Servicemanual

1.0 Release

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1. INTRODUCTION

Although ***Hemolyzer 3*** is a member of Analyticon's *Hemolyzer family,* it has special and different characteristics compared to other *junior family* members. We issue a dedicated Service Manual for this instrument; information herein applies for ***Hemolyzer 3***.

To be well up in the instruments, **please read this manual carefully** to have the knowledge for servicing the instruments perfectly and avoid extra costs and wasting precious time.

This **Hemolyzer 3 Service Manual** contains the functional descriptions of the analyzer, operation of the fluidic systems, adjustments and settings, and very important information for the Service Personnel about the service operations and possible problems.

1.1. Name and serial number

Name: **Hemolyzer 3** Hematology Analyzer
Serial No.: Every instrument has its own serial number, which is printed on the rear panel label and it can be read out from Device Information or from the self test submenu. This identity number is write-protected by Analyticon.

1.2. Intended use

Hemolyzer 3 hematology analyzer is a fully automated cell counter for *in vitro* diagnostic use. The compact instrument was developed for small clinics, point-of-cares and vet offices.

Hemolyzer 3 can process 60 samples per hour and is intended to determine the following 18 hematology parameters from a 25µl whole blood sample:

- WBC - LYM# - MID# - GRA# - LYM% - MID% - GRA% (three-part WBC differential)
- HGB - RBC - HCT - MCV - RDW - MCH - MCHC
- PLT - MPV - PCT – PDW

1.3. Integrated software

The integrated software controls the instrument operations, displays, stores, recalls data, and allows the user to perform QC and calibration procedures and modify the user settings. The software version number can be read out from the Device Information or from the Self test submenu.

Software is absolutely *"Plug and Play"*, it can read out and detect the type and the serial number of the instrument, therefore it will run the correct program for the hardware, without any user or service help. Every **Hemolyzer 3** software version is upgradeable (using an USB drive) by the latest program developed by Analyticon, and it can be downloaded from:

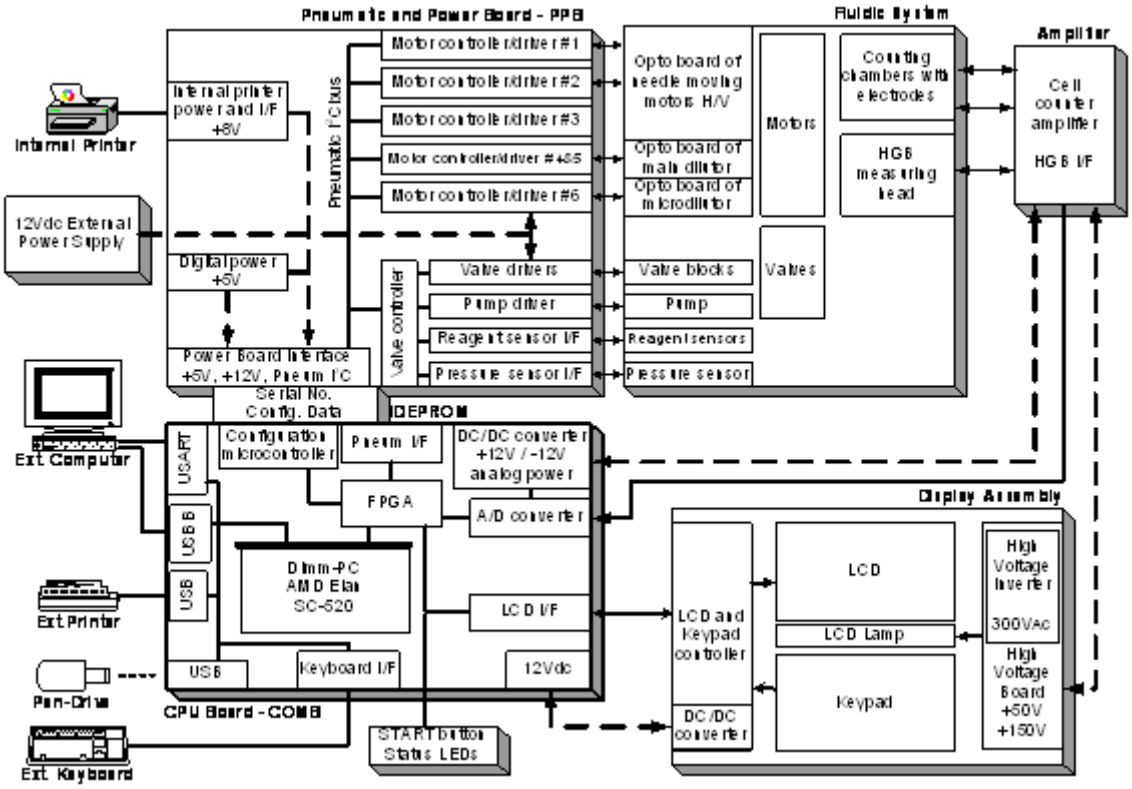
http://www.analyticon-diagnostics.com/

2. FUNCTIONAL DESCRIPTION

2.1. Main electronic parts of the analyzer

Hemolyzer 3 contains the following electronic parts:

1. Counting chambers with electrodes and measuring apertures
2. HGB Measuring Head
3. Cell Counter Amplifier Board (behind the chambers)
4. CPU Board with DIMM-PC and measurement processing unit (COMB Board)
5. Pneumatic and Power Board (PPB) with motor controllers, valve & pneumatic controller, pump driver and power supply for internal printer (+8V) and digital circuitry (+5V)
6. Safe configuration E^2PROM board connecting CPU board and PPB
7. Motors with common opto-board of needle moving motors (H/V)
8. Main dilutor block with opto-board for diluent, lyse
9. Micro-dilutor block with opto-board for sampling
10. Valve boards (set of 5 and max. 7)
11. Peristaltic Pump
12. Pressure Sensor
13. Digital Reagent Sensor Board
14. Graphic LCD Display Module with High Voltage Board
15. LCD and Keyboard controller and Keyboard Panel
16. Internal Printer



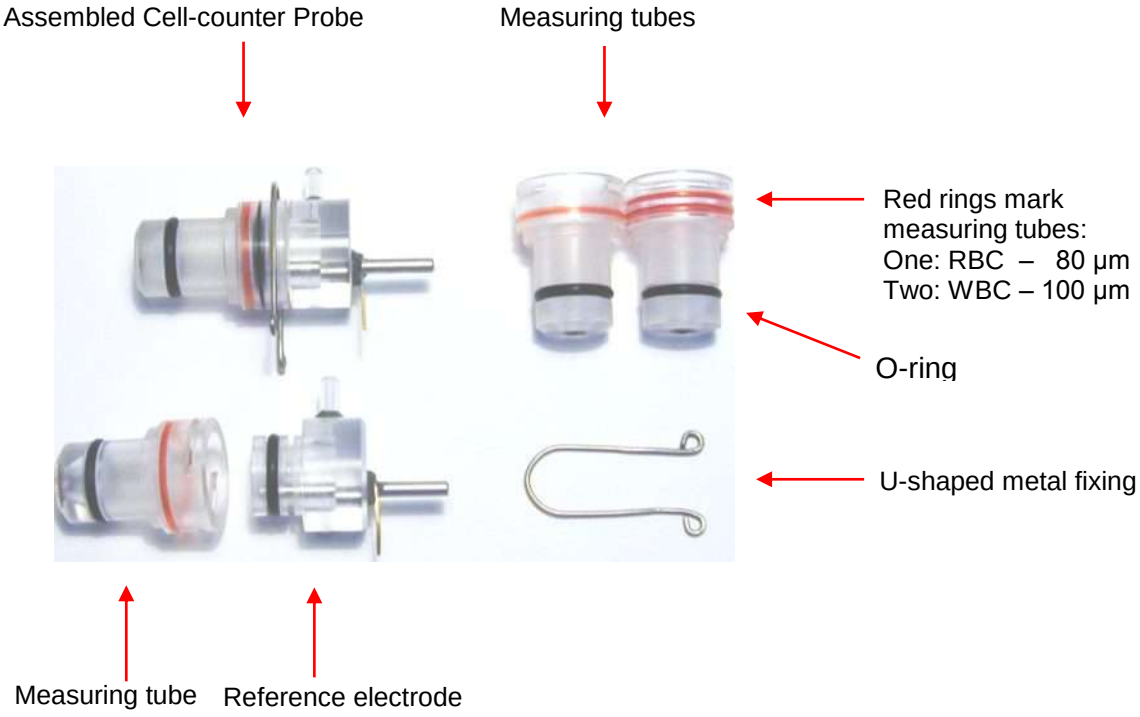
Hemolyzer 3 *Electronic Functional Block Diagram*

2.1.1. Counting chambers with electrodes and measuring apertures

Impedance method is used for determination of volume and number of cells. In this method a known volume of dilution is drawn through a small aperture. Constant current is passed through the aperture from one side to the other. When a cell passes through the aperture, it causes a change in resistance, which generates a voltage pulse.

The amplitude of the voltage pulse is proportional to the ratio of cell volume per aperture volume. This is used to determine the volume of cells. The number of cells can be obtained by counting the pulses.

In the instrument there are two Cellcounter Probes: WBC probe with 100 µm aperture, and RBC probe with 80 µm aperture. Both have a ground electrode assembly and U-shaped metal fixing as it is shown in the next figure.

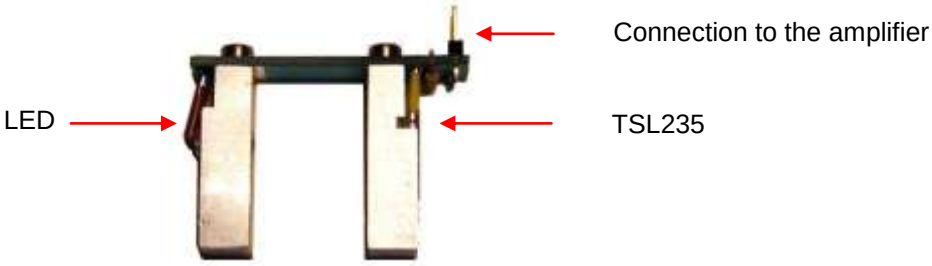


The aperture is made of ruby and it is moulded into the measuring tube.

2.1.2. HGB Head

Hemoglobin head is placed on the two sides of the WBC chamber.

It contains: light source (LED) at 540 nm wavelength and Photo Detector (TSL235). The Photo Detector converts the light to frequency. The HGB concentration is a logarithmic function of this frequency measured by the FPGA circuit of the COMB card.



The analyzer performs enhanced Hemoglobin measurement technology for HGB measurement. The output of HGB head is frequency (TSL235 detector is light to frequency converter). This signal is counted by a digital counter in the FPGA circuit/micro-controller.

This counter counts up while the LED is on and counts down while the LED is off, the LED and the counter directions are switched with a 100 Hz signal. This method provides “real time backlight correction”, which makes the HGB measurement more precise in changing backlight environment situation as well.

There are two kinds of HGB measurements:

- Sample measurement (before RBC counting)
- Diluent measurement (in WBC washing phase)

The HGB result is calculated from these measurements by:

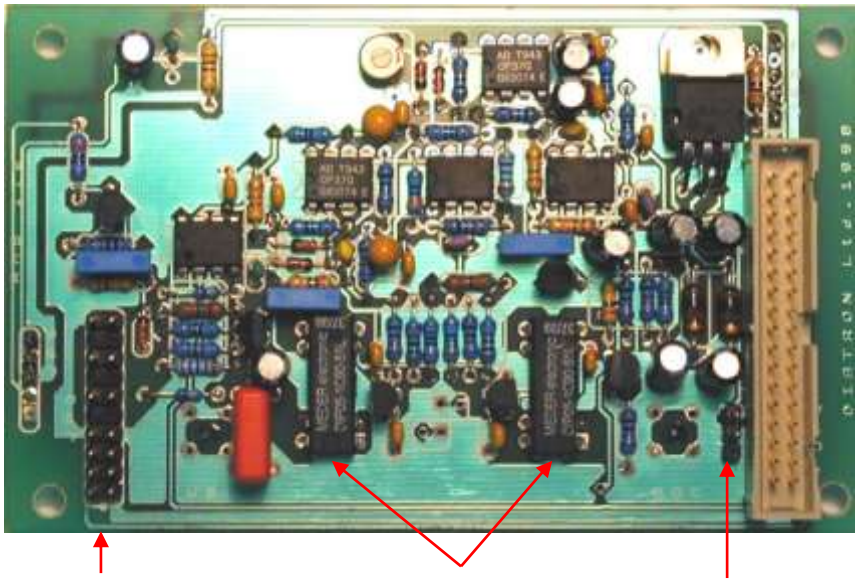
$$HGB \cong \log (CNT_{diluent\ light} / CNT_{sample\ light})$$

In spite of the fact that Hemolyzer 3 is less sensitive to incident light changes it is recommended to keep side door closed during measurements.

2.1.3. Cell counter Amplifier Board

Amplifier board includes its own voltage regulator, the connection interfaces to HGB head, to high voltage board and to COMB card. In this board there is the current generator circuit, which works from 50 V measuring voltage (generated by High Voltage Board) and the probe voltage (DC) is amplified with a voltage follower (output: ELV). Nominal measuring current is **870 µA**.

Amplifier board includes two input connectors for the chambers (measuring electrodes). There are two reed relays on the input side: IC10 can select between the two channels (RBC, WBC) with RSW signal; IC11 connects high voltage to the selected probe with HSW signal. Test circuit makes possible to generate test pulses (with TEST and PLS signals through FETs) for checking the proper operation of the amplifier channel.



Amplifier board includes a 3-stage main amplifier channel, which gains to the input signal to the 0...5 V range (this is the input range of the A/D converter, which is placed on the COMB card). There is an offset potentiometer, P1 in the third amplifier stage, manufacturer sets the correct offset voltage.

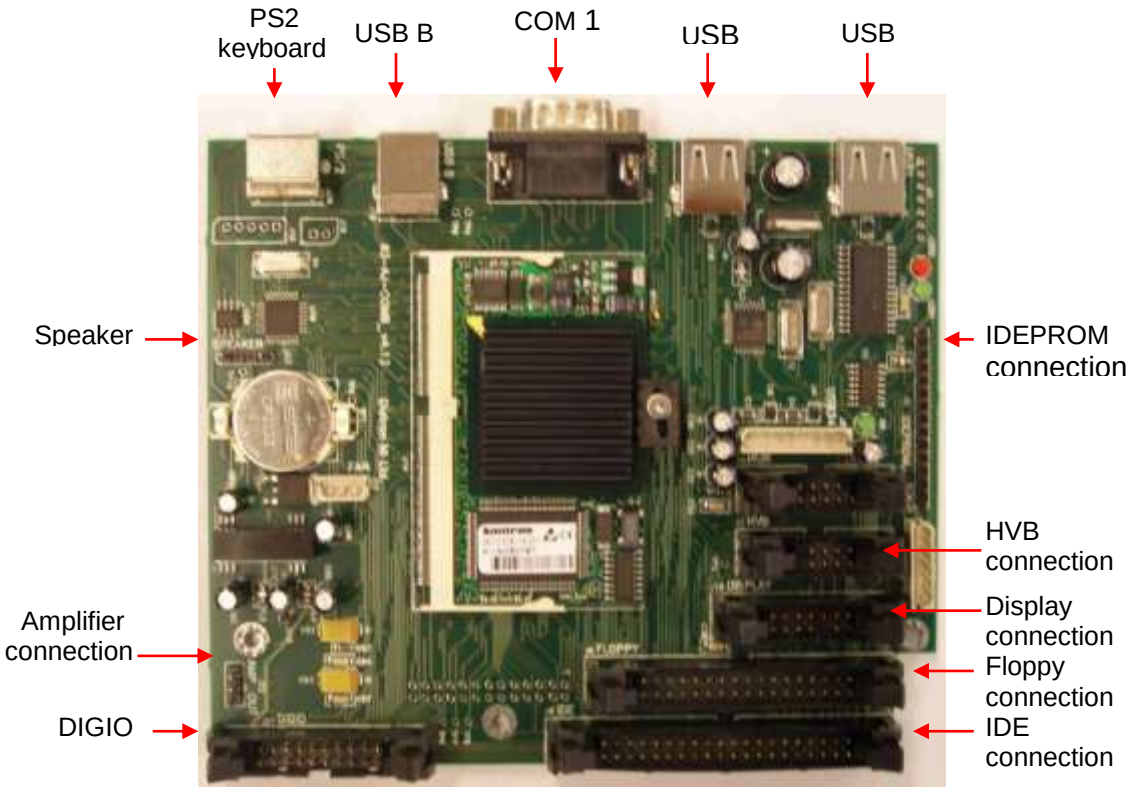
Adjust the offset voltage only in case it is out of the +/- 5mV range.

DHON signal (from the COMB card) switches on the LED in the HGB head via a transistor (Q3), but the Photo Detector in the HGB head is working continuously.

The other side of the amplifier board contains special connectors for the chambers and the HGB head.

2.1.4. Control and Measurement Board (COMB) with DIMM-PC core

The compact **COMB** incorporates a single PC and its environmental functions, as well as the specific measurement processing functions in one board.



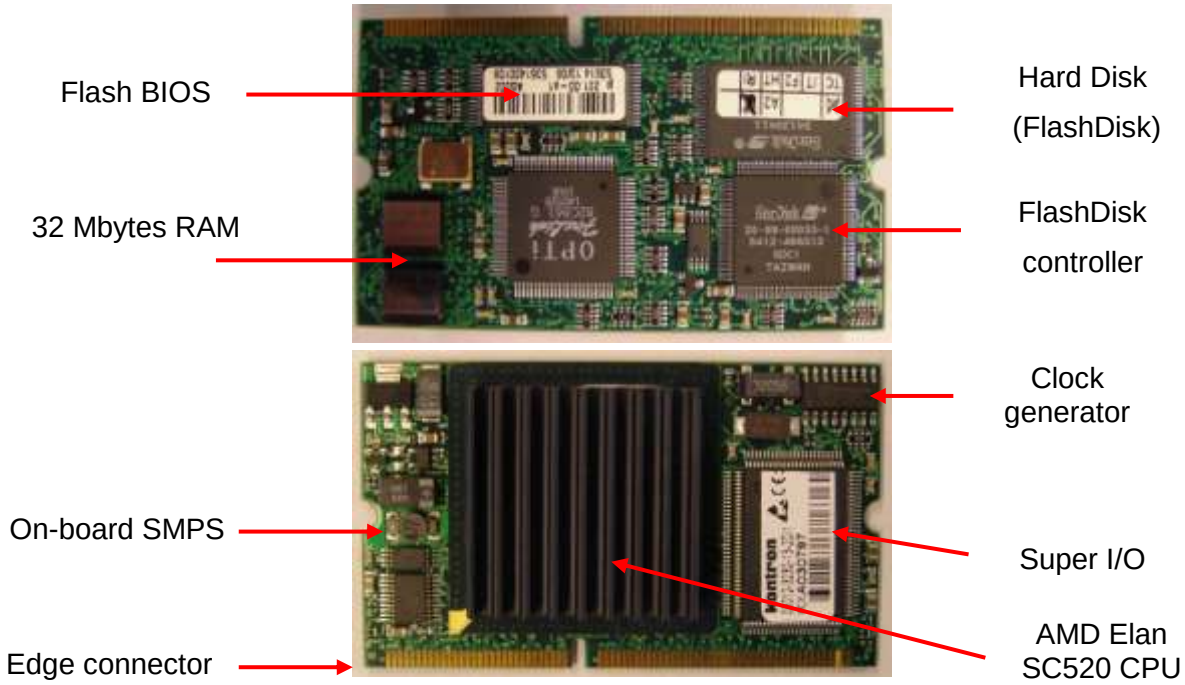
PC system of the COMB board is based on the DIMM-PC module, which is a credit card size PC with AMD Elan SC520 133 MHz micro-controller. DIMM-PC itself contains 16 or 32Mbyte RAM and same size of FlashDisk that acts like a hard disk. DIMM-PC module is easily replaceable as it has an open socket (it has also a screw for safe fixing). COMB card contains single ICs and some drivers/protection-circuits for the interfaces such as COM1, PS2, USB, IDE and Speaker.

Measurement processing is based on a FPGA circuit. After power on, the FPGA holds the DIMM-PC in wait state (with –IOCHRDY signal) until the PIC configures the FPGA circuit from the IDEPROM (status LED is red during configuration). After that the FPGA controls the entire pneumatic system through the Pneumatic I^2C bus, the Keyboard and Display module with video RAM for MDA (Monochrome Display Adapter) emulation, and Start button & status LED. FPGA circuit also performs measurement data acquisition by using the 10-bit A/D chip. FPGA makes digital data processing and stores the results in the internal FIFO memory. Cell parameters are sent to the DIMM-PC by single DMA cycles.

2.1.5. DIMM-PC* Module

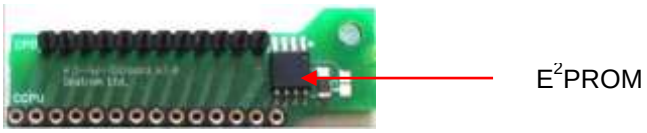
The MB4 board incorporates a credit-card sized PC, named **DIMM-PC***. The processor on the DIMM-PC is a 133MHz Pentium-class core, with 32Mbytes on-board RAM, and 32Mbytes on-board FlashDisk. This is the HDD (hard disk drive) of the analyzer, so instrument software with all user settings, calibration, database, etc. is stored on the DIMM-PC.

- *DIMMPC® is the Trade Mark of Kontron Embedded Modules GmbH*



2.1.6. Configuration and ID E^{2}PROM board (IDEPROM)

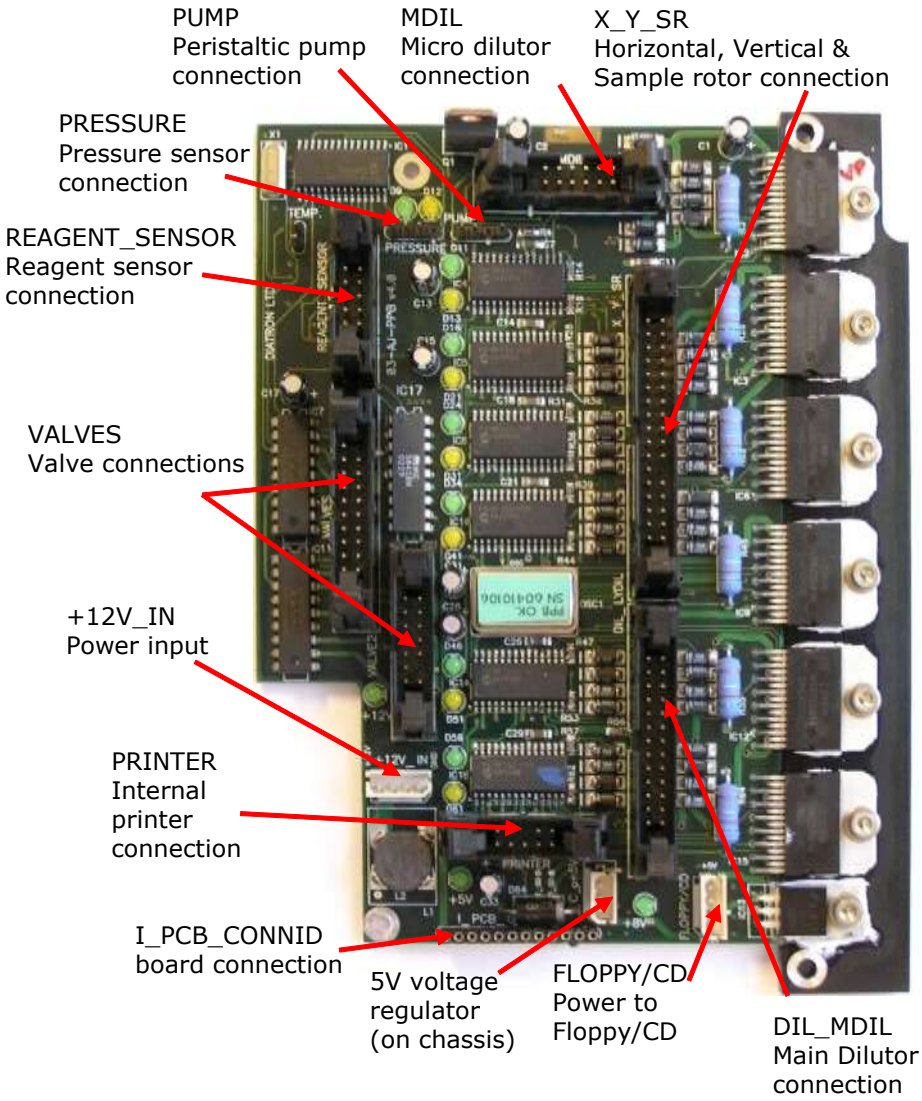
This board is the interconnection between COMB and PPB cards: Pneumatic I^{2}C bus, power lines and internal printer signals are connected through this card. The board also contains a 24FC256 serial E^{2}PROM, which stores the FPGA's configuration data and identity information of the instrument (Serial Number, OEM, model, etc.).



Keeping the hardware identity information (write-protected), IDEPROM allows running the correct software.

2.1.7. Pneumatic and Power Board (PPB)

PPB card contains the main power regulator circuits, valve and motor driver circuits and other connections for the fluidic and pneumatic system's parts.



PPB card contains the main power regulator circuits, valve and motor driver circuits and other connections for the fluidic and pneumatic system's parts.

Power system generates +5V (Digital power), +8V (Printer power) and +12V (Motor and valve power) from the single +12V DC input signal.

Motor driver part consists of six separated PIC micro-controllers with power drivers. Horizontal, Vertical and Sample rotor motors have one combined ribbon cable connection. Main Dilutor (with two motors) and Micro-dilutor have separated connectors.

Valve driver section is based on the valve driver PIC micro-controller and three 8-bit, powered output shift registers (with built in protection diodes) and there are two common ribbon cable connections for the 4 valve boards. The peristaltic pump has a separated Darlington driver circuit for more reliable operation.

All the 7 (6 for motors, 1 for pneumatic) microcontroller have 2 LEDs: a yellow one and a green one.

The yellow one indicates motor moving or holding and active valve or pump moving. (it means current flows into motors, valves or pump)

The green one has 3 states:

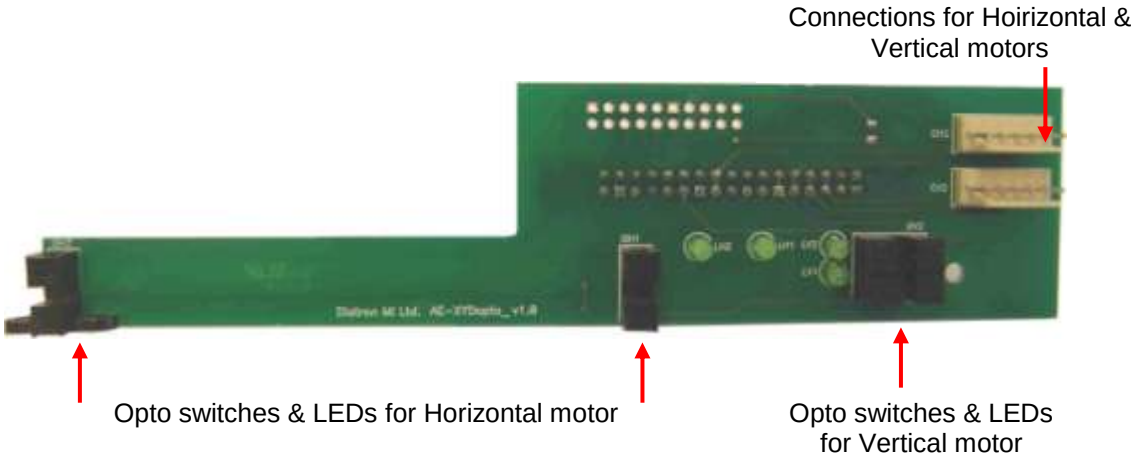
- dark: (after initialization phase) error state,
- blinking: communication in progress - normal state
- on(just lighting): OK - normal state

2.1.8. Opto-boards for stepper motors

There are five stepper motors in the system: Horizontal and Vertical motors, which make the movements of the sampling needle; the main Dilutor motors (2), which move the syringes and the micro Dilutor motor, which drives the sampling phase. The stepper motor opto boards make the connections between the motor driver ICs and motors, and have opto switches for the motor's home and end positions. The actual status of the stepper motor's optos is indicated by two LEDs on each stepper motor opto boards.

