User Guide

PMD 2450 Precision Microwave Detector (LDU 1000)
Versions: PMD 2450-1, PMD 2450-2, PMD 2450-3,

GTA 1000-1 Dual Energy Gamma Transmission Ash Analyzer with Am-241 and Cs-137

GTA 1000-2 Dual Energy Gamma Transmission Ash Analyzer with X-rays and Cs-137

GTA 2000 Triple Energy Gamma Transmission Ash Analyzer with X-rays, Am-241 and Cs-137

GTD 1000 Gamma Transmission Density Gauge with Am-241, Cs-137 or Co-60

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The content of this user guide was reviewed for conformity with the described hard- and software.

Nevertheless, deviations cannot be ruled out. The information in this user guide is reviewed regularly and any corrections that may be required will be included in subsequent editions. We appreciate your suggestions for improvement.

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NOTICE / Licence Exempt:

This device complies with Part 15 of the FCC Rules and with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two Conditions.

(1) this device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d´Industrie Canada applicables aux appareils radio exempt de licence. ***. L'exploitation est autorisée aux deux conditions suivantes :***

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le onctionnement.

NOTICE :

Changes or modifications made to this equipment not expressly approved by Indutech instruments GmbH may void the FCC authorization to operate this equipment.

NOTE: *This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

WARNING! PROFESSIONAL INSTALLATION REQUIRED.
Installation by professionals only!

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1. Introduction

Overview

1.1 Overview

This user guide describes how to work with LDU 1000 as the Precision Microwave Detector (PMD 2450), as **GTA** (**G**amma **T**ransmission **A**sh) Analyzer or as **GTD** (**G**amma **T**ransmission **D**ensity) Gauge. You will find information on the basic principle of measurement as well as on the performance of the evaluation unit of the PMD 2450.

Chapter 1: Introduction

This introduction includes information on working with the instrument and information on the fields of applications of the PMD 2450, GTA and GTD.

In addition, it includes codes of practice for handling radioactive sources.

Chapter 2: Basics

This chapter provides a summary of the theoretical basis of the principles of measurements, including the function of the microwave measurement for determination of the moisture content as well as the physical basis of radiometry.

Chapter 3: Software

This section of the user guide describes the structure and operation of the PMD software, in particular, the menu structure, the measurement operation and the service functions.

Chapter 4: Getting Started

Here you find important information on how to take the system into operation.

Chapter 5: Technical Data

In this chapter you will find all technical information relating to the hardware.

1.2 User Instructions

Purpose and Contents

This user guide describes the LDU 1000 as PMD 2450 GTA or GTD and all product variants.

Target Group

The user guide has been written for users with a certain level of basic knowledge.

User Guide Structure

The user guide comprises 5 chapters. Each chapter describes a different subject matter.

Document Guidance

The following items in this manual provide user guidance:

- Overall table of contents at the start of the user guide
- Overview about the content at the beginning of each chapture

Availability

The user guide is available as:

- printout on paper
- PDF file

(download Adobe Acrobat Reader under http://www.adobe.de)

1.3 Safety Instructions

The PMD 2450 has been designed and manufactured for the on-line measurement of the

- water content in solid matter, powders and bulk goods
- density of aqueous solutions
- consistency of aqueous solutions
- residual carbon in flue ash

The instrument is not suited for determining the water content of

- ice
- crystal water

The GTA has been designed and manufactured to determine the ash content of coal.

The GTD allows to determine the density of materials

Documentation

The user guide should be available to all employees in

- Project planning
- Installation
- Getting started
- Operation

Before getting started and operating the components described in this user guide, please keep in mind:

Idle Status

- The instrument may be connected and modified by trained professional personnel only.
- National regulations and directives in the respective country of use have to be observed (installation, safety precautions ...).

Disposal

National regulations have to be observed to dispose off the instrument!

1.4 Radiation Protection

Radiometric measurement methods are employed in many applications of the LDU 1000. Since these methods utilize radioactive sources, we will briefly discuss how to work with nuclear radiation.

Overview

Nuclear radiation acting on living cells may trigger chemical and biological reactions which, depending on the intensity, energy and action time, may modify, damage or destroy cells.

To rule out health hazards, an international limit value has been stipulated for the highest permissible radiation exposure of the operating personnel of 1 mSv (100 mrem) per year as limit from the non-monitored area to the monitored in-plant area.

The shielding design as well as the setup of the measuring system at the measurement point ensures that the radiation exposure will stay below this limit value in any case, provided the measuring system is handled properly.

Radiation protection areas outside the shielding should be identified accordingly and secured, if necessary.

Code of Practice

Essentially, each employee has to endeavor – through cautious behavior and adherence to the radiation protection regulations – to keep the radiation exposure as low as possible, even within the legal limit values.

The radiation absorbed by the body, and thus the harmful effect, is dependent on three factors, which are therefore important for the basic code or practice:

Distance

The radiation intensity follows a square law of distance: doubling the distance to the radiation source reduces the intensity to one quarter.

→ Always observe a fairly large distance to the source.

Action time

The longer the period of exposure to radiation, the higher the level of radiation exposure.

→ Do not stay in the immediate vicinity of the source longer than absolutely necessary.

This means that maintenance work or source replacement have to be planned thoroughly to ensure that work can be performed quickly and the period of stay in the vicinity of the source is kept to a minimum.

Shielding

The source is shielded by the material surrounding it. There is an exponential relationship between the shielding effect and the product of thickness and density of the shielding material. Therefore, these materials have a high specific density and have to be sufficiently thick.

→ Do not take the source out of its shielding.

If necessary, the useful radiation beam has to be shielded as well.

Radition Protection Officer

A radiation protection officer has to be appointed in every factory. He or she is the contact for all issues relating to the measuring facility. He or she draws up the radiation protection rules tailored to the needs of the factory and defines codes of conduct which also may serve as basis of job instructions.

Special incidents or accidents have to be reported to the radiation protection officer immediately who will then inform him/herself on the spot about the situation and take appropriate action, if safety or function of the facility is endangered.

In addition, the radiation protection officer has to make sure that the regulations of the Radiation Protection Ordinance shall be complied with, in particular, the obligation of book-keeping and reporting special events as well as the duty of instructing other employees.

Disposal of Radioactive Source

All radioactive sources which are either not needed any more or which have decayed have to be disposed off at a governmental collection site or returned to the supplier.

In particular, the national regulations for disposal of radioactive sources have to be observed.

2. Basics

This chapter describes the theoretical basis of the principles of measurement, including the function of the microwave measurement for determining the moisture content as well as the physical basis of radiometry.

Overview

List of Illustration

2.1 Use and Function

2.1.1 PMD Moisture meter

The microwave moisture meter PMD 2450 is capable of measuring the water content of virtually any material noncontacting and on-line. Costly mechanical sampling devices and sample dividers are not needed. The material layer to be measured can be transmitted by microwaves directly on a conveyor belt, in a chute, a pipeline or a container made of nonconductive material. The measurement is carried out through the wall or the conveyor belt.

Strongly varying layer thicknesses and bulk densities of the product being measured may be compensated for by an additional radiometric area weight measurement. Thus, the PMD 2450 works independent of the measurement geometry.

Since measurement is performed in transmission, the entire material transmitted is evaluated, ensuring representative measurement at all times.

Figure 1 shows the basic configuration of the moisture measurement. Microwaves are emitted by an antenna, pass through the material layer and are finally picked up by the antenna on the opposite side. The additional radiometric area weight measurement, which is not included with the basic version, consists of a radiation source in a shielding container and a scintillation detector. Both antennae as well as the scintillation detector are connected to the evaluation unit PMD 2450 using the connection cables supplied with the instrument; the evaluation unit is set up directly next to the measuring point.

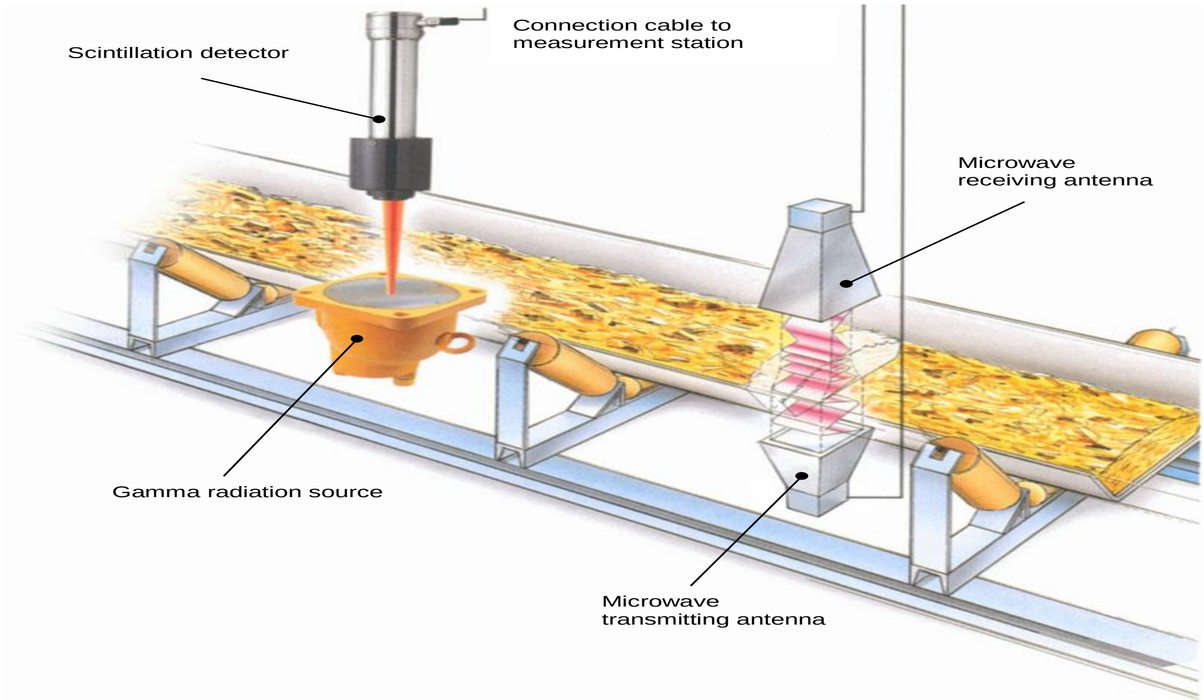

Figure 1: Principle of measurement

Figure 1 shows the standard configuration. This configuration may be adapted to special measurement tasks. One PMD 2450 can manage two directly adjacent measuring points (see Figure 2); however, a microwave unit can be used only at one measuring point.

GTA Ash measurement

In addition to the Cesium transmission line the Ash measurement GTA has an Americium transmission line and/or a transmission with an X-ray tube as source. Because of the effect that the absorption of low energy gamma rays is dependent on the atomic number of the material and the fact, that the constituents of the ash have an higher atomic number than the constituents of coal, this method allows to determine the ash content of coal.

GTD Density measurement

For density measurement one gamma transmission line is necessary. As source Am, Cs or Co is used.

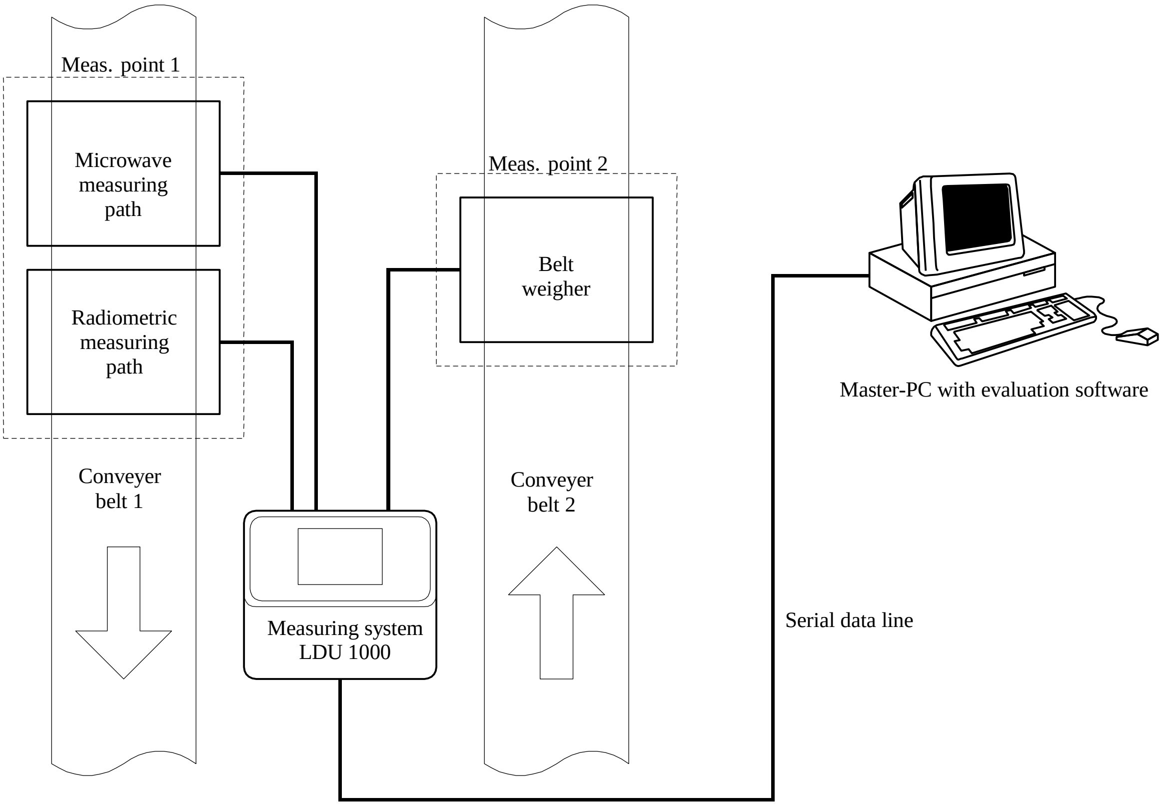

Figure 2: Configuration with two measuring points

In addition to measurements on conveyor belts, the PMD 2450 also offers the opportunity to determine the moisture in chutes, containers or pipelines. In pipelines one can measure the moisture or dry matter contents not only of bulk goods, but also of liquids. At variable product temperature, a temperature sensor may be used in each of the two measuring channels in order to get a temperature-compensated measuring signal.

