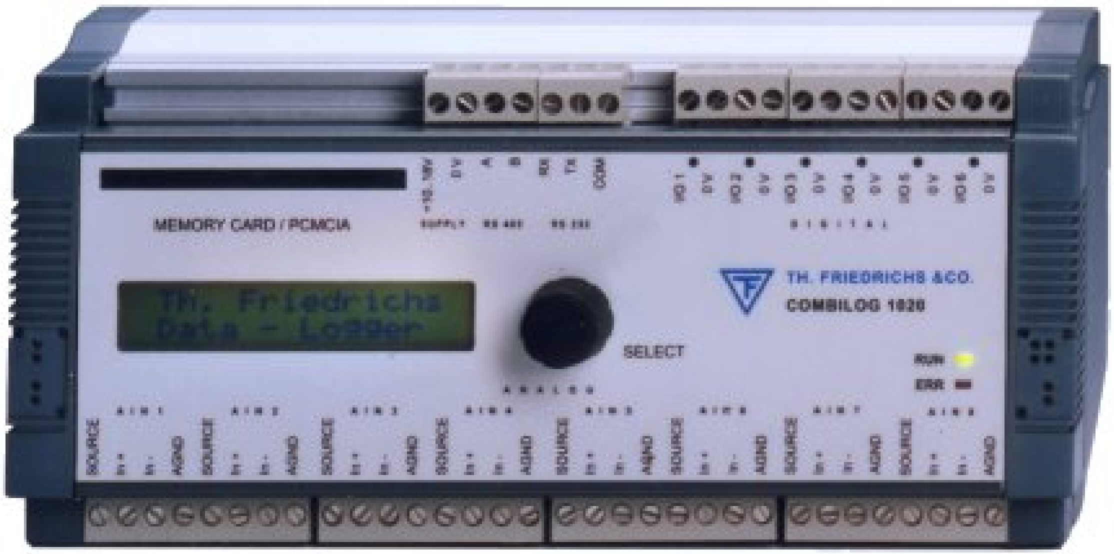
COMBILOG 1020

Datalogger



Hardware Manual Version 3.10

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CHAPTER SURVEY

TABLE OF CONTENTS

1 GENERAL PRELIMINARY REMARKS

1.1 On This Manual

The manual contains all important information concerning the function, installation and initiation of the datalogger *COMBILOG 1020.*

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 datalogger *COMBILOG 1020* 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 datalogger *COMBILOG 1020*, 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 datalogger *COMBILOG 1020*.

1.3 Contact for Inquiries

In case of inquiries concerning the datalogger *COMBILOG 1020* please contact your local distributor or directly
Theodor Friedrichs & Co. GmbH.

2 SYSTEM DESCRIPTION

2.1 System Overview

The *COMBILOG 1020* is a datalogger with compact design, combined with integrated LC-display and memory slot suitable for PCMCIA memory cards.
This datalogger was developed for meteorological, hydrological and environmental measuring systems, but it is equally suitable for countless further applications in industrial production.
The *COMBILOG 1020* features high performance, compact design (SMD components), low power consumption and moderate price.

The datalogger is equipped with 8 analog and 6 digital measuring channels; further channels for numeric calculation may be configurated. Two serial interfaces, RS232 and RS485, are built-in, featuring communication via ASCII, PROFIBUS or MODBUS. Data storage is achieved by internal RAM or PCMCIA memory card, optionally.
„SELECT“ switch and 2-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 1020 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. Especially for battery supplied systems the datalogger can be delivered with reduced internal processor clock. Please note, that in this case the performance may be reduced too.

For applications like outdoor use there is a version with stainless steel housing available, as well as various other accessories.
Configuring of the datalogger is accomplished by means of an easy to handle WINDOWS™ 98/ME/NT/2000/XP 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 1020. Some typical applications are e.g. measurement of temperature via resistance thermometers (Pt100), operation with combined sensors with current- or voltage output (e.g. windspeed measurement with DC generator) or position measurement and weight measurement by displacement transducers and force transducers. With these applications the datalogger *COMBILOG 1020* 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 measurings, 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 analog and 6 digital inputs are not sufficiant, other modules can be connected to the datalogger 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 datalogger *COMBILOG 1020* 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 datalogger 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).

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
- ❑ 256 kB RAM internal data storage, extendadble upto 8 MB with PCMCIA SRAM card (max. 65536 datasets)
- ❑ linear Flash memory cards up to 16 MB

Inputs and Outputs:

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

Power Supply:

- ❑ Power supply: +10 ... +18 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 key for digital inputs/outputs
- ❑ LED-status key for malfunction and operation (ERR / RUN)
- ❑ LC-display (2 x 16 characters) and push-/turn knob for operation

Measured Value Processing:

- ❑ Linearization, 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
- 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 linearization
- 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:

- Loading of a new download program
- 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 and RS 232 communication interface
- Autonomous function independent of subsequent systems
- Definition of the transmission protocol (ASCII,PROFIBUS, MODBUS (on request))
- 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
- Module jack, ground connection

Innovations from software version 3.00:

- Extendable to 32 channels
- Resistance measurement in 2-, 3- and 4 wire mode
- Measurement of thermocouples
- Master function for data exchange with other modules on the same bus
- Use of SRAM cards for memory expansion
- Baud rate up to 38,400 bps
- 2 versions:
  Standard version with 20 MHz processor clock
  Low power version with 5 MHz processor clock
- Additional communication commands for memory management and password protection
- Automatic report in case of programmable conditions via modem or SMS
- Selectable scan rate between 0.5 sec. and 60 min, averaging interval between 1 s and 12 h
- Event controlled averaging interval

2.4 Configration Software

The COMBILOG 1020 is delivered with a configuration software for MS WINDOWS 98/ME/NT/2000/XP. This software allows the individual configuration of the datalogger.

Measuring channels are defined as variables in a variable table.

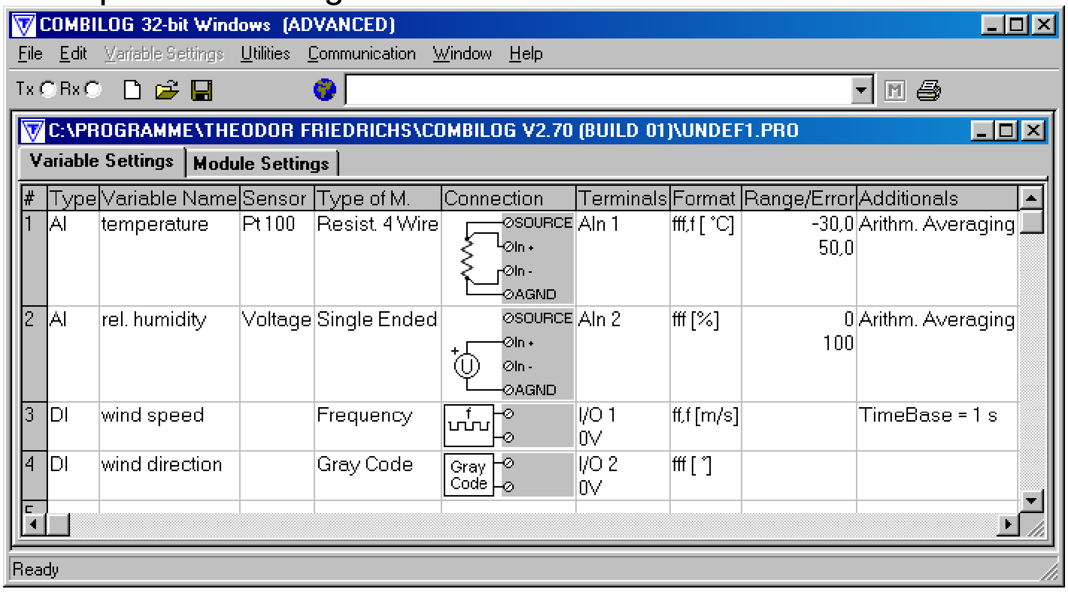
Predefined sensors can be selected from the integrated database. The linearization of the sensor signals will be performed automatically. Additional sensors can be defined.

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 datalogger 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:



3 INSTALLATION

3.1 Mounting / Fixing

The datalogger *COMBILOG 1020* 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 datalogger. First push the two straps on the bottom behind the notch of the DIN rail and then press the datalogger on the DIN rail until the two straps on the top snap in.

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

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

3.2 Protective System

The datalogger has an IP20 protective system. For outdoor installations datalogger *COMBILOG 1020* can be installed in a stainless steel shell type 9910, thus featuring IP65 standard.

3.3 Ambient Temperature

The admissible ambient temperature for the datalogger *COMBILOG 1020* is -30 °C to +60 °C. The admissible storage temperature is between -40°C and +85°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 datalogger *COMBILOG 1020* shows following elements:

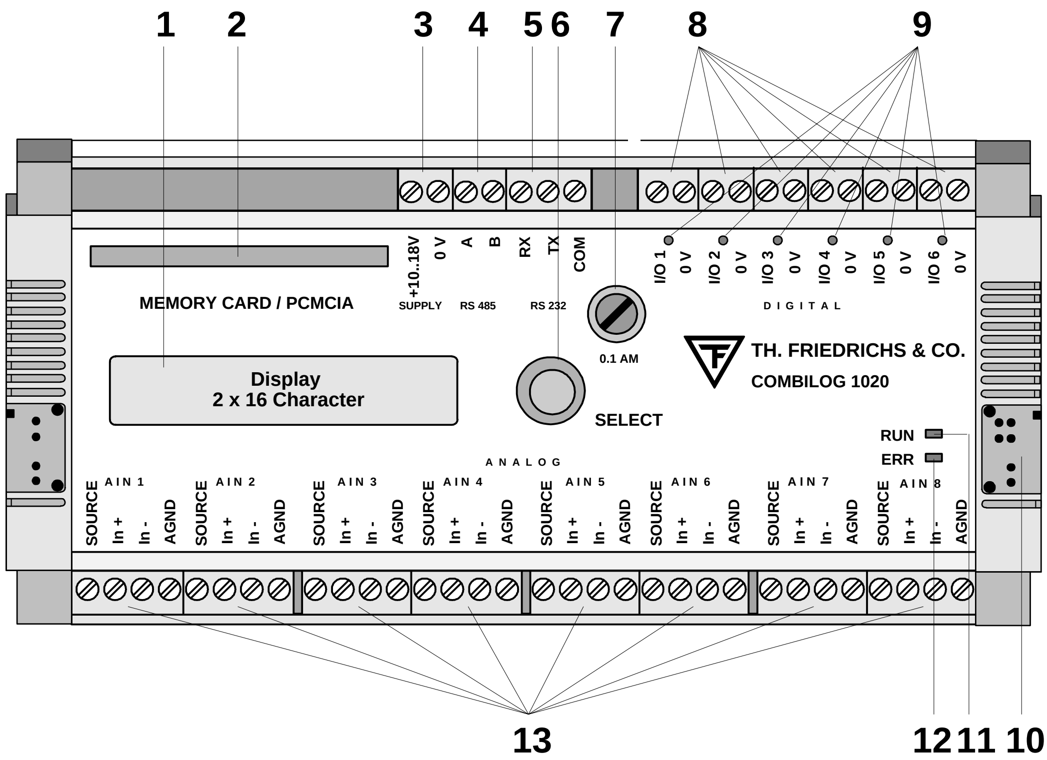


Figure 3.1 Front panel

Description of the Parts:

Number	Description
1	LC-display
2	Interface for memory card
3	Voltage supply
4	interface connection RS485
5	PC interface RS232
6	Press/rotary knob
7	Fuse 0.1 A M *

Number	Description
8	6 digital I/Os
9	Status-LEDs for digital I/Os
10	Module jack connection
11	LED RUN (green)
12	LED ERR (red)
13	8 analog inputs

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

* Integrated multifuse from serial number 090323

Pin Assignment:

Terminal	Assignment
+10..18V	Voltage supply +
0V	Voltage supply -
A	RS485-bus interface A
B	RS485-bus interface B
RX	RS232 receive
TX	RS232 transmitt
COM	RS232 ground

Terminal	Assignment
I/O *1…6*	Digital I/O *1…6*
0 V	Ground for digital I/Os
SOURCE	Source output
In+	Analog input +
In-	Analog input -
AGND	Ground for analog input

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: M3 screw with toothed washer 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 datalogger.

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 datalogger. Assure that the toothed washer is firmly pressed into the housing surface.

3.6 Power Supply

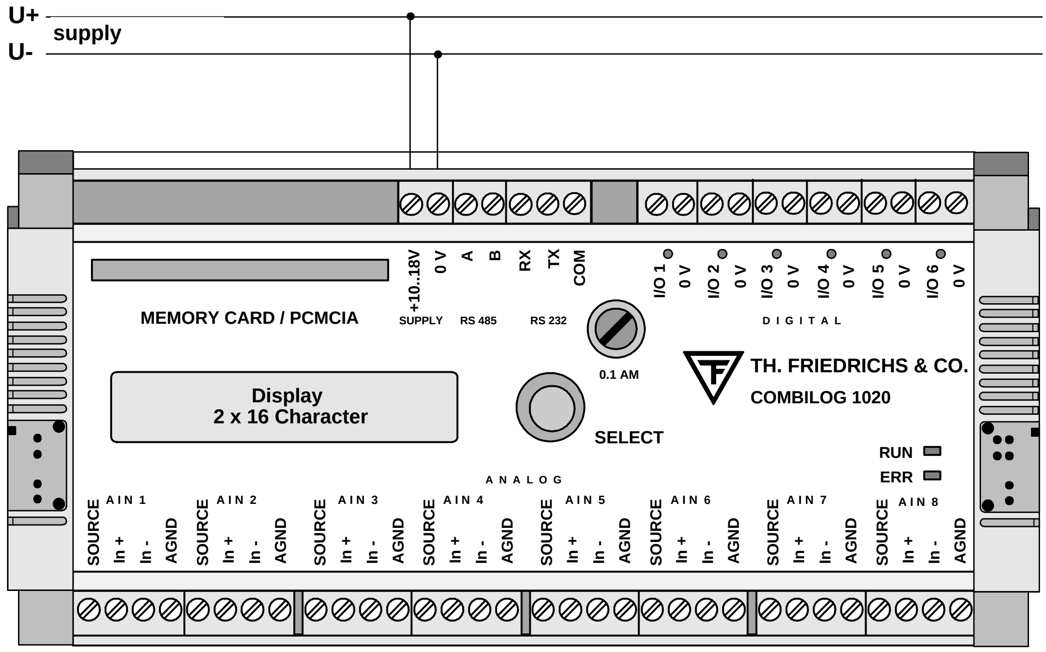


Figure 3.2 Connection of the distribution voltage

Voltage range

- ❑ +10 ... +18 VDC

Power input

- ❑ 0.1 W typical (up to 1W maximum, depending on configuration)

Internal protector (reversible)

- ❑ excess current 0.1 A M
- ❑ excess voltage

Non-regulated DC voltage between +10 and +18 VDC is sufficient for the power supply of the datalogger *COMBILOG 1020*. 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. 70 mA at 12 VDC) the datalogger can also be remote-fed via longer lines. Several dataloggers 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 datalogger’s supply voltage unnecessarily, a separate power supply for sensors with a large current requirement is recommended.

3.7 Bus Connection

In general the datalogger 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).

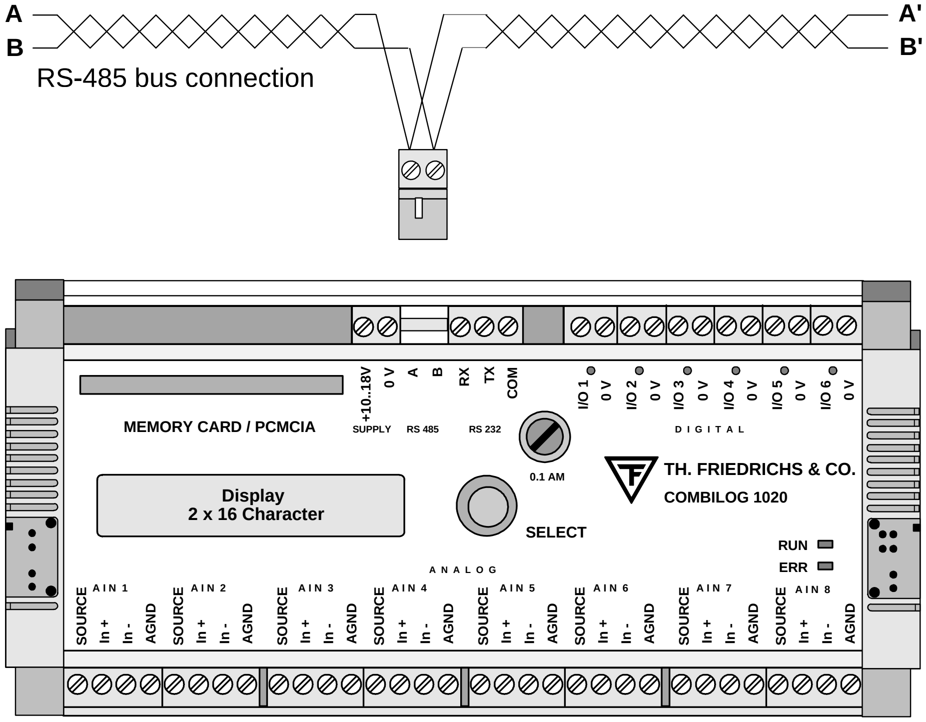


Figure 3.3 Connection of the datalogger to the bus

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 dataloggers remains valid, even if one datalogger is replaced by another.

