HACH LANGE

RTC105 N/DN-Module

Real-Time Control System for Nitrogen Removal

User manual

02/2013, Edition 3A

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Section 1   Technical data

These are subject to change without notice.

Embedded PC (compact industrial PC)	
Processor	Pentium®1, MMX compatible, 500 MHz clock rate
Flash memory	2 GB compact flash card
Internal working memory	256 MB DDR-RAM (not expandable)
Interfaces	1× RJ 45 (Ethernet), 10/100 Mbit/s
Diagnostic LED	1× power, 1× LAN speed, 1× LAN activity, TC status, 1× flash access
Expansion slot	1× CompactFlash type II slot with ejector mechanism
Clock	Internal, battery-buffered clock for time and date (battery can be replaced)
Operating system	Microsoft Windows®2 CE or Microsoft Windows Embedded Standard
Control software	TwinCAT PLC Runtime or TwinCAT NC PTP Runtime
System bus	16 bit ISA (PC/104 standard)
Power supply	Via system bus (through power supply module CX1100-0002)
Max. power loss	6 W (including the system interfaces CX1010-N0xx)
Equipment properties	
Dimensions (L × W × H)	350 mm × 120 mm × 96 mm (13.78 in. × 4.72 in. × 3.78 in.)
Weight	Approximately 0.9 kg (1.98 lb)
Analog input	0/4 to 20 mA for flow rate measurement
Internal resistance	80 ohm + diode voltage 0.7 V
Signal current	0 to 20 mA
Common mode voltage (U_{CM})	35 V max.
Measurement error (for entire measurement range)	< ± 0.3 % (from measurement range end value)
Electrical surge resistance	35 V DC
Electrical isolation	500 V_{eff} (K-bus/signal voltage)
Digital outputs	Aeration and alarm activation
Number of outputs	2 (KL2032), 4 (KL2134), 8 (KL2408), 16 (KL2809)
Nominal load voltage	24 V DC (–15 % / +20 %)
Load type	ohmic, inductive lamp load
Max. output current	0.5 A (short-circuit proof) per channel
Reverse polarity protection	Yes
Electrical isolation	500 V_{eff} (K-bus/field voltage)

Technical data

Digital inputs	Release of aeration control for plants in accumulation operation (SBR, sequencing batch reactor)
Number of inputs	2
Nominal voltage	24 V DC (–15 % / +20 %)
Signal voltage "0"	–3 to +5 V
Signal voltage "1"	15 to 30 V
Input filter	30 ms
Input current	5 mA (typ.)
Electrical isolation	500 V_{eff} (K-bus/field voltage)
Environmental conditions	
Working temperature	0 to 50 °C (32 to 122 °F)
Storage temperature	–25 to +85 °C (–13 to 185 °F)
Relative humidity	95 %, non-condensing
Miscellaneous	
Pollution degree **Protection class** **Installation category** **Maximum altitude**	3 III I 2000 m (6.562 ft.)
Degree of protection	IP20
Installation	DIN rail EN 50022 35 × 15

[1] Pentium is a registered trademark of the Intel Corporation.

[2] Microsoft Windows is a brand name for operating systems of the Microsoft Corporation.

Section 2 General Information

2.1 Safety information

Please read this entire manual before unpacking, setting up, or operating this equipment. Pay attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

To prevent damage to or impairment of the device's protection equipment, the device may only be used or installed as described in this manual.

2.1.1 Use of hazard information

> **⚠ DANGER**
> Indicates a potentially or imminently hazardous situation that, if not avoided, can result in death or serious injury.

> **⚠ WARNING**
> Indicates a potentially or imminently dangerous situation that, if it is not avoided, can lead to death or to serious injuries.

> **⚠ CAUTION**
> Indicates a possible dangerous situation that can have minor or moderate injuries as the result.

> *NOTICE*
> Indicates a situation that, if it is not avoided, can lead to damage to the device. Information that requires special emphasis.

Note: Information that supplements points in the main text.

2.1.2 Precautionary labels

Read all labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

⚠	This symbol is a warning triangle. Follow all safety notes that follow this symbol to prevent possible injuries. If this symbol is located on the device, it refers to information in the operating- and/or safety notes of the user manual.
⚡	This symbol can be attached to a housing or a barrier in the product and shows that electric shock risk and/or the risk of a death through electric shock exists.
🗑	Electrical equipment marked with this symbol may not be disposed of in European domestic or public disposal systems after 12 August 2005. In conformity with European local and national regulations, European electrical equipment users must now return old or end-of life equipment to the manufacturer for disposal at no charge to the user. *Note: You obtain instructions on the correct disposal of all (marked and not marked) electrical products that were supplied or manufactured by Hach-Lange at your relevant Hach-Lange sales office.*

> **⚠ CAUTION**
> The manufacturer is not responsible for any damages due to misapplication or misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect processes during a possible equipment malfunction.

2.2   Areas of application

The RTC105 N/DN-Module is a universally applicable open-loop and closed-loop controller for setting nitrification and denitrification times at waste water treatment plants, dependent on load. There are several variants available for plants that operate intermittently (*non*-continuous operation, charging) or in accumulation (SBR, Sequencing-Batch-Reactor).

In addition, the RTC105 N/DN-Module can optionally be equipped with a closed-loop controller for setting the dissolved oxygen concentration (O_2) in the activated sludge tank.

The single-channel version of the RTC module controls one activated sludge tank. The two-channel version controls two activated sludge tanks (or two SBR reactors) simultaneously.

N O T I C E
The use of an RTC module (real time controller) does not release the operator from the duty of care to the system.
In particular, the operator must make sure that instruments connected to the RTC open/closed-loop controller are always fully functional.
To make sure these instruments supply correct, reliable measurement values, regular maintenance work (for example, cleaning of the sensors and laboratory comparative measurements) is essential! (Refer to the user manual for the relevant instrument.)

2.3   Scope of delivery

N O T I C E
The combination of pre-assembled components supplied by the manufacturer does not represent a standalone functional unit. In accordance with EU guidelines, this combination of pre-assembled components is not supplied with a CE mark, and there is no EU declaration of conformity for the combination.
However, the conformity of the combination of components with the guideline can be proved through technical measurements.

Each RTC105 N/DN-Module is supplied with:

• A SUB-D connector (9 pin)

• Ferrite core, foldable

• User manual

Check that the order is complete. All listed components must be present. If anything is missing or damaged, contact the manufacturer or distributor immediately.

