# ESP32-PICO-V3

## Datasheet

Version 1.0

Espressif Systems

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# 1. Overview

## 1.1 Features

**MCU**

- ESP32 embedded, Xtensa® dual-core 32-bit LX6 microprocessor, up to 240 MHz

- 448 KB ROM for booting and core functions

- 520 KB SRAM for data and instructions

- 16 KB SRAM in RTC

**Wi-Fi**

- 802.11 b/g/n

- Bit rate: 802.11n up to 150 Mbps

- A-MPDU and A-MSDU aggregation

- 0.4 $\mu$s guard interval support

- Center frequency range of operating channel: 2412 ~ 2484 MHz

**Bluetooth®**

- Bluetooth V4.2 BR/EDR and Bluetooth LE specification

- Class-1, class-2 and class-3 transmitter

- AFH

- CVSD and SBC

**Hardware**

- Interfaces: ADC, DAC, touch sensor, SD/SDIO/MMC Host Controller, SPI, SDIO/SPI Slave Controller, EMAC, motor PWM, LED PWM, UART, I²C, I²S, infrared remote controller, GPIO, pulse counter

- 40 MHz crystal oscillator

- 4 MB SPI flash

- Operating voltage/Power supply: 3.0 ~ 3.6 V

- Operating temperature range: –40 ~ 85 °C

- Dimensions: (7 × 7 × 0.94) mm

## 1.2 Description

The ESP32-PICO-V3 is a System-in-Package (SiP) device that is based on ESP32 with ECO V3 wafer, providing complete Wi-Fi and Bluetooth® functionalities. It integrates a 4 MB SPI flash.

At the core of ESP32-PICO-V3 is the ESP32 (ECO V3) chip, which is a single 2.4 GHz Wi-Fi and Bluetooth combo chip designed with TSMC's 40 nm low-power technology. ESP32-PICO-V3 integrates all peripheral components seamlessly, including a crystal oscillator, flash, filter capacitors and RF matching links in one single package. Module assembly and testing are already done at SiP level. As such, ESP32-PICO-V3 reduces the complexity of supply chain and improves control efficiency.

With its ultra-small size, robust performance and low-energy consumption, ESP32-PICO-V3 is well suited for any space-limited or battery-operated applications, such as wearable electronics, medical equipment, sensors and other IoT products.

Comparing to other ESP32 series chips, ESP32-PICO-V3 has an additional pin GPIO20. For chip security purpose, flash pins DI, DO, /HOLD, /WP are not led out.

> **Note:**
>
> - For details on ESP32, please refer to the document *ESP32 Datasheet*.
>
> - For details on ESP32 ECO V3, please refer to *ESP32 ECO V3 User Guide*.

## 1.3  Applications

- Generic Low-power IoT Sensor Hub
- Generic Low-power IoT Data Loggers
- Cameras for Video Streaming
- Over-the-top (OTT) Devices
- Speech Recognition
- Image Recognition
- Mesh Network
- Home Automation

- Smart Building
- Industrial Automation
- Smart Agriculture
- Audio Applications
- Health Care Applications
- Wi-Fi-enabled Toys
- Wearable Electronics
- Retail & Catering Applications

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**Figure 1: ESP32-PICO-V3 Block Diagram**

# 3. Pin Definitions

## 3.1 Pin Layout



**Figure 2: Pin Layout of ESP32-PICO-V3 (Top View)**

> **Note:**
> The pin diagram shows the approximate location of pins. For the actual mechanical diagram, please refer to Figure 7.

## 3.2 Pin Description

ESP32-PICO-V3 has 48 pins. See pin definitions in Table 1.

**Table 1: Pin Definitions**

| Name | No. | Type | Function |
|------|-----|------|----------|
| VDDA | 1 | P | Analog power supply (3.0 V ~ 3.6 V) |

