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IoT Based Solar Power Monitoring System

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CHAPTER 1

INTRODUCTION

In this project we will develop an **IoT Based Solar Power Monitoring System** using **ESP32 WiFi Module**. The ESP32 connects to the **WiFi Network** and uploads the Solar Sensing parameters like **Solar Panel Voltage**, **Temperature**, and Light Intensity on **Thingspeak** Server.

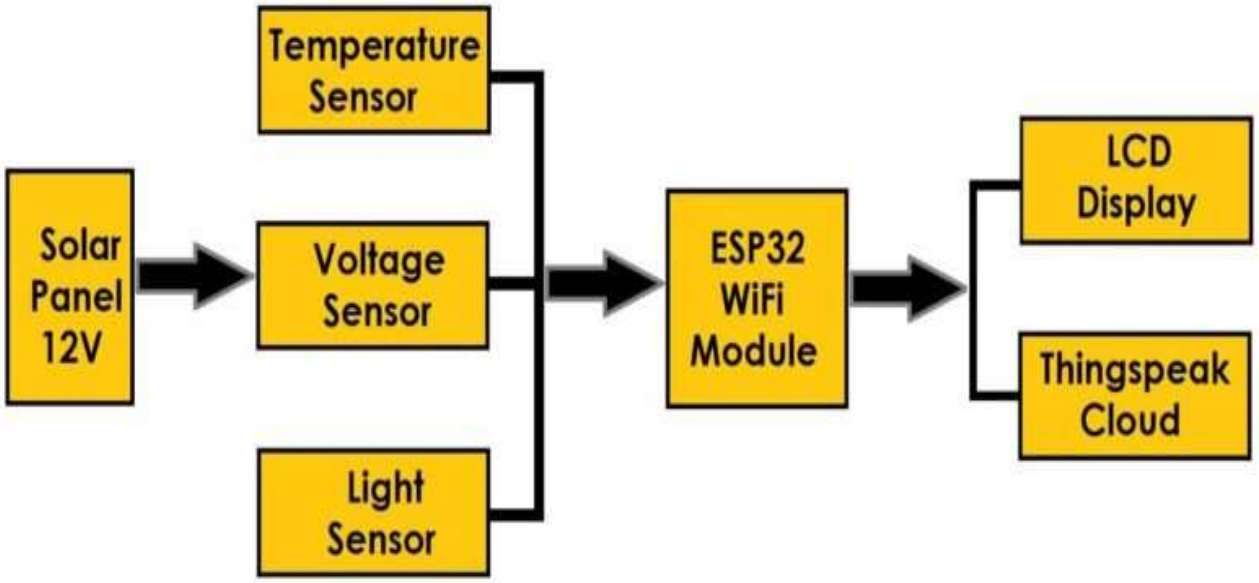
Solar power plants need **Solar Panel Monitoring** for **optimum power** output. Solar energy is the future of the energy industry. Countries all around the world are focusing on renewable and clean **sources of energy**. Sunlight is the most abundant resource available everywhere and each day. We can use **Sunlight** to generate **electricity** which is pollution free. There are continuous research and innovations going on to improve the **efficiency of solar cells**, reduce the cost of manufacturing **solar panels** and improve power distribution from solar plants. This project is also aimed at innovation to improve the **efficiency of solar panels**.

The project allows the monitoring **power** output of a solar panel, incident **light intensity**, and the operating **temperature** using an ESP32 WiFi + BLE Microcontroller. The Solar Panel and the **sensors** are precisely connected to the **ESP32 controller** which supervises the panels and loads. Thus, users can view the voltage, temperature, and **Solar Irradiance** online from any part of the world.

There are a wide variety of possible uses of this technology, including Solar cities, Smart villages, Microgrids, and Solar street lighting.

CHAPTER 1

1.1. BLOCK DIAGRAM



1.2 DESCRIPTION

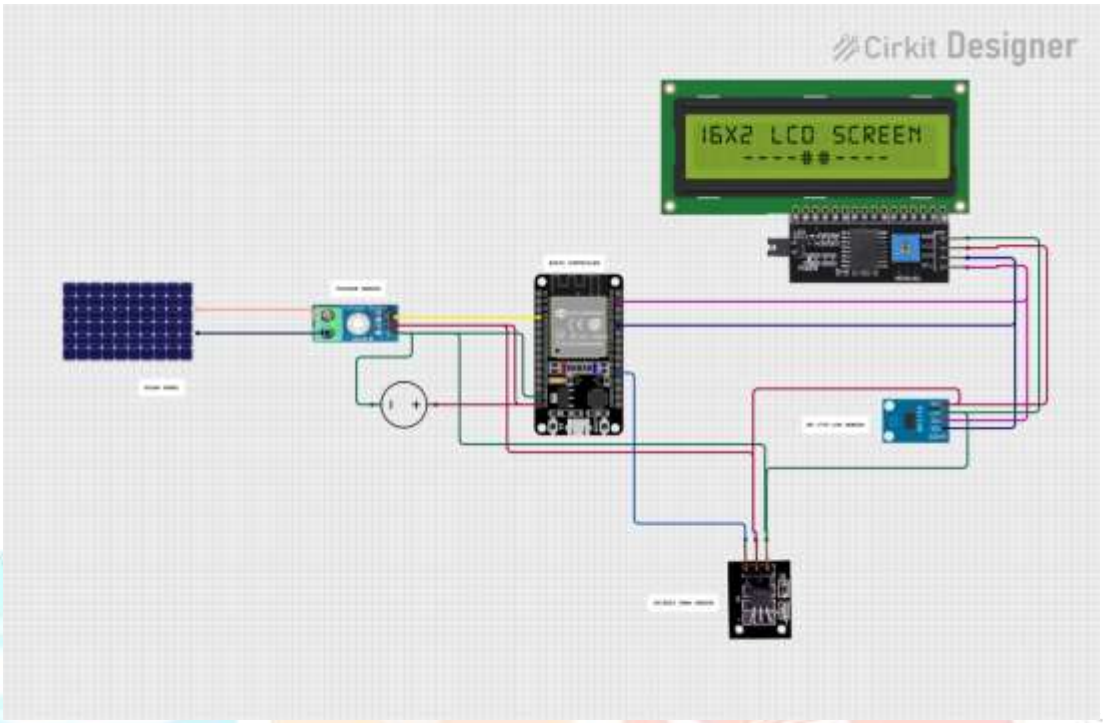
Let us take a look at a **block diagram** of **IoT Based Solar Power Monitoring System** with ESP32. The ESP32 is interfaced with the voltage Sensor, LM-35 temperature sensor, and LDR sensor. These three sensors are used to monitor the **power** output, **temperature**, and incident **light intensity** respectively.

A **character LCD** is also interfaced with the board for real-time display of the measured parameters. The solar panels are assumed to be installed with **internet hotspots** at their installation site. The ESP32 not only displays the measured parameters on the LCD screen but also sends the measured values to the **Thingsepak cloud server**.

