COMBILOG 1022
Data Logger

Hardware Manual Version 1.09

THEODOR FRIEDRICHS
Precise in all conditions

Technical data are subject to change!

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CHAPTER SURVEY

TABLE OF CONTENTS

1 GENERAL PRELIMINARY REMARKS

1.1 About this Manual

The manual contains all important information concerning the function, installation and initiation of the data logger *COMBILOG 1022.*

The description of the configuration software for the *COMBILOG-System* is available as Online-Help within the configuration software *COMBILOG.EXE.*

1.2 Important Notice

Make sure to use the data logger *COMBILOG 1022* exclusively in accordance with the notices, technical data and operating conditions mentioned in this manual. In case of inexpert handling or wrong application possible disturbances, measuring errors, effects on or from other appliances and facilities as well as possible endangering of human lives or tangible assets cannot be excluded!

Therefore if you have not yet operated the data logger *COMBILOG 1022*, you should first of all study this manual thoroughly. While initiating or operating the appliance or in case service is required always observe the notices given in this manual.

Please note further that there are other special regulations to be observed in case of application in potentially explosive surroundings (EExe, EExi, ...). These, however are not subject of this manual, which only explains the general use of the data logger *COMBILOG 1022*.

1.3   Contact for Inquiries

In case of inquiries concerning the data logger *COMBILOG 1022* please contact your local distributor or directly *Theodor Friedrichs & Co. GmbH*.

2 SYSTEM DESCRIPTION

2.1 System Overview

The *COMBILOG 1022* is a data logger with compact design, combined with integrated LC-display and memory slot suitable for SD cards.

This data logger was developed for meteorological, hydrological and environmental measuring systems, but it is equally suitable for countless further applications in industrial production.

The *COMBILOG 1022* features high performance, compact design (SMD components), low power consumption and moderate price.

The data logger is equipped with 8 analogue and 6 digital measuring channels; further channels for numeric calculation may be configured. Four serial interfaces RS232, RS485, USB and Ethernet are built-in, featuring communication via ASCII, PROFIBUS or MODBUS. Data storage is achieved by internal Flash or SD memory card, optionally.

„SELECT" switch and 4-line LCD on the front panel allow to enter or modify a number of different modes and functions, such as scan rate and averaging time, as well as offset or gain.

The *COMBILOG 1022* can easily be mounted on a 35 mm standard rail using its „snap-in" clamp and is therefore suitable for control cabinet installation or similar.

Thanks to its low power consumption, battery supplied systems are possible, whereby the use of a solar panel enables any extension of measuring period.

For applications like outdoor use there is a version with stainless steel housing available, as well as various other accessories. Configuring of the data logger is accomplished by means of an easy to handle WINDOWS^{TM} 98/ME/NT/2000/XP/7/8/10 software.

2.2 Range of Application

As described under (2.1), the most varying measurement tasks can easily be accomplished by means of the *COMBILOG 1022*. Some typical applications are e.g. measurement of temperature via resistance thermometers (Pt100), operation with combined sensors with current- or voltage output (e.g. wind speed measurement with DC generator) or position measurement and weight measurement by displacement transducers and force transducers. With these applications the data logger *COMBILOG 1022* supports measuring methods with 2-, 3- and 4-wire technique. The signal processing required in accordance with the sensors used, such as gain, linearisation, offset correction etc. can be adjusted individually by software. An external amplifier is not required.

The digital signal inputs can be used, for example, to connect switches, initiators, digit emitters and oscillators. Thus status indications can be collected and tasks like e.g. position measurements, displacement measurements, angular measurements, frequency measurements and timings can be carried out. Furthermore special 8-bit-Graycode-transmitters can be connected. Special calculations of measured values are possible by arithmetic channels. In case the 8 analogue and 6 digital inputs are not sufficient, other modules can be connected to the

data logger via the RS485 bus. In this case the *COMBILOG* is used as a bus master to read the measured values from the slave modules.

All data can be transmitted via the integrated RS485 communication interface to a subsequent control (PLC) or to a computer (PC). Up to 127 modules can be connected with the two-wire line over distances of several km. At the same time the communication interface features programming and configuring the individual application from a PC.

If the data logger *COMBILOG 1022* is not integrated in a bus, an additional RS232-interface is available for the user. This interface allows only a point-to-point connection up to max. 20 m (65 feet), but all functions of the RS485-interface remain available.

Furthermore the data logger can send messages in case of user definable conditions automatically via modem or SMS.

A configuration program is included (requires Microsoft WINDOWS 98/ME/NT/2000/XP/7/8/10).

2.3   Features

Function:

- ❑ Measurement inputs for all common types of sensors for I, U and R.
- ❑ Several different sensors can be connected simultaneously
- ❑ Measured values monitored by programmable thresholds
- ❑ Detection of sensor errors
- ❑ Detection of communication errors
- ❑ Programmable error handling
- ❑ Calculation of average values, minima, maxima, standard deviation and other arithmetic functions
- ❑ 7 MByte Flash internal data storage, extendible with external SD card

Inputs and outputs:

- ❑ 8 analogue inputs (for 2-, 3- and 4-wire connection)
- ❑ 6 digital inputs/outputs (I/O ports), configurable

Power supply:

- ❑ Power supply: +10 ... +28 VDC
- ❑ All connections protected against excess voltage, excess current and reverse polarity
- ❑ Battery operation is possible due to low power consumption

Display and operation:

- ❑ LED-status indication for digital inputs/outputs
- ❑ LED-status indication for malfunction and operation (ERR / RUN)
- ❑ LED-status indication for the ethernet interface

- ❑ LC-display (4 x 16 characters) and push-/turn knob for operation

Measured value processing:
- ❑ Linearisation, scaling and conversion into physical units
- ❑ Option to adjust, modify or reset the processing parameters individually
- ❑ Master function to retrieve data from external modules
- ❑ Programmable averaging
- ❑ Automatic message transmission via modem or SMS
- ❑ Non-volatile storage for program, parameters and data

Configuration:
- ❑ Configurable with PC-software under WINDOWS™ 98/ME/NT/2000/XP/7/8/10
- ❑ Menu-guided sensor selection in plain text
- ❑ Free configuration of up to 32 channels
- ❑ Data base for the most common sensors
- ❑ Definition of user-specific sensors
- ❑ Setting of type and principle of measurement
- ❑ Display of pin assignment
- ❑ Input of linearisation
- ❑ Alarm settings
- ❑ Programmable error handling
- ❑ Arithmetic combination of sensor channels
- ❑ Configurable measuring rate and averaging interval
- ❑ Configuration on file (offline-operation)
- ❑ Configuration via bus (online-operation)

Programming:
- ❑ Allocation of address and baud rate via bus
- ❑ Password to save the configuration and the data memory
- ❑ Synchronizing of date and time with the host PC

Communication:

❑ Integrated RS 485, RS 232, USB and Ethernet communication interface

❑ Autonomous function independent of subsequent systems

❑ Definition of the transmission protocol (ASCII and PROFIBUS or MODBUS)

❑ Definition of the telegram format (baudrate and parity)

❑ Definition of the output format
(field length / decimals / unit)

❑ Simple instruction set

Shell:

❑ Compact structural shape

❑ Attractive design

❑ Fast mounting

❑ Snap-on mounting on DIN rail 35 mm / 1.4 inch

❑ Protection IP20

❑ Plug-in screwed terminals

❑ Ground connection

2.4   Configuration Software

The *COMBILOG 1022* is delivered with a configuration software for MS WINDOWS 98/ME/NT/2000/XP/7/8. This software allows the individual configuration of the data logger.

Measuring channels are defined as variables in a variable table. Predefined sensors can be selected from the integrated database. The linearisation of the sensor signals will be performed automatically. Additional sensors can be defined.

Additional parameters like scan rate, averaging interval, data recording, error handling, automatic message generation, master function etc. are configurable. A password enables protection of the configuration and the stored data. Instantaneous measured values can be watched directly.

In case a software update for the data logger is necessary, the configuration program provides a download function, that sends the new program to the logger.

Communication is supported via standard interface (RS232), telephone or GSM modem or TCP/IP protocol.

Example for a configuration:
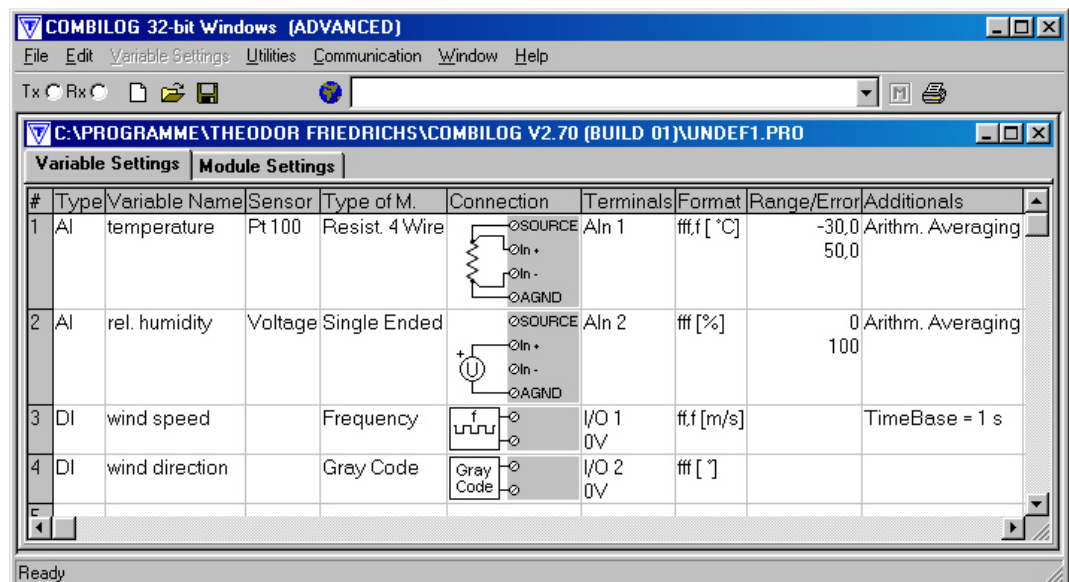
An online help support the user in configuration questions.

3 INSTALLATION

3.1 Mounting / Fixing

The data logger *COMBILOG 1022* has a snap-on mounting for installation on standard profile rails 35 mm (1.4 inch) according to DIN EN 50022.

Installation on the DIN rail is performed by means of the four straps on the rear side of the data logger. First push the two straps on the bottom behind the notch of the DIN rail and then press the data logger on the DIN rail until the two straps on the top snap in.

In order to take the data logger off the DIN rail slide the module lateral off the rail or in case it is not possible lift the data logger slightly so that the straps on the top get off the notch and the data logger can be taken off easily by pulling.

Attention: Refer to protection earth hints in chapter **3.5**!

3.2 Protective System

The data logger has an IP20 protective system. For outdoor installations data logger *COMBILOG 1022* can be installed in a stainless housing type 9920, thus featuring IP66 standard.

3.3   Ambient Temperature

The admissible ambient temperature for the data logger *COMBILOG 1022* is -45 °C to +85 °C. The admissible ambient temperature for the LC-Display is between -20°C and +60°C and becoming very slow below 0°C.

Attention: For certain memory card types, differing temperature ranges have to be considered.

3.4   Front panel / Pin Assignment

The front panel of the data logger *COMBILOG 1022* shows following elements:
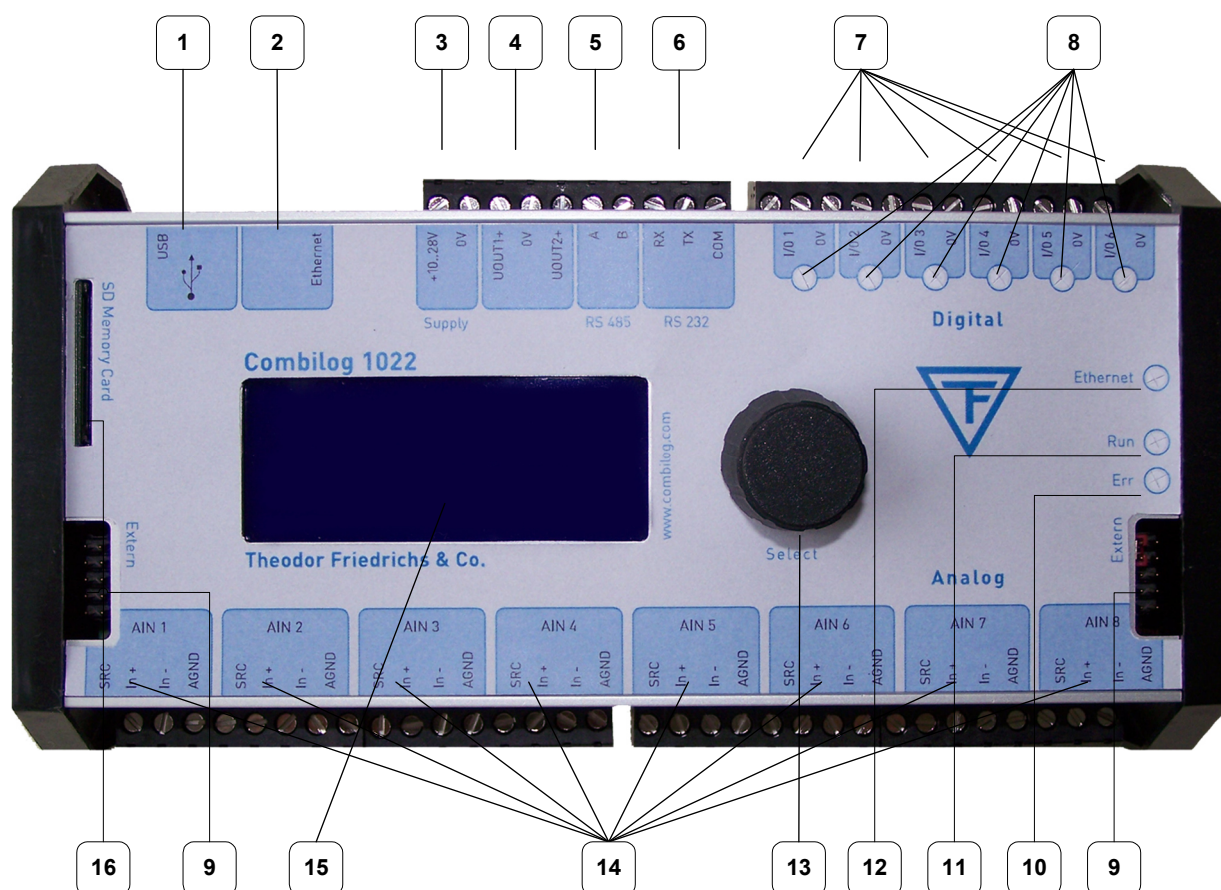
Figure 3.1   Front panel

Description of the parts:

Number	Description
1	USB
2	Ethernet
3	Voltage supply
4	Power switch
5	RS485
6	RS232
7	6 digital I/Os
8	Status-LEDs for digital I/Os

Number	Description
9	Module jack connection
10	LED ERR (red)
11	LED RUN (green)
12	Ethernet Link / Traffic
13	Press/rotary knob
14	8 analogue inputs
15	LC-display
16	Interface for memory card

Table 3.1   Description of the parts on the front of the device

Pin assignment:

Terminal	Assignment
+10..28V	Voltage supply +
0V	Voltage supply -
A	RS485-bus interface A
B	RS485-bus interface B
RX	RS232 receive
TX	RS232 transmit
COM	RS232 ground

Terminal	Assignment
I/O +	Digital I/O 1…6
0 V	Ground for digital I/Os
SOURCE	Source output
In+	Analogue input +
In-	Analogue input -
AGND	Ground for analogue input
UOUT 1 / 2	Power switch output

Table 3.2   Pin assignment

3.5   Connection

❑   Connection   : plug-in screw terminals
❑   Nominal cross section   : 1.5 mm² (0.02 square inch)
                                   unifilar/fine-strand (AWG 16)
❑   Length of wire stripping : 6 mm (0.2 inch)
❑   Alternatively available   : LP-terminals (spring loaded)
                                   (upon request)
❑   Protection earth   : 6.3 mm series tabs at rear
                                   side of housing

The best way to pull off the screw terminals is to use a small screwdriver, placed as a lever between terminal and the front of the data logger.

Not more than 2 leads should be connected with one clamp. In this case the leads should have the same conductor cross section.

Note: Wire connection is only allowed during power off.
Note: In order to avoid influences from noise on the sensor signals shielded wires should be used for the power supply, the bus connection and the signal lines.

ATTENTION: Before final installation, a suitable protection earth cable with terminal has to be connected to the ground connector at the back of the data logger. Assure that the connection has a low impedance after mounting.

3.6   Power Supply
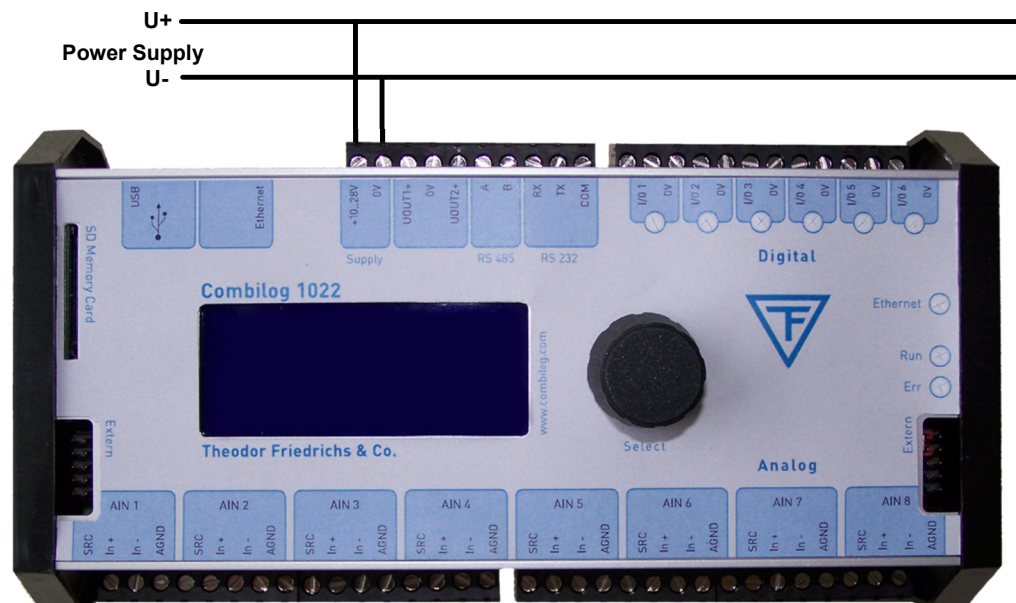
Figure 3.2   Connection of the distribution voltage

Voltage range

❑   +10 ... +28 VDC

Power input

❑   0.1 W typical

(up to 1.1 W maximum, depending on configuration)

Internal protector (reversible)

❑   excess current 0.5 A M

❑   excess voltage

Non-regulated DC voltage between +10 and +28 VDC is sufficient for the power supply of the data logger *COMBILOG 1022*. The input is protected against excess voltage and current and against reverse polarity. The power consumption remains approximately constant over the total voltage range, due to the integrated switching controller.

Due to its low current consumption (max. 110 mA at 12 VDC) the data logger can also be remote-fed via longer lines. Several data loggers can be supplied parallel within the admissible voltage range, considering the voltage drop in the lines. The supply lines can also be installed in one common cable, together with the bus line, if required.

In order not to charge the data logger's supply voltage unnecessarily, a separate power supply for sensors with a large current requirement is recommended.

3.7 Bus Connection

In general the data logger is connected to the bus by applying the signal leads A and B of the incoming bus cable and A' and B' of the outgoing bus cable together to one terminal on the module (figure 3.3).

Alternatively the bus can also be connected by a "stub cable" as shown in figure 3.4.

Owing to the removable terminal, the bus connection to other data loggers remains valid, even if one data logger is replaced by another.
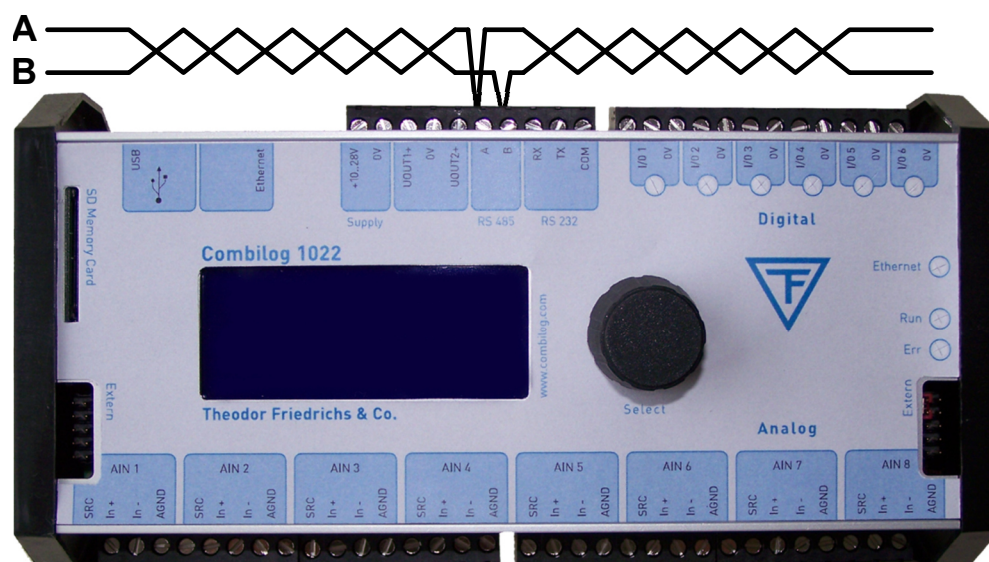
Figure 3.3   Connection of the data logger to the bus

Note: When connecting the logger to the bus, the two bus interfaces A and B must not be interchanged.

Note: The stub cable should be as short as possible, not longer than 30 cm (12 inch).
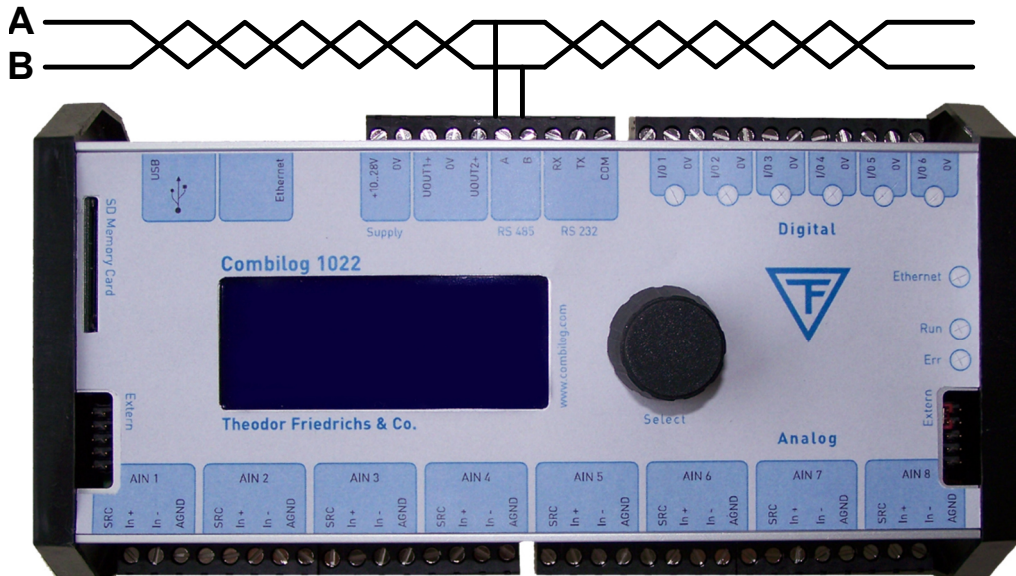
Figure 3.4   Connection of the data logger to the bus by a stub cable

3.8   Sensor Connection

The analogue and digital signal inputs and outputs are wired according to measurement task, to the transducer (sensor) that is used, and to the number of connected sensors. The pinout arrangements for the various types of measurement are described in chapter 5. The respectively valid pin assignment is determined by means of the configuration software.

Since the digital outputs are "passive" the processing of external elements always requires an external current supply. In case of larger loads this should be independent of the data logger supply.

At the connection of inductive loads a connection with a diode is required in order to prevent possible damages by induced voltage.

Following devices can be connected directly to the digital outputs: signal lamps, small relays, switching relays for larger loads, acoustic signal installations, buzzer respectively beeper etc., as long as the connected loads are not exceeding the values described in the technical data chapter 12.

3.9 Several Sensors at one Data Logger

The data logger *COMBILOG 1022* can simultaneously receive and process sensor signals from several different sensors. As many sensors can be connected as there are analogue and digital signal inputs and outputs available (14 sensors max.; 8 analogue and 6 digital sensors).

4 SIGNAL PROCESSING

The data logger *COMBILOG 1022* has eight analogue inputs and six digital inputs/outputs. Several different sensor signals as well as digital inputs and digital output signals can be connected and processed simultaneously.

4.1 Analogue Inputs

The analogue inputs serve to collect sensor signals, or to acquire control values respectively. They are particularly designed to measure voltages, currents and resistances.

There are 8 equal analogue inputs, each input can be configured individually.

Note: Overloads of more than ± 10 VDC will lead to false measuring results in the according analogue input channel. Overloads of more than ± 15 VDC will also have influence on the measuring accuracy of the other input channels!

4.2 Digital Inputs/Outputs

The six digital inputs/outputs of the data logger can be configured - independent of each other - as inputs or as outputs. The current status (in/out) is signalized by one LED each.

As inputs the I/Os can be used for collecting feed-back signals, for measuring frequencies, as counters or for receiving special serial 8-bit-Graycode signals. Status information can be issued by the outputs. Thereby host-controlled or process-controlled status outputs are possible.

The digital inputs have an excess voltage protection (transil diodes), with nominal threshold +30 V. Input voltages between +2.0 VDC and +30 VDC are interpreted as logic *LOW* ("0"), input voltages lower than +0.9 V as logic *HIGH* ("1"). The maximum input current is 1.5 mA.
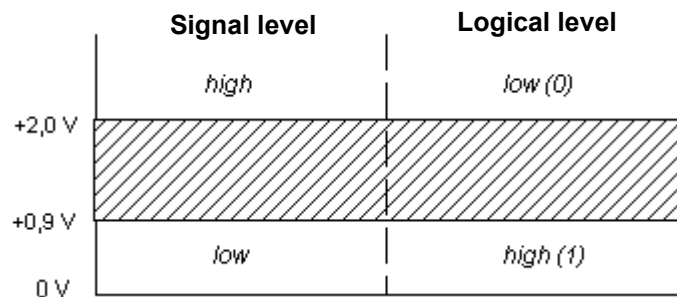
Figure 4.1   Definition of signal levels and logic levels

The outputs are open-collector type with a maximum voltage of +30 VDC and a maximum current of 100 mA.

4.3 Power Switch

The data logger *COMBILOG 1022* has two power switches which act as voltage supplies for external sensors.

A power switch can be assigned to an analogue channel and configured with a lead time (see chapter Power Switch).

The supply is switch on with a configurable time before the selected analogue input channel will be measured.

4.4 Internal Reference Voltage, Offset- and Drift Correction

An internal reference voltage serves to adjust the entire analogue signal processing automatically.

