D.6.1 Description of simplified monitoring approach and – equipment

Description of Task 6.1

A simplified approach for monitoring the buildings using standardised data acquisition equipment and methods will be defined at the beginning of the outPHit project. A central data base will be set up by PHI in order to compile all data in an accessible form. This will include a systematic approach to data formatting and an interface to the central data base. Algorithms to evaluate the data thus collected will be developed and applied uniformly to all projects, thus yielding comparable results. Central procurement and configuration by UIBK and PHI will limit the technical expertise required on the partner's side. A detailed instructions document will wrap up background information, technical information on the system as well as troubleshooting advice on the monitoring system and the database.

Last updated 12.03.2021 by Max Maier

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OUTPHIT – DEEP RETROFITS MADE FASTER, CHEAPER AND MORE RELIABLE
outPHit pairs such approaches with the rigour of Passive House principles to make deep retrofits cost-effective, faster and more reliable. On the basis of case studies across Europe and in collaboration with a wide variety of stakeholders, outPHit is addressing barriers to the uptake of high quality deep retrofits while facilitating the development of high performance renovation systems, tools for decision making and quality assurance safeguards.
outphit.eu

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Contents

PART A: PRE-MONITORING

1. OVERVIEW

Within D6.1 a pre- and post-monitoring process is defined and described. This **part A** describes the monitoring concept to evaluate the energy efficiency, comfort and indoor air quality (IAQ) before the refurbishing of the project (status quo). Together with the post-monitoring, an evaluation of the success in terms of reduction of energy consumption as well the as enhancement of comfort and health will be possible. In order to quantify the savings as well as the enhancement in IAQ, it is necessary to document the status quo as good as possible. Due to restricted time and resources, this pre-monitoring is limited to the essential and feasible minimum.

The preparation, procedure, necessary sensors as well as GDPR-related issues for this pre-monitoring is described in part A, whereas the post-monitoring is described in detail in part B.

Table 1 provides an overview of the monitoring equipment for this pre-monitoring of the outPHit project. It is intended to gather as much data and experience as possible about the observed buildings and the renovation process, also if not all of the described measures can be done.

Table 1: Overview equipment pre-monitoring

Measured Value	Device / equipment	Remarks	Example Device
Temperature **Relative air humidity** **CO_2 - concentration**	Standalone data logger	One per apartment + Reference measurement	Data logger Humlog 20 TCO
Air quality	Impact sampler/air sampler		
	Petri dishes (MEA, DG18)	3 per measured flat + reference measurements	
	Sellotape		
	Photo tripod		
	Forensic UV lamp		
Surface temperature	Infrared camera		Therm App
	Surface thermometer		

2. PREPARATION OF THE MONITORING

2.1. Measuring Period

The most interesting period for the monitoring is during the heating season. Due to closed windows and cold outside temperatures the parameters of the air quality

(temperature, CO_2-concentration, relative humidity) are probably the worst of the whole year. Also the measured data of the air quality could be merged and compared to energy consumption data. The preparation of the monitoring takes up to 2 to 3 months.
If data can only be gathered in the summer months, these values are also interesting when it comes to the evaluation of overheating and air quality.
To provide reliable data, a measuring period of six weeks is recommended.

2.2. General Data Protection Regulation (GDPR)

The monitoring process includes the handling of personal data. Therefore the most time-consuming part of the preparation is a safe data handling process according to the General Data Protection Regulation (GDPR). The national implementation differ across Europe due to the national legislation. At least the following steps are assumed to be essential:

- **Agreement of tenants** and information (legal reason for processing personal data, example is attached)
    - Easy to understand
    - Explanation of the project
    - Purpose of gathering data
    - Inform about a responsible person in your company
    - Inform about the right to withdraw from the agreement
    - Ask for energy bills of the last years
- If more than one party handles the gathered data:
  Agreement on data security and data handling between parties
- Consultation of the **data protection officer** of your company
- Preparation of **data handling**
    - Storing data (protected, limited access)
    - Data exchange (only if necessary, protected)
    - Preparation of a document/Excel-file to document every step of data processing
    - Preparation of technical and organisational measures (TOMs)
- Information about **data breach process** in your company
- **Ensure individual rights** of affected persons
- Consider to **anonymise data** as soon as possible

2.3. Energy consumption data

To evaluate the buildings energy efficiency consumption data should be gathered. If the pre-monitoring takes place during the heating season, access to energy meters enable to merge the collected data of the room temperature and energy consumption. Therefore, the agreement of the tenants is mandatory (paragraph 2.2). The data could be collected by the property manager.

Annually (or better monthly) bills of the energy consumption (as many of the last few years as possible) can be requested in the letter to the tenants/owners to cover a large period of the building's energy performance.

2.4. Preparation of the equipment

Examples and requirements for the monitoring equipment are described in section 3. The shipping of the devices could take up to 2-4 weeks.

For the measurement of the air quality a microbiological laboratory is needed and should be contacted early.

3. MONITORING EUQIPMENT AND MEASUREMENTS

3.1. Temperature, relative air humidity and CO_2 – concentration

Due to the upcoming renovation of the monitored buildings, standalone data loggers are considered to be most effective for the pre-monitoring. A logger that is independent of the electricity grid for a period of six weeks is recommended. At least one data logger for every measured unit (flat/apartment) of the building is needed. If more data loggers are available, more rooms of one unit of a building can be investigated at the same time.

To evaluate CO2-concentration, one more data logger is placed outside of the building to provide reference values. This logger must be placed at a dry and safe place (e.g. roof of a building entrance). If there is a nearby weather/climate station this data can also be used as a reference.

Figure 1 shows an example of a data logger that fulfils the requirements of the measurement. Data sheets and the user manual can be found attached. The listed price for one device is € 908.53 (excl. VAT).

Figure 1: Data logger: Humlog 20 TCO (company E+E Elektronik)

Table 2 shows the technical data of the data logger "Humlog 20 TCO" and the considered minimum accuracy for the monitoring. The accuracy of the Humlog 20 TCO is depicted as specified in the technical data sheet of the manufacturer.

Table 2: Technical data of data logger: Humlog 20 TCO

Measured Value	Unit	Sensor	Accuracy	Minimum accuracy
Temperature	[°C]	NTC	± 0,3	± 0,5
Relative humidity	[%]	capacitive	± 2	± 2,5
CO_2-conentration	[ppm]	NDIR	± (50 + 3 %)	± 50

The “Humlog 20 TCO” must be set up within the software “SmartGraph3”. “Smart-Graph3” can be downloaded as freeware here:
http://www.smartgraph3.de/DownLoad/
A manual for the software is included in the programme.

The following settings are recommended for the pre-monitoring:

Table 3: recommended settings for the pre-monitoring, using the “Humlog 20 TCO”

Setting	Value	remarks
Duration	6 weeks	If possible: During heating season
Power supply	Battery	Battery lifetime tested > 6 weeks No grid supply needed at measuring point Data does not get lost at the end of battery life-time
Measuring point	On Cupboard in the bed-room	Room is used for a long time during sleep (CO_2-concentration)
Active Channel 1	Act. Temper-ature	SmartGraph3 -> Devices –> Manage Devices ->Storage Settings -> Select Active Channels
Active Channel 2	Act. Relative Humidity	SmartGraph3 -> Devices –> Manage Devices ->Storage Settings -> Select Active Channels
Active Channel 3	Act. CO2 Concentra-tion	SmartGraph3 -> Devices –> Manage Devices ->Storage Settings -> Select Active Channels
Sample Interval	1 min	Open Window can be detected SmartGraph3 -> Devices –> Manage Devices ->Storage Settings
Store Interval	1 min	SmartGraph3 -> Devices –> Manage Devices ->Storage Settings -> Select Active Channels
Local altitude	Altitude of monitored building	SmartGraph3 -> Devices –> Manage Devices ->Information
Device mode	M3 Rec	Button on the backside of the device Press short to change mode, Press long to con-firm
Clock	Sync Clock	Make sure that time is displayed right when starting the measurement (compare Figure 1: values for actual date and time instead of “Set time” on the bottom of the device should be displayed) SmartGraph3 -> Devices –> Manage Devices ->Sync Device Clock Icon

3.2. Inside surface temperature - Infrared thermography

To evaluate the air quality and energy performance of buildings, the surface temperatures of the coldest spots (thermal bridges) can be recorded with an infrared camera. A significant difference between inside and outside temperature is essential for good measurements results.

