TCG Sensor with usb / wifi read-out XEN-5320

Firmware version 3

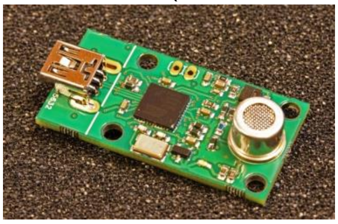
Features

Firmware version 3

- Measurement speed
  - Standard: All data 3 Hz
  - Fast: Limited data 40 Hz, USB only
  - Burst: only output voltage, 750 Hz, USB only
  - Tau: burst with heater on/off, USB only
- Signal output formats
  - Hydrogen 0-100%
  - Helium 0-100%
  - General output
  - Vacuum reading
  - Custom 23-point look-up table (several examples available)
- Digital output: WIFI, USB
- Analog output: 0.5 - 2.5 V (optional)
- Temperature and Humidity compensated
- Temperature range -20 ºC to +55 ºC
- Humidity range 0-95% non-condensing
- Start-up time: <1 second
- Standard data refresh time: 0.3 second
- T_{90} sensing and T_{10} recovery time: 0.6 s
  Optional ultrafast sensing element: <0.05 s
- Power supply USB, Li-ion battery (optional)
- Error warning

Comes with LabView read out software.

XEN-5320 sensor:
Above: WIFI version including battery and housing (63 × 51 × 24 mm^3);
Below: USB PCB (40 × 20 × 10 mm^3).



Applications

- Hydrogen and helium gas experimentation
- Response time measurement of hydrogen sensors and other gas sensors
- Response time measurement of gas valves and gas mixing systems
- Detection of gas dispersion rate in jets and plumes
- Fuel cell exhaust measurement
- Binary gas composition measurement
- Vacuum measurement

The XEN-5320 sensor is designed for R&D applications

The sensor is not conform the standards for hydrogen detection sensors.
The sensor is not designed to be a reliable safety device.
The sensor is intended for test experiments only, under expert supervision, in safe experimental environments.

Contents

1 Description

The XEN-5320 is an intelligent gas sensor for the measurement of gas composition, such as helium in air (hydrogen mimicking), oxygen (diving applications) or nitrogen; hydrogen in air or nitrogen (fuel cell applications). In addition, it can serve as a thermocouple-vacuum sensor, and it can give a general output signal, useable for other gas compositions.
The sensor is based on the measurement of the thermal conductivity of the ambient gas, using the proven thermal conductivity sensor XEN-TCG3880.
To compensate for the influence of temperature and humidity, these are measured separately and a correction is made for them in the micro-controller. Each device is factory calibrated (zeroed), the customer can re-zero. Gain adjustment is also possible.

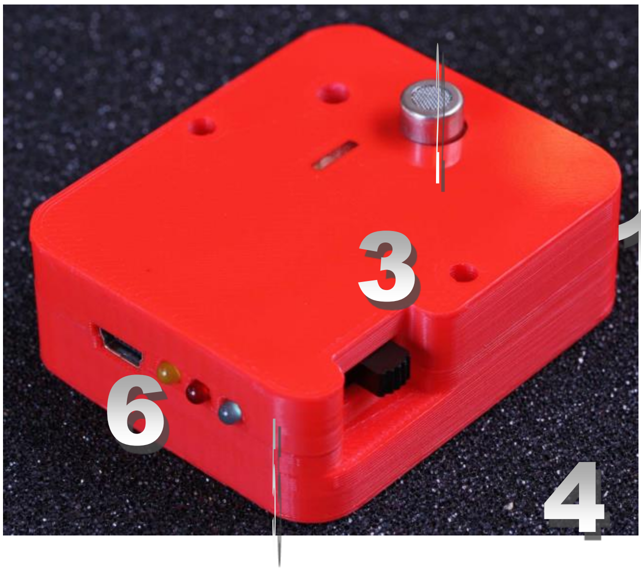


Figure 1a: The XEN-5320 WIFI version (63 × 51 × 24 mm^3).
1) The XEN-TCG-3880 thermal conductivity sensor with built-in Pt100 temperature sensor.
2) Ventilation opening for the Sensirion SHT21 humidity sensor.
3) LEDs of the WIFI module: green (bottom) flashing when the WIFI module is operational; yellow (middle) transmitting; red (top) no connection. For details see the RN-171 data sheet.
4) On/off switch.
5) XEN-5320 LEDs: green (right) flashing when the XEN-5320 is operational; red (middle) Li-ion battery is charging; yellow (left) battery full.
6) USB mini-connector.

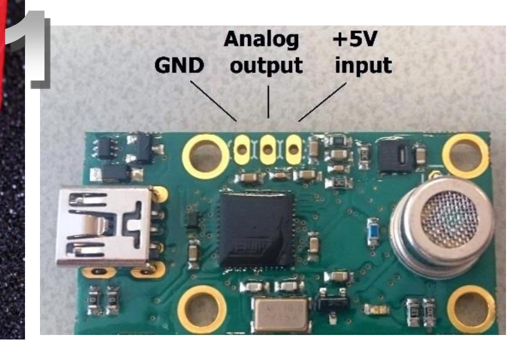
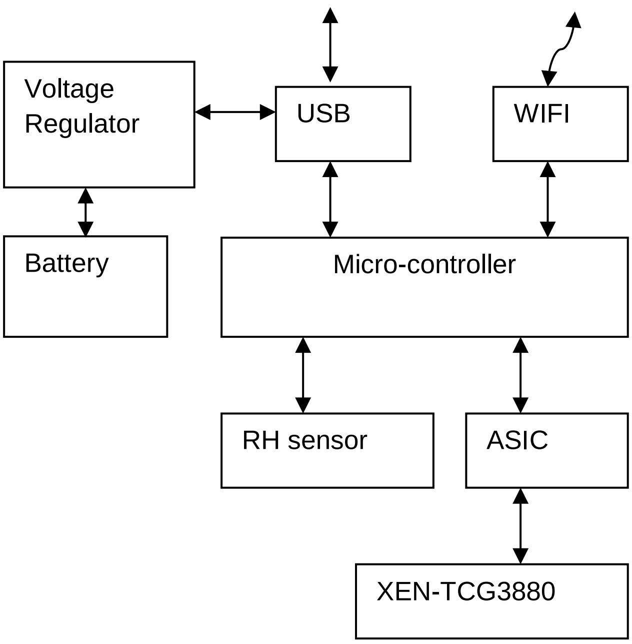


Figure 1b: The XEN-5320 USB version (40 × 20 × 10 mm^3).
On the left the USB connector;
On the right the XEN-TCG3880 thermal conductivity sensor with built-in Pt100 temperature sensor.
Visible above the XEN-TCG3880 is the Sensirion SHT21 humidity sensor.
Indicated is the optional analog output and DC power supply.

Standard the read-out and powering is done via USB.
Optionally, wireless read-out can be done by WIFI (module RN-171 from Roving Networks), with Li-ion battery power. The Li-ion battery is charged via the USB mini-connector.

LEDs are present to indicate the status of the WIFI module, the status of the battery, and the status of the micro-controller.
Biasing and measurements of the thermal conductivity sensor is via a Xensor-designed ASIC.
The XEN-5320 performs 3 measurements per second in the standard measurement mode.
Temperature measurement is done using a Pt100, and also using the temperature sensor of the humidity sensor (SHT21 of Sensirion).
Via digital communication the XEN-5320 can be instructed to calculate the output signal of the sensor assuming a helium-air mixture or a hydrogen-nitrogen mixture. The calculation of the output signal can also be done using a user-supplied look-up table, for any mixture for which data are available.
Other options are to give the output signal uncalculated (i.e., only compensated for temperature and humidity), or with a calculation yielding the ambient vacuum pressure, assuming a reduced pressure of air.
See the Par. on I/O for details about the programming of the XEN-5320 read-out.

2 Block Diagram



3 Specifications

Preliminary Specifications (at 23 ºC, 101 kPa, 50 %RH)

Item	*Typical*	*Unit*	*Remarks*
General			
Sensitivity for traces of H_2	-2.0	%/%	Signal change for concentration in air
Sensitivity for traces of He	-1.1	%/%	Signal change for concentration in air
Sensitivity for traces of CO_2	+0.4	%/%	Signal change for concentration in air
Sensitivity for vacuum	-4.7	%/Pa	For low pressures
Inaccuracy H_2 and He	1 to 3	%FS	Built in curves
Inaccuracy vacuum	10	%	Between 1 Pa and 10 kPa
Noise	0.04	%	Of signal in air
Offset drift	0.2	%/yr	Of signal in air
Operating limits			
Temperature operating range	-20 to + 55	ºC	For best accuracy
Temperature changes	<1	ºC/min	Maximum rate of change
Humidity operating range	0-95	%RH	Non-condensing
Humidity changes	<1	%RH/min	Maximum rate of change
Pressure range	800-1200	mbar	Best accuracy
	200-800	mbar	Reduced accuracy
Operation speed			
System start up time	«1	Second	
T_{90} response time	«1	Second	For 0% to 2% hydrogen in air.
T_{10} recovery time	«1	Second	For 2% to 0% hydrogen in air.
T_{63} response time RH sensor	8	Seconds	
Data update rate	3.3	Hz	WIFI / USB versions
Accelerated Data update rate	40	Hz	USB version, limited data
Maximum Output voltage update rate	750	Hz	USB version, output voltage only
Electrical			
Current consumption	20	mA	USB
Average current consumption with WIFI	65	mA	
Battery life	15	hrs	950 mAh, when new
Analog output: optional	0.5-2.5	V	For 0-100% output signal (or custom)
Storage			
Temperature storage limits	10-40	ºC	
Humidity storage limits	20-70	%RH	
Dimensions			
USB version	40×20×10	mm^3	no housing, PCB version.
WIFI/battery version	63×51×24	mm^3	housing standard; including the extruding TCG sensor and LEDs.

