Temperature and Humidity measurement for the BGV Demonstrator

version 0.4

10/03/2015

Changelog

v0.1	08/07/2014	Initial version.
v0.2	08/07/2014	Update after the discussion between Alain, Bernd, Ewald and Plamen.
v0.3	27/01/2015	Update after the discussion with Francisco Josa about the humidity measurement. New info added in Section 5.

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1 Introduction

Official reference information about the BGV Demonstrator can be found in the BGV Demonstrator ECR [1].

The purpose of the measurement system described in this document is to monitor the temperature and the humidity near the BGV, see Table 1. The goal is to develop a system which can acquire the signals of up to 8 temperature sensors and up to 2 humidity sensors.

All sensors (probes) will be located outside the vacuum. The expected radiation dose at the location of the sensors is about 20 Gy/year (depends on the exact location).

Table 1: Parameters to be monitored and *initial* and *maximal* number of sensors.

Parameter	**Exp. range**	**N sensors initial**	**N sensors max**
Temperature of the gas tank	10 – 200 °C	3	8
Temperature in the tent	10 – 50 °C	1	
Humidity in the tent	Close to ambient	1	2

2 Sensors

Temperature sensors

PT100 with 4 wires. Prefer a robust (steel) sensor with minimal size and weight.

Humidity sensors

Seems difficult to find radiation tolerant systems. The following types were mentioned by colleagues:

- Hygrometrix **HMX–2000** : discontinued. The official website `www.hygrometrix.com` is not working.
- Novasina **Hygrodat 100** : not radiation tolerant (?), used by EN/CV. The datasheet can be seen in Fig. 1 and Fig. 2
- Vaisala **HMT 120**/**130** : not radiation tolerant. The datasheet can be seen in Fig. 3 and Fig. 4

Another non rad-tolerant model is planned for the BGV: **Novasina QuantaDat** / **nSens multi-sensor system**, see Section A

3 Readout chain

The following chain will be developed. Details on the components are given below.

Temperature measurement

PT100 → Junction box → Long cables T → PLC

Humidity measurement

Humidity sensor → Transmitter → Long cables H → PLC

Components

PT100

Type with 4 wires with length of 7 m. Use 4-wire LEMO-1 connector to connect to the junction box. To be ordered/provided by Alain.

Junction box

Gets as input up to 8 PT100 (LEMO-1 connectors). These signals are connected inside the box to the wires of the long cables. Provide the possibility to connect 2 "Long Cables T". It was agreed to look for a robust box that can be fixed on the tunnel floor. To be ordered/provided by Alain.

Long Cables T

Use 2 NE26 cables with connectors 28BPMB on each side. These long cables connect the BGV setup in the LHC tunnel (C7L4, DCUM 9775 m) and the BGV electronics racks in UA43 (BY12 – BY14). The cables length is about 60 m. These cables are now available.

PLC

A crate where one can install several modules. One module can acquire the signals of up to 8 PT100. 6 U space is foreseen in rack BY12=UA43. The power consumption is modest (5A on 24V). To be defined and ordered by Alain.

Humidity sensor

See Section 2. Alain will try to get more info from a colleague from EN/CV.

Transmitter

Can be placed in the electronics tunnel (less radiation), which is about 30 m from the location of the BGV setup. Part of the humidity measurement package.

Long cables H

These cables connect the humidity transmitter to the PLC in the BGV electronics racks. The required length depends on the location of the transmitter. Part of the humidity measurement package.

4 Control and Logging

- Control: FESA class. The relevant expert is Frank Locci (BE/CO).
- Acquisition and Timber logging

- Ethernet link. Should be connected to the CERN Technical Network.

At the moment it seems that we have (or will have) what is needed. Details to be defined and developed when we progress with the BGV network.

5 Humidity measurement

Discussion with Francisco Josa, EN-CV-DOW (27/01/2015)

5.1 Measurement basics

We are interested to measure the *dew point* inside the manifold and inside the tent. There is only one good method to measure *directly* the dew point – light reflection off a mirror cooled by a Pelletier element. These sensors are rather expensive, fragile and need regular maintenance. Alternatively, the dew point can be calculated from the temperature and the relative humidity (RH) – this is the approach used in many modern humidity sensors.

