SMART GRID CONTROL & MANAGEMENT USING MATLAB

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Abstract:
This document introduces a management system for battery banks of lead-acid types utilized in e-vehicles. It includes a diagnostic, measurement, and monitoring system aimed at enhancing the performance of lead-acid batteries to improve their efficiency and sustainability. This issue highlights the necessity for research on traction batteries due to the ongoing demand for smaller vehicles that come with lightweight and portable equipment. It is thorough that batteries undergo strict evaluation and diagnosis before being rented or exchanged to ensure their condition is meticulously maintained. The evaluation of the battery's State-of-Charge and State-of-Health is based on its load voltage, no-load voltage, load current, and temperature collected during testing. The determination of State-of-Charge, State-of-Health, Discharge Rate, and Remaining Useful Life is subsequently achieved by applying the principles of correlation and regression to the recorded real-time parameters displayed on the LCD module. This research establishes a foundation for the holistic and ongoing advancement of battery identification, monitoring, and diagnosis, representing a significant progression in the E-Vehicle sector.

Keywords: Power line communications; Demodulation; Smart grids; Transmission line measurements; Smart Grid; remote monitoring.

INTRODUCTION

One aspect of the country's ongoing economic development is the use of commercial transportation. As transportation technology advanced in the Philippines, e-vehicles became popular in 2015 and attracted manufacturers to produce them [1]. As the backbone of its development, the traction battery sector will be significant alongside the booming e-vehicle sector. In an e-vehicle, the battery is the equivalent of the petrol tank in a traditional vehicle. The alternative to gasoline is traction batteries. According to data analyzed by the Electric Vehicle Association of the Philippines (eVap), lead-acid batteries are the most widely used traction battery type in the Philippines. More e-vehicles with lead-acid batteries are produced than those with lithium batteries. Given that it is less expensive than other varieties, it is useful [2]. Furthermore, it is simple to assemble because it uses lead plates and an electrolyte composed of diluted sulfuric acid [3]. In contrast to electrical analogies, electromechanical batteries are built using a significant network of electrical components, including passive and electromotive forces.

RELATED WORK

In May 2016, O. P. Mahela and A. G. Shaik published "Topological features of power quality improvement techniques: A thorough study" in Renewable and Sustainable Energy Reviews, vol. 58, pp. 1129-42.
In order to satisfy customers, utilities are now constantly looking for accurate and affordable power quality (PQ) improvement methods. The goal of this study is to give academics, designers, and engineers working in this field a thorough overview of the state of topological features of methods used to enhance the power quality in distribution networks. This review aids in choosing a PQ improvement method that is appropriate for a certain application in terms of both technical and financial considerations. For ease of reference, over

300 research publications on the most advanced PQ improvement strategies have been thoroughly examined, categorized, and listed.

IEEE Power and Energy Technology Systems Journal, vol. 2, Feb. 2015; N. D. Tuyen and G. Fujita, "PV-Active Power Filter Combination Supplies Power to Nonlinear Load and Compensates Utility Current."
These days, photovoltaic (PV) generation is becoming more and more common, yet normal loads need higher-quality power. In essence, an active power filter (APF) function is intended to be integrated into a single PV generator that supplies nonlinear loads. This study presents a three-phase, three-wire system that includes a detailed PV generator, a dc/ac voltage source converter that serves as an APF, and a dc/dc boost converter that uses maximum power point tracking to extract maximum radiation power. The PV-APF controller is designed using the instantaneous power theory and performs dependably. The combined system can simultaneously correct for the harmonic current consumed by nonlinear loads and inject the maximum power from a PV unit, as demonstrated using the MATLAB/Simpower Systems tool.

Electrical Power and Energy Systems, vol. 51, pp. 298-306, 2013. S. S. Patnaik and A. K. Panda, "Three-level H-bridge and three H-bridgesbased three-phase four-wire shunt active power filter topologies for high voltage applications."

