RainFlow RF4

Precipitation Monitoring Sensor

GENERAL DESCRIPTION

The extremely robust and zero-maintenance RainFlow RF4 sensor is an evolving acoustic instrument for the comprehensive measurement of the type, amount, intensity and structure of liquid and solid precipitation.

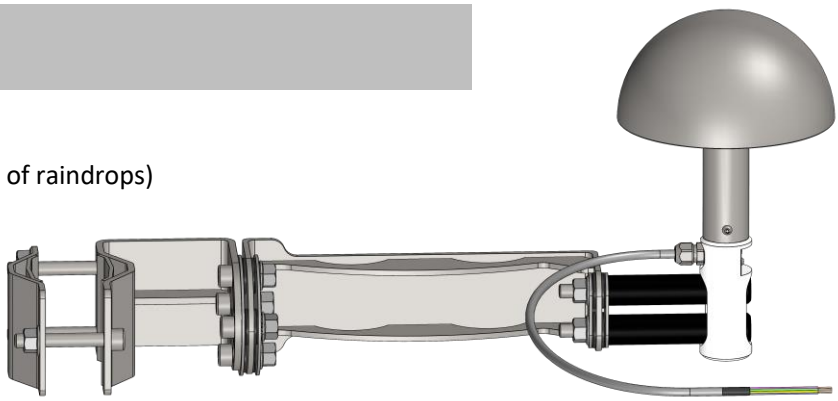
- RainFlow RF4 is a very low-power, maintenance-free and totally sealed acoustic instrument with no mobile parts.
- The sensing part of the instrument is a polished stainless steel hemisphere supported by a strong stainless steel arm.
- Impact of raindrops or hailstones induces change in internal acoustic pressure.
- The instrument includes a dedicated analog conditioning module, a digital I/O module and an analog restitution module. It can thus be connected to, or communicate conveniently with almost any external analog or digital central unit (data logger, industrial module interface, instrumentation DAQ, USB port). It features continuous or pulse analog voltage outputs, SDI-12 communication (meteorological standard communication protocol), TTL-Serial (3V3), RS-232 (with adaptor) or RS-485 (with adaptor).
- The full configuration of the sensor can be customized at any time, in a non-volatile memory, with a Plug-and-Play computer connection thanks to the universal USB dongle accessory provided with the sensor and the free ISAW-Toolbox software suite. The sensor can also be configured remotely, using serial commands.

KEY FEATURES

- Maintenance-free & special design and construction to resist the highest winds, extreme temperatures, rime, sunlight and abrasion.
- Lightweight, corrosion free, UV/Ozone stable, non-obstructable. Resistant to shock, vibration, lightning, ashes, 100% RH and even to temporary submersion. Operating temperature from −40 °C to 80 °C (−50 °C to 100 °C extended).
- Plug-and-Play or totally configurable to fit any application.
- Very low power consumption: 2.1 mA continuous for a nominal operation (10% duty-cycle).
- Adaptable to any structure thanks to a range of very high standard stainless steel clamping accessories.
- Directly connect the sensor to your central unit or configure any analog or digital communication through the USB dongle accessory.
- Compatible with almost any external analog or digital central unit, with a very long extension cable (typ. up to 200 m), with IoT (LPWAN) transceivers, with industrial control systems (BMS, SCADA, etc.).
- The measured rain, disdrometry and hail data can be stored into a simple datalogger included with the sensor.

TYPICAL APPLICATIONS

- Monitoring of rain and hail precipitation
- High-resolution disdrometry (number and size of raindrops)
- Offshore weather buoys
- Forecast of soil erosion



RainFlow RF4

Precipitation Monitoring Sensor

MEASUREMENT CAPABILITY

■ The sensor measures and distinguishes liquid and solid precipitation. It is especially optimized for rain measurement and hail detection.