Especially for measurement of extreme low voltages, currents and resistances, the configuration software features an additional compensation of temperature drift. With current- and voltage measurement, this is realized by an internal offset measurement. The measured offset is subsequently applied to correct the measured values. For Maximum accuracy with current measurement (temperature drift less than 25 ppm/K) it is recommended to accomplish the measurement via an external shunt with a correspondingly low temperature coefficient (< 5 ppm/K). For this purpose, the input channel has to be configured as a voltage input.

For resistance measurement, a drift correction requires an additional input channel which has to be equipped with a suitable reference resistance. This resistance should have a low temperature coefficient (< 5 ppm/K). In the configuration table, this channel has to be defined as a reference channel with resistance input for drift correction, whereby the nominal value of this resistance (at 20°C) has to be indicated.

Using the above described methods, the analogue inputs can almost completely be kept free from temperature drift.

4.5 Internal Processing

Next to collecting the analogue input signals, the analogue multiplexer at the input of the circuit collects the internal reference voltage. All these values are then transmitted to the programmable amplifier PGA, where the signals are amplified according to the kind and type of the connected sensors and then supplied to the A/D converter.

The A/D converter digitalises all incoming signals with a definition of 16 bit and at a rate that can be preset for the module by the user. The Sigma-Delta-procedure used for the A/D-conversion guarantees a high accuracy and a high linearisation. The A/D-converter processes an integrated amplifier with the amplifier stages of 1, 2, 4, 8, 16, 32 and 64. For very small signals, the module switches to an additional amplifier with amplifier stages of 100, 200, 800 and 3200. The amplification in alignment with the accuracy and resolution of the calculated measuring values results from the selection of the measuring range which will be configured by assistance of the configuration software.

This software also configures the ADC internal low pass filter, depending on the mains frequency and desired ADC frequency (selectable between 10 and 400 Hz). Standard configuration for the low pass filter is 50 Hz.

The microprocessor µP now edits the measuring signal in digital form.

First the processor linearises and scales the signal and holds it ready for transmission via bus in programmable units. Further the processor monitors the measured values for excess of freely programmable threshold values. Thus a monitoring of failure or breaking of the sensing element or short-circuit can also be realised. The data logger can be activated - by means of appropriate configuration - to provide a corresponding signal at the digital I/O in case of alarm. The digital I/Os are directly addressed and monitored respectively by the microprocessor µP.

Hereafter an arithmetical averaging of the values is carried out. The average interval is the same for each channel and is adjustable in steps of 0.25, 1, 2, 3, 4, 5, 10, 15, 20 and 30 seconds, 1, 2, 3, 4, 5, 10, 15, 20, 30 minutes, resp. 1, 2, 3, 4, 6, 8 and 12 hours. The calculated average values are finally stored in the memory.

Note: The *COMBILOG 1022* averages and logs data as fast as possible, even faster than 4 Hz, if an average value of 0.25 s is selected. The seconds at the time stamps will not be shown in this special case.

Note: The selected value 0.5 s will be actually the real value 0.25 s within the configuration software.

The special user program, the data for configuration, linearisation and scaling etc. that are required by the processor µP for all tasks are retentively stored in an EEPROM.
The timing control of the data processing is realised by an internal real time clock buffered by Gold cap capacitor.

4.6　Scan Rate and Power Consumption

The A/D-converter digitalizes every signal at a rate that can be preset by the user. The scan rate can be selected between 0.25 sec. and 1 hour. In this selected time period all configured channels are scanned and processed correspondingly. The power consumption of the data logger *COMBILOG 1022* depends on this scan rate. Between the measuring cycles the data logger will be set into a so-called "Sleep-Mode". During this mode the data logger needs only about 20 mA with supply for the serial lines being active.

Note: A scan rate of 0.25 s causes an unsignificant higher variation of instantaneous values but does not affect the averaging.

4.7　Signal Processing

Arithmetical averaging is carried out using several measuring values. The averaging interval, which is the same for all channels, can be set to one of the values 0.25, 1, 2, 3, 4, 5, 10, 15, 20, 30 seconds or 1, 2, 3, 4, 5, 10, 15, 20, 30 minutes or 1, 2, 3, 4, 6, 8, 12 hours respectively. The calculated values are finally stored in the memory.

Note: The *COMBILOG 1022* averages and logs data as fast as possible, even faster than 4 Hz, if an average value of 0.25 s is selected. The seconds at the time stamps will not be shown in this special case.

Note: The selected value 0.5 s will be actually the real value 0.25 s within the configuration software.

With the configuration software the kind of averaging is selectable: Normal averaging or averaging of wind direction (consideres the discontinuity at NORTH). For counter variables not the average, but the number of pulses is calculated.

A change of the average interval can be initiated by certain program conditions, thus featuring temporary higher time resolution of measured signals.

5   FUNCTIONAL DESCRIPTION

The data logger *COMBILOG 1022* has a total of 32 logical chan-
nels for the collection, processing and output of various kinds of
sensor information. These 32 channels can be configured as:

- ❑ Analogue Input Channel
- ❑ Digital Input Channel
- ❑ Digital Output Channel
- ❑ Arithmetic Channel
- ❑ Setpoint Channel
- ❑ Alarm Channel

For each channel various kinds of channel information and pro-
cessing functions can be determined. The table in appendix C
gives a survey of the channel set-ups with the data logger *COM-
BILOG 1022*. The channel set-ups are carried out by means of
the configuration software.

5.1   Analogue Input Channel

The analogue Input Channel collects and processes the signals
of the most common types of sensors. A large number of stand-
ardised sensors is already stored in the *COMBILOG* internal
sensor data base. Further sensors can be added by the user.

Following measuring principles are provided:
- ❑ Voltage measurement
- ❑ Current measurement
- ❑ Resistance measurement
- ❑ Temperature measurement with thermocouples

For each of these principles the data logger *COMBILOG 1022* offers several types of measurement. For voltage measurement the types of measurement *single-ended* and *differential* can be used. Currents up to 25 mA are directly measured by the data logger. Current measurements of more than 25 mA can be carried out by measuring voltage drop at an external shunt. Resistance measuring can be carried out in 2-, 3- and 4-wire technique.

Each analogue input channel can be assigned an individual sample rate (see chapter Single Channel Configuration).

5.1.1   Voltage Measurement

Two methods are available for voltage measurement: *single-ended* and *differential* measurement.

With the single-ended type the voltage to be measured is connected between an analogue input (In+) and analogue ground (AGND). Differential measurements are realized by using two analogue inputs (In+ and In-). Measuring range is between 0 and ±10 V.

Note: With *differential* measurements both voltages have to be within 10 V referred to AGND (Common-Mode-Range).

It is recommended to connect the In- to A_{GND} with a high ohmic resistance.

Voltage Measurement
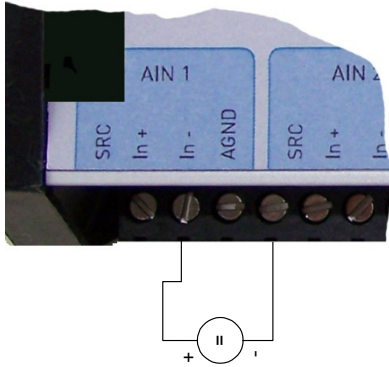
Connection scheme   **Circuit**
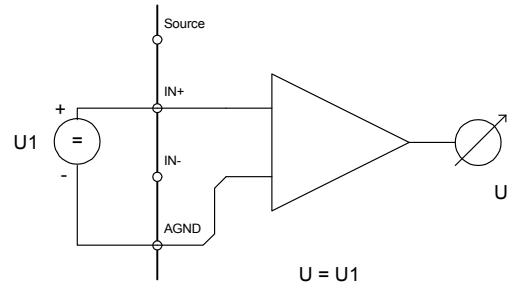
Figure 5.1   Voltage measurement - single-ended
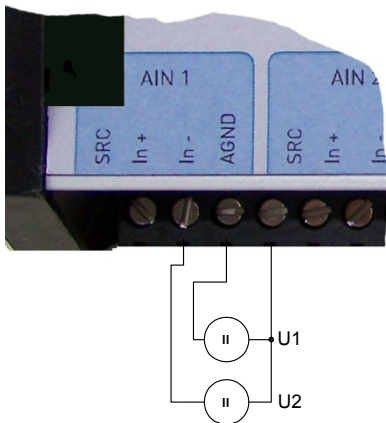
Connection scheme   **Circuit**
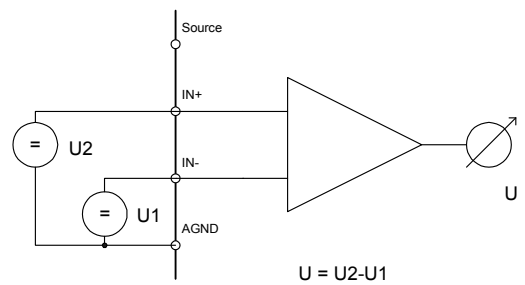
Figure 5.2   Voltage measurement - differential

5.1.2 Current Measurement

For current measurement the current source is connected between an analogue input (In+) and analogue ground (A_{GND}). The load required for measurement is controlled by an internal resistor R_{int} to 100 Ω. The power capacity of this shunt is limited to 125 mW. This results in a measuring range of 25 mA maximum.

Higher currents can be measured by means of an external resistor which is connected parallel to the current source to the analogue signal input and analogue ground (A_{GND}). The power capacity of this external shunt has to be adapted to the current source to be measured, so that the voltage occurring at the analogue input does not exceed +10 V. The analogue input is configured as voltage input. The voltage has to be divided by R_{ext}.

Note: The precision of the current measurement with external shunt depends on the precision of the resistor being used.

Note: The input resistance of the current measurement channel depends on the current to measure!

Current Measurement
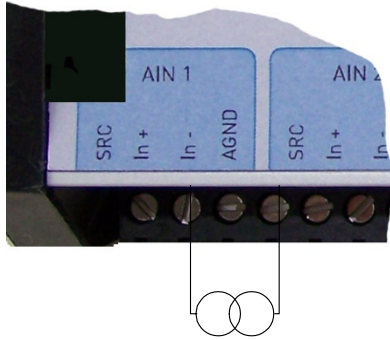
Connection scheme   **Circuit**
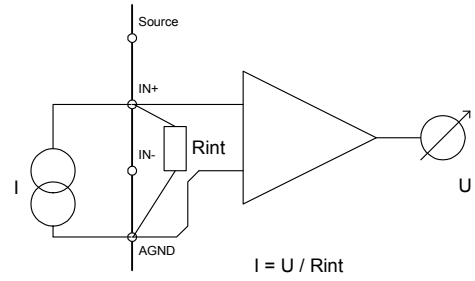
Figure 5.3   Current measurement with internal shunt
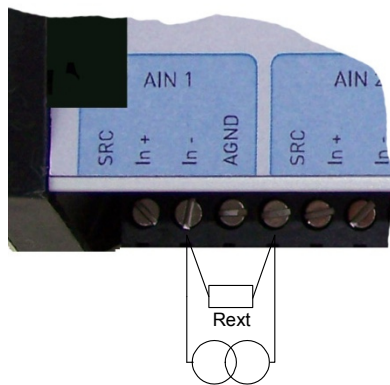
Connection scheme   **Circuit**
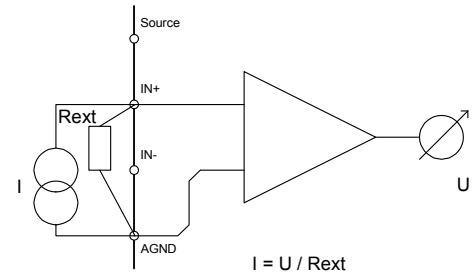
Figure 5.4   Current measurement with external shunt

5.1.3 Resistance Measurement

Resistance measurement is carried out by means of voltage measurement at a resistor, measuring the resulting voltage drop. The constant current required for the resistance measurements is provided by the internal supply of the data logger.

For this purpose the sensor module connects a supply point internally with the analogue measurement input via a reference resistor R_o. The voltage drop U_o via resistor R_o is required as a reference for further signal processing by the module. The resistance value of the sensor can be calculated from the input signals U_i as a multiple of the reference resistor R_o. Measuring range is between 0 and 20 kΩ.

Note: The data logger *COMBILOG 1022* supports resistance measurement in 2-, 3- and 4-wire technique. With resistance measurement in 2-wire technique the supply lines cause an additional voltage drop, thus distorting the measuring result and influencing the measuring accuracy. Therefore it is necessary to pay attention especially with resistance measurement in 2-wire-technique. Wires with impedance as low as possible should be used. Make sure that the leads are well connected to the data logger and the sensor. With resistance measurement using 3-wire technique the potential on the supply lines will be subtracted by software. Therefore 2 measurements are necessary, resulting in double measuring time. With resistance measurement in 4-wire technique the drop of potential is picked up directly at the sensor, so that the measuring results are not influenced by the supply lines.

Resistance Measurement

Connection scheme   **Circuit**
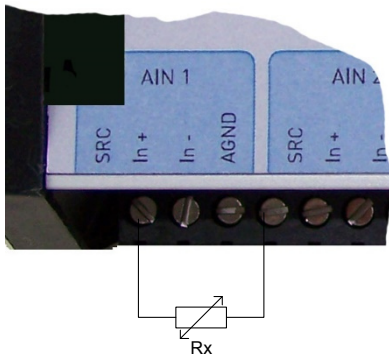
measuring resistance

$$Rx = U/U0 * R0, \quad \triangle Rx = 2 * RL$$

Figure 5.5   Resistance measurement in 2-wire technique

Connection scheme   **Circuit**
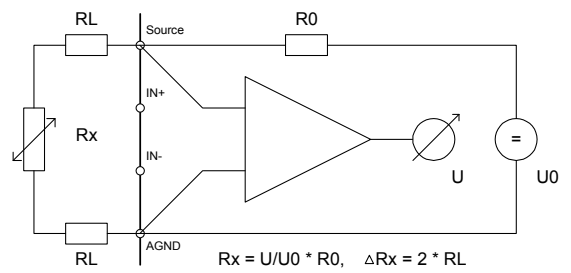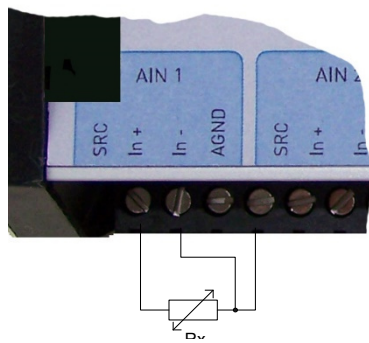
measuring resistance

$$Rx = (U1/U0-2*U2/U0) * R0, \quad \triangle Rx = 0$$

Figure 5.6   Resistance measurement in 3-wire technique

Connection scheme   **Circuit**
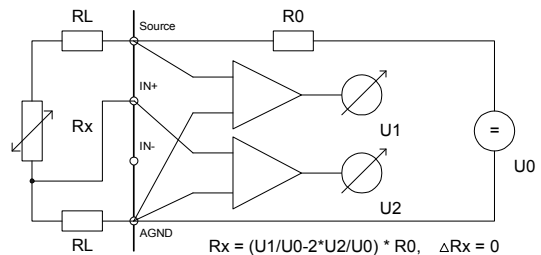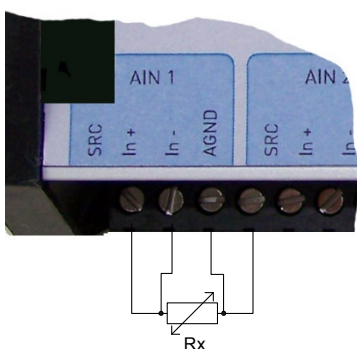
measuring resistance

$$Rx = (U2 - U3)/U0 * R0, \quad \triangle Rx = 0$$

Figure 5.7   Resistance measurement in 4-wire technique
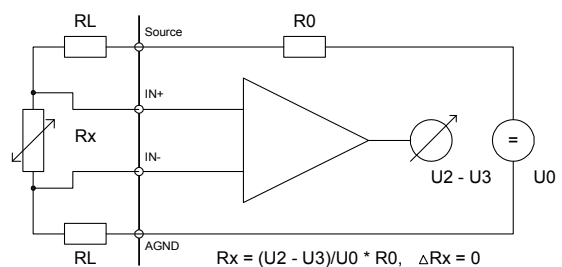
Temperature Measurement with Thermocouple

Thermocouples consist of two "thermoelectric wires" made of different materials (e.g. platinum and platinum rhodium) that are welded to each other at one end. If the contact and the other ends of the thermoelectric wires have different temperatures, a "thermoelectric voltage" U_{th} appears at the contact of both thermoelectric wires. This voltage is largely proportional to the temperature difference. It can be measured and used for temperature measurement purposes. With data logger *COMBILOG 1022* the thermoelectric voltage is measured differentially.

Since thermocouples can only measure a temperature difference (difference between temperature to be measured and temperature at the connecting terminals on the sensor module), a terminal temperature (internal cold junction compensation, TC_{int}) or a known temperature reference (external cold junction compensation, TC_{ext}) also have to be determined.

With measurement of temperature with internal cold junction compensation an additional temperature sensor is necessary to measure the temperature ϑ_k at the "cold" terminal. A special cold junction terminal is available, where a Pt100 temperature sensor is integrated directly in the terminal block. The temperature of the test point is determined on basis of linearization trace to $\vartheta_x = Lin(U_x + Lin^{-1} \vartheta_k)$.

If the temperature is measured by external cold junction compensation, a second thermocouple of the same type is required, which is connected in series with the first one. The polarity is selected so that the thermoelectric voltages subtract each other. The second thermocouple is set to a fixed reference temperature ϑ_r (mostly $\vartheta_r = 0°C$). The data logger then calculates the temperature at the measuring position by means of the linearisation curve as $\vartheta_x = \text{Lin}(U_x + \text{Lin}^{-1} \vartheta_r)$. The data logger will be informed about the reference temperature ϑ_r via the configuration software ("cold junction temperature").

Temperature Measurement with Thermocouple

Connection scheme   **Circuit**

$\vartheta x = Lin (U2 + Lin^{-1}\ \vartheta k), \vartheta k = Lin (U1)$

special terminal clamp ICJ 104
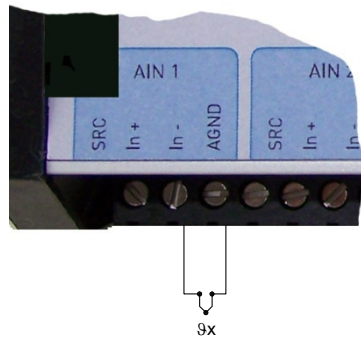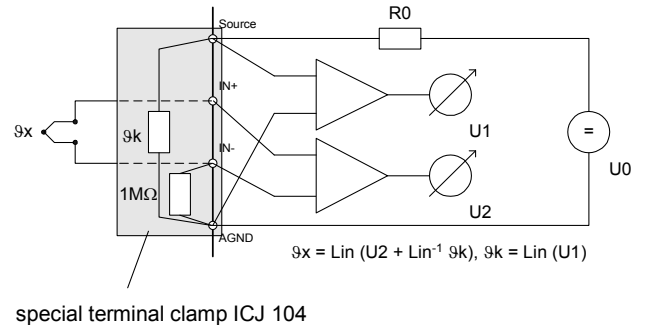
Figure 5.8 Temperature measurement with internal cold junction compensation by special terminal clamp ICJ 104

Connection scheme   **Circuit**

$\vartheta = Lin (U1 + Lin^{-1}\ \vartheta p)$
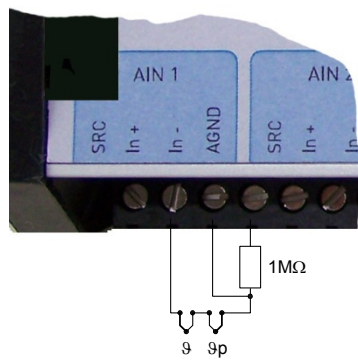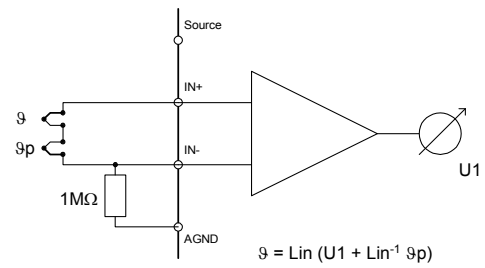
Figure 5.9 Temperature measurement with external cold junction

5.2   Digital Input Channel

The following functions can be realized by means of the Digital Input Channel:

- ❑   Digital status recording
- ❑   Frequency measurement
- ❑   Counter
- ❑   8 bit Graycode transducers, Type 4122 / 4123
- ❑   8 bit status input, with additional (external) module

The above mentioned functions are based on incremental measurements except the digital status and Graycode recording. Incremental measuring means to count while measuring. Pulses are counted e.g. from wind speed sensors.

Furthermore it is possible to connect up to 6 sensors with a serial 8 bit Graycode output to the *COMBILOG 1022*, e.g. wind direction sensor type 4122 / 4123.

By means of an external module type 1025 8 bit status signals can be measured at each input. This module converts the 8 bit into a serial signal, and the *COMBILOG* will compose it to 1 byte again.

5.2.1 Digital Status Recording

For the acquisition of digital status information (on/off, closed/open, left/right, etc.) the signal fed to the digital input is collected and is held ready for further processing in the data logger *COMBILOG 1022* or for transmission via bus.

The digital input is set (switch closed) as long as the signal voltage remains under the threshold value of 1.0 V. The digital information can be scanned as 1/0 information via bus.
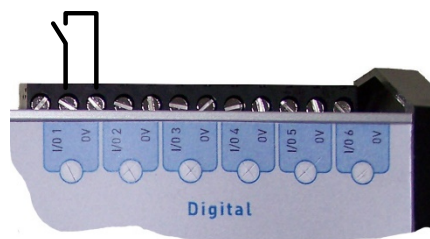
Connection scheme   **Circuit**
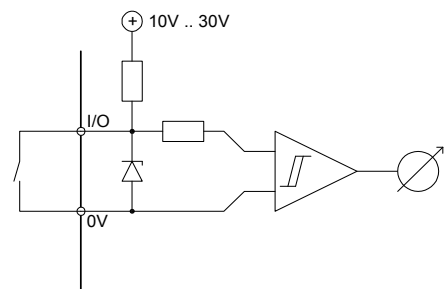
Figure 5.10   Digital status recording

signal diagram:
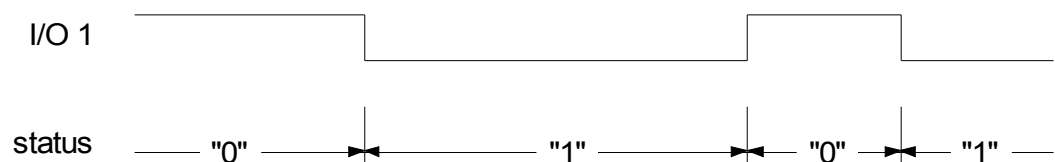
5.2.2   Frequency Measurement

With frequency measurements the data logger counts the pulses within a certain time interval at the digital input. The user can preset this time interval by setting the time base (TB) in the range between 0.1 sec and 10 sec. The frequency is calculated by the sensor module from the number of pulses and the time base *TB* as:

$$\text{frequency f} = \frac{\text{number of impulses per time interval TB}}{\text{length of time intervall TB}} \text{ Hz}$$

With frequency measurements always the negative signal edge (1 -> 0) is counted.

The lower the frequency *f,* the larger the interval between two pulses, and the larger the time base *TB* has to be. On the other hand the updating of the measured value decreases with an increasing time base. Thus the time base should be selected so as to make *TB* $\approx$ *1/f$_u$*, *f$_u$* being the lowest frequency respectively the smallest change in frequency to be determined by the data logger. The error with frequency measurements thus amounts to $\Delta f = f_u = 1/TB$.

Note: The high-end frequency for the frequency measurement, i.e. the highest frequency to be measured. It is 4000 Hz.

Frequency Measurement
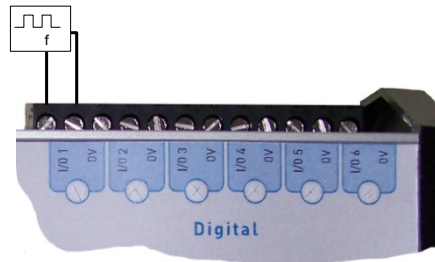
Connection scheme   **Circuit**
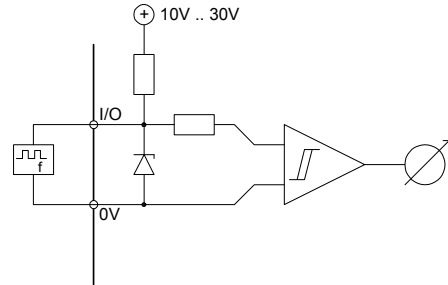
Figure 5.11   Frequency measurement

signal diagram:

- high level:
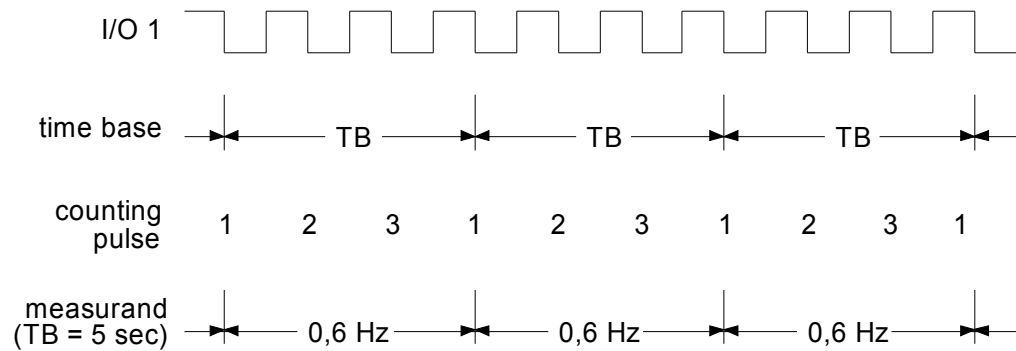
- low level:
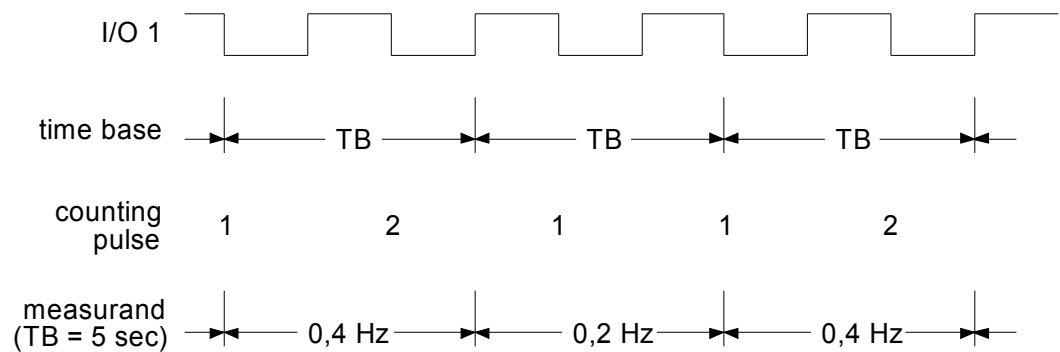
5.2.3 Progressive Counter

When configuring a digital input as a progressive counter the data logger *COMBILOG 1022* constantly monitors the digital input for a signal variation. If a negative signal edge (1 -> 0) occurs at the input, the current result is increased by 1.