5.2 Sensor for BGV

Francisco has experience and is very positive about the company Novasina. His group have been using the HygroDat 100-EC sensors (see Fig. 1) in the last 10 years: they perform as described in the datasheet and are very stable with time. EN-CV have good relation with the company, which is Swiss. A new improved model was proposed to be tested, Francisco will get one for us.

Task: If we have no news from Francisco, call him in $\sim$10 days.

The temperature measurement is done with an NTC probe, complying to military standards – very robust and reliable. Relative humidity: there are two variants of the Novasina sensor, which measure the RH using the effect from the water vapor on the capacitance, or on the resistance of a circuit, which includes special substance (see columns “Electrolitical ...” and “Capacitive ...” in Fig. 2). The resistance method has the advantage that one can extend the distance between probe and transmitter up to 100 m. The disadvantage is that the temperature measurement is limited to $-20\ ^{\circ}C$ due to the properties of the electrolyte. For the BGV, to measure Dew point down to $-40\ ^{\circ}C$ we must use the capacitive variant. This is possible, as the distance between probe and transmitter is about 25 m.

Concerning the Vaisala sensors (Fig. 3): also good and widely used, but the contact with the company (Finland) is not so good.

READOUT

The Novasina transmitter can be programmed to provide as output the value of the dew point. One can get a voltage range 0 – 10 V, or current range 4 – 20 mA. He advises us to use the latter,

as it is less affected by noise (but it is more difficult to acquire as we need to open the circuit – relevant for our case?). This output range is set to correspond to an adjustable dew point range. E.g. 4 mA = $-40\ ^{\circ}C$, and linear increase to 20 mA = $+40\ ^{\circ}C$.

Next step: what to do with the signal from the transmitter.

- *Use our THMS PLC*. Talk with Raphael: can they acquire this signal? Do we log directly the current, or can we convert in the PLC to dew point?
- *Use the WAGO system*. It is a readout system used by EN-CV. Relatively cheap and simple. Available on the CERN store. Has ethernet connection, data logging possible.

5.3 Development of the system, things to check

Francisco stressed the importance of the following: the dew point of the compressed air must be lower than the coldest element in the manifold and in the tent – otherwise we will get condensation and frost.

Francisco will check the actual value of the dew point of the compressed air in LHC P4 (the nominal value is $-40\ ^{\circ}C$ [2]).

It is our task to operate the chiller such that we don't get elements with T below the dew point. We need to have a good idea about this, make thermal pictures, etc.

If we need to lower down the dew point of the compressed air, we can install a dedicated dryer on our compressed air line. Francisco can give us an advice/help for that.

Task: Send to Francisco the length estimate for the link between probe and transmitter.

Questions and Info for Francisco

- In total we need 2 humidity sensors
- Can we use two sensors with a single transmitter?
- What cables do we need to install near the transmitter: power supply, ethernet?
- How many wires we need to connect the transmitter and the readout: 2?
- Does the transmitter output also the temperature? Additional wires?

Appendix A Technical data of humidity sensors

Novasina QuantaDat / nSens multi-sensor system

This system will be used for the BGV dew point measurements. A single transmitter can acquire and process the input of up to 4 sensors (T only or combined T+RH). The BGV dew point

monitoring will employ 2 sensors – one in the detector cooling manifold, and one in the detector tent.

