

AUTOMATION OF SOLAR SYSTEM FOR MAXIMUM POWER POINT TRACKING

**Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in**

Electronics and Communication Engineering.

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of DASARI TEJUMESH CHANDRA (37130101), DESABOYINA SATHYANARAYANA(37130361) who carried out the project entitled "AUTOMATION OF SOLAR SYSTEM FOR MAXIMUM POWER POINT TRACKING" under our supervision from August, 2020 to April, 2021.

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DECLARATION

We D. TEJ UMESH CHANDRA (37130101), D. SATHYANARAYANA (37130361) hereby declare that the Project Report entitled “AUTOMATION OF SOLAR SYSTEM FOR MAXIMUM POWER POINT TRACKING ” done by us under the guidance of Dr. M. R. EBENEZAR JEBARANI M.E., Ph.D., at SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Electronics and communication Engineering.

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Abstract

Solar energy is rapidly advancing as an important means of renewable energy resource. Solar tracking enables more solar energy to be generated because the solar panel is able to maintain a perpendicular profile to the sun's rays. Though initial cost of setting up a solar tracking system is high, this paper proposes a cheaper solution.

Design and construction of a prototype for solar tracking system with single degree of freedom, which detects the sunlight using Light Dependent Resistors (LDR), is discussed in this project.

The control circuit for the solar tracker is based on an Nodemcu microcontroller. This is programmed to detect the sunlight through the LDRs and then actuate the stepper motor to position the solar panel where it can receive maximum sunlight. Compared with any other type of motor, the stepper motor is more controllable, more energy efficient, more steady and has high tracking accuracy and suffers little environmental effect.

Theoretical analysis and research results have been shown in this paper to advocate that the designed system realized precise automatic tracking of the sun and can greatly improve the utilization of solar energy.

CHAPTER-1

Introduction:

- The aim is to design the system, which will automatically track the sun's position and accordingly change the direction of the solar panel to get the maximum output from the solar cell.
- Along with this we are going to make a solar monitoring system using GSM and GPS module.
- To implement a solar tracking system which will automatically track sun's position to increase the efficiency of solar system.
- The GSM facility is provided within the system which helps the user to monitor the system from anywhere in the world.
- The objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities.
- The integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.
- . Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure.
- Experts estimate that the IOT will consist of about 30 billion objects by 2020.
- . It is usually embedded as part of a complete device including hardware and mechanical parts.
- The embedded systems read data from input sensors. This data is then processed and the results displayed in some format to a user or users
- Control the environment; embedded systems generate and transmit commands for actuators.

CHAPTER-2

Literature survey:

Author: ZubovDmytro,

In this paper, the energy saving algorithm for the dual axis light (solar) tracker is discussed using hardware with four photoresistors and Arduino open source electronic prototyping platform. In addition to the specified tolerance for the light sensors, the specified tolerance for two servo motors is proposed. Here, servo motors are switched off to save the energy if the light intensity is changed within the certain range during the particular time-frame. It was shown that the load on power supply is close to zero in this case.

Author: 1Subhasri.G, 2Dr.Jeyalakshmi.C

A sunlight based framework is the device for orienting solar photovoltaic modules and solar thermal collectors toward the sun. Thinking about the state of the art of the innovation, successful strategy, robust control philosophy and the potential added benefit of different research work which can be employed on an extensive scale in maintainable manner. Presently we are entering in a new period of processing innovation i.e. Internet of things (IoT). IoT is a sort of “universal global neural network” in the cloud which associates various things.

Author: Ankit Makwana* and Devang Lad

Limited non renewable energy resources and increasing power demand is a major topic of concern around the world. In recent decades, renewable energy resources are widely used in order to satisfy the increasing power demand and to minimize the damage to the environment. The aim of the paper is to present a unique solar tracking technique which can be used to extract maximum power from the photovoltaic cell by using a close loop control system along with a 5-LDR sensor module which is strategically designed to generate feedback signal in order to track the sun's azimuth and elevation angle.

Author: Abhishek Shukla¹, Dr. Suraya Prakash

Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. It has emerged as one of the most promising renewable energy source characterized by a huge potential of conversion into electrical power.

Author:ShreyasiChakraborty, Nilanjana Mukherjee, Rashmi Biswas

The renewable sources of energy are becoming one of the utmost priorities of the present day world due to their innumerable advantages. In particular, solar energy is progressing as a potential inexhaustible and non-polluting energy source to suffice our ever-increasing energy requirements. However, the solar panels which are the fundamental solar-energy conversion components are fixed at a certain angle and are not able to track the sunlight direction with diurnal and seasonal changes. This limits the area of exposure of sunlight on solar panels and efficiency of the solar tracking system involving solar panels

CHAPTER-3

Existing system:

- **Solar panel tracking** solutions are a type of device that host mounted photovoltaic panels, which use the sun to generate electricity.
- In existing system the panels are Stationary mounts, which hold these panels in a fixed position, can have their productivity compromised when the sun passes to a less-than-optimal angle.

Drawbacks:

- Solar trackers are slightly more expensive than their stationary counterparts, due to the more complex technology and moving parts necessary for their operation.
- Some ongoing maintenance is generally required, though the quality of the solar tracker can play a role in how much and how often this maintenance is needed

CHAPTER-4

Proposed system:

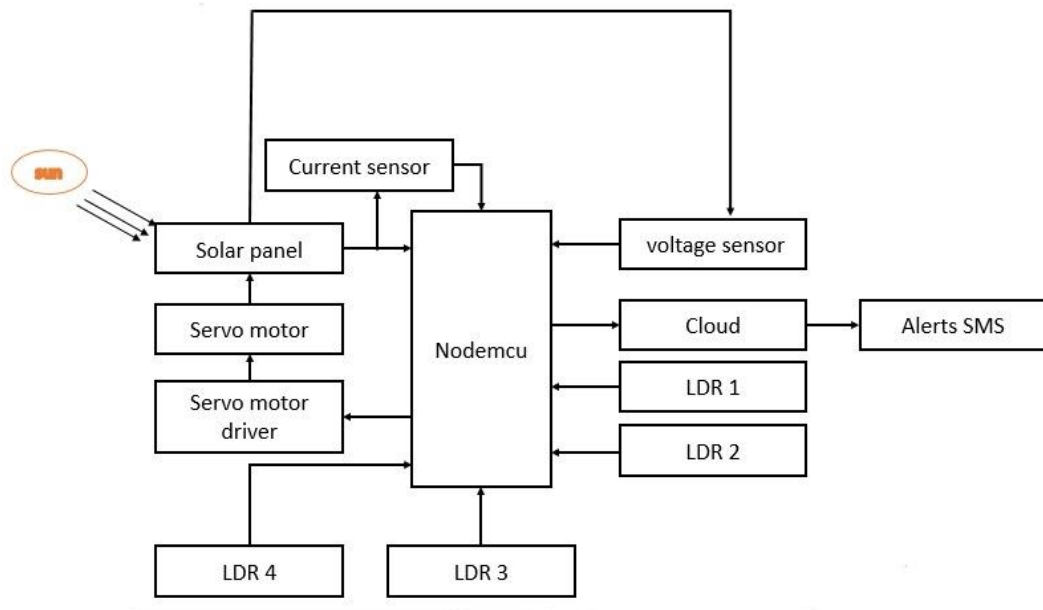
- The Dual axis solar tracking system is successfully designed and implemented. The Arrangement of LDRs along with their partition increases solar tracking accuracy there by increasing solar panel efficiency.

- By connecting this system to the internet, users can keep an eye on the whole system from anywhere in the world. In this way overall system efficiency is enhanced.
- The current sensor is used to calculate the current flowing through it.
- And it's an electrically operated switch is used for switching of large currents

Advantages:

- Inexpensive
- North-south and east-west movement
- Parts readily available
- Portable

Block Diagram:



Hardware required:

- Nodemcu
- Solar panel
- LDR
- Servo motor driver
- Servo motor
- Switch

Hardware used:

- . Arduino
- . nodemcu

CHAPTER-5

5.1 EMBEDDED SYSTEMS:

5.1.1 Overview of embedded systems

An embedded system is a special-purpose^{xiv} computer system designed to perform one

or a few dedicated functions, often with real-time computing constraints. It is usually embedded as part of a complete device including hardware and mechanical parts. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems have become very important today as they control many of the common devices we use.

Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale.

Physically, embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Handheld computers share some elements with embedded systems — such as the operating systems and microprocessors which power them — but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected.

Embedded systems provide several functions

Monitor the environment; embedded systems read data from input sensors. This data is then processed and the results displayed in some format to a user or users

Control the environment; embedded systems generate and transmit commands for actuators.

Transform the information; embedded systems transform the data collected in some meaningful way, such as data compression/decompression

Although interaction with the external world via sensors and actuators is an important aspect of embedded systems, these systems also provide functionality specific to their applications. Embedded systems typically execute applications such as control laws, finite state machines, and signal processing algorithms. These systems must also detect and react to faults in both the internal computing environment as well as the surrounding electromechanical systems.

There are many categories of embedded systems, from communication devices to home appliances to control systems. Examples include;

Communication devices

e.g.: modems, cellular phones

Home Appliances

e.g.: CD player, VCR, microwave oven

Control Systems

e.g.: Automobile anti-lock braking systems, robotics, and satellite control

5.1.2 Block diagram of an embedded system:

An embedded system usually contains an embedded processor. Many appliances that have a digital interface -- microwaves, VCRs, cars -- utilize embedded systems. Some embedded systems include an operating system. Others are very specialized resulting in the entire logic being implemented as a single program. These systems are embedded into some device for some specific purpose other than to provide general purpose computing . A typical embedded system is shown in Fig 1.1

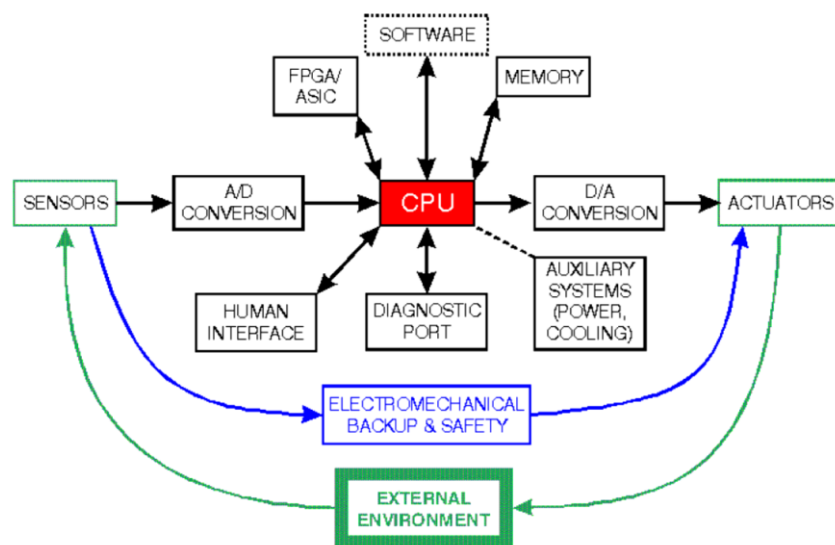


Fig 5.1 Block diagram of a typical embedded system

5.1.3 Characteristics of embedded systems

Embedded systems are characterized by a unique set of characteristics. Each of these characteristics imposed a specific set of design constraints on embedded systems designers. The challenge to designing embedded systems is to conform to the specific set of constraints for the application.

5.1.4 Application Specific Systems: ^{xvi}

Embedded systems are not general-purpose computers. Embedded system designs are optimized for a specific application. Many of the job characteristics are known before the hardware is designed. This allows the designer to focus on the specific design constraints of a well-defined application. As such, there is limited user reprogrammability. Some embedded systems, however, require the flexibility of reprogrammability. Programmable DSPs are common for such applications.

5.1.5 Reactive Systems

As mentioned earlier, a typical embedded systems model responds to the environment via sensors and control the environment using actuators. This requires embedded systems to run at the speed of the environment. This characteristic of embedded system is called “reactive”. Reactive computation means that the system (primarily the software component) executes in response to external events. External events can be either periodic or aperiodic. Periodic events make it easier to schedule processing to guarantee performance. Aperiodic events are harder to schedule. The maximum event arrival rate must be estimated in order to accommodate worst case situations. Most embedded systems have a significant reactive component. One of the biggest challenges for embedded system designers is performing an accurate worst case design analysis on systems with statistical performance characteristics (e.g., cache memory on a DSP or other embedded processor). Real time system operation means that the correctness of a computation depends, in part, on the time at which it is delivered. Systems with this requirement must often design to worst case performance. But accurately predicting the worst case may be difficult on complicated architectures. This often leads to overly pessimistic estimates erring on the side of caution. Many embedded systems have a significant requirement for real time operation in order to meet external I/O and control stability requirements. Many real-time systems are also reactive systems.

5.1.5 Distributed Systems

A common characteristic of an embedded system is one that consists of communicating processes executing on several CPUs or ASICs which are connected by communication links. The reason for this is economy. Economical 4 8-bit microcontrollers may be cheaper than a 32-bit processors. Even after adding the cost of the communication links, this approach may be preferable. In this approach, multiple processors are usually required to handle multiple time-critical tasks. Devices under

control of embedded systems may also be physically distributed.

5.1.6 Heterogeneous Architectures

Embedded systems often are composed of heterogeneous architectures (Fig 1.2). They may contain different processors in the same system solution. They may also be mixed signal systems. The combination of I/O interfaces, local and remote memories, and sensors and actuators makes embedded system design truly unique. Embedded systems also have tight design constraints, and heterogeneity provides better design flexibility.

5.2 POWER SUPPLY

All electronic circuits work only in low DC voltage, so we need a power supply unit to provide the appropriate voltage supply for their proper functioning. This unit consists of transformer, rectifier, filter & regulator. AC voltage of typically 230volts rms is connected to a transformer voltage down to the level to the desired ac voltage. A diode rectifier that provides the full wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit can use this dc input to provide dc voltage that not only has much less ripple voltage but also remains the same dc value even the dc voltage varies somewhat, or the load connected to the output dc voltages changes.

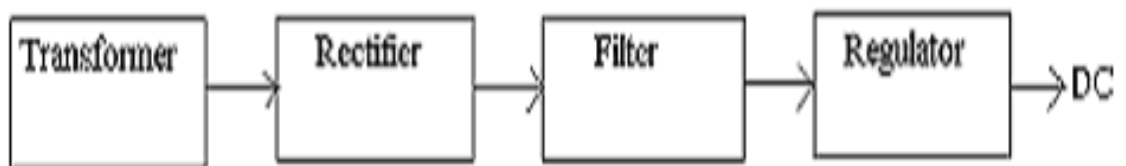


Fig 5.2 .General Block of Power Supply Unit

5.2.1 TRANSFORMER:

A transformer is a static piece of which electric power in one circuit is transformed into electric power of same frequency in another circuit. It can raise or lower the voltage in the circuit, but with a corresponding decrease or increase in current. It works with the principle of mutual induction. In our project we are using a step down transformer to providing a necessary supply for the electronic circuits. Here we step down a 230volts ac into 12volts ac.

5.2.2 RECTIFIER:

xvi

A dc level obtained from a sinusoidal input can be improved 100% using a process

called full wave rectification. Here in our project for full wave rectification we use bridge rectifier. From the basic bridge configuration we see that two diodes(say D2 & D3) are conducting while the other two diodes (D1 & D4) are in off state during the period $t = 0$ to $T/2$. Accordingly for the negative cycle of the input the conducting diodes are D1 & D4. Thus the polarity across the load is the same.

In the bridge rectifier the diodes may be of variable types like 1N4001, 1N4003, 1N4004, 1N4005, 1N4007 etc... can be used. But here we use 1N4007, because it can withstand up to 1000v.

5.2.3 FILTERS:

In order to obtain a dc voltage of 0 Hz, we have to use a low pass filter. So that a capacitive filter circuit is used where a capacitor is connected at the rectifier output & a dc is obtained across it. The filtered waveform is essentially a dc voltage with negligible ripples & it is ultimately fed to the load.

5.2.4 REGULATORS:

The output voltage from the capacitor is more filtered & finally regulated. The voltage regulator is a device, which maintains the output voltage constant irrespective of the change in supply variations, load variations & temperature changes. Here we use fixed voltage regulator namely LM7805. The IC LM7805 is a +5v regulator which is used for microcontroller.

5.2.5 FEATURES AND DESCRIPTION OF REGULATORS

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

5.3 NODEMCU:

NodeMCU is an open source [IoT](#) platform.^{[4][5]} It includes [firmware](#) which runs on the [ESP8266 Wi-Fi SoC](#) from [Espressif Systems](#), and hardware which is based on the ESP-12 module.^{[6][7]} The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the [Lua](#) scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson^[8] and [SPIFFS](#)

NodeMCU was created shortly after the [ESP8266](#) came out. On December 30, 2013, [EspressifSystems](#)^[6] began production of the ESP8266.^[10] The ESP8266 is a Wi-Fi SoC integrated with a [Tensilica](#) Xtensa LX106 core,^[citation needed] widely used in IoT applications (see [related projects](#)). NodeMCU started on 13 Oct 2014, when Hong committed the first file of nodemcu-firmware to GitHub.^[11] Two months later, the project expanded to include an open-hardware platform when developer Huang R committed the [gerber](#) file of an ESP8266 board, named devkit v0.9.^[12] Later that month, Tuan PM ported [MQTT](#) client library from [Contiki](#) to the ESP8266 SoC platform,^[13] and committed to NodeMCU project, then NodeMCU was able to support the MQTT IoT protocol, using Lua to access the MQTT broker. Another important update was made on 30 Jan 2015, when Devsaurus ported the u8glib^[14] to NodeMCU project,^[15] enabling NodeMCU to easily drive LCD, Screen, OLED, even VGA displays.

In summer 2015 the creators abandoned the firmware project and a group of independent contributors took over. By summer 2016 the NodeMCU included more than 40 different modules. Due to resource constraints users need to select the modules relevant for their project and build a firmware tailored to their needs.

5.3.1 ESP8266 Arduino Core^[edit]

As Arduino.cc began developing new MCU boards based on non-AVR processors like the ARM/SAM MCU and used in the Arduino Due, they needed to modify the Arduino IDE so that it would be relatively easy to change the IDE to support alternate toolchains to allow Arduino C/C++ to be compiled for these new processors. They did this with the introduction of the Board Manager and the SAM Core. A "core" is the collection of software components required by the Board Manager and the Arduino IDE to compile an Arduino C/C++ source file for the target MCU's machine language. Some ESP8266 enthusiasts developed an Arduino core for the ESP8266 Wi-Fi SoC, popularly called the "ESP8266 Core for the Arduino IDE".^[16] This has become a leading software development platform for the various ESP8266-based modules and development boards, including NodeMCUs.

NodeMCU is an open source [LUA](#) based firmware developed for ESP8266 wifi chip. By exploring functionality with ESP8266 chip, NodeMCU firmware comes with ESP8266 Development board/kit i.e. NodeMCU Development board.

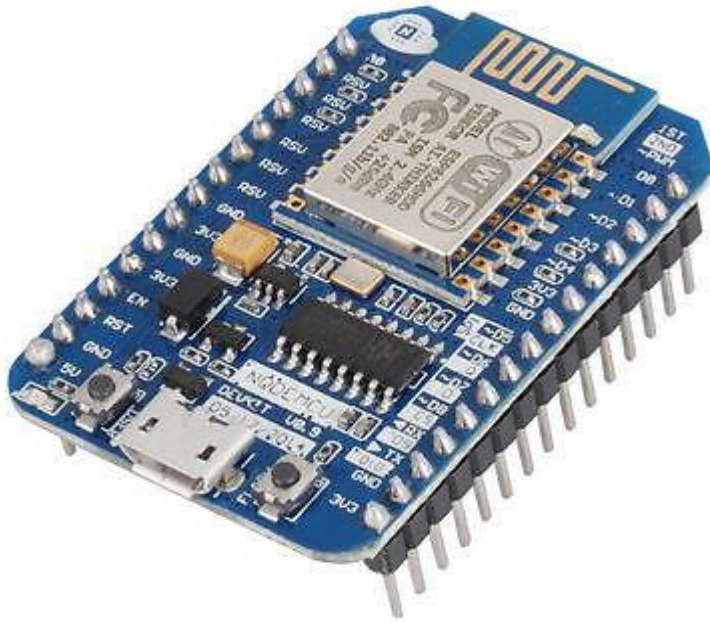


fig 5.3 nodemcu development board v1

5.3.2 NodeMCU Development Board/kit v0.9 (Version1)

Since NodeMCU is open source platform, their hardware design is open for edit/modify/build.

NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. The **ESP8266** is a low-cost [Wi-Fi](#) chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer [ESP8266 WiFi Module](#).

There is Version2 (V2) available for NodeMCU Dev Kit i.e. **NodeMCU Development Board v1.0 (Version2)**, which usually comes in black colored PCB.

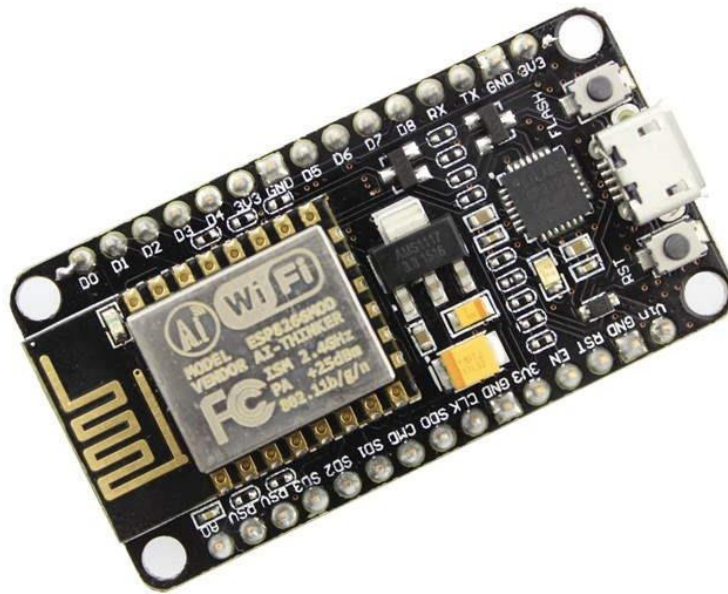


fig 5.4 nodemcu development board v2

NodeMCU Development Board/kit v1.0 (Version2)

For more information about NodeMCU Boards available in market refer [NodeMCU Development Boards](#)

NodeMCU Dev Kit has **Arduino like** Analog (i.e. A0) and Digital (D0-D8) pins on its board.

It supports serial communication protocols i.e. UART, SPI, I2C etc.

Using such serial protocols we can connect it with serial devices like I2C enabled LCD display, Magnetometer HMC5883, MPU-6050 Gyro meter + Accelerometer, RTC chips, GPS modules, touch screen displays, SD cards etc.

NodeMCU Development board is featured with wifi capability, analog pin, digital pins and serial communication protocols.

To get start with using NodeMCU for IoT applications first we need to know about how to write/download NodeMCU firmware in NodeMCU Development Boards. And before that where this NodeMCU firmware will get as per our requirement.

There is online NodeMCU custom builds available using which we can easily get our custom NodeMCU firmware as per our requirement.

To know more about how to build custom NodeMCU firmware online and download it refer [Getting started with NodeMCU](#)

After setting up ESP8266 with Node-MCU firmware, let's see the IDE (Integrated Development Environment) required for development of NodeMCU.

5.3.3 NodeMCU with ESPlorer IDE

[Lua](#) scripts are generally used to code the NodeMCU. Lua is an open source, lightweight, embeddable scripting language built on top of C programming language.

For more information about how to write Lua script for NodeMCU refer [Getting started with NodeMCU using ESPlorerIDE](#)

5.3.4 NodeMCU with Arduino IDE

Here is another way of developing NodeMCU with a well-known IDE i.e. Arduino IDE. We can also develop applications on NodeMCU using Arduino development environment. This makes easy for Arduino developers than learning new language and IDE for NodeMCU.

For more information about how to write Arduino sketch for NodeMCU refer [Getting started with NodeMCU using ArduinoIDE](#)

Well, there is a programming language difference we can say while developing application for NodeMCU using ESPlorer IDE and Arduino IDE.

We need to code in C\C++ programming language if we are using Arduino IDE for developing NodeMCU applications and Lua language if we are using ESPlorer IDE.

Basically, NodeMCU is Lua Interpreter, so it can understand Lua script easily. When we write Lua scripts for NodeMCU and send/upload it to NodeMCU, then they will get executes sequentially. It will not build binary firmware file of code for NodeMCU to write. It will send Lua script as it is to NodeMCU to get execute.

In Arduino IDE when we write and compile code, ESP8266 toolchain in background creates binary firmware file of code we wrote. And when we upload it to NodeMCU then it will flash all NodeMCU firmware with newly generated binary firmware code. In fact, it writes the complete firmware.

That's the reason why NodeMCU not accept further Lua scripts/code after it is getting flashed by Arduino IDE. After getting flashed by Arduino sketch/code it will be no more Lua interpreter and we got error if we try to upload Lua scripts. To again start with Lua script, we need to flash it with NodeMCU firmware.

Since Arduino IDE compile and upload/writes complete firmware, it takes more time than ESPlorer IDE.

5.4 Solar panel:

The term solar panel is used colloquially for a photo-voltaic (PV) module.

A PV module is an assembly of photo-voltaic cells mounted in a framework for installation. Photo-voltaic cells use sunlight as a source of energy and generate direct current electricity. A collection of PV modules is called a PV Panel, and a system of Panels is an Array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.

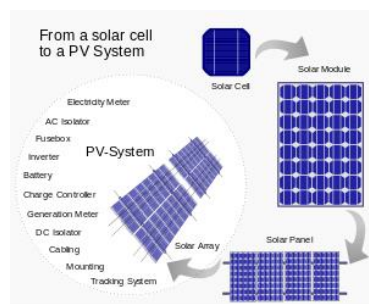


fig 5.5 solar panel^{xxi}

Theory:

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. Most modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can be either the top layer or the back layer. Cells must be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells are connected electrically in series, one to another to the desired voltage, and then in parallel to increase amperage. The wattage of the module is the mathematical product of the voltage and the amperage of the module. The manufacture specifications on solar panels are obtained under standard condition which is not the real operating condition the solar panels are exposed to on the installation site. [1]

A PV junction box is attached to the back of the solar panel and functions as its output interface. External connections for most photovoltaic modules use MC4 connectors to facilitate easy weatherproof connections to the rest of the system. A USB power interface can also be used.[citation needed]

Module electrical connections are made in series to achieve a desired output voltage or in parallel to provide a desired current capability (amperes) of the solar panel or the PV system. The conducting wires that take the current off the modules are sized according to the ampacity and may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated.[citation needed]

Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.[citation needed]

Solar panels also use metal frames consisting of racking components, brackets, reflector shapes, and troughs to better support the panel structure.

History:

In 1839, the ability of some materials to create an electrical charge from light exposure was first observed by Alexandre-Edmond Becquerel. [2] Though the premiere solar panels were too inefficient for even simple electric devices they

were used as an instrument to measure light.[3] The observation by Becquerel was not replicated again until 1873, when Willoughby Smith discovered that the charge could be caused by light hitting selenium. After this discovery, William Grylls Adams and Richard Evans Day published "The action of light on selenium" in 1876, describing the experiment they used to replicate Smith's results.[2][4]

In 1881, Charles Fritts created the first commercial solar panel, which was reported by Fritts as "continuous, constant and of considerable force not only by exposure to sunlight but also to dim, diffused daylight." [5] However, these solar panels were very inefficient, especially compared to coal-fired power plants. In 1939, Russell Ohl created the solar cell design that is used in many modern solar panels. He patented his design in 1941.[6] In 1954, this design was first used by Bell Labs to create the first commercially viable silicon solar cell.[2] In 1957, Mohamed M. Atalla developed the process of silicon surface passivation by thermal oxidation at Bell Labs.[7][8] The surface passivation process has since been critical to solar cell efficiency. [9]

Each module is rated by its DC output power under standard test conditions (STC) and hence the on field output power might vary. Power typically ranges from 100 to 365 Watts (W). The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 W module will have twice the area of a 16% efficient 230 W module. Some commercially available solar modules exceed 24% efficiency.[10] [11]

Depending on construction, photovoltaic modules can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence, much of the incident sunlight energy is wasted by solar modules, and they can give far higher efficiencies if illuminated with monochromatic light. Therefore, another design concept is to split the light into six to eight different wavelength ranges that will produce a different color of light, and direct the beams onto different cells tuned to those ranges.[12] This has been projected to be capable of raising efficiency by 50%.

A single solar module can produce only a limited amount of power; most installations contain multiple modules adding voltages or current to the wiring and PV system. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for energy storage, charge controller,

interconnection wiring, circuit breakers, fuses, disconnect switches, voltage meters, and optionally a solar tracking mechanism. Equipment is carefully selected to optimize output, energy storage, reduce power loss during power transmission, and conversion from direct current to alternating current.

Scientists from Spectrolab, a subsidiary of Boeing, have reported development of multi-junction solar cells with an efficiency of more than 40%, a new world record for solar photovoltaic cells.[13] The Spectrolab scientists also predict that concentrator solar cells could achieve efficiencies of more than 45% or even 50% in the future, with theoretical efficiencies being about 58% in cells with more than three junctions.