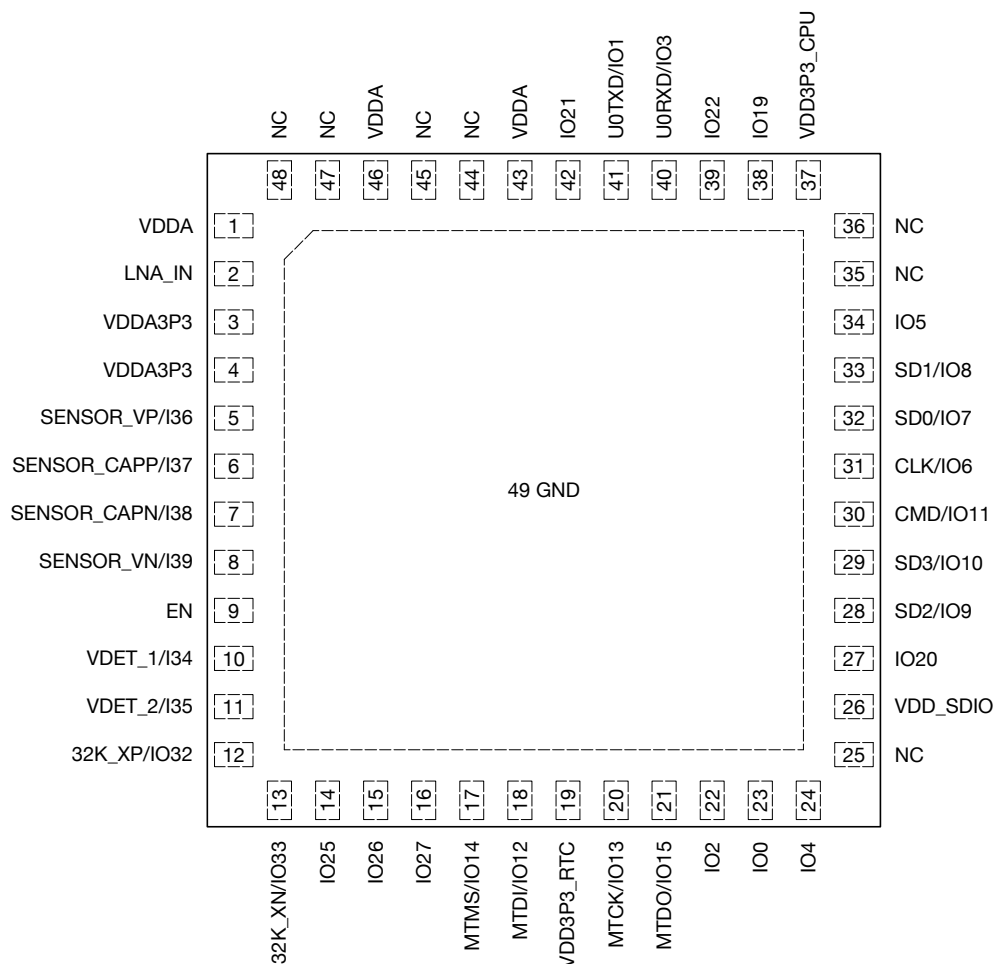| Name | No. | Type | Function |
|------|-----|------|----------|
| LNA_IN | 2 | I/O | RF input and output |
| VDDA3P3 | 3 | P | Analog power supply (3.0 V ~ 3.6 V) |
| VDDA3P3 | 4 | P | Analog power supply (3.0 V ~ 3.6 V) |
| SENSOR_VP/I36 | 5 | I | GPIO36, ADC1_CH0, RTC_GPIO0 |
| SENSOR_CAPP/I37 | 6 | I | GPIO37, ADC1_CH1, RTC_GPIO1 |
| SENSOR_CAPN/I38 | 7 | I | GPIO38, ADC1_CH2, RTC_GPIO2 |
| SENSOR_VN/I39 | 8 | I | GPIO39, ADC1_CH3, RTC_GPIO3 |
| EN | 9 | I | High: On; enables the SiP<br>Low: Off; the SiP powers off<br>Note: Do not leave this pin floating. |
| VDET_1/I34 | 10 | I | ADC1_CH6, RTC_GPIO4 |
| VDET_2/I35 | 11 | I | ADC1_CH7, RTC_GPIO5 |
| 32K_XP/IO32 | 12 | I/O | 32K_XP (32.768 kHz crystal oscillator input), ADC1_CH4, TOUCH9, RTC_GPIO9 |
| 32K_XN/IO33 | 13 | I/O | 32K_XN (32.768 kHz crystal oscillator output), ADC1_CH5, TOUCH8, RTC_GPIO8 |
| IO25 | 14 | I/O | GPIO25, DAC_1, ADC2_CH8, RTC_GPIO6, EMAC_RXD0 |
| IO26 | 15 | I/O | GPIO26, DAC_2, ADC2_CH9, RTC_GPIO7, EMAC_RXD1 |
| IO27 | 16 | I/O | GPIO27, ADC2_CH7, TOUCH7, RTC_GPIO17, EMAC_RX_DV |
| MTMS/IO14 | 17 | I/O | ADC2_CH6, TOUCH6, RTC_GPIO16, MTMS, HSPICLK, HS2_CLK, SD_CLK, EMAC_TXD2 |
| MTDI/IO12 | 18 | I/O | ADC2_CH5, TOUCH5, RTC_GPIO15, MTDI, HSPIQ, HS2_DATA2, SD_DATA2, EMAC_TXD3 |
| VDD3P3_RTC | 19 | P | Input power supply for RTC IO (3.0 V ~ 3.6 V) |
| MTCK/IO13 | 20 | I/O | ADC2_CH4, TOUCH4, RTC_GPIO14, MTCK, HSPID, HS2_DATA3, SD_DATA3, EMAC_RX_ER |
| MTDO/IO15 | 21 | I/O | ADC2_CH3, TOUCH3, RTC_GPIO13, MTDO, HSPICS0, HS2_CMD, SD_CMD, EMAC_RXD3 |
| IO2 | 22 | I/O | ADC2_CH2, TOUCH2, RTC_GPIO12, HSPIWP, HS2_DATA0, SD_DATA0 |
| IO0 | 23 | I/O | ADC2_CH1, TOUCH1, RTC_GPIO11, CLK_OUT1, EMAC_TX_CLK |
| IO4 | 24 | I/O | ADC2_CH0, TOUCH0, RTC_GPIO10, HSPIHD, HS2_DATA1, SD_DATA1, EMAC_TX_ER |
| NC | 25 | — | NC |
| VDD_SDIO | 26 | P | Output power supply. See note 1 under the table. |
| IO20 | 27 | I/O | GPIO20. See note 3 under the table. |
| SD2/IO9 | 28 | I/O | GPIO9, SD_DATA2, HS1_DATA2, U1RXD. See note 3 under the table. |
| SD3/IO10 | 29 | I/O | GPIO10, SD_DATA3, HS1_DATA3, U1TXD. See note 3 under the table. |
| CMD/IO11 | 30 | I/O | See note 2, note 3 under the table. |
| CLK/IO6 | 31 | I/O | See note 2, note 3 under the table. |
| SD0/IO7 | 32 | I/O | GPIO7, SD_DATA0, HS1_DATA0, U2RTS. See note 3 under the table. |
| SD1/IO8 | 33 | I/O | GPIO8, SD_DATA1, HS1_DATA1, U2CTS. See note 3 under the table. |
| IO5 | 34 | I/O | GPIO5, VSPICS0, HS1_DATA6, EMAC_RX_CLK |

| Name | No. | Type | Function |
|------|-----|------|----------|
| NC | 35 | — | NC |
| NC | 36 | — | NC |
| VDD3P3_CPU | 37 | P | Input power supply for CPU IO (1.8 V ~ 3.6 V) |
| IO19 | 38 | I/O | GPIO19, VSPIQ, U0CTS, EMAC_TXD0 |
| IO22 | 39 | I/O | GPIO22, VSPIWP, U0RTS, EMAC_TXD1 |
| U0RXD/IO3 | 40 | I/O | GPIO3, U0RXD, CLK_OUT2 |
| U0TXD/IO1 | 41 | I/O | GPIO1, U0TXD, CLK_OUT3, EMAC_RXD2 |
| IO21 | 42 | I/O | GPIO21, VSPIHD, EMAC_TX_EN |
| VDDA | 43 | P | Analog power supply (3.0 V ~ 3.6 V) |
| NC | 44 | — | NC |
| NC | 45 | — | NC |
| VDDA | 46 | P | Analog power supply (3.0 V ~ 3.6 V) |
| NC | 47 | — | NC |
| NC | 48 | — | NC |

**Notice:**

1. Note that the embedded flash is connected to VDD_SDIO which is driven directly by VDD3P3_RTC through a 6 Ω resistor. Due to this resistor, there is some voltage drop on this pin from VDD3P3_RTC.

2. Pins CMD/IO11 and CLK/IO6 are used for connecting the embedded flash, and are not recommended for other uses. For details, please see Section 5 Schematics.

3. IO6/IO7/IO8/IO9/IO10/IO11/IO20 belong to VDD_SDIO power domain and cannot work when VDD_SDIO power shuts down.

4. For peripheral pin configurations, please refer to *ESP32 Datasheet*.

## 3.3 Compatibility with ESP32-PICO-D4

ESP32-PICO-V3 is a new product but it is very similar to ESP32-PICO-D4. It may be possible to update an ESP32-PICO-D4 hardware design to use ESP32-PICO-V3 with minimal or no hardware changes, but please pay attention to the following:

- Usage of six pins has changed:

**Table 2: Usage of Pins on ESP32-PICO-V3 and ESP32-PICO-D4**

| Pin No. | ESP32-PICO-V3 | ESP32-PICO-D4 |
|---------|---------------|---------------|
| 25 | Not connected | GPIO16, used by embedded flash |
| 27 | GPIO20, can be used | GPIO17, used by embedded flash |
| 32 | SD0 (GPIO7), can be used | SD0 (GPIO7), used by embedded flash |
| 33 | SD1 (GPIO8), can be used | SD1 (GPIO8), used by embedded flash |
| 35 | Not connected | GPIO18, can be used |
| 36 | Not connected | GPIO23, can be used |

- None of the embedded flash data pins are connected externally on ESP32-PICO-V3. These are connected internally to GPIO16, GPIO17, GPIO18, and GPIO23.

- It is not possible to connect an external PSRAM chip to ESP32-PICO-V3.

- If a 32.768 kHz crystal is connected to ESP32-PICO-D4 then please refer to *ESP32 ECO V3 User Guide* for information about necessary hardware changes for ESP32-PICO-V3.

- Refer to *ESP32 ECO V3 User Guide* for information about possible software changes and optimizations for ESP32 ECO V3.

- EMC compliance and RF performance tests should be repeated after a design is updated to use ESP32-PICO-V3.

- Refer to *ESP32-PICO-D4 Datasheet* for more information about ESP32-PICO-D4.