Data sheet: http://www.novasina.com/view/data/2085/Flyer_DB_Manuals/Air/Flyer_QuantaDat_E_004881_00.pdf

Technical data: http://www.novasina.com/view/data/2085/Flyer_DB_Manuals/Air/Technical%20data%20sheet_QuantaDat_nSens_004914.00.pdf

Other humidity sensors

novasina
The Art of Precision Measurement

HygroDat 100-EC

The standard for precise humidity and temperature measurement in industrial processes

80 176
75 167
70 158
65 149
60 140
55 131
50 122
45 113
40 104
35 95
30 86
25 77
20 68
15 59
10 50
5 41
0 32
-5 23
-10 14
-15 5
°C -20 -4 °F

General Information

Novasina is one of the leading companies for precise relative humidity and temperature measurement. Thanks to an intense and efficient research and development in air humidity and water activity measurement, Novasina's own built sensors offer an extraordinary values in accuracy, long term stability as well as robustness. Such measurement sensors are the heart of the measuring system that has been built especially for industrial application.

The versatile HygroDat 100-EC detects by a remote sensor the actual relative air humidity and temperature value and converts them into an analogue or digital signal. The very performing micro processor enables as well the calculation and output of other climate parameters such as dew point, enthalpy, mixing ration etc.. The whole system has been built with an open system architecture what makes it very flexible.

For the first time ever, the HygroDat 100-EC offers the possibility to measure the relative humidity using two different measurement principles. For it, depending on the application, 5 different sensor types are available.

A clearly arranged 2 line LC-Display as well as an intuitive menu complete the system. The ergonomic design allows an employment even under difficult conditions.

Fast, robust, accurate
Thanks to the continuous development of measurement sensors, Novasina is able to offer high precision measuring instruments with outstanding technical features at attractive price levels. The sensors can be installed up to 30m respectively 100m, depending on the version, from the transmitter. For testing and adjustment purposes, the well-proven Novasina SC humidity standards, based on saturated salt solutions can be used.

Various, easy to call functions support the service and mounting personnel during their work.

The complete system can be calibrated and adjusted on site up to 5 humidity points.

Main Features

- Highest accuracy
- Highest repeatability
- Easy installation, starting up and service
- Menu driven service tools
- 5 different remote probes for various applications
- 2 configurable analogue output signals
- 2 line LC-Display SI units US / ISO
- Climate parameter calculation functions: dew point, enthalpy, mixing ratio
- 5 point humidity calibration
- Fieldbus CAN or RS-232 data interface
- Calibration alarm for quality insurance

Applications

- Industrial HVAC plants
- Clean rooms, pharmaceutical-, chemical- and semicon industry
- Health care (hospitals)
- Paper- and textile industry
- Meteorological data acquisition
- Archives, museums, ware-houses, cultural protection, agriculture
- Combustion-process control
- Drying processes

Transmitter	*Article No.*
HygroDat 100/24V with polycarbonate housing	**111 6930**
HygroDat 100/230V with polycarbonate housing	**111 6931**
HygroDat 100/24V with aluminium housing	**111 6932**
HygroDat 100/230V with aluminium housing	**111 6933**

Sensor probe (E = electrolytic)	*Type*
E-Sensor with **polycarbonate** shaft	**HIA-11.....13**
E-Sensor with **stainless steel** shaft	**HIS-11.....13**
Novasina humidity measuring cell (electrolytic)	**CC - 1**

Sensor probe (C = digital capacitive)	*Type*
C-Sensor with **polycarbonate** shaft	**HIC-11.....13**
C-Sensor with **stainless steel** shaft	**HICS-11....13**
C-Sensor with **stainless steel** shaft **(high temperature)**	**HICH-11....13**
Novasina humidity measuring cell **(dig. capacitive)**	**DCC - 1**

Figure 1: Datasheet Hygrodat – page 1.