2.2 Microwave Measuring Principle

The material layer to be measured is transmitted by microwaves. The principle of measurement is based on the physical effect of

- phase shift (reduction of the propagation speed at high relative permittivity)
- attenuation (intensity decrease due to dielectric loss)

of electromagnetic waves passing through moist material. Since water has a high relative permittivity, moist material differs from dry material due to changed dielectric properties.

Incident microwaves set free water molecules, which are not yet bound to dry matter, in rotation depending on the orientation of the electromagnetic field. This causes the phase shift and the attenuation.

Thus, the PMD 2450 determines the amount of free water in the material being measured.

Measurement of

- ice
- crystal water

is not possible.

Weakly bound water can be detected depending on the bond strength. Therefore, the measurement effect may depend on the particle-size distribution and the chemical composition of the product being measured if the binding of water to solid materials is changed.

Conducting materials such as graphite or coke cannot be transmitted by microwaves. Likewise, the transmission of metal walls is not possible. The transmissionor metal-reinforced conveyor belts is possible under specific conditions. Walls made of plastic, rubber or insulating materials having a fairly low relative permittivity and low dielectric losses and have no influence on the measurement.

Phase measurements are additionally unambiguous only in the range of 360°. Therefore the phase shift must be corrected by a multiple of 360°.

The phase shift is standardized on frequency. If we speak in the following about phase shift, always the stadardized value is meant, i.e. the dimension is degrees/GHz. The attenuation is expressed in a logarithmic scale. The dimension is dB.

To get the phase shift and the attenuation caused by the material layer, a zero measurement i.e. a measurement without material must be done. The phase shift and the attenuation are the differences of the measurement with and without material.

The water content W in the material being measured depends in good approximation linear on the occurring phase shift Φ and the attenuation D according to the following equation

$$W = A * \frac{\phi}{\rho * d} + B * \frac{D}{\rho * d} + C \qquad (1)$$

taking into account that both, attenuation D and phase shift Φ are proportional to the area weight $\rho * d$ of the material.

ρ refers to the bulk density and d to the layer thickness. A, B, C are the coefficients of the calibration function.

Whereas conventional microwave moisture meters only use the attenuation, the PMD 2450 allows the moisture measurement using either the effects of

- phase shift
- attenuation
- combination of phase shift and attenuation

of microwaves passing through the material.

The microwave phase shift method is able to achieve a significantly higher accuracy than the generally used microwave attenuation method; this is true not only for a constant measurement geometry, but in particular on conveyor belts with varying material load. In contrast to the attenuation measurement, the phase measurement is hardly affected by material parameters such as temperature, salt content (electrolytic conductivity) and grain size. Moreover, the phase measurement is much less affected by disturbance variables (e.g. interferences) and by reflections. With a pure phase measurement one can, therefore, achieve an unequalled accuracy in on-line water content measurements for a variety of products. The phase method is exclusively employed for a majority of measurement tasks.

A pure attenuation measurement may be carried out if the above mentioned disturbance variables are not an issue. In contrast to conventional microwave moisture meters, the PMD 2450 can utilize a wide variety of measuring frequencies in a broad frequency belt for phase measurements as well as attenuation measurements. Thus, the influence of a variable measuring geometry (conveyor belts with varying load) due to multiple reflections is significantly reduced.

A further increase of the measurement accuracy can be obtained through combination of attenuation and phase measurement for some special applications only. However, this is only meaningful if the attenuation is not distorted by additional other interferences or disturbance reflections in variable measurement geometries or varying salt contents and temperatures. A possibly remaining grain size influence, which may occur with pure phase measurements, may be reduced by a combined measurement.

2.3 Radiometric Measurement

Equation (1) (see 2.2) shows that the influence of varying material layer thickness and bulk good density disappears through standardization relative to the transmitted area weight. The area weight is either determined by an additional radiometric measuring path or by an infrared sensor.

The radiometric transmission measurement is based on the physical effect that Gamma radiation passing through material being measured is subject to an intensity decrease. The residual radiation having the intensity I, which is picked up by the scintillation detector, indicates the area weight, where the bulk density results in the transmission path. A constant distance between radiation source and scintillation detector is required. The intensity decrease may be described by the law of absorption

$$I = I_o \cdot e^{-\eta \cdot \rho \cdot d} \tag{2}$$

I_0 refers to the intensity of the un-attenuated radiation and η to the material-specific linear attenuation coefficient (absorption coefficient). This coefficient is defaulted by the PMD 2450 depending on the radiation sources used.

From equation (2) follows

$$\ln \frac{I_0}{I} = \eta \cdot \rho \cdot d \tag{3}$$

which simplifies the calculation (1) of the water content:

$$W = A \cdot \frac{\Phi}{\ln \frac{I_0}{I}} + B \cdot \frac{D}{\ln \frac{I_0}{I}} + C \tag{4}$$

In addition to the water content W in percent, the PMD 2450 also displays the area weight ρ*d in g/cm^2. This value is calculated on the basis of the count rate ration according to (3), where deviations from the defaulted absorption coefficient can be corrected. The thickness of an addition wall to be transmitted or the conveyor belt only causes very minor constant radiation attenuation, i.e. it does not have any influence on the measurement effect. Thus, the radiometric measurement is extremely immune to interferences and is very reliable.

The intensity of the radiation source decreases in the course of time. The time period in which it has decreased to half its original intensity is referred to as half-life period which differs depending on the type of radiation source. The PMD 2450 automatically compensates for the radiation decomposition depending on the selected radiation source.

A radiometric area weight compensation need not be performed when layer thickness and bulk density are constant in a fixed measuring geometry. This is the case, for example, on conveyor belts transporting the same load all the time, or in pipelines or chutes which are always filled with the same material having a constant density.

2.4 Scintillation Detector

A scintillation detector is used as radiation detector; its characteristic feature is its high specific sensitivity to Gamma radiation and a service life that is not affected by radiation exposure and is, therefore, not limited. Despite low source activities, the scintillation counter supplies a high count rate which simplifies result processing. The scintillation detector is equipped with a drift stabilization compensating for age and temperature related changes, thus ensuring high long-term stability.

The scintillation detector consists of a NaI(Tl) crystal, a photomultiplier and an electronics module in a sturdy cylindrical stainless steel housing with integrated connection box.

Figure 3: Scintillation detector

Gamma radiation triggers flashes of light in the crystal, their frequency being proportional to the radiation intensity. The crystal is optically coupled to a photomultiplier. The flashes of light release electrons from the light-sensitive photomultiplier cathode. This flow of electrons is amplified by a so-called dynode system and, due to the high voltage applied, accelerated towards the anode, there generating an electrical pulse for each incident flash of light. These pulses are amplified in the electronics unit, then reduced by a division factor of 1, 2, 4, 8 and 16 and shaped into low-impedance square pulses of approx. 10V.

The electronics unit also generates the high voltage required for operation of the photomultiplier. The +/- 15V supply voltage and standard pulses are transferred to the evaluation unit via the connection cable supplied.

For ambient temperatures exceeding 50°C, the scintillation counter may be equipped with a water cooling device which is available as an accessory.

The standard version of the scintillation detector receives radiation from the front. On request, a special detector shielding may be supplied for radial irradiation. This shielding may also be installed later.

2.5 Radiation Source

Gamma sources are used as radiation emitters. Typically, Cs-137, Am-241 or X-rays are used. The radiation emitted by these isotopes is subject to a natural intensity decrease. Each isotope has a characteristic half-life, i.e. the period after which only half of the original radiation intensity is still available.

The most frequently used isotope for area weight compensation or density measurement is Cesium (Cs-137), which is available as a point source. Its nuclear energy of 660 keV suffices to transmit normal pipe and chute walls. This nuclide is preferably used to transmit thicker layers. Cs-137 can be shielded very effectively. Its half-life is 30.3 years.

The radiation absorption of Cs-137 is relatively uniform and virtually independent of the chemical composition of most common products being measured.

Americium (Am-241) is available as a surface source, emitting radiation with 60 keV energy. It is used for measurements involving low area weights and thin layers. Due to its low energy, Am-241 can be shielded easily. Its half-life of 433 years is very long. Am-241 can be replaced by X-rays. These allows also to generate radiation with a lower energy.

The radiation absorption depends on the atomic number of the chemical elements included in the product being measured. Therefore, its use is restricted to products of virtually constant chemical composition.

2.6 Shielding

The radiation source is firmly installed in a shielding. The shielding container for Cs-137 is made of a sturdy cast iron or stainless steel housing filled with lead. The front of the container is closed by a metal plate. The radiation exit channel can be closed by a built-in rotating shutter. The shutter is operated from the rear via a lever which can be secured by a lock in open and closed position. A lock protects the source against unauthorized removal.

The Am-241 area source is firmly installed into a shielding. The container front is also covered by metal plates. The shielding is provided with a lockable radiation exit channel with rotating shutter and lever.

The X-ray tube is shielded. As an option X-ray tube is controlled by a thermal switch to avoid overheating and to switch the high voltage off in case of a fire.

2.7 Evaluation Unit

The evaluation unit of the PMD 2450 is installed in a suitable wall housing.

The microwave unit supplies the necessary high frequency and is directly connected to the horn antenna via cable. The high frequency connections are provided with HF-sockets which are located on the left side wall of the housing.

The PMD 2450 calculates the measured values, controls the microwave unit and supplies all control and operating voltages required for connection of the scintillation detectors. All inputs and outputs as well as the operating voltage are passed through PG bushings into the wall housing and connected to terminal strips inside the PMD 2450.

The evaluation unit is operated via touch screen.

Results and parameters are displayed on the LC display.

Various displays can be selected with the arrow keys (see chapter 3.2).

All system parameters can be selected and edited menu-guided. Standard parameters are defaulted by the manufacturer, which significantly simplifies system calibration. Unauthorized manipulation of parameters can be prevented by entering a password.

The measured data supplied by a connected scintillation detector, temperature sensor or tachometer are computed together with the microwave data obtained. The natural intensity decrease of the radiation source used is automatically compensated for nuclide-specifically.

The system function is permanently monitored. In case of power failure or if the instrument is turned off, all parameters and the time remain stored.

In its basic version the PMD 2450 is equipped with the following Euro cards:

- SE 0100 CPU
- SE 0006 adapter card with counter – in, analog I/O, digital I/O
- VNA 2750 microwave cassette
- power supply unit

2.8 Horn Antenna

Horn-shaped emitters made of stainless steel are used as microwave antenna. The openings of the horn-shaped emitters are finished dust-tight with a plastic window. The radiation exit windows should be cleaned regularly because dust deposits may distort the results depending on area weight and water content. The antennae do not contain any electronic components; however, they should be protected against mechanical damage.

Transmitting and receiving antenna are of equal design. They are connected to the HF-sockets on the housing.

Figure 4: Horn antenna for microwaves

3. Operation

This chapter of the user guide describes the structure and operation of software. Hereby the structure is explained for the moisture meter PMD 2450. The operation of the functions of the LDU 1000 follows the same structure and rules.

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List of Illustration

3.1 Software Structure

3.1.1 Applications

The software of the LDU 1000 is designed as a modular system. Basically, the following parameters can be measured at two measuring points:

Measuring point 1	Measuring point 2
MW values	
Thermal value	
Ash	Ash
Belt weigher	Belt weigher
Density	Density

By upgrading the hardware by the microwave module VNA 2700 and installation of the necessary software components, the LDU 1000 becomes a PMD 2450, which supports microwave measurements (MW values), e.g. to determine the moisture.

The microwave measurement is available only at measuring point 1.

Microwave measured values

The PMD 2450 is a microwave measuring system determining the phase shift and attenuation by the product being measured according to the principle of transmission. From these two measurable variables one can calculate certain physical measured values, e.g. the water or salt content of a product.

Thermal value

The thermal value is composed of the moisture and the ash content of a product being measured.

Since the moisture content can be measured only at measuring point 1, the thermal value can also be measured at this measuring point only.

Ash

The ash content e.g. of coal is measured radiometrically using an Americium source.

Optionally, the measuring point can be supplemented by an X-ray measuring path.

Belt weigher

The PMD 2450 is capable of measuring the mass flow on a conveyor belt with up to 5 radiometric measuring paths.

Area weight compensation

Compensation of layer thickness and bulk density is carried out via a counter or analog input, depending on the selected compensation method.

In most cases, the radiometric measuring path with Cs-137 is set up.

Temperature compensation

Using a temperature sensor, e.g. a PT100, the bulk good temperature can be determined and taken into account for calculation of the microwave value.

Belt speed

The belt speed is measured by a tachometer, whose pulses are fed into a counter input.

Note

Upon delivery of the instrument, the software components are configured depending on the application. The sensors to be connected are allocated to the inputs, as shown in the wiring diagram.

3.1.2 Measurements and Batch Runs

Often one needs to know the mean value of measured values over a certain time. To this end, so-called batches or batch runs can be performed. The current measured values are averaged and displayed according to the counter-timer method (sum of all measured values divided by the elapsed measuring time).

Batch runs can be started and stopped any time, just like regular measurements, see also chapter 3.5.

A batch run always refers to an entire measuring point, i.e. when starting a batch all measurable variables of a measuring point are averaged.

The current batch and the last batch are displayed in the measurement display, i.e. one sees the value of the current averaging and also the mean value of the previous batch run.

When a batch is stopped, the current batch value is added to the value of the last batch value and the current batch value is reset to 0.

Note
Batch operation is meaningful only with on-going measurement. Therefore, starting a batch while a measurement has been stopped will initiate a measurement start. Accordingly, when a measurement is stopped while a batch is running, the batch is stopped as well.

3.1.3 Hierarchical Menu Guidance

Parameters and service functions are included in a hierarchically structured, clearly arranged user-friendly menu.

This menu is operated by means of softkeys which can be pushed directly on the display. This allows very intuitive user guidance.

Chapter 3.6 contains a detailed description of the main menu with all submenu items.

3.1.4 Control of External PC

The LDU 1000 can be remote-controlled via the serial port of an external PC. A special communication protocol has been defined which is send and received via the specially designed PC program „LDU Communication". Thus, for example, important measurements can be started and stopped via PC. Moreover, all parameters can be set via PC.