4 Measurement Speeds and Modes

The XEN-5320 Version 3 is a versatile sensor that determines the thermal conductivity of surrounding gases, while compensating for temperature and humidity influences. The XEN-5320 has 4 measurement speed settings, and 5 modes to calculate a signal output.

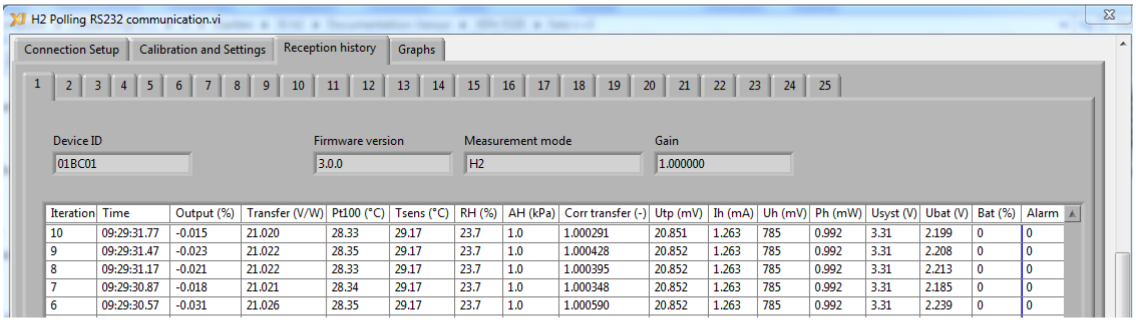
The XEN-5320 uses the XEN-TCG3880 sensing element for the measurement of the thermal conductivity. Please consult the data sheet of the XEN-TCG3880 for information on how the sensing element works, and which options are available.
Standard the XEN-TCG3880-P2RW sensing element with extra ground connection is used. This has a typical response time of 125 ms (0 - 63%). Optionally, faster sensing elements can be used if fast phenomena have to be measured. Then, instead of a cap with filter, sensors with an open cap, i.e., a 7 mm opening at the top, can be used. These have a typical response time of the order of 25 ms (0 - 63%). This depends on the gas being monitored.
The XEN-5320 uses the Sensirion SHT21 for the humidity and humidity-temperature sensing. Please consult the data sheet of the SHT21 for further information on the accuracy of this element. The time constant of this sensor is typically 8 s (0-63%), although at high temperatures this may be lower.

4.1 Measurement Speed

The XEN-5320 WIFI has one measurement speed, all measured and calculated data are delivered at about 3 Hz output rate. Other measurement speeds of the USB version (see below) may also be available when using WIFI communication, but reliable operation according to the specifications is not guaranteed in that case.
The XEN-5320 USB version has more measurement speeds. All data that are measured in a specific speed can be shown graphically, they can be displayed numerically, and they are stored in a file. This can all be done using the free LabView software from Xensor Integration. Alternatively, the user can operate the sensors with his/her own communication software.

4.1.1 Standard Measurement Speed

The Standard measurement speed gives about 3 Hz data output rate, and performance according to the specifications. The thermopile output voltage Utp (mV) is the average of 30 measurements. All shown measurement data are supplied. The XEN-5320 can conveniently be read out using the Standard XEN-5320 LabView program. Detailed information is given in the XEN-5320 LabView program manual.

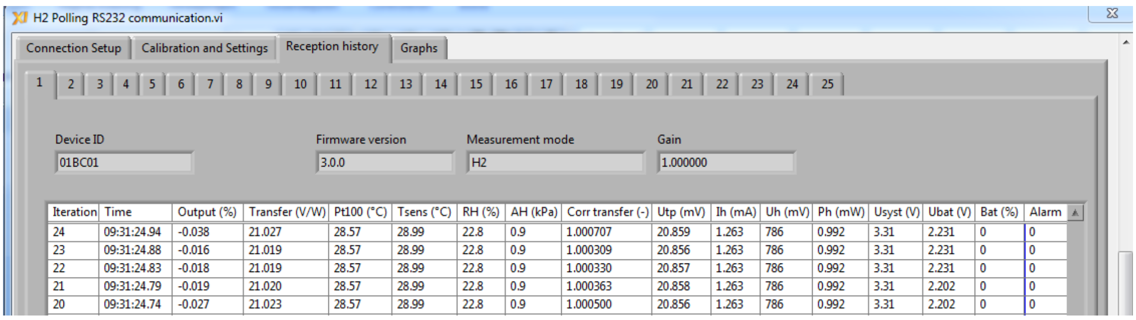


Iteration	Time	Output (%)	Transfer (V/W)	Pt100 (°C)	Tsens (°C)	RH (%)	AH (kPa)	Corr transfer (-)	Utp (mV)	Ih (mA)	Uh (mV)	Ph (mW)	Usyst (V)	Ubat (V)	Bat (%)	Alarm
10	09:29:31.77	-0.015	21.020	28.33	29.17	23.7	1.0	1.000291	20.851	1.263	785	0.992	3.31	2.199	0	0
9	09:29:31.47	-0.023	21.022	28.35	29.17	23.7	1.0	1.000428	20.852	1.263	785	0.992	3.31	2.208	0	0
8	09:29:31.17	-0.021	21.022	28.33	29.17	23.7	1.0	1.000395	20.852	1.263	785	0.992	3.31	2.213	0	0
7	09:29:30.87	-0.018	21.021	28.34	29.17	23.7	1.0	1.000348	20.852	1.263	785	0.992	3.31	2.185	0	0
6	09:29:30.57	-0.031	21.026	28.35	29.17	23.7	1.0	1.000590	20.852	1.263	785	0.992	3.31	2.239	0	0

Figure 1: Output of the XEN-5320 in Standard mode at about 3 Hz data rate. All data are measured or calculated.

4.1.2 Fast Measurement Speed

The Fast measurement speed gives a data output rate of the order of 40 Hz, measuring transfer (output voltage, heater voltage and current, and derived data), temperature and humidity data. The thermopile output voltage is not averaged in time. The actual data rate when using the Xensor Labview read-out program depends on the data display mode and size of the data file. Not displaying the data with a small file allows a data rate of over 40 Hz. This can drop to 15 Hz or less when using the reception history (numerical data) or having large data files (many MB). Graphical displaying of data has a smaller impact on the data rate. A LabView program is available for both the Standard and the Fast measurement mode. In the Fast mode, be aware of the large amount of data generated.
The data output rate is for a single device. In an experiment, it dropped from ~44 Hz to ~22 Hz when 5 devices were connected. This was for displaying the output graphs, or another page. When displaying the Reception history page, the rate even dropped to ~11 Hz. And it is to be expected that the rate when displaying the graphs will drop when the number of displayed measurements increases above 20 000.



Iteration	Time	Output (%)	Transfer (V/W)	Pt100 (°C)	Tsens (°C)	RH (%)	AH (kPa)	Corr transfer (-)	Utp (mV)	Ih (mA)	Uh (mV)	Ph (mW)	Usyst (V)	Ubat (V)	Bat (%)	Alarm
24	09:31:24.94	-0.038	21.027	28.57	28.99	22.8	0.9	1.000707	20.859	1.263	786	0.992	3.31	2.231	0	0
23	09:31:24.88	-0.016	21.019	28.57	28.99	22.8	0.9	1.000309	20.856	1.263	786	0.992	3.31	2.231	0	0
22	09:31:24.83	-0.018	21.019	28.57	28.99	22.8	0.9	1.000330	20.857	1.263	786	0.992	3.31	2.231	0	0
21	09:31:24.79	-0.019	21.020	28.57	28.99	22.8	0.9	1.000363	20.858	1.263	786	0.992	3.31	2.202	0	0
20	09:31:24.74	-0.027	21.023	28.57	28.99	22.8	0.9	1.000500	20.856	1.263	786	0.992	3.31	2.202	0	0

Figure 2: Output of the XEN-5320 in Fast mode at about 40 Hz data rate. Only Utp, Uh, Ih, Tsens and RH sens are measured, Pt100, Usyst and Ubat not.

4.1.3 Burst Measurement Speed

The Burst measurement speed only delivers the thermopile output voltage of the sensing element, no corrections for any parameter, including reference calibration parameters. But it can do this at a data rate of up to 750 Hz (for a few seconds), or 250 Hz for minutes on end. For gathering the burst data a separate LabView program is available, see Fig. 3. Details of the program are given in the Burst program manual.
When measuring at the highest rates (measurement interval 1 or 2, being 1.3 or 2.6 ms) usually there is a limited number of measurements after which the communication will break down. This is in the order of 1000 – 4000 measurements, or 1 – 8 seconds. In that case the measurement still has to be stopped by pushing the stop button, after which a new measurement can be started. Otherwise the XEN-5320 may be stuck, and it may be necessary to disconnect the XEN-5320 and shut down the Burst program.
At a measurement interval of 3 or more, measurements can be kept up for much longer. The extent of the maximum measurement depends partly on the computer that is being used.
In some case, hundreds of thousands of measurements can be made with the slightly longer intervals.