The main factors influencing power quality in a three-phase, four-wire distribution system are reactive power, excessive neutral current, unbalanced loads, and the existence of current harmonics. Unbalanced and non-linear loads are the primary causes of these disruptions. In order to compensate for load, a novel three-level H-bridge (3L-HB) topology of three-phase four-wire shunt active power filter (APF) has been created. There is no need for large, costly coupling transformers because this can be directly linked to the distribution lines. Additionally, this shunt APF architecture has been contrasted with a two-level design based on three H-bridges (3HB). The Opal RT-Lab's real-time performance analysis is used to examine the APFs' performances. The topological differences and load compensation capacities of the two topologies under perfect, distorted, and unbalanced supply voltage conditions have been compared. The unbalanced loading scenario—that is, when the system contains both three-phase and single-phase loads—is taken into account when making observations.

[4] IEEE Transactions on Power Electronics, vol. 29, October 2014, "ILST Control Algorithm of Single-Stage Dual Purpose Grid Connected Solar PV System," B. Singh, C. Jain, and S. Goel.
A single-stage, three-phase grid-connected solar photovoltaic (SPV) system is presented in this study. The suggested method serves two purposes by enhancing the distribution system's power quality in addition to feeding harvested solar energy into the grid. Maximum power point tracking (MPPT), feeding SPV energy to the grid, mitigating harmonics of loads linked at the point of common coupling (PCC), and balancing grid currents are the functions of the system that is being described. A three-phase voltage source converter (VSC) is used by the SPV system to carry out each of these tasks. For VSC control, an enhanced linear sinusoidal tracer (ILST)-based control method is suggested. A variable dc link voltage is employed for MPPT in the suggested system. For quick dynamic reaction, an instantaneous compensation technique that incorporates variations in PV power is employed. First, using MATLAB and the Simulink and sim-power system toolboxes, the SPV system is simulated. The simulation's output is then experimentally confirmed. For better power quality and VSC utilization, the suggested SPV system and its control algorithm are installed in a three-phase distribution system. Grid current and PCC voltage total harmonic distortions (THDs) are measured in accordance with IEEE-929 and IEEE-519 standards.

[5] "PI and fuzzy logic controllers for shunt sctive power filter-A report," ISA Trans., vol. 51, pp. 163-169, 2012, by P. Karuppanan and K.K. Mahapatra.
A shunt Active Power Filter (APF) for reactive power compensation and harmonic reduction in the distribution network is presented in this study. Because the compensation method solely relies on source current extraction, it requires fewer sensors and is less complicated. To manage the DC-side capacitor voltage of the inverter, the necessary reference current is extracted from the distorted line-current using a Proportional Integral (PI) or Fuzzy Logic Controller (FLC). PWM-current controlled Voltage Source Inverter (VSI) is used

to create the shunt APF, and a unique Adaptive-Fuzzy Hysteresis Current Controller (A-F-HCC) is used to generate the switching patterns. The superior qualities of this unique strategy are established by comparing the suggested adaptive-fuzzy-HCC with fixed-HCC and adaptive-HCC techniques. The shunt APF system based on FLC is validated by means of thorough simulation for R-L and diode-rectifier loads.

[6] "Performance Comparison of PI and Fuzzy Controller for Indirect Current Control Based Shunt Active Power Filter," ICPEICES-2016, pp. 1-6, July 2016, N. Gotherwal, S. Ray, N. Gupta, and D. Saxena.
Industrial automation and the increase in non-linear loads have raised awareness of power quality issues and brought focus to their mitigation. In this situation, shunt active filters effectively enhance power factor, adjust reactive power, and address issues brought on by current harmonics. A shunt active power filter that lowers current harmonics in a three-phase, three-wire system is presented in this study. The fuzzy logic controller and the traditional PI controller's performance are contrasted. To create a switching pattern, the PWM current-controlled Voltage Source Converter (VSC) is employed as a shunt active power filter with a hysteresis controller. It has been found that shunt active power filters work better than indirect current control using fuzzy logic controllers and active-reactive power theory. Both steady state and transient situations have been demonstrated to yield effective simulation results.

EXISTING SYSTEM

The estimating approach in the current system correlates the capacity loss of the battery with Peukert's coefficient. It is computed that the Peukerts coefficient is a function of the battery's capacity loss. Seven samples of a single battery type were used in their investigation, and the outcomes of the suggested method were contrasted with the same number of sample history data from the same battery type.