The port can either be configured as RS232 or RS485.

For more details on data communication please refer to chapter 3.8.

3.2 General Operation

3.2.1 Display with Touch Panel

The evaluation unit LDU 1000 is operated by means of softkeys which can be pushed directly on the display. This allows very fast and clear user-guidance.

3.2.2 Button Overview

A button is depicted as a rounded black rectangle with a symbol or text printed on it.

If a button is pushed, the position on the touch panel is evaluated and the respective function is triggered.

The „↵" button is needed to go to a selected menu or to edit a parameter.

„**ESC**" button: exit menu, cancel parameter entry.

Note
Entered parameters will be stored only when you return from the menu to the measurement display. Otherwise, the old parameters are still valid when you turn the instrument off and on again.

With the „**Arrow**" keys the cursor bar is moved into the menu and parameters are entered via selection lists.

Push the „**Key**" button to log on to the system before you can make any changes.

To protect the system against unauthorized access, you should log off again by pushing the „**Key**" button before you exit the instrument.

Push the „**Ctrl**" button to open the control menu to start and stop measurements and batch runs.

Push the „**Start**" button to start a certain measurement, and the „**Stop**"-button to stop a measurement.

Push the „**Menu**" button to open the main menu from within the measurement display.

The „**Values**" button opens a submenu and you can view the measured values of a special measurement, e.g. the zeroing.

3.2.3 Input Menu

Text entry

Texts such as password or belt name are entered via alphanumeric keyboard.

Each alphanumeric button contains three characters. Occasionally, one button has to be pushed several times or it has to be kept pushed until the desired letter appears.

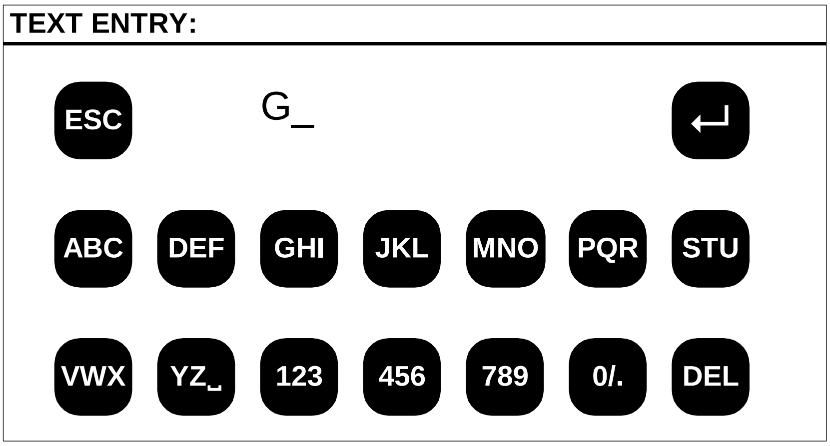

Figure 5: Menu for text entry

About one second after the last button stroke, the flashing cursor bar advances to the next position and you may enter the next character.
Push „**DEL**“ to delete the last character.
Push „**ESC**“ to cancel the entry sequence.
Push „↵“ at the end to confirm entries.

Figure 5 shows the keyboard for input of a password.

Note
When entering the password, the character entered last is replaced by an asterisk after about one second.

Numerical entry

Figure 6 shows the menu for entering numbers.
Push „**DEL**“ to delete the last digit.
Push „**ESC**“ to cancel the entry sequence.
Push „↵“ to confirm the entered number.

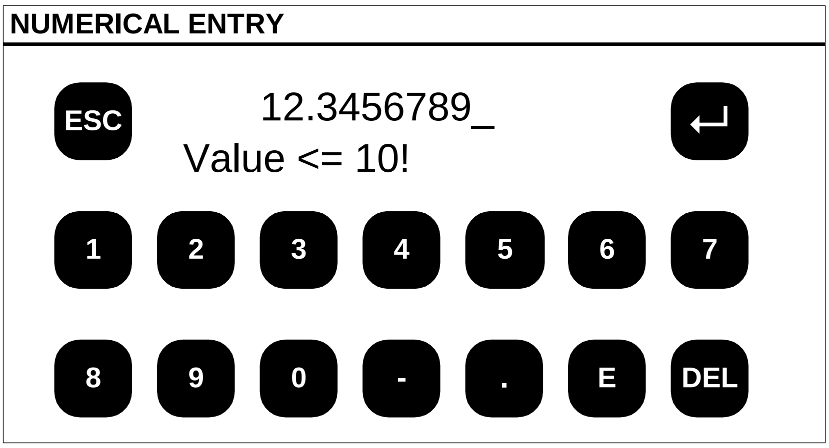

Figure 6: Numerical entry menu

Certain input limits have been defined for each parameter. If the entered value is outside these limits, an error message appears and the value is not accepted.

These input menus are primarily needed for definition of the calibration coefficients, but are also used for other parameters.

Selection lists

Some parameters cannot be set as you like, but can only be set to certain default values which are chosen from selection lists.

Figure 7 shows the selection list for definition of the language. On the left side you see a list of items you may choose (here: German or English), on the right side you see the currently selected item.

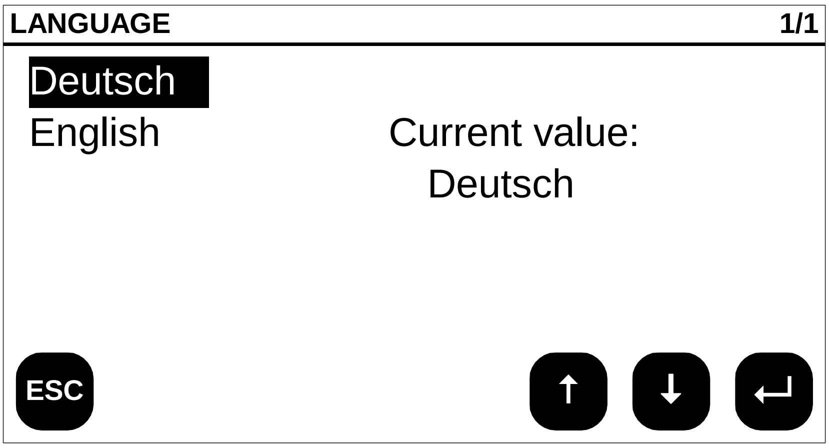

Figure 7: Selection list menu

Push the „**Arrow**“ keys to browse through the selection list and push „↵“ to select the desired item.

Push „**ESC**“ to cancel the selection process.

3.3 Measurement Display

3.3.1 Structure

After power on of the instrument the measurement display is displayed (see Figure 8).

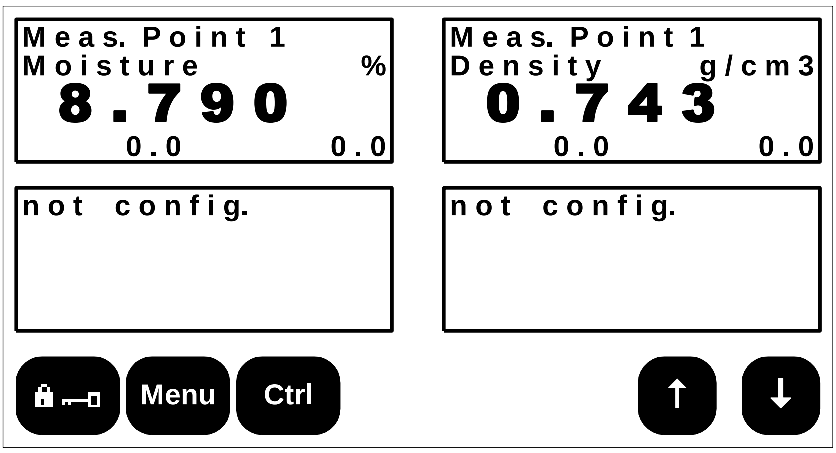

Figure 8: Measurement display

The measurement display shows 4 fields, each displaying the values of one measurable variable. If the instrument is in the logged-on status (see chapter 3.4), you can go to the second page of the measurement display by pushing the „**Arrow**“ key. The second page is structured in the same manner as the first one. In total, the measured values of 8 measurable variables can be displayed, 4 on each page of the measurement display.

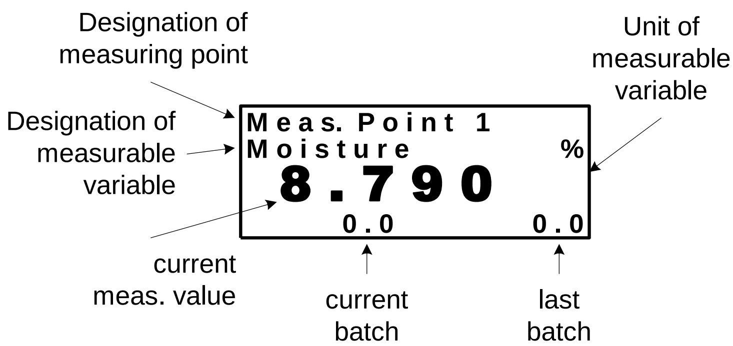

Figure 9: Box displaying the measurable variable

As shown in Figure 9, each field displays the designation of the measuring point, the designation of the measurable variable with the respective unit, the currently measured value as well as the values of the current and last batch.

<u>Note</u>
The displayed unit of the belt weigher t/h (tons per hour) refers here only o the currently measured value. The unit of the batch value is tons.

The configuration of the measurement displays, i.e. the definition which measured value is to be displayed in which field, is described in chapter 3.6.3 (Display).

A measurement starts automatically upon power on of the instrument if at least one counter or analog input has been configured.

See chapter 3.7 for a detailed description of the measurement process.

3.3.2 Buttons

In the logged-off status, only one button is active in the measurement display at first, i.e. the log-on button („**Key**“ button). To have access to various functions, you have to log on to the system first by pushing this button. This process is described in detail in the following chapter.

After you have logged on correctly, you get back to the measurement display.

The instrument is now in the processing mode (see Figure 8). In the bottom line of the display you see next to the „**Key**“ button the „**Menu**“ and „**Ctrl**“ (Control) buttons as well as two „**Arrow**“ keys.

With the „**Key**“ button you can log on again and protect the instrument against unauthorised access. The current function is symbolized by the padlock. An open padlock stands for „log-on“, a closed padlock for „log off“.

Push the „**Menu**“ button to return to the main menu, where all parameters are set and many service functions are available (see chapter 3.6).

Push the „**Ctrl**“ button to open the control menu, where you can start and stop the measurement and the batch for both measuring points, see also chapter 3.5.

With both „**Arrow**“ keys you may move from the first page of the measurement display to the second one (and back).

3.4 Log-on via Password Entry

Protection against unauthorized access

During regular operation, the user interface of the PMD 2450 is locked to protect the instrument against unauthorized access. To have access to the menu, you have to log on to the instrument.

For safety reasons you should log off as soon as you have completed your entries.

If no button is pushed for 15 minutes, the user is automatically logged off by the program.

Four user levels

We distinguish 4 groups or levels of users in ascending order; the lowest group has the fewest, the highest group the most rights in the system. Depending on the selected user level, more or less instrument functions are available.

Each level is protected by a separate password.

These user groups are from bottom to top:

- User (fewest rights)

- Sampler
- Administrator
- Service (most rights)

Log-on process

If the instrument is in the logged-off state, you have to push the „**Key**“ button to go from the measurement display to the user level selection menu.

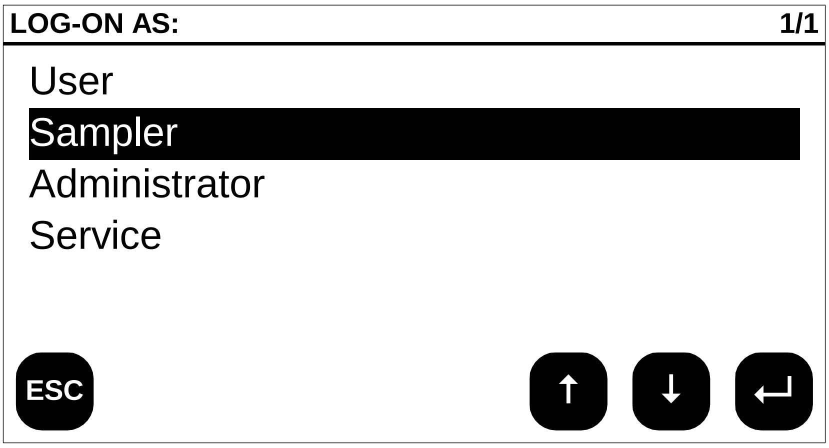

Figure 10: User level selection menu

Select the desired user level with the „**Arrow**“ keys and confirm your selection by pushing the „↵“ button.

An input menu with an alphanumeric keyboard appears (see chapter 3.2.3) and you can enter the password. Each character entered is replaced by an asterisk after about one second.

You have to push the „↵“ button to confirm the password. If your entry is correct, you get back to the measurement display. If not, an error message will be displayed („***Password wrong!***“), the entered character chain is deleted and you can enter the password again.

Push the „**ESC**“ button to cancel the log-on process and you get back to the measurement display.

Default password

All user levels are protected ex factory by the following passwords:

- User = A
- Sampler = D
- Administrator = G

You may change this default setting in the menu ***Parameters → Passwords*** (chapter 3.6.3).

With the function ***Factory setting*** in the ***Service menu*** (chapter 3.6.4) you may reset the passwords again to the above values.

3.5 Control Menu

Push the „**Ctrl**“ button in the measurement display to get to the Control menu to start and stop measurements and batches for both measuring points.

On the left-hand side you see control buttons for measuring point 1, on the right-hand side those for measuring point 2.

Push a „**Start**“ button to start a measurement; the „**Start**“ button turns into a „**Stop**“ button.

On the other hand, a measurement is stopped by pushing a „**Stop**“ button and the „**Start**“ button appears again in place of the „**Stop**“ button.

