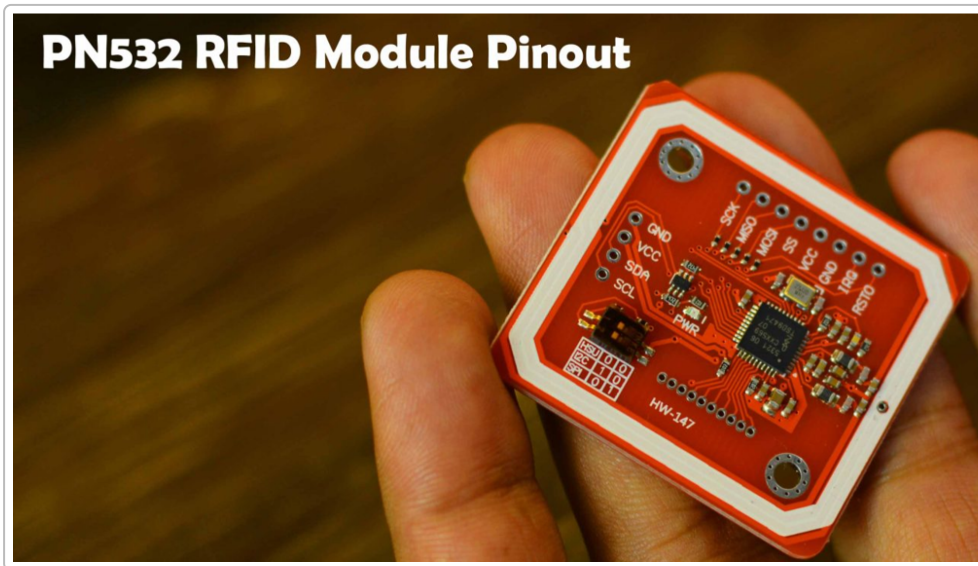
ChatGPT

Hardware Components Specification Verification

ESP32 WROOM-32D

- **Power:** Operates at 2.7–3.6 V (nominal 3.3 V) [1]. The dev-board (CH340C, USB-C) has an onboard regulator, so it accepts 5 V USB input.
- **Logic levels:** All I/O are 3.3 V (max 3.6 V) [1]. The USB-serial (CH340C) converts to 3.3 V for the ESP32.
- **Baud rates:** Default boot UART = 115200 baud; the ESP32's hardware UARTs can run up to multiple Mbps (e.g. 115200–460800 typically).
- **Level shifting:** None needed for 3.3 V devices. (To connect a 5 V device, use a level shifter.)
- **Pull-ups:** The ESP32's I^{2}C lines (GPIO21/SDA, 22/SCL) require external pull-ups to 3.3 V (the user's 4.7 kΩ are suitable). The module itself does not include I^{2}C pull-ups.
- **Current draw:** Must supply ~500 mA peak (datasheet lists IVDD ≈0.5 A) [1]. Typical USB supply is 500–1000 mA, so use a stable 5 V source if driving Wi-Fi/Bluetooth.
- **Compatibility:** The ESP32's GPIOs can source/sink ≈40 mA each. Ensure any connected sensor/support logic is 3.3 V.



PN532 NFC Module V3: The PN532 breakout contains an NXP PN532 chip (requires 2.7–3.6 V, typical 3.3 V) [1]. The V3 board adds a 3.3 V regulator and a 4050-type level translator, so it can accept 5 V input and even 5 V TTL on I^{2}C/UART lines [2] [3] (SPI pins remain 3.3 V). In I^{2}C mode the chip's default 7-bit address is 0x24 (shown as 0x48) [4]. The breakout **requires pull-ups** on SDA and SCL to 3.3 V (Adafruit recommends ~1.5 kΩ, here 4.7 kΩ was chosen) [5]. It also supports SPI and High-Speed UART (default 115200 baud). No extra components are needed beyond decoupling capacitors.

- **Power:** Feed VCC to 5 V (board regulator) or 3.3 V. GND common.
- **Interface:** Use I^{2}C (SDA/SCL) or SPI/HSU (set SEL0/SEL1 jumpers accordingly). For I^{2}C, connect SDA→GPIO21, SCL→GPIO22.

- **Speed:** I²C up to 100/400 kHz (with pull-ups) or SPI at up to ~1 MHz. UART default 115200 baud (can often be changed in software).
- **Level shifting:** Not needed for ESP32 (3.3 V signals match the PN532 I/O). The board tolerates either logic level on I²C/UART.
- **Note:** The module's datasheet (PN532) specifies 100 nF decoupling [6]. The Adafruit breakouts use a 4050 buffer. Many cheap clones say "supports 5 V", but confirm with pull-ups as above.