The values may range from -2^{31} to $+(2^{31}-1)$ (about -2.1 to +2.1 billion). Above $+2^{31}-1$ the counting continues with -2^{31}. The values can be reset to zero via the bus interface or internally after the procedure of the averaging interval.

Note: The maximum counting rate is 2400 Hz.

Note: After a voltage cut-off the counter is reset to zero.
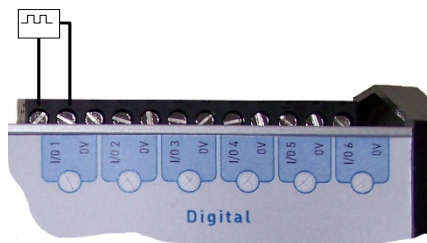
Connection scheme   **Circuit**
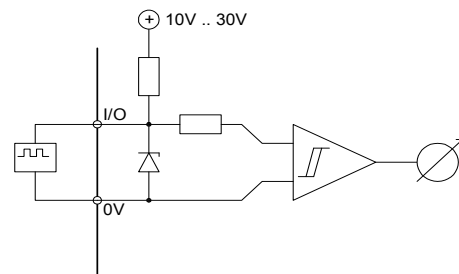
Figure 5.12   Progressive Counter

signal diagram:

I/O 1					
counting pulse	+1	+1	+1	+1	+1
counting measurand	n+1	n+2	n+3	n+4	n+5
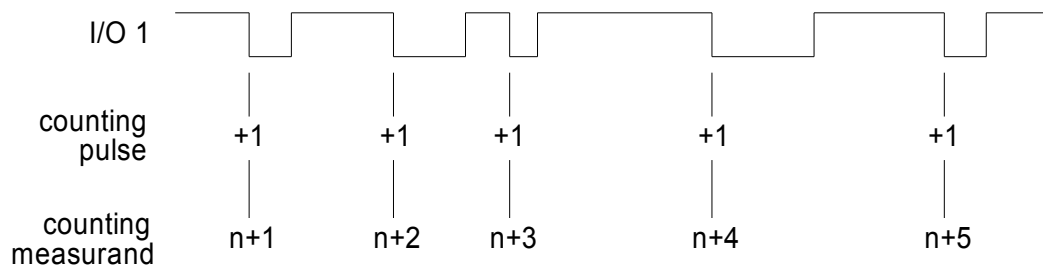
5.3 Digital Output Channel

5.3.1 Digital Status Output

The digital output channel supports:

❑ digital status output, host-controlled
❑ digital status output, process-controlled

Via the digital inputs/outputs I/O 1 to I/O 6 on the data logger *COMBILOG 1022* digital status can be output in digital form, according to the configuration. A typical case of application would be e.g. the local output of an acoustic or optical signal in case a limiting value is exceeded or undershot by a measured value.
All outputs are open-collector.

The supply voltage can range from 10 up to 28 VDC. It has to be either supplied externally or taken from the power supply of the data logger.

The status of the digital output can be scanned as 1/0 information via bus.

With the host-controlled digital status output, the digital output is set according to the status information received by the data logger via bus.

With the process-controlled output of status information the data logger monitors measured values, resp. sensor channels from excess of default threshold values. The digital output is set if one or several threshold conditions are fulfilled.

The thresholds can be freely defined by the user. The user can also preset the logical signal level (see also the configuration software *COMBILOG.EXE)*.

Thus it is possible to activate a digital output depending on a specified time or periodically. This can be realized in connection with an arithmetic channel, that can calculate the time or a time interval from the internal real time clock. A typical application is to switch off a modem after a specified time to reduce the power consumption of battery powered systems.
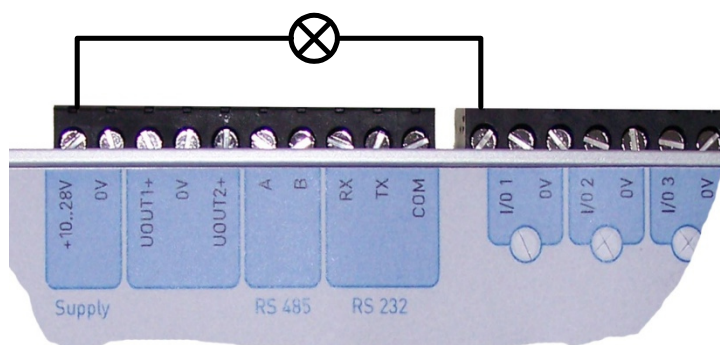
Connection scheme   **Circuit**
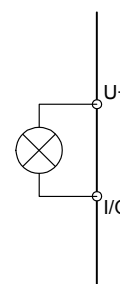
Figure 5.13   Digital status output

signal diagram:
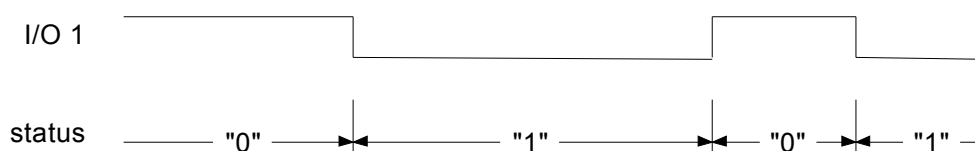
5.4 Arithmetic Channel

By means of the arithmetic channel sensor channels and constants can be connected with each other via arithmetic operations. The result is allocated to the arithmetic channel. The formula can contain up to 20 operands. The calculation is performed with a stack depth of 20. The value is handled as a 4-byte floating point format with 24 significant bits according to IEEE, standard 754. The full scale is -10^{37} to $+10^{37}$.

A typical application for the arithmetic channel is e.g. the determination of a value that cannot be measured directly, but calculated from other values (e.g. power as a product of voltage and current). Or the arithmetic channel is used for further mathematical preparation of a measuring signal, in order to obtain a particular desired format, linearisation or similar.

Special functions for which the existing commands are not sufficient, can be carried out by a user specific download program for the *COMBILOG 1022*. For this case, some implemented special functions can be used for assistance.

5.4.1 Special Function 1

To integrate a serial channel the special function 1 is to be used. The serial channel converts an ASCII telegram into a float value. Two variants are possible to choose, constant length or variable length. With constant length the conversion starts at startposition and ends at start position + length. With variable length the conversion starts at start position and ends at the first delimiter character.

Should the conversion be unsuccessful the default value will be taken. There are several different types of special function 1, which cover the following sub-section 5.4.1.1 to 5.4.1.3. Nevertheless, by defining multiple arithmetical channels *spec1()* with different starting positions, several values of a data telegram can be evaluated.

5.4.1.1 Basic Type

The call to special function 1 is defined as:

spec1(*INTERFACE; TYPE; START; VAR; DEFAULT*)

- INTERFACE
  - 1: RS232
  - 2: RS485
- TYPE
  - 1: constant length
  - 2: variable length
- START: start position (starting with '0')
- VAR
  - for TYPE = 1: value length
  - for TYPE = 2: delimiter character (ASCII value)
- DEFAULT: on error this is value will be returned

In defining more than one arithmetic channel with this function you can extract more than one value from one ASCII telegram.

The received ASCII-telegram needs to be added with the Special Characters <CR> , <LF> or <CR>+<LF> at the end.

Example:

To convert a variable value with start position 10, delimiter #, interface RS485 and default value –1 from "Value:_0023,6697#END" the call to spec1() should be spec1(2; 2; 10; 35; -1) and the result is 3.6697.

5.4.1.2 *Basic Type With Timeout*

This type is available from firmware version 2.30. It works the same as the Basic Type, but with additional specification of a timeout. The timeout is expressed in ms (milliseconds) and after this time the default value will be outputted. In this way one can detect the failure of a serial sensor directly.

The call to special function 1 as a Basic Type with Timeout is defined as follows:

spec1(*INTERFACE; TYPE; START; VAR; DEFAULT; TIMEOUT*)
- INTERFACE
  - 1: RS232
  - 2: RS485
- TYPE
  - 1: constant length
  - 2: variable length
- START: start position (starting with '0')
- VAR
  - for TYPE = 1: value length
  - for TYPE = 2: delimiter character (ASCII value)
- DEFAULT: on error this is value will be returned

- TIMEOUT: Maximum timeout in [ms], within the sensor must have responded. Otherwise, the default value is set. Possible values are 0 to 360000, i.e. the maximum possible timeout is 1 hour.

The received ASCII-telegram needs to be added with the Special Characters <CR> , <LF> or <CR>+<LF> at the end.

Example:

To convert a variable value with start position 5, delimiter ; , in-terface RS232, default value -999 and timeout 15 seconds from the ASCII-telegram " **0123;45678;901;**" the call to spec1() should be as follows:

spez1(1;2;5;59;-999;15000) and the result is 45678.

However, it will change to -999, if there is no new ASCII-telegram received within 15 seconds.

5.4.1.3 _Modbus- Protocol For Serial Sensors_

This type is available from firmware version 2.38 and offers the possibility to query a serial sensor via Modbus® protocol

In the following, the configuration is described using the example of SMP3 (Smart pyranometer).

The call to special function 1 is defined as follows:

spez1(_INTERFACE; TYP; ADDR; CMD; REG-START; REG-SIZE; DEFAULT; TIMEOUT_)

- **INTERFACE**
  - 2: RS485
- **TYP**
  - 3: Modbus® Protocol
- **ADDR**: Address of the sensor used
- **CMD**: Modbus® command
  - 4: Read Input Register
- **REG-START**: Address of the register to be read
- **REG-SIZE**: Size of the register to be read
  - 1: 16-bit Unsigned Word

  - 2: 32-bit Unsigned Integer

  - 3: 16-bit Signed Word

  - 4: 32-bit Signed Integer

  - 5: 32-bit Float

- **DEFAULT**: On error, this value is set

- **TIMEOUT**: Maximum timeout in [ms], within the sensor must have responded. Otherwise, the default value is set.

Example:

Querying the inside temperature using the example of SMP3

interface :	RS485	Sensor adress:	1
Baudrate:	19200	Input Register:	8 (16-bit Register)
Parity:	Even	Default-Wert:	-1
Sampling:	1s	Timeout:	1.5s

Spec1(2; 3; 1; 4; 8; 1; -1; 1500)

5.4.2 Special function 2

With special function **spec2()** some special meteorological values can be calculated. The following functions are defined.

5.4.1.2 *Air pressure on sea*

- **spec2(*air pressure; height; 1*);**
  Calculates the air pressure on sea level out of air pressure at given height.

Example:

The air pressure is 990 hPa and were measured at a measuring station, which lies 235 m above sea level. Calling spec2 (990; 235; 1) results in 1018 hPa at sea level.

5.4.1.2 *True wind*

- **spec2(*app_wind; fair_wind; wind_angle; 2*);**
  Calculates the true wind speed out of apparent wind, fair wind and the enclosed angle.

Example:

A ship is moving at a speed of 1 m/s north. The wind is measured with an anemometer on board and apparently blowing from the west 3 m/s.
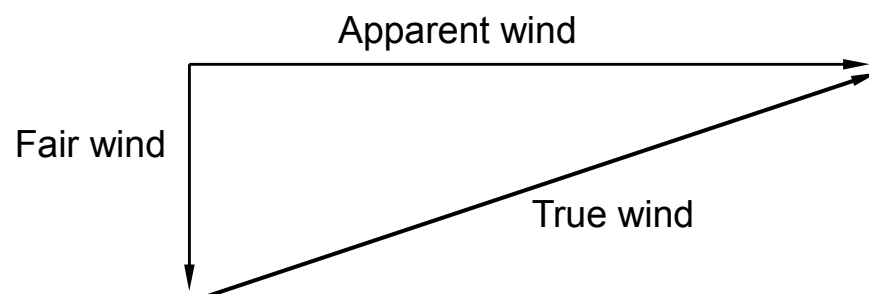
spec2(3;1;90;2) or **spec2(3;1;270;2)** resulting both that the true wind is 3.2 [m/s].

5.4.2.3 Evaporation acc. to Penman-Monteith

- **spez2(*temperature; radiance_balance; saturation_deficit ; wind_speed; 3*);**
  Calculates the evaporation acc. to Penman-Monteith.

5.4.3 Calculation of Arithmetic Channels

Note: The calculation time of an Arithmetic Channel is min 0.2 ms. The overall calculation time is the sum of the times of all operands in the formula plus 0.2 ms. This has to be taken into account when calculating the sample rate.

Arithmetic Operators

operations	abbreviation	time
Addition	+	0.26 ms
Subtraction	-	0.26 ms
Multiplication	*	0.26 ms
Division	/	0.26 ms
Modulo	%	0.24 ms
Truncate value	trunc	0.16 ms
Minimum value	min	0.16 ms
Maximum value	max	0.16 ms
Absolute value	abs	0.16 ms
Square root	sqrt	0.26 ms
Exponential function to base e	exp	0.56 ms
Logarithm to base e	ln	0.26 ms
Logarithm to base 10	log	0.26 ms
Sine	sin	0.44 ms
Cosine	cos	0.44 ms
Tangent	tan	0.66 ms
Inverse sine	arcsin	0.70 ms
Inverse cosine	arccos	0.70 ms
Inverse tangent	arctan	0.62 ms
Lowest value from a selection	Low	0.30 ms
Highest value from a selection	high	0.30 ms
X^Y	power	1.64 ms
Integrator	integ	0.18 ms
Differentiator	deriv	0.18 ms
Read from external module	read	
Write to external module	write	
Time /seconds of the day)	SecondsOfDay	0.18 ms
Sample rate	SampleTime	0.18 ms
Free space on SD-Card	SDSpace	0.20 ms
Free space in RAM	RAMSpace	0.1 ms

Application specific function 1	spec 1	1)
Application specific function 2	spec 2	1)
Application specific function 3	spec 3	1)
Application specific function 4	spec 4	1)

1) No specification available as the time depends to the specific function and the program.

Table 5.1   Arithmetic operators and processing times

The times given in the above table are based on an operating frequency of 48 MHz.

Remarks:

❑   Division (/)

When dividing by zero, the positive full scale ($+10^{37}$) will be assigned to the Arithmetic Channel if the numerator is positive and the negative full scale (-10^{37}) will be assigned if the numerator is negative.

❑   Square root (**sqrt**)

The square root of a negative number is zero.

❑   Logarithm to Base e (**ln**)

For a value ≤ 0 the negative full scale will be assigned to the Arithmetic Channel.

❑   Logarithm to Base10 (**log**)

For a value ≤ 0 the negative full scale will be assigned to the Arithmetic Channel.

❑   Arc functions (**sin**, **cos**, **tan**)

The arc values must be taken in radians ($2\pi = 360°$).

If calculating the tangent, the positive full scale will be assigned to the Arithmetic Channel for the arc value $\frac{\pi}{2}$ and the negative full scale for the arc value $-\frac{\pi}{2}$.

❏ Inverse functions for sin (**arcsin**), cos (**arccos**), tan (**arctan**)
The results of the inverse functions are given in radians (2π = 360°). At the function **arcsin** the value $+\frac{\pi}{2}$ will be assigned to the Arithmetic Channel for a value >1 and the value $-\frac{\pi}{2}$ will be assigned for a value <-1. At the function **arccos** the value 0 will be assigned to the Arithmetic Channel for a value >1 and the value will be assigned for a value <-1.

❏ Minimum and maximum of a channel value (**min, max**)
With this function the minimum and maximum value of a channel appeared since the last reset has been triggered off can be determined ("*pull-pointer-function*"). The result value can be reset to the actual value of the measured channel via the bus or at the end of the average interval.

❏ The functions *read* and *write* enable the data logger to receive measured values from other modules connected to the same bus, resp. to send values to them (master function)

Note: Logic combinations, e.g. if-then relations, are not yet possible respectively would require user-specific software (upon request).

5.5 Setpoint Channel

This channel features transmission of values via bus to the data logger *COMBILOG 1022*. The values are allocated to the setpoint-channel and are thus at the disposal of the data logger for further processing.

A typical application for the setpoint-channel is e.g. the dynamic variation of control thresholds.

5.6 Alarm Channel

The Alarm Channel has the same features as the process-controlled digital output channel, the only difference is that the status information is not output locally at the digital output, but can only be scanned via the bus.

5.7 Serial Channel

The serial channel output transmits the ASCII formatted strings of the logging channels onto the configured interface. The serial channel function can be configured using the build in web page (see chapter 12.9)

5.8 Threshold Values

The user can preset the conditions for process-controlled digital status output on the data logger and for the output of an alarm signal via bus. This is carried out by means of the configuration software *COMBILOG.EXE*.

5.9   Error Handling

The data logger *COMBILOG 1022* can detect independently certain defects, which are result of a line break, short-circuit or communication interrupt, for example. For these defects the user can preset a certain behaviour for the data logger via the configuration software.

In case of a sensor failure the last valid value can be maintained, set to the corresponding limits or set to a default value.

Furthermore the *COMBILOG 1022* can send messages via modem or SMS automatically to report errors or other conditions, e.g. if the data memory capacity becomes zero.

6   DISPLAY / MENU OPERATION

6.1   Display and Operation

The data logger *COMBILOG 1022* has a display with 4 lines of 16 characters each, in order to allow the indication of the measured values of each channel. Furthermore the settings of the data logger can be recalled and changed if desired (therefore the input by the press/ rotary knob must be unlocked; refer to the corresponding section 6.2 "Menu Items")

The operation is performed via the combined press/rotary knob at the right side of the display. By turning the knob the menu items or informations can sequentially be indicated. A confirmation or a call of a function is performed by pressing the knob.

6.2   Menu Items

In the following diagrams all display pictures with the corresponding operation steps are indicated. Following symbols are used for the operation steps:

Symbols:

 .....turn the knob clockwise

 .....turn the knob counter clockwise

 .....press the knob briefly (confirmation)

 .....press the knob for approx. 1 second minimum(abortion)

Main menu
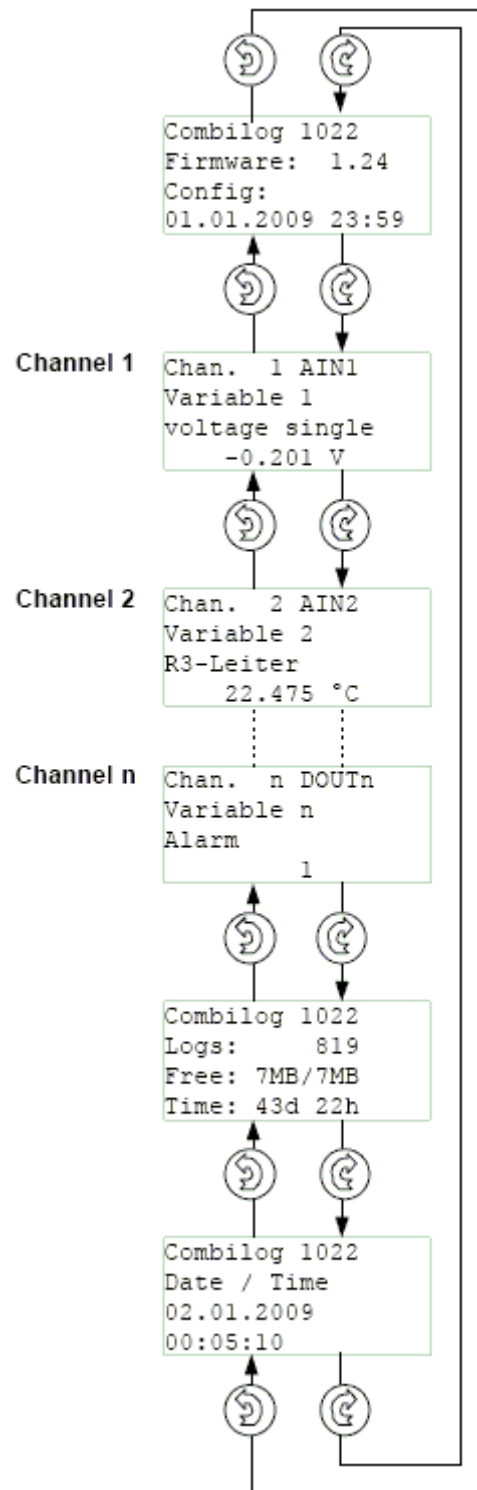
Note: The number, designation and indication of the measured value of the channels depend on the configuration.

Configuration menu
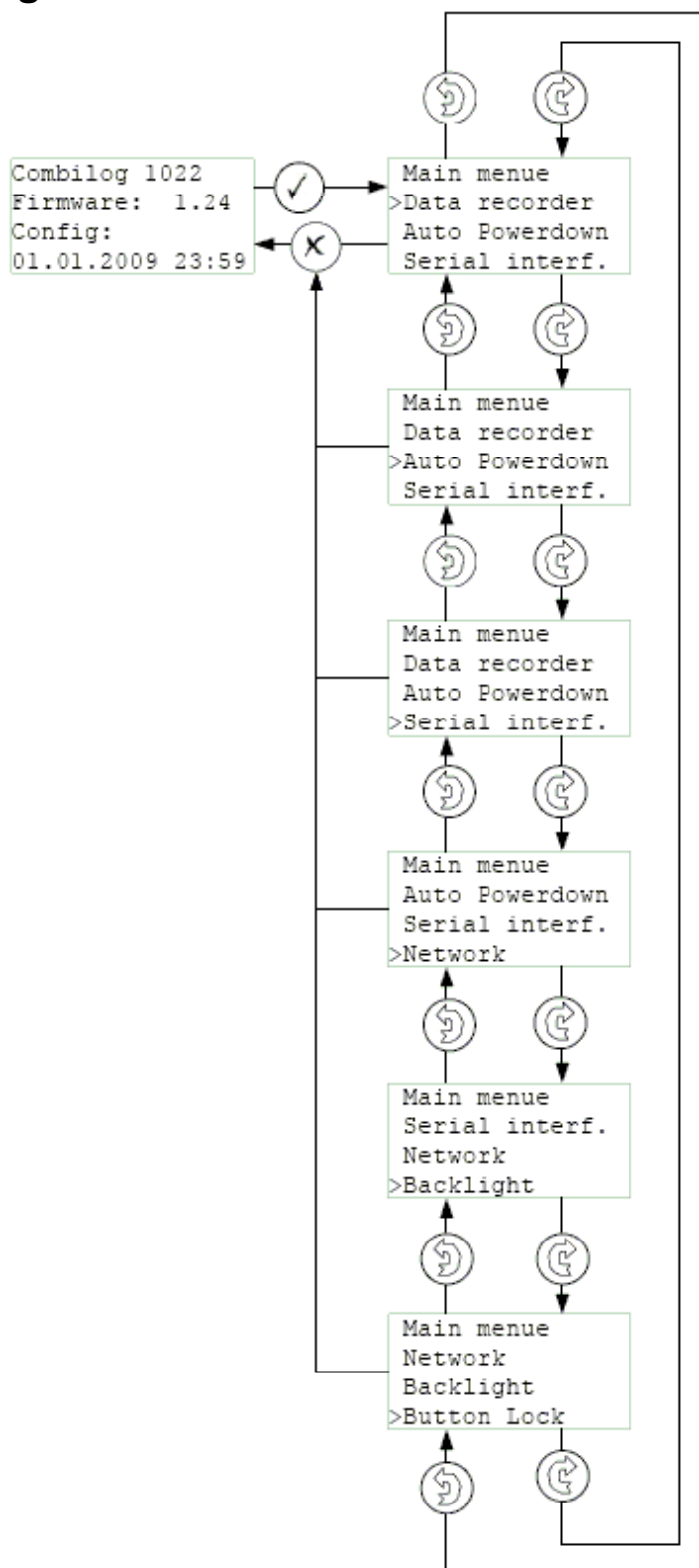
Note: If the push/turn selection knob is pressed at any point in the configuration menu for about 1 second you will return to the initial position in the main menu.

Setting of the display backlight

```
Mainmenue                    Configuration              Change +
Serial interf.    (✓)        Backlight
Network           (✗)                                   Change -
>Backlight                      50%     50%
```
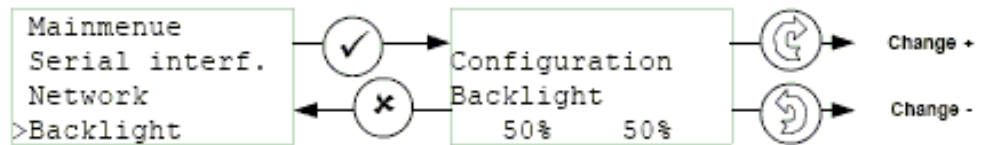
Note: The value of the display backlight can be set in steps from 0 % to 100 %. With low values the display will be set dark and with the value 100 % it will be set to maximum brightness.

Setting the scan rate and the averaging interval

Configuration menu
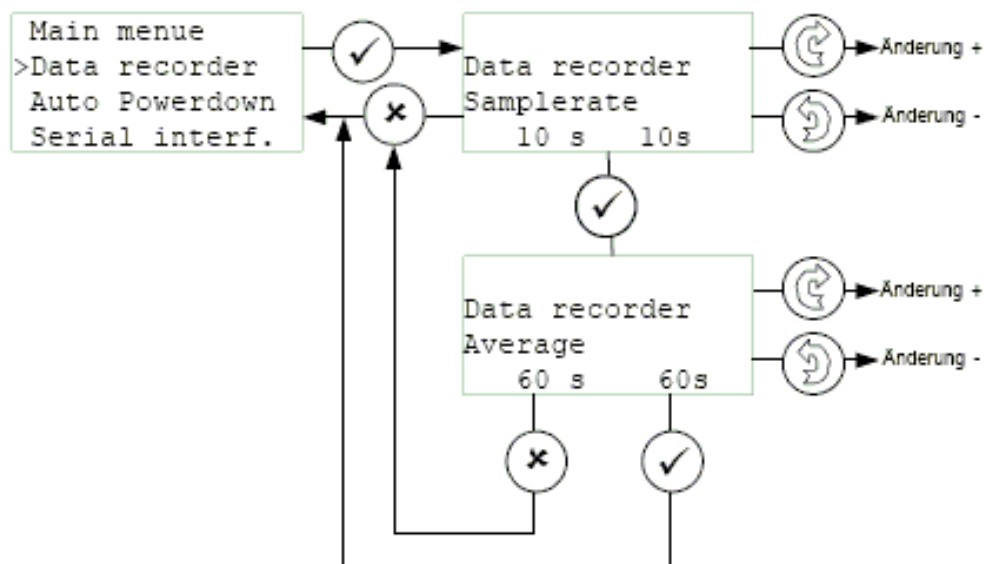
Note: The scan rate determines after which time interval the measured values of the channels will be measured again. Scan rate is selectable between 0.25 s and 1 h.

At "Averaging" the averaging interval can be set. It determines the time interval for the averaging of the measured values. Averaging interval is selectable between 0.25 s and 12 h.

In the example the measured values will be measured again every 10 seconds and after 60 seconds the average value will be calculated (here by means of 6 measured values).

Note: The *COMBILOG 1022* averages and logs data as fast as possible, even faster than 4 Hz, if an average value of 0.25 s is selected. The seconds at the time stamps will not be shown in this special case.

