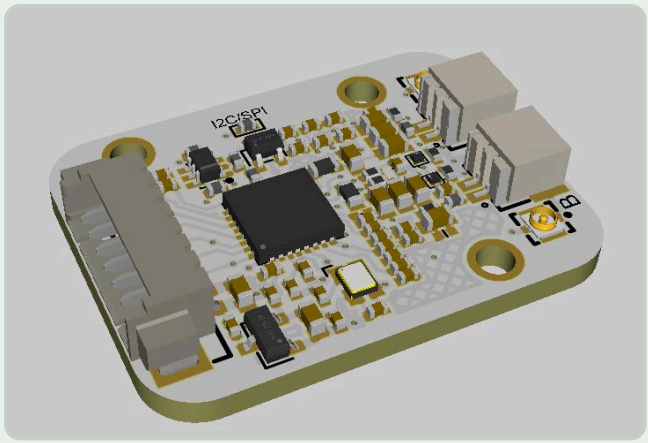
USER MANUAL · HARDWARE V1

ST25R3916B Mini AAT NFC Reader Module with Dual Antennas

The reader module supports Automatic Antenna Tuning (AAT) on both 13.56 MHz antenna paths. Connect the two PCB loops using one 40 cm lead per loop and poll the two reading areas from a single host.

13.56 MHz | 3.3–5.0 V input | I²C by default



Reader module, 3D rendering.

Product overview

The ST25R3916B reader IC drives two external single-ended antenna paths. Host firmware selects A or B and associates each detection with the active path. The ESP32-S3 example polls the antennas in turn and switches the RF field off between antenna visits.

Each antenna has a voltage-controlled matching network. The host uses the reader's amplitude and phase measurements to select a tuning setting for each path. This gives the firmware a way to compensate for changes in antenna loading within the range of the matching network.

Included in the kit

- 1 reader module
- 1 large PCB antenna, 311 × 215 mm
- 1 small PCB antenna, 283 × 187 mm
- 2 antenna leads, 40 cm each

Reader IC	STMicroelectronics ST25R3916B-AQWT
RF frequency	13.56 MHz
Power input	3.3–5.0 V DC at host connector pin 6. The reference hookup uses 5 V.
Host interface	I²C by default, 7-bit address `0x50`. SPI selectable via the marked I²C/SPI mode link.
Antenna ports	Two independent matching paths with an alternate micro-coax connector on each
Module footprint	Approx. 27 × 20 mm, PCB outline
Antenna leads	**40 cm each**, between the reader module and each loop
Loop frame sizes	Outer 311 × 215 mm. Inner 283 × 187 mm. Nominal antenna PCB thickness 0.8 mm.

Wiring and antenna installation

Host connector

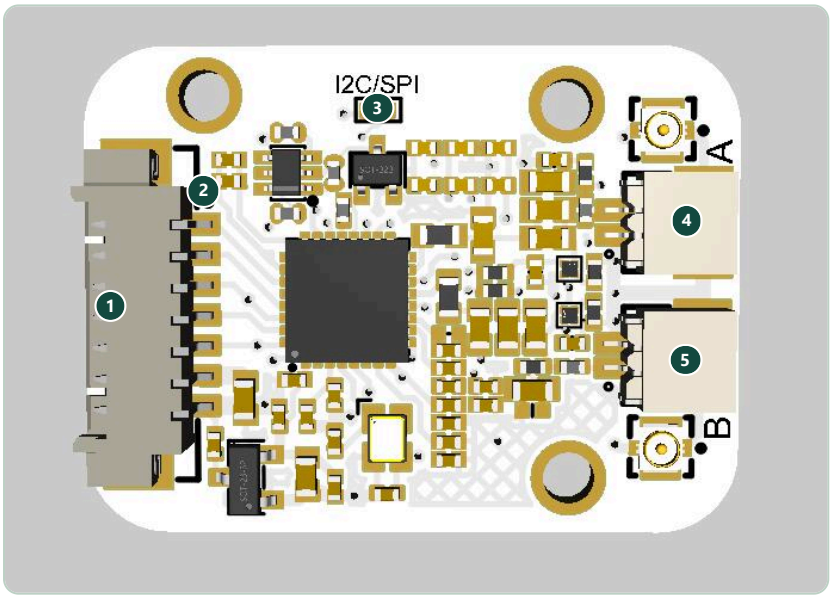
Disconnect power before wiring. Viewed from the component side with the **I2C/SPI** marking at the top and the host connector at the left, pin 1 is at the top of the connector and pin 7 is at the bottom. Check the connector pin numbers against the component-side view below before applying power.

