INTERNATIONAL JOURNAL of RENEWABLE ENERGY RESEARCH
S. Hesari , Vol.6, No.4, 2016

Design and Implementation of Maximum Solar Power Tracking System Using Photovoltaic Panels

Sadegh Hesari

* Young Researcher and Elite Club, Bojnourd Branch , Islamic Azad University , Bojnourd, Iran

(Hesari.sadegh@yahoo.com)

‡ Corresponding Author; Sadegh Hesari, Tel: +98 9152549200, Hesari.sadegh@yahoo.com

Received: 22.05.2016 Accepted: 28.06.2016

Abstract- The aim of this paper is to design and construct a solar photovoltaic system that can receive a maximum power from sun. Two solar panels, two stepping motors and one Atmega IC were used in this design. One of the panels rotates 200 steps in a complete round and 200 voltage samples are received from the stepping motor to be carried to the main panel, which commands the best movement toward the best position. Maximum power point tracking (MPPT) has been conducted using an online method. As such, the proposed system has also been tried via MATLAB software. The simulation results confirm the proposed approach.

Keywords: Solar Panel, Stepping Motor, Maximum Power Point Tracking (MPPT).

1. Introduction

Solar energy, as a green energy resource, can be used to supply many energy usages in the form of thermal and/or electric energy. Given the increased cost of energy obtained from fossil fuels, as science and technology progress, the cost of energy production using renewable energies decreases and approaches economic efficiency [1-3]. Solar energy enjoys a host of advantages including worldwide availability and numerous applications in various fields[10,11]. The Sun is the biggest and the only energy source for earth, the energy emitted from which is used in different ways in order to supply the usages that otherwise were supplied by fossil and non-fossil fuels. Various methods have been proposed in maxim power point tracking in order to achieve the maximum energy from solar panels, including: 1) offline methods such as: Open Circuit Voltage (OCV) [3], Short-Circuit Current (SCC) [4], and 2) online methods such as perturbcance and observation (P&O)[9-10], Extremum-Seeking Control (ESC) method and IncCond method; and 3) Hybrid methods.

One of the disadvantages of offline methods is their power loss, because in both OCV and SCC methods there is a need to stop the load on solar panel. This can lead to power loss.

In online methods[11,12], P&O method suffers from two main disadvantages: first, in this algorithm, the employed perturbation range in the system is the main factor of variation in both oscillations and the output power convergence rate, in which a higher perturbation leads to a higher oscillation range and if the perturbation is low, the oscillation range around MPP reduces to minimum but the convergence rate will continue to reduce. Second, if the working variations in the system is fast, the algorithm can lead to an error in tracking.

ESC method does not have the disadvantages of P&O method, but its implementation is very complex and its evaluation signal has a small range [1].

IncCond method is an effective method under high speed and environmental variations. However, its main disadvantage is that this method requires complex control circuits.

In hybrid methods the control signal is connected to two parts and each part is placed on an independent algorithm loop: the first part is associated with the offline part, determined by environmental conditions of the problem such as light intensity and temperature, and the second part is conducted using online tracking method.

In this paper both the environmental conditions of the problem and the control section have been designed through an online method. The basics of the system, the control part, stepping motor, ATmega IC and the simulation results are presented in the next sections. The last section concludes the paper.

2. Basics of the System

The photovoltaic system used in this paper is consisted of: 1- solar panel; 2- stepping motor; and 3- controlling board. The proposed approach in this paper is presented in figure 1.

