean, renewable energy source. When contemplating to use the produced energy from the solar photovoltaic system, it is important to know how much energy can be produced according to location, temperature and conversion efficiency. Solar energy is the technology used to make use of the sun's energy. The energy which is delivered from the photovoltaic system which consists of one or more photovoltaic modules is dependent on its characteristics and the current which is drawn from its solar cells. Using a monitoring system to analyze the performance has the main role to be able to track the amount of energy which is produced by the photovoltaic system in real-time. This paper proposes a modelling system which is designed and implemented to simulate real photovoltaic panel characteristics based on LabVIEW environment (Laboratory Virtual Instrument Engineering Workbench) which has high performance in analysis and data acquisition applications. All data will be presented in LabVIEW's interface which is provided from the designed data acquisiton circuit. The designed electronic circuit has the ability to implement the maximum power point tracking (MPPT) algorithm according to its DC-DC converter design which is connected with microcontroller as buck converter. The maximum power of the system is not directly calculated by the microcontroller. The voltage corresponding to the maximum power point has been calculated and continuously updated accordingly by the designed mathematical model in LabVIEW. All PWM signals have been controlled in LabVIEW and sent to the microcontroller which forms the interface between the PC and the connected DC loads. In this paper, two different scenarios have been applied to analyze P&O algorithm performance. The P&O algorithm is one of the well known methods based on the trial and error process in finding and tracking the MPP [11].

2. Material and Method

2.1. System description

The proposed system was designed employing DC-DC buck converter circuit connected with a low cost 8-bit microcontroller. The designed circuit has half bridge MOSFET connected with the microcontroller which controls the PWM signals that determines the needed voltage level for the load. Input voltage level was detected in LabVIEW which is connected with the designed circuit via a serial communication. The main purpose of using LabVIEW environment is to be able to control all signals digitally and to implement P&O algorithm outside of the microcontroller. Fig. 1 shows the block diagram of the system.

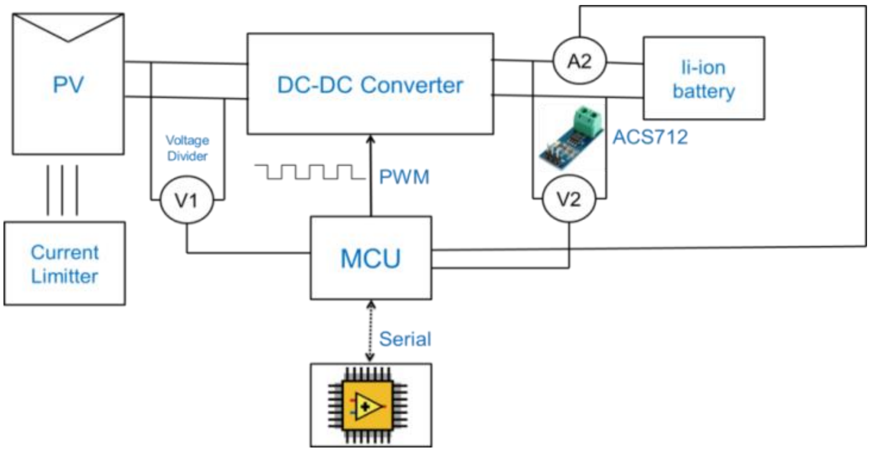

Fig. 1 The block diagram of the designed system

DC-DC converters convert one level of DC voltage to another. In the designed project, a buck DC/DC converter is used which step down the voltage and step up the current. At every cycle, the designed circuit was handshaking with LabVIEW environment through the serial communication interface to measure the photovoltaic voltage and current and deduces the real photovoltaic power, then updates the duty cycle percentage of the PWM signal by sweeping the operating demand voltage according to the needed variation of the power. Fig. 2 depicts the designed DC-DC converter circuit.

Fig. 2 DC-DC Converter Circuit

P&O algorithm has been used in the presented system since it has low cost, reduced number of parameters, and flexible for new improvements which may result a high level efficiency. P&O method depends on investigating the relationship between the photovoltaic panel power and its voltage. Fig. 3 shows P&O operating principle.