If the accuracy of the thermal camera is considered too low to provide reliable data, the camera could be used to identify the coldest spots on the surrounding walls. Moreover a thermometer for surface temperatures can provide more accurate values.

The surface temperature and surface humidity are the decisive factors for mould. Therefore, room temperature and humidity (data logger) and surface temperature of the coldest spot of a room should be recorded at the same time.

3.3. Air quality – Moulds, cultivable airborne fungal spores

For the detection and enumeration of moulds in the air, a measurement according to “DIN ISO 16000-18: Sampling by impaction” is proposed. The entire measurement process and mandatory materials are depicted in the DIN ISO 1600-18.

To investigate moulds in the observed buildings, air samples must be evaluated in a microbiological laboratory. The necessary equipment and the date of the measurements should be discussed early in cooperation with the laboratory.

The air sampling can be done by the outPHit project partner himself, at the same time when installing/removing the data loggers. This reduces expenditure of the outPHit project partner and the expenditure of time for the tenants of the observed building. The process should also be discussed with the consulted laboratory.

A reference measurement of the outdoor air is mandatory each day. Furthermore, the surface temperature (thermography), room temperature and relative humidity (data logger) should be gathered at the same time. Additionally, a forensic UV-lamp can detect mould visually on the walls. Therefore, the room must be dark.

Inform the tenants that the windows of the evaluated rooms must have been kept close for 8h (as long as possible) before the measurement is taken.

Approximately up to 3 apartments can be measured per day.

PART B: POST-MONITORING

1.1. Preparation of the equipment

Monitoring data is of particular interest in the refurbished condition as a measure of success. Therefore, a more comprehensive data acquisition scheme is to be set up to sample more data in high temporal resolution (e.g. 15min).
As outPHit strives to provide deep retrofits with minimal intrusion to inhabited spaces retrofitting a long-term monitoring system is a challenging task. No system that relies on dedicated wiring is feasible in this case. Hence, the possibilities of power line communications with AV greenPHY standard are currently being explored by partner PHI (March 2021). Low and medium bandwidth Powerline communication has seen a boost in recent years as a result of smart metering and CSS electric vehicle chargers. It uses existing 220V wiring for both maintenance free energy supply to sensors and communication. As 128 bit AES encryption is a standard feature also secure communication and protection of personal data on this physical communication layer can be ensured.
Thus far tests yield promising results, but are still in an early phase. If critical shortcomings were found a LoRaWAN radio based system presents a ready alternative- if at the cost of less convenient energy supply.
In either case a single board computer, with remote access for maintenance and supervision, will be deployed in each project to collect and log data and relay it to the central data base over an ssh/encrypted channel.

Room air sensors and their specifications will correspond to those of the standalone data loggers from part A.

1.1. Temperature, relative air humidity and CO_2 – concentration

Table 4: tentative specifications for post- monitoring room sensors

Measured Value	Unit	Sensor	Accuracy	Minimum accuracy
Temperature	[°C]	NTC	± 0,3	± 0,5
Relative humidity	[%]	capacitive	± 2	± 2,5
CO_2-conentration	[ppm]	NDIR	± (50 + 3 %)	± 50

1.2. Energy consumption

Metered energy data (meter readings) will be acquired. Depending on the building services solution this will go beyond electricity meters and also include heat meters, gas meters or district heating. Details will be tailored to suit the individual project's needs.
As the design of the monitoring equipment must follow the design decisions taken in the course of the various projects no fixed plan can be given at this point in time (March 2021).
In order to avoid any interference with utilities it is proven to pick up LED-blinks at the electricity meters as a convenient interface. Heat meters often also provide

pulse output. Else a bridge to MeterBus or wireless MeterBus offer alternatives. Gas meters can be equipped with a pulse output via a reed switch. If all else fails a reasonable evaluation of energy consumption is also possible based on monthly manual meter readings if these are taken very carefully and reliably.

1.2. Weather data

A reference CO_2 measurement outdoors should be part of each project's sensor suite and can favourably be combined with exterior temperature and relative humidity.

Due to budget constraints a meteorological grade irradiance sensor will not be an option. If good quality irradiance data is available from a weather station in reasonable distance procuring and using this data will be preferred over deploying an irradiance sensor on site. Otherwise a photovoltaic global irradiance sensor on site will be used.

1.3. Inside surface temperature - Infrared thermography

To evaluate the air quality and energy performance of buildings, the surface temperatures of the coldest spots (thermal bridges) can be recorded with an infrared camera. A significant difference between inside and outside temperature is essential for good measurements results.

If the accuracy of the thermal camera is considered too low to provide reliable data, the camera could be used to identify the coldest spots on the surrounding walls. Moreover, a thermometer for surface temperatures can provide more accurate values.

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Inform the tenants that the windows of the evaluated rooms must have been kept close for 8h (as long as possible) before the measurement is taken.

Approximately up to 3 apartments can be measured per day.

1.5. Data Processing Documentation

A draft document for Data Processing Documentation for the post-monitoring campaign has been developed, including responsible persons, purpose and scope of the monitoring, specification of acquired data and the technical and organisational measures to protect personal data.
This document will be the guide line for further work and will be adapted for each monitoring project.

APPENDIX

- Example: Letter (description of project) and agreement with tenants
- Data sheet Humlog 20 TCO
- User Manual Humlog 20 TCO

Example: Letter (description of project) and agreement with tenants

Remarks on usage:
This is an example for a covering letter that informs the tenants of a building that will be monitored in outPHit. In this case, two partners conduct the measurements together. On page 3, there is an example for a description of the measurements.
Pages 4 and 5 are an example for a GDPR-conform information about data processing and data protection and a "declaration of consent" that must be returned by the tenants (called "extra letter" in the covering letter).
This is meant to be a template and needs to be adopted to your intended use!
Usually you are only one company that conducts the measurements, so [project partner 1] and [project partner 2] should be both replaced by the name of your company.

Michael Mustermieter
Musterstraße 15
1234 Musterhausen
Österreich

Date: xx.xx.xxxx

Dear tenant!

[May insert an introduction]

The *[project partner 1]* is conducting a research project together with the *[project partner 2]* and other project partners within the framework of the European Union.

The research project is called ***outPHit*** and deals with how your building can be renovated to be suitable for your grandchildren with the least possible intervention, but in the most climate-friendly and cost-saving way. For the *[project partner 1]*, this means being able to provide you with an even more pleasant, modern and healthy life in your home in the future.

It is important to the [project partner 1] that your housing situation is fairly represented and considered

in the project. To give you the opportunity to participate in this important study, between [time period when you approach tenants], scientists of the *[project partner 2]* will approach you personally. On behalf of the [project partner 1], they would like to take measurements of the comfort and air quality in your home. Details are described on page 3 in this letter.

It goes without saying that all collected data is evaluated completely anonymised.

The staff of the *[project partner 2]* will be happy to provide you with further information about the aims and tasks of the research project while they take the measurements.

Take the opportunity to actively shape the upcoming renovation of your building and your future living quality! You will benefit from the later implementation of the results.

Stay healthy and thank you very much for your participation!

[Name]

Your personal contacts for the research project *outPHit*:

Contact person of the	Contact person of the
[project partner 1]:	[project partner 2]:
[Name]	**[Name]**
[company and department]	**[company and department]**
[mail, phone]	[mail, phone]

Enclosure:
Description of the planned measurement in your flat – [project partner 2]

Description of the planned measurements in your home before the renovation

[project partner 2], [name of responsible person]

In order to be able to evaluate the improvements in indoor air, comfort and energy savings through the planned refurbishment, we depend on your assistance and agreement.