Class #	Class Label	Drop Diameter Min. - Max. (mm)
1	0.75	- 0.75
2	1.00	0.75 - 1.00
3	1.25	1.00 - 1.25
4	1.50	1.25 - 1.50
5	1.75	1.50 - 1.75
…		
25	6.75	6.50 - 6.75
26	7.00	6.75 - 7.00
27	99	7.00 -

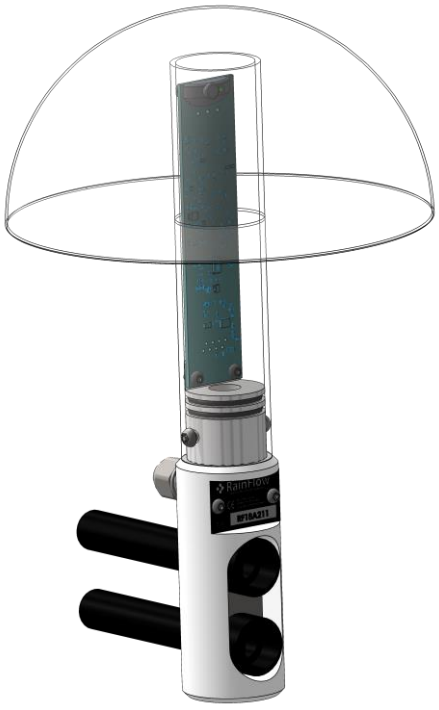
■ For rain, the sensor determines **the intensity** (up to **250 mm** per hour) as well as **the number of drops and their size** (disdrometry function, DSD). The disdrometry function provides a statistic value result, defined as a distribution expressing the percentage of drops situated in as many drop-size classes, according to a classification table (see opposite). The sensor's classification table for drop-size includes **27 classes** of equal intervals. The upper marker of the smallest class is a diameter of 0.75 mm and the lower marker of the biggest class is a diameter of 7 mm. The upper and lower markers typically correspond to the thresholds of respectively the detection and saturation of the sensor, with a certain margin of operation (drops with a diameter under 0.75 mm and over 7.00 mm can still be detected).

■ For hail, the sensor determines **the occurrence of solid precipitation** and **the number of solid impacts per second** during the measuring period of the event, and this up to **5 impacts per second** (Note: for a solid precipitation sensor with a higher temporal resolution and a particle-size determination function, please refer to the specialized HailFlow HF4 sensor).

OPERATING PRINCIPLE

■ The RainFlow RF4 sensor measures the **impact of individual liquid or solid particles** on a stainless steel hemisphere using a specialized microphone, signal processing and calculation. The hemispheric sensing surface is a 402 cm^2 wind-omnidirectional head, containing the electronics of the system and mounted on a rigid foot.

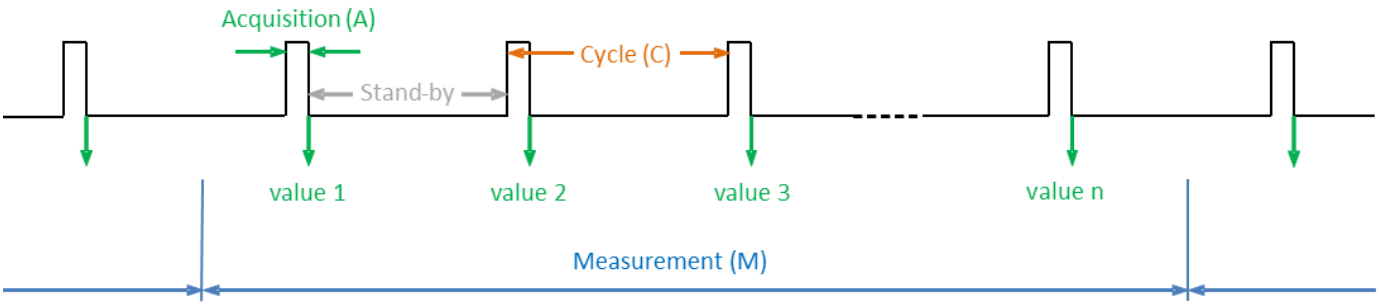
■ The sensor intercepts the falling particles – raindrops or ice pellets – whatever their falling angle. A high-resolution impulse detector converts the acoustic signal of each individual impact into a voltage, proportional to the **momentum of the impact transferred to the sensing surface** (the higher the transfer of momentum to the sensing surface, the higher the impulse acoustic response caught by the microphone). For each individual impact, the momentum that is transferred to the sensing surface depends on the particle's mass, velocity, type and incidence angle on the hemisphere, so all these factors have to be taken into account when determining the **size classes, type, amount and intensity of the precipitation**.