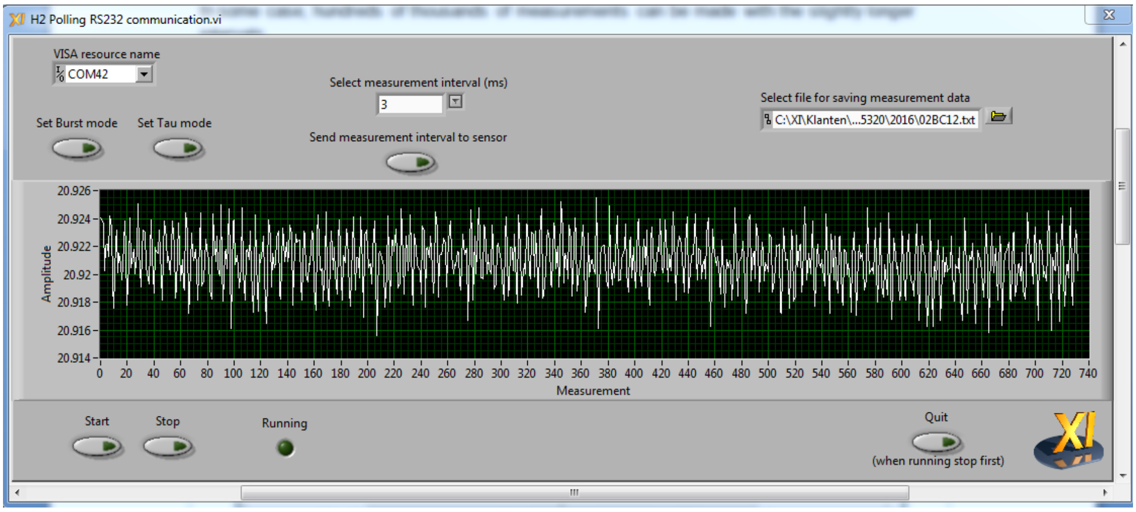


Figure 3: Output of the XEN-5320 in Burst mode with a 3 measurements averaging (4 ms interval), measuring air. Peak to peak noise is shown to be 300 ppm.

4.1.4 Tau Measurement Speed

The Time constant output (Tau) measurement speed delivers the thermopile output voltage of the sensing element at 1.3 ms intervals (when choosing an interval of 1) while turning the heating power on and off at about 45 ms intervals, see Fig. 4. This allows to calculate the time constant of the sensing element as well as the output voltage, and with it the heat capacity of the surrounding gas. This therefore gives an independent extra characterizing parameter of the gas mixture, and may allow for ternary gas mixtures to be determined. The step interval of 45 ms is chosen to reduce power line interference in case two subsequent wave forms, at 90 ms interval (≈4½ × 20 ms and 5½ × 16.66 ms), are added.

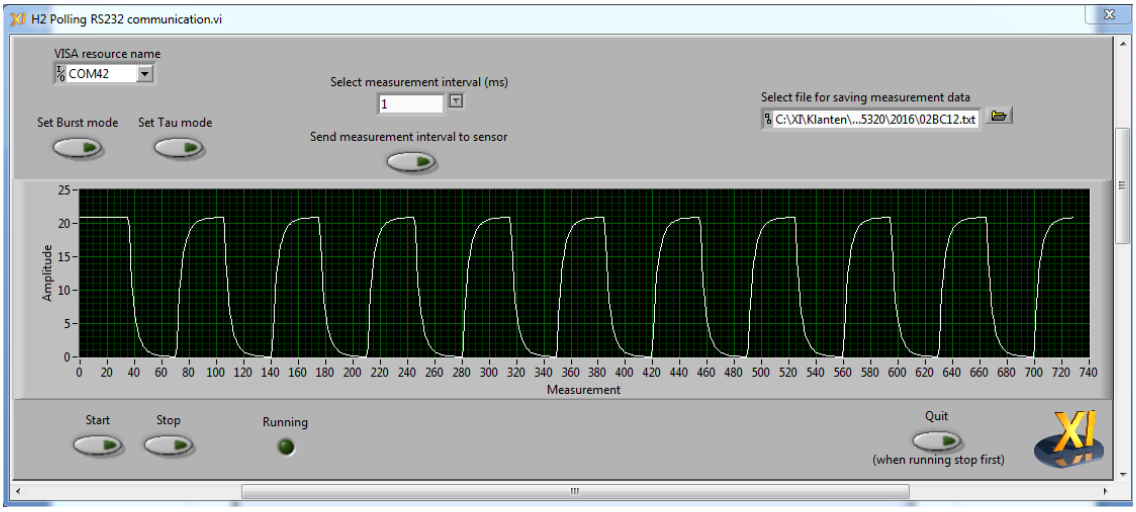
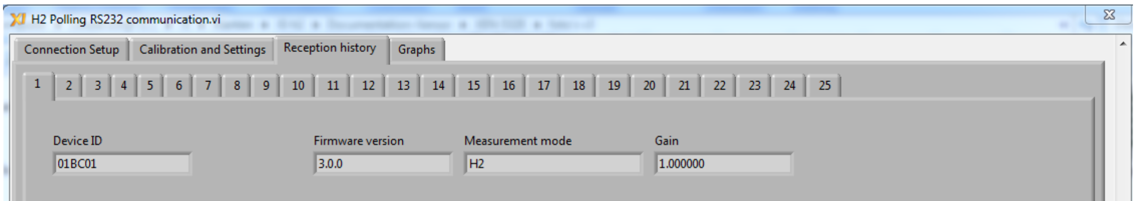


Figure 4: Output of XEN-5320 in air using the Tau measurement at 1.3 ms interval, read out with the Burst LabView program.

4.2 Output Data

When we look at the reception history as shown in Fig. 1, repeated below, we can see various data columns. We discuss them briefly here, they are discussed in more detail in the manual for the LabView program.



Iteration	Time	Output (%)	Transfer (V/W)	Pt100 (°C)	Tsens (°C)	RH (%)	AH (kPa)	Corr transfer (-)	Utp (mV)	Ih (mA)	Uh (mV)	Ph (mW)	Usyst (V)	Ubat (V)	Bat (%)	Alarm
10	09:29:31.77	-0.015	21.020	28.33	29.17	23.7	1.0	1.000291	20.851	1.263	785	0.992	3.31	2.199	0	0
9	09:29:31.47	-0.023	21.022	28.35	29.17	23.7	1.0	1.000428	20.852	1.263	785	0.992	3.31	2.208	0	0
8	09:29:31.17	-0.021	21.022	28.33	29.17	23.7	1.0	1.000395	20.852	1.263	785	0.992	3.31	2.213	0	0
7	09:29:30.87	-0.018	21.021	28.34	29.17	23.7	1.0	1.000348	20.852	1.263	785	0.992	3.31	2.185	0	0
6	09:29:30.57	-0.031	21.026	28.35	29.17	23.7	1.0	1.000590	20.852	1.263	785	0.992	3.31	2.239	0	0

Figure 5: Output data of the XEN-5320.

The measurement starts with measuring the thermopile output voltage Utp of the sensing element, and the heating current Ih and voltage Uh used to heat up the membrane of the sensing element. Ih×Uh gives the heating power Ph, and Utp/Ph gives the uncorrected Transfer (V/W). Also measured are the temperature of the sensor using the Pt100, and the Relative

Humidity using the Sensirion SHT21 sensor. This Sensirion also provide the temperature Tsens, measured at some distance of the thermal conductivity sensing element.
Using Tsens and RH the Absolute Humidity AH (in kPa) is calculated, and with AH and the Pt100 Temperature a correction for humidity and temperature is calculated. With this correction, a normalized Corrected transfer Corr transfer (-) is calculated, which is used to determine the Output (%) of the XEN-5320. If Corr transfer is unity, the output signal is zero. Other data measured are the system voltage, usually 3.3 V (Usyst), and, for the WIFI versions which are battery powered, the battery voltage Ubat and the estimated battery load percentage Bat%. Users can use the output of the sensor to determine the signal they are after (dependent on the measurement mode setting, helium or hydrogen concentration, or vacuum pressure, for instance). But they can also analyze more raw data, such as transfer or even Utp, using the txt file that holds all measurement data, see Fig. 6, where the txt file has been opened using EXCEL. The txt file generated by the Standard LabView program has a typical size of 0.1 kB per measurement. Thus, for 100 000 measurements a file of about 10 MB is obtained.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Device ID	Factory Device ID	Firmware	Measurement mode	Speed	Sensitivity	TC Transfer	AH1	AH2	AH3	Y_AH_Cal	TF_Cal (V/W)	Temp_Cal (~C)	Gain			
2	01BC01	01BC01	3.0.0	H2	Fast	-1.93	250	-0.00245	0.000075	0	0.995915	20.965	25.789	1			
3	Iteration	Time	Output (%)	Transfer (V/W)	Pt100 (~C)	Tsens (~C)	RH (%)	AH (kPa)	Corr trans	Utp (mV)	Ih (mA)	Uh (mV)	Ph (mW)	Usyst (V)	Ubat (V)	Bat (%)	Alarm
4	0	15:52:53.46	-0.082	21.01	30.46	30.69	21.8	1	1.001542	20.895	1.263	787	0.995	3.3	2.205	0	0
5	1	15:52:53.72	-0.092	21.014	30.38	30.69	21.8	1	1.001736	20.897	1.263	787	0.994	3.3	2.231	0	0
6	2	15:52:53.75	-0.077	21.008	30.38	30.69	21.8	1	1.001443	20.894	1.263	787	0.995	3.3	2.231	0	0
7	3	15:52:53.77	-0.078	21.008	30.38	30.69	21.8	1	1.001471	20.893	1.263	787	0.995	3.3	2.231	0	0
8	4	15:52:53.80	-0.066	21.003	30.38	30.69	21.8	1	1.001241	20.894	1.263	787	0.995	3.3	2.231	0	0

Figure 6: Output data of the XEN-5320 in file.