Dilutor and Micro-dilutor have its own separated opto-board, located directly in the units.

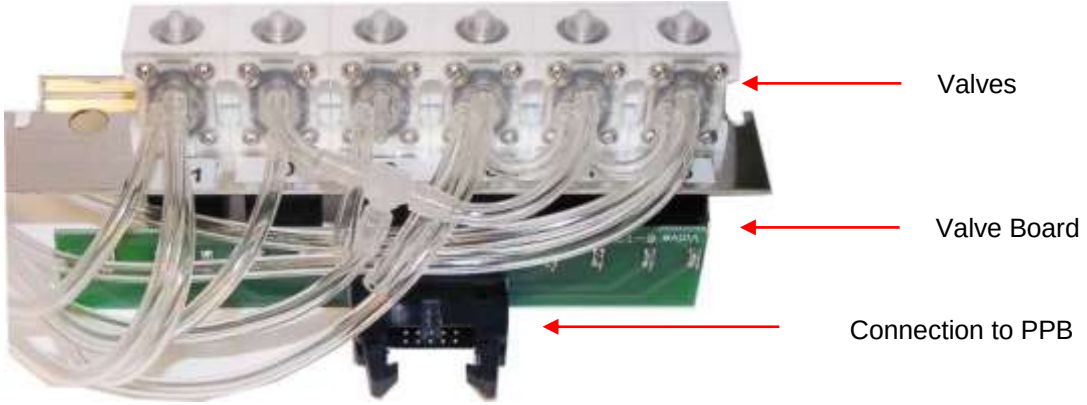
Horizontal and Vertical motors have a common Opto-board, called XYopto Board:



The other side of the board contains a ribbon cable connection to the COMB.

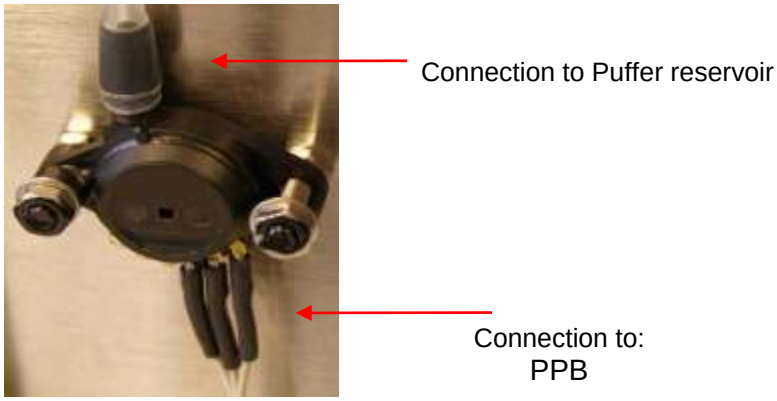
2.1.9. Valve boards

There are two kinds of valve boards: Valve board 0-5 and Valve board 6-12.
The valve boards are connected to controller and driver chips are located on the PPB.



2.1.10. Pressure Sensor

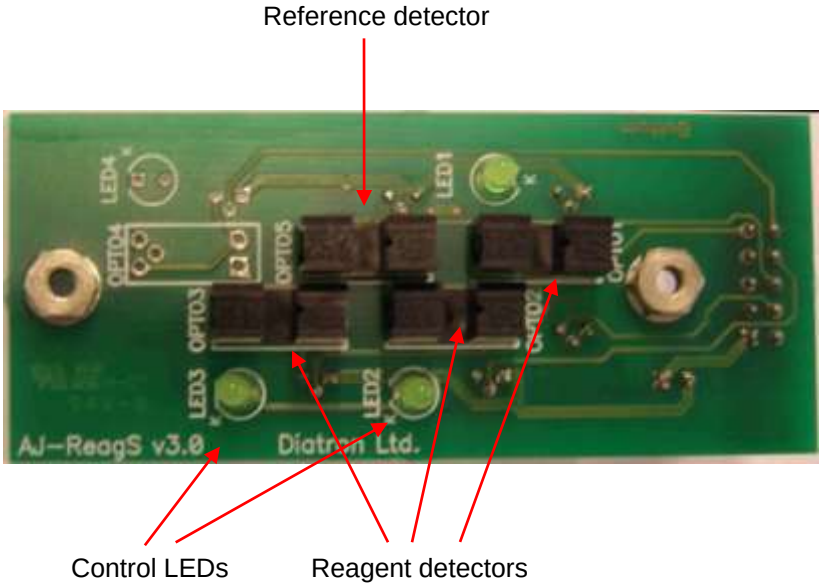
This is an MPX5100AP calibrated pressure sensor, which can measure the required air pressure and vacuum. The Pressure Sensor is connected directly to the PPB card.



The pressure sensor can operate from +5V only. It is a calibrated sensor with 0-1.1 Bar input range. Do not apply more than 1.5 Bar to it, because it can ruin the pressure sensor.

2.1.11. Digital Reagent Sensor Board

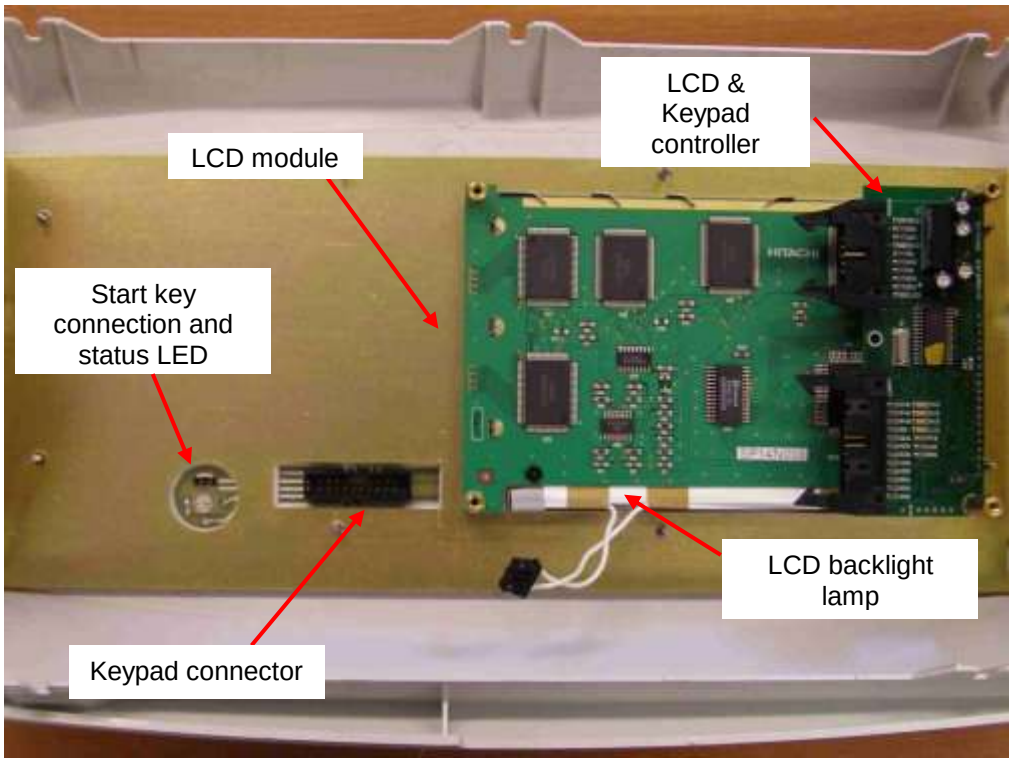
This board contains four liquid detector opto-detectors (optos) and a reference opto for automatic temperature and stray light compensation. The reference opto is located in the middle and it has the same temperature and backlight conditions as the sensing ones.



The Reagent Sensor Board is connected to the PPB card, and the valve driver micro-controller makes the sensing and compensating operations.

Instrument makes automatic initialization – called calibration – of reagent sensors during priming phase of fluidics.

2.1.12. LCD Display Module with High Voltage Board



Display assembly contains the 320x240 dots color graphical LCD display and the high voltage board. LCD has a high voltage backlight lamp (high voltage board generates the required voltage).

There is a special temperature compensation circuit in the display module, which makes possible to use the LCD module in wide temperature ranges with the adjusted contrast.

High Voltage Board (HVB) generates LCD backlight voltage (300V), aperture cleaning voltage (150V), and measuring voltage (50V). The high voltage board is connected to the system through the amplifier board and the COMB card. This unit contains INVC191 inverter, which is a high voltage, high frequency circuit producing suitable voltage for CCFL (cold cathode fluorescent lamp) of the LCD.

The CFSW digital signal (from the COMB card) controls HVB: logical LOW turns inverter on. The MVON digital signal (from the COMB card) switches the measuring voltage (50 V) on/off by O1 opto switch.

> ***Warning! Be careful with servicing this board in active state, because the high voltage (300V) at LCD lamp connector can cause damages or electric shock.***

Start key is a micro-switch, connected to the COMB card (through the Display ribbon cable). The status LED indicates the actual status of the analyzer and it has two colors: red and blue (See User's Manual). The LED has three pins and the actual color depends on the controlled pins. Start key and status LED are controlled by COMB.

2.1.13. Keypad

The analyzer has a 29-button **foil keypad** including numerical keypad (0-9, "."), cursor moving, OK and Del buttons, and 6-6 function buttons, above and under the LCD display as it is shown in the picture below:

2.1.14. External Power Supply

The analyzer works with an external power supply. The next figure shows the power supply unit generating 12VDC.

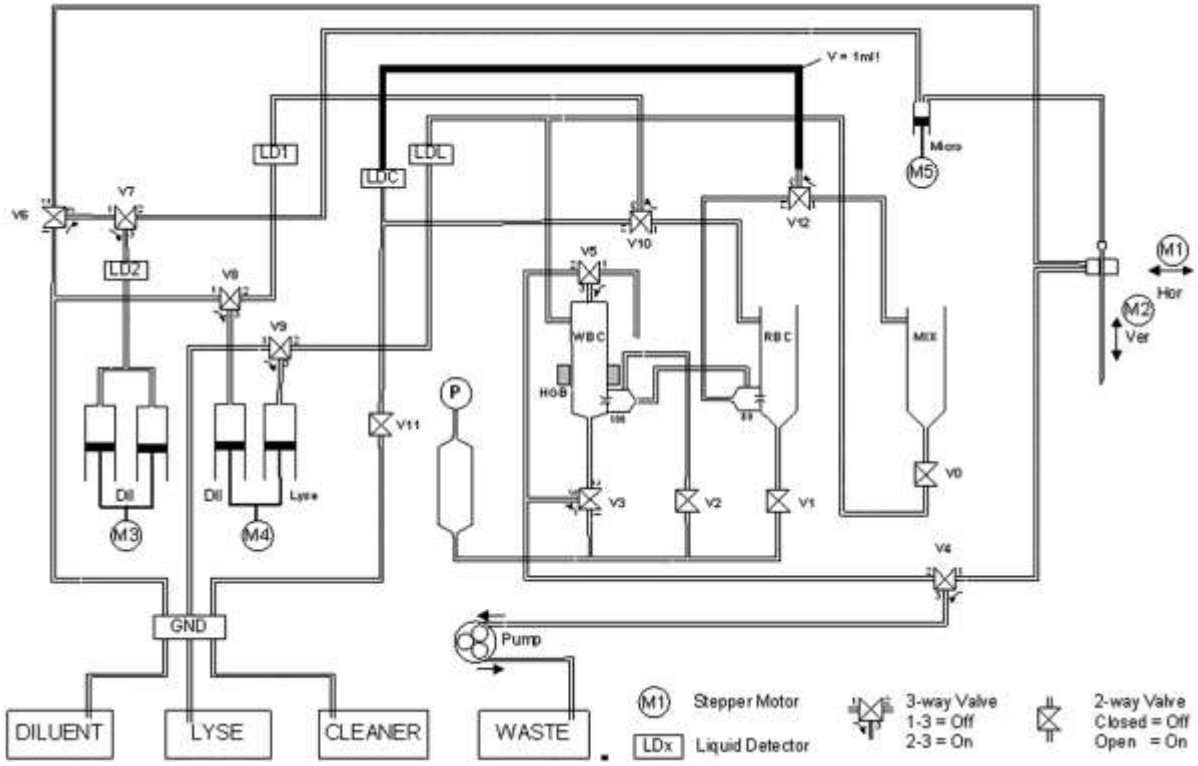
The power supply modules have an auto range input, which makes possible to use them with 230V or 115V mains outlet and it has the CE and UL safety certification. The input socket of the power supply is a standard 3-terminal plug, with power cable connection; the output is a special, lockable socket as it is shown in the picture.

2.2. Main mechanic and fluidic parts of the Analyzer

Hemolyzer 3 Hematology Analyzers consist of the following mechanic and fluidic parts:

1. Sampling needle
2. Washing head
3. H&V moving unit
4. Micro Dilutor
5. Dilutor
6. Chambers
7. Cell-counter probes
8. Puffer reservoir
9. Pump
10. Valves
11. Tubing

Hemolyzer 3 Fluidic Schematics



2.2.1. Sampling needle

Sampling needle is assembled in the H&V moving unit and it makes the sample aspirations. Correct setting of sampling needle is necessary and very important (see Chapter Adjustments).

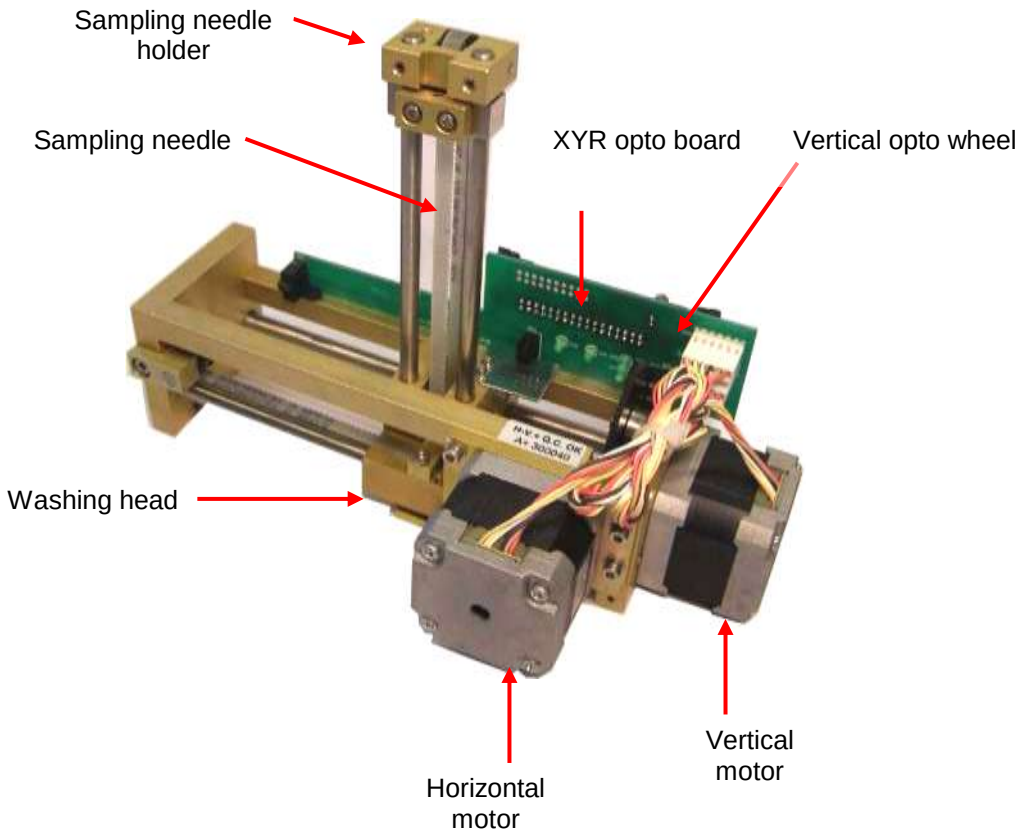
2.2.2. Washing head

Washing head is located at the bottom of the H&V moving unit and it is for cleaning the outer surface of the sampling needle. This washing process is made with diluent reagent and the fluid is drained by the pump. The arrows on the picture show the direction of diluent flow during sampling needle washing.

Clean or replace washing head yearly, or after 10 000 measurements.

2.2.3. H&V moving unit

This unit contains slides to move the sample sampling needle in Horizontal and Vertical directions, two stepper motors, XYR opto board, opto wheel, washing head and the sampling needle. It moves the needle to the desired position: from sampling position, to washing head, and to the measuring chamber.



Both stepper motors have optical end-switch sensors for detecting these positions. These are required for correct initialization and error detection. All sensors have status LEDs to show actual conditions.

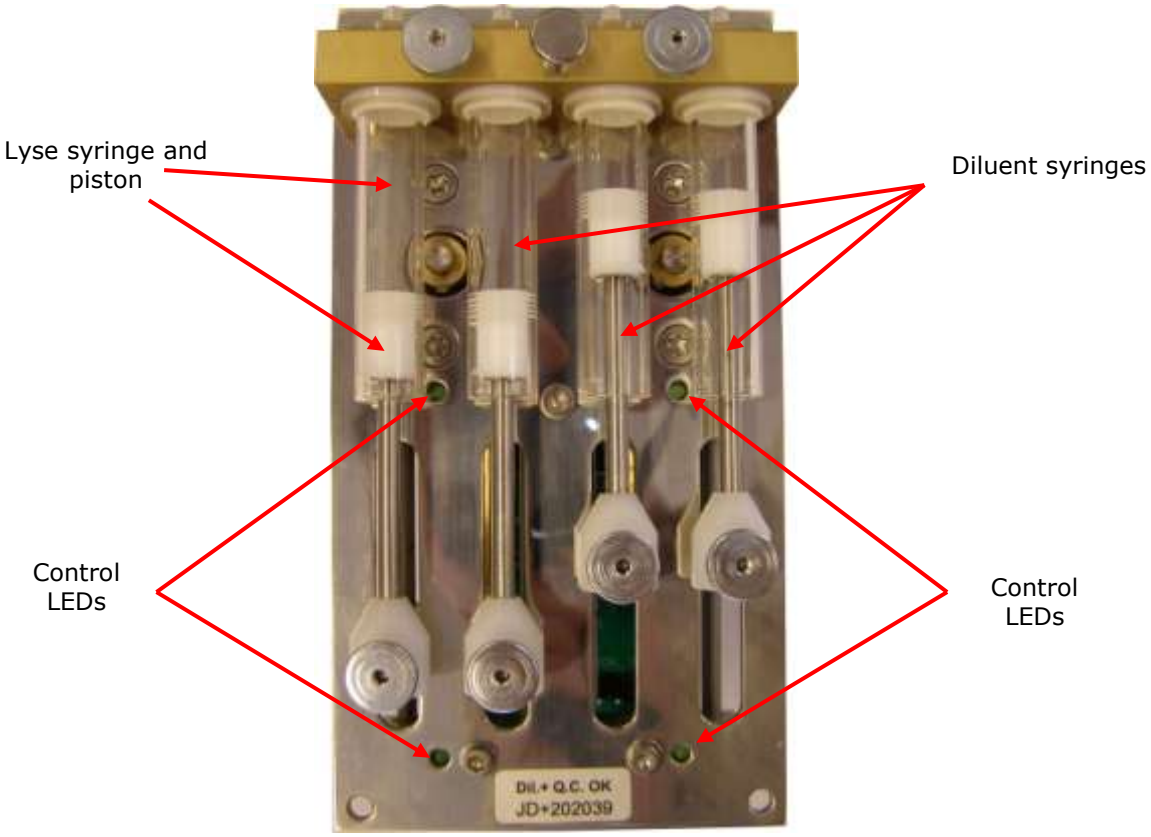
The Vertical motor works with a special opto wheel for detecting home & end positions. See the Adjustment section of this manual to place this wheel to the proper position.

> ***Greasing of the horizontal/vertical guiding rods should be done regularly using "Photolube" (A598), a PTFE-based thin lubricant.***
>
> ***It is recommended to check and repeat greasing of guiding rods every year, or after 10000 measurements.***

2.2.4. Main Dilutor

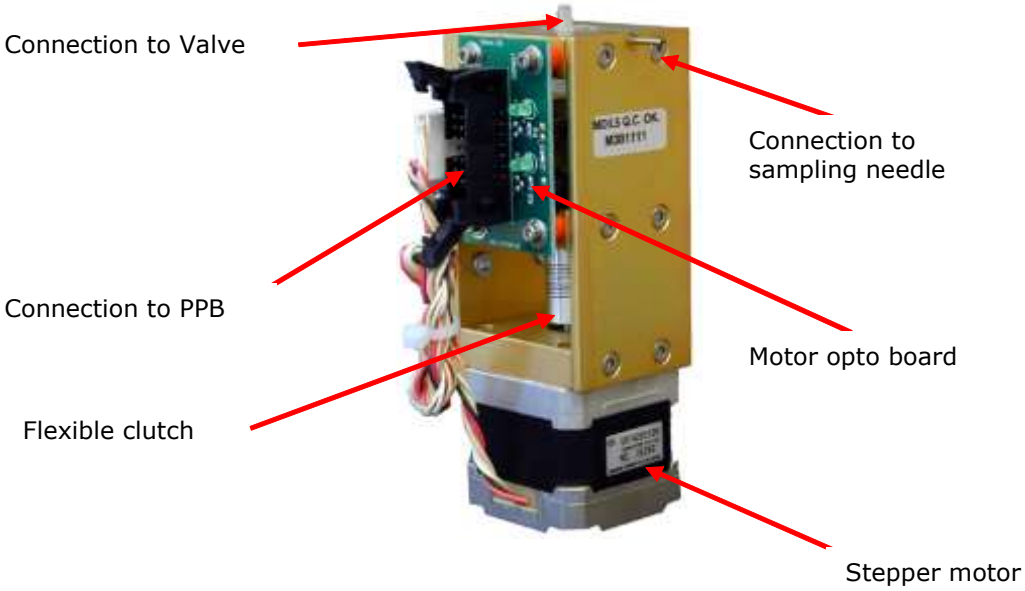
There are two stepper motors, a common motor opto board, four syringes and piston rods with gear transmission.

> ***Maintenance should be provided to the piston tips, by applying neutral silicon grease to the cogged end of the Macro and Lyse pistons, between the syringe and the tip itself. This will ensure optimum sealing and longer lifetime of piston tips.***
>
> ***Greasing of the cogged transmission parts (cogwheel and cogged bar) should be done regularly using machine grease.***
>
> ***It is recommended to check and repeat greasing of piston tips, and transmission gear every year, or after 10000 measurements.***



2.2.5. Micro Dilutor

Micro dilutor is taking the precise sample (25 or 50µl) into the sampling needle. It includes a stepper motor, a motor opto board and the micro syringe.



2.2.6. Puffer reservoir

The glass puffer reservoir is directly connected to the pressure sensor.

During measurement, there is no pump activity, so the puffer reservoir maintains measuring vacuum stable. The instrument measures atmospheric pressure and adjusts measuring vacuum according to it.

2.2.7. Pump

Pump generates regulated vacuum and drains the fluidic system. It is connected to the PPB and it has its own driver circuit (Darlington).

If the tube of the peristaltic pump becomes worn, it can be broken, causing Pressure error.

> ***It is recommended to check the state of the tube, and replace it every 2 years, or after 20 000 measurements. Always replace the peristaltic pump tube to the same PharMed® type, with the same length.***

For servicing the tube of the pump, open the peristaltic pump from its top (see picture) and remove the tube together with the white plastic side wall (see picture):

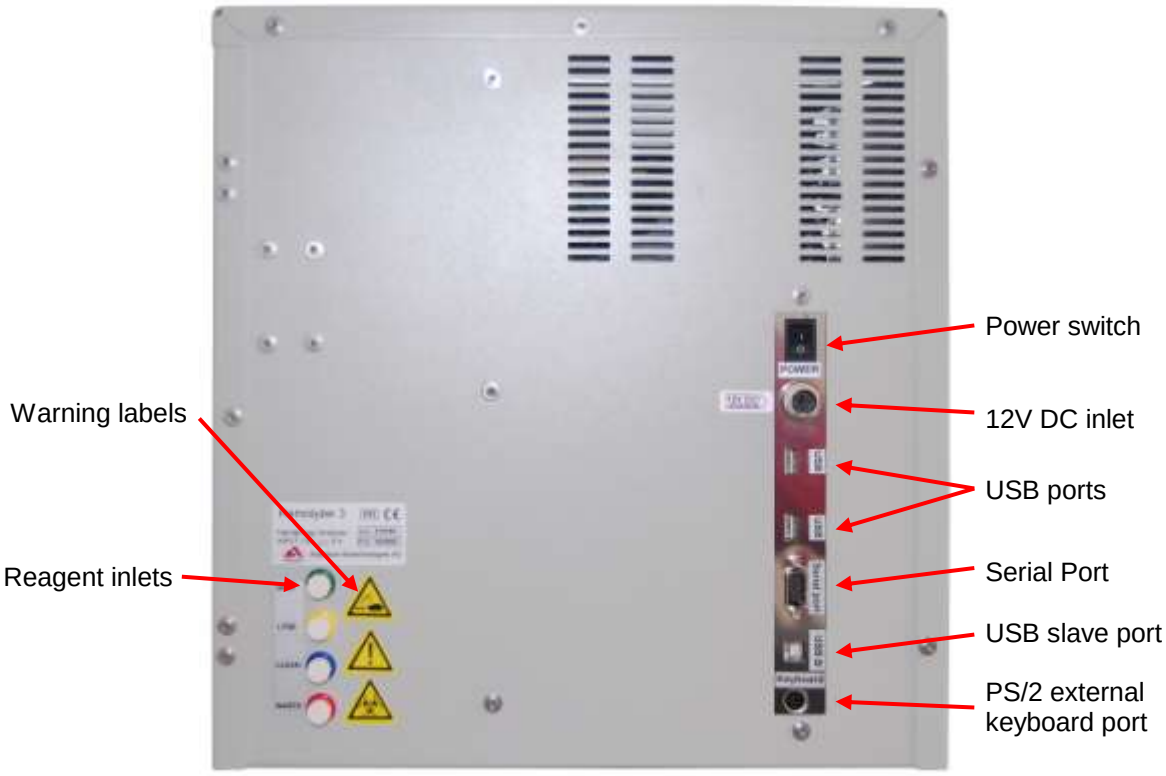
In case of damaged tubes, it can be replaced by a new one by opening the two metal locks located at the two ends of the tube (see picture).