Setting of the Automatic Switch Off and the LED Display

Configuration menu
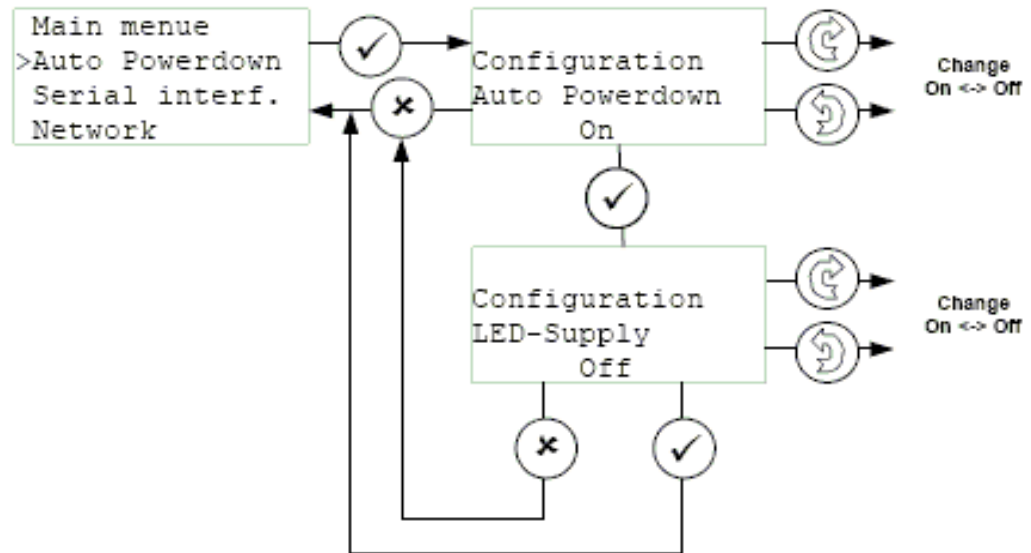
Note: With the automatic switch off function the data logger can be set to the saving mode if no operation is made by the press/ rotary knob in a certain time interval (30 seconds). In this case the display will be set off until a further operation takes place.

If "LEDs" is set to *ON* the LED-display is switched on and the two LEDs RUN and ERR on the front of the data logger show the actual operating state (mode) of the data logger. With the selection *OFF* the LEDs will be switched off.

Setting of the Baud Rate and the Address

Configuration menu
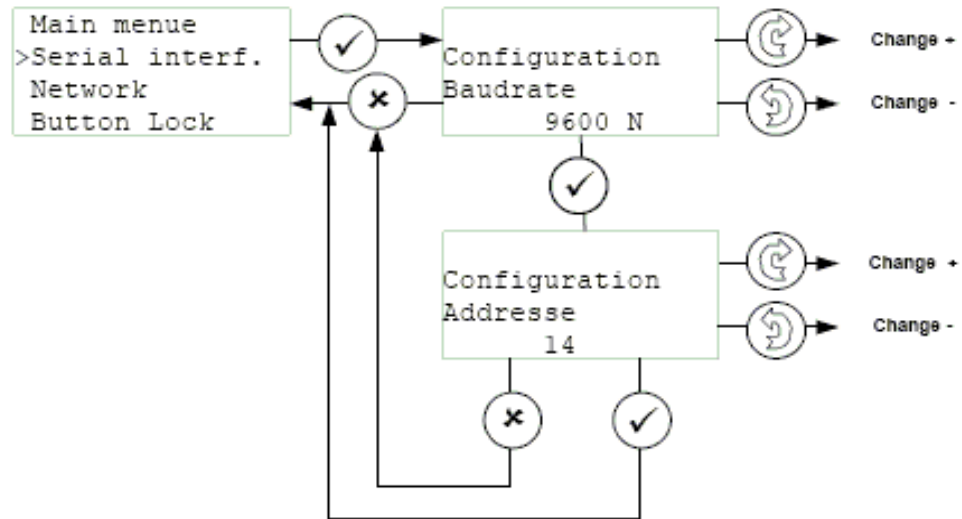
Note: Possible values for the baud rate are 2400, 4800, 9600, 19200 and 38400 bps. Additionally to the baud rate the parity can be set. Possible values are N (no parity), E (even parity) and O (odd parity).

For the address a value between 1 and 127 can be set.

Lock or unlock the press/rotary knob input

Configuration menu
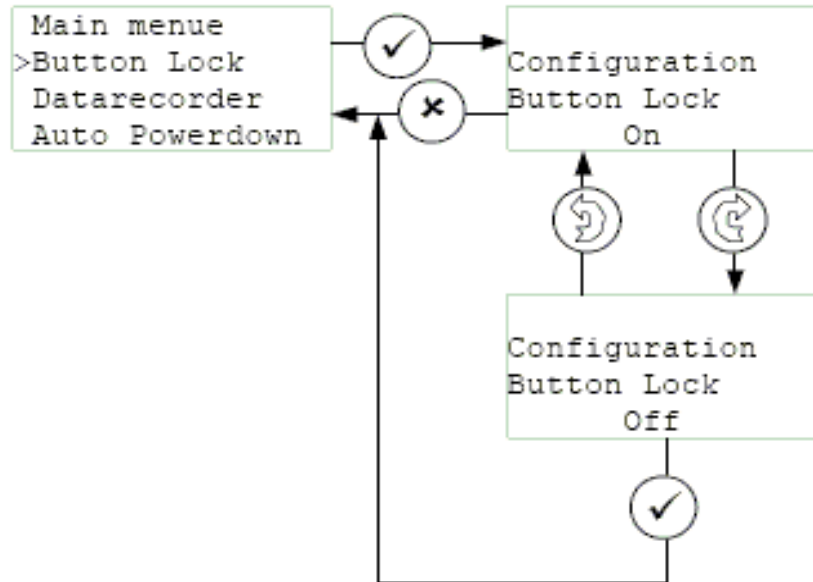
Normally the changing of configuration parameters by the press/rotary knob is locked (disabled). To change the parameter the press/rotary knob must be unlocked (enabled).

Note: If no operation is performed at the data logger for approx. 30 seconds it will return to the main menu and the press/rotary knob input will automatically be locked.

Network settings
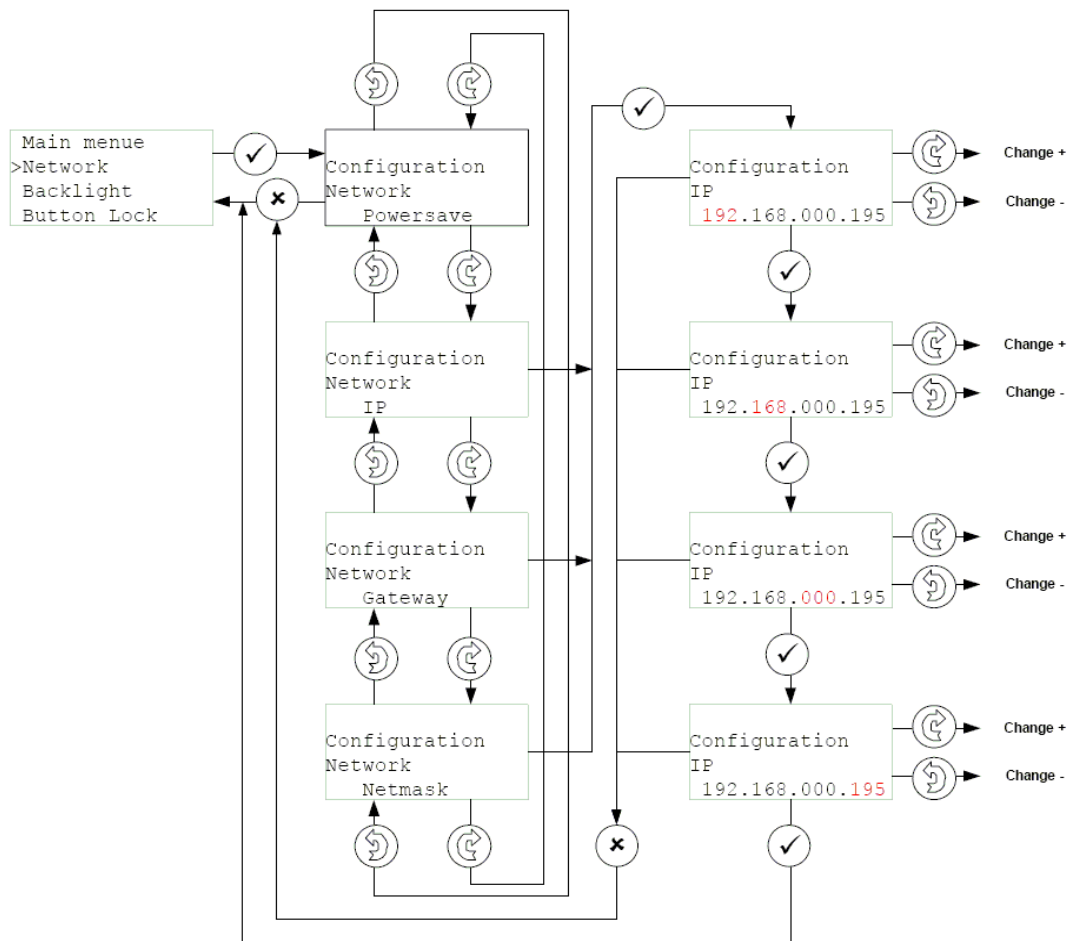
If the power save feature for the ethernet interface is enabled no connection can be established using this interface.

Due to the relatively high power consumption it is essential for low power applications like mobile battery powered systems to have the ethernet power save function enabled.

The IP, gateway and netmask selection modifies the selected address. The flashing number is actually selected for modification. Rotating the knob counts the number up or down while pressing the knob selects the next number.

Channels settings
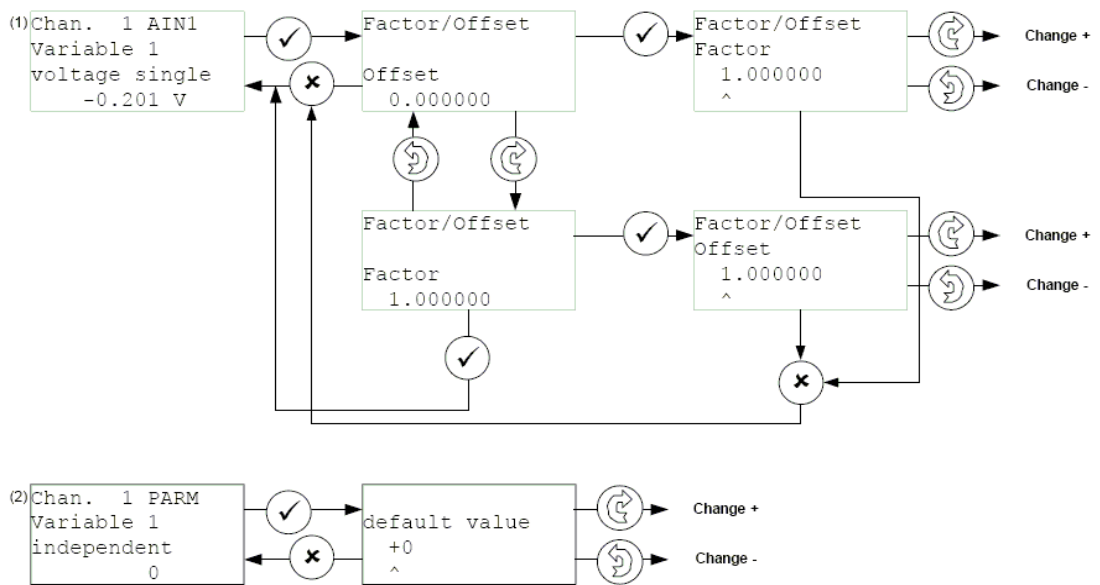
In order to change the values the press/rotary knob must be pressed. Thereby a cursor will be set on the first character of the value. Pressing the knob again moves the cursor one character to the right. The value at the place of the cursor can be altered by turning the knob. Clockwise (=upwards) or counter-clockwise (=downwards).

Note: Depending on the type of channel different settings can be made.

(1)   the definition of offset and factor is possible for the analogue input channel, the digital input channel and the digital output channel. These settings are used to convert the measurement value from the unit of the measured value to the unit of the measurement display.

(2)   For the setpoint channel a setpoint value can be defined if this is allowed by the configuration software *COMBILOG.EXE*. This value can be used by the data logger for further processing (e.g. for the arithmetic channel).

For the arithmetic channel and the alarm channel no settings can be made.

Display and delete the data memory

Main menu
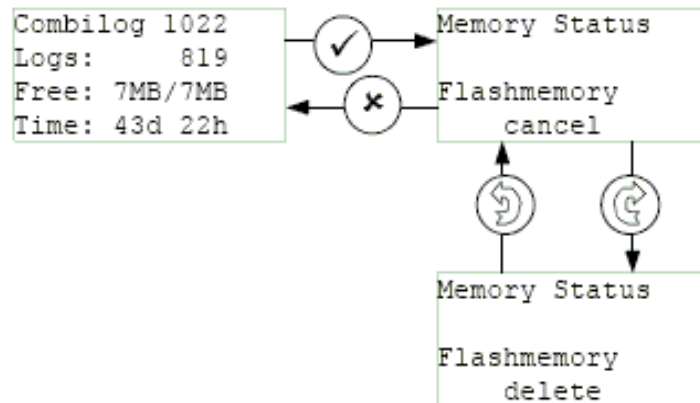
The display shows the number of stored datasets and the maximum capacity of the data memory. The fourth line shows the approximate time until the data memory is filled. This time is displayed in days (d) or hours (h) and is calculated by the data logger assumed that the average interval is constant.

Setting of the date and time
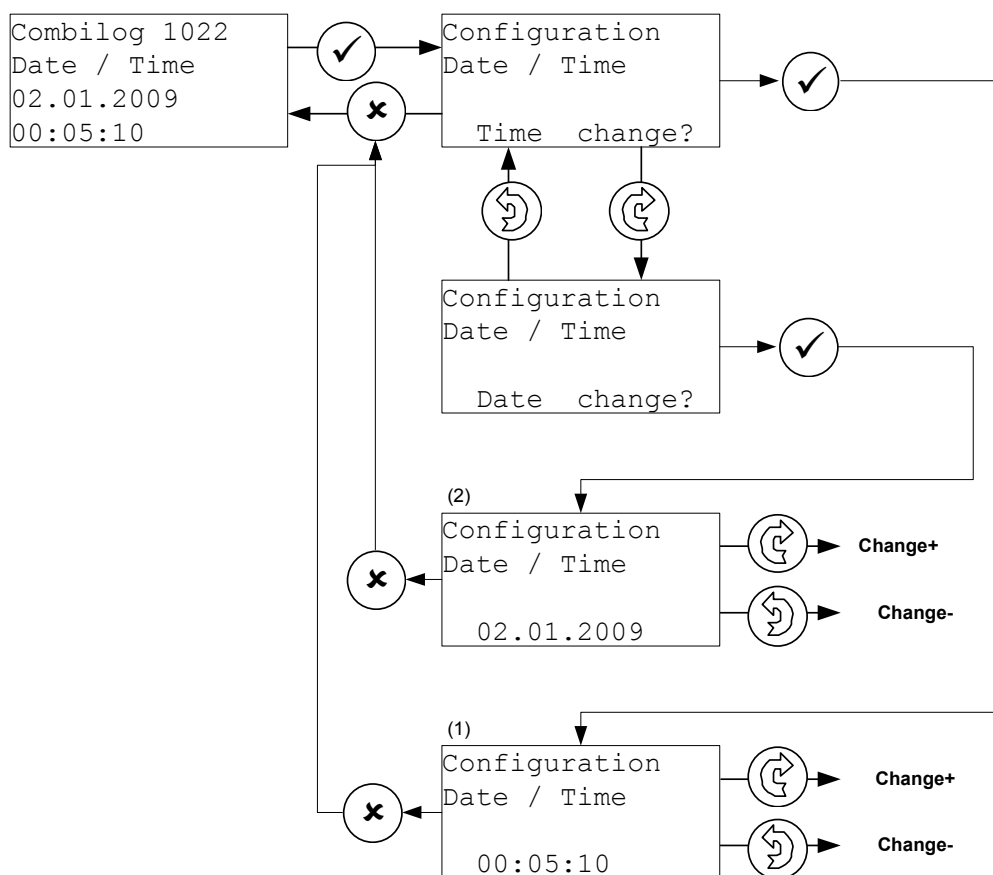
In order to change the date and the time the press/rotary knob must be pressed when the time[1] respectively date[2] is displayed. For this purpose a cursor will be set on the first character of the date respectively time indication. Pressing the knob again will move the cursor one character to the right. The value at the place of the cursor can be altered by turning the knob.

Note: The time will be stopped if the press/rotary knob is pressed in the main menu, date and time display. The time will continue running if the date or time setting is confirmed by pressing the knob.

6.3 SD-Card

If a SD-card is inserted into the card slot an additional menu item is displayed in the main menu. Choosing this menu item one can update the firmware of the data logger or eject the SD-card.

```
Main menue
>SD-Card
 Data recorder
 Auto Powerdown
```

```
SD-Card
>remove card
 update files
```

```
Updatefiles

COMBL.BIN
```

Change+

Change-

```
Do you want to
update with:
COMBL.BIN
      [Yes/No]
```

Change +

Change -

```
FIRMWARE
UPDATE
AND
RESTART
```
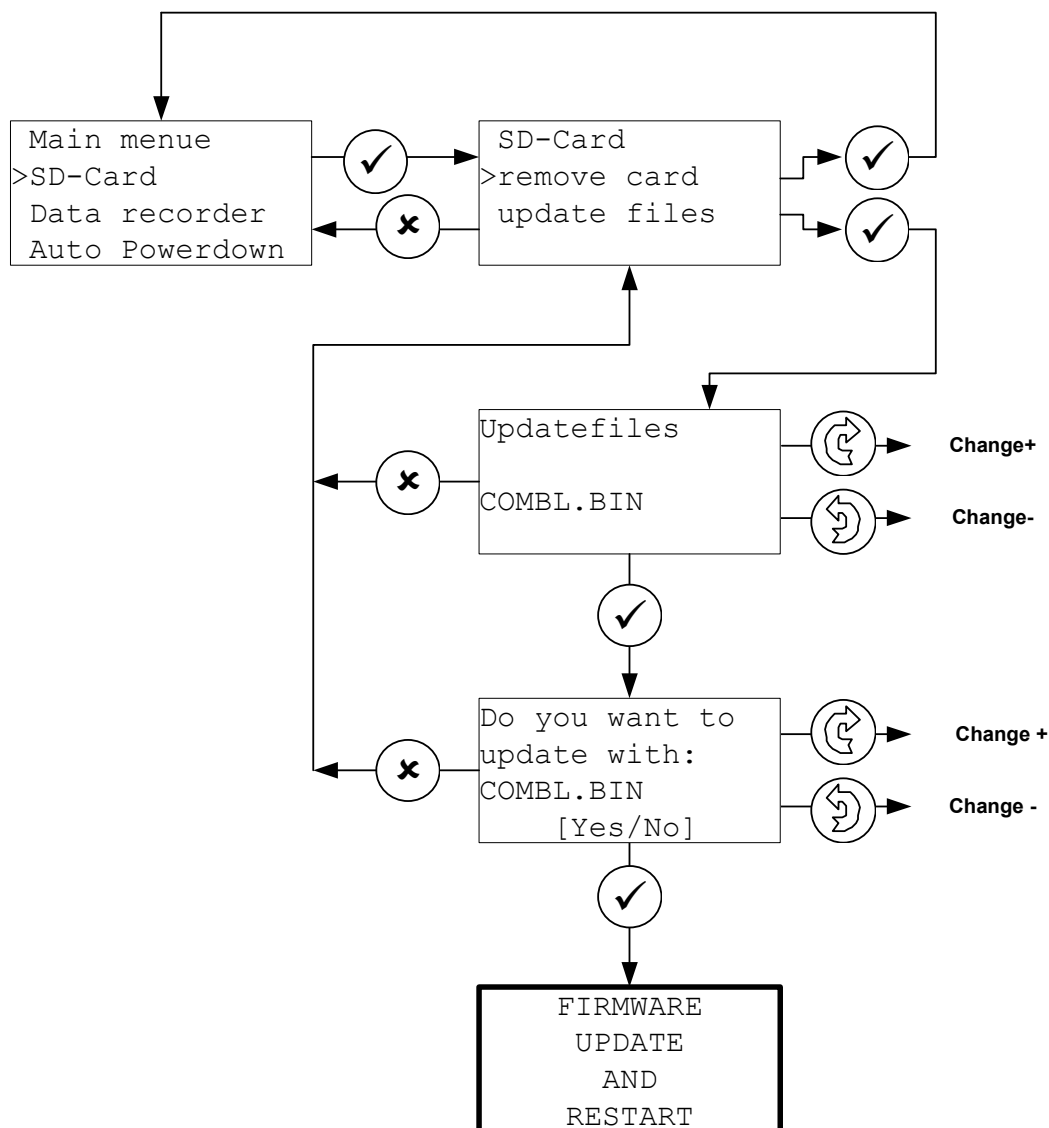
6.3.1 Remove Card

If a SD-card is configured as logging destination the card has to be logged off of the system before removing it. Otherwise written data can be lost.
For card removal you choose this menu item. The card will be logged out of the system without any further question.

6.3.2 Firmware Update

Using the menu item 'update files' one can start the firmware update procedure. Therefore a special firmware update file must reside in the directory 'updates' on the SD-card.
After choosing ' update files' all files in the directory 'updates' are presented for selection.
Selecting one file starts the update procedure after a security question. If the file contents for some reason seems to be corrupted, the firmware update stops. If there was no error during file checking the data logger starts the reprogramming and starts a system reboot during which the new image is written into the program flash.

Warning:
As a firmware update is a critical process a backup of all logged data and of the configuration is highly recommended!

Note: We recommend SD-Cards with a maximum storage capacity of 2GB.

7　DATA STORAGE

7.1　General Remarks to Data Storage

The *COMBILOG 1022* is able to store the calculated mean values. Data storage with the *COMBILOG 1022* can be accomplished in three different manners:

Internal flash: 7 MByte are available as circulated buffer for data recording.

External SD card: The records are continuously stored on this card.

Internal flash and external SD-card: The records are stored in parallel in the internal flash and on the external SD-Card.

7.2　Modes of Data Storage

No data storage
In this mode the *COMBILOG 1022* operates as measuring module, processes measuring values and sends the results to a PC upon command.

Continuous data storage
This is the normal operation of the data logger. The measured values, selected for storage, are continuously written to internal or external memory, with the preset averaging interval.

Conditional data storage

Measured values are stored in the memory as long as a condition defined by the *configuration program* is valid (e.g. a threshold is exceeded).

Conditional data storage with zoom function

In this mode two time bases for data recording are available. The selection between these time bases depends on a condition selected by the *configuration program.*

7.3   Storage Medium

The *COMBILOG 1022* has 3 storage modes.

- **Flash:** storage only in internal Flash
- **SD-Card:** storage only on external SD-Card
- **Flash & SD-Card:** data will be stored on both mediums

Note: The storage medium can be configured on the website. Have a look at section webserver.

7.4 Internal Data Storage

The *COMBILOG 1022* is delivered with 8 MByte flash memory. For data recording 7 MByte memory are available as circular memory (first in, first out). If the memory is read out, at first the oldest record will be output and the corresponding space is enabled.

The data memory can be read out via one of the serial interfaces. Communication commands are described in chapter 11.8.

Every record consists of a length information, date, time and measured values.

L	Time	M1	M2	...	Mx	S1	S2	…	Sx

L	Length of record (2 Byte)
Time	Date and time of record (8 Byte)
M1	First measured value (4 Byte)
M2	Second measured value (4 Byte)
Mx	Last measured value (4 Byte)
S1	First external channel (only with master function)
S2	Second external channel
Sx	Last external channel

Memory demand for one record:

Number of bytes = 8 + 4 * number of measured values

The duration of data recording until the data memory is filled can be calculated by the following formula:

$$d = \frac{7 * 1024^2 * M}{(8 + 4 * n) * 86400}$$

d =   duration of data recording in days
n =   number of values to be stored (without date and time)
M = averaging interval in seconds

Example:
Storage of eight measured values per minute.

Number of Bytes = 8 + (4 * 8) = 40 bytes per record
Memory demand per day = 24 * 60 * 40 = 57600 Bytes

At 7 MBytes internal flash 7 * 1024² * 60 / (40 * 86400) = 127,4 days can be recorded.

7.5   External Data Storage with SD Card

The data will be stored in a file on the SD Card. The name of the file depends of store mode. Three different modes of file storage:

Day file
Every day a new file will be created with the name consists of day, month and year.

Example: 02062008.csv
This file contained data from 2. June 2008

Month file
Every month a new file will be created with the name consists of month and year.
Example: 062008.csv
This file contained data from June 2008

Continues file
New data will be append to the file.
The name of the file: cl_log.csv

The file contain also additional information about channel configuration.
If the memory card is filled, no further data will be recorded.
Data recording is performed in ASCII format. A separation mark (";" or tabulator) and the decimal character ("." or ",") is selectable by the user.

Note: The data logger can write data to pre-formatted memory cards only. The data logger supports the FAT 32 file system.

Theodor Friedrichs & Co. delivers pre-formatted memory cards, that can directly used for the *COMBILOG*.

Structure of the data file:

Ident	Friedrichs V2.01 V4.01			
Location	COMBILOG			
Serial No	123456			
Sample Rate	1			
Slowest	1			
Fastes	1			
Store Rate	60			
Date Time	Variable 1	Variable 2	...	Variable n
02.06.2008 12:01:48	3.45	1.28	...	3.44
02.06.2008 12:01:48	3.45	1.28	...	3.44
02.06.2008 12:01:48	3.45	1.28	...	3.44
02.06.2008 12:01:48	3.45	1.28	...	3.44

Structure of a record:

T	Time	T	M1	T	M2	T	...	T	Mx	T	S1	T	S2	T	...	Sx	CR	LF

T	Separation mark (Tabulator or ";")
Time	Date and time of the data record (DD.MM.YY HH:MM:SS)
M1	First measured value
M2	Second measured value
Mx	Last measured value
S1	First external channel
S2	Second external channel
Sx	Last external channel
CR	Carriage Return
LF	Line Feed

Note: With the Configuration program a ";" or a "TAB" (ASCII 09hex) can be selected as delimiter and a ":" or a ";" is selectable as decimal point.

Memory demand for one record:

NumBytes = 20 + field length (M1) + 1 + field length (M2) + 1…
+ field length (Sx) +1

NumBytes = 20 + number of measured values * (8 +1)
(fixed field length of 8 characters)

Example:

Storage of eight measured values per hour:

NumBytes = 20 + 8 *(8 + 1) = 92 bytes per record

Memory demand per day = 24 * 92 = 2208 bytes

Following equation can be used:

$$d = \frac{k * M}{l * 86400}$$

d = period of data recording in days

k = capacity of the memory card in byte

l   = length of one data set in byte

M   = average interval in seconds

8 MASTER FUNCTION

8.1 Master Function

The two interfaces and the master function of the *COMBILOG 1022* allows a configuration of a complex measurement system. In such a system with activated master function the data logger as master is able to read out the other bus users (slaves)

This feature is used to extend the number of inputs and outputs of the *COMBILOG 1022* in case the 8 analogue inputs and 6 digital inputs/outputs of the data logger are not sufficient. Other *COMBILOG 1022* can be connected to the RS-485 interface as slaves. The master data logger reads out the measured values (actual instantaneous values only!) of the slave modules automatically via the bus and stores them in its memory. By this method complex systems to record up to 92 channels can be realised easily.

The advantage of this master function is a flexible distribution of a number of inputs and outputs and the sensors can be located in an area over some kilometres. The data storage is central in the master data logger.

These data can be read out directly via the RS232 interface or via telephone or GSM modem.