Currently, the best achieved sunlight conversion rate (solar module efficiency) is around 21.5% in new commercial products[14] typically lower than the efficiencies of their cells in isolation. The most efficient mass-produced solar modules[disputed – discuss] have power density values of up to 175 W/m² (16.22 W/ft²).[15]

Research by Imperial College London has shown that solar panel efficiency is improved by studding the light-receiving semiconductor surface with aluminum nanocylinders, similar to the ridges on Lego blocks. The scattered light then travels along a longer path in the semiconductor, absorbing more photons to be converted into current. Although these nanocylinders have been used previously (aluminum was preceded by gold and silver), the light scattering occurred in the near-infrared region and visible light was absorbed strongly. Aluminum was found to have absorbed the ultraviolet part of the spectrum, while the visible and near-infrared parts of the spectrum were found to be scattered by the aluminum surface. This, the research argued, could bring down the cost significantly and improve the efficiency as aluminum is more abundant and less costly than gold and silver. The research also noted that the increase in current makes thinner film solar panels technically feasible without "compromising power conversion efficiencies, thus reducing material consumption".[16]

Solar panel efficiency can be calculated by MPP (maximum power point) value of solar panels.

Solar inverters convert the DC power to ~~XX~~AC power by performing the process of maximum power point tracking (MPPT): solar inverter samples the output Power

(I-V curve) from the solar cell and applies the proper resistance (load) to solar cells to obtain maximum power.

MPP (Maximum power point) of the solar panel consists of MPP voltage (V_{mpp}) and MPP current (I_{mpp}): it is a capacity of the solar panel and the higher value can make higher MPP.

Micro-inverted solar panels are wired in parallel, which produces more output than normal panels wired in series, with the output of the series determined by the lowest performing panel. This is known as the "Christmas light effect". Micro-inverters work independently to enable each panel to contribute its maximum possible output for a given amount of sunlight

Technology:

Most solar modules are currently produced from crystalline silicon (c-Si) solar cells made of multicrystalline and monocrystalline silicon. In 2013, crystalline silicon accounted for more than 90 percent of worldwide PV production, while the rest of the overall market is made up of thin-film technologies using cadmium telluride, CIGS and amorphous silicon[18]

Emerging, third generation solar technologies use advanced thin-film cells. They produce a relatively high-efficiency conversion for the low cost compared to other solar technologies. Also, high-cost, high-efficiency, and close-packed rectangular multi-junction (MJ) cells are preferably used in solar panels on spacecraft, as they offer the highest ratio of generated power per kilogram lifted into space. MJ-cells are compound semiconductors and made of gallium arsenide (GaAs) and other semiconductor materials. Another emerging PV technology using MJ-cells is concentrator photovoltaics (CPV).

Thin film

In rigid thin-film modules, the cell and the module are manufactured in the same production line. The cell is created on a glass substrate or superstrate, and the electrical connections are created in situ, a so-called "monolithic integration". The substrate or superstrate is laminated with an encapsulant to a front or back sheet, usually another sheet of glass. The main cell technologies in this category are CdTe, or a-Si, or a-Si+uc-Si tandem, or CIGS (or variant). Amorphous silicon has a sunlight conversion rate of 6–12%

Flexible thin film cells and modules are ~~created~~ created on the same production line by depositing the photoactive layer and other necessary layers on a flexible

substrate. If the substrate is an insulator (e.g. polyester or polyimide film) then monolithic integration can be used. If it is a conductor then another technique for electrical connection must be used. The cells are assembled into modules by laminating them to a transparent colourless fluoropolymer on the front side (typically ETFE or FEP) and a polymer suitable for bonding to the final substrate on the other side.

Main articles: Smart module and Solar micro-inverter

Several companies have begun embedding electronics into PV modules. This enables performing MPPT for each module individually, and the measurement of performance data for monitoring and fault detection at module level. Some of these solutions make use of power optimizers, a DC-to-DC converter technology developed to maximize the power harvest from solar photovoltaic systems. As of about 2010, such electronics can also compensate for shading effects, wherein a shadow falling across a section of a module causes the electrical output of one or more strings of cells in the module to fall to zero, but not having the output of the entire module fall to zero.

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5.5 LDR-LIGHT DEPENDENT RESISTOR

A **Light Dependent Resistor** (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a **LDR**, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.

5.5.1 Working Principle of LDR

A **light dependent resistor** works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity (Hence resistivity) reduces when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy is incident on the device more & more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing and hence it is said that the resistance of the device has decreased. This is the most common **working principle of LDR**

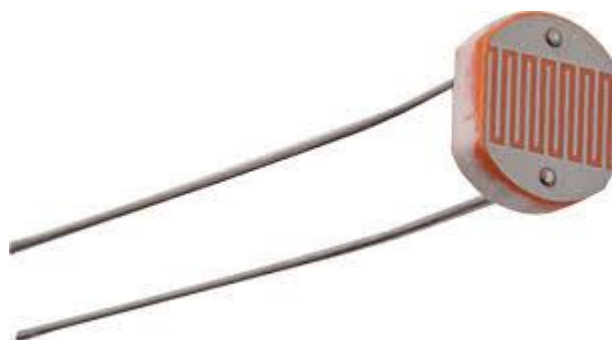


fig 5.6 diagram of LDR

Diagram of LDR Sensor

5.5.2 Characteristics of LDR

LDR's are light dependent devices whose resistance decreases when light falls on them and increases in the dark. When a **light dependent resistor** is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as $10^{12} \Omega$. And if the device is allowed to absorb light its resistance will decrease drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular **LDR**. Photocells or LDR's are non linear devices. Their sensitivity varies with the wavelength of light incident on them. Some photocells might not at all respond to a certain range of wavelengths. Based on the material used different cells have different spectral response curves.

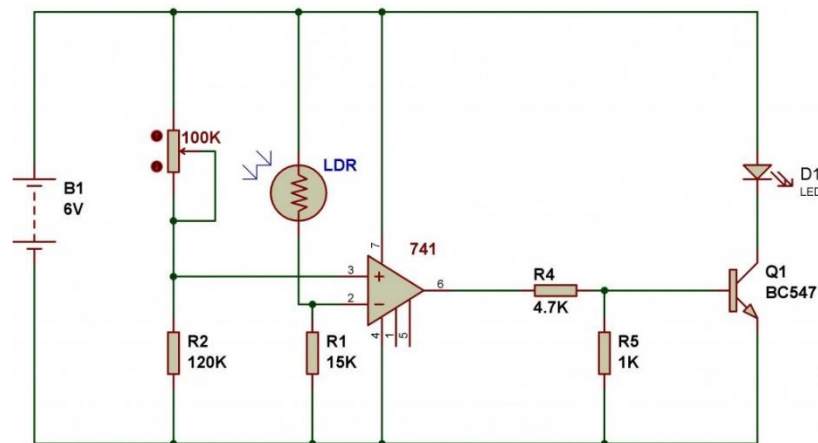


fig 5.7 circuit diagram of LDR sensor

Circuit diagram of LDR Sensor

When light is incident on a photocell it usually takes about 8 to 12ms for the change in resistance to take place, while it takes seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors. Also, **LDR's** are less sensitive than photo diodes and photo transistor. (A photo diode and a photocell (LDR) are not the same, a photo-diode is a p-n junction semiconductor device that converts light to electricity, whereas a photocell is a passive device, there is no p-n junction in this nor it "converts" light to electricity).

XX

Types of Light Dependent Resistors:

Based on the materials used they are classified as: i) intrinsic photo resistors (Un doped semiconductor): These are pure semiconductor materials such as silicon or germanium. Electrons get excited from valance band to conduction band when photons of enough energy falls on it and number charge carriers increases.

ii) Extrinsic photo resistors: These are semiconductor materials doped with impurities which are called as dopants. Theses dopants create new energy bands above the valence band which are filled with electrons. Hence this reduces the band gap and less energy is required in exciting them. Extrinsic photo resistors are generally used for long wavelengths.

5.5.3Construction of a Photocell

The structure of a light dependent resistor consists of a light sensitive material which is deposited on an insulating substrate such as ceramic. The material is deposited in zigzag pattern in order to obtain the desired resistance& power rating. This zigzag area separates the metal deposited areas into two regions. Then the ohmic contacts are made on the either sides of the area. The resistances of these contacts should be as less as possible to make sure that the resistance mainly changes due to the effect of light only. Materials normally used are cadmium sulphide, cadmium selenide, indiumantimonide and cadmium sulphonide. The use of lead and cadmium is avoided as they are harmful to the environment.

5.5.4Applications of LDR

LDR's have low cost and simple structure. They are often used as light sensors. They are used when there is a need to detect absences or presences of light like in a camera light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyer belt, etc.

IOT:

5.6INTERNET OF THINGS:

The Internet of things (IOT) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data. In 2013 the

Global Standards Initiative on Internet of Things (IOT-GSI) defined the IOT as "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" and for these purposes a "thing" is "an object of the physical world (physical things) or the information world (virtual things), which is capable of being identified and integrated into communication networks". The IOT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IOT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IOT will consist of about 30 billion objects by 2020. Typically, IOT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a smart grid, and expanding to areas such as smart cities. "Things", in the IOT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring, or field operation devices that assist fire fighters in search and rescue operations. Legal scholars suggest regarding "Things" as an "inextricable mixture of hardware, software, data and service". These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices. Current market examples include home automation (also known as smart home devices) such as the control and automation of lighting, heating (like smart thermostat), ventilation, air conditioning (HVAC) ^{xx}systems, and appliances such as washer/dryers, robotic vacuums, air purifiers, ovens, or refrigerators/freezers that

use Wi-Fi for remote monitoring. As well as the expansion of Internet-connected automation into a plethora of new application areas, IOT is also expected to generate large amounts of data from diverse locations, with the consequent necessity for quick aggregation of the data, and an increase in the need to index, store, and process such data more effectively. IOT is one of the platforms of today's Smart City, and Smart Energy Management Systems

HISTORY

As of 2016, the vision of the Internet of things has evolved due to a convergence of multiple technologies, including ubiquitous wireless communication, real-time analytics, machine learning, commodity sensors, and embedded systems. This means that the traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of things (IOT). The concept of a network of smart devices was discussed as early as 1982, with a modified Coke machine at Carnegie Mellon University becoming the first Internet-connected appliance, able to report its inventory and whether newly loaded drinks were cold. Mark Weiser's seminal 1991 paper on ubiquitous computing, "The Computer of the 21st Century", as well as academic venues such as UbiComp and PerCom produced the contemporary vision of IOT. In 1994 Reza Raji described the concept in IEEE Spectrum as "[moving] small packets of data to a large set of nodes, so as to integrate and automate everything from home appliances to entire factories". Between 1993 and 1996 several companies proposed solutions like Microsoft's at Work or Novell's NEST. However, only in 1999 did the field start gathering momentum. Bill Joy envisioned Device to Device (D2D) communication as part of his "Six Webs" framework, presented at the World Economic Forum at Davos in 1999. The concept of the Internet of things became popular in 1999, through the Auto-ID Centre at MIT and related market-analysis publications. Radio-frequency identification (RFID) was seen by Kevin Ashton (one of the founders of the original Auto-ID Centre) as a prerequisite for the Internet of things at that point. Ashton prefers the phrase "Internet for Things. ^{xx} If all objects and people in daily life were equipped with identifiers, computers could manage and inventory them. Besides

using RFID, the tagging of things may be achieved through such technologies as near field communication, barcodes, QR codes and digital watermarking. In its original interpretation, one of the first consequences of implementing the Internet of things by equipping all objects in the world with minuscule identifying devices or machine-readable identifiers would be to transform daily life. For instance, instant and ceaseless inventory control would become ubiquitous. A person's ability to interact with objects could be altered remotely based on immediate or present needs, in accordance with existing end-user agreements. For example, such technology could grant motion-picture publishers much more control over end-user private devices by remotely enforcing copyright restrictions and digital rights management, so the ability of a customer who bought a Blu-ray disc to watch the movie could become dependent on the copyright holder's decision, similar to Circuit City's failed DIVX.

5.6.1APPLICATIONS:

According to Gartner, Inc. (a technology research and advisory corporation), there will be nearly 20.8 billion devices on the Internet of things by 2020. ABI Research estimates that more than 30 billion devices will be wirelessly connected to the Internet of things by 2020. As per a 2014 survey and study done by Pew Research Internet Project, a large majority of the technology experts and engaged Internet users who responded—83 percent—agreed with the notion that the Internet/Cloud of Things, embedded and wearable computing (and the corresponding dynamic systems will have widespread and beneficial effects by 2025. As such, it is clear that the IOT will consist of a very large number of devices being connected to the Internet. In an active move to accommodate new and emerging technological innovation, the UK Government, in their 2015 budget, allocated £40,000,000 towards research into the Internet of things. The former British Chancellor of the Exchequer George Osborne, posited that the Internet of things is the next stage of the information revolution and referenced the inter-connectivity of everything from urban transport to medical devices to household appliances. The ability to network embedded devices with limited CPU, memory and power resources means that IOT finds applications in nearly every field. [48] Such systems could be in charge of collecting information in settings ranging from natural ecosystems to buildings and factories^{xx}, thereby finding applications in fields

of environmental sensing and urban planning. On the other hand, IOT systems could also be responsible for performing actions, not just sensing things. Intelligent shopping systems, for example, could monitor specific users' purchasing habits in a store by tracking their specific mobile phones. These users could then be provided with special offers on their favourite products, or even location of items that they need, which their fridge has automatically conveyed to the phone. Additional examples of sensing and actuating are reflected in applications that deal with heat, water, electricity and energy management, as well as cruise-assisting transportation systems. Other applications that the Internet of things can provide is enabling extended home security features and home automation. The concept of an "Internet of living things" has been proposed to describe networks of biological sensors that could use cloud-based analyses to allow users to study DNA or other molecules. However, the application of the IOT is not only restricted to these areas. Other specialized use cases of the IOT may also exist. An overview of some of the most prominent application areas is provided here.

MEDIA:

In order to hone the manner in which things, media and big data are interconnected, it is first necessary to provide some context into the mechanism used for media process. It has been suggested by Nick Couldry and Joseph Turow that practitioners in media approach big data as many actionable points of information about millions of individuals. The industry appears to be moving away from the traditional approach of using specific media environments such as newspapers, magazines, or television shows and instead tap into consumers with technologies that reach targeted people at optimal times in optimal locations. The ultimate aim is of course to serve, or convey, a message or content that is (statistically speaking) in line with the consumer's mind set. For example, publishing environments are increasingly tailoring the messages (advertisements) and content (articles) to appeal to consumers that have been exclusively gleaned through various data-mining activities. The media industries process big data in a dual, interconnected manner: Targeting of consumers (for advertising by marketers) Data-capture^{xx} Thus, the Internet of things creates an opportunity to

measure, collect and analyse an ever-increasing variety of behavioural statistics. Cross-correlation of this data could revolutionise the targeted marketing of products and services. For example, as noted by Danny Meadows-Klue, the combination of analytics for conversion tracking with behavioural targeting has unlocked a new level of precision that enables display advertising to be focused on the devices of people with relevant interests. Big data and the IOT work in conjunction. From a media perspective, data is the key derivative of device interconnectivity, whilst being pivotal in allowing clearer accuracy in targeting. The Internet of things therefore transforms the media industry, companies and even governments, opening up a new era of economic growth and competitiveness. The wealth of data generated by this industry (i.e. big data) will allow practitioners in advertising and media to gain an elaborate layer on the present targeting mechanisms used by the industry.

INFRASTRUCTURE MANAGEMENT:

Monitoring and controlling operations of urban and rural infrastructures like bridges, railway tracks, on- and offshore- wind-farms is a key application of the IOT. The IOT infrastructure can be used for monitoring any events or changes in structural conditions that can compromise safety and increase risk. It can also be used for scheduling repair and maintenance activities in an efficient manner, by coordinating tasks between different service providers and users of these facilities. IOT devices can also be used to control critical infrastructure like bridges to provide access to ships. Usage of IOT devices for monitoring and operating infrastructure is likely to improve incident management and emergency response coordination, and quality of service, up-times and reduce costs of operation in all infrastructure related areas. Even areas such as waste management can benefit from automation and optimization that could be brought in by the IOT.

5.6.2MANUFACTURING NETWORK:

Control and management of manufacturing equipment, asset and situation management, or manufacturing process control bring the IOT within the realm of industrial applications and smart manufacturing as well. The IOT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and

supply chain networks, by networking machinery, sensors and control systems together. Digital control systems to automate process controls, operator tools and service information systems to optimize plant safety and security are within the purview of the IOT. But it also extends itself to asset management via predictive maintenance, statistical evaluation, and measurements to maximize reliability. Smart industrial management systems can also be integrated with the Smart Grid, thereby enabling real-time energy optimization. Measurements, automated controls, plant optimization, health and safety management, and other functions are provided by a large number of networked sensors. The National Science Foundation established an Industry/University Cooperative Research Centre on intelligent maintenance systems (IMS) in 2001 with a research focus to use IOT-based predictive analytics technologies to monitor connected machines and to predict machine degradation, and further to prevent potential failures. The vision to achieve near-zero breakdown using IOT-based predictive analytics led the future development of e-manufacturing and e-maintenance activities. The term IIOT (Industrial Internet of Things) is often encountered in the manufacturing industries, referring to the industrial subset of the IOT. IIOT in manufacturing could generate so much business value that it will eventually lead to the fourth industrial revolution, so the so-called Industry 4.0. It is estimated that in the future, successful companies will be able to increase their revenue through Internet of things by creating new business models and improve productivity, exploit analytics for innovation, and transform workforce. The potential of growth by implementing IIOT will generate \$12 trillion of global GDP by 2030 while connectivity and data acquisition are imperative for IIOT, they should not be the purpose, rather the foundation and path to something bigger. Among all the technologies, predictive maintenance is probably a relatively "easier win" since it is applicable to existing assets and management systems. The objective of intelligent maintenance systems is to reduce unexpected downtime and increase productivity. And to realize that alone would generate around up to 30% over total maintenance costs. Industrial big data analytics will play a vital role in manufacturing asset predictive maintenance, although that is not the only capability of industrial big data. Cyber-physical systems (CPS) is the core technology of industrial big data and it will be an interface between human and the cyber world. Cyber-physical systems can be designed by following the 5C (connection, conversion, cyber, cognition,

configuration, architecture), and it will transform the collected data into actionable information, and eventually interfere with the physical assets to optimize processes.

ENERGY MANAGEMENT :

Integration of sensing and actuation systems, connected to the Internet, is likely to optimize energy consumption as a whole. It is expected that IOT devices will be integrated into all forms of energy consuming devices (switches, power outlets, bulbs, televisions, etc.) and be able to communicate with the utility supply company in order to effectively balance power generation and energy usage. Such devices would also offer the opportunity for users to remotely control their devices, or centrally manage them via a cloud based interface, and enable advanced functions like scheduling (e.g., remotely powering on or off heating systems, controlling ovens, changing lighting conditions etc.). Besides home based energy management, the IOT is especially relevant to the Smart Grid since it provides systems to gather and act on energy and power-related information in an automated fashion with the goal to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. Using advanced metering infrastructure (AMI) devices connected to the Internet backbone, electric utilities can not only collect data from end-user connections, but also manage other distribution automation devices like transformers and re closers.

BUILDING AND HOME AUTOMATION:

IOT devices can be used to monitor and control the mechanical, electrical and electronic systems used in various types of buildings (e.g., public and private, industrial, institutions, or residential) in home automation and building automation systems. In this context, three main areas are being covered in literature: The integration of the internet with building energy management systems in order to create energy efficient and IOT driven “smart buildings”. The possible means of real-time monitoring for reducing energy consumption and monitoring occupant behaviours. The integration of smart devices in the built environment and how they might be used in future applications.

TRANSPORTATION:

The IOT can assist in integration of ^{xx}communications, control, and information

processing across various transportation systems. Application of the IOT extends to all aspects of transportation systems (i.e. the vehicle, the infrastructure, and the driver or user). Dynamic interaction between these components of a transport system enables inter and intra vehicular communication, smart traffic control, smart parking, electronic toll collection systems, logistic and fleet management, vehicle control, and safety and road assistance.

METROPOLITAN SCALE DEPLOYMENTS :

There are several planned or ongoing large-scale deployments of the IOT, to enable better management of cities and systems. For example, Songdo, South Korea, the first of its kind fully equipped and wired smart city, is near completion. Nearly everything in this city is planned to be wired, connected and turned into a constant stream of data that would be monitored and analysed by an array of computers with little, or no human intervention. Another application is a currently undergoing project in Santander, Spain. For this deployment, two approaches have been adopted. This city of 180,000 inhabitants, has already seen 18,000 city application downloads for their smartphones. This application is connected to 10,000 sensors that enable services like parking search, environmental monitoring, and digital city agenda among others. City context information is used in this deployment so as to benefit merchants through a spark deals mechanism based on city behaviour that aims at maximizing the impact of each notification. Other examples of large-scale deployments underway include the Sino-Singapore Guangzhou Knowledge City; work on improving air and water quality, reducing noise pollution, and increasing transportation efficiency in San Jose, California; and smart traffic management in western Singapore. French company, Sigfox, commenced building an ultra-narrowband wireless data network in the San Francisco Bay Area in 2014, the first business to achieve such a deployment in the U.S. It subsequently announced it would set up a total of 4000 base stations to cover a total of 30 cities in the U.S. by the end of 2016, making it the largest IOT network coverage provider in the country thus far. Another example of a large deployment is the one completed by New York Waterways in New York City to connect all the city's vessels and be able to monitor them live 24/7. The network was designed and engineered by Fluidmesh^{xl} Networks, a Chicago-based company

developing wireless networks for critical applications. The NYWW network is currently providing coverage on the Hudson River, East River, and Upper New York Bay. With the wireless network in place, NY Waterway is able to take control of its fleet and passengers in a way that was not previously possible. New applications can include security, energy and fleet management, digital signage, public Wi-Fi, paperless ticketing and others.

CONSUMER APPLICATION:

A growing portion of IOT devices are created for consumer use. Examples of consumer applications include connected car, entertainment, residences and smart homes, wearable technology, quantified self, connected health, and smart retail. Consumer IOT provides new opportunities for user experience and interfaces. Some consumer applications have been criticized for their lack of redundancy and their inconsistency, leading to a popular parody known as the “Internet of Shit.” Companies have been criticized for their rush into IOT, creating devices of questionable value, and not setting up stringent security standards.

UNIQUE ADDRESSABILITY OF THINGS:

The original idea of the Auto-ID Centre is based on RFID-tags and unique identification through the Electronic Product Code however this has evolved into objects having an IP address or URI. An alternative view, from the world of the Semantic Web focuses instead on making all things (not just those electronic, smart, or RFID-enabled) addressable by the existing naming protocols, such as URI. The objects themselves do not converse, but they may now be referred to by other agents, such as powerful centralized servers acting for their human owners. Integration with the Internet implies that devices will use an IP address as a unique identifier. Due to the limited address space of IPv4 (which allows for 4.3 billion unique addresses), objects in the IOT will have to use the next generation of the Internet protocol (IPv6) to scale to the extremely large address space required. Internet of things devices additionally will benefit from the stateless address auto-configuration present in IPv6, as it reduces the configuration overhead on the hosts, and the IETF 6LoWPAN header compression. To a large extent, the future of the Internet of things will not be possible without the support of IPv6; and consequently the global adoption of IPv6 in the coming years will be

critical for the successful development of the IOT in the future. A combination of these ideas can be found in the current GS1/EPC global EPC Information Services (EPCIS) specifications. This system is being used to identify objects in industries ranging from aerospace to fast moving consumer products and transportation logistics.

TRENDS AND CHARACTERISTICS

INTELLIGENCE:

Ambient intelligence and autonomous control are not part of the original concept of the Internet of things. Ambient intelligence and autonomous control do not necessarily require Internet structures, either. However, there is a shift in research to integrate the concepts of the Internet of things and autonomous control, with initial outcomes towards this direction considering objects as the driving force for autonomous IOT. In the future the Internet of things may be a non-deterministic and open network in which auto-organized or intelligent entities (Web services, SOA components), virtual objects (avatars) will be interoperable and able to act independently (pursuing their own objectives or shared ones) depending on the context, circumstances or environments. Autonomous behaviour through the collection and reasoning of context information as well as the objects ability to detect changes in the environment, faults affecting sensors and introduce suitable mitigation measures constitute a major research trend, clearly needed to provide credibility to the IOT technology. Modern IOT products and solutions in the marketplace use a variety of different technologies to support such context-aware automation but more sophisticated forms of intelligence are requested to permit sensor units to be deployed in real environments.

NETWORK ARCHITECTURE:

The Internet of things requires huge scalability in the network space to handle the surge of devices. IETF 6LoWPAN would be used to connect devices to IP networks. With billions of devices being added to the Internet space, IPv6 will play a major role in handling the network layer scalability. IETF's Constrained Application Protocol, Zero MQ, and MQTT would provide lightweight data transport. "MQ" in "MQTT" came from IBM's MQ Series message queuing product line. Fog computing is a viable alternative^{xiii} to prevent such large burst of data flow through Internet. The edge devices' computation power can be used to analyse

and process data, thus providing easy real time scalability.

Size considerations

The Internet of things would encode 50 to 100 trillion objects, and be able to follow the movement of those objects. Human beings in surveyed urban environments are each surrounded by 1000 to 5000 trackable objects.

Space considerations

In the Internet of things, the precise geographic location of a thing—and also the precise geographic dimensions of a thing—will be critical. Therefore, facts about a thing, such as its location in time and space, have been less critical to track because the person processing the information can decide whether or not that information was important to the action being taken, and if so, add the missing information (or decide to not take the action). (Note that some things in the Internet of things will be sensors, and sensor location is usually important. The GeoWeb and Digital Earth are promising applications that become possible when things can become organized and connected by location. However, the challenges that remain include the constraints of variable spatial scales, the need to handle massive amounts of data, and an indexing for fast search and neighbour operations. In the Internet of things, if things are able to take actions on their own initiative, this human-centric mediation role is eliminated. Thus, the time-space context that we as humans take for granted must be given a central role in this information ecosystem. Just as standards play a key role in the Internet and the Web, geospatial standards will play a key role in the Internet of things.

Sectors

There are three core sectors of the IOT: enterprise, home, and government, with the Enterprise Internet of Things (EIOT) being the largest of the three. By 2019, the EIOT sector is estimated to account for nearly 40% or 9.1 billion devices.

ENABLING TECHNOLOGIES FOR IOT:

There are many technologies that enable IOT. Crucial to the field is the network used to communicate between devices of an IOT installation, a role that several wireless or wired technologies may full fill:

SHORT-RANGE WIRELESS:

- Bluetooth low energy (BLE) – Specification providing a low power variant to classic Bluetooth with a comparable communication range.

- Light-Fidelity (Li-Fi) – Wireless communication technology similar to the Wi-Fi standard, but using visible light communication for increased bandwidth.
- Near-field communication (NFC) – Communication protocols enabling two electronic devices to communicate within a 4 cm range.
- QR codes and barcodes – Machine-readable optical tags that store information about the item to which they are attached.
- Radio-frequency identification (RFID) – Technology using electromagnetic fields to read data stored in tags embedded in other items.
- Thread – Network protocol based on the IEEE 802.15.4 standard, similar to Zigbee, providing IPv6 addressing.
- Transport Layer Security (network protocol) | TLS – Network security protocol.
- Wi-Fi – Widely used technology for local area networking based on the IEEE 802.11 standard, where devices may communicate through a shared access point.
- Wi-Fi Direct – Variant of the Wi-Fi standard for peer-to-peer communication, eliminating the need for an access point.
- Z-Wave – Communication protocol providing short-range, low-latency data transfer at rates and power consumption lower than Wi-Fi. Used primarily for home automation.
- Zigbee – Communication protocols for personal area networking based on the IEEE 802.15.4 standard, providing low power consumption, low data rate, low cost, and high throughput.

MEDIUM-RANGE WIRELESS:

- Hallow – Variant of the Wi-Fi standard providing extended range for low-power communication at a lower data rate.
- LTE-Advanced – High-speed communication specification for mobile networks. Provides enhancements to the LTE standard with extended coverage, higher throughput, and lower latency.

LONG-RANGE WIRELESS:

- Low-power wide-area networking (LPWAN) – Wireless networks designed to allow long-range communication at a low data rate, reducing power and cost for transmission.
- Very small aperture terminal (VSAT) – Satellite communication technology using small dish antennas for narrowband and broadband data.

WIRED:

- Ethernet – General purpose networking standard using twisted pair and fibre optic links in conjunction with hubs or switches.
- Multimedia over Coax Alliance (MOCA) – Specification enabling whole-home distribution of high definition video and content over existing coaxial cabling.
- Power-line communication (PLC) – Communication technology using electrical wiring to carry power and data. Specifications such as Home Plug utilize PLC for networking IOT devices.

SIMULATION:

IOT modelling and simulation (and emulation) is typically carried out at the design stage before deployment of the network. Network simulators like OPNET, Net Sim and NS2 can be used to simulate IOT networks. Digital Twins may also be implemented to produce updates on the status and health of an asset, based upon sensor readings integrated with a computational model of the asset.

GOVERNMENT REGULATION ON IOT:

One of the key drivers of the IOT is data. The success of the idea of connecting devices to make them more efficient is dependent upon access to and storage & processing of data. For this purpose, companies working on IOT collect data from multiple sources and store it in their cloud network for further processing. This leaves the door wide open for privacy and security dangers and single point vulnerability of multiple systems. The other issues pertain to consumer choice and ownership of data and how it is used. Presently the regulators have shown more interest in protecting the first three issues identified above. Current regulatory environment: A report published by the Federal Trade Commission (FTC) in January 2015 made the following three recommendations:

- Data security – At the time of designing IOT companies should ensure that data collection, storage and processing would be secure at all times. Companies should adopt a “defence in depth” approach and encrypt data at each stage.
- Data consent – users should have a choice as to what data they share with IOT companies and the users must be informed if their data gets exposed.
- Data minimization – IOT companies should collect only the data they need and retain the collected information only for a limited time.

However, the FTC stopped at just making recommendations for now. According to an FTC analysis, the existing framework, consisting of the FTC Act, the Fair Credit Reporting Act, and the Children’s Online Privacy Protection Act, along with developing consumer education and business guidance, participation in multi stake holder efforts and advocacy to other agencies at the federal, state and local level, is sufficient to protect consumer rights.

