bNovate TECHNOLOGIES

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Reference Handbook

BactoSense

Rapid Bacterial Monitoring System

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1 General user information

1.1 Purpose of the reference handbook

This reference handbook provides the user with more detailed information that supplements the instruction manual.

The reference handbook is intended for all persons who are familiar with the contents of the instruction manual and require detailed information about topics such as instrument configuration, data analysis, data export and troubleshooting.
This document is part of the product. It should be stored in a safe place and always be close at hand for the user.

The most recent version of this document can be ordered from the bNovate representative in your country. A list with all bNovate representatives can be found on our website: www.bnovate.com/distribution-partners.

Additional associated product documentation can be found in the table below.

1.2 Additional documentation

Table 1-1 Additional documentation

40102	Instruction Manual	Describes the intended use of the product and general operations.
40101	Quick Guide	Basic information needed to quickly operate the BactoSense.
40108	Cleaning Kit User Manual	Usage of the reagent kit to decontaminate the BactoSense.
40107	Validation Kit User Manual	Usage of the reagent kit used to validate proper functioning of the BactoSense.
50112	CE declaration of conformity	Compliance with the underlying directives and standards.
50114	CB test report	UL/CSA/FCC compliance report, also under CH-11152 on https://certificates.iecee.org

1.3 Safety symbols

The safety symbols used in this document are explained below.

DANGER!

Electric shock that may result in serious injury or death

Ignoring this notice may lead to electrical shocks and death.

EXPLOSION HAZARD!

Explosion that may result in serious injury or death

Ignoring this notice may cause explosions resulting in serious property damage and death.

WARNING!

Injury or hazards to health with long-term effects

Ignoring this warning may lead to injuries with possible long-term effects.

CAUTION!

Material damage

Ignoring this notice may cause material damage to the instrument and its peripherals.

1.4 Pictograms

All pictograms used in this document are explained below.

Additional information about the current topic.

Practical procedures when working with the BactoSense.

The screenshot is an example of the graphical user interface and may be different on your device.

2 Integration and configuration

2.1 Alarm configuration

The following rules apply to alarms:

- Only **Advanced** and **Admin** users can change the alarm settings.
- Alarms are only active in the **Auto mode**.

BactoSense records alarms in the following ways:

- A popup is displayed in the graphical user interface
- An alarm bell icon appears in the top bar if the last measurement exceeded the alarm threshold. The alarm is shown in the measurement summary when viewing a result.
- A signal can be sent out to a PLC through digital outputs (configurable).

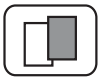


Figure 2-1 Alarm configuration in the BactoSense graphical user interface.

1	Select, enable or disable alarms. Users can configure up to 9 alarms.	**2**	Name of the currently selected alarm.
3	Source of the alarm: Which measurement result should be evaluated. See figure 2-2.	**4**	Condition: Trigger the alarm when the measured parameter is larger than (>) or smaller than (<) the threshold.
5	Threshold	**6**	Display: If checked, a line will be shown on the Auto mode plot, in the selected color.

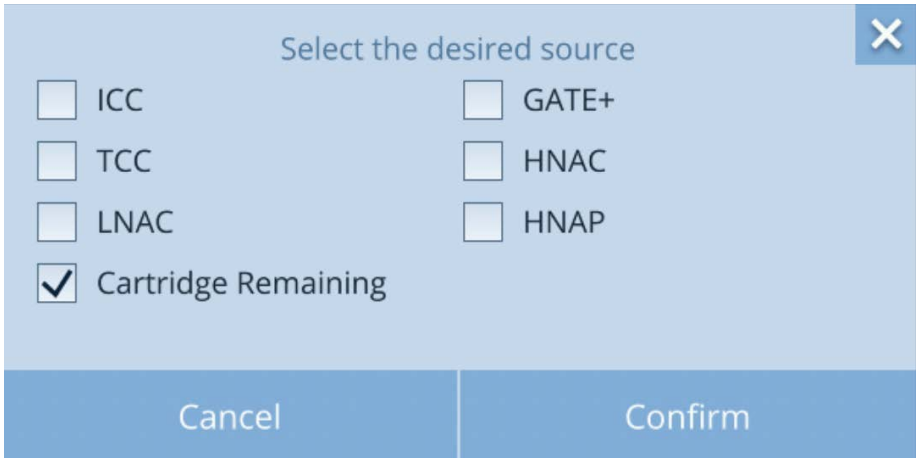


Figure 2-2 BactoSense alarm sources. For a selected source, a condition and a threshold are set. In the example above, an alarm is triggered on a certain cartridge filling level.

The following procedure describes how to configure the alarm:

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Auto mode settings** button.	
3.	Press **Alarms**.	
4.	Activate, select and configure the alarms (according to figure 2-1 and figure 2-2).	By default, no alarms are active.
5.	Press **Save** to save the alarm configuration.	

2.2 Digital input configuration and PLC mode

The instrument can be controlled from an external Programmable Logic Controller (PLC). In order to avoid any conflicts when starting a process, the PLC first locks the instrument into "PLC Mode", in which the instrument acts as a slave to the PLC. In this mode, all functions of the GUI related to running protocols and other processes are blocked. Once in PLC mode, protocols can be started and aborted from the PLC, using the Instrument's digital inputs. The digital outputs then provide feedback to the PLC for safe operation.

This section describes the configuration of digital inputs on the BactoSense. The physical connection of the inputs to the BactoSense is described in the instruction manual in section 5.4 and 5.6.

The PLC mode is a remote-controlled Auto mode: the PLC can request a single measurement, or start the scheduler to run protocols at predefined intervals. Measurements started from the PLC also appear in the Auto mode results.

When no wires are connected to the digital inputs, their state is 0000.

Table 2-1 Overview of digital input states and associated functions.

DESCRIPTION	DIGITAL INPUT			
	1	2	3	4
Force PLC mode: The instrument is idle but a slave to the PLC.	1	0	0	0
Run configurable protocol / measurement interval	1	1	0	0
Run configurable protocol / measurement interval	1	0	1	0
Run configurable protocol / measurement interval	1	0	0	1
Abort current protocol	1	1	1	1
Slave mode deactivated. End of PLC mode.	0	0	0	0

To run a protocol several times, either use the scheduler option, or trigger a new measurement from the PLC by resetting the input state to 1000, then back to the corresponding "Run" state.

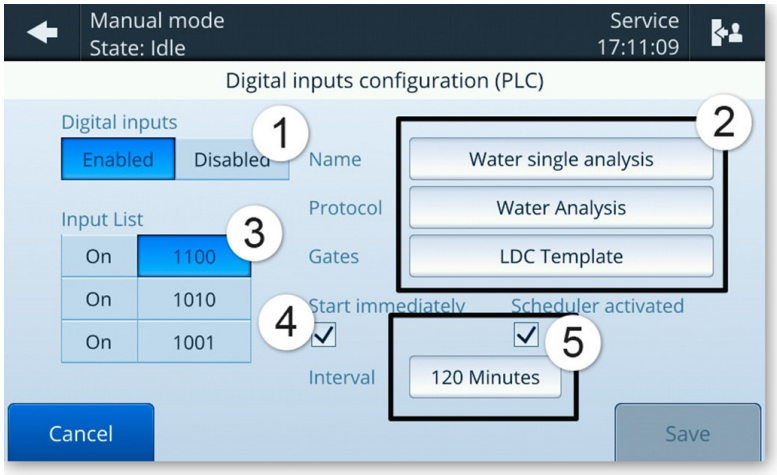


Figure 2-3 Digital input configuration

1	Enable or disable digital inputs. If disabled, PLC mode is never active.	**2**	Protocol parameters: Sample name, protocol, and gate.
3	Select the input state you wish to configure. When the state selected in (3) is applied to the DI, the protocol defined in (2), (4) and (5) will be executed	**4**	If enabled, start the protocol immediately after the input state has changed. If not, wait for the duration of the scheduler interval before starting.
5	Scheduler settings: if the scheduler is activated, the protocol will be repeated at the selected interval, until the input state is changed. If the scheduler is disabled, the protocol will run only once.		

To configure the three configurable digital input states, follow these steps:

	WORK STEP	**ADDITIONAL INFO / IMAGES**
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Auto mode settings** button.	
3.	Press the **Digital inputs** button.	
4.	Make sure the toggle button is set to **Enabled**.	
5.	Switch on and select the state you wish to configure in the Input list, enter a name for the sample, choose a protocol and choose a gate.	
6.	If you want the protocol to repeat automatically, enable the "Scheduler activated" check box, and choose an interval.	
7.	In the above case, choose if you want the protocol to execute immediately or at the end of the first interval with the "Start immediately" check box.	This option is only useful if the scheduler is activated.
8.	Press the **Save** button.	

2.3 Digital output configuration

This section describes the configuration of digital outputs on the BactoSense. The physical connection of the outputs to the BactoSense is described in the instruction manual in section 5.4 and 5.5.

The values of digital outputs are modified in the following situations:

- When the instrument is powered off, all outputs are set to 0.
- When the instrument is powered on, the outputs show the current error state: none / critical / non-critical.
- At the end of a measurement in Auto mode, the outputs are changed to indicate errors and alarms, according to user-defined settings.
- When Reset is clicked on the output test screen or when Save is pressed on the digital output settings, the outputs are updated to show the error state only (alarms are ignored).
- After manually clearing the errors, the outputs are automatically reset (and therefore show the new error state and no alarms).
- At specific times during the measurement, extra signals can be relayed. By default, neither of them is relayed to the outputs. These are:
  - Process running. Active when a protocol is running.
  - Sampling device in use. Active when the sampling device is being used. It drops back to inactive after the sample preparation step of measurement protocols.
  - Low cartridge. Active when the cartridge level is below 15 %, or if the cartridge is estimated to be empty within a month based on the current measurement frequency.
  - Expired cartridge. Active when the cartridge is expired.

The digital output state at the end of a measurement is defined according to these default values, which can be changed in the settings:

- If there are no errors and no alarms, all terminals are set to the user-defined base state. By default, this is 1 everywhere.
- In case of a critical error, the first output is set to 0.
- Non-critical errors set the second output to 0.
- Alarms set the third and fourth output to 0.
- In case of conflict in the output settings, priority is given to:
  - 1. Critical errors
  - 2. Non-critical errors
  - 3. Cartridge states
  - 4. Alarm

Only Admin users can change the output settings, as these can critically affect external PLC systems.

The following procedure describes how to adjust the digital outputs.

