Team ID : PNT2022TMID07068

HARDWARE REQUIREMENTSINTRODUCTION OF NODEMCU ESP32:

What Is Esp32?

ESP32 is the name of the chip that was developed by Espressif Systems. This provides Wi-Fi (and in some models) dual-mode Bluetooth connectivity to embedded devices. While ESP32 is technically just the chip, modules and development boards that contain this chip are often also referred to as "ESP32" by the manufacturer. The differences between these are explained further on in the article. The ESP32 chip has a Ten silica Xtensa LX6 microprocessor in both dual-core and single-core variations, with a clock rate of over 240 MHz There are now several different chip models available, including:

- ESP32-D0WDQ6 (and ESP32D0WD)
- ESP32-D2WD
- ESP32-S0WD
- And the system in package (SiP) – ESP32-PICO-D4

Models are available with combined Wi-Fi and Bluetooth connectivity, or just Wi-Fi connectivity.

The ESP32 is most commonly engineered for mobile devices, wearable tech, and IoT applications – such as Nabto. Moreover, with Mongoose OS introducing an ESP32 IoT Starter Kit, the ESP32 has gained a reputation as the ultimate chip or module for hobbyists and IoT developers. While this reputation is not unmerited, the low-cost device can also be used in a number of different production systems, and its capabilities and resources have grown impressively over the past four years.

ESP32 FEATURES:

Processors – As previously mentioned, the ESP32 uses a Tensilica Xtensa 32-bit LX6 microprocessor. This uses 1 or 2 cores (all chips in the series are dual-core, except the ESP32-S0WD). The clock frequency reaches up to 240MHz and it performs up to 600 DMIPS (Dhrystone Million Instructions Per Second). Moreover, its low power consumption allows for ADC conversions, computation, and level thresholds, all while in deep sleep mode.

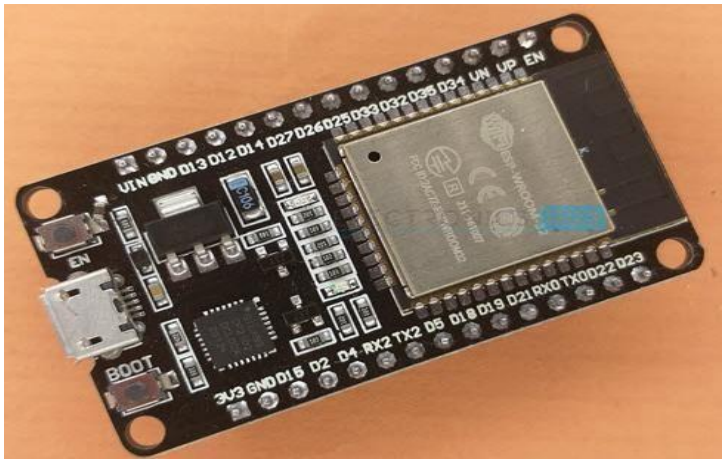


Diagram of ESP32

Wireless connectivity – The ESP32 enables connectivity to integrated Wi-Fi through the 802.11. Moreover, dual-mode Bluetooth is made possible with the v4.2 BR/EDR and features Bluetooth Low Energy (BLE).

Memory – Internal memory for the ESP32 is as follows – ROM: 448 KiB (for booting/core functions), SRAM: 520 KiB (for data/instructions), RTC fast SRAM: 8 KiB (for data storage/main CPU during boot from sleep mode), RTC slow SRAM: 8 KiB (for co-processor access during sleep mode), and Fuse: 1 KiBit (256 bits used for the system (MAC address and chip configuration) and 768 bits reserved for customer applications). Moreover, two of the ESP32 chips – ESP32-D2WD and ESP32-PICO-D4 – have internally connected flash. The others are as follows: 0 MiB (ESP32-D0WDQ6, ESP32-D0WD, and ESP32-S0WD chips), 2 MiB (ESP32-D2WD chip), and 4 MiB (ESP32-PICO-D4 SiP module).

External Flash and SRAM – ESP32 supports up to four 16 MiB external QSPI flashes and SRAMs with hardware encryption based on AES to protect developers' programs and data. It accesses the external QSPI flash and SRAM through high-speed caches.