HLK-LD2410C Radar Sensor

- **Power:** 5–12 V DC input [7] (user supplies 5 V). Typical current ~80 mA at 5 V.
- **Logic levels:** Outputs are digital (GPIO or UART) at 3.3 V TTL [8]. Common ground with ESP32.
- **Baud rate:** The default serial baud is **256000** (factory setting 0x0007 = 256000) [9]. It can be reconfigured via commands if needed (e.g. to 115200).
- **Level shifting:** None needed between the module and ESP32 (both use 3.3 V for UART/GPIO). Connect its TX→ESP RX1 and RX→ESP TX1 directly.
- **Outputs:** Provides "Human presence" data via UART (ASCII) or a high/low GPIO. Use UART for detailed info.
- **Notes:** Detection range up to ~5 m [10] with 0.75 m resolution. No I²C address. Ensure Serial1 on the ESP32 matches the radar's baud.

Waveshare Finger Vein Module (A)

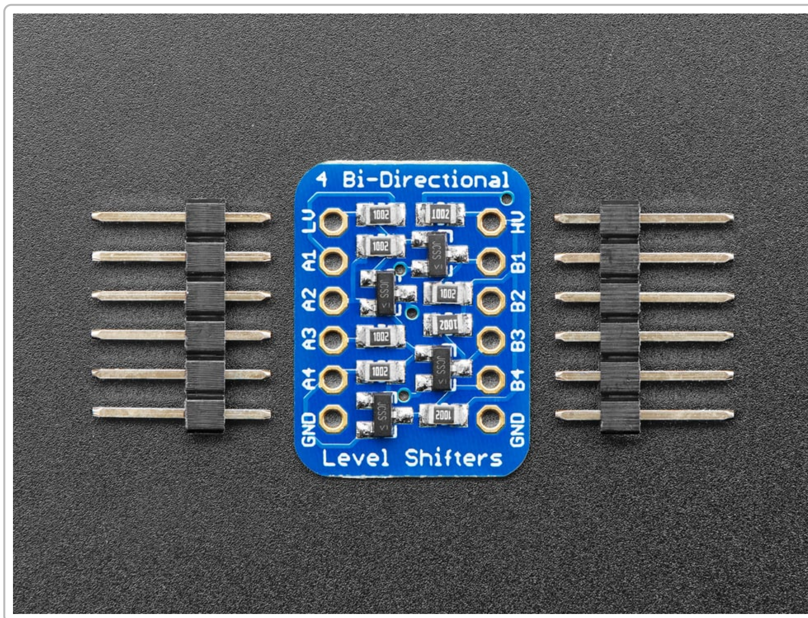
- **Power:** 3.3 V only [11]. Supply from ESP32's 3.3 V rail. Do NOT feed 5 V.
- **Logic levels:** UART interface at 3.3 V TTL [12]. Connect TX/RX to ESP32 UART2 (e.g. GPIO16/GPIO17).
- **Baud rate:** Default 57600 bps [12] (configurable via commands).
- **Level shifting:** Not needed (all I/O is 3.3 V).
- **Current draw:** ~43 mA active [11] (standby ~2 μA). Ensure 3.3 V supply can provide this.
- **Pull-ups:** None required; it's not I²C.
- **Notes:** The device is self-contained (Cortex-M4F + imaging). Only one connector pinout is exposed. No external passive parts are needed other than wiring. The module is IP56-rated, so it's sealed.

HLK-TX510 Face Recognition Test Suit

- **Power:** 5 V via USB-C [13]. The kit normally uses a 5 V/1 A adapter (measured draw ~300 mA). Ensure the USB-C cable/port presents +5 V (use CC pull-downs if needed on the breakout).
- **Logic levels:** Communications use TTL UART pins on the P2 header. These are 5 V levels. The user's wiring correctly routes ESP32 (3.3 V) through a level shifter to the TX510's TX/RX.
- **Baud rate:** 115200 bps [14]. (Sometimes documentation calls this "Frequency: 115200".)
- **Level shifting:** Required. The module's UART I/O are 5 V TTL, so the ESP32 uses a 3.3 V↔5 V converter.
- **Pull-ups:** Not applicable (UART).
- **UART pins:** The correct labels (after firmware updates) are TX=USI1_SDO, RX=USI1_SCLK on P2 [15]. The wiring should connect TX510's TX pin→ESP RX and TX510's RX→ESP TX.
- **Notes:** The display and cameras are on the board, but irrelevant to the UART interface. Use the included commands to enroll/delete faces. If using custom power injection, remember CC resistors for USB-C.

