AndiScan micro

Model A2/Mark-ii

User Guide

SQi-AndiX

Disclaimer

The manufacturer is not responsible for any damage or injuries caused by using this device and by utilization of the values measured by the device. It is an ultimate responsibility of the device operator to use the device safely and to correctly interpret the measured values.

User Guide version A2.6.0 (28.12.2023)

User Guide describes AndiScan Model A2/Mark-ii
with SW version US_A2.6.0/TXR_A2.6.0

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1 Welcome

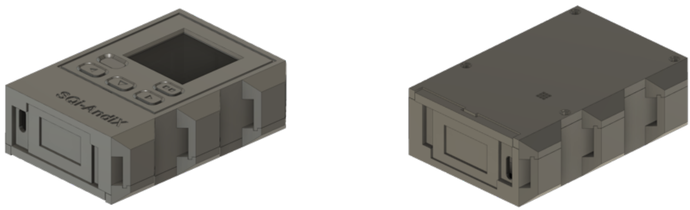
AndiScan micro is an advanced ballistic velocity Doppler radar for measuring muzzle velocity of projectiles. It operates in 24GHz frequency band. It is a highly integrated and extremely small form-factor device that is intended to be directly mounted on the rifle. This frees the user from a complicated setup alignment and it also allows to perform measurements under dynamic conditions.

The device is a high precision measurement instrument. It uses highly advanced signal processing optimized for velocity measurement precision and for small device form-factor. The device provides the user with a full velocity measurement statistic including graphical histogram data. Besides that, it also analyses the received signal properties. Based on that, the device can explicitly estimate its own measurement precision. It is defined as a stochastic confidence interval for measurements.

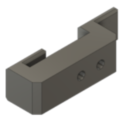
2 Description of the device

2.1 Package contents

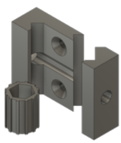
(A) radar device



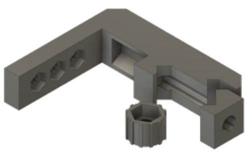
(B) rechargeable battery 16340
(C) charging USB cable
(D) micro SD memory card (inserted in the device)
(D1) SD card adapter
(H) hard storage box
(K) device mount bracket



(M1) picatinny mount adapter

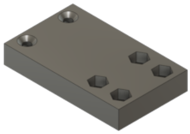


(M2) picatinny bracket narrow



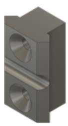
(N1) bracket vertical

(N2) bracket horizontal extension

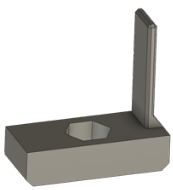


(R1) adapter UIT

(R2) adapter Spuhr

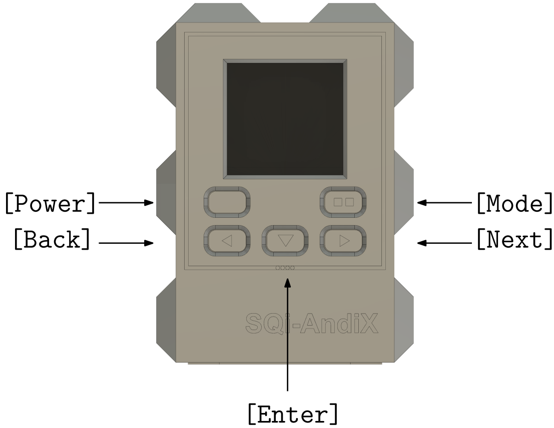


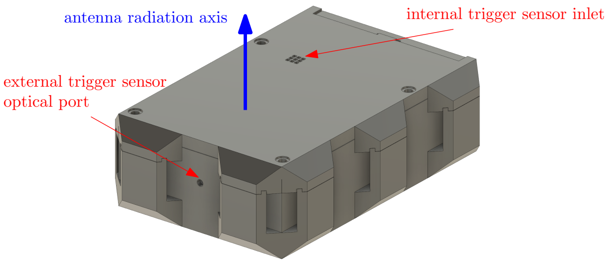
(T) tripod adapter

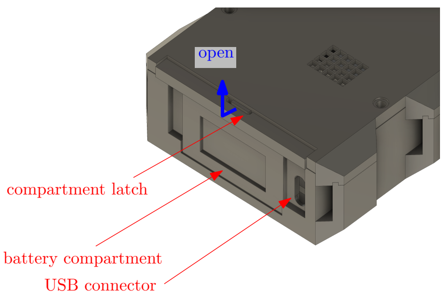


(S1) additional mounting screws M3x20 for bracket extension, M4 for Spuhr adapter

2.2 Device







- There are no user-serviceable parts inside the device except those accessible by opening the battery compartment. The battery compartment allows the access to the battery and the SD card (under the battery).
- Remote trigger sensor is an *optional accessory sold separately*.

3 Installation and preparation for operation

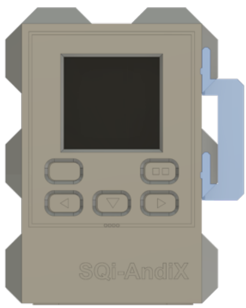
The antenna of the device is placed under its back cover. The back of the device should be pointed in the direction of fire. The antenna radiation axis is perpendicular to the back cover. The display should face towards the back of the firearm. The device can be mounted directly on the rifle or on a nearby standing tripod.

3.1 Rifle mounting

A direct mount on the rifle frees the user from keeping an eye on the device and the rifle alignment, since this is guaranteed by the device mount itself. It also makes the measurement triggering easier due to a direct mechanical contact of the device with the rifle. It causes a better shot shock-wave guidance from the chamber to the device. Several mounting options are provided. Some of the mounting brackets/extension have holes positioned on multiple places that allow the user to find the best position on the rifle.

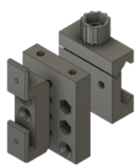
The device (A) side slots fit into a device mount bracket (K). The device bracket is then attached to the mount according to the user's choice.

Some caution needs to be applied when using direct mounting on highly recoiling rifles to avoid excessive mechanical torque stress on the mounting slots. For such situations, the tripod mounting is recommended.



3.1.1 Picatinny side-mounted

Use parts (K)(M1)(N1)



3.1.2 Picatinny top-mounted

Use parts (K)(M1)(N1)(N2)

3.1.3 Picatinny bottom-mounted

Use parts (K)(M1)(N1)(N2) and reverse upside-down the orientation of (K) bracket.

3.1.4 UIT adapter

The UIT slot adapter (R1) allows the user to use arbitrary Picatinny mounting assembly on UIT slot.