■ The terminal velocity depends on the particle's diameter, following an established physical law that can be adequately integrated in a statistical calculation model for precipitation. Liquid and solid particles can be distinguished within certain limits by their acoustic signature: elastic impact for lithometeors (long impulse response, high frequency response), non-elastic impact for hydrometeors (damped impulse response, lower frequency response). This signature can be recognized by the internal calculator. Considering the incidence angle, the more radial the direction of the impact, the higher the transferred momentum is. This geometrical bias can be satisfactorily corrected by fitting sampling distribution compensation. The higher the spatial density of the precipitation is, the better it operates.

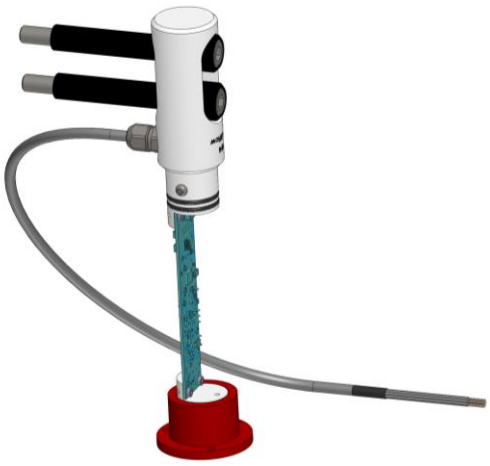
The RainFlow RF4 sensor has been initially calibrated in an artificial precipitation laboratory (WSL Birmensdorf) and then further developed through specialized scientific researches. It was then constantly improved thanks to extensive laboratory testing under controlled artificial drop generators and long-term field trials at several natural sites, including very harsh and various environments. The measurement performance of the RainFlow RF4 sensor is now in excellent accordance with most sensors on the market (tipping bucket gauges, weighing-recording gauges and optical devices).

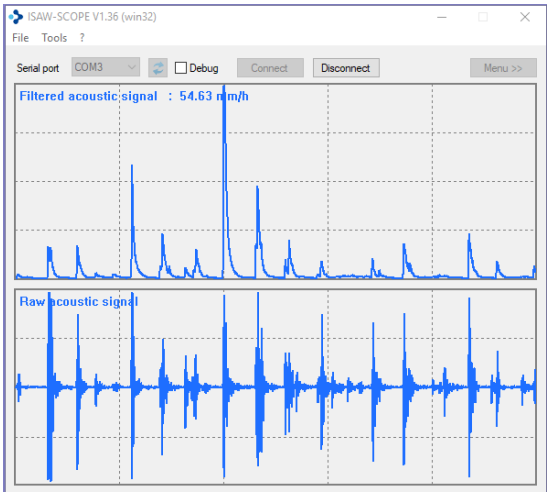
For operation where power consumption is an issue, the sensor includes an integrated power management that allows the sensor to operate under a strict power consumption optimum with regards to the desired writing resolution of the data.

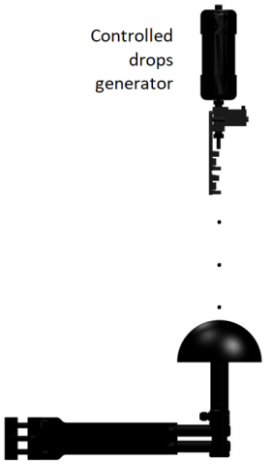


SENSOR CALIBRATION

Each sensor is factory-calibrated individually at a firmware as well as an electronic level, using a full chain acoustic calibrator that tunes the sensor to the desired nominal acoustic sensitivity with an accuracy of at least ±3%. A second and final round of calibration, taking into account the global vibroacoustic response of each individual sensor, is concluded under a controlled artificial rain drop generator with a said performance precision of ±15% of the instrument in real rain conditions.







SPECIFICATIONS

MEASURING CHARACTERISTICS

Measuring characteristics	
Measuring surface	160 mm outer diameter hemisphere (402 cm^2)
Precipitation detected by the sensor	Liquid (undifferentiated): rain, drizzle/rain, mixed rain/snow, sleet. Solid: hail.
Rain Intensity accuracy	± 15% at 100% duty-cycle (most global precision and accuracy criteria)
Rain DSD	27 classes from ≤ 0.75 mm to ≥ 7.0mm with a detection threshold (minimum detectable diameter) of about 0.5 mm
Measurement accuracy (liquid only)	A spatially distributed flux of controlled drops of a nominal diameter equal to the centre diameter of the class ± 20% produces an output centred in the corresponding class with typically ± 50% of the flux concentrated into the two lateral size-classes.
Hail detection*	Counting of the number of hailstone impacts up to 5 impacts per second and for hailstone diameter detection threshold of 0.5 cm.
Particle velocity	Not measured.