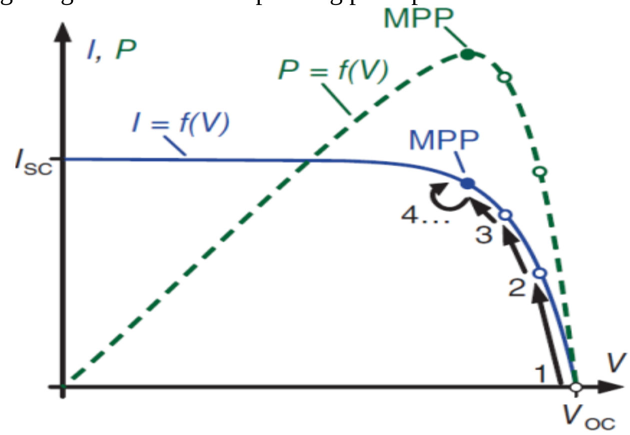

Fig. 3 P&O operating principle

Based on the principle of P&O algorithm, the process occurs basically by observing the change that will happen as a result of changing the operating point of PV modules which leads to determine the next change towards the maximum power point tracking. A prototype MPPT charge controller is tested with a 60 W photovoltaic panel and li-ion battery. The designed MPPT controller improves the efficiency of the photovoltaic panel when compared to conventional charge controllers thanks to the accuracy and the sample rate of the system. The basic flowchart of the used P&O method is shown in Fig. 4.

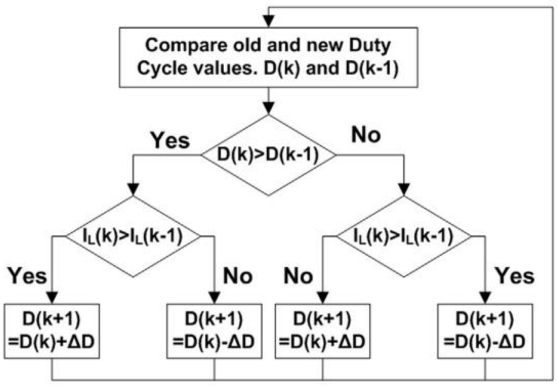

Fig. 4 P&O algorithm flowchart

The intensity data have been set by using a real solar simulator (QuickSun 540LA) as shown in Fig. 5. In the first scenario, two different irradiation values (500, 1000) W/m^2 have been tested according to two different outputs (6V, 12V) during a constant temperature value (25°C). In the second scenario, constant light intensity (1000 W/m^2) has been applied for two different outputs (6V, 12V) during two different temperature values (25°C and 35°C). Each scenario was repeated until reaching the maximum power point when $\frac{dPpv}{dVpv} = 0$. One of the advantages of using this algorithm that knowing the PV characteristics is not needed to apply the system. In the following sections, the modeling of the proposed system in LabVIEW (Fig. 6) is explained.

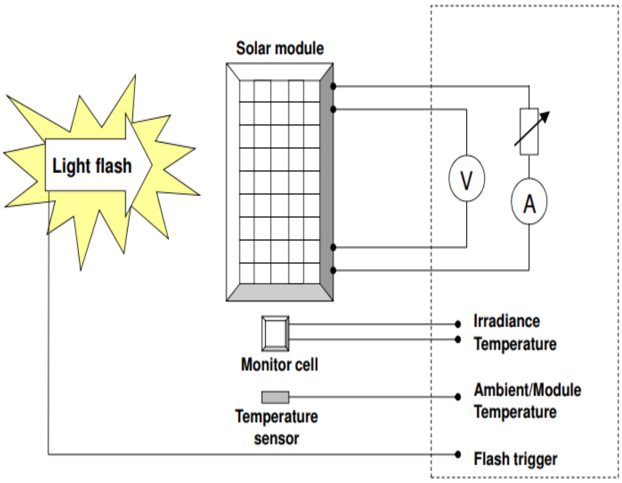

Fig. 5 Sun-Simulator operating principle [22]