5V 1-Channel Relay Module

- **Power:** 5 V DC for the coil and logic [16]. Connect VCC+ to 5 V, GND to ground.
- **Trigger:** This board is **optically isolated, low-level trigger** by default [17]. That means driving the IN pin LOW (0 V) activates the relay. A jumper allows high-level triggering if needed.
- **Input current:** The coil draws ~70–80 mA. The opto-LED input needs ~15–20 mA drive [17].
- **Level shifting:** If using low-level trigger, the ESP32 can pull IN to GND directly (0 V) with no shifter. If configured for high-level trigger, 3.3 V from the ESP32 may not be seen as a full HIGH on a 5 V board (you'd need a buffer or modify R1 from 1 kΩ to ~220 Ω). In doubt, continue using the level shifter on the input.
- **Pull-ups:** The module includes a 1 kΩ pull-up on IN (to 5 V) when the jumper is set for high-level operation [18]. No additional resistor is needed.
- **Flyback:** Board has a built-in diode for the coil. No external diode needed.
- **Notes:** If isolating, remove the VCC–JD-VCC jumper and supply coil separately. Otherwise keep jumper in place. Each relay channel can switch up to 10 A at AC250 V/DC30 V (SPDT contacts). Ensure the ESP32 ground is common if not fully isolating.



Logic Level Converter (4-channel): These cheap 4-ch shifter boards use BSS138 MOSFETs with built-in ~10 kΩ pull-ups on each channel [19]. They support a wide range: the LV side can go as low as ~1.8 V (3.3 V is normal) and the HV side up to ~10 V (5 V normal) [19]. They're **bidirectional (open-drain)**, so they are ideal for I^2C or other open-drain signals. They also work for slow push-pull signals: Adafruit notes they handle TTL serial and SPI up to ~2 MHz [19]. However, they are *not* meant for high speeds or heavy loads (do not drive LEDs or motors through them). Pull-ups to the HV rail are already on-board; for I^2C we already add 4.7 kΩ to 3.3 V. No other parts are needed on these modules.

- **Wiring:** Connect HV to 5 V, LV to 3.3 V (common GND). Place signals on corresponding A/B side pins.
- **Speed:** Suitable for I^2C (100/400 kHz) and UART (e.g. $\leq$115200 baud). Not for >2 MHz SPI or clocked buses.

- **Alternatives:** For higher-speed level shifting, use dedicated ICs (e.g. TXB0108 for general GPIO, or a proper I²C level shifter). For simple logic conversion, these modules suffice.
- **AliExpress note:** These modules are ubiquitous on Chinese sites; functionality matches the Adafruit description [19], but quality of soldering/pull-ups may vary.

USB-C Breakout Board

- **Purpose:** USB-C socket breakout to inject 5 V into our 5 V rail.
- **CC pins:** Must add pull-down resistors. Specifically, solder ~5.1 kΩ 1% resistors from CC1 and CC2 pins to GND [20]. This advertises to the upstream port that we are a device, causing it to supply 5 V on VBUS. Without CC resistors, the host will not enable VBUS [20].
- **Connections:** VBUS pin → +5 V rail. GND → ground. (D+ and D– exist but are unused.) CC1/CC2 with pull-downs to GND.
- **No extras:** The board is passive. It likely has no fuse or TVS. If reliability is a concern, consider adding a resettable fuse on VBUS.
- **Notes:** Ensure the orientation of the Type-C connector is correct for your application (some breakouts have pins for flip orientation). Check continuity of 5 V line after adding CC resistors.

NTAG215 NFC Cards

- **Type:** NXP NTAG215, NFC Forum Type 2 tag (ISO14443A).
- **Frequency/Data rate:** 13.56 MHz RF at 106 kbit/s [21].
- **Memory:** 504 bytes user memory [22] (about 540 bytes total EEPROM including lock bytes [23]). Organized in 4-byte pages.
- **Passive:** No power supply or wiring – the PN532 provides the RF field. Place the card within a few centimeters of the antenna. The datasheet notes up to ~10 cm under ideal conditions [21] (practically ~2–5 cm in our coil).
- **Addressing:** The cards are polled by the PN532; no I²C address. Use the PN532 library to detect UID and read/write pages.
- **Compatibility:** Fully supported by NFC libraries. Each card has a unique 7-byte UID. Write protection and NDEF formats follow NFC spec.
- **Notes:** The NTAG215 is commonly used (e.g. in collectible “Amiibo” figures). Performance of Chinese NTAG tags is usually identical to genuine NXP. Write endurance is ~100k cycles. For multiple cards, ensure proper anti-collision handling.

Sources: Specifications and datasheets from Espressif, NXP, Waveshare, Hi-Link, Adafruit, etc., have been used to verify each parameter [1] [11] [2] [17] [19] [20] [22] [21]. Any absent data was not found in these sources.

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[2] [3] PN532 RFID NFC Module with Arduino, How to use HSU UART, SPI, & I2C
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