A resolution passed by the Senate in March 2015, is already being considered by the Congress. This resolution recognized the need for formulating a National Policy on IOT and the matter of privacy, security and spectrum. Furthermore, to provide an impetus to the IOT ecosystem, in March 2016, a bipartisan group of four Senators proposed a bill, The Developing Innovation and Growing the Internet of Things (DIGIT) Act, to direct the Federal Communications Commission to assess the need for more spectrum to connect IOT devices

Several standards for the IOT industry are actually being established relating to automobiles because most concerns arising from use of connected cars apply to healthcare devices as well. In fact, the National Highway Traffic Safety Administration (NHTSA) is preparing cyber security guidelines and a database of best practices to make automotive computer systems more secure.

5.6.3 DATA STORAGE AND ANALYTICS:

A challenge for producers of IOT applications is to clean, process and interpret the vast amount of data which is gathered by the sensors. There is a solution proposed for the analytics of the information referred to as Wireless Sensor Networks. These networks share data among sensor nodes that are send to a distributed system for the analytics of the sensory data. Another challenge is the storage of this bulk data. Depending on the application there could be high data

acquisition requirements which in turn lead to high storage requirements. Currently the internet is already responsible for 5% of the total energy generated and this consumption will increase significantly when we start utilizing applications with multiple embedded sensors.

SECURITY:

Concerns have been raised that the Internet of things is being developed rapidly without appropriate consideration of the profound security challenges involved and the regulatory changes that might be necessary. Most of the technical security issues are similar to those of conventional servers, workstations and smartphones, but the firewall, security update and anti-malware systems used for those are generally unsuitable for the much smaller, less capable, IOT devices. According to the Business Insider Intelligence Survey conducted in the last quarter of 2014, 39% of the respondents said that security is the biggest concern in adopting Internet of things technology. In particular, as the Internet of things spreads widely, cyber-attacks are likely to become an increasingly physical (rather than simply virtual) threat. In a January 2014 article in Forbes, cyber-security columnist Joseph Steinberg listed many Internet-connected appliances that can already "spy on people in their own homes" including televisions, kitchen appliances, cameras, and thermostats. Computer-controlled devices in automobiles such as brakes, engine, locks, hood and trunk releases, horn, heat, and dashboard have been shown to be vulnerable to attackers who have access to the on-board network. In some cases, vehicle computer systems are Internet-connected, allowing them to be exploited remotely. By 2008 security researchers had shown the ability to remotely control pacemakers without authority. Later hackers demonstrated remote control of insulin pumps and implantable cardioverter defibrillators. David Pogue wrote that some recently published reports about hackers remotely controlling certain functions of automobiles were not as serious as one might otherwise guess because of various mitigating circumstances; such as the bug that allowed the hack having been fixed before the report was published, or that the hack required security researchers having physical access to the car prior to the hack to prepare for it. The U.S. National Intelligence Council in an unclassified report maintains that it would be hard to deny "access to networks of sensors and remotely-controlled objects by enemies

of the United States, criminals, and mischief makers... An open market for aggregated sensor data could serve the interests of commerce and security no less than it helps criminals and spies identify vulnerable targets. Thus, massively parallel sensor fusion may undermine social cohesion, if it proves to be fundamentally incompatible with Fourth-Amendment guarantees against unreasonable search." In general, the intelligence community views the Internet of things as a rich source of data. As a response to increasing concerns over security, the Internet of Things Security Foundation (IOTSF) was launched on 23 September 2015. IOTSF has a mission to secure the Internet of things by promoting knowledge and best practice. Its founding board is made from technology providers and telecommunications companies including BT, Vodafone, Imagination Technologies and Pen Test Partners. In addition, large IT companies are continuously developing innovative solutions to ensure the security for IOT devices. As per the estimates from KBV Research, the overall IOT security market would grow at 27.9% rate during 2016-2022 as a result of growing infrastructural concerns and diversified usage of Internet of things. In 2016, a distributed denial of service attack powered by Internet of things devices running the Mirai malware took down a DNS provider and major web sites.

DESIGN:

Given widespread recognition of the evolving nature of the design and management of the Internet of things, sustainable and secure deployment of IOT solutions must design for "anarchic scalability." Application of the concept of anarchic scalability can be extended to physical systems (i.e. controlled real-world objects), by virtue of those systems being designed to account for uncertain management futures. This "hard anarchic scalability" thus provides a pathway forward to fully realize the potential of Internet of things solutions by selectively constraining physical systems to allow for all management regimes without risking physical failure. Brown University computer scientist Michael Littman has argued that successful execution of the Internet of things requires consideration of the interface's usability as well as the technology itself. These interfaces need to be not only more user-friendly but also better integrated: "If users need to learn different interfaces for their vacuums, their locks, their sprinklers, their lights, and their coffeemakers, it's tough to say that their lives have been made any easier."

CONFUSING TERMINOLOGY:

Kevin Lonergan at Information Age, a business-technology magazine, has referred to the terms surrounding IOT as a “terminology zoo”. The lack of clear terminology is not “useful from a practical point of view” and a “source of confusion for the end user”. A company operating in the IOT space could be working in anything related to sensor technology, networking, embedded systems, or analytics. According to Lonergan, the term IOT was coined before smart phones, tablets, and devices as we know them today existed, and there is a long list of terms with varying degrees of overlap and technological convergence: Internet of Things (IOT), Internet of Everything (IOE), Industrial Internet, Pervasive Computing, Pervasive Sensing, Ubiquitous Computing, Cyber-Physical Systems (CPS), Wireless Sensor Networks (WSN), Smart Objects, Cooperating Objects, Machine-to-Machine (M2M), Ambient Intelligence (AMI), Operational Technology (OT), and Information Technology (IT). Regarding IIOT, an industrial sub-field of IOT, the Industrial Internet Consortium's Vocabulary Task Group has created a "common and reusable vocabulary of terms" to ensure "consistent terminology" across publications issued by the Industrial Internet Consortium. IOT One has created an IOT Terms Database including a New Term Alert to be notified when a new term is published. As of March 2017, this database aggregates 711 IOT-related terms, however, without any attempts to reduce terminological ambiguity and complexity.

5.7 Arduino:

Introduction

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making

it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

The Arduino hardware and software was designed for artists, designers, hobbyists, hackers, newbies, and anyone interested in creating interactive objects or environments. Arduino can interact with buttons, LEDs, motors, speakers, GPS units, cameras, the internet, and even your smart-phone or your TV! This flexibility combined with the fact that the Arduino software is free, the hardware boards are pretty cheap, and both the software and hardware are easy to learn has led to a large community of users who have contributed code and released instructions for a **huge** variety of Arduino-based projects.

For everything from robots and a heating pad hand warming blanket to honest fortune-telling machines, and even a Dungeons and Dragons dice-throwing gauntlet, the Arduino can be used as the brains behind almost any electronics project.

There are many varieties of Arduino boards (explained on the next page) that can be used for different purposes. Some boards look a bit different from the one below, but most Arduinos have the majority of these components in common

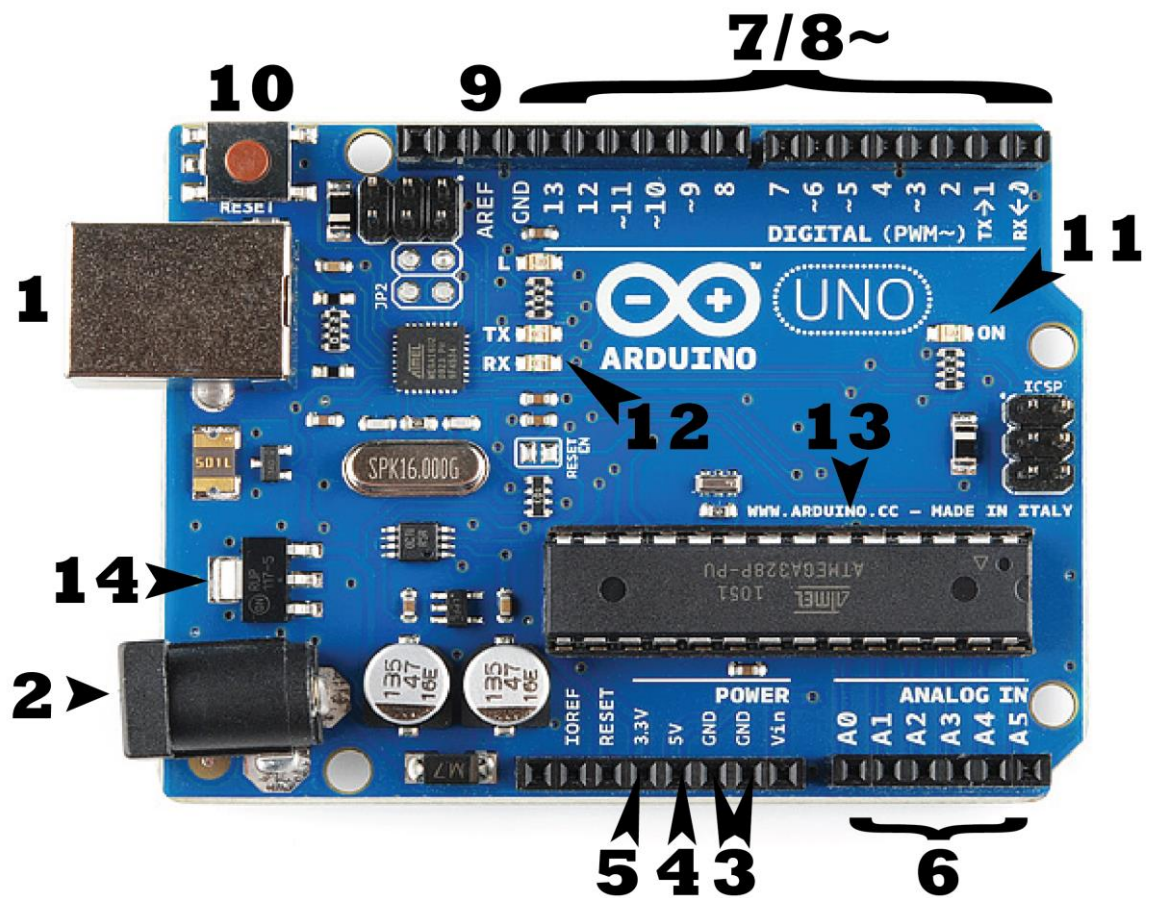


fig 5.8 arduino

Power (USB / Barrel Jack)

Every Arduino board needs a way to be connected to a power source. The Arduino UNO can be powered from a USB cable coming from your computer or a wall power supply that is terminated in a barrel jack. In the picture above the USB connection is labeled **(1)** and the barrel jack is labeled **(2)**.

NOTE: Do NOT use a power supply greater than 20 Volts as you will overpower (and thereby destroy) your Arduino. The recommended voltage for most Arduino models is between 6 and 12 Volts.

Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)

The pins on your Arduino are the places where you connect wires to construct a circuit (probably in conjunction with a breadboard and some wire. They usually have black plastic 'headers' that allow you to just plug a wire right into the board. The Arduino has several different kinds of pins, each of which is labeled on the board and used for different functions.

- **GND (3):** Short for 'Ground'. There are several GND pins on the Arduino, any of which can be used to ground your circuit.
- **5V (4) & 3.3V (5):** As you might guess, the 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts.
- **Analog (6):** The area of pins under the 'Analog In' label (A0 through A5 on the UNO) are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value that we can read.
- **Digital (7):** Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering an LED).
- **PWM (8):** You may have noticed the tilde (~) next to some of the digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM). We have a tutorial on PWM, but for now, think of these pins as being able to simulate analog output (like fading an LED in and out).
- **AREF (9):** Stands for Analog Reference. Most of the time you can leave this pin alone. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

Reset Button

Just like the original Nintendo, the Arduino has a reset button **(10)**. Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This can be very useful if your code doesn't repeat, but you want to test it multiple times. Unlike the original Nintendo however, blowing on the Arduino doesn't usually fix any problems.

Power LED Indicator

Just beneath and to the right of the word “UNO” on your circuit board, there’s a tiny LED next to the word ‘ON’ **(11)**. This LED should light up whenever you plug your Arduino into a power source. If this light doesn’t turn on, there’s a good chance something is wrong. Time to re-check your circuit!

TX RX LEDs

TX is short for transmit, RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for serial communication. In our case, there are two places on the Arduino UNO where TX and RX appear – once by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs **(12)**. These LEDs will give us some nice visual indications whenever our Arduino is receiving or transmitting data (like when we’re loading a new program onto the board).

Main IC

The black thing with all the metal legs is an IC, or Integrated Circuit **(13)**. Think of it as the brains of our Arduino. The main IC on the Arduino is slightly different from board type to board type, but is usually from the ATmega line of IC’s from the ATMEL company. This can be important, as you may need to know the IC type (along with your board type) before loading up a new program from the Arduino software. This information can usually be found in writing on the top side of the IC. If you want to know more about the difference between various IC’s, reading the datasheets is often a good idea.

5.7.1 Voltage Regulator

The voltage regulator **(14)** is not actually something you can (or should) interact with on the Arduino. But it is potentially useful to know that it is there and what it’s for. The voltage regulator does exactly what it says – it controls the amount of voltage that is let into the Arduino board. Think of it as a kind of gatekeeper; it will turn away an extra voltage that might harm the circuit. Of

course, it has its limits, so don't hook up your Arduino to anything greater than 20 volts.

The Arduino Family

Arduino makes several different boards, each with different capabilities. In addition, part of being open source hardware means that others can modify and produce derivatives of Arduino boards that provide even more form factors and functionality. If you're not sure which one is right for your project, check this guide for some helpful hints. Here are a few options that are well-suited to someone new to the world of Arduino:

Arduino Uno (R3)

The Uno is a great choice for your first Arduino. It's got everything you need to get started, and nothing you don't. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a USB connection, a power jack, a reset button and more. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

5.7.2 ARDUINO IDE

The Arduino project provides the Arduino integrated development environment (IDE), which is across-platform application written in the programming language Java. It originated hierarchy of operation menus. from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions.

A program written with the IDE for Arduino is called as ketch. Sketches are saved on the development computer as text files with the file extension into. Arduino Software (IDE) pre-1.0 saved sketches with the extension.pde. The Arduino IDE supports the languages C and C++using special rules of code structuring. The

Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub `main()` into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program `avrdude` to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

Thanks to its simple and accessible user experience, Arduino has been used in thousands of different projects and applications. The Arduino software is easy-to-use for beginners, yet flexible enough for advanced users. It runs on Mac, Windows, and Linux. Teachers and students use it to build low cost scientific instruments, to prove chemistry and physics principles, or to get started with programming and robotics. Designers and architects build interactive prototypes, musicians and artists use it for installations and to experiment with new musical instruments. Makers, of course, use it to build many of the projects exhibited at the Maker Faire, for example. Arduino is a key tool to learn new things. Anyone - children, hobbyists, artists, programmers - can start tinkering just following the step by step instructions of a kit, or sharing ideas online with other members of the Arduino community. There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Net media's BX-24, Phidgets, MIT's Handy board, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems

ARDUINO:

The Arduino microcontroller is an easy to use yet powerful single board computer that has gained considerable traction in the hobby and professional market. The Arduino is open-source, which means hardware is reasonably priced and development software is free. This guide is for students in ME 2011, or students anywhere who are confronting the Arduino for the first time. For advanced Arduino

users, prowl the web; there are lots of resources.

This guide covers the Arduino Uno board (Sparkfun DEV-09950, \$29.95), a good choice for students and educators. With the Arduino board, you can write programs and create interface circuits to read switches and other sensors, and to control motors and lights with very little effort. Many of the pictures and drawings in this guide were taken from the documentation on the Arduino site, the place to turn if you need more information. The Arduino section on the ME 2011 web site, <https://sites.google.com/a/umn.edu/me2011/>, covers more on interfacing the Arduino to the real world.

This is what the Arduino board looks like.



fig 5.9 arduino board

The Duemilanove board features an Atmel ATmega328 microcontroller operating at 5 V with 2 Kb of RAM, 32 Kb of flash memory for storing programs and 1 Kb of EEPROM for storing parameters. The clock speed is 16 MHz, which translates to about executing about 300,000 lines of C source code per second. The board has 14 digital I/O pins and 6 analog input pins. There is a USB connector for talking to the host computer and a DC power jack for connecting an external 6-20 V power source, for example a 9 V battery, when running a program while not connected to the host computer. Headers are provided for interfacing to the I/O pins using 22 g solid wire or header connectors. For additional information on the hardware, see <http://arduino.cc/en/Main/ArduinoBoardUno>.

The Arduino programming language is a simplified version of C/C++. If you know C, programming the Arduino will be familiar. If you do not know C, no need to worry as only a few commands are needed to perform useful functions.

An important feature of the Arduino is that you can create a control program on the host PC, download it to the Arduino and it will run automatically. Remove the USB cable connection to the PC, and the program will still run from the top each time you push the reset button. Remove the battery and put the Arduino board in a closet for six months. When you reconnect the battery, the last program you stored will run. This means that you connect the board to the host PC to develop and debug your program, but once that is done, you no longer need the PC to run the program.

1. Arduino Duemilanove board
2. USB programming cable (A to B)
3. 9V battery or external power supply (for stand-alone operation)
4. Solderless breadboard for external circuits, and 22 g solid wire for connections
5. Host PC running the Arduino development environment. Versions exist for Windows, Mac and Linux

Installing the Software

Follow the instructions on the Getting Started section of the Arduino web site, <http://arduino.cc/en/Guide/HomePage>. Go all the way through the steps to where you see the pin 13 LED blinking. This is the indication that you have all software and drivers successfully installed and can start exploring with your own programs.

Connecting a Battery

For stand-alone operation, the board is powered by a battery rather than through the USB connection to the computer. While the external power can be anywhere in the range of 6 to 24 V (for example, you could use a car battery), a standard 9 V battery is convenient. While you could jam the leads of a battery snap into the Vin and Gnd connections on the board, it is better to solder the battery snap leads to a DC power plug and connect to the power jack on the board. A suitable plug is part

number 28760 from www.jameco.com. Here is what this looks like.



fig 5.10 battery connected to arduino

Warning: Watch the polarity as you connect your battery to the snap as reverse orientation could blow out your board.

Disconnect your Arduino from the computer. Connect a 9 V battery to the Arduino power jack using the battery snap adapter. Confirm that the blinking program runs. This shows that you can power the Arduino from a battery and that the program you download runs without needing a connection to the host PC

Moving On

Connect your Arduino to the computer with the USB cable. You do not need the battery for now. The green PWR LED will light. If there was already a program burned into the Arduino, it will run.

Warning: Do not put your board down on a conductive surface; you will short out the pins on the back!

Start the Arduino development environment. In Arduino-speak, programs are called “sketches”, but here we will just call them programs.

In the editing window that comes up, enter the following program, paying attention to where semi-colons appear at the end of command lines.

5.8 Servo Motors:

A **servomechanism**, or **servo**, is an automatic device that uses error-sensing negative feedback to correct the performance of a mechanism. The term correctly applies only to systems where the feedback or error-correction signals help control mechanical position or other parameters. For example, the car's cruise control uses closed loop feedback, which classifies it as a servomechanism.

RC servos are hobbyist remote control devices servos typically employed in radio-controlled models, where they are used to provide actuation for various mechanical systems. Due to their affordability, reliability, and simplicity of control by microprocessors, RC servos are often used in small-scale robotics applications.

RC servos are composed of an electric motor mechanically linked to a potentiometer. A standard RC receiver sends Pulse-width modulation (PWM) signals to the servo. The electronics inside the servo translate the width of the pulse into a position. When the servo is commanded to rotate, the motor is powered until the potentiometer reaches the value corresponding to the commanded position.

RC servos use a three-pin 0.1" spacing jack (female) which mates to standard 0.025" square pins (which should be gold-plated, incidentally). The most common order is Signal, +voltage, ground. The standard voltage is 6VDC, however 4.8V and 12V has also been seen for a few servos. The control signal is a digital PWM signal with a 50Hz frame rate. Within each 20ms timeframe, an active-high digital pulse controls the position. The pulse nominally ranges from 1.0ms to 2.0ms with 1.5ms always being center of range. Pulse widths outside this range can be used for "over travel" -moving the servo beyond its normal range. This PWM signal is sometimes (incorrectly) called Pulse Position Modulation (PPM).

The servo is controlled by three wires: ground, power, and control. The servo will move based on the pulses sent over the control wire, which set the angle of the actuator arm. The

servo expects a pulse every 20 ms in order to gain correct information about the angle. The width of the servo pulse dictates the range of the servo's angular motion.

A servo pulse of 1.5 ms width will typically set the servo to its "neutral" position or 45°, a pulse of 1.25 ms could set it to 0° and a pulse of 1.75 ms to 90°. The physical limits and timings of the servo hardware varies between brands and models, but a general servo's angular motion will travel somewhere in the range of 90° - 120° and the neutral position is almost always at 1.5 ms. This is the "standard pulse servo mode" used by all hobby analog servos.

RC servos are usually powered by the receiver which in turn is powered by battery packs or an Electronic speed controller (ESC) with an integrated or a separate Battery eliminator circuit (BEC). Common battery packs are either Ni-Cd, NiMH or lithium-ion polymer battery (Li-Po) type. Voltage ratings vary, but most receivers are operated at 5 V or 6 V.

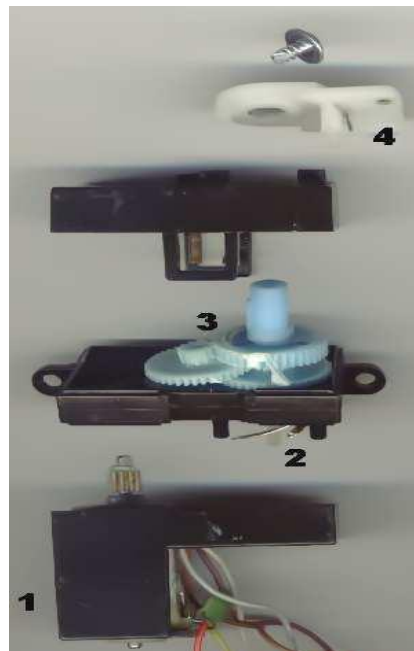


Fig 5.11 servo motor

Fig. 4.2.1 Small R/C servo mechanism

- | | |
|------------------------------------|-------------------|
| 1. Electric motor | 3. Reduction gear |
| 2. Position feedback potentiometer | 4. Actuator arm |

RELAYS

A relay is an electro-magnetic switch which can be used in case of using a low voltage circuit to switch on and off a light bulb (or anything else) connected to the 220v mains supply, i.e., it is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts.

The coil current can be on or off so relays have two switch positions and most have doubled left row (change over). Relay allow one circuit to switch a second circuit which is completely separated from the first. For example a low voltage battery circuit can use a relay to switch a 230VAC mains circuit. There is no electrical connection inside the relay between the two circuits the link is magnetic and mechanical

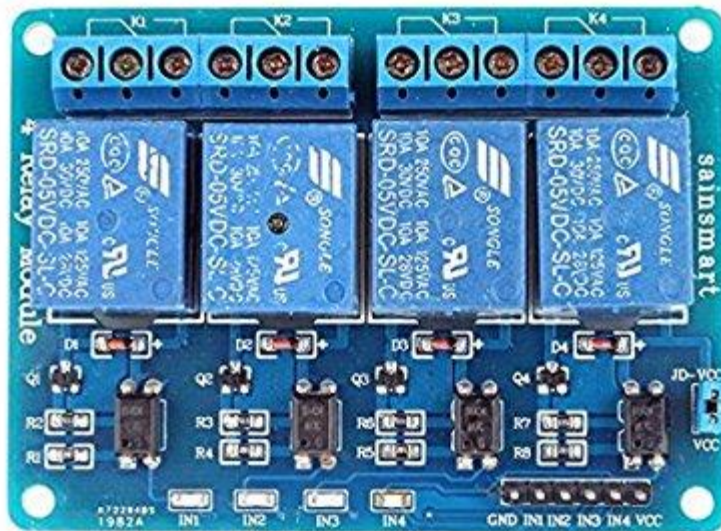


fig 5.12 relay

5.9 ACS712 CURRENT SENSOR

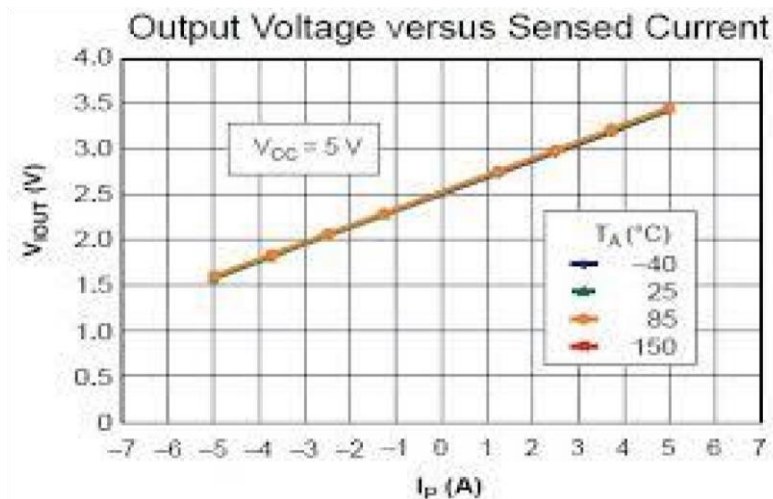
The Allegro ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switchedmode power supplies, and over current fault protection. The device is not intended for automotive applications. For the automotive grade version, seeacs714.



fig 5.13 current sensor

ACS712 Current Sensor

The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper stabilized Bi CMOS Hall IC, which is programmed for accuracy after packaging.



5.10 Voltage sensor:

Introduction

We have already seen how to measure external voltages using Arduino in the project **DIGITAL ARDUINO VOLTMETER**.

If you want to measure external voltages using Arduino, you have to make use of the Analog Input pins of the Arduino Board. If you recall a little bit about the Arduino Analog Pins, their input voltage is limited to 5V i.e. you can measure up to 5V directly using the Analog Input Pins of the Arduino.

But what if you want to measure voltages that are greater than 5V? You cannot directly use the Analog Input Pins of the Arduino as you might fry the ATmega328P IC on the Arduino UNO board (or the relevant Microcontroller IC depending on the Arduino Board you are using).

Here comes the Voltage Sensor Module to the rescue. Using this Voltage Sensor Module, you can measure voltages up to 25V.

A Brief Note on the Voltage Sensor Module

The Voltage Sensor is a simple module that can be used with Arduino (or any other microcontroller with input tolerance of 5V) to measure external voltages that are greater than its maximum acceptable value i.e. 5V in case of Arduino.



Following is the image of the Voltage Sensor Module used in this project.

Fig 5.14 voltage sensor

Pins of the Voltage Sensor

Before going into the details of the Voltage Sensor like its functionality and schematic, let me give you an overview of the available Pins of the Voltage Sensor Module.

Basically, a 25V Voltage Sensor, like the one used here, has 5 pins in total. Two of them are on the two-pin screw terminal and three are male header pins.

The Screw Terminal pins are marked as VCC and GND and they must be connected to the external source of voltage i.e. the voltage that needs to be measured.

Coming to the three male headers, they are marked as S, + and -. The S pin is the "Sense" pin and it must be connected to the Analog Input of the Arduino. The "-" pin must be connected to the GND of the Arduino. The pin marked as "+" is not connected to anything (it is an N/C Pin).

The following image shows the pins of a Voltage Sensor Module.

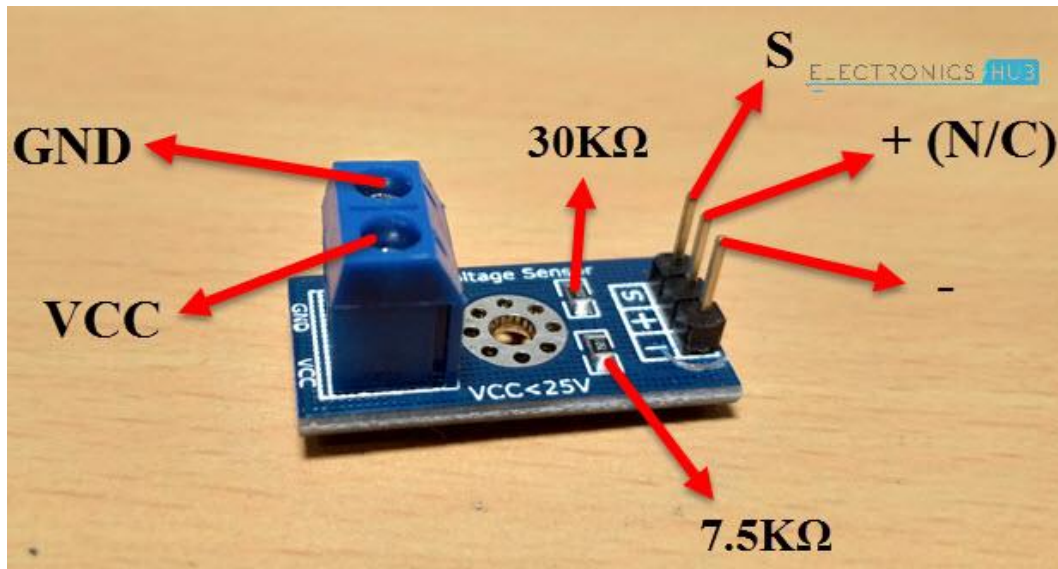


fig 5.15 pins of voltage

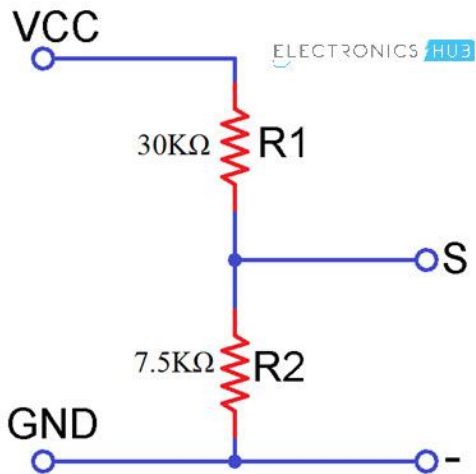
sensor

- **VCC**: Positive terminal of the voltage to be measured (0-25V)
- **GND**: Negative terminal of the voltage to be measured
- **S**: Analog Input of Arduino
- **+**: Not connected (N/C)
- **-**: GND of Arduino

Schematic of Voltage Sensor

Now, let us talk about the important thing about the voltage sensor: its schematic. The Voltage Sensor is basically a Voltage Divider consisting of two resistors with resistances of 30KΩ and 7.5KΩ i.e. a 5 to 1 voltage divider.