Arrangement of such a measurement system with *COMBILOG 1022* and slave modules is described by following steps:

❑ Configure all slave modules with the same bus parameters as the master data logger (same protocol type, same baud rate and parity). All modules must have different modules addresses.

❑ Connect the master data logger via RS232 with the host PC and start the configuration program.

❑ Set the bus parameter for the master function with *module settings.* Baud rate is selectable between 2400 and 38400 bps and independent of the settings of the RS232 interface.

❑ Select all values to be measured by the master data logger by defining the module address and the channel number of the corresponding slave module. Up to 60 external channels can be selected.

❑ Connect all slave modules with the master via the RS485 bus. After downloading the configuration to the master data logger the data transmission between master and slave modules is started.

Note, that the configuration of slave modules is not possible after activating the master function.

All collected slave values will be added to the normal dataset, that is defined by the logging function of the master. No further calculation (averaging etc.) is executed. If averaging is necessary, use the *read* function of the arithmetic channel!

The scan rate corresponds to the "Logging Interval"

Within one RS485 bus system, only one *COMBILOG 1022* can be defined as master.
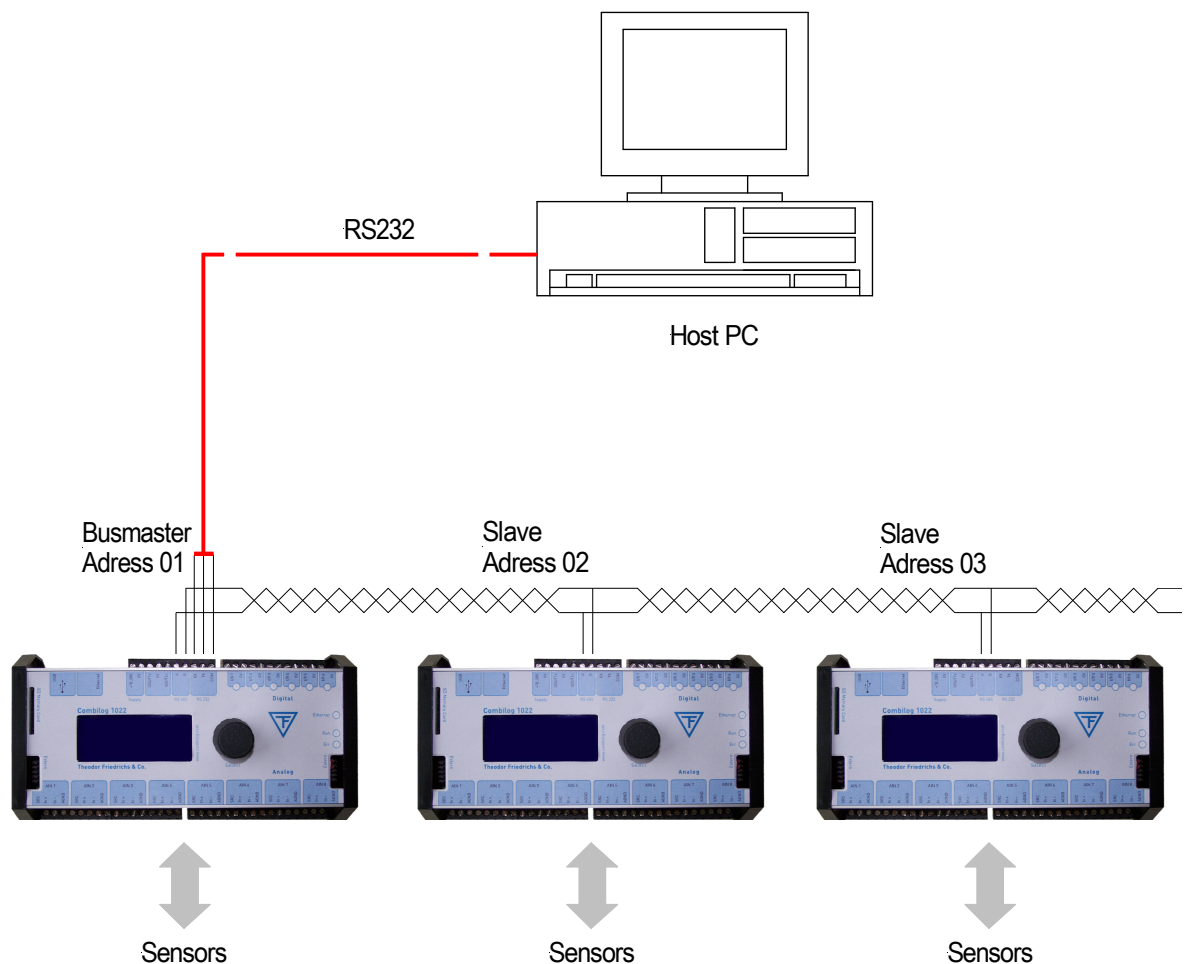
Figure 8.1   Example Master Slave System

9 INITIATION AND TEST

9.1 Before Connecting the Device

Before connecting the supply voltage to the data logger *COMBILOG 1022*, once again check all connections. Watch that the supply voltage never exceeds 28 VDC.

9.2 After Connecting the Device

After connecting the supply voltage the data logger displays the current operating state on the two LEDs at the front of the device (if the LED-display has not been switched off). The meanings of the LEDs are given in table 9.1 on the following page.
If the module was switched off for a longer time, the settings of date and time should be checked and corrected if necessary (see chapter 6.2).

9.3 Configuration of the Data Logger

Before entering into operation the data logger has to be programmed and configured as to its specific application. In most cases the programming has already been carried out on delivery (see status of RUN-LED and ERR-LED, table 9.1). The configuration has to be carried out by the user by means of the configuration software *COMBILOG.EXE* on a PC. The installation procedure is described in APPENDIX E.

RUN (green LED)	ERR (red LED)	meaning
off	off	The supply voltage has been selected too low or the power supply cannot supply the required power.
	flash	The data logger is in the monitor mode. A valid program has not yet been loaded; the appliance is not yet ready for operation.
	on	There is a sensor error detected. Possible causes may be: 1. wrong configuration, 2. line break or short circuit, 3. measured value too high or too low.
flash	flash	The data logger is in the download mode. Currently a program or a configuration is transmitted to the data logger.
on	off	The supply voltage has been connected correctly. There is no error. Data transmission to the module via bus is not active.
	on	There is a sensor error detected. Possible causes may be: 1. wrong configuration, 2. line break or short circuit, 3. measured value too high or too low.
short off	X	A telegram has just been dispatched from the data logger via the bus to a control system or to a PC.

Table 9.1   Assignment of LED functions (flash frequency approx. 1Hz)

10   STRUCTURE OF THE BUS TOPOLOGY

The coupling of the data logger *COMBILOG 1022* to a communication bus is performed via an integrated RS485 interface. The second interface, the RS232 computer interface, is only usable in order to build point-to-point connections for a distance of max. 20 m (65 feet). At the *COMBILOG 1022* the same data will permanently be given out. Only the physical characteristics of the two interfaces are different whereas only those of the RS485 are appropriate in order to build a bus topology. The RS485 bus topology is characterized by the following features:

❑ *Bus interface:*
RS485, half duplex

❑ *Bus topology:*
line pattern, closed at both ends by the characteristic impedance, stub cable to the party max. 30 cm (12 inch).

❑ *Bus medium:*
shielded, twisted pair cable

❑ *Transmission speed:*
ASCII-protocol:
- 2400 Bit/s
- 4800 Bit/s
- 9600 Bit/s
- 19200 Bit/s
- 38400 Bit/s

❑ *Line length:*

depends on the transmission speed, max. 1.2 km (0.75 miles) per bus segment, max. 4.8 km (3 miles) via a physical bus string with 3 repeaters.

❑ *Number of bus users:*

max. 32 bus users per bus segment, max. 127 bus users via a physical bus string.

10.1   Bus Interface

The bus interface in the data logger is an RS485 interface. Its advantages compared with RS232 connections are a larger number of users, its higher transmission speed, its higher immunity from interferences and the extended line length.
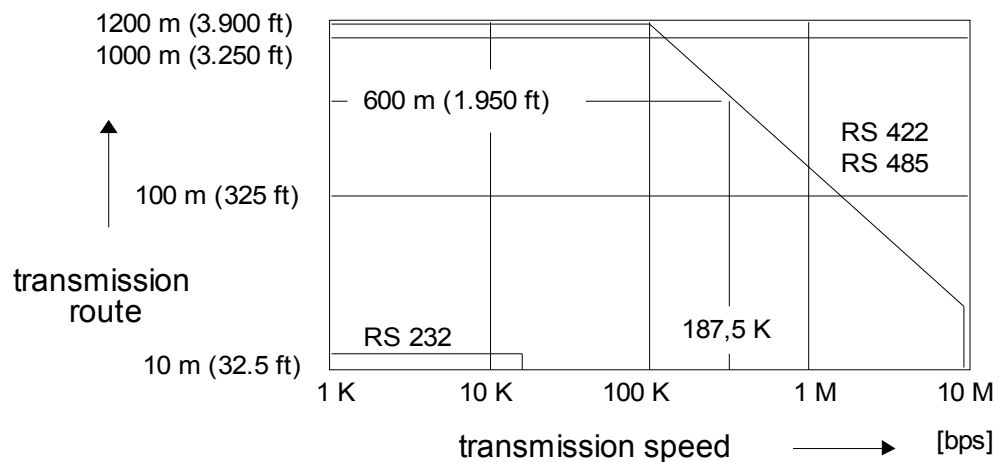
Figure 10.1   *Interrelation between transmission speed and line length*

10.2   Bus Structure

The bus structure is a line structure where each bus segment will be blanked off with characteristic impedance on both ends. Branches can be build up over a bi-directional signal amplifier, so called repeater. Other than that branches are not permitted (no tree topology). The max. stub to a user is not allowed to exceed 30 cm (12 inches).

The following figures show a few examples for a possible set-up of bus topologies. The meaning of the symbols is:

☐ : bus user
▨ : repeater
■ : bus termination
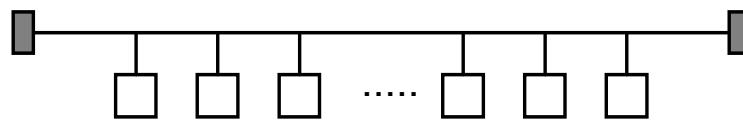
Figure 10.2   Simple line structure
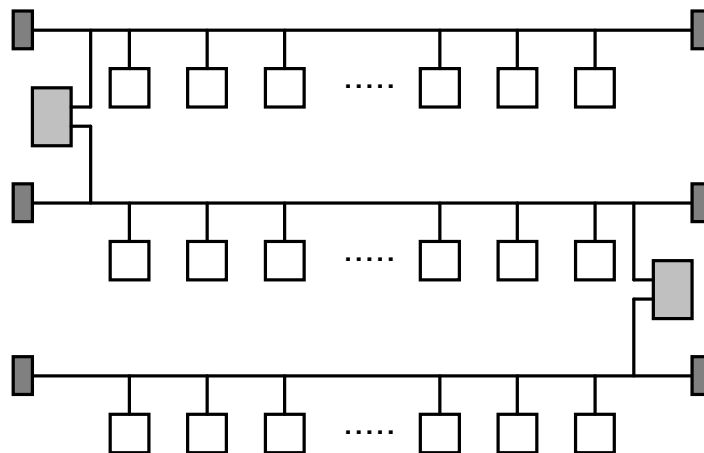
Figure 10.3   Extended line structure
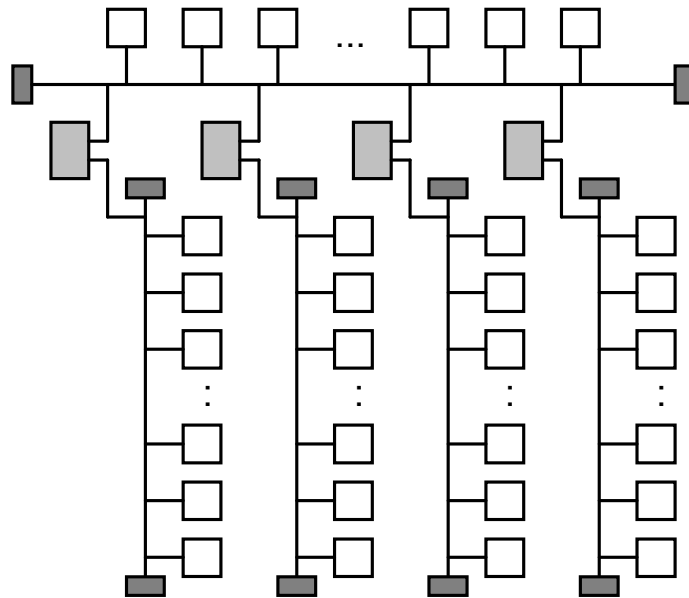
Figure 10.4 Line structure with branches

The RS485 interface permits the simultaneous connection and operation of a maximum of 32 bus users per bus segment. Further bus segments can be constituted via bi-directional repeaters, and thus the number of bus users can be extended to max. 127.

10.3 Transmission Speed and Line Length

The transmission speed with the data logger *COMBILOG 1022* can be adjusted between 2,400 baud and 38.4 kbps. The permissible line lengths are reduced with increasing transmission speed. At the given transmission speeds these line lengths are about 1,200 m (3,900 feet) per bus segment. With 3 repeaters topologies with a dimension of max. 4.8 km (3 miles) can be set up.

Note: These specifications refer to bus cables with a conductor cross section of 0.22 mm² and a permissible signal attenuation of max. 6 dB referred to the overall length. According to previous experience the line length can be twice as long if a two-wire circuit with a conductor cross section of at least 0.5 mm² is used.

10.4　Bus Cable

For setting up a bus topology a shielded twisted pair with at least two leads and the following electric characteristic values should be used:

- ❑ characteristic impedance : 100 ... 130 Ω at f > 100 kHz
- ❑ operating capacity : max. 60 pF/m
- ❑ conductor cross section : min. 0.22 mm² (AWG 24)
- ❑ attenuation : max. 6 dB referred to the overall length

10.5 Bus Plug

For installing the bus cable and the bus interface, 9-channel D-sub miniature plugs and sockets are used. The pin assignment for the RS485 connection according to PROFIBUS/MODBUS specification is given in table 10.2.
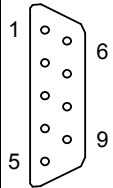
Plug	Pin	RS485 notation	Meaning Profibus	Meaning Modbus
	1		Shield, Protective Ground	
	2		RP, Reserved for Power	VP, positive 5...24 V D.C. Power Supply
	3		RxD/TxD-P, Receive / Transmit Data-P	PMC, Port Mode Control
	4		CNTR-P, Control-P	
	5	B / B´	DGND, Data Ground	B/B´, transceiver terminal 1, V1 voltage (V1 > V0 für binary 1 [OFF state])
DB 9	6		VP, Voltage Plus	
	7		RP, Reserved for Power	
	8	C / C´	RxD/TxD-P, Receive / Transmit Data-N	C/C´, signal and power supply common
	9	A / A´	CNTR-N, Control-N	A/A´ transceiver terminal 0, V0 voltage (V0 > V1 for binary 0 [ON state])

Table 10.2   Pin assignment D-sub miniature plug according to

PROFIBUS / MODBUS

Only signal leads A and B (and Shield) are absolutely obligatory for a (shielded) connection. All others can be installed together with these signal leads if required.

10.6 Bus Termination

In order to avoid signal reflections on the bus, each bus segment has to be blanked off at its physical beginning and at its end with the characteristic impedance. For this purpose, a terminating resistor Rt is installed between the bus leads A and B. An additional pull-down resistor between ground (Data Ground) and the bus lead A and an additional pull-up resistor between potential (VP) and the bus lead B are not set when *COMBILOG 1022*. Only the termination resistor Rt needs to be connected.
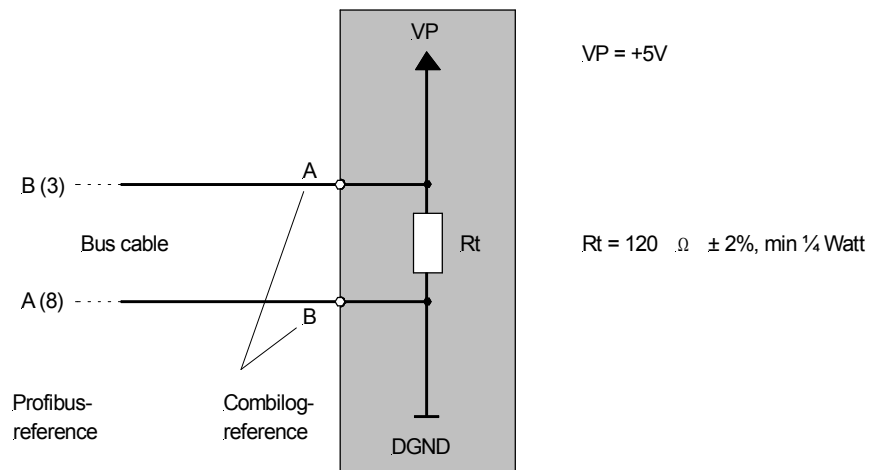
Figure 10.5   Bus termination

Note: The numbers in brackets in figure 10.5 indicate the pin number for the connection via the 9-channel D-sub miniature plug.

The bus termination can be carried out in various ways.
It can either be carried out via external resistors and a separate power supply, independent of the module, according to figure 10.5. In this case we recommend to use the indicated resistor for the bus termination.

Or the bus termination is connected with the bus users at the beginning and at the end of a bus line. Most of the RS485 connections for controls, computers, repeaters, interface converters, etc. offer this option.

Also with data logger *COMBILOG 1022* this option is given. Via a jumper, which has to be mounted on the right or left connector on the front panel, the bus termination at the data logger can be switched on. In Figure 10.6, the right bus is shown. The left bus has an identical layout.
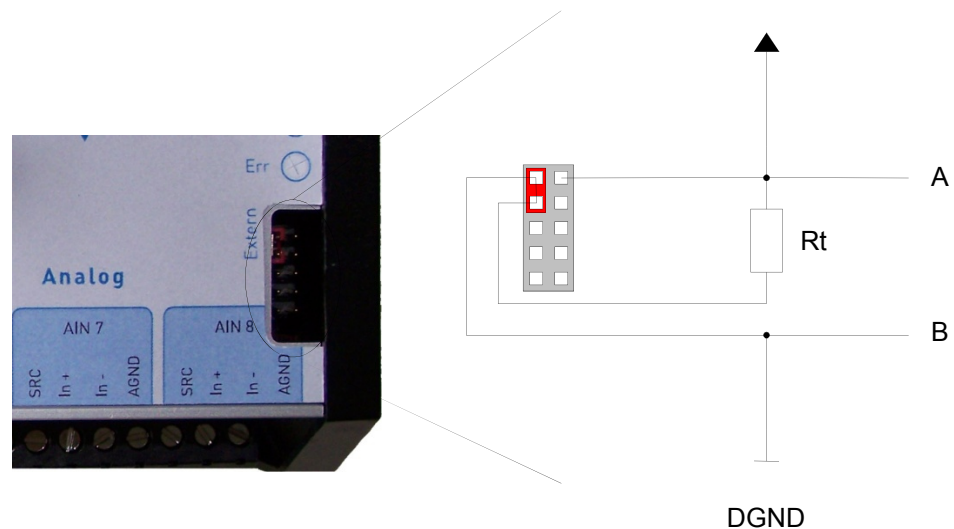
Figure 10.6   Bus termination on the COMBILOG 1022

Note: In the case of using jumpers, please make absolutely sure that the jumper clips are installed as indicated in Figure 10.6, and that the bus leads or the bus termination are not short-circuited by mistake!

10.7   Shielding

In case of increased interference we recommend to use shielded bus cables. In this case, a shielding should also be carried out for the cables from power supply and for the signal cables.

There are varying experiences and recommendations concerning the kind of shield connection. In general the shield should be connected with the protector ground (not data ground!) at each bus connection. If necessary the shield should be earthed additionally several times along the course of the cable. With smaller distances, e.g. with stub cables, the immunity from noise often is improved if the shield is only applied to the stub cable exit.
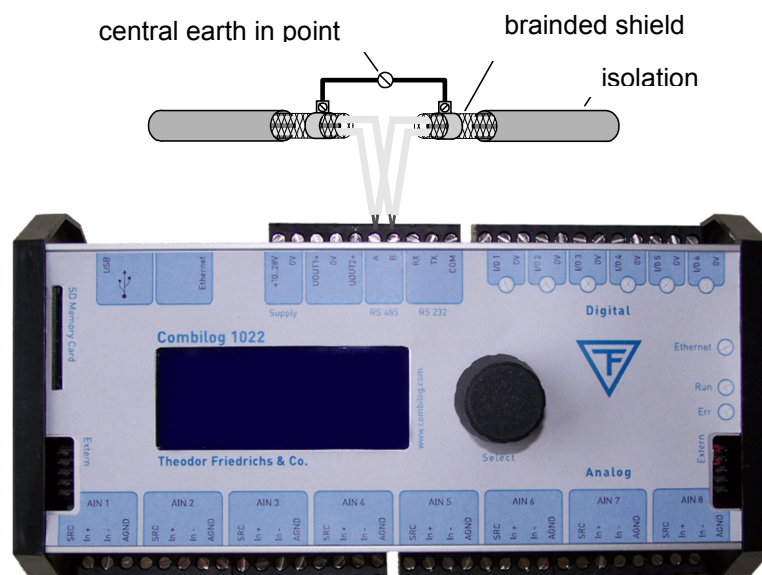
Figure 10.7   Earthing of the bus line shield on the COMBILOG 1022

Bus parties such as controls (PLCs), computers (PCs), repeaters and interface converters, a.s.o., mostly offer the possibility of applying the shield directly to the appliance or to separate shield rails. The shield rails offer the advantage of preventing possible interfering signals from being led to the appliance via the shield. These are already branched off before via the protector ground.

The *COMBILOG housing* has no direct shield terminals. The shield of the bus cable can be earthed e.g. by so-called shield clamps.

Note: The shield must not be connected to bus interfaces A or B!

Note: The shield should always be connected to earth in a large surface, low-inductive manner.

10.8   PC Bus Connection

The bus interface of the data logger is based on the RS485 standard. Since most of the hosts are "only" equipped with RS232 interfaces, an interface converter or a plug-in board with RS485 drivers is required for conversion purposes.

Theodor Friedrichs offers a compact interface converter.

Furthermore a repeater module is available from *Theodor Friedrichs.* This module can be used as a repeater or as a converter. It also enables to connect the necessary bus termination with a switch. The *repeater/converter* has a snap-on mounting for installation on standard profile rails (DIN rail) 35 mm (1.4 inch) according to DIN EN 50022.

10.9 Potential Equalization

The difference between the actual physical voltage potentials DGND of all connections with the bus must not exceed ±7 Volt. If this cannot be guaranteed, an equalization has to be provided. For most of the connections this means that the minus connection of the power supply has to be fed-through as a compensating line from connection to connection.

10.10 Adjustment of Address and Baud Rate

Before a control unit (PLC) or a computer (PC) can interchange data with a data logger via the bus, address and baud rate for the data logger have to be defined. Following hints have to be considered:

❑   All devices have to be adjusted to the same baud rate.
❑   Within the bus topology the same address must not appear twice.

bus parameter	ASCII-protocol / MODBUS-Protocol	PROFIBUS-protocol
address	1 127	1 126
baud rate	2,400 bps	-
	4,800 bps	-
	9,600 bps	9,600 bps
	19,200 bps	19,200 bps
	38,400 bps	-

Table 10.3   Setting variants for address and baud rate

for the data logger COMBILOG 1022

If no other specifications are made on delivery, the data logger has address 1 and baud rate 19,200 bps, no parity as default. The adjustment can be changed via bus by means of the configuration software *COMBILOG.EXE:*

Adjustment via bus by means of the configuration software:
The condition for adjusting address and baud rate via bus is that there are no different data loggers with the same address on the bus. Otherwise the bus connection has to be disconnected or the supply voltage has to be interrupted for the duration of the adjustment with those data loggers having the same address as the data logger that is to be newly adjusted. The data logger to be newly adjusted does not necessarily have to be set to the same baud rate as the PC, as the adjustment procedure is accomplished as described below:

The adjustment or modification of address and baud rate via bus is always carried out together with the loading of a new configuration by means of the configuration software *COMBILOG.EXE.* The download is carried out as described in the online help for the configuration software. The LEDs at the front indicate which data logger is being newly adjusted at the moment. If the LED *ERR* changes from "off" to "flash", a new program is just being transmitted to the data logger. The values are taken over as soon as the data transmission via bus has been successfully completed.

Note: The address "0" is reserved for transmission via PROFI-BUS. This address can therefore not be assigned to a logger.

Note: The address "127" is reserved for broadcast transmission in the PROFIBUS-protocol (Level 2) and may only be assigned for these cases.

Adjustment via Interface, RS232 by means of the configuration software:

In addition to the bus interface RS485, the data logger *COMBILOG 1022* has an RS232 computer interface. By means of the configuration software *COMBILOG.EXE* addresses can be assigned and bus parameters can be adjusted via the RS232 interface similarly as when using the RS485 interface.

11   COMMUNICATION

11.1   Bus Interface

The bus interface of the data logger is an RS485 interface according to the specifications of the EIA-RS485 USA standard. The host interface is an RS232 interface according to the specifications of the EIA-RS232.

11.2   Bus Protocol

The following protocols are available for the data logger *COMBILOG 1022:*
- ❑   ASCII-protocol
- ❑   PROFIBUS-protocol (Level 2) according to DIN 19245, part 1
- ❑   MODBUS-RTU-protocol according to PI-MBUS-300 Rev. D

The ASCII protocol can be operated simultaneously with the PROFIBUS or the MODBUS protocol. The binary protocols PROFIBUS and MODBUS can only be used exclusively. You can select the desired binary protocol through a web page.
The ASCII protocol and the PROFIBUS protocol will be delivered as standard.

11.3   Data Format

The data logger *COMBILOG 1022* supports following data formats:

For-mat	Start-bit	Data-bit	Parity-bit	Stop-bit	Character length	ASCII / Modbus	Profibus
8N1	1	8	N	1	10	X	
8E1	1	8	E	1	11	X	X
8O1	1	8	O	1	11	X	
8N2	1	8	N	2	11	X	
8E2	1	8	E	2	12	X	
8O2	1	8	O	2	12	X	

Table 11.1   Supported data transfer formats

The data format 8E1 with even parity (E=even) corresponds to the PROFIBUS-definitions according to DIN 19245, part 1, and is supported by the data logger both in the PROFIBUS-protocol and in the ASCII- and MODBUS-protocol. This data format should therefore generally be selected for the transmission.

For modem connections, which in most cases can be carried out without a parity-bit, the second data format is available. This data format is only supported by the ASCII-protocol and the MODBUS-protocol.

The data format is defined via configuration software *COMBILOG.EXE*. If there are no other specifications, the default adjustment is "no parity".

11.4 Output Format

The data format can be user defined by means of configuration software *COMBILOG.EXE*. The data logger adjusts the data formats accordingly and makes sure that the data are available in the selected unit.