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).

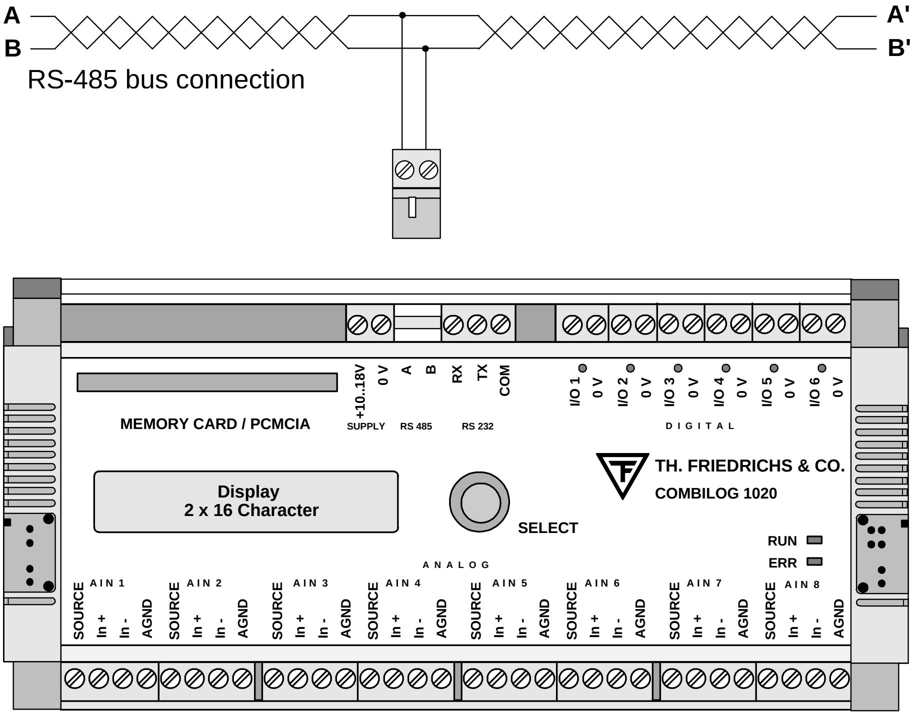


Figure 3.4 Connection of the datalogger to the bus by a stub cable

3.8 Sensor Connection

The analog 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 datalogger 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: signallamps, 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 Datalogger

The datalogger *COMBILOG 1020* can simultaneously receive and process sensor signals from several different sensors. As many sensors can be connected as there are analog and digital signal inputs and outputs available (14 sensors max.; 8 analog and 6 digital).

3.10 Module Jack

The datalogger *COMBILOG 1020* has a bus connection facility on the left and on the right side of the housing, featuring interconnection of the 10…18 VDC supply and the bus signal, for several COMBILOG's.

This kind of bus connection and of power supply is particularly advantageous if several dataloggers are mounted on one common profile rail side by side. In this case the connection via the terminals can be dropped, except for one module.

Note: It is necessary to take care that the current at the Module Jack is not higher than permitted. Thus, the power supply preferably should be led to the centre of the module line. For the same reason, it is not allowed to connect more than 6 dataloggers via the Module Jacks in one line.

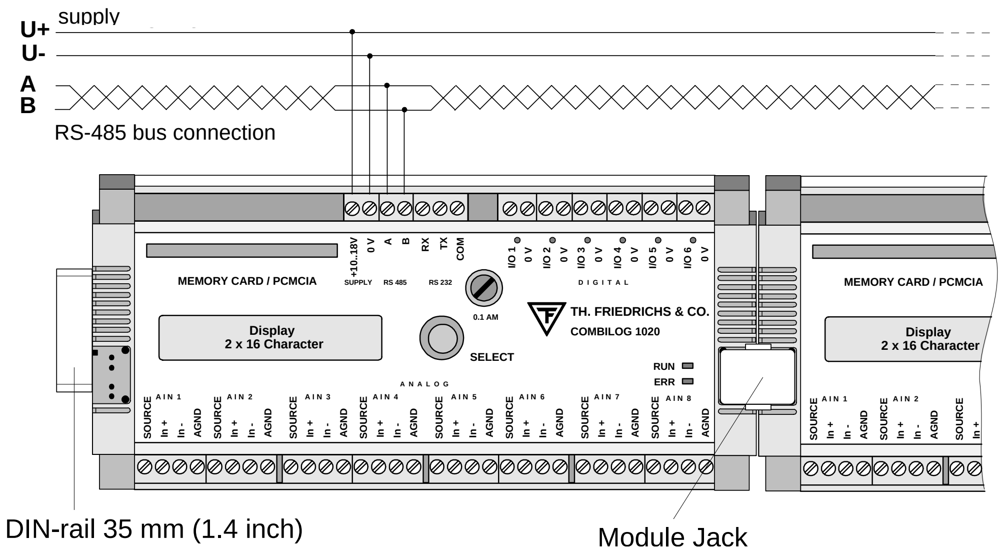


Figure 3.5 Connection of two COMBILOG 1020 with Module Jacks

4 SIGNAL PROCESSING

The datalogger *COMBILOG 1020* has eight analog 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 Analog Inputs

The analog 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 analog inputs, each input can be configured individually.

Note: Overloads of more than ± 10 VDC will lead to false measuring results in the according analog 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 datalogger 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 18 V. Input voltages between 3.5 VDC and 18 DC are interpreted as logic *LOW* ("0"), input voltages lower than 1.0 V as logic *HIGH* ("1"). The maximum input current is 1.5 mA.

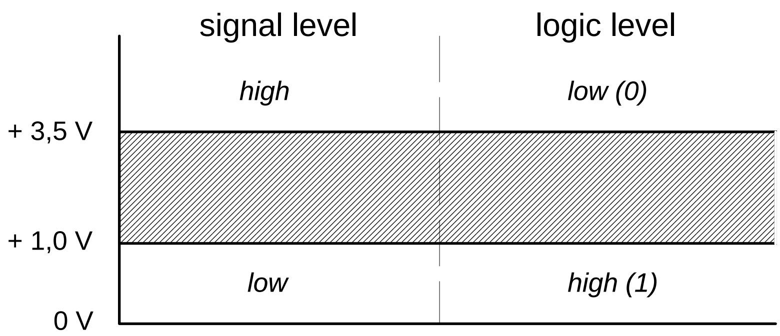


Figure 4.1 Definition of signal levels and logic levels

The outputs are open-collector type with a maximum voltage of 18 VDC and a maximum current of 100 mA.

4.3 Internal Reference Voltage, Offset- and Drift Correction

An internal reference voltage serves to adjust the entire analog 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 analog inputs can almost completely be kept free from temperature drift.

4.4 Internal Processing

Next to collecting the analog input signals, the analog 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-convertion guarantees a high accuracy and a high linearization. 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, 400, 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 enables use of a low pass filter, depending on the mains frequency (selectable between 10 and 400 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 datalogger 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 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 values are finally stored in the memory.

The special user program, the data for configuration, linearization and scaling etc. that are required by the processor µP for all tasks are retentively stored in a Flash EPROM.

The timing control of the data processing is realised by an internal real time clock buffered by Gold cap capacitor.

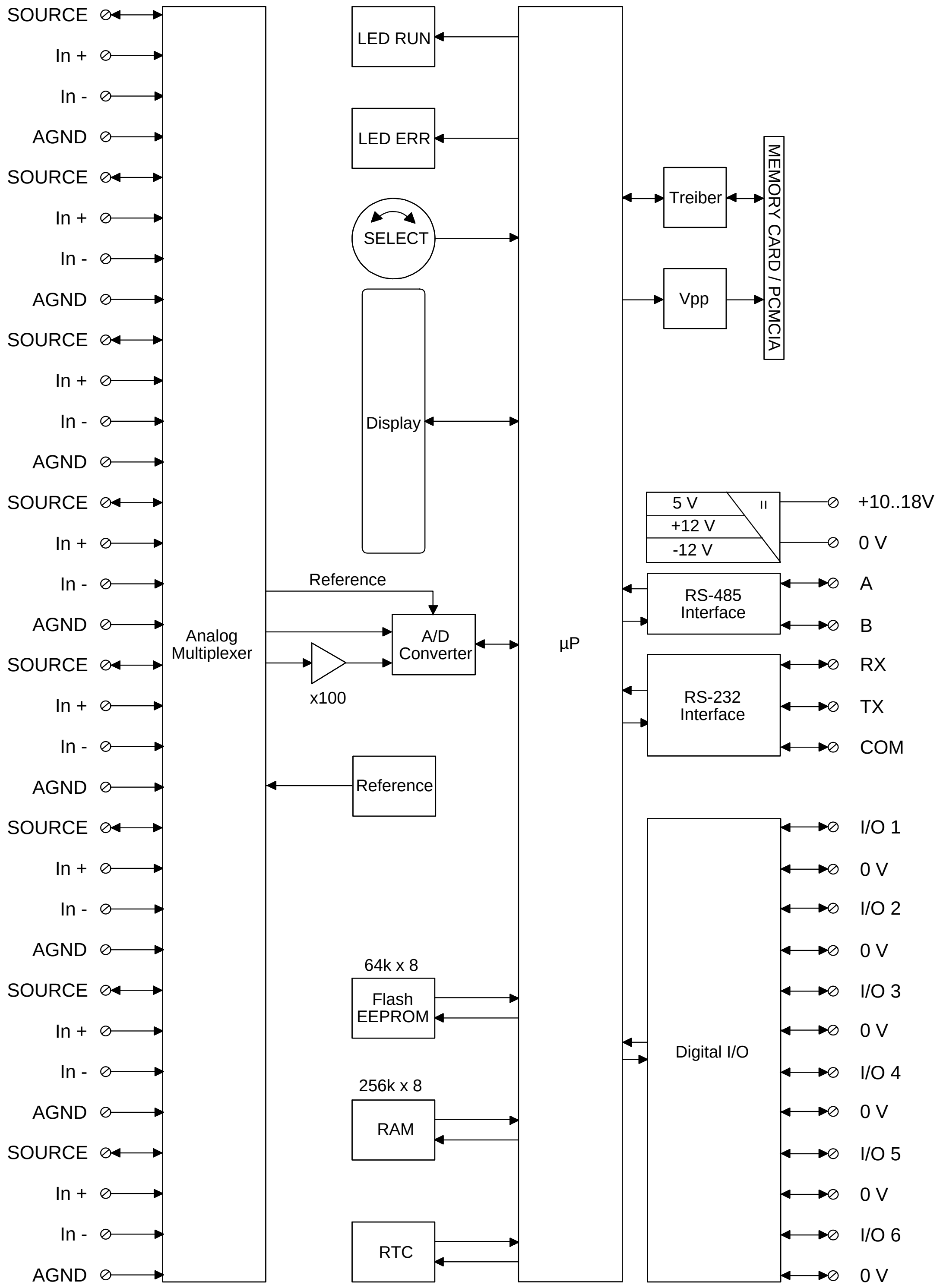


Figure 4.2 block diagram of the datalogger COMBILOG 1020

4.5 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 0.5 sec. and 1 hour. In this selected time period all configured channels are scanned and processed correspondingly. The power consumption of the datalogger *COMBILOG 1020* depends on this scan rate. Between the measuring cycles the datalogger will be set into a so-called “Sleep-Mode“. During this mode the datalogger needs only about 5 mW. The average current consumption over a longer time period will be accordingly:

filter	number of used analog inputs	scan rate 1 sec	10 sec	60 sec
50 / 60 Hz	1	20 mA	6.5 mA	5.3 mA
	2	25 mA	7.0 mA	5.3 mA
	3	30 mA	7.5 mA	5.4 mA
	4	35 mA	8.0 mA	5.5 mA
	5	40 mA	8.5 mA	5.6 mA
	6	45 mA	9.0 mA	5.7 mA
	7	50 mA	9.5 mA	5.8 mA
	8	55 mA	10.0 mA	5.8 mA
200 Hz Accu-operation	1	16.3 mA	6.1 mA	5.2 mA
	2	17.5 mA	6.3 mA	5.2 mA
	3	18.8 mA	6.4 mA	5.2 mA
	4	20.0 mA	6.5 mA	5.3 mA
	5	21.3 mA	6.6 mA	5.3 mA
	6	22.5 mA	6.8 mA	5.3 mA
	7	23.8 mA	6.9 mA	5.3 mA
	8	25.0 mA	7.0 mA	5.3 mA

Table 4.1 Current consumption at 12 VDC depending on the scan rate (5 MHz version)

The above values in table 4.1 are based on an internal clock frequency of 5 MHz (low power version) and an ambient temperature 20°C and are only valid if LEDs and LCD-display are switched off. At an internal clock frequency of 20 MHz (standard version) the basic power consumption is about 25 mA, independent of filter frequency and number of configured channels, rising up to 65 mA during measurement (for about 100 ms per channel at 50 Hz filter).

Note: A scan rate of 0.5 s causes an unsignificant higher variation of instantaneous values but does not affect the averaging.

4.6 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 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.

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 intitiated by certain program conditions, thus featuring temporary higher time resolution of measured signals.

5 FUNCTIONAL DESCRIPTION

The datalogger *COMBILOG 1020* has a total of 32 logical channels for the collection, processing and output of various kinds of sensor information. These 32 channels can be configured as:

- Analog Input Channel
- Digital Input Channel
- Digital Output Channel
- Arithmetic Channel
- Setpoint Channel
- Alarm Channel

For each channel various kinds of channel information and processing functions can be determined. The table in appendix C gives a survey of the channel set-ups with the datalogger *COMBILOG 1020*. The channel set-ups are carried out by means of the configuration software.

5.1 Analog Input Channel

The Analog Input Channel collects and processes the signals of the most common types of sensors. A large number of standardised sensors is already stored in the COMBILOG's 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 datalogger *COMBILOG 1020* 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 datalogger. Current measurements of more than 25 mA can be carried out by measuring voltage drop at an external shunt. Resistance measurings can be carried out in 2-, 3- and 4-wire technique.

Voltage Measurement

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

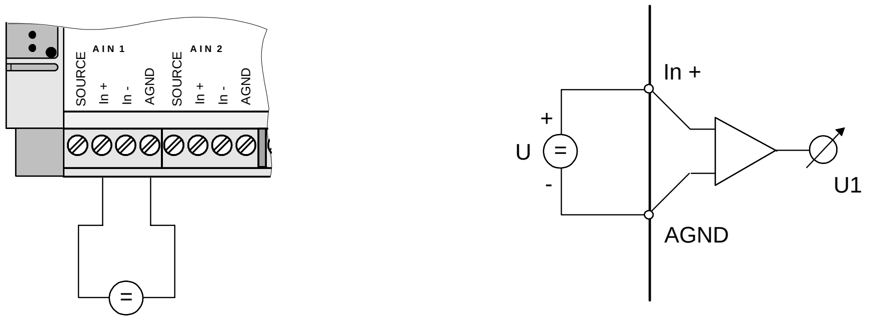
With the single-ended type the voltage to be measured is connected between an analog input (In+) and analog ground (AGND). Differential measurements are realized by using two analog inputs (In+ and In-). Measuring range is between 0 and ±10 V.