The following image shows the schematic of the Voltage Sensor Module with an input voltage limit of 25V.



Make your Own Voltage Sensor

Using a pre-built voltage sensor module is very easy and if you don't have one then you can easily build one yourself. All you need are two resistors.

If you want to make your own voltage sensor that can measure voltages up to 25V like this Voltage Sensor Module, then you have to get a 30KΩ and a 7.5KΩ resistor.

Interfacing a Voltage Sensor with Arduino

Now that we have seen a little about the Voltage Sensor, let us now proceed with Interfacing a Voltage Sensor with Arduino and measure some external voltages.

The Arduino Voltage Sensor Interface is pretty straight forward. Connect the voltage to be measured to the screw terminal of the Voltage Sensor, connected the output of the voltage divider to the Arduino. That's it.

After interfacing the Voltage Sensor with Arduino, you can either view the results on the serial monitor of the Arduino IDE or on a 16×2 LCD Display. I have gone with the LCD Display.

Circuit Diagram of Arduino Voltage Sensor Interface

Following image shows the circuit diagram of Interfacing a Voltage Sensor with Arduino.

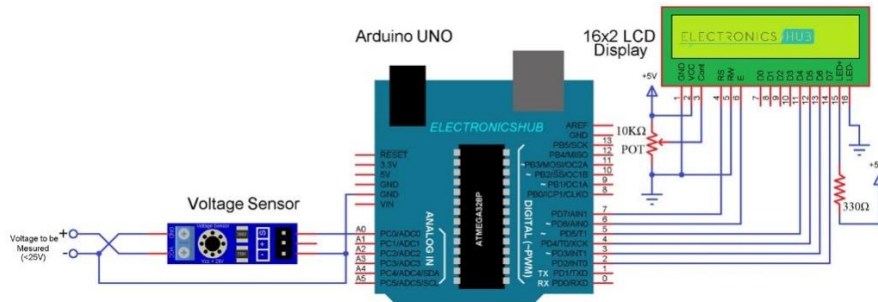


fig 5.16 circuit diagram of Arduino voltage sensor

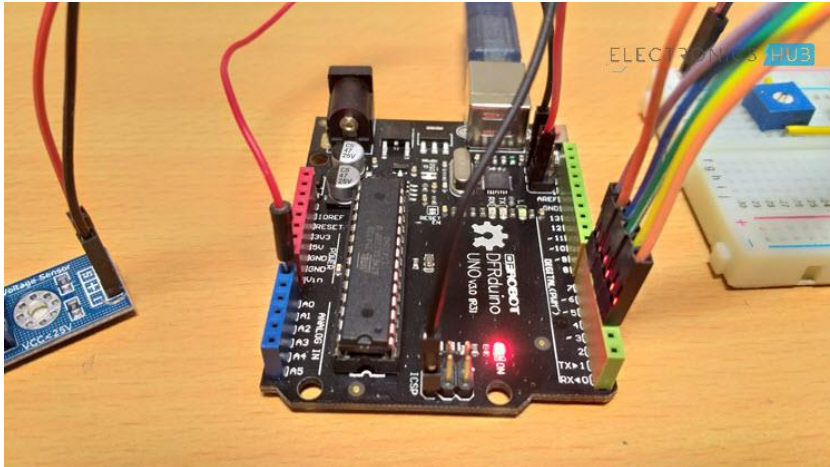
Components Required

- Arduino UNO [\[Buy Here\]](#)
- Voltage Sensor Module (for < 25V)
- 16×2 LCD Display [\[Buy Here\]](#)
- 10KΩ Potentiometer
- 330Ω Resistor
- Connecting Wires
- Mini Breadboard

Circuit Design

First, connect the “S” and “–” pins of the Voltage Sensor to A0 (Analog Input) and GND of Arduino respectively. Then connect the external voltage pins (voltage to be measured) to the screw terminal (check for polarity).

Coming to the LCD, Digital I/O Pins 7 and 6 of Arduino UNO are connected to RS and E while the Pins 5 through 2 of Arduino UNO are connected to D4 through D7 respectively.

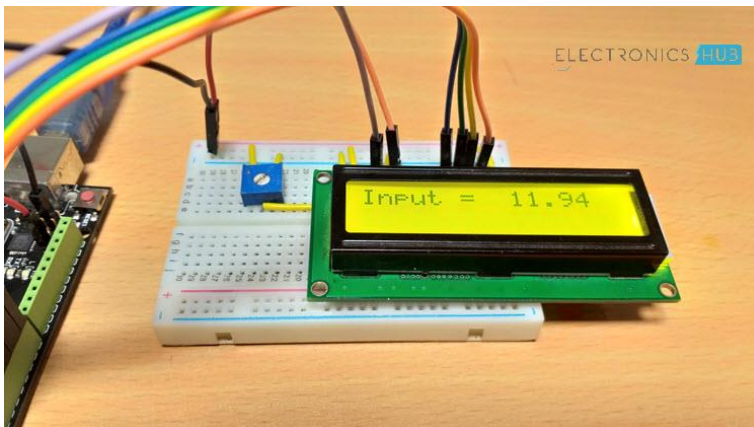


Working

I think the working of the project might be understood by now. Since the Voltage Sensor module is basically a voltage divider circuit, you can calculate input voltage using the formula

$$V_{in} = V_{out} * (R2 / (R1 + R2))$$

Here $R1 = 30000$, $R2 = 7500$ and V_{out} can be calculated from Analog Input of Arduino by using $V_{out} = (\text{analogvalue} * 5 / 1024)$.



I have implemented the same in the code. When I connected a 12V external supply as input to the Voltage Sensor, the calculated voltage is 11.94V, which is accurate enough.

5.11 Ubidots:

Introduction

Welcome to the Ubidots REST API hardware docs. Here you would reference how to send or retrieve data from your hardware devices using our supported communication protocols: **HTTP**, **MQTT** and **TCP/UDP**.

The purpose of this section is to help you understand what happens in the backstage when communicating with Ubidots, so you can replicate this in your firmware. For this reason, we avoid the use of examples using libraries. However, if you'd like to use one of our libraries (Python, C, and more), check out our [compatible devices](#) and [API clients](#) sections.

Every time a device updates a sensor value in a variable, a data-point or "**dot**" is created. Ubidots stores dots that come from your devices inside variables, and these stored dots have corresponding **timestamps**:

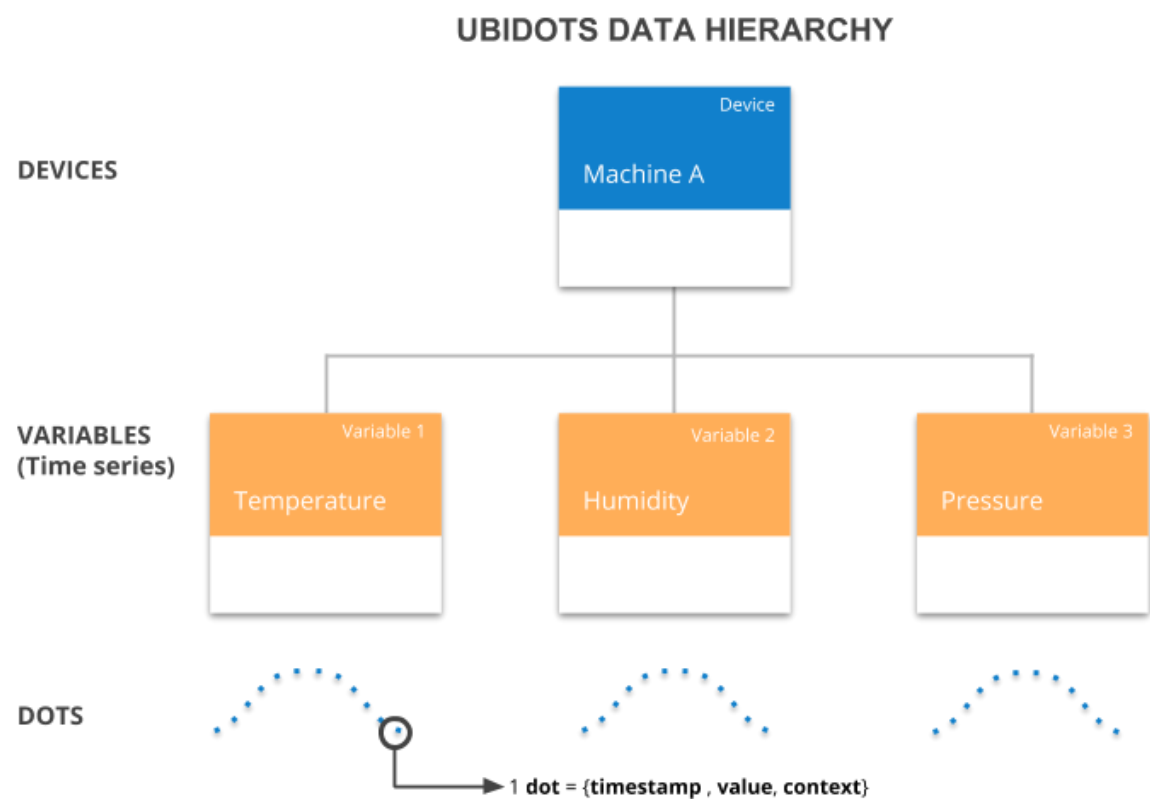


fig 5.17 ubidots data hierarchy

Each dot contains these items:

Item	Description	Mandatory
------	-------------	-----------

Item	Description	Mandatory
value	A numerical value. Ubidots accepts up to 16 floating-point length numbers.	YES
timestamp	Unix Epoch time, in milliseconds. If not specified, then our servers will assign one upon reception.	NO
context	An arbitrary collection of key-value pairs. Mostly used to store the latitude and longitude coordinates of GPS devices.	NO

Table 5.1

A numerical value. Ubidots accepts up to 16 floating-point length numbers.

```
{"value" : 34.87654974}
```

Timestamps

A **timestamp**, as best described [here](#), is a way to track time as a running total of seconds. This count starts at the Unix Epoch on January 1st, 1970 at UTC. Therefore, the unix time stamp is merely the number of seconds between a particular date and the Unix Epoch. Please keep in mind that when you send data to Ubidots, you must set the timestamp in milliseconds; also, if you retrieve a dot's timestamp, it will be in milliseconds.

```
"timestamp" : 1537453824000
```

The above timestamp corresponds to Thursday, September 20, 2018 2:30:24 PM.

PRO-TIP: A useful tool to convert between Unix timestamps and human-readable dates is [Epoch Converter](#).

Context

Numerical values are not the only data type supported; you can also store *string* or *char* data types inside what we call **context**. The **context** is a key-value object that allows you to store not only numerical but also string values. An example use of the **context** could be:

```
"context" : {"status" : "on", "weather" : "sunny"}
```

A **context** is commonly used to store the latitude and longitude coordinates of your device for GPS/tracking application use cases. All Ubidots maps uses the *lat* and *lng* keys from a dot's **context** to extract the coordinates of your device, in that way you just need to send a single dot with the coordinates values in the variable context to plot a map instead of sending separately both latitude and longitude in two different variables. Below you can find a typical **context** with coordinates values:

```
"context" : {"lat":-6.2, "lng":75.4, "weather" : "sunny"}
```

Please note that you can mix both string and numerical values in the **context**. If your application is for geo-localization purposes, make sure that the coordinates are set in decimal degrees.

Time Series

Based on the above, we can illustrate an Ubidots time series like this:

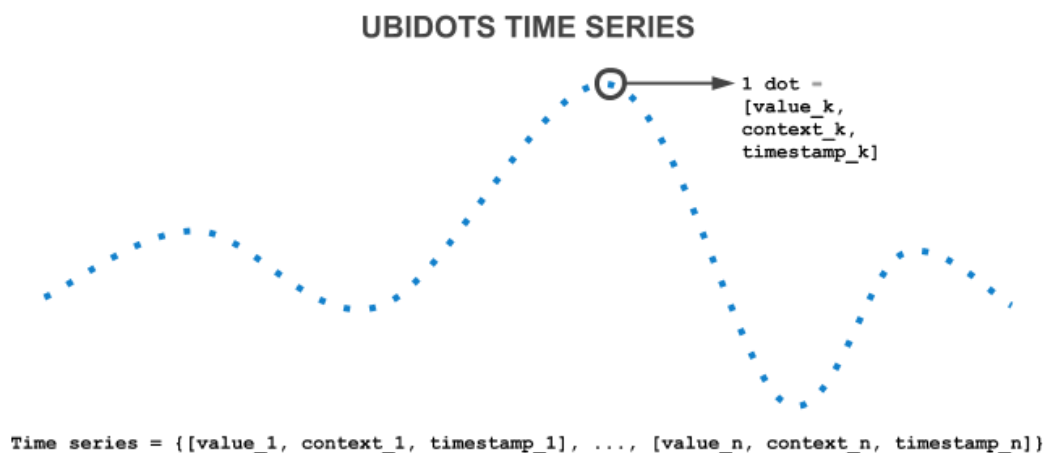


fig 5.18 ubidots time series

Ubidots is an agnostic platform, this means that it does not really care what hardware device you are using, as long as you're able to interact with us through at least one of these protocols:

- [HTTP](#)
- [MQTT](#)
- [TCP/UDP](#)

HTTP

HTTP is the main internet protocol for information exchange in the Internet. It also supports data encryption, which is usually called *secure HTTP* or *HTTPS*. When you use a web browser (MS Edge,

Firefox, Google Chrome, etc) you are sending and receiving packages using *HTTP* or *HTTPS*. Because of this, it was not surprising to see *HTTP*s become a popular option for data exchange within IoT.

When a developer is to implement *HTTP* communication, then he should look for a *RESTful Application Programming Interface*, or *REST API*, which exposes all the endpoints required to interact with a third party application (like Ubidots). In this section, you can reference our *REST API* to understand how to send and retrieve data from our servers.

Note: Our goal with this section is to help you understand what's happening behind when communicating with Ubidots, enabling you to replicate it within your own firmware. Because of this, we avoid using our custom libraries in all the examples.

HTTP requests

The following methods are specified within the *HTTP* standard:

HTTP Method	Description
GET	Used to retrieve information
POST	Used to create a new element
PATCH	Used to update existing elements
DELETE	Used to delete existing elements

Table 5.2

HTTP is a **request/response** protocol, this means that every request that you make is answered by the server. This response includes a number (response code) and a body. For example, when you make a request to retrieve a file on a webpage "(e.g. "Get me the file 'webside.html'")", you build a *GET* request. If the request is correct, the server will typically return a 200 response code, along with the file requested (body).

Under the same logic, when a device sends a *GET* request to the Ubidots' server (i.e. requesting the last value of a variable), then the server sends back a response with the status of the request (response code), and a body, which would be the a value with its context and timestamp.

An *HTTP* request also needs the parameters below:

- **Host:** Specifies the server you will be making *HTTP* requests to.
- **Path:** This is typically the remaining portion of the URL that specifies the resource you want to consume, be it a variable or a device. For example, if an API endpoint

is: industrial.api.ubidots.com/api/v1.6/devices/my-device then the path would be /api/v1.6/devices/my-device

- **Headers:** Define the operating parameters of the *HTTP* request such as authentication, Content-Type, Content-Length, etc.
- **Body/payload:** In the case of POST and PATCH requests, this is the data sent by your device to the server. GET requests typically do not have a body because they are meant to request data, not to send data.

Ubidots accepts data as *JavaScript Object Notation* or *JSON*. *JSON* is a typical *HTTP* data type, it is a collection of name/value pairs. In various programming languages, this is treated as an object, record, struct, dictionary, hash table, keyed list, or associative array. It is also human readable and language independent. An example of a *JSON* data type that Ubidots accepts can be referenced below:

```
{"temperature": {"value":10, "timestamp": 1534881387000, "context": {"machine": "1st floor"}}
```

A typical *HTTP* request to Ubidots should be set as below:

```
POST {PATH} HTTP/1.1<CR><LN>
Host: {HOST}<CR><LN>
User-Agent: {USER_AGENT}<CR><LN>
X-Auth-Token: {TOKEN}<CR><LN>
Content-Type: application/json<CR><LN>
Content-Length: {PAYLOAD_LENGTH}<CR><LN><CR><LN>
{PAYLOAD}
<CR><LN>
```

Where:

- {PATH}: Path to the resource to consume
Example: /api/v1.6/variables/ to get user's variables information.
- {HOST}: Host URL.
Example: industrial.api.ubidots.com
- {USER_AGENT}: An optional string used to identify the type of client, be it by application type, operating system, software vendor or software version of the requesting user agent.
Examples: ESP8266/1.0, Particle/1.2
- {TOKEN}: Unique key that authorizes your device to ingest data inside your Ubidots account.
- {PAYLOAD_LENGTH}: The number of characters of your payload.
Example: The payload {"temperature": 20} will have a content-length of 19.

- {PAYLOAD}: Data to send.
Example: {"temperature": 20}

PRO TIP: The easy way of handle *HTTP* and *HTTPS* requests is by using **cURL**, a command line tool. To learn how to install cURL on Windows, MacOSX or Linux please refer to this [guide](#).

API URLs

API access can be over *HTTP* or secure HTTP, *HTTPS*, using the following endpoints based on your Ubidots Account type.

Security Note: We strongly advise to use *HTTPS* to make sure your data travels encrypted, avoiding the exposure of your API token and/or sensor data.

HTTP

Ubidots Account	Endpoint	Port
Educational	http://things.ubidots.com	80
Industrial	http://industrial.api.ubidots.com	80

Table 5.3

HTTPS

Ubidots Account	Endpoint	Port
Educational	https://things.ubidots.com	443
Industrial	https://industrial.api.ubidots.com	443

Ubidots supports SSL v1.1, TLS v1.2 and v1.3. You can download our root certificates in different formats:

- [PEM file](#): A certificate chain with two root certificates from our certificate authorities (CAs).
- [DER file](#): Same as the PEM file, with an alternative encoding.
- [CRT file](#): Same as the PEM file, with a different extension. Often referred to as .crt, .cert or .cer.

NOTE: To avoid future inconveniences, we advise to **use both certificates** in your device's auth routines. While the second is the current valid certificate, we will use the first after 2021.

Fixed IPs

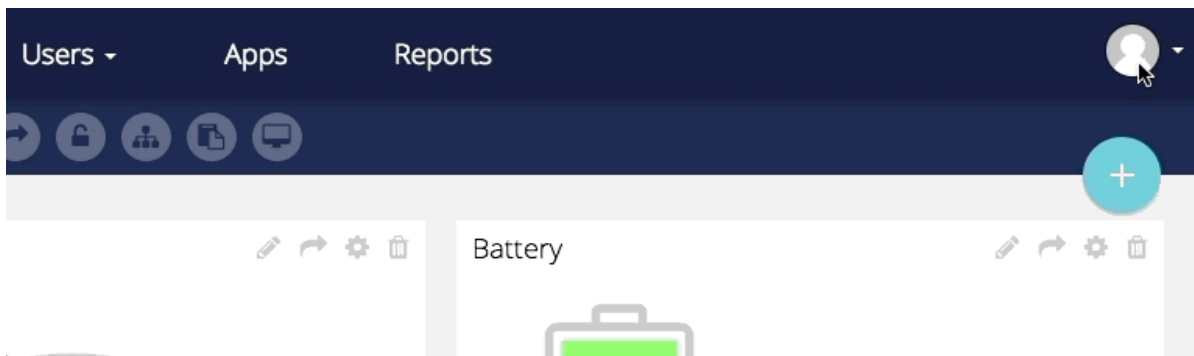
Ubidots also supports fixed IPs address for data ingestion, but we highly advise to our users to implement their firmware routines using the dns endpoints instead of fixed IPs, as these last ones may change in the future.

Ubidots Account	ipv4	ipv6	Port
Educational	50.23.124.68	2607:f0d0:2101:39::2	80/443
Industrial	169.55.61.243	2607:f0d0:3:b::2	80/443

HTTP Authentication

Every request requires a *token*. A *token* is an unique key that authorizes your device to ingest data inside your Ubidots account.

The easiest way to get yours is clicking on "**API Credentials**" under your profile tab:



Also, 6 hour valid *tokens* can be generated using your account *API-KEY*. If you desire to learn how to do it, please refer the [Ubidots REST Software API reference](#).

There are two ways to send a *token* in a request:

1. Send the *token* as parameter in the endpoint, setting it with the ?token= expression. This is the easiest one to implement but the most unsecure method to send your authentication credentials.
2. Send the *token* as a request header. For this, use the X-Auth-Token header.

Security Note: While sending your *token* as a URL parameter can be quite comfortable in some devices, we only advise to do this for prototyping stages. For production stages, we strongly advise sending the token using the X-Auth-Token header.

```
GET
https://industrial.api.ubidots.com/api/
```

Send data

Our REST API allows you send data to the platform in two different ways:

- Send data to a **device**
- Send data to a **variable**

If you're looking for more advanced API capabilities, such as editing a device name, or listing all of your devices, please refer to our [Ubidots Software REST API Reference](#).

Send data to a device

Request structure:

```
POST /api/v1.6/devices/{DEVICE_LABEL} HTTP/1.1<CR><LN>
Host: {Host}<CR><LN>
User-Agent: {USER_AGENT}<CR><LN>
X-Auth-Token: {TOKEN}<CR><LN>
Content-Type: application/json<CR><LN>
Content-Length: {PAYLOAD_LENGTH}<CR><LN><CR><LN>
{PAYLOAD}
<CR><LN>
```

Expected Response:

```
HTTP/1.1 200 OK<CR><LN>
Server: nginx<CR><LN>
Date: Tue, 04 Sep 2018 22:35:06 GMT<CR><LN>
Content-Type: application/json<CR><LN>
Transfer-Encoding: chunked<CR><LN>
Vary: Cookie<CR><LN>
Allow: GET, POST, HEAD, OPTIONS<CR><LN><CR><LN>
{PAYLOAD_LENGTH_IN_HEXADECIMAL}<CR><LN>
{"{VARIABLE_LABEL}": [{"status_code": 201}]}<CR><LN>
0<CR><LN>
```

The easiest way to **send values to Ubidots** is by specifying your [Device label](#) in the request *path* and making a POST request to it.

Replace the {DEVICE_LABEL} with the unique label of the desired device to send data to. If the device does not exist in your Ubidots account, it will be automatically created. Device labels can contain any alphanumeric character, without blank spaces, i.e *weather-station*, *my-home*, *esp8266*.

To set the variables values, just create a *JSON* data payload as below

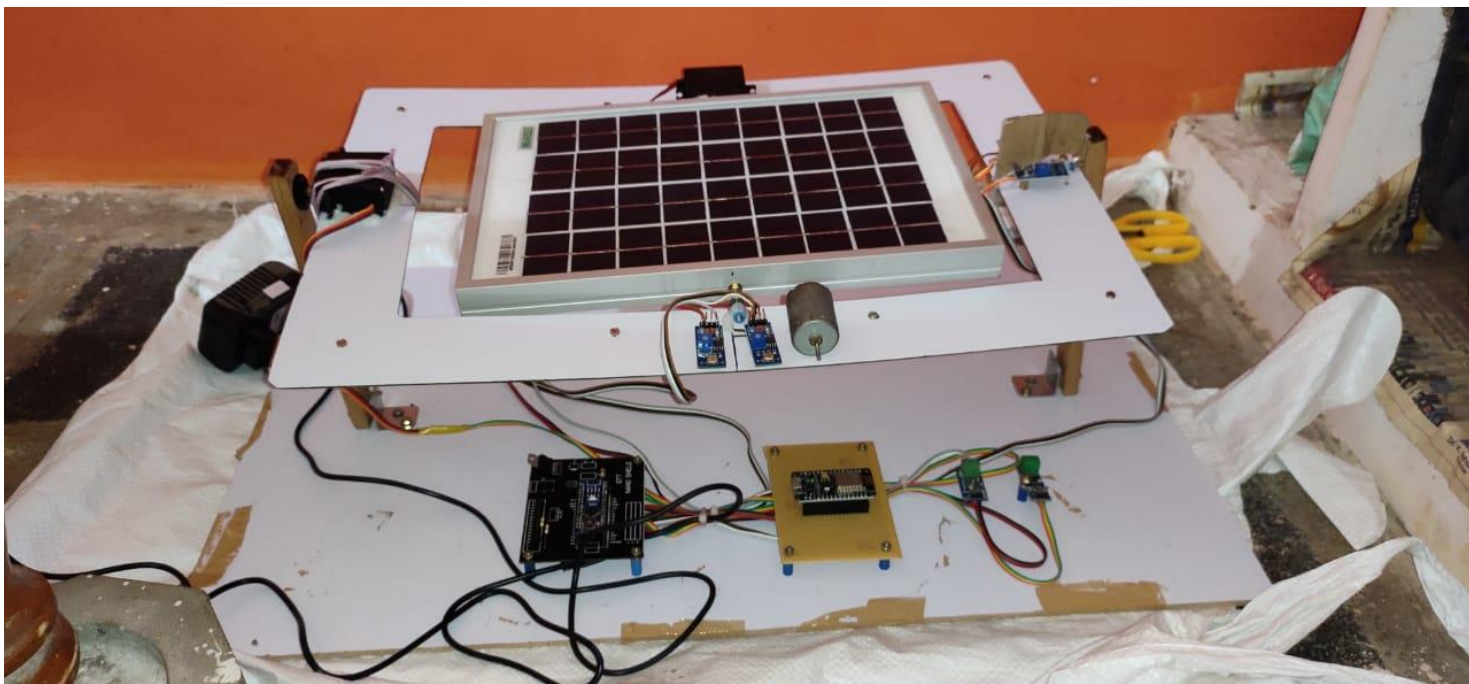
N° Variables	JSON structure
One	<code>{"variable-label": VALUE}</code>
Multiple	<code>{"variable-label-1": {"value": VALUE, "timestamp": TIMESTAMP, "context": {"key": VALUE}}, ... , "variable-label-n": {"value": VALUE, "timestamp": TIMESTAMP, "context": {"key": VALUE}}}</code>

timestamp and *context* parameters are optional.

NOTE 1:: By default, the Ubidots backend will take the latitude and longitude values inside any variable labeled as **"gps"**, **"location"**, **position** or **"coordinates"** automatically to get your device coordinates in all of the map widgets. Alternatively, you change the default location variable.

NOTE 2: All timestamps must be in milliseconds. If you set a timestamp for a variable value, it will be stored with the date represented by it. You can easily convert dates to timestamps values [here](#).

Fig 5.19 :Geotagged photo



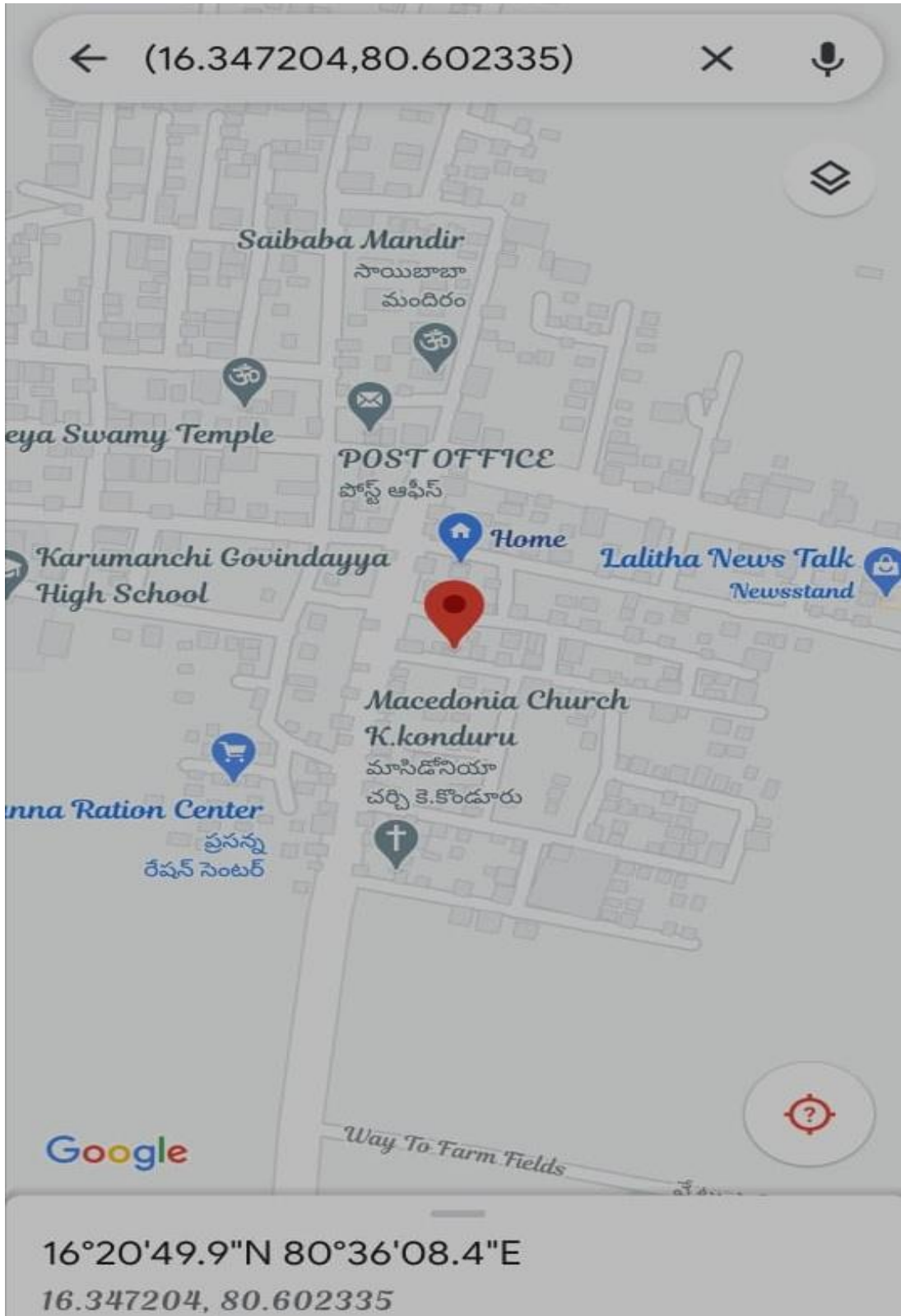


Fig 5.20 : Geotagged location

CHAPTER-6

Result:

The experiment that has been done, the solar panel was used to produce the outcome which is voltage, current, and power. Besides measuring from the solar panel, the parameter can be monitor from serial monitor in Arduino IDE. After a few second, the data stream created and saved in the Ubidots platform. The data that sent to the Ubidots platform will save in the data stream. All the data that saved in data stream will compile and show a few output that gain from solar panel.