2.3. Assembled Analyzer

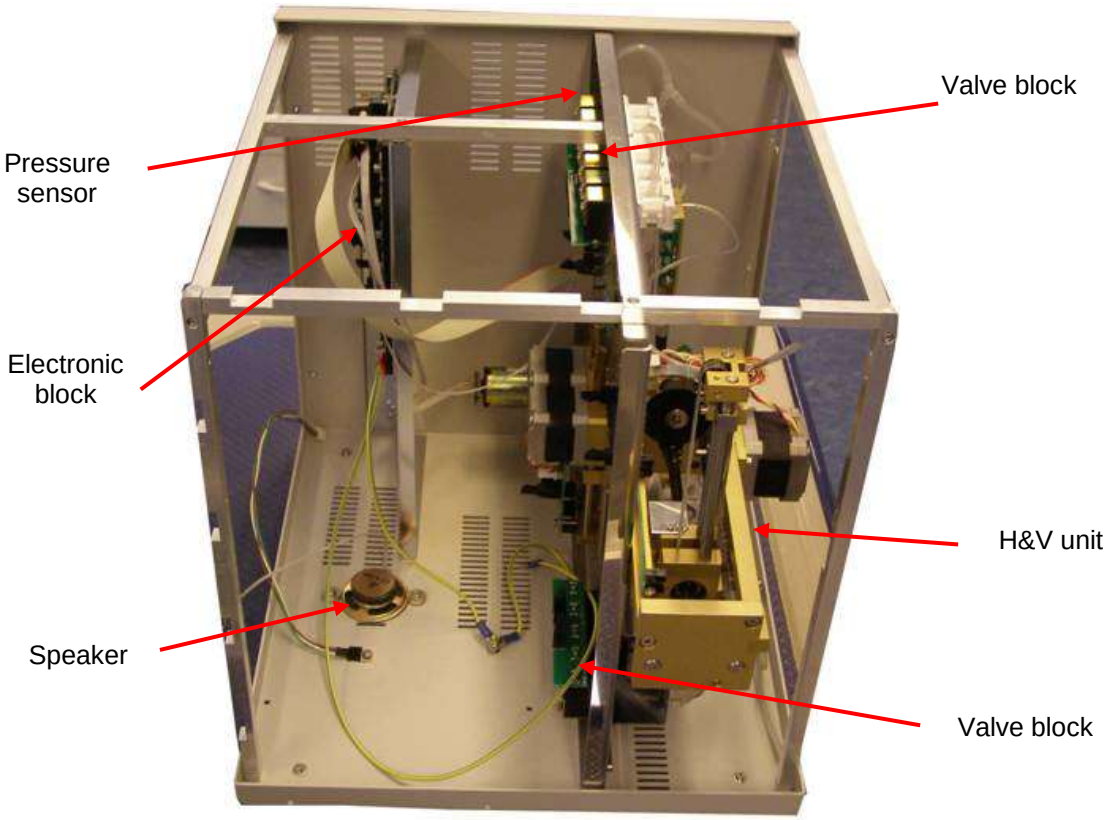
2.3.1. Hemolyzer 3

Front Panel

Rear panel:



Construction – front:



Construction – right side

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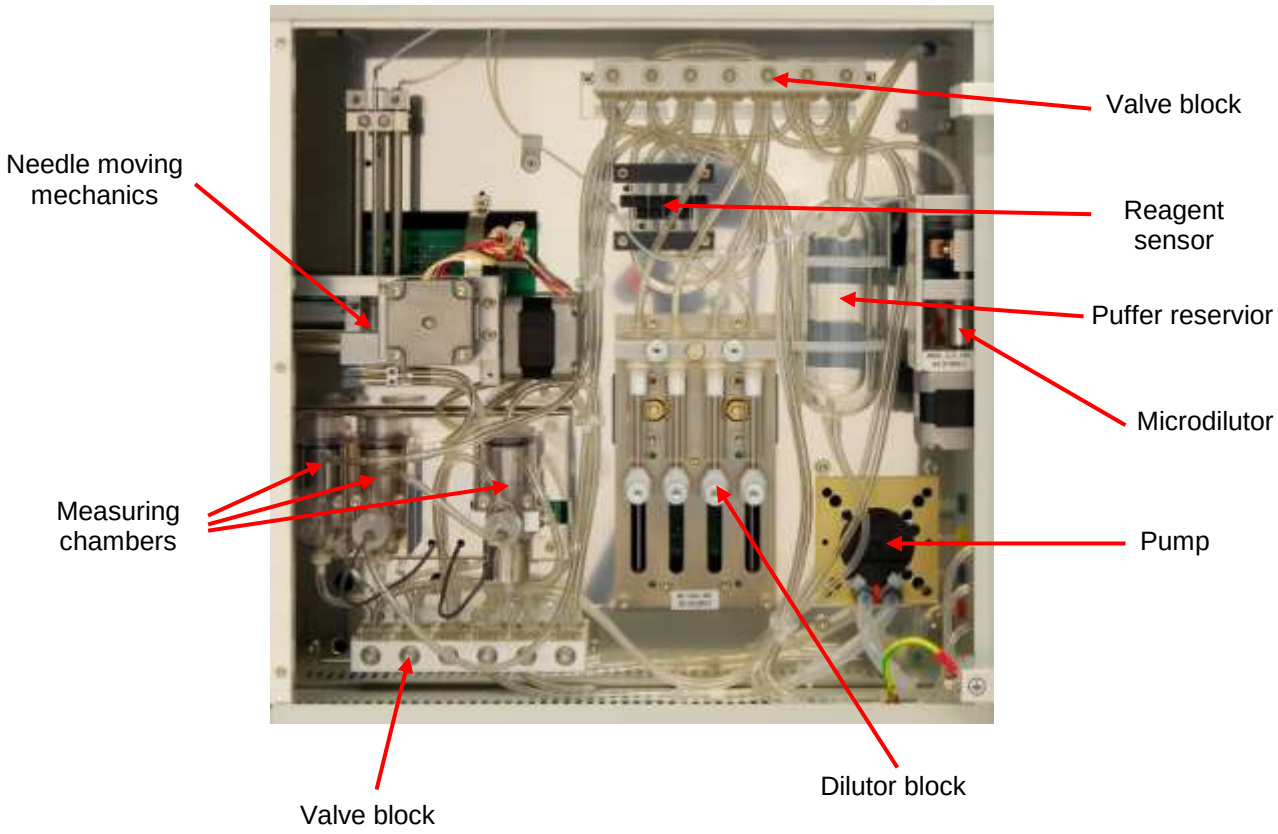
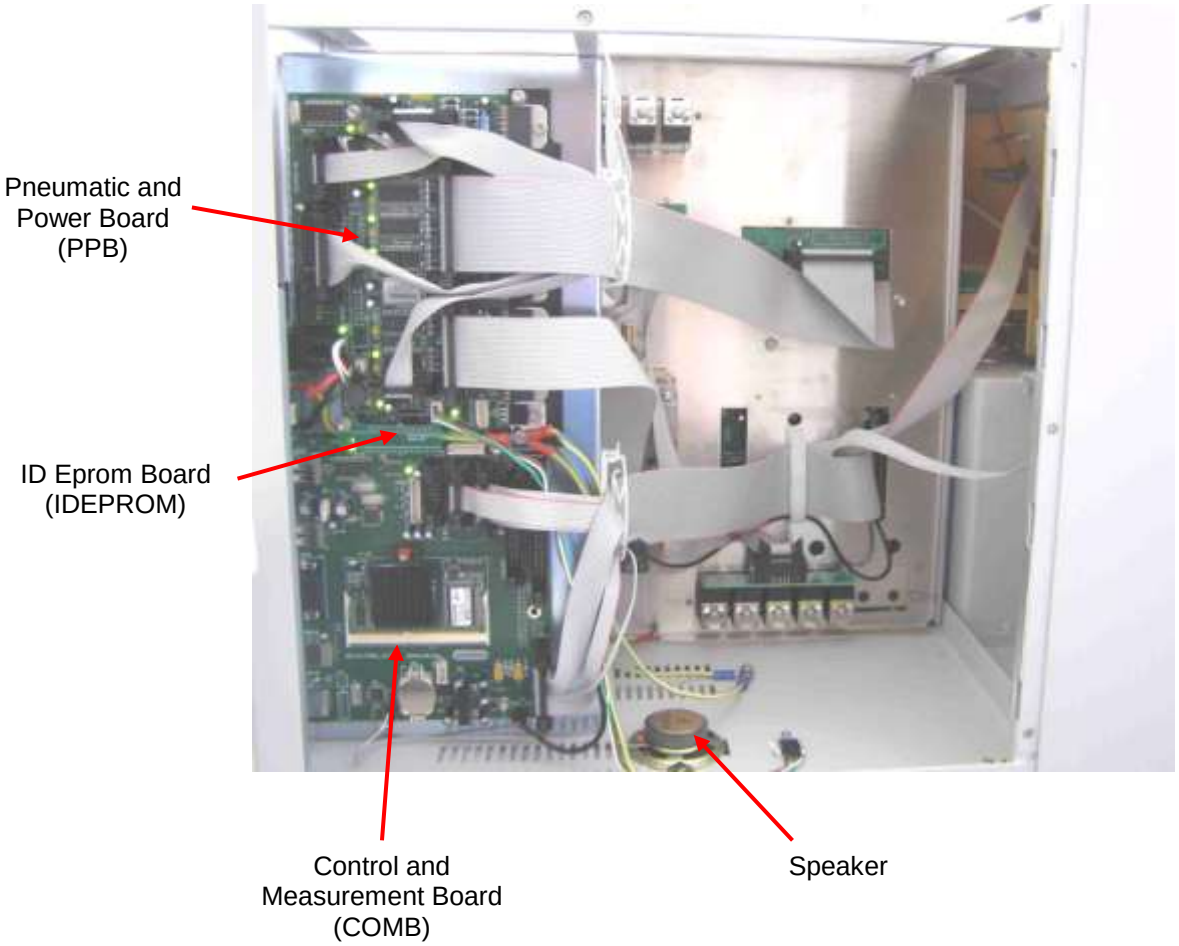


Construction – left side:



3. ADJUSTMENT

Mechanical and hardware adjustments are described in this section. Software settings are included in Section 5.2.

3.1. Mechanical settings

There are two important mechanical settings in the system:

- **Opto wheel setting (Vertical motor)**
- **Sampling needle setting**

> ***The manufacturer adjusts the analyzer during production. However, in case of repairs in the mechanical system, these adjustments should be checked. The omission of these settings can cause malfunction or damages to the instrument.***

3.1.1. Opto wheel setting

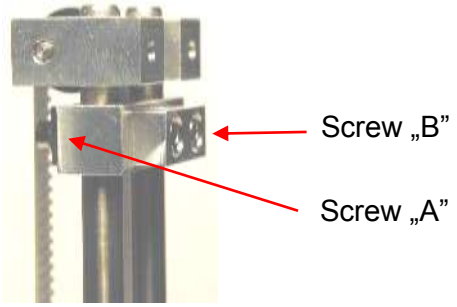
This setting is necessary for the vertical motor movements because this adjustment sets the opto end-switches of the H&V moving unit. The top of this block is called HV head and it is shown in the figure below.

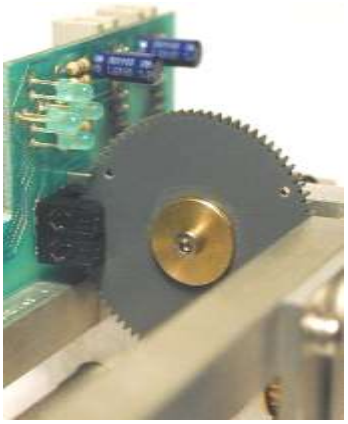
Set the distance to **1-2 mm** between the moving carriage and the stable part of the head.

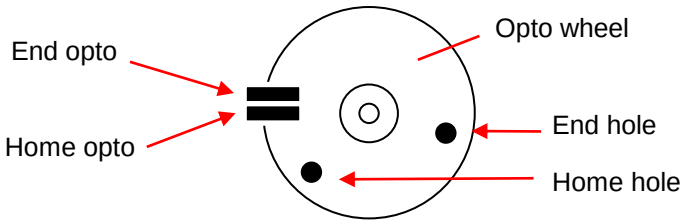
Loose „A” screws to allow free movement of the timing belt.

Adjust the opto wheel to home position, i.e. home hole must be in home sensor, and LED corresponding to home opto sensor goes on.

Fasten „A” screws.







Check the end position as well: move the needle down. Adjustment is successful if end LED goes on before moving part reaches end of mechanical range.

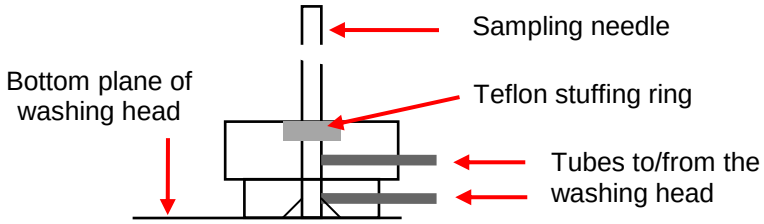
Once this adjustment is necessary, never miss sampling needle setting described in the next section.

3.1.2. Sampling needle setting

This adjustment sets the sampling needle to the operational position.

In Service menu, in Miscellaneous submenu of AJ/AJvet and in Service menu of AJB select *Needle setting*.

The software moves the needle back and up, and turns on horizontal and vertical motors (AJ/AJvet) to keep needle in place. AJB holds only the vertical motor during needle setting.



Check the setting of the needle. If end of the needle is at the bottom of the washing head, needle is set correctly. If not, open screws “B” (see above), and adjust the needle to the bottom of the washing head. Fasten “B” screws.

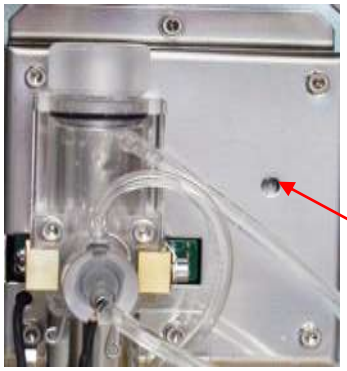
> ***Set the end of the tip to the washing head’s bottom plane, while the carriage is held by motors. (Needle setting menu). Fix the „B” screws.***

> ***Be careful with the bent upper end of the sampling needle, because if badly aligned, during movement it can hit other mechanical components causing mechanical jam, and therefore damages or error.***

3.2. Hardware settings

3.2.1. Amplifier offset setting

Amplifier offset should be between ±5mV. Run self test to determine whether offset is within this range. If it is out of range, it should be re-set, by the following way.



1. Locate the opening for offset setting potentiometer on the measuring block (see enclosed picture).
2. In Service menu select Offset adjustment menu.
3. Adjust the potentiometer to reach 0 mV.

Opening for offset adjustment on measuring block

4. OPERATION OF THE FLUIDIC SYSTEM

This section describes the main steps of **Hemolyzer 3** fluidic functions. The instrument's Fluidic Schematics are shown in section 2.2 of this manual. The following figures show total measurement flow diagram and detailed descriptions of basic processes for understanding the fluidic system work.

The following steps are introduced in this section:

1. Basic processes
   - 1.1. Sampling process
   - 1.2. Needle washing process
   - 1.3. Diluting process
   - 1.4. Fluid transfer from MIX chamber to WBC chamber
   - 1.5. Lysing process
   - 1.6. Counting process
   - 1.7. Aperture priming process
   - 1.8. WBC chamber draining process
   - 1.9. RBC chamber draining process
   - 1.10. Cleaner priming process
2. Main functions of the fluidic system
   - 2.1. Initialization
   - 2.2. Wake up
   - 2.3. Measurement cycle
   - 2.4. Standby
   - 2.5. Cleaning
   - 2.6. Hard cleaning
   - 2.7. Shutdown

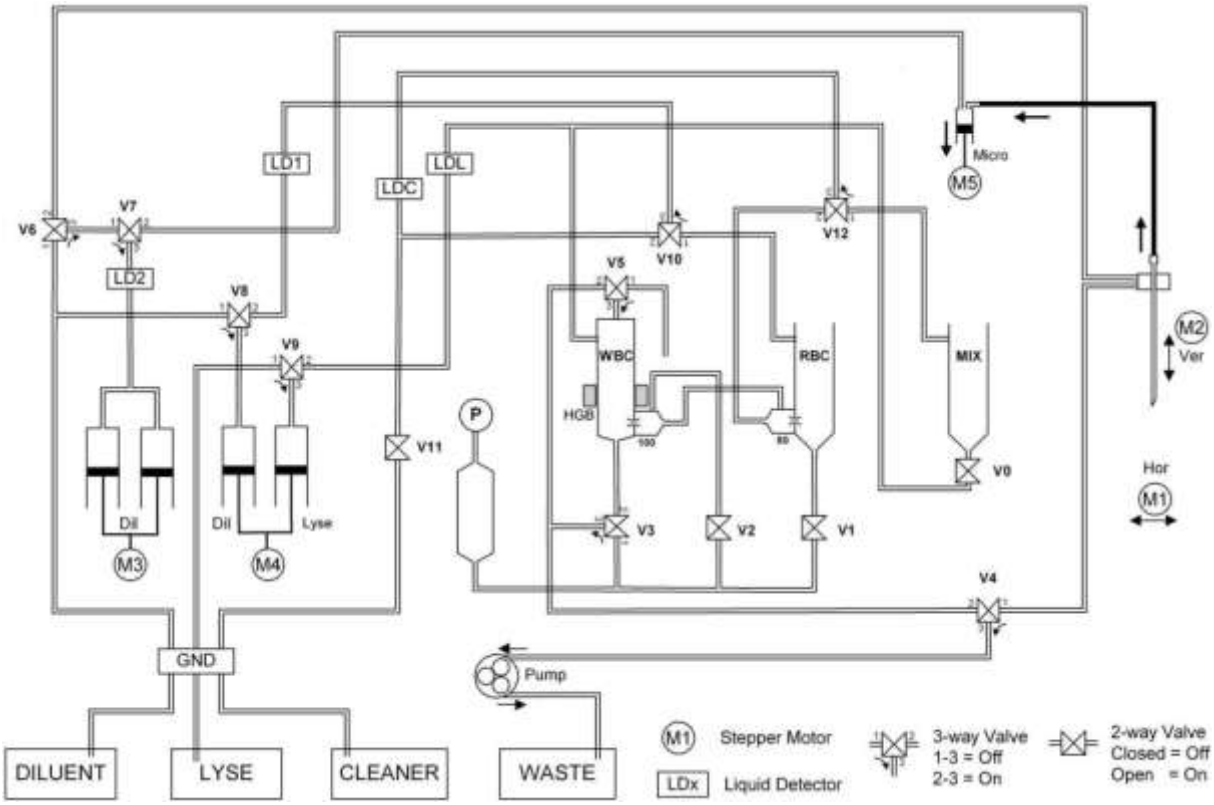
In the detailed process description figures, the active tube is filled with black or gray color, while an arrow (→) shows the direction of the flow. Moving mechanic parts have another arrow indicating direction of movement. In the section of the basic processes only relevant valves are mentioned in this section (ON or OFF) while all the other valves are in either ON or OFF state depending on the status of the instrument and other parallel running process.

Hemolyzer 3 employs a software waste full checking feature. Software integrates volume of the reagents used.

4.1. Basic processes

4.1.1. Sampling process

The aspirating needle aspirates 25 µl (50 µl in prediluted mode) of blood sample. The Micro-dilutor syringe makes the aspirating while the M5 Micro-dilutor motor moves down.

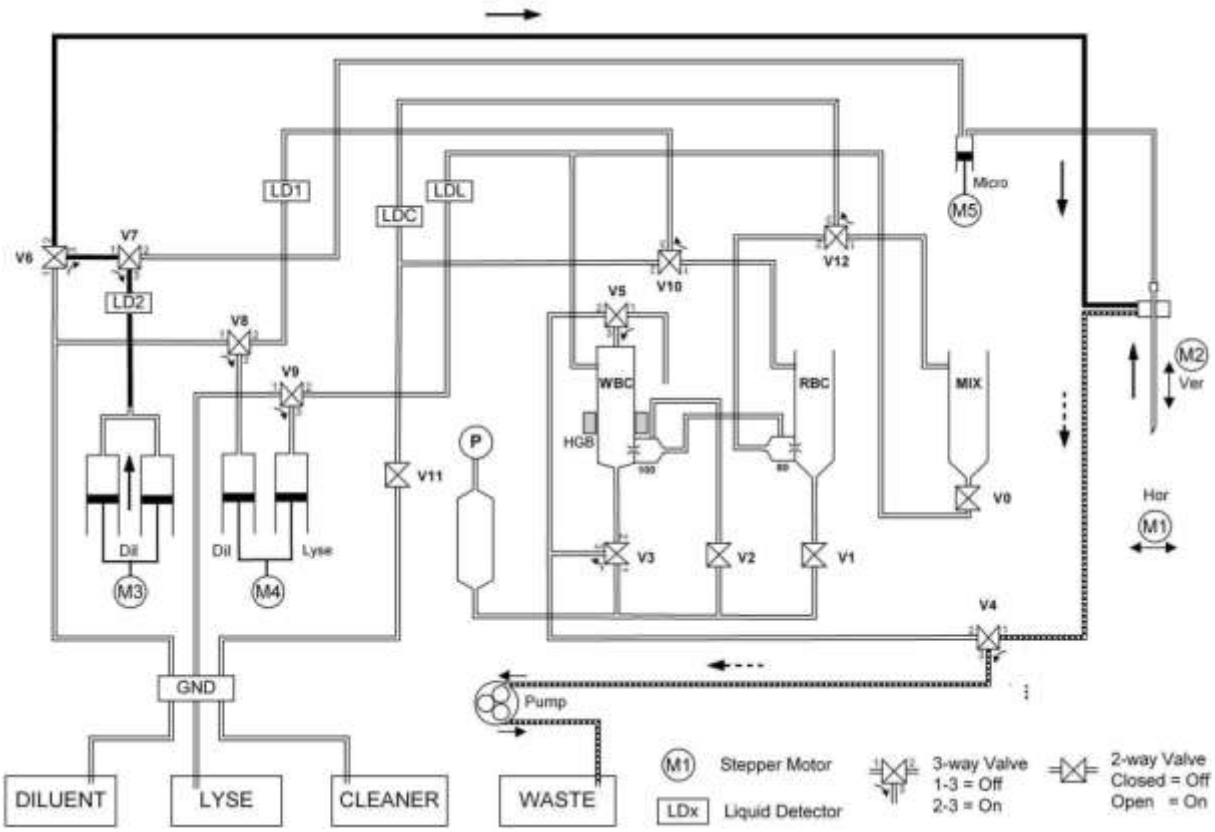


There is another sampling process for the second (RBC) dilution, when 35 µl of primary dilution is aspirated from the MIX by the aspirating needle. Both of the samples are separated from the diluent with a small air bubble and there is another air bubble between the sample and the end of the needle.

4.1.2. Needle washing process

The instruments clean the sampling needle with diluent in the washing head after sampling. It is important to clean the outer surface of the sampling needle to avoid inaccurate sampling.

The Macro syringe doses and the pump drains the diluent from the washing head, while the sampling needle moves upwards so that the total length of it is washed and cleaned. This process is called total sampling needle washing, and it is mainly used after taking primary sample from sample tube.



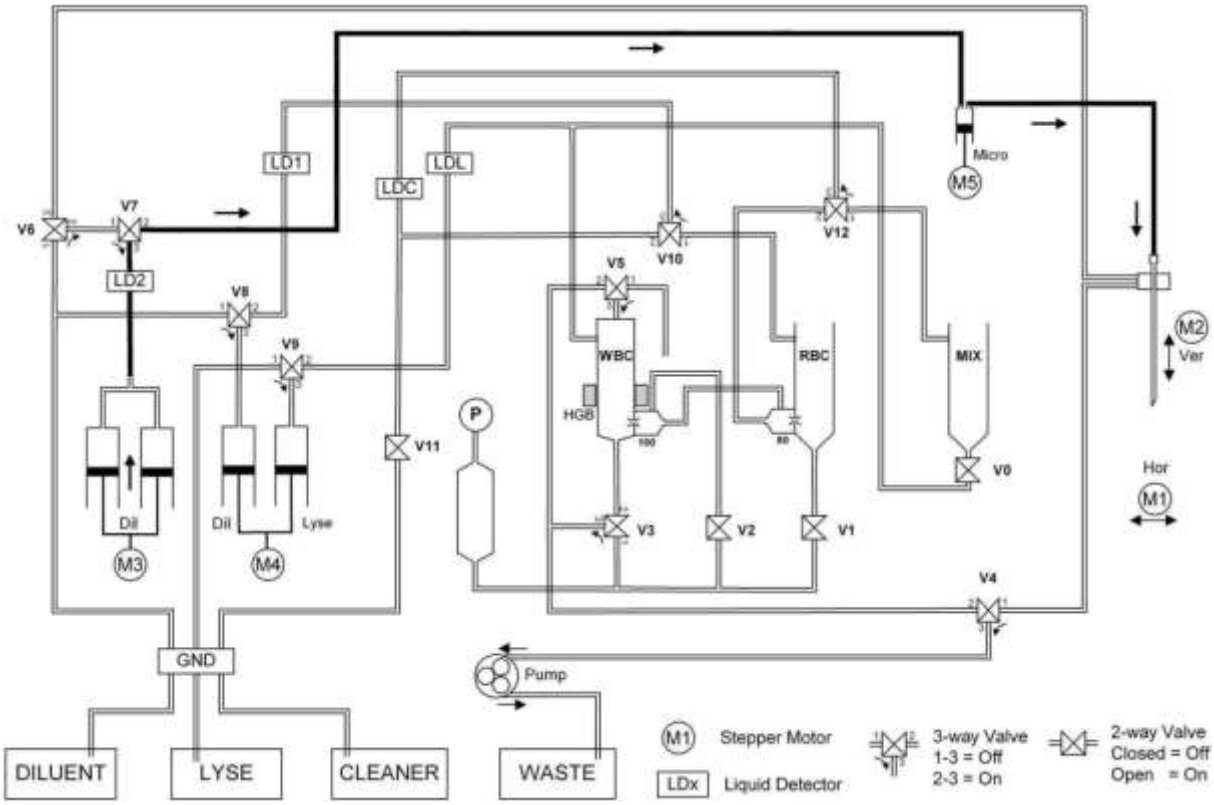
Another process, which is washing only a smaller part of the sampling needle, is the same but the needle does not move in the total length. Some procedures perform this kind of sampling needle washing.

The M3 Macro syringe pushes the diluent through V11 (Off), V12 (On). The Pump aspirates the diluent from the washing head through V4 (On), while the M2 Vertical motor moves the sampling needle up.

4.1.3. Diluting processes

Before the dilutions the MIX and the RBC chambers are filled up with 1 ml of diluent. This method prevents the chamber from dirt and makes the diluting process faster.