The voltage, temperature & light parameters can be monitored in real-time and logged on Thingspeak Server for analytics and performance evaluation.

CHAPTER 2

2.1. CIRCUIT DIAGRAM



2.2. WORKING

Let us see the **schematic** for IoT Based Solar Power Monitoring System with ESP32 WiFi Module.

The ESP32 is the main controller for the entire project. There are 3 sensors that directly connect to the GPIO pin of ESP32. The 3 sensors are Voltage Sensor (0-25V), DS18B20 Temperature Sensor & BH1750 Sensor.

Connect the input of Voltage Sensor to GPIO14 of ESP32 Board. On the other side of the Voltage, the Sensor connects the Solar Panel with a voltage range between 3V-25V as the voltage sensor's maximum sensing capacity is 25V only. Similarly, connect the input of the DS18B20 temperature sensor to the GPIO34 of ESP32. The BH1750 requires a resistor of 2.2K in series to measure the analog voltage fed to the ESP32 Analog pin. The BH1750 input pins connect to the GPIO35 of ESP32.

Connect the SDA & SCL pin of I2C LCD Display to GPIO21 & GPIO22 respectively. You can power the LCD Display, & LDS18B20 via 5V pin of ESP32.

By using the Thing Speak site, we can monitor our data and control our system over the Internet, using the Channels and web pages provided by Thing Speak. So first you need to sign up for Thing Speak. So visit https://thingspeak.com and create an account.

Then create a **new channel** and create three variables as voltage, temperature & lux.

After uploading code, the ESP32 will connect to the Wi-Fi Network. Then it will establish a connection with Thing speak Server using the API Key. Then it shows voltage, temperature & lux. On Thing Speak site.

At the same time, you can see the Solar Power measuring parameters on the LCD Display.

CHAPTER 3

LIST OF COMPONENT

SR. NO	COMPONENT NAME	QUANTITY	PRISE
1	BH1750	1	500=00
2	LM7805	1	25=00
3	Voltage sensor	1	360=00
4	Temperature Sensor	1	650=00
5	Diode 1N4007 (rectifier diode)	8	16=00
6	LED (RED,GREEN)	2	25=00
7	9.1V (Zener diode)	1	20=00
8	14V (Zener diode)	1	05=00
9	transformer	1	560=00
10	104/224 600V capacitor	2	50=00
11	Capacitor 220uf/25V	6	30=00
12	Capacitor 100pf	2	10=00
13	Capacitor 1000uf	1	15=00
14	Resistor 1KE	3	03=00
15	Resistor 1.5K	1	04=00
16	Resistor 1.8K	1	04=00
17	Resistor 4.7K	4	04=00
18	10K	2	08=00
19	22K	1	08=00
20	Voltmeter	1	450=00
21	Solar panel 10Watt	1	3200=00
22	Buzzer	1	35=00
23	Transformer 12V-0-12V	1	150=00
24	Mains scrod	1	25=00
25	Other accessories	-	800=00

CHAPTER 4

COMPONENT

The basic component used in this project its description and function is given bellow.

1. **Resistor**
2. **Diode**
3. **Capacitor**
4. **Transformer**
5. **Data-sheet**

4.1RESISTOR

A package of material which exhibits a certain resistance made up into a single unit is called a resistor. Different res. having the same resistance value may be different in physical size and construction depending on its power and applications.

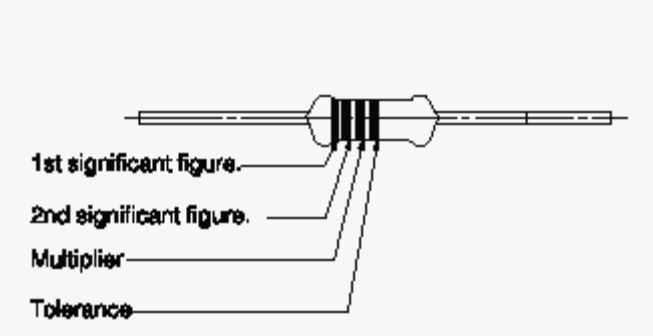
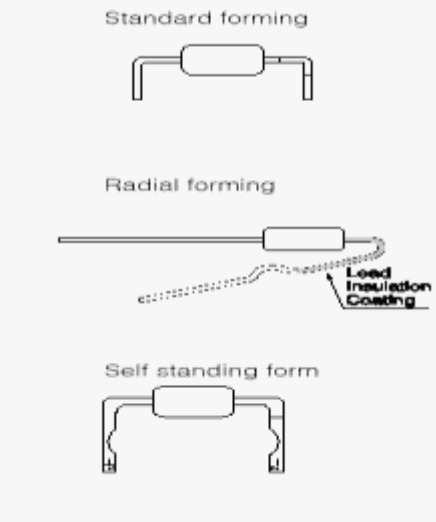


Figure above shows a typical carbon film res. which is commonly used in the market. Chip resistor is becoming more common nowadays replacing carbon film resistor.

Figure below shows the typical form of the carbon form of resistors.

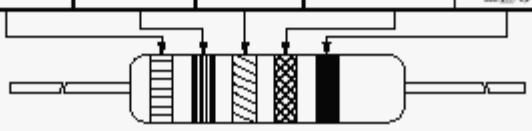


VALUE AND TOLERANCE OF RESISTANCE

Unit of resistance is ohms; the symbol for ohm is an omega. Res. values are normally shown using colored bands. Each color represents a number as shown in the table below.

Color code

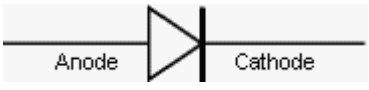
Color	First digit	Second digit	Third digit	Multiplier	tolerance	
					%	Code
Black	0	0	0	1		
Brown	1	1	1	10	±1	F
Red	2	2	2	10^2	±2	G
Orange	3	3	3	10^3	±0.05	W
Yellow	4	4	4	10^4		
Green	5	5	5	10^5	±0.5	D
Blue	6	6	6	10^6	±0.25	C
Violet	7	7	7	10^7	±0.1	B
Grey	8	8	8			
White	9	9	9			
Gold				10^{-1}	±5	J
Silver				10^{-2}	±10	K
None					±20	M



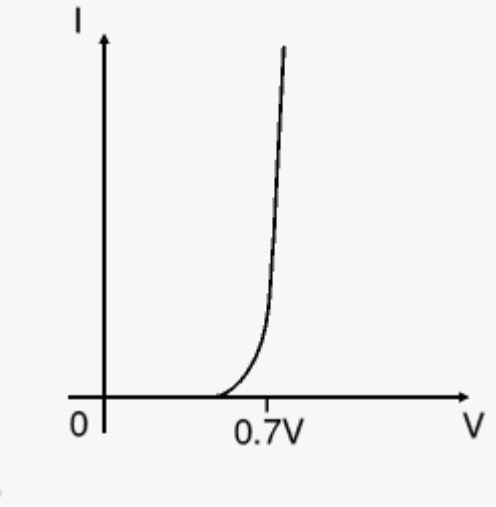
Resistor Colour Code	
Colour	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

4.2 DIODE

There are many types of semiconductor diodes namely Selenium, Germanium and Silicon types. Selenium type is commonly used in the early days in ac power suppliers but in recent years it has been replaced by silicon type as it sometimes emit toxic fumes when it burnt out. The characteristic is that it allows current to flow in one direction as shown in the symbol below. It has a cathode and an anode which determine the flow of the current. Current can only flow from anode to cathode.