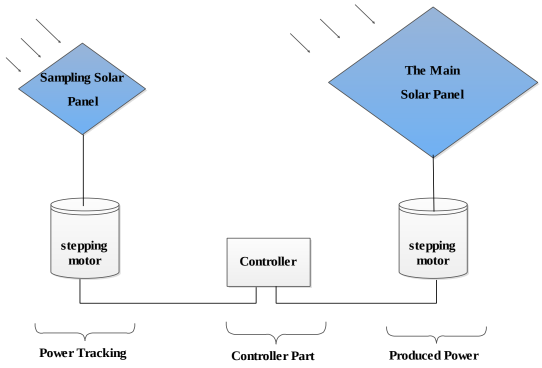


Fig.1. The photovoltaic system used in this paper

2.1. The control part

It can be said that the most important disadvantage of solar panels is their high initial price, and its energy production is similar to other methods such as wind energy [8]. Therefore, maximum power point tracking for optimal condition in PV systems is of utmost importance. In order to achieve MPPT in PV systems, the terminal voltage in PV (or current) is regulated using a control signal. As it was mentioned in previous section, there are various methods to achieve MPPT, including offline, online and hybrid methods [1,9]. In this paper, an online method has been used. Figure 2 shows the flowchart of the proposed approach.

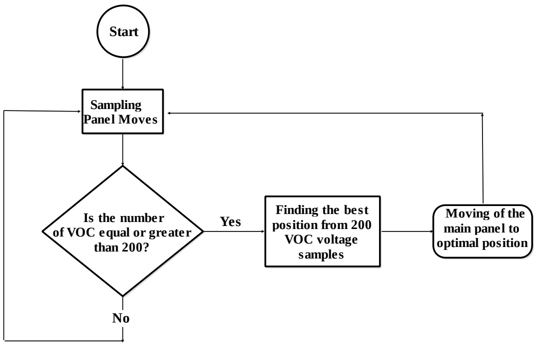


Fig.2. The flowchart of the proposed control

The flowchart presented in figure 2 is explained as the following:

First, the sampling panel (fig.1) starts tracking and 200 VOC voltage samples are measured in a complete cycle; then in the control process with ATmega 32 IC the best position out of the 200 voltage samples are found and the command of the best position in terms of the number of steps, movement, and direction is given to the motor with a bigger solar panel (see fig.1). This cycle is repeated consecutively and in an online manner in order to find the best position of the solar panels. Fig.8 shows the proposed system.

2.2. Stepping motor

Stepping motor can be used for displacing, moving, position determination and many more functions where an accurate control over the position of a shaft, leverage, etc. is required. Stepping motor is a multifunctional device which converts electrical pulses into mechanical movements and is used in many devices including discs, matrix choppers and robotics. Each stepping motor has a movable permanent magnetic core called rotor, and is surrounded by a fixed part called stator [5, 6]. Fig.3 shows a general stepping motor which has four stator coils and a center tapped coil.

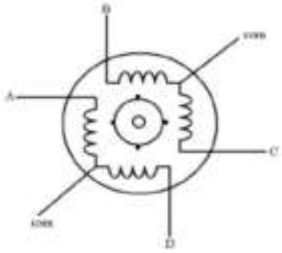


Fig.3. interior structure of a stepping motor

The performance of a stepping motor is similar to that of a DC motor, although the only difference is in their shaft movement. As it can be seen in fig.3, a stepping motor has six coils, four of which are used for four stator coils and there are two center tapped coils (in most motors these two tapped coils are connected internally and as a result the motor has five coils). When a pulse is applied to each coil, the motor starts moving. For a stepping motor, usually the following pulses should be applied to each coil.

Table 1. The applied pulses to each coil

Motor Direction	A	B	C	D	Motor Direction	A	B	C	D
Clockwise	1	0	0	0	Anticlockwise	0	0	0	1
	0	1	0	0		0	0	1	0
	0	0	1	0		0	1	0	0
	0	0	0	1		1	0	0	0

Therefore, in order to gain an appropriate performance from stepping motor coils, they should be fed appropriately. This means that when using a stepping motor, not only the electrical characteristics of the device should be known, but also its mechanical characteristics should be recognized [7]. When a pulse is applied to one of the coils, the motor moves one step. Table 2 shows the number of pulses that should be applied to each motor with a specified step angle. For example, the number of pulses to be applied on a motor with 1.8 step angle to rotate a complete round is 200.

Table 2. The step angle for some step numbers in a round

The number of steps in one round	Step angle
500	0.72
200*	1.8
48	7.5
24	15
4	90

In this paper, 200 steps with an angle of 1.8 are considered.

