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Maximum Power Point Tracking Dual Axis Solar Panel Using Arduino UNO

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Abstract: Renewable energy is the only way to reduce global energy shortages. Solar is a high-yield renewable resource. Solar energy is becoming a major renewable energy source. Modern technologies include solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants, and artificial photosynthesis utilise solar light and heat. We represented the Dual Axis Solar panel with a 10W, 21V, 0.57 solar panel. We built a solar panel framework. Crafting the framework using cardboard cuts project costs. Trackers point solar panels at the sun. These devices rotate to follow the sun to maximum energy capture. Solar trackers can boost electricity generation by a third or even 40% in some countries compared to fixed-angle modules. When modules are constantly adjusted to the optimal angle as the sun moves, solar conversion efficiency improves. This paper designs an Arduino UNO-based Dual Axis Solar Tracking system to move solar panels toward maximum sunlight. The fixed solar system could maximise solar panel production by improving efficiency. LDRs send a signal to the Arduino UNO, which sends it to the servo motor connected to it, which positions the Axis Solar Panel in the sun's direction. This allowed Arduino UNO to track dual-axis solar panels with maximum power. Our technology is more efficient, small, low-cost, and easy to use.

Keywords: Power Supply; ArdunioUnio; Servo Motor; Solar Panel; LDR; Embedded C; Module Solar Panel;5v Charger; Ardunio Ide.

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Introduction

The working capital of a firm is crucial to its survival and performance in the long run. When short-term bills aren't paid on time, many firms have to close their doors [7]. The capacity of a business In most cases, an energy crisis occurs when population density rises since energy consumption rises in tandem with it. Everyone wants to use renewable resources someday, but we aren't getting the most out of them just yet. We're getting closer, but we could get there even faster if we upgraded the technology that uses renewable resources to boost their output. There are now options for both programmed and non-programmed dual-axis solar panels [8-11]. On the other hand, an Arduino UNO-based dual-axis solar panel would be the superior choice. Most of the time, microcontrollers are beneficial to us. Data on energy production, for instance, might be derived from seasonal factors and similar characteristics. A solar tracker can be described as a pair of axis solar panels. Throughout the day, solar trackers monitor the sun's movement across the sky [12-17]. Depending on the kind of actuation and the axis of rotation, solar trackers can be classified into multiple groups. Sunflowers follow the sun's ebb and flow from east to west, and our Axis Solar Tracker does the same. The solar panel's orientation is unaffected by the sun's orbital movement, even when the seasons change [18]..

Literature Survey

Power generation rate might be increased by maximising the surface area of the solar panels exposed to sunlight, according to Mohamad et al. [1], if solar tracking devices could follow the movement of the sun. A solar tracker can drastically reduce the amount of solar panels required to produce the same amount of electricity. One way to categorise sun tracking systems is by axis, and two axes are the most common. Simulated and experimental studies comparing solar tracking system performance to that of static solar panel systems and to that of other solar tracking system mechanisms have been undertaken by a number of researchers. Experts in the field concur that solar tracking systems consistently outperform their static counterparts. Systems with tracking devices are more resistant to changes in weather conditions, according to certain studies that looked at how weather impacts solar panel performance.

According to Kaur et al. [2], solar photovoltaic cells and the photovoltaic effect may effectively convert solar energy into electrical energy, and the sun is a plentiful supply of this kind of energy. But regular PV cells have a poor conversion efficiency. This is due, in large part, to the fact that a PV cell's output is proportional to the amount of light hitting its surface. An immobile solar panel would have far lower absorption efficiency at certain times of the day and year due to the fact that the sun's position in the sky is constantly changing. This is because solar photovoltaic cells are most productive when they are perpendicular to the sun and have lower productivity otherwise. In order to optimise energy generation and enhance efficiency, solar trackers have been implemented. In order to maximise the power output from solar panels, this paper details the design and construction of a low-cost active dual-axis solar tracking system. In order to keep the panel perpendicular to the sun, it employs Light Dependent Resistors to detect the sun's position. This information is then sent to an Arduino Uno microprocessor, which in turn controls a pair of servo-motors. All goes well with the design's construction and subsequent testing in Lab View to reveal efficiency gains. According to the evaluation, the new system outperforms the stationary solar PV system by 13.44%.

