



## CAN Physical Layer Analyzer

# CANwatch

User manual

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Document version: 1.3  
Documentation date: July 5th, 2022

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For technical assistance please contact:

EMS Dr. Thomas Wünsche  
Sonnenhang 3

D-85304 Ilmmünster

Tel. +49-8441-490260  
Fax +49-8441-81860  
Email: [support@ems-wuensche.com](mailto:support@ems-wuensche.com)

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**FCC:** CANwatch is designed as test equipment for use that is in accordance with FCC regulation 15.103(c). It may be used only in accordance with FCC regulation 15.103(c), with the use limited EXCLUSIVELY to that of industrial, commercial, or medical test equipment. Please note that the operator of CANwatch shall be required to stop operating the device upon a finding by the FCC or its representative that the device is causing harmful interference. Operation of the device shall not resume until the condition causing the harmful interference has been corrected.

**WARNING:** CANwatch hardware and software may not be used in applications where damage to life, health or private property may result from failures in or caused by these components.

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# 1 Overview

## 1.1 Attributes

- Analyzer for the physical layer of CAN based systems
- Designed for systems according to ISO 11898 high speed
- Diagnosis of signal shape and level
- Indication of the percent frequency of error frames
- Easy operation, usable by installers and plant operators
- LED display for error indication

## 1.2 General Description

CANwatch is an analyzer supporting easy detection of errors during installation and operation of CAN networks. CANwatch monitors the analog signals on the bus and detects errors like e.g. invalid levels, overshoots, slow slopes and short circuits of signal lines to supply lines.

Besides the diagnosis of problems during installation, CANwatch allows recognition of signal deficiencies below the level causing failures. This allows preventive error recognition and thus an increase in the availability of automated systems.

CANwatch offers an easy solution for installers and plant operators for detection and correction of errors on the physical layer of a CAN based system. Until now this was usually left to CAN specialists using expensive and bulky hardware equipment.

## 1.3 Ordering Information

12-10-001-xx	<b>CANwatch</b> CAN physical layer analyzer for rail mount application with LED display
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**Note:** xx denotes language of delivery:

- 10 German
- 20 English

## 2 Operation

### 2.1 Measuring Principle

CANwatch is a passive device whose function is based on the analysis of static and dynamic parameters of the CAN signal. The evaluation of the signal shape is mainly based on the difference level between the signals CAN high and CAN low. The protocol based information of the CAN telegrams has no influence on the function of the device (except error frames) and therefore CANwatch is suitable for all CAN based higher layer protocols.

### 2.2 Connection

#### Connection

CANwatch has two D-Sub9 plugs for the connection to the CAN. The CAN connector is also used for the power supply of CANwatch. CAN bus cables can alternatively be plugged into connector 1 (upper-left plug) or connector 2 (upper-right plug). Optional extensions (in the planning stage) can be operated at connector 1 exclusively.

**Attention:** In addition to the contacts for CAN signal and supply CANwatch uses additional control lines. These are also connected to the D-Sub-plugs. The corresponding contacts may only be connected to permitted accessories, connection to other signals may cause permanent damage of CANwatch or other devices.

#### Initialization

For the analysis process CANwatch is connected to the bus via connector 1 or 2. After successful initialization of the processor, the device performs a test of the LEDs. These are simultaneously switched on for a short period of time (about 0.5 sec.). Thereafter CANwatch starts with the determination of the baud rate.

The other measurements (level test, testing for over-/undershoots, slow slopes, error-frames) are started after the determination of the baudrate and repeated cyclically as long as CANwatch is connected to the supply voltage.

## 2.3 Display

CANwatch shows the result of the analysis on a display consisting of twelve LEDs. Each LED represents a bus state or a warning. The meaning of the different displays is as follows.

### **CAN OK**

CANwatch sets this LED with each recognized telegram and resets it cyclically. During normal operation this LED will be flickering according to telegram traffic: the brighter it lights, the more telegrams are evaluated.

### **Serious CAN Failure**

CANwatch lights this LED to indicate basic errors on the CAN (e.g. short circuit of GND and CAN high or CAN low respectively).

### **CAN-High locked**

This LED is activated if CANwatch recognizes a short circuit of the CAN high line to a fixed level. This is assumed by the actual software at levels of the CAN high signal of about 0 V against ground. The LED remains set until the failure is no longer detected after a new evaluation or a difference signal occurs between CAN high and CAN low. This test is performed with a cycle time of about 6 seconds.

### **CAN-Low locked**

This LED is activated if CANwatch recognizes a short circuit of the CAN low line to a fixed level. This is assumed by the actual software at levels of the CAN low signal of about 0 V against ground. The LED remains set until the failure is no longer detected after a new evaluation or a difference signal occurs between CAN high and CAN low. This test is performed with a cycle time of about 6 seconds.

### **Over-/Undershoots**

CANwatch lights this LED, if the CAN difference signal of a registered telegram is affected by over-/undershoots in a degree that undisturbed communication on the bus can no longer be guaranteed.