Silicon V-I characteristics are shown in the figure below. The junction barrier for silicon is about 0.7V and for Germanium is about 0.3V. It is also called forward voltage drop. Most of the diode used today is of silicon type as they are robust and reliable from DC to RF small signal applications.



The Peak Reverse Voltage (PIV) of silicon types is available up to 1000 volts or more. They can also carry up to 100A DC current. In typical applications, it is advisable to ensure that it operates within the maximum ratings specified by the manufacturer and apply the Failure Mode and Effects Analysis to the device. The temperature of the device is one of the more important parameter to consider. Heat sinks may be used where they have to handle large amount of power.

When reverse voltage is applied, there will be a small leakage current usually in the region of uA. Beyond this voltage, it will breakdown and will be damaged permanently.

TYPES OF COMMERCIAL AVAILABLE DIODE

Diode	Maximum Current	Maximum Reverse Voltage
1N4001	1A	50V
1N4007	1A	1000V
1N5401	3A	100V
1N5408	3A	1000V

4.3 ALUMINUM ELECTROLYTIC CAPACITOR

Compact but glossy, these are available in the range of <1 µF to 1 F with working voltages up to several hundred volts DC. The dielectric is a thin layer of aluminum oxide. They contain corrosive liquid and can burst if the device is connected backwards. The oxide insulating layer will tend to deteriorate in the absence of a sufficient rejuvenating voltage, and eventually the capacitor will lose its ability to withstand voltage if voltage is not applied. A capacitor to which this has happened can often be "reformed" by connecting it to a voltage source through a resistor and allowing the resulting current to slowly restore the oxide layer. Bipolar electrolytic (also called Non-Polarized or NP capacitors) contain two capacitors connected in series opposition and are used when the DC bias voltage must occasionally reverse. Bad frequency and temperature characteristics make them unsuited for high-frequency applications. Typical values are a few nf to fared.

A **capacitor** or **condenser** is a passive electronic component consisting of a pair of condenser separated by a dielectric. When a voltage potential difference exists between the conductors, an electric field is present in the dielectric. This field stores energy and produces a mechanical force between the plates. The effect is greatest between wide, flat, parallel, narrowly separated conductors.

The applications of capacitor are energy storage, power factor correction, signal coupling, noise filters, and motor starters.

4.4 TRANSFORMER

A transformer is a device that moves electrical energy from one circuit to another through electromagnetism and without change in frequency. They are an important part of electrical systems. Transformers can come in many different sizes, from a very small coupling transformer inside a stage microphone to big units that carry hundreds of MVA used in power grids.

The main reason to use a transformer is to make power of one voltage level into power of another voltage level. High voltage is easier to send a long distance, but less voltage is easier and safer to use in the office or

home. Transformers are used to increase or decrease alternating current (AC) voltage in circuits. The transformer is usually built with two coils around the same core. The primary coil is connected to supply side while secondary coil supplies power to load. The second one is called the output coil.

THERE ARE SEVERAL BASIC TYPES OF TRANSFORMERS:

- Step-up transformer: the voltage output is greater than the voltage input.
- Step-down transformer: the voltage input is greater than the voltage output.
- Some transformers have the same output voltage as input voltage and are used to electrically isolate two electrical circuits.

VOLTAGE AND CURRENT MEASURMENT ON DMM

A millimeter or a multicenter, also known as a VOM (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical millimeter would include basic features such as the ability to measure voltage, current, and resistance. Analog millimeters use a micro

ammeter whose pointer moves over a scale calibrated for all the different measurements that can be made. Digital millimeters (DMM, DVOM) display the measured value in numerals, and may also display a bar of a length proportional to the quantity being measured. Digital millimeters are now far more common than analog ones, but analog millimeters are still preferable in some cases, for example when monitoring a rapidly-varying value.

A millimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems.

MOTOROLA

1N4001 thru 1N4007

CHARACTORISTICS OF DIODE

- Weight: 0.4 gram (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are readily Solder-able
- Lead and Mounting Surface Temperature for Soldering Purposes: 220°C Max. For 10 Seconds, 1/16″ from case.
- Shipped in plastic bags, 1000 per bag.
- Available Tape and Reeled, 5000 per reel, by adding a “RL” suffix to the Part number
- Polarity: Cathode Indicated by Polarity Band
- Marking: 1N4001, 1N4002, 1N4003, 1N4004, 1N4005, 1N4006, 1N4007

MAXIMUM RATING

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	VRRM VRWM VR	50	100	200	400	600	800	1000
Non–Repetitive Peak Reverse Voltage (half wave, single phase, 60 Hz)	VRSM	60	120	240	480	720	1000	1200
RMS Reverse Voltage	VR(RMS)	35	70	140	280	420	560	700

FAIRCHILD SEMICONDUCTOR®

LM78XX 3-TERMINAL 1A POSITIVE VOLTAGE REGULATOR

FEATURES

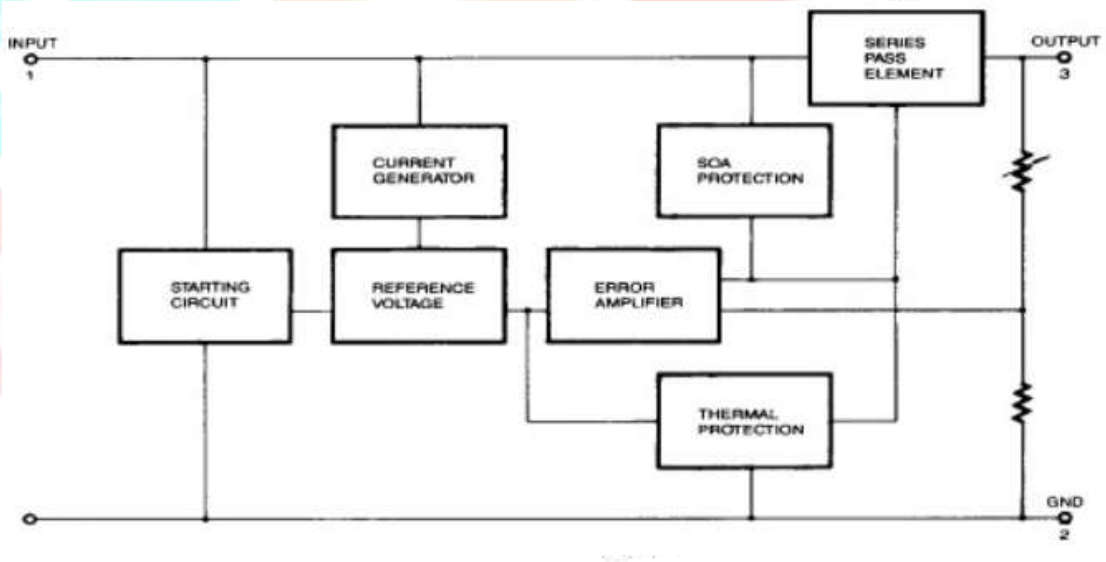
- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