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**

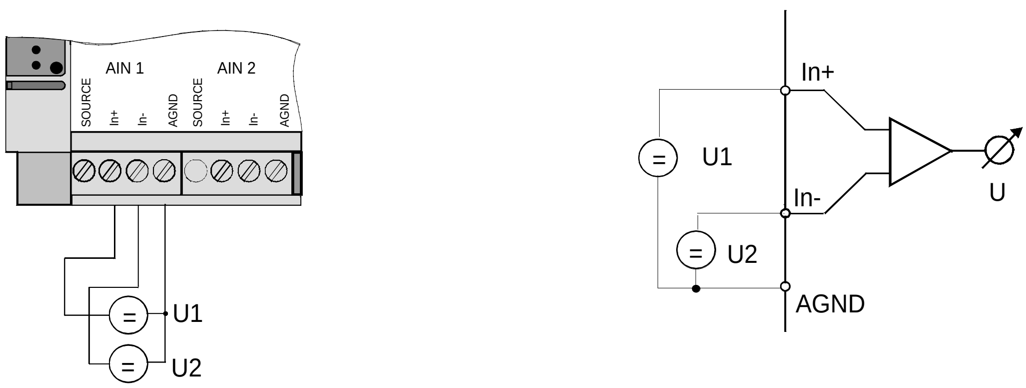


measuring voltage U

U = U1

Figure 5.1 Voltage measurement - single-ended

Connection scheme **Circuit**



measuring voltage U

U = U1 – U2

Figure 5.2 Voltage measurement - differential

Current Measurement

For current measurement the current source is connected between an analog input (In+) and analog 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 analog signal input and analog 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 analog input does not exceed +10 V. The analog 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

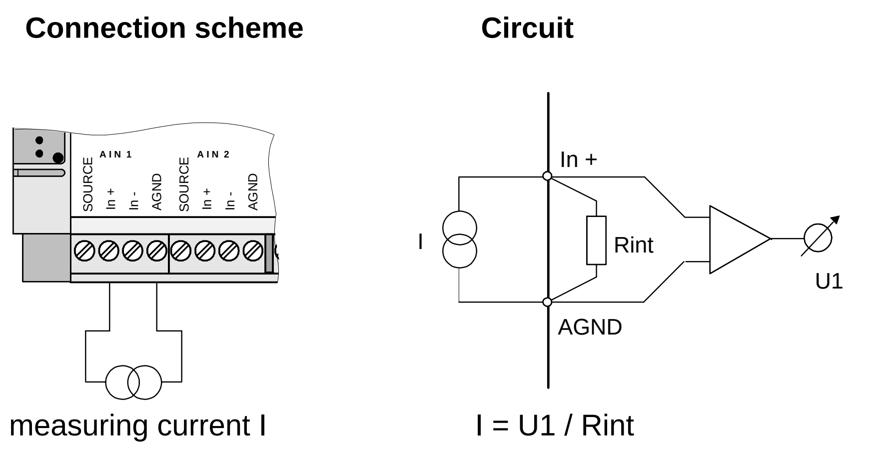


Figure 5.3 Current measurement with internal shunt

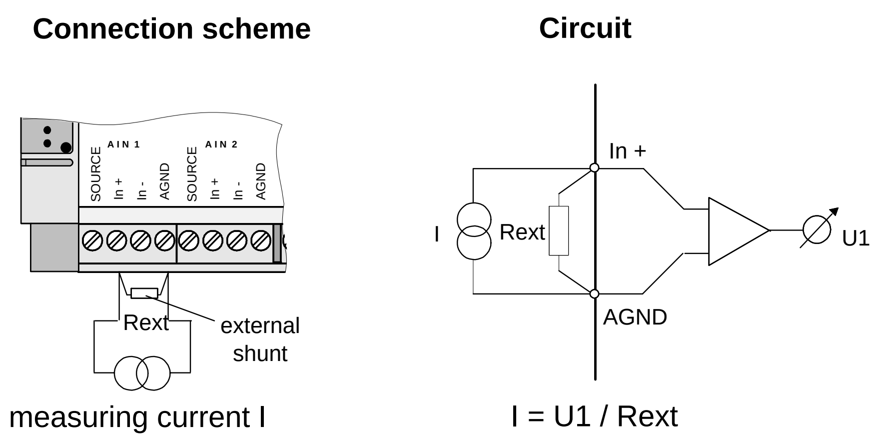


Figure 5.4 Current measurement with external shunt

Resistance Measurement

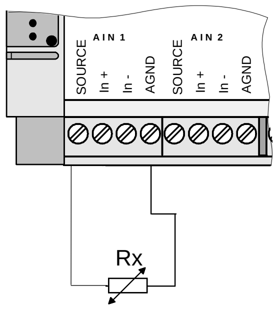
Resistance measurement is carried out by means of voltage measurement at a resistor, measuring the resulting voltage drop. The constant current required for the resistance measurings is provided by the internal supply of the datalogger.

For this purpose the sensor module connects a supply point internally with the analog 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 datalogger *COMBILOG 1020* 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 datalogger 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.

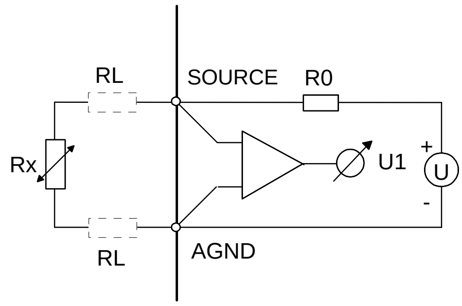
Resistance Measurement

Connection scheme



measuring resistance

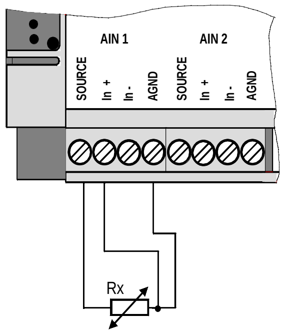
Circuit



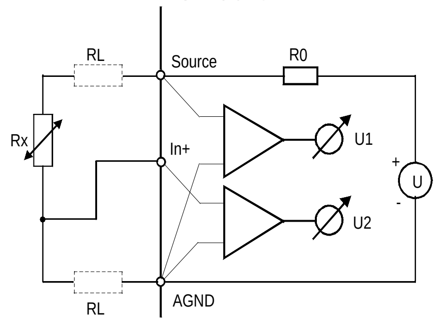
Rx = U1/U0 * R0, ΔRx = 2*RL

Figure 5.5 Resistance measurement in 2-wire technique

Connection scheme



Circuit

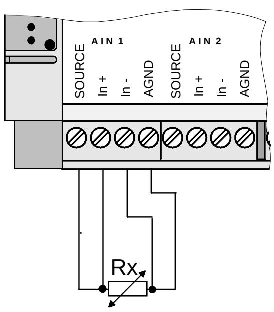


measuring resistance

Rx = (U1/U0-2*U2/U0) * R0, ΔRx=0

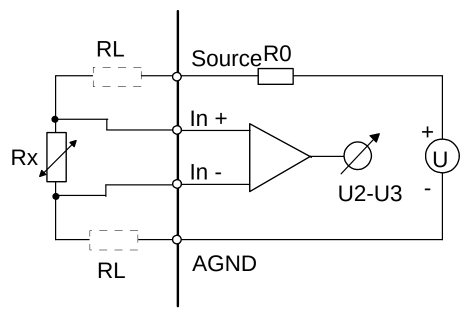
Figure 5.6 Resistance measurement in 3-wire technique

Connection scheme



measuring resistance

Circuit



Rx = (U2-U3)/U0 * R0, ΔRx = 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 eachother 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 datalogger COMBILOG 1020 the thermoelectric voltage is measured differentially.

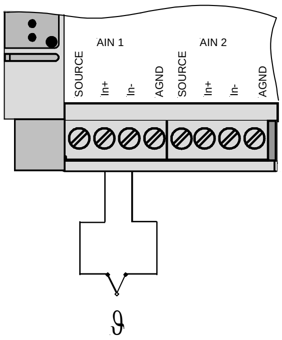
Since thermocouples can only measure a temperature difference (difference between temperature to be measured and temperature at the connecting terminals on the sensor module), a terminal temperature (internal cold junction compensation, TC_{int}) or a known temperature reference (external cold junction 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 linearisation trace to $\vartheta_x = \mathrm{Lin}(U_x + \mathrm{Lin}^{-1}\,\vartheta_k)$.

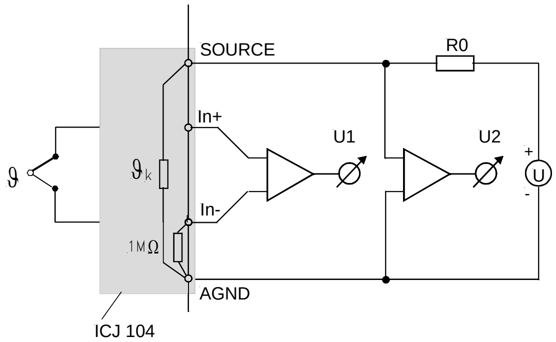
If the temperature is measured by external cold junction compensation, a second thermocouple of the same type is required, which is connected in series with the first one. The polarity is selected so that the thermoelectric voltages subtract each other. The second thermocouple is set to a fixed reference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

Temperature Measurement with Thermocouple

Connection scheme



Circuit

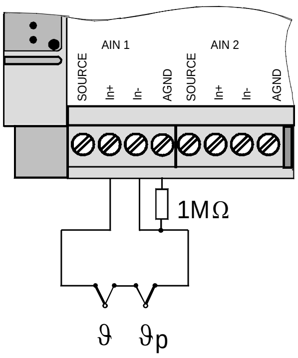


ϑ = Lin (U1+ Lin^{-1} ϑ_k)

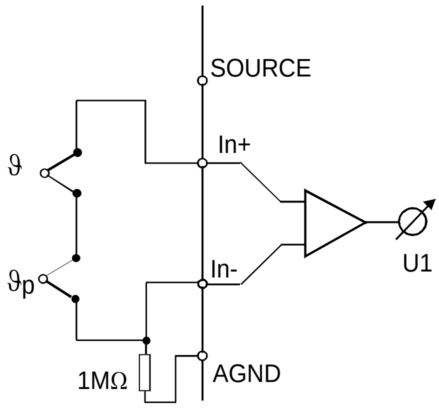
ϑ = Lin‘ (U2)

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

Connection scheme



Circuit



ϑ = Lin (U1 + Lin$^{-1}\vartheta_p$)

Picture 5.9 Temperature measurement with external cold junction compensation

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
- ❑ 8-bit-status input, with additional (external) module

The above mentioned functions are based on incremental measurings 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 1020*, e.g. wind direction sensor type 4122.

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.

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 datalogger *COMBILOG 1020* 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.

Digital Status Recording

Connection scheme **Circuit**

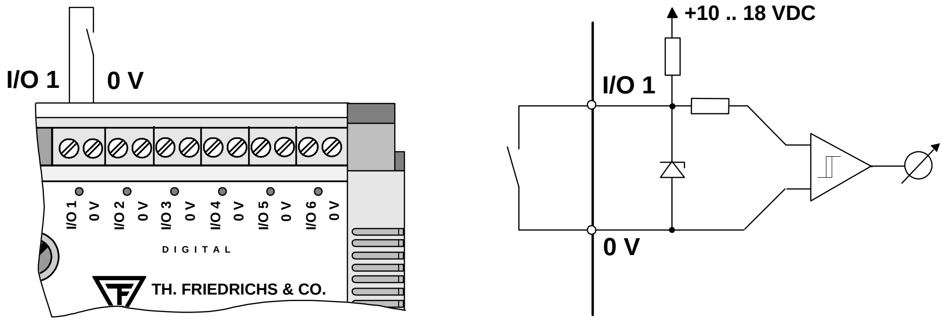
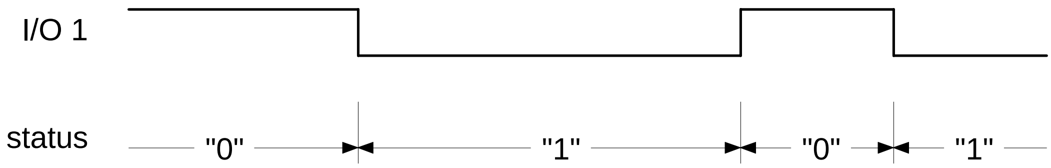


Figure 5.10 Digital status recording

Signal diagram:



Frequency Measurement

With frequency measurements the datalogger 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:

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

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 datalogger. 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, depends on the internal clock frequency of the processor. It is 1100 Hz for the 5 MHz version (low power version) and 2000 Hz for the 20 MHz version (standard version).

Frequency Measurement

Connection scheme **Circuit**

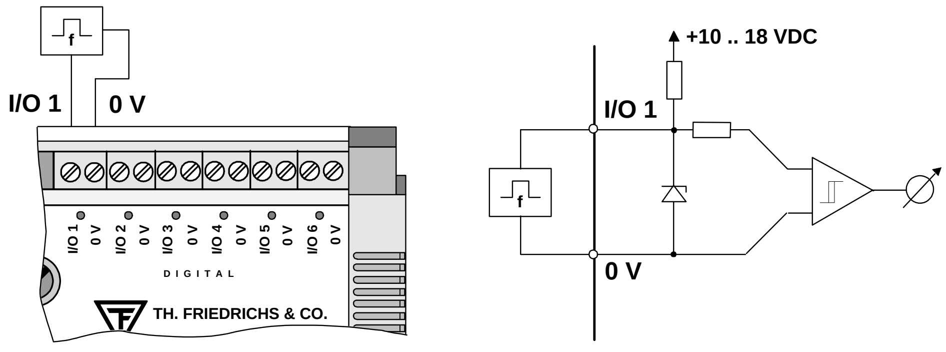
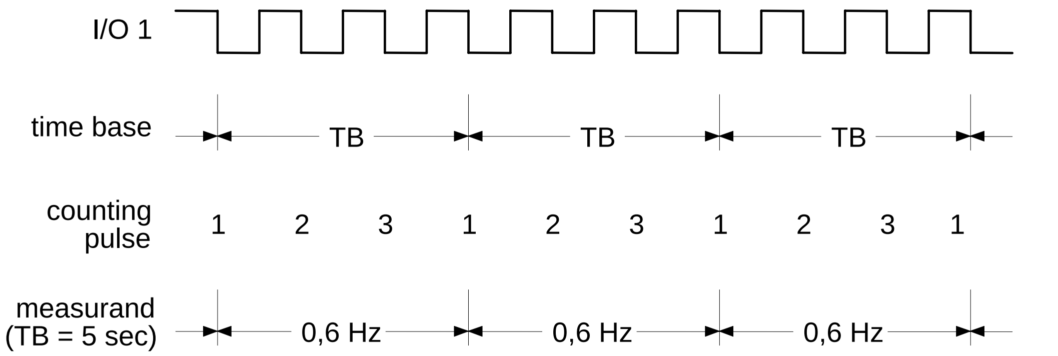


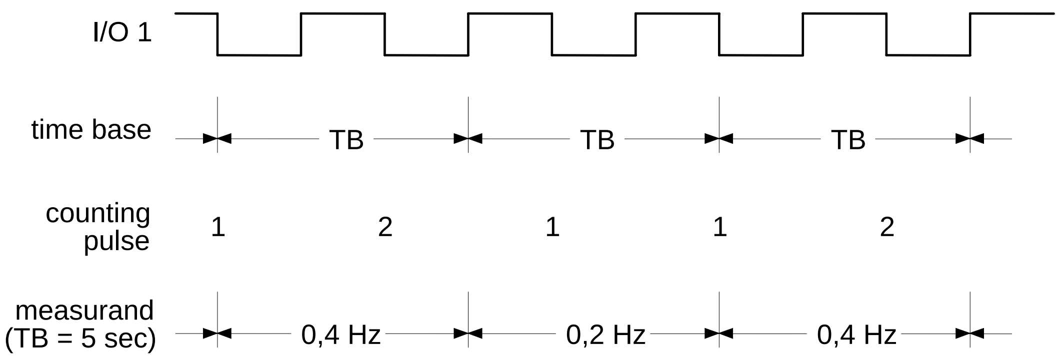
Figure 5.11 Frequency measurement

Signal diagram:

- high level:



- low level:



Progressive Counter

When configuring a digital input as a progressive counter the datalogger *COMBILOG 1020* 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 depends on the internal clock frequency of the processor. It is 1100 Hz for the 5 MHz version (low power version) and 2000 Hz for the 20 MHz version (standard version).

Note: After a voltage cut-off the counter is reset to zero.

Progressive Counter

Connection scheme **Circuit**

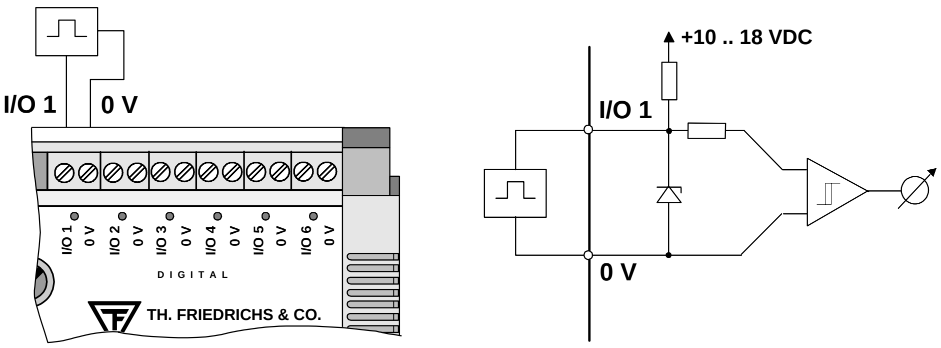
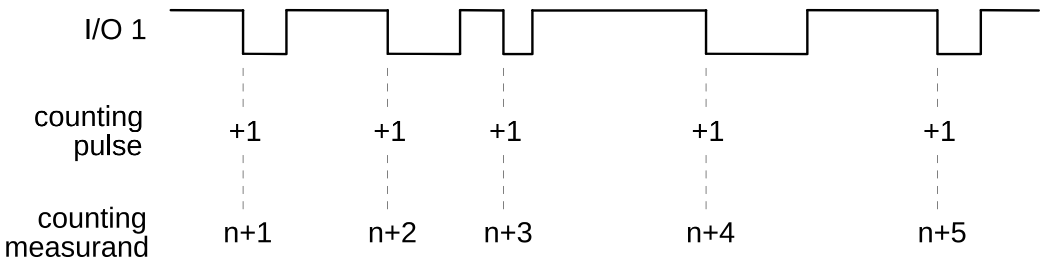


Figure 5.12 Progressive Counter

Signal diagram:



5.3 Digital Output Channel

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 datalogger *COMBILOG 1020* 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 18 VDC. It has to be either supplied externally or taken from the power supply of the datalogger.

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 datalogger via bus.

With the process-controlled output of status information the datalogger 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 comsumption of battery powered systems.