Security – IEEE 802.11 standard security features are all supported, including WFA, WPA/WPA2 and WAPI. Moreover, ESP32 has a secure boot and flash encryption.

ESP32 Functions:

ESP32 has many applications when it comes to the Internet of Things (IoT). Here are just some of the IoT functions the chip is used for:

Networking: The module's Wi-Fi Antenna and dual-core enables embedded devices to connect to routers and transmit data.

Data Processing: Includes processing basic inputs from analogy and digital sensors to far more complex calculations with an RTOS or Non-OS SDK.

P2P Connectivity: Creates direct communication between different ESPs and other devices using IoT P2P connectivity.

Web Server: Access pages written in HTML or development languages.

ESP32 APPLICATIONS:

The ESP32 modules are commonly found in the following IoT devices:

- Smart industrial devices, including Programmable Logic Controllers (PLCs)
- Smart medical devices, including wearable health monitors
- Smart energy devices, including HVAC and thermostats
- Smart security devices, including surveillance cameras and smart locks

Chip versus Modules versus Development Boards:

The ESP32 is just the name of the chip. Device manufacturers and developers have three different choices in terms of which format they buy this

in, and the decision of which one to go with will depend on their individual circumstances:

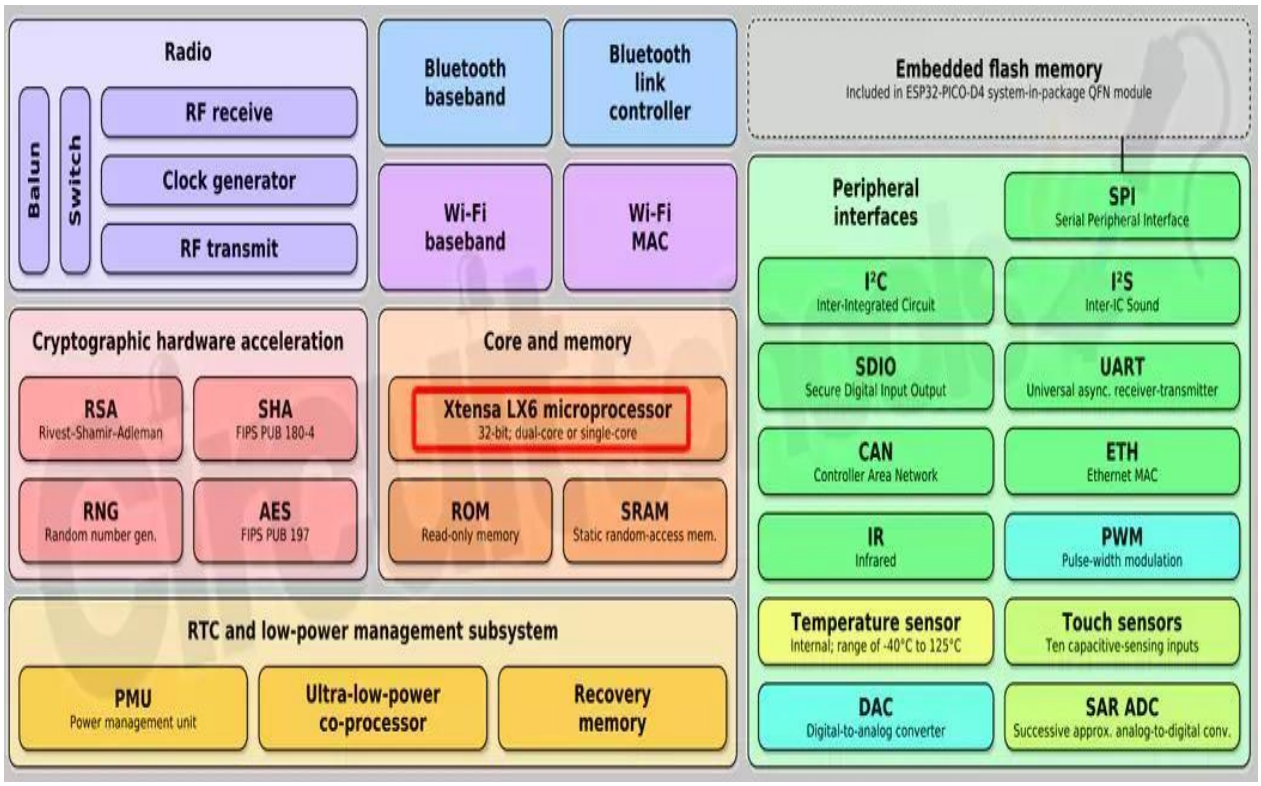
ESP32 Chip: This is the bare-bones chip that is manufactured by Espressif. It comes unshielded and can't be attached to a module or board without soldering. Therefore, most device manufacturers do not purchase just the chip, as this will add an additional layer of complexity to the production process.