DESCRIPTION

The MC78XX/LM78XX/MC78XXA series of three terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

TO-220

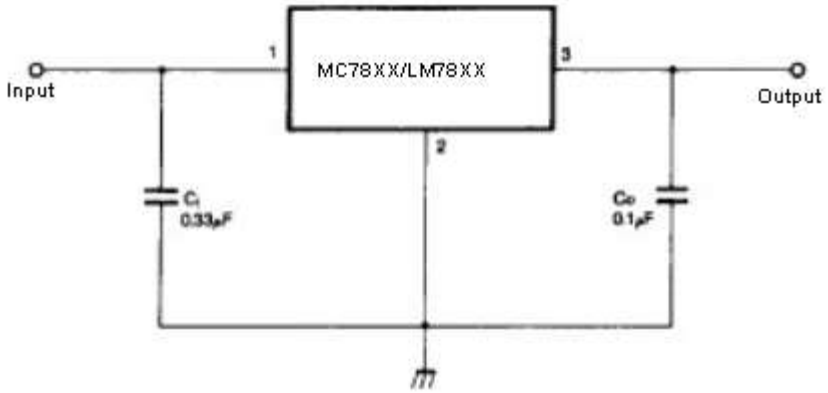
Internal Block Diagram



ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Input Voltage (for VO = 5V to 18V) (for VO = 24V)	VI VI	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	RþX	5	o C/W
Thermal Resistance Junction-Air (TO-220)	RþA	65	o C/W
Operating Temperature Range	TOPR	0 ~ +125	o C
Storage Temperature Range	TSTG	-65 ~ +150	o C

TYPICAL APPLICATIONS



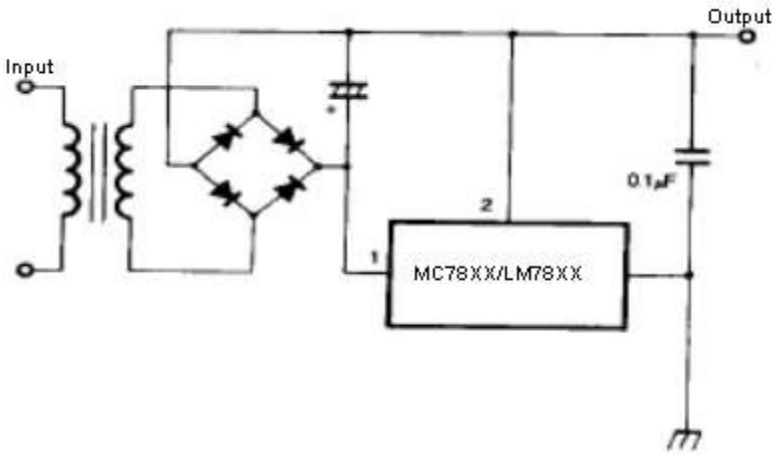
Notes:

1) To specify an output voltage. Substitute voltage value for "XX." A common ground is required between the input and the Output voltage. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.

2) CI is required if regulator is located an appreciable distance from power Supply filter.

3) CO improves stability and transient response.

NEGATIVE OUT PUT VOLTAGE CIRCUIT



FAIRCHILD
SEMICONDUCTOR®

BC546/547/548/549/550

Switching and Applications

- High Voltage: BC546, VCEO=65V
- Low Noise: BC549, BC550
- Complement to BC556 ... BC560

Pin-out diagram

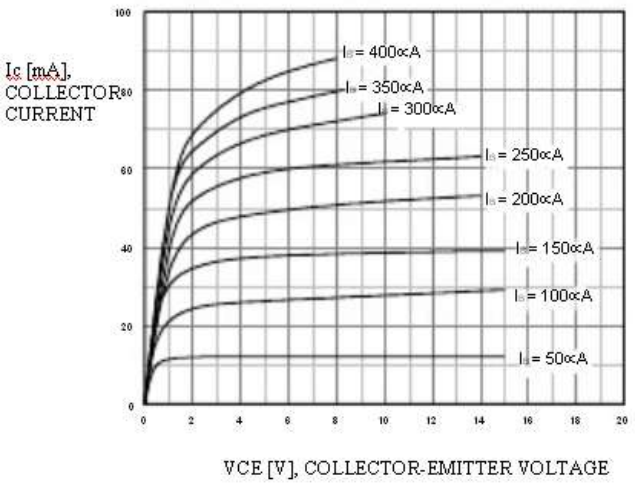
TO-92

1. Collector 2. Base 3. Emitter

Absolute Maximum Ratings

Symbol	Parameter	Value	Units
VCBO	Collector-Base Voltage : BC546 : BC547/550 : BC548/549	 80 50 30	 V V V
VCEO	Collector-Emitter voltage : BC546 : BC547/550 : BC548/549	 65 45 30	 V V V
VEBO	Emitter-Base Voltage : BC546/547 : BC548/549/550	6 5	V V
IC	Collector Current (DC)	100	mA
PC	Collector Power Dissipation	500	mW
TJ	Junction Temperature	150	ºX

Typical Characteristics



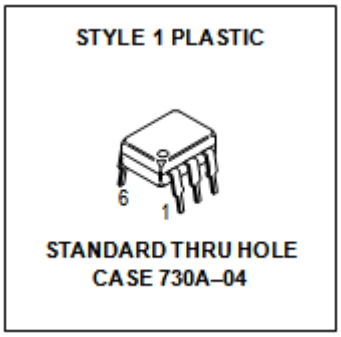
MCT2E

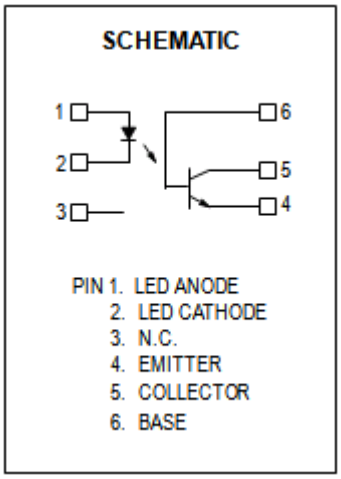
The MCT and MCT2E devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

APPLICATIONS

- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- I/O Interfacing
- Solid State Relays
- Monitor and Detection Circuits

PINOUT DIAGRAM





MAXIMUM RATINGS (T_A = 25C unless otherwise noted)

INPUT LED

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25□C with Negligible Power in Output Detector Derate above 25□C	P_D	120	mW

OUTPUT TRNASISTOR

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA

ESP 32 CONTROLLER

1. **Introduction to ESP32 WROOM**:
- The ESP32 WROOM is a powerful and versatile microcontroller module developed by Espressif Systems.
- It is part of the ESP32 series of chips, which integrate Wi-Fi and Bluetooth capabilities, making it ideal for IoT (Internet of Things) applications.