Digital Status Output:

Connection scheme **Circuit**

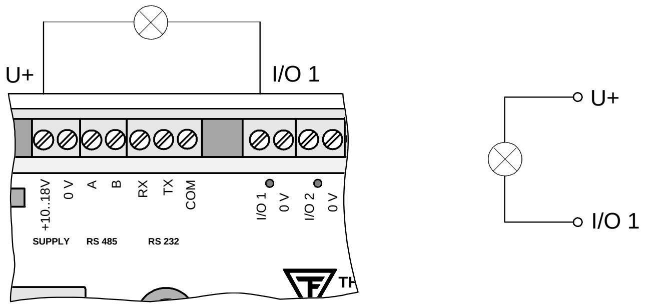
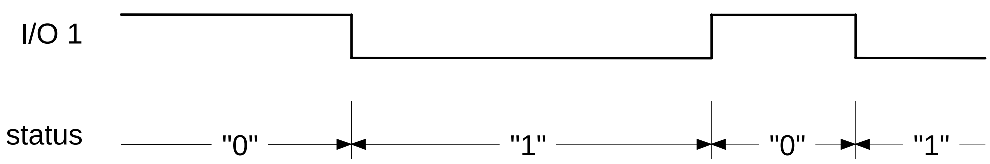


Figure 5.13 Digital status output

Signal diagram:



5.4 Arithmetic Channel

By means of the Arithmetic Channel sensor channels and constants can be connected with eachother 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, linearization 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 1020. For this case, some implemented special functions can be used for assistance.

Note: The calculation time of an Arithmetic Channel is 0.6 ms. The overall calculation time is the sum of the times of all operands in the formular plus 0.6 ms.

Arithmetik Operators

Operations	Short symbol	Time
Addition	+	0.80 ms
Subtraction	-	0.80 ms
Multiplication	*	0.80 ms
Division	/	1.10 ms
Modulo	%	0.90 ms
Truncate value	trunc	0.20 ms
Minimum value	min	0.20 ms
Maximum value	max	0.20 ms
Absolute value	abs	0.10 ms
Square root	sqrt	2.68 ms
Exponential function to base e	exp	3.92 ms
Logarithmical to base e	In	3.70 ms
Logarithmical to base 10	log	3.80 ms
Sine	sin	3.20 ms
Cosine	cos	3.60 ms
Tangent	tan	3.60 ms
Inverse sine	arcsin	3.20 ms
Inverse cosine	arccos	7.00 ms
Inverse tangent	arctan	3.20 ms
Lowest value from a selection	Low	1.50 ms
Highest value from a selection	high	1.50 ms
X^Y	power	8.80 ms
Integrator	integ	0.20 ms
Differentiator	deriv	0.20 ms
Read from external module	read	1)
Write to external module	write	1)
Time /seconds of the day)	SecondsOfDay	1.10 ms
Sample rate	SampleTime	0.10 ms
Free space on PCMCIA-Card	PCMCIASpace	0.90 ms
Free space in RAM	RAMSpace	1.70 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)
Dewpoint from temp. and humidity	DP1	
Dewpoint from dry and wet temp.	DP2	
Humidity from dry and wet temp.	RH	
Standard deviation	Sdev	
Vector of wind speed	WSv	
Vector of wind direction	WDv	

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 20 MHz. The 5 MHz version requires time values 4 times higher.

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.
- Logarithmical to Base e (**ln**)
  For avalue ≤ 0 the negative full scale will be assigned to the Arithmetic Channel.
- Logarithmical 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 tangents, 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 ($2\pi = 360°$). 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 datalogger 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 a user-specific software (upon request).

5.5 Setpoint Channel

This channel features transmission of values via bus to the datalogger *COMBILOG 1020*. The values are allocated to the setpoint-channel and are thus at the disposal of the datalogger 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 Threshold Values

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

5.8 Error Handling

The datalogger *COMBILOG 1020* 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 datalogger 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 1020 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 datalogger *COMBILOG 1020* has a display with 2 lines of 16 characters each, in order to allow the indication of the measured values of each channel. Furthermore the settings of the datalogger 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 menue 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:

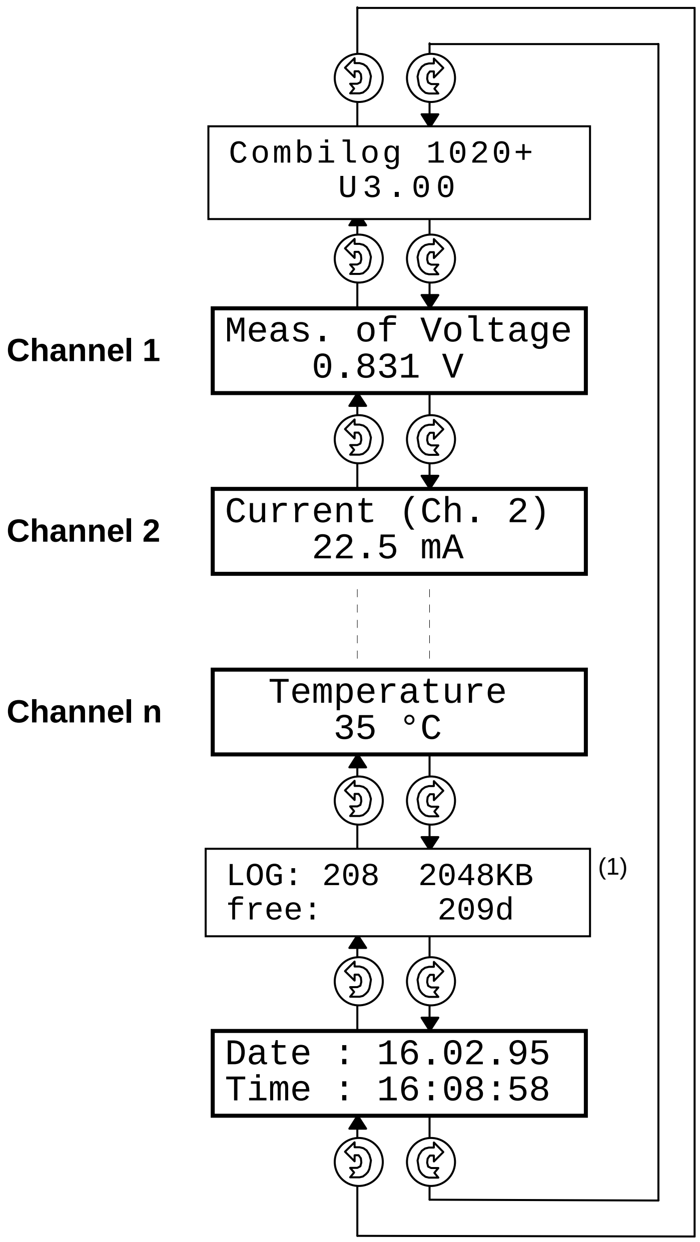
 ...... turn the knob clockwise

 ...... turn the knob counter clockwise

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

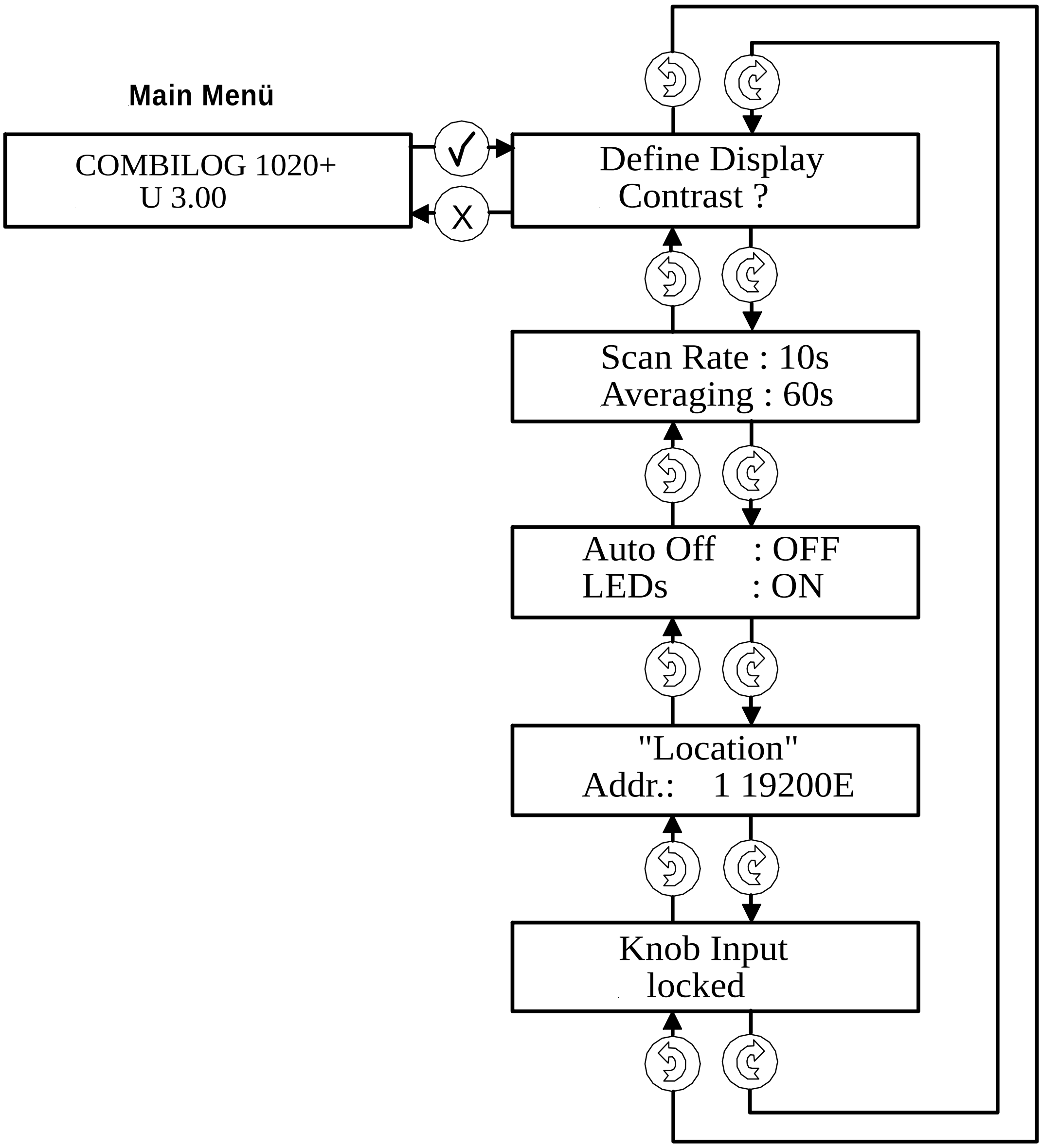
 ...... press the knob for approx. 1 second minimum
.... (abortion)

Main Menu:



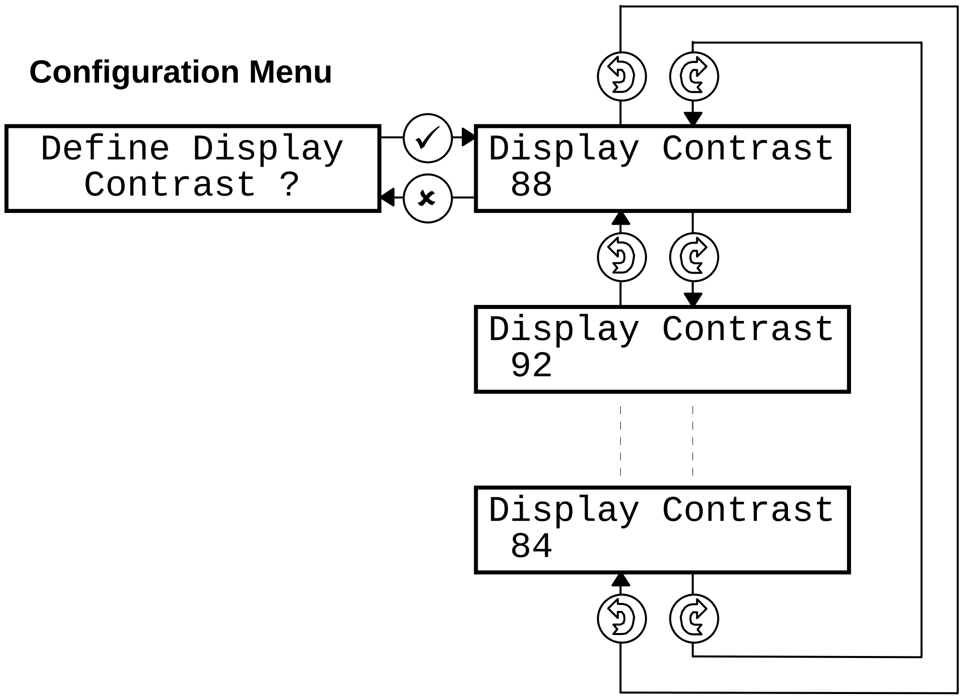
Note: The number, designation and indication of the measured value of the channels depend on the configuration.

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.

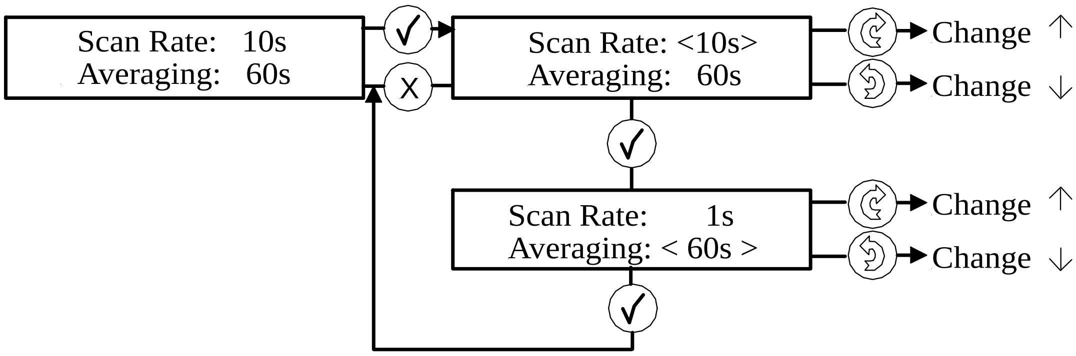
Setting of the Display Contrast:



Note: The value of the display contrast 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

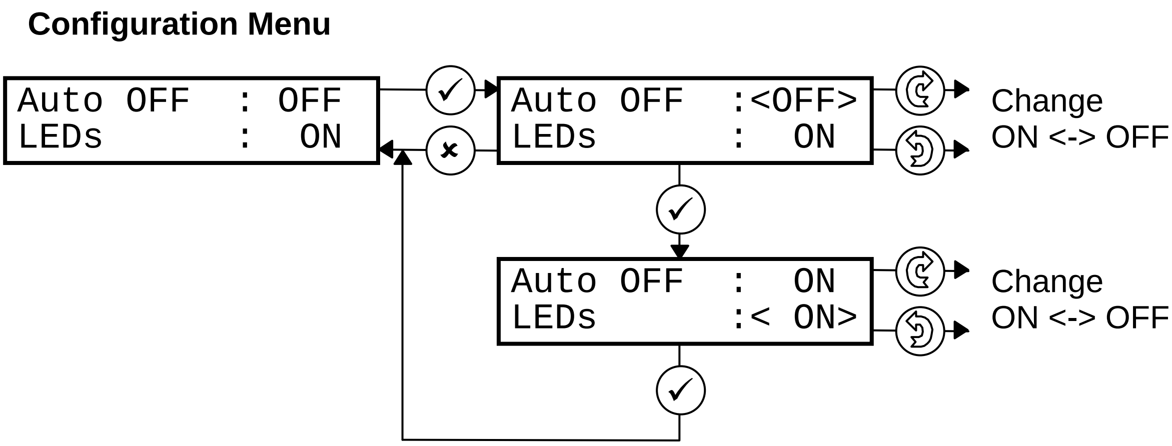


Note: The scan rate determines after which time interval the measured values of the channels will be measured again. Scan rate is selectable between 0.5s and 1h.

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 1s and 12h.

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).

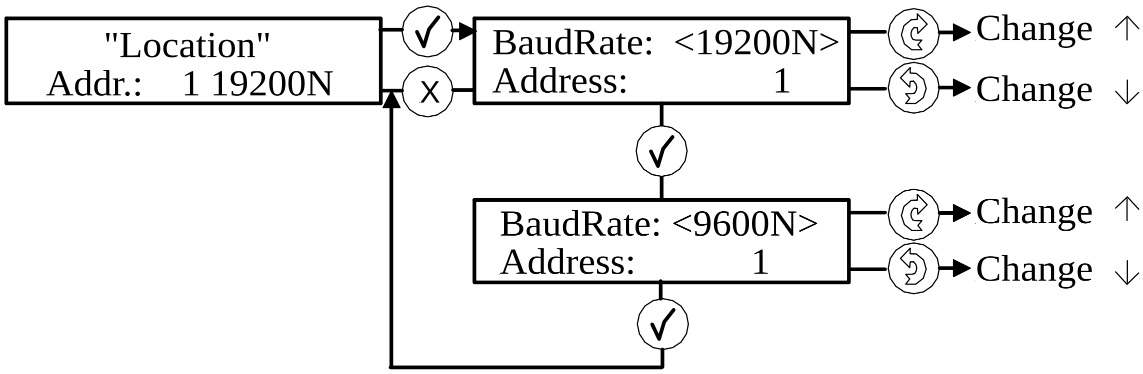
Setting of the Automatic Switch Off and the LED Display:



Note: With the automatic switch off function the datalogger 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 datalogger show the actual operating state (mode) of the datalogger. With the selection *OFF* the LEDs will be switched off.