ESP32 Modules: These are surface mountable modules that contain the chip. The benefit of purchasing a module is that these can be easily mounted onto an MCU in the production process. The chip is also usually shielded and pre-approved by the FCC, which means device manufacturers do not need to worry about adding additional steps to the production process to achieve FCC compliance with regard to Wi-Fi shielding.

ESP32 Development Boards: These are IoT MCU development boards that have the modules containing the ESP32 chip preinstalled. They are used by hobbyists, device manufacturers and developers to test and prototype IoT devices before entering mass production. There is a wide variety of makes and models of ESP32 development boards, produced by different manufacturers.

ESP32 ARCHITECTURAL BLOCK DIAGRAM:

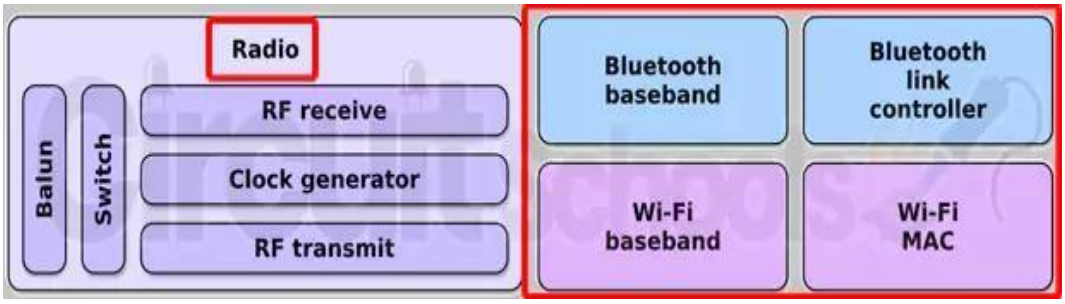
Below is the Architectural block diagram of ESP32 which shows all the functional blocks of ESP32 SOC.



Architectural Diagram of Esp32

Wireless Connectivity:

The ESP32 SoC chip has **WiFi connectivity**, being compatible with **802.11 b / g / n** in the 2.4GHz band, reaching speeds of up to 150 Mbits/s. It also includes Bluetooth communication compatible with **Bluetooth v4.2** and *Bluetooth Low Energy* (BLE).

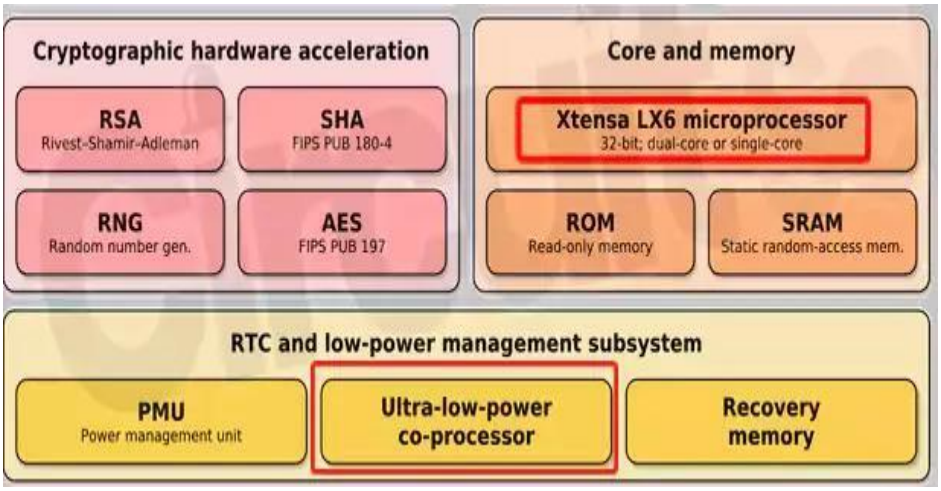


The **radio block** is closely tied to the **wireless communication modules.** In fact, this is the one that actually transmits and receives the information. That is, it takes the digital data from the Wi-Fi and **Bluetooth modules** and converts them into electromagnetic signals that travel through the air to communicate with

your **mobile phone or your** *router*. *It* also performs the reverse operation: translate the electromagnetic waves generated by other devices into **digital data** that the Wi-Fi and Bluetooth modules are capable of interpreting.