PROPOSED SYSTEM

The user interface stores the specs of new batteries in a database, and a new LCD display will be decoded to reveal the battery specifications. The LCD display module serves as the battery identification system, gathering information during each battery charge and discharge. An Arduino-based circuit that functions as a voltmeter, ohmmeter, ammeter, and thermometer makes up the measuring system. Battery specs, measured parameters, and LCD display module data were all imported into the diagnostic system's database.

METHODOLOGY

Our project's block diagram illustrates its many components, with the primary goal being to maintain our vehicle's battery's charge and balance. As is well known, there are various techniques for battery balance, including active and passive techniques. Because we have chosen to use lithium batteries in our project, we are employing the passive method. In order to prevent overcharging and overheating, we must balance the battery in this way. Maintaining battery balancing is the next task we are working on for our project. There are three distinct phases in this. Initially, we use solar energy to charge our battery when the car is parked or operating.

The PIC micro-controller is used to implement the hardware system of the suggested converter. The system design for coding the pulses into the PIC controller uses software such as Proteus, Mplab, and Micropro. In order to drive the pulses to the MOSFET, the power supply circuit is made to regulate the PIC and driver circuit.

MICROPRO:

PIC Micro controller programming is the focus of this versatile programmer. With the exception of the 17 series, all PIC series ICs may be programmed with this hardware via the PC's RS232 port. For onboard programming of compatible flash PIC devices, this programmer furthermore supports ICSP programming. The CD-ROM contains the MPLAB IDE, the PIC CCS C compiler demo software, the MPLAB plug-in, and programming instructions. The operating systems Windows 98, 2000, and XP are all compatible with the programming software. In addition to the printed copy that comes with the Kit, the CD also includes a soft copy of the user manual. Programming a variety of PIC Micro controllers, such as EEPROMS, PIC12, PIC16, and PIC18 series of ICs, is the responsibility of this dedicated programmer.

CONTROLLER UNIT:

A microcontroller is a tiny computer on a single integrated circuit that has a CPU core, memory, and programmable input/output peripherals. It is sometimes shortened to µC, uC, or MCU. Along with a usually little quantity of RAM, program memory in the form of NOR flash or OTP ROM is also frequently placed on chip. Unlike microprocessors found in personal computers or other general-purpose applications, microcontrollers are made for embedded applications.

Because of its low cost, widespread availability, broad user base, comprehensive library of application notes, availability of free or inexpensive development tools, and ability to serially program (and re-program with flash memory), PICs are popular among both industrial developers and amateurs. In September 2011, Microchip declared that their ten billionth PIC processor was on its way.

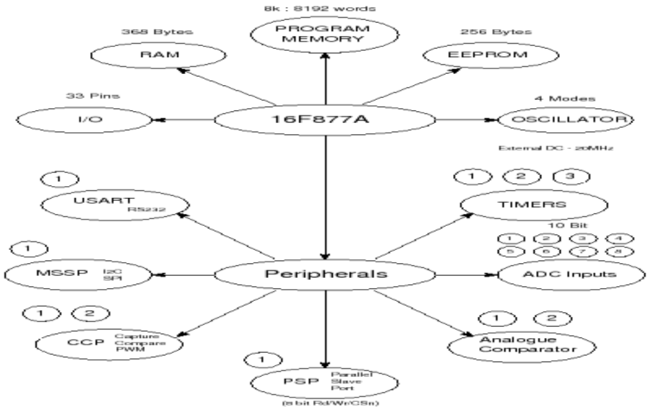

Fig 18: Micro-controller Peripherals

Peripheral Details:

Timer0: 8-bit prescaler and timer/counter Timer1: a 16-bit timer/counter with a prescaler that may be increased while you sleep by using an external clock or crystal. Timer2: 8-bit timer/counter featuring a prescaler, postscaler, and 8-bit period register Two modules for capture, comparison, and PWM Resolution is 12.5 ns, maximum capture is 16 bits. Synchronous Serial Port (SSP) with SPI (Master mode) and I2C (Master/Slave) with a maximum resolution of 16 bits and a maximum resolution of 200 ns; Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with a 9-bit address detection; Parallel Slave Port (PSP) with an 8-bit width and external RD, WR, and CS controls (40/44-pin only); and Brown-out detection circuitry for Brown-out Reset (BOR).