Setting of the Baud Rate and the Address:

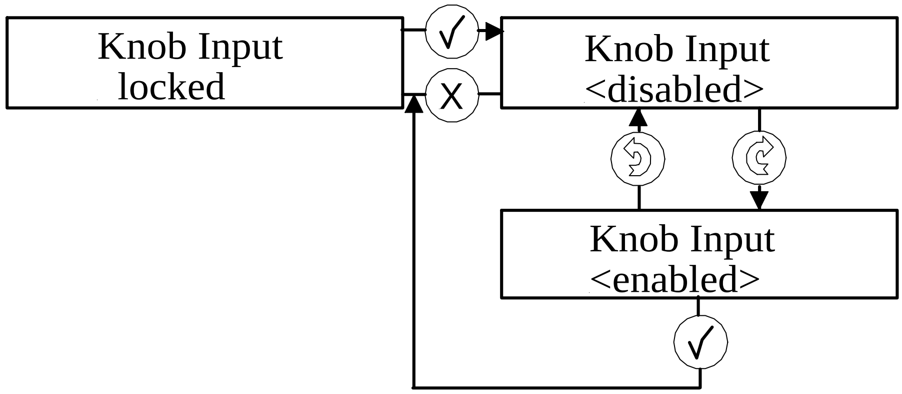
Configuration Menu



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 126 can be set.

Lock or Unlock the Press/Rotary Knob Input:

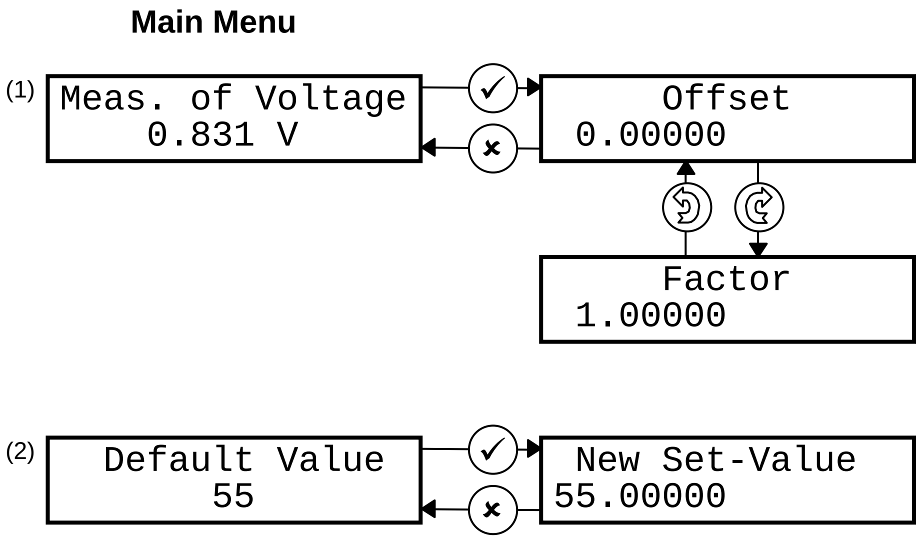
Configuration Menu



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 datalogger for approx. 30 seconds it will return to the main menu and the press/rotary knob input will automatically be locked.

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 counterclockwise (=downwards).

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

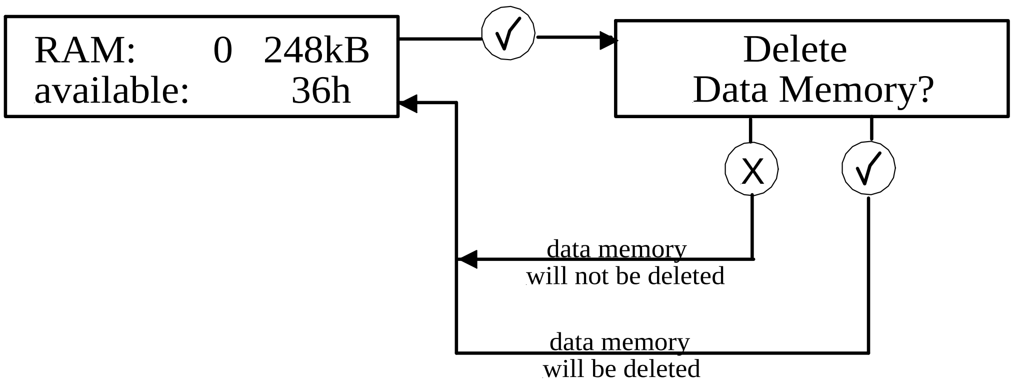
(1) the definition of offset and factor is possible for the analog input channel, the digital input channel and the digital output channel. These settings are used to convert the measurement value from the unit of the measured value to the unit of the measurement display.

(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 datalogger for further processing (e.g. for the arithmetic channel).

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

Delete the Data Memory:

Main Menu

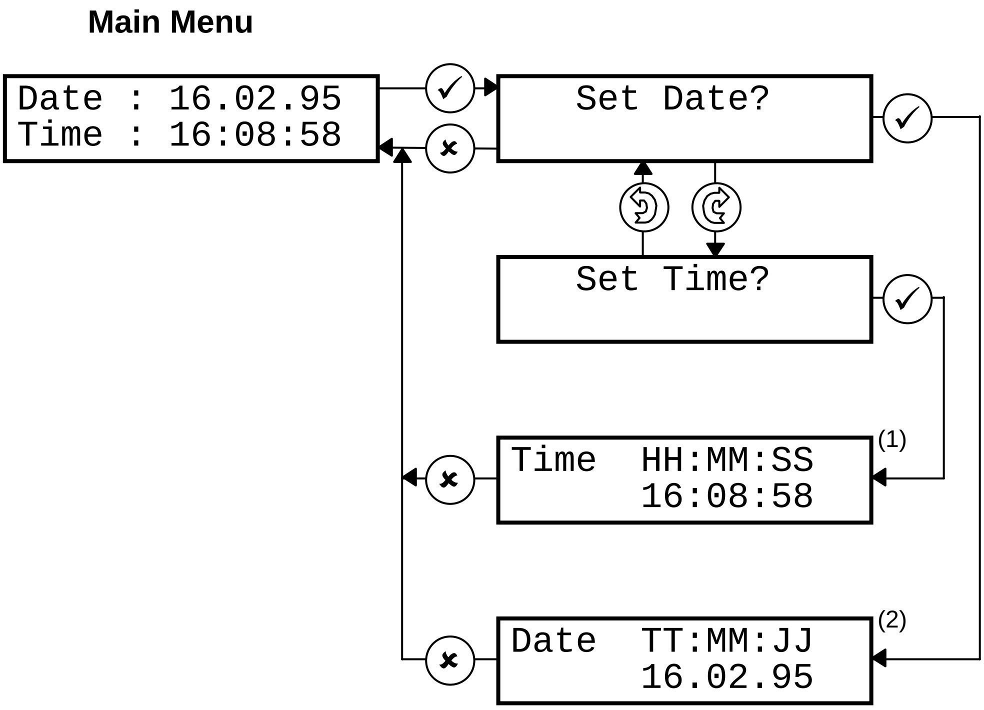


The display shows the number of stored datasets and the maximum capacity of the data memory in the first line. The second line shows the approximate time until the data memory is filled. This time is displayed in days (d) or hours (h) and is calculated by the datalogger assumed that the average interval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

Note: The data memory of the internal RAM can only be deleted if no PCMCIA memory card is inserted in the datalogger. By deleting the memory all stored events (measured values of the channels) will be lost.

Note: In case of using an SRAM memory card the internal data memory is not used. The card must not be pulled out, because all data will be lost after reinserting!

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.

7 DATA STORAGE

7.1 General Remarks to Data Storage

Data storage with the COMBILOG 1020 can be accomplished in three different manners:

Internal RAM: 252 KByte are available as circulated buffer for data recording.

External PCMCIA SRAM Card: This is an extension up to 32 Mbytes memory. The internal RAM will be deactivated if an SRAM Card is used, i.e. the card replaces the internal RAM. The maximum number of datarecords is limited to 65565.

External PCMCIA Flash Card: The records are continuously stored on this card. The maximum memory capacity is 16 MByte.

7.2 Modes of Data Storage

No Data Storage

In this mode the COMBILOG 1020 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 datalogger. 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 Internal Data Storage

The COMBILOG 1020 is delivered with 256 Kbytes RAM memory. For data recording 252 Kbytes memory are available as circulate 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 = 10 + 4* number of measured values

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

$$d = \frac{2580 * M}{(10 + 4 * n) * 864}$$

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 hour.

Number of Bytes = 10 + (4 * 8) = 42 bytes per record
Memory demand per day = 24 * 42 = 1008 bytes

At 256 Kbytes internal RAM 2580 * 3600/ (42 * 864) = 255,9 days can be recorded.

The data memory is buffered by a capacitor (gold cap), that ensures preservation of data for several days in case the main power is switched off.

7.4 External Data Storage with PCMCIA SRAM Card

A linear PCMCIA SRAM Card can be plugged into the PCMCIA slot to replace the internal data memory. Depending on the type of card up to 32 Mbytes are available for data storage. The structure for data storage is the same as for the internal RAM.

Note: After plug-in a PCMCIA SRAM Card the card and the data in the internal RAM will be erased automatically. If the card is plugged out the data get lost! Data can be read out via one of the communication lines only!
Note: Independing from the capacity of the used SRAM memory card datarecording is limited to 65536 datasets!

7.5 External Data Storage with PCMCIA Flash Card

The COMBILOG 1020 can be equipped with PCMCIA Flash Cards of the Intel Series 2 with 2 MB or 10 MB.
On the flash card the data will be stored in a file named COMBILOG.LOG, containing also additional information about channel configuration. This file occupies the hole memory space of the card, independent of the real written number of data.
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.

If a PCMCIA Flash Card is plugged in a COMBILOG 1020 during operation all data from the internal RAM will be transmitted to the PCMCIA Flash Card when the next record is to be stored. During this time continuous data storage is interrupted. The following records are stored on the PCMCIA Flash Card. If no more memory is available on the card the records are stored on the internal RAM again (circulate buffer).

Note: The datalogger can write data to pre-formatted memory cards only. The following file systems are supported:

- Microsoft Flash File System
- TrueFFS®-FTL (MSystems)

To read the cards on a PC a driver for the respective file system must be installed. At present only 16 bit drivers are available for the file systems above, so it can not be used for Windows NT/2000.

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

Structure of the data file COMBILOG.LOG:

Identification	COM1020 M2.10U3.00				
Location	COMBILOG				
Serial No	123456				
Sample Rate	1				
Store Rate	3600				
Code	Time	Variable 1	Variable 2	...	Variable n
0	01.11.99 08:00:00	3.45	1.28	...	3.44
0	01.11.99 08:00:00	3.45	1.28	...	3.44
0	01.11.99 08:00:00	3.45	1.28	...	3.44
0	01.11.99 08:00:00	3.45	1.28	...	3.44

Structure of a record:

K	T	Time	T	M1	T	M2	T	…	T	Mx	T	S1	T	S2	T	…	Sx	CR	LF

K	Sign “0” for data record
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 09_{hex}) can be selected as delimiter and a ":" or a ";" is selectable as decimal point.

Memory demand for one record:

NumBytes = 21 + field length (M1) + 1 + field length (M2) + 1……
+ field length (Sx) +1

NumBytes = 21 + number of measured values * (8 +1)
(fixed field length of 8 characters)

Example:

Storage of eight measured values per hour:
NumBytes = 21 + 8 *(8 + 1) = 93 bytes per record
Memory demand per day = 24 * 93 = 2232 bytes

2 Mbytes Flash Card: 1904000 / 2232 = 853 days

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 1020 allows a configuration of a complex measurement system. In such a system with activated master function the datalogger 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 1020 in case the 8 analog inputs and 6 digital inputs/outputs of the datalogger are not sufficient. Other COMBILOG’s 1020 can be connected to the RS-485 interface as slaves. The master datalogger 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 datalogger either in the internal buffered RAM or on a PCMCIA card.

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 1020 and slave moduls is described by following steps:

- ❑ Configure all slave modules with the same bus parameters as the master datalogger (same protocol type, same baudrate and parity). All modules must have different modules addresses.
- ❑ Connect the master datalogger via RS232 with the host PC and start the configuration program.
- ❑ Set the bus parameter for the master function with *module settings.* Baudrate 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 datalogger 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 datalogger 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 1020 can be defined as master.

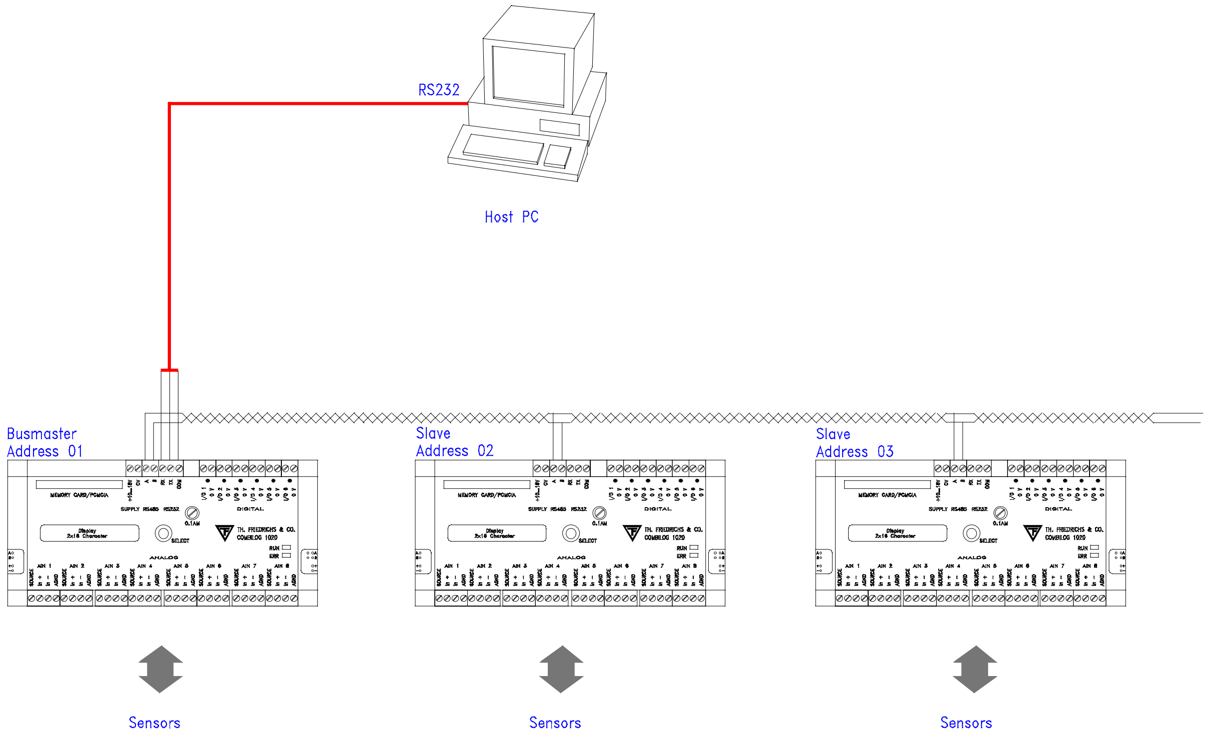


Bild 8.1   Example Master Slave System

9 INITIATION AND TEST

9.1 Before Connecting the Device

Before connecting the supply voltage to the datalogger *COMBILOG 1020*, once again check all connections. Watch that the supply voltage never exceeds 18 VDC.

9.2 After Connecting the Device

After connecting the supply voltage the datalogger 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 Datalogger

Before entering into operation the datalogger 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 datalogger 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 datalogger is in the download mode. Currently a program or a configuration is transmitted to the datalogger.
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 datalogger 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 datalogger *COMBILOG 1020* to a communication bus is performed via an integrated RS485 interface. The second interface, the RS232 computer interface, is only useable in order to build point-to-point connections for a distance of max. 20 m (65 feet). At the *COMBILOG 1020* 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 / 4800 / 9600 / 19200 bps / 38400 bps
  PROFIBUS-protocol: 9.6 / 19.2 kbps / 38.4 kbps

- **_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 datalogger 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.