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Auto mode settings** button.	
3.	Press the **Digital outputs** button.	
4.	Choose the **base state**, i.e. the output state when everything is fine: Output | 1 | 2 | 3 | 4 **Base state** | **1** | **1** | **1** | **1**	1: The switch is closed. 0: The switch is open.
5.	Choose which output the **critical error state** should be signaled on: Output | 1 | 2 | 3 | 4 **Critical error** | **0** | **/** | **/** | **/**	By default, a critical error opens output 1. 1: The switch is closed. 0: The switch is open. /: The switch is not affected by this error.
6.	Choose which terminal the **non-critical error state** should be signaled on: Output | 1 | 2 | 3 | 4 **Non-critical error** | **/** | **0** | **/** | **/**	By default, a non-critical error opens output 2.
7.	Assign **alarms** to the remaining outputs: Output | 1 | 2 | 3 | 4 **Alarm 1** | **/** | **/** | **0** | **0** **Alarm 2 ...** | **...** | **...** | **...** | **...**	You can only assign alarms that are enabled. You can assign several alarms to the same output.
8.	Press the **Save** button.	

2.4 Analogue output configuration

This section describes the configuration of analogue outputs on the BactoSense. The physical connection of the outputs to the BactoSense is described in the instruction manual in section 5.4 and 5.5.

The analogue current output is changed in the following situations:

- When the instrument is powered off, both outputs are set to 0 mA.
- When the instrument is powered on, both outputs are set to 2 mA.
- When a measurement in Auto mode terminates after cell counting, the value is set between 4 and 20 mA, according to range and source definition of the analogue output settings. If the measurement fails due to an error before cell counting begins, the output remains at its previous value.
- When a user manually tests the output, the current is set to whatever value the user has chosen. The reset button sets them to 4 mA.

Only **Admin** users can edit the analogue 4 .. 20 mA outputs.

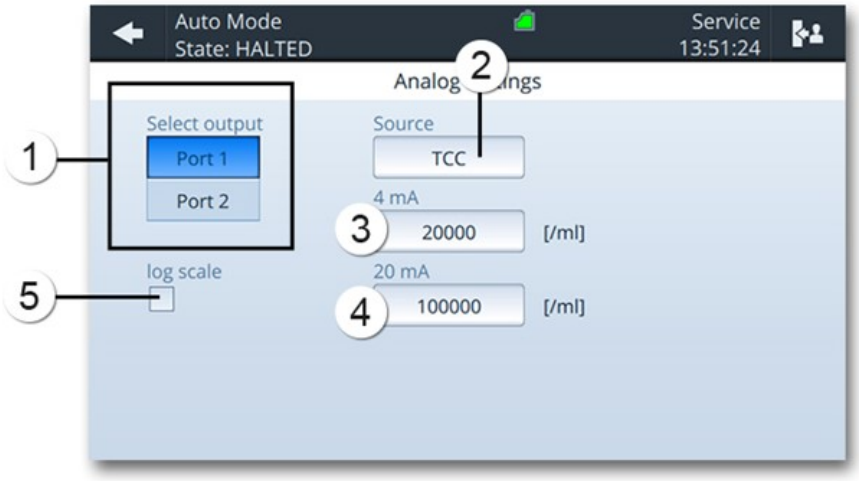


Figure 2-4 Analogue output settings

1	Output port selection	**2**	Source: Defines which measurement result is transmitted by this output port.
3	Lower limit 4 mA: Which value of the measurement result should correspond to 4 mA.	**4**	Upper limit 20 mA: Which value of the measurement result should correspond to 20 mA.
5	If selected, interpolates the chosen cell count value range with a logarithmic scale as follows: $\text{ratio} = 1 + 9 \times \left(\frac{\text{counts} - \text{low}}{\text{high} - \text{low}}\right)$ $\text{output} = 4\text{mA} + \log_{10}(\text{ratio}) \times 16\text{mA}$ counts: Measured cell count low: Lower cell count limit high: Higher cell count limit output: Current amplitude in mA		

The following procedure describes how to adjust the analogue outputs.

	WORK STEP	**ADDITIONAL INFO / IMAGES**
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Auto mode settings** button.	
3.	Press the **Analog outputs** button.	
4.	Choose **Port 1** or **Port 2** (figure 2-4)	
5.	Choose the source (figure 2-4, position 2).	

	WORK STEP	ADDITIONAL INFO / IMAGES
6.	Define the lower limit of the range (figure 2-4, position 3).	When the source is equal to this value, 4 mA will be output on the selected port.
7.	Define the upper limit of the range (figure 2-4, position 4).	When the source is equal to this value, 20 mA will be output on the selected port.
8.	Press the **Save** button.	

2.5 Digital and analogue output testing

CAUTION!

The Test outputs interface allows to generate a physical output signal for testing purposes. Make sure that such tests do not generate an alarm on your control system.

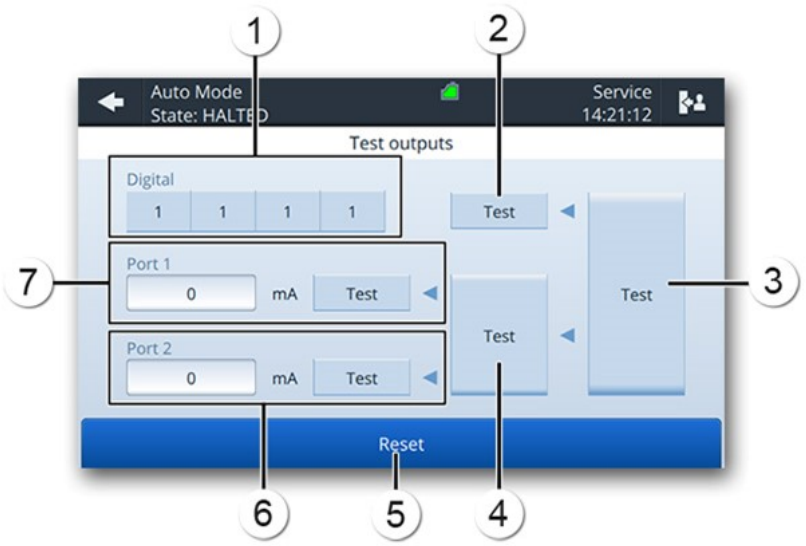


Figure 2-5 Testing analogue and digital outputs

1	Define state of digital outputs for test.	**2**	Set digital outputs to the state defined in (1).
3	Set all digital and analogue outputs at once.	**4**	Set current on both analogue outputs.
5	Reset outputs to their state before the tests.	**6**	Set current on port 2.
7	Set current on port 1.		

The following procedure describes how to test the analogue and digital outputs.

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Auto mode settings** button.	
3.	Press the **Test outputs** button.	
4.	Enter the test values that you wish to send to the PLC.	For digital outputs: 1: The output is turned on. 0: The output is turned off.
5.	Tests can be triggered individually or together (see figure 2-5): • Testing only the digital outputs on the terminals 1 .. 4. • Testing only the analogue outputs 4 .. 20 mA on ports 1, 2 or both. • Testing all outputs.	The output signals can be measured on the terminals.
6.	Press the **Reset** button.	

2.6 Demo mode

Demo mode can be used when demonstrating the device or when learning how to navigate the menus and use the functions. When it is activated, the instrument reboots into a special mode that displays demonstration data (the owner's measurement results are hidden). All the instrument's functions are replaced by simulations that never move the hardware or modify the results database. This means protocols can be started without needing to load a sample, and users can pretend to delete or re-gate results without ever changing the data. If the demo mode is activated, the message ***Demo*** is displayed in the upper middle of the screen.
When the instrument is reverted to normal mode, the owner's data is shown again, and all functions are active again.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Enter the **System settings** button, and then the **Demo mode** button.	 
3.	Select the **Activate demo mode** box.	
4.	Press the **Save and restart** button.	
5.	The device reboots automatically.	

To return into normal mode, follow the same procedure, but uncheck the **Activate demo mode** box.

2.7 Factory reset

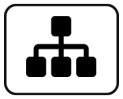
Factory reset reverts most of the instrument settings to the factory values: Gating limits, measurement interval, default protocol names, users, language and network settings. This option is accessible only by the Admin and Service logins.

The following procedure describes how to perform a factory reset:

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **System settings** button, then the **Factory reset** button.	 
3.	Use the check boxes to select which parameters you wish to reset: • Instrument settings • Measurements incl. errors and logs • both	Service logs, validation results and the software update history are not deleted.
4.	Then press the **Reset the device and reboot** button.	

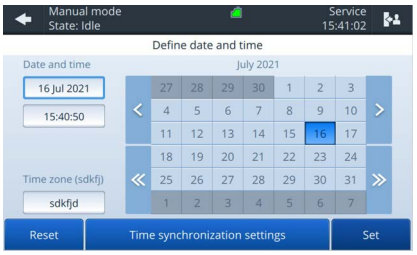
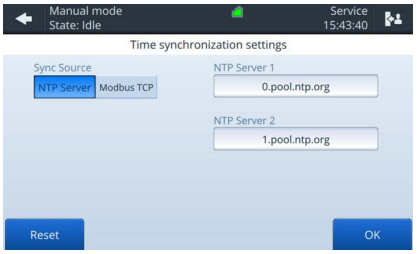
2.8 Network configuration

Ask your network administrator for the correct settings.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **System settings** button.	
3.	Press the **Network** button.	
4.	A: For **Dynamic IP** check the **DHCP** check box (a). Note: This is the preferred configuration for most cases when the BactoSense is connected to a router or switch. B: For **Static IP** uncheck the **DHCP** check box (a) and enter the desired network configuration (b). Note: This is the preferred configuration when the BactoSense is directly connected to a laptop via Ethernet. Make sure to also adjust the network configuration on the laptop accordingly.	
5.	Press the **Save** button.	
6.	Press the **Reboot now** button.	

2.9 Set NTP Servers

Network Time Protocol (NTP) is a computer network protocol which is used to synchronise time on computers across a network. By default, these are set to synchronise to the Network Time Foundation servers (ntp.org). You have the possibility to set custom NTP servers in the *Date and Time* menu.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **System settings** button.	
3.	Press the **Date & Time** button.	
4.	Press **Time synchronisation settings** button.	
5.	Select the desired **Sync Source.**	Time synchronization can be done via NTP server or Modbus TCP. More information about Modbus TCP can be found in section 3.1
6.	Update NTP servers.	
7	Press the **OK** button.	By editing and changing a server address and pressing **OK**, it will automatically ping the server and update the time.