Host connector pinout · 7 positions, 1.25 mm pitch

Pin	Signal	ESP32-S3 Mini, I²C	SPI function
1	IRQ	GPIO4	IRQ
2	BSS / CS	Leave open	Chip select
3	SCLK / SCL	GPIO9 (SCL)	SCLK
4	MOSI	Leave open	MOSI
5	MISO / SDA	GPIO8 (SDA)	MISO
6	VCC	3.3–5.0 V DC. This example uses 5 V from a suitable USB supply rail.	3.3–5.0 V DC
7	GND	Host ground	Host ground

The module's I²C pull-ups are tied to its onboard logic rail, nominally 3.0 V with the specified regulator. Use a host compatible with that logic level, share ground, and keep SDA and SCL free of 5 V pull-ups. The example starts I²C at 100 kHz.

To select SPI, power down, remove the **I²C/SPI mode link** inside the printed **I2C/SPI** outline and leave the two pads open. Rewire the bus for SPI and use a host driver configured for SPI. The quick-start sketch below uses I²C.



1 Host connector 2 Host connector pin 1 3 I²C/SPI mode link
4 Antenna A socket 5 Antenna B socket

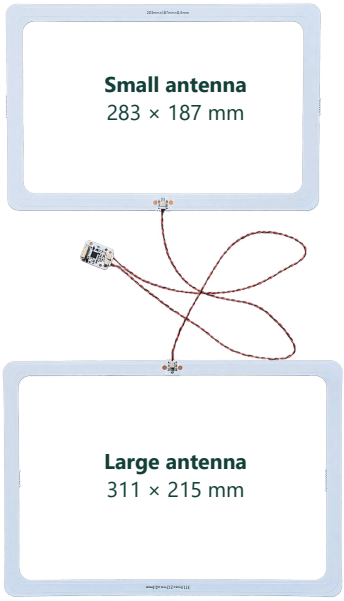
Reader module, component-side 3D view. The round micro-coax sockets next to A and B are alternate connections for the corresponding antenna paths.

Separate and connect the antennas

1. With the module unpowered, separate the large and small PCB frames at the factory breakaway tabs if they are still joined. Install the two frames separately.
2. Connect each frame to one of the reader's two-pin antenna ports using its own 40 cm lead. The two ports are labeled A and B on the reader.



Before separation. The two frames are joined on the manufacturing panel. This is a 3D rendering.



After separation. Each frame has its own 40 cm lead to the reader. Background removed from the product photo.

Reader-side antenna ports

Path	Two-pin connector	Alternate micro-coax connection
A	Pin 1 GND, pin 2 RF	Round socket next to A
B	Pin 1 RF, pin 2 GND	Round socket next to B

Use one connector per RF path. Each antenna frame has one feed connector. Check the RF and ground assignments at both ends if using a custom harness.

For the reference Type B configuration, connect the small antenna to port A and the large antenna to port B. The example applies a Type B tuning and drive profile on port B for this large antenna. Recheck the profile and rerun tuning if you change the antenna assignment.

Secure both frames and route the leads in their installed positions before tuning. Test each antenna with the other installed, then verify dual-path polling.

Quick start with ESP32-S3

> **Use expendable test tags with the example firmware.**
> After startup, the example repeatedly writes random data and verifies the readback. It leaves the test data on the tag. Keep production and personal tags outside the reading area.

