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Smart Detection of Sunlight using Arduino on Solar Power Systems

Supriyono*, Hassan Khamis Hassan, Marwan Effendy
Department of Mechanical Engineering, Universitas Muhammadiyah Surakarta, Jl. A.Yani Surakarta, Surakarta 57102, Indonesia

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Abstract:
Sunlight is an environmentally friendly energy source, which has great potential for use as an alternative renewable energy source in overcoming the energy crisis in the future, mainly in tropical countries. This paper presents an automatic solar tracking system that uses Arduino UNO to demonstrate the production of daytime energy from sunlight. A small prototype with the ability to rotate up to 180 degrees on the horizontal and vertical axes has been successfully fabricated in order to realise the experiment. The system was equipped with four sensors to track sunlight movement. By using the Arduino UNO program as a basis for the solar tracking, in terms of the power gained,the system managed to maintain a high percentage with an average of 58%.Thesefindings show that the systemis more trackable and can increase power efficiency in the exploitation of sunlight.

Keywords: *Arduino UNO, Solar panel, Micro servo motor MG995, and LDRsensor.*

I. Introduction

Some writing shows contrasts in sun based following whereas-many contemplates center around various breadths, including-the work by Ghanaian and Sundaramurthy[1].In their paper they suggested a strategy by which it was conceivable doing monitoring of full measurement of intensity delivered by a sun based board by accepting high-power daylight utilizing an Arduino board.

A model has been made with two Arduino boards,one of which was utilized to interface each sunlight based board with a PC for information procurement and the other with the servomotor. Moreover,Jain and Jain[5] proposed a sun oriented following framework with an Arduino UNO micro-controller board rather than regular sunlight based boards, especially one mounted with a micro-controller-based following framework that produces upgraded yield.

This tracker doing utilization of declination-clock mounting framework that finds the essential hub in the east-west direction.Based on this mounting framework, an ordinary following procedure and every day modification methodology were produced for level photo-voltaic and concentrating sun oriented power frameworks separately. Findings-indicate that the normal vitality productivity of typical following Polycythemia Vera surpassed 23.6% contrasted with fixed Polycythemia Vera, while the normal proficiency of every day balanced Polycythemia Vera was over 32%. This investigation uncovered that twofold hub sun oriented track as polar-pivot and azimuth/rise including sun powered development models, while the dynamic shut circle input control was the most effective,generating over 40% of vitality return instead of fixed Polycythemia Vera boards.

Different improvements of a double pivot following framework dependent on an open-circle framework where the tracker works on numerical figuring as indicated by the sun's geometry to foresee the precise clear position of the sun were accomplished. The controller targets expanding the sun oriented Polycythemia Vera cell's proficiency by compelling daylight to be occurrence oppositely to the Polycythemia Vera-board at all times.The recreation study demonstrated dependable execution of the proposed following framework.

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At the end,it was discovered that the programmed sunlight based tracker caught greatest sun powered power with the assistance of the micro-controller both in great and awful climate conditions. In addition, three places of the Polycythemia Vera board were considered, which were ordinary , tilted fixed and even. Henceforth, so as to improve the ideal intensity of the framework, it is prescribed to utilize an Arduino program that can catch daylight by trailing the way of the sun with a light-needy resistor.

II. EXPERIMENT

2.1 Solar tracking system setup

Figure 1(a) is a square graph of a sun based following framework which was masterminded by a program that sends sign to the Arduino UNO, at that point promptly advances the sign to a small scale servo engine MG995 driven by a LDR sensor. The small scale servo engine MG995 works the framework as indicated by the touchy LDR following light from the sun which makes the sun oriented board pivot. Therefore, the higher the force of the light got by the LDRsensors, the more volts produced by the sensors and the more dynamic the following framework. On the other hand,[13] presents a sun oriented following technique to control photovoltaic board movementsso as to improve the transformation productivity of the system.The planned calculation was actualized on a sunlight based following exploratory stage utilizing a tri-positional control methodology, utilizing estimated values for radiation from fitting sensors and guaranteeing direction of the stage's two situating engines. The arrangement was formed into a virtual instrument utilizing the graphical programming condition LabVIEW, which speaks to control calculation directions of PV developments so as to pursue the sun's radiation while amplifying sun powered vitality.