2.10 Retrieve service information

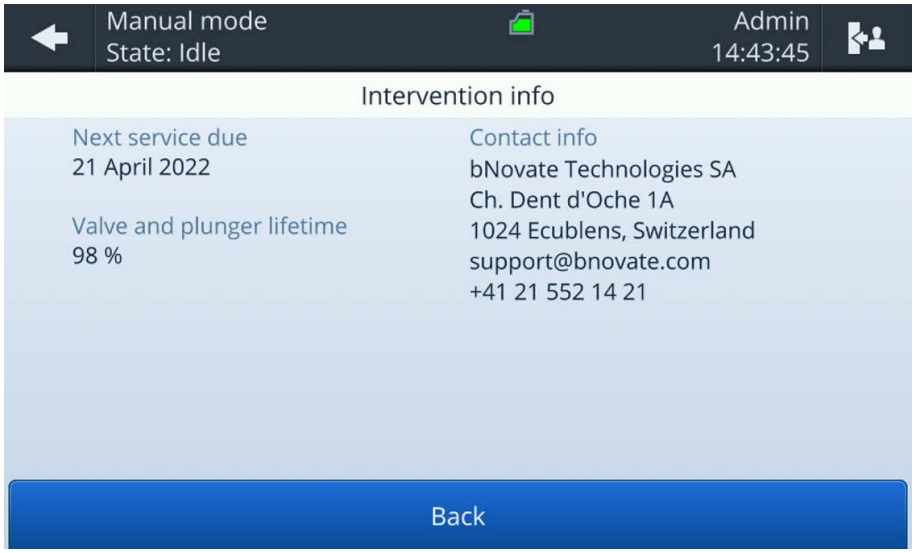


Figure 2-6 Intervention info screen

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Maintenance** button.	
3.	Press the **Intervention info** button.	
4.	An intervention should be scheduled before the next service due date or before the valve and plunger lifetime reaches 0%. If a service is needed a warning will be attached to the measurement result.	

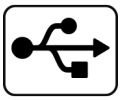
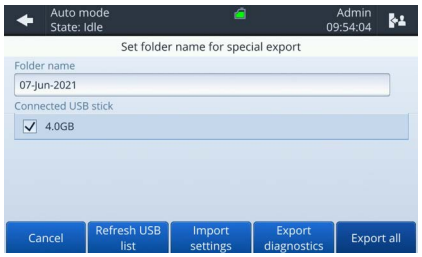
2.11 Review the service intervention log

The following procedure describes how to view details of past service interventions.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Maintenance** button.	
3.	Press the **Intervention log** button.	
4.	Past service interventions are listed in this log screen.	

2.12 Import / export settings

Settings are exported to a USB drive as per section 6.1.1. The settings are compiled to a timestamped file ending with ***.bnv**. In order to import the settings in a new instrument, or as a backup, it is necessary to copy the ***.bnv** file at the root of the USB drive, or in the directory the file was exported to. If multiple copies of the settings are located in one USB drive, the system will use the most recent one.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the Bacto-Sense user interface.	
2.	Press the **Maintenance** button.	
3.	Press the **Special export import** button.	
4.	Connect a USB drive. If needed, press the **Refresh USB list** button until the drive is detected.	Make sure the ***.bnv** file is at the root of the USB drive. The USB drive should be formatted in FAT32, which is the common standard.
5.	Press **Import settings**	
6.	Select the settings you want to import. Measurement settings include gate sets, IO settings, alarms, and date and time settings. Network settings include IP, DNS, and NTP addresses	
7.	Press **Import settings** and wait until the device reboots	

3 Field bus interface

3.1 Modbus TCP

3.1.1 General information for operating with Modbus TCP

The BactoSense can be operated via the Modbus Transmission Control Protocol (TCP). The following requirements must be met:

- The computer and/or the management or control system must be compatible with Modbus TCP.
- The computer and/or the management or control system must have software that can properly process the data provided by the BactoSense.
- The BactoSense must have at least software version 2.0.
- The BactoSense must have the Modbus TCP optional license (see section 3.1.2).
- The BactoSense must have the Modbus TCP service activated in the System settings / System services menu.
- The BactoSense must be connected to the bus system.
- To be able to work with the Modbus TCP, the network settings must be set correctly.

Additional information

- The Modbus TCP interface is integrated by default in the BactoSense.
- The Ethernet socket is located at the right-hand side of the instrument.
- The address table necessary for programming can be found separately in the section 3.1.3.
- All registers are encoded big-endian.
- Modbus TCP communication runs on port 502.
- The error code list can be found in section 7.2 (non-critical errors) and section 7.3 (critical errors).
- Modbus TCP can be used for time synchronization. Follow the instructions in section 2.9 and select *Modbus TCP* as a sync source.

3.1.2 How to activate the Modbus TCP license

- The Modbus TCP option can be activated anytime, before or after purchase.
- To enable the communication interface, please order the option (article number 200071) through your bNovate representative.
- An authentication code will then be sent to you.
  It can be transmitted by mail, e-mail or by phone.
- Each BactoSense unit has its own authentication code .

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Select **System settings**, and then **System services.**	
3.	Check the box **Enable Modbus TCP** and press **OK**	
4.	Enter the Modbus license key you received from your bNovate representative	
5.	Press the **OK** button to activate the service	A window will appear to confirm the changes.

3.1.3 Address list on Modbus TCP:

The following values can be read with Modbus function 3 or 4 and written with Modbus function 16.

REGISTER NO	ADDRESS (OFFSET)	DATA TYPE	FUNCTION	VALUES
300201 400201	0x00C8	Unsigned integer bits 0-15	Digital Inputs	Bit 0: Input 1 Bit 1: Input 2 Bit 2: Input 3 Bit 3: Input 4
300202 400202	0x00C9	Unsigned integer bits 0-15	Power control	Bit 0: Reboot Bit 1: Power off
300203 400203	0x00CB	Uint16	Watchdog	Write setpoint in seconds to activate or reset countdown. After the value is written, a countdown decrements it by 1 every second. During countdown, reading the register returns the setpoint. If countdown reaches 0, any ongoing protocol is aborted. Reading the register returns 0 Write 0 to disable countdown.
300204 400204	0x00CC	Uint16	Test register	Write 1 to display a message on DI source page of GUI. Resets to 0 at startup.
300211 400211	0x00D2	UInt16: Year	Get/Set Date and Time. Time is changed as soon as write is finished. Only the fields where registers were written are changed: if only month is written, only the month is updated.	
300212 400212	0x00D3	UInt16: Month		
300213 400213	0x00D4	UInt16: Day		
300214 400214	0x00D5	UInt16: Hour		
300215 400215	0x00D6	UInt16: Minute		
300216 400216	0x00D7	UInt16: Second		

The following values can be read with Modbus function 3 or 4.

REGISTER NO	ADDRESS (OFFSET)	DATA TYPE	FUNCTION	VALUES
300001 400001	0x0000	UInt16 (individual bits)	Digital Outputs	Bit 0: Output 1 Bit 1: Output 2 Bit 2: Output 3 Bit 3: Output 4
300002 400002	0x0001	UInt16 (individual bits)	Instrument Status 0 = No 1 = Yes	Bit 0: Process running Bit 1: Critical Error Bit 2: Non-critical error Bit 3: PLC mode active Bit 4: Rapid heating (in winter mode) Bit 5: Background heating (winter mode) Bit 6: Sampling device in use
300003 400003	0x0002	UInt16 (individual bits)	Alarm status, i.e., alarms raised during last measuremen t.	Bit 0: Alarm 1 Bit 1: Alarm 2 Bit 2: Alarm 3 …
300004 400004	0x0003	UInt32 MSB (individual bits)	Warning status, i.e. warnings raised during last measuremen t.	Bit 0: Warning W01 Bit 1: Warning W02 … Bit 31: Warning W32
300005 400005	0x0004	UInt32 LSB (individual bits)		
300006 400006	0x0005	UInt16	Error code	See error code list. Note: E00 (unhandled software error) is renamed to 999 to avoid confusion with "no error". Non-critical error codes remain until either cleared automatically by a successful protocol or cleared manually.
300007 400007	0x0006	UInt16	Heartbeat	Seconds of the clock. The value changes every second, use this to monitor responsiveness of the system.

REGISTER NO	ADDRESS (OFFSET)	DATA TYPE	FUNCTION	VALUES
300008 400008	0x0007	UInt16	Measuremen t stage	IDLE 0 INITIALIZING 1 HEATING 2 FILLING 3 PRIMING 4 MIXING 5 INCUBATING 6 ANALYZING 7 CLEANING 8 FLUSHING 9 PROCESSING 10 VALIDATING 11 MOVING 12 EJECTING 13 EXPORTING 14 RENAMING 15 DELETING 16 SAVING 17 SELFCHECK 18 ABORTED 19 UNKNOWN 98 ERROR 99
300011 400011	0x000A	UInt16	Measuremen t Progress	[0, 100] 0 .. 100 %
300012 400012	0x000B	Float 32 MSB	Temperature of IO board	Celsius
300013 400013	0x000C	Float 32 LSB		
300014 400014	0x000D	UInt16	Humidity at IO board	[0, 100] 0 .. 100 %
300015 400015	0x000E	UInt16: Year	Date and time of last sampling	
300016 400016	0x000F	UInt16: Month		
300017 400017	0x0010	UInt16: Day		
300018 400018	0x0011	UInt16: Hour		
300019 400019	0x0012	UInt16: Minute		
300020 400020	0x0013	UInt16: Second		
300021 400021	0x0014	UInt16	Cartridge percentage	[0, 100] 0 .. 100 %

REGISTER NO	ADDRESS (OFFSET)	DATA TYPE	FUNCTION	VALUES
300022 400022	0x0015	UInt32 MSB	Cartridge serial no	
300023 400023	0x0016	UInt32 LSB		
300024 400024	0x0017	UInt32 MSB	Fill serial no	
300025 400025	0x0018	UInt32 LSB		
300026 400026	0x0019	Uint16	Cartridge type	1 = TCC-D 1002 = ICC-A
300027 400027	0x001A	UInt16: Year	Cartridge expiration date	UTC date
300028 400028	0x001B	UInt16: Month		
300029 400029	0x001c	UInt16: Day		
300031 400031	0x001E	UInt32 MSB	Instrument Serial number	
300032 400032	0x001F	UInt32 LSB		
300033 400033	0x0020	String char 1-2	Software version	When shorter than 16 characters, the string is padded with null characters. Example: '1.4.0-BS\0\0\0\0...'
300034 400034	0x0021	String char 3-4		
300035 400035	0x0022	String char 5-6		
300036 400036	0x0023	String char 7-8		
300037 400037	0x0024	String char 9-10		
300038 400038	0x0025	String char 11-12		
300039 400039	0x0026	String char 13-14		
300040 400040	0x0027	String char 15-16		
300041 400041	0x0028	UInt16	Memory remaining	Approx measurements remaining before disk is full

REGISTER NO	ADDRESS (OFFSET)	DATA TYPE	FUNCTION	VALUES
300042 400042	0x0029	UInt16	Lifetime of valve remaining	[0, 100], percentage of movements remaining before service.
300043 400043	0x002A	UInt16	Lifetime of plunger remaining	[0, 100], percentage of movements remaining before service.
300044 400044	0x002B	UInt16: Year	Next service due date	UTC date
300045 400045	0x002C	UInt16: Month		
300046 400046	0x002D	UInt16: Day		
300101 400101	0x0064	UInt32 MSB	TCC	
300102 400102	0x0065	UInt32 LSB		
300103 400103	0x0066	UInt32 MSB	ICC	Always 0 if cartridge does not provide ICC
300104 400104	0x0067	UInt32 LSB		
300105 400105	0x0068	UInt32 MSB	Gate+	Always 0 if cartridge does not provide Gate+
300106 400106	0x0069	UInt32 LSB		
300107 400107	0x006A	UInt32 MSB	HNAC	
300108 400108	0x006B	UInt32 LSB		
300109 400109	0x006C	UInt32 MSB	LNAC	
300110 400110	0x006D	UInt32 LSB		
300111 400111	0x006E	Float 32 MSB	HNAP	
300112 400112	0x006F	Float 32 LSB		
300121 400121	0x0078	UInt32 MSB	Live TCC	Same as TCC, but the value is updated live during a measurement.
300122 400122	0x0079	UInt32 LSB		