3.1.5 Spuhr adapter

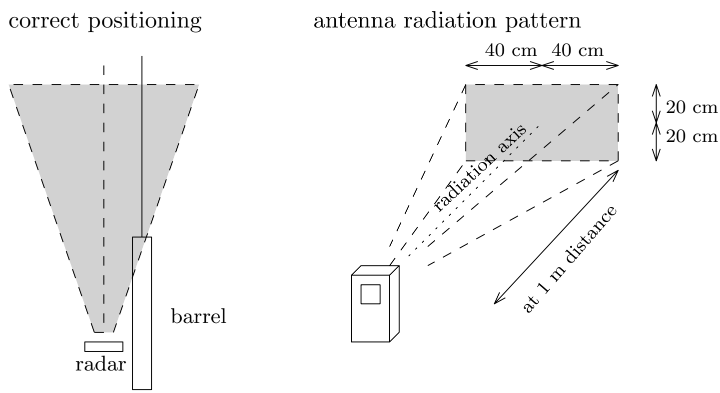
The Spuhr adapter (R2) allows the user to use arbitrary Picatinny mounting assembly. It is recommended to attach the adapter on a bottom left-side row of M4 threads and keep an eye on the depth of screw protrusion.

3.2 Tripod mounting

When the rifle does not allow to use rifle mounted adapters, the user can use a traditional tripod mount adapter (T) which attaches to standard 1/4" tripod interface. The support plate of (T) should be below the device (A). Its length is designed to allow unobstructed use of the device USB port.

3.3 General tips for positioning of the device

- ***The positioning of the device is very important. Please follow the instructions below. In case of problems, see Section 6 with additional hints and troubleshooting guide.***
- The device should be pointed with its back side in the shot direction with horizontal +/- 20 deg and vertical +/- 10 deg tolerance at maximum.



- Ideally, the device is positioned with its vertical center at the barrel level and with its side position as close as possible to the barrel (8-10 cm is optimal, 15-20 cm is acceptable). The forward position should be roughly at the chamber level, or slightly forward towards the muzzle (roughly 30-70 cm back from muzzle). Do ***not*** position the device in front of the muzzle or in the hot gas path of the muzzle brake.
- A special attention is needed when measuring the gun with a ***muzzle brake***. The hot gasses and plasma from the muzzle brake are strong blocks for radio waves. Some muzzle brakes are quite aggressive in creating a "wall" for the signal. Avoiding this is a necessity. The solution is to allow the signal to go "around" by putting the device e.g. a bit higher - some experimentation is needed.
- If some special measurement scenario requires that, the device does not need to be positioned with the vertical orientation having display on top and the battery compartment at the bottom. Any orientation is possible. However, keep an eye on keeping the radiation antenna axis in line with the direction of fire.

- Radio waves are strongly affected by metallic parts (bipod, large forearm). The device should be in such a position that its radiation pattern is not shaded by these obstacles in the direction of the measurement. For the first experiments, it is best to use the tripod mount and once the correct position is found, the direct mounts can be used. The correct position is defined by having sufficiently strong received signal, which is indicated by Signal-to-Noise Ratio (SNR) and power profile (see Sections 4 and 6).

4 Device operation

4.1 Powering the device

- The device is ***switched on*** by a ***short press of the [Power] key***. The device is ***switched off*** by a ***long 2 seconds press of the [Power] key***. A shut down operation takes about 8 seconds, and can be cancelled by pressing any other key. Alternatively, an *immediate* switch off is done by a double-click of [Power] key. A ***hard switch off*** is (e.g. if the device is not responsive) is done by a ***long 10 seconds press***. The power button is recessed to prevent its inadvertent press.
- The device can be powered by its internal battery and/or external USB power (e.g. a USB powerbank). If powered by an external USB power, the internal battery is charged. Internal battery does not need to be inserted when using the external USB power.
- When charging the internal battery from the external USB power, the device will always be powered on and cannot be switched off using [Power] button.
- Internal battery power
    - Internal battery is a replaceable ***Li-ion RCR123A rechargeable 16340 size cell***. It is strongly recommended to use only supplied type and to use the one with internal overcharge and discharge security circuit. Also, different brands of batteries have different sizes and this can cause some issues on the reliability of the battery contact connection. They are designed with tight tolerances to avoid disconnection during the rifle recoil and other manipulations.
    - A mechanical construction of the battery compartment is optimized to provide a tight reliable contact. It is *not* intended for a frequent battery change. The battery is intended to be removed only when it reaches its end-of-life. Under normal situation, the battery should be charged inside the device from an external battery power.
    - The device is ***not compatible*** with CR123 standard ***non-rechargeable lithium battery***.
    - Battery operation time depends on the device mode used. The following are estimated values based on a typical 800mAh battery cell and typical operation and environment characteristics.
        - Device in Armed State (WiFi off) .. approx. 1h20m

        - Device in Ready State (WiFi off) .. approx. 3h05m
        - Device in Armed State (WiFi on) .. approx.1h05m
        - A full battery recharge cycle (using USB external power) is approx. 1h
    - Battery critical warning is activated on approximately last 5 minutes of power supply.
    - The display battery status *B0-B9* shows the battery level during standard operation *when the charger is **not plugged in***. A *charging state* is indicated by *4-LEDs on the front panel*. ***The battery is not fully charged until the LEDs stop flashing.*** It is the only indicator of the charging level!
    - Even when the device is switched-off, the battery still powers the real-time clock and some internal circuits. The battery completely discharges after about 4 weeks when the device is not in use. A battery left in deeply discharged state for long time, may need one or two "refresh" charge/discharge cycles.
- External USB power
    - Any external 5V USB power source (e.g. a powerbank) capable of providing 1.4 A at 5V can be used. Please, take care to use a high quality and short cables to prevent voltage loss over the resistance of the cable.
- Switching between power sources
    - While operating on the internal battery, you can plug-in the external USB any time and the device continues to work uninterrupted.
    - While operating on external USB power, even with fully charged internal battery, unplugging the USB power causes the device to restart. Please save your data to SD card before doing that.
- Real-time clock (RTC)
    - RTC is powered from the device battery all the time the battery is inserted. RTC requires very small supply current and it is capable of operating on the voltage as low as about 1.0 Volt. It therefore keeps the time even if battery is discharged. For the situation when the battery is removed, there is an internal backup capacitor that is capable of powering RTC for about 2.5 min. The battery can be temporarily removed (e.g. for accessing SD card) without losing the timekeeping.

4.2 Modes of operation

- Every press of the [Mode] key cyclically switches the device into the next mode. There are the following modes:
  - [TRG] Triggered Measurement
  - [MAN] Manual Measurement (* enabled only in Expert Mode)
  - [DAT] Data View Mode
  - [CFG] Configuration Mode
- The current mode is indicated in the status line of the display.