CORE

As we have already mentioned that the ESP32 has dual core low-power Ten silica Xtensa 32-bit LX6 microprocessors. As you can observe from the above core block image, it has an ultra-low-power co-processor that is used to perform analog-digital conversions and other operations while the device is operating in deep sleep low-power mode. In this way, a very low consumption by the SoC is achieved.

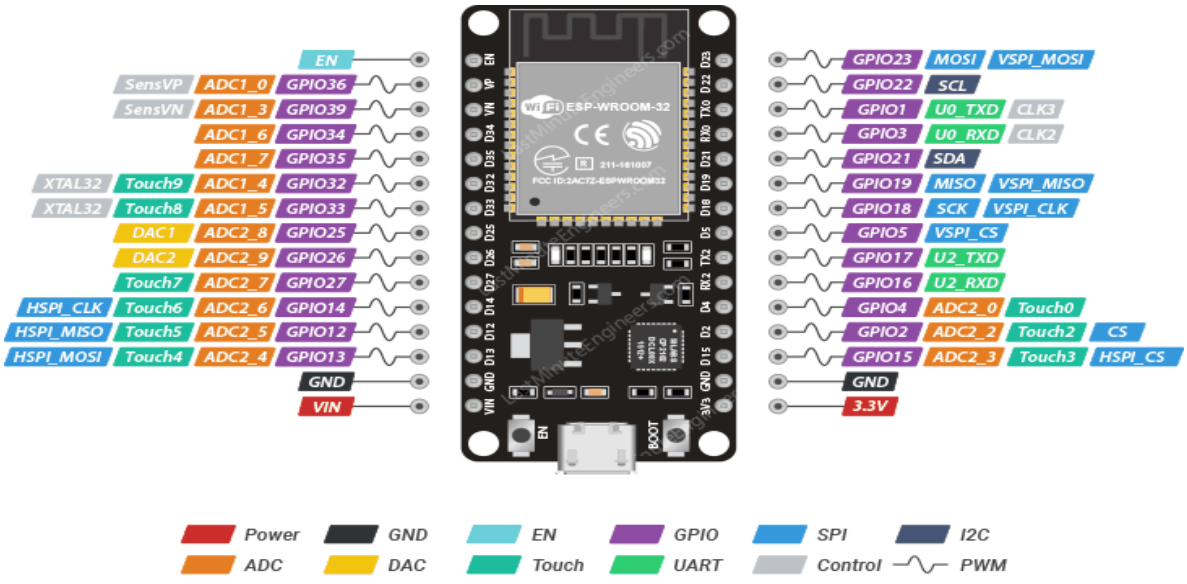


It is important to note that these processors offer great typical advantages of a digital signal processor:

- **Operating frequency**: 240 MHz (executes instructions 15 times faster than an Arduino UNO board)
- It allows to perform operations with real numbers (numbers with commas) very efficiently.
- Allows you to multiply large numbers instantly.

ESP32 PINOUT DIAGRAM AND PINS:

The ESP32 development board has a total of 30 pins that connect it to the outside world. For simplicity, pins with similar functionality are grouped together. The pinout is as follows:



ESP32 Pinout diagram

Specifications of ESP32:

ESP32 has a lot more features than ESP8266 and it is difficult to include all the specifications in this Getting Started with ESP32 guide. So, I made a list of some of the important specifications of ESP32 here. But for complete set of specifications, I strongly suggest you to refer to the Datasheet.

- Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz.
- 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM.
- Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps.
- Support for both Classic Bluetooth v4.2 and BLE specifications.
- 34 Programmable GPIOs.
- Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC
- Serial Connectivity include 4 x SPI, 2 x I2C, 2 x I2S, 3 x UART.

- Ethernet MAC for physical LAN Communication (requires external PHY).
- 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.
- Motor PWM and up to 16-channels of LED PWM.
- Secure Boot and Flash Encryption.
- Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, ECC and RNG.