In the Fast Measurement Mode, not all data are measured. Pt100 is skipped, and instead the Tsens of the Sensirion is used. Also the battery data are not measured. In the zero measurement, all data are measured, including reference elements present in the XEN-5320, so this takes a little longer, and the reference values of voltage, resistance of this zero measurement are used throughout all subsequent measurements. This may introduce some inaccuracy if the environmental conditions change significantly during the measurement. In the Standard Measurement Mode, all reference elements are measured each measurement.

For the Burst and Tau mode only thermopile output voltage and time data are recorded, see Fig. 7.

03BC40.txt - Kladblok

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4.027112	28893.21
12.466502	28897.04
16.113680	28900.89
17.832352	28904.72
18.699907	28908.56
19.155523	28912.41
19.397383	28916.25
19.530474	28920.09
19.600740	28923.93
19.639368	28927.77
19.665205	28931.60
19.679007	28935.45
19.686758	28939.28
19.690096	28943.13

Figure 7: Output data of the XEN-5320 in file, in Burst or Tau mode, first Utp in mV, then microcontroller time in ms..

Normally, the output is the thermopile output voltage Utp and the microcontroller time in increments of 10 µs. However, if the XEN-5320 has been connected to power already a long time, the time will be given in 0.1 ms or 1 ms increments instead. To obtain output in 10 µs increments, disconnect the sensor and start anew.

4.3 Measurement Modes

Many data are measured and calculated by the XEN-5320 and the associated LabView programs. One column of data is special, in that is varies with the Measurement Mode that is chosen. It is the Output (%) column, which displays the output signal of the XEN-5320 expressed in a chosen parameter. They are explained below.

4.3.1 H2 Measurement Mode

In the H2 measurement mode, the Corr Transfer is used to get the hydrogen concentration in Nitrogen (or air), using a look-up Table that correlates the Corr Transfer to the hydrogen concentration measured at Xensor. Typical values are a Corr. Transfer of 1.000 for nitrogen and 0.191 for pure hydrogen. This can be slightly different for different sensing elements.
In this Version 3 the typical inaccuracy of this Table is estimated to be 1-3%, assuming a zero has been performed. As a trial a gain parameter can be used to set the pure hydrogen output value to 100 %. Further calibrations will be carried out to refine this method and make it more accurate. Look at the Xensor website for the latest data. When improved Tables or methods become available, the user can decide to use the custom curve output, see below.

4.3.2 He Measurement Mode

This Mode does the same as the H2 mode, but now for helium. For helium, a second order polynomial equation is used to calculate the helium concentration in air.
Typical values are a Corr. Transfer of 1.000 for air and 0.220 – 0.228 for pure helium. This can be slightly different for different sensing elements.
In this Version 3 the typical inaccuracy of this Table is estimated to be 1-3%, assuming a zero has been performed. As a trial a gain parameter can be used to set the pure helium output value to 100 %. Further calibrations will be carried out to refine this method and make it more accurate. Look at the Xensor website for the latest data. When improved Tables or methods become available, the user can decide to use the custom curve output, see below.

4.3.3 GEN Measurement Mode

In this Mode, the output simply reflects the deviation of the Corr transfer from unity. Because this is an all purpose output, the ADC range of the electronics is widened from 50 mV Full Scale to 200 mv FS, because in vacuum situations the output voltage can exceed 50 mV.

A consequence of this is that zeroing when changing to this 200 mV range has to be carried out again, since the ADC offset in the 50 mV range and the 200 mV may be slightly different.

4.3.4 VAC Measurement Mode

In the Vacuum Measurement Mode, the output (%) gives the vacuum pressure based on the Corr transfer and a look up Table. Default this Table is based on air at atmospheric pressure. The option exists to choose Table parameters for a different gas. For several gases these parameters are supplied by Xensor. Even though a simple, and physically incorrect model is used for the pressure calculation, a surprisingly accurate calculation is made. In the 1 Pa – 10 kPa range errors are below 10%. Also here, the option exists for the user to use his/her own custom curve.

4.3.5 Custom Curve Measurement Mode

For those who want to create their own output signal, there is the option to upload a custom curve in the form of a 23-point look up Table. This can be used to create a more accurate helium, hydrogen or vacuum signal, or make a curve for different gas mixtures. This curve will remain in the XEN-5320 EEPROM until it is replaced by a new curve. The Custom curve Table entries are printed into the txt file each time a new measurement using this Table is started.

4.3.6 Burst and Tau

Although the Burst and Tau measurements are in the first place choices for speed, they are listed in the Measurement Mode list in the Standard LabView program if the device is in Burst or Tau measurement mode. But they cannot be chosen using the Standard LabView program, only in the Burst program.

4.4 Response time and Transients

The standard XEN-TCG3880P2WR (with welded cap and silicon roof: heat sink near the membrane) has a response time tau (0-63%) of about 150 ms, see Fig. 8, in which the time is measured in increments of 4 ms. This is for a change between synthetic air and 2% hydrogen in synthetic air, at a flow rate of about 1 l/min.
The cap over the sensor is responsible for the large time constant, since a significant volume of gas has to be exchanged by diffusion. When removing the top of the cap, the response is 5 times faster at about 30 ms for the same experiment, see Fig. 9. The sensing element has been slightly modified to avoid large flow noise.
For other gases, different times may be found, depending on the properties of the gases.
It is found that these measurements are significantly influenced by the set up of the experiment. A different flow rate or different flow tubing (dead volume above the sensor) may have a large influence on the measured values.

However, the measurement of humidity and temperature by the separate RH sensor is much slower, and the consequence is that in transient conditions, where temperature and/or humidity are changing rapidly, the calculated output of the sensor can be off. This is caused by the fact that response time of the thermal conductivity gauge to humidity changes is much faster than that of the humidity sensor, which has a tau (0-63%) of the order of 8 s. And while temperature transients may be dampened by the fact that all solids take time to change their temperature, the humidity is a gas phase property, and this can change as fast as any gaseous constituent. This is shown in Fig. 10, where the humidity sensor adapts slowly to steps in the humidity levels, while the thermopile output voltage of the thermal conductivity gauge (standard version) responds quickly. As the XEN-5320 calculates a %-output correcting for humidity using the slow humidity sensor, transients are seen in the %-output signal.

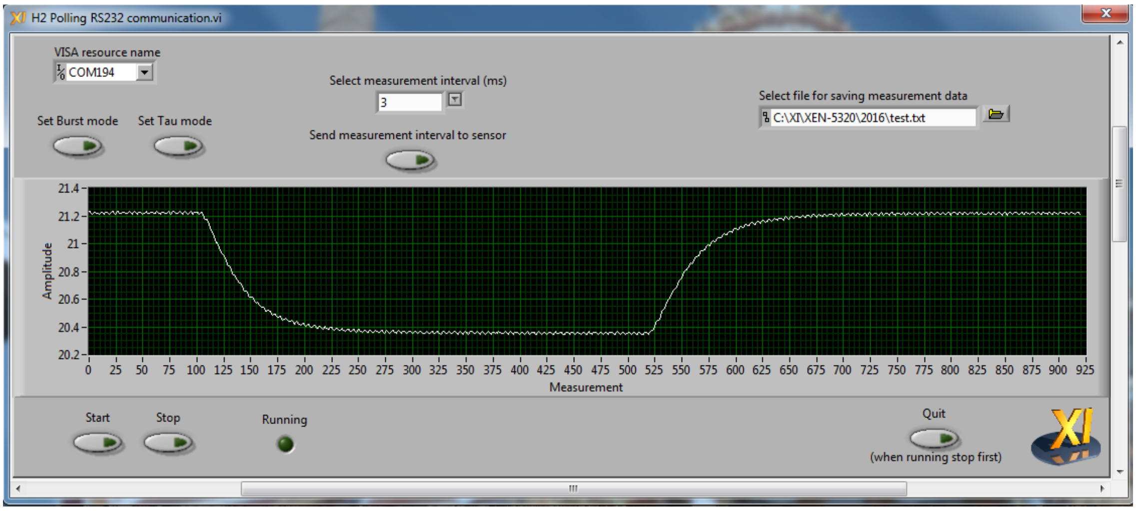

Figure 8: Response of XEN-5320 with the standard sensing element to a 2%-change in hydrogen concentration. Each measurement is about 4ms. The tau (0-63%) is approximately 150 ms.