## 3.4   Strapping Pins

ESP32 has five strapping pins: MTDI, GPIO0, GPIO2, MTDO, GPIO5. The pin-pin mapping between ESP32 and the SiP is as follows, which can be seen in Chapter 5 *Schematics*:

- MTDI = IO12

- GPIO0 = IO0

- GPIO2 = IO2

- MTDO = IO15

- GPIO5 = IO5

Software can read the values of these five bits from register "GPIO_STRAPPING".

During the chip's system reset release (power-on-reset, RTC watchdog reset and brownout reset), the latches of the strapping pins sample the voltage level as strapping bits of "0" or "1", and hold these bits until the chip is powered down or shut down. The strapping bits configure the device's boot mode, the operating voltage of VDD_SDIO and other initial system settings.

Each strapping pin is connected to its internal pull-up/pull-down during the chip reset. Consequently, if a strapping pin is unconnected or the connected external circuit is high-impedance, the internal weak pull-up/pull-down will determine the default input level of the strapping pins.

To change the strapping bit values, users can apply the external pull-down/pull-up resistances, or use the host MCU's GPIOs to control the voltage level of these pins when powering on ESP32.

After reset release, the strapping pins work as normal-function pins.

Refer to Table 3 for a detailed boot-mode configuration by strapping pins.

### Table 3: Strapping Pins

| Voltage of Internal LDO (VDD_SDIO) | | | |
|------|-----------|---------|----------------|
| Pin  | Default   | 3.3 V   | 1.8 V          |
| MTDI | Pull-down | 0       | 1              |
| Booting Mode | | | |
| Pin  | Default   | SPI Boot | Download Boot |
| GPIO0 | Pull-up  | 1       | 0              |

| GPIO2 | Pull-down | Don't-care | | 0 | |
|---|---|---|---|---|---|
| Enabling/Disabling Debugging Log Print over U0TXD During Booting | | | | | |
| Pin | Default | U0TXD Active | | U0TXD Silent | |
| MTDO | Pull-up | 1 | | 0 | |
| Timing of SDIO Slave | | | | | |
| Pin | Default | FE Sampling FE Output | FE Sampling RE Output | RE Sampling FE Output | RE Sampling RE Output |
| MTDO | Pull-up | 0 | 0 | 1 | 1 |
| GPIO5 | Pull-up | 0 | 1 | 0 | 1 |

**Note:**

- FE: falling-edge, RE: rising-edge.

- Firmware can configure register bits to change the settings of "Voltage of Internal LDO (VDD_SDIO)" and "Timing of SDIO Slave", after booting.

- The operating voltage of ESP32-PICO-V3's integrated external SPI flash is 3.3 V. Therefore, the strapping pin MTDI should hold bit "0" during the SiP power-on reset.

# 4. Electrical Characteristics

## 4.1 Absolute Maximum Ratings

Stresses beyond the absolute maximum ratings listed in the table below may cause permanent damage to the device. These are stress ratings only, and do not refer to the functional operation of the device that should follow the recommended operating conditions.

Table 4: Absolute Maximum Ratings

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| VDD33 | Power supply voltage | –0.3 | 3.6 | V |
| $T_{STORE}$ | Storage temperature | –40 | 85 | °C |

> **Note:**
> Please see Appendix IO_MUX of *ESP32 Datasheet* for IO's power domain.

## 4.2 Recommended Operating Conditions

Table 5: Recommended Operating Conditions

| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| VDD33 | Power supply voltage | 3.0 | 3.3 | 3.6 | V |
| $I_{VDD}$ | Current delivered by external power supply | 0.5 | — | — | A |
| T | Operating temperature | –40 | — | 85 | °C |
| Humidity | Humidity condition | — | 85 | — | %RH |

## 4.3 DC Characteristics (3.3 V, 25 °C)

Table 6: DC Characteristics (3.3 V, 25 °C)

| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| $C_{IN}$ | Pin capacitance | - | 2 | - | pF |
| $V_{IH}$ | High-level input voltage | 0.75×VDD[1] | - | VDD[1]+0.3 | V |
| $V_{IL}$ | Low-level input voltage | –0.3 | - | 0.25×VDD[1] | V |
| $I_{IH}$ | High-level input current | - | - | 50 | nA |
| $I_{IL}$ | Low-level input current | - | - | 50 | nA |
| $V_{OH}$ | High-level output voltage | 0.8×VDD[1] | - | - | V |
| $V_{OL}$ | Low-level output voltage | - | - | 0.1×VDD[1] | V |

| Symbol | Parameter | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{OH}$ | High-level source current (VDD[1] = 3.3 V, $V_{OH}$ >= 2.64 V, output drive strength set to the maximum) | VDD3P3_CPU power domain [1, 2] | - | 40 | - | mA |
| | | VDD3P3_RTC power domain [1, 2] | - | 40 | - | mA |
| | | VDD_SDIO power domain [1, 3] | - | 20 | - | mA |
| $I_{OL}$ | Low-level sink current (VDD[1] = 3.3 V, $V_{OL}$ = 0.495 V, output drive strength set to the maximum) | | - | 28 | - | mA |
| $R_{PU}$ | Resistance of internal pull-up resistor | | - | 45 | - | kΩ |
| $R_{PD}$ | Resistance of internal pull-down resistor | | - | 45 | - | kΩ |
| $V_{IL\_nRST}$ | Low-level input voltage of CHIP_PU to power off the chip | | - | - | 0.6 | V |

**Note:**

1. Please see Appendix IO_MUX of *ESP32 Datasheet* for IO's power domain. VDD is the I/O voltage for a particular power domain of pins.

2. For VDD3P3_CPU and VDD3P3_RTC power domain, per-pin current sourced in the same domain is gradually reduced from around 40 mA to around 29 mA, $V_{OH}$>=2.64 V, as the number of current-source pins increases.

3. Pins occupied by flash and/or PSRAM in the VDD_SDIO power domain were excluded from the test.

## 4.4  Current Consumption Characteristics

With the use of advanced power-management technologies, ESP32 can switch between different power modes.

For details on different power modes, please refer to Section *RTC and Low-Power Management* in *ESP32 Datasheet*.

**Table 7: Current Consumption Depending on RF Modes**

| Work mode | Description | | Average (mA) | Peak (mA) |
|---|---|---|---|---|
| Active (RF working) | TX | 802.11b, 20 MHz, 1 Mbps, @19.5 dBm | 233 | 368 |
| | | 802.11g, 20 MHz, 54 Mbps, @14 dBm | 181 | 258 |
| | | 802.11n, 20 MHz, MCS7, @13 dBm | 178 | 248 |
| | | 802.11n, 40 MHz, MCS7, @13 dBm | 162 | 205 |
| | RX | 802.11b/g/n, 20 MHz | 110 | 111 |
| | | 802.11n, 40 MHz | 116 | 117 |

**Note:**

- The current consumption measurements are taken with a 3.3 V supply at 25 °C of ambient temperature at the RF port. All transmitters' measurements are based on a 50% duty cycle.

- The current consumption figures for in RX mode are for cases when the peripherals are disabled and the CPU idle.

**Table 8: Current Consumption Depending on Work Modes**

| Work mode | Description | | Current consumption (Typ) |
|---|---|---|---|
| Modem-sleep | The CPU is powered on | 240 MHz | 30 ~ 68 mA |
| | | 160 MHz | 27 ~ 44 mA |
| | | Normal speed: 80 MHz | 20 ~ 31 mA |
| Light-sleep | — | | 0.8 mA |
| Deep-sleep | The ULP co-processor is powered on. | | 150 $\mu$A |
| | ULP sensor-monitored pattern | | 100 $\mu$A @1% duty |
| | RTC timer + RTC memory | | 10 $\mu$A |
| | RTC timer only | | 5 $\mu$A |
| Power off | CHIP_PU is set to low level, the chip is powered off. | | 1 $\mu$A |

**Note:**

- The current consumption figures in Modem-sleep mode are for cases where the CPU is powered on and the cache idle.