1. With power off, connect the host connector to the ESP32-S3 Mini as shown above. Confirm the antenna frames are separate, connect both with the 40 cm leads and keep the antennas clear of tags during startup.
2. Download the repository containing both Arduino libraries, **ST25R3916_ELECHOUSE** and **NFC-RFAL**. Build and flash the dual-antenna I^2C test sketch using the linked guide. Arduino libraries · Basic test guide
3. Open the native USB serial port at **115200 baud**. Power-cycle or reset the host with both antennas connected. Check for `IC_IDENTITY`, both `PATH` messages and `AAT_BOOT status=PASS`.
4. Place one writable test tag close to the center of one loop. Check for the correct channel and an `AUTO_RESULT` of `PASS`. Remove the tag and repeat on the other loop.

Reference firmware and test guide

The guide covers ESP32-S3 build and upload, startup tuning, testing each antenna, and reproducing the write/read distance measurements. The example uses the Arduino ESP32 core 3.3.8 and native USB serial. ESP32-S3 example source · Basic test guide

Serial controls

Send single-letter and digit commands as individual characters. Terminate `@` commands with a newline. `s` stops polling and turns off the RF field. The example resumes its default automatic test mode after a reset.

Command	Action
`i` / `t`	Print help and status / toggle detailed logging.
`s`	Stop polling and switch off RF.
`a`, `1`, `2`	Run automatic tests on both paths, A only, or B only.
`n`, `v`, `b`, `f`	Poll NFC-A, NFC-A/V, NFC-A/B/V (default), or NFC-A/B/V/F.
`@AUTO STATUS`	Show automatic-test settings and per-path counts.
`@READ B T <UID>`	Read 16 bytes starting at Type 2 page 4 on path B. Replace `<UID>` with the tag's hexadecimal UID. Send `s` before placing the tag to prevent automatic writes.

Automatic Antenna Tuning

Each antenna path has its own electronically adjustable matching circuit and tuning setting.

The firmware selects one path and varies its 8-bit DAC while holding the other DAC fixed. At startup the self-test probes several DAC settings and checks for a change in amplitude or phase. The tuning search then uses the measured response to select a setting and verifies the values by register readback. If the self-test fails, the firmware reports a fault and retains the previous setting on that path.

The reference example runs the tuning routine at startup or on request. For a baseline, keep both loops and cables in their final positions, clear tags and hands from the coils, and tune the two paths separately. Then measure with a tag held in a repeatable position, using the same DAC and drive settings.

```
s
@AAT A
@AAT B
@AAT EVAL A EMPTY
@AAT EVAL B EMPTY
```

With the test tag in place, send `@AAT EVAL A LOADED` or `@AAT EVAL B LOADED` for the appropriate path. Each evaluation takes eight amplitude and phase samples without changing the DAC or writing to the tag. `EMPTY` and `LOADED` are labels entered by the operator. Send `a` after removing the tag to resume dual-path polling.

- `@AAT STATUS` shows whether the DAC outputs are enabled, whether each tuning search ran, and the expected and actual DAC codes. This command pauses polling.
- `target_fit_pct` expresses how close the amplitude and phase readings came to the configured firmware targets. Confirm RF behavior with the intended tag, enclosure and cable geometry.
- `DAC_LIMIT` or `MEAS_LIMIT` indicates proximity to a tuning or measurement limit. Inspect the antenna, feed and matching network before interpreting the readings.

When integrating your own host, retain one tuning state per path and verify that protocol changes preserve those values. See the ST application notes for antenna matching and DAC control. ST AN5322 · ST AN5592

Reference host LEDs

Indication	Meaning
RGB blue, steady	Startup AAT checks passed. The blue indication clears on first tag detection.
RGB blue, blinking	Startup AAT fault. Inspect `AAT_SELFTEST`, `AAT_WARNING` and `AAT_BOOT` in the serial log. Blue takes priority over the B green indication.
Discrete LED / RGB green	Antenna A uses the discrete LED. Antenna B uses RGB green. Steady indicates a successful write and matching readback, fast blinking indicates failed or unsupported testing, and off indicates no current result for a present tag.