REGISTER NO	ADDRESS (OFFSET)	DATA TYPE	FUNCTION	VALUES
300123 400123	0x007A	UInt32 MSB	Live ICC	Same as ICC, but the value is updated live during a measurement.
300124 400124	0x007B	UInt32 LSB		
300125 400125	0x007C	UInt32 MSB	Live Gate+	Same as Gate+, but the value is updated live during a measurement.
300126 400126	0x007D	UInt32 LSB		
300127 400127	0x007E	UInt32 MSB	Live HNAC	Same as HNAC, but the value is updated live during a measurement.
300128 400128	0x007F	UInt32 LSB		
300129 400129	0x0080	UInt32 MSB	Live LNAC	Same as LNAC, but the value is updated live during a measurement.
300130 400130	0x0081	UInt32 LSB		
300131 400131	0x0082	Float 32 MSB	Live HNAP	Same as HNAP, but the value is updated live during a measurement.
300132 400132	0x0083	Float 32 LSB		

4 Results and data analysis

4.1 Measurement results

The figure below shows the result of a selected measurement. From here, the user can delete or rename the measurement, look up older results (and export them), or export the result. Expert users can repeat the cell counting with new gates. Some actions are bound to specific accounts (Basic, Advanced or Admin).

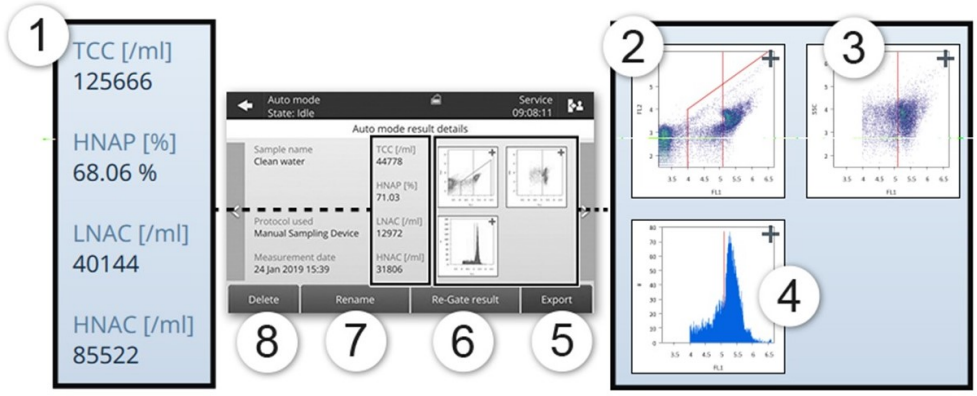


Figure 4-1 : Display of a single measurement result, acquired using a TCC cartridge

①	Result parameters are displayed. For details refer section 4.3.
②	The FL2 vs FL1 dotplot shows all detected events according to the amplitude of their fluorescence signals FL1 (535 nm, X-axis) and FL2 (715 nm, Y-axis). The red polygon and vertical line define the gates. For details refer to section 4.3.
③	The SSC vs FL1 dotplot shows only cells inside the FL1 - FL2 polygon gate, according to their fluorescence signal FL1 (535 nm) and scattered light signal SSC (488 nm).
④	The FL1 histogram shows all cells inside the FL1 - FL2 polygon gate, binned according to their fluorescence in FL1.
⑤	**Export** saves this result to a USB stick. More information can be found in the instruction manual in section 7.6.1.
⑥	**Re-Gate result** allows to apply a different gating to the measurement data. For details refer to section 4.4.1.
⑦	**Rename:** To rename the measurement.
⑧	**Delete:** To delete the measurement permanently (requires confirmation).

Multiple selection & batch operations: In the list of measurements, long-press on one measurement to activate the selection of multiple measurements, then select **Delete / Re-gate** or **Export**.

4.2 Introduction to gates

Following flow cytometry standards, the BactoSense uses gates to count cells in samples.

We define:

- **Gate**: A line or polygon applied to a dotplot to quantify populations of measured cells.
- **Set of gates, or gating set**: A collection of two or more gates, used for the gating strategy. The types of gates are fixed, but users can change the limits of each gate. These are different for TCC and ICC measurements.
- **Gating strategy**: Defines how the gates are combined to count cells. For example, HNAC is the number of cells that are inside the TCC polygon and higher than the HNA limit. These strategies are different for TCC and ICC measurements.

Gating sets are specific for a type of cartridge. As an example, only gating sets of type *TCC* can be used with measurements performed using a TCC cartridge.

4.2.1 Default gating sets

The BactoSense has preconfigured gating sets for all available cartridge types. These gating sets are called **Default gating sets**. They have been carefully designed to be applicable to the **vast majority of samples**.

- The default gates on the BactoSense can be found when pressing on **Gate settings** in the **Home menu** of the BactoSense user interface.
- Default gating sets can neither be modified nor deleted.
- New gating sets can be created by editing a copy of an existing gating set, as described in section 4.4.2.

4.2.2 List of available gating sets and operations

A list of all available gating sets on the BactoSense can be found when pressing **Gate settings** in the **Home menu** of the BactoSense user interface.

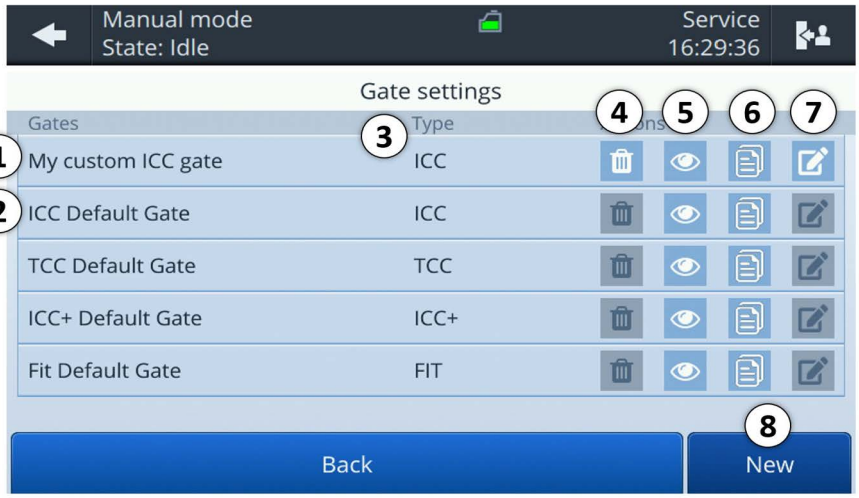


Figure 4-2 List of available gating sets and options to copy and create new sets. Default gates are preconfigured and cannot be deleted or edited.

1	Example of a custom gate for the ICC cartridge.	**2**	ICC default gate. Default gates are preconfigured.
3	Gate types, to be used with the respective cartridge type.	**4**	Delete an existing gating set. Default gates can not be deleted.
5	Preview the gating set.	**6**	Create a copy of the gating set.
7	Edit the gating set. Default gates can not be edited.	**8**	Create a new gating set.

4.3 Gates and result parameters

Depending on the cartridge used for a measurement, different parameters are measured. The following sections give an overview over the different cartridge types, their gating sets and result parameters.

4.3.1 TCC cartridge

TCC refers to *Total Cell Count*. The TCC cartridge is therefore used to measure the concentration of all cells.

Table 4-1 Gating set used for the TCC cartridge.

GATE	TYPE	DESCRIPTION
TCC	Polygon	A polygon defined on the FL1-FL2 plane. Points inside this polygon are counted as cells (TCC).
HNA limit	Vertical line	A threshold on FL1. Points within TCC but larger than the HNA limit in FL1 are counted as HNAC. Points within TCC but smaller than the limit are counted as LNAC.

Table 4-2 Result parameters obtained from the TCC cartridge.

PARAMETER	UNIT	NAME	DESCRIPTION
TCC	1/mL	Total Cell Count	Total number of cells detected inside the TCC gate. It is an addition of HNAC and LNAC: $\mathrm{TCC} = \mathrm{HNAC} + \mathrm{LNAC}$
HNAP	%	High Nucleic Acid Percentage	The percentage of HNA cells relative to TCC: $\mathrm{HNAP} = \frac{\mathrm{HNAC}}{\mathrm{TCC}} \times 100$
LNAC	1/mL	Low Nucleic Acid Count	The number of cells inside the TCC gate, but below the HNA/LNA boundary (vertical line gate).
HNAC	1/mL	High Nucleic Acid Count	The number of cells inside the TCC gate and above the HNA/LNA boundary (vertical line gate).

For further information on how to adjust the gates see section 4.4.

4.3.2 ICC cartridge

ICC refers to *Intact Cell Count*. The ICC cartridge is therefore used to measure the concentration of intact cells.

Table 4-3 Gating set used for the ICC cartridge.

GATE	TYPE	DESCRIPTION
ICC	Polygon	A polygon defined on the FL1-FL2 plane. Points inside this polygon are counted as intact cells (ICC).
HNA limit	Vertical line	A threshold on FL1. Points within ICC but larger than the HNA limit in FL1 are counted as HNAC. Points within ICC but smaller than the limit are counted as LNAC.

Table 4-4 Result parameters obtained from the ICC cartridge.

PARAMETER	UNIT	NAME	DESCRIPTION
ICC	1/mL	Intact Cell Count	Total number of intact cells inside the ICC gate: $\mathrm{ICC} = \mathrm{HNAC} + \mathrm{LNAC}$
HNAP	%	High Nucleic Acid Percentage	The percentage of HNA cells relative to ICC: $\mathrm{HNAP} = \frac{\mathrm{HNAC}}{\mathrm{ICC}} \times 100$
LNAC	1/mL	Low Nucleic Acid Count	The number of LNA cells inside the ICC gate, but below the HNA/LNA boundary (vertical line gate).
HNAC	1/mL	High Nucleic Acid Count	The number of HNA cells inside the ICC gate and above the HNA/LNA boundary (vertical line gate).

For further information on how to adjust the gates see section 4.4.

4.3.3 ICC+ cartridge

The ICC+ cartridge is similar to the ICC cartridge, but allows the user to use one additional polygon gate.

Table 4-5 Gating set used for the ICC+ cartridge.

GATE	TYPE	DESCRIPTION
ICC	Polygon	A polygon defined on the FL1-FL2 plane. Points inside this polygon are counted as intact cells (ICC).
Gate+	Polygon	A user-defined polygon on the FL1-FL2 plane.
HNA limit	Vertical line	A threshold on FL1. Points within ICC but larger than the HNA limit in FL1 are counted as HNAC. Points within ICC but smaller than the limit are counted as LNAC.