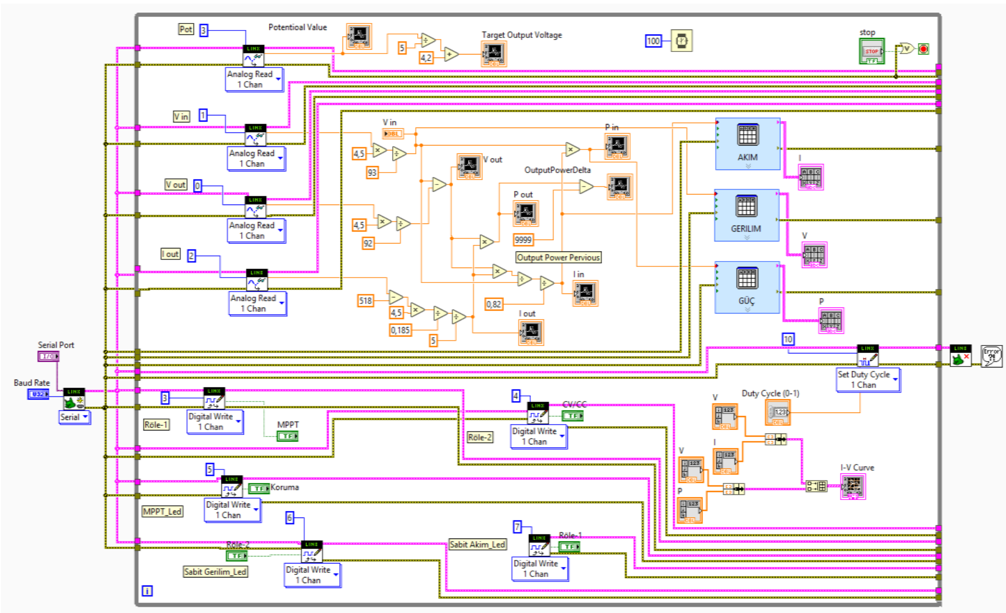

Fig. 6. Overall LabVIEW model of the proposed system

2.2. Block diagram modeling

In this paper, the concept of block diagram tools is to be used as the graphical source code of LabVIEW program. The designed front panel objects have been used as terminals on the block diagram. Basically, those block functions vary from simple arithmetic functions to advanced data acquisition operations. In this study, calculations of all programmed analog signals are translated as the following equation in Fig. 7.

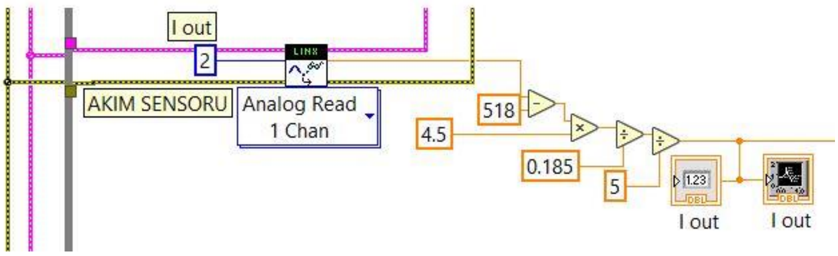

Fig. 7 Current sensor’s equation

The implemented maximum power point tracking model calculates the needed voltage (V_{mp}) applied by changing the duty cycle of the feedback PWM signal. Fig. 8 shows the MPPT block diagram model.

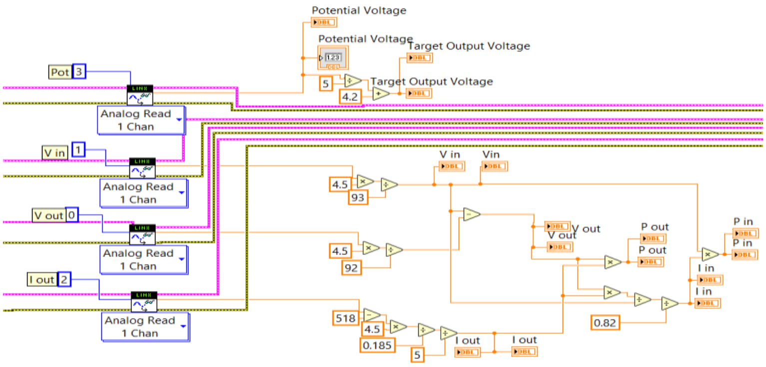

Fig. 8 MPPT block diagram model

Block diagram design has analog signals input coming from the DC-DC converter circuit which belongs to photovoltaic voltage, output voltage and output current. PWM signal has been configured according to the needed charging voltage by changing the duty cycle percentage.

2.3. Front panel design

The front panel has indicators which are the interactive objects constructed as the block diagram terminals to interface the input/output channels [9]. In this work, all received data have been recorded in LabVIEW inside arrays according to the acquired sampling rate. The recorded data have been implemented in the designed front panel as graphs to be able to analyze and monitor the voltage readings in real time. Every indicator of the front panel has been associated with either voltage, current, or power. Fig. 9 shows the front panel.

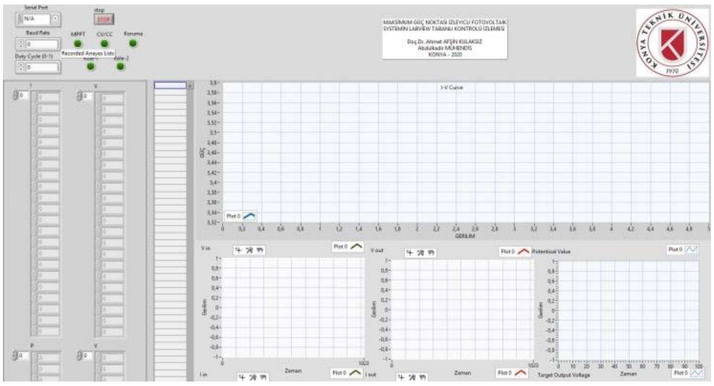

Fig. 9 Front panel

In this work, produced energy from photovoltaic module has been implemented to charge Li-ion battery according to the following test platform which is shown in Fig. 10.