For transmission in ASCII-format, the format settings listed in table 11.2 can be chosen. By transmission in MODBUS-format the output format (integer or real) is recognised automatically (table 11.4). The Coding of a real value in MODBUS-format is as follows:

Coding of the real value: $x =$ s ee...ee mmm.....mmm

Value: $(-1)^S \cdot 2^{e-127} \cdot 1,m$ # : <1> <- 8 -> <----- 23 ---->

Value (0 < e < 255): $(-1)^{S} * 2^{e-127} * 1,m$

Value (e=0): $(-1)^{S} * 2^{e-126} * 0,m$

format settings	range of values
unit	dependent on sensor
field length	1 8
decimals	0 . . . field length-1 (max. 6)

Table 11.2   Format settings for transmission in ASCII-format

format settings	length	range of values
b o o l	1 Byte	(dez 0: FALSE) und (dez 255: TRUE)
integer	2 Byte	(dez - 32768) $\leq$ i $\leq$ (dez +32767)
r e a l	4 Byte	(dez - 2^{129}) $\leq$ x $\leq$ (dez + 2^{129})
SET 8	1 Byte	(dez 0) $\leq$ i $\leq$ (dez 255)

Table 11.3   Format settings for transmission in PROFIBUS-format

format	length	range of values
integer	2 byte	$(\text{dec} - 32768) \leq i \leq (\text{dec} +32767)$
Real	4 Byte	$(\text{dec} - 2^{129}) \leq x \leq (\text{dec} + 2^{129})$

Table 11.4   Format settings for transmission in MODBUS-format

Example: The value 50.3094 is to be displayed.

Transmission in ASCII-format:

decimals	field length 6	field length 7	field length 8
0	_ _ _ _ 5 0	_ _ _ _ _ 5 0	_ _ _ _ _ _ 5 0
1	_ _ 5 0 . 3	_ _ _ 5 0 . 3	_ _ _ _ 5 0 . 3
2	_ 5 0 . 3 1	_ _ 5 0 . 3 1	_ _ _ 5 0 . 3 1
3	5 0 . 3 0 9	_ 5 0 . 3 0 9	_ _ 5 0 . 3 0 9
4	E . 3 0 9 4	5 0 . 3 0 9 4	_ 5 0 . 3 0 9 4
5	-	E . 3 0 9 4 0	5 0 . 3 0 9 4 0
6	-	-	E . 3 0 9 4 0 0

Table 11.5   Output formats for transmission in ASCII-format ("_":blank).

Transmission in PROFIBUS and MODBUS-format:

decimals	bool	integer		real	
0	-	00 32	(50)	42 49 3C D3	(50.3094)
1	-	01 F7	(503)	42 49 3C D3	(50.3094)
2	-	13 A6	(5030)	42 49 3C D3	(50.3094)
3	-	xx xx	(50309)	42 49 3C D3	(50.3094)
4	-	xx xx	(503094)	42 49 3C D3	(50.3094)
5	-	xx xx	(5030940)	42 49 3C D3	(50.3094)
6	-	xx xx	(50309400)	42 49 3C D3	(50.3094)

Table 11.6   Output formats for the transmission to PROFIBUS /
MODBUS-format
(the decimal notation is given in brackets).

Following points have to be considered, referring to the above example:

❑ Decimals are not cut off, but are rounded off.

❑ In case of overflow with a transmission in ASCII-format the identification key "E" (for Format Error) is given at the first position in the transmission format.

❑ With transmission in MODBUS-format no identification key is given in case of overflow. The number of decimals must, however, not be selected too large, if the value is to be transmitted in integer-format (range of values in integer-format limited to -32768 to +32767).

11.5   Transmission Sequence

The data are transmitted from and to the data logger with following sequence:

ASCII-Protocol
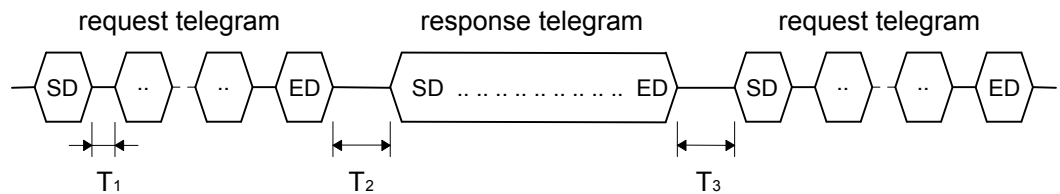
Profibus-Protocol
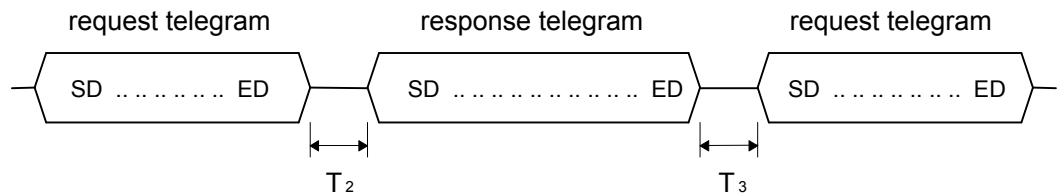
Modbus-Protocol
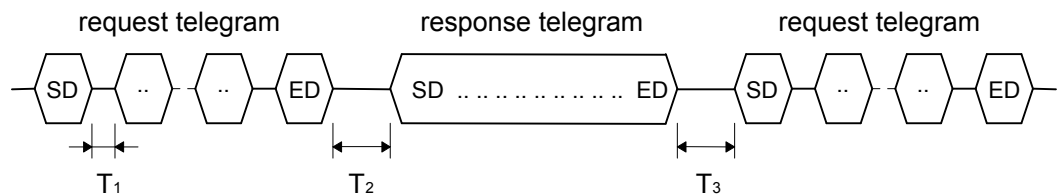
T1:   time between two characters

T2:   time between last character of request-telegram and first character of corresponding response-telegram

T3:   time between last character of response-telegram and first character of next request-telegram

Minimum and maximum appearing values for periods T1, T2 and T3 and the adjustment ranges are given in table 11.6.

protokol	baudrate	T1 min	T1 max	T2 min	T2 max	T3 min	T3 max
adjustable		no	yes	yes	no	no	yes
A S C I I	2400 bit/s 4800 bit/s 9600 bit/s 19200 bit/s 38400 bit/s	0	1 CT	1... 5 CT 1..11 CT 1..23 CT 1..42 CT 1..85 CT	T2 min x 1.2	3 CT	0.1 s to 600 s
P R O F I B U S	2400 bit/s 4800 bit/s 9600 bit/s 19200 bit/s 38400 bit/s	0	0	1... 5 CT 1..11 CT 1..23 CT 1..42 CT 1..85 CT	T2 min x 1.2	3 CT	0.1 s to 600 s
M O D B U S	2400 bit/s 4800 bit/s 9600 bit/s 19200 bit/s 38400 bit/s	0	1,5 CT	3,5 CT	T2 min x 1.2	3,5 CT	0.1 s to 600 s

Table 11.7   Values and adjustment range for periods T1, T2 and T3
(CT: character time: 1 CT = character length [bit] / baud rate [bps])

Note: In the ASCII-protocol T_{2max} is at least 12 msec. In the PRO-FIBUS and MODBUS protocol T_{2max} is at least 2 msec.

The values for T_{2min} and T_{3max} and the behaviour of the data logger if the time T_{3max} is exceeded (communication timeout, see also chapter 5.8, error handling) can be adjusted by means of the configuration software *COMBILOG.EXE*. The default values for T_{2min} is 1 CT and for T_{3max} 60 sec.

11.6   ASCII protocol

11.6.1   Telegram Format for the ASCII Protocol

For the request-and response telegrams the ASCII-protocol distinguishes between telegrams without and with check sum. The telegrams are characterized with different start-delimiters (SD). A request telegram without a check sum will lead to a response telegram which also contains no check sum. The same applies to for requests with check sum, accordingly. Furthermore there are two short telegrams with the length of one character each to perform a positive or negative acknowledgement.

request telegram without checksum:
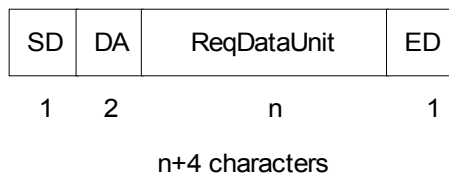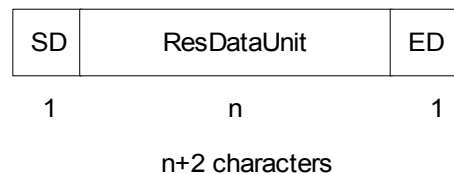
SD	DA	ReqDataUnit	ED
1	2	n	1

n+4 characters

response telegram without checksum:

SD	ResDataUnit	ED
1	n	1

n+2 characters

request telegram with check sum:

SD	DA	ReqDataUnit	FCS	ED
1	2	n	2	1

n+6 characters

response telegram with checksum:

SD	ResDataUnit	FCS	ED
1	n	2	1

n+4 characters

Positive Acknowledge

ACK
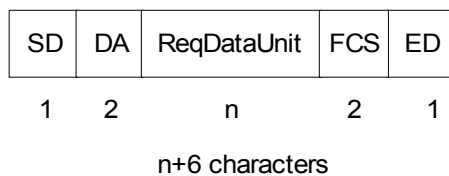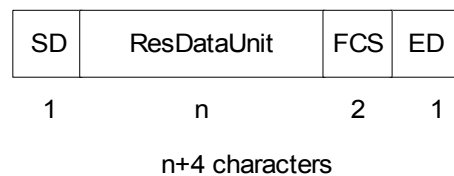
1 character

Negative Acknowledge

NAK

1 character

SD: *Start-Delimiter (length = 1 byte):*

The Start-Delimiter SD marks the beginning of a telegram. It assumes the following values in an ASCII-protocol:

SD	request telegram	response telegram
with check sum	#	>
without check sum	$	=

Table 11.8   Start-Delimiter (SD) in the ASCII-protocol

DA: *Destination-Address (length = 2 byte):*

The Destination-Address DA identifies the communication partner's address, to whom data shall be transmitted or from whom data shall be requested. Destination-Address can assume values from 1 to 127 in an ASCII-protocol. The value is here given as a two-digit ASCII-string (ASCII "01".."7F").

ReqDataUnit: *Request-Data-Unit (length = 1 ... n byte):*

The Request-Data-Unit identifies a data field in the request telegram, which contains the data for the communication partner with the DA address.

ResDataUnit: *Response-Data-Unit (length = 1 ... n byte):*

The Response-Data-Unit identifies a data field in the response telegram, which contains the data for the calling communication partner.

FCS: Frame-Check-Sequence (length = 2 byte):

The Frame-Check-Sequence FCS identifies the running digital sum of the telegram. This is the sum of the ASCII-values in the telegram *modulo* 256. It is calculated in the ASCII-protocol from Start-Delimiter (SD), Destination Address (DA) and Data-Unit: CheckSum_ASCII = [SD+DA+DataUnit] *mod* 256. In the ASCII-protocol the value is given as a two-digit ASCII-string (ASCII "00"..."FF").

ED: End-Delimiter (length = 1 byte):

The End-Delimiter ED identifies the end of the telegram. In an ASCII-protocol it has the value *hex* 0D ("Cr").

ACK: Acknowledge (length = 1 byte):

With a request, where no data are returned, the correct execution of the instruction is acknowledged by an "Acknowledge"-character (*hex* 06).

NAK: No-Acknowledge (length = 1 byte):

When a request has not been performed correctly, a "No Acknowledge" (*hex* 15) is sent back.

11.6.2 Instruction Set in the ASCII-Protocol

Check sum	request telegram	reply with orderly performance	reply in case of error
read device identification			
with	# aa V cc <cr>	> v..v cc <cr>	NAK
read device information			
with	# aa S cc <cr>	> s..s cc <cr>	NAK
read status information			
with	# aa Z cc <cr>	> z..z cc <cr>	NAK
read channel information			
with	# aa B kk cc <cr>	> i..i cc <cr>	NAK
read data from one channel			
with	# aa R kk cc <cr>	> d..d cc <cr>	NAK
write data to a channel			
with	# aa W kk d..d cc <cr>	ACK	NAK
reset / tare a channel			
with	# aa D kk cc <cr>	ACK	NAK
Read the events from pointer 1			
with	# aa E cc <cr>	> 1 b..b cc <cr> > 0 e cc <cr>	NAK
Repeat reading the events from pointer 1			
with	# aa F cc <cr>	> 1 b..b cc <cr> > 0 e cc <cr>	NAK
Pointer setting (1) to top of memory			
with	# aa C cc <cr>	ACK	NAK
Pointer setting (1) to a certain date			
with	# aa C t..t cc <cr>	ACK	NAK
Pointer setting (1) to position x			
with	# aa Cx..x cc <cr>	ACK	NAK
Read the events from pointer 2			
with	# aa e cc <cr>	> 1 b..b cc <cr> > 0 e cc <cr>	NAK

Check sum	request telegram	reply with orderly performance	reply in case of error
Repeat reading the events from pointer 2			
with	# aa f cc <cr>	> 1 b..b cc <cr> > 0 e cc <cr>	NAK
Pointer setting (2) to memory start			
with	# aa c cc <cr>	ACK	NAK
Pointer setting (2) to a certain date			
with	# aa c t..t cc <cr>	ACK	NAK
Pointer setting (2) to a position X			
with	# aa c x..x cc <cr>	ACK	NAK
Sending password			
with	# aa P p.p cc <cr>	ACK	NAK
write date and time			
with	# aa G t..t cc <cr>	ACK	NAK
read date and time			
with	# aa H cc <cr>	> t..t cc <cr>	NAK
read measuring rate and averaging interval			
with	# aa X cc <cr>	> n..n cc <cr>	NAK
write measuring rate and averaging interval			
with	# aa Y n..n cc <cr>	ACK	NAK
delete data memory			
with	# aa C.ALL cc <cr>	ACK	NAK
read number of events			
with	# aa N cc <cr>	> a..a cc <cr>	NAK
transparent modus on (only at masterfunction)			
with	# aa T1 cc <cr>	ACK	NAK
transparent modus off (only at masterfunction)			
with	# aa T0 cc <cr>	ACK	NAK

Table 11.9   Instruction set in the ASCII-Protokoll

Note: In case a password is entered, by means of the configuration program, this password has to be transmitted to the data

logger before memory reading or erasing respectively before pointer setting. If there is no further communication within 1 minute, password release is deleted.

For passwords, only capital letters and numbers are accepted.

char	meaning	length	range
#	start delimiter for request telegram with check sum	1	ASCII "#"
>	start delimiter for response telegram with check sum	1	ASCII ">"
$	start delimiter for request telegram without check sum	1	ASCII "$"
=	start delimiter for response telegram without check sum	1	ASCII "="
<cr>	end delimiter (carriage return)	1	*hex* 0D
ACK	positive acknowledge	1	*hex* 06
NAK	negative acknowledge	1	*hex* 15
aa	destination address	2	ASCII "01".."7F"
cc	check sum	2	ASCII "00".."FF"
kk	channel number - for internal channels - for external channels	2	ASCII "01".."20" "80".."BB"
v..v	device identification	28	ASCII - string
s..s	device information	28	ASCII - string
z..z	status information	12	ASCII - string
i..i	channel information	32	ASCII - string
d..d	channel value	max. 8	ASCII - string
b..b	events	variable	ASCII - string
e	error code	1	ASCII "1".."2"
t..t	date and time	12	ASCII - string
n..n	measuring rate and averaging interval	7	ASCII - string
a..a	number of events	5	ASCII - string
p..p	password	max. 8	ASCII - string

Table 11.10

Explanation of the command characters in the ASCII-protocol

device identification (v...v)		length = 28 char
\<vendor name\>	ASCII ("Friedrichs")	10 char
\<model name\>	ASCII ("COMBILOG")	8 char
\<hw-revision\>	ASCII ("xy.yy")	5 char
\<sw-revision\>	ASCII ("xy.yy")	5 char

x ... "M"   : monitor program

x ... "A","U": universal program

x ... "T"   : calibration and test program

x ... "S"   : application specific program

y.yy   : version

device information (s...s)		length = 28 char
\<location\>	ASCII	20 char
\<serial number\>	ASCII	6 char
\<number of channels\>	ASCII	2 char

status information (z...z)		length = 12 char
\< channel status \>	ASCII	8 Char
\< module status \>	ASCII	4 Char

\<channel status\> =	K32..K29	K28..K25	…	K8..K5	K4..K1
Byte:	1	2	…	7	8

\<module status\> =	M16..M13	M12..M9	M8..M5	M4..M1
Byte:	9	10	11	12

If the bit Kn in the channel status is set it indicates that an error has occurred in channel n. A channel error is given when the measuring value is outside of the linearisation, e.g. in case of a sensor break down or of a short circuit of transmission.

If the bit Mn in the module status is set it indicates that an error has occurred in the data logger. Valid is:

M1 = 1: EEPROM error   M5 = 1: RTC error
M2 = 1: FLASH error   M6   (currently not occupied)
M3 = 1: ADC error   …
M4 = 1: configuration error M16   (currently not occupied)

channel information (i...i)		length = 32 char
<channel type>	ASCII	1 char
<channel notation>	ASCII	20 char
<data format>	ASCII	1 char
<field length>	ASCII	1 char
<decimals>	ASCII	1 char
<unit>	ASCII	6 char
<channel configuration>	ASCII	1 char
<type of calculation>	ASCII	1 char

Coding <channel type>:
ASCII "0"   Empty Channel (EM)
ASCII "1"   Analouge Input Channel (AI)
ASCII "2"   Arithmetic Channel (AR)
ASCII "3"   Digital Output Channel (DO)
ASCII "4"   Digital Input Channel (DI)
ASCII "5"   Setpoint Channel (VO)
ASCII "6"   Alarm Channel (AL)

Coding <channel configuration>:
Bit 1:   tare/reset possible
Bit 2:   average value storage configured

Coding <type of calculation>:

ASCII "0":　normal calculation of average value

ASCII "1":　calculation of average value with wind direction

ASCII "2":　calculation of the sum over the averaging interval

ASCII "3":　continuous sum

ASCII "4":　vectorial average for wind velocity

ASCII "5":　vectorial average for wind direction

events (b...b)		length = variable
<year>	ASCII	2 char
<month>	ASCII	2 char
<day>	ASCII	2 char
<hour>	ASCII	2 char
<minute>	ASCII	2 char
<second>	ASCII	2 char
<separation mark>	ASCII (";")	1 char
<average value channel 1>	ASCII	8 char
<separation mark>[1]	ASCII (";")	1 char
<average value channel n>[1]	ASCII	8 char
<separation mark>[1]	ASCII (";")	1 char

[1]...The response telegram will only contain these fields if they have been defined.

The transmission of average values is performed by 8 hexadecimal characters in the IEE Std 754 Short Real Format (Example: 50,3094 -> 42 49 3C D3).

Depending on the programming language being used, different terms are used, e.g. format "single" with use of Turbo Pascal. (refer to appendix H)

error code (e)		length = 1 char
<error code>	ASCII	1 char

Coding <error code>:

ASCII "1"	event memory empty
ASCII "2"	read-out of memory presently impossible as data are being fed to the memory
ASCII "3"	unvalid password

date and time (t..t)		length = 12 char
<year>	ASCII	2 char
<month>	ASCII	2 char
<day>	ASCII	2 char
<hour>	ASCII	2 char
<minute>	ASCII	2 char
<second>	ASCII	2 char

measuring rate and averaging interval (n..n)		length = 7 char
<measuring rate in sec.>	ASCII	2 char
<averaging interval in sec.>	ASCII	5 char

11.7　PROFIBUS protocol

11.7.1　Telegram Format for the Profibus Protocol

For data transmission via PROFIBUS following telegram formats are relevant for the data logger *COMBILOG 1020*:

Formats with fixed information section length without data field:

SD1	DA	SA	FC	FCS	ED

Formats with variable information section length with data field:

SD2	LE	LEr	SD2	DA	SA	FC	DataUnit	FCS	ED

Formats with fixed information section length with data field:

SD3	DA	SA	FC	DataUnit	FCS	ED

With PROFIBUS the various telegram formats are differentiated by varying Start-Delimiters (SD). They can also be called SD1-, SD2- or SD3-telegrams in this context. The telegram formats are valid both for request and response telegrams. However, a request telegram does not necessarily have to be followed by a response telegram of the same format. In addition to that there is a telegram which consists of one character only and which is used as either positive or negative acknowledgement, according to the kind of request.

Short acknowledgement:

SC

SD: *Start-Delimiter (length = 1 byte):*

The Start-Delimiter SD identifies the beginning of a telegram. It can assume the following values in the PROFIBUS-protocol:

telegram format	request telegram	response telegram	data field length
SD1	hex 10	hex 10	0
SD2	hex 68	hex 68	1 ... 246 (32)
SD3	hex A2	hex A2	8

Table 11.11   Start-Delimiter (SD) in the PROFIBUS-protocol

LE: *Length (length = 1 byte):*

The Length LE identifies the length of the telegram with variable data field length (SD2-telegram) and comprises the characters from DA to DataUnit. Thus it corresponds to the length of DataUnit+3 and can have values between 4 and 249. In the PROFIBUS-DP-protocol the length of the data field is generally limited to 32 bytes. Since the data logger has no telegrams with a usable data length of more than 32 bytes, the data logger can also be integrated in bus topologies with DP-protocol.

LEr: *Length-Repeated (length = 1 byte):*

The Length-Repeated LEr corresponds to the specification Length LE. It is stated again in the telegram for data protection control purposes.

DA: Destination-Address (length = 1 byte):

The Destination-Address DA identifies the address of the communication partner to whom the data shall be transmitted or from whom data shall be requested. Destination-Address can have values from 0 to 127 in the PROFIBUS-protocol. It is stated here as a hexadecimal value (hex 00 .. 7F).

SA: Source-Address (length = 1 byte):

The Source-Address SA identifies the address of your own appliance and is reported to the communication partner with the telegram. Source-Address can have values from 0 to 127 (*hex* 00 .. 7F).

FC: Frame-Control (length = 1 byte):

The Frame-Control FC identifies the type of telegram (request or response telegram), the type of station (passive or active station), the type of data transmission (send and/or request data, with or without acknowledgement, etc.) and the telegram acknowledgement (successful transmission or unsuccessful transmission). For the entire listing, coding and meaning of the Frame-Control see the PROFIBUS-Norm DIN 19245, part 1.

ReqDataUnit: Request-Data-Unit (length = 0 ... n byte):

The Request-Data-Unit identifies a data field in the request telegram which contains the data for the communication partner with the DA address.

ResDataUnit: *Response-Data-Unit (length = 0 ... n byte):*

The Response-Data-Unit identifies a data field in the response telegram which contains the data for the calling communication partner.

FCS: *Frame-Check-Sequence (length = 1 byte):*

The Frame-Check-Sequence FCS identifies the check sum of the telegram. In the PROFIBUS-protocol this is the sum of the ASCII-values from DA to DataUnit *modulo* 256: Check-Sum_PROFIBUS = [DA+SA+FC+DataUnit] mod 256. In the PROFIBUS-protocol the value is stated as a hexadecimal value (*hex* 00 .. FF).

ED: *End-Delimiter (length = 1 byte):*

The End-Delimiter ED identifies the end of the telegrams. In the PROFIBUS-protocol it has the value *hex* 16.

SC: *Short-Acknowledgement-Frame (length = 1 byte):*

The Short-Acknowledgement-Frame SC identifies a telegram that can be sent back to the communication partner as an acknowledgement. With SDA-requests it can be used as a positive receive acknowledgement. With SRD-requests it can be returned as a negative acknowledgement.

11.7.2 Instruction Set in the PROFIBUS-Protocol

Layer 2-adoption in PROFIBUS protocol:

With PROFIBUS every bus user has so-called "service access points" (SAPs), via which he can exchange data with the communication partners. With the data logger *COMBILOG 1022* the SAPs are used for identifying (addressing) the various data and commands of the data logger. By specifying the DSAP-number (DSAP: Destination SAP) in the data field of the request telegram the data logger can be informed as to which data shall be transmitted or which function the data logger shall carry out. The data logger can also be informed as to which own SAP (SSAP: Source SAP) the data are to be returned.

Request/Response telegram (Example SD2-telegram):

SD2	LE	LEr	SD2	DA	SA	FC	ReqDataUnit ResDataUnit	FCS	ED

DSAP	SSAP	
= 0	= 0	Data
> 0	= 0	DSAP │ Data
= 0	> 0	SSAP │ Data
> 0	> 0	DSAP │ SSAP │ Data
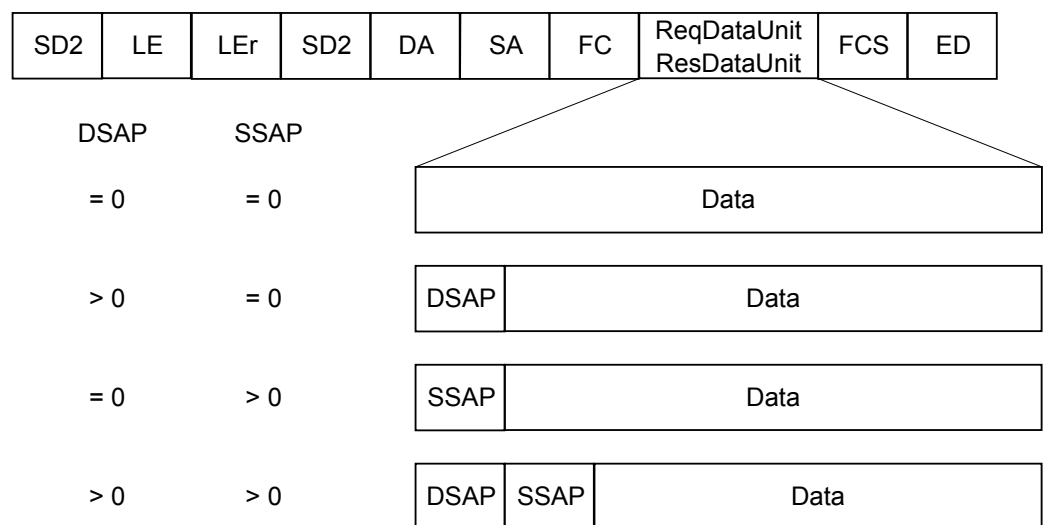
A DSAP - respectively SSAP-entry is identified by setting the highest bit in the address byte of Destination-Address (DA) or Source-Address (SA) respectively. The entry itself is carried out in the first, resp. the second position in the ReqDataUnit data field.

The DSAP- and SSAP-entries in the request telegram also appear in the response telegram, where DA, SA, DSAP and SSAP in the response telegram correspond to SA, DA, SSAP and DSAP in the request telegram!

If no storage expansion is carried out in the request telegram, the orders are carried out via the Default-SAP. The Default-SAP has the number 0. It does not have to be indicated separately in the telegram.

DSAP and SSAP entries are only possible with telegrams with data field (SD2 and SD3 telegrams).

PROFIBUS - layer 2 commands			
DSAP	service	data to the module (ReqDataUnit)	data from the module (ResDataUnit)
read device identification			
0	ident	no data	<ident>
read status information			
10	SRD	no data	<status>
read device information			
11	SRD	no data	<Ginfo>
read channel information			
12	SRD	<channel number>	<Kinfo>
read data from a channel			
13	SRD	<channel number.>	<Kx>
write data to a channel			
14	SRD	<channel number> <Px>	response without data
	SDA	<channel number> <Px>	pos./neg. acknowledge
	SDN	<channel number> <Px>	no response
tare / reset a channel			
15	SRD	<channel number>	response without data
	SDA	<channel number>	pos./neg. acknowledge
	SDN	<channel number>	no response
read, write and tare / reset channels			
0	SRD	[<tare/reset>[<P1>[... [<Pn>]]]]	<status> <K1> ... <Kn>
	SDA	[<tare/reset>[<P1>[... [<Pn>]]]]	pos./neg. acknowledge
	SDN	[<tare/reset>[<P1>[... [<Pn>]]]]	no response

Table 11.12   PROFIBUS - layer 2 commands

Note: If more data are in the ReqDataUnit as required, they will be ignored.