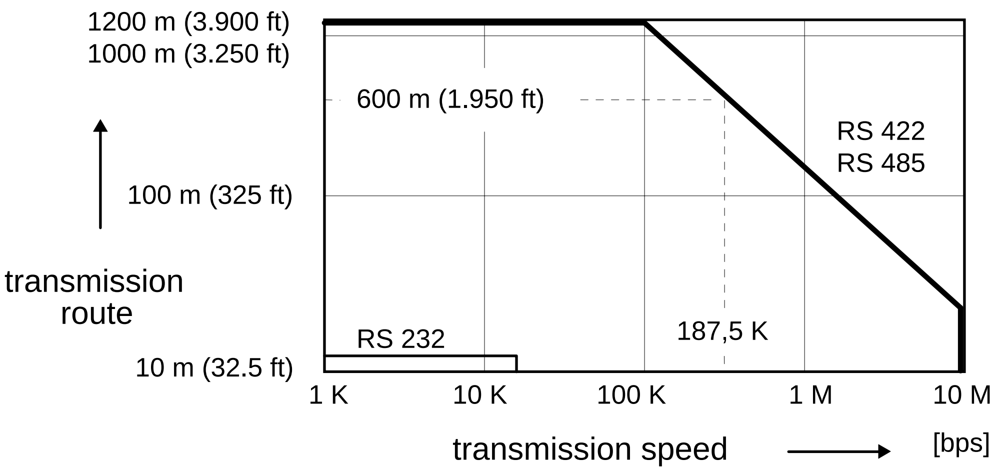


Figure 10.1 Interrelation between transmission speed and line length

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 and ■ : bus termination.

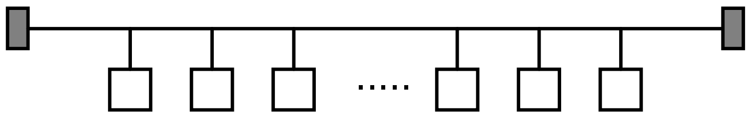


Figure 10.2 Simple line structure

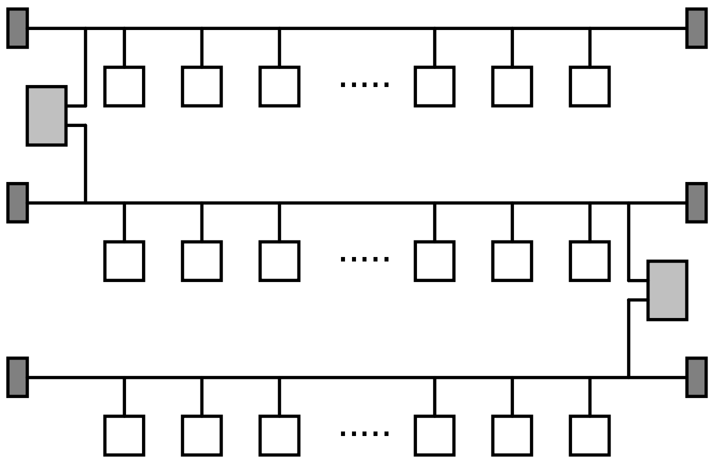


Figure 10.3 Extended line structure

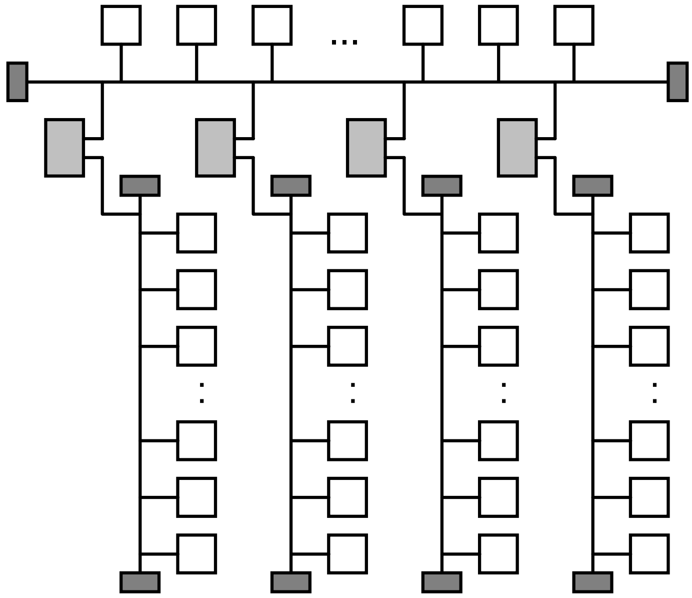


Figure 10.4 Line structure with branches

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 datalogger *COMBILOG 1020* 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. 6dB referred to the overall length

10.5 Bus Plug

For installing the bus cable and the bus interface, 9-channel D-subminiature plugs and sockets are used. The pin assignment for the RS485 connection according to PROFIBUS is given in table 10.2.

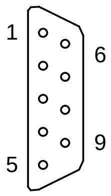
plug	PIN	RS485-notation	signal	meaning
	1	-	Shield	Shield, Protective Ground
	2	-	RP	Reserved for Power
	3	B / B´	RxD/TxD-P	Receive/Transmit-Data-P
	4	-	CNTR-P	Control-P
	5	C / C´	DGND	Data Ground
	6	-	VP	Voltage Plus
DB 9	7	-	RP	Reserved for Power
	8	A / A´	RxD/TxD-N	Receive/Transmit-Data-N
	9	-	CNTR-N	Control-N

Table 10.2 Pin assignment D-subminiature plug according to PROFIBUS

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. In addition to that the bus lead A is connected via a pull-down resistor Rd to ground (DataGround) and the bus lead B is connected via a pull-up resistor Ru to potential (VP). These resistors provide a defined quiescent potential in case there is no data transmission on the bus. This quiescent potential is level *high*.

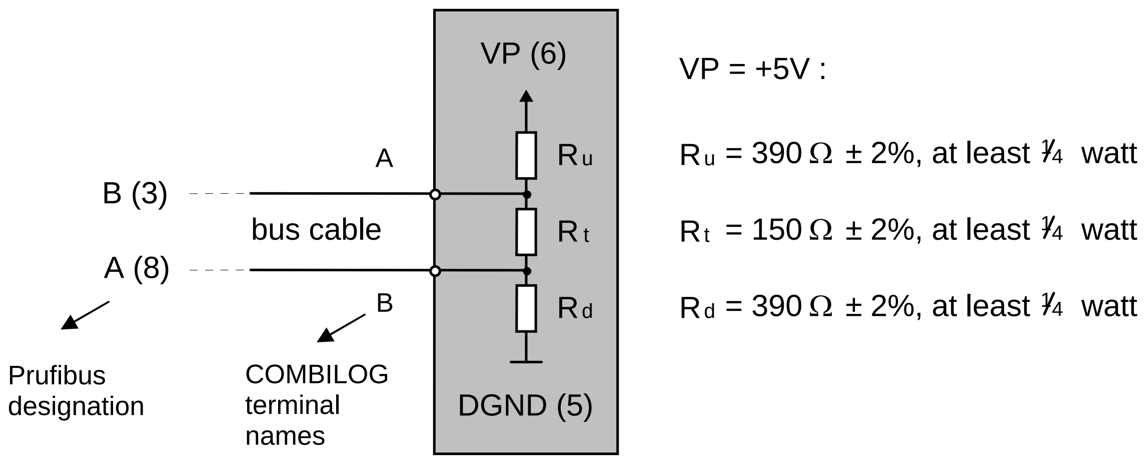


Figure 10.5 Bus termination

Note: The numbers in brackets in figure 10.5 indicate the pin number for the connection via the 9-channel D-subminiature 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 resistors 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 datalogger *COMBILOG 1020* this option is given. Via the bus termination plug which is available as accessory and installed at the right port on the frontside of the device, the bus termination at this module can be additionally connected. Two jumpers which connect the bus with the bus termination in the datalogger are integrated in the bus termination plug.

Note: Instead of the bus termination module separate jumpers can also be used for the bus termination. In this case, please make absolutely sure that the jumper clips are installed as indicated, and that the bus leads or the bus termination are not short-circuited by mistake!

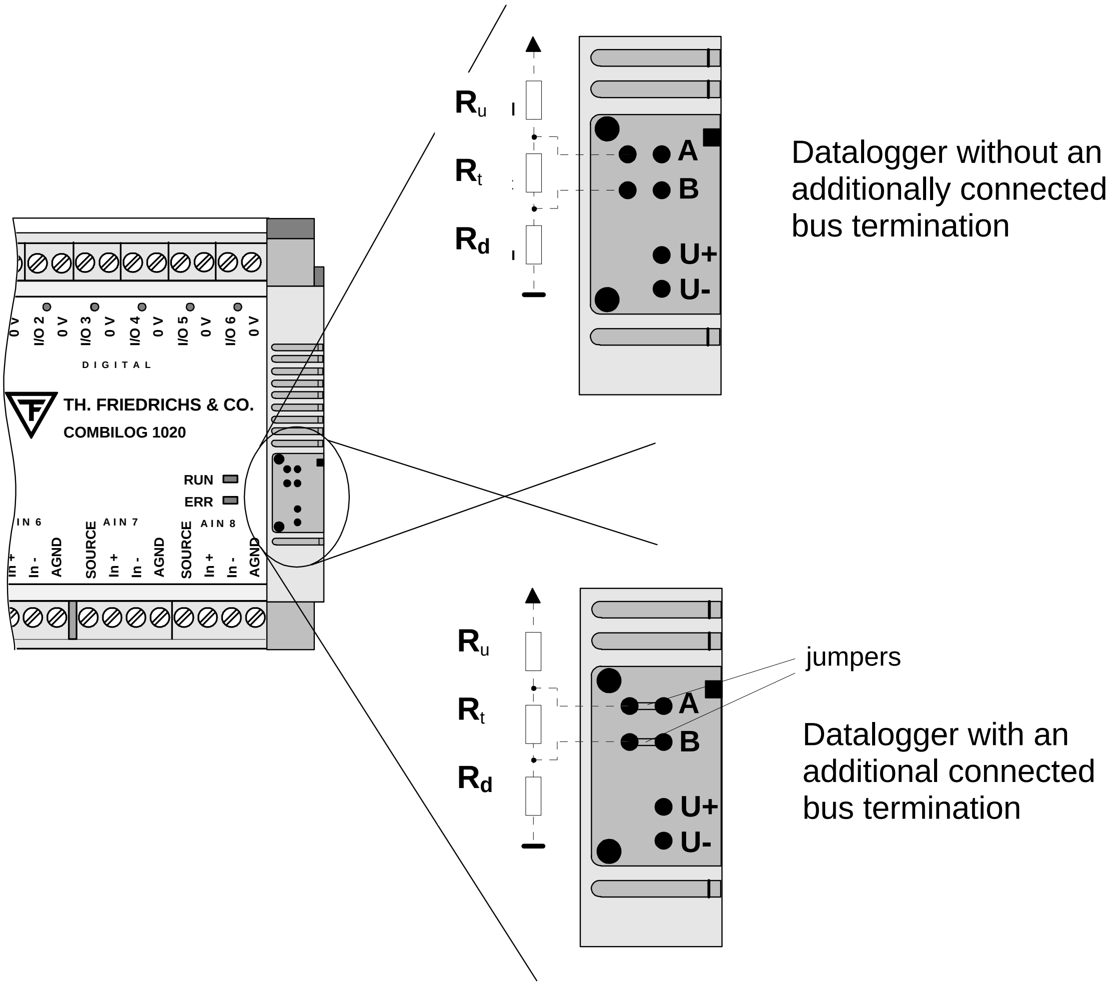


Figure 10.6 Bus termination on the COMBILOG 1020

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 DataGround!) 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.

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

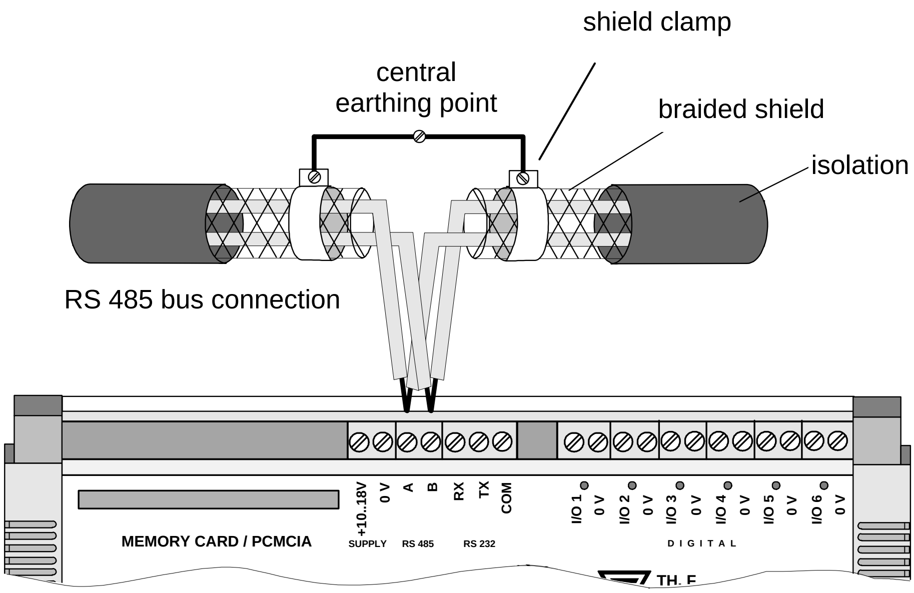


Figure 10.7 Earthing of the bus line shield on the COMBILOG 1020

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 datalogger 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 datalogger via the bus, address and baud rate for the datalogger 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.

The setting variants for the bus parameters for the datalogger *COMBILOG 1020* are:

bus parameter	ASCII-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 datalogger COMBILOG 1020

If no other specifications are made on delivery, the datalogger 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 dataloggers 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 dataloggers having the same address as the datalogger that is to be newly adjusted. The datalogger 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 datalogger 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 datalogger. 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 PROFIBUS. 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 datalogger *COMBILOG 1020* 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 datalogger 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 datalogger *COMBILOG 1020:*

- ❑ 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 and the PROFIBUS protocol can be operated simultaneously and will be delivered as standard. The MODBUS protocol requiresa different firmware version and should be ordered separately.

11.3 Data Format

The datalogger *COMBILOG 1020* supports following data formats:

Format	Start-bit	Data-bit	Parity bit	Stop-bit	Length of character	ASCII	PROFI-BUS	MODBUS
8N1	1	8	N	1	10	X	-	X
8E1	1	8	E	1	11	X	X	X
8O1	1	8	O	1	11	X	-	X
8N2	1	8	N	2	11	X	-	X
8E2	1	8	E	2	12	X	-	X
8O2	1	8	O	2	12	X	-	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 datalogger 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 datalogger adjusts the data formats accordingly and makes sure that the data are available in the selected unit.

For transmission in ASCII- and PROFIBUS-format, the format settings listed in table 11.2 and 11.3 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- and PROFIBUS-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	(dec 0: FALSE) and (dez 255: TRUE)
integer	2 byte	(dec - 32768) $\leq$ i $\leq$ (dec +32767)
r e a l	4 byte	(dec - 2^{129}) $\leq$ x $\leq$ (dec + 2^{129})
SET 8	1 byte	(dec 0) $\leq$ i $\leq$ (dec 255)

Table 11.3 Format settings for transmission in PROFIBUS-format

format	length	range of values
integer	2 byte	(dec - 32768) ≤ i ≤ (dec +32767)
Real	4 Byte	(dec – 2^{129}) ≤ x ≤ (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- and 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.

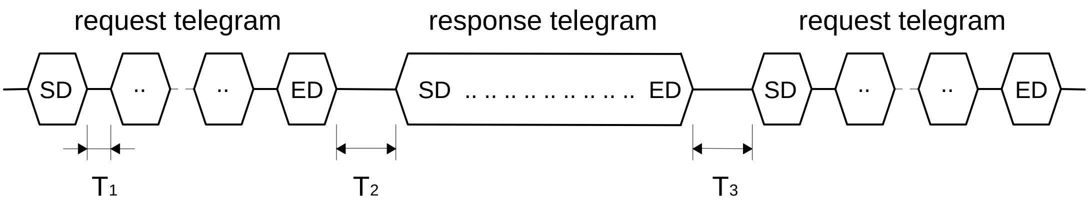
- In case of overflow with a transmission in ASCII-format the identification key "E" (for Format Error) is given at the first position in the transmission format.

- With transmission in PROFIBUS- and 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 ASCII-Protocol

11.5.1 Transmission Sequence

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



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.

protocol	baud rate	T1 min	T1 max	T2 min	T2 max	T3 min	T3 max
adjustable		no	no	yes	no	no	yes
ASCII	2400 bps			1... 5 CT			
	4800 bps			1..11 CT	T2 min		0.1 sec
	9600 bps	0	1 CT	1..23 CT	x	3 CT	to
	19200 bps			1..42 CT	1.2		600 sec
	38400 bps			1..85 CT			

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. The values for T_{2min} and T_{3max} and the behaviour of the datalogger 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.

11.5.2 Telegram Format

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.

