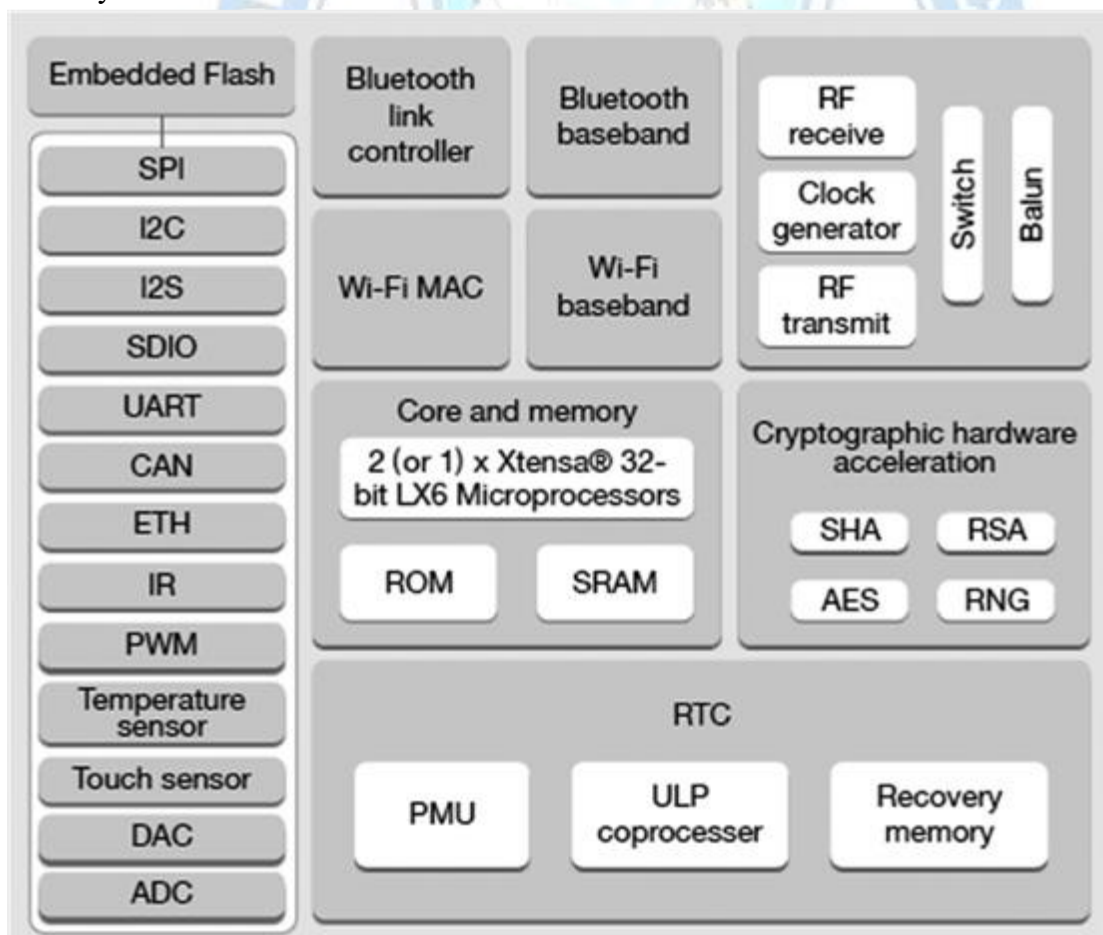


ARCHITECTURE OF ESP32

- **ESP32** is a **32-bit low-power System-on-Chip (SoC)** developed by **Espressif Systems**.
- It combines a **dual-core processor, Wi-Fi, Bluetooth**, memory, and many peripherals on a single chip.
- It is widely used in **IoT, embedded systems**, and **wireless communication** applications.

At the heart of the block is the dual-core Xtensa LX6 processor and memory. At the left hand side we can see the peripheral interface blocks such as SPI, I2C, I2S, SDIO, UART, CAN, ETH, IR, PWM, temperature sensor, touch sensor, DAC, and ADC. The Bluetooth and Wi-Fi modules are situated at the top middle part of the block diagram. The clock generator and the RF transceiver are located at the top right hand of the block. The middle right hand is reserved for the cryptographic hardware accelerator modules such as the SHA, RSA, AES, and RNG. Finally, the bottom middle part is where the RTC, PMU, co-processor, and the recovery memory



Dual-Core Xtensa LX6 Processor

- ESP32 uses **dual-core Xtensa LX6 processors**.
- Each processor is **32-bit**.
- Maximum clock speed is **240 MHz**.

- Supports **7-stage pipelining** for faster execution.
- Up to 70 external and internal interrupt sources with 32 interrupt vectors are available. Debugging can be done with the JTAG interface.
- Includes:
 - Floating Point Unit (FPU)
 - DSP Instructions
 - 32-bit Multiplier
 - 32-bit Divider
 - 40-bit MAC (Multiply and Accumulate)

Features

- Executes user programs.
- Supports multitasking.
- Faster data processing.
- Handles interrupts efficiently.