***Note:** For more specific hail detection, use the HailFlow HF4 sensor, variant of the RF4 specialized in hail detection.

MAXIMUM RATINGS

Voltage ranges and measuring scales	
Voltage outputs	Continuous analogue voltage or pulse analog voltage, user selectable +0 to +2.5V or +0 to +5V are available. Pulse threshold, integrator timeout and duration are also user selectable. The continuous analog voltage persists on the outputs so that output voltages can be read at any time.
Rain intensity scaling	Sensitivity @voltage range +2.5V: [10 mV/(mm/h)] i.e. +2.5V corresponds to 250 mm/h
	Sensitivity @voltage range +5V: [20 mV/(mm/h)] i.e. +5V corresponds to 250 mm/h
Hail	Sensitivity @voltage range +2.5V or +5V: 5 hit/s

MECHANICAL DATA

Mechanical data	
Material	Stainless steel, plastic and anodized aluminium (breakdown voltage > 40 V/µm)
Installation	Universal mounting kit provided (ordering reference: RFBRA)
Weight	1.4 kg without mounting kit
Dimensions (H×W×D)	260 mm × 430 mm × 160 mm with mounting kit

INTERFACES

Interfaces	
Analog	Pulse and continuous (and persistent) voltages, 0-2.5V or 0-5V
SDI-12	Yes, 1.3 certified (fully complies with the NR Systems SDI-12 Verifier)
Serial 3V3 TTL	Yes
Modbus RTU (RS485)	Yes, with the Modbus adapter accessory

POWER SUPPLY

Supply	Ratings
Voltage	6 V to 30 V DC (9.6 V and 16 V DC in case of powering through the SDI-12 terminals)
Current	< 1 mA in stand-by mode and 20 mA max in acquisition mode. For a typical nominal duty-cycle of 10%: 2.1 mA (20 mA for duty-cycle of 100%).

ENVIRONMENTAL CONDITIONS

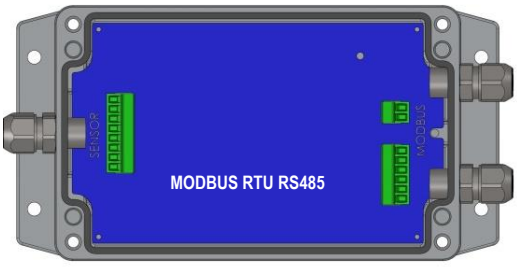
Environmental conditions	
Temperature range	-40°C to +80°C. Can even operate over this range.
Relative humidity	0 to 100%
Protection	IP67, survive to 1 m temporary immersion in salt water
Standards	EN 61326-1: 2013, CE compliant 2014/30/EU, CE compliant

WIRING & I/O MAPPING

■ The sensor can simply be used by reading DC outputs (+0 to +2.5V or +0 to +5V continuous or pulse analog voltages available). Note that the continuous DC analog voltages are persistent on the outputs so that output voltages can be read at any time (the reading interval from your peripheral is independent from the duration of the time integration of the sensor).

Wire	Signal	User selectable	Plug and Play default factory settings
White	Power	No	Positive power supply (6 to 30) VDC
Brown	Signals GND	No	OUT1 GND, OUT2 GND and SDI-12 GND
Green	OUT1	■ Disabled ■ Rain intensity (Persistent, +0V to full-scale +2.5V or +5V) ■ Rain intensity (Pulse, +0V to full-scale +2.5V or +5V) ■ Hail (Persistent, +0V to full-scale +2.5V or +5V)	Rain intensity, persistent, +0V to full-scale +5V
Yellow	OUT2	■ Disabled ■ Rain intensity (Persistent, +0V to full-scale +2.5V or +5V) ■ Rain intensity (Pulse, +0V to full-scale +2.5V or +5V) ■ Hail (Persistent, +0V to full-scale +2.5V or +5V) ■ Raw signal (±2.5V) (Note: direct, unfiltered AC output of the sensor)	Hail, persistent, +0V to full-scale +5V
Blue	SDI-12	■ Disabled ■ Rain intensity, rain disdrometry and hailstones counting	SDI 12 bus active, address: 0; Rain intensity, rain disdrometry and hailstones counting
Grey	RX	■ Disabled ■ Rain intensity, rain disdrometry and hailstones counting	RS-232 active, Rain intensity, rain disdrometry and hailstones counting
Pink	TX		
Black	Power GND (0V)	No	Power GND (0V)

