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<td>Declaration of Conformity</td>
<td>47</td>
</tr>
</tbody>
</table>
1 Important Information

1.1 Preliminary Remarks

The product, manufactured by BERTHOLD TECHNOLOGIES GmbH & Co. KG (hereinafter referred to as Berthold), is handed over to you complete and functionally reliable.

These operating instructions show you how to:

- set up the product
- make electrical connections
- perform measurements
- define software settings
- service the product

Read this manual thoroughly and completely before working with the product. It is our aim to provide you with all the information required for the safe and complete operation.

However, if you have any questions that are not answered in this operating manual, please feel free to contact Berthold.

This document describes the B-OMS resonator mechanical and electrical connections. This also describes how to operate the device using the provided UI software. Further information about device can be found in separate documents.

1.2 Place of Storage

These operating instructions as well as all relevant product-related documentation for the respective application must be readily available and accessible at any time in the vicinity of the device.

1.3 Target Group

These operating instructions are intended for trained professionals who are familiar with the handling of electrical and electronic components as well as communication and measurement technology.

A trained professional is someone who due to their technical training, know-how, experience and knowledge of relevant regulations is able to assess the tasks assigned to them and who can identify possible dangers.
1.4 **Validity of the Operating Manual**

The operating instructions become valid when the Berthold product is handed over to the operator. The version number and release date of this operating manual are stated in the footer. A change management is not offered by the manufacturer Berthold. Modifications to this operating manual are possible at any time without giving reasons.

**NOTE**

The current revision of the operating instructions replaces all previous versions.

1.5 **Copyrights**

These operating instructions contain information protected by copyright. No section may be copied or reproduced in any form without the prior consent of the manufacturer.

1.6 **Convention**

<table>
<thead>
<tr>
<th>Identification</th>
<th>Meaning</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quotation marks</td>
<td>Field in the software-user interface</td>
<td>“Calibrate”</td>
</tr>
<tr>
<td>Vertical line</td>
<td>Path</td>
<td>Settings</td>
</tr>
<tr>
<td>Angle brackets</td>
<td>Keys and buttons</td>
<td>&lt;Update&gt;</td>
</tr>
<tr>
<td>Round brackets</td>
<td>Graphic reference</td>
<td>Attach the plug (Fig. 1, item 1)</td>
</tr>
</tbody>
</table>

In the description of the software, the term “click” is used to refer to a procedure that is being triggered. This also refers to the tapping of a button or area on the touchscreen when no mouse is used for control.

1.7 **Definitions, terms, acronyms, abbreviations**

The definitions, terms, acronyms and abbreviations not commonly known are listed in the following table.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO</td>
<td>Analog Out</td>
</tr>
<tr>
<td>MCU</td>
<td>Microcontroller Unit</td>
</tr>
<tr>
<td>CSV</td>
<td>Comma Separated Value</td>
</tr>
<tr>
<td>SD</td>
<td>Secure Digital</td>
</tr>
<tr>
<td>SW</td>
<td>Software</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
</tbody>
</table>
1.8 Symbols Used in the Operating Manual

In this manual, warning signs appear whenever there is a risk of personal injury or property damage. The security measures described must be observed to prevent hazards.

⚠️ **DANGER**

Indicates an **imminent** major hazard which, if not avoided, will result in serious injury or death.

⚠️ **WARNING**

Indicates a potentially hazardous situation which, if not avoided, could result in serious injury or death.

⚠️ **CAUTION**

Indicates a **potentially hazardous** situation which, if not avoided, could result in moderate or minor injury or property damage.

ℹ️ **NOTE**

Failure to observe this information can lead to disturbances in the sequence of operations and/or damage to property.

**IMPORTANT**

Paragraphs with this symbol provide important information on the product and how to handle it.

💡 **Tip**

Includes application tips and other useful information.
1.8.1  Symbols Used on the Device

⚠️ The product must not be disposed of with household waste.

1.9  Conformity

Berthold declares, at its sole responsibility, that the design of this product, as marketed by Berthold, conforms to the relevant EU directives stated in the original declaration of conformity (see chapter 10Declaration of Conformity).

This declaration shall lose its validity if the product is modified without prior consultation with Berthold.
2
Safety

2.1 Hazards and Safety Measures

- Read this manual thoroughly and completely before working with the product.
- Keep this manual in a safe place so that it is accessible to all users at all times.

2.2 Intended Use

The measuring system LB 571 has been designed to determine the water or moisture content or the concentration of almost any bulk material. The resonance microwave measurement technique employed enables precise moisture online measurement.

You act in compliance with the intended use if you:

- strictly adhere to the instructions and action sequences and do not carry out any unauthorized actions that endanger your safety and the functionality of the system!
- observe all specified safety instructions!
- carry out, or have carried out, the required maintenance work!
- only use Berthold accessories and spare parts.

The following is not in compliance with the intended use and must be prevented:

- Failure to observe the safety instructions and information on operation, maintenance and disposal provided in the operating instructions.
- Failure to observe the operating instructions for the delivered products.
- Use under terms and conditions other than those stated by the manufacturer in their technical documentation, data sheets, operating and installation manuals and other specifications.
- Use of the product or parts thereof that are damaged or corroded. This also applies to the seals and cables used.
- Modifications and changes to the system components.
- The product is not suitable for use in potentially explosive atmospheres and must therefore not be operated in such areas. The product is not explosion-proof.
- Operation in a state where live parts are accessible.
- Operation without observing the manufacturer’s recommended safety precautions.
- Manipulating or bypassing existing safety devices.