PROFIBUS - DP commands			
DSAP	ser-vice	data to the module (ReqDataUnit)	data from the module (ResDataUnit)
read, write and tare / reset channels			
56	SRD	[<Reset>[<P1>[... [<Pn>]]]]	<Status> <K1> ... <Kn>
read, write and tare / reset of writeable channels			
57	SRD	[<Reset>[<P1>[... [<Pn>]]]]	<P1> ... <Pn>
DP global control			
58	SRD	no	short quit (SC)
DP get configuration			
59	SRD	no	short quit (SC)
DP get diagnose			
60	SRD	no	80 0C 00 03 <status>
DP get parameter			
61	SRD	no	short quit (SC)
DP check configuration			
62	SRD	no	short quit (SC)

Table 10.12 PROFIBUS - DP commands

Note: If more data are in the ReqDataUnit as required, they will be ignored.

<ident> device identification		length = 32 byte
<length vendor name>	binary (hex 0A)	1 byte
<length controller type>	binary (hex 08)	1 byte
<length hw-release>	binary (hex 05)	1 byte
<length sw-release>	binary (hex 05)	1 byte
<vendor name>	ASCII ("Friedrichs")	10 byte
<controller type>	ASCII ("COMBILOG")	8 byte
<hw-Revision>	ASCII ("xy.yy")	5 byte
<sw-Revision>	ASCII ("xy.yy")	5 byte

x … "V" : universal program

y.yy : version

<Ginfo> device information		length = 27 byte
<location>	ASCII	20 byte
<serial number>	ASCII	6 byte
<number of channels>	binary	1 byte

<status> status information		length 6 byte
<channel status>	binary	4 byte
<module status>	binary	2 byte

<channel status> = K32..K25 K24..K17 K16..K9 K8..K1

Byte 1 Byte 2 Byte 3 Byte 4

<module status> = M16..M9 M8..M1

Byte 5 Byte 6

If the bit Kn in the channel status is set it indicates that an error has occurred in channel n. A channel error is given when the measuring value is outside of the linearisation, e.g. in case of a sensor break down or of a short circuit of transmission.

If a bit in the module status is set it indicates that an error has occurred in the data logger. Valid is:

bit 1 = 1: EEPROM error   bit 5 = 1:   (RTC-Error)

bit 2 = 1: FLASH error   bit 6 = 1:   (currently not occupied)

bit 3 = 1: ADC error   …

bit 4 = 1: configuration error   bit 16 = 1: (currently not occupied)

<Kinfo> channel information		length = 32 byte
<channel type>	binary	1 byte
<channel notation>	ASCII	20 byte
<data format>	binary	1 byte
<field length>	binary	1 byte
<decimals>	binary	1 byte
<unit>	ASCII	6 byte
<host input>	binary	1 byte
<type of calculation>	binary	1 byte

Coding <channel type>:

hex 00: Empty Channel (EM)

hex 01: Analogue Input Channel (AI)

hex 02: Arithmetic Channel (AR)

hex 03: Digital Output Channel (DO)

hex 04: Digital Input Channel (DI)

hex 05: Setpoint Channel (SP)

hex 06: Alarm Channel (AL)

Coding <data format>:

hex 00: no format

hex 01: B O O L

hex 02: INTEGER

hex 03: R E A L

hex 04: S E T 8

Coding <host input>:

hex 00: host input is not possible

hex 01: host input is possible

        (tare/reset/dig.out/setpoint values)

Coding <type of calculation>:

hex 00: normal calculation of average value

hex 01: calculation of average value with wind direction

hex 02: calculation of the sum over the averaging interval

hex 03: continuous sum

hex 04: vectorial average for wind velocity

hex 05: vectorial average for wind direction

read data from channel:		length = 2..5 byte
<channel number>	binary	1 byte
<channel value Kx>	binary	1, 2 or 4 byte

write data to a channel:		length = 2..5 byte
<channel number>	binary	1 byte
<channel value Px>	binary	1, 2 or 4 byte

tare/reset a channel:		length = 1 byte
<channel number>	binary	1 byte

read, write and tare/reset channels:		length ≥1 byte
<tare/reset>	binary	1 byte
<channel value P1>	binary	1, 2 or 4 byte
<channel value P2>	binary	1, 2 or 4 byte
:	.	.
<channel value Pn>	binary	1, 2 or 4 byte

ReqDataUnit: [<tare/reset> [<P1> [.... [<Pn>]]]]

ResDataUnit: <K1 > . . . . < Kn >

If a bit is set in the <tare/reset> byte, the corresponding sensor channel is tared or reset respectively. The values following the <tare/reset>-byte are allocated to the writeable channels of the data logger, according to the order of their appearance. Writeable channels are setpoint channels and digital output channels.

11.8 MODBUS protocol

11.8.1 Telegram Format for the MODBUS-RTU Protocol

The request and response telegrams in the RTU-mode used by the sensor modules start with an idle-interval of at least 3.5 character lengths. The simplest way of attaining this is by waiting for at least 4 character-times after receiving the last character of a telegram. The telegrams have no Start-Delimiter and no End-Delimiter either. The first field after that idle-interval is the ISM-Address (ADR) followed by the function number (FNR) and the function parameters or data respectively. At the end the telegrams contain a check sum (CRC) with a length of 16 bits. The check sum is calculated from the whole telegram without the CRC itself. The CRC-polynomial is: $u^{15} + u^{13} + 1$. The start value is hex FFFF.

request telegram

idle interval	ADR	FNR	function parameters / data	CRC
> 3,5 CT	1 byte	1 byte	n byte	2 byte

response telegram

idle interval	ADR	FNR	function parameters / data	CRC
> 3,5 CT	1 byte	1 byte	n byte	2 byte

11.8.2 Instruction Set in MODBUS-RTU Protocol

With the MODBUS-protocol the data are read and written via register accesses. The following register accesses are defined for the communication with the sensor modules:

Function number	Function
03 hex	Read Holding Register (Read/Write-Register)
04 hex	Read Input Register (Read-Only-Register)
06 hex	Pre-set Single Register
08 hex	Diagnostic
10 hex	Pre-set Multiple Register

Table 11.15 MODBUS commands

Read Holding Register

Description:

By this command input/output registers (read/write registers) can be read.

request telegram

ADR	FNR 03	REGSTA MSB	LSB	REGNUM MSB	LSB	CRC MSB	LSB

response telegram

ADR	FNR 03	BYTNUM	D0	D1	…	Dn	CRC MSB	LSB

ADR .... module address (hex 00..7F)

FNR .... function number (hex 03)

REGSTA ..... address of the first register to be read

REGNUM .... number of registers to be read

BYTNUM ..... number of data bytes (max. 64)

D0 - Dn .... data bytes (max. 64)

CRC .... check sum

CRC polynomial: $u^{15} + u^{13} + 1$

CRC start value: hex FFFF

Example:

To read the stored location in the following request message is sent to the data logger:

REQUEST:

	ADR	FNR	REGSTA		REGNUM		CRC	
			MSB	LSB	MSB	LSB	MSB	LSB
Request	01	03	2F	FF	00	0D	BC	EB

REPLY:

	ADR	FNR	BYTNUM	Number of records			
				High Word		Low Word	
Reply	01	03	1A	00	00	00	58

Number of values		Timestamp					
in a record		Day	Month	Year	Hour	Minute	Second
00	03	30	05	12	09	00	58

Zero Word		Value 1 real			
		High Word		Low Word	
00	03	46	FD	90	AB

Value 2 real				Value 3 real				CRC	
High Word		Low Word		High Word		Low Word			
46	FD	91	9A	46	FD	91	9A	E5	9C

In this case, the register 0x3001 is included in the query. This means that the registers 0x3002 - 0x30BD be automatically filled with the next record. So, the request string is always the same. If you don't get the register 0x3001, the old record keeps always in the registers 0x3002 - 0x30BD.

For sequential reading of the records you should repeat the request message.

Read Input Register

Description:
By this command input registers (read-only registers) can be read.

Request Telegram

ADR	FNR	REGSTA		REGNUM		CRC	
	04	MSB	LSB	MSB	LSB	MSB	LSB

Response Telegram

ADR	FNR	BYTNUM	D0	D1	…	Dn	CRC	
	04						MSB	LSB

ADR .... module address (hex 00..7F)
FNR .... function number (hex 04)
REGSTA ..... address of the first register to be read
REGNUM .... number of registers to be read
BYTNUM ..... number of data bytes (max. 64)
D0 - Dn .... data bytes (max. 64)
CRC .... check sum
CRC polynomial: $u^{15} + u^{13} + 1$
CRC start value: hex FFFF

Example:

To read the stored location in the following request message is sent to the data logger

	ADR	FNR	REGSTA		REGNUM		CRC	
			MSB	LSB	MSB	LSB	MSB	LSB
Request	01	04	03	04	00	0A	31	88

In this case, the registers 0x0304 - 0x030D, that includes the location with a maximum of 20 characters, are read out.

	ADR	FNR	BYTNUM	Databytes									
				D0	D1	D2	D3	D4	D5	D6	D7	D8	D9
Reply	01	04	14	4D	61	73	74	20	33	00	00	00	00

Databytes										CRC	
D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	MSB	LSB
00	00	00	00	00	00	00	00	00	00	F2	EE

Decoded to the reply message from hexadecimal to ASCII, then it is easy to see that BYTNUM = 20, i.e. 20 characters.
These 20 characters are included in the data bytes D0-D19 and the decoded result is "Mast 3."
So "Mast 3" is the location name of the logger.

<div style="border: 1px solid black; padding: 10px; text-align: center;">

Preset Single Register

</div>

Description:

By this command a single register can be written.

Request Telegram

ADR	FNR	REGSTA		REGNUM		CRC	
	6	MSB	LSB	MSB	LSB	MSB	LSB

Response Telegram

ADR	FNR	REGADR		DATA		CRC	
	6	MSB	LSB	MSB	LSB	MSB	LSB

ADR .... module address (hex 00..7F)

FNR .... function number (hex 06)

REGADR ..... address of the register to be written

DATA ……..... data word (hex 0000…FFFF)

CRC .... check sum

CRC polynomial: $u^{15} + u^{13} + 1$

CRC start value: hex FFFF

Example:

Channel 1 is configured as a digital output channel and will now be manually set from LOW to HIGH. For setting to HIGH the following request message is sent:

	ADR	FNR	REGADR		DATA		CRC	
			MSB	LSB	MSB	LSB	MSB	LSB
Request	01	06	00	00	00	01	48	0A

The LED lights on the digital output. After sending the request message, in this case no reply telegram is sent.

Description:

By this command a diagnostic telegram will be sent to the data logger. If the telegram has been received in correct form the module will send this telegram back unchanged (echo telegram).

Request Telegram

ADR	FNR	SUBFCT		DATA		CRC	
	8	00	00	A5	37	MSB	LSB

Response Telegram

ADR	FNR	SUBFC		DATA		CRC	
	8	00	00	A5	37	MSB	LSB

ADR .... module address (hex 00..7F)

FNR .... function number (hex 08)

SUBFCT ..... sub function number (hex 0000)

DATA .... data word (hex A537)

CRC .... check sum

CRC polynomial: $u^{15} + u^{13} + 1$

CRC start value: hex FFFF

Example:

Regardless of the measurement operation of the Combilogs you want to know whether a communication is present. The following request message will be sent:

	ADR	FNR	SUBFCT		DATA		CRC	
			MSB	LSB	MSB	LSB	MSB	LSB
Request	01	08	00	00	A5	37	DA	8D

And you get the message back unchanged:

	ADR	FNR	SUBFCT		DATA		CRC	
			MSB	LSB	MSB	LSB	MSB	LSB
Reply	01	08	00	00	A5	37	DA	8D

Preset Multiple Register

Description:

By this command a large, continuous field of registers can be written.

Request Telegram

ADR	FNR	REGSTA		REGNUM		BYTNUM	D0	...	Dn	CRC	
	10	MSB	LSB	MSB	LSB					MSB	LBS

Response Telegram

ADR	FNR	REGSTA		REGNUM		CRC	
	10	MSB	LSB	MSB	LSB	MSB	LSB

ADR .... module address (hex 00...7F)

FNR .... function number (hex 10)

REGSTA ..... address of the first register to be written

REGNUM .... number of registers to be written

BYTNUM ..... number of data bytes (max. 64)

D0 - Dn .... data bytes (max. 64)

CRC .... check sum

CRC polynomial: $u^{15} + u^{13} + 1$

CRC start value: hex FFFF

Register Contents

Channel values in integer format			
Register	**Type**	**Contents**	**Range**
0000	ro/rw	Channel 1 integer value	-32768 ... 32767
0001	ro/rw	Channel 2 integer value	-32768 ... 32767
:	:	:	:
0007	ro/rw	Channel 8 integer value	-32768 ... 32767
:	:	:	:
001F	ro/rw	Channel 32 integer value	-32768 ... 32767

Channel values in real format			
Register	**Type**	**Contents**	**Range**
0020	ro/rw	Channel 1 real high word	0 ... 65535
0021	ro/rw	Channel 1 real low word	0 ... 65535
0022	ro/rw	Channel 2 real high word	0 ... 65535
0023	ro/rw	Channel 2 real low word	0 ... 65535
:	:	:	:
002E	ro/rw	Channel 8 real high word	0 ... 65535
002F	ro/rw	Channel 8 real low word	0 ... 65535
:	:	:	:
005E	ro/rw	Channel 32 real high word	0 ... 65535
005F	ro/rw	Channel 32 real low word	0 ... 65535

Attention: The low word and the high word of a channel must always be read or written simultaneously.

Note: The possibility of a writing command on the registers 0000 to 005F depends on the configuration. With the following channel types a writing command is valid if this has been allowed by the Configuration Software.

Digital Counter with Reset Function:

After a write command to this channel the counter will be set to zero.

Arithmetic Variable with min/max-Function and Reset Function:

After a write command to this channel the pull-pointer will be re-set.

Setpoint Variable:

After a write command to this channel the new value will be set.

Digital Output Variable (Host Output):

A write command to this channel will set the corresponding channel to '1' or '0' respectively.

Device information			
Register	**Type**	**Contents**	**Range**
0300	ro	Number of channels	2 Byte
0301..0303	ro	Serial number	6 Char
0304..030D	ro	Location	20 Char

Device identification			
Register	**Type**	**Contents**	**Range**
0400..0404	ro	Vendor name ("Friedrichs")	10 Char
0405..0408	ro	Model name ("COMBILOG")	8 Char
0409..040C	ro	HW-revision ("xy.yy___")	8 Char
040D..0410	ro	SW-revision ("xy.yy___")	8 Char

x ... "V":   Universal program

y.yy :   Version

Status information			
Register	**Type**	**Contents**	**Length**
0500	ro	Module status	2 Byte
0501..0502	ro	Channel status	4 Byte

<Module status>:   M16..M13 , M12..M9 = hex xy   = 1. Byte

                          M8..M5 , M4..M1   = hex xy   = 2. Byte

If the bit Mn in the module status is set it indicates that an error has occurred in the sensor module, the following applies:

M1 = 1: EEPROM - Error

M2 = 1: Flash - Error

M3 = 1: ADC - Error

M4 = 1: Configuration - Error

M5 = 1: No memory card

M6 = 1: RTC - Error

M7...M16 Are currently not occupied

<Channel status>:   K32..K29 , K28..K25 = hex xy   = 1. Byte

                          K24..K21 , K20..K17 = hex xy   = 2. Byte

                          K16..K13 , K12..K9   = hex xy   = 3. Byte

                          K8..K5 , K4..K1   = hex xy   = 4. Byte

If the bit Kn in the channel status is set it indicates that an error has occurred in channel n.

Channel information			
Register	**Type**	**Contents**	**Length**
1000	ro	Channel 1 Variable type	2 Byte
1001	ro	Channel 1 Measuring principle	2 Byte
1002	ro	Channel 1 Field length	2 Byte
1003	ro	Channel 1 Decimals	2 Byte
1004	ro	Channel 1 Reset, storage	2 Byte
1005...1007	ro	Channel 1 Units	6 Char
1008...1011	ro	Channel 1 Variable name	20 Char
1012...101F	ro	Channel 1 Reserve	28 Char
1000...101F		Channel information for Channel 1	
1020...103F		Channel information for Channel 2	
1040...105F		Channel information for Channel 3	
1060...107F		Channel information for Channel 4	
1080...109F		Channel information for Channel 5	
10A0...10BF		Channel information for Channel 6	
10C0...10DF		Channel information for Channel 7	
10E0...10FF		Channel information for Channel 8	
1100...111F		Channel information for Channel 9	
1120...113F		Channel information for Channel 10	
1140...115F		Channel information for Channel 11	
1160...117F		Channel information for Channel 12	
:		:	
13E0..13FF		Channel information for Channel 32	

Coding <Channel type>:

hex 0 Empty channel (EM)

hex 2 Arithmetic channel (AR)

hex 3 Digital output channel (DO)

hex 4 Digital input channel (DI)

hex 5 Setpoint channel (VO)

hex 6 Alarm channel (AL)

Coding < Measuring principle >:

Digital Input:

hex 0 No input

hex 1 Host input

hex 2 Frequency

hex 3 Progressive counter

hex 7 Interval counter

Digital Output:

hex 0 No output

hex 1 Host output

hex 3 Process output

Coding <Reset, storage>:

hex 0 No reset, no storage of channels

hex 1 Reset valid, no storage of channels

hex 2 No reset, storage of channels enabled

hex 3 Reset valid, storage of channels enabled

Read data from external channel			
Register	**Type**	**Contents**	**Range**
2000	ro	Channel 1 real High Word	0 ... 65535
2001	ro	Channel 1 real Low Word	0 ... 65535
2002	ro	Channel 2 real High Word	0 ... 65535
2003	ro	Channel 2 real Low Word	0 ... 65535
:	:	:	:
2076	ro	Channel 60 real High Word	0 ... 65535
2077	ro	Channel 60 real Low Word	0 ... 65535

Attention: The low word and the high word of a channel must always be read or written simultaneously.

Read data logger			
Register	**Type**	**Contents**	**Range**
2FFF	ro	Number of records High Word	0 … 65535
3000	ro	Number of records Low Word	0 ... 65535
3001	ro	Number of values in a record	0 ... 65535
3002	ro	Timestamp:	
		Day High Byte	1 … 31
		Month Low Byte	1 … 12
3003	ro	Timestamp:	
		Year High Byte	0 … 99
		Hour Low Byte	1 … 24
3004	ro	Timestamp ((minute/second)	
		Minute High Byte	0 … 59
		Second Low Byte	0 … 59
3005	ro	Zero Word	0
3006	ro	Value 1 real High Word	0 ... 65535
3007	ro	Value 1 real Low Word	0 ... 65535
3008	ro	Value 2 real High Word	0 ... 65535

3009	ro	Value 2 real Low Word	0 ... 65535
:	:	:	:
30B8	ro	Value 92 real High Word	0 ... 65535
30B9	ro	Value 92 real Low Word	0 ... 65535

Note: The oldest record will be load to the register 3002 to 30B9 while reading register 3001. The number of values depends on the configuration.

Reserved for download functions

Register

FD00..FFFF

11.9   Sample Program

The task is:

The measured value in channel 2 shall be read from the sensor module with the address number 10. The value has been configured with a field length of seven, two decimals, the unit "°C" and the binary format "Integer".

Sample program for ASCII-transmission without check sum: (Notation in QBasic, V. 1.0):

```
OPEN "COM1: 9600,N,8,1,D50,RS"
FOR RANDOM AS #1                        , initialize interface
REQ$ = "$0AR2"+chr$(13)                 , configure telegram
PRINT #1, REQ$                          , send request telegram
RES$ = INPUT$(9,#1)                     , receive response telegram
VALUE$ = MID$(RES$,2,7)                 , determine measured value
PRINT "Temperature = ", VALUE$          , output measured value
CLOSE                                    , enable interface
END                                     , end program
```

Note: In several programming languages the initialisation of the serial interface with even parity and 8 data bits will not be supported. The COM-interface in the PC and the bus interface in the data logger have to be adjusted and configured on "(N)o parity".

11.10 Autocall Function

The auto call function enables the data logger *COMBILOG 1022* to send messages automatically via modem or as SMS. The conditions, at which messages should be send, can be defined by the configuration program. Following options are available:

Dial Conditions:

- ❑ On System Error: The data logger has detected an internal hardware error
- ❑ On Range Error: The measuring range of a variable has been exceeded.
- ❑ On Alarm: One of up to 4 definable threshold values has been exceeded.

In case of using a telephone modem up to 3 telephone numbers can be defined, being dialled one after another in case of a dial condition is fulfilled.

After establishing a connection the data logger sends a status message, and the remote subscriber can communicate with the data logger, e.g. to read out the data memory. The data logger will hang up the modem, if there is no further communication for more than 30 seconds.

Format of the status message:

=	Time	;	N	;	Location	;	SN	;	A	;	KS	;	MS

=	Start-Delimiter
Time	Date/Time (12 character, format YYMMDDHHmmSS)
;	delimiter
N	Module address (2 char)
Location	Module location (20 char)
SN	Serial number (6 char)
A	Alarm condition (2 char)
	01 at system error
	02 at range error
	03 at threshold condition
CS	channel status (8 char, see chapter 11.8)
MS	module state (4 char, see chapter 11.8)

Example:
=000121083120;01;Testboard   ;090658;03;00000000;0000

In case of using a GSM modem it is possible to send messages as **SMS** (short message service). In the configuration program the user has to define the number of the service centre (depending on the net provider), the destination number and the message itself. For every dial condition described above, including the 4 possible alarm conditions, a message can be defined separately. This message will be transmitted together with the device type (*COMBILOG*), the serial number and the location of the module.

To get a list of supported GSM modems please contact your local distributor or Theodor Friedrichs & Co. directly.
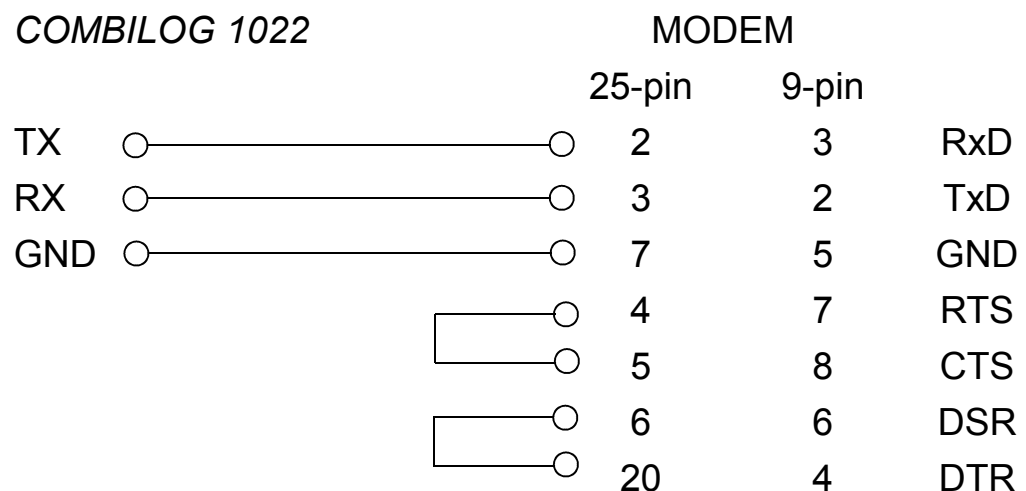
11.11 Modem Connection

In case of using a telephone or GSM modem with the *COMBILOG* the modem must at first be initialized by means of a terminal program. Set the interface settings of the terminal program to 19200 bps, no parity, and enter the following AT commands. Refer to your modem manual for a detailed description of the commands, because some commands may differ depending on the modem type.

Load default settings	AT&F
Set baud rate to 19200 bps	device dependent
Set auto answer on*	ATS0=1
Set DSR on	AT&C0
Ignore DTR	AT&D0
Save configuration	AT&W0

* In case the modem is connected to the RS232 port of the *COMBILOG*, the data logger will response the incoming call after 4 rings automatically. Note, that the ring will not be recognised at the RS485 port.

Set the RS232 interface of the *COMBILOG* to 19200 bps, no parity.

Prepare a cable between modem and *COMBILOG* as shown:

COMBILOG 1022		MODEM		
		25-pin	9-pin	
TX	○——————○	2	3	RxD
RX	○——————○	3	2	TxD
GND	○——————○	7	5	GND
	○	4	7	RTS
	○	5	8	CTS
	○	6	6	DSR
	○	20	4	DTR

12   WEBSERVER

12.1   General

The Web server can be used to configure and view settings of the *COMBILOG 1022*. To access the *COMBILOG 1022* web server type the IP into the location bar of your browser. The status pages of *COMBILOG 1022* can be viewed without entering a password. However, if you want to view or change settings of the data logger you have to login with your password. Now you can navigate through the settings pages using the navigation links on the left site.

12.2   System Info

On this site you have a quick overview about CPU frequency, firmware version, serial number, system temperature and network settings.

12.3   System Log

The system log saves important internal events with continuous number and date / time. E.g. every system boot is recorded.
If not all events fit into one screen the first shown event can be selected by typing the number in "Start Log" and reloading the page with the "Show".button.
The system log can be downloaded to the PC using the "Download" button.
With the link "clear systemlog" all events will be deleted.

12.4   Data View

On this page all configured channels are displayed. The channels are displayed in groups of 8 channels per page. The group can be selected using the links 1 – 8, 9 – 16, 17 – 24 and 25 – 32 at the top of the page.

12.5   Data Logger

This page gives a short overview of the logger configuration. Settings like general sample rate (for all channels but the analogue channels, minimum and maximum analogue channel sample rate, average interval and zoom interval are displayed. In addition the format characters for the logger data file are displayed.

12.6   Configuration / Login

By selecting the link "Configuration" the configuration pages will be entered. Before you can access the configuration pages you have to enter the password, which is set for the data logger. If no password is specified you have to enter '000000'.

12.7   Single Channel Configuration

This page gives an overview of the active analogue channel configuration and allows changing the sample rate for each single analogue channel.

To change the sample rate for an analogue channel one has to select the channel in the channel select drop down box and the desired sample rate in the sample rate drop down box. Pressing the 'Save' button saves the configuration.

12.8   Power Switch

On this page the switch-able supply outputs can be configured. For each of the two switches an analogue channel and a lead time can be configured.

12.9   Serial Channel

The serial output channel for EIA-232 and EIA-485 can be activated or deactivated on this page. If the serial channel is activated the data logger outputs an ASCII formatted string to the serial interface with every logging interval.

12.10   Logger Configuration

Using this page the logger can be configured. Besides the settings which can be made with the configuration program COMBILOG.EXE you can define the mode for the optional SD card.

You can select the destination media for the logger (internal flash, SD card or both) and if SD card is selected as one of the logger media you can define the file mode (daily, monthly or continuous).

12.11   Password

On this page the password for the data logger can be changed.

12.12   Protocol

The data logger *COMBILOG 1022* supports two different binary protocols in addition to the ASCII protocol. On this page one can choose which of the two possibilities, PROFIBUS or MODBUS, is to be used for communication. The binary protocols exclude each other.