In order to control the motor we need capabilities such as forward and backward movement, speed control, current control and immediate suspense of motor, which are provided easily in L298 drive. This IC is consisted of 15 legs and can implement tasks such as forward and backward motor rotation, speed control, current control and immediate suspense of motor. One leg is used to determine the rotation direction (clockwise vs anticlockwise). Fig.4 shows the control circuit of L298 IC driver.

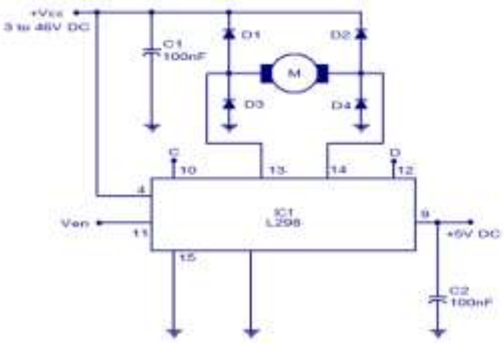


Fig.4. Control circuit of L298 IC driver

2.3. *ATmega IC*

This IC is programmed by BASCOM software and is assembled in the system hardware. In appendix, the proposed algorithm for finding the best position by ATmega 32 IC is presented. A variable called Direct is defined, which at first is equal to zero in order for the sampling panel to rotate clockwise when it is mounted on the stepping motor. If Direct equals 1, the motor starts rotating in an anticlockwise direction. In order to detect the direction one should go in Orient part, if the Sample-step variable is bigger than the previous step then they are deduced and the result is put in value-1 variable in order for the motor to rotate according to this value in an anticlockwise direction. If Sample-step variable is smaller than the previous step then their difference is put in value-1 variable and the motor will rotate in clockwise direction. Sub-programs such as move-main and move-smale are defined for the sampling motors and motors carrying the main panel.

3. The Simulation Results

We tested the proposed system structured in fig.8 for 7 hours (from 9 AM to 4 PM) with an irradiance of 1000 in North-East of Iran. Using a voltmeter the voltage of the main panel was measured every 30 minutes, which is summarized in fig.9.

The control model of this system is also designed by MATLAB software and is partitioned as the following:

1) Produce 200 random VOC voltage samples between 3 and 6 volt for the sampling panel (this stage tracks the voltage for the sampling panel)

2) Compare the produced 200 random voltages

3) Finding the best position (in the algorithm the positions are specified from 1 to 200)

4) Move the main panel to the best position found in stage 3

5) Return to stage 1

This program is conducted by considering three irradiation intensity (G). Table 3 shows the characteristics of the used paned. We have tried to show the effect of irradiance on this solar panel in MATLAB software part.

Table 3. The characteristics of the panel

1.Model Number: 0.6 w , 6v

2. Material: Monocrystalline Silicon

3. Number of Cells: 12

4. Max.Power: 0.6 w

5. Max.Current: 100 mA

6. Max.Voltage: 6 v

7. Short Circuit Current: 110 mAh

8. Tolerance Current: ± 10 %

9. Cell Efficiency: 15%

In figures 5 to 7 the results obtained from the simulations in MATLAB software are presented.