Table 4-6 Result parameters obtained from the ICC+ cartridge.

PARAMETER	UNIT	NAME	DESCRIPTION
ICC	1/mL	Intact Cell Count	Total number of intact cells inside the ICC gate: $\mathrm{ICC} = \mathrm{HNAC} + \mathrm{LNAC}$
HNAP	%	High Nucleic Acid Percentage	The percentage of HNA cells relative to ICC: $\mathrm{HNAP} = \frac{\mathrm{HNAC}}{\mathrm{ICC}} \times 100$
LNAC	1/mL	Low Nucleic Acid Count	The number of LNA cells inside the ICC gate, but below the HNA/LNA boundary (vertical line gate).
HNAC	1/mL	High Nucleic Acid Count	The number of HNA cells inside the ICC gate and above the HNA/LNA boundary (vertical line gate).
Gate+	1/mL	Gate+	Concentration of cells, particles or other events inside of the user-defined Gate+ polygon.

For further information on how to adjust the gates see section 4.4.

4.4 Change gates

4.4.1 Regate measurements

Regating is the process of applying a different gating set to existing measurement data.

- A prerequisite for regating is the presence of such additional gating set. Find all available gating sets for your cartridge type when pressing **Gate settings** on the **Home menu** of the BactoSense user interface.
- The process of modifying an existing gating set is described in section 4.4.3.

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Depending on how the measurement was performed, press **Results (manual)** or **Results (auto)** to see the list of results.	
3.	To regate a **single measurement**, select the measurement to see the result details page. To regate **multiple measurements** (batch), long-press on the measurement, until it is highlighted and a check box appears on the left. Then tap on more measurement to also select them for regating.	
4.	Then press the **Re-gate** button.	
5.	Select the desired gating set by checking its box.	
6.	Press the **Confirm** button to start the regating process.	Depending on the number of measurements, regating can take several minutes.
7.	After finishing, press **OK**.	

4.4.2 Create a new gating set

New gating sets can be created either from a copy of an existing gating set, or from scratch.

Creating a new gating set from a copy

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Gate settings** button.	
3.	In the list of available gating sets, identify the gating set from which you want to make a copy to create the new gating set.	Make sure the gating type (e.g. TCC, ICC) matches with your target application.
4.	Press the **Copy icon** to create a copy of the gating set.	
5.	In the newly generated copy, press the **Edit icon** and follow the editing instructions in section 4.4.3.	

Creating a new gating set from scratch

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Gate settings** button.	
3.	In the action bar at the bottom, press **New**.	
4.	In the name field, type a name for the set of gates. In the type field, select for which cartridge type the set of gates will be used.	
5.	Then follow the gate configuration on-screen wizard as describe in the gate editing instructions in section 4.4.3.	
6.	After finishing, you can select the new gating set when creating new measurements, or regate existing measurements, as described in section 4.4.1.	

4.4.3 Edit existing gating sets

Apart from default gating sets, all other gating sets can be modified. Gate editing can comprise renaming, changing the position of the vertical gate, and changing the number and position of the corners of the polygon gate.

In this section, the general process of editing a gating set is described. Section 4.4.4 describes a specific strategy to adjust gating sets for TCC and ICC measurements.

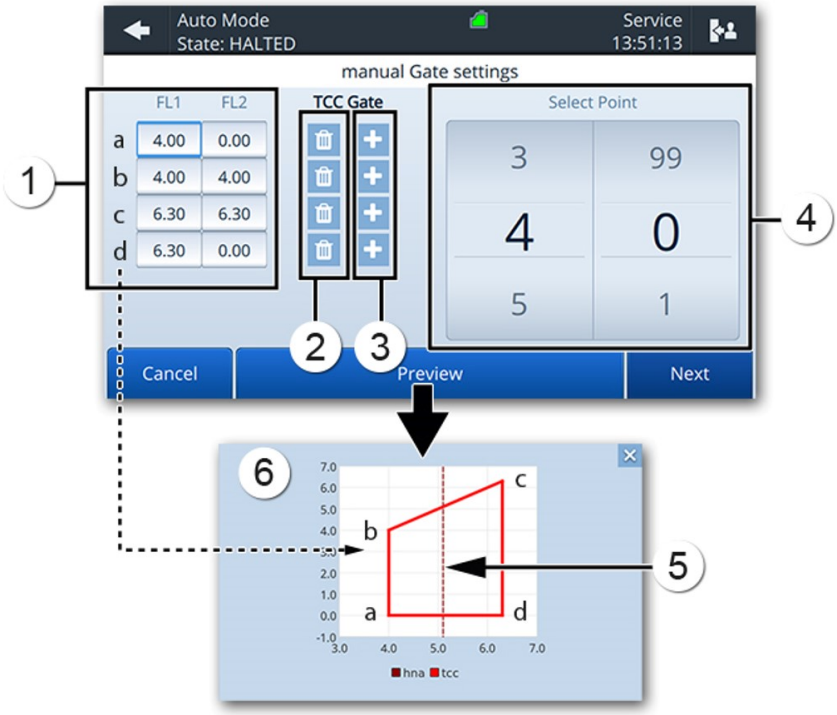
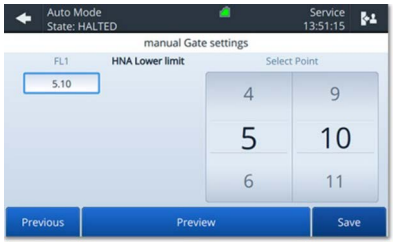


Figure 4-3 Gate settings for TCC

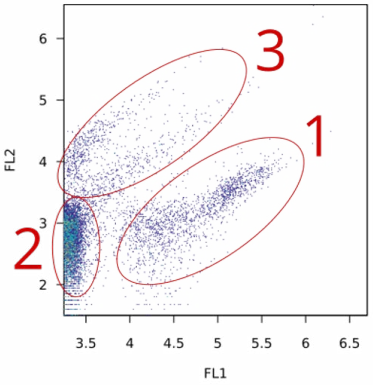
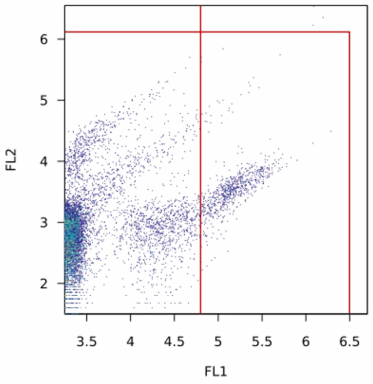
①	Coordinates of the gate's points. a: First point in the gate b: Second point in the gate c: Third point in the gate d: Fourth point in the gate	②	Remove a point from the gate.
③	Add a new point to the gate.	④	Modify the selected coordinate. In this screenshot, the FL1 (a, FL1) coordinate of the first point is selected, so we can move the first point in the gate along the FL1axis (x-axis).
⑤	HNA/LNA boundary: this gate is defined on the next screen.	⑥	Preview

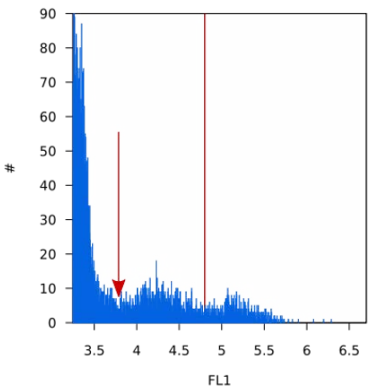
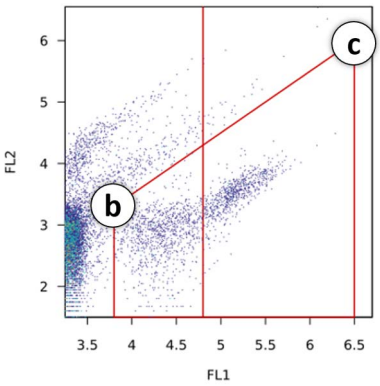
The following procedure describes how to adjust a gate:

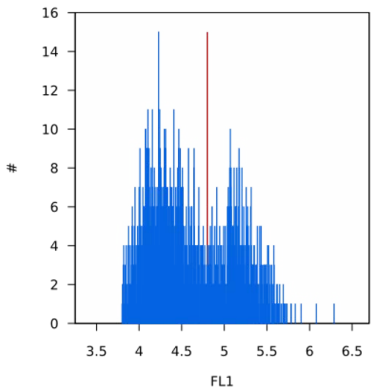
	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Gate settings** button.	
3.	Press the **Edit** button of the gate you wish to edit.	
4.	Change the name if desired, then press the **Next** button.	
5.	Adjust the number and position of polygon corners (for TCC and ICC refer to section 4.4.4). A polygon gate can have between 3 and 6 corners.	
6.	Press the **Next** button.	
7.	Enter the HNA lower limit (for TCC and ICC refer to section 4.4.4).	
8.	Press the **Save** button and confirm.	
9.	After finishing, you can select the modified gating set when creating new measurements, or regate existing measurements, as described in section 4.4.1.	

4.4.4 Strategy to adjust gates for TCC and ICC

The BactoSense is delivered with default gate sets that are suitable for the vast majority of samples. If needed however, advanced users have the possibility to adjust the gate.
A general procedure to adjust the gate is explained below and is valid for both TCC and ICC cartridges.

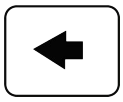
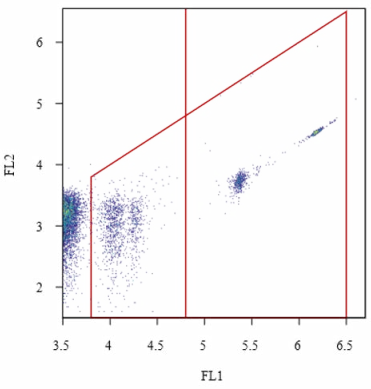
	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Measure a water sample using the standard **Water analysis** protocol. On the Result details page, the FL1 vs FL2 dotplot shows: 1) LNA and HNA cells in the water 2) Electrical noise from the optical detectors 3) Debris/background noise (This can include damaged cells, aggregates or other particles)	
2.	Navigate to the **Home menu** of the BactoSense user interface and press the **Gate settings** button.	
3.	Depending on your needs, perform one of the following: • Create a new set of gates • Edit an existing set of gates • Copy an existing set of gates and edit the copy	
4.	Give a name to this set of gates and press **Next**.	
5.	Place the polygon gate at each extremity (left and right). For example, use these four points: FL1 / FL2 3.0 / 0.0 3.0 / 6.1 6.5 / 6.1 6.5 / 0.0	
6.	Press **Next** and **Save**. Confirm that you wish to Save the new set of gates.	
7.	Navigate to the result view of the water sample you measured previously.	