2.4   Instrument overview

Figure 1   **Base module RTC 24 V version**
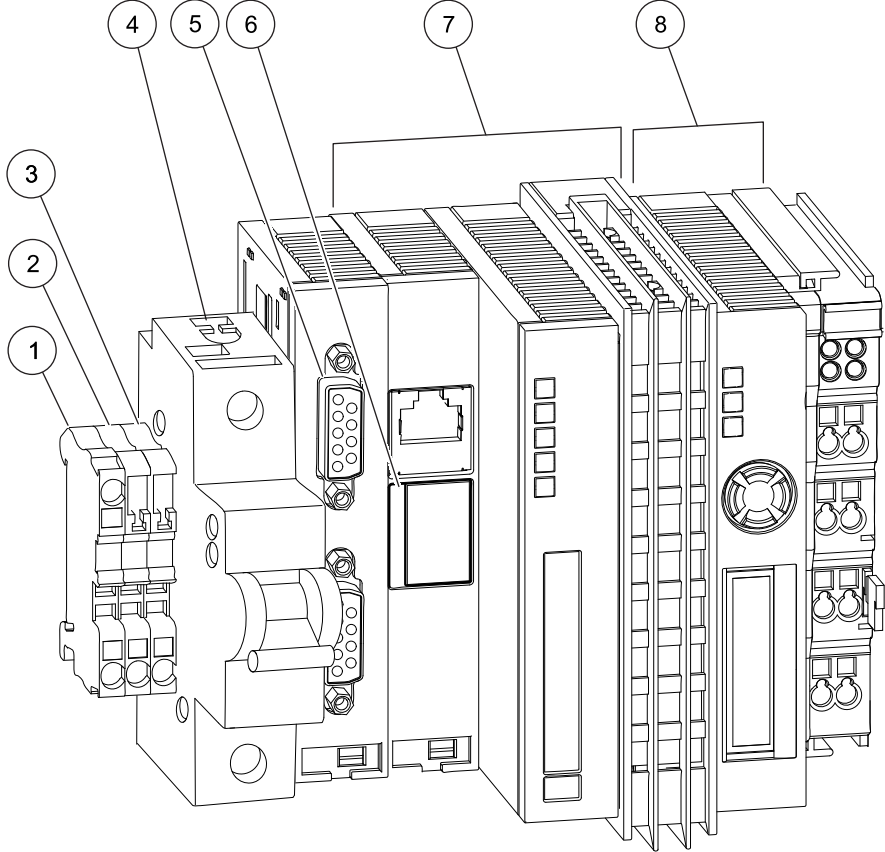
1	PE (protective earth)	**5**	sc 1000 connection: RS485 (CX1010-N031)
2	24 V	**6**	Battery compartment
3	0 V	**7**	CPU base module, consisting of Ethernet port with battery compartment (CX1010-N000), CPU module with CF card (CX1010-0021) and passive aeration element.
4	Automatic circuit breaker (ON/OFF switch for item 7 and 8 without fuse function).	**8**	Power supply module, consisting of bus coupler (CX1100-0002) and terminal module 24V.

Note: All components are pre-wired.

Figure 2   **Base module RTC 100-240 V version**
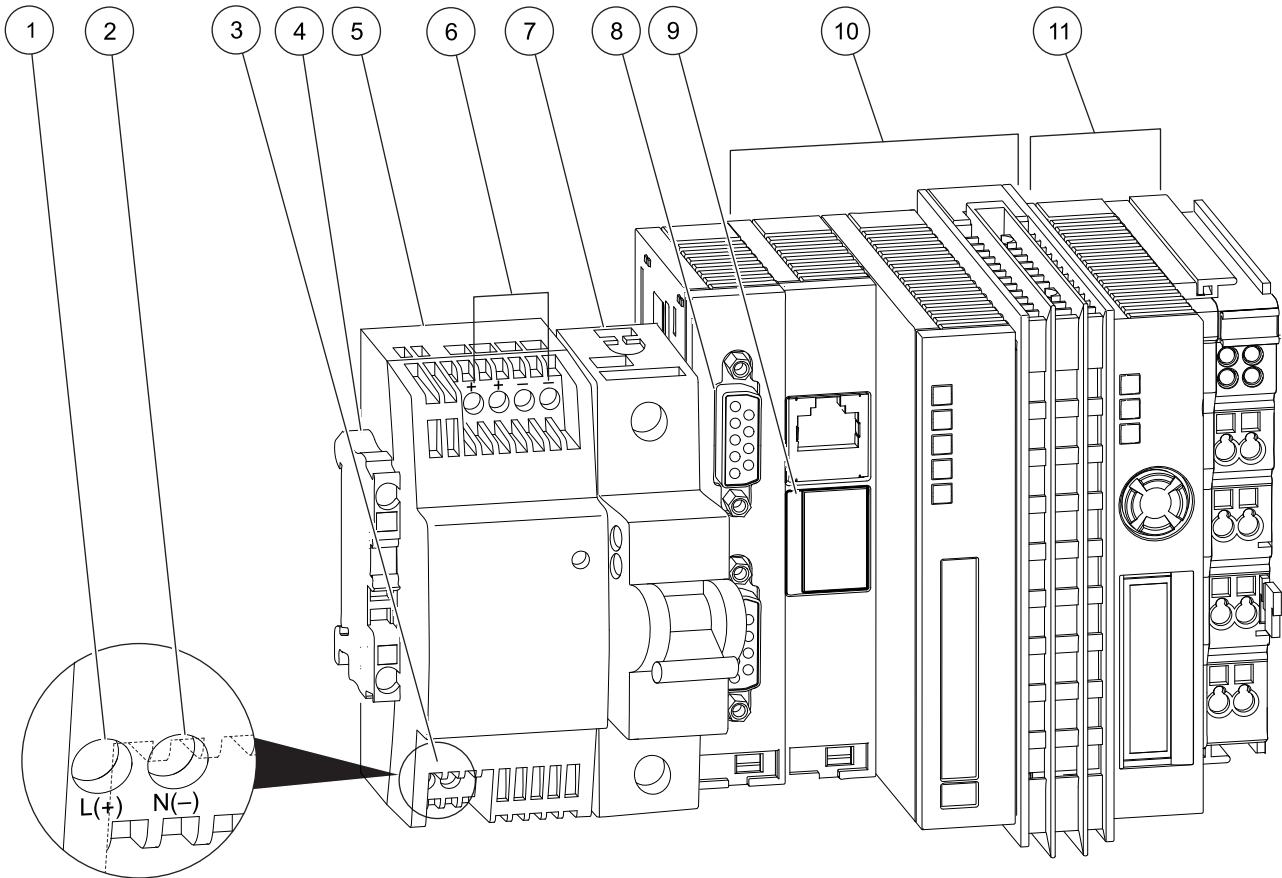
1	L(+)	7	Automatic circuit breaker (ON/OFF switch for item 10 and 11 without fuse function).
2	N(–)	8	sc 1000 connection: RS485 (CX1010-N041)
3	Input AVC 100–240 V / Input DC 95–250 V	9	Battery compartment
4	PE (protective earth)	10	CPU base module, consisting of Ethernet port with battery compartment (CX1010-N000), CPU module with CF card (CX1010-0021) and passive aeration element.
5	24 V transformer (Specifications refer section 3.1.1, page 13)	11	Power supply module, consisting of bus coupler (CX1100-0002) and terminal module 24V.
6	Output DC 24 V, 0.75 A		

Note: All components are pre-wired.

Figure 3   **Design of the analog and digital input and output modules**
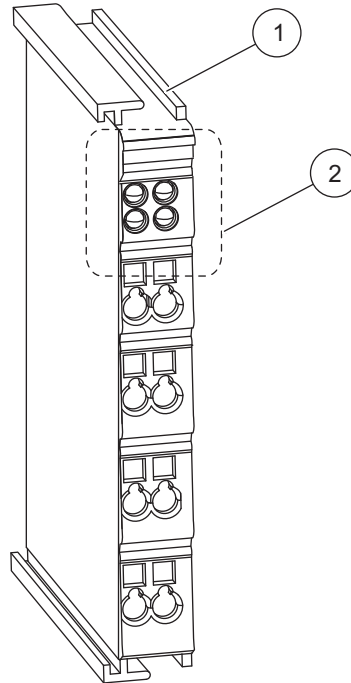
1	Analog or digital input or output module or bus termination module	**2**	LED area with installed LEDs or free LED installation spaces.