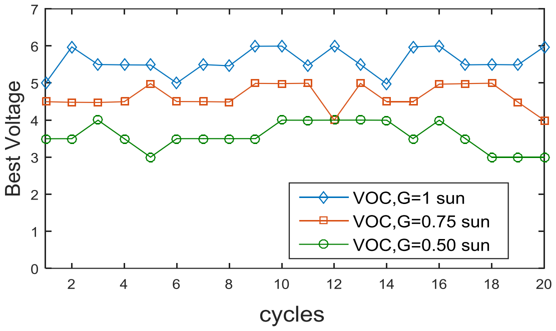


Fig.5. Optimum voltage tracking with 20 cycles

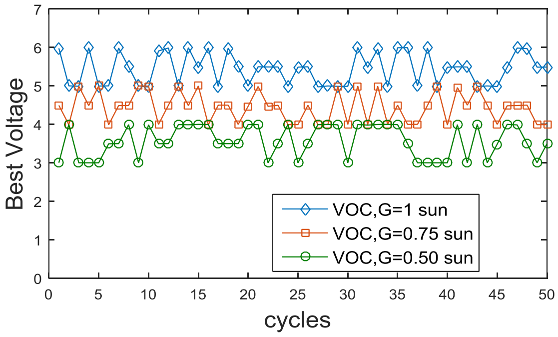


Fig.6. Optimum voltage tracking with 50 cycles

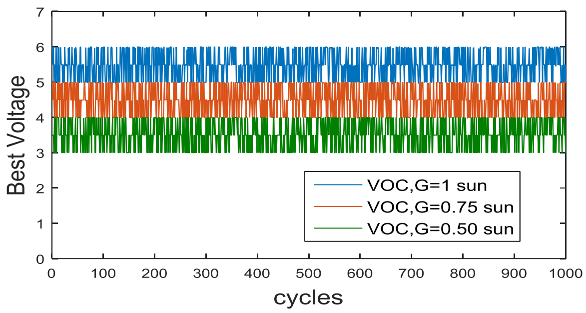


Fig.7. Optimum voltage tracking with 1000 cycles

It can be observed in figures 5 to 7 that when the irradiation intensity reaches its maximum, the panel voltage shows a higher value and can produce more power than lower irradiation intensities such as 0.75 and 0.5. The number of trackings are considered to be equal to 20, 50 and 1000 in MATLAB software. As it can be seen in the pictures, the maximum voltage tracking as a result of maximum power is achieved easily.