Internal Memory

520 KB SRAM and 448 KB ROM (for booting) are available on-chip. The Real Time Clock module contains 8 KB slow memory and 8 KB fast memory. 1 Kbit of eFuse is available with 256 bits used for the MAC address and chip configuration, and the remaining 768 bits reserved for customer applications.

External Memory

Up to 4 x 16 MB external flash and SRAM memory that can be accessed through a highspeed cache are supported. Up to 16 MB of the external flash are mapped onto the CPU code space and up to 8 MB of the external flash/SRAM are mapped onto the CPU data space. Although data read is supported both on the flash and SRAM, data writing is supported only on the SRAM.

General Purpose Timers

4 x 64-bit general purpose software controllable timers are supported by the ESP32 processor. The timers have 16-bit pre-scalers (2 to 65535) and auto-reload up/down counters. The timers can generate interrupts if configured.

Watchdog Timers

Three watchdog timers with programmable timeout values are available. Two watchdog timers, called the main Watchdog Timers are inside the general purpose timers, while the third one, called the RTC Watchdog Timer, is inside the RTC module. The actions taken when a watchdog timer resets can be: interrupt, CPU reset, core reset, and system reset.

The System Clock

An external crystal clock controls the system timing when the processor is reset. The clock frequency is typically 160 MHz, configured with the help of a PLL.

An 8 MHz accurate internal clock is also available. The programmer can either select the external or the internal clock.

Real Time Clock (RTC)

An RTC is provided that can be clocked using an external 32 kHz crystal, an internal RC oscillator (typically 150 kHz), an internal 8 MHz oscillator, or an internal 31.25 kHz clock derived by dividing the 8 MHz internal oscillator by 256.

General Purpose Input-Outputs (GPIOs)

There are 34 GPIOs that can be configured as digital, analog, or capacitive touch screen. Digital GPIOs can be configured to have internal pull-up resistors or pull-down resistors or set to high impedance state. Input pins can be configured to accept interrupts on either edges or on level changes.

Analog To Digital Converter (ADC)

The ESP32 processor includes 18 channels of 12-bit ADC. Small analog voltages can be measured by configuring some of the pins as programmable gain amplifiers.

Digital To Analog Converter (DAC)

The ESP32 processor includes two independent 8-bit DACs.

Hall Sensor

A hall sensor is available on the processor based on a resistor. A small voltage that can be measured by the ADC is developed when the sensor is in a magnetic field.

Temperature Sensor

An analog internal temperature sensor is available that can measure the temperature in the range -40 °C to +125 °C. The measured temperature is converted into digital form using an ADC. The measurement is affected by the temperature of the chip and the modules active inside the chip and thus the temperature sensor is only suitable for measuring temperature changes rather than measuring the absolute temperature.

Touch Sensor

Up to 10 capacitive touch sensors are provided that can detect the capacitive changes when a GPIO pin is in direct contact with a finger or any other suitable object.

UART

Three UARTs with speeds up to 5 Mbps are provided for RS232, RS485 and IrDA serial communications.

I2C Interface

ESP32 processor supports up to two I2C bus interfaces that can be configured as master or slave modes. The interface supports 400 Kbits/s fast transfer mode with 7-bit/10-bit addressing mode. External devices compatible with the I2C bus can be connected to these

pins.

I2S Interface

ESP32 processor supports up to two I2S bus interfaces that can be configured in master or slave modes, in full or half duplex. The clock frequency can be from 10 kHz to 40 MHz.

Infrared Controller

Up to 8 channels of programmable infrared remote controller transmissions are supported by ESP32. The transmitting and receiving waveforms can be stored in shared 512 x 32-bit memory.

Pulse Width Modulation

Pulse Width Modulation (PWM) is used to control devices such as motors, electric heaters, smart lights and so on. ESP32 offers one programmable hardware PWM module and 16 software configurable PWM modules.

LED PWM

The LED PWM can be used to generate up to 16 independent digital waveforms with configurable duty cycles and periods. The duty cycle can be changed by software in a step by step mode.

Pulse Counter

Up to 8 channels of pulse counters are provided to capture pulses and count pulse edges. An interrupt can be generated when the count reaches a pre-defined value.

SPI Interface

Up to 4 SPI interfaces are supported by ESP32 in master and slave modes. External devices compatible with the SPI bus interface can be connected to these pins.

Hardware Accelerators

ESP32 supports hardware accelerators for implementing mathematical operations on algorithms such as AES, SHA, RSA and ECC. These accelerators help to increase the operation speed and also reduce the software complexity.

Wi-Fi

ESP32 includes a Wi-Fi module that can be used in projects to communicate with other Wi-Fi devices, such as mobile phones, PCs, laptops and iPads, through a network router.

Bluetooth

A Bluetooth module is included on the ESP32 processor. With the help of this module we can develop projects to communicate with other Bluetooth compatible devices, such as mobile phones, PCs, iPads, and others.

Controller Area Network (CAN)

ESP32 includes a CAN bus controller that can be programmed to communicate with other ESP32 processors or other CAN bus compatible devices.

SD Card Support

ESP32 supports SD memory cards, thus making it possible to store data on a memory card, for example.