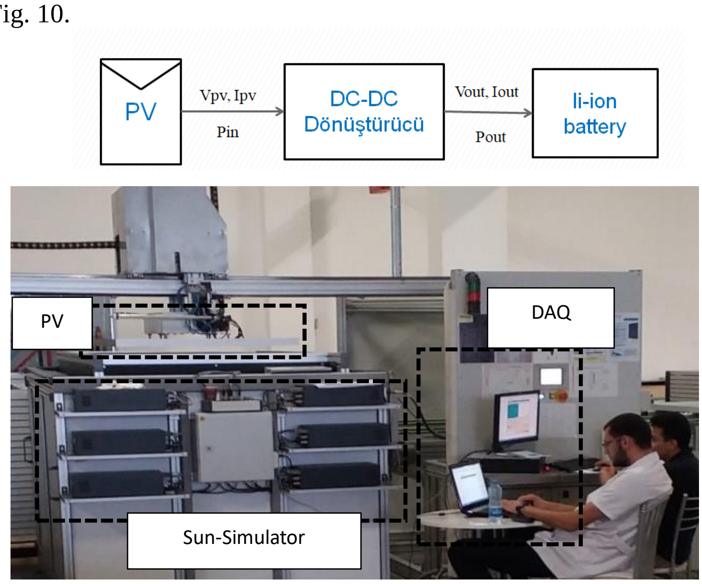

Fig. 10 Test platform principle

3. Results and Discussion

In this study, the designed P&O algorithm in LabVIEW shows an acceptable performance for the two presented scenarios. The first applied irradiation from the sun simulator ($500\ \mathrm{W/m^2}$) has been tested to charge 6V and 12V batteries load during the constant temperature (25°C) as shown in Fig. 11 and Fig. 12, respectively. The same procedures have been repeated for different applied irradiation ($1000\mathrm{W/m^2}$) which have been done according to the standard test conditions (STC) as shown in Fig. 13 and Fig. 14, respectively. The efficiency of the designed system has been presented in Table 1 according to different test conditions. Fig. 15 presents the results for all recorded samples of the acquired voltages and currents from DC-DC converter.

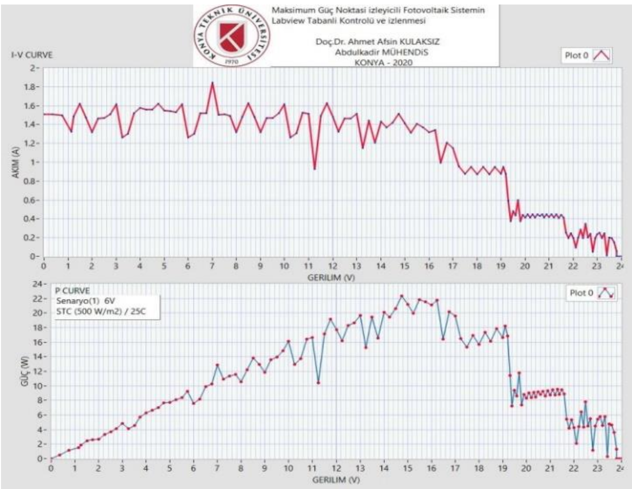

Fig.11 The power curves of 6V battery load under (25°C, $500\ \mathrm{W/m^2}$)

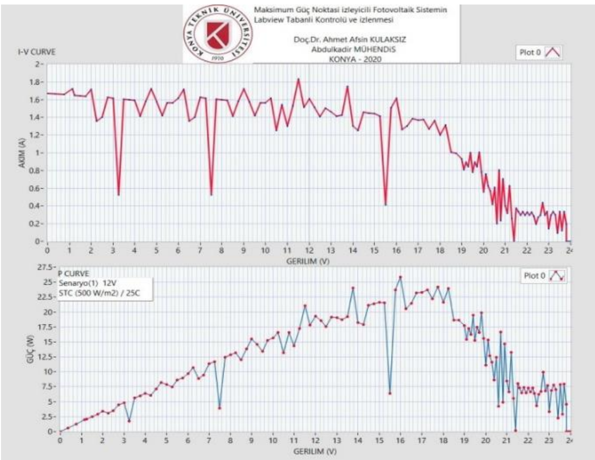

Fig. 12 The power curves of 12V battery load under (25°C, $500\ \mathrm{W/m^2}$)