Note: The number of LEDs indicates the number of channels.

2.5   Theory of operation

2.5.1   Theory of operation of the RTC105 N/DN-Module

On the RTC105 N/DN-Module, the times for nitrification and denitrification are determined according to the current NH_4-N (ammonium nitrogen) and NO_3-N (nitrate nitrogen) concentrations. The controller assesses absolute measured values as well as slew or decay rate of the measurements.

Dependent on the validity of the measured values for NH_4-N and NO_3-N in the activated sludge container, the controller works as a:

•   combination controller for NH_4-N and NO_3-N,

• NH_4-N controller or

• NO_3-N controller.

Operation is guaranteed even if all measurements fail. A time frame with adjustable minimum and maximum nitrification and denitrification times is defined. This time frame has fixed limits for the RTC module; these fixed limits are not fallen below or exceeded. In addition, the time frame has priority above all other settings.

The controllers are designed as proportional-differential controllers (PD controllers). They enable assessment of absolute deviation of the measured values from their selectable target values and the assessment of their change over time.

During analysis, the RTC105 N/DN-Module differentiates between aerated/non-aerated phases according to the following criteria:

The **nitrification phase** is complete, if

- the deviation of the NH_4-N concentration and the NO_3-N concentration from their target values (if applicable, in conjunction with the decay rate of the NH_4-N concentration and the slew rate of the NO_3-N concentration) exceed a specific amount to the detriment of the NO_3-N concentration.

The aforementioned time frame is always in effect, thus the nitrification is

- complete, if the maximum nitrification time (**NITRI MAX**) has expired

- not complete until the minimum nitrification time (**NITRI MIN**) has occurred.

The **denitrification phase** is complete, if

- the deviations of the NH_4-N concentration and the NO_3-N concentration exceed their target values (if applicable in conjunction with the slew rate of the NH_4-N concentration and the decay rate of the NO_3-N concentration) by a specific amount to the detriment of the NH_4-N concentration.

The time frame is always in effect, thus the denitrification is

- complete, if the maximum denitrification time (**DENITRI MAX**) has expired

- not complete until the minimum denitrification time (**DENITRI MIN**) has occurred.

2.5.1.1 Controller behavior with low nitrogen content

If both the NO_3-N and the NH_4-N concentrations are very low, there is no selection criteria for whether there should be more or less aeration. To save energy, the aeration is switched off in this case. However, the time frame remains in effect. That is, the switch off cannot occur until the minimum nitrification time has been completed.

2.5.1.2 Time delay control (2-channel version)

In the RTC module variant for two activations, the time frame (which ensures useful cyclical operation under all conditions) is responsible for aerating activation 1 and activation 2 with a time delay. Thus, in one tank there is nitrification and in the other denitrification, for the longest time frames possible. This reduces load peaks in power consumption.

Note: Time delay control only works with time frames that are set to be the same!

2.5.2 Function principle of the O_2 control

The optional oxygen control allows the aeration power to be adapted to the respective need in the aeration phases. The oxygen control has up to 6 different aeration stages per channel. These aeration stages are activated by min-max limit controllers. These min-max limit controllers also receive a time assessment that takes the change rate into consideration.

2.5.3 Control for reactors in accumulation operation (SBR plants)

For control of SBR plants, the controller is notified of sedimentation and drain process by a binary input signal. This stops the control and, in a final measure, the controller switches off the aeration request.

A change of the binary input signals to the RTC Module the drain process has ended. Depending on the configured pre-selection, the RTC module starts a nitrification or denitrification phase with selectable duration.

Section 3   Installation

> ## ⚠ DANGER
> Only qualified experts may perform the tasks described in this section of the manual, while adhering to all locally valid safety regulations.

> ## ⚠ CAUTION
> Always lay cables and hoses so that they are straight and do not pose a tripping hazard.

> ## ⚠ CAUTION
> Before switching on the power supply, you must refer to the instructions in the relevant operating manuals.

3.1   Installation of the RTC Module

Only install the RTC Module on a DIN rail. The module must be attached horizontally, with at least 30 mm (1.2 in.) space at the top and bottom to make sure that the passive aeration element can function correctly.

When used indoors, the RTC Module must be installed in a control cabinet.
When used outdoors, the RTC Module requires a suitable enclosure that follows the technical specifications.

The RTC Module is only operated via the sc1000 controller (see the user manual for the sc1000 controller).

Note: The software version of the sc1000 controller must be V3.20 or above.

3.1.1   Power supply to the RTC module

> ## ⚠ WARNING
> Alternating current may destroy the direct current system and therefore jeopardize user safety. Never connect an alternating current voltage to the 24 V direct current model.

Table 1 Supply voltage of the RTC Module

Voltage	24 V DC (–15 % / +20 %), max. 25 W
Recommended fuse	C2
With 110–230 V option	230 V, 50–60 Hz, approximately 25 VA

Note: An external deactivation switch is recommended for all installations.

3.2   Connection of process measuring instruments (for NH$_4$-N, NO$_3$-N and O$_2$)

The measurement signals of the sc sensors for measuring NH$_4$-N and NO$_3$-N (e.g. AMTAX sc, NH4D sc, NITRATAX plus sc, NO3D sc, AN-ISE sc, ...) are supplied to the RTC module via the RTC communication card (YAB117) in the sc1000.

This also applies to the O$_2$ measurement, if a corresponding O$_2$ control is available.

3.2.1   Power supply of the sc sensors and the sc1000 controller

See operating instructions of the respective sc sensors and the sc1000 controller.

3.3 Connecting the sc 1000 controller

The supplied SUB-D connector is attached to a two-wire, shielded data cable (signal or bus cable). For additional information regarding the data cable connection, refer to the enclosed assembly instructions.

3.4 Connection to the automation unit on the plant side

Depending on the variant and option, the RTC105 N/DN-Module is equipped with various components that can be connected to the automation unit of the plant:

- The volumetric flow rate is provided to the RTC module as a 0/4 to 20 mA signal for all variants and options

- The RTC module provides the digital nitrification/denitrification output signal of 0 or 24 V

- The RTC module provides a digital signal with 0 or 24 V for up to 6 different aeration stages (per channel)

- The RTC module provides a general fault signal of 0 or 24 V

- For the SBR variant, a digital (0 or 24 V) release signal must be provided to differentiate between sedimentation/decantation phases, or feed (0 V) and nitrification or denitrification phases (24 V).