Fig.8. The maximum power point tracking hardware

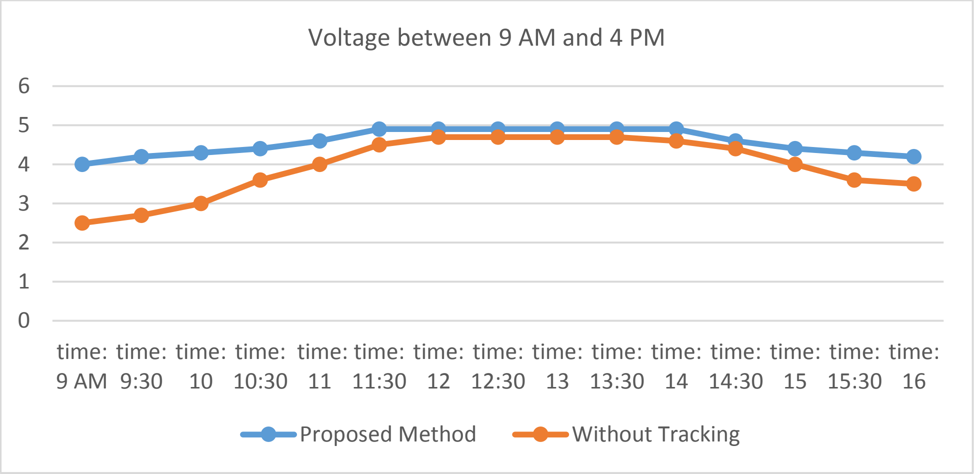


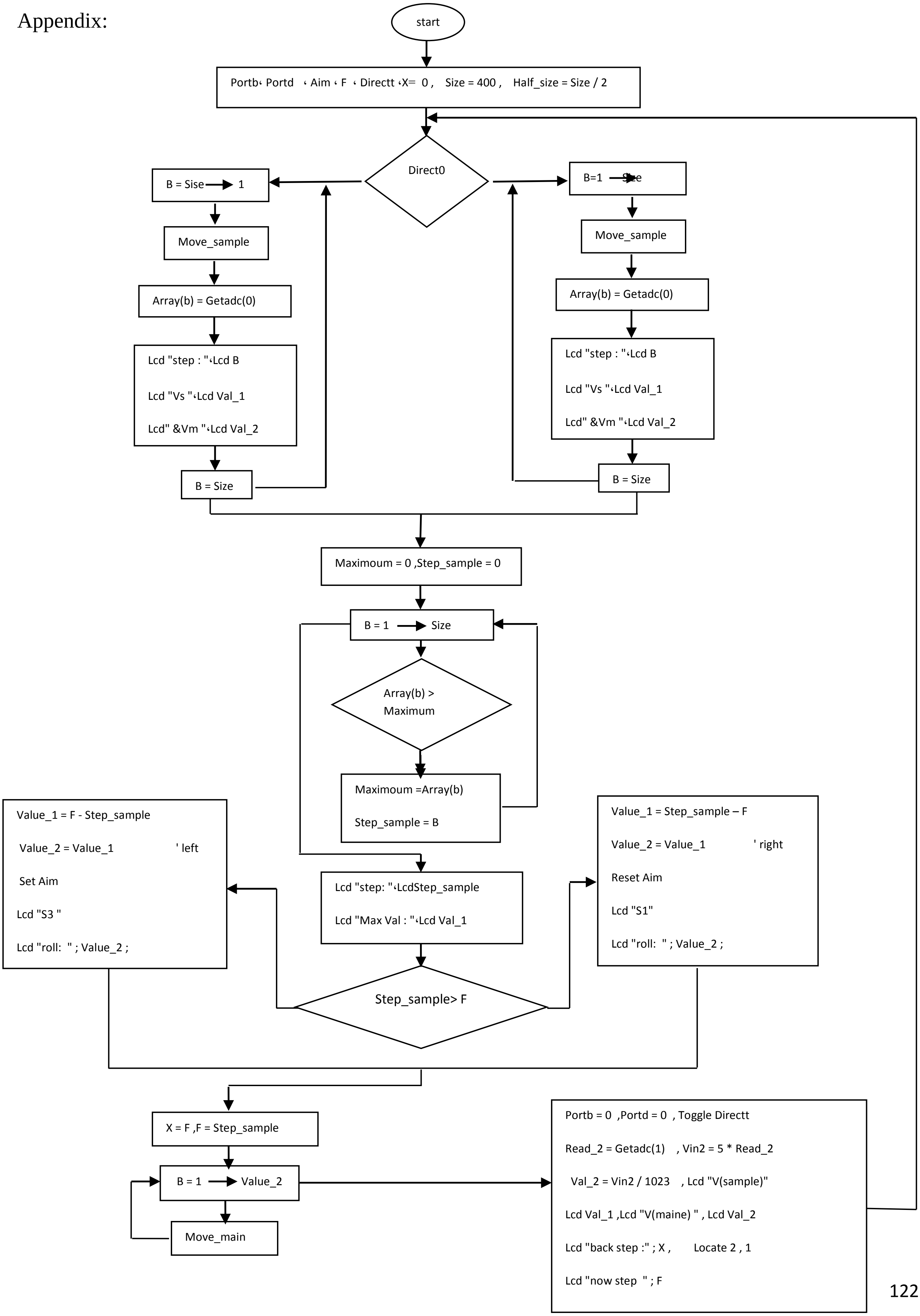
Fig.9. The proposed system voltages between 9 AM and 4 PM

Figures 8 and 9 show the experimental system model and its results, respectively. 15 points were tested during 7 hours, from 9 AM to 4 PM. The voltage of every mode was measured by a voltmeter. Figure 9 provides the results of these tests. Also, the proposed system was compared to the system without tracking. It was observed that, compared to the system without tracking, the proposed system enjoys a better condition in most of the tested hours.

4. Conclusion

In this paper a system is proposed to track the maximum power from solar energy. As it was observed in the hardware system (fig.8), the system used two solar panels, one served as an online sun tracking and the other as the power producer. The proposed system is very cheap, because it uses electronic devices and is easily applicable in large scales. The proposed approach was also tested by MATLAB software and worked well. The results of three irradiation intensity were compared and an optimum tracking was achieved in each of them.