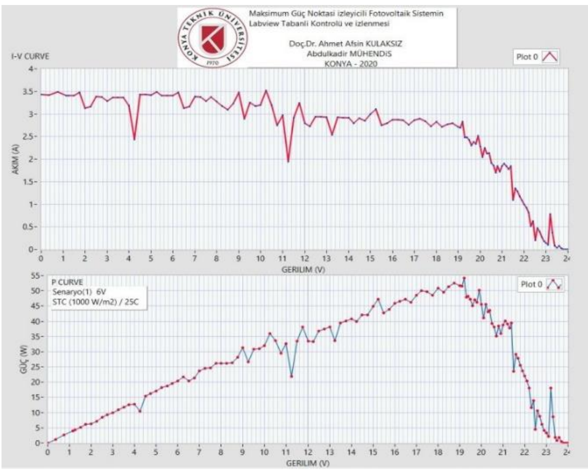

Fig. 13 The power curves of 6V battery load under (25°C, $1000\ W/m^2$)

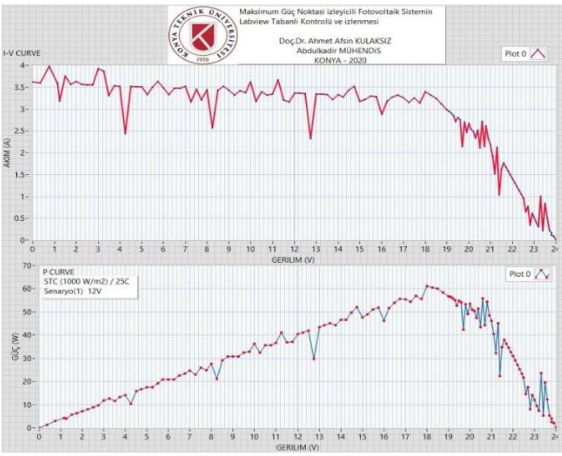

Fig. 14 The power curves of 12V battery load under (25°C, 1000 W/m^2)

The presented results showed that the used method's performance in LabVIEW environment has supportive tools to trace the maximum power point easily and give the ability for recording and manipulating the data for analysis requirements.

Table 1. The performance analysis of the system

Methods	Load	Irradiance	Temperature	Vpv	Ipv	P pv	Vo	Io	Po	Performance
Scenario (1)	6 V	$1000W/m^2$	25°C	19.1 V	2.6 A	49.66 W	6 V	7.2 A	43.2 W	86 %
	6 V	$500W/m^2$	25°C	14.7 V	1.5 A	22 W	6 V	2.7 A	16.2 W	73 %
	12 V	$1000W/m^2$	25°C	18 V	3.4 A	61.2 W	12 V	4.43 A	53.24 W	87 %
	12 V	$500W/m^2$	25°C	18.2 V	1.3 A	23.66 W	12 V	1.6 A	19.2 W	81 %
Scenario (2)	6 V	$1000W/m^2$	25°C	19.1 V	2.6 A	49.66 W	6 V	7.2 A	43.2 W	86 %
	6 V	$1000W/m^2$	35°C	12.4 V	3.6A	44.64 W	6 V	5.7 A	34.2 W	76 %
	12 V	$1000W/m^2$	25°C	18 V	3.4 A	61.2 W	12 V	4.43 A	53.24 W	87 %
	12 V	$1000W/m^2$	35°C	12.5 V	3.6 A	45 W	12 V	3.38 A	40.56 W	90 %