Table 2 Signal assignment of the individual assemblies of the RTC module

| | | | | | RTC module options | | | |
| | | | | | 1 channel | | 2 channel | |
Assembly	Designation	Terminal	Signal	Assembly		with O$_2$		with O$_2$
1-fold analog input	KL3011	1–2	0/4 to 20 mA	Feed volume flow	X	X	X	X
2-fold digital output	KL2032	1	+24 V/0 V	Nitrification/denitrification	X			
		5	+24 V/0 V	No fault/fault	X			
4-fold digital output	KL2134	1	+24 V/0 V	Container 1: nitrification			X	
		5	+24 V/0 V	No fault/fault Channel 1			X	
		4	+24 V/0 V	Container 2: nitrification			X	
		8	+24 V/0 V	No fault/fault Channel 2			X	
8-fold digital output	KL2408	1	+24 V/0 V	Container 1: nitrification/denitrification		X		
		5	+24 V/0 V	Container 1: aeration stage 1 ON/OFF		X		
		2	+24 V/0 V	Container 1: aeration stage 2 ON/OFF		X		
		6	+24 V/0 V	Container 1: aeration stage 3 ON/OFF		X		
		3	+24 V/0 V	Container 1: aeration stage 4 ON/OFF		X		
		7	+24 V/0 V	Container 1: aeration stage 5 ON/OFF		X		
		4	+24 V/0 V	Container 1: aeration stage 6 ON/OFF		X		
		8	+24 V/0 V	No fault/fault		X		

Table 2 Signal assignment of the individual assemblies of the RTC module

| | | | | | RTC module options | | | |
| | | | | | 1 channel | | 2 channel | |
Assembly	Designation	Terminal	Signal	Assembly		with O$_2$		with O$_2$
16-fold digital output	KL2809	1	+24 V/0 V	Container 1: nitrification/denitrification				X
		2	+24 V/0 V	Container 1: aeration stage 1 ON/OFF				X
		3	+24 V/0 V	Container 1: aeration stage 2 ON/OFF				X
		4	+24 V/0 V	Container 1: aeration stage 3 ON/OFF				X
		5	+24 V/0 V	Container 1: aeration stage 4 ON/OFF				X
		6	+24 V/0 V	Container 1: aeration stage 5 ON/OFF				X
		7	+24 V/0 V	Container 1: aeration stage 6 ON/OFF				X
		8	+24 V/0 V	No fault/ fault on channel 1				X
		9	+24 V/0 V	Container 2: nitrification/denitrification				X
		10	+24 V/0 V	Container 2: aeration stage 1 ON/OFF				X
		11	+24 V/0 V	Container 2: aeration stage 2 ON/OFF				X
		12	+24 V/0 V	Container 2: aeration stage 3 ON/OFF				X
		13	+24 V/0 V	Container 2: aeration stage 4 ON/OFF				X
		14	+24 V/0 V	Container 2: aeration stage 5 ON/OFF				X
		15	+24 V/0 V	Container 2: aeration stage 6 ON/OFF				X
		16	+24 V/0 V	No fault/ fault on channel 2				X

| | | | | | additional for SBR variant | | | |
| | | | | | 1 channel | | 2 channel | |
Assembly	Designation	Terminal	Signal	Assembly		with O$_2$		with O$_2$
2-fold digital input	KL1002	1	+24 V/0 V	Release controller channel 1	X	X	X	X
		5	+24 V/0 V	Release controller channel 2	–	–	X	X

Section 4   Parameterization and operation

4.1   Operating the sc controller

The RTC module can only be operated using the sc1000 controller, in conjunction with the RTC communication card. Before the RTC module is used, the user must be familiar with the functionality of the sc1000 controller. Learn how to navigate through the menu and perform the relevant functions.

4.2   System setup

1. Open the **MAIN MENU**.

2. Select **RTC MODULES / PROGNOSYS** and confirm.

3. Select the **RTC MODULES** menu and confirm.

4. Select the RTC module and confirm.

4.3   Menu structure

4.3.1   SENSOR STATUS

SENSOR STATUS			
RTC			
ERROR	Possible error messages: **RTC MISSING, RTC CRC, CHECK KONFIG, RTC FAILURE**		
WARNINGS	Possible warning messages: **MODBUS ADDRESS**, **PROBE SERVICE**		

Note: Refer to Section 6 Troubleshooting, page 35 for a list of all possible error and warning messages together with a description of all necessary countermeasures to be taken.

4.3.2   SYSTEM SETUP

The system setup is dependent on the number of channels.

For 1 channel:
refer to 4.4 1-channel RTC105 N/DN-Module parameterization on sc1000 controller, page 17.

For 2 channel:
refer to 4.5 2-channel RTC105 N/DN-Module parameterization on the sc1000 controller, page 20

4.4   1-channel RTC105 N/DN-Module parameterization on sc1000 controller

The following menu entries can be found in the MAIN MENU.

4.4.1   1-channel closed-loop control

RTC MODULES / PROGNOSYS			
RTC MODULES			
RTC			
CONFIGURE			
	SELECT SENSOR	Selection list of available, relevant sensors for the RTC module in the sc network (refer to 4.6 Select sensors on page 26).	
	PRESELECT PROG.		
	NH4-N & NO3-N	Control based on ammonium and nitrate measurements	
	NH4-N	Control based on ammonium measurements	
	NO3-N	Control based on nitrate measurements	
	TIME CONTROL	Control based on the preselected nitrification and denitrification times	
N/DN-CONTROL			
	TARGET VALUES	(Refer to 4.9.1 Target values, page 28)	
	NH4-N	Selected ammonium output value	[mg/L]
	NO3-N	Selected nitrate output value	[mg/L]
	NH4/NO3 WEIGHT	(Refer to 4.9.2 Valuation ratio, page 28)	[none]
	TIME FRAME	(Refer to 4.9.3 Time frame, page 28)	
	NITRI MIN	Preselection of a minimum aeration time	[min]
	NITRI MAX	Preselection of a maximum aeration time	[min]
	DENITRI MIN	Preselection of a minimum non-aerated time	[min]
	DENITRI MAX	Preselection of a maximum non-aerated time	[min]
	ADD TIME BIO-P	Additional non-aerated time to enable biological phosphorous elimination	[min]
	CTRL PARAMETER		
	P GAIN NH4+NO3	Gain factor: strength of reaction to the ammonium and nitrate contents, if both measurements are available. Determines the length of the entire cycle time (nitrification and denitrification). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]
	DERIV TIME NH4	Derivative time for ammonium: Closed-loop controller monitors the ammonium value that is expected to be reached after the configured derivative time. (Refer to 4.9.6 Derivative times, page 30)	[min]
	DERIV TIME NO3	Derivative time for nitrate: Closed-loop controller monitors the nitrate value that is expected to be reached after the configured derivative time. (Refer to 4.9.6 Derivative times, page 30)	[min]
	P GAIN NH4	Gain factor: strength of the reaction to the ammonium content. Determines the length of the aerated phase (applies if only ammonium measurement is available). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]
	P GAIN NO3	Gain factor: strength of the reaction to the nitrate content. Determines the length of the non-aerated phase (applies if only nitrate measurement is available). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]

4.4.1 1-channel closed-loop control (Continued)

RTC MODULES / PROGNOSYS			
RTC MODULES			
RTC			
CONFIGURE (Continuation)			
MODBUS			
ADDRESS		Start address of an RTC within the MODBUS network.	
DATA ORDER		Specifies the register order within a double word. Presetting: NORMAL	
DATALOG INTRVL		Indicates the interval in which the data is saved in the log file.	[min]
SET DEFAULTS		Restores the factory settings.	
MAINTENANCE			
RTC DATA			
RTC MEASUREMEN		Specifies the value measured by the RTC, e. g. the influent measurement.	
RTC ACTUAT VAR		Specifies the variable calculated by the RTC, e. g. whether the aeration should be switched on or off.	
DIAG/TEST			
EEPROM		Hardware test	
RTC COMM TO		Communication time-out	
RTC CRC		Communication check sum	
MODBUS ADDRESS		Here, the address is displayed where the communication actually takes place. Presetting: 41	
LOCATION		Here, a location name can be assigned for better identification of the RTC module, e.g. activation 2.	
SOFT-VERSION		Shows the software version of the RTC communication card (YAB117) in the sc1000.	
RTC MODE		Shows the installed RTC module variant, e.g. 1-channel closed-loop control.	
RTC VERSION		Shows the software version of the RTC module.	