On an alternate note,[14]discussed the structure and usage of a two-pivot PV sun tracker utilizing a mix of an open-circle following system with a chip, in which the controller depended on a sun based development model, and a shut circle procedure which relates to an electro-optical controller. The momentary power created by the clusters was estimated by a sensor that discharged a sign relative to the power. In the end, a relative and indispensable (PI) control system was executed for every coordination freely. Meanwhile,[15]denotes the plan, usage, and testing of a half breed double hub sun oriented following framework in contrast with the presentation of both static and ceaseless double hub sunlight based following frameworks. Furthermore, [16] structured a sun powered following framework with a mirror sponsor utilizing a microcontroller to utilize sunlight based vitality and to amplify the productivity of the sun powered following framework.

Figure 1(b) portrays segments of the reenactment of the Arduino program for the telling Arduino code composed with the Arduino programming to confirm work in activity in order to ensure no mistake. In such manner, Proteus affirmed that the framework was working reliably. A comparative reproduction origination was completed by[17] utilizing Proteus programming to mimic the code and judge whether the real framework can proceed according to desires.

Arduino UNO is a microcontroller board dependent on ATMEGA328. It has 14 advanced information/yield pins, six simple sources of info, a 16 MHz precious stone oscillator, a USB association, a power jack, an ICSP header, and a reset catch. A few investigations commented on the utilization of Arduino as a fundamental program to follow daylight, among which was [18]that utilized Proteus programming joined with two sections, an Arduino Uno microcontroller and H-Bridge IC which was utilized to control the engine, and composed an Arduino program as a methodology in utilizing LDR to detectsunlight by following the area of the lightsource. Finally,[19]introduces a model of a programmed sun oriented tracker that was intended to utilize Arduino UNO with a breeze sensor to check wind consequences for boards in order to see whether wind speed surpasses a specific edge.

Indisputably, the engraving project of the sun

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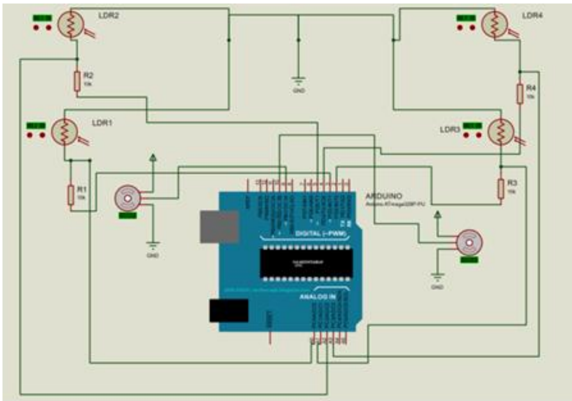
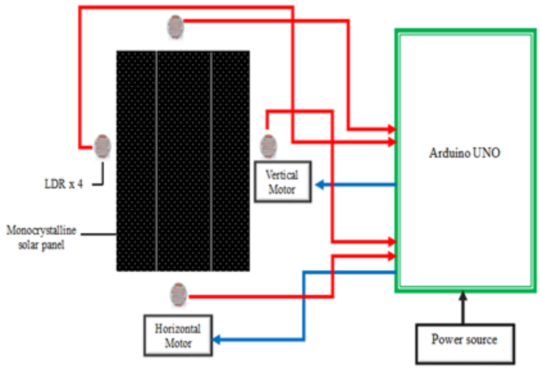
powered following framework was the main critical advance in making a thought for the Arduino program. The Arduino program was considered to make the framework simpler to apply and to distinguish the daylight way more promptly.



