American Journal of Engineering Research (AJER) **2022**
American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-11, Issue-03, pp-33-40
www.ajer.org
Research Paper Open Access

Design and Implementation of an Arduino-Baseddual Axissolar Tracking System

Agbetuyi Ayoade Felix[1],Fagbuaro Olawale E[2], Agbetuyi Oluranti A[3], Babasanmi Olaoluwa[4]
1,and 4are from departmentof Electrical and Information Engineering
Covenant University, Ota, Nigeria
2is Federal Polytechnic Ilaro, Ogun State
3 is from department of Physics, Ekiti State University, Ado Ekiti

Abstract—*Solar energy has become a very important source of renewable energy in a world that the demand for energy keeps on growing and fossil fuel is damaging the ecosystem. Solar trackers continuously change orientation throughout the day so as to stay aligned to the sunlight since the position of the sun in the sky changes with the time of the day. This is expected toincrease the amount of energy captured by the solar panel. A prototype of an Arduino based dual axis Solar tracking System was designed and implemented in this paper. The project work has two parts; hardware & software. The hardware involves ATmega328p microcontroller controlling two servo motors to move the solar tracker with the use of Light Dependent Resistors (LDRs) as sensors for sunlight. The software part involves programming the microcontroller.The output power of the panel with fixed configuration has been compared with that of tracking configuration. The results show an increase of 23.53% efficiency in the power captured by dual axis configuration.*
IndexTerms—Solar tracker, Solar Energy,Arduino,Microcontroller,Dual-axis.

Date of Submission: 02-03-2022 Date of acceptance: 17-03-2022

I. INTRODUCTION

In the world today where the demand for energy is increasing due to the increase in population and technological advancement, there are growing concerns for our ecosystem in terms of global warming, other sources of energy which are renewable must be explored. One of such sources of energy is the solar energy. Diverse sorts of inexhaustible or efficient power energy assets like hydropower, wind power, and biomass energy are right now being used for the supply of energy request but among the ordinary sustainable power sources, solar energy is the most fundamental and essential asset of manageable energy. Solar energy is radiant light and heat from the sun that has been utilized by human beings since the beginning using a range of solar energy technologies in terms of photovoltaic systems, passive solar day lighting, solar heating processes.Solar energy is radiated from the sun and it differs from place to place depending on the position on the earth. Place close to the equator receive more radiation from the sun than places with high latitude [1].

The solar tracker mechanism is an electromechanical framework that guarantees solar radiation is constantly opposite to the surface of the photovoltaic cells (solar cells) which amplifies energy harnessing[2].

Now higher efficiency can be achieved by capturing the maximum amount of sun rays upon the solar panel which increases the efficiency, the panels have to be arranged in such a way that the rays from the sun fall directly on them by tracking the solar radiation or the movement of the sun done with the aid of a solar tracker [3]. This work searches for a way to improve the efficiency of solar panels using dual axis solar tracking system. In this case the solar panel is positioned for maximum power output[4].

Dual axis solar trackers have two degrees that act as both horizontal and vertical axes of rotation. These trackers can track the sun in both east to west and north to south directions. The tracker scan tracks the sun movement from any region of the world. The trackers could be operated under the control of computers, or may have tracking light sensors that control the motors that tilt the panel towards the sun [5].

II. RELEVANCE AND APPLICATION OF THE SOFTWARE

Solar energy applications range from large scale use to small ones which include generation of electricity for commercial and industrial use. Also it can be used in generation of power to small solar calculators. It can also work perfectly well in all parts of the world most especially inAfrica and Nigeria where electricity generation is very low and many citizens live without it.

Nigeria needs an alternative that is cheap, effective, easy to install and could generate electricity for millions of people that electricity is not available to[6]. Solar energy is readily available in Nigeria. It is the freest and the most abundant energy and it is the only form of energy that fits the description of needed energy.

Nigeria is enriched with a lot of free solar energy. Utilizing the nation's deserts and large land expanse and exploiting 320 to 350 radiant days a year, Nigeria could without much of a stretch create 5,000 trillion kWh of solar energy. [1]

At the end of the day, Nigeria could install around 1,000 GW of solar generationwhichequals to 40 times the present current maximum demand (around 25 GW) — utilizing only 0.5 percent of its territory. Also, Nigeria can create more than 100 GW from wind control[7].