4.4.2 1-channel closed-loop control, SBR option

RTC MODULES / PROGNOSYS			
RTC MODULES			
RTC			
CONFIGURE			
N/DN-CONTROL			
TIME FRAME		(Refer to 4.9.3 Time frame, page 28)	
START N/DN?		Preselection of phase with which the treatment process is to be started.	
N-PHASE		Nitrification phase	
DN-PHASE		Denitrification phase	
TIME INITPHASE		Preselection of duration for the first treatment phase (in % of the corresponding MAX time)	[%]

4.4.3   1-channel closed-loop control, O$_2$ closed-loop control option

RTC MODULES / PROGNOSYS			
RTC MODULES			
RTC			
CONFIGURE			
O2 control			
MAX O2	Maximum O$_2$ concentration in the nitrification phase. (Refer to 4.10.2.1 Maximum value MAX O2, minimum value MIN O2, page 31)	[mg/L]	
MIN O2	Minimum O$_2$ concentration in the nitrification phase. (Refer to 4.10.2.1 Maximum value MAX O2, minimum value MIN O2, page 31)	[mg/L]	
DERIVATIV.TIME	Differentiation time of controller	[min]	
ABSORPTION	Absorption time to influence the switch frequency between the aeration stages	[min]	
NO. OF STAGES	Number of controlled aeration levels (maximum 6)	[none]	
SUBST AERATION	If the oxygen sensor (e.g. LDO) signals a fault, the set aeration stage is selected (stages 1 to 6)	[none]	

4.5   2-channel RTC105 N/DN-Module parameterization on the sc1000 controller

In addition to the 1-channel version, there is also a 2-channel version that can regulate two activated sludge tanks or two SBR reactors at the same time. The relevant parameters therefore appear twice and are identified as channel 1 and channel 2.

4.5.1   2-channel closed-loop control

RTC MODULES / PROGNOSYS			
RTC MODULES			
RTC			
CONFIGURE			
SELECT SENSOR	Selection list of available, relevant sensors for the RTC module in the sc network (refer to 4.6 Select sensors on page 26).		
PRESELECT PROG.			
CHANNEL 1			
NH4-N & NO3-N	Control based on ammonium and nitrate measurements		
NH4-N	Control based on ammonium measurements		
NO3-N	Control based on nitrate measurements		
TIME CONTROL	Control based on the preset nitrification and denitrification times		
CHANNEL 2			
NH4-N & NO3-N	Control based on ammonium and nitrate measurements		
NH4-N	Control based on ammonium measurements		
NO3-N	Control based on nitrate measurements		
TIME CONTROL	Control based on the preset nitrification and denitrification times		

4.5.1　2-channel closed-loop control (Continued)

RTC MODULES / PROGNOSYS			
RTC MODULES			
RTC			
CONFIGURE (continue)			
N/DN-CONTROL			
CHANNEL 1			
TARGET VALUES	(Refer to 4.9.1 Target values, page 28)		
NH4-N	Selected ammonium output value	[mg/L]	
NO3-N	Selected nitrate output value	[mg/L]	
NH4/NO3 WEIGHT	(Refer to 4.9.2 Valuation ratio, page 28)	[none]	
TIME FRAME	(Refer to 4.9.3 Time frame, page 28)		
NITRI MIN	Preselection of a minimum aeration time	[min]	
NITRI MAX	Preselection of a maximum aeration time	[min]	
DENITRI MIN	Preselection of a minimum non-aerated time	[min]	
DENITRI MAX	Preselection of a maximum non-aerated time	[min]	
ADD TIME BIO-P	Additional non-aerated time to allow a biological phosphorous elimination.	[min]	
CTRL PARAMETER			
P GAIN NH4+NO3	Gain factor: strength of reaction to the ammonium and nitrate contents, if both measurements are available. Determines the length of the entire cycle time (nitrification and denitrification). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]	
DERIV TIME NH4	Derivative time for ammonium: Closed-loop controller monitors the ammonium value that is expected to be reached after the configured derivative time. (Refer to 4.9.6 Derivative times, page 30)	[min]	
DERIV TIME NO3	Derivative time for nitrate: Closed-loop controller monitors the nitrate value that is expected after the configured derivative time. (Refer to 4.9.6 Derivative times, page 30)	[min]	
P GAIN NH4	Gain factor: strength of the reaction to the ammonium content. Determines the length of the aerated phase (applies if only ammonium measurement is available). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]	
P GAIN NO3	Gain factor: strength of the reaction to the nitrate content. Determines the length of the non-aerated phase (applies if only nitrate measurement is available). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]	

4.5.1   2-channel closed-loop control (Continued)

RTC MODULES / PROGNOSYS			
RTC MODULES			
RTC			
CONFIGURE (Continuation)			
N/DN-CONTROL (Continuation)			
CHANNEL 2			
TARGET VALUES	(Refer to 4.9.1 Target values, page 28)		
NH4-N	Selected ammonium output value	[mg/L]	
NO3-N	Selected nitrate output value	[mg/L]	
NH4/NO3 WEIGHT	(Refer to 4.9.2 Valuation ratio, page 28)	[none]	
TIME FRAME	(Refer to 4.9.3 Time frame, page 28)		
NITRI MIN	Preselection of a minimum aeration time	[min]	
NITRI MAX	Preselection of a maximum aeration time	[min]	
DENITRI MIN	Preselection of a minimum non-aerated time	[min]	
DENITRI MAX	Preselection of a maximum non-aerated time	[min]	
ADD TIME BIO-P	Additional non-aerated time to allow a biological phosphorous elimination.	[min]	
CTRL PARAMETER			
P GAIN NH4+NO3	Gain factor: strength of reaction to the ammonium and nitrate contents, if both measurements are available. Determines the length of the entire cycle time (nitrification and denitrification). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]	
DERIV TIME NH4	Derivative time for ammonium: Closed-loop controller monitors the ammonium value that is expected to be reached after the configured derivative time. (Refer to 4.9.6 Derivative times, page 30)	[min]	
DERIV TIME NO3	Derivative time for nitrate: Closed-loop controller monitors the nitrate value that is expected to be reached after the configured derivative time. (Refer to 4.9.6 Derivative times, page 30)	[min]	
P GAIN NH4	Gain factor: strength of the reaction to the ammonium content. Determines the length of the aerated phase (applies if only ammonium measurement is available). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]	
P GAIN NO3	Gain factor: strength of the reaction to the nitrate content. Determines the length of the non-aerated phase (applies if only nitrate measurement is available). (Refer to 4.9.5 Gain factors, page 29)	[1/mg/L]	
MODBUS			
ADDRESS	Start address of an RTC within the modbus network.		
DATA ORDER	Specifies the register order within a double word. Presetting: NORMAL		
DATALOG INTRVL	Indicates the interval in which the data is saved in the log file.	[min]	
SET DEFAULTS	Restores the factory default settings		

4.5.1   2-channel closed-loop control (Continued)

RTC MODULES / PROGNOSYS			23
RTC MODULES			
RTC			
MAINTENANCE			
	RTC DATA		
		RTC MEASUREMEN	Specifies the value measured by the RTC, e. g. the influent measurement.
		RTC ACTUAT VAR	Specifies the variable calculated by the RTC, e. g. whether the aeration should be switched on or off.
	DIAG/TEST		
		EEPROM	Hardware test
		RTC COMM TO	Communication time-out
		RTC CRC	Communication check sum
		MODBUS ADDRESS	Here, the address is displayed where the communication actually takes place. Presetting: 41
	LOCATION		Here, a location name can be assigned for better identification of the RTC module, e.g. activation 2.
	SOFT-VERSION		Shows the software version of the RTC communication card (YAB117) in the sc1000.
	RTC MODE		Shows the installed RTC module variant, e.g. 2-channel closed-loop control.
	RTC VERSION		Shows the software version of the RTC module.