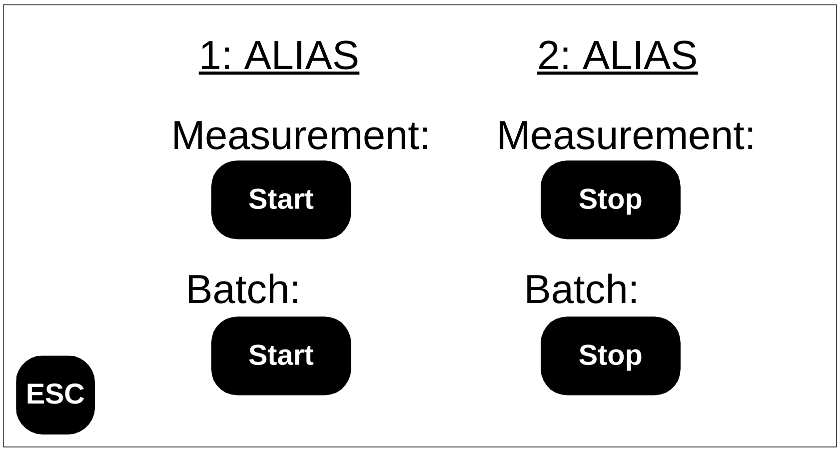

Figure 11: Control menu

Note
Batch mode makes sense only while a measurement is running. Therefore, starting a batch while a measurement is stopped will also start a measurement. Accordingly, when a measurement is stopped while a batch is running, the batch is stopped as well.

Note
If you would like to make entries on a larger scale, it is advisable to stop all measurements in order to speed up the reaction of the display.

The evaluation of microwave data is very time-consuming and may therefore slow down the presentation on the display.

3.6 Menu Guidance

3.6.1 Structure

The PMD 2450 menu is structured hierarchically, i.e. from the main menu you have access to various submenus which in turn provide access to further submenus.

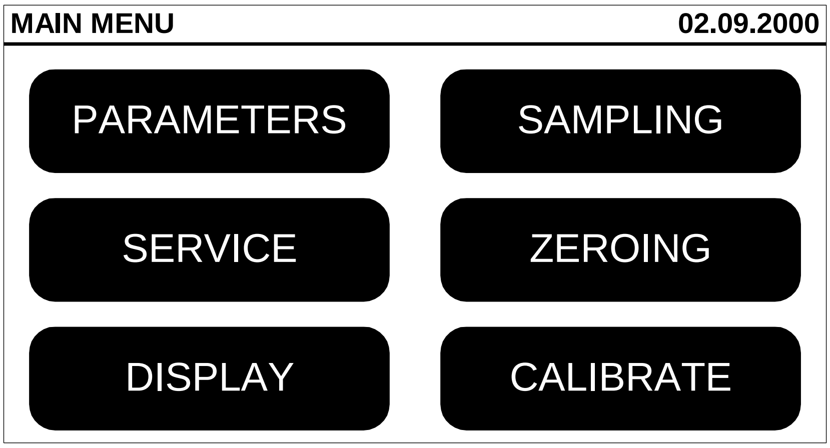

Figure 12: Main menu of PMD 2450

Note
We will describe the menu items which are available to the instrument administrator. Users on a lower level do not have access to some parts of these menus.

Push the „**Menu**“ button in the measurement display to call the main menu (Figure 12). The main menu comprises six submenus:

Parameters

This menu includes important system parameters, for example, parameters for the overall configuration or parameters which define certain hardware properties.

Service

This menu is particularly important during start-up and to identify errors; it includes many hardware test functions and shows intermediate results of the calculated measurable variables.

Display

Push the „Display“ button to return to the measurement display.

Note
All parameters entered will be saved only when you return to the measurement display!

If you turn the instrument off after you have edited parameters and before you have pushed the „Display“ button, the values you have changed will be lost and after power on you will again work with the previously set values.

Sampling

Sampling is important for calculation of the calibration coefficients.

Presently, this calculation is exclusively performed by a PC program; therefore, the „**Sampling**“ button is not yet used.

Zeroing

Separate zeroing is performed for both measuring points to take the influence of the conveyor belt on the measurements into account.

Calibrate

In this menu you enter all calibration parameters determined through sampling.

Moreover, here you may define alarm thresholds for the individual measurable variables.

With the exception of some special items on the Service menu, all submenus have the same structure:

The menu name appears in the left-hand side of the menu header, the current page number and the total number of pages of the menu on the right-hand side.

Below that appear the menu data, i.e. various parameters and / or submenus.

If the menu date is a parameter, the parameter name is left-justified, the value of the parameters right-justified in the same row.

A submenu is also left-justified and is identified by three dots at the end of the name.

The footer includes buttons to scroll through the menu, to open submenus, to enter parameters or to quit the menu.

3.6.2 Buttons

Push any of the large buttons on the main menu to open the respective submenu.

Push the „↲“ button to open further submenus and input menus to edit a parameter.

With the „**Arrow**“ keys you can scroll through individual menu rows.

Pushing the „↓“ key in the bottom menu row will take you to the next the menu page, if the menu comprises several pages. Otherwise you get back to the first menu row.

With the „↑“ key you always jump from the first menu row into the last row on the previous page of the menu.

Push „**ESC**“ to exit a menu or to cancel an entry sequence.

Push the „**Start**“ or „**Stop**“ button to start and stop special measurements, e.g. the zeroing.

Push the „**Values**“ button to open a submenu and to view the data of a special measurement, for example the zeroing.

3.6.3 Parameters

This menu contains important system parameters, for example, parameters for the overall configuration or parameters which define certain hardware properties.

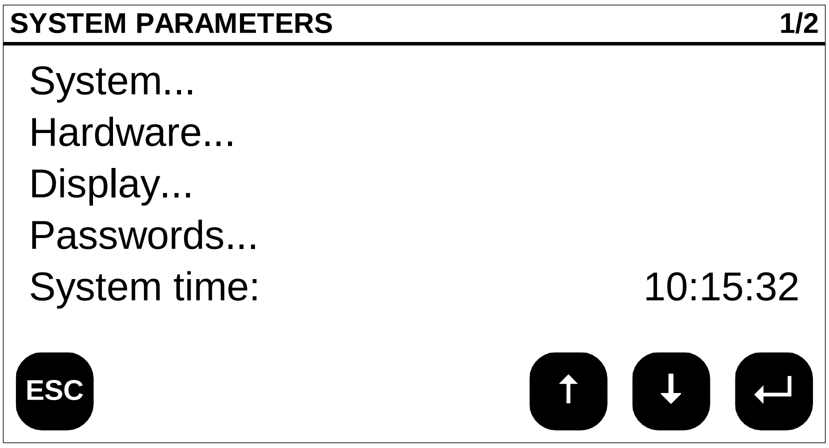

Figure 13: Parameter menu

System

The System menu comprises the following parameters and submenus:

Port Configuration

Allocation of inputs and outputs and serial port configuration.

These functions are accessible to the service engineers only. This menu is not available to all lower user levels.

Virtual Ports

Virtual ports are used to simulate measured value transmitters which are needed for the measurement configuration, but which are not available. For example, a tachometer can be simulated at constant belt speed.

The PMD 2450 can simulate 6 virtual counters, 4 analog inputs and 8 virtual digital inputs.

At the counter and analog inputs you may enter values for the zeroing, in addition to the current values. These are needed to ensure that the software treats the virtual inputs in the same manner as the hardware inputs.

Integration Times

Here you can enter the integration times ***Int2*** for measuring point 1 and measuring point 2 separately. ***Int2*** defines for each measuring point the number of measured values which are included in the averaging.

The moving average calculation over N seconds is valid for all applications of the respective measuring point.

The integration time ***Int1*** (averaging of raw data) which is valid for both measuring points cannot be changed.

Send to PC

The LDU 1000 provides different data telegrams to the PC:

- raw values (as phase shift attenuation, countrates or analog and digital inputs, etc.)
- measuring values (as moisture, ash, density etc.)
- both, raw and measuring values
- frequency response. This telegram transmits the microwave data for each frequency. This telegram is used for start-up and service only and can be received with a terminal program of the PC.

Here you select which telegram is sent by the LDU 1000.

Hardware

In this menu the hardware of the measurement sequence and its components are described in more detail, for example, the belt positions of the respective detectors or the half-life times of the radioactive source.

The measurement geometry, i.e. the distances of the sensors, are defined as follows. The last sensor, viewed in conveying direction, serves as reference point and has the distance „**0**“.

All other distances are measured from this zero point and are indicated in meters.

For all detectors you can define a lower failure threshold which, if it is not reached, triggers a collective failure message and – if configured – is sent to a digital output.

If both measuring points have been configured, first the inputs of measuring point 1 are listed in the respective submenu and then those of measuring point 2.

Counter

The respective tachometer constant has to be entered for the tachometer. Moreover, you can define a failure threshold.

For all other counters you may define the belt position as well as the half-life time of the radioactive source in addition to the failure threshold. If the half-life time is 0, no half-life time correction of the counter pulses takes place.

Analog inputs

Enter the belt position for the analog inputs and define a failure threshold.

Digital inputs

Here you define the delay time of the digital inputs. If this time is unequal to 0, the respective digital input is not immediately evaluated, but only after the time entered here in seconds has elapsed.

Microwave

In addition to the belt position, three special parameters are entered here for the microwave measurement:
The MW mode defines the measurement mode for the microwave. We distinguish between:

- measurement with constant fixed frequency (CW normal),
- measurement at different fixed frequencies (CW-swept) and
- measurement with several frequencies and best fit (sweep).

The CW frequency defines the frequency used for measurement at constant fixed frequency.

The third parameter defines if an internal attenuation element should prevent a too high microwave output. This attenuation element can either always be turned off, always be turned on or turned on or off automatically depending on the attenuation of the product being measured.

Display

The measurement display is configured here.

For each measuring point you can enter a belt name with max. 13 characters via alphanumeric keyboard (see chapter 3.2.3). This belt name then appears in the individual measurement fields instead of the term „***Measuring point 1***“ or „***Measuring point 2***“.

The individual measurement fields are configured via selection list where the number of a measurement field is allocated to a certain measurable variable.
Figure 14 shows the numbering of the measurement field in the measurement display from right to left and from top to bottom: field 1 is in the upper left corner, next to it is field 2, below those fields 3 and 4. Fields 5 – 8 are arranged in the same manner on the second page of the measurement display (push the „**Arrow**“ keys to go this page).

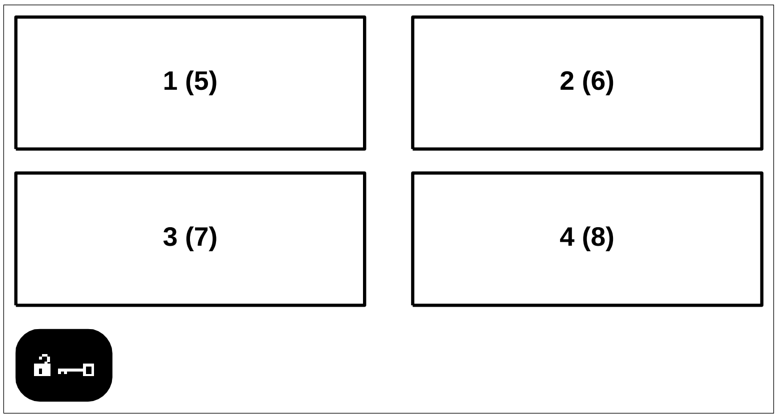

Figure 14: Numbered fields in the measurement display

Passwords

On the „***Passwords***“ menu you may assign new passwords to the various user levels.

The „***User***“ and the „***Sampler***“ can only change their own password. The instrument administrator is entitled to change all passwords.

With the „**Arrow**“ keys, select the user level whose password you want to change and confirm your entry with the „↵“ button. Now enter the new password on the alphanumeric keyboard and confirm it with the „↵“ button. You have to enter the new password a second time and confirm it with „↵“.

Time and date

Enter the system time and the system date.

Push the „↵“ button to open the numerical entry window. Enter the current time or the current date and confirm your entry with the „↵“ button.

The new time is now written into the battery-buffered real-timer clock on the microprocessor insert card. The time is retained even after power off of the instrument and you need not enter it new after every system start.

Language

Select the desired language from a selection list (see chapter 3.2.3).

Presently, German and English are available, with English being the default language.

Program version

Shows the version number of the current software.

The instrument administrator may perform a software update via this menu item. Chapter 3.9 describes the individual steps in detail.

Last parameter change

Shows when the parameters of the measuring system have been changed last.

Note
Date and time of the last parameter change serve only for your information and cannot be changed! They are updated automatically, as soon as a parameter is changed.

3.6.4 Service

The Service menu includes many functions to test the hardware, to display intermediate result when calculating the measured values as well as quality criteria for assessment of the microwave measured values.

Test Hardware

Test of the hardware inputs and outputs of the adapter card SE0006 as well as the microwave cassette.

To test the microwave cassette, the measurement for measuring point 1 has to be running; all other inputs can also be carried out with stopped measurement.

To test the outputs it is advisable to stop the measurements first, so that the manually set values will not be overwritten by the measurement routine.

The „↵“ button is used to set a certain value for the outputs; on the other hand, it is without function for the inputs.

Test Microwave

The attenuation D and the phase shift phi ($0° \leq phi \leq 360°$) of the measured microwave radiation is displayed while a measurement is running.
The correction factor n is important for calculation of the correct phase shift, which may be larger than 360° and which is calculated according to $phi_{corr} = n * 360° + phi$.
Delta phi finally indicates the difference between the measured phase shift and a phase shift calculated according to plausibility criteria.

Test Counter Inputs

Here you see the count rates of the 6 counter inputs, measured in cps.

Test Analog Inputs

Values of both current inputs in mA.

Test Digital inputs

Shows the logical states (0 / 1) of the 8 digital inputs.

Test Analog Outputs

With the „↵“ button you can set the 4 current outputs each to a value between 0 mA and 20 mA. The current is then set accordingly and can be measured using an Ampere meter.

Test Digital Outputs

Set / Reset the 4 digital outputs with the „↵“ button and measure the set values again using a Voltmeter.

Note

The digital outputs are wired such that relays connected to it pick up in the normal state and are released in case of alarm. For this reason, a voltage of 5 V is applied at the logical 0, 0 V at the logical 1.

View All Inputs

In this menu all values of the hardware inputs averaged over the integration time ***Int2*** are displayed.

If a measurement is running, these values are updated each second.