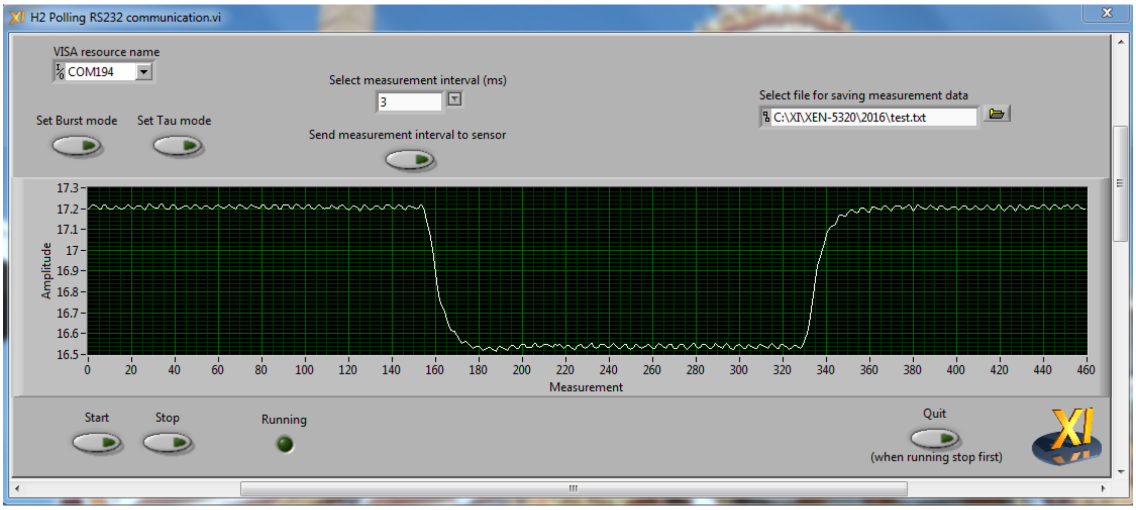

Figure 9: Response of XEN-5320, with the sensing element with an open cap, to a 2%-change in hydrogen concentration. Each measurement is about 4ms. The tau (0-63%) is approximately 30 ms.

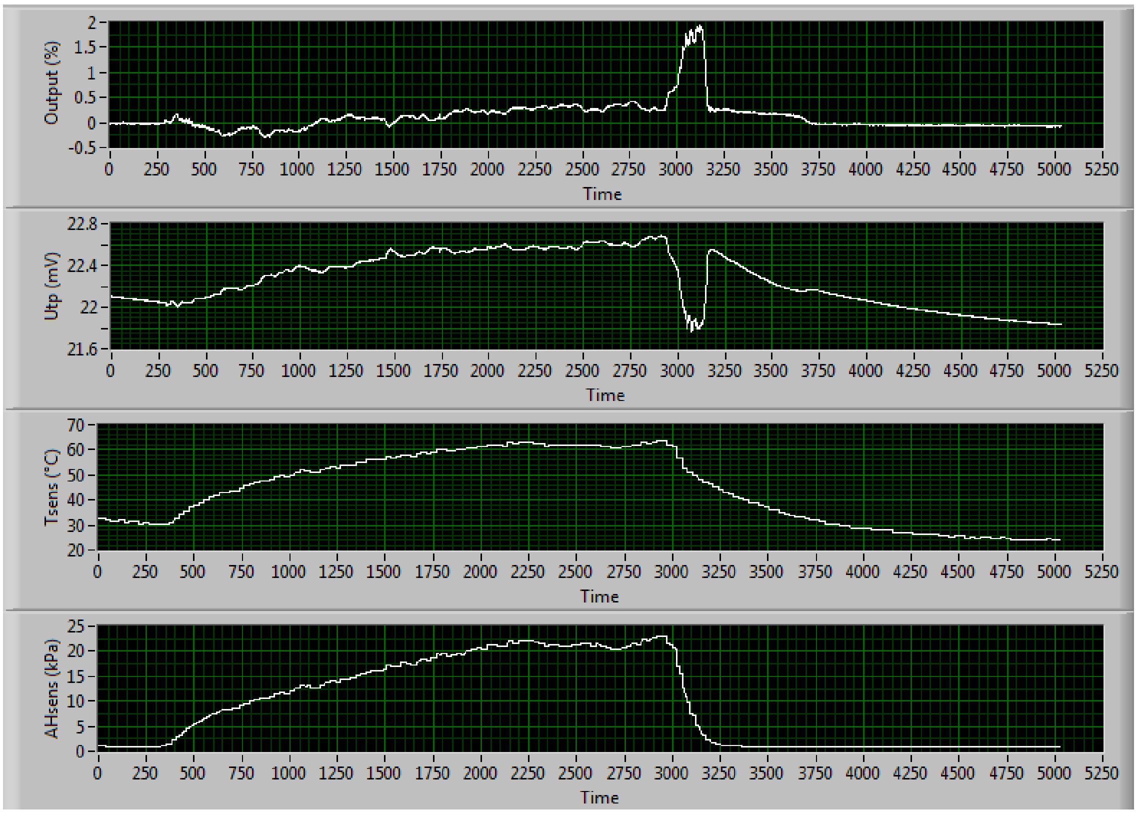

Figure 10: Response of XEN-5320 to steps in humidity (and temperature) when immersing the XEN-5320 into a bottle with very hot water at the bottom, and retracting it into open air. Measurement rate ≈40 Hz.

At measurement 300 in Fig. 10 the XEN-5320 is exposed to the hot steamy air, around measurement 2900 it is brought back into open air at ambient temperature in front of a ventilator to quickly refresh the gases inside the cap. The measurement rate is about 40 Hz. Especially the move into open air and violent waving around measurements 2900-3200 leads to a quick decrease in humidity at the sensor, while the correction for this is much slower, as shown by the humidity sensor's calculated absolute humidity AH (bottom graph). Consequently, the thermopile output voltage Utp goes down very quickly, while the calculated output percentage (top graph), which was correcting reasonably for humidity before, now shows a significant error between measurement 3000 and 3200, which is about 5 seconds.
Because of the higher temperatures (60 ºC) the response of the humidity sensor is faster than at room temperature. The temperature decrease is much slower than the humidity decrease, the latter is gas exchange, the temperature decrease is strongly influenced by the solid state materials.
Condensed water drops may influence the behavior after measurement 2900, as well as the fact that various parts of the sensing element may cool down at different rates.

4.5 Accuracy and Noise

The accuracy of the XEN-5320 is determined by several effects. The zero of the sensor can be recalibrated, but also be determined from the measurement results in case a measurement is being performed that should give back zero output.
The gain of the measurement, how an output signal is calculated, depends on the temperature and humidity measurement and correction, and also on the calibration curve for a specific gas combination. The gain can be corrected for.
In general the calibration curve for a gas combination is determined at room temperature (≈ 20-25 ºC). At other temperatures, it is expected that this curve will be different. This introduces an error. For di-atomic gases such as nitrogen, hydrogen and CO the ratio of the thermal conductivity at 300 K and at 400 K is roughly the same. For the mon-atomic gas helium, this ratio is slightly lower, while for the tri-atomic gas CO_2 it is much higher. Especially for CO_2 one will expect an error when using the room-temperature sensitivity curve at other temperatures.
Also the correction for temperature and humidity will introduce errors, firstly because of the inaccuracy of the temperature and humidity measurement, and secondly because of the inaccuracy of the correction factors used. They may be slightly different for individual sensors.

At a typical -250 ppm/ ºC temperature coefficient (TC) of the sensor's basic signal (the transfer = output voltage of the TCG sensor divided by the input heating power), the correction for a 40 ºC temperature deviation is 10 000 ppm. If the TC is off by 10%, this means that an error of 1000 ppm is be introduced by the temperature correction alone.

For the humidity it holds that the correction factor, at low humidities, is of the order of -2500 ppm/kPa. and 1 kPa is equivalent to about 33% RH at room temperature. Also here noticeable errors can be introduced if the correction factor is inaccurate. At high temperatures the problems can get out of hand, for instance, at 80 ºC 100% RH is equivalent to about 47 kPa. Now, an error in % RH measurement of 5% RH is equivalent to 2 kPa, or an error of about 5000 ppm in the output signal. See below for some details on the humidity measurement and errors.

Finally there is noise in all measurements that are made, and this introduces noise in the output signal as well. The total noise level of the sensor is of the order of 250-500 ppm of the transfer, see Fig. 11 for a typical read-out, with 0.3 s data refresh time.

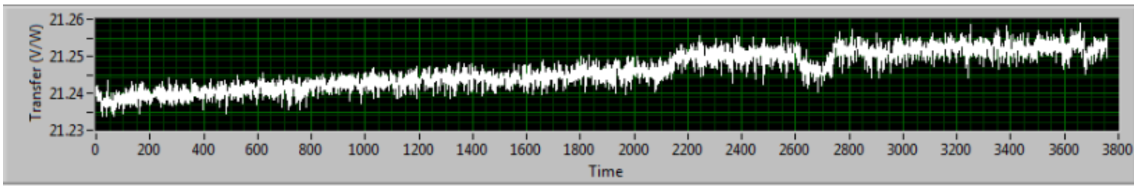

Figure 11: Transfer of XEN-5320 at 0.3 s data refresh time. The peak-to-peak noise of this measurement is typically 0.005 on 21.24, or 250-500 ppm. RMS noise is then of the order of 50-100 ppm.

If the parameter being measured allows it, averaging of the signal is an option, thereby greatly reducing the noise.

4.6 Calibration

In order to minimize the inaccuracies described above, it helps to calibrate the sensor as close as possible to the eventual operating conditions. This will at least eliminate any errors occurring due to the difference between room temperature and operating conditions.
When using the LabView program for reading and storing the measurement data, the user has the option to further analyze the stored data and determine correction curves around the user's point of operation.
The Custom Calibration Curve Measurement Mode even allows the user to calculate the output with a user-determined calibration curve of his/hers specific XEN-5320.
The XEN-5320 offers the possibility to perform a zero calibration, and also a gain calibration. This will position the begin point and the end point of the calibration curve at the right value, minimizing the errors.
Fig. 12 shows a XEN-5320W unit being calibrated with helium, using the flow adapter (XEN-85030).

Figure 12: Fast calibration of the XEN-5320W with minimal gas usage with the help of the flow adapter XEN-85030.