Measure comfort and air quality before the refurbishment:

You will receive a small measuring device which displays temperature, humidity and CO_2-concentration in your room. It is placed best in your bedroom on a cupboard or shelf for approximately 6 weeks, if possible. Please leave the device there as undisturbed as possible for this period.

This measuring device will be picked up again by an employee of the *[project partner 2]* after approximately 6 weeks by appointment. When the device is collected, your indoor air quality will be measured on site for about 20 minutes. Surface temperatures of the indoor walls are also recorded with a thermal imaging camera.

Heating costs before the refurbishment:

To determine the energy consumption savings for heating through the renovation as best as possible, we need a monthly meter reading (in the case of a central gas heating) or the gas bill, if possible. If your flat is heated by wood, oil or a district heating, your energy consumption would be very interesting, too (e.g. stated through bills, amount of oil/wood…).

Electricity costs before the refurbishment:

In order to be able to determine possible electricity savings through the renovation, a monthly value of your electricity meter is required. The collection of the values is carried out by an employee of the *[project partner 1]*.

In order to measure living comfort and air quality and to determine electricity consumption, the [project partner 2] and the [project partner 1] are asking for your consent in the coming days, in an extra letter with a reply envelope.
To determine heating costs, the [project partner 2] and [project partner 1] would like to ask you to tell us how you currently heat your home and to provide us with the relevant information or documents after the winter 2020/2021.

****
****
[address]

Date **********
Phone **********
Mail **********
Homepage **********

Information on data protection
Costumer ID: **********

Your building will be undergoing a major renovation that is carried out by us with special care, in a climate-friendly way and with the use of the latest technologies. As you know, the renovation of your home is also supported by the European Union (EU) within the framework of the *outPHit* research project. The aim is to reduce energy demand and CO_2 emissions and to increase your comfort, your healthy living and the use of renewable energy sources for heating and electricity.

In the following the relevant project partners for the measurements before the renovation are described. Further, we prepared the enclosed declaration of consent for you:

The **[project partner 1]** checks the quality of the planned measures and aims to carry out the best possible comprehensive renovation for you.

The **[project partner 2]** uses the collected data for scientific research studies and statistical evaluation and supports the *[project partner 1]*.

The following values will be collected as part of the research project:
Living comfort and indoor air quality in your flat; Your current heating costs; Your current electricity consumption; Total water consumption of the building; General electricity consumption of the building. We would like to point out that the collected data is <u>not</u> evaluated on a personal basis (completely anonymised evaluation)

Kind regards,

[Name]
[company]

<u>Enclosure:</u>
Declaration of consent (please return)

Declaration of consent

Who receives data?	What is measured?	How long?	Yes	No
[project partner 1] **[project partner 2]**	▪ Room temperature, room humidity and CO_2 at one point in your home (approx. 6 weeks) ▪ Indoor air quality in your flat (approx. 20 min) ▪ Surface temperature on indoor walls (approx. 10 min) ▪ Electricity meters are monitored monthly ▪ Information and documents on your heating costs ▪ Monitoring of total amount of water used in your building	Until [date, end of monitoring]	☐	☐

Pre-survey:

	Which system do you use for space heating?	Yes
Information about your system for heating and domestic hot water	▪ Gas (single oven)	☐
	▪ Gas (central heating system)	☐
	▪ Oil	☐
	▪ Electricity	☐
	▪ Wood	☐
	▪ District heating	☐
	▪ [further options, if relevant for your building, e.g. heat pump]	☐
	▪ Other, please specify _____	
	Which system do you use for domestic hot water?	**Yes**
	▪ Gas	☐
	▪ Electricity (boiler)	☐
	▪ District heating	☐
	▪ [further options, if relevant for your building, e.g. solar]	☐
	▪ Other, please specify _____	

Your consent for the measurements and the further use of data can be revoked at any time by an informal message by post to [address] or e-mail [mail]. The revocation does not affect the legitimacy of the data which is processed up to that point. You can find more information on your rights on personal data, storage periods, etc. in the attached information sheet in accordance with the GDPR.

Name: _____ Date: _____ Signature: _____

****

Please return the original document to us. Thank you very much!

Humlog 20

Data logger for Humidity, Temperature, Air Pressure and CO_2

The Humlog 20 facilitates exact and professional recordings for climatic measurements of humidity, temperature, air pressure and CO_2 concentration.
The long battery life and large memory allow for continuous data recording over long periods of time. The configuration of the data logger and the evaluation of the measurement data are simple and straight-forward using SmartGraph3 software, which is included in the scope of supply. The built-in Ethernet interface makes the Humlog 20 Network capable, and ensures maximum reliability in data transmission. For various requirements in the application, the four models **THI**, **THIP, TCO** and **E** are available. The Model **E** offers the highest flexibility with analog and digital interface for external sensors.

Humlog 20 THI

Measurement Categories	Model THI	THIP	TCO	E
Temperature (air)	✓	✓	✓	
Relative humidity	✓	✓	✓	
Absolute humidity	✓	✓	✓	
Dew point temperature	✓	✓	✓	
Barometric air pressure		✓		
Relative air pressure		✓		
CO_2 Concentration			✓	
External input - digital RH/T-Sensor				✓
External input - Pt100, Thermocouple				✓
Analog input voltage 0-1 V				✓
Analog input current 0/4-20 mA				✓
Functions				
Power supply battery	✓	✓	✓	✓
Power supply USB	✓	✓	✓	✓
Power supply LAN (PoE)	optional	optional	optional	optional
Measured data storage	3,200,000	3,200,000	3,200,000	3,200,000
Typical battery life	> 1 year	> 1 year	> 4 months	> 4 months
LC-display	✓	✓	✓	✓
One-button operation	✓	✓	✓	✓
1-point calibration by operator	✓	✓	✓	✓
°C/°F switchable	✓	✓	✓	✓
Optical / acoustical alarm	✓	✓	✓	✓
Date / time	✓	✓	✓	✓
Records MIN/MAX/AVG	✓	✓	✓	✓
SmartGraph3 evaluation software	✓	✓	✓	✓
Functions Software				
Graphical representation	✓	✓	✓	✓
Numerical data display	✓	✓	✓	✓
Print function	✓	✓	✓	✓
Export function (e.g. Excel)	✓	✓	✓	✓
Gathered printouts of all measurement sites	✓	✓	✓	✓
User administration	✓	✓	✓	✓
Administration of up to 255 data logger	✓	✓	✓	✓

Humlog 20 THIP

Humlog 20 TCO

Humlog 20 E

Typical Applications

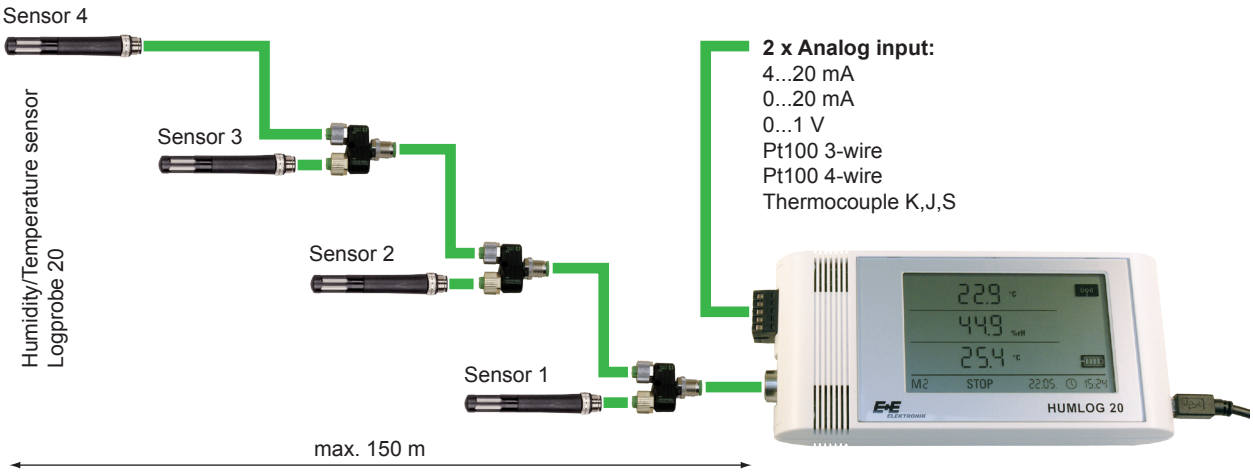
museums and exhibition spaces
clean rooms
warehouses
electronic-data-processing centres
calibration laboratories