CHAPTER-7

Conclusion:

- In this system we proposes the dual axis solar tracker has been developed successfully. The monitoring system is equipped with ESP8266 WIFI module in order to transfer the data from solar panel to IOT monitoring system.
- The system can work in one condition which is the dual axis solar tracker must work within the WIFI coverage so that the user can attach the system with ESP8266 WIFI module and access the solar panel parameter via IOT monitoring System.
- The other success part is to develop the solar tracker to have two angle. There are 2 movements in this solar tracker that can be classifies as horizontal and vertical. Both of the movements are used two servo motor 180-degree angle.
- In order to determine the functionality of the system, an experiment done to determine either the sensor will operate properly when the tracker is testing in outdoor.
- The outputs in storage of IOT system can improve in the future by improve or change the platform. Lastly, the solar tracker can have made a game changer to our world and it safe more to use because it does not have any pollution.

References:

- [1] Arsalan, S. 2013. Sun Tracking System with Microcontroller 8051, Intl. J. Sci& Eng. Research, Vol. 4, 2998.
- [2] Anuraj, A.,and Gandhi R., 2014, Solar Tracking System Using Stepper Motor, Intl. J. Electronic & Electrical Eng., Vol.7 , 561
- [3] Chhatwani, P. K., and Somani, J. S., 2013, Intelligent Solar Tracker System Implemented On 8051 Microcontroller, Intl. J. Eng. Trends Technol., Vol 4, 4267.

- [4] Saxena, A. K., and Dutta, V., 1990, A versatile microprocessor based controller for solar tracking, Photovolt Specialists Conf., 21st IEEE Proc.
- [5] Nirmal, H. B., and Naveed, S. A., 2013, Microcontroller Based Automatic Solar Power Tracking System, Intl. J. Electrical Eng. & Technol., Vol 4, 109.
- [6] Tudorache, T., and Kreindler, L., 2010, Design of a Solar Tracker System for PV Power Plants, Acta Polytech. Hung., Vol 7, 23.

AUTOMATION OF SOLAR SYSTEM FOR MAXIMUM POWER POINT TRACKING

by DASARI TEJ UMESH CHANDRA AND
DESABOYINA SATHYANARAYANA

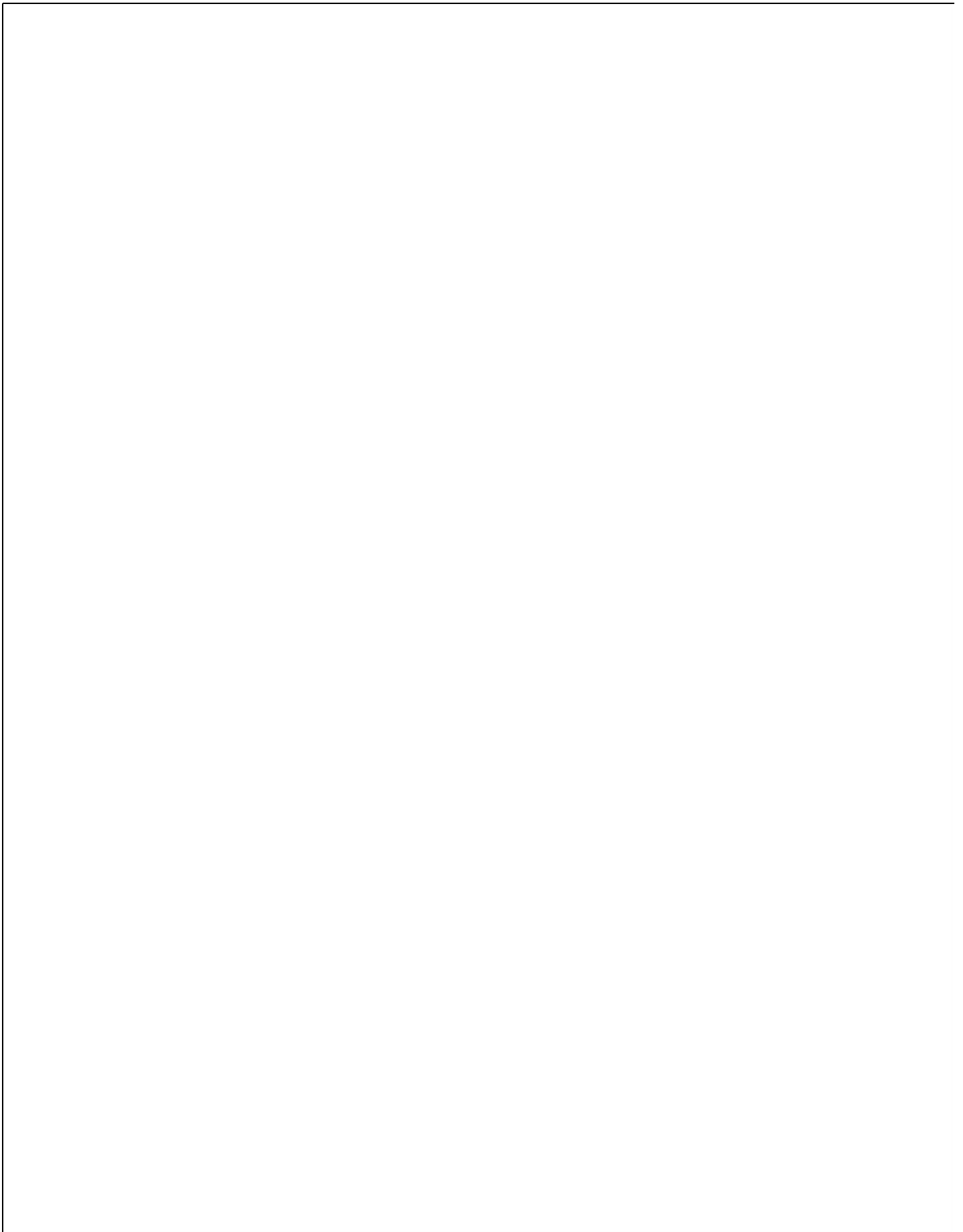
Submission date: 17-Apr-2021 10:03AM (UTC+0700)

Submission ID: 1561549387

File name: plagiarism.docx (2.78M)

Word count: 18379

Character count: 102106



Abstract

Solar energy is quickly advancing as a very important suggests that of renewable energy resource. star pursuit allows additional alternative energy to be generated as a result of the solar battery is in a position to keep up a perpendicular profile to the sun's rays. although initial value of putting in a star pursuit system is high, this paper proposes a less expensive answer.

Design and construction of a paradigm for star pursuit system with single degree of freedom, that detects the daylight victimisation lightweight Dependent Resistors (LDR), is mentioned during this paper.

The negative feedback circuit for the star hunter is predicated on associate degree Nodemcu microcontroller. will be) programmed to find daylight{the daylight} through the LDRs and so actuate the stepper motor to position the solar battery wherever it can receive most sunlight. Compared with the other sort of motor, the stepper motor is additional manageable, additional energy economical, additional steady and has high pursuit accuracy and suffers very little environmental impact. Theoretical analysis and analysis results are shown during this paper to advocate that the designed system realised precise automatic pursuit of the sun and might greatly improve the employment of alternative energy.

Introduction:

The aim is to style the system, which can mechanically track the sun's position and consequently modification the direction of the solar battery to induce the most output from the electric cell.

Along with this we have a tendency to ar reach ing to create a star watching system victimisation GSM and GPS module.

To implement a star pursuit system which can mechanically track sun's position to extend the potency of scheme.

The GSM facility is provided within the system that helps the user to watch the system from anyplace within the world.

Literature survey:

Author: ZubovDmytro,

In this paper, the energy saving algorithmic rule for the twin axis lightweight (solar) hunter is mentioned victimisation hardware with four photoresistors and Arduino open supply electronic prototyping platform. additionally to the desired tolerance for the sunshine sensors, the desired tolerance for 2 servo motors is planned.

Here, servo motors ar shifted to avoid wasting the energy if the sunshine intensity is modified at interval the bound vary throughout the actual timeframe. it had been shown that the load on power offer is getting ready to zero during this case.

Author: 1Subhasri.G, 2Dr.Jeyalakshmi.C

A daylight based mostly framework is thatJhe device for orienting star electrical phenomenon modules and star thermal collectors toward the sun. wondering the

state of the art of the innovation, triple-crown strategy, strong management philosophy and therefore the potential additional advantage of various analysis work which might use on an in depth scale in reparable manner. Presently we have a tendency to ar getting into in a very new amount of process innovation i.e. net of things (IoT). IoT could be a style of "universal international neural network" within the cloud that associates numerous things.

Author: Ankit Makwana* and Devang Lad

Limited non renewable energy resources and increasing power demand could be a major topic of concern round the world. In recent decades, renewable energy resources ar wide utilized in order to satisfy the increasing power demand and to attenuate the injury to the atmosphere. The aim of the paper is to gift a singular star pursuit technique which might be wont to extract most power from the solar cell by employing a shut loop system together with a 5-LDR sensing element module that is strategically designed to come up with feedback signal so as to trace the sun's angle and elevation angle.

Author: Abhishek Shukla¹, Dr. Suraya Prakash

Solar energy is quickly gaining infamy as a very important suggests that of increasing renewable energy resources. it's emerged jointly of the foremost promising renewable energy supply characterised by a large potential of conversion into power.

Author:ShreyasiChakraborty, Nilanjana Mukherjee, Rashmi Biswas

The renewable sources of energy are getting one in all the utmost priorities of the current day world because of their multitudinous blessings. specially, alternative energy is progressing as a possible inexhaustible and non-polluting energy supply to serve our ever-increasing energy necessities. However, the star panels that ar the elemental solar-energy conversion parts ar mounted at a definite angle and aren't ready to track the daylight direction with diurnal and seasonal changes. This limits the world of exposure of daylight on star panels and potency of the star pursuit system involving star panels

Existing system:

- Solar panel pursuit solutions ar a kind of device that host mounted electrical

phenomenon panels, that use the sun to come up with electricity.

- In existing system the panels are Stationary mounts, that hold these panels in a very mounted position, will have their productivity compromised once the sun passes to a less-than-optimal angle.

Drawbacks:

- Solar trackers are slightly dearer than their stationary counterparts, because of the additional complicated technology and moving elements necessary for his or her operation.
- Some in progress maintenance is usually needed, although the standard of the star hunter will play a task in what proportion and the way typically this maintenance is required

Proposed system:

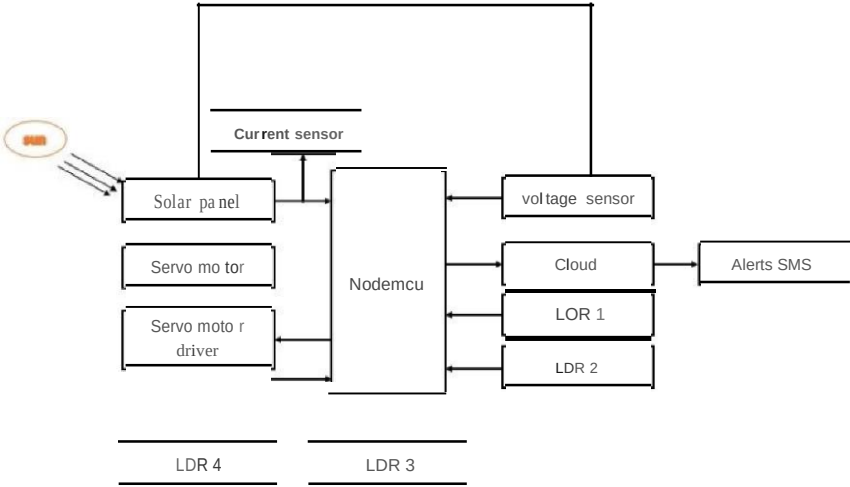
- The twin axis star pursuit system is with success designed and enforced. The Arrangement of LDRs together with their partition will increase star pursuit accuracy there by increasing solar battery potency.
- By connecting this method to the net, users will keep an eye fixed on the full system from anyplace within the world. during this approach overall system potency is increased.
- The current sensing element is employed to calculate this flowing through it.
- And it's associate degree electrically operated switch is employed for change of huge currents

Advantages:

- Inexpensive
- North-south and east-west movement
- Parts pronto offered

Portable

Block Diagram:



Hardware required:

- Nodemcu
- Solar panel
- LDR
- Servo motor driver
- Servo motor
- Switch

Hardware used:**EMBEDDED SYSTEMS****1.1.1 summary of embedded systems**

An embedded system could be a special-purpose system designed to perform one or many dedicated functions, typically with period computing constraints. it's sometimes

embedded as a part of an entire device together with hardware and mechanical components. In distinction, a general pc, like a private pc, will do many various tasks betting on programming. Embedded systems became vital nowadays as they management several of the common devices we have a tendency to use. Since the embedded system is devoted to specific tasks, style engineers will optimize it, reducing the dimensions and value of the merchandise, or increasing the responsiveness and performance. Some embedded systems are factory-made, taking advantage of economies of scale.

Physically, embedded systems vary from transportable devices like digital watches and MP3 players, to giant stationary installations like traffic lights, manufactory controllers, or the systems dominant nuclear energy plants. quality varies from low, with one microcontroller chip, to terribly high with multiple units, peripherals and networks mounted within an outsized chassis or enclosure.

In general, "embedded system" isn't Associate in Nursing precisely outlined term, as several systems have some component of programmability. for instance, hand-held computers share some parts with embedded systems — like the operational

systems and microprocessors that power them — however aren't really embedded systems, as a result of they permit totally different applications to be loaded and peripherals to be connected.

Embedded systems offer many functions

Monitor the environment; embedded systems scan knowledge from input sensors.

This knowledge is then processed and therefore the results displayed in some format to a user or users

Control the environment; embedded systems generate and transmit commands for actuators.

Transform the information; embedded systems rework the information collected in some significant approach, like knowledge compression/decompression

Although interaction with the external world via sensors and actuators is a vital side of embedded systems, these systems conjointly offer practicality specific to their applications. Embedded systems generally execute applications like management laws, finite state machines, and signal process algorithms. These systems should conjointly sight and react to faults in each the inner computing surroundings additionally because the encompassing mechanical device systems.

There are several classes of embedded systems, from communication devices to home appliances to regulate systems. Examples include;

Communication devices

e.g.: modems, cellular phones

Home Appliances

e.g.: CD player, VCR, kitchen appliance

Control Systems

e.g.: Automobile anti-lock braking systems, robotics, and satellite management

1.1.2 diagram of Associate in Nursing embedded system:

An embedded system sometimes contains Associate in Nursing embedded processor. several appliances that have a digital interface -- microwaves, VCRs, cars -- utilize embedded systems. Some embedded systems embody Associate in Nursing software system. Others are terribly specialised leading to the whole logic being enforced as one program. These systems are embedded into some device for a few specific purpose aside from to produce general purpose computing . A typical embedded system is shown in Fig 1.1

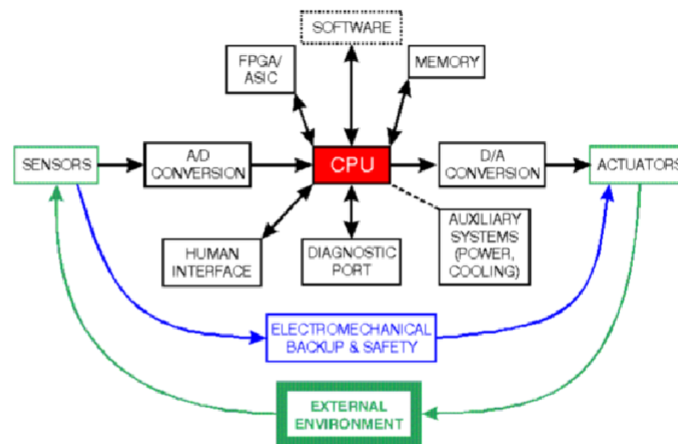


Fig 1.1 diagram of a typical embedded system

1.1.3 Characteristics of embedded systems

Embedded systems are characterised by a singular set of characteristics. Every one of those characteristics obligatory a particular set of style constraints on embedded systems designers. The challenge to coming up with embedded systems is to evolve to the particular set of constraints for the applying.

1.1.4 Application Specific Systems:

Embedded systems aren't general computers. Embedded system styles are optimized for a particular application. Several of the task characteristics are renowned before the hardware is intended. This enables the styleer to specialise in the particular design constraints of a well-defined application. As such, there's restricted user reprogrammability. Some embedded systems, however, need the flexibleness of reprogrammability. Programmable DSPs are common for such applications.

1.1.5 Reactive Systems

As mentioned earlier, a typical embedded systems model responds to the surroundings via sensors and management the surroundings victimisation actuators. This needs embedded systems to run at the speed of the surroundings. This characteristic of embedded system is termed "reactive". Reactive computation implies that the system (primarily the code component) executes in response to external events. External events may be either periodic or aperiodic.

periodic events build it easier to schedule process to ensure performance. periodic events are more durable to schedule. the utmost event arrival rate should be calculable so as to accommodate worst case things. Most embedded systems have a big reactive element. one among the largest challenges for embedded system designers is acting Associate in Nursing correct worst case design analysis on systems with applied math performance characteristics (e.g., cache memory on a DSP or alternative embedded processor). Real time system operation implies that the correctness of a computation depends, in part, on the time at that it's delivered. Systems with this demand should typically style to worst case performance. however accurately predicting the worst case is also troublesome on difficult architectures. This typically results in too demoralised estimates error-prone on the aspect of caution. several embedded systems have a big demand for real time operation so as to satisfy external I/O and management stability necessities. several period of the systems are reactive systems.

1.1.5 Distributed Systems

A common characteristic of Associate in Nursing embedded system is one that consists of communication processes death penalty on many CPUs or ASICs that are connected by communication links. the explanation for this is often economy. Economical four 8-bit microcontrollers is also cheaper than a 32-bit processors. Even when adding the price of the communication links, this approach is also preferred. during this approach, multiple processors are sometimes needed to handle multiple time-critical tasks. Devices in check of embedded systems might also be physically distributed.

1.1.6 Heterogeneous Architectures

Embedded systems typically are composed of heterogeneous architectures (Fig one.2). they'll contain totally different processors within the same system answer. they'll even be mixed signal systems. the mix of I/O interfaces, native and remote reminiscences, and sensors and actuators makes embedded system style really distinctive. Embedded systems even have tight style constraints, and the heterogeneousness provides higher style flexibility.

2. POWER SUPPLY

All electronic circuits works solely in low V_{CC} voltage, therefore we want a power offer unit to offer the applicable voltage offer for their correct functioning .This

unit consists of electrical device, rectifier, filter & regulator. AC voltage of usually 230volts rms is connected to a electrical device voltage all the way down to the amount to the specified ac voltage. A diode rectifier that provides the full wave corrected voltage that is at first filtered by a straightforward capacitance filter to manufacture a dc voltage. This ensuing dc voltage sometimes has some ripple or ac voltage variation . A regulator circuit will use this dc input to supply dc voltage that not solely has abundant less ripple voltage however conjointly remains a similar dc worth even the dc voltage varies somewhat, or the load connected to the output dc voltages changes.

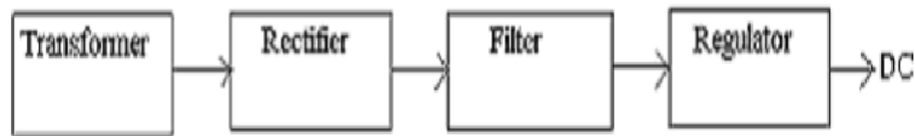


Fig 1.General Block of Power offer Unit

2. one TRANSFORMER

A electrical device could be a static piece of that wattage in one circuit is reworked into wattage of same frequency in another circuit. It will raise or lower the voltage within the circuit, however with a corresponding decrease or increase in current. It works with the principle of mutual induction. In our project we have a tendency to square measure employing a step down electrical device to providing a necessary offer for the electronic circuit. Here we have a tendency to step down a 230volts ac into 12volts ac.

2.2 RECTIFIER:

A dc level obtained from a curved input may be improved 100% employing a method referred to as full wave rectification. Here in our project for full wave rectification we have a tendency to use bridge rectifier. From the essential bridge configuration we have a tendency to see that 2 diodes(say D2 & D3) square measure conducting whereas the opposite 2 diodes (D1 & D4) square measure in off state throughout the amount $t = \text{zero to } T/2$. Accordingly for the negative cycle

of the input the conducting diodes square measure D1 & D4 .Thus the polarity across the load is a similar.

In the bridge rectifier the diodes could also be of variable sorts like 1N4001, 1N4003, 1N4004, 1N4005, 1N4007 etc... may be used. however here we have a tendency to use 1N4007, as a result of it will face up to up to 1000v.

2.3 FILTERS:

In order to get a dc voltage of zero cycle per second, we've to use an occasional pass filter. so a electrical phenomenon filter circuit is employed wherever a capacitance is connected at the rectifier output& a dc is obtained across it. The filtered wave is basically a dc voltage with negligible ripples & it's ultimately fed to the load.

2.4 REGULATORS:

The output voltage from the capacitance is a lot of filtered & finally regulated. The transformer could be a device, that maintains the output voltage constant regardless of the amendment in offer variations, load variations & temperature changes. Here we have a tendency to use mounted transformer particularly LM7805. The IC LM7805 could be a +5v regulator that is employed for microcontroller.

2.5 FEATURES AND DESCRIPTION OF REGULATORS

- Output Current up to 1A
- Output Voltages of five, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- short Protection
- Output junction transistor Safe operative space Protection

NODEMCU:

NodeMCU is associate open supply IoT platform.[4][5] It includes microcode that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware that is predicated on the ESP-12 module.[6][7] The term "NodeMCU" by default refers to the microcode instead of the event kits. The microcode uses the Lua scripting

language. it's supported the eLua project, and engineered on the Espressif Non-OS SDK for ESP8266. It uses several open supply comes, like lua-cjson[8] and SPIFFS

NodeMCU was created shortly when the ESP8266 came out. On Dec thirty, 2013, EspressifSystems[6] began production of the ESP8266.[10] The ESP8266 could be a Wi-Fi SoC integrated with a TensilicaXtensa LX106 core,[citation needed] wide utilized in IoT applications (see connected projects). NodeMCU started on thirteen Oct 2014, once Hong committed the primary file of nodemcu-firmware to GitHub.[11] 2 months later, the project dilated to incorporate associate open-hardware platform once developer Huang R committed the gerber file of associate ESP8266 board, named devkit v0.9.[12] Later that month, Tuan PM ported MQTT consumer library from Contiki to the ESP8266 SoC platform,[13] and committed to NodeMCU project, then NodeMCU was ready to support the MQTT IoT protocol, mistreatment Lua to access the MQTT broker. Another necessary update was created on thirty January 2015, once Devsaurus ported the u8glib[14] to NodeMCU project,[15] facultative NodeMCU to simply drive digital display, Screen, OLED, even VGA displays.

In summer 2015 the creators abandoned the microcode project and a gaggle of freelance contributors took over. By summer 2016 the NodeMCU enclosed over forty completely different modules. because of resource constraints users have to be compelled to choose the modules relevant for his or her project and build a microcode tailored to their wants.

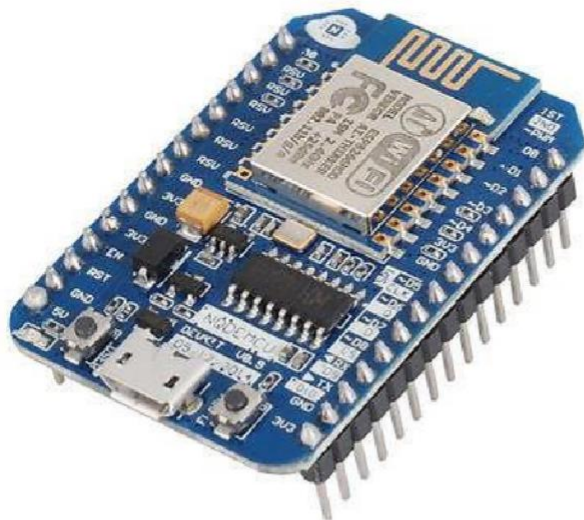
ESP8266 Arduino Core[edit]

As Arduino.cc began developing new MCU boards supported non-AVR processors just like the ARM/SAM MCU and utilized in the Arduino Due, they required to change the Arduino IDE so it'd be comparatively straightforward to vary the IDE to support alternate toolchains to permit Arduino C/C++ to be compiled for these new processors. They did this with the introduction of the Board Manager and therefore the surface-to-air missile Core. A "core" is that the assortment of software system elements needed by the Board Manager and therefore the Arduino IDE to compile associate Arduino C/C++ supply file for the target MCU's machine language. Some ESP8266 enthusiasts developed

associate Arduino core for the ESP8266 WiFiSoC, popularly referred to as the "ESP8266 Core for the Arduino IDE".[16] This has become a number one software system development platform for the varied ESP8266-based modules and development boards, together with NodeMCUs.

Introduction

NodeMCU is associate open supply LUA based mostly microcode developed for ESP8266 local area network chip. By exploring practicality with ESP8266 chip, NodeMCU microcode comes with ESP8266 Development board/kit i.e. NodeMCU Development board.



NodeMCU Development Board/kit v0.9 (Version1)

Since NodeMCU is open supply platform, their hardware style is open for edit/modify/build.

NodeMCU Dev Kit/board encompass ESP8266 LAN enabled chip. The ESP8266 could be a low-priced Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For a lot of info regarding ESP8266, you'll be able to refer ESP8266 LAN

Module.

There is Version2 (V2) out there for NodeMCU Dev Kit i.e. NodeMCU

Development Board v1.0 (Version2), that typically comes in black coloured PCB.



NodeMCU Development Board/kit v1.0 (Version2)

For a lot of info regarding NodeMCU Boards out there in market refer NodeMCU Development Boards

NodeMCU Dev Kit has Arduino like Analog (i.e. A0) and Digital (D0-D8) pins on its board.

It supports serial communication protocols i.e. UART, SPI, I2C etc.

Using such serial protocols we are able to connect it with serial devices like I2C enabled liquid crystal {display|LCD|digitaldisplay|alphanumeric display} display, meter HMC5883, MPU-6050 Gyro meter + measuring device, RTC chips, GPS modules, bit screen displays, Coyote State cards etc.

How to begin with NodeMCU?

NodeMCU Development board is featured with LAN capability, analog pin, digital pins and serial communication protocols. xvi

To get begin with victimization NodeMCU for IoT applications initial we'd like to

understand regarding a way to write/download NodeMCU computer code in NodeMCU Development Boards. And before that wherever this NodeMCU computer code can get as per our demand.

There is on-line NodeMCU custom builds out there victimization that we are able to simply get our custom NodeMCU computer code as per our demand.

To know a lot of regarding a way to build custom NodeMCU computer code on-line and transfer it refer obtaining started with NodeMCU

How to write codes for NodeMCU?

After putting in place ESP8266 with Node-MCU computer code, let's see the IDE (Integrated Development Environment) needed for development of NodeMCU.

NodeMCU with ESPlorer IDE

Lua scripts square measure usually wont to code the NodeMCU. Lua is Associate in Nursing open supply, light-weight, embeddable scripting language designed on prime of C artificial language.

For a lot of info regarding a way to write Lua script for NodeMCU refer obtaining started with NodeMCU victimization ESPlorerIDE.

NodeMCU with Arduino IDE

Here is differently of developing NodeMCU with a well known IDE i.e. Arduino IDE. we are able to additionally develop applications on NodeMCU victimization Arduino development setting. This makes simple for Arduino developers than learning new language and IDE for NodeMCU.

For a lot of info regarding a way to write Arduino sketch for NodeMCU refer obtaining started with NodeMCU victimization ArduinoIDE

Difference in victimization ESPlorer and Arduino IDE

Well, there's a artificial language distinction we are able to say whereas developing application for NodeMCU victimization ESPlorer IDE and Arduino IDE. We need to code in C\C++ artificial language if we tend to square measure

victimization Arduino IDE for developing NodeMCU applications and Lua language if we tend to square measure victimization ESPlorer IDE.

Basically, NodeMCU is Lua Interpreter, thus it will perceive Lua script simply. after we write Lua scripts for NodeMCU and send/upload it to NodeMCU, then they'll get executes consecutive. it'll not build binary computer code file of code for NodeMCU to put in writing. it'll send Lua script because it is to NodeMCU to induce execute.

In Arduino IDE after we write and compile code, ESP8266 toolchain in background creates binary computer code file of code we tend to wrote. And after we transfer it to NodeMCU then it'll flash all NodeMCU computer code with freshly generated binary computer code code. In fact, it writes the entire computer code.