Berthold is liable and guarantees only that the device complies with its published specifications. If the product is used in a manner that is not described in this user's manual, the protection of the devices is compromised, and the warranty will be voided.
2.3 Qualification of Personnel

**NOTE**
All work on and with the device must be performed by persons having at least a general knowledge under the guidance of a technical expert or an authorized person.

In this operating manual, reference is made at various points to the qualification of persons who may be entrusted with various tasks during installation, operation and maintenance.

There are three groups of persons:

- Competent persons
- Trained persons
- Authorized persons

**Competent persons**
Competent persons are, for example, fitters who can perform various tasks such as transport, assembly and installation of the device under the supervision of an authorized person. This may also include site personnel. These persons must have experience in dealing with the device.

**Trained persons**
Persons who through their technical training have acquired sufficient knowledge in the respective field and who are familiar with the relevant national industrial safety regulations, accident prevention regulations, guidelines and accepted engineering standards.

Trained personnel must be able to safely assess the results of their work and be familiar with the contents of these operating instructions.

**Authorized persons**
Authorized persons have either been appointed to perform a task as a result of legal regulations or have been authorized by Berthold to perform specific tasks.

2.4 Operator’s Responsibilities

The operator of the product must regularly train his personnel on the following topics:

- Observance and use of the operating instructions and the statutory provisions.
- Intended use of the product.
- Observance of the instructions of the site security and the operator’s operating instructions.
- Regular inspection/maintenance of the product.
3 System Description

The LB 571 microwave resonator for moisture measurement in real time has an integrated evaluation unit and is commissioned and calibrated using PC software. The resonator is kept at constant temperature by using PTC heaters inside device.

- Sensor and electronics form one unit
- Analog output signal directly from the sensor (4 ... 20 mA)
- Digital inputs
- Several calibration curves
- Measuring range: 0...30 % moisture
- Temperature range: 0...65 °C

3.1 Overview

An overview of the resonator with its external dimensions and connections are explained in this chapter. Mechanical installation and depth adjustment of resonator is done by using a separate process installation flange around the resonator.

Figure 1  LB 571 Overview
3.2 Measuring Principle

Microwaves penetrate the bulk material, causing a rotation of the free water molecules. Placing a moist material on the field of the sensors causes a decrease of the resonance frequency and quality factor of the resonator. Both effects are measured and used as a direct indication of the moisture content.

The resonator consists of a ceramic disc, which is embedded in a metal plate. The upper side of the ceramic remains without a metal layer. From this side, the electromagnetic field interacts with the product to be measured. The measured data are processed in the integrated evaluation unit and output as a measurement signal.

![Figure 2 Measuring Principle](image-url)
3.3 Measurement arrangements

The BT wave LB 571 microwave resonator can measure the moisture in bulk goods. Easy assembly via flange connection offers multiple installation options.

![Measurement arrangements](image)

**1 Conveyor belt**
**2 Chute**
**3 Screw conveyor**

Figure 3 Measurement arrangements

**Conveyor belt (gliding carriage)**
The resonator can be mounted on a conveyor belt for measurement. The contact with the bulk material must be even and at a constant height.

**Sliding plate**
For example, the resonator can be installed under a silo on a material slide.

**Screw conveyor**
The resonator can be attached to a tube of a screw conveyor by means of a flange.

**NOTE**
With bulk goods that are transported by screw conveyor, there is a possibility that material will stick to the measuring position. Therefore remove a part of the separating spiral or replace the part with a plastic part.
3.4 External Connections

The external connections are numbered on Figure 4 and described with text below the figure.

1 E480152 V1.1 Material temperature sensor assembly
2 E48157 V1.0 USB/RS422 adapter assembly (connection for service laptop)
3 MicroSD-card slot under cap
4 Electronics and its interfaces under cover
5 Supply voltage input (24 VDC)
6 I/O cabling

Figure 4 LB 571 External connections
4 Installation

4.1 General Information

The national regulations applicable in the respective country of use must be observed. Installation, repair and maintenance work on the devices may only be carried out by trained personnel (see chapter 2.3).

**NOTE**

This device is not explosion-proof and must not be used in hazardous areas.

Only mounting accessories approved by Berthold may be used to install the device. The device are to be operated exclusively in a fixed installation.

4.2 Unpacking / Scope of Delivery

The system is delivered with the appropriate components, depending on the order. Check that the delivery is complete and undamaged as ordered. Immediately report any missing, defective or incorrect.

4.3 Environmental Conditions

**WARNING**

Danger due to installation in potentially explosive areas!

The device is not explosion protected and is not designed for hazardous environments.

**NOTE**

The device must be installed weatherproof.

For more details on the required environmental conditions see chapter 9 Technical Information.
4.4 Mounting of the System

The system can be mounted at a conveyor belt, in a screw conveyor or in a gliding carriage (3.3 Measurement arrangements).

**NOTE**

Please note the installation conditions of the respective measuring arrangement, see 3.3 Measurement arrangements

- Observe the permissible ambient conditions in chapter 9 Technical Information.
- The device must be installed weatherproof.
- The device must not be entered, used as a climbing aid or used for any other purpose (storage, fixing point).

**IMPORTANT**

- The device must be mounted flat on the surface of the mounting device / flange.
- The operator is responsible for selecting the connection elements, and tightening torque.
- It is recommended to turn the device so that the cable screws point downwards.