VIEW ALL INPUTS

Microwave		Counters		Dig In	
Att :	0.016	1 :	0.0	1 :	1
Phi :	-1.713	2 :	0.0	2 :	1
		3 :	0.0	3 :	1
		4 :	0.0	4 :	1
Analog In		5 :	0.0	5 :	1
		6 :	0.0	6 :	1
1 :	0.0			7:	1
2 :	0.0			8:	1

ESC

Figure 15: View all inputs menu

Calculation Steps

Intermediate results for calculation of the measurable variables are displayed in this menu.
The results for each measuring point are display in a separate submenu. Both submenus basically have the same structure. Below, only the submenu of measuring point 1 will be discussed.
The software supports all applications.
However, if not all applications have been implemented, the respective submenus are missing.

Tacho

Displays the current belt speed [m/s] calculated according to
Tacho constant * count rate.
If no tachometer is available, the respective row shows the info „Tacho not configured".

Area weight

Current area weight determined either radiometrically or by an analog sensor.

Microwave data

VIEW MICROWAVE DATA

Att	: 0.016	Phi-check :	0.0
Phi	: -1.713		
		n :	0
m	: 1.000	Delta Phi :	-5.590
Att/m	: -0.014	Chi-Sq :	0.0
Phi/m	: -2.034	Offset :	0.0
MW1	: -2.070		
MW2	: -0.011		

ESC

Figure 16: View Microwave data menu

On the left-hand side you see various intermediate values, on the right-hand side several assessment criteria for the measured values.

Where:

Att: ***Int2***-averaged attenuation corrected by zeroing

Phi: ***Int2***-averaged phase shift corrected by zeroing

m: ***Int2***-averaged area weight

Att/m: Attenuation standardized with respect to the area weight

Phi/m: Phase shift standardized with respect to the area weight

MW1: Microwave value 1 determined with coefficient set 1

MW2: Microwave value 1 determined with coefficient set 2

Phi-check: Phase shift calculated according to plausibility criteria

n: Correction factor indicating the number of 360° shifts of the phase

Delta Phi: Difference of measured phase shift to Phi-check.

Chi-Sq: Only in sweep mode:
Square of fit error Chi at best fit due to the phase values measured at 10 different frequencies

Offset: Only in sweep mode:
Phase shift determined according to the best fit at frequency 0Hz.

Ash data

This menu shows the most important intermediate values for calculation of the ash content.

VIEW ASH DATA MP1

Raw data		ln(I/Io)		Factors	
Am :	0.0	Am :	0.0	Q1 :	0.0
X :	---	X :	---	Q2 :	0.0
				Q3 :	0.0
m :	0.0				
		Ash:	0.0		

ESC

Figure 17: View Ash Data menu

The signal flow occurs from left to right:
The left column lists the raw data, i.e. the count rates of the Americium source (Am) and the X-ray rube (X) averaged over the integration time ***Int2*** as well as the area weight m averaged over ***Int2***.
The averaged count rates serve only for your information and do not enter directly into the calculation formula.
The center column shows the natural logarithms averaged over ***Int2*** of the count rates referring to the zeroing, i.e.
ln(I/Io)Am and $\ln(I/Io)_X$.
In the right column, finally, the values of the center column are standardized with respect to the area weight, i.e.:
$Q1 = \ln(I/Io)_{Am} / m$

$Q2 = \ln(I/Io)_X \;/ m$
$Q3 = [\ln(I/Io)_X]^2 / m$
The factors Q1 – Q3 are inserted in the calculation formula for the ash content. The ash content calculated according to this formula appears at the bottom of this page.

Belt weigher data

Figure 18 shows the menu for the belt weigher calculation.

VIEW BELT WEIGHER MP1							
Raw data			ln(I/Io)				
1	:	0.0	1	:	0.0	Average:	
2	:	---	2	:	---		0.0
3	:	---	3	:	---	Tacho:	
4	:	---	4	:	---		0.0
5	:	---	5	:	---		
			Belt w.:		0.0		
ESC							

Figure 18: View Belt weigher data menu

Up to 5 measuring paths can be installed vertically to the belt moving direction to ensure fairly accurate calculation of the throughput.

As with the ash data, the signal flow occurs from left to right.
In the left column appear the count rates of the belt weigher counters 1 – 5 averaged over ***Int2***.
However, these values serve only for your information and do not enter directly into the calculation of the throughput.
The center column shows the natural logarithms averaged over ***Int2*** of the count rates referring to the zero rate, i.e.
$\ln(I/Io)_{\text{counter 1}}$ to $\ln(I/Io)_{\text{counter 5}}$.
To the very right you see the mean value of the data in the center column. This value is inserted into the calculation formula to calculate the throughput. Moreover, the belt speed averaged over ***Int2*** appears in this column.

At the bottom of this page you see the throughput calculated on the basis of the above data.

Set Factory Defaults

All instrument parameters are reset to their default settings.

Caution

Factory setting should be selected only in exceptional cases, because all parameters differing from the factory setting have to be entered new!

Moreover, all calibration and zeroing data will be lost!

It is therefore advisable to send all parameters to the PC via the serial port, before selecting factory setting, in order to be able to enter certain parameter groups again quickly. At least the hardware calibration should be put into intermediate storage on the PC, because these calibrations can only be carried out new by service engineers!

Note

You may reset the instrument to the factory setting at system start by pushing the upper left corner of the display while turning on the instrument.

3.6.5 Sampling

Sampling is possible by means of a PC program and is not implemented in the PMD 2450.

3.6.6 Zeroing

Zero measurements are performed in this menu – separately for both measuring points. Therefore, we will only describe zeroing of measuring point 1, zeroing for measuring point 2 is done in the same manner.

In addition, this menu includes the basic microwave-calibration (provided the software supports the microwave application).

MW Basic Calibration

Basic calibration is necessary for all following microwave measurements. Therefore, it has to be performed and stored before the zero measurement. Any zero measurement of the microwave which may have been carried out earlier will be deleted and has to be repeated after basic microwave calibration!

Basic calibration is always performed with empty belt, just like the zero measurement!

This measurement is independent of the microwave measurement mode and, therefore, it need not be repeated after a change-over, for example, from CW-normal to sweep.

To perform basic calibration, call the respective submenu and push the „**Start**“ button. The measurement takes only one second and is automatically terminated. The attenuations and phase shifts for all 10 adjustable frequencies are displayed in a result menu.

You can repeat the measurement by pushing the „**Start**“ button again.

Save the values at the end by pushing the „**Save**“ button or push the „**ESC**“ button to discard the measured values.

Push the „**Values**“ button to view stored measured values of the last basic calibration.

Zero measurement

Zero measurement is necessary to take influences of the conveyor belt on the measurement into account. Therefore, it always has to be performed without the product being measured, i.e. with empty belt.

Zero measurement is performed separately for both measuring points. Thus, it is possible, for example, to continue regular measurements at one of the measuring points, while a zero measurement is running at the other measuring point.

To perform a zero measurement, select the respective measuring point on the Zeroing menu and confirm your choice by pushing the „↵“ button. You will get to a submenu, where you can enable or disable the individual inputs which are to be selected with the „**Arrow**“ key and the „↵“ button. Selected inputs are identified by a checkmark (**x**). Only these inputs are zeroed after the start.

Which inputs are to be displayed in this menu is dependent on the applications supported by the software. In individual cases, the menu contents may therefore differ from the one depicted in Figure 19.

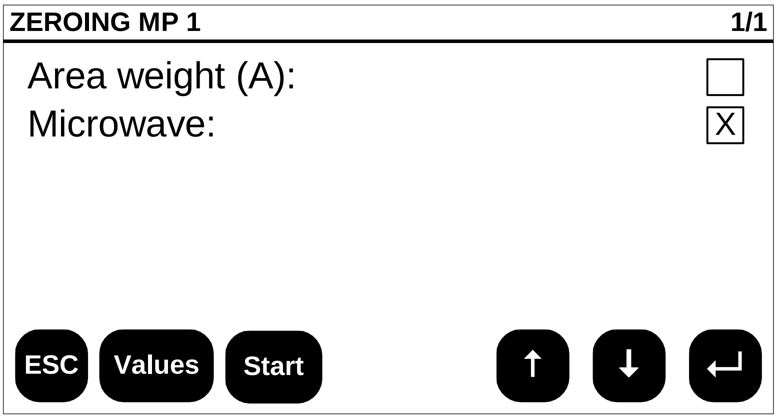

Figure 19: Zeroing menu

After you have selected all inputs which are to be zeroed, push the „**Start**“ button to start the zero measurement. The individual inputs will now be listed in a result menu; the zero value stored last and below it the current zero value is displayed for each input. The current zero value is averaged according to the counter-timer method (sum of all measured values divided by the elapsed measurement time) and updated each second.

If more than two inputs are zeroed at the same time, the result menu covers several pages; with the „**Arrow**“ keys you can go to the various pages.

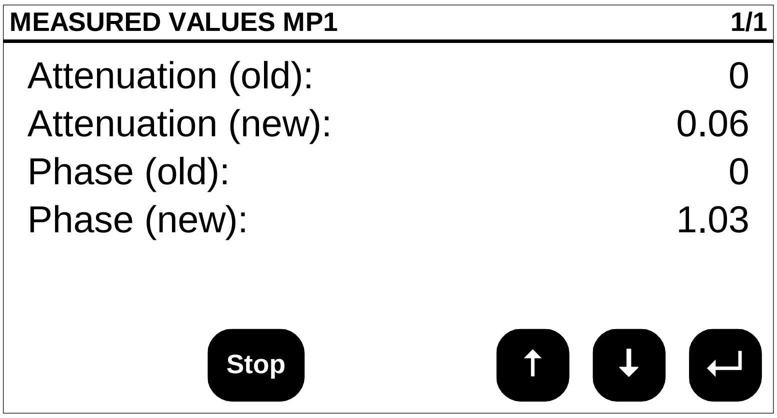

Figure 20: Measurement display of zero measurement

Push the „**Stop**“ button to stop the zero measurement. Push the „**Start**“ button again to repeat the measurement.

Push the „Save“ button to save the measured values as zero values. Not only the zero value is stored for each input, but also the current date. This is important for half-life time correction of the counter.

However, push „**ESC**“ to exit the menu if you want to discard the measured values.

Push the „**Values**“ button (see Figure 19) to view the stored zero values and the date of the zero measurement any time.

If you know the zero values – e.g. from comparative measurements – you may also enter them here manually. To do this, select the respective zero value with the „**Arrow**“ keys. Then push the „↵“ button to open the Numerical entry menu and type in the desired zero value.

If you exit the Numerical entry menu by pushing the „↵“ button, the entered value is accepted and the date of the zero measurement of the respective input is set to the current date.

Note

The zero measurement of the microwave is dependent on its measurement mode and, therefore, it has to be performed in the same mode as the later measurement. If you want to change the microwave measurement mode later, you, therefore, have to repeat the zero measurement.

3.6.7 Calibrate

Coefficients for calculation of the measurable variables are entered and different alarm limits are defined on the Calibrate menu.

The menu is divided into a submenu for measuring point 1 and one for measuring point 2. These submenus have an identical structure, apart from the fact that there are no microwave parameters for measuring point 2. Below we will therefore only describe the submenu for measuring point 1.

MW phase calculation

Here you enter the coefficients for calculation of the corrected phase shift regarding the multiple of 360°. If the measurerd phase shift is standardized on the frequency, a 360° jump is displayed as a jump of about 133°/GHz in the calculation steps submenu of the Service menu.

Coefficients

4 values must be entered to calculate Phi_{check} from attenuation and area weight:

- k1: slope of attenuation
- k2: slope of area weight

- k3: offset
- x: this value is normally 0

The measured phase shift phi is then shifted by a multiple of 360°, so that:
$phi_{check} - 180° \leq phi \leq phi_{check} + 180°$.
These coefficients are usually determined only during start up. Therefore, details to find the proper values for k1, k2 and k3 are given in chapter 4: Getting started.

Parameters

Delta Phi (max) indicates the largest permitted difference between the corrected phase shift phi and the calculated phase phi_{check}. Delta Phi (max) may be max. 180°.
If the measured difference Delta Phi is larger than Delta Phi (max), the measured value is discarded and the last valid measured value is used for calculation of the measurable variables.
In the sweep mode a best fit is drawn through the phase values measured at 10 different frequencies. Quality criteria of this best fit are the square of the fit error Chi-Sq and the so-called offset, which indicates the phase shift at the frequency 0 Hz determined according to the best fit.
Chi-square (max) and Offset (max) each indicate the largest value permitted for these quality criteria.
If the measured fit error or the offset are greater than the maximum value entered here, the microwave value is rejected and the last valid measured value is used for calculation of the measurable variables.

Calibration parameters

Here you enter the coefficients for calculation of the measurable variables. Most of these coefficients are the result of sampling.

Analog inputs

The ***type*** defines if the input is a 0-20 mA input, or a 4-20 mA input or an input for temperature measurement using a PT100.

The value at the bottom is the measured value, corresponding to the smallest current value: with 0-20 mA input to the value at 0 mA, with 4-20 mA input to the value at 4 mA.
The value at the top corresponds to the measured value at 20 mA.
If it is a PT100 input, the value at the bottom and the value the top have no meaning.
The number of the analog input is also displayed for you information, but this number cannot be changed here.

Analog outputs

The type determines the current range of all four analog outputs. You may select the ranges 0-20 mA and 4-20 mA.
The value in case of error defines the behavior of the analog outputs: either the outputs keep their last valid value before the error has occurred or they are set to the smallest value permitted (depending on the type, 0 mA or 4 mA).
An error always exists if a hardware input fails or a belt alarm (including belt standstill or minimum load) occurs at one of both measuring points.
Again, a bottom value and a top value are defined here, each indicating the value at the smallest output current permitted (0 mA / 4 mA) and the value at 20 mA.
The number of the analog input is also displayed for you information, but this number cannot be changed here.

Area weight

You need three coefficients (A – C) to calculate the area weight.
The last one (C) is a constant.

Measurement value = X1

A = Gradient $X1^2$

B = Gradient X

C = Offset

Calorific value

The Calorific value is a Combination of Ash and Moisture content. Sampling provides four

coefficients (A – D) for calculation.
The last one (D) is a constant.