Features

large data memory
large format display
USB and Ethernet interface
network-capable
powerful software for data analysis

Humlog 20 E Configurations Examples

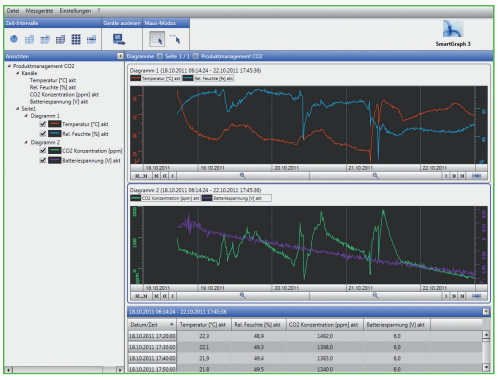
The Humlog 20 E is equipped with an digital input, which allows the connection of up to four external humidity/temperature sensors.
Two additional analog inputs for sensors with voltage or current output, Pt100 temperature sensors in 3 and 4 wire technology or Thermocouple J, K and S offers highest flexibility in the application.
Each fully equipped Humlog 20 E is a 10 channel data logger that can record various data.

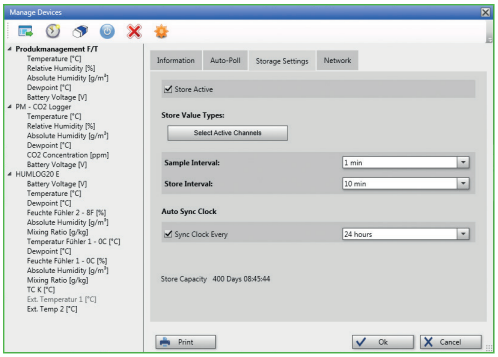


Software SmartGraph3

With SmartGraph3 the gathering of measured data is simple and as intuitive as possible:

- An Humlog 20 data logger is automatically recognized and added as a “network device”.
- In addition to its data-readout function, the software possesses a recording mode that enables parallel recording to be displayed on the computer.
- The data from any desired number of Humlog 20 devices can be read out simultaneously.
- The zoom function allows for quick analyses of critical time periods.
- The exporting of measured data in csv format enables it to be imported into EXCEL.
- The device configuration can be printed out in order to check installation parameters.
- Alarm limits - like the measured data - are chronologically managed at various times so that when changes in alarm limits occur, they can be retracted.
- Automatic data readout of all measured data is supported.





Technical Data

General

Dimensions		length 166 mm, width 78 mm, depth 32 mm
Housing / protection class		plastic ABS / IP40
Battery lifetime	THI, THIP:	> 1 year
	TCO, E:	> 4 months
Data storage		16 MB, 3,200,000 measured values
LC-Display		size 90x64 mm
Weight		approx. 250 g
Interface		USB, LAN (Ethernet)
Measurement rate		10/30 s, 1/10/12/15/30 min, 1/3/6/12/24 h
Storage rate		1/1012/15/30 min, 1/3/6/12/24 h
Power supply		Battery 4 x LRG AA Mignon (not in the scope of supply) or USB optionally the power supply via PoE (Power over Ethernet) is possible
Working range	Temperature:	-20...50 °C (-4...120 °F)
	Humidity:	0...95 %RH (non condensing)
CE compatibility according		EN61000-6-2 EN55022 EN6100-4-2 to EN6100-4-6

Measurements

Relative Humidity

Sensor	capacitive
Measurement range	10...95 %RH
Accuracy at 20°C	±2 %RH
Resolution	0.1 %RH

Temperature

Sensor	NTC
Measurement range	-20...50 °C (-4...120 °F)
Accuracy	±0.3 °C (0...40 °C; 32...102 °F), otherwise ±0.5 °C
Resolution	0.1 °C

Air pressure (only Model THIP)

Measurement range	300...1300 hPa absolute
Accuracy at 25°C	±0.5 hPa in the range of 700...1100 hPa
Resolution	0.1 hPa

CO_2 (only Model TCO)

Sensor	NDIR 2-Beam Principle
Measurement range	0...5000 ppm
Accuracy	± (50 ppm +3 % of measured value)
Resolution	1 ppm
Long-term stability	20 ppm/year
Response time t_{90}	< 195 s for measurement rate 10 s
Temperature dependence	typ. 2 ppm CO_2/°C (0...50 °C / 32...122 °F) different from 25 °C (77 °F)

Voltage input 0-1V (only Model E)

Measurement range	0...1 V
Accuracy	±(200 µV +0,1 % of measured value)
Resolution	500 µV

Current input (only Model E)

Measurement range	2-wires: 4...20 mA 3-wires: 0...20 mA
Accuracy	±(4 µA +0,1 % of measured value)
Resolution	5 µA
Resistance	max. 50 Ohm

Thermocouple K, J, S (only Model E)

Measurement range	for K, J:	-200...1200 °C
	for S:	-50...1700 °C
Accuracy	for -200...0 °C:	±(1 °C +0,5 % of measured value)
	for 0...1700 °C:	±(1 °C +0,2 % of measured value)
Resolution	0,2 °C	

Pt100 (only Model E)

Measurement range	-200...500 °C
Accuracy	±(0,2 °C +0,1 % of measured value)
Resolution	0,02 °C

Technical Data Logprobe 20

General

Housing / protection class		plastic PC / IP65
Working range	Temperature:	-40...80 °C (-40...176 °F)
	Humidity:	0...100 %RH
CE compatibility according [1]		EN61326-2-3 EN61326-1
Maximum cable length		150 m

Measurements

Relative Humidity

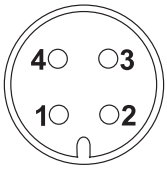
Sensor	capacitive	
Measurement range	relative humidity	0...100 %RH
	absolute humidity	0...290 g/m³
	mixing ratio	0...550 g/kg
	dew point temperature	-40...80 °C (-40...176 °F)
Accuracy at 20°C	±2 %RH (0...90 %RH) ±3 %RH (90...100 %RH)	

Temperature

Sensor	Pt1000 DIN B
Measurement range	-40...80 °C (-40...176 °F)
Accuracy	±0.2 °C at 20 °C (68 °F); ±0.4°C (-10...50 °C 14...122 °F); ±0.6 (-40...80 °C -40...176 °F)

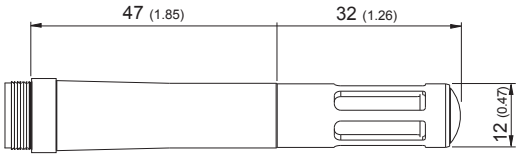
1) is not protected against surge

Connection Diagram



1...+UB
2...RS485 B
3...RS485 A
4...GND

Dimensions mm (inch)



Ordering Guide

DATA LOGGER		Accessories - Data logger	
Temperature and relative humidity	**HUMLOG20 THI**	Power supply for Humlog 20	**HA030106**
Temperature, rel. humidity, air pressure	**HUMLOG20 THIP**	theft-proof installation kit	**HA030104**
Temperature, rel. humidity, CO_2	**HUMLOG20 TCO**		
external inputs	**HUMLOG20 E**		
optional PoE (Power over Ethernet)	**-POE** (add to the end)		
HUMIDITY/TEMPERATURE SENSOR for Humlog 20 E		**Accessories - Humlog 20 E**	
RH/T-Sensor with metal grid filter	**LOGPROBE20-HTPC**	T-coupler M12 - M12	**HA030204**
RH/T-Sensor with stainless steel sintered filter	**LOGPROBE20-HTPD**	cable 2 m (6.6 ft)	**HA010816**
		cable 5 m (16.4 ft)	**HA010817**
		cable 10 m (32.8 ft)	**HA010818**
		male connector M12x1 self-assembled	**HA010706**
		female connector M12x1 self-assembled	**HA010708**

Order Example

HUMLOG20 THI
Data logger for Temperature and relative Humidity

HUMLOG20 TCO-POE
Data logger for Temperature, relative Humidity and CO_2 with PoE (Power over Ethernet)

Operating manual

data logger THI · THIP · TCO

BA-THI-THIP-TCO-05-EN

Table of contents

In order to use your data logger according to its intended use and utilise its complete range of functions, carefully read all documentation about this device.