---

**Figure 5 Mounting LB 571**

1  Adjustable ring holder
2  Fixing screw M6x25
5 Commissioning

5.1 Safety Instructions

⚠️ DANGER

Risk of fatal injury due to electric shock!

- Do not touch any live components or live areas of the system.
- The installation may only be carried out by a qualified electrician.
- Observe the relevant safety regulations.
- Only open the housing in a dry environment and to carry out installation, maintenance and repair work.
- The measuring system, the connected relay contacts and all inputs and outputs must be disconnected during installation and service work on the hardware and during cabling.
- Only connect devices to the product that meet the applicable safety standards.

In case of electric shock, carry out the required initial measures and inform the emergency medical service immediately.

NOTE

Ensure that the supply voltage is within the admissible range!
5.2 Cables and wires

Only use cables whose diameters are permissible for the respective cable gland. The cables must meet the requirements and wire cross-sections specified in the technical data.

The connected cables must be suitable for a temperature which is at least 10°C above the maximum permissible ambient temperature.

- Carry out the line connection with special care.
- The connecting cable and its installation must comply with the applicable regulations.
- When laying the cables, make sure that mechanical damage to the conductor insulation on sharp-edged or moving metal parts is excluded.
- Use the Berthold approved cable or a cable with equivalent specifications for connection.

Lay the connecting cables in such a way that

- no dirt or moisture gets into the terminal compartment,
- the conductors are not damaged during stripping,
- the conductor insulation or the collar of the ferrule extends into the housing of the terminal body,
- bare conductive parts of the cables (e.g. wires of a stranded wire) do not protrude from the terminal body,
- the length of the ferrule or stripped wire is 8 mm so that the wire is held securely in the clamp,
- all strands are pressed with a ferrule,
- the conductor insulation extends into the collar of the ferrule,
- the minimum permissible bending radii for the respective conductor cross-section are not undershot,
- the cables are strain-relieved and installed without abrasion.

Cable glands and dummy plugs

- Cables may only be fed into the wall housing via a cable entry.
- The screw connections must be suitable for the respective application.
- All cable glands must be fitted according to the manufacturer’s instructions and tightened to the appropriate tightening torque (cable gland M20 = 5.5 Nm).
- The feedthroughs not required for installation must be closed with suitable dummy plugs.
- The permissible cable cross-section must be matched to the cable used.
- The cable conduits and dummy plugs must be designed to meet the applicable protection level requirements or the requirements of the operating environment.
- We recommend ordering missing fittings, dummy plugs or adapters from Berthold.
5.3 Electrical Connection

The resonator electronics and its electrical connections are implemented inside the mechanics.

The following electrical interfaces can be found on the device: 24 VDC / 10 A supply voltage, 3x digital inputs, 2x digital outputs, 2x current outputs. These connections are described in this section. The inrush current of the resonator is 10 A.

**NOTE**
Only components approved by Berthold may be used to commission the device.

![Diagram](image)

**Figure 6** Remove cover

**Tip**
For devices that are already in operation the cover of the housing can be difficult to remove. Therefore, loosen a cap nut of a cable gland to reduce the negative pressure.

1. Loosen 4 hex socket screws (Figure 6, Pos.1) and remove cover (Figure 6, Pos.3) carefully.
   - The connections (Figure 7) are visible.
2. Open the cap nuts of the cable glands (Figure 6, Pos.4) and insert the cables.
3. Connect cables to the terminals according to the connection diagram. Observe the information in chapter 5.2 Cables and wires.

**IMPORTANT**

Connectors marked on Figure 7 are in use. Pin number 1 is always on left side as shown on connector X8. Connector interfaces are shown on the table next page.

**Connector Pin Assignment**

4. Make sure that all lines are correctly connected and routed.
5. Tighten the cap nuts of the cable glands (Figure 6, Pos.4) with a tightening torque of 5.5 Nm.
6. Make sure there is a locking washer (Figure 6, Pos.2) on each hex socket screw (Figure 6, Pos.1).
7. Make sure that the entire circumference of the O ring seal (Figure 6, Pos.5) is undamaged and correctly inserted in the cover.
8. Attach the cover (Figure 6, Pos.3) and tighten all screws with a tightening torque of 1.5 Nm.

The electrical installation was carried out correctly.
### X5

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Colour</th>
<th>Connection</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+3.3V</td>
<td>Brown</td>
<td>Material temperature sensor (PWM)</td>
<td>Internal connections to material temperature connector</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Black</td>
<td>Material temperature sensor (PWM)</td>
<td>Internal connections to material temperature connector</td>
</tr>
<tr>
<td>3</td>
<td>TEMP1</td>
<td>Blue</td>
<td>Ceramics temperature sensor (PWM)</td>
<td>Internal connections to ceramics temperature sensor</td>
</tr>
<tr>
<td>4</td>
<td>+3.3V</td>
<td>Red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>TEMP2</td>
<td>Blue</td>
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### X6

<table>
<thead>
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<th>Pin</th>
<th>Name</th>
<th>Colour</th>
<th>Connection</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>+24V</td>
<td>Black</td>
<td>Power input +24VDC</td>
<td>Supply voltage +24VDC</td>
</tr>
<tr>
<td>2</td>
<td>+24V</td>
<td>Black</td>
<td>Heater 1 supply voltage</td>
<td>Internal connections</td>
</tr>
<tr>
<td>3</td>
<td>+24V</td>
<td>Black</td>
<td>Heater 2 supply voltage</td>
<td>Internal connections</td>
</tr>
<tr>
<td>4</td>
<td>Regulation</td>
<td>Black</td>
<td>Heater 1 control (GND)</td>
<td>Internal connections</td>
</tr>
<tr>
<td>5</td>
<td>Regulation</td>
<td>Black</td>
<td>Heater 2 control (GND)</td>
<td>Internal connections</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td></td>
<td>Power input GND</td>
<td>Supply voltage GND</td>
</tr>
</tbody>
</table>