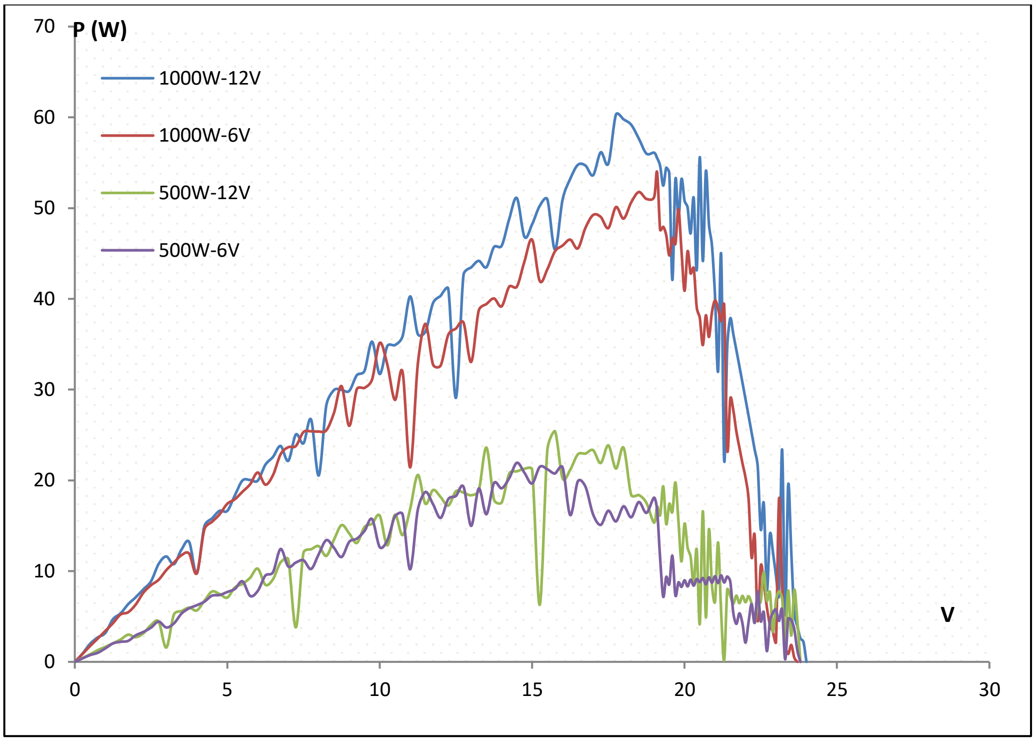

Fig. 15 The power curves for the first scenario

In the first scenario, two different irradiations (500, 1000) W/m^2 have been tested according to two different outputs (6V, 12V) during a constant temperature value (25°C). In the second scenario, constant light intensity (1000 W/m^2) has been applied for two different outputs (6V, 12V) during two different temperature values (25°C and 35°C).

The needed procedure's results in order to complete the comparison between the two presented scenarios are shown in Fig. 16 and Fig. 17, respectively. Fig. 18 presents the results for all recorded samples of the acquired voltages and currents from DC-DC converter.

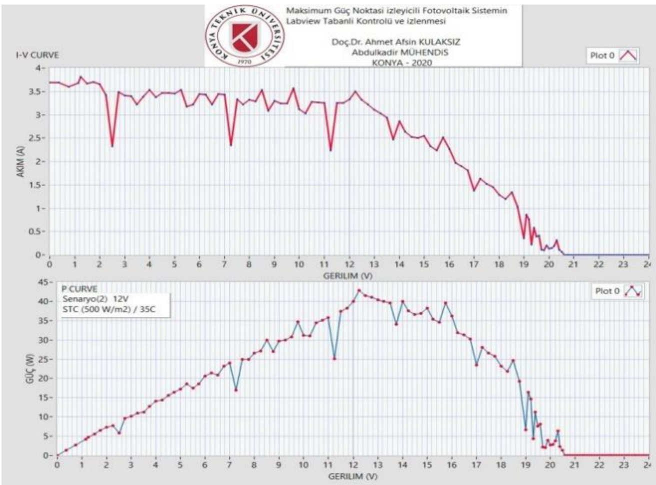

Fig. 16 The power curves of 6V battery load under (35°C, 1000 W/m^2)

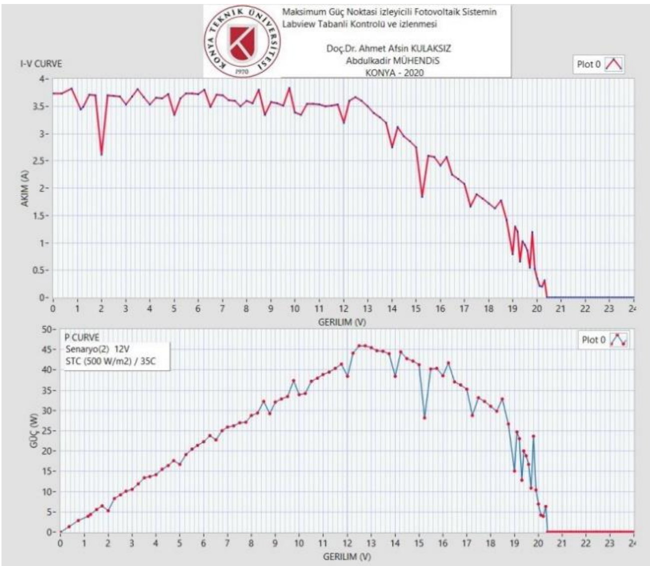

Fig. 17 The power curves of 12V battery load under (35°C, 1000 W/m^2)