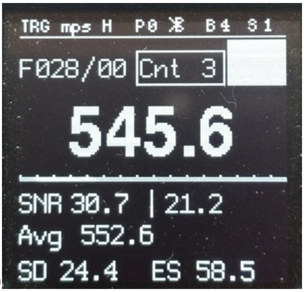
4.3 Measurement data storage and organization

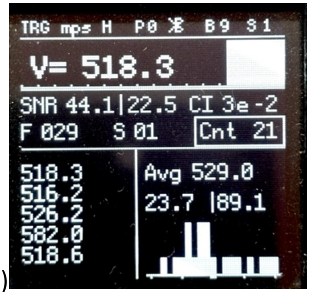
- Measured data are organized in a hierarchy of (1) Folder, (2) Series, (3) Shot number. Maximum counts are the following.
  - 1000 folders, named F000 - F999, Fint = internal memory
  - 100 series in one folder, named S00 - S99
  - 100 shots in one series, counted from 1 - 100
- The data are stored on the SD card memory. Until the series is finalized, the shots can be browsed and deleted. The data saving can be configured (C8 configuration screen) to be manual or automatic.
- In manual save mode, the data are saved only by ***explicit*** save/finalize [Next_Long] press. This allows to speed up signal processing between shots. Until this point, the data are stored in an internal (Fint) memory ***only***. The save/finalize operation on the last series also increments the series counter and clears the display for new data series.
- In autosave mode, the unit autosaves the series data to SD card after each shot or after you edit (delete) shots. At the end, it is finalized by a manual save [Next_Long] which also opens the new series for recording. Autosaving slightly increases processing time after the shot by about 20-40% (depending on number of shots in series, type of SD card and state of its buffer). It also creates and occupies new folder even if the series is not finalized by explicit saving or all shots are deleted from series (it will create file with 0 shot count).
- Active series measurement can be browsed directly in the measurement screen by [Back/Next] buttons. Arbitrary shot (either the last one or any previous when in browsing mode) can be deleted by [Back_Long] press. The series is finalized (no further editable) to SD card by [Next_Long] press.

- Each time you turn on the unit, the device checks for already used folders and a new folder is created. A similar procedure happens when the count of series rotates from 99 to 00. The device configuration file stores the last used folder name, and a new folder is created with the next sequential number.
- The device will never overwrite any existing folder. This ensures that all your data are completely under your control. If the next sequential folder name is already used, the device will search for an unused folder name. If there is no unused folder name, the device stops and prompts you to insert a new fresh storage card or to manually erase the existing one. In order to do that, remove the SD card from the device and erase it on your personal computer.
- You can safely temporarily remove (and reinsert) the SD card, even if the device is powered on, provided that you make sure that the device is not trying to access it. The device accesses the SD card in the following situations: (1) during device start up, (2) when storing current series, after the new series is started, (3) when exiting from the configuration mode. When doing this temporary removal, please reinsert the same unmodified card, otherwise the device might be confused by a different folder structure.
- Inserting and removing the SD card. The device has a very small form factor and must have a robust construction. The placement and access to the SD card had to be adjusted to that. The SD card has a spring-loaded push-push slot. SD card is placed under the battery. Use tweezers to access it. *The card is oriented with contacts facing the display side of the device*.

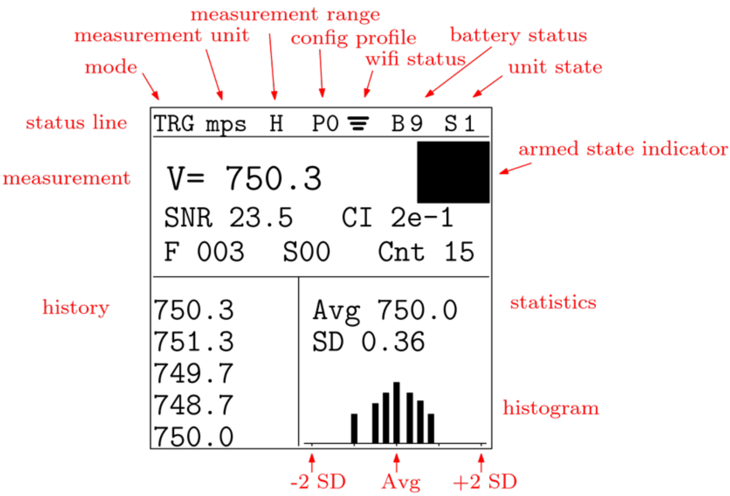
4.4 Triggered Measurement

- The triggered measurement triggers the device by (a) ***acoustic pressure sensor (ACST)*** when the shot is fired or by (b) ***direct signal detection (SIG)***.
    - Acoustic pressure triggering has independent triggering and measurement signal processing and allows adjustments in trigger timing by setting its gain.
    - The direct received signal detection detects the movement even for silent objects and it is not disturbed by other shooters at the firing line.
- The screen in Triggered Measurement Mode has 2 configurable (C8 configuration screen) options - (a) large and (b) standard.

(a) 

(b) 

- Screen fields



- Status line
    - TRG .. indicates the Triggered Measurement
    - measurement unit .. {mps, fps, kph, mph}
    - measurement range .. H (High), W (Wide), M (Mid), L (Low)
    - WiFi status .. (no icon) WiFi off, (icon) WiFi on, (highlighted icon) WiFi client connected
    - battery status .. B9 means fully charged battery, B0 means battery seconds before being cut-off.
    - unit activity states
        - S0 "ready state" .. transmitter and receiver are in idle low-power consumption mode
        - S1 "armed state" .. device is waiting for the shot and it is ready to immediately activate the measurement upon the triggering
        - S2 "active state" .. device is actively transmitting and receiving the signal
- Measurement field
    - V= .. shows the velocity measurement. In the standard response mode, the "***" indicator at the place of the measured value indicates, that the unit has been triggered but the measured signal signal-to-noise ratio (SNR) is below the detection threshold.
    - armed status indicator shows large rectangle when the unit is in armed state.
    - animated long rectangle over the measurement field indicates the undergoing active state.
    - SNR .. shows the signal-to-noise ratio [dB] of the current measurement. The higher the value the stronger signal was received, and the measurement has a better precision. When signal detection trigger is selected, the measurement screen shows two SNR values. The first shows the standard measurement SNR the second shows the signal detection SNR.
    - CI .. confidence interval. Based on the SNR value, the device predicts the statistic interval for its own velocity measurement error. The true velocity is expected to be within +/- CI tolerance with 99% probability.
    - F .. indicates current folder for storing data
    - S .. indicates current series for storing data