Appendix:


start
Portb، Portd ، Aim ، F ، Directt ،X= 0 , Size = 400 , Half_size = Size / 2
Direct0
B = Sise → 1
Move_sample
Array(b) = Getadc(0)
Lcd "step : "،Lcd B
Lcd "Vs "،Lcd Val_1
Lcd" &Vm "،Lcd Val_2
B = Size
B=1 → Size
Move_sample
Array(b) = Getadc(0)
Lcd "step : "،Lcd B
Lcd "Vs "،Lcd Val_1
Lcd" &Vm "،Lcd Val_2
B = Size
Maximoum = 0 ,Step_sample = 0
B = 1 → Size
Array(b) > Maximum
Maximoum =Array(b)
Step_sample = B
Value_1 = F - Step_sample
Value_2 = Value_1 ' left
Set Aim
Lcd "S3 "
Lcd "roll: " ; Value_2 ;
Lcd "step: "،LcdStep_sample
Lcd "Max Val : "،Lcd Val_1
Value_1 = Step_sample – F
Value_2 = Value_1 ' right
Reset Aim
Lcd "S1"
Lcd "roll: " ; Value_2 ;
Step_sample> F
X = F ,F = Step_sample
B = 1 → Value_2
Move_main
Portb = 0 ,Portd = 0 , Toggle Directt
Read_2 = Getadc(1) , Vin2 = 5 * Read_2
Val_2 = Vin2 / 1023 , Lcd "V(sample)"
Lcd Val_1 ,Lcd "V(maine) " , Lcd Val_2
Lcd "back step :" ; X , Locate 2 , 1
Lcd "now step " ; F

References

[1] Ali Reza. Reisi and Mohammad Hassan. Moradi, Shariar Jamasb "Classification and comparison of maximum power point tracking techniques for photovoltaic system". elsevier, pp. 433-443, 2013.

[2] Francisco M. Gonzalez-Longatt, "Model of photovoltaic Madual in Matlab," 2DO CONGRESO IBEROAMERICANO DE ESTUDIANTES DE INGENIERÍA ELÉCTRICA, ELECTRÓNICA Y COMPUTACIÓN, 2005.

[3] Harf. GW and Branz. HM and Cox.CH "Experimental tests of open-loop maximum power point tracking control system" .solar cells 1984;13:185-95

[4] Noguchi T. Tagashi, S. Nakamoto R "short –current pulse-based maximum-power-point tracking method for multiple photovoltaic and converter module system", IEEE Transactions on Induction Electronics 2002;49(1):217-23.

[5] Gregory S. Chirikjian, David Stein," Kinematic Design and Commutation of a Spherical Stepper Motor", IEEE/ASME TRANSACTIONS ON MECHATRONICS, VOL. 4, NO. 4, DECEMBER 1999.

[6] Benetta Aranjo, Prashant Kumar Soori, and Puja Talukder,"stepper motor drives for robotic applications", IEEE,2012.

[7] I. C. Stica, L. Krindler, A. Sarca," A Robust Method for Stepper Motor Stall Detection", 8 International Symposium on advance topic in electrical engineering , May 23-25, 2013, Bucharest, Romania.

[8] Hassan Fathabadi, "Novel high accurate sensor-less dual-axis solar tracking system controlled by maximum power point tracking unit of photovoltaic systems ", Applied Energy , Volume 173, 1 July 2016, Pages 448–459.

[9] S. Saravanan, Ramesh BabuN," Maximum power point tracking algorithms for photovoltaic system – A review", Renewable and Sustainable Energy Reviews, Volume 57, May 2016, Pages 192–204.

[10] Mohamed A. Enany n, Mohamed A. Farahat, AhmedNasr." Modeling and evaluation of main maximum power point tracking algorithms for photovoltaic systems", Renewable and Sustainable Energy Reviews, Volume 58, May 2016, Pages 1578–1586.

[11] Deepak Verma, Savita Nema, A. M. Shandilya, Soubhagya K. Dash," Maximum power point tracking (MPPT) techniques: Recapitulation in solar photovoltaic systems", Renewable and Sustainable Energy Reviews, Volume 54, February 2016, Pages 1018–1034

[12] A. Kheldouna, R. Bradaib, R. Boukenouic, A. Mellit,"A new Golden Section method-based maximum power point tracking algorithm for photovoltaic systems ", Energy Conversion and Management, Volume 111, 1 March 2016, Pages 125–136.