Special Microcontroller Applications:

100,000 cycles of writing and erasing Enhanced Flash program memory with a normal erase/write cycle of one million Typical data EEPROM memory More than 40 years of data EEPROM retention software-controlled self-reprogramming capability, Serial programming in-circuit using two pins, With its own on-chip RC oscillator for dependable operation, the 5V In-Circuit Serial Programming Watchdog Timer (WDT) requires only one source. Protection of programmable code, Sleep mode, which saves power, two pins are used for In-Circuit Debug (ICD) and oscillator selection.

CMOS Technology:

Fast, low-power Flash/EEPROM technology, completely static design, broad operational voltage range (2.0V to 5.5V), temperature ranges for commercial and industrial settings, little power usage.

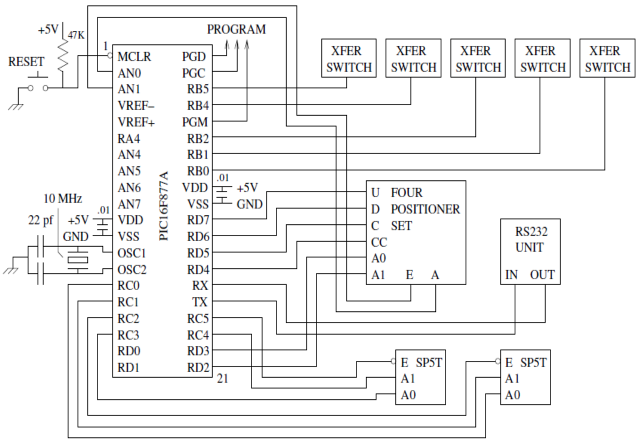

Fig 19: Microcontroller PIC16F877A

MOSFET GATE DRIVER:
With separate high and low side referenced output channels, the High And Low Side Driver (IR2112) is a high voltage, high speed power MOSFET and IGBT driver. Ruggedized monolithic construction is made possible by proprietary HVIC and latch immune CMOS technology. Up to 3.3V logic, logic inputs can be used with conventional CMOS or LSTTL outputs. A high pulse current buffer step in the output drivers is intended to minimize driver cross conduction. Matching propagation delays makes high frequency applications easier to operate. An N-channel power MOSFET or IGBT operating at 600 volts in the high side configuration can be driven by the floating channel.

In this project, the converter functions as a shunt active filter (2-quadrant) for unity power factor operation and dc voltage regulation, and the driver circuit is utilized to drive the bi-directional converter switches. The n-type and p-type BJTs are employed for amplification in this case.