Autonomous positioning with open-loop dual-axis sun tracking is the subject of research by Sidek et al. [3]. Polyuthrene and conventional cylindrical aluminium hollow were used in the design and fabrication of the solar tracker (PE). A Master Control Unit (MCU) with auxiliary devices, such as an encoder and Global Positioning System (GPS), governed the control system of the solar tracker (GPS). The system also included an algorithm for the sun's path, which used GPS data and an astronomical equation. A comparison was made between the fixed-tilted Photovoltaic (PV) system and the dual-axis solar tracking system in terms of their power generating performance. Based on the sun's travel trajectory algorithm, the solar tracker can autonomously position itself to within ±0.5° of precision. While using very little power, the integrated Proportional Integral Derivative (PID) positioning system enhances the tracking of azimuth and elevation angles. It turns out that in clear weather, the suggested solar tracker can produce 26.9% more electricity than fixed-tilted PV systems, and in severe overcast, it can generate 12.8 percent more power. In general, transportable solar tracking systems can benefit from the open-loop dual-axis solar tracker's reduced configuration requirements and its ability to instantly deploy to any point on Earth.

According to Ha and Phung [4], smart city energy generation must be reliable and efficient. This research details the steps needed to create trustworthy control schemes for microgrid management that can be easily incorporated into smart building management systems. Reliable controllers and the hardware to implement them are suggested here for use in establishing microgrids in the event of solar energy system failure recovery. The system's scalable functioning is facilitated by the utilisation of the Internet of Things (IoT) as its central component. To provide reliability in solar tracking, the control strategy employs many controllers that operate together using a network-based token mechanism. For reliable operation, the system makes use of information gathered from both offline sensors and online resources through IoT networks. Solar energy harvesting meets design requirements, and control dependability is preserved even when communication or hardware failures occur, according to experiments carried out in a 12-story building. The findings provided evidence that the suggested method is a viable and useful tool for smart building energy management.

According to Fatemi et al., one of the latest and most effective ways to get the most power out of solar panels, stabilise the operating point, and minimise oscillations in generated power is the Extremum Seeking Method (ESM). ESM works by following the search pattern of the Extremum point on the P-V curve of PV panels. The two biggest issues with this approach are the lengthy transition time caused by changing climatic conditions and the significant overshoot of PV output power. In this study, we offer a hybrid approach that combines the standard ESM method with model predictive control (MPC) to solve this issue. The proposed maximum power point tracking (MPPT) approach is tested by comparing the PV panel's output power and voltage to that of a traditional MPPT method, the P&O method. Both the experimental and MATLAB/Simulink simulation results show that the proposed MPPT scheme is accurate.

According to Medhane et al. [6], the two most crucial components of a photovoltaic (PV) water pumping system are: The correct maximum power point tracking (MPPT) system is essential for an effective motor run and good photovoltaic system control. Two stages make up the power conversion system. In the initial stage of power conversion, maximum power point tracking (MPPT) control is used to control the duty ratio of the DC-DC boost converter in order to harvest the most power possible from a solar PV system. When choosing a motor and drive, it is important to keep the current profile low in order to minimise motor power loss while injecting the same amount of power. Using several MPPT approaches, this research seeks to maximise the energy extracted from solar power. This research presents a method to increase the energy transfer capacity of SPV systems using a perturbed maximum power point tracking (MPPT) algorithm and an observations (P&O) approach.

Existing And Proposed Systems
We can't glean any data or characteristics from this system, even though it tracks the sun just as well as single-axis or non-programmable axis solar panels [19-23]. During seasonal changes, the Single Axis Solar tracking system does not provide the maximum output from the solar panel. Even if they produce maximum output, our present solar panels either single-axis or non-programmable dual-axis do not make full use of the available resources (Figure 1).