4.5.2   2-channel closed-loop control, SBR option

| RTC MODULES / PROGNOSYS			
RTC MODULES			
RTC			
CONFIGURE			
N/DN-CONTROL			
CHANNEL 1			
TIME FRAME	(Refer to 4.9.3 Time frame, page 28)		
START N/DN?	Preselection of phase with which the treatment process is to be started.		
N-PHASE	Nitrification phase		
DN-PHASE	Denitrification phase		
TIME INITPHASE	Preselection of duration for the first treatment phase (in % of the corresponding MAX time)	[%]	
CHANNEL 2			
TIME FRAME	(Refer to 4.9.3 Time frame, page 28)		
START N/DN?	Preselection of phase with which the treatment process is to be started.		
N-PHASE	Nitrification phase		
DN-PHASE	Denitrification phase		
TIME INITPHASE	Preselection of duration for the first treatment phase (in % of the corresponding MAX time)	[%]	

4.5.3   2-channel closed-loop control, O$_2$ closed-loop control option

RTC MODULES / PROGNOSYS			25
RTC MODULES			
RTC			
CONFIGURE			
O2 CONTROL			
CHANNEL 1			
	MAX O2	Maximum O$_2$ concentration in the nitrification phase. (Refer to 4.10.2.1 Maximum value MAX O2, minimum value MIN O2, page 31)	[mg/L]
	MIN O2	Minimum O$_2$ concentration in the nitrification phase. (Refer to 4.10.2.1 Maximum value MAX O2, minimum value MIN O2, page 31)	[mg/L]
	DERIVATIV.TIME	Differentiation time of controller	[min]
	ABSORPTION	Absorption time to influence the switch frequency between the aeration stages	[min]
	NO. OF STAGES	Number of controlled aeration levels (maximum 6)	[none]
	SUBST AERATION	If the oxygen sensor (e. g. LDO) signals a fault, the set aeration stage is selected (stages 1 to 6).	[none]
CHANNEL 2			
	MAX O2	Maximum O$_2$ concentration in the nitrification phase. (Refer to 4.10.2.1 Maximum value MAX O2, minimum value MIN O2, page 31)	[mg/L]
	MIN O2	Minimum O$_2$ concentration in the nitrification phase. (Refer to 4.10.2.1 Maximum value MAX O2, minimum value MIN O2, page 31)	[mg/L]
	DERIVATIV.TIME	Differentiation time of controller	[min]
	ABSORPTION	Absorption time to influence the switch frequency between the aeration stages	[min]
	NO. OF STAGES	Number of controlled aeration levels (maximum 6)	[none]
	SUBST AERATION	If the oxygen sensor (e. g. LDO) signals a fault, the set aeration stage is selected (stages 1 to 6).	[none]

4.6 Select sensors

1. To select sensors and their sequence for the RTC module, press RTC > CONFIGURE > SELECT SENSOR.

Figure 4 **Select sensor**
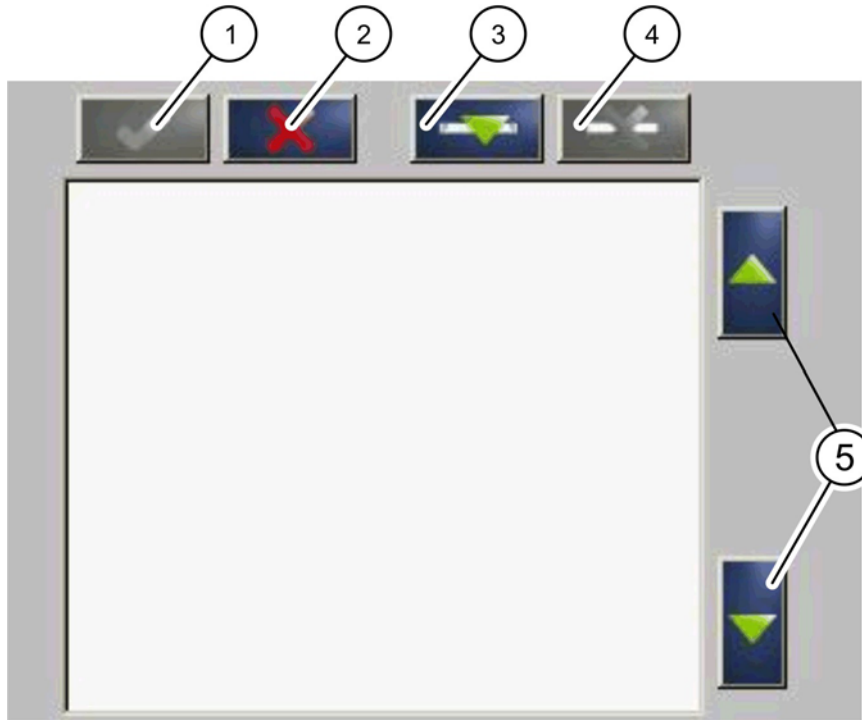
1	**ENTER** — Saves the setting and returns to the CONFIGURE menu.	4	**DELETE** — Removes a sensor from the selection.
2	**CANCEL** — Returns to the CONFIGURE menu without saving.	5	**UP/DOWN** — Moves the sensors up or down.
3	**ADD** — Adds a new sensor to the selection.		

2. Press **ADD** (Figure 4, item 3).

   A selection list of all subscribers to the sc1000 network opens.
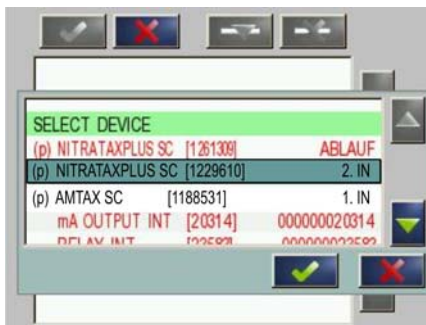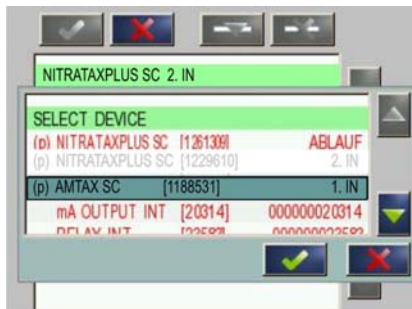

3. Press the required sensor for the RTC module and confirm by pressing **ENTER** below the selection list.

   Sensors in black type are available for the RTC module. Sensors in red type are not available for the RTC module.