This **operating manual** describes the functions of the hardware.

A separate manual – the **software manual** – describes how to use the software and configure the data logger with the software and can be opened after the software has been installed by using the help function in the software.

Your new data logger was built according to current state-of-the-art technology and fulfils valid European and national directives. This conformity has been tested and the corresponding declarations and documents are kept on file by the manufacturer.

To maintain this condition and ensure safe operation, as a user, you must observe the following safety instructions:

1. Safety

We accept no liability for damages caused by non-observance of this manual or unprofessional handling. Any warranty claims are voided in such cases!

Before starting the measuring device for the first time, read this manual from front to back!

For reasons of safety and conformity (CE), any unauthorised changes made to the device construction or components which are to be used with the measuring device are prohibited!

Before using the device, observe the following:

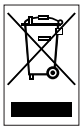
- *Never measure live parts.*
- *Observe the storage and operating conditions.*
- *The user is the only party who is responsible for determining measured results as valid, who can draw conclusions and take actions! The correctness of the results presented is excluded from any liability or guarantee. Liability for damages which have been caused by utilising the presented measured results is strictly excluded.*

2. Intended use

The data logger is designed to detect and record a range of measured values that can be detected by measuring device sensors described in the technical data. The measured data can be detected at variable selectable recording or request intervals, then saved and transmitted to a connected PC.

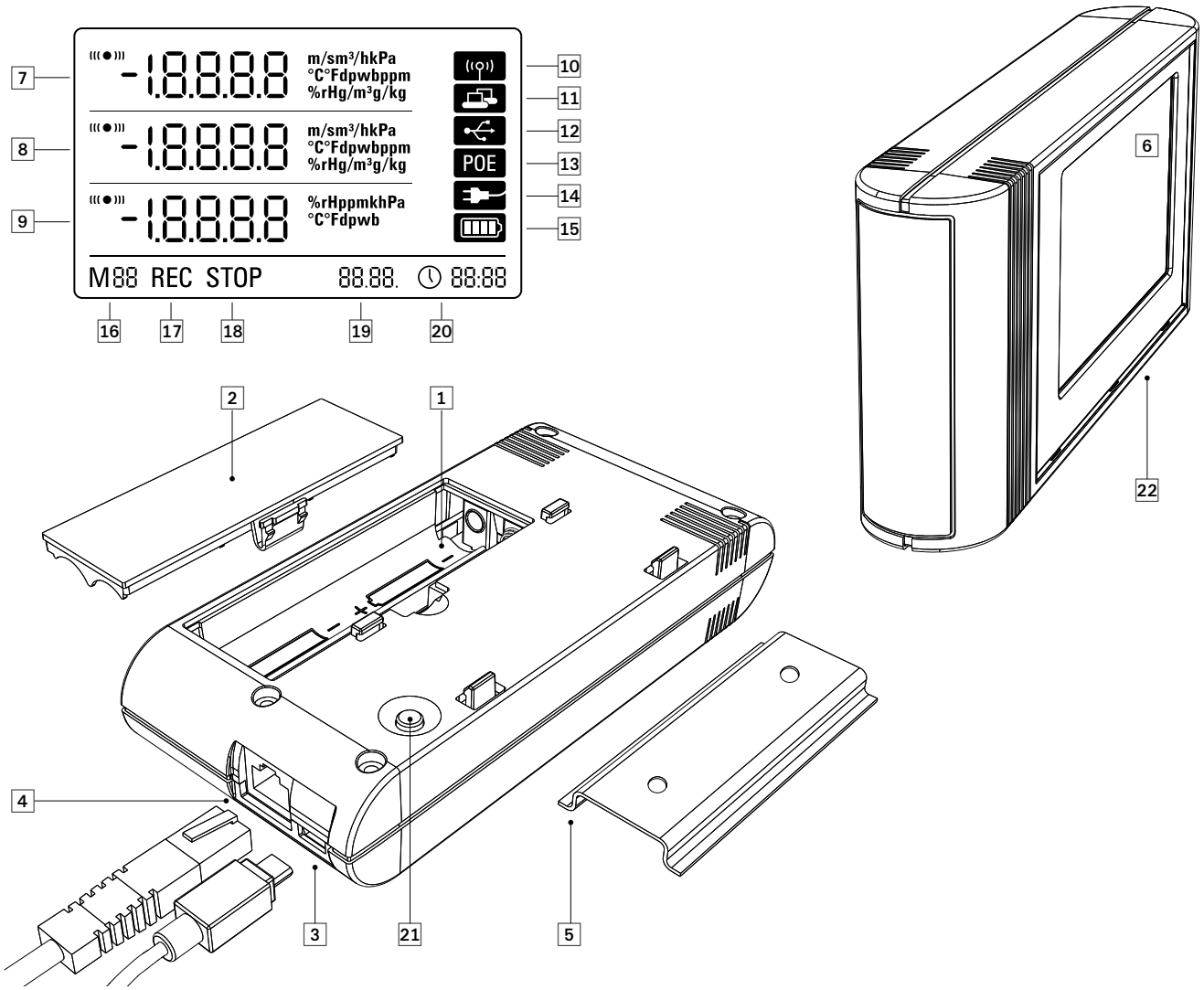
The measuring device may only be used for this intended use while complying with specified technical data.

Any other use is considered misuse and contrary to the intended use.



The product must not be disposed of with household waste. Dispose of this device in a manner compliant with the relevant legal requirements.

3. Equipment



1. Battery compartment
2. Battery cover
3. PC connection USB type micro B
4. Network connection RJ45
5. Mount track for fastening
6. LCD display:
   7. *Measured value row 1*
   8. *Measured value row 2*
   9. *Measured value row 3*
   10. *Display symbol for active acoustic signal*
   11. *Display symbol for active network connection*
   12. *Display symbol for active USB connection*
   13. *Display symbol for power supply over a network*
   14. *Display symbol for power supply over USB*
   15. *Display for battery level*
   16. *Display for mode marker*
   17. *Display for active measured value recording*
   18. *Display for inactive measured value recording*
   19. *Display for date*
   20. *Display for time*
21. Mode selection button
22. Data logger with internal sensors (THI /THIP /TCO)

4. Scope of supply

The following components are included in the standard scope of supply:

- Data logger
- USB connection cable
- CD-ROM with operating manual, SmartGraph software and software manual
- Factory certificate

5. Preparation before starting

5.1. Software

5.1.1. Installation conditions

To configure your data logger and read the recorded measured values, the SmartGraph software must be installed on a PC with the following minimum requirements.

Supported operating systems:

- Windows XP from Service Pack 3 (32 bit or 64 bit version)
- Windows Vista (32 bit or 64 bit version)
- Windows 7 (32 bit or 64 bit version)

Hardware requirements:

- Processor speed: 1 GHz, minimum
- CD-ROM drive
- USB or network connection RJ45
- 512 MB RAM, minimum
- 4 GB of free hard disk space, minimum
- Adobe Acrobat Reader software

5.1.2. Installation of the SmartGraph software

Insert the CD-ROM into your PC drive and install the software by following the instructions in the installation wizard.

5.1.3 Preparing data logger configuration

Connect the data logger to your PC via the USB cable provided in the scope of supply. The measuring device is automatically detected by the operating system.