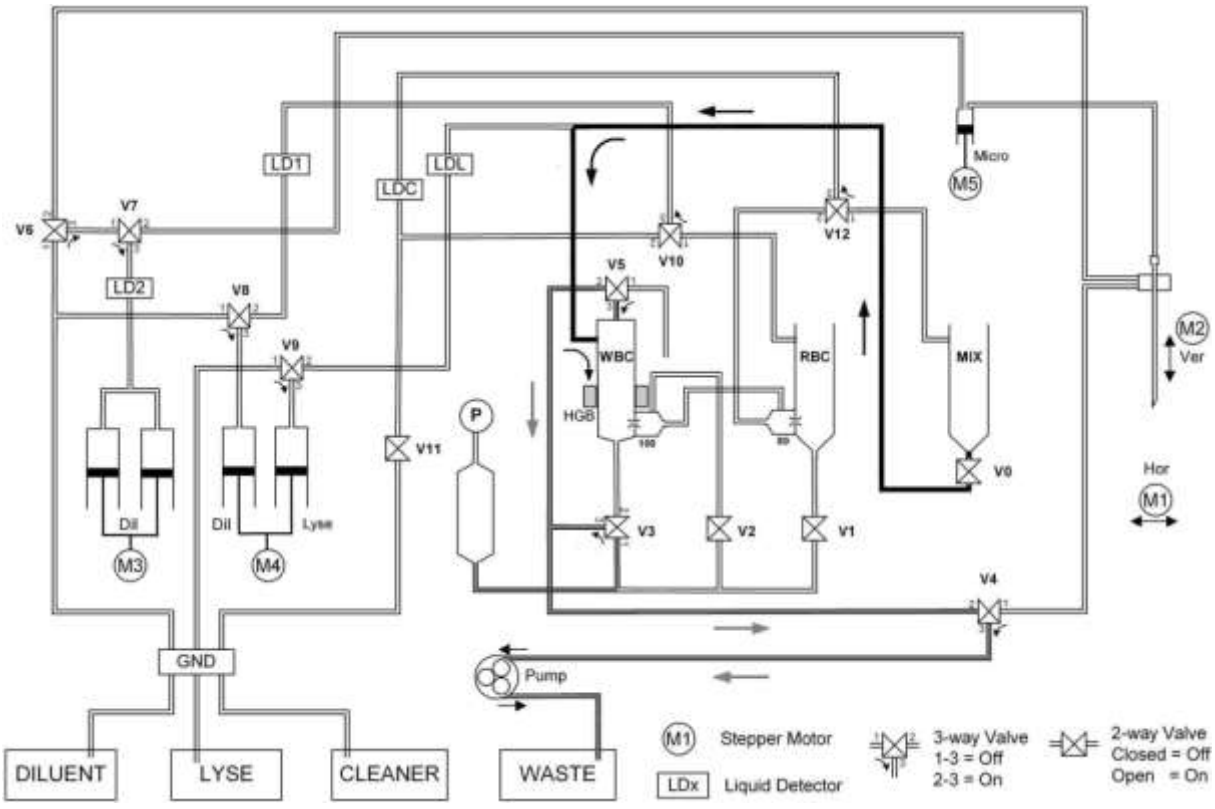
The sampling process has aspirated 25µl of sample (or 35µl of primary dilution), which is in the sampling needle. In the first diluting step the sample is dispensed into the MIX chamber with 3 ml of diluent (1.0 ml is waiting in the MIX chamber), which comes from the Macro syringe through V11 (On) and Micro-dilutor, while the M3 Dilutor motor moves upwards. This process makes the 1:160 first dilution rate in the MIX chamber.



The second sampling process aspirates 35 µl of primary dilution and then it is added with 4.0 ml of diluent (1.0 ml + 3.0 ml) into the RBC chamber. This process makes 1:18285 dilution rate in the RBC chamber.

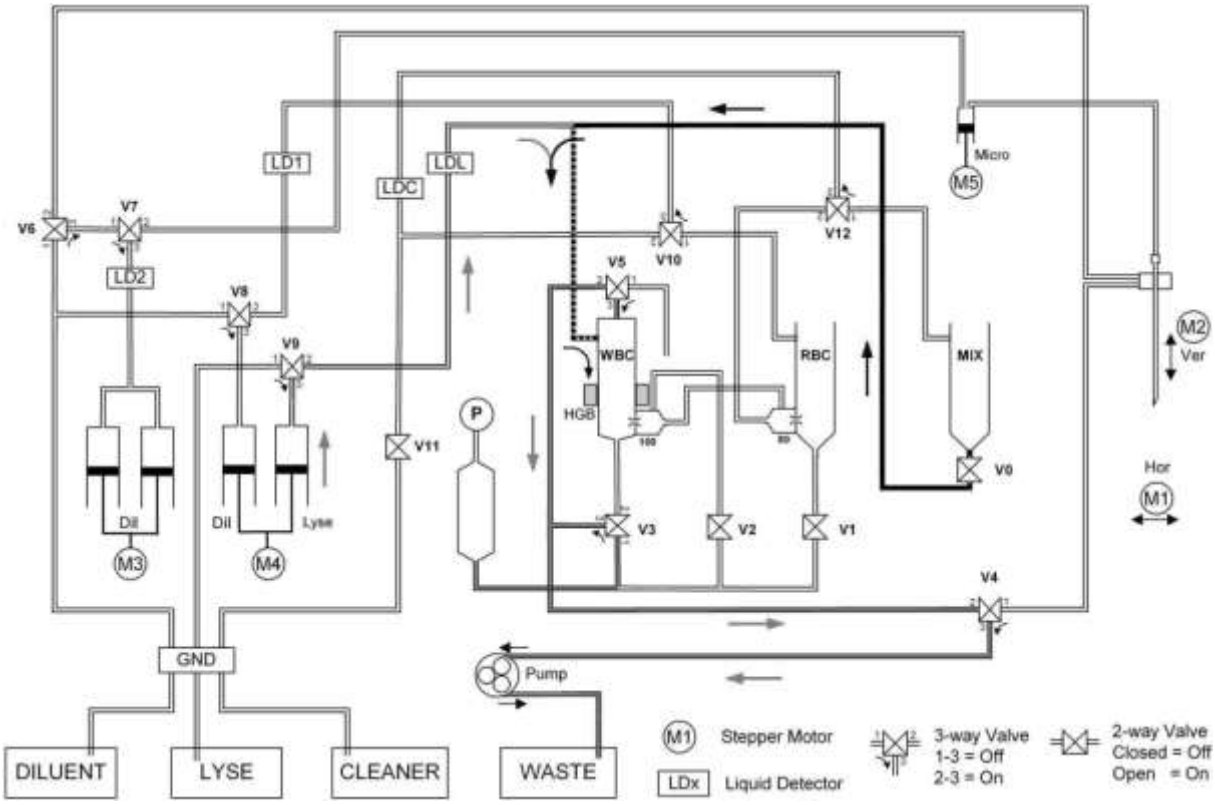
4.1.4. Fluid transfer from MIX chamber to WBC chamber

In **Hemolyzer 3**, during this step the liquid remaining in the mixing chamber flows via the V0 (On) into the WBC chamber, because the vacuum – which is in the puffer reservoir and maintenated by the pump – aspirates the fluid through V5 (On) and V3 (On), while V2 and V1 are Off. Simultaneously, the peristaltic pump supports this procedure via V4 (On).



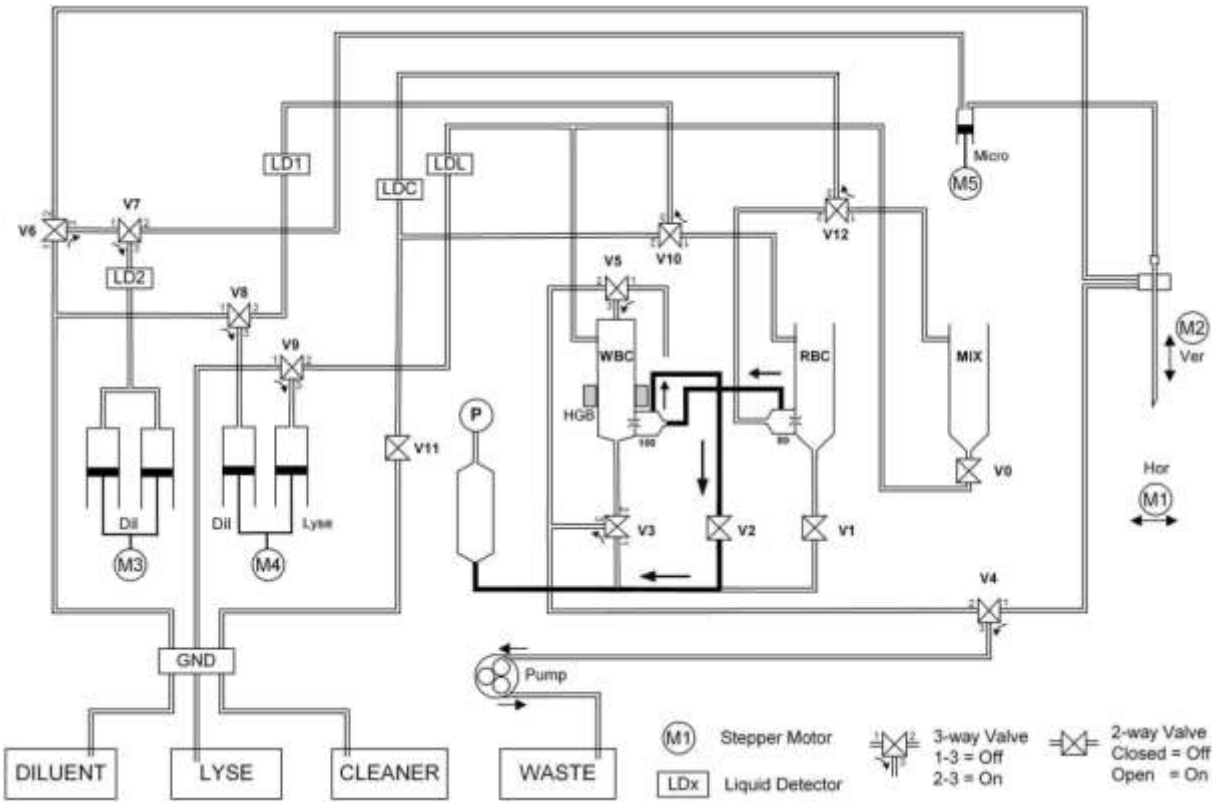
4.1.5. Lysing process

During this step the primary dilution remaining in the mixing chamber flows into the WBC chamber, like a simple MIX WBC transfer, but in this case simultaneously, 0.8 ml of lysing reagent is added through V9 (On), while the Lyse syringe moves upwards. This process makes the 1:192 dilution rate and good mixing with lyse.



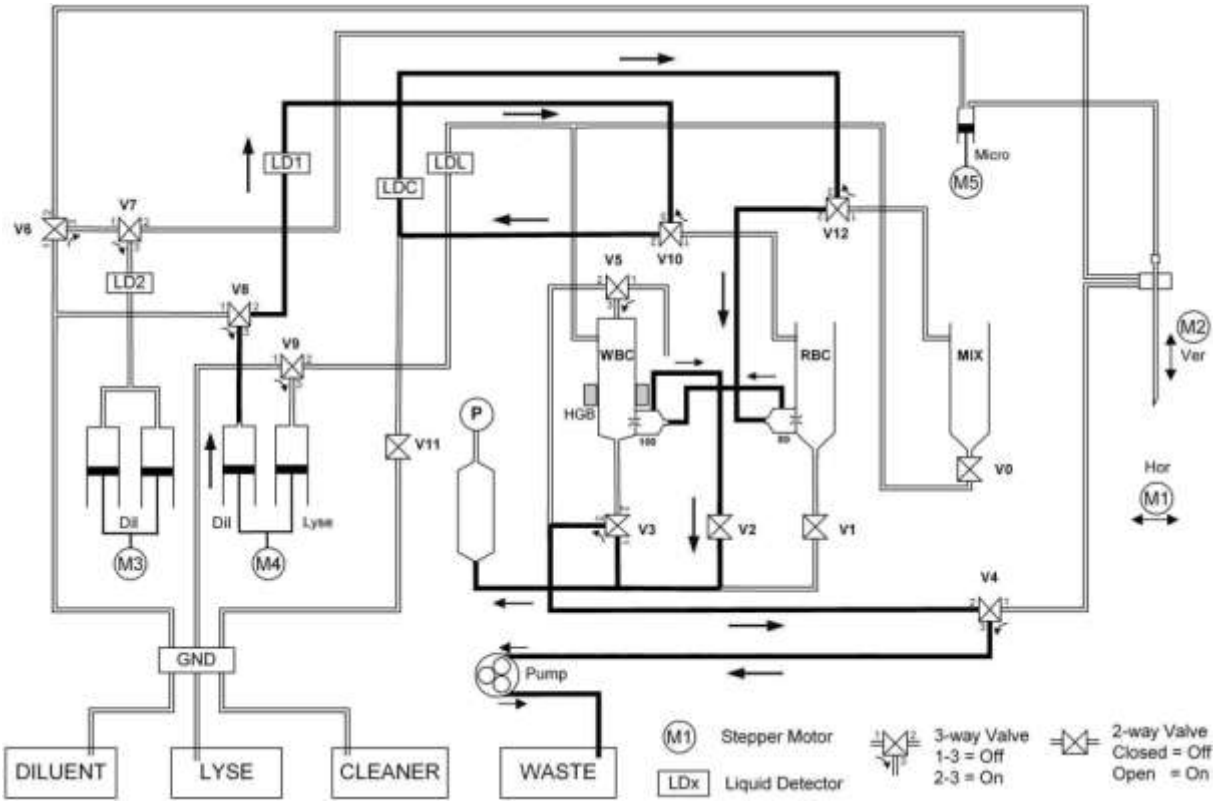
4.1.6. Counting process

The regulated vacuum (it is generated by the pump in the puffer reservoir) aspirates the diluted sample (WBC and RBC) from the chamber through V2 (On) valve. The instrument counts the cells for 5 seconds in both counting phases (at first WBC and after it the RBC).



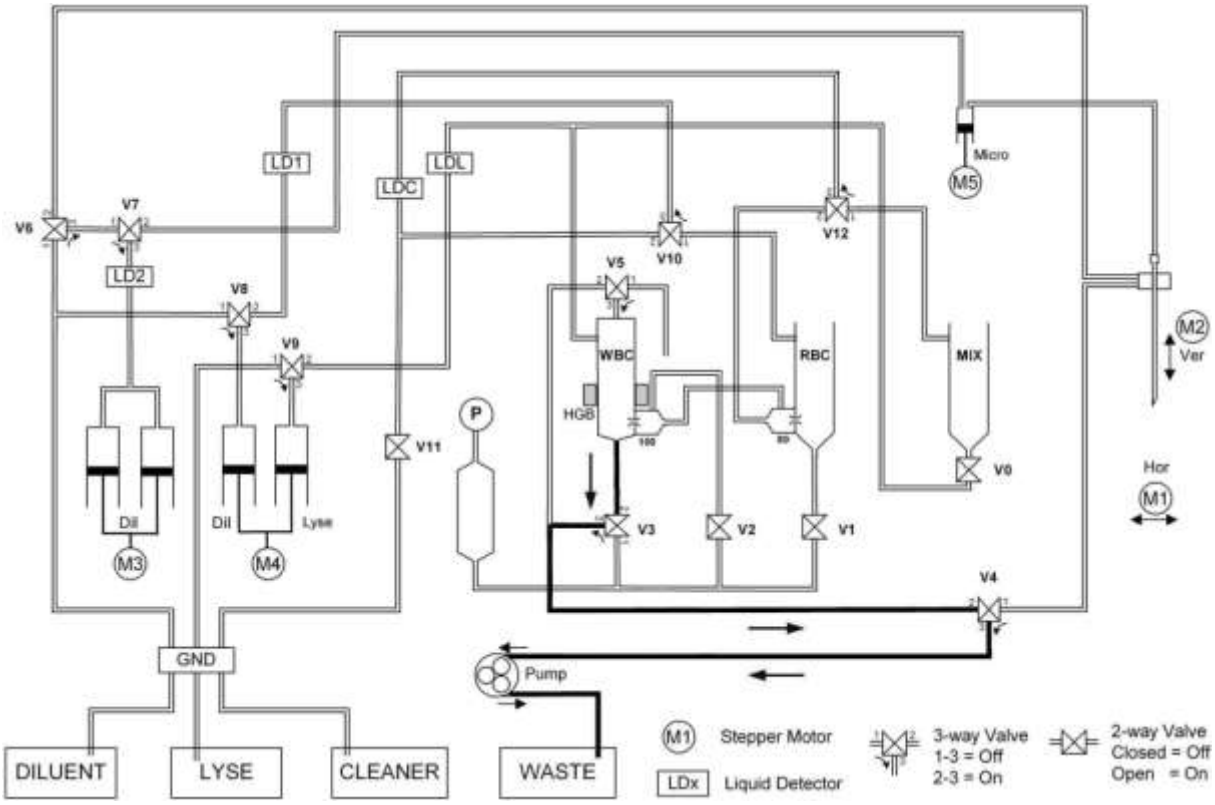
4.1.7. Aperture priming process

In this process the aperture branch and backsides of the apertures are filled with diluent and . After generating vacuum in the puffer reservoir the pump continues the drainig of the aperture branch (V2 and V3 On, V1 and V5 Off) meanwhile the diluent syringe of M4 dilutor unit pushes diluent through V10 (On), V6 (On) and V8 (On).



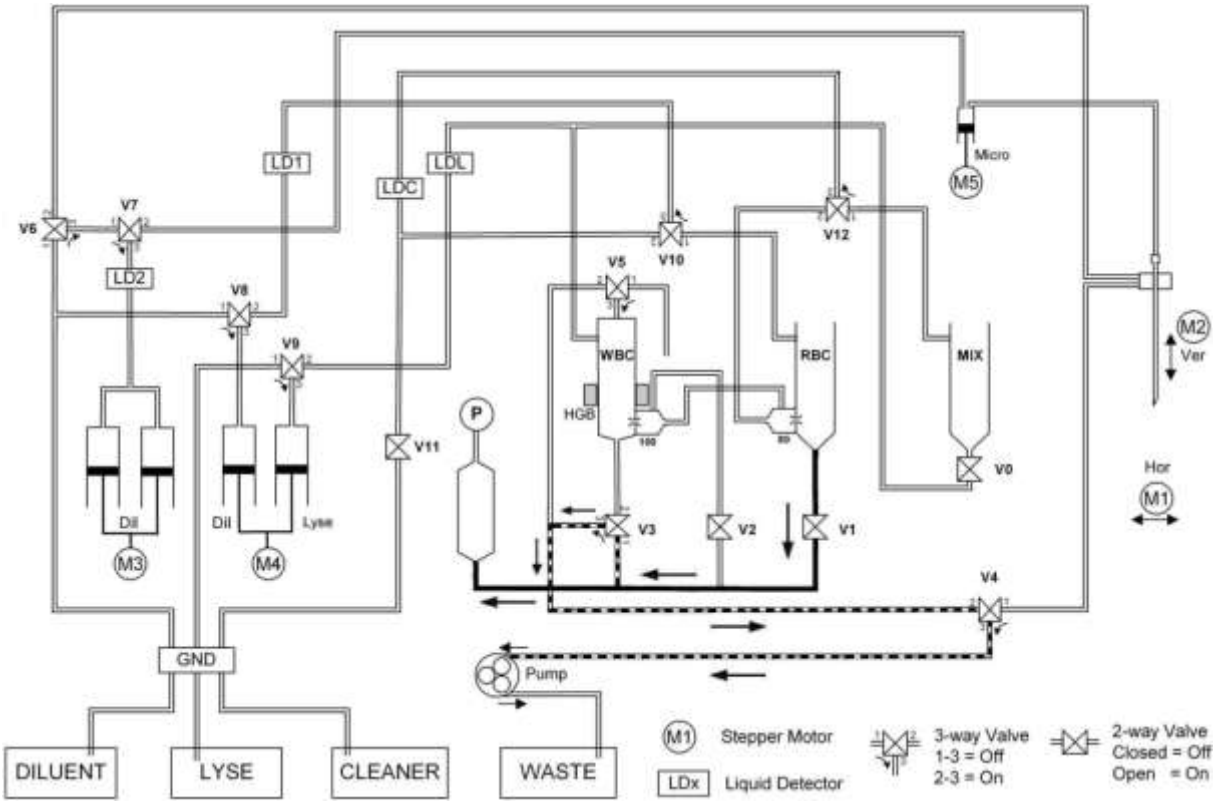
4.1.8. WBC chamber draining process

The WBC chamber draining is performed via V3 (On) and V4 (On) valves by the pump while the V5 must be off. The WBC chamber draining is always executed without using the puffer reservoir. So other tasks like RBC chamber draining can be performed parallel with this operation.



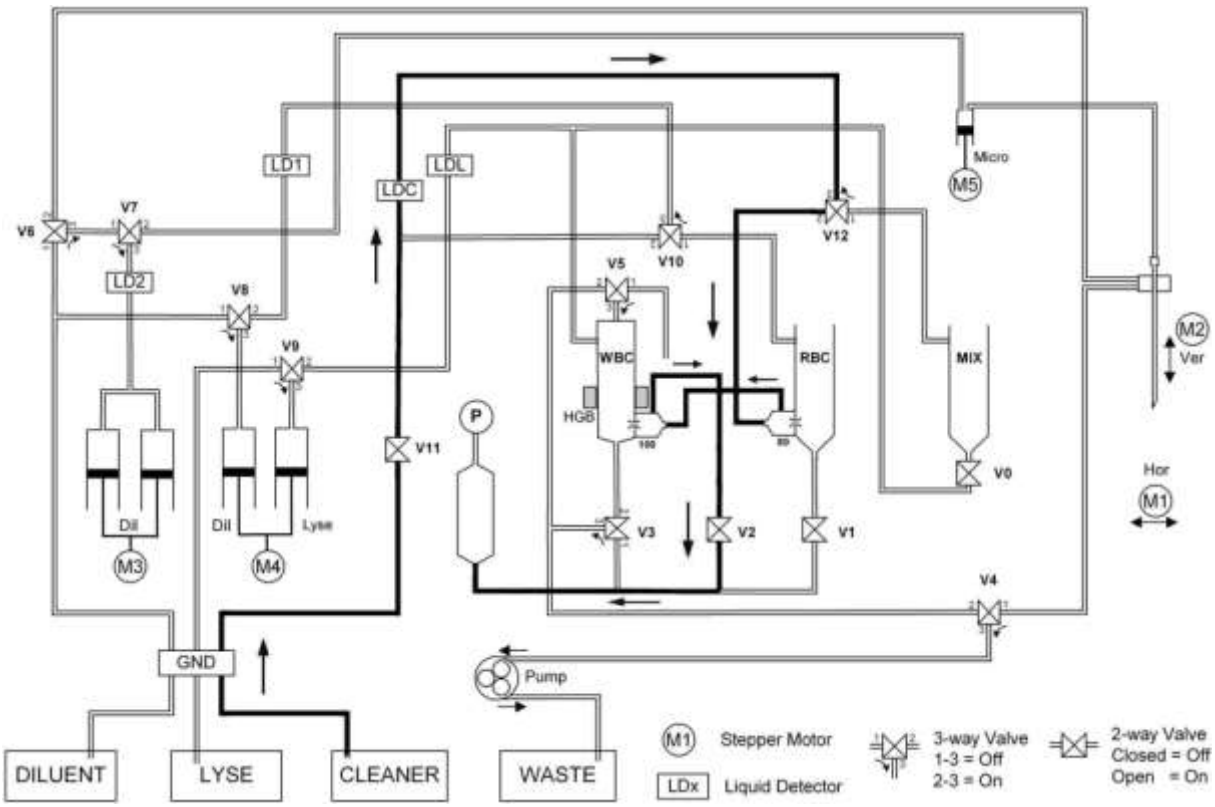
4.1.9. RBC chamber draining process

The RBC chamber is drained by the vacuum in the puffer reservoir through V1 (On) valve (V2 must be off). This vacuum is made (and maintenated) by the peristaltic pump. During the draining the pump can perform either other task like WBC chamber draining or needle wash, or can help the draining of the RBC chamber.



4.1.10.Cleaner priming process

The cleaner solution is primed by vacuum in the following way: V7 (On), Cleaner Detector, V6 (On), back side of the RBC aperture, back side of the WBC aperture, V2 (On), V3 (On), V4 (On) and the peristaltic pump. The V1 and V5 valves are off. The flow of the cleaner is controlled by the vacuum, generated in the puffer reservoir before the start of the priming. After the priming the remaining cleaner between the cleaner detector and V6 (approx. 1 ml) can be dosed into the mix chamber.



4.2. Main functions of fluidic system

4.2.1. Initialization

Fluidic initialization process performs the following steps:

- Positioning all mechanical components (stepper motors) by scanning moving range (with end-switches)
- Checking the atmospheric pressure
- Checking of pump and pressure sensor by generating measuring vacuum
- Priming of reagents and calibrating reagent sensors
- Fill the tubing with the reagents
- Cleaning of tubing & measuring chamber
- Cleaning of aperture with high-pressure back-flush, cleaner reagent & high-voltage burning

4.2.2. Wake up

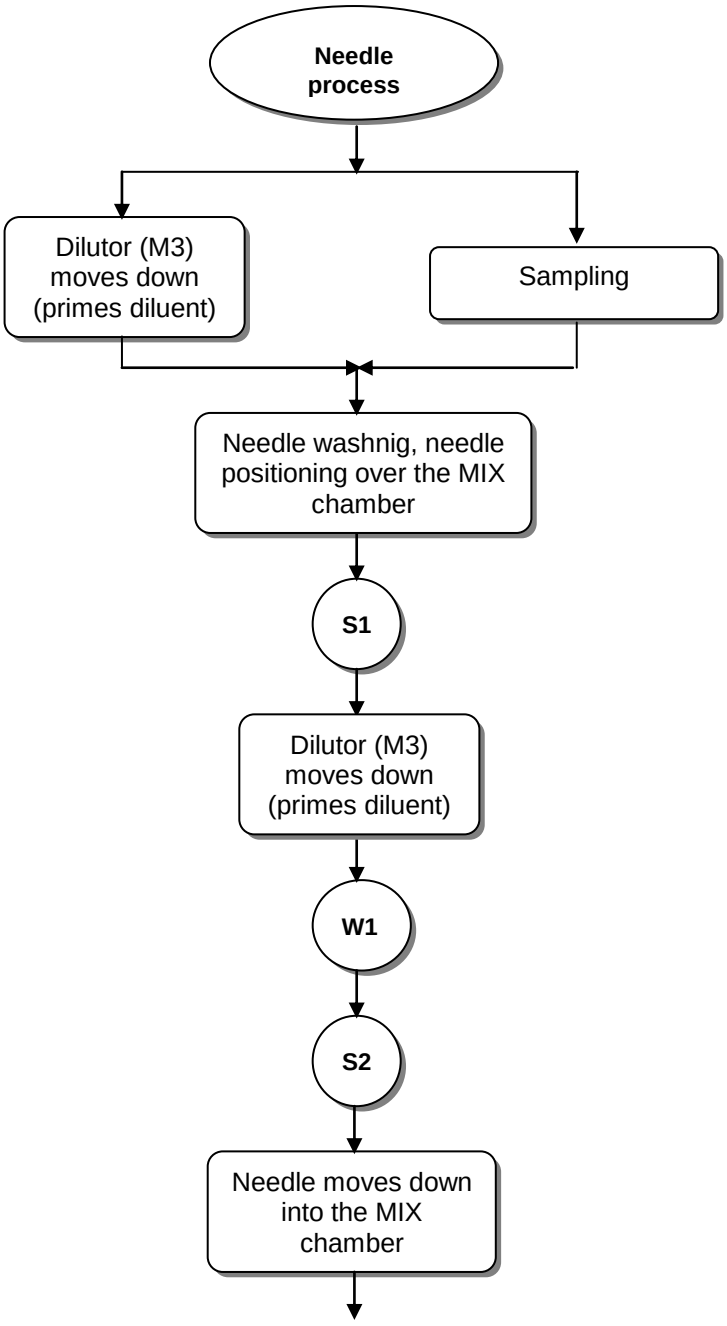
If the instrument is in standby state the wake up process is taken place in order to make the instrument ready to measure. During this process the needle is go out and down to the sampling position and the M1 and M2 stepper motor hold it until the start button pressed or the instrument go into standby. While the needle is moving the microdilutor (M5) is aspirate some air into the needle (this bubble is going to separate the dilent and the blood). After this procedure the status LED is turned blue and measurement can be started.