Solar energy is proving to be the fastest and most efficient way to get all of Nigeria connected to electricity.

The sun chart is a visualization of the suns path through the sky formed by plotting using the angles of elevation and altitude of the sun in a given day The Sun chart for Lagos, Nigeria as shown in figure 1 shows Nigeria's sunset, sunrise, dawn and dusk times for a whole year.

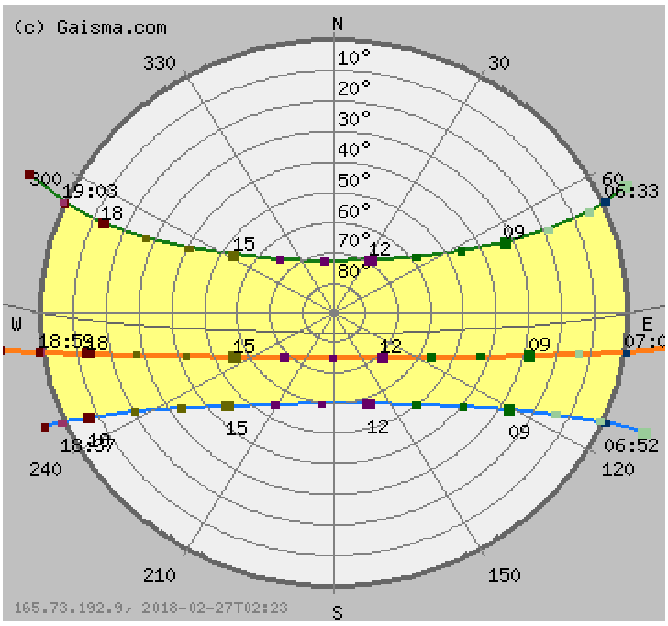


figure 1: Sun chart for Lagos, Nigeria[8]

III. METHODOLOGY

The Arduino was used to implement the dual axis solar tracker solar tracker. The Arduino board analyzes the light based on its intensity and send signals to the servo motors.

The Microcontroller ATmega328 on the Arduino is powered by the USB interface on the Arduino board which is connected to a 7AH 12volts DC battery. The voltage is regulated down from 12volts to 7volts for the Arduino board and down to 5volts to power one of the servo motors which was not powered by the Arduino.

The servo motors are basically performing functions of the sun tracking. One of the servo motors tracks the suns east-west movement while the other tracks the suns north- south movement.

Light dependent resistors (LDRs) which are sensitive to light are used for sensing sunlight to control the cell. As photons fall on the LDRs, electrons located at the valence band are energized and move to the conduction band of the semiconductor[9]. When excess electrons flow to the conduction band, current increases and this signifies that resistance has reduced [10]. The solar tracker uses 4 LDRs for sensing as well as 10k complementary resistors connected in series with each LDR as shown in figure 2. The 10k resistors are used to implement changes in the light intensity and send the voltage signals to the Arduino. The Arduino now compares signal received and then determines the direction of the servo motor. It used in order to increase the output voltage when there is increase in light intensity.

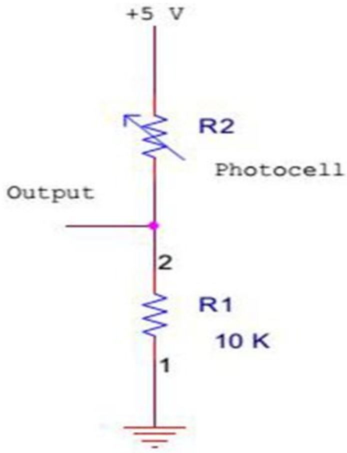


Figure 2: Voltage divider circuit

The four LDRs control the movement of the solar cell in both axis. Two of the LDRs are placed on both sides of the cell to track the suns east west movement and the other two are placed on the top and bottom of the cell to track the suns up down movement. The output voltage of the LDRs opposite each other are compared and used to position the cell.

IV. DESIGN SPECIFICATION

The design of this project includes the mechanical, electronic and software design. The mechanical design provides the framework in which the project is structured, the electronic design clarifies the electrical components used in this project. The software is the algorithm in which the microcontroller operates on. The algorithm is used to control the whole project.