    - Cnt .. indicates total number of measurements in a given series and it is displayed when the display shows the last measurement.
    - No .. indicates current index of the measurement in browsing mode.
- Fast and Standard response TRG modes
    - In the Fast response mode the unit triggers always but reports the SNR and velocity measurement only if it exceeds the threshold. It substantially reduces the unit TRG recovery time on false triggering events, e.g. when there are many other shooters on the firing line and false triggering appears frequently. The unit responses to the false triggering but keeps previous velocity and SNR readings on the display.
    - Standard response mode shows the measured SNR value on ***any*** trigger event, even when it is below the detection threshold. It has slower recovery time and the "***" velocity reading and SNR value override previous readings. It is useful when experimenting with the device positioning.
- Power profile of the measurement
    - There is 16 slot line display (below the V= measurement field) showing relative power of the received signal over the measurement window. It allows to identify possible problems with ACST triggering or with antenna.
    - display: ı ı ı ı ı ı ı ı-ı-ı-ı-ı-ı-ı-ı-ı-ı-
        - triggering too early (triggered earlier than the bullet left the barrel, or before it entered antenna radiation pattern)
        - a strong signal but more prone to side-offset error
        - decrease ACST TrigGain, or move device backward from the muzzle or closer to the barrel
    - display: ı-ı-ı-ı-ı-ı-ı-ı-ı ı ı ı ı ı ı ı
        - triggering too late
        - weaker signal but negligible side-offset problem
        - increase ACST TrigGain, or move the device closer to the muzzle

- display: I I-I-I-I-I-I-I-I-I-I-I-I-I-I-I I
    - just right compromise between signal strength and side-offset problem
- History field
    - last 5 measurements are shown
- Statistics
    - Avg .. shows average velocity of the whole series
    - SD .. shows Standard Deviation of the whole series and can be configured to show SD together with ES (Extreme Spread)
- Histogram
    - the horizontal axis has a center point corresponding to the average measured value, the horizontal range is +/- 2 SD
    - the line height is proportional to the number of measurements in the vicinity of a given distance from the average value
- Operations in TRG mode
    - Key [Enter] toggles between ready and *Fast Response Mode* armed state. In order to measure the shot, the unit must be in armed state.
    - Key [Enter]-Long-Press activates *Standard Response Mode*. It is indicated by "*" in armed state white flag.
    - Keys [Back]/[Next] allows browsing back and forth in shots. The browsing mode is indicated by showing the shot number (No) in contrast with showing total count (Cnt) when the screen shows the last measurement.
    - Key [Next]-Long-press finalises and stores the current series into a SD card and starts the new series.
    - Key [Back]-Long-press deletes the current viewed shot. A repeated pressing deletes as many values as needed.

4.5 Manual Measurement

- It is enabled only in Expert Mode.
- The screen has identical fields as in the Triggered Measurement mode. The only difference is MAN mode indicator in the status line.
- The key operations are identical to TRG mode with the only difference that [Enter] directly triggers the measurement. There are only two device states in this mode: S0 (ready) and S2 (active).

4.6 Data View Mode

- Data View Mode allows the user to see the stored measured data on the SD card.
- When entering the mode, the current or the last stored folder/series is prefilled by default for a quick access to the last stored series. However, any SD card stored data are accessible.
- Operations in DAT mode
  - Key [Enter] .. shows the data of the selected folder/series. If the series needs multiple screens to show the data, pressing [Enter] shows the next screen. The screen counter (D0, D1, D2,..) is on right side of the status line.
  - Key [Next] .. increases the series counter
  - Key [Back] .. decreases the series counter. If the current series is S00, it decreases the folder counter and shows the series S00 in that folder. This allows to quickly move across the folders.
  - Long press of [Next][Back] jumps fast over 10 values.
  - In order to view internal memory measurements, go to Fint folder which is at minus one position from F000.
- Folder/Session Management (FSM) mode enables (a) a direct access to setting Folder and Session number, (b) listing Series files in Folder, (c) deleting Series, (d) deleting Folder.
  - FSM mode is activated by a long press of [Enter] in DAT mode.
  - When deleting Folder/Series, the time progress sequence of Folder/Session is preserved. The newer one will go after the highest number already used.
  - If the maximum value of the Folder range number is reached, the device tries to find some unused number in Folder sequence. If there is no one, the device prompts the user for an action to empty the space. If the deleted Folder or Session is the last one, than its number is reused, otherwise it is increased as usual.

4.7 Configuration Mode

- Configuration Mode allows to set various system settings. These are organized each on a separate screen. The configuration screen number is indicated in the display status line.
- Up to 10 Configuration Profiles can be set (e.g. for different rifles or measurement scenario). A selection of the profile is activated by

pressing and keeping pressed the [Enter] button during the welcome screen. The selected profile is indicated in display status line by P0-P9. All changes made in configuration screens are stored in the selected profile. The DATAxx.CSV file contains a corresponding ConfProfile marker of the profile used during the measurement. Also, for easier orientation in stored data, a subset of folders is dedicated to each profile (e.g. ConfProfile 2 uses F200..F299). The default profile #0 uses (for backward compatibility reasons) the whole range F000..F999.

- A selected configuration profile can be reset to factory defaults (by erasing its CONFIG file) in ConfigProfile selection screen.
- Operations in CFG mode
  - Key [Enter] .. activates editing mode and the current edited field lights up. [Back]/[Next] change the parameter value. Another [Enter] press either leaves the editing mode or activates another field.
  - Key [Next] .. moves to the next configuration screen.
  - Key [Back] .. moves to the previous configuration screen.
  - Key [Mode] .. leaves the configuration mode. All configured values are actuated only when the user leaves the CFG mode and they are also stored at that moment to the SD card.
- C0 screen .. System Information
  - HW .. device HW ID
  - SW .. version of the SW
  - DeviceID .. serial number of the device
  - Tx [C] .. temperature of the unit processor
  - Tb [C] .. temperature of the unit transceiver
  - Current date and time .. use [Enter] to jump between fields and [Next][Back] to adjust the value.
- C1 screen .. Velocity Unit
  - VelUnit .. unit of the measurement {mps, fps, kph, mph}
- C2 screen .. Trigger Mode and Gain
  - The measurement is triggered either by (a) standard acoustic pressure trigger (ACST) or direct signal detection trigger (SIG), both in 10 levels of sensitivity. The highest level 10 is extremely sensitive and is intended only for very special conditions.