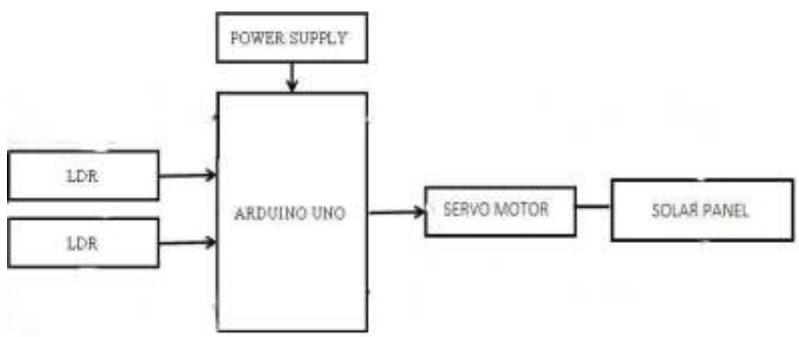

Figure 1: Existing block diagram

Proposed System:
In this setup, an Arduino uno is programmed to control two servo motors, which in turn spin the solar panel to face the sun in different directions (Figure 2).

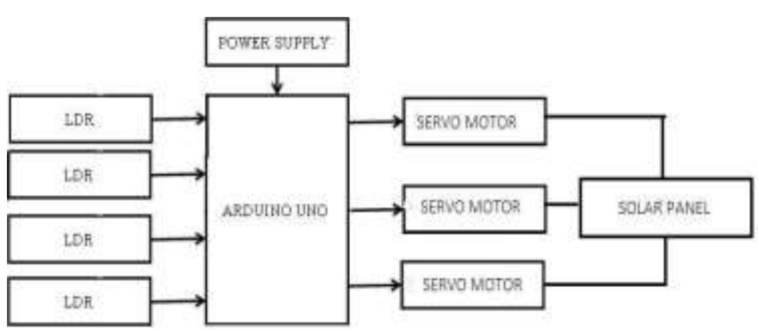

Figure 2: Proposed block diagram

Making the most of the available resource is the goal of this Arduino Uno-based dual-axis solar panel development paper. With the ever-expanding realm of technology, we are constantly innovating our tracking solar panels to ensure optimal output with no human intervention required [24-29]. This dual-axis solar panel is going to be way more useful for modern buildings that are attempting to employ all the renewable resources that are accessible. The external attributes could not be retrieved by the present solar tracker [30-34]. To sum up, our solar panel will be dual-axis, and we will be able to access external properties through the Arduino UNO. The schematic for an axis solar panel that uses an Arduino Uno is shown in Figure 3.

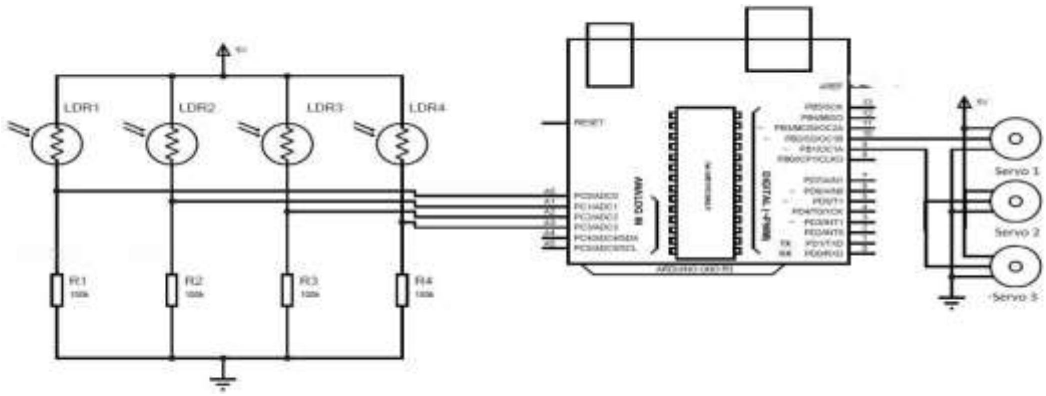

Figure 3: Proposed circuit diagram

When powered from an external source, the voltage that the Arduino board receives as input (as opposed to 5 volts from the USB connection or other regulated power source). This pin can be used to either deliver voltage or access the power jack for power supply [35-41]. The 5V pin is used to output a regulated 5V power from the board's regulator. Depending on your needs, you can power the board through its VIN pin, the USB connector (5V), or the DC power jack (7 - 12V) (7-12V). Bypassing the regulator and supplying voltage via the 5V or 3.3V pins can cause damage to your board. Not recommended. A supply voltage of 3.3 volts is produced by the onboard regulator. Up to 50 Ma, current can be drawn. To ground the 5V VIN pins, you use the ground pins [42-49].