A. HARDWARE DESIGN

The circuit consists of the following components:

- Arduino Uno
- Servo Motors ×2
- Solar Cells
- Light Dependent Resistors ×4
- Resistors
- Voltage Regulators
- 12 Volts Battery
- Voltmeter
- Ammeter

The Mechanical design of the servo motors to the frame is as shown in figure 3.

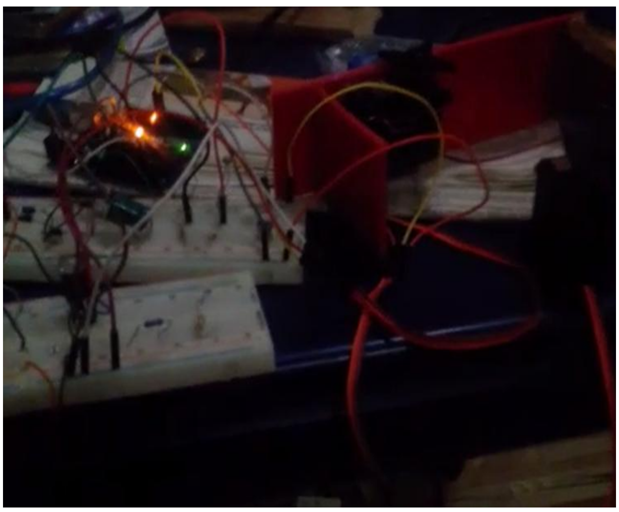


Figure 3: Mechanical design of the servo motors to the frame

B. SOFTWARE DESIGN

The software part involves the programming of the the ATmega238 and the algorithm in which the solar tracker depends on. The block diagram is shown in figure 4.

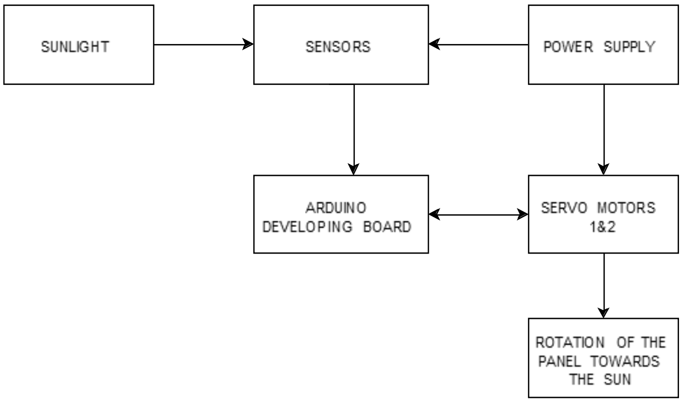


Figure 4: Block Diagram

The circuit diagram of the solar tracker is shown in figure 5 below.