- When Wi-Fi is enabled, the chip switches between Active and Modem-sleep modes. Therefore, current consumption changes accordingly.

- In Modem-sleep mode, the CPU frequency changes automatically. The frequency depends on the CPU load and the peripherals used.

- During Deep-sleep, when the ULP co-processor is powered on, peripherals such as GPIO and I²C are able to operate.

- The "ULP sensor-monitored pattern" refers to the mode where the ULP coprocessor or the sensor works periodically. When ADC works with a duty cycle of 1%, the typical current consumption is 100 $\mu$A.

## 4.5 Wi-Fi RF Characteristics

### 4.5.1 Wi-Fi RF Standards

**Table 9: Wi-Fi RF Standards**

| Name | Description | |
|---|---|---|
| Center frequency range of operating channel [note1] | 2412 ~ 2484 MHz | |
| Wi-Fi wireless standard | IEEE 802.11b/g/n | |
| Data rate | 20 MHz | 11b: 1, 2, 5.5 and 11 Mbps |
| | | 11g: 6, 9, 12, 18, 24, 36, 48, 54 Mbps |
| | | 11n: MCS0-7, 72.2 Mbps (Max) |
| | 40 MHz | 11n: MCS0-7, 150 Mbps (Max) |

**Note:**

1. Device should operate in the center frequency range allocated by regional regulatory authorities. Target center frequency range is configurable by software.

2. For the modules that use IPEX antennas, the output impedance is 50 Ω. For other modules without IPEX antennas, users do not need to concern about the output impedance.

## 4.5.2  Transmitter Characteristics

**Table 10: Transmitter Characteristics**

| Parameter | Rate | Typ | Unit |
|---|---|---|---|
| TX Power [note] | 11b, 1 Mbps | 19.5 | dBm |
| | 11b, 11 Mbps | 19.5 | |
| | 11g, 6 Mbps | 18 | |
| | 11g, 54 Mbps | 14 | |
| | 11n, HT20, MCS0 | 18 | |
| | 11n, HT20, MCS7 | 13 | |
| | 11n, HT40, MCS0 | 18 | |
| | 11n, HT40, MCS7 | 13 | |

**Note:**
Target TX power is configurable based on device or certification requirements.

## 4.5.3  Receiver Characteristics

**Table 11: Receiver Characteristics**

| Parameter | Rate | Typ | Unit |
|---|---|---|---|
| RX Sensitivity | 1 Mbps | −97 | dBm |
| | 2 Mbps | −94 | |
| | 5.5 Mbps | −91 | |
| | 11 Mbps | −88 | |
| | 6 Mbps | −92 | |
| | 9 Mbps | −91 | |
| | 12 Mbps | −89 | |
| | 18 Mbps | −87 | |
| | 24 Mbps | −84 | |
| | 36 Mbps | −80 | |
| | 48 Mbps | −76 | |
| | 54 Mbps | −75 | |
| | 11n, HT20, MCS0 | −91 | |
| | 11n, HT20, MCS1 | −88 | |
| | 11n, HT20, MCS2 | −85 | |
| | 11n, HT20, MCS3 | −83 | |
| | 11n, HT20, MCS4 | −80 | |
| | 11n, HT20, MCS5 | −75 | |
| | 11n, HT20, MCS6 | −74 | |
| | 11n, HT20, MCS7 | −72 | |
| | 11n, HT40, MCS0 | −88 | |
| | 11n, HT40, MCS1 | −85 | |
| | 11n, HT40, MCS2 | −82 | |

| Parameter | Rate | Typ | Unit |
|---|---|---|---|
| | 11n, HT40, MCS3 | −80 | |
| | 11n, HT40, MCS4 | −76 | |
| | 11n, HT40, MCS5 | −72 | |
| | 11n, HT40, MCS6 | −71 | |
| | 11n, HT40, MCS7 | −69 | |
| RX Maximum Input Level | 11b, 1 Mbps | 5 | dBm |
| | 11b, 11 Mbps | 5 | |
| | 11g, 6 Mbps | 0 | |
| | 11g, 54 Mbps | −8 | |
| | 11n, HT20, MCS0 | 0 | |
| | 11n, HT20, MCS7 | −8 | |
| | 11n, HT40, MCS0 | 0 | |
| | 11n, HT40, MCS7 | −8 | |
| Adjacent Channel Rejection | 11b, 11 Mbps | 35 | dB |
| | 11g, 6 Mbps | 27 | |
| | 11g, 54 Mbps | 13 | |
| | 11n, HT20, MCS0 | 27 | |
| | 11n, HT20, MCS7 | 12 | |
| | 11n, HT40, MCS0 | 16 | |
| | 11n, HT40, MCS7 | 7 | |

## 4.6 Bluetooth Radio

### 4.6.1 Receiver – Basic Data Rate

**Table 12: Receiver Characteristics – Basic Data Rate**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Sensitivity @0.1% BER | - | −90 | −89 | −88 | dBm |
| Maximum received signal @0.1% BER | - | 0 | - | - | dBm |
| Co-channel C/I | - | - | +7 | - | dB |
| Adjacent channel selectivity C/I | F = F0 + 1 MHz | - | - | −6 | dB |
| | F = F0 − 1 MHz | - | - | −6 | dB |
| | F = F0 + 2 MHz | - | - | −25 | dB |
| | F = F0 − 2 MHz | - | - | −33 | dB |
| | F = F0 + 3 MHz | - | - | −25 | dB |
| | F = F0 − 3 MHz | - | - | −45 | dB |
| Out-of-band blocking performance | 30 MHz ~ 2000 MHz | −10 | - | - | dBm |
| | 2000 MHz ~ 2400 MHz | −27 | - | - | dBm |
| | 2500 MHz ~ 3000 MHz | −27 | - | - | dBm |
| | 3000 MHz ~ 12.5 GHz | −10 | - | - | dBm |
| Intermodulation | - | −36 | - | - | dBm |

## 4.6.2 Transmitter – Basic Data Rate

**Table 13: Transmitter Characteristics – Basic Data Rate**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| RF transmit power | - | - | 0 | - | dBm |
| Gain control step | - | - | 3 | - | dB |
| RF power control range | - | −12 | - | +9 | dBm |
| +20 dB bandwidth | - | - | 0.9 | - | MHz |
| Adjacent channel transmit power | F = F0 ± 2 MHz | - | −55 | - | dBm |
| | F = F0 ± 3 MHz | - | −55 | - | dBm |
| | F = F0 ± > 3 MHz | - | −59 | - | dBm |
| $\Delta f1_{avg}$ | - | - | - | 155 | kHz |
| $\Delta f2_{max}$ | - | 127 | - | - | kHz |
| $\Delta f2_{avg}/\Delta f1_{avg}$ | - | - | 0.92 | - | - |
| ICFT | - | - | −7 | - | kHz |
| Drift rate | - | - | 0.7 | - | kHz/50 $\mu$s |
| Drift (DH1) | - | - | 6 | - | kHz |
| Drift (DH5) | - | - | 6 | - | kHz |