(a) Block diagram



(b) Components

FIGURE 1: Diagram of solar tracking system

2.2 Solar tracking model design

Figure 2(a) portrays an establishment model structure of a sun oriented following system.The sun based board is mounted on an engine which thus is mounted on a casing. The planned model was organized by the measurement and weight of the sun powered paneland those of the miniaturized scale servo engine MG995. Past establishments, for example, [20]involved a programmed sun powered following framework which was created to decrease unpredictability and chop down expenses while contemplating high productivity with lower costs. [21] This paper displays the demonstrating, recreation and equipment execution of a sunlight based following framework that utilizing bond diagram approach. In this work, the plan and advancement of a high-effectiveness double hub sunlight based following framework utilized another algorithmic method to follow the greatest power point . Because of the trial, the power created by the proposed following framework had a general increment of about 55% more than by a static sunlight based board in bright days and about 55% under incompletely concealed conditions. [22] The plan was expected to lessen establishment costs by tying down the following framework to the ground, and to improve pressing thickness by making a littler shadow impression than that of a traditional pole type following framework.

Figure 2(b) shows a model made with parts introduced and fixed inside, including-an Arduino board and different segments that-make the sun oriented tracker work sequentially. .Each board had been associated with an obstruction type load which was equivalent to the trademark opposition (40 Ω) in agreement withheld board's datasheet at standard working conditions .

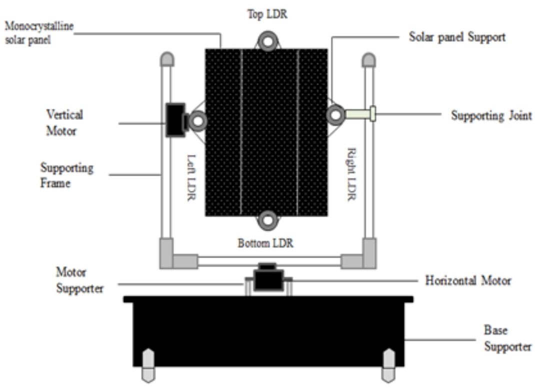
On a comparative note, [24]introduced the genuine model of a task which had the accompanying highlights: (a) a 12/24Vdc sun oriented charge controller that shields the framework from over-burden, cut off, voltage and over-charge- at temperatures running from 20 to 60 degree Celsius, (b) double usefulness of politeness switches for manual tilting of the engine and adjustment of the LCD clock, and (c) improved nano-watt innovation that decreases control utilization during-operations.

Models in [25] were-also arranged with an Arduino controller which regulated-the following system by talking with its and a stepper motor driver concerning the advancement of sun situated radiation. In the mean time, [26]evaluated the introduction of dynamic, successive, and hybrid figuring for sun put together after assessments with respect to splendid and obscure days. The sun arranged tracker was arranged in an open field where it could get sunlight for the span of the day. Voltage measurements-were taken from 8 a.m. to 7 p.m.

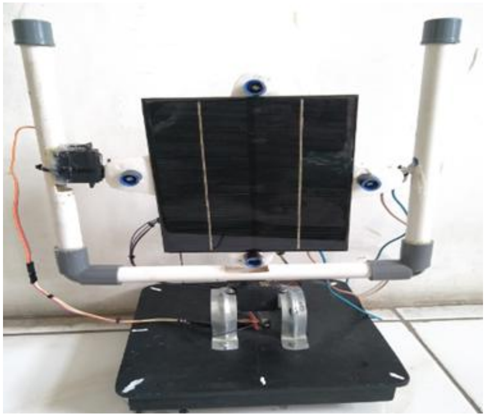
Readings from regular fixed-mount sun controlled panels-were similarly recorded to choose the measure voltage. Thusly, an examination was performed to choose the essentialness created, ate up, and got by the cross breed sun controlled tracker.