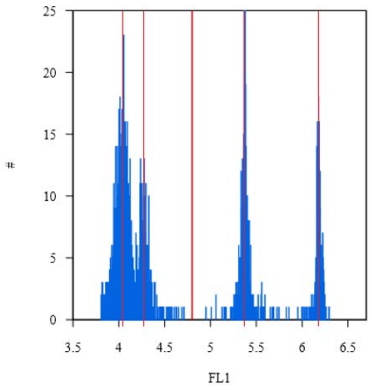
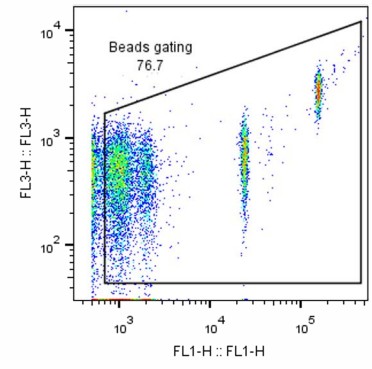
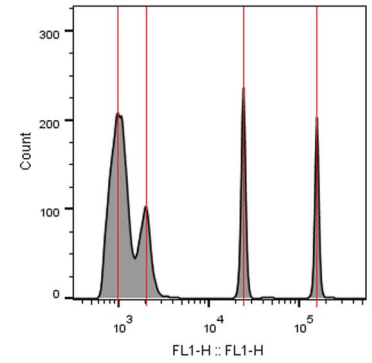
	WORK STEP	ADDITIONAL INFO / IMAGE
8.	On the result view, press the **Re-gate result** button.	
9.	Select the gate you just created, and re-process the data with the new gate by pressing the button **Confirm**.	
10.	Open the FL1 histogram and locate the first valley after the noise peak, i.e. the first minimum after the peak at the extreme left (arrow in the picture). Write down the FL1 value of this minimum (e.g. 3.8).	
11.	Return to **Gate settings** and again edit your gate. Place the left limits of the gate at the previously determined FL1 value. This will exclude the electrical noise of the optical detectors. If needed, for the FL2 axis, place the points “b” and “c” of the gate just below the debris/background area (generally appearing as straight diagonals).	
12.	Save the adjusted gate.	
13.	Navigate again to the result view of the water sample you measured previously.	
14.	On the result view, press the **Re-gate result** button.	
15.	Select the gate you just created, and re-process the data with the new gate by pressing the button **Confirm**.	

	WORK STEP	ADDITIONAL INFO / IMAGE
16.	To place the HNA/LNA limit, open again the FL1 histogram and locate the minimum between the LNA and HNA peaks (vertical line on the image). Write down its FL1 value (e.g. 4.8).	
17.	Return to **Gate settings** and again edit your gate.	
18.	Navigate to the HNA Lower limit configuration step. Enter the previously identified HNA/LNA limit to the FL1 field, press **Save** and confirm.	
19.	Regate the water analysis measurement again and verify that the gate is suitable. Further adjust if needed.	

4.5 Comparison with other flow cytometers

To compare results of the BactoSense to another flow cytometer, a reference solution containing auto fluorescent beads can be analyzed. This method allows the user to compare the measurement scales of different devices.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	It is recommended to use the Validation Kit which contains a ready to use beads solution.	Read the instructions of the **Validation Kit** for more information.
2.	Install the manual sampling device according to the instruction manual.	
3.	Take of one of the Validation kit's beads solutions and load it into the sampling device.	Read the instructions of the **Validation Kit** for more information.
4.	Press the **Home** button. Press the **Back** button as many times as needed for the **Home** button to appear.	 
5.	Select **Manual mode** and confirm with **Start**.	
6.	Choose the **Prime** protocol from the list.	See instruction manual, section 7.7.3.
7.	Press the **Next** and **Start** button. Let the priming protocol finish.	
8.	Choose the **Beads Analysis** protocol from the list and run it.	
9.	Wait for the results and if necessary, precisely adjust the gate of the FL1 vs FL2 dot plot to count only the 4 populations of beads. It is important to ensure that noise, background, and debris are not counted into the gate.	See section 4.4.3 to adjust the gate. 

	WORK STEP	ADDITIONAL INFO / IMAGE
10.	On the FL1 vs counts histogram, estimate the log value of each peak's center on the FL1 axis. In this example, we obtain approximately (in log): 1st peak = 4.05 2nd peak = 4.3 3rd peak = 5.35 4th peak = 6.2	
11.	Measure the same beads with the other flow cytometer you want to compare and repeat the steps 10 and 11. In this example, we obtain approximately (in log): 1st peak = log(10^3) = 3 2nd peak = log(2*10^3) = 3.3 3rd peak = log(2.4*10^4) = 4.4 4th peak = log(1.6*10^5) = 5.2	 
12.	With the different values obtained for both devices, it is now possible to compare their scales and their measurement windows.	

5 Web user interface

5.1 General information

- The web interface allows users to browse and export results and other data from a remote computer, as well as monitor the state of the instrument (active process, cartridge level, alerts etc.)
- The BactoSense needs to be connected to the same network as the computer that accesses the web interface.
- The web interface can be loaded on any browser on desktop computers or mobile devices.
- Take care about data and network security with all usual measures (see instruction manual).

5.2 Connect to the web user interface

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	Connect the BactoSense via Ethernet to a safe network (e.g. LAN). Connect your device (e.g. computer or tablet) to the same network.	
2.	Navigate to the **Home menu** of the BactoSense user interface. Press the **System info** button.	 
3.	Retrieve the **IP address** of the BactoSense shown on the System info page.	
4.	On your device, open a web browser.	
5.	Enter the IP address of the BactoSense in the address bar and press Enter.	
6.	On the login page, use the same username and password as for the BactoSense and press **Login**.	

5.3 Start page in manual mode

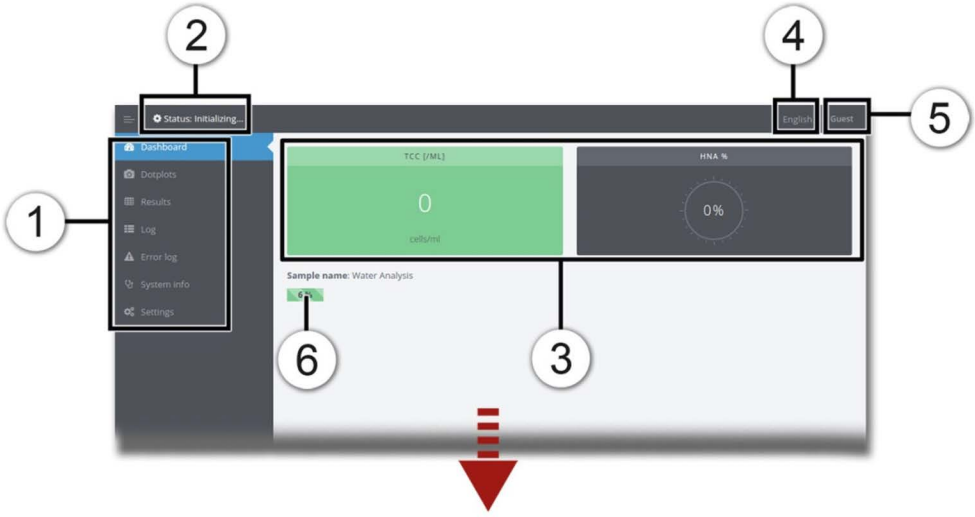
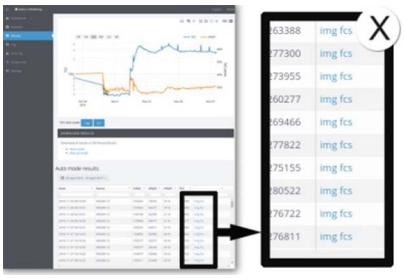


Figure 5-1 Start page on web user interface

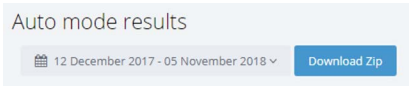
①	Menu	②	State of the instrument
③	Dashboard with latest results	④	Language: Drop-down menu for changing the language.
⑤	Logout from Web interface and reboot BactoSense options	⑥	Progress of the current measurement

5.4 Download an FCS-file

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	On the web interface, select the **Results** page on the navigation panel on the left.	
2.	Navigate to the result you wish to export.	
3.	Click on the **fcs** link (Position X).	
4.	Wait for the download to complete.	

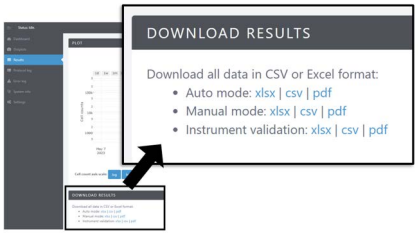
5.5 Download a zip file with multiple results

The results from multiple measurements can be downloaded as a zip file. This zip includes the FCS file and summary plots of each measurement.

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	On the web interface, select the **Results** page on the navigation panel on the left.	
2.	Find the results for the mode you are interested in: **Auto** or **Manual mode** results.	
3.	Select the date range you want and click **Download ZIP**. A progress bar will appear at the top of the browser until the zip starts downloading.	
4.	Wait for the download to complete.	

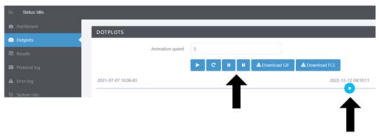
5.6 Download all results as CSV, XLSX or PDF

The list of all results can be downloaded from the web interface in either Excel XLSX, CSV or PDF format. The **Auto mode** results are separated from **Manual mode** results.

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	On the web interface, select the **Results** page on the navigation panel on the left.	
2.	Find the **DOWNLOAD RESULTS** section, just below the top PLOT section.	
3.	Click on the desired file (xlsx, csv or PDF) to start the download.	
4.	Wait for the download to complete.	

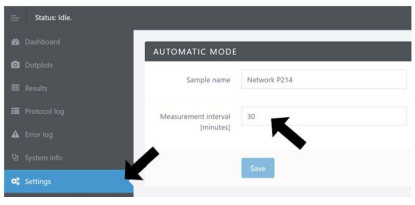
5.7 Animate the evolution of dot plots

The web interface can animate dot plots from the **Auto mode**, to help visualize the progression of the measurements. This feature shows static images in rapid succession; therefore the animation can only be exported using screen recording software.

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	On the web interface, select the **Dotplots** page on the navigation panel on the left.	
2.	Use the previous and next arrows or the slider to centre the slider on the desired date range.	
3.	Press the Play button to start the animation.	
4.	Adjust the animation speed if needed using the animation speed field.	
5.	The animation can be downloaded as GIF file when pressing the *Download GIF* button.	

5.8 Change the measurement interval

If the instrument is in **Auto mode**, the measurement interval can be changed from the web interface.

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	On the web interface, select the **Settings** page on the navigation panel on the left.	
2.	Change the duration of the measurement interval.	
3.	Click **Save** to confirm.	