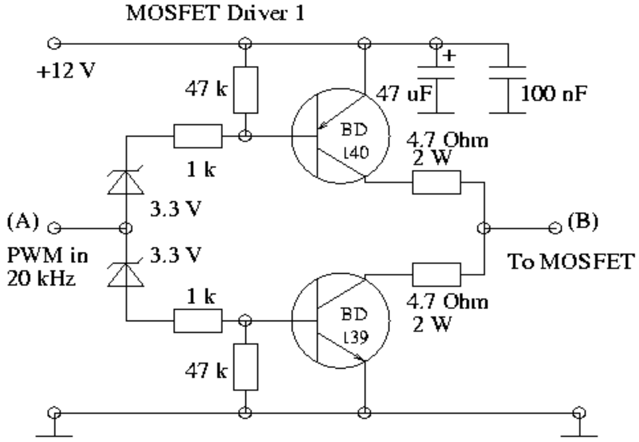

Fig 20: DRIVER CKT IR2110

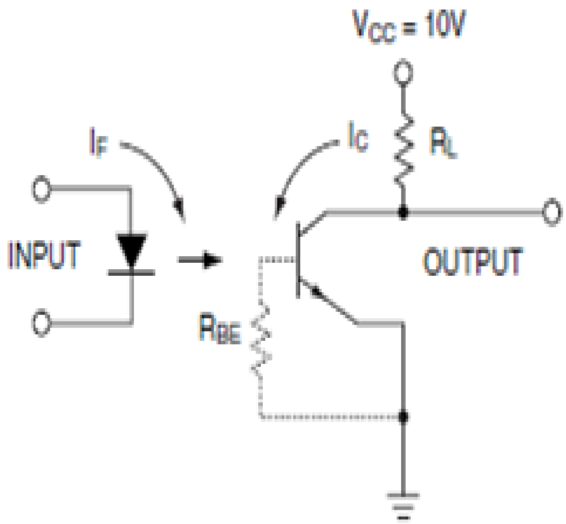

Fig 21: Operation of the MOSFET gate driver

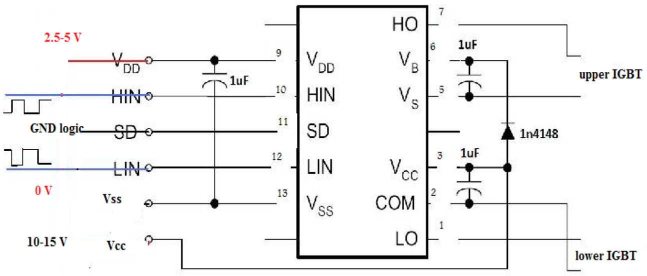

Fig 22: Driver Circuit operation

Fig 23: IR2110 Driver

MOSFET

A cross section of an n-MOSFET when the gate voltage VGS is below the threshold necessary for creating a conductive channel; there is minimal or no conduction between the source and drain terminals; the switch remains off. When the gate becomes more positive, it draws in electrons, leading to the formation of an n-type conductive channel in the substrate beneath the oxide, which permits the flow of electrons between the n-doped terminals; the switch is now on.

The metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a type of transistor employed for amplifying or switching electronic signals. The fundamental concept behind this transistor type was first patented by Julius Edgar Lilienfeld in 1925. Twenty-five years later, when Bell Telephone sought to patent the junction transistor, they discovered that Lilienfeld already possessed a patent that was phrased in a manner that encompassed all varieties of transistors. Bell Labs managed to reach an agreement with Lilienfeld, who was still alive during that period. (It remains unknown whether they compensated him financially or not.) At that time, the Bell Labs version was named the bipolar junction transistor, or simply junction transistor, while Lilienfeld's design was termed field effect transistor.

An insulated-gate field-effect transistor or IGFET is a related term that is nearly synonymous with MOSFET. The term might be broader, given that many "MOSFETs" utilize a gate that may not be metallic and a gate insulator that may not be an oxide. Another alternative term is MISFET for metal–insulator–semiconductor FET. Generally, the semiconductor of choice is silicon, but some chip manufacturers, particularly IBM and Intel, have recently begun using a chemical compound of silicon and germanium (SiGe) in MOSFET channels. Unfortunately, numerous semiconductors that possess superior electrical characteristics compared to silicon, such as gallium arsenide, do not create effective semiconductor-to-insulator interfaces, rendering them unsuitable for MOSFETs. Ongoing research is focused on developing insulators with appropriate electrical properties on alternative semiconductor materials.

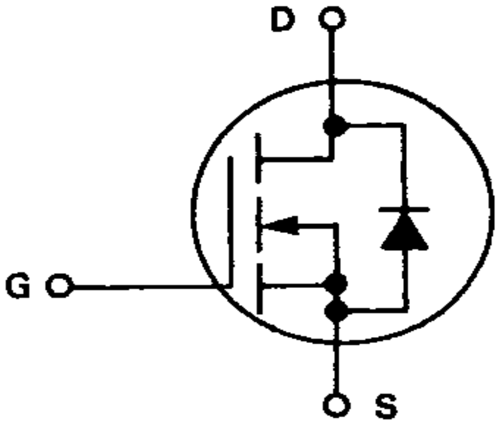

Fig 24: MOSFET

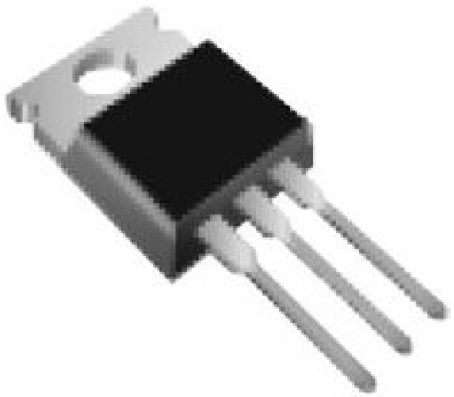

Fig 25: IRF840

PRODUCT SUMMARY		
V_{DS} (V)	500	
$R_{DS(on)}$ (Ω)	V_{GS} = 10 V	0.85
Q_g (Max.) (nC)	63	
Q_{gs} (nC)	9.3	
Q_{gd} (nC)	32	
Configuration	Single	