    - Value 0 completely switches off the internal trigger. This is intended for the use of Remote Trigger. TrigCal is the value set by sensor autocalibration (only for information).
- C3 screen .. Detection Threshold
    - DetThr [dB] .. detection threshold in dB, values {13, 17, 20, 23}. The shot is detected as a valid measurement if the current measurement SNR exceeds this value. The higher the value the stronger the received signal must be for a device to evaluate it as a valid measurement. The optimal value depends on many factors (the bullet caliber, the triggering delay, the position of the device). Some experimentation is needed. The lower values are recommended for small calibers, the larger values for large calibers. The recommended all-purpose default value is 17 dB. The smaller values should be used only when the device frequently does not capture strong enough signal. As a guidance, use the SNR value shown on the measurement screen for a current shot. Noise background SNR (no bullet present) should be around 10 dB and lower. Occasionally, if there is radio interference, it could be slightly higher.
- C4 screen .. Velocity Range
    - VelRange .. {Low, Mid, Wide, High}
        - Low setting is enabled only in the Expert mode
    - Min/Max .. the minimum and maximum value of the measurement range
    - dv .. device measurement resolution for a given range. Notice however that this is just a numerical resolution limit. The true indicator of the measurement precision is given by CI and SNR factors.
- C5 screen .. Communication Interface
    - options
        - BLE (Bluetooth Low Energy)
        - WiFi
    - Network .. the name of the WiFi Access Point (AP)
    - Password .. the password for accessing the WiFi AP or BLE by Remote Shell Application.
    - IP .. the IP address to which the web client on a computer or a smartphone should be pointed to.
    - MAC .. MAC address of the device

- C6 screen .. Carrier Frequency
    - CarrierFreq .. the carrier frequency of the device, values {24150, 24160,..,24220} MHz. Make sure that no other radar device in 24GHz band uses the same frequency in the vicinity of this device.
- C7 screen .. Carrier Frequency Offset
    - Fine adjustment of carrier frequency .. e.g. for avoiding interference with other devices
- C8 screen .. Measurement Screen Options
    - Select SD (Standard Deviation) or SD with ES (Extreme Spread) to be shown on measurement screen
    - Display layout - standard or large
    - SD memory card save - manual or auto
- C9 screen .. RF Rx gain
    - Set high/low gain of the receiver front end amplifier .. may be used to increase gain for very small targets or to decrease gain for very large targets
- C10 screen .. Internal memory erase
    - Use [Enter] to erase internal memory of stored measurements. SD card data are *not* affected.
- C11 screen .. V0/Vx side offset compensation
    - *A* is the side offset of the device antenna center to the barrel. Setting A= 0 completely switches off the compensation.
    - *D* is the distance from the muzzle to the device
    - Use [Enter] to jump between fields and [Next][Back] to adjust the value.
    - The device calculates the compensation of the measured velocity to obtain real V0 velocity (see Section 5.2). The value *R* is calculated automatically based on the user-set values *A* and *D* and the true measured signal properties.
    - Values *c* and *dV* show the true (based on received signal) corrections. Value cmax shows the maximum correction that corresponds to the geometry of the measurement and it gives a rough idea how the measurement is affected by the geometry.

4.8 Data on SD memory card

- The data on SD card are stored with the following hierarchy:
    - CONFIG.CSV (or CONFIG-n.CSV) .. This is system configuration file. Do not modify it, unless you perfectly know what you are doing. If the file is missing, e.g. on a newly formatted SD card, the system uses the factory default settings and the file is then stored for the next use.
    - CONFPROF.CSV .. This files stores the current selected configuration profile number.
    - F000 - F999 .. These are named folders storing your series data.
    - Fxxx/DATA00.CSV - Fxxx/DATA99.CSV .. These are files each storing one series data.
    - DATAxx.CSV files contain measurement data: Velocity, SNR, CI, Time Stamp for each shot, and numerical values of PowerProfile. PowerProfile data is a set of 16 numbers [0..8] describing relative signal strength over the measurement window segments.
- All files on the card use CSV (Comma Separated Values) format and can be easily imported to your personal computer.
- The device supports FAT16 and FAT32 file systems on standard SD and SDHC cards. You can name your card arbitrarily.
- All data files are stamped with current date and time (as it is set on C0 configuration screen).
- The device can be used without the SD card inserted. In this case, it starts with factory default settings that can be subsequently changed in configuration mode (of course without being saved to SD). Measurements are stored in Fint internal memory.

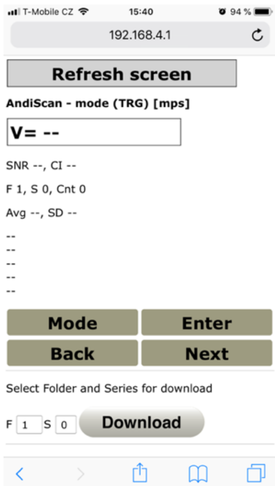
4.9 Internal data memory

- The device stores last 100 measurements in its internal memory *regardless whether they were explicitly stored on SD card*. Each measurement is stored immediately after it is done. This ensures that you never lose your measurement. Internal memory is accessible in Data view mode as any other data stored on SD card. Internal memory is placed on (-1) folder position (Fint). Internal memory can be erased in C10 configuration screen.

4.10 Communication Interface (WiFi, BLE)

4.10.1 WiFi

- The WiFi access is implemented as web mini-server over WiFi Access Point (AP) provided by the device. The purpose of this functionality is twofold.
    1. ***Remote control:*** It allows the client device (smartphone) on the shooting range to perform as a remote control and remote view of the measurements.
    2. ***Wireless access to SD card:*** It allows to access the data (CSV files) without the need of removing the SD card from the device. This is typically used when transferring the measured data to the personal computer for further evaluation and archiving.
- In order to use the WiFi access, connect your smartphone or computer to the WiFi AP with the name and password shown on C5 WiFi configuration screen. Keep in mind that the WiFi is actually activated only after leaving the configuration mode. Observe the WiFi status icon in the status line on the screen and wait till your client is connected. Then point your web browser to the IP address shown in the C5 WiFi configuration screen.
- The web page you will see on your device is shown below. Please notice (!) that the web page does *not* update itself after finished measurement. You need to update it manually using the button on the page top



- Activated WiFi access decreases the battery life. It is recommended to activate it only when it is necessary. Due to the nature of WiFi/AP and web communication protocol, the activity of the web client and/or WiFi/AP protocol might interfere with some critical timings of the internal radar signal processing. This may cause some technical issues. Also, some operations may take longer time, since WiFi/AP and web server need to perform their own operations.

4.10.2 Remote Shell application and Bluetooth (BLE) connectivity

- AndiScan A2/Mark-ii can be connected to external device (any of iOS, Android, mac, win) by BLE interface. It allows to fully remote control the device and access the data stored on the device. Installation instructions and user guide are available online.
    - https://www.sqi-andix.com/a2-remshapp-guide/

4.11 Firmware configuration

- Power on the device and when the Welcome screen appears press within 1 second the [Mode] Key and keep it pressed until the Firmware configuration screen appears.
- Key [Enter] changes the configuration value.
- Key [Mode] moves to the next configuration screen. When the last configuration screen is left, the device starts into the standard operation.
- Firmware Configuration #1 - Expert Mode
    - Expert mode enables Manual measurement mode and Low measurement range.
    - It is intended only for an advanced user or when the user needs to test the device operation on slowly moving objects (other than the firearm projectiles).
    - The Low range is suitable for measuring velocity of the objects of the ordinary environment. For example, when you want to test the device at home, you can measure the velocity of your hand movement, etc.
    - (!) Important notes:
        - A high care is needed when setting the device configuration (namely TrigGain, DetThr) to suit the intended use. Also, the user should carefully evaluate the validity of the obtained result. By a principle of the device operation, the Mid and Low ranges are particularly vulnerable to self-interference in the device signal processing. Some measured values might be false ones.
        - The device is designed to measure only objects *departing* from the device. It will not correctly measure the objects that are approaching.