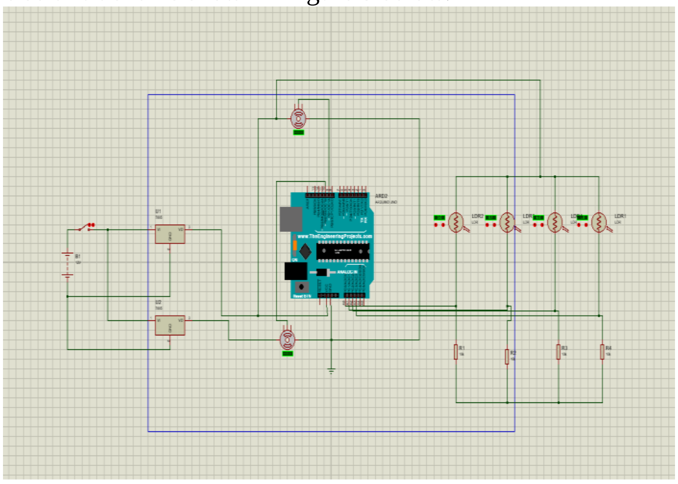


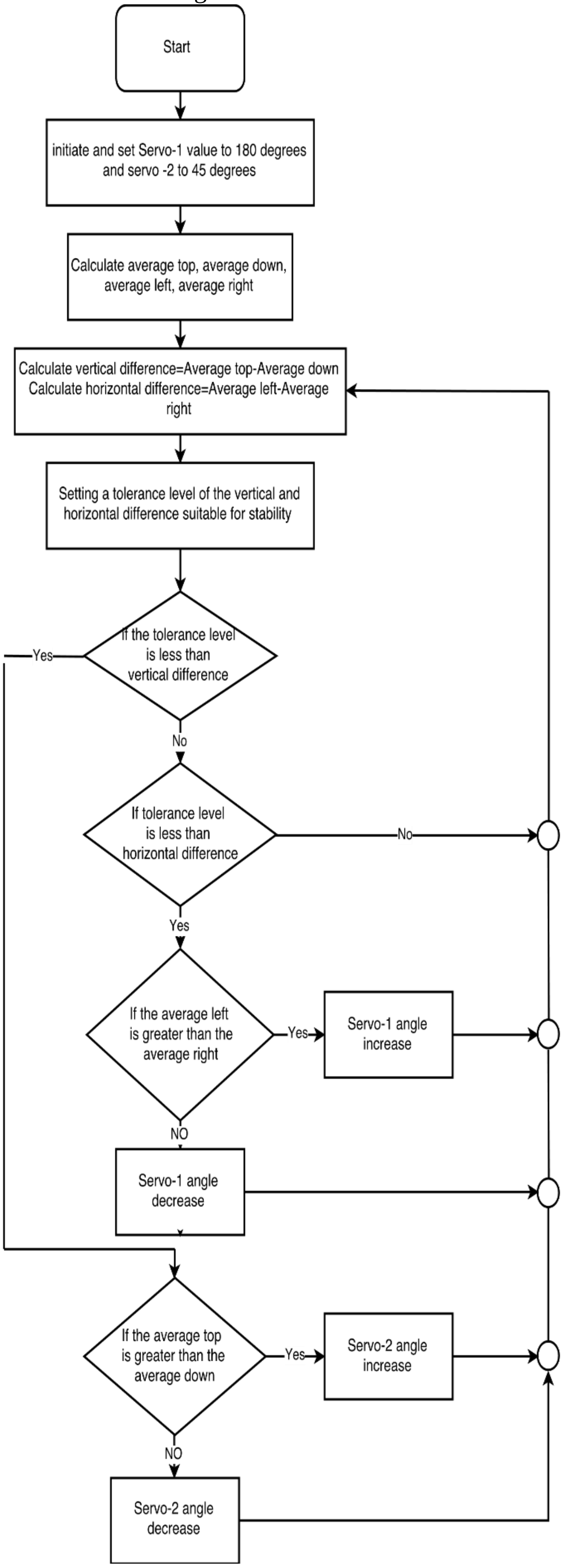
Figure 5: Circuit diagram

C. ALGORITHM CONTROLLING MOTOR

There is voltage input from four LDRs.

- The inputs are in analog values ranging from 0-5v and they are converted to digital ranging from 0-1023bits.
- The four digital values are compared with each other. The left LDR is compared with the right one and the top LDR is compared with the bottom LDR and the differences are calculated.
- Tolerance in the difference between LDRs is set for stability of the tracker so as to rotate in case of any slight change not related to the suns movement.

Figure 6: Flow Chart



- The Servo motor rotates based on the error proportional angle gotten from the differences of the digital values of the voltage input when the difference is greater than the tolerance value.
- If the input voltages of the LDRs are the same, the servo motors will not rotate.

D. FLOW CHART

The flow chart in figure 6 illustrates the process of implementation of the algorithm. When the tolerance level is greater than the difference between top and bottom LDR input voltage there is no rotation. The same happens when the tolerance level is greater than the difference between the left and right LDRs. The first servo motor is set to an angle of 180 degrees why the second servo motor is set to an angle of 45 degrees[5].

V. RESULTS AND DISCUSSION

The results of this project are gotten from the output voltages of the solar cell of both types of solar trackers i.e. dual axis and the fixed frame trackers. The results are recorded for two days and tabulated as shown in table 1. The output voltage from the solar cell depends on the amount of sunlight it is receiving. A voltage meter is connected to the solar cell to read the output voltage.
These results were gotten on the 24th of March 2018 at Covenant University Daniel Hall.