That's the rationale why NodeMCU not settle for any Lua scripts/code once it's obtaining flashed by Arduino IDE. once obtaining flashed by Arduino sketch/code it'll be no a lot of Lua interpreter {and we tend to land that we} got error if we try and transfer Lua scripts. To once more begin with Lua script, we'd like to flash it with NodeMCU computer code.

Since Arduino IDE compile and upload/writes complete computer code, it takes longer than ESPlorer IDE.

Solar panel:

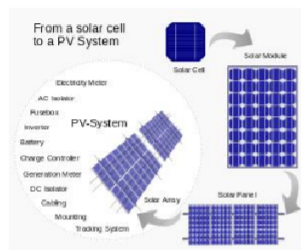
The term solar battery is employed conversationally for a photo-voltaic (PV) module.

A PV module is Associate in Nursing assembly of photo-voltaic cells mounted in an exceedingly framework for installation. Photo-voltaic cells use daylight as a supply of energy and generate electricity. a group of PV modules is named a PV Panel, and a

xvi

system of Panels is Associate in Nursing Array. Arrays of a electrical phenomenon

system provide star electricity to electrical instrumentation.



Theory:

Photovoltaic modules use light-weight energy (photons) from the Sun to get electricity through the electrical phenomenon impact. Most modules use wafer-based crystalline chemical element cells or thin-film cells. The structural (load carrying) member of a module will be either the highest layer or the rear layer. Cells should be shielded from mechanical injury and wetness. Most modules square measure rigid, however semi-flexible ones supported thin-film cells also are out there. The cells square measure connected electrically nonparallel, one to a different to the required voltage, so in parallel to extend electrical phenomenon. The electric power of the module is that the product of the voltage and also the electrical phenomenon of the module. The manufacture specifications on star panels square measure obtained underneath commonplace condition that isn't the \$64000 operational condition the star panels square measure exposed to on the installation web site. [1]

A PV junction box is hooked up to the rear of the solar battery and functions as its output interface. External connections for many electrical phenomenon modules use MC4 connectors to facilitate simple weatherproof connections to the remainder of the system. A USB power interface may also be used.[citation needed]

Module electrical connections square measure created nonparallel to realize a desired output voltage or in parallel to produce a desired current capability (amperes) of the solar battery or the PV system. The conducting wires that take this off the modules square measure sized in keeping with the ampacity and should contain silver, copper or different non-magnetic semiconductive transition metals. Bypass diodes could also be incorporated or used outwardly, just in case of partial module shading, to maximise the output of module sections still

lit.[citation needed]

Some special star PV modules embody concentrators during which light-weight is concentrated by lenses or mirrors onto smaller cells. this allows the utilization of cells with a high price per unit space (such as atomic number 31 arsenide) in an exceedingly cost-efficient manner.[citation needed]

.Solar panels conjointly use metal frames consisting of painful parts, brackets, reflector shapes, and troughs to raised support the panel structure.

History:

In 1839, the flexibility of some materials to form associate electrical charge from light-weight exposure was 1st discovered by Alexandre-Edmond Becquerel.[2] tho' the premiere star panels were too inefficient for even straightforward electrical devices they were used as associate instrument to live light-weight.[3] The observation by Becquerel wasn't replicated once more till 1873, once Willoughby Smith discovered that the charge may well be caused by light-weight touching atomic number 34. when this discovery, William Grylls Adams and Richard Evans Day revealed "The action of sunshine on selenium" in 1876, describing the experiment they accustomed replicate Smith's results.[2][4]

In 1881, Charles Fritts created the primary industrial solar array, that was reported by Fritts as "continuous, constant and of tidy force not solely by exposure to daylight however conjointly to dim, subtle daylight." [5] but, these star panels were terribly inefficient, particularly compared to coal-fired power plants. In 1939, Russell Ohl created the electric cell style that's utilized in several fashionable star panels. He proprietary his style in 1941.[6] In 1954, this style was 1st employed by Bell Labs to form the primary commercially viable Si electric cell.[2] In 1957, Mohamed M. Atalla developed the method of Si surface passivation by thermal oxidation at Bell Labs.[7][8] The surface passivation method has since been essential to electric cell potency.[9]

Each module is rated by its DC output power beneath normal check conditions (STC) and therefore the on field output power would possibly vary. Power generally ranges from a hundred to 365 Watts (W). The potency of a module determines the realm of a module given constant rated output – associate V-day economical 230 W module can have doubly the realm of a 16 PF economical 230 W module. Some commercially on the market star modules exceed pure gold potency.[10] [11]

Depending on construction, electrical phenomenon modules will manufacture electricity from a variety of frequencies of sunshine, however typically cannot cover the complete star vary (specifically, ultraviolet, infrared and low or subtle light). Hence, abundant of the incident daylight energy is wasted by star modules, and that they will offer way higher efficiencies if lighted with monochromatic light-weight. Therefore, another style idea is to separate the sunshine into six to eight completely different wavelength ranges that may manufacture a special color of sunshine, and direct the beams onto completely different cells tuned to those ranges.[12] This has been projected to be capable of raising potency by five hundredth.

A single star module will manufacture solely a restricted quantity of power; most installations contain multiple modules adding voltages or current to the wiring and PV system. A electrical phenomenon system generally includes associate array of electrical phenomenon modules, associate electrical converter, battery pack for energy storage, charge controller, interconnection wiring, circuit breakers, fuses, disconnect switches, voltage meters, and optionally a star trailing mechanism. instrumentality is rigorously chosen to optimize output, energy storage, cut back power loss throughout power transmission, and conversion from DC to electricity. Scientists from Spectrolab, a subsidiary of Boeing, have reported development of multi-junction star cells with associate potency of quite four-hundredth, a replacement record for star electrical phenomenon cells.[13] The Spectrolab scientists conjointly predict that concentrator star cells may win efficiencies of quite forty fifth or perhaps five hundredth within the future, with theoretical efficiencies being concerning fifty eight in cells with quite 3 junctions.

Currently, the simplest achieved daylight conversion rate (solar module efficiency) is around twenty one.5% in new industrial products[14] generally less than the efficiencies of their cells in isolation. the foremost economical factory-made star modules[disputed – discuss] have power density values of up to one hundred seventy five W/m² (16.22 W/ft²).[15]

Research by Imperial school London has shown that solar array potency is improved by studding the light-receiving semiconductor surface with metallic element nanocylinders, kind of like the ridges on plaything blocks. The scattered light-weight then travels on a extended path^{xxi} within the semiconductor, riveting a lot of photons to be reborn into current. though these nanocylinders are used

antecedently (aluminum was preceded by gold and silver), {the light-weight{the sunshine} scattering occurred within the near-infrared region and visual light was absorbed powerfully. metallic element was found to possess absorbed the ultraviolet a part of the spectrum, whereas the visible and near-infrared elements of the spectrum were found to be scattered by the metallic element surface. This, the analysis argued, may bring down the value considerably and improve the potency as metallic element is a lot of rich and fewer expensive than gold and silver. The analysis conjointly noted that the rise in current makes dilutant film star panels technically possible while not "compromising power conversion efficiencies, so reducing material consumption".[16]

Solar panel potency will be calculated by MPP (maximum power point) worth of star panels.

Solar electrical converters convert the DC power to AC power by playing the method of most electrical outlet trailing (MPPT): star inverter samples the output Power (I-V curve) from the electric cell and applies the correct resistance (load) to star cells to get most power.

MPP (Maximum power point) of the solar array consists of MPP voltage (V_{mpp}) and MPP current (I_{mpp}): it's a capability of the solar array and also the higher worth will create higher MPP.

Micro-inverted star panels area unit wired in parallel, that produces a lot of output than traditional panels wired serial, with the output of the series determined by the bottom playing panel. this is often referred to as the "Christmas light-weight effect". Micro-inverters work severally to modify every panel to contribute its most attainable output for a given quantity of sunligh

Techonolgy:

Most star modules area unit presently made from crystalline Si (c-Si) star cells manufactured from multicrystalline and monocrystalline Si. In 2013, crystalline Si accounted for quite ninety % of worldwide PV production, whereas the remainder of the market is created of thin-film technologies victimization Cd chemical compound, CIGS and amorphous silicon[18]

.Emerging, third generation star technologies use advanced thin-film cells. They turn out a comparatively high-efficiency conversion for the low price compared to different star technologies. Also, high-cost, high-efficiency, and compact rectangular multi-junction (MJ) cells ar ideally employed in star panels on orbiter,

as they provide the very best quantitative relation of generated power per kilo raised into house. MJ-cells are compound semiconductors and manufactured from metallic element compound (GaAs) and different semiconductor materials. Another rising PV technology exploitation MJ-cells is concentrator photovoltaics (CPV).

Thin film

In rigid thin-film modules, the cell and therefore the module are factory-made within the same mechanical system. The cell is formed on a glass substrate or superstrate, and therefore the electrical connections are created in place, an alleged "monolithic integration". The substrate or superstrate is laminated with an associated degree of encapsulant to a front or back sheet, sometimes another sheet of glass. The most cell technologies during this class are CdTe, or a-Si, or a-Si+uc-Si, or CIGS (or variant). Amorphous semiconductor includes a daylight conversion rate of 6–12%.

Flexible skinny film cells and modules are created on a constant mechanical system by depositing the photoactive layer and different necessary layers on a versatile substrate. If the substrate is an associated degree material (e.g. polyester or polyimide film) then monolithic integration will be used. If it's a conductor then another technique for electrical association should be used. The cells are assembled into modules by laminating them to a clear colourless fluoropolymer on the front aspect (typically ETFE or FEP) and a chemical compound appropriate for bonding to the ultimate substrate on the opposite aspect.

Main articles: good module and star micro-inverter

Several corporations have begun embedding physics into PV modules. This permits acting MPPT for every module singly, and therefore the activity of performance knowledge for observation and fault detection at module level. A number of these solutions create use of power optimizers, a DC-to-DC convertor technology developed to maximise the ability harvest from star electrical phenomenon systems. As of regarding 2010, such physics may also catch up on shading effects, whereby a shadow falling across a part of a module causes the electrical output of 1 or a lot of strings of cells within the module to fall to zero, however not having the output of the whole module fall to zero.

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LDR-LIGHT DEPENDENT resistance

What is a light-weight Dependent resistance or a photograph Resistor?

A Light Dependent resistance (LDR) or a photograph resistance may be a device whose ohmic resistance may be a perform of the incident nonparticulate radiation. Hence, they're light-weight sensitive devices. they're conjointly referred to as as image conductors, image conductive cells or just photocells. they're created of semiconductor materials having high resistance. There ar many alternative symbols wont to indicate a LDR, one among the foremost normally used image is shown within the figure below. The arrow indicates light-weight falling thereon.

Working Principle of LDR

A light dependent resistance works on the principle of image physical phenomenon. image physical phenomenon is associate degree physical phenomenon during which the fabrics physical phenomenon (Hence resistivity) reduces once light-weight is absorbed by the material. once light-weight falls i.e.

once the photons fall on the device, the electrons within the valence band of the semiconductor material are excited to the conductivity band. These photons within the incident light-weight ought to have energy bigger than the band gap of the semiconductor material to form the electrons jump from the valence band to the conductivity band. thus once light-weight having enough energy is incident on the device a lot of & a lot of electrons are excited to the conductivity band which ends in sizable amount of charge carriers. The results of this method is a lot of and a lot of current starts flowing and thus it's aforementioned that the resistance of the device has attenuated. this is often the foremost common regulation of LDR

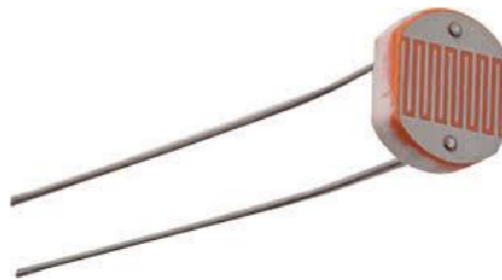
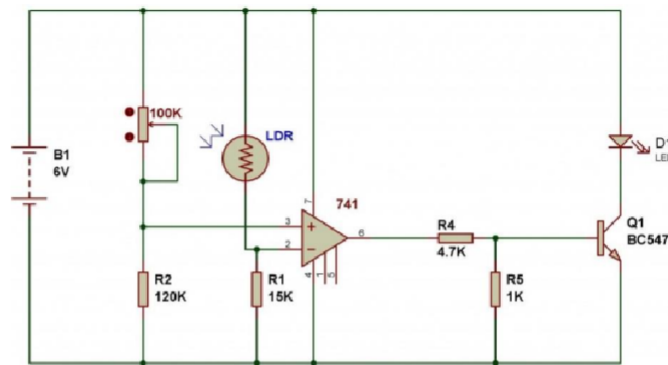


Diagram of LDR sensing element

Characteristics of LDR

LDR's are light-weight dependent devices whose resistance decreases once light-weight falls on them and will increase within the dark. once a light-weight dependent resistance is unbroken in dark, its resistance is extremely high. This resistance is named as dark resistance. It will be as high as $10^{12} \Omega$. And if the device is allowed to soak up light-weight its resistance can decrease drastically. If a continuing voltage is applied to that and intensity of sunshine is enhanced this starts increasing. Figure below shows resistance vs. illumination curve for a specific LDR. Photocells or LDR's are non linear devices. Their sensitivity varies with the wavelength of sunshine incident on them. Some photocells won't in any respect response to an exact vary of wavelengths. supported the fabric used completely different\completely different\ cells have different spectral response curves.



Circuit diagram of LDR device

When light-weight is incident on a sensor it always takes concerning eight to 12ms for the modification in resistance to require place, whereas it takes seconds for the resistance to rise back once more to its initial price when removal of sunshine.

This development is named as resistance recovery rate. This property is employed in audio compressors. Also, LDR's area unit less sensitive than image diodes and image semiconductor device. (A image diode and a sensor (LDR) aren't constant, a photo-diode could be a tangency conductor that converts light-weight to electricity, whereas a sensor could be a passive device, there's no tangency during this nor it "converts" light-weight to electricity).

Types of light-weight Dependent Resistors:

Based on the materials used {they area unit|they're} classified as: i) intrinsic image resistors (Un doped semiconductor): These are pure semiconductor materials like atomic number 14 or atomic number 32. Electrons get excited from framing band to physical phenomenon band once photons of enough energy falls on that and variety charge carriers will increase.

ii) unessential image resistors: These area unit semiconductor materials doped with impurities that area unit referred to as as dopants. Theses dopants produce new energy bands on top of the valence band that area unit crammed with electrons. therefore this reduces the band gap and fewer energy is needed in exciting them. unessential image resistors area unit usually used for long wavelengths.

xx

Construction of a sensor

The structure of a light dependent resistor consists of a light sensitive material which is deposited on an insulating substrate such as ceramic. The material is deposited in zigzag pattern in order to obtain the desired resistance & power rating. This zigzag area separates the metal deposited areas into two regions. Then the ohmic contacts are made on the either sides of the area. The resistances of these contacts should be as less as possible to make sure that the resistance mainly changes due to the effect of light only. Materials normally used are cadmium sulphide, cadmium selenide, indium antimonide and cadmium selenonide. The use of lead and cadmium is avoided as they are harmful to the environment.

Applications of LDR

LDR's have low price and straightforward structure. they're usually used as light-weight sensors. they're used once there's a necessity to discover absences or presences of sunshine like in an exceedingly camera photometer. utilized in street lamps, grandfather clock, thief alarm circuits, intensity meters, for investigation the packages moving on a belt, etc.

IOT:

INTERNET OF THINGS:

The Internet of things (IoT) is that the inter-networking of physical devices, vehicles (also stated as "connected devices" and "smart devices"), buildings, and alternative things embedded with physics, software, sensors, actuators, and network property that modify these objects to gather and exchange knowledge. In 2013 international the world wide the world Standards Initiative on net of Things (IOT-GSI) outlined the IOT as "a global infrastructure for the data society, sanctioning advanced services by interconnecting (physical and virtual) things supported existing and evolving practical data and communication technologies" and for these functions a "thing" is "an object of the physical world (physical things) or the data world (virtual things), that is capable of being known and integrated into communication networks". The IOT permits objects to be detected or controlled remotely across existing network infrastructure, making opportunities for a lot of direct integration of the physical world into computer-based systems, and leading to improved potency, accuracy and economic profit additionally to

reduced human intervention. once IOT is increased with sensors and actuators, the technology becomes AN instance of the a lot of general category of cyber-physical systems, that conjointly encompasses technologies like good grids, virtual power plants, good homes, intelligent transportation and good cities. every issue is unambiguously distinctive through its embedded ADPS however is in a position to interoperate inside the present net infra-structure. specialists estimate that the IOT can accommodates concerning thirty billion objects by 2020. Typically, IOT is anticipated to supply advanced property of devices, systems, and services that goes on the far side machine-to-machine (M2M) communications and covers a range of protocols, domains, and applications. The interconnection of those embedded devices (including good objects), is anticipated to lead off automation in nearly all fields, whereas conjointly sanctioning advanced applications sort of a good grid, and increasing to areas like good cities. "Things", within the IOT sense, will consult with a good form of devices like heart observance implants, chip transponders on domestic animals, electrical clams in coastal waters, cars with integral sensors, desoxyribonucleic acid analysis devices for environmental/food/pathogen observance, or field operation devices that assist hearth fighters in search and rescue operations. Legal students counsel relating to "Things" as AN "inextricable mixture of hardware, software, knowledge and service". These devices collect helpful knowledge with the assistance of varied existing technologies so autonomously flow the info between alternative devices. Current market examples embody home automation (also referred to as good home devices) like the management and automation of lighting, heating (like good thermostat), ventilation, air-con (HVAC) systems, and appliances like washer/dryers, robotic vacuums, air purifiers, ovens, or refrigerators/freezers that use Wi-Fi for remote observance. further because the growth of Internet-connected automation into a excessiveness of latest application areas, IOT is additionally expected to get giant amounts of knowledge from numerous locations, with the ensuing necessity for fast aggregation of the info, and a rise within the have to be compelled to index, store, and method such knowledge a lot of effectively. IOT is one in every of the platforms of today's good town, and good Energy Management Systems

HISTORY

As of 2016, the vision of the web of things has evolved thanks to a convergence of multiple technologies, together with present wireless communication, time period analytics, machine learning, artefact sensors, and embedded systems. this implies that the normal fields of embedded systems, wireless device networks, management systems, automation (including home and building automation), et al. all contribute to sanctioning the web of things (IOT). The idea of a network of good devices was mentioned as early as 1982, with a changed Coke machine at Carnegie moneyman University turning into the primary Internet-connected appliance,, able to report its inventory and whether or not recently loaded drinks were cold. Mark Weiser's seminal 1991 paper on present computing, "The laptop of the twenty first Century", likewise as educational venues like UbiComp and PerCom made the up to date vision of IOT. In 1994 Reza Raji delineate the thought in IEEE Spectrum as "[moving] tiny packets of knowledge to an oversized set of nodes, thus on integrate and change everything from home appliances to entire factories". Between 1993 and 1996 many firms projected solutions like Microsoft's at Work or Novell's NEST. However, solely in 1999 did the sector begin gathering momentum. Bill Joy visualized Device to Device (D2D) communication as a part of his "Six Webs" framework, conferred at the globe Economic Forum at Davos in 1999. The thought of the web of things became well-liked in 1999, through the Auto-ID Centre at university and connected market-analysis publications. Radio-frequency identification (RFID) was seen by Kevin Sir Frederick Ashton (one of the founders of the first Auto-ID Centre) as a requirement for the web of things at that time. Sir Frederick Ashton prefers the phrase "Internet for Things. If all objects and folks in way of life were equipped with identifiers, computers may manage and inventory them. Besides victimization RFID, the tagging of things could also be achieved through such technologies as close to field communication, barcodes, QR codes and digital watermarking. In its original interpretation, one in every of the primary consequences of implementing the web of things by mobilisation all objects within the world with minuscule distinguishing devices or machine-readable identifiers would be to remodel way of life. as an example, instant and constant internal control would become present. a

personality's ability to act with objects might be altered remotely supported immediate or gift desires, in accordance with existing end-user agreements. for instance, such technology may grant motion-picture publishers rather more management over end-user personal devices by remotely imposing copyright restrictions and digital rights management, that the ability of a client WHO bought a Blu-ray disc to observe the film may become passionate about the copyright holder's call, the same as Circuit City's failing DIVX.

APPLICATIONS:

per Gartner, Inc. (a technology analysis and consultatory corporation), there'll be nearly twenty.8 billion devices on the web of things by 2020. ABI analysis estimates that over thirty billion devices are wirelessly connected to the web of things by 2020. As per a 2014 survey and study done by church bench analysis web Project, an oversized majority of the technology specialists and engaged web users WHO responded—83 percent—agreed with the notion that the Internet/Cloud of Things, embedded and wearable computing (and the corresponding dynamic systems can have widespread and helpful effects by 2025. As such, it's clear that the IOT can include a really sizable amount of devices being connected to the web. In a vigorous move to accommodate new and rising technological innovation, the united kingdom Government, in their 2015 budget, allotted £40,000,000 towards analysis into the web of things. the previous British Chancellor of the treasury martyr John James Osborne, posited that the web of things is that the next stage of the data revolution and documented the inter-connectivity of everything from urban transport to medical devices to home appliances. the flexibility to network embedded devices with restricted processor, memory and power resources means IOT finds applications in nearly each field. [48] Such systems might be answerable of collection data in settings starting from natural ecosystems to buildings and factories, thereby finding applications in fields of environmental sensing and concrete coming up with. On the opposite hand, IOT systems may even be answerable for performing arts actions, not simply sensing things. Intelligent searching systems, for instance, may monitor specific users' buying habits in an exceedingly store by trailing their specific mobile phones. These users may then be given special offers on their favorite product, or

perhaps location of things that they have, that their icebox has mechanically sent to the phone. further samples of sensing and causative square measure mirrored in applications that touch upon heat, water, electricity and energy management, likewise as cruise-assisting transportation systems. different applications that the web of things will give is sanctionative extended home security measures and residential automation. The thought of AN "Internet of living things" has been projected to explain networks of biological sensors that might use cloud-based analyses to permit users to review polymer or different molecules. However, the applying of the IOT isn't solely restricted to those areas. different specialised use cases of the IOT may additionally exist. an outline of a number of the foremost outstanding application areas is provided here.

MEDIA:

so as to hone the way within which things, media and massive knowledge square measure interconnected, it's initial necessary to supply some context into the mechanism used for media method. it's been urged by Nick Couldry and Joseph Turow that practitioners in media approach massive knowledge as several unjust points of data regarding many people. The business seems to be moving removed from the normal approach of victimization specific media environments like newspapers, magazines, or tv shows and instead faucet into shoppers with technologies that reach targeted individuals at optimum times in optimum locations. the last word aim is in fact to serve, or convey, a message or content that's (statistically speaking) in line with the consumer's approach. for instance, business environments square measure progressively trade the messages (advertisements) and content (articles) to attractiveness to shoppers that are completely gleaned through varied data-mining activities. The media industries method massive knowledge in an exceedingly twin, interconnected manner: Targeting of shoppers (for advertising by marketers) Data-capture therefore, the web of things creates a chance while being crucial in permitting clearer accuracy in targeting. the web of things so transforms the media business, firms and even governments, gap up a brand new era of economic process and fight. The wealth of knowledge generated by this business (i.e. massive data) can enable practitioners in advertising AND media to achieve an elaborate layer on the current

targeting mechanisms employed by the business.

INFRASTRUCTURE MANAGEMENT:

observance and dominant operations of urban and rural infrastructures like bridges, railway tracks, on- and offshore- wind-farms may be a key application of the IOT. The IOT infrastructure are often used for observance events or changes in structural conditions that may compromise safety and increase risk. It also can be used for planning repair AND maintenance activities in an economical manner, by coordinating tasks between completely different service suppliers and users of those facilities. IOT devices also can be accustomed management vital infrastructure like bridges to supply access to ships. Usage of IOT devices for observance and operative infrastructure is probably going to enhance incident management and emergency response coordination, and quality of service, up-times and cut back prices of operation all told infrastructure connected areas. Even areas like waste management will have the benefit of automation and improvement that might be brought in by the IOT.

producing NETWORK:

management and management of producing instrumentality, plus and scenario management, or producing method management bring the IOT at intervals the realm of commercial applications and sensible producing furthermore. The IOT intelligent systems change fast producing of latest product, dynamic response to product demands, and time period improvement of producing production and provide chain networks, by networking machinery, sensors and management systems along. Digital management systems to modify method controls, operator tools and repair data systems to optimize plant safety and security area unit at intervals the ambit of the IOT. however it additionally extends itself to plus management via prophetic maintenance, applied math analysis, and measurements to maximise responsiveness. sensible applied science systems also can be integrated with the sensible Grid, thereby sanctionative time period energy improvement. Measurements, machine-driven controls, plant improvement, health and safety management, and different functions area unit provided by an outsized range of networked^{xx} sensors. The National Science

Foundation established AN Industry/University Cooperative analysis Centre on intelligent maintenance systems (IMS) in 2001 with a probe focus to use IOT-based prophetic analytics technologies to observe connected machines and to predict machine degradation, and more to stop potential failures. The vision to realize near-zero breakdown exploitation IOT-based prophetic analytics diode the longer term development of e-manufacturing and e-maintenance activities. The term IIOT (Industrial net of Things) is usually encountered within the producing industries, concerning the commercial set of the IOT. IIOT in producing may generate such a lot business worth that it'll eventually cause the fourth age, therefore the questionable business four.0. it's calculable that within the future, triple-crown firms are going to be ready to increase their revenue through net of things by making new business models and improve productivity, exploit analytics for innovation, and remodel work force. The potential of growth by implementing IIOT can generate \$12 trillion of world GDP by 2030 whereas property and information acquisition area unit imperative for IIOT, they ought to not be the aim, rather the muse and path to one thing larger. Among all the technologies, prophetic maintenance is perhaps a comparatively "easier win" since it's applicable to existing assets and management systems. the target of intelligent maintenance systems is to cut back sudden period of time and increase productivity. And to comprehend that alone would generate around up to half-hour over total maintenance prices. Industrial huge information analytics can play a significant role in producing plus prophetic maintenance, though that's not the sole capability of commercial huge information. Cyber-physical systems (CPS) is that the core technology of commercial huge information ANd it'll be an interface between human and therefore the cyber world. Cyber-physical systems are often designed by following the 5C (connection, conversion, cyber, cognition, configuration, architecture), and it'll remodel the collected information into unjust data, and eventually interfere with the physical assets to optimize processes

ENERGY MANAGEMENT :

Integration of sensing and exploit systems, connected to the web, is probably going to optimize energy consumption as a full. it's expected that IOT devices are going to be integrated into all varieties of ^{xx}energy intense devices (switches, power

shops, bulbs, televisions, etc.) and be ready to communicate with the utility provide company so as to effectively balance power generation and energy usage. Such devices would additionally provide the chance for users to remotely management their devices, or centrally manage them via a cloud primarily based interface, and change advanced functions like planning (e.g., remotely powering on or off heating systems, dominant ovens, ever-changing lighting conditions etc.). Besides home primarily based energy management, the IOT is very relevant to the sensible Grid since it provides systems to assemble and act .

BUILDING and residential AUTOMATION:

IOT devices are often accustomed monitor and management the mechanical, electrical and electronic systems employed in numerous sorts of buildings (e.g., public and personal, industrial, establishments, or residential) in home automation and building automation systems. during this context, 3 main area unitas are being lined in literature: the combination of the net with building energy management systems so as to make energy economical and IOT driven "smart buildings". The attainable means that of period observation for reducing energy consumption and observation indweller behaviours. the combination of sensible devices within the engineered surroundings and the way they may be employed in future applications.

TRANSPORTATION:

The IOT will assist in integration of communications, control, and knowledge process across numerous transportation systems. Application of the IOT extends to all or any aspects of transportation systems (i.e. the vehicle, the infrastructure, and therefore the driver or user). Dynamic entombaction between these parts of a transport system allows inter and intra transport communication, sensible control, sensible parking, electronic toll assortment systems, supply and fleet management, vehicle management, and safety and road help.

METROPOLITAN SCALE DEPLOYMENTS :

There area unit many planned or current large-scale deployments of the IOT, to alter higher management of cities and systems. as an example, Songdo, Republic

of Korea, the primary of its kind totally equipped and wired sensible town, is close to completion. Nearly everything during this town is planned to be wired, connected AND become a continuing stream of information that will be monitored and analysed by an array of computers with very little, or no human intervention. Another application may be a presently undergoing project in Santander, Spain. For this readying, 2 approaches are adopted. This town of one hundred eighty,000 inhabitants, has already seen eighteen,000 town application downloads for his or her smartphones. This application is connected to ten,000 sensors that alter services like parking search, environmental observation, and digital town agenda among others. town context data is employed during this readying therefore on profit merchants through a spark deals mechanism supported town behaviour that aims at increasing the impact of every notification. alternative samples of large-scale deployments current embrace the Sino-Singapore urban center information City; work on up air and water quality, reducing pollution, and increasing transportation potency in San Jose, California; and sensible traffic management in western Singapore. French company, Sigfox, commenced building AN ultra-narrowband wireless information network within the point of entry Bay space in 2014, the primary business to attain such a readying within the U.S. It later on proclaimed it might discovered a complete of 4000 base stations to hide a complete of thirty cities within the U.S. by the tip of 2016, creating it the most important IOT network coverage supplier within the country so far. Another example of an oversized readying is that the one completed by big apple Waterways in big apple town to attach all the city's vessels and be ready to monitor them live 24/7. The network was designed and designed by Fluidmesh Networks, a Chicago-based company developing wireless networks for essential applications. The NYWW network is presently providing coverage on the Hudson, East River, and higher big apple Bay. With the wireless network in situ, Empire State Waterway in an exceedingly positionlis ready} to require management of its fleet and passengers in a means that wasn't antecedently attainable. New applications will embrace security, energy and fleet management, digital accumulation, public Wi-Fi, paperless ticketing et al.