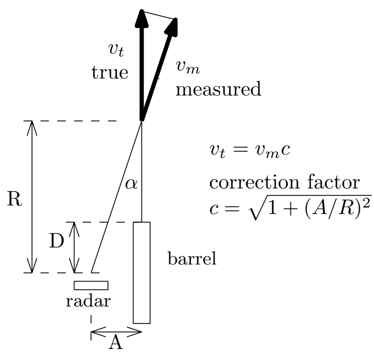
5 Data statistics and measurement processing details

5.1 Measurement accuracy and precision

Accuracy is a measure of systematic bias of the measurement. Mathematically it is given by a mean bias, i.e. a difference between the true value and the mean measurement value, if the same experiment was repeated many times. Precision is a measure of the measurement error dispersion from the mean value. Mathematically it is given by variance of the measurement. For unbiased measurement, the variance equals to the Mean Square Error (MSE) of the measurement, which is an ultimate fidelity indicator.

5.2 Impact of radar position offset

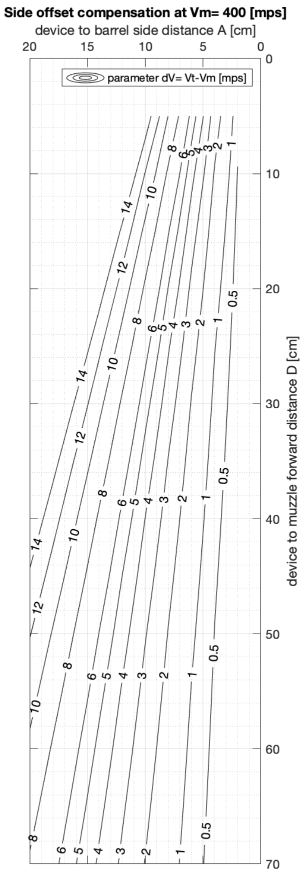
The closer the device is side-wise positioned to the barrel, the better. The distance between the barrel and the device antenna causes a reduction of the perceived bullet velocity as it is measured by the device. This is dictated by a simple geometry (see Figure below). While the distance *A* is well under user control, the distance *R* depends on many factors with many interactions (device triggering delay, bullet actual speed, accuracy of device antenna aiming, etc.). The device can be configured to compensate this effect (C11 configuration screen) automatically. The value *R* is calculated automatically based on the user-set values *A* and *D* and true measured signal properties.

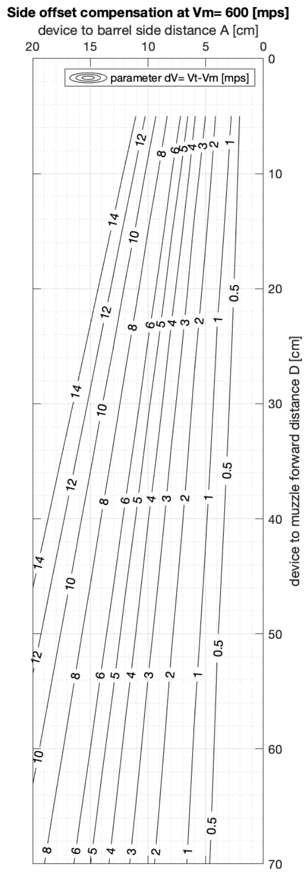


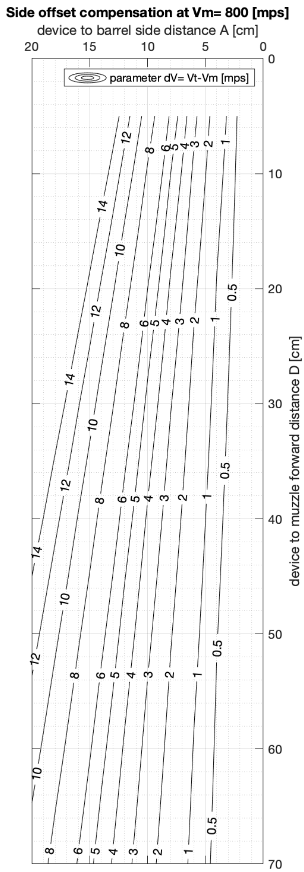
The effect of this side offset can be quite significant. The table below shows the multiplicative correction coefficient and can be used as a rough guidance for typical values of *R*. It differs from case to case. Under normal conditions, the distance of the measurement R (in H/W velocity ranges) is 1-2 meters typically, 3-5 m at maximum.

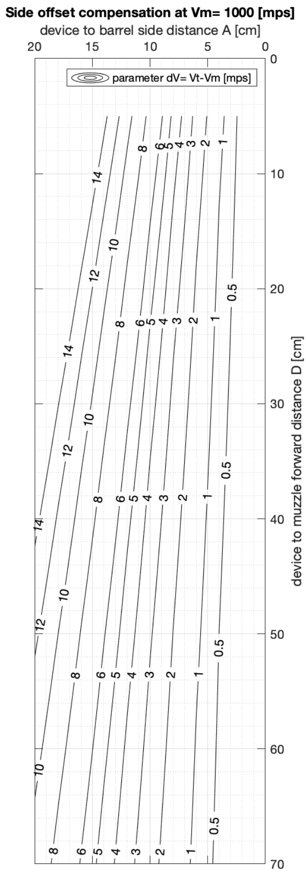
A [m]	R [m]	c
0.1	1.0	1.005
0.2	1.0	1.020
0.1	2.0	1.001
0.2	2.0	1.005

In absolute values, i.e. the difference dV= Vt-Vm, the impact can be interpreted easier. Graphs below show (under typical conditions, in H/W measurement range) the dV values for selected Vm velocities. *Example: A= 10 cm, D= 40 cm, Vm= 800 mps, the correction read from the graph is dV= 3.9 mps, the true velocity is Vt= 803.9 mps.*









5.3 Impact of triggering delay

For a Doppler based radar device, it is practically impossible to directly measure the true V0 velocity (i.e. at zero distance from the muzzle). All radar devices measure VR, where R is a given distance in meters from the muzzle. AndiScan performs a highly precise velocity measurement at a very short (but nonzero) range. A very short triggering delay is critically needed for this. A direct device mount on the rifle and utilization of the shock wave mechanical transmission, together with optimized internal signal processing, allows to keep the delay minimal. Practically, under normal conditions and under a typical triggering delay, the value R is 1-2 meters (3-5m at maximum).