■ The USB dongle accessory and the ISAW-toolbox software suite allow you to get introduced to the sensor by immediately establishing a connection with a computer or laptop, realizing a quick and simple communication start test, accessing all settings menus and seeing live data with a simple scope utility. You also have permanent access to the configuration and communication setups of the sensor directly in a terminal console mode. Remote access is also possible by using other standard serial communication modes (Serial 3V3 TTL, RS-232, Modbus RTU RS-485 or extended SDI-12 commands).

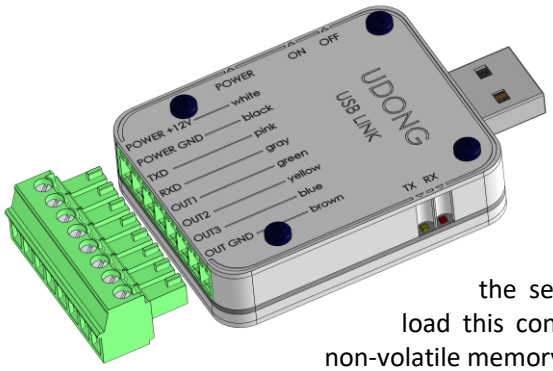


■ When adding or replacing an ISAW sensor, it is possible to pre-configure it in order to achieve Plug and Play functionality without any on-site configurations. The sensor is totally stand-alone, so that the full lifetime operation of the sensor on your installation doesn't require any software installation or maintenance.

■ When choosing an SDI-12 interface for your sensor, you can configure the data frame content you need, set the address of your choice, connect more than one ISAW sensor (as well as other SDI sensors) to a single data recorder and use extension cables up to typically 150 m with a very low current drain.