CONSUMER APPLICATION:

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A growing portion of IOT devices are units created for client use. samples of client applications embrace connected automobile, diversion, residences and sensible homes, wearable technology, quantified self, connected health, and sensible retail. client IOT provides new opportunities for user expertise and interfaces. Some client applications are criticized for his or her lack of redundancy and their inconsistency, resulting in a well-liked parody called the "Internet of Shit." firms are criticized for his or her rush into IOT, making devices of questionable worth, and not fixing demanding security standards.

UNIQUE ADDRESSABILITY OF THINGS:

The original plan of the Auto-ID Centre relies on RFID-tags AND distinctive identification through the Electronic Product Code but this has evolved into objects having an science address or URI. another read, from the planet of the linguistics net focuses instead on creating all things (not simply those electronic, smart, or RFID-enabled) available by the prevailing naming protocols, like URI. The objects themselves don't converse, however they'll currently be observed by alternative agents, like powerful centralized servers acting for his or her human homeowners. . and consequently the world adoption of IPv6 within the coming back years are going to be essential for the successful development of the IOT within the future. a mix of those concepts are often found within the current GS1/EPC world EPC data Services (EPCIS) specifications. this technique is being employed to spot objects in industries starting from part to fast paced client merchandise and transportation supplying.

TRENDS AND CHARACTERISTICS

INTELLIGENCE:

close intelligence and autonomous management don't seem to be a part of the first thought of the net of things. close intelligence and autonomous management don't essentially need web structures, either. However, there's a shift in analysis to integrate the ideas of the net of things and autonomous management, with initial outcomes towards this direction considering objects because the thrust for autonomous IOT. within the future the net of things is also a non-deterministic and open network within which auto-organized or intelligent entities (Web services,

SOA components), virtual objects (avatars) are going to be practical and able to act severally (pursuing their own objectives or shared ones) reckoning on the context, circumstances or environments. Autonomous behaviour through the gathering and reasoning of context data further because the objects ability to find changes within the surroundings, faults touching sensors and introduce appropriate mitigation measures represent a significant analysis trend, clearly required to produce quality to the IOT technology. fashionable IOT product and solutions within the marketplace use a spread of various technologies to support such context-aware automation however a lot of subtle types of intelligence square measure requested to allow detector units to be deployed in real environments.

NETWORK ARCHITECTURE:

The Internet of things needs vast quantifiability within the network area to handle the surge of devices. IETF 6LoWPAN would be accustomed connect devices to information processing networks. With billions of devices being other to the net area, IPv6 can play a significant role in handling the network layer quantifiability. IETF's forced Application Protocol, Zero MQ, and MQTT would offer light-weight information transport. "MQ" in "MQTT" came from IBM's MQ Series message queuing product. Fog computing could be a viable different to forestall such massive burst of information flow through web. the sting devices' computation power may be accustomed analyse and method information, therefore providing straightforward real time quantifiability.

Size concerns

The Internet of things would write in code fifty to one hundred trillion objects, and be able to follow the movement of these objects. folks in surveyed urban environments square measure every encircled by one thousand to 5000 traceable objects.

Space concerns

In the web of things, the precise geographic location of a thing—and conjointly the precise geographic dimensions of a thing—will be essential. Therefore, facts a

couple of issues, like its location in time and area, are less essential to trace as a result of the person process {the data|the knowledge|the data} will decide whether or not or not that information was necessary to the action being taken, and if so, add the missing data (or attempt to not take the action). (Note that some things within the web of things are going to be sensors, and detector location is typically necessary. The GeoWeb and Digital Earth square measure promising applications that become doable once things will become organized and connected by location. However, the challenges that stay embrace the constraints of variable spatial scales, the requirement to handle large amounts of information, Associate in Nursing compartmentalisation for quick search and neighbour operations. within the web of things, if things square measure able to take actions on their own initiative, this human-centric mediation role is eliminated. Thus, the time-space context that we have a tendency to as humans deem granted should lean a central role during this data scheme. even as standards play a key role within the web and therefore the internet, geospatial standards can play a key role within the web of things.

Sectors

There square measure 3 core sectors of the IOT: enterprise, home, and government, with the Enterprise web of Things (EIOT) being the most important of the 3. By 2019, the EIOT sector is calculable to account for nearly four-hundredth or nine.1 billion devices.

ENABLING TECHNOLOGIES FOR IOT:

There square measure several technologies that alter IOT. Crucial to the sphere is that the network accustomed communicate between devices of AN IOT installation, a task that many wireless or wired technologies might full fill:

SHORT-RANGE WIRELESS:

- Bluetooth low energy (BLE) – Specification providing an occasional power variant to classic Bluetooth with a comparable communication vary.
- Light-Fidelity (Li-Fi) – Wireless communication technology the same as the Wi-Fi normal, however victimisation light communication for multiplied information

measure.

- Near-field communication (NFC) – Communication protocols sanctioning 2 electronic devices to speak among a four cm vary.
- QR codes and barcodes – Machine-readable optical tags that store info regarding the item to that they're connected.
- Radio-frequency identification (RFID) – Technology victimisation magnetism fields to scan knowledge keep in tags embedded in alternative things.
- Thread – Network protocol supported the IEEE 802.15.4 standard, the same as Zigbee, providing IPv6 addressing.
- Transport Layer Security (network protocol) | TLS – Network security protocol.
- Wi-Fi – wide used technology for native space networking supported the IEEE 802.11 normal, wherever devices might communicate through a shared access purpose.
- Wi-Fi Direct – Variant of the Wi-Fi normal for peer-to-peer communication, eliminating the requirement for AN access purpose.
- Z-Wave – Communication protocol providing short-range, low-latency knowledge transfer at rates and power consumption less than Wi-Fi. Used primarily for home automation.
- Zigbee – Communication protocols for private space networking supported the IEEE802.15.4 standard, providing low power consumption, low rate, low cost, and high turnout.

MEDIUM-RANGE WIRELESS:

- Hallow – Variant of the Wi-Fi normal providing extended vary for low-power communication at a lower rate.
- LTE-Advanced – High-speed communication specification for mobile networks. Provides enhancements to the LTE normal with extended coverage, higher turnout, and lower latency.

LONG-RANGE WIRELESS:

- Low-power wide-area networking (LPWAN) – Wireless networks designed to permit long-range communication at an occasional rate, reducing power and

value for transmission.

- Very tiny aperture terminal (VSAT) – Satellite communication technology victimisation tiny dish antennas for narrowband and broadband knowledge.

WIRED:

- Ethernet – General purpose networking normal victimisation twisted combine and fibre optic links in conjunction with hubs or switches.
- Multimedia over Coax Alliance (MOCA) – Specification sanctioning whole-home distribution of high definition video and content over existing concentric cabling.
- Power-line communication (PLC) – Communication technology victimisation electrical wiring to hold power and knowledge. Specifications like Home Plug utilize PLC for networking IOT devices.

SIMULATION:

IOT modelling and simulation (and emulation) is often disbursed at the look stage before preparation of the network. Network simulators like OPNET, internet Sim and NS2 are often accustomed simulate IOT networks. Digital Twins can also be enforced to supply updates on the standing AND health of an quality, based mostly upon detector readings integrated with a machine model of the quality.

GOVERNMENT REGULATION ON IOT:

One of the key drivers of the IOT is knowledge. The success of the thought of connecting devices to create them a lot of economical depends upon access to and storage & process of information. For this purpose, corporations engaged on IOT collect knowledge from multiple sources and store it in their cloud network for additional process. This leaves the door wide open for privacy and security dangers and single purpose vulnerability of multiple systems. the opposite problems pertain to shopper alternative and possession of information and the way it's used. Presently the regulators have shown a lot of interest in protective the primary 3 problems known on top of. Current restrictive environment: A report^{xl} revealed by the Federal Trade Commission (FTC) in January 2015 created the

subsequent 3 recommendations:

- Data security – At the time of planning IOT corporations ought to make sure that knowledge assortment, storage and process would be secure in the slightest degree times. corporations ought to adopt a “defence in depth” approach and write knowledge at every stage.
- Data consent – users ought to have a alternative on what knowledge they share with IOT corporations and also the users should be told if their knowledge gets exposed.
- Data minimisation – IOT corporations ought to collect solely data they have and retain the collected information just for a restricted time.

However, the FTC stopped at simply creating recommendations for currently. consistent with AN FTC analysis, the prevailing framework, consisting of the FTC Act, the truthful Credit coverage Act, and also the Children's on-line Privacy Protection Act, beside developing shopper education and business steering, participation in multi stake holder efforts and support to different agencies at the federal, state and native level, is spare to safeguard shopper rights.

A resolution elapsed the Senate in March 2015, is already being thought of by the Congress. This resolution recognized the necessity for formulating a National Policy on IOT and also the matter of privacy, security and spectrum. moreover, to produce AN impetus to the IOT system, in March 2016, a two-party cluster of 4 Senators projected a bill, The Developing Innovation and Growing the web of Things (DIGIT) Act, to direct the Federal Communications Commission to assess the necessity for a lot of spectrum to attach IOT devices

Several standards for the IOT business are literally being established with reference to cars as a result of most considerations arising from use of connected cars apply to aid devices moreover. In fact, the National road Traffic Safety Administration (NHTSA) is getting ready cyber security pointers and a info of best practices to create automotive laptop systems safer.

DATA STORAGE AND ANALYTICS:

A challenge for producers of IOT applications is to scrub, method and interpret the immense quantity of information that is gathered by the sensors. there's an answer planned for the analytics of the knowledge noted as Wireless device

Networks. These networks share knowledge among device nodes that area unit send to a distributed system for the analytics of the sensory knowledge. Another challenge is that the storage of this bulk knowledge. reckoning on the appliance there may be high knowledge acquisition needs that successively cause high storage needs. presently the web is already liable for five-hitter of the entire energy generated and this consumption can increase considerably after we begin utilizing applications with multiple embedded sensors.

SECURITY:

issues are raised that the web of things is being developed apace while not applicable thought of the profound security challenges concerned and also the regulative changes that may be necessary. Most of the technical security problems area unit just like those of typical servers, workstations and smartphones, however the firewall, security update and anti-malware systems used for those area unit usually unsuitable for the a lot of smaller, less capable, IOT devices. in keeping with the Business business executive Intelligence Survey conducted within the half-moon of 2014, thirty ninth of the respondents aforesaid that security is that the biggest concern in adopting web of things technology. especially, because the web of things spreads wide, cyber-attacks area unit possible to become Associate in Nursing more and more physical (rather than merely virtual) threat. in an exceedingly Gregorian calendar month 2014 article in Forbes, cyber-security editorialist Joseph Steinberg listed several Internet-connected appliances which will already "spy on folks in their own homes" as well as televisions, room appliances, cameras, and thermostats. Computer-controlled devices in vehicles like brakes, engine, locks, hood and trunk releases, horn, heat, and dashboard are shown to be prone to attackers World Health Organization have access to the on-board network. In some cases, vehicle laptop systems area unit Internet-connected, permitting them to be exploited remotely. By 2008 security researchers had shown the flexibility to remotely management pacemakers while not authority. Later hackers incontestible remote of endocrine pumps and implantable cardioverter defibrillators. David Pogue wrote that some recently printed reports concerning hackers remotely dominant bound functions of vehicles weren't as serious mutually would possibly otherwise guess owing to

numerous mitigating circumstances; like the bug that allowed the hack having been mounted before the report was printed, or that the hack needed security researchers having physical access to the automotive before the hack to arrange for it. The U.S. National Intelligence Council in Associate in Nursing unclassified report maintains that it'd be arduous to deny "access to networks of sensors and remotely-controlled objects by enemies of the u. s., criminals, and mischief manufacturers... Associate in Nursing open marketplace for mass device knowledge may serve the interests of commerce and security no but it helps criminals and spies determine vulnerable targets. Thus, massively parallel device fusion could undermine social cohesion, if it proves to be basically incompatible with Fourth-Amendment guarantees against unreasonable search." generally, the intelligence service views the web of things as a fashionable supply of information. As a response to increasing issues over security, the web of Things Security Foundation (IOTSF) was launched on twenty three Gregorian calendar month 2015. IOTSF incorporates a mission to secure the web of things by promoting information and best apply. Its beginning board is formed from technology suppliers and telecommunications firms as well as BT, Vodafone, Imagination Technologies and Pen take a look at Partners. additionally, massive IT firms area unit unceasingly developing innovative solutions to confirm the safety for IOT devices. As per the estimates from KBV analysis, the general IOT security market would grow at twenty seven.9% rate throughout 2016-2022 as a results of growing infrastructural issues and wide-ranging usage of web of things. In 2016, a distributed denial of service attack powered by web of things devices running the Mirai malware took down a DNS supplier and major websites.

DESIGN:

Given widespread recognition of the evolving nature of the look and management of the web of things, property and secure readying of IOT solutions should style for "anarchic quantifiability." Application of the thought of uncontrolled quantifiability are often extended to physical systems (i.e. controlled real-world objects), by virtue of these systems being designed to account for unsure management futures. This "hard uncontrolled scalability" therefore provides a pathway forward to completely notice the potential of web of things solutions by by

selection constrictive physical systems to permit for all management regimes while not risking physical failure. Brown University computer user archangel Littman has argued that successful execution of the web of things needs thought of the interface's usability yet because the technology itself. These interfaces ought to be not solely additional easy however conjointly higher integrated: "If users ought to learn completely different interfaces for his or her vacuums, their locks, their sprinklers, their lights, and their coffeemakers, it's powerful to mention that their lives are created any easier."

CONFUSING TERMINOLOGY:

Kevin Lonergan at modern era, a business-technology magazine, has noted the terms close IOT as a "terminology zoo". the shortage of clear nomenclature isn't "useful from a sensible purpose of view" and a "source of confusion for the top user"...According to Lonergan, the term IOT was coined before sensible phones, tablets, and devices as we all know them nowadays existed, and there's a protracted list of terms with variable degrees of overlap and technological convergence: web of Things (IOT), web of Everything (IOE), Industrial web, Pervasive Computing, Pervasive Sensing, omnipresent Computing, Cyber-Physical Systems (CPS), Wireless sensing element Networks (WSN), sensible Objects, Cooperating Objects, Machine-to-Machine (M2M), close Intelligence (AMI), Operational Technology (OT), and data Technology (IT). concerning IIOT, associate degree industrial sub-field of IOT, the commercial web pool's Vocabulary Task cluster has created a "common and reusable vocabulary of terms" to make sure "consistent terminology" across publications issued by the commercial web Consortium. IOT One has created associate degree IOT Terms information as well as a brand new Term aware of be notified once a brand new term is revealed. As of March 2017, this information aggregates 711 IOT-related terms, however, with none tries to scale back word ambiguity and complexity.

Arduino:

Introduction

Arduino is Associate in Nursing ASCII textfile platform used for building physics comes. Arduino consists of each a physical programmable circuit card (often said

as a microcontroller) and a bit of package, or IDE (Integrated Development Environment) that runs on your pc, wont to write and transfer code to the physical board.

The Arduino platform has become quite fashionable individuals simply beginning out with physics, and permanently reason. not like most previous programmable circuit boards, the Arduino doesn't want a separate piece of hardware (called a programmer) so as to load new code onto the board – you'll merely use a USB cable. In addition, the Arduino IDE uses a simplified version of C++, creating it easier to find out to program. Finally, Arduino provides a customary type issue that breaks out the functions of the micro-controller into a a lot of accessible package.

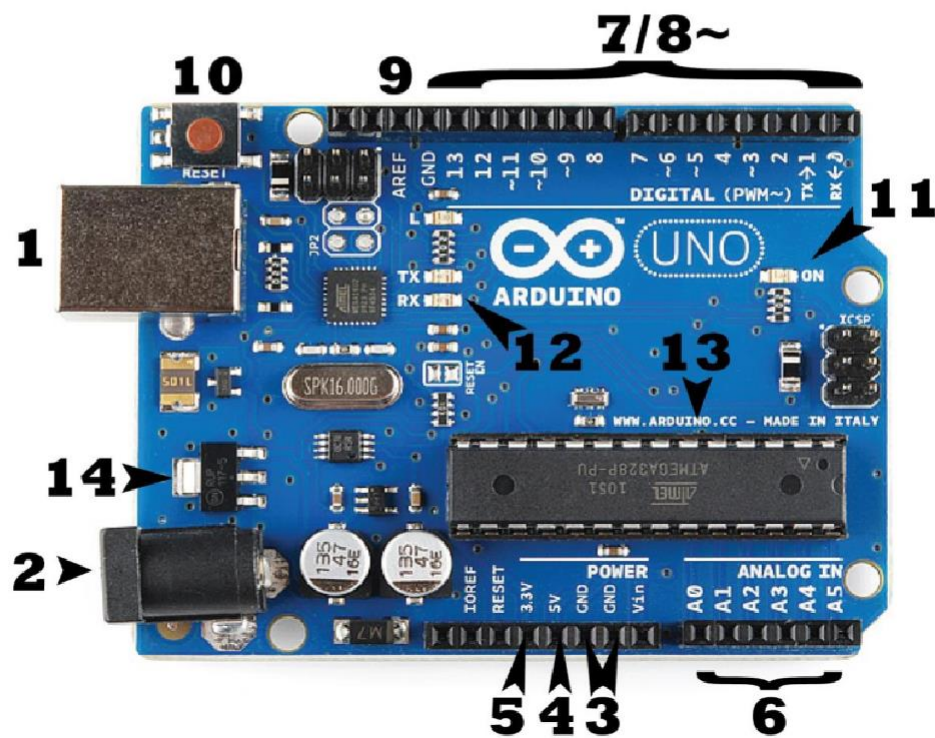
What will it Do?

The Arduino hardware and package was designed for artists, designers, hobbyists, hackers, newbies, and anyone curious about making interactive objects or environments. Arduino will act with buttons, LEDs, motors, speakers, GPS units, cameras, the web, and even your smart-phone or your TV! This flexibility combined with the actual fact that the Arduino package is free, the hardware boards ar pretty low cost, and each the package and hardware ar straightforward to find out has LED to an oversized community of users World Health Organization have contributed code and free directions for a large kind of Arduino-based comes.

For everything from robots and a warmer hand warming blanket to honest fortune-telling machines, and even a Dungeons and Dragons dice-throwing gauntlet, the Arduino is used because the brains behind virtually any physics project.

What's on the board?

There ar many sorts of Arduino boards (explained on consecutive page) which will be used for various functions. Some boards look a small amount totally different from the one below, however most Arduinos have the bulk of those elements in common



Power (USB / Barrel Jack)

Every Arduino board desires some way to be connected to an influence supply. The Arduino UNO is power-driven from a USB cable coming back from your pc or a wall power provide that's terminated during a barrel jack. within the image on top of the USB association is labelled (1) and also the barrel jack is labelled (2).

NOTE: don't use an influence provide bigger than twenty Volts as you'll overpower (and thereby destroy) your Arduino. The counseled voltage for many Arduino models is between six and twelve Volts.

Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)

The pins on your Arduino ar the places wherever you connect wires to construct a circuit (probably in conjunction with a board and a few wire. they sometimes have black plastic 'headers' that permit you to merely plug a wire right into the board. The Arduino has many totally different sorts of pins, every of that is labelled on the

board and used for various functions.

- GND (3): Short for 'Ground'. There are many GND pins on the Arduino, any of which might be wanted to ground your circuit.
- 5V (4) & 3.3V (5): As you would possibly guess, the 5V pin provides 5 volts of power, and the 3.3V pin provides 3.3 volts of power. Most of the straightforward elements used with the Arduino run blithely off of five or 3.3 volts.
- Analog (6): {the arable world the realm} of pins underneath the 'Analog In' label (A0 through A5 on the UNO) are Analog In pins. These pins will browse the signal from associated nursing analog device (like a temperature sensor) and convert it into a digital price that we are able to browse.
- Digital (7): Across from the analog pins are the digital pins (0 through thirteen on the UNO). These pins are used for each digital input (like telling if a button is pushed) associated nursing digital output (like powering an LED).
- PWM (8): you will have noticed the diacritical mark (~) next to a number of the digital pins (3, 5, 6, 9, 10, and eleven on the UNO). These pins act as traditional digital pins, however can even be used for one thing known as Pulse-Width Modulation (PWM). we've got a tutorial on PWM, except for currently, consider these pins as having the ability to simulate associated nursing analog output (like weakening an LED in and out).
- AREF (9): Stands for Analog Reference. Most of the time you'll leave this pin alone. it's generally wanted to set associated nursing external reference voltage (between zero and five Volts) because the higher limit for the analog input pins.

Reset Button

Just like the first Nintendo, the Arduino includes a button (10). Pushing it'll quickly connect the reset pin to ground and restart any code that's loaded on the Arduino. this will be terribly helpful if your code doesn't repeat, however you wish to check it multiple times. not like the first Nintendo but, processing on the Arduino doesn't sometimes fix any issues.

Power LED Indicator

Just below and to the proper of the word "UNO" on your printed circuit, there's a small light-emitting diode next to the word 'ON' (11). This light-emitting diode ought to remove darkness from whenever you plug your Arduino into an influence supply. If this lightweight doesn't activate, there's an honest likelihood one thing is

wrong. Time to re-check your circuit!

TX RX LEDs

TX is brief for transmit, RX is brief for receive. These markings seem quite a bit in physical science to point the pins liable for serial communication. In our case, there square measure 2 places on the Arduino UNO wherever American state and RX seem – once by digital pins zero and one, and a second time next to the American state and RX indicator LEDs (12). These LEDs can provide North American country some nice visual indications onceever our Arduino is receiving or transmittal information (like when we're loading a replacement program onto the board).

Main IC

The black factor with all the metal legs is AN IC, or microcircuit (13). think about it because the brains of our Arduino. the most IC on the Arduino is slightly completely different from board kind to board kind, however is typically from the ATmega line of IC's from the ATMEL company. this could be vital, as you'll got to understand the IC kind (along together with your board type) before loading up a replacement program from the Arduino software system. This data will sometimes be found in writing on the highest aspect of the IC. If you would like to grasp a lot of regarding the distinction between varied IC's, reading the datasheets is usually an honest plan.

Voltage Regulator

The transformer (14) isn't truly one thing you'll (or should) move with on the Arduino. however it's probably helpful to grasp that it's there and what it's for. The transformer will specifically what it says – it controls the number of voltage that's let into the Arduino board. think about it as a sort of gatekeeper; it'll recoil an additional voltage which may hurt the circuit. Of course, it's its limits, thus don't attach your Arduino to something larger than twenty volts.

The Arduino Family

Arduino makes many completely different boards, every with completely different capabilities. additionally, a part of being open supply hardware means others will modify and turn out derivatives of Arduino boards that give even a lot of kind factors and practicality. If you're undecided that one is true for your project, check this guide for a few useful hints. Here square measure a couple of choices that square measure well-suited to somebody unaccustomed the globe of Arduino:

Arduino Uno (R3)

The Uno could be a nice alternative for your initial Arduino. It's got everything you wish to induce started, and zip you don't. It's fourteen digital input/output pins (of that six is used as PWM outputs), six analog inputs, a USB affiliation, an influence jack, a push button and a lot of. It contains everything required to support the microcontroller; merely connect it to a laptop with a USB cable or power it with a AC-to-DC adapter or battery to induce started.

ARDUINO IDE

The Arduino project provides the Arduino integrated development surroundings (IDE), that is across-platform application written within the programming language Java. It originated hierarchy of operation menus. from the IDE for the languages process and Wiring. It includes a code editor with options like text cutting and pasting, looking out and replacement text, automatic indenting, brace matching, and syntax highlight, AND provides easy one-click mechanisms to compile and transfer programs to an Arduino board. It conjointly contains a message space, a text console, a toolbar with buttons for common functions.

A program written with the IDE for Arduino is termed as sailing vessel. Sketches square measure saved on the event laptop as text files with the file extension into. Arduino software system (IDE) pre-1.0 saved sketches with the extension.pde. The Arduino IDE supports the languages C and C++using special rules of code structuring. The Arduino IDE provides a software system library from the Wiring project, that provides several common input and output procedures. User-written code solely needs 2 basic functions, for beginning the sketch and also the main program loop, that square measure compiled AND joined with a program stub main () into an practicable cyclic programme with the antelope tool chain, conjointly enclosed with the IDE distribution.

The Arduino IDE employs the program argued to convert the practicable code into a document in positional representation system encryption that's loaded into the Arduino board by a loader program within the board's code.

WHY ARDUINO?

Thanks to its easy and accessible user expertise, Arduino has been utilized in thousands of various comes and applications. The Arduino software system is easyto-use for beginners, nonetheless versatile enough for advanced users. It runs on waterproof, Windows, and Linux. lecturers and students use it to make

low value scientific instruments, to prove chemistry and physics principles, or to induce started with programming and artificial intelligence. Designers and designers build interactive prototypes, musicians and artists use it for installations and to experiment with new musical instruments. Makers, of course, use it to make several of the comes exhibited at the Maker Faire, as an example. Arduino could be a key tool to find out new things. Anyone - youngsters, hobbyists, artists, programmers - will begin tinkering simply following the step by step directions of a kit, or sharing ideas on-line with alternative members of the Arduino community. There square measure several alternative microcontrollers and microcontroller platforms accessible for physical computing. optical phenomenon Basic Stamp, internet media's BX-24, Phidgets, MIT's Handy board, and plenty of others supply similar practicality. All of those tools take the untidy details of microcontroller programming AND wrap it up in an easy-to-use package. Arduino conjointly simplifies the method of operating with microcontrollers, however it offers some advantage for lecturers, students, and interested amateurs over alternative systems

ARDUINO:

.The Arduino microcontroller is a straightforward to use nevertheless powerful single board pc that has gained goodly traction within the hobby and skilled market. The Arduino is ASCII text file, which implies hardware within reason priced and development software system is free. This guide is for college students in American state 2011, or students anyplace United Nations agency ar tackling the Arduino for the primary time. For advanced Arduino users, prowl the web; there ar various resources.

This guide covers the Arduino Uno board (Sparkfun DEV-09950, \$29.95), a decent alternative for college students and educators. With the Arduino board, you'll write programs and build interface circuits to scan switches and different sensors, and to regulate motors and lights with little effort. several of the photographs and drawings during this guide were taken from the documentation on the

Arduino website, the place to show if you would like additional info. The Arduino section on the American state 2011 computing device, <https://sites.google.com/a/umn.edu/me2011/>, covers additional on interfacing the

Arduino to the \$64000 world.

This is what the Arduino board seems like.



The Duemilanove board options an Atmel ATmega328 microcontroller in operation at five V with two K of RAM, thirty two K of non-volatile storage for storing programs and one K of EEPROM for storing parameters. The clock speed is sixteen Mc, that interprets to regarding corporal punishment regarding three hundred,000 lines of C ASCII text file per second. The board has fourteen digital I/O pins and six analog input pins. there's a USB connection for lecture the host pc AND a DC power jack for connecting an external 6-20 V power supply, as an example a nine V battery, once running a program whereas not connected to the host pc. Headers are provided for interfacing to the I/O pins victimisation twenty two g solid wire or header connectors. for added info on the hardware, see <http://arduino.cc/en/Main/ArduinoBoardUno>.

The Arduino artificial language could be a simplified version of C/C++. If you recognize C, programming the Arduino are going to be acquainted. If you are doing not grasp C, no have to be compelled to worry as solely some commands are required to perform helpful functions.

An important feature of the Arduino is that you simply will produce a sway program on the host computer, transfer it to the Arduino and it'll run mechanically. take

away the USB cable affiliation to the computer, and also the program can still run from the highest whenever you push the button. take away the battery and place the Arduino board in a very closet for 6 months. after you reconnect the battery, the last program you keep can run. this implies that you simply connect the board to the host computer to develop and right your program, however once that's done, you not want the computer to run the program.

What you would like for a operating System

1. Arduino Duemilanove board
2. USB programming cable (A to B)
3. 9V battery or external power offer (for complete operation)
4. Solderless board for external circuits, and twenty two g solid wire for connections
5. Host computer running the Arduino development surroundings. Versions exist for Windows, raincoat and UNIX system

Installing the software system

Follow the directions on the obtaining Started section of the Arduino computing device,

<http://arduino.cc/en/Guide/HomePage>. Go all the approach through the steps to wherever you see the pin thirteen semiconductor diode blinking. this is often the indication that you simply have all software system and drivers with success put in and might begin exploring together with your own programs.

Connecting electric battery

For complete operation, the board is powered by electric battery instead of through the USB affiliation to the pc. whereas the external power are often anyplace within the vary of vi to twenty four V (for example, you may use a automobile battery), a customary nine V battery is convenient. whereas you may jam the leads of electric battery snap into the Vin and Gnd connections on the board, it's higher to solder the battery snap results in a DC power plug and hook up with the ability jack on the board. an appropriate plug is an element range 28760 from WWW.jameco.com. Here is what this seems like.



Warning: Watch the polarity as you connect your battery to the snap as reverse orientation might blow out your board.

Disconnect your Arduino from the pc. Connect a nine V battery to the Arduino power jack victimisation the battery snap adapter. make sure that the blinking program runs. This shows that you simply will power the Arduino from electric battery which the program you transfer runs with no need a affiliation to the host computer

Moving On

Connect your Arduino to the pc with the USB cable. you are doing not want the battery for currently. The inexperienced water-cooled reactor semiconductor diode can light-weight. If there was already a program burned into the Arduino, it'll run.

Warning: don't place your board down on a semiconductive surface; you may short out the pins on the back!

Start the Arduino development surroundings. In Arduino-speak, programs are known as "sketches", however here we'll simply decision them programs.

In the written material window that comes up, enter the subsequent program, listening to wherever semi-colons seem at the tip of command lines.