Fig 26: Product Summary

Vishay's third generation Power MOSFETs provide designers the best possible balance of low on-resistance, ruggedized device design, quick switching, and affordability. For all commercial-industrial applications with

power dissipation levels up to about 50 W, the TO-220AB package is universally recommended. The TO-220AB is widely used in the industry because of its low packaging cost and low thermal resistance.
This advanced power MOSFET, which operates in the breakdown avalanche mode, is an N-Channel enhancement mode silicon gate power field effect transistor that has been built, tested, and proven to withstand a certain amount of energy. Applications for all of these power MOSFETs include motor drivers, relay drivers, switching regulators, switching converters, and drivers for high power bipolar switching transistors that need low gate drive power and high speed. Integrated circuits can be used directly to operate these kinds.

DIODE:

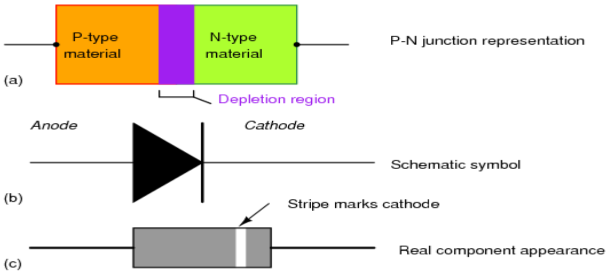

Fig 27: Diode

INDUCTOR

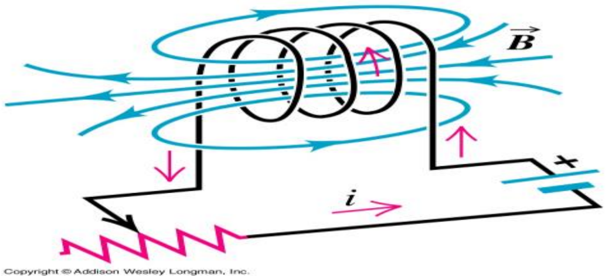

Fig 28: Inductor

A passive, two-terminal electrical component used to store energy in a magnetic field is called an inductor, reactor, or coil. Although the wire is usually twisted in loops to strengthen the magnetic field, all conductors have inductance. Faraday's law of electromagnetic induction states that a voltage is induced as a result of the coil's time-varying magnetic field, and Lenz's law states that this voltage is opposite to the change in current that produced it. Because they can delay and bend alternating currents, inductors are one of the fundamental parts used in electronics where voltage and current fluctuate over time. Chokes are inductors that can be used to prevent AC signals from flowing through a circuit or as components of filters in power supplies. In some switched-mode power supply, the energy storage component is an inductor. A certain percentage of the regulator's switching frequency is used to energize the inductor, which is then de-energized for the rest of the cycle. The input-voltage to output-voltage ratio is established by this energy transfer ratio. To maintain extremely precise voltage control, this XL is used in conjunction with an active semiconductor device.

CAPACITOR

Fig 29: Capacitor

A passive, two-terminal electrical component used to store energy in an electric field is called a capacitor (previously called a condenser). Practical capacitors come in a broad variety of shapes, but they all have at least two electrical conductors divided by an insulator, or dielectric. For instance, a common design uses metal foils separated by a thin layer of insulating film. In many everyday electrical devices, capacitors are utilized as components of electrical circuits. A static electric field forms across the dielectric when there is a potential difference (voltage) between the conductors, which results in the accumulation of positive charge on one plate and negative charge on the other. The electrostatic field stores energy. One constant value, capacitance, expressed in farads, defines an ideal capacitor. This is the proportion of each conductor's electric charge to the potential difference between them. Capacitor conductors are frequently referred to as "plates," a reference to an earlier method of construction, because the capacitance is highest when there is a small space between large regions of conductor. In reality, a breakdown voltage is produced by the dielectric between the plates passing a tiny amount of leakage current and having a limit on the strength of the electric field, while the conductors and leads introduce resistance and an unwanted inductance. In electronic circuits, capacitors are frequently used to smooth the output of power supplies, filter networks, resonant circuits that tune radios to specific frequencies, and to block direct current while permitting alternating current to flow.