2. **Key Features**:
- Dual-core Tensilica LX6 microprocessors, which can be individually controlled.
- Integrated Wi-Fi (802.11 b/g/n) and Bluetooth (BLE) connectivity.
- Low power consumption, supporting various power modes for energy-efficient operation.
- Rich set of peripheral interfaces including UART, SPI, I2C, GPIO, etc.
- Support for multiple development frameworks and programming languages including Arduino, MicroPython, and ESP-IDF (Espressif IoT Development Framework).
- Integrated security features such as secure boot, flash encryption, and cryptographic accelerators.
- Extensive documentation and community support.

3. **Technical Specifications**:
- Processor: Dual-core 32-bit LX6 microprocessors
- Clock Frequency: Up to 240 MHz
- Flash Memory: Up to 16 MB
- RAM: Up to 520 KB SRAM
- Wireless Connectivity: Wi-Fi 802.11 b/g/n, Bluetooth BLE
- Operating Voltage: 2.2V to 3.6V
- Operating Temperature: -40°C to +125°C
- Dimensions: Typically 18 mm x 25.5 mm

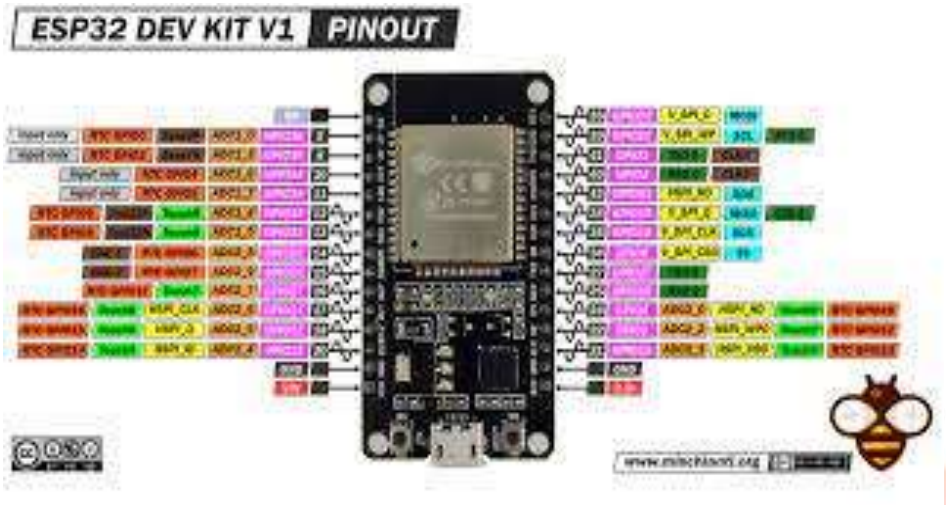
4. **Development Environment**:
- The ESP32 WROOM can be programmed using various development environments such as the Arduino IDE, MicroPython, and the Espressif IoT Development Framework (ESP-IDF).
- Arduino IDE provides an easy-to-use interface for beginners and a vast library ecosystem for rapid development.
- MicroPython offers a Python interpreter optimized for microcontrollers, allowing for quick prototyping and development.
- ESP-IDF provides low-level access to the hardware, allowing for maximum customization and optimization.

5. **Applications**:
- IoT devices such as smart home appliances, environmental monitoring systems, and wearable devices.
- Industrial automation and control systems.
- Wireless sensor networks.
- Prototyping and proof-of-concept development for various projects.

6. **Conclusion**:
- The ESP32 WROOM board offers a powerful and flexible platform for developing IoT and embedded projects.
- Its combination of processing power, wireless connectivity, and low power consumption make it suitable for a wide range of applications.

- With its extensive documentation and support, developers can quickly prototype and deploy their projects using the ESP32 WROOM.

By including these points in your project report, you can provide a comprehensive overview of the ESP32 WROOM board and its capabilities.



Pin Information:

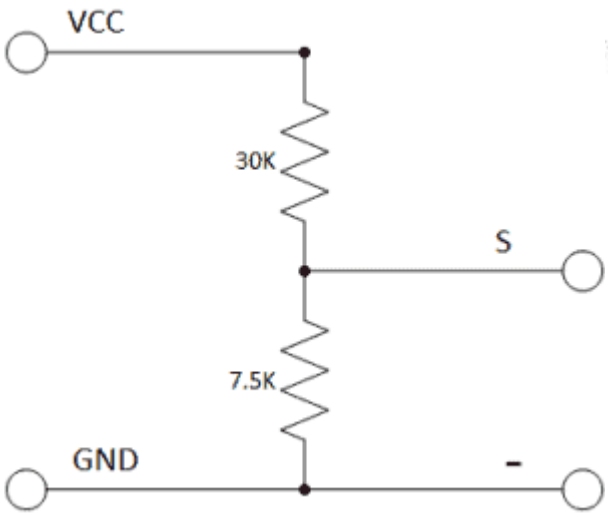
1. **Power Pins**:
   - **VIN**: Input voltage (typically 3.3V).
   - **3V3**: 3.3V output pin.
   - **GND**: Ground pin.
2. **Digital Pins**:
   - **GPIO0 - GPIO34**: General-purpose input/output pins.
   - **TX0, RX0**: Serial UART communication pins (UART0).
   - **TX1, RX1**: Serial UART communication pins (UART1).
   - **SCL, SDA**: I2C communication pins.
   - **MOSI, MISO, SCK**: SPI communication pins.
3. **Analog Pins**:
   - **ADC1_0 - ADC1_8**: Analog-to-digital converter pins.
4. **Special Function Pins**:
   - **EN**: Chip enable pin.
   - **BOOT**: Boot mode selection pin.
   - **IO0**: Bootstrapping pin for programming the chip.
   - **IO13**: Built-in LED pin (may vary depending on the development board).
   - **IO16**: Wake-up pin from deep sleep mode.
5. **Additional Pins**:
   - **VBAT**: Battery input pin.

- **RTC GPIOs**: Pins dedicated for real-time clock (RTC) functions.
- **HSPI/VSPI**: Pins for high-speed and versatile serial peripheral interface.
- **U0RXD, U0TXD**: Serial UART communication pins (UART0, alternative).
- **U1RXD, U1TXD**: Serial UART communication pins (UART1, alternative).
- **DAC1, DAC2**: Digital-to-analog converter pins.
- **SD2, SD3**: Secondary SPI data pins.