USB Overcurrent Protection

The USB ports on your computer are protected from overcurrent and short circuits by the Arduino Uno's resettable poly fuse [50]. Even though most computers have built-in safeguards, the fuse adds an additional degree of security. Until the short or overload is resolved, the fuse will shut off the connection if the current applied to the USB port exceeds 500 mA [51-53].

Physical Characteristics

With the USB connector and power jack protruding beyond the former limit, the maximum length of the Uno PCB is 2.7 inches, and the maximum width is 2.1 inches. The board has four screw holes that make it easy to mount it to a surface or case. Be aware that the spacing of the other pins is 100 mil (0.16 inches), however the distance between digital pins 7 and 8 is 160 mil (0.16 inches). In most homes, the process of controlling lights and appliances is done by hand and needs regular maintenance [54-61]. On the other hand, human error or unforeseen situations might lead to power loss during appliance control. This issue can be circumvented by controlling the loads according to the intensity of the light using the light-dependent resistor circuit. A device constructed of semiconductor material with a high resistance is known as a photo resistor or an LDR. A light-dependent resistor circuit, or LDR, and how it works is explained in this article [62-65].

An insulating substrate, such as ceramic, is sandwiched between a light-sensitive substance in a light-dependent resistor (LDR) [66-68]. The necessary power rating and resistance are achieved by placing the material in a zigzag pattern. The two sections of metal placement are delineated by the zigzag area (Figure 4).

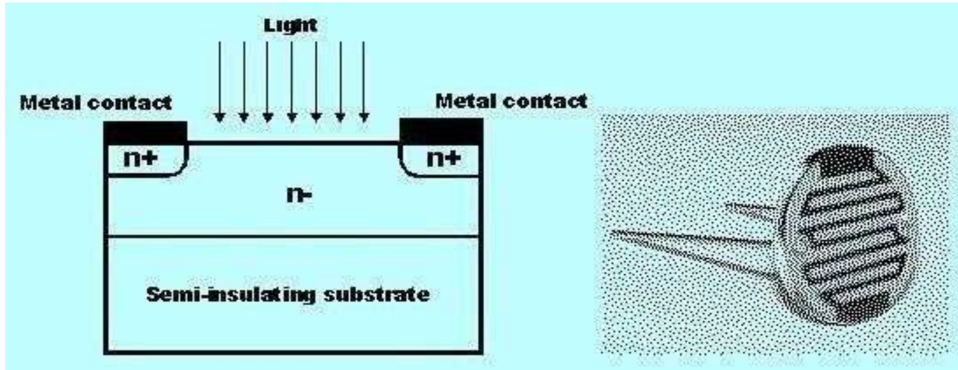

Figure 4: LDR Construction

If you want the resistance to fluctuate mostly as a result of the light impact, you need to make sure that the Ohmic connections on each side of the area have very low resistances. Because of their harmful effects on the environment, lead cadmium materials are shunned [69-72]. An optical phenomenon known as photoconductivity is the basis of an LDR's operation. Absorption of light causes a decrease in the material's conductivity. The light-dependent reaction (LDR) occurs because valence-band electrons in the material are excited to transition to conduction band when light hits it [73-77]. The energy of the photons striking the material must be greater than its band gap, though, for the electrons to undergo a transition from valance to conduction (Figure 5).

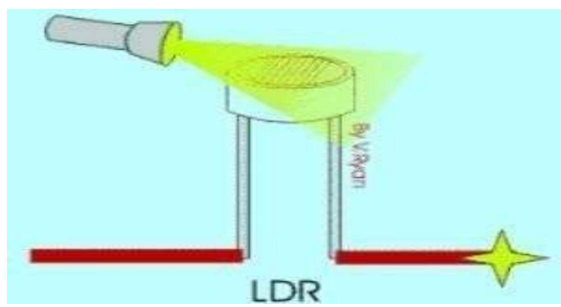

Figure 5: Working Principle Of LDR

The conduction band attracts a greater number of electrons and, thus, a greater number of charge carriers when the energy of the light is abundant. The device's resistance drops as a result of this process and as the current flow increases [78-81]. One inexpensive and easy-to-understand gadget is the light-dependent resistor. These gadgets can in handy in situations where you need to know if there's light or not. A few examples of where you might see LDRs in action are in light intensity metres, alarm locks, street lights, and burglar alarm circuits. Here we have described one paper, specifically the power conservation of intensity-controlled street lights using LDR, to help you better grasp this idea [82-87].

