# Overview

ESP32 is a single 2.4 GHz Wi-Fi-and-Bluetooth combo chip designed with the TSMC ultra-low-power 40 nm technology. It is designed to achieve the best power and RF performance, showing robustness, versatility and reliability in a wide variety of applications and power scenarios.

## Featured Solutions

### Ultra­Low­Power Solution

ESP32 is designed for mobile, wearable electronics, and Internet-of-Things (IoT) applications. It features all the state-of-the-art characteristics of low-power chips, including fine-grained clock gating, multiple power modes, and dynamic power scaling. For instance, in a low-power IoT sensor hub application scenario, ESP32 is woken up periodically only when a specified condition is detected. Low-duty cycle is used to minimize the amount of energy that the chip expends. The output of the power amplifier is also adjustable, thus contributing to an optimal trade-off between communication range, data rate and power consumption.

### Complete Integration Solution

ESP32 is a highly-integrated solution for Wi-Fi-and-Bluetooth IoT applications, with around 20 external components. ESP32 integrates an antenna switch, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules. As such, the entire solution occupies minimal Printed Circuit Board (PCB) area.

ESP32 uses CMOS for single-chip fully-integrated radio and baseband, while also integrating advanced calibration circuitries that allow the solution to remove external circuit imperfections or adjust to changes in external conditions. As such, the mass production of ESP32 solutions does not require expensive and specialized Wi-Fi testing equipment.

## Wi­Fi Key Features

* 802.11 b/g/n
* 802.11 n (2.4 GHz), up to 150 Mbps
* WMM
* TX/RX A-MPDU, RX A-MSDU
* Immediate Block ACK
* Defragmentation
* Automatic Beacon monitoring (hardware TSF)
* 4 × virtual Wi-Fi interfaces
* Simultaneous support for Infrastructure Station, SoftAP, and Promiscuous modes

Note that when ESP32 is in Station mode, performing a scan, the SoftAP channel will be changed.

* Antenna diversity

## Bluetooth Key Features

* Compliant with Bluetooth v4.2 BR/EDR and Bluetooth LE specifications
* Class-1, class-2 and class-3 transmitter without external power amplifier
* Enhanced Power Control

• +9 dBm transmitting power

* NZIF receiver with –94 dBm Bluetooth LE sensitivity
* Adaptive Frequency Hopping (AFH)
* Standard HCI based on SDIO/SPI/UART
* High-speed UART HCI, up to 4 Mbps
* Bluetooth 4.2 BR/EDR Bluetooth LE dual mode controller
* Synchronous Connection-Oriented/Extended (SCO/eSCO)
* CVSD and SBC for audio codec
* Bluetooth Piconet and Scatternet
* Multi-connections in Classic Bluetooth and Bluetooth LE
* Simultaneous advertising and scanning

## MCU and Advanced Features

### CPU and Memory

* + - * Xtensa® single-/dual-core 32-bit LX6 microprocessor(s)
      * CoreMark® score:
        + 1 core at 240 MHz: 504.85 CoreMark; 2.10 CoreMark/MHz
        + 2 cores at 240 MHz: 994.26 CoreMark; 4.14 CoreMark/MHz
      * 448 KB ROM
      * 520 KB SRAM
      * 16 KB SRAM in RTC
      * QSPI supports multiple flash/SRAM chips

### Clocks and Timers

* + - * Internal 8 MHz oscillator with calibration
      * Internal RC oscillator with calibration
      * External 2 MHz ~ 60 MHz crystal oscillator (40 MHz only for Wi-Fi/Bluetooth functionality)
      * External 32 kHz crystal oscillator for RTC with calibration
      * Two timer groups, including 2 × 64-bit timers and 1 × main watchdog in each group
      * One RTC timer
      * RTC watchdog

### Advanced Peripheral Interfaces

* + - * 34 × programmable GPIOs
      * 12-bit SAR ADC up to 18 channels
      * 2 × 8-bit DAC
      * 10 × touch sensors
      * 4 × SPI
      * 2 × I2S
      * 2 × I2C
      * 3 × UART
      * 1 host (SD/eMMC/SDIO)
      * 1 slave (SDIO/SPI)
      * Ethernet MAC interface with dedicated DMA and IEEE 1588 support
      * TWAI®, compatible with ISO 11898-1 (CAN Specification 2.0)
      * RMT (TX/RX)
      * Motor PWM
      * LED PWM up to 16 channels
      * Hall sensor

### Security

* + - * Secure boot
      * Flash encryption
      * 1024-bit OTP, up to 768-bit for customers
      * Cryptographic hardware acceleration:
        + AES
        + Hash (SHA-2)
        + RSA
        + ECC
        + Random Number Generator (RNG)

Block Diagram