### X8

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Colour</th>
<th>Connection</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IOUT_1 (+supply)</td>
<td>Brown</td>
<td>Aout 1: 4-20mA Moisture-% (Passive)</td>
<td>Moisture-% to system</td>
</tr>
<tr>
<td>2</td>
<td>IOUT_1 (load)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>IOUT_2 (+supply)</td>
<td>Blue</td>
<td>Aout 2: 4-20mA Temperature (Passive)</td>
<td>Material temperature to system</td>
</tr>
<tr>
<td>4</td>
<td>IOUT_2 (load)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>D_IN_1 +</td>
<td></td>
<td>Digital input 1 (24VDC)</td>
<td>Sample button or digital input connection for sampling</td>
</tr>
<tr>
<td>6</td>
<td>D_IN_1_GND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>D_IN_2 +</td>
<td></td>
<td>Digital input 2 (24VDC)</td>
<td>Product choice via digital input</td>
</tr>
<tr>
<td>8</td>
<td>D_IN_2_GND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>D_IN_3 +</td>
<td></td>
<td>Digital input 3 (24VDC)</td>
<td>Product choice via digital input</td>
</tr>
<tr>
<td>10</td>
<td>D_IN_3_GND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>D_OUT_1 (+supply)</td>
<td>Brown</td>
<td>Digital output 1 (24VDC/max. 50 mA)</td>
<td>Alarm output to system</td>
</tr>
<tr>
<td>12</td>
<td>D_OUT_1 (load)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>D_OUT_2 (+supply)</td>
<td>Blue</td>
<td>Digital output 2 (24VDC/max. 50 mA)</td>
<td>Spare</td>
</tr>
<tr>
<td>14</td>
<td>D_OUT2 (load)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>TXD+</td>
<td>Brown</td>
<td>RS422 serial communication (full duplex)</td>
<td>Internal connections to RS422 connector used by PC UI</td>
</tr>
<tr>
<td>16</td>
<td>TXD-</td>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>RXD+</td>
<td>Blue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>RXD-</td>
<td>Black</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6 Start up and Calibration

When resonator is powered up (24VDC/10A) and USB/RS422 adapter is connected to the PC, device can be operated by using the UI software.

6.1 UI folder structure

<table>
<thead>
<tr>
<th>Name</th>
<th>Date modified</th>
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<td>07/03/2019 10:06</td>
<td>File folder</td>
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<td>Calibration</td>
<td>07/03/2019 11:10</td>
<td>File folder</td>
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<tr>
<td>CalibrationArchive</td>
<td>27/11/2018 08:47</td>
<td>File folder</td>
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<tr>
<td>calibset</td>
<td>07/03/2019 11:12</td>
<td>File folder</td>
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<td>Data</td>
<td>19/03/2017 13:08</td>
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<td>Diagnostics</td>
<td>07/03/2019 00:00</td>
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<tr>
<td>Firmwares</td>
<td>06/03/2019 14:45</td>
<td>File folder</td>
</tr>
<tr>
<td>FromFlash</td>
<td>07/03/2019 11:15</td>
<td>File folder</td>
</tr>
<tr>
<td>settings</td>
<td>06/03/2019 14:49</td>
<td>File folder</td>
</tr>
</tbody>
</table>

Figure 8  UI folder structure

Meaning of the above folders are as follows:

**Bin:**  Executable UI and a General log-file.

**Calibration:**  Sample files (*.OLC) stored on PC.

**CalibrationArchive:**  Not used.

**Calibset:**  Calibrations stored on PC (*.XML).

**Diagnostics:**  Measurement data –files stored on PC.

**Firmwares:**  MCU firmware release.

**FromFlash:**  Stored sample (calib-xx.CSV) and online data (online-xx.CSV) files, which have been downloaded from SD-card using the UI.

**Settings:**  Windows, device and recipe setting-files (parameters) stored on PC.

More detailed information about these further in this document.
6.2 Setting up PC connection

In order to operate resonator using the UI:
1. Connect USB/RS422 adapter to PC’s USB port.
2. Wait until PC has installed adapter drivers.
3. Open Device Manager and check via which COM port device is accessible.

4. Power up resonator (24VDC).
5. Open /bin -folder and double-click BTwave-2.15.0.exe.

- BTwave UI starts with an Online view.
6. Click Maintenance button.
7. A Login to maintenance pop-up window appears.
8. Login by typing the Password: pass1 and click OK.
9. Open Parameters/Windows tab. See Figure 8 below.

![Figure 12 Windows Parameters](image)

10. Change COM port to Windows parameters 0# (Address) as found on Device Manager. When value is changed → text goes RED
11. Accept new value by clicking Enter button on PC and value turns YELLOW
12. Finally click Save to PC button
13. Restart UI and you should be connected. See Figure 9 for successful connection (Figure 8 shows an unsuccessful connection)

![Figure 13 UI successful connection](image)

The following information of the device is shown on Figure 14:

SW=MCU firmware version, HW=hardware version, (480023) = serial number
6.3 Setting device parameters

Setting device time

When connection to device is established, next step is to set PC time to device. It is explained below:

1. Login as shown in chapter 4.2.
2. Navigate to Diagnostics2 tab as shown on the next Figure.

3. Click Set device time to PC time button.
4. See that date and time below Set device time to PC time button has changed.
6.4 Writing and reading product parameters

Device parameters can be saved to and read from device using Parameters tab and selecting Device. A comment explains the function of each parameter.