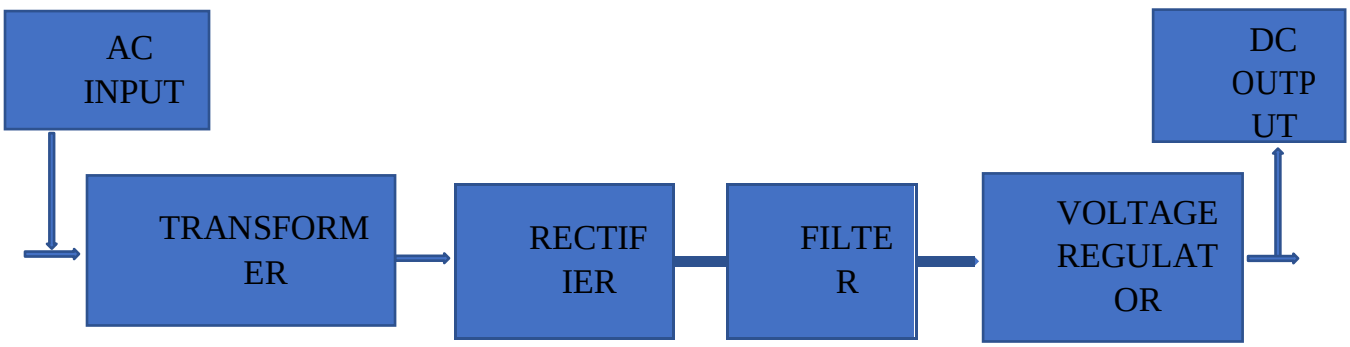
ESP32 APPLICATIONS:

- Smart industrial devices, including Programmable Logic Controllers (PLCs)
- Smart medical devices, including wearable health monitors.
- Smart energy devices, including HVAC and thermostats.
- Smart security devices, including surveillance cameras and smart locks.

POWER SUPPLY:

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters.

POWER SUPPLY BLOCKS



A transformer is defined as a passive electrical device that transfers electrical energy from one circuit to another through the process of

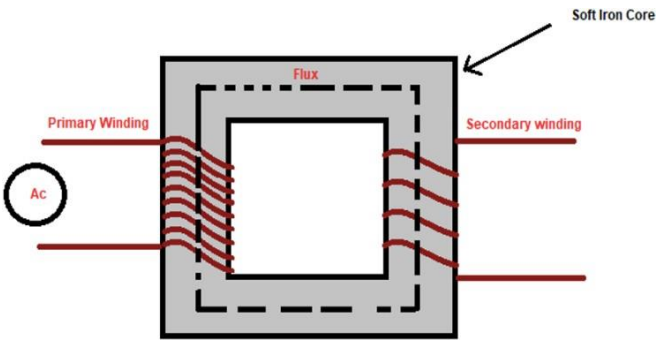
electromagnetic induction. It is most commonly used to increase (‘step up’) or decrease (‘step down’) voltage levels between circuits.

Working principle of transformer

The working principle of a transformer is very simple. Mutual induction between two or more windings (also known as coils) allows for electrical energy to be transferred between circuits.

Step down transformer

A step-down transformer is a type of transformer that converts the high voltage (HV) and low current from the primary side of the transformer to the low voltage (LV) and high current value on the secondary side of the transformer. The reverse of this is known as a step-up transformer.



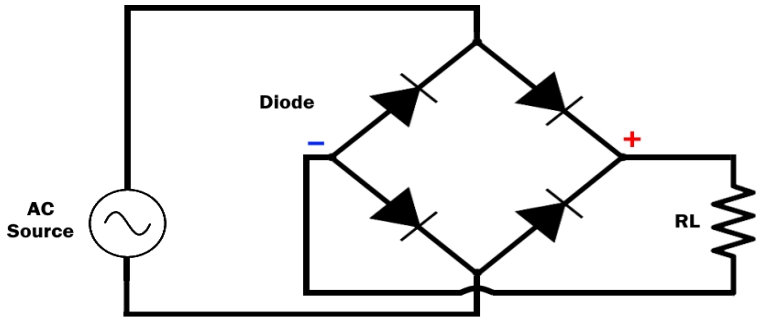
Step down transformer

RECTIFIER

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The reverse operation is performed by the inverter.