These indications use the LEDs on the reference ESP32-S3 host. LED wiring varies between ESP32-S3 Mini boards.

Tag support in the reference example

The example polls ISO/IEC 14443 A and B and ISO/IEC 15693 by default. A tag's ability to accept test data depends on its protocol, memory layout and write permissions.

Tag type	Discovery	Automatic write and readback
MIFARE Classic 1K / 4K	UID, ISO/IEC 14443 A	16 bytes in ordinary data block 4. The example requires a 4-byte UID, SAK `0x08` or `0x18`, and default Key A `FFFFFFFFFFFF`.
NFC Forum Type 2 / 4A	UID, ISO/IEC 14443 A	39-byte NDEF Text message. Requires an existing writable NDEF mapping with enough space.
NFC Forum Type 4B	PUPI, ISO/IEC 14443 B	39-byte NDEF Text message on an existing writable mapping. Place one Type B test card in the reading area at a time.
ISO/IEC 15693 / NFC-V	UID	Random data in block 8. The tag must have a readable memory layout and a writable block 8.
NFC-F	Optional IDm discovery using `f`	Discovery only in this example.

Each tag and path has a minimum one-second interval between automatic test attempts. A `PASS` requires a successful write, a successful read, and matching length and contents. For application integration, validate identifier detection and data transactions separately at the required tag positions.

Measured read/write distances

Maximum distances observed with the two 40 cm leads and each listed sample. A successful test wrote random data and verified an exact readback.

Test sample	Sample size and format	Large antenna	Small antenna
MIFARE Classic S70	85 × 56 mm PVC card	18 cm	15.5 cm
ICODE SLIX2	85 × 56 mm PVC card	29 cm	26 cm
ICODE SLI	85 × 56 mm PVC card	25 cm	24 cm
NTAG215	Ø25 mm round tag	4.7 cm	3 cm
ISO/IEC 14443 B	85 × 56 mm PVC card	4 cm	4.7 cm
ISO/IEC 15693	Ø25 mm round tag	8 cm	8 cm
M1	Ø25 mm round tag	2.7 cm	3 cm

The large-antenna ISO/IEC 14443 B measurement and the small-antenna NTAG215 and M1 measurements used separately selected drive and tuning settings. All other measurements used startup AAT settings.

Bench verification

Project tests on 20 November 2026 recorded repeated ISO/IEC 15693 block 8 write/read passes on both ports. Logs from 24 November recorded both AAT startup checks passing on a bench configuration, with mixed outcomes on some longer-distance tag tests. Qualify the read and write distances for the installed antenna, tag type and operating conditions.

Troubleshooting

Symptom	What to check
`I2C_0x50_NACK`	Check the host connector orientation, the 3.3–5.0 V supply at pin 6, common ground, SDA/SCL wiring and that the I²C/SPI mode link is present for I²C. Reset after correcting the wiring.
Blue LED blinks at startup	Find the failing path in `AAT_SELFTEST`. Power down and reseat its matching 40 cm lead. Clear tags from the reading area and restart with both loops connected.
A tag appears on both paths	Run `1` and `2` separately with a test tag. Verify loop assignment, spacing or orientation, and the installed structures around the loops. A tag can couple to both loops even when fields are switched in turn.
Tag detected, write/read fails	Try a single expendable tag closer to the loop. Check its memory protections and, for NDEF, confirm a writable mapping and at least 39 available bytes. Inspect the detailed result and verify the Type B profile matches the connected loop.
Performance changes after replacing a loop or cable	Check the feed, cable length and fixed matching components. Retune with the final installation clear of tags. Verify both discovery and data transactions before use.
No serial output	Check the native USB port and the CDC-on-boot build setting. Reopen the port at 115200 baud and power-cycle the host.

Technical references

- STMicroelectronics device electrical and register reference. ST25R3916B datasheet
- ELECHOUSE public reader libraries and examples. ELECHOUSE ST25R3916 repository