![Device parameters screenshot](image)

**Figure 16  Device parameters**

- **Load from device:** Loads parameters from sensor FLASH memory to PC.
- **Save to device:** Saves parameters to sensor FLASH memory and also to SD-card parameters folder as ASCII file.
- **Load from PC:** Loads parameters from UI settings–folder from file `DeviceParameters.XML`.
- **Save to PC:** Saves parameters to UI settings–folder to file `DeviceParameters.XML`.

Parameters saved to device SD-card are only a copy of internal FLASH-memory contents. Parameters are never copied from SD-card to FLASH-memory.

Only the following parameters may need changes during start-up:

And their meanings are as follows:

- **3# Min_moisture (%):** Minimum moisture reading in % given out by device. Default 0 %.
- **4# Max_moisture (%):** Maximum moisture reading in % given out by device. Default 100 %.
- **5# AO1_I_min:** Analog output channel 1 minimum current output (mA) value. Output calibrated to 4 mA during production. Channel disabled if set to -1. Default 4 mA.
- **7# AO1_scale_min (%):** Analog output channel 1 minimum moisture (%) value. Default 0 %.
- **8# AO1_scale_max (%):** Analog output channel 1 maximum moisture (%) value. Default 100 %.
- **10# AO2_I_min:** Analog output channel 1 minimum current output (mA) value. Output calibrated to 4 mA during production. Channel disabled if set to -1. Default 4 mA.
- **12# AO2_scale_min (°C):** Analog output channel 2 minimum material temperature (°C) value. Default 0 °C.
13# AO2_scale_max (°C): Analog output channel 2 maximum material temperature (°C) value. Default 100 °C.

25# Product_choice: Product ID selection automatically from binary inputs or manually set by UI. 0=Auto (Selection made by binary inputs), 1=MAN (See Param #26). Default 0.

26# Product_nr: If Param 25# set to manual selection, this can be used for changing product ID number (0-3) from UI: e.g. 0=material 1, 1=material 2, etc. (See Param 25#).

33# Output_filtering: Output filtering of moisture reading in seconds (1-300 seconds). Default 20 s.

90# Temp_reg_hi (°C): High limit for ceramic temperature control (°C). Enter max. product temperature. Default 40°C

91# Temp_reg_low (°C): Low limit for ceramic temperature control (°C). Enter max. product temperature-0.1°C. Default 39.9 °C.

98# SD_card_detect: Shows if SD-card is inserted or not. 0=no SD-card inserted, 1=SD-card inserted. This is a read-only parameter on the device, but if set to 0, sample file will only be saved on the PC and can't be found on the device afterwards.

**Setting ceramics temperature**

For compensation and stability issues temperature of ceramics should be set:

Parameter 90# (see figure 9) = max. product temperature

Parameter 91# (see figure 9) = max. product temperature -0.1°C
6.5 Sampling by using digital input

Calibrating data is stored into calib_data –folder in SD-card. Calibration data can be written to the SD-card by toggling digital IO-line or trigger calibration sampling from UI software. If IO-line is toggled for example by pushing button connected to it, MCU starts saving calibration sample to the SD-card. Interval of sampling is always 1 seconds. Sample length is defined in device parameters #60 (Sample_time) if IO-line is used for triggering sample.

Calibration data can be read from SD-card using UI-software by selecting Read from SD-card … under Calibration tab. From the opened window, sample list can be fetched by selecting Get sample list from SD-card as shown on the Figure.

![Figure 17 Read and selected calibration samples](image)

6.6 Analog outputs control

There are two analog outputs available. AO1 (Analog Out1) is controlled by filtered moisture value.

AO2 is controlled by filtered material temperature value. There are totally 6 parameters related to each analog output in device parameters.

If AOx_I_min value is set to -1, the equivalent channel is disabled.

Analog outputs control parameters:

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOx_I_min</td>
<td>Minimum current value for analog out. Channel disabled = -1</td>
</tr>
<tr>
<td>AOx_I_max</td>
<td>Maximum current value for analog out</td>
</tr>
<tr>
<td>AOx_scale_min</td>
<td>Minimum moisture or temperature value which produces minimum current output value</td>
</tr>
<tr>
<td>AOx_scale_max</td>
<td>Maximum moisture or temperature value which produces maximum current output value</td>
</tr>
</tbody>
</table>
### 6.7 Calibration

In order to have device measuring moisture content, it must be calibrated using the material it will be measuring. Reference samples should be taken covering the whole moisture range used at the plant.

#### 6.7.1 Sampling

Before starting with sampling, please ensure that the SD-card is inserted in the device.