A = Gradient Ash

B = Gradient Moisture

C = Ash ∗ Moisture

D = Offset

Ash

The ash content is calculated using a formula with nine coefficients (A – I); coefficient I is a constant.
At measuring point 1 the water content of the product being measured can be taken into account as well. To do this, enter the moisture content determined during sampling under mean value moisture.

A = Gradient Americium

B = Gradient X-Ray tube

C = Gradient X-Ray tube square

D = Load correction

E = Moisture compensation

F = Moisture compensation X-Ray

G = Moisture compensation X-Ray

H = Moisture compensation Load correction

I = Offset

Moisture

The moisture content is calculated using a formula with eight coefficients (A – H); coefficient H is a constant.

A = Gradient Attenuation

B = Gradient Phase shift

C = Load correction

D = Temperature compensation Attenuation

E = Temperature compensation Phase shift

F = Ash kompensation Attenuation

G = Ash compensation Phase shift

H = Offset

Density

The density content is calculated using a formula with three coefficients (A – C); coefficient C is a constant.

A = Gradient material layer

B = Gradient material layer square

C = Offset

Material layer thickness

The material layer thickness is calculated using a formula with three coefficients (A – C); coefficient C is a constant. The calculation is based on the difference of the reading from the belt weighter in relation to a zero measurement.

Temperature compensation

The temperature compensation is calculated using a formula with three coefficients (A – C); coefficient C is a constant.

Measurement value = X1

A = Gradient Temperature

B = Gradient Temperature square

C = Offset

Belt weigher

The formula for calculation of the throughput has three coefficients (A – C), the last one being a constant.

Potash content

You need four coefficients (A – D) to calculate

the potassium content.
Coefficient D is a constant.

MW-Value 1 and 2

From the microwave raw data attenuation and phase one can determine different measurable variables, such as moisture content, pH-value, salt content and others.

Under MW measured value you may therefore select from a list which physical variables are to be calculated with the following coefficients. This name then appears in the measurement display instead of the term „MW-value“.
There are eight coefficients (A – H) for calculation of the desired microwave value; coefficient H is a constant.

For compensation of the material temperature as well as for ash compensation, enter the value determined during sampling under mean value material temperature or mean value ash.

Alarm Meas. Values

Here you can define a lower and upper alarm threshold for each measurable variable. In this manner you may set a window for each measurable variable, within which the measured value should lie.

Moreover, you may enter a switching hysteresis in % for each measurable variable.

The lower alarm will be reset only when the measured value exceeds the value

(1 + hysteresis[%] / 100) * $limit_{low}$.

Accordingly, the upper alarm is reset only when the measured value drops below the value

(1 - hysteresis[%] / 100) * $limit_{high}$.

A digital output can be assigned to each alarm. These outputs are wired such that a relay connected to them picks up during operation and is released if an alarm is triggered.

Alarm Belt

A belt alarm occurs if either the minimum load or the minimum speed of the belt is not reached.

In this menu you can define a minimum load as well as a minimum speed.

Again, there is also a switching hysteresis, so that the belt alarm will be reset only when the value

(1 + hysteresis [%] / 100) * $\text{limit}_{\text{low}}$ is exceeded.

With active belt alarm, the measurement continues to run; however, averaging over the ***Int2***-time is stopped and continues only after the belt alarm is over. Therefore, the measured value does not change during belt alarm.

Following a belt alarm, the ***Int2***-averaging does not start new, but continues regularly, as if averaging has never been interrupted.

Example

The ***Int2***-time is 10 seconds.

In the first second after the end of the belt alarm the last 9 values before the alarm has been triggered and the first value after the end of the alarm are used for averaging.

3.7 Measurement Process

3.7.1 Start and Stop of Measurements and Batch Runs

Push the „**Ctrl**“ button in the measurement display to get to the control menu where you can start and stop measurements and batches for both measuring points.

On the left-hand side you see the control buttons for measuring point 1, on the right-hand side those for measuring point 2.

Push the respective „**Start**“ button to start a measurement; the „**Start**“ button turns into a „**Stop**“ button.

On the other hand, push a „**Stop**“ button to stop a measurement; the „**Start**“ button appears again in place of the „**Stop**“ button.

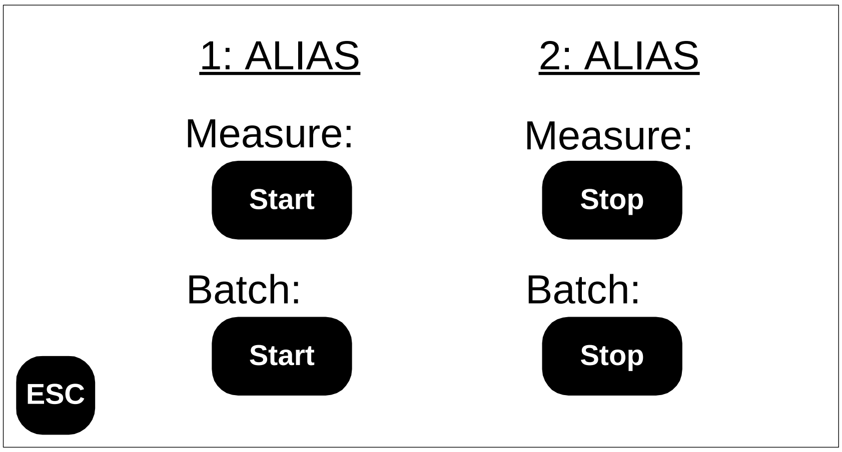

Figure 21: Control menu

Note
Batch mode makes sense only during on-going measurement. Therefore, starting a batch while a measurement is stopped will also start a measurement. Accordingly, when a measurement is stopped while a batch is running, the batch is stopped as well.

Note
If you would like to make entries on a larger scale, it is advisable to stop all measurements in order to increase the reaction of the display.

Evaluation of the microwave data is very time-consuming and may therefore slow down the presentation on the display.

3.7.2 Regular Measurement Process

The measurement process is the same for both measuring points, except that no microwave evaluation is available for measuring point 2. Below we will therefore only describe measurement process for measuring point 1.

Readout of hardware inputs

All hardware inputs of the instrument are read out every 250 ms and saved for later averaging.

A special feature is the microwave measurement at measuring point 1:

If switching of the internal attenuation element is dependent on the attenuation of the product being measured, it will be examined prior to each microwave measurement if the attenuation element should be turned on or off for the following measurement.

In the CW mode a measurement is performed every 250 ms. In the normal CW mode one always measures using the same frequency, in the swept CW-mode, however, the frequency changes with each measurement.

In the sweep mode 10 measurements at 10 different frequencies are performed once per second, the measured attenuations are averaged and the search for phase shift is determined by a best fit.

Processing raw data

Before processing the raw data any further, the zero measurement is subtracted first or, in the case of counters, standardized with respect to the zero measurement.

If a tachometer has been configured, the raw data are now correlated, i.e. the belt distance between the individual measuring stations is taken into account.

The data processed in this manner is then averaged over the ***Int2***-time, i.e. the mean value of the last ***Int2*** values is calculated.

Calculating measurable variables

The individual measurable variables are now calculated using the ***Int2***-averaged raw data.

If a batch is running in addition to the measurement, the calculated measurable variables for the batch value are averaged accordingly.

Sending a data telegram

A data telegram including the current measured values is sent to an external PC every second.

In the menu ***Parameters → System*** (see chapter 3.6.3) you can define if the instrument should send measured raw data or calculated measured data to the PC.

Setting hardware outputs

After calculation of the measured data, the alarm thresholds are checked and the digital outputs are set accordingly.

Moreover, the configured current outputs of the measured values are set accordingly.

3.7.3 Error and Alarm States

This chapter briefly describes how the instrument behaves if errors and active alarms occur.

Hardware failure

Hardware failure occurs when a measured raw value falls below the failure threshold of the respective hardware input.

In this case a collective failure message may be generated and output as error to a digital output.

Measurements continue to run, however, until they are stopped manually.

Alarm of measurable variable

A lower and upper alarm threshold defining a measurement display can be entered for each measurable variable. If the measured value is outside this permitted range, an alarm is triggered which can be sent to a digital output.

Belt alarm

A belt alarm occurs if either the minimum load or the minimum speed of the belt is not reached.

As with the alarm thresholds of the measurable variables, there is also a switching hysteresis, so that the belt alarm will be reset only when the value

$(1 + \text{hysteresis [\%]} / 100) * \text{limit}_{low}$ is exceeded.

With active belt alarm, the measurement continues to run; however, averaging over the ***Int2***-time is stopped and continues only after the belt alarm is over. Therefore, the measured value does not change during belt alarm.

Following a belt alarm, the ***Int2***-averaging does not start new, but continues regularly, as if averaging has never been interrupted.

<u>Example</u>

The ***Int2***-time is 10 seconds.

In the first second after the end of the belt alarm the last 9 values before the alarm has been triggered and the first value after the end of the alarm are used for averaging.

3.8 Data Communication

3.8.1 Overview

The measuring system PMD 2450 supports communication with a PC via the RS232 / RS485 port and thus allows remote control of the measuring system. To this end, a special PC program has been designed to retrieve and edit parameters and send them again to the PMD 2450. Moreover, measurements can be started and stopped from the PC.

The serial port parameters are set in the menu ***Parameters → System → Port Configuration → Serial Port***. However, this menu is accessible only to service engineers.

The hardware has to be adapted to the configuration accordingly:

RS 232 Setup

- Jumper J1 on circuit board SE 0008 has to be set to open
- Screened, 5 wire cable, max. 30 m long

RS 485 Setup

- Jumper J1 on circuit board SE 0008 has to be set to closed
- Screened, twisted cable
- Terminate both ends with 120 Ohm each (close J2 on circuit board SE 0008, do not forget terminating resistor on PC side).

3.8.2 Telegram Types

Special data strings have been defined for data communication between PMD 2450 and external PC to transfer parameters or to send commands to the PMD 2450.

These telegrams are divided into the following four groups:

Communication

The communication telegram can be sent in both directions: the PC sends commands to the PMD 2450 via this telegram, the PMD 2450 sends its answer to the PC.

Command telegram

The PC can request all other telegrams individually via the communication telegram and thus send all parameters of the system to the PC.
Moreover, measurement, batch run and zero measurement can be started and stopped separately for both measuring points.

Answer telegram

The PMD 2450 sends the communication telegram as an answer to telegrams received, which otherwise do not expect any further data string. The answer telegram is sent when a measurement has been started or stopped from the PC or if parameters have been set via a telegram from the PC.
In this manner, you can check from the PC if a command has really been executed or parameters have been received correctly.

Command and answer telegrams basically have the same structure; for example, the command to start measurement at measuring point 1 and the answer that measurement at measuring point 1 has been started are identical.

System

The system parameters group comprises three telegrams which define the hardware parameters as well as the system configuration.

Each of these telegrams can be sent in both directions.

PMD 2450 hardware

Hardware calibration analog inputs
Hardware calibration analog outputs
Isolation measurement of the microwave
Attenuation and phase of internal attenuation element

Configuration

System date and time
Send raw or measured data each second?
Port assignment of counter inputs
Port assignment of analog inputs
Port assignment of analog outputs
Port assignment of digital inputs
Port assignment of digital outputs
Averaging times Int 1 and Int 2
Microwave measurement mode
Microwave fixed frequency
Execute phase check (with phi_{check})?
Delay times of digital inputs
Configuration of measurement display
Language

Peripherals hardware

Tacho constants for both measuring points
Belt positions
Fail thresholds
Half-life times
Attenuation and phase of basic microwave calibration
Zero microwave measurement
Zero measurement (value / date) of real counters
Zero measurement and measured value of virtual counters
Zero measurement (value / date) of real analog inputs
Zero measurement and measured value of virtual analog inputs
Values of virtual digital inputs

Calibration

The telegrams *Coefficients* and *Thresholds* are

summarized under Calibrate.
Both telegrams can be sent from the PMD 2450 to the PC and vice versa.

Coefficients

Calibration of analog inputs
Calibration of analog outputs
Parameters for phi_{check}
Parameters for area weight of measuring point 1
Parameters for microwave value 1
Parameters for microwave value 2
Parameters for ash of measuring point 1
Parameters for belt weigher of measuring point 1
Parameters for density of measuring point 1
Parameters for thermal value of measuring point 1
Parameters for area weight of measuring point 2
Parameters for ash of measuring point 2
Parameters for belt weigher of measuring point 2
Parameters density of measuring point 2

Thresholds

Speed of measuring point 1, lower alarm threshold and hysteresis
Area weight of measuring point 1, lower alarm threshold and hysteresis
Microwave value 1, lower and upper alarm threshold as well as hysteresis
Microwave value 2, lower and upper alarm threshold as well as hysteresis
Ash of measuring point 1, lower and upper alarm threshold as well as hysteresis
Belt weigher of measuring point 1 lower and upper alarm threshold as well as hysteresis
Density of measuring point 1, lower and upper alarm threshold as well as hysteresis
Thermal value of measuring point 1, lower and upper alarm threshold as well as hysteresis
Speed of measuring point 2, lower alarm threshold and hysteresis
Area weight of measuring point 2, lower alarm threshold and hysteresis
Ash of measuring point 2, lower and upper alarm threshold as well as hysteresis
Belt weigher of measuring point 2 lower and upper alarm threshold as well as hysteresis
Density of measuring point 2, lower and upper alarm threshold as well as hysteresis

Data

There are a total of three data telegrams; raw data and measured data telegram can only be sent by the PMD 2450, the telegram with the values of the analog output only by the PC.

Raw data

Values of real and virtual counter
Values of real and virtual analog inputs
Values of real and virtual digital inputs
Attenuation and phase of the microwave
Phase offset of best fit (in the sweep mode)
Fit error Chi-Sq of best fit (in the sweep mode)
Delta phi
Correction factor n
Temperature of PT100
Area weight of measuring point 1
Area weight of measuring point 2

Measured data

Microwave value 1, Current measured value as well as current and last batch value
Microwave value 2, Current measured value as well as current and last batch value
Ash of measuring point 1, Current measured value as well as current and last batch value
Belt weigher of measuring point 1, Current measured value as well as current and last batch value
Density of measuring point 1, Current measured value as well as current and last batch value
Thermal value of measuring point 1, Current measured value as well as current and last batch value
Ash of measuring point 2, Current measured value as well as current and last batch value
Belt weigher of measuring point 2, Current measured value as well as current and last batch value
Density of measuring point 2, Current measured value as well as current and last batch value

Frequency response

The content if the telegram is:

telegram adress
telegram adress
frequeny [Mhz]
attenuation [dB]
attenuation*f(x)
Phi [°/Ghz]
PhiCheck [°/GHz]
Delta (Phi-PhiCheck) [°]
area weight

Analog outputs

This telegram allows you to set the analog output directly from the PC.