Similarly,an experimenting [27] explored the impacts of utilizing multi-tomahawks sun-following frameworks on the electrical age of a level photo-voltaic framework to assess its exhibition under Jordanian atmospheres. In [28], examinations between trial results got from fixed tendencies of sun oriented boards and those procured with the sun based tracker demonstrated a 45% increase of by and large put away warm vitality, and that-the vitality gain relied upon the season. Low tendencies were ideal in summer while in winter higher tendencies were required. Besides, trial confirmation in [29] showed that the power yield of a sun powered board with a following framework was more prominent than that of a framework without tracker.

So as to play out an exploratory investigation on a sun oriented following framework regarding power age of the PV board, information from the sun oriented following methodology during daytime are gathered utilizing a multimeter. As a result,the structured model demonstrated that sunlight based following can produce more power than a fixed sun oriented board.



(a) Installation



(b) Prototype

FIGURE 2: Prototype of solar tracking system

III. DATA COLLECTION

Figure 3 delineates information assortment from a test of the sun based following framework, which consequently tracks daylight toward the sun with the sensors. The current and voltage drop were estimated by an advanced multi-meter while control esteems, control gain esteems, and so forth were additionally determined. On the different hand,analysis of information in [30]disclosed that during cloudy conditions, tilting a sunlight based module or sensor away from the apex decreasing irradiance comparative with a level setup, in which the sensor or module highlighted the pinnacle .Observations prompted an improved following calculation where a sun powered cluster would follow the sun during without cloud periods utilizing 2-hub following when the sun based plate was unmistakable, yet it would show up in the flat design when the sky gets cloudy. During a shady period, a level module direction raised the sun powered vitality catch by almost half when contrasted with 2-hub sunlight based following inside a similar period.

It was augmented as sun powered vitality was most prominent on without cloud days when there was sufficient direct sunshine.Hence, ideal power was produced more on bright days than on overcast days.

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FIGURE 3: Data collection

IV. MEASURING TECHNIQUE AND DATA PROCESSING

Power (P)**.**Equation (1) belowrefers to [12], where I represents electric power current, $V$the voltage recorded by the multimeter, and P theDC power output that reflects the rate of transferred energy in the electrical circuit.

$$P = I \times V \quad (1)$$

Power gain (P_g)**.** For the performance of the system's power gain, equation (2) was used, where P_t is the power output of the solar tracking system, P_f thepower output of a fixed solar system, and P_g the power gain.

$$P_g = \frac{P_t - P_f}{P_t} \times 100\% \quad (2)$$

Efficiency. The efficiency of power from the solar panel is obtained throughequation (3), in which P_0 denotes the actual power output ofthe solar panel and P_{max} the maximum power output of the solar panel.

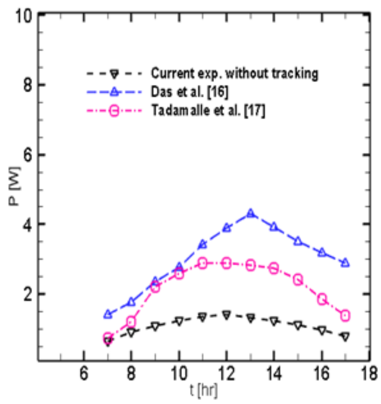
$$\eta = \frac{P_o}{P_{max}} \times 100\% \quad (3)$$

V. RESULTS AND DISCUSSION

Figure 4(a) depicts power without tracking, where the power in [16] was 72% higher than in the current experiment, due to the fact that a mirror booster was used to maximize power.Meanwhile, [17]had almost the same poweras the experiment at about 14% early in the morning, but in the afternoon [17]had 35% more power than the current experiment which was at a low of 18%,whereas [16]'s power,at around 47%, was greater. This was made possible by the AT89S52 microcontroller and Zigbee transmitter used by [16] that were able to maximize power, while the current experiment used ATMEGA 328.