Alternatively, you can configure your data logger via a LAN connection over your local network if the network function is enabled. Further information about the network function is provided in chapter 6.2.2.

Start the SmartGraph software. The program automatically detects the connected data logger and adds it to the list of available data loggers. The data logger can now be configured via the software.

Further detailed information about using the software is provided in the software manual which you can open from the help function of the SmartGraph software.

Functions of the professional version

Information about upgrading your SmartGraph software to the professional version (improving the device license) is provided in the software manual.

5.2. Note at initial startup

After starting the device for the first time, the message “SET TIME” appears on the display. However, no settings need to be made directly on the device. The time synchronises itself with the PC time automatically when connected to the SmartGraph software for the first time.

6. Operation

The PC software SmartGraph is the central configuration interface for your data logger. All additional configuration and visualisation specifications can only be set by software.

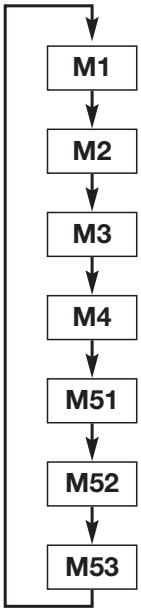
Basic settings can be directly configured with one-button operation by using the mode selection button on your data logger.

You can restrict the one-button operation with the mode selection button from your software if necessary (key lock). It is not possible to operate your data logger with the mode selection button in this case.

6.1. Switching on and off

When current is being supplied, the data logger cannot completely switch off, but can only be set to an operating mode with minimal energy consumption (M1). In this mode, measured value detection, measured value display and data recording are inactive. An overview of the four various operating modes is provided in the next chapter.

6.2. Basic settings and operating modes



Seven basic settings can be configured by using the mode selection button. These include the four various operating modes, the network function, a global reset of settings and the acoustic function.

Briefly pressing the mode selection button changes to the current setting level.

Briefly pressing the mode selection button allows navigation through the individual setting modes.

Each chosen mode is shown for four seconds and can be selected.

Within this time, the mode marker flashes in the bottom left corner of the display (M1, M2, M3, M4, M51, M52, M53).

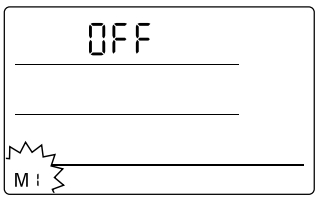
Pressing the mode selection button for 1 second confirms your selection.

The data logger then changes to the selected mode.

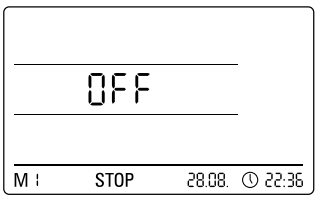
If no selection is confirmed within the four second period, the setting level is left and the display returns back to the original mode without making changes.

6.2.1. The four operating modes

Operating mode M1



Selection of the operating mode M1

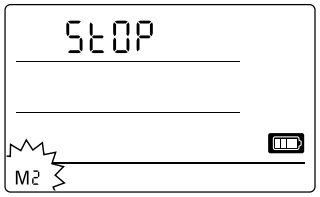


Display of the operating mode M1

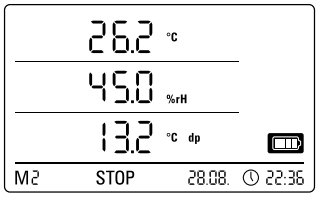
Measured value recording is inactive. “OFF” is shown in the second measured value row. The STOP symbol is shown.

In this operating mode (data logger delivery state), the power consumption is minimal because measured values cannot be requested or shown.

Operating mode M2



Selection of the operating mode M2

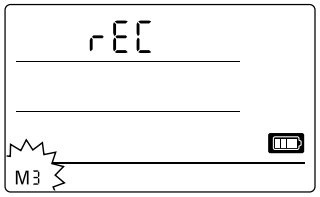


Example display of the operating mode M2

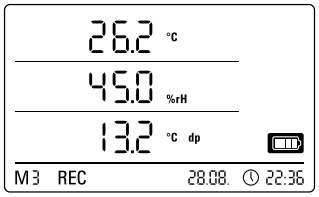
Measured value detection is active. The measured values which have been configured in the SmartGraph software are shown in all three measured value rows at the selected sensing rate.

In this operating mode, data recording is inactive; the displayed measured values are not saved in the memory. The display for measured value recording thus shows STOP (no data recording).

Operating mode M3



Selection of the operating mode M3

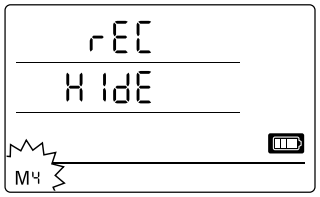


Example display of the operating mode M3

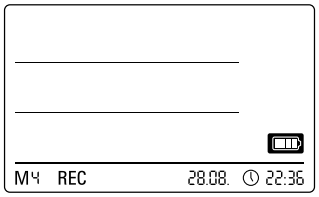
Measured value detection and data recording are active. The measured values which have been configured in the SmartGraph software are shown in all three measured value rows at the selected sensing rate.

Additionally, in this operating mode, up to twenty measuring channels, which can be selected in the SmartGraph software, are stored in the measured value memory. The display for measured value recording thus shows REC (data recording).

Operating mode M4



Selection of the operating mode M4



Display of the operating mode M4

Measured value detection and data recording are active; but measured value display is inactive.

Measured values are not shown in any of the three measured value rows. Still, in this operating mode, up to twenty measuring channels, which can be selected in the SmartGraph software, are stored in the measured value memory. The display for measured value recording thus shows REC (data recording).

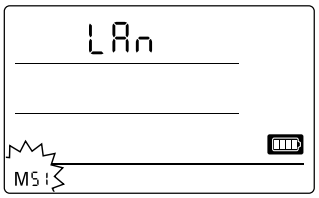
6.2.2. Network function (M51)

Requirements for connecting over a IPv4 network.

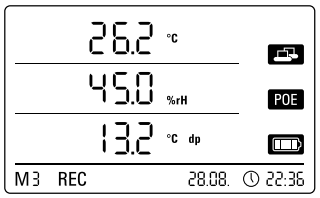
To automatically identify the IP configuration of a data logger (which has received an IP address in the IP network via DHCP for example), it is necessary that UDP broadcasts are allowed through the network.

Note: Based on their concept, UDP broadcasts do not operate through a router (NAT), but instead only within its own network. If the data logger is outside of the network, using fixed IP addresses through a system administrator is highly recommended.

Connect to the network



Selection of the network function M51



Example display of the network function M51

If the data logger is connected to a local network and the network function is activated, then software configuration and data reading from the data logger can be carried out over the network.

A signal which is broadcast from the data logger over UDP allows the SmartGraph software to automatically find the measuring device in the local network.

The first time that the data logger is connected to the network (add network device), it may be necessary to adjust the data logger's network settings to the configuration of the available network in the SmartGraph software. The factory preset is DHCP.

Further information about the network function is provided in the software manual which you can open from the help function of the SmartGraph software.

With the professional version of the SmartGraph software, it is also possible to retrieve and log current and saved measured values of the data logger in adjustable request intervals over the network.

Use in network mode

For continuous use of the network card, the data logger must be mounted on a wall. There must be free air convection within a gap of a half metre and the zone must not be interrupted by external sources of convection (fans, lighting etc.).

Power supply in network mode

Using the network card, which is built into the data logger, raises the power consumption of the measuring device.

When the device is running on batteries alone and not connected to an external power supply, it automatically deactivates the network function after 12 minutes without communicating with the network. In this case, the network function must be restarted by an external power supply either manually or automatically.

When using the data logger in LAN mode, the power should thus be supplied by a USB power supply.

In the optionally available PoE design, the data logger can have its power supplied directly over the network connection.