The configured standard protocol is PROFIBUS.

12.13   Logout

Using this link one leaves the configuration pages and re activates the password protection for the configuration area inside the web server.

13   SPECIFICATIONS

13.1   Power Supply

❑   Voltage range: +10 ... 28 VDC

❑   Power input: depending on scan rate
approx. 240 mW at measuring rate
60 s = 20.00 mA (at 12 V)
approx. 240 mW at measuring rate
10 s = 20.00 mA (at 12 V)
approx. 264 mW at measuring rate
1 s = 22.00 mA (at 12 V)
(all currents measured with
deactivated LC display and
ethernet but with activated
RS232 / RS485 drivers)

13.2   Signal Inputs/Outputs

❑   Analogue inputs: 8, isolated from processor core
no isolation between channels

❑   Digital inputs/outputs: 6 (direction configurable)

13.3   Signal Processing

❑   Scan rate: 0.25, 1, 2, 3, 4, 5, 10, 20, 30 sec.
1, 2, 3, 4, 5, 10, 20, 30, 60 min.

❑   Averaging interval: 1, 2, 3, 4, 5, 10, 15, 20, 30 sec.
1, 2, 3, 4, 5, 10, 15, 20, 30 min.
1, 2, 3, 4, 6, 8, 12h

❑   A/D-conversion: Delta-Sigma, precision app.16 Bit

❑   Accuracy of the real
time clock: <1 s / day

13.4   Analogue Inputs (8 per Module)

as voltage input:
- ❑ Types of measurement: single-ended, differential
- ❑ Ranges: ±10 V / ±5 V / ±2.5 V / ±1.25 V / ±625 mV / ±100 mV / ±25 mV / ±6.25 mV
- ❑ Input impedance: 100 MΩ
- ❑ Accuracy: 0.01 .... 0.30 % (dependent on range)
- ❑ Resolution: 0.003 .. 0.03 % (dependent on range)
- ❑ Linearity: 0.01 %
- ❑ Temperature drift: 25 ppm/K or 0.4 µV/K; 2 ppm/K or 0.02 µV/K with additional drift correction

as current input:
- ❑ Types of measurement: single-ended
- ❑ Ranges: 25 mA / 12.5 mA / 6.25 mA / 3.125 mA / 1 mA / 250 µA / 62.5 µA
- ❑ Input impedance: 100 Ω
- ❑ Accuracy: 0.05 ... 0.30 % (dependent on range)
- ❑ Resolution: 0.003 ... 0.03 % (dependent on range)
- ❑ Linearity: 0.01 %
- ❑ Temperature drift: 25 ppm/K or 12 nA/K

as resistance input:

- ❑ Types of measurement: 2-,3- and 4-wire
- ❑ Ranges: 20 kΩ / 10 kΩ / 5 kΩ / 2.5 kΩ / 1.25 kΩ / 625 Ω / 312.5 Ω / 200 Ω
- ❑ Output current: 0.5 mA
- ❑ Accuracy: 0.05 %, (dependent on range)
- ❑ Resolution: 0.003 .. 0.03 %, (dependent on range)
- ❑ Linearity: 0.01 %
- ❑ Temperature drift: 25 ppm/K
  5 ppm/K with additional (ext.) drift correction

13.5 Digital Inputs/Outputs (6 per Module)

as input:

- ❑ Function: status, frequency, counter, 8-bit Graycode receiver
- ❑ Input voltage: max. +30 VDC
- ❑ Input current: max. 1.5 mA
- ❑ Input frequency: max. 4000 Hz
- ❑ Switching threshold (low): > 3.5 VDC
- ❑ Switching threshold (high): < 1.0 VDC
- ❑ Counter width: 16 bit

as output:

- ❑ Function: host-out, process-out
- ❑ Output voltage: max. 30 VDC
- ❑ Output current: max. 100 mA
- ❑ Type of output: open collector

13.6   Interfaces

- Base: RS 485, RS 232, Ethernet, USB RS232 and RS485 galv. isolated from processor core, no isolation between channels
- Data format: 8E1 / 8N1 / 8O1
- Protocol: ASCII, PROFIBUS, MODBUS
- Baud rate ASCII: 2,400 / 4,800 / 9,600 / 19,200 bps 38,400 bps
- SD Card interface

13.7   Operating Conditions

- Operating temp.: -40 to +85 °C*
- Storing temperature: -40 to +85 °C (different values for operation with memory cards)
- Moisture: 0 to 95 % at +50 °C, non-condensing

*) Display LCD only -20 to +60 °C

13.8   Electromagnetic Compatibility

The *COMBILOG 1022* has been tested to his electromagnetic compatibility according to DIN EN 61000-6-3:2005 and DIN EN 61000-6-2:2006 and passed these tests.

Refer to: Test report *COMBILOG*, DOCID:
07-L-00634-01R_EMC_data logger_Combilog_1022.pdf
dated 11.06.2007.

The instrument is equipped with CE label.

13.9 Shell

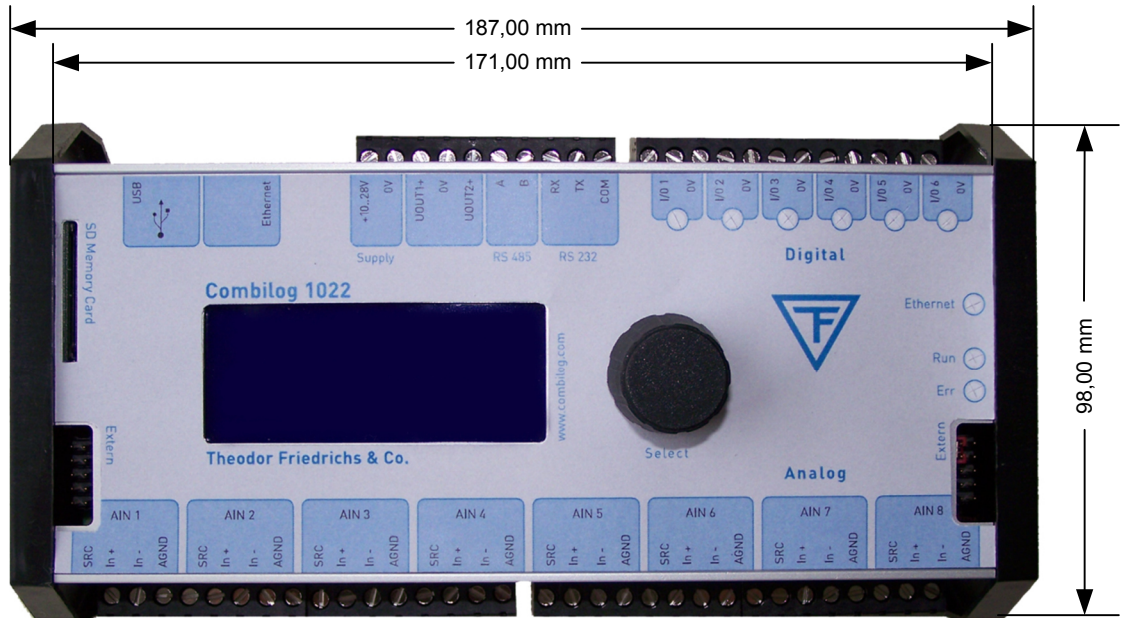- ❑ Material: Aluminium and ABS
- ❑ Dimensions: w 187 x h 97 x d 73 mm

    w 7.36 x h 3.82 x d 2.87 inch
- ❑ Weight: approx. 720 g
- ❑ Protection class: IP 20
- ❑ Type of installation: snap-on mounting
- ❑ Mounting rail   35 mm according to

    DIN EN 50022
- ❑ Connection technique: plug-in terminal screws
- ❑ Nom. cross section: max. 1.5 mm² (AWG 16),

    unifilar/fine-strand
- ❑ Strip length: 6 mm (0.2 inch)

13.10 Circuit

- ❑ Microprocessor: AT91SAM7X512
- ❑ A/D-conversion: 16 bit, sigma-delta-procedure
- ❑ Real Time Clock
- ❑ Program memory: 512 kByte   Flash
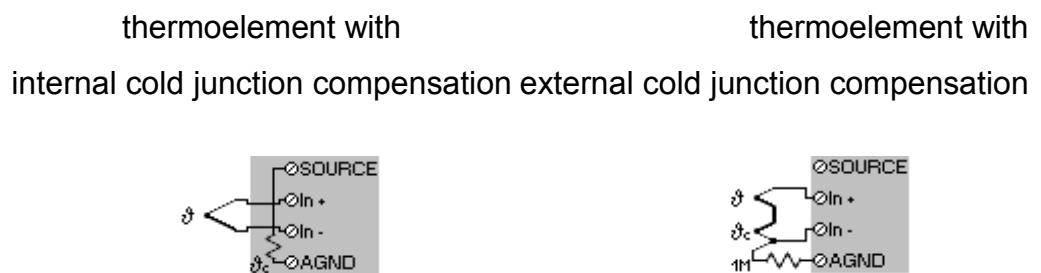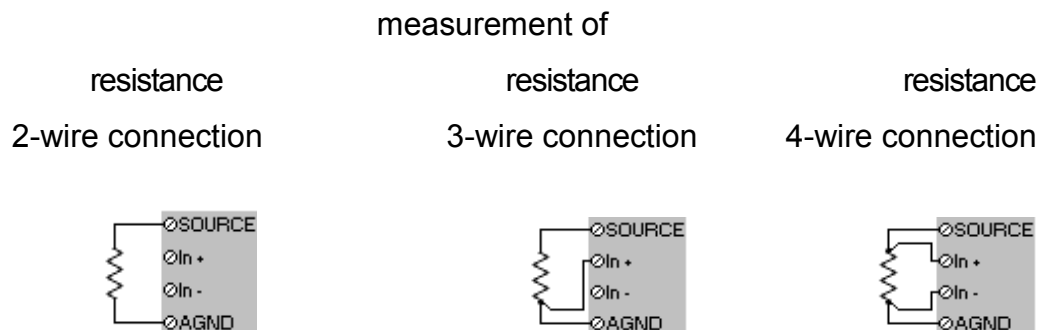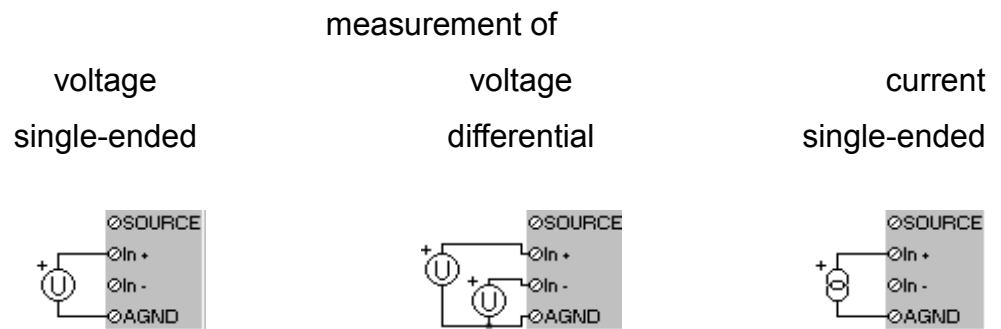- ❑ Data memory: 7 MByte
- ❑ SD Card interface

14   SIMPLIFIED DRAWINGS

14.1   Front View

APPENDIX

A. Pinout Arrangements for analouge Sensors at the Data Logger

measurement of

voltage	voltage	current
single-ended	differential	single-ended

measurement of

resistance	resistance	resistance
2-wire connection	3-wire connection	4-wire connection

thermoelement with   thermoelement with

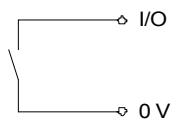internal cold junction compensation external cold junction compensation

B. Pinout Arrangements for digital Sensors at the Data Logger

digital status output

```
          o  U+
  ⊗
          o  I/O
```

digital status recording

```
          o  I/O

          o  0 V
```

frequency measurement

```
  ┌──┐
  │ ⌐⌐│      o  I/O
  │ f │
  └──┘      o  0 V
```

progressive counter

```
  ┌──┐
  │ ⌐⌐│      o  I/O 1
  │  │
  └──┘      o  0 V
```
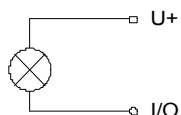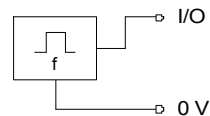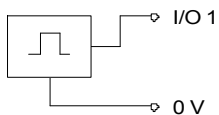
sensor for wind direction

8 bit gray-code

```
  ┌────────┐
  │  + Vs │A  o  +10..18V
  │   0V  │B  o  0V
  │  Out  │D  o  I/O
  │  GND  │C  o  0V
  └────────┘
```
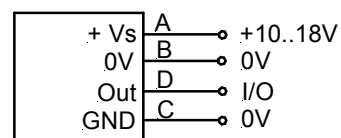
4122. _000

4123. _000

C.   Pinout Arrangements for analouge Sensors of Th. Friedrichs (Examples)

Voltage measurement, single-ended:

AIN 1
SOURCE   In +   In -   AGND

pink   blue

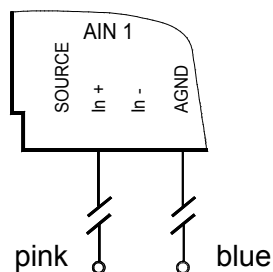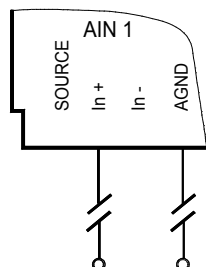|		
Humidity		3033
Pressure Vout AGND		5002
	yellow green	5004
Radiation	red blue	6006, 6012
	white green	6004

Voltage measurement, differential:

AIN 1
SOURCE   In +   In -   AGND
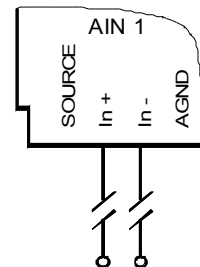
Radiation	U+	U-	6020
	UG+	UG-	6022, 6023
	UR+	UR-	6022, 6023

Voltage measurement, single-ended with external addition:

AIN 1
SOURCE   In +   In -   AGND

WS	1	2	4011 (R=5kΩ)
WS	1	2	4021 (R=4kΩ)
WS	1	2	4091.2 (R=500Ω)

Current measurement, single-ended:

AIN 1
SOURCE   In +   In -   AGND
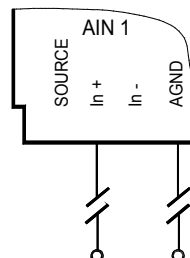
Pressure	1	2	5010
WD	E	C	4122 (0…20mA)
WD	E	C	4123 (0…20mA)
WD	F	C	4122 (4…20mA)
WD	F	C	4123 (4…20mA)
WS	E	C	4034 (0…20mA)
WS	E	C	4035 (0…20mA)
WS	F	C	4034 (4…20mA)
WS	F	C	4035 (4…20mA)

Resistance measurement, 4-line:
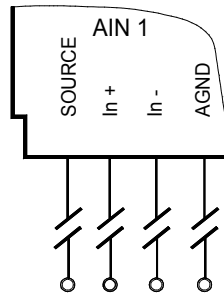
Pt100	1	2	3	4	2010, 2014, 2015, 2017, 2018, 2019,
Pt100	1	2	3	4	2020, 2030, 2100, 3010, 3033, 3100, 3130
Humidity	1	2	3	4	3112
Pt100	5	6	7	8	3112.1
WD	1	2	3	4	4121, 4191.1
Pressure	1	2	3	4	5006

D.   Pinout Arrangements for digital Sensors of Th. Friedrichs (Examples)

Status:

Sun yes/no white brown 6038.1
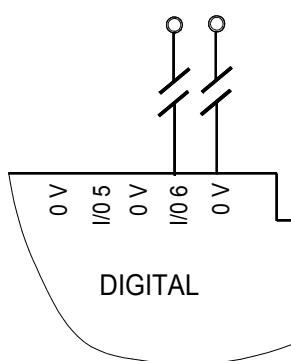
Frequency measurement:

WS   1   4   4091.1

WS   D   C   4034

WS   D   C   4035

Counter:

Precipitation   1 2   7041

                1 2   7051

Gray code:

WD   D   C   4122

WD   D   C   4123

E. Configuration Table for the Data Logger

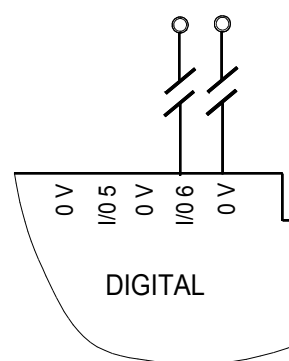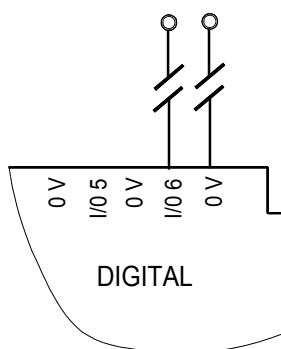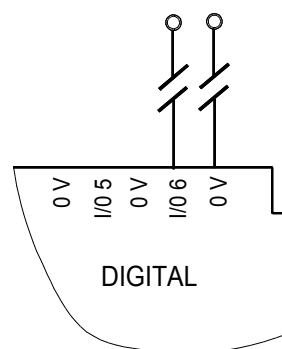| channel	designation	sensor	type of mea-	connection	terminal	format	range error	option
analog input	comment	voltage current resistance	differential single-ended 2/3/4-wire	according to type of mea-surement	according to type of mea-surement	unit field length decimals binary format	limits error handling tare settings	type of averaging for data storage offset correction
digital input	comment		status frequency up counter gray-code	according to type of mea-surement	according to type of mea-surement	unit field length decimals binary format		time base conv. factor data memory summing reset
digital output	comment		host out process out	according to type of mea-surement	according to type of mea-surement	unit field length decimals binary format	bus timeout	threshold value
arithmetic	comment					unit field length decimals binary format	data memory	formular
setpoint	comment					unit field length decimals binary format	bus timeout	setpoint input data memory
alarm	comment					unit field length decimals binary format		threshold value

F. Accuracy / Resolution / Noise / Linearity / Temp-Drift

Overview measuring ranges				
gain step	gain factor	voltage measurement	current measurement	resist. measurement
0	1	-	-	20 kΩ
1	2	±10 V	-	10 kΩ
2	4	±5 V	-	5 kΩ
3	8	±2.5 V	25 mA	2.5 kΩ
4	16	±1.25 V	12.5 mA	1.25 kΩ
5	32	±625 mV	6.25 mA	625 Ω
6	64	±312.5 mV	3.125 mA	312.5 Ω
7	100	-	-	200 Ω
8	200	±100 mV	1000 µA	-
9	800	±25 mV	250 µA	-
A	3200	±6.25 mV	62.5 µA	-

Overview measuring accuracy					
type of measurements		voltage single-end.	current measur.	voltage differential	all
gain step	gain factor	accuracy[1]			resolution noise
0	1	0.01 %	0.05 %	0.03 %	0.003 %
1	2				
2	4				
3	8				
4	16				
5	32	0.03 %		0.10 %	0.010 %
6	64				
7	100	0.03 %		0.03 %	0.003 %
8	200				
9	800	0.10 %			0.010 %
A	3200	0.30 %			0.030 %

(1)   values correspond to 80 % of the measuring range

Voltage measurement - single-ended					
range	accuracy[1][3]		Resolution / noise[1]	linearity[2]	temperat. drift[2]
±10 V	1.0 mV				
±5 V	0.5 mV	0.01 %	0.003 %		
±2.5 V	0.3 mV				
±1.25 V	0.1 mV				25 ppm/K
±625 mV	0.2 mV			0.01 %	2 ppm/K[4]
±312.5 mV	0.1 mV	0.03 %	0.010 %		
±100 mV	30 µV	0.03 %	0.003 %		
±25 mV	25 µV	0.10 %	0.010 %		0.4 µV/K
±6.25 mV	20 µV	0.30 %	0.030 %		0.02 µV/K[4]

(1)   values for T=20 °C

(2)   values estimated from the hardware specification

(3)   values correspond to 80 % of the measuring range

(4)   with additional offset compensation

Voltage measurement - differential					
range	accuracy[1][3]		Resolution / noise[1]	linearity[2]	temperat. drift[2]
±10 V	3.0 mV				
±5 V	1.5 mV				
±2.5 V	0.8 mV	0.03 %	0.003 %		
±1.25 V	0.4 mV				
±625 mV	0.6 mV			0.01 %	25 ppm/K
±312.5 mV	0.3 mV	0.10 %	0.010 %		2 ppm/K[4]
±100 mV	30 µV	0.03 %	0.003 %		
±25 mV	25 µV	0.10 %	0.010 %		0.4 µV/K
±6.25 mV	20 µV	0.30 %	0.030 %		0.02 µV/K[4]

(1)   values for T=20°C

(2)   values estimated from the hardware specification

(3)   values correspond to 80% of the measuring range

(4)   with additional offset compensation

Current measurement					
range	accuracy[1][3]		Resolution / noise[1]	linearity[2]	temperat. drift[2]
25 mA	12.5 µA		0.003 %	0.01 %	25 ppm/K
12.5 mA	6.25 µA				
6.25 mA	3.13 µA	0.05 %			
3.125 mA	1.5 µA		0.010 %		
1 mA	0.50 µA		0.003 %		
0.25 mA	0.25 µA	0.10 %	0.010 %		12 nA/K
0.0625 mA	0.20 µA	0.30 %	0.030 %		

(1) values for T=20°C

(2) values estimated from the hardware specification

(3) values correspond to 80% of the measuring range

Resistance measurement					
range	accuracy[1][3]		Resolution / noise[1]	linearity[2]	temperat. drift[2]
20 kΩ	10 Ω	0.05 %	0.003 %	0.01 %	25 ppm/K
10 kΩ	5 Ω				
5 kΩ	2.5 Ω				
2.5 kΩ	1.25 Ω				
1.25 kΩ	0.63 Ω				
625 Ω	0.31 Ω				
312.5 Ω	0.15 Ω		0.010 %		5 ppm/K[4]
200 Ω	0.1 Ω		0.003 %		

(1) values for T=20 °C ,

(2) values estimated from the hardware specification

(3) values correspond to 80 % of the measuring range

(4) with external drift compensation, reference resistance with TCR 1

Achievable absolute accuracy

with voltage measuring incl. drift correction: typical ±3 µV

Achievable accuracy for temperature measurement with Pt 100 resistance (measuring range -200°...850 °C, temperature range -200°...200 °C, scan rate 1 s, averaging interval 1 min)

without drift correction: ≤ 0.1 °C with ambient temperatures 0 °C...+40 °C

with external drift correction: typical 0.05 °C

with ambient temperatures

-40 °C...+85 °C

Reference resistance 100 Ω, TCR 1

G. Algorithms for special meteorological Parameters

Index of constants

SVP = Saturation vapor pressure in hPa

VP = Actual vapor pressure in hPa with air temperature TT

TT = Dry bulb temperature in °C

HT = Wet bulb temperature in °C

SP = Air pressure, reduced to average gravity and 0 °C,
at station altitude; normally 1013.246 hPa is calculated

RF = Rel. humidity in %

DT = Dew point temperature in °C

$$C = 0.00066 * (1 + 0.00115 * HT)$$

C_1 = 6.1078

C_2 = 17.84362 (at TT < 0 °C)

C_2 = 17.08085 (at TT > 0 °C)

C_3 = 245.425 (at TT < 0 °C)

C_3 = 234.175 (at TT > 0 °C)

Saturation vapor pressure

$$SVP(TT) = C_1 * e^{\frac{C2*TT}{C3+TT}}$$

by MAGNUS (1)

Actual Vapor Pressure VP

$$VP = SVP(HT) - C * SP * (TT - HT)$$

by SPRUNG (2)

Rel. humidity RF from dry- and wet bulb-temperature

$$RF = \frac{VP}{SVP(TT)} * 100\%$$

(3)

Dew point temperature DT

a)   Dew point from psychrometric measurement (dry- and wet bulb temperature)

$$DT = \frac{C_3 * \ln\frac{VP}{C_1}}{C_2 - \ln\frac{VP}{C_1}}$$

(4)

b)   Dew point from rel. humidity and air temperature

$$DT = C_3 \frac{\ln\left(0.01 * RF * \frac{SVP}{C_1}\right)}{C_2 - \ln\left(0.01 * RF * \frac{SVP}{C_1}\right)}$$

(5)

Standard deviation

$$s = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}}$$

Vector mean value of wind direction (VecD) and wind speed (VecV)

The components of the horizontal wind vector *u(WV, WD)* are given as single values, with

WV - wind speed

WD - wind direction

The single components of the wind vector are determined by:

$$u_1 = WV * \cos(WD)$$
$$u_2 = WV * \sin(WD)$$

The mean values are subsequently gained by:

$$\overline{u_1} = \frac{1}{n}\sum_{i=1}^{n} u_1 i$$

$$\overline{u_2} = \frac{1}{n}\sum_{i=1}^{n} u_2 i$$

with i = Summation index

n = Number of single values within averaging period

$$\overline{WV} = \sqrt{\overline{u_1}^2 + \overline{u_2}^2}$$

$$\overline{WD}' = \text{arctan} \left| \frac{\overline{u_2}}{\overline{u_1}} \right| \quad \text{with} \quad 0° \leq \overline{WD}' \leq 90°$$

As $\overline{u_1}$ and $\overline{u_2}$ may also be relative and arctan is only defined for a range 0°...90°, the true direction angle $\overline{WD}$ is determined by following table:

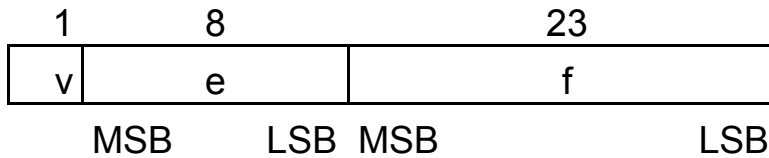| $\overline{u_1}$	+	-	-	+
$\overline{u_2}$	+	+	-	-
$\overline{WD}'$	$\overline{WD}'$	$180° - \overline{WD}'$	$180° + \overline{WD}'$	$360° - \overline{WD}'$

For $\overline{u_1} = 0$ $\quad \overline{WD} = 0°$, is defined.

H. Description of Short Real Format

The data type occupies 4 byte (32 bit, corresponding 8 hexadecimal numbers) which are placed as follows:

Width

1	8	23
v	e	f

MSB   LSB MSB   LSB

Position

Value w of a number stored in this format can be determined as follows:

if   0 < e   and   e < 255   then $w = (-1)^v * 2^{e-127} * (1.f)$

if   e = 0   and   f <> 0   then $w = (-1)^v * 2^{e-126} * (0.f)$

if   e = 0   and   f = 0   then $w = (-1)^v * 0$

I. Notes for installing Configuration Software COMBILOG.EXE

The *COMBILOG 1022* can completely be configured by means of the *COMBILOG.EXE* program.

This program is included with the delivery of the *COMBILOG* and is supplied compressed on a CD Rom. Installation is carried out as follows:

1. Start WINDOWS on your PC.
2. Insert the CD Rom into the selected drive.
   Choose the Program Manager and click „Execute" in the File menue. Enter drive indication and the name of your program "SETUP.EXE".
3. Follow the hints of the installation program.

After successful installation a new program group called *COMBILOG* is created.
Start this program by click on the *COMBILOG* icon. As soon as the program is started, you can call any „help"-chapter by means of the „F1"-key.