Specifications

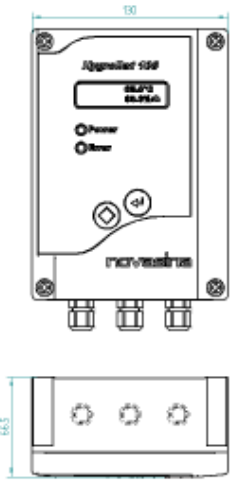
Type	HygroDat 100-EC	
Physical measurement principle	Electrolytical humidity measurement	Capacitive humidity measurement
Measurement range : humidity	6%...100% RH (w.saturation protect.)	0....100% RH
Measurement range : temperature	-20 ... +80°C / -4.....176°F	-40 ... +120°C / -40.....248 °F
Measurement range : dew point	-40 ... +60°C / -40.....140°F	-40 ... +60°C / -40.....140°F
Measurement range : spec. enthalpy	0.. 166KJ/kg / +8..... 79 btu/lb	0.. 166KJ/kg / +8..... 79 btu/lb
Measurement range : mixing ratio	0 ... 49 g/kg / 0.....343 grn/lb	0 ... 49 g/kg / 0.....343 grn/lb
Basic accuracy : temperature	+/- 0.2K (0.....50°C)	+/- 0.2K (0.....50°C)
Basic accuracy : humidity	+/- 0.5% RH (at 25°C & 5 p.cal.SAL-SC)	+/- 2% RH (at 25°C & 5 p.cal.SAL-SC)
Basis resolution : (RH / T)	0.1% RH / 0.1K	0.1% RH / 0.1K
Typical repeatability : (RH / T)	< 0.3% RH / <0.1K	< 1.0% RH / <0.1K
Operating temp. : Transmitter	-0 ... 50° C / 14 ....140°F	-0 ... 50° C / 14 ....140°F
Operating temp. : Sensor probe	-20 ... 80° C / -4 .... 176°F	-40 ... 120° C / -40 ... 248°F
Power supply	16 ... 30V AC / 15... 40V DC or	90 ... 260V AC (50/60Hz)
Power consumption	3.5 VA AC / 3.0 W DC or	3.5 VA AC
Electromagnetic compatibility	EN 50081-2 / EN61000-3-2/-3 /	EN 50082-1/-2
IP-protect. / shock / safety regul. / vibration	IP 65 / IEC 68-2-6 /	IEC 61010-1 / IEC 68-2-6
Analogue output signals (configurable & adjustable for PLC / DDC)	Voltage : 0 ... 10 VDC / 2 .... 10 VDC (at load >= 10k Ohm) Current : 0 ... 20 mA / 4 .... 20 mA (at load <= 500 Ohm)	
Digital interface	Fieldbus : CAN 20 k .... 500 kBaud / Protocol : based CANopen Serial : RS-232 ASCII Protocolstring (PC-Tool "Novalog 32")	
Storage temperature : Transmitter	-10 ... 60° C / 32 ....122°F (not condensing)	
Storage temperature : Sensor probe	-10 ... 60° C / 32 ....122°F (not condensing)	

E - Accessories :

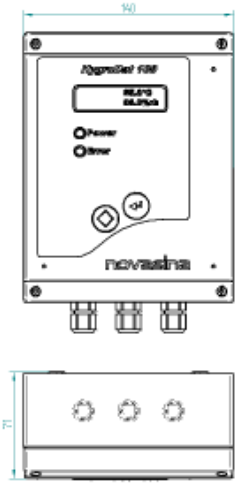
		Article-No.
E-sensor (1.5m cable)	HIA -11 L=100 mm	111 7245
E-sensor (10 m cable)	HIA -12 L=100 mm	111 7247
E-sensor (20 m cable)	HIA -13 L=100 mm	111 6934
Metal web filter with "Cellgard"	MF-1	111 1018
Sinter filter	SF-1	110 7330
Metal web filter w. acitve carbon	AF-1	111 3675
Protection cap w. "Cellgard filter"	CF-1	110 7355
Mounting flange for duct mounting		111 5343
Mounting flange for wall mounting		111 7360
E-sensor (1.5m cable)	HIS -11 L=160 mm	111 7532
E-sensor (10m cable)	HIS -12 L=160 mm	111 7533
E-Sensor (20m cable)	HIS -13 L=160 mm	111 7534
E-Sensor (20m cable)	HIS -23 L=310 mm	111 6652
Metal web filter with "Cellgard"	TS-1	111 7524
Sinter filter	SS-1	110 7183
Metal web filter w. active carbon	AS-1	111 7525
Mounting flange for duct mounting		111 7538
Mounting flange for wall mounting		111 7588