However, this is allowed only if the analog output is not used by the measurement routine!

Value of analog output 1
Value of analog output 2
Value of analog output 3
Value of analog output 4

3.9 Software Update

A software update of the PMD 2450 can easily be performed by a service engineer.

The required tools as well as the individual steps are described in detail below.

Tools

- PC with free serial port (e.g. COM1) and Windows operating system
- Normal zero modem cable,
  each TxD and RxD or RTS and CTS crossed
- Terminal program to send the new software to the instrument
- We recommend using the terminal program TeraTerm (TTerm), because transfer is much faster with this program than with the Windows hyper terminal program
- New program version Vx_x.hex (e.g. V2_5.hex)

Preparation

- All system and the calibration parameter telegrams have to be sent to the PC and should be saved temporarily, since the parameters contained therein may get lost during update
- An update always has to be performed in the RS232 mode. If a RS485 line is being used normally, open jumper J1 on circuit board SE 0008 and replace the twisted two-wire connection cable to the PC by a 5-wire data cable (zero modem cable)
- Now start the terminal program ***ttermpro.exe*** (or another one) and check the following settings (in ***Tera-Term*** in ***Setup menu → Serial Port***)

Port:	COM1 (or correspondingly)
Baud rate:	9600
Data:	8
Parity:	none
Stop:	1 bit
Flow control:	Hardware

- In the ***Parameters*** submenu of the PMD 2450, select the item ***Program version*** and confirm with the „↵“-button. Answer the prompt that comes up with „***Yes***“ and then confirm it once more.
  Now call the boot program (Boot loader), which deletes the current program and then prompts you to send the new program.

Note
The boot program can also be started directly at system start. To do this, push the upper right corner of the LCD display during power on.

Start transfer

Select the menu item ***File → Send File*** in the ***TeraTerm*** program (or in another terminal program)
Search for the file with the new program version ***Vx_x.hex*** (e.g. ***V2_5.hex***) and select this file by double-clicking on it.
Now starts the transfer of the new programs.

During transfer, dots are depicted in the ***TeraTerm*** program window and „***Downloading***“ appears on the PMD 2450 display.

The transfer takes about 7 – 10 minutes. (Please do not move the window of the terminal program during this time).

Then the new program is started immediately.

Parameter transfer

Parameters may get lost during program update. Please check during the first system start immediately following the update if the parameters have been loaded correctly. In case of error, the following message is displayed:

```
Loading Parameters...       ERROR

Cannot load Parameters!
Restarting for Defaults!
```

In this case, all parameters are set to the default setting.
To restore the original configuration again, send all system and calibration parameter telegrams from the PC to the PMD 2450.

4. Getting Started

This chapter describes how to take the PMD 2450 into service.

Start-up always has to be performed by a service engineer, since some submenus and parameters are accessible only to the highest user level.

Overview

4.1 Assembly

4.1.1 Microwave Horn Antenna

The horn antennas are fixed at the measuring frame rectangular to the material with the supplied mounting adapters. The two antennas must be in line, but the beam of the antennas is so wide, that a fine-adjustment is not necessary.

4.1.2 Sources

The shielding container are supplied filled with the ordered sources. The shieldings are fixed at the mounting frame with the supplied fixing adapters at the provided places. (See figure 1: Principle of measurement.) The sources are locked when supplied, i.e. the useful beam is blocked. The source is allowed to open only in coordination with the radiation protection officer. The useful beam is strongly collimated, typical 5°. Therefore it is necessary, that the detector is adjusted on the beam. (see the chapter Detector).

4.1.3 Detector

The szintillation detector has to be mounted with the supplied fixing adapter to the mounting frame at the provided place. (see Fig.1: Principle of measurement) The adapter has slotted holes and is adjustable in x- and y-direction. A fine adjustment is necessary because of the narrow collimated useful beam (typical 5°). The fine-adjustment is done with opened shielding. This work is therefore to be done during start up by trained personal only in cooperation with the radiation protection officer. The adjustment is to be done with a hand held radiation detector. The adjustment is fine, if at all sides of the detector window the same radiation level is detected. Then the center of the beam is exactly adjusted to the detector.

4.1.4 Analog Sensors

Sensors with analog 0/4-20 mA outputs are optionally used according the customer specific installation. The LDU 1000 provides 2 analog inputs. One of them can alternatively configured to connect directly a PT 100 temperature sensor. Contactless temperature measurements are performed with infrared temperature sensors. Optical, laser or ultrasonic distance sensors are used for distance measurements. The area weight can be determined by a belt scale as an alternative to the nuclear method.

4.1.5 Digital Switches

Digital switches can be options of the supplied system, e.g. the sampling switch or supplied by the customer and are possibly installed far away from the installation point, e.g. a set of switched for the type selection, which is installed in the control room. In general, the digital inputs of the LDU 1000 are controlled by potential free contacts. They can be switched manually, by relays or directly by the PLC. The cabling for the external contacts must be taken in account before the start up.

The following functions are controlled by digital switches:

- sampling
- beltstop
- measurement start / stop
- batch start / stop
- zero measurement start / stop
- type selection (4 Bit)

These functions are available for both measuring points. The LDU 1000 provides 8 digital inputs, i.e. not all functions provided by the software can be realized. A selection must be done during the engineering of the installation.

4.2 Software Configuration

Once all measuring units as well as possible outputs have been connected to the LDU 1000, connect the instrument to mains supply and turn it on. Since the instrument has a wide range input of 90 – 260 VAC, the standard voltage ranges 110V AC (60 Hz) and 230 V (50 Hz) are covered. Different country-specific supply voltages need not be observed.

The program jumps directly to the measurement display. Log on to the system as a service engineer and then push the **Menu** button to go to the main menu.

Note

All settings, calibration and zero values will be written into the non-volatile memory only after you have closed the main menu and returned to the measurement display!

However, if you turn the instrument off before you have changed over to the measurement display, the changes made up to that point will be lost!

4.2.1 Language

Select the language you want to work with in the Parameters submenu. You may choose either German or English; English is the default setting.

4.2.2 Time and Date

In the Parameters submenu, check the system time and the system date and correct this data, if necessary.

4.2.3 System Parameters

Now select the submenu ***Parameters → System***.

Port Configuration

Assignment of In- and Outputs

In Port Configuration you define the functions of the individual in- and outputs by allocating the number of the respective input or output to a function.

The configuration is defined on the following menus:

- Counter / analog inputs
- Analog outputs
- Digital inputs and
- Digital outputs

A certain port is selected from a selection list.

Virtual inputs are identified in the selection list by a (V).

Serial port

Three parameters are defined on the Serial Port submenu which are important for communication with an external PC.

The instrument ID indicates the PMD 2450 instrument address which is sent to the PMD 2450 along with each telegram. This address is important particularly if several PMD 2450's are combined to a network, because in this manner each individual instrument of the network can be addressed via PC.

The baud rate indicates the data transfer rate; the default setting is 9600 baud.

The mode, finally, defines if connection with the PC has been established via RS232 or via RS485 line.

The hardware has to be adapted to the configuration accordingly:

RS 232

- Jumper J1 on circuit board SE0008 has to be open
- Screened, 5-wire cable, max. 30 m long

RS 485

- Jumper J1 on circuit board SE0008 has to be closed
- Screened, twisted cable
- Terminate both ends with 120 Ohm each (close J2 on circuit board SE0008)

For more information on serial communication please refer to chapter 3.8.

Virtual ports

Here you enter the values for the virtual signal transmitter.

To make sure these virtual inputs are treated in the same manner as the real ones, you may also enter values for the zeroing for the counter and analog inputs.

Integration times

Integration time 1 defines how many raw data will be averaged for calculation of the area weight. It is defined as a multiple value of the so-called dead-time, which is 250 ms. The ***Int-1*** time is presently 4, i.e. the calculated area weight is average over one second. Presently, this value cannot be changed.

In addition to the fixed ***Int-1*** time, there is a second integration time ***Int-2*** for each measuring point. ***Int-2*** defines over how many seconds (rather: values averaged over how many ***Int-1***) the raw data for calculation of the actual measured values will be averaged.

Telegram type

Here you define if the PMD 2450 should each second send the current raw data or the already calculated measurable variables to an external PC during measurement.

4.2.4 Hardware Parameters

Go to the following settings in the menu ***Parameters → Hardware***.

Note
Depending on the applications, some submenus described below may not be available.

Counter inputs

Enter the belt position as well as a failure threshold for each counter; for the tachometers, you enter the tachometer constant instead of the belt position.

Analog inputs

Here you define the belt position and a failure threshold.

Digital inputs

Here you may define a delay time for the digital inputs. In this case, the respective input is not evaluated immediately, but only after the time defined here is over.

Microwave

In addition to the belt position, three microwave measurement parameters are defined here: measurement mode, fixed frequency in case of a CW-measurement and the mode of operating the internal attenuation element.

Note
The last measuring station in moving direction of the conveyor belt has belt position 0. All other positions are defined relative to this reference point.

4.2.5 Display Configuration

Here you choose from a selection list which measurable variable is to be displayed in which field of the measurement displays.

If needed, you may assign each measuring point a unique name.

4.2.6 Passwords

We recommend changing the default setting of the passwords in any case, in order to rule out any unauthorized access to the instrument.

4.3 Zeroing

Once you have configured the system, you may now perform the required zero measurements to take the influence of the conveyor belt on the measurement into account.

To do this, call the ***Zeroing menu*** on the main menu.

Zero measurements are always carried out without any product, i.e. with empty belt.

4.3.1 Basic Microwave Calibration

Before carrying out the actual zeroing, you have to perform a basic calibration of the microwave cassette.

Basic calibration is important for all subsequent measurements and, therefore, has to be carried out prior to the zeroing.

This measurement is independent of the microwave measurement mode and, therefore, need not be repeated after changing from CW-normal to sweep.

4.3.2 Zeroing

Following the basic microwave calibration, a zero measurement is performed separately for both measuring points, as described in detail in chapter 3.6.6 (Zeroing).

4.4 Sampling and Calibration

After the zero measurement the sampling can be started for all systems apart form the PMD 2450. Here some special settings are necessary to eliminate ambiguity of the phase measurement.

Additional settings for the PMD 2450.

During startup it must be checked, if the multiple of 360° is proper selected. Otherwise the whole sampling work is useless. Therefore this step is extremely important.

The multiple of 360° is selected by proper coefficients k1, k2 , k3 and x to calculate Phi_{check}.

The following measurements are performed with a running belt with a constant load. If it is impossible to get a constant load, the full belt can be stopped. Select the telegram “frequency response” and visualize the reading with a terminal program on the PC. Displayed are the readings of at 10 frequencies, as described in chapter 3.8. – The telegram has no header, but the readings are transmitted in the order as described here.

At first a proper value for x must be selected: x can be selected in the range between 0 and 2. To find a proper value for x in the frequency telegram the attenuation*f(x) must be observed. This value should be independent of frequency. For comparable dry materials the value is 0. For materials with a higher moisture x becomes higher.

In the second step proper values for k1, k2 and k3 must be determined. The phase shift versus frequeny must be observed: If the phase shift versus frequency is more or less constant the multiple of 360° is correct. If the slope is negative, the multiple of 360° is to high. If the slope is positive the multiple of 360° to small. Therefore the curve with the smallest positive or negative slope must be found.

At first we set k1=0 and k2=0. We work with k3 only. Check at first if within the frequency response is no phase jump. If a phase jump is observed set k3 to a positive value, that no phase jump happens.

If this is achieved, set k3 to an approximately average value of Phi.

If the slope of Phi versus frequency is now positive, increase k3 by 133°. Repeat this step until the slope becomes negative. Reduce K3 by 133° and check, if this is the smallest positive or negative slope, which can be obtained. If this slope is obtained, set again K3 to the average of Phi.

Calculate now k1 and k2:

k1 = 0,1 * k3 /attenuation*f(x)

k2 = 0,9 * K3 / area weight

Enter now the values for k1 and k2 and set k3=0. Observe the frequency response telegram and check, if approximately Phi = Phi_{check}. Maybe, a little change of k3 is necessary. Now we have start-values for k1 to k3, which must be approved.

In the first step change the load within minimum and maximum of the normal use and check, if the phase shift has no phase jumps.

After this check switch the telegram to raw and measured data.

Sampling can be started and stopped directly at the PC or with an optional the sampling switch, which is installed near the place, where the samples are taken. The switch is connected to the digital input of the LDU 1000, which is defined as sampling trigger.

In the first step sampling is started and stopped. The load as well as the moisture content should vary within the full range. In this stage it is not necessary to take samples for the laboratory analysis.

These samples are stored in the sampling table of the PC. With sufficient samples a regression can be started on the PC to calculate new values for k1, k2 and K3, as described in the manual of the IT-RQDS LDU Acquisition. Input these values in the LDU. The system is now calibrated for k1, k2, k3 and x. From time to time the coefficients should be checked based on the samples taken recently.

Determination of the calibration coefficients.

Now sampling can be started for all implemented measures together, e.g. moisture, ash and calorific value.

Sampling is carried out exclusively via the PC program IT-RQDS. To get the required raw data, you have to start a regular measurement in the PMD 2450 and send the raw data or the raw and measured data telegram to the PC each second. These values are then processed for sampling by the PC program.

During the sampling periods samples are taken for the laboratory. The length of the sampling period depends on the conditions at the installation site. If an mechanical sampling system is available the sampling time is determined by the frequency of the sampler to get a representative sample according the national or international standards, which must be applied. However, the sampling time should not be to long to avoid, that

extreme high of low values are averaged. Therefore it is maybe necessary to increase the frequency of the sampler, if possible. If no mechanical sampling system is available the samples must be taken manually and the sampling time will be comparably short to reduce the laborious work. Typical is a sampling period of 10 minutes with a sampling frequency of two sub-samples per minute.