## 4.6.3 Receiver – Enhanced Data Rate

**Table 14: Receiver Characteristics – Enhanced Data Rate**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| $\pi$/4 DQPSK | | | | | |
| Sensitivity @0.01% BER | - | −90 | −89 | −88 | dBm |
| Maximum received signal @0.01% BER | - | - | 0 | - | dBm |
| Co-channel C/I | - | - | 11 | - | dB |
| Adjacent channel selectivity C/I | F = F0 + 1 MHz | - | −7 | - | dB |
| | F = F0 − 1 MHz | - | −7 | - | dB |
| | F = F0 + 2 MHz | - | −25 | - | dB |
| | F = F0 − 2 MHz | - | −35 | - | dB |
| | F = F0 + 3 MHz | - | −25 | - | dB |
| | F = F0 − 3 MHz | - | −45 | - | dB |
| 8DPSK | | | | | |
| Sensitivity @0.01% BER | - | −84 | −83 | −82 | dBm |
| Maximum received signal @0.01% BER | - | - | −5 | - | dBm |
| C/I c-channel | - | - | 18 | - | dB |
| Adjacent channel selectivity C/I | F = F0 + 1 MHz | - | 2 | - | dB |
| | F = F0 − 1 MHz | - | 2 | - | dB |
| | F = F0 + 2 MHz | - | −25 | - | dB |
| | F = F0 − 2 MHz | - | −25 | - | dB |
| | F = F0 + 3 MHz | - | −25 | - | dB |
| | F = F0 − 3 MHz | - | −38 | - | dB |

### 4.6.4 Transmitter – Enhanced Data Rate

**Table 15: Transmitter Characteristics – Enhanced Data Rate**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| RF transmit power | - | - | 0 | - | dBm |
| Gain control step | - | - | 3 | - | dB |
| RF power control range | - | −12 | - | +9 | dBm |
| $\pi/4$ DQPSK max w0 | - | - | −0.72 | - | kHz |
| $\pi/4$ DQPSK max wi | - | - | −6 | - | kHz |
| $\pi/4$ DQPSK max \|wi + w0\| | - | - | −7.42 | - | kHz |
| 8DPSK max w0 | - | - | 0.7 | - | kHz |
| 8DPSK max wi | - | - | −9.6 | - | kHz |
| 8DPSK max \|wi + w0\| | - | - | −10 | - | kHz |
| $\pi/4$ DQPSK modulation accuracy | RMS DEVM | - | 4.28 | - | % |
| | 99% DEVM | - | 100 | - | % |
| | Peak DEVM | - | 13.3 | - | % |
| 8 DPSK modulation accuracy | RMS DEVM | - | 5.8 | - | % |
| | 99% DEVM | - | 100 | - | % |
| | Peak DEVM | - | 14 | - | % |
| In-band spurious emissions | F = F0 ± 1 MHz | - | −46 | - | dBm |
| | F = F0 ± 2 MHz | - | −44 | - | dBm |
| | F = F0 ± 3 MHz | - | −49 | - | dBm |
| | F = F0 +/− > 3 MHz | - | - | −53 | dBm |
| EDR differential phase coding | - | - | 100 | - | % |

## 4.7 Bluetooth LE Radio

### 4.7.1 Receiver

**Table 16: Receiver Characteristics – BLE**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Sensitivity @30.8% PER | - | −94 | −93 | −92 | dBm |
| Maximum received signal @30.8% PER | - | 0 | - | - | dBm |
| Co-channel C/I | - | - | +10 | - | dB |
| Adjacent channel selectivity C/I | F = F0 + 1 MHz | - | −5 | - | dB |
| | F = F0 − 1 MHz | - | −5 | - | dB |
| | F = F0 + 2 MHz | - | −25 | - | dB |
| | F = F0 − 2 MHz | - | −35 | - | dB |
| | F = F0 + 3 MHz | - | −25 | - | dB |
| | F = F0 − 3 MHz | - | −45 | - | dB |
| Out-of-band blocking performance | 30 MHz ~ 2000 MHz | −10 | - | - | dBm |
| | 2000 MHz ~ 2400 MHz | −27 | - | - | dBm |
| | 2500 MHz ~ 3000 MHz | −27 | - | - | dBm |
| | 3000 MHz ~ 12.5 GHz | −10 | - | - | dBm |

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Intermodulation | - | −36 | - | - | dBm |

## 4.7.2 Transmitter

**Table 17: Transmitter Characteristics – BLE**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| RF transmit power | - | - | $0^{note}$ | - | dBm |
| Gain control step | - | - | 3 | - | dB |
| RF power control range | - | −12 | - | +9 | dBm |
| Adjacent channel transmit power | F = F0 ± 2 MHz | - | −55 | - | dBm |
| | F = F0 ± 3 MHz | - | −57 | - | dBm |
| | F = F0 ± > 3 MHz | - | −59 | - | dBm |
| $\Delta f1_{avg}$ | - | - | - | 265 | kHz |
| $\Delta f2_{max}$ | - | 210 | - | - | kHz |
| $\Delta f2_{avg}/\Delta f1_{avg}$ | - | - | +0.92 | - | - |
| ICFT | - | - | −10 | - | kHz |
| Drift rate | - | - | 0.7 | - | kHz/50 $\mu$s |
| Drift | - | - | 2 | - | kHz |

**Note:**

There are a total of eight power levels from 0 to 7, and the transmit power ranges from −12 dBm to 9 dBm. When the power level rises by 1, the transmit power increases by 3 dB. Power level 4 is used by default and the corresponding transmit power is 0 dBm.