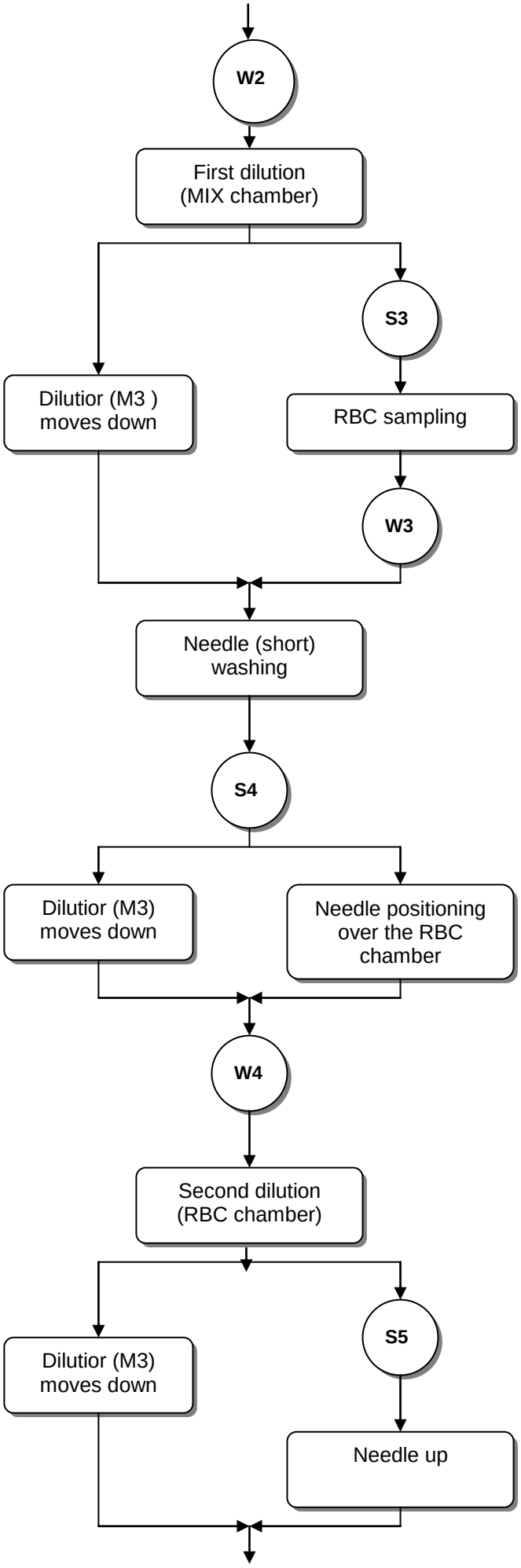
Simultaneously the MIX and the WBC chamber is drained (WBC draining, MIX→WBC, WBC draining). During the last WBC chamber draining the MIX is filled with 5.0 ml diluent. Then this volume is moved into the WBC chamber.

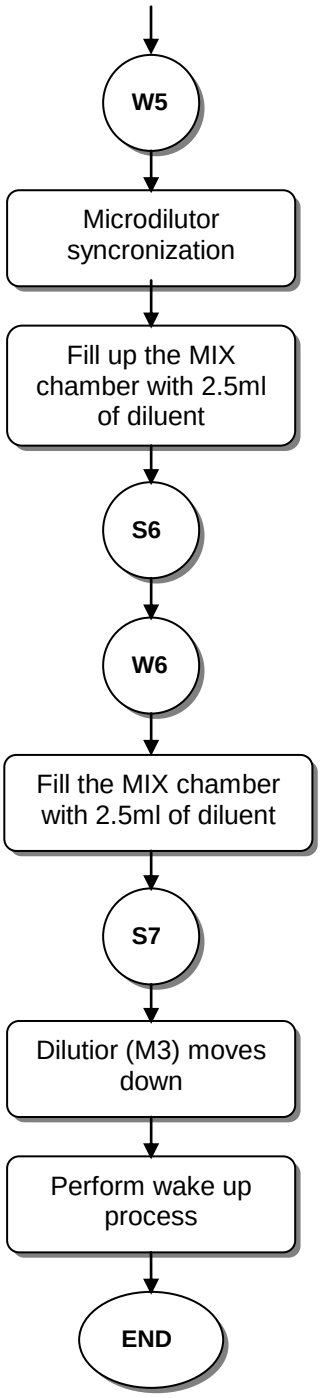
4.2.3. Measurement cycle

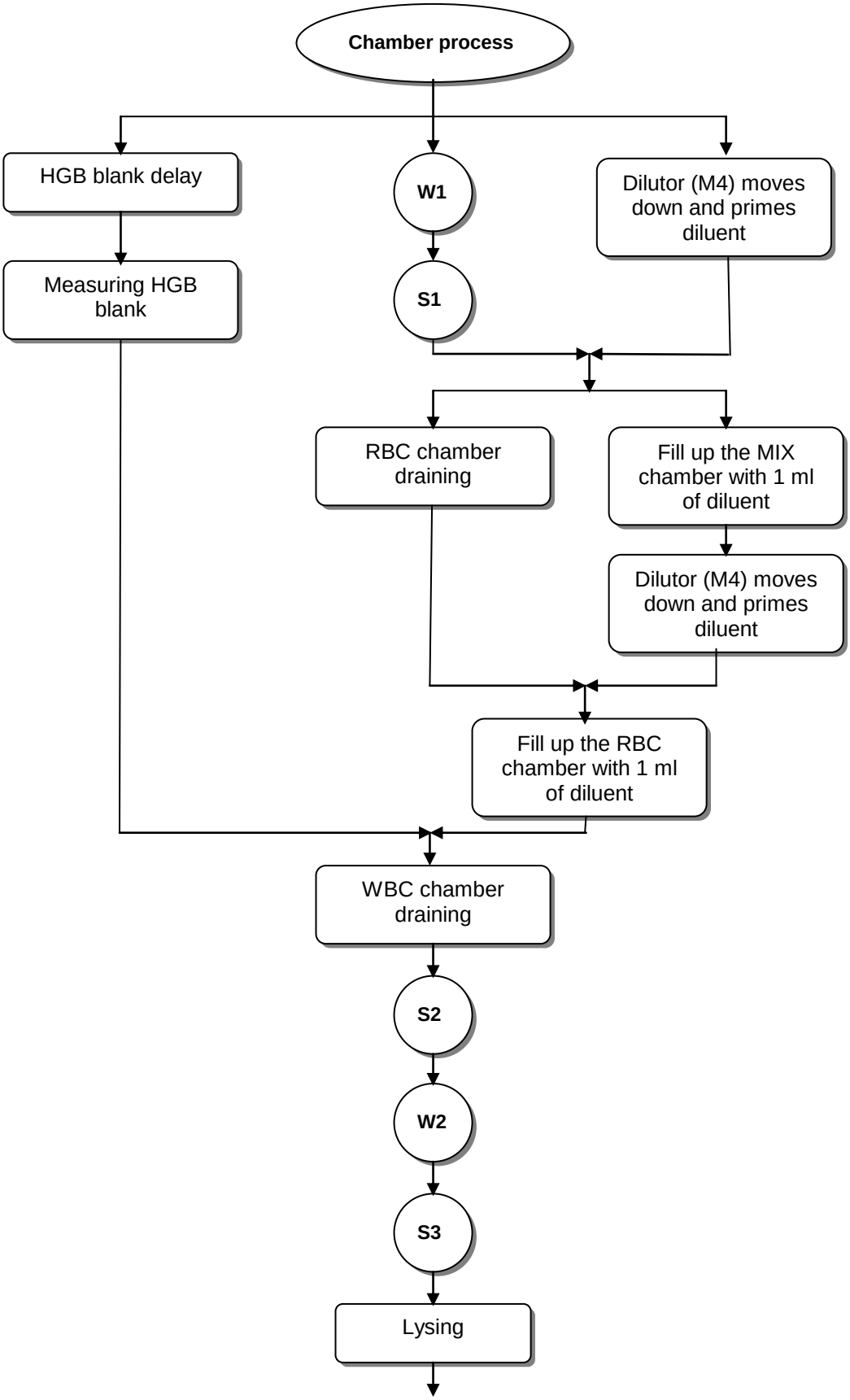
Before the start of the measurement cycle the instrument is in ready state (status LED is green). In this state the sampling needle is in the sampling position: out and down. The Mix chamber is empty, the WBC chamber contains 5.0 ml of diluent (the wake up process or previous measurement put it into the chamber and the blank HGB measured with this liquid used). The RBC chamber contains the last rinsing amount of diluent of the previous measurement cycle or the standby volume.

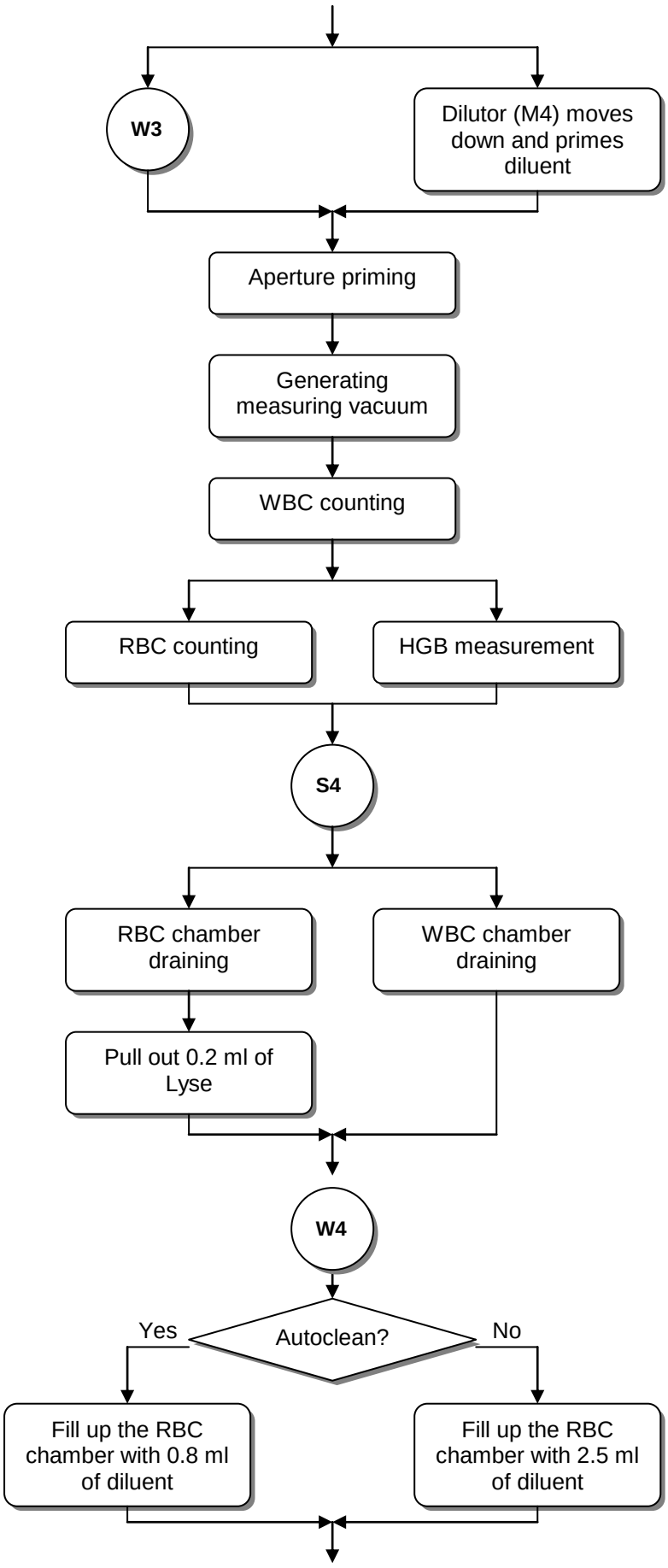
The following two flowcharts introduce the entire measurement cycle. One of these flowcharts describes the fluidic transfers related the needle, the other one the chamber related activities. The flowcharts has synchronization points where one of them waiting (**W**) for the others signal (**S**).

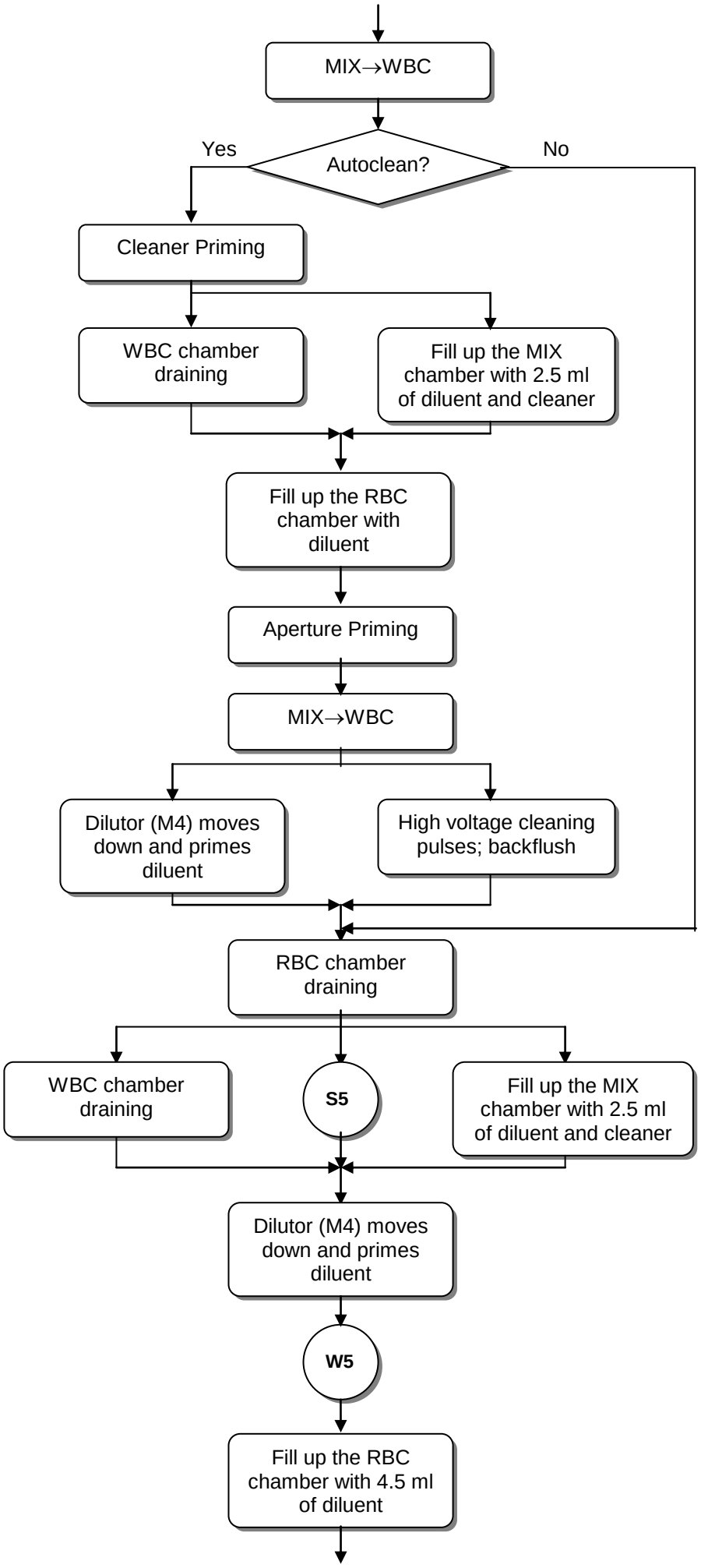


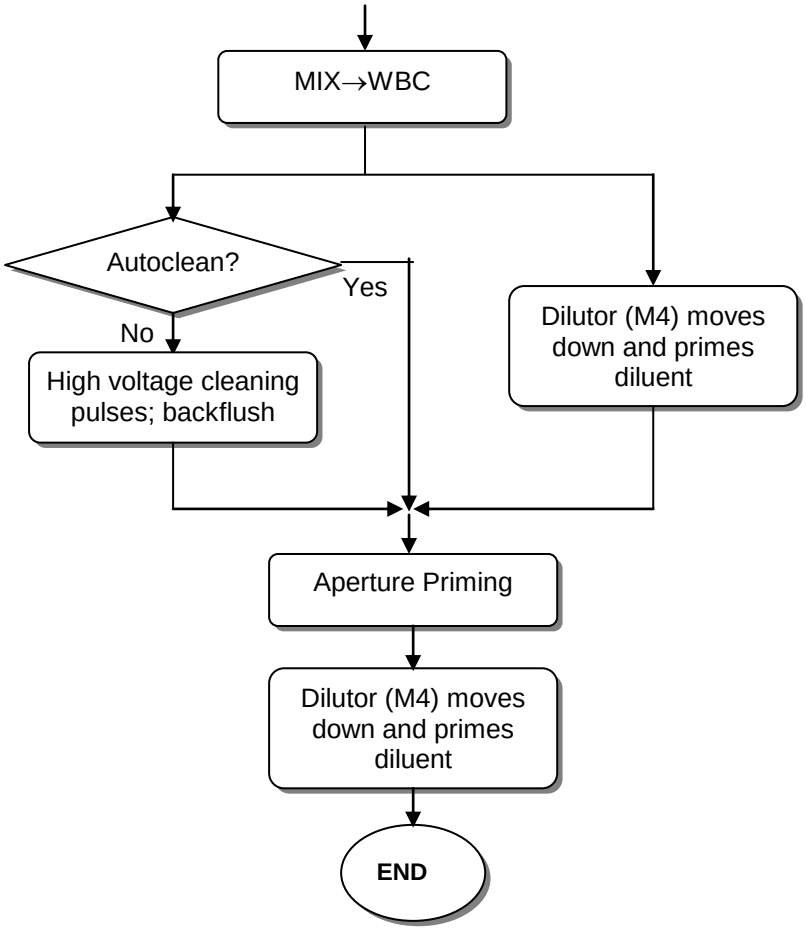

W2
First dilution
(MIX chamber)
S3
Dilutior (M3)
moves down
RBC sampling
W3
Needle (short)
washing
S4
Dilutior (M3)
moves down
Needle positioning
over the RBC
chamber
W4
Second dilution
(RBC chamber)
S5
Dilutior (M3)
moves down
Needle up


W5
Microdilutor syncronization
Fill up the MIX chamber with 2.5ml of diluent
S6
W6
Fill the MIX chamber with 2.5ml of diluent
S7
Dilutior (M3) moves down
Perform wake up process
END


Chamber process
HGB blank delay
W1
Dilutor (M4) moves down and primes diluent
Measuring HGB blank
S1
RBC chamber draining
Fill up the MIX chamber with 1 ml of diluent
Dilutor (M4) moves down and primes diluent
Fill up the RBC chamber with 1 ml of diluent
WBC chamber draining
S2
W2
S3
Lysing


W3
Dilutor (M4) moves down and primes diluent
Aperture priming
Generating measuring vacuum
WBC counting
RBC counting
HGB measurement
S4
RBC chamber draining
WBC chamber draining
Pull out 0.2 ml of Lyse
W4
Yes
Autoclean?
No
Fill up the RBC chamber with 0.8 ml of diluent
Fill up the RBC chamber with 2.5 ml of diluent


MIX→WBC
Yes
Autoclean?
No
Cleaner Priming
WBC chamber draining
Fill up the MIX chamber with 2.5 ml of diluent and cleaner
Fill up the RBC chamber with diluent
Aperture Priming
MIX→WBC
Dilutor (M4) moves down and primes diluent
High voltage cleaning pulses; backflush
RBC chamber draining
WBC chamber draining
S5
Fill up the MIX chamber with 2.5 ml of diluent and cleaner
Dilutor (M4) moves down and primes diluent
W5
Fill up the RBC chamber with 4.5 ml of diluent



4.2.4. Standby

Standby process is executed when the instrument is in ready state and the standby time (see Service Settings) ellapsed

In the beginning of the standby process the needle goes up and is washed and the chambers are drained. After this the 3.0 ml diluent is put into MIX (via needle) and the RBC chamber (via V8), and the diluent from the MIX is transferred into the WBC chamber and at last MIX chamber is filled with 1 ml of diluent and the back side of the apertures are primed. The diluent in the chambers prevent the apertures and chambers from dirt, drying out and salt build up.

4.2.5. Cleaning

Cleaning function drains all of the chambers and fills the RBC chamber and the MIX chamber with 2.5 ml of diluent. After moving content of the MIX chamber into the WBC chamber the aperture branch is primed with cleaner (see 4.1.10.). The remaining cleaner between the cleaner detector and the V6 valve is pushed into the MIX chamber with diluent. After this the WBC chamber is drained and the cleaner with diluent transferred here from the MIX chamber. Then the apertures are cleaned with high voltage burn and with backflush. The RBC chamber rinsed with 5.0 ml of diluent and the remaining cleaner is pushed out with diluent from the aperture branch (and back side off the apertures). At least the volumes of the standby state are dosed into the chambers.

4.2.6. Hard cleaning

Before the hard cleaning a wakeup procedure is executed. After pressing the start button the M3 dilutor aspirates 0.2 ml from the hard cleaning solution. Half of this amount is dosed into the MIX chamber (diluted with 5.0ml diluent coming from the other dilutor unit M4 through V10, V8 , V6) and the remaining cleaning solution is pushed into the RBC chamber with 5.0 ml diluent (see diluting process). Then the M4 dilutor unit pulls and pushes the diluted cleaner solution via the aperture combined with high voltage burns. After this the chambers are drained and rinsed with diluent.

4.2.7. Shutdown

The fluidic shutdown performs the following steps:

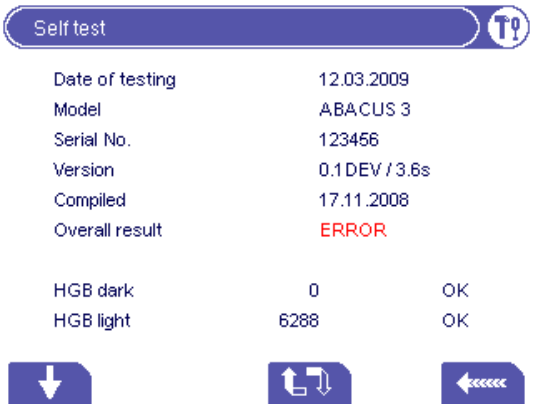
- Drains chambers
- Perform a cleaning cycle
- Priming chamber with diluent to avoid drying out of aperture (MIX 2.0 ml, RBC 5.0 ml, WBC 5.0 ml)
- Sampling needle is positioned above MIX chamber, needle up
- All of the syringes are positioned down

5. CHECKING THE PROPER OPERATION

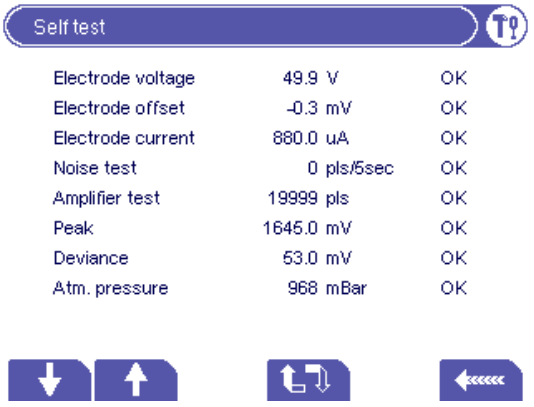
There is a built-in Self test and Service menu in the analyzer.

5.1. Self test

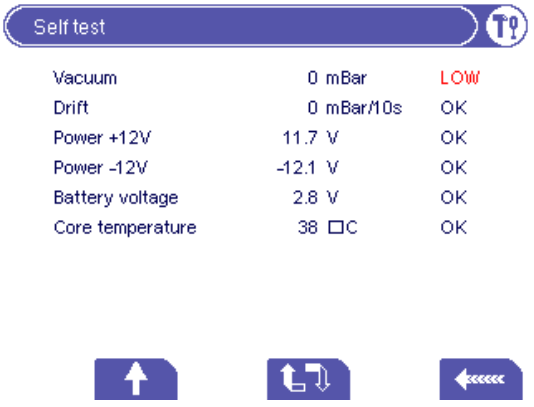
5.1.1. Self test Screens



Self test can be used to check the operation of the instrument.
The first panel shows general information about the instrument. (See menu on the left.)
With the new COMB card, the PCPNIF firmware version is empty, and the MPU firmware version holds the COMB version number**.**
Overall test result is displayed, which can be *Successful* (in case of every test result is *OK*) or *Errors* (if *HIGH, LOW* or *ERROR*).
The panels contain tested parameters, as follow:
HGB light/dark (LED is on/off).



Measuring **Electrode voltage**, **current** and **offset**.
Amplifier **Noise test** during a 5-second period.
Amplifier transfer by generating 20000 **test** pulses, incl. gain related **peak** value, noise related **dev**iation.
Atmospheric pressure stands for outer pressure.



Vacuum reports pump operation (vacuum made by the pump in a 10-second period of time).
Drift represents pressure loss of vacuum measured in a 10-second period of time.
Power ±12V shows the amplifier voltage value.
Power Batt reports the voltage value of the battery. If battery fails, system time will stop.
Core Temp shows CPU temperature of the Control and Measurement Board (COMB).

At the end of a **result line status message** is displayed, which means that the actual test result is at the normal range (*OK*), higher (*HIGH*), lower (*LOW*) than the pre-determined limits, or the result is an error (*ERROR*).

5.1.2. Normal range of Self Test parameters

Parameter	Unit	Lower bound	Upper bound
HGB light	count	3000	60000
HGB dark	Count	0	3000
Electrode voltage	V	45	55
Current	µA	830	930
Offset	mV	-5.0	5.0
Amplifier test	count	19990	20005
Peak of test pulses	mV	1500	1800
deviation (noise)	mV	0	80
Noise test	pls/5sec	0	5
Outer pressure	mBar	500	1050
Vacuum	mBar	125	420
Drift	mBar/10sec	0	10
Power +12V	V	11.0	12.5
Power –12V	V	-13.0	-11.0
Power Batt.	V	1.8	4.5
Core Temp.	°C	-	-

5.1.3. Troubleshooting Guide for Self test

Parameter	Mark	Possible reason	Remedy
HGB dark	*HIGH*	Instrument door open	Close instrument door
HGB light	*LOW*	HGB head not connected or HGB LED out of order	Check HGB head connections check HGB LED during measurement
	HIGH	Instrument door open or HGB LED too bright	Close door or replace HGB LED resistor on amplifier board
Electrode voltage	*LOW* or *HIGH*	Fault on High Voltage or Amplifier board	Check measuring voltage (50V) on High voltage and Amplifier boards
Current	*LOW* or *HIGH*	Fault on Amplifier board	Check current generator, and test generator FET on Amplifier board
Offset	*LOW* or *HIGH*	Fault on Amplifier board	Check the offset potentiometer on Amplifier board
Amplifier test	*LOW*	Amplifier Boards is not connected to main board	Check cables and connectors coming from the Amplifier
	HIGH	Instrument not grounded	Check mains ground lead
Peak of pulses	*LOW* or *HIGH*	Fault on Amplifier board	Check current generator, and test generator FET on Amplifier board
Dev. (noise)	*HIGH*	Instrument not grounded	Check mains ground lead
Noise	*HIGH*	Instrument not grounded	Check mains ground lead
Outer pressure	*LOW* or *HIGH*	Pressure sensor, cable or connector problem	Check pressure sensor, cable connections and controller board pressure connector
Vacuum	*LOW*	Peristaltic pump failure	Check peristaltic pump
Drift	*HIGH*	Leakage in pneumatics	Check tubing in pneumatics

5.2. Service Menu

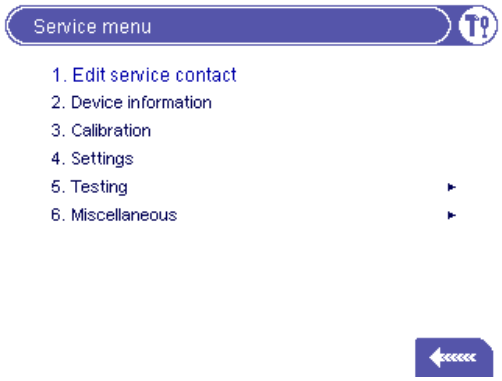
5.2.1. Entering to Service Menu

There is a Service menu for servicing and operation checking purposes. The entry point is in the User's Service screen, where Service Information is displayed.