If a sampling according Iso/Dis 15239 or similar standards is required, the frequency of sub- samples should be doubled and the sub-samples are collected alternating to a sample A and sample B to calculate the sampling and laboratory error.

If the laboratory results are available the results are manually entered in the sampling table of IT-RQDS LDU Acquisition. If a A- and B-sample is available, use the avarage.

With a sufficient number of samples the calibration coefficients are determined with the calibration part of the IT-RQDS LDU Acquisition, which are later used to convert the raw data into measured values. The values of the measures should be spread over the full range. A typical number of samples is 30.

The Calculation of the coefficients is described in the manual of the IT-RQDS LDU Acquisition. The result is displayed in a graphic and it is easy to determine and exclude out-layers. The coefficients must be transferred to the LDU 1000. This can be done manually or over the RS232/ RS 485 data link. With the new calibration coefficients the LDU 1000 displays and transmits the calibrated measures over analog and digital outputs.

5. Technical Data

In this section you will find all technical information on the hardware.

Overview

List of Illustration

5.1 Microprocessor Module SE 0100 (CPU)

The functions described here are implemented on the CPU board SE0100, but not all functions are available via the connections. See also Adapter Board SE 0006.

Microprocessor

Motorola MC68340 with 32 bit central processor unit; max. 25 MHz, programmable.

Memory

Two flash EPROM's with up to 1 MByte memory each; one static RAM with 512 Kbyte.

Real timer clock

Integrated crystal, frequency tolerance (< 50 ppm, ageing effect (< 5 ppm / year.

RS 232 ports

Two asynchronous serial ports with hardware handshake; baud rate 40 to 76.8 k baud adjustable, V 24 electrical driver.

RS 485 port

RS485 driver module can be activated alternatively for second RS232 port via jumper.

Digital inputs

Three digital inputs via 25 pole socket for status monitoring; standard CMOS level; input filter with pull-up resistors.

Open collector outputs

Three open collector outputs via 25 pole socket for connection of external relays, + 12 V, max. 100 mA.

Counter inputs

Six counter inputs via 25 pole socket, CMOS level, positively edge-triggered, pulse width > 100 ns, input impedance 1 kOhm, max. count rate up to 8 MHz, dependent on readout rate of counter modules.

Acoustic

Piezo signal transmitter, 83 dB in 10 cm distance.

Data lines

Via 64 pole connector, buffered with bus driver, D8 to D15.

Address lines

Via 64 pole connector, buffered with bus driver, A0 to A7.

Chipselect outputs

Via 64 pole, buffered with bus driver, CS4 to CS10, active in low status.

Read / Write outputs

Via 64 pole, buffered with bus driver, active in low status.

Interrupt inputs

Four inputs via 64 pole connector, active low, with pull-up resistors.

Digital I/O

Seven digital I/O's programmable as in/outputs; via 64 pole connector; with pull-up resistor. Four lines alternatively as interrupt inputs.

Reset outputs

Two outputs via 64 pole connector, pos. and neg. logic.

BDM connector

Motorola-specific 10 pole BDM connector for program development.

Power supply

+5V, +12V, -12V; 64 pole connector

Mechanical size

Eurocard format, 160 mm x 100 mm, 4 TE.

Ambient conditions

Operating temperature range: 0°C to 50°C, relative humidity: 10 to 90%, no condensation.

5.2 Adapter Board SE 0006

The following functions are accessible via the connector in the cable chute. The ADC input is not lead out but it is connected to the microwave cassette via the back panel.

5.2.1 Analog Input of ADC for the Microwave Unit

(only internally)

ADC	14 bit resolution
Polarity	Positive
Pulse height	0V – 5 V
Input impedance	150 kOhm
Input capacity	20 pF
Input leakage current	± 1 µA
Conversion time	Max. 3.33 µs
Integral non-linearity	Max. ± 1 LSB
Differential non-linearity	Max. ± 1 LSB
Unipolar offset error	Max. ± 4 LSB
Full-scale error	Max. ± 4 LSB

5.2.2 Counter Inputs

Level	Positive, > 3.5 V
Pulse width	> 0.5 µs
Count rate	Max. 250 000 cps
Input impedance	Approx. 300 Ohm
Input	With current limiting and over voltage protection

5.2.3 Analog Inputs

Channel 1 as current input	Jumper J5 closed 0 mA – 20 mA
Channel 1 as voltage input	Jumper J5 open 0 V – 5 VDC
Channel 2 as current input	Jumper J6 closed 0 mA – 20 mA
Channel 2 as voltage input	Jumper J6 open 0 V – 5 VDC
Input filter	RC, differential amplifier
ADC	10 bit resolution
Differential non-linearity	± 1 LSB
Zero-scale error	± 1 LSB
Full-scale error	± 1 LSB
Conversion time	21 µs

5.2.4 Analog Outputs

Range	0 mA – 20 mA
Load	Max. 350 Ohm
DAC	12 bit resolution, internal reference: 4.095 V
Over voltage protection	16 V varistors
Differential non-linearity	± 0.2 LSB
Integral non-linearity	± 2 LSB
Zero-Scale error	± 3 mV
Offset error	± 2 mV

5.2.5 Current Output for PT100

Constant-current source	10 mA, adjustable via poti R86
Load	Max. 500 Ohm, corresponding to 5 V voltage drop

5.2.6 Digital Inputs

Level	Active at pull-down on GNDA (electr. isolated)
Pulse width	> 50 ms
Input	Optocoupler, 10 mA, protective circuit

5.2.7 Digital Outputs

Open collector output	Jumper J1 – J4 open, max. 100 mA, max. +12V ext. supply
Voltage output	Jumper J1 – J4 closed, low = 0.3 V, high = 5 V, 4.7 kOhm
Output	electrically isolated, recovery diode, protective circuit

5.2.8 Connector Configuration

Pin configuration of connector ST1

(64 pole (32 x A/C), only for internal purposes)

Pin	Designation
1A	Power supply. +5V
1C	Power supply. +5V
2A	Ground (GND)
2C	Ground (GND)
3A	Read (negated)
3C	Write (negated)
4A	Cardselect CS4 (neg)
4C	Cardselect CS5 (neg)
5A	Cardselect CS6 (neg)
5C	Cardselect CS7 (neg)
6A	Cardselect CS8 (neg)
6C	Cardselect CS9 (neg)
7A	CSP
8A	Address A0
8C	Address A1
9A	Address A2
9C	Address A3
10A	Address A4
10C	Address A5
11A	Address A6
11C	Address A7
12A	Data D0
12C	Data D1
13A	Data D2
13C	Data D3
14A	Data D4
14C	Data D5
15A	Data D6
15C	Data D7
19A	
19C	V2
20A	RES\
20C	RES
21A	A-signal microwave
21C	Gnd A-signal
22A	V1
22C	P/M
23A	R/I
23C	R/T
24A	Gnd
24C	Gnd
25A	N/Test
25C	Hi/Lo
26A	Lock1
26C	Lock2
27A	LE2
27C	LE1
28A	CLK
28C	Data
29A	CSPLL2
29C	CSPLL1
30A	+15V
30C	+15V
31A	-15V
31C	-15V
32A	Ground (Gnd)
32C	Ground (GND)

Pin configuration of connector ST2

(Front side of SE0006, only internally)

Pin	Designation
1	+12 V A
2	+12 V A
3	Gnd-A
4	-12 V A
5	Gnd-A
6	+5 V A
7	Gnd-A
8	Digital input 1
9	Digital input 2
10	Digital input 3
11	Digital input 4
12	Digital input 5
13	Digital input 6
14	Digital input 7
15	Digital input 8
16	Gnd-A
17	Digital output 1
18	Digital output 2
19	Digital output 3
20	Digital output 4
21	Gnd-A
22	Counter 1 (-)
23	Counter 1 (+)
24	Gnd-A
25	Counter 2 (-)
26	Counter 2 (+)
27	Gnd-A
28	Counter 3 (-)
29	Counter 3 (+)
30	Gnd-A
31	Counter 4 (-)
32	Counter 4 (+)
33	Gnd-A
34	Counter 5 (-)
35	Counter 5 (+)
36	Gnd-A
37	Counter 6 (-)
38	Counter 6 (+)
39	+12 V A
40	Analog output 1
41	Analog output 2
42	Analog output 3
43	Analog output 4
44	+12 V A
45	Current outp. (-) for PT100
46	Gnd-A

47	Analog input 2 (-)
48	Analog input 2 (+)
49	Analog input 1 (-)
50	Analog input 1 (+)

5.3 Connector Configuration on Connection Board SE 0008

5.3.1 Serial Ports

The connection board SE 0008 accommodates the electrically isolated port, which works as RS232 with jumper J1 open, and as RS485 port with jumper J1 closed. The type has to be set in the software.

The configuration has to be adapted in accordance with the hardware as follows:

RS 232 Setup

- Jumper J1 on circuit board SE 0008 has to be open
- Screened, 5 wire cable, max. 30 m long

RS 485 Setup

- Jumper J1 on circuit board SE 0008 has to be close
- Screened, twisted cable
- Terminate both ends with 120 Ohm each (close J2 on circuit board SE 0008, do not forget terminating resistor on the PC side)

Pin configuration

The serial port is connected to connector ST3 on the connection board SE 0008, see also

Pin	**Function**
1	Electrically isolated ground
2	TxD (RS232)
3	RxD (RS232)
4	RTS (RS232)
5	CTS (RS232)
6	A (RS485)
7	B\ (RS485)
8	Electrically isolated ground

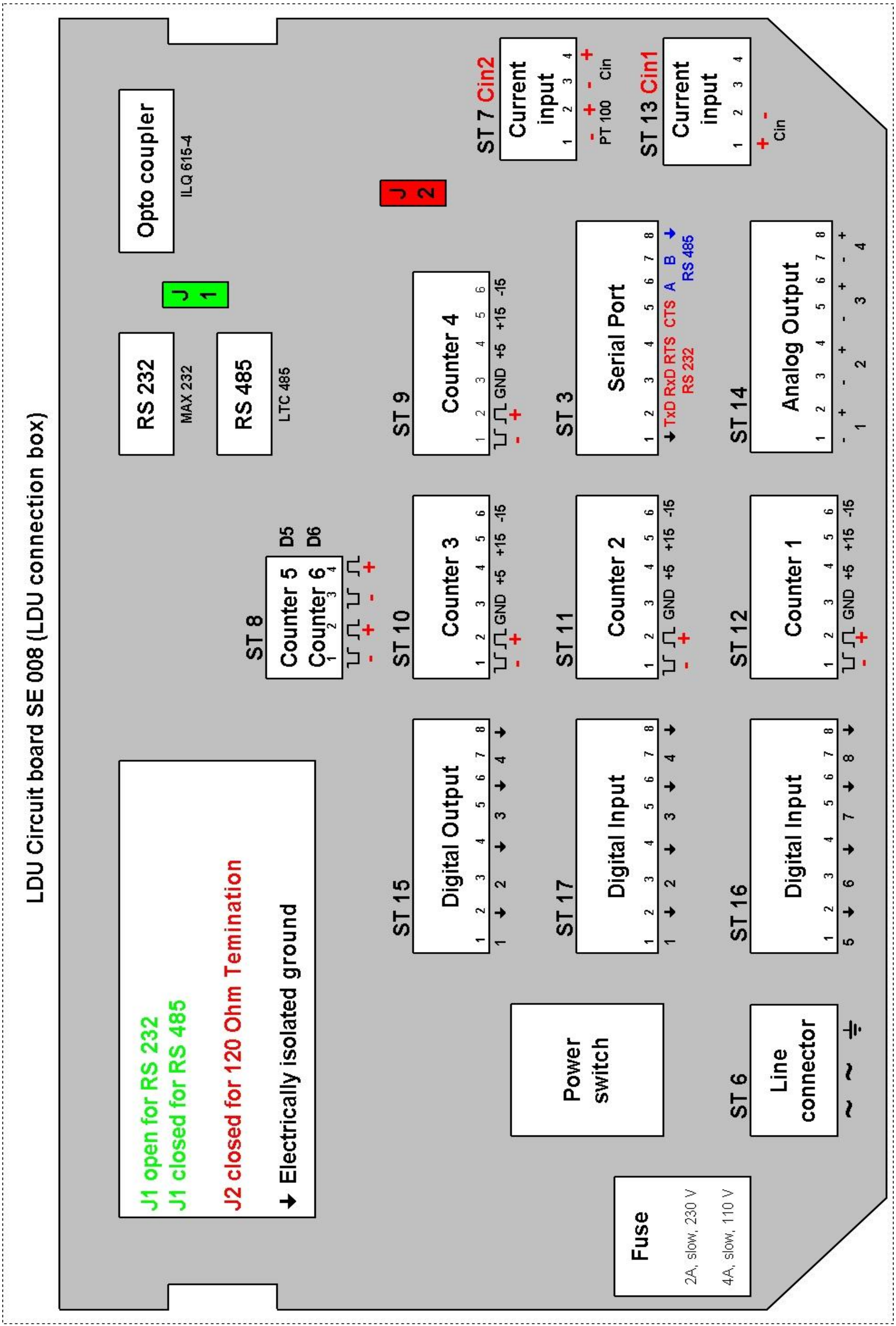

Figure 22: Connector configuration on circuit board SE 0008 in the cable chute

5.3.2 Power Supply

Long range input for
110 VAC (60 Hz) or 230 VAC (50 Hz)

The measuring system is firmly connected (fixed) to the external supply via a three-wire cable (type 3 x 0.75 mm^2). Please observe the correct allocation of the 3 wires. (PH, MP and protective conductor). The terminals of the external power supply have to be clearable and before being wired they have to be cleared. For power supply, the left PG next to the fuse should be used.

Connect the cable provided with wire end sleeves to connector ST6 (front left) to terminals 1, 2 and 3 (yellow-green cable to terminal 3).

Fuse: At 230 VAC: 2 A, T
At 110 VAC: 4 A, T

5.3.3 Housing Dimensions

Width: 30.5 cm

Height: 37.5 cm

Depth: 24.0 cm

5.3.4 Protection Type

IP65

5.3.5 Ambient Temperature

-20°C – +50°C

5.3.6 Relative Humidity

0 – 90%, no condensation