5 Instructions for use

5.1 Range and Poisoning

Since the TCG is not poisoned by an overdose of gas, the operating range is 0-100% for non-corrosive and non-condensing gases. The digital output gives all concentrations, if calibration curves are available for the user-specified gas.
The capacitive humidity sensor can be sensitive to poisoning by silicone vapors, so these have to be avoided.

5.2 Selectivity

The TCG-based device is non-selective in that it will give an output in the presence of any gas having a thermal conductivity different than air.
The sensor is especially useful for the measurement in air or nitrogen of *helium* and *hydrogen*, which have thermal conductivities that are 6x resp. 7x as high as that of air at room temperature.
Most other gases have much lower thermal conductivities than helium, with *neon* at 2x the thermal conductivity of air as the highest of the others. So, other gases give much smaller signal changes. *Methane* and *natural gas* have a thermal conductivity of about 40% higher than that of air, and CO_2 (*carbon-dioxide*) nearly 40% lower. These gases can still easily be measured in air using the XEN-5320.
However, CO (*carbon-monoxide*), for example, has about the same thermal conductivity as air, so this gas is very difficult to detect with a thermal conductivity measurement.

5.3 Proper ventilation

Above all other measures, the user must take care that the sensing element is properly ventilated so that the gas to be measured can access the sensing element through diffusion into the cap via the hole in the cap. Blocking this hole or proper ventilation of the instrument in general will make the device non-functional, while still it will indicate values that appear to be proper.

5.4 Condensing and water dropping onto the sensors

Precaution must be taken against condensing of water vapour in the sensor or water drops falling onto the sensors, as this may lead to (irreversible) malfunctioning. Preferably the sensor is installed in such a way that the *opening of the thermal conductivity gauge is downwards*, to avoid contamination by water drops, dust or other matter falling onto the gauge and the humidity sensor. However, the sensor will function properly in any orientation.

5.5 Humidity sensor influence and care

More specific caution should be taken when subjecting the humidity sensor to extreme values of temperature and humidity. When subjected to temperatures below zero or humidities around zero, the humidity sensor may take some time to recover. It is therefore not advised to use the XEN-5320 at these extremes and then suddenly expose the XEN-5320 to high temperatures (above room temperature) and humidities, this can temporarily lead to falsely indicated concentrations.
Another problem may be that condensation of water vapour can occur, with the risk of short circuits.
Exposure to very high humidities over the 90% RH may lead to some drift of the sensor, and thus to drift of the XEN-5320 at the high end of the temperature range. For more details, go to the Sensirion website for the SHT21 RH sensor.

5.6 Batteries and extreme environmental conditions

For customers requiring higher operating temperatures than 55 ºC, it is advised to use the sensor without battery, because the battery is not designed to function at high temperatures. The XEN-5320 in the USB version (no battery, no WIFI) has been successfully tested for short periods (hours) at temperatures of 90 ºC and humidities of 90% RH (around 63 kPa water vapour partial pressure, at sea level pressures around 100 kPa). The XEN-5320-U has also been tested down to -70 ºC.

However, temperature and humidity correction are less accurate at these extreme environmental conditions, and no guarantees are given about the performance and reliability in these conditions.

5.7 Flow and sudden changes in the ambient

Sudden temperature shocks and humidity shocks may lead to spurious signals in the sensor output. Also sudden movement of the sensor and strong air flow directly onto the sensor may lead to spurious signals.
Although the sensor has a double shielding against flow effects, exposing the sensor to gas flows may influence the calibration curves and correction curves for temperature and humidity, and lead to residual offset (output signals) even when exposed to the calibration gas only.

6 Self diagnosis

In the LabView read out program version 3.0 some simple self-diagnosis calculations are made and the results are shown in the displayed and filed data. The idea of the self-diagnosis is twofold. To warn for situations where the XEN-5320 is still working fine, but is outside the operating conditions that provide reliable date. And to raise the alarm if the XEN-5320 is putting out data that are unreliable, and may indicate instrument failure.

The version 3.0 is still a trial version of this self-diagnosis, it is not yet implemented into the XEN-5320 itself. Table 1 below shows the various criteria and their alarm code. The codes of the criteria that are met are added and displayed and stored. The code value displayed and stored is the sum of all the codes that are active. And the higher the code, the more serious the situation is.

Table 1: Self-diagnosis criteria and codes

#	Criterion	W/A	Value
0	No Warning or Alarm		0
1	T <-20 ºC or >+55 ºC	Warning	1
2	T<-70 ºC or >+90 ºC	Alarm	2
3	$\|T_{Pt100}$-Tsensirion$\|$ >10 ºC, alarm	Alarm	5
4	$\|T_{Pt100} – T_{Pt100\ -15\ s}\|$ > 1 ºC	Warning	10
5	$\|RH – RH_{–15\ s}\|$ > 1 kPa	Warning	20
6	Output < -0.5%	Warning	50
7	Incorrect data received	Warning	100
8	Ph < 0.4 mW or Ph > 1.6 mW	Alarm	200
9	Transfer <3 or >200	Alarm	500
10	Usyst < 2.7 V or Ubat < 3.5 V (WIFI only)	Alarm	1000

Criteria #1-2
The XEN-5320 has been tested for short times in the temperature range of -70 ºC to +90 ºC, but inaccuracies start to increase outside the specified -20 ºC to +55 ºC operating range, and most electronic components are not specified for this temperature range. Therefore, a warning is given when the environment is outside the specified operating range, and an alarm is given if the environment goes beyond the tested range. No knowledge exists about the behavior and durability outside the wider temperature range.

Criterion #3
If the Pt100 and Sensirion temperature deviate more than 10 ºC from each other, this may indicate malfunctioning, and invalid output data (only the absolute humidity AH and the output

signal (%) are affected by wrong temperature data). An exception is for very low temperatures, as the TSensirion is rated down to -40 ºC and will not indicate lower than -47 ºC.

Criteria #4-5
In the XEN-5320 a correction is made for temperature and humidity. If the environment is changing too fast in temperature or humidity, spurious signals may occur. Hence, a warning is given, and the user should verify if the measured and calculated data are reliable.

Criterion #6
For Hydrogen leak detection applications, an output signal below -0.5% may lead to unreliable hydrogen leak detection. For instance, if the output is -1.5% (H_2), and 2 % hydrogen is accumulated due to a leak, this will change the output from -1.5% to 0.5%, and the user will not be given any hydrogen alarm, while in fact there should be alarm. Thus, maximally -0.5% offset is allowed, but failing this criterion only results in a warning as the XEN-5320 is not intended as a hydrogen alarm device.

Criterion #7
When incorrect data are received by the LabView program a warning is issued as well. Incorrect data can be, for instance, that not all data in a string of data are received properly.

Criteria #8-9
If the power Ph supplied to the sensing element's heater is outside the normal operating values, this is an indication that the sensing element is defective. Thus, an alarm is given.
Similarly, if the transfer of the sensing element is out of the normal operating values, this is also an indication that the sensing element is defective. And thus, an alarm is given.

Criterion #10
If the system voltage drops significantly below 2.7 V, the microcontroller will shut down and operation will cease. For USB operation it is not expected that the Usyst will drop this low, unless voltage-regulating components are compromised.
For battery-operated WIFI versions, the battery will shut down at 2.75 V. But at 3.5 V there is only enough energy left for about 20 minutes, so warning #10 will also be given if the battery voltage drops below 3.5 V. The alarm will hopefully alert the user to take appropriate action.

Example
If, for example, in an experiment the temperature is dropping fast (more than 1 ºC in 15 s), going below -70 ºC, then the code 18 or 68 could be encountered, being the sum of codes 1+2+5+10 and possibly +50 if a negative output signal (<-0.5%) is returned.
The temperature is below normal and extended operating temperatures, the Pt100 temperature will deviate from the Sensirion temperature, which stops at -47 ºC, and the temperature is dropping fast. As the sensor is less accurate at these very low temperatures, an output warning might also occur.

7 I/O and Communication commands

Extended instructions for using the LabView program with the XEN-5320 are given in the separate manual. Below, the commands to the XEN-5320 via USB and WIFI are explained for those who want to set up their own communication.

7.1 Commands

For those who want to organize their own communication between XEN-5320 and control device (computer, lap top, smart phone?), the following commands are available.
For USB commands with (USB)
For WIFI command with (WIFI)

a	start measurement and send 1x data (USB)
A	reset Fast mode (USB)
b	start measurements and keep sending data until char s is received (WIFI)
d	send device info (WIFI+USB)
e	send device name, factory ID and firmware (WIFI)
f	start measurements and keep sending data until char s is received (Burst and Tau mode) (USB)
k	receive vacuum curve (USB)
l	send vacuum curve (USB)
m	receive custom curve (USB)
n	send custom curve (WIFI+USB)
p	go into WIFI module programming mode (USB)
+	exit WIFI module programming mode (USB)
s	stop sending data (after commands ‘b’ and ‘f’)
t	receive mode and speed (WIFI+USB)
u	send device name, factory ID, firmware, mode and gain (WIFI+USB)
v	receive burst/tau mode interval value (Burst and Tau mode) (USB)
x	perform zero calibration (WIFI+USB)
y	perform gain calibration (WIFI+USB)
z	receive new device ID (USB)

An entry between brackets **(?)** indicates the parameter.
+CR indicates that the preceding data are followed by a Carriage Return.

7.2 WIFI commands

In Red: Sent by Computer to XEN-5320
In Purple: Received by computer from XEN-5320

Below examples are given for the various commands.