# 5.   Schematics
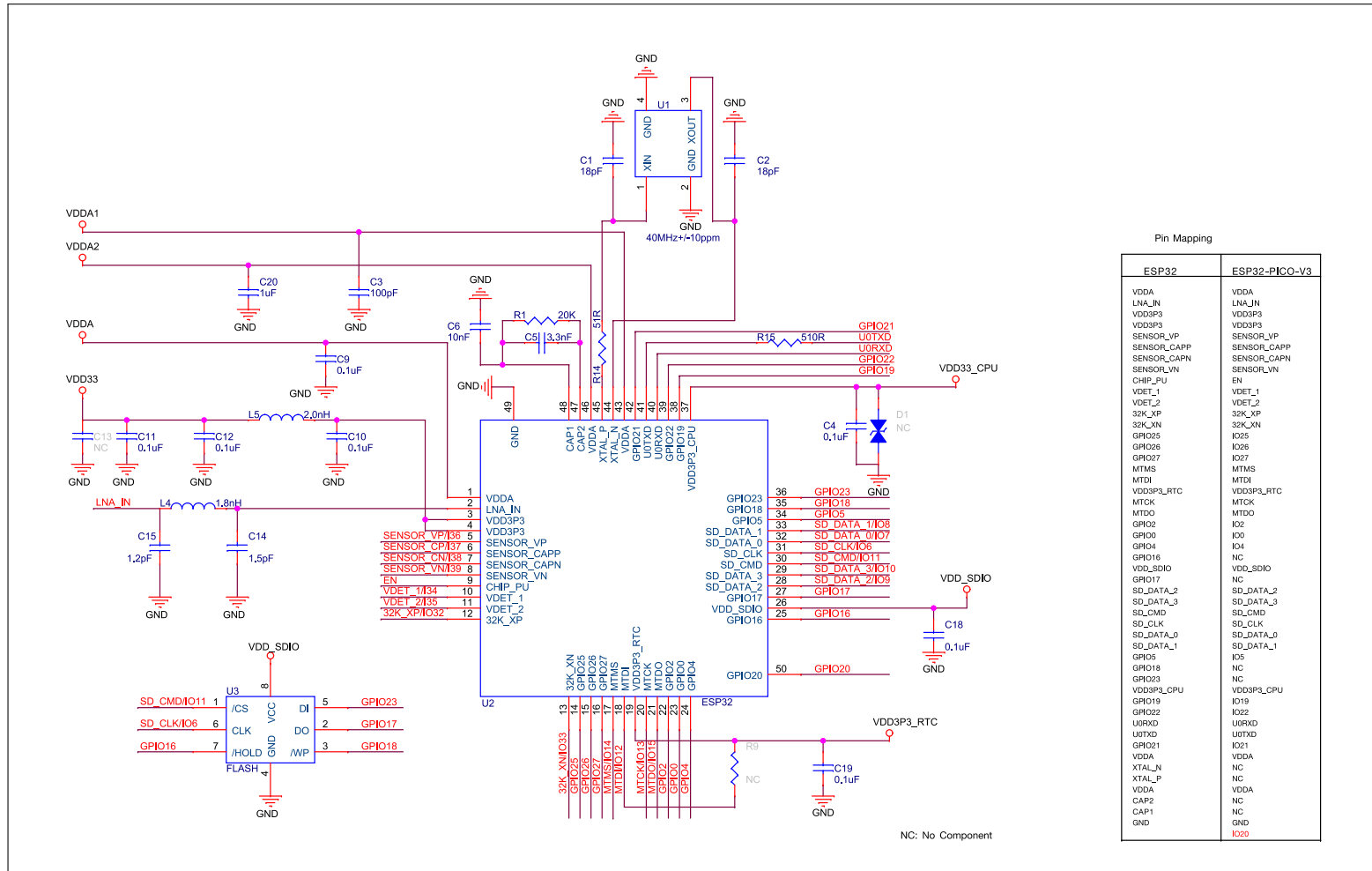
This is the reference design of the module.



**Figure 3: ESP32-PICO-V3 Schematics**

# 6.   Peripheral Schematics

This is the typical application circuit of the module connected with peripheral components (for example, power supply, antenna, reset button, JTAG interface, and UART interface).
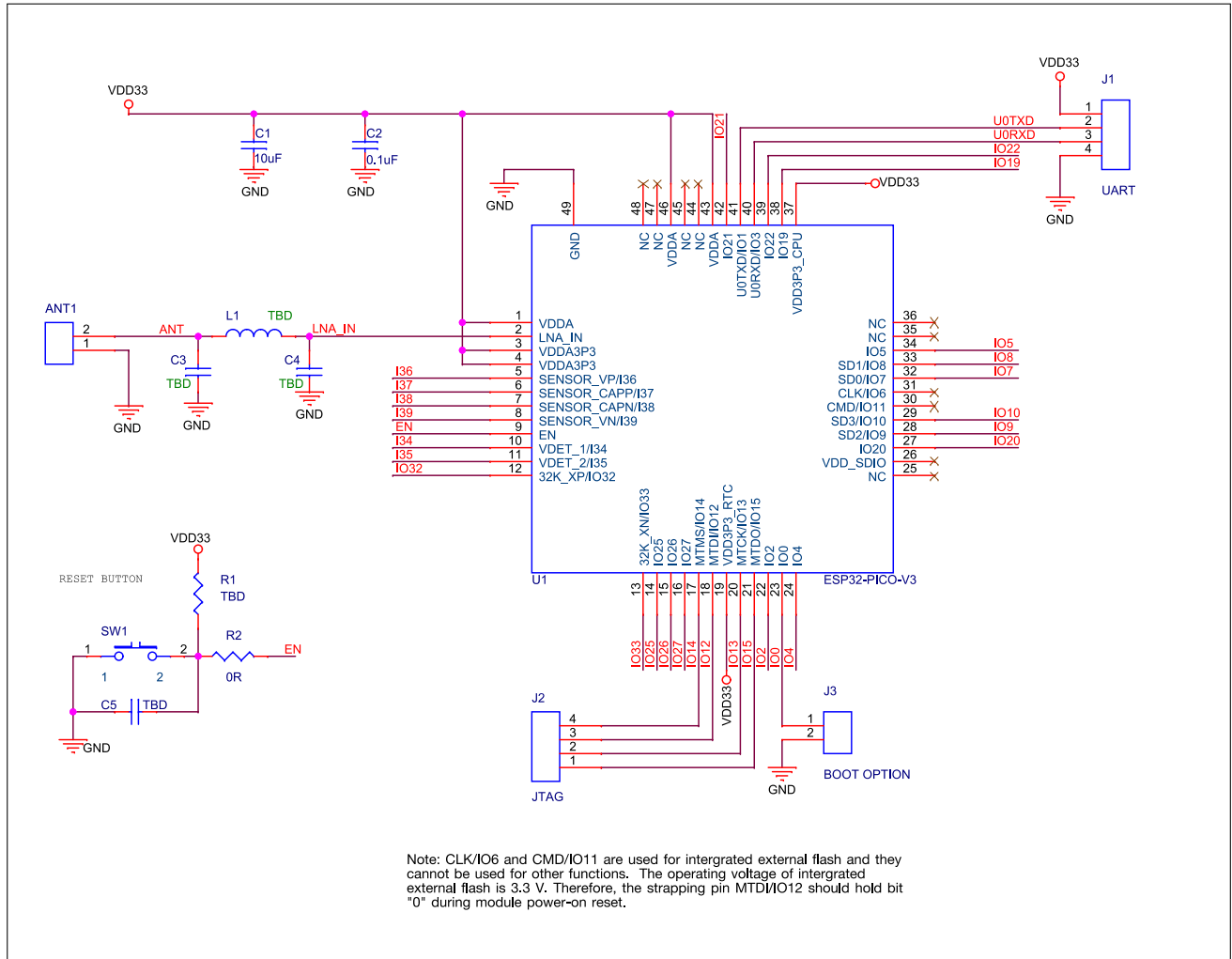


**Figure 4: ESP32-PICO-V3 Peripheral Schematics**

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**Note:**

To ensure the power supply to the ESP32 chip during power-up, it is advised to add an RC delay circuit at the EN pin. The recommended setting for the RC delay circuit is usually R = 10 kΩ and C = 0.1 μF. However, specific parameters should be adjusted based on the power-up timing of the module and the power-up and reset sequence timing of the chip. For ESP32's power-up and reset sequence timing diagram, please refer to Section *Power Scheme* in *ESP32 Datasheet*.
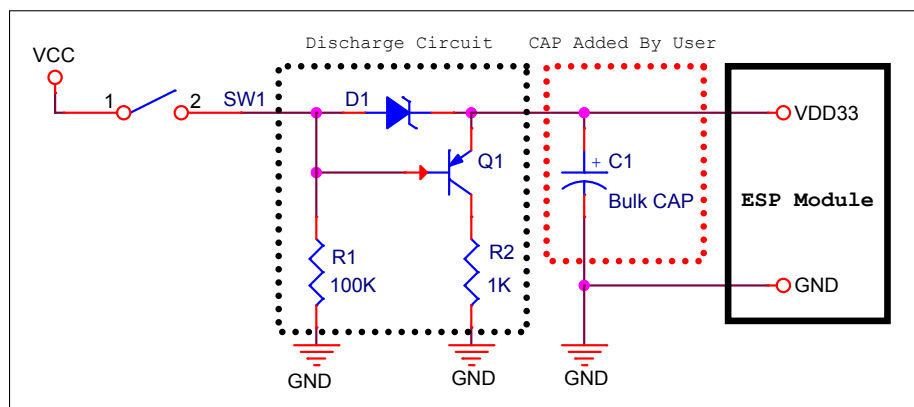
---