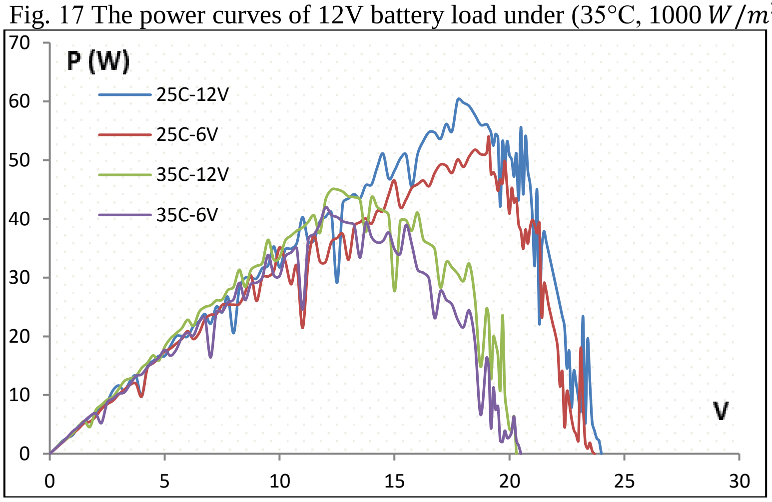

Fig. 18 The power curves for the second scenario

4. Conclusions and Recommendations

Synchronous development of the software technologies and power optimization studies in solar energy systems can be performed using cost-effective systems [19]. The designed system using LabVIEW can be used as data acquisition system in educational laboratories as well as conducting relevant experimental studies suitable for market use in the laboratory environment [21]. Effective data acquisition in photovoltaic systems might help the studies to determine the equivalent circuit parameters of the PV panels and provide the necessary data for the realization of different artificial intelligence based MPPT algorithms [5]. This LabVIEW based study can be transferred to the real application environment. Therefore, low-cost systems have been examined in this work and further research is highly recommended for future applications.

In this study, test studies were carried out using a test platform prepared in a laboratory environment. The behavior of the used algorithm was examined according to different test conditions and it presented how MPPT can be affected by radiation levels. The presented results have shown that when all parameters are constant, a higher irradiance level will lead to greater output current and consequently leads to the maximum power point. On the other hand, the results showed that the temperature has a large effect on the output voltage and power of the photovoltaic modules. Therefore, at high temperatures, the low voltage modules may not be able to fully charge the Li-ion battery. The proposed method of the study can be emphasized as innovation based on LabVIEW which can deal with other MPPT algorithms effectively.

References

Acharya, P., Shaikh, M., Jha, S. ve Papadakis, A., 2016, Electrical Modelling Of a Photovoltaic Module, Engineering and Industry Series Volume Power Systems, Energy Markets and Renewable Energy Sources in South-Eastern Europe.

Akdeniz, H. Y., 2019, Arduino tabanlı MPPT solar şarj kontrolörü tasarımı ve uygulaması.

Akkaya, R. ve Kulaksiz, A., 2004, A microcontroller-based stand-alone photovoltaic power system for residential appliances, *Applied Energy*, 78 (4), 419-431.

Bakım, S., 2016, Yeni Bir P&O Tabanlı MPPT Algoritması Tasarımı ve Performansının Testi.

Bishop, R. H., 2007, National Instruments' LabVIEW 8, Student Edition, Pearson.

Bitter, R., Mohiuddin, T. ve Nawrocki, M., 2017, LabVIEW: Advanced programming techniques, Crc Press, p.

Büyükgüzel, B. ve Aksoy, M., 2016, A current-based simple analog MPPT circuit for PV systems, *Turkish Journal of Electrical Engineering & Computer Sciences*, 24 (5), 3621-3637.

Chalh, A., Motahhir, S., El Hammoumi, A., El Ghzizal, A. ve Derouich, A., 2018, Study of a Low-Cost PV Emulator for Testing MPPT Algorithm Under Fast Irradiation and Temperature Change, *Technology and Economics of Smart Grids and Sustainable Energy*, 3 (1), 11.

Chehouri, A., Ghandour, M. ve Livinti, P., 2014, A real time simulation of a photovoltaic system with maximum power point tracking.

Çoramık, A. G. D. M., Ege, Y. ve Çıtak, Ö. G. D. H., Bir Veri Toplama Uygulaması: Arduino, LINX ve LabVIEW.

El Hammoumi, A., Motahhir, S., Chalh, A., El Ghzizal, A. ve Derouich, A., 2018, Low-cost virtual instrumentation of PV panel characteristics using Excel and Arduino in comparison with traditional instrumentation, *Renewables: Wind, Water, and Solar*, 5 (1), 3.

Eşme, E., 2006, Uzaktan kontrol edilebilen bir kalp cihazı tasarımı, *Selçuk Üniversitesi Fen Bilimleri Enstitüsü*.

Gaga, A., Errahimi, F. ve Es-Sbai, N., 2014, Design and implementation of MPPT solar system based on the enhanced P&O algorithm using Labview, *2014 International Renewable and Sustainable Energy Conference (IRSEC)*, 203-208.

Hemza, A., Abdeslam, H., Rachid, C., Pasquinelli, M. ve Barakel, D., 2015, Tracing current-voltage curve of solar panel Based on LabVIEW Arduino Interfacing, *International Journal of Informatics Technologies*, 8 (3), 117.