**Slow Slopes**

If CANwatch sets this LED, the CAN difference signal of a registered telegram is affected by slow signal slopes in a degree that undisturbed communication on the bus can no longer be guaranteed.

**Invalid Dominant Level**

If CANwatch lights this LED, a telegram with dominant level above or below the threshold level of ISO 11898 was registered. The valid range of dominant levels for receiver nodes is specified between 0.9 V and 5 V.

**Invalid Recessive Level**

If CANwatch activates this LED, a telegram with recessive level above or below the permitted level according to ISO 11898 was registered. The valid range of recessive levels for receiver nodes is specified between -1 V and 0.5 V.

**Error-Frame Display**

The indication of the error frames is the percentage of errors compared to the number of registered telegrams. E.g. 0.1 - 1 % errors means that the number of error frames related to the number of registered and evaluated telegrams is 0.1 - 1 %. The display is divided into the ranges 0.1 - 1 %, 1 - 5 %, 5 - 100 %.

**Invalid Termination**

The LED Invalid Termination is not supported at present. Invalid bus termination can be recognized from signal deformations (over-/undershoots, invalid dominant level, invalid recessive level).



## 2.4 Guidelines for Interpretation

An absolute statement regarding the function of a CAN net in the (broad) range between correct signals and severely disturbed signals is not possible. Therefore results from evaluations of CANwatch should not be used for decisions between valid and invalid, but as hints on possible problems. If CANwatch gives a warning concerning critical signal shapes, the communication on the bus is not definitely disturbed.

### Flash Codes

The LEDs "Invalid Dominant Level", "Invalid Recessive Level", "Slow slopes", "Over-/Undershoots" and the LEDs for the frequency of error frames indicate the time of error events by means of flash codes.

When CANwatch detects an error, the corresponding LED lights up. The error indication is done by four different LED states:

LED-state	flashing-mode	Unit
on	-	error happened < 1 second ago
quickly flashing	100 ms on 100 ms off	error happened < 5 seconds ago
slowly flashing	100 ms on 300 ms off	error happened > 5 seconds ago
off	-	no error

### Repeated Indications

It may happen that one error causes several error indications at the same time. If e.g. a signal line is drawn to a fixed potential and this causes invalid levels in addition, the LEDs "CAN-High locked" or "CAN-Low locked" and "Invalid Dominant Level" or "Invalid Recessive Level" will light up.

## 3 Technical Data

### 3.1 Configuration of Connectors

#### Pin Configuration Connector 1

Connector 1 is made up of a D-Sub9 plug configured to comply with CiA DS 102 version 2.0. In addition to this specification, contacts are used for additional purposes.

Pin	Name	Description
1	-	Reserved by CiA, not connected
2	CAN_L	CAN low bus line
3	GND	CAN Ground
4	S1	Control line (do not connect)
5	S2	Control line (do not connect)
6	(GND)	(optional ground)
7	CAN_H	CAN high bus line
8	S3	Control line (do not connect)
9	V+CAN	Power supply

**Attention:** The control lines are reserved for compatible accessories and may not be connected to signals of the system which is to be tested.

#### Pin Configuration Connector 2

According to connector 1, however the pins 4, 5, 8 (control lines S1 - S3) are not used.

#### Hint

The pins 2, 3, 6, 7, 9 of connector 1 are connected with the corresponding pins of connector 2. The shields of both D-Sub-plugs are connected to each other.

### 3.2 Absolute Limiting Values

Any (also temporary) stress in excess of the limiting values may cause permanent damage on CANwatch and connected devices.

Parameter	Min.	Max.	Unit
Storage temperature	-20	80	°C
Operating temperature	0	60	°C
Power supply (Pin 9)	-100	35	V
Input voltage (Pin 2, 7)	-2	7	V