An electromechanical device that generates torque and speed in response to input voltage and current is known as a servo motor [88]. In a closed-loop system, a servo motor responds to commands for torque and speed from a servo controller, which in turn uses a feedback device to close the loop. The servo controller receives commands for the motor's behaviour based on the feedback device's supply of information, which may be location, velocity, or current. Many different sizes, styles, and varieties of servo motors exist on the market. When Joseph Facort installed a feedback mechanism to help steer a steam-powered ship's rudders in 1859, he was the first to use the term servo. A servo mechanism, of which a motor is one component, also requires control electronics, a feedback device, and a feedback device [89-95]. No size restriction applies to the AC or DC motor, and it can be brushed or brushless, rotary or linear. Some examples of possible sensors for the feedback device are tachometers, resolvers, encoders, linear transducers, and Hall-effect devices. To ensure the servo motor is responding as expected, the control electronics that supply power to the motor are compared with the command reference and feedback data. Servo motors have a wide range of uses, from basic DC motors in toy aeroplanes and other hobby applications to complex motion controller-driven brushless motors in multi-axis machining centres [96-101]. Vehicle cruise control systems are typical servo mechanisms; they include an engine (the motor), a speed sensor (the feedback), and electronics that compare the actual speed of the vehicle to a preset speed [102]. A basic closed-loop system, as the car slows down, the sensor sends a signal to the electronics, which then increase the gas pedal to get the speed up to the desired set point (Figure 6).

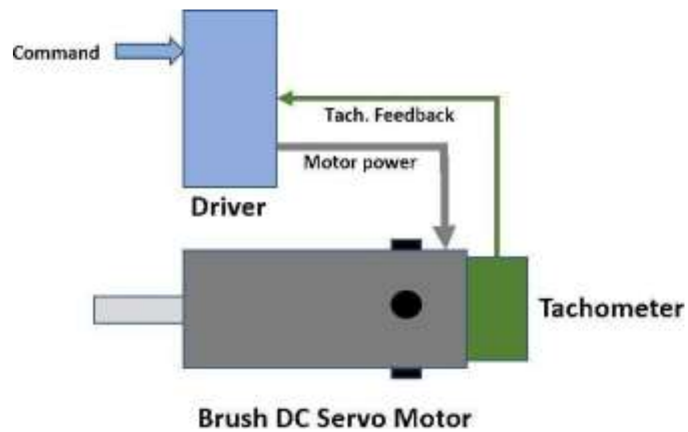

Figure 6: Components of Servo Motor

A basic industrial servo motor is a DC permanent magnet motor that has a built-in tachometer to measure speed and produce a voltage output that is directly proportionate to it. The voltage read from the tachometer is used by the drive electronics to provide the motor with the voltage and current it needs to run. Here, we see the driver set to a specified speed, which is actually a command reference voltage. The driver's circuitry checks the tachometer feedback voltage to see if the target speed has been reached; this process is called a closed velocity loop. As the driver manipulates the engine power to sustain the specified requested speed, the velocity loop keeps an eye on both the commanded and tachometer-reported velocities [103-109]. Precision motion control is achieved in a more advanced servo system by optimising the performance of numerous embedded loops. There are current, velocity, and location loops in the system, and they all make use of precision feedback components. As one loop sends a signal to the next, the system keeps tabs on the right feedback components and makes adjustments in real time to conform to the specified criteria. In a torque or current loop, the base loop is located. The acceleration or thrust produced by a rotary motor (or a linear motor) is directly proportional to the current that flows through it. A current sensor monitors the amount of current going into the motor and reports back any changes. The control electronics receive a signal from the sensor, which is usually a digital or analogue signal that is proportional to the motor current. This signal is deducted from the signal that is commanded [110-117]. The loop will remain satisfied as long as the current remains above the commanded current for the servo motor. The loop will keep going at sub-second update rates, increasing the current until it reaches the desired current.