To start taking samples, go to Calibration tab shown on below figure and follow the steps shown below:

1. Click New sample...
2. Below Moisture measurement view opens
3. Click Start (button toggles to Stop) and start collecting a sample for reference determination.
4. When finished sampling, click Stop button.
5. The above steps 3 and 4 can be repeated.
6. Finally click Close button.
6.7.2 Download samples

When enough samples have been collected, they can be downloaded from device SD-card to the PC by going to Calibration tab (see Figure 24) and continuing as explained below:

1. Click Read from SD-card … button
2. Below Read From SD-card view opens (except no samples shown)

![Read from SD-card](image)

Figure 20 Samples from SD-card

3. Click Get sample list from SD-card button and a list of all samples saved to SD-card are shown as on above figure.
4. Select samples by clicking the sample field (marked X).
5. Click Export selection to PC button and download starts.
6. Finally click Close button and samples appear in the list of samples taken.
   - It is also possible to remove samples from SD-card by selecting samples and clicking Delete selected.
6.7.3 Save reference values to samples

UI must have reference values for samples used in calculating moisture measurement parameters for the device. This is also done under Calibration tab and as shown below:

1. Double-click on a sample shown above and Calibration File view below opens, where you can give additional information for the sample.

2. Type reference value on Lab % box

3. Type used product on Product ID box. This is by default set to the product, which has been active when sample was taken.

4. Type comments on Additional Information box

5. Click Save and view closes

It is also possible to remove samples from SD-card and PC by clicking Remove file.
6.7.4 Calibrate device

When reference values has been inserted, device can be calibrated as explained below:

1. Select samples (X) to be used in calibration as above
2. Click Calibrate… button
3. Below autocalibrator view opens

Figure 23 Calibration

4. Click the green Calibrate button marked with the arrow

Figure 24 Calibration
The moisture calculation parameters are optimized by the UI for best correlation between the measured signals and the Lab-% values. The calculation parameters are shown in the quadratic box on the right.

The moisture reading is based on multivariable density compensated measurement. The calibration may be improved by using the below calculation methods:

**Temperature:** If material temperature range for the collected samples is big, then temperature compensation should be used by ticking the *Temperature* check box.

**Polyfit:** If this is ticked parameter Coeff A will affect the calculation (value different than 0). Should not be used until the whole moisture range is covered by the samples. If material is quite homogenous and the whole moisture range is covered by the samples, the parameter optimization may be used without the *Polyfit*.

The statistics for the calibration is shown in the bottom right corner. These are as follows:

- **error:** RMSE (Root Mean Square Error) between the difference of Measured-% and Lab-% of the samples.
- **steyx:** Comparison between Measured-% and Lab-% of the samples using excel function STEYX.
- **cor:** Correlation between Measured-% and Lab-% of the samples using excel function CORREL.

5. When parameter optimization is done, click *Move Parameters to Pending List* … button marked with the arrow in the autocalibrator

6. Below view opens with the active material selected

![Save Parameters to Pending List](image)

**Figure 25** Save parameters to pending list

7. Select calibrated material, write a comment and click OK.

8. UI opens *Parameters History* tab under the *Parameters* tab. See below figure.
Figure 26 Parameter History

The green marked box appears under List of pending Material 1 parameters. This is the saved calibration and its calculation parameters can be seen on the right side on the figure. This calibration still needs to be activated to MCU as follows:

9. Click Activate parameters button and below view opens.

Figure 27 Activate parameters

10. Add optional comments if needed and click Activate button and below view opens.
11. Finally click the blue Go to calibration button and the following view opens.

12. To have UI calculating new moisture values with the new parameters, click Yes and samples are recalculated on Calibration tab.

- Repeat these steps for the other materials (products) to be calibrated by using their product ID.
7 Diagnostics

7.1 Measurement diagnostics

Measurement signals are shown on Diagnostics tab as shown on the next Figure.

Figure 30  Diagnostics view.

The Figure shows the main monitoring window for sensor operations. It shows different signals collected from sensor, such as resonator frequency response, frequency, Q-value, attenuation, calculated moisture content (also shown on Moisture graph: red line=raw and green line=filtered), temperature reading (material and ceramic), digital input line status (I/O) and sensor error code generated by MCU.

By ticking Save to diagnostics log measurement data is stored to PC Diagnostics – folder

7.2 Writing and reading online data

Online data is written to SD-card all the time device is functional and SD-card is inserted.

Online data can be imported from SD-card to UI from Flash History tab. Set start and end dates and time of day and click Download to start loading data from sensor.
After end time or end of data is reached, downloading is finished and moisture of downloaded data is shown on the UI. It is possible to change data shown on graph from the dropdown list shown with arrow.

Full contents of downloaded data is stored to /FromFlash –folder on PC. File format is same CSV-file as used in calibration samples. Only one CSV-file is created per download request regarding of start and end time interval.

Downloading can be stopped before end time is reached by clicking Stop button.

It may take up to 30 seconds before download starts after pushing button. It depends how quick start time is found on SD-card files.

Measurement loop is not active when downloading is in progress. After downloading is finished measurement loop starts again.
7.3 Writing and reading product parameters

Recipe parameters are saved to internal FLASH memory after Activate Parameters is selected from UI. In addition recipe parameters are saved to SD-card parameters–folder. Parameters are never copied from SD-card to internal FLASH.

Selecting Get Active Parameters loads recipe parameters from sensor FLASH memory to UI.

![Recipe/Product parameters](image)

Figure 32 Recipe/Product parameters

7.4 Inserting and removing SD-card on the fly

It is possible to remove and insert SD-card to the device on the fly. If device is writing data to the SD-card when card is removed MCU SW may get stuck.

It is possible to use a watchdog timer device parameters #99 (Watchdog_enable) resetting the MCU after 5 seconds. Current output is not affected during reset and all parameters are recovered from internal FLASH memory to continue measurement as before system reset. Device is also capable of doing measurements without SD-card inserted.
7.5 Service Mode

To update device firmware, serial number and to test I/O signals, device can be set to a service mode. To have these operations available, *Toggle Service Mode* button. Figure 20 shows the view when service mode is on.