Table 1. Readings from fixed and tracking configurations

Time	Fixed system (Volts)	Tracking system (Volts)	Fixed system (Current)	Tracking system (Current)	Fixed system (watts)	Tracking system (watts)
7:00AM	3.95	5.23	0.01	0.014	0.0395	0.073
8:00AM	4.52	5.88	0.013	0.026	0.0587	0.153
9:00AM	5.25	6.15	0.025	0.055	0.1313	0.338
10:00AM	5.97	6.45	0.057	0.067	0.3403	0.432
11:00AM	6.36	6.68	0.097	0.11	0.6169	0.735
12:00PM	6.79	6.87	0.14	0.15	0.9506	1.031
1:00PM	6.79	6.86	0.12	0.13	0.8148	0.892
2:00PM	6.83	6.86	0.117	0.13	0.7991	0.891
3:00PM	6.69	6.83	0.092	0.096	0.6155	0.656
4:00PM	6.25	6.82	0.036	0.059	0.225	0.402
5:00PM	5.85	6.68	0.022	0.03	0.1287	0.201
6:00PM	4.75	6.19	0.008	0.012	0.038	0.074

From table 1, it can be observed that the maximum intensity of the sun occurs at midday as we have the highest values of output voltage, current and power at that time. The morning and evening have diminishing values less than the mid-day values. At night, the tracker is switched off because there is little or no sunlight which means the solar cell is not receiving any energy and in order to save energy. Figure 6(a), 6(b) and 6(c) show graphs of voltage, current and power against time respectively.

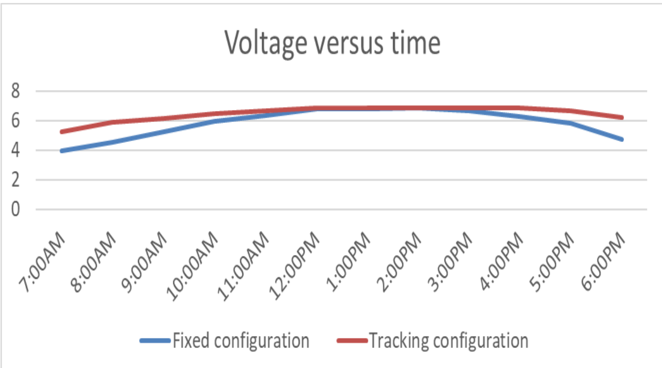


Figure 6(a): Graph Showing the output voltages between fixed and tracking configurations.

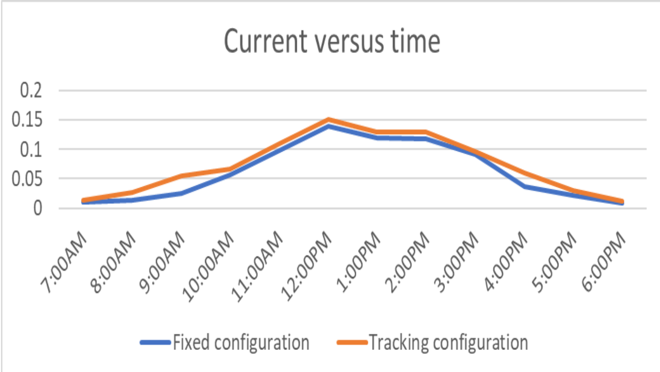


figure 6(b): Graph Showing the output current between fixed and tracking configurations.

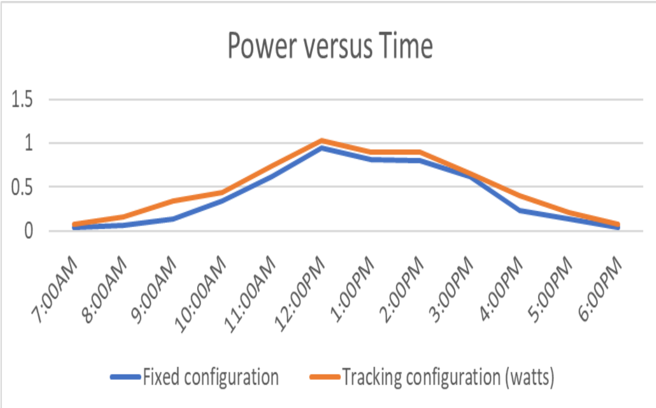


figure 6(c): Graph Showing the output power between fixed and tracing configurations.

The graphs above show the relationships between the voltage, current, power and time of both fixed and tracking configurations. It can seen that the voltages, current and power of the solar cell increases during the day to its peak value at midday and then starts reducing till sun goes down.