Similarly, a voltage that is proportional to velocity operates the velocity loop. As soon as the current falls below the desired velocity, the velocity loop instructs the current loop to raise the voltage by increasing current. After receiving a command from a PLC or motion controller, the position loop passes it on to the velocity loop, which in turn feeds it with the necessary current to speed up, slow down, or stop the motor as needed to reach the specified position. Optimal synchronisation between the three loops allows for precise and fluid operation of the servo mechanism [118-124].

Powering electrical loads, solar panels absorb sunlight, a sustainable energy source, and transform it into electricity. Layers of silicon, phosphorous (which supplies the negative charge), and boron make up each solar cell that makes up a solar panel (which provides the positive charge). Photons are converted into electricity when they pass through solar panels. The process begins with photons hitting the solar panel's surface, which releases electrons from their atomic orbits and into the electric field created by the cells

[125-131]. This field then guides the freed electrons into a directed current. The term for this complete process is the Photovoltaic Effect. Most houses have enough room on their roofs to accommodate solar panels, which can create enough energy to cover a home's electrical needs during the day and send any surplus power back into the grid, which homeowners pay for when they use their electricity at night.

Solar panels are an extremely useful tool for generating power for many uses [132-138]. Live off the grid. It's a no-brainer. To live "off-grid" is to reside in an area that does not have access to the conventional power grid. Installation of solar panels is a great way to power off-grid dwellings and cottages. Installing electric utility poles and running cables from the closest main grid access point no longer requires exorbitant expenses. If cared for correctly, a solar electric system can generate electricity for more than 30

years at a lower cost (Figure 7).

Figure 7: Solar Panel

In addition to enabling you to live off-grid, the most significant advantage of utilising solar power is its status as a clean and sustainable energy source [139-141]. The urgency of doing all in our power to lessen the burden of greenhouse gas emissions on our planet's atmosphere has grown in response to the emergence of global climate change. Due to the lack of moving parts, solar panels are low-maintenance. When cared for correctly, their sturdy construction ensures that they will endure for decades. Finally, an advantage of solar panels and solar power is that, after the original investment in the system has been recouped, the electricity it generates for the rest of its lifespan—which may be anywhere from fifteen to twenty years, depending on the system's quality—is completely free! Customers who invest in grid-tie solar power systems can start reaping the benefits as soon as their systems go live, which might mean goodbye to monthly electricity costs altogether. Getting more money from the power company is the finest part for the owner of the system [142-144]. How? You can sell the excess power you generate from your solar panels to your utility provider, and sometimes even earn a profit. Solar panels can provide power, but they also have numerous additional uses and advantages. There are too many to mention them all. However, you will get a general understanding of the adaptability and ease of solar power as you explore our website [145]. In electrical circuits, a resistor is a component that controls the amount of current that can flow. A specified voltage can be supplied to an active device, like a transistor, by means of a resistor. Under all other circumstances, the current flowing through a resistor in a direct-current (DC) circuit is directly proportional to the voltage across it and inversely proportional to the resistance of the metal. The Ohm's law is famous for this. If the resistor in an AC circuit does not have any inductance or capacitance, then this rule applies (Figure 8).

Figure 8: Resistor

There are several methods for making resistors. The carbon-composition resistor is the most ubiquitous kind in electronic systems and gadgets. After being combined with clay, finely ground carbon (graphite) is allowed to solidify. The ratio of carbon to clay determines the resistance; a larger ratio results in lower resistance. A second variety of resistor is wound on an insulating substrate using Nichrome or a comparable wire. A carbon-composition resistor of the same physical size cannot withstand currents as high as this component, a wire wrapped resistor. The component displays resistance and serves as an inductor due to the wire's winding into a coil. Because inductance makes the device sensitive to variations in frequency, this can have an unfavourable effect in AC circuits but has no influence on DC circuit performance. To power electrical equipment, an electric battery can be used. It consists of electrochemical cells that can be connected to an outside source. The positive end of a battery, known as the cathode, and the negative end, known as the anode, are responsible for supplying electricity. An external electric circuit will allow electrons to flow from the terminal marked negative to the positive terminal. Redox reactions transform high-energy reactants into lower-energy products when an external electric load is linked to a battery. The external circuit receives electrical energy from the free-energy difference. Though originally used to describe devices with several cells, the term "battery" has now expanded to encompass single-cell devices as well.