Bridge rectifier

A bridge rectifier uses four diodes to convert both half cycle of the input AC into DC output



Schematic diagram for bridge rectifier

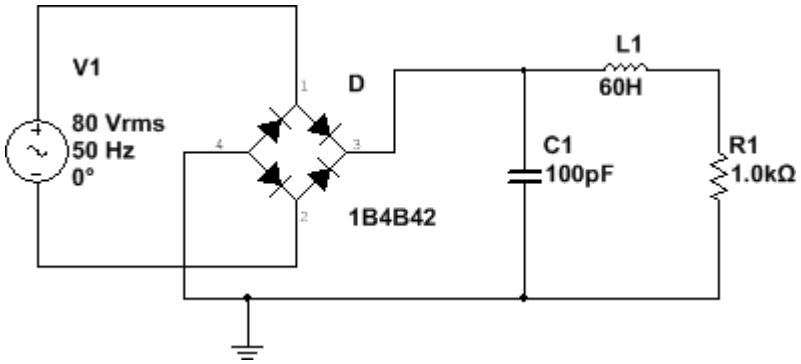
FILTER

The purpose of power supply filters is to smooth out the ripple contained in the pulses of DC obtained from the rectifier circuit while increasing the average output voltage or current.

VOLTAGE REGULATOR

A voltage regulator is a system designed to automatically maintain a constant voltage. A voltage regulator may use a simple feed-forward design or may include negative feedback. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

Voltage regulator



Schematic diagram of voltage regulator

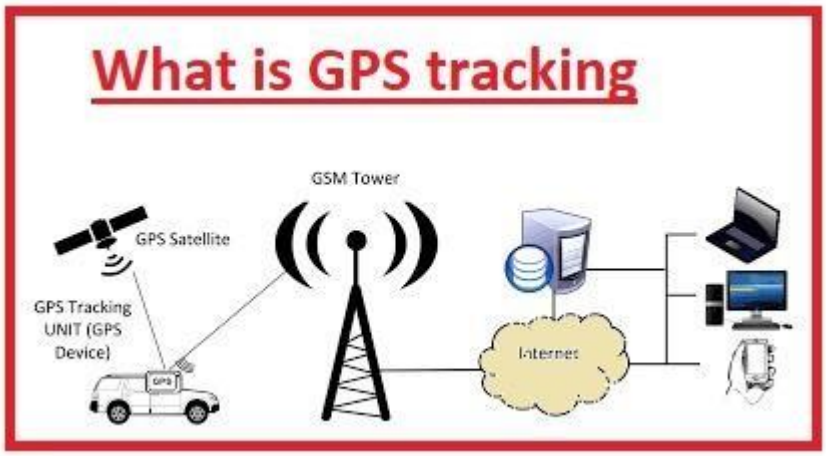
Advantages of voltage regulator

- Output voltage regulation is good (tap switching) to very good (double conversion)
- Ultrafast voltage correction speed.
- No restrictions on the number of correction cycles.
- Versatility of kVA rating, voltage and configuration.
- Very low or no regular maintenance.
- Good line isolation.

WHAT IS GPS TRACKING:

GPS tracking enabled remote monitoring / monitoring of specific locations using GPS technology to track and monitor the location and route of one or more objects. GPS tracking is very important for police, firefighters, military and businesses that require constant monitoring of moving objects such as cars, arrows and individuals. GPS tracking systems typically use Automatic Vehicle Locator (AVL) systems that use a car network, each equipped with a portable radio receiver, GPS receiver and GPS antenna.

In addition, GPS technology uses interactive maps instead of static maps to determine current traffic and highway conditions. GPS-enabled smartphones and other portable devices are often used to track and monitor targeted objects.