0-25V Voltage Sensor Module

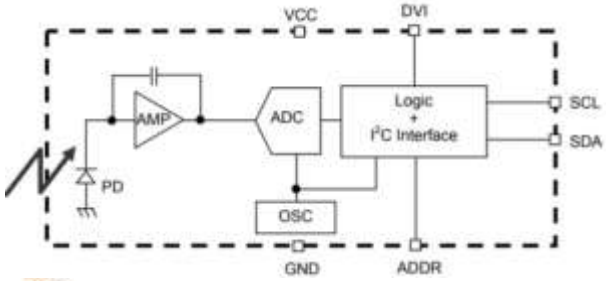
The **Voltage Sensor Module** is a simple but very useful module that uses a potential divider to reduce an input voltage by a factor of 5. The **0-25V** Voltage Sensor Module allows you to use the analog input of a microcontroller to monitor voltages much higher than it is capable of sensing.

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. Hence the output voltage is reduced by a factor of 5 for any input voltage. The internal circuit diagram of the Voltage Sensor Module is given below.



BH1750

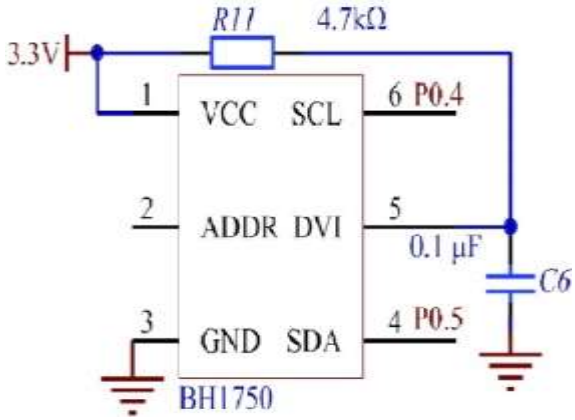
BH1750 is a Digital Ambient light sensor. It is easy to interface with a microcontroller, as it uses the I2C communication protocol. It consumes a very low amount of current. This sensor uses a photodiode to sense the light. This photodiode contains a PN junction. When light falls on it, electron-hole pairs are created in the depletion region. Due to the internal photoelectric effect, electricity is produced in the photodiode. This produced electricity is proportional to the intensity of light. This electricity is changed into a voltage by the Opamp.



Ambient light sensors contain a photodiode that can sense light and convert it into electricity. Light is measured depending upon its intensity. From the block diagram, PD is the photodiode which is used to sense the light. Its response is approximate to the human eye response.

In BH1750 sensor an Opamp – AMP is integrated which converts the current from the photodiode into voltage. BH1750 uses an ADC to convert the analog values provided by AMP into digital values. The logic+I2C block shown in the block diagram is the unit where illuminance values are converted to LUX and the I2C communication process takes place. OSC is the internal clock oscillator of 320kHz, used as a clock for internal logic.

Pin Diagram



BH1750 is available as a 5-pin IC. Pin description of the IC is given below-

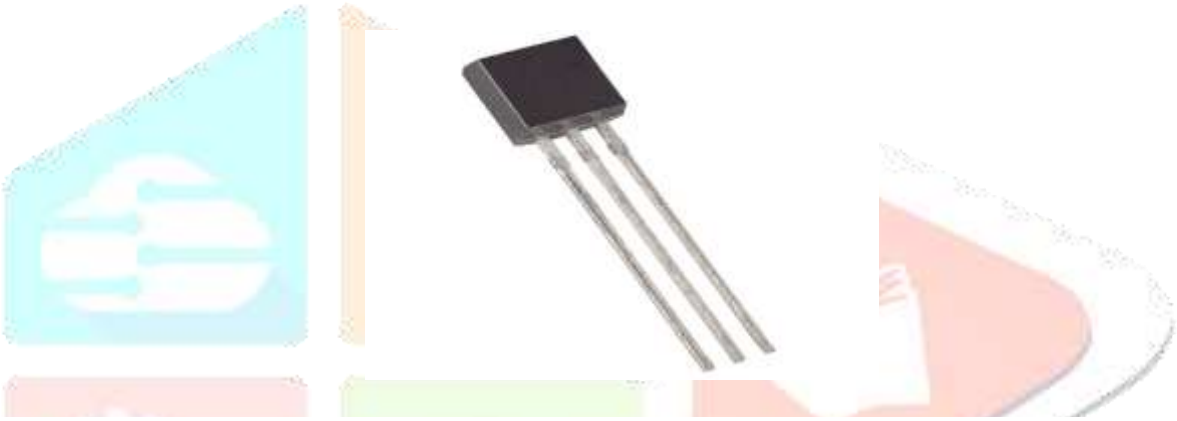
- Pin1- Vcc – is the power supply pin. The supply voltage is in the range of 2.4V to 3.6V.
- Pin-2 – GND- is the ground pin. This pin is connected to the ground of the circuit.
- Pin-3 – SCL- is the Serial Clock Line. This pin is used to provide a clock pulse for I2C communication between the sensor and the microprocessor.
- Pin-4 – SDA-is the Serial Data Address. This pin is used by I2C communication to transfer the data from the sensor to the microcontroller.
- Pin-5- ADDR- is the Device Address Pin. This pin is used when more than one module are connected, for selecting the address.

There is another pin DVI which is the bus reference voltage terminal of the I2C module. It is also used as an Asynchronous reset terminal. After Vcc is applied DVI should be set to power-down mode. The IC may not function properly if this reset terminal is not set after applying Vcc.

DS18B20

The DS18B20 is one type of temperature sensor and it supplies 9-bit to 12-bit readings of temperature. These values show the temperature of a particular device. The communication of this sensor can be done through a one-wire bus protocol which uses one data line to communicate with an inner microprocessor. Additionally, this sensor gets the power supply directly from the data line so that the need for an external power supply can be eliminated. The applications of the DS18B20 temperature sensor include industrial systems, consumer products, systems which are sensitive thermally, thermostatic controls, and thermometers.

DS18B20 Pin Configuration



- Pin1 (Ground): This pin is used to connect to the GND terminal of the circuit
- Pin2 (Vcc): This pin is used to give the power to the sensor which ranges from 3.3V or 5V
- Pin3 (Data): The data pin supplies the temperature value, which can communicate with the help of 1-wire method.

Specifications

The specifications of this sensor include the following.