7.2.1 WIFI command *b*

b
a-65.287162784b21.095815656c31.775995264d32.472824096e39.639038080 f1.930234880g1.000118255h0.020606604i0.001256073j0.777675776 k0.000976817l3.282298080m3.947505216n a-65.287162784 b21.095815656c31.775995264d32.472824096e39.639038080f1.930234880g1.000118255h0.020606604i0.001256073j0.777675776k0.000976817l3.282298080m3.947505216n

Computer sends command *b*
Computer receives the data string: **a(output in ppm)b(transfer)c(temp PT100)d(temp senserion)e(rel humidity)f(abs humidity)g(corrected transfer)h(thermocouple)i(heater current)j(heater voltage)k(heater power)l(v supply)m(battery voltage)n+CR**
n is the stop sign for the data of the measurement. Then come new measurement data starting with 'a'.
The data transfer will be stopped by sending the char *s* to the sensor.

7.2.2 WIFI command *d*

d
START02BC22NAME02BC22FID2.0.1SOFTH2MODEStandardSPEED-1.930000CAL250.000000CAL-0.002450CAL0.000075CAL-0.000000CAL0.995915CAL20.965000CAL25.789000CAL1.000000GAIN

Computer sends command *d.*
Computer receives **START(device name)NAME(factory ID)FID(firmware version)SOFT(measurement mode)MODE(measurement speed)SPEED(sensitivity)CAL(TC transfer)CAL(AH1)CAL(AH2)CAL(AH3)CAL(Y_AH_CAL)CAL(TF_CAL)CAL(temp cal)CAL(gain)GAIN+CR**

7.2.3 WIFI command *e*

e
o02BC22NAME02BC22FID3.0.0SOFT

Computer sends command *e.*
Computer receives **o(device name)NAME(factory ID)FID(firmware version)SOFT**

7.2.4 WIFI command *n*

n
CustomHelium NAMEa1b-0.050000c1.058000da2b0.000000c0.998000da3b0.050000c0.940000da4b0.100000c0.884000da5b0.150000c0.830000da6b0.200000c0.778000da7b0.250000c0.729000da8b0.300000c0.681000da9b0.350000c0.635000da10b0.400000c0.592000da11b0.450000c0.550000da12b0.500000c0.511000da13b0.550000c0.474000da14b0.600000c0.438000da15b0.650000c0.405000da16b0.700000c0.374000da17b0.750000c0.345000da18b0.800000c0.318000da19b0.850000c0.293000da20b0.900000c0.270000da21b0.950000c0.249000da22b1.000000c0.230000da23b1.050000c0.213000d
Done

Computer sends command *n.*
Computer receives **Custom(name custom curve)a(gas fraction value 1)b(Corr transfer value 1)da(gas fraction value 2)b(Corr transfer value 2)d** etc up to value 23 followed by a **CR** and the text **Done**

7.2.5 WIFI command *t*

t
Enter mode

Computer sends command *t*.
Computer receives the text **Enter mode**. Now a command should be entered (0 = H2, 1 = He, 2 = General, 3 = Vacuum, 4 = Burst, 5 = Tau, 6 = Custom curve) **without** CR! After the command mode has been sent the text **Enter speed** is received and now a command should be entered (0 = standard speed, 1 = Fast speed) without CR.

7.2.6 WIFI command *u*

u
START02BC13NAME02BC13FID2.0.1SOFTH2MODE1.000000GAIN

Computer sends command *u.*
Computer receives **START(device name)NAME(factory ID)FID(firmware version)SOFT(measurement mode)MODE(gain)GAIN+CR**

7.2.7 WIFI command *x*

x

Computer sends command x.

When the auto calibration has been finished a **CR** is received. During auto calibration no char should be sent or the calibration routine will be stopped.

7.2.8 WIFI command *y*

y
Error
or
Done

Computer sends command *y*.
In the case of an invalid gain calibration **Error+CR** is received. In the case of a valid gain calibration **Done+CR** is received.

7.3 USB commands

7.3.1 USB command *a*

a
a716299.000000b-8.004925c29.794994d29.373268e50.541443f2.063262g-0.382457h-0.007101i0.001250j0.709453k0.000887l3.309419m4.194404na703089.750000b-7.469872c29.766468d30.370705e48.977417f2.157631g-0.356963h-0.006627i0.001250j0.709502k0.000887l3.308895m4.191533n

Computer sends command *a*.
Computer receives the data string: **a(output in ppm)b(transfer)c(temp PT100)d(temp senserion)e(rel humidity)f(abs humidity)g(corrected transfer)h(thermocouple)i(heater current)j(heater voltage)k(heater power)l(v supply)m(battery voltage)n**+**CR**
Note that this command does not work in Burst or Tau mode.

7.3.2 USB command *A*

A

Computer sends command *A*.
Nothing is received. Command *A* should be followed by *a* to commence the measurements. This command, used only in Fast mode, causes the first measurement after *a* is sent to be a complete measurement. All later measurements until the next *A* is sent are reduced measurements.
This command should be issued before each new measurement session in Fast mode.

7.3.3 USB command *d*

d
START02BC22NAME02BC22FID2.0.1SOFTH2MODEStandardSPEED -1.930000CAL250.000000CAL-0.002450CAL0.000075CAL-0.000000CAL0.995915CAL20.965000CAL25.789000CAL1.000000GAIN

Computer sends command *d*.
Computer receives **START(device name)NAME(factory ID)FID(firmware version)SOFT(measurement mode)MODE(measurement speed)SPEED(sensitivity)CAL(TC transfer)CAL(AH1)CAL(AH2)CAL(AH3)CAL(Y_AH_CAL)CAL(TF_CAL)CAL(temp cal)CAL(gain)GAIN + CR**

7.3.4 USB command *f*

f
a0.177708b4516877.50ca0.146325b4516879.00ca0.122316b4516880.00ca0.106625b4516881.50ca0.088098b4516882.50ca0.073541b4516884.00ca0.066735b4516885.00ca0.055581b4516886.50ca0.046696b4516888.00ca0.045561b4516889.00ca0.037999b4516890.50c

Computer sends command *f*.
Computer continuously receives the data string **a(thermopile output)b(sensor system time in ms)c**. The data transfer can be stopped by sending the command *s* and is stopped automatically when the send buffers in the sensor's microcontroller are full.
Note that this command only works in Burst or Tau mode.

7.3.5 USB command *k*

k
Enter new vacuum curve name

Computer sends command *k*.
Computer receives **Enter new vacuum curve name**. Now a new vacuum curve name needs to be sent followed by a CR. The maximum number of characters that can be stored is 10. If more than 10 char are sent, the computer receives **(Sensor system time)Too many char, curve name not saved!**. If a valid device name is given the computer receives **Curve name saved** followed by a **CR**.
Next **Enter G0** is received. Now a value for G0 in (W/V/Pa) should be entered followed by a CR.
Next **Enter Gmem** is received. Now a value for Gmem in (W/V) should be entered followed by a CR.
Next **Enter Pt1** is received. Now a value for Pt1 in (Pa) should be entered followed by a CR.
Next **Enter Pt2** is received. Now a value for Pt2 in (Pa) should be entered followed by a CR.

Next **Enter Tcal** is received. Now a value for Tcal in (°C) should be entered followed by a CR. Next a **CR** followed by the text **Done** is received by the computer.

7.3.6 USB command *l*

l
VACDefaultNAMEa0.000357b0.007500c17.500000d199.600010e22.000000f
Done

Computer sends command *l*.
Computer receives VAC**(vacuum curve name)a(G0)b(Gmem)c(Pt1)d(Pt2)e(Tcal)f +CR** and the text **Done**.

7.3.7 USB command *m*

m
Enter new custom curve name

Computer sends command *m*.
Computer receives **Enter new custom curve name**. Now a new vacuum curve name needs to be sent followed by a CR. The max number of characters that can be stored is 10. If more than 10 char are sent the computer receives (Sensor system time)**Too many char, curve name not saved!**. If a valid device name is given then **Curve name saved + CR** is received. Next **Enter gas fraction value 1** is received. Now a value for gas fraction value 1 should be entered followed by a CR. Next **Enter Normalized transfer value 1** is received. Now a value for normalized transfer value 1 should be entered followed by a CR. This procedure is repeated for all 23 values. When finished the computer receives a CR, the text **Done + CR +(sensor system time)** is received.

7.3.8 USB command *n*

n
CustomHelium NAMEa1b-0.050000c1.058000da2b0.000000c0.998000da3b0.050000c0.940000da4b0.100000c0.884000da5b0.150000c0.830000da6b0.200000c0.778000da7b0.250000c0.729000da8b0.300000c0.681000da9b0.350000c0.635000da10b0.400000c0.592000da11b0.450000c0.550000da12b0.500000c0.511000da13b0.550000c0.474000da14b0.600000c0.438000da15b0.650000c0.405000da16b0.700000c0.374000da17b0.750000c0.345000da18b0.800000c0.318000da19b0.850000c0.293000da20b0.900000c0.270000da21b0.950000c0.249000da22b1.000000c0.230000da23b1.050000c0.213000d
Done

Computer sends command *n*.

Computer receives **Custom(name custom curve)a(gas fraction value 1)b(Corr transfer value 1)da(gas fraction value 2)b(Corr transfer value 2)d** etc up to value 23 followed by a **CR** and the text **Done**.

7.3.9 USB command *p*

p

Computer sends command *p*.
Now all chars are echoed to the WIFI module, and all chars received from the WIFI module are echoed back the computer. This process ends until char + is sent by the computer.