Figure 4(b) shows power with tracking, in which [16]'s power in the morning was 33% while that of the current experiment was 29%.Using an AT89S52 microcontroller,[17]also had higher power at 38% than the experiment. As for power in the afternoon, the experiment had 27% while [16]had 41% and [17]had 32%, the former's low rate compared to the others'attributed to bad weather. In the evening the experiment's power was 19% whilstthose of [16] and [17]were 34% and 38% respectively, also due to the concealment of the sun in the former's case.

Figure 4(c) represents power comparisons between the current experiment and [16]. The current experiment's power without tracking in the morning was 25% whereasthat of [16] was 75% greater due to the fact that a mirror was used as a booster. In the afternoon the experiment and [16] maintained their respective power. In the evening power of the experiment dropped to 14% while that of[16]rose to 85% because of the mirror booster. In regard to power with tracking,at 53% the experiment's power in the morning was higher than that of [16]at 47%. In the afternoon and evening the experiment's rate declined but that of [16]went up, both by 11 points. In general,[16] and [17]'s experiments produced greater percentagesthan the current experiment, although findings indicated that the current experiment provided more constant results.



a.Power without tracking

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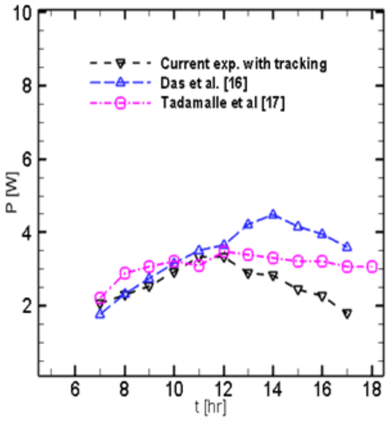
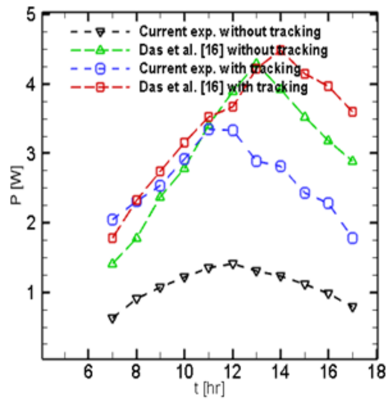


b. Power with tracking



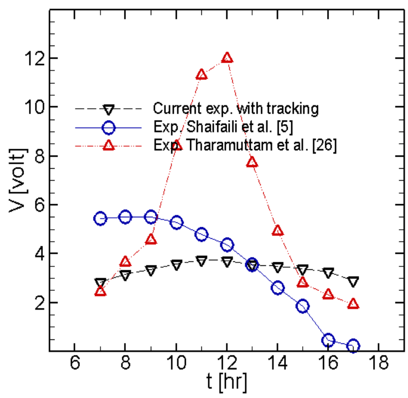
c. Power comparisons

FIGURE 4: Power records

Figure 5(a), (b) and (c) are voltage graphs that represent voltage without tracking, with tracking, and comparisonsin that order. Figure 5(a) shows that in [26] the voltage without tracking was 23% early in the morning as compared to that of the current experiment which was 27%, while thatof [5] was 50%,owing to a different way of tracking involving a hybrid solar-tracking algorithm, a prototype design, and experimental data analysis that combined three methods, namely hybrid, chronological and active.However,[5]'s experiment indicated that the voltage gained was high in early morning but suddenly fell to approximately 9% in the evening when the sun radiation diminished, since the system used three LDRs and a low-grade solar panel. The voltage of [26]also augmented drastically at first but descended sharply by 36% in the evening, whereas the current experiment had stable volts at roughly 55% in the evening, because the system was sufficiently able to receive signals from the sun's radiation with four LDRs and the ATMEGA 328microcontroller.