A common example of a primary battery is the alkaline battery found in flashlights and many portable electronic gadgets. These batteries are designed to be used once and then thrown away because the electrode materials are irreversibly changed after discharge. Reverse current can return the electrodes to their original composition, allowing secondary (rechargeable) batteries to be discharged and recharged repeatedly with the help of an applied electric current. Some common examples of this type of battery include the lead-acid variety found in automobiles and the lithium-ion variety found in many types of portable electronics. At one end of the spectrum are tiny cells that power hearing aids and wristwatches; at the other end of the spectrum are enormous battery banks the size of rooms that supply backup or emergency power for computer data centres and telephone exchanges. In comparison to more typical fuels like gasoline, batteries have a substantially lower specific energy. The greater efficiency of electric motors in transforming electrical energy into mechanical work in comparison to combustion engines mitigates this to some extent in autos. A basic text editor for entering programme code is located in the centre of the IDE. You can check the compilation status, memory use, programme faults, and other helpful notifications in the output window, which is located at the bottom of the IDE.

Arduino projects are called sketches, and they are often written in a stripped-down version of C++ that lacks key functionalities. As a result of the differences between microcontroller and computer programming, a number of libraries tailored to certain devices are available (e.g., changing pin modes, outputting data on pins, reading analogue values, and timers). This can lead consumers astray if they believe a "Arduino language" is used to programme an Arduino. But C++ is how the Arduino is programmed. All it does is make use of the device's specific libraries. Most projects will use the six buttons below the navigation bar, however more complicated ones will use the IDE's built-in features. Under the terms of the GNU General Public License, version 2, the IDE's source code is made available to the public. The Arduino IDE is compatible with C and C++ thanks to its unique syntax and guidelines for code organisation. The Wiring project's software library is available in the Arduino IDE and contains numerous standard input and output routines.

The IDE release also includes the GNU toolchain, which is necessary for compiling and linking user-written code into an executable cyclic executive programme. This code just requires two essential functions: beginning the sketch and the main programme loop. A loader programme in the firmware of the Arduino board reads the executable code from the Arduino IDE and saves it as a text file in hexadecimal format. Arduino projects are called sketches, and they are often written in a stripped-down version of C++ that lacks key functionalities. All of the embedded systems that we use on a daily basis—from smartphones to washing machines to digital cameras—are built on embedded C programming. There is software integrated in every processor. The embedded software is the primary factor since it determines how the embedded system operates. The microcontroller is usually programmed using embedded C. In the past, assembly-level programming was the norm for developing embedded applications. Nevertheless, mobility was not an option. A number of high-level languages, such as COBOL, Pascal, and C, emerged and eliminated this drawback.

Still, embedded systems have been and still are big fans of the C language. Written C code has many advantages, including greater reliability, scalability, portability, and understandability. The C programming language was created in 1969 by Dennis Ritchie. There may be one or more functions in it, and each function consists of a set of statements that carry out some kind of operation. Because of its position as a middle-level language, C is able to facilitate both high- and low-level programmes. We should be familiar with RAM organisation before delving into the specifics of embedded C programming. Nevertheless, embedded systems have widely adopted and still do so the C programming language.

Conclusion

Programmers for embedded systems need to be well-versed in hardware architecture. The control and monitoring of external devices is largely accomplished by these programmes. Additionally, they control and utilise the microcontroller's internal architecture, including its interrupt handling, timers, serial connection, and other functions. Variables of various types, such as integers, characters, floats, etc., can be declared using the data type system. The embedded C programme makes use of four different data kinds for storing information in RAM. Store any single character with the 'char' data type, an integer with the 'int' data type, and a precision floating point number with the 'float' data type. The table below provides information about the size and range of several data formats on a 32-bit system. The event suggests that the solar panel can track the sun's movement in all directions, not only vertically and horizontally. By utilising a minimal array of solar panels, this gadget is able to produce optimal illumination while simultaneously reducing energy expenditures. It is highly advantageous and economical, and it will help us get the most energy out of this system no matter the season. We can also find out how the climate, weather, and seasons affect the voltage and current.

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