11.5.3 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 k cc <cr>	> i..i cc <cr>	NAK
read data from one channel			
with	# aa R k cc <cr>	> d..d cc <cr>	NAK
write data to a channel			
with	# aa W k d..d cc <cr>	ACK	NAK
reset / tare a channel			
with	# aa D k 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

Tabelle 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 datalogger 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"
k	channel number	2	ASCII "00".."FF"
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 datalogger. 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"	Analog 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

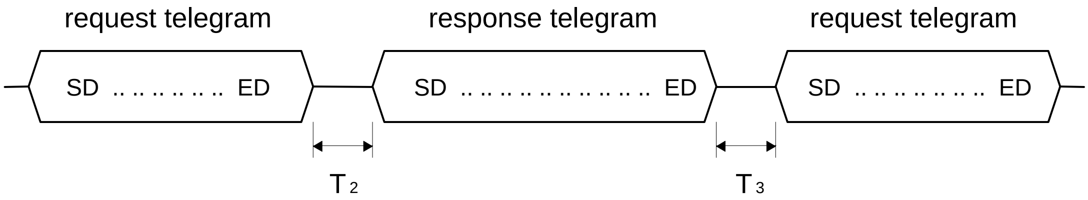
date and time (t..t)		length = 12 char
<year>	ASCII	2 char
<month>	ASCII	2 char
<day>	ASCII	2 char
<hour>	ASCII	2 char
<minute>	ASCII	2 char
<second>	ASCII	2 char

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

11.6 PROFIBUS-Protocol

11.6.1 Transmission Sequence

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



T2: time between request-telegram and corresponding response-telegram
T3: time between response-telegram and next request-telegram

Minimum and maximum appearing values for periods T2 and T3 and the adjustment ranges are given in table 11.11.

protocol	baud rate	T2 min	T2 max	T3 min	T3 max
adjustable		yes	no	no	yes
PROFIBUS	9.6 kbps 19.2 kbps	1..23 CT 1..42 CT	T2min x 1.2	3 CT	0.1 to 600 sec

Table 11.11 Values and adjustment range for periods T2 and T3 (CT: character time: 1 CT = character length [bit] / baud rate [bps])

Note: In the PROFIBUS-protocol T2max is at least 2 msec with baud rates 9,600 bps and 19,200 bps.

The values for T2min and T3max and the behaviour of the datalogger if the time T3max 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 T2min is 1 CT and for T3max 60 sec.

11.6.2 Telegram Format

For data transmission via PROFIBUS following telegram formats are relevant for the datalogger *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 11.12 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 datalogger has no telegrams with a usable data length of more than 32 bytes, the datalogger 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: CheckSum_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.

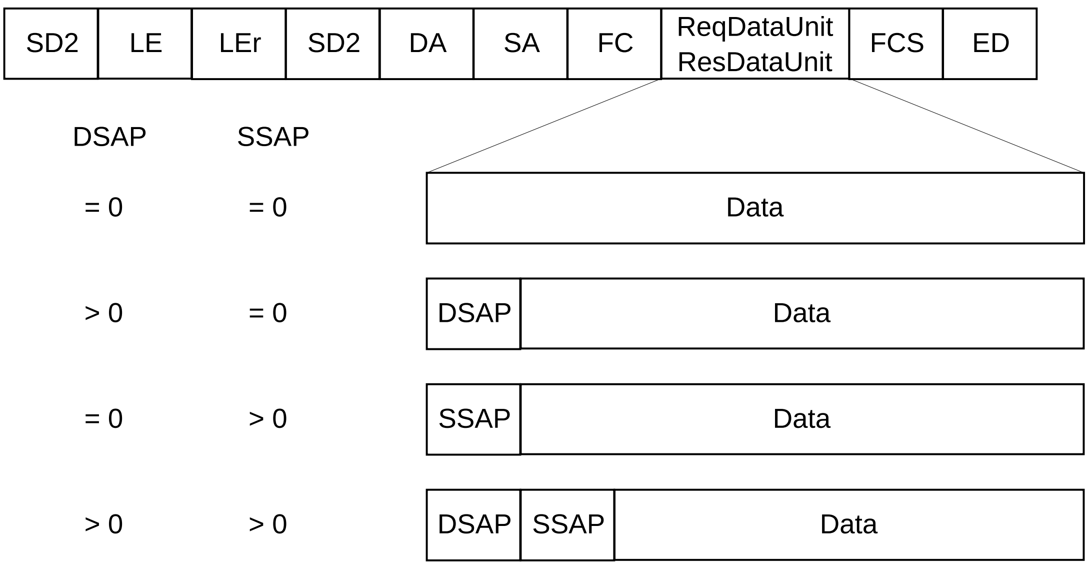
SC: *Short-Acknowledgement-Frame (length = 1 byte):*
The Short-Acknowledgement-Frame SC identifies a telegram that can be sent back to the communication partner as an acknowledgement. With SDA-requests it can be used as a positive receive acknowledgement. With SRD-requests it can be returned as a negative acknowledgement.

11.7 Instruction Set in the PROFIBUS-Protocol

Layer 2-adaption 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 datalogger *COMBILOG 1020* the SAPs are used for identifying (addressing) the various data and commands of the datalogger. By specifying the DSAP-number (DSAP: Destination SAP) in the data field of the request telegram the datalogger can be informed as to which data shall be transmitted or which function the datalogger shall carry out. The datalogger can also be informed as to which own SAP (SSAP: Source SAP) the data are to be returned.

Request/Response telegram (example SD2-telegram):



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			
	SRD	<channel number> <Px>	response without data
14	SDA	<channel number> <Px>	pos./neg. acknowledge
	SDN	<channel number> <Px>	no response
tare / reset a channel			
	SRD	<channel number>	response without data
15	SDA	<channel number>	pos./neg. acknowledge
	SDN	<channel number>	no response
read, write and tare / reset channels			
	SRD	[<tare/reset>[<P1>[... [<Pn>]]]]	<status> <K1> ... <Kn>
0	SDA	[<tare/reset>[<P1>[... [<Pn>]]]]	pos./neg. acknowledge
	SDN	[<tare/reset>[<P1>[... [<Pn>]]]]	no response

Table 11.13 PROFIBUS - layer 2 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 08)	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 ... “M“ : monitor program x ... “T“: calibration and test program

x ... “U“ : universal program x ... “S“: application specific 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 datalogger. 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 = 29 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	4 byte
<host input>	binary	1 byte

Coding <channel type>:
hex 00: Empty Channel (EM)
hex 01: Analog 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

Coding <host input>:
hex 00: host input is not possible
hex 01: host input is possible (tare/reset/dig.out/setpoint values)

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

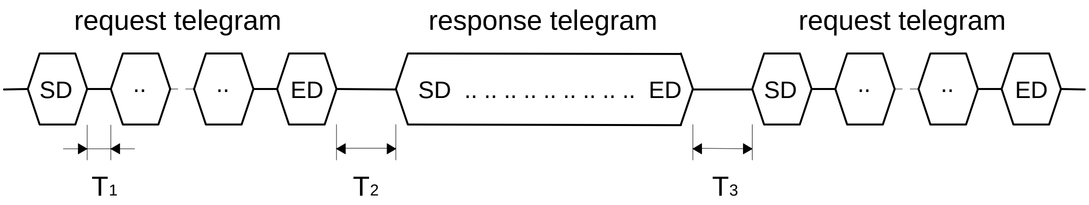
ReqDataUnit: [<tare/reset> [<P1> [.... [<Pn>]]]]
ResDataUnit: <K1 > . . . . < Kn >

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 datalogger, according to the order of their appearance. Writeable channels are setpoint channels and digital output channels.

11.8 MODBUS-Protocol

11.8.1 Transmission Sequence

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



T1: time between two characters

T2: time between request-telegram corresponding response-telegram

T3: time between response-telegram and next request-telegram

Minimum and maximum appearing values for periods T1, T2 and T3 and the adjustment ranges are given in table 11.14.

protocol	baud rate	T1 min	T1 max	T2 min	T2 max	T3 min	T3 max
adjustable		no	no	yes	no	no	yes
M O D B U S	2400 bps 4800 bps 9600 bps 19200 bps 38400 bps	0	1,5 CT	3,5 CT	T2min x 1.2	3,5 CT	0.1 to 600 sec

Table 11.14 Values and adjustment range for periods T1, T2 and T3
(CT: character time: 1 CT = character length [bit] / baud rate [bps])

Note: In the MODBUS-protocol T_{2max} is at least 2 msec. The values for T_{2min} and T_{3max} and the behaviour of the datalogger 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.

11.8.2 Telegram Format

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-polynom 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

11.8.3 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 com-munication 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	REGSTA		REGNUM		CRC	
	03	MSB	LSB	MSB	LSB	MSB	LSB

response telegram

ADR	FNR	BYTNUM	D0	D1	…	Dn	CRC	
	03						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 databytes (max. 64)

D0 - Dn .... databytes (max. 64)
CRC .... check sum
CRC polynom: $u^{15} + u^{13} + 1$
CRC start value: hex FFFF

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 databytes (max. 64)
D0 - Dn .... databytes (max. 64)
CRC .... check sum
CRC polynom: $u^{15} + u^{13} + 1$
CRC start value: hex FFFF

Pre-set Single Register

Description:

By this command a single register can be written.

request telegram

ADR	FNR	REGADR		DATA		CRC	
	06	MSB	LSB	MSB	LSB	MSB	LSB

response telegram

ADR	FNR	REGADR		DATA		CRC	
	06	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 …….... dataword (hex 0000…FFFF)

CRC .... check sum

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

CRC start value: hex FFFF

Diagnostic

Description:

By this command a diagnostic telegram will be sent to the Datalogger. 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	
	08	00	00	A5	37	MSB	LSB

response telegram

ADR	FNR	SUBFCT		DATA		CRC	
	08	00	00	A5	37	MSB	LSB

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

FNR .... function number (hex 08)

SUBFCT ..... subfunction number (hex 0000)

DATA .... dataword (hex A537)

CRC .... check sum

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

CRC start value: hex FFFF

Preset Multiple Register

Description:

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

request telegram

ADR	FNR	REGSTA		REGNUM		BYTNUM	D0	D1	...	Dn	CRC	
	10	MSB	LSB	MSB	LSB						MSB	LSB

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 databytes (max. 64)
D0 - Dn .... databytes (max. 64)
CRC .... check sum
CRC polynom: $u^{15} + u^{13} + 1$
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 reset.

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 ... “ M“ : Monitor program
x ... “ U“ : Universal program
x ... “ T“ : Calibration and test program
x ... “ S“ : Application specific program
x ... “ R“ : MODBUS-RTU-Program
xy.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 datalogger

Register	Type	Contents	Range
3000	ro	Number of records	0 ... 65535
3001	ro	Number of values in a record	0 ... 65535
3002	ro	Value 1 real High Word	0 ... 65535
3003	ro	Value 1 real Low Word	0 ... 65535
3004	ro	Value 2 real High Word	0 ... 65535
3005	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

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 datalogger have to be adjusted and configurated on "(N)o parity".

11.10 Autocall Function

The autocall function enables the datalogger COMBILOG 1020 to send messages automatically via modem or as SMS. The conditions, at whitch messages should be send, can be defined by the configuration program. Following options are available:
Dial Conditions:

- On System Error: The datalogger 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 treshold values has been exceeded.

In case of using a telephone modem up to 3 telephone numbers can be defined, being dialed one after another in case of a dial condition is fulfiled.
After establishing a connection the datalogger sends a status message, and the remote subscriber can communicate with the datalogger, e.g. to read out the data memory. The datalogger 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 center (depending on the net provider), the destination number and the message itself. For every dial condition described obove, 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

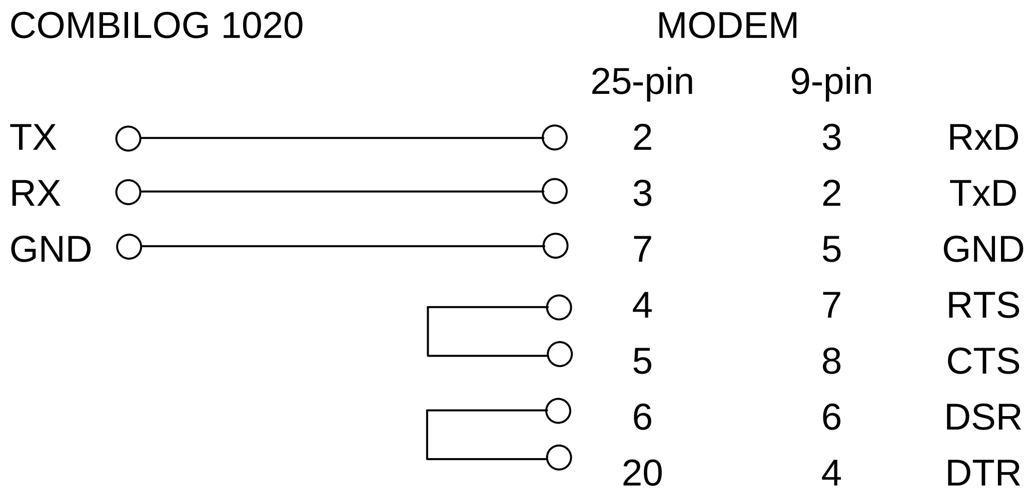
In case of using a telephone or GSM modem with the COMBILOG the modem must at first be initialized by means of a terminal program. Set the interface settings of the terminal program to 19200 bps, no parity, and enter the following AT commands. Refer to your modem manual for a detailed description of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

Load default settings	AT&F
Set baudrate to 19200 bps	device dependend
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 datalogger 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:



12 SPECIFICATIONS

12.1 Power Supply

- ❑ Voltage range: +10 .. 18 VDC
- ❑ Power input: depending on internal clock frequency and scan rate

  5 MHz version: approx. 70 mW at measuring rate 60 s = 5.83 mA (at 12 V)
  approx. 75 mW at measuring rate 10 s = 6.25 mA (at 12 V)
  approx. 420 mW at measuring rate 1 s = 35 mA (at 12 V)

  20 MHz version: approx. 400 mW

12.2 Signal Inputs/Outputs

- ❑ Analog inputs: 8, non-isolated
- ❑ Digital inputs/outputs: 6 (configurable)

12.3 Signal Processing

- ❑ Scan rate: 0.5, 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 ca.16 Bit
- ❑ Accuracy of the real time clock: <1 s / day

12.4 Analog 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 / 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

12.5 Digital Inputs/Outputs (6 per Module)

as input:

- Function: status, frequency, counter, 8-bit-graycode-emitter
- Input voltage: max. +18 VDC
- Input current: max. 1.5 mA

Input frequency: max. 2000 Hz

- Switching threshold (low): > 3.5 VDC
- Switching threshold (high): < 1.0 VDC

as output:

- Function: host-out, process-out
- Output voltage: max. 18 VDC
- Output current: max. 100 mA
- Type of output: open collector

12.6 Interfaces

- Base: RS 485, RS 232,
- Data format: 8E1 / 8N1 / 8O1
- Protocol: ASCII, PROFIBUS
  MODBUS (on request)
- Baud rate ASCII: 2,400 / 4,800 / 9,600 / 19,200 bps / 38,400 bps
- Baud rate PROFIBUS: 9,600 / 19,200 bps
- PCMCIA interface for memory cards

12.7 Operating Conditions

- ❑ Operating temp.: -30 to +60 °C*
- ❑ Storing temperature: -40 to +85 °C
  (different values for opertion with memory cards)
- ❑ Moisture: 0 to 95 % at +50 °C, non-condensing

*) Display LCD only -20 to +60 °C

12.8 Electromagnetic Compatibility

For the below table, the basic standards EN50081-1:92/-2:93 (Emission of noise) and EN 50082-1:92/-2:95 (Immunity from noise) for domestic and commercial applications are considered.

Emission of noise	Range	Requirements	Standard	BK	Result	AM
Radio interference voltage	150 kHz...0.5 MHz	66Q...56Q dB (µV) 56M...46M dB (µV)	EN 55022 (class B)	-	O.K.	
	0.5 MHz...5 MHz	56Q dB (µV) 46M dB (µV)				
	5 MHz...30 MHz	60Q dB (µV) 50M dB (µV)				
Radio interference field intensity	30 MHz...230 MHz 230 MHz..1000 MHz	10 m: 30 dB (µV/m) 10 m: 37 dB (µV/m)	EN 55022 (class B)	-	O.K.	1
Immunity from noise	**Range**	**Requirements**	**Standard**	**BK**	**Result**	**AM**
High frequency excitation	0.15 MHz....80 MHz	10 Veff 80% AM (1 kHz)	ENV 50141	A	O.K.	2
High frequency radiation	80 MHz...1000 MHz	10 V/m 80% AM (1 kHz)	ENV 50140	A	O.K.	3
High frequency radiation	900 ± 5 MHz	10 V/m 80% ED (200 Hz)	ENV 50140	A	O.K.	
High frequency radiation	50 Hz	30 A/m	EN 61000-4-8	A	not relevant	4
Electrical fast transients, asymmetr.	Supply lines Data lines Signal lines	±2.0 kV ±1.0 kV ±1.0 kV	EN 61000-4-4	B	O.K.	5
Electro static discharge (ESD)	Housing	±4 kV Contact discharge ±8 kV Air discharge	EN 61000-4-2	B	O.K.	6

Q: Quasipeak, M: Average, BK: Evaluation criteria, AM: Remarks

Remarks:

(1) Measured in 3 m distance, evaluated with 10 dB higher level limits.

(2) Influence on RS 485 communication in a range (19.66±3) MHz is possible.

(3) In a range 80...100 MHz with field intensities > 3 V/m and 100...115 MHz with field intensities > 7 V/m , variation of display contrast and sporadic communication errors or interrupts, like checksum error, timeout etc., are possible.

With field intensities up to 3 V/m, the influence on the data acquisition, choosing a sensitive range, may be as follows:

Voltage measurement	(6.25 mV range):	± 50 µV typical;	± 200 µV max.
Current measurement	(1 mA range):	± 1 µA typical,	± 5 µA max.
Resistance measurement	(200 Ω range):	± 0.1 Ω typical,	± 0.2 Ω max.