Figure 5(b) describes voltage with tracking, in which the current experiment had higher voltage at about 30% than [5]at around 26%, while [26]had roughly 44% in the morning because the components and program employed to track sunlight were different. The experiment in [26] used a magnetometer that yielded higher solar power radiation, along with active, hybrid and chronological algorithms.Thereby, that experiment in tracking gained a much greater rate, yet it abruptly dropped due to unstable weather to about 33% while that of [5]dipped to around 28%.On the contrary, the current experiment maintained voltage at 39% in the evening on account of the availability of sunlight around the environment that produced the voltage with minimum requirements.

Figure 5(c) denotes comparisonsof voltage between the current experiment and that of [5] with and without solar tracking.With tracking, the current experiment had voltage of about 40% in the morning whilst [5] had 60%, as the former was unable to catch sunlight since the weather was unstable. In the experiment of [5] voltage without tracking had a stark drop of 25 % against that in the current experiment which remained at 75% in the evening, lending evidence that the current experiment is better than others in relation to its solar tracking system.



a. Voltage without tracking

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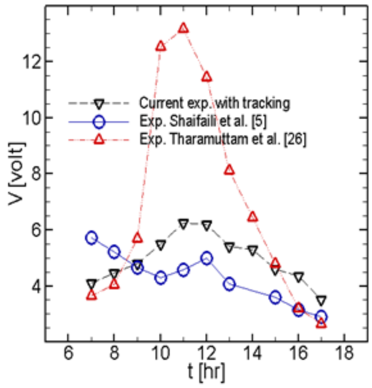
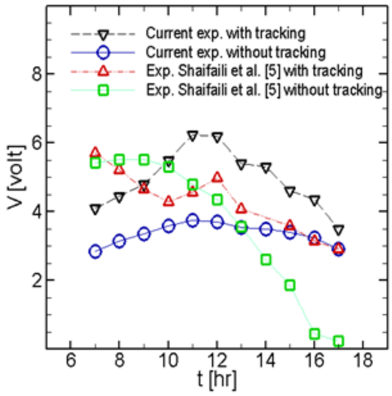


b. Voltage with tracking



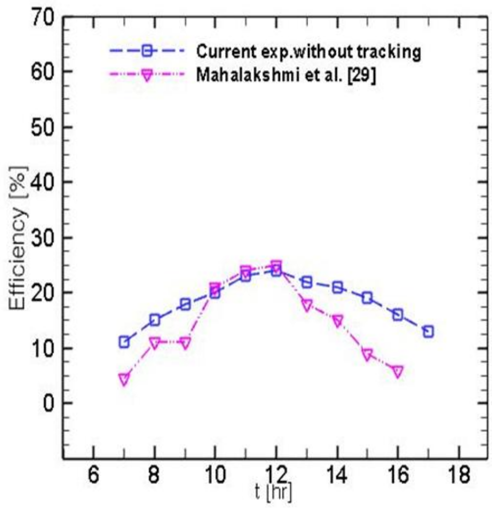
c. Voltagecomparisons

FIGURE 5: Voltage records

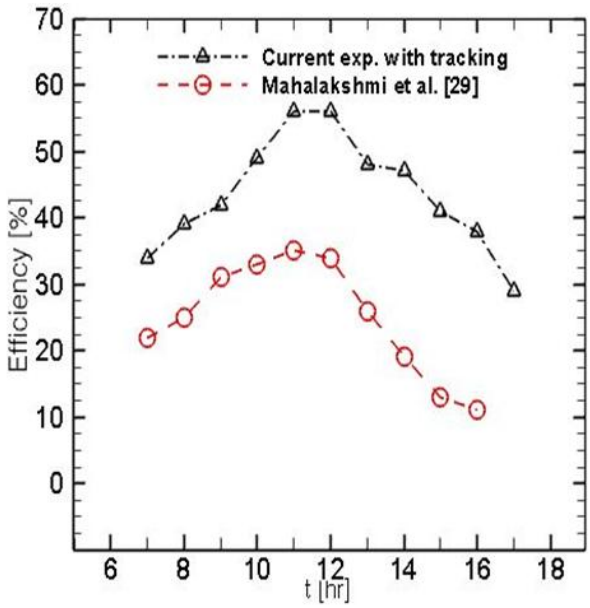
Figure 6 (a) illustrates efficiency without tracking, where the current experiment reached approximately 63% in the morning whereas [29] managed to achieve about 38%. In the afternoon the experiment's ratewent down by 14% but that of[29]escalated by 13%, while in the evening they respectivelyincreased by 14% and decreased by 13%,because the current experiment had the ability to track sunlight by solar radiation as opposed to [29].