The delay of triggering operation has some impact on the measurement accuracy and precision. A delayed triggering means that the projectile velocity is not measured close to the muzzle but further down range where the bullet is already slowing down. If the delay was constant this would affect only the accuracy. In fact, it will be somewhat balanced with the measurement geometry explained above. The higher the distance R is, the lower the measurement geometry induced bias is, but on the other hand, the higher the effect of slowing projectile is. However, if the delay differs from shot to shot it also affects the precision. It depends on many factors - the position of the device, the mounting option (rifle mounted vs. tripod mounted), presence of suppressor, and many others. Some experimentation with the device configuration may be needed.

Numerical value of the actual velocity decrease, if the measurement is done at R distance instead of 0 distance, depends on the bullet ballistic coefficient and the true V0 velocity. For small distances R, the velocity drop is approximately linear with distance. Table below shows velocity decrease in m/s per 1 m of the distance R as a function of the G7 ballistic coefficient and the true V0. The device itself does not perform any post-processing correction of this error.

V0 [m/s]	**500**	**600**	**700**	**800**	**900**	**1000**
G7= 0.1	0.95	1.03	1.12	1.20	1.29	1.37
G7= 0.2	0.48	0.52	0.56	0.60	0.63	0.69
G7= 0.3	0.32	0.34	0.37	0.40	0.43	0.46
G7= 0.4	0.24	0.26	0.28	0.30	0.32	0.34

5.4 Impact of internal signal processing

The internal signal processing in the device is designed in such a way that it produces negligible accuracy decay. Numerically it is better than 50 ppm. On the other hand, the precision is strongly affected by signal-to-noise ratio (SNR) of the received signal reflected from the projectile. The noise level is practically given by the receiver hardware and some level of external interference noise. The received signal level is however significantly influenced by the projectile effective reflection area, the start and end projectile distance on which it is intercepted by a finite signal frame of the measurement, the antenna alignment and many other factors. The device monitors the SNR and provides an estimate of the expected precision in terms of confidence interval (CI). CI is set as

$$CI = 3 \times SDr$$

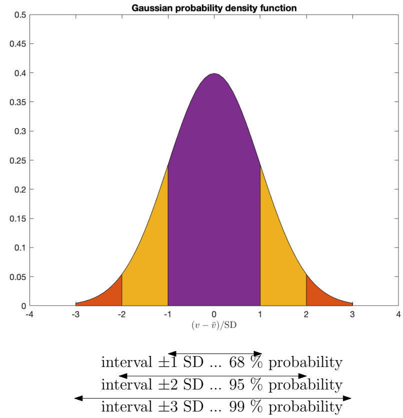
where SDr is standard deviation of the radar own measurement. For unbiased measurement, the MSE equals to the measurement variance $(SDr)^2$. Please, do not confuse SDr, which describes the precision of the own radar measurement, with SD, which describes dispersion of projectile velocities across the series.
As the measurement error closely follows normal Gaussian distribution, we then easily evaluate that +/- CI interval represent 99% confidence value.
The confidence interval (CI) value is shown in a compact exponential notation to save space on the display and to allow its more straightforward interpretation. The exponential notation consists of mantissa (m) and exponent (x) used in a notation m e x. The CI value is then $CI = m \times 10^x$. For example, 2e-3 means $2 \times 10^{-3} = 0.002$.

5.5 Statistics of the sample set of measured velocity series

The device calculates (uncorrected) velocity sample standard deviation (SD) estimate as

$$SD = \sqrt{\frac{1}{N}\sum_{n=1}^{N}(v_n - \overline{v})^2}$$

where v_n is the n-th measured value, $\overline{v}$ is the mean velocity and N is the sample size. This SD estimate is consistent (approaches the true value for large N), however, for small N, it is slightly biased towards smaller SD.
Under normal conditions, when your shooting equipment does not change, you use the same ammo type (or the same reloading recipe), and the sample set is sufficiently large, the statistic distribution of muzzle velocities nicely follow normal Gaussian distribution. It is fully described by two numerical values. Its mean value (Avg) and the variance. The variance is square value of the SD. These two values are uniquely bound together. However, from the practical point of view, the SD is easier to interpret, since it directly measures the width of the interval into which fall measured velocity values with given probability.



It is important to stress, that mean (Avg) and standard deviation (SD) are estimated by the algorithms programmed into the device and are based on sample measured data. They approach the true values when the sample size is very large (practically several tens, or hundreds). If the sample size is small (particularly for values less than 10), the estimation precision suffers. However, the two characteristics Avg, SD are the best robust statistics available. They are robust in the sense, that even for substantially small sample sizes, they still provide relevant statistics.

The histogram shown in the device measurement screen shows the statistic distribution of the measurements over the $+/-$ 2 SD width on the horizontal axis centered around the mean value. For large sample sizes, it will approach the theoretical normal Gaussian distribution.

Frequently used Extreme Spread (ES) characteristics is definitely *not* a robust estimation characteristic, especially for small sample sizes. In order to avoid its misleading interpretations, a usage of SD is recommended.

6 Troubleshooting and Usage Recommendations

- After a shot, the device did not react in any way.
    - If using ACST trigger mode, make sure that the acoustic or vibration excitation of the shot is properly accessible on the device, eg. by removing acoustic/vibration attenuation obstacles, repositioning of the device, or using different point for rifle mounted configuration.
    - If using SIG trigger mode, make sure that signal path is not blocked (e.g. by bipod).
    - Make sure that the device is in TRG mode and Armed (S1) state.
    - Check the configuration of the trigger sensitivity (TrigGain) and try to increase the level. For ACST trigger mode, too high TrigGain value can however cause excessive false triggering by neighbor shooters.
- The device is correctly triggered after a shot, but no velocity measurement result is shown, only "***" appears on the display in Standard Response TRG mode, or the previous measurement is still shown in Fast Response TRG mode.
    - Try to reposition or realign (if the device is mounted on tripod) the device to increase the actual SNR measured value. To see the measured SNR (even if it is below the threshold), the Standard Response TRG must be used.
    - Monitor the value of SNR on the display and adjust the configuration of the detection threshold (DetThr). Lower its value to allow the real measured SNR exceed the threshold. Too low DetThr value can however cause the excessive false detections caused by noise and/or interference.
- The device stopped responding to the key presses.
    - Wait few seconds and make sure that the device is not performing some longer operation, e.g. a search for a free folder, saving to SD card, or some BLE/WiFi activity.
    - If this is not the case, restart the device by long 10 seconds press of [Power] key until it switches off and then power the device again.
- The device triggers and measures the velocity but the SNR values are low (well below 20dB).