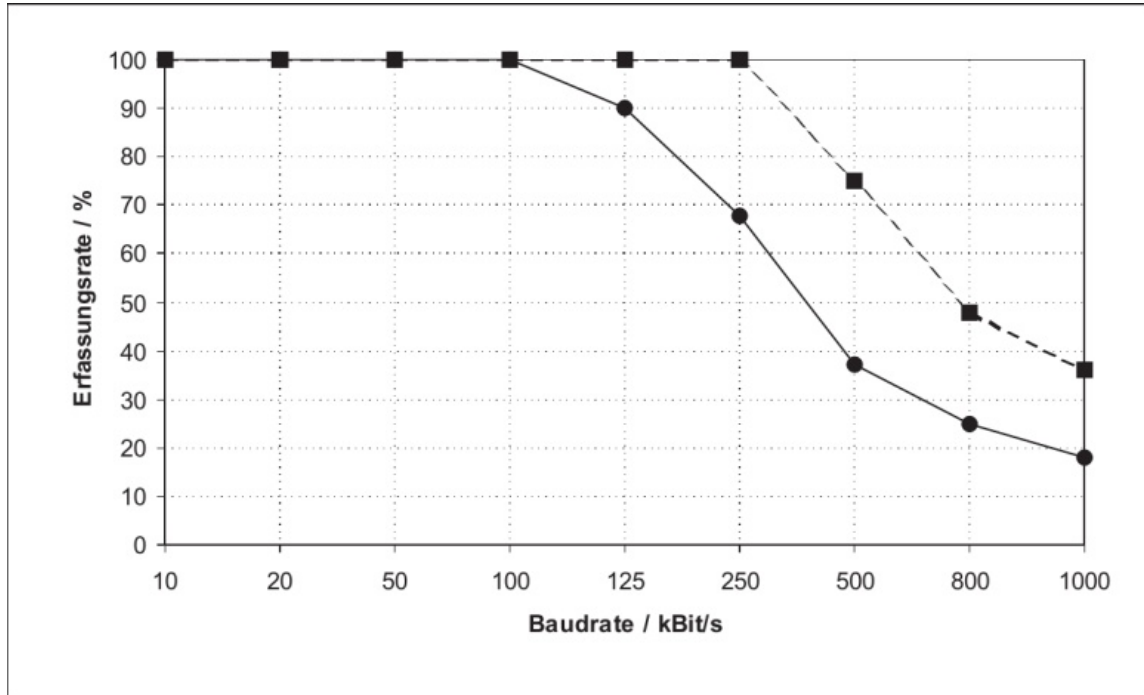
**Attention:** Due to requirements of measurement technology the inputs of CANwatch are not equipped with overvoltage protection (including ESD). Connection to overvoltage and electrostatic discharge must be avoided.

### 3.3 Nominal Values

Parameter	Min.	Max.	Unit
Supply voltage (Pin 9, V+CAN)	10	30	V
Current consumption (Pin 9, V+CAN = 24 V)	20	65	mA
Input voltage (Pins 2, 7)	-2	7	V
Baudrates	10	1000	kBit/s

### 3.4 Evaluation Characteristics

The number of telegrams that CANwatch can maximally register and evaluate are shown in the figure. The values are related to telegrams with standard format and one byte of data.



*Percentage of registered telegrams depending on the baud rate*

— Busload 50 % (constant distance of telegrams)  
- - - - Busload 10 % (constant distance of telegrams)

## 4 Small CAN Troubleshooting Guide

### 4.1 Pin configuration of CAN connector

To support troubleshooting of CAN networks, the following list includes possible reasons for errors indicated by CANwatch.

#### **Over-/Undershoots**

The diagnosis/indication of over-/undershoots can be triggered by the following installation defects:

- Impedance mismatch with resulting reflections (number and position of termination resistors, bus topology ... ).
- Interferences with strong electric or magnetic fields near cables (e.g. caused by electric motors, power lines).

Interferences are not over-/undershoots in a classical sense, but the effects on the signal shape are quite similar.

#### **Slow Slopes**

Slow slopes can be caused by correlation of several parameters. Influence on slopes results from:

- Capacitance (cables, devices)
- Resistance (line and drivers), filter inductivities
- Slow slope settings in the transmitter

#### **Short Circuits**

Short circuits can be caused by:

- Damage of the bus cables
- Wiring errors

**Invalid Dominant Levels**

Invalid dominant levels can be caused by:

- Too high line resistance
- Too many or faulty termination resistors
- Output resists in the transceiver drivers
- Mislead currents

**Invalid Recessive Levels**

Invalid recessive levels may be caused by:

- Missing termination resistors
- Mislead currents

**Invalid Bus Termination**

Under certain conditions, invalid bus termination may be detected by measuring DC resistance. The following cases have to be distinguished:

- The terminating resistors are totally missing
- Only one bus termination resistor is installed
- More than two bus termination resistors are installed

A reliable indication of correct termination cannot be given through measurement of DC resistance. E.g. there is no possibility to recognize placement of both resistors at the same end of a cable.

Other termination errors may arise from the topology of the net.

A reliable statement concerning valid termination has to consider the high frequency behavior. This may be achieved by evaluation of the signal shapes by means of the indicators Slow Slopes and Over-/Undershoots.

## **5 Appendix**

### **5.1 Instruction for Disposal**

#### **Electronic Equipment Act (WEEE)**

EMS is selling its products exclusively to commercial customers. This is the reason why all devices are designed for commercial use and have to be disposed appropriately. In accordance to § 10 para. 2 clause 3 Electronic Equipment Act (WEEE) the disposal of EMS products is regulated the following way.

The equipment must not be disposed at the public collection points. In accordance with the applicable law the disposal has to be done by the customer for own account. The same applies to products, which have been sold to third parties, if those parties do not take care of a disposal in accordance to the applicable law. As an alternative the products can be returned to EMS free of charge.

### **5.2 FCC Statement**

#### **Standards Exemption and Use in Accordance with FCC regulation 15.103(c)**

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