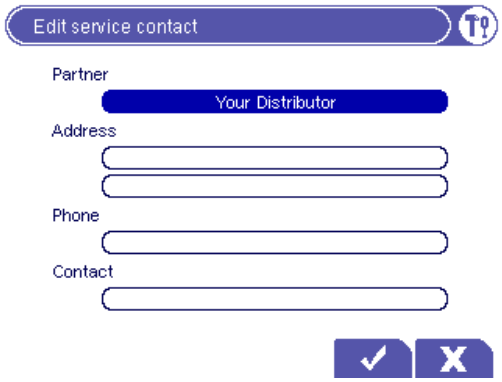
> ***Enter the code to access Service menu: 6484***

5.2.2. Main Service Menu

The Main Service menu provides access to submenus and service utilities.



5.2.3. Edit service contact



Here you can edit the Information card fields by cursor keys, or by an external keyboard.

Press the OK button, if a field is completed.

This information will appear in the User Service menu.

5.2.4. Device Information

In the Device Information menu the model name, the serial number, the software version and compilation date appear.

5.2.5. Service Calibration

The analyzer provides a menu for Service calibration purposes.

In result calculations the service calibration factors are used as the user calibration factors, so they are multiplied for each parameter: $\mathbf{RBC_{Disp.} = Fact_{RBC\ User} * Fact_{RBC\ Serv.} * RBC_{Measured}}$

If the user factor is near the bound (0.80 - 1.20), by setting the corresponding service factor, the user factor can be adjusted to 1.00.

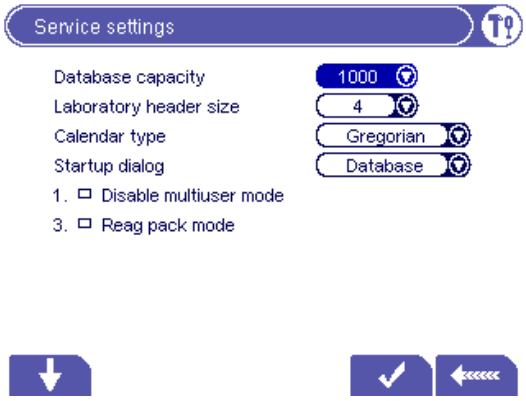
Example: **Fact** $_{\text{RBC User}}$ = 1.19 and **Fact** $_{\text{RBC Serv}}$ = 0.96, and
Fact $_{\text{RBC User}}$ = 1.00 and **Fact** $_{\text{RBC Serv}}$ = 1.14 gives the same result for RBC.

Apply user calibration **factors** function is used to combine user and service calibration factors. The software will multiply the existing factors, and move them to the Service level to set user factors to 1.00.

5.2.6. Settings

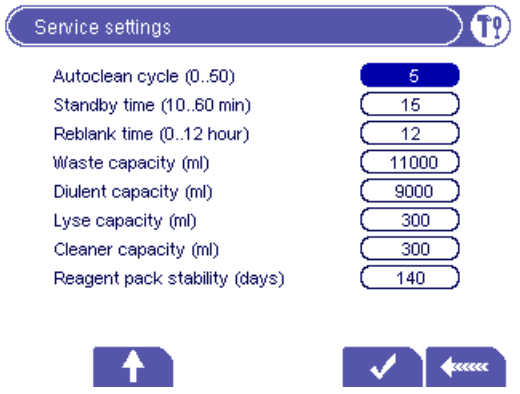
5.2.6.1. Pneumatic/Measurement options

Service Person can set the parameters of the automatic functions in this dialog menu.



Standby time: after how many minutes the instrument goes to standby mode (default = 15 min).

Reblank time: after how many minutes the instrument makes a blank measurement if it was in standby mode (default = 1 hour). If it is set to 0, then no ReBlank is performed.



Rinse time: If this time is set, then the instrument will make an automatic, extended washing procedure (with more diluent) of the chamber(s) to get wash dirt out of the chambers (dust). If it is set to 0, then no Rinse is performed.

Autoclean cycle: after how many measurements the instrument makes an autocleaning.

Disable 3-part diff.: for using quick lyse (without 3-part differential) the errors and the bad 3-part parameters can be excluded from the results

Disable markers: setting this option to Yes will omit the vertical markers from printed reports.

Stretch histogram: setting this option to Yes will modify the WBC histogram range from 0-300 fl instead of 0-400 fl (this is recommended for Veterinary mode).

Reagent code: This code can be used to modify the offset of the HGB function. Enter a value between 0 and 30 (default is 9).

Extended Probe Voltages: This option is ON by default. It makes the instrument accept the physically highest probe voltages to allow operation at lower operating temperature range.

Maintenance day: You can select from week days. According to this setting, the instrument will ask the user to do weekly maintenance during shut down.

Laboratory header lines: you can choose how many lines to contain the header of the blood result.

Reagent pack: Using packed reagent in Reagent status menu system displays the reagent pack installation day and the **Reagent open stability** period. User can change reagents only together. In case of “No” reagents can be changed separately, the date of expiry is ignored.

Waste container capacity: it essential to set the correct volume of the waste container for proper usage of the software ”waste full” alert, code: 5006. Set this value two liters less than the total volume of waste container.

Lyse container capacity: Enter here volume of lyse container.

Cleaner container capacity: Enter here volume of cleaner container.

Rinse container capacity: For future development. Enter here 0.

It is possible, but not recommended ignoring the reagent volume check entering 0 as volume of containers.

Clogging detections, bubble volumes for development, do not touch them!

5.2.6.2. Operation Settings

LCD light off delay: LCD backlight switches off after 4 hours, by pressing key switches back. Still the light is off, the LED is flashing yellow.

Disable multi-user mode: by this setting the multi-user mode can be disabled

Instrument startup procedure: You can select to start the instrument with Database screen (without any pneumatic initialization) or with Measurement screen (with pneumatic initialization).

Database capacity: You can choose here the capacity of database at installation. Changing later all measured data will be lost. Using larger database the instrument software startup time can be increased.

Native keyboard: Setting it to Yes will utilize the external PC keyboard with the language specific layout.

Calendar mode: You can select between the Gregorian and the Jalaali (Persian) calendar. All dates will be converted accordingly.

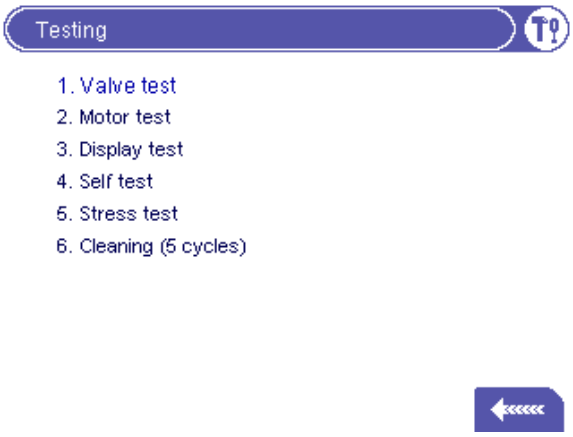
Patient data: There are two options: Birthdate and Age. According to this setting, both in the sample information dialog and in the database, the instrument will prompt for the age or the date of birth. If age is specified, it can be given in years or months.

5.2.6.3. Edit Service Code

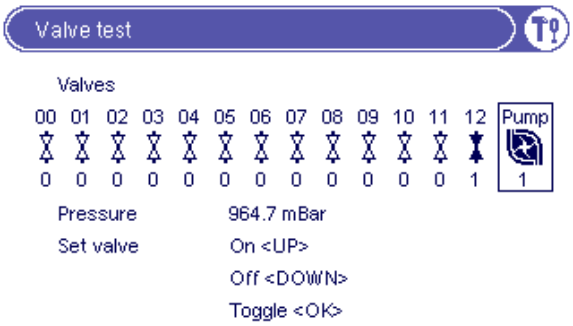
You can change here the default (6484) service code to a maximum 12 character alphanumeric code. It is recommended not to change the code, if it was changed, it is hardly recommended to save the new code.

5.2.7. Service Testing Menu

Service Testing menu provides tools for checking hardware.



5.2.8. Valve Test Menu



In the menu on the left you can see the valve numbers and a number under each that represents the actual state of the valve. **P means peristaltic pump**.

Selected valve number is shown in inverse. 0 is **Off** state, 1 is **On** state.

Use cursor keys for selecting and setting valve state, or press OK to toggle state.

5.2.9. Motor Test Menu

Pressing numeric key on keyboard the regarding motors start operation repeatedly, until pressing ‘1‘ , or another key. All motors stop at initial positions.

5.2.10. Display and Keyboard Test

Display and keyboard test is provided to check keypad and LCD panel.

Press a key to test and the LCD will show the code of the pressed key, and will be invert the colors at each touch of a key for testing that every LCD dot is functioning.

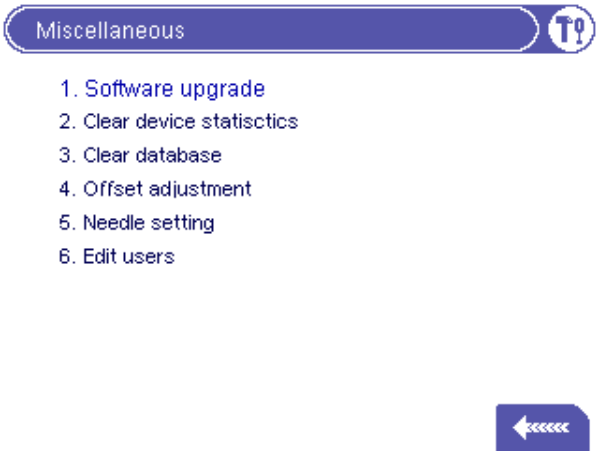
5.2.11. Stress Mode

In **Stress mode,** the instrument performs measuring cycles without sample (blank measurements) continuously. This can be used for burn-in tests, or to check pneumatic system after changing any main fluidic parts.

You can have information about stability, cleanliness, HGB operation, and counting time stability. Results of the last 10 PLT and HGB blank is displayed as well.

You can detect any kind of noise, or bubbles in the system if the PLT is not stable low, or HGB has big variation. To exit from this mode **press the START button** (at the end of a normal cycle) until the Stress operation is finished.

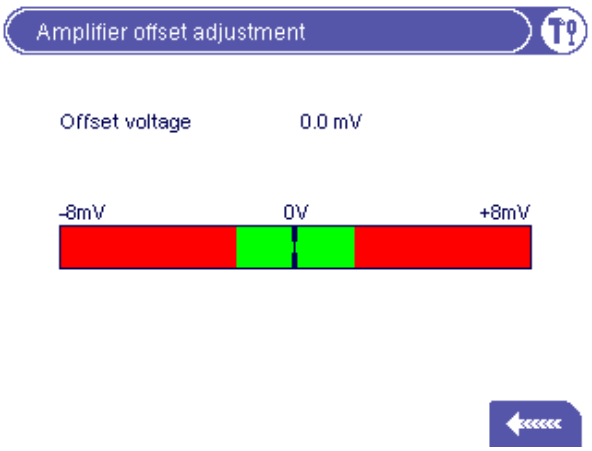
5.2.12. Miscellaneous Settings



In this menu, you can directly perform **Software upgrade** (this will restart the instrument).

Clear Device Statistics: Device statistics (number of measurements, aperture-clogging and other errors) can be cleared.

Clear Database: The whole Database (measurement results including histograms) can be cleared.



Offset adjustment: You can adjust the offset on the amplifier board. The lower indicator (line) represents the measured voltage.

Needle setting: By entering this menu the needle will go to the position you can adjust it.

You can **Log in as supervisor** if the Multi-user mode was selected in the User's Settings submenu. (Number 4 if present, shows the availability of this function.)

In supervisor mode, you have the ability to change any user passwords and you have full access over user settings. **Always log out after this supervisor log in.**

5.2.13. Multi-user Rescue Code

It the supervisor password has been forgotten, there is a rescue code for service purposes to access the supervisor level. The Service user data are as follows:

User ID: **0** (zero),
Name: **Service,**
Password: **729456** (This forms a capital "A" on the keypad)

6. SERVICE OPERATION

6.1. Opening the instrument

On the right side of the instruments there is a side door, which allows reaching of the fluidic system and the mechanical parts. Other parts of the analyzer (electronic parts, etc.) can be reached by opening the top-left cover.

- How to take off the **top-left cover**:

First unscrew the 5 cover fixing screws located on the rear panel, 3 screws on the upper side and 2 screws on the vertical side. After this, pull the cover backwards a few centimeters to release sliding locks, and then you can turn it upwards to take it off completely. Care for internal printer flat cable: disconnect it from the printer connector. In this way you will be able to reach the electronics.

6.2. MDA (Monochrome Display Adapter) emulation mode

MDA emulation mode was developed to help the manufacturer and Service Personnel in the checking phase of the instruments. This mode is available during the total operation but especially useful for checking the BIOS setup and OS functions. This mode should be handled the same as the service menu, the user does not have to know these options.

At power-on, the controller PIC display module displays the greeting screen. After 6 seconds, it starts to scan the keypad and behaves like an **MDA** adapter to the PC, although the displayed screen is still holding the greeting screen.

If you switch to **MDA emulation mode**, the system boot events can be displayed, and the CMOS SETUP program can be started, if necessary.

If the main program will not start in 90 seconds, the PIC will automatically switch to MDA displaying mode to give information about the reason of hang-up. This can be some CMOS failure, if the motherboard settings are lost for some reason, and the system is waiting for user confirmation: F1 **on external keyboard,** or running setup - both require external keyboard to be connected.

Hold the „**i**” button, and press and release the „**.**” button on the foil keyboard of the analyzer to activate the **MDA** mode, which uses the LCD like a primary computer monitor (80 characters by 25 rows). The LCD is smaller than the standard monitor area therefore just about a quarter of the total screen is displayed (40 characters by 16 rows).

Quarter 1 on LCD	Quarter 2 on LCD
Quarter 3 on LCD	Quarter 4 on LCD

Definition of displayed LCD quarters in MDA emulation mode

- to change the actual quarter displayed, use the arrows (cursor keys) on the keypad,
- to find the cursor, press the „**i**” button,
- to go back to the normal graphic displaying mode press „**i .**” again.

6.3. Key BIOS settings for correct operation

The required settings are enclosed in this section.

(In MDA mode, continuous changing of screen may appear. To avoid this, press left and up arrow on the keypad in any order.)

- **MAIN:**
- Legacy Diskette A: 1.44/1.25 MB
- Primary Master: FlashDisk SDTE-XX
- **ADVANCED:**
  - PNP OS Installed: No
  - Reset Configuration Data: No
    - **I/O device configuration:**
      - Local Bus IDE Adapter: Disabled
      - Floppy disk controller: Enabled ; [in case of Floppy drive]
        Base I/O address: Primary
      - Serial Port A: Enabled
        Base I/O address: 3F8
        Interrupt: IRQ4
      - Serial Port B: Enabled
        Base I/O address: 2F8
        Interrupt: IRQ3
      - Parallel Port: Enabled
        Mode: EPP
        Base I/O address: 378
        Interrupt: IRQ7
    - Watchdog Settings
      Mode: Disabled
    - I/O Chip Select:
      I/O Base: Disabled
  - Halt on Errors: No
- **SECURITY:**
- Fixed disk boot sector: Normal
- Virus check reminder: Disabled
- System backup reminder: Disabled
- **BOOT:**
- Quick Boot mode: Enabled
  - **Boot Device Priority:**
    - CD-ROM Drive
    - Hard Drive
      DV-XX (Slave device)
      FlashDisk SDTE-XX
      Bootable Add-in Cards
    - Removable Devices
      Legacy Floppy Drives
    - Network Boot

6.4. Checking the BIOS setup

It is suggested to check it if the instrument hangs after switching on, or software does not start (or cannot be upgraded from floppy disk).

- Connect an external keyboard (US layout) to the instrument.
- Press F2 and keep pressed and switch the instrument on.
- Release F2 when the instrument beeps.
- Switch the instrument to MDA emulation mode (by pressing "**i.**" on the keypad)
- Check the key points listed above (or from the enclosed Main Board Manual), if you find differences, set these settings
- Go to the ***Exit*** menu (upper right quarter of the display) and select ***Exit Saving Changes***. Confirm this by selecting ***Yes*** in the pop up window.
- The instrument will restart with the new (correct) BIOS setup configurations

6.5. BIOS-Description

The ***DIMM-PC/520-I*** is equipped with a JUMPtec Embedded BIOS, which is located in a Flash EPROM onboard. This device has an 8bit wide access. Faster access is provided by the shadow RAM feature (default). For a detailed description of the BIOS Setup, please refer to the section below.

The Setup Guide

With the PhoenixBIOS Setup program, it is possible to modify BIOS settings and control the special features of the computer. The setup program uses a number of menus for making changes and turning the special features on or off.

General Information

To start the PhoenixBIOS setup utility press <F2> during the string, Press <F2> to enter, setup is displayed during boot-up. The Main Menu will be displayed.

The Menu Bar

The Menu Bar at the top of the window lists all the different menus. Use the left/right arrows to make a selection.

The Legend Bar

Use the keys listed in the legend bar on the bottom to make your selection or exit the current menu. The list below describes the legend keys and their alternates:

Key Function

<F1> or <Alt-H>	General help window
<Esc>	Exit this menu
left or right Arrow key	Select a different menu
up or down Arrow key	Move cursor up and down
<Tap> or <Shift-Tap>	Cycle cursor up and down
<Home> or <End>	Move cursor to top or bottom of current window
<PgUp> or <PgDn>	Move cursor to next or previous page
<F5> or <->	Select the previous value for the current field
<F6> or <+> or <Space>	Select the next value for the current field
<F9>	Load default configuration values for this menu
<F10>	Save and Exit
<Enter>	Execute command or select submenu
<Alt-R>	Refresh screen

To select an item, simply use the arrow key to move the cursor to the field you want. Then use the plus and minus keys to select a value for that field. The Save Value commands in the Exit Menu save the values currently displayed in all the menus.

To display a sub menu, use the arrow keys to move the cursor to the sub menu you want. Then press <Enter>. A pointer (4) marks all sub menus.

The Field Help Window

The help window on the right side of each menu displays the help text for the currently selected field. It is updates as the cursor is moved to each field.

The General Help Window

Pressing <F1> or <Alt-F1> on any menu brings up the General Help Window that describes the legend keys and their alternates. Press <Esc> to exit the General Help Window.

The Main Menu

You can make the following selections on the Main Menu itself. Use the sub menus for other selections.

6.6. DOS functions on the instrument

To run the computer part of the instrument like a normal PC, the Service Personnel should have a floppy drive with cables (see chapter 9.5), and an **MS-DOS** 6.22 operating system **boot floppy** disk.

- Take off upper cover of instrument
- Connect an external keyboard
- Connect the floppy drive to PPB board Floppy/CD power connector, COMB board FLOPPY connector.
- Put the MS-DOS boot floppy into the floppy disk drive
- After turning on, go to the BIOS setup (press F2 repeatedly on the keyboard and switch to MDA mode by pressing "i**.**").
- Change the ***Boot Device Priority*** in the ***BOOT*** menu: The ***Removable Devices*** must be the first in the list. Select ***Removable Devices*** and move it up by pressing “+” on the keyboard.
- Save the actual settings to CMOS, the instrument will restart (***Exit Saving Changes***)
- The instrument will boot from the floppy and the software will be terminated
- Switch to MDA mode by pressing "i**.**"
- Do not forget to restart the instrument and set back ***Boot Priority*** list after servicing, (***Hard Drive*** first)

7. TROUBLESHOOTING

The analyzer checks the operations of several mechanic, fluidic and electronic parts during measurement. The system shows the type of the error on the LCD display if any kind of malfunction is detected.

The electronic parts have a very little chance to fail, only the connections and cables could disconnect, which can cause the malfunction of the electronic system. The mechanic and fluidic system have a bit more chance to go wrong because it has moving parts.

This section allows to know what to do when a troubleshooting message appears on the screen.

7.1. Error codes

%s: filename concerned, %d: error type concerned, %u: error specific string

7.1.1. Software/system errors

Code	Message	Reason(s)	Remedy
1001	Error %d on opening file %s	Fatal system or program error!	The same as in case of error 1000.
1002	Cannot create file %s	Fatal system or program error!	The same as in case of error 1000.
1003	Data file %s is corrupt, new will be created, all stored measure data will be lost	Stored data file is corrupt or missing! Disk or software error.	New stored data file will be created automatically (by User confirmation).
1004	Error %d on indexing file %s	Fatal system or program error!	The same as in case of error 1000.

7.1.2. Pneumatic errors

Code	Message	Reason(s)	Remedy
1100	Fatal pressure error. Power off the system!	Cannot make the measuring vacuum!!	Check the pump and the tubes, fittings and valves around the puffer reservoir.
1101	Waste is full! Empty waste container! The system assumes that you will do it before going on!	Waste container is full!	Empty waste container!
1102	Check Diluent container!	Diluent reagent container become empty, or one of the diluent fluid sensor is too sensitive or there are a lot of bubbles in the diluent tubes!	Replace the Diluent reagent container with a filled one. If this error still remains with a filled diluent reagent container, calibrate sensors, and check the tubings and the fittings.
1103	Check Lyse container!	Lyse reagent containner become empty, or the lyse fluid sensor is too sensitive or there are lot of bubbles in the lyse tubes!	Replace the Lyse reagent container with a filled one. If this error still remains with a filled lyse reagent container, calibrate sensors and check the tubings and the fittings.

1105	Vacuum error	The measuring vacuum has been dramatically decreasing during the measurement or absolutely lost!	Leakage in the pneumatic system (check the pump, fittings, tubings, pressure sensor, puffer reservoir and valves).
1106	Pneumatical error occurred! Device: %s Error code: %s Status: %x Retry?	Fatal error in mechanical subsystem.	If frequently happens this error check the proper operation of the motor modules (home/end opto switches, ribbon cables and moving of motors).
1107	Check Cleaner container!	Cleaner reagent container became empty, or the clean fluid sensor is too sensitive or there are lot of bubbles in the cleaner tubes!	Replace the Cleaner reagent container with a filled one. If this error still remains with a filled cleaner reagent container, calibrate sensors and check the tubings and the fittings.
1113	Unrecoverable pneumatical error occurred!\n Device: %s\n Error code: %s\n Status: %x\n Please turn off the instrument and turn it on again!	Fatal error in mechanical subsystem. Possibly mechanical jam.	Check the proper operation of the motor modules (home/end opto switches, ribbon cables and the motor moving).

7.1.3. Measure errors

Code	Message	Reason(s)	Remedy
1200	Fatal “MeasInit” error. Power off the system!	Fatal electronic error.	Call service.
1201	Fatal HGB error. Power off the system!	HGB channel did not give a ready signal!	Call service.

7.1.4. Printing errors

Code	Message	Reason(s)	Remedy
1400	Printer error %d	Printer error!	Check the connections between the instrument and the printer and check the printer setup in the Settings/Printer settings sub-menu.
1401	Printer is out of paper and error %d	Printer is out of paper and there are some other printer errors!	Feed the printer with paper. Check the connections between the instrument and the printer and check the printer setup in the Settings/Printer settings sub-menu.
1402	Printer is out of paper	Printer is out of paper!	Feed the printer with paper.
1403	Printer was not set up correctly	The selected printer type does not match to the printer!	Modify the printer setup in the Settings/Printer settings sub-menu.
1404	Paper width is too large	Paper width steps over the margin!	Modify the paper setup in the Settings/Printer settings sub-menu.
1405	Paper height is too large	Paper height steps over the margin!	Modify the paper setup in the Settings/Printer settings sub-menu.
1406	Paper width is too small	Paper width steps over the margin!	Modify the paper setup in the Settings/Printer settings sub-menu.
1407	Paper height is too small	Paper height steps over the margin!	Modify the paper setup in the Settings/Printer settings sub-menu.
1408	Left margin is too large	Left margin is too large!	Modify the margin setup in the Settings/Printer settings sub-menu.
1409	Top margin is too large	Top margin is too large!	Modify the margin setup in the Settings/Printer settings sub-menu.
1410	Spacing is too large	The distance between two results is too high!	Modify the vertical spacing setup in the Settings/Printer settings submenu.
1411	Error #%d in printer initialization!	Printer software error!	Check the connections between the instrument and the printer and check the printer setup in the Settings/Printer settings sub-menu. Try to make a software upgrade.

7.1.5. Other errors

Code	Message	Reason(s)	Remedy
1900	You have to add at least one user to use multi user mode!	Multi-user problem	Follow the instruction, or change to single user mode in the User settings submenu.
1921	%s sensor calibration failed! The system turned off the %s sensor.	Reagent container became empty, or there are lot of bubbles in reagent tubes.	Replace the reagent container with a filled one. If this is still a problem with a filled reagent container, turn on the sensor and try recalibrating and check the tubings and the fittings.

7.2. Warning messages

7.2.1. Pneumatic warnings

Code	Message	Reason(s)	Remedy
5001	Remove reagent tubing at rear reagent inputs (Diluent, Lyse, and Cleaner).	First message of preparing for shipment.	Remove the reagent tubing and leave waste connected. After pressing ✔ the analyzer drains itself.
5002	Connect min. 100 ml distilled water to reagent inputs using cleaning tube kit.	Second message of preparing for shipment.	Connect cleaning tube kit with at least 100 ml distilled water and press ✔. After this the analyzer will be rinsed with the distilled water.
5003	Remove cleaning tube kit. Keep reagent inputs free.	Third message of preparing for shipment.	Remove the reagent tubing and leave waste connected. After pressing ✔ the analyzer drains itself.
5004	You can power off the system!	The preparing for shipment function is finished.	Power off the instrument.
5005	Apertures are partially clogged. Try cleaning!	During the measurement one or both of the apertures were clogged (“C” for WBC, “c” for RBC aperture).	Try cleaning, perform blank measurement. If the problem still persists use the hard cleaning function.
5006	Please empty waste container!	The calculated waste volume has reached its maximum level.	Check and empty the waste container. Press ✔.
5008	There are no accepted blank values. Measure blank?	The last blank measurement was unsuccessful.	If you press ✖ you will exit from measurement. If you press ✔ the blank measurement will start.
5009	The blank results are expired! Measure blank?	The reblank time has expired.	If you press ✖ you will exit from measurement. If you press ✔ the blank measurement will start.

7.2.2. Database relating warnings

Code	Message	Reason(s)	Remedy
5101	%u data record(s) is selected.	There are %u data records present in the database which match the selection.	Press ✔.
5106	No such type of data	There are no %u data records present in the database which match the selection.	Press ✔ and check the selection.
5108	Connect an USB storage device with data!	This message appears at View external function.	Connect storage media into the USB port and press ✔.
5109	% data record(s) will be saved on an USB storage device. Insert a storage device into the USB port.	The analyzer will save %u number of data records.	Insert USB storage media and press ✔.

7.2.3. Warnings relating to QC measure

Code	Message	Reason(s)	Remedy
5200	Your previous QC data will be lost. Are you sure?	When you press ✔ for accepting new QC target values.	If you press ✔ the new values will be accepted and all of the measurements on the selected QC level will be deleted. If you press ✘ old values remain

7.2.4. Calibration relating warnings

Code	Message	Reason(s)	Remedy
5300	Some or all of the calibration factors are out of range!	During automatic calibration at least one of the factors are out of the range 0.8 or 1.2.	Check the target values and the control blood and repeat the calibration. If the problem still persists contact the Service Personnel.

7.2.5. Hardware relating warnings

Code	Message	Reason(s)	Remedy
5400	+12V too low!	The +12V is not sufficient, the measurements are unreliable.	Contact the Service Personnel.
5401	-12V too low!	The -12V is not sufficient, the measurements are unreliable.	Contact the Service Personnel.
5402	Battery voltage too low!	The battery has been discharged.	Check Date and Time settings. This problem has no effect on measurement. Contact Service Personnel.