From table 1, the maximum sunlight can be gotten from the solar cell using the solar tracker at 12 noon. The angle of the solar panel in which the solar panel is positioned perpendicular to the sun at that time can be calculated using the altitude and azimuth angles as shown in calculations of angles relating to the suns geometry.

The increase in efficiency can be calculated, but there are moments when the power of the tracking configuration in comparison with the fixed configuration is minimal at midday as both systems receive almost the same amount of irradiation.

To calculate the increase in efficiency,

$\%increase\ in\ efficiency = \frac{P_T - P_F}{P_F} * 100$……...4.1

Where P_T is the total power from panel with tracking configuration. P_F is the total power from panel with fixed configuration.

$$\%increase\ in\ efficiency = \frac{5.87814 - 4.75841}{4.75841} * 100 = 23.53\%$$

There is 23.53% power gain using the tracking configuration as compared with the fixed configuration which means the use of the dual axis solar tracker caused an increase in the efficiency of power generation by 23.53%.

The prototype of this project work is as shown in figure 7.

Figure 7: Completed project

VI CONCLUSION

Efforts have been made to bring about maximizing solar generation system by the use of solar tracking mechanisms to track the movement of the sun. In this work, a dual axis solar tracker was designed, implemented and tested.The power capture using the tracking configuration increases by 23.53% as compared with the fixed configuration. Thismeans thatthe use of the dual axis solar tracker caused an increase in the efficiency of power generation by 23.53%.

It can be inferred from the result that the use of solar tracker will increase the power output gotten from the solar panel as compared to the panels on fixed tracking.

REFERENCES

[1]. H. P. Garg, and J. Prakash, *Solar Energy: Fundamentals and Applications*. New Delhi: Tata McGraw-Hill., 2000.

[2]. K. Zipp, "What is a solar tracker?," *Solar Power World*,16-Feb-2018.[Online].Available: https://www.solarpowerworldonline.com/2013/04/how-does-a-solar-tracker-work/. [Accessed: 24-Aug-2018].

[3]. Sabir Hossain, Bodius Salam, Al shriar, and M. Chakraborty, "Azimuth-Altitude Dual Axis Solar Tracker," in *International Conference on Mechanical Engineering and Renewable Energy*, Chittagong, bangladesh, 2015, pp. 5-6.

[4]. Christy Etukudor, Hope Orovwode, Samuel Wara, Felix Agbetuyi, Anthony Adoghe, B.O Obieje, C.N Oparaocha "Optimum Tilt and Azimuth Angles for Solar Photo voltaic Systems in South-west Nigeria" IEEE PES & IAS Power Africa Conference (Cape town South Africa) pp 348-353, June 28-29, 2018

[5]. S. Makhija, A. Khatwani, M. F. Khan, V. Goel, and M. M. Roja,"Design & Implementation of an Automated Dual Axis Solar Tracker with data-logging,"in *2017 International Conference on Inventive Systems and Control (ICISC)*, 2017, pp. 1-4.

[6]. Obiakor Chukwuemeka and Agbetuyi Ayoade Felix "Design Of A Hybrid Off- Grid Solar System For Residential Buildings In Remote Benja Village" International Journal of Mechanical Engineering & Technology (IJMET), Volume 9, Issue 8, August 2018,pp.141–152;

[7]. J. P. Iwuoha. (2013, February 15). Solar Energy is Africa's next Big Thing. Available: http//www.smallstarter.com. [Accessed 22 December 2017].

[8]. Lagos, Nigeria - Sunrise, sunset, dawn and dusk times for the whole year," *Sunrise, sunset, dawn and dusk times around the World - Gaisma*. [Online]. Available: https://www.gaisma.com/en/location/lagos.html. [Accessed: 24-Aug-2018].

[9]. Agbetuyi Ayoade Felix, Orovwode Hope, Olowoleni J.O and Nwangwu Chukwuebuka "Design and Implementation of a solar Energy Measurement and Monitoring System" IEEE PES & IAS Power Africa Conference (Cape town South Africa) pp 833-840, June 28-29, 2018

[10]. T.A. Papalias and M. Wong. (2006). Making sense of Light Sensors. Available: http://www.embedded.com [Accessed 13 May 2018.]