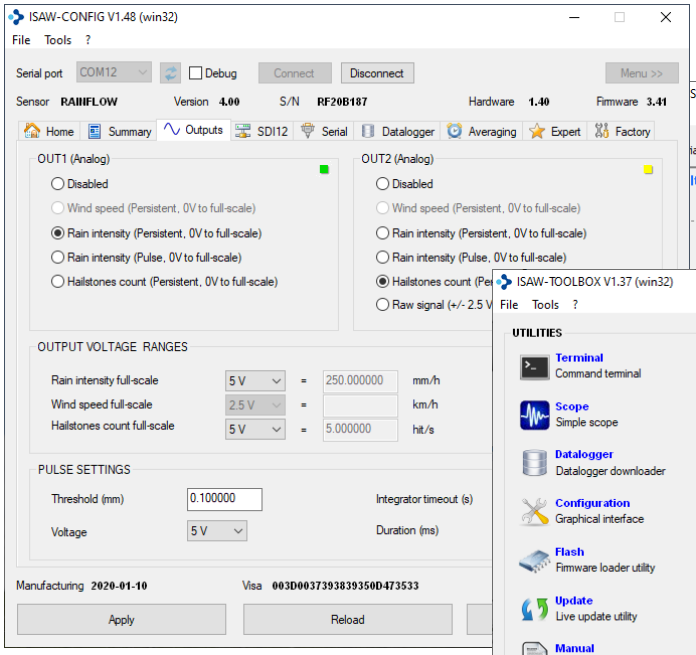
CONFIGURATION

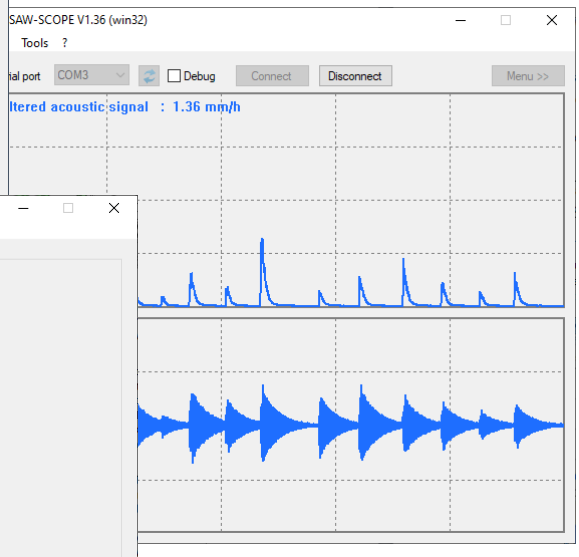
■ Configuration includes measuring settings (e.g. averaging durations), power settings, communication and mapping settings (e.g. analog and/or digital outputs, voltage scales, duty-cycle, bus address, etc.). Following the instructions in the *ISAW User Guide* you can adapt the default configuration at any time to almost any mode of use. The sensors are compatible with both analog and/or digital peripherals. The default configuration, as well as any other customized configuration, is non-volatile, ensuring that your sensor remains in the desired operating configuration whatever the powering scenarios. Thus, even in case of repeated power failures, the sensor will always restart automatically in the desired configuration mode.



■ For advanced use requiring a customized setting of the sensor, or simply to adjust some factory default settings (e.g. changing voltage range, pulse duration, SDI address, etc.), the non-intrusive and standalone freeware ISAW-Toolbox allows you to immediately configure the sensor exactly to your needs and load this configuration permanently in the non-volatile memory of the sensor.

■ Free download the ISAW-Toolbox software suite at www.isaw-products.com. Connect the sensor to your computer using the USB dongle accessory. The USB dongle has an 8-pin quick connector for the sensor's wires, a built-in power converter, and a USB plug for direct connection to a Windows, Linux, or Mac OS machine.





DISDROMETRY OUTPUT (DSD)

The output of the disdrometry function is a set of 60 semicolon-separated values, only available on digital outputs, as:

`DROP;<counter>;<unit>;<hit_count>;<unit>;<unit>;<class>;<distrib>;<class>;<distrib>;<class>;<distrib>; … ;<class>;<distrib>`

where `<counter>` is a frame counter incremented at each result
`<unit>` is the unit of the following values in the frame: “hit”
`<hit_count>` is the number of drops [hit]
`<unit>;<unit>` are the units of the following pairs of values in the frame: “mm;%”
`<class>` is the fixed drop size class in millimetres [mm] (see table on p. 2)
`<distrib>` is the percentage of drops within the class [%]

Example: `DROP;1;hit;0;mm;%;0.75;0;1.00;0;1.25;0;1.50;0;1.75;0;2.00;0;2.25;0;2.50;0;2.75;0;3.00;0;3.25;0;3.50;0;3.75;0;4.00;0;4.25;0;4.50;0;4.75;0;5.00;0;5.25;0;5.50;0;5.75;0;6.00;0;6.25;0;6.50;0;6.75;0;7.00;0;99.00;0`

HAIL DETECTION OUTPUT

The output of the hail detection function is a counting of the number of impacts detected by the sensor as solid impacts:

- **Digital outputs:** a set of 7 semicolon-separated values as:

  `HAIL;<counter>;<unit>;<hit_count>;<unit>;<mean_rate>;<max_rate>`

  where `<counter>` is a frame counter incremented at each result
  `<unit>` is the unit the of following value in the frame: “hit”
  `<hit_count>` is the number of hailstones [hit]
  `<unit>` is the unit the of following values in the frame: “hit/s”
  `<mean_rate>` is the mean rate during measurement [hit/s]
  `<max_rate>` is the max rate [hit/s]

- **Analog outputs:** a voltage proportional to the maximum count rate reached during one acquisition duration A over the writing interval W (full-range corresponding to 5 hit/s).

Notes:

- For hail detection, it is recommended to set a duty-cycle of 100% (or close to 100%, or at least with a small stand-by duration between two successive acquisitions), so that a short duration event could not remain undetected or too much underestimated because of a too-long stand-by mode of the sensor.
- For a more specialized hail detection function, please refer to the **HailFlow HF4 sensor** notice. The HailFlow HF4 sensor is able to detect up to 25 hailstone impacts per second and to distinguish between 15 classes of hailstone diameter.