**Figure 5: Discharge Circuit for VDD33 Rail**

**Note:**

The discharge circuit can be applied in scenarios where ESP32 is powered on and off repeatedly by switching the power rails, and there is a large capacitor on the VDD33 rail. For details, please refer to Section *Power Scheme* in *ESP32 Datasheet*.
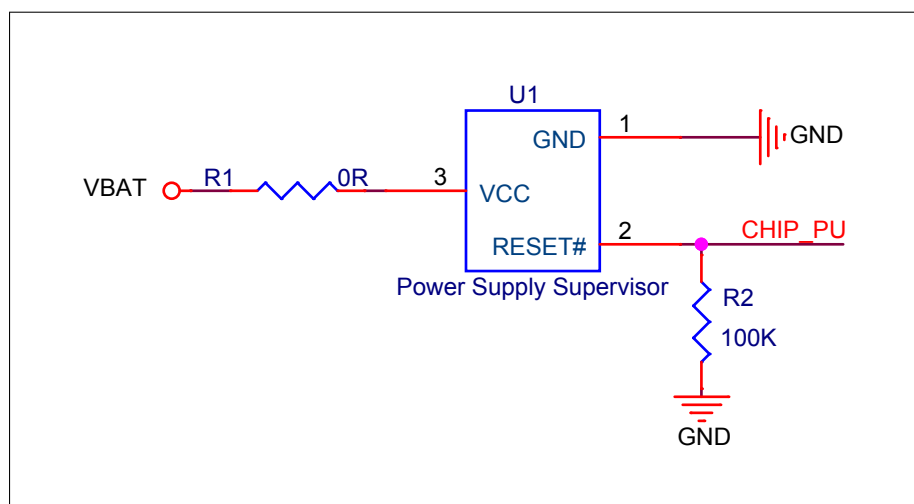


**Figure 6: Reset Circuit**

**Note:**

When battery is used as the power supply for ESP32 series of chips and modules, a supply voltage supervisor is recommended to avoid boot failure due to low voltage. Users are recommended to pull CHIP_PU low if the power supply for ESP32 is below 3.0 V.
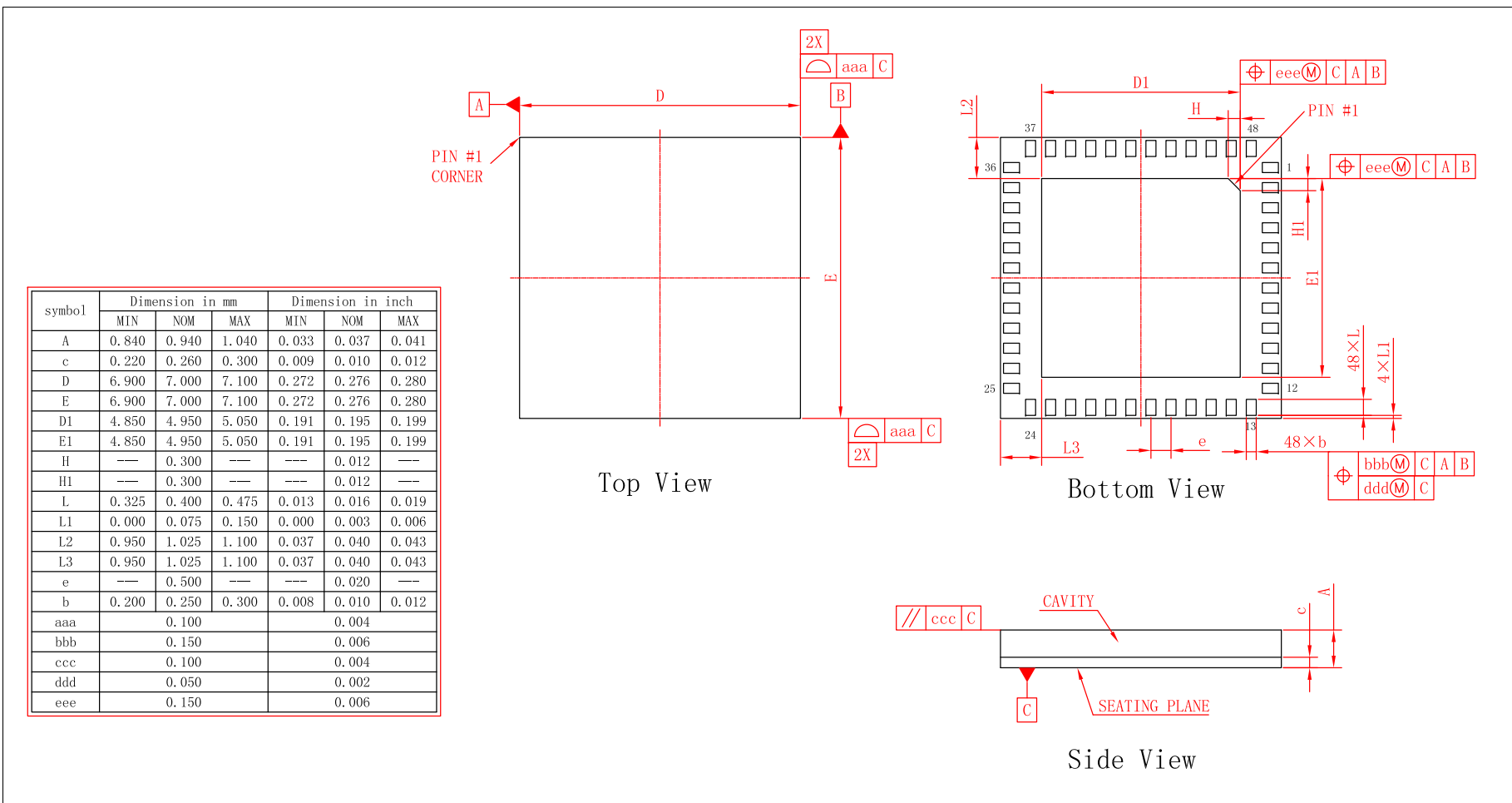
# 7.  Package Information



| symbol | Dimension in mm | | | Dimension in inch | | |
|--------|------|------|------|------|------|------|
|        | MIN  | NOM  | MAX  | MIN  | NOM  | MAX  |
| A      | 0.840 | 0.940 | 1.040 | 0.033 | 0.037 | 0.041 |
| c      | 0.220 | 0.260 | 0.300 | 0.009 | 0.010 | 0.012 |
| D      | 6.900 | 7.000 | 7.100 | 0.272 | 0.276 | 0.280 |
| E      | 6.900 | 7.000 | 7.100 | 0.272 | 0.276 | 0.280 |
| D1     | 4.850 | 4.950 | 5.050 | 0.191 | 0.195 | 0.199 |
| E1     | 4.850 | 4.950 | 5.050 | 0.191 | 0.195 | 0.199 |
| H      | ---- | 0.300 | ---- | ---- | 0.012 | ---- |
| H1     | ---- | 0.300 | ---- | ---- | 0.012 | ---- |
| L      | 0.325 | 0.400 | 0.475 | 0.013 | 0.016 | 0.019 |
| L1     | 0.000 | 0.075 | 0.150 | 0.000 | 0.003 | 0.006 |
| L2     | 0.950 | 1.025 | 1.100 | 0.037 | 0.040 | 0.043 |
| L3     | 0.950 | 1.025 | 1.100 | 0.037 | 0.040 | 0.043 |
| e      | ---- | 0.500 | ---- | ---- | 0.020 | ---- |
| b      | 0.200 | 0.250 | 0.300 | 0.008 | 0.010 | 0.012 |
| aaa    | 0.100 | | | 0.004 | | |
| bbb    | 0.150 | | | 0.006 | | |
| ccc    | 0.100 | | | 0.004 | | |
| ddd    | 0.050 | | | 0.002 | | |
| eee    | 0.150 | | | 0.006 | | |

**Figure 7: ESP32-PICO-V3 Package**

# 8. Product Handling

## 8.1 Storage Condition

The products sealed in Moisture Barrier Bag (MBB) should be stored in a noncondensing atmospheric environment of < 40 °C/90%RH.