7.2.6. Other warnings

Code	Message	Reason(s)	Remedy
5901	Insert software update media! The system will restart.	Software upgrade (USB).	After pressing ✔ the system will restart.
5904	This function will delete all selected records.	Delete.	If you press ✔ all records will be deleted. If you press ✔ it will be not deleted.
5906	Now it is safe to turn the instrument off…	Shut down process has been finished.	Power off the analyzer
5907	Now it is time to wipe the washing head with a damp cloth. Make sure it is clean, then you proceed.	Maintenance day	You have to perform weekly maintenance. If you want to change the maintenance day contact Service Personnel.

7.3. Possible Causes of Noise

Generally high count of any particle - even if you think it should be low, or near zero - can be caused by NOISE, i.e. something interferes with measurement.

The most important thing in these cases to identify the source of NOISE, otherwise you cannot protect the system against it.

NOISE can come from has several sources, and the different NOISE sources are added.

Sometimes we have to fight one of them, but sometimes more. Only one of them is enough to make problem.

7.3.1. Contaminated reagent

The most probable cause: real particles are in the reagent, and therefore the PLT blank is continuously high (e.g. always 30-40). You can easily sort out this case by replacing diluent by opening a new tank. PLT blank must go down is several blank measurements (below 10).

How can a good reagent become bad by time?

- If the reagent tube was contaminated, and some bacteria begin to grow inside, once you put an infected reagent tube into a new tank, by time it can become infected as well, i.e. the background (PLT blank) becomes high. Wash the reagent tube - which is in connection with the reagent - with 1% of bleach solution, then rinse with clean distilled water or diluent. It can avoid the bacteria to grow inside.
- If tank is open – and cap is not installed or closed - external dust can make reagent dirty.

7.3.2. Bad earth grounding

In this case external - ground referenced - noise can get into the system by ground coupling. If system ground is not good enough, ground terminal can become a noise source as well, i.e. external signals will be coupled into the system instead of protecting it.

If no earth ground is available, you can use a screw at the rear panel to connect a ground potential to the case, so that noise immunity can be increased.

Measure voltage on ground terminal to make sure earth grounding is correct. AC voltage lower than 1V is accepted in this case.

At some places - as a bad practice - electricians like to connect earth ground terminal to neutral wire. Depending on the resistance of the neutral back wire (where it is really earthed), several volts can appear, and this way any inductive noise will be coupled into the instrument. It is better to create a real earth grounding and connecting it to the rear screw.

7.3.3. External electrical noise

If another instrument is near the analyzer can radiate electromagnetic signals in the 1 kHz - 100 kHz frequency region it can be picked up by the system (especially if they are very close to each other, or the grounding is not quite perfect).

You can easily identify this noise source: by relocating the instrument noise (high PLT blank) disappears. In this case you have to identify the possible noise source (switch mode power supplies, computer monitors, since they are not shielded, centrifuges due to high switching noise of rotor contacts, etc.), the power of the electromagnetic source, because if high power is present, maybe relocation does not solve your problems, sometimes the electric power supply makes the coupling, so UPS solves the problem.

Another source of coupling in external noise can be the reagent tanks and tubes. Especially radio transmitters can cause problems of radiating so that even the reagents (diluent) guides in the noise. A metal pack for the diluent tank, then a good earth grounding of this metal box allows this coupling to disappear forever.

7.3.4. Internal noise sources

The most annoying but real cause is some sort of internal noise. The reason for this phenomenon is that inside electrode - hot point - of the measuring circuit must be well insulated from surrounding electronics, otherwise inside noise sources can take their effect.

7.3.4.1. Bad chamber insulation:

- **bad shielding of the chamber** (floating shield couples signals to the chamber, and does not prevent against them). Check grounding of shield, remove it and clean the surface between the shield and the metal base.
- **bad reference electrode connection** (floating ground reference). Repair is required.
- **bad sealing of aperture**. Replacement of measuring tube is required.
- **broken measuring chamber** starts to conduct through the gaps (ground path). Replacement of chamber is required.
- **contaminated draining tube** starts to conduct due to protein or lipid build-up. It is very easy to identify this case. After replacing the drain tube of the measuring chamber (mainly WBC), WBC histogram peak, or PLT becomes low soon. Normally a good cleaner is required to dissolve lipid or protein build-up. Sometimes the cleaner is not strong enough to keep this tube clean enough. Periodic washing using 1% hand warm bleach solution helps.

7.3.4.2. Bad insulation of electronic signal paths:

In these cases check for any capacitive coupling of electronic signals to the chamber:

- **interference with HGB head** (high-frequency signal is coupled to the chamber). HGB head metal parts must be grounded. The ground comes externally, it must be in place, otherwise HGB head does not shield, but couples in noise.
- **interference with internal high voltage inverter** (high-frequency signal is coupled to the chamber). Repair is required: avoid near contact of HVB cable to chamber or shielded amplifier cable.
- **interference with internal start button** (polling signal to start button may cause noise). Guide start button wires as far from chamber as possible. You may try mix them up on the start micro-switch if applicable.
- **interference with display cable** (high-frequency LCD signal is coupled to the chamber by the ribbon cable). Keep the ribbon cable far from the chamber.
- **interference with CPU fan or other digital logic traces** (CPU fan or other digital signal radiates to chamber or to the shielded amplifier cable). Try keeping the ribbon cables far from the chamber and shielded cable.

7.3.4.3.C. Bad components, or connections:

- **bad soldering, salt residuals or component failure on amplifier** (especially if some reagent could get in the amplifier section). Cleaning of PCB/electrode socket or replacement of amplifier is required. Check for the correct soldering of reference cable and its connector.
- **circuit board bad soldering or component failure**. Check the shielded cable connections as well. Sometimes inside out connection (hot electrode goes outside as a shield) is the problem: both ends of amplifier signal cable must be reversed.
- **analog signal ribbon cable** (it picks up noise). Check the ribbon cable between the circuit board and the amplifier. Maybe it is pinched under some screws or components. This may cause trouble and even noise.

7.3.4.4.D. Pneumatic failures, liquid paths that conduct noise into the chamber:

- **liquid remains under the chamber in drain tube** (during measurement the conducting liquid remains inside the drain tube making noise to appear there).
  - Check chamber draining path for clogging or salt crystals.
  - Check the pump operation. Since draining of the chamber goes under pressure control, maybe a bad pressure sensor or connection can cause trouble.
  - Clean the draining path. Do not use alcohol, but bleach. Replace chamber if necessary.
- **liquid remains in the washing inlet at top of the chamber** (during measurement the conducting liquid remains inside the chamber wash tube making noise to appear). The software is not compatible with the mechanics, or related valve is bad/partly clogged, or the tubing is clogged/loose.
- **lyse path guides in noise** (during counting, if the a liquid in the draining tube is touching lyse reagent in T-fitting, noise can appear). Check the lyse path, and the lyse valve as well.

8. MAINTENANCE

8.1. Weekly Maintenance by User

User should carry out on the first workday, before starting up the analyzer.

8.1.1. Cleaning the washing head

User should clean the lower surface of the sampling needle washing head using a soft cloth, immersed in warm tap water to remove salt build-up.

8.2. Periodic Maintenance by Service

The instruments should be checked and maintenance must be carried out in every 6 months, or after 10 000 measurement cycles.

8.2.1. Check Self test and Device statistics

Run the built-in Self test and check the overall test result. Check the device statistics to find common problems.

8.2.2. Cleaning and Greasing Dilutor Block

The dilutor block driving wheels and gear bar should be cleaned from dirt and must be greased with A597 grease between the gear bar and the support, and between cogged wheels.

8.2.3. Checking and Lubricating Dilutor Piston Tips

The cogged end of PTFE dilutor pistons should be cleaned and lubricated by neutral silicon grease, A599. Apply just a thin layer, and move it along the perimeter of the piston, so that some of the material goes into the gaps between the sealing rings.

Repeat this step for lyse and dilutor pistons as well. Check the condition of the micro piston sealing, and replace if necessary.

8.2.4. Cleaning and Lubricating Needle Moving Mechanics

The H&V moving mechanics sliding bars should be cleaned from dust.

Lubricating of the sliding bars must be made using A598 Photolube, oil containing PTFE. **Grease or pure lubricating oil is not suitable.**

8.2.5. Checking and Replacing Washing Head

Check the state of the washing head, and replace if necessary. After replacing washing head, do not forget to perform correct adjustment of sampling needle height (see Section 4.1.2).

8.2.6. Checking and Replacing Peristaltic Pump Tube

Replace peristaltic pump tube if needed. You can check it by opening the lock, and removing the tube for inspection.

Check for leakage of the tubing. Reassemble the head.

Warning! Be careful, DO NOT twist the tube while reposition it into the head, because it will cause malfunction in a very short period of time.

8.2.7. Checking condition of lyse tubing

Lyse reagent get the tubing material hard, at connections air can be aspirated to the system, which decreases volume of lyse reagent. Check the hardness of tubings at rear panel lyse connection by hand. If you feel the Tygon tubing hard compared by other tubing, replace them.

8.2.8. Bleaching of Fluidic System

It is recommended to run a bleaching procedure to remove stains from the fluidic system.

1. Connect 2-5%, hand warm, clean bleach solution to all reagent inputs, and perform priming on all reagent inputs.
2. Leave it in the tubing for not more than 2-3 minutes.
3. Remove the bleach, prime on air.
4. Connect distilled water (100 ml), and perform priming all reagents, again.

   Connect reagents, and run priming again.

9. SPARE PARTS

CODE	NAME
AP104	**Hemolyzer 3** plastic front panel
APX104	Front panel (**Hemolyzer 3**, excl. keyboard)
AP132	Foil keyboard
A133	HVB board with inverter (complete)
AP136	LCD display
A137	Lamp for LCD
AP140	Amplifier board (Hemolyzer 3, complate)
J156	Power supply
AP157	Mains switch
AP730	Loudspeaker
J100	PPB board (complete)
AP170	IDEEPROM board
J112	Control board (COMB 4.12)
J113	Control board for DIMMPC
A192	DIMMPC (CPU)
A195	DIMMPC safe ring
AP300	XY needle movement block (complete)
A301	Timing belt for XY block
A302	Stepper motor
A303	Bearing for XY block
A304	Timing pulley for X (mounted)
A305	Timing pulley for Y (mounted)
A306	Gear for Y opto
AP307	H&V motor opto board (complete)
A308	Opto switch I.
A309	Opto switch II.
A310	Head washer
AP311	Aspirator tip
A313	Seeger ring (D 19)
A314	Seeger ring (RA5)
A321	Return pulley for XY
AP400	Meas. Block excl. Amplifier (Hemolyzer 3)
A401	Cone for chambers

CODE	NAME
A402	Sealing ring for chamber
A403	U-shaped metal fixing for apertures
A404V2	Cone for WBC chamber
A405	Shield for WBC chamber
A406	Sealing ring for WBC chamber
AP450	MIX chamber
AP420	RBC chamber
A421	RBC aperture (80 µm)
A422	Ground electrode for RBC/WBC
AP430	WBC chamber
A431	WBC aperture (100 µm)
A433	Upper part for WBC chamber
A434	HGB meas. head (complete)
J5P900	Microdilutor unit (complete)
AP501	Valve unit I. (complete)
AP502	Valve unit II.(complete)
A504	2/2 valve
A505	3/2 valve
A506	Valve coil for both valves
A507	2/2 valve head
A508	3/2 valve head
A510	Puffer reservoir Abacus
A511	Puffer reservoir holder (pair)
J530	Pressure sensor with cable (complete)
AP240	Reagent sensor board
A541	4/2 plastic tube (silicon)
A542	5/3 plastic tube (silicon)
A543	4/1.8 Tygon tube
A544	5/3 reagent tube
A545	3,2 mm T connector
A546	Y connector
A547	2,3/3,2 fitting
A548	O ring for WBC chamber
A549	O ring for apertures

CODE	NAME
A550	Diluent cont. connector
A551	Colour locking ring
A552	Colour lock nut (inside)
A553	Colour coding ring (outside)
A554	Luer female
A555	Luer male
A556	2,3 mm T connector
A557	Teflon regent cont. Connector
J558	Reagent tubing set
AP560	Peristaltic pump
A561	Tube for peristaltic pump
A563	Cassette for pump
A564	Fixing for pump (pair)
A565	Connector for pump (pair)
A610	Micro switch
APX105	**Hemolyzer 3** cover with printer
APX107	Complete start bar
AP620	Instrument door
AP621	Door lock
AP640	**Hemolyzer 3** sample union
A650	Screw for loudspeaker
A701	Mains cable
J728	5V regulator with cable
J7502	34P ribbon cable (XY block)
J7503	10P ribbon cable (printer)
C722	Amplifier shielded cable
AP701	Ground cable (15 cm)
AP702	Ground cable (25 cm)
AP703	Ground cable (62 cm)
AP7501	10P ribbon cable (reagent sensor)
AP7502	20+14P ribbon cable (LCD)
AP7503	20P ribbon cable (VALVE)
AP7504	20P ribbon cable (HVB board)

CODE	NAME
AP7505	34P ribbon cable (amplifier board)
AP7506	14P ribbon cable (microdilutor)
AP7507	26P ribbon cable (dilutor)
AP7508	3P ribbon cable (start button)
AP7509	10P ribbon cable (HUR)
AP132	Foil keyboard
AP140	Amplifier board (complete)
AP250	Dilutor block (complete)
AP251	Lyse syringe with piston
AP202	Lyse syringe
S210	Bearing for dilutor
J214	Dilutor panel (mounted)

10. APPENDICES

10.1. Warning flags

In the followings we summarize the **warning flags** and give an explanation of their possible cause and a few hints to overcome the problem:

Uppercase letters refer to WBC or HGB problems:

Flag	Meaning	Recommended user action
W	WBC three part warning or WBC three part diff. unsuccessful	⇒ Repeat the measurement. Possibly lyse problem. ⇒ Check the discriminators in the WBC histogram. If the discriminators are in the proper place (the populations can be separated by eye) then the results can be accepted.
E	No WBC three part	⇒ Possibly lyse problem, but in some pathological samples (too high lymphocytes), it can be happened.
H	HGB blank is high, or no HGB blank	⇒ Repeat the blank measurement and accept it. ⇒ Possibly lyse or diluent problem.
B	WBC blank is high, or no WBC blank	⇒ Repeat the blank measurement and accept it. ⇒ Possibly lyse or diluent problem.
L	WBC/RBC limit warning	⇒ Check the 1. RBC-LYM discriminator. If it is in the minimum point (or close to it), accept the results. Otherwise repeat the measurement. ⇒ If the retried action makes very similar results and the discriminator is in a wrong place then the MID and GRA results are OK, but the WBC and LYM results can be higher because of the RBCs.
R	Too many RBC cut from WBC	⇒ Repeat the measurement. Possibly lyse problem. ⇒ If the WBC measuring time is too high (more than 8 sec.) it could be aperture clogging. In that case perform cleaning and repeat the measurement.
M*	WBC coincidence is too high. Linearity error.	⇒ The results are out of the linearity range. Make a dilution with an external dilutor with a pre-defined dilution range. Do not forget to correct the results with the defined factor.
D	WBC data package errors	⇒ Perform cleaning, redo measurement (aperture clogging). ⇒ If it is a general problem, please call your Service Personnel.
S	WBC time error	⇒ The same action as in case of the **D** warning flag.
C	WBC clogging	⇒ Aperture clogging. The same action as in case of the **D** warning flag.

Table 9. Summary of warning flags related to WBC/HGB

Warning flags in lowercase refer to RBC or PLT problems:

Flag	Meaning	Recommended user action
p	PLT blank is high, or no PLT blank	⇒ Repeat the blank measurement and accept it. ⇒ Diluent problem. Replace diluent, open a new tank.
b	RBC blank is high, or no RBC blank	⇒ Repeat the blank measurement and accept it. ⇒ Diluent problem. Replace diluent, open a new tank.
l	RBC/PLT limit warning	⇒ The RBC/PLT valley is too high. It is rather a diagnostic flag. If the discriminator is in a wrong place (in the PLT or RBC histogram) then repeat the measurement for a correct PLT result.
k	RBC peak warning	⇒ Perform cleaning and repeat the measurement (clogging). ⇒ If it is a general problem, change the RBC aperture.
m*	RBC/PLT coincidence is too high. Linearity error.	⇒ The same action as in case of the **M** warning flag.
d	RBC/PLT data package errors	⇒ The same action as in case of the **D** warning flag.
s	RBC/PLT time error	⇒ The same action as in case of the **D** warning flag.
c	RBC/PLT clogging	⇒ The same action as in case of the **C** warning flag.

Table 10. Summary of warning flags related to RBC/PLT

10.2. Serial Communication Protocol

This document describes protocols 1.0, 1.7, 2.20, 2.23 and 3.0.
Only protocol version 3.0 contains sending Limits for parameters.

10.2.1.General Description

Hemolyzer 3 software is able to make serial connection link to a receiver device (computer) by connecting to the serial port of the instrument. If Serial Communication Speed (Utilities / Settings / Customize / General Settings) Baud Rate setting is set to a valid value (other than “Offline”), Hemolyzer 3 will try to initiate a communication sequence.

Hemolyzer 3 initiates serial communication, the receiver must respond to this request.

The hardware protocol is: **8 data bit, 1 stop bit, no parit**y. If the other side is not responding within 1 second, Hemolyzer 3 will repeat the transmission twice, but if still no response, the other side will be supposed to be not ready to receive data, and thus Hemolyzer 3 will not try to communicate any more.

From this state it can wake up by receiving an <ENQ> (ASCII code 5) character from the other side, and Hemolyzer 3 will immediately respond with an <ACK> (ASCII code 6). From this point Hemolyzer 3 will send data if it is ready for transmission.

The communication is based on packages. **There are 7 package types**:

- INIT package: Device identification, software version, current date and time.
- DATA package: Sample and patient information, measured parameters, and markers.
- RBC package: Sample information, RBC histogram.
- WBC package: Sample information, WBC histogram.
- PLT package: Sample information, PLT histogram.
- XML file with FULL record structure information
- FULL record transmission

The communication sequence is always started with an INIT package. If the link is successful, Hemolyzer 3 will send DATA package, and the receiver can request RBC, WBC and PLT packages at acknowledge.

If serial communication protocol is set to version 3.0, Hemolyzer 3 will send XML and FULL packages.

Special characters used in the communication:

Character	ASCII code
<SOH>	1
<STX>	2
<ETX>	3
<EOT>	4
<ENQ>	5
<ACK>	6
<HT>	9
<LF>	10
<NAK>	21
<SPACE>	32

10.2.2.Format of Packages Sent

The packages sent by Hemolyzer 3 are always between a <SOH> and <EOT> character, and they consist of header, data and tail. The header consists of a package identifier and a package type descriptor. The tail includes the checksum. Typical format:

<SOH>MID CMD**<STX>**MESSAGE**<ETX>**CHKSUM**<EOT>**

MID: Message ID, one capital letter between ' A' and ' Z'

CMD: Command, one capital letter – package type descriptor

- ' I' for INIT;
- ' D' for DATA;
- ' R' for RBC;
- ' W' for WBC;
- ' P' for PLT.
- 'X' for XML descriptor
- 'F' for full record transmission

MESSAGE: the message consists of ASCII characters (between 32..128)

CHKSUM: two hexadecimal digits of a one-byte checksum which contains the lower byte of the sum of characters between the <SOH> and <ETX> (incl. those, too).

10.2.3.Format of Acknowledge of the Receiver

The receiver must acknowledge transmission by the following message:

<ACK>CMD MID

CMD: the type of the next package to send – this makes possible to a request for histograms. If no more packages are required, <SPACE> should be sent.

MID: the identifier of the package that acknowledged by this message.

If receiving of the message was not successful, <NAK> should be sent, and Hemolyzer 3 will repeat the last package.

The receiver has approx. 1 second to reply. Otherwise Hemolyzer 3 will repeat the last transmission, twice automatically. But if still no response after 3 trials, Hemolyzer 3 will not start to communicate any more, even if there is data to send (see General Description).

10.2.4.Detailed Description of Packages

The packages sent by Hemolyzer 3 are placed between a header and a tail. There are 5 main types of them: INIT, DATA and histogram packages, XML descriptor, and FULL record. The histogram package can be: RBC, WBC, and PLT. Format is the same, only the type descriptor differs.

INIT package

Hemolyzer 3 sends the general identifiers by this package during initiation of a communication:

DEVICE**<HT>**VERSION**<HT>**DATE**<HT>**TIME**<HT>**DB_VERSION

DEVICE: device identifier: „Hemolyzer 3"

VERSION: version of the software, e.g. „1.3"

DATE: date in YYYYMMDD format

TIME: time in HHMMSS format

VERSION: Database version in Mmm (Major.minorminor) format

DATA package

This package contains sample and patient data, the measured parameters and the markers of histograms. One data element consists of two items: name and value, which are separated by a <HT> character, and closed by <LF>:

```
SNO<HT>152<LF> internal identifier
DATE<HT>19980715<LF> date of measurement (YYYYMMDD)
TIME<HT>114500<LF> time of measurement (HHMMSS)
PID<HT>2<LF> patient identifier (0..9999)
NAME<HT>JOE SMITH<LF> patient name (max. 32 characters)
MODE<HT>0<LF> patient type
WRN<HT>0<LF> warning bits [1] (32-bit hexadecimal)
PM1<HT>12<LF> PLT lower marker [2]
PM2<HT>204<LF> PLT upper marker [2]
RM1<HT>51<LF> RBC lower marker [2]
WM1<HT>23<LF> WBC upper marker [2]
WM2<HT>57<LF> WBC LYM-MID marker [2]
WM3<HT>92<LF> WBC MID-GRA marker [2]
PARN<HT>22<LF> number of parameters to send
P01<HT> 6.6<HT>0<LF> first parameter ID [3], value and flag [4]
P02<HT>4.29<HT>0<LF> second parameter ID, value and flag
...
P22<HT> 8.2<HT>0<LF> last parameter ID, value and flag
```

Remarks:

[1] Position and meaning of the warning flags:

Bit	Mask	Letter	Meaning
0	0x00001	c, q	RBC/PLT clogging.
3	0x00008	m	RBC/PLT Coincidence is too high. Linearity error.
6	0x00040	b	RBC Blank is high, or no RBC blank.
7	0x00080	p	PLT blank is high, or no PLT blank.
8	0x00100	C, Q	WBC clogging.
11	0x00800	M, N	WBC coincidence is too high. Linearity error.
14	0x04000	B	WBC Blank is high, or no WBC blank.
15	0x08000	H	HGB Blank is high, or no HGB blank.
16	0x10000	E	No WBC three part.

The detailed description can be found in the User’ s Manual

[2] The markers are given in histogram channel between 0 and 255, where 0 means that the marker could not be found.

[3] The parameter IDs in Hemolyzer 3 are: P01: WBC (10^9/l); P02: RBC (10^{12}/l); P03: HGB (g/l); P04: HCT (%); P05: MCV (fl); P06: MCH (pg); P07: MCHC (g/l); P08: PLT (10^9/l); P09: PCT (%); P10: MPV (fl); P11: PDWsd (fl); P12: PDWcv (%); P13: RDWsd (fl); P14: RDWcv (%); P15: LYM (10^9/l); P16: MON (10^9/l); P17: GRA (10^9/l); P18: LYM% (%); P19: MON% (%); P20: GRA% (%); P21: RBCtime (sec); P22: WBCtime (sec).

[4] The parameter value is always 4 characters wide, spaces from left added if necessary. It can be 9999, if the value could not be displayed in 4 digits, or ---- if the value could not be calculated because of an error.

The meaning of the parameter flags:

Flag	Displayed	Meaning
0		Value correct.
1	+	Value high(more than upper limit)
2	–	Value low(less than lower limit)
3	*	Value is unreliable.
4	E	Value not given because of error. Value is----.
5		Value cannot be calculated. There is no value!

RBC, WBC and PLT package

The format of the histogram packages are the same, they differ in type descriptor only. The package contains the sample data (to identify the package) and the histogram.

```
SNO<HT>152<LF> internal identifier
DATE<HT>19980715<LF> date of measurement (YYYYMMDD)
TIME<HT>114500<LF> time of measurement (HHMMSS)
PID<HT>2<LF> patient identifier (0..9999)
CHN<HT>256<LF> number of histogram channels (256)
9<HT> value of first histogram channel
...
1<HT> value of 255th histogram channel
0 value of the last histogram channel
```

XML record descriptor package

Each time a communication is initialized, Hemolyzer 3 will send an XML file in ASCII mode. A receiver application should be aware of this, by saving this XML file for later use.

This package contains the description of the FULL record format. FULL record format means transmission of a record stored in Hemolyzer 3 as is, in binary format. Data sent in an 'F' package should be interpreted according to the description in the XML file below. Would an 'F' package arrive without an 'X' package received earlier, receiver application can ask for the XML descriptor by sending a request for an 'X' package. (See WBC, RBC, PLT histogram package request.)