- This sensor is a programmable and digital temperature sensor
- The communication of this sensor can be done with the help of a 1-Wire method
- The range of power supply is 3.0V – 5.5V
- Fahrenheit equal s to -67°F to +257°F
- The accuracy of this sensor is ±0.5°C
- The o/p resolution will range from 9-bit to 12-bit
- It changes the 12-bit temperature to digital word within 750 ms time
- This sensor can be power-driven from the data line
- Alarm options are programmable
- The multiplexing can be enabled by Unique 64-bit address
- The temperature can be calculated from -55°C to +125°C.
- These are obtainable like SOP, To-92, and also as a waterproof sensor

Working Principle

The working principle of this DS18B20 temperature sensor is like a temperature sensor. The resolution of this sensor ranges from 9-bits to 12-bits. But the default resolution which is used to power-up is 12-bit. This sensor gets power within a low-power inactive condition. The temperature measurement, as well as the conversion of A-to-D, can be done with a convert-T command. The resulting temperature information can be stored within the 2-byte register in the sensor, and after that, this sensor returns to its inactive state.
If the sensor is power-driven by an exterior power supply, then the master can provide read time slots next to the Convert T command. The sensor will react by supplying 0 though the temperature change is in the improvement and reacts by supplying 1 though the temperature change is done.

DS18B20 Temperature Sensor Applications

The applications of DS18B20 include the following.

- This sensor is extensively used to calculate temperature within rigid environments which includes mines, chemical solutions, otherwise soil, etc.
- This sensor is used to measure the liquid temperature.
- We can use it in the thermostat controls system.
- It can be used in industries as a temperature measuring device.
- This sensor is used as a thermometer.
- It can be used in devices like which are sensitive to thermal.
- These are used in HVAC systems.
- Applications where the temperature has to be measured at multiple points.

Thus, this is all about a DS18B20 temperature sensor. This sensor can be accessible in two packages like simple DS18B20 sensor and waterproof DS18B20 sensor which are used in hydro-projects to determine the temperature of the water.

Thing Speak server

ThingSpeak is an IoT (Internet of Things) platform that enables users to collect, store, analyze, visualize, and act on data from sensors or devices. It offers an easy-to-use interface for IoT applications and integrates with various hardware platforms and programming languages. Below is some information about ThingSpeak server:

Overview:
•ThingSpeak is a cloud-based IoT platform developed by MathWorks.
•It provides APIs for collecting, processing, and analyzing data in real-time.
•Users can create channels to store and organize their data, and then use MATLAB or other programming languages to analyze and visualize it.

Features:
•Data Collection: ThingSpeak allows users to send data from IoT devices to their channels using HTTP, MQTT, or other protocols.
•Data Processing: Users can perform data processing tasks such as filtering, averaging, and scaling using MATLAB code.
•Data Visualization: ThingSpeak provides built-in tools for visualizing data in the form of charts, maps, and gauges.
•React to Data: Users can set up MATLAB Analysis and MATLAB Visualizations to trigger actions based on data conditions.

•Integrations: ThingSpeak integrates with MATLAB, MATLAB Online, and Simulink for advanced data analysis and modeling.

APIs and Protocols:
•ThingSpeak provides RESTful APIs for accessing and manipulating data stored in channels.
•It supports protocols such as HTTP, MQTT, and TCP/IP for sending data to channels from IoT devices.
•ThingSpeak also supports integration with other IoT platforms and services through APIs and webhooks.

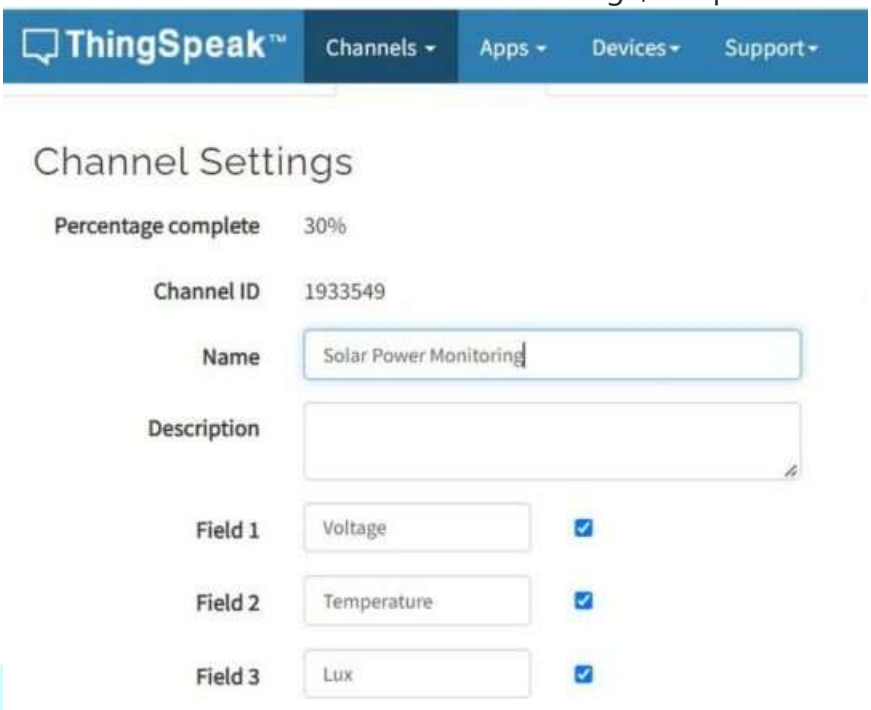
Security:
•ThingSpeak ensures data security and privacy through HTTPS encryption for data transmission.
•Users can control access to their channels using API keys and channel permissions.
•ThingSpeak complies with industry-standard security practices to protect user data.

Usage and Pricing:
•ThingSpeak offers free and paid plans with varying limits on the number of channels, data points, and features.
•The free plan allows users to create a limited number of channels and store up to a certain number of data points per channel.
•Paid plans offer higher data storage limits, additional features, and priority support.

