Solar Panels Characteristic Determining Circuit Design and Implementation

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***Abstract*— In this study, a circuit design was realized in which the characteristics of the panels can be determined by determining the instantaneous values of+ the MPPs of four different solar panels. The design of the circuit was implemented in the Proteus circuit program. The maximum power point tracking (MPPT) algorithm was implemented using the PIC18f4520 microprocessor. The connection of each panel to the designed circuit was carried out using relays. Four different solar panels connected to designed circuit with using three relays. The MOSFET was used as a load for measuring current and power values of the panels. Thus, high power measurements were made with a MOSFET using as a load. It also covered little space in the designed circuit system. So instantaneous current, voltage and power values of four different solar panels measured with designed characteristic determining circuit.**

***Keywords*— Solar Panel, Microcontroller, PV Characteristic, Control**

I. INTRODUCTION

The energy need has always been one of the essential requirements in the lives of human beings. Today, the vast majority of the energy produced is from fossil fuels. These resources are limited and the negative effects on the environment. For this reason, the interest in renewable energy sources has been increasingly observed day by day. Solar energy is at the top of renewable energy sources today. Photovoltaic systems are the commonly used in the world wide for producing electrical energy. Installations of solar panels have been growing at a very high average annual rate around the world [1,2].

In photovoltaic panels which is consist of lots of solar cells. The solar cell allows to converting sunlight into electricity. Solar panels average lifetime is 10-15 years according to using environmental conditions. Generally solar panels well-known reliability but some solar panels degrade or even fail when operating outdoors for extended periods [3-5]. At the solar panels Current-Voltage (I-V) characteristics are usually used for the degradation determining. Parameters obtained from this testing process. These parameters can be short-circuit current (ISC), open-circuit voltage (VOC), maximum power (Pmax) and fill factor (FF=Pmax/ISCVOC). At the same time, the I-V characteristics can be determined and to compare the actual power produced by solar panel under outdoor operating conditions. The one of the most important issue in the solar panels is to determine the how much the panel produced the energy [6]. I-V characteristics generally used by designers in power converter systems, also it is used in solar panel systems design. Hence these systems can be created more cost effective. The characteristic (I-V) and parameters of solar panels are provided by the manufacturers. However, the outdoor operating conditions are different from the manufacturers data. So,behaviour and performance of photovoltaic modules is determined according to these data. Therefore, determining the I-V characteristic is crucial.

Generally solar panels I-V curve obtained with using resistor type of load. Panels load with resistor so it is used for collecting momentary current and voltage change values and extracting the I-V curve. Also, solar panels can be tested with different types of methods. A simple variable resistor was used for solar panel testing process [7]. Each point of the I-V curve was obtained by varying the resistor from zero to infinity. The accuracy of this type of load is low, because the change of charge can be done manually. Therefore, the use of such methods is not sustainable.

Electronic DC loads are commonly used for solar panel testing process. The load can vary over the entire range in a very short time. However, these systems are expensive. Also, it is possible to design an electronic DC load using quite simple and much cheaper circuits. Power MOSFETs can be used for as a electronic load for these type of applications [5]. In fact, a power MOSFET operating in the active region can be used as an electronic load to test PV modules [8] – [12].

In this paper, a circuit design is realized in which current, voltage and power values of four different solar panels can be determined at the same time. Thus, the system in which the I-V curve of four different panels can be extracted is tested and operated. When the work done is examined, it is observed that there are no studies that can distinguish the characteristics of four different solar panels at the same time. MOSFET is used for load task in circuit design. MOSFET is used as a MOSFET resistor by driving it in liner mode. Thus, the values of the panel in the 250W power are determined by the MOSFETs used as resistors. In this way, an electronic card and system design has been realized which is less costly and takes up less space in the system.

A. MOSFET Linear Mode Operation

The MOSFETs are mainly used in switching applications such as DC/DC converters and motor control using pulse width modulation (PWM). The MOSFETs can be operated in the cut-off, linear, or saturation region according to applying relative voltages of its terminals [13].

MOSFET is not a very popular application to use as a load. The SOA (Safe Operating Area) chart needs to be consulted in order to determine the MOSFET working capacity as a load [14].

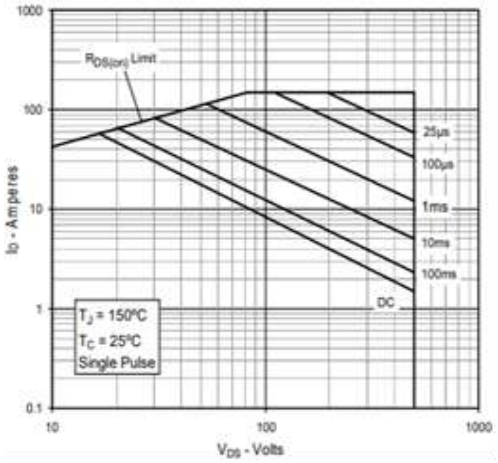

Fig 1. IXTK60N50L2 Safe Operating Area [15]

For instance, for a 10ms wide pulse, a MOSFET could support 100V from drain to source with nearly 25A flowing through it. This equates to a power dissipation of 2500W.