    - Under normal conditions, most common calibers (.22 - .338) should have values of SNR above 20dB, the higher the better. Low values might mean also a delayed triggering causing the measurement to start late when the projectile is already at some distance from the muzzle.
    - It is generally a good practice to keep the TrigGain as high as possible to allow the device to react fast during early shot stages. Decrease this value only when the device is frequently false triggered by other shooters in the vicinity (only when using ACST trigger mode).
- False triggering (in Standard Response TRG mode)
    - False triggering (showing "***" result) is on its own harmless. It only declares that the device was triggered but did not find any projectile in its radiation pattern. The measurement itself is very short (about 1 ms) and the readiness for the next measurement takes few hundred milliseconds. In extreme case, when the neighboring shooter shoots exactly in the same time window, the intended shot might be missed. However, this situation is highly unlikely.
    - Fast Response TRG mode substantially reduces the recovery time and do not overwrite the previous value with "***".
    - False triggering by other shooters is practically eliminated when using SIG trigger mode.
    - False reading (showing any numerical value) could happen only when neighboring shooter shoots the projectile into a radiation pattern of the device, i.e. withing about +/- 20 degrees angle and within the distance from the device at about max 5-7 meters. Anything outside of this range does not practically affect the measurement.
- Positioning of the device - triggering.
    - Positioning of the device is critical for fast triggering of the measurement. The faster the better. Delayed triggering means that the projectile would be far down the range and the reflected signal will be weak.
    - It is a good practice to find the position of the device that *guarantees values SNR about 20dB and higher*. These values are a good indicator that the device is triggered fast enough to capture the projectile close to the muzzle.

    - If the device is mounted on a rifle with metallic forearm (or on the rifle scope mount), the mechanical vibrations from the ignition in the chamber are quickly relayed to the device and it triggers. If the triggering relies on pressure wave propagation from the muzzle, usually a position close to muzzle produces the best results. Please keep in mind that the acoustic pressure travels about 3 times slower than a typical projectile shot from a rifle. It means that acoustic pressure wave travels 1 meter distance in about 3 ms and during that time the projectile is already 3 meters downrange.
- Positioning of the device - reflections of radio waves
    - Metallic parts (forearm, bipod, etc.), vicinity of concrete ground or other highly reflecting surfaces close to the device infer with transmitted radio waves. A consequence is usually a distortion of the radiation pattern of the transmitted radio waves - typically the axis of the radiation is no longer perpendicular to the back of the case. As a consequence, the direction of the maximum gain of the antenna no longer aligns with the trajectory of the projectile. A slight repositioning of the device usually helps. Repositions as small as few centimeters can affect the pattern. The wavelength of the signal is about 12mm and any change comparable to the wavelength makes some impact.
- Trigger Gain Level 10 in ACST mode unstable
    - The trigger gain level 10 (config screen C2, TrigGain=10) is a highly sensitive setting intended for very special circumstances where no other means help to trigger the device. Its calibration is very sensitive to temperature changes and under some conditions it can be unstable. It might start self-triggering of the device. If this happens, switch off the device by a long 10 s press of [Power] key. Then set lower TrigGain value.
- False measurement with value on the lower-end margin of the measurement range (i.e. cca 484 mps for H range, and cca 242 mps for W range).
    - Under specific conditions, particularly *extremely strong high frequency vibrations in a specific direction*, the device can show false reading with the measured value at the

lower-end margin of the measurement range. This is caused by exceeding vibration resistance limits of some electronic components. This is rather unavoidable due to a very small form factor of the device.

- The solution is to avoid these extreme vibrations, e.g. by mounting the device on the tripod.

7 Service and Maintenance

- Do not unscrew the back cover of the device. There are no user serviceable parts inside. There is a high danger of damaging sensitive electronics.
- The only user accessible parts (battery and SD card) are inside the battery compartment. Under normal conditions, this is supposed to be accessed only when changing the battery at the end of its life or when inserting a new SD card. A regular battery charging is done using the USB connector. Also, there is no need to take the SD card out on a regular basis. All stored data are accessible over WiFi connection.
- To save the battery power, keep the device in Ready (S0) state unless you are actually performing the measurement. The power consumption in Armed (S1) state is much higher and also the transceiver and microprocessor chip internal temperature rise substantially. The small form-factor of the device is vulnerable to overheating, particularly when the device is operated in hot environment.
- Avoid exposing the device to water, heavy rain or direct long-lasting sunshine.
- Factory Defaults. The device is set into factory defaults settings by deleting (e.g. on personal computer) the configuration CONFIG.CSV file from the SD card. At the next start of the device, the new CONFIG.CSV is created. Folders F000..F999 may be left untouched and the device will respect their presence and preserves the stored data. By inserting a new or fresh formatted SD card, the device will set the factory defaults and starts creating folders from F000.
- Firmware update. Follow the detailed instructions on www.SQi-AndiX.com.
- In the case of the device malfunction and/or damage, please contact the manufacturer (see www.SQi-AndiX.com) for the technical assistance and the instruction regarding repairs and part replacements.

8 Technical Specification

dimensions	(H) 92 x (W) 66 x (D) 28 mm
weight (including internal battery)	141 g
operational environment temperature range	-20 deg C .. 50 deg C
operating frequency band	24.150-24.220 GHz channel spacing 10 MHz two devices can be safely operated on neighboring channels
transmitter output power	11 dBm
internal battery	Li-ion RCR123A *rechargeable* 16340 size cell standard 800mAh capacity. ***Device is not compatible with lithium CR123 battery.***
external power	through USB-C connector
storage card	micro SD (or SDHC) card FAT16 and FAT32 file system
units of measurement	mps, fps, kph, mph
velocity measurement range	High (H) 484 - 1502 mps Wide (W) 242 - 1308 mps Mid (M) 30 - 303 mps (*) Low (L) 1.0 - 121 mps
processing resolution granularity	0.303 mps at H/W range 0.038 mps at M range 0.015 mps at L range
measurement precision (**) (99% confidence)	0.50 mps H/W range, SNR= 20dB 0.06 mps M range, SNR= 20dB 0.03 mps L range, SNR= 20dB 0.16 mps H/W range, SNR= 30dB 0.02 mps M range, SNR= 30dB 0.008 mps L range, SNR= 30dB
measurement accuracy (***)	internal processing .. < 50ppm measurement geometry .. < 0.5%
minimum time between triggered measurements	approx. 1 s

(*) only in Expert Mode
(**) expected value based on theoretical analysis
(***) under typical conditions; geometry impact can be compensated (see Section 5.2)