Information for system administrators

Broadcast over UDP:

PC sends to UDP:255.255.255.255:52010
(data logger receives at UDP port 52010*)

data logger replies to UDP:255.255.255.255:52005
(PC receives at UDP port 52005*)

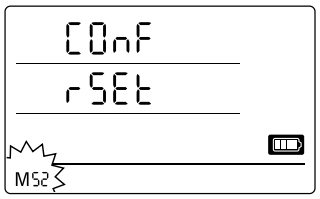
Data transmission over TCP:

data logger receives at TCP port 52015*

** The ports can be reconfigured, but this is not recommended.*

Open or lost TCP connections are closed by the data logger after a TCP timeout of 120 seconds.

6.2.3. Factory settings (M52)



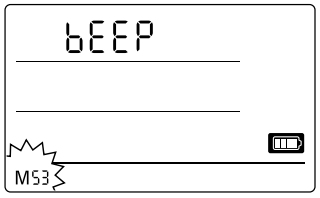
Selection of the reset function M52

This function resets the device settings to factory settings.

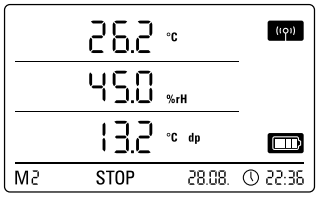
Even when resetting the device to factory settings or when there are no batteries in the device, the measurement data remains in the memory and is not deleted.

Information about deleting the measured data is provided in chapter 9.2.

6.2.4. Acoustic function (M53)



Selection of the acoustic function M53



Example display of the acoustic function M53

Activating or deactivating the acoustic function switches the data logger's acoustic signal either on or off. If the acoustic function is active, the function's display symbol is shown on the display.

When the acoustic function is active, alarm results are indicated as a tone, provided an active alarm has been preset for one or more of the three display measured values in the SmartGraph software.

If the acoustic function is not active, then none of the navigation steps which require the mode selection button on the data logger to be pressed are acknowledged by a tone. The same applies for selecting a mode. If no selection is made, and thus the setting level is exited, then a tone is also emitted.

7. Measured values display and data recording

7.1. Sensors, channel groups and measuring channels

Model THI

The THI data logger has two internal sensors to detect measured values from a total of six channel groups. These channel groups (measured values) are: Air temperature in °C, air temperature in °F, dew point in °C, dew point in °F, relative humidity in % and absolute humidity in g/m³.

For each channel group, there are four measuring channels for recording: Current measured value (cur), minimum measured value (min), maximum measured value (max) and average measured value (mid). In total, there are 24 measuring channels available for your THI data logger, as shown in table 1.

Model THIP

The THIP data logger has three internal sensors to detect measured values from a total of eight channel groups. These channel groups (measured values) are: Air temperature in °C, air temperature in °F, dew point in °C, dew point in °F, relative humidity in %, absolute humidity in g/m³, relative air pressure in hPa and absolute air pressure in hPa.

For each channel group, there are four measuring channels for recording: Current measured value (cur), minimum measured value (min), maximum measured value (max) and average measured value (mid). In total, there are 32 measuring channels available for your THIP data logger, as shown in table 1.

Table 1: Overview of sensors, channel groups (measured values) and measuring channels of the data logger

Sensor / measured value sensor		Channel group (measured value)	Unit	Available measuring channels for data recording (max. 20 channels available for saving) and for displaying* (max. 3 channels for display)				Displayable in the display-measured value row
all models	internal temperature sensor	Temperature	[°C]	cur	min	max	mid	1, 2, 3
		Temperature	[°F]	cur	min	max	mid	1, 2, 3
		Dew point	[°C]	cur	min	max	mid	1, 2, 3
		Dew point	[°F]	cur	min	max	mid	1, 2, 3
	internal humidity sensor	Relative humidity	[%]	cur	min	max	mid	1, 2, 3
		Absolute humidity	[g/m³]	cur	min	max	mid	1, 2
only THIP	internal air pressure sensor	Relative air pressure**	[hPa]	cur	min	max	mid	1, 2, 3
		Absolute air pressure	[hPa]	cur	min	max	mid	1, 2, 3
only TCO	internal carbon dioxide sensor	CO_2 concentration**	[ppm]	cur	min	max	mid	1, 2, 3

* *When selecting a channel for display, the current measured value (cur) is always automatically shown.*

** *For more specific determination of measured values, entering the site height via the SmartGraph software is necessary.*

Model TCO

The TCO data logger has three internal sensors to detect measured values from a total of seven channel groups. These channel groups (measured values) are: Air temperature in °C, air temperature in °F, dew point in °C, dew point in °F, relative humidity in %, absolute humidity in g/m³ and CO_2 concentration in ppm.

For each channel group, there are four measuring channels for recording: Current measured value (cur), minimum measured value (min), maximum measured value (max) and average measured value (mid). In total, there are 28 measuring channels available for your TCO data logger, as shown in table 1.

7.2. Displaying measured values

One of the channel groups specified in table 1 for displaying measured values can be configured to be displayed on each of the three measured value rows. Here, the current measured value is always shown on the display.

7.3. Data recording

If either of the operating modes M3 or M4 are selected, then the data logger is in logging mode (REC) and the measured values of the measuring channels selected for recording are saved in the device.

Up to 20 of the measuring channels specified in table 1 can be simultaneously recorded in the data memory of the measuring device.

Recording begins immediately from the moment that the operating mode M3 or M4 is selected and is carried out in ring mode. This means that when the memory limits are reached, the recording does not stop but continues to record. The older values are simply overwritten by the newest measured values.

Tip: Current, minimum, maximum and average measured values for a channel group each represent one measuring channel. If these values should be available for later documentation and evaluation, each of the measuring channels must already be selected during memory organisation for recording, because it is not possible to calculate these values in the software.

The specifications for type, duration and scope of data recording in the logging mode can be individually set in the software. Detailed information is provided in the software manual.

8. Alarm function

8.1. Alarm configuration

An alarm function can be configured in the measuring device administration for each of the measuring channels selected for display or recording.

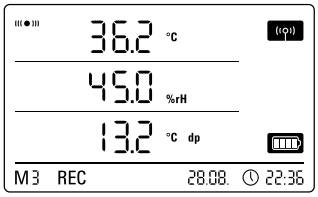
By defining an upper and lower alarm limit value, a value corridor is specified. This is the so-called good range and when the range is exited, an alarm sounds.

Note: The alarm function can only be represented on the display for the channel groups of the three measuring channels selected for measured value display, and only in the operating modes M2 and M3!

However, saving alarm results of other selected measuring channels in logging mode is independent of the selected display of the measured values. That means that the alarm results of the measuring channels which are not for display but for data recording are also recorded.

Even in the operating mode M4 when displaying measured values is deactivated, all preselected alarm results are recorded!

8.2. Alarm display



Example display for an alarm result of the measuring channel shown in the first measured value row.

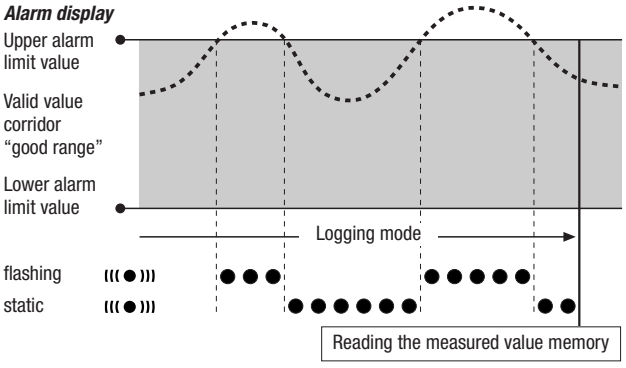
The alarm display is only possible for measured values which are preselected for displaying and which have been configured with an active alarm function.

If an alarm occurs at one of these measuring channels, the alarm symbol flashes beside the measured value display for this channel while the good range is exited.

If the measured value then reaches the defined value corridor, that is, the good range, then the alarm symbol stops flashing and is shown continually.

This indicates that an alarm result has occurred. If the good range is exited during the course of a measurement, the alarm symbol flashes again.

Reading the measured value memory deletes the alarm display.



Additionally, a hysteresis can be set by which the measured value must return to the valid range to switch off the alarm.