   Note: For sensors marked (p), PROGNOSYS is available if these sensors have been selected in conjunction with an RTC module (refer to the PROGNOSYS user manual).
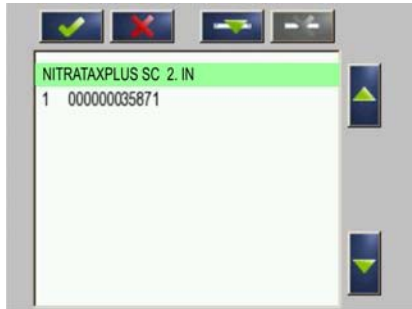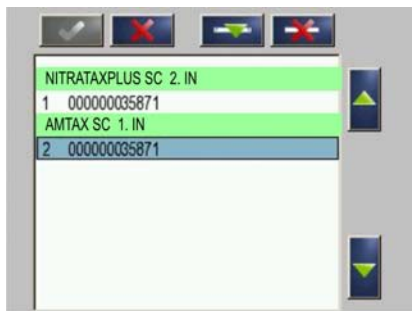
4. The selected sensor is shown in the sensor list.
Press **ADD** (Figure 4, item 3) to open the selection list again.

5. Select the second sensor for the RTC module and confirm by pressing **ENTER** below the selection list.

Note: Previously selected sensors are shown in gray.

The selected sensors are shown in the sensor list.

6. To sort the sensors in the order specified for the RTC module, press the sensor and use the arrow keys to move it (Figure 4, item 5).
Press **DELETE** (Figure 4, item 4) to remove an incorrect sensor from the sensor list again.
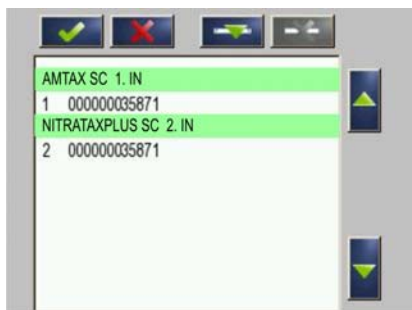
7. Press ENTER (Figure 4, item 1) to confirm the list once it is finished.

4.7   Control programs

To adapt to local circumstances and the instruments available, there are 4 different programs available for calculating the time intervals for the nitrification and denitrification

Table 3 Control programs to calculate the time intervals for nitrification and denitrification

TIME CONTROL	FIXED TIME FRAME
NH4-N	Control based on the NH_4-N concentration
NO3-N	Control based on the NO_3-N concentration
NH4-N and NO3-N	Control based on the NH_4-N and NO_3-N concentration

4.8   Automatic program change

If a measurement signal fails, e. g. during an operational fault, an automatic program change occurs from NH_4-N and NO_3-N to the respective measurement still available (NH_4-N or NO_3-N). If neither the NH_4-N nor the NO_3-N measurement is available, the program automatically switches back to the fixed time frame. If the measurements are available again after a failure, it is automatically switched back to the preselected program. The change between programs occurs with a delay of 5 minutes.

4.9   Explanations of nitrification/denitrification controller parameters

4.9.1   Target values

The RTC105 N/DN-Module assesses both the NH_4-N and the NO_3-N concentration in the activated sludge tank. Selected target values for both parameters are entered via the **NH4-N** or **NO3-N** parameters. The target values shall correspond to the average selected or achievable output values.

Table 4 Target values, default setting

NH4-N	2.5 mg/L
NO3-N	2.5 mg/L

4.9.2   Valuation ratio

The valuation ratio **NH4/NO3 WEIGHT** can specify, how the NH_4-N concentration in combination with the NO_3-N concentration affects the controller result. Ratios >1 result in a stronger influence on the NH_4-N concentration. Ratios < 1 affect a greater influence on the NO_3-N concentration. The preset ratio is 1.0. The valuation ratio should only be changed if you absolutely wish to avoid the increase of one of the two parameters by a specific value. A change in the valuation ratio can cause an undesired decrease of the (non)aerated phases, within the set time frame.

Table 5 Valuation ratio, default setting

NH4/NO3 WEIGHT	1.0

4.9.3   Time frame

The sum of the maximum times for nitrification and denitrification should be approximately 1.25 times the desired cycle time

(1 cycle = 1 unaerated phase + 1 aerated phase). The desired cycle time shall lie between 90 and 360 minutes.

High NH_4-N (NO_3-N) concentrations with low NO_3-N (NH_4-N) concentrations require a check of the maximum times **NITRI MAX** or **DENITRI MAX**. If the nitrification or the denitrification is limited by the corresponding maximum time, this maximum time shall be increased or the other be decreased.

The values for **NITRI MIN** and **DENITRI MIN** shall ensure a useful cyclical process under all operating conditions. They should be set as low as possible, and if possible, should have no influence on the control.

Table 6 Time frame, default setting

NITRI MAX	60 min
NITRI MIN	30 min
DENITRI MAX	60 min
DENITRI MIN	30 min

4.9.4   Increased biological phosphorous elimination (BIO-P)

If an increased biological phosphorous elimination is desired, by selecting the parameter ADD TIME BIO-P after the denitrification phase, a forced non-aerated phase for phosphorous dissolution (for NO_3-N approx. 0 mg/L) is introduced.

Table 7 BIO-P, default setting

ADD TIME BIO-P	0 min

4.9.5   Gain factors

In all versions of the RTC105 N/DN-Module, the gains

•   P GAIN NH4+NO3

•   P GAIN NH4 and

•   P GAIN NO3

(below), determine the resulting cycle time:
This applies to the controllers

• NH_4-N and NO_3-N,

• NH_4-N and

• NO_3-N.

The gains shall first be set equally and selected so that the desired cycle length (nitrification + denitrification) is set in the middle. With average load, the switch should occur between the respective minimum or maximum time and not be limited by either the maximum or the minimum times. If the control reaches the maximum times too frequently, the **P GAIN** are too small. In contrast, if the cycles are too short or if the controller frequently only runs the minimum times, the **P GAIN** are too big.

Changes should be made in increments of ±0,1. If no satisfactory behavior can be achieved with a set time frame, the time frame shall be adapted.

In general, all gains P GAIN are set to the same values.

- **P GAIN NH4+NO3** only applies if both measurements (NH$_4$-N and NO$_3$-N) are present.

- **P GAIN NH4** only applies if only the NH$_4$-N measurement supplies valid values.

- **P GAIN NO3** only applies if only the NO$_3$-N measurement supplies valid values.

The target value multiplied by the associated gain factor **P GAIN** must always be greater than 1.0.
(For **P GAIN NH4+NO3**, the average value of the target values of **NH4-N** and **NO3-N** applies)

Table 8 Gain factors, default setting

P GAIN NH4+NO3	1.0 /(mg/L)
P GAIN NH4	1.0 /(mg/L)
P GAIN NO3	1.0 /(mg/L)

4.9.6 Derivative times

The derivative times **DERIVATIV.TIME NH4** and **DERIV TIME NO3** assess the change rates of the applicable parameters.

DERIV TIME NO3 shall only be used if larger quantities of NO$_3$-N are present in the inlet.

DERIV TIME NH4 can be changed to counteract NH$_4$-N peaks in the inlet on time by increasing the nitrification times. The derivative time is increased in increments of 1.0 minute. An observation time frame must follow every change, in which it is checked, how strongly the cycle time increases and the NO$_3$-N concentration increases in the medium.

Table 9 Derivative times, default setting

DERIV TIME NO3	0 min.
DERIV TIME NH4	0 min.

4.10 Explanations of oxygen controller (O$_2$ control option)

4.10.1 General aeration parameters

NO. OF STAGES defines the number of the aeration stages. The RTC105 N/DN-Module with the option for oxygen closed-loop control can actuate between 1 and 6 discrete aeration stages.