Servo Motors:

A control system, or servo, is an automatic device that uses error-sensing feedback to correct the performance of a mechanism. The systems wherever

feedback or error-correction signals facilitate management mechanical position or different parameters. as an example, the car's controller uses closed-loop system feedback, that classifies it as a control system.

RC servos are amateur device devices servos generally used in radio-controlled models. wherever they're accustomed offer deed for varied mechanical systems. thanks to their affordability, dependability, and ease of management by microprocessors, RC servos are usually employed in small-scale AI applications.

RC servos are composed of an electrical motor automatically coupled to a potentiometer. a customary RC receiver sends Pulse-width modulation (PWM) . The physical science within the servo translates the breadth of the heartbeat into a foothold. once the servo is commanded to rotate, the motor is powered till the potentiometer reaches the worth cherish the position.

.The servo is controlled by 3 wires: ground, power, and management. The servo can move supported the pulses sent over the management wire, that set the angle of the mechanism arm. The

servo expects a pulse each twenty ms so as to realize correct info regarding the angle. The breadth of the servo pulse dictates the vary of the servo's angular motion.

A servo pulse of one.5 ms breadth can usually set the servo to its "neutral" position or 45° , a pulse of one.25 ms may set it to 0° and a pulse of one.75 ms to 90° . The physical limits and timings of the servo hardware varies between brands and models, however a general servo's angular motion can travel somewhere within the vary of 90° - one 20° and therefore the neutral position is nearly continually at 1.5 ms. this can be the "standard pulse servo mode" employed by all hobby analog servos.

RC servos are sometimes powered-up by the receiver that successively is powered-up by battery packs or Associate in Nursing Electronic speed controller (ESC) with Associate in Nursing integrated or a separate Battery agent circuit (BEC). Common battery packs are either Ni-Cd, NiMH or lithium-ion compound battery (Li-Po) sort. Voltage ratings vary, however most receivers are operated at five V or half-dozen V.

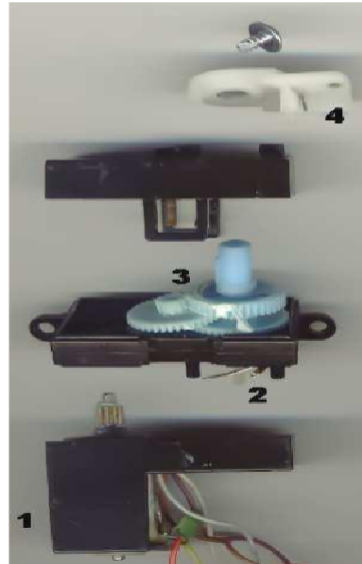


Fig. 4.2.1 tiny R/C servo mechanism

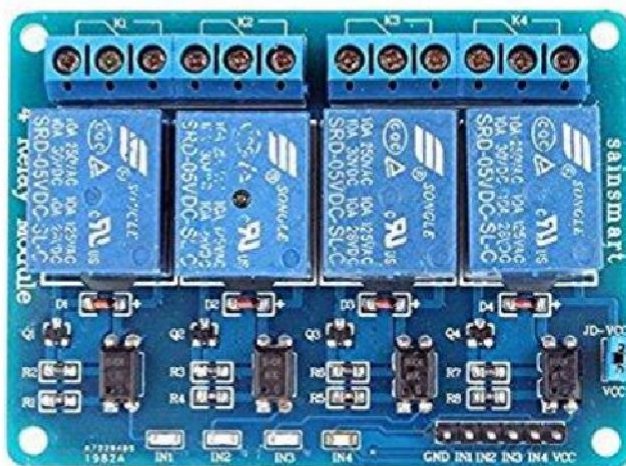
1. electrical motor 3. gears
2. Position feedback potentiometer 4. mechanism arm

RELAYS

A relay is Associate in Nursing electro-magnetic switch which may be employed in case of employing a low voltage circuit to change on and off a lightweight bulb (or something else) connected to the 220v mains offer, i.e., it's Associate in Nursing electrically operated switch. Current flowing through the coil of the relay creates a force field that attracts a lever and changes the switch contacts.

The coil current is on or off thus relays have 2 switch positions and most have doubled left row (change over). Relay sallow one circuit to change a second circuit that is totally separated from the primary. as an example a coffee voltage battery circuit will use a relay to change a 230VAC mains circuit. there's no

electrical association within the relay between the 2 circuits the link is magnetic and mechanical



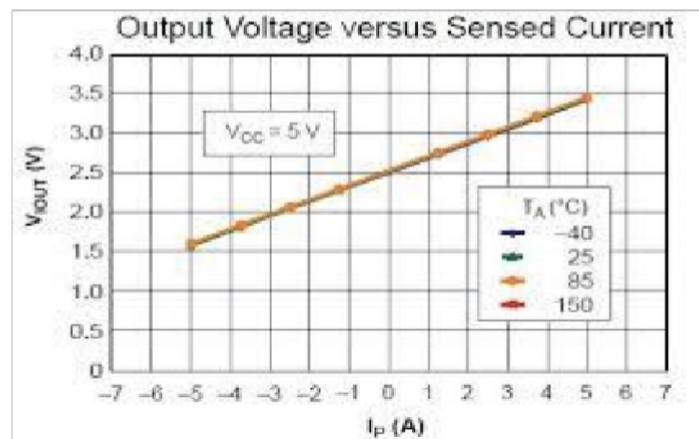
ACS712 CURRENT detector

The Allegro ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package permits for straightforward implementation by the client. Typical applications embody control, load detection and management, switchedmode power provides, and over current fault protection. The device isn't supposed for automotive applications. For the automotive grade version, seeacs714.



ACS712 Current detector

The device consists of an exact, low-offset, linear Hall detector circuit with a copper physical phenomenon path placed close to the surface of the die. Applied current flowing through this copper physical phenomenon path generates a force field that is detected by the integrated Hall IC and regenerate into a proportional voltage. Device accuracy is optimized through the shut proximity of the magnetic signal to the Hall electrical device. A precise, proportional voltage is provided by the low-offset, chopper stable metallic element CMOS Hall IC, that is programmed for accuracy once packaging.



Voltage sensor:

Introduction

We have already seen a way to live external voltages mistreatment Arduino within the project DIGITAL ARDUINO meter.

If you wish to live external voltages mistreatment Arduino, you've got to form use of the Analog Input pins of the Arduino Board. If you recall a touch bit regarding the Arduino Analog Pins, their input voltage is restricted to 5V i.e. you'll be able to suffice to 5V directly mistreatment the Analog Input Pins of the Arduino.

But what if you wish to live voltages that ar bigger than 5V? you can't directly use the Analog Input Pins of the Arduino as you would possibly fry the ATmega328P IC on the Arduino UNO board (or the relevant Microcontroller IC betting on the Arduino Board you're using).

Here comes the Voltage detector Module to the rescue. mistreatment this Voltage detector Module, you'll be able to live voltages up to 25V.

A Brief Note on the Voltage detector Module

The Voltage detector may be a straightforward module which will used with Arduino (or the other microcontroller with input tolerance of 5V) to live external voltages that ar bigger than its most acceptable worth i.e. 5V just in case of Arduino.

Following is that the image of the Voltage detector Module employed in this project.



Pins of the Voltage detector

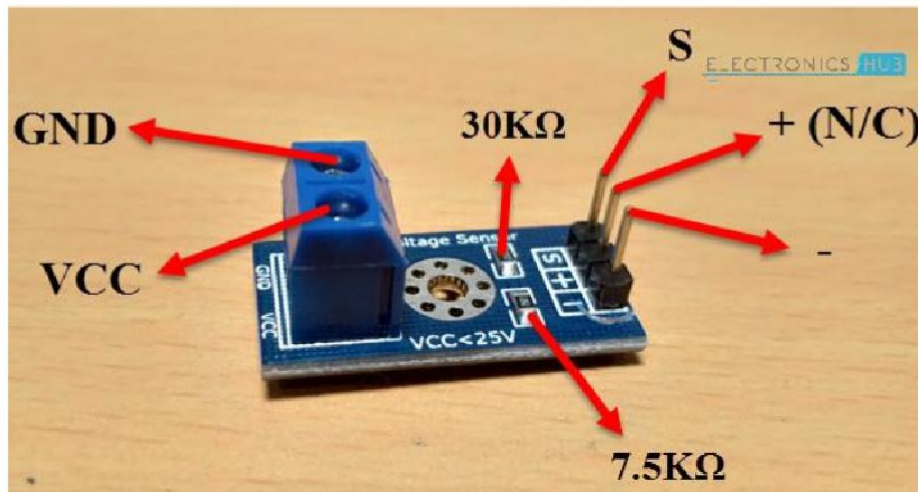
Before going into the small print of the Voltage detector like its practicality and schematic, let Maine offer you an summary of the on the market Pins of the Voltage detector Module.

Basically, a 25V Voltage detector, just like the one used here, has five pins in total. 2 of them ar on the two-pin screw terminal and 3 ar male header pins.

The Screw Terminal pins are marked as VCC and GND and that they should be connected to the external supply of voltage i.e. the voltage that must be measured.

Coming to the 3 male headers, they're marked as S, + and -. The S pin is that the "Sense" pin and it should be connected to the Analog Input of the Arduino. The "-" pin should be connected to the GND of the Arduino. The pin marked as "+" isn't connected to something (it is Associate in Nursing N/C Pin).

The following image shows the pins of a Voltage detector Module.



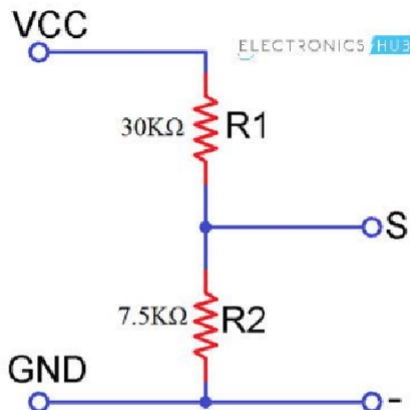
- VCC: Positive terminal of the voltage to be measured (0-25V)
- GND: Negative terminal of the voltage to be measured
- S: Analog Input of Arduino
- +: Not connected (N/C)
- -: GND of Arduino

Schematic of Voltage detector

Now, allow us to {talk

regardingI mentionI citeI point outI referI nameI remarkI quoteI observeI bring upI point outI sayI state} the vital factor about the voltage sensor: its schematic. The Voltage detector is largely a resistor consisting of 2 resistors with resistances of 30KΩ and seven.5KΩ i.e. a five to one resistor.

The following image shows the schematic of the Voltage detector Module with Associate in Nursing input voltage limit of 25V



Make your Own Voltage sensing element

Using a pre-built voltage sensing element module is extremely straightforward and if you don't have one then you'll simply build one yourself. All you would need are 2 resistors.

If you would like to create your own voltage sensing element which will live voltages up to 25V like this Voltage sensing element Module, then you have got to induce to induce and a seven.5K Ω electrical device.

Interfacing a Voltage sensing element with Arduino

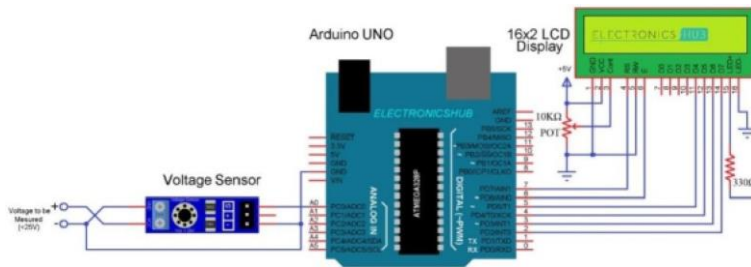
Now that we've got seen a touch concerning the Voltage sensing element, allow us to currently proceed with Interfacing a Voltage sensing element with Arduino and live some external voltages.

The Arduino Voltage sensing element Interface is pretty undemanding. Connect the voltage to be measured to the screw terminal of the Voltage sensing element, connected the output of the potential divider to the Arduino. That's it.

After interfacing the Voltage sensing element with Arduino, you'll either read the results on the serial monitor of the Arduino IDE or on a 16x2 liquid crystal display show. I even have gone with the liquid crystal display show.

Circuit Diagram of Arduino Voltage sensing element Interface

Following image shows the circuit diagram of Interfacing a Voltage sensing element with Arduino.



Components needed

Arduino UNO [Buy Here]

Voltage sensing element Module (for < 25V)

16x2 liquid crystal display show [Buy Here]

10KΩ Potentiometer

3300 electrical device

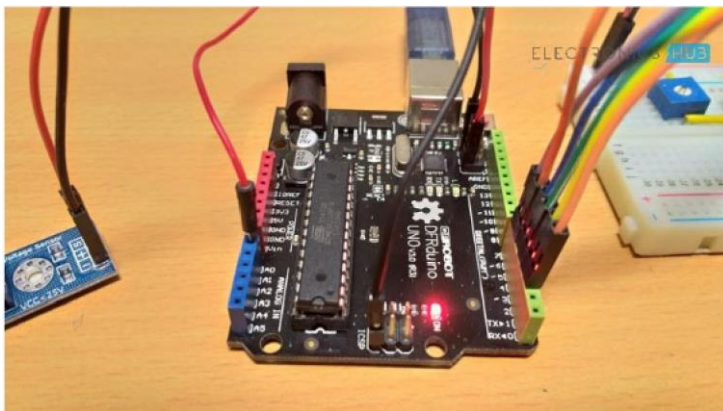
Connecting Wires

Mini board

Circuit style

First, connect the "S" and "-" pins of the Voltage sensing element to AO (Analog Input) and GND of Arduino severally. Then connect the external voltage pins (voltage to be measured) to the screw terminal (check for polarity).

Coming to the liquid crystal display, Digital I/O Pins seven and vi of Arduino UNO are connected to RS and E whereas the Pins five through a pair of of Arduino UNO are connected to D4 through D7 severally.



Working

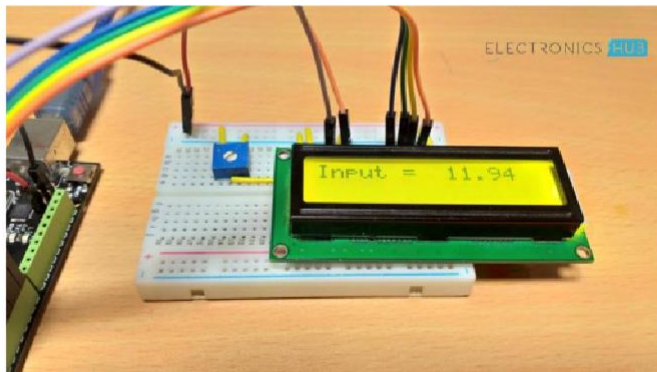
I think the operating of the project may well be understood by currently. Since the Voltage sensing

element module is largely a potential divider circuit, you'll calculate input voltage mistreatment the formula

$$V_{in} = V_{out} * (R2 / (R1 + R2))$$

Here $R1 = 30000$, $R2 = 7500$ and V_{out} will be calculated from Analog Input of Arduino by mistreatment

$$V_{out} = (\text{analogvalue} * \text{five} / 1024) ..$$



I have enforced an equivalent within the code. once I connected a 12V external provide as input to the Voltage sensing element, the calculated voltage is eleven.94V, that is correct enough.

Ubidots:

Introduction

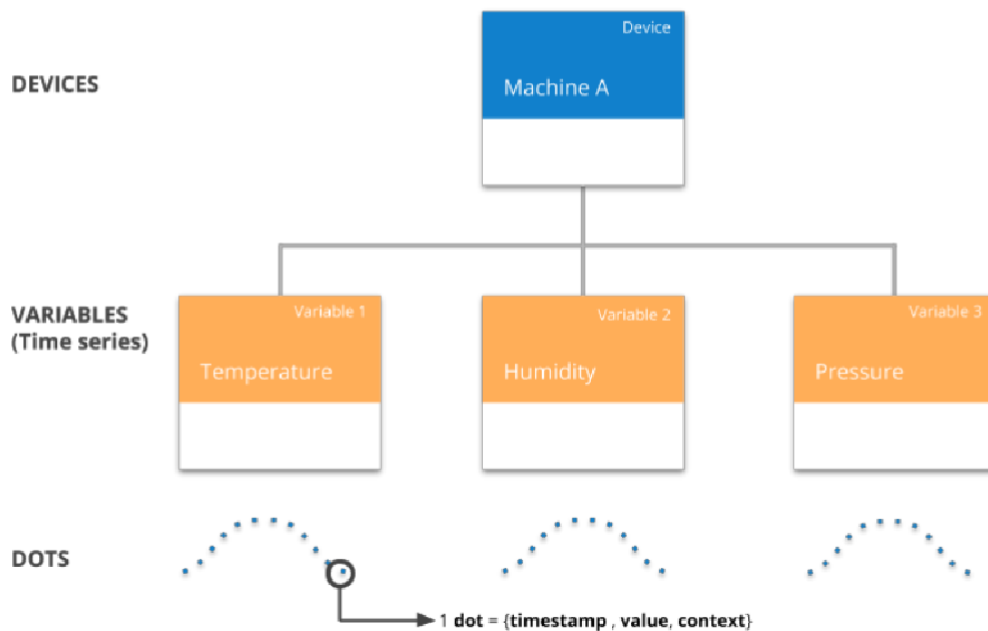
Welcome to the Ubidots REST API hardware docs. Here you'd reference the way to send or retrieve information from your hardware devices mistreatment our supported communication protocols: protocol, MQTT and TCP/UDP.

The purpose of this section is to assist you perceive what happens within the backstage once human activity with Ubidots, therefore you'll replicate this in your code. For this reason, we tend to avoid the utilization of examples mistreatment libraries. However, if you'd wish to use one among our libraries (Python, C, and more), examine our compatible devices and API shoppers sections.

How Ubidots Works?

Every time a tool updates a sensing element price in an exceedingly variable, a data-point or "dot" is made. Ubidots stores dots that return from your devices within variables, and these hold on dots have corresponding timestamps

UBIDOTS DATA HIERARCHY



Each dot contains these items:

Item	Description	Mandatory
------	-------------	-----------

value	A numerical price. Ubidots accepts up to sixteen floating-point length numbers.	YES
-------	---	-----

timestamp	Unix Epoch time, in milliseconds. If not nominal, then our servers can assign one upon reception.	NO
-----------	---	----

context	An discretionary assortment of key-value pairs. principally wont to store the latitude and meridian coordinates of GPS devices.	NO
---------	---	----

Values

A numerical price. Ubidots accepts up to sixteen floating-point length numbers.

thirty four.87654974}

Timestamps

A timestamp, as best represented here, may be a thanks to track time as a running total of seconds.

This count starts at the UNIX system Epoch on Jan first, 1970 at UT. Therefore, the UNIX system time stamp is just the quantity of seconds between a specific date and therefore the UNIX system Epoch.

Please confine mind that once you send information to Ubidots, you need to set the timestamp in milliseconds; additionally, if you retrieve a dot's timestamp, it'll be in milliseconds.

"timestamp" : 1537453824000

The on top of timestamp corresponds to Th, Gregorian calendar month twenty, 2018 2:30:24 PM.

PRO-TIP: A useful gizmo to convert between UNIX system timestamps and human-readable dates is Epoch device.

Context

Numerical values don't seem to be the sole information kind supported; you'll additionally store string or char information sorts within what we tend to decision context. The context may be a key-value object that enables you to store not solely numerical however additionally string values. associate example use of the context might be:

"context" :

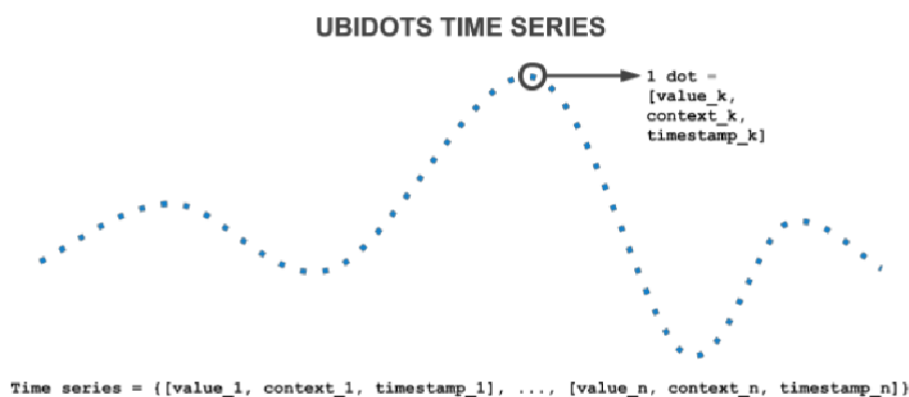
A context is often wont to store the latitude and meridian coordinates of your device for GPS/tracking application use cases. All Ubidots maps uses the skeletal muscle and lng keys from a dot's context to extract the coordinates of your device, therein approach you simply ought to send one dot with the coordinates values within the variable context to plot a map rather than causing individually each latitude and meridian in 2 totally different variables. .

"context" :

Please note that you just will combine each string and numerical values within the context. If your application is for geo-localization functions, ensure that the coordinates ar set in decimal degrees.

Time Series

Based on the on top of, we are able to illustrate associate Ubidots statistic like this:



Ubidots is associate agnostic platform, this implies that it doesn't extremely care what hardware device you're mistreatment, as long as you are able to move with United States of America through a minimum of one among these protocols:

- HTTP

- MQTT
- TCP/UDP

HTTP

HTTP is that the main net protocol for info exchange within the net. It additionally supports encryption, that is sometimes referred to as secure protocol or HTTPS. once you use an internet browser (MS Edge, Firefox, Google Chrome, etc) you're causing and receiving packages mistreatment protocol or HTTPS. as a result of this, it had been not stunning to examine HTTPS become a preferred choice for information exchange inside IoT. When a developer is to implement protocol communication, then he ought to hunt for a quiet Application Programming Interface, or REST API, that exposes all the endpoints needed to act with a 3rd party application (like Ubidots). during this section, you'll reference our REST API to grasp the way to send and retrieve information from our servers.

Note: Our goal with this section is to assist you perceive what's happening behind once human action with Ubidots, facultative you to duplicate it inside your own code. due to this, we tend to avoid victimisation our custom libraries altogether the examples.

HTTP requests

The following strategies ar specific inside the protocol standard:

HTTP Method	Description
GET	Used to retrieve data
POST	Used to make a replacement component
PATCH	Used to update existing components
DELETE	Used to delete existing components

HTTP could be a request/response protocol, this suggests that each request that you simply build is answered by the server. This response includes variety (response code) and a body. as an example, after you build letter of invitation to retrieve a file on a webpage "(e.g. "Get ME the file 'websiteside.html'")", you build a GET request. If the request is correct, the server can usually come a two hundred response code, at the side of the file requested (body).

Under constant logic, once a tool sends a GET request to the Ubidots' server (i.e. requesting the last price of a variable), then the server sends back a response with the standing of the request (response code), and a body, which might be the a worth with its context and timestamp.

An protocol request additionally wants the parameters below:

- Host: Specifies the server you'll be creating protocol requests to.
- Path: this can be usually the remaining portion of the uniform resource locator that specifies the resource you wish to consume, be it a variable or a tool. as an example, if associate degree API end is: `industrial.api.ubidots.com/api/v1.6/devices/my-device` then the trail would be `/api/v1.6/devices/my-`

device

- **Headers:** outline the operational parameters of the protocol request like authentication, Content-Type, Content-Length, etc.
- **Body/payload:** within the case of POST and PATCH requests, this can be the information sent by your device to the server. GET requests usually don't have a body as a result of they're meant to request information, to not send information.

Ubidots accepts information as JavaScript Object Notation or JSON. JSON could be a typical protocol information kind, it's a group of name/value pairs. In varied programming languages, this can be treated as associate degree object, record, struct, dictionary, hash table, keyed list, or associative array. it's additionally human clear and language freelance. associate degree example of a JSON information kind that Ubidots accepts may be documented below:

}}

A typical protocol request to Ubidots ought to be set as below:

POST HTTP/1.1

Host:

User-Agent:

X-Auth-Token:

Content-Type: application/json

Content-Length:

Where:

- : Path to the resource to consume

Example: /api/v1.6/variables/ to induce user's variables data.

- : Host uniform resource locator.

Example: industrial.api.ubidots.com

- : associate degree facultative string wont to determine the kind of shopper, be it by application kind, software package, computer code seller or computer code version of the requesting user agent.

Examples: ESP8266/1.0, Particle/1.2

- : distinctive key that authorizes your device to ingest information within your Ubidots account.
- : the quantity of characters of your payload.

Example: The payload can have a content-length of nineteen.

- : information to send.

Example:

PRO TIP: the straightforward means of handle protocol and HTTPs requests is by victimisation cURL, a program line tool. to be told the way to install cURL on Windows, MacOSX or UNIX operating system please see this guide.

API URLs

API access may be over protocol or secure protocol, HTTPs, victimisation the subsequent endpoints supported your Ubidots Account kind.

Security Note: we tend to powerfully advise to use HTTPs to create certain your information travels encrypted, avoiding the exposure of your API token and/or detector information.

HTTP

Ubidots Account	Endpoint	Port
Educational	http://things.ubidots.com	80
Industrial	http://industrial.api.ubidots.com	80

HTTPs

Ubidots Account	Endpoint	Port
Educational	https://things.ubidots.com	443
Industrial	https://industrial.api.ubidots.com	443

Ubidots supports SSL v1.1, TLS v1.2 and v1.3. you'll transfer our root certificates in several formats:

- PEM file: A certificate chain with 2 root certificates from our certificate authorities (CAs).
- DER file: Same because the PEM file, with an alternate secret writing.
- CRT file: Same because the PEM file, with a special extension. usually remarked as .crt, .cert or .cer.

NOTE: To avoid future inconveniences, we tend to advise to use each certificates in your device's auth routines. whereas the second is that the current valid certificate, we'll use the primary once 2021.

Fixed IPs

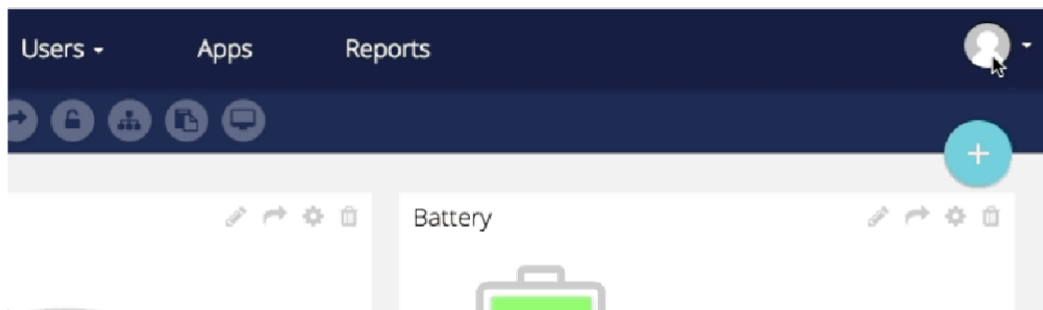
Ubidots additionally supports mounted IPs address for information body process, however we tend to extremely advise to our users to implement their code routines victimisation the dns endpoints rather than mounted IPs, as these last ones could modification within the future.

Ubidots Account	ipv4	ipv6	Port
Educational	50.23.124.68	2607:f0d0:2101:39::2	80/443
Industrial	169.55.61.243	2607:f0d0:3:b::2	80/443

HTTP Authentication

Every request needs a token. A token is associate degree distinctive key that authorizes your device to ingest information within your Ubidots account.

The easiest thanks to get yours is clicking on "API Credentials" beneath your profile tab:



Also, six hour valid tokens may be generated victimisation your account API-KEY. If you need to be told the way to bonk, please refer the Ubidots REST computer code API reference.

There ar 2 ways that to send a token during a request:

1. Send the token as parameter within the end, setting it with the ?token= expression. this can be the best one to implement however the foremost unsecure technique to send your authentication credentials.
2. Send the token as letter of invitation header. For this, use the X-Auth-Token header.

Security Note: whereas causation your token as a uniform resource locator parameter may be quite comfy in some devices, we tend to solely advise to try to to this for prototyping stages. For production stages, we tend to powerfully advise causation the token victimisation the X-Auth-Token header.

GET

<https://industrial.api.ubidots.com/api/>

Send data

Our REST API permits you send information to the platform in 2 completely different ways:

- Send information to a tool
- Send information to a variable

If you are looking for a lot of advanced API capabilities, like written material a tool name, or listing all of your devices, please visit our Ubidots computer code REST API Reference.

Send information to a tool

Request structure:

POST /api/v1.6/devices/ HTTP/1.1

Host:

User-Agent:

X-Auth-Token:

Content-Type: application/json

Content-Length:

Expected Response:

HTTP/1.1 200 OK

Server: nginx

Date: Tue, 04 September 2018 22:35:06 GMT

Content-Type: application/json

Transfer-Encoding: chunked

Vary: Cookie

Allow: GET, POST, HEAD, OPTIONS

The easiest way to send values to Ubidots is by specifying your Device label within the request path and creating a POST request to that.

Replace the `<device-label>` with the distinctive label of the required device to send information to. If the device doesn't exist in your Ubidots account, it'll be mechanically created. Device labels will contain any character set character, while not blank areas, i.e weather-station, my-home, esp8266.

To set the variables values, simply produce a JSON information payload as below

N° Variables	JSON structure
--------------	----------------

One	
-----	--

Multiple	<pre>{ "variable-label-1": worth, "timestamp": TIMESTAMP, "context": }, ... , "variable-label-n": worth, "timestamp": TIMESTAMP, "context": }</pre>
----------	---

timestamp and context parameters square measure ex gratia.

NOTE 1:: By default, the Ubidots backend can take the latitude and longitude values within any variable labelled as "gps", "location", "position" or "coordinates" mechanically to urge your device coordinates altogether of the map widgets. instead, you modify the default location variable.

NOTE 2: All timestamps should be in milliseconds. If you set a timestamp for a variable price, it'll be hold on with the date delineated by it. you'll simply convert dates to timestamps values here.

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