C - Accessories :

		Article-No.
C-sensor (1.5-30m cable)	HIC -1x L=100 mm	111 9578
Metal web filter with "Cellgard"	MF-1	111 1018
Sinter filter	SF-1	110 7330
Metal web filter with active carbon	AF-1	111 3675
Protection cap with "Cellgard" filter	CF-1	110 7355
Mounting flange for duct mounting		111 5343
Mounting flange for wall mounting		111 7360
C-sensor (1.5-30m cable)	HICS -1x L=160 mm	111 9575
C-sensor (1.5-30m cable)	HICS -2x L=310 mm	111 9558
C-sensor (1.5-30m cable)	HICH -1x L=160 mm	111 9580
Metal web filter with "Cellgard"	TS-1	111 7524
Sinter filter	SS-1	110 7183
Metal web filter with active carbon	AS-1	111 7525
Electric-installation box for C-sensors (high temp.)		111 9586
Mounting flange for duct mounting		111 7538
Mounting flange for wall mounting		111 7588



Version : "PC"
Polycarbonate housing



Version : "AL"
Aluminium housing

DOC No. 200 323.081.02

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Figure 2: Datasheet Hygrodat – page 2.

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Vaisala HUMICAP® Humidity and Temperature Transmitters HMT120 and HMT130

The HMT120/130 with and without a display.

Features/Benefits

- Vaisala HUMICAP® technology with humidity sensor HUMICAP® 180R
- 2-wire loop-powered or 3-wire voltage output configurations
- Interchangeable probe (easy field calibration)
- Accurate and reliable
- Resistant to dust and most chemicals
- Optional LCD display
- USB cable available for a PC connection for maintenance
- Wall-mounted or with a remote probe
- Constant output probe available
- Can be mounted outdoors using a Vaisala installation kit and the Vaisala Radiation Shield DTR504A
- Enclosure IP65
- NIST traceable (certificate included)
- Suitable for cleanrooms and demanding HVAC and light industrial applications

The Vaisala HUMICAP® Humidity and Temperature Transmitters HMT120 and HMT130 are designed for humidity and temperature monitoring in cleanrooms and are also suitable for demanding HVAC and light industrial applications.

Performance

The HMT120/130 incorporates Vaisala HUMICAP® technology that measures relative humidity accurately and reliably. The Vaisala HUMICAP® is resistant to dust and most chemicals.

The transmitter enclosure is optimized for use in cleanrooms. The smooth surface of the enclosure makes it easy to clean and the enclosure material is chosen to tolerate purifying agents. Furthermore, the cabling can be done through the back wall of the transmitter.

Interchangeable Probe

The HMT120/130 transmitters use a fully interchangeable relative humidity probe. The probe can be easily removed and replaced with a new one without having to adjust the transmitter, which allows for easy and quick recalibration of the transmitter. The probe can be adjusted using one of Vaisala's portable meters as a reference.

Also available is a constant output probe with fixed RH and T output for convenient inspection of the monitoring system and signal transfer line.

Available Options

The HMT120 and HMT130 transmitters are available as wall mounted or with remote probe. For high temperature applications or where space is limited, the remote probe is ideal. The transmitters come with an optional LCD display, which shows the measurement results of selected parameters in selected units. The parameters are displayed simultaneously at two separate rows on the display.

Figure 3: Datasheet HMT120/130 – page 1.