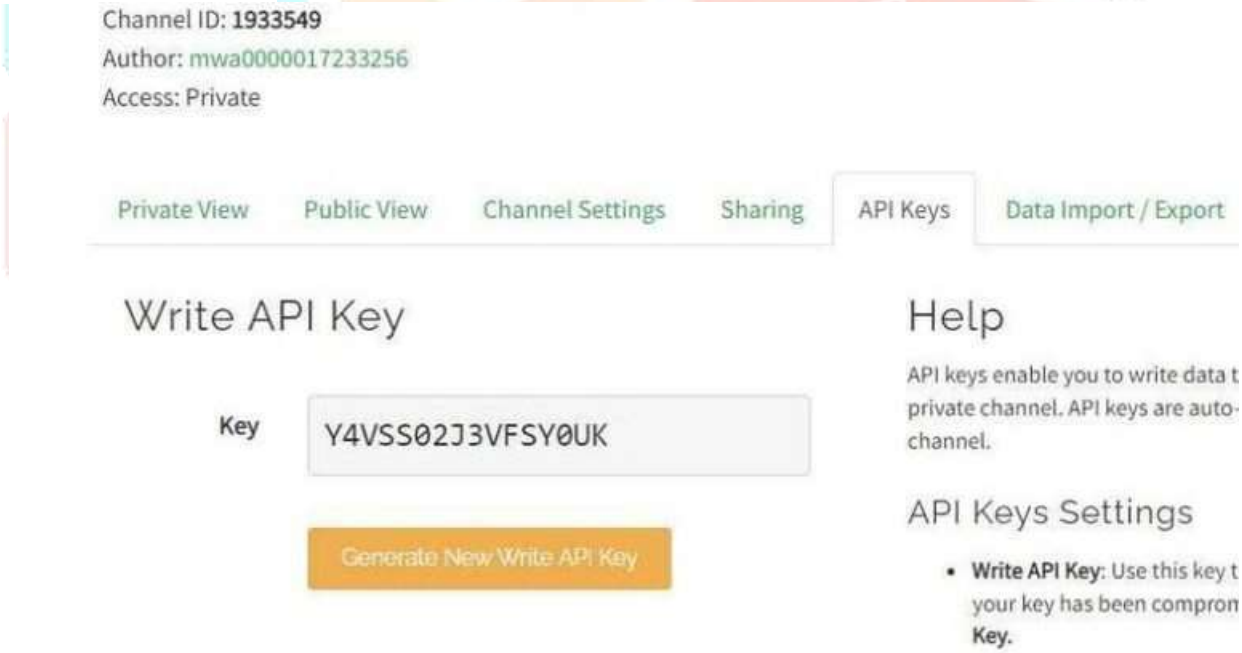
Applications:
•Environmental monitoring: Weather stations, air quality monitoring.
•Home automation: Smart home devices, energy monitoring.
•Industrial IoT: Remote monitoring of equipment and machinery.
•Agriculture: Soil moisture monitoring, crop health monitoring.

Conclusion:
•ThingSpeak provides a robust and flexible platform for IoT applications, allowing users to collect, analyze, and act on data from sensors and devices.
•Its integration with MATLAB and support for various APIs and protocols make it suitable for a wide range of IoT projects.
ThingSpeak provides very good tool for IoT based projects. By using the ThingSpeak site, we can monitor our data and control our system over the Internet, using the Channels and web pages provided by ThingSpeak. So first you need to sign up for ThingSpeak. So visit https://thingspeak.com and create an account.

Then create a **new channel** and create three variables as voltage, temperature & lux.



Then create the **API keys**. This key is required for programming modifications and receiving data from ESP32 WiFi Module.



RESULTS AND CONCLUSION

Advantages

Advantages of IoT-based Solar Power Monitoring System:

- **Real-time Monitoring**: Allows for continuous monitoring of solar power generation, consumption, and system health in real-time.
- **Remote Access**: Enables users to access monitoring data from anywhere with an internet connection, enhancing convenience and accessibility.
- **Data Analysis**: Provides valuable insights into energy production patterns, consumption trends, and system efficiency through data analytics.
- **Early Detection of Issues**: Facilitates early detection of faults or malfunctions in the solar power system, enabling prompt maintenance and minimizing downtime.
- **Optimization**: Allows for optimization of energy usage and system performance based on monitoring data, leading to increased efficiency and cost savings.
- **Scalability**: IoT-based systems can easily scale to accommodate additional sensors or devices, making it suitable for both residential and commercial solar installations.

3. Disadvantages of IoT-based Solar Power Monitoring System:

- **Cost**: Initial setup costs for IoT devices, sensors, and connectivity infrastructure can be relatively high.
- **Complexity**: Implementing and managing an IoT-based monitoring system may require technical expertise and resources.
- **Security Risks**: IoT devices and data transmission may be vulnerable to security threats such as hacking or unauthorized access if proper security measures are not implemented.
- **Reliability**: Dependence on internet connectivity and cloud services may pose reliability concerns, especially in areas with poor network coverage or connectivity issues.
- **Data Privacy**: Collection and storage of monitoring data raise privacy concerns, and measures must be taken to ensure compliance with data protection regulations.

Application:

1. **Residential Solar Installations**:
   - Homeowners can use IoT-based monitoring systems to track the performance of their solar panels, monitor energy production, and optimize energy consumption patterns.
   - Real-time monitoring allows homeowners to identify any issues or inefficiencies in their solar power systems promptly, enabling timely maintenance and maximizing energy yield.
2. **Commercial and Industrial Solar Installations**:
   - Businesses and industries with large-scale solar installations can benefit from IoT-based monitoring systems to manage energy usage effectively and optimize system performance.
   - Monitoring data can be used to track energy consumption patterns, identify peak demand periods, and implement energy-saving measures to reduce operational costs.
3. **Utility-Scale Solar Farms**:

- IoT-based monitoring systems are essential for utility-scale solar farms to monitor the performance of thousands of solar panels distributed over vast areas.
- Remote monitoring capabilities enable operators to detect faults or malfunctions in individual panels or inverters, minimizing downtime and maximizing energy production.

4. **Off-Grid and Remote Area Solar Systems**:

- Off-grid and remote area solar systems rely heavily on IoT-based monitoring systems for remote management and control.
- Monitoring data helps in assessing energy generation and consumption, battery storage levels, and system health, allowing for efficient resource management and maintenance.

5. **Smart Grid Integration**:

- IoT-based solar power monitoring systems play a crucial role in smart grid integration by providing real-time data on energy generation and consumption.
- Integration with smart grid systems enables dynamic pricing, demand response, and grid balancing, leading to a more efficient and reliable energy distribution network.

6. **Environmental Monitoring and Research**:

- IoT-based solar power monitoring systems can be used for environmental monitoring and research purposes.
- Monitoring solar radiation levels, weather conditions, and energy production data helps researchers in studying climate patterns, assessing renewable energy potential, and designing sustainable energy solutions.

7. **Educational and Research Institutions**:

- Educational institutions and research organizations utilize IoT-based solar power monitoring systems for hands-on learning and research purposes.
- Students and researchers can study the performance of solar panels, analyze monitoring data, and develop innovative solutions for improving solar energy efficiency and management.

4. Conclusion:

- Despite certain challenges, IoT-based solar power monitoring systems offer significant advantages in terms of real-time monitoring, remote access, data analysis, and system optimization.
- The benefits of increased efficiency, cost savings, and early fault detection outweigh the drawbacks associated with initial costs, complexity, and security concerns.
- With advancements in technology and continued innovation, IoT-based solar power monitoring systems are poised to play a crucial role in the transition towards sustainable energy solutions.

5. Results of the IoT-based Solar Power Monitoring System:

- Provide a summary of the results obtained from the implementation of the IoT-based solar power monitoring system.
- Include data on energy production, consumption patterns, system efficiency, and any insights or optimizations made based on the monitoring data.
- Discuss any challenges encountered during the implementation process and how they were addressed.

- Highlight the practical implications and benefits of the monitoring system in terms of energy management, cost savings, and environmental impact.

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