5.9 Take screenshots of the GUI

Take screenshots of the BactoSense GUI from the web interface:

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	On the web interface, select the **System info** page on the navigation panel on the left.	
2.	Press the **Get screenshot** button at the bottom of the page.	
3.	The screenshot is displayed below.	

5.10 Reboot from web user interface

The BactoSense can be rebooted from the web interface according to the following procedure.

The instrument cannot switch on remotely.

	WORK STEP	ADDITIONAL INFO / IMAGES
1.	In the top right corner of the web interface, click on the username to show the dropdown list of options.	
2.	Select **Reboot** and confirm the confirmation request.	
3.	The instrument reboots and a new login is required.	

6 Data access and export

6.1 Export data to USB device

To export measurement data, refer to the instruction manual, section 7.6.1.

6.1.1 Export settings, diagnostics, or all to USB device

The "Special import/export" function allows users to export either all measurement data from the instrument, or to export only diagnostics data which can be interpreted by service technicians.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Navigate to the **Home menu** of the BactoSense user interface.	
2.	Press the **Maintenance** button and then the **Special export import** button.	
3.	Connect a USB mass storage device. The USB flash drive should be formatted in FAT32. If needed, press the **Refresh USB list** button until the device is displayed.	
4.	The name of the folder which will be created on the USB device is displayed in the Folder name field. Enter a new folder name if desired.	
5.	• To export all data, press the **Export all** button. • To export diagnostics data, press the **Export diagnostics** button. • To export settings, press the **Export diagnostics** button. Do not remove the USB mass storage device during the data transfer.	Exporting all data can take several hours. If the available storage capacity of the USB mass storage device is too small, a notification will be shown.
6.	After completion of the export, press the **OK** button and remove the USB device.	

6.2 Retrieve data via FTP

BactoSense data can be remotely accessed using the FTP protocol (RFC 3659).

- FTP authentication uses the username/password pairs used in the GUI of the instrument. Default account names are: basic, advanced, and admin.
- The CSV and Excel files are generated on-the-fly, and thus always contain the latest measurement data.

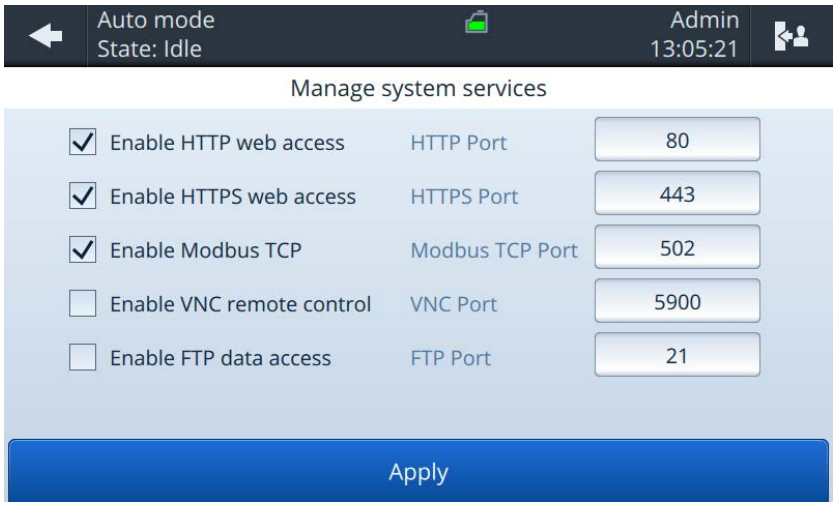


Figure 6-1 The Manage services view of the BactoSense user interface.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	• Install an FTP client on the device you want to use to retrieve data, e.g. your laptop. • Alternatively, the Windows file explorer can be used.	
2.	Connect the BactoSense via Ethernet to a safe network (e.g. LAN). Connect your device to the same network.	For information about network configurations (i.e. static and dynamic IP settings), refer to section 2.8.
3.	Navigate to the **Home menu** of the BactoSense user interface.	
4.	Press the **System settings** button.	
5.	Press the **System services** button.	
6.	Make sure the **Enable FTP data access** check box is checked.	
7.	Choose a port for the FTP server.	The default port is port 21.

	WORK STEP	ADDITIONAL INFO / IMAGE
8.	Press the **Apply** button to reboot the BactoSense.	Only needed in case you changed the configuration.
9.	Retrieve the IP address of the BactoSense by navigating to the **Home menu** of the BactoSense user interface, and pressing the **System info** button.	For information about network configurations (i.e. static and dynamic IP settings), refer to section 2.8.
10.	For FTP client: Open the client and enter the login details. For the Windows file explorer: Enter the following address in the address bar: ftp://user:password@ip:port	• User/username: Username to log in to the BactoSense • Password: Password to log in to the BactoSense • Host/ip: IP address of the BactoSense • Port: Port configured in System services view (see figure 6-1)

6.3 Retrieve files via HTTP or HTTPS

The HTTP and HTTPS servers are enabled by default and available through a web browser or any HTTP request library. Use the following procedure to retrieve specific files via HTTP or HTTPS. As an alternative, consider the web interface (chapter 5) or FTP (section 6.2).

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Connect the BactoSense via Ethernet to a safe network (e.g. LAN). Connect your device to the same network.	For information about network configurations (i.e. static and dynamic IP settings), refer to section 2.8.
2.	Navigate to the **Home menu** of the BactoSense user interface.	
3.	Press the **System settings** button.	
4.	Press the **System services** button.	
5.	For HTTP: Make sure the **Enable HTTP data access** check box is checked. For HTTPS: Make sure the **Enable HTTPS data access** check box is checked.	
6.	Choose a port for the HTTP or HTTPS server.	The default port for HTTP is 80. The default port for HTTPS is 443.

	WORK STEP	ADDITIONAL INFO / IMAGE
7.	Press the **Apply** button to reboot the BactoSense.	Only needed in case you changed the configuration.
8.	Retrieve the IP address of the BactoSense by navigating to the **Home menu** of the BactoSense user interface, and pressing the **System info** button.	
9.	Open a web browser on your device and enter the target file address into the address field. The file address has the following form: For HTTP: *http://ipaddress:port/export/filename.extension?hash=myhash* Example: *http://192.168.1.2/export/history_auto.xlsx?hash=QWRtaW46MTExMQ* For HTTPS: https://ipaddress:port/export/filename.extension?hash=myhash Example: *https://192.168.1.2/export/history_auto.xlsx?hash=QWRtaW46MTExMQ*	

Name	Description
ipaddress	Local IP address of the instrument
port	Port of the HTTP or HTTPS server (by default 80 and 443, respectively)
filename	Name of the target file. Example: history_auto
extension	File extension (csv, xlsx,pdf)
myhash	Security key containing user identification. The key is unique to any user-password combination. It is possible to find the key in the web interface (chapter 5) by copying the link shown when downloading a file. For example: *hash=QWRtaW46MTExMQ*

6.4 GUI relay using VNC

Virtual Network Computing (VNC) is a graphical desktop-sharing system to remotely control another computer. It transmits the keyboard and mouse input from one computer to another, relaying the graphical-screen updates, over a network.
The embedded VNC server in the BactoSense is capable of sharing the user interface over the local area network (LAN) only (exception: remote access using a VPN).

CAUTION!

VNC is an insecure protocol and is not recommended outside of a local network or with a VPN connection.

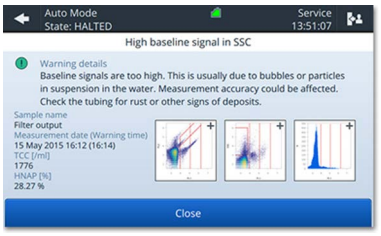
A VNC connection can slow down the user interface since it is very taxing in terms of processing power. Be sure to close your VNC connection after use.

	WORK STEP	ADDITIONAL INFO / IMAGE
1.	Install a VNC client on your computer.	
2.	Connect the BactoSense via Ethernet to a safe network (LAN). Connect your computer to the same network.	For information about network configurations (i.e. static and dynamic IP settings), refer to section 2.8.
3.	Navigate to the **Home menu** of the BactoSense user interface.	
4.	Press the **System settings** button.	
5.	Press the **System services** button.	
6.	Make sure the **Enable VNC remote control** check box is checked.	
7.	Choose a port for the VNC server.	The default port is port 5900.
8.	Press the **Apply** button to reboot the BactoSense.	Only needed in case you changed the configuration.
9.	Retrieve the IP address of the BactoSense by navigating to the **Home menu** of the BactoSense user interface, and pressing the **System info** button.	
10.	Open the VNC client on your computer and connect to the BactoSense using the IP address and port identified previously.	Your VNC client may allow you to change connection settings to optimize the speed of the connection if needed.
11.	Disable the VNC connection in the BactoSense System services page after finishing.	The VNC connection can slow down the user interface on the BactoSense.

7 Error messages and troubleshooting

7.1 Warnings

Warnings appear when unusual behavior is detected during an otherwise successful measurement. They can indicate reduced accuracy of the measurement results or indicate impending errors. Unlike errors, warnings do not prevent the instrument from functioning, but users should pay attention to them as they can indicate sources of inaccuracies.

WARNING	
When unusual behavior is detected, a warning is shown next to the measurement results. More information on the warning can be found by clicking on the corresponding warning entry next to the measurement results or directly in the warning log.	

The following warning messages can be displayed:

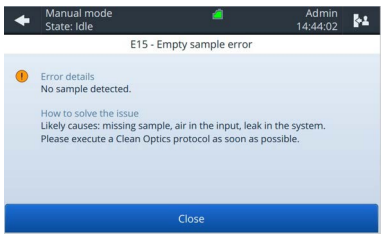
Table 7-1 Warnings

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
W01	Cartridge expired	Cartridge reagents have expired. Measurement accuracy could be affected.	• Please replace the cartridge as soon as possible.
W02-04	High baseline signal in FL1 / FL2 / SSC	Baseline signals are too high. This is usually due to bubbles or particles in suspension in the sample. Measurement accuracy could be affected.	• Check the inlet tubing for any signs of deposits. • Check the water connections, be sure that they are all tight (no air entry). • If the warning persists, please perform cleaning of instrument with the cleaning kit.
W05	Incubator temperature off target	Temperature during incubation was more than 2 °C off target. Cell counts may be affected. The incubator may be defective.	• If the problem persists, please contact customer service.
W07	TCC out of range	TCC is above the specification limit of BactoSense of 2’000’000 cells/ml.	• Please dilute the sample to ensure accuracy of the measurement.

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
W08	Air bubbles detected	The sample appears to contain air bubbles.	• Check sampling device is installed properly. • Check the sample for bubbles. • If using online sampling device, check water is supplied at correct pressure.
W10	Enclosure too cold	Enclosure is too cold, rapid heating has been activated before continuing protocol.	• Instrument cannot safely operate if internal temperature is too cold. • Rapid heating attempts to heat the enclosure to ensure safe operations. • Measurements will start once internal temperature is sufficient.
W11	Service required	Service of the instrument is required. Measurement precision can no longer be guaranteed. **Continued operation can lead to leaks, which can damage the instrument.**	• Next service date is overdue. • Valve and plunger have reached end of life. • Please contact your service representative.
W13	Laser end of life	Laser has reached end of life.	• Please contact your service representative.