![Figure 20 Service Mode ON view](image)

Different outputs can be tested by setting their bits/values and clicking *Update values* button.
7.6 Firmware update

New firmware can be uploaded to sensor using UI software. It is done from Diagnostics2 tab and toggling Service Mode ON. Then continue as follows:

1. Click Update device software
2. Browse and select Firmware version from PC Firmwares -folder and click Open.
3. Firmware upload starts.

When firmware upload is ready (see above figure), sensor boots itself automatically. Rebooting takes approximately 20-25 seconds. After reboot, UI may need restarted.
8 Error Codes and Alarms

8.1 Watchdog

It is possible to use on-chip hardware watchdog timer to recover software deadlocks. Watchdog timer can be enabled in device parameters #99 (Watchdog_enable). Watchdog timer timeout is fixed to 5 seconds.

8.2 Error codes

There are following general error codes defined. Errors are inserted to the error code word bit by bit. Each error corresponds one bit so totally 16 errors can be defined. Error code is read by UI in diagnostics tab.

Errors are cleared automatically if they disappear. Watchdog error is only cleared by powering down the resonator.

Error types in error code can’t be masked. All error types are always active. In other hand errors which generate alarm can be defined.

### Error Codes

<table>
<thead>
<tr>
<th>Error code</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SENSOR_RESONANCE_LEVEL_ERR</td>
<td>0x0001</td>
<td>Resonance level under threshold value. Threshold defined using device parameters #92</td>
</tr>
<tr>
<td>SENSOR_TEMP_MATERIAL_ERR</td>
<td>0x0002</td>
<td>Unable to read material temperature sensor</td>
</tr>
<tr>
<td>SENSOR_TEMP_CERAME_ERR</td>
<td>0x0004</td>
<td>Unable to read cerame temperature sensor</td>
</tr>
<tr>
<td>SENSOR_ANALOG_OUT_1_ERR</td>
<td>0x0008</td>
<td>Unable to write to Iout channel 1</td>
</tr>
<tr>
<td>SENSOR_ANALOG_OUT_2_ERR</td>
<td>0x0010</td>
<td>Unable to write to Iout channel 2</td>
</tr>
<tr>
<td>SENSOR_SD_CARD_WRITE_ERR</td>
<td>0x0020</td>
<td>Unable to write to the SD-card</td>
</tr>
<tr>
<td>SENSOR_PLL_CONFIG_ERR</td>
<td>0x0040</td>
<td>Phase locked loop was not configured correctly at startup</td>
</tr>
<tr>
<td>SENSOR_RTC_ERR</td>
<td>0x0080</td>
<td>Real-time clock not setup or has been resetted</td>
</tr>
<tr>
<td>SENSOR_WD_RESET_ERR</td>
<td>0x0100</td>
<td>Indicates that last reset was caused by watchdog. Is cleared by power on reset only.</td>
</tr>
<tr>
<td>SENSOR_HEATING_CTRL_ERR</td>
<td>0x0200</td>
<td>Indicates that FET which controls ceramic heating is not functional</td>
</tr>
<tr>
<td>SENSOR_SD_CARD_INIT_ERR</td>
<td>0x0400</td>
<td>SD-card initialization is not succeeded. There is problem to mount file system in startup or after re-inserting SD-card. Writes to SD-card can’t be made.</td>
</tr>
</tbody>
</table>
8.3 Alarm generation

8.4 Enabling alarms

Error codes causing an alarm can be defined using device_parameters #70 (Alarm_mask). By setting corresponding bit high in mask defines that error is taken into account for alarm generation. Multiple errors can be defined by setting multiple bits high.

Alarm mask examples

<table>
<thead>
<tr>
<th>Alarm mask value (hex)</th>
<th>Alarm mask value (dec)</th>
<th>Error code(s) to cause alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0001</td>
<td>1</td>
<td>SENSOR_RESONANCE_LEVEL_ERR</td>
</tr>
<tr>
<td>0x0002</td>
<td>2</td>
<td>SENSOR_TEMP_MATERIAL_ERR</td>
</tr>
<tr>
<td>0x0004</td>
<td>4</td>
<td>SENSOR_TEMP_CERAME_ERR</td>
</tr>
<tr>
<td>0x0008</td>
<td>8</td>
<td>SENSOR_ANALOG_OUT_1_ERR</td>
</tr>
<tr>
<td>0x0010</td>
<td>16</td>
<td>SENSOR_ANALOG_OUT_2_ERR</td>
</tr>
<tr>
<td>0x0020</td>
<td>32</td>
<td>SENSOR_SD_CARD_WRITE_ERR</td>
</tr>
<tr>
<td>0x0040</td>
<td>64</td>
<td>SENSOR_PLL_CONFIG_ERR</td>
</tr>
<tr>
<td>0x0080</td>
<td>128</td>
<td>SENSOR_RTC_ERR</td>
</tr>
<tr>
<td>0x0100</td>
<td>256</td>
<td>SENSOR_WD_RESET_ERR</td>
</tr>
<tr>
<td>0x0200</td>
<td>512</td>
<td>SENSOR_HEATING_CTRL_ERR</td>
</tr>
<tr>
<td>0x0400</td>
<td>1024</td>
<td>SENSOR_SD_CARD_INIT_ERR</td>
</tr>
<tr>
<td>0x0087</td>
<td>(1+2+4+128) = 135</td>
<td>SENSOR_RESONANCE_LEVEL_ERR SENSOR_TEMP_MATERIAL_ERR SENSOR_TEMP_CERAME_ERR SENSOR_RTC_ERR</td>
</tr>
<tr>
<td>0x07FF</td>
<td>(1+2+4+8+16+32+64+128+256+512+1024)=2047</td>
<td>All errors generate alarm</td>
</tr>
</tbody>
</table>

Delay prior alarm is triggered from occurrence of bitwise OR of errors and can be defined from device_params #71 (Alarm_delay).