Figure 6(b) displays efficiency with tracking, which was 61% in the morning in the current experiment and slightly lower at 40% in [29]. In the afternoon the rate of the experiment was 62%, higher than that of [29] which was 38%. Finally, in the evening the efficiency of the current experiment and [29] improved and lessened by 13% respectively.

Figure 6(c) presents efficiency comparisons between the current experiment and [29], where the current experiment without tracking gave average efficiency of approximately58% while [29]had an average of 42%. With tracking, the experiment had 66% on average whereas [29] showed an average of 34%,markedly lower than the former owing to the fact that the current experiment used four LDR sensors which was able to track the sun more effectively.



a. Efficiency without tracking



b. Efficiency with tracking

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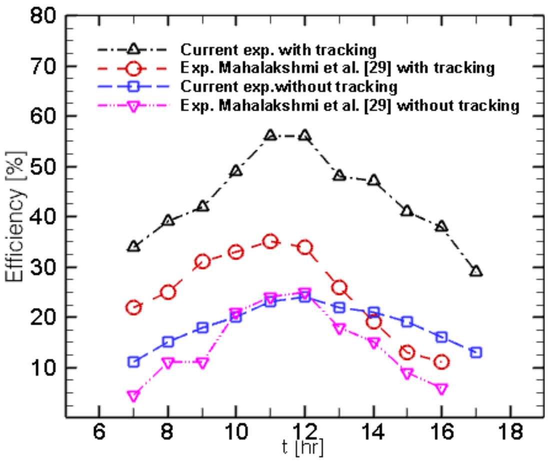

c. Efficiency comparisons

FIGURE 6: Efficiency

Figure 7 represents power gain, which in the current experimentattained as far as 70% in the morning compared to previous experiments such as[16]at approximately 65% and [17]with 60%.In the afternoon the current experiment managed to obtain55%, but [16]and [17]only gained 10% and 8% in that order.Then, in the evening the current experiment'sgain declined by five points while that of [16]dramatically soared by 62% and that of[17]went up by 45%. According to theseoutcomes, the current experiment successfully maintaineda high percentage of power gain because its system was capable of capturing solar radiation effectively, and has therefore proved that the system was more effective in capturing solar radiation than others.

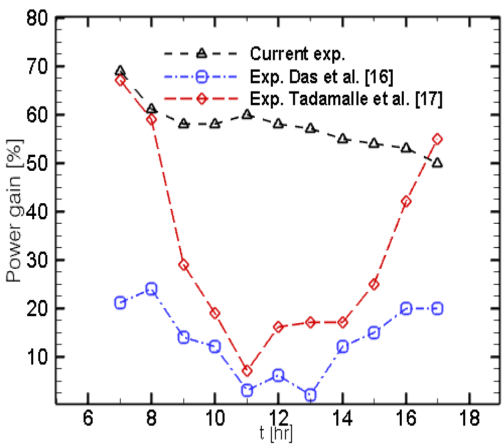

FIGURE 7: Power gain

VI. CONCLUSION

Overall,results indicate that, using the Arduino UNO program as a basis for solar tracking, the current experiment managed to retainconstant percentages in terms of power and voltage, maintain higher efficiency rates than other experiments, and keep power gain at 50% or above. In conclusion, these findings show that the system was able to maintain high percentages and increase power gain since it used four LDRs and ATMEGA328 whichwere able to track sunlight moreeffectively.

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