In Figure 1, static DC operation area limits determined as "DC" named line. The use of the MOSFET as a load is more secure in this region. In case of continuous operation in linear mode, the MOSFET's R_{DS}(on) and dynamic parameters are irrelevant to judge power dissipation. This situation is the simplest condition where the MOSFETs are fully enhanced (switched ON). The MOSFET with the lowest R_{DS}(on) takes the highest proportion of the current and dissipates the most power on the MOSFET. (power dissipation $P = V_{DS} \times I_D$).

The designed electronic circuit system was tested in four solar panels system shown in Figure 2 and data were taken.

Fig 2 Four Solar Panels

It is seen that the characteristic determining circuit. was kept at the back of the installed system by created closed area in Figure 3.

Fig. 3 Solar Panel Characteristic Determining Circuit and Solar System

Prepare your paper in full-size format on US letter size paper (8.5 by 11 inches).

B. PCB Design with Using SMT and Through Hole Technique

Healthy and long-term operation of designed circuits may vary according to the production type. It is also important that the designed circuit for continuous and long-term operation as well as its operation. Circuit components were classified based on their mounting style. There are two types mounting techniques at industrial designs for continuous and smoothly operation of electrical circuits. Through hole and surface mounting techniques are commonly used. SMT has helped significantly in solving the space problems that were commonly noticed with the Through Hole mounting. Also, EMI (Electromagnetic Interference) effect can be decreased with using SMT. The characteristic determining circuit's designed circuit view is shown in Figure 4. Real-time designed PCB card can be seen at Figure 5. Complete designed circuit system is given at Figure 6. Also, MOSFET load is shown at the system with red arrow.

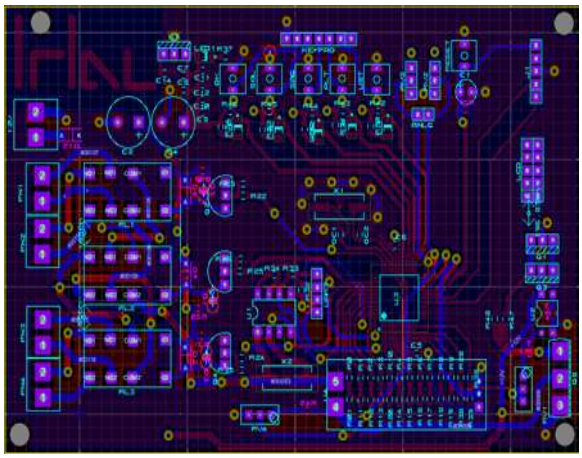

Fig 4 Solar Panel Characteristic Determining Circuit Proteus ISIS Designed Circuit

Fig 5 Solar Panel Characteristic Determining Circuit Proteus ARES Designed Circuit Top View

Fig 6 Implemented and Tested Solar Panel Characteristic Determining Circuit

C. Experimental Results and Discussion

Current voltage and power values of solar panels were taken instantaneously. These values are shown in Figure 7. In the designed system, the values of each solar panel are shown. Finally, the power values of all the panes are reflected on the LCD screen together. As seen in Fig. 7, the power values of the solar panels are 40.34, 41.26, 40.34, 40.89W respectively. Low power values were obtained due to the cloudy weather during the measurement. The current, voltage and power values of each solar panel measured instantaneously are given in Table 1.

Fig 7 Measured Power of Solar Panels

Table1. Measured Volt, CurrentandPowerValues of Solar Panels

Measured Variables	Solar Panel 1	Solar Panel P2	Solar Panel P3	Solar Panel P4
Volt (V)	30,65	26,87	30,65	31,07
Current (A)	1,31	1,53	1,31	1,31
Power (W)	40,34	41,26	40,34	40,89

At the same time, current, voltage and power values of four different solar panels can be determined. The study is unique in terms of determining the characteristics of multiple panels at the same time. Progressive work may include the ability to collect and store data that is designed for the circuit. In this way, the data of four solar panels can be gathered and the characteristic curves of the solar panels can be easily obtained.

II. CONCLUSIONS

This paper has presented a solar panel characteristic determined robust electronic circuit. Current and voltage values have to be known for determining solar panel characteristic. This circuit allows measuring four different solar panels current and voltage values. Hence four solar panels characteristic can be determined at the same time. Electronic circuit is based on simple, low-cost and widely used components. The characteristics of PV modules are traced using a power MOSFET as an electronic fast varying load controlled by means of an optimized sweeping gate-source voltage, which consists of a rectified sinusoid with variable.

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