Software Implementation

MATLAB

MATLAB® is a high-degree technical computer language and interactive surroundings for algorithm improvement, facts visualization, statistics evaluation, and numerical computation. Using MATLAB, you may clear up engineering pc problems faster than with conventional programming languages consisting of C, C++, and Fortran. MATLAB is an evaluation and visualization device that provides sturdy aid for matrices and matrix operations. In addition, Matlab has extraordinary portraits skills and its personal effective programming language. One of the motives why Matlab is this kind of precious device is using Matlab software packages designed to guide a specific project. These varieties of software program are referred to as toolkits, and precise toolkits are inquisitive about image processing gear. Rather than describe all the abilities of Matlab, we can restrict ourselves to the features relevant to photograph processing. We will introduce capabilities, instructions, and techniques as wished. The correct characteristic is a key-word that takes several parameters and produces some output, together with a matrix, string, graph, and so forth. Examples of such functions are sin, imprint, and closed. There are many correct functions, and as we are able to see, it is very smooth (and on occasion important) to jot down your very own.

The trendy Matlab data kind matrix all is a information type that may be handled as a type of array. However, snap shots are organized as factors whose factors are the gray values (or possibly RGB values) in their elements. If the order of the characters is correct, then correct every cost as it appears; the period of a string is the period of a wire. We will see more Matlab commands in this bankruptcy, and in later chapters we are able to talk snap shots.

When you begin Matlab, you may have an empty window called window_ where you enter instructions. Considering the massive number of Matlab capabilities and the various parameters they can take, a command line style interface is an awful lot greater efficient than a complicated drop-down menu. MATLAB may be used in a ramification of programs, consisting of sign and picture processing, communications, layout, take a look at and measurement, financial modeling, and evaluation. Additional toolkits (units of unique MATLAB functions) are available inside the MATLAB surroundings to resolve precise styles of issues in these application regions.

MATLAB offers many features for documenting and distributing your paintings. You can link your MATLAB code with different languages and applications, and distribute your MATLAB algorithms and programs.
When running with snap shots in Matlab, there are many things to recall, along with loading photos, the usage of the right format, storing exclusive types of records, a way to show pictures, and converting among exclusive photo codecs.

The Image Processing Toolbox affords a entire set of algorithmic and graphical gear for image processing, analysis, visualization, and set of rules development. You can perform image enhancement, picture de-blurring, feature detection, noise reduction, photograph segmentation, spatial transformation, and picture registration. Many of the obligations in the toolkit are multi-threaded, allowing you to use multi-middle and multi-processor computers.

\CONCLUSION

Summarizing the main conclusions, talking about the project's importance, and pointing out any possible future advancements or uses are all part of wrapping up an Arduino Nano battery charging project. This is an example of a conclusion: To sum up, using an Arduino Nano to charge batteries offers a potential path for a number of uses. We were able to effectively design and install a battery charging system that provides flexibility, efficiency, and dependability throughout this project. We were able to efficiently monitor the charging process by utilizing the Arduino Nano's capabilities, guaranteeing the battery would be charged safely and under ideal conditions. The flexibility that our method provides is one of its major benefits. The Arduino Nano platform is appropriate for a variety of projects and applications due to its easy customization and interaction with various battery kinds and charging methods. Additionally, by using Arduino Nano, we have set the stage for future improvements and growth. Features like wireless charging, intelligent charging algorithms based on battery parameters, and interaction with IoT systems for remote monitoring and control could be included in future iterations of this project. All things considered, our research shows how the Arduino Nano may be used for battery charging, providing an affordable and adaptable solution for a range of applications. As technology develops further, battery charging systems that use Arduino Nano could be essential to powering tomorrow's systems and gadgets.

FUTURE SCOPE

In conclusion, there are many potential uses for Arduino Nano battery charging in the future, such as integrating with renewable energy systems, implementing smart charging algorithms, establishing Internet of Things connectivity, investigating wireless charging technologies, creating battery management systems, and developing applications for portable electronics and education. Battery chargers based on Arduino Nano technology have the potential to significantly influence how energy storage and power distribution are developed in the future.

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