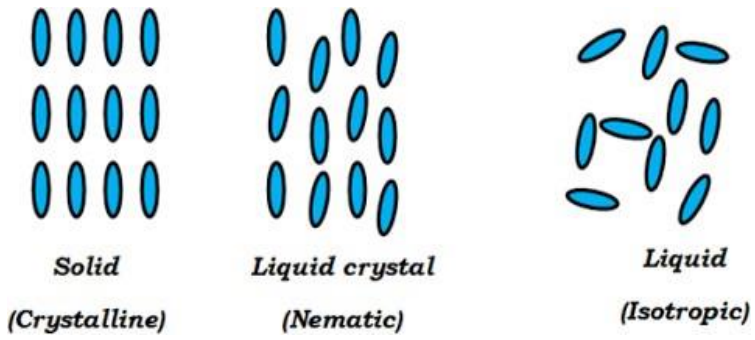
Working Principle of GPS:

GPS modules contain tiny processors and antennas that directly receive data sent by satellites through dedicated RF frequencies. From there, it'll receive timestamp from each visible satellite, along with other pieces of data.

What is Liquid Crystal Display:

Liquid Crystal Display (LCD) is a flat display screen used in electronic devices such as laptop, computer, TV, cell phones and portable video games. As the name says liquid crystal is a material which flows like a liquid and shows some properties of solid. These LCD are very thin displays and it consumes less power than LEDs.

Molecular arrangement of Liquid Crystal:



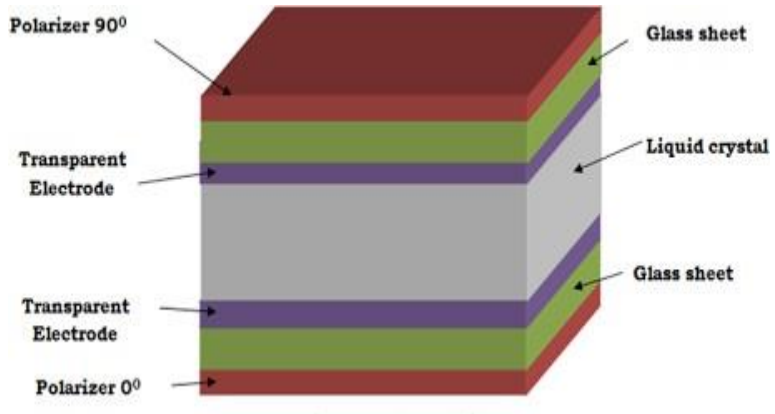
Molecular arrangement of Liquid Crystal

As the name says the molecular structure of liquid crystal is in between solid crystal and liquid isotropic. In Liquid crystal display (LCD) nematic type

of liquid crystal molecular arrangement is used in which molecules are oriented in some degree of alignment. For example, when we increase the temperature the ice cube melts and liquid crystal is like the state in between ice cube and water.

Construction of Liquid Crystal Display:

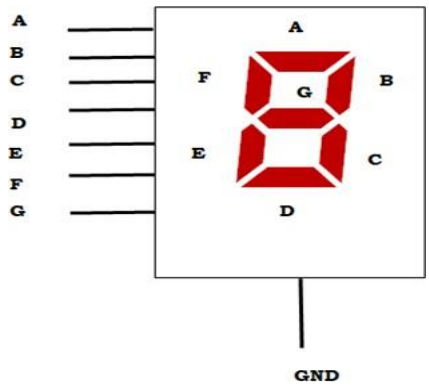
Construction of LCD consists of two polarized glass pieces. Two electrodes are used, one is positive and the other one is negative. External potential is applied to LCD through this electrode and it is made up of indium-tin-oxide. Liquid crystal layer of about 10µm- 20µm is placed between two glass sheets. The light is passed or blocked by changing the polarization.



Liquid Crystal Display

Working of Liquid Crystal Display:

The basic working principle of LCD is blocking of light. It does not produce light on its own. So external light source is used. When the external light passes from one polarizer to the next polarizer, external supply is given to the liquid crystal, the polarized light aligns itself so that the image is produced in the screen. When the external bias is applied the molecular arrangement is disturbed and it and that area looks dark and the other area looks clear.



LCD Display

In positive LCD display the segments are dark and the background is white and the polarizers are placed perpendicular to each other. In the negative LCD display the segments are white in the dark background and the polarizers are aligned to each other.

ADVANTAGES:

- It is thin and compact
- Low power consumption
- Less heat is emitted during operation
- Low cost

DISADVANTAGES:

- Speed of operation is low
- Lifespan is less
- Restricted viewing angles

APPLICATIONS:

- Used in digital wrist watch
- Display images in digital cameras
- Used in numerical counters
- Display screen in calculators
- Mainly used in television
- Used in mobile screens

- Used in video players
- Used in image sensing circuits