7.2 Non-critical errors

Non-critical errors prevent a measurement from terminating successfully, but do not prevent the instrument from running another measurement afterwards. These errors do not require human intervention. Some non-critical errors are promoted to critical errors if they repeat three times.

NON-CRITICAL ERRORS	
The protocol stops. The cause of the error is usually fixed by repeating the analysis or waiting. • Another measurement can immediately be started. If it completes successfully, the error state is cleared. • More information on the error can be found in the error log, by clicking on the corresponding error entry.	

The following non-critical error messages can be displayed:

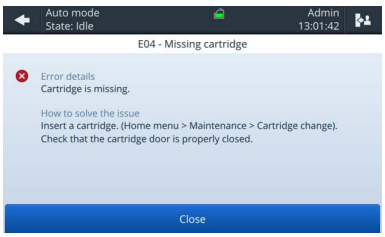
Table 7-2 List of non-critical errors.

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
E01	Cartridge door open	Cartridge door is open and prevents measurements from running.	• Close door and retry the measurement.
E08	Enclosure too damp	Enclosure humidity is too high for safe operation.	• Replace desiccant bag, by unscrewing the large cap on the left-hand-side of the instrument (see instruction manual, section 8.2.5). • If the problem persists, please contact customer service.
E09	System overheated	Inside temperature is too high for safe operation.	• Reduce ambient temperature or increase measurement interval to allow instrument to cool down.
E14	Laser too hot	Laser temperature is too high for safe operation.	• Reduce ambient temperature or increase measurement interval to allow instrument to cool down.
E15	Mixer inflation error	Underpressure detected during mix or dispense.	• Missing sample. • Air in the input. • Leak in the system. • Please execute the Clean Optics protocol (see instruction manual, section 7.7.1).
E18	Pump underpressure error	Underpressure detected during dispense.	• Missing sample. • Air in the input. • Leak in the system. • Please execute the Clean Optics protocol (see instruction manual, section 7.7.1).

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
E19	System overheated	The inner temperature is too high for operation.	• Reduce ambient temperature, or increase measurement interval to allow instrument to cool down.
E33	Processing memory overflow	Signal processing circuits memory has overflown.	• Please execute the Clean Optics protocol (see instruction manual, section 7.7.1). • Retry the measurement.
E42	Enclosure too cold despite heating	Enclosure temperature remains too cold after heating procedure.	• Ambient temperature is less than 5 °C. • Increase ambient temperature.
E44	Pump module startup error	The pump module failed to power on correctly.	• Simply retry the measurement.
E45	Low valid volume ratio error	The valid volume ratio is too low. This can be caused by a too elevated bacterial content in the water or turbidity/debris.	• The accuracy of the measurement is probably very low. Repeat the measurement while diluting the sample with clear water.
E46	Cartridge is still busy	The cartridge was still initializing when the measurement started.	• Non-critical error. Repeat the measurement. If the problem persists, contact a service technician.
E48	Microfluidic subsystem busy	The microfluidic controller is performing another task while the measurement was taken.	• Non-critical error. Repeat the measurement. If the problem persists, contact a service technician.
E49	GPIO Timeout error	The processing board is waiting for another module to respond.	• Non-critical error. Repeat the measurement. If the problem persists, contact a service technician.

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
E50	Pump motion blocked	The motion of the pump is blocked.	• Non-critical error. Repeat the measurement. If the problem persists, contact a service technician.
E51	Unable to get temperature reading	Unable to get temperature reading. The control loop is thus disabled.	• Non-critical error. Repeat the measurement. If the problem persists, contact a service technician.
E52	Cartridge valve motion blocked	The motion of the cartridge valve is blocked.	• Non-critical error. Repeat the measurement. If the problem persists, contact a service technician.

7.3 Critical errors

CRITICAL ERRORS	
If a **critical error** occurs during operation, it has the following effects: • The protocol immediately stops. • The instrument goes into critical error state, and manual intervention is needed before any new protocol can be launched. • The cause of the error must be solved by an operator, then the errors can be manually cleared from the **Error Log.**	

The following critical error messages can be displayed:

Table 7-3 List of critical errors.

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
E00	General error	Unhandled error.	• Please contact customer service
E02	Cartridge empty	Cartridge is empty.	• Replace cartridge (see instruction manual, section 6.5.4)
E04	Cartridge missing	Cartridge is missing.	• Insert a cartridge (see instruction manual, section 6.5.6)
E05	Full waste bag	Cartridge waste bag is full.	• Replace cartridge (see instruction manual, section 6.5.4)
E06	Cartridge communication impossible	Cartridge is disconnected, door is open, or cartridge electronics are damaged.	• Make sure the cartridge's electronic cable is connected properly, and that the door is properly closed. • If that doesn't help, replace the cartridge and inform customer service.

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
E07	Storage disk full	Insufficient storage space to continue operation.	• Delete old measurements and try again (see instruction manual, section 8.2.7) • This will delete the measurements permanently from the device. • Export measurements as backup solution.
E12	FPGA initialization error	Failed to initialize the signal processing chip.	• Reboot the instrument.
E16	Processing error	An error was discovered while processing the signals.	• The accuracy of the latest result is not guaranteed. Please repeat the analysis.
E17	Overpressure detected	Overpressure detected during dispense.	• Likely cause: The output filter is probably clogged. • Optical flow cell blocked. • Please call customer service.
E20	Abnormal shutdown	Protocol interrupted for unknown reasons, usually due to a power cut.	• Usually indicates a power cut, or other external interruption to the measurement. • Perform a Clean Optics and Clean Sampling Device protocol before starting a new measurement (see instruction manual, section 7.7.1).
E23	Temperature Sensor Communication Error	Communication with temperature sensor on IO board failed.	• Service required.
E24	Laser Communication Error	Communication with optical unit failed.	• Service required.
E25	Pump Communication Error	Communication with pump module impossible.	• Service required.

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
E26	Power Supply Communication Error	Communication with power supply module impossible.	• Service required.
E27	Pump Communication timeout	Communication with pump module timed out.	• The cartridge door is open. • A cable is disconnected. • A circuit board is damaged, either in the pump or cartridge.
E28	Empty dye supply	Dye tube connected to cartridge is empty.	• The tube is disconnected. • Cartridge is defective. • Repeat the cartridge change procedure, making sure that all tubes are properly connected.
E29	Empty rinse fluid supply	Rinse fluid tube connected to cartridge is empty.	• The tube is disconnected. • Cartridge is defective. • Repeat the cartridge change procedure, making sure that all tubes are properly connected.
E30	Empty bleach supply	Bleach tube connected to cartridge is empty	• The tube is disconnected. • Cartridge is defective. • Repeat the cartridge change procedure, making sure that all tubes are properly connected.
E31	Cartridge electronics failure	Cartridge level can no longer be determined accurately.	• Replace cartridge and contact customer service.
E32	Incompatible cartridge	Cartridge type is incompatible with this instrument or software.	• Make sure that you have the correct cartridge type for this instrument.

ERROR CODE	NAME	DESCRIPTION	CAUSES / WHAT TO DO
E33	Processing memory overflow	Signal processing circuits memory has overflowed.	• Please execute the Clean Optics protocol (see instruction manual, section 7.7.1). • Retry the measurement.
E38	Cartridge not ready error	The new cartridge has not been initialized correctly	• Execute the "Cartridge Change" procedure (see instruction manual, section 6.5.4).
E39	Laser current limit reached	The laser has reached its upper current limit; indicating end of life.	• The laser needs to be replaced. Contact a service technician.
E40	Set of gates not found	Reference to the set of gates selected for the measurement cannot be found in the instrument settings.	• The set of gates has been deleted. • Change the set of gates and retry the measurement.
E41	Set of gates incompatible	The set of gates selected for the measurement cannot be used with this cartridge.	• Correct cartridge change procedure was not followed. • Incorrect digital input configuration. • Change the set of gates and retry the measurement.
E43	External temperature too low	Ambient temperature is outside of the instrument specifications.	• Increase ambient temperature. • Trying to operate or store the instrument below 5 °C can cause damage to the device.
E47	Unable to find main reference magnet during homing	During initialization, the valve did not home properly.	• Service required.
E53	Unable to communicate with motor	The communication to the motor controller of the mixer is defective.	• Service required.

7.4 Low temperature operation and standby heating

The instrument needs to operate in a controlled temperature range to ensure reliable and reproducible measurement results. At very low and very high ambient temperatures (below 5 °C or above 30 °C), protocols are forbidden from running. At temperatures between 5 °C and 20 °C, the instrument regulates the enclosure temperature in two ways:

Standby heating is activated between protocols to maintain a sufficiently enclosure temperature. It is automatically powered off after 12 hours. In the top bar a snowflake icon appears when the standby heating is on.

Rapid heating is activated at the beginning of a protocol. Once the internal temperature is warm enough, the protocol is allowed to execute. The instrument status switches to "Heating..." during this phase and a warning is attached to the measurement (table 7-1, W10). If after several hours the instrument cannot heat itself enough to ensure an accurate measurement, the protocol exits with an error (table 7-2, E42).

Measurements are delayed by rapid heating.
To avoid this, keep the instrument temperature above 10 °C.

8 Table of acronyms

Table 8-1 Acronyms

ACRONYM	DESCRIPTION
FCS	Flow Cytometry Standard (FCS) is a data file standard for the reading and writing of data from flow cytometry experiments. The FCS specification has traditionally been developed and maintained by the International Society for Advancement of Cytometry (ISAC). FCS used to be the only widely adopted file format in flow cytometry.
FL1	Fluorescence Signal 1 (535 nm).
FL2	Fluorescence Signal 2 (715 nm).
GUI	Graphical User Interface.
HNA	High Nucleic Acid = Bacteria with a large amount of DNA which produce a strong fluorescence emission. They are generally regarded as the active part of a microbial community.
HNAC	High Nucleic Acid Count. The number of HNA bacteria inside the TCC or ICC gate, and above the HNA / LNA limit.
HNAP	High Nucleic Acid Percentage = The percentage of HNA bacteria relative to the cell count (HNAC / TCC for TCC cartridge, HNAC / ICC for ICC cartridge)
ICC	Intact Cell Count = Total number of intact bacteria inside of the ICC gate.
LNA	Low Nucleic Acid = Bacteria with a smaller amount of DNA which produce a weaker fluorescence emission than HNA bacteria.
LNAC	Low Nucleic Acid Count. The number of LNA bacteria inside the TCC or ICC gate below the HNA / LNA limit.
SSC	Side scatter signal. Scattered light increases with the internal complexity (granularity) of the detected object.
TCC	Total Cell Count = Total number of bacteria detected inside the TCC gate.

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