XML file sent by Hemolyzer 3:

```
<DB_Struct_DAT>
        <Header>
                <Field name="Head" type="char" length="9"/>
                <Field name="Modified" type="DateTime" length="1"/>
                <Field name="Length" type="DWORD" length="1"/>
                <Field name="Order" type="BYTE" length="1"/>
                <Field name="Dummy1" type="BYTE" length="1"/>
                <Field name="Dummy2" type="WORD" length="1"/>
                <Field name="Capacity" type="WORD" length="1"/>
                <Field name="RecLen" type="WORD" length="1"/>
                <Field name="Dummy3" type="BYTE" length="7"/>
        </Header>
        <Record>
                <Field name="RecNo" type="WORD" length="1" path="Measures/Measure" alias="RecNo"/>
                <Field name="TimeStamp" type="DateTime" length="1" path="Measures/Measure" alias="Date"/>
                <Field name="OperatorID" type="WORD" length="1" path="Measures/Measure" alias="OpID"/>
                <Field name="SampleID" type="char" length="8" path="Measures/Measure" alias="SID"/>
                <Field name="PatientID" type="char" length="20" path="Patient" alias="PID"/>
                <Field name="Name" type="char" length="32" path="Patient" alias="Name"/>
                <Field name="BirthDate" type="DateTime" length="1" path="Patient" alias="Birth"/>
                <Field name="Sex" type="BYTE" length="1" path="Patient" alias="Sex" extID="Sex"/>
                <Field name="Doctor" type="char" length="16" path="Measures/Measure" alias="Doctor"/>
                <Field name="LimitsLow" type="float" length="23" path="Measures/Measure" alias="field_LimitLow" incr="1"/>
                <Field name="LimitsHigh" type="float" length="23" path="Measures/Measure" alias="field_LimitHigh" incr="1"/>
                <Field name="PatTypeName" type="char" length="20" path="Measures/Measure" alias="PatTypeName"/>
                <Field name="VetMode" type="WORD" length="1" path="Measures/Measure" alias="field_VET" source="PatTypeName"/>
                <Field name="HistoRBC" type="BYTE" length="256" path="Measures/Measure/field_RBCH" alias="D" extID="Histo"/>
                <Field name="HistoPLT" type="BYTE" length="256" path="Measures/Measure/field_PLTH" alias="D" extID="Histo"/>
                <Field name="HistoWBC" type="BYTE" length="256" path="Measures/Measure/field_WBCH" alias="D" extID="Histo"/>
                <Field name="PLTlo" type="BYTE" length="1" path="Measures/Measure/field_PLTH" alias="PM1"/>
                <Field name="PLThi" type="BYTE" length="1" path="Measures/Measure/field_PLTH" alias="PM2"/>
                <Field name="RBClo" type="BYTE" length="1" path="Measures/Measure/field_RBCH" alias="RM1"/>
                <Field name="WBClo" type="BYTE" length="1" path="Measures/Measure/field_WBCH" alias="WM1"/>
                <Field name="LYMhi" type="BYTE" length="1" path="Measures/Measure/field_WBCH" alias="WM2"/>
                <Field name="GRAlo" type="BYTE" length="1" path="Measures/Measure/field_WBCH" alias="WM3"/>
                <Field name="Param" type="float" length="23" path="Measures/Measure" alias="field_P" incr="1" extID="Param"/>
                <Field name="Flag" type="BYTE" length="23" path="Measures/Measure" alias="field_P" alias2="_f" incr="1" extID="Flag"/>
                <Field name="Warning" type="DWORD" length="1" path="Measures/Measure" alias="field_WRN"/>
                <Field name="Lyse" type="float" length="1" path="Measures/Measure" alias="field_LYSE"/>
                <Field name="Lyse_2" type="float" length="1" path="Measures/Measure" alias="field_LYSE2"/>
                <Field name="Options" type="WORD" length="1" path="Measures/Measure" alias="field_OPT" extID="Options"/>
                <Field name="PrVMinW" type="WORD" length="1" path="Measures/Measure" alias="PrVMinW"/>
                <Field name="PrVMaxW" type="WORD" length="1" path="Measures/Measure" alias="PrVMaxW"/>
                <Field name="PrVMinR" type="WORD" length="1" path="Measures/Measure" alias="PrVMinR"/>
                <Field name="PrVMaxR" type="WORD" length="1" path="Measures/Measure" alias="PrVMaxR"/>
                <Field name="PrVMinW2" type="WORD" length="1" path="Measures/Measure" alias="PrVMinW2"/>
                <Field name="PrVMaxW2" type="WORD" length="1" path="Measures/Measure" alias="PrVMaxW2"/>
                <Field name="Age" type="BYTE" length="1" path="Measures/Measure" alias="field_AGE"/>
                <Field name="ClogReport" type="char" length="29" path="Measures/Measure" alias="ClogReport"/>
        </Record>
        <Misc>
                <Field path="Measures/Measure" alias="Type" value="Haematology"/>
                <Field path="Measures/Measure" alias="field_PLTH" value=""/>
                <Field path="Measures/Measure/field_PLTH" alias="CHN" value="256"/>
                <Field path="Measures/Measure" alias="field_RBCH" value=""/>
                <Field path="Measures/Measure/field_RBCH" alias="CHN" value="256"/>
                <Field path="Measures/Measure" alias="field_WBCH" value=""/>
                <Field path="Measures/Measure/field_WBCH" alias="CHN" value="256"/>
                <Field path=".." alias="Version" value="2.22"/>
                <Field path="Measures/Measure" alias="Version" value="2.22"/>
                <Field path="Measures/Measure" alias="MeasureMode" value="3"/>
        </Misc>
        <MaxParams value="23"/>
        <DB_VESRION value="2.22"/>
</DB_Struct_DAT>
```

Explanation of a Field of Record tag (Record tag should be used to interpret 'F' package):

<	Starting tag of field descriptor
Field name=”RecNo”	Name of field (can be used as reference in PC application)
tpe=”WORD”	Type descriptor of field
length=”1”	How many bytes should be used for storing (length)
…	Technical tags
/>	Closing of field tag

<Field name="LimitsLow" type="float" length="23" path="Measures/Measure" alias="field_LimitLow" incr="1"/>

This field is an array, contains 23 entries, as indicated. Interpretation of these entries is not listed in the XML file. You will find them below:

```
#define PAR_WBC   0
#define PAR_RBC                          1
#define PAR_HGB   2  // always transmitted in g/l unit
#define PAR_HCT   3
#define PAR_MCV   4
#define PAR_MCH   5  // always transmitted in g/l unit
#define PAR_MCHC  6
#define PAR_PLT   7
#define PAR_PCT   8
#define PAR_MPV   9
#define PAR_PDWsd 10
#define PAR_PDWcv 11 // note that it matches with PAR_PDW
#define PAR_PDW   11 // note that it matches with PAR_PDWcv
#define PAR_RDWsd 12
#define PAR_RDWcv 13 // note that it matches with PAR_RDW
#define PAR_RDW   13 // note that it matches with PAR_RDWcv
#define PAR_LYM   14
#define PAR_MON   15
#define PAR_GRA   16
#define PAR_LYMp  17
#define PAR_MONp  18
#define PAR_GRAp  19
#define PAR_RBCt  20
#define PAR_WBCt  21
#define PAR_WBCt2 22
```

Use the above identifiers to interpret entries in the array.
PARAM and FLAG interpretation should happen accordingly.

This package starts with the ‘X’ package identifier, contains 2 size descriptor bytes (SIZE1 and SIZE2), and the XML file in ASCII format. Use this as a descriptor of the structure sent in F package.

<SOH><MESSAGE_ID >X<STX>
<SIZE1><SIZE2><PAYLOAD (XML file in ASCII format): SIZE1*256+SIZE2 BYTES>
<ETX><CHKSUM1><CHKSUM2><EOT>

FULL record package

This package starts with the ‘F’ package identifier, contains 2 size descriptor bytes (SIZE1 and SIZE2), and a record in binary format. Interpretation of the binary information should happen using field definitions of the XML file received in an ‘X’ package.

<SOH><MESSAGE_ID >F<STX>
<SIZE1><SIZE2><PAYLOAD (actual binary record): SIZE1*256+SIZE2 BYTES>
<ETX><CHKSUM1><CHKSUM2><EOT>

10.2.5.Serial Protocol 1.0

Receiver sends that it is ready to receive now.
<ENQ>

Hemolyzer 3 sends acknowledge.
<ACK>

Hemolyzer 3 sends INIT to initiate link (there is data to send):
<SOH>AI<STX>Hemolyzer 3<HT>1.3<HT>20011005<HT>125027<ETX>30<EOT>

Receiver sends acknowledge:
<ACK><SPACE>A

Hemolyzer 3 sends DATA package:
<SOH>BD<STX>SNO<HT>152<LF>DATE<HT>19980715<LF>TIME<HT>114500<LF>
PID<HT>2<LF>NAME<HT>JOE SMITH<LF>MODE<HT>0<LF>WRN<HT>0<LF>
PM1<HT>12<LF>PM2<HT>204<LF>RM1<HT>51<LF>WM1<HT>23<LF>WM2<HT>57<LF>
WM3<HT>92<LF>PARN<HT>22<LF>P01<HT> 6.6<HT>0<LF>P02<HT>4.29<HT>0<LF>
P03<HT> 167<HT>0<LF> ... P21<HT> 8.2<HT>0<LF>P22<HT> 5.3<HT>0<LF>
<ETX>7C<EOT>

Receiver acknowledges DATA transmission, and requests for RBC package:
<ACK>RB

Hemolyzer 3 sends RBC package:
<SOH>CR<STX>SNO<HT>152<LF>DATE<HT>19980715<LF>TIME<HT>114500<LF>
PID<HT>2<LF>CHN<HT>256<LF>9<HT>16<HT>26<HT> ... 1<HT>0<ETX>F2<EOT>

Receiver acknowledges RBC transmission, and requests for WBC package:
<ACK>WC

Hemolyzer 3 sends WBC package:
<SOH>DW<STX>SNO<HT>152<LF>DATE<HT>19980715<LF>TIME<HT>114500<LF>
PID<HT>2<LF>CHN<HT>256<LF>0<HT>15<HT>84<HT> ... 5<HT>3<ETX>69<EOT>

Receiver acknowledges WBC transmission, and closes the link.
<ACK><SPACE>D

It is possible to request for PLT histogram, but it is not shown in this example.

10.2.6.Serial Protocol 1.7

Receiver sends that it is ready to receive now.
<ENQ>

Hemolyzer 3 sends acknowledge.
<ACK>

Hemolyzer 3 sends INIT next time to initiate link (there is data to send):
<SOH>AI<STX>Hemolyzer 3<HT>2.22<HT>20011005<HT>135212<ETX>30<EOT>

Receiver sends acknowledge:
<ACK><SPACE>A

Hemolyzer 3 sends DATA package:
<SOH>BD<STX>SNO<HT>152<LF>DATE<HT>19980715<LF>TIME<HT>114500<LF>
SID<HT>2<LF>PID<HT>26<LF>NAME<HT>JOE
SMITH<LF>MODE<HT>0<LF>WRN<HT>0<LF>
PM1<HT>12<LF>PM2<HT>204<LF>RM1<HT>51<LF>WM1<HT>23<LF>WM2<HT>57<LF>
WM3<HT>92<LF>PARN<HT>22<LF>P01<HT> 6.6<HT>0<LF>P02<HT>4.29<HT>0<LF>
P03<HT> 167<HT>0<LF> ... P21<HT> 8.2<HT>0<LF>P22<HT> 5.3<HT>0<LF>
<ETX>7C<EOT>

Receiver acknowledges DATA transmission, and requests for RBC package:
<ACK>RB

Hemolyzer 3 sends RBC package:
<SOH>CR<STX>SNO<HT>152<LF>DATE<HT>19980715<LF>TIME<HT>114500<LF>
SID<HT>2<LF>PID<HT>26<LF>CHN<HT>256<LF>9<HT>16<HT>26<HT> ...
1<HT>0<ETX>F2<EOT>

Receiver acknowledges RBC transmission, and requests for WBC package:
<ACK>WC

Hemolyzer 3 sends WBC package:
<SOH>DW<STX>SNO<HT>152<LF>DATE<HT>19980715<LF>TIME<HT>114500<LF>
SID<HT>2<LF>PID<HT>26<LF>CHN<HT>256<LF>0<HT>15<HT>84<HT> ...
5<HT>3<ETX>69<EOT>

Receiver acknowledges WBC transmission, and closes the link.
<ACK><SPACE>D

It is possible to request for PLT histogram, but it is not shown in this example.

10.2.7.Serial Protocol 2.20, 2.23

This version utilizes a bit upgraded header information:

```
<SOH>BD<STX>SNO<HT>152<LF>DATE<HT>19980715<LF>TIME<HT>114500<LF>
SID<HT>2<LF>PID<HT>26<LF>NAME<HT>JOE
SMITH<LF>MODE<HT>0<LF>WRN<HT>0<LF>
PM1<HT>12<LF>PM2<HT>204<LF>RM1<HT>51<LF>WM1<HT>23<LF>WM2<HT>57<LF>
WM3<HT>92<LF>PARN<HT>22<LF>P01<HT> 6.6<HT>0<LF>P02<HT>4.29<HT>0<LF>
P03<HT> 167<HT>0<LF> ... P21<HT> 8.2<HT>0<LF>P22<HT> 5.3<HT>0<LF>
AGE<HT>24<LF><ETX>7C<EOT>
```

A parameter called AGE is included in the header info. This represents the age of the given patient (if selected in service menu, and defined at sample info screen).

The interpretation of this value is:
If the age value is greater than 128, then it represents months in the following way: MONTHS = AGE – 128 (months).
If it is less than 128, then it represents years.

This parameter has been removed in version 2.23

10.2.8.Serial Protocol 3.0

This version utilizes a new approach to record transmitting:

It sends the INIT package, where instrument and PC should establish the communication. After connection is established, Hemolyzer 3 will send an ‘X’ package with the XML file to give a description to the binary data sent in the ‘F’ (FULL) package.

From then on, ‘F’ packages are sent, and receiver software must interpret the binary data using the descriptors in the XML file.

Structures, and data for interpreting ‘F’ record, without using an XML parser to get data based on <Record> tag of XML file (these structures are “locked” to HMII SW 2.68m):

```
typedef struct _DateTime
{
  unsigned minute   : 6;    // 0..59      (64   = 2^6   : 6 bits)
  unsigned hour     : 5;    // 0..23      (32   = 2^5   : 5 bits)
  unsigned day      : 5;    // 1..31      (32   = 2^5   : 5 bits)
  unsigned month    : 4;    // 1..12      (16   = 2^4   : 4 bits)
  unsigned year     : 12;   // 0..4095    (4096 = 2^12  : 12 bits)
} DateTime;

#define MaxParams 23

struct TMeasData
{
  WORD      RecNo;              //              2 bytes
  DateTime  TimeStamp;          //              4 bytes
  WORD      OperatorID;         //              2 bytes
  char      SampleID[8];        //              8 bytes
  char      PatientID[20];      //             20 bytes
  char      Name[32];           //             32 bytes
  DateTime  BirthDate;          //              4 bytes
  BYTE      Sex;                //              1 byte
  char      Doctor[16];         //             16 bytes
  float     LimitsLow[MaxParams];// 23 * 4  =  92 bytes
  float     LimitsHigh[MaxParams];// 23 * 4  = 92 bytes
  char      PatTypeName[20];     //             20 bytes
  WORD      VetMode;            //              2 bytes
  BYTE      HistoRBC[256];      //            256 bytes
  BYTE      HistoPLT[256];      //            256 bytes
  BYTE      HistoWBC[256];      //            256 bytes
  BYTE      PLTlo;              //              1 byte
  BYTE      PLThi;              //              1 byte
  BYTE      RBClo;              //              1 byte
  BYTE      WBClo;              //              1 byte
  BYTE      LYMhi;              //              1 byte
  BYTE      GRAlo;              //              1 byte
  float     Param[MaxParams];   // 23 * 4  =   92 bytes
  BYTE      Flag[MaxParams];    // 23 * 1  =   23 bytes
  DWORD     Warning;            //              4 bytes
  float     Lyse;               //              4 bytes
  float     Lyse_2;             //              4 bytes
  WORD      Options;            //              2 bytes
  WORD      PrVMinW;            //              2 bytes
  WORD      PrVMaxW;            //              2 bytes
  WORD      PrVMinR;            //              2 bytes
  WORD      PrVMaxR;            //              2 bytes
  WORD      PrVMinW2;           //              2 bytes
  WORD      PrVMaxW2;           //              2 bytes
  BYTE      Age;                //              1 byte
  char      ClogReport[29];     //             29 bytes
                                // Total:    1240 bytes
};
```

Data map of TmeasData inside an F package

Field name	explanation	note	no. of bytes	data type
RecNo	Internal Record ID	1	2	WORD
TimeStamp	Timestamp of sample	2	4	DateTime
OperatorID	Operator ID. Important in multiuser mode only.	1	2	WORD
SampleID	Sample ID	3	8	char
PatientID	Patient ID	3	20	char
Name	Patient name	3	32	char
BirthDate	Birth date of patient	2	4	DateTime
Sex	Gender of patient	4	1	BYTE
Doctor	Doctor's name	3	16	char
LimitsLow	Array of Low limits for parameters, 23 values	5	23 x 4 bytes	float array
LimitsHigh	Array of High limits for parameters, 23 values	5	23 x 4 bytes	float array
PatTypeName	Species name	3	20	char
VetMode	Internal ID of species	6	2	WORD
HistoRBC	Array of RBC histogram, 256 values	7	256	BYTE
HistoPLT	Array of PLT histogram, 256 values	7	256	BYTE
HistoWBC	Array of WBC histogram, 256 values	7	256	BYTE
PLTlo	Lower threshold of PLT graph	7	1	BYTE
PLThi	Upper threshold of PLT graph	7	1	BYTE
RBClo	Lower threshold of RBC graph	7	1	BYTE
WBClo	Lower threshold of WBC graph	7	1	BYTE
LYMhi	Upper threshold of LYMs on WBC graph	7	1	BYTE
GRAlo	Lower threshold of GRAs on WBC graph	7	1	BYTE
Param	Array of measured values (23 elements)	5	23 x 4 bytes	float array
Flag	Array of flags of measured values (23 elements)	8	23 x 1 bytes	BYTE array
Warning	Binary representation of measurement flags	9	8	DWORD
Lyse	Volume of lyse reagent used for sample, ml	5	4	float
Lyse_2	Volume of lyse reagent used for sample, ml	5	4	float
Options	Options set for sample	10	2	WORD
PrVMinW	Probe voltage min for WBC	11	2	WORD
PrVMaxW	Probe voltage max for WBC	11	2	WORD
PrVMinR	Probe voltage min for RBC	11	2	WORD
PrVMaxR	Probe voltage max for RBC	11	2	WORD
PrVMinW2	Probe voltage min for WBC2	11	2	WORD
PrVMaxW2	Probe voltage max for WBC2	11	2	WORD
Age	Age of patient as filled in PatID dialog	12	1	BYTE
ClogReport	Clogging information of sample	3	20	char

Note 1:

WORD data format is stored back to front.
E.g. Decimal value 13553
Hexadecimal value 34 F1
Stored as: F1 34

Note 2:

DateTime type is a packed binary format.
It contains YEAR-MONTH-DAY-hour-minute in the following format:

YYYYYYYYYYYY MMMM DDDDD hhhhh mmmmmm

e.g.:
11/27/2005, 13:37 is stored as:

2005	in binary on 12 bits is:	0111 1101 0101
11	in binary on 4 bits is:	1011
27	in binary on 4 bits is:	1 1011
13	in binary on 5 bits is:	0 1101
37	in binary on 6 bits is:	10 0101

Concatenating these we get: 0111 1101 0101 1011 1101 1011 0110 0101
In hexadecimal these become: 7D 5B DB 65, and gets stored back-to-front
It is stored as: 65 DB 5B 7D

Note 3:

Character strings are stored in character arrays, space not used within a string is always filled with 0's:

String to store: George
Gets stored on 20 chracters as: 'G' 'e' 'o' 'r' 'g' 'e' 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Note 4:

Sex is decoded as:
Sex = 0 Not specified
Sex = 1 Male
Sex = 2 Female

Note 5:

Float numbers are stored on 4 bytes, according to the IEEE 745 standard

Note 6:

Vetmode stores the internal database identifier for the record. It is of no importance here.

Note 7:

Histogram representation. Each histogram is stored in an array of 256 bytes. Each byte represents the histogram value at the given point, as a value from 0 to 255.

PLTlo – lowest PLT volume. Actual volume: PLTlo x 50 fl / 256
PLThi – highest PLT volume. Actual volume: PLThi x 50 fl / 256
RBClo – lowest RBC volume. Actual volume: RBClo x 200 fl / 256
WBClo – lowest WBC volume. Actual volume: WBClo x 400 fl / 256
LYMhi – highest LYM volume. Actual volume: LYMhi x 400 fl / 256
GRAlo – lowest GRA volume. Actual volume: GRAlo x 400 fl / 256

Full scale and resolution of histograms:
PLT – 50 fl, 1 fl x 50/256
RBC – 200 fl, 1 fl x 200/256
WBC – 400 fl, 1 fl x 400/256

Note 8:

Flags for individual parameters. See page 4, remark 4

Note 9:

Warning flags, see page 3, remark 1.

Note 10:

Options flag
'Options' field interpretation:

Option (mask)	Displayed	Meaning
0x0001	PREDIL	sample was run in pre-diluted mode
0x0002	RBCEXT	sample was run in RBC extended mode (not used in HMII code)
0x0004	WBCONLY	sample was run in WBC only mode - RBC related values filled with 0.0

Note 11:

Probe voltages, max and min values for separate measurements. Each value is stored on 1 byte. Actual Probe Voltage of given measurement can be calculated as PrVxxxx * 50V /1024.

Note 12:

'Age' field interpretation:

```
Age_unit = (Age > 128) ? MONTH : YEAR;
if (Age_unit == MONTH) Age_of_patient = Age - 128;      // this in 'MONTHS'
else Age_of_patient = Age;                  // this in 'YEARS'
```

Note: depending on database settings, either BirthDate, or Age gets filled.

LimitsLow, LimitsHigh and Param match in their structure, they contain values for parameters in the order below (indices go from 0 to MaxParams-1):

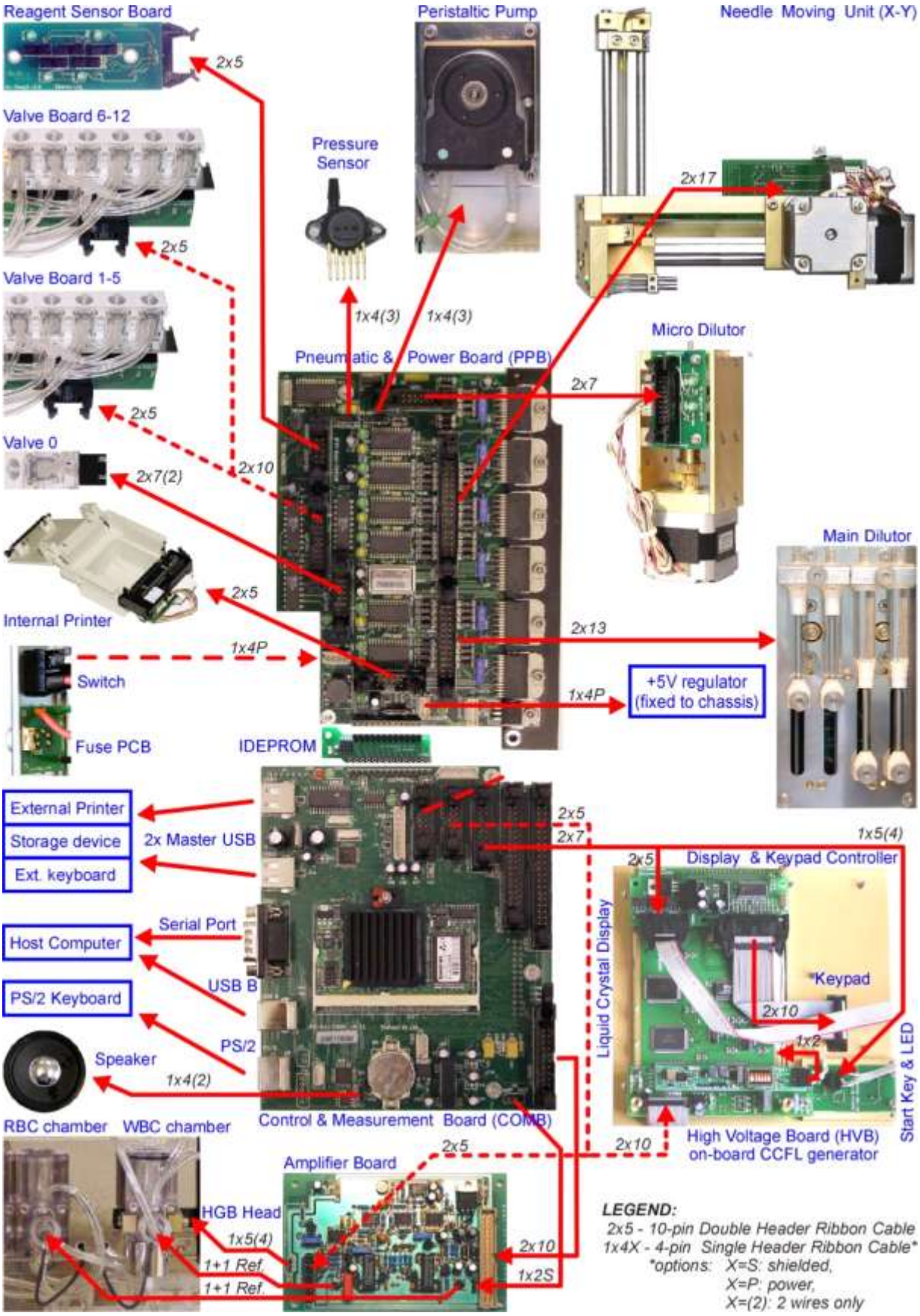
WBC	RBC	HGB	HCT	MCV	MCH	MCHC	PLT	PCT	MPV	PDWsd
PDWcv/PDW	RDWsd		RDWcv/RDW	LYM	MID	GRA	LYMp	MIDp	GRAp	
	RBCt									
WBCt	WBCt2									

Units can be found on page 4, note 3.

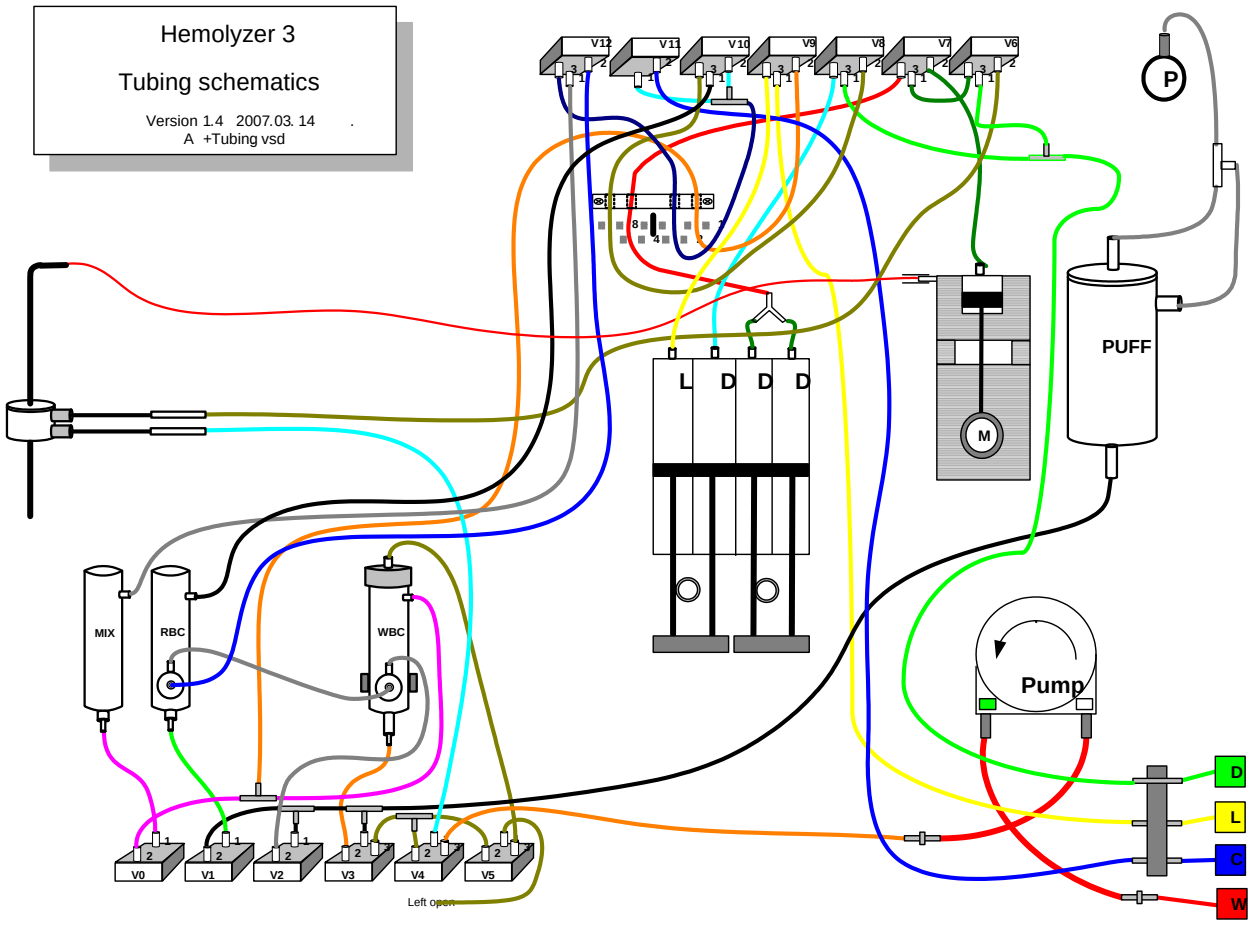
'Flags' has the same order, but contains values 0..5 each referring to the corresponding parameter

'Flags' field value interpretation can be found on page 4, note 4

10.3. Hemolyzer 3 cabling diagram



10.4. Hemolyzer 3 tubing schematics



10.5. Recommended kit of tools

- PC standard keyboard (PS/2)
- Floppy drive with cables: A154+J727+J7505
- Screwdrivers:
  - Cross Slot Screwdrivers (Philips)
  - Slot Screwdrivers
  - Hexagon Screwdrivers (3.5, 2.5, 2.0, 1.5 mm sizes)
- Pocket digital multimeter
- Diagonal Cutter (plier)
- Nipper