With field intensities up to 10 V/m, this influence may be as follows:

Voltage measurement	(6.25 mV range):	± 1 mV typical, (125±15) MHz	± 5 mV max.
Current measurement	(1 mA range):	± 4 µA typical, (125±15) MHz	± 20 µA max.
Resistance measurement	(200 Ω range):	± 2 Ω typical, (125±15) MHz	± 10 Ω max.

(4) The COMBILOG datalogger is not equipped with any HF-field sensitive components, therefore according tests are not relevant. Such tests were still accomplished; no influence was detected.

(5) Influence on RS 485 communication from approx. 0.4 kV: self-restoring.

(6) Influence on display from approx. 0.4 kV: self-restoring.

Refer to: Test report COMBILOG, DOCID: BW024003.DOC dated 22.02.1996.

The requirements of EMV rules 89/336/EWG are fulfilled for domestic areas. Further EU rules concerning CE-labelling are not applicable at present.
The instrument is equipped with CE label.

12.9 Shell

- Material: Aluminium and ABS
- Dimensions: w 189 x h 90 x d 83 mm
  w 7.4 x h 3.5 x d 3.3 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 technic: plug-in terminal screws
- Nom. cross section: max. 1.5 mm² (AWG 16), unifilar/fine-strand
- Strip length: 6 mm (0.2 inch)

12.10 Circuit

- Microprocessor: HITACHI H8
- A/D-conversion: 16 bit, sigma-delta-procedure
- Real Time Clock
- Program memory: 64 kbyte Flash-EPROM
- Data memory: 256 kbyte, buffered RAM
- PCMCIA interface for linear SRAM or Flash memory cards up to 32 MByte

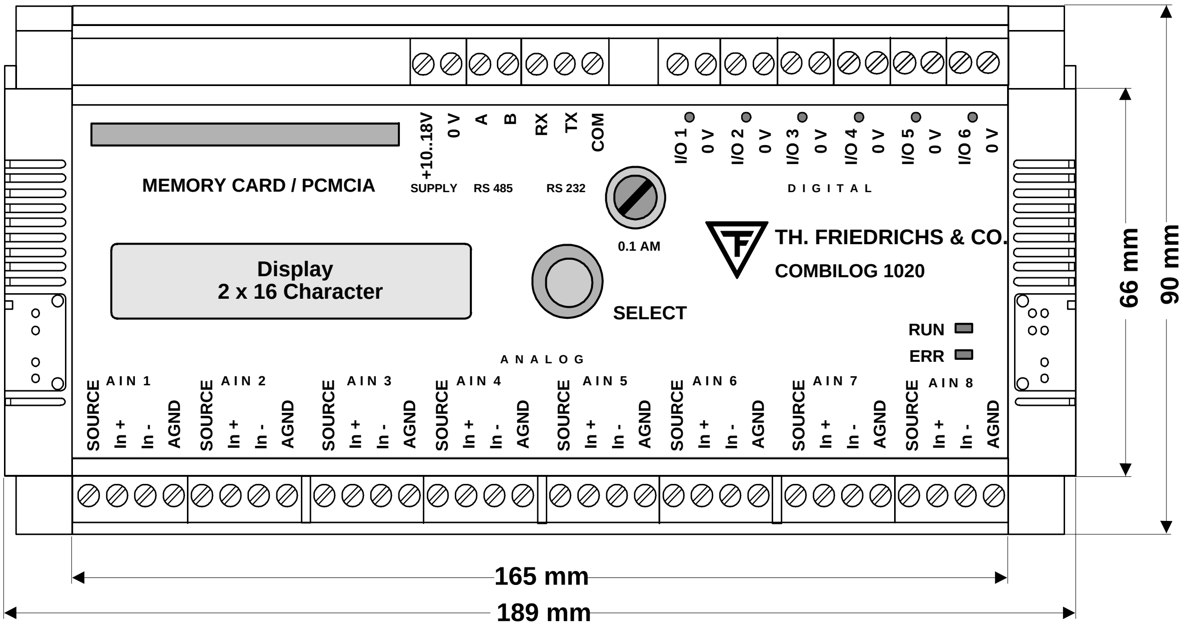
12.11 Accessories / Notice for Orders

The *COMBILOG* System comprises a number of options and accessories, thus facilitating a quick and easy build-up and connection. The main components are given in the following ordering code:

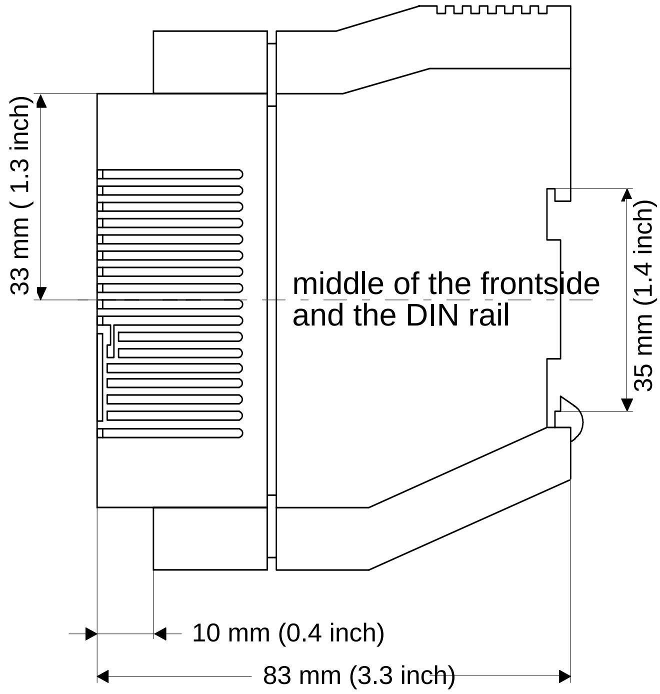
Ordering Code	**Type-no.**
datalogger COMBILOG, with 6 digital and 8 analog inputs, RS232 and RS485 interfaces, with 256 kB RAM internal data storage and PCMCIA port, with manual for hardware and 3.5“ disk for configuration	**1020.2000**
PCMCIA Flash Memory Card, 2 MB	**1035.4000**
PCMCIA Flash Memory Card, 10 MB	**1035.5000**
PCMCIA SRAM Card, 2 MB	**1036.1000**
Reader unit for PCMCIA memory cards PC built-in version, incl. software	**1041.0000**
Charger for 12 V batteries	**1050.0000**
Stainless steel housing IP65 protected, with terminal bar for external supply	**9910.1- - -**
As above, but with 12 V battery supply	**9910.2- - -**
As above, but with 12 V battery supply, incl. controller and solar panel	**9910.3- - -**
with additional clamp for 2 m masts	**.-1- -**
with additional clamp for 6 m masts	**.-2- -**
with additional clamp for 10 m masts	**.-3- -**
Sun protection roof for stainless steel housing type 9910	**9911.0000**

13 SIMPLIFIED DRAWINGS

13.1 Front View



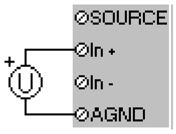
13.2 Side View



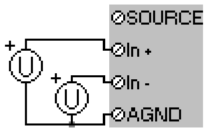
APPENDIX

A. Pinout Arrangements for Analog Sensors at the Data-logger

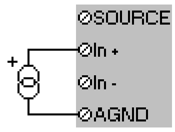
measurement of voltage single-ended



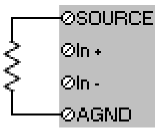
measurement of voltage differential



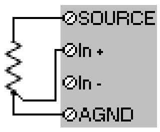
measurement of current single-ended



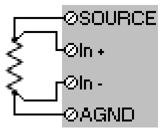
measurement of resistance 2-wire connection



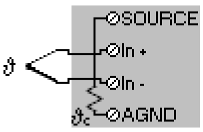
measurement of resistance 3-wire connection



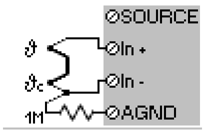
measurement of resistance 4-wire connection



Thermoelement with internal cold junction compensation

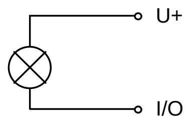


Thermoelement with external cold junction compensation

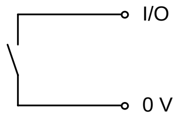


B. Pinout Arrangements for Digital Sensors at the Datalogger

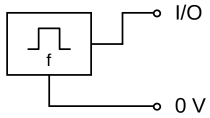
digital status output



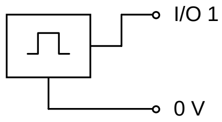
digital status recording



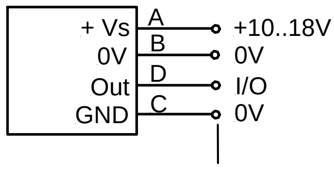
frequency measurement



progressive counter



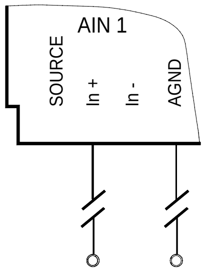
sensor for wind direction
8 bit gray-code



4122. x000

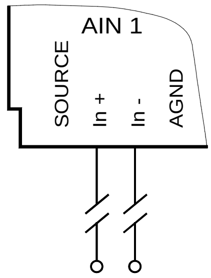
C. Pinout Arrangements for Analog Sensors of Th. Friedrichs (Examples)

Voltage measurement, single-ended:



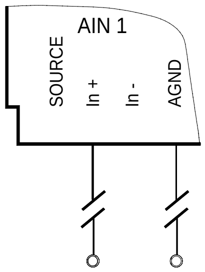
Humidity	6	shield	3030
Pressure	Vout	AGND	5002
Radiation	red	blue	6005, 6012
	white	green	6004

Voltage measurement, differential:



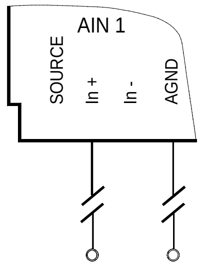
Radiation	U+	U-	6020
	UG+	UG-	6022, 6023
	UR+	UR-	6022, 6023

Voltage measurement, single-ended with external addition:



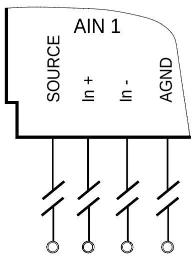
WS	1	2	4011 (R=5kΩ)
WS	1	2	4021 (R=4kΩ)
WS	1	2	4091.2 (R=500Ω)

Current measurement, single-ended:



Pressure	1	2	5008
	4	3	5004.0, 5004.1
WD	E	C	4122 (0…20mA)
WD	F	C	4122 (4…20mA)
WS	E	C	4034 (0…20mA)
WS	F	C	4034 (4…20mA)

Resistance measurement, 4-line:

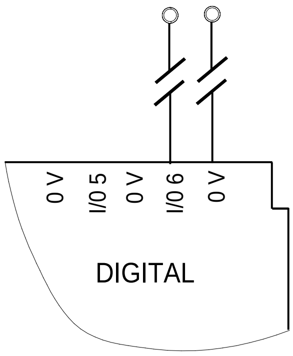


Pt100	1	2	3	4	2010, 2014, 2015, 2017, 2018, 2019,
Pt100	1	2	3	4	2020, 2030, 2100, 3010, 3030, 3100, 3130
Humidity	1	2	3	4	3112
Pt100	5	6	7	8	3112.1
WD	1	2	3	4	4121, 4191.1
Pressure	1	2	3	4	5006

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

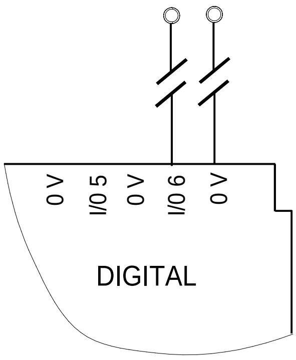
Status:

Sun yes/no	white	brown	6039 (6-pol.)
Transmitter	3	4	7001
Drop	2	4	7001
Rain	1	4	7001



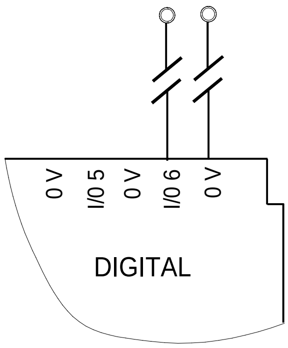
Frequency measurement:

WS	1	4	4091.1
WS	1	2	4041
WS	2	4	4033.01
WS	D	C	4034



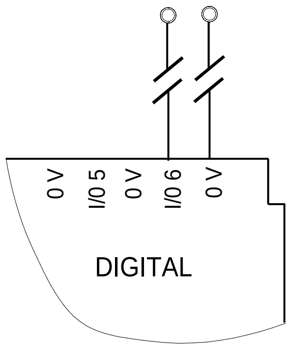
Counter:

Precipitation	1	2	7041, 7051



Gray Code:

WD	D	C	4122



E. Configuration table for the datalogger

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	-

<table>
<tr><th colspan="6">Overview Measuring Accuracy</th></tr>
<tr><td colspan="2">type of measurements</td><td>voltage single-end.</td><td>current measur.</td><td>voltage differential</td><td>all</td></tr>
<tr><th>gain step</th><th>gain factor</th><th colspan="3">accuracy(1)</th><th>resolution noise</th></tr>
<tr><td>0</td><td>1</td><td rowspan="5">0.01 %</td><td rowspan="9">0.05 %</td><td rowspan="5">0.03 %</td><td rowspan="5">0.003 %</td></tr>
<tr><td>1</td><td>2</td></tr>
<tr><td>2</td><td>4</td></tr>
<tr><td>3</td><td>8</td></tr>
<tr><td>4</td><td>16</td></tr>
<tr><td>5</td><td>32</td><td rowspan="2">0.03 %</td><td rowspan="2">0.10 %</td><td rowspan="2">0.010 %</td></tr>
<tr><td>6</td><td>64</td></tr>
<tr><td>7</td><td>100</td><td rowspan="2">0.03 %</td><td rowspan="2">0.03 %</td><td rowspan="2">0.003 %</td></tr>
<tr><td>8</td><td>200</td></tr>
<tr><td>9</td><td>800</td><td colspan="3">0.10 %</td><td>0.010 %</td></tr>
<tr><td>A</td><td>3200</td><td colspan="3">0.30 %</td><td>0.030 %</td></tr>
</table>

(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	0.01 %	0.003 %	0.01 %	25 ppm/K 2 ppm/K(4)
±5 V	0.5 mV				
±2.5 V	0.3 mV				
±1.25 V	0.1 mV				
±625 mV	0.2 mV	0.03 %	0.010 %		
±312.5 mV	0.1 mV				
±100 mV	30 µV	0.03 %	0.003 %		
±25 mV	25 µV	0.10 %	0.010 %		0.4 µV/K 0.02 µV/K(4)
±6.25 mV	20 µV	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
(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	0.03 %	0.003 %	0.01 %	25 ppm/K 2 ppm/K(4)
±5 V	1.5 mV				
±2.5 V	0.8 mV				
±1.25 V	0.4 mV				
±625 mV	0.6 mV	0.10 %	0.010 %		
±312.5 mV	0.3 mV				
±100 mV	30 µV	0.03 %	0.003 %		
±25 mV	25 µV	0.10 %	0.010 %		0.4 µV/K 0.02 µV/K(4)
±6.25 mV	20 µV	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
(4) with additional offset compensation

current measurement					
range	accuracy(1)(3)		resolution/noise(1)	linearity(2)	temperat. drift(2)
25 mA	12.5 µA	0.05 %	0.003 %	0.01 %	25 ppm/K
12.5 mA	6.25 µA				
6.25 mA	3.13 µA		0.010 %		
3.125 mA	1.5 µA				
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

<table>
<tr><th colspan="6">resistance measurement</th></tr>
<tr><th>range</th><th colspan="2">accuracy(1)(3)</th><th>resolution/noise(1)</th><th>linearity(2)</th><th>temperat. drift(2)</th></tr>
<tr><td>20 kΩ</td><td>10 Ω</td><td rowspan="8">0.05 %</td><td rowspan="5">0.003 %</td><td rowspan="8">0.01 %</td><td rowspan="8">25 ppm/K
5 ppm/K(4)</td></tr>
<tr><td>10 kΩ</td><td>5 Ω</td></tr>
<tr><td>5 kΩ</td><td>2.5 Ω</td></tr>
<tr><td>2.5 kΩ</td><td>1.25 Ω</td></tr>
<tr><td>1.25 kΩ</td><td>0.63 Ω</td></tr>
<tr><td>625 Ω</td><td>0.31 Ω</td><td rowspan="2">0.010 %</td></tr>
<tr><td>312.5 Ω</td><td>0.15 Ω</td></tr>
<tr><td>200 Ω</td><td>0.1 Ω</td><td>0.003 %</td></tr>
</table>

(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, scan rate 1 s, averaging interval 1 min)

without drift correction:	≤ 0.1°C with ambient temperatures -10°C...+30°C
with external drift correction:	typical 0.05°C with ambient temperatures -30°C...+60°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 $\vec{u}(WV, WD)$ 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 $\overline{u_1} = 0$, $\overline{WD} = 0°$ is defined.

H. Description of Short Real Format

The datatype 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 1020 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 several installation disks or CD Rom. Installation is carried out as follows:

1. Start WINDOWS on your PC.
2. Insert the first installation disk 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.