Hussein, K., Muta, I., Hoshino, T. ve Osakada, M., 1995, Maximum photovoltaic power tracking: an algorithm for rapidly changing atmospheric conditions, *IEE Proceedings-Generation, Transmission and Distribution*, 142 (1), 59-64.

Kangal, H., 2008, Fotovoltaik sistem analizi ve Labview tabanlı MPPT simülasyonu, *Yüksek Lisans Tezi, Gazi Üniversitesi, Fen Bilimleri Enstitüsü, Ankara*.

Karaköse, E. A. M. ve Akın, E., Elektrik ve Bilgisayar Mühendisliği Eğitiminde Sanal Laboratuvarların Kullanımı, *Elektrik Elektronik Bilgisayar Mühendislikleri Eğitimi1. Ulusal Sempozyumu*, 166-169.

Karami, N., Moubayed, N. ve Outbib, R., 2017, General review and classification of different MPPT Techniques, *Renewable and Sustainable Energy Reviews*, 68, 1-18.

Kulaksız, A. ve Akkaya, R., 2003, Maksimum güç noktası izleyicili foto voltaik güç sisteminin mikro denetleyici tabanlı kontrolü, *Yeni ve Yenilenebilir Enerji Kaynakları Sempozyumu, Kayseri-Türkiye*, 53-61.

Kulaksiz, A. A., ALHAJOMAR, F. ve GOKKUS, G., 2019, Rapid Control Prototyping based on 32-Bit ARM Cortex-M3 Microcontroller for Photovoltaic MPPT Algorithms, *International Journal of Renewable Energy Research (IJRER)*, 9 (4), 1938-1947.

Kulaksız, A. A., 2007, Maksimum güç noktası izleyicili ve UVM inverterli fotovoltaik sistemin yapay sinir ağları tabanlı kontrolü, *Selçuk Üniversitesi Fen Bilimleri Enstitüsü*.

Masoum, M. A., Dehbonei, H. ve Fuchs, E. F., 2002, Theoretical and experimental analyses of photovoltaic systems with voltageand current-based maximum power-point tracking, *IEEE Transactions on energy conversion*, 17 (4), 514-522.

Mertens, K., 2018, Photovoltaics: fundamentals, technology, and practice, John Wiley & Sons, p.

Motahhir, S., Chalh, A., Ghzizal, A., Sebti, S. ve Derouich, A., 2017, Modeling of photovoltaic panel by using proteus.

Motahhir, S., Chalh, A., El Ghzizal, A. ve Derouich, A., 2018, Development of a low-cost PV system using an improved INC algorithm and a PV panel Proteus model, *Journal of Cleaner production*, 204, 355-365.

Mühendis, A. ve Kulaksız, A. A., 2019, LabVIEW Based Monitoring System Applied for Virtual Photovoltaic Modules Characteristics, 2nd International Instructional Technologies in Engineering Education Conference (2nd IITEEC 2019), İzmir.

Mutoh, N., Matuo, T., Okada, K. ve Sakai, M., 2002, Prediction-data-based maximum-power-point-tracking method for photovoltaic power generation systems, *2002 IEEE 33rd Annual IEEE Power Electronics Specialists Conference. Proceedings (Cat. No. 02CH37289)*, 1489-1494.

nath Naidu, B., 2016, Voltage based P&O algorithm for maximum power point tracking using labview, *Innovative Systems Design and Engineering*, 7, 12-16.

ONAT, N. ve ERSÖZ, S., FOTOVOLTAİK SİSTEMLERDE MAKSİMUM GÜÇ NOKTASI İZLEYİCİ ALGORİTMALARININ KARŞILAŞTIRILMASI.

Pociask-Bialy, M. ve Maciejko, R., 2018, QuickSun 830A module solar simulator. Study of mini PV modules, *E3S Web of Conferences*, 00083.

Sumathi, S., Surekha, P. ve Surekha, P., 2007, LabVIEW based advanced instrumentation systems, Springer Berlin, p.

Tariq, A. ve Asghar, M. J., 2006, Development of microcontroller-based maximum power point tracker for a photovoltaic panel, *2006 IEEE Power India Conference*, 5 pp.

Velkovski, B. ve Pejovski, D., 2016, Application of Incremental Conductance MPPT method for a photovoltaic generator in LabView, *Poster 20th International Student Conference on Electrical Engineering*, 1-6.

Xiao, W. ve Dunford, W. G., 2004, A modified adaptive hill climbing MPPT method for photovoltaic power systems, *2004 IEEE 35th annual power electronics specialists conference (IEEE Cat. No. 04CH37551)*, 1957-1963.

Yahfdhou, A., Mahmoud, A. ve Youm, I., 2013, Modeling and optimization of a photovoltaic generator with Matlab/Simulink, *International Journal of I Tech and E Engineering*, 3 (4), 108-111.