The module is rated at moisture sensitivity level (MSL) 3.

After unpacking, the module must be soldered within 168 hours with factory conditions 25±5 °C/60%RH. The module needs to be baked if the above conditions are not met.

## 8.2 ESD

- Human body model (HBM): 2000 V

- Charged-device model (CDM): 500 V

- Air discharge: 6000 V

- Contact discharge: 4000 V
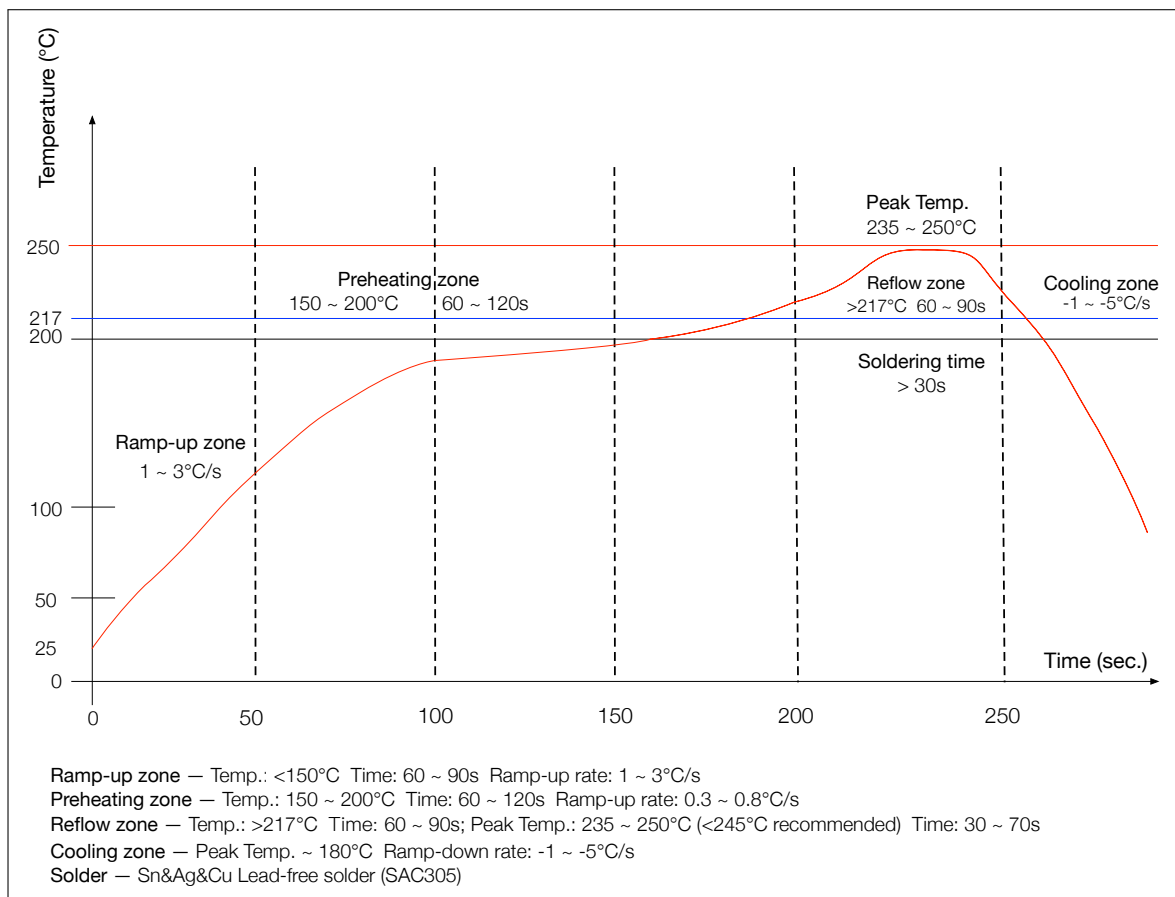
## 8.3 Reflow Profile



Figure 8: Reflow Profile

> **Note:**
> Solder the module in a single reflow. If the PCBA requires multiple reflows, place the module on the PCB during the final reflow.

# 9. MAC Addresses and eFuse

The eFuse in ESP32 has been burnt into 48-bit mac_address. The actual addresses the chip uses in station, AP, BLE, and Ethernet modes correspond to mac_address in the following way:

- Station mode: mac_address

- AP mode: mac_address + 1

- BLE mode: mac_address + 2

- Ethernet mode: mac_address + 3

In the 1 Kbit eFuse, 256 bits are used for the system (MAC address and chip configuration) and the remaining 768 bits are reserved for customer applications, including flash-encryption and chip-ID.

# 10. Learning Resources

## 10.1 Must-Read Documents

The following link provides documents related to ESP32.

- *ESP32 Datasheet*

  This document provides an introduction to the specifications of the ESP32 hardware, including overview, pin definitions, functional description, peripheral interface, electrical characteristics, etc.

- *ESP32 ECO V3 User Guide*

  This document describes differences between V3 and previous ESP32 silicon wafer revisions.

- *ECO and Workarounds for Bugs in ESP32*

  This document details hardware errata and workarounds in the ESP32.

- *ESP-IDF Programming Guide*

  It hosts extensive documentation for ESP-IDF ranging from hardware guides to API reference.

- *ESP32 Technical Reference Manual*

  The manual provides detailed information on how to use the ESP32 memory and peripherals.

- ESP32 Hardware Resources

  The zip files include the schematics, PCB layout, Gerber and BOM list of ESP32 modules and development boards.

- *ESP32 Hardware Design Guidelines*

  The guidelines outline recommended design practices when developing standalone or add-on systems based on the ESP32 series of products, including the ESP32 chip, the ESP32 modules and development boards.

- *ESP32 AT Instruction Set and Examples*

  This document introduces the ESP32 AT commands, explains how to use them, and provides examples of several common AT commands.

- *Espressif Products Ordering Information*

## 10.2 Must-Have Resources

Here are the ESP32-related must-have resources.

- ESP32 BBS

  This is an Engineer-to-Engineer (E2E) Community for ESP32 where you can post questions, share knowledge, explore ideas, and help solve problems with fellow engineers.

- ESP32 GitHub

  ESP32 development projects are freely distributed under Espressif's MIT license on GitHub. It is established to help developers get started with ESP32 and foster innovation and the growth of general knowledge about the hardware and software surrounding ESP32 devices.

- **ESP32 Tools**

  This is a webpage where users can download ESP32 Flash Download Tools and the zip file "ESP32 Certification and Test".

- **ESP-IDF**

  This webpage links users to the official IoT development framework for ESP32.

- **ESP32 Resources**

  This webpage provides the links to all available ESP32 documents, SDK and tools.

# Revision History

| Date | Version | Release notes |
|------|---------|---------------|
| 2020-04-16 | V1.0 | First release |