CONFIGURATION EXAMPLE

Parameter	Description	Value
sens-type	Sensor type	RAINFLOW
sens-version	Sensor version	4.00
sens-date	Sensor manufacturing date	2019-12-10
sens-sn	Sensor serial number	RF19I007
hw-version	Hardware version	1.40
hw-date	Hardware manufacturing date	2019-12-10
hw-sn	Hardware serial number	002D0040363230360C473431
hw-dev-id	Hardware device identifier	0x416 (STM32L151CBT6)
hw-extflash	Hardware flash identifier	0x202013 (M25P40)
fw-version	Firmware version	3.42
fw-build	Firmware build info	Jan 10 2020 at 17:48:18 by GCC 7.2.1
cfg-ident	Config identifier	_RF_
cfg-version	Config version	0.26
range-rain	Rain range (2V5|5V)	5V
range-hail	Hail range (2V5|5V)	5V
fscale-rain	Rain fullscale (mm/h)	250.000000
fscale-hail	Hail fullscale (hit/s)	5.000000
thld-rain	Rain noise threshold (mV)	5
out1-mode	OUT1 mode (off|rain|pulse|hail)	rain
out2-mode	OUT2 mode (off|rain|pulse|hail|raw)	hail
sdi12-mode	SDI12 mode (off|rain)	rain
sdi12-addr	SDI12 address	0
serial-mode	SERIAL mode (off|rain)	rain
logger-mode	Data logger mode (off|on|cyclic)	off
logger-cfg	Data logger field config	0x1F1F
logger-usage	Logger record count usage	0
logger-capa	Logger record count capacity	0
avg-a	Acquisition duration (s)	6
avg-c	Cycle duration (s)	60
avg-m	Measurement duration (s)	600
pulse-thld	Pulse threshold (mm)	0.100000
pulse-to	Pulse integrator timeout (s)	3600
pulse-ms	Pulse duration (ms)	50
pulse-lvl	Pulse level (2V5|5V)	5V
lin-xc1	Rain coeff XC1	0.150000
lin-xe1	Rain exponent XE1	1.000000
calib-date	Calibration date	2019-12-10
calib-rain	Rain calibration factor	1.286000
cons-idle	Console idle timeout (s)	10
sys-clk	System clock type (internal|external)	external
sys-speed	System clock speed (4MHz|8MHz|16MHz|32MHz)	16MHz
sys-uptime	Sensor uptime (s)	50
sys-status	System status	OK
misc-pwrdly	Power delay before acquisition (ms)	100
misc-dbg	Debug status field	0x0000
misc-admin	Administrator status	no
misc-scopemode	Non persistent scope mode	no

GENERAL CONDITIONS

ORDERING

The RainFlow RF4 sensor is available with or without mounting kit, and a set of complementary accessories (tripod mast, splash shield, Modbus adapter, cable extension) allows you to select the equipment that perfectly matches your operating situation (see *RF4 Catalogue)*.

SHIPPING

Eco-friendly packaging, worldwide shipping within 1-5 days a.r.o., URGENT BUSINESS shipping mode.

CONDITIONS OF USE

Always remember that ISAW sensors are acoustic instruments and could thus potentially be affected by structure-borne vibrations issuing from the supporting structure (for example, a steel cable impacting repetitively on a metal mast when subjected to wind); or to a lesser extent by parasitic low-frequency noise from the immediate environment (for example, excessive proximity to heavy traffic or machinery could lead to parasitic signals). It is recommended that you pay attention to avoiding possible parasitic noise when mounting the project.

DISCLAIMER

When using ISAW sensors, IAV Technologies SARL is not responsible for the choice, selection, relevance and usage appropriateness of the sensor's installation site; nor for the usage, interpretation, and extrapolation of the information made available to the users. Any known system issues that may induce dysfunction or skew the measurements are reported to the users through documentation updates. To continually improve the system, the ISAW Products division of IAV Technologies SARL reserves the option to continuously evolve the sensor's hardware, software, and user recommendations.

WARRANTY

ISAW sensors are repairable products and benefit of a two-year warranty. The sensor, the USB dongle accessory and the mounting accessories are designed and produced with the highest standards. The equipment has a total of more than 100 mechanical and electrical spare parts and 250 electronic components. In case of failure, DO NOT TRY to open the sensor. Opening is destructive unless it is done at the factory for repair. None of the moving or user-serviceable parts require routine maintenance. Opening the unit will void the warranty. In the event of failure, before returning the unit, we recommend that you:

1. Check all cables and connectors for continuity, bad contacts, corrosion, etc.
2. Conduct a bench test e.g. using the Scope utility.
3. Contact us directly for advice.