Technical Data

Performance

RELATIVE HUMIDITY	
Measurement range	0 ... 100 %RH
Accuracy including non-linearity, hysteresis, and repeatability	
temperature range	0 °C ... +40 °C
0 ... 90 %RH	±1.5 %RH
90 ... 100 %RH	±2.5 %RH
temperature range	-40 ... 0 °C, +40 ... +80 °C
0 ... 90 %RH	±3.0 %RH
90 ... 100 %RH	±4.0 %RH
Factory calibration uncertainty at +20 °C (+68 °F)	±1.5 %RH
Humidity sensor	Vaisala HUMICAP® 180R
Stability	±2 %RH over 2 years
TEMPERATURE	
Measurement range	-40 °C ... +80 °C
Accuracy over temperature range	
at +15 °C ... +25 °C	±0.2 °C
at 0 ... +15 °C and at +25 °C ... +40 °C	±0.25 °C
at -40 °C ... +0 °C and at +40 °C ... +80 °C	±0.4 °C
Temperature sensor	Pt1000 RTD Class F0.1 IEC 60751
Operating temperature range	
transmitter body, no display	-40 °C ... +60 °C
transmitter body, with display	-20 °C ... +60 °C
HMP110 probe	-40 °C ... +80 °C
Storage temperature range	-50 °C ... +70 °C
Electromagnetic compatibility	EN 61326-1 and EN 55022

Inputs and Outputs

HMT120 TWO-WIRE TRANSMITTER (LOOP POWERED)	
Current output signals	4 ... 20 mA
External loop voltage	10 ... 30 VDC (R_L = 0 ohms)
	20 ... 30 VDC (R_L < 500 ohms)
HMT130 THREE-WIRE TRANSMITTER	
Voltage output signals	0 ... 1 V, 0 ... 5 V, 0 ... 10 V
	or user defined between 0 ... 10 V
Min output resistance	1 kohm
Serial output	RS485, non-isolated
Relay output	1 relay (max. 50 VDC, 200 mA)
Supply voltage	10 ... 35 VDC
	15 ... 35 VDC (when output 0 ... 10 V)
	24 VAC (±20 %)
Current consumption at 24 VDC	8 mA, if relay closed 15 mA
Max. additional error caused by the analog outputs after calibration at +20 °C ambient temperature	±0.1 % of FS output signal
Temperature dependence of the analog outputs	±0.005 % of FS output signal

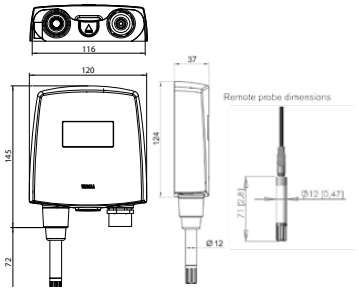
Mechanics

Material	
transmitter housing	PBT plastic
display window	PC plastic
probe body	Stainless steel (AISI 316)
probe grid filter	Chrome coated ABS plastic
Housing classification	IP65
Connections	
inputs and outputs	Screw terminals 0.5 ... 1.5 mm²
probe interface	4-pin M8 female panel connector
Probe cable lengths	3 m, 5 m, 10 m - up to 50 m
Display (optional)	128 x 64 resolution full graphics
	B&W display without backlight
Weight (including probe)	270 g

Accessories

Humidity and temperature probe	HMP110*
Humidity and temperature replacement probe	HMP110R*
Constant output probe	HMP110REF*
Humidity sensor	HUMICAP® 180R
Probe mounting flange	226061
Probe mounting clamps, 10 pcs	226067
HMP110 sensor protection	
plastic grid filter	DRW010522SP
plastic grid with membrane filter	DRW010525
stainless steel sintered filter	HM46670SP
Probe cable 3 m	HMT120Z300
Probe cable 5 m	HMT120Z500
Probe cable 10 m	HMT120Z1000
Radiation shield	DTR504A
Rain shield with installation kit	215109
Duct installation kit	215619
HMI41 connection cable	25917ZZ
HM70 connection cable	211339
USB serial interface cable	219685

**See separate order form*



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Scan the code for more information

CE

Figure 4: Datasheet HMT120/130 – page 2.

References

[1] G. Bregliozzi et al., “Beam Gas Vertex (BGV) Demonstrator of a Beam Profile Monitor in LHC”, Engineering Change Request LHC-BGV-EC-0002 v.1.0, https://edms.cern.ch/document/1324635/1.0

[2] L. Annila, “LHC Compressed Air Circuit”, Engineering Specification, EDMS 335007, https://edms.cern.ch/document/335007/1.0