7.3.10 USB command +

+
Computer sends command +.
This ends echoing all chars to and from the WIFI module, initiated by the command *p*.

7.3.11 USB command *t*

t
Enter mode

Computer sends command *t*.
The computer receives the text **Enter mode**. Now a command should be entered (0 = H2, 1 = He, 2 = General, 3 = Vacuum, 4 = Burst, 5 = Tau, 6 = Custom curve) **without** CR! After the command mode has been sent the text **Enter speed** is received and now a command should be entered (0 = standard speed, 1 = Fast speed) without CR.

7.3.12 USB command *u*

u
START08AC26NAME02BC22FID2.0.1SOFTH2MODE1.000000GAIN

Computer sends command *u*.
The computer receives **START(device name)NAME(firmware version) (factory ID)FID SOFT(measurement mode)MODE(gain)GAIN**

7.3.13 USB command *v*

v
Computer sends command *v*.

Nothing is received. Now a command (1,2,3,4,5,6,7,8 or 9) should be sent without CR to set the interval time in Burst and Tau mode. The interval time is approximately 1.28 ms times the entered number. When measuring in Burst or Tau, the returned values are the average over the entered number of internal (1.28 ms) measurements.

7.3.14 USB command *x*

x
[00:21:53]

Computer sends command *x*.
A zero calibration is started.
When the zero calibration has been finished **CR +CR + (system time)** from the sensor board is received. During zero calibration no char should be send or the calibration routine will be stopped.
To get a proper zero calibration, this calibration should be carried out in the Standard speed mode (see command *t*).

7.3.15 USB command *y*

y
Error
or
Done

Computer sends command *y*.
A gain calibration is started.
In the case of an invalid gain calibration **Error +CR +CR** is received. In the case of a valid gain calibration **Done +CR +CR** is received.
To get a proper gain calibration, this calibration should be carried out in the Standard speed mode (see command *t*).

7.3.16 USB command *z*

z
Enter device ID

Computer sends command *z*.
The computer receives **Enter device ID**. Now a new device ID needs to be sent followed by a CR. The max number of characters that can be stored is 10. If more than 10 char are sent the computer receives **Too many char, device name not saved!**. If a valid device name is given the computer receives **Device name saved**.

8 Trouble shooting

The measurement data show a lot of zero's instead of real data.	It can be that your computer shows only zeros after the decimal separator, if this separator is a comma. This separator should be changed into a point (.), and then, correct trailing digits will appear. This can be done in the Country & Language part of the configuration screen of your PC.
The time data are wrong when importing the measurement file into EXCEL.	Be sure to define the time data column as 'time' in the cell properties. To get parts of seconds displayed, use an adapted format such as u:mm:ss.00.
When importing the measurement data into EXCEL they are of an incorrect magnitude.	This is a point/comma settings result. When importing the data in EXCEL, use the advanced settings to exchange the designation of a point and a comma.
Communication of the LabView program with the WIFI router is not working.	Be sure to have the settings of the computer and the router exactly as explained in the WIFI chapter.
The communication with the WIFI devices is not working.	Be sure to have the settings of the devices corresponding to the settings of the router.
Measurement mode change or zeroing does not work.	Stop the measurement before performing these actions.
The Burst/Tau program is stuck.	When the measurement stops without command due to communication problems, first click the stop button before resuming measurements.
The Burst/Tau program is still stuck.	Disconnect the XEN-5320, if necessary also exit the Burst program and start anew.
The Burst/Tau program is still stuck after restart, or the XEN-5320 is stuck.	First disconnect and reconnect the XEN-5320 and restart using the Standard LabView program. Using the Measurement Mode Page set the measurement mode to H2 and the speed to Standard and check if the device now measures correctly. If so, change to the desired settings. If not, repeat this action.

9 Order Information and Accessories

Order codes for the XEN-5320 sensor and accessories

Option	*Order code*	*Content*	*Remarks*
USB	XEN-5320-U	USB PCB	Bare PCB
USB with socket	XEN-5320-US	USB PCB with socket and separate sensing element (b)	Bare PCB
USB with housing	XEN-5320-UH	USB PCB + housing	(a)
WIFI/battery	XEN-5320-W	USB PCB + housing + WIFI + battery	(a)
Flow Adapter	XEN-85030-W XEN-85030-N	W for high flows (1 l/min) with 4.5 mm bore; N for low flows (50 ml/min) with 2 mm bore.	(a)
Housing for USB PCB	XEN-85040	Housing	(a)
Other gas curve	-	Calibration curve for other gas	On request

(a) Housing color depending on availability
(b) Sensing element XEN-TCG3880P2RW is standard, an ultrafast version UF is optional

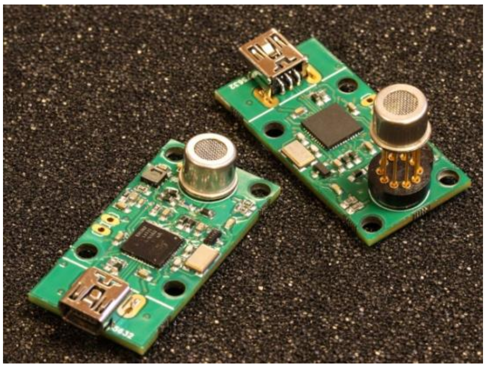

Figure 13: XEN-5320-U and XEN-5320-US with standard sensor.

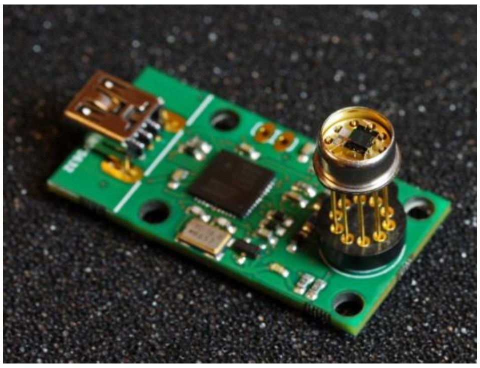

Figure 14: XEN-5320-US with ultrafast (UF) sensor.

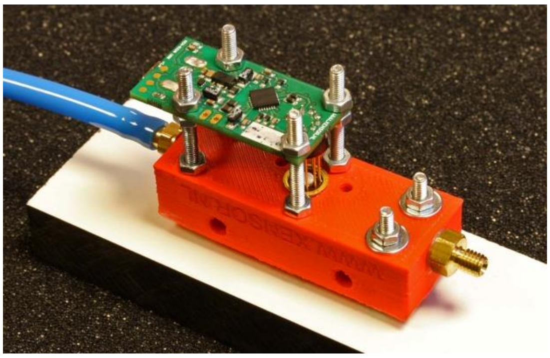

Figure 15: XEN-5320-US with UF sensor, mounted on a flow adapter (XEN-85030-N).

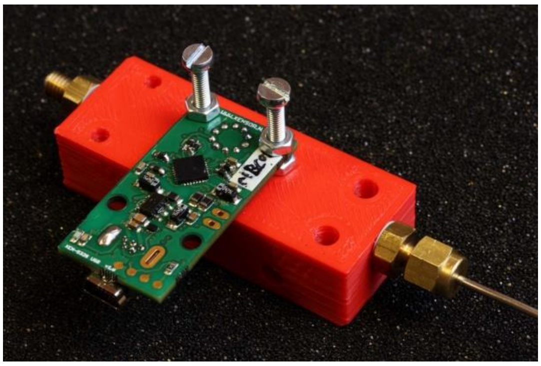

Figure 16: XEN-5320-U with standard sensor, mounted on a flow adapter (XEN-85030-N).

10 CE and FCC EMC tests of XEN-5320

The XEN-5320 USB version and WIFI version have passed EMC-testing according to CE FCC standards.

For the XEN-5320-U (USB), the results are valid for:

- PCB-board versions v.6, analog and digital outputs.
- PCB-board versions v.5, only valid for the digital output.

For the XEN-5320-W (WIFI) version, the results are valid for:

- PCB board version v.5.

Older versions have not been tested.

The devices under test have passed the applicable CE emission tests, immunity tests, ESD tests and EFT tests, at laboratory test levels.
For the EFT tests it holds that the USB version passes for USB cables up to 30 m.
For the EFT tests it holds that the WIFI version passes for USB cables less than 3 m.

The devices under test have passed the applicable emission tests according to FCC standards.

The following standards have been tested.

CE tests

- Conducted emission, test with a LISN, and Radiated emission up to 1 GHz, SAC, EN 55011 (2009) + A1 (2010), EN 61326-1 (2013) for class A and B equipment, and EN 301 489-01 V1.9.2 & EN 301 489-03 V1.6.1.
- Radiated Immunity, standards EN-IEC 61000-4-3 (2006) + A1(2008) + A2 (2010). Conducted immunity, standards EN-IEC 61000-4-6 (2014), EN 61326-1 (2013) and EN 301 489-01 V1.9.2 & EN 301 489-03 V1.6.1.
- Electro Static Discharges (ESD), EN-IEC 61000-4-2 (2009), EN 61326-1 (2013) and EN 301 489-01 V1.9.2 & EN 301 489-03 V1.6.1.
- Electrical Fast Transients (EFT), standards EN-IEC 61000-4-4 (2012).

FCC tests

- Radiated emission up to 1 GHz (SAC), ANSI C63.4 (2014), and Par. 15.31 (f) (1) of 47 CFR 15 & ICES-003 (Issue 6). FCC Public Notice DA 09-2478; KDB Publication 714737

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) this device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Note
For the XEN-5320-W (WIFI), PCB board version v.5, the Low Voltage Directive test is pending.