When alarm conditions disappear, alarm is switched off after the same device_params #71 (Alarm_delay). Watchdog error needs power down of device for getting cleared.

If device alarm output is triggered, connect to the device using the UI and check active errors. Below are some checkpoints in case of errors:

SENSOR_RESONANCE_LEVEL_ERR
Check parameters and that measurement signal is ok during material measurement (above -50 dB). If not, empty resonator surface and check that signal is ok and approx. -10 dB (see chapter 10.1). Change device.

SENSOR_TEMP_MATERIAL_ERR
Check that material temperature reading is ok, otherwise try changing temperature sensor. Change device.

SENSOR_TEMP_CERAME_ERR
Check that ceramic temperature reading is ok, otherwise try powering device off, if it does not help, change device.

SENSOR_ANALOG_OUT_x_ERR
Check that connections and parameters are ok. If connection is not needed, disable output channel by setting AOx_I_min to -1.
SENSOR_SD_CARD_XXX_ERR
Check that SD-card is inserted. Change SD-card.

SENSOR_PLL_CONFIG_ERR
Check that parameters are ok. Try powering device off, if it does not help, change device.

SENSOR_RTC_ERR
Set device time to PC time. See chapter 6.3.

SENSOR_WD_RESET_ERR
Check that parameters are ok. Try powering device off, if it does not help, change device.

SENSOR_HEATING_CTRL_ERR
Check that ceramic temperature reading is ok. Check heater connections (see chapter 3.1). Change device.
# Technical Information

## Mechanical Data

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (without holder ring / cable glands)</td>
<td>- Ø 149 mm</td>
</tr>
<tr>
<td></td>
<td>- height 100.5 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>3.6 kg</td>
</tr>
<tr>
<td>Protection class</td>
<td>IP65</td>
</tr>
<tr>
<td>Sensor material</td>
<td>Ceramic Al2O3</td>
</tr>
<tr>
<td>Housing material</td>
<td>Stainless steel AISI 316L</td>
</tr>
<tr>
<td>Cable screw connection</td>
<td>2x M20, 1x M8</td>
</tr>
</tbody>
</table>

## Electronics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>18-30 VDC / 2A. Inrush current 10 A</td>
</tr>
<tr>
<td>Sensor interfaces</td>
<td>2x Analog Outputs (4…20 mA) for moisture and material temperature signals (galvanically isolated, load &gt;0 ohms but &lt;800 ohms @24 VDC, passive)</td>
</tr>
<tr>
<td></td>
<td>3x digital Input (24 VDC, 2x inputs reserved for product selection (max. 4 products), sample taking)</td>
</tr>
<tr>
<td></td>
<td>2x digital outputs (alarm output, 1 spare output load max. 50 mA @ 24 VDC)</td>
</tr>
<tr>
<td>Interface to PC</td>
<td>RS422/USB</td>
</tr>
<tr>
<td>maximal connection terminals cable cross-section</td>
<td>- Supply voltage connector = 1,5mm²,</td>
</tr>
<tr>
<td></td>
<td>- I/O connector = 0,5mm²</td>
</tr>
<tr>
<td>Guidelines</td>
<td>- RoHS: 2011/65/EG</td>
</tr>
<tr>
<td></td>
<td>- EMV-directive 2014/30/EG: EN61326-1</td>
</tr>
</tbody>
</table>

## Environmental Conditions

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended moisture range</td>
<td>0…30 %¹ (depending on the Material under test)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.1 weight % (standard deviation) depending on product and process in calibrated measuring range</td>
</tr>
<tr>
<td>Temperature range</td>
<td>+0…65 °C (32…149 °F)</td>
</tr>
<tr>
<td>Material temperature</td>
<td>&gt; 0 °C</td>
</tr>
<tr>
<td>Microwave output power</td>
<td>&lt; 10 mW</td>
</tr>
<tr>
<td>Measurement time</td>
<td>10 ms</td>
</tr>
</tbody>
</table>

¹ If conditions differ, please contact Berthold.
10 Declaration of Conformity

EU-Declaration of Conformity

We, hereby declare under our sole responsibility that the design of the following microwave resonator brought into circulation by us comply with the relevant harmonized rules of the EU.

This declaration loses its validity should modifications or unsuitable and improper use take place without our authorisation.

Product name: microwave resonator

BTWave

Type / model: LB 571-02

<table>
<thead>
<tr>
<th>directive</th>
<th>applied standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC 2014/30/EU</td>
<td>EN61326-1 2013</td>
</tr>
<tr>
<td>RoHS 2011/65/EG</td>
<td></td>
</tr>
</tbody>
</table>

This declaration is issued by the manufacturer:

BERTHOLD TECHNOLOGIES GmbH & Co. KG
Calmbacher Str. 22, D-75323 Bad Wildbad, Germany
released by

Dr. Jürgen Briggmann
Head of R&D
Bad Wildbad, 20th of November, 2019
We reserve the right to make changes in the course of further technical development.