Table 10 General aeration parameters, default setting

NO. OF STAGES	3

SUBST AERATION defines which aeration stage is to be activated in case of an invalid O$_2$ measurement.

Table 11 Substitute aeration, default setting

SUBST AERATION	3

4.10.2 Aeration control with stage actuation

Oxygen controllers with stage actuation are min-max limit controllers that receive an additional time assessment. This time assessment considers the change rate.

4.10.2.1 Maximum value MAX O2, minimum value MIN O2

The parameters, **MAX O2** and **MIN O2**, define an upper and lower oxygen limit value. **MAX O2** is the O$_2$ concentration that when exceeded, the controller begins to switch back the aeration stage. Below the O$_2$ concentration **MIN O2**, the aeration stages are switched higher.

The oxygen concentration in the activated sludge tank will fluctuate between the average value of MIN O2 and MAX O2 during operation. The closer the two values are to each other, the more frequently the blower switches on during the nitrification phase.

Table 12 Maximum value MAX O2, minimum value MIN O2, default setting

MAX O2	2.0 mg/L
MIN O2	0.7 mg/L

4.10.2.2 DERIVATIVE TIME

The **DERIVATIV.TIME** allows the controller to also react to the change rate of O$_2$ concentration. This enables the controller to react more quickly to the deviations from the target value.

Table 13 Derivative time, default setting

DERIVATIV.TIME	0 min

4.10.2.3 ABSORPTION

The closed-loop controller contains an absorption to prevent too frequent switching. A switch procedure is triggered dependent on how much time has past since the last switch and to what extent a limit value has been exceeded or not met. An increase in the **ABSORPTION** parameter causes a decrease in the switch frequency between the fan stages. On the other hand, the limit values **MAX O2** and **MIN O2** are more heavily exceeded.

Section 5   Maintenance

5.1   Maintenance schedule

> ### ⚠ DANGER
> Multiple hazards
> Only qualified personnel must conduct the tasks described in this section of the manual.

	Interval	Maintenance task
Visual inspection	Application-specific	Check for contamination and corrosion
CF card	2 years	Replacement by manufacturer's service department (Section 8, page 39)
Battery, type CR2032 Panasonic or Sanyo	5 years	Replacement

Section 6   Troubleshooting

6.1   Error messages

Possible RTC errors are displayed by the sc controller.

Displayed errors	Definition	Resolution
RTC MISSING	No communication between RTC and RTC communication card	Supply RTC with voltage Test connection cable Reset the sc1000 and the RTC (switch so it is completely voltage free and switch back on)
RTC CRC	Interrupted communication between RTC and RTC communication card	Make sure +/- connections of the connector cable between RTC and RTC communication card in the sc1000 are installed correctly. Change, if necessary.
CHECK KONFIG	The sensor selection of the RTC was deleted by removal or selection of a new sc1000 participant.	From **MAIN MENU > RTC MODULES / PROGNOSYS > RTC MODULES > RTC > CONFIGURE > SELECT SENSOR**, select the correct sensor for the RTC again and confirm.
RTC FAILURE	Brief general read/write error on the CF card, mostly caused by a brief interruption to the power supply.	Acknowledge error. If this message is shown frequently, eliminate the cause of the power disruptions. If necessary, inform the service team of the manufacturer (Section 8).

6.2   Warnings

Possible RTC sensor warnings are displayed by the sc controller.

Displayed warnings	Definition	Resolution
MODBUS ADDRESS	The RTC menu **SET DEFAULTS** was opened. This deleted the Modbus address of the RTC in the sc1000.	**MAIN MENU > RTC MODULES / PROGNOSYS > RTC MODULES > RTC > CONFIGURE > MODBUS > ADDRESS**: Access this menu and set the correct MODBUS address.
PROBE SERVICE	A configured sensor is in service status.	The sensor must exit service status.

6.3   Wear parts

Component	Number	Service life
CF card, type for RTC module	1 piece	2 years
Battery, type CR2032 Panasonic or Sanyo	1 piece	5 years

Section 7   Replacement parts and accessories

7.1   Replacement Parts

Description	Cat. No
DIN rail NS 35/15, punched according to DIN EN 60715 TH35, made of galvanized steel. Length: 35 cm (13.78 in.)	LZH165
Transformer 90–240 V AC/24 V DC 0.75 A, module for top hat rail assembly	LZH166
Terminal for 24 V connection without power supply	LZH167
Grounding terminal	LZH168
SUB-D connector	LZH169
C2 circuit breaker	LZH170
CPU base module with Ethernet port, passive ventilation element. (CX1010-0021) and RS422/485 connection module (CX1010-N031)	LZH171
Power supply module, consisting of a bus coupler and a 24 V terminal module (CX1100-0002)	LZH172
Digital output module 24 V DC (2 outputs) (KL2032)	LZH173
Digital output module 24 V DC (4 outputs) (KL2134)	LZH174
Analog output module (1 output) (KL4011)	LZH175
Analog output module (2 outputs) (KL4012)	LZH176
Analog input module (1 input) (KL3011)	LZH177
Digital input module 24 V DC (2 inputs) (KL1002)	LZH204
Digital output module 24 V DC (8 outputs) (KL2408)	LZH205
Digital output module 24 V DC (16 outputs) (KL2809)	LZH206
Bus termination module (KL9010)	LZH178
RTC communication card	YAB117
CF card, type for RTC module	LZY748-00

Replacement parts and accessories

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Section 9   Warranty and liability

The manufacturer warrants that the supplied product is free of material and manufacturing defects, and undertakes to repair or to replace any defective parts without charge.

The warranty period is 24 months. If a maintenance contract is taken out within 6 months of purchase, the warranty period is extended to 60 months.

With the exclusion of further claims, the supplier is liable for defects, including the lack of assured properties, as follows: all parts that, within the warranty period calculated from the day of the transfer of risk, can be demonstrated to have become unusable or that can only be used with significant limitations owing to circumstances prior to transfer of risk, in particular due to incorrect design, substandard materials or inadequate finish, shall be repaired or replaced at the supplier's discretion. The identification of such defects must be reported to the supplier in writing as soon as possible, but no later than 7 days after the discovery of the fault. If the customer fails to notify the supplier, the product is considered approved despite the defect. Further liability for indirect or direct damages is not accepted.

If device-specific maintenance- or inspection work prescribed by the supplier is to be performed within the guarantee period by the customer (maintenance) or by the supplier (inspection) and these requirements are not met, claims for damages that result from non-observance of these requirements are void.

Further claims, in particular for consequential damages, cannot be made.

Wear and damage caused by improper handling, incorrect installation or non-designated use are excluded from this clause.

The process instruments of the manufacturer have proven their reliability in many applications and are therefore often used in automatic control loops to enable the most economical and efficient operation of the relevant process.

To avoid or limit consequential damage, it is therefore recommended that the control loop be designed such that an instrument malfunction results in an automatic changeover to the backup control system. This guarantees the safest operating condition both for the environment and the process.

Appendix A MODBUS address setting

The same slave address must be set for Modbus communication both on the sc1000 controller display and on the RTC105 N/DN-Module. Since 20 slave numbers are reserved for internal purposes, the following numbers are available for assignment:

1, 21, 41, 61, 81, 101…

The start address 41 is preset at the factory.

NOTICE

If this address is to be or must be changed because, for example, it has already been allocated for another RTC module the changes must be made both on the sc1000 controller and on the CF card of the RTC module.

This can only be done by the manufacturer service department (Section 8)!

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