8.3. Acoustic alarm

If an alarm goes off while the acoustic function is activated (see chapter 6.2.4. Acoustic function), then an alarm tone sounds and only stops when the measured value returns to the good range.

8.4. Using the alarm hysteresis

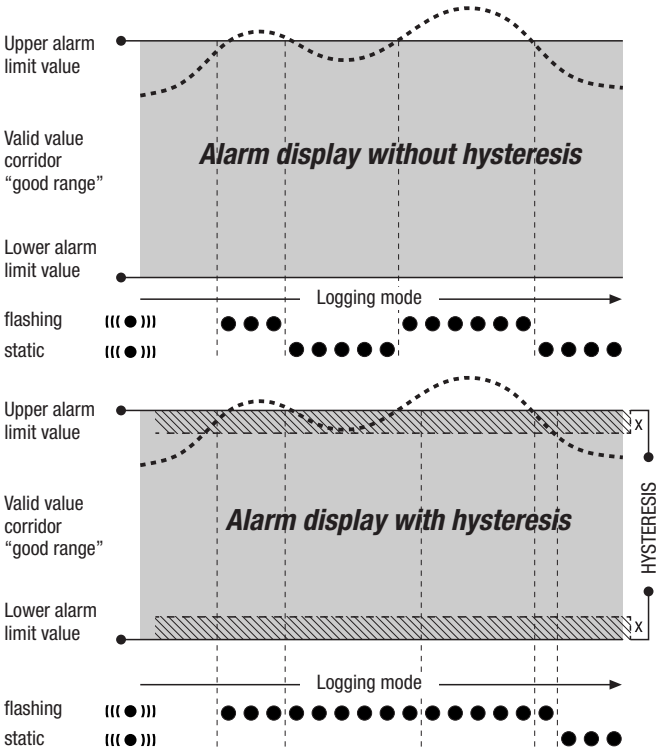
If you use the alarm function without alarm hysteresis, then an alarm sounds and is recorded each time the preset limit values are exceeded.

If your limit values have been selected very close to each other, then this means that an alarm situation occurs very often.

For example, if you set a room temperature of 24 °C as the upper alarm limit and a room temperature of 10 °C as the lower alarm limit and the room temperature continually deviates between 23.5 and 25 °C during the measuring period, then there will be many individual alarm signals created and recorded.

To prevent this, you can define an alarm hysteresis. With this setting, you define a value by which the measured value must have returned to the valid value corridor, the good range, to switch off the alarm.

If an alarm hysteresis of 1 °C was set, the alarm in the previous example would go off once as 24 °C was exceeded and then only stop as the temperature drops below 23 °C again.



9. Notes on maintenance and operation

9.1. Battery change

If "LO bAtt" appears in the upper row of the display, then the batteries need to be changed.

Data cannot be recorded while batteries are being changed. If data recording is running, pause it and ensure that the data logger is in operating mode M1 or M2 before changing the batteries.

To replace the batteries, open the battery compartment, remove the used batteries and then insert new batteries, while observing the correct poles.

Time is maintained for at least a minute during battery change, even when batteries are not inserted.

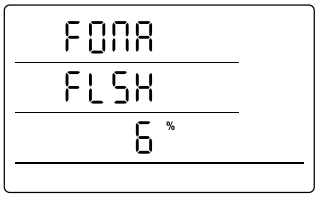
Only use appropriate batteries which comply with the technical data. Other types of batteries can cause operating errors. Do not use rechargeable batteries!

Do not dispose of used batteries in the household rubbish or throw them in the fire; instead, dispose of them according to the relevant legal requirements.

9.2. Deleting measured data

The detected measured data are permanently saved in the internal Flash memory. Even when resetting the device to factory settings or when there are no batteries in the device, the measurement data remains in the memory and is not deleted.

Saved data can only be deleted via the SmartGraph3 software as a whole and not individually.



Display for deleting measured data. In the display, 6 % of the data have been deleted so far.

The deletion process takes approx. 2 minutes. During this time, the following messages appears on the display: "FOMA FLSH xxx %".

During the entire deletion period, access to the device is not possible and it does not respond to requests from the SmartGraph3 software.

After memory has been completely deleted, "FOMA FLSH 100 %" is shown on the display. Afterwards, the display returns to normal operation.

Further detailed information about using the software is provided in the software manual which you can open from the help function of the SmartGraph software.

9.3. Positioning for mobile use

For mobile measured value recording, the data logger can be positioned at any site. Observe the permissible ambient conditions for operation (see technical data). Due to its compact dimensions, the data logger can be hidden for non-intrusive applications.

9.4. Mounting on a wall

For stationary data detection, the data logger can also be mounted on a wall or a similar holding device. A mount track is included in the scope of supply for fastening.

For network operation, wall mounting is absolutely necessary. Additional information about network operation is provided in chapter 6.2.2.

9.5. Moving to another site

Especially when moving from cold to warm ambient conditions, e.g. when moving into a heated room after storage in a car over night, depending on humidity in the room, condensation may form on the printed circuit board.

This physical trait can lead to false measured values. Unfortunately, it is necessary for the construction and cannot be prevented in any measuring devices. In these cases, please wait approx. 5 minutes until the measuring device has "acclimatised" before starting to measure.

10. Technical data

Technical data of the data loggers		THI	THIP	TCO
Air temperature	Operating principle	NTC		
	Measuring range	-20 °C to + 50 °C		
	Accuracy	± 0.3 °C (0…40 °C), otherwise 0.5 °C		
	Screen resolution	0.1 °C		
Relative humidity	Operating principle	capacitive		
	Measuring range	0 to 100 % RH		
	Accuracy	±2 % RH		
	Screen resolution	0.1 % RH		
Air pressure	Measuring range	–	300 … 1,300 hPa abs.	–
	Accuracy	–	700 … 1,100 mbar at 25 °C ±0.5 hPa	–
	Screen resolution	–	0.1 hPa	–
CO_2 concentration	Operating principle	–	–	NDIR
	Measuring range	–	–	0 … 5,000 ppm
	Accuracy	–	–	±50 ppm +3 measured value at 20 °C and 1,013 mbar
	Screen resolution	–	–	1 ppm
	Long term stability	–	–	20 ppm/a
Memory organisation	Sensing interval	10/30 s, 1/10/12/15/30 min, 1/3/6/12/24 h		
	Saving interval	1/10/12/15/30 min, 1/3/6/12/24 h		
	Data storage	16 MB, 3,200,000 measured values		
	Data recording	up to 20 simultaneous measuring channels		
Configuration and dimensions	LCD display	W 90 x H 64 mm		
	Housing	Plastic		
	Dimensions	L 166 x W 32 x H 78 mm		
	Weight	approx. 250 g		
	Interfaces	USB, LAN		
Power supply	internal	4 x LR6 AA batteries, battery life > 1 year	4 x LR6 AA batteries, battery life > 1 year	4 x LR6 AA batteries, battery life 2 to 6 months (depending on the sensing rate)
	external	USB, LAN (PoE configuration)		
Permissible operating ambient conditions	Air temperature	-20 °C to +50 °C		
	Relative humidity	0 to 95 % RH, < 20 g/m³ (non-condensing)		
	Height	10,000 m above sea level		
Scope of supply	Standard	Measuring device, CD-ROM with SmartGraph 3 PC software for representing the evaluation of measured values graphically and numerically and operating manual, USB connection cable, batteries		
	Optional	Measuring device in PoE configuration		

11. Status codes

In the event of a sensor error, the following codes may appear on one of the three LCD rows instead of the measured value

E 2C .....Initialisation error at the sensor

E 27 .....Faulty calibration data

E 36 .....Channel disabled (e.g. channel configured in the LCD, but sensor logged off or removed)

E 50 .....Value to be displayed too large to fit on display

E 51 .....Value to be displayed too small to fit on display

E 52 .....Channel value in the saturation (upper limit)

E 53 .....Channel value in the saturation (lower limit)

E 54 .....Data error. Received data are not plausible

E 55 .....Measurement not possible of sensor not reachable